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An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years (2000-2015) to Inform Research and Management Programs

by

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Abstract:
In 2000, Samuels *et al.* provided a comprehensive review of the scientific literature available at the time, which included 107 references related to the effects "swim-with dolphin" tours have on animals' health and behavior. Over the last fifteen years, opportunities to view marine mammals in the wild have increased through commercial and private vessel-based platforms, in water "swim-with" activities, and land-based observation stations. Additionally, "structured" provisioning programs and illegal feeding interactions with a number of marine mammal species have increased. This current literature review updates and builds upon Samuels *et al.* 2000, by including almost 190 new references from 2000-2015 pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions. The scope has also been expanded to include additional species of cetaceans, pinnipeds, and sirenians. Our updated review highlights the major animal responses to viewing activities in four major themes: (1) behavior, (2) habitat use, (3) health, and (4) reproduction. Reoccurring responses documented in all four interaction themes include changes in animals' behavioral budgets and ranging patterns, habitat displacement, avoidance behaviors, and reduced maternal care. Many studies highlighted the risks and effects associated with interactions, such as increased energetic demands, predation, acoustic disturbance, reduced juvenile survivorship, boat collision, and entanglement injuries. This updated literature review provides a comprehensive analysis of human-marine mammal interactions to date that can help guide future potential research projects and management strategies.

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Introduction

Global tourism targeting marine mammals has grown dramatically over the past 20 years intensifying concerns among scientists and managers about impacts of these activities on animal populations and individuals. For example, in 1998, the whale watching industry included 9 million whale watchers across 87 countries, and generated over $1 billion USD in total expenditure (Hoyt 2001). Ten years later, by 2008, the market grew to 13 million whale watchers across 119 countries and generated a total expenditure of $2.1 billion USD (O'Connor et al. 2009). These numbers are specific only to whale-watching and do not represent the variety of other tourism activities targeting a broader range of marine mammal species. Tourism has expanded from vessel-based observation platforms to in-water "swim-with" activities (e.g., Samuels & Bejder 2004, Lundquist 2007, Lundquist et al. 2008, Courbis & Timmel 2009) and land-based observation stations (e.g., Boren et al. 2002, Cassini et al. 2004, Orsini et al. 2006). Food provisioning to facilitate closer interactions with marine mammals is also expanding. Food provisioning includes "structured" provisioning programs where controlled feeding is allowed (e.g., Mann et al. 2000, Mann & Kemps 2003, Foroughirad & Mann 2013) and illegal food provisioning (e.g., Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Finn et al. 2008, Donaldson et al. 2010, Donaldson et al. 2012).

A great deal of scientific literature has been published on marine mammal tourism impacts. In 2000 and 2003, Samuels et al. provided a comprehensive review of the scientific literature pertaining to swimming with wild dolphins, which included 107 references and found that swim-with activities occur worldwide with more than 20 cetacean species. The literature described four basic categories of cetaceans involved in in-water encounters with humans: (1) lone, sociable, (2) food-provisioned, (3) habituated, and (4) not habituated. In many cases, swim-with activities were disturbing to targeted animals; however, the majority of sources of information were descriptive, anecdotal, and not suitable for management purposes (Samuels et al. 2000, Samuels et al. 2003). At the time, their review highlighted the need for science to better assess the impacts from cetacean-focused tourism and assess the potential long-term effects.

In the years following the Samuels et al. reviews, the marine tourism industry has continued to grow and the potential for disturbance and long term impacts to marine mammals has intensified. Since 2000, research on human-marine mammal interactions has expanded and provided additional scientific findings and recommendations that should be considered in future management decisions. This current literature review updates and builds upon Samuels et al. (2000, 2003) by including almost 190 new references from 2000-2015 pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions. The scope has also been expanded to include additional species of cetaceans, pinnipeds, and sirenians.

This updated review includes four chapters organized by human-marine mammal interaction type: vessel, swimmer, feeding, and land-based interactions. The vessel interaction chapter was further sub-divided into two categories, vessel-based tour interactions and vessel traffic interactions, since animals' response to and impacts from these activities vary. While vessel traffic interactions may not be considered a "tourism" activity, it is not uncommon for vessels to opportunistically sight a marine mammal during transit and then consequently approach for a closer view. The feeding interaction chapter is also structured differently from the other three chapters to accommodate the differences in legal requirements (or lack thereof) associated with feeding marine mammals around the world.

Each chapter in the review is structured to highlight how human interactions impact animal behavior (individual and group), habitat use, health, and reproduction/development. Throughout the literature, different themes for each impact emerged and formed the basis for the subsections (e.g., subsections in vessel interactions may differ from ones in land-based interactions). At the end of each chapter there is a summary of conclusions and risks to both human and marine mammals associated with human interactions. Management recommendations proposed throughout the literature are also summarized at the end of each chapter; recommendations for vessel and swimmer interactions are combined since swim-with activities typically use a vessel to approach dolphins, and therefore management measures are very similar.

The purpose of this review is to provide an updated compilation of research on human-marine mammal interactions that have been documented in the fifteen years following the Samuels et al. (2000) review effort. This review not only provides the most current literature, but also is an expanded effort to include other types of human-marine mammal interactions with other species worldwide. New scientific findings and recommendations have emerged in the last fifteen years that can help guide future potential research projects and management decisions.

Chapter 1. Vessel Interactions

Introduction

Vessel-based tours targeting marine wildlife are the most common type of marine mammal watching activity (Hoyt 2001). These tours are associated with the greatest threats to marine mammals because they repeatedly target specific cetacean communities in easily accessible coastal habitats for prolonged periods (Nowacek et al. 2001, Bejder et al. 2006a). In addition, high densities of vessel traffic utilizing the same environment as marine mammals pose significant threats to the animals' behavior, habitat use, communication, health, reproduction, and survivorship (e.g., Allen & Read 2000, Nowacek et al. 2001, Buckstaff 2004, Bechdel et al. 2009, Jansen et al. 2010, French et al. 2011).

In this chapter, each vessel-based interaction type is broken into a separate sub-section: (a) vessel-based tour interactions, and (b) vessel traffic interactions. "Vessel-based Tour Interactions" includes literature examining animals' behavioral responses to vessels (e.g., commercial tour boats, jet skis, kayaks) that are specifically aimed at viewing wildlife and where the passengers remain onboard. "Vessel Traffic Interactions" includes literature examining behavioral responses and movement patterns of marine mammals within the same habitat as vessels that are not specifically engaged in viewing wildlife (e.g., commercial fishing vessels, freighters, cruise liners, and commercial or recreational whale watching boats in transit). This distinction between the two sub-sections was made in order to discern the direct effects of tourism on marine mammals (i.e., vessel-based tour interactions) from the cumulative effects that vessel traffic, not related to tourism, has on marine mammals (i.e., vessel traffic interactions).

We included 146 scientific papers, dissertations, theses, and workshop reports that focused on vessel-based tours and vessel traffic interactions with 28 marine mammal species. Species include 17 odontocetes (killer, sperm, and short-finned pilot whales, bottlenose, Indo-Pacific bottlenose, spinner, dusky, Commerson's, Burrunan, Irrawaddy, Hector's, pantropical spotted, common, Indo-Pacific humpback, Chilean, Guiana, and Risso's dolphins); 5 pinnipeds (Australian and New Zealand fur seals, South American and California sea lions, and harbor seals); 4 mysticetes (humpback, minke, fin, and gray whales); manatees and dugongs. Vessel interactions were documented worldwide spanning over 30 countries, archipelagos, island nations, and sovereign states. Vessel types include motorized commercial and recreational whale watching boats, jet skis, kayaks, commercial and recreational fishing vessels, freighters, cruise liners, and trawlers.

Part A: Vessel-based Tour Interactions

"Vessel-based Tour Interactions" includes literature examining animals' behavioral responses to vessels (e.g., commercial tour boats, jet skis, kayaks) that are specifically aimed at viewing wildlife and where the passengers remain onboard.

1.1 Behavioral Effects

1.1.1 Behavioral Budgets

Vessel-based tour interactions have been documented to directly or indirectly alter the behavioral budgets of several marine mammal species through acoustic or visual stimuli, or physical contact. Behavioral budgets (also commonly referred to as activity budgets) quantify how much time an animal allocates to various behaviors and are typically used to identify behavioral patterns. The most commonly documented animal responses to vessel-based tourism are decreased foraging or resting activities, and increased travel behavior. For example, Christiansen et al. (2013b) used a novel modeling approach to quantitatively infer activity budgets from minke whale (*Balaenoptera acutorostrata*) behavior to inform the link between behavior and bioenergetics. Using this approach, they showed that the cumulative time minke whales spent foraging and surface feeding decreased from 15.3% to 8.8% during interactions with whale-watching boats. This represents a potential 42% decrease in the proportion of time spent engaged in energy acquiring activities (Christiansen et al. 2013b). For common dolphins (*Delphinus delphis*), foraging behavior was documented to decrease by 11.9% (Stockin et al. 2008) and 12.4% (Meissner et al. 2015) in the presence of a tour vessel. Additionally, common dolphins targeted for tourism were significantly less likely to continue foraging after the approach of a tour vessel (Stockin et al. 2008, Meissner et al. 2015). Lusseau et al. (2009) evaluated the effects of tour vessels on endangered southern resident killer whales along San Juan Island, Washington, USA. When vessels were present, whales decreased the proportion of time spent foraging and increased time spent traveling (Lusseau et al. 2009). Similar to common dolphins (Stockin et al. 2008, Meissner et al. 2015), the likelihood of killer whales to continue foraging when already engaged in foraging behavior significantly decreased when vessels were within 100 to 400 m (Lusseau et al. 2009). General patterns of decreased foraging behavior in the presence of tour vessels have also been documented for bottlenose dolphins (*Tursiops truncatus*) (Samuels & Bejder 2004, Underhill 2006, Yazdi 2007, Arcangeli & Crosti 2009, Scarpaci et al. 2010, Symons et al. 2014, Pirotta et al. 2015); dusky dolphins (*Lagenorhynchus obscurus*) (Coscarella et al. 2003); Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) (Christiansen et al. 2010, Steckenreuter et al. 2011, Steckenreuter et al. 2012); pantropical spotted dolphins (*Stenella attenuata*) (Montero-Cordero & Lobo 2010); Risso's dolphins (*Grampus griseus*) (Visser et al. 2011); fin whales (*Balaenoptera physalus*) (Jahoda et al. 2003); and killer whales (*Orcinus orca*) (Bain et al. 2006, Bain et al. 2014).

Decreased resting behavior has also been documented in response to tour vessels across multiple species, including bottlenose dolphins (Constantine et al. 2003, Constantine et al. 2004, Lusseau 2004, Östman-Lind et al. 2004, Arcangeli & Crosti 2009); common dolphins (Stockin et al. 2008); dusky dolphins (Lundquist 2011, Lundquist et al. 2012); pantropical spotted dolphins (Östman-Lind et al. 2004, Montero-Cordero & Lobo 2010); Risso's dolphins (Visser et al. 2011); and spinner dolphins (*Stenella longirostris*) (Forest 2001, Östman-Lind et al. 2004). For example in the presence of tour vessels, a 34% decrease in resting behavior was documented for bottlenose dolphins in New Zealand (Lusseau 2003a) and a 10% decrease for bottlenose dolphins in Chile (Yazdi 2007). In addition, Australian and New Zealand fur seals (*Arctocephalus sp.)* were documented to decrease the amount of time spent resting as tour boats approached closely to haul-out sites (Shaughnessy et al. 2008, Cowling et al. 2014a).

Generally, marine mammals travel more in the presence of tour vessels, likely as a type of avoidance tactic, which is further discussed in subsequent sections. Indo-Pacific bottlenose dolphins were found to cease resting behavior and shift to traveling behavior when tour boats approached (Stensland & Berggren 2007, Christiansen et al. 2010, Steckenreuter et al. 2011, Steckenreuter et al. 2012). One study found Indo-Pacific bottlenose dolphins increased travel behavior by 28.8% when tour vessels were near (Steckenreuter et al. 2012). Southern right whales in Argentina that were traveling prior to a disturbance, showed a significant increasing tendency to continue traveling instead of starting to rest, as a result of a vessel approach (Vermeulen et al. 2012). Other species documented to increase their traveling behavior in the presence of tour vessels include bottlenose dolphins (Lusseau 2003a, 2004, Underhill 2006, Arcangeli & Crosti 2009); common dolphins (Stockin et al. 2008, Meissner et al. 2015); dusky dolphins (Coscarella et al. 2003); Commerson's dolphins (*Cephalorhynchus commersonii*) (Coscarella et al. 2003); Hector's dolphins (*Cephalorhynchus hectori*) (Nichols et al. 2001); fin whales (Jahoda et al. 2003); and killer whales (Bain et al. 2006). Increased milling behavior is also a commonly documented response to vessel-based tours among species, and is typically seen in conjunction with increased travel behavior (Stockin et al. 2008, Lundquist 2011, Lundquist et al. 2012, Steckenreuter et al. 2012).

The majority of literature on vessel-based interactions report similar conclusions on changes in animals' behavior and behavioral budgets. However, the literature also suggests various factors that may affect animals' behavioral responses to vessels, such as age class or sex, as well as the number of vessels, type of vessel, distance of vessel, and methods of vessel approach. Factors such as age class play a role in the resting behavior of New Zealand fur seals; juvenile seals rested less than adult seals when vessels approached (Shaughnessy et al. 2008, Cowling et al. 2014a). The juvenile age class tends to be more skittish than adults and more likely to flee to the water. Juveniles may also be more rambunctious and curious of their environment, resulting in decreased resting behavior compared to adults (Shaughnessy et al. 2008, Cowling et al. 2014a). Symons et al. (2014) found sex-based differences in bottlenose dolphin foraging behavior in New Zealand. Females increased the frequency of foraging dives, but decreased dive duration, perceiving a risky situation with the vessel nearby; however, males performed fewer, but longer foraging dives under the perception of decreasing risk. Males opt for a riskier, but energetically less expensive option in order to reserve energy for competition for female resources. Females, on the other hand, choose the more risk-averse foraging strategy due to high potential costs, such as death of herself or her calf. Despite these gender differences, the literature shows that, in general, both males and females achieve a lower net energy gain from a foraging bout when a vessel is present and behaving intrusively. Vessel characteristics (i.e. number of vessels, type of vessel, distance vessel approaches animal, and method of approach) have also been documented to affect how much time animals spend foraging, traveling, and resting (Nichols et al. 2001, Lusseau 2003a, Constantine et al. 2004, Underhill 2006, Cowling et al. 2014a).

Changes to behavioral budgets may also differ across species due to natural variations in life history patterns. For example, dusky and spinner dolphins exhibit different onshore and offshore diurnal movement and feeding patterns. Dusky dolphins in Argentina rest at night and feed during daylight hours on pelagic schooling fish, whereas dusky dolphins in New Zealand and spinner dolphins in Hawaii forage offshore at night in the pelagic layers and return inshore during the day to rest (Würsig et al. 1991, Coscarella et al. 2003, Dans et al. 2008, Dans et al. 2012). As a result, dolphin-watching in Argentina disrupts dusky dolphin foraging behavior (Coscarella et al. 2003, Dans et al. 2008, Dans et al. 2012), while dolphin-watching in New Zealand and Hawaii disrupts resting behavior for dusky dolphins and spinner dolphins (Forest 2001, Danil et al. 2005, Lundquist 2011, Lundquist et al. 2012, Symons 2013, Tyne 2015, Tyne et al. 2015).

