Night Birds Returning:

Phase 2: Invasive Black Rat Eradication from Murchison and Faraday Islands

Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site

Detailed Environmental Impact Assessment

Parks Canada Agency

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1. Project

1.1 Scope of Project

Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site (herein referred to as Gwaii Haanas) is a protected area cooperatively managed by the Archipelago Management Board (AMB). The AMB comprises representatives from Parks Canada Agency, Fisheries and Oceans Canada, and the Council of the Haida Nation. The following project has been vetted through, and received the full support of the AMB.

The project involves the complete eradication of invasive black rats (*Rattus rattus* sp.) from two islands within the Gwaii Haanas National Park Reserve with a long-term goal of restoring nesting seabird habitat and associated ecosystem processes. The project is one of the Parks Canada Agency's Action-on-the-Ground initiatives aimed at restoring ecological integrity to parks and park reserves across Canada.

The project is Phase 2 of the 5 year *Night Birds Returning* program ("night birds" as translated from the Haida language are "ancient murrelets") which aims to restore nesting seabird habitat and ecosystem processes on selected islands within the Gwaii Haanas National Park Reserve. Phase 1 (completed in 2011) consisted of the eradication of invasive Norway rats (*Rattus norvegicus*) from the Bischof Islands and Arichika Islands.

Phase 2 of the *Night Birds Returning* initiative has the following objectives:

- Complete and permanent eradication of black invasive rats (*Rattus rattus sp.*) from Murchison and Faraday Islands (728ha)
- Reduced threat of rat invasion to adjacent rat-free Ramsay Island and enhanced protection of its globally significant seabird colonies
- Enhanced breeding success of several species of seabird, including the federally listed Ancient Murrelet, a Species-at-Risk
- Restoration of native ecosystem processes
- Recovery of other floral and faunal populations negatively impacted by rats
- Develop partnerships with local and international partners (e.g. Haida Nation, Island Conservation Canada)
- Build awareness and support of Gwaii Haanas' protection and monitoring programs through outreach and education about ecological integrity and the impacts of introduced species to local culture and ecology
- Improve visitor experience through restoration of these popular visitor destinations, and
- Significantly improve the Gwaii Haanas website through the addition of interactive, web-friendly content.

Rat eradication on Murchison and Faraday islands will be undertaken by an aerial broadcast of bait containing a brodifacoum rodenticide at a designated application rate across the two islands. Bait is applied using a helicopter with a spreader bucket using multiple low-altitude parallel swaths of the island's emergent land area. The helicopter pilot will follow flight lines guided by Global Positioning System (GPS) to ensure accuracy of coverage. Hand-broadcast of bait will also be required for smaller islets and where aerial broadcast is not appropriate or feasible.

The project requires the reduction of introduced hyperabundant Sitka Black-tailed deer (*Odocoileus hemionus sitkensis*) on the target islands prior to rat eradication implementation. Introduced deer pose a risk to rat eradication success since they are likely to compete for bait thereby reducing bait availability for rats, and hence potentially compromising rat eradication success. In addition, if deer succumb to rodenticide through direct consumption of the baits, their carcasses will pose a secondary poisoning risk to avian scavengers and other non-target species. A cull of approximately 200 introduced deer will be undertaken on the target islands prior to commencement of aerial baiting operations for rats, and will involve of a range of sequential techniques to ensure cull success and to reduce deer wariness. Techniques include shoreline culling through shooting from boats, attractants at baiting stations, tree stand-hunting, corral and box trap capture and a line drive. Culls will be conducted by Parks Canada personnel and contracted personnel. Meat from the culls will be gifted to the Haida Gwaii Watchmen program and some carcasses disposed of off-island (i.e. deposited on adjacent islands at some distance from the target islands) to reduce possible increases in food sources for rats on the target islands. The details of this cull are discussed at appropriate places within this Detailed Environmental Impact Assessment.

1.2 Background

1.2.1 Impacts of Invasive Rats on Island Ecosystems

The impacts of introduced predatory mammals are one of the leading causes of species extinction on islands (Blackburn et al. 2004; Duncan and Blackburn, 2007). Rats living in close association, or commensally, with humans (Towns et al., 2006) have been introduced to 90 percent of the world's islands and have a pronounced impact on island ecosystems. In addition, the extinction of many island mammals, birds, reptiles and invertebrates has been attributed to the impacts of invasive rats (Andrews 1909; Daniel and Williams, 1984; Meads et al., 1984; Atkinson, 1985; Tomich, 1986; Hutton et al., 2007). It is estimated that 40-60 percent of all recorded bird and reptile extinctions globally have been caused by invasive rats (Atkinson, 1985).

Even if species are not extirpated, rats can have negative direct and indirect effects on native species and ecosystem function. For example, comparisons of rat-infested and rat-free islands, and pre- and post-rat rat eradication experiments, have shown that rats depress population size and recruitment of birds (Mulder et al., 2011; Campbell, 1991; Thibault, 1995; Jouventin et al., 2003), reptiles (Whitaker, 1973; Bullock, 1986;Towns, 1991;Cree et al., 1995), plants (Pye et al., 1999) and terrestrial invertebrates (Bremner et al., 1984;Campbell et al., 1984). Of great public concern, rats have significant negative impacts on seabirds, consuming eggs, chicks and adults and causing seabird population declines, with the most severe impacts on highly vulnerable burrow-nesting seabirds (Atkinson, 1985; Kaiser et. al., 1997; Towns et al., 2006; Jones et al., 2008). Seabird species that nest in high density colonies are particularly vulnerable to rat predation. Rat invasion of even very small islands, is of great concern due to potentially large population effects on seabird population viability. The seabird species nesting on Murchison and Faraday Islands include ground-nesting Ancient Murrelet, Cassin's Auklet, Leach's Storm Petrels and Fork-tailed storm petrels. These species lay only 1 egg each year, with the exception of the Ancient Murrelet which may lay 2 eggs. As a result, these species are highly vulnerable to rat predation.

In addition to direct predation of seabirds, rats feed opportunistically on plants and alter the floral communities of island ecosystems (Campbell and Atkinson, 2002), in some cases degrading the quality of nesting habitat for birds that depend on the vegetation. On Tiritiri

Matangi Island, New Zealand, ripe fruits, seeds and understory vegetation showed significant increases after rats were eradicated (Graham and Veitch, 2002). Rats can also affect the abundance and age structure of intertidal invertebrates (Navarrete and Castilla, 1993), directly and indirectly affecting species richness and abundance of a range of invertebrates (Towns et al., 2009). Rats have contributed to the decline of endemic land snails in Hawaii (Hadfield et al., 1993), Japan (Chiba, 2010) and American Samoa (Cowie, 2001).

There is also increasing evidence that rats alter key ecosystem properties. For example, total soil carbon, nitrogen, phosphorous, mineral nitrogen, marine-derived nitrogen and pH are lower on rat-invaded islands relative to rat-free controls (Fukami et al., 2006). In rocky inter-tidal habitats, invasive rats have indirectly affected invertebrate and marine algal abundance, changing intertidal community structure from algae to invertebrate dominated systems (Kurle et al. 2008). Such changes are a result of indirect negative effects of rats causing a reduction in seabird populations; rat predation often drives seabird colonies to near-extirpation (Moller, 1983; Atkinson, 1985; McChesney and Tershy, 1998), resulting in the loss of seabird-derived nutrients on islands (Fukami et al., 2006). Where rats co-exist with other predators (such as cats or predatory birds), the collective direct impact of introduced predators on seabirds is greater than the sum of the individual impacts because rats also act as a food resource to higher level predators when seabirds are absent from the islands (Moors and Atkinson, 1984; Atkinson 1985).

Given the widespread successful colonization of rats on islands and their impact on native species, rats are identified as key species for eradication (Howald et al., 2007).

1.2.2 Impacts of Invasive Rats on Seabirds within Gwaii Haanas

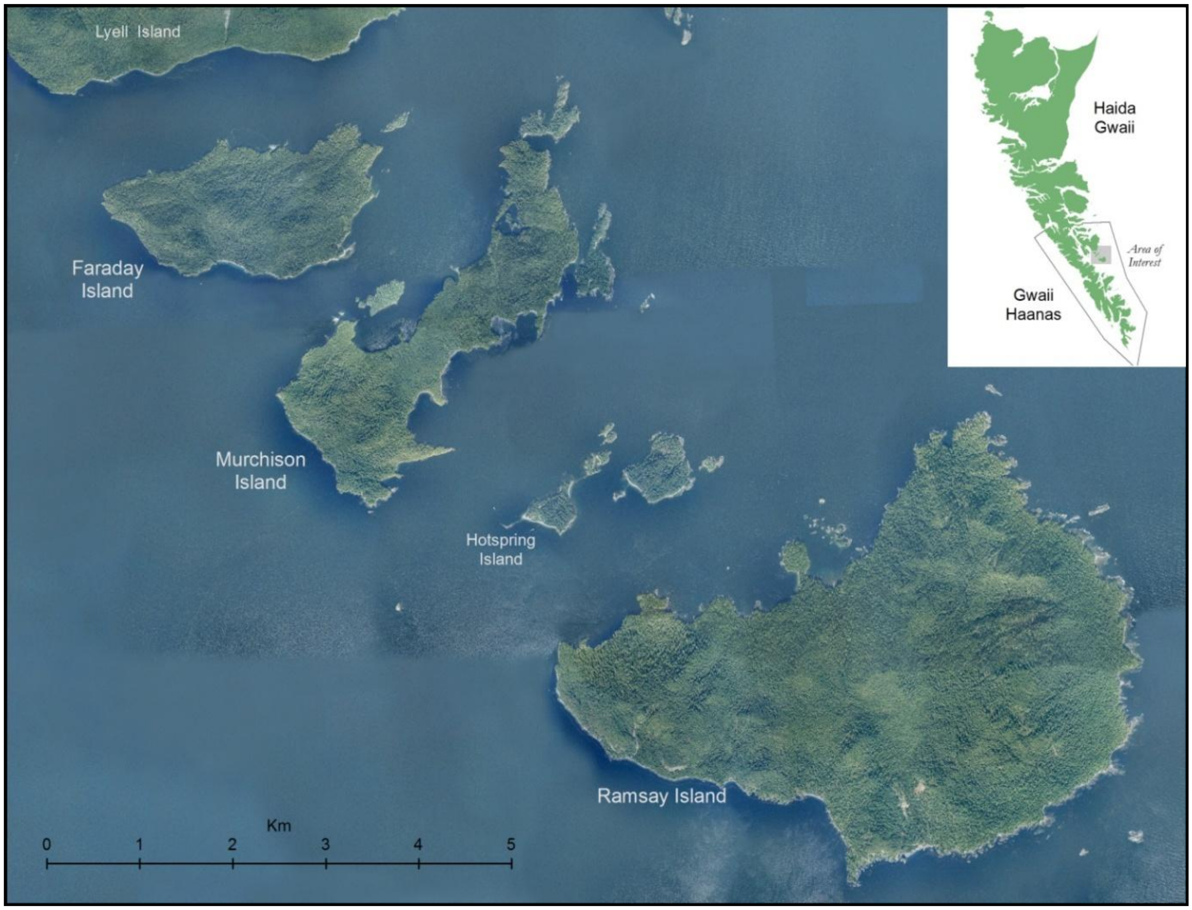

Figure 1: Murchison and Faraday Islands and their proximity to Ramsay Island.

Murchison and Faraday Islands are historically important areas for nesting seabirds. In 1977 Murchison Island supported 800 breeding pairs of ancient murrelets and 200 pairs of Cassin's auklets, as well as pelagic cormorants, glaucous-winged gulls and pigeon guillemots (Campbell and Garrioch, 1979). But by 1985, with signs of rats evident, surveys estimated the breeding population of ancient murrelets at 20 pairs and only 50 pairs of Cassin's auklets (Rodway et al., 1988). More recent surveys in the late 1990s and 2000s have found only black oystercatchers, pelagic cormorants and pigeon guillemots nesting on this island (Parks Canada, unpublished data). These species are also ground nesting with low fecundity and are vulnerable to rat predation.

Faraday Island has been the site of less survey activity but one survey (with limited search effort) conducted in 1977 found no signs of burrow nesting seabirds (Rodway et al., 1988). This suggests that rats may already have extirpated seabirds by as early as 1977. Because of its close proximity to Murchison, it is likely that rats colonizing Murchison have colonized Faraday at the same time. Monitoring conducted in 2012 by Parks Canada agency using acoustic recording units, suggests that there may be some prospecting Ancient Murrelets still active on Faraday but this is yet to be confirmed (C. Bergman, pers. comm.. February 7, 2013).

Murchison and Faraday Islands have also supported at least nine nesting sites for bald eagles and there are a number of additional eagle nest sites on adjacent islands (Parks Canada unpublished data). Monitoring of annual fledging success of bald eagles within Gwaii Haanas indicates that annual fledging success between 1998 and 2011 was higher (94%) on rat-free islands, compared to rat-infested islands (62%); further, it was speculated that this is most likely due to the presence of seabirds which are a low-cost food source for eagles (Bergman and Burles, unpublished data).

Murchison and Faraday islands are considered high priorities for rat eradication due to:

1) their historical[4] importance as breeding sites for Ancient Murrelets, Cassin's Auklets, Leach's and Fork-tailed Storm Petrels;
2) the presence of suitable, historically important seabird nesting habitat;
3) their proximity to nearby rat-free islands of Ramsay, House and Hotsprings Islands which have globally significant populations of Ancient Murrelets and Cassin's Auklets;
4) their inclusion in the Ramsay and Northern Juan Perez Islands Important Bird Area (IBA);
5) High likelihood of seabirds recolonizing these islands once they are rat-free, which will bolster local and regional populations of these seabird species;
6) Relatively low probability of rat recolonization.

Today, Ramsay Island and nearby islands support some of the largest remaining colonies of Ancient Murrelets[5] in Canada (i.e. Ramsay Island - 18,000 breeding pairs, House Island – 2700 breeding pairs, Agglomerate Island – 2200 breeding pairs) and Cassin's Auklets (Ramsay Island – 13,000 breeding pairs, Alder Island – 3200 breeding pairs). Ramsay, Hotsprings and House islands are currently rat-free, yet remain at risk of rat invasion from nearby Murchison and Faraday islands due to their proximity. The accidental introduction of rats to these islands can occur through movement of vessels and other equipment, or rats swimming or drifting on debris. The eradication of invasive rats from Murchison and Faraday Islands is a critical element in ensuring on-going and long-term protection of globally significant seabird populations in this island group.

