Husbandry and Care of Marine Mammals (Chapter 31, ZOOKEEPING)

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Introduction and Natural History
This chapter does not limit itself to a specific order or taxon; animals from several taxa are lumped together here because of the environment in which they live. When referring to "zoos and aquariums," specialized zoos such as marine mammal parks or dolphinariums are included. Marine mammals all live at least part of their lives in salt water. However, in each of the groups we find some species that live in fresh water.

This chapter will provide basic information about the husbandry and care of marine and semiaquatic mammals. After studying this chapter the reader will understand

• the enclosure and environmental needs of marine mammals
• food and food preparation for marine mammals
• their propagation and maternal care
• their environmental enrichment and training needs
• their handling and transportation.

Pinnipedia
The first group to be discussed is the superfamily Pinnipedia ("fin footed" mammals) from the suborder Caniformia ("doglike"), which is divided into the following families.

Phocidae (Seals)
The most well-known members of this family are kept in zoos and aquariums.

• The harbor seal (*Phoca vitulina*) ranges from temperate waters to arctic areas, and is found in both the North Atlantic and North Pacific Oceans.
• The gray seal (*Halichoerus grypus*) lives in the temperate and subarctic coasts of the North Atlantic Ocean.

Otariidae (Sea Lions and Fur Seals)
• The Californian sea lion (*Zalophus californianus*) lives along the Californian coast to Mexico, including Baja California. Separate populations live on the Galapagos Islands and in the southern Sea of Japan, although the latter is thought to be extinct.
• The Patagonian or South American sea lion (*Otaria flavescens*) lives on the South American coasts from Rio de Janeiro, on the Atlantic Ocean, and Peru, on the Pacific Ocean, down to the most southern part of South America.
• The Steller's sea lion (*Eumetopias jubatus*) lives along the North Pacific coasts of Japan, Russia, Canada, and the United States.
• The Australian sea lion (*Neophoca cinerea*) lives on offshore islands of western to southern Australia, and is seldom seen in zoos or aquariums.
• The South American fur seal (*Arotocephalus australis*) lives off the neotropical Pacific and Atlantic seacoasts from southern Peru down to Cape Horn and up to southern Brazil.
• The South African fur seal (*Arotocephalus pusillus*) lives in and around the southern and southwestern coasts of Africa as well as the southern and southeastern coasts of Australia, and is the fur seal more commonly found in zoos and aquaria.

Odobenidae (Walruses)
• The walrus (*Odobenus rosmarus*), which is found throughout the entire arctic region, is not often seen in zoos or aquariums.

Odontoceti
The second group is the suborder Odontoceti or "toothed whales": the dolphins, porpoises, and orcas.

Delphinidae (Marine Dolphins)
• The bottlenose dolphin (*Tursiops truncatus*), which lives everywhere except in polar waters, is the most well-known dolphin species in zoos and aquariums.
• The Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), which lives in cool to temperate waters of the North Pacific Ocean, is also commonly found in zoos and aquariums.
• Representatives of the larger delphinid species are the orcas or killer whales (*Orcinus area*). These are found living in all oceans, but they prefer colder waters.
• The beluga whale (*Delphinapterus leucas*) is found in arctic and subarctic waters along the Canadian, Alaskan, Russian, Greenland, and Norwegian coasts. A group of approximately 500 also live in the Gulf of Saint Lawrence.
• One of the smaller species maintained in zoos and aquariums is the Commersons dolphin (*Cephalorhynchus commersonii*), which lives along the Patagonian coast to Cape Horn and through the Strait of Magellan to the Falkland Islands. A second population is found around Kerguelen Island in the

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***Ouwehands Dierenpark Rhenen, The Netherlands**

