Whale and Small Vessel Interactions: exploring regulatory compliance and management implications in the Salish Sea

by

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Abstract

Compliance is a key feature for the management of non-consumptive wildlife viewing, as it can link management measures to performance and aid in developing recommendations that promote sustainable practices. Whale watching is a prominent wildlife viewing industry that is steadily rising in demand around the world. Managing vessel-cetacean encounters and operator behaviour (both commercial and recreational) is key to limiting impacts on cetaceans, yet the scale of regulatory compliance is often poor or unknown. Although efforts exist to regulate whale watching, challenges arise for the assessment of compliance in marine environments, as they are inherently spatially vast, lack physical boundaries, and can involve mobile stressors (i.e. vessels) and species. Chapter 1 reviews the shift in paradigms from consumptive to non-consumptive activities and highlights challenges for those tasked with managing the growing wildlife tourism industry, and in particular, whale watching. After reviewing a suite of measures prevalent around the world, this chapter then focuses on the Salish Sea's approach to managing whale watching. This area epitomizes a major whale watching hub and displays complex, multi-jurisdictional and constantly evolving measures. Due to a lack of knowledge in this region, Chapter 2 shifts from theory to practice and assesses regulatory compliance with marine mammal distance regulations from 2018 to 2019 in the Salish Sea. Although compliance was nearly 80%, key drivers including vessel and species type were found to significantly influence non-compliance. Recreational vessels were non-compliant 41.9% of the time and 74.2% of non-compliant encounters occurred around killer whales across both years. The findings of the study demonstrate that case-specific investigation of compliance is necessary as each region is unique in its approach to management. Lastly, recommendations are proposed that can benefit marine managers and policymakers to enhance the performance of measures and subsequently minimize risk to cetaceans.

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Dedication/Acknowledgement

This work is dedicated first and foremost to my father, who has taught and inspired my love and passion for the ocean. Thank you for the endless hours on the West Coast and for teaching me how to navigate the roughest waters of the ocean and in life. Thank you to my mother for always being there to listen, support and build me up in the toughest of times. I learned how to be a strong, resilient and compassionate person from you. To the rest of my family and friends, thank you and I love you all. Ben: thank you for being my rock when I was wavering, giving laughter during my hardest times, loving nature as much as I do and being my adventure partner for life.

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Chapter 2 of this thesis was co-authored and is a submitted and provisionally accepted manuscript to an academic journal (Marine Policy). For this manuscript, I led the research, fieldwork, data preparation, analysis and writing. Dr. Darimont, Dr. McWhinnie and Dr. Canessa supported this project through aiding in development of research objectives and analyses. Further, Dr. Darimont and Dr. McWhinnie aided in writing and editing throughout the formulation of this manuscript

Introduction

Marine mammals face increasing anthropogenic pressures through a plethora of human activities worldwide. Vessel traffic is one such stressor to marine mammals which has seen substantial expansion over the past several decades (Halpern et al., 2008; Rahim, Islan & Kuruppu, 2016). Corresponding impacts from vessels to marine mammals form a large part of the conservation science literature and are inherently of interest to marine managers (Ban & Alder, 2008; Halpern et al., 2015).

A major contributor to marine vessel activities is whale watching. This increasingly popular activity occurs frequently and predominantly in densely populated coastal areas (Pine et al., 2016; Cominelli et al., 2018). Three main methods of whale watching exist: air-based, land-based, and vessel-based (Finkler & Higham, 2004). The most common form of whale watching occurs from vessel-based tours due to greater reliability in encountering cetaceans (whales, dolphins, porpoises) (Andersen & Miller, 2008; Kessler et al., 2014; Mallard, 2019), while cetacean encounters from air-based and land-based tours are typically less predictable (Findlay, 1997; Finkler & Higham, 2004). Vessel-based whale watching (hereafter referred to simply as whale watching) may be defined as either commercial, through designated tourism companies, or recreational, by non-commercial whale watching vessels such as pleasure boats, fishing boats, kayaks or sailboats, which may opportunistically encounter cetaceans. Whale watching can cause impacts on the cetaceans they are viewing, leading to cetacean mortality, physical and behavioural changes and abandonment of key habitats (Williams et al., 2006; Stamation et al., 2010; Huntington et al., 2015; Meissner et al., 2015; Senigaglia et al., 2016; Rockwood et al., 2017).

As a response to empirically identified impacts to cetaceans and in conjunction with the increasing popularity of whale watching, management measures that target these activities are now increasingly prevalent around the world. These measures have been exercised across nations and jurisdictions and typically aim to direct vessel behaviour with the intention of minimizing vessel impacts (Duprey et al., 2008; Kessler & Harcourt, 2013; Sitar et al., 2016l; Seely et al., 2017). To gauge performance, regulatory compliance with management measures is often used as a benchmark. As is the case with wildlife viewing more broadly, without adequate compliance, measures thus have the potential to be rendered ineffective (Higginbottom et al., 2003; Chalcobsky et al., 2017). Further, to direct efforts, managers concerned with whale watching impacts on cetaceans require information on not only the scale of compliance but also an understanding of the drivers that lead to non-compliance (Duprey et al., 2008). These factors are often case-specific and are thus a key aspect of any implemented measures.

British Columbia (BC), Canada is a global hotspot for whale watching, with the first commercial operators emerging in the early 1980s. The Salish Sea, in particular, has become the centre for whale watching in BC (Seely et al., 2017). The region's reputation for world-class whale watching stems from its nutrient-rich waters supporting various cetacean species, including killer whales *(Orcinus orca)*, both Bigg's (transient) and southern resident ecotypes, humpback whales (*Megaptera novaeangliae*), grey whales (*Eschrichtius robustus*), and minke whales (*Balaenoptera acutorostrata* (Duffus, 1996; Lusseau et al., 2009; Gaydos & Pearson, 2011; Rosa et al., 2012). Due to a relatively reliable presence of killer whales, the area is now known as one of the best places in the world to see these charismatic and rare megafauna (Seely et al., 2017). Along with commercial whale watching vessels, this region also hosts a large abundance of other small vessel traffic, including recreational boats, sailboats, recreational and commercial fishing boats, and

kayaks (Gray et al., 2011; Giles & Koski, 2012). These recreational vessels also opportunistically view cetaceans (Duffus & Dearden, 1993).

For cetaceans in the Salish Sea, a number of anthropogenic stressors exist. One of the three main identified threats to killer whales and humpback whales by Fisheries and Oceans Canada (DFO) are vessels and their associated impacts (Fisheries and Oceans Canada, 2007, 2013, 2018). A recent 2018 DFO census estimated that there were 75 individuals in the critically endangered southern resident killer whale population (Fisheries and Oceans Canada, 2018), and by December 2019, this number dropped to 73 (Center for Whale Research, 2019). In addition, estimates of 250 Bigg's killer whales (threatened under Canada's Species at Risk Act [SARA]) and 1,313 humpback whales (species of concern under SARA) along the coast of BC are conservative and baseline-deficient (Fisheries and Oceans Canada, 2007; Fisheries and Oceans Canada, 2013). The vulnerable statuses of these species are of added concern as the popularity of whale watching in the Salish Sea has led to an accumulation of vessel-cetacean encounters (Seely et al., 2017). As a response to these concerns, there has been an increased interest in developing and amending regulations to manage and minimize the risk vessels pose to cetaceans. However, relatively little research has explored compliance with guidelines and regulations in the Salish Sea. One study explored vessel compliance around southern resident killer whales within the Salish Sea (Seely et al., 2017), yet this study lacked the consideration of compliance around other cetaceans that are frequently observed such as Bigg's killer whales and humpback whales. In addition, this study was conducted prior to new marine mammal regulatory amendments, and as such, compliance with current measures is unknown.

In Chapter 1, I review the history, development and management of whale watching through the contextual lens of human and wildlife interactions. I begin by detailing the evolution

of human-wildlife engagement from consumptive to non-consumptive and how changes in human behaviour have led to these shifting paradigms. More specifically, I describe how human perspectives of viewing wildlife at close distances influence compliance and increases the likelihood of disturbances. Correspondingly, management is often tailored to regulate distances to wildlife. I then review the literature of whale watching impacts on cetaceans and how various social and psychological influencers have the potential to guide operator behaviour around cetaceans. Next, I summarize global management measures for whale watching and describe the advantages and limitations of each measure. Finally, I review the complex development and current state of management measures specific to the Salish Sea to provide context for the challenges managers and policymakers face in this region.

Against the theoretical background highlighted in Chapter 1, in Chapter 2, I investigate vessel compliance with marine mammal distance regulations in the Salish Sea. Using on-water observational data conducted over a two-year period, I identify vessel compliance and uncover specific correlates of non-compliance with regulations. I assess how covariates such as species type, vessel operator, and spatial and temporal variability might influence the scale of non-compliant encounters. From these findings, I then detail recommendations on how compliance may be improved and suggest where and how enforcement, monitoring and education efforts can be best allocated.

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Chapter 1: Management of non-consumptive uses of wildlife: A review of whale watching management

1. Introduction

Humans and wildlife have a multi-faceted relationship that results in direct or indirect interactions in both terrestrial and marine environments. Human perspectives of wildlife are meaningfully shaped by the nature of each interaction (Graham et al., 2005; Thatcher et al, 2019). On one hand, tourism operators who generate revenue from wildlife are likely to see wildlife as a beneficial contributor to their livelihood (Stem et al., 2003; Blackburn et al., 2016; Frank, 2016; Eshoo et al., 2018). On the other hand, negative perspectives of wildlife could derive from interactions with wildlife that threaten human well-being, such as if wildlife had killed one's livestock (Graham et al., 2005; Ogra & Badola, 2008; Liu et al., 2011). Fundamentally, human activities involving wildlife fall under two broad categories (consumptive and non-consumptive), each of which results from specific human goals and motivations (Macmillan & Phillips, 2008). Such activities, whether willful or not, can lead to impacts on wildlife populations and ecosystems, and can result in biodiversity loss (Duffus & Dearden, 1990).

1.1 Consumptive activities

Historically, interactions with wildlife were principally for consumptive use. Consumptive activities can be defined as activities that result in the killing or removal of animals from their environment (Duffus & Dearden, 1990). Typically derived from an anthropocentric perspective (Øian et al., 2017), consumptive activities aim to provide food, clothing or entertainment (Macmillan & Phillips, 2008). Activities such as sport and commercial fishing, and subsistence and trophy hunting fall under the consumptive lens (Macmillan & Phillips, 2008). Hunting has led

to depletions in terrestrial carnivores, including lions (*Panthera leo)* (Rosenblatt et al., 2014) spotted hyenas *(Crocuta crocuta)* (Croes et al., 2011), brown bears (*Ursus arctos)* (Ripple et al., 2019), cheetahs *(Acinonyx jubatus)* (Croes et al., 2011) leopards *(Panthera pardus)* (Croes et al., 2011) and Sumatran tigers *(Panthera tigris sumatrae)* (Wibisono & Pusparini, 2010). Similarly, fishing represents the largest pressure on marine species (Jackson et al., 2001). One such example is the collapse of the Atlantic cod fishery in Newfoundland and Labrador, Canada as a result of overfishing and poor fisheries management, where stocks were estimated to be 3 billion cod fewer in 1991 than they were in the 1960s (Hutchings & Myers, 1994). Marine consumptive uses may also include ornamental fishing (Fujita et al., 2014) and non-commercial or indirect means such as predator control (Bowen & Lidgard, 2013) or bycatch in fisheries (Ban & Alder, 2008).