1.2.3 Alternatives considered to proposed project

In considering this project, Parks Canada Agency undertook a feasibility assessment to consider three possible methods for rat eradication of Murchison and Faraday (Parks Canada Agency 2012a). This feasibility study is available by contacting the Gwaii Haanas Field Unit. The feasibility study considered three methodological approaches for rat eradication from Murchison and Faraday including ground-based bait station method (as was used in Phase 1), hand-broadcast method and aerial broadcast. Aerial broadcast is the preferred methodological option for these islands based on the following:

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[4] In 1977 an estimated 800 breeding pairs of Ancient Murrelets were on Murchison Island. By 1984 there were 20 pairs. Rats had already been introduced more than a decade earlier hence historical colony size was likely much larger (Campbell and Garrioch, 1979; Rodway et. al. 1988).

[5] Larger Ancient Murrelet colonies on Haida Gwaii such as those at Frederick, Hippa or Rankine have either never been colonized by rats or, as in the case of Langara, are now rat-free as a result of rat eradication undertaken in the mid-1990s by the Canadian Wildlife Service.

Eradication efficacy
Aerial broadcast operations maximize bait-exposure probability for every target individual, ensuring bait is present in all potential rat territories on Murchison and Faraday islands including inaccessible coastal cliffs, bluffs, or other steep, rocky areas. In addition, bait is readily available to all rats at the same time thereby reducing inter- and intra-species dominance which can occur when using bait stations when animals defend stations.

Reduced Level of Disturbance to Vegetation, Soil and Wildlife
Aerial broadcast method results in a significantly shorter eradication duration (i.e. two applications, usually 7–14 days apart) compared to a bait station approach (i.e. stations serviced every 2 days for a period of several months and then maintained for 2 years); hence the level of disturbance to vegetation, soil and wildlife is reduced. An aerial broadcast does not require continued access to the bait stations via the development of trails. In addition, the short duration of this approach means the periods of direct and indirect exposure period for non-target species are significantly shorter (i.e. weeks/months vs. up to two years or longer for bait stations).

Personnel safety
Murchison and Faraday islands have significant areas of steep and inaccessible terrain (i.e. coastal bluffs, rocky outcrops) which are havens for rats. An aerial broadcast method reduces risk of injury to field personnel, particularly during the fall months when weather constraints can add to risk. In addition, fewer personnel are involved over a shorter period of time reducing fatigue of personnel.

Likelihood of Success
The feasibility study concluded that an aerial broadcast approach provides the highest likelihood of success for Murchison and Faraday rat eradication.

Island Size – Cost and Time Required
On larger islands, such as with Murchison and Faraday, aerial eradications are less labour intensive and less costly than bait stations or hand broadcasting due to the smaller infrastructure and field team size required. Aerial broadcast of pellet rodenticide bait has become the most common method of rodenticide delivery on large islands (greater than 100 ha) and has been used in the majority of successful eradications globally (Howald et. al., 2007). Over the last 30 years, continued refinements to this technique have increased likelihood of success and have resulted in reduced negative impacts to non-target species. To date more than 75% of the total area treated globally has been accomplished using aerial baiting techniques (Towns and Broome, 2003, Howald et al., 2005, Howald et al., 2007).

The project is a continuation of similar work undertaken by Parks Canada Agency in 2011 (Phase 1) in which Norway rats were eradicated from the Bischof Islands and Arichika Islands using a ground-based approach (bait stations). Phase 2 differs primarily in its methodology (i.e. aerial broadcast).

1.2.4 Regulatory Reviews, Permits and Approvals

Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site (herein referred to as Gwaii Haanas) is a protected area cooperatively managed by the Archipelago Management Board (AMB). The AMB comprises representatives from Parks Canada Agency, Fisheries and Oceans Canada, and the Council of the Haida Nation. The AMB reviews and makes decisions on activities such as research, special events, and major projects. This project has been reviewed and approved by the AMB, and is consistent with the Gwaii Haanas Management Plan for the Terrestrial Area. Aircraft landings are a restricted activity within National Parks, including Gwaii Haanas National Park Reserve. An Aircraft Landing Permit will be required from the Gwaii Haanas AMB. Research and monitoring activities associated with monitoring ecological improvements associated with the rat eradication require a Parks Canada Research and Collection permit. All required research permits have been reviewed and issued by the AMB.

The *Pest Control Products Act* controls the manufacture, sale, import, and use of pesticides in Canada. The Act prohibits anyone from manufacturing, selling, or importing a pesticide unless the product has been registered under the Act, and meets prescribed standards, including packaging and labelling requirements established under the regulations. The Act is administered by the Pest Management Regulatory Agency, an agency under the authority of the Minister of Health. The Act is designed to regulate a wide variety of pesticides including fungicides, insecticides, and herbicides as well as anti-microbial agents such as disinfectants, swimming pool chemicals, and wood preservatives.

Health Canada's Pesticide Management Regulatory Agency (PMRA) must approve the registration of the aerial formulation of the bait containing the rodenticide for use in Canada for this project prior to commencement of aerial baiting operations. Parks Canada is working with Bell Laboratories Inc (Madison, WI) to facilitate the registration of Brodifacoum 25W Conservation Pellets®. This product will be registered only for use by, and under supervision of, government agencies for eradication of non-native rats and mice from islands for conservation purposes. An application to register this product was submitted by Bell Laboratories Inc. in October 2012 and approval of registration is expected in July 2013. As part of the registration process, PMRA may provide further requirements and/or recommendations for the use of the bait product for projects like those outlined here.

Under the *Species at Risk Act* (SARA), Parks Canada is responsible for the protection and recovery of listed species found in national parks, national marine conservation areas, national historic sites and other protected heritage areas administered by Parks Canada. Parks Canada also works with other federal government departments to protect species at risk, including Fisheries and Oceans Canada (for aquatic species) and Environment Canada (for all other species). Hence for the project proposed here Parks Canada has a responsibility to ensure that the project activities outlined here are SARA compliant by issuing a permit. A permit can be issued through the Environmental Assessment or can be addressed through a Recovery Plan or Action Plan in which there s an authorization of the activities that promotes the recovery of the SAR. Parks Canada has determined that SARA permits for Northern Goshawk *laingi*, Saw-whet Owl and Haida Ermine are required (R. Vennesland, email comm., April 9, 2013), and the process for obtaining these permits is underway.

Parks Canada Animal Care Committee review is required to ascertain that protocols used for handling rats (i.e. use of radio telemetry during efficacy monitoring as described in section 8.1) and protocols for introduced deer cull meet Parks Canada standards for Animal Care. An application was submitted to the Parks Canada Animal Care Committee in February 2013 and approval was granted on March April 3, 2013.

The Migratory Birds Convention Act prohibits the destruction of nests and eggs of migratory bird species. Because the eradication is occurring in September and October when nesting season has been completed for migratory birds, and because most migratory species will not be present on the island, risk to migratory birds will be mitigated. However, there is a possibility that some individual adult birds (i.e. glaucous-winged gulls) may be impacted by secondary poisoning or may consume bait pellets. Parks Canada has sought advice from Environment Canada to ensure that mitigative measures outlined in this EIA are adequate to sufficiently address risk and minimize impacts to migratory birds (see section 4.1). The response from Environment Canada was that there is no authorization or approvals process in place for incidental mortality from this kind of project (Gary Donaldson, pers. comm.)

The Fisheries Act is federal legislation that governs protection of fish habitat (both physical habitat and water quality). Section 35 of the Act deals with Harmful Alteration, Disruption and Destruction of fish habitat. Section 36 of the Act prohibits the deposit of deleterious (toxic or harmful) substances into fish-frequented waters or in a place or under conditions where it may enter fish-frequented waters (see Section 36(3) of Fisheries Act). The Act prohibits persons from depositing, or permitting the deposit, of deleterious substances into waters frequented by fish, unless the deposits are of the type, quantity, or concentration authorized by regulation. Deleterious substances are defined under the Act as any substances that, if added to water, would degrade or alter the quality of the water so that it is rendered deleterious to fish or fish habitat, or to the use by humans of fish that frequent the water. Deleterious substances may include substances considered toxic, such as industrial chemicals and pesticides.

Parks Canada has determined through engagement with Fisheries and Oceans Canada that an authorization under section 35 of the Fisheries Act for possible harmful alteration or destruction of fish habitat is not required (R. Talbot, email comm. February 26, 2013). A Scientific License to undertake sampling of marine invertebrates is required by Fisheries and Oceans Canada (R. Talbot, email comm. February 26, 2013).

Fresh water features are considered optimal rat habitat. It is therefore critical to ensure that there are no baiting gaps in the vicinity of the temporary streams on Murchison and Faraday islands. Because these temporary streams are non-fish bearing, any bait entering them during the aerial broadcast operation is predicted to have little or no impact on fish habitat or fish life. Creating a ‘no bait’ buffer around these streams would be extremely challenging due to terrain and vegetation cover and may result in the presence of baiting gaps, thereby increasing the risk of eradication failure.

Nonetheless, to ensure that this project does not contravene the *Fisheries Act*, further engagement with Environment Canada regarding Section 36 of the Fisheries Act which regulates the deposition of deleterious substances in water bodies was initiated by Parks Canada to determine if incidental deposition of rodenticide into non fish-bearing intermittent streams would contravene Section 36 of the *Fisheries Act*. Environment Canada’s response (M. Pagé, April 30, 2013) to this question and a review of a draft of this DEIA was:

- Environment Canada is unable to advise if this project and planned mitigation measures will avoid contravening Section 36 of the Fisheries Act or not, and are strongly encouraging that all reasonable measures are taken to ensure compliance with that particular section of the *Fisheries Act*, including (but not limited to) mitigating measures outlined within the DEIA;

- Regulations to authorize deposits of certain deleterious substances have been established for key industry sectors pursuant to Section 36 (e.g., pulp and paper, metal mining) but none exist for this type of application;
- Environment Canada does not have authority under the *Fisheries Act* to issue such approvals, authorizations, permits or other certifications of any kind related to the deposit of deleterious substances in contravention of the Act.

Although the project is not occurring on provincial land, as part of best practices, personnel involved in the handling of the bait will be trained in appropriate bait handling procedures and will receive a Provincial Pesticide Applicator's License.

1.2.5 Conformance with relevant Parks Canada Policy

This project is consistent with Parks Canada policy, directives and management plans.

The Gwaii Haanas Management Plan for the Terrestrial Area identifies introduced species, including rats, as key threats to the ecological integrity of the park reserve and calls for "the preparation and implementation of plan(s) to manage introduced species in order to minimize their impacts on indigenous species and their habitats" (Archipelago Management Board, 2003).

In response to the negative ecological impacts caused by introduced invasive rats, Gwaii Haanas National Park Reserve has developed a Rat Management Strategy (Burles, 2009) which prioritizes islands for rat eradication based on conservation value. This strategy has informed the development of the proposed project and has identified rat eradication on these islands as a high priority for seabird conservation and ecosystem restoration.

The project conforms also with Parks Canada Agency's Directive 4.4.11 (*Management of Hyperabundant Wildlife Populations*).

Under the *Species-at-Risk Act (S.C. 2002, c. 29)* in Canada, federal management plans and recovery strategies identify conservation strategies and management actions for a number of species in decline. The Management Plan for Ancient Murrelet in Canada identifies introduced mammalian predators, particularly rats, as the highest priority threat to Ancient Murrelet populations and establishes a management objective to maintain or increase the current breeding population within the Canadian range (Environment Canada, 2012). Recovery strategies for other federally-listed Species-at-Risk in Canada, including for the endemic Saw-whet Owl *brooksi* subspecies (*Threatened* in Canada), the endemic Northern Goshawk *laingi* sub-species (*Threatened* in Canada) and the Haida Ermine (*Threatened* in Canada) also identify invasive species as having detrimental effects on these populations. Rats are nest predators of Saw-whet Owls and have been linked to a decrease in native mice and shrew populations, which are important prey species for both Saw-whet Owl and Haida Ermine (Parks Canada Agency, 2012; Parks Canada Agency, 2011). Predator access to eggs and juveniles has potential negative impacts to goshawk recovery (Parks Canada Agency 2012). Rat eradication will benefit all these species.

1.3 Project Description

1.3.1 Bait Application Rate and Methodology

Bait will be broadcast by helicopter (Bell 206B Jet Ranger or equivalent) using a bait bucket and will consist of multiple low-altitude (45-150m above ground) parallel swaths of Murchison and Faraday Island's emergent land area including nearby islands (Murchison Passage, Little Faraday, and East Murchison islands) as well as adjacent islets. The helicopter pilot will follow flight lines guided by a Geographical Positioning System (GPS) to ensure accuracy of coverage. In order to prevent uneven coverage or gaps in application subsequent flight swaths will overlap the previous swaths by 50%.

The first bait application (rate: 16kg/ha) will be applied to the entire land mass of Murchison and Faraday islands, as well as associated smaller islands, and islets. In order to maximize the chances of eradication success a second application of bait at a reduced rate (12kg/ha) will occur approximately 14-21 days (weather dependant) after the first to minimize the likelihood of missing competitively inferior adult rats or juvenile rats that survive the initial broadcast because they did not have an opportunity to feed on bait. The reduced target application rate for the second broadcast accounts for an expected reduction in the number of bait consumers (rats) following the first bait application.

Associated islets and a built structure (abandoned settler's cabin on Murchison Island) will be baited using hand-broadcasting techniques (using same application rates) as it is not feasible to do these areas by helicopter.

Bait will be applied according to the approved Pest Management Regulatory Agency (PMRA) label for Brodifacoum 25W Conservation Pellets®.

Approximately 25,084kg of bait (Brodifacoum 25W Conservation Pellets®) is required for two applications on Murchison and Faraday islands' 728ha of emergent land. An additional 15% of this amount will be made available as contingency bait. The contingency bait will be used to fill in significant (≥ 10m) gaps between bait swaths and also to replace spoiled, spilled, or otherwise unusable bait.

Along coastlines a directional deflector will used to control the direction bait is distributed from the bucket. The directional deflector will broadcast bait to the onshore side of the helicopter, to minimize bait drift entering the ocean on the opposite, or seaward, side. Additionally, the hopper may be used with the broadcast motor off and spinner removed to sow narrow swaths of bait onto land areas that are less than 25m and greater than 10m wide.

