California Sea Lion (*Zalophus californianus*) and Steller Sea Lion (*Eumetopias jubatus*) Interactions with Vessels in Pacific Rim National Park Reserve: Implications for Marine Mammal Viewing Management

by

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ABSTRACT

Sea lion viewing is an integral component of whale watching trips in the Broken Group Islands (BGI), Pacific Rim National Park Reserve (PRNPR). Pinniped viewing has become a management concern in PRNPR and viewing guidelines have been created to prevent potential disturbance by vessels. Effective management of sea lion viewing requires understanding how sea lions react to vessels and subsequently mitigating aspects of vessel activity that cause disturbance. The objective of this study was to evaluate the effectiveness of the Park's Pinniped Viewing Guidelines (PVG) in preventing sea lion disturbance. This was done by determining the kind and level of behavioural response California and Steller sea lions had to vessel activity in comparison to behaviours exhibited in the absence of vessels. Vessel approaches were controlled for predetermined measures of distance, speed, vessel types and numbers. Analysis included comparing behavioural responses during vessel interactions with behavioural states during scans. Significant change in behaviour was tested for each category of distance, speed, vessel type and number. A total of 160 scan and interaction pairs were sampled during 38 days over two seasons. Thirty-nine (24%) of vessel interactions resulted in disturbance. Variance in behaviours was significant for vessel approaches within 0-25 m (n=79; 38%); vessels approaching 'fast' (n=17; 47%); for motorized vessels under 5 tons (n=107; 30%), and for both 1-vessel (n=113; 23%) and 2-vessel (n=18; 39%) interactions. The results of this research demonstrate that PRNPR's PVG are effective in minimizing sea lion disturbance in the BGI when vessel operators follow the prescribed approach distance and speed guidelines. Recommendations regarding viewing by various vessel types and numbers are given, as well as suggestions for increasing understanding of sea lion behaviour.

Supervisor: Dr. Philip Dearden, (Department of Geography)

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Dedication

In memory of my father, who, through words and actions taught me to never give up; to my mother, who modeled the strength I needed to get through this challenge; and to the sea lions who were, and continue to be, my inspiration.

Chapter 1: Introduction

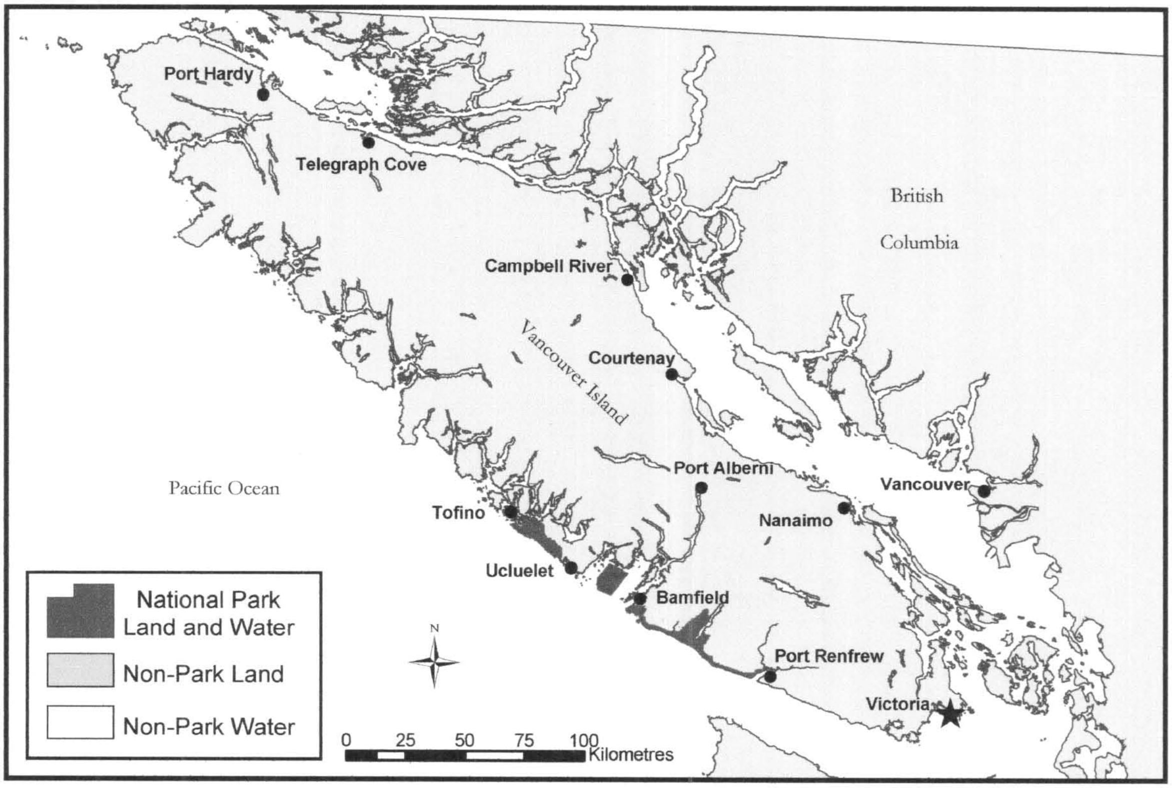
1.1 Rationale

Marine mammal viewing, particularly of whales, has become one of the fastest growing sectors of the wildlife-based tourism industry (Lien 2000, Hoyt 2001). There are many known benefits of marine mammal viewing, including socio-economic, scientific, recreational and educational. The impact of marine mammal viewing activities on wildlife is poorly known. Given the size, speed and noise generated by all types of vessels, there is concern regarding the potential disturbance vessels may have on marine mammals. Seals and sea lions (pinnipeds) are frequently viewed during whale watching trips, particularly when whales are not in the vicinity. Because pinnipeds may 1) experience repeated vessel interactions, and 2) be observed reliably at designated haulouts, sea lions are ideal animals for studying marine mammal/vessel interactions.

When marine mammal viewing activities interfere with the normal daily activities of sea lions – such as foraging, resting, socializing and avoiding predators - viewing activities become a conservation threat and management priority. Vessel activity around pinnipeds has become a management concern in Pacific Rim National Park Reserve (PRNPR) on British Columbia's west coast (Figure 1).

The objective of this study was to investigate impacts of vessels on sea lions in the Broken Group Islands (BGI), PRNPR and to evaluate the Park's Pinniped Viewing Guidelines (PVG). This was done by determining if the animals' behavioural responses to vessel activity are indicative of disturbance. Effects of vessel activity were examined by investigating affects of specific approach speeds, viewing distances, and numbers of vessels and vessel types. Behavioural responses of sea lions to various types and levels of vessel activity were measured and compared with behaviours in the absence of vessels. Results of this study will be offered as scientifically defendable recommendations to PRNPR regarding its PVG.

Figure 1: Location of Pacific Rim National Park Reserve



Several studies have examined the effects of human disturbance on seals (Phocidae) at haulouts (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Allen *et al.* 1984, Calambokidis *et al.* 1991, Suryan and Harvey 1999, Born *et al.* 1999, Lelli and Harris 2001, Henry and Hammill 2001) and a few have addressed disturbance of sea lions (Otariidae) (Mathews 2000, Kucey 2005). Previous studies failed to incorporate a systematic approach to testing variables associated with vessel activity (vessel type, distance and speed). This study is the first to experimentally test and quantify sea lion behaviour in response to varying vessel approach distances, speeds, vessel types and numbers of vessels.

1.2 Marine Mammal Viewing

Whale watching has contributed to establishing marine tourism as the largest growth sector in tourism (Hall 2001), the fastest growing wildlife-based tourism industry (Hoyt 2001), and has become the largest wildlife-based tourism activity in British Columbia

(Malcolm and Lochbaum 1999). The potential impact of human disturbance on marine mammals has become a concern related to marine mammal viewing activities (Gill *et al.* 1996).

Wildlife observers actively seek and approach wildlife and are therefore more likely to interact with wildlife than recreational boaters who encounter wildlife accidentally (Boyle and Samson 1985). Pursuing interactions are likely to disturb marine mammals because encounters are frequent and are longer in duration than accidental encounters. Issues regarding marine mammal viewing encompass additional complexities due to the lack of scientific information regarding wildlife disturbance (Duffus and Dearden 1990). Effects of wildlife viewing on marine mammals may be subtle and difficult to quantify. In most cases, management must proceed before scientific information regarding wildlife impacts is available (Duffus and Dearden 1990).

The concentration and predictability of Pacific gray whales *(Eschrichtius robustus)* between March and September in Barkley and Clayoquot Sounds are the basis for the commercial whale watching industry in and around PRNPR. Pinniped viewing is an integral component of these whale watching excursions in Park waters. Non-consumptive use and visitation to national parks can degrade ecosystem integrity and habitat for wildlife (Parks Canada 2000).

1.3 Development of Marine Mammal Viewing Guidelines in Pacific Rim National Park Reserve

In the late 1990s PRNPR began to receive complaints of vessels approaching whales closely and allegedly harassing them in Park waters. The Park documented that both commercial and private boaters were not observing local voluntary guidelines. Concern regarding unknown effects of whale watching on marine mammals and their habitat prompted PRNPR to host a Marine Wildlife Disturbance Workshop in February 2000. The purpose of the workshop was to review the voluntary whale watching guidelines for Clayoquot and Barkley Sounds and discuss the revision of these guidelines with industry, government, researchers, First Nations and concerned members of the public. Common to all participants was the concern for the long-term well being of marine wildlife and the sustainability of the marine mammal viewing industry on the west coast of Vancouver Island. Consultations focused both on species-specific and site-specific issues. The result was a set of Marine Wildlife Viewing Guidelines (which included the PVG) that were approved by Park management and finalized in the fall of 2003 (Appendix I).

1.4 Need for Science-Based Guidelines

Given the concerns attributed to the effects of marine mammal viewing, the rapid growth of the whale watching industry, and the increase in number of vessels in proximity to marine mammals, it has become necessary to develop regulations or guidelines to manage boating behaviour around marine mammals. The specifications of most regulations are arbitrary. Regulations should be based on the biology and behaviour of species that they are designed to protect (Duffus and Dearden 1992). A code of conduct based on scientific research is more likely to be followed by operators, supported by local authorities and accepted by the public, than an arbitrary code (Duffus and Dearden 1992). Detailed studies that investigate the effects of vessels on sea lions do not exist but would be of great value in developing appropriate guidelines. Only one previous study in Alaska focused on the effect of vessels on Steller sea lions (Mathews 2000). Existing information related to sea lion behaviour in PRNPR is anecdotal. Parks Canada's policy is to take a precautionary approach in management decision-making to actively avoid environmental harm when there is little or no scientific information to make management decisions (Parks Canada 2001).

Whale watching businesses operating within the Park generally show concern for sea lions and have regulated their activities through peer pressure and the use of locally developed guidelines. These original guidelines, and the more recent Marine Wildlife Viewing Guidelines, are not based on science. Though researchers were consulted, approach speeds and distances were created *ad hoc*. Testing the validity of the PVG is important. Results will provide scientific data for management decision-making that will allow whale watching activities to proceed in a sustainable manner for the long term while protecting sea lions.

1.5 Disturbance

"Disturbance" to marine mammals through wildlife viewing activities has not been defined objectively, and this has resulted in management challenges in PRNPR. One definition of "disturbance" as it pertains to whale watching is: "...whale watching activities may disturb cetaceans in the performance of normal daily activities which are critical to their survival, and that such disturbances, if persistent and repetitive, could cause long term conservation impacts" (Lien 2000:2). This approach can be applied to pinnipeds. Essential life processes of sea lions include foraging, resting, reproducing, caring for young, avoiding predators, as well as communicating and socializing, with their group. Any human activity that interrupts a sea lion engaged in these activities interferes with the animal's ability to carry out its life processes. "If an animal cannot carry out its life processes its own survival may be at risk. If such disruption to life processes occurs to a particular segment, or to a significant number of individuals within the population, it follows that conservation may be at risk" (Lien 2000:6).

1.6 Pinniped Viewing

Viewing pinnipeds can be the main purpose of a trip or one aspect of it. For the purposes of this thesis I define pinniped viewing as: "tours by boat, air or from land, formal or informal, with at least some commercial aspect, to see pinnipeds". Concern about the impact of viewing pinnipeds has only been recognized recently. Studies of impacts of pinniped watching are limited and there is no evidence of long-term negative impact on individuals, groups or populations. Existing scientific studies on the effects of vessel interactions examine short-term effects. Information from these studies indicates that vessel activities disrupt and prevent animals from conducting their normal activities (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Allen *et al.* 1984, Calambokidis *et al.* 1991, Suryan and Harvey 1999, Born *et al.* 1999, Mathews 2000, Lelli and Harris

2001, Henry and Hammill 2001). Impacts of short-term disturbances may be exacerbated by the fact that some groups of pinnipeds are already endangered or threatened in parts or all of their range (COSEWIC 2003).

Viewing may entail risks to sea lions that are concentrated in areas considered to be critical habitat. Pinnipeds that exhibit site fidelity are more vulnerable to concentrated disturbances than animals that are dispersed and vary their locations. Sea lion viewing has become concentrated at specific haulout areas in the BGI, increasing the vulnerability of the animals to repeated short-term disturbance. Impacts from viewing activities may therefore be to a few individuals or groups of pinnipeds. The likelihood of frequent and repetitive disturbances has increased over the past few years as the number of whale watching businesses increase in Ucluelet and the number of recreational boaters increases in the BGI.

1.7 Pinniped Viewing in Pacific Rim National Park Reserve

Viewing sea lions is a planned component of regular whale watching trips in Barkley Sound. The whale watching vessels that operate in Barkley Sound have increased in number since the first whale watching company began operating from the village of Ucluelet in 1978. There are now four companies offering regular whale watching trips in Barkley Sound that also visit the sea lion haulouts in the BGI unit of PRNPR (Figure 2). Commercial operators spend 5 to 60 min (mean, 5-10 min) viewing or being in the presence of sea lions. Two of the companies operate two boats and the other companies each operate one boat. Each vessel makes one to three trips daily to the BGI between the months of July and September. If each of these vessels makes two trips per day during these months, there are 1080 potential opportunities for sea lions to be disturbed by commercial vessels. The potential increases if interactions with recreational boats and kayaks are considered.

Parks Canada has a mandate to protect ecological integrity (Canada 2000). Policy requires Parks Canada to base its management decisions on science (Parks Canada 1994). The science Parks Canada needs to make decisions regarding pinniped viewing however, is lacking. Therefore, research on sea lion/vessel interactions is important to ensure that decisions regarding whale watching reflect Parks Canada's interests to protect sea lions, as well as the interests of whale watching operators, to ensure the long term sustainability of the whale watching industry in PRNPR.

1.8 Sea Lions in Pacific Rim National Park Reserve

Sea lions are found in all 3 units of PRNPR (Long Beach unit, West Coast Trail unit, and the BGI unit) (Figure 2). These haulout sites are resting areas where breeding and pupping rarely occur. Steller *(Eumetopias jubatus)* and California sea lions (*Zalophus californianus*) are the two sea lion species viewed by local whale watching operators in the BGI.

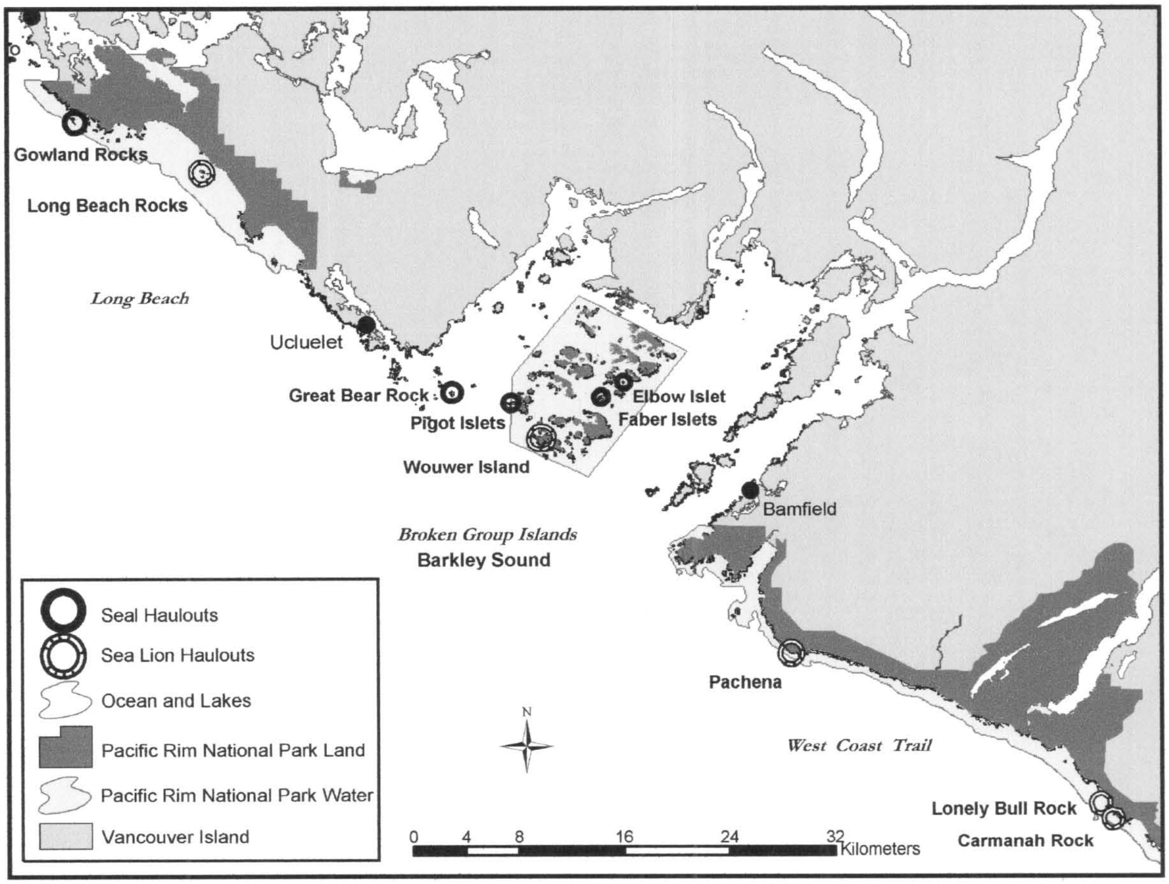
1.8.1 Steller Sea Lions

Steller sea lions occur along the coastal rim of the North Pacific from the Bering Sea to California and are year-round residents in British Columbia (Calambokidis and Baird 1994). Long Beach Rocks and Carmanah Rocks are year-round haulout sites for Steller sea lions and there are seasonal haulouts in the BGI where Steller sea lions congregate from mid summer until late fall. Steller sea lion populations in northwest Alaska (known as the 'western stock') have declined by 85% since the late 1970s (Loughlin 1998) and were listed as 'endangered' in 1997 in the United States (US Federal Registrar 1997). PRNPR is a significant area for Steller sea lions of the 'eastern stock'. In 1992 the western stock was listed as 'threatened' in Canada (COSEWIC 2003). Although considered to be stable and increasing slightly, the eastern stock was listed recently (November 2003) as a Species of Special Concern in Canada (COSEWIC 2003).

1.8.2 California Sea Lions

California sea lions mix with Steller sea lions on some British Columbia haulouts. In British Columbia, California sea lions are distributed mainly off the western coast of Vancouver Island from Barkley Sound area south to Race Rocks in Juan de Fuca Strait and north to Denman Island in Georgia Strait. Within PRNPR, the main California sea lion haulouts are in the BGI, although some are also observed at Long Beach Rocks and Carmanah (Figure 2).

Figure 2 Pinniped haulouts in Pacific Rim National Park Reserve



Only adult and sub-adult male California sea lions occur in British Columbia, during the late summer, fall and winter. In May through July, animals congregate on islands off California and Mexico to pup and breed. At the end of the breeding season, males leave the rookeries and migrate north as far as central Vancouver Island to feed and rest (Bigg 1985). California sea lions usually are first seen in the BGI at the beginning of August and their numbers increase steadily through October.

In early 1900s the number of California sea lions was very low and increased in the early 80s (Bigg 1985). The population in the BGI has steadily increased through the 90s (B. Congdon pers. comm. 2003) and in 2001 numbers reached historical levels of over 2000 individuals in Barkley Sound (P. Gearin pers. comm. 2002, pers. obs.). Increased use by California sea lions makes this the most important haulout for this species within the Park.

