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THE ROLE OF ZOOS AND OCEANARIUMS IN THE CONSERVATION OF MARINE MAMMALS

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ABSTRACT

Passage of the Marine Mammal Protection Act of 1972 in the United States reflected a recognition of the detrimental effect humans were having on marine mammals. It set the stage for increased research, conservation programs and improved care of captive animals. While zoos have been successful in propagating certain terrestrial species for reintroduction to the wild, it is not economically feasible to do this with marine mammals. Zoos can, however, help preserve marine mammals by participating in rehabilitation programs, supporting research and educating the public. These efforts require exhibits, husbandry practices and management of animals that will allow natural behaviour. The net result of this should be an enhanced public awareness of marine mammals which will help ensure their conservation.

INTRODUCTION

IN THIS paper I am going to draw attention to the need for marine mammal conservation, suggest how zoos can contribute to this effort and briefly discuss important aspects of captive husbandry and exhibit design.

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In 1972, the United States Congress enacted the Marine Mammal Protection Act because '.... certain species and population stocks .... are or may be in danger of extinction or depletion as a result of man's activities.' (Public Law 92-522, 1972). This act resulted from the increasing number of marine mammals which were becoming endangered. Indeed, two species have gone extinct in the past 200 years, the Steller's sea cow, *Hydrodamalis gigas*, in about 1768 and the Caribbean monk seal-*Monachus monachus*, not seen since 1952. Five other species have come close to extinction over the last century (Table 1). Only one of these, the northern elephant seal (*Mirounga angustirostris*), has made a substantial comeback. A cetacean species endemic to India has also reached a critically low level, the Ganges river dolphin, *Platanista gangetica* (McClung, 1978).

Some marine mammals live in international waters or migrate from one country to another. Others inhabit coastal waters. Protection of these species therefore requires both strong national laws and international agreements. Table 2 lists some of the agencies and laws or agreements involved in the protection of marine mammals in the U.S. and internationally. In the U.S. the Marine Mammal Protection Act is the most comprehensive protective legislation for a particular group of animals. The USDA Marine Mammal Animal Welfare legis,

TABLE 1. *Pinniped species that reached critically low population levels during the past century.*

Species	Estimated Lowest Population	Present Status	Source
Juan Fernandez fur seal	Believed extinct 1880-1956	500-1000 ; increasing	Norris & Atkins 1971
Guadalupe fur seal	Believed extinct 1897-1926	1000-2000 ; increasing	Pierson 1978
Atlantic walrus	?	ca. 10,000 ; declining	Reeves 1978
Carribean monk seal	0	Not sighted since 1952	Kenyon 1977
Mediterranean monk seal	Present level	500-1000 ; declining	Sergeant et al. 1978
Northern elephant seal	<100 by 1982	48,000 ; increasing	Le Boeuf 1977

TABLE 2. *List of regulatory agencies and legislation involved with marine mammal care in captivity and protection in the wild*

Regulatory Agencies

National Marine Fisheries Service (NMFS) Department of Commerce

Fish and Wildlife Service (FWS) Department of Interior

Animal And Plant Health Inspection Service (APHIS) Department of Agriculture

State Fish And Game Commissions

Legislation

Marine Mammal Protection Act

Endangered And Threatened Wildlife And Plants Act

Convention On International Trade in Endangered Species

Marine Mammal Animal Welfare Act

lation is unique in establishing regulations for housing and care of captive marine mammals. A further indication of the need to preserve marine mammals is the number and percentage of species listed on the USFWS Endangered Species List and on the CITES (Table 3). Similar legislation in other countries also include a high proportion of marine mammals.

TABLE 3. *Number and per cent of marine mammal species listed on the U.S. Fish and Wildlife Service (USFWS) Endangered Species List and on the Convention for International Trade of Endangered Species (CITES)*

	Number (%) Listed	
	USFWS	CITES
Sirenians (4 species) ..	4 (100)	3 (75)
Cetaceans (75 species) ..	8 (11)	23 (31)
Pinnipeds (34 species) ..	3 (9)	4 (12)

Depletion of stocks in most marine mammals has not been due to loss of or deterioration in habitat, as is so often the case with terrestrial species. Instead, depletion has been the result of overhunting. For example, by mid-1880, 1000 fin whales (*Balaenoptera physalus*) were being taken per year, and by 1958-1968 more than 60,000 whales were being killed annually.

