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A Test Of Educational Methods To Reduce Boating Disturbance To Harbor Seals

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A TEST OF EDUCATIONAL METHODS TO REDUCE BOATING DISTURBANCE TO HARBOR SEALS

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TO HARBOR SEALS

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ABSTRACT

A TEST OF EDUCATIONAL METHODS TO REDUCE BOATING DISTURBANCE TO HARBOR SEALS

by Rachel Nicole Solvason

Environmental education can affect attitudes and behaviors, but determining the most effective methods for protecting wildlife requires research. This study examined the effect of two modes of environmental education, one passive and one active, on the behaviors of boaters toward harbor seals (*Phoca vitulina*) at Corkscrew Slough in Redwood City, California, an area where harbor seals haul out and pup. Thirty-one boaters viewed an interpretive sign (passive environmental mode) and 30 experienced a docent talk (active) both designed to educate boaters on protecting harbor seals; 31 boaters received no environmental information (the control), therefore were not exposed to the interpretive sign or the docent talk. I collected data on how these boaters responded to harbor seals in Corkscrew Slough and on the response of harbor seals to the boaters. Data were analyzed with ANOVA and Chi-square to assess differences between treatments. Boaters exposed to signs or docents stayed significantly further from the seals compared to boaters not exposed to any environmental education. However, neither the sign nor the docent reduced the length of time boaters spent traveling through the Slough compared to the control, nor was the number of boaters stopping to observe seals reduced. Harbor seals showed no difference in disturbance responses to boaters, no matter what the mode of education for the boaters. These results suggest signs and docents may change some boater behavior but that managers should not depend solely on these educational approaches to protect sensitive wildlife

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Introduction

Effectively managing recreational activities in highly urbanized areas is essential for managers, especially when wildlife and humans are in close proximity, as human activities can have lasting negative effects on animal behavior and populations. As the human presence in wildlife habitat increases, educating the public is seen as a key strategy for wildlife managers looking to reduce negative impacts to wildlife (Lim & McAleer, 2005).

Environmental education is used by managers in natural areas as a tool to balance the ecological, social, and economical needs of a visited area (Lim & McAleer, 2005) and to increase visitor knowledge and satisfaction (Orams, 1995). Active and passive interpretive services are used to increase visitor compliance and to create pro-environmental attitudes (Orams, 1995). Through this process of maximizing positive interaction, visitors are more likely to become physically or emotionally attached to the location, resulting in an increased desire to willingly act more responsibly. This concept is known as place attachment (Reynolds & Braithwaite, 2001; Williams & Vaske, 2003).

Although numerous interpretive methods are used by managers, the effectiveness of different methods in varying situations is often not known. Understanding the level of effectiveness of active and passive interpretive services is essential for managers who seek to balance ecological, social, and economical factors at public access sites. Providing managers with effective tools can help insure positive visitor response and increase visitor compliance with resource protection rules. Public access must be balanced with ecological protection if natural areas are to continue to support wildlife and provide recreational services to visitors (Hvengaard, 1995).

Background

A network of boat launch sites known as the San Francisco Bay Area Water Trail (Water Trail) is planned for the San Francisco Bay (the Bay) (California Coastal Conservancy, 2011). The Water Trail is expected to connect the nine Bay Area counties and join three regional trail systems: San Francisco Bay Trail; Bay Area Ridge Trail; and California Coastal Trail. Sites along the Water Trail will allow visitors and residents to experience the Bay's historic, cultural, scenic, and environmental richness on a single day or multi-day basis. Boat launch sites are expected to be located on private and public lands, and land owners will be responsible for deciding their own management goals and strategies. Several boat launch sites are already a part of the trail.

The increased access to the Bay that the Water Trail will provide has created concern among wildlife advocates and managers concerning sensitive wildlife and their habitats. One species of concern is the harbor seal (*Phoca vitulina*), a marine mammal protected by the federal Marine Mammal Protection Act of 1972. The Water Trail Environmental Impact Report (Water Trail EIR) lists interpretive programs as one way to reduce impacts to marine species such as the harbor seal (California Coastal Conservancy, 2011). However, methods of environmental education that are effective in protecting harbor seals from disturbance have not been tested. The Water Trail provides an excellent opportunity to test how effective different public education methods are at changing the behavior of boaters toward wildlife.

Literature Review

The theoretical background for environmental education lies in theory and research on human behavior. Ajzen's (1991) Theory of Planned Behavior (TPB), an extension of the earlier Theory of Reasoned Action (Fishbein & Ajzen, 1975), attempts to predict and explain planned and deliberate human behavior. The TPB states that an individual's behavior is driven by his or her intention to act. In turn, intention to act is influenced by the relationship between three motivational factors 1) the individual's attitude towards the behavior, 2) subjective norms, and 3) perceived behavioral control. The stronger an individual's intention to act, the more likely he or she is to engage in a particular behavior (Ajzen, 1991). Based on this theory, it is essential managers understand the targeted audience's motivational factors in order to predict whether or not specific educational programs will be successful at influencing positive behavioral change and/or adoption of responsible environmental behaviors.

The model of Responsible Environmental Behavior (REB) (Figure 1) focuses on the most influential contributing factors associated with pro-environmental behavior (Hines, Hungerford, & Tomera, 1987). This model envisions a person's intention to act as influenced by an individual's personality factors (which include Ajzen's (1991) three motivational factors), as well different types of knowledge and action skills. Other factors, including sociodemographic variables such as income, education, age, gender, and situational factors, such as economic constraints, social pressures, and opportunities to choose a different action, can also influence an individual's original intention (Hines et al., 1987).

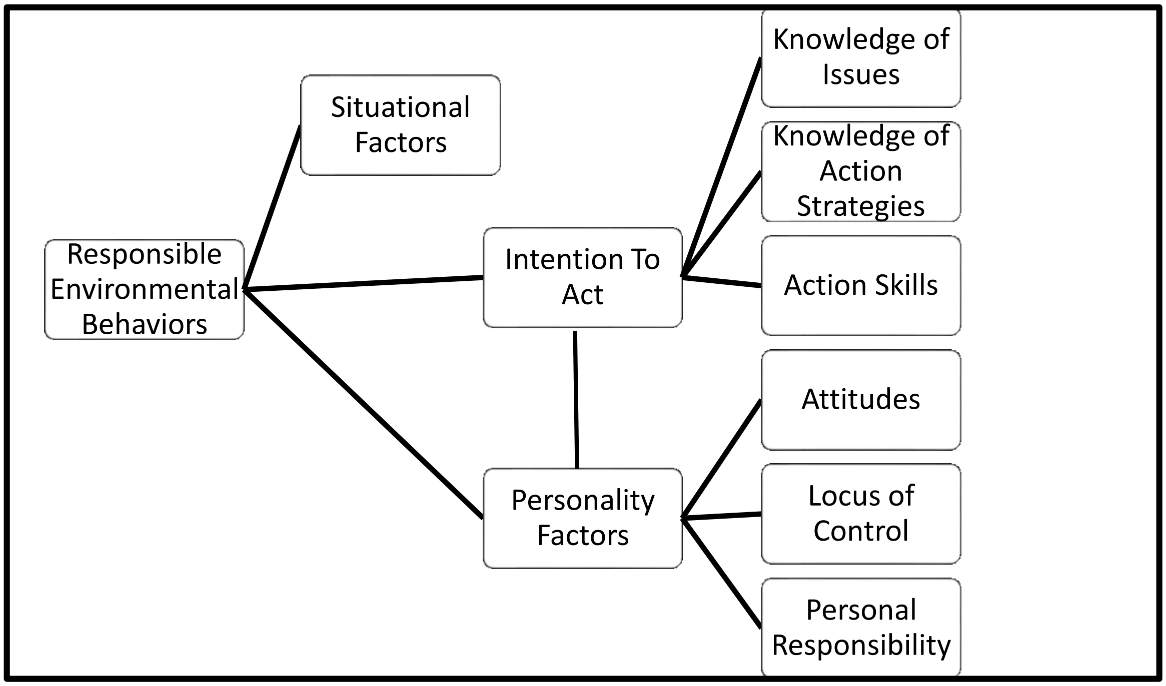

Figure 1. The Model of Responsible Environmental Behavior. Image adapted from Hines, Hungerford, and Tomera, 1987.

Both the TPB (Ajzen, 1991) and REB (Hines et al., 1987) models identify attitude as a general motivational predictor of intention to act. There are two types of predisposed attitudes that predict behavior: attitudes toward the topic as a whole and attitudes toward taking action (Ajzen & Fishbein, 1980). General attitudes toward the environment can be influenced by affiliating groups, agencies, organizations, and minorities (Ajzen, 1991). In general, attitudes toward a particular environmental action rather than the environment as a whole are a stronger predictor for action or inaction (Vicente & Reis, 2008).

In addition to attitudes, knowledge is considered a pre-requisite for predicting (Hines et al., 1987). However, researchers found that an individual's knowledge about skills and strategies for resolving an environmental issue increased a person's intention to act in an environmentally responsible manner as compared to providing only increased knowledge of an issue (Hwang, Kim, & Jeng, 2000). For example, Mckenzie-Mohr, Nemiroff, Beers, and Desmarais (1995) found an increase in household recycling participation when individuals were given information on how to recycle (knowledge of action) as opposed to only information on why recycling was important (knowledge of the issue).

As with attitudes, knowledge influences personality factors such as personal responsibility and locus of control (LOC), which is an individual's perception that he or she has the ability to create change through his or her own behaviors (Hines et al., 1987). Both morality and a desire for social approval can increase an individual's personal responsibility to care about the welfare of others or, in this case, the environment (Kaiser & Shimoda, 1999; Kaiser, Wolfing, & Fuhrer, 1999). By applying both the models of TPR and REB when creating educational tools, managers may be able to increase its ability to predict user adoption of responsible environmental behaviors, thereby increasing the ability to reduce potential threats as a result of human activities to surrounding wildlife areas (Kaiser et al., 1999).

Marine species response to disturbance stimuli. The number of people participating in recreational activities in marine environments is increasing (Orams, 1998). While not all recreational activities, such as boating, are intended to be harmful to wildlife, even such non-consumptive activities are capable of altering habitats and disturbing wildlife by simulating conditions comparable to predation (Frid & Dill, 2002). For some animals, distinguishing between true predation stimuli and human disturbance stimuli may be impossible. Therefore, human disturbance may result in an increase in the number of disruptions to an animal's routine behavior (Frid & Dill, 2002). Marine mammals, including whales, porpoises, and seals, have been shown to be negatively affected by human disturbances.

Human disturbances may disrupt foraging, resting, breeding and nursing, increase animal vigilance and, over time, can create chronic stress (Frid & Dill, 2002; Kelly, Glegg, & Speedie, 2004; Beal, 2007). As a result, repeated disturbance may potentially increase net energy loss required for breeding and tending young and contribute to long-term negative effects to the health of individuals and overall populations (Knight & Cole, 1995; Gill, Sutherland, & Watkinson, 1996; Frid & Dill, 2002; Kelly et al., 2004; Beal, 2007). For example, Williams, Lusseau, and Hammond (2006) studied the energy costs of behavioral responses of killer whales (*Orcinus orca*) to boats in British Columbia, Canada. They showed that when boats were present killer whales spent less time feeding resulting in an 18% decrease in energy intake, a significant loss of energy.