1.9 Guidelines and Regulations

Many countries have adopted a regulatory approach to manage human activities around marine mammals, particularly whales (Carlson 2001). Few guidelines or regulations are specific to viewing pinnipeds. Guidelines that address pinniped viewing such as the Marine Mammal Viewing Guidelines (including specific guidelines for the Northwest, Southwest, Southeast, Alaska and Hawaiian Islands regions) (National Oceanic and Atmospheric Association (NOAA)), Best Practices Guidelines (Whale Watch Operators Association of the Northwest 2001), Be Whale Wise (Marine Mammal Monitoring Project 2001), Boater Guidelines (Soundwatch 2002), seek to implement a common-sense precautionary approach. Guidelines and regulations generally involve specification of approach distances, minimization of vessel speed, avoidance of abrupt changes in speed, minimization of noise, and the number of vessels engaged in viewing at any one time.

1.9.1 Current Management Regimes and Enforcement

Fisheries and Oceans Canada (FOC) has federal authority for the management of marine mammals as outlined in the Marine Mammal Regulations under the *Fisheries Act*. The Act requires that "No person shall disturb a marine mammal except when fishing for marine mammals under the authority of these regulations" (FOC 1995, Section 7). The intent of this regulation is to manage human activities that will, or could affect marine mammal populations in Canadian waters, and to ensure their long-term conservation. These regulations predate the existence of non-consumptive use of whales, and regulations are no longer adequate in addressing marine mammal viewing issues. At the time of this writing, FOC is rewriting its Marine Mammal Regulations to address non-consumptive use of marine mammals.

Parks Canada has additional regulatory tools to manage sea lion viewing within PRNPR. Regulation of the PVG for commercial whale watching vessels falls under the Business Regulations of the *Canada National Park Act*. The PVG form part of the Terms and Conditions for the Park Business Licenses which are required by all commercial whale watching companies operating within the Park. Violations of the PVG by commercial operators are dealt with under the Business Regulations. Recreational boaters or other visitors found disturbing sea lions can be charged either under the *Fisheries Act* or the *Canada National Parks Act* (Section 4).

1.9.2 Park Pinniped Viewing Guidelines

The purpose of the Park PVG is to ensure the long-term protection of sea lion populations and their habitats, and to ensure the sustainability of the local whale watching industry. The following are particulars outlined in the Guidelines:

Speed: Slow down to 5 knots (*no wake speed*) at 250 m

Distance: Do not approach closer than 50 m "*no go zone*"

Vessel Type and Numbers: Up to 3 vessels "*under 5 tons*" or 1 vessel "*over 5 tons*" inside the "*close viewing zone*" (50-100 m)

To investigate impacts of vessels on sea lions in the BGI and to evaluate the Park's PVG these particulars need to be evaluated. To do so, the following hypotheses are tested:

Distance:

1. Approaching closer than 50 m to a haulout causes sea lion disturbance.

Speed:

2. Not slowing down to 5 knots (*no wake speed*) at 250 m from a haulout causes sea lion disturbance.

Vessel Type and Numbers:

3. Vessels "*under 5 tons*" cause less disturbance to sea lions than vessels "*over 5 tons*".

4. *One vessel* approaching a haulout causes less disturbance than more than one vessel.

The PVG also specify a 100 m minimum viewing distance for pinnipeds at other locations within the Park. A 300 m (1000 foot) minimum viewing distance is required for aircraft and the Guidelines make specific reference to viewing by both fixed-wing aircraft and helicopters. Personal watercraft are considered to be inappropriate for viewing marine mammals and are prohibited in the BGI. Opportunistic observations of interactions with fixed-wing aircraft and helicopters were made, as were approaches with personal watercraft.

I begin this thesis with a review of the literature on pinniped disturbance with emphasis on factors associated with vessel interactions. In chapter three I introduce the research design and observational methods. I follow this with a chapter on data analysis and then present the results in chapter five. The results are then discussed in context of the Park's PVG and suggestions for compliance and future research needs are made.

Chapter 2 Pinniped Disturbance

Pinniped viewing has become a management concern in PRNPR due to: not knowing 1) whether vessel activity causes a disturbance to sea lions within the Park; and, 2) if repeated disturbances could have long-term consequences for the sea lion population that inhabits the Park. Parks Canada's management priority is the protection of ecological integrity which includes maintaining the composition and abundance of native species and biological processes (Canada 2000). It is therefore important that the PVG be evaluated for their effectiveness in preventing disturbance. If they do not meet this objective, the growing number of sea lion/vessel interactions may pose a threat to ecological integrity and the sustainability of pinniped viewing in PRNPR.

Stress responses to a disturbance are both physiological and behavioural (Stratakis and Chrousos 1995). Only behavioural responses to vessel interactions are investigated here. This chapter reviews literature pertaining to pinniped disturbance. Definitions of disturbance are provided, followed by an overview of how responses to disturbance by humans are measured. Causes and effects are reviewed with special emphasis on disturbances caused by vessels.

2.1 Definition and Measurement of Pinniped Responses to Disturbance

Only two definitions of pinniped disturbance have been defined operationally: 1) an increase in activity level by 20% (Mathews 2000), and 2) one or more than one pinniped entering the water (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Allen *et al.* 1984, Calambokidis *et al.* 1991, Suryan and Harvey 1999, Born *et al.* 1999, Lelli and Harris 2001). For this study, the following two behaviours were interpreted as an indicator of disturbance: *stampeding* (rapid movement on land *towards* the water) and *flushing* (rapid retreat *into* the water). A human interaction with sea lions that resulted in *stampeding* or *flushing* was considered a 'disturbance event' or simply, a 'disturbance'. *Stampeding* was included as a measure of disturbance for two reasons: 1) it signified an interruption in normal activities; and, 2) at the onset of a stampede *flushing* could not be predicted. The inclusion of *stampeding* as a measure of disturbance makes this research more liberal in its assessment of disturbance: previous work only considers a pinniped to be disturbed if it rapidly enters the water in reaction to a human activity.

Only behavioural measures of disturbance have been used as indicators to investigate pinniped responses to vessel activity. Changes in pinniped behaviour at haulout sites are relatively simple to measure (Suryan and Harvey 1999) although it is difficult to recognize and quantify disturbance effectively (Gill *et al.* 1996). There are difficulties in interpreting results because most studies do not control for physiological and environmental factors. This is due to the difficulty in designing experiments that account for the myriad of variables that influence an individual sea lion's behaviour. Avoidance of sources of disturbance is the most commonly used behavioural measure in studies of disturbance (Gill *et al.* 2001). The actual fitness costs of such changes in behaviour need to be quantified before they can be used as reliable estimates of the impact of disturbance on populations (Gill *et al.* 2001). Science has not yet established quantitative links between behavioural changes associated with disturbance and the fitness costs that might affect survival and reproductive success (Moberg 1987, Gill *et al.* 2001).

Changes in behaviour can be indicative of disturbance. Pinnipeds on land sometimes raise their heads in an alert response to an approaching vessel, aircraft or person. An alert response may be the only visible manifestation of disturbance, or may be followed by avoidance – movement towards, or into the water (Richardson *et al.* 1995). Movement may be slow or pinnipeds may stampede abruptly. Both of these behaviours represent avoidance, but there is a gradation in intensity of the disturbance (Richardson *et al.* 1995). Avoidance reactions may not always be directed away from the source of disturbance; sea lions on a beach often flush, and once in the water frequently approach boats.

On the Channel Islands, California, the usual alarm reaction of non-breeding California sea lions consists of rapid movement towards the water, even if this involves leaping off a high cliff onto a rocky beach below (Peterson and Bartholomew 1967). The alarm reaction is highly contagious, and usually spreads rapidly through an aggregation. If the reaction is of low intensity several animals will simultaneously sit up, look about and gradually retreat from the direction of the disturbance. If the disturbance is more extreme, the sea lions will move rapidly to the waters' edge before stopping to look about. Sometimes hundreds of animals flush into the water without pausing to identify the source of the disturbance (Peterson and Bartholomew 1967). After entering the water they typically begin barking, form groups (rafts) and swim back toward the shore with heads held high from the water as if trying to observe the cause of their alarm (Peterson and Bartholomew 1967).

2.2 Sources of Disturbance

To achieve Parks Canada's goal of preventing disturbance of sea lions in PRNPR, sources of disturbance need to be identified and the animals' responses understood. Human activities causing disturbances, particularly vessel interactions, can thereby be managed better to protect sea lions from being disturbed.

Disturbances can be caused by human activities or by natural events. California sea lions exhibit rapid movements and stampede as a result of human activity on or near rookeries (Bowles and Stewart 1980). Low flying helicopters, humans on foot, vessel traffic and loud boat noise are major disturbing influences to pinnipeds (Bowles and Stewart 1980, Kucey 2005). Natural disturbances may include any loud or sudden noise or the appearance of an unfamiliar object. Alarm calls or other sudden activity of gulls, escape reactions of cormorants, harbour seals or sea lions, or any sudden movement cause sea lions to stampede (Peterson and Bartholomew 1967, Bowles and Stewart 1980).

A major cause of disturbance is noise which can disturb animals by interrupting normal activities (Bowles 1995, Fair and Becker 2000). Many reactions to ships or boats by pinnipeds are presumably reactions to noise (Richardson *et al.* 1995). Reactions often are at long distances and usually follow changes in engine and propeller speed. Variability and rate of change in sound are important (Richardson *et al.* 1995). Marine mammals often are more responsive to sounds with varying or increasing levels than to steady sounds (Richardson *et al.* 1995). Effect of vessel noise is therefore an important factor to consider when investigating pinniped/vessel interactions.

2.3 Factors Affecting Disturbance

Reactions to human presence vary depending on numerous factors. Reactions can be affected by the nature of human activity including variables associated with the interaction, time and location of encounter, number of humans, and previous experience with humans (Bowles and Stewart 1980, Richardson *et al.* 1995). Variability can be attributed to characteristics of man-made noise such as its attenuation rate and background noise level (Richardson *et al.* 1995). Current activity level, age, sex class, moult, reproductive state and breeding status can all affect responses to human presence, as can motivational state and recent exposure to predator pressure (Calkins 1983, Bowles 1995, Richardson *et al.* 1995, Orsini 2004). Season, time, weather, tide and location are other factors that also affect responses (Richardson *et al.* 1995, Kucey 2005). Reactions can vary between individuals, groups and species (Bowles and Stewart 1980, Richardson *et al.* 1995, Lien 2000). All these variables make it very difficult to generalize impacts. Large sample sizes would be needed to characterize the variation in responsiveness (Richardson *et al.* 1995, Fair and Becker 2000).

Reactions to vessels are most important to consider when evaluating the Park PVG because most human activity around sea lions in PRNPR is by vessel. Additionally, variables associated with vessel interactions such as approach distance and speed can be controlled and therefore managed, whereas natural influences cannot. Parks Canada could incorporate those factors into the Park PVG which influence sea lion disturbance and which are relevant to vessel interactions in PRNPR.

2.3.1 Vessel Distance

Sea lions are more responsive to vessel interactions when on land (Peterson and Bartholomew 1967) but rarely react unless approached within 100-200 m (Bowles and Stewart 1980). The only work that has investigated vessel disturbance to Steller sea lions is by Mathews (2000). Mathews found that in Alaska, Steller sea lion disturbance is correlated with vessel approach distance and vessel type. Forty-four percent of encounters that resulted in a major disturbance occurred when boaters approached the haulout closer than the 100 yards (90 m) minimum viewing distance, and all cases of overt disturbance except one, occurred when vessels approached the haulout closer than 160 m (Mathews 2000). Over half the interactions within 110 m did not elicit measurable changes in behaviour (Mathews 2000). Similar variability in the distance at which a disturbance response occurs with Steller sea lions could be expected to occur in PRNPR.

Because quantitative analysis of sea lion disturbance by vessels is limited, it is useful to refer to similar work done with seals. Boat operators are a common cause of harassment to harbour seals (*Phoca vitulina*) (Allen *et al.* 1984, Calambokidis *et al.* 1991, Kroll 1993). The distance at which a disturbance occurred is affected by vessel type (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Kovacs and Innes 1990, Calambokidis *et al.* 1991). Kayaks disturb harbour seals at a significantly greater distance than motorized boats (Calambokidis *et al.* 1991, Henry and Hammill 2001). Since the distance at which a disturbance occurs has been found to be correlated with vessel type, evaluating whether the viewing guidelines prevent pinniped disturbance from kayakers becomes important.

2.3.2 Vessel Speed

Kucey (2005) observed Steller sea lions to react strongly to approaching boats that did not slow down, however no data exist on the affects of speed on sea lion behaviour. Data on phocids are equivocal. One study demonstrated harbour seals were less disturbed when vessels approached at slow speeds (Murphy and Hoover 1981) and another found that powerboat speed did not significantly influence seal disturbance (Suryan and Harvey 1999).

2.3.3 Vessel Type and Number

The PRNPR PVG outline restrictions pertaining to particular vessel types and numbers. The Guidelines specify vessel types *under 5 tons* and *over 5 tons* but do not specify *kayaks*. Interestingly, kayaks have been found to elicit the most extreme disturbance response in pinnipeds by any vessel type. The most extreme responses from Steller sea lions occurred during kayak approaches (Mathews 2000) and most disturbances to harbour seals were also caused by non-motorized boats, primarily kayaks and canoes (Allen *et al.* 1984, Johnson *et al.* 1989, Lelli and Harris 2001). There has been no systematic study of the reaction of sea lions to various vessel numbers.

2.3.4 Fixed-wing Aircraft

Steller sea lions exhibit variable reactions to aircraft and overflights can cause disturbance (Calkins 1983). Calkins (1983) found type of aircraft to have substantially different effects on sea lions and Kucey (2005) found the magnitude of aircraft disturbances in Steller sea lions to be determined by altitude. Approaching aircraft usually cause some or all animals to rush into the water (Harestad 1978, Johnson *et al.* 1989). The PRNPR PVG specify a minimum altitude of 1000' (300 m) for viewing pinnipeds in the Park. Alert reactions have been elicited in California sea lions by large aircraft at 300 m and by light aircraft at 150-180 m; aircraft flying <30 m have resulted in partial or complete abandonment of haulouts by seals (Bowles and Stewart 1980).

2.3.5 Helicopters

Helicopters are considered a major disrupting influence to California sea lions (Bowles and Stewart 1980). They may be more disturbing than fixed-wing aircraft, but the lack of scientific data makes evaluation difficult (Richardson *et al.* 1995). Responses vary with altitude and species. Sometimes helicopters at altitudes >300 m cause no observable reaction whereas helicopters flying at altitudes <300 m can cause severe reactions to California sea lions (Bowles and Stewart 1980, Kroll 1993). On one occasion >1000 Steller sea lions were observed stampeding off a beach in response to a Bell 205 helicopter more than 0.6 km away (Harestad 1978, Withrow *et al.* 1985).

Documented responses to helicopters <300 m indicate that over-flights occurring at low altitudes have a higher probability of eliciting a disturbed response by sea lions in the BGI. The variability of California sea lion reactions to helicopters at different altitudes makes it essential to incorporate altitude restrictions that reflect behavioural measures of disturbance. Parks Canada banned helicopters from viewing pinnipeds in PRNPR based on the assumption that disturbances caused by helicopters are extreme.

2.3.6 Humans on Foot

The PVG do not address viewing sea lions by foot. A Parks Canada trail opens onto a beach area on Wouwer Island where hundreds of sea lions haul out during the late summer. This coincides with the months of highest visitor use in the BGI. Disturbances from humans on haulouts are known to be extreme: most interactions with humans on foot cause major reactions resulting in 75-100% of hauled sea lions running to, or entering, the water (Peterson and Bartholomew 1967, Bowles and Stewart 1980). Considering the effect of disturbance by humans on foot in the study site would be of benefit for Park management. People walking near or on sea lion rookeries and haulouts have caused major short-term disturbances to California sea lions (Kroll 1993) and to Steller sea lions (Lewis 1987, Kucey 2005). People on foot have caused disturbances at a distance of 256 m (Calambokidis *et al.* 1991) but one can closely approach sea lions if maintaining a low profile – probably due to their poor aerial vision rather than indifference to humans (Peterson and Bartholomew 1967, Calambokidis *et al.* 1991).

2.3.7 Environmental Factors

Temperature, tidal cycle, sea state, wind direction and time of day have been found to affect sea lion haulout behaviour (Peterson and Bartholomew 1967, Harestad 1978, Cehak 1978, Bowles and Stewart 1980, Richardson *et al.* 1995, Orsini 2004). Temperature, sea state, wind direction, time of day and season seem to have the greatest potential to influence sea lion responses to vessel interactions. Sea lions move seaward as temperatures increase (Bowles and Stewart 1980). California sea lions are sensitive to high air temperatures and sometimes stampede on sunny days for no apparent reason (Peterson and Bartholomew 1967). Heavy surf causes California sea lions to move inland above breakers (Peterson and Bartholomew 1967) and Steller sea lions abandon haulouts wetted by waves (Cehak 1978). Wind direction can affect the distance at which sea lions react on haulouts. Reactions occur at greater distances when the wind blows from a noise source towards the animals, presumably because wind can enhance transmission of the sound (Richardson *et al.* 1995). Wind can also carry the scent of people and boat exhaust. The number and activity level of Steller sea lions are related to time of day. The number of Steller sea lions hauled out increases during early morning and decreases in the evening (Schusterman 1968). Level of activity increases at haulouts as the day progresses, with sea lions being most active between 10:30 and 15:30 (Bowles and Stewart 1980). Moult may also affect sea lion behaviour: seals haul out longer when they are moulting (Kovacs and Innes 1990).

2.3.8 Predation Risk

Predation risk is another factor that may affect pinniped reactions to vessels. Prey have evolved anti-predator responses to generalized threatening stimuli such as loud noises and rapidly approaching objects. Therefore, sea lion responses to approaching vessels are likely to follow the same patterns used when encountering predators. From an evolutionary perspective, disturbance (from human presence) should be analogous to predation risk (Frid and Dill 2002). It would be advantageous for sea lions to respond to the sight of transient (mammal-eating) killer whales (*Orcinus orca*) with anti-predator behaviour (Deecke *et al.* 2002) because sea lions are prey of transient killer whales. The alert reaction of sea lions in the presence of kayaks close to shore could be because sea lions perceive kayakers as killer whales or as unfamiliar objects and hence, a potential danger (Deecke *et al.* 2002).

2.3.9 Habituation

Habituation is a phenomenon involving the progressive lessening of responses to stimuli that are learned to lack significance to an animal (Thorpe 1963). Wild mammals often habituate to background activities that are steady and predictable and are less likely to habituate to unpredictable disturbances such as abrupt change in speed or direction of approach and sudden changes in sound or movement (Schultz and Bailey 1978). When developing viewing guidelines it is important to ensure that predictability of vessel behaviour is incorporated.

Past experience with vessels plays an important role in influencing pinniped responses to vessels. Startle or flight reactions to airborne noise habituate at different rates for different species, for different populations, and for different groups within a population as a function of age, sex, season and time of day (Schusterman 1981, Schusterman and Moore 1981). Disturbances also vary in different locations (Johnson *et al.* 1989). Murphy and Hoover (1981) noticed habituation of harbour seals as the season progressed. Harbour seals permit close approaches by tour boats that repeatedly visit haulout locations (Bonner 1982) and distances of initial disturbance reactions are greater than subsequent interactions (Suryan and Harvey 1999). In areas with high vessel traffic, harbour seals may habituate and show no evidence of disturbance (Johnson *et al.* 1989, Brasseur 1993). Australian sea lions (*Neophoca cinerea*) frequently visited in a nature reserve appeared to habituate whereas the same species was more sensitive at breeding sites (Stirling 1972).

2.3.10 Recovery

Recovery time is the length of time it takes for sea lions to return to their pre-disturbance state after a disturbance. Recovery is important because it is an indication of the level of disturbance and the length of time an animal's normal activities are interrupted. The duration of the disruption is rarely quantified rigorously and depends on the level of disturbance (Richardson *et al.* 1995).