Between 1810 and 1834, when Guadalupe fur seals, *Arctocephalus townsendi*, almost became extinct from hunting, 200,000 seals were being taken per year (McClung, 1978).

In recent times, however, since most marine mammals live in coastal waters and a few live within confined bodies of water, increased levels of pollutants or other human activities have begun to affect some species substantially. Grey seals, *Halichoerus grypus*, (National Swedish Environment Protection Board, 1982) and ringed seals, *Phoca hispida*, (Helle *et al.*, 1976) in the Baltic Sea and harbour seals, *Phoca vitulina*, in the North Sea (Reinjders, 1979) are failing to reproduce because of high PCB levels in the fish they eat. PCBs appear to produce sterility in females.

In the West Indian manatee, *Trichecus manatus*, most present-day mortalities are due to boat collisions, flood control structures or fishing gear (Odell and Reynolds, 1979). These problems are clearly the result of expansion of human habitation and activities in areas that were once remote.

Role of Zoos in Conservation

It is clear from the above discussion that for many marine mammals a multifaceted conservation effort is needed. One might ask how can zoos, oceanariums and aquariums contribute to such an effort? Zoos have played a role in preserving and propagating several terrestrial species with the direct aim of reintroducing them to the wild. Some examples of such programs include golden lion tamarin, wisent and arabian oryx. Tamarins are currently being introduced to a preserve in Brazil by the National Zoological Park, wisent were reintroduced into nature reserves in Poland by a number of European zoos and the arabian oryx, bred at the San Diego Zoo and Phoenix Zoo, was sent to a reserve in Jordan.

As Campbell (1980) points out, nonetheless, these small successes '. . . should not blind anyone to the numerous problems entailed in the captive breeding of animals for reintroduction into wild habitats.' (p. 263). The cost of such programs are high. Between 1970 and 1980, the cost of setting up a reintroduction program with peregrine falcons was over a million dollars, and the program is still only in its early stages. Space to hold and breed animals is essential for any program with reintroduction in mind. William Conway of the New York Zoological Society (1980) believes that zoos will only have sufficient economic and space resources to preserve 100-150 species. The size and cost of maintaining most marine mammals makes it unrealistic to view zoos as a last hope for preventing them from extinction by captive propagation and reintroduction.

In species where population levels are extremely low, zoos can play a role in holding and rehabilitating sick or stranded animals. This requires some facilities and short-term commitments to individuals but is far less costly than long-term breeding for reintroduction. A rehabilitation program on this scale is not likely to prevent extinction of a species but might help delay it. Successful rehabilitation programs usually involve the cooperation of government agencies and zoos. Examples of successful marine mammal rehabilitation programs in the U.S. are those involving manatees, seals and dolphins. In the case of manatees, the USFWS supports and coordinates the program and institutions such as the Miami Seaquarium and Marine land of Florida provide the holding space and care of the animals. For seals and dolphins, the National Marine Fisheries Service, part of the U.S. Department of Commerce, provides the support and coordination and there are many facilities on both the east and west coasts which participate in the housing and care of the animals.

The two most important conservation roles that zoos can play are to support research on marine mammals and to raise the public awareness of them. The success of conservation programs like that for golden lion tamarins is only possible after many years of basic research (see Kleiman, 1980).

For marine mammals, studies of animals in the wild have been limited because of logistics. Most of what we know about pinnipeds is from their terrestrial behaviour which includes breeding, molting and resting (Ridgway and Harrison, 1981). For cetaceans, studies are mostly restricted to surface behaviour, acoustical analyses (see Herman, 1980), and information obtained from stranded animals (Geraci and St. Aubin, 1979) although telemetric studies are beginning to broaden our view (Jennings and Gandy, 1980; Butler and Jennings, 1980). Projects with animals in captivity should be encouraged despite the artificial environments because we can study facets of the animals which are not readily available in the wild.

Public support of conservation programs, which sometimes conflict with people's livelihoods, can only be achieved when there is public awareness of the animals and the problems. One must keep in mind that the public generally does not have access to marine mammals in the wild. Their exposure is therefore limited to images in books and films. Zoos provide an opportunity for people to see and appreciate the beauty and gracefulness of these creatures which is bound to have a far greater impact than any book or film. Marine mammals in an exhibit at the National Zoo are viewed by approximately one million people each year, far more than could ever view them in, their natural habitats.