When the fundamental goal of the bait application for rat eradication is to "leave no gaps," higher than anticipated bait application rates can occur when transitioning from one baiting zone to the next. Due to the uneven nature of any coastline the inland flight paths on a target island will inevitably result in areas of the coastal fringe receiving no bait coverage above the mean high tide line. In order to ensure that no bait gaps occur along the coast, a perimeter run is made with a directional deflector mounted on the bucket to minimize bait drift entering the marine environment following the inland bait application. A second coastal perimeter run located inland from the first run is also completed to further reduce the probability of baiting gaps where the coastal and inland zones meet. These perimeter runs are crucial to minimize risk of bait coverage gaps because coastal areas are prime rat habitat. As a consequence there will be an area of overlap between bait applications along the coast and the inland zone. This can result in a greater amount of bait being applied to the area of overlap, which may result in a higher than expected application rate in these areas compared to other parts of the island. While attempts can be made to minimize overlap zones, it is not possible to anticipate how much overlap will occur prior to the operation as this will depend on factors, such as wind, encountered on the day of the bait application.

Concurrent to the aerial bait application, three to five personnel trained in hand broadcast baiting and who also have a provincial pesticide applicators certificate will treat rocky islets adjacent to Murchison and Faraday islands (Figure 2) that remain above water at high tide and that are too small for aerial broadcast. The hand broadcast team will apply bait at the prescribed application rate set for the first and second bait application (16kg/ha and 12kg/ha respectively). Islets identified for hand broadcast will be treated during or immediately after the adjacent area is treated by aerial broadcast. Bait will also be hand broadcast directly inside the single abandoned building on Murchison Island at a rate that does not exceed the specifications of the bait product use label.

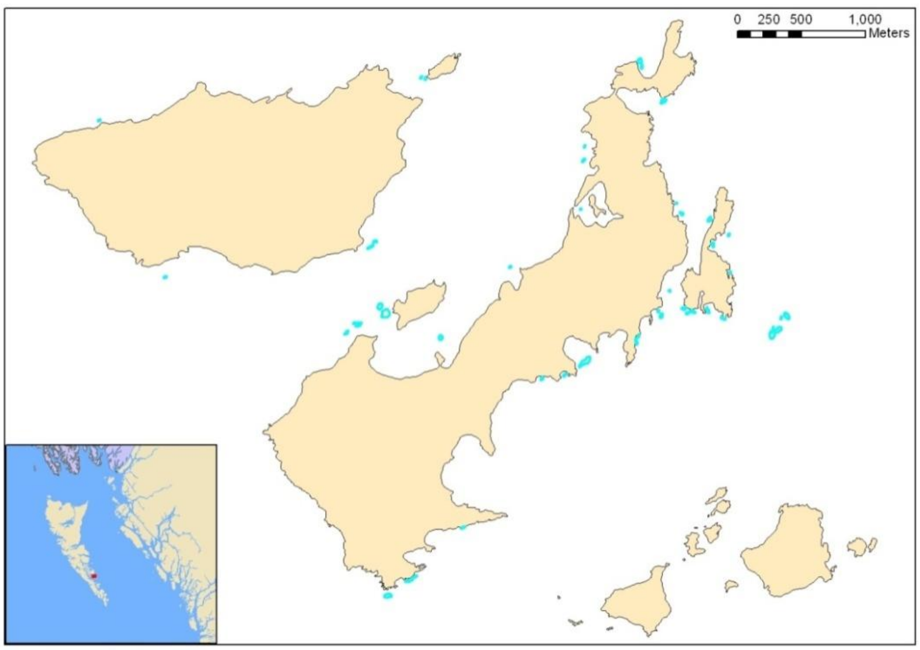

Figure 2: Associated Islets of Murchison and Faraday Islands that will be treated by hand-broadcast.

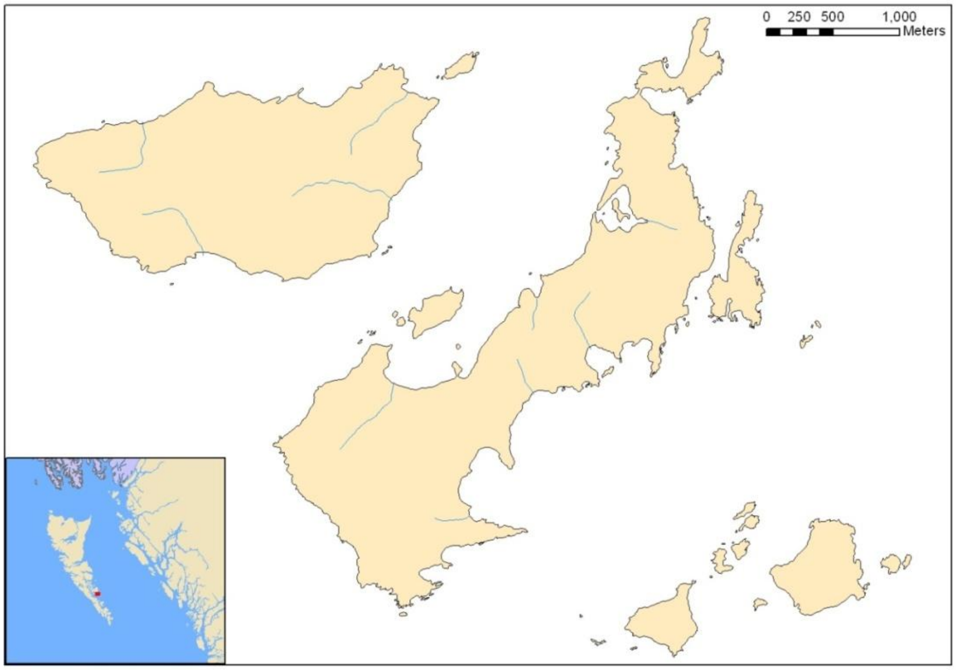

Figure 3: Location of streams (intermittent, non-fish-bearing) of Murchison and Faraday Islands.

There are ten intermittent streams on Murchison and Faraday islands (Figure 3). None of these streams have been identified as fish bearing during aquatic inventories in Gwaii Haanas conducted or summarized by Broadhead (2009) and Krishka (1997). Furthermore, no fish were observed in the streams on Murchison Island during the time when the private cabin on the island was occupied by its owners (P. Dyment pers. comm. with R. Gautier) and no fish were observed in these streams during a reconnaissance in December 2012.

Fresh water features are considered optimal rat habitat. It is therefore critical to ensure that there are no baiting gaps in the vicinity of the temporary streams on Murchison and Faraday islands. Because these temporary streams are non-fish bearing, any bait entering them during the aerial broadcast operation is predicted to have little or no impact on fish habitat or fish life.

Creating a 'no bait' buffer around these streams would be extremely challenging due to terrain and vegetation cover and may result in the presence of baiting gaps, thereby increasing the risk of eradication failure.

1.3.2 Project Schedule

The intensive eradication component, including aerial broadcast application and associated field activities will occur during September and October 2013. The first aerial broadcast application will occur on or after September 8 and 9, 2013 (weather permitting) with a second application to occur on or after September 28 and 29, 2013 (weather permitting). Logistical preparations including staging of facilities will occur in August 2013. Deer cull activities will be conducted from April 2012 through to August 2013, with a temporary suspension of culling during the last week of May and throughout June to minimize stress on animals, particularly juveniles, during peak fawning times.

A detailed project schedule outlining specific project components is provided in Table 1.

Description	August																	September																														October									
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10
Organize equipment & supplies (all purchases completed by August 1)																																																									
Calibrate bait buckets																																																									
Bait delivered to Vancouver barge company and loaded into Seaspan containers																																																									
Stage floating camp																																																									
Install and pre-bait live traps for rat radio collaring																																																									
Rat radio collaring																																																									
Biosecurity check of contract barge (Vancouver and/or Queen Charlotte)																																																									
Staging of barge (including bait) at Murchison																																																									
Arm bait stations on all facilities (floating camp, barge, work boats)																																																									
Unload/sort equipment & supplies at Murchison Camp																																																									
Off-island Personnel Arrive to Haida Gwaii																																																									
Final staff training (overview of project, practice hand baiting, etc.)																																																									
Eradication Team arrives at Murchison camp																																																									
Eradication preparations																																																									
Aerial Baiting application																																																									
Hand-broadcast application rocky islets, and abandoned cabin																																																									
Aerial baiting equipment demobilization (helicopters, bucket, barge, bait containers, etc.)																																																									
Bait station checks - all facilities																																																									
Efficacy (rat radio tracking) and non-target monitoring (carcass searches)																																																									
Camp clean-up & demobilization																																																									
Eradication Personnel Depart																																																									

Table 1: Eradication Implementation Timeline

1.3.3 Staging Facilities

The eradication activities will be staged from a contracted barge (approx 150' x 45') anchored in a bay on the south-east end of Murchison Island. The barge will have a helicopter landing zone, a bait loading area, and 3 sea containers for storage of equipment and bait.

Figure 4: Location of Staging Facilities

A floathouse (145'X25') will be anchored in the vicinity of the barge and will provide accommodation and serve as the base of operations (i.e. computer, GIS facilities, radio communications etc) office facilities for field personnel. The floathouse, which is owned by Parks Canada Agency, will provide accommodation for approximately 20 persons involved in the eradication. All wastewater (toilets, sinks, showers) will be treated using a Transport Canada-certified peroxide-based marine sanitation device. The treated effluent meets applicable national and international marine pollution regulations - Vessel Pollution and Dangerous Chemicals SOR/2012-69, and MEPC 159(55), respectively.

The Gwaii Haanas II (the park reserve's 60ft vessel) will be used to support staging operations and will provide additional accommodation to field crews.

Figure 5: Example of Contracted Barge for Baiting Operations and Existing Floathouse

1.3.4 Fuel Storage and Use

Helicopter fuel (Jet A) will be transported and staged to the project site by a contracted barge company. A total of 30 drums (205L/drum) will be stored in approved drums on the barge for a period of approximately 40 days.

All helicopter fuel will be supplied only by an accepted aviation fuel refinery or bulk dealer. The contractor supplying fuel to the project site shall indicate the source of the fuel to the helicopter contractor and to Parks Canada Agency.

In regards to the management of helicopter fuel during the project, the following safety measures will apply:

- The Pilot or Helicopter Engineer will check the Bill of Lading to ensure the fuel is of the proper grade;
- A daily free water test of all helicopter fuel, in tanks or drums, using, as a minimum, a “clear and bright test” will be performed by the pilot and/or helicopter engineer. If any doubt whatsoever exists about the test results an accepted water detection kit will be used by the Helicopter Pilot and/or engineer in accordance with fuel compliance procedures. The contracted helicopter company will be responsible for providing the water detection kits to their crews. The results of these tests will be recorded and filed at the Helicopter Operator’s base at the end of the job;
- Daily, before the commencement of fuelling operations, at least a one-half (1/2) litre sample of fuel from the drain at the filters/separator unit will be drawn and examined for the presence of water and/or sediment;
- The standpipe used to draw fuel from drum will be at least 2.5cm clear from the bottom of the drum;
- The Helicopter Pilot or the Helicopter Engineer will maintain written records of all required fuel contamination checks. These records will be available for inspection.

Fueling of helicopter will occur designated fuel area at the Loading Zone on the barge and will be undertaken only by the Helicopter Engineer or Pilot.

During helicopter refueling, the bait bucket motor will be refueled with unleaded fuel dispensed from a small jerry can. The fuel drums will be appropriately positioned with the refueling equipment and nozzle bonded to the helicopter before starting the refueling operation. To control spills, self-closing nozzles will be used and not blocked open or dragged along the ground. Additionally, a fuel catchment pan will be placed beneath the helicopter to prevent spillage onto the ground.

A fuel spill response plan will be adhered to and posted at clearly marked locations on the barge. A fuel spill kit will be kept on site.

1.3.5 Bait Storage and Disposal

Approximately 25,084kg of bait will be stored on the barge and used in the aerial broadcast. The bait will be pre-packaged by the manufacturer in 318kg bags suitable for loading into the bucket (i.e. Bulkift bags), and within a second polyethylene bag with desiccants to further protect it from moisture. These bags will be placed in weatherproof cardboard laminate pods for protection from moisture during transport and during storage. Hand-broadcast bait for use on rocky islets and other inaccessible areas will be packaged in 20L containers, which will be stored in cargo containers on the barge. For staging from Vancouver or Prince Rupert and for secure storage on island, the bait will be transported and stored in 3 high-cube freight containers of 53' ftx8'x10ft6" in size that will be secured on the barge. These cargo containers will be sourced in Vancouver or Prince Rupert and transported to Haida Gwaii by the contractor.

As per requirements by Health Canada's Pesticide Management Regulatory Agency, bait will be stored in original closed containers, in a cool, dry place inaccessible to unauthorized personnel. The freight containers will be lockable. An inventory of bait will be kept and updated regularly. Appropriate warning signage will be posted outlining the rodenticide and its appropriate uses.

All excess, unused bait will be returned to the Gwaii Haanas maintenance compound. After 6 months it may deteriorate and lose its effectiveness. After such a time any unused bait will be disposed of by Parks Canada Agency to an appropriate waste disposal facility in the lower mainland of British Columbia.

A bait spill response plan will be adhered to and posted at clearly marked locations on the barge.

1.3.6 Deer Population Reduction Prior to Baiting Operations

Introduced, hyperabundant Sitka black-tailed deer will be culled prior to the rat eradication with a view to reducing competition with rats for bait and to reduce non-target risk to avian scavengers. Because deer are attracted to the bait pellets, they may create gaps in bait coverage thereby reducing rat access and potentially compromising eradication success. In addition, if deer succumb to rodenticide poisoning, their carcasses present a risk of secondary poisoning to other non-target species (i.e. avian scavengers).

A detailed deer population reduction plan has been developed by Parks Canada (Gwaii Haanas Field Unit) which outlines a number of techniques, including shoreline hunting (from boats), hunting at attractant stations, live trapping using box traps, use of tree stand hunting and a line drive to corral animals. Two large cull efforts are planned for early April 2013 and late August 2013 respectively in which the objective is to remove approx 40-50 animals/cull. From late April to mid-August 2013, low level cull efforts using shoreline culls and attractant hunting will be used. Culling will be suspended temporarily during peak fawning times.