Recovery of pinnipeds following disturbance could be as brief as 5 minutes (Allen *et al.* 1984) or as long as several weeks (Peterson and Bartholomew 1967). Steller sea lions showed increased activity for 1.5-4.5 hours following a disturbance caused by an aircraft (Harestad 1978); took 1-5 hours to recover after a census-caused disturbance, (Bowles and Stewart 1980); and 4.3 days to recover following disturbances caused by human presence on shore (Kucey 2005). In comparison, after being displaced from attempts to mark them, California sea lions gradually reoccupied their old site over a period of several weeks (Peterson and Bartholomew 1967). The number of animals that eventually hauled out after being disturbed was always lower than the original number (Allen *et al.* 1984, Kucey 2005).

2.4 Effects of Pinniped Disturbance

Disturbances have both short and long term effects (Young 1998). Studies of pinniped disturbance have documented short-term responses (Richardson *et al.* 1995). Short-term effects include changes in certain variables from normal to heightened or decreased and then back to normal within an observable time scale – usually within minutes or hours. Disturbance may include interference with important behaviours and cause energetic imbalances such as: interruption in, or cessation of, resting, feeding or socializing (Calambokidis *et al.* 1991); increased alertness (Bowles and Stewart 1980, Orsini 2004); temporary or permanent separation of females from pups resulting in pup starvation or death (Bowles and Stewart 1980, Richardson *et al.* 1995); and short term or permanent abandonment of haulout sites (Peterson and Bartholomew 1967, Bowles and Stewart

1980, Calambokidis *et al.* 1991, Richardson *et al.* 1995). When disturbances cause sea lions to abandon a beach animals may redistribute themselves within and among sites and reconstitute their social structure (Peterson and Bartholomew 1967). These disruptions may adversely affect the efficiency of avoiding predators, finding food, mating and caring for young (Richardson *et al.* 1995).

Effects of disturbance may be mild (such as a change in behaviour) or cause displacement, injury or mortality (Suryan and Harvey 1999). Bodily damage can occur due to panic jumps off high rocks, and both injury to, or death of, pups can result during stampedes from rookeries (Bowles and Stewart 1980, Lewis 1987, Richardson *et al.* 1995).

The consequences of short-term disruptions to normal activities and long term effects often are difficult to measure (Richardson *et al.* 1995, Suryan and Harvey 1999). Long term effects include changes which have some type of ecological significance (Young 1998) and may include reduction of fitness on a local or regional basis (Duffus and Dearden 1993). Effects of repeated short-term disturbances may be cumulative and lead to long-term consequences (Lewis 1987) however, the effects at the population level are not known (NMFS 2002). Sea lion reactions to long-term vessel disturbances vary: in some cases sea lions have abandoned rookeries and in other instances they have returned almost immediately (Peterson and Bartholomew 1967, Bowles and Stewart 1980, Calkins 1983, Allen *et al.* 1984, Lewis 1987, Calambokidis *et al.* 1991). Long-term consequences of repeated disturbances are of most concern (Richardson *et al.* 1995). If many sea lions continue to occur in an area subject to ongoing or intermittent disturbance, concern arises that human disturbance substantially interferes with activity patterns of hauled out pinnipeds and could potentially have consequences to their life cycle (Richardson *et al.* 1995, Orsini 2004).

If human presence is a stressful disturbance then it can be expected to result in the adrenocortical stress response found in most vertebrates (Siegel 1980). In this response, levels of circulating glucocorticoids such as cortisol increase in pinnipeds (Liggens *et al.* 1979) and results in a number of physiological changes (MacArthur *et al.* 1982, Richardson *et al.* 1995, Hadley 1996). Normal short-term adrenocortical responses are usually adaptive while prolonged elevated levels of glucocorticoids can be physiologically damaging (Sapolsky 1987) and potentially lead to population decline (Axelrod and Reisine 1984, Lee and McDonald 1985).

The energetic consequences of disturbances via interrupted feeding or rapid swimming or both have not been quantified in sea lions (Richardson *et al.* 1995). It is not practical to calculate the increased energetic cost of sea lions entering the water following a disturbance. It could be expected that a single incident would have little effect on the energetic status of a sea lion however, repeated incidents of interrupted feeding and rapid swimming due to disturbance probably would have negative effects if disturbances occur frequently and for long periods (Bowles 1995, Richardson *et al.* 1995). Even frequent interruptions resulting in less time resting could have energetic consequences, as was found with grey seals (*Halichoerus grypus*) (Lidgard 1996).

2.5 Chapter Summary

Published research has documented measures of pinniped disturbance, types of disturbances, and effects of disturbance by humans. Vessel activity has been found to significantly affect sea lion behaviour. In particular, distance and vessel type influence sea lion behaviour. Many other factors influence pinniped disturbance however, and differences in reactions demonstrate that there are species and site-specific differences. To evaluate the PVG in PRNPR it is necessary to identify how sea lions react to vessel interactions in the Park. This requires identifying at what approach distance and speed sea lions become disturbed, and what influence the number and type of vessels have on sea lion behaviour. Understanding the numerous species and site-specific variables that effect sea lion responses to viewing activities is required to ensure the PVG achieve the Park's management objective.

Chapter 3 Methods

3.1 Study Site

The study area was located within the BGI unit of PRNPR in Barkley Sound, British Columbia (Figure 2). Wouwer Island, located at 48° 52′N and 125° 22′W, was the primary study site (Figure 3). This site was chosen to conduct observations because whale watching vessels provided consistent and predictable interactions with sea lions at this haulout during the summer months.

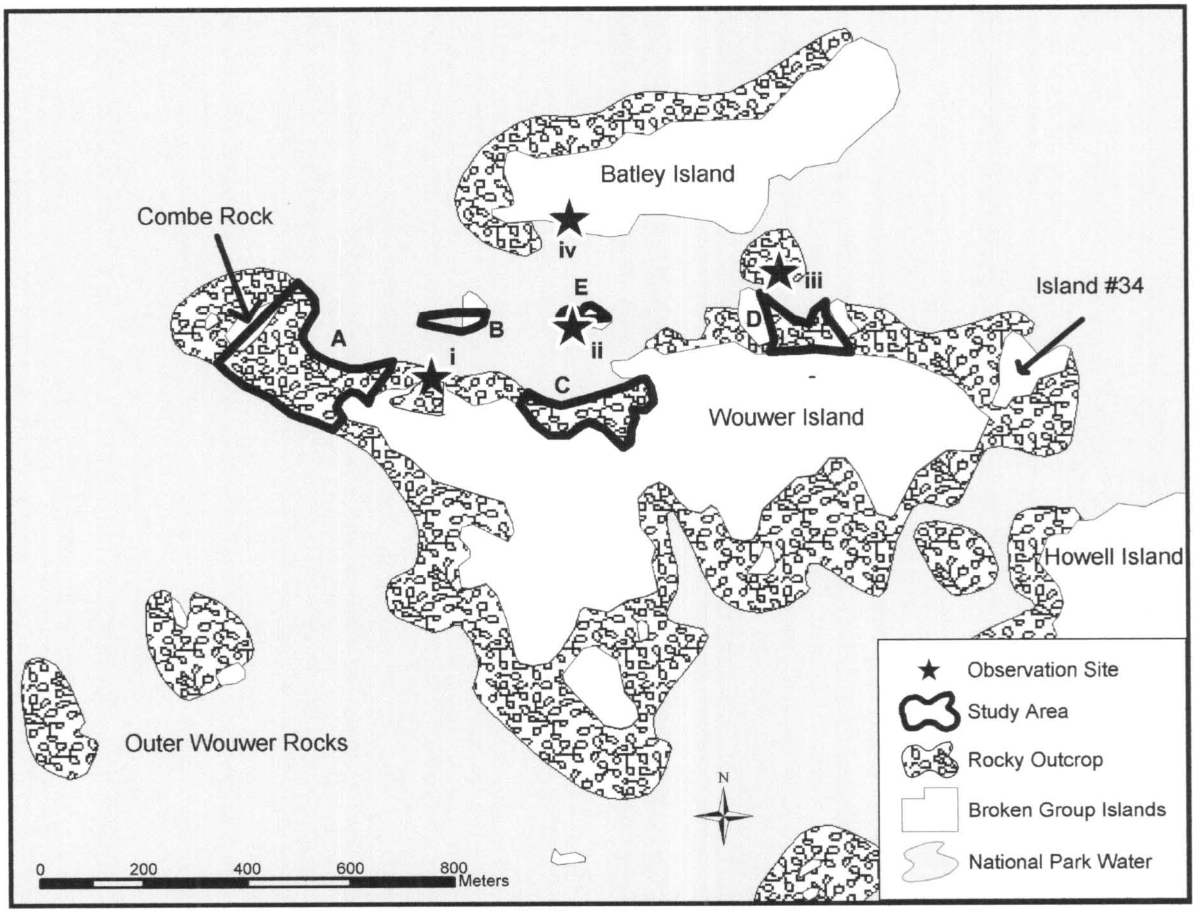
Sea lions haul out on the outermost islands in Barkley Sound which are fully exposed to the Pacific Ocean. These islands include Wouwer, Batley, and the small islets around them. Their shores are composed primarily of rocky cliffs with rock or flat rock shelves near the waterline. Wouwer Island has three small sandy beach areas on its north shore. A Parks Canada trail opens onto these beaches.

Steller sea lions annually haul out on an islet south of Wouwer beginning in July and start moving to the west side of Wouwer and onto Combe Rock during the first week of August. Male California sea lions also start arriving from their breeding grounds at this time and their numbers increased to greater than 2000 individuals by the end of September (P. Gearin pers. comm. 2001, pers. obs.). As the population of sea lions increases throughout the summer, the haulout area expands to the eastern most point of Wouwer, to the western and southern shores of Batley Island, and to the three islets between them.

Study areas were chosen because vessels approached these haulouts to view animals. Observations were made at four areas; 1) the western side of Wouwer including Combe Rock (Area A, Figure 3) n = 19 observations; 2) the western most islet on the northwestern side of Wouwer (Area B) n = 70 observations; 3) three beaches located centrally on the northern side of Wouwer (Area C) n = 46 observations; and 4) one beach further east on the northern side of Wouwer (Area D) n = 21 observations (Figure 3). In

2000 a few observations were also made on another islet between Wouwer and Batley Islands (Area E) n = 4 observations.

Figure 3 Study Site, Broken Group Islands, Pacific Rim National Park Reserve



Observations were made from three separate locations (Figure 3). Areas A and B were observed from a precipice on the north side of Wouwer (i), 260-320 m from Area A and 180 m from Area B. Area C was observed from the middle of 3 islets located between Wouwer and Batley (ii), 222 m away. Area D was observed from a small islet locally referred to as "Bonsai" (iii), 140 m away. All observations were conducted by the researcher. The study animals were not observed to be disturbed by my presence while I made observations.

Originally, only Areas A and B were chosen for observation, however after a storm on 22-24 August 2001 most animals vacated the area and moved to the three small pocket beaches (Area C) approximately 600 m east of Area B on Wouwer Island. Several sea lions also were observed further east on Wouwer, as well as on Batley Island and the small islets between Wouwer and Batley. Because the animals had moved, and subsequently the vessels no longer made approaches to the former sampling areas, it became necessary to move the study site. Area D was therefore chosen in an attempt to achieve similar sample sizes among study areas.

3.2 Testing Variables

Using a laser range finder (Bushnell Yardage Pro 500), distance buoys were set up to test behavioural reactions at 25, 50, 100, 150 and 250 m from three of the four haulout areas (Areas B, C, and D). Four whale watching operators (Table 1) voluntarily participated in this study, enabling the use of an experimental design. Via VHF radio, participating whale watching vessel operators were directed to approach each haulout area to one of the distance categories at one of the following speeds: *slow* (<7 knots), *medium* (7-15 knots), or *fast* (>15 knots). Because a kayak can only maintain no-wake speed, 'speed' for this vessel type was disregarded. Vessel types were categorized as: *over 5 tons*, *under 5 tons*, or *kayak*. All participating whale watching vessels were categorized according to their vessel license as per the Small Vessel Regulations (Table 1). All other motorized vessels were categorized *under 5 tons* if estimated to be less than 8.5 m in length (as per 'tonnage by length' outlined in Schedule IV of the Small Vessel Regulations). When possible, approaches were tested with more than one vessel. The number of vessels involved in an interaction was recorded and distance was measured from the vessel closest to the sea lions. Groups of kayaks were treated as a single unit due to high variability in group numbers. These specific categories were chosen as measures to evaluate the Park's PVG criterion and to make recommendations regarding the prescribed vessel approach distance, speed, type and numbers.

Table 1: Whale watching companies and vessels participating in the study

Company	Vessel Name	Vessel Type
Aquamarine Adventures	Sundancer	< 5 tons (rigid hull inflatable)
Broken Island Adventures	Grunt Sculpin	< 5 tons (fiberglass outboard)
Jamie's Whaling Station	Blue Thunder Shearwater Devilfish Lady Selkirk	< 5 tons (rigid hull inflatable) < 5 tons (rigid hull inflatable) < 5 tons (rigid hull inflatable) > 5 tons
Subtidal Adventures	Contender Dixie IV	< 5 tons (rigid hull inflatable) > 5 tons

3.3 Behavioural Observations

Research was conducted in August 2000 and August, September and October 2001. Observations were made between the hours of 09:00 and 17:00 to follow the schedule of Brian Congdon, Subtidal Adventures who provided transportation to and from the study site.

Behavioural observations were made using 7x10 Nikon binoculars for all observations in 2000 and the first six observation days in 2001. A Sony 400x Hi-8 video recorder was then used beginning 12 August 2001 for later analysis. Until that date the population of sea lions was small enough to allow observations and data recording to be done instantaneously. Seventy-eight animals were present on 13 August 2001, totalled 98 on 16 August 2001 and continued to increase thereafter. These large numbers made it impossible to accurately count all individual sea lion behaviours instantaneously at the time of vessel interaction because responses happened too quickly. Video recordings were later viewed to determine the number of each species engaged in each of the predetermined behaviours.

3.3.1 Scans

Sea lion behaviour provides a measurable indicator of disturbance. Obvious changes in sea lion behaviour, such as rapid movement towards the water or entering the water could be interpreted as evidence of disturbance from an approaching vessel. The behaviour of a sea lion would be expected to remain "normal" in the absence of vessels. The behavioural state of sea lions in the absence of vessels ("normal" sea lion behaviour), had to first be established as a control with which to compare behaviour during vessel interactions. To measure this pre-interaction behavioural state, scan samples (Altmann 1974) were made every 30 minutes when no vessels were present. Scan sampling involves sampling the behavioural state of all visible members of the group within a specified and fairly brief period of time. Some observations were made *ad libitum* (Altmann 1974).

During scan samples, all individuals engaged in one of the following five mutually exclusive behaviours were counted and recorded:

- *Resting* - recumbent with head on substrate or on another animal;
- *Resting Head Up* - recumbent with head raised;
- *Standing* - standing;
- *Moving* - slow to moderate movement from one location to another, regardless of direction;
- *Stampeding* - rapid movement on land **towards** waterline;
- *Flushing* - rapid retreat **into** water.

The number of individuals for each species engaged in each behavioural category was recorded during each scan (see Appendix II).

In addition, the following were also noted for each scan:

- *Level of vocalization*: very quiet (1) to very loud (5);

and environmental variables:

- *Cloud cover* - to the nearest 10%,
- *Sea height* – estimated, in m,

- *Sea state* - glassy, ripple, choppy, or whitecaps
- *Wind direction* - relative to compass bearing
- *Tide height* - in metres, (Canadian Hydrographic Service 2000, 2001)
- *Wind velocity* (m/s), and *air temperature* (Celsius) were measured with a Brunton Sherpa "atmospheric data centre" (Mountain Equipment Co-op) held at arm's length by the researcher at the observation site.

3.3.2 Interactions

Observations of sea lions were made during each vessel interaction by scanning sea lions on the haulout for the same behavioural categories noted above as well as for level of vocalization. The number of individuals for each species engaged in these behaviours was recorded on a data sheet (see Appendix III). The following were also recorded during vessel interactions: approach distance and speed, vessel type, and number of vessels. Observations were made at the closest distance to which a vessel approached. *Ad libitum* observations also were made of animals in the water adjacent to the haulout. Animals *swimming* (actively moving from one location in the water to another) were recorded in the presence of vessels. Other behavioural reactions were recorded for interactions with humans on foot, fixed-wing aircraft, helicopters and personal water craft. When possible, the distance or altitude was also recorded.

Chapter 4 Analysis

4.1 Disturbance

Only two behaviours were interpreted as a disturbance response: *stampeding* and *flushing*. These categories were combined for analysis because each response occurred infrequently during the study. A disturbance response only occurred in the presence of vessels whereas *resting*, *resting head up*, *standing* and *moving* were behaviours that always occurred in the absence of vessels as well. Comparing changes in these measures did not indicate a disturbance (as defined in this study) and therefore were found to have little utility. It should be noted that animals were observed entering the water on eight occasions in the absence of vessels, however *stampeding* – interpreted as the behaviour indicative of the highest degree of disturbance, only occurred in the presence of vessels.

Other investigations only considered retreat *into* the water (flushing) to be a disturbance (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Allen *et al.* 1984, Calambokidis *et al.* 1991, Suryan and Harvey 1999, Born *et al.* 1999, Lelli and Harris 2001). This study also interpreted rapid movement *to* the water's edge (*stampeding*) as a disturbance. Rapid movement was considered to require a significant amount of energy whereas subtle changes in behaviour, such as a change from *resting* to *resting head up* were not. Occasionally if one or a few individuals rushed to the waters' edge a chain reaction occurred in which many other sea lions (over 80% or up to 100 individuals) also stampeded. These situations were considered 'major disturbances'.

4.2 Behavioural Sequence

To analyze behavioural change between scan and vessel interaction samples, knowledge of the behavioural sequences preceding disturbance was necessary. When sea lions displayed a "disturbed" response a sequence of behaviours occurred which led to, and culminated in, disturbance. These behaviours are as follows: *resting, resting head up*, *standing*, *moving*, *stampeding*, and *flushing*. Preventing sea lion disturbance requires knowledge of the sequence of behaviours from an animal identifying a stimulus (*resting* *head up*) to a disturbance response (*stampeding* or *flushing*) and then identifying at which behaviour in this sequence a disturbance is likely to occur. To achieve the goals of PRNPR's PVG it is critical to identify vessel behaviours that cause disturbance and incorporate them into the Guidelines.

4.3 Pooled Species, Sites and Years

Behavioural reactions for each species during vessel interactions were compared with behavioural states for each species recorded during half-hour scans. This was possible only for observations made at Area B where proximity to sea lions and their small numbers permitted differentiation between sea lion species. Fifty-four scan/interaction pairs were available for California sea lions and 37 pairs for Steller sea lions. Video quality was too coarse to differentiate between species at other observation areas. Species were therefore pooled for overall analysis at all sites.

Data from each of the four observation areas were pooled when testing for the affects of distance, speed, vessel type and vessel number. Differences in reaction between two rocky sites and two sandy sites were compared. Because there were no obvious year-to-year differences in the ranges of environmental variables tested over the study period, the two years of data were analyzed as a single data set.

4.4 Video Analysis

Video analysis was conducted with a Sony PV-C1321-K TV. Each of the interaction samples were matched to the most recent scan sample not affected by a vessel. From the total 160 matched pairs of observations (before and during vessel approach), distances were measured for 158 interactions, speed for 128 interactions, and vessel type and vessel number were documented for all interactions (Appendix IX).

Analysis included comparing behavioural reactions during vessel interactions with behavioural states recorded during half-hour scans. This was done by counting and comparing the frequency of animals engaged in the two behaviours interpreted as disturbance for each interaction and preceding scan. Because interactions were videotaped, it was possible to count all animals at each site.

The frequency of animals observed in each behavioural category was entered as a ratio of the total count. The number of sea lions hauled out during a scan rarely was the same as the number of sea lions hauled out during the following interaction. The difference in the ratio for each behavioural category during an interaction and the preceding scan was the value used for statistical analyses. The potential effect of group size was eliminated because I counted all individuals during scan and interaction samples.

4.5 Statistical Analysis

Both parametric and non-parametric tests were utilized to test for change between scan and vessel interaction behaviours among and within each variable. Results of statistical analysis were considered significant at $\alpha = 0.05$. SPSS Version 11.0 was used for all analyses.

