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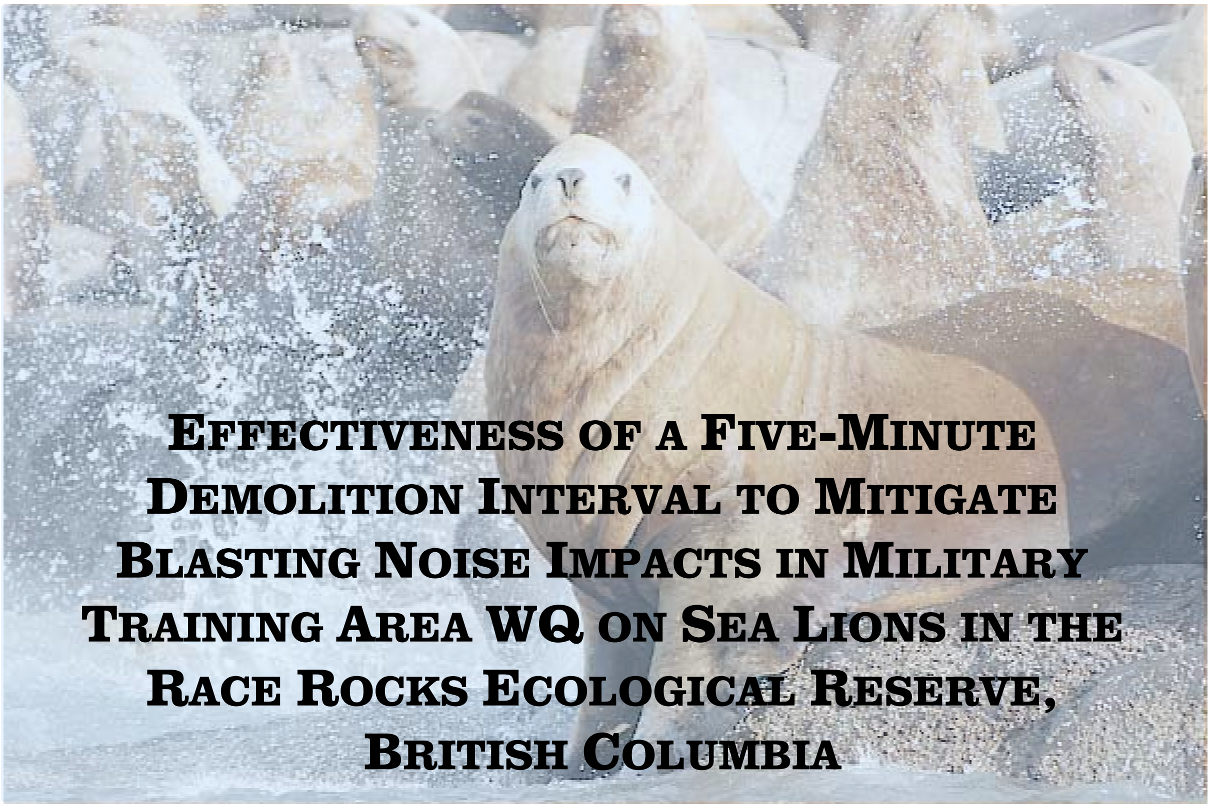

Effectiveness of a Five-Minute Demolition Interval to Mitigate Blasting Noise Impacts in Military Training Area WQ on Sea Lions in the Race Rocks Ecological Reserve, British Columbia

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EXECUTIVE SUMMARY

Noise from explosions at the Bentinck Island Demolition Range at Canadian Forces Ammunition Depot (CFAD) Rocky Point has the potential to disturb pinnipeds (seals and sea lions) hauled out in the Race Rocks Ecological Reserve (RRER). Such disturbance is prohibited by the *Marine Mammal Regulations* (MMRs) under the *Fisheries Act* and may be inconsistent with the conservation interests and economic goals of other stakeholders.

Previous research (Demarchi et al. 2008) suggested that by extending the interval between projects (demolitions) in a run by up to ~5 min, the probability of disturbing sea lions to the point of vacating a haulout was diminished. Accordingly, the objective of this research was to determine whether spacing projects within a run by at least 5 min amounted to an effective means of mitigating the adverse effects of disturbance on sea lions within RRER. Using observational methods consistent with previous DND-sponsored research by LGL Limited at Race Rocks, pinniped behaviour in RRER was monitored in response to demolitions on Bentinck Island during three training courses during autumn 2008 and 2009. Data collected since 2002 were included to bolster sample sizes, as appropriate.

Study results for Harbour seals and California sea lions are presented, but hypothesis testing focused on Steller sea lions due to a number of considerations, including their conservation status, abundance at RRER, and higher sensitivity to disturbance. A total of five hypotheses were tested. First, analyses confirmed that Steller sea lions are sensitive to disturbance and that blasting causes increased activity levels and movement off a haulout. Such movements appear to be short-term with little or no consequence for longer-term use of RRER by the species. Second, there was no indication that by spacing the first two blasts of the day a minimum of 5-min apart that the reaction of Steller sea lions was notably different than in cases where blasts were spaced closer in time. Third, the maximum displacement during any given day of blasting appeared to be independent of the minimum blasting interval during the day. Fourth, the difference in number of Steller sea lions hauled out at the end of the day as compared to the beginning of the day appeared to be independent of the minimum interval between blasts during the day. Finally, as expected, the responses of Steller sea lions to blast noise is related to noise level, with louder blasts tending to cause greater levels of disturbance. Despite the foregoing, the evidence to date suggests that it is doubtful that blasting is having adverse effects on the population of Steller sea lions that use RRER.

Assuming that demolition training in WQ is to continue, there are three remaining options to consider: seasonal timing windows for blasting, habituation of sea lions to blast noise, and range relocation to an alternate site on Bentinck Island or to the Whirl Bay Underwater Demolition Range. For reasons explained in the text, the Christopher Point Ordnance Disposal Range does not constitute an acceptable location regarding any attempts to mitigate blasting noise impacts on pinnipeds in RRER. Monitoring of the effectiveness of any alternate site at reducing sea lion disturbance should be conducted prior to any final decisions on range relocation.

The risk of pinniped disturbance in RRER will persist as long as explosives are detonated in WQ when pinnipeds are present. The key challenge is to achieve a balance between the needs of military training and sea lion conservation. As a species of *Special Concern* and on Schedule 1 of *SARA*, and considering the content of the existing and proposed *MMRs*, conservation concerns surrounding Steller sea lions are likely to remain constant or even grow in the future, regardless of whether or not population-level effects occur as a result of military operations in WQ. Options to address this situation are presented.

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Cover photo: Steller sea lions hauled out in Race Rocks Ecological Reserve, October 2009. Tim Edgell.

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ABBREVIATIONS

~	Approximately
asl	Above Sea Level
C4	C4 plastique is a white, plastic, high-explosive made of RDX (Royal Demolition Explosive; a.k.a. cyclonite or hexogen; chemical name, trinitrotriazine) and an inert plastic binder.
CASL	California sea lion
CFAD	Canadian Forces Ammunition Depot
CFB	Canadian Forces Base
cm	Centimetre
dB	Decibel (F – flat-weighted; A – A weighted; Leq – equivalent continuous noise level)
DFO	Department of Fisheries and Oceans [Canada]
DND	Department of National Defence [Canada]
ELSE	Northern Elephant Seal
GPS	Global Positioning System
ha	Hectare
HASE	Harbour Seal
kg	Kilogram
KIR	Key Indicator Resource
km	Kilometre
m	Metre
min	Minute
mm	Millimetre
MMRs	Marine Mammal Regulations
N	North
NE	Northeast
NNE	North by Northeast
NNW	North by Northwest
PST	Pacific Standard Time
PWGSC	Public Works and Government Services Canada
RRER	Race Rocks Ecological Reserve
RSOs	Range Standing Orders
s	Second
SARA	Species At Risk Act
SD	Standard Deviation
sec	Second
SSE	South by Southeast
STSL	Steller Sea Lion
WQ	[Military Training Area] Whiskey Quebec

1. INTRODUCTION

Race Rocks Ecological Reserve (RRER) is a small island group off the southernmost point of Vancouver Island. It is a provincial ecological reserve and has been proposed as a federal marine protected area. The area supports a diversity of marine algae, invertebrates, fish, birds, and mammals. Marine birds occur there throughout the year, and use the area for breeding, foraging, and roosting. Pinnipeds (seals and sea lions) are the largest and most charismatic inhabitants of Race Rocks. They are the focus of this study which explores the relationship between DND training activities and disturbances to the local pinniped population.

Harbour seals are present year-round in RRER. They haul out on the exposed rocks and also give birth there. Adjacent waters provide foraging opportunities. Northern elephant seals, California sea lions, and Steller sea lions (also referred to as northern sea lions) also haul out in RRER and forage in nearby waters, but unlike harbour seals, these larger pinnipeds breed elsewhere[1]. Haulouts are important components of sea lion habitat, with juveniles typically spending >20 hours per day on a haulout during autumn (Pitcher et al. 2005). Killer whales transit the area intermittently, sometimes hunting pinnipeds.

A major portion of RRER is contained within the Department of National Defence (DND) Military Training Area WQ (Whiskey Quebec); however, no training activities actually occur within RRER boundary. The effects of the demolition training and ordnance disposal activities in WQ were studied by LGL Limited in 1997 and 1998 (Demarchi et al. 1998), 2002 and 2003 (Demarchi and Bentley 2004), 2007 (Demarchi et al. 2008), and 2008 (Demarchi (2009). That research has shown that DND training exercises involving detonation of high explosives on Bentinck Island and on Christopher Point elicited variable responses from seals and sea lions hauled out in RRER. Reactions to blasting included no response, short-term increases in animal activity, or stampedes to the water while abandoning the haulout. Steller sea lions are particularly prone to disturbance, insomuch that individuals were frequently displaced from their haulouts by such events. However, the fact that these animals typically return to the haulout shortly after the disturbance suggests they are resilient to disturbance, and provides compelling evidence that DND blasting does not exclude them from RRER. Although some non-military factors were found to elicit similar disturbance responses (Demarchi and Bentley 2004), the effects of military actions were the primary focus of research by LGL Limited.

Group-living confers certain benefits to sea lions in that vigilance duties can be shared. In the event that a threat is present, not all animals need to detect it before responding. Rather, it only takes one or two animals to react strongly; their actions are sufficient to initiate a stampede that rapidly spreads through the group, especially if they physically contact or displace others when moving to the water (see “Inherent Sensitivity” in Figure 7 in Demarchi [2009]). And while slow-motion video confirms that most, if not all, animals hear the blasts on Bentinck Island and raise their heads in near unison, I hypothesize that the net displacement response of all animals is likely indicative of the disturbance thresholds of the more sensitive members of the group. In other words, when one individual rushes towards the water, others (that might not have otherwise gone to the water) will likely follow. Demarchi (2009) summarized factors that, acting alone or

[1] Note that the first two records of northern elephant seal pupping in RRER were recorded in early 2009 and another in January 2010 (http://www.racerocks.com/racerock/eco/taxalab/miroungaa/newborn/jan3009.htm)

in combination, could result in sea lion disturbance. Several researchers have commented on the sensitive nature of this species, documenting haulout temporary abandonment by Steller sea lions for reasons both known and unknown (e.g., Porter 1997; Demarchi and Bentley 2004; Kucey 2005).

Pinniped responses to disturbance at Race Rocks are most likely the result of learning experiences elsewhere or simply the result of reactions to loud noises or sudden changes in the environment. For example, several decades ago seals and sea lions were hunted extensively under government-sanctioned culls aimed at reducing perceived conflicts with commercial fisheries. Outside RRER, pinnipeds continue to be shot and shot at with rifles during First Nation subsistence hunts, animal control at aquaculture facilities (see Hume 2000), and as perceived pests and competitors by commercial fishermen. Because high-powered rifles produce an impulsive noise with similar acoustic properties as detonations in WQ, it is possible that sea lions associate blast noise with the threat of being shot. This could explain their taking refuge in the water in response to blast noise.

Prior to 2008, one or more local members of the Pacific Whale Watch Association (formerly Whale Watch Operator's Association Northwest)[2] filed complaints with Canadian Forces Base (CFB) Esquimalt about detonations at Bentinck Island. Complaints focused on potential revenue loss should pinnipeds – a major tourist attraction – be displaced from Race Rocks because of persistent noise disturbances. In the operators' view, noise disturbance by DND blasting causes pinnipeds to leave haulouts in RRER, thus reducing marine mammal viewing opportunities for clients and negatively affecting revenue potential.

At the same time, the Department of Fisheries and Oceans (DFO) has expressed concerns to DND about military actions that disturb seals and sea lions; such disturbance is prohibited by the *Fisheries Act* and its associated *Marine Mammal Regulations* (*MMRs*). The existing *MMRs* prohibit the disturbance of marine mammals (cetaceans, pinnipeds, sea otter, polar bear). However, DFO felt that the regulations were too general and did not inform the public about behaviours that are unacceptable when viewing marine mammals in their natural environment. Consequently, beginning around 2002, a process to revise the *MMRs* was undertaken by DFO to address a number of concerns related to human-marine mammal interactions. Section 8 of the draft *MMRs*[3] is of particular relevance to the situation discussed herein:

> *8. (1) Notwithstanding any provision of these regulations, subject to Part VI, no person shall disturb a marine mammal or disrupt the normal life processes of a marine mammal.*

As with the existing *MMRs*, Part VI of the draft *MMRs* contains a provision for contravening Section 8 the regulations:

> *48. The Minister may issue a licence authorizing the disturbance of a marine mammal or the disruption of the normal life processes of a marine mammal provided that:*

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2 http://pacificwhalewatch.org/

3 http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/marinemammals/mmr-update_e.htm

(a) all reasonable alternatives to the activity that would reduce the impact on the marine mammal have been considered and the best solution has been adopted; and

(b) all feasible measures will be taken to minimize the impact of the activity on the marine mammal.

Military training exercises in WQ continue in compliance with CFB Esquimalt Range Standing Orders (RSOs; summarized in Appendix I of Demarchi and Holst 2008). Nonetheless, DND commissioned a study to investigate ways to lessen the (real and perceived) impacts of military demolition training exercises on marine mammals at RRER and the local ecotourism industry (Demarchi and Holst 2008). Such an effort is consistent with gaining a scientific understanding of the situation as it pertains to Sections 48 (a) and (b) of the draft *MMRs*.

This report presents the results of a pinniped monitoring project that ran concurrently with DND demolition trials, as per recommendations in Demarchi et al. (2008) pertaining to the time interval between projects (blasts) in a run during 2008 and 2009. It builds upon Demarchi (2009) and where appropriate, includes data from monitoring sessions in 2002 through 2007.

2. STUDY GOAL & OBJECTIVES

The goal of this research program, described by Demarchi and Holst (2008), is to identify practical means of mitigating the impacts of military demolition training on pinnipeds (namely Steller sea lions) hauled out in the RRER. Demarchi et al. (2008) demonstrated that spacing demolitions by intervals of 5 min or more, instead of 30 sec (as per current RSOs), showed potential to reduce the probability of sea lions moving from a haulout into the water. They also showed that demolitions at an alternate location on Bentinck Island resulted in reduced noise propagation toward RRER, thereby reducing the magnitude of pinniped disturbance. Consequently an attempt was made in 2008 (Demarchi 2009) to assess the efficacy of 5-min spacing as mitigation. In 2008, only two autumn training sessions on Bentinck Island were completed, limiting the sample size available for behaviour analyses. Further testing of the 5-min interval was conducted in 2009.

The objective of the present study was to assess the effectiveness of a minimum 5-min interval between projects detonated at the main demolition site on Bentinck Island as a means of mitigating the adverse behavioural effects of blasting noise on pinnipeds (namely Steller sea lions) in RRER. If successful, such mitigation would help to justify continued training activities on the existing demolition area of Bentinck Island. Among other possible constraints, having to move the demolition range to an alternate site would entail costs associated with range permitting and development.

Although harbour seals and California sea lions were also studied, Steller sea lions were selected as the key indicator resource (KIR), and subjected to additional analyses, for several reasons:

- The *Species at Risk Act* designation of the Steller sea lion is Schedule 1, *Special Concern* (all other pinnipeds in the study area are designated *Not at Risk*). It is presently the subject of a draft management plan (Fisheries and Oceans Canada 2008);

- It is the only species of pinniped for which RRER might be considered critical habitat (according to the definition of critical habitat in the *Species at Risk Act*) (Demarchi and Bentley 2004);
- Steller sea lion is the most sensitive pinniped to disturbance in RRER (Demarchi and Bentley 2004);
- The monitoring databases for this species are most amenable to analyses, having the largest sample sizes due to the species' abundance and duration of seasonal presence in RRER; and,
- Steller sea lion abundance in RRER is not as strongly confounded by tide height and sea state as is the abundance of other pinnipeds (e.g., harbour seal).

This research involved testing a number of hypotheses regarding the interactions between blast noise and sea lion disturbance.

Hypothesis 1. Irrespective of project interval, blasting on Bentinck Island displaces sea lions.

***Rationale**: Although blast-induced effects on sea lions at RRER have been well documented by past LGL research and form the basis of this entire project, the current project provides an opportunity to examine the situation using a larger dataset.*

To be considered an effective mitigation when it comes to addressing potential impacts on Steller sea lions, the minimum 5-min spacing should yield conclusive evidence consistent with following hypotheses:

Hypothesis 2. For those days when the time interval between the first two blasts (i.e., projects) within the first run[4] of the day is a minimum of ~5 min, the second blast of the day should result in a lesser proportion of Steller sea lions moving to the water from monitored haulouts than on days when the interval between blasts (projects) is less (e.g., < 2 min).

***Rationale**: All other things being equal, the first two blasts of the day should provide the best opportunity to measure the effects of blast interval on resting individuals. This is because observations associated with the first two blasts have lowest potential to reflect any short-term effects of habituation to prior blast noise, and because the biasing effects of previous blasts on animal abundance on a haulout are minimized (see point 3 of §4.2). Differences in displacement as a function of blast interval would be potentially indicative of mitigative effects.*

Hypothesis 3. For those days when the time interval between blasts (i.e., projects) within a run is a minimum of ~5 min, the maximum value of the proportion of Steller sea lions on monitored haulouts that are displaced to the water by blast noise should be lower on days when the interval between projects is consistently shorter (e.g., ≤2 min).

[4] See §3.1 for a description of "runs" and "projects".

***Rationale**: In the event that Hypothesis 2 is true, reduced maximum displacement following all runs on a given day when a minimum 5-min project interval is applied would constitute further evidence of the effectiveness of the minimum 5-min interval.*

Hypothesis 4. The difference between a) the number of Steller sea lions in RRER at the end of a day of blasting with minimum 5-min intervals between projects and b) the number at the beginning of such days (i.e., afternoon census total minus morning census total) should be notably less than the difference observed on days when the interval between projects is shorter (e.g., ≤2 min).

***Rationale**: Analyses conducted under Hypothesis 2 and Hypothesis 3 address localized displacement from selected haulouts in RRER. Past research by LGL Limited shows that many displaced animals typically return to their former haulout or haul-out elsewhere in RRER within minutes or hours after the disturbance. If a longer blast interval reduces disturbance by displacing fewer animals and allowing a quicker return to a haulout for those animals that are displaced, counts (census) of all animals in RRER should reflect this.*

The final hypothesis examined in this study pertains to the relation between blast noise level and sea lion disturbance.

Hypothesis 5. Above some undefined threshold, higher (louder) levels of blast noise are expected to cause higher levels of disturbance (e.g., as measured by displacement from a haulout).