Long-term disturbance stimuli can cause marine mammals to shift habitats or abandon an area completely, resulting in changes in species distribution (Knight & Cole, 1995; Gill, Norris, & Sutherland, 2001). A long-term study by Bejder et al. (2006) compared populations of bottle nose dolphin *(Tursiops truncatus)* in high vessel traffic areas to low vessel and no vessel traffic areas to determine whether or not the cost of the disturbance outweighed the energy cost to relocate. The researchers found declining populations of bottle nose dolphins in locations experiencing high vessel traffic and increasing populations in adjacent low vessel traffic locations. These results indicated bottle nose dolphins shifted habitat areas to avoid disturbances caused by high numbers of vessels. If the disturbance is intense enough, shifting habitat can reduce access to resources due to over-crowding and competition (Gill et al., 2001; Lafferty, 2001; Frid & Dill, 2002). However, in highly urbanized areas where alternative habitats may not be available, animals may have no choice but to habituate to disturbance stimuli and may experience reduced health and/or habitat quality (Gill et al., 2001).

Each species has its own response thresholds for disturbance stimuli (Frid & Dill, 2002). Factors influencing these thresholds include, but are not limited to, disturbers' approach angle, approach speed, length of stay in the animal's habitat, and/or proximity to individuals or refuge. The number of disturbers, as well as the disturbed animal's net cost to flee, also influence an animal's response to perceived predation (Frid & Dill, 2002). In general, flight response rates and flight initiation distances increase when disturbance stimuli approach more directly and more quickly (Frid & Dill, 2002).

Harbor seal biology. Along the North American Pacific coast, the harbor seal (*Phoca vitulina*) ranges from Alaska to Baja California, Mexico. The harbor seal is a small phocid seal and member of the pinniped family (Grigg et al., 2009). Adult harbor seals weigh roughly 65 to 105 kg and is 1.2-1.8 m in length, with males slighter larger than females. The average lifespan ranges from 25-30 years (Antonelis & Fiscus, 1980). Harbor seals have no external ear flaps and their small flippers require they flop on their bellies in order to move. As opportunistic feeders, harbor seals pursue seasonally abundant species of fish (Antonelis & Fiscus, 1980). Pelage colors for male and females are the same, ranging from grey to dark brown and black with lighter molting spots (Antonelis & Fiscus, 1980). Some populations appear to have a reddish pelage from the deposition of iron oxide precipitates, a condition recorded in the San Francisco Bay (Allen et al., 1993).

Harbor seals residing along the California coast rely on available secluded beaches, rocky intertidals, or mudflats in bays and estuaries for haul-out sites (Antonelis & Fiscus, 1980). Hauling out, when seals move onto land, is needed for seals to rest, molt, breed, birth and nurse pups (Fox, 2008; Gunvalson, 2011). Ideally, haul-out zones are located in shallow waters but with easy access to deep waters for foraging and providing a quick escape from predators (Nordstrom, 2002).

In the San Francisco Bay, females give birth on land between February and April and spend much of the lactation period in the water foraging with pups. Pups are weaned approximately four weeks after birth; however, females may begin foraging trips before pups are weaned, leaving pups unattended onshore (Thompson, Miller, Cooper, & Hammond, 1994). For this reason, harbor seals may repeatedly forage in a specific location and chose foraging sites relatively close to haul-out and pupping sites (Suryan & Harvey, 1998; Grigg et al., 2009).

Harbor seal disturbance studies. Recreational activities, such as boating, occur near coastlines and overlap with harbor seal habitat. Haul-out zones may be in areas accessible to recreationists and may be sought out for wildlife viewing, especially in highly urbanized areas such as the Bay (Orams, 1998). Disturbance to resting seals can be detrimental to their health, especially if the disturbance is repeated or pups are disturbed.

Harbor seals responding to disturbance may become alert, agitated, or may even flee into the water. Seals that flush tend to trigger other individuals to follow, as seals often flush en mass (Allen & Huber, 1984). Each of these behaviors results in a loss of net energy and increased continual stress levels for the entire hauled-out population (Suryan & Harvey, 1998; Grigg et al., 2009). Average seal "recovery time" – the time for a seal that has flushed to return to the haul-out site – is between 10 and 30 minutes (Allen et al., 1984; Allen & Huber, 1984; Fox, 2008). Fox (2008) observed the impacts of small boats on a group of harbor seals along Corkscrew Slough, Bair Island, in San Francisco Bay. Bair Island is a well-known, long-term harbor seal haul-out area in the San Francisco Bay and is frequented by motorized and non-motorized boats. Fox (2008) measured seal responses to boaters, including flush rates and recovery time back to the haul-out zone. Non-motorized boats, such as kayaks and canoes, had the greatest impact with flushing occurring over 50% of the time (Fox, 2008). In their study of harbor seals in Metis Bay, Quebec, Henry and Hammill (2001) also found harbor seal flush rates were higher when they were approached by kayaks as opposed to motorized boats.

Other studies have indicated that harbor seal flush rates vary depending on season. Anderson, Teilman, Dietz, Schmidt, and Miller (2012) found harbor seals were less likely to flush post breeding season when they are either tending to pups or molting. The net energy required to relocate is too high during times when sensitive activities such as tending pups are taking place, as predicted by the risk-disturbance hypothesis (Frid & Dill, 2002). Lack of relocation did not necessarily mean that the impact to the harbor seals were less; instead it is an indication of their willingness to tolerate the disturbance

(Anderson et al., 2012). If possible, harbor seals may re-locate to an alternative haul-out location. However, where habitat is limited or other factors exist, such as the presence of pups, seals are forced to remain at repeatedly disturbed sites. The potential for adverse effects to harbor seal reproduction rates is greater in areas experiencing continual disturbance (Allen & Huber, 1984).

Allen and Huber (1984) recorded sources of disturbance to hauled-out harbor seals and the seals' behavioral responses to the disturbance in the Point Reyes, California region. Fisherman and boaters (motorized and non-motorized) were found to be the major source of disturbance, especially for hauled-out seals in Tomales Bay where disturbance was greatest. In this area, fishing occurred year-round and boats were able to travel close to the haul-out sites. Following a disturbance, 42% of harbor seals would not return to the haul-out site. The recovery rate for those seals that did return was approximately 18 min (Allen & Huber, 1984). Tomales Bay and Drakes Estero in the Point Reyes area, also frequently disturbed by humans, showed declines in seal reproduction rates compared to more remote areas, suggesting a possible relationship between human disturbance and harbor seal reproductive success (Allen & Huber, 1984). Since then, researchers have found additional evidence that boaters can have negative effects on harbor seal populations (Henry & Hammill, 2001; Fox, 2008; Gunvalson, 2011).

Although the results of many studies show human activities can have a negative impact on harbor seals, several indicate little effect on the factors measured. For example, Grigg (2012) captured 19 adult harbor seals from Castro Rock, a well populated haul-out site in the north San Francisco Bay, and tracked seals using satellite telemetry for four years to determine the in-water distribution of the animals in an area highly populated by people. Grigg (2012) hypothesized human activity would significantly affect the foraging habitat selected by seals but found that human activity was not a significant factor in foraging distribution. This study suggests harbor seals in the Bay may either already be habituated to the high levels of human activity or may be limited to foraging areas and are unable to avoid human activity (Grigg, 2012).

Managing disturbance in natural areas. Environmental education is one of the most common indirect control methods used by managers to affect visitor behaviors and promote positive attitudes towards the environment (Orams, 1995; Kuo, 2002; Marion & Reed, 2007). Environmental interpretation, also known as interpretation services (Moscardo, Woods, & Saltzer, 2004), provides natural, historical, and cultural information (Moscardo, 1998) and aids in conveying management goals of sustainability through the use of preservation and conservation messages (Orams, 1995; Madin & Fenton, 2004; Hughes & Morrison-Saunders, 2005; Randall & Rollins, 2009). Interpretation increases knowledge and understanding of rules, regulations, and appropriate behavior and can influence pro-environmental attitudes and beliefs (Orams, 1995; Winter, Cialdini, Bator, Rhoads, & Sagarin, 1998; Madin & Fenton, 2004; Hughes & Morrison-Saunders, 2005).

For the purpose of this thesis research, interpretation was divided into two different categories: passive and active. Passive interpretation, also known as non-personal interpretation, is information delivered through written messages on interpretive signs, brochures, and/or exhibit displays (Munro, Morrison-Saunders, and Hughes, 2008). Munro, Morrison-Saunders, and Hughes (2008) characterized passive services as providing a one-way interaction between management and visitors and, because of this, it may be less effective at relaying messages. Active services provide a two-way interaction between management and visitors and are delivered verbally by a trained trail guide or docent or through an educational program (Munro et al., 2008). Guided tours and educational programs are all included under the "docent program" category because they are delivered verbally, demonstrate role-model behavior and provide on-site, in-person information to visitors. Docent programs allow visitors an opportunity for conversation to go deeper than an interpretive sign or other passive services could provide.

Interpretive signs. Interpretive signs are the most economical educational tool and therefore the most frequently used by natural area managers (Brown, Ham, & Hughes, 2010). Design, placement, and purpose are important characteristics when creating an effective interpretive sign. Bramwell and Lane (1993) recommend managers limit sign use to carefully selected areas and address key information that is not oversimplified. Cole, Hammond, and McCool (1997) found visitors' abilities to correctly identify agency-recommended behaviors was effective when signs consisted of 2-8 low impact messages regarding one or two separate concepts, requiring a minimum of 25 seconds to read.

In addition to increasing knowledge, interpretive signs can enhance a visitor's experience in a natural area by providing deeper cultural, historical, and ecological understandings of the area (Moscardo, 2003; Poudel & Nyaupane, 2013). Hughes and Morrison-Saunders (2005) surveyed visitors' knowledge and attitudes at Tree Top Walk in Western Australia before and after additional interpretive signs were installed around the park. The signs effectively increased knowledge of repeat visitors. There was also a significant increase in overall visitor satisfaction and a positive perception of a learning experience after the signs were installed compared to before. The additional signs addressed historical, ecological, and structural aspects that existing signs lacked. The placement of the new signs was significant in that previous signs were placed at the trailhead only, making it difficult and frustrating for visitors trying to recall information and identify subjects while on the trail.

Interpretive signs can be effective at reinforcing visitor's pre-existing attitudes and/or beliefs towards certain activities. However, there is debate as to whether signs are successful at changing already existing attitudes and beliefs (Mallick & Driessen, 2003). Mallick and Driessen (2003) surveyed 118 individuals at three different locations within the Cradle Mountain Lake St. Clair National Park in Tasmania regarding their beliefs and attitudes towards wildlife feeding and the effects (if any) the "Keep Wildlife Wild" interpretive signs located in the park had on their opinions. The majority of visitors to the park were already opposed to wildlife feeding (92.2%). Of those visitors, 84.6% who saw the sign said it re-enforced their attitudes and beliefs. Only a small number of the remaining visitors (3.9%) said the sign influenced their belief and attitude towards wildlife feeding and their decision not to feed wildlife; thus, 11.5% said the sign had no effect on their opinion (Mallick & Driessen, 2003).

