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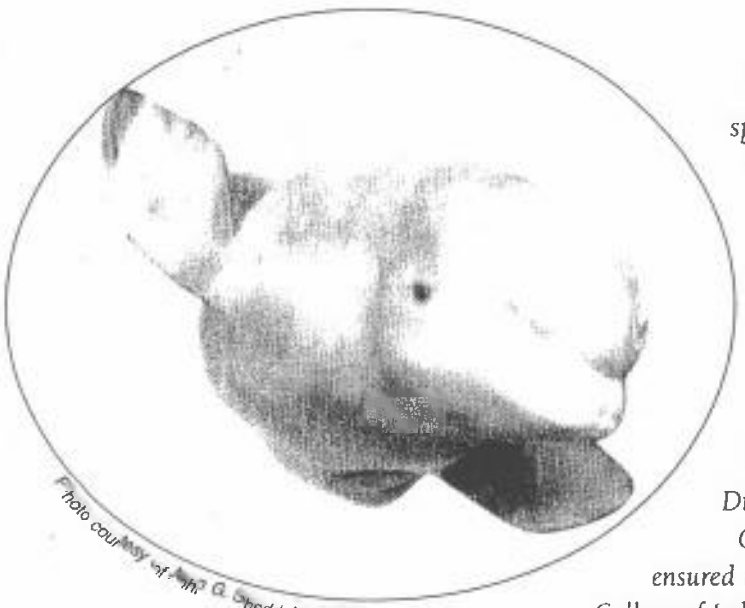
AVMA Animal Welfare Forum:
Marine Mammals



November 6, 1998, Chicago, Illinois

The following papers were submitted by speakers at the 1998 AVMA Animal Welfare Forum, held at the Chicago Marriott O'Hare in Chicago, Ill. These papers have not undergone peer review; opinions expressed are those of the authors and not necessarily those of the American Veterinary Medical Association.

During the Forum, the 1998 Animal Welfare Award was presented to Dr. Leslie Dierauf of Sante Fe, NM.

Contributions from the following sponsors ensured the success of the Forum: American College of Laboratory Animal Medicine, Church & Dwight Company Inc, Fort Dodge Animal Health, Hartz Mountain Corporation, Hill's Pet Nutrition Inc, Innovative Veterinary Diets Inc, Merial, Novartis Animal Health, Pasteur Merieux Connaught, Ralston Purina Company, Summit Industries Inc, and Veterinary Pet Insurance Company.

The AVMA Animal Welfare Forum is an annual event planned by the Animal Welfare Committee, under the direction of the Executive Board. For additional information about the Forum or the Animal Welfare Award, please contact the AVMA Division of Education and Research.

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Welcome

Leonard F. Seda, DVM
President-Elect

Good morning and welcome to the American Veterinary Medical Association's Ninth Annual Animal Welfare Forum. It is my pleasure to welcome you on behalf of the more than 62,000 members of the American Veterinary Medical Association. The Animal Welfare Forum is held each year as the highlight of the AVMA's Animal Welfare Week, which is a series of media events designed to promote the welfare of animals. Throughout the years, the forum has served as a useful platform for highlighting and exploring important animal welfare concerns affecting many different species. This year's forum is of particular interest, because in recent years, marine mammals have captured the attention and imagination of the public.

From endangered manatees to stranded seals, many critical issues impact the health and well-being of marine mammals. The AVMA Animal Welfare Committee has assembled an excellent panel of speakers to review these issues and to help each of us discover new ways to make a difference. As veterinarians, we are always being asked to comment on animal health issues and this forum provides speakers and attendees with an opportunity to discuss the problems facing marine mammals. In addition, the forum exposes the media and the public to the behaviors, health, and welfare concerns of these fascinating creatures. Our goal for this Forum, as it has been for all previous forums, is to promote the well-being of animals. The AVMA is proud of the vital role veterinarians have played in advancing marine mammal welfare.

Ceteceans in captivity: A discussion of welfare

James F. McBain, DVM

Cetaceans are the order of mostly marine mammals known as whales, dolphins, and porpoises. Revered by some cultures and eaten by others, historic association with cetaceans has been a mixed bag. Native Inuit in the Arctic hunt small-toothed whales for subsistence; this relationship has existed unchanged for many centuries. They are among the few remaining people who simultaneously venerate and consume cetaceans. Commercial whalers have hunted certain species of great whales to near extinction. California gray whales fit that description until treaty protection allowed their population to return to the current healthy numbers.

Volunteers along the coast of southern California count gray whales migrating between the Arctic and Baja, Calif. I had the good fortune to participate in the rehabilitation of an abandoned gray whale calf stranded on the coast of southern California in January 1997. The calf was returned to the Pacific Ocean as a healthy yearling in March 1998. That same year, the Makah Indians of Washington State announced their intention to restore their tradition of harvesting gray whales.

Killer whales were used for target practice by military pilots during World War II. As recently as the 1990s, Alaskan longline fishermen began shooting killer whales that had learned the signature sounds of their winches. Each time the fishermen hauled their gear, killer whales would show up for the smorgasbord being raised from the bottom of the sea. Researchers with knowledge of the precise hearing capabilities of killer whales assisted fishermen in achieving a nonballistic solution to the problem. In 1994, a pod of killer whales became trapped in Barnes Lake. A mixed group of regulators, researchers, corporate volunteers, and concerned Alaskans worked for several days before successfully freeing the starving pod.

Dolphins at Monkey Mia in Australia were a familiar sight to fishermen around Shark Bay. These fishermen inadvertently trained the dolphins to accept food from their fishing boats. As time passed, tourists became aware of the friendly dolphins residing there and began feeding them as well. The area soon became known internationally, and the attraction became so popular that the government built a campground to accommodate tourists. A poorly designed public restroom sewer system contaminated the Bay, causing the death of 6 dolphins.

Thousands of dolphins are killed annually in our quest for tuna in the tropical eastern Pacific Ocean. Attempts to decrease dolphin mortality have increased the killing of sharks, sea turtles, and tuna of reproductive age. The Baiji or Yangtze River dolphin is consid-

From SeaWorld of California, 500 Sea World Dr, San Diego, CA 92109.

ered by many Chinese to be a national treasure equal to the panda. Fishermen in China's Yangtze River continue to use fishing gear called "rolling hooks." These hooks, along with overfishing and excessive commercial traffic, will result in extinction of the Baiji dolphin in the near future.

These events have shaped our thinking and led to a public desire to protect marine mammals. Cetaceans are arguably the most protected nonhuman animal species on earth. The United States is a signatory to a tremendous number of international legal regimens intended to protect marine mammals. The International Convention for the Regulation of Whaling was established in 1946 to manage the taking of whales in international waters. The Convention on International Trade in Endangered Species (CITES) was signed in 1973 to ensure sustainable trade of wild flora and fauna. The Marine Mammal Protection Act and the Endangered Species Act govern marine mammal conservation in waters under US jurisdiction and dictate the related conduct of US citizens when they are outside areas of US sovereignty. These 2 acts are the most restrictive in the world, particularly regarding research and animals in captivity. The United States allows and requires scrutiny of all handling of, and research on, marine mammals by government agencies, the public, and the courts. This high degree of legal protection provides a framework that should ensure the welfare of cetaceans.

The art and science of the care of captive cetaceans have come a long way since the days when P. T. Barnum first collected and displayed beluga whales. The Animal Welfare Act (AWA) has established standards for virtually all aspects of cetacean care, including facility design, water quality, nutrition, social grouping, transport, and medical treatment. Curators, trainers, and veterinarians, overseen by USDA inspectors, ensure the well-being of captive dolphins. The reason for my participation in today's Forum is to provide insight into the current standard of care for the 454 dolphins and whales living in North American oceanariums.

Exceeding AWA standards is the goal of most oceanariums. I am amazed when I look at the San Diego pool where the first Shamu was housed alone in 1965. It has a volume of 100,000 gallons. That is a far cry from the current 7-million gallon home of Shamu and 5 other killer whales. Water quality is as important as water volume. Modern systems allow water quality to be maintained without high concentrations of residual oxidants (eg, chlorine). An example of how important water quality is for long-term health may be found in the sea lion population off the coast of California. A large percentage of beached adult California sea lions on that coast are suffering from transitional cell carcinoma. I believe, as do many others, that this is the result of a carcinogenic by-product of civilization that has found its way into the natural home of the California sea lion.

Captive cetaceans eat frozen instead of live fish. This is a necessary choice but not one that should negatively impact a captive cetacean's well-being. High quality live fish are not available in adequate volume, but frozen fish are. The dolphins under my care receive top quality fish for 2 reasons: they are the most nutritious, and our dolphins, being fish experts, will not accept nothing less than "restaurant quality." In recent years, some species of fish our dolphins favor as food are becoming less available.

A company that provides artificial diets for zoo animals, with our encouragement and assistance, is developing an artificial fish equivalent that may become part of the diet of captive dolphins. This is good for our dolphins, but does not benefit wild populations in overfished areas of the world. In addition to top quality fish, our dolphins receive a custom-designed multiple vitamin supplement. This supplement supplies vitamins that may be damaged during the freezing process. Thiamin is one such vitamin that can be destroyed during freezing, storage, and thawing of fish that contain thiaminase (a natural enzyme). In addition to thiamin, vitamins C and E are provided because of potential oxidation during storage. There are a few other vitamins prophylactically included in supplements because they are known to be present in low quantities in live fish.

The volume of food a dolphin receives is as important as quality. Food intake is determined by what the dolphin requires, contrary to the old approach of feeding only what dolphins will work for. Willingness to work may have nothing to do with the amount of food dolphins require. Determinants of food intake in my practice are weight, activity level, appetite, and the dolphin's health status. Food quality or volume should never be allowed to adversely impact health.

Appropriate social grouping is the single most important consideration affecting the overall health of cetaceans. Most dolphins and small-toothed whales are social species and require a social environment. The larger, more varied habitats being designed and built today support that goal. Cetaceans should be kept with conspecifics (members of their own species). If this is not possible, they should be kept with members of a closely related, compatible species. A third less desirable option is to house them with members of a completely unrelated species. A social group provides a catalyst for physical and sexual activity. Actions resulting from the dynamics of a social group are essential for cetaceans' mental and physical health.

Keiko, of "Free Willy" fame, lived for many years with dolphins in a substandard facility in Mexico City. Well-meaning individuals moved Keiko to a superior facility in Newport, Oregon, and then to Iceland. Unfortunately, Keiko has lived in isolation since leaving Mexico, his only companions being a few fish and humans. I don't believe that this is in Keiko's best interest. I admit that the family dog may be willing to substitute humans for conspecifics, and I believe that a dolphin could adapt to that situation; however, most humans would not fare well paddling around the pool and roughhousing all day with a 500-lb dolphin, much less with a 10,000-lb killer whale. I believe that the only time social isolation of cetaceans is acceptable is when the attending veterinarian feels it is necessary for the animal's safety or the well-being of the animal or its companions. Social companionship for cetaceans is essential and required by the AWA.

Transport of cetaceans from one facility to another may be necessary for various reasons. Some animals are

moved to maintain genetic diversity or the best possible social balance. Research requirements may also dictate transport of cetaceans. Short moves may be accomplished by use of a foam pad with water sprayers providing limited cooling as well as moisture for the skin. Long-distance transportation is best done in a container that allows the animal to be suspended in water. Water helps support body weight and permits normal thermoregulation. Air transportation of whales and dolphins is a safe and efficient means of moving them over long distances rapidly.

Veterinary care of cetaceans is my area of expertise, and the field has advanced markedly since my first involvement with marine mammals in 1972. At that time, veterinarians were usually summoned only if an animal was ill, and little preventive medicine was practiced. This is changing as oceanariums see value in having veterinarians participate in decisions related to husbandry, management, water quality, and facilities maintenance and design. The basics of a preventive medicine program are achieved if these activities are combined with regular physical examinations, laboratory analyses, and medical care. Willingness of veterinarians to network and share their successes and failures with other veterinarians, combined with a trend toward preventive medicine, is responsible for advances in cetacean medicine.

There is an eclectic group of topics associated with cetacean welfare or well-being worthy of discussion. These topics include training or tricks, captive reproduction, echolocation in concrete pools, bent dorsal fins, longevity, and release or reintroduction. I feel compelled to discuss these subjects because many are shrouded in misinformation, or at least incomplete information.

Training dolphins to perform useful and sometimes spectacular behaviors contributes to their well-being. Some people refer to these behaviors as tricks, but they are not tricks to those of us who work with dolphins. Often these are husbandry behaviors that facilitate oral, nasal, and external body examinations, as well as collection of blood, urine, and fecal samples. Many dolphins will voluntarily slide onto a scale so that their weight can be monitored. Other so-called tricks are replays or extensions of natural dolphin behaviors. A trained dolphin leaping and spinning through the air is not substantially different from a dog jumping for a ball. The animal enjoys doing it and humans enjoy watching it. What is observed is a display of the animal's innate abilities. The real value of these behaviors accrues to the animals. Dolphins, like dogs, have evolved as social hunters. To eat they must find prey, determine how to catch it (individually or cooperatively), and kill it. This process requires animals to use their senses and cognitive abilities. Through training we can provide an environment that is challenging and stimulating, and encourage animals to use innate tools and senses that normally would ensure their survival in the wild. Next time you see dolphins performing you will recognize that these behaviors are not just tricks. On my morning rounds it is not unusual to see a dolphin, without trainers present, practicing a behavior it learned the day before.

Most dolphins in captivity today were not collected from the wild, but were born in oceanariums. In the early days of zoologic display, newly collected specimens replaced those that died. This was also true for marine mammals. There were many individuals who believed that dolphins and killer whales would not reproduce in captivity. As we have learned more about animals and their needs, we have seen reproduction become almost commonplace. The birth of a dolphin or killer whale calf is no longer a newsworthy event. More than 60% of the dolphins housed at SeaWorld were born in captivity; for killer whales, that figure is 65%. Data on captive dolphins indicate that calf survival rates equal or outstrip those achieved in the wild. Data available on wild populations are limited. Approximately 45% of known births in the few studied wild populations result in failure to thrive. This percentage is identical to that estimated by Dr. Michael Bigg for killer whales residing on the east coast of Vancouver Island. In contrast, approximately 23% of captive dolphins born in North America fail to thrive. This finding is not surprising because survival rates in a controlled environment should be greater.

I have witnessed captive reproduction events that help explain certain findings in studies of wild populations. In the wild, some mothers raise unrelated calves. I observed this when 2 pregnant female dolphins gave birth in our nursery pool. Speedy, having given birth to several calves, was the oldest and most experienced. She had a stillborn 6 hours before Sharky gave birth to a healthy male calf. Speedy immediately claimed the calf as her own. Sharky initially appeared confused, but never made any attempt to claim her calf. Speedy went on to raise the dolphin we call Sparky.

Biosonar or active echolocation separates toothed whales from most other species of animals, bats being the exception. (Let's not worry about bats for the moment. Even small children can tell the difference between a dolphin and a bat.) Use of sonar is one explanation for the large brain size of dolphins relative to that of other species. (Remember, I said, "Let's not worry about bats.") The ocean is a very noisy place. This was true before man arrived, but is especially true since. The large brain of the dolphin may enable it to filter sound and interpret sonar. Some individuals claim that dolphins living in concrete pools go "mad" from the sound of their own sonar bouncing off the walls. I would be quite concerned if this was true. On the contrary, dolphins are able to modulate the sounds they make to suit their environment. Our dolphins actively click, squeak, and whistle in their pools. One morning, a member of the animal care staff told me that one of our Commerson's dolphins would not eat a fish with an itraconazole capsule hidden in it. I asked the staff member to place an equal-sized capsule with different contents into another fish. After many trials, I am convinced the dolphin could tell, by the use of its biosonar, which fish contained an itraconazole capsule. There is no question that captive dolphins routinely use biosonar. Previously we had concerns about the noise level in our dolphin pools and tested our pools for ambient sound. We found the pools to be generally quieter than the ocean. Is lack of noise a concern? I do

not believe it is, and as it turns out dolphins are able to add noise to their environment if they want it.

