EAZA and EAAM

BEST PRACTICE GUIDELINES FOR OTARIIDAE AND PHOCIDAE

EAZA Marine Mammal TAG

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Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. As a baseline, EAZA developed the “Minimum standards for the accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the characteristics, size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

The specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such, the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

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Content

Section 1: Biology and field data

Three groups of mammals have entered the sea: Cetaceans, Sirenians and Pinnipeds. Cetaceans are the most successful and highly adapted, represented with numerous species in every ocean. Pinnipeds have not become as completely aquatic as Cetaceans or Sirenians; they must return to land (or ice) to bear and rear their young. Nevertheless, they have gone through extensive adaptations to render them well fitted to aquatic life.

1.1 Biology

Taxonomy

The order Carnivora (carnivores) is divided in 9 families, of which seals, walruses and sea lion species belong to the families Otariidae (eared seals), walruses (Odobenidae) and Phocidae (earless seals). The family of eared seals consist of fur seals and sea lions and the family of the earless seal consist of numerous seal species. Phocidae are divided in 13 genera. Walruses, two subspecies, Otarids, fur seals have 2 genera, whilst sea lions include 5 genera (Wilson & Reeder, 2005). European zoological facilities maintain 12 species of Pinnipeds and an overview of the systematic position of Pinnipeds is represented in Table 1.

***Table 1**: Phocidae and Otariidae that are maintained in European zoological parks*

Species name (Scientific)	Species name (English)
Phocidae	**Earless seals**
Halichoerus grypus	Grey seal/ Gray seal
Phoca vitulina	Harbour seal/ Common seal
Phoca hispida (Pusa hispida)	Ringed seal
Erignathus barbatus	Bearded seal
Mirounga leonina	Southern elephant seal
Otariidae	**Eared seals**
Arctocephalus australis	South American fur seal
Arctocephalus pusillus pusillus	Cape (South African) - Australian fur seal
Callorhinus ursinus	Northern fur seal
Eumetopias jubatus	Steller's/Northern sea lion
Otaria byronia/flavescens	Southern/South American sea lion
Zalophus californianus	California sea lion

Morphology

True seals

True seals (Phocidae) are distinguished from eared seals (Otariidae) by the absence of external visible ear *pinnae*, internal testes and the inability to draw their hind limbs forward under their body when on land, which results in their typical “humping” method of locomotion on land. This latter character, the absence of tusks, and a notched tongue also distinguish them from the family Odobenidae (walruses). Most phocid pups are born with a *lanugo* coat. This coat has a “greenhouse effect” reflecting the sun onto the skin to prevent heat loss. The fore- and hind flippers of phocids are characterized by the presence of well-developed claws, which they can use

to groom their hairs and for climbing. Phocids use the fore flippers to steer when swimming, while the hind flippers are used for propulsion by moving them sideways. Earless seals have a small but obvious tail (about 8 cm long), and although not used in swimming, it is tucked between the hind flippers and helps towards a smooth outline.

The epidermis is 100-200 μm thick with a blubber layer underneath, which is less dense than in cetaceans. The epidermis is keratinised, and the dermis has sebaceous glands - which secrete oil to waterproof the skin and hair and tubular sweat glands. All phocids have hair on both flipper surfaces.

Seals moult annually after the breeding season. The moulting period is species dependent and it is the second-largest period of time that an adult seal spends on land. Animals of different genders and age groups moult at different times during the year.

Northern hemisphere phocids

Most northern phocids are 130-180 cm in length and their pups measure 60-90 cm. The grey, hooded and bearded seal species are somewhat larger, measuring 220-270 cm. Their pups are 100-130 cm long, except for grey seal pups, which are somewhat smaller, measuring 95 cm. Northern phocids have well developed claws on both fore and hind flippers. Phocids in the northern hemisphere have also colonised freshwater areas; for example, the harbour seal in freshwater lakes of northern Quebec, the ringed seal in lakes in Lagoda and Saimaa (Russia and Finland respectively) and the Baikal seal in Lake Baikal in Siberia. The northern phocids have karyotype 2n = 34 chromosomes in bearded and hooded seals, and 2n = 32 chromosomes in the remaining eight species (grey, harbour, spotted, ringed, Caspian, Baikal, harp and ribbon seals).

Southern hemisphere phocids

Southern phocids are longer than northern phocids, measuring 220-300 cm. Pups are between 80 and 160 cm long (dependent on the species). Southern phocids have reduced claws on the hind flippers. Phocids of the Southern Hemisphere can be found from the Antarctic to as far as the sub-tropical waters of the Mediterranean Sea. All southern phocids have karyotype 2n = 34 chromosomes.

Eared seals

The eared seals (Otariidae) include fur seals and sea lions which have small, but noticeable, external ear flaps. Eared seals have a different kind of fur than earless seals. The guard hairs of the fur seal are surrounded more under the fur than the guard hairs of the sea lion. The eared seals' tail is short and flattened. All flipper surfaces are essentially naked. Claws at the ends of the digits are well developed in some species and poor in others. They have nails on the middle three digits. The long front flippers are used for propulsion through the water, while the long hind flippers are used more for steering. They also can move the hind flippers forward and under the body, enabling Otariids to 'walk' on land as a quadruped.

The epidermis thickness in sea lions is comparable to that of phocids, while thinner (c. 50 μm) in fur seals. The epidermis is keratinized and the dermis has sebaceous and tubular sweat glands. The sebaceous glands secrete oil to waterproof the skin and hair. Otariids have a pelage with glabrous skin in the flipper areas.

Sea lions moult once a year, usually after the breeding season, but not as obviously as earless seals. During moult an animal loses its fur and a new one replaces the entire coat. Sea lion pups moult twice during their first six months of life. All Otariids have scrotal testes and two pairs of abdominal nipples. They have a karyotype of 2n=36 chromosomes.

The most obvious differences between the two subfamilies of eared seals are the blunter nose and sparse under fur of the sea lion, whereas the fur seal has a sharper nose and abundant under fur. Sea lions are larger than fur seals (except the very large South African fur seal). They usually have only five upper cheek teeth (fur seals have six) and the third upper incisor is large, with a circular cross-section. The tip of the sea lion's *baculum* (the penis bone that is found in all carnivores) is broad, whereas it is narrow in fur seals. Compared to sea lions, fur seals have a larger difference in size between males and females and they have larger colonies.

Sea lions

The five sea lion species are rather more diverse than the closely similar fur seals. Each is placed in its own genus and all have different characteristics and separate distributions, though the Steller's sea lion and the Californian sea lion do overlap to some extent.

Fur seals

Fur seals comprise two genera, *Arctocephalus* and *Callorhinus*. Besides the geographical distribution, the differences between these two genera are small. The most obvious one is that in the northern fur seal (*Callorhinus ursinus*) the fur on the fore flipper extends only to the wrist, where it terminates in a sharp, straight line. In the other species, the fur extends past the wrist on the dorsal surface of the flipper.

Description

Anatomy

The morphology of pinnipeds is very distinct from other mammals.

Respiratory System

In phocids the trachea is divided into two primary bronchi immediately outside the lungs. The pleural cavities and lungs are generally found dorsal and lateral to the heart. Lobation in pinnipeds is generally similar to that in dogs; two lobes on the left side (the cranial lobe being divided in an anterior and posterior part) and three on the right side (with the small intermediate one). Reduction of lobation occurs in some phocids. Pinnipeds have, like cetaceans, sirenians and sea otters, terminal airways reinforced with either cartilage or muscle, which cannot be found in any other mammal species. Bronchial glands are especially numerous in larger calibre bronchi and bronchioles in phocids. The inter-alveolar septa have a single row of capillaries. They have numerous and large mucous glands.

In Otariids the larynx is similar to carnivores. The bifurcation of the trachea in Otariids is more anteriorly, at the level of the first rib, and the two bronchi run parallel until they enter their respective lung dorsal to the heart. The trachea is incomplete dorsally in the *Zalophus*. Otariids have cartilage extending to the terminal airways. They have numerous and large mucous glands. Lungs are multilobe.

Cardiovascular System

Pinnipeds hearts tend to be broader and flatter than those of terrestrial animals. The anterior aorta increases greatly in width, between its beginning and the level of the brachiocephalic artery, to form the aortic bulb. There is some correlation between the size of the bulb and the diving habit of the seal. However, most of the modifications of the pinnipeds vascular system are to be found in the venous system in relation to the animal's diving habits. The body is well supplied with numerous anastomosing networks of veins that form plexuses in many parts of the body. The cardiovascular system has a post-caval sphincter cranial to the diaphragm. It is better developed in phocids than in Otariids and it is an adaptation to diving. The numerous hepatic veins have dilated to form a large saccular hepatic sinus, located posterior to the diaphragm and anterior to the liver. The capacity of this sinus can vary with age and can hold several litres of blood in adult elephant seals. It receives blood from the posterior vena cava and conveys it to the heart. Most of the blood returning from the intracranial sinuses leaves through an intravertebral vein. These vessels then join to form the large, flat, thin-walled extradural intravertebral vein, which is located dorsally to the spinal cord, between the spinal *dura mater* and the roof of the vertebral canal. It is one of the venipuncture sites in phocids. In Otariids, the paired extradural veins lie ventro-laterally to the spinal cord.

Digestive System

The teeth consist of incisors, canines and post canines. Deciduous teeth occur, phocids sometimes shedding these teeth shortly after birth and in some Otariid species the teeth can still be found at an age of 3-4 months. The tongue is notched and the monogastric stomach is similar to other carnivores. The liver and stomach occupy the wide anterior end of the cavity, while the extensively coiled intestine fills most of the posterior end. The junction of the small and large intestines may be marked by the presence of a cecum. The small intestine is very long, measuring 20 to 25 times the body length. The cecum is vestigial but present in pinnipeds. A gall bladder is present too.

Urogenital System

In phocids males have inguinal testes that are not visible externally. Each testis is embedded in a heat exchanger (to keep the temperature low). The penile orifice is posterior to the umbilicus. The penis is composed primarily of *corpus cavernosum penis*, with a weakly developed *cavernosum* urethra surrounding the urethra. They have a large *os penis* (*baculum*). In Otariids, males have scrotal testes. Penile orifice is posterior to the umbilicus. The distal end of the penis is *corpus cavernosum,* which ossified to form the large *os penis* (*baculum*). Females of both families have a bicornuated uterus with a common external opening for the anus and vagina, cranial-ventral to the base of the tail. They have 2 to 4 abdominal nipples (species dependent). The mammary glands are internal.

Kidney and spleen

The kidney is of a lobulated and reniculated type. The kidney is efficient in concentrating urine: it absorbs water and excretes excess salt in the urine. The spleen has a similar shape as in carnivores.

Central Nervous System (CNS)

The superficial cortical anatomy varies but the deeper anatomy shows little variance from other terrestrial mammals. Otariids have a spinal cord that is particularly short.

Senses:

Hearing

Phocids have no external ear pinna while Otariids have a small scroll-like external structure. Extrinsic and intrinsic muscles close the external meatus and constricting the lumen of the tube, preventing the entry of water. Sound reception occurs by massive ear bones. The meatus is open to air and closed to water. They have cavernous tissue in the middle ear and external auditory meatus that helps equalize pressure between these inside air spaces and the outside environment while diving. The skull is acoustically isolated from the ear. Phocids seem to hear higher frequencies underwater (up to 60kHz, or even up to 180 kHz for the harbour seal) than Otariids (up to probably 70-80 kHz, but best at less than 60 kHz). The opposite is true for airborne sounds (between 12 and 20 kHz), but all pinnipeds are more sensitive to underwater sounds than they are to airborne sounds. On land the hearing range is up to 20 kHz for phocids and 12 kHz for Otariids. Phocids hear by making scanning movements with the head, this way they can locate the origin of a sound very precisely. There is no concrete evidence to suggest that pinnipeds use echolocation.

Sight

Water absorbs more light than air does. So, the pinniped eye is adapted to low-light vision. Pinnipeds have large globes, commonly about 40 mm in diameter. A large eye, like larger aperture on a camera lens, can gather more light. To give light entering the globe a better chance of stimulating the sensory cells of the retina, pinniped eyes are backed by a prominent reflective layer, the *tapetum lucidum*. It reflects any light passing through the retina back to the sensory cells. The pinniped eye is also characterised by a rounded lens, and a pinpoint stenopeic (or reversed tear shape) pupil.

Because pinnipeds spend their life partially in water and partially on land, they use both under water and aerial vision. On land, vision is likely emmetropic especially under bright conditions. In water, vision is also good even in low-light conditions. Vision is used for prey detection, avoiding predators, and for spatial orientation during migrations. Because of a great diversity of pinniped species in terms of systematic position and ecology, the role of vision diverges widely as well. However, in aquatic conditions, most pinnipeds use both visual and tactile modalities to search for food. Most pinnipeds have maximum spectral sensitivity within a range of 496-500 nm. In contrast to humans, pinnipeds' vision is most likely restricted to black and white. Though, the pinniped retina is predominantly composed of rods. It has been discussed that some species could discriminate colours in the blue-green spectrum (they might see them but cannot discriminate between colours).

Pinniped eyes have a nictitating membrane, which can wipe sand and debris away. They have a very active lacrimal gland producing constant tearing that protects the cornea. Unlike most terrestrial mammals, pinnipeds lack a duct for draining eye fluids into the nasal passages. When a seal is out of the water, fluid surrounding the eyes gives them a wet, "tear-rimmed" look.

Smell

Smell is highly developed in pinniped females for pup recognition and in males for breeding purposes (to locate females in oestrus). Pinnipeds cannot smell under water.

Taste

The tongue of pinnipeds is usually rather short, wide at the back and tapering to a notched tip. The habit of swallowing food entirely would not suggest any great development of taste buds, so pinnipeds may have a limited sense of taste, although it is quite common to encounter individuals with different food type preferences.

Touch

Pinnipeds are tactile mammals with a variable sensitiveness to touch. Elephant seals, walruses and sea lions are strongly thigmotactic, and this probably has at least a certain amount of thermoregulatory function; while some seals, like the Hawaiian Monk seal, are never lying in contact with another. They all possess relatively abundant whiskers, or vibrissae, containing nerve fibres, which make them sensitive organs. They may use their whiskers to aid in navigation or to detect vibrations from prey in the water. They possess three kinds of whiskers: rhinal, superciliary and mystacial. The most prominent and numerous one are the mystacial whiskers. Superciliary whiskers, located above the eyes, are usually better developed in phocids than in Otariids. Rhinal whiskers, one or two on each side, just posterior to each nostril are found only in phocids.

Physiology

Respiration

The nostrils are closed in relaxed position (when underwater) and the contraction of muscles will open them. The breathing rhythm when on land is fairly different between the different species, and of course, breathing stops when diving, which can last up to one hour for some seal species.

Mechanics: the apneustic plateau evolved because of the aquatic environment. RR 5-26/minute. The respiration cycle occurs in 0.5-0.8 seconds, the flow rates during those cycles are of 30-70 l/second. Tidal lung volume is 46-75% of VC (vital capacity), probably due to the elastic nature of the lungs. The alveolar collapse occurs at a depth of 50-100meters. When a pinniped goes beyond this depth the terminal bronchiole sphincters will close. This leads to pressure gradients that prevent nitrogen from entering the blood stream.

Diving animals have a tremendous respiratory reserve and efficiency. In diving animals, 46% of the tidal volume enters alveolar exchange, compared with the 15% in humans and horses (Williams *et al*. 1991, Reed *et al*. 1994, Ponganis 2011).

Thermoregulation

The average internal body temperature of a pinniped is about 36.5 to 37.5 °C. In colder weather, the insulating power of the blubber is important in seals and sea lions, whereas in fur seal, the thick layer of the underfur, and the trapping of air within, effectively insulates the fur seal from its environment. The arterio-venous anastomoses in the hind flippers (in which peripheral arteries are surrounded by numerous veins) play also a very important role in thermoregulation. These are more superficial in fur seals and seals, and deeper in the dermis in sea lions. In cold circumstances, the blood vessel in the skin and blubber contract, and just enough blood is allowed to maintain sufficient skin temperature. Sea lions also gather in groups and this close bodily contact would prevent heat loss. However, in warmer circumstances, when it is necessary to lose heat, the blood supply to these anastomoses is increased and the flippers are extended and spread in the air. In general, pinnipeds are more tolerant to cold than heat.

Thermoregulation on seals (Courtesy of Tania Monreal Pawlowski)

Reduction of limb size/spindle shape of body reduces total surface-to-area-to-mass-ratio, restricts the area to which blood can come in contact with, thus reducing heat loss. Seals have to maintain a body temperature of 38 °C in water with a temperature of 0 to 5 °C. Peripheral arteries are surrounded by numerous veins; heat is lost to surface or to returning veins. The metabolic rate is relatively higher in smaller pelagic animals. To protect themselves from the cold, pinnipeds develop large layers of blubber under their skin. This blubber also helps in the streamlining of their shape, allowing these torpedo-shaped animals to chase their prey under water with amazing effectiveness.

Cardiovascular adjustments

Bradycardia

Bradycardia is a physiological adaptation common in diving aquatic animals. Pinnipeds have the ability to reduce their heart rate from 80-120 beats per minute to 6-20 beats in order to make deep and sustained dives.

The animals have an oxygen conserving mechanism and body heat is conserved by peripheral vasoconstriction.

Redistribution of blood flow

The bulbous dilation of the ascending aorta acts as a passive heart to help insure circulation during the prolonged diastolic period. The animal is able to shunt blood to the heart/brain/liver from peripheral vessels during submersion. The kidneys and adrenals are isolated from circulation during diving. The hepatic sinus and posterior vena cava become dilated during diving. The caval sphincter then regulates the flow of blood back into the heart. The blood is very acid during/just after diving. The muscle haemoglobin is responsible for 50% of total oxygen carrying capacity in some animals. Pinnipeds also have a larger relative volume of blood than other mammal species, allowing them to store large amounts of oxygen in their blood on very deep and prolonged dives. Phocids are deeper divers than Otariids; dives of up to 1600 metres and 2 hours have been recorded.

Osmoregulation

Seawater consumption normally does not occur in Pinnipeds (apart from adult male Otariids during fasting in the breeding season, when they lack the amount of water needed for sweating and urinating for thermoregulation). Most can derive all necessary water for urine, faecal and insensible pulmonary loss from the food they eat and, while swallowing, they virtually take no seawater in. Pinnipeds minimise water loss by producing small amounts of concentrated urine. They have small urinary bladders, so they have short urine storage.

Diuresis

Postprandial diuresis in most animals is related to high protein diet. Antidiuretic Hormone (ADH) is essentially absent. Diving results in inhibition of ADH with diuresis.

Vocalizations

To communicate with each other, Pinnipeds use a variety of vocalizations including barks, clicks, moans, chirps, growls and squeak, with a wide variation between species. The sounds produced under water are not always the same as those made in air. Earless seals tend to make more sounds underwater and are rather quiet while on land. Vocalization may play a role in navigation, social behaviour and foraging. Males vocalize to show dominance and to defend their territory, while females may use the communication to locate their young on returning from feeding in the sea, recognizing the individual cries of her pup. All pups vocalize to call their mothers soon after birth and during lactation period.

Locomotion

Swimming

Pinnipeds exhibit sustained swimming speeds for horizontal swimming and diving of 2.2 to 9.4 km/h. Dive velocities for small pinnipeds are associated with the minimum cost of transport to prolong dive duration and distance covered. Phocids may travel at speeds of 22-37 km/h, but they generally cruise at 9 km/h or less. They swim by moving their rear flippers and lower body in a lateral, or side-to-side, sculling motion. The hind flippers may either be held together and spread or used alternately in a series of strokes.

Otariids use their fore flippers as means of propulsion in the water and can maintain a speed of 18.5 km/h for 3 to 5 minutes, although bursts of 24.1 to 28.8 km/h have been reported. Surfing in front of waves or large whales seems to be a fun activity for sea lions.

Walking and climbing

Phocid seals cannot turn their hind flippers under their bodies and are somewhat less agile on shore than Otariids. On land phocids lunge, bounce and wriggle along, using the fore flippers for balance. Some species, such as grey seals, also use the fore flippers to help pull them forward. Terrestrial locomotion on ice is in fact easier for many of the pagophilic, "ice-loving," phocids, which sled across the ice at high speeds. The Antarctic Crabeater seal is the fastest sprinter on ice, reaching reported speeds of up to 25 km/h when chased.

Walking speeds are low (2.6 km/h) for fur seals and sea lions, which must coordinate movements of the enlarged flippers. A gallop or a bounding gait can be used for faster terrestrial speeds of 7.9 to 13.0 km/h.

Otariids are capable to climb fences and vertical walls.

Diving

Pinnipeds can dive for up to 30 minutes, to depths of 152 to 243 m. Female northern elephant seals can dive to a depth of 396 m, with one recorded as deep as 1600 m and remaining submerged for 2 hours. The Weddell seal has been recorded diving for as long as 1 hour and 13 minutes and as deep as 579 m. Sea lions species can dive to depths between 135 to 272 m, of which Californian sea lions can dive up to 250 m. Dives of the Northern fur seal have been recorded at 108 to 144 meters.

Dolphins have their lungs full of air during diving, while pinnipeds have them partially filled, related to neutral buoyancy. The reason they can dive this deep and stay underwater this long is because they have a high tolerance for carbon dioxide. The oxygen in their body concentrates in their heart and central nervous system rather than in non-vital organs. During diving, pulse rate and metabolic activity are reduced (from 150 to 10 pulses/min) and blood supply to the organs (except to the brain) is reduced.

Sleep

Pinnipeds are able to show one eye open sleep named “asynchronous eye closure” (ASEC). ASEC is associated with unihemispheric sleep wherein the cerebral hemisphere contra lateral to (i.e. neurologically connected to) the closed eye sleeps while the other cerebral hemisphere remains awake with its associated eye open and functional. Among mammals, uni-hemispheric sleep is restricted to aquatic species (cetaceans, eared seals and manatees). In contrast to mammals, unihemispheric sleep is widespread in birds, and may even occur in reptiles. Unihemispheric sleep allows surfacing to breathe in aquatic mammals and predator detection in birds to mediate the trade-off between the need to remain vigilant and the need to sleep. Despite the apparent utility in being able to sleep unihemispherically, very few mammals sleep in this manner.

1.2 Field Data

Conservation status/Zoogeography/Ecology

Distribution

Phocids inhabit all Oceans apart from the Indian Ocean. Otariids are distributed along the coastlines of the Pacific and southern Oceans (South Atlantic, Indian Ocean and the Arctic basin) but are absent in the Northern Atlantic. Every species has its own specific geographical distribution.

Although most pinnipeds migrate to some extent, the distance is extremely variable depending on the species. Some seal species make seasonal migrations to rookeries (breeding grounds) or warm-water birthing grounds. Reproduction and migration are often timed with seasonal changes in the availability of food for the adults and young. The arctic seals migrate with the movement of food, but also with the seasonal movement of the ice pack. Some northern fur seals may make an annual round trip of over 5000 miles.

Habitat

In general, phocids are adapted to more variable climates than Otariids. Although both, Otariids and phocids, can be found all over the world, only phocids live in climates as severe as the Arctic and Antarctic regions. Otariids can be found in temperate colder waters and are in tropical

latitudes associated with cold water up welling currents. Although there are many more Otariids than phocids species found in the subtropical and tropical waters of the world, the Hawaiian and Caribbean monk seal (now presumed extinct) are perfectly adapted to warmer climates.

Conservation status

The distribution and status of conservation in the wild can be found for each species in the IUCN red list (http://www.iucnredlist.org). All pinniped species are mentioned in the IUCN red list and the Monk seals (*Monachus monachus* and *Monachus schauinslandi*) and Guadalupe Fur Seal (*Arctocephalus townsendi*) are also listed in Appendix I of CITES; the other *Arctocephalus* species and Southern elephant seal (*Mirounga leonina*) are listed in Appendix II

Table 2: *Conservation status of the Phocidae and Otariidae species*

	Phocidae	Otariidae
Extinct	West Indian monk seal	Japanese sea lion
Endangered	Caspian seal Mediterranean monk seal Hawaiian monk seal	Galapagos fur seal New Zealand sea lion Australian sea lion Galapagos sea lion
Vulnerable	Hooded seal	Northern fur seal
Near threatened		Steller's/Northern sea lion
Least Concern	Bearded seal Grey seal Leopard seal Weddell seal Crab-eater seal Northern elephant seal Southern elephant seal Ross seal Harp seal Harbour seal Ringed seal Baikal seal Ribbon seal Larga seal	South American fur seal New Zealand/Southern fur seal Antarctic/Kerguelen fur seal Cape (South African) and Australian) fur seal Sub Antarctic fur seal Southern/South American sea lion California sea lion Juan Fernández fur seal Guadalupe fur seal

Predation

For phocids the main predators are man (e.g. fisheries, hunters), bears, foxes, wolves, birds of prey, killer whales, leopard seals (that feed on Crabeater seals), walruses (that feed on ringed seals) and some species of sea lions (that feed on pups of other seals).

For most species of Otariids, the main predators are the killer whale and various shark species.

Population

Commercial sealing developed into a profitable business in Europe and colonial America by the 1700s. Pinnipeds were hunted and harvested for their blubber and fur. Even though the hunting of seals is now much less intense than in the past, threats from pollution, especially oil spills, and

the accumulation of marine debris, such as lost or discarded fishing line and nets, still cause many deaths among seals.

Behaviour

Activity

Unlike whales and dolphins, pinnipeds live in the water and on land (or ice), generally hauling out on land during mating season, to rest, to give birth, lactate and moult. Phocids spend most of their time in the water (safer than on land, due to their slow locomotion on land), whilst Otariids spend a lot of time in rookeries on land.

Sleeping

In addition to forage underwater, pinnipeds often also sleep in the water. Although harbour seals prefer to sleep on land, they are often forced to sleep in the water during high tides, when hauling grounds are scarce or unavailable. When sleeping underwater most seals wake up frequently and regularly to surface and breathe. Northern elephant seals, however, may possibly sleep hundreds of meters underwater. Harbour seals sleeping on the surface of the water often assume a posture known as bottling; most of the seal's body remains submerged, but the animal's face pokes above the surface like a snorkel, allowing the animal to breathe regularly while sleeping or resting. Elephant seals sometimes rest in the water in a similar manner. The long proboscis of the adult male is conspicuous on the water's surface, and the seal can actually be heard snoring and gurgling, during each expiration. Seals in zoological gardens and aquaria can also be found sleeping on the bottom of the pool (also belly up), which may cause panic among visitors and inexperienced people, thinking the seal is dead.