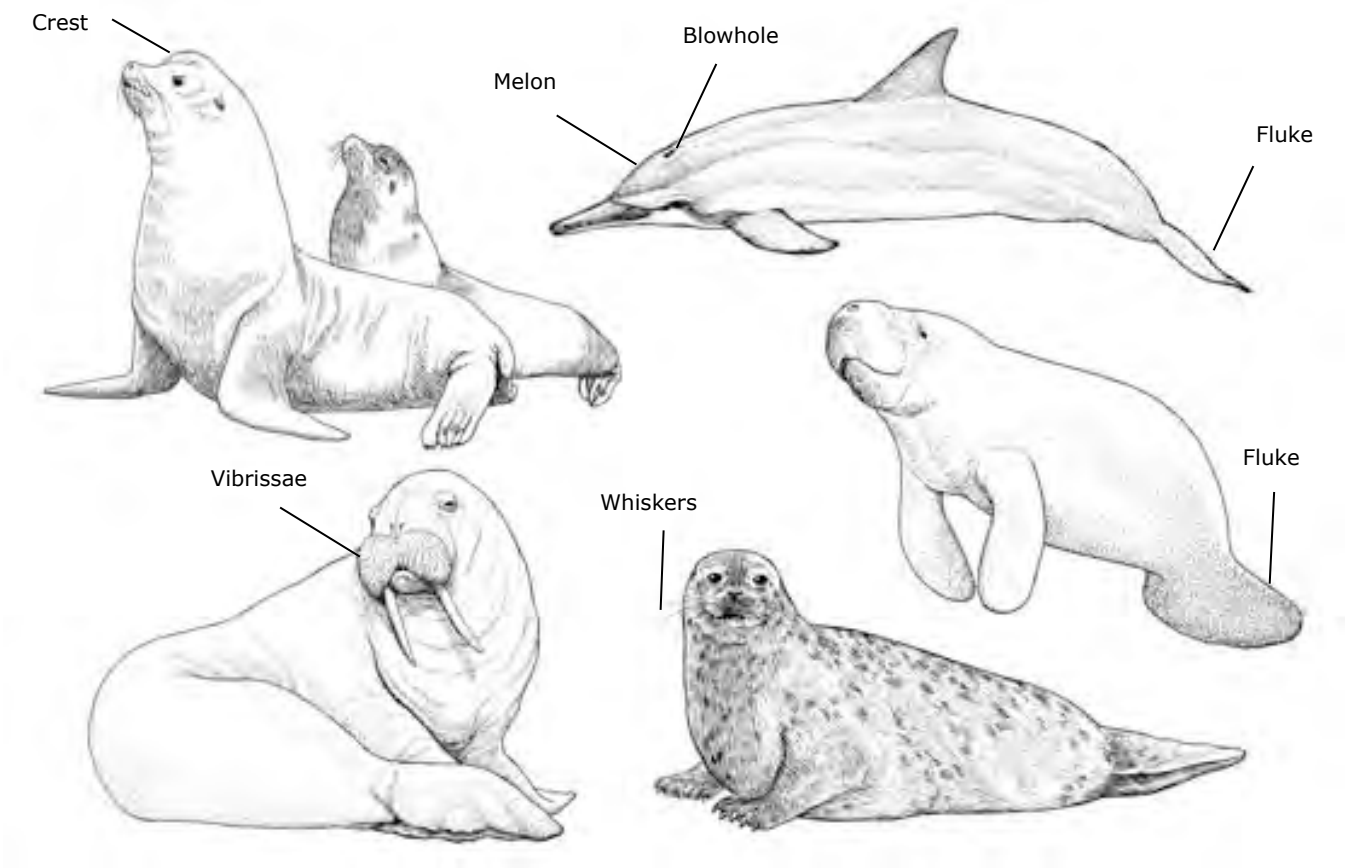

Figure 31.1. Basic anatomical features of marine mammals. Clockwise, from upper left: Californian sea lion (*Zatophus catifornianus*), spinner dolphin (*Stenetta tongirostris*), West Indian manatee (*Trichechus manatus*), harbor seal (*Phoca vitulina*), walrus (*Odobenus rosmarus*). Illustrations by Kate Woodle, www.katewoodleillustration.com

southern Indian Ocean; these dolphins are different in appearance and are not generally found in zoos and aquariums.

Phocoenidae (Porpoises)
• Harbor porpoises (*Phocoena phocoena*) are found in coastal regions of the North Atlantic, Arctic, and North Pacific Oceans, and also in the Baltic, Mediterranean, and Black Seas. They are seldom seen in captivity, but there have been recent breeding successes in Europe.

Sirenia
Trichechidae (Manatees and the Dugong)
• The West Indian manatee or sea cow (*Trichechus manatus*) is found off the coast of Florida, along the southeastern coast of the United States, south along the Gulf of Mexico to Texas, along the coast of Central and South America, and in the Greater Antilles. Of sirenia, this is the species most commonly found in captivity.

This is in no way a complete list of all marine mammal species kept in zoos and aquariums; it is just an overview of the most familiar species a keeper can expect to care for (Klinowska 1991; King 1983; Animal Diversity Web 2010; Grzimek 1973; Coffey 1977; Bateman 1986).

Basic External Anatomy
Pinnipedia
The pinniped species are very similar anatomically, but there are differences between them. They all are well adapted to living and hunting in the world's seas and oceans, a hostile and dangerous environment. The main differences between seals, sea lions, and walruses are as follows.

• Seals use their front flippers to move on land; they "crawl" on their bellies using their front flippers. They do not have external ears (pinnae). When swimming, they use their hind flippers and their lower backs. Unlike sea lions, seals quite often have spots, rings, or patches in their fur that vary in color from gray to brown. The males are slightly larger than the females.
• Sea lions and fur seals can walk on land. They turn their hind flippers to the front and use them in conjunction with their front flippers for walking on land, and their front flippers are generally larger than those of seals. All sea lions have external ears, even though they are sometimes difficult to see. Sea lions are brown to tan in color. Spots are not found in sea lion fur.
• The walrus is in between the seals and sea lions in the use of its flippers, on land as well as in the water. Of course, its tusks are a very clear difference. Walruses with tusks are seldom seen in zoos and aquariums, because they wear the tusks down too

rapidly, which can lead to their infection and removal. External pinnae are not present. The fur seen on the seals and sea lions is almost absent in the walrus. Instead, it has a very thick skin, which in mature males can be 2.5 to 4 cm (1 to 1.5 in.) thick around the neck area. All species of pinniped have whiskers (vibrissae); in the walrus these are more like bristles (heavier and thicker), but they are still called vibrissae. They are used for locating food on the seabed. Seals and sea lions also use their whiskers for locating food in murky waters. They sense the vibrations from moving fish and hunt and catch them in this way.

Dolphins and Porpoises
These mammals have adapted to living their whole lives in water, and they give birth in the water. Dolphins use their tails and horizontal flukes for swimming. In dolphins, the dorsal fin is very distinctive. The beluga whale lacks a dorsal fin but has a slight ridge along its back. The dolphin s blowhole or "nose" is on the top of its head and is a special adaptation to life in water. The melon between the blowhole and the tip of the snout is an outstanding feature; it is part of the nasal system, and is seen in all dolphin and porpoise species. The melon is the bioacoustic part of the echolocation system in dolphins and porpoises, and an environmental adaptation which is still not completely understood. When above water, the dolphin s tail is very distinctive; it differs from that of a fish in that the fluke is horizontal instead of vertical. This adaptation means that the dolphin swims by moving its tail up and down, whereas fish move theirs from side to side.

Manatees
These are the only vegetarians in the group of marine mammals. The manatee's big rounded tail fluke is different from those of the other species previously discussed. The shape of the mouth is also characteristic: the upper lip is very thick and protrudes upward, ending in a disc-like structure. The nostrils are on the upper part of the snout and can be opened and closed at will. The tips of the flippers can be touched together at the chest, and this adaptation allows the manatee to use its flippers in feeding. The manatee has a very thick skin, with only a sparse covering of hair.