A toy company has marketed a stuffed "Free Willy" killer whale. It has a malleable dorsal fin so that children can position it upright if Willy is happy and bend it over if he is sad. This is a cute idea, but it has no foundation in reality. The primary structural component of the dorsal fin is collagen or connective tissue; there is no bone or cartilage. Collagen becomes soft as it warms to normal or higher than normal body temperature. If you have seen dolphins being born, you have witnessed noodle-like dorsal fins and limp flukes. Fins and flukes remain limp until they are cooled by the water.

Occasionally, an adult whale or dolphin will have a bent dorsal fin. This happens in the wild as well as in captivity; however, it is more common among captive cetaceans. Captive dolphins learn to search for and receive food from above the surface of the water. This is a major departure from the wild where most of their food is found underwater. This behavioral modification results in captive dolphins spending a disproportionate amount of time closer to the surface than do their wild counterparts. This behavior prolongs exposure of the dorsal fin to the air where it becomes warmer than usual because air is less conductive than water. Combine frequent softening with the high frequency of turns associated with life in a dolphin pool and some individuals will experience, over time, bending of the dorsal fin. Susceptibility appears to reflect genetics and behavior (resting and swimming patterns). Tall dorsal fins (male killer whales) are more likely to be affected than short ones. As I mentioned before, bent fins also are observed in wild cetaceans. I believe the cause is different, but the result is the same. In the wild, I suspect the dorsal fin softens as the result of fever or illness that causes the animal to float at the surface with its dorsal fin exposed for an extended period of time. The weight of a tall, softened dorsal fin unsupported by water causes it to bend. Bent dorsal fins appear to be a primarily aesthetic problem. They do not appear to be painful and do not noticeably affect the animal's ability to swim or turn.

I once overheard an exhibit narrator inform a questioning public that if a killer whale or dolphin did not have a dorsal fin they would spin and corkscrew uncontrollably through the water. This is false. There are species of dolphins and whales that do not have dorsal fins, nor do seals or sea lions. So why is a dorsal fin important? The testicles of male cetaceans are located internally but, like other mammals, must be maintained below body temperature. The dorsal fin functions as a heat exchange organ that provides cooled blood for male gonads. The dorsal fin may provide other benefits but cooling is the only function for which it appears to be required.

Longevity of dolphins in captivity has received a great deal of media attention. Unfortunately, misinformation has confused what appears to be a simple question. Is the life expectancy of a captive dolphin equivalent to that of a dolphin residing in the wild? Actually, no one knows. In responding to this question, opinions are expressed or attempts are made to base answers on limited statistical evidence. After all, statistics are often used as a means of providing simple answers to questions that do not have simple answers. Although I am not a statistician, I will try to clear up some of the resulting confusion.

"Maximum longevity" is often used in statements such as "they can live to be X years old." Maximum longevity is a difficult number to obtain by direct observation of animals with long life spans. It requires specific knowledge of the time of birth and death of the oldest member of the population. Obtaining this answer would require a long study period and, ultimately, would not reflect the norm. Humans have a maximum longevity of about 160 years. Clearly, this information is of limited use. Using this method, if everything else was equal, would mean the largest population should have the maximum longevity.

"Average longevity" sounds like a number that might be useful, but in actuality it is not because it is sensitive to the proportion of animals in a population that have been recently acquired or born. Birth or addition of several young animals in a small population results in a drastically lower average longevity. This figure is also of limited value unless the entire cohort in question has died. It appears that live animals can bring down the average value. Occasionally maximum longevity is compared with average longevity. For example, "In the wild, dolphins can live to be 60 years old whereas average longevity in captivity is only 6 years." This comparison of dissimilar statistics is inappropriate and not informative.

Some respected cetacean biologists consider "annual survival rate" to be the best means of statistically comparing captive and wild populations. My simplistic description of this method is that it compares the percentage of animals that were alive at the beginning of the year with those alive at the end of the year. In a study comparing captive dolphins to the wild population off the west coast of Florida, there was no significant difference in annual survival rate between the 2 populations. There is a significant improvement in captive population survival when data from the last 5 years are compared with previous years' data. This may be loosely interpreted as indicating an overall improvement in dolphin husbandry. Annual survival rate is known to be subject to error when applied to small populations.

"Age distribution graphs" are a simple and visual way to compare populations. A graph of the age group distribution of wild dolphins from Sarasota Bay versus that of captive dolphins in North American dolphinariums reveals surprising similarity. Once again, this method of comparison, although useful, does not produce a final answer to the longevity question.

Release, return, or reintroduction of cetaceans to the ocean is another subject about which the public is getting partial or misleading information. "Reintroduction" is a term that population biologists would like to reserve for the process of reestablishing a species in a habitat. If the focus is on an individual cetacean, biologists would prefer we use "release" or "return to the wild." When the question of candidacy for release comes up, beached cetaceans should be separated from those that have been under the long-term care of man.

Beached animals are usually in captivity for short

periods, generally long enough to return them to health. Every effort is made to keep these animals as wild as possible. No attempt is made to desensitize them to human contact. The intent of their stay in captivity is rehabilitation and release. This is different from animals that have lived for many years in public display facilities. For display, the usual goal is to train the animal for public presentations. The early part of this process includes desensitization to humans. Not only will dolphins lose their innate fear of humans, they will develop substantial dependence on humans. Any remnant of innate fear is usually erased.

The effect of bonding was clearly evident during a recent experience with 2 beached cetaceans. A neonatal gray whale calf, that later became known as JJ, was stranded on the coast of California. JJ spent 14.5 months undergoing rehabilitation, during which time she grew from 14 ft long and 1,670 lb (759 kg) to more than 30 ft long and nearly 20,000 lb (9,091 kg). Wild gray whales are opportunistic feeders that graze rather than hunt. Unlike dolphins, gray whales do not appear to be dependent on their mothers to learn hunting or feeding skills, and JJ, like wild gray whales, was weaned by 8 months of age. Shortly after weaning, gray whales usually leave their mothers. It is common to find solitary yearlings feeding between Baja, Calif and Alaska. Adult gray whales do not appear to have a necessary social component to their feeding process. Group interactions seem to revolve around migration and sexual activity. I have been told by biologists that the reason gray whales migrate together is that they start out from roughly the same area and have the same destination—much like people in a cross walk. In other words, gray whales are relatively independent.

After 14 months in captivity, JJ showed no substantial interest in humans. Because she grazed on food distributed in the bottom of her pool, she never developed a strong association between humans and feeding. JJ appeared to still be wild when she was released and never looked back. We lost contact with JJ 2 days after her release, but hope she is doing well. In 3 or 4 years we hope to see her in a Baja, Calif lagoon. We recognize that, in spite of our best efforts, there is a strong possibility she will not survive because natural mortality in her age group appears to be fairly high.

The tale of Buster, a young common dolphin, began in much the same way. He was stranded as a very small calf and hand raised. Dolphins usually nurse for 12 months or more. Like dogs, dolphins are social and tend to form strong social bonds with their caretakers. It appears there is an extended period of dependency after weaning when they learn the social and hunting skills needed to function as contributing members of the pod. Long before Buster was large enough to consider releasing, it was apparent he was totally bonded to, and dependent on, humans. His caretakers were equally bonded to Buster. As hard as we try to maintain emotional distance between ourselves and beached animals, it did not work with Buster. He is now integrated into a group of bottlenose dolphins at SeaWorld of California. Because he is faster and more agile than the bottlenose dolphins he lives with, he seems to consider himself quite superior.

When discussing a long-term captive cetacean's candidacy for release, there are a number of questions that must be asked. Will return of the individual benefit the wild population? Is there a risk of introducing a new disease of known or unknown cause into the wild? Is there a risk of introducing inappropriate behaviors to the wild population? Does the candidate to be released have a substantial chance of success? Is the need for release compelling enough to accept the risks to the wild population? The likelihood that release of a long-term captive animal is a good idea is slim. Government-sponsored commissions in Spain, Canada, and the United States agree. Iceland opposes release of long-term captive killer whales in their waters. When humans elect to remove animals from the wild for prolonged public display, they have an obligation to provide these animals with the best care possible for the remainder of their lives.

Discussion of cetacean welfare is not complete without considering how animals perceive their situation. So how do they feel about life in captivity? I believe the animals I work with are happy. This is not scientific, but I think most people can tell if their cats or dogs are happy. It is rarely difficult to determine if animals are unhappy—you simply need to watch them. A couple of anecdotal accounts provide additional insight. The US Navy has a large number of dolphins trained to work in the open ocean. Occasionally a dolphin will go AWOL (absent without leave). Navy trainers address this problem by leaving the dolphin's pen gate open and usually find the dolphin back in its pen by morning. In 300,000 open ocean assignments, only 6 dolphins have failed to return. I also had an experience, many years ago in British Columbia, that fascinates me to this day. This incident involves harbor seals in a floating pen at a small oceanarium on Vancouver Island. One day the curator expressed concern that many seals were not eating and had not done so for nearly 2 weeks. He had not called earlier because all the seals appeared healthy and did not seem to be losing weight. He explained that the seals would perform show behaviors but would not eat their fish. This surprised me. Of the marine mammals I had worked with, harbor seals always seemed to be the most independent, and I suspected they were the least responsive to training. My suspicion was that small fish had invaded the ocean pen and the seals were eating their fill, so I asked that a diver be sent into the pool to check for fish. We watched the bubbles from his scuba equipment for several minutes as we waited for the diver to pronounce the pool full of fish. He finally surfaced and removed his mask, exposing an "I know something you don't know" smile. The diver informed us that the pool did contain a few fish, but more importantly, there was a hole in the pool that was approximately 3 ft in diameter. The opening in the pen was large enough for seals to come and go at their leisure. The seals had been going out to the bay to feed, but had not missed a show in 2 weeks!

As I have said on many occasions, and still firmly believe, the life of a marine mammal in the care of man is not inherently better or worse than life in the wild—it is just different.

Ethical considerations in marine mammal management

Steven R. Brown, DVM

Since the beginning of recorded history, and probably well before, mankind has been enamored by marine mammals. The earliest human contacts presumably were sporadic and incidental to animals being stranded on neighboring beaches. Aristotle wrote in *Historica Animalium*[1] that "It is not known for what reason they run themselves aground on dry land; at all events it is said they do so at times, and for no obvious reason."[1] Even today there are often no obvious reasons for mass strandings of cetaceans. These misfortunate animals became sources of food, fuel, clothing, tools, and art.[2] As humans became more aware of their value, cetaceans began to be actively hunted. There is archaeologic evidence of aboriginal hunting of manatees in Florida as early as 8500 to 6000 BC.[3] The area now known as Greenland is believed to have been colonized by Eskimos nearly 4,500 years ago. Evidence indicates these early people actively hunted seals and small cetaceans, such as harbor porpoises and narwhals.[1] Regardless of their potential use to humans, an aura of mystique seemed to surround their existence.

The earliest record of mankind's encounter with whales is from the *Chronicle of Conquest of Alexander the Great*[1] in the fourth century BC. His sailors were terrified at the first sight of a whale blow during their travels in the Indian Ocean. Initial fear of large cetaceans must have been countered with awe, because some marine mammals were bestowed with godly characteristics. Alexander the Great conferred the title "The Great Priest of Poseidon" upon a youth in the Temple of Babylon when he became aware that the boy had established a friendship with and was regularly riding a dolphin. The emperor believed dolphins were the children of gods and that the youth's relationship was a sign of the esteem of the sea god Poseidon.[4,5]

Legends and folklore support mankind's view of marine mammals as mysterious. There are many references to the "dolphin rider." Taras, a demigod son of Poseidon, was saved from drowning by a dolphin. Later, a town was built at the site where the dolphin beached the boy. To commemorate the event, a coin was issued with the image of a boy riding a dolphin.[6] Another legend describes Telemachos, the son of Ulysses, falling into the sea and being saved by a dolphin.[5] An Aesop tale refers to a monkey that was rescued by a dolphin after the monkey was stranded in a shipwreck. Subsequently, the dolphin drowned the monkey for telling a lie.[4] Arion, a Greek who lived during the seventh century BC, was saved from murderers at sea when he was able to ride a dolphin to safety.[7,8] Furthermore, the legend of Aphrodite refers to his/her birth from "bloody sea foam" and being carried out to sea on the back of a dolphin.[7]

Northwest Indian legends commonly refer to the special nature of marine mammals. One such tale is the story of a maiden that explored the sea floor. She so enjoyed the sea that she transformed herself into a sea otter. To her dismay she was then hunted by her human relatives.[9] In another legend describing the battle between the thunderbird and his prey, the killer whale was so fierce that trees were uprooted, "and, that is why there are prairies in the midst of forests on the Olympic peninsula today."[9]

An Icelandic story tells of a man that found a seal skin near a cave. After hiding the skin in his home he returned to the cave to find a lovely maiden whom he subsequently took as his wife. In later years she found the seal skin and returned to live in the sea as a seal.[10]

Many creation stories allude to the charm of the sea and its creatures. Interestingly, the whale is the first animal mentioned in the Bible. Genesis 1:21 of the *Bible* says, "and God created great whales, and every living creature that moveth, which the waters brought forth abundantly."[11] An ancient concept has creation flowering from the womb of a fish or whale woman (leviathan). This was similarly proposed by Berosos, a priest of Baal of Babylon, in 300 BC.[7] In his version, a fish/whale woman became pregnant after making love with the god of light and subsequently gave birth to the various orders of the universe. Around 350 BC, Aristotle was the first to record a distinction between fish and dolphins or whales.[1] Prior to that, and for some time thereafter, a whale was simply a leviathan, which has been variously descriptive of crocodiles, sharks, or whales. Many Greek stories refer to the god Apollo and his battle with Delphyne (a dolphin woman).[7] After his victory, Apollo transformed himself into a dolphin. Homer described Okeanos and "the genesis of gods and everything else."[7] Okeanos was artistically portrayed as an old man with 4 dolphins radiating from his beard. Another ancient belief was that waves of the sea were wombs, each filled with a child. Over time, children would be delivered to the beach.

As humans learned of the "usefulness" of marine mammals, there began what some individuals have described as the "1,000 year war,"[1] which was primarily waged against whales. The Basques from the Bay of Biscay in northern Spain were probably the first people to hunt whales in an organized manner, and their efforts may have started as early as the Stone Age.[1] The maritime historian J. H. Parry reported in *The Discovery of the Sea*[1] that "if man found whales they took them for what they believed them to be; huge,

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mysterious, threatening creatures. On their early maps, they figured them as large, scaly animals with a frightening array of unlikely appendages; horns, fringes, crests, armor, lumps, bumps, ridges, horrific dentition, and often twin pipes gushing water into the air."[1] This perception of whales is further exemplified by the story of a sixth century Irish monk, Saint Brendon, and his companions who sailed in the North Atlantic. They found refuge on a treeless "island" where they built a campfire. The heat of the fire caused the island to sink whereupon they discovered it was actually a whale they named Jasconius.[1,12]

Whaling appears to have begun in the north Atlantic as early as the ninth century. Oil derived from the whale harvest was used in lighting and the manufacture of soap, wool, leather, and paint. Whale meat was fed to the poor and ship crews. Baleen was considered decorative, and whale bones were used in fencing and home construction. Whale tongue was considered a delicacy and was reserved for clergy and royalty. Blubber, known as Lenten fat, could be eaten as a meat substitute on sacred days.[1] After the Middle Ages, small waists became fashionable and this created a great demand for baleen, which was used in the manufacture of corsets.[2,8] The Basques were whaling off Newfoundland in North America as early as 1400.[1] Commercial whaling expanded rapidly and soon the preferred catch, right whales, was depleted.