In water eared seals engage in unihemispheric sleep, in which one side of the brain sleeps while the other side is awake. This phenomenon is observed most notably in birds, but also in aquatic mammals. Unihemispheric sleep allows them to continue to swim and breathe, keeping track of other group members and eventually watching for predators. On land, otarids will sleep in a variety of positions, often on top of their conspecifics. Research demonstrates that the northern fur seal shows both mono-hemispheric sleep and bi-hemispheric sleep on land. Other Otariids probably show this behaviour too.

Diet and feeding behaviour

Pinnipeds are carnivorous opportunistic feeders, consuming a wide variety of organisms found on or beneath the surface of the water. The various species of pinnipeds are characterised by one or more of the following diet types: marine zooplankton or krill; marine fish and squid; marine molluscs and crustaceans; marine mammals and birds; and freshwater fish. There is often considerable overlap in the food resources used by a particular species.

The diet of pinnipeds varies seasonally and/or geographically in a relatively predictable way. Food resources change predictably throughout the year. The predictability of a pinniped’s environment increases as one moves from the equator (the least predictable environment) to the polar regions where food resources are most abundant and predictable from year to year. The diet of Otariids that live in temperate and tropical climates varies more from year to year. This variability is caused

primarily by El Nino Southern-Oscillation (ENSO) event, which affects the abundance of food resources in an unpredictable way (www.csa.com/discoveryguides/archives/elnino.php).

Daily food consumption by seals ranges from 6-8% of their body weight per day and depends on the caloric content of the prey and season. Captive feeding experiments showed that harbour seals consume daily approximately 4% of their body weight in summer and about 8% in winter. Pinnipeds have a higher metabolic rate than terrestrial mammals of similar size. A harbour seal of 85 kg consumes approximately 3 kg of food per day, while a 1100 kg northern elephant seal consumes 22 kg per day. Wild sea lions often feed cooperatively, eating 5% to 8% of their body weight each day, which is between 7 - 16 kg of food. Their teeth are especially designed for grasping and tearing their food; however, their food is swallowed whole. With their back molars, they crush shells and crustaceans.

Many species of pinnipeds fast during the annual moult and also in captivity they may have the physiological inclination not to eat, despite having access to food at all time.

Water intake

Most of their water intake comes directly from the fish they eat, although they may also occasionally drink small amounts of seawater while fasting throughout the breeding season. Water is also produced as a by-product of the fat metabolism where 0.45 kg (1 lb.) of fat produces 0.64 kg (1.4 lb.) of water.

Reproduction

Generalization is used in this chapter as there is a tremendous variability in reproductive physiology among the three pinnipeds families and there is still a lack of specific information for many species. Much of the information is derived from the most studied species in captivity, the harbour seal and Californian sea lion.

Social and sexual behaviour

Males are not involved in caring for the pups. Therefore, the best strategy for males is to copulate with as many females as possible, whereas the strategy of females is to successfully rear their pups.

Some species maintain harems (e.g. elephant seals). Habitat features and the skills of the defending males limit the number of females that can be defended. Large, open beaches are more difficult for a male to control than more topographically irregular sites, where geographic barriers will aid established males in limiting the approach of intruding males. Reproductive success will also be affected by the fighting and signalling ability of males and how long they can remain beside females without leaving to feed.

In most phocids mating occurs in the water at about the time the pups are weaned, although females mating for the first time or that have not given birth in a specific year may breed outside of the peak period of the post-parturient animals. There is inter-male competition for receptive females and no obvious social organisation during the breeding season.

In Otariids, social order is determined by place of copulation (migratory species), those on land have a harem system. Only the largest and strongest bulls maintain harems of many cows. The

remainders are called bachelor bulls and are driven away to live elsewhere during this period. Until late in July when the harem structure dissolves, the herd bull keeps constant vigil over its females. Occasionally a young, strong bachelor succeeds in besting an older bull thereby acquiring the herd. The herd bull does not leave its harem, even for food, for perhaps three months. Only the largest ocean waves can drive him from the ledge into the sea. Females display no loyalty and when a harem is broken by a storm, the bull may never recover all of his chosen mates. Therefore, much of his work involves keeping his 'wives' from slipping away in search of food or because of high waves and/or a rough ocean. Naturally, the bull looses weight and is exhausted by the end of the breeding season. Males generally spend the remainder of the summer by themselves, resting and regaining weight and strength. The females become very aggressive after pupping.

Sexual maturity

Sexual maturity in pinnipeds tends to occur between 4 to 7 years of age, but recorded isolated cases in captivity have shown male Otariids to sire at 2 years of age and females of the same age to already be pregnant. The age varies thus individually, for each species, with the population size and/or availability of resources.

The age at which eared seals become sexually mature varies for each species. Females are called cows, while males are called bulls. Cows congregate in closely packed, moderate to large groups. Bulls defend territories and fast during the breeding season. One distinct characteristic of a full-grown breeding Otariid male is the presence of a sagittal crest, a raised forehead that appears at about 10 years of age. The dominant male will mate with an average of 16 females in one season. Males compete for dominance, leaving the younger males without a chance to mate for the season. For example, Californian sea lions mate approximately 20 to 30 days after the birth of their pup, leaving only about one month out of the entire year that a cow is not pregnant.

Gestation period/birth rate

The reproductive cycle of pinnipeds is dominated by three basic phases: oestrus, embryonic diapause, and foetal growth and development. Otariids generally have a postpartum oestrus 6 to 12 days after delivery, the Californian sea lion being an exception, with this one occurring 1 month after birth. In phocids, oestrus begins toward the end of lactation, which is much shorter (about 21-42 days) than in Otariids (6-12 months), or after weaning. Oestrus can last from 1 to 9 weeks, with some animals being induced ovulators.

Pinnipeds are classified as having obligate embryonic diapause. Reactivation of the embryo appears to be controlled by photoperiod, with most animals implanting during a decreasing photoperiod. Water temperature and nutritional availability may also be important factors regulating pinniped reproductive cycles. The time when the embryo resumes cellular divisions is a critical point during embryonic development of the foetus and, in non-pregnant females, is a period of reactivation of sexual activity. The embryonic diapause/delayed implantation is 2 to 4 months in seals (species dependent) and up to 3 months in sea lions; with an average total gestation period lasting about 11 months for both and hence an active gestation period (when the embryo is growing) dependent on the period of delay in the attachment of the blastocyst between 7 to 9 months.

The total gestation period, that is the entire period between fertilisation and parturition varies (average of 11,5 months in earless seals), depending on the time-lapse between pupping and mating. In spite of the length of the total gestation period the actual time during which the embryo is growing (the active gestation period) depends on the period of delay in the attachment of the blastocyst. This varies between 3 to 5 months according to the species of seal involved. Each mother usually gives birth to a single pup. Twins have been reported and in some cases mothers may adopt other pups.

Grey seal birth (courtesy of Anna Jakucinska)

Pups and pupping season

Nursing periods last a few weeks in seals, to over a year in some fur seals and Otariids. In most phocids, foraging is suspended during the breeding season, and thus the constraints imposed by the need to nurse youngsters at the breeding colony are not a factor in shaping their foraging patterns. In comparison to Otariids, phocids may have a reproductive pattern that is better suited for dealing with dispersed or unpredictable prey, or prey that is located at great distances from the rookery. The ability of some phocids to forage over long distances is influenced by reducing the importance of feeding during lactation. However, fasting during lactation places a limit on the duration of investment and this limits the total amount of energy that a phocid mother can invest in her pup. Inversely, in Otariids it is not unusual for the mother to begin foraging for food at sea soon after the pup is born and the nursing pups may go without food for several days with no ill effects.

Pinnipeds milk is extremely rich in fat (50%) and consequently the pup growth is very rapid. This means that the phocid mother nurses her pup for a brief, intense period (anywhere from one

month to a mere four days), before abruptly weaning her fat offspring and returning to sea to feed. In most phocids, foraging is suspended during the breeding season. However, fasting during lactation places a limit on the duration of investment and this limits the total amount of energy that a phocid mother can invest in her pup. The only phocid clearly exhibiting distinct foraging trips during lactation is the harbour seal (*Phoca vitulina vitulina*). Foraging of lactating harbour seals is constrained by the need for females to care for their pups on land. Their foraging trips appear to be near the breeding colony because trip durations average only 7 hours. At the end of lactation, however, female harbour seals change their foraging patterns, beginning to dive deeper and continuously for extended periods. Mother and pup recognise each other through sound and smell. This bond is very strong, and a female can pick her own pup out of dozens of others. When the mother returns to sea, the pup is left to learn to swim and hunt for fish and squid on its own, while living of fat stores. The seal pups make in fact the transition from utter dependency to independence by instinct.

Grey seal pup suckling (Courtesy of Anna Jakucinska)

Harbour seal successful suckling (Courtesy of Acquario di Genova)

When monitoring if suckling attempts are successful in animals in far distance it is very useful to watch with a binocular if the pup has its mouth directly on the teat and if milk is leaking from its mouth.

In Otariids the female goes ashore just before giving birth. After birth, the mother will nurse her pup for a few days and then depart to sea to feed, leaving the pup in a nursery group or a protected area for three to five days. Upon her return, she will call the pup, using a distinctive bark that the pup will answer. Mother and pup recognize each other through sound and smell, because this bond is very strong: a female can pick her own pup out of dozens of others. The mother will continue this cycle of feeding and nursing for several weeks until the pup is old enough to swim and keep up with her. She will then depart to sea, taking the pup with her, teach it to swim, feed and avoid predators. The pup will be weaned in a year, when the mother comes to shore to give birth to her next pup. The length of lactation increases with the increasing age of the female.

California sea lion pup nursing (Courtesy of Tania Monreal Pawlowski)

Pups build immunity through the antibodies present in the milk of the mother. In early stages of life, they are hardly exposed to diseases and will contract fewer infections. The pups contract parasites when they start eating fish, but this does not affect their health, except if the animal is already weak. Mortality among pups is caused by different factors, including complete weakness, congenital defects and malnutrition. Drowning and oppression are less common.

Section 2: Management in Zoos and Aquariums

2.1 Enclosure

A comfortable and pleasant environment is conductive to good well-being.

As for every species, the enclosure has to meet the physical, behavioural, social and psychological needs of the individuals that will occupy it. The ideal enclosure would be representing as much as possible their natural habitat in all aspects and occupational activities are of outmost importance in daily management. Checklists that define all the enclosure needs are very useful during the building of new enclosures facilities to guarantee that all the inputs and resources provided for the species housed can meet welfare criteria.

Housing facilities

Pinnipeds should be kept in enclosures consisting mostly of ornamental pools (e.g. with rocky islands, beaches etc.) and extra areas as places to haul out, rest and sunbathe. Indoor and outdoor housing facilities for marine mammals have to be structurally sound and have to be maintained in good repair, to protect the animals from injury, to contain the animals, and to restrict the entrance of unwanted animals and persons.

A well-designed pinniped exhibit should include the following components:

- pools (main and separation/secondary pools)
- deck space (for hauling out and ample space for territories)
- quarantine and isolation facility
- shelter
- separation enclosures (which can only be used as a temporary measure)
- working area (trainers/keepers/animals)

Pools

Pinnipeds require both water and deck or "haul-out" space. Pools are required for exercise, maintaining competitiveness and natural swimming habits, as well as for promoting physical fitness. In temporary rehabilitation situations, pools are helpful in preparing animals for transition to the wild. Natural seawater pens or large oceanarium pools are in a sense ideal; yet, for the purpose of inspection or sampling they provide limited access to viewing or handling animals.

Circular pools have been widely used in rehabilitation centres and backstage. They have advantage over angular pools as they provide better water flow. New architectural designs and advances in LSS technology are now offering much more variability in creating “artificial” environments than before.

Any primary enclosure pool, except for natural seawater pools subject to tidal action, shall be constructed of materials having a nonporous, waterproof finish, which facilitate proper cleaning and disinfecting. Any ramps or haul-out areas in primary enclosure pools, and any natural seawater pools subject to tidal action, have to be constructed with materials that facilitate proper cleaning. Pools and enclosures should be maintained in good repair as part of a regular on-going maintenance programme. Therefore, vinyl plastic pools are virtually useless for pinnipeds. Standard grade fiberglass pools can be used. This fiberglass material is available in a no glare,

tannish-brown finish, reducing excessive heating and reflection. Even if salt water is utilised, these fiberglass and epoxy materials are non-corrosive.

It is recommended to paint or have the pool in a dark colour as light coloured pools in combination with bright sunlight (though generally giving a good view for the public) tend to cause excessive reflection, which is a major cause for blepharospasm in these animals.

Grey seal underwater rockwork (Courtesy of Hering-Hagenbeck).

As most phocids do not have climbing abilities, they are better housed with sunken pools where the water level is close to the edge, so that exiting the pool is easy. Gently sloping sides or edges below the water surface allow seals to rest in shallow water. Ramps of similar material as mentioned above can be constructed. A ramp covering with the epoxy granular flooring material allows for a slip-resistant, nonporous, inclined surface for pool entry. Beware that highly motivated individuals can jump by just utilizing hind flipper strong movement from the water surface to land or above walls even higher than 1 or 2 meters.

Otariids, on the contrary, can climb very high obstacles and it is important to keep this into consideration during design and construction of the exhibit fencing and perimeter (but shallow areas and gentle sloping sides should be available when pups are kept in these pools, specially the first few weeks).

Some facilities also utilize hidden surrounding electric fencing with low voltage in order to discourage the animals from climbing and escape. Trials on California sea lions (conducted with Dr. Jenifer Zeligs, an internationally recognized expert on marine mammal behaviour) also highlighted the extreme sensitivities of pinnipeds to non-lethal electric gradients (Zeligs and Burger 2008, Burger et al 2012). Following tests to determine field levels that animals could discern, deterrence trials were conducted on four California sea lions. Field trials were conducted at levels using about 50 V at a pulse frequency of just 2 Hz. Successful deterrence was achieved in

all trials, even when a favourite prey item (herring) was introduced on the far side of the deterrence array.

South American fur seal climbing exhibit rockwork (Courtesy of Hering-Hagenbeck).

A number of additional pools should be available – either outside or inside – serving several purposes such as social management, temporary separation of different groups for research, maternal needs, veterinary care, training, environmental stimulation and variability.

In mixed male/female groups, where reproduction is occurring, a separate maternity area for mother(s), with pool, haul-out and dry area, has to be available. Care should be taken, in case of visible to the public, to have enough space or shelter area where the mother(s) and pup(s) can retreat. Other separated pools and dry area (again either inside or outside) should be available at the same time (e.g. separation of reproductive males, sick/recovering animal, separation/holding area for working animals, etc.). Inside pool(s) (with adjacent dry area and animal separation possibilities) have shown to be very useful for the medical training of and access to the animals kept in human care.

Even during temporary separation, they should always have access to water at will, and as such, inside pools have to be conceived and designed in order to be filled and started with short notice when animals are destined to them and also maintained for long term such as permanent pools.

Deck space

Several beach areas in the enclosure are recommended. Pinnipeds spend much time on land where their socialization process takes place. They need the possibility to avoid each other and

go on land all at the same time such as not to be forced to stay in the water. They feel safe close to the water. Otariids are good climbers and areas to climb on are recommended.

Dry areas for safe interaction (e.g. working with the animals or intervention possibilities) between keepers/trainers and animals are mandatory.

The floors of the facility should be hard and durable, impervious to water, readily sanitised, non-toxic and resistant to physical and chemical damage. Floors should also be made from natural materials and protected in such a way that the sun does not make them burn in very warm weathers or cold stun in winter.

Pinnipeds playfully slide and rub for hours on end, and can wear down the hairs over the abdomen and bony prominences even on a smooth deck.

A professional epoxy surface compound is recommended for floor covering. This surface material has no seams or pores, and provides an easy-to-clean-tile-like finish. The use of multicolour granular aggregates embedded in the clear epoxy resin allows no reflective colour choices, a slip-resistant yet nonabrasive surface, and chemical and water penetration resistance. Because the ceramic epoxy material is applied with trowel and roller, smooth-edged curbs for direction of wastewater flow can be designed directly into the flooring.

The surface beneath the compound should be as smooth as possible before applying the covering. Floors must have the proper pitch towards drains. Haul-out decks should have a low barrier to prevent the escape of excreta into the pool.

Shelter

A natural or artificial shelter, which is appropriate for the species concerned, should be provided for all marine mammals kept outdoors. The functions of shelters include protection from the physical environment (extreme temperatures, water, and atmospheric aspects such as wind and low humidity), protection from con-specifics, public, and is a good way to provide them with the possibility to choose different context.

In countries where summer is very hot there should also be areas that are sprayed with cold water and ground areas, where animals lay down, constructed with material that does not become too warm for them, in order to avoid overheating. Shade should also be provided.

Quarantine and isolation facility

Ideally, independent, completely self-contained quarantine facilities should be available for new arrivals and diseased animals. Such temporary holding quarters need not necessarily comply with all the optimal space requirements established for the principal animal colony. Isolation pens and enclosures for use during contagious disease outbreaks among animals should be easily accessible by staff personnel, yet separate and distant from non-contagious animal enclosures. Preferably, the “quarantine” area should be situated below drainage flow from non-contagious pen enclosures. Foot baths and clothing should be positioned at quarantine entrance and exit points. Entrances to the non-contagious isolation facilities closest to the quarantine area must also have microbiological isolation tools such as foot baths, hands washing systems, clothing changing area, disinfecting agents, freshwater available etc.

Pens

Though all Pinnipeds are best maintained where they have access to water, it is possible, if necessary, to hold them in pens for the minimum necessary time for medical purposes at a time (such as 2 weeks post surgically in some circumstances), provided they are kept cool, clean, well ventilated, washed frequently, have enough space to move freely, proper lighting and photoperiod and are kept with prophylactic treatment for endemic external parasites (especially in endemic countries).

Ideally, the pens must be constructed of non-toxic, corrosion-resistant, nonabrasive material, such as vinyl clad or galvanised chain link fencing, or plastic or stainless steel wire or rods. For young and older animals, it's important there is a slope to the shore, so the animals can crawl to the shore. The mesh or spaces should be small enough to prevent a full mouth grasp for gnawing, and constructed so as to prevent the mouth from being cut. Pen floors should be designed so as not to entrain waste water, uneaten food, or excreta. Even under the best of conditions, pen enclosures are a compromise, and should be used only as a temporary measure.

Boundaries

All outdoor housing facilities must be enclosed by a perimeter fence of sufficient height (at least 3 to 4 meters above water level for larger pinnipeds) or width to keep zoo animals inside and avoid intrusion of wild animals and unauthorized persons. The fence must be constructed in a way to protect marine mammals by restricting animals and unauthorized people from going through, under or over. It can indeed function as a secondary containment system for the animals in the facility when appropriate. For natural seawater facilities, such as lagoons, the perimeter fence must prevent access by other species and unauthorized persons to the natural seawater facility from the abutting land, and must encompass the land portion of the facility from one end of the natural seawater facility shoreline the other end shoreline defined by low tide.

A perimeter fence is not required:

- Where the outside walls of the primary enclosure are made of sturdy, durable material, which may include certain types of concrete, wood, plastic, metal or glass, and are high enough (at least 3 to 4 meters as mentioned above) and constructed in a manner that restricts entry by animals and unauthorised persons or escape of the pinniped to the outside.
- where the outdoor housing facility is protected by an effective natural barrier that contains the marine mammals to the facility and restricts entry by animals and unauthorised persons where appropriate alternative security measures are employed.

The exhibits and pools should be located far from the trees. Leaves could be dangerous when falling into the water. The sea lions swallow them and might get impacted or even be toxicated.

All marine mammals shall be provided with protection from abuse and harassment by the public by using physical barriers, such as fences, walls, glass partitions, and/or distance for the entire exhibit perimeter and/or provide a sufficient number of employees or attendants to supervise the viewing public. These mandatory precautions will also allow safety for visitors and public.

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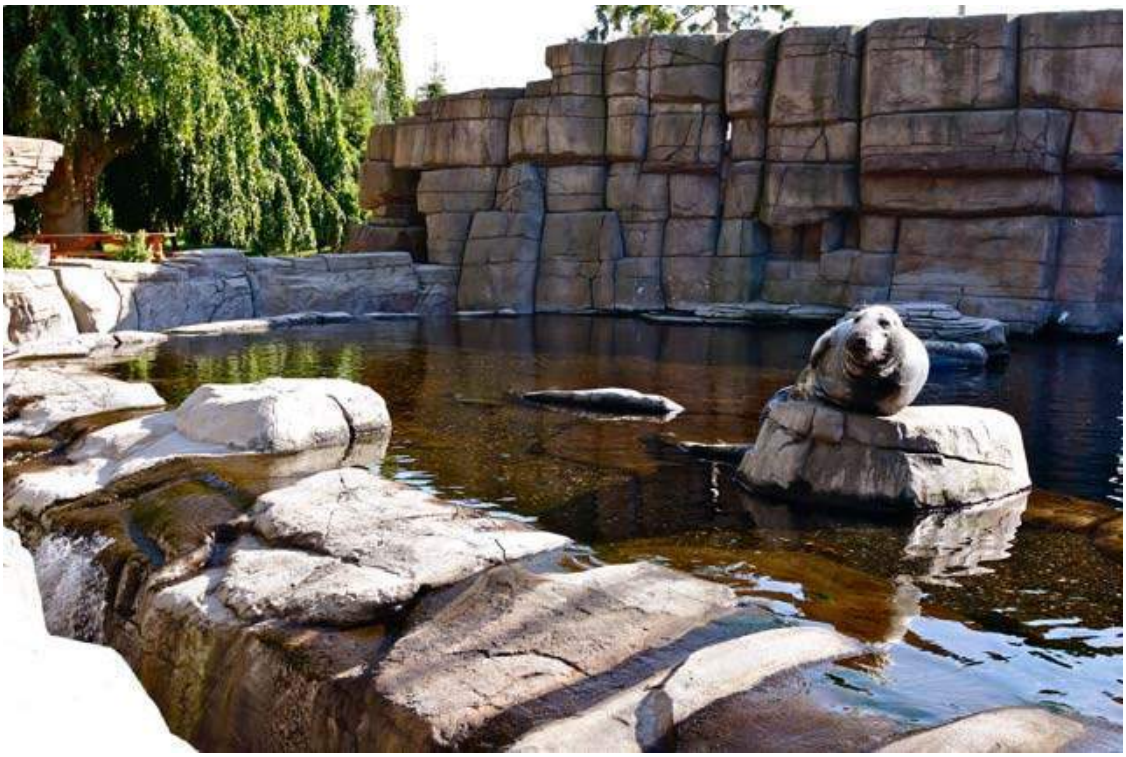


Grey seal exhibit and boundaries (Courtesy of: Dr. Hering-Hagenbeck).

Dimensions

Measurements are a significant part of the general exhibits requirements for every animal species. They are as important as environmental and behavioural enrichment. These standards only lay down general principles of animal keeping, to which the members of the Marine Mammal TAG feel themselves committed.

Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size of enclosures.

The Marine Mammal TAG strongly recommends that users of this information consult with the editors and individual species EAZA program coordinators in all matters related to analysis and interpretation of the data, especially before implementation (Marine mammal TAG November 28, 2017).

The following requirements for pinnipeds are utilized for EAZA and EAAM inspections for accreditation.

General concepts:

Pinnipeds should be kept in outside enclosures whenever possible provided their environmental temperature meets their physiological and natural requirements.
Environmental temperature should also be constantly monitored.
All enclosures should therefore be furnished with a Life Support system to manage the bio-load and to provide appropriate disinfection of the water; water quality parameters should be run on a regular basis (at least: pH, water temperature, salinity, ORP and/or DPD tests) and disinfection confirmed with biweekly microbiological analysis.

The enclosures are defined as follows:

- **Main housing facility**: an enclosure that houses animals during a long period of the day and is usually an outside facility.
- **Secondary housing facility**: an enclosure that is used for housing animals for a certain period of time which can be used as separation and/or quarantine facility (if an independent filtration system exists or if it can be isolated from the main system). Its dimension can be smaller than the main, since they will not be used for prolonged period of time, although it should meet the minimum and considered as a whole without internal subdivisions.

- Main enclosures used for interactive programs must have an area of the enclosure forbidden to public entrance that allows the animals to choose where to go in every moment of the day
- A presentation pool, that is not accessible to the animals apart from the presentation/ demonstration, shall not be included in the minimum. Channels between pools have to be excluded from the calculation.
- Enough shade should be provided, in all areas where animals could be isolated for longer period of time, in order to avoid any uncomfortable overheating. In cases where temperatures are higher than natural temperatures for the species for a long period of time, cooling devices (such as: water chillers, fans or sprinklers, etc.) should be used to control the environment.
- Indoor facilities must be ventilated by natural or artificial means.
- Natural lighting and photoperiod that allow normal physiological and behavioural functions appropriate to the species
- The colours utilized to paint the different parts of the exhibits, pools and holdings should be dark and as natural as possible, by using paints that avoid light reflection (ie: difference nuances of grey, green, brown and dark blue with more natural sandy or muddy colour at the bottom).
- Recent research leads us to believe that the depth might be very relevant for physiological parameter of pinnipeds due to water pressure.
- Rotating animals between enclosures that meet the minimum dimensions and other enclosures that do not, is not an acceptable means of complying with the minimum space requirements. Enclosures housing two or more sexually mature males should have separate areas with sufficient visual barriers (such as fences, gates and/or rock work) to provide relief from aggressive animals, especially during breeding season.
- Enclosures must have floor areas between the beach and the backdoors to allow correct and safe management for the trainers and veterinarians. In case of utilization of sand, its type should be safe for ingestion.