***Rationale**: Pinnipeds cannot respond to that which they do no perceive. As blast noise rises from lower levels, closer to ambient (background) conditions, to the highest levels associated with blasting in WQ, animal behaviour could be expected to pass along a continuum from little to no reaction, through to complete haulout abandonment over the short term.*

3. STUDY AREA

3.1 Military Training and Exercise Area WQ

CFB Esquimalt conducts military explosives training in Marine Training and Exercise Area WQ (Figure 1). WQ is near Rocky Point on southern Vancouver Island, British Columbia, and is owned by the Federal Government (DND). WQ encompasses 1075 ha of terrestrial and marine environment, including a portion of RRER. No military training occurs within RRER.

Two ranges within WQ are used for ordnance-based demolitions training: the Whirl Bay Underwater Demolition Range, and the Bentinck Island Demolition Range (Figure 1). Surplus and outdated ordnance is disposed (detonated) at WQ by Canadian Forces Ammunition Depot (CFAD) Rocky Point, at the Christopher Point Ordnance Disposal Range. Training activities at WQ are controlled by Base Operations, CFB, Esquimalt, and must be conducted in accordance with the CFB Esquimalt Range Standing Orders (RSOs). Ordnance disposal activities are overseen by CFAD Rocky Point.

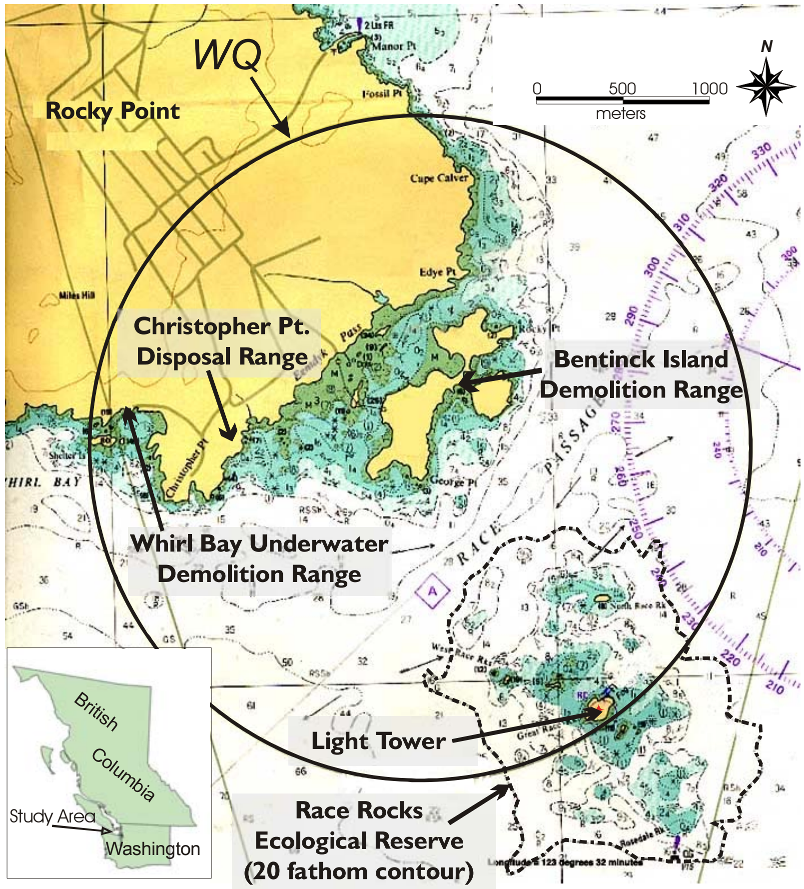

Figure 1. Map of southern Vancouver Island and vicinity, showing Rocky Point, Race Rocks Ecological Reserve (bounded by the 20-fathom contour), and Military Training Area WQ (circle). General locations of standard demolition training and ordnance disposal sites are indicated.

Bentinck Island (31 ha) comprises three forested lobes connected by sandy isthmuses. The forests consist of mature stands of Douglas fir, arbutus, and shore pine. The central isthmus region, which is also the main demolition site, consists of three low-lying and connected banks of sand and pebble (Figure 2). Bentinck Island is separated from Rocky Point by Eemdyk Passage – a shallow channel that supports an abundance of macroalgae, including ecologically important species like bull kelp and eelgrass. Harbour seals seem to be the only pinniped to use Eemdyk Passage and killer whales have been observed transiting the area (pers. obs.). Bentinck Island is separated from RRER by Race Passage.

The Bentinck Island Demolition Range is used primarily by Canadian Forces Fleet School (Seamanship Division) for above-water beach-clearing and obstacle-creation exercises, usually involving metal cutting and the displacement and demolition of rocks and logs. The range is used for ~12 training courses per year, each spanning 1–4 days. During a course, the range is active from 08:00 to ~15:00 although 1–2 nighttime training sessions may be conducted annually. That range is licensed for a maximum individual charge size of 4 slabs[5] (2.3 kg) of C4 (Appendix I of Demarchi and Holst 2008). A typical demolition (a.k.a. project) – used to cut

[5] one slab of C4 weighs 0.56 kg

timber, steel, or clear obstacles from beaches – consists of 1–4 slabs of C4. Two to three projects are usually set up (but not detonated) simultaneously by one or more training groups; such a project queue is called a run. A typical range day involves 2–4 runs of 1–3 projects (i.e., 4–12 blasts in total). Prior to 1998, there was no minimum time interval between projects of a run. From 1998 to 2004, projects in the same run were detonated at a minimum interval of 2 min in an attempt to mitigate disturbance to pinnipeds on Race Rocks. RSOs have since been revised, requiring a minimum interval of 30 sec between projects. Despite this, during autumn 2008 and 2009, range personnel were instructed to space projects within a run a minimum of 5 min apart.

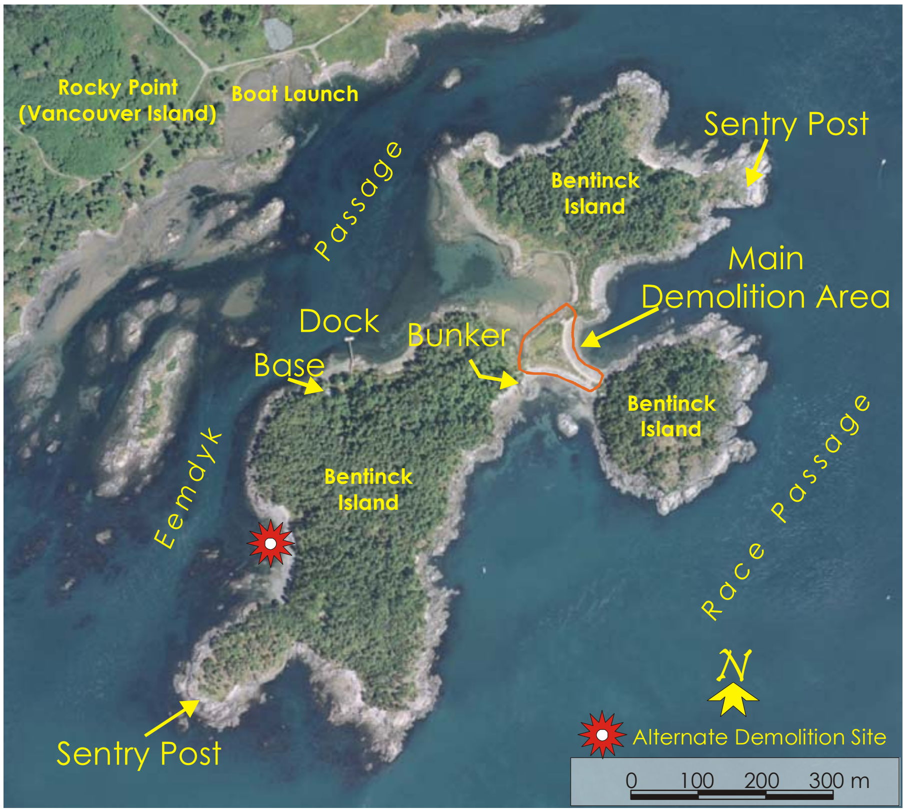

Figure 2. Aerial photo (taken in 2005) of Bentinck Island. Locations of key features relevant to demolition training exercises are shown. Only the main demolition area was used during monitoring in 2008 and 2009. The alternate site was tested in 2007 (Demarchi et al. 2008). Source of photo: Capital Regional District Natural Areas Atlas (http://www.crd.bc.ca/es/natatlas/atlas.htm).

Projects are detonated by non-electric (fuse) and electric (wire) means. The first project in a run is typically "non-electric", with the length of the fuse (of a known burn rate – usually specified as seconds per foot) calculated to allow for adequate time for all personnel to retreat to the bunker. Subsequent charges are usually "electric" and have none of the time limitations on the spacing (time) between detonations as is the case for non-electric detonations. Thus, there is considerable flexibility in the timing between projects. Tamping (sand-filled polypropylene sacks) is sometimes used to help confine the explosion and possibly reduce blast noise (PO1 McEvoy pers. comm. 2007). Demolition training is conducted on the central beaches of Bentinck Island. Some project locations have a direct line-of-sight to most of RRER, while others are not line-of-sight – being blocked to a modest degree by beach and island topography.

The nearest haulout used by seals and sea lions in RRER is ~1.2 km from the blasting site (see Appendix I of Demarchi et al. 2009). We observed pinnipeds from the top of the light tower on Great Race Rock.

Surplus ordnance is disposed by way of high-order[6] detonation at the Christopher Point Ordnance Disposal Range (Figure 1). Disposal activities are conducted on an as-required basis, and unlike the other ranges in WQ, activities on the Christopher Point Ordnance Disposal Range are not tied to training schedules. Under federal authorization, the disposal area is licensed for a maximum single explosive charge size of 13.6 kg. Twelve such charges are permitted per day. However, as a means of mitigating public concerns about blast noise, a voluntary reduction[7] in maximum charge size to 6.8 kg was adopted in 1987 (Explosives Safety Officer [ESO] A. Carter, pers. comm. 1997). Use of the range varies greatly among years, but anywhere from one to 12 high-order detonations on up to 25 days (7%) of the year is a reasonable approximation (ESO A. Carter, pers. comm. 1997). The disposal site is situated in a mowed clearing. The range has a line-of-sight to Race Rocks. The nearest haulout used by seals and sea lions in RRER is ~2.0 km away.

3.2 Race Rocks Ecological Reserve

The pinniped study area comprises the exposed portion of RRER, adjacent to Rocky Point on southern Vancouver Island (Figure 1). RRER is provincial Crown land and is defined as the seabed and exposed land within the 20-fathom depth contour. Race Rocks is a complex composed of one island (Great Race Rock; 1.48 ha; Figure 3) and a number of smaller islets and reefs. Terrestrial vegetation occurs only on Great Race Rock, and consists of grasses and small forbs of both native and exotic origin. Lester B. Pearson College of the Pacific (LBPC) operates several provincially owned buildings, including an ecoguardian (caretaker) residence, guest house, boat shed, tank room, crane shed, and diesel generator shed. Ancillary equipment operated by LBPC includes a concrete boat dock and launch, fixed crane, fuel pumping equipment, and diesel tanks. The Canadian Coast Guard leases a concrete helipad, light tower, and support infrastructure located on Great Race Rock. Great Race Rock was added to RRER in 2001.

RRER is near the eastern end of central Juan de Fuca Strait[8]. It is in the Nanaimo Lowland Ecosection of the Eastern Vancouver Island Ecoregion of the Georgia Depression Ecoprovince (Demarchi et al. 1990). The climate of the study area is mild, being moderated by the Pacific Ocean. Tides are semidiurnal[9] with strong diurnal inequality, meaning that there is a considerable difference between the heights of successive low and high tides, respectively. In winter, the highest tides typically occur during day, while the opposite is true during summer. As reported by Demarchi and Bentley (2004), predicted values ranged from -0.11 to 3.06 m at William Head (located ~4.5 km north of Race Rocks) (Hopper 2002). Tidal flow through Race Passage can reach 7 knots.

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[6] That is, they are exploded rather than disposed of by non-explosive means.

[7] Some larger charges, such as the Mark-7 anti-tank mines (each containing 8.6 kg of TNT) are occasionally detonated.

[8] http://www.weatheroffice.gc.ca/marine/region_e.html?mapID=03

[9] Having typically two high and two low values every 24 hours.

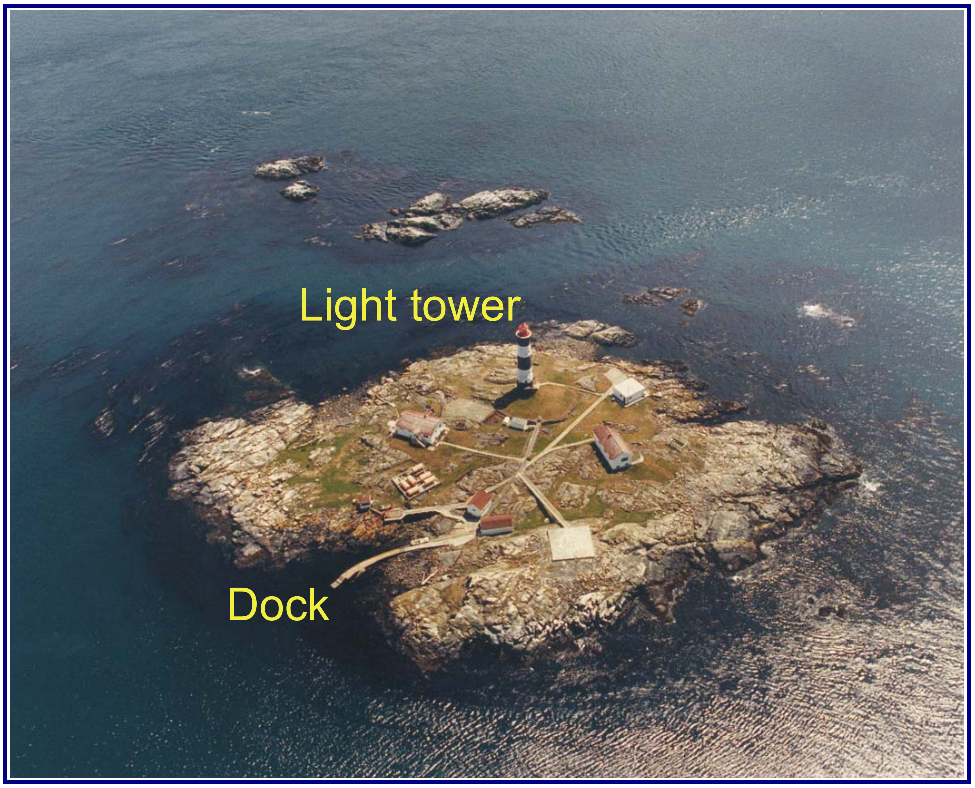

Figure 3. Aerial photo of Great Race Rock as viewed from the northwest. Observations during this study were made from atop the light tower. Photo by Heath Moffat; used with permission from Lester B. Pearson College.

Sea lion abundance in RRER typically peaks during autumn. Over 1300 have been observed on in RRER at one time, where they crowd together on haulouts – often with no space between individuals (Photo 1). Hauling out on non-rookery haulouts confers a number of benefits to sea lions including rest; decreased risk of predation by killer whales and sharks; and opportunities for nursing, grooming, and social interactions. Some basic information on sea lions is presented below. Further information on the biophysical features of RRER can be found in Wright and Pringle (2001), Province of B.C. (2002), and Demarchi and Bentley (2004).

Steller Sea Lion

The Steller sea lion (Photo 2) is a member of family Otariidae (eared seals). The breeding range of this species is from California, along the Pacific coast to Alaska and northeast Asia. Two stocks are recognized: the Western Stock that ranges from Russia to the Gulf of Alaska; and an Eastern Stock that ranges from southeast Alaska to California. In B.C. between 1912 and 1968, thousands of Steller sea lions were killed in a campaign to reduce the perceived conflict between this species and commercial fishermen. A review of historic data (Bigg 1988b) indicated that control programs and commercial harvests conducted in B.C. during 1912–1967 eradicated one breeding area and reduced numbers on the remaining rookeries to about 25–30% of peak levels observed in the early 20th century, prior to any large-scale culls. Numbers of Steller sea lions on Race Rocks appear to have rebounded since the control program ended (Bigg 1988b). Presently there is considerable concern about conservation of the western stock because of a dramatic, unexplained decline beginning around 1970 (Trites and Donnelly 2003). Conversely, the Eastern

Stock (the one which occurs at Race Rocks) has exhibited a modest increase during this period (Bigg 1988a; Calkins et al. 1999). Despite this increase, in November 2003 COSEWIC upgraded this species' listing from "Not at Risk" to "Special Concern" for several reasons: there are only three breeding locations in B.C., the species is sensitive to human disturbance while on land, the threat of acute oil spills, and unexplained declines in other populations to the north and west of B.C.

Photo 1. Two examples of sea lions hauled out (no disturbance) in the RRER. Top: Steller sea lions hauled out in Area 2–5, 20 November 2003. Bottom: Mixed group of adult male California and Steller sea lions hauled out in Area B, 16 October 2009.

The closest rookery to RRER is on the Scott Islands off northern Vancouver Island (Bigg 1988b; Loughlin et al. 1984). Steller sea lions migrate into the study area where they spend a considerable amount of time hauled-out. Bigg (1988b) identified RRER as a haulout site used by Steller sea lions during their nonbreeding season, with peak abundance occurring during September through May. All sexes and age-classes of Steller sea lions occur there.

Photo 2. Subadult male Steller sea lion hauled-out on Great Race Rock. October 2009.

California Sea Lion

The California sea lion (Photo 3) is a member of the eared seal family, Otariidae. California sea lions move north into the study area from breeding colonies in Mexico and California after each summer breeding season, then return south in the late winter and spring. Peak abundance in B.C. is between September and May. Most of the animals in B.C. are adult and subadult males but females are known to occur. The number of California sea lions using B.C. coastal waters has increased substantially during the last century, and in particular, since 1980 (Bigg 1988a). Bigg (1988a) reported that California sea lions were not present on Race Rocks prior to 1965. Records from 1971 (summarized in Bigg 1988a) indicate a maximum of ~30 animals at Race Rocks. Since then, numbers have increased to several hundred animals at times.

In recent years there has been a continued northward expansion of the species on both the east and west coasts of Vancouver Island (P. Olesiuk, pers. comm. 2002). A few radio tags deployed on California sea lions in the early 1990s revealed that while in B.C. waters, California sea lions are very mobile and do not remain in the same area (haulout) for extended periods (P. Olesiuk pers. comm. 2002). In B.C., California sea lions appear to readily and rapidly shift their distributions in response to the movements of their main prey, salmon and herring (P. Olesiuk pers. comm. 2002). A northward shift in schools of adult herring during the mid-winter pre-spawning period has resulted in a concomitant shift in California sea lions. For example, they no longer occur in the same abundance at Harmac (near Nanaimo) as in the past, but greater numbers are now seen near Hornby Island to the north (P. Olesiuk pers. comm. 2002). During late 2009, California sea lions were notably absent from the waterfront of San Francisco[10]. It is

[10] http://news.bbc.co.uk/2/hi/americas/8438215.stm

likely that they left the area in search of prey. Large numbers of California sea lions were later spotted off the coast of Oregon, and it is possible that the large numbers reported in this study during 2009 were a result of that northward migration.

Photo 3. Adult male California sea lion hauled-out on Great Race Rock. The vast majority of California sea lions at Race Rocks are adult and subadult males. October 2009.

