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Short Note

The First Successful Hand-Rearing of a Neonate Hawaiian Monk Seal (*Monachus schauinslandi*) and Post-Release Management Challenges

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The Hawaiian monk seal (*Monachus schauinslandi*) is the most endangered marine mammal species whose entire range lies within the United States. Primary distribution of the Hawaiian monk seal is throughout the Northwestern Hawaiian Islands (NWHI) from Nihoa Island to Kure Atoll. Over the past decade, the abundance of monk seals in the eight main Hawaiian Islands (MHI) has increased to approximately 150 individuals, and pups are born in the MHI annually. Currently, the 85% of the population that resides in the NWHI is declining at approximately 4%/y. In contrast, preliminary estimates of the demographic rates for the 15% of the population that resides in the MHI yield a positive intrinsic growth rate of 6.5%/y (Baker et al., 2011). While there is considerable uncertainty in the estimated rates for the MHI, these opposing trends suggest that the abundance of the two regions may be nearly equal in as soon as 15 to 16 y (Baker et al., 2011).

Pups born in the MHI generally appear to be more robust than pups born in the Northwest chain, and pup survival appears to be better. The increase in the MHI and the fitness of these animals may be the foothold the species will need to recover.

Pinniped pups have been successfully hand-reared for many years in zoos and aquariums as well as in rehabilitation centers around the world. The most commonly hand-reared pinnipeds are the California sea lion (*Zalophus californianus*), the harbor seal (*Phoca vitulina*), and the Northern elephant seal (*Mirounga angustirostris*) (Gage, 1993). Harbor seals are the most common species of phocid to be hand-reared, yet little has been published about the composition of harbor seal milk. Rearing of other species is poorly documented (Gage & Townsend, 2001).

It is very rare for monk seals to be hand-reared, although centers in the Mediterranean have had some success (Androukaki et al., 2002). From 1990 until the end of 2010, the Mediterranean monk seal (*M. monachus*) rescue and rehabilitation program of the MOm/Hellenic Society for the Study and Protection of the Monk Seal admitted 21 animals: 19 orphan pups and two weaned pups. There were additional rescue cases that involved seals dying during transfer on site or even before arrival of the rescue team. Others were treated and released on site because the mother was there. From those 21 animals that were admitted in the rehabilitation center, nine were successfully released (M. Psaradellis, pers. comm., 2010).

Only two attempts have been made to rehabilitate Hawaiian monk seals prior to the case described here. On 3 June 1981, a male pup was abandoned by its mother on French Frigate Shoals and transferred to Sea Life Park (Oahu) for rehabilitation. However, the pup died after 16 d (Pacific Islands Fisheries Science Center, pers. comm.). The second, and the topic of this note, began on 1 May 2008 when a male Hawaiian monk seal pup (KP2) was discovered abandoned on Kauai with his mother still in the general vicinity. The young female was a second-time mother who had abandoned her pup the year before (2007). Efforts to reunite the seal pup with its mother in 2007 led to aggression by the mother toward the pup. Researchers and managers decided to intervene after 5 d; however, the pup was severely compromised and was euthanized due to poor prognosis. With the impending birth of the 2008 pup, it was decided to intervene earlier if the mother were to abandon the pup. On 2 May 2008, three attempts to reunite KP2 with his mother by placing the pup in close proximity to the mother failed. These attempts

resulted in increased aggressive behavior toward the pup and its subsequent abandonment.

The National Marine Fisheries Service (NMFS) collected KP2 for captive care on 2 May 2008. The U.S. Coast Guard (USCG) transported the seal to the NMFS Kewalo Research Facility in Honolulu. Approximately 24-h-old, KP2 weighed 15.7 kg and appeared dehydrated. Subcutaneous and oral fluids were administered for rehydration. Broad spectrum antibiotics (clavumox at 20 mg/kg and enrofloxacin at 5 mg/kg) were given orally for 10 d due to the concern for potential systemic infection as the seal pup was not receiving maternal antibodies in milk. For the first 24 h, KP2 was given oral electrolytes by gastric tube, then was fed a formula of Milk Matrix 30/55® (Petag, Hampshire, IL, USA), salmon oil, and electrolyte solution previously used for neonatal harbor seals. The concentration of this formula was increased gradually at every other tubing. However, the pasty consistency and green coloration of KP2's feces suggested that he never properly digested this formula, although this could have been normal meconium for this species. Due to lack of weight gain and the green feces, after 6 d on the artificial milk-based formula, KP2's formula was changed to a fish gruel (thawed human-quality individually quick frozen herring and electrolyte solution) with salmon oil. This formula had been used successfully on a neonatal Mediterranean monk seal (Androukaki et al., 2002) and was based on previous work at monk seal Head Start programs (Norris et al., 2011). The amount and concentration of the fish gruel/salmon oil mix were increased gradually, and the weight of the seal was monitored weekly. Formula was supplemented with 1 Mazuri Vita-Zu tablet/24 h (Vitamins A, E, C, riboflavin, and thiamine). The pup gained 52 kg over his 7.5 mo in human care (Figure 1).