Temporary enclosures can be used for numerous reasons provided that the curator and/or the attending veterinarian of the Institution presents a training and husbandry plan that includes health and welfare goals, together with working dates that justify the temporary situation such as:

- non-medical and medical training
- holding for transfer purposes

- Blind, disabled or mutilated animals (only when not comfortable within the social group)
- Medical and surgical procedures
- Quarantine for animals which may require quarantine under the supervision of a veterinarian for a minimum of 30 days unless otherwise directed by the veterinarian
- Female due to give birth and nursing
- It can also be used to address aggressive episodes (as long as its only temporary and a permanent solution is found).

The definition of “pinniped space requirements” has not yet reached the stage where the use of a strict formula can be scientifically defended. To overcome this lack of information, a “minimum space requirement” for facilities housing pinnipeds in zoos and aquaria is hereby established; this suggestion is in order to provide the animals with sufficient space for natural postural and social adequate freedom of movement, on land and in the water.

In order to define these minimum measures, the following parameters are kept into consideration:

- the physiological needs of the individuals;
- the needs to separate them at different moments for longer period of time;
- the volume and the treatment of the water that should be sufficient to yield low bio load and keep good water quality, both for the animals and for the aesthetic of the exhibit;
- the size of the enclosure is not the final well-being indicator, the occupational and enrichment activity of the animal is of equal importance, if not more. As such animals should have access on a daily basis to several complexes of pools, that can vary a lot in sizes-shapes-depths, but it would be mandatory to provide in all cases a main pool and at least an extra secondary pool following minimum requirements.

The average sizes available from Wilson, D.E. & Mittermeier, R.A. 2014 (Handbook of the Mammals of the World. Vol 4. Sea Mammals. Lynx Edicions, Barcelona) have been considered as a fair indicator of the maximum growth potential of individuals from the different species utilizable to calculate minimum space requirements. In principle the main pool (table 3) will have to be as built as if the number of animals is at least 6 and incremented according to the real number of animals. The same individual criteria for pool and land areas will be applied to the secondary pool (table 4) which will be sized according to the maximum number of individuals that it should host; the depth will be the maximum average size of the animals.

Table 3 Main Pool Minimum space requirements:

Species with similarly range size	Average species length (m)	Group size	Land area (m^2)*	Additional land area per extra animal (m^2)	Pool area (m^2)	Additional pool area per extra animal (m^2)*	Minimum Volume (m^3)
P. hispida	1.6	1-6	18	3	72	12	153
P. vitulina	1.9	1-6	24	4	92	15	233
H. grypus	2.3	1-6	30	5	120	20	367
A. tropicalis *A. australis*	1.9	1-6	20	3,3	80	13	202
A. pusillus *Z. californianus* *O. flavescens*	2.6	1-4 to max 1-6	36	6	144	24	500
E. jubatus	3.3	1-4 to max 1-6	54	9	216	36	948

Table 4 Secondary Pool Minimum space requirements:

Species with similarly range size	Average species length (m)	Land area / each individual (m2)	Pool area / each individual (m2)	Minimum depth (m)
P. hispida	1.6	3	12	1,6
P. vitulina	1.9	4	15	1,9
H. grypus	2.3	5	20	2.3
A. tropicalis *A. australis*	1.9	3,3	13	1,9
A. pusillus *Z. californianus* *O. flavescens*	2.6	6	24	2,6
E. jubatus	3.3	9	36	3.3

Table 5 Example: a secondary pool for 2 *P. vitulina* and 2 *Z. californianus* should be as follows:

Species with similarly range size	Average species length (m)	Land area / each individual (m2)	Pool area/individual (m2)	Minimum depth (m)
P. vitulina	1.9	8	24	1,9
A. pusillus *Z. californianus* *O. flavescens*	2.6	12	48	2,6

Notes:

(1) Land surface is defined as a dry resting, social and working area.
*Total land area was defined assuming that each animal should have the same space and assuming that the mean size is calculated in a group that includes adult males and females, together with pups and youngsters and therefore the maximum length is not the same for each individual. Each pool must have land areas that allow all animals to haul out simultaneously without touching each other or causing significant conflict between individual. Additional land area per extra animal (m^2) used the formula rational: π (pigreco) x R^2 where R is half of the length of the animal and represents the surface of a circle using the animal size as diameter; to this 1 square meter of space was added around the phocid species and 0,5 meters for Otariids.

(2) Water surface / pool area: sufficient space must be provided both horizontally and vertically to enable animals to exercise, make normal postural and social adjustments with adequate freedom of movement and to protect them from undue dominance or conflict. To calculate the additional pool area (m2) we considered that each extra animal should have the same individual space of the initial group.
*The institution willing to keep pinniped collections with more than 15 individuals are advised by the MMTAG to get in touch with the species coordinator to discuss and decide the final pool surface and the secondary needs.

(3) Minimum Volume was calculated considering that the depth should be at least one third more than the average length of the anima for at least half of the surface of the pool. It is advised to have a varied bottom topography that incorporates a part of the vertical column of water where the animal can float freely vertically.

Substrate Furnishings and Maintenance

Water and power supply

Reliable and adequate sources of water and electric power shall be provided by the facility housing marine mammals. Emergency sources of water and electric power should be present in the event of failure of the primary sources, when such failure could reasonably be expected to be detrimental to the good health and well-being of the marine mammals housed therein.

Light

Indoor facilities should include a combination of natural and artificial lighting. Natural lighting installations such as windows of roofs that can be opened, should be built in a safe position easy to reach by the maintenance staff without disturbing the animals and impossible to reach by the animals. Natural photoperiod should be maintained to guarantee proper physiological cycling and moult. (Daniel J.C. 1981., Campagna C. 1985, Boyd I.L. 1991. , Boyd I.L. 1991a, Atkinson S. 1997., Mo *et a*l. 2000).

Storage

Supplies of food shall be stored in facilities, which adequately protect such supplies from deterioration, mouldings, or contamination by vermin. Refrigerators and freezers shall be used for perishable food. No substance known to be, or that may be toxic or harmful to marine mammals shall be stored or maintained in the marine mammal food storage areas.

Waste disposal

Provision shall be made for the removal and disposal of animal and food wastes, dead animals, trash and debris. Disposal facilities shall be provided and operated such as to minimize vermin infestation, odours, and disease hazards, and implement all legal regulations in terms of disposal and waste management.

Washroom facilities

Facilities such as washrooms, basins, showers or sinks, shall be provided to maintain cleanliness among employees and attendants.

No material should be left in the animal's exhibit, either inside or outside. Pinnipeds are known to bite off many things and may swallow pieces and parts of material.

Some animals can unlock gates, open fridge doors and take pins out of gates. Some gates need safety locks for individuals that have learnt this behaviour.

Environment

Temperature

Marine mammals possess efficient means of temperature control, using blubber, hair, and rather uniquely adapted vascular mechanisms. The temperature range provided in the captive environment should take into account that of the animal's natural habitat of origin. In general, extremes of both heat and cold should be prevented, although, generally most species are more able to tolerate cold than heat. Ambient temperatures of about 26 °C are the thermal maximum of most well blubbered pinnipeds. Hyperthermia can be avoided by providing access to shade and some means of wetting the animals, whether by pool, hose, or spray mist when ambient temperatures rise above 26 ºC. Water temperature can be cooled. Healthy, robust, harbour seals, grey seals, harp seals and ringed seals can tolerate water at freezing temperatures, and air temperatures well below -20 °C. Hypothermia is rare, but can become a problem in undernourished animals. Provision of waterproof heating pads or kennel areas with heat lamps can prevent hypothermia, especially in pups. If air and water temperatures of indoor facilities are regulated by heating or cooling devices, rapid changes in air and water temperatures should be

avoided. The water surface of pools in outdoor primary enclosures, housing ice or cold water dwelling species of pinnipeds, shall be kept sufficiently free of solid ice to allow for entry and exit of the animals. A marine mammal shall not be introduced to an outdoor housing facility until it is acclimated to the air and water temperature that it will encounter therein.

Ventilation

Enclosed facilities should be designed to provide a relatively uniform distribution of clean air, and to avoid strong draughts onto any pen enclosure. They shall be ventilated by natural or artificial means to provide a flow of fresh air for the marine mammals and to minimise the accumulation of toxic and chemical fumes and objectionable odours. Incoming air should be fresh, not re-circulated. The volume must be such as to assure an adequate supply of oxygen, reduce noxious or unpleasant odours, dilute airborne pathogens, and reduce saltwater humidity, which tends to be corrosive. In accordance with generally-accepted standards for laboratory animal enclosures practical experiences at Acquario di Genova recommend that a minimum of 10 air changes per hour for air conditioned rooms, up to 20 air changes per hour; whilst the recirculation system can contemporarily provide air circulation up to 40-50 times per hour; air systems could ideally also include microfiltration for microbial prevention (such as HEPA Filters).

Lighting

Indoor housing facilities for marine mammals shall have ample lighting, by natural or artificial means or both, of a quality, distribution and duration that is appropriate for the species involved. Sufficient lighting must be available to provide uniformly distributed illumination that is adequate to permit routine inspections, observations, and cleaning of all parts of the primary enclosure including any den areas. The lighting shall be designed so as to prevent overexposure of the marine mammals contained therein to excessive illumination. The photoperiod, photo spectrum and photo intensity of natural outdoor sunlight should be duplicated as closely as possible in the pool or deck enclosure. Moult and reproduction are both influenced by light (Mo et al.), and natural photoperiod using incandescent or fluorescent lighting will provide the proper stimulus for these physiological activities. More "natural light" can be provided relatively simply by using "natural spectrum" fluorescent bulbs (HQI) and automatic time switches coupled to outdoor ambient light, using light-sensitive photo-cells.

Noise

The effect of noise is not clear yet but it is recommended to avoid permanent high noise levels as much as possible. Research on this subject is necessary, in order to determine the threshold levels above which the health and well-being of pinnipeds is reduced. Circulating water systems usually produce pump noise, and for this reason should be built away from the pools and mounted on materials that isolate the pump vibrations from the pool. Animals seem to adjust to these continuous sounds, but further research on whether possible chronic stress (or temporary or permanent hearing threshold shifts) can be caused by prolonged noise should be evaluated. Some species of animals respond adversely to loud sounds that occur during renovations. Even noise from some distant construction activities (even outside a company/zoo) can be transmitted with little attenuation through the ground and into a pool enclosure depending on where it originates (air, soil or water borne). Under such conditions, the behaviour of some animals may be noticeably

affected. Based on the experience with other aquatic mammal species permanent noise levels exceeding 40 dB above the hearing threshold curve (basic audiogram) should be avoided.

WATER QUALITY AND TREATMENT

Appropriate water quality is an essential component of aquatic organisms husbandry.

A system for water treatment must effectively mimic the natural aquatic environment and effectively maintain proper water quality, remove animal wastes and control algal growth to prevent the growth of harmful microorganisms and guarantee a reasonable level of water clarity free of toxic chemicals

An appropriate Life support system requires specialized design and installation and its function must be carefully monitored and maintained.

In general there are two types of systems:

- OPEN WATER SYSTEMS that replace wastewater with new water.
- CLOSED WATER SYSTEMS that recirculate the wastewater.

One of the simplest solutions derives from pumping water into the exhibit from a natural source (e.g. the sea) and eliminate the waste out, or constructing the exhibit as a sea-pen or fenced off lagoon. Unfortunately, such facilities have to be located in coastal areas and, moreover, such locations have to be free from pollution. "Semi-open" and "closed" systems are therefore more commonly used. These respectively provide for continuous partial replacement, or for occasional replacement of water lost through evaporation or waste. Closed systems also have the advantage that they can be isolated (and continue to filter) in case of poor inlet water quality.

All marine Pinnipeds live in a seawater environment, either natural or artificial (apart from Baikal seals who naturally live in fresh water). Artificial seawater can be prepared by adding commercial sea salts to reach a natural salinity range of 25-35 gr/l, or by adding NaCl with a pH of 7.5-8.2. Water quality should be monitored carefully starting right from the source, particularly when well water is used.

Many facilities still maintain marine pinnipeds in fresh water, although seawater is their natural environment. This mainly occurs due to distance from the seashore and costs limitations to maintain proper salinity. People should be aware though that constant fresh water environment for pinnipeds can promote corneal oedema that can grow up to total blindness; in those cases, the animals should be treated with saline dips or eye drops. It is quite common practice the supplementation of oral salt in those facilities where access to seawater is not possible, but there is no evidence that salt supplementation increases the level of salinity in the tear film or aqueous humour.

One should also seriously re-consider, in terms of animal welfare, the real need to such a prolonged maintenance of these species in unnatural conditions.

Filtration

The use of biological filtration systems is strongly recommended and should be built in new enclosures. Although it can be difficult and expensive to change old systems that used to be disinfected with chlorine, that limits the possibilities for a biological filter to grow; there are

alternative disinfection systems that are very practical, with minimal negative effects on animals and caregivers and that allow for the growth of filtering microorganism that maintain the ammonia cycle: UV lamps, and ozone in protein-skimmers. These compounds are utilized in combination with mechanical filtration.

Filters commonly used in recirculation systems are sand/ gravel filters and nowadays glass sand filters. They remove waste physically and to some extent by biological degradation. Mechanical filtration in a water treatment system is primarily designed to remove particulate matter; the most common type is a sand pressure filter. These filters consist of closed vessels containing a body of sand held above an under drain supporting assembly. Normally water is pumped into the vessel and passes the sand which strains and retains particulate matter. As soon as the sand gets clogged the pressure across the filters increases. When the prescribed pressure level for cleaning the filter bed is reached, the filter flow is reversed (filter backwash) and the dirt and water used for the cleaning operation is diverted to waste; sometimes, compressed air is used to "fluidise" the filter bed during the back wash cycle to ensure total cleaning. When the water washing the filter bed appears to run clean, the system flow is returned to normal direction and continues to filter the pool's water. The sand in the filters should be checked regularly and usually changed every 10 years

Most commercial systems designed for public swimming pools or public water supplies are often considered suitable and applied to pinniped facilities, although the dimensions, the quality of the pipes, valves and pumps needs to be checked appropriately before installation; the frequency of their use is much higher with constant 24 hour animal load and, in terms of costs, it is better to acquire good materials during construction rather than having to replace them constantly afterward. Many filters are now designed in fibreglass what gives them extended use in salt-water applications.

Some facilities utilize flocculants to precipitate the nutrients and remove them mechanically; these chemicals need to be monitored in order to avoid toxicity to the animals.

Turnover rate

The turnover rate is the amount of time it takes for a treatment system to pass all the volume of a pool through the Life Support System once. A water turnover rate of 1 hour (to a maximum of 4 hours) is considered desirable for a closed or semi-closed system. Every system needs replacement of a certain percentage of water per week or months according to evaporation, waste and drainage and to maintain water quality. No systems currently exist that totally frees a closed circuit system from the many complex biochemical changes that take place; in this sense, the metabolism of the animals within the closed environment, obligate in fact a periodic water disposal and replacement. This indeed remains the current situation and it is advisable that the exhibits do undertake periodic partial water changes. The turnover rate is very much dependent on the pool bio-load.

Biological treatment

The use of some form of biological control of organic pollution within aquatic mammal pools is a relatively new development, which has grown, in part, from the popularity of large public

aquariums and mixed mammal/fish exhibits. The following biological treatments are discussed below:

Nitrification

The principles of nitrification involved are the deliberate culturing of species of aerobic bacteria known for their ability to convert ammonia to nitrite and nitrite to nitrate. The process is termed nitrification and is normally achieved in chambers sited after particulate filtration that contains media such as stones or plastic shapes that offer a large surface area for the bacteria to grow on. Nitrification, the conversion of ammonia to nitrate, is a process that takes place under aerobic conditions and is carried out by bacteria. The first step in the process is the conversion of ammonium (NH_4^+) to nitrite (NO_2^-). The next step in the nitrification process is the conversion of nitrite (NO_2^-) to nitrate (NO_3^-) carried out by one of the four species of nitrite oxidisers. Under aerobic conditions, nitrate is the end stage of nitrogen metabolism. For the removal of nitrate there are two possible pathways. There are algae that can use nitrate-N for the formation of organic nitrogen compounds, provided there is plenty of light available. When the light is not enough, they will start metabolising organic nitrogen and in that way increase the nitrate concentration. Under anaerobic conditions, several bacteria species can use nitrate in respiration instead of oxygen..

Complementary to these biological systems is the use of the “protein” skimmer or foam fractionation. Foam fractionation usually takes place prior to the biological system and is designed to generate foam that can be removed from the system as waste; the bubbles within the generated foam contain dissolved organics that are attracted by the air/water interface of the bubbles. The foam generators on these systems can also incorporate a small concentration of ozone that increases the oxidation of organic population; in these cases, the outlet of the ozone should be managed as toxic waste appropriately. The effect in fresh water is minimal if not absent compared to the effect in salt water, although tests are carried out at the moment on new freshwater systems for other species.

Disinfection

The process is not meant as sterilization but includes all the technical processes conceived to reduce the likelihood of pathogens presence in the water, thus avoiding the total bacterial reduction to zero.

UV light

UV light radiation is a widely accepted method for disinfecting treated wastewaters. Its disinfection property can be also incorporated into biological systems with UV-C lamps, which produce radiation that damages all forms of life by disrupting cell DNA-bonding. Its germicidal action is attributed to its ability to photochemically damage links in the DNA molecules of a cell, which prevents the future replication of the cell, effectively "inactivating" the microorganism. UV radiation is the most effective region of the electromagnetic spectrum (between 230 and 290 nm); this corresponds to the UV absorbance spectrum of nucleic acids. The optimum germicidal wavelength is in the range of 255 to 265 nm.

The dominant commercial source of UV light for germicidal applications is mercury vapour, electric discharge lamps. They are commercially available in **"low-pressure"** and **"medium pressure"** configurations.

Low pressure:

- UV output is monochromatic at wavelength of 254 nm
- Energy efficient (converting approximately one-third of its input energy to UV light at the 254 nm wavelength).
- The UV power output low (11watt to 75watt)
- Effective operating lamp (15% emission lost after 9000 hours).
- New developments: amalgam lamp power outputs 1,5 to 5 times higher

Medium pressure:

- UV output is polychromatic light
- Low efficiency (converting approximately 10-20% of their input energy to germicidal UV radiation).
- The UV power output high (1Kwatt to 3,5Kwatt)
- Effective operating lamp (30% emission lost after 5000 hours).

The process takes place in sealed chambers containing UV light tubes that pass the treated water around (the UV-C tubes are protected by quartz sleeves). A correct turbulent flux around quartz sleeves must be considered. Water section to be treated around quartz sleeves should be always less than 25 mm. Air spill on top of collector is important to reduce the air in the collector. The total germicidal effectiveness is quantified as the " UV Dose" and measured in $mW/cm^2/sec$.

For ultraviolet sterilization to be successful, the water must have a low suspended content. In a closed circuit, it will be necessary to trap suspended material upstream of the UV unit by **mechanical filtration and microfiltration up to 5 microns** to reduce suspended organic matter and turbidity.

A further advantage to the use of this technique is the fact that it does not get in touch with the water and with the animals and therefore preferable to use of chemicals that, if used injudiciously, can be more life threatening than the organisms and excreta which they are designed to control.

Chemical treatment

Various chemical treatments are used in combination with filters to eliminate microorganisms, algae, etc. Chemicals that may be used in water treatment include:

- Chlorine treatment
- Ozone
- Copper salts

Chlorine treatment

Chlorine has been used in public water treatment since the beginning of the century. Chlorine as sodium hypochlorite is perhaps the most commonly misused chemical treatment. Chlorine is an elemental gas and a member of the halogen family. However, it is rarely supplied in its gaseous form (Cl_2) that can be very dangerous if mishandled. It is mainly supplied dissolved in a liquid called sodium hypochlorite; this contains approximately 10-15 % of available chlorine (Cl^-). Moreover, chlorine can also be produced in salt-water pools *in-situ* by electrolytic cells. In recent times, along with many other chemicals, it has received closer inspection as to its threats to the environment. However, its beneficial utilisation in ensuring safe water for public consumption and recreation must be balanced against the above concerns. As regards to pinnipeds as well, chlorination has been used successfully and safely for many years, however inappropriate, incorrect or unexperienced utilization might lead to unbalanced residuals and too high combined

compounds which can cause severe problems such as, primarily, eye and skin problems together with microorganism imbalance in cetaceans and pinnipeds pools. Safety caution should be taken to avoid inappropriate application by inexperienced staff, which could cause severe problems.

The chlorination of water is a complex affair and therefore a brief and simple technical explanation of its action in water may be helpful in understanding the process and avoid common application problems. The use of chlorine in the management of a pinniped exhibit has different purposes:

- disinfection of the water to reduce the likelihood of the presence of pathogens;
- oxidation of organic matter produced by the animals
- reduction of algal bio load allowing water clarity maintenance.

When chlorine is added to pure water it is found predominantly as free available chlorine. This so called free chlorine is non-toxic up to high levels and inactivates pathogenic agents within a short time. However, this situation is complicated when it involves water containing organic matter - particularly ammonia - as a number of chlorine related compounds called chloramines could be formed. Although chloramines are available to kill pathogens, they do so at a much slower rate than free chlorine. Unfortunately, they are also responsible for eye irritation in humans and other mammals. The distribution of chloramines, and thus the degrees of mucus membrane and eye irritation, is pH dependant. Water adjusted to a pH of seawater (7.8 - 8.4) will have a predominance of mono-chloramine (NH_2Cl). Fortunately, early research in chlorination techniques found that continuing adding chlorine to water containing these compounds resulted in a second chemical reaction. This second reaction, sometimes referred to as "break-point chlorination", effectively breaks down the troublesome chloramines and results in predominance of the non-toxic free chlorine thus resolving irritation problems, but the total chlorine levels in these cases can be very high. However, for this process to take place safely in a marine mammal pools, it has been demonstrated that there is an animal bio load to water ratio to reach appropriate level of disinfection, thus avoiding damage to the animals.

The use of chlorine has more disadvantages. Chlorination works better against bacteria than against fungi. This could increase the chance of fungal infections. The chlorination of (artificial) seawater is far more difficult than that of fresh water or of a pure NaCl solution. The presence of magnesium makes breakpoint chlorination impossible and also iron and manganese interfere with proper chlorination.

Pinnipeds show a lower tolerance to chloramines than cetaceans and chloramines levels must be strictly monitored and controlled. Chlorine at high levels, not only plays a significant role in health, skin and eye problems but, in constant moderate levels, also creates an environment that is imbalanced in terms of microflora growth (with prevalence of fungi versus bacteria) and might provoke bacterial selection. Ratios between free chlorine and chloramines residuals (combined chlorine) should be at least 3:1 or even better 4:1 and a maximum level of total Chlorine of 1ppm.

In case of a crisis, chlorine can also be used as a shock system. This means that a high dosage of chlorine is added to the pool during the night, while animals are safely kept from the pool. Before the animals are released again in the pool the chlorine levels are neutralized by sodium thiosulphate and pH should be adjusted to normal levels in order to avoid any sudden pH change to the animals.

If one decides to change from chlorine to biological system, it is wise to take some precautions for the animal's immune system thus avoiding a sudden change during stressful situations (i.e.: moult, birth, lactation).

Ozone treatment

Ozone (O_3) is a form of oxygen that is very reactive and can be used to oxidise organic material. Ozone is very unstable and has to be produced on site; it is generally mixed with treated water in a special reaction chamber and removed in a degassing chamber before the treated water returns to the pool, as it can be very noxious and dangerous.

Ozone has many advantages, including a high potential to kill both bacteria and virus, and has the bonus of producing water with a high clarity that may exclude the need to use coagulation and flocculation chemicals such as aluminium sulphate. It has the major advantage when applied and monitored correctly that it does not leave any form of disinfectant residual in the pool water and therefore does not get in contact with the animals. However, ozone has disadvantages as well: because of its volatile nature, it needs proper means of destruction at the site of creation and outlet. Ozone does not control algae and bacteria growth on pool surfaces.

Nevertheless, these problems can be resolved by using ozone in tandem with chlorination, to allow the benefit of in pool residuals to control bacteria and algae growths. Ozone's high effectiveness at oxidising organic matter also allows a lower concentration of total chlorine residuals.

Although more expensive, it is suggested that in totally closed water systems the use of ozone sterilisation is favourable and more effective, rather than exclusive reliance on chlorination.

The management of ozone systems requires trained personnel skilled to monitor its concentration, the ORP in the water, and to apply proper safety protocols.

Water quality parameters

Provided that parameters matching the natural environment should be maintained, whenever changes to the water quality management occur, they should be dealt with a moderate adjustment, thus avoiding sudden changes and allow for gradual habituation.

One of the best safeguards to good water quality is careful regular monitoring to maintain accurate records on water conditions. These should include data on:

- temperature
- salinity
- pH ammonia cycle compounds ($N\text{-}NH_4$, NO_2, NO_3)
- presence and quantity of oxidants and
- presence of algicidal compounds (Chlorine and /or copper) and flocculants such as aluminium or iron
- ORP
- Bacterial count (coliforms, enterobacteria) and colture (*Pseudomonas aeruginosa*, *Salmonella* sp. , Candida sp.)

While doing these tests with proper analytical instruments or in a certified laboratory, one should also keep track of all the technical operations that take place in the exhibit, which might interfere with the function of the LSS such as:

- changes in bio-load (the amount of food added to the system which might vary by season, the number of animals, a birth event which “pollutes” the water, a death, external objects and specimens dropped by birds, food left-over, etc.)
- frequency of filter backwash, water change and pool cleaning
- levels of nitrate (NO_3) should be contained within the system and maintained below 50 mg/l. Both nitrate and phosphate represent nutrient enrichment and implement rapid algae growth. Records should be kept for the water quality parameters on a regular basis, to be able to establish if parameters found out of range need immediate intervention or not and the type of it.

No scientific data are present for the best values of water quality, which exactly meets the needs of captive pinnipeds but considering that the natural environment of these animals is the sea one should preferably aim to duplicate the natural ones. Meijer G.H. 2008. Husbandry guidelines for eared seals (*Otariidae*). EAZA Marine Mammal TAG. 116pp.