4. METHODOLOGY

4.1 Data Collection and Analyses

Monitoring sessions were conducted in 2008 and 2009 (Table 1) to test the effectiveness of a minimum 5-min blasting interval as a means of reducing pinniped disturbance (a detailed summary of all detonations monitored since 2002 is provided in Appendix I). Methodology was consistent with that used in previous studies: 1997 and 1998 (Demarchi et al. 1998), 2002 and 2003 (Demarchi and Bentley 2004), 2007 (Demarchi et al. 2008), and 2008 (Demarchi 2009). The focus of the study was demolitions on Bentinck Island, but detonations on Christopher Point were also monitored for three reasons: a) because of their similar potential to disturb pinnipeds, b) as a means of bolstering sample sizes for data analyses, and c) to assess the potential for the Christopher Point Ordnance Disposal Range to be used as an alternate training range in the event of a decision to close the Bentinck Island Demolition Range for all or part of the year. For monitoring associated with Bentinck Island activities, the first day in each monitoring session during 2008–09, referred to as "Pre-Bentinck monitoring", provided a measure of baseline conditions prior to demolition exercises. With one exception (11 September 2009), the last day of each monitoring session, referred to as "Post-Bentinck monitoring", provided an indication of animal abundance and behaviour 1 day after the Bentinck Island range was last active. During the late-summer and autumn periods of 2008–09, with the exception of the 12 September night shoot, monitoring occurred on all days when the Bentinck Island range was active. Those days are referred to as "Bentinck monitoring". Monitoring sessions conducted more than 1 day in advance of active training are referred to as ">1 Pre-Bentinck monitoring".

Table 1. Dates of monitoring sessions and dates within each session when detonations occurred on training ranges in WQ in 2008 and 2009. The minimum time (minutes) between any two projects (or detonations) is indicated. Monitoring days with no detonations and prior to active range days are referred to as Pre-Bentinck monitoring days; monitoring days with no detonations that occur after 1 or more active range days are referred to as Post-Bentinck monitoring days. For information on individual charges (e.g., size and time), refer to Appendix I.

Monitoring Session	Active Range and Date(s)	Minimum Daily Interval (min)	Comments
11–13 September 2008	Bentinck Island (12)	-	Night shoot; 1 detonation
21–24 October 2008	Bentinck Island (22,23)	5	
3–7 November 2008	Bentinck Island (4–6)	5	
4, 9–11 September 2009	Bentinck Island (10–11)	5–7	
1–3 October 2009	Bentinck Island (2)	5	
7–9 October 2009	Bentinck Island (8)	6	
13,15,16 October 2009	Bentinck Island (15)	54	
27,28 October 2009	Christopher Point (27,28)	2	Ordnance Disposal
16,17 November 2009	Christopher Point (16,17)	1–2	Ordnance Disposal
29,30 November, 1,2 December 2009	Bentinck Island (30,1)	5	
13–18 December 2009	Bentinck Island (14–17)	5–16	

Most observations were opportunistic. Although the project observers on Great Race Rock were in radio contact with DND personnel on Bentinck Island, the observers did not dictate charge size or interval except for some trials in 2007 (see Demarchi et al. 2008). While all detonations on Bentinck Island were never < 5 min apart in 2008–09, some detonations prior to 2008 and those on Christopher Point did occur at shorter intervals. Such data were used as a basis of comparing the effectiveness of a 5-min interval at reducing pinniped disturbance.

Travel between Rocky Point/Pedder Bay and Race Rocks was by inflatable boat. Observations were made from atop the Great Race Rock light tower (except on two occasions, noted below), and only pinnipeds within the ER boundary were documented. Because the September 2008 training was a night shoot and the single detonation occurred after the observers had departed for the day, we used real-time images from the LBPC remote-controlled webcam[11] to document and gauge pinniped responses to that blast. On 6 November 2008, the third day of a demolition training course on Bentinck Island, gale-force winds prevented travel to Race Rocks. Pinniped observations that day were made from the bunker on Bentinck Island with binoculars (8x) and a tripod-mounted spotting scope (15–45x).

Two biologists recorded data for four different Microsoft Access 2002 databases using paper dataforms and a hand-held Compaq iPAQ computer running Visual CE v6.1. Digital photographs were taken regularly throughout the monitoring sessions. Some digital videos were

[11] www.racerocks.com

also taken. Digital sound recordings of most blasts in 2009 were obtained to allow for examination of the relation between noise level and the magnitude of sea lion disturbance. The purpose of this monitoring was not to conduct an intensive assessment of blast noise levels and animal responses, but rather to provide a general indication of the potential effects of noise level on animal response. Recordings were made using a Zoom H2 (120GL) Handy Recorder. Settings were: moderate gain, no autogain, no low pass cutoff, 100 sensitivity, front microphone (90 degrees) only, stereo to mono processing, 44.1 kHz sampling rate, and WAV (uncompressed) file format. A foam wind screen and a rain cover (Ziploc bag) were placed over the unit. The unit was mounted on a short tripod and placed outside on the walkway atop the light tower on Great Race Rock. The clocks on all digital equipment were synchronized. Additional information about data collection is presented in Appendix II.

The project databases were maintained in MS Access. Summary outputs, using structured queries, were imported to MS Excel and SYSTAT 12 for graphical and analytical purposes. ANOVA, two-sample t-tests (assuming unequal variance), and Tukey HSD tests were run to determine statistical differences among and between means. Levene's test was used to examine homogeneity of variance. Spearman's rho was used to test for correlations involving ranked data. Sample values confined between 0–100% were arcsine transformed. Some sample values were averaged during the course of a day because they are more appropriate statistical testing than individual values obtained from repeated observations of the same animals on the same day.

Sound levels of individual blasts were ranked from highest to lowest using a subjective rating system that involved listening to each blast (using standardize audio settings) as well as examining the visual features (peak-to-peak levels, duration) of the waveform in the audio program Audacity (ver 1.2.4). Ranked levels were then evenly split into five bins.

Data were collected and assembled into four discrete, but related (linkable), databases:

Database 1: Environmental Conditions – Wind speed in knots and direction in degrees off true north were measured at the top of the light tower using on-site meteorological equipment operated by the Coast Guard. Air temperature was measured with a thermometer located in the shade atop the tower. Other parameters were estimated visually. Because animal responses to disturbance may vary with time of day, cloud cover, wind speed, wind direction, wave height, swell condition, and tide height, environmental parameters were measured in the morning and at the end of the day, and whenever notable changes in conditions occurred throughout the day. Tidal data were obtained for Pedder Bay (~6 km northwest of RRER) from Fisheries and Oceans website[12] and for William Head (~4.5 km north of RRER) using the computer program WXtide32 v2.7 (Hopper 2002).

Database 2: Counts of bird and pinniped species in the study area – These data provided information about daily changes in the number of animals[13] using the study area. A census of birds and pinnipeds was conducted twice daily (morning and afternoon). Morning counts occurred prior to any blasting and whenever possible, afternoon counts typically occurred ≥1 hour after the last blast of the day. That lag provided some time for disturbed animals to return to a haulout. Only animals that were supported by terrestrial features (i.e., islands, islets, rocks,

[12] http://www.waterlevels.gc.ca/cgi-bin/tide-shc.cgi?queryType=showZone&language=english&region=1&zone=9

[13] Only pinniped data are reported here.

man-made structures, etc.) within one of the sub-areas (see Demarchi and Bentley 2004) were counted because of the difficulties in seeing animals in the water or counting birds in the air. Further, only animals visible from the tower were counted except where otherwise noted. In the past, some animals were hidden from view, but in our opinion and based on our familiarity with the area, the vast majority (>90%) of individuals were visible from the tower. For the first time since monitoring began in 1997, in 2008 notable numbers of pinnipeds were observed using the north side of Area 13, out of view from the tower. The number of sea lions using that area was therefore estimated during morning and afternoon boat trips to and from RRER, respectively. Such conditions did not occur in 2009. Crowding may have also biased the estimates because some animals obscured our view of others – especially when they were resting in the prone position. Increased activity (e.g., heads up) sometimes resulted in a higher and more reliable sea lion count per given sub-area. Considering these visibility biases, sea lion counts are believed to be modestly conservative. In other words, the counts are likely to be modestly lower than the actual values.

Database 3: Sweep counts of animal density and behaviour in selected areas – These data allowed us to evaluate differences (in behaviour and haulout density) pre- and post-disturbance. Counts of pinnipeds, on sub-areas selected for daily monitoring prior to any blasting, were usually made at ~30–60 min intervals during the observation period, plus additional counts were made immediately before and in the minutes following a blast or the closest approach by people or boats. Unlike the census counts under Database 2, sweep counts were based on a sample of sub-areas in RRER, and as such, the reactions of all pinnipeds in RRER to disturbance stimuli were not monitored.

Two visible measures of disturbance are: 1) the change in body position (i.e., activity level; head-down or head-up of pinnipeds[14]), and 2) the change in numbers of pinnipeds hauled out. Potential disturbance stimuli were noted during sampling of activity levels (e.g., if an ecotour boat was situated such that the passengers were focusing on the animals in the selected sub-area; or if a blast had recently occurred). Descriptions of visible effects (or lack thereof) of a given stimulus were also noted for each record. For each species, the proportion of active animals was calculated by dividing the number of individuals with heads up by the total number in a given sub-area. Because increased activity could lead to modest increases in total counts whereby animals previously hidden from view become visible as they raised their heads, observers also attempted to determine whether animals moved to the water after a disturbance event in addition to making total counts in an area pre- and post-disturbance to calculate displacement. That way, if the sequential sampling records did not show a change in numbers (e.g., via increased counts due to heads up) but animals were observed moving to the water, displacement was duly noted.

Database 4: Tracking potential disturbance events. A 250 x 250-m grid was superimposed on a map of the study area to track non-military disturbances in RRER. The position and timing of each disturbance stimulus was entered into the survey grid. Disturbances were recorded only once per individual grid cell, even if the disturbance temporarily left then re-entered that same cell. The time at which each detonation was detectable by observers at Race Rocks (by sound) was also recorded to the nearest second.

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[14] It is acknowledged that sea lions sometimes rest in a head-up position, but in LGL's extensive experience at Race Rocks, the proportion of such animals is very small.

4.2 Study Limitations

Analysis and interpretation of the study's results are complicated or compromised by several factors which were beyond the investigator's control:

1. The study was conducted at a single (unreplicated) site. Consequently, data from one or more control sites (i.e., sites with biophysical properties similar to those of Race Rocks, but without any military disturbances) are not available for comparison – and nor does a suitable control site even exist. Furthermore, military activities, ecotourism, and other human activities have been occurring near or in RRER for many years and no historic baseline (pre-disturbance) data from Race Rocks are available for comparison.
2. Environmental conditions and human-induced disturbance events (with the exception of some blasting trials in 2007 [Demarchi et al. 2008]) are two broad categories of factors that affect pinniped behaviour either directly or indirectly (see Figure 7 in Demarchi 2009) and are that not under the investigators' control. Animal activity and departure from a haulout occur naturally and are potentially affected by many variables such as: time of year, time of day, weather, sea state, tide height, local prey availability, time since feeding, inter- and intra-specific interactions, behavioural differences among individuals, animal body condition, animal migration, and interactions between these variables. In other words, human-induced effects on sea lion behaviour are confounded by natural effects, making it difficult to understand and be able to predict how particular disturbance factors influence the number of animals hauled out in RRER (see Figure 7 of Demarchi 2009). Thus, observations of pinniped responses to disturbances were made opportunistically. By sampling on numerous occasions before, during, and after days when blasting occurred in WQ, it is assumed that any biasing effects of non-military disturbance factors that affect pinnipeds will be spread randomly across monitoring days, thereby reducing bias. For example, there is no reason to expect that sea or weather conditions were consistently different among monitoring days.
3. Residual effects of disturbance can persist for hours or more, and individual animals are likely to retain knowledge of past disturbances. Therefore, multiple observations of the same animals are not statistically independent of each other, especially when consecutive samples are recorded over short periods of time (e.g., multiple samples in a single day). For example, if a disturbance occurs at time = t and animals move to the water, a sample of animal numbers and activity from that same haulout taken at time = t + 1 is likely to differ from another hypothetical sample taken without a previous disturbance.
4. Total counts allow for the estimation of changes in the total numbers of animals populating the study area, but without individual identification or a sample of radio-tagged animals, one cannot reasonably determine what proportion of the local population is either temporarily or permanently abandoning RRER following each disturbance. Similarly, in the absence of such tagging, it is not possible to distinguish sea lions that return to a haulout after being displaced from a blast from those returning from at-sea foraging or those migrating individuals that arrive at the haulout after, and independent of, blasting activity.
5. For the most part, the number of animals moving to and from a haulout can be estimated by the difference in numbers before and after a disturbance. Error in this estimate results when animals move in and out of view while remaining on the haulout (e.g., when some

animals obscure the view of others, or when blasting results in animals that were previously hidden from view raising their heads, and in doing so, becoming visible from the tower).

6. Afternoon counts do not always occur after a consistent period of time after the last blast of the day. Therefore, the time available for pinnipeds numbers to recover after the final blast of the day was not consistent among monitored days.
7. In the absence of direct mortality, it is practically impossible to determine how changes in animal behaviour or numbers hauled out might result in a biologically significant effect at a population level (see Demarchi 2002; Demarchi and Bentley 2004).

5. RESULTS & DISCUSSION

Environmental conditions during the study encompassed a range of air temperatures, precipitation classes, cloud cover, wind directions, wind speeds, sea state, and ocean swell heights (Appendix III). Visibility was excellent throughout most of the monitored area during the entire study.

Since 2002, up to seven northern elephant seals were observed on a given day during late-summer–autumn monitoring sessions. As per previous observations (e.g., Demarchi and Bentley 2004), elephant seals occurred in very low numbers (< 7) and did not appear reactive to blasting noises. Consequently, only Steller sea lions, California sea lions, and harbour seals are examined below.

5.1 Census Totals & Activity Levels

Total numbers of pinnipeds on each of the two daily surveys for all monitoring sessions in 2002–09 are summarized in Appendix IV. As documented by Demarchi et al. (1998), Demarchi and Bentley (2004), Demarchi et al. (2008), and Demarchi (2009), daily numbers of harbour seals hauled out in RRER were not overtly affected by blasting on Bentinck Island. Rather, harbour seal numbers are strongly related to tide height (Demarchi and Bentley 2004; Demarchi et al. 2008; Demarchi 2009). Demarchi and Bentley (2004) showed that even in the absence of any potential human-caused disturbance, numbers of harbour seals hauled out in RRER will diminish to zero during rising tides and/or moderate to high swells. Stormy seas and high tides result in waves and swells that wash over much of the intertidal haulout areas used by this species, resulting in fewer seals maintaining their positions on the rocks. And while the haulout behaviour of sea lions can also be affected by tide and swells, they tend to haul-out higher on the rocks than harbour seals, and are therefore less vulnerable to routine displacement off the haulout by water. The three main species of pinnipeds are covered below.

Steller Sea Lion

Hypothesis 1

Figure 4 shows how the number of Steller sea lions hauled out in RRER changed during each monitored day and across monitored days in 2008 and 2009 (data from Appendix IV). The data are partitioned by the type of day with regard to blasting on two ranges in WQ: Bentinck Island and Christopher Point. The number of Steller sea lions hauled out in RRER was highly variable, ranging from nearly 700 animals in late October 2009 to nearly 0 at other times. Changes in numbers over time and within days were primarily the result of natural movements on and off of their haulouts, but some animals were displaced by blasting on Bentinck Island and Christopher Point.

Table 2 summarizes the proportion of days whereby the difference between the number of Steller sea lions at the end of the monitored day compared to the beginning of the day was negative (i.e., numbers declined). Data are partitioned by the type of monitoring day. The pattern of daily change in net number of Steller sea lions hauled out in RRER suggests that blasting in WQ displaces animals on some, but not all, days. For example, ordnance disposal on Christopher Point during 16 and 17 November 2009 caused a substantial reduction in numbers (Figure 4), but effects of ordnance disposal on 27 and 28 October were either not as pronounced or did not reduce the total number of animals. Similarly, demolitions on Bentinck Island during 10 September 2009 caused a considerable reduction in number of Steller sea lions, but on other days when that range was active, net increases were observed (e.g., 2 October 2009). In some cases, including 2 October 2009, considerable displacement was observed in response to individual blasts, but animals hauled shortly after the blasts, albeit often elsewhere in RRER (e.g., from Area 2–5 to Area 6–7, Area 13, or Area A). Declines in numbers of Steller sea lions were also observed on some days with no blasting. Such departures are believe to be the result of natural factors, including rising tides and rough seas washing over the haulouts as well as departures for foraging and migration.

Numbers of Steller sea lions in RRER at the end of the monitoring days (i.e., numbers tallied during the second daily census) for each monitoring session are presented in Figure 5. While numbers of Steller sea lions hauled out in RRER fluctuate considerably with such factors as migration, sea conditions, and human-caused disturbances – including blasting – there is no indication that demolitions on Bentinck Island cause meaningful numbers of Steller sea lions to leave RRER. Telemetry studies of individual animals would be the only reliable means of assessing the extent to which any individual animals, displaced from a haulout in response to a blast, actually left RRER as opposed to remaining there. Although some animals bear brands and/or tags from research projects elsewhere, such identifiers are not always readily visible due to animal positioning and behaviours. Thus, while a sighted brand or tag would confirm an individual's presence, the lack of such a sighting cannot be interpreted as evidence that an animal left RRER.

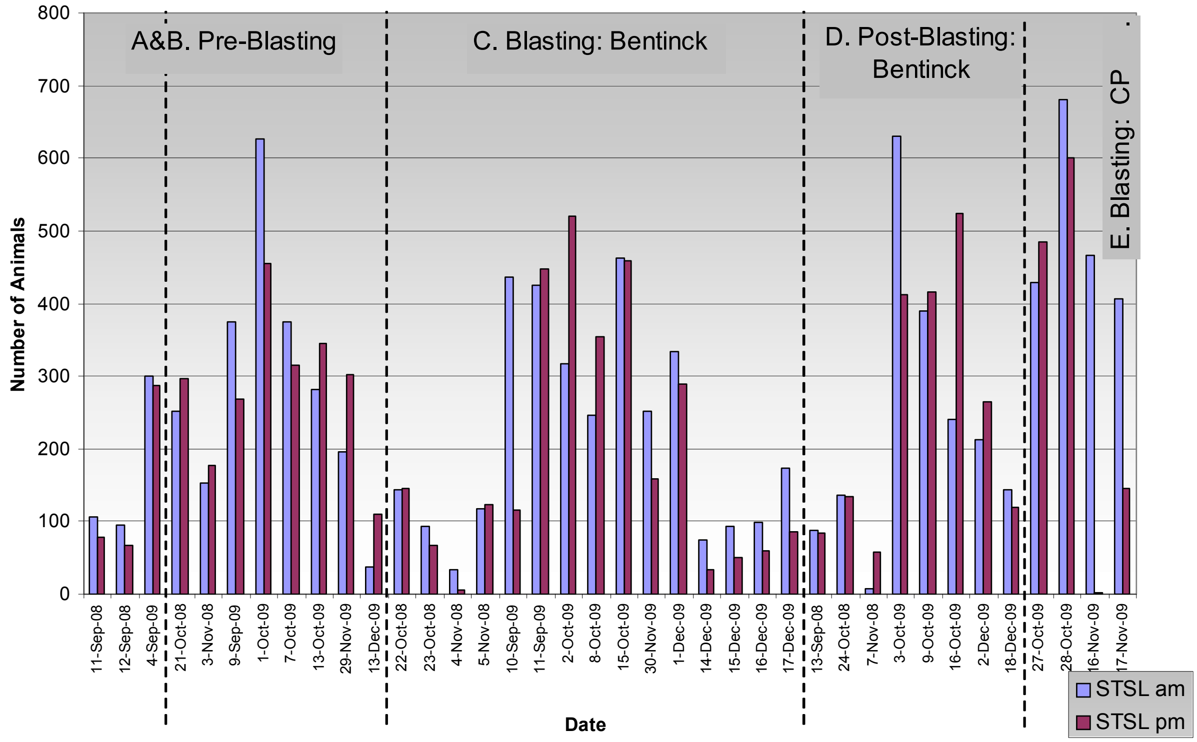

Figure 4. Total number of Steller sea lions (STSL) in the Race Rocks census area during the morning (am) and afternoon (pm) counts as partition by different types of monitoring day: A=monitoring days more than 1 day prior to blasting on Bentinck Island; B=1day prior to blasting on Bentinck Island; C=monitoring during days when blasting occurred on Bentinck Island; D=monitoring 1 day after blasting on Bentinck Island; E=monitoring during days when blasting occurred on Christopher Point. Blasting on 12 September occurred after the second count that day. On days when animals were present on the north side of Area 13 and not visible from atop the light tower, numbers were estimated during morning and afternoon boat trips to and from Great Race Rock (24 October and 3–5 November) and added to the respective tower counts.