A Kruskal-Wallis test was used to test for difference in numbers of sea lions *stampeding* and *flushing* between scan and vessel interactions among the five distance categories and among the three speed categories. Kruskal-Wallis was used because data for distance and speed did not meet the requirements for parametric tests (Zar 1984). ANOVA was used to test for difference in the frequency of disturbed sea lions between scan and vessel interactions among the three vessel types. ANOVA was used because data for vessel type met the requirements of parametric tests (Zar 1984).

To determine at what distance category (and speed, vessel type, and vessel number category) a disturbance occurred, t-tests (Zar 1984) were used to test for a significant change in the frequency of sea lions *stampeding* and *flushing* during scan and vessel interactions. T-tests were also used to compare vocalization levels pre- and post-interactions. Combined effects of distance, speed, vessel type and number of vessels on lion behaviour were examined with t-tests. The data for each particular combination of these variable categories were selected and the number of sea lions *stampeding* or *flushing* was compared between those particular scan and interaction samples.

Combinations included:

- Distance x Speed
- Distance x Vessel Type
- Distance x Vessel Number
- Speed x Vessel Type
- Speed x Vessel Number
- Vessel Type x Vessel Number

Although combinations of these variables would be best examined by multivariate analysis, higher level multivariate test statistics could not be employed because sample sizes of varying combinations were too small.

Chi^2 was used to test for significant differences in the number of disturbance events between each distance, speed, vessel type and vessel number category. Chi^2 was also used to test for significant differences in sea lion responses between rocky and sandy haulouts.

4.6 Environmental Variables

Temperature, sea state and wind direction affect pinniped haulout behaviour (Peterson and Bartholomew 1967, Harestad 1978, Cehak 1978, Bowles and Stewart 1980, Richardson *et al.* 1995). These variables were not considered in the analysis however because environmental factors cannot be controlled and therefore are not incorporated in the Park's PVG. It would be impractical to have a specific set of viewing guidelines which reflected, for example, a specific tide height, wind direction, and cloud cover and varying combinations thereof. Because these conditions cannot be controlled, it makes more sense to only identify thresholds of influencing factors such as vessel approach distances and speeds which can be managed to prevent disturbance.

The effect of differences in environmental measures are accounted for because sampling was consistent throughout the pinniped viewing season. Scan and interaction samples were made under similar conditions: there was little difference in temperature, cloud cover, sea state, wind speed and direction throughout the study period (Table 2).

Table 2: Environmental variable measurements

	Cloud cover (%)	Sea height (m)	Sea state	Temp. (°C)	Wind direction	Wind speed (km/h)	Tide (m)
Minimum	0	0.0	glassy	16.0	northeast	0.0	0.67
Maximum	100	2.0	white caps	26.0	northwest	14.0	4.03
Range	100	2.0		10.0	all directions	14.0	3.36
Mean	76	0.9	ripple	21.0	northwest	6.0	2.47
Range of measures % of time this range occurred	50-100 77%	0.0-1.0 93%	glassy – ripple 72%	17.0-24.0 85%	northwest, west, southwest 66%	0.0-9.0 77%	1.2-3.4 75%

4.7 Recovery

Recovery time is the time taken for animals to return to the pre-disturbance behavioural state before vessel interactions. Recovery time was estimated to determine the period of time necessary to follow a vessel interaction before sampling subsequent scans and interactions. This was to ensure independence of samples - that scan and interaction data were representative measures of sea lion behavioural states and responses.

Recovery rate was assessed by estimating the length of time that passed before sea lions were observed to return to their pre-interaction state after a vessel interaction. This was done by scanning the haulout for several minutes after an interaction and noting when sea lions appeared to recover, or until a vessel passed the study area. Rate of recovery was opportunistically estimated six times between 8 and 16 August 2001. Other research on pinniped disturbance has not addressed the requirement for independence of samples and there is no consistency in the scientific literature regarding how to define or measure recovery in local wildlife populations (Allen *et al.* 1984, Gill *et al.* 1996, Born *et al.* 1999, Suryan and Harvey 1999, Engelhard *et al.* 2002).

Although observations were *ad hoc* and qualitative, the importance of recovery rate was recognized and a best attempt was made to ensure sampling independence. Recovery time was observed to be proportional to the level of disturbance. If no disturbance occurred, i.e. only an alert reaction resulted, recovery ranged from 3 sec to 3 min. When a large proportion of animals *stampeded* or *flushed*, recovery time took anywhere from 10 min (observed for one focal individual to return to a resting state) to 3 hrs (for a haulout to be repopulated to the pre-disturbance number). A time of 20 min was adopted as protocol for recording and using both scan and interaction data after a vessel had passed through the study site because it appeared to take approximately 20 min on average for sea lions to return to a pre-interaction behavioural state unless a major disturbance occurred.

4.8 Analysis of Additional Variables

It was not always possible to obtain altitude measurements for interactions involving aircraft or distance measurements for interactions with humans on foot. As well, sample sizes for these interactions and those with personal watercraft were too small to analyze statistically. Descriptions of these disturbance events are given. Other observations which are also presented qualitatively include differences in reaction between species, sites, as well as other notable observations.

Chapter 5 Results

5.1 Overview of Study Results

Behavioural reactions of sea lions to all variables tested – vessel distance, speed, vessel type and the number of vessels, as well as combinations of these variables are given. Opportunistic observations of other interactions that are relevant to the Guidelines are also presented. These include sea lion responses to fixed-wing aircraft, helicopters, personal watercraft and humans on foot. Opportunistic observations of behavioural reactions to vessels at other pinniped haulouts in the Park are also included, as are other observations which are relevant to the PVG.

Sea lions were present in the study area on all days that observations took place (Table 3). As the summer progressed there was an increase in the number of sea lions and a shift in the distribution of animals among the four observation sites (Figure 3). During the beginning of the study sea lions were hauled out at Areas A and B. By the third week of August there was a major shift: fewer sea lions hauled out in Areas A and B and sea lions were hauled out at Area C for the first time during the study. By the beginning of September the number of sea lions continued to increase and the distribution spread to Area D. At this time the number of animals changed little in Area C but numbers did not return to early August levels at Areas A and B.

Table 3: Samples per study area

Study area	Survey dates	No. days	No. interaction and scan sample pairs
A	13 – 19 August 2001	4	19
B	14 – 22 August 2000, 7 – 25 August 2001	11	70
C	24 August 24 – 9 September 2001	12	46
D	12 September – 1 October 2001	9	21
E	11 – 12 August 2000	2	4
Totals		**38**	**160**

In total, 255 scan and interaction pairs were observed. Due to non-independence of samples, only 160 of these pairs (63%) were usable for statistical analysis (Table 3). A disturbance response (at least one animal *stampeding* or *flushing*) occurred during 39 of the 160 independent interactions. Twenty-five additional interactions by aircraft, personal watercraft and humans on foot were also observed and described but are not statistically analyzed due to small sample sizes. Overall, 30% of all interactions observed resulted in sea lion disturbance.

Only eight sea lions were observed entering the water during control periods (n = 160 control periods) compared with 597 individuals *stampeding* or *flushing* during vessel interactions (n = 160 vessel interactions). The few animals that moved towards the water (and in some cases entered the water) during scan samples moved slowly and did not appear to be reacting to any observable stimulus. As a result it can be assumed that 100% of all 39 disturbances were caused by vessels.

A total of 142 hours of observation were conducted over a period of 38 days. On average, eight interactions were observed daily, and a maximum of 21 interactions occurred during the peak of the whale watching season. Two vessel interactions on average caused a disturbance each day. Frequency of disturbances was greater on days with high vessel traffic. For example on 5 September 2001, six disturbances occurred within a 6-hr period. This was the day of highest vessel traffic and the most disturbance events.

5.2 Disturbance Response

A group of disturbed sea lions responded in a predictable manner. Prior to disturbance, sea lions usually rested in prone position. A few individuals stood with heads raised and some individuals groomed themselves or interacted with neighbouring animals. During a disturbance, sea lions characteristically lifted their heads and looked in the direction of the perceived threat.

The disturbance response was strongly influenced by the activity of neighbouring sea lions. When one or more sea lions moved towards or entered the water, surrounding individuals generally followed and the reaction sometimes spread to the rest of the group. The speed and extent of the reaction depended on the characteristics of a vessel's approach. If the level of response was high, some animals stampeded towards the surf line. Most often it was the younger individuals that reacted first or with the most intensity, followed by adult females and finally, bulls. Animals near the tideline surged into the water. Those further inland became alert and some moved towards and entered the water. Startled animals further inland did not necessarily move all the way to the tideline but joined the main group of animals moving towards the water. During major disturbance events 80% of the animals stampeded towards the surf line. This movement may have extended for several minutes after the interaction.

Those sea lions which entered the water usually grouped together forming rafts. They either approached the vessel, watched it from a distance, or swam away. The group usually dispersed over time and re-hauled. Because the sea lions were not marked and therefore could not be identified individually, it was not possible to determine whether sea lions re-hauled at the same site following a disturbance.

5.3 Factors Influencing Disturbance

5.3.1 Vessel Distance

Vessel distance had the most influence on sea lion behaviour, and reactions varied with distance category. Sea lions displayed a disturbed response as far as the *76-100 m* distance category but the mean distance for disturbance was within the *0-25 m* distance category (Table 4). For disturbances caused by vessels (N = 39 disturbances), 36 (92%) of the disturbances occurred within the 50 m minimum viewing distance.

Distance affected change in behaviour resulting in disturbance. There was a significant difference in the number of sea lions that became disturbed when approached to the five distance categories (Kruskal-Wallis, df = 4, p = 0.001). The number of sea lions that *stampeded* or *flushed* during approaches to *0-25 m* was significant (one sample t-test, t = -3.82, df = 78, p = 0.000). There was a significant difference in the number of disturbance events between vessel approaches to 0-50 m and 50-100 m ($X^2 = 8.276$, df = 1, $p < 0.05$). There was also a significant difference in the number of disturbance events between vessel approaches to *0-25 m* and *26-50 m* ($X^2 = 8.086$, df = 1, $p < 0.05$).

Table 4 Disturbance responses – distance

Approach distance category	(A) No. approaches	(B) No. disturbances	Percent of approaches with disturbance at this distance (B/A)	Percent of disturbances in this distance category (B/38)
0-25 m	79	30	38	79
26-50 m	44	6	14	15
51-75 m	13	1	8	3
76-100 m	10	1	10	3
100+ m	12	0	0	0
Total	**158**	**38***		

*39 disturbances occurred but only 38 disturbances occurred at known distances.

5.3.2 Vessel Speed

Speed affected change in behaviour resulting in disturbance. There was a significant difference in the number of sea lions that became disturbed when approached at the three different speeds (Kruskal-Wallis, df = 2, p = 0.018). Proportionately, most disturbance events were caused by approaches made at a *fast* speed (N = 8 disturbances, 47%) (Table 5). There was a significant difference in the number of disturbance events between *slow* and *fast* approaches ($X^2 = 4.451$, df = 1, $p < 0.05$), however a significant number of sea lions became disturbed when vessels approached at all three speeds – *slow*, *medium* and *fast* (one sample t-test, t = -2.747, df = 76, p = 0.004, one sample t-test, t = -1.865, df = 31, p = 0.036, one sample t-test, t = -2.598, df = 16, p = 0.010), respectively.

5.3.3 Vessel Type

Sea lions displayed a disturbed response with all vessel types (Table 6), however there was no significant difference among the three vessel types in the number of sea lions that *stampeded* or *flushed* (ANOVA, $F = 0.524$, $df = 2$, $p = 0.593$). The number of sea lions disturbed by approaches with vessels *under 5 tons* was significant (one sample t-test, $t = 3.58$, $df = 114$, $p = 0.000$). There was no significant difference in the number of disturbance events between motorized vessels and *kayaks* ($X^2 = 0.261$, $df = 1$, $p < 1.0$) nor between vessels *under 5 tons* and *kayaks* ($X^2 = 0.963$, $df = 1$, $p < 1.0$).

Table 5: Disturbance responses – speed

Approach speed category	(A) No. approaches	(B) No. disturbances	Percent of approaches with disturbance at this speed category (B/A)	Percent of disturbances in this speed category (B/31)
Slow	77	17	22	55
Medium	34	6	18	19
Fast	17	8	47	26
Total	**128**	**31**		

Table 6: Disturbance responses - vessel type

Vessel type category	(A) No. approaches	(B) No. disturbances	Percent of approaches with disturbance from this vessel type category (B/A)	Percent of disturbances in this vessel type category (B/39)
> 5 tons	24	1	4	3
< 5 tons	107	32	30	82
Kayak	29	6	21	15
Total	**160**	**39**		

Sea lion responses to *kayak* approaches were not statistically significant (one sample t-test, $t = -1.27$, $df = 28$, $p = 0.1065$). Interestingly however, the most extreme response to a vessel was elicited by a kayak and the furthest distance at which a disturbance occurred was also caused by a kayak. The number of sea lions disturbed by vessels *over 5 tons* was also not significant (one sample t-test, t = -1.00, df = 15, p = 0.1665). This may be due to a small sample size of approaches by this vessel type (Table 6). Due to seabed topography and vessel size it was not possible to have close approaches made by larger vessels.

5.3.4 Number of Vessels

The number of vessels simultaneously approaching a haulout affected sea lion responses. The number of sea lions *stampeding* or *flushing* in response to *1 vessel* was significant (one sample t-test, t = -3.12, df = 112, p = 0.001) as was the number of sea lions disturbed by *2 vessels* (one sample t-test, t = -1.74, df = 17, p = 0.050). The difference in number of disturbance events made by *1* and *2 vessels* however, was not significant (X^2 = 2.078), df = 1, p < 0.20) (Table 7).

Table 7: Disturbance responses - vessel number

Vessel number category*	(A) No. approaches	(B) No. disturbances	Percent of approaches with disturbance from this vessel number category (B/A)	Percent of disturbances in this vessel number category (B/39)
1	113	26	23	67
2	18	7	39	18
Total	**160**	**39**		

*For motorized vessels only. One or more kayaks considered as a single unit.

5.4 Variable Combinations

Particular combinations of variable measures affected sea lion responses resulting in disturbance. Sample sizes were not large enough to compare measures for each category within each variable in combination with all other category measures. A few particular combinations are noteworthy. Combinations were chosen only for those variable categories that were found to affect behavioural change resulting in disturbance at a statistically significant level. The combination of the following elements of a vessel approach was most likely to cause a significant number of sea lions to be disturbed: a vessel *under 5 tons* approaching at *fast* speed to *0-25 m* from a haulout (one sample t-test, $t = -2.75$, $df = 13$, $p = 0.009$). This combination of variables occurred during 14 interactions and disturbances occurred during 8 (57%) of these.

5.4.1 Distance and Speed

The combination of a vessel approaching to *0-25 m* at *fast* speed significantly affected the number of sea lions that *stampeded* or *flushed* (one sample t-test, $t = -2.71$, $df = 13$, $p = 0.009$) (Figure 4). Most disturbance events (57%) occurred with this distance and speed combination (Table 8). There was no significant difference in the number of disturbance events between *slow* and *fast* approaches made within the 50 m "*no go zone*" ($X^2 = 3.228$, $df = 1$, $p < 0.10$).

Figure 4: Mean no. of sea lions disturbed for approaches made with each distance and speed category combination

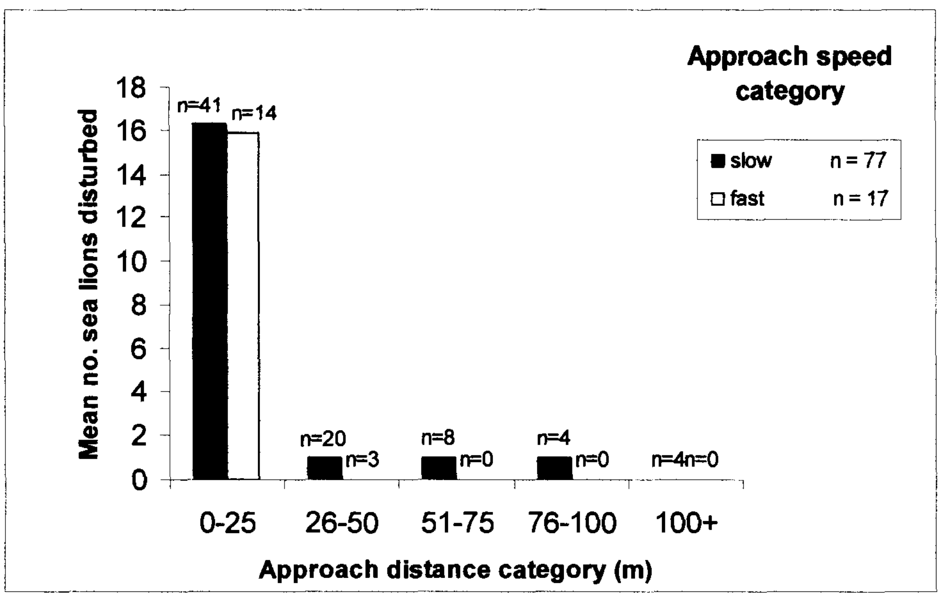


Table 8 Disturbance responses – distance and speed

Approach speed category	Approach distance category	(A) No. approaches	(B) No. disturbances	Percent of approaches with disturbance at this speed and distance category (B/A)	Percent of disturbances in this speed and distance category (B/31)
Slow	0 – 25 m	41	13	32	42
	26 – 50 m	20	2	1	6
	51 – 75 m	8	1	13	3
	76 – 100 m	4	1	25	3
	100+ m	4	0	0	0
	totals	**77**	**17**	**22.1**	**54.8**
Medium	0 – 25 m	14	6	43	19
	26 – 50 m	10	0	0	0
	51 – 75 m	3	0	0	0
	76 – 100 m	2	0	0	0
	100+ m	4	0	0	0
	totals	**33**	**6**	**18.2**	**19.4**
Fast	0 – 25 m	14	8	57	26
	26 – 50 m	3	0	0	0
	51 – 75 m	0	0	0	0
	76 – 100 m	0	0	0	0
	100+ m	0	0	0	0
	totals	**17**	**8**	**47.1**	**25.8**
Total	**all**	**127**	**31**		

5.4.2 Distance and Vessel Type

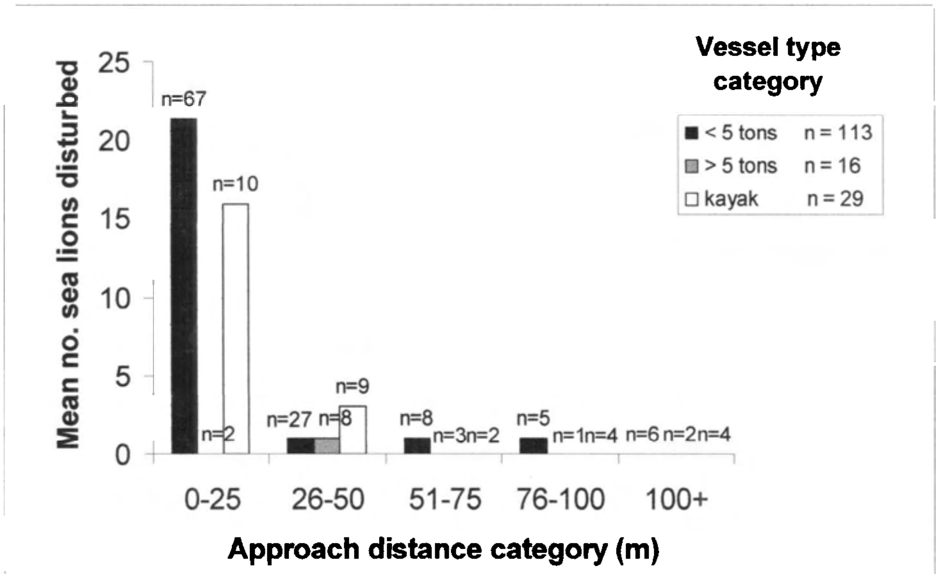
Thirty-three (25%) interactions with motorized vessels resulted in disturbance and six (21%) *kayak* interactions resulted in disturbance. There was no significant difference in the number of disturbance events between motorized vessels and *kayaks* ($X^2 = 0.058$, df = 1, $p < 1.0$) (Table 9).