On the other hand, interpretive signs designed with persuasive messages targeting visitor's perceived attitudes and normative beliefs have been found to be effective at changing behavior (Brown et al., 2010). Brown, Ham, and Hughes (2010) found interpretive services were most influential in changing behaviors when managers first identified the population to target. In Russell Falls Track in Mountain Field National Park, Tasmania, Brown et al. (2010) first identified visitor beliefs and attitudes towards picking up litter. They created two signs based on their findings and tested their effectiveness. The underlying common belief of surveyed visitors was the behavioral belief of "setting a good example." One sign used verbiage implementing an intention component, which attempted to stimulate a commitment by visitors to picking up trash as a way of setting a good example to others. The second sign attempted to appeal to the personal norm, moral obligation, by creating a sense of what was the "right" way to act. A crushed aluminum can was placed in the middle of the walking path, and visitor compliance in picking up the can was recorded on control days (no sign present) and treatment days (where one of two signs were present). On days when signs were present, litter pickup increased 15-20% compared to days when no sign was present, indicating that that both messages were effective in influencing visitor's behavior (Brown, et al., 2010). Although research shows the importance of targeting signage to the intended audience, Munro, Morrison-Saunders, and Hughes (2010) note that educational components designed to meet mitigation requirements rarely include this information.

Docent programs. Docent programs have been shown to be effective at changing visitor behavior (Littlefair & Buckley, 2008; Munro et al. 2008) if formal and well structured (Orams & Hill, 1998). Several studies have examined the effectiveness of varying approaches to docent programs (Littlefair & Buckley, 2008) to determine which variation of material presentation was most effective. Littlefair and Buckley (2008) evaluated the effectiveness of five different tour guide approaches to reducing litter, noise, and trampling at the Central Eastern Rainforest Reserve Australia World Heritage Area. Verbal interpretation by a tour guide was provided in five different ways: a control, generic, role-model, appeal, and complete program. In the control program, the tour guides gave little to no information on the site and carried on unrelated conversations with the tourists. In the generic program, guides provided information on the area's natural history, but did not include environmental impacts. In the role-model program, guides discussed natural history and lead by example by staying on paths, picking up litter, and talking quietly. Guides did not actually inform the trail users on how to minimize impacts, instead they acted them out. The appeal program explained to the visitors the negative effects of tourism to that area and informed visitors how to minimize their impacts. Finally, the complete program combined the role-model and the appeal program, providing the visitors with a tour guide who informed visitors of their impact and acted out appropriate behaviors in order to reduce their impact. Littlefield and Buckley (2008) found that some programs were more successful than others, depending on the audience. In general, the complete program was the most effective in reducing litter, noise, and trampling.

Orams and Hill (1998) further evaluated the effectiveness of an educational program at a popular bottle nosed dolphin feeding tourist destination in Tangalooma Bay, Australia. Data were collected before and after program implementation to determine effectiveness at increasing compliance to management rules and regulations for feeding dolphins. The education program consisted of three main features: a visitor center, a briefing before the feeding, and a public address system during the feeding. To determine compliance, staff assessed the number of pats and/or touches to dolphins by visitors, the number of cautions staff had to give visitors, and the overall number of inappropriate behaviors. Orams and Hill (1998) found that after the educational program was implemented there were significant decreases in all three measured behaviors.

Gunvalson (2011) studied a seasonal volunteer-based docent program called Team Ocean in Monterey Bay, California to determine the program's effectiveness at reducing recreationists' disturbances to sea otters and harbor seals. Team Ocean is a group of volunteers who kayak the Monterey Bay informing other boaters of appropriate boating behaviors near resting sea otter and harbor seal sites. On days when Team Ocean was present, sea otter disturbances were significantly reduced compared to days when they were absent. Gunvalson’s study showed the program did not have to be as formally structured as Orams and Hill (1998) implied nor did it have to be costly.

Problem Statement

Boat access to the San Francisco Bay (the Bay) is increasing, amplifying the probability of human and wildlife interactions. For example, the San Francisco Bay Area Water Trail is a planned network of boat launches designed to provide boaters with increased access to the Bay. Human presence creates the potential for increased disturbance to wildlife and such disturbance can lead to changes in species foraging, resting, and distribution as well as lead to decreases in reproduction rates and overall demographic changes (Knight & Cole, 1995).

Evaluating interpretive services for their effectiveness in meeting management goals, such as protecting wildlife, is necessary in order to determine the appropriate education measures. Increasing visitor knowledge of a site, influencing pro-environmental beliefs and attitudes, and increasing compliance of responsible environmental behavior can minimize negative environmental impacts caused by visitors to wildlife (Munro et al. 2008; & Hughes, 2008).

Several studies show that interpretive services, such as interpretive signs and docents, are useful and economical tools for land managers to change beliefs and behaviors of visitors in order to reduce their impacts (Moscardo et al., 2004; Gunvalson, 2011). However, few studies have compared the effectiveness of different services in changing visitors' immediate behaviors (Littlefair & Buckley, 2008; Gunvalson, 2011). The Water Trail EIR recommends using interpretive services, for example signs, at the trailhead of each participating boat launch, to inform boaters of sensitive species and to encourage non-disruptive boating behavior. However, whether or not the signs may be effective in reducing disturbances to wildlife is not known.

This study evaluated whether active or passive environmental education methods changed environmental behaviors when compared to control conditions with no interpretive services. I designed information to be delivered by signs or docents that focused on providing boaters "knowledge of the issue" (that boaters can disturb harbor seals) and "knowledge of action strategies" (how to avoid disturbing seals while boating). These two factors are identified in the model of Responsible Environmental Behavior as directly influencing boaters' "intensions to act" and then undertake responsible behavior (Hines et al., 1987). The information was not designed based on the attitudes and beliefs of the target audience as this information is often not know or incorporated into educational mitigations (Munro et al., 2010). I assessed the extent to which information by signs versus docents reduced the disruptive behaviors of boaters toward harbor seals at Corkscrew Slough, Bair Island in Redwood City, California.

This is the first study conducted to determine if typical methods, such as signage or docents, will reduce boater disturbance of harbor seals in the Bay. As such, the results will provide managers with information on whether environmental education is indeed an effective measure to protect harbor seals and, what other measures might be better. Many educational studies have tested whether peoples' knowledge has increased and/or intention to act is changed by education treatments, but few have followed subjects to determine if they actually changed their actions (Orams, 1997; Wood & Moscardo, 1998; Hughes & Morrison-Saunders, 2002; Mallick & Driessen, 2003; Tubb, 2003; Madin & Fenton, 2004; Hughes & Morrison-Saunders, 2005; Shalene & Crooks, 2006; Powell & Ham, 2008; Poudel & Nyaupane, 2013). What makes this study unique is that data were collected on subjects' behaviors after experiencing educational treatments.

Objectives

The objective of this research was to collect data on the effectiveness of two different education modes in affecting boaters' behaviors toward harbor seals. First, I conducted a survey of boaters to assess their attitudes and knowledge toward boaters to answer these study questions:

1. What are the demographics of the boaters in Redwood City, California?
2. What is the level of boaters' knowledge about wildlife, especially harbor seals, at Bair Island in Redwood City, California?
3. What are boaters' attitudes in Redwood City with respect to increasing their knowledge of wildlife and taking other measures to protect sensitive wildlife?

Then, I conducted a study comparing boaters' behavioral responses to two educational methods, signs and docents, as they boated by harbor seals in Corkscrew Slough. I also collected data on harbor seal responses to boaters. This study addressed this research question and two hypotheses:

What is the background rate for harbor seal activities (resting, alert, and flush) in Corkscrew Slough, California and the rates of these activities in the presence of boaters?

$H_0$1: Boater approach rates, angle or distance to harbor seals and rates of stopping to observe seals do not differ between boaters exposed to signage, those exposed to docents or those having no educational experience at the boat launch.

H_02: Harbor seal flush rates do not differ between boaters exposed to signage, those exposed to docents or having no educational experience at the boat launch.

Methods

Study Region and Site

The Bay is an eastern inlet body of water off the central California coastline of the Pacific Ocean and is roughly 155 km² from north to south. The Bay is composed of four smaller bays: San Pablo Bay, Suisun Bay, Central Bay, and South Bay, and supports 90% of California's remaining coastal wetlands. It represents one of the largest estuarine ecosystems in the Pacific (Cohen, 2000). The mudflats and marshlands support over 200 invertebrate and plant species as well as rare and migratory birds, mammals, reptiles, and fish. As part of the Pacific flyway, the Bay provides shelter and food for a number of species of resident and wintering migrating birds (Cohen, 2000). While some animals, such as the endangered Chinook salmon (*Oncorhynchus tshawytscha*) and the rare shovelnose guitarfish (*Rhinobatos productus*), use the Bay as a temporary nursery, other species, including the endangered saltmarsh harvest mouse (*Reithrodontomys raviventris*) and the federally-protected harbor seal (*Phoca vitulina*), are permanent residents (Cohen, 2000; Fox 2008).

The Bay Area is characterized by a Mediterranean climate consisting of wet winters and dry summers (Nichols, Cloern, Luoma, & Peterson, 1986; Cohen, 2000). Tides are semi-diurnal, consisting of four unequal tides in a 24h period: two high tides and two low tides.

The study site was located in Redwood City in San Mateo County, California, roughly 55 km south of San Francisco. On the eastern edge of Redwood City is Bair Island Ecological Reserve (the Reserve), a restored 1,600 acre tidal marsh owned by the Don Edwards San Francisco Bay National Wildlife Refuge. This wetland provides habitat for over 150 different wildlife species, including the harbor seal (Cohen, 2000; Fox, 2008). Located east of Highway 101, the Reserve is surrounded on three sides by residential and commercial structures including a port, a small-craft airport and a sewage plant. Serving as a floodplain and recreational resource, the inner part of the Reserve, referred to as Inner Bair Island, is adjacent to the San Francisco Bay Trail, a 500-mile network of pedestrian and bicycle paths. A public boat launch is located in the Port of Redwood City Marina (RWC Marina) just south of Bair Island on Redwood Creek. Small boats such as kayaks, canoes, small motor boats, and sail boats can launch from the RWC Marina into Redwood Creek. There are sloughs between the inner, middle, and outer sections of Bair Island that draw boaters who are looking to explore the Bay's rich environment.

Corkscrew Slough is a 3-mile long, winding waterway located between the middle and outer portions of the Reserve, with openings at both Redwood Creek and Steinberger Slough (Figure 2). The opening at Redwood Creek is deeper and wider and is used most often by harbor seals and boaters to enter Corkscrew Slough (Fox, 2008). A tidal gate installed in approximately 2012 is located near the opening of Steinberger Slough making it difficult for boaters to access Corkscrew Slough via Steinberger Slough during low tide. Overall, Corkscrew is relatively shallow with mudflats exposed at low tide along much of the Slough, making it most accessible to boaters at high tide. Historic harbor seal haul-out and pupping sites are found along the pickleweed (*Salicornica virginia)* banks inside of Corkscrew Slough as well as on the Bay side of Outer Bair Island (Fox, 2008).