1.2 A shift towards non-consumptive activities

More recently, there has been an overall global transition from consumptive activities towards non-consumptive activities. In the U.S., expenditures on sport hunting and fishing steadily declined from 1996 to 2006, instead being replaced by spending on non-consumptive activities, such as nature and wildlife based tourism (Sun et al., 2015). These activities aim to interact with wildlife without the deliberate intent of killing, harming or impacting the health of wildlife populations (Barstow, 1986; Higham et al., 2016).

Of all non-consumptive activities, wildlife viewing comprises the largest. Trave et al., (2017) estimated that globally up to 440 million people engage in wildlife tourism excursions every year. Of the 2.2 million international tourists who visited Australia in 2006, approximately 43% engaged in wildlife viewing (Ballantyne et al., 2009). Wildlife viewing operations can generate economic benefits for both operators and communities. In 2008, safari wildlife viewing tours in Tanzania were visited by over 750,000 international tourists and generated US$1.2 billion

in revenue (Sekar et al., 2014). For many small communities, wildlife tourism can be especially beneficial allowing for communities to economically transition away from less sustainable industries (i.e. hunting, fishing) (Gallagher & Hammerschlag, 2011; Cagua et al., 2014; Honey et al., 2016). For example, in the Republic of Maldives, whale sharks were hunted extensively for their oil up until the 1990s when whale shark diving and 'swim with' programs began, substantially benefitting both locals and government (Cagua et al., 2014). In many cases, alongside wildlife tourism operators, other businesses such as restaurants, transportation, hotels and the sale of merchandise such as souvenirs, mutually prosper (Davis et al., 1997; Wilson & Tisdel, 2001), allowing local people across various sectors to begin relying on new streams of revenue (Balmford et al., 2002).

Expansion of the wildlife tourism industry comes in light of a variety of societal advancements. These include changes in food preferences, a heightened awareness of conservation issues and an increased fascination with observing wildlife in their natural habitats (Macmillan & Phillips, 2008). Kellert (1980) defines interactions with wildlife as falling under nine categories: Naturalistic, ecologistic, humanistic, moralistic, scientistic, aesthetic, utilitarian, dominionistic and negativistic, with users able to identify with more than one group. For example, the general public engaged in wildlife viewing is thought to be less concerned with biological functioning (i.e. scientistic) and more inclined to be fascinated by the perceived affection (i.e. humanistic) and aesthetics (i.e. aesthetic) of wildlife. Each category is suggested to be the basis of understanding human motivations for activities involving wildlife (Kellert, 1980; Reynolds & Braithwaite, 2001). Studies on human perspectives of wildlife suggest that shifting paradigms, resulting from increased bio-centric worldviews coupled with increased human fascination and emotional association with

nature, are indicative of an overall reduction in negative perspectives towards wildlife (i.e. dominionistic, negativistic) (Scheffer, 1976; Curtin, 2005).

Tourism operators focusing on wildlife have the added opportunity to educate the public about species and conservation issues. Owing to wildlife viewing eliciting positive physical, psychological and spiritual responses within people (McIntosh & Wright, 2017), when engaged in wildlife viewing, people have a stronger likelihood to be engaged, responsive and to actively learn about conservation concerns (Ballantyne et al., 2009). Correspondingly, those same people may be more likely to be passionate about and contribute to the protection of species they care about (Beaumont, 2001; Powell & Ham, 2008; Ballantyne et al., 2009). Conservation aims may be achieved through the application of educational materials, signage and naturalist guides (Zeppel & Muloin, 2008; Curtin, 2010; Karanth et al., 2012; Garcia-Cegarra & Pacheco, 2017). For example, visitors attending presentations at a land-based whale watching platform in Oregon, U.S. demonstrated a greater understanding of the environmental pressures whales face compared to visitors who did not attend the presentations (Christensen, Rowe & Needham, 2007). Another study in Los Organos, Peru suggested that 17.8% of whale watching customers gained knowledge of whale conservation concerns. Moreover, they reported that the knowledge they gained whilst on tour led to a greater willingness to change individual behaviour (Garcia-Cegarra & Pacheco, 2017). While not all wildlife viewing operators have an explicit focus on education, those that do have the added opportunity to accommodate the needs of both wildlife and tourists (Ballantyne et al., 2009).

1.3 Impacts on wildlife from non-consumptive activities

Although wildlife tourism can contribute positively, the proliferation of wildlife viewing has led to growing concerns about how these activities may affect wildlife. Possible impacts to

species from wildlife viewing are numerous and may include behavioural changes (Christiansen & Lusseau, 2015), reduced reproductive fitness and success (Giese, 1996), changes to or a reduction in foraging (Olson et al., 1997), and habitat displacement (Fortin et al., 2016), all of which can lead to long-term population-level impacts (Christiansen & Lusseau, 2015; Fortin et al., 2016). Commercial operators typically focus on charismatic and captivating megafauna and these animals are often rare or highly endangered, which can compound impacts (Walpole & Leader-Williams, 2002; McIntosh & Wright, 2017). For example, African elephants (*Loxodonta africana)* in Madikwe Game Reserve, South Africa were shown to alter behaviours in the presence of tourist vehicles including herds exhibiting avoidance behaviour to a large number of safari vehicles (Szott et al., 2019). In addition, commercial wildlife viewing activities often focus on areas of significant ecological importance, such as key foraging, socializing and breeding grounds, as these areas can ensure higher probabilities of wildlife encounters (McIntosh & Wright, 2017). One study found that established bear viewing operators in Alaska, U.S. and British Columbia (BC), Canada, deliberately position tourists at spawning salmon rivers due to high predictability of seeing bears feeding during certain seasons (Nevin & Gilbert, 2005). However, the presence of humans in these crucial areas was found to lead to reduced bear presence, foraging times and selection of alternative sites (Penteriani et al., 2017).

Human behaviour is an integral component of understanding what contexts predict impacts to wildlife. Reynolds & Braithwaite (2001) found that important aspects of viewing wildlife for people included engaging in experiences that were exhilarating, authentic, unique and involved. Additionally, tourists often report some of the most memorable wildlife encounters to involve up-close encounters (Reynolds & Braithwaite, 2001; Curtain, 2010; Verbos et al., 2018). For example, interviews with customers involved in penguin tourism in New Zealand revealed higher quality

experiences were linked to perspectives of "the closer the better" (Schänzel & McIntosh, 2000). Several separate studies that examined whale watching customer expectations found that the majority of customers wanted to be closer to whales, despite an understanding of distance regulations (Knight, 2009; Kessler et al., 2014; Cornejo-Ortega et al., 2018). Proximity is seen to be linked to the idea that certain behaviours may only be visible at close distances, and that close approaches are a necessary criterion for intimacy (Knight, 2009; Schänzel & McIntosh, 2000). For commercial operators, these pressures have the potential to lead guides to approach closer to wildlife in order to ensure the satisfaction of their customers, and thus increase the chance for positive reviews and gratuities (Reynolds & Braithwaite, 2001). Although close encounters are highly sought after, in many cases they can lead to various impacts on wildlife such as harassment or habituation (i.e. reduction of avoidance or escape responses) (Smith et al., 2005). Coupled with the substantial growth in wildlife viewing, the desire for close encounters by users necessitates the rethinking of management in minimizing human impacts.

This chapter sets out to provide a broad overview of whale watching, current management measures and how compliance is often used as an indicator for efficacy. This review begins by exploring the evolution of human interactions with whales from largely consumptive to non-consumptive industries. Impacts from vessels engaged in whale watching are then detailed. In response to observed impacts, this chapter sets out to review various management measures that have emerged globally, yet compliance (and its associated correlates) to these measures is poor or unknown. These concepts culminate in a case study of whale watching in the Salish Sea, along with a detailed review of its complex and varied management measures.

2. History and Development of Whale Watching

2.1 From whaling to whale watching

Throughout history, whaling has been a prominent consumptive activity. Originally, the use of cetaceans (whales, dolphins and porpoises) occurred in the manner of subsistence and indigenous cultural hunting (Monks et al., 2001; Beland et al., 2018). Expanding global markets for whale oil and bone led to commercial whaling commencing between the 18th and 20th centuries, depending on the region (Cunningham et al., 2012; Smith et al., 2012). Consequently, high demands and advancing technologies led to the ability to efficiently harvest vast numbers of whales, triggering a mass depletion in populations around the globe (Smith et al., 2012; Drew et al., 2016). For instance, in the 1800s over 100,000 baleen whales were killed by American whalers alone (Drew et al., 2016). Many species became extirpated, extinct, or brought to the brink of extinction including blue whales *(Balaenoptera musculus),* sperm whales *(Physeter macrocephalus),* bowhead whales *(Balaena mysticetus),* Southern right whales *(Eubalaena australis),* North Atlantic right whales *(Eubalaena glacialis),* North Pacific right whales *(Eubalaena japonica)* and humpback whales *(Megaptera novaeangliae)* (Smith et al., 2012; Dorsey, 2013).

As a response to rapid declines, the dominant whaling nations came together and developed the International Whaling Commission (IWC) in 1946 to regulate the harvest of whales. However, for the first few decades, the IWC was largely ineffective in its goals to sustain populations (Dorsey, 2013). It was not until the "Save the Whales" movement in the 1970s that immense pressure grew from the public to stop commercial whaling. This movement symbolized whales as political and conservation icons, burgeoning the inception of environmental organizations including Greenpeace (Dorsey, 2013). Public pressure culminated and prompted a 1986

international agreement, signed by the IWC, to ban global commercial whaling (Barstow, 1986). Despite a few countries continuing to harvest whales to this day (i.e. Iceland, Norway, Japan) (Barstow, 1986; Cunningham et al., 2012), an overall shift occurred in the 1980s towards a non-consumptive alternative: whale watching.

Similar to other wildlife viewing industries, whale watching has grown substantially in popularity over the past few decades. In 1994, 5.4 million people participated in commercial whale watching tours in 65 countries, generating an estimated US$504.3 million in revenue (Hoyt, 1995). By 2008, this number propelled to 13 million people in over 119 nations, generating approximately US$2.1 billion (O'Connor et al., 2009). This thriving industry is thought to be in part related to humans having a deep-rooted emotional connection with whales; throughout history, societies have revered whales as a commodity, icon, and as entertainment (Brito et al., 2019). In addition, as charismatic and rare megafauna, coupled with increasing bio-centric worldviews, demand for the public to view whales in their natural environment continues to rise (Knight, 2009). As a result of growing human fascination with whales, non-commercial (i.e. recreational) whale watching is also increasing in many areas (Duprey et al., 2008; Seely et al., 2017; Montes et al., 2018).

2.2 Vessel impacts to cetaceans

2.2.1 Overview

Cetaceans can be found in every ocean and are regularly in close proximity to vessels. Studies have revealed that the persistent and cumulative presence of vessels leads to various impacts on cetaceans. Impacts include acoustic disturbances (chronic and acute) (Veirs et al., 2016; Cominelli et al., 2018) ship strikes (Bezamat et al., 2015; Rockwood et al., 2017), pollutants (Lachmuth et al., 2011) and physical and behavioural disturbances (Stamation et al., 2010; Pirotta et al., 2015). Species including killer whales (*Orcinus orca)* (Holt et al., 2009), fin whales

(*Balaenoptera physalus)* (Clark et al., 2009), humpback whales (Stamation et al., 2010), North Atlantic right whale (Clark et al., 2009), and beluga whales (*Delphinapterus leucas)* (Gervaise et al., 2012) have been documented to be affected by acoustic disturbances, resulting in changes to call frequencies and duration. Another impact on whales, and especially baleen whales, from vessels, is the risk of ship strikes. Rockwood et al., (2017) found that the primary manner of death for blue whales, humpback whales and fin whales along the West Coast of the U.S. was ship strikes. Pollutants from vessels, such as marine discharge and air pollution, have also been shown to affect respiratory functions in southern resident killer whales (Lachmuth et al., 2011). Behavioural disturbances, including changes in diving and resting patterns, reduced foraging periods and social behaviours resulting from vessels have also been observed in both toothed and baleen whales (Williams et al., 2002; Holt et al., 2009; Schuler et al., 2019; Clemente et al., 2018).