Table 9 Disturbance responses – motorized and non-motorized vessels

Vessel type category	Approach distance category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel type and distance category (B/A)	Percent of disturbances in this vessel type and distance category (B/37)
Motorized	0 – 25 m	69	27	39	73
	26 – 50 m	35	3	9	8
	56 – 75 m	11	1	9	3
	76 – 100 m	6	1	17	3
	100+ m	8	0	0	0
	totals	**129**	**32**	**24.8**	**86.5**
Non-motorized	0 – 25 m	10	3	30	8
	26 – 50 m	9	3	33	8
	56 – 75 m	2	0	0	0
	76 – 100 m	4	0	0	0
	100+ m	4	0	0	0
	totals	**29**	**6**	**20.7**	**16.2**
Total		**158**	**37**		

The number of sea lions that were disturbed by vessels *under 5 tons* approaching to *0-25 m* was significant (one sample t-test, t = -3.51, df = 65, p = 0.001) (Figure 5). There was no significant difference in the number of disturbance events caused by vessels *under 5 tons* and *kayaks* approaching within 50 m of sea lions ($X^2 = 0.004$, df = 1, $p < 1.0$) (Table 10).

Figure 5: Mean no. of sea lions disturbed for approaches made with each distance and vessel type category combination



5.4.3 Distance and Vessel Number

Based on sample size, both *1* and *2 vessel* approaches to within 0-25 m caused disturbances 38% of the time (Table 11). The number of sea lions that became disturbed when o*ne vessel* approached to *0-25 m* was significant (one sample t-test, $t = -3.239$, $df = 60$, $p = 0.001$) (Figure 6). There was no significant difference in the number of disturbance events between *1* and *2 vessels* approaching within 50 m ($X^2 = 0.493$, $df = 1$, $p < 1.0$). Sample sizes were too small to compare the number of disturbance events with *1* and *2 vessels* at distances greater than 50 m.

Table 10: Disturbance responses – distance and vessel type

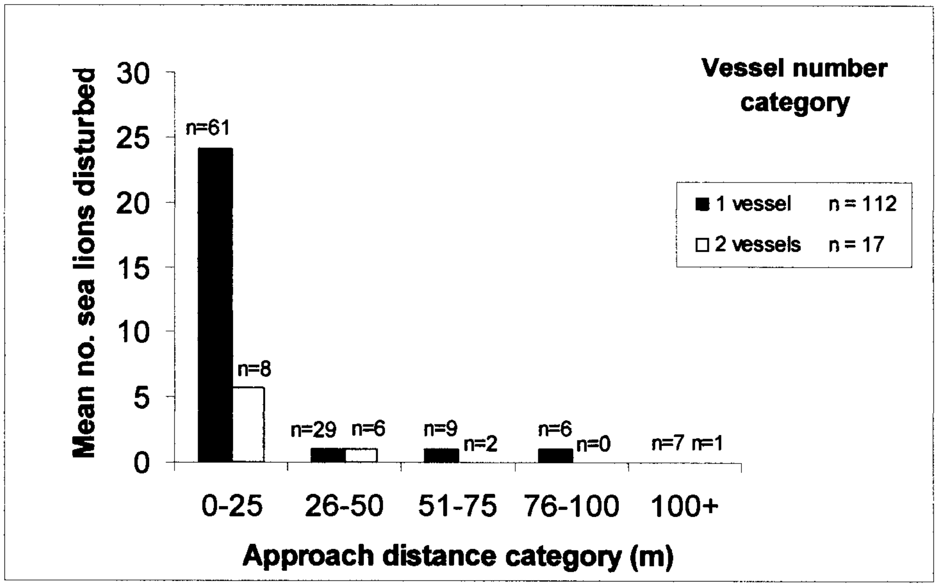
Vessel type category	Approach distance category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel type and distance category (B/A)	Percent of disturbances in this vessel type and distance category (B/39)
> 5 tons	0 – 25 m	2	0	0	0
	26 – 50 m	8	1	13	3
	51 – 75 m	3	0	0	0
	76 – 100 m	1	0	0	0
	100+ m	2	0	0	0
	totals	**16**	**1**	**6.3**	**2.6**
< 5 tons	0 – 25 m	67	27	40	69
	26 – 50 m	27	2	7	5
	51 – 75 m	8	1	13	3
	76 – 100 m	5	1	20	3
	100+ m	6	0	0	0
	totals	**113**	**31**	**27.4**	**79.5**
kayak	0 – 25 m	10	3	30	8
	26 – 50 m	9	3	33	8
	51 – 75 m	2	0	0	0
	76 – 100 m	4	0	0	0
	100+ m	4	0	0	0
	totals	**29**	**6**	**20.7**	**15.4**
Total		**158**	**39**		

Table 11: Disturbance responses – distance and vessel number

Vessel number category*	Approach distance category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel number and distance category (B/A)	Percent of disturbances in this vessel number and distance category (B/31)
1	0 – 25 m	61	23	38	74
	26 – 50 m	29	1	3	3
	51 – 75 m	9	1	11	3
	76 – 100 m	6	1	17	3
	100+ m	7	0	0	0
	totals	**112**	**26**	**23.2**	**83.9**
2	0 – 25 m	8	3	38	10
	26 – 50 m	6	2	33	6
	51 – 75 m	2	0	0	0
	76 – 100 m	0	0	0	0
	100+ m	1	0	0	0
	totals	**17**	**5**	**29.4**	**16.1**
Total		**129**	**31**		

*For motorized vessels only. One or more kayaks considered as a single unit.

Figure 6: Mean no. of sea lions disturbed for approaches made with each distance and vessel number category combination



5.4.4 Speed and Vessel Type

The number of sea lions that were disturbed when vessels *under 5 tons* approached a haulout at *fast* speed was significant (one sample t-test, t = -2.60, df = 16, p = 0.010), as was the number of disturbed sea lions when vessels *under 5 tons* approached sea lions at *slow* speed (one sample t-test, t = -1.96, df = 67, p = 0.027) (Figure 7). The difference in number of disturbance events for vessels *under 5 tons* was significant for *slow* and *fast* approaches ($X^2 = 4.011$, df = 1, $p < 0.05$). Sample sizes for *fast* approaches were limited only to vessels *under 5 tons* (Table 12) so statistical comparisons could not be made with vessels *over 5 tons*.

Figure 7: Mean no. of sea lions disturbed for approaches made with each speed and vessel type category combination

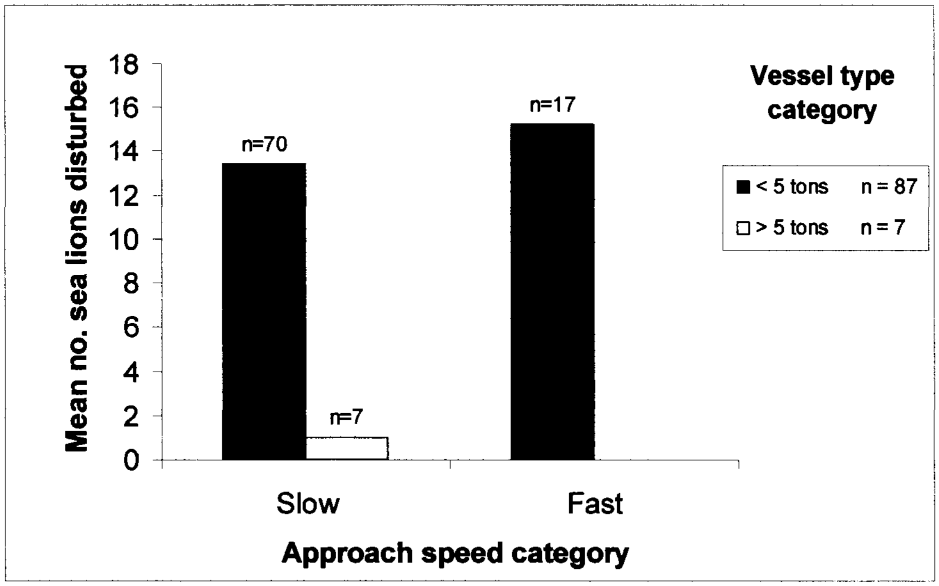


Table 12 Disturbance responses - speed and vessel type

Vessel type category	Approach speed category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel type and speed category (B/A)	Percent of disturbances in this vessel type and speed category (B/31)
> 5 tons	Slow	7	1	14	3
	Medium	8	0	0	0
	Fast	0	0	0	0
	totals	**15**	**1**	**6.7**	**3.2**
< 5 tons	Slow	70	16	23	52
	Medium	26	6	23	19
	Fast	17	8	47	26
	totals	**113**	**30**	**26.5**	**96.8**
Total		**128**	**31**		

5.4.5 Speed and Vessel Number

The number of sea lions that *stampeded* and *flushed* when *1 vessel* approached at *slow* speed was significant (one sample t-test, t = -1.68, df = 64, p = 0.049) (Figure 8). The number of sea lions that became disturbed when *1 vessel* approached at *fast* speed was also significant (one sample t-test, t = -2.15, df = 13, p = 0.026) (Figure 8). *Two vessels* simultaneously approaching at *fast* speed proportionately caused more disturbances than *1 vessel* (Table 13) however the sample size was too small (n = 3) to make inferences.

Figure 8: Mean no. of sea lions disturbed for approaches made with each speed and vessel number category combination

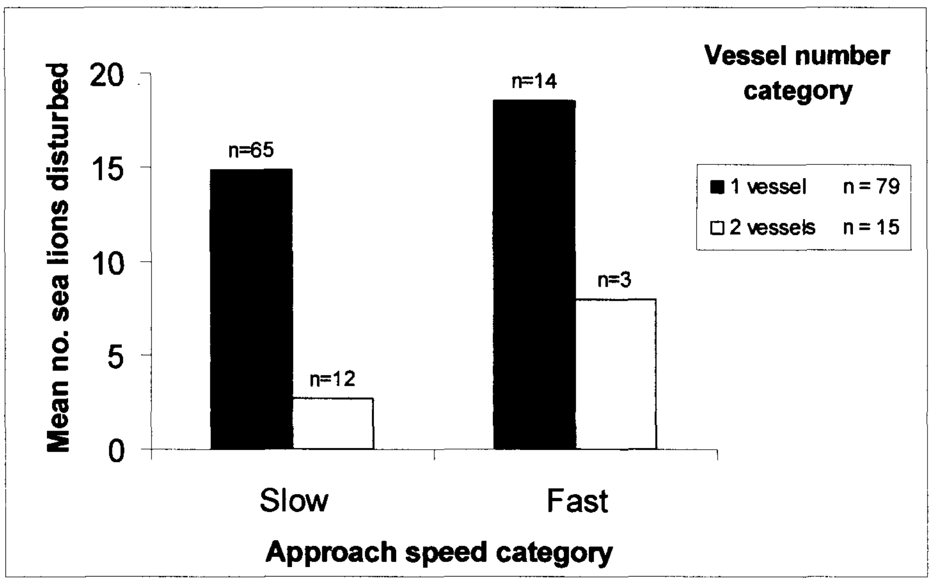


Table 13: Disturbance responses - speed and vessel number

Vessel number category*	Approach speed category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel number and speed category (B/A)	Percent of disturbances in this vessel number and speed category (B/31)
1	Slow	65	14	22	45
	Medium	33	6	18	19
	Fast	14	6	43	19
	totals	**112**	**26**	**23.2**	**83.9**
2	Slow	12	3	25	10
	Medium	1	0	0	0
	Fast	3	2	67	6
	totals	**16**	**5**	**31.3**	**16.1**
Total		**128**	**31**		

*For motorized vessels only.

5.4.6 Vessel Type and Vessel Number

The number of sea lions that became disturbed when *1 vessel under 5 tons* approached a haulout was significant (one sample t-test, $t = -2.92$, $df = 90$, $p = 0.002$) (Figure 9). The probability of disturbing a significant number of sea lions was marginal when *two vessels under 5 tons* approached a haulout (one sample t-test, $t = -1.74$, $df = 15$, $p = 0.051$). There were only two occasions in which *2 vessels over 5 tons* simultaneously approached a haulout (Table 14) so statistical comparisons could not be made.

Figure 9: Mean no. of sea lions disturbed for approaches made with each vessel type and vessel number category combination

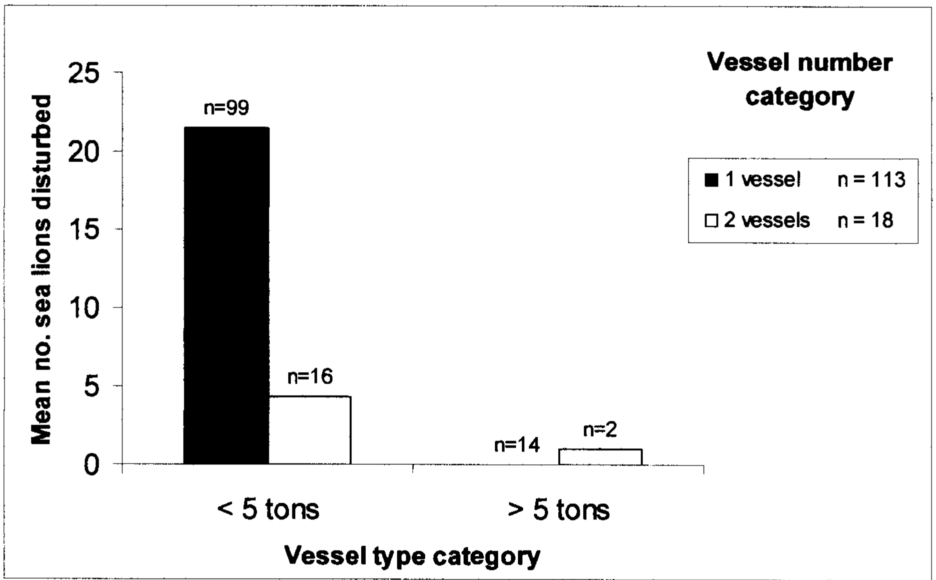


Table 14: Disturbance responses - vessel type and vessel number

Vessel number category*	Vessel type category	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance from this vessel number and vessel type category (B/A)	Percent of disturbances in this vessel number and speed category (B/33)
1	> 5 tons	14	0	0	0
	< 5 tons	99	26	26	79
	totals	**113**	**26**	**23.0**	**78.8**
	> 5 tons	2	1	50	3
2	< 5 tons	16	6	38	18
	totals	**18**	**7**	**38.9**	**21.2**
Total		**131**	**33**		

*For motorized vessels only.

5.5 Other Interactions

Sample sizes were small for the following interactions therefore observations are presented regardless of independence (Table 15). Observations of these interactions are important to consider when evaluating the Park PVG because the Guidelines specify a minimum viewing distance for aircraft and make reference to viewing by helicopter and personal watercraft.

Table 15: Disturbances responses – other interactions

Source of disturbance	(A) No. of approaches	(B) No. of disturbances	Percent of approaches resulting in disturbance (B/A)
Fixed-wing aircraft	11	4	36.4
Helicopter	4	1	25.0
Personal Watercraft	3	3	100.0
Humans on foot	3	3	100.0
Total	**21**	**11**	

5.5.1 Fixed-wing Aircraft

Aircraft affected sea lion behaviour. Disturbance occurred during four overflights (n = 11 overflights) (Table 15). Three of the four disturbances were characterized by planes which circled a haulout or flew at an altitude <300 m. Only one disturbance was observed with an aircraft flying at an altitude of >300 m.

5.5.2 Helicopters

Helicopters affected sea lion behaviour. Of the four interactions observed, disturbance occurred only once (Table 15). This disturbance was caused by a large helicopter during an over-flight at an elevation of 200 m. Sound played an important role in sea lion responses. Helicopters that were large, flew at a low altitude, or circled the haulout – situations in which noise levels were high, elicited greater disturbed responses. Smaller helicopters and those that passed near, but not directly over haulouts (at distances of 400 m or more), did not cause disturbances.

5.5.3 Personal Watercraft

Personal watercraft (PWC), (sometimes referred to as jet skis® or seadoos) elicited a major disturbed response by sea lions. Three PWC approaches were conducted at Area C on 5 September 2001 (Table 15). All interactions resulted in disturbance. The first approach was made to a distance of *50 m* at a *slow* speed. Nineteen sea lions *flushed*, 21 *stampeded* and the remainder moved towards the water or stood oriented towards the PWC (N = 55 sea lions). No animals remained resting or in an alert state. Ten minutes after the interaction, over 30 individuals had entered the water and most of these sea lions followed the PWC as it departed. Vocalization of the animals increased significantly.

The second PWC approach was made to within *5 m* of the beach at a speed of 20 knots. Forty-eight percent of the animals *stampeded* and 12% *flushed.* Ten minutes later the PWC made another *fast* approach to *5 m*. Seventy-seven percent of the remaining animals *stampeded*, 18% *flushed*, and the rest of the sea lions moved towards the water.

5.5.4 Humans on Foot

All three human interactions observed in the study area resulted in disturbance (Table 15). Disturbances by humans on foot were marked by a wave of animals emptying the beach and entering the water. Recovery after such disturbances took over three hours. If standing upright on a haulout, humans elicited a major disturbed response regardless of distance from the animals.

On 13 August 2001 one adult human walked towards Area A on the west side of Wouwer and came within approximately 50 m of the sea lions. Twenty-eight percent of the sea lions *stampeded* or *flushed.* On 31 August 2001 an individual was spotted in the tree line above the beaches at Area C. A disturbance resulted when the sea lions became aware of the person's presence. Forty-nine percent were disturbed (N = 90 sea lions present). On the third occasion, two people were observed high up in the log zone at Area C on 8 September 2001. When the animals became aware of the human presence 75% of the sea lions *stampeded* to the water's edge and 25% *flushed.* Vocalization significantly increased (to 4.5). This was the most extreme disturbance reaction observed during the study. The chain reaction of animals clearing the beach lasted six minutes and recovery scans indicated that it took approximately three hours for the sea lions to recover. This was longer than a recovery observed for any vessel interaction.

5.6 Additional Observations

5.6.1 Vocalization

Most disturbances were characterized by a significant increase in vocalization volume (paired sample t-test, $t = -3.449$, $df = 92$, $p = .000$) (Table 16). This increase was more pronounced in the California sea lions due to their distinctive bark. On occasion there was a 5-30 sec period of silence or decreased level of vocalization at the moment of vessel interaction which was followed by escalating noise level of 3.0-4.0 (on a scale of 5.0).

Table 16: Vocalization levels during scan and interaction samples

	Vocalization during scans	Vocalization during interactions
N	155	93
Minimum	1.0	1.0
Maximum	3.5	5
Range	2.5	4.0
Mean	2.5	2.7

5.6.2 Difference Between Sites

The normal behavioural state of sea lions was generally more active on sandy haulout sites than on rocky haulouts. This was particularly the case at Area C. Sea lions interacted more with one another on sandy beaches and the majority of these interactions were of an aggressive nature. More disturbances occurred at sandy sites (Areas C and D) where 30% of interactions resulted in a disturbed response (n = 67 interactions) however the number of disturbances between sites was not significant ($X^2 = 1.875$, $df = 1$, $p < 0.2$) (Table 17).

Table 17: Disturbance responses – rocky vs. sandy haulouts

Haulout type	(A) No. of approaches	(B) No. of disturbances	Percent of approaches with disturbance at this distance (B/A)	Percent of disturbances in this distance category (B/39)
Rocky (Areas A, B and E)	93	19	20	49
Sandy (Areas C and D)	67	20	30	51
Total	**160**	**39**		

5.6.3 Observations at Other Sites

The sea lions on the exposed islets southwest of Wouwer (Figure 2) were disturbed at further distances than the animals observed at the inner Wouwer study site. An extreme example of this sensitivity occurred on 25 September 2001. Upon approach, 5% of the sea lions *flushed* at a distance of *150 m* (N = 88 sea lions present). On 5 August 2003 a vessel *over 5 tons* approached the outer Wouwer islets and an animal *flushed* at a distance of *84 m* (N = 60 sea lions present).

Steller sea lions were easily disturbed by vessel traffic at Carmanah and neighbouring Lonely Bull Rock (Figure 2). Opportunistic observations of vessel interactions at Carmanah and Lonely Bull Rock were made on 6 August 2001 prior to clearing the haulouts of animals for scat collection. An *over 5 ton* vessel approached Lonely Bull Rock at *slow* speed to a distance of 63 m. Ten animals *flushed* (N = 30 sea lions present) and when the vessel was within *35 m*, 5 more animals entered the water.

