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Aversive Conditioning and Monk Seal–Human Interactions in the Main Hawaiian Islands
Aversive Conditioning Workshop, Honolulu, Hawaii
November 10-11, 2009

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Pacific Islands Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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PREFACE

This report has been sponsored by the Pacific Islands Fisheries Science Center in collaboration with Biological Consulting and provides the summary of the National Marine Fisheries Service's experience with seals that have developed aberrant behaviors and the strategies implemented to achieve desired behavior modification.

The report was prepared for an Aversive Conditioning Workshop in Honolulu, Hawaii during November 10-11, 2009. The workshop focused on the effects human interactions have on the Hawaiian monk seal. Because the report was prepared by an independent investigator, its statements, findings, conclusions, and recommendations do not necessarily reflect the official views of the National Marine Fisheries Service, NOAA, U.S. Department of Commerce.

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INTRODUCTION

The most critically endangered genera of extant pinnipeds, *Monachus*, are found in tropical and subtropical waters of the central Pacific and Mediterranean Sea. The Hawaiian monk seal (*Monachus schauinslandi*) evolved 10–11 million years ago, although it remains unclear as to when this species first reached the ca. 5 million years old main Hawaiian Islands (MHI) (Fyler et al., 2005). Currently, the majority of the estimated 1161 Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI). It is estimated that less than 10% of the population is found along the MHI (Carretta et al., in review).

Historical utilization patterns of the MHI remain unclear (Baker and Johanos 2004). Monk seals were likely present prior to Polynesian colonization of the MHI ca. 2,000 years ago and were quickly extirpated following human arrival (Bellwood, 1978, Kenyon, 1980). Kenyon and Rice (1959) documented only seven sightings within the MHI between 1928 and 1956. Seals only became common after 1970 on Niihau, and it is suggested that these individuals may have spread to other parts of the MHI during the past 30 years (Baker and Johanos, 2004). In addition to this natural recolonization of the MHI, 21 adult male seals were translocated from the NWHI in 1994 in an attempt to alleviate a biased sex-ratio within the Laysan Island subpopulation (Hiruki et al., 1993). These translocated males were dispersed across the MHI.

The current best minimum abundance estimate for the MHI is 113 seals (Carretta et al., in review), and it appears that the population is continuing to expand. In contrast, the larger population in the NWHI has demonstrated a 4.5% annual decline over the past 10 years. Thus, the MHI monk seal population has attained additional importance from a management and species recovery perspective. For the species as a whole, the increasing utilization of the MHI allows for greater terrestrial and foraging habitat availability and thus increased total abundance and carrying capacity. The excellent condition of weaned pups may indicate abundant foraging resources favorable for continued population growth in the MHI (Baker and Johanos, 2004). This increasing MHI population provides a buffer against population level extinction probability.

Despite the population level benefits of an expanding MHI subpopulation, there are unique concerns and management challenges associated with growth in the region. Increased exposure to humans and domesticated animals elevates the possibility of disease exposure and transmission throughout the population. The number of fishery-related injury and mortality (from hooking or entanglement) has been increasing in recent years. Significant vessel traffic around the MHI increases the potential for collision and impact from sewage discharge and oil spills (Antonelis, 2006; Littnan et al., 2006). Finally, with an increasing Hawaiian monk seal subpopulation in the MHI, there have been an ever increasing number of human-seal interactions.

Since 1991, the National Marine Fisheries Service (NMFS) has documented 23 high profile cases of human-seal interactions in the MHI (Appendix A). The increasing number of these types of interactions has proven a complicated challenge for management and responders. In recent years, a number of notable events concerning interactions have necessitated NMFS intervention, with most being a direct result of socialization. A typical scenario involves a pup weaning in a location devoid of conspecifics and subsequently socializing with humans. As the weaned seal grows and behaviors become more pronounced, the seal becomes a human safety risk or incurs injuries as a result of interacting with people. Historically, NMFS typically intervenes by translocating the seal to locations where there are more seals and less human interaction. However, once the behavior of socializing with humans is established, there are few locations in the MHI entirely devoid of humans and the cycle of undesirable behavior typically continues.

Mitigating human-seal interactions via translocation has been successful in a few instances, most notably on Kauai with yearling and younger (pups immediately after weaning) animals moved from high-density human areas to the more remote northern end of the island. In most other areas of the MHI, translocations and other methodology have proven unsuccessful in permanently resolving human interactions with individual animals. It is thus important to explore alternative, nonlethal techniques in an attempt to alleviate the increasing number of seal-human interactions while preserving this important population. As the MHI seal population increases, these human-seal interaction events are likely to continue and will require more attention and resources from NMFS. If alternative techniques can be successfully applied, in conjunction with successful translocation in specific areas, it is hypothesized the population will reach a minimum density in remote areas of the MHI where pups are not born in isolation from other seals and the undesired human socialization behaviors may subsequently diminish.

As each interaction situation entails a unique set of circumstances and complications, a variety of methods may be necessary to resolve each situation. One technique used by both terrestrial and marine wildlife managers involves the application of aversive conditioning techniques. Aversive conditioning attempts to alter an organism's behavior by pairing the application of a negative 'experience' with the undesired behavior to condition against the behavior (Shivik and Martin, 2000). This method involves a detailed understanding of animal behavior and training techniques as well as the availability of aversive stimuli.

This review will explore the potential application of aversive conditioning to mitigate human-seal interaction situations within the MHI monk seal subpopulation. It begins with a summary of behavioral and training terminology associated with aversive conditioning, followed by a review of selected case studies with a variety of terrestrial and marine wildlife species and a discussion of the stimuli options.

AVERSIVE CONDITIONING

Introduction

Behavioral conditioning is typically applied in either a zoo environment or with domestic animals. However, there have been increasing numbers of human-wildlife conflicts where behavior modification techniques have been evaluated in an attempt to resolve these conflicts. The term “aversive conditioning” has been linked to a range of aversive applications to wildlife conflicts, many of which are reviewed here for consideration with the Hawaiian monk seal. Aversive conditioning attempts to alter an animal’s behavior by combining the application of negative ‘experience’ with an undesired behavior to condition against the behavior. A grasp of behavioral theory and rigorous observation of the target animal’s behavior is necessary for conditioning to occur.

Behavioral theory outlines the two basic ways in which learning is promoted: classical and operant conditioning. Classical conditioning is learning that takes place when a neutral stimulus is paired with an unconditioned stimulus that already produces an unconditioned response. The animal then responds to the once neutral stimulus the same way it responded to the conditioned stimulus. The classic Pavlovian example is to ring a bell (neutral stimulus) followed by the arrival of food (unconditioned stimulus) causing a dog to salivate (unconditioned response). The dog is thereby conditioned to salivate when it hears a bell ringing.

Operant conditioning is shaping behavior via consequences. Certain consequences strengthen the behavior that precedes them while others dissuade preceding behaviors. These consequences or training techniques include reinforcement and punishment and there are four possible scenarios (Table 1). Positive or negative reinforcement both increase the likelihood a behavior will occur again, whereas positive or negative punishment will decrease the likelihood the behavior will occur again. In finding a behavior modification technique suited for management of human-wildlife conflict situations, positive punishment and negative reinforcement are the two techniques in which aversive control of behavior is used. The key difference between positive punishment and negative reinforcement is that in positive punishment, the aversive is presented contingent on the animal’s behavior. For example, an electric shock is delivered when a certain undesired behavior is performed. In negative reinforcement the aversive is presented regardless of the animal’s behavior (Reid, 1996). In this case, the electric shock ceases when a certain desired behavior is performed. It is important to note the term “negative” means to take away whereas “positive” means to present. A grasp of these scenarios and behavioral patterns of the animal to be conditioned is necessary for the behavior modification to be successful.

