Universidade de Lisboa
Faculdade de Ciências
Departamento de Biologia Animal

Southern Resident Killer Whales and Ecotourism

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Mestrado em Biologia da Conservação
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Abstract

On a global scale, there has been a rapid growth of the whale watching industry in the last decade. In 1998, a total of 87 countries was involved in commercial cetacean tourist activities, with more than nine million people participating (Hoyt 2001).

Off San Juan Island, Washington, USA, southern resident killer whales (*Orcinus orca*) population is the key resource of the tourism industry. Due to its predictablility and to the fact that it is readily found it became the main target of the industry, being watched nearly at a daily basis from May through September. A fleet of almost 80 vessels and over 500,000 people annually engage in whale watching in this region (Koski 2008).

Recently, the southern resident population of killer whales experienced an almost 20% decline (Krahn et al. 2002), resulting in their listing as 'depleted' under the US Marine Mammal Protection Act (MMPA) and 'endangered' under the US Endangered Species Act (ESA) and the Canadian Species at Risk Act (SARA).

This combination of intense tourism activity and a fragile population has unsurprisingly brought apprehensivness and several attempts to assess the effects of tourism activities on marine mammals have been made . Recent studies have shown that vessel presence can have short-term bahavioral impacts which may rsult in long-term impacts.

This study examined vessels' density when whales are present in the west coast of San Juan Island, and the performance of surface active behaviors (SABs) by southern resident killer whales. The results show that over 70% of the vessels involved in this activity are at least at ½ mile from shore, when whales are traveling very close to shore. The performance of SABs was greater with fewer boats present. These results allowed the assessment of further measures to regulate vessels' traffic in this region.

Keywords: killer whale, ecotourism, whale watching, regulations, vessels.

Resumo

Muitas populações de mamíferos marinhos estão agora sujeitas a um aumento da exposição às embarcações e sons associados. Barcos de pesca comerciais, barcos de observação de cetáceos, embarcações de recreio, barcos de transporte de carga, entre outros, têm aumentado dramaticamente por quase todo o planeta. Este aumento generalizado do número de embarcações contribui de várias formas para a degradação do ambiente marinho e seus habitantes.

No Pacífico Nordeste são reconhecidas três formas distintas de orcas, *Orcinus orca,* designadas de residentes, transeuntes e "offshores". A distribuição geográfica destas populações sobrepõe-se consideravelmente, no entanto são geneticamente distintas (Stevens et al. 1989, Hoezel & Dover 1991, Hoezel et al. 1998, Barrett-Lennard 2000, Barrett-Lennard & Ellis 2001, Hoezel 2004, Krahn et al. 2004). Também exibem diferenças de comportamento, morfologia, ecologia e acústica (Baird 2000, Ford et al. 2000). A população de orcas residentes integra quatro comunidades: sul, norte, sul do Alasca e oeste do Alasca (Krahn et al. 2002, 2004). A designação de "residente" vem de estudos iniciais (Bigg 1982), no entanto o desenvolvimento da investigação veio mostrar que o termo não é indicativo dos padrões de movimentação destas comunidades (Dahlheim & Heyning 1999, Baird & Whitehead 2000, Baird 2001).

A população de orcas residentes do sul é constituída por 3 grupos de matriarcados relacionados ou pods (J, K e L) e ocorre nas águas interiores (Estreito de Georgia, Estreito de Juan de Fuca e Puget Sound) do Estado de Washington, EUA e British Columbia, Canadá, principalmente durante o Verão e Outono. No entanto, esta população ictiofágica concentra a sua actividade no Estreito de Haro (Hauser 2007), ao longo da costa oeste da Ilha de San Juan, onde existem os principais corredores de migração de salmão (Felleman et al. 1991, Ford et al. 2000).

Entre 1996 e 2001, esta população sofreu um declínio drástico de quase 20% (Krahn et al. 2002), o que resultou na sua classificação como "depleted" sob o US Marine Mammal Protection Act (MMPA) e como "endangered" sob o US Endagered Species Act (ESA) e sob o Canadian Species at Risk Act (SARA). Esta é uma população que tem sido objecto de estudo por mais de 30 anos, no entanto, ainda é desconhecida a principal causa deste declínio acentuado. A contaminação ambiental, redução na abundância ou qualidade de presas (salmão-real, *Oncorhynchus*

tshawytscha e salmão-cão, *O. Keta*) e distúrbios físicos e acústicos são apontadas como as principais ameaças de origem humana (NMFS 2006).

O tráfego de embarcações e a extraordinária concentração de barcos comerciais com propósito de observação de orcas em Puget Sound estão incluídos nas possíveis causas e podem ter contribuído de diversas formas para o declínio observado. Ocasionalmente ocorrem colisões entre embarcações e orcas residentes do norte que resultam em ferimentos ou morte dos animais (Visser 1999, Ford et al. 2000). Em 2005 foi observado um caso de colisão na população residente do sul (K. C. Balcomb comunicação pessoal). A presença de embarcações pode causar *stress* nos animais (Romano et al. 2004). O ruído causado pelas embarcações, ao interferir com o seu sistema sensorial acústico altamente desenvolvido, além de potencialmente poder suprimir os sinais de eco-localização (Bain & Dahlheim 1994) reduzindo a eficácia na procura de presas, também interfere com o seu sistema de navegação e comunicação com os outros indivíduos e pode provocar danos auditivos temporários ou permanentes (Erbe 2002). Respostas comportamentais à presença das embarcações podem resultar num aumento do dispêndio de energia ou interrupção e redução da actividade alimentar, o que se traduz num balanço negativo de energia (Bain & Dahlheim 1994, Gordon & Moscrop 1996, Erbe 2002, Williams et al. 2002a, 2002b).

Em 1998, Hoyt (2001) estimou o valor da indústria de observação de cetáceos em Washington em $13.6 milhões e em British Columbia em $69.1 milhões. Destes valores, cerca de 60-80% provavelmente derivam da observação de orcas na Bacia de Georgia e Puget Sound (Osborne, no prelo). A comunidade de Friday Harbor (San Juan Island, Washington) é considerada por Hoyt (2001) uma das comunidades transformadas pela indústria de observação de cetáceos, em termos de benefícios económicos.

Nesta região, o horário de funcionamento das companhias de observação de cetáceos estende-se desde as 9:00 às 21:00H no Verão e até ao pôr-do-sol na Primavera e início do Outono (Bain et al. 2006). Desde o nascer do sol e até ao fim do dia, as orcas estão em contacto com embarcações, não só as de observação de cetáceos mas também embarcações de recreio, embarcações de investigação científica, embarcações de pesca desportiva e embarcações comerciais de transporte de carga que estão presentes 24h por dia.

Entre 1998 e 2008, uma média de quase 20 embarcações (comerciais, privadas, de investigação, caiaques e outras) foi observada consistentemente, entre as 9:00 e as 18:00H, de Maio a Setembro, num raio de 804 metros (½ milha) em redor da população de orcas residentes do sul (Koski 2008). Para o mesmo período de tempo, o número máximo de embarcações observadas em redor das orcas, até uma distância de 804 metros, variou de 69 a 120 barcos (Koski 2008).

Existem vários exemplos na literatura de que as perturbações crónicas podem ser factores que reduzem a qualidade de vida dos animais, a eficiência de procura de presas (Galicia & Balassarre 1997), o processo de acasalamento e estrutura social (Lacy & Martins 2003) ou o sucesso reprodutivo dos animais (Safina & Burger 1983).

Nestas circunstâncias de reduzido tamanho populacional (nos últimos 18 meses 8 orcas morreram, sendo a população actual constituída por 85 indivíduos), reduzida taxa de reprodução e existência de diversas ameaças de origem humana que evitam a sua recuperação ou possivelmente causam um maior declínio populacional, é urgente identificar meios de recuperação e conservação da população de orcas residentes do sul.

Neste sentido, neste estudo foram feitas observações em três locais da costa oeste da Ilha de San Juan, entre 15 de Junho e 25 de Setembro de 2008, com o intuito de analisar a situação de tráfego de embarcações e inferir opções de medidas de conservação para a população de orcas residentes do sul. Os locais escolhidos foram Hannah Heights, Land Bank e County Park, todos eles caracterizados por grandes concentrações de embarcações e pelo facto de as orcas estarem presentes frequentemente e a uma distância reduzida da costa. Os dados recolhidos incluíram: quantidade de embarcações presentes; tipo e actividade das embarcações; estados de actividade das orcas e contabilização de comportamentos activos de superfície.

As observações relativas às embarcações foram estruturadas de acordo com a distância ao observador e posição relativamente às orcas. Foram utilizadas quatro categorias: "inshore of whales" (barco posicionado entre a costa e as orcas); a ¼ milha (402 metros) do observador; a ½ milha (804 metros) do observador; campo de visão (todas as embarcações presentes além de ½ milha do observador). As amostragens foram realizadas sempre que as orcas estavam presentes num dos três locais de estudo, a uma distância de ½ milha do observador.

O método de amostragem utilizado na recolha de dados foi o "scan sampling", a intervalos de 10 minutos, com excepção dos comportamentos activos de superfície das orcas que foram registados continuamente.