The same vessel then approached the haulout at Carmanah Rocks. The haulout was slowly circled eight times to sight for branded individuals. Seventy-four percent of the animals *flushed* when the vessel approached within *154 m* (N = 31 sea lions present). When approaching the eastern side of the haulout, two sea lions *flushed* when the vessel was at a distance of *310 m*. This was the farthest distance at which sea lions were observed flushing in reaction to a vessel. The vessel then circled to the northern side of the haulout where one sea lion *flushed* when approached to a distance of *72 m* (N = 28 sea lions present).

Observations were only made twice at Long Beach Rocks (Figure 2). Twelve animals stampeded when approached to *50 m* by a 17' inflatable vessel in July 2000. Observations were made a second time on 4 August 2003. A vessel *over 5 tons* approached the largest of the Long Beach Rocks. Five animals *flushed* (N = 118 sea lions present) when the vessel was at a distance of *89 m*.

5.6.4 Motor on/off and Change in Sound

Sudden changes in sound volume or pitch affected sea lions' reactions to vessels and triggered disturbance responses. On 6 September 2001 the Dixie IV made an approach at *medium* speed to a distance of *25 m* at Area C. The vessel drifted at this distance for 10 minutes and there was little change in sea lion behaviour. When the throttle was shifted into reverse however, the sound created caused a disturbance response. Fifty percent of the sea lions *stampeded* and 9% *flushed* (N = 53 sea lions present). This caused a chain reaction in which 18 more sea lions *flushed* and 15 animals moved towards the water. On another occasion, when Sundancer shifted gears at Area C the sudden change in sound elicited a disturbed response in which all animals *stampeded* and 20% *flushed* (N = 188 sea lions present).

5.6.5 Movement in Vessels

Passengers usually remained seated in the rigid hull inflatable vessels unless they stood up to take photographs. Because vessels were generally able to approach relatively close to sea lion haulouts, the effect of movement inside a vessel was tested on one occasion. All passengers on the Contender were asked to stand and wave their arms when the vessel approached to within *25-50 m* of Area C. Prior to passengers doing this, the Contender slowly drifted to 15 m. No change in sea lion behaviour was observed. Movement within the vessel triggered a disturbance response. Forty sea lions *stampeded*

(N = 53 sea lions present). This was not the only time sudden movement in a vessel elicited a disturbance response. On 9 September 2001, passengers stood up and were moving on the Contender when it slowed to 10 m after a fast approach. Eighty-eight percent of the animals were disturbed (N = 55 sea lions present). On a third occasion, all sea lions *stampeded* when a passenger jumped up on the bow of the Dixie IV to take photographs when the vessel was 30 m from the haulout.

5.7 Summary

Results indicate that of all variables associated with vessel disturbance, approach distance had the greatest affect. Also significant, but to a lesser degree, was the affect of speed. Particular categories within each variable of distance, speed, vessel type and vessel numbers also had a significant influence on sea lion reactions.

At a statistically significant level, disturbance was more likely:

- at a distance of *0-25 m*
- when boats approached at a *fast* speed
- with vessels *under 5 tons*
- with *2* vessels

Combinations of particular categories within variables were also more likely to cause disturbance. These include:

- a vessel approaching *to 0-25 m* at *fast* speed
- a vessel *under 5 tons* approaching to *0-25 m*
- *one vessel* approaching to *0-25 m*
- a vessel *under 5 tons* approaching at *fast* speed
- *one vessel* approaching at *fast* speed
- *one vessel under 5 tons*

Other observations indicated that fixed-wing aircraft, helicopters, PWC and humans on foot affected sea lion behaviour. Larger and closer aircraft caused greater disturbance responses than smaller aircraft and those passing at higher elevations. Humans on foot caused the most extreme disturbance responses.

Chapter 6 Discussion

The PRNPR PVG meet their objective to prevent disturbance of sea lions from vessels in the BGI. The 50 disturbances observed in this study resulted from interactions with vessels, aircraft, jet skis and humans on foot. Reactions to vessels are the most important factors to consider when evaluating the PRNPR PVG because this and other studies have found vessels to be the most common cause of disturbance to pinnipeds (Allen *et al.* 1984, Calambokidis *et al.* 1991, Kroll 1993). Distance, speed, vessel type and the number of vessels all influenced sea lion behavioural reactions during vessel interactions. These variables are the most important to consider because they can be controlled to minimize sea lion disturbance.

6.1 Vessel Interactions

6.1.1 Vessel Distance

The 50 m minimum viewing distance outlined in the PVG minimizes disturbance of sea lions from viewing activities at "inner Wouwer" in the BGI. All but two disturbances by vessels occurred within 50 m of hauled sea lions and most disturbances occurred within the *0-25 m* distance category. The distance at which sea lions showed a disturbed response was considerably less in this study than what was observed by Mathews (2000). Steller sea lion disturbance only occurred when vessels were within 25 m in this study whereas almost half of the disturbance events in Glacier Bay occurred when boaters approached the haulout within 100 m (Mathews 2000).

There was variation in the distance at which Steller sea lions displayed a disturbed response. In this study disturbances occurred as close as 3 m and, on one occasion, within the 76-100 m category. This variation was also observed in Glacier Bay where Steller sea lions were disturbed as close as within 100 m yet as far away as 345 m. It is recommended that the PVG minimum viewing distance of 50 m be retained. There was a significant difference in the number of disturbance events between approaches made to within 50 m of a haulout and those made further than 50 m. The PVG emphasize that the

50 m '*no go zone*' is a minimum distance and that a greater distance may be required. This precautionary measure addresses other factors such as seasonal effects that may be beyond the scope of management.

A narrow passage between Wouwer and Batley (Figure 3) only allows for approximately a 6 m distance to be maintained from either side when transiting through by vessel. Although the Guidelines state to avoid circling islands or traveling close to shore at close distances, this is one area where avoiding close proximity to land is not possible. The sea lions that hauled out on either side of this channel showed no indication of disturbance, regardless of vessel type.

6.1.2 Vessel Speed

The PVG to slow down to 5 knots (*no-wake speed*) minimizes disturbance of sea lions from viewing activities in the inner BGI. Vessel approaches caused sea lions to become disturbed whether they approached '*fast*' or '*slow*'. There was a significant difference in the number of disturbance events between *slow* and *fast* vessel approaches. It is therefore recommended that vessels slow down well beyond 100 m when approaching sea lions in the study area. It is not unreasonable to recommend the greater distance of 250 m as required by the PVG. Slowing down at 250 m does not distract from the viewing experience and moving closer gradually allows sea lion behaviour to be monitored upon approach. If signs of agitation are observed, drivers can alter vessel approach distance to avoid disturbing animals.

6.1.3 Vessel Type

The PVG to have vessels within the 50-100 m '*close viewing zone*' minimizes disturbance of sea lions by vessels in the study area. Disturbance most frequently occurred with vessels *under 5 tons* but there was no significant difference in the number of disturbance events between vessel types.

Pinniped studies differentiate between motorized vessels and kayaks but not between motorized vessels of various sizes (i.e. *under 5 tons* and *over 5 tons*). This study found motorized vessels to be the primary cause of disturbance. Calambokidis and Baird (1994), Suryan and Harvey (1999) and Lelli and Harris (2001) found this as well.

The PVG outline restrictions pertaining to vessel types *under 5 tons* and *over 5 tons* but do not specify *kayaks*. Interestingly, other studies have found kayaks to be more likely to elicit a disturbed response in pinnipeds and to elicit the most extreme disturbance response by any vessel type (Allen *et al.* 1984, Johnson *et al.* 1989, Suryan and Harvey 1999, Mathews 2000, Lelli and Harris 2001).

It is not known why pinnipeds have shown extreme reactions to kayaks in other studies and in this study on occasion. It can be hypothesized that the presence of a kayak may be perceived as a marine mammal-eating killer whale because animals respond to disturbance from humans in the same way as they respond to the risk of predation (Gill *et al.* 1996). It has been suggested that sea lions may have a perceptual "search image" for the detection of predators based on visual cues (Baird and Stacey 1989). Sea lions exhibit alert and avoidance reactions in the presence of transient killer whales (Baird and Stacey 1989). A kayak's low profile with the shape of the upright paddler could be mistaken for a killer whale's fin. The fact that sea lions only see in black and white (except the blue-green spectrum) (Schusterman 1981) may add to such a perception. Kayaks are quiet and can approach shores closely. Because they are quiet, reactions to kayaks may be sea lions responding to kayakers' movements (Murphy and Hoover 1981). The PVG stipulate that kayakers should avoid hugging the shore and avoid 'sneaking up' to animals. The Guidelines also suggest that paddlers make a regular, repetitive, low volume noise (such as tapping the deck or hull of their vessel) to avoid startling animals.

6.1.4 Vessel Number

The number of sea lions disturbed by approaches with either *1* or *2 vessels* was significant, however there was no significant difference in the number of disturbance events when comparing approaches *1* and *2 vessels*. *Two vessels* viewing sea lions at a distance of *50-100 m* was not found to cause a significant number of sea lions to become disturbed so it is suggested this minimum viewing distance is appropriate. It is not possible to make recommendations for *3 vessels* within the '*close viewing zone*' because 3 motorized vessels were not observed together in the study area and no systematic study of the reaction of pinnipeds to various numbers of vessels has been made.

6.1.5 Variable Combinations for Distance, Speed, Vessel Type and Vessel Number

Of distance, speed, vessel type and number of vessels, distance was the variable that most significantly elicited a disturbed response. Because 77% of vessel approaches within the 50 m minimum viewing distance did not cause a disturbance, it suggests that speed, vessel type and the number of vessels may have also influenced sea lion behaviour. Some of these variable combinations are related.

There was a significant difference in the number of disturbance events between *fast* and *slow* approaches, but not for approaches within the Guidelines' minimum viewing distance. Most disturbance events occurred with *fast* approaches to within *0-25 m* and sea lions only became disturbed in significant numbers with this speed and distance combination. A vessel travelling at fast speed however, cannot immediately slow down: to slow to 5 knots by 50 m requires slowing down at a further distance. It is therefore appropriate for the PVG to require slowing down to 5 knots (*no-wake speed*) at a distance of at least 100 m in the study area to reduce disturbance.

Disturbances occurred most frequently within *0-25 m* of sea lions for both motorized vessels and *kayaks*. Of these disturbances most were caused by vessels *under 5 tons*. Others found that distance was affected by vessel type in causing a disturbance however their results indicated that seals enter the water at greater distances with kayaks and canoes compared to motorized boats (Calambokidis *et al.* 1983a, Kovacs and Innes 1990, Calambokidis *et al.* 1991, Henry and Hammill 2001).

There was no significant difference in the number of disturbance events between approaches with *1* and *2 vessels*. The combined effect of distance and the number of vessels causing disturbance in pinnipeds has not been investigated in other studies. A viewing distance of *50-100 m* appears adequate to minimize disturbance by two vessels viewing sea lions: disturbance events occurred with *2 vessels* within *50 m* of hauled out sea lions but not at greater distances. It is not possible to make recommendations regarding the distance at which *3 vessels* should remain away from a haulout because *3 motorized vessels* together were not observed in the study area.

Approaching haulouts at 5 knots (*no-wake speed*) reduced sea lion disturbance in the study site. There was a significant difference in the number of disturbance events between *slow* and *fast* approaches. Although the number of sea lions disturbed was significant for both *slow* and *fast* approaches by vessels *under 5 tons*, there is little relevance to having speed specifications for different vessel types: generally, only vessels *under 5 tons* are capable of reaching *fast* (cruising) speeds. Vessels *over 5 tons* observed in the study area travelled no faster than *medium* speed. Due to the geography and conditions, it would not be safe for a vessel of any type to pass between Wouwer and Batley Islands at *fast* speed. Although over half of the total disturbances were caused during *slow* approaches, a *slow* approach is the most conservative speed at which to approach sea lions. This precautionary approach is incorporated into the Guidelines. No investigation of the combined effect of *speed* and *vessel type* on pinniped behaviour has been made to be able to provide a comparison with my results.

Two vessels approaching at *fast* speed proportionately caused more disturbances than *1 vessel* approaching at the same speed, however sample size were too small to test for significant differences. Regardless of whether *1* or *2 vessels* are present, slowing down to '*no-wake*' speed at 250 m, as required by the Guidelines, appears to be appropriate to limit disturbance. Recommendations cannot be made regarding *3 vessels*, however the common sense approach would be to require all vessels, regardless of the number and type, to slow down when approaching haulouts.

Results indicate that the probability of *2 vessels under 5 tons* causing a significant number of sea lions to become disturbed is marginal. Interactions with *2 vessels* proportionately caused more disturbances than interactions with *1 vessel*, however the number of approaches with *2 vessels over 5 tons* is too small to make statistical comparisons with approaches by *2 vessels under 5 tons*. The PVG to have no more than *3 vessels under 5 tons* within the '*close viewing zone*' could not be tested because 3 motorized vessels were not observed together in the study area at the same time.

6.2 Other Interactions

6.2.1 Fixed-wing Aircraft

The Park Guideline minimum over-flight altitude of 300 m may not be adequate to prevent disturbance. One disturbance (N = 4 disturbances) occurred during an over-flight of >300 m. Sound and flight pattern influenced sea lion responses. Planes that were loud, flew low or circled above haulouts caused more animals to be disturbed. Similar to this study, other findings indicate that response to fixed-wing aircraft depend on type of aircraft, altitude and flight pattern (Calkins 1983, Kucey 2005).

It is assumed that the PVG are intended for 'light aircraft' such as Cessnas that are involved in sea lion viewing. Only these smaller planes were observed making low overflights and circling the haulout. To reduce disturbance by larger aircraft a more precautionary approach would be to accept the Department of Transport 600 m minimum altitude prescribed for aircraft in Canadian National Parks.

6.2.2 Helicopters

The Park Guidelines state that helicopters are not appropriate for marine wildlife viewing and that helicopters should maintain a minimum altitude of 300 m if transiting areas with marine mammals. Other studies have found helicopters to be a major disrupting influence to California sea lions (Bowles and Stewart 1980, Richardson *et al.* 1995). Though only four helicopter interactions were observed during my study, extreme responses to helicopters documented by others at altitudes of approximately 300 m (Bowles and Stewart 1980, Kroll 1993) indicate that helicopters could elicit an extreme disturbance response by sea lions in the BGI. It is therefore recommended that the PVG continue to prohibit helicopters from engaging in viewing activities. Requiring helicopters to maintain a minimum altitude of 600 m when flying over haulout areas would be a precautionary measure to minimize sea lion disturbance.

6.2.3 Personal Watercraft

The PVG state that PWC are not appropriate for marine wildlife viewing and are prohibited in the BGI. During all experimental approaches made during this study, PWC were found to elicit extreme disturbance responses in sea lions. Though no studies have assessed the affect of PWC on sea lions, Henry and Hammill (2001) observed that seadoos were frequent causes of disturbance to seals. It is recommended that PWC be prohibited from viewing sea lions in PRNPR due to the considerable disturbance they cause to pinnipeds.

6.2.4 Humans on Foot

Humans on foot were observed to cause major disturbances to sea lions each time people were observed on Wouwer Island. The most extreme disturbance observed during this study occurred in reaction to humans with 100% of the sea lions *stampeding* or *flushing*. This extreme reaction has been observed by others (Richardson *et al.* 1995, Kucey 2005). The Guidelines do not permit people to go ashore. Cehak (1974) suggests that people could watch sea lions on Wouwer Island without disturbing them when approaching on the beach, however I disagree. I recommend that humans should not be permitted to go ashore near the haulouts on Wouwer after 1 August when sea lions begin moving into the area.

6.3 Additional Observations

6.3.1 Animals in the Water

The PVG do not specify approaching sea lions in the water: it is assumed that the PVG refer to viewing sea lions hauled out on land. Because up to 2500 sea lions inhabit the study area during the whale watching season it is to be expected that many of these individuals will be in the water as vessels transit through. Sea lions rafting in the water when vessels approached were observed dispersing. Dispersal occurred regardless of vessel type and when vessels were within 25-35 m of the animals. This observation is similar to Richardson *et al.* (1995) who also found that sea lions in the water tolerated close and frequent approaches by vessels. Because of the high concentration of sea lions in the study site and a relatively narrow (200 m) channel between Wouwer and Batley Islands (including the islets between them) it is not possible to completely avoid sea lions in the water.

6.3.2 Differences Between Species

Observations indicated that Steller sea lions were more easily disturbed than California sea lions. Video samples in which sea lion species could be identified (n = 54 samples), California sea lions were disturbed once and Steller sea lions were disturbed four times. The distance at which disturbance occurred in this study was at substantially closer distances than what was observed for Steller sea lions (Mathews 2000) and California sea lions (Bowles and Stewart 1980) in other studies. Each species' life history and ecology are factors determining where and when each may be subjected to stress and how each responds (Fair and Becker 2000).

The opportunistic observations made of harbour seal reactions are not adequate to make scientifically-based recommendations for viewing seals in the Park. The PVG do not specify viewing seals, except at Gowland Rocks in the Long Beach unit of the Park (Figure 2). Viewing seals within PRNPR is done more on an opportunistic basis whereas sea lions are targeted as part of whale watching trips. Ensuring seals are protected from disturbance is important particularly since pupping occurs at some of the 25 known haulout sites in PRNPR (Campbell pers. comm.).

Opportunistic observations of seals at Great Bear and Pigot Islets in Barkley Sound (Figure 2) were made on four occasions in 2001. Overall, harbour seals became alert and disturbed at a further distance than sea lions. Seals became alert as far as 100 m and were observed flushing as far as 69 m. Because seals were observed to react to vessels at distances much further than 50 m and because other studies found harbour seals to become disturbed on average between 100 m and 200 m (Calambokidis *et al.* 1983a, Calambokidis *et al.* 1983b, Kovacs and Innes 1990, Calambokidis *et al.* 1991, Suryan and Harvey 1999) the 50 m minimum viewing distance is most likely too close to minimize disturbance in PRNPR. As a precautionary measure, the Guidelines stipulate that vessel behaviour (including viewing distance) should be based on the most sensitive species or the most easily disturbed species on site. Further investigation is required to determine whether the PVG are effective for preventing disturbance of seals.

6.3.3 Difference Between Study Areas

Different reactions were observed among study sites both in the presence and absence of vessels. Sea lions were generally more active during their pre-disturbance states on sandy beaches than on surrounding rocky haulouts. Cehak (1978) also observed that sea lions on Wouwer's sandy beaches behaved in a manner unlike that of other animals in the study site. Animals interacted more with one another, and the majority of these interactions were of an aggressive nature.

Site may have influenced the rate of disturbance due to the affect of topography on sound propagation. Rocky sites provide greater attenuation for distant noise sources whereas noises close to shore (<3 km) are attenuated more over sandy beaches (Johnson *et al.* 1989). Site influences behavioural responses of pinnipeds (Born *et al.* 1999). Sea lion responses vary among sites (Bowles and Stewart 1980, Kucey pers. comm.) and harbour seal reactions also vary within regions, indicating less tolerance to vessels in some areas (Calambokidis *et al.* 1991, Suryan and Harvey 1999). It would not be practical to have differing viewing guidelines for rocky and sandy haulout sites in the BGI so guidelines should be based on reactions at the most sensitive site.

6.3.4 Observations at Other Sites

PRNPR developed site-specific viewing guidelines to reflect sensitivities of certain species at specific sites. Opportunistic observations made during this study in combination with local knowledge suggest that sea lion tolerance to vessels is greater in the study site than at other haulouts in the Park (B. Congdon pers. comm., B. Gisborne pers. comm. and J. Etzkorn pers. comm.).

The priority for management in many cases is developing a working knowledge of a species in a particular site (Duffus and Dearden 1990). This study can only specify responses by Steller and California sea lions to types and levels of vessel activity at Wouwer Island, BGI, PRNPR. Repeated observations of both species employing the same experimental design and observation methodology needs to be conducted at other haulouts in the Park to determine whether site-specific differences exit.

The PVG require a minimum viewing distance of 100 m at Carmanah. Steller sea lions are easily disturbed by vessel traffic at this site and at neighbouring Lonely Bull Rock. Five observations resulted in disturbance occurring at an average distance of 90 m and as far as 310 m. The disturbance which occurred at 310 m was the furthest distance at which sea lions reacted to a vessel. It is not possible to evaluate whether the Guidelines' 100 m minimum viewing distance is adequate to limit disturbance based on the few opportunistic observations conducted. My observations and those made by Gisborne (pers. comm.) and Etzkorn (pers. comm.) suggest however, that maintaining a 100 m minimum viewing distance is likely required to reduce disturbance at Carmanah.