1.1.2 Avoidance

1.1.2.1 Horizontal Avoidance

Horizontal avoidance tactics are defined as a change in the animal's heading or swim pattern and are one of the most common methods marine mammals (other than pinnipeds) use to evade tour boat pressure. Horizontal avoidance has been documented in bottlenose dolphins (Latusek 2002, Lusseau 2004, 2006, Yazdi 2007, Machernis 2014); Indo-Pacific bottlenose dolphins (Bejder et al. 2006a, Lemon et al. 2006, Steckenreuter et al. 2012); Indo-Pacific humpback dolphins (*Sousa chinensis*) (Piwetz et al. 2012); Hector's dolphins (Martinez et al. 2011); spinner dolphins (Delfour 2007, Timmel et al. 2008); dusky dolphins (Lundquist 2011, Lundquist et al. 2012); Guiana dolphins (*Sotalia guianensis*) (Filla & Monteiro-Filho 2009); humpback whales (*Megaptera novaeangliae*) (Scheidat et al. 2004, Morete et al. 2007, Schaffar et al. 2009, Stamation et al. 2009, Schaffar et al. 2013); fin whales (Jahoda et al. 2003); killer whales (Williams et al. 2002a, Williams et al. 2002b, Bain et al. 2006, Williams et al. 2011); sperm whales (*Physeter microcephalus*) (Richter et al. 2006); and West Indian manatees (*Trichechus manatus*) (Nowacek et al. 2002). Killer whales, in particular, are a good example of how cetaceans modify their swim pattern to avoid vessels on two spatial scales (1) deviation and (2) direction. Increased deviation is reflected by a less predictable swim path from one surfacing event to another, and decreased directedness is reflected by a less predictable path on the scale of an entire observation session. Killer whales have been documented to increase total swim effort to horizontally avoid vessels, but display different avoidance tactics in response to varying numbers of tour vessels and approach distances (Williams et al. 2002a, Williams et al. 2002b, Williams & Ashe 2007). For example, as the number of vessels increased, killer whales maximized path directedness; however, when fewer vessels were around, the whales were observed to swim in a more zigzag pattern (Williams & Ashe 2007, Williams et al. 2009). An endangered population of humpback whales on their breeding ground in New Caledonia exhibited similar decreased swim path directedness when boats were present within 1000 m of the animals (Schaffar et al. 2009)

Another horizontal avoidance tactic marine mammals use to avoid vessel-based tours is altering their swim speed. Minke whales increased their swim speeds from 1.62 m/s to 2.64 m/s during whale watch interactions in Faxaflói bay, Iceland, accounting for a 4.4% increase in estimated energy expenditure (Christiansen et al. 2013b, Christiansen et al. 2014). Humpback whales increased their swim speeds over 50% when approached by tour vessels in Brazil (Morete et al. 2007) and manatees exhibited short bursts of increased swim speeds when moving away from vessels in Belize (Nowacek et al. 2002). In contrast, large groups of dusky dolphins have been observed to decrease swim speeds as multiple boats approached closely (Lundquist 2011, Lundquist et al. 2012, Lundquist et al. 2013). Slower swims speeds exhibited by this species may be a response to the reduced ability to communicate and coordinate pod movements, due to increased background noise from vessel motors (Lundquist 2011, Lundquist et al. 2012, Lundquist et al. 2013).

Factors related to both the vessels (vessel type, number of vessels, approach method) and the animals (group size, sex) play a role in determining the type of avoidance behavior displayed. Fast and unpredictable vessels, such as motor boats and jet skis, tend to elicit horizontal avoidance responses in bottlenose dolphins (Mattson et al. 2005, La Manna et al. 2013). Northern resident killer whales displayed different avoidance tactics in response to motorized vessels and kayaks; the whales were not observed trying to outpace kayaks as they did with motorized vessels, since kayaks are unable to keep up with the whale's swim speed (Williams et al. 2011). The number of vessels can affect the type of avoidance strategy marine mammals display. For example, killer whales displayed a more tortuous swim pattern when there were only a few vessels (1-3), but adopted a straighter swim path as vessel number increased (>3) (Williams & Ashe 2007). The authors hypothesized that an irregular path may be a useful avoidance tactic with a single vessel, but ineffective when vessel numbers increase. In a multiple-vessel scenario, a dive that takes a whale further from one vessel may bring it closer to another (Williams et al. 2002b). In terms of approach method, vessels that attempt to "leapfrog" marine mammals by positioning in the animals' predicted path or approach "head on," often elicit horizontal avoidance responses, as exhibited by Burrunan dolphins (*Tursiops australis*) (Filby et al. 2014), gray whales (*Eschrichtius robustus*) (Heckel et al. 2001), and killer whales (Williams et al. 2002a). Williams et al. (2002a) reported northern resident killer whales increased their path deviation and reduced their swim path directness when a vessel was "leapfrogging," reflecting an increase of 17% in the distance a whale would have to swim to cover 100 m of straight-line distance.

Differences in animals' group size and sex have also played a role in avoidance responses. Common dolphins, for example, typically form larger groups to provide better protection from predation and other threats such as vessel interactions (Neumann & Orams 2005), thus they display less avoidance behavior than species traveling in smaller groups (Tseng et al. 2011, Filby et al. 2014). In addition, sex-differences in avoidance techniques have been noted in northern resident killer whales, such that females swam faster and increased the angle of deviation between surfacings, while males maintained swim speed, and chose a smooth, but less direct path compared to females (Williams et al. 2002b).

1.1.2.2 Vertical Avoidance

In some instances, marine mammals exhibit vertical avoidance behaviors by altering dive patterns, dive times, and respiration rates. We found no recent literature regarding pinnipeds and vertical avoidance behaviors. Rather, the majority of literature focused on cetaceans and found that altering dive times, often measured by inter-breath intervals (IBI) is the most commonly used vertical avoidance tactic. Studies have documented species to either increase or decrease their IBI in response to the circumstances of the disturbance source. Marine mammals documented to exhibit this type of avoidance tactic include bottlenose dolphins (Lusseau 2003b, Underhill 2006, Symons et al. 2014); Indo-pacific bottlenose dolphins (Stensland & Berggren 2007); Irrawaddy dolphins (*Orcaella brevirostris*) (Stacey & Hvenegaard 2002); humpback whales (Schaffar et al. 2009, Stamation et al. 2009); fin whales (Jahoda et al. 2003); killer whales (Bain et al. 2006); sperm whales (Richter et al. 2006); and minke whales (Christiansen et al. 2014). For example, bottlenose, Indo-Pacific bottlenose, and Irrawaddy dolphins increased their IBI presumably to avoid close vessel approaches or underwater acoustic disturbance from vessels (Stacey & Hvenegaard 2002, Lusseau 2006, Stensland & Berggren 2007). Minke whales and killer whales, however, responded by decreasing IBI when disturbances, such as tour vessels, were on the whales' foraging grounds, or when there were greater than 12 tour vessels in the surrounding area (Bain et al. 2006, Christiansen et al. 2013a).

An animal's sex is also a factor in determining dive patterns and respiration rates when vessels are present. Lusseau (2003b) observed that male bottlenose dolphins increased their mean IBI when vessels were greater than 400 m away, whereas females only did so when boats were within 400 m and potentially impeding the movement of a group of dolphins. Lusseau (2003b) suggests this phenomenon may be due to differences in metabolic rates between males and females. Males have increased energy stores so they are able to absorb the energetic costs of vertically avoiding vessels, whereas females have less energy stores, compared to males, especially when reproductively mature. Thus, females only increase their mean IBI when the risk of incurring injury from a vessel is high (Lusseau 2003b).

1.1.3 Surface Active Behavior

The literature largely supports the finding that surface active behaviors (e.g., spy hops, breaches, tail slaps, flipper slaps) and aerial displays by cetaceans typically increase in response to vessel-based disturbances (Forest 2001, Bain et al. 2006, Morete et al. 2007, Courbis & Timmel 2009, Noren et al. 2009, Stamation et al. 2009, Kessler et al. 2013). Surface active behaviors may be a general indicator of disturbance, or may serve as agonistic acts towards boat approaches. For example, spinner dolphin aerial displays were observed most frequently midday, coinciding with peak tourism hours during dolphin resting periods (Courbis & Timmel 2009). Interrupting rest periods can significantly increase rates of predation and diminish foraging efficiency (Forest 2001, Courbis & Timmel 2009). Southern resident killer whales' surface active behaviors increased by 70% when boats were as far as 224 m away (Noren et al. 2009). Williams et al. (2009) noted that killer whales were less likely to perform surface active behaviors as vessel numbers increased, but more likely to exhibit these behaviors as vessels got closer to the whale (Williams et al. 2009). Some surface active behaviors, such as breaches, slaps, and fluke lifts, may be used as a threat display when vessel traffic is close, but not close enough to elicit an avoidance response. Half of humpback whale groups in Tonga showed increased surface active behaviors when vessels approached closer than 30 m, even though recommended viewing guidelines are set at 10 m (Kessler et al. 2013). Although less commonly documented, in some vessel-based interaction studies, animals' surface active behaviors decreased. For example, Hawaiian spinner dolphins decreased aerial displays entering and exiting their resting bay, which may have been an avoidance strategy from being seen and targeted by nearby tour vessels (Forest 2001). Similarly, Morete et al. (2007) observed decreased rolling behaviors from humpback whale calves in the presence of vessels, possibly inhibiting important social and developmental skills, such as motor skills and coordination. While there are different theories explaining the purpose and timing of surface active behaviors in response to vessel tours, all of these activities have additional energetic costs associated with them (Williams et al. 2009). No literature regarding surface active behaviors for pinnipeds has been documented.

1.1.4 Acoustics

Noise from vessel engines is problematic for a variety of reasons, such as causing a startle response, masking natural sounds, impacting hearing, and potential injury. Acoustic masking is a growing concern; it interferes with or obscures communication by limiting the range at which signals can be heard, or reduces the quality of information being sent (Erbe 2002, Jensen et al. 2009, Albuquerque & Souto 2013, Guerra et al. 2014). For endangered Southern resident killer whales, vessels idling within 200 m from whales do not interfere with the soundscape or reduce the active space of echolocation signals. However, in accordance with the "Be Whale Wise" guidelines, vessels can power up to normal cruising speeds within 400 m of whales. At this range and speed, Holt (2008) estimated the horizontal detection range of a 50 kHz echolocation signal is reduced by as much as 360 m relative to ambient conditions (400 m under ambient conditions, 40 m under masked conditions). Interference with communication can have significant biological effects, especially if it impacts an animal's ability to forage, socialize, navigate, or communicate for group cohesion purposes (Foote et al. 2004, Holt et al. 2008, Albuquerque & Souto 2013, Pirotta et al. 2015). In response to increased ambient noise, some species alter their communication by changing their whistle structure, clicks, or call duration. For example, bottlenose dolphins and killer whales are known to increase repetition rates, call duration, and call amplitude by 1 dB for every 1 dB increase in ambient noise level (Foote et al. 2004, Holt et al. 2008, Hawkins & Gartside 2009a). In New Zealand, dolphin groups with mothers and calves increased their whistle rates, producing shorter and higher-frequency whistles around fast moving and loud tour boats, compared to groups with no calves (Guerra et al. 2014). This demonstrates the need for vocal contact with calves outweighs the costs of whistling more and may help to restore group cohesion (Guerra et al. 2014). Australian fur seals also altered their vocalizations by changing their pattern of calls and barks in response to high levels of motor boat noise (Tripovich et al. 2012).

Increased noise associated with the distance and speed of a vessel may also influence the received sound levels and a marine mammal's acoustical response. When comparing a fast zodiac at 51 km/h with a slow zodiac at 10 km/h, Erbe (2002) recorded stark differences in detection distance, masking distance, behavioral response, and temporary threshold shifts (TTS) for killer whales in Haro Strait, British Columbia. Temporary threshold shifts occur when an animal is exposed to intense sound, so that their hearing threshold becomes elevated, but returns to pre-exposure level after a period of time (Finneran et al. 2001). In Erbe's (2002) comparison between killer whales' responses to fast boats versus slow boats, she reported that: (1) killer whales detected fast boats 16 km away versus slow boats 1 km away; (2) behavioral responses were elicited when fast boats were 200 m away versus slow boats that were 50 m away; (3) fast boats masked calls at 14 km whereas slow boats masked calls at 1 km; and (4) TTS occurred at 5 dB for 30-50 mins when exposed to fast boats within 450 m compared to slow boats that were 20 m away.

1.1.5 Vigilance/Flushing/Haul Out/Aggression

Vigilance and flushing behaviors are characterized in pinnipeds by general alertness, upright or head-up posture, and fleeing to the water (Andersen et al. 2012). These behaviors are observed in response to vessels across a wide geographic range from species including: Australian fur seals (Shaughnessy et al. 2008, Stafford-Bell 2012, Tripovich et al. 2012); harbor seals (*Phoca vitulina*) (Henry & Hammill 2001, Johnson & Acevedo-Gutiérrez 2007, Fox 2008, Jezierski 2009, Andersen et al. 2012, Osinga et al. 2012, Hoover-Miller et al. 2013, Young et al. 2014); New Zealand fur seals (Boren et al. 2002, Shaughnessy et al. 2008, Cowling et al. 2014a);

and South American sea lions (Pavez et al. 2011, Pavez et al. 2014). These behavioral responses are significantly impacted by spatial/seasonal differences (breeding vs non-breeding haul-out sites) and animal age/sex class. For example, molting and breeding seasons are energetically taxing times for pinnipeds. During these times, seals are likely to conserve energy and remain on land, explaining the increased vigilance and decreased flushing behaviors observed during vessel approaches (Henry & Hammill 2001, Boren et al. 2002, Andersen et al. 2012). As for spatial and age/sex class factors, responses and rationale vary. For example, New Zealand fur seal pups tend to be more alert and shift their behavior from resting to vigilance when vessels approach their haul-out sites (Cowling et al. 2014a). This reaction from seal pups may be explained by their inexperience around vessels and uncertainty regarding the threat they might pose (Cowling et al. 2014a). During a study conducted in Chile, Pavez et al. (2014) documented South American female sea lions at a non-breeding haul-out site exhibited a larger response to tourism disturbance likely because they did not have newborn pups to care for or protect, thus were not constrained to remaining on land. In contrast, females at the breeding site typically remained on land during vessel disturbances to tend to their newborn pups. Sub-adult males, no matter what site (breeding or non-breeding), displayed a more noticeable response to disturbance. Sub-adults do not effectively compete in reproduction such that they do not need to defend females or territories, and are usually on the periphery of the colony trying to abduct females or pups (Pavez et al. 2014). Lastly, adult males displayed greater disturbance behavior at the non-breeding site, where they were not constrained to land in order to defend females and territories.

In some studies, vigilance and flushing responses were complex and varied depending on species, vessel approach distances, and vessel type. Australian fur seals moved to the water when a vessel approached within 40 m of a haul-out site (Shaughnessy et al. 2008), whereas South American sea lions had a much higher tolerance for approach distance and flushed when vessels were less than 25 m (Pavez et al. 2011). Similarly, California sea lions increased alertness when boats approached within 20 m (Labrada-Martagón et al. 2005). When evaluating disturbance response among vessel types (i.e. motorboat vs. kayak/canoe), harbor seals in particular appeared to be more sensitive to close approaches by motorboats than by kayaks. In Washington State, disturbed harbor seals retreated to the water when motor boats stopped within 190.5+/-124.8 m of their haul-out location, compared to when kayaks stopped within 91+/-36.3 m (Johnson & Acevedo-Gutiérrez 2007). Similarly, harbor seals in Canada flushed to the water when boats were greater than 200 m of their haul-out site, and flushed when kayaks were within 100-140 m (Henry & Hammill 2001). Although seals appear to be less sensitive to kayaks than motor boats, kayaks likely still elicit a predator-prey response since they are quiet, close to the surface of the water, and less conspicuous, thus mimicking the characteristics of a predator and inducing flushing behavior (Henry & Hammill 2001, Fox 2008, Jezierski 2009, Hoover-Miller et al. 2013).

Increased aggression between animals has also been observed as a result of tour-vessel disturbance. The average number of displays of territorial disputes increased between Australian fur seals as the number of recreational vessels within 200 m of the haul-out site increased (Stafford-Bell 2012), and also in response to increasing motor boat noise (Tripovich et al. 2012). These responses may be due to increased stress levels and a heightened sense of emotion from the threat of approaching vessels and their associated motor noise (Stafford-Bell 2012, Tripovich et al. 2012).

1.1.6 Physiological Responses

Measuring behavioral responses alone may not be the only indicator of an animal's level of disturbance, and in fact may underestimate it. Measuring changes in heart rate have also been used to characterize the "unseen" physiological responses to disturbance. For example, harbor seal heart rate increased by 5 bpm upon initiation of vigilance behavior when experimentally approached by vessels in Southeast Alaska (Karpovich et al. 2015). After responding to vessels by entering the water, seals exhibited a lower heart rate while in the water, and a higher heart rate of 6 bpm during the next haul out, with the elevated heart rate persisting for at least 180 minutes (Karpovich et al. 2015). This physiological response indicates that vessel disturbance has a prolonged influence on the energetic balance of harbor seals, which could result in decreased opportunities to forage or care for young, and translate into longer term implications.