Do total de 116 dias de esforço de amostragem, resultaram 42 dias (117horas) de observação da actividade das orcas e embarcações. Foram feitas 329 observações; 188 em Hannah Heights, 108 em Land Bank e 33 em County Park. A discrepância no número de observações em cada sítio é devida ao facto de os três locais distarem pouco entre si (para o caso de Hannah Heights e Land Bank) e ao facto de que em County Park, na grande maioria dos dias em que as orcas estão presentes, viajarem a uma distância superior a ½ milha da costa.

Durante o período de estudo, uma média de 517.8, 251.4 e 135.2 embarcações foram contabilizadas em Hannah Heights, Land Bank e County Park, respectivamente. O número máximo de barcos presentes num dado momento foi registado em County Park, com um total de 69 embarcações envolvidas na actividade de observação de cetáceos.

Nos três locais estudados, mais de 70% das embarcações observadas encontravam-se a distâncias superiores a ½ milha da costa. Dentro de ½ milha da costa, a maioria das embarcações presentes são embarcações comerciais, com excepção de County Park, onde os caiaques representam 81% das embarcações. Dentro de ¼ milha e "inshore of whales", a maioria das embarcações presentes, são embarcações privadas em Hannah Heights e caiaques em Land Bank e County Park.

Em Hannah Heights, foram contabilizadas um total de 2589 embarcações, das quais 83% estavam no campo de visão (fora da ½ milha) e 17% a ½ milha do observador. Das embarcações presentes dentro de ½ milha da costa, 8% eram barcos comerciais de observação de cetáceos, 6% eram embarcações privadas, 2% caiaques e 1% de outro tipo de embarcações.

Em Land Bank, foram contabilizadas um total de 1257 embarcações, das quais 84% estavam no campo de visão (fora da ½ milha) e 16% a ½ milha do observador. Das embarcações presentes dentro de ½ milha da costa, 6% eram barcos comerciais de observação de cetáceos, 4% eram embarcações privadas, 4% caiaques e 1% de outro tipo de embarcações.

Em County Park, foram contabilizadas um total de 676 embarcações, das quais 73% estavam no campo de visão (fora da ½ milha) e 27% a ½ milha do observador. Das embarcações presentes dentro de ½ milha da costa, 3% eram barcos comerciais de observação de cetáceos, 1% eram embarcações privadas, 22% caiaques e 1% de outro tipo de embarcações.

Em média, a maioria das embarcações são comerciais, no entanto as orcas também atraem uma grande quantidade de embarcações privadas e caiaques. As embarcações comerciais tendem a ficar afastadas da costa mais de ½ milha e as embarcações privadas e caiaques navegam mais perto da costa e frequentemente entre a costa e as orcas (principalmente em County Park). O número total de embarcações é superior ao dobro da média de embarcações, o que significa que nenhum dos valores é representativo das condições de tráfego de embarcações a que esta população está sujeita.

Julho e Agosto são os meses de maior actividade. O período de maior actividade ocorre entre as 11:00 e as 16:00H, com uma pequena diminuição entre as 12:00 e as 13:00H. No entanto, os sítios estudados são usados regularmente por quantidades consideráveis de embarcações, independentemente do mês e da hora do dia.

Nos três locais de estudo, os comportamentos activos de superfície das orcas ocorreram predominantemente quando poucas embarcações estavam presentes e a actividade diminuíu com o aumento do número de embarcações. Esta tendência foi particularmente forte em County Park (R^2=0.529, F=15.592, P=0.002) e em Hannah Heights (R^2=0.718, F=15.325, p=0.008), mas menor em Land Bank (R^2=0.385, F=5.011, P=0.055). Apesar desta tendência, pequenos picos de ocorrência de comportamentos activos de superfície foram observados em Land Bank e em County Park, com 41 a 45 embarcações presentes, e com 21 a 25 embarcações presentes, respectivamente.

Os efeitos da actividade humana nas populações animais são geralmente inferidos e quantificados apartir de mudanças de comportamento verificadas nos animais em resposta à presença humana e o grau de impacto humano medido desta forma é posteriormente usado para definir prioridades de conservação.

No entanto, a complexidade do acesso aos impactos da actividade humana nas populações animais, pode levar a conclusões incompletas e imprecisas (Bedjer et al. 2006), que por sua vez comprometem os esforços de conservação.

É evidente que esta população está sujeita a uma grande pressão de tráfego de embarcações. Devido à falta de dados relativos ao comportamento desta população em situação de menor ou nenhum tráfego de embarcações, é extremamente difícil avaliar quais serão as consequências a longo prazo desta pressão turística.

No entanto, mudanças de comportamento de curto prazo foram observadas e analisadas para as populações residentes do sul e do norte (Kruse 1991; Kriete 2002; Williams et al. 2002a, 2002b, 2006, 2009; Foote et al. 2004; Bain et al. 2006; Noren et al. 2007; Lusseau et al. 2009). Embora ainda seja incerto se é a presença e actividade das embarcações, os sons por elas produzidos ou uma combinação destes factores que causam impacto nos animais, é necessário que se adoptem medidas precaucionárias que minimizem os impactos já observados e documentados.

Com este estudo foi possível inferir possíveis medidas para a promoção do desenvolvimento sustentável do ecoturismo de observação de cetáceos na Ilha de San Juan. Tendo ainda um grande grau de incerteza em relação a muitos aspectos do impacto do ecoturismo nesta população são aqui propostas medidas de carácter precaucionário para a regulação do tráfego de embarcações:

• Na costa oeste da ilha de San Juan, limitar ou interditar o acesso das embarcações de observação de cetáceos, privadas e caiaques até ½ milha da costa, durante o período do ano em que a população de orcas residentes do sul está presente (Maio a Setembro). Com este estudo não foi possível abrangir toda a costa oeste da ilha, no entanto existem evidências que a situação observada nestes três locais estende-se por toda a costa (Koski 2008). Tendo em conta que mais de 70% das embarcações que regularmente participam na actividade de observação de cetáceos, encontram-se além de ½ milha de distância da costa, o impacto de fechar esta área ao tráfego de embarcações seria mínimo e reduziria o tempo de exposição às embarcações e sons associados;

• Limitar o número de licenças para a observação de cetáceos;

• Limitar o número de horas do dia permitidas para a actividade de observação de cetáceos,

• Limitar o número de viagens que cada companhia efectua;

• Limitar o tempo de estadia com os animais;

• Incentivar a actividade de observação de cetáceos a partir da costa, visto nesta ilha, as condições para tal serem extremamente vantajosas. Para este fim, seria aconselhado a existência de estruturas de apoio e de suporte educacional.

Palavras-chave: orca, ecoturismo, observação cetáceos, regulação, embarcações.

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1. Introduction

The worldwide increase of human communities along the coast, the recent shift in the way people relate to whales, the demand for mass consumption and consequent increase in possession of goods, along with the increase in number, safety and speed of vessels has led to the spectacular growth of the whale watching industry. The demand for high quality natural experiences, particularly those based on large “charismatic” animals like whales appear to be limitless (Shackley, 1996).

In the northeastern Pacific Ocean, three distinct forms of killer whales *Orcinus orca* are recognized: residents, transients, and offshores. The designations of “resident” and “transient” originates from early studies (Bigg 1982), but succeeding studies have shown that the terms are not representative of their movement patterns (Dahlheim & Heyning 1999, Baird & Whitehead 2000, Baird 2001). These populations do not interbreed so they are genetically distinct (Stevens et al. 1989, Hoezel & Dover 1991, Hoezel at al. 1998, Barrett-Lennard 2000, Barrett-Lennard & Ellis 2001, Hoezel 2004, Krahn et al. 2004). They also display differences in ecology, behavior, morphology, and acoustics (Baird 2000, Ford et al. 2000). Four distinct communities constitute the resident ecotype: southern, northern, southern Alaska, and western Alaska (Krahn et al. 2002, 2004).

The southern resident population contains three pods – J pod, K pod, and L pod – and occurs in Washington State, USA and British Columbia, Canada inshore waters (Southern Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), primarily in the summer and fall (Bigg 1982, Ford et al. 2000, Krahn et al. 2002). Winter and early spring movements are largely unknown but the southern residents are known to travel as far south as Monterey Bay in central California and as far north as the Queen Charlotte Islands, British Columbia. These piscivorous whales concentrate their summer activity throughout Haro Strait (Hauser 2007) where are the major corridors of migrating salmon (Felleman et al. 1991; Ford et al. 2000).

The southern resident population of killer whales experienced an almost 20% decline from 1996 to 2001 (Krahn et al. 2002), resulting in their listing as ‘depleted’ in May 2003 under the US Marine Mammal Protection Act (MMPA) and ‘endangered’ in April 2004 under the US Endangered Species Act (ESA) and in June 2003 under the Canadian Species at Risk Act (SARA). As the ESA requires, NOAA Fisheries as designated critical habitat for the southern resident killer whales, on November 2006.

Three areas were designated: a core summer area around the San Juan Islands, a fall/winter area in Puget Sound and a transit corridor along the Strait of Juan de Fuca.

The major threats to the recovery of this distinct population segment (DPS) include reduction in prey (chinook salmon, *Oncorhynchus tshawytscha* and chum salmon, *O. keta*) availability and quality, pollution and contaminants, small population size and effects from vessels and sound. Although intensive ecological and biological research has been conducted on this DPS it is still unknown which of the factors have caused the decline or if it was caused by one of the threats or the combination and cumulative effects of exposure to all these factors.