As time passed, additional species, such as the sperm whale, were targeted. Sperm whales were especially prized for 2 by-products, ambergris (whale vomit), and spermaceti. Ambergris, which originates in the intestinal tract of the sperm whale, has been variously used as a love potion, in cosmetics, and in fixing perfume. Whaling records reveal that as much as $60,000 worth of ambergris could be harvested from a single whale.[1,2,8] Spermaceti, a waxy substance found in the melon, has been used in the manufacture of heat-resistant, durable lubricants and smokeless candles.

Records indicate that the busiest year in North American whaling was 1846.[1] Even though marine mammals were no longer perceived as having godly characteristics, a mystique remained. Young men on Martha's Vineyard and Long Island vied for positions on whaling ships, although their share in a catch might be only 26 cents per day compared to 90 cents per day for unskilled labor on land. According to one source,[1] "on Nantucket the influence of whaling was so strong that eligible maidens would not even consider a suitor unless he had been a-whaling."

Understanding the origins of aboriginal or native whaling is important, especially in light of the much publicized Makah tribe's plan to resume hunting. Eskimos and many northwest Indians may have been whaling for nearly a thousand years prior to commercial whaling in the rest of the world. The Aleutians used an obsidian spear greased with human fat and adorned with portions of a human corpse or a widow's garment as part of their ritual.[1] After spearing a whale they returned home in hopes of it washing ashore. Apparently the Haida and Tlingit were not whalers, but revered killer whales as spiritual lords of the sea. They believed a killer whale could drag a boatload of fishermen to the bottom of the sea where they would be transformed into whales.[1] Northwest Indians are famous for their stylized killer whale images portrayed on masks, textiles, carvings, and totem poles.[13]

Members of the Umialik tribe of northern Alaska are recognized bowhead whale hunters. Prior to a hunt, rituals are preformed to honor the spirit of the whale so as not to offend the hunted. The whaling captain enforces a code of conduct: no women or children are allowed on the ice, and wives must remain docile because their behavior can influence that of the whales. If hunters are not successful, it is concluded the village is unworthy.[1]

The Nootka of Vancouver Island hunted gray whales from cedar dugout canoes, using spears with long lines attached to seal skin floats.[1] Quarry were towed ashore by canoes attached in tandem, creating a train. Successful harpooners received highest honors, consisting of a cut across their noses. In 1904 ethnologist Franz Boas was able to confirm their prehunt ritual, which included abstaining from sex, bathing daily in fresh water, rubbing their skin with hemlock branches until they bled, and not eating or sleeping for 4 days. If a human corpse was available, it was placed on the beach face down and a stake was driven through the base of the skull to the mouth. A hollow tube was then placed in the hole and the chief shouted through the tube asking the whales to drift ashore. The whaling crew went to sea in 35-ft canoes that carried 8 men per vessel and used 18-ft spears made from heavy yew. Whales were repeatedly speared until they weakened and were towed to shore. Some people consider the Makah a subtribe of the Nootka. Evidence from Middens at Ozette, Washington indicates the Makahs were intensive whalers that harvested gray, killer, right, sperm, fin, and blue whales.[1]

The 19th century produced a number of publications and an invention that had a substantial impact on attitudes toward whales and their populations. In 1821, Sir Walter Scott wrote *The Pirate*.[1] In this fictitious tale, a beached whale is described. When local people attempted to kill the animal they only succeeded in angering it, which caused it to "put out a great roar." In reality, whales do not roar.[14] James Fenimore Cooper's 1823 publication, *The Pilot*,[1] describes a right whale. On being harpooned, "the roaring of the fish was like the bellowing of a herd of bulls." In 1851, Herman Melville published *Moby Dick*.[1] Although Melville had served on 3 whaling vessels and was familiar with the behaviors of whales, he chose to write a fictional tale of the battle between good and evil that involved a vindictive whale. Jules Verne's *Twenty Thousand Leagues Under the Sea*,[1] published in 1870, describes the unlikely scene of "cruel and destructive sperm whales attacking black whales." The aforementioned publications support a callous attitude toward whales and Svend Foyn's 1868 invention, the harpoon cannon, served to increase the efficiency of harvesting declining whale stocks.[1,15]

Perceptions regarding marine mammals have changed considerably during the latter part of the twentieth century.[15,16] Richard Ellis has described the position of marine mammals as moving "from deity to

commodity and back to deity."[1] This attitude change arguably began in Great Britain in 1835 when the first animal welfare act was established.[17] In 1866, The American Society for the Prevention of Cruelty to Animals became the first American animal welfare organization. Change was accelerated by the so-called "animal rights movement." H. Guither reports, "The animal rights movement today is the successor to the antiwar and human rights crusades of the 1960s and 1970s."[17] Greenpeace began in 1969 as a protest movement against detonation of a nuclear device on Amchitka Island in the Aleutians[1]; in subsequent years, it became famous for its anti-whaling efforts. Through the efforts of Greenpeace and many other national organizations (eg, National Audubon Society, World Wildlife Fund, Sierra Club, and the Humane Society of the United States), 2 milestones in marine mammal welfare were reached. In 1972, the United States passed the Marine Mammal Protection Act and in 1982, the International Whaling Commission established a moratorium on commercial whaling.

Many other events assisted in raising the public's awareness of the value of marine mammals. In 1938, the first oceanarium in America opened as Marine Studios in Florida and included an exhibit of bottlenosed dolphins. As years passed and the number of aquariums around the world increased, millions of people were exposed and sensitized to life in the oceans. In the 1960s, people were captivated by the television antics of "Flipper" the dolphin. Publications such as Robert Merle's *The Day of the Dolphin* (1967)[1] and Joan McIntyre's *Mind in the Waters* (1974)[7] helped rekindle interest in marine mammals, and Jacques Cousteau brought marine images into our living rooms that many of us would not otherwise have seen.[1]

Now we are faced with new ideologic concepts that challenge our ethics. Many individuals in the animal rights movement believe that eliminating abuse and suffering is not enough. Gary Francione asserts, "What you do when you merely ameliorate the conditions of enslavement is that you perpetuate the enslavement."[17] Authors such as Tom Regan, Peter Singer, and Ingrid Newkirk put to task the traditional interpretation of Genesis 1:28, which says, "Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."[11]

The mystique of marine mammals has impacted our attitudes and actions toward these animals. If one accepts that premise, then we must be wary to what extent that mystique affects current thinking. One of Keiko's (the killer whale of "Free Willy" fame) handlers recently used the metaphor that, "killer whales are able to suck the brains out of people and leave a quivering shell of emotion."[a] Do we consistently rely on science for management decisions or are we influenced by marine mammals' mystique? Is science enough?

Current public empathy with marine mammals has prompted many questions that deserve thoughtful consideration. Should wild sea mammals be collected to meet aquarium/oceanarium display needs? Should marine mammals currently in captivity be released to the wild? Should the moratorium on commercial whaling be lifted on species that may be thriving? Should aboriginal whaling be permitted if only to patronize a cultural history? Should research and experiments on marine mammals be banned? Should population control measures be taken if a marine mammal species threatens a human food supply or damages property? Should efforts to rehabilitate stranded animals be stopped if successful return to the wild is unlikely? Should rehabilitated animals be returned to the wild, and under what conditions? Should marine mammals not be used in animal-assisted activity or therapy? What health risks do animals released to the wild face? What health risks do wild animals exposed to released animals face?

Speaking from an animal welfare perspective, Daniel O. Webers has said, "as more humans awaken to the deep identity of other sentient beings, the seeds of evolution are created—seeds that will ultimately foster not only harmony between humans and other animals, but also between humans and other humans."[17] Victor B. Scheffer adds, "Surely . . . wise whale management is going to call for cooperative decisions by poets as well as biologists . . . conservation is too important to be left to either group."[b]

[a]Glenn M, Senior Animal Care Specialist, Sea World, San Antonio, Tex.

[b]Scheffer VB. *The status of whales*. San Francisco: Pacific Discovery 29, 1976;2, 4.

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The Florida manatee: On the verge of extinction?

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The Florida manatee (*Trichechus manatus latirostris*), with an estimated population of 2,300 animals, is one of the most endangered marine mammals in the coastal waters of the United States. Long-term survival of this species is seriously jeopardized by human-related and perinatal mortality, as well as destruction and degradation of habitat caused by widespread development in Florida.[1] Because manatees are able to produce only a single calf every 2.5 to 5 years, the mortality rate may exceed the population's ability to produce new animals.

Natural History

The Florida manatee is a large, herbivorous, totally aquatic mammal that is 1 of 4 living species in the order Sirenia.[2] In folklore, the Sirenia were mythical mermaids whose song deceived ancient seafarers. Sirenians are believed to have evolved from 4-footed land mammals more than 60 million years ago. The closest living terrestrial relatives of the Sirenia are the Proboscidea (elephants) and Hyracoidea (hyraxes),[3] and the Florida manatee shares many unique hematologic and immunologic features with the elephant.

Sirenians live in tropical and subtropical regions and include 1 species of dugong (*Dugong dugon*), generally found in coastal regions of the Indopacific; the West African manatee (*Trichechus senegalensis*), found in coastal waters, rivers, and lakes of western and west-central Africa; the Amazonian manatee (*Trichechus inunguis*), which is restricted to the fresh water rivers and lakes of the Amazon basin; and the West Indian manatee (*Trichechus manatus*).[4] The West Indian manatee includes 2 subspecies. The Antillean manatee (*Trichechus manatus manatus*) is found in the West Indies, the Caribbean, and coastal waters and rivers of Mexico, Central America, and northeastern South America. The Florida manatee inhabits the coastal waters and rivers of the southeastern United States and Gulf of Mexico, and may be found as far west as the Texas coast. Florida is essentially the northernmost range for the West Indian manatee. Manatees are intolerant of cold weather, so during the winter cold temperatures restrict the manatee population to Florida.[5] During the winter, Florida manatees can be found in warm water natural springs, south Florida canals and lakes, and warm water effluents of electric power plants and other industrial sources.

The Florida manatee is unusual in that it can move freely between salinity extremes. It can live for extended periods in fresh water, brackish, and marine habitats. It can be found in clear, muddy, and heavily polluted water. The manatee's highly responsive immune system may be the reason they are able to survive the latter.[a]

Manatees usually prefer water depths of 3 to 7 ft (0.9 to 2.1 m) for grazing on various sea grasses and fresh water plants, and for resting. They tend to travel in waters 10 to 16 ft (3.0 to 4.9 m) deep and are rarely seen in waters deeper than 20 ft (6.1 m). The typical Florida manatee habitat is shallow coastal waters, lakes, and rivers of both coasts of Florida. Tracking studies indicate that manatees often migrate large distances along the east coast of the United States. Most manatees migrate seasonally between winter gathering sites and summer distribution areas.

Unlike many marine mammal species, manatees are considered minimally social.[6] Except for cow-calf relationships that may last for 2 years and cold weather-related aggregations, most relationships appear temporary. Additionally, the Florida manatee is not territorial and does not display apparent intraspecific or interspecific aggression. Temporary social interactions may include behaviors such as mouthing, bumping, chasing, body surfing, group somersaulting, barrel rolling, and upside-down gliding.

It is difficult to accurately estimate the manatee population because of the unique characteristics of the manatee and the environment it inhabits. Manatee counts are highly variable and, to date, a way has not been found to estimate the number of animals not detected during population surveys.[7] In 1996, a winter population survey identified 2,639 manatees. In 1997, 2 population surveys were conducted during the winter. A January survey yielded a count of 2,229 and a February survey resulted in a count of 1,709 manatees. An increasing number of documented manatee deaths since 1978, including a large proportion of human-related deaths, have caused serious concerns about the long-term survival of this species (Table 1).[7]

Anatomy, Physiology, and Behavior

Because the manatee's geographic range is restricted, many people are unaware of this species and the unique problems it faces. A basic understanding of the manatee's biologic character is helpful. Manatees are large, fusiform mammals with flat, rounded, spatulate tails. Adults can reach a mean length of 9 to 10 ft (2.7 to 3 m) and weigh between 900 and 1,200 lb (409 to 545 kg). A maximum length of 12 ft (3.6 m) and weight of 3,900 lb (1,772 kg) have been reported. Female manatees tend to be larger and heavier.[2] The manatee has a low metabolic rate, which is likely an adaptive feature.[5] However, this may seriously restrict this large tropical mammal's ability to maintain body temperature in the colder winter weather of northern Florida, and may account for the manatee's susceptibility to cold.

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Table 1—Manatee mortality in the southeastern United States (excluding Puerto Rico)

Year	No. of vessel-related deaths (%)	No. of flood gate and lock deaths (%)	No. of other human-related deaths* (%)	No. of perinatal deaths (%)	No. of other deaths† (%)	Total deaths in southeast United States
1978	21 (25)	9 (11)	1 (1)	10 (12)	43 (51)	84
1979	24 (31)	8 (10)	9 (12)	9 (12)	28 (36)	78
1980	16 (25)	8 (12)	2 (3)	13 (20)	26 (40)	65
1981	24 (21)	2 (2)	4 (3)	13 (11)	74 (63)	117
1982	20 (17)	3 (3)	2 (2)	14 (12)	78 (67)‡	117
1983	15 (19)	7 (9)	5 (6)	18 (22)	36 (44)	81
1984	34 (26)	3 (2)	1 (1)	26 (20)	66 (51)	130
1985	35 (28)	3 (2)	3 (2)	23 (19)	59 (48)	123
1986	33 (26)	3 (2)	1 (1)	27 (22)	61 (49)	125
1987	39 (33)	5 (4)	4 (3)	30 (26)	39 (33)	117
1988	43 (32)	7 (5)	4 (3)	30 (22)	50 (37)	134
1989	51 (29)	3 (2)	5 (3)	39 (22)	78 (44)	176
1990	49 (23)	3 (1)	4 (2)	45 (21)	113 (53)	214
1991	53 (30)	9 (5)	6 (3)	53 (30)	54 (30)	175
1992	38 (23)	5 (3)	6 (4)	48 (29)	70 (42)	167
1993	35 (24)	5 (3)	7 (5)	39 (27)	61 (41)	147
1994	51 (26)	16 (8)	5 (3)	46 (24)	76 (39)	194
1995	43 (21)	8 (4)	5 (2)	56 (28)	91 (45)	203
1996	60 (14)	10 (2)	1 (0)	61 (15)	284 (68)§	416
1997‖	56 (29)	8 (3)	9 (4)	61 (25)	111 (45)	245

*Includes deaths caused by entanglement and ingestion of marine debris, drowning in shrimp nets, poaching, vandalism, etc. †Includes deaths due to cold stress, other natural causes, and undetermined causes. ‡Includes 38 deaths attributed to a spring red-tide event in southwestern Florida. §Includes 149 deaths attributed to a spring red-tide event in southwestern Florida. ‖Data for 1997 are preliminary.

Source: Florida Department of Environmental Protection.