Respiration rates may also be used as a proxy for oxygen consumption to estimate energy expenditure in larger cetaceans. On minke whale feeding grounds in Faxaflói bay, Iceland, whale watching boat interactions resulted in increased respiratory rates from 0.88 breaths/min to 1.12 breaths/min, suggesting that vessel presence elicited a stress response (Christiansen et al. 2014). This increase in respiratory rates corresponds to an overall 23.2 % increase in estimated energy expenditure (Christiansen et al. 2014).

1.1.7 Neutral

There is very little literature that documents a neutral response (i.e., showing no apparent response to a stimulus) by animals to tour vessel interactions. In areas of low-level tourism in Patagonia, Argentina and Mercury Bay, New Zealand, a neutral response to vessel presence was reported for Commerson's and common dolphins (Failla et al. 2004, Neumann & Orams 2005, Neumann & Orams 2006). This neutral response is likely due to very low levels of tourism resulting in less behavioral, physical and acoustic disturbance (i.e. Failla et al. 2004).

1.2 Group Behavior Effects

1.2.1 Group Size, Cohesion, and Acoustics

Some studies focused on group behavior of marine mammals in response to tour-vessel interactions. Results from these studies varied and documented how groups became more compact, spread out into smaller sub-groups, or increased in size. All of these responses likely indicate avoidance strategies by the animals. For example, increasing group compactness during vessel encounters may serve as a tactic to better track other group members' movement patterns and respond more quickly in the context of a presumed threat (Bejder 2005, Bejder et al. 2006a, Steckenreuter et al. 2011, Steckenreuter et al. 2012). In other cases, bottlenose dolphins in Australia and Chile spread out into smaller sub-groups in response to vessel encounters (Yazdi 2007, Arcangeli & Crosti 2009), which resulted in as much as 27% more groups with a 12% decrease in group size (Arcangeli & Crosti 2009). Dividing into smaller sub-groups may make movement patterns less predictable to a perceived threat (Yazdi 2007). In many cases, cohesion between mother and calf pairs increased as did overall group size when calves were present among the group during a disturbance event (Latusek 2002, Mattson et al. 2005, Scarpaci et al. 2010, Steckenreuter et al. 2012). This was likely used as added protection for the calf or other animals when the number of tour vessels increased, or distance between tour vessel and animals decreased. Conversely, Guerra et al. (2014) documented significantly less cohesiveness and coordinated movement for bottlenose dolphin groups with calves during and after a vessel disturbance. Simultaneous with the disturbance event, the researchers also recorded elevated whistle rates. The increased whistle rate is likely a method to compensate for masking effects of vessel noise and to restore group cohesion after the passage of a vessel (Guerra et al. 2014).

The increase of whistle production to restore group cohesion has also been documented for a resident inshore bottlenose dolphin population in Port Phillip Bay, Australia (Scarpaci et al. 2000). Whistle production was significantly higher in the presence of tour boats while animals were engaged in traveling, feeding, and socializing behavior. Since these behaviors typically require more coordination through acoustic signals, the authors suggest that increased whistle production was a result of disrupted group cohesion from either the physical separation of individuals in a group or from masking effects (Scarpaci et al. 2000).

1.3 Habitat Use Effects

1.3.1 Displacement

Tour vessel interactions can displace marine mammals from their preferred habitat and affect their distribution and abundance. In 2006, Bejder et al. (2006b) published a landmark study that clearly documented habitat displacement of bottlenose dolphins in Shark Bay, Australia as a result of tour vessel interactions. Specifically, the average dolphin abundance decreased by 14.9% when the number of tour boats increased from zero to two vessels over several years of monitoring (Bejder et al. 2006b). In contrast, dolphin abundance increased by 8% in an adjacent bay less frequented by vessels. This finding provides strong support for the long-term shift in habitat use from an area of high tourism to one with fewer disturbances (Bejder et al. 2006b). Similarly in Hawaii, there is strong evidence suggesting that spinner dolphins were temporarily displaced from their most important resting bay to a previously less-used secondary resting bay due to increased pressure from tour boats (Östman-Lind et al. 2004). More recent work has estimated a reduction in the Hawaiian Island stock population of spinner dolphins (Tyne et al. 2014). The genetic distinctiveness of this stock and the ease of human access into their preferred habitat make this stock more vulnerable to negative impacts from human disturbance (Tyne et al. 2014). In Fiordland, New Zealand, Lusseau et al. (2006) reviewed the effects of tourism on bottlenose dolphins in Milford Sound and Doubtful Sound and also documented habitat displacement in response to tourism pressure. Specifically in Milford Sound during peak tourism season, dolphins spent less time within the heavily trafficked fjord compared to other seasons, and when they did visit, the dolphins spent more time at the entrance of the fjord in the "no boat" zone (Lusseau 2005).

1.3.2 Ranging Patterns

Tour vessel interactions have been documented to influence animals' ranging patterns. For example, differences in ranging patterns were found between conditioned (illegally provisioned animals) and non-conditioned bottlenose dolphins in Panama City, Florida (Samuels & Bejder 2004). Conditioned animals remained within less than one nautical mile from where boats, jet skis, and swimmers congregated and interacted with (i.e., illegally fed) the animals. Conversely, non-conditioned dolphins traveled up to several nautical miles away from the interacting vessels along the coastline or into a nearby bay (Samuels & Bejder 2004). In another area of Florida, Sarasota Bay, a few routinely provisioned animals were only sighted in an unnaturally small portion of the bay, at the southern extent of the normal population range, where boating and tourist traffic is high (Cunningham-Smith et al. 2006). In both studies, it is important to note that the animals were so heavily conditioned to being fed by people that it was difficult to discern the effects of vessel interactions on animals' ranging patterns alone.

1.4 Health Effects

1.4.1 Contaminant Exposure

Only one study modeled the potential health effects of exhaust emissions from whale watching boats on southern resident killer whales in British Columbia (Lachmuth et al. 2011). A pollution dispersion model was run and incorporated data on whale and vessel behavior, atmospheric conditions, and exhaust emissions from whale watching vessels. The model suggested that during average-case whale watching scenarios (i.e., 20 vessels maintaining the 100 m viewing distance guideline, mixed wind speeds, and average mixing height) the World Health Organization's Air Quality Guidelines for carbon monoxide (CO) and nitrogen dioxide (NO_2) were occasionally exceeded depending on environmental factors; however, they were always exceeded when 20 or more vessels violated the viewing distance guideline and were closer than 100 m. Whales' exposure to airborne contaminants is highly dependent on environmental factors as exemplified and accounted for in the model. Acute and chronic exposure to engine exhaust emissions can have different health effects depending on concentration and duration, but overall can result in asthma, respiratory infection, and changes in pulmonary function, arterial vasoconstriction, and mortality, as seen in other mammals (Lachmuth et al. 2011). While Lachmuth et al. (2011) highlight the potential for health effects from exposure to vessel exhaust, there is no evidence to date that southern resident killer whales suffer from health issues directly related to CO and NO_2 emissions.

1.5 Reproductive Effects

1.5.1 Reproductive Rate/Survivorship

Studies in the literature have documented a negative correlation between vessel exposure, and both female reproductive rates and juvenile survivorship. For bottlenose dolphins in Shark Bay, Australia, between 1993 and 2004, females chronically exposed to tour vessel interactions exhibited a reduced ability to produce and successfully rear offspring (Bejder 2005). The majority of calves born to females exposed to high vessel pressure did not survive to weaning, likely as a result of malnutrition, increased disease susceptibility, or increased predation (Bejder 2005). French et al. (2011) found California sea lions' reproductive rates decreased in response to the presence of vessels within 50 m; however at the same time, pups' growth rates increased. In this particular case, the increase in growth rates is likely a result of the reduction in reproductive rates, which allows for more available resources for the remaining pups to utilize (French et al. 2011). Although it was not specified in the study that the vessels were specifically targeting the sea lions for tourism purposes, the close approach distance of 50 m is likely a means to actively view the animals from a closer distance. Juvenile survivorship and fitness were also jeopardized for West Indian manatees (King & Heinen 2004) and Indo-Pacific bottlenose dolphins (Stensland & Berggren 2007) due to decreased time spent nursing in the presence of tour-vessels.

1.5.2 Neutral

There are two studies that document neutral impacts to marine mammal reproduction from vessel-based interactions. Weinrich & Corbelli (2009) found humpback whale calving and calf survival rates did not change because of exposure to whale watching tours in the Gulf of Maine. Neither the length of exposure to tours nor the number of interactions between vessels and whales affected calf production or survival (Weinrich & Corbelli 2009). Christiansen et al. (2015) estimated that the cumulative time minke whales spend near whale watching boats on feeding grounds in Faxaflói Bay, Iceland was 0.2%, or 7.13 hours. This constitutes only a 0.66% energy loss from blubber storage for pregnant females. The authors concluded that the impacts of whale watching on minke whale fetal growth is negligible (Christiansen et al. 2015).

Part B: Vessel Traffic Interactions

"Vessel Traffic Interactions" includes literature examining behavioral responses and movement patterns of marine mammals within the same habitat as vessels that are not specifically engaged in viewing wildlife (e.g., commercial fishing vessels, freighters, cruise liners, and commercial or recreational whale watching boats in transit). Throughout the literature, there is no common understanding of how various terms (i.e., vessel, boat, ship, vessel traffic, etc.) are used to describe a situation. Due to this inconsistency, it can be very challenging to decipher an animal's response to either vessel-based tour interactions or vessel traffic interactions. This section highlights papers that may include a mix of vessel types, but are primarily non-targeted vessel traffic. However, it is not uncommon for a recreational vessel, for example, in transit to opportunistically sight a marine mammal and then move closely to approach and get a better viewing. While this may not be considered a "tourism" activity, this section emphasizes the impact non-tourism based vessels have on marine mammals and provides a baseline of impacts animals experience without additional anthropogenic pressures from tourism.

1.6 Behavioral Effects

1.6.1 Behavioral Budgets

Vessel traffic interactions have been documented to alter an animal's behavioral budget. The most commonly cited behavioral changes include decreased foraging, resting or socializing, and increased traveling behaviors. For example, Williams et al. (2006) documented decreased foraging and increased traveling by killer whales in the presence of vessel traffic. The Williams et al. (2006) study was one of the first to suggest vessel traffic affects killer whale foraging, reducing energy acquisition by 18%. A similar result was found for dugongs in Australia, which decreased foraging in a heavily trafficked zone when vessels passed within 50 m (Hodgson & Marsh 2007). The decreased time spent foraging resulted in an overall energy deficit of 0.8-6% (Hodgson & Marsh 2007). Bottlenose dolphins in Florida and Italy also have been found to decrease foraging and increase traveling in the presence of vessel traffic (Bechdel et al. 2009, Papale et al. 2011). In addition to changes in foraging and traveling behavior, socialization patterns were observed to change in response to vessel traffic. For example, killer whales were observed spending 14% less time rubbing their bodies on pebble beaches in the presence of vessel traffic, which is typically an important component of their socializing repertoire when not disturbed (Williams et al. 2006).

1.6.2 Avoidance

1.6.2.1 Horizontal Avoidance

Horizontal avoidance is one of the most commonly observed avoidance tactics used by marine mammals, other than pinnipeds, especially in busy traffic conditions and in narrow channels. Typical avoidance behaviors include a change in heading, away from traffic, accompanied by increased swim speed. Horizontal avoidance behaviors in response to vessel traffic have been documented for bottlenose dolphins (Gregory & Rowden 2001, Nowacek et al. 2001, Latusek 2002, Papale et al. 2011); Chilean dolphins (Ribeiro et al. 2005); Indo-Pacific humpback dolphins (Ng & Leung 2003); Irrawaddy dolphins (Kreb & Rahadi 2004); killer whales (Smith 2008); humpback whales (Smith 2008); and the West Indian manatee (Miksis-Olds et al. 2007). For example, in Core Sound, North Carolina, bottlenose dolphins swam in more direct paths in the presence of high vessel traffic; however, when no boats were in the study area, the animals changed heading in between surfacings and were able to utilize their environment without vessel restrictions (Latusek 2002). Bottlenose dolphins and manatees have also been observed to increase swim speeds to evade vessel traffic (Nowacek et al. 2001, Miksis-Olds et al. 2007, Papale et al. 2011).

Horizontal avoidance tactics are often affected by vessel type and vessel speed. In general, marine mammals tend to avoid vessels moving at high speeds such as jet skis, personal watercraft, motorboats, and ferries (Ng & Leung 2003, Goodwin & Cotton 2004, Miksis-Olds et al. 2007, Baş et al. 2014). Irrawaddy river dolphins in Brazil surfaced significantly less in the presence of motorized canoes, speedboats, and actively changed direction to avoid tugboats that occupied over three quarters of the river width (Kreb & Rahadi 2004). Bottlenose dolphins in Cardigan Bay, Australia avoided kayaks over 50% of the time, often traveling up to distances 200 m away, possibly due to a startle response from a kayak's relatively silent movement compared to motor boats (Gregory & Rowden 2001).

1.6.2.2 Vertical Avoidance

Several species of dolphins utilize vertical avoidance strategies to evade high densities of vessel traffic. Specifically, animals have been documented to increase dive duration, increasing their IBI, so that the amount of time spent at the surface is limited. Increased time underwater to evade vessel traffic has been documented for bottlenose dolphins (Nowacek et al. 2001, Hastie et al. 2003, Goodwin & Cotton 2004, Papale et al. 2011, Rako et al. 2012, Baş et al. 2014); Indo-Pacific humpback dolphins (Ng & Leung 2003); Irrawaddy dolphins (Kreb & Rahadi 2004); and killer whales (Williams et al. 2009). Similar to horizontal avoidance tactics, vertical avoidance behaviors are elicited by high speed boats and an increased presence of vessel traffic.

1.6.3 Surface Active Behaviors

Humpback whales' surface active behaviors (i.e., spy-hopping, tail slapping, or breaching) have been documented to be affected by vessel traffic. Humpback whales in Australia were observed to decrease their surface active behaviors by almost 50% when the number of vessels increased from zero boats to 1-3 boats (Smith 2008).

1.6.4 Flushing

Harbor seals exhibit a flushing response to vessel traffic (Jansen et al. 2010). In Alaska, harbor seals flushed in response to the passing of cruise ships at different distances (Jansen et al. 2010). Harbor seals were 25 times more likely to flee into the water when cruise ships passed within 100 m than when ships passed within 500 m (Jansen et al. 2010).

1.6.5 Physiological Responses

Harbor seals showed a 4 bpm increase in heart rate with each additional vessel present in a fjord in southeast Alaska while hauled out (Karpovich et al. 2015). The observed heart rate could be attributed to the seals becoming more alert and aware of vessels in the area and potentially experiencing stress. Vessel size also had an impact on seals' heart rate. Smaller vessels (i.e. skiffs, inflatables, kayaks) comprise approximately 23% of vessel traffic in two neighboring fjords. Karpovich et al. (2015) found that these smaller vessels had the largest impact on harbor seals' heart rates, likely due to their unpredictable movement patterns and ability to closely approach haul-out sites.

1.6.6 Neutral

Two studies did not report any significant behavioral changes by dolphins in response to vessel traffic (Gregory & Rowden 2001, Failla et al. 2004). In Bahia San Julian, Argentina, Commerson's dolphins have been documented to have a neutral response to vessels when there is a low frequency and intensity of vessel traffic (Failla et al. 2004). In Cardigan Bay, Australia, bottlenose dolphins were also documented having a neutral response to vessel traffic 62% of the time (Gregory & Rowden 2001). Authors suggest this neutral response may be a result of conditioning to vessel traffic; however, they did note that dolphins exhibit avoidance behavior when kayaks were nearby, suggesting that response may be a factor of vessel type (Gregory & Rowden 2001).