Containment, Enclosure, and Environmental Considerations
Each species included in this chapter needs to be kept in a minimum of at least one pool. Many of the species' needs are similar, although there are also some differences. For example, land areas, which are important for seals and sea lions, are not needed for dolphins and manatees. Some institutions , however, have installed shallow concrete shelves with imbedded smooth stones into the exhibits to allow the cetaceans to beach themselves for a scratch. Exhibits have to be built and furnished not only to accommodate the basic needs of the species kept in them, but also to allow the animals to exhibit and exercise their species-specific behaviors.

Unlike seals, sea lions, walruses, and manatees, marine dolphins cannot be kept in fresh water. They will become exhausted swimming, because of the difference in specific gravity between salt and fresh water, which affects their buoyancy. Saltwater is more dense than fresh water. Secondly, their skin will start to slough, much like the skin of a person who stays in water too long. Dolphins should be housed in a saltwater pool with a salinity between 20 to 30 parts per million. Freshwater dolphins are kept in fresh water. Legislation imposes the use of salt water for all marine mammal species in some countries.

Seals, sea lions, walruses, and manatees can be kept in fresh water. It can be discussed what is the best for the animals; while they all (except the manatee) originate from salt water, in practice they do not seem to have problems living in fresh water. However, the author strongly recommends the use of saltwater in all marine mammal exhibits.

Water and air temperatures should be kept within a range that approximates the animals' natural environment (Table 31.1), although most sea lions do not have problems living for short periods of time in water at o °C, with outside air temperatures well under o °C. Seals and fur seals also live and even give birth in very cold conditions. For example, the ringed seal (*Phoca hispida*) gives birth in a snow and ice lair in which water and air temperature can vary to a great extent. One should keep in mind that pinnipeds can, in general, be more endangered by heat than by cold. Sea lions and fur seals exposed to direct summer sun can suffer from heat prostration within an hour. Shade should be provided in all cases.

Table 31.1. Acceptable temperature ranges for some marine mammal species

Species	**Temperature range**
Seal	0-25 °C (32-77 °F)
Sea lion	5-25 °C (41-77 °F)
Bottlenose dolphin	10-32 °C (50-89 °F)
Manatee	24-29 °C (75-84 °F)

Dolphins are similar to the pinnipeds in their sensitivity to variation in temperature. They can stand a great variety of temperatures as long as they have time to acclimate to them. For example, a marine mammal should never be moved from an exhibit with a temperature of 20 °C to a pool with a temperature of 10 °C. Manatees, which live only in tropical areas, need heated water. In countries with cool temperatures they must have indoor exhibits, although they are to a certain extent capable of coping with a wide variety of temperatures.

Pool Sizes
In several countries, such as the United States, Germany, and Belgium, there are rules and regulations describing minimum sizes for pools and land areas for many marine mammal species kept in

captivity. The European Association of Zoos and Aquaria (EAZA) husbandry guidelines also set minimum standards for these marine animals. It has to be noted that these standards are only minimums, and that keepers should strive to improve upon them where possible.

All animals should be provided with as much usable space as possible. Both the size and the shape of a pool and land area are important considerations. "Kidney-" or irregularly shaped pools are preferred. Irregularly-shaped pools need to have rounded contours, with corners of not less than an angle of 90 degrees, to prevent animals from being cornered during fights or chases. For seals, sea lions, and walruses there should be a shallow sloped side for easy access and egress for all animals, including young and very old individuals. In many pools the land areas are made of concrete and are painted or coated, but in some cases the adjacent land areas for seals and sea lions are of sand, soil, and rocks. Planted areas should be considered, as they can make the environment even more interesting. Dolphins can also be enclosed in areas of natural bays or harbors, although this is not a common practice for zoological facilities.

A maternity pool and associated holdings should be provided for all species. In a dolphin area, a maternity pool fitted with a lifting platform will be beneficial for the animals and keepers when mother or baby needs to be handled. The maternity area should in all circumstances offer the female a sense of security and allow her, when necessary, to be able to easily defend her young from conspecifics.

A separate area for sick or injured animals is also a necessity. Keep in mind that separating a social animal from its group can affect the group dynamics and could perhaps cause negative ramifications within it. A close companion animal can help to alleviate behavioral concerns, and may even help speed up recovery.

Natural daylight is preferred for all species, although quite a few zoos and aquariums have only indoor exhibits and pools, in which case natural light cycles should be provided. These, of course, should supply enough light to imitate the animals' natural daylight cycle by means of windows and artificial lighting. When considering outdoor exhibits, especially in areas with a lot of sunshine and high temperatures, shade should be provided over a part of the exhibit pool. Dolphins especially can suffer from severe sunburn when left without shade. In colder climates some form of shelter should be provided. Some facilities have land areas raised on pillars so that animals can shelter underneath as needed. This makes the most efficient use of space and exhibit volume.

In indoor exhibits and holdings, one should keep in mind that a good exchange of fresh air is essential. Most marine mammals breathe just above the water surface or, when on land, close to the substrate. It is therefore very important that the exchange of air or ventilation has appropriate movement at floor and surface levels. This is even more important when chlorine is used for the treatment of water or cleaning. Chlorine and other unwanted derivatives that originate in a pool tend to appear just above the water surface.

Food and Water

What kind of food can a keeper be expected to use to feed marine mammals? The wide variety of places and diversity of habitats that the animals come from, and the fact that zoos and aquariums are spread widely over the world, mean that a massive variety offish species are available to choose from. Manatees have their own completely different dietary needs, which will be discussed later, but other marine mammals will eat most of the fish species we can offer them. In general, it is possible to feed them species that are locally available. It can take some time to get them used to food species other than those they normally eat, however, so the keeper should make the changes slowly.