KP2 was managed in a 9.1 m diameter fiberglass pool for 4 mo and then a 18.3 × 18.3 m shoreline pen at Marine Corps Base Hawaii in Kane'ohe for an additional 3.5 mo. Swim time, depth, and access to water were all slowly increased and carefully monitored. Teeth were observed erupting at Day 25, after which attempts to wean KP2 were made. From 19 July, live "moi" (*Polydactylus sexfilis*), a local bait fish, were placed in the pool, and KP2 caught and killed the moi from the first day they were introduced. When the seal was in the shoreline pen, he was offered live octopus for enrichment and nutrition. The seal would consume only parts of the octopus but spent hours interacting with it. This behavior was thought to be mentally enriching for the animal and important in maintaining the seal's natural behavior. Interestingly, on several occasions, he was observed positioning rocks on the sea bottom of his pen by nudging rocks with his snout. Small reef and near-shore fish would congregate in the "artificial reef" that he created, at which time he would knock over rocks and scan the water column for food items.

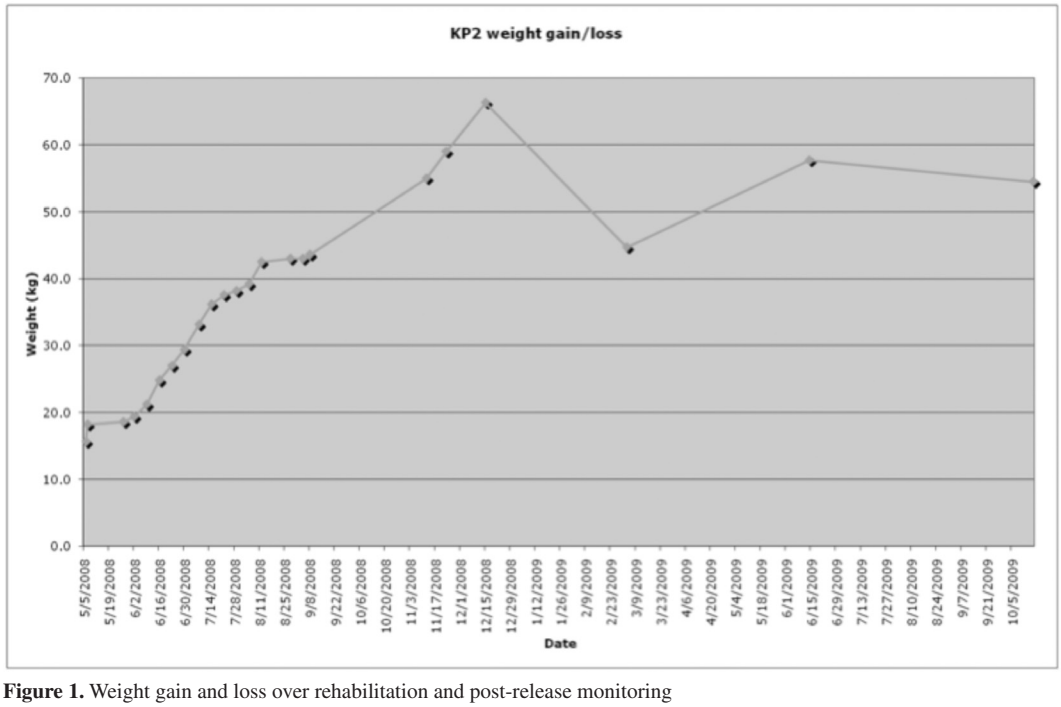

Figure 1. Weight gain and loss over rehabilitation and post-release monitoring

The seal developed bilateral corneal edemas within 2 mo of entering captivity. Corneal edemas are commonly observed in captive pinnipeds and have been identified in monk seals (Hirst et al., 1983; Braun et al., 1996; Dunn et al., 1996). To identify the cause of this edema, a series of diagnostic tests for infectious agents were run, using response to treatment as a diagnostic aid for the effectiveness of serial therapy (see Tables 1 & 2). The exact etiology of the idiopathic corneal edema remains unknown. Multiple environmental risk factors likely predisposed this animal to corneal disease. These factors include UV light exposure (Kennedy et al., 1997; Newkirk et al., 2007; Doughty & Cullen, 2008) and water quality parameters (nitrate spikes, fluctuating salinity, and spikes in bacteria levels). After the gradual onset of the condition in the unnatural environment (the rehabilitation enclosure/pool), the edema regressed in the natural environment (shoreline pen) after several weeks.

The release of rehabilitated marine mammals in the U.S. is a condition of their removal from the wild, providing certain criteria are met. (NOAA/NMFS marine mammal release criteria can be found at www.nmfs.noaa.gov/pr/health/eis.htm.) These criteria were developed to minimize threats to wild populations from potential infectious diseases and genetic abnormalities, as well as to ensure the welfare and immediate survival of the released individual. As KP2 met these criteria, he was released at 7 mo of age. Prior to his release, KP2 was instrumented with a small satellite-linked, time-depth recorder and VHF tag (Wildlife Computers, Redmond, WA, USA) using approved Pacific Islands Fisheries Science Center permitted protocols.

