Journal of Marine Animals and Their Ecology

Vol 4, No 2, 2011
Printed in Canada

Invited Commentary

Captive Pinniped Eye Problems, We Can do Better!

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While many advances have been made in husbandry practices, nutrition, medicine, and life support system designs for marine mammals, a large percentage of captive pinnipeds still suffer from ocular conditions such as corneal disease, premature cataracts, and lens luxations (1,2,3). (Figures 1 and 2) Recent studies have identified a number of causative factors for this including some that can be corrected in captive settings such as exhibit designs, water quality and water additives (2,3).

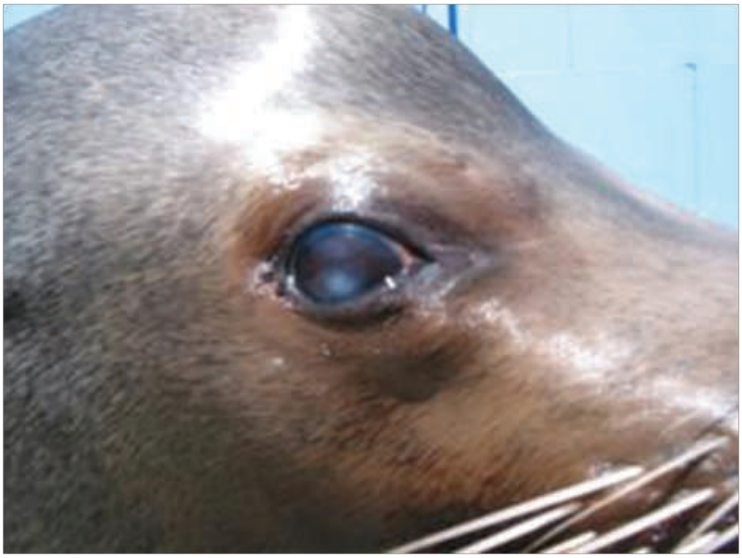

Figure 1 - Moderate corneal opacity in a California sea lion. Many captive pinnipeds develop mild to severe corneal lesions, subluxated lenses and cataracts as a result of chronic exposure to excessive oxidants, UV light or both.

The environmental challenges that are imposed on captive pinnipeds as compared to those living in the wild must always be considered. Wild pinnipeds swim and dive in oceans and bays to capture their prey. The sandy ocean floor is relatively non-reflective, especially as the animals move to deeper water, so diving mammals do not experience significant light reflected from the bottom back into their eyes. Wild pinnipeds

Figure 2 - More severe corneal pathology in a sea lion likely caused by exposure to excessive oxidants in the water. This animal was exposed for years to city water with chlorine levels exceeding 2.5 PPM.

rarely have access to shade in their environment nor do they seek it. When on land they spend most of their time interacting with other animals or sleeping or resting with their eyes closed. They have little reason to gaze skyward. However, captive pinnipeds are frequently housed in pools painted a light blue color which is very effective at reflecting most of the UV light energy back towards the animals as they dive and swim. As well, captive pinnipeds are often housed in deep grottos or pools where they must look up frequently to see out of the exhibit or to catch fish (Figure 3). When keepers, trainers, or members of the public feed the animals they may inadvertently force the animals to look directly into the sun to get their fish reward. These conditions may cause damage to the eyes of captive pinnipeds because they are forced to be exposed to far more UV light than their wild counterparts. This is supported by studies such as a recent publication that identified pinnipeds with no access to shade were 10 times more likely to

Received December 9, 2011; Accepted December 31, 2011
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develop cataracts or lens luxations (2). In another 6-year study conducted on captive otariids, keratitis or keratopathy was identified in 142 eyes of 113 sea lions (62.8%) (1). A surprising percentage (21%) of young animals under the age of 10 years were affected. Further supporting the premise that UV light is a key causative factor, flare-ups occurred primarily during seasons when the sunlight exposure increased or became more intense. Flare-ups were also seen in northern latitudes in the winter on bright sunny days when snow was continuously on the ground. Interestingly, animals housed indoors had less severe corneal disease for their age and fewer flare-ups of keratitis. Clearly, exhibit design issues such as pools and surrounding colors that are overly reflective coupled with a lack of shade are critical to eye health issues.

Figure 3 - Pinnipeds held in captive situations are often fed from above their pools by the staff or by the public, forcing them to look skyward far more frequently than their wild counterparts.

Water quality issues may also play a causative role in pinniped ocular disease, therefore water quality in pinniped pools is important to eye health (3). While it is important to maintain clean water for the animals living in captive situations, the use of excessive oxidants to sterilize the water may in turn be harmful to the eyes of the animals living in those pools. Chlorine or bromine may cause corneal damage themselves. In the more sophisticated life support systems these chemicals are carefully monitored, however oxidant spikes may still occur. Spikes in oxidant levels or exposure to noxious chemical byproducts formed by the combination of organic materials with oxidants added to purify the water may cause or contribute to pinniped eye disease (1,5). Most marine mammal water quality experts make every effort to maintain total chlorine levels below 1 PPM in marine mammal pools. In less sophisticated systems the chlorine levels may frequently spike above 1 PPM. Some pools are filled with fresh municipal water where the total chlorine frequently exceeds 2.5 PPM. In some instances 100% of the pinnipeds housed in these pools suffer from obvious corneal damage (personal observation, Figures 1 and 2).