In general, the most common species offish fed to captive marine mammals are herring (*Clupea harengus*), mackerel (*Scomber scombrus*), whiting (*Merlangius merlangus*), blue whiting (*Micromesistius poutassou*), capelin (*Mallotus villosus*), and sprats (*Sprattus sprattus*). Although not fish, squid (*Loligo* sp.) are also commonly fed. Some institutions feed their animals a mix of these species ad libitum (at will). Other establishments will weigh the daily food intake. Still another method is to feed on nutritive and caloric value. This last method means, however, that the feeder fish from each shipment must be analyzed before they can be fed to the mammals, and this can be rather expensive. Weighing the feeder fish and monitoring the mammals' daily intake is a well-balanced method. In most cases, the use of common sense and the monitoring of feeding practices by experienced keepers is a very good way to ensure the feeding of good quality fish. On average, the daily food intake of a normal healthy animal is between 5 and 8% of its body weight.

In some species there are seasonal differences in food intake. For instance, a bull in mating season will commonly lose its appetite; also, females will not eat during the first period of lactation. If the aquarium is not analyzing the feeder fish, the keeper should pay more attention to their quality, and should ensure that they come from dependable suppliers. Frozen fish should be as fresh as possible; the dates of catch are known by the suppliers. One should open boxes of feeder fish and check the contents. There should be no damage, or any excessive blood between the fish. The fish should not look dull or off color; they should not smell sour or abnormal. When thawed, they should have bright red gills, clear eyes, and firm, elastic skin. Old or refrozen fish are dull and soft, and their eyes will be red-bordered and cloudy; after they thaw, one can poke them with a finger and the indentation will remain. Fish should be ordered and bought as fresh as possible and stored in a freezer at the correct temperature of -30 to -18 °C (-22 to -0.4 °F). The storage offish should be

Good Practice Tip: After feeding, temporarily store leftover fish in a cooler or immediately dispose of it appropriately. Fish can spoil very fast and quickly become a breeding ground for bacteria. Feeding old or improperly stored fish can harm the health of the animals.

organized in a system of "first in/first out" to ensure that it is as fresh as possible when fed, and no old fish stays in the freezer. Once removed for thawing, fish must be used within 24 hours, and kept refrigerated between 2 to 6 °C (35.6 to 42.8 °F). Hygiene in the fish preparation area and during all handling is very important (Chrissey 1998).

There are different methods of thawing fish. Thawing it by submerging it in slow flowing water is one method, but it is one in which the loss of vitamins and nutrients can be significant. Thawing fish by leaving it packed or unpacked in open air can cause it to dry out rather easily. Thawing in a cooler unit with forced air can minimize the loss of nutrients and vitamins and keep the drying out to a minimum. Variations are possible in all methods; the last method is preferred by the author.

As all fish eaters are hunters; they should be fed several times a day. Feeding them as much as they can eat on four or five occasions per year is no problem, and might even be desirable. In the wild, the animals will sometimes find a jackpot of food and will eat until they are satiated. Many marine mammals are used in presentations and shows; this provides a good opportunity to spread their feeding times throughout the day. But since a day is 24 hours, one should feed not only during presentations, but also at the beginning and end of the working day.

Keepers will use fish as a reward for aquatic mammals during presentations, and this must be considered when calculating the mammals' daily feed intake. As most of the fish will be deep frozen and stored for months before being fed, they will lose vitamins. They should be supplemented in the daily diet as prescribed by a nutritionist or veterinarian. Keepers should know, however, that over time new knowledge about animal diets and supplements is obtained; the composition, quantity, and types of vitamins prescribed may change. The subject requires more research and discussion.

Manatees are not carnivores (hunters), but herbivores (plant eaters). Depending on their geographic location, they may eat seagrasses, algae, roots, fallen fruits, or leaves. In captivity they feed on a variety of food items, with lettuce and endive as major food sources. Spinach, grass, aubergine (eggplant), carrots, bananas, cauliflower, beets, apples, and sweet potatoes are also fed. The diet fed will sometimes depend on the individual animal's preference. The keeper must remember that the floating foods can offer a challenge for the exhibit's filtration system. Food should be fed frequently throughout the day, and preferably in such a way that it will not float directly into the filter system. Feeding in racks and putting grates in front of the outlets will help to prevent this. As these animals are "grazers," a keeper will have to feed a large amount of greens over the course of the day: approximately 18 to 25 kg (39.5 to 55 lbs.) for an adult animal. Feeding this amount over the day will not only benefit the animals but also prevent floating parts of the food from getting directly into the filtration system.

Marine mammals do not drink, as they obtain the water they need from the food they eat, partly by extracting the moisture from their food and partly by metabolizing their body fat. This is why it is so important to ensure the best quality and freshest food for them. Sometimes dolphins may need extra hydration. It can be given to them by injecting fresh water into their feeder fish, or by giving them water through a stomach tube. The latter should only be done by experienced keepers in consultation with or on the direction of a veterinarian. Seals and sea lions do not drink, but fasting bull sea lions during mating season may sometimes appear to drink seawater.

Observing marine mammals can be challenging compared to monitoring the behaviors of the terrestrial animals. Once marine mammals are in the water, they may be out of sight; light refraction and wave movement will further hinder observations. First the keeper must learn to recognize their normal swimming patterns. Experienced keepers are a valuable resource for advice about what is seen or not seen. Most animals will show the first signs of ill health or other problems by moving about in a manner different from what is normal (e.g., hanging vertically at the water's surface, showing a curve in the back, tilting sideways, swimming very slowly or rapidly). Together with other signs, these behaviors can indicate problems. One should be careful with conclusions—for example, either slow or rapid swimming can indicate pain. Alternatively, movement in a healthy bottlenose dolphin may be completely different from movement in a healthy manatee. Always be aware that some behaviors are species-specific, and also that sometimes there are differences between individual animals. New keepers and visitors are always surprised if a keeper walking alongside a pool, seeing nothing more than part of a head and back, greets an animal by name. The author remembers being surprised that even an experienced relief keeper didn't see the difference between the light and dark female sea lions that he was regularly responsible for. Observation is a very important skill that has to be learned. One must keep watching all the time, not only for little things but also for the overall appearance of the animals and their habitat. One should not hesitate to ask or inform the more experienced keepers about anything one may observe.