Vessel traffic may have contributed to the decline through a variety of mechanisms, including collisions (Ford et al. 2000), toxins from unburned fuel and exhaust (Lachmuth 2008), stress (Ayres & Wasser unpublished data), and reduced foraging efficiency due to masking of echolocation signals (Bain 2002, Williams et al. 2009).

Whale watching as a commercial endeavor — with important educational, environmental, scientific, and other socioeconomic benefits — is now at least a $1 billion USD industry attracting more than 9 million participants a year in 87 countries and territories (Hoyt 2001). In 1998, Hoyt (2001) estimated the value of the overall whale-watching industry in Washington at US$13.6 million and in British Columbia at US$69.1 million, based on estimated customer expenditures for tours, food, travel, accommodations, and other expenses. An estimated 60-80% of this value likely originated from the viewing of killer whales in the Georgia Basin and Puget Sound (Osborne, unpublished data). The community of Friday Harbor, San Juan Island, was considered by Hoyt (2001) to be one of the communities transformed by whale watching.

A vast fleet of whale watching companies originating from nearby inland water ports in the United Sates and Canada largely uses the core summer area of the southern residents summer range (Hauser 2007). Operating from May to September, the whale watching companies offer one to six daily trips (Osborne & Otis, 2000). Commercial viewing activity runs from about 09:00 to 21:00 in summer, and until sunset in spring and early fall (Bain et al. 2006). Apart from the whale watch industry fleet, many other vessels use this area regularly, these include: private leisure vessels, scientific research vessels, monitoring vessels, kayaks, seiners, gill-netters and freight vessels.

The mean number of vessels following groups of killer whales during the peak summer months increased from five boats in 1990 to 18-26 boats from 1996-2005

(Osborne et al.1999, Baird 2001, Erbe 2002, Koski, 2008). Annual maximum counts of 72-120 boats were made near whales from 1998-2005 (Koski 2004, 2006).

It is evident that southern resident killer whales are exposed to a high level of vessel traffic. As Hoyt (2001) denoted Haro Strait may well present a case of whale watching in numbers greater than is ideal from the point of view of tourists and the marine environment.

Effects of vessel traffic have been documented in a wide range of cetacean species. These studies show that cetacean-watching tourism elicit long and short-term behavioral changes which include stopping feeding, resting, social interaction and abandoning nursing areas (Jurasz & Jurasz 1979; Baker et al. 1983; Dean et al. 1985; Glockner-Ferrari & Ferrari 1985, 1990; Norris et al. 1985; Bauer & Herman 1986; Hall 1982; Krieger & Wing 1984; Salden 1988; Forest 2001; Morton & Symonds 2002; Lusseau 2003a, 2005; Constantine et al. 2004; Bejder 2006a, 2006b); decreasing use of primary habitats and even relocating to other areas (Allen & Read 2000; Lusseau 2005); changing travel patterns to avoid vessels (Au & Perryman 1982; Kruse 1991; Au & Green 2000; Constantine 2001; Nowaceck et al. 2001; Williams et al. 2002a, 2002b; Lusseau 2003b, 2006; Bejder et al. 2006a; Lemon et al. 2006; Williams & Ashe 2007); altering spatial distribution among individuals (Au & Perryman 1982; Bejder et al. 1999, 2006a; Nowaceck et al. 2001; Jelinski et al. 2002); effects on acoustic behavior (Van Parijs & Corkeron 2001); effects on energy budgets (Chilvers et al. 2003, Coscarella et al. 2003; Lusseau 2003a, 2004; Constantine et al. 2004; King & Heinen 2004; Lemon et al. 2006; Williams et al. 2006; Hodgson & Marsh 2007; Lusseau et al. 2009); and altered surface and dive durations (Janik & Thompson 1996; Au & Green 2000; Jahoda et al. 2003; Lusseau 2003a, 2003b; Ng & Leung 2003).

Furthermore, previous studies specifically concerning the southern resident killer whales population have shown that vessel presence can have acoustic (Erbe 2002, Foote et al. 2004, Holt et al. 2009) and short-term behavioral impacts which may result in increased energy expenditure, or disrupt feeding activity, which in turn may reduce energy acquisition (Kruse 1991; Bain et al. 2006; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2002a, 2006, 2009).

This study aimed to analyze the present situation of near shore vessel's activity when whales are present in the west coast of San Juan Island and to determine how the performance of surface active behaviors (SABs) by southern resident killer whales varies with the amount of vessels present. These behaviors imply energetic costs (Yazdi et al. 1999) and given the present situation of this population with possible food limitations (Ford et al. 2005), added energetic expenditures should be regarded with concern.

The analyses of these data was used to assess conservation measures that can be taken to limit this population's exposure to vessel traffic and associated sounds.

2. Methods

2.1. Field site and Study population

San Juan Island, Washington State (48º 33' N, 123º 05' W) is well known for its whale watching industry. Killer whales are the main target species of the industry, easily surpassing other species such as gray whales, porpoises, and pinnipeds (Hoyt 2001). Owing to the fact of being more reliable and predictable than transients or offshores, the southern residents are the primary attraction for tourists.

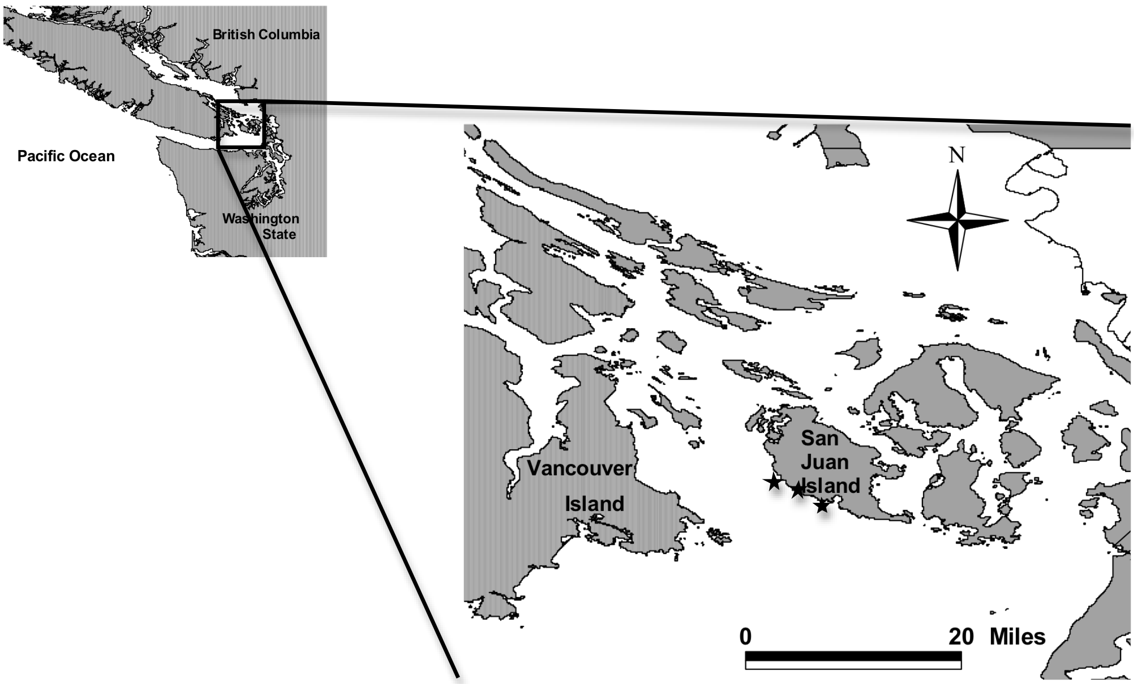


Figure 1. Study area, with stars indicating from West to East, approximately, the location of County Park, Land Bank and Hannah Heights, respectively.

This population has been studied and monitored for over 30 years, and in addition the Center for Whale Research has gathered a photo-identification database that allows the individual identification of each of the members of the southern residents.

The southern resident stock of killer whales peaked at 97 animals in the 1990's and then declined to 79 in 2001. On July 1, 2009, the population was composed by 85 individuals (Center for Whale Research, unpublished data).

Commercial, vessel-based, whale watching tourism in this region began in 1977. Between 1984 and 1998, it increased almost continuously until a peak of 80 vessels engaged in the activity (Osborne *et a*l. 2002, Koski 2004). Since 2000, the annual number of vessels has stabilized (Koski 2008). In 2008 there were 76 active commercial whale watch vessels, of which 54 were from Canadian companies and 22 from U.S. companies.

Commercial whale-watching boats range in size and configuration from open vessels measuring less than 7 m in length, capable of holding 6-16 people to large 30 m vessels which can carry up to 280 customers (NMFS 2006). Koski (2008) estimated that over 500,000 people annually engage in whale watching in Haro Strait. Consistently, from 1998 to 2006, an average of nearly 20 vessels have been observed within a half-mile range of the whales between 09:00 and 18:00H from May to September (Koski 2008).

Besides the commercial vessels, also private boaters, kayaks and small numbers of aircraft participate in viewing whales whenever the opportunity arises.

Only very recently a state bill with the prohibition of approaching killer whales within 100 yards (approximately 92 meters) was approved, becoming effective in June 2008.

Under the ESA and the MMPA the harassment of marine mammals by the public, including commercial whale watch operators, is prohibited. The MMPA defines harassment as "any act of pursuit, torment, or annoyance which: (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" (MMPA 2007).