2 Site Description

2.1 Project Site Location

The project site is within the Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site which covers some 5000 km^2 of terrestrial area and marine waters (up to 10km off shore) in the southern portion of the Haida Gwaii archipelago, off the northwest coast of British Columbia. This area is managed cooperatively by Parks Canada Agency, Fisheries and Oceans Canada and the Haida Nation.

Murchison Island and Faraday Islands are located south of Lyell Island and northwest of Ramsay Island (See Figure 1 section 1.2.2). Ramsay Island and the northern Juan Perez Sound islands are recognized by BirdLife International as an International Bird Area, a priority area for the conservation of globally threatened species. Ramsay Island is currently rat-free and supports globally significant breeding populations of ancient murrelets (~20,800 pairs) and Cassin's auklets (~13,000 pairs) and regionally significant populations of Fork-tailed and Leach's storm petrels, pigeon guillemots, and black oystercatchers.

Faraday Island lies closest to Lyell (the nearest island with rats) hence the swimming distance for a rat is 730m at the low tide. The waters here in Faraday Passage are subject to consistently strong currents. The figure below shows approximate distances from Lyell Island (rat infested) to Faraday and Murchison Islands and their associated islets.

The project site was chosen due it significance for seabird populations, but also because risk of reinvasion form nearby rat-infested islands is manageable (i.e. rats are not likely to swim this distance). The current between Faraday Island and Lyell Island is strong and water temperatures are cool. Rat invasion is more likely due to inadvertent introductions through vessel movements. A comprehensive biosecurity protocol to reduce risk of rat introductions to islands within Gwaii Haanas is under development and available in draft form.

2.2 Project Site Size

Murchison Island is 400 ha in size and has a maximum elevation of 154m. It has two forested islets on the east and west sides and several rocky islets. Faraday Island is 316ha in size and has a maximum elevation of 198m. It has one forested islet on the east side and several small rocky islets.

Total emergent land area of both islands and associated islets is 728 ha.

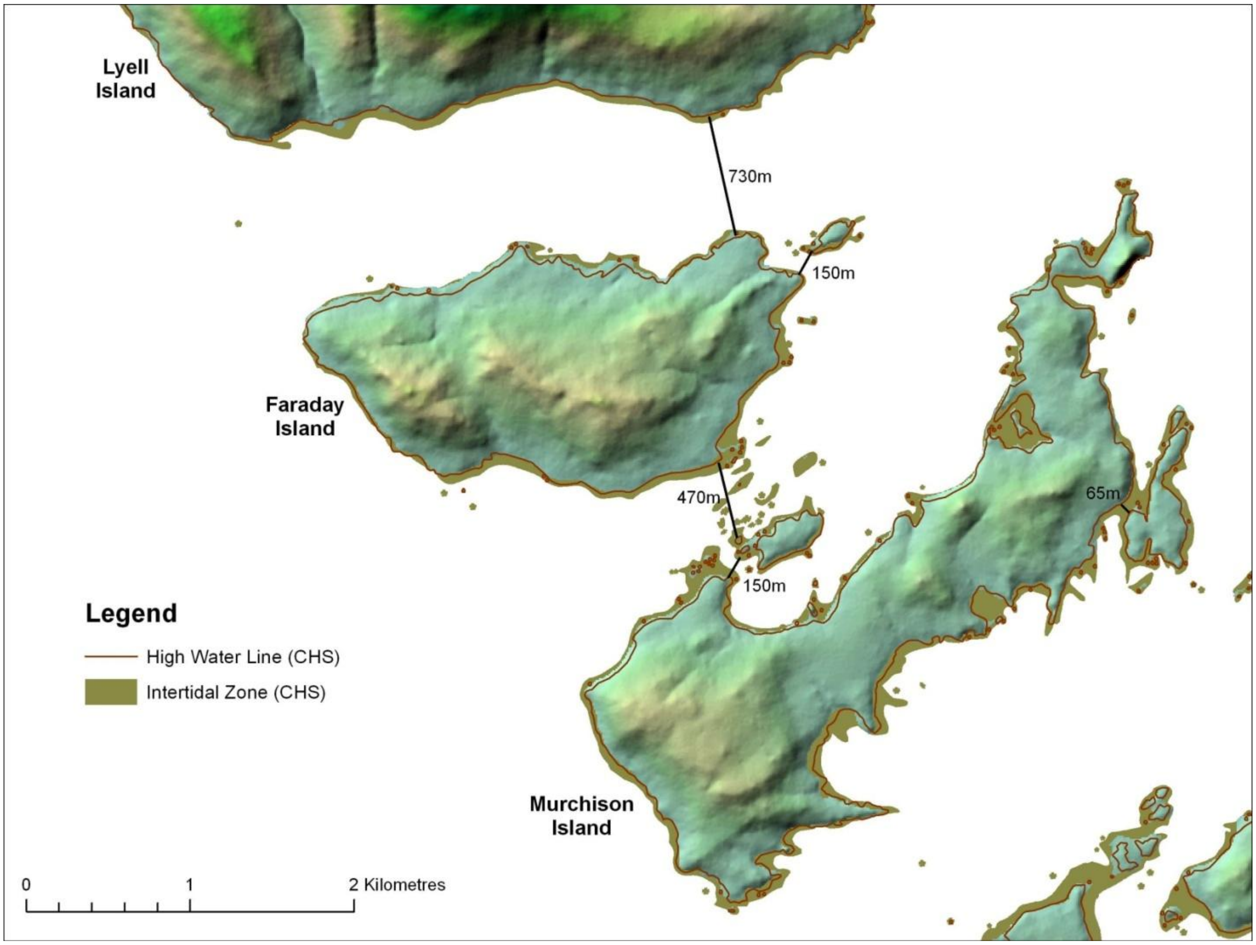

Figure 6: Distances between Lyell Island and Murchison and Faraday Islands.

2.3 Specific Land Use History

The land is completely within the Gwaii Haanas National Park Reserve, and is surrounded by the Gwaii Haanas National Marine Conservation Area Reserve. It is also a Haida Heritage Site.

Since 1995, the area has been managed cooperatively managed by the Government of Canada (Parks Canada Agency) and the Haida Nation. In 2010, the surrounding marine area was designated as a National Marine Conservation Area reserve.

The islands were historically used by the Haida. Evidence of pre-historic use of Murchison Island can be found in the archaeological record; in addition, evidence of historic hand-logging has been found. Evidence of pre-historic use has also been found in the archaeological record on Faraday Island.

2.4 Climate

Haida Gwaii is the most tectonically active area in Canada. Landslides are common due to combinations of steep slopes, intense rainfall, frequent strong winds and seismic activity.

Annual precipitation can be in excess of 5000mm per year; however the east coast (where Murchison and Faraday Islands are located) receives considerably less rain. Clouds and fog are common and relative humidity is high throughout the year. Mean annual temperature averages 7.5 C.

2.5 Geology

Haida Gwaii is one of the most tectonically active areas in Canada. Landslides are common due to combinations of steep slopes, intense rainfall, frequent strong winds and seismic activity. Colluvium is the most widespread of all surficial sediments in Gwaii Haanas. Its abundance and the prevalence of its processes of formation (weathering, mass wastage, soil creep) on Haida Gwaii is an indication of the inherent instability of this upland landscape. Gwaii Haanas is part of the most seismically active area in Canada. For Murchison and Faraday Islands specifically, there is mostly low mass movement potential, low to moderate surface erosion potential, low to no landslide deposition potential and no flooding and bank erosion potential (Westland Group, 1994).

2.6 Soil types and Geomorphology

Murchison and Faraday Islands fall within the coastal western hemlock wet hypermaritime (CWHwh) biogeoclimatic sub-zone. Soils processes in this eco-region tend to be dominated by intense weathering and leaching resulting in the formation of Humo-Ferric and Ferro-Humic Podzols.

According to the Ecological Classification of Gwaii Haanas (Westland Resource Group, 1994), the Murchison Ecosection occurs as dry, rocky headlands in exposed marine environments. The landscape is controlled by bedrock and portions of exposed rock are often prominent. Slopes are highly variable (0 to 70%, average 28%), and typically hummocky. Surface layer is described as organic veneer over bedrock and bedrock outcrops. Depth of the humus layer ranges from 1 to 58 cm (average 34 cm), and comprises poorly decomposed humus (Hemimor), and sparse, dry litter (Xeromor). Soil nutrient regime is considered to be relatively poor / acidic (oligotrophic to submesotrophic). Despite the relatively high amount of precipitation and humidity typical for this area, the soil moisture regime is considered to be relatively dry (xeric to subxeric), likely because of the well- to imperfect drainage associated with Typic Folisol soil development (upland organic material of forest origin) (Soil Classification Working Group, 1998).

2.7 Vegetation

Murchison and Faraday Islands fall within the coastal western hemlock wet hypermaritime (CWHwh) biogeoclimatic sub-zone. Here at lower elevations are classic coastal rainforests, dominated by large western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*) and red cedar (*Thuja plicata*). These forests are quite productive and would normally support common shrubs including salmonberry (*Rubus spectabilis*), black twinberry (*Lonicera involucrata*) and salal, and many herbs. However, browse pressure from introduced Sitka black-tailed deer has greatly reduced understory vegetation, save for that found on a handful of small off-shore islets and islands where deer are absent.

Within the Murchison Island Ecosection, stunted Sitka spruce and western red cedar are common, with low conifers and salal dominating the shrub layer; herbs are uncommon and often nearly absent, in response to continued deer browse (Westland Resource Group, 1994).

Figure 7: Example of Vegetation on Murchison Island

2.8 Hydrology

On Murchison Islands there are six streams, and on Faraday Island there are four streams (see Figure 3). These streams run only intermittently.

Figure 8: An example of intermittent, non-fish bearing stream on Murchison Island.

2.9 Aquatic Resources

None of the streams on Murchison and Faraday Islands (Figure 3 and Figure 8) have been identified as fish bearing during aquatic inventories in Gwaii Haanas conducted or summarized by Broadhead (2009) and Krishka (1997). None have been identified as fish-bearing based on Department of Fisheries and Oceans' Fisheries Information Summary System or escapement data. No fish were observed in the streams on Murchison Island during the time when the private cabin on the island was occupied by its owners (P. Dyment pers. comm. with R. Gautier) and no fish were observed in these streams during a reconnaissance in December 2012 (Dyment, pers. comm. December 11, 2012).

2.10 Wildlife Resources

According to the Ecological Classification of Gwaii Haanas (Westland Resource Group, 1994), the Murchison Island Ecosection is considered to be of medium to high importance for deer mouse, black bear, raccoon (introduced), land otter, bald eagle nesting, ancient murrelet nesting, and nesting songbirds. Table 2 summarizes the wildlife importance evaluations within the Ecological Classification of Gwaii Haanas.

See Section 3 for detailed description of wildlife resources, including species composition of the islands.

Wildlife (INT indicates introduced species)	**Ecosection Habitat Evaluation Criteria**	**Importance**
Deer mouse (*Peromyscus maniculatus*)	Windswept headlands & nearshore cliffs	Medium
INT Red Squirrel (*Tamiasciurus hudsonicus*)	Spruce / pine comprise 1-9% cover	Low
INT Black-Tailed Deer (*Odocoileus hemionus sitchensis*)	Herb & palatable shrub cover 20-49%	Low
Black Bear (*Ursus americanus carlottae*)	One or two of the food resources were rated as having medium abundance.	Medium
Marten (*Martes americana*)	Windswept shoreline forest and headlands	Low
INT Raccoon / Land Otter (*Procyon lotor* / *Lontra canadensis*)	Linear shoreline ecosections and rocky headlands	Medium to High
Bald Eagle Nesting (*Haliaectus leucocephalus*)	High frequency of nests per unit length of shoreline (about 0.3/km or higher)	High
Peregrine Falcon Nesting (*Falco peregrinus pealei*)	Ecosections which border 1 to 4% of Gwaii Haanas eyries	Low
Ancient Murrelet Nesting (*Synthliboramphus antiquus*)	Ecosections containing 5 to 24% of colony area	Medium
Other burrow-nesting seabirds	Ecosections associated with few nesting seabirds	Low
Surface-nesting seabirds	No known nesting by these species	Nil
Marbled Murrelet nesting potential (*Brachyramphus marmoratus*)	Other ecosections having some tree cover	Low
Nesting Songbirds	Successional vegetation (disturbance)	High

Table 2: Wildlife Importance Evaluations - Murchison Island Ecosection.

2.11 Cultural Heritage Elements & Visitor Experience Opportunities

See Section 3.2 and Section 3.3 for a summary of the cultural heritage elements and the visitor experience opportunities of the project area and potential impacts.

3 Environmental Impacts

3.1 Valued Components: Natural Resources

Valued natural resource components were selected by identifying species or groups that would potentially be present in the area, those that are directly targeted by the eradication (i.e. deer and rats), and non-target species with a likelihood to be directly impacted by bait consumption or indirectly affected through secondary poisoning. Project risks to the wildlife that are identified as being potentially present were evaluated, based on peer-reviewed literature, Parks Canada published reports, personal communications and observations, the environmental chemistry and toxicology of the rodenticide brodifacoum, and other sources of information.

The following summary of environmental fate and biological persistence of contaminants has been abridged from Wojtaszek 2000 (used with permission from the author).

Non-polar, organic chemicals dissolve poorly in polar solvents such as water. In the environment, non-polar, organic contaminants tend to go into solution with or be adsorbed to other organic compounds such as lipid [fat] or particulate organic carbon. This passive process, known as partitioning, has chemicals moving into phases (air, water, sediment, biota) in which they can achieve maximum thermodynamic and entropic stability (Mackay 1991). An important part of assessing the environmental fate of contaminants is predicting the extent to which these substances will concentrate in an organism, which could be much greater than the chemical concentrations in the organism's surroundings (Mackay 1982). A chemical's log K_{ow} is the ratio of the "ability" of 1-octanol (lipid surrogate) versus that of water to "hold" the chemical (Mackay 1991).

The log K_{ow} of brodifacoum is 8.5 (brodifacoum MSDS). This is a high value, which is greater than that of most PCBs. This high log K_{ow} is indicative of brodifacoum's preferential partitioning into non-polar environmental matrices, such as organic soils and sediments, and the fats within biological tissues.