Table 1. Four scenarios of operant conditioning. Adapted from Reid, 1996.

	Positive (present)	**Negative (take away)**
Good stimulus	**Positive reinforcement—present something good behavior is more likely**	**Negative punishment—take away something good behavior is less likely**
Bad stimulus	**Positive punishment—present something bad behavior is less likely**	**Negative reinforcement—take away something bad behavior is more likely**

Understanding behavioral theory is necessary to steer an animal in a specific behavioral direction. In addition, to succeed in altering a behavior, a thorough understanding of the motivation driving each action is critical. Shaping behavior cannot be successfully accomplished based on trainer intuition. Rather, assessed behavior patterns gained from scientific observation and documentation of each moment of activity will increase the chance of success. Once behavior patterns are established, motivation becomes clear allowing for initiation of modification techniques. Understanding the scenarios of operant conditioning will provide explanations for behavioral changes and therefore act as a guide for approximations (steps) to reach the terminal response (behavioral goal).

It is important to note the difference between disrupting an animal's behavior with the use of an aversive mechanism and modifying the behavior of an animal through conditioning. Shivik et al. (2003) define disruptive stimuli as undesirable stimuli that prevent or alter particular behaviors of animals. These stimuli immediately disrupt the animal's actions by startling, causing pain or discomfort and will cause an animal to retreat or otherwise not illicit a particular behavior. An animal will normally habituate to the stimuli which eventually renders the approach ineffective (Shivik, 2006). Habituation occurs or the animal will "push through" an initially perceived aversive stimuli. If the disruptive stimulus is used in combination with the animal having an option of alternative behavior, the disruptive stimulus may be sufficient. However, if the animal has no alternative, habituation most likely will occur as the animal will learn that the disruptive stimulus is inconsequential after the stimulus is presented. Therefore the animal will endure the fright, discomfort or pain to survive or obtain what it needs. Modifying an animal's behavior through conditioning by using aversive control involves creating a link between a behavior and a negative outcome. Aversive stimuli cause discomfort, pain or an otherwise negative experience and are paired with specific behaviors to reduce the occurrence of these behaviors (Shivik et al., 2003).

The following sections provide a review of human-wildlife interactions in which aversive conditioning was attempted in an effort to mitigate interactions for the purposes of public safety, resource preservation or species protection. This is only a subsample of the many cases of aversive conditioning used in human-wildlife conflict and described in the literature. These cases were selected to demonstrate various behaviors attempted to be mitigated, particularly those relevant to Hawaiian monk seal-human interactions in the MHI. The various forms and application techniques of aversive stimuli are reviewed, again with a bias towards possible application in the MHI. A summary of common stimuli and the application of those stimuli used in aversive conditioning of wild animals can be found in Appendix B.

Application of Aversive Stimuli: Species Case Studies

Asian Elephant and African Elephant

The African elephant (*Loxodonta Africana*) and the Asian elephant (*Elephas maximus*) are increasingly in conflict with humans throughout parts of Asia and sub-Saharan Africa. These elephants inflict millions of dollars worth of damage to subsistence level and commercial crops (Osborn and Rasmussen, 1995). Farmers and wildlife managers have employed traditional practices of using drums and fire to drive the elephants away, as well as electric fencing, disturbance shooting and killing problem elephants, all of which have proven ineffective (Osborn, 2002). Free-ranging elephants in Zimbabwe were tested to evaluate the effectiveness of a capsicum oleoresin spray as a repellent against crop destruction (Osborn, 2002). Capsicum oleoresin spray was found to be effective as an immediate deterrent, although long-term use and effectiveness was not tested. Osborn (2002) suggests the resin may also be used as an unconditional stimulus to further avoidance of the conditional stimulus. For example, a novel sound (e.g., whistles or horn) would be introduced so that the elephants would subsequently associate that sound with adverse reactions (pain) to the resin. Periodic reinforcement of the sound with oleoresin would be necessary so the animal does not learn that the single stimulus (sound) is a false threat.

American Black Bear

Urban sprawl encroachment toward public lands has increased the occurrence of human-wildlife conflicts. The black bear (*Ursus americanus*) causes property damage, loss of pets, predation on livestock, and human deaths (Beckmann et al., 2004). Federal and state agencies continue to look for nonlethal deterrents in an attempt to handle nuisance bears. As part of this effort, between 1997 and 2002, Beckmann et al. (2004) captured 62 black bears in culvert traps set in urban patches. Capture-and-handling protocol involved initial tranquilization and immobilization, followed by translocation and release into rural areas. On release, one group (n = 21) was simultaneously shot with a rubber slug, 12-gauge rubber buckshot, and pepper spray, while also being yelled towards. A second group (n = 20) was exposed to the same deterrents but followed with additional harassment by dogs. The third group (n = 21) received no deterrents on release. More than 90% (57/62) of the bears returned to urban areas from which they were originally removed. Beckmann et al. (2004) concluded “the deterrents were not very effective in altering the behavior of bears.” However, capture with the subsequent use of deterrents established positive public relations and provided managers with weeks to months of not having to “deal” with a nuisance bear. Based on the public perception that wildlife managers were making an earnest effort to rid the urban patches of the nuisance bears, Beckmann et al. (2004) deemed the use of deterrents as an effective management tool despite the relative ineffectiveness on the behavior of the bears.

In a separate conflict event involving black bears in Minnesota, nuisance bears cued into prepackaged military meals (MREs) found on a military base. Following unsuccessful deterrent attempts using high pressure water and shooting rubber bullets, Ternant and Garshelis (1999) implemented Conditioned Taste Aversion (CTA). Five nuisance bears were given MREs treated with thiabendazole (TBZ) which caused illness less than 90 minutes after consumption. Following treatment of TBZ laced MREs, the bears avoided future consumption of MREs. It was concluded that CTA was successful, although the aversion did not persist indefinitely and the authors recommend reinforcing the CTA every 1–2 years.

Louisiana Black Bear

As a result of fragmented habitat separated by urban development, an increase in human–bear conflicts has occurred in Louisiana. The Louisiana black bear (*Ursus americanus luteolus*) subspecies is listed as threatened under the Endangered Species Act, necessitating the use of nonlethal deterrents in conflict events. In an effort to find effective deterrent solutions, Leigh and Chamberlain (2008) conducted a study evaluating the effectiveness of aversive conditioning on the Louisiana black bear. In their study, 11 bears were immobilized then placed in culvert traps. After a recovery period (up to 24 hours), the bears were released. On release, 5 bears were treated with rubber buckshot and 6 bears were treated with rubber buckshot and harassment from dogs. Ten bears returned to urban or industrial areas within 5 months. The authors concluded that aversive conditioning had limited effectiveness.

Although this study used similar methods to Beckmann et al. (2004) on American black bears, translocation of the immobilized bear did not occur. However, the recovery time of up to 24 hours from the onset of nuisance behavior introduced problems with the experimental design, as the aversive stimuli was not applied until well after the nuisance behavior was performed. It is also not clear if the nuisance behavior at the time of capture was specific (garbage raiding) or general (the bear was located in an urban area). As such, these studies did not truly test 'aversive conditioning' techniques as described earlier in this report but, rather, tested a variety of aversive stimuli options. Shooting rubber buckshot at the bear as it leaves the culvert trap will not necessarily condition the bear to generalize and avoid the urban area where it was trapped; rather the bear is more likely to learn to avoid the person shooting at it (Shivik, 2004).