The Whale Watch Operators Association Northwest (WWOANW) has developed the 'Best Practices Guidelines' for commercial operators to follow when observing southern residents (WWOAN 2004). There are also the "Be Whale Wise" guidelines developed by the National Marine Fisheries Service (NMFS) Northwest Regional Office in partnership with The Whale Museum Soundwatch Boater Education Program (USA), Straitwatch (Canada), commercial operators, whale advocacy groups, whale researchers, and United States and Canadian government agencies and enforcement divisions.

These guidelines recommend that boaters parallel whales no closer than 100 yards, approach animals slowly from the side rather than from the front or rear, and avoid putting the vessels within 400 yards (approximately 366 meters) in front of or behind the whales. Vessels are also recommended to reduce their speed to less than 7 knots (13 km/h) within 400 yards of the whales, and to remain on the offshore side of the whales near shore.

The guidelines specific for kayaks recommend that kayakers should not intentionally position themselves in the path of whales, paddle into groups of whales or chase whales. Kayakers should also leave a distance of at least 100 from whales, position themselves towards the shore, raft up together and stop paddling.

2.2. Sampling design

From 12 June to 25 September 2008, the behavior of whales and the density of boats were monitored from three land-based observation sites along the West coast of San Juan Island. One site, hereafter referred to as Hannah Heights, was located at 48º 29' 33'' N, 123º 07' 10'' W. The other site was located at San Juan County Land Bank (48º 30' 22'' N, 123º 08' 32'' W), a short distance North of Hannah Heights and adjacent to Lime Kiln State Park. This site was chosen because, together with Lime Kiln State Park and San Juan County Park, it provides daytime public access and it's one of the few places were whale watching is practiced from shore. These two sites were chosen because whales are known to pass them frequently while traveling and socializing (Felleman et al. 1991, Hoezel 1993, Heimlich-Boran 1988) very close to shore.

The third site was located at approximately 11 miles (5Km) North of Land Bank, at the San Juan County Park (48º 32' 34'' N, 123º 09' 41'' W). This site was chosen because it is popular among kayakers as well as other boaters. It is a free launching site for kayaks, and the great majority of the commercial companies in the island and from other places use it to get access to the water. Furthermore, at this location, the whales seldom travel close to shore.

The three sites are situated within the Whalewatch Exclusion Zone of the San Juan County Marine Stewardship Area were there is a voluntary no-boat zone of ½ mile (804 meters) from the lighthouse beacon and ¼ mile (402 meters) offshore elsewhere when whales are present.

At each site surface active behaviors, henceforth SABs (Table 1), and vessel's activity were surveyed concurrently.

The data collected regarding vessel's activity included counts of vessels by type and activity, and by distance to the shore: within the field of view, within ½ mile (804m) and ¼ mile (402m), and inshore of whales. The vessels considered on field of view, were all the vessels present beyond ½ mile from shore. The vessels considered within ½ mile were all the vessels present from shore up to ½ mile (including the vessels at ¼ mile and inshore of whales). Also, the vessels considered at ¼ mile were all the vessels present at this distance from shore and depending on the whale's position, it can also include vessels that are on the inshore side of whales.

In compliance with The Whale Museum Soundwatch Boaters Education Program, a set of standardized vessel types and activities, established in 2007, and agreed upon with US and Canadian management and research agencies, was used to categorize vessel's activity (Koski 2006).

Vessel activity categories included *transiting; whale oriented; fishing; research, enforcement; acoustic*. Vessel type categories included *ecotour* vessels (Canadian, US, kayak, aircraft); *commercial* (aircraft); *private* (aircraft, kayak/paddle, motor, sail); *marine* (charter, fishing, tug with log barge, monitoring, cruise ship, tug with tow, ferry, freighter); *government* (BC Parks, Coast Guard, DFO, military, NOAA, WDFW); *research.*

Table 1. Definition of surface active behaviors performed by southern resident killer whales, according to Noren et al. (2009).

Surface Active Behaviour	Description
Breach	The body of the whale clears the water completely and then lands on the lateral or ventral side, generating a large splash.
Cartwheel	The whale performs an exaggerated tail slap by hurling the posterior portion of the body, from the dorsal fin to the tail, out of the water and over its head. The entire posterior end of the whale (dorsal, lateral or ventral side up) lands, generating a large splash.
Dorsal Slap	The whale slaps the water with its dorsal fin by rolling onto its side with force, generating a splash.
Half breach	One half to two-thirds of the anterior portion of the whale

	clears the water and then lands on the lateral or ventral side, generating a large splash.
Pectoral fin slap	The whale slaps one or both pectoral fins (ventral or lateral side up), generating a splash.
Spyhop	The whale rises vertically out of the water so that the both eyes are exposed. The pectoral fins can either be in or out of the water.
Tail slap	The whale slaps its tail (dorsal or ventral side up) on the surface of the water, generating a splash.

2.3. Data Collection

Shore-based observations were conducted whenever the whales were present at one of the field sites within a ½ mile (804 meters) range from the shore, following a research schedule based on a combination of reports from monitoring of VHF commercial traffic and the local sighting network. Vessel and whale positions and activity were recorded using a Bushnell 40x spotting scope and binoculars. Distances were measured using a TruPulse laser range finder hypsometer.

Scan sampling was conducted at 10 minute intervals to characterize the activity state and the number of vessels within the field of view, within an ½ mile (804 meters), and a ¼ mile (402 meters) radius from shore, and on the inshore side of whales.

Taking in consideration that the distances from shore to the vessels were taken using a laser range finder pointing to different vessels in a semi circular area, distances to vessels directly out in front of the observer are accurate but there is a source of error for distances taken to vessels not straight out from the observer position, these vessels were, in some circumstances, closer to shore.

Continuous, all-occurrence sampling was used to collect SABs. All SABs were pooled, regardless of the individuals sex, age, and pod membership. Having in consideration that Williams et al. (2009), found no sex-specific or age-specific differences in SABs performance in the southern resident population.

2.4. Sample Size

The observations were conducted whenever the whales were present at the study sites, and the weather conditions were suitable (data taken in rain, fog, or Beaufort sea state over 3 conditions was neglected). Data were collected from all three killer whale pods (J, K, L).

In total 116 days were spent searching for whales, and 42 days (117 hours) were spent monitoring vessel's and whales' activity. In these 42 days, 329 observations were made: 188 at Hannah Heights, 108 at Land Bank and 33 at County Park.

The discrepancy in observations at the three sites is due to the movements and speed of the whales. Often, when going up the island the whales would change to the opposite direction and vice versa or would gain speed, making it impossible to observe their activity in all three sites. Furthermore, the small quantity of data at County Park is explained through the fact that the whales travel by this site in a very different manner, compared to the first two sites. In the bulk of the time spent at this location the whales were outside the ½ mile study area.

2.5. Data analysis

Data analysis focused on quantifying variation in vessel activity among locations, months and time of day. Descriptive statistics (i.e. means and standard deviations) were calculated for each variable, and pie charts and histograms were produced when necessary.

Statistical associations between SABs performance and vessel's density were quantified using linear regression analyses (Zar 1996).

The data collected were analyzed using Excel 2004 (Microsoft) and the Statistica 7.0 software. Significance of statistical testing was set at $P<0.05$.

3. Results

3.1. Vessel's activity

From June to September, 329 scans were conducted and subsequently analyzed. Throughout the season southern resident killer whales have had an average of 13.8, 11.6 and 20.5 at Hannah Heights, Land Bank and County Park respectively, vessels around them. The maximum number of vessels observed in a moment with whales was 69 at County Park.

3.1.1. Vessel's activity throughout the season

At Hannah Heights and Land Bank (Table 2), the proportion of vessels within field of view and ½ mile ranges are very similar, with over 80% of the vessels present outside the ½ mile range and only 17% and 16%, inside the ½ mile range, respectively. Also proportion of vessels by categories inside the ½ mile range is almost identical, with commercial whale watch vessels in majority followed by private vessels and kayaks.

At County Park, the proportion of vessels inside the ½ mile range increases to nearly 30% and the majority of vessels observed inside this range are kayaks reaching 22%(Table 2).

Table 2. Vessel quantities, in the three study sites, from June to September. N=total number of observations; n=total number of vessels present throughout the season.

	Average number of vessels per observation	Vessels in field of view (%)	Vessels at 1/2 mile (%)	Vessels at 1/2 mile by categories (%)	
Hannah Heights	13.8	83	17	8	Ecotour
N=188				6	Private
n=2589				2	Kayak
				1	Others
Land Bank	11.6	84	16	6	Ecotour
N=108				4	Private
n=1257				5	Kayak
				1	Others
County Park	20.5	73	27	3	Ecotour
N=33				1	Private
n=676				22	Kayak
				1	Others

The observations conducted in the field of view range (Figure 2) show a majority (more than 50%) of commercial whale watch vessels present for the three study sites, followed by private vessels (more than 20%). Differences occur in the case of the kayaks, which are predominantly present at County Park.

In the ½ mile range (Figure 3) at Hannah Heights, as in the field of view, the majority of vessels present are commercial whale watch vessels followed by private vessels. Yet, the amount of kayaks increases in the ½ mile range, relatively to field of view. At Land Bank, commercial whale watch boats are also in majority but now followed by kayaks and after by private vessels. In County Park the setting changes dramatically, with kayaks representing almost the totality of vessels present.