Table 2. Proportion of days showing a net decline in the number of pinnipeds during the course of the monitored day (i.e., number during second daily census minus number during first daily census) as partitioned by the type of monitoring day with regard to blasting in WQ. Sample sizes indicate the number of monitored days when at least 10 individuals were present during one of the two daily surveys. Data from 2008 and 2009.

	Percent of Days with Decline		
Monitored Day	**Steller sea Lion**	**California Sea Lion**	**Harbour Seal**
>1 day before blasting on Bentinck Island (>1Pre-Bentinck)	100% (n=3)	0% (n=3)	100% (n=3)
1 day before blasting on Bentinck Island (1Pre-Bentinck)	38% (n=8)	25% (n=4)	50% (n=8)
Blasting on Bentinck (Bentinck)	67% (n=15)	60% (n=5)	46% (n=13)
1 day after blasting on Bentinck (Post-Bentinck)	50% (n=8)	0% (n=4)	63% (n=8)
Blasting on Christopher Point	75% (n=4)	0% (n=2)	100% (n=3)

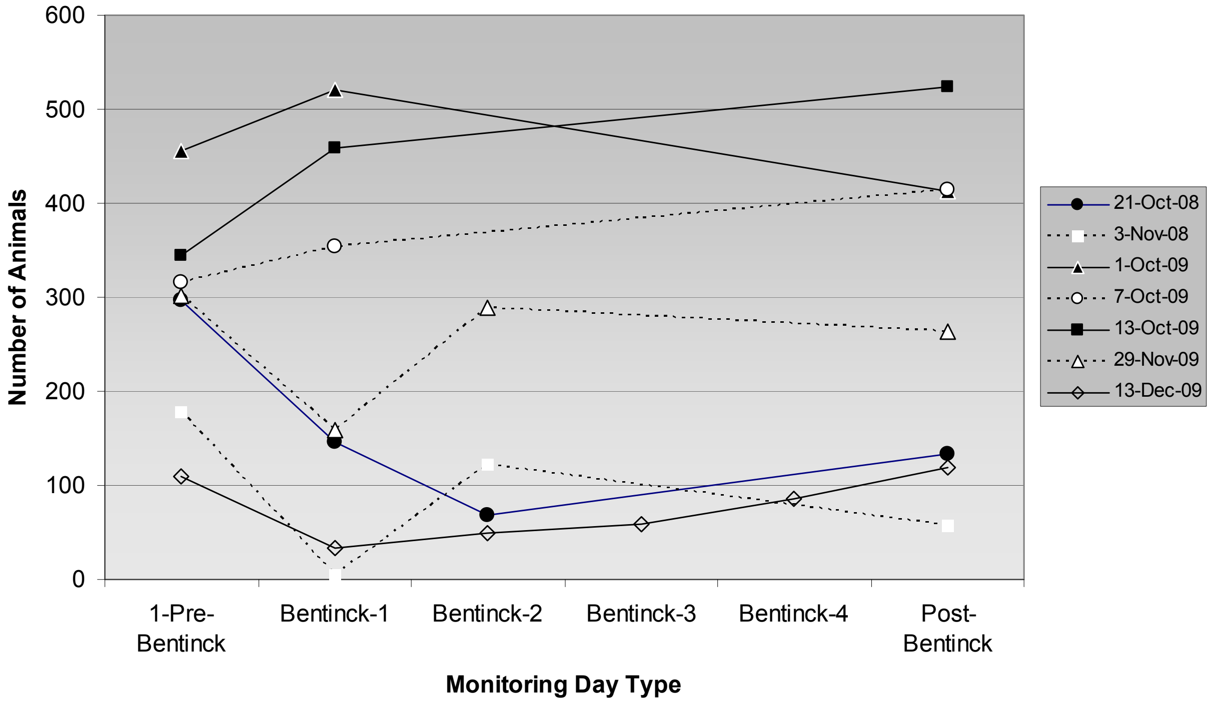

Figure 5. Total number of Steller sea lions in the Race Rocks census area during the afternoon (pm) counts as partition by different types of monitoring day: "1-Pre-Bentinck"= 1 day prior to blasting on Bentinck Island; "Bentinck-1" through "Bentinck-4" = (sequential) days when blasting occurred on Bentinck Island; "Post-Bentinck" = 1 day after the last day of blasting on Bentinck Island. Data from 2008 and 2009. The legend indicates the first day of each discrete monitoring session.

As measured in Area 2–5, the main haulout used by the species[15], Steller sea lions were least active before blasting and on days after blasting, and were most active during days when the Bentinck Island range was active (Figure 6). At 28% (Pre-Bentinck), 48% (Bentinck), and 32% (Post-Bentinck), the mean daily activity values were significantly different ($F_{2,68}$=14.632 $P< 0.001$). Pairwise comparisons indicated that Pre- and Post Bentinck activity levels were not significantly different (P=0.754), but that Bentinck activity levels were significantly greater than Pre-Bentinck ($P< 0.001$) and Post-Bentinck (P=0.025) levels. The similarity between pre- and post-blasting conditions suggests that Steller sea lions returned to near pre-blast activity levels within one day after blasting. On some days when blasting occurred, numbers of Steller sea lions on the haulout dropped drastically and remained low all day (e.g., blasting on Christopher Point 16 and 17 November 2009). The absence of at least 10 animals from which an activity sample could be taken obviously has a biasing effect on the results of activity data. As a result, the low sample sizes and comparatively low levels of activity shown for days when Christopher Point was active must be interpreted with caution.

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[15] From 2002 through 2009, 72% of all census counts of this species have been from Area 2–5; the next highest proportion for a single census area was is 6%.

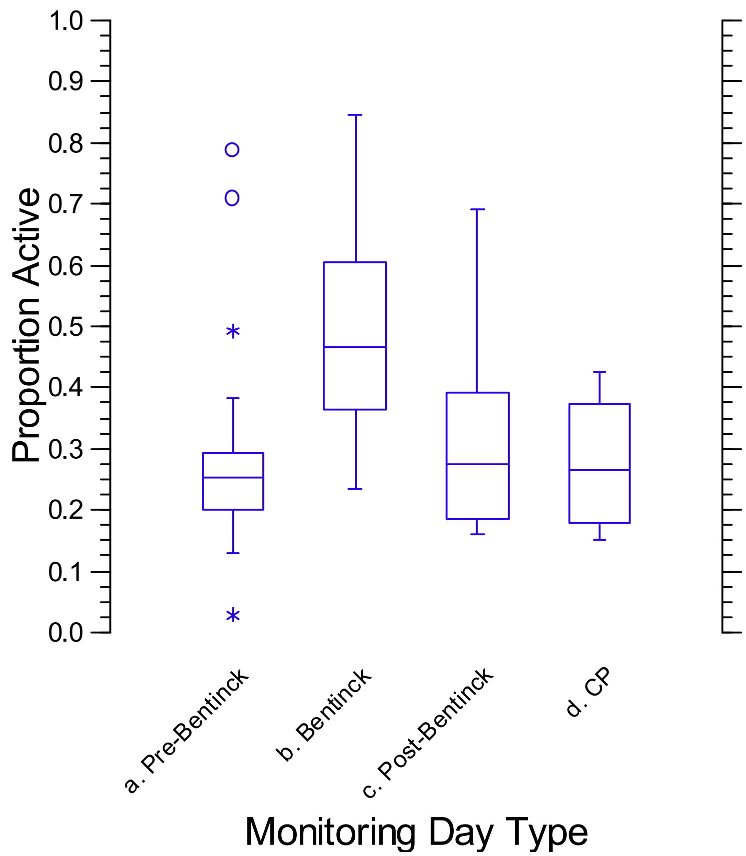

Figure 6. Boxplot summary of daily aggregate mean values of the proportion of Steller sea lions active grouped by samples from monitoring days at least 1 day prior to when the Bentinck demolition range was active ("a. Pre-Bentinck" n=34), samples during days when the range was active ("b. Bentinck" n=29), samples taken the day following a day when the Bentinck range had been active ("c. Post-Bentinck" n=8), and samples taken when Christopher Point ("d. CP" n=4) was active. Only samples involving 10 or more animals are included. Data from 2002 through 2009 from Area 2–5 only. The boxplot shows the range of the sample quartiles and the sample median. Outside values (*) and far outside values (o) are indicated.

Displacement of Steller sea lions from haulouts appeared to vary in response to non-military disturbance events pooled together on pre- and post-Bentinck demolition days (e.g., aircraft, pleasure and commercial vessels, pedestrians, on Great Race Rock; Figure 7). For situations involving ≥10 animals prior to a disturbance event, an increased range of displacement response was observed during post-Bentinck monitoring days, but the medians were essentially the same and the difference between the two means was not significant (P=0.123). Given the disruptive effects that blasting can have on sea lion behaviour, distribution, and abundance; together with the range of data shown in Figure 7, blasting likely has the potential to sensitize some animals to other, non-military disturbances for at least 1 day post-blasting, but that the magnitude of this effect is variable.

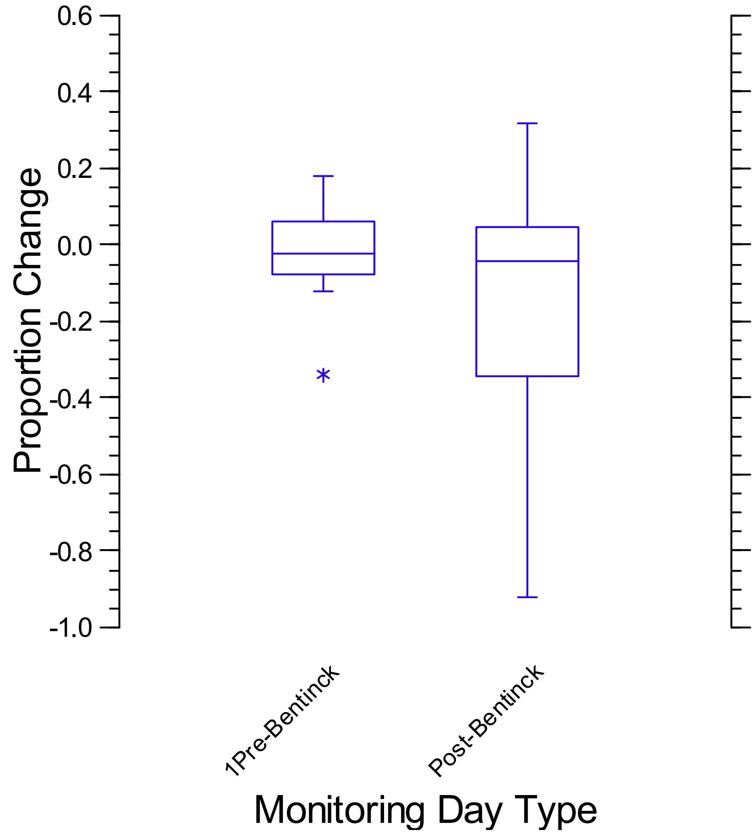

Figure 7. Boxplot summary of the change in the proportion of Steller sea lions hauled out on monitored areas in response to discrete, non-military disturbance events other than weather or sea conditions, grouped by the type of monitoring day. Only records with at least 10 animals counted prior to the onset of disturbance are included. A value of -1 is complete haulout abandonment (i.e., 100% of animals to the water); a value of 0 indicates no change, and a positive value indicates an increase (see item 5 of §4.2). Sample sizes: 1Pre-Bentinck (i.e., 1 day prior to blasting on Bentinck Island; 18), Post-Bentinck (i.e., one day after blasting on Bentinck Island; 22). The boxplot shows the range of the sample quartiles, the sample median, and any outside values (*).

Hypothesis 2

An examination of the effectiveness of the minimum 5-min interval, as per Hypothesis 2 (page 4), did not suggest that a 5-min interval is an effective mitigation measure as mean displacement was not significantly different between the 0.5–2 and 5–7 min intervals (P=0.532; Figure 8). That result and data summarized in Figure 8 show that an interval of up to 5–7 min between the first and second blasts of the day caused displacement from the haulouts that was similar to that caused by first and second blasts separated by up to 2 min. While the results for the 3–4 min spacing likely reflect the small sample size (n=3), it is possible that the reduced changes in proportions after second blasts that were 51–62 min apart indicate that a blast interval of this magnitude might result in reduced displacement. However, it too had a low sample size (n=4). It must be noted that the 71% decline in Steller sea lions (on Area 2–5; an outside value under the 51–62 min interval) according to a count after the second blast on 17 December 2009 was biased by displacement caused by the activities associated with a DFO boat and personnel engaged in rescuing an entangled Steller sea lion on Area 2–5[16]. That record was excluded from the chart. Also, the increase (~72%) in animals following one of the blasts in the 0.5–2 min category was deemed independent of blasting. It just so happened that tens of Steller sea lions were returning to the haulout around the time of the first demolition run. Consequently, that record was also excluded from the chart.

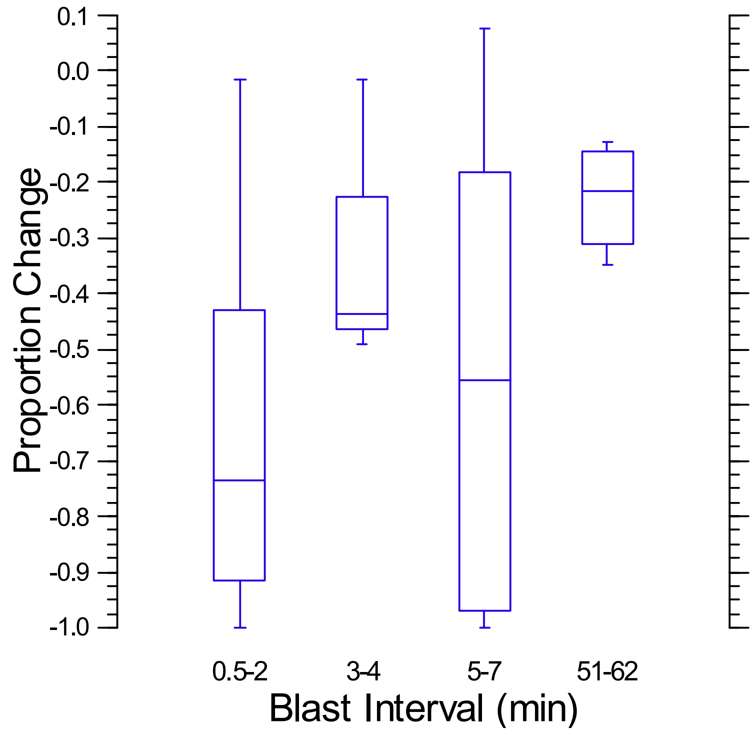

Figure 8. Boxplot summary of the change in the proportion of Steller sea lions hauled out after the second blast of the day as grouped by the interval (min) between the first and second blasts. Only haulouts with at least 30 animals prior to the first blast are included. A value of -1 is complete haulout abandonment (i.e., all animals to the water); a value of 0 indicates no change, and a positive value indicates an increase (see item 5 of §4.2). Includes blasts from the main demolition area on Bentinck Island and on Christopher Point during the period 2002 though 2009. Sample sizes: 0.5–2 (11), 3-4 (3), 5-7 (14), and 51–62 (4). The boxplot shows the range of the sample quartiles, and the sample median.

Hypothesis 3

An examination of the effectiveness of the 5-min interval, as per Hypothesis 3 (page 4), also suggested that a 5-min interval was not an effective mitigation measure for reducing disturbance of Steller sea lions. The data from Area 2–5 summarized in Figure 9 show that blast intervals of up to 5–7 min yielded a range of maximum daily levels of displacement from the haulouts that was similar to those caused by blasts separated by up to 2 min. Excluding category e. days (i.e., intervals >15 min) due to low sample size, mean values of displacement were significantly different ($F_{4,58}$=11.472 $P< 0.001$). Pairwise comparisons of mean values for the five monitoring

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[16] http://racerocks.ca/racerock/admin/intervention/2009entangle.htm

day types indicated that: a) displacement from the haulout (Area 2–5) was significantly greatest on days when blasting occurred (P< 0.001), but that b) displacement on such days did not differ significantly as a function of blast interval (P=1.000), and c) displacement did not differ significantly between pre- and post-Bentinck monitoring days (P=0.873).

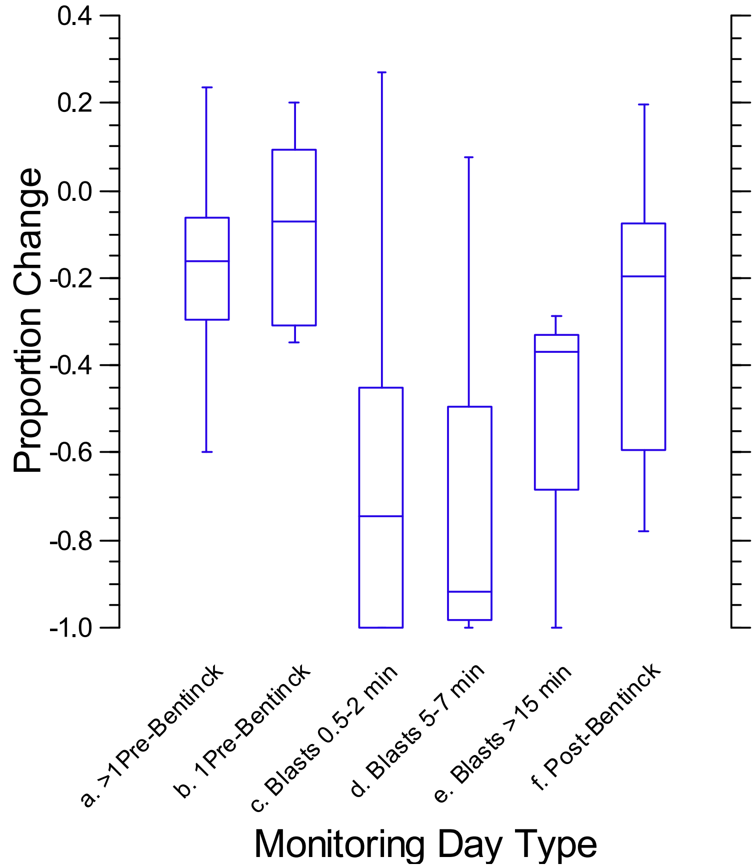

Figure 9. Boxplot summary of the maximum decrease (or minimum increase) in the proportion of Steller sea lions hauled out on Area 2–5 during the course of the day as grouped by the minimum interval (min) between any two blasts on a given day. Only records with at least 30 animals counted during the first sample of the day are included. A value of -1 is complete haulout abandonment (i.e., 100% of animals to the water); a value of 0 indicates no change, and a positive value indicates an increase (see item 5 of §4.2). Includes blasts from the main demolition area on Bentinck Island and on Christopher Point during the period 2002 though 2009. Sample sizes: a. >1Pre-Bentinck (i.e., more than 1 day prior to blasting on Bentinck Island; 19), b. 1Pre-Bentinck (i.e., 1 day prior to blasting on Bentinck Island; 9), c. Blasts 0.5–2 min (i.e., Bentinck Island and Christopher Point; minimum of 0.5–2 minutes between any two blasts; 16), d. Blasts 5–7 min (i.e., Bentinck Island and Christopher Point; minimum of 5–7 minutes between any two blasts; 12), e. Blasts >15 min (i.e., Bentinck Island and Christopher Point; minimum of 15 minutes between any two blasts; 3), f. Post-Bentinck (i.e., one day after blasting on Bentinck Island; 7). The boxplot shows the range of the sample quartiles and the sample median.