Beyond providing a passive availability of animals, zoos can further provide active programs to educate the public about the biology of marine mammals, their status in the wild and their interactions with humans.

Animal requirements and exhibit design

The first step to accomplishing an increased public awareness of marine mammals is to keep them successfully in captivity. Keeping marine mammals is an expensive and complex task. Exhibit requirements are much greater than for many terrestrial species. In the remaining part of the paper, I will briefly review animal requirements and exhibit design, husbandry practices, the costs of maintaining certain species, and ways in which the public can be educated.

Some aspects of animal requirements and exhibit design are similar regardless of the taxonomic group of marine mammals being exhibited while others vary from one type to another. I will first discuss those aspects common to all groups and then briefly discuss aspects specific to each of the following groups: sirenians, pinnipeds and ceteceans. Confining a marine mammal to a pool can have a great impact on the animal's health because bacteria and fungi are able to concentrate at much higher levels in these areas than they do in open water. This, in conjunction with the likely higher stress level produced by captivity, may cause some agents which are not usually pathogenic to become pathogens (Montali *et al.*, 1981). It is therefore extremely important to maintain good water quality.

Water systems

There are three main types of aquatic systems for captive marine mammals (see Fig. 1): a complete flow-thru system in which water is pumped directly in and out of the primary holding pool without any treatment; a partial flow-thru system, where the water is treated before going into the primary pool (some water may be recirculated as well but there is still a continuous flow of water in and out of the pool); and a closed loop system, where the primary pool is filled with water which is then