Within a ¼ mile from shore (Figure 4) and on the inshore side of whales (Figure 5) we can observe a similar situation. At Hannah Heights the majority of boats present are private vessels, followed by kayaks. At Land Bank and County Park, almost exclusively kayaks are present.

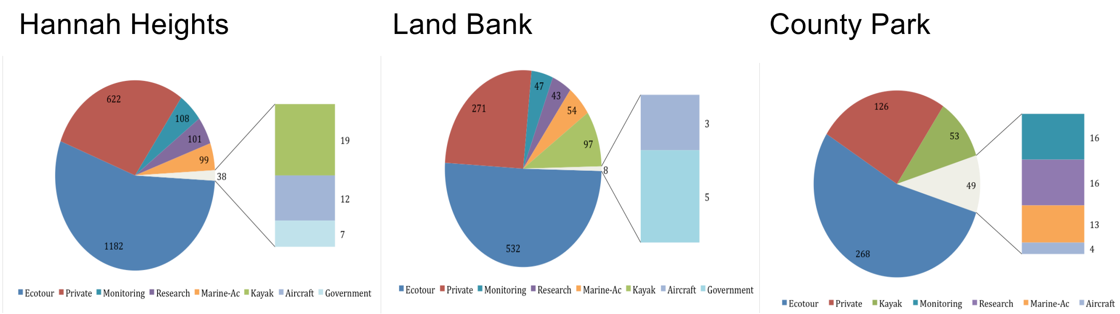


Figure 2. Vessels with whales, from June to September, within field of view.

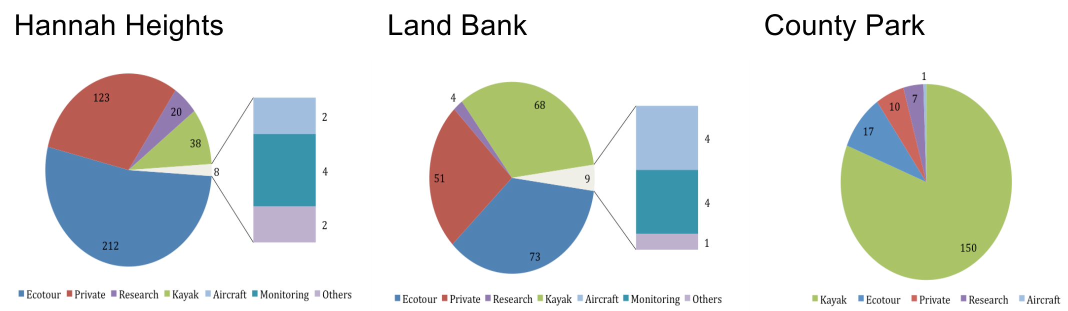


Figure 3. Vessels with whales, from June to September, within ½ mile (804m) from shore.

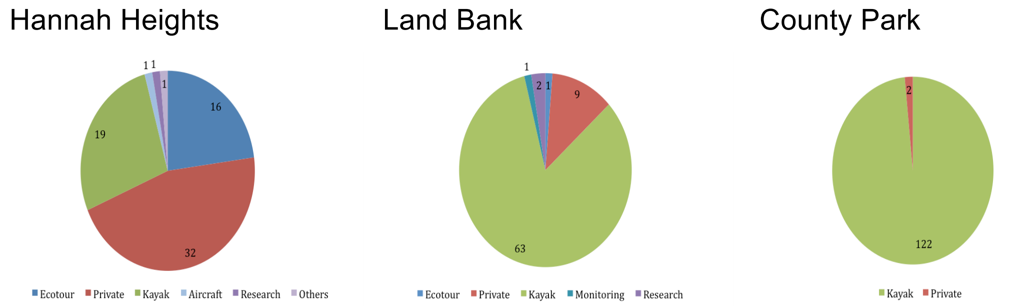


Figure 4. Vessels with whales, from June to September, within 1/4 mile (402m) from shore.

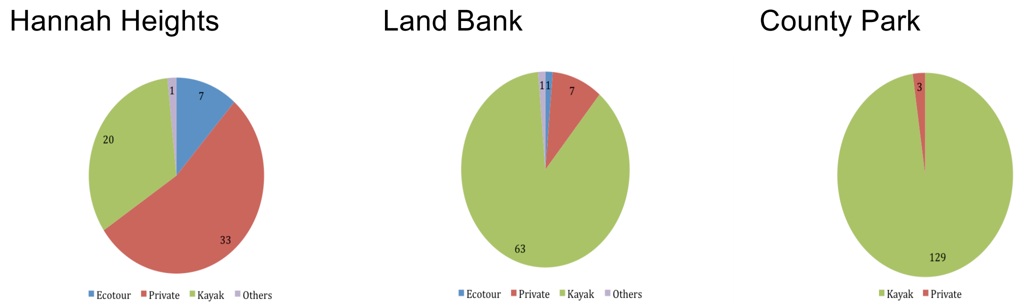


Figure 5. Vessels with whales, from June to September, on the inshore side of whales.

3.1.2. Vessel's activity by month

The total monthly number of vessels in the field of view for Hannah Heights reached its peak in August, with 958 vessels. The monthly maximum number of vessels was 553 whale watch vessels in July. Within the ½ mile range, from June to September, 212 commercial whale watch vessels were observed followed by 123 private vessels and 38 kayaks. The monthly maximum number of vessels observed was 120 whale watch vessels in July. Within the ¼ mile range and inshore of whales the category with the monthly maximum number of vessels was private vessels with 16 in August.

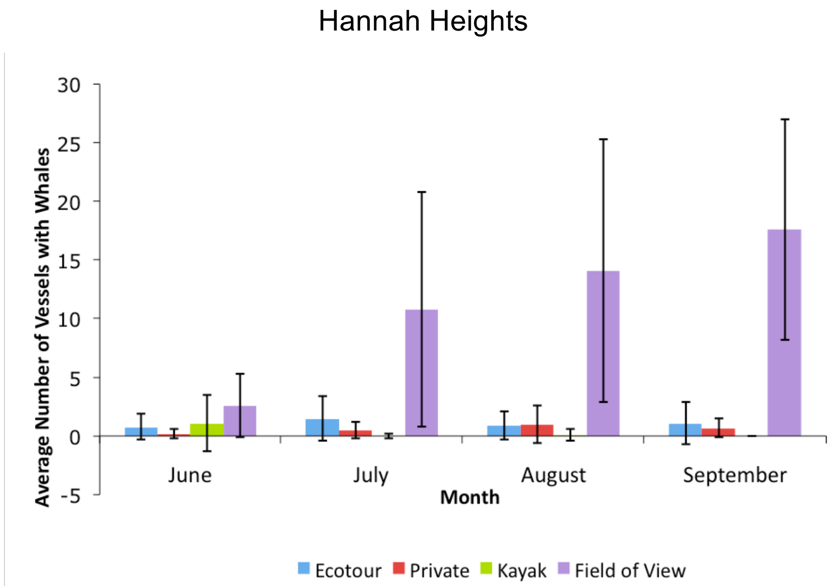
The total monthly number of vessels in the field of view for Land Bank reached its peak in August, with 544 vessels. The monthly maximum number of vessels was 257 whale watch vessels in July. Within the ½ mile range, from June to September, 73 commercial whale watch vessels were observed followed by 68 kayaks and 51 private vessels. The monthly maximum number of vessels observed was 42 whale watch vessels in August. Within the ¼ mile range and inshore of whales the category with the monthly maximum number of vessels was kayaks with 37 in August.

The total monthly number of vessels in the field of view for County Park reached its peak in July, with 252 vessels. The monthly maximum number of vessels was 143 whale watch vessels in July. Within the ½ mile range, from June to September, 150 kayaks were observed followed by 17 commercial whale watch vessels and 10 private vessels. The monthly maximum number of vessels observed was 61 kayaks in August. Within the ¼ mile range and inshore of whales the category with the monthly maximum number of vessels was kayaks with 49 and 57, respectively, both registered in August.

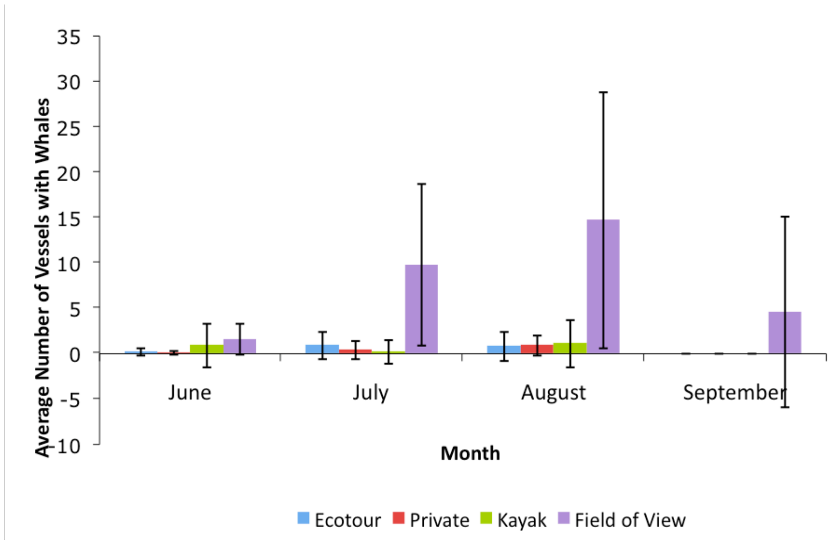
The monthly average number of vessels with whales (Figure 6) is below 1 within ½ mile from shore, for whale watch vessels and private vessels in the three study sites. The average number of kayaks is clearly higher at County Park with an average number of 6.8 kayaks and an average of nearly 1 for Hannah Heights and Land Bank.