2.2.2 Impacts derived from whale watching

Whale watching (commercial and recreational) is increasingly ubiquitous and as such, more studies are examining impacts from these stressors. Engine noise from whale watching vessels affects humpback whales (Stamation et al., 2010; Sprogis et al., 2020), southern right whales (Arguelles et al., 2016; Arias et al., 2018) and masks echolocation in killer whales (Erbe, 2002; Holt et al., 2009) and sperm whales (Richter et al., 2006). In addition to acoustic impacts, behavioural changes have been seen from whale watching vessels. For example, Williams et al., (2006) found that vessel presence led to northern resident killer whales changing activities. Although the activity change involved shifting from one low-energy activity to another, the authors surmised that if individuals lacked reliable prey sources, changing activity budgets could be detrimental (Williams et al., 2006). Another study by Ng & Leung (2003) found that Indo-Pacific humpback dolphins (*Sousa chinensis*) altered their travel patterns and exhibited longer dive

patterns around dolphin watching vessels. Close approach distances are further found to lead to impacts. Close proximity (<100m) was found to elicit behavioural changes in southern resident killer whales such as a reduction in foraging time and shifts in activity states (Lusseau et al., 2009). Moreover, sperm whales (Richter et al., 2006) and Southern Right whales (Arias et al., 2018) have been seen to alter travel direction when vessels approach within 100m and 50m, respectively. However, studies on vessel impacts typically focus on individual cetaceans rather than population-level changes, as these assessments are often difficult (Lusseau et al., 2009; Houghton et al., 2015).

2.3 Challenges in monitoring whale watching vessels

Of all vessel types, small vessels are the most likely to engage in whale watching. In addition to commercial whale watching vessels, small vessels also include recreational power vessels, sailboats, commercial fishing vessels, sports fishing vessels and kayaks (Hermannsen et al., 2019). By contrast, large vessels include tankers, bulk carriers, container ships, cruise ships, and ferries. Unlike large vessels, small vessels are more difficult to study due to unpredictability in their movement patterns and non-mandatory position reporting (David et al., 2011; Guzman et al., 2013; Coomber et al., 2016). Vessel-satellite monitoring systems such as Automatic Identification Systems (AIS) allow for the traceability of large vessels through movement patterns. The International Maritime Organization (IMO) requires AIS to be on all passenger vessels and vessels over 299 gross tonnes (International Maritime Organization, 2014). This method of monitoring allows for detailed schemes to identify and manage where large vessels might pose risk to, or overlap with, cetacean habitat. However, a lack of mandatory position reporting on small vessels leads to data-deficiency in small vessel movement, particularly in the presence of cetaceans. This is concerning as over the past several decades, small vessel traffic has steadily

increased in coastal inland waters around the world (Pine et al., 2016). As such, the management of whale watching requires unique measures and different monitoring methods.

3.0 Global Whale Watching Management Measures

There is presently a range of measures used to manage both recreational and commercial whale watching. According to a 2012 global review on whale watching management, there were 22 jurisdictions with regulations, 15 with codes of conduct, 53 with voluntary guidelines, 4 with decrees and 9 with guidelines for operators (Carlson, 2012). Currently, the two most commonly applied management measures are voluntary guidelines and mandatory regulations. Within these management measures, specific tools are employed including the commission of minimum vessel approach distances, vessel speed reductions, spatial restrictions, and limitations for numbers of vessels and time spent viewing (Duprey et al., 2008; Wiley et al., 2008; Kessler & Harcourt, 2013; Seely et al., 2017). However, there are advantages and limitations associated with both management approaches and their associated tools.

3.1 Voluntary guidelines

Voluntary guidelines are defined as general rules but are unenforceable by a governing body. They are often adopted because of the relatively low costs, time efficiency, and ease of adaptability to emerging best practices (Duprey et al., 2008; Wiley et al., 2008; Giles & Koski, 2012). For example, in Kaikoura, New Zealand, a voluntary practice to limit vessel disturbances was created collaboratively between the New Zealand Department of Conservation and ecotourism companies. The guideline suggests a two hour ‘rest period’ for dusky dolphins during which time vessels are requested to cease interactions with dolphins in order to provide vessel-free periods for dolphins (Duprey et al., 2008). In Massachusetts, U.S.A., voluntary guidelines were also fashioned in collaboration with government agencies and ecotourism companies which recommended vessel

speeds, distances to cetaceans and appropriate vessel approach behaviours to cetaceans (Wiley et al., 2008). Despite the ease of implementation, the voluntary nature of guidelines may result in a lack of regulation and enforceability, which can then lead to a lack of incentive for vessels to comply (Wiley et al., 2008).

3.2 Mandatory regulations

Mandatory regulations commonly materialize in nations that have sizeable commercial whale watching industries. For instance, the Australian government created minimum vessel approach distances, acceptable vessel approach behaviours and limited the number of vessels viewing cetaceans at any given time to three. These regulations also stipulate a mandatory 100-metre minimum approach distance to humpback whales, and a 300-metre minimum viewing distance for humpbacks mother and calf pairs (Kessler & Harcourt, 2013). Further, vessels are required to vacate the area if an animal exhibits visible signs of disturbance. A noticeable advantage of mandatory regulations is that they can be legally enforced by a government agency. This allows penalties and fines to be used to discipline non-compliant behaviour. For example, in BC, Canada, a recreational boater in 2012 was fined $7,500 for harassing a pod of killer whales (Stevenson, 2011). Limitations of mandatory regulations are that they can be complex and difficult to understand for the general public (Duprey et al., 2008). These factors can lead to a lack of compliance or general distrust towards government (Gjerdalen & Williams, 2000). Additionally, mandatory regulations suffer from the challenge of rigidity and often lack the ability to easily adapt to align with new research (Duprey et al., 2008). While voluntary guidelines and mandatory regulations exist across numerous jurisdictions, compliance with these measures is often either highly variable or entirely unknown (Arias, 2015; Bragagnolo et al., 2017).

3.3 Compliance with whale watching management measures

Compliance with whale watching regulations is a key component of ascertaining the performance of management measures. However, studies focused on whale watching have routinely found low levels of compliance with regulations and guidelines (Duprey et al., 2008; Wiley et al., 2008; Kessler & Harcourt, 2013; Sitar et al., 2016). For example, Kessler and Harcourt (2013) examined small vessel compliance with regulations around humpback whales off Sydney, Australia and observed low overall compliance with all regulations tested. Wiley et al., (2008) found only moderate compliance (74-88%) with voluntary speed restrictions around humpback whales in Massachusetts, U.S.A. In Bocas del Toro, Panama, bottlenose dolphin (*Tursiops truncatus*) watching received attention from the IWC due to concerning vessel behaviour. In response, the Panamanian government enacted several regulations including a 100-metre minimum distance requirement, a 30-minute maximum observation time, and limitations to the number of vessels viewing cetaceans at once (Sitar et al., 2016). Despite these requirements, the authors found only 55% of vessels were observed to comply to the permitted number of vessels and 71% of vessels were closer with bottlenose dolphins than the minimum approach distance. As such, despite the implementation of management measures, vessel compliance is not necessarily assumed.

3.4 Potential drivers of non-compliance

An understanding of what drivers predict non-compliant behaviour in whale watching users is necessary to direct case-specific management efforts. Correlates such as vessel type, education and knowledge of regulations, temporal factors, number of vessels, and visitor expectations onboard commercial whale watching vessels have been seen to influence non-compliance rates (Duprey et al., 2008; Wiley et al., 2008; Kessler & Harcourt, 2013; Sitar et al., 2016; Malcom et

al., 2017). Non-compliance may be influenced by multiple drivers simultaneously and additional drivers unspecified above are also possible given the relatively little research in this field.

3.4.1 Vessel type

Substantial discrepancies in compliance rates in relation to vessel type have been documented. For example, Seely et al., (2017) found that recreational vessels were much more likely to violate regulations around southern resident killer whales in Washington State, U.S.A. than commercial whale watching vessels. The authors offered that this was likely due to recreational boaters being unaware of cetaceans in the area while transiting, and an overall unfamiliarity with guidelines and regulations (Seely et al., 2017). Further, in Kaikoura, New Zealand, the sole dolphin watching tourism company in the area was one hundred percent compliant with all voluntary guidelines, while recreational vessels and other commercial operators who principally targeted other species were much less compliant (Duprey et al., 2008). Higher commercial compliance for whale watching is seen to be related to two factors: the incentive to comply to help ensure the success and longevity of their business through the preservation of species, and avoiding fines and negative media (Duprey et al., 2008; Kessler & Harcourt, 2013). However, commercial vessels often cumulatively comprise the largest presence around cetaceans and therefore inherently contribute to impacts (Lusseau, 2004; Meissner et al., 2015; Senigaglia et al., 2016).

3.4.2 Temporal trends

Temporal trends in compliance rates is another important driver for ascertaining compliance. For instance, Kessler & Harcourt, (2013) found more vessel encounters and violations of regulations around humpback whales on weekends in Sydney, Australia compared to weekdays.

Weekends are also generally more popular for recreational boating which leads to the potential for heightened encounters, and subsequently non-compliance (Duprey et al., 2008). However, scaled to daily presence, commercial vessels may be more likely to spend longer periods viewing cetaceans (Jelinski et al., 2002) which is an important consideration for assessing cumulative presence or compliance with regulatory time limitations. Information from when non-compliant encounters are more likely to occur can aid policymakers in identifying how to best allocate monitoring and (sometimes limited) enforcement resources (i.e. by day of week, times of day) (Duprey et al., 2008; Parson, 2012).

3.4.3 Customer satisfaction

Social pressures, such as satisfaction by customers, onboard commercial whale watching vessels can drive non-compliant behaviour. Satisfaction can be defined as when expectations and outcomes align (Dann, 1981). If the desired outcome is not achieved (i.e. not seeing a particular cetacean species or behaviour on a tour), a reduction in passenger satisfaction may occur (Bentz et al., 2016). Certain expectations have the potential to increase pressure on vessel captains to infract in order to satisfy their customers, ensuring they receive good customer reviews, and increasing gratuities (Malcolm et al., 2017). For instance, a study in Puerto Vallarta, Mexico found that the number of whales seen by customers and the proximity of whales to boats influenced customer satisfaction (Malcolm et al., 2017). Expectations for whale watching passengers is therefore an important driver to consider when assessing why non-compliance with regulations and guidelines may occur (Valentine et al., 2004; Bentz et al., 2016).

4. History and Development of Whale Watching Management Measures in the Salish Sea

Since the early 1980's the Salish Sea, a transboundary body of water that encompasses both BC, Canada and Washington State (WA), U.S.A. (Figure 1.1), has been a prominent area for both commercial and recreational whale watching (Duffus & Dearden, 1993). The industry has seen substantial growth over the past several decades and in 2012, over 530,000 people encountered cetaceans from a vessel in the Salish Sea. Moreover, visitor volume is increasing annually (Giles & Koski, 2012). Communities, such as Victoria, Vancouver and the San Juan Islands, have long-established commercial whale watching industries, with an estimated 93 commercial whale watching vessels operating in the region in 2015 (Seely et al., 2017). By 2015, the industry was estimated to have generated a revenue of US$40 to 50 million (Seely et al., 2017). The two main species that are viewed in the area are killer whales (Bigg's [transient] and southern resident ecotypes) and humpback whales. Although considered the same species, southern resident and Bigg's killer whales are distinct ecotypes that differ in their behavior, genetics, prey selection and ecology (Ford & Ellis, 2006).