2.2 Feeding

Wild pinnipeds are piscivorous (fish-eating animals) and most institutions have traditionally fed herring (*Clupea harengus*), smelt (*Osmerus* sp.), mackerel (*Scomber sp.*) and, more recently, capelin (*Mallotus villosus*). The most widely fed invertebrate is squid (*Loligo sp.*). The food species chosen in human care will generally depend on seasonality, commercial availability (including cost evaluation) and, more and more nowadays also sustainable fishery practices. Each food item has different nutritional characteristics, which, in turn, may show marked seasonal variations both within and between food species. Finest fish quality should be purchased for pinnipeds and, in case of planning new pinniped exhibits, the cost for their appropriate nutrition should be considered and budgeted.

Diet

A good quality diet, consisting of a mix of fish and invertebrate species should provide a balanced source of fats, proteins, vitamins and minerals. A diet is considered to be "nutritionally balanced" when it provides appropriate levels of known dietary essential nutrients, based on current knowledge and information. A nutritionally balanced diet must be provided in a suitable form and correct proportion based on the most appropriate physiological models for the species. Nutritional status, natural feeding ecology, gastro-intestinal morphology, nutrients contained in the diet of free-ranging individuals, and feeds available to the institution should be taken into consideration when formulating a balanced diet. The "diet" is made by all feeds offered and/or accessible to an animal, regardless of purpose. Foods used for enrichment, training programs, and/or treats must be included in calculations when balancing the complete diet. A nutritionally balanced diet provides the animal with all the known nutrients it requires without gross excesses or deficiencies.

The selection of food items needs to be varied to include high and low fat products and it is of paramount importance to avoid feeding a single food type. Pinnipeds feed on a wide variety of fish species, which is thought to satisfy their specific nutrient requirements. When feeding captive

piscivorous animals, it is often limited to feeding a few species of fish and marine invertebrates, which may vary considerably in nutrient content. In zoos and aquaria, therefore, the recommended method of feeding most piscivorous animals is to feed them at least three, and preferably more, species of fish. These should include finfish and invertebrates, which complement each other in nutrient concentrations and, to the extent possible, represent the types of items the animals may consume in the wild. Knowledge of the specific fish species consumed by wild piscivorous animals may aid in selecting the most appropriate fish to purchase. Free ranging pinnipeds also consume squid. One of the characteristics of squid is that they appear to have higher concentrations of copper than finfish. This may reflect a higher requirement for copper or simply a higher tolerance. Given these compositional differences, the feeding of squid, in addition to finfish, may deserve serious consideration.

Given the goal of a balanced diet, it would be preferable to offer more than one species of fish, but holding stored fish for prolonged periods may cause nutrient losses. The objective is to provide a balanced diet by utilizing the freshest fish possible. Practically, there are two basic approaches to offering fish as food:

- Offering one species of fish on a seasonal basis, or
- Offering several species of fish throughout the year.

If one fish species is offered seasonally, a new species should be rotated into the diet. The rotation may occur as often as quarterly. The advantage of the seasonal approach is that relatively fresh fish would be fed. The disadvantages include:

- Offering only one type of fish at a time may provide a nutrient profile that is not nutritionally balanced (for example, too fatty or too lean, low or high in a specific nutrients);
- The quality of the one type of fish may happen to be poor or unacceptable, and there is no backup supply;
- The fish may be unpalatable to one or more of the animals in the collection;
- Some species are harvested only at specific times or once a year.

The other approach is to obtain the catch seasonally, and store the fish for 6 to 9 months distributing its use. The advantages include:

- Several fish species are available and fed simultaneously for a nutritional balance; and
- Backup supplies are on hand in case of palatability problems or poor quality.

The disadvantage is that frozen fish loose nutrients over time.

Uncertainties in the future availability of fish stocks, reliance on farm fish, and the development of technologies such as a fish substitute for marine mammal diets are the factors which make selection of appropriate fish and their handling of utmost importance. Such uncertainties and possibilities require an awareness and evaluation of the nutritional content and quality of diets, as well as a very well informed system of food fish procurement and sourcing from sustainable industries (such as MSC).

Whole fish also contains thiaminase, depending on the species of fish, which destroys VitaminB1 (Thiamin).

	Herring	Capelin
Thiaminase	Yes	Possible

→ Thiamine below the detection limit of 0.2 mg/kg OM

→ Supplementation of thiamine is very important when feeding herring and capelin

Food components

The nutritional status of zoo and aquarium animals, which rely entirely on fish as food, is dependent on the quality and composition of the fish they consume. The nutrient composition of fish may vary immensely. Concentrations of fat and protein, as well as many vitamins and minerals, differ depending upon species, age and gender, stage of life cycle, and season and location of catch and storage time. The fat content of the fish highly influences the vitamin E requirement of the animals. Fat and protein (gross energy content) generally diminish over time and therefore one should always keep this in mind when when feeding fish that is stored for more than 180 days.

Table 6 *Proximate composition of species commonly fed to marine mammals, specified in season of capture. (Extracted from: Worthy, 2001) References: 1. Worthy, 1990; 2. Lawson, et al., 1998*

Item	Season	H_20	Protein	Fat	Ash	Energy	Ref
		in %				*MJ/kg*	
Capelin	Summer	80.3	12.9	3.1	2.4	4.16	1
		68.2	16.1	13.7	2.1	8.4	2
Herring	Summer	65.8	15.5	13.6	2.3	9.74	1
	Autumn	69.7	16.5	8.9	2.3	6.93	1
		68.2	17.5	9.9	2.6	8.15	1
	Winter	65.0	20.1	13.7	0.8	9.4	2
Mackerel	Summer	74.9	18.8	3.2	3.5	5.59	1
Smelt	Winter	74.5	12.1	8.8	1.7	6.80	1
Squid	Winter	76.8	16.7	2.2	1.5	4.58	1
		73.5	13.7	10.9	1.9	6.90	2
	Summer	75.1	17.0	6.6	1.4	5.90	2

Moisture

Moisture in fishes varies with the amount of fat. Marine mammals depend on this moisture as their source of water, together with water derived from the combustion of fats. Poorly preserved, dehydrated fish jeopardize this important water source. Numerous facilities prevent water loss by introducing ice cubes into the diets.

Fat

The fats acids in fish are principally unsaturated, and vary in percentage in relation to location, season, reproductive activity, and the nutritional status of the organisms. Nevertheless, it is useful to class these feeds according to their relative fat content. Ether extract, an estimate of fat, is highly variable within and among fish species, ranging from about 2-50% on a dry matter basis (DMB), depending upon physiological stage, diet and season. Generally, anchovies, herring and mackerel have consistently high fat content. Fat is an important factor in fish storage; it becomes rancid, since the unsaturated fatty acids are oxidated, and even under optimum freezing conditions fatty fishes have a relatively short shelf life.

Protein

Fish are rich in high quality protein, having an amino acid pattern similar to that of other consumable meats, which means that the protein is highly digestible and has a high bioavailability. Whole fish are relatively good sources of most nutrients and similar to other whole prey items, typically contain a substantial concentration of protein (40-80 % DMB).

Carbohydrate

The carbohydrate content of fish is very low in contrast to invertebrates, which have nutritionally significant amounts.

Minerals

Most fish species are a valuable source of major and trace minerals. Some trace minerals, such as selenium, are present in fairly high concentrations in whole fish, ranging to nearly 5 ppm. In this instance, much of the selenium is in a complex with relatively low bioavailability. Sufficient selenium is available to meet the needs of piscivorous animals but without danger of selenium toxicity.

Sodium is present in fish and marine invertebrates at 0.2-5.5 % DMB. Although it is partially washed out at thawing it is difficult to justify NaCl supplementation for piscivorous animals without further evidence; on the contrary, it is desirable and recommended to maintain a saltwater environment for aquatic marine animals to prevent this supplementation with the use of seawater for the exhibit.

Piscivorous animals generally consume entire fish, including bones, skin, scales, and viscera. Bones and scales are the primary sources of calcium in whole fish but are not taken into account in most fish analyses.

Minerals are abundant in whole fish; however, it is well to keep in mind that their concentrations can be markedly affected by storage and handling procedures and get literally lost in the thawing liquid so the supplementation of trace minerals is advised (Cu, Zn, Fe).

Vitamins

Some species of fish may contain very high concentrations of the fat-soluble vitamins A and D. Vitamin E probably also occurs in ample amounts in fresh fish; however, since it is a natural antioxidant and fish oils oxidize readily, much of the vitamin E originally present may be destroyed prior to feeding. Vitamin concentrations, however, are quite variable with vitamin A ranging from

7,000 to 336,000 IU/kg (DMB), vitamin D3 ranging from 450 to 16,800 IU/kg (DMB), and vitamin E ranging from 23 to 433 IU/kg (DMB). Many zoos and aquaria utilize nutritional supplements for piscivorous animals that contain substantial amounts of vitamins A and D. At high dietary levels, both of these vitamins are potentially toxic, and the addition of vitamins A and D to a diet of whole fish may not be advisable (apart from pregnant and lactating females).

After a storage time of 60 days vitamin A and vitamin E are reduced over time, whilst Vitamin D remains relatively stable: for this reason either Reduce storage time or adapt supplementation after storage time of 60 days (Liesegang, Gimmel, Baumgartner, 2018, personal communication)

As by minerals, vitamins are abundant in whole fish, but their concentrations can be markedly affected by storage and handling procedures.

Quality standards

In this paragraph monitoring food quality during storage, thawing and feeding is described. Sampling techniques, nutrient analyses (calories, fat, carbohydrate, protein and ash contents) and the parameters of quality (ammonium volatile, histamine, peroxide, cadaverin, bacterial count on muscle surface and flesh, etc) are given as well. For more detailed information about monitoring quality please refer to 'Handling Fish Fed to Fish-Eating Animals' by S. Crissey (1998). The complete paper can be found on: http://www.nal.usda.gov/awic/pubs/fishhndl.htm.

The quality of fish can be determined by certain control factors during inspection and preparation. There is no decisive test to determine the quality of fish, but Table 7 provides an overview of descriptions of acceptable, inferior, and unacceptable fish (Crissey, 1998).

Table 7 *A compilation of descriptions of control factors. (Extracted from Crissey, 1998)*

Factor	Acceptable	Inferior	Unacceptable
General appearance	shine or luster to skin; no breaks in skin; no bloating or protrusion of viscera; no dehydration	some loss of sheen	luster gone, lumpy
Eyes	translucent, full; may be slightly sunken	dull or cloudy, slightly sunken	dull, sunken; cornea opaque (white); red-bordered eyes
Gills	bright red to pink; moist	pink to slight brownish	grayish-yellow and covered with mucus
Odor (smell)	fresh odor	mild sour or "fishy" odor	medium to strong odor, fatty fish may smell rancid
Feel	firm and elastic; meat does not stay indented when touched	moderately soft, slight indentation left when touched	soft, spongy and flabby; exudes juice and easily indented when handled; may break open or skin may split when handled
Vent(hole)	normal in shape and color	slight protrusion	noticeable discoloration

Lateral line	normal, no discoloration	pinkish tinge	red to dark red

Storage

It is recommended to store fish before being consumed, in a freezer with temperatures maintained at -18-20 °C. Refrigeration is appropriate for short-term storage prior to feeding and thawing of fish. Temperatures of less than 4-6°C are optimal for refrigeration. All the freezer and fridge parameters (temperature and humidity) should be constantly monitored and recorded to allow proper adjustments according to the requirements.

Once fish is removed from the freezer, it must be fed within 24 hours. Refrigerators and freezers for fish storage should only be used for perishable food, and animal-food-storage areas cannot contain any substances known to be toxic or harmful to marine mammals. “Relative humidity should be maintained at 85-90 % in refrigerated spaces, where a high humidity in the freezers helps to decrease dehydration of the frozen items” (Crissey, 1998).

Thawing

Fish should be initially thawed in a refrigerated space with temperatures that do not exceed 4-6°C. It is preferred that during thawing, fish is kept in plastic wrapping or a container that allows the fish to thaw consistently. Fish frozen in larger blocks may take longer than 24 hours to thaw: the outer fish may be removed to promote the thawing of inner fish. In case of urgent need, a smaller portion can be cut from a large, but half cut fish should not be utilized due to microbial contamination and micronutrients loss.

The following procedures utilized in the past are NOT recommended:

- Fish thawing in potable running cool water of 21°C is NOT recommended since it can result in an increased loss of water soluble vitamins, and promotes the start of microbial growth; it also leads to an enormous water waste.
- Thawing fish in standing water is also not recommended due to the increased risk of microbial growth and contamination, as well as a loss of water-soluble vitamins and other nutrients.

Fish should be fed cold, not frozen. The time between processing fish and feeding should be kept at a minimum (Crissey, 1998). Once thawed, fish must be fed within 24 hours depending on the temperature (if it is hot no longer than 12 hours!).

We provide as an example the thawing differences in Mackerel (latest results not yet published! Liesegang, GImmel, Baumgartner 2018, personal communication):

Thawing in fridge:

- Water content: 66.6 % OM
- Thiamine: 0.42 mg / kg OM

Thawing under running water:

- Water content: 62 % OM

- Thiamine: under detection limit of 0.2 mg / kg OM

Food quantity

The quantity of fish that should be fed is dependent on many factors: fish species and its caloric content, age weight of the animals, climate, etc. So, it is difficult to give precise quantities, but a general indication of the dietary requirements can be given.

Daily average amount of food intake varies per life stage or per species. Marine mammals should be fed on the basis of caloric requirements; small, young, actively growing animals or lactating females require relatively more energy (food) than older or larger animals. Changes of this amount will occur as the animal goes through physiological and motivational changes, and during different seasons of the year. Though food consumption is often expressed on the basis of percentage of body weight, it should be borne in mind that herring for example can provide three to four times more calories than smelt, but it varies seasonally and by location of capture.

When preparing to feed marine mammals, one should first determine the caloric value of each fish type on a lot-by-lot basis. Then calculate the amount of food that provides the quantity of calories necessary to keep the animal in good health, making allowances for growth, activity, etc., which varies according to temperature, season and physiological status. It is recommended to fish whole fish since eviscerated fish is often dehydrated and with lower nutritional values.

Table 8 *Daily average amount of fish required per individual according to the life stage.*

Life stage Phocids	Average (Kg)	Life stage Otariids	Average (Kg)
Harbour seal: new born (approx. 2 weeks old)	0,5	Juvenile	7--10
Harbour seal: young (3-4 weeks old)	1,5-2.0	Yearling	2--3
Harbour seal: adult	3.0-6.0	during breeding period	none/few
Grey seal: adult with young	10-15	Mature	5--15
Baikal seal: adult	5,0-6,0	Older	5--8

In the year 2000 a research study on the food consumption of Californian sea lions was done at Harderwijk Marine Mammal Park. The results were published in the paper '*Food Consumption and Growth of Californian Sea Lions* (*Zalophus californianus californianus*) by R.A. Kastelein, N.M. Schooneman, N. Vaughan and P.R. Wiepkema. Extensive chapters on metabolism and nutrition are published in both editions of the texts by Leslie Dierauf and Frances Gulland (Handbook of Marine mammal medicine published by CRC).

Behavioural conditioning utilizes food as primary reinforcement and supports the keepers when training the animal for routine husbandry procedures, including moving them from exhibit to exhibit. The food intake will usually be increased if the rations are spread over the course of a day. Occasional reduced consumption or even refusal of one or two meals should not in itself be a cause for immediate concern. Some species go into prolonged fasts during moult and periods of reproductive activity. Marine mammals should be fed individually by hand. New animals might need time to get acquainted to the procedure by going through an acclimation process that starts by taking fish from the pool first and then slowly from the keepers.

Vitamin supplementation or oral medicines can be introduced in the gills or in the mouth of the fish and pushed through to its abdomen.

Eating difficulties

It is the responsibility of the keeper to monitor the pinniped's appetite and feeding behaviour and report it on individual daily records. The daily food intake needs to be adjusted so that the keeper can maintain behavioural motivation for husbandry and training purposes, while at the same time satisfying the animal's appetite. If a pinniped begins chewing its fish excessively or becomes selective with fish types after previously eating all fish types, this may indicate that the animal is not very hungry. A further decrease in appetite is obvious if the pinniped pulls the fish apart using their front flippers and their teeth, flicking it around instead of eating it straight away. The keeper can attempt to prompt the animal to eat better. Proper husbandry training facilitates the task of creating proper feeding schedules to avoid undesirable behaviours. It is in fact also not desirable to reinforce poor eating behaviour. If the animal does swallow the fish whole but has been eating slower than normal, it may be desirable for the keeper to finish the session. If this behaviour is accepted, over time the animal will continue these eating habits. The keeper can signal that the feeding session is finished, and resume at a later time, when the feeding behaviour may have improved. If there is no improvement, and depending on the situation, the keeper can either walk away, removing themselves from the feeding session, or pen the animal and terminate the session and warn the veterinarian that there might be an appetite issue with this individual. These are only few examples where operant training protocols could strongly assist in the nutritional management of each individual.

These animals often require special feeding attention. They become more selective and sometimes need continuous coaxing to eat. When necessary, pinnipeds can be force fed, either by placing fish in their mouths or by use of a stomach tube. The latter is the preferred method of administering fluids to dehydrated animals.

Fasting

Spontaneous fasting is common, although it should always be considered individually and discriminated from potential pathology (such as anorexia, foreign body ingestion or other).

Some seals may go without food voluntarily, when the weather is either extremely warm or extremely cold. These animals become very lethargic, and are just floating in the water, trying to minimize energy loss. It is not unusual to see them sleep for the majority of the day. Females have been observed to loose appetite for some weeks and to become fussy with feeding during the

breeding season. Otariids are also known to have gone without food for longer than a month without pathological conditions.

Bodyweight should be recorded regularly. In general, the weight of an animal is considered a good parameter to rely upon to determine its clinical condition and to evaluate seasonal trends. The graph below shows the yearly body weight of a sub-adult Harbour seal born in Spring 1998. The marked decrease in body weight in the period from June to September is due to the summer period, in which most seals will limit their food intake and live on their blubber layer. From September onwards the weight increased as the seal was preparing for the winter (courtesy of Acquario di Genova).

Water

The pinnipeds water intake comes directly from the fish they eat, although they occasionally can drink small amounts of water while fasting throughout the breeding season.

Pinnipeds maintained in seawater can have access to fresh drinking water from a basin, trough, or tap although it is not mandatory since they acquire freshwater from properly thawed fish.

Rocks

All pinnipeds take in and regurgitate sand, gravel, or stones, presumably as a part of a natural process. Rocks can be found in the stomachs of pinnipeds; the reason for this behaviour is not known, even though it is suggested that they take in rocks to create a false sensation of fullness during fasting. Other reasons why seals swallow rocks may be that rocks may aid in the physical breakdown of fish flesh and hard fish bones. Stones could even be used by pinnipeds as ballast to enable them to dive so as to catch fish. More research on this subject is needed particularly when compared to the risk of foreign body ingestion inadvertently dropped in their environments (i.e. coins, plastic toys, pen cups, kids rings and pendants, etc. etc.) or be dropped into the water by seabirds overflying their space; these objects often cannot be excreted and create serious problems, which are difficult to diagnose and might require surgical treatment, even leading to death.

Forced feeding

Any pinniped that becomes very weak and ill, refusing to eat or drink supplementary fluids, may need to be forced fed. This may also occur to a new animal that has just arrived in an emaciated and dehydrated condition for rehabilitation and is refusing to eat, or during certain stages of pup weaning. Forced feeding is not a nice experience for the animal and should therefore be kept as short and positive as possible. If it is carried out in the right way, the animals should eat by themselves within four or five days.

When the need arises to force-feed young pinnipeds, it is always done as gently as possible and by experienced staff. One person catches the animal and holds it down; a second person opens the mouth with the help of one or two towels, ropes or rubber hoses and a third person wearing protective gloves or at least protecting the first finger, gently pushes a firm, medium size fish down the throat. It is important not to overfeed the animal, especially in the first couple of trials, to ensure a mild level of hunger and also interest (or even participation) in the following sessions. If it is not somewhat hungry, the animal may not learn how to swallow for an abnormally

prolonged period. It is important to teach the animal to swallow by itself, which is accomplished by not pushing the fish all the way down right away. The fish is pushed forward only in small steps and the keepers wait at each step, to determine if the animal might swallow on its own. This is more likely to occur if the animal is slightly hungry during the procedure.

It is important to point out that force-feeding can most often be avoided during weaning, if the animal learns to eat with the help of play behaviours. The keeper can encourage the animal to eat by playing with it. Tossing fish pieces, pulling fish pieces on a rope through the pool or simply dangling fish in front of the animal can encourage it to eat proving this method as being quite successful.

2.3 Social structure and behaviour

Natural social contexts and species-specific needs including population size, sex ratio and separation capabilities, and are vital elements when determining habitat size in order to create the right environment for every individual. Pinniped population management is achieved by consulting and working in collaboration with the relevant EEP/ESB Coordinator, not only for breeding decisions, but also, in general terms, to best allocate individuals. The co-ordination given by the program coordinators should be in line with the Marine Mammal TAG's Regional Collection Plan for pinnipeds.

This chapter deals with social structure and behaviour.

Social structure

Captive marine mammals must be given access to other animals except when they are temporarily maintained in isolation for medical treatment, parturition or in need of special attention. Careful attention should be provided to the species involved, their natural habitat and the available space in the zoo together with a good social structure increase individual welfare and prevents unwanted behavioural problems.

Group size and composition

For social species, a group size of between five and seven individuals can be considered a good standard. It is also possible to establish a larger group, and it is even recommended. Keeping several males in one enclosure will increase the social interactions and will improve the expression of their natural behaviours.

Males and females should be housed together during breeding season for their social interaction and reproduction. Behaviour varies according to whether the pinnipeds are in the breeding season or not and its consequences vary between phocids and Otariids. Adult males are the dominant animals in the social structure. The social order of all pinnipeds is generally determined by the order of copulation, and those species that copulate on land typically observe a harem system. For some species, keeping several males in one enclosure can increase social interactions and competition between males. The character of the males should also be taken into account. Some males are more aggressive than others and, for example, in order to house 2 male Otariid bulls together, the exhibit should be structured providing enough space for escaping behaviour.

In the wild hierarchy in females does not exist, but such a hierarchy can arise in a confined environment and it can change in time. This can be very reassuring for the group and should therefore not necessarily be avoided, so it is important to be able to recognize its establishment and manage it on a daily basis.

Best distribution of age is to have as many age classes as possible. Important is to have different generations. Pups are very important for the amount of activity of the whole group. When housing several males in one enclosure a good age structure is even more important to prevent aggressiveness. Social conflicts are good as long as it doesn't come to real aggression.

There are different solutions for surplus males. They can be castrated, but this results in a change in morphology (sea lions lose their mane) and behaviour. Otariid all males groups can also be housed as a bachelor group in one enclosure and euthanasia of surplus males is not a preferred solution but an option in line with EAZA population management guidelines.

Any new introduction of animals into a pre-established group should be preceded by a complete veterinary health check and possibly carried out by utilizing a neutral territory as initial place of introduction to other animals. When the introduction takes place it must be in an area that allows for escape routes for animals, as initial aggression is anticipated and often unavoidable. In the event of aggression taking place, the animals need to be given sufficient time to establish their hierarchy. They should be reassessed again before deciding to separate them. Otherwise, the dominant animal is being conditioned to practice aggression. With old age, aggressive and dominant behaviour can decrease enabling the animal to be housed successfully with other animals.

Sharing Enclosure with other Species

Socialisation can be possible with some other species. Housing different species together encourages the animals to exhibit inter-specific and intra-specific behaviours, such as territory displays (e.g. flipper-splashing, vocalisations) and reproductive displays and behaviours (e.g. bubble-blowing, following, copulation). It is also a good educational ground to compare the differences between species and orders. In general, success in affecting compatibility is depending on the following species specific aspects to be considered in order to make a responsible decision when housing different species of mammals together:

- Size and shape of the habitat (or habitat size and shape), climate control, furnishing of exhibit area
- Species: true seals can be better accommodated than Otariids
- Sex: males are more difficult to house together
- Age: older animals versus youngsters
- Previous experience of sharing same environment and its duration
- Temperament: whether either animal is aggressive, and/or territorial. The level of this will change with the time of year, e.g. in breeding season (this is difficult to tell when males are on their own and there is no breeding behaviour to observe).

It is also very important to prepare and predict upfront how to carry out the following procedures:

- feeding

- behavioural control
- breeding and social compatibility
- health checks
- individual and group welfare evaluation

A good advice is to base the combination on the one existing in the wild: this is also very important to respect coherence between the zoological representation of the natural environment (ie: Californian sea lions, harbour seals and sea otters share the same habitat in the wild); harbour seals have been maintained in some instances with female or young grey seals (since males might be very aggressive towards the individuals of the smaller species) always paying strong attention to the dominance that can develop during feeding time. For this reason, it might be easier to base the combination on differences in dominance and combine aggressive with non-aggressive species. Young and juvenile Californian sea lions are also often displayed with bottlenose dolphins, mainly during demonstrations to the public.

Earless seals can be housed together with sea lions, walruses and with other true seal species (e.g., grey and harbour seals), although cross breeding might occur and should be prevented. Aquatic bird species cannot be housed with seals due to their predation on these birds when they approach water, but other families of flying birds certainly can (as long as the veterinary tests show no signs of possible diseases transmission).

Individual marine mammals that are not compatible should not be housed in the same enclosure. When housing species together: a consistent, methodical and creative preparation of mixed enclosures is important and should take into account all previous practical experience. Trials to match compatible species have been carried out with few successes and many failures so it is advisable to have a back-up plan that includes a reserve-enclosure, in case the process turns in an unexpected way. Problems take place mostly on the fields of tolerance and use of space related to size of the exhibit area, feeding regimes and habits, animal husbandry, and it is therefore not advisable to house incompatible animals together.

Behaviour

An important element in determining habitat size and creating the right environment for any animal is to base it on its social needs and possible related conflicts. Consideration of the population size, sex ratio and separation capabilities are important elements of the animal's environment. In this context stress, behaviour problems and minimising procedures for aggression are described.