Hypothesis 4

Finally, an examination of the effectiveness of 5-min interval, as per Hypothesis 4 (page 5), provided no evidence to suggest that days with a minimum blasting interval of 5–7 min resulted in less within-day displacement of Steller sea lions than days when the minimum interval was 0.5–2 min (Figure 10). Excluding category "e" days (i.e., blast intervals >15 min) due to low sample size, mean values of displacement were not significantly different between any type of monitoring day ($F_{4,68}$=1.504 P=0.211). Thus, while Figure 10 indicates that the median proportion of change (decline during a day) tended to be greater on blasting days, there was considerable variation in this parameter across all types of monitoring day. While significant levels of displacement occur as a result of blasting (Figure 9), the absence of a significant difference among the values in Figure 10 indicates that a statistically significant number of displaced animals are not leaving RRER, but rather they are returning to a haulout in RRER in the minutes to hours following the final blast from Bentinck Island. Data in Figure 5 further demonstrate that differences across a period spanning a pre-blasting day, one or more blasting days, and a post-blasting day are not indicative of displacement from RRER after blasting. This is further evidence that those animals displaced to the water return to a haulout in RRER soon after.

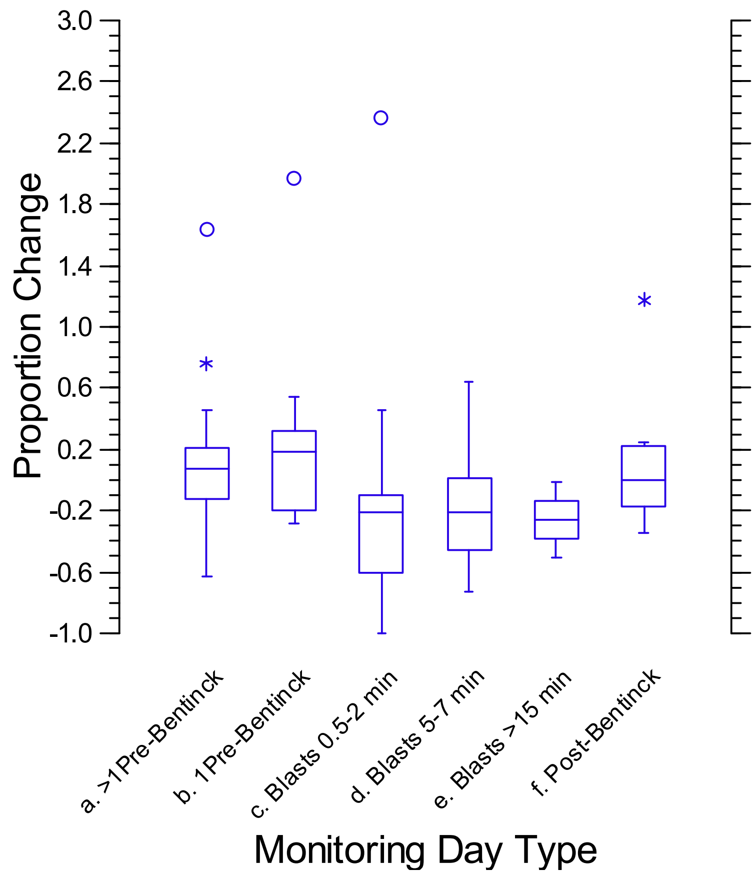

Figure 10. Boxplot summary of the change in the proportion of Steller sea lions hauled out in the entire Ecological Reserve (ER) in the afternoon compared to the morning as grouped by the type of monitoring day. Data from 2002 through 2009. Includes only days with ≥10 animals in RRER during the morning count. Sample sizes: a. >1Pre-Bentinck (i.e., >1 day prior to blasting on Bentinck Island; 35), b. 1Pre-Bentinck (i.e., 1 day prior to blasting on Bentinck Island; 11), c. Blasts 0.5–2 (i.e., Bentinck Island and Christopher Point; minimum of 0.5–2 minutes between any two blasts; 20), d. 5–7 (i.e., Bentinck Island and Christopher Point; minimum of 5–7 minutes between any two blasts; 14), e. >15 (i.e., Bentinck Island and Christopher Point; minimum of 15 minutes between any two blasts; 3), f. Post-Bentinck (i.e., 1 day after blasting on Bentinck Island; 9). The boxplot shows the range of the sample quartiles and the sample median. Outside values (*) and far outside values (o) are indicated.

Hypothesis 5

In 2009, a total of 67 blasts were monitored. Of those, 10 were associated with ≥50 Steller sea lions leaving a haulout (Table 3). All cases involved Area 2–5 – the most heavily used by the species. The confounding effects of sea conditions (namely the combined effects of tide level and swell conditions) cannot be discounted and some of displacement occurred independent of blasting and in response to water washing over the haulout (see Photo 4). While it is possible that blasting compounded ongoing swell-based disturbances for those blasts that were not masked by water-generated noise, the three blasts on Bentinck Island shown in Table 3 were all associated with low to nil swell conditions and the loudest blast levels.

Table 3. Summary of blasting events associated with at least 50 Steller sea lions leaving a haulout. Changes are based on values from the first post-blast sample compared with those from the nearest pre-blast sample. Blast number by day, location (CP=Christopher Point; BI=Bentinck Island), relative noise level (increasing from 1–5), swell height (N=nil; L=low; M=moderate; H=high), and monitored area are indicated.

Blast Date & Time	Blast #	Location	Noise Level	Swell	Area	Change in STSL	Change in STSL (%)
27/10/2009 10:48	4	CP	4	M	2-5	-338	-84.50%
16/11/2009 11:42	2	CP	5	M	2-5	-324	-83.51%
16/11/2009 14:06	4	CP	4	H	2-5	-167	-95.98%
27/10/2009 11:36	6	CP	3	M	2-5	-145	-70.39%
15/10/2009 9:45	1	BI	4	N	2-5	-112	-33.23%
08/10/2009 10:43	2	BI	5	L	2-5	-76	-26.12%
15/10/2009 14:14	5	BI	5	N	2-5	-75	-26.13%
27/10/2009 14:18	8	CP	2	L	2-5	-63	-13.10%
17/11/2009 11:59	2	CP	1	H	2-5	-62	-23.22%
27/10/2009 10:06	2	CP	2	M	2-5	-50	-11.11%

Photo 4. Examples of the influence of sea conditions on the availability of haulout space for Steller sea lions on Area 2–5. Top photo: ~614 Steller sea lions, 28 October 2009, swell height nil, tide height ~1.9 m. Bottom photo: ~400 Steller sea lions 27 October 2009, swell height high, tide height ~2.2 m.

Demarchi and Holst (2008) hypothesized that the probability of animal disturbance due to blast noise was, in part, a function of received noise levels above a given threshold. Preliminary tests by Demarchi et al. (2008) concluded that noise level did indeed appear to influence animal response, with blasts on the main demolition area of Bentinck Island being generally louder and tending to displace more Steller sea lions as compared with blasts on the alternate location (see Figure 2). Those authors concluded that, despite the alternate location being ~170 m closer to Area 2–5, the steep shoreline bank and trees on the island blocked the line-of-sight and attenuated noise transmission toward RRER.

Disturbance of Steller sea lions in 2009 was correlated with noise levels as measured atop the light tower (Figure 11; Spearman's rho = -0.523, n=26). For haulouts closest to Bentinck Island (i.e., Areas 2–5, 6–7, 8–12, 13), and including only records involving: a) at least 30 animals prior to a blast b) swell conditions less than moderate, and c) no other ongoing disturbances such as the sea lion rescue on 17 December 2009, the number of animals remaining on a haulout after a blast decreased with increased noise level of the blast.

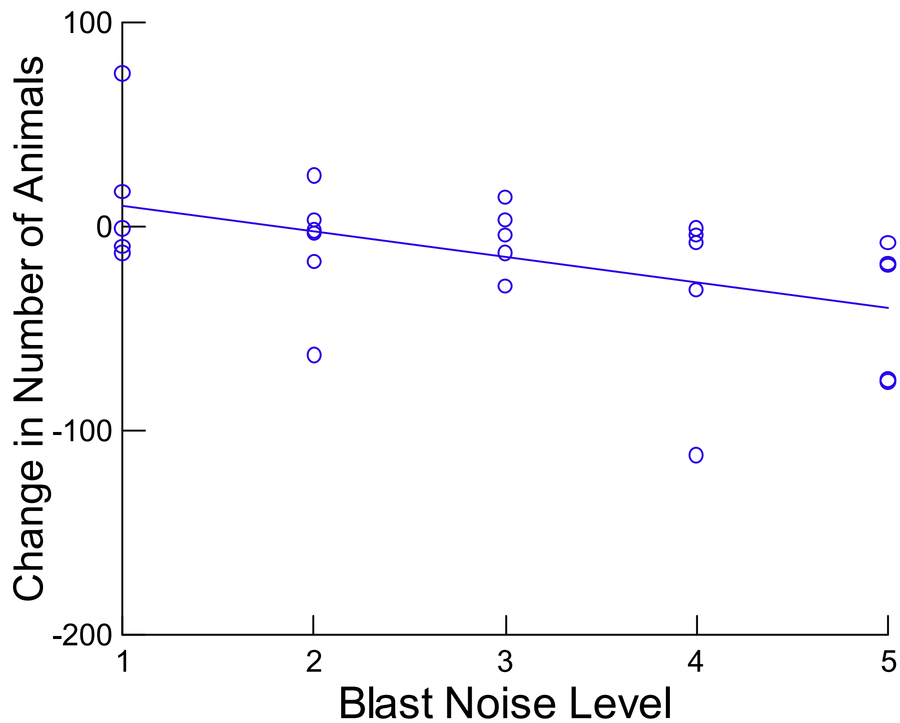

Figure 11. Plot of change in number of Steller sea lions on a haulout as a function of relative blast-noise level for detonations on Christopher Point and Bentinck Island. Blasts are ranked by increasing noise level from 1 to 5. Includes data from 2009, haulouts closest to Bentinck Island (i.e., Areas 2–5, 6–7, 8–12, 13), and only records involving: a) at least 30 animals prior to a blast b) swell conditions less than moderate, and c) no other ongoing disturbances such as the sea lion rescue on 17 December 2009.

California Sea Lion

Figure 12 shows how the number of California sea lions hauled out in RRER changed during each monitored day and across monitored days in 2008 and 2009 (data from Appendix IV). The data are partitioned by the type of day with regard to blasting on two ranges in WQ: Bentinck Island and Christopher Point. The number of California sea lions hauled out in RRER was highly variable, ranging from more than 900 animals in mid October 2009 to 0 at other times (Figure 12). Changes in their numbers over time and within days were primarily the result of natural movements on and off of the haulouts.

Table 2 summarizes the proportion of days the difference between the number of California sea lions at the end of the monitored day compared to the beginning of the day was negative (i.e., numbers declined). Data are partitioned by the type of monitoring day. The pattern of daily change in net number of California sea lions hauled out in RRER suggests that blasting on Bentinck Island tends to reduce their numbers. However, owing in part to the fact that California sea lions were not always present in RRER, this interpretation is based on small sample sizes. Further, the declines on at least two days (i.e., 10 and 11 September 2009) were modest.

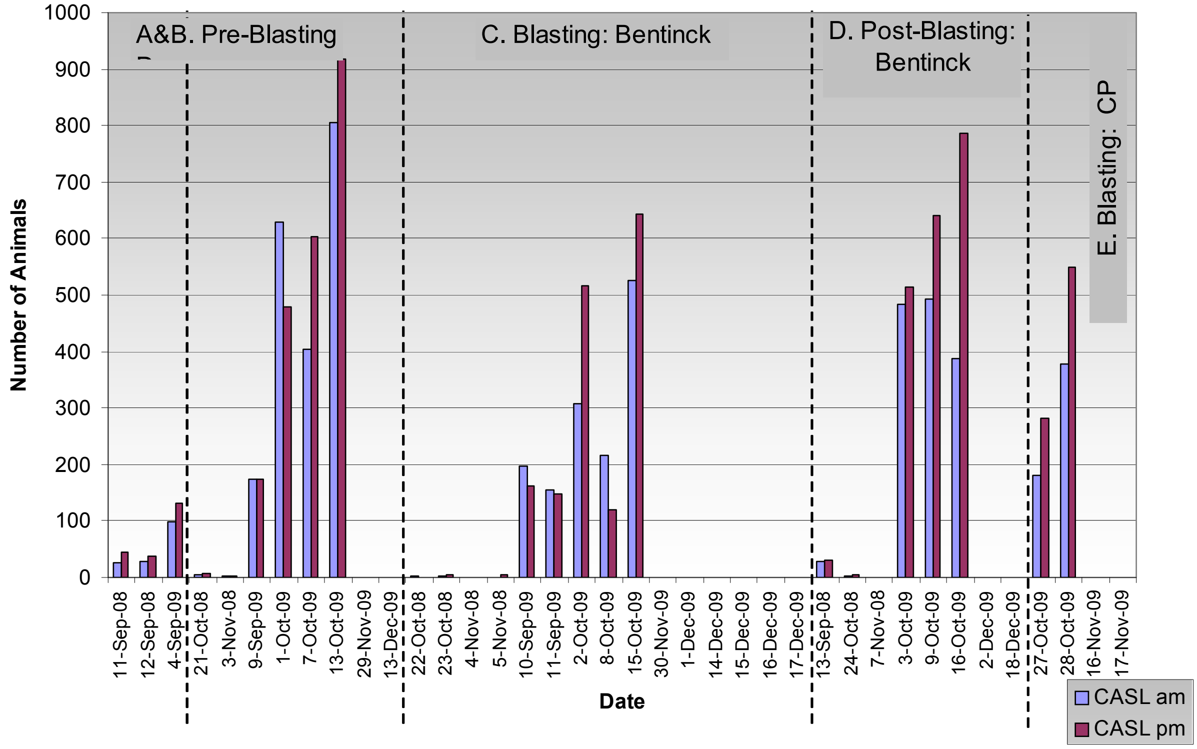

Figure 12. Total number of California sea lions (CASL) in the Race Rocks census area during the morning (am) and afternoon (pm) counts as partition by different types of monitoring day: A=monitoring days more than 1 day prior to blasting on Bentinck Island; B=1day prior to blasting on Bentinck Island; C=monitoring during days when blasting occurred on Bentinck Island; D=monitoring 1 day after blasting on Bentinck Island; E=monitoring during days when blasting occurred on Christopher Point. Blasting on 12 September occurred after the second count that day.

Numbers of California sea lions in RRER at the end of the monitoring days (i.e., numbers tallied during the second daily census) for each monitoring session are presented in Figure 13. While numbers of California sea lions hauled out in RRER fluctuate considerably with such factors as migration, sea conditions, and human-caused disturbances, there is no indication that demolitions on Bentinck Island cause meaningful numbers of California sea lions to leave RRER. Telemetry studies of individual animals would be the only reliable means of assessing the extent to which any individual animals, displaced from a haulout in response to a blast, actually left RRER as opposed to remaining there. Although some animals bear brands and/or tags from research projects elsewhere, such identifiers are not always readily visible due to animal positioning and behaviours. Thus, while a sighted brand or tag would confirm an individual's presence, the lack of such a sighting cannot be interpreted as evidence that an animal left RRER.

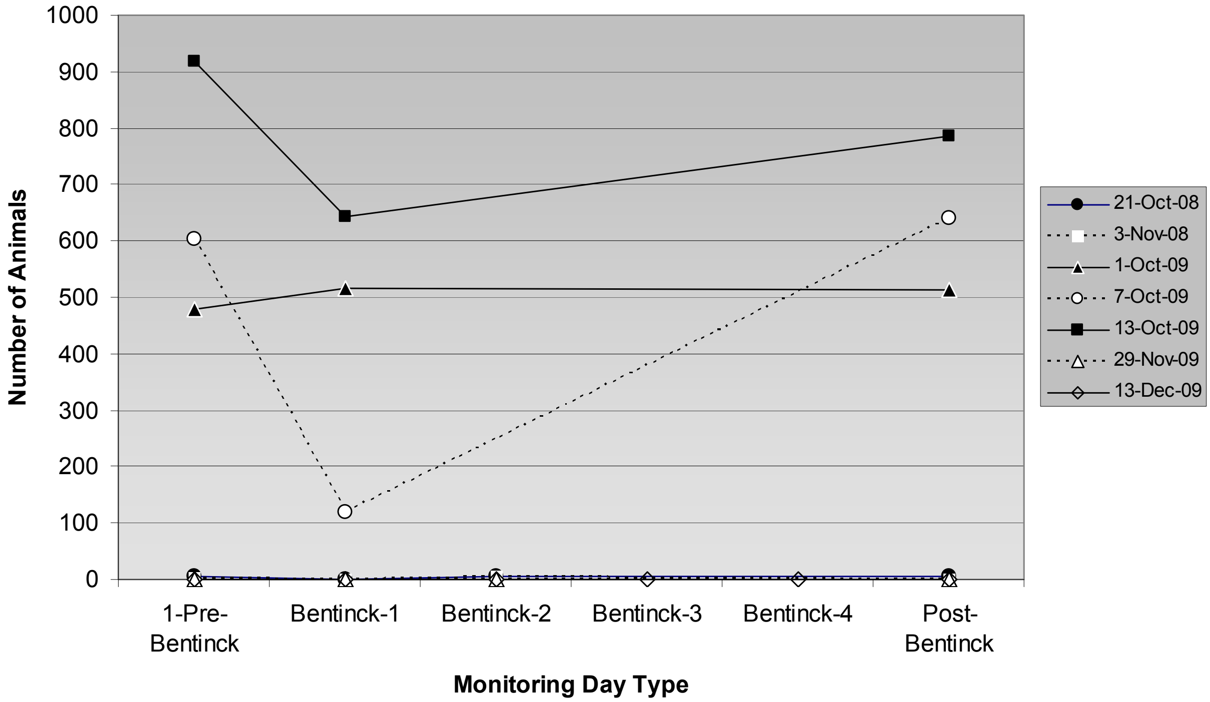

Figure 13. Total number of California sea lions in the Race Rocks census area during the afternoon (pm) counts as partition by different types of monitoring day: "1-Pre-Bentinck"= 1 day prior to blasting on Bentinck Island; "Bentinck-1" through "Bentinck-4" = (sequential) days when blasting occurred on Bentinck Island; "Post-Bentinck" = 1 day after the last day of blasting on Bentinck Island. Data from 2008 and 2009. The legend indicates the first day of each discrete monitoring session.

As measured in Area A, the main haulout used by the species[17], California sea lions were least active on days before blasting (Pre-Bentinck) and on days after blasting (Post-Bentinck), and were most active during days when the a demolition range was active (Bentinck; Figure 14). At 18% (Pre-Bentinck), 35% (Bentinck), and 21% (Post-Bentinck) the mean daily activity values were significantly different ($F=7.029_{2,29}$ $P=0.003$). Pairwise means comparisons indicated that Pre-Bentinck mean activity levels were, on average, significantly lower than Bentinck activity levels ($P=0.003$) and not significantly different from Post-Bentinck levels ($P=0.907$). Post-Bentinck levels were also not significantly from Bentinck levels ($P=0.123$). This latter result was likely due to the small sample size obtained during Post-Bentinck monitoring days, together with the wider range of values obtained during Bentinck monitoring days. The absence of at least 10 animals from which an activity sample could be taken obviously has a biasing effect on the results of activity data. As a result of the low sample size, levels of activity on the day when Christopher Point was active must be interpreted with caution.

[17] From 2002 through 2009, 55% of all census counts of this species have been from Area A; the next highest proportion for a single census area was is 15%.