Due to the increasing popularity of commercial and recreational whale watching, both Canadian and American governments began developing whale watching regulations in the 1970s. The broadly defined goals of these regulations were to reduce impacts on cetaceans from vessels, manage vessel traffic around cetaceans, create a safe environment for boaters and cetaceans (i.e. to avoid collisions) and aid in sustaining a long-term whale watching industry (Malcolm, 2003; Stevenson, 2011). In addition to mandatory regulations, numerous voluntary guidelines with similar goals were also created by non-governmental groups. Since the inception of these regulations and guidelines, numerous adaptations and iterations have occurred to aim to achieve these goals.

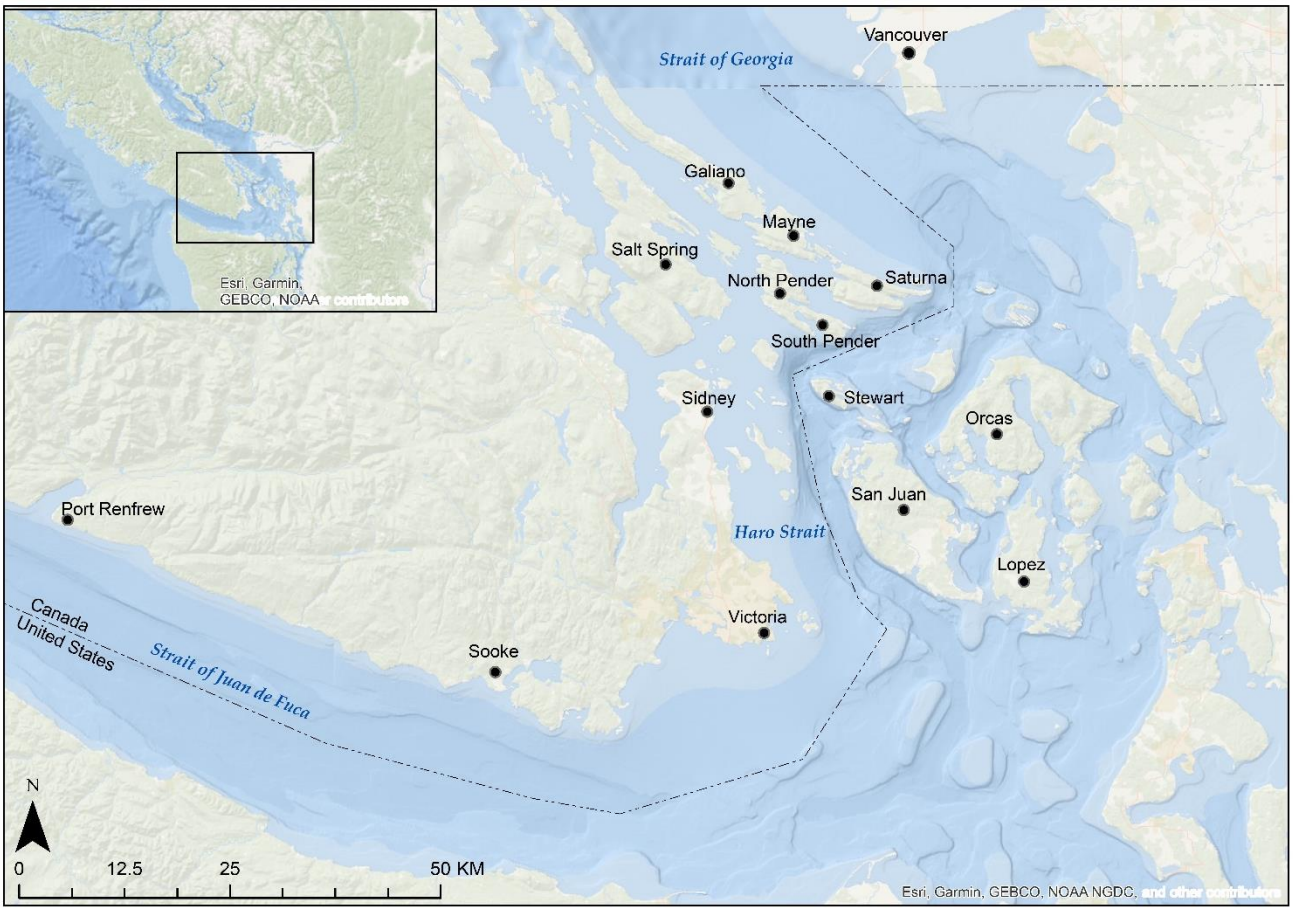

Figure 1.1. Study area map of the Salish Sea. This map used NAD 1983 UTM 10 coordinate system and Transverse Mercator projection

4.1 U.S. regulations in the Salish Sea

The U.S. federal government created the marine mammal protection act (MMPA) in 1972 to protect all marine mammals from being "hunt[ed], harass[ed], capture[d], or kill[ed]" in response to growing concern over the conservation of these taxa (National Oceanic and Atmospheric Administration, 2019). However, the enactment of the original iteration of the act only highlighted potential impacts from vessels but excluded regulation for viewing marine mammals (Giles & Koski, 2012; National Oceanic and Atmospheric Administration, 2019). Following the MMPA, the U.S. Fish and Wildlife Service enacted the Endangered Species Act (ESA) in 1973 to protect all endangered or threatened species by prohibiting the "take" of species

listed under the act (U.S. Fish and Wildlife Service, 2020). The implementations of these acts were crucial for the protection of whales as they were the first legal steps to protect species from anthropogenic activities.

The first major milestone for U.S. whale watching regulations specific to the Salish Sea was in 2007 when San Juan County, WA implemented a mandatory 100-yard minimum approach distance around killer whales (San Juan County, 2007). This local regulation was implemented for the protection of southern resident killer whales (listed as endangered under the ESA in 2005) as the waters around San Juan County are an important feeding area (San Juan County, 2007). WA State followed suit in 2008 by enacting a 300-foot (100-yard) minimum approach distance around southern resident killer whales (Giles, 2014). Subsequently, in 2011, the National Oceanic and Atmospheric Administration (NOAA) implemented a mandatory 200-yard minimum approach distance around all killer whales and 100-yard distance for other cetaceans, such as humpback whales (Giles & Koski, 2012). In 2019, WA State amended their regulations to increase minimum approach distance by vessels around southern resident killer whales to 300-yards (Washington State Legislature, 2019).

4.2 Canadian regulations in the Salish Sea

Across the border, the Canadian federal government developed the Fisheries Act in 1985 that prohibited the hunting of marine mammals. Later, in 1993, they created the Canadian Marine Mammal Regulations (CMMRs) (Giles & Koski, 2012). The main objectives of the CMMRs were to eliminate the hunting of marine mammals and did not include regulations on small vessels viewing cetaceans (Giles & Koski, 2012; Stevenson, 2011). To address conservation concerns for vulnerable species in 2002, the Species at Risk Act (SARA) was implemented to prohibit activities that could lead to a wildlife species becoming extirpated or extinct (Fisheries and Oceans Canada,

2002). Activities that lead to harassment, killing, disturbance, or capturing wildlife are strictly prohibited under SARA to this day (Fisheries and Oceans Canada, 2002). Several cetacean species found in the Salish Sea are currently listed under SARA including southern resident killer whales (endangered), Bigg's killer whales (threatened) and humpback whales (species of concern) (Fisheries and Oceans Canada, 2007, 2013, 2018).

The initial development of regulations for whale watching began in 2003 with Fisheries and Oceans Canada (DFO) proposing an amendment to CMMRs. However, these developments were short-lived and abandoned in 2005. It was not until 2012 that the regulations were once again brought forward and this time included the enactment of a mandatory 100-metre minimum approach distance to all cetaceans in Canadian waters (Giles & Koski, 2012). In 2018, the DFO announced new amendments to the CMMRs stating that all vessels must stay 200 metres away from all killer whales and 100-metres away from other marine mammals, such as pinnipeds and other cetaceans (Fisheries and Oceans Canada, 2018). This amendment ultimately allowed for marine mammal distance viewing regulations to nearly align with American regulations. However, regulations specific to killer whales were again short-lived and amended in 2019. Vessels viewing killer whales in southern resident killer whale critical habitat (i.e. the Salish Sea) must not approach closer than 400 metres from June 1st-October 31st. However, an exception was given to commercial whale watching vessels by allowing them to view Bigg's killer whales at 200 metres (Fisheries and Oceans Canada, 2019).

In addition to marine mammal distance regulations, the Canadian government in conjunction with BC's provincial government have added a number of spatial and seasonal vessel regulations. For example, BC's Ministry of Environment states that vessels may not enter Race Rocks Ecological Reserve at any time when cetaceans are present (BC Parks, n.d.). Further, in

2019, Transport Canada introduced interim sanctuary zones around the east coast of Saturna Island, south-west of North Pender Island and Swiftsure Bank from June 1st- October 31st. These zones stipulate that all vessels (with some exceptions) are prohibited from entering the controlled areas (Fisheries and Oceans Canada, 2019). Cumulatively, these areas are designated with the intent of providing refuge for cetaceans, yet neither the compliance nor the effectiveness of these spatial and seasonal regulations are presently known.

4.3 Voluntary guidelines in the Salish Sea

Historically, the lack of mandatory regulations in the Salish Sea in conjunction with whale watching being under immense public scrutiny led to non-governmental organizations (NGOs) fashioning voluntary guidelines. In 2002, the Canadian and American governments, along with the NGOs Soundwatch Boater Education Program, and the Pacific Whale Watching Association (PWWA [representing operators within the commercial whale watching industry]), created the Be Whale Wise (BWW) voluntary guidelines (Figure 1.2) (Stevenson, 2011; Giles & Koski, 2012). These guidelines outline recommended cetacean viewing practices for vessels in Canadian and American waters to follow. In its inception, BWW suggested vessels slow down to less than 7 knots within 400 metres of cetaceans, stay at least 100 metres away from all cetaceans, limit viewing time to 30 minutes and to not feed, touch or swim with marine mammals (Be Whale Wise, 2019). BWW guidelines have been amended several times to match shifting American and Canadian mandatory regulations (Stevenson, 2011).