Gray Wolf

Human-wildlife conflicts involving gray wolf (*Canis lupus*) predation on livestock and other domestic animals are well documented (Fritts and Carbyn, 1995; Shivik and Martin, 2000; Bangs and Shivik, 2001; Shivik et al., 2003; Shivik, 2006). Many nonlethal deterrent and aversive conditioning techniques have been evaluated to manage conflict situations where both predator and prey require protection. Shivik et al. (2003) explored disruptive stimulus and aversive conditioning techniques with captive wolves. Three stimuli treatments were initiated to examine differences in the consumption rate of a prey resource. The first treatment was a movement activated guard device (MAG)—movement to within 2 m of a unique food source would activate light and sound stimuli. In a second treatment, electronic training collars were activated if the wolf approached within 2 m of the food source. The third treatment was a control with no deterrent to food source. The MAG device was demonstrated to be an effective deterrent while the effectiveness of the training collar was not evident. Further research is necessary to evaluate the long-term effectiveness (a result of possible habituation) of the MAG device.

Cliff Swallows

Cliff swallows (*Petrochelidon pyrrhonota*) are migratory birds that breed in colonies and frequently nest on highway structures (Conklin et al., 2009). Protected by the Migratory Bird Treaty Act, active nests cannot be altered or removed from structures, thus causing logistical conflict with the Department of Transportation maintenance efforts (Conklin et al., 2009). Experiments to test the deterrent effects of bioacoustics and structural modifications were conducted. Recordings of swallow alarm calls were broadcasted, and plastic sheeting was adhered to the structures to create a surface area less conducive to mud adhesion for nest construction. Conklin et al. (2009) found that alarm calls, in combination with structural modification, reduced nest construction but did not completely deter cliff swallows from nesting. As with all deterrent devices, effectiveness is greatest when a suitable alternative location is nearby.

California Condor

In 1987, the last wild California condor (*Gymnogyps californianus*) was captured and brought into captivity, joining 21 other condors to begin an intensive captive breeding program in an effort to save the species from extinction (Snyder and Snyder, 2000). Reintroduction of the California condor into the wild began in 1992. In the first few years following the initial releases, collision and electrocution from power lines was a leading cause of death for condors released in California (Snyder and Snyder, 2000; Woods et al., 2007). A recommendation to include aversive conditioning in release methods was implemented and aversion training for all captive reared birds has since become standard training procedure (Snyder and Snyder, 2000). Aversive conditioning with hot-wired dummy utility poles were placed in the captive pens and delivered a 6-volt shock every time a condor perched on the pole. The condor's tendency to perch on utility poles has been significantly reduced and subsequent death from electrocution or collision has decreased substantially (Cohn, 1999; Woods et al., 2007).

California Sea Lion

During the mid-1980s, up to 60 male California sea lions (*Zalophus californianus*) were present around the Hiram M. Chittenden (Ballard) Locks in Seattle, Washington (Gearin et al., 1986). To return to spawning grounds, the Lake Washington steelhead must travel through the fish ladder around the dam and into Lake Washington. Steelhead densities at the bottom of the locks provided attractive foraging conditions for sea lions. Beginning with a large male sea lion nicknamed "Hershel," an increasing number of sea lions cued into this prime foraging opportunity. Between 1986 and 1992, California sea lions consumed between 42% and 65% of the total Lake Washington winter steelhead run (Jeffries and Scordino, 1997). This significant deleterious effect on the Lake Washington steelhead stock initiated efforts to reduce or eliminate the sea lions from the locks. Underwater firecrackers, or "seal bombs" (a flash of bright light in conjunction with an explosion) in combination with boat hazing or chasing a sea lion out of the area were used (Gearin, pers. comm.). Other deterrents included acoustic harassment devices (AHD) that produced sounds in the 12–17 kHz range (Greenlaw, 1987) and taste-aversion conditioning using lithium chloride. In the winter of 1985–1986, the application of these deterrents reduced sea lion steelhead predation significantly (Gearin et al., 1986). However, less success was observed the following winter when the same approach was applied. The sea lions had become habituated to the deterrent devices and predation rates increased (Gearin et al., 1988). Nuisance sea lions were captured and translocated to the outer coast of Washington and southern California. However, most returned within 2 weeks (Washington) or 30-45 days (California). In 1994, the MMPA was amended to allow for lethal removal of sea lions at the locks under certain conditions. In 1995, authorization for the lethal removal of 5 nuisance sea lions was granted. Two of these sea lions disappeared during the tribal fishery in nearby Shilshole Bay and 3 were captured and shipped to Sea World in Orlando for permanent captivity (NMFS, pers. comm.).

More recently, at the Bonneville Dam on the Columbia River, California sea lions, Steller sea lions (*Eumetopias jubatus*) and Pacific harbor seals *(Phoca vitulina richardsi*) have cued into a similar foraging opportunity as found at the Ballard Locks. Here pinnipeds are preying on the threatened and endangered Columbia River spring Chinook salmon (*Oncorhynchus tshawytscha),* steelhead trout (*O. mykiss*) and white sturgeon (*Acipenser transmontanus*) stocks (Brown et al., 2009). Most of the nonlethal deterrent methods tested at the Ballard Locks were also applied at Bonneville including AHDs, underwater firecrackers, and a vessel chase. As a result of almost immediate habituation, these methods were deemed largely ineffective (Brown et al., 2007). In addition to methods tried at Ballard Locks, cracker shells (shotgun shell with projectile), rockets, and rubber buckshot were used, but sea lions also quickly habituated or were only deterred briefly (Fraker and Mate, 1999; Brown et al., 2007). Based on the significant detrimental impact to ESA listed salmonid stocks at the dam, application for the lethal removal of identifiable individual nuisance sea lions was submitted and granted in 2008 (NOAA, 2007). In 2009, members of the International Marine Animal Trainers Association (IMATA) were consulted to evaluate the pinniped behavior at the Bonneville Dam to provide recommendations that may improve the efficacy of the deterrents (Brown et al., 2009). Those recommendations are currently under evaluation.

Pacific Harbor Seal

Pinniped-salmonid interactions are common management concerns throughout rivers and estuaries of the Pacific Northwest. In an attempt to reduce Pacific harbor seal (*Phoca vitulina richardsi*) foraging during the Fraser River gill-net test fisheries, the use of an underwater electrical gradient was evaluated by Forrest et al. (2009). A pulsed low voltage direct current (DC) effectively deterred seals from foraging in the test fishing gill net. Prior to field study, captive seals were tested for minimum threshold response to stationary DC electric gradient. Pulse frequency was set at 2.25 Hz, and pulse width was increased in small increments (75,100, 200, and 400μs) until an avoidance response was observed. In a second trial on wild foraging seals, pulse frequency was set at 2.0 Hz with pulse widths of 200, 500 and 1000μs. Using the response data from these initial trials, a drift gill net with an electrical array set at pulse frequency of 2.0 Hz and pulse width at 1000μs was deployed alongside a nonelectrical section of net. Results show seals were repelled to 2–3 m from the net while the electric gradient was on. However, immediately following cessation of the gradient, the seals returned to forage. As a result of the short-term application of this study (22 days), possible habituation to the electrical gradient was not addressed.

Hector's Dolphin

Entanglement in commercial fishing gear is a leading cause of mortality for Hector's dolphin (*Cephalorhynchus hectori*), one of the rarest marine dolphins in the world (Stone et al., 1997). Underwater pingers (ADDs) emitting a 10 kHz sound were evaluated in New Zealand to determine the effectiveness of reducing small cetacean bycatch and mortality of this species (Stone et al., 1997). In an area with high dolphin density, two field trials were initiated. In the first trial, active or passive pingers were attached to a buoy and raised or lowered using a remote controlled device. Dolphin movements were tracked in the study area. In a second trial, a passive pinger was first placed in the water followed by an active pinger. Although the pingers were not affiliated with commercial fishing gear during trials, the authors concluded dolphins avoided the area when the pingers were active.