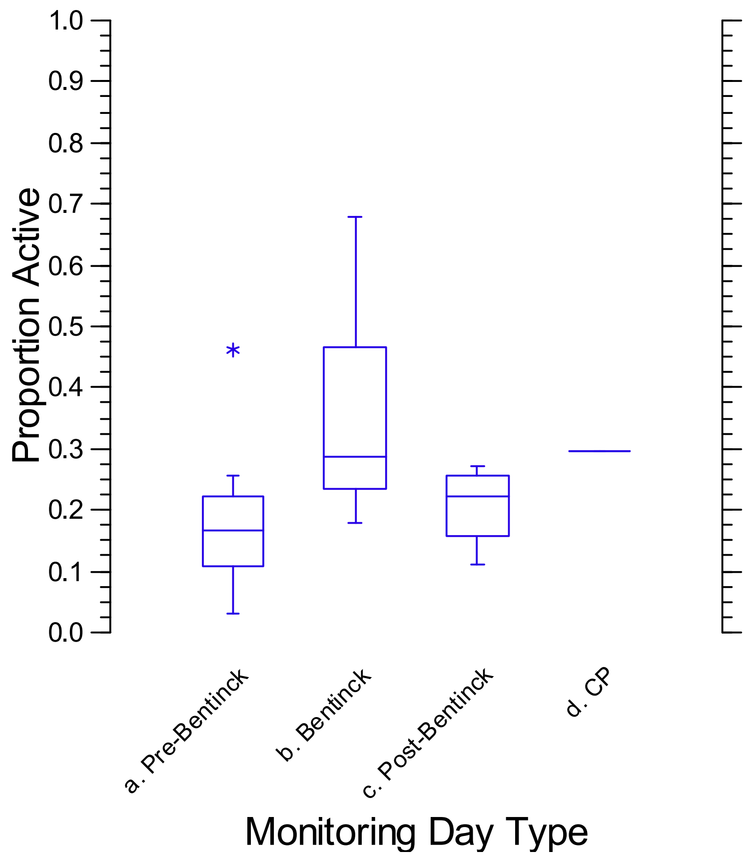

Figure 14. Boxplot summary of daily aggregate mean values of the proportion of California sea lions active grouped by samples from monitoring days at least 1 day prior to when the Bentinck demolition range was active ("a. Pre-Bentinck" n=16), samples during days when the range was active ("b. Bentinck" n=12), samples taken the day following a day when the Bentinck range had been active ("c. Post-Bentinck" n=4), and samples taken when Christopher Point ("d. CP" n=1) was active. Only samples involving 10 or more animals are included. Data from 2002 through 2009 from Area A only. The boxplot shows the range of the sample quartiles and the sample median. Outside values (*) are indicated.

Harbour Seal

Figure 15 shows how the number of harbour seals hauled out in RRER changed during each monitored day and across monitored days in 2008 and 2009 (data from Appendix IV). The data are partitioned by the type of day with regard to blasting on two ranges in WQ: Bentinck Island and Christopher Point. Table 2 summarizes the proportion of days the difference between the number of harbour seals at the end of the monitored day compared to the beginning of the day was negative (i.e., numbers declined). Data are partitioned by the type of monitoring day. Declines were observed during all types of monitoring days. Interestingly, the lowest proportion of days exhibiting a decline was when the Bentinck Island range was active. It is unclear whether blasting bolsters numbers of seals at RRER by displacing them from Eemdyk Passage or whether this is simply an artifact of the sampling conditions. Although some conditions have low sample sizes, the overall pattern of daily change in net number of harbour seals hauled out in RRER appears to be independent of blasting in WQ.

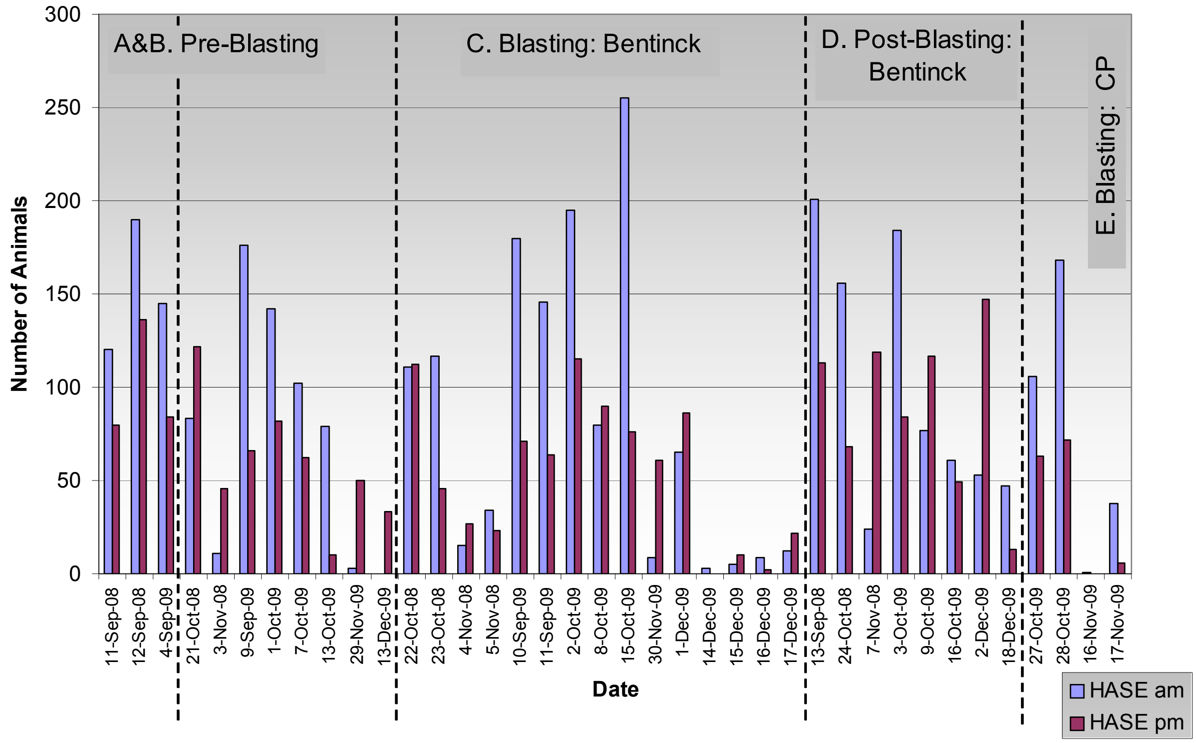

Figure 15. Total number of harbour seals (HASE) in the Race Rocks census area during the morning (am) and afternoon (pm) counts as partition by different types of monitoring day: A=monitoring days more than 1 day prior to blasting on Bentinck Island; B=1day prior to blasting on Bentinck Island; C=monitoring during days when blasting occurred on Bentinck Island; D=monitoring 1 day after blasting on Bentinck Island; E=monitoring during days when blasting occurred on Christopher Point. Blasting on 12 September occurred after the second count that day.

Numbers of harbour seals in RRER at the end of the monitoring days (i.e., numbers tallied during the second daily census) for each monitoring session are presented in Figure 16. While numbers of harbour seals hauled out in RRER fluctuate considerably with such factors as swell height, tide level, and human-caused disturbances, there is no indication that demolitions on Bentinck Island cause meaningful numbers of harbour seals to leave RRER. Telemetry studies of individual animals would be the only reliable means of assessing the extent to which any individual animals, displaced from a haulout in response to a blast, actually left RRER as opposed to remaining there.

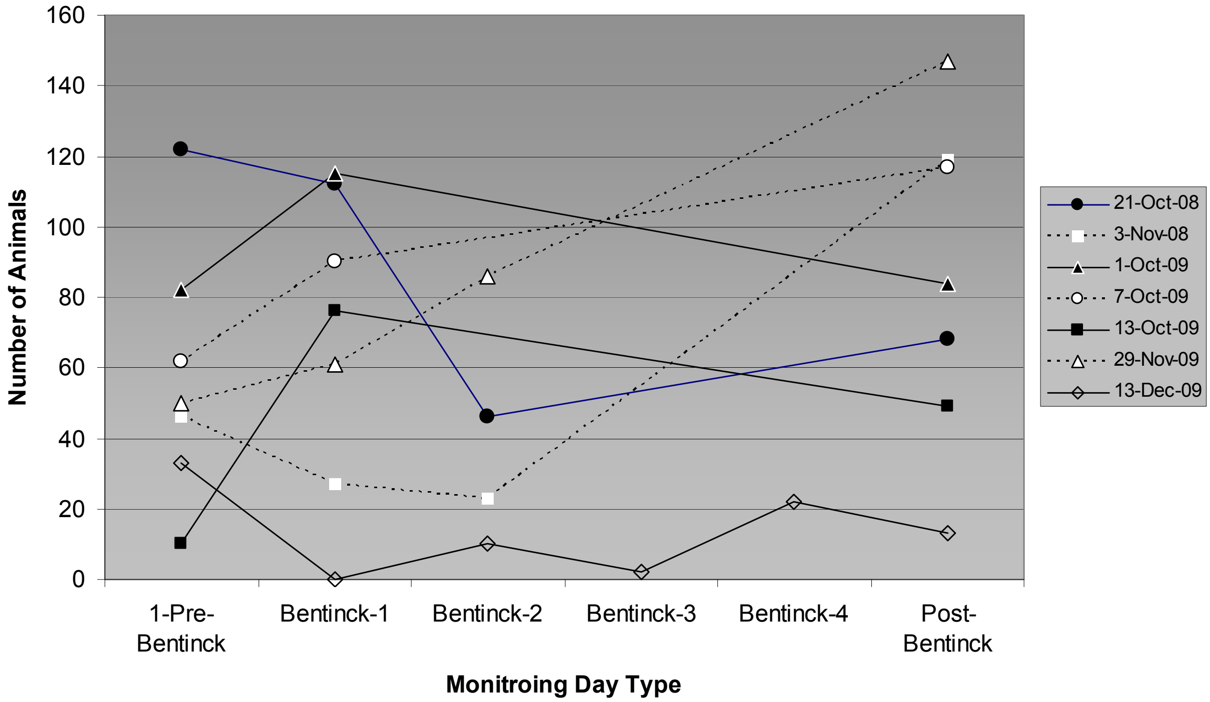

Figure 16. Total number of harbour seals in the Race Rocks census area during the afternoon (pm) counts as partition by different types of monitoring day: "1-Pre-Bentinck"= 1 day prior to blasting on Bentinck Island; "Bentinck-1" through "Bentinck-4" = (sequential) days when blasting occurred on Bentinck Island; "Post-Bentinck" = 1 day after the last day of blasting on Bentinck Island. Data from 2008 and 2009. The legend indicates the first day of each discrete monitoring session.

6. CONCLUSIONS & RECOMMENDATIONS

Monitoring since 1997 (i.e., Demarchi et al. 1998; Demarchi and Bentley 2004; Demarchi et al. 2008; Demarchi 2009; this study) has demonstrated a causal link between blast noise in WQ and pinniped responses in RRER. Blast noise raises animal activity levels and often displaces them from haulouts to the water. Steller sea lions are particularly prone in this regard.

Blasting sometimes causes sea lions to vacate a haulout, but it does not appear to displace them from RRER. Monitoring sessions in 2008 and 2009 were conducted to test the preliminary observation reported by Demarchi et al. (2008) suggesting that the magnitude of sea lion disturbance could be reduced by spacing projects at least 5 min apart. According to results presented herein, there is no compelling evidence suggesting that spacing projects by at least ~5 min constitutes a mitigation measure that notably reduces sea lion disturbance (and in particular, Steller sea lions) as compared with shorter (e.g., < 2 min) blast intervals. There is modest evidence that an extended interval of >50 min might reduce disturbance under some conditions, but the fact remains that the first detonation of the day has been observed to cause most or all of the sea lions to leave a haulout on some occasions.

Despite obvious short-term effects on animal behaviour, there is no evidence that military training in WQ causes significant adverse effects on pinnipeds in RRER. The fact that RRER is not a rookery for sea lions means that the risks of pup abandonment or trampling injuries due to blast-caused disturbances (e.g., stampedes) are very low. Nor are there any risks of acoustic trauma in the form of a permanent or temporary threshold shift in hearing. Demarchi et al. (2008) showed that blast noise from Bentinck Island typically exceeds the threshold level for behavioural responses of pinnipeds to in-air noise of 109 dBF (peak) as proposed by Southall et al. (2007; Tab. 5), but is below the level of 149 dBF (peak) proposed by those same authors (Tab. 3) as a threshold for auditory injury. Findings of the present study are consistent with Holst and Greene (2003), who concluded that, despite eliciting behavioural responses, military training exercises in California involving target and missile launches only had minor, short-term, and localized, effects on pinnipeds, with no negative consequences for the pinniped populations.

Steller sea lions that occur at Race Rocks are part of a population that has increased substantially since government-sanctioned culls were halted in the late 1960s (Bigg 1988a,b; Fisheries and Oceans Canada 2008). According to counts conducted by LGL Limited, peak numbers of sea lions at Race Rocks continue to increase – despite the fact that the Bentinck Island Demolition Range has been active since prior to when LGL Limited began monitoring in 1997.

Assuming that on-land demolition training in WQ is to continue, there are three remaining options to consider in an attempt to mitigated adverse effects: seasonal timing windows for blasting, habituation of sea lions to blast noise, and range relocation. As discussed by Demarchi et al. (2008), atmospheric conditions strongly influence noise transmission, but it is impractical to factor weather into training schedules as a means of mitigation. Options to modify charge features or demolition runs are either limited by training requirements or do not sufficiently influence animal responses to constitute effective mitigation.

Seasonal Windows – Recognizing that conditions vary among years, pinniped use of RRER follows fairly predictable, seasonal patterns (Demarchi and Holst 2008). Harbour seal pupping occurs during early–mid summer. In late summer, adult and subadult male sea lions begin arriving. Numbers of sea lions build through the autumn with the arrival of male California sea lions and of other sex and age classes of Steller sea lions (including females and juveniles). California sea lions typically depart some time in mid-late autumn, while numbers of Steller sea lions typically begin declining in early winter. Table 4 summarizes the periods when blasting would present low, moderate, and high concerns regarding potential disturbance of harbour seals (pupping) and sea lions. Note that concerns about harbour seal pupping are hypothesized; unlike effects on sea lions, blasting effects on pupping harbour seals have not been quantified (Demarchi and Bentley 2004). Considering the foregoing, the 4-month period of February–May presents the fewest concerns about the effects of disturbance on pinnipeds in RRER.

Table 4. Semi-monthly periods of sensitivity to disturbance of Steller and California sea lions and harbour seals (pupping) at Race Rocks Ecological Reserve. Green shading = low sensitivity; yellow = moderate sensitivity; red = high sensitivity. Information is based on data collected by LGL Limited, but note that the timing of animal abundance is somewhat variable.

Ecosystem Component	January		February		March		April		May		June		July		August		September		October		November		December	
Sea lion presence	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red
Harbour seal pupping	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green

Habituation – This remains the last option to explore if the Bentinck Island Demolition Range is to continue being used year-round. The success of this approach depends primarily on the ability of sea lions to learn that blasting on Bentinck Island does not threaten them and that fleeing to the water is an unnecessary response. To test this approach, experimental trials would be needed to examine the ability of sea lions to habituate to blast noise by subjecting them to impulsive noises of lower levels (e.g., large, gas cannon or very small explosive charges on Bentinck) prior to demolitions. Refer to Demarchi and Holst (2008) for further information on this approach.

Alternate Training Location(s) – During specific times of the year (e.g., late summer through early winter when sea lion abundance is greatest; Table 4), conducting demolitions at an alternate site in WQ could reduce noise propagation towards RRER, thus reducing the probability of disturbing sea lions. Presently, there are two candidate sites for consideration.

Compared to the main demolition area of Bentinck Island, detonations on a beach along the western side of the southern lobe of Bentinck Island (the "alternate demolition site" in Figure 2) resulted in lower received levels of noise at RRER and reduced levels of pinniped disturbance (Demarchi et al. 2008). Although that alternate site is similar in distance to RRER, it is behind a ~5-m rock and soil bank, and a stand of mature Douglas fir trees. These physical barriers are believed to account for most or all of the difference in noise levels received at RRER (Demarchi et al. 2008). Note that this site does not have its own safety bunker and was only used during limited trials in 2008 (Demarchi et al. 2008).

The beach associated with the Whirl Bay Underwater Demolition Range (Figure 1) is another possible alternative. That area is farther from RRER than is either the Bentinck Island or Christopher Point ranges, and line-of-sight is blocked by Christopher Point proper. Additionally, the Whirl Bay range has a safety bunker and relocating there would likely have the added benefit of reducing disturbances to harbour seals around Bentinck Island (Demarchi et al. 1998). Note, however, that Demarchi et al. (1998) documented disturbance of sea lions at RRER in response to underwater blasts in the Whirl Bay range involving charges similar in size to those used on Bentinck Island. Because in-air noise levels of above-water demolitions would exceed the in-air levels of underwater charges (i.e., water muffles the in-air noise of underwater explosions), pinnipeds in the RRER would be disturbed under certain atmospheric conditions (see Demarchi et al. 2008 for a discussion of atmospheric effects).

For greater certainty, relocating the Bentinck Island Demolition Range to the Christopher Point Ordnance Disposal Range is not believed to be a viable alternative. Compared with the main demolition area on Bentinck Island, the Christopher Point demolition area is only ~400 m farther away from any haulout in RRER and has line-of-sight to RRER. Accordingly, detonations on that range have the capability to readily disturb sea lions in RRER (this study).

Any formal plans to relocate the Bentinck Island Demolition Range – either seasonally or permanently – to another site in WQ should be proceeded by a pinniped monitoring study. The purpose of that study would be to assess the effects of trial blasting at the selected site(s) on sea lions in RRER *before* decisions on capital expenditures for range improvements or decommissioning are taken.

* * *

In conclusion, the key challenge of continuing blasting in WQ is to achieve a balance between the needs of military training and sea lion conservation. The evidence to date suggests that it is doubtful that blasting is having adverse effects on the population of Steller sea lions that use RRER. However, for all intents and purposes we will never know conclusively whether this is the case – there are too many other factors influencing population dynamics. For example, following many years of multi-million dollar research into understanding the cause(s) of decline in the western stock of Steller sea lions (i.e., Gulf of Alaska to Russia), disturbance (e.g., as studied by Kucey 2005) is not believed to have played a notable role (Guénette et al. 2006), whereas factors such as commercial fishing, predation, inter-specific competition, and ocean productivity likely did.

The risk of pinniped disturbance in RRER by demolitions training will persist as long as explosives are detonated in WQ at times when pinnipeds are present. As a species of *Special Concern* and on Schedule 1 of *SARA*, and considering the content of the proposed *MMRs*, conservation concerns surrounding Steller sea lions are likely to remain constant or even grow in the future, regardless of whether or not population-level effects occur. Further, if Race Rocks eventually becomes a Marine Protected Area (it is presently an Area of Interest for Marine Protected Area status[18]), public and agency concerns regarding the marine life within it can only be expected to increase. In this regard, proactive measures to address sea lion disturbance by military operations are prudent. This includes ongoing communications and education with stakeholders, ongoing research into mitigation options, and publishing one or more peer-reviewed, scientific manuscripts demonstrating the minor, short-term, and localized, effects blasting apparently has on pinnipeds in RRER.

[18] http://www.dfo-mpo.gc.ca/oceans/marineareas-zonesmarines/mpa-zpm/index-eng.htm

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Appendix I. Date and time of detonations in WQ monitored* by LGL Limited since 2002. Blast codes: BI=detonation on the main demolition area of Bentinck Island; BI_Alt=detonation on the alternate site on Bentinck Island (see Figure 2 and Demarchi et al. 2008); CP=detonation on Christopher Point (CFAD); WB=underwater detonation in Whirl Bay. All Bentinck Island projects consisted of 1–4 slabs (0.56 kg/slab) of C4 plastique explosive plus blasting caps and detonation cord. Actual charge sizes are indicated, in parentheses, for demolitions on Bentinck Island from 2007-09. Detonations on Christopher Point comprised a wide assortment of explosives and explosive accessories. Detonations in Whirl Bay consisted of 1–41 slabs of C4 detonated in shallow water.