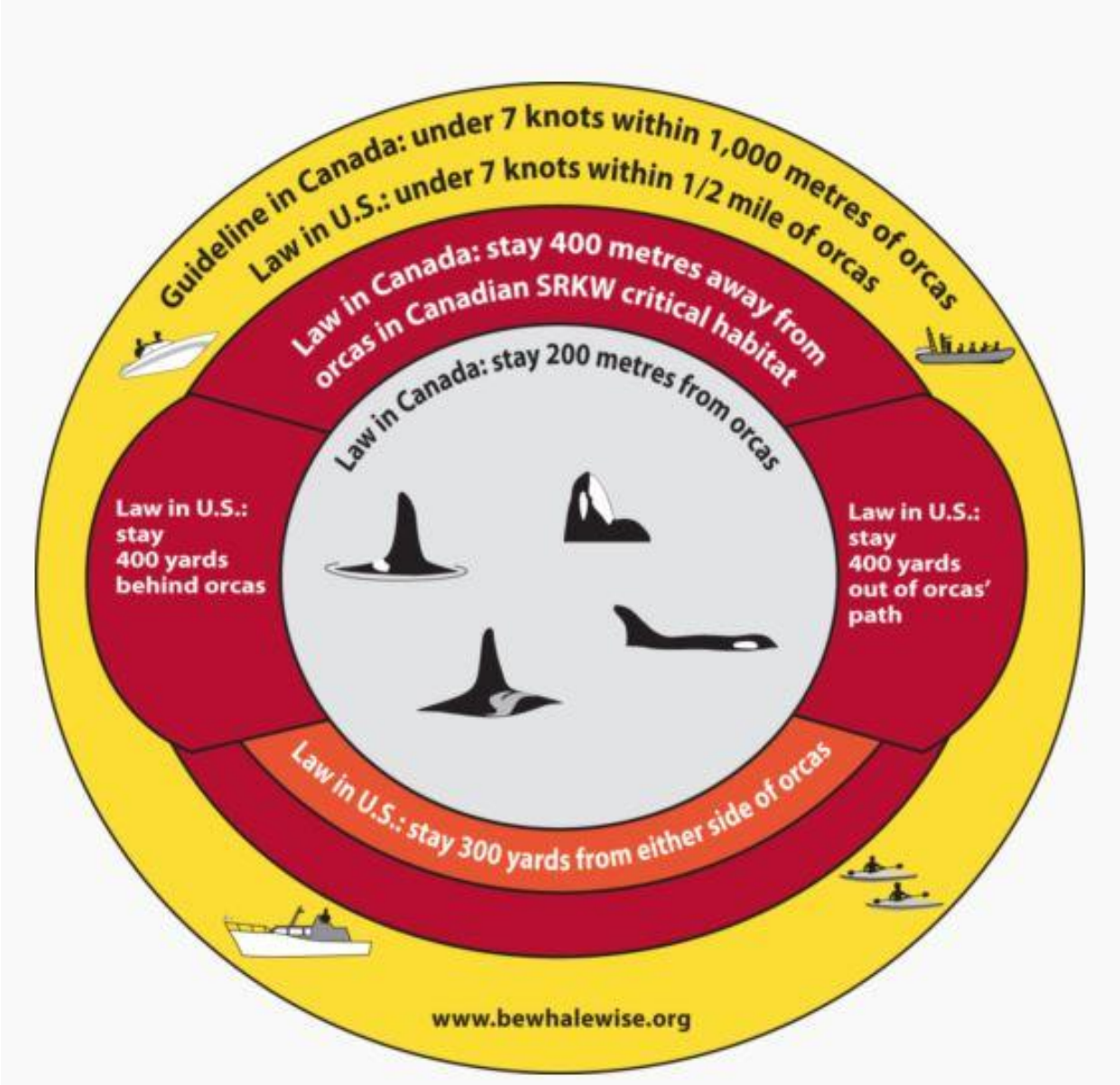

Figure 1.2. Be Whale Wise voluntary guidelines for cetacean viewing in the Salish Sea, updated in 2019. Reprinted [or adapted] from Federal Regulations, *Be Whale Wise*, n.d., Retrieved June 25th, 2020, from https://www.bewhalewise.org/federal-regulations/

The PWWA have similarly adopted their own set of voluntary guidelines, drawn from the BWW guidelines and mandatory Canadian and U.S. regulations. These guidelines suggest that vessels slow down to 7 knots within 1 kilometre of cetaceans, limit viewing time to 60 minutes,

limit vessel viewing to 30 minutes if there are more than 10 PWWA vessels present (out of an estimated 57 Canadian and 36 U.S. members in 2015; Seely et al., 2017), and not approach closer than 200 metres/yards from killer whales and 100 metres/yards to other cetaceans, depending on whether vessels are in Canadian or American waters (Pacific Whale Watching Association, n.d). The biggest difference between the PWWA guidelines compared to BWW guidelines is that they introduced a vessel limit around cetaceans.

Lastly, the Washington Department of Fish and Wildlife (WDFW) also created voluntary guidelines in 2018. They suggested a voluntary quarter-mile vessel "no go zone" on the west side of San Juan Island and half-mile off Lime Kiln Lighthouse, in an attempt to minimize vessel disturbance and presence around southern resident killer whales (Washington Department of Fish and Wildlife, 2018). The rationale behind this voluntary management measure was that the west side of San Juan is recognized as critical foraging habitat for this ecotype (Giles & Koski, 2012; Washington Department of Fish and Wildlife, 2018).

To conserve vulnerable species, information regarding the mitigation of their threats is critical (Parson, 2012). It is clear that managers in the Salish Sea have been active at creating and amending a suite of measures. However, despite the array of regulations and guidelines in the Salish Sea, the effectiveness of these measures is relatively unknown. Further, the totality of these measures may become convoluted and confusing. Therefore, more research is needed to examine how and why compliance might vary. This can ultimately help managers and policymakers reflect on the performance of implemented measures and lead to amendments or the constructive use of resources.

5. Conclusion

Although there has been a shift in paradigms in human-wildlife engagement, the recognition of impacts from non-consumptive activities is now well-established. Whale watching is a key instance of one such activity where anthropogenic presence can be a stressor on wildlife. This increasingly prominent activity, engaged in by both commercial operators and recreational boaters, is garnering more attention by researchers, marine managers and the general public. As a response, various governments, stakeholders and industry partners have been increasingly interested in the development and amendment of measures that can help promote more sustainable whale watching practices, while mitigating threats to cetaceans.

The purpose of this chapter was to provide an overview of the development of whale watching, its associated impacts and historical and current management schemes through the contextual lens of evolving human and wildlife interactions. Against this background, the growth of whale watching was then highlighted and an array of management measures was detailed. This then set the stage for the consideration of the respective advantages and limitations of guidelines and regulations, while considering that measures do not necessarily equate to compliance and are influenced by various external factors. Finally, a comprehensive review on the Salish Sea, as a notable region for whale watching, demonstrated a case where management of whale watching is a top priority.

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Chapter 2: Spatial and vessel type patterns of compliance with distance regulations: small boats, humpback, and killer whales in the Salish Sea

Abstract

To support optimal monitoring and enforcement investment, management aimed at minimizing disturbance to wildlife requires an understanding of how regulatory compliance might vary spatially as well as across species and human-user groups. In the Salish Sea, humpback whales (Megaptera novaeangliae) and two ecotypes (southern resident and Bigg's) of killer whales (Orcinus orca) now interact with a large and growing number of small commercial and recreational vessels that partake in whale watching. Those vessels often approach close to cetaceans and thus pose risk via collision, marine noise and pollution, exposure to which may result in disturbance, injury and death. The primary management tool for mitigating impacts is minimum distance regulations. Compliance, however, is poorly understood. We examined commercial and recreational small vessel compliance with viewing distances across two seasons (June-September, 2018 and 2019) in over ≈404 hours of on-water observation. Overall vessel compliance was nearly 80%, but several distinct patterns emerged. Recreational boats were significantly more likely to violate distance regulations and boaters were more likely to be non-compliant around killer whales. Compliance did not vary with day of week or time of day. Spatially, non-compliance was concentrated in waters closer to coastal communities. Collectively, these patterns suggest that optimal enforcement could be targeted to identify areas of high non-compliance, especially for killer whales, with effort spread across days and times. Finally, we discuss how investments in education could target recreational boaters at a time when multiple and interacting stressors are accumulating in the Salish Sea.

1. Introduction

Non-consumptive encounters with wildlife can impose harm. Accordingly, regulations to manage human-wildlife encounters are now common, applied not only to hunting and fishing (Arias, 2015; Bragagnolo et al., 2017) but also outdoor recreation (Schlacher et al., 2013; Fortin et al., 2016) and wildlife viewing (Duffus & Dearden, 1990; Smith et al., 2010). The efficacy of regulation, however, scales to compliance. Inadequate compliance can result in adverse impacts (Orams, 2002; Worm et al., 2009; Campbell et al., 2012). Therefore, effective management requires an understanding of what contexts predict compliance as well as potential correlates (Cross et al., 2013; Abrams et al., 2020). Research has emphasized the need to consider human behaviour. For example, people might vary in motivations and expectations (Gore, 2011, Pieraccini et al., 2016). Similarly, social acceptability of non-compliance may vary (Jones, 2010; Thomassin et al., 2010), as can knowledge of regulations (Garcia-Cegarra & Pacheco, 2017). Accordingly, managers require knowledge about who engages in non-compliant behaviour, as well as where and when it occurs.

Understanding compliance is particularly important within marine systems, where human and wildlife encounters are frequent, complex and often poorly understood. Marine vessel activity, which has steadily increased in coastal waters around the world (Pine et al., 2016) often overlaps with wildlife habitat. The whale watching industry has become increasingly popular; in 2008, the global commercial whale watching sector earned $US2.1 billion (Chalcobsky et al., 2017). In addition to commercial whale watching, recreational vessels such as sailboats, fishing (including charter) boats and kayaks also opportunistically watch cetaceans (Seely et al., 2017; Montes et al., 2018). Collectively, this presence increases the likelihood of whale-vessel encounters.

Encounters between vessels and cetaceans can potentially result in a variety of negative impacts. These include ship strikes (lethal and non-lethal; Conn & Silber, 2013; Rockwood et al., 2017), exposure to and ingestion of pollutants (Lachmuth et al., 2011), acoustic impacts (chronic and acute; Erbe, 2002; Holt et al., 2009; Houghton et al., 2015; Frankel & Gabrielle, 2017), and physical/behavioural disturbances that might result reduced fitness (Lusseau, 2006; Schuler et al., 2019). Several species of cetaceans such as killer whales (*Orcinus orca)* and humpback whales (*Megaptera novaeangliae)* have exhibited changes in diving and resting patterns (Williams et al., 2002; Clemente et al., 2018), social behaviours (Noren et al., 2009; Schuler et al., 2019), communication (Jensen et al., 2009; Holt et al., 2009; Houghton et al., 2015) and foraging patterns (Williams et al., 2006; Lusseau et al., 2009; Christiansen et al., 2013) in the presence of vessels. These short-term impacts may lead to increased energetic costs, with chronic or repeated exposure to vessels having the potential to lead to long-term population-level effects (Bejder et al., 2006; Stensland & Bergren, 2007; New et al., 2015).

Given such potential impacts, management often aims to reduce stressors associated with vessel movement in important cetacean areas. Common measures include minimum approach distances, limits to the number of vessels, restrictions on vessel positioning, and restrictions to speed (Wiley et al., 2008; Kessler & Harcourt, 2013; Sitar et al., 2016; Mallard, 2019). Across these management approaches studies have generally identified high levels of non-compliance (Wiley et al., 2008; Sitar et al., 2016; Seely et al., 2017). Examining vessel distance is particularly important because related distance regulations are considered a key approach to minimizing impacts (Williams et al., 2002; Stamation et al., 2010).

Compliance is especially important in areas that host endangered and at-risk cetaceans, such as the Salish Sea. This waterbody comprises the Strait of Georgia, the Juan de Fuca Strait,

Haro Strait, and Puget Sound, and straddles the boundary line between British Columbia, Canada, and Washington State, U.S.A. (Giles & Koski, 2012; Seely et al., 2017). Killer whales (KWs) (both southern resident [SRKWs] and Bigg's [BKWs] ecotypes) and humpback whales (HWs) are two common cetacean species to frequent the area and are listed under the Canadian Species at Risk Act (SARA) and U.S. Endangered Species Act. In addition, the Salish Sea has been designated as critical habitat for the SRKWs (Fisheries and Oceans Canada, 2018) and is increasingly used by BKWs - now widely recognised as forming part of the key habitat for many individuals in this population (Ford et al., 2013; Shields et al., 2018). Impacts associated with vessel activity have been recognised as key threats to the recovery of both species (Fisheries and Oceans Canada, 2007; Fisheries and Oceans Canada, 2013; Fisheries and Oceans Canada, 2018; National Oceanic and Atmospheric Administration, 1991; National Oceanic and Atmospheric Administration, 2008). Accordingly, mandatory marine mammal distance regulations (MMDRs) have been imposed in the Salish Sea. MMDRs have varied from 100 and 400 metres, depending on year, species, jurisdiction and vessel type (Appendix, Table A.1).