In the field of view, the average number of vessels is much higher than in the ½ mile in all three sites. At Hannah Heights the average number of vessels present reached 17.6 in September, in Land Bank 14.7 in August, and in County Park 20.1 in August.

The busiest months are July and August in all three sites.



Land Bank



County Park

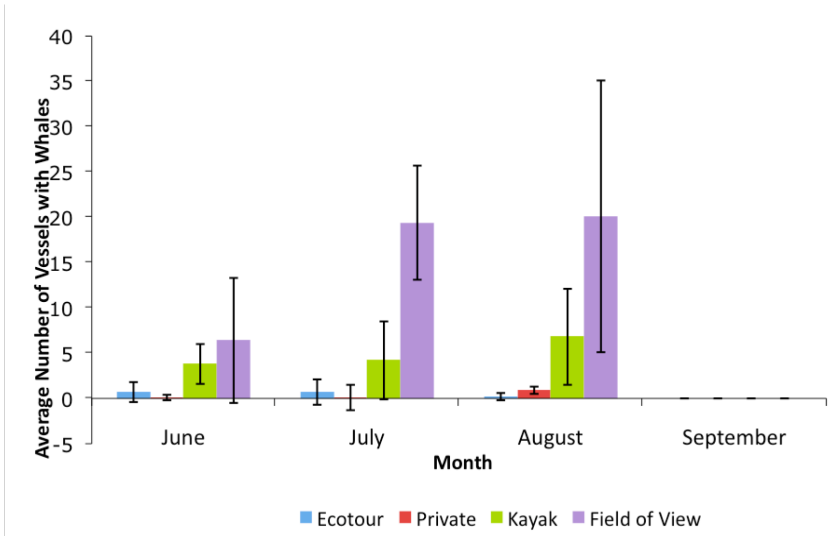
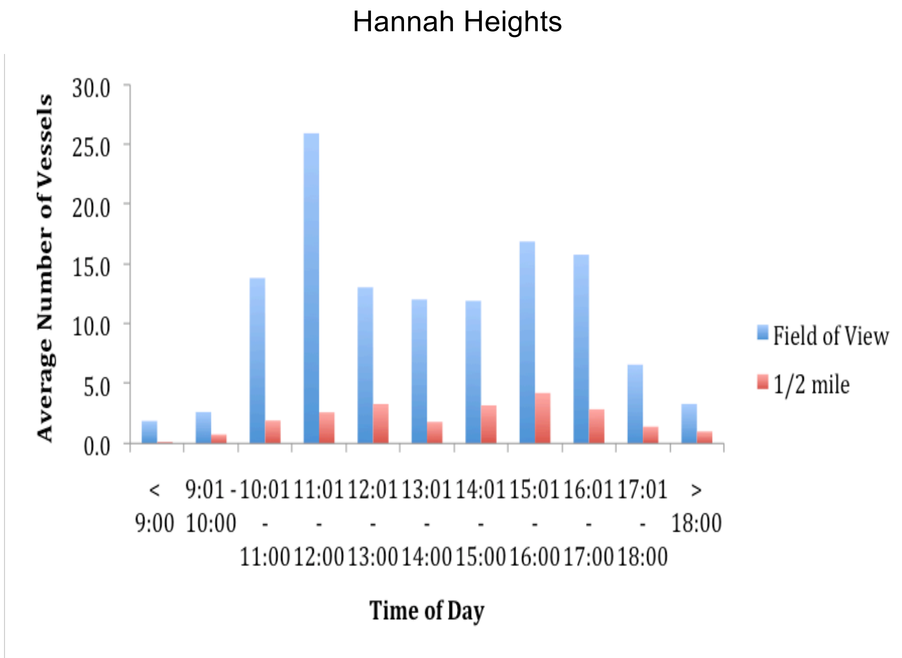


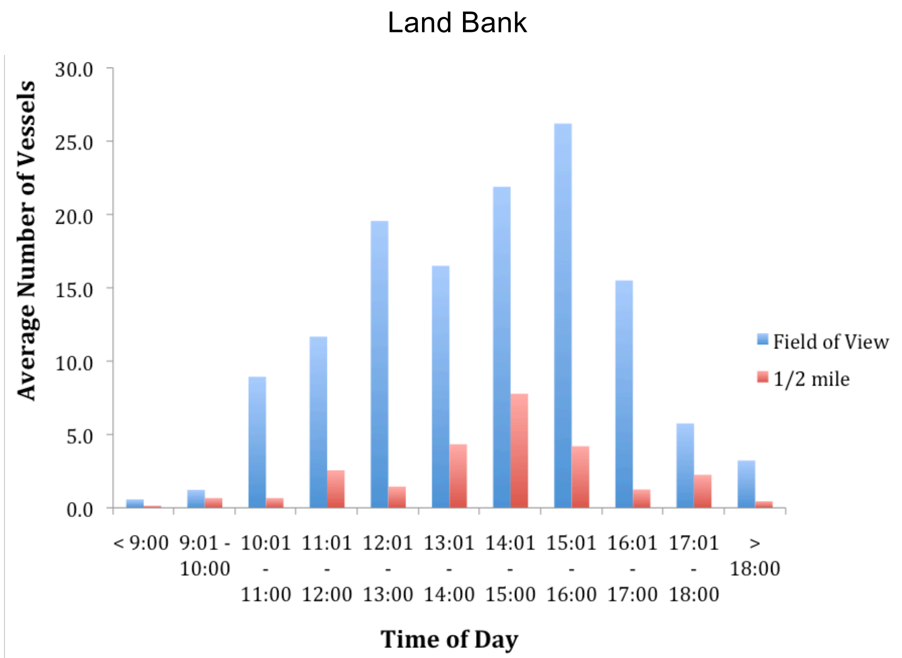
Figure 6. Average number of vessels with whales within ½ mile from shore (divided by categories Ecotour, Private and Kayak) and in the field of view, from June to September, at the three study sites.

3.1.3. Vessel's activity by time of day

In Hannah Heights and Land Bank, vessels were constantly present from before 09:00 until after 18:00. In County Park, there is an interruption between 13:00 and

14:00. In all three sites, the hours between 11:00 and 16:00 are the busiest, with a slight decrease around 12:00 and 13:00 (Figure 7).





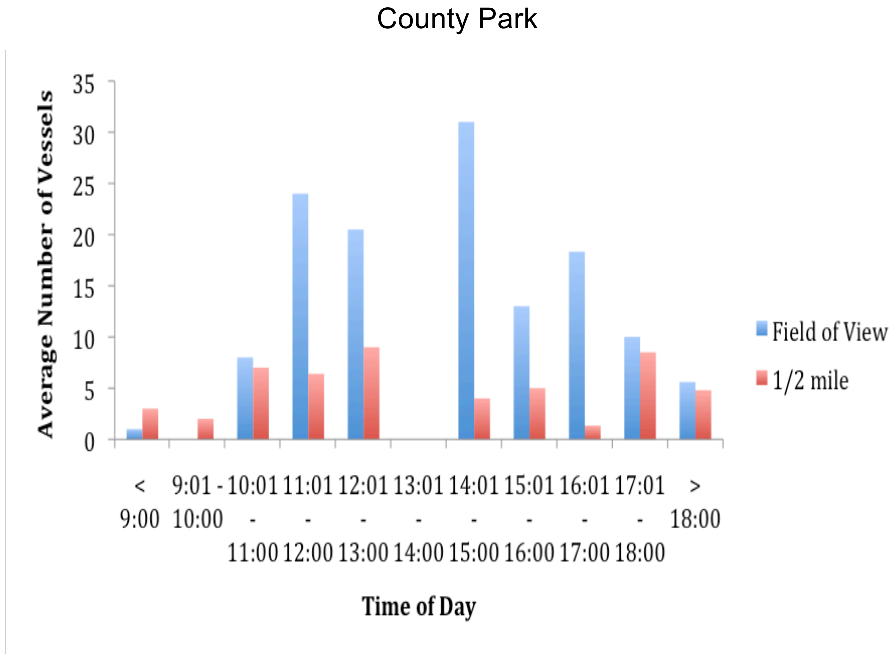


Figure 7. Average number of vessels with whales by time of day, from June to September, at the three study sites.

3.2. SABs and vessel density

The occurrence of the seven specific display behaviors (Table 1) selected for analyzes was observed in 29% of the observations made at Hannah Heights, in 39% of the observations at Land Bank and in 48% of the observations made at County Park.

Tail slaps were the most frequently observed type of behavior in all three sites (Figure 8), representing practically half of the total observations in Hannah Heights and surpassing 50% in Land Bank. In County Park, tail slaps were observed fewer times than in the prior sites, representing almost 40% of the observations.

The second most observed behavior was breach, being more represented in County Park, with 34%. The other behaviors were observed in a lesser degree, and cartwheel was seldom observed.