On 16 December 2008, the USCG transported KP2 to Kalaupapa, a remote peninsula on the island of Molokai. The release site was selected on the basis of its being used regularly by other monk seals, thus providing opportunities for nonhuman socialization and diminishing the likelihood of KP2 interacting with humans. Between 1997 and 2009, 46 pups have been born at Kalaupapa, with seven born in 2010 (e.g., Brown et al., 2011).

From December 2008 to March 2009, KP2 remained in the vicinity of Kalaupapa and was observed on three occasions socializing with other seals; his movement patterns for 3 mo post-release appeared normal (Figure 2). One criteria of release was that KP2 was to be captured in 3-mo intervals over the next year for medical examinations, ensuring health status and gathering baseline information for future cases. Weight measurements obtained during these recaptures showed an initial weight loss immediately after release but subsequent weight gain (Figure 1)—an indication that despite hand-rearing in an artificial environment, KP2 developed foraging abilities after release.

Between March and July 2009, KP2 began spending more time at Kaunakakai Wharf, a populated, high-human-use area of Molokai. The pup demonstrated behaviors indicative of conditioning to humans. This likely was the result of his captive rearing in the absence of any animal contact, as well as being provisioned in the wild by well-meaning fishermen. In an effort to change the seal's undesirable behavior, displacement techniques such as the use of crowding boards, loud noises, and palm fronds were used by authorized volunteers to counter-condition his habit of hauling out on the Kaunakakai Pier. At one point, KP2 was captured and transported by helicopter back to Kalaupapa to encourage him to socialize with other seals in the remote area. However, within 2 d, he swam the approximate 80.4 km back to Kaunakakai Pier. Despite efforts to educate the many pier users to ignore KP2 and not reinforce maladaptive behaviors, many continued interacting with the seal. KP2's behavior eventually evolved as he demonstrated undesirable behavior in the form of rough play. These behaviors included following swimmers, kayakers, and surfers and, in some cases, laying on swimmers and not allowing them to get out of the water. There were several accounts of him dragging people under the water. This rambunctious behavior quickly became a public safety concern.

On 17 October 2009, KP2 was collected and placed aboard a USCG C-130 plane. He was transported to the island of Oahu for a medical examination at the Waikiki Aquarium in Honolulu. Clinical examination, hematology, and serum chemistry did not reveal any abnormalities, but ocular ultrasound showed the development of lenticular bilateral cataracts, although the corneal edema had mostly resolved. At this point, KP2 was deemed nonreleasable, and plans were made to house him in California for conservation research purposes (e.g., Williams et al., 2011) with the goal of eventually returning him to Hawaii for permanent public display.