According to Eason and others (2002 and references therein), once within an organism, brodifacoum is readily absorbed through the intestine, and concentrated in the liver, with slow depuration therefrom. Based on this information, organisms could have brodifacoum introduced into their tissues through passive exposure (e.g. dermal contact) or through ingestion.

According to the World Health Organization – Food and Agriculture Organization (2012), oral LD_{50} for rats, mice, cats, and dogs is 0.27, 0.4, 0.25, and 0.25 mg brodifacoum per kg body weight, respectively, which is considered to be extremely toxic. LD_{50} values for avians ranges from approx. 1 to 20 mg/kg (International Programme on Chemical Safety, 1995), which is considered very toxic. Brodifacoum exposure can occur transdermally; personnel handling armed bait and contaminated carcasses should do so with the appropriate personal protective equipment.

3.1.1 Wildlife

There is a minor risk of short term disturbance to any wildlife that are present, resulting from the staging barge, floating accommodations facility, helicopter and small boat activity, and the deer cull associated with the project. This is restricted to mainly Murchison and Faraday Islands; however some noise disturbance may be experienced at nearby S. Lyell Island, Hotsprings Island and House Islet.

Noise-related disturbance from helicopters will be for a total of two (2) two-day periods during the aerial application of bait. One helicopter will be used and will conduct aerial baiting operations for a total of 31 hours (approximately 8 hours/day) over the two islands.

Noise related to boat activity will occur more frequently; however, the area regularly experiences motorized watercraft traffic associated with tourist transportation to popular Hotsprings Island and boaters' use of nearby mooring buoys. The motorized watercraft noise associated with this project is not expected to have any effects above and beyond what the area regularly experiences. Any other effects of aircraft and watercraft noise specific to a group of wildlife will be identified in the following sections, as applicable.

Adverse effects from helicopter noise disturbance are forecasted to comprise temporary, short-term displacement of wildlife on or near the subject islands. These effects are considered to be negligible because of the short duration of the disturbance, the disturbance being confined to the Murchison/Faraday area, the occurrence of this disturbance outside of sensitive bird and marine mammal life stages (e.g. outside of known breeding seasons) (Harfenist et al. 2002; Heise et al. 2003, respectively), and the mobility of the wildlife in the area.

Disturbance to wildlife from deer cull activities comprises noise from firearms, watercraft (covered above) and human presence on Murchison and Faraday Islands associated with the deer cull, as well as on Hotsprings Island, House Island, and southern Lyell Island to reduce the potential for deer to immigrate to Murchison and Faraday Islands. These activities will be taking place across several 7-day periods, with the majority of activity taking place in April and again in August 2013. From April to August 2013, routine shoreline and inland culls will take place periodically with a suspension of culling activity to occur from late May throughout June to reduce stress to animals during and around peak fawning period of the first two weeks of June. This suspension also coincides with peak seal pup birthing period. The effects of the deer cull on specific groups of wildlife will be elaborated in the following sections, as applicable.

Disturbance to wildlife from the presence of the staging barge and floating accommodations is mainly restricted to the marine area that will be shaded by the presence of these facilities, areas immediately associated with the anchorage of these facilities on the sea floor, and large trees to which the floating facilities will be tied on nearby land. The marine sanitation devices installed on the floating accommodations treat both wastewater (i.e. from showers) and sewage to Transport Canada and International Marine Pollution standards. These floating facilities will be in place for approx. 4 months (June to October, 2013). Given the depth of the area (21m according to CHS marine charts), and the relatively short length of time that the facilities will be situated there, impacts to benthic communities from shading and anchoring are anticipated to be minor and transient. There is a strong likelihood that the area will recover from any impacts by the next growing season.

3.1.1.1 Birds

The timing of rodenticide bait application will be outside of the breeding season of all avians (marine birds - Harfenist et al. 2002; songbirds – C. Bergman, pers. comm. Jan.28, 2013). Therefore, the risk of rodenticide contamination being carried by breeding birds from Murchison / Faraday Islands to nests and vulnerable young located on or off-site is nil, given that there will be no birds breeding during the time where eradication activities will be taking place, and that rodenticide bait pellets are anticipated to be physically broken down and unavailable for ingestion by the next breeding season. The timing of deer cull activities and associated human presence may coincide with avian breeding seasons. There is a risk of disturbance due to firearms noise and human presence associated with the deer cull. Noise from firearms may discourage breeding birds from occupying the area, may cause birds to abandon their nests / burrows, or cause generalized stress to breeding birds and their young. For this reason, cull activities should ideally take place outside of the breeding season. Where this is impractical, long arms equipped with noise reducers should be used to minimize noise disturbance. The spatial extent of these effects are anticipated to be centered on the immediate areas where firearms will be used, extending as far as the associated noise will be carried, which depends on the firearms being used. The temporal extent of these effects (conservatively) can extend through the duration of the breeding season.

The presence of humans may cause some transient, localized disturbance. There may be trampling of burrows suitable for burrow-breeding birds. In the case where trampled burrows are unoccupied (outside of the breeding season), there is sufficient alternative burrow habitat available in the area. During times where burrows are occupied (breeding times), culling activities involving human presence on land should be focused away from these sensitive areas so as to avoid trampling. People participating in deer cull activities should be made aware of the location of any known seabird burrow habitat (site maps will be provided to field crews that show locations of burrows), and avoid these areas during sensitive times such as breeding. The spatial and temporal extent of these effects is limited to the immediate areas and times of human occupation.

The ecosystem effects of deer culls on similar ecosystems has been well-documented (see Gaston et al. 2008; Martin and Balizinger, 2002; and applicable sections of Gwaii Haanas 2007). Some recovery of understory vegetation is anticipated, which has been shown to be beneficial for forest songbirds and forest invertebrates (Allombert et al. 2005 a&b, respectively). The effects of understory vegetation recovery on marine birds, wading birds, raptors and corvids are unknown. The spatial extent of these effects is anticipated to be limited to the areas where deer populations have been reduced. The temporal extent of these effects is dependent upon the length of time that these areas maintain reduced / nil deer numbers.

3.1.1.1.1 Marine Birds, Shorebirds, Waterfowl, Kingfishers

Bird's species that may be present at the time of bait application include marine birds, shorebirds, waterfowl and kingfishers as presented in Table 3.

Species	**Species-at-Risk Status**	**Timing of Occupancy at Murchison and Faraday Islands**	**Breeding Season**	**Likelihood of presence during rodenticide deployment**	**Likelihood of presence during deer cull activities**
Ancient Murrelet (*Synthliboramphus antiquus*)	SARA - Special Concern	Seasonal; remnant breeding activity on Murchison Island	Spring, young hatched by mid-June	Unlikely	High
Marbled Murrelet (*Brachyramphus marmoratus*)	SARA - Threatened	Year-round	Spring, nesting activity mid-May through early August	Low	High
Cassin's auklet (*Ptychoramphus aleuticus*)	COSEWIC C	Year-round; remnant breeding activity on Murchison Island	Spring; young fledged by July	Unlikely	High
Mallard Duck (*Anas platyrhynchos*)	BC List - Yellow	Year-round; Late summer / winter on water only	Spring	Low	Low
Harlequin Duck (*Histrionicus histrionicus*)	BC List – Yellow	Year-round	No evidence of breeding in Gwaii Haanas.	High	High
Pacific Loon (*Gavia pacifica*)	BC List – Yellow	Year-round; congregate in estuaries during salmon migrations. Marine areas important in fall / winter	Late spring, summer	Low	Low
Common Merganser (*Mergus merganser*)	BC List – Yellow	Year-round, nearshore activity	May-June	High	High
Belted Kingfisher (*Megaceryle alcyon*)	COSEWIC C	Year-round	April - July	High	High
Black Oystercatcher (*Haematopus bachmani*)	BC List - Yellow	Year-round	Late spring, summer	High	High
Common Snipe (*Gallinago gallinago*) *(Gallinago delicate)*	BC List - Yellow	Summer	April -June	Unlikely	Low
Common Murre (*Uria aalge*)	BC List - Red	Year-round; at sea when non-breeding	Late spring, summer; breeding at Kerouard	Unlikely	Unlikely

			Islands only.		
Glaucous-Winged Gull (*Larus glaucescens*)	BC List – Yellow	Year-round; fall congregation in estuaries to feed on salmon	Late spring, summer	High	High
Mew Gull (*Larus canus*)	BC List - Yellow	During spring/fall migrations and winter. Very few.	Late spring / early summer	Unlikely	Unlikely
Great Blue Heron, *fannini* subspecies (*Ardea herodias fannini)*	SARA - Special Concern	Year-round	February-April. Known nests on Murchison Island	High	High

Table 3: Marine-associated birds that may be present during project activities.

Marine birds found near the Murchison and Faraday islands during the winter months when the eradication is proposed include Ancient Murrelet, Marbled Murrelet, and Cassin's Auklet (Parks Canada, 2012b). Only Mallard, Harlequin Duck, Pacific Loon, and Common Merganser are common waterfowl during the winter months. Belted Kingfishers meanwhile are year-round residents. Black Oystercatcher and Common Snipe are year-round resident shorebirds. Two gulls that may be at risk of both primary and secondary poisoning are the Glaucous-winged Gull (*Larus glaucescens*) and Mew Gull (*Larus canus*), which are opportunistic feeders (Verbeek 1993).

Fish comprise the diet of Ancient Murrelet, Marbled Murrelet, Common Murre, Cassin's Auklet, Pacific Loon, Common Merganser, Belted Kingfisher, and to a lesser extent, Glaucous-winged and Mew gulls (Harfenist et al. 2002). During the 2011 Bischof Islands rat eradication, an Ancient Murrelet carcass was recovered; subsequent toxicology analysis showed no brodifacoum was detected in the liver. Following the planned mitigative measures that are part of the aerial bait application methodology (bait deflector bucket, coastal perimeter bait application at high tide), the likelihood of brodifacoum transfer at detectable concentrations into the marine ecosystem is low. The probability of rodenticide contamination of fish is also therefore low given the low probability of brodifacoum transfer to the marine environment, and the short (several hours) length of time that bait pellets are expected to remain intact, given the high tide timing of coastal area bait application. The probability of exposure through exclusively fish prey species is likely low to nil, given the already low likelihood of brodifacoum presence in fish. The probability of fish-eating birds being exposed to brodifacoum concentrations that cause mortality, morbidity, or survivability-affecting sublethal effects is anticipated to be negligible (U.S. Fish and Wildlife Service, 2007), given the low likelihood of contamination of fish and very low likelihood of consuming the number of contaminated fish required to result in bird body burdens that cause these sublethal effects.

The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. Taking into consideration the likelihood of exposure and persistence of brodifacoum in the applicable environmental compartments (see 3.1.1.5 Fish), the low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Zero risk is anticipated well before the breeding season following bait application, owing to bait pellet deterioration and subsequent dilution and breakdown of rodenticide active ingredient, and depuration of rodenticide from exposed fish.

Mallard and Harlequin Ducks, Black Oystercatchers, and Common Snipe feed mostly upon aquatic invertebrates. Given their diet, exposure from direct consumption of rodenticide bait is highly unlikely. Following the planned mitigative measures that are part of the aerial bait application methodology (bait deflector bucket, high tide timing of bait application in coastal areas), the likelihood of brodifacoum transfer at detectable concentrations into the marine ecosystem is low. An exposure scenario where bait enters a stagnant pool inhabited by invertebrates is possible, but associated wave/water action at high-tide would preclude the formation of stagnant pools. Although the accumulation of brodifacoum within the tissues of marine invertebrates is possible, it is improbable given this exposure scenario. Any birds that are foraging for invertebrates in these areas (especially sessile invertebrates such as mussels) are at risk (albeit very low) of brodifacoum exposure. Taking into consideration the persistence of brodifacoum in marine invertebrates (see section 3.1.1.4), and the low likelihood (from the mitigative measure of using a bait deflector and high tide timing of bait application) of bait entering the marine environment, the overall likelihood of brodifacoum exposure in these birds is very low to negligible; any possible exposure would be highly localized. The likelihood of adverse effects therefore is low to negligible, on the whole, given the low to negligible risk of brodifacoum exposure. A worst-case scenario event of the mortality of one or more individuals that experience secondary exposure through eating a substantive contaminated invertebrate meal from within a bait-contaminated stagnant pool is highly unlikely, following this reasoning. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. The low risk of adverse effects is expected to be highest in the 12 hour period following rodenticide application (the longest time until the subsequent high tide). Given the potential for brodifacoum residues to persist in the tissues of exposed filter-feeding invertebrates (see section 3.1.1.4; Primus et al. 2005), zero risk to these birds is anticipated by two years following bait application, as any brodifacoum residues present in the tissues of longer-lived (>1yr) invertebrates would have had sufficient time to depurate.

Two gulls that may be at risk of both primary and secondary poisoning are the Glaucous-winged Gull (*Larus glaucescens*) and Mew Gull (*Larus canus*), which are opportunistic feeders (Verbeek, 1993). During the 2008 Rat Island, Alaska eradication project 320 Glaucous-winged Gull carcasses were recovered and toxicology tests implicated brodifacoum in 24 of the 34 tested (Salmon & Paul, 2010). It was theorized this species ingested rodenticide bait pellets (primary poisoning pathway) and possibly also dead or dying rats (secondary poisoning pathway). Although possible, it is unlikely that this situation would be replicated on Murchison and Faraday islands due to the significant vegetation cover (crown closure), which would limit visibility of the rodenticide bait and dead or dying rats to coastline scavengers such as Glaucous-winged Gulls or Mew Gulls as well as other species. As well, carcass searches and recovery will further limit access to rodenticide-contaminated carcasses. During the 2011 Bischofs Islands rat eradication, a California gull carcass was recovered; subsequent toxicological analysis showed that the liver did not contain any detectable brodifacoum residues. Spatially, exposure of gulls is limited to the eradication islands. Temporally, exposure of gulls will be limited by the amount of time that bait pellets remain intact (approx. 1.5 weeks per application, conservatively), and by the amount of time that poisoned carcasses that have not been located from carcass searches remain in a condition where their tissues can be consumed – this is estimated to be 3 months following last bait application, conservatively, because of the combination of rapid decomposition rates in a wet environment (approximately 1 month), and cooler conditions that may slow down carcass decomposition.