Stress

Some degree of temporary physiological stress is a natural part of life and involves numerous uncertainties in the environmental conditions to which all organisms are exposed. Stress is a condition of the animal as a consequence of a threatening or overburdening event that causes insecurity in the animal. For example: placing a stranded animal in an artificial environment can induce stress especially if the animal is ousted from its colony or in the initial introduction period. Isolation, limited social interactions and low social ranking can also induce some form of stress, which can become permanent if the animal doesn't manage to cope with it. It is therefore very

important that experienced staff monitor the animals and recognize signs of stress, which should be reported to management and the veterinarian.

The following behavioural indicators can be considered to be negative or undesirable reactions to a social situation and should definitely be reported and discriminated from events that require medical attention:

- Poor response to keepers
- Aggressiveness to keepers
- Poor motivation to eat
- Lack of social interaction
- Nervousness
- Auto induced lesions

The animal refuses to swim or play with other animals, keeping distance from and refusing to interact with trainers during play sessions, showing no interest in toys and enrichment devices introduced to the animals in their exhibit, while other animals show a definite interest in these activities. Stressed individuals might start suckling on its fur or its flipper showing stereotyped behaviour to cope with the situation. Suckling on the animals own fur is a behaviour that can be developed from a young age and is engaged during and after what seems to be a challenging situation for the animal. It is considered to be a displacement activity, which is defined as 'the performance of a behavioural act outside the particular functional context of the behaviour to which it is normally related'.

Crying and bleating. Young seals are known to exhibit this behaviour and their mothers recognise them by this call, but if this behaviour occurs regularly, not always coinciding with feeding times and more often than in other animals, it might be a sign of stress.

A good welfare status can be assured by having a well-structured group in the first place and through behavioural enrichment. If stress signs are persistent, a proper analysis of the situation and behavioural observation will be necessary, probably followed by a change in management, which can also result in the transfer of the individual.

Behavioural problems

Pinnipeds live in colonies and in confined environments it is important to be able to guarantee the welfare of every individual animal. Unbalanced age/sex ratio within the social group and restricted space might diminish individual welfare. Aggressive hierarchical dominance behaviour is natural in the wild but is disruptive to the captive colony and tends to lead to the infliction of damage to subordinates. There will always be individuals that can disrupt a group, particularly during breeding season. Restricted space limits the possibilities of the animals to escape.

If breeding is to occur, some degree of sociability must occasionally be present in every mammal. In animals with a harem system, such as the elephant seal, the same hormone that activates the reproductive system of males also increases aggression and territorial defence. Females due to giving birth usually become more aggressive soon after parturition, a phenomenon that may simply be due to an increased tendency to withdraw. Pinniped females follow the usual mammalian pattern of increased aggressiveness towards others with a sense of protection of their young.

Due to migration, drift speculations have been made about effects of captivity of migrating species during migration season. It is suggested that the gonadotropic hormones initiate migration, which might lead to consider temporary separation.

Sometimes too much food can increase the possibility of undesirable regurgitation behaviour. Behavioural problems in gating/penning or increased aggression really need to be assessed as to whether they are occurring because the animal's daily food intake is too high or too low. In order to assess this correctly, keepers need to know and be aware of the animals in their care.

Compatibility problems in zoo animals can generally and to some extent be managed and minimised following these procedures:

- Removing either the offending or the victimised animal from the exhibits
- Modifying the aggressive behaviour through training techniques
- Minimising body weight fluctuations, paired with direct reinforcement of non-aggression
- Plan new introductions with inclusion of pairs or small groups or even remove the entire group and reintroduce all the animals together
- Removing the dominant animal and reintroducing it only after the new ones have become established

These precautions notwithstanding, it is difficult to solve dominance or other incompatibility problems once they arise, except by permanent separation.

2.4 Breeding

All the main steps of pinniped captive breeding are described in the following chapter: mating, pregnancy, birth and the development and care of young.

Mating

The breeding season differs among species. The natural period for breeding may change in captivity. In European zoos the breeding season for grey seals starts in December/ January and for harbour seals in May/July. The breeding season for all Otariids starts middle of May and usually lasts until early August. The natural period for breeding may change in captivity. It happens that there are two breeding seasons: one in December and one in the period May – August. If breeding is to occur, some degree of sociability must occasionally be present in every mammal. During reproduction periods, there is either a modification of the space requirements or a change in territorial behaviour of the males for copulation to occur.

In animals with a harem system, such as elephant seal, grey seal, fur seal or sea lions this change requires a great deal of the neural system, since apparently the same hormone that activates the reproductive system of males also increases aggression and territorial defence. These changes in behaviour are vital, since a harem system dictates that a male becomes belligerent toward the males with which it was peaceable feeding or playing even a month prior to the increase in testis size. Male grey seals would fight so violently that it would result in severe bleeding and permanent damage. Adult males can gain weight rapidly before the mating season starts under influence of increased testosterone production. During the mating period, males eat a lot less than normal, or even nothing, and they lose weight. The need to replicate this important annual biological cycle serves no purpose for males that are not part of a breeding programme.

Males of the seals that mate in water, for example the harbour seal, have been observed fighting for access to females. When providing enough females, it is possible to keep more than one male in the enclosure. Baikal seal mates in water as well, and is assumed to be polygamous with little or no pair bonding. In captive harbour seals, behavioural observations during courtship are not reliable indices of paternity, and genetic tests must be performed in order to define paternal lineage. In one population of grey seals, large males sired significantly fewer pups than would otherwise have been indicated from their observed mating opportunities. Females tended to produce several pups fathered by the same male, who in many cases was not the large attendant male.

Pregnancy

Once mating has occurred, pinnipeds delay blastocyst implantation and the pregnancy process and duration in captivity is similar to the situation in the wild. In trained pinnipeds females, pregnancy can be followed and monitored with ultrasound examination, and prediction of birth date can be as close as 15 days in harbour seals (Gili et al. 2006).

A common concern in facilities housing marine mammals is the control of fertility in captive animals (e.g. Harbour seal). The harbour seal is a prolific breeder in the captive setting. The most common methods of reducing fertility have been: physical separation, castration of males and contraception.

For female phocids Porcine Zona Pellucida vaccine (PCP) has been found as a contraception method. The vaccine causes an auto-immune antibody response directed against recently ovulated ova that blocks sperm binding. Without sperm binding, the sperm is unable to fertilize the ova. This vaccine has been effectively applied to captive populations. Although this vaccine may have its use in captive populations, it is suggested that in some species it may not be reversible, and the females might stay infertile forever.

Birth

Pinnipeds will usually produce one pup. However, twins have been recorded. Adoption of pups by captive harbour seals has been reported; never in Patagonian or California sea lions.

At birth, the foetus surrounded by its lost lanugo emerges from the bathing fluid of the sac surrounding it, and it loses its mother's circulation via the umbilical cord.

The difficulty and the duration of the birth are highly variable. If the young mammal goes without oxygen (asphyxia) for too long, the oxygen content of the blood becomes inadequate to satisfy the demands of the brain, and permanent cerebral damage may then occur. After the birth, the mother immediately mouths the pup or picks it up. Mother and pup are then involved in smelling and vocalising to each other, which is assumed to be important for establishing mutual recognition. In an inaccessible area there is less threat of disturbance from human activity. Therefore, most pinnipeds in captivity will wait giving birth until the evening, when there is no one around. If this bond is not established, the mother and pup will not be able to recognize each other, which will result in the mother ignoring the pup and eventually the death of the pup. This might occur when the labour has been too intense or when physical separation has occurred to save the pup. This has also occurred in the case of a caesarean section performed in a harbour seal that could not deliver due to the rotation of the umbilical cord around the pup. In this case the surgical lesion was too

close to the place where the pup searches for the mammary glands and this behaviour led the female to stave off the pup (Gili, pers. communication).

Grey seal birth (Courtesy of Anna Jakucinska)

The average birth weight of a pup is very variable among species. For harbour seals the average weight is 8-10 kg, for elephant seals this is 35 kg. For California sea lions it is around 13-18 kilos

There are some species of seals (e.g. Baikal seals) that have a very different kind of breeding than the “normal” way. Wild Baikal seals give birth in dens. A captive two-day-old Baikal pup was placed into an artificially constructed den once. Within one minute it had dug one-third of its length into the snow wall and in eight hours it had made a 1,5 m long tunnel. It would appear that the pup wants to tunnel through the snow wall and get out. But this is not the reason. As soon as it sees that the wall of the den is becoming thin and is beginning to let through a lot of light, it stops the digging of the tunnel. If a Baikal pup is put out on bare ice, it will start wriggling and seeking a shadowy place, pressing up to the legs of humans. If the person starts walking away, it will follow. The reason why Baikal pups make tunnels is that its skin itches because of the moult from its white new-born fur to its silver-grey pup fur, and also because by now it has picked up a mass of parasitic lice from its mother. Besides, the growing pups have a great need for movement.

To minimise the metabolic overhead associated with lactation, phocids have shortened the lactation period to 4-50 days instead of the months seen in Otariids and Odobenids. During the lactation period, lasting an average of 18 days in grey seals, the pups quadruple their weight to over 40 kg.

In Otariids males have been observed to have a heavier birth weight than females. Pups double their weight in about 70 days. It showed that parturition usually took between 12 - 79 minutes, occasionally extending to 2.5 hours. After the birth, the mother immediately mouths the pup or picks it up. Mother and pup are then involved in smelling and vocalizing to each other, which is

assumed to be important for establishing mutual recognition. Separation prior to parturition can be stressful for the female and can cause various problems, such as the death of the pup. Females should therefore stay in the group when giving birth. Patagonian sea lion females separated before parturition and 7-60 days after giving birth have resulted in higher pup survival. It's also better for the dyads health to avoid mating during postpartum oestrus.

A female who has pupped recently needs special attention. Possibly, she will not eat the first days after birth. Careful monitoring of her health and appetite during pre and post parturition and the lactation period needs to be carried out, as her appetite will increase with the extra demands of lactation.

In the case of a female and pup that were separated at birth, neither recognized the other when reunited two days later. In some species, it is important that the pups are protected from the bulls that might become more aggressive during breeding time when the female is ready for mating. In an inaccessible area there is also less threat of disturbance from human activity.

Development and Care for Young

Pups grow rapidly in the first month. Harbour, hooded, and bearded seal pups differ from Otariids and other phocids pups by the presence of a thin blubber layer at birth. Observe maternal care closely and ensure that the pup is suckling regularly. It is possible that the pup looks like it is suckling but may not be receiving enough mother's milk: it will usually keep on calling for a while until it becomes tired and exhausted and starts sleeping all day long; in this case close evaluation of the pup might be mandatory. It is very important to monitor the pup's condition. If the pup is rejected, it may need to be taken for hand rearing. To evaluate if the suckling is successful without disturbing the mother binoculars might be used to check the dropping of milk from the teats of the female during and after suckling events. At Acquario di Genova many harbour seals pups have been born and raised both by the mothers or hand-raised and the protocol includes visual evaluation of the status of the pup at birth and, if ok, leave it with a mother for a maximum of 24 hours without intervention to give every possible chance of natural suckling; if after this time non successful suckling events have occurred the pup is taken for a very short period of time with gloves and clean clothes, checked and diagnostically evaluated, given fluids and repositioned with a mother for a few more hours. If still nothing happens it is then retrieved for hand-rearing.

Pups remaining with their mothers learn behaviour from them. Hand-reared pups need to be taught certain behaviours. For example, if a pup in captivity had never eaten fish before, it needs to be taught how to eat it and it starts with playing. However, they still display innate behaviours such as swimming, grooming, thermoregulation, courtship behaviour, and for the males, territorial and hierarchical display behaviour. Forced feeding should only be used as a last resort, considering this is a difficult process and carried out only by experienced keepers. The animal might be negatively affected when this process is done incorrectly. Problems can be permanent and even lethal in case of wrong fluid administration!

A hand-raised pup should have easy access to an area where it can remove itself from view. If this is not provided, the young animal could show signs of stress, which, if ignored, could lead to illness. It should also be housed in an area with shade and space to swim and exercise. If there are other Pinnipeds of the same age and species family, they could be placed together for periods during the day to observe their interaction, and if compatible, could be housed together. If

compatible, it is better for an animal to be with other animals than on its own. Pups need protection from temperatures and especially cold and wet ground surfaces in the first four weeks of life. Only then, the body fat layer is thick enough to provide sufficient thermoregulation. Pups are highly susceptible to pneumonia. This can be avoided with a shelter. Depending on a pups age and condition a shallow pool may be provided. The water level of the pool should be equal to the beach area, so the pup can enter and exit the pool easily. This will avoid prolonged periods of time spent in the water trying to exit. A weak pup in poor condition or ill, may require more protection from heat loss. Despite all these precautions, phocid pups are very good swimmers from birth (whilst Otariids enter the water after a few days a week from birth and need assistance of the mother to learn to swim). A successful birth of harbour seal occurred in the water at Acquario di Genova: the pup started to swim right away and the mother gave the first help to get him out of the water on the beach. At the beginning pups float in the first meter of water for a few days before learning to dive.

Newly acquired or newborn pups, should be attended by a minimum number of keepers with responsibility for its care. This provides a situation in which the pup can more easily learn to trust and feel comfortable building a relationship with humans. However, it is also important that it is attended by more than one keeper, to get used to routine. The awareness of early conditioning is crucial for the future behaviour of the animal.

Otariid pups grow rapidly in the first 18 months. Once weaned, growth is slower. When they are 18 months and till 3 years old they are called juveniles and are very active. They have to search for their food and their success will depend upon their ability to feed.

Hand- Rearing

Pinnipeds can be reared successfully in captivity. Hand reared animals still have normal reproductive cycle and behaviour. The formula needs to be based on the nutrients in the mother's milk, to be low in lactose, and high in fat. As the pup grows bigger it requires less milk in proportion to its bodyweight. For more information on hand-rearing please refer to the following books by - L.J. Gage: Hand-rearing wild and domestic mammals

- CRC Dierauf/Gulland Handbook of marine Mammal Medicine Edition 1 and 2.

Harbour seals are the most common species of phocids to be hand-reared. Below the procedure of hand-rearing a harbour seal pup is provided:

Formula (Harbour seal formula, HSF):

- Zoologic® Milk Matrix 30/55 450 ml (dry)
- Filtered water 450 ml
- Fish oil (salmon, menhaden, capelin etc.) 350 ml
- Lecithin granules 1 tsp
- Pinniped multivitamin 1 tablet

Do not use a blender to mix this formula to avoid air bubbles. Scoop dry ingredients into a large bowl, add the 450 ml water, and blend slowly with a wire whisk until powder is dissolved. Mix in oil and lecithin granules. Be careful not to overmix the formula, as it tends to thicken and turn pasty. The formula should be smooth with no lumps, ideally the consistency of pancake dough. Warm up to 25 to 30 °C prior to feeding. Although the formula can be kept refrigerated and used

for 24 hours, this is not recommended as the formula tends to thicken over time and may not pass through the stomach tube. It is simpler and less aggravating to make the amount required just prior to feeding. Beware also that hand-reared animals usually do not experience behavioural changes or discomfort in adulthood during breeding season.

Delivery methods and techniques

Bottles with lamb or human baby nipples have been used successfully and should be given priority, although they are more labour intensive, and tend to result in pups being more used to human handling; thus the choice of method will be influenced by plans for the pup's future release possibility.

A valid alternative, for rehabilitated animals destined to be released is the tubing technique with a clear vinyl stomach tube (1 cm outside diameter). Estimate the length of tubing required by measuring from the animal's snout to the last rib and clearly mark this distance on the tube for future reference. Pass the tube to this depth each time. A 400 ml dose syringe or several 60 or 140 ml catheter-tipped syringes will need to be filled with the appropriate mixture and used to deliver the formula slowly.

Harbour seal gastric tubing (Courtesy of Acquario di Genova)

Feeding frequency and daily requirements

The tube-fed pups are fed approximately every four hours. Tables showing how to rehydrate pups and work them up slowly from an electrolyte solution to full-strength formula can be found on the Handbook of Marine mammal medicine Dierauf/ Gulland, 2001.

Once the pups have been on the full-strength formula for 24 hours, the volume may be increased by 20 to 25 ml each day.

Weaning

Weaning occurs when the offspring transfers its nutritional dependence from milk to solid food. Weaning is sometimes initiated earlier in captivity than in the wild. This is started by offering the pup small bits of fish while the mother is being fed. Once the pup is actively eating the fish and showing a healthy appetite towards fish whilst still suckling, then it can be weaned.

Weaning true seals under human care is generally a straightforward procedure. In preparation for weaning, the mother can be moved to a different area for intervals during the day, thus avoiding useless stress to both animals and it is therefore important to remember that each individual case will be different. Research shows that the time of weaning is influenced by whether the female gives birth the next breeding season. Harbour seal pups are very precocious and can therefore be weaned very easily. Weaning of the pup can be either abrupt or gradual; both mother and pup becoming less interested in each other towards the end of the nursing period (4 - 50 days depending on the species). Playing with small fish and occasional ingestion is the beginning of the process, which can take a few days to a couple of weeks. Only when pups absolutely do not show feeding behaviour, force-feeding fish should be applied. Once a pup has reached one month of age, is clinically healthy, gaining weight satisfactory, and the teeth have erupted, it is time to introduce fish diet. Initially, the pup is shown a fish by placing the pup into a pool and offering the fish held with forceps. The preferred fish for pups is small herring, but smelt may be used. Smaller fish are preferred for the fish introduction process whenever available. Floating fish in the water or offering live fish are other alternatives to fish introduction. This is repeated on a daily basis until the pup exhibits a response. Fish pieces and/ or whole fish may be offered at this point. Harbour seals tend to start eating fish with only little encouragement, although swallowing fish may be difficult if the offered fish is too large. Pups tend to gnaw and chew larger fish prior to actually swallowing. Force-feeding is necessary if the pup has not responded to the above methods of offering fish. Force-feeding involves restraining the pup, placing the fish in the animal's mouth, and assisting the swallowing reflex by gently pushing the fish past the gag point. It is best to use long, slender fish, preferably herring. The fish should be firm, not frozen. Dipping the fish in water before placing into the mouth is helpful. During the force-feeding process, the number of stomach tubings gradually decreases.

Weaning in general is a critical issue for Otariids where, very occasionally, females will continue to suckle yearlings to the detriment of a new pup. Observations indicate that at one year, they are still dependent on their mothers for survival, suggesting that 12 to 15 months is the time needed for pups to grow and develop to the point where they can survive on their own. Weaning can start around 3 to 6 month in otarids and around 1 year for fur seals and it is a very common problem that fur seals and sea lions do not wean successfully on their own. Many times they have to be force fed fish over a long period to encourage them to eat fish on their own. This is a difficult process and many problems have occurred when inexperienced people attempt to force feed pinnipeds, for the animals as well as for the inexpert handlers (including severe bites). The animal might be negatively affected when this process is done incorrectly. Problems can be permanent and even lethal. Usually it maintains the two food sources until 18 months of age. If it is desired

for the mother to breed sooner, then the pup may be encouraged to wean earlier. If it has a healthy appetite for fish and is maintaining a good weight, this should be possible.

Other practical information

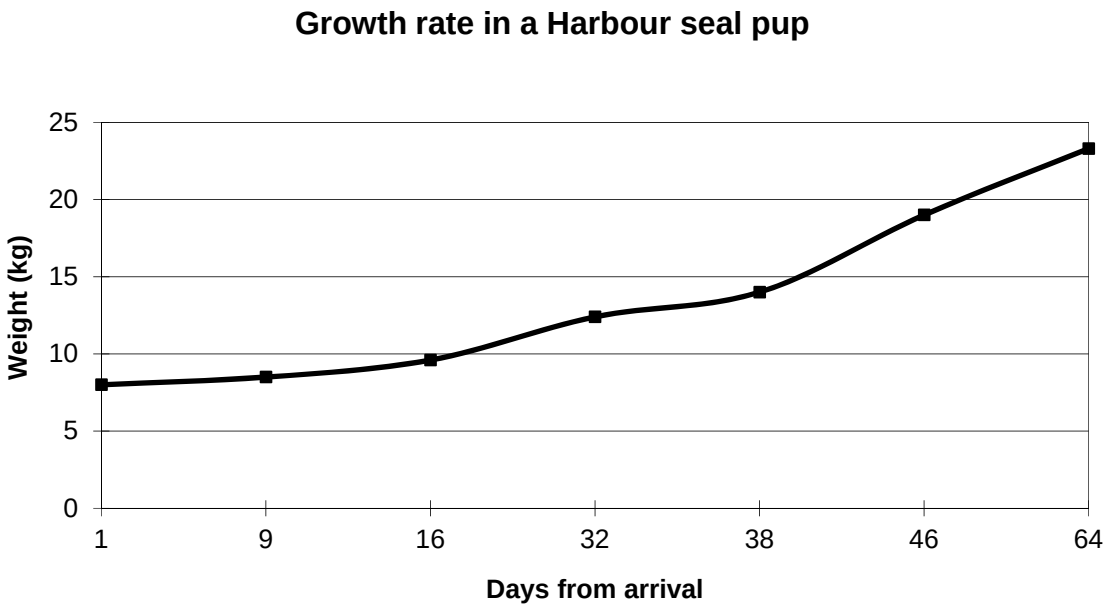
Although access to water at all times is beneficial to older pups, access may be restricted for pups with lanugo coats and those that are severely emaciated.

Grey seal pup with lanugo (Courtesy of Hering-Hagenbeck)

Provision of child-safe heating pads for these pups to lie on further reduces caloric consumption. If the harbour seal pup is to be rehabilitated for release, handling and human interaction should be very limited. The recommended release weight is 35 kg, but pups may even be released at 20 kg if the girth is adequate and body shape is more stout than long.

Not much information is available on growth rates. Growth rates can be very helpful in hand-rearing pups to determine mean weight increase in the growing process of true seals.

Graph 1 shows the growth rate of a female few days old Harbour seal pup, found abandoned by the mother. The pup was taken to EcoMare in the Netherlands where it was forced fed. Due to the unknown date of birth, the graph starts at day 1 from arrival. Feeding of fish started on day



12, and on day 64 the pup had recovered and joined a group of seals (Courtesy of EcoMare). For more detailed information, please consult CRC Handbook of Marine Mammal Medicine: Health, Disease and Rehabilitation. Edited by Leslie A. Dierauf

2.5 Behavioural enrichment

Marine mammals are naturally playful and curious animals. When living in zoos, they need stimulation of all kinds. Most pinnipeds demonstrate extensive investigatory behaviour and manipulate any strange object. This chapter is about enrichment of pinnipeds maintained in artificial confined environments. After a brief introduction the different methods of providing enrichment are included: exhibit construction and furniture including naturalistic and artificial enrichment, social interaction, food hiding, and training of the animals.

The term enrichment will be defined very broadly, encompassing the animal's entire captive environment, its physical, social and cognitive environment, the role of human caretakers (feeding, cleaning, training, other interactions), diet (type, presentation, and variety), etc. Providing behavioural and environmental enrichment is important for the psychological and physiological wellbeing of any captive animal.

Environmental enrichment is necessary to provide behavioural enrichment and to avoid inappropriate behavioural problems thus reducing aggression, stereotypic patterns and stress-related problems. Environmental enrichment programmes provide an increase in the activity of the animals. The animals are stimulated and given the opportunities to choose and search new tools by interacting and exploring the environment and engaging with different challenging feeders or playtools. The public also responds positively and watch the animals exploring their environment and interacting with each other.

The only limit to what you can provide should be your own imagination, provided the safety of the animals. In the wild these animals would have many other stimuli. The adaptation of the animal in its natural environment as well as its biological requirements should be the basement for a good reference. There is a responsibility to provide random behavioural and environmental enrichment to the best of our ability. Enrichment must always be properly planned and should be goal derived. It is important to know what behaviour wants to be stimulated and why. How it will be stimulated is up to the keepers to think about, but evaluation and re-adjustments are of utmost importance to ensure the achieved reaction is the expected one by the keepers. If the expected behaviour is not achieved it is not necessarily wrong, it just needs to be re-thought. What caretakers believe to be "positive" or "enriching", might not always be right, so observation, evaluation and adjustments are important, making sure to maintain positive behaviours in the group. Specific tools to provide enrichment to large individuals might become quite expensive but these constraints cannot be compared to the wellbeing of the animals.

Seals can be tough to enrich at times, especially with non-food items. For enrichment to maintain its value it is important for it to occur randomly, for varying lengths of time and at different times of the day. To avoid satiation, all tools utilized should be varied and also rotated, on a random basis retaining its novelty characteristics. They should also be presented in different ways and in creative locations within the habitats. Good relation between animals and carers should be encouraged and training new behaviours can be enriching. Behaviours often observed include natural sparing, foraging, playing with objects, grooming, investigating, resting, sleeping, swimming and porpoising.

The best type of enrichment is con-specifics. This gives an animal the chance to display more natural behaviours, such as mating, competition, caring of young, play, etc. A Pinniped should therefore always be kept in a group.

Social interaction

In the wild eared seals are naturally social animals, and it is extremely beneficial for sea lions to be in contact with other sea lions or seals. On the contrary most seal species are somewhat unsociable. Multiple species relationships are a growing form of environmental enrichment. There are some species, like the elephant seals and grey seals that are gregarious and gather together for breeding, moulting and hauling out. It is thought that the necessity to avoid predators is one of the main reasons that harbour seals prefer to haul out in groups rather than alone. Mimicking the same conditions under human care should make the animals more at ease providing social bonds forged among each other which can play an even greater role in the well-being of these animals, positively affecting their quality of life. Social interaction on its own can be a powerful enrichment tool affecting positive behavioural changes in animals in good health. One must recognize if social behaviour starts to be ‘undesirable’ at times, and in these cases early detection and proper enrichment programs may have a definite role in creating and encouraging an overall improvement.

The exhibit

Most enrichment programmes today provide the animals with enclosures and novel experiences designed to stimulate and encourage natural behaviours for the species held. The design of the exhibit is a large part of all enrichment programmes. The naturalistic exhibits now being built at

many zoos often provide great enrichment value for animals since they are conceived by considering their natural history and targeting the expression of species-typical behaviour as a goal for the exhibit. Although these exhibits are aesthetically pleasing it is impossible to build the natural environment in its integrity. The role of enrichment is to ensure that the exhibits are naturalistic for the inhabitant and enjoyable for the viewer. Animals should be motivated to use the exhibits in its full potential. The lack of activity, overweight animals, aberrant behaviour, and the well-worn paths at some exhibits are poignant reminders that there is something lacking in the lives of the animals that inhabit them. These aspects should suggest and induce the management to modify the exhibit accordingly.