1.7 Group Behavior Effects

1.7.1 Group Cohesion and Acoustics

Several studies document how vessel traffic affects different species of dolphins and humpback whales' group cohesion, respiratory rates, and communication. For example, group cohesion became tighter with increased boat traffic for bottlenose dolphins in Sarasota, Florida (Nowacek et al. 2001) and Chilean dolphins in Chile (Ribeiro et al. 2005), likely as a means to help coordinate movements among group members. Dolphins also exhibit increased breathing synchrony in response to high vessel traffic. Thirty and a half percent of a bottlenose dolphin group in Moray Firth, Scotland, synchronized their breathing, likely as an antipredator tactic from the perceived threat of vessels (Hastie et al. 2003). Dolphin species also utilize their acoustic abilities to help establish group cohesion. For example, bottlenose dolphins' whistle rate in Sarasota, Florida, increased prior to the passing of vessels, likely as a result of heightened arousal or an attempt to establish group cohesion before the disturbance (Buckstaff 2004). In contrast, Indo-Pacific humpback dolphins in Australia increased their whistle rate after vessels passed within 1.5 km, with mom/calf pairs exhibiting the highest whistle rate, likely to re-establish cohesion (Van Parijs & Corkeron 2001). Acoustic disturbance also has general impacts on species' foraging and social behavior. Bottlenose dolphin call rates and creaks associated with foraging and social behavior decreased in the presence of various types of vessels in Portugal (Luís et al. 2014). In Brazil, the number of individual humpback whale singers decreased in the presence of high vessel traffic, indicating that they either stopped singing in response to the traffic, or possibly moved out of the recording range (Sousa-Lima & Clark 2008).

1.8 Habitat Use Effects

1.8.1 Habitat Preferences

In many cases, dolphins prefer certain habitats for protection while engaged in specific behaviors, like foraging. High densities of vessel traffic have the potential to disturb animals and alter their habitat use. There are three publications that examine bottlenose dolphin habitat use in response to vessel traffic. Two papers document a shift in habitat usage and the other did not. Allen & Read (2000) documented bottlenose dolphins in Clearwater, Florida shifting away from primary foraging habitats during periods of high boat density (Allen & Read 2000). During weekdays with less boat traffic, the dolphins strongly preferred foraging in the channel and spoil island habitats; however, on weekends, with more vessel traffic, the animals did not exhibit strong patterns of habitat selection (Allen & Read 2000). The authors suggest the dolphins shifted their foraging habitat preference to directly avoid vessel traffic, or in response to the movement of prey influenced by vessel traffic (Allen & Read 2000). Select habitats also provide protection from predators and anthropogenic impacts. Bottlenose dolphins in Core Creek, North Carolina, prefer the deeper waters of the Intercoastal Waterway and were observed to spend 85% of their time there when vessel traffic was low (Latusek 2002). However, as vessel traffic increased, animals were observed occupying the shallower waters outside of the Intercoastal Waterway and reduced the time spent in their preferred habitat by 17% (Latusek 2002). Lastly, La Manna et al. (2010) examined the relationship between bottlenose dolphin distribution in the Straits of Italy and the type and number of vessels present. The authors did not observe any disruptions in habitat preference. These results may be explained by the ecological importance of the area with high prey availability and plentiful foraging opportunities (La Manna et al. 2010).

1.8.2 Displacement

Short-term and localized habitat displacement has been documented for bottlenose dolphins in Croatia in response to high boat traffic conditions (Rako et al. 2012, Rako et al. 2013). In Croatia, Rako et al. (2012) documented a significant decrease in bottlenose dolphin sightings in areas of high anthropogenic pressure. The authors suggest that localized displacement from critical habitat may be occurring as a result of a large number of high speed boats, which increase underwater noise (Rako et al. 2012, Rako et al. 2013). Continued short-term avoidance strategies may result in long-term displacements from preferred habitat.

1.9 Health Effects

1.9.1 Mortality

High volumes of vessel traffic within marine mammal habitats can increase the risk of boat collision injuries and mortalities. In the Indian River Lagoon, Florida, from 1996 to 2006, Bechdel et al. (2009) reported 43 bottlenose dolphins, or 6% of the population, exhibited scars indicative of boat collisions. Two counties within the Indian River Lagoon, St. Lucie and Martin, have the highest number of registered boats per square kilometer of habitat. The highest rates of dolphin boat collision coincided with these two counties (Bechdel et al. 2009). Confirmed collisions have also been identified for other small cetacean and large whale species worldwide (Van Waerebeek et al. 2007). Among large whale species, vessel-caused mortality and traumatic injuries have been documented primarily for southern right, humpback, and Bryde's whales, but also include sperm, blue, sei, and fin whales (Van Waerebeek et al. 2007). Secondary deaths as a result of vessel strike have also been documented (e.g., an orphaned calf died three weeks after its mother was killed by a boat) (Bechdel et al. 2009). The risk of vessel-strike mortality is also increased for species that do not appear to leave areas with high levels of vessel traffic and for animals that become habituated to vessels. For example, two Hector's dolphin calves were found dead in Akaroa Harbor, New Zealand, an area known for increasing competitive use between humans and marine mammals (Stone & Yoshinaga 2000). One calf was confirmed dead from propeller wounds and the other was most likely a result of vessel collision. The authors suggest that vessel strikes will increase as the high volume of vessel traffic in the harbor is expected to increase over time, potentially resulting in serious consequences for the Hector's dolphin population (Stone & Yoshinaga 2000).

2.0 Reproductive Effects

2.0.1 Reproductive Rate/Juvenile Survivorship

One paper looking at general vessel traffic exposure documented a decline in harbor seal pup survivorship. In response to vessel traffic in Alaska, 77% of harbor seals flushed into the water when cruise ships passed within 200 m (Jansen et al. 2010). Pups, with little insulating blubber, are likely to incur energy deficits if they spend more than 50% of their time in the water, such that a flushing response to cruise ship traffic may decrease their chance of survivorship (Jansen et al. 2010).

Conclusions and Summary of Risks from Vessel Interactions

There are recurring themes throughout the published literature on marine mammal responses to tour based interactions and vessel traffic. One common finding is the effect of tour vessels and vessel traffic on marine mammal activity budgets, such as decreased foraging and resting, and increased time traveling (e.g., Lusseau 2004, Williams et al. 2006, Stockin et al. 2008, Arcangeli & Crosti 2009, Steckenreuter et al. 2012, Christiansen et al. 2013b, Meissner et al. 2015). These changes in behavior can have short-term effects resulting in decreased prey acquisition, increased energy expenditure from additional travel, and increased predation from lack of rest. Changes in short-term behavioral patterns may alter long-term survival and reproduction at the individual and population level (e.g., Bejder 2005, Lusseau 2005, Lusseau & Bejder 2007, Currey et al. 2009, French et al. 2011, Peters et al. 2013). In addition, when certain behaviors are disrupted by vessel presence, it takes a significantly longer time for an animal to return to the previous state it was engaged in prior to the disturbance, exacerbating the effects of the disturbance (e.g., Meissner et al. 2015).

Horizontal and vertical avoidance techniques were also commonly documented among marine mammals to evade the pressure of tourism and vessel traffic. The biological effects from these behavioral responses include both long and short-term habitat displacement (e.g., Allen & Read 2000, Lusseau 2005, Bejder et al. 2006b, La Manna et al. 2010). The area an animal occupies is not arbitrary; rather, it is driven by habitats that provide optimal feeding, resting, and calving opportunities, as well as protection from predation. However, when vessels create disturbance in these critical habitats, animals may avoid those areas, potentially compromising their refuge to engage in biologically significant behaviors (e.g., Allen & Read 2000, Lusseau 2005, Lusseau et al. 2009, Rako et al. 2013). In some cases, the availability of suitable habitat elsewhere to retreat to is not available, so marine mammals remain in the same location, despite the disturbance (Gill et al. 2001).

Responses to disturbance can put marine mammals at risk for potential illness, injury, or death. Vessel interactions increase animals' risk of boat collision injuries or mortalities, predation, and may reduce juvenile survivorship (e.g., Currey et al. 2009, Jansen et al. 2010). Slow moving animals, such as manatees, are often unable to evade high speed vessels or heavily trafficked zones and risk injury from boat collision (Nowacek et al. 2002). Dolphin calves and juveniles are less experienced around vessels and have been documented alive and dead with propeller scars across their bodies (e.g., Nichols et al. 2001, Kreb & Rahadi 2004, Lusseau 2005). Vessel interactions may result in habitat avoidance or mother-calf separation, which increases animals' risk of predation (Van Parijs & Corkeron 2001, Lusseau 2005). Vessel traffic and tour boat interactions have also been documented to elicit flushing among pinniped species, in which incidences of stampeding to the water have resulted in death, especially for pups (Pavez et al. 2011, Andersen et al. 2012, Osinga et al. 2012).

Behavioral studies on mysticetes (Christiansen et al. 2015, Christiansen & Lusseau 2015) and odontocetes (Richter et al. 2006, Bain et al. 2014) have documented that short-term behavioral responses do not always translate into long-term consequences. Christiansen et al. (2015) measured the effects of behavioral disturbances caused by whale watching in Iceland on minke whale fetal growth. Although feeding activities were disrupted and energy expenditure increased, as capital breeders that only eat during a foraging season and fast the rest of the year, the energetic disturbance constituted less than 1% of the animal's overall energy requirement, resulting in a negligible impact on fetal growth. Similarly for odontocetes, Bain et al. (2014) concluded that southern resident killer whales are only affected by the whale watching industry 25% of the year, resulting in energetic consequences on the order of 3-4%. Authors of these studies acknowledge that despite these results, behavioral disturbance is not absent. However, when the pressure from tourism or vessel interactions is seasonal, due to specific whale watching seasons, or accounted for in species' life history patterns, the long-term consequences may be less severe.

Other studies have documented how short-term avoidance and behavioral responses can lead to long-term biologically significant effects for individuals and populations (e.g., Bejder 2005, Lusseau 2005, Bejder et al. 2006a, Bejder et al. 2006b, Lusseau 2006, Lusseau et al. 2006, Williams et al. 2006). Changes in individual marine mammal energy budgets in response to tourism pressure and vessel traffic are commonly reported. When changes in energy budgets begin to reduce the survival and reproduction probability of individuals, the consequences become exaggerated as the population declines and tourism and vessel traffic pressure remains constant (Lusseau et al. 2006). Short-term shifts in habitat use from areas of high to low disturbance may eventually result in long-term habitat displacement (Lusseau 2005, Bejder et al. 2006a, Bejder et al. 2006b, Lusseau et al. 2006).

Throughout the literature, terminology used to describe disturbance can be problematic, specifically with regard to the terms tolerance and habituation, and how they are both used and interpreted. Misuse of terms or a misunderstanding of the range of factors that influence animals' responsiveness to disturbance could give the false impression that human interactions have neutral or benign consequences (Bejder et al. 2009). Habituation is a longer term process and requires sequential measures recorded from the same individuals over time; most studies, however, are restricted to measuring short-term behavioral responses. If a study is short-term in nature, there is a need to collect and consider the range of factors that may influence an animals' response in order to accurately define biological relevance of observed short-term effects (Higham & Shelton 2011). This is an important idea to keep in mind as some papers document a neutral response to vessel interactions, implying that the interaction is resulting in no negative effect on the target species. While this may be the case, especially in low tourism areas, it may not necessarily be true if considered out of context or over a very short time period.

Tour-based interactions and vessel traffic elicit a variety of responses that impact the overall behavior, habitat use, health, and reproduction of marine mammals. Typically, there are several factors associated with the nature of these interactions, such as vessel approach type, number of vessels, or vessel approach distance, which may influence an animal's response. The location of interactions and the extent of anthropogenic pressure also play a large role in recorded behavioral responses. Each response is also dependent on the species, life history patterns, biology, and social structure of animals involved. However, in general, the literature suggests that marine mammals tend to most commonly exhibit horizontal or vertical avoidance strategies or shift locations in response to vessel pressures. These responses to disturbance affect the animals' energetics, however the specific long-term repercussions to the animal's health and survival is still undetermined for most species.

Chapter 2. Swimmer Interactions

Introduction

For this literature review, we characterize swimmer interactions as any activity between a human swimmer(s) in the water and a marine mammal(s). Swimmer interactions are typically associated with commercial or recreational vessels but are occasionally land-based. The majority of literature available (2000-2015) and presented in this review focuses on swim-with tourism from commercial boats. These types of tours vary how they conduct swimming with marine mammals and may allow passengers to either free-swim, snorkel, or hold onto a line attached to a boat called a "mermaid line", or something similar to keep swimmers close to the tour vessel. In some studies, the authors measure animals' response to both vessels and swimmers, but separately analyze and document the results from each type of interaction. Thus, there are overlapping references to papers cited in this chapter and Chapter 1. However, this chapter specifically summarizes animals' responses to swimmer presence.

We included 38 scientific papers, dissertations, theses, and workshop reports that document effects of swimmer interactions on 15 marine mammal species. Species include 8 odontocetes (bottlenose, Indo-Pacific bottlenose, common, spinner, Burrunan, and Hector's dolphins, short-finned pilot whales and beluga whales); 3 pinnipeds (Australian and New Zealand fur seals, and California sea lions); 3 mysticetes (minke, dwarf minke, and southern right whales); and manatees. Swim-with activities are primarily documented in the United States, New Zealand, and Australia, with some literature from Argentina, East Africa, Canary Islands, Canada, and Mexico. However, this is not an exhaustive list of all the species or geographic areas where swim-with activities take place. After conducting an extensive web search, Rose et al. (2005) found that swims with humpback and minke whales are most common among whale species, and occur primarily in the Dominican Republic, Tonga, and Great Barrier Reef. Swim-with activities are known to occur with even more species (e.g., killer whale, bowhead whale, blue whale, gray whale, fin whale, sei whale, southern right whale, and sperm whale); however, the impacts from those interactions have not been well-documented in the published scientific literature, and are therefore not included in this review.

2.1 Behavioral Effects

2.1.1 Behavioral Budgets

It is well established throughout the literature that swim-with activities alter the natural behavioral budgets of many marine mammal species including spinner dolphins (Forest 2001, Östman-Lind et al. 2004, Danil et al. 2005, Courbis & Timmel 2009, Symons 2013, Johnston et al. 2014, Tyne 2015), common dolphins (Neumann & Orams 2006, Meissner et al. 2015), bottlenose dolphins (Constantine et al. 2003, Samuels & Bejder 2004, Peters et al. 2013), Hector's dolphins (Nichols et al. 2001), Indo-Pacific dolphins (Stensland & Berggren 2007), Burrunan dolphins (Filby et al. 2014), southern right whales (*Eubalaena australis*) (Lundquist 2007, Lundquist et al. 2008), and manatees (King & Heinen 2004).

Swimmer interactions alter natural behavior by changing the amount of time an animal spends engaged in essential activities necessary for their survival, such as foraging, resting, mating, and socializing. The changes in activity budgets caused by swimmers are similar to changes in activity budgets associated with vessel interactions. The most frequently documented behavioral changes are decreased time spent resting and foraging and increased time spent traveling and milling. For example, southern right whales in Argentina spent one-third less time resting and socializing in the presence of swimmers and increased their time spent traveling during the interaction by 22% (Lundquist 2007, Lundquist et al. 2008). Spinner dolphins in Hawaii rest inshore during the day and forage offshore at night; daytime access to shallow, sandy bottom coves and bays are essential for the animals to rest and avoid predators (Würsig et al. 1991, Norris et al. 1994, Thorne et al. 2012). However, these resting bays have become targets for swim-with tours since they are easily accessible to the public. Johnston et al. (2014) observed vessels and/or swimmers within 150 m of dolphins in over 75% of their sampling events. As a result of swimmer disturbances, Danil et al. (2005) documented spinner dolphins departing bays much earlier in the afternoon than expected, depriving them of rest and shelter. Tyne et al. (2015) further document the importance of these resting bays by illustrating that resting spinner dolphins displaced from these areas are unlikely to engage in resting behavior elsewhere.

In Florida, West Indian manatees decreased the amount of time they spent foraging when swimmers were in close proximity (King & Heinen 2004). Numerous studies have also documented increased milling behavior in response to swimmers by bottlenose dolphins (Constantine et al. 2003, Peters et al. 2013); West-Indian manatees (King & Heinen 2004); and Burrunan dolphins (Filby et al. 2014), suggesting that marine mammals are being disrupted from crucial feeding, socializing, and resting behaviors. Swim-with interactions continue to alter bottlenose dolphins' behavioral budgets long after swimmers have exited the water and vessels have departed the study area (Peters et al. 2013).

2.1.2 Avoidance

Throughout the published literature, horizontal avoidance tactics such as changes in swim speed, direction, or movement patterns were used by marine mammals to avoid swimmer interactions. Such tactics have been documented in Indo-Pacific bottlenose dolphins (Stensland & Berggren 2007); spinner dolphins (Delfour 2007, Timmel et al. 2008); southern right whales (Lundquist 2007, Lundquist et al. 2008); humpback whales (Kessler et al. 2013), and manatees (King & Heinen 2004). In most cases, the species have been documented increasing swim speed and changing swim direction more frequently as the number of swimmers increased.