Hawaiian Monk Seal

An increase in seal-initiated interactions with humans in the MHI has led to an increased necessity for agency intervention. In an effort to reduce problematic behavior, various forms of aversive stimuli or hazing have been attempted in situations where a Hawaiian monk seal is hauled out in a location likely in conflict with people. These include waving a palm frond and clapping, yelling or slapping a palm frond on the water, collectively referred to as "noise." Between March and October 2009, 22 aversive deterrent application events were applied to a single seal (KP2) that frequented human/seal conflict areas (NMFS, unpublished data). After 3 months and 18 deterrent applications, these techniques were deemed ineffective. Although likely habituation to these deterrents can be inferred, the effectiveness of these deterrents cannot be fully analyzed based on the lack of a clearly defined protocol, a standardized seal observation, and an analysis of seal behavior pre- and post-application.

Aversive Stimuli Methods and Techniques

Capsicum Oleoresin Spray

Capsicum oleoresin spray contains capsaicin, a chemical found in fruits of the *Capsicum* genus. Capsicum stimulates nocireceptors of the trigeminal system, producing intense pain generating systemic physiologic and behavioral responses consonant with extreme discomfort (Cordell and Araujo, 1993; Steffee et al., 1995; Osborn, 2002). Oleoresin spray products (pepper spray) have been developed primarily for dogs, bears, and humans (Steffee et al., 1995). The effects of capsicum have been studied on bears (Hunt, 1984; Herrero and Higgins, 1998), ungulates (Andelt et al., 1992), birds, rats (Mason et al., 1991) and dogs (Chanda et al., 2005). Based on anatomical and physiological differences, it is not clear to what extent capsicum oleoresin spray would have on a marine mammal.

Tactile Harassment

Tactile harassment techniques include, but are not limited to, the use of shotgun shells with rubber buckshot, rubber slugs, "cracker" shells (shotgun shell with projectile), and crossbow with rubber tipped arrow. This type of repellent is logistically difficult because of the required expertise of the weapon operator. These types of deterrents have typically been used on pinnipeds (Gearin et al., 1986; Fraker and Mate, 1999) and bears (Hunt, 1985; Beckmann et al., 2004)

Biosonics/Bioacoustics

Bioacoustic aversive stimuli involve deterring species via species-specific alarm or distress call broadcasts (Bomford and O'Brian, 1990; Deecke et al., 2002). The use of bioacoustics was first reported more than 40 years ago (Frings and Frings, 1963). Vocalizations from predators have been successful in repelling its natural prey in some cases (Cummings and Thompson, 1971; Deecke et al., 2002), but not in others (Shaughnessy et al., 1981; Scordino and Pfeifer, 1993; Conklin et al., 2009). In cases where bioacoustics were reported to be successful in altering behavior, the alarm calls or predator vocalizations were less prone to habituation than other aversive sounds (Bomford and O'Brian, 1990).

Acoustic Harassment and Deterrent Devices

Acoustical harassment devices (AHDs) are designed to induce pain or frighten marine mammals to permanently displace them from specific locations where conflict occurs. AHDs are used at aquaculture sites in the Bay of Fundy, NB, Canada where conflict between seals and aquaculture/fishing interests occurs (Mate and Harvey, 1986). Acoustic deterrent devices (ADDs, also referred to as "pingers") have low acoustical power and are designed to alert marine mammals to fishing gear or other potential hazards (Johnston and Woodley, 1998). These devices have been tested on set net fisheries on the west coast of the United States (Gearin et al., 1996), sink gillnets on the east coast (Baldwin and Kraus, 1995; Kraus et al., 1997), and in various countries as a means to prevent cetacean or pinniped bycatch in fishing nets (Lein, 1995; Stone et al., 1997; Barlow and Cameron, 2003; Culik et al., 2001; Monteiro-Neto et al., 2004). Almost all studies indicate the pinger's effectiveness in reducing cetacean bycatch.

Kraus et al. (1995) suggest small cetaceans travel without continually echolocating, thus when approaching a set net with active pingers the cetacean is alerted to the presence of the net, thereby avoiding it. This is referred to as the "alerting" hypothesis. Alternatively, the "aversion" hypothesis assumes the animal avoided the area as a result of a strong aversion of the pinger. Kastelein (2001) studied different types of pingers and found varied reactions from fright responses to attraction. If the pinger is actually acting as an aversive (AHD), and the cetacean is in the area of the fishing gear for foraging purposes, the animal will likely habituate and over time the pinger will lose effectiveness. If the pinger is alerting the cetacean to the presence of the net, the animal may register the net as a hazard and flee. Conversely, the pinger may act as an attractant indicating foraging opportunity.

As outlined by Kraus (1999), AHDs have had to become increasingly loud over the years to remain effective. Current AHD sound source levels range between 194 and 200 db re 1 micropascal at 1 m with fundamental frequencies between 10 to 25 kHz (Johnston and Woodley, 1998). Few studies have been conducted to assess affects on non-target species. Mate (1993) conducted pond tests using swept frequencies between 2 and 20 kHz, with no observed effects on salmonid movement and reproduction. However, evidence has shown that cetaceans are repelled by these sounds (Olesiuk et al., 1996). Audible sound above approximately 130 dB and infrasonic or ultrasonic sound > 140 dB causes pain and sometimes sickness in vertebrates (Kryter, 1970; Pinel, 1972; Beuter and Weiss, 1986). Rats will habituate to sound frequencies capable of inflicting pain and even physiological damage (Campbell and Bloom, 1965), illustrating that pain-inducing intensities have little potential for behavioral control when the undesired behavior is strongly motivated.

Underwater Electrical Deterrent

An underwater electric deterrent system emits a pulsed low-voltage DC electric gradient integrated with a fishing net to deter seal depredation. This system was developed for specific application to harbor seal depredation on a gill-net test fishery on the Fraser River, B.C. (Forrest et al., 2009). Trails of activated electrical fishing nets were conducted in freshwater rivers. Factors which may affect the electric current and response of the target species include water conductivity (salt water), amperage, voltage gradient, electrode orientation, pulse duration, pulse frequency and pulse waveform as well as the species, weight, age, length, conductivity, motivation, and habituation of the animal (Forrest et al., 2009). As with acoustic deterrent devices, it is not clear what effects pulsed DC voltage has on nontarget species.

Movement Activated Guard Device (MAG), Radio Activated Guard Device (RAG) and Electronic Training Collars

Movement activated guard devices (MAGs), radio activated guard devices (RAGs) and electronic training collars are all activated contingent on the specific behavior attempting to be deterred. As such, these devices provide one of the strongest and most direct behavioral applications to aversive conditioning. Activation of the device triggers a strobe light and loud sound effects (RAGs and MAGs) or electric shock (electronic training collar) (Andelt et al., 1999; Shivik et al., 2003). These devices have been primarily tested on canids.

Electrical Fencing, Wire

Electrical fencing is another form of an electrical deterrent. An electrical fence does not create an impenetrable physical barrier. However, the electrical fence emits a shock as the animal crosses the barrier and will effectively illicit an unconditional flee response from the animal. This form of deterrent has excluded or inhibited movements of the California condor (Cohn, 1999; Snyder and Snyder, 2000), moose (Leblond et al., 2007), white-tailed deer (Seamans and Vercauteren, 2006) and feral pigs (Reidy et al., 2008). However, electrical fencing has been demonstrated to be costly and ineffective with elephants (Thouless and Sakwa, 1995; Okello and D'Amour, 2008).