3.1.1.1.2 Songbirds and Upland Game Birds

Granivorous bird species, including but not limited to Song Sparrows (*Melospiza melodia*), Fox Sparrows (*Passerella iliaca*)00, and Sooty Grouse (*Dendragapus fuliginosus*); and insectivorous bird species, including but not limited to Winter Wren (*Troglodytes troglodytes*) and Varied Thrush (*Ixoreus naevius*) present on Murchison and Faraday islands during the eradication are at risk of brodifacoum exposure (Parks Canada Agency, 2012b).

All granivorous bird species found on Murchison and Faraday islands during the eradication would be at high risk for primary exposure resulting from direct ingestion of the rodenticide bait pellets after each bait application (e.g. Howald et al., 2009). Although not considered at risk either provincially or federally (Conservation Data Centre, 2012), Sooty Grouse are of particular concern because of their low dispersal ability from other islands (C. Bergman pers. comm., undated 2012). However, this species will significantly benefit from rat eradication on Murchison and Faraday islands (because rats predate their nests) and could be re-introduced from nearby islands if the population is negatively impacted by the eradication operation. Sparrows, wrens, and other passerine birds have been found dead after rodent eradications in New Zealand and California, and estimated mortality rates have varied from very low to nearly 100% (Eason and Spurr, 1995, Howald et al., 2005). During the Langara Island rat eradication project researchers confirmed that Song Sparrows were exposed to brodifacoum (Howald et al., 1999). During the 2011 Bischofs Islands rat eradication, two fox sparrow carcasses were recovered; analysis of liver tissues yielded detectable concentrations of brodifacoum. Spatially, direct exposure of granivorous birds is limited to the eradication islands. Temporally, exposure of granivorous birds is limited to the period that the bait pellet remains intact for consumption (1.5 weeks per application, conservatively) (Parks Canada Agency 2012c). Zero risk of brodifacoum exposure to granivorous birds is anticipated after 1.5 weeks following each bait application, owing to the removal of the exposure pathway (direct ingestion of bait pellets) via bait pellet disintegration to the point that they cannot be ingested (pellets expected to be completely disintegrated by 1.5 weeks).

Insectivorous bird species, such as Winter Wren (*Troglodytes troglodytes*) and Varied Thrush (*Ixoreus naevius*) may be exposed to the rodenticide by eating invertebrates that have fed on the rodenticide baits (secondary poisoning), although no evidence of this was detected on Langara Island in 1995 after two years of rodenticide availability (Kaiser et al., 1997). Insectivorous birds have been documented to have died due to ingestion of ants and cockroaches that had eaten brodifacoum baits (Eason et al., 2002). As well, a variety of invertebrates were detected consuming placebo bait during bait biomarker trials (Parks Canada Agency 2012c; see section 3.1.1.4). If terrestrial invertebrates are attracted to the bait in higher-than-background densities, this situation may present an attractive feeding opportunity for insectivorous birds, resulting in secondary exposure via the ingestion of contaminated invertebrates. For that reason, there is a potential for individual birds to inadvertently target invertebrates with brodifacoum body burdens – this would be the worst-case exposure scenario. There is a risk of these birds being exposed to brodifacoum concentrations that cause mortality, morbidity or survivability-affecting sublethal effects; therefore individual birds may be adversely affected. The half life of brodifacoum in terrestrial invertebrates is largely unknown, which presents a degree of uncertainty. The spatial extent of any appreciable risk to insectivorous birds is restricted to those present on Murchison or Faraday Island during bait application or soon after application (conservatively 1.5 weeks, based on the amount of time that bait remains intact and available to terrestrial invertebrates). The temporal extent of risk to insectivorous birds is anticipated to be a few months (conservatively) following bait application, with the highest risk being within the 1.5 week period following bait application and declining to negligible risk based on bait pellet deterioration after 1.5 weeks, dispersal of contaminated invertebrates, and depuration of rodenticide from the bodies of contaminated invertebrates.

Based on currently available knowledge, the songbirds or upland game birds found on Murchison and Faraday are not federally or provincially designated as Species at Risk (Conservation Data Centre, 2012). Given the global and local abundance of these species, and presence of suitable habitat on nearby islands (e.g. Lyell, Hotsprings, Ramsay, and Moresby Islands), an aerial eradication would not result in any population level effects even in the unlikely event that significant localized mortalities occur as a result of the operation. Transient birds will quickly occupy any vacant, high quality habitat; hence it is unlikely that any change in the localized population numbers for these species would be observed pre- and post-eradication.

Granivorous or insectivorous birds exposed to the rodenticide may be preyed on or scavenged by Bald Eagles, Common Ravens, Northwestern Crows, Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*), Northern Saw-whet Owl, *brooksi* subspecies (*Aegolius acadicus brooksi*), and/or Sharp-shinned Hawk (*Accipiter striatus*) leading to secondary and /or tertiary poisoning of these species.

3.1.1.1.3 Wading Birds

The Great Blue Heron, *fannini* subspecies (*Ardea herodias fannini*) is designated under the federal Species at Risk Act as Special Concern (Schedule 1). The best available estimates suggest that the population size in Canada is 4,000-5,000 nesting adults (COSEWIC, 2008). The global population is likely between 9,500 and 11,000 nesting adults. During the nesting season the principal diet is small fish which is supplemented with mammals during the winter months (COSEWIC, 2008). Because this species is known to prey on rats and other rodents, it is possible that mortalities may occur during an aerial eradication if Great Blue Herons prey on rats that have fed directly on the rodenticide bait. However, it should be noted that three heron nests have been previously located on Murchison Island (D. Burles pers. comm.), and Great Blue Herons were regularly observed during the Bischofs eradication in 2011 foraging in intertidal areas but no carcasses were recovered despite over 900 hours of formal and informal carcass searches being conducted during the operation (Parks Canada Agency, 2012).

Based on known local presence and a diet that includes fish and rodents, the risk of exposure to brodifacoum via consumption of contaminated fish is anticipated to be negligible, following the reasoning stated above in section 3.1.1.1.1 (low likelihood of marine contamination, low likelihood of fish contamination). There is a possibility that individual mortalities may result from exposure to rodenticide via ingestion of rodent carcasses – this likelihood will be reduced through carcass searches and collection. Nonetheless, the unlikely loss of a few individuals would not result in any long term population level effect or even a local population effect because transient birds would quickly occupy any vacant, high quality foraging habitat. Spatially, this risk is limited to the eradication islands. Temporally, this risk will persist as long as rodent carcasses are accessible, visible, and still in a consumable state (prior to advanced decomposition), which is anticipated to be 3 months, conservatively, because of the combination of rapid decomposition rates in a wet environment (approximately 1 month), and cooler conditions that may slow down carcass decomposition.

3.1.1.1.4 Birds of Prey & Corvids

Vulnerable birds in this category comprise Northern Goshawk (*laingi* subspecies), Northern Saw-whet Owl (*brooksi* subspecies), Sharp-shinned Hawk, Peregrine Falcon (*pealei* subspecies), bald eagles, common raven, and northwestern crow (Table 4). Northern Goshawk, *laingi* subspecies and Northern Saw-whet Owl, *brooksi* subspecies are designated under the federal Species at Risk Act as Threatened (Schedule 1).

Initially there will be a high risk of secondary poisoning for bird species that may prey on dead or dying rats and non-target species via secondary and tertiary poisoning routes. For example, on Macquarie Island, New Zealand, researchers reported Giant Petrels (*Macronectes giganteus*) eating gull, rabbit and rat carcasses and dying up to 6 months after completion of the aerial eradication (P. McClelland pers. comm.). Red squirrels (*Tamiasciurus hudsonicus*, not native to Haida Gwaii), dusky shrews (*Sorex monticolus*), deer mice (*Peromyscus keeni*), granivorous birds that have ingested the bait, and insectivorous birds affected via secondary poisoning comprise the routes of secondary and tertiary poisoning. There is also risk of attracting avian scavengers from nearby locations to the islands as was the case with the Rat Island eradication (Salmon and Paul, 2010).

Species	**Species-at-Risk Status**	**Timing of Occupancy at Murchison and Faraday Islands**	**Breeding Season**	**Likelihood of presence during rodenticide deployment**	**Likelihood of Presence during deer cull activities**
Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*)	SARA - Threatened	Year-round; one individual observed hunting in area in 2012	April (mating / eggs) to late August (juvenile dispersal)	Unknown	Unknown
Northern Saw-whet Owl, *brooksi* subspecies *(Aegolius acadicus brooksi)*	SARA - Threatened	Year-round	March to July	High	High
Sharp-shinned Hawk (*Accipiter striatus*)	COSEWIC -Not at risk	Year-round	Spring - Summer	Medium	Medium
Peregrine Falcon, *pealei* subspecies *(Falco peregrinus pealei)*	SARA – Special Concern	Year-round	April to July	High	High

Bald Eagle *(Haliaeetus leucocephalus)*	COSEWIC – Not at risk	Year-round	Late winter to early summer	High	High
Common Raven (*Corvus corax*)	BC List - Yellow	Year-round	April - summer	High	High
Northwestern Crow (*Corvus caurinus*)	BC List - Yellow	Year-round	April – August	High	High

Table 4: Birds of Prey and Corvids that may be present during project activities.

Northern Goshawk, Saw-whet Owl, and Sharp-shinned hawk are present in Juan Perez Sound but are uncommon (D. Burles pers. comm., undated; C. Bergman pers. comm., undated). For example, during the Bischofs rat eradication field personnel observed only one Northern Goshawk and one Saw-whet Owl but no Sharp Shinned Hawks over the course of two months on the islands (Parks Canada Agency, 2012). All three species are at risk of secondary poisoning resulting from predating / scavenging rats or passerines that have fed directly on the rodenticide bait. Within this group of avian predators and scavengers, Peregrine Falcon (*pealei* subspecies) is considered to be the least at risk of exposure to brodifacoum, based on their exclusive diet of seabirds (COSEWIC, 2007). Although seabirds are at very low to negligible risk of exposure to brodifacoum from the rat eradication, the likelihood of encountering concentrations sufficient to cause deleterious effects is negligible.

Given the slow action of the rodenticide, it is possible for exposed passerines to disperse to nearby areas (e.g. S. Lyell Island, Ramsay Island) and either succumb to rodenticide poisoning in an area located away from the eradication site, or retain rodenticide residues within their tissues if they survive.

Following the information summarized in Eason et al. (2002), the LD_{50} (mg brodifacoum consumed per kg body weight of consumer per day) of brodifacoum in birds appears to be an order of magnitude greater than that of rats and other rodents. In other words, birds appear to be less sensitive to the effects of brodifacoum, per unit of body weight. Roughly speaking, a bird of prey or scavenger would have to consume ten times more brodifacoum per unit of body weight than a rat in order to achieve a lethal dose. Although this may appear to be a protective buffer, the persistence of brodifacoum within the tissues of dead and surviving mammals and non-target avians could result in avian raptor / scavenger body burdens that are lethal, or could cause sublethal issues (e.g. too weak to fly) that can affect survival.

Given the significant vegetation cover and high degree of crown closure on Murchison and Faraday islands (compared to Rat Island) visibility of dead or dying rats or non-target species to avian scavengers is anticipated to be limited. The known habit of poisoned rats retreating to burrows, crevices, and other inaccessible locations (Howald et al., 2010) reduces this risk. Removal of contaminated carcasses during the planned routine of carcass searching limits the risk even further. Following proposed mitigative measures to draw avian scavengers away from the project site using uncontaminated deer carcasses deposited on high visibility locations away from Murchison/Faraday Islands, this risk is further reduced. Given the small number of potential territories on Murchison and Faraday islands for each species the eradication may pose a risk to one or two individual birds but is unlikely to have any long term population level effect because transient birds will quickly occupy any vacant, high quality habitat. It is unlikely that any change in the Gwaii Haanas Northern Goshawk, Saw-wet Owl, or Sharp-shinned Hawk population sizes would be observed pre- and post-eradication.

Therefore, considering contaminated mammalian and avian prey, spatial extent of any risk centres on Murchison and Faraday Islands, and decreases with distance; the spatial extent of risk beyond Murchison and Faraday Islands (dispersal of surviving passerines) includes S. Lyell Island, Hotsprings Island, House Islet, Ramsay Island, and surrounding areas. Temporal extent of risk is anticipated to be 6 months (conservatively) based on the amount of time that carcasses remain intact enough for consumption by scavengers (3 months, conservatively), the persistence of brodifacoum in rat liver ($t_{1/2}$= 130 days; Eason et al. 2002), and environmental dilution based on dispersal of avian prey items that survived brodifacoum exposure. See below for information on further risks to Saw-whet owls.

British Columbia contains the majority of the **Northern Goshawk, *laingi* subspecies** population worldwide. It occurs on Vancouver Island, Haida Gwaii, and on the western side of the coastal ranges of British Columbia (COSEWIC, 2007). Estimates of population abundance are imprecise, but are thought to be approximately 700 individuals. Based on the best available population estimates approximately 50% of the global population of *A. gentilis laingi* resides within Canada (Parks Canada, 2012). Red Squirrels and various songbirds dominate breeding season diets of Northern Goshawk, *laingi* subspecies (Roberts 1997, Doyle, 2003b). This means rats are also potential prey due to the similarity in body size to red squirrels. No information is available on non-breeding season diets. Territory size in Haida Gwaii is estimated at 10.8 ± 0.6 km but there is a high annual variability in territory occupancy (Doyle, 2003a). Therefore, based on the size of Murchison and Faraday islands, a maximum of one territory could be present if it is indeed occupied although habitat quality for this species on the islands has not been assessed. Local knowledge of one family who lived on Murchison Island until the 1980s did not contain any reports of goshawks on the island (D. Burles pers. comm., undated).