In all three sites, SABs occurred predominantly when fewer vessels were present, decreasing as the amount of vessels increased (Figure 9). At Hannah Heights and County Park, the majority of SABs occurred in the presence of 0 to 25 vessels. At Land Bank, the performance of SABs was greater when 0 to 15 vessels were present. Aside from this observed trend, a small peak in SABs occurrence was observed in

Land Bank and County Park, with 41 to 45 vessels present, and with 21 to 25 vessels present, respectively.

This trend was strong in County Park (R^2=0.529, F=15.592, P=0.002) and Hannah Heights (R^2=0.718, F=15.325, p=0.008), but slighter in Land Bank (R^2=0.385, F=5.011, P=0.055).

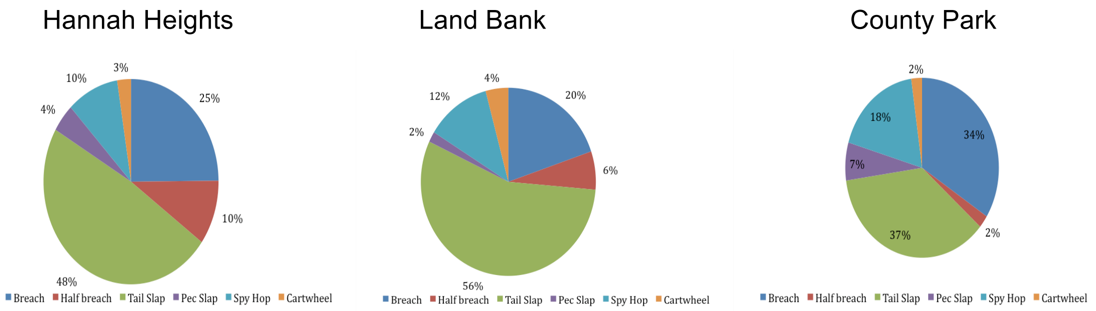
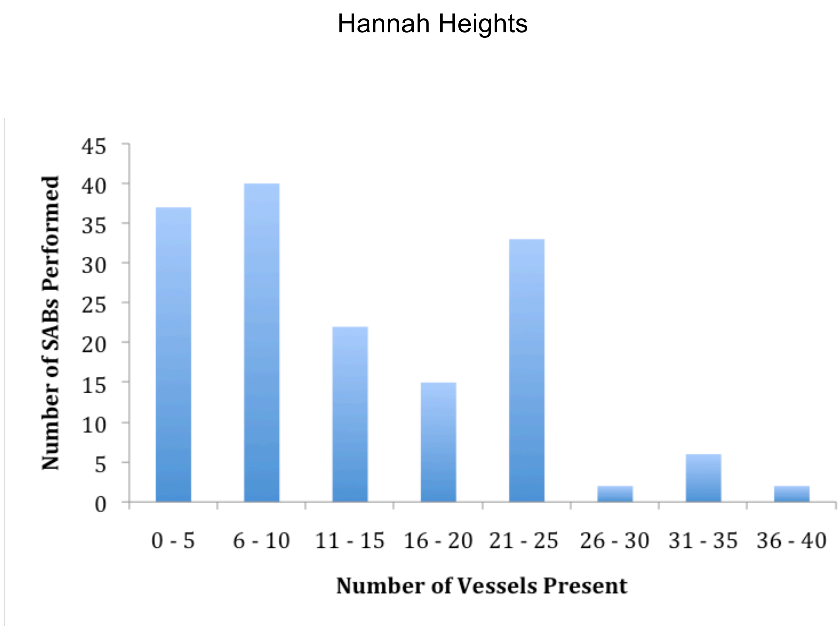
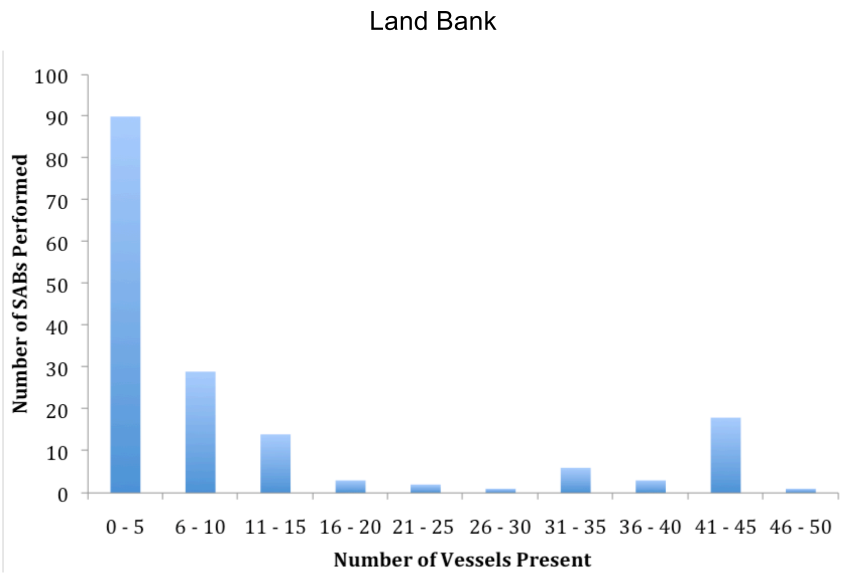


Figure 8. Surface active behaviors (%) performed by southern resident killer whales, from June to September on each study site.





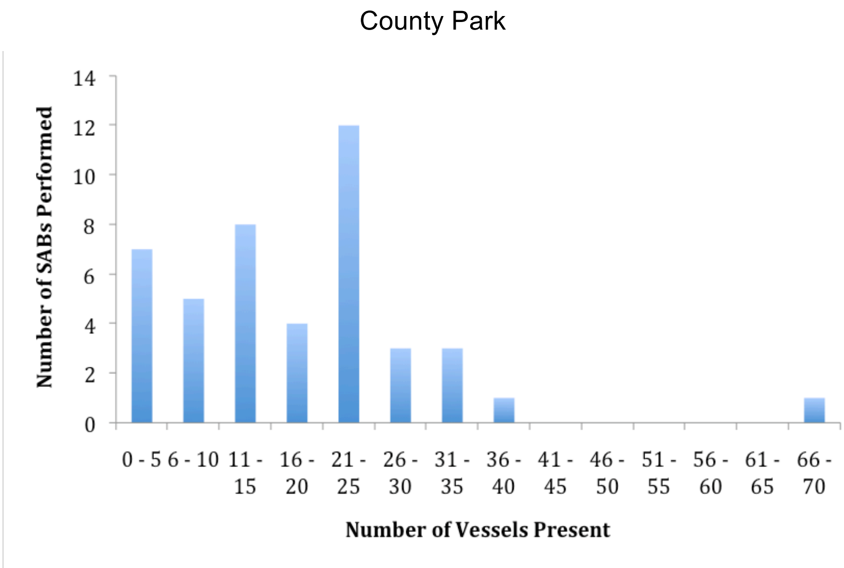


Figure 9. Quantity of surface active behaviors performed in relation to the amount of vessels present.

4. Discussion

Overall, the majority of vessels present tend to be whale watch vessels. However the vessels that come closer to shore are private vessels and kayaks. With extremely few exceptions, all the boats observed are whale oriented.

There is a lot of variation in the number of vessels around the whales, and the maximum number was more than double the mean number.

July and August are the most crowded months and June and September tend to have less traffic. Nevertheless, altogether the three sites studied are used regularly by a considerable amount of vessels, independently of the month or time of the day.

In compliance with the Whale Watch Operators Association Northwest voluntarily imposed code of conduct, the commercial whale watch vessels, with some exceptions, tend to stay out of the ½ mile range from shore, although this type of vessels represents the majority of vessels present in this range. Contrarily, the private boaters and kayaks get much closer to shore and often on the inshore side of whales. This is not surprising, regarding that many of the private boaters come from other regions in the country and may not be informed on the “Be Whale Wise” guidelines. Nevertheless, even after being informed several private boaters keep on approaching the whales and the shore, more often than what it would be desirable (personal observation). The kayaks are generally in compliance with the recommendations, which advises them to stay close to shore. Nevertheless a substantial amount of kayakers (including commercial companies) do go outside the ½ mile range from shore to follow the whales.

The scenery in the field of view and ½ mile from shore at Hannah Heights and at Land Bank is very similar with whale watching vessels representing the bulk of vessels present, followed by private vessels and small quantities of kayaks. Although in Land Bank the quantity of kayaks is higher than in Hannah Heights.

County Park is a free launching site for kayakers, therefore the great number of this type of vessel present in this study site. In the field of view range, the same tendency of the prior study sites remains, but in the ½ mile range, the number of kayaks surpasses the quantities of whale watch and private vessels.

Although the function of performing SABs is still poorly understood, these behaviors are performed during several contexts and have been associated with several purposes. In previous studies of killer whales SABs have been associated to vessel approaches (Duffus & Baird 1995; Noren et al. 2009; Williams et al. 2002a, b, 2009), to social behavior (Ford et al. 2000) and to feeding behavior (Simila & Ugarte 1993). Other studies with cetaceans, associate the performance of SABs to sexual and aggressive behaviors (*Cephalorhynchus hectori*, Sloten 1994) and to social behaviors (*Physeter macrocephalus*, Waters & Whitehead 1990).

It is worth mentioning that, during this study, in one close encounter between a kayak and a calf, the progenitor relocated herself between the kayak and the calf and performed three consecutive breaches (personal observation). This witnessed display may be evidence that SABs are performed in response to disturbance.