Conditioned Taste Aversion

Conditioned taste aversion (CTA) pairs a nonlethal dose of poison, causing gastronomic repulsion to a specific food source. As elucidated by Gustavson et al. (1974), if an animal eats a poisoned meal and survives, it will develop an aversion to the flavor of that meal. Conover (1989) tested effects of 17 substances used for CTA on raccoons. Lithium chloride, an emetic, was one of the compounds tested. In laboratory testing, lithium chloride had no aversive effect on raccoons. Lithium chloride has been used in field trials with coyotes (Conover and Kessler, 1994) and deemed ineffective based on the behavioral conditioning aspects of the CTA. During the Ballard Locks salmonid-sea lion conflict outlined previously, tethered steelhead laced with lithium chloride were fed to sea lions. As a result, vomiting ensued but the sea lion immediately returned to foraging (Gearin et al., 1988; Jeffries and Scordino, 1997). CTA efforts may have been unsuccessful because the sea lions have not associated the CTA with the actual foraging behavior, mirroring the results of Conover and Kessler (1994).

Bitrex™, composed of denatonium benzoate, is another substance commonly used in CTA. Bitrex™ has low toxicity, yet the bitterness of taste renders the substance extremely aversive. At concentrations of 200–300 ppm, Bitrex™ is used as a repellent to domestic animals (Kleinkauf et al., 1999). In a study to test the effects of Bitrex™ on wood mice, common shrews and bank voles, Kleinkauf et al. (1999) found that common shrews and bank voles exhibited no sign of taste aversion whereas wood mice did. Interestingly, aversion was significant only when food was treated with Bitrex™ concentrations of 100–300 ppm. At concentrations greater than 500 ppm, aversion rates decreased. Kleinkauf et al. (1999) suggested that because of the close relation to lignocaine, at high concentrations Bitrex^{TM} may have an anesthetic effect on taste buds. Additionally, the extreme bitterness of the Bitrex^{TM} may not be considered unpleasant in some species having an inhibitor substance in the oral cavity which may reduce the bitter taste sensation, or for which the species natural diet consists of relatively bitter foods (Kleinkauf et al., 1999).

Thiabendazole (TBZ) is another common substance used in CTA aversion. TBZ is used to treat gastrointestinal worm infestations in animals, including humans (Standen, 1963). The effectiveness of TBZ is predicated on its unique characteristics, such as rapid absorption which leads to quick onset of illness, thus, providing a strong association between food taste and illness (Revusky, 1968; Nicolaus et al., 1989), a distinct lack of taste, thus reducing detectability, and low toxicity. As mentioned above, Ternant and Garshelis (1999) successfully used TBZ as the illness-inducing agent for CTA on American black bears.

Noise, Lights, Palm Fronds, and Other Disruptive Stimuli

In nearly all human-wildlife conflicts, an attempt at resolving the issue involves the use of noise including yelling, clapping, barking, sirens and firecrackers; or visual deterrents including flashing lights, fladry and, most uniquely, waving palm fronds. However, as most conflicts progress, the initial fright response to these deterrents become ineffective as a result of habituation (Linhart et al., 1984; Shivik, 2004).

Aversive Conditioning: Summary

A few patterns emerge from this review of application of aversive stimuli to wildlife conflict situations. First, studies involving the methodical application of an aversive stimulus to a specific behavior have the most success (e.g., CTA with black bears, MAGs with gray wolves). Attempts that require the animal to generalize or associate the aversive stimulus to nonspecific behavior have the least success. Stimuli used as a deterrent have demonstrated limited effectiveness for long-term use as a result of habituation but can be effective for short-term use on naïve animals. As demonstrated in a number of studies where the undesired behavior involves resource depredation, habituation to aversive deterrents occurs because the undesired behavior is already strongly established and the motivation behind the behavior overrides the aversive. In these cases, animals may experience pain ranging up to physiological damage yet still exhibit the undesired behavior. While many studies show promising results, testing of deterrent devices such as AHDs, electronic shocking devices, and poisons used in CTA must be further evaluated to determine effects on target as well as nontarget species.

The reviewed studies seem to indicate that the feasibility and effectiveness of aversive conditioning in the wild environment is limited. Based on the uniqueness of each situation, species-specific nonlethal tools must be developed with scientific rigor. A clearly defined management protocol carried out by qualified trained personnel is required for the benefit of the target and nontarget species as well as for the overall success of any aversive program.

HAWAIIAN MONK SEAL – HUMAN INTERACTIONS

Introduction

In the last decade, an increasing number of human-seal interactions have had negative impacts on the health and behavior of MHI seals and have proven a complicated challenge for management and responders. Recurring themes in behavior from the seals involved reflect a need to study the history of NMFS management practices and response to these events, as well as the need for developing strategies to handle similar situations in the future. To initiate this process, this review was compiled to highlight successes, lessons learned, and challenges encountered in NMFS response history.

Since 1991, there have been 23 documented cases of NMFS involvement with a seal of concern (Appendix A). These cases were of “concern” because of the seals proximity to high human traffic areas or the seals proximity to a freshwater source, imposing disease concerns. Of these cases, 18 were translocated to areas with the potential for greater socialization with other seals, less potential for human interaction, and minimal disease or entanglement risk. In 3 cases, the seal died or disappeared prior to NMFS intervention. In one case, the seal died while being held in captivity for observation. In another case no translocation was attempted, but a concerted effort to educate the community was implemented. Of the 23 documented seals of concern, a minimum of 13 seals were resighted in 2008 or 2009 with at least 8 remaining in the wild in the MHI. In the 15 cases where the seal did not “remain in the MHI,” there appears to be no occurrence of natural death from age. The strategies employed for removal from the MHI population include translocation outside of the MHI, unnatural death (gunshot wound, boat propeller injury, entanglement, Toxoplasma infection), reported dead as a pup or weaned seal, placed into captivity or disappearance.

In developing revised strategies for handling future conflict events, the successful cases where NMFS intervened and the seal remained in the MHI population are particularly informative. As mentioned, 35% (n = 8) of all NMFS case interventions resulted in the seal remaining in the wild in the MHI. Of these cases, 6 have had no further reported deleterious interactions. Chronologies of these 6 seals are highlighted in Appendix A. An evaluation of NMFS initial response to these cases, showed that an immediate intervention and translocation to an area where socialization with humans was less probable was the common strategy. In three cases, aversive handling during capture and translocation was implemented.

Lessons can also be learned from the 65% of cases where NMFS intervened but the resulting outcome was not beneficial to MHI monk seal population growth. Of these cases, many were translocated multiple times after extended periods of time in locations where human interaction was evident. In none of these cases was aversive conditioning attempted prior to the translocation.

Interviews

Overview

In an effort to garner a variety of key perspectives of these past events, interviews with Hawaiian monk seal recovery personnel valuable to current and past monk seal recovery management and response effort were conducted in September–October 2009. An attempt was made to interview a broad cross section of personnel involved in all aspects of the Hawaiian monk seal recovery program. Represented groups are listed in Appendix C. Seventeen of the 20 individuals who were contacted for an interview responded to the interview request. To standardize interviews, questions were asked regarding 4 individual seals on which NMFS has spent large amounts of time and resources in response to conflict events. Each interview lasted 30 to 90 minutes depending on involvement and length of responses. An opportunity during the interview allowed the interviewee to provide their suggestions and recommendations for future monk seal recovery management and response actions. Supporting documentation was also provided by many.

The interview process provided great insight to the difficulties faced by those involved in monk seal recovery efforts. Many reiterated the uniqueness of the human-wildlife dynamic surrounding Hawaiian monk seal recovery in the MHI, as well as the challenges in finding any one acceptable resolution to superficially similar conflicts. Other common concerns of interviewee responses included the lack of funding resources which limits response efforts and contributes to the lack of law enforcement presence. Respondents are also concerned that local residents' view of the Hawaiian monk seal is, in many cases, less than favorable. This perspective appears to arise largely from ongoing tensions with the U.S. government and regulations imposed surrounding the presence of an endangered species and which interferes with recreational or commercial interests. Some respondents said current communication failures have led to a severe rift between NMFS and some local communities, setting relations and, therefore, recovery efforts back enormously. In addition, even if efforts to inform the local community were successful there is still the constant flow of uniformed tourists visiting from around the world presenting additional challenges. It was also noted that much of the current response effort falls to volunteers with varying backgrounds and the ability to handle sensitive conflict issues. In addition, these volunteers have been subjected to increased negativity from their communities as conflict events worsen.