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Adult manatees are gray to brown, whereas calves are dark brown at birth and change to grayish-brown at about 2 months of age. Their skin is characterized by a thick epidermis and sloughs continually, which helps eliminate growth of marine organisms. Hair is distributed sparsely over the body. There are 3 to 4 nails at the end of each pectoral flipper. The ribs and pectoral limbs lack bone marrow cavities.[3] The manatee has no hind limbs, but vestigial pelvic bones are present. Despite their size and appearance manatees are surprisingly agile and acrobatic underwater and usually swim at speeds of about 2 to 7 mph.[6]

The head of the manatee is unique. A flexible, prehensile upper lip acts as a "shortened trunk" that is similar to the trunk of its terrestrial cousin, the elephant. The lip is used to gather and manipulate plant matter into the mouth. Both lips are highly tactile and contain many modified vibrissae (perioral bristles).[8] In addition to their use in food gathering, the lips are important in social interaction and communication. The nostrils are located dorsally on the snout and have valves that close when the manatee dives. Eyes are small and widely spaced with eyelids that close in a circular manner. Retinal histologic examination reveals that manatees see color. Depth perception is poor, but long distance acuity appears to be good.[6]

Manatees hear well despite small auditory canals and a lack of external pinnae.[6] They can emit a wide range of sounds that are used for communication, rather than echolocation as in cetaceans. These sounds are typically used to maintain contact with other adults, especially during sexual and play behaviors. Sound communication is especially prominent between cows and dependent calves. In addition to sound, sight, and touch, manatees probably communicate through taste and smell.

The lungs are located in the dorsal and horizontal body plane and extend through most of the body's length. This arrangement and high bone density are likely important for buoyancy control. Resting respiratory rate is about 1 breath every 4 minutes.[6] Dives with up to 27 minutes between breaths have been reported. Heart rate is about 50 to 60 beats/min with bradycardia during diving.

The digestive system of the manatee is extraordinary and probably reflects evolution of specialized anatomic features for dealing with a herbivorous diet and the incidental ingestion of water of varying salinity.[9-11] Incisors are absent and are replaced by horny gum plates. The molar teeth are uniformly shaped, but of different sizes, and are continually replaced in a forward direction when worn. Tooth replacement is likely an adaptation to a diet of plants mixed with sand. The manatee has a gastrointestinal tract characterized by an enlarged hindgut, as do other nonruminant herbivores such as horses. However, other adaptations not seen in most other mammals are also present. Gross anatomic adaptations include a simple saccular stomach with a discrete accessory digestive gland (the cardiac gland), a large duodenal ampulla with paired duodenal diverticulae, and a large cecum with paired cecal diverticulae. Unique histologic features include submucosal mucous glands along the greater curvature of the stomach and nonkeratinized, stratified, squamous epithelial cells overlying the glandular mucosae of the pyloric antrum, midgut cecum, colon, and rectum.[9] The immense size of the manatee and its large intestine is striking and indicates that manatees have a low rate of

digesta passage and efficient breakdown of cellulose.[9,10] Hindgut digestion of cellulose produces abundant gas and flatulence. Indeed, presence or absence of flatulence can be used as a prognostic indicator for manatees. Manatees graze 5 or more hours per day and typically consume between 4 and 10% of their body weight in wet vegetation per day.[12]

Male manatees have a genital opening just caudal to the umbilicus. Females have a genital opening just cranial to the anus. Females also have prominent axillary teats. During estrus a cow will be pursued by many bulls, and this mating "herd" may persist for a month.[6] In some instances, cows will attempt to flee insistent bulls. When the female is receptive she will copulate with one or more bulls in succession. The reproductive physiologic characteristics of manatees are largely unknown; a comprehensive study is planned in the near future.

Manatees have a low reproductive rate. Typically, a single calf is produced with a birth interval of approximately 3 to 5 years. The gestation period is about 13 months, and calves are dependent on their dams for about 2 years. Newborn calves are about 4 ft (1.2 m) long and weigh about 70 lb (32 kg). Calves nurse underwater for 3 to 5 minutes every 1 to 2 hours around the clock. Manatee milk is higher in fat and protein compared with that of most mammals and contains no lactose.[13]

Contrary to popular assumption, manatees are capable of understanding discrimination tasks, and they show signs of complex associated learning and advanced long-term memory.[14] This has been partially demonstrated through successful transfer of generalized tasks. In behavioral tests, manatees exhibit complex discrimination and task learning abilities on a par with dolphins and pinnipeds in similar acoustic and visual studies.

Manatees are long-lived and appear remarkably resilient to natural disease and the effects of traumatic human-related injury. Recent research at the University of Miami School of Medicine and Florida International University indicates these traits may partially result from a remarkably efficient and responsive immune system.[15a] Further investigation of these traits is warranted and may provide important information for comparative immunologic studies.

Manatee Mortality

A well-organized manatee carcass salvage program has existed since the early 1970s. Manatees that die in Florida are necropsied in an effort to identify and quantify mortality factors. Before this century, sources of manatee mortality were probably cold winters and opportunistic hunting. Hunting is no longer an important mortality factor. Unfortunately, other human-related activities seriously threaten the future of this species. Up to 33% of annual manatee deaths for which a cause of death can be determined, are directly related to human activities.[7,16] Deaths that are indirectly related to human activities may drive the human-related category of manatee mortality to more than 60% annually.

The single largest human-related mortality factor is collision with boats,[1,7,16] which may cause sharp (ie, propeller) or blunt (ie, hull impact) trauma. Most boat-related injuries treated at the Miami Seaquarium are caused by blunt trauma resulting from impact with boat hulls. Boat speed and size are primary variables for severity of impact injury. Other direct human-related causes of manatee mortality include crushing in flood-control structures (eg, flood gates and canal locks) and entanglement in, or ingestion of, fishing gear or discarded trash. Manatees are often seen with fish hooks embedded in their lips and crabtrap lines wrapped around their pectoral flippers. Recently, Miami Seaquarium received a juvenile manatee that had a discarded plastic circular band (used to bind newspapers) wrapped tightly around the midthorax. The manatee swam through this loop as a calf and literally grew into it. When the manatee was rescued, the plastic loop had penetrated the skin, subcutis, skeletal muscle, and rib periosteum circumferentially around the thorax.

Unrestricted development in Florida with loss and degradation of habitat is another serious threat to the manatee. No other species of marine mammal lives in such close association with humans. Grassbed feeding areas are disappearing because of pollution, dredging, and surface run-off. Coastal habitat that provides refuge from human activities and harassment is also disappearing. The perinatal manatee death rate is also high (Table 1). Its cause is unknown, but 2 factors operating separately or in combination may be involved. First, cows may be killed, leaving dependent calves behind. These calves ultimately die from malnutrition, exposure, or opportunistic disease. Second, experienced multiparous cows may be killed at such a high rate that inexperienced nulliparous cows are recruited into the breeding population. These inexperienced cows may abandon their calves, which ultimately die from the aforementioned causes. Perinatal deaths, therefore, may represent indirect human-related mortality. This is disturbing, because low reproductive rates mean that manatees must maintain high adult survival rates to ensure their existence.

With 2 notable exceptions, natural early mortality is uncommon in this species. Cold weather-associated deaths have been reported, but their pathogenesis is not known. It is suspected that "cold stress" mortality results from integration of metabolic, nutritional, and immunologic factors with secondary opportunistic disease, particularly bacterial and fungal dermatopathies and pulmonary infections.

Red tide-associated mortality may also represent an emerging problem for the Florida manatee. Red tides are composed of dinoflagellates that produce potent neurotoxins. The dinoflagellate *Gymnodinium breve* produces a potent neurotoxin known as brevetoxin. Brevetoxicosis was a primary component of the 1996 manatee epizootic along the west coast of Florida,[17] and at least 150 manatees died.[18] Some people believe that more frequent red tides may be the result of human-related activities, pollution, and global climate shifts. If correct, recent red tide-associated deaths may also represent indirect human-related mortality.

Total annual manatee deaths are now more than twice that reported during the late 1970s and early 1980s (Table 1).[7] As previously mentioned, the sharp increase in mortality in 1996 was associated with brevetoxicosis. However, even without those deaths, 1996 mortality reached a record high. Given the high proportion of deaths directly and indirectly caused by humans, it is clear that human activities can substantially affect the rate and direction of change in the manatee population.

Manatee Conservation

Manatees are protected at the federal level by the Endangered Species Act (ESA) of 1973 and the Marine Mammal Protection Act of 1972. At the state level the manatee is protected by the Florida Manatee Sanctuary Act of 1978, which established the entire state of Florida as a refuge and sanctuary for manatees. This act allows boat speed regulations in designated manatee areas to be enforced. The Florida Department of Environmental Protection (DEP) and the Florida Game and Freshwater Fish Commission enforce this act. Federal laws are enforced by the US Fish and Wildlife Service (F&WS) in cooperation with state agencies. Under the ESA it is a violation to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect an endangered species." Violations can result in fines up to $20,000 and up to 1 year of imprisonment. However, offenders are rarely penalized to the extent of the law.

Federal, state, oceanaria, and private and industry groups lead by the Save the Manatee Club and Florida Power and Light Company have joined in efforts to save the Florida manatee. A recovery plan has been developed that sets priorities for research and management and includes a schedule for implementation of objectives. In addition to this plan, the F&WS began the Sirenia Project in the early 1970s to plan and conduct basic research on manatees. The manatee carcass salvage plan benefits from strong cooperation between federal and state agencies, private organizations, and industry groups. The salvage plan is administered by the DEP and is supported by a marine mammal pathobiology laboratory in St. Petersburg, Florida.

Private oceanaria in Florida have spent millions of their own dollars for manatee rescue, rehabilitation, and release programs. This clinical work has led to improved manatee husbandry and medical care and has generated important information about biologic characteristics of manatees. Oceanariums designed as critical care facilities include the Miami Seaquarium, Sea World of Florida, and Lowry Park Zoo. Homosassa Springs Wildlife Park, Mote Marine Laboratory, and Epcot Living Seas are secondary recovery facilities. Coordination of these conservation efforts is accomplished through regularly scheduled Interagency/Oceanaria Working Group meetings.

The cost of manatee rescue, rehabilitation, and release programs is high. Estimated cost of raising a single orphan manatee calf that does not have medical complications is $40,000/y. One manatee at the Miami Seaquarium affected by massive boat trauma had medical costs approaching $200,000. Much of this cost is subsidized by oceanaria.

The goal of the oceanaria program is to release manatees back to into the wild. The program has been successful partly because of medical and behavioral release criteria established by the Interagency/Oceanaria Working Group. Decisions to release manatees are usually reviewed by this group. Manatees are carefully monitored after release by federal or state funded transmitter-based tracking programs. Satellite or VHF transmitters are generally fitted for each manatee. Postrelease monitoring includes regularly scheduled captures to assess physical and medical status as a means of evaluating the success of the release. Long-term follow up is a critical component of a responsible, ethical, and humane marine mammal release program. Experience with the program has indicated that short-term captive and rehabilitated adult manatees are more likely to survive in the wild than long-term captive and rehabilitated adults or human-reared orphaned calves.

Manatee Medicine

Manatee medicine has progressed rapidly during the past 10 years. Critical care facilities in Florida use the latest diagnostic and treatment techniques for manatees in rescue and rehabilitation conservation programs. Artificial milk formulas have been developed for raising orphaned manatee calves, and baseline clinicopathologic reference ranges have been established for adults and calves. Clinical research has begun to characterize the manatee immune system, the pathogenesis of brevetoxicosis, and reproductive factors.[15,17,a] Diagnostic techniques including radiography, ultrasonography, magnetic resonance imaging, and thermography have been used successfully and combined with new anesthetic, medical, and surgical procedures. Most manatees treated in oceanaria manatee conservation programs have human-related traumatic injuries (eg, boat impact and entanglement) or are orphaned dependent calves. Because of the manatee's unique pulmonary anatomy, boat-related traumatic injury typically involves thoracic trauma including rib fractures, pulmonary contusions, lacerations, lung torsions, and pneumothorax. Spinal injuries are also common. Secondary infection, which is usually opportunistic, can complicate blunt and sharp boat-related trauma. Treatment for thoracic injuries ranges from rest to surgical intervention. Manatees that have sustained human-related traumatic injury are often anorexic and develop life-threatening dehydration and gastrointestinal stasis. These manatees are supported with fluids delivered by stomach tube. A gruel composed of blended vegetables is also provided by stomach tube. Reestablishment of gut function and motility is critical for a successful outcome.

Orphan manatees are a unique challenge for veterinarians and are probably the most difficult manatees to successfully rear and release. Unlike adult manatees, which appear remarkably resilient to natural disease, orphaned calves frequently develop gastrointestinal, inflammatory, or other infectious conditions. This may be related to nutritional or cow-calf immunologic factors. In addition, the necessity of hand-rearing these calves results in frequent, unavoidable human contact

that may desensitize these manatees to humans and preclude their release.

Cold stress in manatees needs more thorough clinical investigation. Care for this condition is largely supportive and usually involves nutritional and fluid treatment, and sometimes parenteral administration of antimicrobials. Understanding the pathophysiologic mechanisms of cold stress becomes more important with the disappearance or sporadic availability of warm water at sites north of the manatee's natural winter range. In the near future, many man-made sources of warm water (eg, power plants) will disappear. Proposed deregulation of Florida's power plant industry may have profound effects on manatee mortality and their population distribution.

Economics, Politics and Charisma—Why Manatees are Losing

Solutions to save the Florida manatee from extinction involve complex geopolitic, socioeconomic, and psychologic factors. The manatee's natural range is primarily restricted to Florida. On national and international levels, most people outside the state of Florida know little about this species and the pressures it faces. Because of geographic isolation, public awareness and resultant political action are not as strong as for other endangered species.

At the state level, the manatee's problem becomes more intriguing and tragic. The Florida manatee has been officially designated as Florida's state marine mammal. Why is the state's official marine mammal suffering such high human-related mortality? One answer reflects Florida's economy, which is driven by various development and water recreation industries. It is the misfortune of the docile manatee to be a casualty of Florida's economic growth by having to cohabitate with humans at their preferred site of living and recreation. The manatee has simply gotten in the way of our selected lifestyle.

Critical issues for the manatee and Florida's water-driven ecosystem relate to people management. Are economic and political decisions going to be made which limit development, particularly of coastal property that is in high demand by man and wildlife? Are politicoeconomic decisions to limit boat speeds, license boaters, and enforce existing federal and state endangered species laws going to be made before manatee mortality results in a genetically irreversible condition? Are we willing to limit our recreation, reproductive, and retirement desires sufficiently to reserve living space for manatees and other wildlife species in the highly sought after coastal environment?

Our ultimate goal should be to preserve enough habitat and maintain ecosystem health to support viable wildlife populations indefinitely. We need to grasp the concept of ecosystem health and understand that ultimately it protects our own delicate position as a single strand in nature's complex web of life. It is to mankind's ultimate benefit to abandon ecologic carelessness and assume moral responsibility for management of the ecosystems we inhabit. Unfortunately, humans need to constantly be reminded why it is a good idea to prevent wildlife species from going extinct because of our direct actions. In the case of manatees, the problem can be addressed through public education.

From a political and wildlife management standpoint, the Florida manatee is a unique challenge for conservation in the United States because the usual components encountered in marine mammal conservation issues are absent. Ray and Domning[19] state "Here is a population free of the hassles of international conflicts (such as whaling), subsistence pressures (as are the bowhead whale and dugong) and competition from commercial and recreational fisheries (such as tuna, salmon, abalone). They (manatees) aren't dangerous (as are polar bears). They are accessible, countable and well-known scientifically in comparison to most pinnipeds and cetaceans. Under proper conditions, they are tolerant of people at close range and are a proven tourist attraction; and they share their range with one of the most affluent, sophisticated and conservation-minded human populations in the world."