Animal training is an essential duty for a keeper working with marine mammals. It allows the animal to be in close proximity to the keeper for observation of all external body parts such as the mouth, teeth,

ears, and eyes. Changes in skin and fur condition, bumps, or lumps can be better examined when the animals are close.

Swimming with closed eyes is often a sign of eye problems, and is particularly common in pinnipeds. It is a problem seen not only in captive marine mammals, but also in the wild. Keeping pinnipeds in chlorinated and/or fresh water can contribute to eye problems. Also, reflection of sunlight on the water and walls might contribute to eye problems; more research is necessary. When an animal withdraws itself from the group it can be a sign of discomfort. Pregnant females due to deliver their young will also often withdraw from the group. A keeper will generally know which animals are pregnant, but some animals may not show signs of pregnancy.

Tools and Equipment

Being involved with the upkeep and maintenance of water treatment systems (life support systems or water filtration) is one of the major differences between keeping marine mammals and caring for other mammals. A keeper working with marine mammals needs a basic understanding of water treatment, even in institutions where water treatment systems are cared for by maintenance specialists.

In some seal and sea lion exhibits, a system of "drop and fill" is still in use. This system requires that once or twice a week, the pool is drained, cleaned, disinfected when necessary, and then refilled. In the case of dolphins and manatees this simple procedure is not feasible, although during a short period at the end of the 1960s and the beginning of the 1970s in traveling dolphin shows this was the procedure of choice. This would have caused stress and discomfort in these animals. All marine mammal species should have good water treatment systems.

What needs to be in a water treatment system and what are the standards for controlling water quality? First of all, water should be cleaned mechanically. This process entails a system whereby water is pumped out of the pool, via a prefilter (for large particles), towards a filter. The filter is usually filled with a sand-gravel mixture (a "filter medium" or "filter bed"). Prefilters are for easy removal of hair, leaves, and fish parts. The water flows through the filter medium, leaves behind most of the unwanted material, and then flows back into the pool. In general, this is not enough to keep pool water completely clean. Very small particles will flow through the filters. Maintenance of clean water requires the use of ferric sulfate or aluminum sulfate mechanically injected in small doses into the water stream towards the filter, which binds the particles that normally would go through the filter bed, causing them to clump together and be trapped by the filter media, and in this way removing them from the water. This process is called flocculation.

To prevent the filter from becoming overloaded with detritus from the pool, the filter is cleaned by reversing the flow ("backwashing") in the filter. This

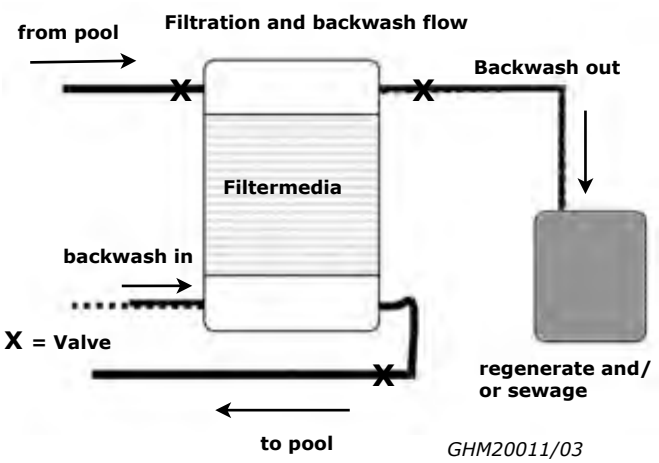

Figure 31.2. Filter backwash to flush the accumulated dirt and debris from the sand filters. By closing and opening the valves at the filter, the normal flow is stopped and a reverse flow is started. This flow loosens the sand bed and takes the dirt from the sand bed to a recycling system or to the sewage. In some systems an airflow is used to loosen the sand bed. Courtesy of G. H. Meijer.

process does not flush the accumulated dirt back into the pool; instead it flushes the dirt out of the system to a sewer, or into a recycling system. When this process is completed, the system is set to the normal direction of flow and it starts filtering again.

In conjunction with the mechanical filtration, which has filtered most of the solids out of the system, an ozone installation can be used to not only remove residues in the water flow but also kill bacteria. As the ozone gas is dangerous to both man and animal, these systems should be operated by experts only, and all precautions to prevent exposure must be adhered to. A fail-safe safety system should be installed, which would include an alarm and an automatic shutoff system in the event of a leak or malfunction. Ultraviolet light is also used for killing or inactivating bacteria and protists in filtration systems.

In general, two systems are used to filter pool water, more or less on the basis of the outline just described. One is a mechanical/chemical system in which chlorine in some form is used to disinfect. This is the system commonly used in public swimming pools. The other system is a mechanical/biological system in which bacteria is used to take care of the residues that are left in the water after the mechanical filtration process is complete. Experts disagree about which of these systems is best to use with marine mammals. In spite of all precautions, safeguards and low-level usage in chlorinated systems, chlorine and its derivatives should not be in the environment for the animals in our care, if it can be avoided and other options are available. Chlorine disinfection of the system, however, is found to be important for maintaining an acceptable bacterial level in the system. Bromine is used as well, but is considered not as effective as chlorine. In a biological system the chlorine disinfection is missing; ozone and/or ultraviolet disinfection can fill the niche,

but it is often used with protein skimming (foam fractionation) in salt water. A keeper and all others responsible for maintaining the animals' environment should, however, keep looking for the best methods of securing a healthy and safe environment for the animals.