Figure 2. Study site with Bair Island Ecological Reserve in Redwood City, CA. Image source: Google Earth™2015.

In a recent seal population count in Corkscrew Slough, Fox (2008) recorded over 60 harbor seals during pupping season (March-July) and smaller populations of scattered seals during non-pupping season (August-February). Harbor seals use the haul-out site year round (Fox, 2008). Fox (2008) suggested Corkscrew Slough is favored by seals over the bayside Outer Bair Island haul-out site due to its accessibility during low and high tides and the Slough's limited accessibility to boaters during low tide.

The RWC Marina, located across Redwood Creek from the Reserve, features one of the only three public boat launches in the South Bay. The launch has a 2-lane ramp with loading docks on each side (Figure 3). To the immediate left of the boat launch is a paved walking path that is closed to the public and to the right is a building containing bathroom facilities and parking frequently used by local junior sailboat groups. Directly behind the boat launch is a public parking lot and a private boat storage facility. Commercial buildings surround the entrance leading to the boat launch.

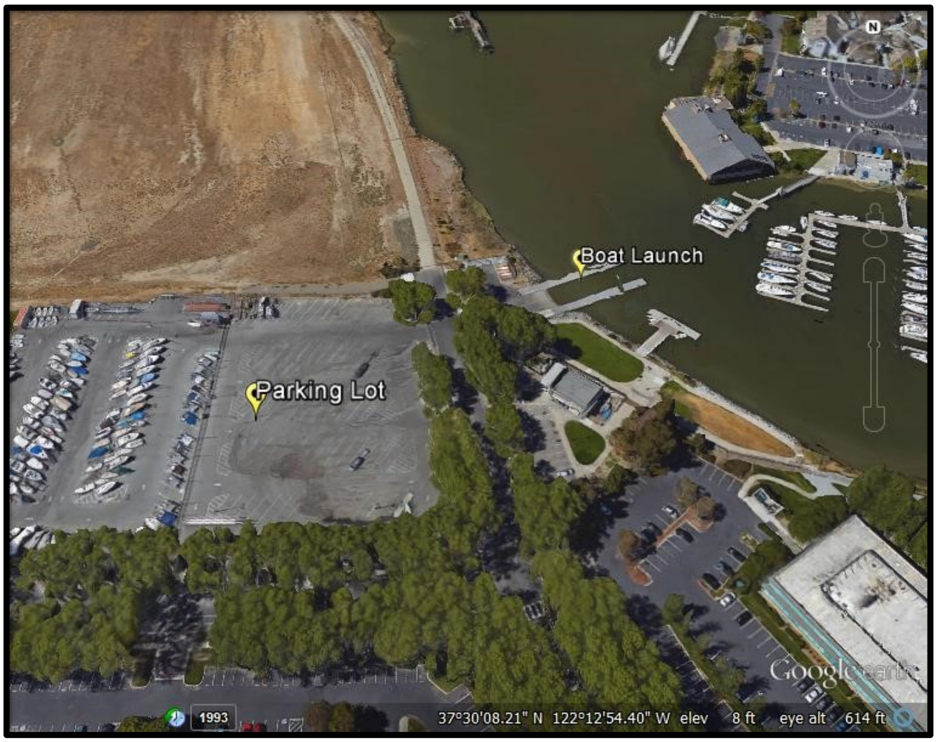

Figure 3. Aerial view of the Redwood City Marina boat launch site. Image source: Google Earth™2015.

Boater Knowledge and Attitudes Survey

I developed a 26 question survey to collect data on boat users' knowledge and attitudes toward their own boating practices and the effects of boating on wildlife, especially harbor seals. Questions included those on boat-user demographics, boating practices when encountering wildlife, and attitudes toward increased public wildlife education (Appendix 1). The questions were meant to provide data that could be useful in providing context for the results of the educational treatment study.

I delivered the survey to boaters at the Port of Redwood City Marina boat launch site during peak activity times from 0900 to 1300 on 3 weekends between August 10 and August 24, 2013. Participants were selected randomly and approached by a researcher in the parking lot located directly behind the RWC Marina boat launch. A total of 31 surveys were collected from willing participants over the age of 18. Sailboat users were purposely not targeted as their watercraft cannot access Corkscrew Slough and the harbor seals there.

Education Treatment Study

Study design. The responses of boaters to two modes of education about boating near harbor seals, educational signs and docents were tested against a control (no educational materials). The overall study approach was to have a temporary interpretive sign or a docent present on different days at the Redwood City Marina boat launch. Researchers at the boat dock noted identifying characteristics of each boater exposed to a treatment and relayed that information to a researcher in Corkscrew Slough who could observe the behavior of the boaters as they passed a group of harbor seals. On control days, there were no interpretive materials and the researcher in Corkscrew Slough collected data on any boater passing the seals. I sought a total of 30 boaters per treatment as a number likely to provide adequate data for statistical analysis.

The interpretive sign was designed to provide boaters with “knowledge of the issue” of boater disturbance to harbor seals and “knowledge of action strategies” to avoid disturbing harbor seals, two key elements of the REB model that lead to “intentions to act” and to “responsible environmental behavior” (Hines et al., 1987). The sign was designed in collaboration with Galli Basson, the Water Trail manager for the Coastal Conservancy who had experience with interpretive signage. The signs were easy to read and understand with low-impact messages (Figure 4 and 5) (Cole et al., 1997). The "knowledge of issues" section of the sign stated

> PLEASE – Protect Harbor Seals in Corkscrew Slough! Harbor seals use the channel banks to rest and nurse their pups. These animals are easily disturbed when approached by boaters and kayakers.”

The “knowledge of action strategies” section of the sign stated

Here is what you can do to protect harbor seals:

1) *Observe them from a distance*. Avoid shorelines and keep to the middle of the waterway.
2) *Pass by quickly*. Do not stop by resting seals.
3) *Pass by parallel to shore*. Do not directly approach seals.

A large photo of a harbor seal followed and below that the sign text ended with “YOUR help will keep these beautiful animals in our bay for years to come!”

On docent days, signs were not present, and docents relayed exactly the same information to boaters as what appeared on the signs and showed them the same harbor seal photo.

Data were collected for each treatment (interpretive sign, docent, and control) between June 7, 2014, and August 20, 2014, on 7 docent days, 11 interpretive sign days, and 4 control days. Not all boaters who left the boat launch traveled through the Slough; therefore, the number of days per treatment varied depending on length of time required to observe the 30 unique boaters per treatment. To target days likely to have the greatest boater activity, I selected dates when high tide occurred approximately between 0800 and 1500 hours. Because Corkscrew Slough is quite shallow, I avoided days when the tide was low and boaters would be scarce.

For the interpretive sign treatment, a researcher placed two identical temporary interpretive signs at the boat launch (Figure 4 and 5). Signs were placed on a 12” x 18” collapsible A-frame at the entrance of each boating dock on either side of the launch ramps where boaters could see them (Figure 4). A researcher nearby counted the number of people who stopped at a sign and the number who walked passed the sign without stopping. For people stopping at a sign, the researcher recorded which sign was approached and the length of time they observed the sign.

For docent treatments, a researcher approached boaters in the parking lot. After verbally providing the information that appeared on the sign and showing a photo of a harbor seal, the researcher recorded 1) whether or not the boater(s) was willing to participate in verbal delivery of information, 2) if the listener engaged in further conversation by continuing the conversation after information was delivered, and 3) whether or not the overall interaction was positive or negative, as perceived by the docent, regardless of whether the individual was willing to participate.

The researcher at the boat launch took note of the identifiable characteristics of the boaters from both educational groups. Characteristics noted included boat type and color, boaters' gender, clothing color and type, and other identifying features. This information identifying specific boaters was relayed via cell phone to a researcher located in Corkscrew Slough, allowing that researcher to identify specific boaters entering the Slough and to know if those boaters had experienced a sign or a docent when they launched their boat.

On control days, no sign or docent was present at the boat launch; therefore boaters were not exposed to any educational material. The observer in Corkscrew Slough collected data on any boaters that passed the harbor seals.

Figure 4. Interpretive sign placement at Redwood City boat launch.

Figure 5. Detailed view of signs placed at the boat launch.

Data collection. To collect data on how boaters interacted with harbor seals, a researcher was positioned along the shore opposite the harbor seals' haul-out site in Corkscrew Slough to observe the behavior of the passing boaters and of the harbor seals in response to the boaters. The researcher accessed the Corkscrew slough using a 12-foot aluminum motor boat. Fox (2008) found motor-boats to be less disturbing than non-motorized boats. The researcher observed harbor seals while remaining anchored in the boat in a small opening on the bank. This observation point was approached as quietly as possible using the lowest motor speed to minimize disturbance to seals. The researcher's motions were minimized once the boat was anchored in order to reduce risk of drawing the attention of hauled out harbor seals. It was not possible to remain unseen by harbor seals due to relatively flat terrain, as described by Fox (2008). Observation session periods varied in the Slough between two and four hours, averaging 3.5 hours.

A "study zone" for data collection was delineated by the first bend after entering the Slough via Redwood Creek and extended to the second bend (Figure 6). The length of the study zone was roughly 500 m long and ranged in width from approximately 90 to 120 m depending on the width of the Slough. Observations of boaters were made once boaters entered the study zone using 10x50 Nikon field binoculars.

The researcher recorded data on four parameters that were derived from the "action strategies" in the signage and docent materials 1) the length of time boaters spent traveling through study zone, 2) boat angle in relation to hauled out seals, 3) boat distance from haul out site, and 4) whether or not boaters stopped to observe hauled out harbor seals.

Figure 6. Study zone (between red lines) and observation point. Image source: Google Earth™2015.

The time boaters spent traveling through study zone was recorded in seconds using a digital stop watch. Boat angle was visually estimated in relation to the hauled out seals and categorized as 45°, 90°, or 180°. The closest distance boaters were from the haul-out site was measured in meters using a Bushnell optical range finder (accurate to ± 1 m). Whether or not boaters stopped to observe seals while in the study zone was categorized as "yes" or "no".

Harbor seal activities were collected using Altmann's (1974) scan sampling method at 10-minute intervals both when boaters were not present to provide background activity levels and when boaters were present in the study zone. Data collected included harbor seal numbers and the behavior (rest, alert, or flee) of each seal. “Rest” refers to a seal that is stationary with eyes closed. “Alert” refers to a seal that a) opened eyes when previously closed, b) raised its head, or c) moved from original position towards or away from water but remained on land. “Flee” refers to a seal that left land and flushed into the water (Suryan & Harvey, 1999; Fox, 2008; Gunvalson, 2011).

Data analysis. All data collected were analyzed using SPSS version 22. Boater knowledge survey data were summarized using descriptive statistics. A one-way Analysis of Variance (ANOVA) was used to identify the significance between the three treatments (sign, docent, control) with respect to boater time passing seals, boater distance from seals, and harbor seal flush rates. Distance from seals was log transformed to meet assumptions of normality and heterogeneity of variances.

Chi-square tests were used to assess the relationship between the percent of seals flushing and boat angle of approach (45°, 90°, 180°) and also to whether boaters stopped or did not stop in the study zone. A Pearson product-moment correlation tested the relationship between percent of seals flushing to boater distance from seals (log transformed) and to the length of time boaters spent in study zone.