Although the issues are complex, means to save the Florida manatee from extinction are quite obvious. The detrimental effects of recreation and other human activities must be minimized.[20] This means restricting boating activity, human harassment, and development that impacts manatees. Unfortunately, regulations addressing these issues are often perceived in legislative and judicial theaters as being prejudicial and injurious to tourism, development, and the boating industry.[21]

Psychologic factors are also responsible for the Florida manatee's precarious status. An unfortunate trait of human behavior is to assign more relative importance to charismatic animal species. Charismatic animals are highlighted in the media and by some animal welfare groups. A few well-known examples include the giant panda, great apes, bottlenose dolphins, and killer whales. These species receive tremendous public awareness, concern, emotion, and economic attention. Attention can also be generated by Hollywood (eg, Keiko, the killer whale of "Free Willy" fame). Millions of dollars can be raised to protect these animals and, in many instances, such efforts should be applauded. Unfortunately, the Florida manatee is not as immediately charismatic as other wild animals. Because of the charisma factor, the manatee is often considered as being less important. Questions from the public that demonstrate this attitude include "What does the manatee do for us?" and "Why is it important to save the manatee?" Similar comments are rarely, if ever, heard from the public regarding the importance of more charismatic and nonendangered dolphins or killer whales. Such high human-related mortality of an endangered species would be probably not be publicly (and politically) tolerated if a more charismatic marine mammal species was involved. The charisma factor benefits wild animal species that may rightfully deserve mankind's attention but can doom other endangered species, such as the manatee, that need immediate attention.

A recent population viability analysis of the Florida manatee indicates that manatees could coexist indefinitely with humans if boating and other regula-

tions being implemented by the state of Florida are completed, enforced, and effective.[21] The authors conclude that if regulation is unsuccessful, the Florida manatee population is likely to slowly decline to extinction. The manatee is running out of time. Its survival may simply depend on a change in our lifestyle. We should have the foresight to temper our desires for speed and growth and learn to cohabitate with this gentle giant.

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The changing world of marine mammal regulations

Barbara Ann Kohn, DVM

You want to exhibit a marine mammal—what laws and regulations do you need to follow? Your research involves studying marine mammals—which Federal agencies have oversight? Who needs to be notified of marine mammal transports, imports, exports, births, deaths, or shipment of medical samples? Who regulates special programs, such as dolphin encounter or swim-with-the-dolphins programs? If you are not satisfied with current regulations, how can you change them? Is there a simple answer to any of these questions?

From the US Department of Agriculture, Animal and Plant Health Inspection Service, Animal Care, 4700 River Rd, Unit 84, Riverdale, Md 20737-1234.

Oversight of protection of marine mammals is the responsibility of 4 Federal agencies and involves at least 3 Federal laws. The US Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) administers and enforces the Animal Welfare Act (AWA). The US Department of Commerce, National Oceanographic and Atmospheric Administration's National Marine Fisheries Service (NMFS) administers and enforces the Marine Mammal Protection Act (MMPA) for cetacean and most pin-

niped species. The US Department of the Interior's Fish and Wildlife Service (F&WS) administers and enforces the MMPA for walrus, manatees, sea otters, and polar bears, and the Endangered Species Act for all species, and the Marine Mammal Commission (MMC) serves as an advisory agency on marine mammal issues under the authority of the MMPA. Another Federal law that can be used in enforcing marine mammal regulations is the Lacey Act. This Act may be used to prosecute violations of other applicable marine mammal laws when such violations involve crossing state lines, and it allows more severe penalties to be levied in many cases.

There are 4 agencies, 3 Acts, and extensive regulations promulgated by and under each, and when any Act is reauthorized or amended by Congress, everything can change. These regulations can be confusing, but hopefully are not conflicting. Jurisdictions of agencies may overlap. To address issues involved in multiple agency oversight, APHIS, NMFS, and F&WS have cooperated in enforcement efforts under the provisions of a Memorandum of Understanding (MOU). The first marine mammal MOU was signed in 1979, in response to the first marine mammal-specific regulations established under the AWA. That MOU remained in effect until Aug 1, 1998. Changes in the MMPA enacted during its most recent reauthorization by Congress became effective Apr 30, 1994. To address changes in authority subsequent to this reauthorization, a second marine mammal MOU was drafted. Negotiations on the document began in 1994. The current MOU was signed in July 1998, and became effective Aug 1, 1998.

Provisions of the MOU recognize agency jurisdictions while providing for effective enforcement of applicable marine mammal regulations through cooperation and sharing, thereby avoiding undue duplication of effort and use of resources. Sharing information on marine mammal facilities and agency enforcement efforts plays a key role in the MOU. The goal of the agreement continues to be to ensure the health, safety, and well-being of marine mammals that fall under the various jurisdictions. Although this agreement is an important tool for affected agencies, it does not change or directly affect promulgated regulations.

A summary of agency oversight is useful. The APHIS has jurisdiction over the care and maintenance of marine mammals in captivity. This includes monitoring the use of animals at research facilities, ensuring that transportation standards for marine mammals within the United States are met, and overseeing the daily care of captive marine mammals. The NMFS oversees the care and conservation of cetaceans and pinnipeds, except the walrus, in the wild. Activities regulated by NMFS include, but are not limited to, fisheries interactions and by-catch issues, harassment and feeding of marine mammals in the wild, stranding and rehabilitation facilities for regulated animals, maintenance of the captive marine mammal inventory, compliance with MMPA requirements for export and transfer/transport notification for captive marine mammals, and issuing importation and take permits for regulated animals. The F&WS has comparable responsibilities for species that fall under its jurisdiction (polar bear, walrus, sea otter, and manatee), except for maintaining an inventory. In addition, the F&WS is responsible for enforcement of the Endangered Species Act, including oversight of captive-bred wildlife registrations and Convention on International Trade in Endangered Flora and Fauna Species (CITES) permits.

Interactions among regulating agencies, congressional changes to existing laws, other political forces, industry groups, research interests, animal concern groups, and advancements in knowledge and skill in caring for marine mammals contribute to changes in marine mammal regulations. But how does the AWA fit in?

The AWA authorizes APHIS to promulgate regulations for the humane care and treatment of most warm-blooded animals used for exhibition, nonagricultural research, and the wholesale pet trade. Horses used for purposes other than biomedical research are excluded from these regulations. By definition, rats, mice, and birds are also currently exempt from regulation under the AWA. This exemption has been, and continues to be, the object of legal action against APHIS. Provisions addressed in AWA regulations and standards include housing construction and maintenance, space requirements, veterinary care, feeding, handling, personnel qualifications, water quality (marine mammals), and transportation. The standards and regulations, as mandated by the AWA, address minimum requirements for the care and handling of regulated animals, not ideal requirements. However, as scientific and experiential knowledge expands and industry practices improve, APHIS has responded by reviewing and revising these regulations.

The regulatory history of marine mammals under the AWA has been varied, with relatively long periods of little change followed by spurts of regulatory activity (Appendix 1). Most changes have sparked vigorous debate. Early in the history of federal marine mammal management, there was little change in regulations aimed specifically at the care of marine mammals. During the most recent decade, laws and regulations have changed more quickly. Many changes reflect improvements in the way marine mammals in captivity are cared for and managed, increased public awareness and activism in animal welfare, and a changing political climate that has encouraged and mandated more encompassing welfare laws that have fewer and more innovative regulations. In addition, performance-based standards have been instituted where applicable.

Methods for promulgation of regulations have also undergone change. Processes such as negotiated rulemaking have been actively encouraged as alternatives to the traditional agency proposal-public comment-final rule paradigm. In the traditional approach, a potential area of rulemaking or revision is first identified by internal sources, special interest groups, concerned members of the public, or any similar source. If the agency decides additional input is needed, they may solicit that input via an Advance Notice of Proposed Rulemaking published in the *Federal Register* (FR). The agency develops the proposed rule

language and provisions, which is then published in the FR, opening a specified comment period during which the public may submit comments for consideration. The comment period does not constitute a vote, but all comments submitted are reviewed and addressed as supplementary information in the published final rule. Merits of the comments are discussed and the rationale for the agencys decision to amend the proposed rule or not, based on those comments, is explained. The implementation date is also set in the published final rule.

The newer approach, negotiated rulemaking, involves using the input and consensus of major stakeholders during development of the rule. Although this method may not lessen the time needed to develop and publish a proposed rule, the quality of the proposed rule and across the board buy-in from major affected and interested parties should result in a stronger and more accepted rule. The time frame between publication of the proposed rule and the final rule should be minimal, because the negotiating parties have agreed to support the consensus. The possibility of lawsuits by stakeholders opposed to provisions of the final rule should also be reduced, because the major stakeholders have already agreed to support those provisions. While using negotiated rulemaking to revise current marine mammal regulations, APHIS found that rules under the Federal Advisory Committees Act and funding have a major impact on the timeliness of the process and on scheduling sessions. Because negotiated rulemaking has been successful and engendered strong support among participating organizations, the USDA has amended internal funding protocols to make this process more user-friendly.

Recent strategies employed by parties seeking regulatory changes under the AWA include the use of petitions and lawsuits. These strategies have been used to initiate discussion of regulatory changes that may or may not have been internally identified as agency priorities, and have allowed APHIS to solicit input from a cross-section of parties as to the need to consider the proposed changes.

With respect to marine mammals, current efforts focus on revision of Part 3, Subpart E (Specifications for the Humane Handling, Care, Treatment, and Transportation of Marine Mammals) of the AWA. Subpart E encompasses sections 3.100 through 3.118. Amendments to this subpart were initially proposed during negotiated rulemaking, and consensus language was developed for 13 of the 18 sections, plus 1 paragraph of a fourteenth section. This docket was published in the FR on Feb 23, 1999. The remaining 5 sections of Subpart E will be addressed by use of the more traditional rulemaking procedure (**Appendix 2**). The nonconsensus language proposed rule is slated to be published in 1999. Public comment will be solicited for both proposed rules.

In January 1995, APHIS published a proposed rule governing **Swim-With-The-Dolphins (SWTD)** interactive programs in response to changes in the MMPA as reauthorized in 1994. Prior to reauthorization of the MMPA, NMFS administered and regulated these programs through special permits. In 1994, oversight of these programs was transferred to APHIS under the AWA. The proposed rule was designed to create oversight for these programs that was comparable to that of NMFS. This was done by translating permit requirements into regulatory language while making sure all AWA criteria were addressed. Specifications were proposed for space, type of animals that could participate in interactive programs, personnel (including training and experience guidelines), handling (types and lengths of interactions between animals and public participants), recordkeeping, and veterinary care (including minimum examination schedules and diagnostics).

Following established rulemaking procedures, APHIS published a proposed rule, opened a public comment period, extended it twice per requests from interested parties, and obtained 22 submitted documents encompassing more than 400 individual comments. All comments were reviewed and addressed during development of the final rule. The final rule was published on Sep 4, 1998, with an implementation date of Oct 5, 1998.

Controversy regarding the final rule began Sep 4, 1998. What caused the controversy? All regulatory protocols were followed. All comments were addressed and considered in light of interactive program issues, scientific knowledge, and current industry standards. So what went wrong? The agency, and at least a portion of the regulated industry, approached the rulemaking with conflicting assumptions about the scope of the proposed rule. Once information regarding specific issues was clarified, some individuals believed they did not have the opportunity to comment on those issues. In addition, APHIS believed that the impact of the rule might need to be reexamined. Currently, key issues of debate include the scope of programs covered (some regulated parties do not want shallow water encounters included in the rule or want them to be considered separately from immersion programs); space requirements for shallow water programs; required ratios between public participants, animals, and attendants for shallow water programs; and qualifications veterinarians must meet before being designated as an attending veterinarian.

In an attempt to address concerns raised after publication of the final rule, APHIS proposed to issue a request for additional public comments on issues related primarily to shallow water programs. In addition, APHIS has elected not to implement 2 key provisions of the final rule for shallow water programs: interactive space requirements and participant to attendant ratios. Decisions regarding final rule provisions for shallow water encounters will be made after APHIS evaluates solicited input.

Changes in marine mammal regulations are seldom straightforward, and often are contentious. Each regulatory agency must balance protecting the welfare of marine mammals with advances in scientific knowledge and experience, the prevailing political climate, personal and political agendas of affected and other interested parties, additional legislative forces (including other laws and regulations), and the potential economic and environmental impacts of a rule.

Negotiated rulemaking may help address some issues up front, but as more people become aware of regulations and the procedures for changing them, and as concern for the welfare of animals grows in industrial and public sectors, regulating the welfare of marine mammals becomes increasingly complex and unpredictable and consumes more time and resources. However, the same forces that can make the process bumpy may make the final product more beneficial to animals.

What is next on the regulatory agenda? Continuing the rulemaking process for revision of Subpart E is a priority of APHIS, as is resolving remaining issues affecting shallow water interaction programs. Issues that involve overlapping jurisdiction of federal agencies not addressed in the MOU will also continue to be examined. An example of one such issue is what to do when marine mammal rehabilitation facilities, operating under the auspices of the MMPA, also exhibit animals, causing them to fall under jurisdiction of the AWA. Procedures and requirements for marine mammal exports will continue to be discussed. Currently, APHIS evaluates authenticated documentation from the receiving foreign facility for comparability with existing AWA regulations and standards. Procedures that facilitate inspection of foreign facilities by APHIS remain under discussion by all 4 federal agencies involved in monitoring marine mammal facilities and activities. Dialog will continue, regulations will be modified to reflect changing needs and knowledge, and APHIS will continue to view humane care and treatment of marine mammals as a major objective.

Appendix 1

Key events in the history of Animal Welfare Act marine mammal regulations.

1966	The Animal Welfare Act (AWA) is enacted by Congress (known as the Laboratory Animal Welfare Act)
1972	Marine Mammal Protection Act (MMPA) enacted by Congress
1977	APHIS first proposed specific AWA standards for marine mammals
1978	APHIS revised proposed rule for specific marine mammal standards
1979	Final APHIS rule for specific marine mammal standards (Part 3, Subpart E)
1979	Memorandum of understanding (MOU) signed by APHIS, NMFS, and F&WS
1983	APHIS proposed rule to update marine mammal standards
1984	APHIS final rule for revised marine mammals standards published
1993	APHIS advance notice of proposed rulemaking for marine mammals standards
1994–1995	Negotiated rulemaking initiated, Committee established and chartered June 1995
1994	Current reauthorization of MMPA
1994	Begin negotiating new MOU for APHIS, NMFS, and F&WS
1995	Swim-With-the-Dolphins (SWTD) proposed rule
1995	First meeting of Negotiated Rulemaking Committee—September 25–26
1996	Second meeting of Negotiated Rulemaking Committee—April 1–3
1996	Third meeting of Negotiated Rulemaking Committee—July 8–10
1998	New MOU signed by APHIS, NMFS, and F&WS
1998	Final SWTD rule published
1998	Notice of enforcement of SWTD rule for wading programs published—October 14
1998	Submission of Negotiated Rulemaking consensus language proposed rule to OMB—November 19
1999	Publication of concensus language proposed rule
1999	Expected publication of notice and request for information regarding SWTD final rule issues—March
1999	Expected publication of nonconsensus language proposed rule for marine mammal standards

APHIS = Animal and Plant Health Inspection Service. NMFS = National Marine Fisheries Service. F&WS = Fish and Wildlife Service. OMB = Office of Management and Budget.

Appendix 2

Consensus and nonconsensus language proposed rules for revision of Part 3, Subpart E of the Animal Welfare Act (specifications for the humane handling, care, treatment, and transportation of marine mammals).