Features used to enrich the exhibit are:

- Gate: the pool can be made with several features that are potentially enriching for the animals. For example a gate that can be used to separate the pool. This allows more individual interaction with the Pinnipeds, varied training opportunities (each side of the exhibit has different features), as well as creating variety in animal grouping.
- Waterfall or artificial produced waves: pinnipeds are attracted to “falling” water and waves are a part of their natural habitat.
- Water currents: seals enjoy swimming in currents; they need less energy and can keep it up for long periods. Currents can be created by placing a boat propeller in the water (make sure to place a cage around the propeller so that the seals can’t get hurt). Make sure the current is not present all the time, to avoid boredom. The current should not involve the entire water column to give the animals the choice of engaging in the current or not.
- Rocks and/or several beach areas: rocks and beach areas stimulate natural behaviour like climbing, hauling out and sunning. On a rock outcropping in the middle of the pool, the pinnipeds can be found playing ‘King of the rock’ mostly during the moulting period. Hauling out and sunning enables to have warmer skin temperatures, which can help speeding up the moulting process. Sand and gravel can also be used on land or on the bottom of the basin.
- Basin with an unequal bottom: animals that swim a lot do of course need a water basin. Sea mammals can display more playing behaviours, and the display of stereotypic behaviour diminishes in a ‘natural’ looking basin. A basin with an unequal bottom provides variety, but also becomes boring or normal after length of time, so additional variety should be used and/or implemented from the start.
- Scents: enrichment incentives such as spreading urine or faeces from other animals, or dispersing aromatic plants or other scents can encourage animals to investigate previously ignored areas of an exhibit. This needs to be discussed with the veterinarian and curator to ensure no risk of disease transmission is possible.
- New environment: the animals spend time exploring their new environment when they are moved into a different habitat or given access to another habitat.

Beware that most Pinniped species are quite curious and quite often it might happen that certain parts of the exhibit attract their attention and their attitude to dismantle and destroy the edges and material that can be “particularly interesting”; this is certainly an enrichment for them despite it being unwanted by their caregivers. All the tools that can be of the size of the mouth should be returned to the keepers by the animals in order to avoid foreign body ingestion.

Food items

Enriching seals with food items are an important type of enrichment. There are many different ways to use food items as enrichment:

- Feeding times: for many mammals it is of use to change feeding times regularly. If the food is spread over different places in the enclosure, it can keep the animals busy for a long time.
- Fish in ice: pinnipeds become very active if you give them a cube of ice with frozen fish. This cube can be made by freezing fish in a bucket, a pan or a fish-sickle. To prevent that the fish is only frozen partly, or that all the fish sinks to the bottom, it is best to freeze part after part. To gain the fish will take much time and effort. Care should be taken that the fish itself is not frozen, to prevent damage to the stomach.
- Blood-sickles: freeze the blood and guts from the fish with water in a bucket and dump it in the pool
- Transparent ball with fish: as a variant on the PVC-tube with fish, a hard transparent ball can be used. The ball (diameter 40-50 cm) must consist of two parts with a rim for the screw holes. In the ball there have to be made holes with several sections so that small herrings, mackerel and sprat can be put through. Put fish in one part and the other part must be screwed on it. Finally a driver must be attached to the ball. Throw the transparent ball with fish into the pool. The seals' curiosity will lure them to the ball, also because they can see the fish. It will take them a long time to get all the fish out. The ball has to be made of solid material, otherwise the seals might be able to break the ball.
- Floats: Instead of the transparent ball floats can be used as well. Just drill a couple of holes (of different sizes) in the float and fill it with fish.
- Fish placed on top of Frisbees and thrown into the pool
- Dead crabs: crabs are very interesting and challenging for eared seals, as they need to be careful not to be nipped by the crab. Crustaceans are a part of their natural diet.

Whenever food is utilized as enrichment always make sure that shredded fish that is not eaten is removed from the basin to avoid rotting, blocking the drains and influence animal health. Calculate the fish amount, observe which animal is eating what and make sure to avoid aggression, and make sure all eat enough, both dominant and less dominant animals.

It is NOT RECOMENDED to feed live fish and or crabs to pinnipeds (despite this would engage the animals in natural chasing and hunting behaviour) for the following reasons:

- the source of the alive fish is not pathogen free
- this behaviour is cruel for the fish in a confined environment with no escape
- It might not be liked by the public
- In some countries is illegal

Enrichment tools

Enrichment tools should be divided in two categories: supervised and unsupervised, depending on the potential hazard for the animal and the need to have interspecies interaction. Enrichment devices should only be left unsupervised if they have been evaluated before and deemed appropriate for the behaviour that wanted to be stimulated. It is hard to find objects that can be left in the water unsupervised. Boat shops can be good sources. It is important to monitor the

exhibit and make sure each tool is accounted for at the collection time and remember that some animals can become aggressive when these are removed. Proper methodology and planning can help avoid this. Make sure all enrichment items are cleaned and disinfected regularly. Sea lions can rip things apart and safety should be the first characteristic to look into!

Eared seals exhibit a natural sense of play. Safe durable objects can be hard to find for eared seals because of their natural chewing and destructive tendencies. In some facilities sea lions are given access to a box so they can choose their own object, and this open choice system could work for seals as well. When given the choice, individual animals will find their own object, which provides an interesting and stimulating experience for them. Simple everyday objects can turn out to be the most favourite. Consider everything appropriate and try different types with constant monitoring. What one animal might find interest, might not interest another. When providing tools for a group of animals, the number should be equal or more than the number of animals to avoid dominance attitudes. Aggression could occur otherwise. To maintain a tool's stimulating value, it is important to only randomly have it available.

A few examples of enrichment tools:

- Air and water hoses: seals enjoy playing with and chasing hoses in the water. When being hosed they position themselves so the high-pressured water massages around e.g. their eyes, ears or nose. The sprays can be below or above the water and set at different intensities and parts of the pool. Sometimes setting up a sprinkler that falls in the pool is fun, because the water spray moves around the pool. Put an air hose with holes in the pole, this creates a 'bubble curtain'.
- Different buoyancy's tools: these will sit on the bottom, which the seals may like to push around. By filling all these objects (ball, milk jug, etc.) with different amounts of water you may get neutral buoyancy, so that it hovers in the pool. Items that are suspended at different heights above the pool can also be interesting, because the animals can hit them and make them swing. Be careful that the animals can't get entangled or 'hung' in them.
- A play float: a float is easy to build with wooden boards with underneath plastic barrels. The barrels have to be tied securely with ropes on the boards. Next to the function of a play element, a float has a function to gain strength in the muscles of the flippers, because the pinnipeds need to use a lot of strength to climb on the float. A foam platform can also be utilized, by placing mop heads underneath a tactile experience is created.
- Visitors: the public can also be used as enrichment, which greatly increases the variation in environment. Interactions stimulate behaviours, such as following the public or simply staring out at the visitors. This can be made possible by for example an underwater viewing window.
- Mirror held by keeper/trainer: this way the animal can see himself and can try to "discover" who he is dealing with, by looking in and behind the mirror.
- Boat: the animals can rub against the boat, or jump in the boat.
- Bubble wands with bubbles blown by keeper
- Water squirt
- Scrubbing brush
- Bowling balls
- Rope
- Plastic bats
- Objects hung from enclosure rope
- Barrel, coconuts, problem solving dogs toys

- Frisbee, ball-shaped floats
- Holding lights at an underwater viewing window
- Frozen in ice blocks
- Different sized boomer balls
  Smooth large rocks, Floating and sinking rings (observation is necessary for safety and swallowing)
- Submerged “kelp” to stimulate the movement of kelp strands (beware of possible ingestion).

“Naturalistic” enrichments

Here two examples of naturalistic ways of enrichment are given.

- Bull kelp: if you have the possibility, you can collect fresh bull kelp from the beach and toss it in the pinniped exhibit. The seals can chew on it, play tug or war with it and carry it around under their flippers. Please note that fresh bull kelp should be cleaned before use, due to infections and pollution problems.
- Driftwood logs: driftwood logs into the exhibit and drill holes in some log and strung bull kelp strands through the holes. The nematocyst keeps the bull kelp from slipping through the hole while the strands dangle in the water. (Bloom, 2002; Mead, 2001; pers. comm. Meijer)

“Relating” with the animals

In most facilities, keepers frequently enter an animal's enclosure for feeding and cleaning and in these occasions, interaction of staff members can also become a part of the enrichment, with or without more tools. The “relating” concept has several forms: interaction between person and animal; non-interaction between person and animal; interaction with tools between a person and animal; and random reinforcement of “relating”. Several variations of these forms exist by changing the number of people and animals involved and even just the keeper’s presence will actually alter, and therefore enrich the environment. Beware that even if the animal does not interact, the keeper can still be there spending time with the animal. This is a relaxing unstructured time the keeper can spend with the animal without the associations of training and feeding. During “relating” animals can be inquisitive. This can be a good time to introduce props to desensitize the animals for future training and husbandry.

Recognition and interaction may not occur immediately with all animals. Animals tend to prefer interaction with each other to interaction with keepers. A young animal familiar with the “relate” concept may show a higher or stronger interest compared to that of an older, more mature animal. An older animal that may have been unfamiliar with this type of play session as a young animal may be less inclined to interact. To capture the interest of an older animal unfamiliar with this concept is a challenge. Even the slightest acknowledgement of an object or trainer is a sign of success. It is probably harder work for the trainer to interest an animal so challenging but, one should not give up since these forms of enrichment aim to provide the psychological and physiological needs of the animals in care. For relate sessions to be successful you need to have a dedicated staff. Having related time on a schedule will ensure it will occur.

The occasional use of random reinforcement can be applied to reinforce desirable behaviour. Particularly on introduction of a person into a new animal's enclosure, the person may be in the water or on land. Calm and non-aggressive behaviour towards the person is desirable and can therefore be reinforced. An animal's environment and all the factors in it, help to shape an

animal's attitude. This could include attitude towards trainers, behavioural conditioning, or other animals. Their overall attitude towards all these variables can be reflected in the behaviour that they display. 'Relate' sessions can be beneficial in establishing rapport with the animal and in attitude shaping towards people and the concepts they introduce.

2.6 Handling

This chapter is about handling Pinnipeds in their captive environment. Not all animals can be handled easily. Some species are dangerous, too active or excitable, or too large and heavy. Such animals may require special tools, cages, ropes, anaesthetics, etc. All specimen can also be trained to make handling as easy and comfortable as possible

Individual Identification and Sexing

For practical collection management purposes and record keeping, all animals should be identifiable by microchips or transponder, although most animals are individually known by name. In most cases microchips are inserted in young animals in their first week during their first medical check when they should also be sexed. Photo ID might also be useful.

For pups, sexing can be established by physical examination of the genital area. As young adolescents, unless physical characteristics such as the scrotum, penile opening or teats are visible, it is difficult to accurately identify the young males from the females visually in true seals. Most pups can be accurately identified at a few days after birth. In the male the distance between the anus and penis is about 10- 15 centimetres. In females, the distance between the anus and vagina is maximally 2 centimetres. Misidentifications in sex determination occur often due to the slit-like opening of the anus.

Capture and restraint

All captive wildlife is at time handled for capture, restraint and/or anaesthesia. The ability to safely perform these procedures is a basic component of professional management and health care programs in zoological collections. The general concepts for physical restraint remain fairly constant over time, however, anaesthetic drugs and associated techniques are continually improving as well as the tools available for human protection and safety; for this reason it is therefore necessary to constantly update procedures.

Facility design

The most important factor governing success in animal handling is the animal facility. Almost every mammal should be housed under conditions that allow shifting and crating without the use of chemical restraint and anaesthesia. This can be accomplished by a combination of properly designed facilities and management practices that permit selective movement and containment of the animals. Certain basic elements of an enclosure facilitate animal shifting and confinement. For example, each individual should have access to a small holding area available that should be utilized on a daily basis and, if necessary, be used for confinement. Such an area permits closer access for observation, anaesthesia, or transfer to a transport container so that it can be moved to a medical facility for examination and treatment. Other secondary benefits include the ability to monitor individual food intake, administer specific medication in the feed, and train the animals to collect individual diagnostic samples. The facility design should include means to weigh the

animal and to shift it to a squeeze cage or a safe place to use a blowpipe. When pinnipeds are acquired into a collection the management should plan to allow staff expertise, time and dedication to ideally have all individuals placed into a training programme for all husbandry behaviours (weight, measurement, close observation, palpation, auscultation, mouth check, eye treatment, faecal collection, gating, injection and blood collection, echography, X-ray etc. etc.) in order to diminish the amount of stress on the animals and the infinite logistic every time one must approach the individual even for simple procedures.

Capture

Pinnipeds are difficult to capture because they can be aggressive and because their heads are very mobile and can inflict severe and often infected bites. Phocids and small Otariids can be handled with stretcher nets, throw nets and hoop nets. Thereafter, one or two people straddling it and securing the head with both gloved hands placed firmly around the neck can restrain a smaller animal. Use as little force as necessary; a small seal can suffocate under the weight of a handler, especially if rocks or sticks are pressing into its thorax. Large ones, because of their agility and speed, are more difficult to capture and restrain, and several people may be required to close in and block the escape route with herding boards. It is important to assess the degree of risk to be taken if the animal is in very close proximity to the water. If an animal flees to the water entangled in a net or after sedation is given, this could be fatal. It is also important to assess the terrain before attempting a capture, as a capture would be useless if the area is inaccessible for transport.

This should be avoided by proper planning of the procedure well ahead and utilizing herding boards, separation fences, or by removing the animals from water access etc. etc. Forms of restraint equipment are: a hoop net or net stick, a wally net, a physical restraint board, and a head bag. These are used in research projects and in captive situations. For research projects and capture of a wild animal, a certain amount of distance from the animal will prove to be safer. A net stick is highly recommended, its design enables the hoop and pole section to be quickly detached after capture. The design of the net with its built in head bag also facilitates easy handling and reduces the risks of injury to the animal and handlers. A net stick works well for animals up to 100 kg - females and young males.

If there are other animals around, it can also act as a fending stick from them. However, a wally net is recommended if attempting to catch a mature male, as they can be very dangerous. It can be pulled tightly to immobilize the animal. These nets can be used on sand or flat surfaces, but would not be appropriate on rocky surfaces and every net is very dangerous for the animal if it falls in the water.

Blocking an animal's vision with any type of head bag or eye cover will help to calm the animal. Keep in mind that the animal needs sufficient possibilities to breath.

Moving into boxes

Pinnipeds can be trained to enter cages and boxes at need.
Where and when this cannot be done due to external circumstances, one strategy for moving a large passive seal (up to 135 kg) is to roll it in a large blanket and onto a stretcher for removal to the transport vehicle. There it is transferred to a cage and the blanket removed immediately.

Boxes can be designed specifically for capture by incorporating such features as an opening at each end with drop-in-doors that will encourage the animal to the netter, believing it has an escape route at the other end.
A seal can also be herded into a box that can then be turned upright and covered with a lid.
A small plastic sheet (such as those sold for snow sledding) can be used to slide heavy wooden cages along sandy beaches.

Restraint

Even with improved anaesthetic techniques, there are situations (e.g., drug injection by hand syringe) in which physical restraint is mandatory. Physical restraint is used primarily for short-term, minor procedures such as injections or collecting blood samples, if the animal is not trained for these procedures.
Before physical restraint is applied, an overall evaluation should include the following questions:

- Can the planned procedure be done with physical restraint only?
- Can the restraint procedure be performed without compromising the safety of the animal or the staff?
- Will the procedure cause significant pain to the animal? If so, an anaesthetic drug should be considered.
- Are the appropriate facilities, equipment and staff available?
- Are skilled people on hand for the restraint procedure?
- Curious onlookers should be banned.
- Answering these initial questions generates additional questions about each individual animal:
- What are the animal's defensive weapons and how are the handlers protected?
- What is the animal's flight distance and how can this estimate be used to facilitate safe capture?
- What unexpected events may occur?

Marine mammals can be physically restrained with the co-operation of a well-trained animal keeper and a skilled animal trainer or, in the case of Pinnipeds, with squeeze cages or nets. For many minor diagnostic and treatment manipulations, a trainer can control the animal so that no further restraint is required. This control can be facilitated by having the animal "beach" (i.e., come out of the water) or by dropping the water level in the exhibit pool to "strand" the animal.

In untrained small to medium-sized animals, nets or squeeze cages are used for diagnostic and treatment manipulations. When marine mammals are removed from the water, care must be taken to prevent skin abrasions and hyperthermia. A smooth work surface and frequent spraying with water help to prevent these problems.

Marine mammals tend to develop apnoea with many anaesthetic drugs; local anaesthesia in association with physical restraint is used for minor surgical procedures and this procedure would be carried out on site. For easier restraint when the animal needs to undergo surgical procedures, it is usually given sedation such as diazepam either by injection or food. After this sedation has taken effect, a head bag is placed over the animal's head to protect the keepers from bites, and calm the animal. Other team members assist in holding the animal to restrain its movement. Depending on the particular situation, the veterinarians can then either perform minor medical procedures on site, or induce general anaesthesia with an injectable or volatile (isoflurane gas

given by mask) anaesthetic agent if the animal needs to be moved for major medical or surgical procedures. It is important to have the pinniped intubated soon after anaesthesia is induced (i.e. unconscious). The animal could then be connected to oxygen or to the aesthetic machine for administration of oxygen or anaesthetic gases not long after.

Stress

Most Pinnipeds become agitated by the capture procedures. As for any animal species, covering the eyes with a hood of dark cloth, towel or blanket, or a moistened jute bag placed over the animal's head may induce calming and thereby help avoided injury to both animal and handler (please beware the animal needs to keep breathing and the material should not cause abrasions on the eyes)

Calming beyond these simple measures requires chemical immobilisation, which is always risky. Apart from the usual problems encountered when sedating or anaesthetising Pinnipeds, there are the added complications of accurately judging the weight, the thickness of blubber that the needle must penetrate, and the health of the subject. Only qualified veterinarians must carry out chemical immobilisation.

Capture from the wild

This might occur as a very exceptional phase of the rehabilitation process and in order to carry out this procedure safely for both, animals and people, a few steps should be planned and followed

Planning ahead

If the animal is in an area, which excludes eye contact, the element of surprise may be an advantage for the capture. Wind direction should be taken into account, since seals have a well-developed sense of smell. This gives the capture plan an advantage. If the seal picks up the scent of approach, it may either flee the site into the water, or become alert and ready to defend itself when the initial capture begins. It is important to consider and organise plans for the escape of staff in possible dangerous situations. Have herding boards on hand at all times during capture and release for self-protection, and for helping to herd the animal into an area. When the animal is in captivity, before proceeding with the restraint, the area needs to be secured from other non-involved staff.

Capture team

To perform a successful capture with minimal stress to the animal, it is important for each member of the capture team to know their particular role and to co-ordinate their actions as a team. It is advisable to rehearse restraint procedures beforehand with the capture team. The strength of even a sick or sedated animal should not be underestimated. The number of staff needed will vary depending on the size, age and possible aggression of the animal. Staff also needs to be physically strong.
Equipment needed will include a net stick, head bag, wally net, herding boards, stretcher and transport cage and the following steps can be followed:

- Step 1. Once a plan of action is developed, the most experienced team member will approach the animal with a net stick. The person in the lead role of securing the net over the animal needs to be

confident and clear in his actions. If the animal can be caught off guard, then the capture will proceed with less stress to the animal and less provoked aggression from the animal.

- Step 2. Once secured in the net stick, the animal could be further restrained for sedation. This method works well with two to three people, depending on the size of the animal.
- Step 3. Once in the net, the animal can be sedated. For injection a jab stick could be used. Do not use a sedative if the animal is sick or too weak to fight. It is important to evaluate the animal's breathing to ensure that it does not become distressed. The net must not be so tight as to limit the animal's breathing. This applies also to the weight placed on the animal by the person straddling it. When using nets, it is important to protect the animal's eyes and nose. Close attention should be paid to the netting around the face, so as not to cut the face.
- Step 4. The transport of the animal can then proceed.

Transportation

First in this chapter the cages are described, then the transport, divided up in transport by airplane and transport by car. Parts of the International Air Transport Association (IATA) regulations are included as well.

Cages

A cage should always be used during transportation. This is especially important for transport from the vehicle to the enclosure, so an uneventful transfer is guaranteed. Transport cages must be large enough to allow an animal to stretch to its full length, raise up its head, and turn around. The use of a so-called “Sky kennel” is allowed for smaller animals and youngsters. Some of the more aggressive species are better off in smaller containers. Pinnipeds need an enclosure, which provides circulating air and “freedom” from contact with excretory wastes. Cage bottom and sides have to be waterproofed to prevent leakage.

Containers should have openings small enough to discourage the animal from biting the caging material (or anyone near it) and thus damaging its mouth or breaking nails while rasping on the walls, but large enough to observe the animal.

Larger Pinnipeds are often placed in squeeze cages similar in principle, though different in design, to those used for the larger wild members of the cat family. Very young animals can be transported together in one cage, but in general animals should always be transported by themselves in order to avoid any damaged inflicted to one another even just during a moment of fear or nervousness. Captive Pinnipeds should be trained to enter a cage.

Never place animals in closed Unitised Load Devices (ULD containers)

IATA: the International Air Transport Association (IATA) has made regulations for the international air transport of animals. In the following text the container requirements are described. There is a new edition every year, frequent changes of requirements are possible, so attention must be paid to gain the most recent version.

IATA Container Requirement applicable to: Elephant seal, Fur seal, Sea lion, True seal species, Walrus.

Materials: solid wood, plywood, strong material, welded wire mesh and burlap.

Principles of design: The following principles of design must be met in addition to the General Container

Dimension: The animal must be able to move freely, turn around and roll.

Frame: the frame must be made from material or solid wood parts bolted or screwed together. If the total weight of the animal plus the container exceeds 60 kg there must be additional re-enforcing metal branching.

Sides: the interior of the container must be completely smooth as the flippers of these animals are very delicate. The four sides, including the door, must be made of strong smooth weld mesh. The mesh must be small enough to prevent the animal pushing its nose outside the container. The bottom must be close boarded up to a minimum height of approximately 15 cm, external to the mesh, to prevent excreta escaping.

Floor: the floor must be solid, leak-proof and either covered with a deep layer of absorbent non-consumable bedding material to a depth of at least 10 cm or have a suitable padded floor covering.

Roof: the top of the container must be made of weld mesh covered with plywood or burlap.

Doors: a sliding or hinged door must be provided at one end, there must be a secure means of fastening that cannot be opened accidentally.

Ventilation: must occur from the weld mesh on all four sides including the door.

Spacer bars/ handles: must be made to a minimum depth of 2.5 cm, must be present on the sides of the container as shown in the illustration.

Feed and water containers are not required to be provided for these species.

Forklift spacer bars: if the animal plus container weighs more than 60 kg forklift spacer bars must be provided as an integral part of the framework.

IATA Manual usually include pictures and drawings of the accepted containers; containers that are conform the principle of written guidelines for the species, but look slightly different from the example will still meet the IATA standards.

PREPARATIONS BEFORE DISPATCH

No special requirements apart from follow-up of local animal transport regulation. Fasting an animal for 24 hours is desired prior to shipment.

GENERAL CARE AND LOADING

Seals can remain out of water for long periods of time. It is therefore, not essential to sprinkle the animals with water during transit. However, these animals must be kept as cool as possible at all times and not be exposed to direct sunlight and draft. Water for cooling (even mixed with ice) must be available if required.

Warning: These animals bite. A "This animal bites" warning should be fixed to the container in addition to the usual labelling.

Transfer

Marine mammals have been shipped successfully by water, road vehicle, and aircraft. Pinnipeds are able to remain out of water without harm for much longer periods than cetaceans and sirenians.

Seals should be fasted for 24 hours before transport regardless of the anticipated length of the journey or the type of conveyance to be used. Plan the transport so animals are absolutely not kept in cages unattended for longer than 2 to 4 hours during any length of the journey. Secure the cages to minimize shifting and jolting, and include equipment for appropriate on and off transfer of animals by hand, forklift or crane. Pinnipeds should not be kept in containers longer than 24 hours; if circumstances force an extension of the time, the removal of the animals and placement into a suitable water enclosure should be considered and thoroughly checked before the following departure for shipping. The temperature has to be monitored during transport. Well-insulated Pinnipeds are prone to overheating and this can be a greater threat than cold and the animals must be closely observed for signs of hyperthermia during transport. Stereotypic behaviour, such as incessant movement, will also compound the problem. They should not be exposed to direct sun during transport. Animals should be shipped in a cargo hold in which the temperature variation is compatible with the species. Temperatures should be below 20°C for most species, and below 10 to 15 °C for polar species.

Good ventilation is important, although draught has to be prevented. They should be transported dry. A wet coat can cause pneumonia. When you give them water, they can choke. So it is important to keep their neck stretched and to give them small quantities of water. The behaviour of the animal has to be observed. Moving a lot is a sign of stress. Be aware of dehydration, the eyes of the seal should be wet. Animals should not be fed during transport, it is dangerous to feed stressed animals. It is natural for seals to live without food for a few days. However it is a good idea to have boxes with fish present.

Airplane

The cargo compartments used to carry marine mammals are the same as those used successfully to transport a variety of pet and other domestic species. Meaning that pressure and temperature can be adapted to the shippers' specifications. Problems may arise with smaller air carriers, or charter aircraft companies unaccustomed to shipping animals. Whether or not an attendant accompanies the animal is dependent on the time of transport and if the animals have to be transited at some airports. Most commercial cargo air carriers are equipped for animal transportation; many in fact, have handled marine mammals.

EUROPEAN UNION

All live animals for importation into the European Union must:

- be accompanied by a veterinary health certificate valid for the Member State of destination
- be transported in accordance with Council Directive 1/2005/EEC on the protection of animals during transport and comply with the CITES requirements

- all regulations and laws of the involved countries (including TRACES paperwork)

Animals may only be imported through an approved border inspection.