The results of the study by Williams et al. (2002a) show that male members of the northern resident killer whale population increase rates of SABs as the number of whale-oriented vessels increase.

This study shows the inverse relation between number of vessels and SABs performance. In the three study sites, the number of SABs clearly decreased as the number of vessels in the vicinity of whales increased. This may be due to the fact of having more data when few boats are present. Further studies in this matter may be needed to evaluate the accuracy of these results. A good approach would be to assess the baseline rate of SABs in the absence of vessels and then compare it with quantities of observed SABs. This analysis would give an estimate of the proportion of SABs due to vessels's presence. This study did not allow this type of analysis because of the nearly absence of data without vessels.

Although, SABs function is still in debate, we can nonetheless use these results to infer that as the amount of vessels increase, the feeding, social and possibly also the sexual behaviors may be inhibited. If this deduction is correct, this is of major concern for this population. Being already in a critical situation of food shortage and low reproductive rates (Krahn et al. 2002), added factors that may disrupt feeding (Lusseau et al. 2009) and sexual behaviors should be avoided.

The most performed SAB was tail slap. This preference is also observed in the northern resident killer whale population (Williams et al. 2002a, b), and it may be explained by the fact that tail slaps are far less energetically expensive to perform than breaches (Waters & Whitehead 1990), and have almost the same visual and acoustic effect.

It is striking that these animals are in an acute situation of vessel traffic. In numerous occasions, the number of vessels present exceeded the number of whales to be watched (personal observation).

Ecotourism is distinct from ordinary tourism for supposedly providing local economic benefit without environmental degradation (Goodwin 1996). Whale watching activities are generally included as a form of ecotourism, but as it has been widely documented in the literature, this activity does affect whales behavior in the Northwest Pacific (Kruse 1991; Kriete 2002; Williams et al. 2002a, 2002b, 2006, 2009; Foote et al. 2004; Bain et al. 2006; Noren et al. 2009; Lusseau et al. 2009) and in other regions of the world (Australia, Janik & Thompson 1996; New Zealand, Constantine & Baker 1997, Barr & Slooten 1998, Bejder et al. 1999, Constantine 2001), although in ways that still need to be clarified with further research. Nevertheless, this type of industry is targeting species that are already in critical situations, listed as endangered and threatened, therefore assuming the potential for disturbance of their natural behavioral patterns in ways that may be detrimental to the whales, a prudent approach should be taken.

Besides the undeniable massive economic benefits, the whale watching industry is supported by many other arguments such as the believe that it may change attitudes toward protecting critical habitat and threatened species (Barstow 1986, Duffus & Dearden 1993), the fact that it provides a platform for research (Corkeron 2003) and that it increases environmental awareness (Orams 1997). Viewing free-ranging animals is better than viewing captive animals and whale watching provides an economically viable alternative to whaling (Corkeron 2003). Furthermore, in 1993, the International Whaling Commission adopted a resolution that declared its desire "to encourage the further development of whale watching as a sustainable use of cetacean resources" (IWC 1994). One view is that the "use" of whales and dolphins as a tourist attraction can be seen as another harmful exploitation of these marine mammals (Orams 1999). Moreover the shift from whaling to whale watching as the primary economic use of whales may not in itself represent improved environmental enlightenment (Corkeron 2003).

Tourists are so eager for interaction with wild animals, especially appealing animals such as killer whales, that these encounters sometimes cause hysterical human behaviors like screaming, shouting, crying and stretching their bodies trying to touch the water or even the killer whales (personal observations). The impact of this kind of tourism in this island is to so high a degree that the killer whales image is used for marketing in all kinds of products ranging from bread to beer; there are several killer whale festivals and events, including meditation for killer whales; and even books on communication with killer whales.

The nearly absence of data on the whale's behavior without the presence of vessels and the difficulties in evaluating cumulative rather than immediate effects on free-ranging animals as resulted in the accepted perception of the southern residents as being "urban whales" and "cosmopolitan" (interview to a commercial operator in Lawrence et al. 1999). Whale watch operators have a clear perception that the whales have become sensitized to vessels presence. However, they believe that self-regulation might help ensure that passengers perceive less harassment of the whales, therefore increasing the passengers' satisfaction with whale-watching experience (Lawrence et al. 1999). There is clearly a focus on the health of the industry rather than in the health of the whales, moreover, government regulations are not perceived as being in the interest of the whales, since stakeholders do not see the industry as harmful for the whales (Lawrence et al. 1999). Nevertheless, there is a perception of the value of the whales that ultimately impels for the conservation of the species although only after it has been demonstrated that there is a pressing need for such protection.

Research has a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education (Kuhn 1962).

Current thinking calls for demonstrations of “biologically significant” effects (International Whaling Commission 2001). But assessing the impacts of ecotourism on whale populations requires techniques that are logistically and financially beyond most research (Corkeron 2003). Given other anthropogenic influences on whale populations, the history of exploitation of most whale species and the magnitude and variability of the ranging patterns of these animals it is unlikely that we could ever attribute even subtle changes to whale watching in time frames useful for managers (Corkeron 2003) and taking in consideration that the southern resident population is seldom without boats nearby, it is extremely difficult distinguish between “disturbed” behavior and “normal” behavior.

The difficulties in the interpretation and understanding of the behaviors of an animal that we can only observe for a scarce amount of time are indisputable, and often give rise to information that is inaccurate and incomplete. We should also take into account the radically different and still largely inaccessible environment where these animals live. The study of animal behavior is heavily influenced by perspective. As Beale (2007) suggested, behavior responses are context dependent and may be quite different between individuals of the same species and even of the same population.

Despite of the intense vessel activity consistently observed in this region, the southern residents continue to return to their traditional summer ranges. This may reflect their strong cultural behaviors or the distribution of their prey (Resident Killer Whale Recovery Team 2007).

The lack of this particular behavioral response led to the belief that this population is “habituated” to vessel traffic, an opinion largely shared by the whale watch operators and also some researchers. The population had the opportunity to acclimate to vessels, because decades before commercial whale watching began there was already present in the southern residents’ range an extensive fleet of fishing vessels, so this population has been in nearly continuous contact with vessels ever since. However research indicates, measurable changes in behavior are still observed more than 30 years after the initiation of whale oriented boating, contradicting the belief that whales have habituated or thoroughly acclimated to the presence of vessels.

Leaving a foraging area might be assumed to be a negative impact (Gill et al. 2001), but the impact is likely to be largely negligible compared with the impact on the individuals subjected to repeated stimuli that do not show behavioral effects but may suffer physiological consequences (Beale 2007). Gill et al. (2001) suggested that a lack of behavioral response may not imply a lack of fitness consequence but may instead reflect a lack of choice and Beale & Monaghan (2004a) provided an empirical test showing that such theoretical arguments translate directly to the field and concluded that it is wrong to assume that the most responsive animals are those that are most vulnerable to disturbance.

This population may simply be dependent on the food that finds on this habitat. It might be more costly abandoning the area than staying. This decision is thoroughly context-dependent. Factors such as the distance to and quality of other suitable sites, the investment that a population has made in a site and the investment needed for searching for another habitat may determine whether an animal leaves a disturbed area or not.

Assuming our level of uncertainty in many aspects that vessels disturbance may affect this already endangered population, and our ignorance of nature's degree of resistance to our activities, precautionary measures that may guarantee a better future for this population should be taken.

With this study it was possible to assess the extent of vessels' activity in the near shore area of the west coast of San Juan Island. These observations made possible to deduct measures for regulating vessels' traffic in this area, promoting a more sustainable form of ecotourism and reducing the frequency of exposure to cumulative impacts of threats.

The proposed measures for the regulation of vessel traffic are the following:

- Limit or interdict, during the period of time that whales are present (generally from May to September), whale watching vessels, private vessels and kayaks, along the west coast of San Juan Island, to an ½ mile range from shore. The scope of this study was limited to a representative part of the west coast of the island but there are evidences that similar levels of vessel activity are observed throughout the west coast (Koski 2008). Taking into account that more than 70% of the vessels that are involved in whale watching activities are already outside of this ½ mile range, the impact of closing this area to vessels traffic would be minimal and it would reduce the exposure time of southern resident killer whales to the vessels and their associated sounds.

- Limit the number of licenses for cetacean observation;

- Limit the number of hours of the day permitted for whale watching activities;

- Limit the number of trips that each company conducts;

- Limit the amount of time permitted with the animals;

- Encourage land-based whale watching activities. In this island the conditions for land-based observations are remarkable, to the point that several scientific studies used this type of platform (e.g. Bain et al. 2006; Williams et al. 2002a, b, 2009). This is also an economically valuable alternative and with adequate environmental education support it can represent a more sustainable way of watching whales while reducing other environmental impacts such as pollution.

These measures only make sense with appropriate enforcement and monitoring. An effort should be made to foster the monitoring programs that already exist, and enforcement clearly needs to be more structured and strengthened.

It may be put in to question if limited spatial protection of a species whose range is so extent is worthwhile but identifying a small but nevertheless important area, in the sense that it is used for essential activities, balances pragmatism and conservation benefit by allowing real management while reducing the exposure to threats.

Additionally, protecting an area, besides the potential to protect the whales it could also help to protect other species living in the same habitat.

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