Consensus language

3.101 Facilities, general
3.105 Feeding
3.107 Sanitation
3.108 Employees or attendants
3.109 Separation
3.110 Veterinary care
3.112 Consignment to carriers and intermediate handlers
3.113 Primary enclosures used to transport marine mammals
3.114 Primary conveyances (motor vehicle, rail, air, and marine)
3.115 Food and water requirements
3.116 Care in transit
3.117 Terminal facilities
3.118 Handling

Nonconsensus language

3.100 Special considerations regarding compliance and/or variance
3.102 Facilities, indoor
3.103 Facilities, outdoor
3.104 Space requirements
3.106 Water quality

Legislation, regulation, and conservation of wild marine mammals

Cindy P. Driscoll, DVM

The Endangered Species Act (ESA) of 1973 and the Marine Mammal Protection Act (MMPA) of 1972 are the principal legislative acts governing activities that involve marine mammals in the wild. The Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) has oversight responsibility for protecting most wild marine mammals. The NMFS is responsible for protection and management of whales, dolphins, porpoises, seals, and sea lions. The MMPA also vests responsibility for marine mammals to the Department of the Interior, Fish and Wildlife Service (F&WS). The F&WS maintains jurisdiction over the remaining marine mammal species: polar bears, manatees and dugongs, walrus, and sea otters. Together the 2 agencies bear responsibility for conservation of marine mammals through direct legislative mandates and partnerships with state, federal, and private organizations, the fisheries industry, and the public.

The ESA and the MMPA were enacted in the 1970s in response to increased recognition of conservation issues. During that period, thousands of dolphins in the eastern tropical Pacific Ocean died as a result of the activities of the tuna purse seine industry. The MMPA was enacted largely because of public outcry and pressure on the federal government to intervene. Since that time, the MMPA and the ESA remain the primary federal means of protecting marine mammals in the wild.

The effects of the MMPA and ESA on the status of marine mammals are immeasurable. Countries throughout the world look to the United States for guidance on marine mammal conservation and then establish policies of their own that are patterned after these 2 acts. In the United States, we have only begun to quantify the impact of these acts on our marine mammal populations. Preliminary positive results include recovery of endangered populations, such as the gray whale, which has been removed from the Endangered Species List.

Growth of marine mammal populations in some regions has led to increased interaction between these animals and humans. Unfortunately, such interaction may be detrimental to certain marine mammal populations. The purpose of this report is to summarize US legislative actions and conservation measures taken to protect marine mammals in the wild since adoption of the ESA and the MMPA. Efforts to minimize the impact of human activities and conserve protected species will be illustrated.

From the National Marine Fisheries Service, 904 South Morris St, Oxford, MD 21654. Dr. Driscoll presently works for the Maryland Department of Natural Resources at the same address.

Endangered Species Act

The ESA of 1973 has as its main purpose to conserve the nation's natural heritage for the enjoyment and benefit of current and future generations. The ESA provides for conservation of species that are in danger of extinction throughout all or a substantial portion of their range. An individual or organization may petition to have a species considered for listing under the Act as endangered or threatened. Listing of a species qualifies it for increased protective measures. Generally, the F&WS coordinates ESA activities for terrestrial and freshwater species, whereas the NMFS is responsible for marine and anadromous species. On submission of a petition, the appropriate agency must reject the petition or accept it and conduct a status review of the species. The status review is initiated by solicitation of public information relevant to that species.

A species may be listed if it is threatened or endangered by any of the following factors: present or threatened destruction, modification, or curtailment of its habitat or range; overuse for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; or other natural or manmade factors affecting its continuance or existence.[1] Once a species is listed, recovery plans are prepared to identify conservation measures initiated to improve a species' status. Critical habitat may also be designated. For marine mammals, the ESA and the MMPA offer similar management authority for endangered and threatened species or stocks (Appendix 1). Many recovery plans are now in place or under development.

Section 7 of the ESA requires all federal agencies to consult with NMFS or F&WS concerning potential effects of their actions on any listed species. Ongoing consultation with other federal agencies must minimize or mitigate potential impacts. Section 10 of the ESA requires permits for nonfederal activities that may affect a listed species.

The Marine Mammal Protection Act

The MMPA of 1972 was last reauthorized in 1994. In passing the MMPA, Congress found that certain species may be in decline as a result of man's activities; that such species should not be permitted to diminish below their optimum sustainable population level and cease being a functioning element of their ecosystem; that measures should be taken to protect habitat and replenish any species that falls below its optimum sustainable population level; that there is inadequate knowledge of the ecology and population dynamics of marine mammals; and that marine mammals are a great international, aesthetic, recreational, and economic resource.[2]

The MMPA established a moratorium, with certain exceptions, on taking of marine mammals in US waters and by US citizens on the high seas, and on importing of marine mammals and marine mammal products into the United States. "Take" and "harassment" are statutorily and respectively defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" and "any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild, or has the potential to disturb a marine mammal in the wild by causing disruption of behavioral patterns including, but not limited to, migration, breeding, nursing, feeding, or sheltering."[2] The MMPA moratorium on taking does not apply to Native Americans, Aleutians, or Eskimos who reside in Alaska and who dwell on the coast of the North Pacific Ocean or Arctic Ocean, if taking is for subsistence purposes, or for creating and selling Native articles of handicrafts and clothing, and is not done in a wasteful manner. The MMPA also provides that the moratorium on taking can be waived for specific purposes if taking will not adversely affect the species or population. It specifies that permits may be obtained to take or import any marine mammal species, including depleted species, to conduct scientific research or to enhance the survival or recovery of a species or population. Notice in the *Federal Register* with the opportunity for public comment is required as part of the process.

In 1994, Congress amended the MMPA, establishing a new regimen to govern taking of marine mammals incidental to commercial fishing. This new regimen includes preparation of annual population assessments for all marine mammals in waters under US jurisdiction, development and implementation of take reduction plans for populations that may be reduced or have fallen below their optimum sustainable levels because of interaction with commercial fisheries, and studies of pinniped-fisheries interactions.[3]

Since the 1994 Amendments became law, NMFS has published several regulations to implement requirements under the Act. These include general authorization for scientific research, development of new management regions for governing incidental taking of marine mammals during commercial fishing, prohibition of intentional lethal taking during commercial fishing, and a final rule that prohibits approaching humpback whales within 100 yards in Hawaii, and authorization for the intentional lethal taking of individually identifiable California sea lions that adversely affect continued existence of steelhead trout at Ballard Locks, Washington.

Partners in Protection

Other agencies that have a role in marine mammal protection include federal, state, and private organizations. The Marine Mammal Commission, under section 101 of the MMPA, consults with its Committee of Scientific Advisors on Marine Mammals regarding recommendations to NMFS and F&WS and other agencies on actions to conserve marine mammals.[3] The US Department of Agriculture, Animal Plant Health Inspection Service maintains jurisdiction over marine mammals in captivity under the direction of the Animal Welfare Act. State agencies work in conjunction with federal agencies to uphold mandates of the MMPA and ESA. Universities, aquaria, stranding facilities, commercial fisheries, animal welfare groups, and other organizations are all partners in protecting marine mammals. Stakeholders from many walks of life are called upon to serve on advisory groups addressing specific areas of concern.

Conservation of marine mammals requires consultation with diverse groups of marine specialists. Within NOAA, many offices play a large role in marine mammal protection. As examples, the National Marine Sactuaries Program and the Office of Law Enforcement are active partners in marine mammal protection. The National Marine Sanctuaries Program was created by Congress under the Marine Protection, Research, and Sanctuaries Act. The Act authorized the Department of Commerce to designate discrete areas as national marine sanctuaries to promote comprehensive management of special conservation, recreational, ecologic, historical, research, educational, or aesthetic resources.

National marine sanctuaries may be designated in coastal ocean waters, submerged lands, and in the Great Lakes and their connecting waters. Currently, there are 12 national marine sanctuaries. These waters provide a safe habitat for species of special concern (threatened and endangered) and provide learning opportunities for educators and researchers. Sanctuaries also permit recreational and commercial fishing, presenting a challenge in managing these areas while balancing environmental protection with economic growth. The most recent designation was the Hawaiian Humpback Whale National Marine Sanctuary, designed to protect critical calving and breeding areas for North Pacific humpback whales.

Law enforcement offices under federal agencies are often the first line of protection for marine mammals. For example, the NOAA Office of Law Enforcement is charged with protection of marine mammals. Also, by enforcing fishing laws, enforcement agencies secure populations of marine species used as food for marine mammals. Enforcement officers play a key role in prosecuting violations of the MMPA and ESA. Other offices and divisions in NMFS and F&WS contribute to overall marine mammal protection and are too numerous to mention here.

Current Areas of Concern

Human interaction with wild marine mammals—A growing concern for federal agencies is the impact of humans on wild marine mammals. Recreation and ecotourism have a direct impact on marine mammals. Typically, these activities involve getting as close to marine mammals as possible, photographing and even touching them.

On the west coast, northern elephant seals have recovered from overharvesting during the late 1800s and have established colonies along the California coast that are easily accessible to people. Recently, these animals have been subjected to busloads of ecotourists anxious to see them more closely. In addition to disrupting natural behaviors (eg, birthing, nursing)

of the seals, visitors often take their dogs to the beach, raising concerns about disease transmission. Harassment is illegal under the MMPA and measures are being pursued to rectify this situation.

Human interaction with bottlenose dolphins is also increasing. Dolphin-watching cruises in the southeastern United States are a growing commercial industry. However, some operators have begun offering opportunities to swim with or feed dolphins. Encounters that harass or otherwise take marine mammals are prohibited under the MMPA. In addition, during elephant seal and dolphin encounters, members of the public are placing themselves in danger of being bitten and injured. Federal agencies require authorizations or permits to conduct photographic or scientific research on marine mammals in the wild.

Noise impacts—Marine mammals often use sound to communicate, sense their environment, navigate, and capture prey. Some marine mammals dive to ocean depths of up to a mile to pursue food sources and locate one another. Manmade sounds can interfere with vital everyday functions by masking natural sounds, and may cause marine mammals to temporarily avoid or abandon feeding and breeding areas or migration routes. Increased mortality and decreased productivity may result when these animals concentrate in unfamiliar areas where food becomes depleted and they are more vulnerable to predation and disease.[4]

Sound can also directly affect distribution and abundance of prey species and result in decreased food resources for marine mammals. Extremely loud or high intensity sounds, such underwater explosives, can cause temporary or permanent hearing loss or, in some cases, injure or kill marine mammals. Low frequency sound may have less direct but serious impacts of habitat avoidance or cumulative hearing loss.

One source of anthropogenic sound that may affect marine mammals is the Acoustic Thermometry of Ocean Climate Program. Scientists in this program measure transmission times of low frequency sounds across ocean basins to detect changes in ocean temperature that may indicate global warming. Other programs that generate anthropogenic sound include military testing of low frequency sound to detect objects in the sea for purposes of national security and shipshock testing of armed forces vessels, which is critical to protection of military personnel. Submarine shipshock testing must be conducted in the ocean and involves detonation of explosive charges in waters off the southeastern coast of the United States. Rocket launches from Air Force bases require the armed forces to consult with federal agencies so that the effects of underwater and air sounds on marine mammals and their behavior can be evaluated. Companies conducting commercial oil exploration by seismic blast must also go through an authorization process and consult with federal agencies to protect marine mammals from harm during incidental harassment.

Conservation of Endangered Species

Northern right whale—Two species of marine mammals that are being threatened or endangered warrant specific mention. The northern right whale (NRW) is the most endangered large whale in US waters. Currently there are approximately 300 NRW remaining in the North Atlantic Ocean. The species was formally listed as endangered in 1973. Northern right whales have been slow to recover from exploitation by commercial whaling. This is partly the result of a slow reproductive rate, but is also caused by human-related mortalities. During the past 20 years, at least 20% of NRW mortalities have been attributed to vessel strikes and more than 50% of the western population of NRW bear scars from entanglement in fishing gear. With anthropogenic causes of mortality increasing, NMFS is developing and updating recovery plans and has instituted protective measures to enhance recovery of the NRW and all threatened and endangered whales. Measures under development include formation of large whale disentanglement and necropsy response teams in all coastal regions, adding a large whale recovery activities coordinator to headquarters staff, and updating the existing recovery plan. In addition, NMFS coordinates international, federal, state, and private efforts to implement recovery plans and designate critical habitat. For the NRW, an aerial survey of calving grounds provides an early warning system for vessels within areas of critical habitat. Take Reduction Plans also have been implemented to reduce taking of marine mammals by commercial fishing operations.

Hawaiian monk seal (HMS)—The HMS is the most endangered pinniped in US waters. This species was listed as endangered when beach counts from the 1970s were found to be 50% of the first recorded counts in the 1950s. Various factors have contributed to decline of the HMS population; however, human activities that have forced seals from birthing and resting areas are especially important. Currently, most seals reside on and near the largely uninhabited northwestern Hawaiian Islands where they are less likely to be disturbed by humans than would be the case near the large islands, which are popular with tourists. Military presence on Midway and Kure Islands disturbed their habitat until recent base closures removed all personnel. Cleanup of these areas by the military is improving the beach environment for HMS.

French Frigate Shoals in the northwestern Hawaiian Islands is currently considered to be the primary birthing ground for HMS. In recent years, sharp increases in pup and juvenile deaths have caused concern. Studies are underway to assess the cause(s) of mortality and the species' decline. A program to rehabilitate and relocate undersized female pups has returned healthy pups to the wild since 1984. In 1995, 12 pups were collected from French Frigate Shoals for rehabilitation. After arrival at the rehabilitation facility on Oahu, the seals began to display signs of an eye ailment that has not yet been described as developing in monk seals or other pinnipeds. Because these seals are not suitable for release, they are expected to be made part of a permanent public display for the purposes of study and exhibition. In 1996, foraging studies began with the use of "critter cam" video attachments to HMS, to document strategies and assess coral reef pro-

ductivity. These studies are being continued in hopes of further determining the importance of individual prey items to the HMS diet.

Other causes of HMS decline have been identified. Hawaiian monk seals died in 1978 near the islands of Laysan and Lisianski in the northwestern Hawaiian Islands because of ciguatera toxin poisoning. In addition, since the 1970s, "mobbing" has contributed to decline of the species. When multiple males gather and attempt to mate with the same female, mobbing results. The female is usually severely injured and often dies. Mobbing is believed to be caused by an unbalanced sex ratio on the 2 islands, and studies addressing this topic are ongoing. Entanglement in fishing gear and shark predation are also important causes of mortality for HMS. Because most populations are located on and near remote islands, it is difficult to quantify the effect of these events.

The Marine Mammal Health and Stranding Response Program

In 1992, the Marine Mammal Health and Stranding Response Act (Public Law 102-587) was passed and became Title IV of the MMPA. Developed in part because of bottlenose dolphin mortality on the east coast in 1987 and 1988, it consists of 3 basic elements: the Marine Mammal Stranding Network, Response to Unusual Mortality Events, and the National Marine Mammal Tissue Bank. To implement the Act, NMFS developed the **Marine Mammal Health and Stranding Response Program (MMHSRP)** that includes the following components: Stranding Networks, the Working Group on Unusual Marine Mammal Mortality Events, the Biomonitoring Program, the National Marine Mammal Tissue Bank, a Quality Assurance Program, and an Information Management Program (currently under development).

Marine Mammal Stranding Networks—The Marine Mammal Stranding Networks are governed by NMFS in 5 regions of the country: Northeast, Southeast, Northwest, Southwest, and Alaska. Facilities or organizations meet minimum requirements and obtain a **Letter of Agreement (LOA)** to handle live or dead marine mammals. Most people in these networks are volunteers and work for universities, aquaria, or state or nonprofit groups. As part of their LOA, network members are required to collect basic data for stranded marine mammals, which includes species name, sex, length, location, and evidence of interaction with humans. Members are encouraged to collect additional health and scientific information but are not required to do so. Information gathered by the stranding networks contributes to our knowledge of strandings attributed to natural causes, fisheries interaction and entanglement, vessel collision, pollution, and disease. Stranding networks are the backbone of the MMHSRP and supply tissue samples for other programs within the MMHSRP.