Date	Time	Code
07-Oct-02	13:50:29	BI
07-Oct-02	13:52:37	BI
10-Oct-02	09:26:45	BI
10-Oct-02	09:29:15	BI
10-Oct-02	10:13:33	BI
10-Oct-02	10:15:46	BI
10-Oct-02	11:09:40	BI
10-Oct-02	11:11:55	BI
10-Oct-02	11:14:00	BI
24-Oct-02	11:26:36	BI
24-Oct-02	11:28:38	BI
24-Oct-02	11:30:46	BI
24-Oct-02	12:15:10	BI
24-Oct-02	12:17:09	BI
24-Oct-02	12:19:14	BI
24-Oct-02	13:00:15	BI
24-Oct-02	13:02:24	BI
24-Oct-02	13:04:19	BI
08-Nov-02	09:24:57	BI
08-Nov-02	09:26:45	BI
08-Nov-02	09:28:48	BI
08-Nov-02	10:16:15	BI
08-Nov-02	10:18:39	BI
08-Nov-02	10:20:43	BI
08-Nov-02	11:04:47	BI
08-Nov-02	11:06:35	BI
08-Nov-02	11:08:30	BI
08-Nov-02	11:52:50	BI
08-Nov-02	11:54:39	BI
08-Nov-02	11:56:40	BI
08-Nov-02	13:08:06	BI
08-Nov-02	13:09:58	BI
08-Nov-02	13:11:55	BI
08-Nov-02	13:42:41	BI
08-Nov-02	13:46:31	BI
02-Dec-02	10:57:38	WB
02-Dec-02	10:59:44	WB
02-Dec-02	11:01:35	WB
02-Dec-02	11:03:31	WB
02-Dec-02	11:05:00	WB
02-Dec-02	12:16:01	WB
02-Dec-02	12:16:34	WB
02-Dec-02	12:17:09	WB
02-Dec-02	13:20:08	WB
02-Dec-02	13:20:59	WB
02-Dec-02	13:21:00	WB
02-Dec-02	13:21:52	WB
02-Dec-02	13:22:59	WB
02-Dec-02	14:22:59	WB
02-Dec-02	14:23:59	WB
02-Dec-02	14:24:00	WB
02-Dec-02	14:25:02	WB

Date	Time	Code
02-Dec-02	14:25:56	WB
02-Dec-02	15:08:30	WB
02-Dec-02	15:09:37	WB
02-Dec-02	15:10:00	WB
02-Dec-02	15:10:18	WB
02-Dec-02	15:11:17	WB
05-Dec-02	10:35:16	BI
05-Dec-02	10:37:15	BI
05-Dec-02	10:49:48	WB
05-Dec-02	10:50:38	WB
05-Dec-02	10:51:53	WB
05-Dec-02	10:52:07	WB
05-Dec-02	11:56:35	WB
05-Dec-02	11:57:23	WB
05-Dec-02	11:58:10	WB
05-Dec-02	11:58:57	WB
05-Dec-02	12:07:57	BI
05-Dec-02	12:09:54	BI
05-Dec-02	13:04:45	BI
05-Dec-02	13:06:52	BI
05-Dec-02	13:20:25	BI
05-Dec-02	14:40:30	WB
20-Jan-03	11:03:00	WB
23-Jan-03	10:05:25	WB
23-Jan-03	10:05:47	WB
23-Jan-03	11:13:20	WB
23-Jan-03	12:33:24	WB
23-Jan-03	12:33:28	WB
23-Jan-03	12:33:36	WB
30-Jan-03	10:31:07	BI
30-Jan-03	10:33:24	BI
30-Jan-03	11:42:26	BI
30-Jan-03	11:44:45	BI
30-Jan-03	12:15:58	BI
20-Feb-03	09:21:00	CP
20-Feb-03	09:46:00	CP
20-Feb-03	09:48:00	CP
20-Feb-03	09:50:00	CP
20-Feb-03	09:51:00	CP
20-Feb-03	11:02:00	BI
20-Feb-03	11:04:00	BI
20-Feb-03	12:28:00	BI
20-Feb-03	12:46:00	BI
20-Feb-03	12:55:00	BI
20-Feb-03	13:15:00	CP
01-May-03	11:13:15	BI
01-May-03	11:15:20	BI
01-May-03	12:08:55	BI
01-May-03	12:11:09	BI
01-May-03	12:13:15	BI
02-May-03	09:42:00	BI
02-May-03	09:44:26	BI

Date	Time	Code
02-May-03	09:46:24	BI
02-May-03	10:27:00	BI
02-May-03	10:27:57	BI
02-May-03	10:32:10	BI
02-May-03	11:15:16	BI
02-May-03	11:17:23	BI
02-May-03	11:19:32	BI
02-May-03	11:54:49	BI
02-May-03	11:56:58	BI
02-May-03	11:59:11	BI
02-May-03	12:30:15	BI
02-May-03	12:32:14	BI
02-May-03	12:47:22	BI
19-Jun-03	10:38:35	BI
19-Jun-03	10:40:45	BI
19-Jun-03	12:10:54	BI
19-Jun-03	12:15:58	BI
19-Jun-03	12:42:17	BI
09-Oct-03	10:27:30	BI
09-Oct-03	10:29:35	BI
09-Oct-03	11:45:45	BI
09-Oct-03	11:48:05	BI
09-Oct-03	12:07:01	BI
27-Oct-03	11:17:40	BI
27-Oct-03	11:19:48	BI
20-Nov-03	10:51:52	BI
20-Nov-03	10:53:49	BI
20-Nov-03	10:55:50	BI
20-Nov-03	11:18:13	BI
20-Nov-03	11:20:12	BI
20-Nov-03	11:22:19	BI
20-Nov-03	11:48:57	BI
20-Nov-03	11:50:52	BI
20-Nov-03	11:52:58	BI
20-Nov-03	12:15:09	BI
20-Nov-03	12:17:06	BI
20-Nov-03	12:19:13	BI
21-Nov-03	08:39:59	BI
21-Nov-03	09:04:01	BI
21-Nov-03	09:05:53	BI
21-Nov-03	09:36:43	BI
21-Nov-03	09:38:43	BI
21-Nov-03	10:10:00	BI
21-Nov-03	10:12:07	BI
21-Nov-03	11:02:28	BI
21-Nov-03	11:04:27	BI
21-Nov-03	11:29:52	BI
21-Nov-03	11:31:52	BI
21-Nov-03	11:54:09	BI
21-Nov-03	11:56:05	BI
21-Nov-03	12:20:51	BI
20-Nov-07	9:49:26	BI(2)

Date	Time	Code
20-Nov-07	9:50:00	BI(1.5)
20-Nov-07	10:46:36	BI(3)
20-Nov-07	10:47:10	BI(2.75)
20-Nov-07	11:35:56	BI(2)
20-Nov-07	11:36:30	BI(2.75)
20-Nov-07	12:20:37	BI(2.25)
20-Nov-07	13:08:28	BI(2)
20-Nov-07	13:09:10	BI(3.25)
21-Nov-07	9:26:57	BI(0.75)
21-Nov-07	9:27:48	BI(3)
21-Nov-07	10:02:03	BI(2)
21-Nov-07	10:49:50	BI(2.25)
21-Nov-07	11:15:58	BI(2)
21-Nov-07	11:53:10	BI(4)
12-Dec-07	13:14:50	BI_Alt(1)
12-Dec-07	13:20:57	BI_Alt(1)
12-Dec-07	13:49:19	BI_Alt(2)
12-Dec-07	13:55:17	BI_Alt(2)
12-Dec-07	14:21:55	BI(1)
12-Dec-07	14:27:44	BI(1)
12-Dec-07	14:47:34	BI(2)
12-Dec-07	14:53:40	BI(2)
12-Dec-07	15:06:52	BI(2)
13-Dec-07	9:58:25	BI_Alt(2)
13-Dec-07	10:05:02	BI_Alt(2)
13-Dec-07	10:32:04	BI_Alt(4)
13-Dec-07	10:38:22	BI_Alt(4)
13-Dec-07	10:44:59	BI_Alt(4)
13-Dec-07	11:23:13	BI(2)
13-Dec-07	11:28:34	BI(2)
13-Dec-07	11:35:13	BI(2)
13-Dec-07	12:03:55	BI(4)
13-Dec-07	12:08:45	BI(4)
13-Dec-07	12:14:00	BI(4)
13-Dec-07	13:31:02	BI(3)
13-Dec-07	13:58:44	BI(3)
13-Dec-07	14:00:00	BI_Alt(2)
13-Dec-07	14:40:40	BI_Alt(2)
13-Dec-07	14:41:22	BI_Alt(2)
13-Dec-07	15:03:40	BI(2)
13-Dec-07	15:04:20	BI(2)
13-Dec-07	15:04:50	BI(2)
12-Sep-08	~20:50	BI(≤4)
22-Oct-08	12:16:51	BI(2)
22-Oct-08	12:22:03	BI(1)
22-Oct-08	12:27:06	BI(1)
22-Oct-08	14:14:12	BI(3)
22-Oct-08	14:19:28	BI(1)
22-Oct-08	14:24:46	BI(1)
22-Oct-08	15:09:55	BI(3)
22-Oct-08	15:15:05	BI(1)
22-Oct-08	15:20:31	BI(1)
23-Oct-08	09:22:22	BI(3)
23-Oct-08	09:28:07	BI(1)
23-Oct-08	09:33:22	BI(1)
23-Oct-08	10:10:05	BI(3)
23-Oct-08	10:15:20	BI(1)
23-Oct-08	10:20:40	BI(1)
23-Oct-08	11:03:10	BI(3)
23-Oct-08	11:08:13	BI(1)
23-Oct-08	11:13:24	BI(1)
23-Oct-08	13:42:43	BI(2)
23-Oct-08	13:47:50	BI(3)
23-Oct-08	13:53:12	BI(3)
04-Nov-08	10:39:22	BI(4)
04-Nov-08	10:44:35	BI(4)
04-Nov-08	11:50:50	BI(4)
04-Nov-08	11:55:52	BI(4)
04-Nov-08	14:09:19	BI(4)
04-Nov-08	14:14:34	BI(4)
04-Nov-08	15:08:35	BI(4)
04-Nov-08	15:13:47	BI(4)
05-Nov-08	10:16:24	BI(4)
05-Nov-08	10:21:42	BI(4)
05-Nov-08	11:31:00	BI(4)
05-Nov-08	11:38:05	BI(4)
05-Nov-08	12:42:52	BI(4)
05-Nov-08	12:48:03	BI(4)
05-Nov-08	14:53:01	BI(4)
05-Nov-08	14:58:22	BI(4)
06-Nov-08	09:58:00	BI(4)
06-Nov-08	10:03:25	BI(4)
06-Nov-08	11:00:58	BI(4)
06-Nov-08	11:06:09	BI(4)
10-Sep-09	12:07:42	BI(1)
10-Sep-09	12:13:44	BI(1)
10-Sep-09	12:45:36	BI(1)
10-Sep-09	12:51:16	BI(1)
10-Sep-09	13:30:05	BI(1)
10-Sep-09	13:35:32	BI(1)
10-Sep-09	14:06:41	BI(1)
10-Sep-09	14:12:06	BI(1)
10-Sep-09	14:43:12	BI(1)
10-Sep-09	14:49:19	BI(1)
10-Sep-09	15:10:19	BI(1)
11-Sep-09	10:46:59	BI(4)
11-Sep-09	10:53:59	BI(4)
02-Oct-09	10:15:30	BI(3)
02-Oct-09	11:17:13	BI(4)
02-Oct-09	12:32:07	BI(4)
02-Oct-09	12:37:46	BI(3)
08-Oct-09	10:37:43	BI(4)
08-Oct-09	10:43:20	BI(4)
08-Oct-09	12:27:21	BI(4)
08-Oct-09	12:35:31	BI(4)
08-Oct-09	13:05:15	BI(1)
15-Oct-09	09:45:45	BI(3)
15-Oct-09	10:43:15	BI(2)
15-Oct-09	11:37:32	BI(2)
15-Oct-09	13:13:10	BI(2)
15-Oct-09	14:14:23	BI(4)
27-Oct-09	10:04:14	CP
27-Oct-09	10:06:56	CP
27-Oct-09	10:46:10	CP
27-Oct-09	10:48:54	CP
27-Oct-09	11:34:05	CP
27-Oct-09	11:36:46	CP
27-Oct-09	14:14:40	CP
27-Oct-09	14:18:15	CP
27-Oct-09	15:05:10	CP
27-Oct-09	15:07:34	CP
28-Oct-09	10:20:05	CP
28-Oct-09	10:24:15	CP
28-Oct-09	11:01:31	CP
28-Oct-09	11:14:36	CP
28-Oct-09	13:57:10	CP
28-Oct-09	13:59:28	CP
28-Oct-09	15:06:35	CP
28-Oct-09	15:09:01	CP
28-Oct-09	15:38:08	CP
29-Oct-09	21:08:00	BI(3)*
16-Nov-09	11:40:00	CP
16-Nov-09	11:42:59	CP
16-Nov-09	14:04:40	CP
16-Nov-09	14:06:45	CP
16-Nov-09	14:40:50	CP
16-Nov-09	14:41:58	CP
17-Nov-09	11:56:12	CP
17-Nov-09	11:59:11	CP
17-Nov-09	13:36:56	CP
17-Nov-09	13:38:21	CP
30-Nov-09	12:45:56	BI(2)
30-Nov-09	12:51:35	BI(1)
30-Nov-09	14:04:45	BI(2)
30-Nov-09	14:10:26	BI(1)
30-Nov-09	14:50:27	BI(2)
30-Nov-09	14:55:49	BI(1)
01-Dec-09	10:05:26	BI(3)
01-Dec-09	10:10:32	BI(1)
01-Dec-09	10:15:32	BI(1)
01-Dec-09	10:56:51	BI(2
01-Dec-09	11:02:04	BI(1)
01-Dec-09	11:07:03	BI(1)
01-Dec-09	11:38:37	BI(2)
01-Dec-09	11:43:46	BI(1)
01-Dec-09	11:48:45	BI(1)
01-Dec-09	13:01:36	BI(1)
01-Dec-09	13:06:40	BI(1)
14-Dec-09	10:39:55	BI(1.5)
14-Dec-09	10:45:11	BI(1.5)
14-Dec-09	11:35:56	BI(2)
14-Dec-09	11:41:05	BI(0.25)
15-Dec-09	09:57:36	BI(4)
15-Dec-09	10:02:40	BI(3.5)
15-Dec-09	11:07:19	BI(2)
15-Dec-09	11:13:46	BI(3.5)
15-Dec-09	12:15:23	BI(3)
15-Dec-09	12:20:48	BI(3.25)
16-Dec-09	10:06:57	BI(4)
16-Dec-09	10:12:08	BI(1.75)
16-Dec-09	11:23:36	BI(1.75)
16-Dec-09	11:28:47	BI(1.75)
17-Dec-09	09:52:22	BI(3)
17-Dec-09	10:43:12	BI(1)
17-Dec-09	11:41:30	BI(3.25)
17-Dec-09	11:57:36	BI(1)

*not monitored by LGL Limited

Appendix II. Data collected during pinniped monitoring sessions at Race Rocks.

Environmental Data

Date: day, month, year of observation
Time: hh:mm:ss of observation
Air: air temperature
Wind: windspeed (knots) from the tower instrument
Wind direction: bearing off true north from the tower instrument
Sea State: Beaufort Scale 0-12
Swell Height: The extent to which swells washed over the haulouts. N=Nil; L=Low; M=Moderate; H=High
Cloud: cloud class 1=clear; 2=broken < 50% cloud cover; 3=broken >50%; 4=unbroken cloud
Rain: rain class N=nil; F=fog; M=misty; D=drizzle; LR=light rain; HR=hard rain; H=hail; S=snow
Vis: horizontal visibility class; U=unlimited; M=moderate (near Vancouver Island still visible); L=low (Vancouver Island not visible; Race Rocks visible); P=poor (not all of Race Rocks complex visible)

Census Data

A census of all marine birds and mammals on land and visible in the study area was conducted twice daily – once in the morning and once at the end of the monitoring day.
Time: hh:mm:ss of start of census for each area
Sub-Area: zone of Great Race Rock (A-H) or islet number (see Figure 2 of Demarchi and Bentley 2004)
Species: 4-letter species code
Number of individuals: count

Activity Data

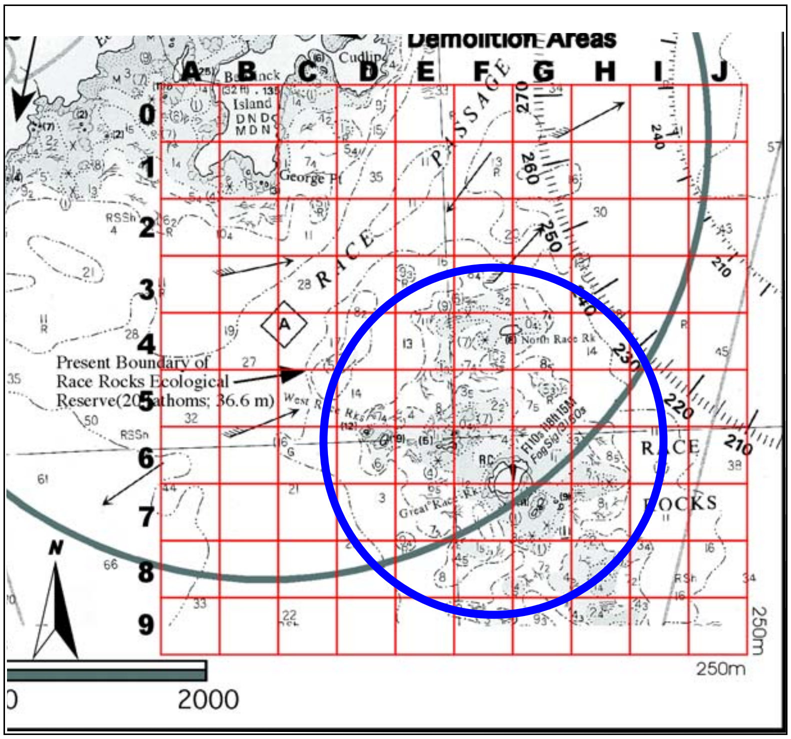
Observations of animal activity during periods of no disturbance and disturbance.

Time: hh:mm:ss of start of sample
Sub-Area: Zone of Great Race Rock or islet number sampled
Disturbance: indicate if a disturbance event is associated with this sample – Y=yes; N=no
Disturbance Type: (see below)
Species: pinnipeds
Count: total number of each pinniped species hauled out in the Sub-Area
Heads Up: number of pinnipeds with raised heads (including ones resting in this position)

Disturbance Data

Observations of potential disturbance factors.

Disturbance type: Aircraft; Bald Eagle; Blast location; Foghorn; Helicopter; Human; Kayak; Pleasure Boat < 6m; Pleasure Boat >6m; Lester B. Pearson College boat; Race Rocks boat; Whale-watching (ecotour) boat (inflatable, fiberglass, or aluminum); Other
Time Begin: hh:mm:ss when disturbance (or potential disturbance) factor entered the monitored area or departed from the helipad or dock on Great Race Rock
Time End: hh:mm:ss when disturbance factor landed/docked in the monitored area, or when it left the monitored area
Zones Entered: List all the alpha-numeric zones that the disturbance factor is present in during the observation period (see figure below).



Grid over the monitored area to track water- and land-based disturbances within blue-line perimeter.