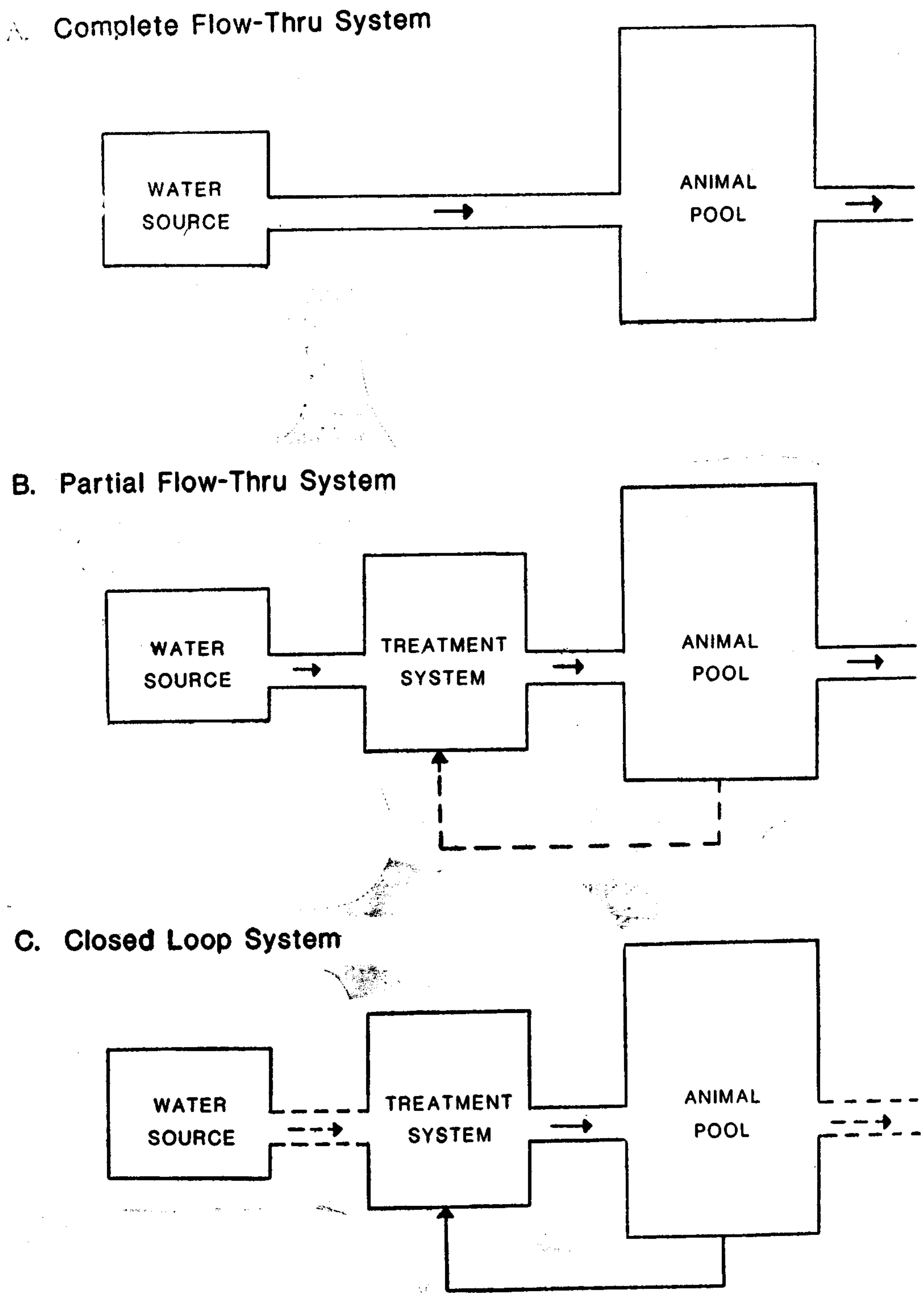

FIG. 1. Diagrams of three types of water treatment systems for marine mammal pools. Solid lines and arrows indicate continuous water flow and dotted lines and arrows represent periodic or optional water flow.

recirculated through the treatment process for a given period before being discarded. The type of system designed will depend to a large extent on the water source and how clean it is. The ideal system is a complete flow-thru system but, usually this is only cost effective if one is set up along a coast which has no coastal pollution. More realistically partial flow-thru systems are used at oceanariums or aquariums along the coast. Inland facilities almost always use closed loop systems because water sources are usually the same as those used for human consumption and thus expensive and limited.

There are two basic needs in water treatment for marine mammal exhibits : one is to remove particulate matter so there is good visual clarity for visitors and the other is to remove biological and chemical matter that is potentially harmful to animals. Removal of particulate matter is traditionally accomplished by mechanical filtration, using filters filled with sand, diatomaceous earth, anthracite or some combination of filters (Plate I). Mechanical filtration alone may not be sufficient to control algae so sometimes algecydes (e.g., copper sulfate or chlorine) are used as well.

Control of bacteria and fungi is usually accomplished with some kind of disinfectant or oxidizing agent. Chlorine is by far the most widely used substance today even though long term exposure to it or its by-products may be harmful. One often sees skin and eye problems that may, directly or indirectly, be attributed to constant exposure to chlorine. It is difficult to test experimentally these hypotheses in a zoo setting but the circumstantial evidence is sufficient to warrant investigating alternatives to chlorine.

There has been only minimal effort made in testing alternative means of disinfecting pools. Spotte and Adams, having tested a variety of treatments (ultraviolet radiation, polymeric resins, ozonation and chlorination) on marine mammal systems, came to the conclusion that none of the methods alone, except chlorination, were viable techniques to control biological matter under closed loop conditions (Adams and Spotte, 1980 ; Spotte and Adams, 1981 ; Adams and Spotte, 1982). If this conclusion holds following further experimentation, then in the future we should develop systems in which the chlorine treatment is done in a storage tank, not the primary animal holding pool. Water could be dechlorinated as it is transferred to the animal pool. Such a system would obviously be more expensive to construct and operate, but would reduce animal health problems.

Sirenians

Space requirements are critical for the well being of captive animals. This is felt to be sufficiently important for marine mammals that the U.S. Government has passed legislation which establishes minimum dimensions for pools (Federal Register, 1984). According to these regulations, a pool for manatees or dugongs should be large enough such that a circle with a diameter of twice the mean length of an adult animal will fit on the surface. The minimum depth of the pool should be one-half the mean adult length. There is still some controversy over the importance of depth, however. It has been argued that breeding might be facilitated by animals being able to float vertically in the pool (Valentry, 1973). Others have argued that this is not necessary (Bertram and Bertram, 1973). At present there has not been enough effort to breed sirenians in captivity to resolve this controversy.