Working Group on Unusual Marine Mammal Mortality Events—The Working Group on Unusual Marine Mammal Mortality Events (WGUMMME) was formed to help NMFS and F&WS examine marine mammal mortality. This group consists of marine mammal scientists, veterinarians, epidemiologists, toxicologists, life history specialists, and pathologists. Since its formation, members of the WGUMMME have been asked to provide their expertise regarding many mortality events, including the manatee die-off of 1996, NRW mortality in the southeastern United States in 1996, and more recently, the west coast die-off involving pinnipeds, leptospirosis, and demoic acid.

Biomonitoring program—Functions of the Biomonitoring program include contamination assessment, health/disease evaluation, specimen archival, and quality assurance. The purpose of this component of the MMHSRP is to provide baseline information on the health of marine mammal populations. Partners in pathologic evaluation include the Armed Forces Institute of Pathology and university and private groups. The NMFS Northwest Fisheries Science Center serves as the lead agency for quality assurance and biomonitoring of contaminants. The NOAA **Marine Environmental Health Research Laboratory (MEHRL)** in Charleston, SC, is also a partner in this effort.

National Marine Mammal Tissue Bank—The **National Marine Mammal Tissue Bank (NMMTB)** was established in 1989 and formalized in 1992. The **National Institute of Standards and Technology (NIST)** maintains a strong relationship with NMFS and houses NMMTB specimens. Specimens of liver, blubber, and kidney have been routinely collected and banked for future use as standard reference materials. The inventory for the NMMTB includes 918 specimens collected from 332 marine mammals representing 22 species.

Quality assurance program—The quality assurance program develops standards and conducts interlaboratory comparisons (performed by external labs) for organic and inorganic analyses. The NIST and MEHRL are partners in this effort.

Future Directions

Marine mammal conservation involves cooperation among federal and state agencies, universities, and private organizations. Federal agencies rely on input from constituents regarding regulation of, and legislation affecting, this national resource. Future protective measures will include education and outreach to teach the public about appropriate behavior around marine mammals. Conservation programs will continue to develop partnerships as we seek to improve the future of protected, endangered and threatened species.

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Appendix 1

Marine mammal species and populations listed as endangered (E) or threatened (T) under the Endangered Species Act and depleted (D) under the Marine Mammal Protection Act, as of Dec 31, 1997[3]

Common Name	Scientific Name	Status	Range
Manatees and dugongs			
West Indian manatee	*Trichechus manatus*	E/D	Eastern North, Central, and South American coasts and rivers from southeast United States to Brazil; Puerto Rico and other Greater Antilles Islands
Amazonian manatee	*Trichechus inunguis*	E/D	Amazon River basin of South America
West African manatee	*Trichechus senegalensis*	T/D	West Africa coasts and rivers; Senegal to Angola
Dugong	*Dugong dugon*	E/D	Northern Indian Ocean from Madagascar to Indonesia; Philippines; Australia; southern China; Palau
Otters			
Marine otter	*Lutra felina*	E/D	Western South America; Peru to southern Chile
Southern sea otter	*Enhydra lutris nereis*	T/D	Central California coast
Seals and sea lions			
Hawaiian monk seal	*Monachus schauinslandi*	E/D	Hawaiian Archipelago
Caribbean monk seal	*Monachus tropicalis*	E/D	Caribbean Sea and Bahamas (probably extinct)
Mediterranean monk seal	*Monachus monachus*	E/D	Mediterranean Sea; Atlantic coast of northwest Africa
Guadalupe fur seal	*Arctocephalus townsendi*	T/D	West coast of Baja California, Mexico, to southern California
Northern fur seal	*Callorhinus ursinus*	D	North Pacific Rim from California to Japan
Steller sea lion	*Eumetopias jubatus*	T/D	North Pacific Rim from Japan to California
Saimaa seal	*Phoca hispida saimensis*	E/D	Lake Saimaa, Finland
Whales, porpoises, and dolphins			
Baiji	*Lipotes vexillifer*	E/D	Changjiang (Yangtze) River, China
Indus river dolphin	*Platanista minor*	E/D	Indus River and tributaries, Pakistan
Vaquita	*Phocoena sinus*	E/D	Northern Gulf of California, Mexico
Northeastern offshore spotted dolphin	*Stenella attenuata*	D	Eastern tropical Pacific Ocean
Eastern spinner dolphin	*Stenella longirostris orientalis*	D	Eastern tropical Pacific Ocean
Mid-Atlantic coastal bottlenose dolphin	*Tursiops truncatus*	D	Atlantic coastal waters from New York to Florida
Northern right whale	*Eubalaena glacialis*	E/D	North Atlantic, North Pacific Oceans; Bering Sea
Southern right whale	*Eubalaena australis*	E/D	South Atlantic, South Pacific, Indian, and Southern Oceans
Bowhead whale	*Balaena mysticetus*	E/D	Arctic Ocean and adjacent seas
Humpback whale	*Megaptera novaeangliae*	E/D	Oceanic, all oceans
Blue whale	*Balaenoptera musculus*	E/D	Oceanic, all oceans
Finback or fin whale	*Balaenoptera physalus*	E/D	Oceanic, all oceans
Western North Pacific gray whale	*Eschrichtius robustus*	E/D	Western North Pacific Ocean
Sei whale	*Balaenoptera borealis*	E/D	Oceanic, all oceans
Sperm whale	*Physeter macrocephalus*	E/D	Oceanic, all oceans

Stranded seals: Important sentinels

Frances M. D. Gulland, Vet MB, PhD

Seals and sea lions may be observed washed up on dry land above the high tide line or trapped in unusual sites where they are considered to be "stranded." Reasons for animals stranding are numerous and often unclear.[1] Seals and sea lions that strand along the California coast while they are still alive are rescued, taken to rehabilitation centers, and later released if restored to health. Rehabilitation of stranded animals is controversial and is not performed in the states of Washington or Oregon.

From The Marine Mammal Center, Marin Headlands, Sausalito, CA 94965.

The primary reason for responding to stranded seals and sea lions in California is concern for individual animal's welfare. As many beaches in this state are well populated by humans, distressed animals are often observed by the public, who expect a humane response from the responsible agency or agencies. In the United States, rehabilitation centers for marine mammals operate under a letter of authority from the National Marine Fisheries Service (NMFS). The NMFS is therefore considered to be the responsible federal agency, although most marine mammal rehabilitation is performed by private organizations or display facilities in addition to activities that serve their main purposes

(eg, display, education, research). The primary mission of rehabilitation centers is to release healthy individuals back into their ocean habitat. However, while stranded animals are under veterinary care, they can provide a wealth of information on the health status of the population from which they came, as well as facilitate public education and the development of novel techniques for the medical care of marine mammals.

When a stranded pinniped is first admitted to a rehabilitation center, a physical examination is performed, and blood and fecal samples are obtained for hematologic, serum biochemical, and parasitologic evaluations. If an animal dies during rehabilitation, a complete necropsy and microbiologic examination of tissue samples are performed. Results of clinical and postmortem examinations may not only assist in identifying the cause of death in affected individuals, but can point to health problems in the free-living population. Because free-living marine mammals usually die at sea or in remote areas, their carcasses are rarely discovered when tissues are fresh enough for productive pathologic examination. Their bodies typically wash up when they are considerably decomposed, if ever.

Important pathogens that can cause epizootics in marine mammals were first identified in stranded seals. **Phocine distemper virus** (PDV), which was responsible for the deaths of at least 18,000 harbor seals in Europe in 1988, was first isolated from stranded seals in 1988,[2] as was **phocine herpes virus (PhHV1)** in 1985.[3] Overcrowding may have exacerbated the outbreak of the latter virus. Similarly, a novel *Brucella* species was identified in seals stranded along the coast of Scotland, United Kingdom.[4] Subsequent serologic testing of free-ranging animals after this *Brucella* species was identified indicates that the organism may be widespread.[5]

In addition to assisting in recognition of novel pathogens, examination of stranded pinnipeds can help to identify toxins in their marine environments. In May of 1988, 74 California sea lions exhibiting seizure activity stranded along the coast of central California. Severe neurologic signs resulted in the deaths of 55 animals and fetal loss in 12 surviving sea lions. Domoic acid was identified in feces and urine from these animals, and was subsequently detected in water, plankton, and anchovies obtained from the area in which the animals stranded. This is the first recorded instance of domoic acid affecting marine mammals, and it was detected in stranded sea lions in rehabilitation rather than in free-ranging individuals or those on rookeries. Because domoic acid is cleared rapidly from plasma in experimentally exposed rodents, it probably also is cleared rapidly from the plasma of exposed sea lions. One therefore expects that domoic acid would only have been detected in urine and feces from these California sea lions if exposure had occurred within a few days of their stranding. Early clinical examination, as a part of routine care during rehabilitation, facilitated detection of this toxin in these California sea lions.

Stranded animals can be valuable sentinels of health in free-ranging pinniped populations. However, because sampling is far from random, and because the age and sex distributions of stranded seal populations are highly skewed, results of disease surveys must be interpreted with caution. Direct parallels between disease prevalence in stranded animals and disease prevalence in the animal's overall population cannot be drawn. Despite these limitations, stranded animals can contribute substantially to our understanding of marine mammal health. In addition, the welfare concerns of humans for individual animals can be directed to enhance understanding of free-ranging pinniped populations.

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The role of Eskimo hunters, veterinarians, and other biologists in improving the humane aspects of the subsistence harvest of bowhead whales

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Whaling captains, village whaling captains associations, the Alaska Eskimo Whaling Commission (AEWC), and other staff of the Department of Wildlife Management of the North Slope Borough have contributed substantially to improved hunting methods and to many studies referenced in this paper. Specifically, the authors recognize the Weapons Improvement Program Committee of the AEWC.

The bowhead whale is a large (up to 60 ft [18.3 m] long) baleen whale that occupies ice-covered seas throughout the year, and is the only true pagophilic (ice-loving) baleen whale.[1] Main prey are copepods and euphausiids (shrimplike organisms) 0.12 to 1.2 in (3 to 30 mm) long.[2] Bowhead whales are closely related to right whales (*Eubalaena* spp)[3] but differ anatomically in several respects including an upper jaw with a higher arch and longer baleen, and absence of bonnet callosities found on right whales.[4] Five bowhead whale populations have been identified: Spitsbergen, Davis Strait, Hudson Bay, Okhotsk Sea, and Bering-Chukchi-Beaufort Seas (BCBS).[5] The subject of this report is the BCBS population, which is hunted by native communities in Alaska and Russia.

Eskimos of Alaska hunted bowhead whales at least 2,000 and possibly 3,800 years ago at Cape Krusenstern, Alaska.[6] The bowhead whale, the subsistence hunt and associated harvest activities, and the sharing of food play a crucial role in the cultural, spiritual, and nutritional well-being of Eskimo people. The subsistence harvest of bowhead whales is carefully regulated internationally by the International Whaling Commission (IWC), nationally in the United States by the National Marine Fisheries Service (NMFS), and locally by the Alaska Eskimo Whaling Commission (AEWC) in Alaska and by the Union of Marine Mammal Hunters in Chukotka, Russia. The Alaska harvest is locally managed through a cooperative agreement between the AEWC and the NMFS.[7] The harvest quota is established by the IWC[8,9] on the basis of estimates of the size and rate of growth of the bowhead whale population and nutritional and cultural needs of Alaskan Eskimos and Eskimo and Chukchi people of Chukotka.[10-12] This limit is an agreed upon maximum number of strikes (successful and unsuccessful strike attempts) or a maximum number of animals actually landed, whichever is achieved first. The AEWC, formed in 1977, oversees 10 Alaskan villages in their harvest of whales and distributes strikes to each village based on need and population size. This is a prime example of successful comanagement of a natural resource by indigenous and federal entities. The success of the AEWC in providing a meaningful role for native hunters in the management of wildlife has stimulated formation of several similar groups, such as the Eskimo Walrus Commission, the Alaska Nanuuq (polar bear) Commission, and the Union of Marine Mammal Hunters (Russia). The National Oceanic and Atmospheric Administration NMFS maintains federal regulatory authority over the bowhead whale and represents the United States at the IWC.

Commercial whaling and subsistence hunting have been the greatest known source of mortality and injury to bowhead whales for many centuries, with commercial whaling severely depleting many populations.[13] Basque whalers apparently had begun commercial bowhead whaling by 1547 along the Labrador coast, but may have been taking bowhead whales near Iceland almost a century earlier.[14] Initially, commercial whaling probably targeted the Spitzbergen and Davis Strait populations.[15] In 1847 and 1848, North Pacific exploitation began in the Okhotsk and Bering Seas and ended for the BCBS around 1914, with few bowhead whales taken until 1930.[1] By the end of Yankee commercial whaling activities (1849 to 1914) an estimated 18,650 whales were killed,[16] which dramatically decreased the BCBS population. This industry also changed native hunting techniques by introducing the exploding projectile, darting gun, and shoulder gun. These tools are still used in combination with traditional Eskimo whaling methods (shorefast ice-based operations) and equipment (bearded seal skin boat or "umiaq") and some modern equipment (eg, small outboard boats in the fall). Though the subsistence hunt is deeply rooted in traditional practices, there is a major effort by hunters and scientists to increase the efficiency of this harvest by decreasing unsuccessful strikes and time to death.

The 1931 League of Nations Convention restricted harvest of bowhead whales to allow only local consumption. This was US law until 1946 when the International Convention for the Regulation of Whaling formed the IWC for the purpose of providing management recommendations. The IWC continues

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this role today with the participation of the United States and approximately 34 other countries. Regarding bowhead whales, the AEWC and the North Slope Borough (a county-like government in northern Alaska) participate as part of the US delegation to the IWC. Quotas for commercial harvesting of any whale were initiated by the IWC in 1964 and were applied to various aboriginal hunts[1] in July, 1977. The most recent harvest quota was set by the IWC in 1997.[12]

Currently, only the BCBS population can sustain a subsistence harvest, and approximately 0.5% of the estimated population is harvested annually.[13] Even with the native harvest, the BCBS population increased at an annual mean rate of 3.2% (95% confidence interval [CI], 1.4 to 5.1%) between 1978 and 1993 and was estimated to be 8,200 (95% CI, 7,200 to 9,400) in 1993.[16]

Although mortality caused by commercial whaling and subsistence hunting has been well documented,[17,18,a] there is little information on other causes of mortality. Other documented human-induced injuries include ship strikes,[19] rope and net entanglement, and ingestion of foreign material.[13] Aspects of natural mortality that have been reported include ice entrapment,[20] likelihood of killer whale predation,[19] and a single instance where the cause of death was determined to be intestinal volvulus.[21]

Various other legislative initiatives and policies affect US bowhead whale management.[1] Three are of particular importance. The **Marine Mammal Protection Act (MMPA)** established the Marine Mammal Commission and charged it with providing information and advice to US federal agencies for conservation and protection of marine mammals. The MMPA permits an aboriginal harvest of marine mammals in Alaska. The **Endangered Species Preservation Act (ESA)** and the **Convention on International Trade in Endangered Species (CITES)** of Wild Flora and Fauna were developed to specifically address populations of species considered to be severely limited and near extinction. The bowhead whale is classified as an endangered species.[1] Finally, the **National Environmental Policy Act (NEPA)** of 1969 mandates that US federal agencies develop environmental impact statements to assess the effects of major federal actions (eg, lease-sales for oil and gas exploration or development). It also guides research for certain regions and activities (including the federal offshore leasing program for oil and gas exploration and development) and ascertains how these activities could affect the bowhead whale. The NEPA has caused substantial funding to be directed toward research[1] to assess the effects of oil exploration and development in arctic Alaska on bowhead whales.