Results

Boater Knowledge and Attitudes Survey

A total of 31 surveys were collected for the boater knowledge survey. Seventy-one percent of the participants were male and 29% were female. Approximately 84% of participants were between the ages of 40 - 65, 10% were 25-34, and 6% were 18-24. The majority were Caucasian (68%) followed by African American and Asian American (10% each), and other (12%). Forty-five percent had advanced degrees, 33% bachelor degrees, and 23% a high school diploma.

The majority of participants used the boat launch to launch kayaks (61%) followed by motorboats and paddleboards (16% each), and sail boats (6.5%). At least 90.3% had visited the boat launch before and the majority return at least 1 to 5 times a year. Approximately 83.9% of participants had heard of Corkscrew Slough. Of the participants who knew of Corkscrew Slough, 74.2% had visited it. A majority of the participants had encountered a harbor seal while boating in the Bay (67.7%). Of those boaters, approximately 85% said they regularly encountered a harbor seal (Figure 7). Seventy-one percent of participants who encountered a seal in the Bay said they did not approach the animal. Almost all participants, 97% of interviewees said they were interested in viewing wildlife while boating, with 46% interested in viewing birds, 34% interested in seeing seals and 13% looking for fish.

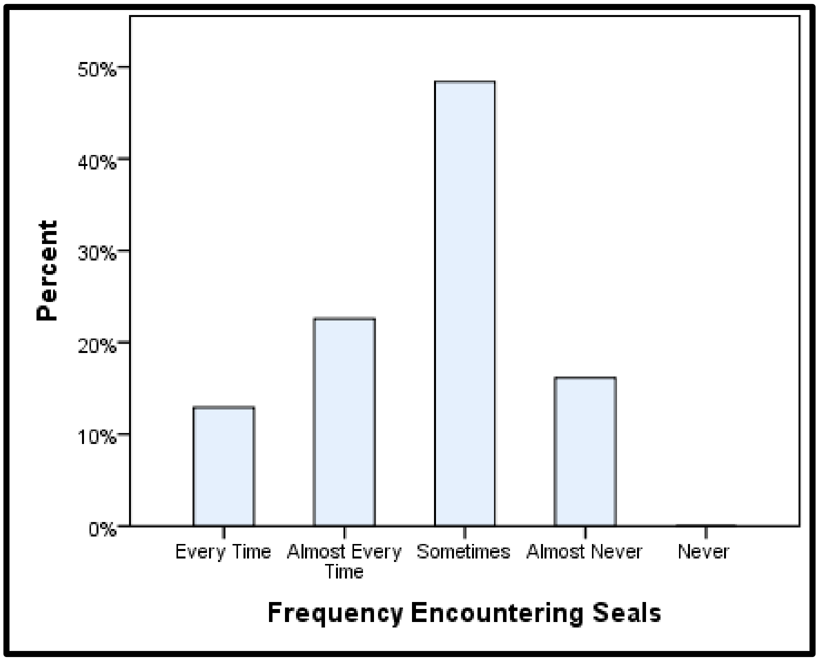

Figure 7. Frequency with which participants (n=31) said they encountered a harbor seal.

Participants' attitudes were generally very supportive of public education about wildlife, seasonal closures to protect species, their willingness to change personal boating practices and their willingness to avoid wildlife disturbance (Table 1). Participants' knowledge of boating practices' effects on wildlife varied. The majority of boaters agreed human activities that change wildlife behavior are harmful to the animals; however, there was uncertainty as to which boating practices were harmful. Boaters were mostly uncertain whether approaching harbor seals by boat or on land disturbed the animals (Table 1).

Table 1. Attitudes and knowledge: Percent of participants (n=31) with varying views.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Attitudes					
I support public education	58.1%	29.0%	12.9%	0%	0%
I support seasonal closures	19.4%	35.5%	29.0%	12.9%	3.2%
I am willing to change personal boating behaviors to protect wildlife	48.5%	41.9%	3.2%	3.2%	3.2%
I avoid disturbing wildlife	64.5%	32.3%	0%	3.2%	0%
I would like to increase own knowledge of boating activities and its effect on wildlife	51.6%	32.3%	12.9%	3.2%	0%
Knowledge					
Human activity that changes wildlife behavior could harm the animal	51.6%	25.8%	9.7%	12.9%	0%
Approaching a harbor seal with a boat will disturb the animal	45.2%	25.8%	19.4%	6.5%	3.2%
Boaters affect seals that are on land	6.5%	22.6%	54.8%	16.1%	0%

Educational Treatment Study

A total of 124 individual boaters were observed passing by at least one of the signs. Approximately 77% did not stop to observe either sign. Of the 33% who did stop, the average length of time he or she stopped was 1 second.

A total of 95 individuals were approached by the docent and 61% were willing to listen to the docent's information. The interaction between willing and unwilling boaters and the docent was overwhelmingly positive (88.7%) and of those who participated, 68% engaged in further conversation with the docent.

A total of 92 boaters were observed in the Slough over 61 hours (31 control, 31 sign treatment, 30 docent treatment), approximately 0.33 boats per hour. The majority of the boaters were kayakers (85%) followed by approximately paddle boarders (9%), motor boaters (4%), and 1% identified as other.

The three treatments differed with respect to the time boaters spent traveling through the study zone ($F(2,89) = 7.493$, $p = 0.001$) (Figure 8). Boaters exposed to signs (4.91 ± 2.50min) spent significantly more time traveling through the study zone compared to the control (2.80 ± 1.74min, $p = 0.001$) or docent groups (3.53 ± 2.24min, $p = 0.040$). There was no difference between the control group and docent group ($p = 0.396$).

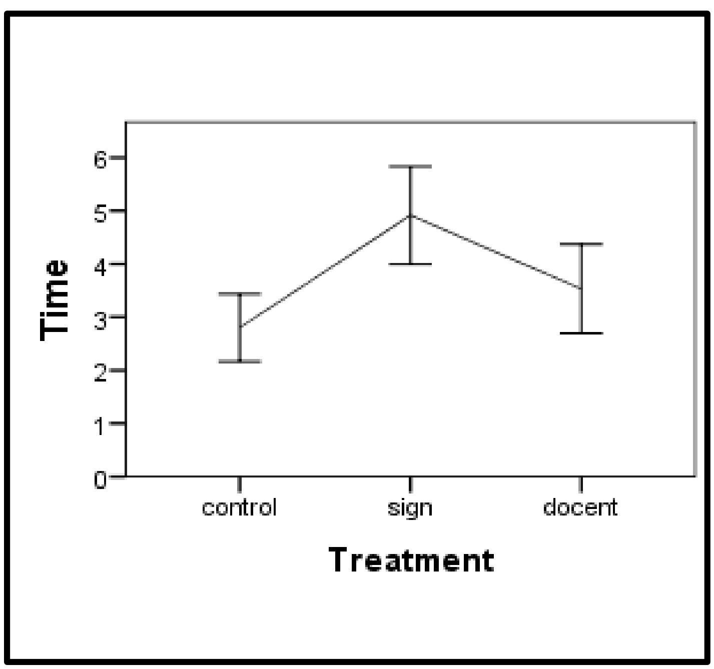

Figure 8. Length of time in minutes ($\bar{x}$ ± SE) boaters spent in study zone.

The three treatments differed with respect to the distance boaters were from the hauled-out seals ($F(2,89) = 4.725$, $p = 0.011$) (Figure 9). Boaters in the control group ($\bar{x} = 32$ m) (1.51 ± 0.24, $p = 0.040$) approached seals more closely than those exposed to sign ($\bar{x} = 47$) (1.67 ± 0.17, $p = 0.001$) or exposed to the docent ($\bar{x} = 48$) (1.68 ± 0.33, $p = 0.020$). Sign and docent groups ($p = 0.396$) did not differ in approach distance.

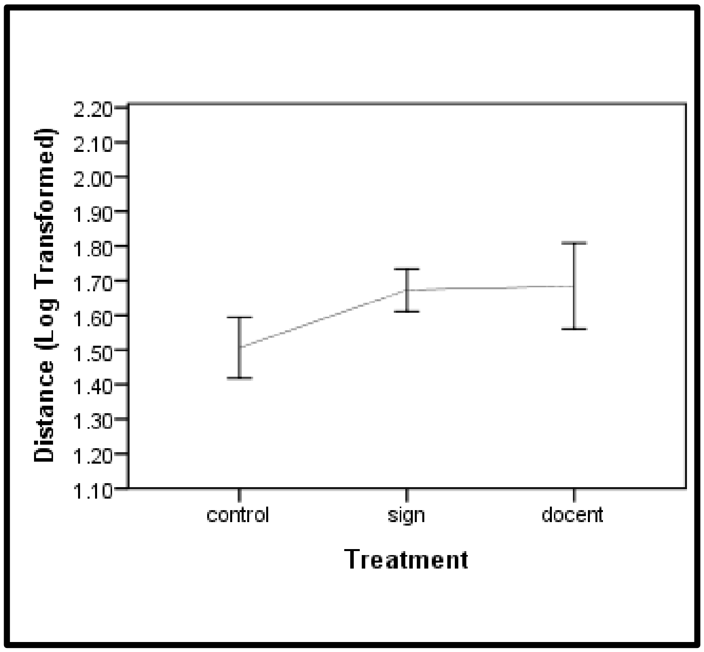

Figure 9. The distance ($\bar{x} \pm SE$) between boaters and the nearest harbor seals.

There was no relationship between boat angle of approach and the three treatment groups ($X^2(4) = 1.623$, $p = 0.805$) (Figure 10).

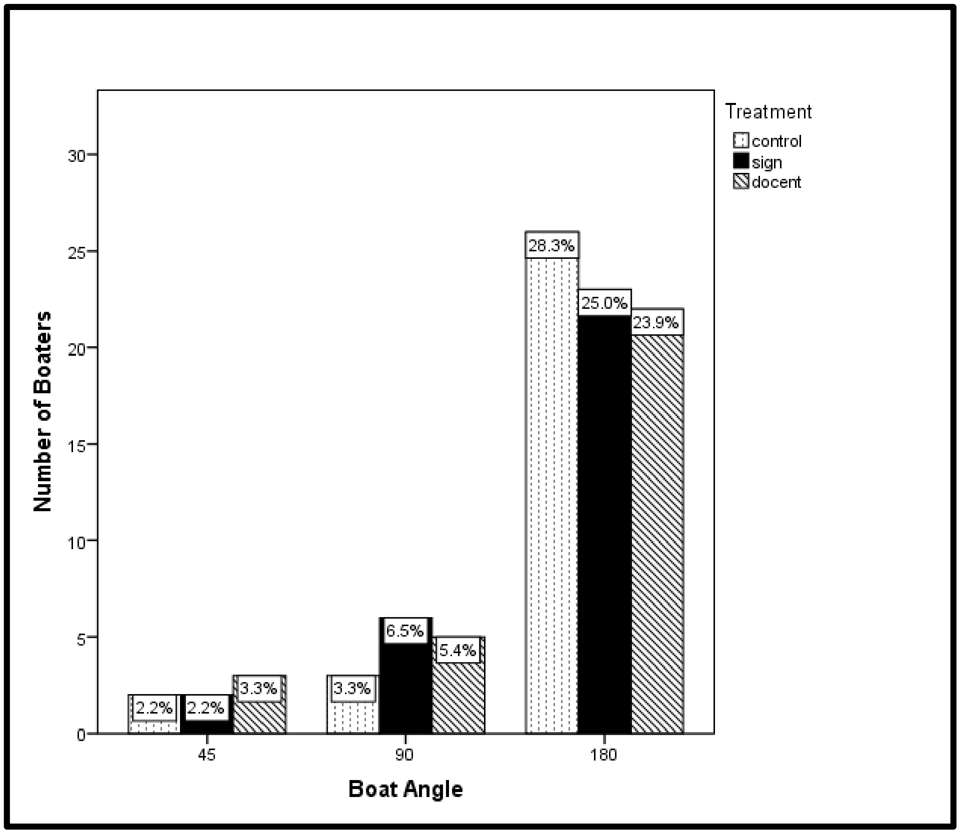

Figure 10. Percent of boaters, by treatment type, approaching seals at different angles.