Water temperature appears to be critical for sirenians. Below about 16° C manatees stop eating (Jenkins, 1978). Comparable observations are not available for dugongs, but one might expect them to respond similarly. The recommended temperature range for sirenia

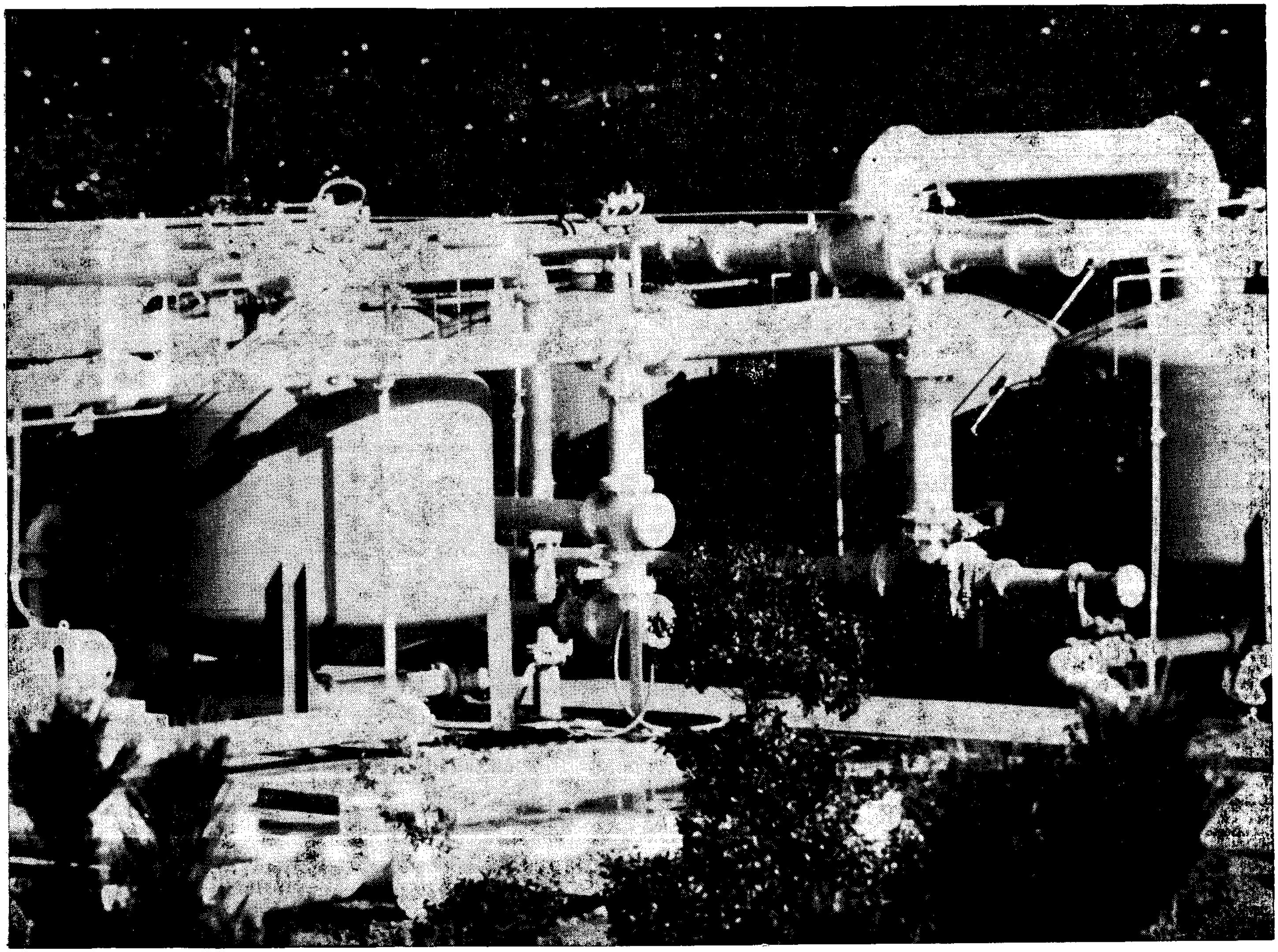

PLATE I. Rapid sand filters for a mechanical filtration system at Marineland in Los Angeles, California.