Pool Cleaning
To keep pools clean and in most cases free from algae, a water vacuum cleaning system should be in place, and can be connected to the filtration system. Independent vacuum systems are also available. One should be aware of the potential dangers when using electrical equipment in the vicinity of water. Water and electricity are not a good combination and can lead to electric shock. Also, animals and electrical cables can lead to potentially dangerous situations in which animals may bite or become entangled in the wires. Animals should not be in a pool that is being cleaned with electrical devices. With algae growth in a pool, it is often necessary to scrub the pool with a brush. Brushes on long poles, such as those made for cleaning swimming pools, are often used. Brushing by hand while using diving equipment is also a common method of cleaning, especially in larger tanks.

Land Area Cleaning
Old-fashioned scrubbing with soap and water on land areas for seals and sea lions is still a good practice. This process would be appropriate for demonstration stages and land-slide areas in dolphin pools. Food preparation areas, especially fish preparation areas, should be kept clean and disinfected at all times. The chance offish being contaminated with all kinds of bacteria is always there, especially in summer. High-pressure cleaning devices should be used with care, especially indoors. Quite often they spread dirt particles and dangerous bacteria instead of removing them.

Diving
In jobs that require working with marine mammals, being an experienced swimmer and diver is often a necessity. Diving is a valuable skill when working in animal shows, as well as when handling animals in water. There can be rules and regulations for diving that do not allow one to work under water without proper training (e.g., in the Netherlands any work underwater with the use of diving equipment may only be done by qualified professional divers). Governments may also have extensive regulations embedded in the health and safety legislation that is in place for work areas. The keeper diver must be aware of these rules and also of the potential dangers of working in water and underwater with live animals. Keepers should only work within the established safety protocol and take all necessary precautions, which probably involves adhering to a two-person policy when working in the water.

Handling
Sometimes it is necessary to move an animal from one area of the facility to another, to another zoo or aquarium, or perhaps to the veterinary clinic. Sometimes it is necessary to restrain an animal. For example, seals, sea lions, and walruses can be restrained using a suitably sized net or a "squeeze" or "crush" cage, depending on the size of the animal. To drive or push the animal, one can use plywood boards that may be fitted with handles to allow for more control. It is important to realize that many of the animals being manipulated weigh much more than the keepers. A male walrus, for example, weighing more than 1200 kg (2640 lbs.), is not an animal that can be pushed into a corner with a plywood board. It is always preferable to train animals to tolerate being handled or moved, instead of forcing them. However well trained or "friendly" an animal is perceived to be, and however well-behaved it is, if in distress it can become totally unapproachable and possibly very dangerous.

With sea lions or seals, an inside area or separation area is necessary. When the animal is confined to that area, the keeper may, with the help of a net, be able to catch the animal or use sheets of plywood to corner it or drive it into a squeeze cage. A squeeze cage can be incorporated as part of the exhibit so that animals become used to it and can be trained to move through it as they enter and leave the holding. Some restraint cages may incorporate weigh scales.

When using a net to catch an animal in water, the risk of drowning it is always there. One should keep in mind that seals and sea lions are well equipped for defending themselves. It would be extremely dangerous to be cornered or in a pool with an angry 300 kg (660 lb.)-plus sea lion male. Even a 50 kg (110 lb) youngster can become more than a handful, especially on a wet and slippery surface.

A lift platform or a lifting floor in one of the pools is a very good tool when a keeper needs to handle a dolphin. Here, training is also most important. Training and voluntary cooperation in difficult situations is by far the best way to manage these totally aquatic animals. Using nets to catch a dolphin is possible, but there is always a possibility of entanglement and of drowning the animal. Draining a pool when possible will allow for an easier approach.

Manatee handling requires many of the same precautions as outlined previously. Catching the animal with a net and lifting it out of the pool may be possible, and a lifting platform may also be considered. The use of a stretcher when the animal needs to be lifted out or away from the pool is recommended.

Before handling and moving an animal, one should first make a plan:
• Develop and follow a protocol.
• Have all the required equipment ready and complete.
• Ensure that enough experienced staff is available.
• Do not be afraid to stop a procedure if there are too many unexpected complications.
(Osinga and de Wit 2002; Joustra 2003; Heukels and von Leeuwen 2008; Elk 2009; Holland 1999; Dierauf 2001; Geraci and Lounsbury 1993.)

Behavior Training
Training of animals is a tool that has been refined and expanded upon to become an essential component of marine mammal husbandry and care. Some keepers responsible for maintaining manatees say that they need to be particularly inventive, since manatees are very independent and are not as interested in interacting with the keeper as most marine mammal species will be.

Basic target training is an essential starting point. If an animal can be further trained to come to the side of the pool and is willing to turn around for the keeper or, in the case of seals and sea lions, to come out of the pool, and if it allows close examination and touching of body parts, then the keeper can make a good assessment of the individual animal's health and condition. This training is not a substitute for honing of the keeper's observational skills, as the animal's behavior in the pool is the first thing to be assessed and is very important. All wild animals will hide their health problems as a part of their natural survival technique. By observing from a distance, the keeper can see changes that cannot be seen when an animal is aware that it is being observed.

Training has been an essential part of marine animals' care for as long as they have been kept in captivity. The sight of a sea lion balancing a ball on its nose is etched in almost every aquarium visitor's memory. Much background information about training will be found in chapters 42 and 43.

Some of the more important behaviors to be taught to marine mammals include training for simple medical procedures, like removal of foreign bodies such as small balls or plastic cups from a cetacean s blowhole or mouth, or fecal and urine sampling, especially in dolphins whose feces quickly dissipate before they can be collected from the pool. Veterinarians usually collect blood, so it is important to include them regularly in an animal's training program. No matter how well-trained or behaved an animal is when a "stranger" is nearby or making contact, it can become anxious. A veterinarian whom the animal associates with discomfort or pain can further aggravate the situation. Time spent in training will be more than paid back in the future. Training is based on trust between the animal and the keeper; it also requires a thorough knowledge of the animal's behavior. A bull in breeding condition can behave in a manner completely different from normal. This reinforces the need for objective daily observations. If the keeper is unsure of an animal or does not trust it, he or she must follow those feelings and stop working with that animal. A keeper who feels uncomfortable may also act in a manner different from normal. The animal may sense this and it may add more tension to the situation. An accident or loss of trust will be the detrimental result.