Nor was there was a relationship between boaters who stopped versus did not stop to observe hauled-out harbor seals with respect to the three treatment types ($X^2(4) = 0.162$, $p = 0.299$) (Figure 11). Although the difference was not statistically significant, the control group boaters were most likely not to stop (22.8%) compared to boaters exposed to a docent (16.3% did not stop) or the signs (17.4% did not stop) (Figure 11).

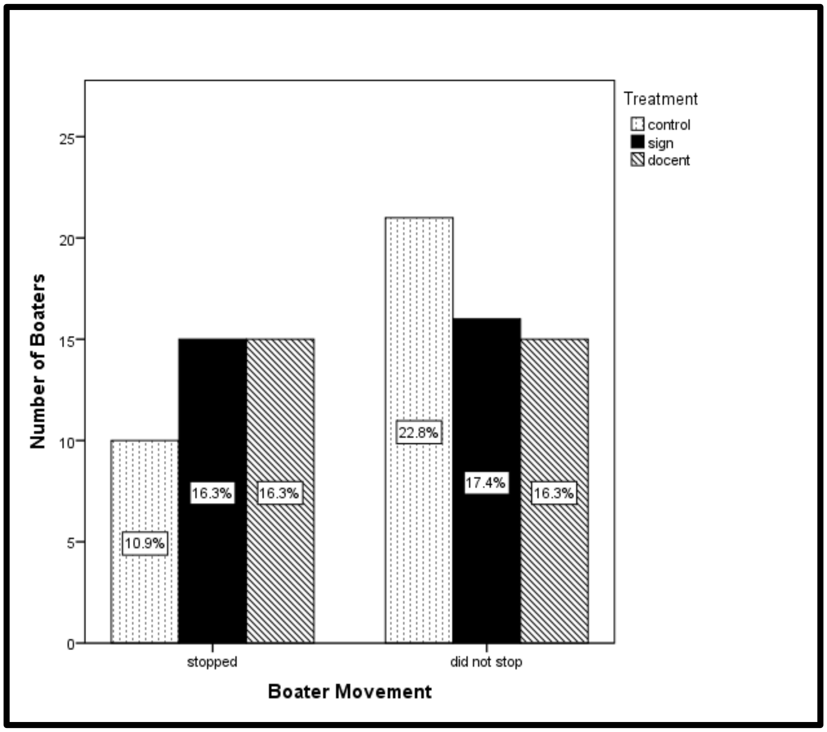

Figure 11. Percent of boaters, by treatment type, stopping or not stopping in the study zone.

A total of 365 scans of harbor seal activity were taken. When no boaters were present (background rate), approximately 90% of the harbor seals remained at rest, 10% were alert, and less than 1% flushed. When boaters were present, no matter what the treatment, seal flush rates were significantly higher than background rates ($F(3,452) = 80.544$, $p = 0.001$) . Seals were also more likely to be alert ($F(3, 452) = 123.263$, $p = 0.001$), and less likely to be resting ($F(3,452) = 46.936$, $p = 0.001$) compared to when boaters were not present (Figure 12).

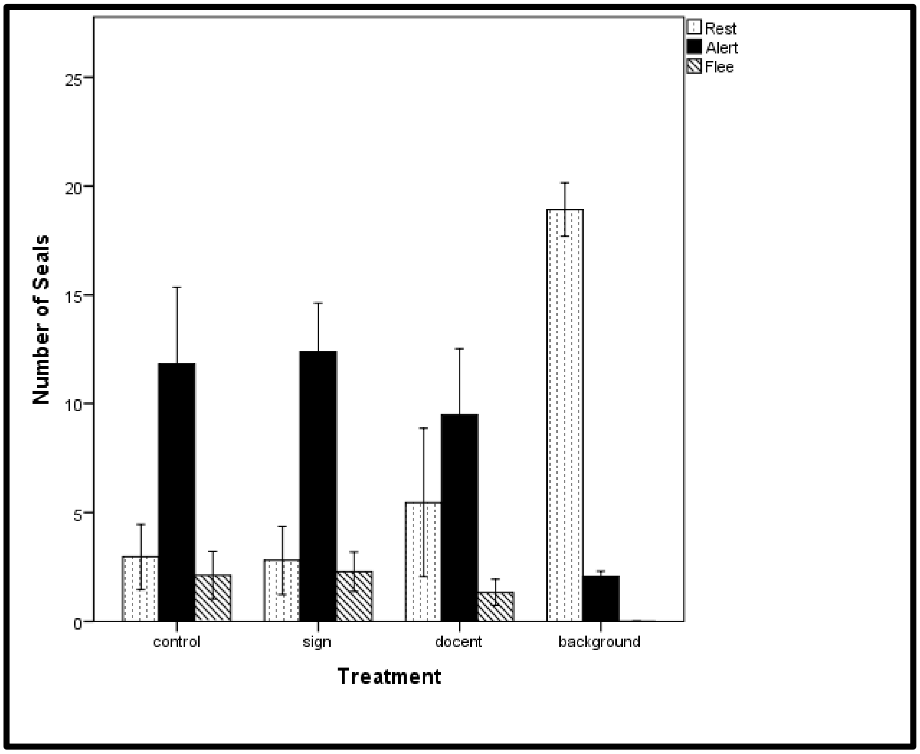

Figure 12. Number of harbor seals ($\overline{x} \pm$ SE) exhibiting different behaviors when exposed to boaters by treatment type and no boaters (background).

There was a negative relationship between the distance of boaters from hauled-out harbor seals and seal flush rates, ($r = -0.385$, $p = 0.001$) (Figure 13), but there was no relationship between the time boaters spent traveling through the study zone and seal flush rates ($r = 0.031$, $p = 0.769$).

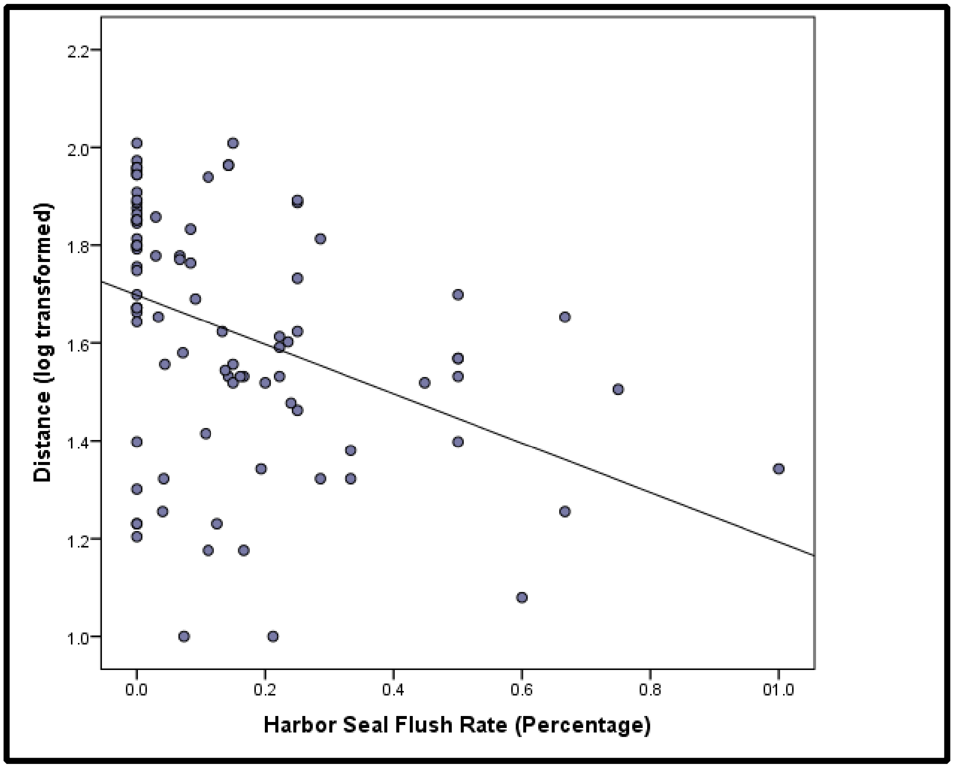

Figure 13. Relationship of boat distance to seals and percent of harbor seals flushing.

Discussion

This study followed boaters exposed to two different types of educational methods to determine if they took environmentally responsible actions. I used the REB model to design signs and docent talks that provided knowledge of an issue (that boaters can disturb seals) and knowledge of actions to reduce those disturbances. Specifically, boaters were asked to stay far from seals, pass by them quickly, not stop near seals, and pass parallel to the shore. The results of this study indicated that neither passive (interpretive sign) nor active (docent) environmental education programs at the Port of Redwood City Marina boat launch successfully affected all the behaviors of boaters passing harbor seals in Corkscrew Slough. Compared to boaters receiving no education and boaters exposed to docents, the boaters exposed to signs spent longer traveling through the Slough, which is in opposition to the messages given. And, the number of boaters stopping to observe hauled-out harbor seals *did not decrease* when exposed to an educational treatment compared to the control. On the other hand, boaters exposed to either signs or docents stayed further from seals than boaters receiving no education. Boaters' angle of approach remained relatively similar across all three treatments, at the desired 180°.

Signs appeared to be less effective than docents. Only 33% of boaters stopped to read the sign and when they did, they stopped for an average of no more than one second. The lack of time spent observing the signs suggests it is unlikely the information was a motivating factor for boaters to adopt more responsible environmental boating behaviors when encountering hauled-out harbor seals. It is difficult to captivate an audience by use of a sign (Orams, 1997), especially at a site such as a boat launch where people are focused on a task and not education.

Signs are traditionally placed at trailheads and entrances, and the signs used for this study were no exception. Winters et al. (1998) suggest signs may be more effective when placed in areas where the behavior is taking place. The signs at the RWC Marina were approximately 2.5 miles from the seals in Corkscrew Slough and this may have been too far away to be effective.