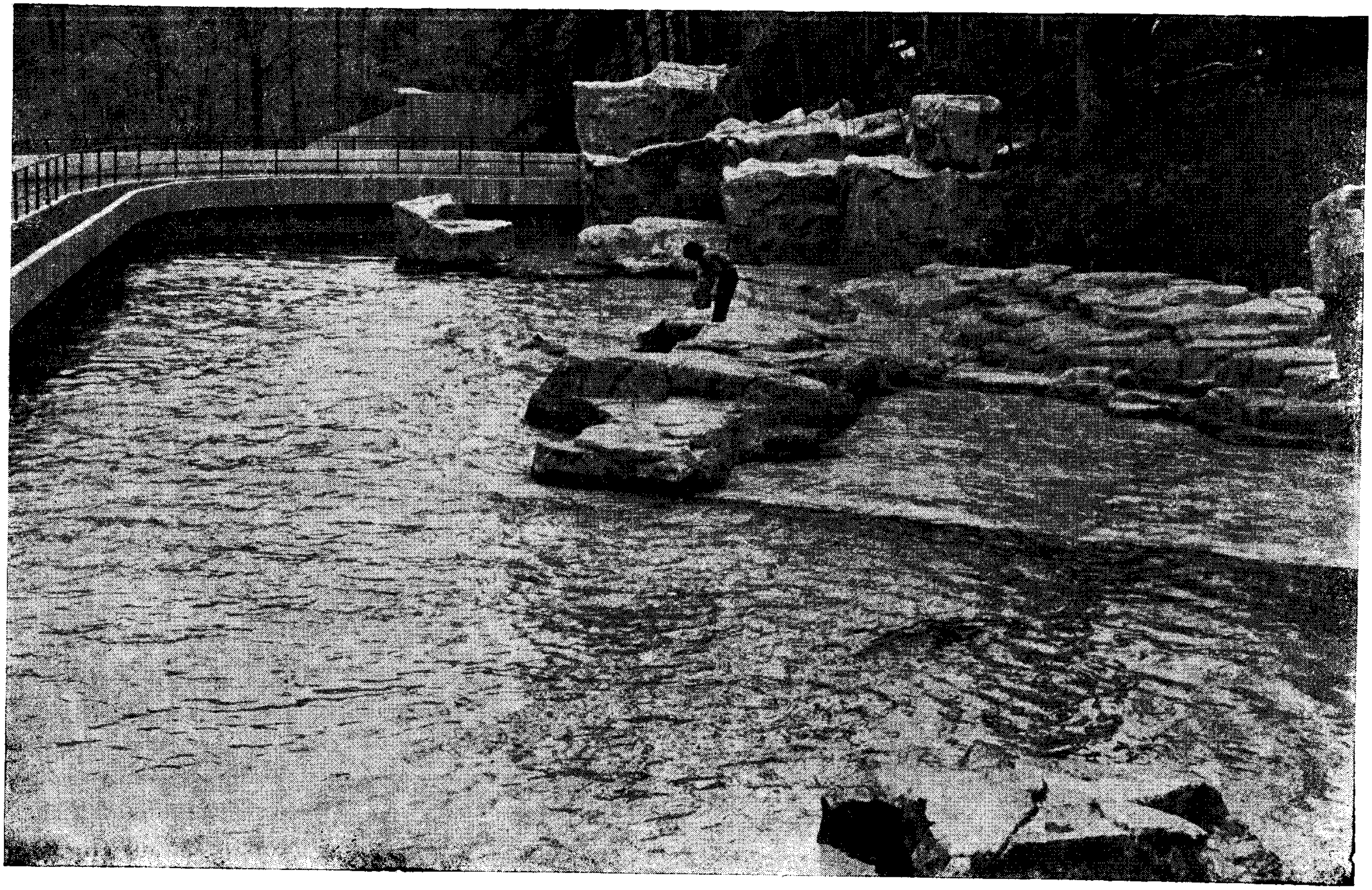

PLATE II. The California sea lion exhibit at the National Zoological Park in Washington, D.C.; an ideal design with rock islands, a large pbeach, a shallow ool for pups and an oblong shape for maximum facilitation of natural behaviours.

is about 20-30° C (Allen *et al.*, 1976 ; Zeiller 1978). With the exception of the Amazonian manatee, it is felt that sirenian exhibits should have the capability of holding fresh or saltwater. There is reasonable evidence to show that algae parasite and bacterial problems can be reduced by periodic changes between fresh and saltwater (Bartman, 1974 ; Brownell *et al.*, 1978).