Other procedures requiring more advanced training, such as hydration techniques, sperm collection, and artificial insemination, maybe possible as the animals' level of conditioning progresses. An enthusiastic and resourceful keeper can achieve a great deal and improve the welfare and care of the animals in his or her charge.

Enrichment
Daily training for shows and presentations, as well as husbandry training, is a great form of enrichment. A keeper should also be looking for ways to make the animals' environment more interesting. Water jets introduced randomly both above and below the water can be enriching, especially if the animals cannot predict their presence. The incorporation of waves into the pool is another valuable enrichment, and can be left running day and night. Addition of a high-speed stream of water into the pool with the help of a well-screened propeller will be very enriching and fun for the animals, and will also build up their swimming muscles and stamina. Introducing fish into the pool without keepers in sight can also be enriching.

A keeper should change her work program every day, as a repetitive routine can become boring both for the keeper and for the animals. Some simple changes may include starting work at a different time or changing the times for cleaning. A keeper who does presentations for the public should vary their starting times as much as possible. Predictable shows or presentations are boring for all involved. One should watch the animals, who sometimes invent their own games. The author has seen sea lions bouncing and catching stones against an exhibit wall, even bouncing them from one wall to another and then catching them again. One should try to think "outside the box." It can be challenging to find new enrichment that will keep the attention of marine mammals in the long run (Pryor 1999; Ramirez 1999).

Reproduction
The gestation period (pregnancy) of most pinnipeds is approximately 11 to 12 months, with the Australian sea lion (*Neophoca cinerea*) having a breeding cycle of 17 to 18 months (it is not clear how long the delayed implantation stage is as opposed to the growing stage). Within days to weeks after birth, mating again takes place, on the same beaches where the previous young have been born. After mating, the fertilized ovum develops into a blastocyst (a hollow ball of cells) and instead of continuously developing, as in most mammals, the pinniped blastocyst does not establish contact with the wall of the uterus. There is then a period of inactivity for approximately three months before the blastocyst imbeds itself in the uterus and continues developing into the embryo. The pinnipeds normally give birth to one pup at a time; twins are occasionally seen, and under some circumstances they survive. In most pinnipeds, one male mates with more than one female (i.e., it is polygynous), with bull sea lions often having harems and defending significant territories. In contrast, a gray seal male may have just one female (i.e., it may be monogamous).

There are great differences in the lactation periods of seals and sea lions. In seals the lactating (suckling) period may be quite short, and it can vary from between three and five days in the hooded seal

(*Cystophora cristata*) up to two years in the walrus (*Odobenus rosmarus*). The harbor seal (*Phoca vitulina*) suckles for about four to six weeks. Gray seals (*Halichoerus grypus*) are weaned at around 16 to 21 days. Sea lions and fur seals have more uniform lactation periods than the other seal species, suckling their young for between 6 and 12 months. During the first period of parental care, the mother stays with the pup and suckling occurs several times a day; later she will leave to feed and suckling becomes less frequent. This period lasts through the summer, and in some cases until the next pup is born. For a keeper, weaning a pup is in most cases not that difficult. Most youngsters will play with fish when they are available, and start eating them as a continuation of play. Some facilities offer additional live fish to make the pups develop greater interest in the fish and start eating them. Some pups do not so easily understand the concept of eating fish. Sometimes the previous year's offspring disturb the relationship between the new offspring and the mother. When the offspring is separated from the mother, it may still sometimes refuse to eat and will need to be forced to eat fish.

Gestation in the bottlenose dolphin lasts approximately 12 months; usually just one offspring is born. Lactation lasts between 18 and 20 months. The reproductive interval is between three and six years, with females becoming pregnant soon after their calves are weaned. Females care for their young, but other females in the group will normally assist with teaching, playing, and defending them. The orca has a gestation period of between 16 and 18 months and its lactation lasts approximately 12 months, with a reproductive interval of between 6 and 10 years. The female raises her young alone within the pod (group) that she lives in. These pods consist of related females and males.

The beluga whale has a gestation period of 14 to 15 months and the lactation period lasts from 1.5 to 2 years. Females reproduce every 2 to 3 years. Little is known about the reproduction of Commerson's dolphin, but the gestation period is thought to be a maximum of 12 months. The total nursing period is not known, but it may last for at least 4 months. The reproductive interval is not known. There is also much to learn about the harbor porpoise, but its gestation period is thought to be around 11 months, and its lactation period between 7 and 8 months. Their reproductive interval is not known. It is possible that the recent births of harbor porpoises in Europe will offer more knowledge about this species' reproductive cycle (Klinowska 1991; King 1983; Animal Diversity Web 2010; Dierauf 2001).

Transportation

For transportation of marine mammals it is very important to have a good plan, including procedures for unforeseen contingencies. Keepers with experience in transporting marine mammals should attend all transportation situations. Good preparation contributes significantly to the success of any animal transport.

Pinnipeds

All pinnipeds can be transported in the same way. Crates should be well ventilated. This can be achieved by using welded wire mesh. For young animals, "sky kennels," commonly used for dogs and cats, are a good means of transportation. Transport crates should be of dimensions that allow the animal the ability to move around (IATA-LAR container requirement 76 should be referred to).