Despite the increasing potential for vessel-whale encounters and recent amendments to regulations, there has been little examination of vessel compliance in the Salish Sea. Seely et al., (2017), for example, estimated that over 500,000 people annually interact with cetaceans via either commercial or "recreational" (i.e. powerboats, sailboats, fishing vessels, kayaks) whale watching vessels in the Salish Sea and that these numbers are increasing. Accordingly, the objectives of this study were to: (1) estimate the level of compliance with MMDRs, (2) identify potential correlates of compliance (e.g. species involved, vessel type [commercial and recreational]) and (3) examine temporal and spatial variation in compliance. We conclude by offering evidence-based recommendations for management related to enforcement and education.

2.0 Methods

2.1 Data Collection

We collected data aboard a commercial whale watching vessel departing from Victoria, British Columbia, Canada. Data were collected from June 17th to September 3rd, 2018, and from June 1st to September 2nd, 2019, which totalled 101 trips (≈404 hours). Multiple encounters were possible per trip. We observed 784 encounters with cetaceans, 198 of which related to the vessel upon which observations were made (with knowledge of captain and crew). To determine if vessels complied with MMDRs, we used a handheld GPS and laser range-finding binoculars (Safran, Vector 21) to measure vessel position and their respective distances to KWs and HWs. The binoculars included a digital compass, which gave the azimuth (bearing), and range-finder to estimate distance with 5-metre accuracy. To estimate positions of other vessels and whales, we used the bearing and distance from the research vessel. Individual vessel identification was not recorded but vessels were broadly grouped as either commercial or recreational whale watching. Finally, we tested whether the vessel aboard which observations were made (also a commercial whale watching vessel) differed in compliance with other commercial vessels. Sampling was designed to examine potential variation in compliance. Data were collected once per day (on weekdays and weekends), either on the morning (10:00) or afternoon (15:00) tours, with each lasting approximately 4 hours. Data collection alternated between mornings and afternoons and only occurred when weather and visibility allowed for distance measurements. We defined a vessel-whale encounter as the period in which a vessel (including the research vessel) appeared to be actively watching whales (i.e., as a focal point for vessel attention) within 500 metres, a distance over which vessel characteristics could be reliably measured. If the research vessel was present longer than 20 minutes, we recorded all vessel distances to cetaceans a second time, which

represented a new encounter. When measuring distances to multiple cetaceans, a focal individual was selected; for KWs, this was the individual with the most identifiable saddle patch or dorsal fin. For HWs, the closest individual to the researcher's position was selected. Accounting for imprecision in range-finding, we defined non-compliance as a vessel at a distance more than 5m closer than the MMDRs. The study area had multiple MMDRs that varied by year, species, and jurisdiction (Appendix, Table A.1).

2.2 Analysis

We evaluated how compliance might vary across a number of contexts. To determine the potential influence of vessel type, species, weekdays vs weekends, and morning vs afternoon, we used nonparametric Kruskal-Wallis tests in RStudio (Version 1.2.1335 – © 2009–2019 RStudio, Inc). BKWs and SRKWs were grouped together due to relatively few encounters of SRKWs (n = 60). By scaling the varied regulations across years and jurisdictions (both Canadian and U.S. waters), we estimated compliance for the entire period. Vessel positions were plotted in ArcMap 10.1 with NAD 1983 UTM 10 coordinate system and Transverse Mercator projection. We used the kernel density tool to produce kernel density estimations (KDE) for pattern visualization of vessel non-compliance using a cell size of 342.756 and the default bandwidth (Sveegaard et al., 2010; Cai et al., 2013).

3.0 Results

Compliance rates were moderate and varied in several important ways. Overall compliance over the period was 79.9% (n = 625 of 784 encounters) and did not differ significantly between years, morning vs afternoons or weekdays vs weekends (Table 2.1). Among all vessels pooled, non-compliance was more frequent with KWs than HWs (n = 118 of 159 non-compliant

encounters; Kruskal-Wallis, P = 0.007; Table 2.1). Pooled across years, commercial vessels were non-compliant more frequently than recreational vessels (n = 115 of 159 non-compliant encounters Kruskal-Wallis, P = < 0.001). However, when scaled to encounter rate, 18.6% of commercial whale watching encounters around KWs and 14.4% around HWs were non-compliant, while recreational vessels did not comply with MMDRs during 45.5% of encounters with KWs and 20% with HWs (Table 2.1). Vessel distances in relation to MMDR thresholds also differed; recreational vessels on average approached closer around both species (μ = 20.2m to minimum distance) and KWs (μ = -3.08m past minimum distance) than commercial vessels (μ = 94.4m, μ = 84.7m, respectively; Fig. 2.1). Recreational vessels also showed higher variation in distance around both species (SD = 181; CV = 8.96%) and KWs (SD =175; CV = 56.82%) than commercial vessels (SD = 113; CV = 1.20%; SD= 111; CV = 1.31%, respectively). After pooling years and species, we found no evidence for a significant difference in compliance between the research vessel and other commercial whale watching vessels (Kruskal-Wallis, P = 0.72, Appendix A, Table A.2). Accordingly, we retained data on compliance from all sources in analyses.

Variable	Killer whales (KWs)		Humpback whales (HWs)		Both Species	
Encounters						
2018	246		115		361	
2019	260		163		423	
Total	506		278		784	
Non-compliant encounters						
2018 **(**P = 0.090)	58		19		77	
2019 **(P = 0.015)**	60		22		82	
Total **(P = 0.007)**	118		41		159	
2018 non-compliant encounters	#	%	#	%	#	%
Vessel type **(P < 0.001)**						
Commercial	41	70.7	19	100.0	60	77.9
Recreational	17	29.3	0	0.0	17	22.1
Vessel type (scaled for encounter rate)						
Commercial	41	20.0	19	16.8	60	18.9
Recreational	17	42.5	0	0.0	17	40.5
Day of week (P = 0.300)						
Weekday	32	55.2	12	54.5	44	57.1
Weekend	26	44.8	7	45.5	33	42.9
Time of day (P = 0.083)						
Morning	27	46.6	12	63.2	39	50.6
Afternoon	31	53.4	7	36.8	38	49.4
2019 non-compliant encounters						
Vessel type **(P < 0.001)**						
Commercial	36	60	19	86.4	55	67.1
Recreational	24	40	3	13.6	27	32.9
Vessel type (scaled for encounter rate)						
Commercial	36	17.1	19	12.7	55	15.3
Recreational	24	48.0	3	23.1	27	42.9
Day of week (P = 0.475)						
Weekday	34	56.7	12	54.5	44	55.0

Weekend	26	43.3	10	45.5	36	45.0
Time of day (P = 0.641)						
Morning	40	66.7	22	100.0	62	75.6
Afternoon	20	33.3	0	0.0	20	24.4
2018/2019 combined non-compliant encounters						
Vessel type **(P < 0.001)**						
Commercial	77	65.3	38	92.7	115	72.3
Recreational	41	34.7	3	7.3	44	27.7
Vessel type (scaled for encounter rate)						
Commercial	77	18.6	38	14.4	115	18.9
Recreational	41	45.5	3	20.0785	44	41.9
Day of week (P = 0.896)						
Weekday	66	55.9	24	54.5	90	56.6
Weekend	52	44.1	17	45.5	69	43.4
Time of Day (P = 0.140)						
Morning	67	56.8	34	82.9	101	63.5
Afternoon	51	43.2	7	17.1	58	36.5

Table 2.1. Percent and frequency of compliance associated with different variables. Bold text identifies significant differences (P < 0.05).

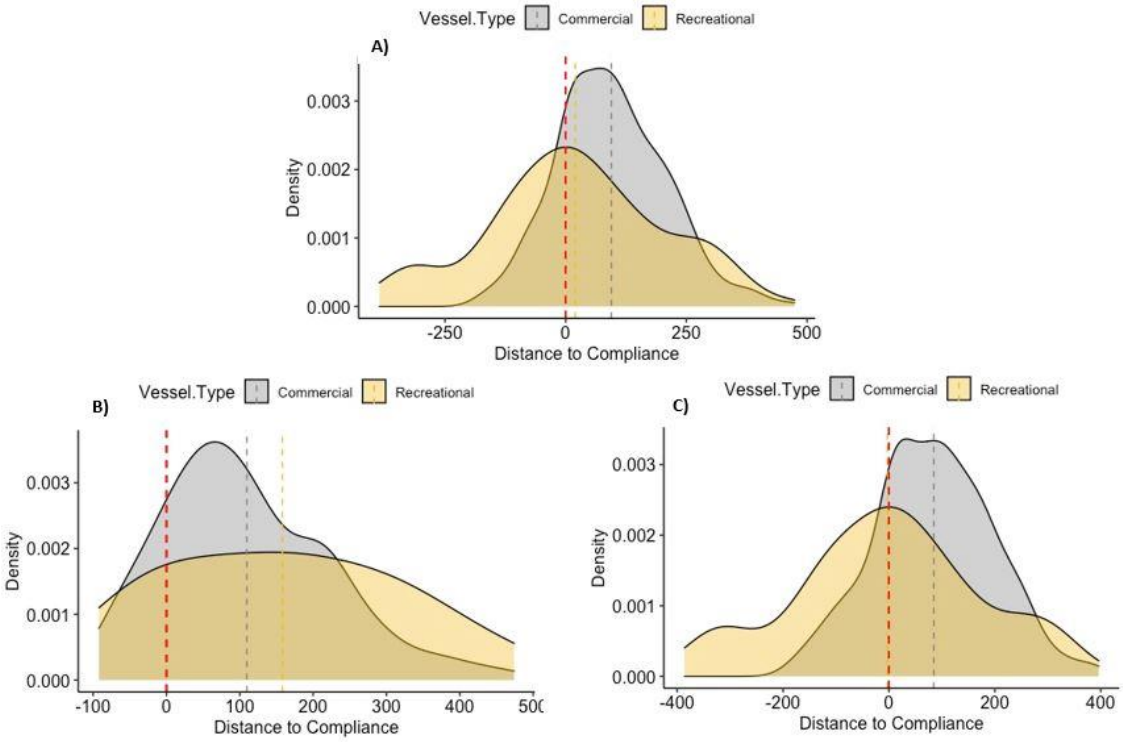

Figure 2.1. (A)Vessel distance in relation to Marine Mammal Distance Regulations (MMDRs) around killer whales and humpback whales; (B) around humpback whales, and (C) killer whales. Positive values are additional distance observed from MMDRs whereas negative values indicate the magnitude of non-compliance. Dashed lines show MMDRs threshold (red), mean distance for commercial (grey) and recreational (yellow) vessels.

Finally, we detected distinct spatial distributions associated with whale-vessel encounters and incidents of non-compliance. Most HW encounters occurred in the Juan de Fuca Strait, whereas KW encounters were more dispersed (Fig. 2.2). Non-compliant encounters around KWs (for all vessel types) clustered near populated areas, such as Victoria, San Juan Island, Sooke, Salt Spring Island and North/South Pender Islands (Fig. 2.2). In contrast, non-compliant encounters around HWs predominantly occurred in the Juan de Fuca Strait (Fig. 2.2).