Certain aspects of swimmers' presence play a role in marine mammals' responses, including swimmer placement, swimmer behavior, and also animal group composition. In general, bottlenose and Hector's dolphins exhibited less avoidance behavior when swimmers were placed parallel to the path of an animal or group of animals in the water (Constantine 2001, Constantine et al. 2003, Martinez et al. 2011), and more prominent avoidance behavior was observed when swimmers were placed in the path of the animals (Martinez et al. 2011). In Tonga, humpback whales departed significantly earlier from an area when approached by splashing swimmers compared to quiet, calm swimmer approaches (Kessler et al. 2013). In Argentina, animal group composition plays an important role in southern right whale's responses to swimmers. Mother-calf pairs and juveniles increase swim speed and adopted less linear swim paths in the presence of swimmers, while mixed adults/juvenile groups showed no significant changes in movement or behavior (Lundquist 2007, Lundquist et al. 2008).

There is little documentation on vertical avoidance behaviors. One study off the south coast of Zanzibar documented that Indo-Pacific bottlenose dolphins increased their proportion of active dives in the presence of swimmers (Stensland & Berggren 2007).

2.1.3 Surface Active Behaviors

Hawaiian spinner dolphins are well-known for surface active behaviors (e.g. leaping, spinning), which can indicate disturbance depending on the intensity, time of day and context (Forest 2001, Delfour 2007, Courbis & Timmel 2009). Courbis & Timmel (2009) documented in 2002 that spinner dolphin aerial displays were reduced in the early morning and late afternoon as animals entered and exited their resting bays. In contrast to this study, between 1993-1994, Forest (2001) indicated in her study that spinner dolphins displayed a bimodal distribution of aerial behavior with higher rates of activity before 7 am and after 3 pm. Similarly, the frequency of aerial activities have been documented to decrease from 2.23 per hour in the 1970s (Würsig et al. 1991, Norris et al. 1994) to 0.750 per hour in the 2002 study (Courbis & Timmel 2009). Courbis & Timmel (2009) suggest for their 2002 study that the diminished aerial behavior could indicate newly adopted cryptic behaviors used to avoid being seen and targeted by vessels engaged in swim-with activities (Courbis & Timmel 2009). Forest (2001) also suggested less aerial behavior entering and exiting the bay may be indicative of diminished energy levels.

2.1.4 Haul out

Only one study reports pinnipeds hauling out as a response to swimmer presence. Stafford-Bell (2012) observed that Australian fur seals hauled out initially when one or two swimmers entered the water. However, over time, the rate of hauling out generally decreased as the number of swimmers increased. In some instances, seals interacted with swimmers and even mimicked their underwater actions, which led authors to conclude that Australian fur seals are becoming habituated to the presence of swimmers in Port Phillip Bay, Australia. Habituation in this study was defined as a reduction in responses to an ongoing stimulus that is not a result of fatigue or adaptation (Stafford-Bell 2012).

2.1.5 Initiation

Some studies reported marine mammals, such as dwarf minke whales (*Balaenoptera acutorostrata*), Hector's dolphins, bottlenose dolphins and southern right whales, initiated interactions with swimmers (Birtles et al. 2002, Lundquist 2007, Lundquist et al. 2008, Martinez et al. 2011, Peters et al. 2013). An interaction is often defined as an animal approaching a vessel, which results in swimmers entering the water to begin an "in-water" interaction, or when an animal approaches swimmers already in the water (Birtles et al. 2002). Interactions are also characterized by the distance between an animal and a swimmer and the length of time they remain within that distance (i.e., remain within 5 m for a minimum of 10 seconds) (Martinez et al. 2011). Authors suggest that animals engaged in milling behavior (Martinez et al. 2011), larger group sizes (Neumann & Orams 2006, Peters et al. 2013), and younger age classes (Constantine 2001, Lundquist 2007, Lundquist et al. 2008) are more likely to initiate an interaction with swimmers in the water.

A handful of studies documented an interaction-neutral-avoidance response to swimmers (Neumann & Orams 2006, Boren et al. 2009, Cowling et al. 2014b). At the beginning of an interaction, animals are likely curious about swimmers in the water and initiate a close approach (Neumann & Orams 2006, Cowling et al. 2014b). This is then followed by a period of lost interest towards the swimmers and neutral behavior, eventually resulting in avoidance of the vessels and swimmers (Neumann & Orams 2006, Cowling et al. 2014b).

2.1.6 Aggressive/Threatening Behavior

In a review of self-initiated behaviors of free-ranging cetaceans directed towards human swimmers, aggressive or threatening behaviors were mainly reported for food-provisioned and lone, sociable dolphins, likely responding to inappropriate human behaviors (Scheer 2010). Samuels & Bejder (2004) reported individual bottlenose dolphins slapping their fluke on the surface of the water when swimmers were in close proximity, leaping over swimmers, and displaying open mouth behavior to threaten swimmers during non-feeding swim-with events. In Tenerife, Canary Islands, short-finned pilot whales were reported to headshake (i.e., an individual rhythmically shakes its head and adjacent body part from left to right with the melon directed towards the swimmer) (Scheer et al. 2004). Frohoff et al. (2000) observed numerous aggressive and threatening behaviors displayed by beluga whales (*Dephinapterus leucas*) in Eastern Canada during swimmer encounters: head jerking (quick movement of an individual's head to avoid physical contact with a human), hitting (forceful contact with a part of its body), jaw slapping (abrupt opening and closing of its jaw underwater producing a slapping noise), open mouth behavior, and pushing (shoving or nudging a swimmer forcefully with its rostrum) (Frohoff et al. 2000). Dwarf minke whales in the northern Great Barrier Reef, Australia were observed displaying open mouth behavior during swimmer interactions (Birtles et al. 2002).

2.2 Habitat Use Effects

2.2.1 Displacement

Habitat displacement as a result of swimmer disturbances has been documented for spinner dolphins in Hawaii. Danil et al. (2005) documented that spinner dolphins in Hawaii spend less time in their primary resting habitat due to high levels of swim-with tours. As the number of swimmers increased, dolphins departed their resting bay earlier than they did if fewer to no swimmers were present (Danil et al. 2005). In the presence of one to five swimmers, dolphins departed the bay around four to five o'clock in the evening. As the number of swimmers increased to greater than 15, dolphins were recorded departing the bay as early as noon to one o'clock (Danil et al. 2005). Should dolphins be displaced from their resting bays, it is unlikely that they will engage in resting behaviors outside of those areas (Tyne et al. 2015). Östman-Lind et al. (2004) provide a similar example of short-term displacement and area avoidance in Makako Bay, Hawaii. They observed two swim-with tour vessels follow a group of spinner dolphins into Makako Bay, where they were joined by two other vessels and spent an hour following the dolphins with 10 or more people in the water. The dolphins then exited the bay and milled offshore for approximately a half hour until the boats and swimmers left, at which time the dolphins re-entered the bay (Östman-Lind et al. 2004). Östman-Lind et al. (2004) have also documented evidence of long-term habitat displacement in Hawaii. Makako Bay was the most frequently used resting bay from 1989-1992, but in the 2004 study, the dolphins were utilizing a different bay to the north much more frequently. The authors attributed this to the higher levels of tourism in Makako Bay and the lower levels of tourism in the bay to the north.

2.2.2 Ranging Patterns

Swim-with tour interactions, similar to vessel-based tour interactions, have been documented to influence animals' ranging patterns. In Panama City, Florida, Samuels & Bejder (2004) reported the ranging patterns for bottlenose dolphins engaged in swim encounters with humans were much smaller than those of animals that did not. Dolphins engaged in swim encounters remained within less than one nautical mile from the area where boats, jet skis, and swimmers routinely congregated for interactions with the animals. However, it is important to note that the animals engaged in swim encounters were conditioned to take food items from people, so their altered ranging patterns could have been confounded with the effects of people feeding them rather than just swimmer interactions alone.

2.3 Development and Reproductive Effects

2.3.1 Reproductive Rate/Juvenile Development

French et al. (2011) found California sea lions' reproductive rates decreased in response to the presence of swimmers/divers within 50 m; however, at the same time, pups' growth rates increased. In this situation, the increase in growth rates is likely a result of the reduction in reproductive rates, which allows for more available resources for the remaining growing pups (French et al. 2011). Although it was not specified in the study that the swimmers/divers were specifically targeting the sea lions for tourism purposes, the close approach distance of 50 m is likely a means to actively view the animals from a closer distance.

Juvenile bottlenose dolphins are more likely to interact with swimmers than adult dolphins (Constantine 2001). The interactions between juveniles and swimmers could be a form of play, similar to those between conspecifics, however, these misplaced interactions could interfere with the development of necessary foraging and social skills (Constantine 2001). In New Zealand, Constantine (2001) documented adult dolphins interacting with swimmers during 26.7% of observations compared to 67.5% for juveniles. In addition, when juveniles were engaged in a sustained interaction with swimmers, they were not observed in close proximity with an adult (Constantine 2001). In Panama City, Florida, a juvenile dolphin was put at risk once every 12 minutes from human interactions, either from vessels or swimmers (Samuels & Bejder 2004).

2.3.2 Nursing

Swimmer presence also results in decreased nursing behavior (King & Heinen 2004, Stensland & Berggren 2007). Manatee calves significantly reduced the amount of time they spent nursing in the presence of swimmers (King & Heinen 2004). Indo-Pacific female dolphins increased their travel time as swim-with tourism activities increased; thus, the authors hypothesized that females would have less available time to nurse their calves, thereby jeopardizing the fitness of the population (Stensland & Berggren 2007).

Conclusions and Summary of Risks from Swimmer Interactions

The primary risks to marine mammals from swimmer interactions include habitat displacement, energetic implications from behavioral changes, increased avoidance and disturbance behavior, and the potential risks to both humans and animals associated with aggressive and threatening behavioral displays and habituation.

Habitat displacement is well documented in the literature as a result of swimmer interactions (e.g., Östman-Lind et al. 2004, Danil et al. 2005). For spinner dolphins, in particular, long-term studies have documented habitat displacement from a favored resting bay that has high tourism pressure, to another less frequently visited bay with less swim-with dolphin tourism pressure (Östman-Lind et al. 2004). Habitat displacement increases the risk of predation as animals abandon their primary habitat and move into unfamiliar and presumably less safe areas (Danil et al. 2005, Bejder et al. 2006b). This new habitat might not provide the essential features (e.g. depth, benthic substrate) that play a key role in performing essential life functions, such a foraging, socializing, or resting (Thorne et al. 2012, Tyne et al. 2015).

Swimmer interactions can also place additional energetic stress on animals as a result of altered activity budgets and increased avoidance tactics. For spinner dolphins, decreased resting time from intense tourism exposure may result in an energetic deficit affecting the fitness of those animals. Using a theoretical model to calculate resting requirements for spinner dolphins based on consumption requirements, the model predicted that spinner dolphins must spend 40-60% of their day resting to be in a positive energetic balance (Symons 2013, Johnston et al. 2014). Based on actual observations, it appears that the resident population is likely meeting their rest requirements; however any increase in tourism exposure may push them over the threshold (Symons 2013). Spinner dolphins also exhibit aerial disturbance behaviors, such as leaping and spinning, that have greater energetic costs than resting behavior would in the absence of swimmers (Forest 2001). The effects of increased energy expenditure are exaggerated for animals that utilize a habitat solely for resting, such as spinner dolphins in Hawaii (e.g., Danil et al. 2005, Courbis & Timmel 2009, Symons 2013, Johnston et al. 2014, Tyne et al. 2015), or for breeding and calving, such as southern right whales in Argentina (Lundquist 2007, Lundquist et al. 2008). When marine mammals expend additional energy in response to swimmers during critical periods, this may interrupt social interactions and foraging opportunities, which could have long-term health and reproductive effects on the population.

Lastly, species such as dwarf minke whales, New Zealand fur seals, and spinner dolphins have been documented to be habituated to swimmers during interactive tours (e.g., Birtles et al. 2002, Timmel et al. 2008, Cowling et al. 2014b). These types of interactions between swimmers and animals in the wild are not natural and pose significant threats to both the animal and human involved. Habituated animals display less avoidance behavior towards vessels and swimmers (Stone & Yoshinaga 2000). They become emboldened to closely approach people and vessels, exposing them to physical risks from boat propellers and health risks from food handouts. Samuels & Bejder (2004) determined juvenile bottlenose dolphins are at risk once every 12 minutes from human interactions. Swimmers interacting with marine mammals in the water may be exposed to aggressive or threatening behaviors from animals during encounters (reviewed in Nichols et al. 2001, Scheer 2010). Headshakes, pushing, hitting, and jaw slaps are just a few examples of high risk behaviors short-finned pilot whales, belugas, and bottlenose dolphins have displayed during swimmer interactions (Frohoff et al. 2000, reviewed in Nichols et al. 2001, Scheer et al. 2004). Biting and open mouth behaviors can be a part of conspecific play behavior; however, when accidentally or intentionally directed towards a person in the water, it could result in serious risk of injury (reviewed in Nichols et al. 2001). Swimmers who are not familiar with or able to recognize threatening behaviors may not know when to terminate an interaction, and therefore, increase their chances of sustaining an injury.

In comparison to vessel interactions, there is significantly less literature documenting swimmer-marine mammal interactions. However, marine mammals' response to swimmers and vessels are similar considering that a vessel transports swimmers to engage in a swim-with interaction. Patterns of habitat displacement, area avoidance, changes in behavioral budgets, and increased risks for humans and animals have been documented in response to swimmer interactions.

Management Recommendations for Vessel and Swimmer Interactions

Management plans designed to regulate vessel and swimmer interactions with marine mammals are typically similar in structure given that vessels are the primary platform for swim-with tours and it is impossible to manage one without considering the interactions of the other. For this reason, the management regimes recommended and discussed in scientific papers, dissertations, and reports have been combined for both interaction types. Reoccurring recommendations highlighted throughout the literature include: (1) increase enforcement of guidelines and regulations, (2) revisit viewing distance and vessel speed guidelines, (3) increase education and awareness, (4) redesign management systems, and (5) implement time-area closures or marine protected areas.

One of the most commonly cited recommendations to reduce harassment from vessels and swimmers is to promote adherence to and increase enforcement of existing guidelines and regulations (e.g., King & Heinen 2004, Delfour 2007, Tosi & Ferreira 2008). Federal and State wildlife viewing guidelines are typically based on scientific research or common sense principles. When these guidelines are responsibly followed by tour operators and participants, the impact from tour boats and swimmers are less harmful. For example, in New Zealand, one study found negligible impacts from swimmers and tour boats on common dolphin behavior, likely because there was a high rate of compliance to the New Zealand Marine Mammals Protection Regulations in this area (Neumann & Orams 2006). Cowling et al. (2014b) reported similar results for New Zealand fur seals when regulation compliance was nearly 100%. In general, when vessels and swimmers adhere to established guidelines or regulations, people often enjoy a higher quality viewing experience because the targeted animals are less likely to avoid the area. For example, tourists have had increased viewing times with humpback whales, Indo-Pacific bottlenose dolphins, and Guiana dolphins when tour vessels were responsible and approached parallel to the animal (Filla & Monteiro-Filho 2009, Hawkins & Gartside 2009a, Stamation et al. 2009).

In most locations where viewing guidelines or regulations exist, compliance is low due to a lack of enforcement. An increase in enforcement personnel on the water would likely serve as a financial incentive for compliance. For example, in the United States, violations of the Marine Mammal Protection Act (MMPA) can be prosecuted civilly or criminally depending on the severity of the offense. Harassment cases most often result in fines. To demonstrate the effectiveness of enforcement, harassment of dolphins significantly decreased when law enforcement vessels were present on the water during a docent program in Sarasota, Florida

(Cunningham-Smith et al. 2006). Enforcement could also improve through self-regulation within a community of users targeting marine mammals in the same area (Heenehan et al. 2015). If a community can build trust and reciprocity to hold one another accountable to follow guidelines or regulations, this might lessen the need for official monitoring and enforcement from agencies (Heenehan et al. 2015).