The PVG require a minimum viewing distance of 100 m at Long Beach Rocks. Steller sea lions at Long Beach Rocks were found to be less tolerant of vessels than the sea lions in the study site. Disturbances occurred at a distance of 50 m and 89 m from the haulout. It is not possible to evaluate the effectiveness of the 100 m minimum viewing distance based only on two observations. These observations indicate however, that maintaining a 100 m minimum distance from Long Beach Rocks may be an appropriate distance to prevent sea lions from being disturbed.

The PVG require a minimum viewing distance of 50 m at 'inner Wouwer' in the study area. The Guidelines do not however, make reference to the haulout on the southwest side of Wouwer Island, referred to as 'outer Wouwer'. It is important that the PVG also protect sea lions from disturbance at outer Wouwer where animals are viewed by Ucluelet whale watching operators in June and July. It was not possible to make observations of sea lion reactions at outer Wouwer because vessels did not regularly visit the haulout during my study. It is not possible to recommend an appropriate minimum viewing distance based on only three observations. Disturbance occurred during each of the three observations at an average distance of 100 m and as far as 150 m. Personal observations and those by tour operators indicate that the 50 m minimum viewing distance which is required on the inside of Wouwer is not adequate to prevent sea lions from being disturbed on outer Wouwer.

6.4 Factors Influencing Disturbance

6.4.1 Age and Sex Classes

A typical reaction to a vessel was noted for age and sex classes. Sub adult and female Steller sea lions were the first to respond to disturbances, followed by California sea lions (all adult males) and finally full grown Steller bulls. Calkins (1983), Bowles and Stewart (1980), Richardson *et al.* (1995) and Orsini (2004) also found age-specific differences in sea lion reactions to disturbance. Additionally, Calkins (1983) found sex classes influenced responsiveness. It is not practical for viewing guidelines to be detailed to the degree that age and sex classes are identified. The Guidelines are precautionary in that they emphasize awareness of the sensitivity of certain species and individuals.

6.4.2 Seasonal Influences

A difference in the sensitivity of sea lions was detected before, during and following the whale watching season. Sea lions became vigilant and were disturbed more easily and at greater distances early in the season and a month after the season had ended. Seasonal variation in California and Steller sea lion responsiveness has been documented previously (Peterson and Bartholomew 1967, Bowles and Stewart 1980, Johnson *et al.* 1989, Kucey 2005). The PVG incorporate seasonal effects by specifying greater caution at the beginning of the season, indicating that animals may require 'more space'. The results of this study reflect sea lion reactions at a specific time of year. Sea lion reactions may not be similar at other times of year, however the Guidelines are appropriate during the whale watching season – the only time sea lions are viewed on a regular basis in the BGI.

6.4.3 Habituation

Habituation is a key factor influencing sea lion responses to vessels in PRNPR and was detected during the whale watching season. The first few approaches to each study area appeared to elicit more of a disturbed reaction than subsequent approaches. Animals appeared to habituate to vessel approaches within 3-4 days and sometimes even within the same day. It could be expected that sea lions would habituate to vessel presence due to the frequent traffic passing through the study site. Predictability of vessel behaviour would minimize disturbance. This entails ensuring vessel behaviour is consistent in speed, movement and volume. The Guidelines address this by requiring the avoidance of the following: loud noises, sudden alteration of vessel speed, sudden alteration of vessel direction and rapid vessel movements.

It could be expected that vessel-specific habituation would occur with commercial whale watching vessels since the Ucluelet whale watching companies operate on a regular schedule, visiting the sea lions up to three times daily. California sea lions can discriminate between stimuli with a slight difference in shape and have demonstrated comprehension of broad categories of types of objects, colors and sizes (Schusterman 1968, Schusterman and Krieger 1984). They also have long-term memory (Schusterman *et al.* 1993, Kastak and Schusterman 2002) which could be reliably applied to recall and differentiate between vessels. Steller sea lions can acclimatize to repeating sound projections (Akamatsu *et al.* 1996) indicating sea lions may become familiar with a vessel's acoustic signature. Discrimination of, and habituation to, commercial vessels was observed by Johnson *et al.* (1989): seals came to recognize the regular tourist boats and remained on the rocks but took to the water on the approach of strange craft.

6.4.4 Motor on/off and Change in Sound

Sea lions were observed to be more responsive to sudden changes in sound than to steady sounds. Sudden changes in sound included the restarting of engines after viewing sea lions with engines turned off, and abruptly changing propeller speed. Such reactions occurred regardless of vessel type and if a vessel was within 25-50 m of a haulout for several minutes. The noise a vessel created and the way it is operated may be a greater determinant of disturbance than close proximity (Orams 2000). Mathews (2000) also observed that sudden isolated noises were more likely to change the behaviour of Steller sea lions than steady continuous noise.

Effect of vessel noise is an important factor to be considered when investigating pinniped/vessel interactions. Observations from this and other studies indicate that consistent direction and speed by boats decrease the likelihood of disturbance (Murphy and Hoover 1981, Richardson *et al.* 1995). The Park Guidelines address this by including a provision to avoid loud noises and sudden alteration of vessel speed (which can cause sudden change in sound levels). Leaving engines running is up to the discretion of the driver. It is safe to shut engines off in the study site, however in some locations where there are reefs and larger ocean swell it is not safe to do so. In some instances it was observed that turning engines off and turning them on again caused a disturbance. Because some of these instances occurred within the 50 m minimum viewing distance it is not possible to determine the affect of noise without considering it in combination with the influence of distance. It is possible that turning engines off and turning them on again at distances greater than 50 m does not cause disturbance.

6.4.5 Movement in Vessel

Movement by people in boats were found to affect sea lion reactions. Movement of individuals on boats were found to alter the behaviour of Steller sea lions (Mathews 2000) and the behaviour of people in tour groups had a direct effect on the behaviour of seals (Kovacs and Innes 1990). The PVG state that rapid movements by boats should be avoided. The Park Guidelines should also specify that rapid movement by people within boats be avoided.

6.5 Implications for Pinniped Viewing Management in Pacific Rim National Park Reserve

The results of this study demonstrate that the PRNPR PVG achieve Parks Canada's objectives to minimize disturbance by vessels at inner Wouwer in the BGI. It is emphasized that these results are specific to California and Steller sea lions in the study site within the BGI. Results are not representative of other pinniped species or of sea lion reactions at other locations within the Park. Compliance with the Guidelines is important to limit sea lion disturbance, particularly with the high volume of vessel traffic in the BGI. Sea lions appear resilient to visitor interactions however, marked increases in visitor use could have negative effects (Johnson 1977).

Results of this and other studies exemplify that responsiveness of sea lions to vessels varies among individuals, locations and times (Richardson *et al.* 1995). These variables need to be considered when managing to prevent disturbance. Management should focus on variables that can be managed – approach speeds and distances for the various vessel types and numbers. Parks Canada could incorporate those factors into the PVG which contribute to sea lion disturbance and are relevant to vessel interactions in PRNPR. The Park Guidelines would be most effective if they are species and site-specific because they would be appropriate for local species and haulout sites. Tour operators are more likely to comply with guidelines that they were involved in developing, particularly if the guidelines are supported by research.

Concern regarding sea lion disturbance in PRNPR is greater for Steller sea lions because they are declining in other portions of their range. Steller sea lions utilize the Park to rest and feed, but are the focus of viewing activities for several months. Short-term reductions of observed numbers and seasonal movements of sea lions within and between Park haulout sites have been observed for over twenty years (prior to the onset of marine mammal viewing activities) (B. Congdon pers. comm.), but are not understood. The lack of obvious long-term effects of human disturbance on the declining Alaskan Steller sea lion populations indicates that Steller sea lions may be resilient to intermittent short-term disturbances (Kucey 2005). However, incidental disturbance is not believed to be harmless (Peterson and Bartholomew 1967): the effects of repeated disturbances over a short period of time may be cumulative (Lewis 1987). Therefore, a precautionary approach is needed to ensure disturbances are limited and cumulative effects are minimized.

The results of this research provide a scientific evaluation of the PRNPR PVG. Relying solely on distance guidelines or regulations to prevent sea lion disturbance however, may not be the most effective approach. Requiring people to maintain a minimum distance from sea lions may lead people to believe that if they comply with the distance guideline sea lions will not be disturbed. Ensuring compliance with the Guidelines entails challenges. Education and enforcement are important, as is the ability to accurately estimate distance on the water.

6.5.1 Issues with Distance Estimation

It is important to see not only how effective the PRNPR PVG are in minimizing sea lion disturbance, but also how effectively vessel captains and enforcement personnel, as well as the general public, are able to interpret and follow these guidelines. This includes determining how well people are able to accurately estimate distance on the water. There is a high degree of variability associated with distance estimation on the water. People are relatively poor at it and tend to overestimate distances (Baird and Burkhart 2000). The goal of the Park's Guidelines is to prevent disturbance. A minimum viewing distance is one tool to achieve this goal. The prescribed minimum viewing distance may not be adequate at all times, in all locations nor with all pinniped species (or individual animals). Viewers need to understand sea lion behaviour and monitor animals for indications of agitation and disturbance. I suggest it is just as important and relevant to understand behaviours indicative of sea lion agitation and disturbance as to abide by minimum viewing guidelines. In this study alone, sea lions were observed to be disturbed by vessels as close as 5 m and as far as 310 m. This variability in distance does not allow for one minimum viewing distance to appropriately reflect sea lion responsiveness to vessels at all Park haulout sites. It can be argued that a minimum viewing distance of 50 m may be adequate in the inner BGI, however, if a disturbance occurs at a distance greater than 50 m, the vessel operator is legally in the right (according to the PVG for inner Wouwer) but in principle is in the wrong (the principle being to prevent disturbance). Under some conditions, observing sea lion behaviour and adjusting vessel approach distance would therefore be more appropriate to minimize disturbance.

6.5.2 Education

Education is a key factor to ensure park visitors in the BGI understand and comply with the PVG. Education can be undertaken in several ways. Currently, all commercial whale watching operators are required to take an orientation given by Parks Canada. The orientation presents and explains the PVG and provides tour operators with information regarding pinniped biology, ecology and general behaviour. A summarized version of the Marine Wildlife Viewing Guidelines is printed in the BGI Paddler's Guide, a Parks Canada information brochure which is given to recreational paddlers. As well, the Broken Group Wardens include messaging pertaining to viewing marine wildlife in the orientations they give to paddlers arriving at Sechart Lodge, a staging area for kayakers in Barkley Sound. The Park has also developed an interpretive display in the Wickaninnish Interpretive Centre at Long Beach which showcases the Guidelines to Park visitors. Additional educational actions could be taken, including posting the Guidelines at various access points to the BGI, including Toquart Bay, providing a summary of the Guidelines with natural history information to local whale watch operators' clients, and writing newspaper articles in the local paper to inform local residents of the benefits of responsible marine wildlife viewing.

The goals of these education-based management strategies are to control interactions between boaters and marine mammals to: 1) protect sea lions from detrimental impacts and, 2) increase enjoyment and understanding for Park visitors. The ultimate goal of education is to impart behavioural change, independent of the fear of enforcement. Educational programs can be used successfully to provide information to boaters engaged in marine mammal viewing (Jahoda and Wiley 1993, Wiley and Jahoda 1995). However, a desired change in boater behaviour is less likely to occur (and may not occur) in the absence of an enforcement presence (Jahoda and Wiley 1993).

6.5.3 Enforcement

Regulation of the Marine Wildlife Viewing Guidelines for commercial whale watching vessels falls under the Business Regulations of the *Canada National Park Act*. The Guidelines form part of the Terms and Conditions for the Park Business Licenses. These licenses are required by all commercial operators conducting whale watching within the Park as per the Business Regulations. Commercial operators observed harassing a marine mammal face a charge under the Business Regulations and can have their Park Business License revoked. Commercial operators therefore have a strong incentive to comply with the Guidelines.

If sea lions are harassed within the Park there are various actions Park Wardens can employ. The first choice of action would be intervention. An intervention would be accompanied with education and either a verbal or written warning. In the last event a charge could be laid. If the act of disturbance is a gross violation, enforcement officers lay a charge under the *Canada National Parks Act*. This is the standard approach for non-compliance in Canadian National Parks (D. Salisbury, Parks Canada pers. comm.).

Fisheries and Oceans Canada's proposed new Marine Mammal Regulations will have implications for PRNPR's PVG. At the time of this writing it is understood that FOC is proposing a minimum viewing distance of 100 m for pinnipeds in British Columbia. This is double the 50 m minimum viewing distance outlined in the PRNPR PVG. The *Canada National Park Act* takes precedence over the *Fisheries Act* in PRNPR waters (Sparks, Parks Canada pers. comm.) however it would be politically prudent to maintain consistency in regulations between the two agencies. For PRNPR to retain its current 50 m minimum viewing distance in Barkley Sound, Parks Canada would have to scientifically justify that 50 m is precautionary enough to minimize sea lion disturbance. The results of this study provides the science Parks Canada requires to justify maintaining a 50 m minimum viewing distance for Steller and California sea lions at inner Wouwer.

6.6 Limitations

This study had limitations that required consideration and adaptation on an as-needed basis. These included; weather, park warden schedules, co-operation and schedules of whale watching companies, and technical capabilities of video recording equipment. Other considerations included:

- Variation in the numbers of animals present between the beginning and end of the field seasons.
- Pseudoreplication of vessels: a comparison of sea lion reactions to different types of vessels (*vessels >5 tons, vessels <5 tons* and *kayaks*) was intended, however responses to the same three vessels *<5 tons* (Contender, Blue Thunder and Sundancer) and two vessels >5 tons (Lady Selkirk and Dixie IV) which frequented the study site were observed.
- Approach distances and speeds could be controlled for whale watching vessels but not for kayaks. This resulted in smaller sample sizes of kayaks making close approaches to haulouts.
- It was not possible to determine the proportion of flushed individuals returning to the same haulout.
- There may have been responses of physiological stress or delayed consequences (such as short-term avoidance or abandonment) that went unnoticed.
- Environmental influences on behaviour were not considered because it was beyond the scope of evaluating the PVG.

6.7 Recommendations

Based on study results, the following are recommended for viewing sea lions in the BGI:

- Do not approach sea lion haulouts closer than 50 m at inner Wouwer, BGI.

- The 50 m minimum distance may not be adequate for all pinniped species, nor for sea lions at all sites at all times: a greater distance may be required earlier in the season or year round at certain sites.
- Slow down to 5 knots (*no wake speed*) when 100 m from the inner Wouwer haulouts.
- Sea lion behaviour should be monitored during approaches. Watch for signs of agitation and slowly back away from animals if they become visibly agitated.
- Descriptions of behaviours that indicate sea lion disturbance should be included in the Guidelines (or incorporated into tour operator orientations). The following is a suggested example: "The following behaviours by sea lions in the presence of vessels may indicate agitation or disturbance and should be avoided:
  - A number of animals raise their heads simultaneously
  - A number of animals move closer to the water
  - A few animals hurriedly enter the water
  - Increased vocalization by sea lions"
- Depart slowly (*no wake speed*) from the inner Wouwer haulouts to a distance of 100 m and then increase speed gradually.
- Personal watercraft are not appropriate for viewing sea lions.
- Helicopters are not appropriate for viewing sea lions.
- Do not go ashore on haulouts.
- Avoid sudden alteration of vessel speed and direction.
- Avoid rapid vessel movements and movement within vessels.
- Avoid loud noises and sudden changes in sound.
- Leave engines on when viewing sea lions.
- Sea lion viewing activities should be monitored to ensure the Guidelines continue to be effective.

6.8 Future Research Needs

- Disturbance responses need to be investigated at other haulout sites (including outer Wouwer) to evaluate whether the PVG are sufficient to prevent sea lion disturbance at other locations within the Park.
- Kayak approaches should be experimentally controlled to assess the affect of distance and angle of approach on sea lion behaviour. Extreme reactions to all three controlled kayak approaches in this study warrant attention.
- Experimentally test whether *3 vessels* "*under 5 tons*" inside *the "close viewing zone*" (50-100 m) is adequate to limit sea lion disturbance.
- Investigate whether a 300 m minimum height for fixed-wing aircraft is adequate to limit disturbance.
- Assess recovery time in greater detail. Quantifying recovery time would provide an indication of the amount of time resting and socializing is interrupted.
- Comprehensive, systematic studies that provide quantitative assessments and address long-term effects are also required, including how behavioural changes in response to disturbance affect demographic parameters such as survival and reproductive success.
- Further study needs to be undertaken to determine appropriate guideline specifications for viewing harbour seals in PRNPR.
- Social dimensions of the Guidelines should be addressed. I suggest that PRNPR maintain communications with the whale watching companies who were involved in the development of the PVG to monitor how the Guidelines affect the enjoyment and satisfaction of their clients. The Park has a legal responsibility however to ensure that sea lion protection receives priority over visitor satisfaction.

6.9 Conclusion

The results of this research demonstrate that PRNPR's PVG are effective in minimizing disturbance of the sea lions at inner Wouwer in the BGI. Disturbance is minimal when following the prescribed distances and speed restrictions. Behavioural change resulting in disturbance is statistically significant for some categories of distance, speed and vessel type, however the biological significance of these disturbances is questionable and cannot be measured with current limits in behavioural research. The responses to vessels by sea lions reflect a combination of environmental influences, habituation and variables associated with vessel interactions - distance, speed, vessel type and number of vessels, as well as the behaviour of passengers on board and sudden changes in sound. Of these, vessel behaviour – specifically distance and speed have a greater effect on sea lion behaviour. Sea lion reactions to vessels are both species and site specific.

The results from this study scientifically justify the effectiveness of the Park PVG's ability to minimize the effects of disturbance by vessel traffic in the BGI, PRNPR. It is hoped that Parks Canada management will consider and incorporate these results into its PVG.

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Appendix I

Pacific Rim National Park Reserve
MARINE WILDLIFE VIEWING GUIDELINES

APPROACH GUIDELINES

- Slow down to 5 knots (no-wake speed) at 250 m
- Vessel behaviour should be based on the most sensitive or easily disturbed species on site (which may not be the species that is sought for viewing)
- Be aware that the "*no go zone*" is a minimum distance: a greater distance may be required earlier in the season and/or year round at certain sites
- Use radio communication with others on-scene to assess the situation
- Approach at an indirect angle that provides the maximum visibility for the animals or birds
- Move closer gradually
- Monitor animal behaviour on approach. Watch for signs of agitation and increase your angle *away* from the animals or birds if they become visibly agitated.
- Do not approach animals head on
- Avoid sneaking up to animals
- Use binoculars instead of your vessel to bring animals into closer view
- Fixed-wing aircraft must maintain a minimum height if 1000 feet
- Helicopters are not appropriate for viewing animals or sea birds. Helicopters should maintain a minimum of 1000 feet.
- Personal watercraft are not appropriate for viewing animals or sea birds. Personal watercraft should maintain a minimum distance of 500 m from flocks, colonies, haul out sites, nesting sites or shorelines.