The same concepts could be applied to docents as well (Orams, 1997). However, in this study, docents were more effective than signs at conveying information. The majority of boaters at the RWC did stop and listen to the docent and many had the opportunity to engage the docent in more discussion. While they did not follow the docent's recommendation not to stop near the seals, these boaters did pass by more quickly than control boaters or boaters exposed to signs. They also stayed further from seal than control boaters, but so did boaters exposed to the signs. Gunvalson (2011) recorded a significant decrease in the number of kayak disturbances to resting sea otters in Monterey Bay and Elkhorn Slough, California, when a docent was present in the water. The physical presence of a docent in the water may lead boaters to believe they are being watched by someone they perceive to have the ability to enforce appropriate behaviors (Woods & Moscardo, 1998) and may appeal to an individual's social norm of moral obligation (Brown et al., 2010).

The physical presence of both signs and docents near the hauled-out seals at Corkscrew Slough may be more effective at changing boater behavior that the methods studied here. Programs that incorporate both information on how to minimize negative impacts along with an example of appropriate behaviors acted out by a docent have been found to be successful at changing behaviors (Orams & Hill, 1998; Littlefair & Buckley, 2008; Gunvalson, 2011).

A potential explanation for lower adoption of recommended behaviors after educational exposure may be that docents and the signs alerted more people to the presence of harbor seals in the Slough. In the case of the sign, it is possible the picture was too large in comparison to the text and did not depict the desired behaviors but instead attracted more attention to the attractive wildlife present in the Slough. Picture size and the beauty of the harbor seal in the picture may influence a boater's perception and understanding of the message. If signs are to be effectively used to protect wildlife, design features that include pictures or symbols depicting behaviors must be further researched.

The picture is not likely to have had the same effect on boaters approached by the docent, as these boaters were not exposed to the picture until after the individual willingly agreed to participate and was relayed the information. Therefore, lack of adoption of recommended behaviors after exposure to the docent may be more directly related to boaters' pre-existing attitudes and beliefs of their own boating behaviors.

The survey of boater knowledge and attitudes at the Redwood City marina indicated these boaters believed their own boating practices were reflective of responsible environmental behaviors and, so, did not have a negative impact on harbor seals. The majority of boaters agreed human activity that changed behavior was harmful to the animal and most boaters had positive attitudes towards minimizing disturbance to wildlife. However, most boaters were not knowledgeable about the negative effects of specific boating behaviors on seals, in particular the effects of close boat proximity to harbor seals on land and in the water. In essence, although they believed in protecting wildlife, they did not believe their activities were having a negative effect. Although most stated they were willing to change personal boating practice, when presented with information that their actions could harm harbor seals and with actions they could take to reduce impacts to harbor seals, boaters did not implement all of them. This is an important finding given many studies of environmental education evaluate effectiveness based on self-reporting surveys and not actual observations of behaviors.

The educational treatments in this study used two key elements from the REB model to try to affect behavioral change: knowledge of an issue and knowledge of action strategies. A potential reason why using these elements was not adequate to get boaters to adopt all the action strategies presented may be that the educational design did not incorporate the targeted audience's beliefs and attitudes. Attitudes towards a particular action, a strong predictor of intention to act (Ajzen, 1991), as well as personality and situational factors, were not represented in the design. Additionally, Ajzen (1991) emphasized the importance of understating the skill level of the targeted audience. It is unknown if boaters obtained the skills to act on the action skills provided. For example, for some boaters it may have been the case that they understood that slowly passing by a resting seal would disturb the animal, but they did not have the skills to quickly navigate to avoid the behavior. In other cases, it is possible the reason the boater stopped was not to observe the seals, but perhaps to rest or other unknown reasons.

Woods and Moscardo (1998) emphasized the importance of knowing your targeted audience's knowledge baseline, beliefs, and attitudes beforehand in order to maximize visitor's response to interpretation. Researchers have shown that understanding and using the attitudes of boaters can be important in environmental education (Brown et al, 2010). In this study, although I conducted a survey on boater characteristics, the signs and docent talks were intentionally designed without incorporating this information in order to maintain consistency with typical sign development. Typically, little to no preliminary research on the targeted audience is required and/or incorporated into an educational component designed to meet mitigation requirements (Munro et al., 2008). This study lends additional support to the concept that educational signs or docents that do not deliver messages targeted to the audience are not likely to have the desired behavioral effects.

Observations of harbor seal reactions to the boaters showed that flush rates did not differ between treatments, including the control boats. Thus, neither form of environmental education resulted in boaters having a lower impact on seals than non-educated boaters. Reducing impacts to seals is the ultimate purpose of the educational program, and neither approach was successful in this goal.

In addition, seals' flush and alert rates in response to boaters were significantly higher than background activity rates. These results are supported by Fox (2008) who found that harbor seals at this location were much more likely to flush or be alert when boaters passed through the Slough compared to when no boats were present. While she found that harbor seals returned to their haul-out within an average of 10 minutes, increased rates of flushing due to boat disturbance expend energy and can endanger pups (Allen et al., 1984). As one of the few historical breeding and pupping sites left, Corkscrew Slough is an important site for managers to take appropriate measures in order to protect harbor seals in the Bay.

A confounding, and perhaps critical, factor at this site is that the main channel of Corkscrew Slough is relatively narrow and very sinuous. In fact, it is too narrow to allow boaters to meet the Marine Mammal Protection Act’s recommended 33 m (or 100 ft) buffer from harbor seals. The many bends in the Slough cause harbor seals to become unexpectedly exposed to passing boats. These factors make it difficult or impossible for boaters to avoid disturbing seals, even if that were their goal. Thus, due to the morphology of this site, it could be the case that, even if educational methods were able to change boater behaviors, impacts to seals would still be high.

This study indicates the limitations of an environmental educational outreach program when 1) pre-existing knowledge, beliefs, and attitudes of the focal population is not understood and/or incorporated into the design, and 2) site conditions render even effective education insufficient to reduce wildlife impacts. Mitigation measures are developed to offset potential ecological and environmental impacts caused by human development or use of a site. More often than not, mitigation requirements do not include preliminary data collection and post program evaluations of educational components. Therefore, success of implemented outreach is unknown and unaccounted for. Preliminary research on the targeted audience during early development and assessment of program's effectiveness after implementation is crucial and should be mandatory when designing an environmental educational component, especially if it is designed to change behavior (Orams, 1997; Tubb, 2003; Shalene & Crooks, 2006; Munro et al., 2008).

While environmental education is a common tool for attempting to protect wildlife, the needs of the focal species at specific sites as well as important features of the habitats that affect impacts to wildlife must be evaluated before determining what educational methods, if any, are likely to be effective. This study found that requiring environmental educational components as mitigation measures to protect wildlife may not ensure impacts to the wildlife will be reduced.

Recommendations

In order to increase boater adoption of desired boating behaviors in the harbor seal haul-out site at Corkscrew Slough and, indeed at other similar sites, educational programs should be carefully designed and tested for effectiveness. Some recommendations for educational program design that come from this study include

1) Collect data on attitudes, beliefs and demographics of the target audience and use that information in designing signs and docent materials.

2) Place signs closer to the disturbance with a warning message. This approach may increase boaters' adoption of appropriate behaviors.

3) Have docents located closer to wildlife or on the water intercepting boaters before they approach wildlife.

4) Evaluate the effectiveness of different educational methods in the context of the needs of the wildlife and the habitat conditions before using them as mitigation measures.

This study indicated that, regardless of the effectiveness of environmental education to produce desired boater behavior changes, the harbor seal population in Corkscrew Slough was negatively affected by the mere presence of boaters. In order to fully protect this population of hauled-out seals from boaters, I recommend limiting boating in the Slough during sensitive times of the year for seals. Harbor seals' most sensitive season is from March to June, when breeding and pupping occurs. Seasonal closures are used at other harbor seal sites, such as Drakes Estero and in the Bay at Mowry Slough, during this timeframe as well (Codde & Allen, 2013). Pupping and nursing season occur before peak boating season, affecting a smaller number of boaters. The survey conducted for this thesis research indicated some support from boaters for a seasonal closure, so this avenue may be a feasible one and have a more significant positive effect on the seals than signage or docents.

Literature Cited

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Process, 50*, 179-211.

Ajzen I. & Fishbein, M. (1980). Understanding attitudes and social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Allen, S.G., Anley, D.G., Page, G.W., & Ribic, C.A. (1984). The effects of disturbance on harbor seal haulout patterns at Bolinas lagoon, California. *Fishery Bulletin, 82*(3), 493-500.

Allen, S.G., & Huber, H.R. (1984). Assessment of pinniped/human interactions in Point Reyes, California 1983-84. National Oceanic and Atmospheric Administration; Stenson Beach, Ca.

Allen, S.G., Stephenson, M., Risenbrough, R.W., Francher, L., Shiller, A., & Smith, D. (1993). Red-pelaged harbor seals of the San Francisco bay region. *Journal of Mammalogy, 74*(3), 588-593.

Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour, 49*(3/4), 227-267.

Anderson, S.M., Teilmann, J., Dietz, R., Schmidt, N.M., & Miller, L.A. (2012). Behavioral responses of harbor seals to human-induced disturbances. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *22*(1), 113-121.

Antonelis, G.A., Jr., & Fiscus, C.H. (1980). The pinnipeds of California current. *CalCOFI Rep, 11*, 68-78.

Beal, C.M. (2007). The behavioral ecology of disturbance responses. *International Journal of Comparative Psychology, 20,* 111-120.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Krutzen, M. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology, 20*(6), 1791-1798.

Bramwell, B. & Lane, B. (1993). Interpretation and sustainable tourism: The potential and the pitfalls. *Journal of Sustainable Tourism, 1*(2), 71-80.

Brown, T.J., Ham, S.H., & Hughes, M. (2010). Picking up litter: An application of theory-based communication to influence tourist behaviour in protected areas. *Journal of Sustainable Tourism, 18*(7), 879-900.

California Coastal Conservancy. (2011). *San Francisco Bay Area Water Trail plan, final environmental impact report* (SCH #2007112080).Oakland, CA: California State Coastal Conservancy.

Codde, S., & Allen, S. (2013). Pacific harbor seal (*Phoca vitulina richardii*) monitoring at Point Reyes National Seashore and Golden Gate National Recreation Area: 2012 annual report. (Natural Resource Technical Report NPS/SFAN/NRTR—2013/806). Ft. Collins, CO: U.S. Department of the Interior.

Cohen, A. (2000). *An introduction to the San Francisco Estuary*. California: San Francisco Estuary Institute.

Cole, D.N., Hammond, T.P., & McCool, S.F. (1997). Information quantity and communication effectiveness: Low-impact messages on wilderness trailside bulletin boards. *Leisure Sciences, 19,* 59-72.

Fishbein, M. & Ajzen, I. (1975). Belief, attitude, intention, and behaviour: An introduction to theory and research. Reading, MA: Addison-Wesley Publishing Co.

Fox, K.S. (2008). Harbor seal behavioral response to boaters at Bair Island Refuge (Master's Thesis). Available from ProQuest Dissertations and Thesis database (UMI No. 1463401).

Frid, A., & Dill, L. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation Ecology, 6*(1), 11-26.

Gill, J.A., Norris, K., & Sutherland, W.J. (2001). Why behavioral responses may not reflect the population consequences of human disturbance. *Biological Conservation, 97*(2), 265-268.