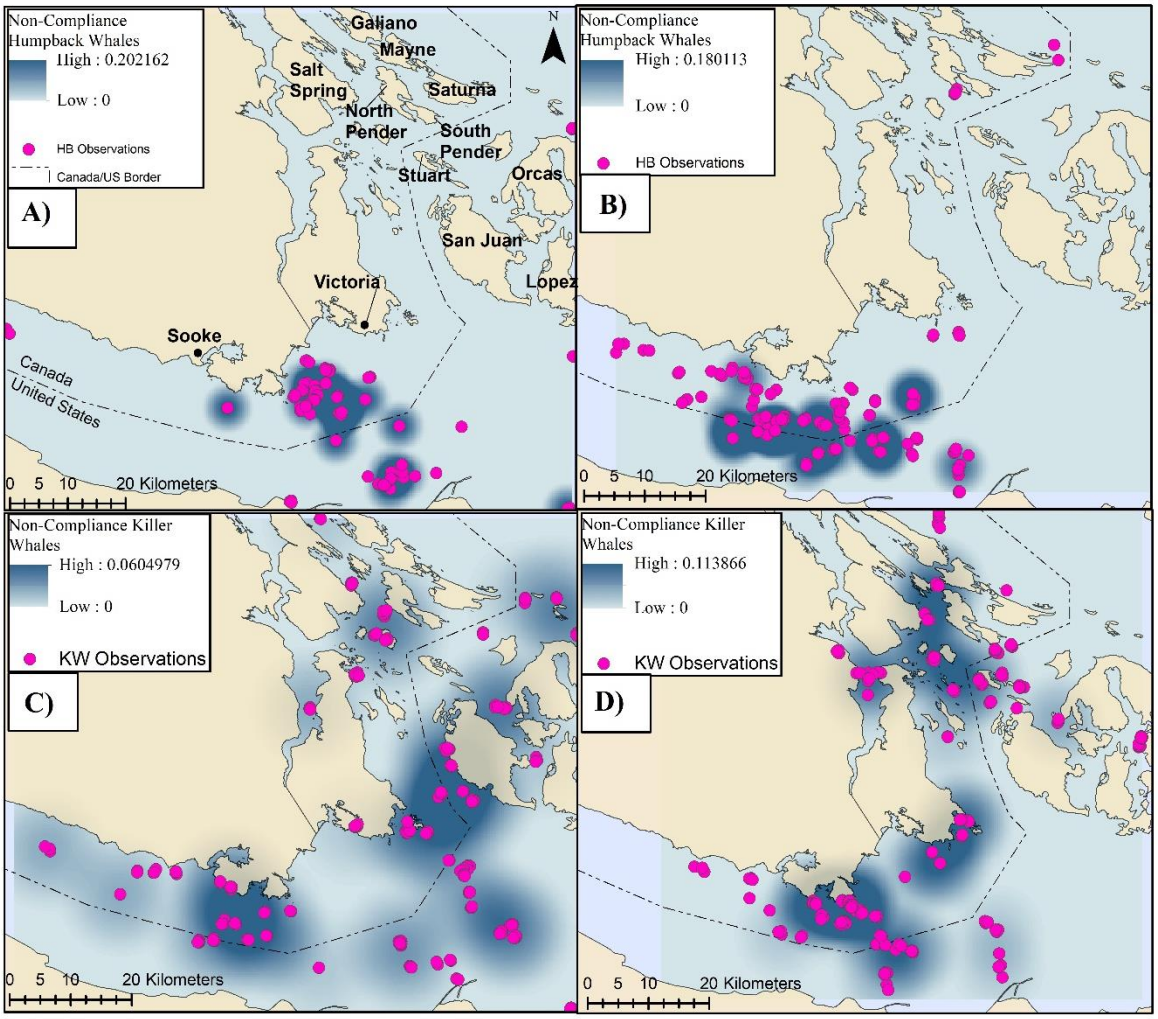

Figure 2.2. Spatial patterns of non-compliant encounters around humpback whales in 2018 (A) and 2019 (B), and around killer whales in 2018 (C) and 2019 (D).

4. Discussion

4.1 Vessel compliance with marine mammal distance regulations in the Salish Sea

Our results revealed distinct patterns in how compliance with MMDRs differed with vessel type, species, and space. Compliance did not differ between 2018 and 2019, despite amendments to MMDRs across years. Recreational vessels were significantly less compliant around KWs. Violations of distance regulations by all vessel types occurred more frequently around KWs than HWs, with distinct spatial variation. We detail below how our findings can inform strategies to

monitor, enforce and educate about MMDRs, and consequently aid in minimizing vessel impacts on cetaceans.

Finding no difference between years allows for inference into management efficacy. This study was conducted during a period when several amendments were made to MMDRs in both the US and Canada (Appendix, Table A.1). Despite these changes, which increased legal viewing distances, the level of compliance remained unaltered. On one hand, and assuming a consistent cohort of boats between years, the fact that non-compliance did not rise with increased legal viewing distances suggests an overall awareness of amendments. On the other hand, commercial operators would be expected to have increased compliance as they have a vested responsibility to follow amendments, and as such, little change in compliance might suggest the opposite. Such a pattern suggests that modifying regulations are likely insufficient without other management means (Duprey et al., 2008).

Compliance was related to vessel type, likely a function of captain knowledge and professional accountability. Commercial whale watching accounted for most encounters. The data, however, might reflect surveys occurring aboard a whale-watching vessel and the popularity of the activity in the area; in 2015 an estimated 93 commercial whale watching vessels operated in the region (Seely et al., 2017). Whereas commercial vessels comprised most non-compliant encounters, once scaled to encounter rate, they were proportionally more compliant with MMDRs than recreational vessels (Table 2.1; Fig. 2.1). Unlike recreationists (including non-whale-watching commercial vessels) who may opportunistically engage in whale watching, commercial whale-watching operators rely on cetaceans to ensure the viability of their businesses and are potentially more incentivized to be compliant (Duprey et al., 2008). However, how compliance

might correlate to shorter-term incentives, such as positive reviews and tips from clients (which might scale positively with approach distance), is currently unknown.

We also found that recreational boats showed greater variation in approach distance. This pattern likely relates to variation across vessel operators in knowledge about regulations, an interpretation supported by other studies (Kessler & Harcourt, 2013; Montes et al., 2018). Seely et al., (2017), for example, surveyed recreational boaters in the Salish Sea and identified that 61% of operators were unaware of MMDRs. Additionally, viewing experience/expectations among both commercial and recreational passengers – which might vary substantially, especially among the latter - could lead to increased pressure on some vessel operators to provide intimate experiences with cetaceans (Orams, 2000; Valentine et al., 2004; Kessler & Harcourt, 2010). This work also provides new insight into how encounters with vessels might differ between species. Most encounters and non-compliant encounters occurred around KWs and average vessel distance to KW MMDRs was smaller (Table 2.1; Fig. 2.1). This demonstrates a potential preference for KW viewing for both recreational and commercial vessel operators. Collectively, this area provides one of the most reliable locations in the world to view this species and commercial operators often focus their marketing efforts on KWs (Giles & Koski, 2012). In addition, commercial whale watching advertising may display whales at close proximity or engaged in particular behaviours (i.e. breaching) (Orams, 2000), which can lead to passenger misperception and dissatisfaction and pressure on captains and crew to deliver these experiences (Ziegler et al., 2012; Malcolm et al., 2017). We suggest marketing adjustments could aid in tempering commercial and recreational whale watching passenger expectations (on preferred species, viewing distances and behaviours). Higher compliance rates around HWs for commercial and recreational operators could be associated with closer allowable distances (Appendix, Table A.1). Regulations governing

distances around HWs in the Salish Sea have not changed since the inception of MMDRs, while several amendments have occurred for KWs. As such, standardized regulations between species could potentially reduce close encounters and promote compliance related to both species.

Understanding which correlates might influence non-compliance can inform decisions for spatial management measures and help prioritise the deployment of monitoring and enforcement resources. We have identified areas with increased frequency of whale-vessel encounters and where non-compliance with MMDRs is higher (Fig. 2.2). The Salish Sea is a substantial area to cover (~17,000km^2; Gaydos & Pearson, 2011); managers could therefore benefit from knowledge to focus efforts on 'high risk' areas (Pennino et al., 2017). Furthermore, given the ability of commercial whale watching vessels to reliably find whales, it is likely that on one hand, the distribution of encounters we documented is broadly representative of HW and KW distribution in this area during summer months. HW sightings were for the most part concentrated within the Juan de Fuca Strait - a primary feeding ground from May to October (Fisheries and Oceans Canada, 2013) and align with a known high degree of site fidelity (Witteveen & Wynee, 2017). By contrast, encounters with KWs showed greater spatial variability, which again aligns with their more mobile spatial ecology (Williams et al., 2009; Ford et al., 2013). Despite this broader distribution, we found that encounters with KWs were more frequently non-compliant near populated coastal communities. On the other hand, encounters may be related to where the research vessel accessed, rather than a reflection of KW and HW spatial distribution relative to proximity to coastal communities.

4.2 Management recommendations

To improve compliance, we recommend greater on-water presence by government enforcement officers. A prior study in the area found that, when enforcement vessels were present,

vessel compliance substantially increased (Seely et al., 2017). However, in 101 days of on-water observations (≈404 hours), we observed government patrol vessels on only three occasions. If resources are limited, we suggest that enforcement be focussed on areas with higher rates of non-compliance, such as Sooke and the Southern Gulf Islands. Additionally, given no temporal pattern in non-compliance, patrols should be conducted throughout the week. We note that our findings and subsequent recommendations differ from other studies that recommended a focus on weekend and holiday enforcement (Duprey et al., 2008; Kessler & Harcourt, 2013). Such contrast highlights the importance of considering site-specific factors that can influence the effectiveness of management measures.

The transboundary nature of some waterways adds complexity. This is especially so when managing mobile stressors and protecting wildlife that does not recognize borders (Thornton et al., 2018). In the Salish Sea, multiple government agencies impose distinct distance regulations for different species, ecotypes and vessel types. Specific details of the varying MMDRs can be confusing, especially for recreational boaters who are generally non-specialists. Uniform regulations may simplify management measures. For instance, the same required distance regulation for all boaters, cetacean-types and jurisdictions could benefit enforcement through reducing ambiguity and confusion. Recreational boaters often use commercial vessels as their guides when viewing cetaceans (Kessler & Harcourt, 2013). Thus, at present, having different distance regulations for the same animals (e.g. 200m for BKWs for commercial operators and 400m for recreational boaters in Canadian waters in 2019; Appendix, Table A.1) could cause recreational boaters to unknowingly infract. Currently, recreational boaters may be able to defend non-compliant behaviour by not knowing the difference between SRKWs and BKWs. In addition, vessels and whales invariably cross the Canada-U.S.A. border. Cross-jurisdictional consistency

would allow for boaters engaged in whale watching to keep the same distance during the same encounter (Seely et al., 2017). Lastly, our recommendation of consistent and integrative MMDRs would allow for simplified educational messaging and materials.

Lower compliance rates by recreational boaters suggests that investments into education could benefit cetaceans. Given lower compliance and higher variation, recreational boaters appear variable but generally less aware of regulations. They might also surmise that, especially with limited visible enforcement, non-compliance will bear little or no consequences. Educational efforts could therefore provide an important means by which to improve vessel conduct around cetaceans. We encourage future examination of how passenger expectations may act as a potential driver for reduced compliance, and whether increased understanding and awareness might counteract this behaviour. Regardless of the reasons, a persistent lack of compliance will ultimately be detrimental to cetaceans (Sitar et al., 2016). Therefore, we add to existing calls by others for greater investment into not only enforcement but also education (Kessler & Harcourt, 2013; Montes et al., 2018). Such investments are important given that threats to cetaceans from multiple stressors are accumulating.

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Conclusion

The overarching goals of managing vessels engaged in whale watching are to mitigate adverse vessel threats to cetaceans. After the implementation of measures, the next step towards achieving effective management becomes the evaluation of compliance and investigation of its associated drivers. Regulations and guidelines risk being ineffective if high levels of compliance are not achieved. In many cases, compliance with whale watching regulations has been shown to be poor or data-deficient (Allen et al., 2007; Higham et al., 2016; Sitar et al., 2016) which ultimately brings into question the validity of said measures.