It is strongly advised to start crate training an animal as early as possible, since an animal that is used to the crate is much less stressed during travel. The animal should not be fed for 24 hours preceding the transport. This will decrease discomfort from pressure on its stomach and intestines. During road transportation, staff must be aware that inside a vehicle that is standing still (e.g., in a traffic jam or travel break) and is exposed to direct sunlight, the temperature can easily rise above 500 C (122 °F); so the vehicle should be well ventilated or air conditioned. Also, drafts on wet skin can overchill the animal to cause stress and predispose it to pneumonia. Pinnipeds cope much better with low temperatures than with high ones. Maximum transport temperatures should be maintained between 20 and 25 °C (between 68 and jj °F) and, if possible, travel should take place at night as temperatures are cooler. Water and ice should be available as part of the equipment, although water to cool the animals may not be needed when temperatures are at normal levels. Even if a transport operation is well prepared, overheating (hyperthermia) may still be caused by stress, so the accompanying keeper must be watchful and aware of the signs. These may include lethargy, an increased respiratory rate, open-mouthed breathing, or hind flippers that are warm to the touch. The keeper should avoid unnecessary handling and attempt to lower the ambient temperature, increase ventilation, and cool the hind flippers. One should be well prepared and plan ahead to ensure a successful outcome.

Dolphins

Both dolphins and manatees have the same crate requirements, which are outlined in the IATA guidelines (IATA-LAR container requirement 55). A watertight crate is required, with enough space in which to hang the dolphin or manatee in a stretcher. There must be sufficient space on all sides to prevent the animal from hitting the sides, front, or back of the crate. The crate should be partly filled with salt water; this will not only lower the body weight pressure on the dolphin or manatee while it is in the stretcher, but will also help to prevent hyperor hypothermia. The crate should not be overfilled with water, as it may splash out of the crate with any sudden movements of the transportation vehicle. This is especially pertinent in aircraft, as salt water can be very damaging. For a dolphin, one should keep the water cool by adding ice cubes or cooled replacement water. A manatee should be moved on a closed celled foam mattress and water. In Europe, manatees have been moved in water alone, with good success (B. Klausen, pers. comm.). Manatees

are more tolerant of warmer temperatures than of cooler, but it is important that the water level and water temperature be monitored and stay within normal ranges within the vehicle, which should be air-conditioned with good ventilation and no drafts.

A mechanical hand sprayer should be available during all transport. Water must not be sprayed over the head nor near the blowhole or nostrils. A sufficient number of experienced attendants should accompany the transport, including an experienced veterinarian and preferably at least one attendant per animal.

Veterinary Care
Every zoos and aquarium should have at least a part-time veterinarian, or one hired by contract for consultations. In the daily routine, keepers should check their animals' overall appearance, their food intake, and, if possible, their feces. Any changes noted in these daily observations may be the first signs of illness and should be noted in a daily report.

Marine mammals can carry intestinal parasites such as tapeworms and roundworms; therefore, a regular program of control has to be in place. Additional laboratory tests of blood and fecal samples or Rontgen photos (radiographs or X-rays) can offer more information in cases of potential health problems.

All marine mammals can also carry a wide variety of diseases from viruses, bacteria, fungi, and other pathogens (causes of illness). If a keeper practices simple, proper hygiene techniques like washing hands after contact with food, animals, feces, or blood and wearing clean clothes and footwear, the risk of spreading or catching a disease is much reduced. Most institutions have hygiene and health protocols, which a keeper should always follow.

Still, there are some infections that a marine mammal keeper should be aware of. For example, *Mycoplasma* in seals can cause "sealer's finger" in humans; this is a very painful bacterial infection that can occur after a seal bite. If properly treated, it will usually heal well. Other diseases seen in marine mammals can also be transferred to humans, including leptospirosis, brucellosis, and tuberculosis. A keeper should inform their physician that they work with zoo animals. In case of a bite wound, a keeper should be aware that the bacteria in the animal's mouth may carry a high risk of infection.

Conservation and Research
Conservation in marine mammals is frequently associated with conservation programs in coastal areas. Most marine mammals are not on the IUCN Red List, but destruction of their habitat could change this very rapidly. For instance, just one accident in the oil industry can change the habitat of a species of marine mammal. Climate change and pollution are also major threats to the marine environment.

As a conservation strategy, protection of these areas makes the most sense, since all species are part of a bigger system and are connected to other species all over the world. Some protected areas include the US national marine sanctuaries; parts of the Wadden Sea along the coast of the Netherlands, Germany, and Denmark and areas of the Mediterranean Sea. The IUCN website can provide more information for keepers who are interested in marine mammal conservation and habitat protection.

A great amount of research is being carried out on marine mammals both in the field (*in situ*) and in zoos and aquariums (*ex situ*). In the field, the research is often focused on population trends, outbreaks of diseases, climate change, and the effects of pollutants. In captivity, research is often on individual animals, and it focuses to physiology (e.g., hearing in seals and sea lions, the use of sonar in dolphins, or the use of vibrissae in walruses), food intake, and behavior (e.g., comparative psychology), to name a few areas. Publications included in the list of further readings in this volume are valuable resources of information.

Summary
Marine mammals are a wide variety of animals that live partly or completely in water (usually seawater). Seals and sea lions give birth to their offspring on land and stay ashore for longer or shorter breeding periods, while dolphins and manatees are adapted to breeding in water. Enclosures should be built to give marine mammals places where they can show their natural behavior, with water and land areas built to their needs.

Good water quality and shelter from the sun and from high or low temperatures should be provided at all times. Great care should be given to providing a good quality of feeder fish or, in the case of manatees, vegetables, including storage and preparation. Good hygiene is also important to prevent transfer of diseases between animals and from animals to keepers.

Observing and understanding marine mammals can be difficult, because most of the time they stay in water. Also, their restraint and transport has its own unique challenges and therefore requires experienced keepers. Training and enrichment are of particular importance in the day-to-day care of marine mammals, and are important to their well-being. A knowledge of filtration technique and water chemistry is very important. Marine mammals are very interesting and uniquely challenging animals for a keeper to care for properly.

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