A few recurring topics of monk seal recovery management were addressed in the majority of interviews. These topics included differing views on the roles researchers and managers should take in recovery efforts, suggestions for protocol improvement, and the handling of chronic conflict situations. The following sections provide a summary of interview responses and are not necessarily the view of the author.

Perspectives on the Proper Strategy for Seal Conflict Resolution

All interviewed personnel echoed the same goal that minimizing seal-human conflict interactions is critically important in determining monk seal distribution and viability in the MHI. The majority urged reform in the manner in which intervention is conceived and applied, but there is a clear divisive line of thought on the specific direction those reforms should take. Most interview respondents echoed the following paraphrased statement:

> *"Decisions are non systematic and a formal decision making process needs to be developed for the future. There needs to be consistency in decisions and defensibility for decisions made."*

Alternatively, another view is summarized in the following statement:

> *"We need to manage these seals using a behavioral continuum and it is not quantifiable whatsoever. It is very soft perception not science. We need to react to problem seals based on a continuum of behavior."*

Interview respondents who agreed with the first statement conveyed widespread skepticism regarding the decision making process and some questioned how NMFS is fully compliant with permit stipulations, given the lack of formal protocols for response. Many felt decisions were made only after a problem seal's behavior escalated to become chronic or dangerous. At this point, the intervention scenario becomes entirely reactive, rather than being proactive and attentive to how an intervention will affect the seal's future behavior. Interviewees felt the lack of a formal process led to delayed response which, in turn, led to predictable habituation problems that could have been solved if NMFS moved rapidly and effectively early on.

Many felt this approach contributed to a lack of confidence and support in the decision making process and required individuals to respond to conflict situations in a manner they did not think was appropriate. Disagreement and uncertainty during the early stages of a conflict situation sometimes led to forced involvement in less than optimal interventions and outcomes that some responders feel should have been avoided if an appropriate response was carried out initially. Reacting to situations based on "soft perception" by one or several individuals requires that all involved parties (both within the agencies and the public) must have confidence in the decisions thus rendered. In this way consistency, communication and defensibility are not guaranteed, thereby creating the perception that responses to conflict situations are arbitrary or even haphazard.

Developing Protocols for Resolving Future Conflicts

In many interviews, respondents suggested that NMFS needs to achieve a consensus written protocol and subsequently adhere to these agreed on protocols or, at a minimum, use the established protocols as the primary reference point in identifying the most appropriate response. Another point mentioned during multiple interviews was that protocol cannot be reached by the unilateral decision made by any one group or based upon the perception of actions to be taken.

A respondent suggested that protocol would initially be applied and field-tested on Oahu, which is one of the most populous monk seal sites in the MHI and also the island having the largest network of agency researchers and trained volunteers. Once the protocols are established, the transferal of these protocols to islands outside of Oahu (which differ in such factors as accessibility and reaction time) will be addressed. There is general agreement that there is currently a "disconnect" and lack of clear guidance for handling conflict situations on islands outside of Oahu. There is a need for surveillance and qualified response teams with equipment on each island to enable fast and efficient response in handling a situation before habituation behaviors develop. Without protocols or equipment in place to handle specific conflict situations, inevitable delays occur as a result of travel paperwork, acquisition of appropriate vessels or gear, and last minute determination of what is allowed under permits. All of these considerations are in flux as NMFS embarks on an expanded monk seal population assessment program in the MHI (initiated in 2009), and pending development and adoption of the MHI Management Plan (in prep by PIRO).

Handling Chronic Conflict Situations (Repeat Offenders)

If habituation/socialization occurs prior to NMFS intervention, respondents suggested that NMFS needs to precisely document the interactions so that the chronology and factors contributing to the situation could be fully analyzed. Interviewees determined there are two options available to handle chronic conflict situations though many felt the major weakness of NMFS response history is the lack of success with the current following options:

1) Implement public education coupled with law enforcement. However, most respondents noted that, to date, public outreach and law enforcement have not proven successful in alleviating ongoing human-seal interactions. Many respondents suggested implementation of an *effective* public education campaign coupled with increased law enforcement presence could prove successful in preventing or handling chronic conflict situations.

2) Move the seal to a place where there are seals. However, once behaviors with humans become established, finding a sufficiently isolated location to translocate the seal where it will not find people has proven a challenge.

As mentioned, as a result of the growing number of human–seal interactions and the limited options to address this detrimental issue, the implementation of aversive conditioning is currently under consideration. Interviewees were asked about the possibility of incorporating aversive conditioning to deter or address future conflict situations. A large portion of the interviewees requested to learn more about aversive conditioning and the specific protocol considered for the Hawaiian monk seal prior to making any comment regarding future use. A minority of the interviewees expressed disapproval for the use of any aversive stimuli to be used on monk seals and was specifically concerned about the application of an aversive during sensitive life stages. For example, a pregnant female or molting animal should not be exposed to the stress incurred during the application of aversive stimuli in an attempt to alter behavior. Regardless of initial concern over the use of aversive conditioning, most respondents stressed the need to have suitable tools to handle conflict situations in place. In regard to the implementation of aversive stimuli as a tool in handling human seal conflict, respondents suggested the following:

1) Identify appropriate techniques garnered from thorough research to prevent or change undesirable monk seal specific behaviors and ensure that personnel with the proper expertise and/or credentials implement these techniques.

2) Develop protocols delineating when and how stimuli will be applied in accordance with what is allowable under permits.

3) Quantify how well a technique is applied and outline the characteristics of a success or failure to determine what factors are instrumental in determining the outcome.

4) Develop protocol for personnel roles and responsibilities following the initiation of aversive stimuli.

For many, the greatest concern in regard to aversive use on nuisance seals is that because of the current lack of resources and clearly defined protocol, the application of aversive stimuli will fall to those unqualified to apply the stimuli and effectively condition the animal. If that is the case, a given technique may be erroneously deemed an ineffective tool due to inappropriate application. Respondents also noted that public perception and backlash needs to be taken into consideration. Application of an aversive must not be carried out by a volunteer or someone without the ability to handle proper public messaging in a highly sensitive situation.

Hawaiian Monk Seal–Human Interactions: Summary

The increasing number of MHI monk seals has led to the increase in human-seal conflict interactions and has necessitated the development of response efforts from NMFS. The relatively recent increase in human-seal conflict and the limited success rate of conflict resolutions have necessitated a review of these efforts. Interviews garnered key perspectives from personnel with a vested interest in current and previous response efforts and highlighted the successes, lessons learned, and challenges of NMFS response history and offered strategies if faced with similar conflict situations in the future.

While many interviewees acknowledged the challenging factors which contribute to less-than-successful interventions, opinions varied on the role researchers and management should take in response efforts addressing human-seal conflict. This divide highlighted the weakness of NMFS response efforts as noted from the majority of interviews. Acknowledging the issues stemming from this divide, suggestions were made for protocol improvement and methods to address future similar chronic conflict situations. It is concluded that there is an urgent need to address the division of thought on the role researchers and managers should take to more successfully respond to human-seal conflict events.