Another management recommendation to reduce disturbance is to revisit viewing distance guidelines. Animal responses to vessel approaches can be dependent on a variety of factors including: species type, vessel type, animal group composition, presence of a calf, mating/breeding season, and behavioral state. All these factors should be considered when developing effective viewing distance guidelines (e.g., Boren et al. 2002, Johnson & Acevedo-Gutiérrez 2007, Yazdi 2007, Steckenreuter et al. 2012). Most recommendations for viewing distance guidelines fall between 100 and 300 m (Jahoda et al. 2003, Scheidat et al. 2004, Morete et al. 2007, Lusseau et al. 2009, Noren et al. 2009, Schaffar et al. 2013). However, disturbance has been recorded at further distances (e.g., Schaffar et al. 2009, Andersen et al. 2012, Young et al. 2014). It is necessary to continue scientific research in order to update guidelines. For example, Noren et al. (2009) found that the existing guidelines that request vessels not to approach within a 100 m radius of whales and slow down to less the 7 knots within a 400 m radius were not sufficient to prevent disturbance to southern resident killer whales and recommended extending the viewing distance based on scientific evidence. Thereafter, in 2011 NOAA Fisheries announced new vessel regulations to prohibit vessels from approaching any killer whale closer than 200 yards and from parking in the path of whales (76 FR 20870, 14 April 2011). The effectiveness of these regulations were evaluated by comparing trends between the 5 years leading up to the regulations (2006-2010) and the 5 years following the regulations (2011-2015) (Ferrara et al. 2017). It was concluded that overall, the vessel regulations seem to have provided some benefit to the whales, but additional time may be needed to ensure that the regulations are sufficient in providing the whales adequate protection (Ferrara et al. 2017). In general, species-specific viewing distance guidelines may be the most effective way to address all the variables discussed above.

Reducing vessel speed can also help minimize human impacts on marine mammal behavior, acoustic impacts, and mortality (Williams et al. 2002a, Ng & Leung 2003, Goodwin & Cotton 2004, Laist & Shaw 2006, Smith 2008, Bechdel et al. 2009, Jensen et al. 2009, Rako et al. 2013). For example, it has been suggested that a boat cruising at 10 km/h and making a slow approach within 50 m of killer whales will have less acoustic and behavioral impacts, than if a boat was approaching faster and closer (Erbe 2002, Jelinski et al. 2002). However, in the absence of or non-compliance to vessel speed guidelines, animals have been recorded to change swim path directness and deviate when motor boats and jet skis speed pass (Williams et al. 2002b, Goodwin & Cotton 2004). Faster vessels also increase sea ambient noise, which has been documented to result in habitat displacement, masking, and temporary threshold shifts for marine mammals (e.g., Erbe 2002, Rako et al. 2013). Preliminary results have shown positive results of implementing and enforcing year-round, slow-speed regulations in Brevard County, Florida to help reduce boat-strike mortalities to manatees (Laist & Shaw 2006). In the 42 months prior to the new rules, there were 2.34 manatees deaths per year, compared to the 0.29 deaths per year following when the rule went into effect (Laist & Shaw 2006).

Another common recommendation is to increase education and outreach efforts with tour operators, recreational boat users, and the general public to mitigate human-wildlife interactions. While tour boat operators are sometimes aware of the guidelines and regulations for marine mammal viewing activities, enhanced outreach efforts can help clarify any issues to help decrease disturbance (e.g., Higham & Carr 2003, Christensen 2007, Morete et al. 2007, Stockin et al. 2008, Stamation et al. 2009, Heenehan et al. 2015). Keane et al. (2008) and Tyne (2015) propose that to achieve a successful management plan, rules and regulations must be supplemented with educational and enforcement programs. In New Zealand, dolphin tour operators must include an educational component to their dolphin-watching tours as a condition of obtaining a cetacean-watching permit (Carlson 2009). Increased education efforts may be particularly beneficial in areas of high density boat traffic, such as the Indian River Lagoon, Florida, where bottlenose dolphin boat collision injuries coincide with the highest number of registered boats per square kilometer (Bechdel et al. 2009). Increasing education efforts among the recreational boating community using pamphlets, signage, and workshops may help facilitate awareness resulting in compliance (Neumann & Orams 2005). An example of successful education and outreach efforts resulting in decreased harbor seal disturbance was documented in Kenai Fjord National Park, Alaska (Hoover-Miller et al. 2013). Through a series of operator workshops, orientations, and collaborations, seal disturbance rates from interactions with motor boats and kayakers decreased by 60% (Hoover-Miller et al. 2013).

Redesigning management systems is one way to reduce the number of boats or commercial tour operators around an individual or group of animals (Bejder et al. 2006b, Martinez et al. 2011, Papale et al. 2011, Steckenreuter et al. 2012, Lundquist et al. 2013, Tyne et al. 2014). Licensing or permitting systems are two ways to accomplish this if the legal framework is in place. In the United States, permits under the MMPA can authorize the "take" of marine mammals for only a limited set of activities, such as scientific research, documentary filming, public display, and commercial fishing operations. The MMPA does not provide a permit mechanism to "take" marine mammals for wildlife viewing or other similar recreational purposes; therefore, those activities must be conducted in a manner that does not harass or injure the animals. Vessel-based and swimmer interactions with marine mammals often cause behavioral changes, which is considered harassment. Behavioral changes can be a consequence of human activities, or it can be argued that they are changes due to natural shifts in activity. Tyne et al. (2015) point out a "need for an enforcement policy to make legislation more easily understood, less ambiguous and more fairly enforced."

Licensing and permitting systems have been implemented or suggested in locations such as New Zealand, New Caledonia, and Australia (e.g., Constantine et al. 2003, Stockin et al. 2008, Scarpaci et al. 2010, Schaffar et al. 2013). These systems are only likely to be successful if the framework provides management agencies sufficient authority to change or revoke an operator's license should numerous violations occur (Bejder et al. 2006b, Higham et al. 2008, Tyne et al. 2014, Tyne 2015). Other factors that play into the success of reducing disturbance through a licensing/permit system are: the number of quotas or permits issued, the frequency of tour operating schedules, targeting the same group of animals as previous tours, and vessel compliance to viewing guidelines (Constantine et al. 2003). The permitted tourism industry that has developed at the Great Barrier Reef in Australia for swimming with dwarf minke whales has resulted in a 91% increase in the number of whales encountered over six seasons (2003-2008) (Curnock et al. 2013). Although the number of permitted operators has remained capped since permits were introduced in 2003, increased encounter rates have resulted from a shift in effort to target minke whale "hotspot" sites. In addition, endorsements to conduct swim –with tours are fully transferable, which has highlighted a substantial latent capacity in the industry (Curnock et al. 2013). Additional longitudinal and controlled studies are helpful to identify whether permits or quotas are effective, and if so, help define an ideal number of permits/quotas to issue to successfully reduce disturbance.

Spatial management through tools like Marine Protected Areas (MPAs) and time-area closures is another technique scientists have recommended to reduce cumulative exposure to human activity within specific marine mammal habitats. MPAs can limit or exclude vessel, swimmer, and other anthropogenic activities from occurring in important marine mammal habitats. Not only can this alleviate tourism pressure on marine mammals, but it can also provide an excellent opportunity to conduct controlled experiments on marine mammal behavior in the absence of human activity (Williams et al. 2006, Smith et al. 2008, Williams et al. 2011). Time-area closures, even as short as a few hours a day, could provide diurnal animals, such as Hector's and spinner dolphins, and non-diurnal animals, like Risso's dolphins, protection from vessel and swimmer pressure during critical resting periods (Martinez et al. 2011, Visser et al. 2011, Gormley et al. 2012, Tyne 2015). Other measures, such as seasonal closures, may be better suited to help relieve anthropogenic pressure during times when environmental variables, such as increased water temperatures or depleted prey resources, increase energetic demands for marine mammals (Lusseau 2003a). In Brazil, the delineation of a coastal reserve to control boat traffic has been successful in reducing impacts on Guiana dolphins (Tosi & Ferreira 2008). Similar suggestions of creating sensitive areas, protection zones, and area closures have been made to protect a number of species around the world (e.g., Stone & Yoshinaga 2000, Lusseau et al. 2006, Bain 2007, Hodgson & Marsh 2007). It is important after any management action is implemented to continue research and monitoring to evaluate the efficacy of the protections put in place (Hartel et al. 2014).

Using the best available science, numerous management techniques have been recommended to reduce disturbance from human-marine mammal interactions. These recommendations are a representative compilation of common themes throughout the scientific literature. They are not all feasible or applicable in each location where interactions occur. Rather, management decisions should be based on the unique characteristics of the location, the specific interaction/disturbance, and the species' behavior and life history patterns. However, given the rapidly evolving nature of tourism, scientists and managers are challenged to continually develop studies with appropriate temporal and spatial scales that quantify the population dynamics of tourism-exposed cetacean and pinniped populations (Tyne et al. 2014). Obtaining current estimates of population size, critical habitat, and baseline population parameters, coupled with behavioral responses to tourism activities, will help to identify when and which populations are most vulnerable and how best to revise and/or develop the most effective management plans (Tyne et al. 2014).

Chapter 3. Feeding Interactions

Introduction

Feeding interactions are characterized by humans intentionally feeding or attempting to feed marine mammals in the wild. Feeding of marine mammals, typically dolphins, occurs worldwide and can have broad behavioral and physical consequences on the animals. The literature in this chapter is divided into one of two sub-sections, “Legal Provisioning Programs” or “Illegal Feeding” to accommodate and highlight differences in the legalities (or lack thereof) of feeding marine mammals around the world. Each sub-section is followed by its own conclusions. The “Legal Provisioning Programs” sub-section describes examples of formal provisioning programs where dolphins are legally fed by park rangers or visitors. The “Illegal Feeding” sub-section highlights documented sites where dolphins are fed illegally by commercial dolphin tours or recreational boaters or fishermen. Feeding wild animals can result in a form of operant conditioning in which animals learn associations between human-related stimuli, their behaviors in response to the stimuli, and a food reward (Samuels & Bejder 2004). These animals are referred to as “conditioned” and can often be recognized by performing solicitous gestures (e.g., head up, beg, following a vessel) when there are human-related stimuli present or suspected of being present (Samuels & Bejder 2004, Donaldson et al. 2012).

We included 18 scientific papers, dissertations, theses, and workshop reports on feeding interactions with common bottlenose, Indo-Pacific bottlenose and tucuxi dolphins. Feeding occurs with other marine mammal species (e.g., manatees and pinnipeds), and there are numerous anecdotal examples of these interactions in social media, the news, and advertising. However, although these activities do occur, they are not scientifically documented. For the purposes of this review, only data and conclusions from scientific, peer-reviewed manuscripts, dissertations, theses, and workshop reports are included.

The effects from legal provisioning programs have been scientifically described in two locations in Australia: Monkey Mia and Tangalooma. The effects from illegal feeding are described in five locations worldwide: Cockburn Sound, Australia; Southeastern Brazil; Panama City Beach, Florida; Sarasota Bay, Florida; and Savannah, Georgia.

Part A: Legal Provisioning Programs

3.1 Monkey Mia in Shark Bay, Australia

Monkey Mia is the longest running dolphin provisioning site in the world. Although feeding dolphins was banned in Western Australia in 1998, Monkey Mia was included in a grandfather clause to continue provisioning bottlenose dolphins. Feeding dolphins in Monkey Mia has a long, evolving history beginning in the 1960s with fishermen tossing bait or unwanted catch to dolphins. In the 1970s, tourists began purchasing buckets of fish to feed dolphins while standing in the water (Mann & Kemps 2003). In 1989, the Department of Conservation and Land Management introduced regulations that limited feeding to specific matrilines of dolphins, and monitored the amount of fish fed to the dolphins monthly. Under this management regime, calf mortality rates increased and dolphin behavioral patterns changed (e.g., decreased maternal care and increased mother-calf separation) (Mann et al. 2000, Foroughirad & Mann 2013). For example, in March 1994, a tiger shark attacked a calf, left unattended by its provisioned mother, while she was being fed at the beach (Mann & Barnett 1999). As a result of this specific incident and increased calf mortality rates, new feeding policies were instituted in 1994 which included: (1) minimizing feeding to three times a day between 8:00-13:00 to allow dolphins time offshore to participate in natural behaviors; (2) restricting adult females to 2 kg of fish per day; (3) restricting feeding to non-calf females within one of the three matrilines, and (4) excluding feeding males to reduce the potential for aggressive displays (Mann & Kemps 2003). Fish quality and handling protocols became stricter and each of the feeding sessions began with an educational session (Mann & Kemps 2003).

Prior to a feeding session, tourists are permitted in the water where dolphins arrive and swim freely among tourists within viewing and touching distance (Smith et al. 2008). When feeding time begins, tourists step back and rangers bring out buckets of fish and provisioned animals approach the ranger's station (Smith et al. 2008). One at a time, a tourist is called over to feed the animal and then return to their position nearshore so the next person can be called (Mann & Kemps 2003). The last fish to each dolphin is fed simultaneously and the tourists are asked to step out of the water. The provisioned dolphins typically leave within five minutes after the feeding session ends (Mann & Kemps 2003).

To evaluate the efficacy of the 1994 management changes, two studies were conducted to investigate factors leading to risky interactions (i.e., potentially injurious to the human or dolphin) and reevaluating calf survivorship (Smith et al. 2008, Foroughirad & Mann 2013). Researchers found that risky interaction rates increased with longer wait times to feeding sessions, but also depended on the individual dolphin (Smith et al. 2008). Foroughirad & Mann (2013) found that calves born to provisioned mothers after 1994 exhibited higher calf survivorship than those born to provisioned mothers before the 1994 management changes; however, there were still marked differences in mother and calf activity budgets. Provisioned mothers provided less maternal care to their offspring compared to their non-provisioned counterparts (Mann & Barnett 1999, Foroughirad & Mann 2013). When mothers were at the provisioning beach near people, calves were unable to attain nursing position and were forced to wait upwards of half an hour before mothers left the beach and calves could regain nursing position (Foroughirad & Mann 2013). Calves of provisioned mothers foraged more than calves of non-provisioned mothers, likely as a way to compensate for decreased milk intake and increased energy expenditure needed to travel to the beach on a daily basis (Foroughirad & Mann 2013). Notably, five offspring born to provisioned mothers after 1994 survived infancy, but did not survive past the juvenile period. Particularly, four of the five offspring were born to one provisioned mother who consistently spent more time in the provisioning area and begging from boats offshore. The low juvenile survivorship is likely due to compromised developmental and social learning skills and insufficient hunting experience due to maternal neglect during the pre-weaning period (Foroughirad & Mann 2013).

3.2 Tangalooma, Moreton Island, Australia

Similar to Monkey Mia, Tangalooma has a long history of feeding interactions between dolphins and humans. In 1989, three methods to establish a regular feeding station at Tangalooma were attempted, but none were successful (Orams 1995). In 1992, another effort was initiated, this time proving successful and by the end of the year, three dolphins regularly visited the resort and accepted hand-held fish. This number grew to approximately six to eight dolphins regularly visiting by 1994.

In 1994, a management regime was established, which included (1) obtaining a reliable source of fish; (2) designating a specific dolphin feeding zone; (3) establishing a regular feeding time; (4) restricting the amount of fish offered to an estimated one third of dolphins' daily food intake; and (5) establishing strict procedures for tourists feeding dolphins. When the dolphins arrive, three to four guests enter the water and one at a time, hold the fish underwater for the dolphins to take. After a fish is taken, the group leaves the water and the next group enters. This "shallow water feeding system" differs from Monkey Mia, such that people are not permitted to remain in the water during the entire time dolphins are in the provisioning zone. This system has reduced the "pushy" and aggressive behaviors dolphins exhibited during feeding times and allows dolphins to spend more time interacting with each other than with humans (Hawkins & Gartside 2009b).

Over the 15 year history of the program, eight calves have participated in the provisioning program. Two calves belonged to mothers who were not provisioned at the time of giving birth, but were subsequently fed at Tangalooma; five calves were born to mothers who were provisioned at the time of birth (one subsequently became orphaned); and one orphaned calf was found adjacent to the provisioning area and began accepting fish from the program (Neil & Holmes 2008). Neil & Holmes (2008) suggest possible explanations for the unusually high calf survival rate (100%) at Tangalooma, considering two calves were orphaned and two were first-borns, which typically experience high mortality rates. Some of these explanations include the location of the provisioning area; Tangalooma is located on an island with boat access only, limiting the potential for unregulated human-dolphin interactions. Neil & Holmes (2008) also point out that the northeast part of Moreton Bay, where the provisioning area is located, has the best water quality from tidal flushing and is remote from sources of pollution. In addition, the authors suggest that the provisioning program may help reduce the risk of predation from foraging-related, mother-calf separation scenarios. Neil & Holmes (2008) further hypothesize that provisioning programs have the potential to help lactating mothers meet their energetic demands without expending as much energy to independently forage in the wild. Lastly, the management regime consisting of short, fixed feeding times, improved fish handling protocols, higher quality of fish, and prohibiting extended contact of hand-feeding may also contribute to 100% calf survivorship at Tangalooma (Neil & Holmes 2008).