I began this thesis by navigating through the evolution of human interactions with wildlife from consumptive to non-consumptive activities in Chapter 1. I then considered the increasing popularity of the latter, and in particular, wildlife tourism along with the behavioural influencers guiding this transition. A fundamental example of shifting paradigms in human behaviour is the global transition from exploitative whaling to whale watching. Initially, non-consumptive activities carried the impression of causing no harm to wildlife but with evidence emerging in the past several decades, many have come to doubt these notions (Duffus & Dearden, 1990). Throughout this chapter, I detailed how whale watching has become a representation of a non-consumptive activity that has been proven to cause impacts on cetaceans (Richter et al., 2006; Williams et al., 2006; Holt et al., 2009; Arias et al., 2018). I extensively reviewed whale watching impacts and the corresponding increase in management measures being implemented across jurisdictions spanning the globe. Finally, I used the numerous and complex measures within the Salish Sea as a key case-study to demonstrate the challenges that have recently come to fruition for management interests.

To address the largely data-deficient body of literature that is whale watching regulatory compliance, in Chapter 2, I performed a case-specific investigation. The Salish Sea was chosen as it embodies one of the earliest commercial whale watching industries in the world, and presently sees scores of tourists annually (Seely et al., 2017). In addition, numerous coastal communities around this area brings about a large presence of recreational boating activity (Gray et al., 2011). Using vessel-based observations of commercial and recreational whale watchers, I identified that current distance viewing regulations are moderate and that there were significant factors that influenced non-compliant behaviour. This study addressed challenges including the Salish Sea being spatially vast (~17,000km^2; Gaydos & Pearson, 2011), transboundary, involving varied species and vessels, and gauging compliance with numerous guidelines and regulations.

Future considerations

The majority of research in the Salish Sea has focused on southern resident killer whales, in part due to their conservation status, chronicled presence and recent worldwide media attention. This study provided new insight on vessel encounters with not only southern resident killer whales, but also humpback whales and Bigg's killer whales, which have seen far less research attention. A 2-year study allowed for inference into compliance across years during a period where amendments occurred, yet no amelioration of compliance was Moreover, drivers of non-compliance were statistically related to vessel-type and species-type, while spatial patterns were also observed and visualized near coastal communities. Finally, temporal patterns were analyzed but yielded no significant differences across various time frames, a considerable incongruity with other well-cited literature (Duprey et al., 2008; Kessler & Harcourt, 2013).

Collectively, this body of work demonstrates the complexities of managing non-consumptive activities targeting mobile marine species, the recognition that implementations of

management measures are insufficient on their own and the necessary task of considering a variety of site-specific correlates. This study provides in-depth findings on distance regulations as one of the most commonly used management tools currently deployed to manage vessel activities around whales. However, future expansion of this research into compliance with other regulations and guidelines (i.e. Be Whale Wise, Pacific Whale Watch Association), such as speed and time limitations and spatially restricted vessel zones, could be considered. Complementary studies could explore passenger (commercial and recreational) expectations and satisfaction and how it might scale with vessel behaviour and non-compliance. A propensity for killer whale viewing was highlighted in this study, as demonstrated through more vessel encounters compared to humpback whales and not necessarily related to species presence within the study area. As such, passenger perspectives exploring species bias would be highly meaningful for managers.

This research contributes important data for not only regional managers but is also relevant for policy managers and cetacean conservation around the world. Using the evidence in this study, managers can better target monitoring and enforcement which have been shown to play a key role in helping to improve compliance with imposed measures. Ongoing challenges for management will likely include education on regulations for recreational boaters and standardizing regulations between jurisdictions, and across species and vessel types. Within management-compliance related literature more broadly, this study can aid in providing a framework for researchers and managers in other regions who are concerned with growing pressures from whale watching and small vessel interactions more generally.

Increasing anthropogenic encroachment into nature creates more avenues for conflict. Cumulative pressures acting on cetaceans including habitat degradation and displacement, pollutants, reduced prey availability, and chronic and acute disturbances from vessel presence. In

addition, non-consumptive activities targeting charismatic species, such as whale watching is on the rise globally, which only acts to compound these pressures. As anthropogenic activities in marine environments are inherently difficult to manage, the optimization of efforts supported by empirical data thus becomes essential, especially for at-risk cetaceans.

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Appendix

Appendix A: Supplementary Figures and Tables

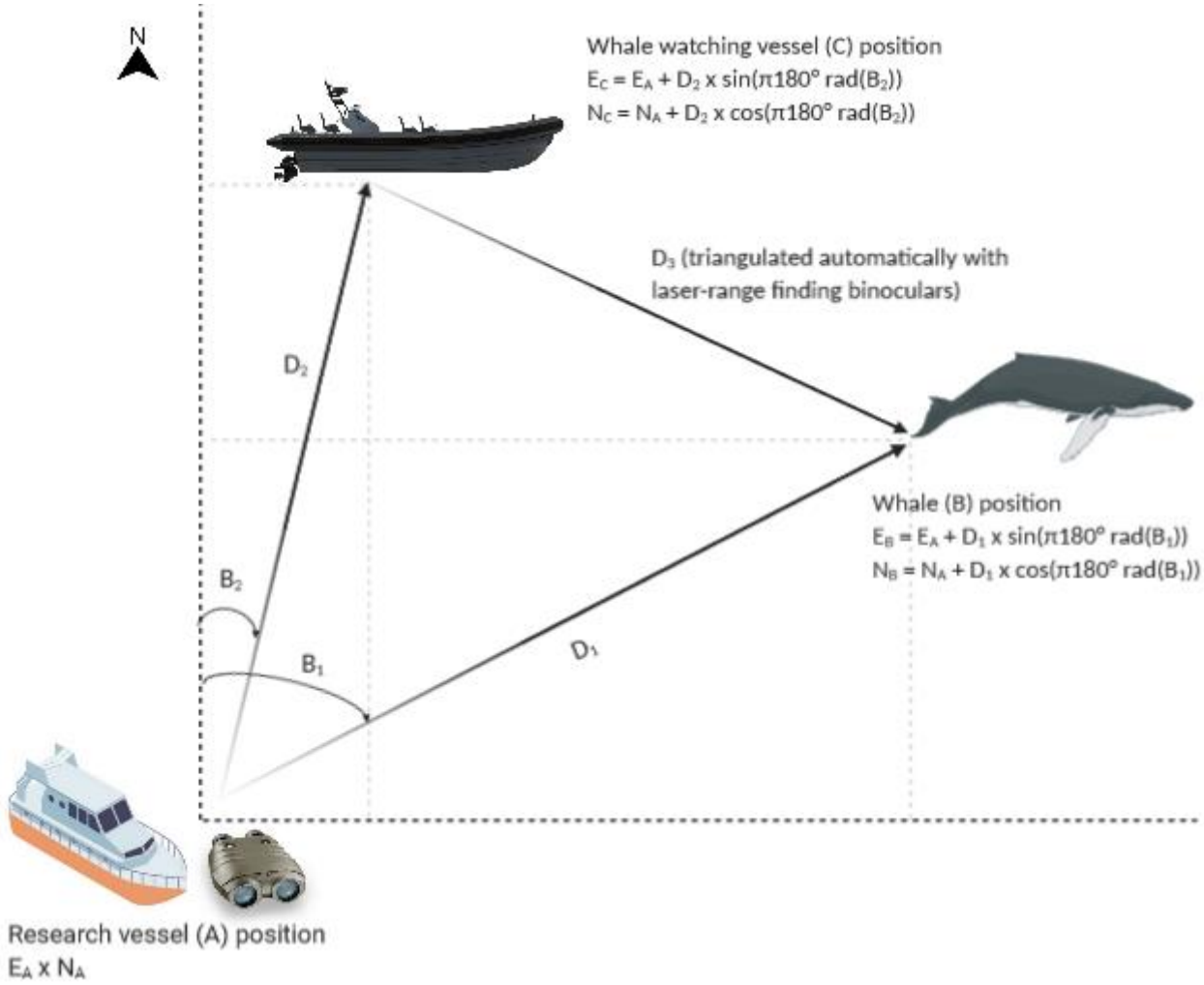

Figure A.1: Graphic illustration of data collection method and formulas used to calculate whale and vessel positions and distances.

Management Tool	Organization, Stakeholder or Government Agency	Mandatory vs Voluntary	Status of Guideline/Regulation (2018-2019)
Minimum Approach Distance	The U.S. Federal Government, National Oceanic and Atmospheric Administration (NOAA)	Mandatory	2018: mandatory 200-yard (183-metre) vessel approach distance (VAD) from all killer whales (KW) and 100 yards (92 metres) around other cetaceans in U.S. waters.
	Washington State, Washington Department of Fish and Wildlife (WDFW)	Mandatory	2019: mandatory 300-yard (274-metre) VAD from Southern Resident killer whales (SRKW).
	The Canadian Federal Government, Department of Fisheries and Oceans (DFO)	Mandatory	2018: amended and stipulated a mandatory 200-metre VAD from all KW and 100 metres around other cetaceans in Canadian waters. 2019: amended and stipulated that in the SRKW critical habitat from June 1st-October 31st a mandatory 400-metre VAD from all KW. PWWA has been given permits allowing 200 metre distance from Bigg's killer whales (BKW).
Vessel Exclusion Zones	British Columbia Provincial Government, Ministry of Environment	Mandatory	2018/2019: Vessels are prohibited within Race Rocks Ecological Reserve when cetaceans are present in reserve boundaries.
	Transport Canada	Mandatory	2019: Mandatory interim sanctuary zones (vessels prohibited, with exceptions) around the east coast of Saturna Island, south-west coast of North Pender Island and Swiftsure Bank from June 1st- October 31st.

	WDFW	Voluntary	2018/2019: Recommendation for vessels to avoid entering ¼ Mile no-go zone on the west side of San Juan and ½ Mile No Go Zone around Lime Kiln Lighthouse.
Speed Restrictions/ Slow Down Zones	Pacific Whale Watching Association (PWWA)	Voluntary	2018: Recommendation for vessels within 1 kilometre to slow down to a minimum 7 knots.
	Be Whale Wise	Voluntary	2018: Recommendation for vessels to slow down within 400 metres (Canada) / yards (U.S.) of cetaceans to a minimum of 7 knots. 2019: Amended to align with PWWA 1 kilometre slow down.
Time Limitations for Viewing Cetaceans	PWWA	Voluntary	2018/2019: Recommendation for vessels to limit viewing time to 60 minutes or to 30 minutes if there are more than 10 PWWA vessels present.
	Be Whale Wise	Voluntary	2018/2019: Recommendation for vessels to limit viewing time to 30 minutes.

Table A.1: Vessel management regulations in the Salish Sea in 2018-2019.

Variable	Killer whales		Humpback whales		Both Species	
Encounters						
Research Vessel	109		89		198	
Other Commercial Vessels	310		174		484	
Total	419		263		682	
Non-compliant encounters						
Research Vessel	25		11		36	
Other Commercial Vessels	52		27		79	
Total	77		38		115	
2018/2019 combined non-compliant encounters	#	%	#	%	#	%
Vessel type (P = 0.719)						
Research Vessel	25	32.5	11	28.9	36	31.3
Other Commercial Vessels	52	67.5	27	71.1	79	68.7
Vessel type (scaled for encounter rate)						
Research Vessel	25	22.9	11	12.4	36	18.2
Other Commercial Vessels	52	16.8	27	15.5	79	16.3

Table A.2: Compliance of research vessel and other commercial whale watching vessels in 2018-2019