This first hand-rearing and release of a Hawaiian monk seal was an important endeavor in capacity for rescuing pre-weaned pups, caring for them in captivity, and releasing them back into the wild population. Several lessons were learned about caring for pre-weaned pups, which is important for adaptive management of the species. The conditioning to seek out human attention and the development of bilateral cataracts emphasize the need to develop facilities and methods that will prevent these seal-specific cases from occurring in future rehabilitation efforts. The successful release of two rehabilitated, prematurely weaned female pups (Norris et al., 2011) suggest that it may be important to raise monk seal pups in contact with other monk seals. Despite KP2's unsuccessful reintroduction to the wild, due to his ocular and behavioral complications, this individual seal

Table 1. Etiological differential diagnosis for corneal edema in KP2

Etiology	Symptoms in other species	Diagnostic test	Comments	Possible differential
Inherited	Not documented	None	--	No
Congenital	Retinal dz/Uveitis	None	Present at birth	No
Immune mediated	Adenovirus infection or vaccination	Adeno serology – Negative	Bee sting 10 d prior to onset of edema	Possible
Vitamin A excess/deficiency	Association of retinal degeneration with corneal	Vitamin A evaluation in fish diet; retinal/lens exam	Vitamin A supplement consistent with those fed other captive seals	Unlikely; role of Lutein/ carotenoids in marine mammals unclear
Vitamin C deficiency	Corneal edema associated with other pathology of eye	Evaluation of levels in diet	No established standard doses	Unlikely
Diabetic corneal edema	Humans	Serum glucose	Serum biochemistry normal	No
Eosinophillic keratitis	Keratitis in cats associated with feline Herpesvirus-1	Cytology	No eosinophilia or keratitis (Eosinophilia not a component!)	No
Degenerative	--	None	Unlikely due to age	No
Idiopathic corneal	--	--	Hypertonic saline treatment ineffective	No; a dystrophy would progress
Toxoplasma gondii	Retinitis/Uveitis	MAT – Negative	--	Unlikely
Infectious Canine Hepatitis CAV-1	Diffuse corneal edema	Serology – Negative PCR – Negative	--	Unlikely
Infectious Canine Hepatitis CAV-2	Diffuse corneal edema	PCR – Negative Serology – Negative	--	Unlikely
Feline Herpesvirus	Conjunctivitis or ulcerative keratitis	PCR – Negative Indirect ELISA – Negative	Corneal edema noted well before clinical signs of keratitis	Unlikely
Calicivirus	Oral ulcers	PCR – Negative	No ocular disease noted previously with other pinniped species	Unlikely
Fungal	Ulcerative keratitis or stromal abscessation	Cytology – Negative	--	No
Leptospirosis	Uveitis in horses and dogs	MAT – Negative	Clinical signs not consistent with Uveitis	No
Bacterial infection	--	Culture swab	Periodic coliform spikes at KRF	Unlikely
Glaucoma	Increased IOP	IOP – Not elevated	--	No
Iatrogenic	Retinal damage in cats given enrofloxacin	--	KP2 treated with two courses of Baytril	Possible, but retina normal
UV Light	Hx of exposure	Removal from environment	--	Possible
Chemical irritant; oxidative damage	Corneal edema with associated keratitis	Removal from environment	Extreme care was taken to minimize risk of exposure to bleach and cleaners	Possible

Table 2. Therapeutic trial for corneal edema in KP2

Therapy	Rationale	Effect
Shade structure	Decrease UV light	No effect
Hypertonic saline ophthalmic drops	For idiopathic corneal edema	No effect
Doxycycline 200 mg PO Sid × 10 d	Antibacterial and anti-inflammatory properties	No effect
Neosporin Ophthalmic drops	Antibiotic	No effect
Rimadyl 150 mg PO Sid	Anti-inflammatory	Decreased blepharospasm
Voltaren Ophthalmic drops	Anti-inflammatory	No effect
Move from pool to beach	Decrease glare of UV light and resolve potential water quality issues	Dramatic improvement

has helped raise awareness about the plight of the Hawaiian monk seal, including its population status, its significance in Hawaiian culture, and the importance of appropriate human behavior by the public toward wild seals. Members of the Molokai community, including Hawaiian cultural practitioners, have embraced the seal as a sign of unity or "Ho'ailona." KP2's story has gained national attention via local and national news media and social media. Furthermore, school programs about this seal are now being developed in Hawaii and across the nation.

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