The limited and mostly unsuccessful use of current options to handle conflict situations has prompted an inquiry of contemplating the possible use of aversive conditioning as an additional tool to use in preventing or handling future chronic conflict events. Advising for the need to thoroughly study aversive conditioning and the effects of aversive stimuli on the target and nontarget species, the majority of the interviewees were hopeful that the incorporation of aversive conditioning would be a useful tool for NMFS response. However hopeful, the majority of the interviewees based support for an aversive program dependant on a well-defined protocol and a thoroughly researched aversive program.

All personnel interviewed are dedicated to the same goal of monk seal recovery and stressed the need to minimize the human-seal conflict for population growth and viability in the MHIs. Through assessment of NMFS' response history and development of strategies to address the shortcomings of previous response efforts, future similar conflict situations may be avoided or may produce more successful outcomes. The challenges presented to NMFS' response efforts to human-seal conflicts in the MHIs are significant. However, many interviewees deemed that the strength of NMFS lies in the access to individuals with the depth of knowledge and experience necessary to professionally and effectively handle the Hawaiian monk seal. Evaluation of successes and lessons learned from NMFS' response history and addressing the suggested strategies for future similar situations may lead to increased growth and viability in the MHIs.

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Appendix A. NMFS-documented Human-seal Interaction Case Summaries

The following 6 seals remain in the MHI with no further reported deleterious human-seal interactions post NMFS intervention.

Seal ID: RH44
Birth location: Poipu, Kauai
Initial interaction location: Poipu, Kauai
Age at first reported human socialization: None observed
Summary: Female weaned seal was translocated to Larson's beach after weaning to avoid socialization with people in high human density area.
Aversive used: None
Current status: Seal pupped on Molokai in 2007, 2008, and on Maui in 2009. No reports of interaction with humans since translocation.

Seal ID: RH58
Birth location: Maha'ulepu, Kauai
Initial interaction location: Maha'ulepu, Kauai
Age at first reported human interaction: Pup
Summary: Female translocated to Larson's Beach after weaning in September 2000 to avoid human socialization.
Aversive used: None
Current status: Seal pupped on Kauai in 2006, 2007, 2009 and observed on Oahu 2008 and 2009. No reports of interaction with humans since translocation.

Seal ID: R2AU / RH40 / R1AQ
Initial interaction location: Poipu, Kauai
Interaction period: March 2003
Age at first reported human socialization: Yearling
Summary: Three juvenile seals (2 male, 1 female) socializing among swimmers at Poipu Beach, Kauai. All 3 seals were tagged, instrumented with VHF transmitters and epidemiologically sampled. All 3 seals were translocated to the north shore Kauai.
Aversive used: All 3 seals experienced aversive handling during capture, instrumentation and translocation.
Current status: R1AQ seen on Kauai 2008, RH40 seen on Kauai 2009, R2AU seen on Oahu and Kauai 2009. No reports of interaction with humans since translocation.

Seal ID: RW22
Birth location: Waialee Beach Park, Oahu
Initial interaction location: Waialee Beach Park, Oahu
Age at first reported human socialization: None observed
Summary: Male weaned seal was translocated to Rabbit Island after weaning to avoid socialization with people in a high human density area.
Aversive used: None
Current status: Re-sighted at Rabbit Island, Oahu in 2009. No reports of interaction with humans since translocation.

The following 2 seals remain in the MHI but with continued human-seal interaction post NMFS intervention.

Seal ID: RV18
Birth location: Kiahuna, Kauai
Initial interaction location: Kiahuna, Kauai
Age at first reported human interaction: Pup
Summary: Male translocated to Kulikoa Pt. after weaning in October 2005 to avoid human socialization. Three separate dehooking events initiated by PIRO/PIFSC between 2006–2008.
Aversive used: None
Current status: Seal observed on Kauai in 2009.

Seal ID: RB24
Birth location: Maha'ulepu, Kauai
Initial interaction location: Maha'ulepu, Kauai
Age at first reported human interaction: Pup
Summary: Female seal was attempted to be translocated after weaning in November 2007 to avoid human socialization; however, the potential release site was deemed unacceptable and the seal was released at birth site. Seal was attacked by a dog in 2007 Maha'ulepu.
Aversive used: None
Current status: Seal observed on Kauai in 2008.

The following 15 seals do not remain in the MHI post-NMFS intervention because of translocation out of the MHI, death, disappearance or placed into captivity.

Seal ID: RZ22
Birth location: Haena Pt., Kauai
Initial interaction location: Haena Pt., Kauai
Interaction period: 1991
Age at first reported interaction: Post-weaning
Summary: Female seal began socializing with swimmers post weaning. The seal was then translocated to Niihau in September 1991 and resighted in 1994.
Aversive used: None
Current status: RZ22 was reported killed by a boat propeller prior to 1999.

Seal ID: RZ20
Birth location: Waialee Beach Park, Oahu
Initial interaction location: Waialee Beach Park, Oahu
Interaction period: 1991
Age at first reported interaction: Pup
Summary: Female born near the mouth of a river with large outflow and potentially fatal conditions during a rainstorm. The pup was initially translocated down the beach away from the river mouth. Due to proximity to a human dense area and to prevent socialization with humans, the seal was translocated post-weaning to Kure in June 1991.
Aversive used: None
Current status: RZ20 observed at Kure in 2008.

Seal ID: RP18
Birth location: Kaneohe Bay Marine Corp Air Station, Oahu
Initial interaction location: Kaneohe Bay Marine Corp Air Station, Oahu
Interaction period: 1996
Age at first reported interaction: Post weaning
Summary: Male seal was reported socializing with humans. The seal began to move around the island post-weaning and disappeared prior to NMFS planned translocation efforts.
Aversive used: None
Current status: RP18 disappeared several months post-weaning in 1996.

Seal ID: TEMP 700 ("Humpy")
Birth location: Unknown
Initial interaction location: Molokini
Interaction period: September 1-17, 1997
Age at first interaction: Unknown
Summary: Seal, unknown sex, was reported interacting with snorkelers including biting, Grabbing, and mounting. Additional sightings of "Humpy" were reported although it was not clear if it is the same seal.
Aversive used: None
Current status: A permanent identification of the seal was not made; therefore, current status is unavailable.

Seal ID: RD34
Birth location: Pacific Missile Range Facility, Kauai
Initial interaction location: Pacific Missile Range Facility, Kauai
Interaction period: August 1999
Age at first reported human interaction: Pup
Summary: Female born in close proximity to a drainage canal. The pup was tagged but not translocated August 1999.
Aversive used: None
Current status: Pup reported dead September 1999.

Seal ID: RM68
Birth location: Poipu, Kauai
Initial interaction location: Poipu, Kauai
Age at first reported human interaction: Pup
Summary: Male translocated to Larson's Beach after weaning in September 2000 to avoid human socialization.
Aversive used: None
Current status: Seal last observed in 2001.

Seal ID: RM34
Birth location: Kamilo, Hawaii. May 2001
Initial interaction location: South Point, Hawaii
Interaction period: 10/15/2003 – 12/1/2003
Age at first reported human socialization: Sub-adult male
Summary: Male born on the Big Island and became habituated to humans within first 2 years. Two separate fishing gear entanglements and dehooking events initiated by PIRO/PIFSC. First reported interaction on 15 October 2003, at Kealakekua Bay, Hawaii. Translocated back to birth location at South Point on 19 October 2003. Returned to Kealakekua Bay within 7 days and reinitiated human interactions. Translocated to Kahoolawe Island on 28 October 2003. Observed at Big Beach, Maui, on 18 November 2003, again interacting with humans. Recaptured on 21 November 2003, and moved to Kewalo Basin NMFS facility for holding. Translocated to Johnston Atoll on 1 December 2003.
Aversive used: None
Current status: RM34 not relocated or detected via satellite tag following release in December 2003.