Conclusions for Legal Provisioning Programs

The legal provisioning programs at Monkey Mia and Tangalooma are very similar, with the one main difference being the “shallow-water feeding system” at Tangalooma, where there are strict limitations for people entering the water with the dolphins. Despite the programs’ similarities, conclusions from research studies at both sites are significantly different. Although calf and juvenile survivorship at Monkey Mia increased significantly after the implementation of new management protocols in 1994, behavioral budgets of provisioned dolphins remained altered. Calves of provisioned mothers received less maternal care compared to calves of non-provisioned mothers, consequently compromising calves’ development of social and foraging skills (Foroughirad & Mann 2013). In comparison, calf survival rate was 100% over the 15 year history of the Tangalooma program (Neil & Holmes 2008). The authors suggest that the geographic location, characteristics of the feeding site, and revised management regime in this area may contribute to high survival rates by reducing predation risk and lowering energy expenditure for lactating mothers.

In comparing the research results at Tangalooma and Monkey Mia, it is important to consider the temporal scale. Monkey Mia is the longest running provisioning program, operating since the 1970s. In comparison, Tangalooma was successfully launched in 1994 after two previous attempts. The evolution of the dolphin feeding program and its effects on animals has been documented for a longer period of time at Monkey Mia and likely more accurately depicts the long-term effects of provisioning. Baseline and longitudinal studies of the general population, apart from the provisioned dolphins that participate in the program, are needed to quantify survival rates and statements regarding the success of the provisioning program in Tangalooma, especially given the contradictory evidence from the Monkey Mia program.

Part B: Illegal Feeding

3.3 Cockburn Sound, Australia

From 1993 to mid-1997, Cockburn Sound, Australia has a resident community of 74 bottlenose dolphins that have been exposed to illegal feeding primarily from recreational fishers since 1993 (Donaldson et al. 2010). The sound supports a number of commercial and recreational fishers and has a growing recreational tourism industry. As these anthropogenic pressures increase, studies have examined the growing number of provisioned animals (Finn et al. 2008), physical effects from interactions with humans (Donaldson et al. 2010), and possible factors that may contribute to dolphins becoming conditioned (Donaldson et al. 2012).

Long-term research has discovered that the number of conditioned dolphins in Cockburn Sound has increased from one animal in 1993 to 14 animals in 2003 (Finn et al. 2008). The majority of conditioned animals are adult males that approach recreational boats and appear to frequently utilize areas where recreational fishers are found such as seagrass beds, boats ramps, and shore-based fishing sites. These behavioral patterns suggest that dolphin's ranging patterns are becoming altered by provisioning. Not only has the number of conditioned dolphins increased since 1993, but so has the frequency at which they have been observed. The conditioned status of these animals is sustained through food handouts by recreational fishers, with anecdotal accounts suggesting other sources as well (Finn et al. 2008). Social learning has also been proposed as a propagation factor for the increased number of conditioned dolphins in this environment (Donaldson et al. 2012).

Illegal feeding increases the risk of injury to conditioned dolphins. Between 1993-2004 there were 12 reported incidences of injured animals in Cockburn Sound, three of which resulted in death (Donaldson et al. 2010). Three of the 14 conditioned animals had scars that were indicative of a boat strike; none of the other 60 dolphins in the resident community displayed boat-strike scars. In addition, two of the 14 conditioned animals became entangled in recreational fishing gear; one became entangled while engaged in feeding interactions (Donaldson et al. 2010). There are also additional examples which emphasize the importance of preventing feeding interactions considering the suite of anthropogenic activities that already exist and put these animals at risk of injury or mortality. For example, over 7 years (1996-2003), five non-conditioned calves became entangled in active or discarded fishing line (Donaldson et al. 2010). In addition, another injury, although not involving a conditioned dolphin, was the result of deliberate harm from what was suspected to be a spear-gun (Donaldson et al. 2010).

3.4 São Paulo estuarine waters, southeastern Brazil

The São Paulo State estuarine waters in southeastern Brazil serve as an important nursing area for tucuxi dolphins (*Sotalia fluviatilis*). The animals typically remain close to shore along estuarine bays and beaches to prey on fishes. In July 1996, a tucuxi mom-calf pair was observed close to a local fisherman's wooden trap to capture mullet (Santos et al. 2000). The adult female was then observed accepting hand-fed mullet from tourists who were aboard the fisherman's boat, an event that had been anecdotally reported since the end of the 1980s. Santos et al. (2000) documented that hand-feeding mullet to dolphins occurs in this community and through photo-identification, have been able to identify multiple dolphins participating in feeding interactions. As the numbers of tourists that come to this region to view tucuxi grow, there have been indications that other local fishermen have interest in conducting feeding tours. Although specific impacts to the tucuxi dolphins have not been documented, Santos et al. (2000) suggests that changes in natural foraging and social behavior, conditioning, and risk of injury or ingestion of contaminated food are all possible.

3.5 Panama City Beach, Florida, USA

For over two decades, Panama City Beach, Florida has been the most significant hotspot in the southeastern United States for illegal feeding and harassment of bottlenose dolphins. Currently, there are approximately 25 vessel-based and swim-with tour operators in the area, as well as a large recreational fishing presence (Machernis 2014). Participants on commercial dolphin tours, commercial tour operators, recreational fishermen, and the general public engage in dolphin feeding (Samuels & Bejder 2004). In 2004, seven dolphins were identified as having chronic interactions with humans (i.e., repeatedly observed to make close approaches to vessels and to display behavior indicative of human interaction). These animals were calculated to be fed once every 39-59 minutes (Samuels & Bejder 2004). During observations, conditioned dolphins spent 77% of their time engaged in human-interaction behaviors (i.e., remain close to vessel/swimmer, head up, beg, lunge at vessel, follow vessel, accept food). Conditioned dolphins may also be offered or teased with human food or non-food items that could be hazardous to their digestive system and further increase their risk of injury, illness, or death. There were marked differences in the ranging patterns between conditioned and non-conditioned animals, with conditioned dolphins spending the majority of time within less than one nautical mile of "Interaction Beach," where dolphin viewing and swim-with tours congregate and the majority of feeding occurs. Samuels & Bejder (2004) also concluded that juveniles are at increased risk of becoming conditioned as a product of social learning and uncontrolled food provisioning. In addition, illegal feeding of wild dolphins increases the risk of humans incurring injuries inflicted by dolphins from aggressive behavioral displays, such as tail-slapping or biting (Samuels & Bejder 2004).

3.6 Sarasota Bay, Florida, USA

Sarasota Bay, Florida is home to approximately 150 resident bottlenose dolphins (Cunningham-Smith et al. 2006). Some individuals in the population are food provisioned or depredate (dolphins taking fish from fishing lines) from recreational fishers (Cunningham-Smith et al. 2006, Powell & Wells 2011). Illegal feeding was documented in 1990, when a distinctively marked male dolphin, known as "Beggar" was observed begging and being fed regularly by boaters (Cunningham-Smith et al. 2006). Subsequently, seven other members from the Sarasota dolphin community were observed begging from vessels, likely due to social transmission, and consequently, there were an increasing number of dolphin bite reports. To address this problem, a three-phase study was initiated to characterize the types and frequency of boater-dolphin interactions and evaluate the efficacy of boater education and enforcement (Cunningham-Smith et al. 2006). Results of this study documented that of the 1,797 human interactions observed, most interactions involved Beggar; 26% involved humans splashing, teasing, and touching him, and 11% involved feeding him. Dolphin bites to eight people were also observed. Harassment towards and feeding of Beggar decreased when law enforcement increased their presence on the water, educating boaters on the harms of feeding wild dolphins and taking punitive actions. However, all illegal feeding and harassment behaviors were observed to increase again once law enforcement was no longer on the scene (Cunningham-Smith et al. 2006). In 2012, Beggar was found dead in Sarasota Bay. A necropsy was performed and while no definitive cause of death could be pinpointed, there were a number of indications that his interaction with humans was likely the leading cause of his death. Findings of the necropsy included several healed boat and puncture wounds, multiple broken ribs and vertebrae, fishing hooks and small pieces of line in the stomach, internal injuries from two stingray barbs, underweight, and dehydration – likely from not eating a normal dolphin diet (Wells et al. 2013)

Human interactions prompted by associations with Beggar may have also contributed to the death of a four-year old male calf in 2000 (Cunningham-Smith et al. 2006). The young calf and his mother were documented associates of Beggar. The calf stranded alive near Beggar's home range, and died shortly afterward, displaying evidence of human interactions, including emaciation, fishing gear entanglement, and lacerations from propeller wounds (Cunningham-Smith et al. 2006).

Powell & Wells (2011) described interactions observed between dolphins and recreational anglers. Their study was prompted by five stranded dolphins in 2006, four of which were recovered entangled in fishing gear and one that had a history of angler interactions. Powell & Wells (2011) found that increased incidences of depredation and other types of angler interactions were more prevalent after red tide events, when prey resources were depleted, and during peak tourist season, when the number of boaters and anglers were at their highest. Dolphins that engaged in depredation and other interactions with anglers had significant shifts in behavior; spending less time traveling and foraging and more time milling and interacting with boats (Powell & Wells 2011).

3.7 Savannah, Georgia, USA

Perrtree et al. (2014) investigated the prevalence of human interactions (begging, depredating, patrolling, provisioning, and scavenging) with bottlenose dolphins in Savannah, Georgia. When compared to other hotspots such as Cockburn Sound, Australia and Panama City Beach and Sarasota, Florida, dolphins in Savannah exhibited the highest rate of human-interaction behaviors (Perrtree et al. 2014). Begging was the most frequently observed dolphin behavior, comprising 22.4% of sightings, while other behaviors observed included patrolling, scavenging, and provisioning (Perrtree et al. 2014). Perrtree et al. (2014) only observed two instances of provisioning, both with commercial shrimp trawlers; however, the authors hypothesized that the reason they did not observe more instances was possibly due to the presence of their research vessel. Documentation of human-dolphin interactions spanned an area of 272 km^2, the largest to date. A high rate of interactions occurring over a large geographic range may be a key factor in the high rates of entanglement, human-induced injuries, altered behavioral budgets, and aggression that have been documented for dolphins in Savannah, Georgia (Perrtree et al. 2014).

Conclusions for Illegal Feeding Interactions

Locations in Australia and the southeastern United States are hotspots for illegal feeding of bottlenose dolphins (Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Powell & Wells 2011, Perrtree et al. 2014). The number of conditioned dolphins in these areas has increased over time and, through social learning, conditioning has been passed down to younger generations (Samuels & Bejder 2004, Cunningham-Smith et al. 2006). Provisioning reinforces the association between people and food for dolphins. Oftentimes, these close interactions lead to dangerous consequences for both the dolphin and human involved (Samuels & Bejder 2004, Cunningham-Smith et al. 2006). Illegal feeding has been shown to alter dolphins' activity budgets (in particular, decreased time spent foraging and socializing), alter ranging patterns, and increase the risk of entanglement or injury (Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Donaldson et al. 2010, Powell & Wells 2011). Illegally feeding dolphins puts the human at risk for injuries (i.e., biting), and disease transmission (Samuels and Bejder 2004). Additionally, depredation is a growing concern in areas where illegal feeding occurs and there is a large community of active anglers (Donaldson et al. 2010, Powell & Wells 2011). Depredation by dolphins introduces increased risk of fishing gear entanglements, as well as injury or mortality from fisher retaliation (Donaldson et al. 2010, Powell & Wells 2011). While illegal feeding continues to persist, scientific documentation of these interactions and their impacts on dolphins is essential to help develop effective management strategies and guide future decision-making.

Management Recommendations for Illegal Feeding Interactions

Illegally feeding wild marine mammals, in particular bottlenose dolphins, is a widespread problem. A diversity of user groups engage in illegal feeding, including dolphin-view tour operators, tourists, recreational boaters, and commercial and recreational fishermen. Consequently, targeted management efforts are very challenging. There are a couple of recommendations suggested throughout the literature offering solutions to help curtail illegal feeding activities, such as increasing targeted education and enforcement and continuing longitudinal research studies. The recommendations cited here mostly pertain to bottlenose dolphins; however, many of the same approaches can be applied to illegal feeding with other marine mammal species.

Increased education and outreach efforts create awareness for the impacts feeding has on dolphins' natural behavior, health, and survival (Cunningham-Smith et al. 2006, Donaldson et al. 2010). In an increasingly urbanized world, there is a growing demand for seeking out interactions with wildlife (Orams 2002). During these interactions, people often forget that feeding marine mammals, or engaging in activities that can lead to potential changes in their natural behavior (i.e., harassment), is illegal in the United States and a violation of the MMPA that can be civilly or criminally prosecuted. Increased signage with well-publicized punitive actions may help deter people from engaging in such activities (Cunningham-Smith et al. 2006). Educating people may also help prevent feeding and harassment of wild animals, as well as reduce associated injuries to both people and dolphins. Cunningham-Smith et al. (2006) documented 18 instances of "Beggar" (the notorious Sarasota, Florida dolphin) biting people when they tried to touch or tease him. For the safety of both the dolphin and the human, it is necessary to target education efforts to all users on appropriate actions they should take when around dolphins (Powell & Wells 2011). Given that education and outreach efforts can be costly, timely, and require an adequate number of personnel, Finn et al. (2008) recommend adopting the "hotspot" approach where efforts are targeted towards popular feeding interaction locations.

Increasing enforcement efforts is another common recommendation to reduce illegal feeding of wild dolphins. The regulatory framework prohibiting feeding interactions is already in place in the United States; however, it is advised that there should be stricter enforcement of these regulations (Cunningham-Smith et al. 2006). Simply the presence of a marked law enforcement vessel reduces illegal activities; while in their absence, violations persist (Cunningham-Smith et al. 2006). When no visible marked enforcement is present, the public perceives the risk of being caught for a feeding violation as small. In the United States, there are limited numbers of enforcement personnel, who are required to spend their time spread across a wide territory to regulate all federal fishing and protected species actions. While increasing the presence of law enforcement is effective in deterring illegal feeding, the financial and physical resources required to do so are considerable, making this a difficult management strategy to implement.

Lastly, in order to document seasonal and long-term impacts of illegal feeding on an individual dolphin or population, continued longitudinal research projects are warranted (Samuels & Bejder 2004, Finn et al. 2008, Powell & Wells 2011). The systematic behavioral methodology used by Samuels & Bejder (2004) to describe dolphin behavior allowed for comparisons between individuals' behavior, socialization, and ranging patterns in the presence and absence of swimmers and vessels. A long-term data set collected with a similar methodology would further illuminate the impacts illegal feeding may have on specific age classes or sexes, activity budgets, habitat use, survival, or reproductive conditions. Longitudinal studies provide a baseline of behavior so that changes or responses to anthropogenic or environmental factors can be parsed and examined over time.

Chapter 4. Land-Based Interactions

Introduction

The pinniped-viewing industry provides people the opportunity to view seals, sea lions, or fur seals in their natural habitat by approaching them on land or anchoring boats near haul-out beaches. Management of the pinniped-viewing industry varies from site to site; some sites have established viewing distance boundaries (e.g., Andersen et al. 2012), while in other locations, tour companies provide guided walks for people who want to view pinnipeds (e.g., Boren et al. 2009). However, most sites are unregulated and tourists can independently approach pinnipeds on land (e.g., Cassini 2001, Boren et al. 2009). Pinniped responses to all forms of land-based approaches depend on a variety of factors that are discussed in this chapter.

Sixteen scientific papers, dissertations, theses, and workshop reports were reviewed that focus on land-based interactions with six pinniped species. The species involved in these interactions include: South American and New Zealand fur seals; Southern elephant, Weddell, and harbor seals; and Australia sea lions. Studies document interactions in ten countries, along beaches, rocky coastlines, and seal reserve sites.