Northern Saw-whet Owl *brooksi* subspecies is endemic only to Haida Gwaii and is non-migratory (COSEWIC, 2006). Saw-whet Owls are highly territorial of the area near potential nests during the spring breeding season. Males defend core areas approximately 70-100 ha in size. Home ranges are often much larger and are estimated at a mean size of 3.52 + 1.3km$_2$. Applying this estimate to Murchison and Faraday islands (total area: 716 ha) suggests that the islands could support approximately 3 territories although habitat quality for this species has not been assessed on the islands. Rats (especially juveniles) are prey items for this species (C. Bergman, unpublished data), which may further increase their density when rats are abundant. On Haida Gwaii Saw-whet Owls appear to be more generalist taking locally available food items other than rodents, which are thought to be the major food source of Northern Saw-whet Owls elsewhere (COSEWIC, 2006). Studies on the diet of these birds collected primarily during the fall suggest high levels of marine invertebrate consumption (Hobson and Sealy 1991, Sealy, 1999). Given the biological persistence of brodifacoum and the potential for certain marine invertebrates to accumulate brodifacoum within their tissues (see 3.1.1.4), Northern Saw-whet Owls may be at risk of toxicant exposure via their fall diet of marine invertebrates. Following the planned mitigative measures that are part of the aerial bait application methodology (bait deflector bucket and bait application at high tide along the coastal perimeter), the likelihood of brodifacoum transfer at detectable concentrations into the marine ecosystem is low. Because of coastal perimeter bait application at high tide, the situation where bait enters a stagnant pool inhabited by invertebrates is unlikely, rendering any appreciable exposure of invertebrates to brodifacoum as low or negligible. Any birds that are foraging for invertebrates in these areas are therefore at very minimal risk of brodifacoum exposure. Taking into consideration the persistence of brodifacoum in marine invertebrates (Primus et al. 2005) *vis a vis* the very low probability of exposure of marine invertebrates, overall likelihood of brodifacoum exposure and adverse effects therefrom to Saw-whet owls deemed to be low to negligible. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. The low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Given the very low potential for invertebrate exposure to brodifacoum, near-zero risk is anticipated by the subsequent saw-whet owl breeding season.

Bald Eagles are at risk of secondary and tertiary poisonings resulting from foraging on dead or dying rats, squirrels, dusky shrews, deer mice, deer, or omnivorous, granivorous, or insectivorous birds, Great Blue Heron, Common Raven or Northwestern Crow.

A 1994 inventory estimated that 15,000 Bald Eagles (9,000 on the coast and 6,000 in the interior) breed in BC and 30,000 overwinter in the Georgia Basin (Blood and Anweiler, 1994). Bald Eagles are plentiful in Juan Perez Sound and there are at least nine historical nests on Murchison and Faraday Islands (C. Bergman, pers. comm., undated). Bald Eagles are opportunistic feeders and their diet includes live prey as well as carrion. Recent collection of prey remains from nests in the Juan Perez area of Gwaii Haanas included remains of deer, seabirds, corvids, gulls and large intertidal invertebrates (Bergman, unpublished data). This behaviour places Bald Eagles at risk of both secondary and tertiary poisoning during a rat eradication operation. For example, during a rat eradication operation on Langara Island, 3 out of 22 Bald Eagle blood samples obtained from live animals tested positive for brodifacoum exposure. No eagles were found dead during the eradication operation (Kaiser et. al., 1997). Similarly no Bald Eagle carcasses were recovered during the Bischofs and Arichika rat eradication operation completed in 2011 even though each island contains several active territories, including two which successfully fledged young (Bergman, unpublished data; Burles, unpublished data).

During the 2008 Rat Island, Alaska eradication project 46 Bald eagle carcasses were recovered and toxicology tests implicated brodifacoum in 12 of the 16 tested (Salmon & Paul, 2010). It was theorized eagles had preyed on dead or dying rats and Glaucous-winged Gulls (secondary and tertiary poisoning pathways). Due to the lack of a forested canopy on Rat Island it was estimated that a large number of rat carcasses were readily visible to avian scavengers (Salmon & Paul, 2010). It is unlikely that this situation would be replicated on Murchison and Faraday islands due to the significant crown closure which would limit visibility of the bait and dead or dying rats to coastline scavengers such as Bald Eagles. However, there is a possibility that some Bald Eagle mortality may result from an aerial eradication on Murchison and Faraday islands although this would not result in any long term population level effect or even a local population effect because transient birds would quickly occupy any vacant territories since high quality habitat is a limiting factor for this species (C. Bergman pers. comm., undated). Recently, researchers have reported that both adult and juvenile Bald Eagles have recolonized Rat Island (G. Howald pers. comm., undated). It is unlikely that any change in the local Bald Eagle population size would be observed pre- and post-eradication on Murchison and Faraday islands.

Taking into consideration the persistence of brodifacoum in marine invertebrates (Primus et al. 2005) *vis a vis* the very low probability of exposure of marine invertebrates, overall likelihood of brodifacoum exposure and adverse effects therefrom to Bald Eagles is deemed to be low to negligible. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. The low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Given the very low potential for invertebrate exposure to brodifacoum, near-zero risk is anticipated by the subsequent Bald Eagle breeding season. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. The low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Considering contaminated mammalian and avian prey, spatial extent of any risk centres on Murchison and Faraday Islands, and decreases with distance; the spatial extent of risk beyond Murchison and Faraday Islands (dispersal of surviving passerines) includes S. Lyell Island, Hotsprings Island, House Islet, Ramsay Island, and surrounding areas. Temporal extent of risk is anticipated to be 6 months (conservatively) based on the amount of time that carcasses remain intact enough for consumption by scavengers (3 months, conservatively), the persistence of brodifacoum in rat liver ($t_{1/2}$= 130 days; Eason et al. 2002), and environmental dilution based on dispersal of avian prey items that survived brodifacoum exposure.

Common Raven and Northwestern Crow are at significant risk of primary poisoning as a result of ingesting the rodenticide bait directly, in addition to the secondary poisoning risk from feeding on dead or dying rats, squirrels, dusky shrews, deer mice, deer, or omnivorous, granivorous, or insectivorous birds, (Kaiser et. al., 1997).

For example, during a rat eradication operation on Langara Island, 13 Common Raven carcasses tested positive for brodifacoum (Kaiser et. al., 1997). Ravens were observed ingesting the rodenticide bait pellets and also feeding on rat carcasses. During the 2011 Bischofs rat eradication operation two Common Raven carcasses were recovered, one of them approximately 3 months after the initial application of rodenticide-armed bait within bait stations. Analysis of liver tissues detected the presence of brodifacoum. Kaiser et al. (1997) also reported trace amounts of brodifacoum on liver tissues of Northwestern Crows during a toxic trial on Lucy Island, British Columbia. No crow carcasses were found during the Bischofs and Arichika rat eradications despite over 900 hours of formal and informal carcass searches being conducted and both species being regularly observed during the eradication operation (Parks Canada Agency, 2012). It is anticipated that an aerial eradiation on Murchison and Faraday islands could have a significant, albeit localized impact on the Common Raven and Northwestern Crow populations. It is also possible that corvids exposed to the rodenticide bait on Murchison or Faraday islands may succumb to the poison on nearby islands such as Lyell Island and Hotsprings Island thereby transporting relatively small amounts of brodifacoum into the other ecosystems. However, the consequence of this scenario is not likely to be detectable or of any significance to the wildlife present on those islands (G. Howald pers. comm., undated).

Any localized corvid mortalities would not result in a long term population level effect or even a local population effect because transient birds would quickly occupy any vacant high quality habitat. It is unlikely that any change in the local corvid population size would be observed pre- and post-eradication. For example, on Langara Island, Common Ravens recolonized the islands within one year after the local population was reduced due to primary and secondary exposure to brodifacoum during the rat eradication operation in 1995 (G. Howald pers. comm., undated).

Considering poisoning through direct ingestion of rodenticide bait - spatially, direct exposure of corvids is limited to the eradication islands. Temporally, primary exposure of corvids is limited to the period that the bait pellet remains intact for consumption (1.5 weeks per application, conservatively) (Parks Canada Agency 2012c). Zero risk of primary brodifacoum exposure to corvids is anticipated after 1.5 weeks following each bait application, owing to the removal of the exposure pathway (direct ingestion of bait pellets) via bait pellet disintegration to the point that they cannot be ingested (pellets expected to be completely disintegrated by 1.5 weeks). Considering contaminated mammalian and avian prey, spatial extent of any risk centres on Murchison and Faraday Islands, and decreases with distance; the spatial extent of risk beyond Murchison and Faraday Islands (dispersal of surviving passerines) includes S. Lyell Island, Hotsprings Island, House Islet, Ramsay Island, and surrounding areas. Temporal extent of risk is anticipated to be 6 months (conservatively) based on the amount of time that carcasses remain intact enough for consumption by scavengers (3 months, conservatively), the persistence of brodifacoum in rat liver ($t_{1/2}$= 130 days; Eason et al. 2002), and environmental dilution based on dispersal of avian prey items that survived brodifacoum exposure.

3.1.1.2 Mammals

3.1.1.2.1 Marine Mammals

The waters surrounding Haida Gwaii are home to twenty species of cetaceans (whales and dolphins) (Heise et al., 2003). Although some of these species are present throughout the year, the vast majority are present from the late winter through until the early summer. Humpback (*Megaptera novaeangliae*), orca (*Orcinus orca*), and minke whales (*Balaenoptera acutorostrata*) are seen regularly in the waters surrounding Gwaii Haanas, along with Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Dall's porpoises (*Phocoenoides dalli*), Steller's sea lions (*Eumetopias jubatus*), and harbour seals (*Phoca vitulina*).

Harbour seals and Steller's sea lions are exclusively carnivorous (almost exclusively piscivorous) and do not feed while on land, so the only possible routes for bait ingestion are accidental (G. Ellis pers. comm., undated). The likelihood of primary exposure is therefore very low and because the likelihood of brodifacoum transfer into the marine ecosystem is low, the probability of secondary exposure through their prey species, although possible, is negligible. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. Taking into consideration the persistence of brodifacoum in the applicable environmental compartments, as well as the very low likelihood of the exposure of fish prey items to brodifacoum, the already low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Zero risk is anticipated by the breeding season following rodenticide application.

The primary risk to marine mammals during the eradication operation and associated deer cull is temporary disturbance resulting from helicopter, boating activities, and noise from firearms. Harbour seals, elephant seals and Steller's sea lions may be hauled out on islets near Murchison and Faraday islands, or on the islands at various times of the day during field operations (Heise et al., 2003). Helicopter, boat activity and the use of firearms around these sites may temporarily disturb individuals causing them to temporarily relocate to an alternate haul out away from the activity or return to the haul out after the disturbance has passed (G. Ellis pers. comm., undated). Use of firearms associated with deer culling could occur during sensitive pinniped breeding times. Known sea lion breeding rookeries at Garcin Rocks and the Kerouard

Islands (Heise et al., 2003; P. Olesiuk, pers. comm., 2009 undated) are located a considerable distance away from where these activities will be taking place, the closest rookery being 53 km away. There are known haul outs for Harbour seals in the Murchison / Faraday area – during late May / early June, they may be birthing pups (Heise et al., 2003). It is strongly recommended that, if seals are hauled out in these areas, deer cull activities be suspended for the month of June and the first part of July to allow for undisturbed birthing of seal pups, and their growth and development to the point that they are strong enough to swim and haul themselves out if disturbed. Cull activities are already set to be suspended during this time period because of peak fawning. The spatial extent of these effects are anticipated to be centered on the immediate areas where firearms will be used, extending as far as the associated noise will be carried, which depends on the firearms being used. The temporal extent of these effects would be limited to the times when active deer culling is taking place. Ecosystem changes associated with the deer cull are expected to have little or no effect on marine mammals, as the ecosystem changes centre on vegetation recovery of terrestrial areas.

3.1.1.2.2 Terrestrial Mammals

As with birds, initially there will be a high risk of primary poisoning from feeding directly on the rodenticide bait pellets as well as a secondary poisoning risk for terrestrial mammals that may prey on dead or dying rats, red squirrels, dusky shrews, and deer mice that have ingested the rodenticide bait pellets. Deer cull activities are anticipated to have little or no negative effect on small mammal populations, including bats. Ecosystem changes associated with the reduction of deer numbers and consequent reduced browsing pressure may be beneficial for small mammals and bats, in that recovery of understory vegetation may provide increased cover and refugia from predators, and more insects upon which shrews and bats can prey (Allombert et al., 2005 a&b).

Native small mammals have either not been detected on Murchison or Faraday islands or exist at extremely low densities as a likely result of direct predation by black rats (Foster, 1965). Two years of pre-eradication monitoring have detected no deer mice and only one dusky shrew (C. Bergman, pers. comm. Jan. 14, 2013). Neither species are considered at risk either provincially or federally (Conservation Data Centre, 2012). During the 2011 Bischofs Island rat eradication, one red squirrel carcass was recovered, and subsequent toxicological testing determined its liver contained detectable brodifacoum residues. However, red squirrels are a non-native species and have not been detected on Murchison or Faraday to date (Bergman, pers. comm. Feb 6, 2013). Further monitoring on the presence/absence of these species on the target islands will occur in 2013.

Initially, any remaining individuals would be at high risk for primary poisoning resulting from direct ingestion of the bait and by preying on insects that have fed on the rodenticide bait (secondary poisoning) during an aerial eradication operation on Murchison and Faraday islands. This, in turn, could lead to secondary and tertiary poisoning incidents in a variety of species that may in turn prey on them. Because of their susceptibility to the rodenticide, it is likely that an aerial eradication operation on Murchison and Faraday islands may have a significant, albeit localized impact on any remaining dusky shrews and/or deer mice given their current low population densities. It may be feasible to reintroduce dusky shrews and/or deer mice to the islands from viable populations on other islands if they are indeed locally extirpated as a result of rat predation pressure combined with the eradication operation.

Considering poisoning through direct ingestion of rodenticide bait - spatially, direct exposure of small mammals is limited to the eradication islands. Temporally, exposure of small mammals is limited to the period that the bait pellet remains intact for consumption (1.5 weeks per application, conservatively) (Parks Canada Agency 2012c). Zero risk of primary brodifacoum exposure to small mammals is anticipated after 1.5 weeks following each bait application, owing to the removal of the exposure pathway (direct ingestion of bait pellets) via bait pellet disintegration to the point that they cannot be ingested (pellets expected to be completely disintegrated by 1.5 weeks).