Importers must give at least one working days' notice of their arrival to the veterinary staff of the border inspection post where the animals are to be presented, specifying the number, nature and estimated time of arrival of the animals.

Health inspection may be completed at the first airport of arrival in the Union or, in certain circumstances; animals may be given provisional clearance and sent under customs supervision to an inspection post at their place of final destination for full clearance.
A brief explanation of Directive 1/2005/EEC is as follows:
ANIMALS:
Animals must be fit for transport. Sick or injured animals are not to be transported but this does not apply to animals that are slightly injured or sick as long as the transport will not cause unnecessary suffering.
Suitable arrangements must have been made, including reception at the airport, transfer into crates etc., loading onto aircraft, and the flight, at stopovers at the destination.
First Aid Care: animals that fall ill or (re) injured during transport must have first aid treatment as soon as possible, be given appropriate veterinary treatment and if necessary be slaughtered humanely.
TRANSPORTER:
All animal transporters must be registered and authorized with a Member State of the EU. This applies to all airlines flying animals into the EU or within the EU. However how this is to be carried out is uncertain, some countries may interpret this ruling that airlines need to be licensed to carry animals while others may consider this unnecessary. Registration in any one State will be recognised by the other Member States. It is advisable that it is perfectly clear before accepting a shipment into the EU what registration will be recognised.
Competent staff: the transporters must entrust the animal(s) to the care of staff that have the appropriate competence and knowledge to care for them before they are allowed to handle animal cargoes.
DOCUMENTATION:
For all species there must be documents which:
- identify the animals
- state who is the owner
- give the place of origin
- indicate the date and time the journey commenced
- indicates that the animal has a health certificate of good health and fit for travel

This information must accompany the animals throughout the journey.

Car

Road vehicles are almost always involved at some point, even if only to transport the animals to and from other means of conveyance. Transport vehicles should meet the standard regulations for transports present in each country keeping in mind that every vehicle must provide protection from direct sun, heat, wind and freezing temperatures (aim for a temperature of 10 to 20 ºC). It should have air circulation and prevent the entry of exhaustive fumes, such as those that may

occur in the back of an open truck, or their build-up in an enclosed vehicle. Keep noise and commotion to a minimum, when transport by car takes more than two days, transport by airplane should be considered. It is suggested to drive at night, when there is less traffic and there is no risk to encounter a traffic-jam. At least two people are necessary for transport, just in case something might happen and to alternate driving.

CITES transport regulations must be respected for all transports. In most countries cars, which transport animals, must be licensed (registered) and specific official veterinary paperwork (Traces documents) should accompany the animals from place of loading to arrival.

Safety

Marine mammal handling techniques are largely a matter of common sense. Pinnipeds, however docile and well trained, could bite and react aggressively when not acquainted to special procedures or when frightened. Some species, particularly grey seals (*Halichoerus grypus*), hooded seals and sea lions can inflict dangerous bites. The most important thing to remember during a capture is that the safety of staff comes first. Handlers should be experienced, which is important for their own protection, as Pinnipeds can inflict very nasty bites.

Pinnipeds use their whiskers on land when socially interacting with each other. The mystical whiskers may be held back against the side of the muzzle, or held erected forwards, the latter usually indicating aggressiveness. Antarctic fur seals, in particular, make much use of the whiskers in female-male interactions. A cow wishing to drive off the attentions of the much larger bull will erect her own whiskers and snap at the muzzle of the bull. This stimulates the bull's whiskers and causes it to withdraw. Biologists working with the fur seals can take advantage of this response: to drive off the attentions of an aggressive seal, it is necessary only to tickle its whiskers with a slender pole, whereupon it retreats.

Bites of pinnipeds can be very dangerous and cause serious infections such as the "seal finger" which is due to *Mycoplasma phocacerebrale* and other Mycoplasma sp. Every bite should be approached by the physician as if it was infectious and the preventive/curative procedure could include:

- Check for anti-tetanus vaccination (no keeper should approach these animals without proper vaccination)
- Clean the lesion possibly without suturing (to avoid internal infection)
- Antibiotic administration (following medical instructions usually tetracycline or quinolone are considered drugs of choice, thus avoiding penicillin)

National regulations usually cover the list of species considered dangerous by every country. In any case, the Annex 1 to "the EAZA standards for the accommodation and care of animals in zoos" provides a list of dangerous and hazardous animals in zoos and aquaria. *Table 8 below shows* the list of dangerous *otaridae and phocidae* (only to non-domestic animals*)* kept in zoological parks, aquarium or safari park conditions. The animals mentioned can do harm to their keepers or to the public due to their physical strength, specific weapons including their poison, and their behaviour. Some of the animals mentioned are dangerous only during the breeding season. Animals not mentioned can*,* under exceptional circumstances (including hand-rearing), and subject to unprofessional handling in some cases be hazardous.

Table 9 *Dangerous Pinnipeds (EAZA Executive Office, September 1994).*

Scientific name	**Common name**
Otariidae	Eared seals
Odobenus spp.	Walrus
Hydrurga leptonyx	Leopard seals
Mirounga spp.	Elephant seals
Halichoerus grypus	Grey seal (adult males)

2.7 Health and welfare

The primary goal of husbandry techniques, applied to any captive animal, is to provide the best health care possible while at the same time respecting the welfare criteria for the species. It is of the outmost importance to know the species well in order to be able to recognize initial signs of diseases as soon as possible. Like many other wild species, pinnipeds usually hide signs of disease for a while, as a form of defence against predators, until it is sometimes too late when signs eventually appear.

As for every other species, daily monitoring of the animals by experienced people and appropriate husbandry and veterinary preventive protocols are extremely important.

General sanitation

Consistent hygiene procedures are absolutely essential to the health and well-being of a marine mammal colony. Maintaining the animals' environment clean and disinfected does not mean sterile and the following sanitary practices and basic hygiene rules should be taken into consideration in every context.

Kitchen and food management:

- Fish decomposes rapidly and attracts vermin. Fish scales adhere tenaciously to almost any surface. Fish thawing and preparation areas tend to accumulate "drip" fluids so:
- Fish should be stored in a freezer at appropriate temperatures at -18 °C for the time prescribed according to the species and date of fishing. Histamine and peroxide index of the fish should be controlled for each new batch upon delivery.
- Thawing should follow standard methodologies internationally recognized (Crissey 1998). Thawing should only occur in a 4 to 6 °C fridge or area. Thawing under running water is no longer recommended.
- All kitchen tools and surfaces should be thoroughly cleaned before and after every use and periodically disinfected following strict hygiene protocols (HACCP)

Enclosure disinfection: enclosures often have wet surfaces, which tend to dissolve and disperse litter and wastes so everything should be cleaned periodically avoiding the drip of the cleaning solutions into the pool. This procedure might be difficult in some natural environments and therefore special cleaning procedures should be then designed and applied.

For this purposes sodium hypochlorite, Virkon, quaternary salts, chlorhexidine and many other types of disinfectants can be utilized. It is advisable that the cleaning and disinfecting solutions are evaluated together with the veterinarian and possibly rotated every few months in order to avoid resistance for some of the microbiological pathogens;

Food items CANNOT be mixed with dead animals. For the latter a proper cooling/freezing facility should be provided until the carcass can be examined by the veterinarian (and/or sent for necropsy) and subsequently disposed as prescribed by the law in each country.

Water management: make sure that the Life Support System of the exhibit and quarantine tanks provide proper disinfection of the water environment in which the animals spend most part of their lives.

Training

The use of a conditioning programme to medical behaviours has many advantages for successful management of pinnipeds in captivity. A behavioural conditioning programme begins with adaptation of the animals to the captive environment. This is followed by basic operant conditioning in order to achieve controlled behaviours, which in turn allow individual feedings and breeding, and facilitate medical treatment and the gathering of research data. The operant conditioning involved in achieving these goals requires basically the reinforcement of desired behaviour and ignoring of unwanted behaviour.

General learning principles

Animals are trained by humans for a series of goals and with the help of a great diversity of training methods and resources. Learning the desired behaviour and/or unlearning undesired behaviour is the central aim for training. Training of animals requires that they are learning. The definition of learning is: 'a relative permanent change in perceptible behaviour by experience or practice as a result of interaction with the environment'. The learning process inside the animal cannot be perceived. Only from the appearance of a change of behaviour by the animal (the learning or training result) can be concluded that the animal learned.

There are a number of general learning principles. Learning by association is the central point with training, which means that animals learn the meaning of new stimuli by making a connection with already known stimuli (classic conditioning) or by making a connection between their own behaviour and the following event (operant conditioning). The phenomenon that animals learn that a certain stimuli has no meaning and can be ignored (habituation), is seen in general as learning by (the lack of) association.

The most important learning principle for training animals is operant conditioning. With this there are four training methods for learning and unlearning of behaviour;

- **positive reinforcement**: application of a positive stimulus to increase the frequency of the behaviour it follows
- **negative reinforcement**: removal of a negative stimulus to increase the frequency of the behaviour
- **(positive) punishment**: application of a negative stimulus to decrease the behaviour it follows.

- **negative punishment**: removal of a pleasant stimulus to decrease behaviour.

Training by reinforcement is based on increasing the desired behaviour by giving the animal a satisfying stimulus (positive reinforcement, e.g. food). Also training can be based on terminating, preventing or avoiding an unpleasant behaviour (negative reinforcement, e.g. the removal of a net in a pool on one side to teach the animal to go through the lock-gate on the other side). To achieve this it is necessary that the animal first finds out that a certain stimulus is unpleasant (punishment; putting the net in) and that, by showing a different (desired by the trainer) behaviour, the unpleasant stimulus can be avoided. Training by punishment is based on decreasing behaviour by giving an unpleasant stimuli (e.g. loud noise), which is called (positive) punishment or denying a pleasant stimulus (e.g. the trainer going away), negative punishment.

Decreasing the frequency of a behaviour by never following it with reinforcement ("ignoring") is called “extinction”. The more proper way to deal with undesired behaviour is reinforcement of incompatible behaviour, i.e. reinforcement of behaviour that makes it impossible for the subject to perform the undesired behaviour.

Research on learning shows that the most optimal result for learning behaviour is accomplished by positive reinforcement (reinforcing desired behaviour), followed on a distance by (positive) punishment. These ‘positive’ methods are generally most easy to use.

Training and welfare

In a human-animal relationship, like training pinnipeds, it is important to make sure the animal welfare is respected. Important for the animal are the values of predictability and control. These ideas can be connected with the learning-principles of conditioning. By classic conditioning an animal learns to predict events in his environment and by operant conditioning an animal learns to influence (control) his environment by the effect of his behaviour. If these conditions are not in balance with the animal, the animal suffers from “stress”. Chronic stress means the animal is in a bad psychical state and if the animal is unable to cope with it, this could eventually pass on its physical condition. Research on welfare concludes that possible causes of stress that could impact and affect welfare can be:

- unpredictability of what could happen
- uncontrollability of what could happen and of the environment
- injury or pain
- excessive fear
- overburdening

A distinction can be made between acute and chronic stress. With acute stress, stimuli or events in the environment are temporarily unpredictable and/or uncontrollable. If the stimuli or events in the environment are long-lasting unpredictable and/or uncontrollable for the animal, chronic stress appears. Acute stress is not always bad, while chronic stress is.

Unpredictability is not a negative thing. In fact, unpredictability can be a strong tool utilized in training. Intermittent reinforcement schedules work best if they are unpredictable. Predictability tends to degrade performance (get boring) and can lead to stress. Trainers must be consistent, but not predictable. Inconsistency of a trainer or between trainers will have a negative effect and may lead to stress.

In addition, to be reinforced an animal needs to be in a "state of deprivation". This is often translated as being hungry, but that is not the same. For an animal that is saturated, food is not a reinforce, but dedicated attention, social interaction and plays, can be. If you can fill a need in an animal, it has some state of deprivation that can be used in training. An animal needs to have some kind of motivation for co-operation in training.

Training Marine Mammals

Marine mammal training programmes must rely heavily on positive reinforcement, which is highly productive and continues to stand as a model for ethical training of animals. Empirical evidence suggests that positive reinforcement has a much greater influence in motivating animals to voluntarily engage in behaviours, whereas punishment suppresses the expression of behaviour. Additionally, positive reinforcement serves to address and avoid the development of undesired behaviours, such as anxiety, escape, active and passive avoidance, frustration, aggression and learning helplessness (a state of 'giving up').

The benefits of behavioural training are:

- It is the best way to improve husbandry control avoiding unnecessary forms of stress from capture or restraint, thus reducing possible injuries.
- It challenges animals to work for food as all wild animals must do.
- It creates a workable relationship with their trainer.
- Animals get well adapted to their captive environment.
- Animals increase their behavioural repertoire.
- Food consumption can be controlled.
- Mating can be carried out according to breeding plan.
- Appropriate medical examinations and treatment can be carried out with simplicity.
- Research data can be collected on demand.
- It creates a safer, more comfortable and more rewarding environment for both, the trainer to work and the animal to live in.

Success in keeping Pinnipeds in captivity for display, education and research requires that the animals be desensitized to the captive environment and their behavioural patterns reshaped. Animals should be assumed to enter a captive environment with apprehension towards all unfamiliar stimuli.

Desensitization, and behavioural reshaping, begins with a keeper developing a strong relation with the animal. This can be established with the animal by short sessions during which it is hand-fed while the keeper 'talks' to it. The sessions must become 'time slots' by being held at exactly the same time each day. These 'time slots' and the appearance of the keeper become a stimulus and the food is the reinforcement. Before long the combination of stimulus and reinforcement will enable the keeper to make physical contact by scratching and petting the animal's neck or muzzle. At this point the animals uncertainty begins to diminish. When the keeper can enter the animals enclosure, hand-feed it, scratch and pet it, and leave the enclosure safely, the necessary foundation upon which further conditioning can be built, has been established.

Behaviours are solicited through a combination of verbal and gestural stimuli. Once satisfied with the level of performance, the trainer blows a whistle conditioned reinforcer) to fix the moment

and the type of exercise and “bridge” the seal to the “next action” which is “to let the seal know he or she is about to receive a food reward” (usually used as a primary reinforce).

- A primary reinforcement is something that an animal finds inherently pleasing, usually satisfying a basic biological need. Consequently, food is one of the strongest one.
- A secondary reinforcement is something that an animal finds inherently pleasing, not necessarily related to a basic biological need (toys, petting, social, etc.). Wild animals can learn that petting and other human interaction are reinforcing once the animal has come to associate people with their feeding and care.

The trainer gives the animal food/fish for each correctly performed behaviour. At the end of the session, the animal receives the remaining food from the pre-measured diet, along with verbal praise. Although the trainer sets the goals and rules of conduct, the animals have ultimate control over their training. If they decide not to participate (which happens sometimes), the session can simply be ended and tried again later. Quite often, the biggest challenge is to make the routines interesting enough to keep the animals occupied.

Husbandry training

Responsible maintenance of pinnipeds requires veterinary husbandry training and collection of biological data. This veterinary care can be achieved in a responsible way through husbandry training. It provides a way to improve husbandry control. Husbandry behaviours lead to better animal management and stress-free interactions for both animal and staff. The important steps are:

- plan carefully
- progress slowly
- desensitise all stimuli
- bridge precisely
- maintain trust
- apply proven operant techniques

The foundation for successful husbandry training is desensitisation. Desensitisation is a continuous process by which new and potentially frightening (and often uncomfortable) conditions are slowly introduced to an animal. Such introductions are paired with positive reinforcement.

Animals can be taught to work closely with keepers and allow a wide range of ‘hands-on’ procedures. It generally consists of the development of a behavioural repertoire that facilitates veterinary access without the use of restraint, anaesthesia or isolation. In the interests of veterinary medicine, it is helpful for seals to learn to co-operate with as many procedures as possible. These include:

- general body check
- collection of blood, urine, saliva, milk, faecal samples
- body cavity and lesion swabs for cytology and culture
- x-rays/ ultrasounds diagnostic examination, measurements and monitoring
- topical treatments and application of ointments and antiseptics to the eyes and skin for the treatment of minor lesions
- intra muscular injections
- mouth check-up / tooth drilling

- heart monitoring
- body weight
- stretcher conditioning
- artificial insemination
- gastric intubation
- nail trimming
- gate and cage training can also be considered a husbandry behaviour

Co-operation in each of these procedures has been accomplished strictly through the use of positive reinforcement training, a process through which the animals are eager to work for their reinforce. You can for example bring each individual into an off-exhibit holding area and work for approximately five to ten minutes on a selected repertoire of behaviours. These behaviours can for example include lying flat and motionless on the floor in order to allow the trainer (or veterinarian) to examine and palpate various parts of the body, a situation which relies on a great deal of mutual trust between animal and handler.

Mouth check training (Courtesy of Tania Monreal Pawlowski)

XRay training (Courtesy of Tania Monreal Pawlowski)

XRay training (Courtesy of Tania Monreal Pawlowski)

Physical examination

Although husbandry training has progressed tremendously in the last decennia, a complete physical examination of a pinniped in a zoological setting is often difficult to accomplish. Physical examinations have to be quick and cursory for an untrained animal that requires restraint in order to maximise safety to the animal and operators. The minimum data collected should include an age estimate, sex, standard length and a body condition score.

The physical examination begins by observing an animal from a distance, noting behaviour, attitude, locomotion, paresis, and any obvious discharge, masses, swellings, or asymmetry.

Thorough knowledge of the normal appearance and behaviour of the species under investigation is required. As such, good communication between the veterinarian and the trainers/keepers who are working with the animals on a daily basis, and as such know them very well, is very important. Furthermore, adequate examination of the musculoskeletal system requires a thorough knowledge of the species' normal patterns of movement.

Palpation of limbs and body contours may reveal swelling, masses, or areas of increased temperature, potentially indicative of inflammation. Flexion of limbs may show increased or decreased mobility, or crepitus suggestive of fractures or arthritis. Abdominal palpation is only feasible in young animals and thick blubber layers may obscure subcutaneous masses or abscesses, and, and may interfere with thoracic auscultation. Thus, young or thin animals can often be examined more easily.

Husbandry training techniques make it possible to ask the animal to lie down, to be approached in different positions, to be touched and palpated. Proper training techniques desensitize the animals to general examination and allow complete examination with the use of different diagnostic tools. These tools can include, but are not limited to, auscultation, ultrasound, X-ray, blood-sampling and microbiological samples collection. In special cases, individuals accustomed to operant conditioning can also be trained for specific tests according to diagnostic needs.

Sample collection

These diagnostic procedures should always be carried out by experienced professional carers. The results of the tests should always be evaluated by veterinarians.

Blood collection

Phocids may be sampled relatively easily from the epidural intravertebral vein/sinus or the plantar interdigital veins of the hind flippers. Choice of site is governed by the size of the animal, the ease of restraint and/or the volume of blood to be collected. Use of the epidural intravertebral vein in northern elephant seal pups has resulted in inadvertent bone marrow contamination of samples, so caution should be taken when using this site in young phocids. To collect blood from the epidural intravertebral vein, restrain the seal in ventral recumbence, and locate the spines of the lumbar vertebrae 3 and 4 by palpating the iliac crest and moving cranially. In fat seals, the tail is a useful guide to locate the midline. Insert the needle perpendicularly between the two vertebral bodies until blood is observed in the needle hub. The size of needle depends upon the size and condition of the seal. A 20-gauge, 1-in. needle is preferred for seal pups, while an 18 to 20G – 2 ¾

to 3” (9 cm) -in needles are preferred for fat adult harbour or grey seals. Spinal needles are not favoured because their bevel is not as sharp as the one of a needle and can be difficult to insert.

The plantar interdigital veins of the hind flippers are located by inserting the needle at a 10 to 20° angle to the skin directly over the second digit, or medial to the fourth digit, at the origin of the interdigital webbing. The sample from this site is often an arterial/venous mix, so post-sampling bleeding must be avoided by applying firm pressure.

In Otariids and small walrus the caudal gluteal vein is commonly used as it can be readily accessed while the animal is manually restrained. It is located lateral to the sacral vertebrae, one third of the distance between the femoral trochanters (wing of the ilium) and the base of the tail. A 21-gauge, 1 1/2” (4cm) -in. needle is suitable for thin fur seal and sea lion pup, a 2-in. (5 to 7cm) needle for animals up to about 150 kg, and a 3-in. (9cm) needle for larger sea lions. The depth of the gluteal vein varies between individuals.

The superficial vessels of the hind flippers of Otariids are small, but can be dilated for visualisation by placing the hind flipper on a bag of warm fluids, by pouring warm water over the flipper or by exerting pressure. Tourniquets placed over the tarsus may aid in dilating the vessels. Because of the small size of the vessels and the slow rate of blood collection, a heparinised butterfly needle (23G) and catheter can be useful. It is also possible to reach interdigital vessels higher up between the digits.

The jugular vein can be used as a collection site in Otariids, though more often as a venous access during anaesthesia. It can be frustrating to locate it. It is accessible at the angle of the jaw, the midcervical region, or at the base of the neck and the use of ultrasound helps in visualizing its location. Pinniped blood clots rapidly, so prior heparinisation of the needle and syringe can be helpful, especially under cold conditions.

Urine

Urine is most commonly collected during urination, although catheterisation of pinnipeds is possible using the technique similar to that for domestic dogs. Abdominal compression of anaesthetised California sea lions has been used successfully to collect urine.

Cystocentesis may also be used to collect urine from anaesthetised animals, by inserting a sterile 2-gauge, 3-in. needle cranial to the pelvis and ventrally, under the control of ultrasound.

Cerebrospinal fluid

Cerebrospinal fluid may be collected from the epidural space at the level of the atlanto-occipital joint from both phocids and Otariids in lateral recumbence by a technique similar to that used in domestic dogs.

Biopsies

Skin and blubber biopsies are often performed on marine mammals for research purposes. Samples may be collected with disposable biopsy punches, or by using a scalpel blade and forceps. Local anaesthetic infiltrated around the site provides analgesia, but sedation may be needed if the animal cannot be adequately restrained to prevent movement. After removal of skin or

blubber samples (typically less than 2 cm in diameter), biopsy sites are usually left un-sutured and allowed to heal by secondary intention, to reduce likelihood of retaining infected tissue.

Ultrasonography, auscultation, radiography and endoscopy are diagnostic tools that have gained an important position in marine mammals' health follow-up in the last two decades; with the non-invasive and portable features of ultrasonography making it a tool of choice for frequent controls of the animals.

These tools can be used under voluntary behaviour with trained animals, or under restraint for complementary diagnostic information. The analysis of the data obtained should always be performed by a veterinarian with the required experience in the specialty.

Diseases and injuries

EAZA zoos and EAAM facilities are required to have an extensive veterinary program for the management of animal diseases, disorders, and injuries - and must have the ability to isolate these animals in a separated area (potentially in a hospital setting) for treatment if necessary. Pinniped keepers/trainers should be trained to provide the animals' dietary, husbandry and enrichment needs, in training and restraint techniques, and to identify and recognize the indicators animals may display if their health becomes compromised. Protocols should be established to report these observations to the veterinary department who will be responsible for addressing health issues, managing short and long term medical treatments and controlling for zoonotic disease transmission.

Full veterinary records need to be kept on an electronic data management system (e.g. ZIMS) and, in order to facilitate this, individual identification and ID/recognition is required. Therefore, it is recommended that all animals should be individually identified within the colony, ideally with microchips (PIT tags). Tags should be inserted underneath the blubber to avoid extrusion or abscess formation and in a position where reading will be easy and safe for the handler. The position of the tag should always be recorded on the animal's record.

The most common diseases, pathological and clinical findings in European facilities are described in the following paragraphs; however skin, eye and tooth problems, often as a result of an inadequate environment or fights between conspecifics, are the most recurrent problems in the captive population.

Much relevant information can be found in the extensive literature and veterinarians are expected to refer to scientific information and communicate directly with colleagues experienced in the area of interest. As continuing professional development, both veterinarians and animal carers should attend appropriate conferences and symposiums.

Integumentary diseases

Pox, papilloma and herpes virus, and fungi (e.g. *Candida albicans*, *Fusarium* sp. and dermatophytes) are common causes of the skin pathology. Natural annual moulting occurs in all species and can vary from loss of hair and epidermis in elephant seals to barely recognisable gradual hair loss in sea lions. Alopecia and acanthosis have occurred in captive harbour seals that failed to moult. Some such cases occur when seals are maintained in constant photoperiod (Mo *et al*.,) and others turn out to be due to hypothyroidism. Sea lions may also suffer patchy and

delayed moulting. Diagnosis was based upon history, and restoration of a natural photoperiod resulted in new hair growth. Skin disease is often related to a poor environment.

Musculoskeletal system

Numerous bacteria can cause deep abscesses, myositis, osteomyelitis, and arthritis. Most of these are opportunistic and might occur following trauma, introduction through contaminated hypodermic needles or surgical instruments, or haematogenous spread as a result of generalised sepsis. *Clostridium perfringens* has been isolated from cases of severe myositis following poor injection techniques. Some neoplastic diseases can manifest clinical signs in the musculoskeletal system.

Traumatic and degenerative diseases of joints are commonly seen, the latter in older animals. Bursitis and joint swellings are seen particularly in the carpus and associated phalanges, whereas degenerative arthritis is most common in the lumbar spine and hind limbs, eventually leading to Otariids dragging their hind flippers.

Physical examination, fine-needle aspiration with cytology and culture of the aspirate, radiographs, computerised tomography, and ultrasound will all facilitate diagnosis of musculoskeletal problems. Treatment is dictated by the diagnosis.

Cardiovascular system:

Cardiac insufficiency as a consequence of heartworm infestation has been documented in captive and wild pinnipeds. Infection by either the canine heartworm *Dirofilaria immitis*, which is endemic in some Mediterranean regions, or the phocid parasite *Acanthocheilonema spirocauda,* may cause dilatation of the pulmonary artery and right ventricle, and can be detected radiographically. The quick SNAP Elisa test seems to also be a reliable diagnostic tool for the identification of microfilaria. Microfilaria observed in blood smears must be distinguished from those of *A. odendhali*. *Successful treatment of documented cases has not been described = CRC book 2001.* Merck Veterinary Manual: Parasitic disease of marine mammals: A graded regimen of levamisole phosphate progressing to a high dosage (40 mg/kg/day for 1 wk) has successfully cleared infection in captive pinnipeds, with the advantage of oral administration.). Preventive treatment of captive animals in *D. immitis* endemic regions during the mosquito season is recommended.