Appendix III. Environmental conditions observed from atop the light tower on Great Race Rock during the study. Swell conditions of N=nil; L=low; M=moderate; H=high indicate the degree to which water washes over the main haulouts (e.g., Area 2-5). Sea state is per the Beaufort Scale. Could cover: 1 clear; 2 >1 and < 50% cloud cover; 3 >50 and <100% cloud cover; 4 100% cloud cover. Rain denotes precipitation level (D=Drizzle; LR=light rain; HR=hard rain). Visibility (Vis.) rates the degree to which the survey area is visible (Un=unlimited; Mod=moderate). Data on 6 Nov 08 were estimated from Bentinck Island.

Date & Time	Air (°C)	Wind (knots)	Wind Dir. (bearing)	Sea State	Swell	Cloud Cover	Rain	Vis.
11/09/2008 8:48	13	6	80	1	N	1	Nil	Un
11/09/2008 12:09	15	11	115	2	N	1	Nil	Un
11/09/2008 15:38	17	5	137	0	N	1	Nil	Un
12/09/2008 10:56	13	13	254	2	N	1	Nil	Mod
12/09/2008 12:28	13	18	262	2	N	1	Nil	Un
12/09/2008 15:03	14	20	243	2	N	1	Fog	Poor
12/09/2008 16:22	14	19	252	3	N	1	Nil	Un
12/09/2008 18:09	14	15	233	3	N	1	Nil	Un
13/09/2008 9:13	14	3	245	1	N	1	Nil	Un
13/09/2008 11:17	14	10	150	1	L	1	Nil	Un
13/09/2008 12:06	14	10	130	1	N	1	Nil	Un
13/09/2008 12:55	16	9	135	1	N	1	Nil	Un
21/10/2008 10:52	12	3	131	2	N	2	Nil	Un
21/10/2008 12:21	10	7	37	2	L	3	Nil	Un
21/10/2008 15:46	10	10	20	2	L	4	Nil	Un
22/10/2008 8:41	8	15	44	2	N	1	Nil	Un
22/10/2008 8:41	8	15	44	2	N	1	Nil	Un
22/10/2008 10:57	9	11	44	2	L	1	Nil	Un
22/10/2008 12:25	10	10	77	2	N	1	Nil	Un
22/10/2008 12:52	10	10	103	1	N	1	Nil	Un
22/10/2008 14:33	11	9	131	2	N	1	Nil	Un
23/10/2008 8:21	8	14	288	2	L	2	Nil	Un
23/10/2008 12:08	12	7	263	2	L	2	Nil	Un
23/10/2008 13:30	11	5	260	1	L	1	Nil	Un
23/10/2008 13:57	11	4	247	1	L	1	Nil	Un
24/10/2008 9:04	9	10	260	1	L	3	Nil	Un
24/10/2008 11:29	10	14	277	2	L	3	Nil	Un
24/10/2008 13:08	10	19	270	2	L	3	Nil	Un
03/11/2008 10:26	10	6	44	1	M	3	Nil	Un
03/11/2008 12:38	10	6	44	1	L	4	Nil	Un
03/11/2008 15:19	10	6	105	1	L	4	LR	Un
04/11/2008 8:56	10	30	250	6	L	3	Nil	Un
04/11/2008 10:16	10	25	245	6	L	3	Nil	Un
04/11/2008 11:50	10	23	260	6	L	3	Nil	Un
04/11/2008 13:09	10	28	265	6	M	3	Nil	Un
04/11/2008 14:34	10	28	270	6	M	2	Nil	Un
05/11/2008 8:35	6	10	67	2	N	3	Nil	Un
05/11/2008 10:14	6	13	60	2	N	3	Nil	Un
05/11/2008 11:35	7	14	56	2	L	3	Nil	Un
05/11/2008 14:34	9	20	70	4	L	4	Nil	Un
06/11/2008 8:21	12	20		6	M	4	LR	Low
06/11/2008 9:33	10	12		4	L	4	LR	Mod
07/11/2008 10:07	12	18	29	2	N	4	LR	Mod
07/11/2008 13:39	12	13	36	0	N	4	Nil	Mod
04/09/2009 10:10	15	7	57	1	N	2	Nil	Un
09/09/2009 10:20	14	10	15	1	N	3	Nil	Un
09/09/2009 12:09	15	4	57	1	N	3	Nil	Un
09/09/2009 13:07	14	5	41	1	N	4	D	Mod
09/09/2009 14:32	13	6	249	1	N	4	Nil	Un
09/09/2009 15:42	13	6	24	1	N	4	Nil	Un

Date & Time	Air (°C)	Wind (knots)	Wind Dir. (bearing)	Sea State	Swell	Cloud Cover	Rain	Vis.
09/09/2009 23:28	14	3	32	1	N	4	D	Un
10/09/2009 9:18	14	6	176	1	N	3	Nil	Un
10/09/2009 10:56	16	10	130	1	N	4	Nil	Un
10/09/2009 11:55	15	11	105	2	N	2	Nil	Un
10/09/2009 13:09	16	7	114	1	N	2	Nil	Un
10/09/2009 16:03	17	11	131	1	N	2	Nil	Un
11/09/2009 9:30	14	10	118	1	N	1	Nil	Un
11/09/2009 10:45	16	14	103	2	N	1	Nil	Un
11/09/2009 13:44	19	14	97	2	L	1	Nil	Un
01/10/2009 12:00	12	12	6	2	N	3	LR	Un
01/10/2009 13:32	11	2	71	1	N	4	LR	Mod
01/10/2009 15:28	12	1	172	1	N	3	Nil	Un
02/10/2009 8:47	10	11	275	1	N	2	Nil	Un
02/10/2009 9:43	10	10	285	1	N	2	Nil	Un
02/10/2009 11:14	10	12	275	1	N	2	Nil	Un
02/10/2009 12:14	10	12	279	1	N	2	Nil	Un
03/10/2009 10:10	10	5	95	1	N	2	Nil	Un
07/10/2009 10:18	12	9	140	1	N	2		Un
07/10/2009 14:42	13	6	150	1	L	2	Nil	Un
08/10/2009 8:46	12	6	85	1	L	2	Nil	Un
08/10/2009 10:22	11	11	99	1	L	2	Nil	Un
09/10/2009 10:29	13	7	106	1	L	2	Nil	Un
09/10/2009 11:56	12	14	45	1	L	2	Nil	Un
13/10/2009 10:00	10	28	33	5	N	4	Nil	Un
13/10/2009 11:57	11	32	42	4	L	3	Nil	Un
13/10/2009 13:28	11	28	61	4	M	3	Nil	Un
13/10/2009 15:36	12	34	99	5	M	3	Nil	Un
15/10/2009 8:44	10	16	30	2	N	3	Nil	Un
15/10/2009 11:11	11	13	30	1	N	4	Nil	Un
15/10/2009 12:50	11	15	54	1	N	3	Nil	Un
16/10/2009 10:04	14	5	350	1	L	4	Nil	Un
16/10/2009 10:44	13	8	281	1	L	4	LR	Un
16/10/2009 12:21	15	5	227	1	L	3	Nil	Un
16/10/2009 13:21	15	17	200	1	M	4	D	Un
16/10/2009 14:45	15	15	228	1	L	3	Nil	Un
27/10/2009 8:54	8	13	280	3	M	2	Nil	Un
27/10/2009 10:24	8	14	270	3	M	2	Nil	Un
27/10/2009 12:44	9	17	285	3	L	3	Nil	Un
27/10/2009 15:30	9	13	308	2	L	2	Nil	Un
28/10/2009 9:00	8	4	26	1	N	4	Nil	Un
28/10/2009 10:27	8	9	20	2	N	4	Nil	Un
28/10/2009 14:21	9	7	82	2	L	4	Nil	Un
28/10/2009 15:46	9	3	40	1	L	4	D	Un
16/11/2009 8:37	10	10	110	3	M	4	D	Un
16/11/2009 10:41	9	12	22	3	M	4	LR	Un
16/11/2009 11:47	9	16	283	3	M	4	LR	Un
16/11/2009 12:40	9	24	285	4	H	4	LR	Un
16/11/2009 13:16	9	29	260	5	H	4	HR	Un
17/11/2009 8:38	8	15	189	4	L	4	D	Un
17/11/2009 9:37	8	16	197	4	L	4	HR	Un
17/11/2009 10:41	7	14	190	4	M	3	Nil	Un
17/11/2009 11:35	7	19	175	4	H	4	Nil	Un
17/11/2009 13:25	7	17	201	4	H	4	LR	Un
17/11/2009 14:05	7	28	224	5	H	4	LR	Un
29/11/2009 9:55	9	7	120	3	M	3	Nil	Un
29/11/2009 11:15	11	0		2	M	3	Nil	Un
29/11/2009 12:32	11	4	49	2	M	3	NIL	Un

Date & Time	Air (°C)	Wind (knots)	Wind Dir. (bearing)	Sea State	Swell	Cloud Cover	Rain	Vis.
29/11/2009 13:13	11	4	164	2	L	2	Nil	Un
30/11/2009 8:55	12	23	258	4	H	3	LR	Un
30/11/2009 10:20	11	26	278	4	H	4	HR	Un
30/11/2009 11:43	9	19	294	4	M	3	Nil	Un
01/12/2009 8:53	6	9	50	1	N	2	Nil	Un
01/12/2009 10:13	7	22	42	2	L	3	Nil	Un
01/12/2009 11:26	7	26	39	4	L	2	Nil	Un
01/12/2009 12:34	7	17	37	3	L	2	Nil	Un
02/12/2009 9:45	5	15	42	2	N	2	Nil	Un
13/12/2009 10:02	1	5	300	2	N	4	Snow	Un
13/12/2009 10:57	3	2	293	1	N	4	Nil	Un
14/12/2009 8:56	2	21	28	4	L	4	D	Un
14/12/2009 10:01	2	26	14	4	L	4	D	Un
14/12/2009 10:54	2	20	15	6	M	4	Nil	Un
15/12/2009 8:42	6	20	10	3	L	4	Nil	Un
15/12/2009 9:36	6	19	28	3	M	3	Nil	Un
15/12/2009 10:57	8	27	30	4	M	4	Nil	Un
15/12/2009 12:06	7	17	56	3	M	4	Nil	Un
15/12/2009 12:52	7	27	56	4	M	4	LR	Un
16/12/2009 8:33	7	12	6	2	L	3	LR	Un
16/12/2009 9:30	7	8	21	1	M	3	D	Un
16/12/2009 11:15	7	8	26	2	H	4	HR	Un
16/12/2009 14:20	7	8	195	2	L	3	Nil	Un
17/12/2009 8:45	7	10	48	1	M	3	Nil	Un
17/12/2009 9:41	7	7	24	1	H	4	Nil	Un
17/12/2009 11:30	7	9	45	2	L	4	Nil	Un
18/12/2009 9:51	8	5	245	1	L	4	LR	Un
18/12/2009 12:24	8	0		1	L	4	LR	Un
18/12/2009 13:41	8	0		1	M	4	Nil	Un

Appendix IV. Total numbers of pinnipeds in Race Rocks Ecological Reserve as counted from atop the light tower during each of the two daily censuses (Cen. 1=A.M.; 2=P.M.) for the monitoring sessions in 2002 through December 2009. Swimming individuals are not included. Due to poor weather, complete counts were not made on 24-Oct-02, 26-Jun-03, 10-Oct-03, and 6-Nov-08. ELSE=Northern Elephant Seal; HASE=Harbour Seal; CASL=California Sea Lion; STSL= Northern (Steller) Sea Lion. Records flagged with "*" include animals on the north side of Area 13 that were counted from the water on daily trips to and from Race Rocks, respectively.

Date	Cen.	ELSE	HASE	CASL	STSL
06-Oct-02	1	0	383	170	264
06-Oct-02	2	4	208	162	255
07-Oct-02	1	1	576	137	204
07-Oct-02	2	0	117	141	159
10-Oct-02	1	1	246	119	144
10-Oct-02	2	2	92	85	209
17-Oct-02	1	2	431	94	142
17-Oct-02	2	3	231	83	250
30-Oct-02	1	2	259	34	102
30-Oct-02	2	2	316	28	149
08-Nov-02	1	5	9	28	112
08-Nov-02	2	5	22	3	91
15-Nov-02	1	0	54	19	262
15-Nov-02	2	0	92	28	287
22-Nov-02	1	0	79	28	247
22-Nov-02	2	1	131	32	295
02-Dec-02	1	2	91	70	348
02-Dec-02	2	2	186	59	528
05-Dec-02	1	1	138	35	342
05-Dec-02	2	2	152	35	365
16-Dec-02	1	2	23	45	296
16-Dec-02	2	4	32	30	317
31-Dec-02	1	2	27	13	344
31-Dec-02	2	1	57	10	401
17-Jan-03	1	4	28	1	176
17-Jan-03	2	4	80	3	245
20-Jan-03	1	2	69	0	165
20-Jan-03	2	1	37	1	161
23-Jan-03	1	4	32	0	130
23-Jan-03	2	4	110	2	203
30-Jan-03	1	4	30	1	153
30-Jan-03	2	4	0	0	60
10-Feb-03	1	7	26	6	39
10-Feb-03	2	6	79	4	29
20-Feb-03	1	6	5	0	0
20-Feb-03	2	6	4	0	0
06-Mar-03	1	3	20	5	0
06-Mar-03	2	3	1	0	0
14-Mar-03	1	3	25	1	2
14-Mar-03	2	3	94	0	0
20-Mar-03	1	2	112	6	0
20-Mar-03	2	0	50	4	1
27-Mar-03	1	2	125	6	1
27-Mar-03	2	2	255	10	0
10-Apr-03	1	10	29	22	3
10-Apr-03	2	8	196	22	0
16-Apr-03	1	14	170	57	46
16-Apr-03	2	12	50	45	41
01-May-03	1	17	197	27	10

Date	Cen.	ELSE	HASE	CASL	STSL
01-May-03	2	19	106	33	8
02-May-03	1	10	96	18	14
02-May-03	2	22	53	15	4
12-May-03	1	13	65	33	6
12-May-03	2	17	168	43	5
25-May-03	1	8	127	34	13
25-May-03	2	14	293	46	16
05-Jun-03	1	9	207	21	5
05-Jun-03	2	4	156	4	0
13-Jun-03	1	4	548	2	0
13-Jun-03	2	9	121	0	0
19-Jun-03	1	6	472	0	0
19-Jun-03	2	6	175	0	0
05-Jul-03	1	7	385	0	0
05-Jul-03	2	5	263	0	0
17-Jul-03	1	8	667	0	0
17-Jul-03	2	5	209	0	0
27-Jul-03	1	5	629	0	1
27-Jul-03	2	8	157	1	1
07-Aug-03	1	10	304	29	9
07-Aug-03	2	9	191	35	10
15-Aug-03	1	6	213	57	43
15-Aug-03	2	6	90	48	16
23-Aug-03	1	2	303	127	130
23-Aug-03	2	4	127	143	149
02-Sep-03	1	6	301	176	216
02-Sep-03	2	5	149	204	230
12-Sep-03	1	3	395	244	305
12-Sep-03	2	2	194	221	311
18-Sep-03	1	1	293	130	165
18-Sep-03	2	6	112	144	222
25-Sep-03	1	2	660	134	257
25-Sep-03	2	4	216	131	220
09-Oct-03	1	2	272	80	118
09-Oct-03	2	3	45	123	397
20-Oct-03	1	3	66	31	109
20-Oct-03	2	1	36	42	287
27-Oct-03	1	0	489	59	301
27-Oct-03	2	2	71	16	201
06-Nov-03	1	0	305	63	440
06-Nov-03	2	4	316	88	476
13-Nov-03	1	1	66	23	374
13-Nov-03	2	1	38	13	311
20-Nov-03	1	0	182	44	555
20-Nov-03	2	2	167	45	497
21-Nov-03	1	3	61	36	404
21-Nov-03	2	1	90	28	318
27-Nov-03	1	2	60	23	355
27-Nov-03	2	2	36	26	363

Date	Cen.	ELSE	HASE	CASL	STSL
19-Nov-07	1	0	26	0	210
19-Nov-07	2	0	59	0	159
20-Nov-07	1	0	25	0	203
20-Nov-07	2	0	57	0	108
21-Nov-07	1	0	26	0	129
21-Nov-07	2	0	73	0	106
22-Nov-07	1	0	1	1	67
22-Nov-07	2	0	45	0	81
11-Dec-07	1	1	29	0	166
11-Dec-07	2	0	56	0	236
12-Dec-07	1	1	28	0	244
12-Dec-07	2	1	30	0	211
13-Dec-07	1	2	18	0	226
13-Dec-07	2	2	5	0	84
14-Dec-07	1	1	9	1	225
14-Dec-07	2	2	17	1	167
11-Sep-08	1	0	120	25	107
11-Sep-08	2	3	80	44	78
12-Sep-08	1	2	190	28	95
12-Sep-08	2	1	136	38	67
13-Sep-08	1	2	201	29	88
13-Sep-08	2	3	113	31	83
21-Oct-08	1	1	83	5	251
21-Oct-08	2	1	122	6	297
22-Oct-08	1	1	111	2	144
22-Oct-08	2	1	112	0	146
23-Oct-08	1	1	117	2	94
23-Oct-08	2	1	46	4	68
24-Oct-08	1	1	156	3	137
24-Oct-08	2	1	68	4	134*
03-Nov-08	1	0	11	2	152*
03-Nov-08	2	0	46	3	177*
04-Nov-08	1	0	15	0	34*
04-Nov-08	2	0	27	1	5
05-Nov-08	1	0	34	1	118*
05-Nov-08	2	0	23	4	123*
07-Nov-08	1	0	24	0	8
07-Nov-08	2	0	119	0	57
04-Sep-09	1	1	145	99	300
04-Sep-09	2	1	84	132	288
09-Sep-09	1	0	176	173	374
09-Sep-09	2	0	66	174	268
10-Sep-09	1	0	180	197	437
10-Sep-09	2	2	71	162	116
11-Sep-09	1	2	146	155	425
11-Sep-09	2	0	64	148	447
01-Oct-09	1	0	142	628	627

Date	Cen.	ELSE	HASE	CASL	STSL
01-Oct-09	2	1	82	478	455
02-Oct-09	1	0	195	307	317
02-Oct-09	2	0	115	516	521
03-Oct-09	1	0	184	484	630
03-Oct-09	2	0	84	513	413
07-Oct-09	1	1	102	404	374
07-Oct-09	2	1	62	603	316
08-Oct-09	1	0	80	215	246
08-Oct-09	2	0	90	119	354
09-Oct-09	1	1	77	494	390
09-Oct-09	2	1	117	641	415
13-Oct-09	1	1	79	805	282
13-Oct-09	2	1	10	918	345
15-Oct-09	1	0	255	525	463
15-Oct-09	2	1	76	643	459
16-Oct-09	1	0	61	388	241
16-Oct-09	2	1	49	787	524
27-Oct-09	1	0	106	180	428
27-Oct-09	2	1	63	281	484
28-Oct-09	1	0	168	378	680
28-Oct-09	2	1	72	550	601
16-Nov-09	1	4	1	0	467
16-Nov-09	2	3	0	0	2
17-Nov-09	1	3	38	0	406
17-Nov-09	2	3	6	1	146
29-Nov-09	1	2	3	0	195
29-Nov-09	2	0	50	0	302
30-Nov-09	1	0	9	0	252
30-Nov-09	2	0	61	0	158
01-Dec-09	1	0	65	0	334
01-Dec-09	2	0	86	1	289
02-Dec-09	1	1	53	0	212
02-Dec-09	2	1	147	1	264
13-Dec-09	1	1	0	0	37
13-Dec-09	2	3	33	0	110
14-Dec-09	1	5	3	0	74
14-Dec-09	2	5	0	0	34
15-Dec-09	1	4	5	0	93
15-Dec-09	2	4	10	0	50
16-Dec-09	1	3	9	0	99
16-Dec-09	2	3	2	0	59
17-Dec-09	1	7	12	0	173
17-Dec-09	2	4	22	0	86
18-Dec-09	1	5	47	0	144
18-Dec-09	2	5	13	0	119