Sirenian anatomy and behaviour (Marsh *et al.*, 1978 ; Domning, 1980) indicate that they are bottom feeders although most species will take food from the surface. Allen *et al.* (1978) suggest that dugongs might not take food from the surface and they provide a diagram of a simple device used at the Jaya Ancol Oceanarium in Indonesia for feeding dugong under water.

Pinnipeds

The U.S. regulations governing marine mammal facilities require that pinniped pools must have a surface area large enough to fit a circle with a diameter one and one-half times the mean adult length of the largest species to be housed in the pool. Its depth must be at least 0.9 m or one-half the average adult length, whichever is greater. In addition to these requirements, pinnipeds must have dry surface areas upon which to give birth, to care for their young and to rest. The regulations set forth a formula for calculating this but its complexity would require too much space to present it here (see p. 26685 of the Federal Register, 1984, vol. 49). Recent work by Bigg (1984), however, provides data which suggests that this requirement might actually be detrimental to reproduction in some species. He argues that the high incidence of still births in captive northern fur seals, *Callorhinus ursinus*, may be the result of year round exposure to a haul out area. In the wild these animals are pelagic most of the year and give birth shortly after arriving on land.

A desirable feature, but not a necessary one, is an oblong shaped pool (Plate II). This allows animals to make fast, long swimming bursts and, it affords an opportunity to perform in those species which breach water when travelling.

Critical water temperatures have not been determined for pinnipeds. Geraci (1978) indicates that healthy temperate and subarctic phocids can tolerate freezing water temperatures. Montali *et al.* (1981) provide some evidence indicating that high water tempera tures (27-32°C) for grey seals may have contributed to fungal lesions. In the absence of good information on threshold water temperatures it is safest to maintain levels that closely approximate those in the wild. This might require the use of heat exchangers to cool the pools.

Cetaceans

The U.S. regulations have divided cetaceans into two groups for the purpose of establishing space requirements. The first group (Group I), which includes the river dolphins, are animals that usually inhabit waters near land and for which considerable information has been developed concerning space requirements. The other group (Group II) comprises animals that live near the surface of the ocean far from land and for which we know very little about space requirements. The minimum surface dimension for Group I species should be large enough to fit a circle of at least 7.3 m or two times the mean adult length in diameter, whichever is largest. That for Group II species should be 7.3 m or four times the average adult length. The minimum depth should be one-half the average adult length regardless of the species.

As for pinnipeds, an oblong pool is desirable for these species to be able to achieve their full breadth of swimming and jumping. For some species, breaching may require greater depths than the minimum requirements.

Cetaceans are not able to locomote on land so any facility housing them must be connected by water to holding pools. The design of this connection is crucial so that the holding pool can serve as a quarantine facility when new animals arrive or there are sick animals in the group. Water should not be able to flow from the holding pool to the primary pool and the holding pool should have its own filtration system.

The water temperature range in which cetaceans can be maintained is reasonably large. Asper (1982) presents acceptable ranges for about 20 species. *Platanista* should be kept in the range of 20-30° C (Geraci, 1978).

Husbandry

Diet

Probably the most critical aspect of marine mammal husbandry is diet. All sirenians are vegetarians with hind-gut fermentation like horses (Marsh *et al.*, 1978) and are especially adapted for digestion of sea grasses. Studies of feeding ecology, not surprisingly, support the anatomical observations (*e.g.* Campbell and Irvine, 1977). In captivity, it is often more feasible to feed substitute food items in lieu of natural foods because of the high cost of obtaining the natural diet. Among the foods fed to captive sirenians are eel grass, mustard greens, long beans, swamp cabbage, lettuce, pasture grasses and water hyacinths (Hartman, 1971 ; Allen *et al.*, 1976 ; Asper and Searles, 1978). Allen *et al.*, (1976) provide proximate analyses of many of these items. Adult manatees eat between 25 and 35 kg of vegetation per day and dugongs appear to eat 50-75 kg per day. One report of the cost of feeding manatees in North America was about $ 1,700 per month (Brownell *et al.*, 1978).

In the wild, seals and whales are catholic in their feeding habits, eating a large variety of fish species, molluscs and crusteceans. In captivity, the predominant diet is frozen fish. Frozen fish is generally much less expensive than fresh fish and can be stored for longer periods of time. Fish quality is extremely important because if fish is not properly handled, it loses its nutritional value and deteriorates rapidly, producing a potential disease hazard (*e.g.* Geraci and Gerstmann, 1966). Frozen fish, especially, should be evaluated before being fed (Oftedal and Boness, 1984). The National Marine Fisheries Service has established a set of standards for judging human consumption quality fish (Title 50, Code of Federal Regulations, Part 260-261). These standards should be applied to fish fed to marine mammals as well. To be acceptable, fish must conform to the standards presented in Table 4.