VIEWING GUIDELINES

- Leaving engine running is up to the discretion of the driver
- Do not go ashore
- Vessels should view animals and shorebirds in rotation with other vessels
- Use radio communication to co-ordinate rotation into and out of *the "close viewing zone*"
- Limit time in the *"close viewing zone"* to 10-15 minutes
- If an animal approaches the vessel, it is appropriate to observe it at whatever distance the animal chooses
- Avoid loud noises
- Avoid sudden alteration of vessel speed
- Avoid sudden alteration of vessel direction
- Avoid sudden alteration of vessel angle
- Avoid rapid vessel movements

- Do not feed the animals or birds
- To avoid startling animals, paddlers should make some sort of regular, repetitive, low volume noise (like tapping floor of vessel)
- Kayakers should avoid hugging the shore

DEPARTURE GUIDELINES

- Move slowly away from the animals or birds when leaving the area
- Depart at "*no-wake speed*" until beyond 250 m and then increase speed gradually

RESEARCH GUIDELINES

- With a research permit, researchers may be allowed to approach animals at a distance less than the *close viewing zone*
- Researchers must display a "research flag" or "research markings" on their vessel indicating they are engaged in research
- Researchers must be contactable by VHF radio

PINNIPED (SEAL AND SEA LION) VIEWING GUIDELINES

APPROACH GUIDELINES

- Slow down to 5 knots (*no wake speed*) at 250 m
- Avoid circling islands or travelling close to shore at close distances
- When viewing pinnipeds, aircraft should be attentive to the response of birds, which may occupy the same site: adjust height and/or approach to avoid flushing birds
- Birthing areas are "*no go zones*": remain at least 250 m offshore
- Avoid approaching pinnipeds on cliff areas or areas with steep drops where animals may injure themselves if they flee the area

VIEWING GUIDELINES

- Do not approach closer than 50 m "*no go zone*"
- Be aware that this 50 m "*no go zone*" is a minimum distance: a greater distance may be required earlier in the season and/or year round at certain sites
- If stopping to view pinnipeds, avoid rapid movements: stop and depart slowly and keep a steady speed when viewing.
- Up to 3 vessels "*under 5 tons*" or 1 vessel "*over 5 tons*" inside *the "close viewing zone*" (50-100 m)

DEPARTURE GUIDELINES

- Move slowly away from the animals or birds when leaving the area
- Depart slowly from the "*no wake zone*" (250 m) and then increase speed gradually

SITE-SPECIFIC VIEWING GUIDELINES

SEA LION ROCKS

Do not approach closer than 100 m "*no-go zone*"

WOUWER ISLAND

- Stay 50 m offshore inner Wouwer

CARMANAH AND PACHENA POINT ROCKS

- Do not approach closer than 100 m "*no-go zone*"

APPENDIX II

DATE:

TIDE								
CLOUD COVER								
PRECIPITATION								
HUMIDITY								
TEMPERATURE								
WIND VELOCITY								
WIND DIRECTION								
SEA STATE								
SEA HEIGHT								
OBSERVATION AREA								
TIME								
SPECIES	**ZACA**	**EUJU**	**ZACA**	**EUJU**	**ZACA**	**EUJU**	**ZACA**	**EUJU**
# ON LAND								
# FLUSHING								
# STAMPEDING								
# MOVING								
# SITTING								
# RESTING HEAD UP								
# RESTING								
# RAFTING IN WATER								
# SWIMMING								
VOCALIZATION								
COMMENTS								

APPENDIX III

DATE:

VESSEL TYPE								
# VESSELS								
OBSERVATION AREA	STRATA		STRATA		STRATA		STRATA	
	TIME		TIME		TIME		TIME	
	S D		S D		S D		S D	
SPECIES	ZACA	EUJU	ZACA	EUJU	ZACA	EUJU	ZACA	EUJU
# ON LAND								
# FLUSHING								
# STAMPEDING								
# MOVING								
# SITTING								
# RESTING HEAD UP								
# RESTING								
# RAFTING IN WATER								
# SWIMMING								
VOCALIZATION								
RECOVERY TIME								
COMMENTS								

Appendix IV:

Scan and interaction observation data

							Scan data			Interaction data		
Scan/ Interaction Pair	Date	Location	No. Vessels	Vessel Type	Distance (m)	Speed	Vocalization	No. Disturbed	Total No.	Vocalization	No. Disturbed	Total No.
1	11-Aug-00	Area E	kayak(s)	kayak	26-50 m	kayak	2.5	0	32	2.5	0	46
2	11-Aug-00	Area E	kayak(s)	kayak	76-100 m	kayak	2.5	0	32	2.5	0	32
3	11-Aug-00	Area E	kayak(s)	kayak	76-100 m	kayak	2.5	0	32	2.0	0	22
4	12-Aug-00	Area E	1	< 5 tons	76-100 m	slow	2.5	0	35	2.5	0	51
5	14-Aug-00	Area B	kayak(s)	kayak	26-50 m	kayak	2.5	0	84	3.0	2	81
6	14-Aug-00	Area B	kayak(s)	kayak	26-50 m	kayak	2.5	0	84	2.5	0	74
7	14-Aug-00	Area B	1	< 5 tons	0-25 m	medium	2.5	0	101	3.0	1	75
8	14-Aug-00	Area B	kayak(s)	kayak	26-50 m	kayak	2.5	0	101	2.5	0	57
9	14-Aug-00	Area B	1	< 5 tons	0-25 m	slow	2.5	0	101	3.0	1	46
10	14-Aug-00	Area B	kayak(s)	kayak	0-25 m	kayak	2.5	0	46	2.5	0	53
11	14-Aug-00	Area B	2	< 5 tons	*	*	2.5	0	36	2.5	2	37
12	15-Aug-00	Area B	1	< 5 tons	0-25 m	slow	2.5	0	45	2.5	0	61
13	15-Aug-00	Area B	kayak(s)	kayak	76-100 m	kayak	3.0	0	51	2.5	0	41
14	15-Aug-00	Area B	1	< 5 tons	*	medium	2.5	0	46	2.5	0	63
15	15-Aug-00	Area B	1	< 5 tons	26-50 m	slow	2.5	0	46	2.5	0	55
16	15-Aug-00	Area B	2	< 5 tons	26-50 m	medium	2.5	0	46	2.5	0	61
17	15-Aug-00	Area B	2	< 5 tons	26-50 m	slow	2.5	0	46	2.5	0	32
18	22-Aug-00	Area B	kayak(s)	kayak	26-50 m	kayak	2.5	0	19	2.5	2	14
19	22-Aug-00	Area B	1	< 5 tons	76-100 m	slow	2.0	0	13	2.0	0	12
20	22-Aug-00	Area A	1	< 5 tons	26-50 m	slow	2.0	0	13	3.0	1	12
21	22-Aug-00	Area B	1	> 5 tons	51-75 m	slow	2.0	0	14	2.5	0	12
22	07-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	1.5	0	5	2.0	0	7
23	07-Aug-01	Area B	1	< 5 tons	0-25 m	fast	1.5	0	15	1.5	5	24
24	07-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	1.5	0	18	1.0	0	16
25	07-Aug-01	Area B	1	< 5 tons	26-50 m	medium	1.5	0	18	1.5	0	19

26	08-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.0	0	26	1.5	0	13
27	08-Aug-01	Area B	1	< 5 tons	100+ m	slow	2.0	0	25	1.5	0	22
28	08-Aug-01	Area B	1	> 5 tons	26-50 m	slow	2.0	0	25	2.0	0	25
29	10-Aug-01	Area B	2	< 5 tons	0-25 m	fast	2.0	0	5	2.0	5	7
30	10-Aug-01	Area B	kayak(s)	kayak	51-75 m	kayak	2.0	0	5	2.5	0	2
31	10-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	2.0	0	5	2.0	0	1
32	10-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	2.0	0	5	.	0	6
33	10-Aug-01	Area B	1	< 5 tons	26-50 m	slow	2.0	0	5	2.0	0	13
34	12-Aug-01	Area B	1	< 5 tons	51-75 m	slow	1.0	0	30	2.0	1	32
35	12-Aug-01	Area B	1	< 5 tons	26-50 m	medium	1.5	0	31	.	0	23
36	12-Aug-01	Area B	1	< 5 tons	0-25 m	slow	1.5	0	31	2.0	1	11
37	12-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.0	1	17	.	0	11
38	13-Aug-01	Area A	1	< 5 tons	51-75 m	slow	3.0	0	72	.	0	69
39	13-Aug-01	Area A	2	< 5 tons	0-25 m	slow	3.0	0	10	.	0	4
40	13-Aug-01	Area A	2	< 5 tons	0-25 m	slow	3.0	0	72	.	1	75
41	13-Aug-01	Area B	1	< 5 tons	0-25 m	slow	1.5	0	33	.	0	22
42	13-Aug-01	Area B	1	< 5 tons	0-25 m	slow	1.5	1	18	.	0	11
43	13-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	1.5	0	33	.	0	18
44	13-Aug-01	Area B	kayak(s)	kayak	0-25 m	kayak	1.5	1	18	.	0	10
45	13-Aug-01	Area A	1	< 5 tons	0-25 m	fast	3.0	0	10	.	0	6
46	13-Aug-01	Area A	1	< 5 tons	0-25 m	medium	1.5	0	65	.	3	65
47	13-Aug-01	Area B	1	< 5 tons	26-50 m	slow	1.5	1	18	.	0	19
48	13-Aug-01	Area B	1	< 5 tons	26-50 m	slow	2.0	0	28	.	0	19
49	13-Aug-01	Area A	1	< 5 tons	0-25 m	slow	.	0	78	.	10	67
50	13-Aug-01	Area B	1	< 5 tons	51-75 m	slow	2.0	0	23	.	0	22
51	13-Aug-01	Area B	1	< 5 tons	26-50 m	slow	1.5	1	18	.	0	9
52	13-Aug-01	Area B	1	< 5 tons	26-50 m	slow	2.0	0	16	.	0	22
53	13-Aug-01	Area B	1	< 5 tons	26-50 m	medium	2.0	0	21	.	0	7
54	16-Aug-01	Area A	1	< 5 tons	0-25 m	slow	2.0	0	24	.	0	30
55	16-Aug-01	Area A	1	< 5 tons	0-25 m	slow	2.0	0	98	.	0	64
56	16-Aug-01	Area B	1	< 5 tons	0-25 m	medium	2.0	0	54	.	0	37
57	16-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.0	0	20	.	0	29
58	16-Aug-01	Area A	kayak(s)	kayak	26-50 m	kayak	2.0	0	24	.	0	32
59	16-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.0	0	33	.	0	40

60	16-Aug-01	Area B	1	< 5 tons	26-50 m	slow	2.0	0	24	.	0	26
61	16-Aug-01	Area B	1	> 5 tons	26-50 m	medium	3.0	0	60	3.0	0	51
62	16-Aug-01	Area B	1	> 5 tons	26-50 m	medium	3.0	0	14	3.0	0	14
63	16-Aug-01	Area B	1	> 5 tons	76-100 m	medium	3.0	0	62	3.0	0	23
64	16-Aug-01	Area B	1	> 5 tons	51-75 m	medium	3.0	0	20	3.0	0	29
65	16-Aug-01	Area A	1	< 5 tons	0-25 m	slow	3.0	0	24	3.0	1	23
66	16-Aug-01	Area A	1	< 5 tons	26-50 m	medium	3.0	0	98	.	0	96
67	16-Aug-01	Area B	1	< 5 tons	0-25 m	fast	3.0	0	58	.	7	25
68	16-Aug-01	Area B	1	< 5 tons	0-25 m	slow	3.0	0	30	.	1	15
69	18-Aug-01	Area A	1	< 5 tons	0-25 m	slow	2.5	0	28	2.5	0	43
70	18-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.5	0	56	2.5	0	23
71	18-Aug-01	Area B	1	< 5 tons	0-25 m	slow	2.5	0	4	2.5	0	52
72	18-Aug-01	Area A	kayak(s)	kayak	0-25 m	kayak	2.5	0	39	3.0	2	30
73	18-Aug-01	Area A	kayak(s)	kayak	0-25 m	kayak	2.5	0	110	2.5	1	32
74	19-Aug-01	Area A	1	< 5 tons	0-25 m	slow	.	0	13	.	0	15
75	19-Aug-01	Area A	1	< 5 tons	26-50 m	slow	.	0	87	.	0	78
76	19-Aug-01	Area A	2	> 5 tons	0-25 m	slow	.	0	13	.	0	10
77	19-Aug-01	Area A	2	> 5 tons	26-50 m	slow	.	0	87	.	1	76
78	24-Aug-01	Area C	2	< 5 tons	0-25 m	slow	2.0	0	104	2.5	0	104
79	24-Aug-01	Area B	1	< 5 tons	51-75 m	slow	2.0	0	33	1.5	0	13
80	24-Aug-01	Area B	2	< 5 tons	51-75 m	slow	2.0	0	20	1.5	0	19
81	24-Aug-01	Area C	1	< 5 tons	26-50 m	slow	2.0	0	52	3.0	0	117
82	24-Aug-01	Area B	1	< 5 tons	26-50 m	fast	2.0	0	33	.	0	22
83	24-Aug-01	Area B	1	< 5 tons	26-50 m	fast	2.0	0	20	.	0	12
84	24-Aug-01	Area C	1	< 5 tons	0-25 m	slow	2.0	0	104	.	4	52
85	24-Aug-01	Area C	1	< 5 tons	76-100 m	medium	2.5	0	104	.	0	104
86	24-Aug-01	Area B	1	< 5 tons	0-25 m	fast	2.5	0	8	3.0	0	8
87	24-Aug-01	Area B	1	< 5 tons	26-50 m	medium	1.5	0	11	2.0	0	12
88	24-Aug-01	Area B	1	< 5 tons	51-75 m	medium	1.5	0	24	1.5	0	6
89	24-Aug-01	Area B	1	> 5 tons	26-50 m	slow	1.5	0	24	.	0	30
90	24-Aug-01	Area B	1	> 5 tons	26-50 m	•	1.5	0	11	.	0	7
91	24-Aug-01	Area B	1	< 5 tons	26-50 m	fast	1.5	0	19	.	0	20
92	25-Aug-01	Area C	1	< 5 tons	0-25 m	fast	2.5	0	146	.	9	60
93	25-Aug-01	Area B	kayak(s)	kayak	26-50 m	kayak	2.0	0	14	.	0	5

94	25-Aug-01	Area B	kayak(s)	kayak	26-50 m	kayak	2.5	0	11	.	0	4
95	25-Aug-01	Area B	1	> 5 tons	26-50 m	medium	2.5	0	13	.	0	11
96	25-Aug-01	Area B	1	> 5 tons	26-50 m	medium	2.5	0	8	.	0	13
97	25-Aug-01	Area C	1	< 5 tons	0-25 m	slow	2.5	0	102	.	0	104
98	25-Aug-01	Area B	1	< 5 tons	0-25 m	medium	2.5	0	8	.	0	10
99	25-Aug-01	Area B	1	< 5 tons	0-25 m	medium	2.5	0	13	.	0	7
100	25-Aug-01	Area C	1	< 5 tons	0-25 m	slow	2.5	0	102	.	0	102
101	25-Aug-01	Area C	1	< 5 tons	26-50 m	slow	2.0	0	64	3.5	0	22
102	26-Aug-01	Area C	kayak(s)	kayak	100+ m	kayak	3.0	0	124	3.0	0	119
103	26-Aug-01	Area C	1	< 5 tons	26-50 m	slow	3.0	2	126	3.0	0	96
104	26-Aug-01	Area C	2	< 5 tons	26-50 m	*	3.0	0	98	.	1	32
105	27-Aug-01	Area C	1	< 5 tons	26-50 m	slow	3.0	0	56	.	0	56
106	29-Aug-01	Area C	1	< 5 tons	76-100 m	slow	3.0	0	125	3.0	1	85
107	29-Aug-01	Area C	2	< 5 tons	100+ m	slow	3.0	0	125	3.0	0	112
108	30-Aug-01	Area C	1	< 5 tons	0-25 m	fast	3.0	0	114	3.0	6	96
109	30-Aug-01	Area C	2	< 5 tons	0-25 m	fast	3.0	0	114	3.0	0	29
110	30-Aug-01	Area C	1	< 5 tons	26-50 m	slow	3.0	0	114	3.0	0	33
111	30-Aug-00	Area C	1	< 5 tons	0-25 m	slow	3.0	0	114	3.0	0	97
112	30-Aug-01	Area C	1	> 5 tons	100+ m	slow	3.0	0	53	3.0	0	72
113	30-Aug-01	Area C	1	< 5 tons	0-25 m	slow	3.0	0	114	.	0	94
114	31-Aug-01	Area C	1	> 5 tons	51-75 m	medium	3.0	0	102	.	0	110
115	31-Aug-01	Area C	1	< 5 tons	100+ m	medium	3.0	0	102	3.0	0	124
116	31-Aug-01	Area C	2	< 5 tons	0-25 m	fast	3.0	0	102	3.0	11	77
117	31-Aug-01	Area C	1	< 5 tons	0-25 m	medium	3.0	0	103	3.0	0	99
118	31-Aug-01	Area C	1	< 5 tons	100+ m	medium	3.0	0	68	.	0	27
119	02-Sep-01	Area C	2	< 5 tons	0-25 m	slow	3.0	0	76	3.0	6	9
120	02-Sep-01	Area C	2	< 5 tons	51-75 m	slow	3.0	0	76	3.0	0	92
121	02-Sep-01	Area C	1	< 5 tons	76-100 m	slow	3.0	0	84	.	0	42
122	02-Sep-01	Area C	kayak(s)	kayak	100+ m	kayak	3.0	0	72	3.0	0	40
123	05-Sep-01	Area C	1	> 5 tons	100+ m	medium	3.0	0	108	4.0	0	56
124	05-Sep-01	Area C	1	< 5 tons	0-25 m	slow	3.0	0	108	3.5	7	63
125	05-Sep-01	Area C	1	< 5 tons	0-25 m	slow	3.0	0	67	3.5	22	65
126	05-Sep-01	Area C	1	< 5 tons	100+ m	slow	3.0	1	82	3.0	0	52
127	05-Sep-01	Area C	1	< 5 tons	51-75 m	slow	3.0	0	58	3.0	0	50

128	05-Sep-01	Area C	1	< 5 tons	100+ m	medium	3.0	1	82	3.0	0	41
129	06-Sep-01	Area C	kayak(s)	kayak	51-75 m	kayak	2.5	0	139	.	0	124
130	06-Sep-01	Area C	kayak(s)	kayak	26-50 m	kayak	2.5	0	139	.	5	107
131	06-Sep-01	Area C	1	< 5 tons	0-25 m	fast	2.5	0	139	3.0	36	82
132	06-Sep-01	Area C	1	< 5 tons	0-25 m	medium	3.0	0	138	.	32	53
133	06-Sep-01	Area C	1	< 5 tons	0-25 m	medium	3.0	0	116	.	16	47
134	06-Sep-01	Area C	kayak(s)	kayak	0-25 m	kayak	3.0	0	116	.	45	50
135	09-Sep-01	Area C	2	< 5 tons	26-50 m	slow	2.5	0	115	3.0	0	7
136	09-Sep-01	Area C	2	< 5 tons	26-50 m	slow	2.5	0	52	3.0	0	38
137	09-Sep-01	Area C	1	< 5 tons	0-25 m	slow	2.5	0	39	3.0	1	43
138	09-Sep-01	Area C	1	< 5 tons	0-25 m	fast	2.5	0	78	3.0	48	55
139	09-Sep-01	Area C	1	< 5 tons	0-25 m	slow	2.5	0	54	3.0	0	25
140	12-Sep-01	Area D	kayak(s)	kayak	100+ m	kayak	3.0	0	189	3.0	0	45
141	12-Sep-01	Area D	1	< 5 tons	0-25 m	medium	3.0	0	88	3.0	0	63
142	12-Sep-01	Area D	kayak(s)	kayak	76-100 m	kayak	3.0	0	51	.	0	45
143	12-Sep-01	Area D	1	< 5 tons	0-25 m	medium	3.0	0	95	.	0	11
144	13-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.0	0	175	3.0	155	155
145	13-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.0	0	47	3.0	0	34
146	13-Sep-01	Area D	1	< 5 tons	0-25 m	medium	3.0	0	158	.	0	149
147	13-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.0	0	276	.	2	138
148	14-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.5	0	39	4.0	0	21
149	15-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.0	0	87	3.0	0	52
150	15-Sep-01	Area D	1	< 5 tons	0-25 m	medium	3.0	0	194	.	1	146
151	15-Sep-01	Area D	1	< 5 tons	0-25 m	medium	2.5	0	185	5.0	185	185
152	20-Sep-01	Area D	kayak(s)	kayak	100+ m	kayak	3.0	0	77	2.5	0	63
153	20-Sep-01	Area D	1	< 5 tons	0-25 m	fast	3.0	0	37	3.0	0	19
154	22-Sep-01	Area D	1	> 5 tons	0-25 m	slow	3.0	0	31	3.0	0	37
155	22-Sep-01	Area D	1	< 5 tons	0-25 m	fast	3.0	0	88	.	0	27
156	27-Sep-01	Area D	1	< 5 tons	0-25 m	slow	3.0	0	23	3.0	0	18
157	27-Sep-01	Area D	1	< 5 tons	0-25 m	slow	2.0	0	23	.	0	21
158	30-Sep-01	Area D	1	< 5 tons	0-25 m	slow	2.5	0	68	3.0	0	43
158	30-Sep-01	Area D	1	< 5 tons	0-25 m	fast	3.0	0	57	3.0	0	73
160	30-Sep-01	Area D	1	< 5 tons	0-25 m	medium	3.0	0	52	3.0	0	67