4.1 Behavioral Effects

4.1.1 Vigilance/Flushing/Move on Land

Across the literature, most pinnipeds' first response to land-based approaches by people is to become alert, by exhibiting a head-up, upright posture (Engelhard et al. 2002, Orsini et al. 2006, van Polanen Petel et al. 2008, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012, Granquist & Sigurjonsdottir 2014). For example, harbor seals (*Phoca* sp.) hauled out on sandbanks in the Dollard Estuary of the Wadden Sea, Germany displayed vigilant behavior 72% of the time when approached on land by people (Osinga et al. 2012). Similarly, harbor seals in the Netherlands displayed vigilant behavior 70% of the time when approached (Groothedde 2011). Vigilance behavior is typically followed by physical avoidance, such as moving away from the source of disturbance, either on land or flushing into the water (Mathews 2000, Cassini 2001, Cassini et al. 2004, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012). Vigilance and flushing behaviors often occur when a person's approach crosses a threshold distance of perceived safety. Threshold distances for both vigilance and physical retreat vary among species and other various factors. For South American and New Zealand fur seals (*Arctocephalus* sp.), the threshold distance before retreat was approximately 10 m (Cassini 2001, Boren et al. 2002). Harbor seals initiated a flight response when pedestrians were within 165-260 m (Andersen et al. 2012). Responses are largely dependent on the animals' sex and reproductive stage, age class, group size, previous exposure to humans, and tourists' behavior and group size.

When measuring pinniped disturbance, animal sex and reproductive stage is an important variable in determining responses. The breeding season and its related activities (i.e., pupping, nursing, and mating) is a sensitive time for pinniped species. Andersen et al. (2012) observed female harbor seals in Denmark were more reluctant to flee to the water during close approaches by humans during the breeding season than any other time of the year. If seals did flush to the water, they were observed returning to the haul-out site immediately after the disturbance. During these sensitive periods, animals have a close association to land and conserve energy by increasing their vigilance and decreasing their flushing threshold distances (Andersen et al. 2012). Boren et al. (2002) drew similar conclusions on the importance of site function, reproductive stage, and sex. At a breeding colony in New Zealand, disturbances resulting in females and pups fleeing to the water have greater consequences on pup body condition and survival during the pupping-mating season than at any other time of the year (Boren et al. 2002). Boren et al. (2002) also observed that male New Zealand fur seals were more likely to remain on land during close approaches by humans at this breeding site. This finding is also supported by breeding male grey seals in Scotland that conserve energy through non-active behaviors in the presence of human disturbance (Bishop et al. 2015). At breeding locations, males invest a considerable amount of time and energy in obtaining and defending territories, females, and the resources females use within those territories (Boren et al. 2002). Therefore, when approached, males are more likely to stand their ground and conserve the energy they invested rather than expend it.

Pinniped age class and group size also play a role in how animals respond to disturbances and perceive habitat suitability. Younger sea lion age classes (i.e., pups and juveniles) have been observed displaying increased vigilance compared to adults in Australia (Orsini et al. 2006). Juveniles have less experience and exposure to disturbance than adults and, therefore, may be less able to judge the risk of harmful stimuli. The size of the group at a haul-out site also contributes to the type of behavioral response. For example, smaller groups of South American fur seals in Peru displayed high rates of vigilance behavior when disturbed by humans, likely because they perceived increased vulnerability being in a smaller group (Stevens & Boness 2003). In larger groups, the vulnerability of individuals to predators may be reduced by the "dilution effect," such that larger groups have lower energy expenditure per individual to perform vigilance behaviors and predator detection (Stevens & Boness 2003). The level of perceived vulnerability associated with group size also results in differences in an animal's assessment of habitat suitability. When grouped in low densities, seals may chose a less suitable habitat for rearing pups (i.e. rocky, uneven surfaces, not optimal for thermoregulation) that are more difficult for humans to access, while larger groups are more likely to breed in more suitable rearing habitats, despite the ease of access for humans (Stevens & Boness 2003).

Previous exposure to human presence is a strong determining factor in pinniped response to human-interactions (Boren et al. 2002, van Polanen Petel et al. 2008). Beaches in Kaikoura and Whakamoa Bay, New Zealand are two highly used haul-out sites by New Zealand fur seals. The haul-out beach in Kaikoura is also a popular tourist destination, whereas Whakamoa is rarely frequented by visitors and was used as the control site in the study (Boren et al. 2002). During controlled approaches, New Zealand fur seals on Whakamoa beach displayed increased vigilance, avoidance, and aggressive behavior, when compared to hauled out seals on Kaikoura beach (Boren et al. 2002). This reduced disturbance response by fur seals on Kaikoura beach may indicate that fur seal behavior has been modified by tourist activities and that habituation may be occurring in areas with high levels of tourism (Boren et al. 2002). A similar conclusion was reported by van Polanen Petel et al. (2008) for Weddell seals (*Leptonychotes weddellii*) in East Antarctica. The percentage of vigilant seal behavior (e.g., looking up at the source of disturbance) over 10 approaches decreased linearly from 67% to 18%, as did time spent looking at the source of disturbance (van Polanen Petel et al. 2008). Repeated and consistently benign approaches to lactating seals resulted in diminished behavioral responses over a two-hour time period (van Polanen Petel et al. 2008). Comparatively, when seals were approached infrequently over the course of 3-4 weeks in a location where all animals in that area had been previously flipper tagged, animals showed no signs of becoming accustomed to humans (van Polanen Petel et al. 2008). The previous, presumably unpleasant experience of being flipper tagged may have led Weddell seals to perceive humans as a threat that required constant monitoring (i.e., vigilant behavior), irrespective of how frequently they had been exposed (van Polanen Petel et al. 2008).

Lastly, tour group size and tourists' behaviors when viewing pinnipeds affect the type of responses they elicit. Harbor seals typically exhibit a greater disturbance response to larger tour group sizes (5-10 people), compared to smaller ones (Groothedde 2011). Pinnipeds in general were observed to display increased avoidance behavior in response to larger groups of 7-9 people in New Zealand (Boren et al. 2009). Additionally, when tourists behave in a disturbing manner (i.e., yelling, clapping, imitating seal sounds, throwing stones), pinnipeds are more likely to avoid the group (Cassini 2001). In most cases, larger group sizes are associated with more disturbing tourist behaviors, which may create the most disturbances to pinnipeds (Granquist & Sigurjonsdottir 2014).

4.2 Habitat Use

4.2.1 Haul-out Utilization

Land-based disturbances affect how pinnipeds utilize a haul-out site, the location at which they haul out, and the recovery time post-disturbance (Mathews 2000, Granquist & Sigurjonsdottir 2014). Harbor seals in Iceland utilize the natural landscape to increase the distance between themselves and tourists (Granquist & Sigurjonsdottir 2014). There is a natural water barrier between seal haul-out sites on skerries (i.e., small rocky islands) and viewing zones on land. When the number of tourists on land increased, harbor seals hauled out onto skerries farther away from the land-based viewing zones (Granquist & Sigurjonsdottir 2014). This demonstrates that the seals changed their haul-out site selection based on the presence of tourists (Granquist & Sigurjonsdottir 2014).

In Glacier Bay National Park, harbor seals rarely flushed to the water when disturbed by vessel wakes, and when they did, the seals re-hauled out after a short period of time (Mathews 2000). Comparatively, when vessel disturbance was accompanied by land-based disturbance from people at nearby camping sites, seals responded by flushing to the water and not re-hauling at the same site out until more than 52 hours later (Mathews 2000). These findings provide additional evidence for the negative effect human disturbance can have on pinniped habitat utilization (Mathews 2000).

Conclusion and Summary of Risks for Land-Based Interactions

Pinnipeds are most disturbed when hauled out on land and approached by pedestrians. Most often pinnipeds respond to disturbance by first increasing their vigilance and then flushing to the water (e.g., Mathews 2000, Cassini 2001, Cassini et al. 2004, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012). Across the pinniped literature, disturbance responses vary depending on the animals' sex and reproductive stage, age class, group size, previous exposure to humans, and tourists' behavior and group size. Breeding seasons are energetically demanding times. Males on breeding colonies are less likely to flee from an established territory they spent a lot of time and energy obtaining and defending (Boren et al. 2002). Similarly, females and pups are more sensitive during the breeding season and have been observed to conserve energy during close approaches by increasing vigilance and decreasing flushing behaviors (Boren et al. 2002, Andersen et al. 2012). Additionally, younger, less experienced pinnipeds and smaller haul out groups tend to flee or show increased vigilance when disturbed (e.g., Orsini et al. 2006). Larger haul out groups have added protection from the "dilution effect," which shapes their response type (Boren et al. 2002, Stevens & Boness 2003, Orsini et al. 2006). Prior experience and continued exposure to human approaches are also factors in how pinnipeds respond to human presence; continued, benign approaches have been shown to result in a habituated response (van Polanen Petel et al. 2008). Lastly, tourist group size and behavior are factors in pinniped disturbance responses (Osinga et al. 2012, Granquist & Sigurjonsdottir 2014). Larger and more boisterous tourist groups tend to create the most disturbances to animals they are observing.

In general, these disturbances pose a risk to animals' health and survival. Vigilance and flushing behaviors have energetic consequences (Stevens & Boness 2003, Orsini et al. 2006, Jezierski 2009, Andersen et al. 2012, Osinga et al. 2012). Some pinniped life stages, such as molting, lactating, and gestation, are already energetically demanding times. The added stress that comes from human disturbances can interfere with and jeopardize these life stages (Orsini et al. 2006). Disturbances can also have significant effects on juvenile survivorship (Osinga et al. 2012). If mothers and pups are constantly flushing to the water, the amount of time pups have on land to nurse is reduced. Also, the experience of flushing among large groups of pinnipeds can result in the stampeding and killing of pups, as well as lead to mother-pup separation (Osinga et al. 2012). For example, in the Netherlands, yearly numbers of orphaned pups fluctuate between 13 and 24 pups due to flushing from disturbance (Osinga et al. 2012). Disturbances can also cumulate into potential habitat displacement (Stevens & Boness 2003, Cassini et al. 2004, Orsini et al. 2006, Boren et al. 2009). Human presence may reduce the quality or quantity of time pinnipeds spend in their preferred habitat, driving them away to seek potentially less suitable haul-out sites (Orsini et al. 2006).

Land-based interactions with pinnipeds and swim-with interactions with dolphins stimulate similar discussion regarding tolerance to disturbance versus habituation. Some research has supported the idea that with repeated exposure to land-based activities, pinnipeds become habituated to human presence and therefore are only likely to be affected by human activities until they reach the point of habituation (van Polanen Petel et al. 2008, Granquist & Sigurjonsdottir 2014). Similar to points discussed in dolphin swim-with interaction literature, there is some misuse of the term habituation. It is argued that a positive factor for habituated animals is that they are able to conserve energy and reduce stress by not responding to stimuli that are perceived as non-threatening (Boren et al. 2002). However, for animals to become habituated, they must go through a series of behavioral modifications before reaching the point of habituation, such that over time, habituation has altered natural behaviors and may ultimately reduce long term survival (Boren et al. 2002). Truly habituated animals may lose their natural wariness of people and not respond appropriately to negative interactions. There may also be other behavioral or physiological long-term effects truly habituated animals experience that have not yet been discovered (Bejder et al. 2009).

Management Recommendations for Land-Based Interactions

One of the most commonly recommended management strategies throughout the pinniped literature to reduce disturbing land-based interactions is to implement guided walking tours and enhance educational programs (e.g., Orsini et al. 2006, Boren et al. 2009, Jezierski 2009, Andersen et al. 2012). The presence of a guide during land-based tours has been found to significantly reduce the amount of vigilance and flushing behavior displayed by pinnipeds (Orsini et al. 2006, Boren et al. 2009, Jezierski 2009). Guides or rangers are effective in teaching tourists how to appropriately behave while viewing wild animals (Boren et al. 2009); inappropriate behaviors, such as running, shouting, clapping, and throwing objects towards seals, can be curtailed. Guided tours can also help regulate the number of people who participate, keeping group sizes smaller and promoting adherence to viewing distance guidelines (Orsini et al. 2006, Granquist & Sigurjonsdottir 2014).

The construction of fences around colony's haul-out sites has also been found to be an effective management tool (Cassini et al. 2004, Groothedde 2011). The presence of a fence forms a physical boundary between animals and tourists and is a simple and affordable means to reduce negative interactions. Cassini et al. (2004) found that after the implementation of a fence, the most disturbing human behaviors (i.e., close approaches, intrusive behavior) and fur seal disturbance responses (i.e., flushing, threat displays, and aggressive behavior towards tourists) were reduced. Cassini et al. (2004) recommended that fences are constructed in conjunction with educational programs to enhance tourists' perceptions and attitudes towards wildlife. One risk of fence construction is resource and space limitations. If fenced areas are not large enough to support an expanding population, animals may abandon the site. However, this can potentially be avoided through population growth models and proper spatial planning (Cassini et al. 2004).

Seasonal site closures and the designation of colonies for tourist activities have also been suggested to reduce human disturbance on pinnipeds. Mating, pupping, and lactation seasons are energetically demanding times, such that disruption by tourists is especially problematic as it causes additional energy spent on vigilance and flushing behaviors. Osinga et al. (2012) recommend closing off pedestrian foot traffic during pupping and mating seasons and constructing an observation platform to observe pinnipeds from a distance. Van Polanen Petel et al. (2008) proposed two very different strategies to help minimize human impact on seals: 1) spread land-based visitation by humans amongst many pinniped colonies at irregular time intervals to avoid cumulative impacts, and 2) target one colony for land-based visitation to reduce the cumulative number of individual pinnipeds being disturbed, although risking potential behavioral changes and conditioning of animals in the visitation colony.

Each management regime is faced with its own host of challenges. The high level of variance among behavioral responses and the differences in human behavior that elicit those responses makes a "one size fits all" management strategy unfeasible and ineffective. Factors such as site function (breeding vs. haul-out site), size of the colony, location and geographical features, ease of human access to a site, and tourist popularity of a site should all be considered in the development of ecotourism management plans for pinniped land-based viewing.

Conclusions

Scientific literature reviews are an important conservation tool that collate and summarize pertinent themes from literature that scientists and managers can then reference and apply to the development of management strategies and new research ideas. The need to update and expand the literature review conducted by Samuels et al. (2000) highlights how much the marine mammal tourism industry has developed over the last 15 years and the necessity to keep up-to-date with existing research. This literature review includes almost 190 new references pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions with odontocetes, mysticetes, pinnipeds, and sirenians.

The marine mammal tourism industry plays a large socioeconomic role in many small, coastal communities throughout the world. All forms of tours have the potential to provide valuable educational opportunities to the public, bringing people closer to animals in their natural habitats and learning first-hand about life history patterns and behaviors. However, as the scientific literature in this review depicts, the marine mammal tourism industry can have individual and population level impacts on target species, as well. It has been well documented across literature that disturbance to marine mammals from vessel, swim-with, feeding, and land-based interactions have short-term behavioral effects that can lead to long-term consequences.

One of the main concerns about tourism is its effect on marine mammal health and survival. Repeated exposure to disturbance may alter an individual animal's behavioral budget, resulting in increased energy expenditure and decreased energy acquisition. Over time, many scientists have argued that these behavioral modifications could ultimately affect the population, through reduced fitness, reduced survival, and long-term habitat displacement (e.g., Östman-Lind et al. 2004, Samuels & Bejder 2004, Christiansen et al. 2010, Christiansen et al. 2013a, Tyne et al. 2014). As research and analysis methodologies have evolved, models have begun to evaluate long-term population consequences of disturbance. Some papers highlighted in this review suggest that while behavioral disruptions from tourism activities are substantial, the cumulative exposure and energetic impact to disturbed individuals is low; at least for certain species and locations (Lusseau 2004, Bain et al. 2014, Christiansen et al. 2014, Christiansen et al. 2015). Nonetheless, the evaluation of long-term consequences of human disturbance is on an upward trajectory in the scientific community. Through the development of different models and scientific frameworks, scientists are taking a population level approach to evaluate anthropogenic impacts on marine mammal populations.

The research conducted over the last fifteen years, collated into this review, provides a thorough background of human interactions and impacts to marine mammals from tourism for scientists to build upon and develop future potential research projects. This review also provides comprehensive information to assist managers in the development of management and conservation strategies. This review highlights that many of the behavioral responses observed are due to inappropriate human behavior; thus, rather than regulate animal behavior, human behavior change and control should be the focus of management regimes.

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