Between 1915 and 1969 Alaskan Eskimos harvested approximately 8 to 10 whales/y, but during the 1970s the harvest increased to approximately 30 whales/y.[22] According to Philo et al,[13] in the 1960s the recorded annual harvest of bowhead whales ranged from 8 to 22, with 2 to 18 whales struck and lost. From 1970 to 1977, the last years of unrestricted hunting, the harvest increased to 15 to 48 landed and 3 to 82 struck and lost.[13] Tillman[23] indicated that the struck and lost ratio was 2 or more struck whales for each whale landed, a hunting efficiency of < 50%. In 1977, an increase in struck and lost whales, an increase in the number of whales harvested, and an erroneous population estimate of 600 to 1,000 whales prompted the IWC to recommend that bowhead whales not be harvested by Alaskan Eskimos in 1978. However, a small quota was granted in response to a promise to increase research efforts.[1]

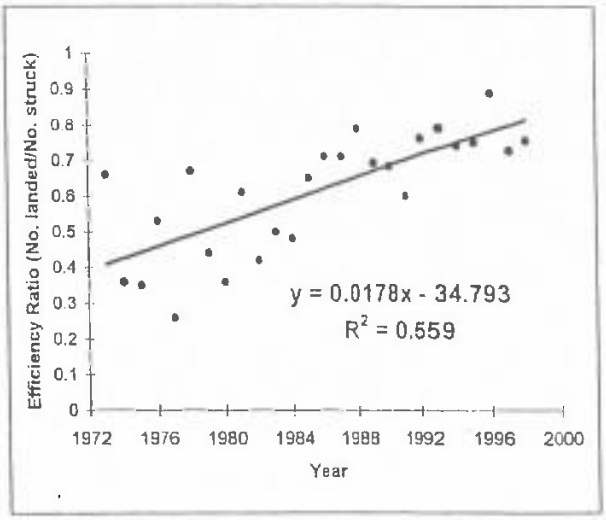

Figure 1—Alaskan Eskimo bowhead whale hunting efficiency by year.[18,26,a] Efficiency is defined as the ratio of whales landed to whales struck. Linear regression reveals a significant ($P < 0.05$) increase in efficiency between 1973 and 1998.

Alaskan Eskimos maintained that the nutritional and cultural stress caused by not harvesting bowhead whales was unwarranted and that such a disruption of their lifestyle was unjustified, because bowhead whale population estimates by scientists were recognized as imprecise. Most information about the bowhead whale is contained in documents prepared in typical Euro-American scientific style. Few reports and agencies have recognized the long-standing expertise of local hunters who are intimately familiar with bowhead behavior, migration patterns, and the ability of bowhead whales to travel rather easily under ice. The hunters knew that counters missed many passing whales because some whales were traveling under the ice and others passed beyond the range of vision of the counters. An ice-based census in northwestern Alaska was initiated in 1976 by US federal agencies and has been conducted by staff of the North Slope Borough approximately every 4 years since 1981. Visual survey techniques were augmented by hydroacoustics in 1983. This census has been of critical importance in establishing reliable population estimates, documenting a substantial population increase over time, and providing much of the data used to determine the harvest quota set by the IWC.

From the initiation of the quota in 1978 through 1989, the annual number of whales harvested decreased to between 8 and 23, and those struck and lost ranged from 6 to 18.[13] Mean efficiency was 66%/y with a yearly mean of 11 whales struck and lost between 1978 and 1995.[18,a] More recent data indicate

that hunting efficiency continued to improve in the mid-1990s[18,a] (Fig 1). Improvements are primarily the result of vigorous efforts by the AEWC and the whaling captains associations in the villages. These efforts include AEWC workshops on improving hunting techniques, encouraging hunters to selectively strike smaller whales, and increased efforts to locate and retrieve struck whales. Efforts to locate struck whales include use of aircraft to find struck whales that move out of visual contact, equipping hunting floats with VHF transmitters,[24] use of two-way radios to improve communications between hunting crews and shore, and use of scuba divers to locate and secure whales that were killed and lost (sank). The AEWC is working with NMFS to develop guidelines that would permit boats not engaged in the hunt to provide emergency assistance under certain conditions so that struck whales could be landed.

When addressing management of wildlife resources we believe it is essential to consider all aspects of an animal's life. This includes consideration of population numbers and trends, behavior (feeding, migration, reproduction), adequacy of habitat, and (if the animal is hunted) methods of harvest. Whales are one of many types of animals harvested by humans for food. Recognizing that whales are taken for food, the IWC has sponsored workshops to consider ways to make the harvest more efficient and thereby reduce whales' suffering. Workshops were held in Cambridge, United Kingdom in 1980; Glasgow, Scotland in 1992[25]; and Dublin, Ireland in 1995.[26] Another workshop is planned for 1999 in Grenada. The AEWC participates in IWC sponsored meetings as part of the US delegation.[26] In 1991, the IWC adopted a resolution to hold a Workshop on Whale Killing Methods to address the efficacy of available methods. Details of this workshop were reported to the Humane Killing Working Group.[25]

A working definition of the humane killing of an animal was established by the IWC during its 1980 workshop and reads as follows:

> . . . causing its death without pain, stress, or distress perceptible to the animal. That is the ideal. Any humane killing technique aims first to render an animal insensitive to pain as swiftly as possible, which in practice cannot be instantaneous in the scientific sense.[25]

Pain has been defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage."[27,28] Inherent in the harvest of any animal for food is induction of sufficient tissue damage to cause death. Therefore, pain in animals destined for food cannot be eliminated if the previous definition of pain is accepted. When discussing the humane aspects of the harvest of whales, we believe it is important to remember that the subsistence harvest of whales by indigenous people is a hunt, and that the hunters have clearly stated that humane considerations have traditionally been a critical aspect of the hunt.[25] Furthermore, we believe that comparing the subsistence hunt of whales by native hunters to the highly controlled commercial slaughter of domestic food producing animals (eg, cattle, pigs) is, for the most part, inappropriate.

Discussion regarding the humaneness of subsistence harvests must be conducted with due consideration of resources available (ie, equipment) and of the environment in which the activity is taking place (ie, weather and ice conditions). In addition, comparisons should be made to hunting of other species (ie, large, terrestrial mammals). When considering the humaneness of human relationships with whales or any other animal, there is much more to consider than simply how the animal dies. For example, when discussing humaneness toward animals, one should consider the animal's type, lifestyle, cause of death, and how long the animal suffers before death.[29] Wildlife have a free-ranging lifestyle where movement and reproduction are not constrained and diet is not manipulated by others. Domestic animals have a captive lifestyle during which their movement and reproduction are constrained, their diet is manipulated, and their life span may be limited. Major aspects of natural death are disease, starvation and predation. Major forms of human-induced death are hunting (wildlife), slaughter (food animals), euthanasia (pet and laboratory animals), and experiment-related (laboratory animals).

Discussion of ways to reduce suffering associated with the harvest of food animals must be continued in many forums, including the IWC. In this regard, efforts should continue to improve harvest techniques. The IWC has recommended that agencies focus on equipment and methods, indication of insensibility and death, causes of death relative to time to death, relating time to death to harvest efficiency, and assessing the physiologic status of hunted whales.[25]

Since its founding, the AEWC (along with the Barrow Whaling Captains Association) has worked to improve the efficiency of the subsistence hunt. Efficiency has steadily increased (Fig 1), primarily because of AEWC-sponsored workshops on hunter education, improved communications, location of lost whales, improved weapons, and establishment of the **Weapons Improvement Program (WIP)**. The committee overseeing the WIP consists of scientists (primarily veterinarians), from the North Slope Borough and Norway, and experienced hunters. Its purpose is to recommend improvements in weapon design and hunting methods that increase hunting efficiency and reduce time to death. The WIP committee organizes seminars and workshops (often held at the AEWC Convention) that promote awareness of, and training in, improved hunting techniques.

The darting gun is the primary weapon for subsistence hunting and consists of a barrel (to hold a projectile) that is attached to a wooden shaft equipped with a harpoon (a metal shaft with a toggled point) and a line and float (Fig 2, 3).[23,25,30,31] One of the most important efforts toward improving the efficiency of the subsistence hunt has been to improve the reliability, safety, and effectiveness of the explosive projectile. The traditional projectile uses black powder as the explosive and is referred to as the black powder projectile. This projectile (approx 28 cm [11.2 in] long and 2.2 cm [0.9 in] in diameter) is fired into the bowhead whale when the darting gun thrown by the Eskimo hunter strikes the whale.

The black powder projectile is limited, because it

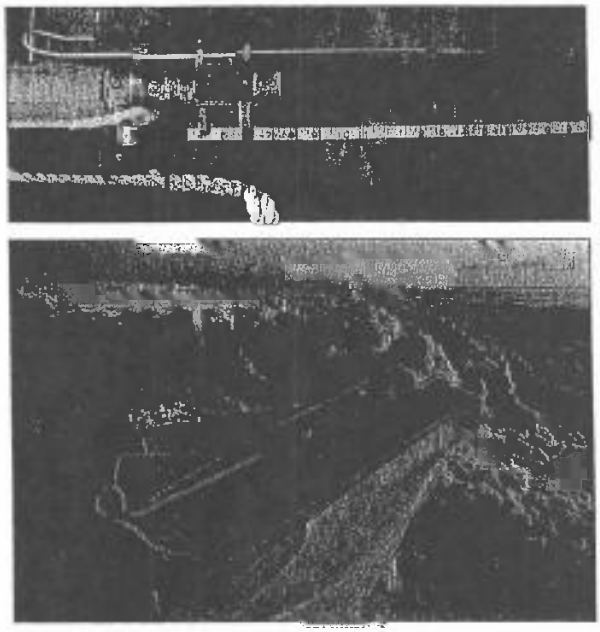

Figure 2—Photographs of darting guns. Top photograph shows barrel that houses projectile and associated hardware. Bottom photograph shows the darting gun with cold harpoon and float line attached and ready for use.

does not use a powerful explosive; it has a fusing system that can be unreliable, and ignition of the fuse occurs in the barrel of the gun, which is dangerous if the projectile becomes jammed or prematurely detonates.[30] The AEWC recognized these limitations and began efforts to improve the effectiveness of the projectile in 1986. Modifying the traditional projectile to use penthrite as the explosive and adapting penthrite technology to bowhead whale harvest methods has been supervised by cooperating scientists from Norway. Penthrite is currently used in the Norwegian minke whale harvest and is highly effective.[31] Development of the penthrite projectile has required great technical expertise and good quality control and assurance to protect hunting crews and to achieve reasonable performance in the field.

Ability of a projectile to penetrate to a suitable depth within an animal impacts its effectiveness and helps reduce time to death. Optimizing penetrability involves use of the best propellant charge (eg, powder type, weight) and use of darting guns with the appropriate barrel diameter for the new penthrite projectile.[30] Studies have been conducted to assess penetrability in the laboratory[30]; however, field evaluation is necessary[31] for a final determination. Laboratory studies revealed that the velocity of the new projectile (which is heavier) was 30% slower than that of the old projectile and indicated that adaptations in propellant charges may be needed.[30] Field trials for the penthrite projectile were conducted in 1988, 1989, and 1990 with promising results. In 1988, 8 whales were struck with the penthrite projectile and 7 (88%) were landed; 5 (63%) died in < 5 minutes. Use of the penthrite projectile reduced median reported time of death from 62 min to 15 min.[31] Overall, 45% of whales were killed within 5 minutes when penthrite was used and only 19% of whales were lost.[31]

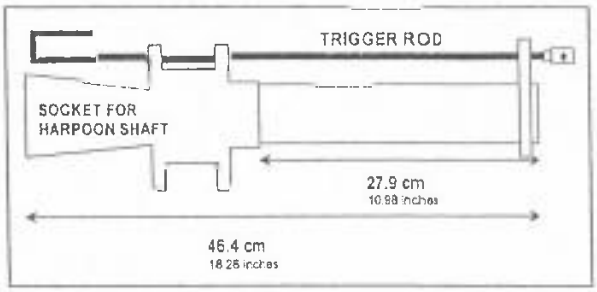

Figure 3—Schematic illustrating dimensions of a typical darting gun.

Modifications (eg, alloy used, fuse head design) were needed, and preliminary 1997 and 1998 data indicate that time to death has been reduced by more than 50% compared with black powder projectiles. This clearly improves the humaneness of the harvest. Once field trials in Barrow are complete, and the AEWC and Barrow Whaling Captains Association can be assured of the projectile's safety and efficiency,[31] we hope widespread use will result in decreased time to death and increased harvest efficiency.

Time to death is a difficult statistic to obtain. For subsistence hunters to determine that a whale is dead at the moment death occurs is an unreasonable expectation because involuntary movements can be confused with struggling or efforts to escape, and the whale is typically observed at a distance. Determinations of death by subsistence hunters must also be conservative, because approaching or attaching lines from one's boat to a whale that may be still capable of movement is dangerous. Estimates of time to death will therefore be imprecise and conservative.

Cetacean physiologic and morphologic characteristics must also be considered when addressing time to death. For example, cetacean blood flow to the brain is through thoracic branches of the aorta and vertebral arteries, and not through internal carotid arteries or vertebral arteries arising from the subclavian artery.[25] Although there appear to be adaptations of the CNS and cardiovascular system in marine mammals that permit them to dive, these have been the subject of much debate and there is no evidence that the cetacean CNS can survive anoxia or decreased perfusion longer than the CNS of other mammals.[25,32]

Achieving immediate death in hunted animals is impossible. Neither hunting activities directed toward other mammals and birds (white tailed deer, turkey, waterfowl) nor slaughter of domestic livestock typically result in instantaneous (occurring without perceptible delay[33]) death, so applying this standard to large marine mammals seems impractical. A more practical definition of "instantaneous" death for whales would be death occurring within 5 minutes of being struck.[31] When properly placed (deep into the cervical or cranial thoracic regions), detonation of the projectile produces immediate unconsciousness that results in "instantaneous" death. Some hunters report that penthrite projectiles produce this effect more often than black powder projectiles.

Hunters and scientists examine landed whales once they are brought onto the sea ice or beach. It is

critical to determine where (anatomic site) and how (angle of penetration) the animal was struck. During the butchering process, the route of penetration is documented so that it is possible to determine at what depth and near what structure(s) detonation of the projectile occurred. Damage to surrounding tissue is evaluated and fragments of the projectile are collected to determine whether the projectile exploded properly. Preliminary data indicate that the cervical and cranial thoracic regions are critical targets, provided there is penetration through muscle tissue. Penetration in these regions results in detonation adjacent to the skull or vertebrae, or within the thoracic cavity.

In assessing the extent of tissue damage, a distinction is made between primary and secondary blast injury. Primary blast injury is a complex interaction between the passing blast wave and tissues (shrapnel is not involved). Depending on the location of the projectile, this can result in concussion-induced brain injury or displacement of gas containing organs (ie, lungs). With respect to the latter, alveolovenous fistulae may form and air emboli may result.[34,35] Air emboli can then occlude vessels in the heart and brain, leading to rapid death. Secondary blast injury is the result of shrapnel that causes tearing of tissues and hemorrhage. It does not involve blast wave-associated emboli.[34,35] Fragmentation and associated damage and hemorrhage are primarily responsible for the animal's death when black powder projectiles are used. Penthrite is a much quicker burning explosive and produces a blast wave that can cause damage farther from the point of detonation. In 1992, the Department of Wildlife Management, North Slope Borough initiated a program to better understand mechanisms of death during harvests. By examining heart, intestine, lung and other tissues, it should be possible to conclude which of the two projectile types is most effective.[35]

Through local, national, and international efforts, the harvest of bowhead whales by Alaskan Eskimos has become more efficient (fewer whales struck and lost) and more humane (fewer whales struck and lost and reduced time to death). Improvements in hunting methods and equipment and cooperative management have made this possible.

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