Digestive system

Specific aetiologies of gastrointestinal disease include both infectious and non-infectious agents. Clinical signs of digestive system disease include: inappetence to anorexia, emesis, regurgitation, gastrointestinal haemorrhage, diarrhoea, melena, steatorrhea, abdominal pain, icterus, electrolyte imbalance, hypoproteinemia, posterior paresis, polydipsia, and photophobia. Abdominal pain or discomfort often manifests itself as inappetence, lethargy, or depression and a tucked-up body position at rest. Physical examination may help to detect and differentiate broken, missing, or worn teeth, oral ulcers, oral foreign bodies such as fish spines and fishhooks, abdominal distension, abdominal masses, perineal swelling, or prolapsed rectum. A complete blood count may identify an infectious cause. Several bacteria have been implicated as causing enteritis in different pinnipeds, including *Clostridium* spp. and *Salmonella* spp. The interpretation of culture of these organisms from faecal samples is difficult, as they have been cultured from

both clinically normal animals and those with severe haemorrhagic enteritis. Neoplastic diseases must also be taken into consideration.

Ingestion of foreign bodies is also a very important occurrence in captive Pinnipeds and careful attention should be given to every object that might inadvertently fall or be left over in the animal exhibit.

Supportive therapy of gastrointestinal disease is important, because fluid, electrolyte, and protein abnormalities can quickly result in mortality if they are not resolved. Since many animals with gastrointestinal disease vomit, fluids, medications, and potentially even nutrition must be provided parentally.

Iatrogenic causes of gastrointestinal disease include feeding inappropriate formulas or spoiled fish, using poorly designed feeding tubes, or feeding at an inappropriate rate or volume. Young animals, especially when debilitated, often go through a period of regurgitation when fed by formula.

This may be prevented by feeding appropriate formulas, monitoring hydration, and gradual introduction to complex diets.

Dental disease is extremely important in captive pinnipeds, especially Otariids and walrus. The teeth of phocids are typically white in appearance, whereas the teeth of Otariids blacken with age due to a combination of saliva and a chromogenic bacterium. Gingival pathology of unknown aetiology occurs in phocids. Fractures and worn teeth are mostly seen in Otariids due to chewing on foreign objects or pool surrounds, the canines and lower incisors being especially affected and resulting in mandibular swelling and abscesses. Attempts at filling and capping pinniped canines are futile and contraindicated, as the tooth roots are very wide and do not close until animals are in their teens. Affected teeth with exposed pulp should be extracted which, in the case of canines, requires significant expertise and usually bone removal. Almost all young walrus wear their tusks excessively on hard exhibit surfaces, and this inevitably leads to apical infection requiring extraction. Prophylactic extraction is practised in some facilities. Attempts at capping tusks have not had long-term success and novel approaches to enclosure design are needed to prevent this, as extraction is difficult and traumatic.

Urogenital system

The most common cause of renal disease in wild pinnipeds is leptospirosis, but this is very rarely seen in captivity unless rodent-borne disease occurs. In captivity, and in sea lions, it is slight to severe kidney decompensation due to chronic dehydration (inappropriate diet).

Renal disease may also occur as a consequence of renal calculi or congenital renal aplasia. Occasional pyelonephritis is seen. Diagnosis of these rare conditions requires radiography and ultrasound, and treatment has not been reported.

Abortions and stillborn pups are frequently observed in pinniped rookeries. Leptospires, herpes viruses, caliciviruses, *Coxiella burnetii*, and high levels of organochlorines have all been reported in the placenta of aborting pinnipeds. Causes of the occasional stillbirths seen in captive pinnipeds

have not been well investigated. Dystocia is relatively uncommon and largely due to posterior presentation. It can usually be easily dealt with by lubrication and manual extraction.

Both hypernatremia and hyponatremia are common in stranded animals and may be consequences of inappropriate stress responses.

Nervous system

Encephalitis has been attributed to morbilliviruses, herpesviruses, rabies, bacteria, fungi, *Toxoplasma gondii*, and *Sarcocystis neurona* infections. Clinical signs are non-specific and include depression, muscular tremors, ataxia, seizures, and occasionally loss of papillary reflex. There may be differences in likelihood of different diseases in different age classes of animals and appropriate diagnostic tests should be addressed, where available.

Eye problems: *the information included in this part is important to assist in the prevention of the consistent occurrence of eye problems in captive pinnipeds*.

Eye problems are common in captive pinnipeds. There may be an increased frequency of eye problems in animals that are maintained in freshwater environments, though some species of free-ranging phocids live entirely in fresh water but are likely to have physiological adaptations to it. Presumably, the aetiology of ocular changes in captive pinnipeds is multifactorial. By-products of chlorine disinfection (chloramines and other oxidising agents), opportunistic pathogens, microtrauma, ultraviolet hypersensitivity, and pH imbalance may lead to corneal opacities, oedema, erosions, ulcers, uveitis, and cataracts. Cataracts frequently lead to synechiae formation, luxation, anterior prolapse, and rupture of the globe and, more rarely, glaucoma. Traumatic lesions, either anthropogenic or from conspecifics, are common in free-ranging and captive animals. Secondary bacterial infections may be responsible for exacerbating the lesions. Various bacteria have been cultured from traumatic lesions, conjunctivitis, and keratitis in pinnipeds.

Visually impaired pinnipeds will thrust their vibrissae outwards for prolonged periods of time. The menace response is difficult to evaluate, as the vibrissae are very sensitive to movement. Visually impaired animals may not avoid obstacles well if placed into new surroundings, but accommodate very quickly using tactile and acoustic cues, thus making diagnosis of blindness difficult. Ophthalmic examination is difficult in pinnipeds because of the prominent nictitating membrane, strong eyelids, frequent corneal opacities and the ability to retract the globe into the ocular cavity. The very narrow pupil limits visualisation of internal eye structures such as the lens and retina, and there seems to be a lack of response from the sea lion iris to the standard topical mydriatic agents (such a tropicamide). With the recent advance of the use of ultrasound for ophthalmologic control in trained animals, some of these problems can be by-passed and a better assessment of some intraocular structures can be obtained. Cataract surgeries have become more frequent in pinnipeds in the last decade, though they generally do require experienced ophthalmologists and anaesthetists.

The extensive problems and disorders of the anterior eye segments may be prevented by managing these species in accordance with the features of their natural environment and characteristics of the seawater, therefore reducing oxidants in the water, painting of the

environment (tank/haul out area and surroundings) in a dark colour, and – even more important – provision of sufficient shade (awnings above land and especially water).

For the purpose of preventing severe ocular disorders that can cause suffering and may lead to blindness, it is essential to establish a basic medical training focussed on the examination and treatment of the eye. To address the frequent occurrence of eye problems with early diagnosis and treatment, it is recommended to keep the whole group of animals on an appropriate level of training, even though ocular disorders might not be obvious yet. Eventually this will reduce stress and avoids restraint or immobilisation in the event of required intervention. Therefore, first of all, pinnipeds should be used to target training and be able to fixate on the target for a couple minutes, so their head holds still during eye examination, such as daily check-ups as well as detailed examinations. Secondly, it is important to train pinnipeds on receiving eye drops, so they can easily be administered in case of sudden disease. Also, it is recommended to have a dry area and to separate the animal for a while during ocular treatment. It can help initial diagnosis to have fluorescein staining within reach of the animal trainer, so corneal lesions can early be recognised. In case of complex ocular disorders or continuing disease, an ophthalmologist should be consulted to assure correct diagnosis and efficient treatment.

Respiratory system

Phocine distemper virus (PDV) and canine distemper virus (CDV) have caused epizootics of pneumonia and death in harbour and Baikal seals, respectively. Virus isolation is difficult, yet necessary to confirm identification of the virus. Treatment is directed at supportive care, and controlling secondary bacterial infections that commonly cause death in infected seals. Antibiotics effective against *Bordetella bronchiseptica*, *Corynebacterium* spp. and *Streptococcus* spp. are recommended. Although clinical recovery is documented, CDV has been isolated from asymptomatic carriers. Commercially available vaccine for PDV currently exists only in Germany, but attenuated CDV vaccines have provided some level of protection from clinical disease.

Influenza virus has also caused epizootics in harbour seals, with clinical signs similar to those in seals with PDV and CDV (dyspnoea, lethargy, blood-stained nasal discharge, and subcutaneous emphysema, with pneumonia as the predominant post-mortem lesion). Diagnosis of the infection is based on viral isolation, and treatment is supportive.

Those diseases are more common in the wild population and as such one has to be careful when tending stranded/rehabilitated animals on the premises where healthy captive animals are kept.

Bacterial pneumonias are common in wild seals and Otariids, both as primary infections and secondary to viral and lungworm infections, but rare in captivity. A variety of organisms may be involved, although Gram-negative organisms are most common. Clinical signs include tachypnea, dyspnoea, lethargy, and cough. Diagnosis is based upon auscultation of the chest, radiography of the lung fields, and bronchoscopy. Treatment with the appropriate systematic antibiotic may be based upon prediction of the likely organism, or culture and sensitivity of organisms from tracheal or bronchial washes.

Interestingly, a *Brucella* spp. isolate was recently obtained from the lung of a harbour seal with *Parafilaroides* spp. infestation (wild case?). Histological examination revealed most of the inflammation and *Brucella* sp. to be around the dead parasites. The role of *Parafilaroides* in the

epidemiology of Brucella infections remains unclear. Marine mammal brucellosis research is still in its infancy; it is suggested that marine mammal brucella comprise at least two new species named *B. cetacea* and *B. pinnipediae*.

Pulmonary granulomas due to infection with *Mycobacterium tuberculosis, M. bovis* and *M. pinnipedii* have been reported in captive and in wild pinnipeds. Pinniped tuberculosis is in fact an emerging disease well established and confirmed in Europe and special management and diagnostic attention should be addressed toward this important zoonosis.

Zoonotic diseases

The most relevant current diseases that might possibly infect animal staff caring for the husbandry and management of pinnipeds are the following:

- *Mycobacterium* sp. (including genus of the *M. tuberculosis* and *M. avium* complex as well as atypical mycobacteria)
- *Leptospira* sp.
- *Listeria* sp.
- *Brucella sp.*
- Enterobacteria of several species (*Salmonella* sp., *Klebsiella* sp., etc.)
- Fungi (*Candida* sp., *Fusarium* sp., etc.)
- Seal finger: a septic infection consequent to seal bites and caused by multiple bacteria including *Mycoplasma* sp. to be generally treated with broad spectrum antibiotics such as doxycycline and avoiding sutures.
- Influenza and morbilliviruses

The above list is only indicative and not complete. It is correlated with current knowledge and experience of veterinarians working with pinnipeds, but it can be modified according to the status of emerging diseases, which might differ between territories and countries, in accordance with legislation and scientific knowledge. Veterinarians should therefore keep track of changes and update the information available on a regular basis.

Veterinary science, especially when it comes to seals and sea lions, is constantly advancing and some tests for the above mentioned diseases, particularly tuberculosis, might not yet be validated or are still under investigation. Nevertheless, the veterinarian involved is advised to search for the most updated information to provide the animals and the staff with the best suitable and reliable tests available.

Pre-movement testing

An agreement between the two facilities should be completed prior to a transport and the following blood profile is advisable to include at least:

- CBC & platelet count
- Liver – kidney enzymes
- Electrolytes
- Protein electrophoresis
- Fibrinogen
- Glucose
- Faecal parasitology

These parameters are also very important to evaluate whether the animal is fit for travel.

Considering the emerging potential risk of zoonotic implications related with this taxon, it is nowadays important to test each individual prior to transfer for the following:

- Tuberculosis (DPP)
- Herpes virus and, possibly, Morbillivirus
- Faecal and nasal swab for zoonotic bacteria (?)
- Leptospirosis and toxoplasmosis are also recommended

Tuberculosis in pinnipeds is caused not only by *M. bovis,* but also by a specific pathogen isolated in the last decade and named *Mycobacterium pinnipedii*. This is an emerging disease that has caused serious consequences in collections involving staff safety at several European institutions in the last ten years. Complete diagnosis to exclude its presence *in vivo* is yet challenging in those cases where suspicion cannot be confirmed by cultural growth. Protocols are constantly updated depending on the status and availability of the tests on the market. Nevertheless, this disease needs careful testing attention prior to any move and should be included in normal routine tests within every permanent collection of pinnipeds in Europe.

Table 9 *the decision tree for the management of this disease published in 2011 by Jurczynski et al..*

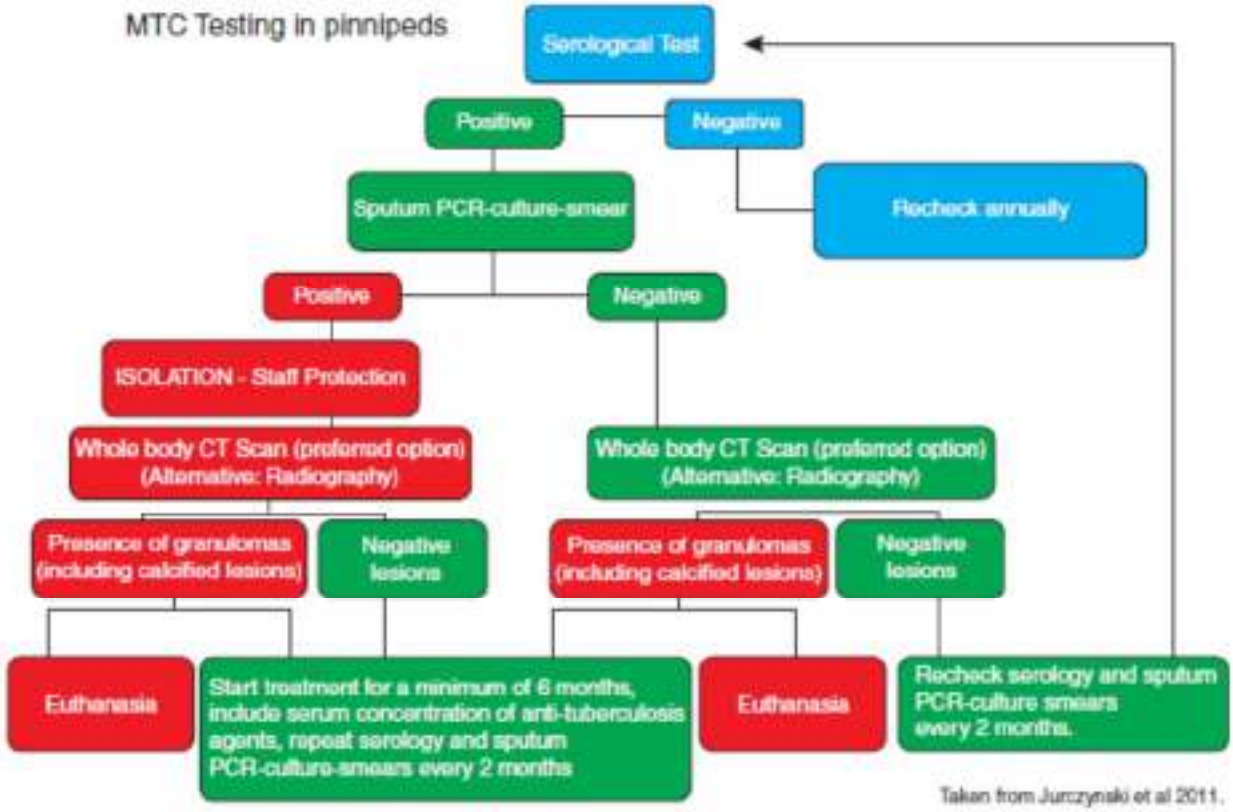


FIG 6: Proposed flow chart to help decision-making process when faced with sea lions with suspected *M pinnipedii* infection (Jurczynski and others 2011)

Following a recent international meeting on Management of Tuberculosis in zoo Animals held at Paris Zoo on December 8th-9th, 2016, the following indications seem to be the most up to date best practice advises to control this disease in pinnipeds, bearing that validation and interpretation of the following tests results are still pending:

- Skin test
    - False positives are in very high proportion
    - Booster effect / vaccination effect in 'negative' animals

- Serology – DPP or ELISA Lelystad or Spain (EZ6 and CFP10)
- IFN-gamma – tried but failed, experimental still

Culture/PCR is gold standard

  - Broncho Alveolar Lavage /oronasal swab
    - Sedation recommended:
      - med/ket – safe protocol available if gas anaesthesia
      - midazolam/butorphanol premed followed by zoletil – risky in older animals
  - Urine and other excretions, because not all forms are pulmonary
  - Do NOT perform on: gastric lavage – chance of detecting aquatic mycobacteria which will complicate interpretations
- Ultrasound and guided biopsies of cervical lymph nodes
- CT scan – commonly recommended in animals that are not too large

Pre-movement TB testing

- History – species and previous moves and contacts with wild born
- Serology: DPP and ELISA (availability dependent)
- Oral swab under trained behaviour: PCR and culture

Facilities should perform the following regular screenings:

- Serology - yearly
- Regular clinical exam including palpation of lymph nodes in the neck under trained behaviour
- Emaciated and those in respiratory distress
  - Will infect the anaesthetic machine
  - Huge anaesthetic risk
  - Pre-med, intubate, ventilate
  - Biopsy lnn, oral swabs, BAL
  - Screen staff when a positive animal is identified

Treatment for pinnipeds

- Oral, daily
- Compliance doable
- Serological negative after treatment in large proportion of treated animals
- Cost might still be prohibitive
- BEWARE: Water cannot be treated – empty, clean, change filters multiple times

All the procedures described in this protocol should be followed and carried out by veterinarians with practical experience in Pinniped veterinary care.

Therapeutic techniques

Therapeutic agents may be delivered to pinnipeds in a variety of ways. Choosing a route of administration must take into account the required frequency, efficacy, and feasibility of administration.

Topical

The use of topical agents may be limited in pinnipeds, especially if the agents are removed once the animals enter the water. However, most pinnipeds can remain out of water for prolonged periods of time, although thermoregulation, ingestion, excretion and coat quality may be affected in the long run. Topical administration is facilitated in trained animals but otherwise may require restraint. Wounds can be sprayed lightly with chlorhexidine or povidone iodine solutions from a short distance away.

The frequency at which some topical agents need to be delivered may limit their use in some instances when the animals have not been trained for it. Many ophthalmic products, for example, require application at least four times per day. The application of topical ophthalmic agents may also be limited by the constant lacrimation typical of pinnipeds, by animal aggression, and/or by blepharospasm. The use of subpalpebral lavage systems has been effective.

Oral

Oral medications are easily administered if an animal is eating. Pills, capsules and small amounts of liquids may be placed into the coelomic cavity of fish. Many animals can detect pills in overstuffed fish and may refuse to eat them. Oral medications can be crushed and mixed into formula or fluids that are either bottle-fed or stomach-tubed to animals. Moderately dehydrated animals may be given fluids via a stomach tube. Animals can also be trained to take pills as such (like morning vitamins). Liquids or powders can be dissolved/suspended in gelatine if the animals are accustomed to eat it.

Aerosol

Nebulization therapy has been used in pinnipeds that have been placed into sealed cages or pens. Care must be taken to ensure the animal does not develop hyperthermia during treatment in enclosed spaces. Placing ice bags underneath a cage grate can be a useful addition when treating small pinnipeds.

Mask aerosol can be accepted by trained animals.

Subcutaneous

Most pinnipeds can be given subcutaneous fluids, as long as the animal can be maintained in a certain position for a prolonged period of time. This may require some restraint and may be more easily accomplished in debilitated animals. The use of smaller suturing fencing material to limit movement may facilitate subcutaneous fluid administration. The subcutaneous route may not be useful in severely debilitated animals with some degree of circulatory collapse that are no longer able to absorb fluids from the subcutaneous space. Some medications, such as ivermectin and certain antibiotics or anti-inflammatory drugs, can also been delivered subcutaneously. The most common site for subcutaneous administration of medications is the craniodorsal thorax between the scapulae.

Intramuscular

Intramuscular injections require the use of relatively long needles to place medications under the blubber. A needle with a minimum length of 5cm in small animals and 7 to 9cm in larger ones is

needed. Injections into the blubber may cause sterile abscess formation and/or result in poor absorption. Intramuscular injection usually requires some degree of restraint, although handling may be minimised with the use of alternative delivery methods such as pole-syringes, blowpipe or darts. However, accurate placement of medications may be compromised with their use and smaller diameter darts may not be long enough. In Otariids the larger muscles overlying the scapulae as well as those around the pelvis, femur, and tibia are appropriate sites for intramuscular injection.

Intravenous

Compared with terrestrial mammals of similar size, there are a limited number of sites for intravenous access in all marine mammal species. The ability of pinnipeds to shunt and pool blood away from peripheral tissues makes some peripheral venipuncture sites a poor choice for emergency drug administration. Intravertebral vein administration is the best route for true seals and walruses. The caudal gluteal and jugular veins are the choices in Otariids, though it will nearly always require complete restraint and/or anaesthesia of the animal. The caudal gluteal vein is also accessible in walrus.

Intraperitoneal

The intraperitoneal route has been used to deliver fluids to severely compromised pinnipeds. Care must be taken to avoid damaging vital organs, or introducing bacteria into the abdominal cavity either via a contaminated needle or by puncturing the gastrointestinal tract.

Anaesthesia and surgery

In general, diving adaptations are more developed in phocids than Otariids, resulting in increased diving performance and, potentially, more anaesthetic complications for the veterinarian.

A method used for pinnipeds is gaseous anaesthesia. The patient is premedicated 10 minutes prior to induction. Anaesthesia is then induced by utilizing the state of the art drugs by placing a face mask on a physically restrained patient and waiting several minutes for the animal to breathe, as breath holding is common in these species. Once anaesthetized, Pinnipeds can be intubated to control respiration.

Injectable anaesthetics have been recommended for use in anaesthetising seals and sea lions (though always in association with intubation and/or gas anaesthesia). The success of procedures using injectable anaesthetics depends on several factors: first, the injection must be IM (intramuscular); second, the patient must be protected from hyperthermia or, more common, severe hypothermia; finally, appropriate resuscitative equipment must be available and the animal should be intubated straight away, since many of the complications are associated with respiratory arrest.

A variety of surgical procedures can be carried out successfully on marine mammals but due to the animals' peculiar respiratory physiology, precautions must be taken to provide positive pressure ventilation, as death might rapidly occur. For this reason anaesthesia and surgery in these species are procedures that require specific veterinary expertise. Volatile anaesthetic gases are the agents of choice, whereas barbiturates and injectable agents in general are

contraindicated. In exceptional situations, a specialist may successfully administer the latter with specific knowledge in veterinary anaesthesiology of marine mammals.

Euthanasia

Please note that euthanasia must be carried out by a veterinarian only.

Euthanasia may be achieved by chemical (inhalant or injectable agents) or physical means. Although many methods will accomplish death, only a few are considered acceptable. Methods that do not create unconsciousness are not considered humane to use alone for euthanasia in an animal. If an animal is properly sedated to a level of unconsciousness, any method of euthanasia is considered humane. Usually lethal injection of barbiturates or other agents (used to euthanize domestic species) is used to accomplish death.

For the specific techniques to achieve proper euthanasia in the different species please consult appropriate textbooks such as: Dierauf/Gulland, Geraci/Lounsbury or the veterinary guidelines for euthanasia.

Post mortem examination

All dead animals must be necropsied by qualified medical staff and a full determination of the cause of death made, assisted by appropriate specific state of the art diagnostic tests.

The post mortem examination should be conducted in accordance with a standardised protocol and relevant government veterinary regulations, which may include national zoo legislation (e.g. EU Zoos Directive, Balai Directive).

The procedure is important to establish the causes of death for epidemiological reasons, zoonotic implications and to collect all the information necessary to constantly improve knowledge of the welfare criteria applicable to the management of these species.

Section 3: Additional research

Most available knowledge on husbandry of Pinnipeds is not based on scientific research, but on the ideas, opinions, feelings and experiences of experts. Additional research is necessary to gain more knowledge and to guarantee responsible management of captive seals.

While writing the Husbandry Guidelines experts made suggestions for additional research to improve the animal management:

- Growth curves of pups must be published
- What is the exact hearing range of seals?
- How well is the development of a seals' taste buds?
- Are preventive injections against Seal Distemper Virus necessary?
- What are the actual Annual Survival Rates and maximum longevity for all species, both males and females?
- Composition of vitamin tablets to be used
- Why do seals swallow rocks?

Biology

- Hearing threshold and disturbance: range (kHz) on land and in water.
- What kind of impact does noise have on pinnipeds?
- Do seals have a form of echolocation or sonar?
- Sight: colour deficiency.
- Relationship sight/touch: the relationship between use of eyes and whiskers and the difference in this between land and water (clear or not clear).
- Mother milk: composition of mother milk in different life phases (fat, protein, water and energy) and in different species.
- Blood parameters: compare values of blood parameters with data of wild seals.

Enclosure

- Effect of water quality on health: sea water versus fresh water, pH changes
- Effect of water treatment noise on health and wellbeing: hearing of the animals; how does this effect health and wellbeing and how can water treatment noise be decreased?
- Effect of fibreglass material on skin: possible splinters in the skin when standard grade fibreglass pools are used.

Feeding

- The use of supplements.
- A diet-table with all nutrients required for Pinnipeds with distinction between young, adult, weaning and old animals.

Behaviour

- Group composition: research on an ideal group composition.
- Separation: males and females outside breeding season.
- Stress: problems of behaviour related to stress.

- Males and pups: the behaviour of males towards pups and the degree of danger for these pups.
- Combined exhibits: more research on housing with other species and examples.

Breeding

- Growth curves: record the growing of pups.
- Causes of death of pups died for unknown reason.

Veterinary medicine

- Vaccination protocols
- Viral agents
- Tuberculosis diagnostic validation
- Chemical contraception
- Hormones levels

The list should be expanded reviewed and possibly coordinated among different zoological collections by the Marine Mammal TAG.

Section 4: References

This list of references consists of three parts; articles & books, CD-rom's and internet sites.

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