Bromine used either as the primary disinfectant or by its presence in source water may combine with organic material to form many undesirable byproducts. The noxious byproducts of these compounds such as halogenated methanes (chloroform, bromoform, bromodichloromethane or dibromochloromethane) are often overlooked and rarely measured (5). These compounds have been shown to be toxic to liver and kidney cells. The mechanism of toxicity involves the initial oxidation by the cytochrome p450 enzyme systems which are present in ocular tissues at about 5% of the concentration in liver cells (4). These enzyme systems will begin the breakdown of drugs or toxins present in ocular tissues thereby producing free radicals, peroxide, or other intermediates in the process. Antioxidants are important in managing these damaging intermediates. Ozone is a powerful oxidant and a popular disinfectant for marine mammal life support systems. If residual ozone enters the animal pools it may cause eye discomfort or damage. Animals exposed to residual ozone in the pools will exhibit epiphora and blepharospasm (Personal observation). If animals are exhibiting eye discomfort and the life support system staff can rule out chlorine or other oxidant spikes, ozone may be the cause. Ozone test kits are commercially available and inexpensive. Some kits simply measure the presence of ozone in the pool water with a test involving a color change. Efforts should be made to ensure ozone is not present in the water where the animals live.

It has long been thought that housing pinnipeds in fresh water would certainly contribute to eye damage. However, I have not found this to be true in all cases. For example, I have observed sea lions housed in one northern latitude fresh water exhibit where the pool was

painted black (non-reflective) and the source water was a constant flow from an underground fresh water aquifer. No chemicals were added to the water, and none of the animals exhibited corneal lesions. In contrast, at a more southern latitude facility, the animals were housed in natural salt water with no chemicals added but the pools were painted a light blue color (very reflective) and many of these pinnipeds had evidence of corneal damage.

What can we do to solve these problems?

For years most pinniped exhibits have been painted a light blue color. While the color does allow the darker-colored animals to be more easily seen by the public, it has considerable drawbacks. Substantial evidence is mounting to support the notion that these light blue pools cause or exacerbate ocular damage. Underwater UV light meters have been employed in some instances in an effort to quantify the amount of UV light reflected from the pool and exhibit walls. "Google Earth" offers an opportunity to view facility pools and subjectively assess the amount of visible light reflected from the animal pools and beamed back to space. Rough comparisons of the reflective properties of pool color on visible light may be made this way between facility exhibits and also at different institutions and may aid in the decision of what colors for exhibits and pools will afford the animals the most ocular comfort. When exhibits are designed or refurbished, ensure that pools and surrounding areas are coated or painted with colors that are not considered UV or light-reflective such as earth tones. The addition of shade in parts of the exhibit or holding pools will also reduce the amount of UV light reflected into the eyes of the resident pinnipeds. Trainers and keepers should be aware of their position when attending to the animals and never force an animal to look directly towards the sun when it is being fed or trained. At facilities where the public feeding of the animals is allowed, position shade structures behind the public or designate feeding areas for the public to stand at different times of the day to prevent the animals from being forced to look directly towards the sun while being fed. A number of zoos and aquariums have already refurbished their exhibits or have built new ones that utilize earth tone colors for the pools and surroundings and have provided shade in some areas of the exhibit and back areas. They have elaborate filtration systems with sophisticated monitoring of chemicals to prevent oxidant spikes in the water. The addition of oxidants to the pool must be carefully monitored and chemical or oxidant spikes quickly mitigated in animal pools. Levels of chlorine in city water should be measured and when elevated above 1 PPM, the water should be treated with sodium thiosulfate or allowed time in open holding tanks for the chlorine to dissipate to reduce the amount of chlorine entering animal pools. Including daily antioxidants known to protect ocular tissue such as carotenoids, lutein and zeaxanthin, in the diet may help to prevent or minimize damage to ocular tissues (2,3). These improvements will allow pinnipeds with existing eye disease to be more comfortable and may be instrumental in preventing painful or premature eye disease in the next generation of captive pinnipeds.

To sum up, pinnipeds housed in captive settings are dependent on the choices we make for them. They have no choice of the color of their surroundings or the depth or size of their pools. We select the food they eat and the manner in which it is distributed to them. We have a responsibility to ensure their diet is wholesome and their environment is appropriate. The choices we make for housing and feeding these animals should be based on what is optimal for their needs, and should not contribute to, or cause pain or discomfort. Ocular disease in captive pinnipeds is commonplace but I believe it is preventable if they were provided with more natural (and less reflective) pools and surroundings, strategic areas of shade, clean water without excessive oxidants or other irritating byproducts, appropriate feeding practices, and wholesome diets that include protective anti-oxidants.

When we commit to housing and exhibiting wild animals in captive settings we should commit to doing it properly or not do it at all.

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