TABLE 4. *Criteria used to judge the quality of frozen fish*

1. Mild odor—no strong, rotten or 'iodine' smell
2. Flesh intact and firm—not soft, spongy or with a tendency to separate
3. Natural skin color and appearance —no discoloration, dehydration or wrinkling of skin
4. Fish intact—no breaks in skin, bloating or protrusion of viscera

Many fish species very seasonally in their nutritional value. Ideally, one should perform gross composition analysis on fish lots received. For example, mackeral analyzed for fat content varied from 3 to 21% and butterfish from 5-18% at different times of the year (Oftedal and Boness, 1984). Simply feeding an amount of fish in terms of per cent body weight of an animal, as recommended in the past (Geraci, 1978), can produce quite different energy intakes at different times of the year.

Vitamin supplements are recommended for pinnipeds and cetaceans. Two vitamins in particular should be given, thiamin and vitamin E. Frozen fish contain enzymes (thiaminases) that breakdown thiamin (Geraci, 1981). In the absence of supplementation, thiamin deficiency, which may result in death, is likely to occur (Geraci, 1972). The recommended dosage of thiamin is 25-35 mg/kg of fish per day. Fish have a high level of polyunsaturated fat (Keyes, 1968) which increases an animals vitamin E requirement (Maynard and Loosli, 1962). Following the death of a yearling sea lion from an apparent vitamin E deficiency (see Oftedal and Boness for a discussion of this case), the National Zoo increased its vitamin E supplements from 200 IU/day to 400 IU/day.

In the U.S., fish of a quality fit for human consumption is expensive. From 1979 to 1983, the National Zoo spent between $ 20,000 and $ 36,000 per year to feed 11-13 seals and sea lions.

Management

Marine mammals because of their size and the fact that much, if not all, of their time is spent in water are difficult to manage in captivity. If there is a need to move them from one place to another or contain them for taking blood, they cannot easily be netted or pushed around like many terrestrial mammals. Further more, the stress associated with such practices may be substantial enough to outweigh any good being done by the treatment. For this reason, many zoos have a policy of waiting until a situation reaches a matter of life or death before they will intervene. An alternative approach to managing animals in this way is to train them using operant conditioning techniques. This requires a greater commitment of staff but in the long term seems to pay off in that animals appear to be healthier although I know of no studies which have quantified this. At the National Zoo, seals have been trained to haul out on cue and follow a keeper to a holding pen, to crawl into a squeeze cage, to sit unrestrained while a blood sample is taken and to hold still while a gross external examination is done. An additional benefit to having trained animals is that they can be used as vehicles for education and increasing public awareness of marine mammals.

Education and Public awareness

Efforts to educate public can occur at several levels and be relatively passive or active. The use of signs to convey information is passive and unless kept short and simple will not be very successful. Lectures,symposia and courses are good because detailed information can be given, but these can only be presented periodically. Generally people who attend lectures are already relatively informed and interested. Thus reaching them with conservation information does not have the impact of reaching those who are less informed. I suggest that public demonstrations using trained animals is an ideal means of actively gaining the attention of large numbers of people who might not be self-motivated enough to become more informed. One approach followed by many large oceanariums is to use a story line which anthropomorhizes the animal. These shows capture the visitor's attention but do not maximize the opportunity to educate the public. An alternative approach is to give informal talks at the exhibit using the trained animals to illustrate aspects of the talk and to keep the publics attention. The interaction between the animal and trainer literally draws an audience who listen intensively for 15-20 minutes. That time then becomes an open forum in which to convey a message. Conservation issues and the biology of marine mammals should be high on that list.

In summary, many marine mammals, like many terrestrial mammals, are in need of conservation efforts. Human activity over the last two centuries has depleted numerous stocks. Zoos can contribute to these efforts mainly through support of research and raising public awareness. A necessary preliminary to making such a contribution is keeping representative marine mammal species in captive environments that allow the animals to exhibit their natural behaviors. With this as a starting point, zoos can further conservation efforts with active education programs and the encouragement and support of research.

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