Seal ID: RK07
Birth location: Poipu, Kauai
Initial interaction location: Nawiliwili Harbor, Kauai
Interaction period: 10/15/2003 – 1/15/2004
Age at first reported human socialization: Adult
Summary: Adult male approaching people at Nawiliwili Harbor to be fed. The first record of feeding was on 15 October 2 003. Anecdotal stories reported seal was fed beginning in 2001 although no reports were received at that time. Observations of the seal were conducted and educational outreach for the community was provided in an effort to stop people from feeding the seal. Socialization with people also occurred at Waikaea canal in Kapaa at the boat ramp where feeding interactions most likely took place.
Aversive used: None
Current status: Last reported human interaction on 15 January 2004. RK07 was found dead on 22 January 2004. Cause of death systemic Toxoplasma gondii infection.

Seal ID: RI19
Birth location: Maha’ulepu, Kauai
Initial interaction location: Maha’ulepu, Kauai
Age at first reported human interaction: Pup
Summary: Male translocated to Na Aina Kai after weaning September 2004, to avoid human socialization.
Aversive used: None
Current status: Seal died from a gunshot wound April 2009.

Seal ID: RI21
Birth location: Poipu, Kauai
Initial interaction location: Poipu, Kauai
Age at first reported human interaction: Pup
Summary: Female translocated to Na Aina Kai after weaning in September 2004, to avoid human socialization.
Aversive used: None
Current status: Seal not re-sighted after 2004.

Seal ID: R6AY
Birth location: Hakalau, Big Island
Initial interaction location: Hakalau, Big Island
Age at first reported human interaction: Pup
Summary: Male born in close proximity to river mouth. Due to disease concerns, the seal was captured and held in captivity for observation.
Aversive used: None
Current status: Seal died in captivity prior to release.

Seal ID: RO32
Birth location: Turtle Bay, Oahu
Initial interaction location: Turtle Bay, Oahu
Age at first reported human interaction: Pup
Summary: Female translocated to Rabbit Island after weaning in July 2006 due to fishing line entanglement and human socialization concerns.
Aversive used: None
Current status: Seal died from entanglement drowning in October 2006.

Seal ID: RO42
Birth location: Papaikou, Big Island. July 2006
Initial interaction location: Black Point, Hawaii
Interaction period: 9/7/2006–2/27/2009
Age at first reported human socialization: Yearling
Summary: Female born on the Big Island near a stream mouth and translocated after weaning due to disease and habituation concerns. The seal moved to Kapanai Beach where there was risk of human socialization as well as disease concerns due to proximity of freshwater stream. Animal then translocated a second time on 19 September 2006, 3 miles south of Lapakahi State Park but began interaction

with the public. Captured on 24 August 2007, and translocated to Keahaou; however, began interaction with people again. Translocated a fourth time on 26 August 2008, to Molokai. Observed interacting with people on Lanai. Translocated a fifth time to captivity on Oahu 23 February 2009, translocated and released at Nihoa Island (NWHI) in February 2009.
Aversive used: None
Current status: Seal has not been resighted on Nihoa in 2009 following release.

Seal ID: RW18
Birth location: Mokuleia, Oahu
Initial interaction location: Mokuleia, Oahu
Age at first reported human interaction: Pup
Summary: Male translocated to Rabbit Island after weaning in July 2008 to avoid human socialization.
Aversive used: None
Current status: Seal found dead at Waimanalo in October 2008.

Seal ID: RW46 (KP2)
Birth location: North Larsen's, Kauai. May 2008
Initial interaction location: Kaunakakai Warf, Molokai
Interaction period: Post captivity socialization with people 2/2009–present
Age at first reported post captivity human socialization: Yearling
Summary: Male born to a mother who had abandoned first pup; therefore, second pup (KP2) was immediately taken into captivity and raised to wean. While in captivity he developed an eye problem; cause was never definitive. Seal was released at 8 months old to Kalaupapa, Molokai on 15 December 2008. Two months post release reports of socialization with people at Kaunakakai Wharf. Volunteers monitored area and used a palm frond and a loud voice to displace the seal when hauled out at the Kaunakakai Pier or other locations where interactions with humans occur. Seal was initially tracked by NMFS via satellite tag data and VHF location. Seal translocated 12 June 2009 back to Kalaupapa, Molokai. Volunteers attempted educational outreach for the community in an effort to stop people from interacting with the seal. Veterinary exam during translocation attempt in October 2009 resulted in seal being held for permanent captivity as a result of animal's near blindness.
Aversive used: loud noise, palm frond
Current status: Seal held in captivity.

Appendix B. Aversive Stimuli Applied to Wild Animals Involved in Human/Wildlife Conflict.

Target Species	Aversive Stimuli Applied	Species Status	References
African elephant (*Loxodonta africana*)	Capsicum oleoresin, electric fence, fire, drums, deterrent shooting	IUCN[1] "near threatened"	Osborn and Rasmussen (1995) Okello and D'Amour (2008)
American black bear (*Ursus americanus*)	Capsicum oleoresin, rubber buckshot, CTA, dogs	IUCN "least concern"	Beckmann et al. (2004), Ternant and Garshelis (1999)
Asian elephant (*Elephas maximus*)	Capsicum oleoresin, electric fence, fire, drums, deterrent shooting	IUCN "endangered"	Osborn and Rasmussen (1995) Thouless and Sakwa (1995)
California condor (*Gymnogyps californianus*)	Electric wire, electric shock	IUCN "critically endangered" ESA[2] "endangered"	Snyder and Snyder (2000), Woods et al. (2007), Cohn (1999)
California sea lion *(Zalophus californianus*)	AHDs, underwater firecrackers (seal bombs), vessel harassment, CTA, rubber projectile	MMPA,[3] IUCN "least concern"	Gearin et al. (1986), Fraker and Mate (1999), Brown et al. (2007)
Cliff swallow (*Petrochelidon pyrrhonota)*	Bioacoustics- alarm calls	MBTA[4] IUCN "least concern"	Conklin et al. (2009)
Gray wolf (*Canis lupus*)	MAG device, RAG device, electronic training collar	ESA "endangered" IUCN "least concern"	Shivik et al. (2003), Andelt et al. (1999)
Hector's dolphin (*Cephalorhynchus hecorti*)	ADDs	IUCN "endangered"	Stone et al. (1997)
Louisiana black bear (*Ursus americanus luteolus*)	Rubber buckshot, dogs	ESA "threatened"	Leigh and Chamberlain (2008)
Moose (*Alces americanus*)	Electric fence	IUCN "least concern"	Leblond et al. (2007)
Pacific harbor seal (*Phoca vitulina*)	underwater electric gradient, ADDs (pingers)	MMPA IUCN "least concern"	Forrest et al. (2009)
Steller sea lion (*Eumetopias jubatus*)	AHDs, underwater firecrackers (seal bombs), vessel harassment, CTA, rubber projectile	MMPA ESA "threatened" IUCN "endangered"	Brown et al. (2007)
White tailed deer (*Odocoileus virginianus)*	Electric fence	IUCN "least concern"	Seamans and Vercauteren (2006)

[1]International Union for Conservation of Nature
[2]Endangered Species Act
[3]Marine Mammal Protection Act
[4]Migratory Bird Treaty Act

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Appendix C. List of Agencies or Groups Who Participated in Interviews Regarding NMFS Intervention History with Seals of Concern.

All interviews were anonymous and individual responses did not necessarily represent the view of the agency or group.

National Marine Fisheries Service, Pacific Islands Regional Office (PIRO)

National Marine Fisheries Service, Pacific Islands Fisheries Science Center (PIFSC)

National Marine Fisheries Service, Headquarters

Marine Mammal Commission (MMC)

Monk Seal Recovery Team

State of Hawaii

Private stakeholders

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Availability of NOAA Technical Memorandum NMFS

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