Gill, J.A., Sutherland, W.J., & Watkinson, A.R. (1996). A method to quantify the effects of human disturbance on animal populations. *Journal of Applied Ecology, 33*(4), 786-792.

Grigg, E.K. (2012). Foraging distribution of pacific harbor seals (*Phoca vitulina richardii*) in a highly impacted estuary. *Journal of Mammalogy, 93*(1), 282-293.

Grigg, E.K., Klimley, A.P. Allen, S.G., Green, D.E., Elliott-Fisk, D.L., & Markowitz, H. (2009). Spatial and seasonal relationships between pacific harbor seals (*Phoca vitulina richardii*) and their prey, at multiple scales. *Fishery Bulletin, 107*, 358-372.

Gunvalson, M.M. (2011). Reducing disturbances to marine mammals by kayakers in Monterey Bay (Master's Thesis). Available from ProQuest Dissertation and Thesis database. Paper 3931.

Henry, E. & Hammill, M.O. (2001). Impacts of small boats on the haulout activity of harbour seals (*Phoca vitulina)* in Metis Bay, Saint Lawrence Estuary, Quebec, Canada. *Aquatic Mammals, 27*, 140-148.

Hines, J.M., Hungerford, H.R., & Tomera, A.N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education, 18*(2), 1-8.

Hughes, M. & Morrison-Saunders, A. (2002). Impact of trail-side interpretive sign on visitor knowledge. *Journal of Ecotourism, 1*(2&3), 122-132.

Hughes, M. & Morrison-Saunders, A. (2005). Interpretation, activity participation, and environmental attitudes of visitors to Penguin Islands, western Australia. *Society and Natural Resources, 18*(7), 611-624.

Hvengaard, G.T. (1995). Ecotourism: A status report and conceptual framework. *Journal of Tourism Studies, 5*(2), 24-35.

Hwang, Y.S., Kim, S., & Jeng, J. (2000). Examining the casual relationship among selected antecedents of responsible environmental behavior. *The Journal of Environmental Education, 31*(4), 19-25.

Kaiser, F.G., & Shimoda, T.A. (1999). Responsibility as a predictor of ecological behaviour. *Journal of Environmental Psychology, 19*, 243-253.

Kaiser, F.G., Wolfing, S., & Fuhrer, U. (1999). Environmental attitude and ecological behaviour. *Journal of Environmental Psychology, 19*, 1-19.

Kelly, C., Glegg, G.A., & Speedie, C.D. (2004). Management of marine wildlife disturbance. *Ocean and Coastal Management, 47*(1-2), 1-19.

Knight, R.L., & Cole, D.N. (1995). Wildlife responses to recreationists. In R. L. Knight & K. L. Gutzwiller (Ed.), *Wildlife recreationists: Coexistence through management research* (pp. 51-70). Washington, DC: Island Press.

Kuo, I-L. (2002). The effectiveness of environmental interpretation at resource-sensitive tourism destinations. *International Journal of Tourism Research, 4*, 87-101.

Lafferty, K.D. (2001). Disturbance to wintering western snowy plovers. *Biological Conservation, 101,* 315-325.

Lim, C., & McAleer. (2005). Ecological sustainable tourism management. *Environmental Modelling & Software, 20*(11), 1431-1438.

Littlefair, C. & Buckley, R. (2008). Interpretation reduces ecological impacts to visitors in world heritage sites. *Royal Swedish Academy of Sciences, 37*(5), 338-341.

Madin, E.M., & Fenton, M. D. (2004). Environmental interpretation in the Great Barrier Reef marine park: An assessment of programme effectiveness. *Journal of Sustainable Tourism, 12*(2), 121-137.

Mallick, S.A., & Driessen, M.M. (2003). Feeding of wildlife: how effective are the 'keep wildlife wild' signs in Tasmania's national parks? *Ecological Management Restoration, 4*(3), 199-204.

Marion, J.L., & Reid, S.E. (2007). Minimizing visitor impacts to protected areas: The efficacy of low impact education programmes. *Journal of Sustainable Tourism, 15*(1), 5-27.

Mckenzie-Mohr, D., Nemiroff, L.S., Beers, L., & Desmariais, S. (1995). Determinants of responsible environmental behavior. *Journal of Social Issues, 50*(4), 139-156.

Moscardo, G. (1998). Interpretation and sustainable tourism. *The Journal of Tourism Studies, 9*(1), 2-13.

Moscardo, G. (2003). Interpretation and sustainable tourism: Functions, examples and principles. *Journal of Tourism Studies, 14* (1), 112-23.

Moscardo, G., Woods, B., & Saltzer, R. (2004). The role of interpretation in wildlife tourism. In K. Higginbottom (Ed.), *Wildlife tourism: Impacts, management, and planning,* (pp. 231-251). Altona, Victoria: Common Ground Publishing.

Munro, J. K., Morrison-Saunders, A., & Hughes, M. (2008). Environmental interpretation evaluation in natural areas. *Journal of Ecotourism*, 7(1), 1-14.

Nichols, F.H., Cloern, J.E., Luoma, S.N., & Peterson, D.H. (1986). The modification of an estuary. *Science, 231*, 567-573.

Nordstrom, C.A. (2002). Haul-out selection by pacific harbor seals (*Phoca vitulina richardii*): Isolation and perceived predation risk. *Marine Mammal of Science, 18*(1), 194-205.

Orams, M.B. (1995). Using interpretation to manage nature-based tourism. *Journal of Sustainable Tourism, 4*(2), 81-94

Orams, M.B. (1997). The effectiveness of environmental education: Can we turn tourists into 'greenies'? *Progress in Tourism and Hospitality Research, 3,* 295-306.

Orams, M.B. (1998). *Marine tourism: Development, impacts and management*. London: Routledge.

Orams M.B., & Hill, G.J.E. (1998). Controlling the ecotourist in a wild dolphin feeding program: Is education the answer? *Journal of Environmental Education, 29*(3), 33-38.

Poudel, S., & Nyaupane, G.P. (2013). The role of interpretive tour guiding in sustainable destination management: A comparison between guided and nonguided tourists. *Journal of Travel Research,* 52(5), 1-14. DOI: 10.1177/0047287513478496

Powell, R.B., & Ham, S.H. (2008). Can ecotourism interpretation really lead to pro-conservation knowledge, attitudes, and behavior? Evidence from the Galapagos Islands. *Journal of Sustainable Tourism, 16*(4), 467-489.

Randall, C., & Rollins, R.B. (2009). Visitor perceptions of the role of tour guides in natural areas. *Journal of Sustainable Tourism, 17*(3), 357-374.

Reynolds, P.C., & Braithwiate, D. (2001). Towards a conceptual framework for wildlife tourism. *Tourism Management, 22*(1), 31-42.

Shalene, G.L., & Crooks, K.R. (2006). Education and conservation of the urban-wildland interface: Testing the efficacy of informational brochures. *The Southwestern Naturalist, 51*(2), 240-250.

Suryan, R.M., & Harvey, J.T. (1998). Tracking harbor seals (*Phoca vitulina richardii*) to determine dive behaviour, foraging activity, and haul-out site use. *Marine Mammal Science, 14*, 361-372.

Thompson, P.M., Miller, D., Cooper, R., & Hammond, P.S. (1994). Changes in the distribution and activity of female harbour seals during the breeding season; Implications for their lactation strategy and mating patterns. *Journal of Animal Ecology, 63*: 24-30.

Tubb, K.N. (2003). An evaluation of the effectiveness of interpretation within Dartmoor National Park in reaching the goals of sustainable tourism development. *Journal of Sustainable Toursim, 11*(6), 476-498.

Vicente, P., & Reis, E. (2008). Factors influencing households' participation in recycling. *Waste Management and Research, 26*(2): 140-146.

Williams, R., Lusseau, D., & Hammond, P.S. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biological Conservation 133*(3), 301-311.

Williams, D.R., & Vaske, J.J. (2003). The measurement of place attachment validity and generalizability of a psychometric approach. *Forest Science, 49*(6), 830-840.

Winter, P.L., Cialdini, R.B., Bator, R.J., Rhoads, K., & Sagarin, B. (1998). An analysis of normative messages in signs at recreation settings. *Journal of Interpretive Research, 3*(1), 39-47.

Woods, B., & Moscardo, G. (1998). Researching interpretive techniques in tourism: and evaluation of effectiveness of pictorial symbolism in reef tourist education. Bureau of Tourism Research. In B. Faulkner, C. Tideswell, & D. Weaver (Eds.), Progress in Tourism and Hospitality Research (pp. 320-333). Canberra, Australia: Bureau of Tourism Research.

Appendix 1. Boater Knowledge and Attitudes Survey

Sample survey

Hello! My name is Rachel Solvason and I am a graduate student conducting research at San Jose State University. I am interested in learning more about boaters and wildlife. Thank you for participating in this anonymous survey.

1. What is your reason main reason(s) for your visit today?

____

____

2. Where is your destination?

____

3. What is the length of your trip? (hours? days?)

____

4. What type of boat are you using today?

____

5. Are you interested in seeing wildlife when you boat? □ Yes □ No

   If so, which species are you most interested in seeing?______________________

____

   Please explain why ____

____

6. What is your sex? □ Male □ Female

7. What is your ethnicity
   - □ Caucasian
   - □ Hispanic/Latino
   - □ African American
   - □ Asian
   - □ Other __________

8. What is your age?
   - □ 18- 25
   - □ 25-40
   - □ 40-65
   - □ 65 +

9. What is your education level?
   - □ under high school
   - □ high school
   - □ bachelor degree
   - □ advanced degree

10. What city do you live in? __________________

11. Have you been to this launch site before? □ Yes □ No
If yes, how often do you visit in a year?
□ 1-5 times
□ 5-10 times
□ 10 or more
□ don't know

12. Have you heard of Corkscrew Slough? □ Yes □ No
If yes, have you visited Corkscrew Slough before? □ Yes □ No
If yes, have you encountered the harbor seals in Corkscrew Slough before? □ Yes □ No

13. How often do you encounter harbor seals in San Francisco Bay while boating?
□ every time
□ almost every time
□ sometimes
□ almost never
□ never

14. Do you approach the harbor seals in San Francisco Bay to get a better look?
□ Yes □ No

15. Are you a member of any local wildlife organizations or clubs? □ Yes □ No
If yes, which ones? ____

16. Have you ever heard of the San Francisco Bay Water Trail? □ Yes □ No

Please write in the number from the chart that represents how you feel about each following topic.

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree

1. Any human activity that changes wildlife behavior could harm the animal. _____

2. Approaching a harbor seal with a boat will disturb the animal. _____

3. Harbor seals on land are affected by boats passing by. _____

4. It is important to quickly pass by harbor seals on land. _____

5. Approaching wildlife with a boat directly will not disturb them. _____

6. I support increased public education to protect wildlife. ______

7. I support seasonal closures to boaters in order to protect sensitive species. _____

8. I am willing to change my boating behavior in order to protect wildlife. ______

9. I avoid disturbing wildlife while boating when possible. _____

10. I would like to increase my knowledge of how boating activities affect wildlife. _____