Insectivorous mammals (dusky shrew) may be at risk to secondary poisoning. A variety of invertebrates were detected consuming placebo bait during bait biomarker trials (Parks Canada Agency 2012c; see section 3.1.1.4). If terrestrial invertebrates are attracted to the bait in higher-than-background densities, this situation may present an attractive feeding opportunity for insectivorous small mammals, resulting in secondary exposure via the ingestion of contaminated invertebrates. For that reason, there is a potential for individual shrews to inadvertently target invertebrates with brodifacoum body burdens – this would be the worst-case exposure scenario. There is a risk of these small mammals being exposed to brodifacoum concentrations that can cause mortality, morbidity or survivability-affecting sublethal effects; therefore individual shrews may be adversely affected. The half life of brodifacoum in terrestrial invertebrates is largely unknown, which presents a degree of uncertainty. The spatial extent of any appreciable risk to shrews is restricted to those present on Murchison or Faraday Island during bait application or soon after application (conservatively 1.5 weeks, based on the amount of time that bait remains intact and available to terrestrial invertebrates). The temporal extent of risk to insectivorous birds is anticipated to be a few months (conservatively) following bait application, with the highest risk being within the 1.5 week period following bait application and declining to negligible risk based on bait pellet deterioration after 1.5 weeks, dispersal of contaminated invertebrates, and depuration of rodenticide from the bodies of contaminated invertebrates.

Bats are represented by four species native to Haida Gwaii: California myotis (*Myotis californicus caurinus*), Keen's myotis (*Myotis keenii*), little brown bat (*Myotis lucifugus alascensis*) and the silver haired bat (*Lasionycteris noctivagans*) (Burles, et al., 2004). These species feed exclusively on flying insects (predominantly) although Keen's myotis are also known to prey on spiders (E-Fauna BC, 2011, Burles, 1999). Little is known about California myotis and little brown bat on Haida Gwaii.

Keen's myotis (*Myotis keenii*), a provincially red-listed bat species in British Columbia (Conservation Data Centre, 2012), has one of the most restricted distributions of any North American bat, being found primarily in the coastal temperate rainforests (COSEWIC, 2003a). However, due to their secretive nature, little is known of their distribution and abundance. The limited information available suggests that reproductive Keen's myotis show high fidelity to maternity roosts (Burles, 1999). The only maternity colony known for the species is located at Hotsprings Island located southeast of Murchison Island; however there have been reports of bats at Murchison Island (R. Gauthier, pers. comm., 2012 undated).

Based on their diet, any bats present on Murchison and Faraday islands during the eradication would be at risk of exposure resulting from ingesting insects that have fed on the rodenticide baits (secondary poisoning). Based on fecal contents of bats found in coastal areas from Oregon to Haida Gwaii, the insectivorous diet of bats varies according to prey availability, with bats preying on flying insects, as well as gleaning insects from plants and feeding on spiders (Burles et al., 2004, and references therein). If terrestrial invertebrates are attracted to the bait in higher-than background densities, this situation may present an attractive feeding opportunity for bats, resulting in primary exposure (incidental ingestion of bait while gleaning invertebrates), as well as secondary exposure via the ingestion of invertebrates. For that reason, there is a probability that individual bats may inadvertently target invertebrates with brodifacoum body burdens, in addition to direct ingestion of bits of bait – this would be the worst-case exposure scenario. The timing of the eradication may also coincide with bat mating activities; the additional energy demands associated with mating activities means that the bats would need to eat more, resulting in greater brodifacoum exposure potential through the pathways identified above. An aerial eradication operation on Murchison and Faraday islands may impact individual animals. If these individuals are in their mating period, then the local population may experience effects such as decreased fecundity for that particular mating and breeding season. Given this information, some bat mortality is anticipated, as well as transient, local population effects. However, no bat mortality was detected in previous eradication operations in New Zealand or during any other eradication where bats were studied (Lloyd, 1994, Lloyd and McQueen, 2002, G. Howald pers. comm., undated). Spatial extent of exposure would be centered on the eradication islands, extending as far as the flying range of potential prey insects (estimated extent would be S. Lyell Island to N. Ramsay Island). The temporal extent of risk to bats is anticipated to be a few months (conservatively) following bait application, with the highest risk being within the 1.5 week period following bait application and declining to negligible risk based on bait pellet deterioration after 1.5 weeks, dispersal of contaminated invertebrates, and depuration of rodenticide from the bodies of contaminated invertebrates. It is anticipated that population-level effects would be temporary, with the population recovering by the subsequent breeding season.

Deer cull activities may result in noise-related disturbance of the bats. It is difficult to say whether firearm noise might temporarily or permanently deafen any bats within a certain range of the rifle being fired. The spatial extent of these effects are limited to the area surrounding the rifle being fired, and the temporal effects range from the immediate recovery of affected bats to longer-term impairment of an individual bat's ability to hear. The anticipated recovery of understory vegetation resulting from reduced deer numbers may be beneficial to bats, via an associated increase in invertebrate prey items (Allombert et al., 2005 a&b). The spatial extent of these effects comprise the areas where deer are being culled. The temporal extent of these effects will extend to however long the area remains deer-free (or deer-reduced).

Large Herbivores which comprise Sitka black-tailed deer (*Odocoilius hemionus sitkensis*) were first introduced to Haida Gwaii in 1878 and on four occasions between 1911 and 1925. The deer's ability to swim has allowed it to spread to most islands in the archipelago, with only a handful of small offshore islands known to be deer free. Current estimates of the deer population throughout Gwaii Haanas are as high as 60,000 individuals (Golumbia, 2001a). Murchison and Faraday Islands are estimated to support approximately 200 deer (Dyment et. al, 2013).

In September 2012, Parks Canada undertook extensive on-site eradication application rate and biomarker trials on the subject islands. Using non-toxic (placebo) bait pellets with biomarker dye, several varying application rates were trialed. The trials confirmed that introduced deer on the subject islands are attracted to the bait and will consume them in significant quantities (Parks Canada Agency, 2012c). This poses a serious risk to eradication success as the deer will compete for access to the bait with rats, thereby potentially jeopardizing eradication success as not all rats may have access to bait. Deer have been observed ingesting rodenticide bait pellets in other studies (Stone et. al. 1999, Landcare Research, 2010). Therefore, although the LD_{50} value for deer is unknown, it is likely that there is a significant potential for primary poisoning of Sitka deer during the aerial eradication operation on Murchison and Faraday islands. It is possible that the degree of poisoning symptoms observed will range from mortality, morbidity, sublethal effects that may/may not affect survivability, or no effects at all, depending on the age and size of animal, and the amount of brodifacoum ingested. Deer that are exposed and succumb to the rodenticide through bait consumption would in turn place scavenging species such as Bald Eagles, Common Ravens, Northwestern Crows, and black bears (*Ursus americanus carlottae*) at risk of secondary poisoning. Furthermore, humans eating deer meat (especially livers and kidneys) from animals exposed to the rodenticide bait would put them at risk of brodifacoum exposure. The spatial extent of the risk of primary poisoning is limited to the eradication islands, and the temporal extent would be for the duration that bait pellets remain intact and ingestible (conservatively, 1.5 week following application; Parks Canada Agency 2012c).

The spatial and temporal extent of deer being vectors of secondary poisoning are broader, given the ability of deer to swim, and the length of time it takes for the carcass to decompose to the extent that tissues would no longer be available for scavenging, as well as the fact that brodifacoum is excreted largely unchanged in the feces (Eason et al. 2002). The spatial extent of this risk will be highest on the eradication islands and is expected to decrease with distance – brodifacoum-contaminated deer could likely reach S. Lyell Island and possibly Ramsay Island. Temporal extent of the availability of brodifacoum-contaminated tissue for scavenging is 6 months (conservatively) from the time of death, based on observations of deer carcass decomposition in a similar environment (B. Wojtaszek, pers. comm., March 5, 2013). Live deer harbouring sublethal amounts of brodifacoum are not expected to contribute to predation-related poisoning, as there are no natural deer predators on Haida Gwaii, with the exception that black bear scat has been observed to contain fur and other body parts of deer. Haida peoples are permitted to hunt deer in Gwaii Haanas. Live deer that may harbour brodifacoum in their tissues may disperse quite a distance from the eradication islands, for quite some time. This presents a potential, albeit small risk, of exposure to humans who may consume deer meat. In order to manage this risk, a temporary hunting closure is recommended for Murchison Island, Faraday Island, Southeast Lyell Island, Hotsprings Island, House Island, and Ramsay to allow any deer sub-lethally exposed to the rodenticide bait the time to depurate the toxin before being potentially consumed by humans. It is expected that brodifacoum residues will persist for a long time, based on the published half-life of brodifacoum in sheep liver (>250 days) (Eason et al. 2002 and references therein). Given the uncertainty of the persistence of brodifacoum in deer liver, and using persistence in sheep liver as a guideline, deer hunting in the area should be closed for two years to allow for brodifacoum residues to depurate 2 half lives' worth of contamination (reducing concentrations by 75%) and this closure should not be lifted until sampling of deer carcasses from the vicinity confirms that rodenticide is not detected in deer tissue, or present at non-toxic concentrations if detected[6], based on analytical detection limits of the laboratory protocol being used. Given that Gwaii Haanas is not open to the public for deer

[6] Current analytical protocols offer a limit of detection of 0.5 parts per million for brodifacoum residues in animal tissue. New analytical protocols are currently being developed that can detect brodifacoum residues in animal tissues to a limit of detection of a few parts per billion (Nick Schrier, Animal Health Laboratory – University of Guelph, pers. comm. April 5, 2013), which is far below tissue concentrations that can cause a toxic response in mammals.

hunting, with the exception of limited Haida First Nations subsistence hunting (as per the 1993 Gwaii Haanas agreement) and deer hunting opportunities are virtually unlimited at other, more easily accessed areas of Haida Gwaii, this temporary closure would have virtually socio-economic or recreational impact on hunters.

In addition to the risk of primary poisoning of deer on Murchison and Faraday islands (and possible consequent secondary poisoning of other native wildlife through scavenging deer carcasses), there is a serious risk that deer may outcompete rats for the bait resulting in bait application 'gaps' on the islands. This in turn increases the risk of eradication failure based on the first fundamental principle of rat eradications: all rats must be at risk of the eradication technique (Cromarty et al., 2002).

In order to manage the risk of deer creating bait gaps and acting as vectors of secondary poisoning, a deer eradication or deer cull is recommended prior to implementing the rat eradication operation on Murchison and Faraday islands to reduce the potential for brodifacoum exposure with this species resulting from direct ingestion of the rodenticide bait pellets. The deer cull will obviously have an effect on the local population of deer. However, recognizing that they are introduced and invasive, deer are considered a pest (as opposed to a valued ecosystem component). Spatial extent of deer cull effects coincides with the areas where deer culling will take place. Temporal extent will depend on how quickly these areas are recolonized by deer migrating from other areas.

Omnivores comprise the raccoon (*Procyon lotor*) and the black bear subspecies (*Ursus americanus carlottae*). The raccoon is an introduced species, while the black bear subspecies is endemic to Haida Gwaii. The diets of both species are diverse and include vegetable matter, small mammals, carrion, fruit, insects, bird eggs, and fish. Based on diet preferences, and the behaviour of a black bear on the Bischofs islands during the 2011 rat eradication (Parks Canada Agency, 2012), both species are at risk of primary poisoning (direct ingestion of rodenticide bait pellets) and secondary poisoning (preying or scavenging rats, dusky shrews, deer mice, or Sitka deer, that have ingested the bait) during an aerial eradication on Murchison and Faraday islands. Although LD_{50} values for these species are unknown, it is possible that an aerial eradication operation on Murchison and Faraday islands may have a significant, albeit localized (non-population level) impact on black bears and raccoons. Raccoon carcasses may be scavenged by bears or avian species such as Bald Eagles and Common Ravens thereby presenting a secondary and tertiary poisoning risk. Surveys for both species prior to implementing eradication operation on Murchison and Faraday islands to confirm presence/absence of these species is advised. Black bear surveys should be conducted using remote cameras and hair traps. If black bears are present on the project islands, Parks Canada should ensure that personnel with appropriate training and bear handing experience are on-island to capture and relocate bears if necessary. The spatial extent of the risk of primary poisoning is limited to the eradication islands, and the temporal extent would be for the duration that bait pellets remain intact (conservatively, 1.5 week following application; Parks Canada Agency 2012c). The spatial extent of the risk of secondary poisoning will be highest on the eradication islands and is expected to decrease with distance – brodifacoum-contaminated deer will likely reach S. Lyell Island, Hotspring/House Islands, and possibly Ramsay Island. Temporal extent of the availability of brodifacoum-contaminated tissue for scavenging is 6 months (conservatively) from the time of prey death, based on the amount of time the carcass remains consumable before complete decomposition.

The effects of the deer cull on omnivores are positive, in that a source of secondary poisoning would be removed, and recovery of understory vegetation would translate to an additional supplemental food source (e.g. berries), and cover for these animals. Spatial extent of these effects is anticipated to be centered on Murchison and Faraday Islands, extending as far as S. Lyell Island and Ramsay Island. Temporal extent would be limited to the amount of time that the area maintains reduced deer numbers.

Carnivores such as the Haida ermine (*Mustela erminea haidarum*) is recognized as a rare endemic sub-species of ermine and is designated as Threatened in Schedule 1 of the Federal Species at Risk Act. Sightings are extremely limited (Golumbia, 2001a). Ermine *haidarum* have been recorded on only four of the major Haida Gwaii islands: Graham, Moresby, Louise, and Burnaby (Reid et al, 1999).

Although possible, it is highly unlikely that ermine are present on Murchison or Faraday islands because of its current distribution, poor swimming ability, and low population levels of dusky shrews and deer mice on the islands resulting from the presence of black rats and raccoons (D. Burles pers. comm. undated, C. Bergman pers. comm. undated). However, if this species is present, it would be at risk of secondary poisoning resulting from the aerial eradication operation although impacts would be limited to individual animals.

River otters (*Lontra canadensis*) are exclusively carnivorous (primarily feeding on fish and marine invertebrates such as crab) although this species has been known to infrequently prey on various bird species and small mammals (D. Guertin pers. comm.). Although possible, given the abundance of fish and marine invertebrates in the waters surrounding Murchison and Faraday Islands it is unlikely that resident river otters would consume terrestrial species. If they did consume terrestrial species, these would comprise a small portion of river otter diet. Furthermore, during the rat eradication operation on the Bischofs and Arichika islands river otters regularly encountered bait stations that were armed with rodenticide bait pellets but did not disturb them (Parks Canada Agency, 2012). The likelihood of primary or secondary terrestrial-based exposure of river otter resulting from an aerial eradication operation on Murchison and Faraday islands is believed to be low. Following the planned mitigative measures that are part of the aerial bait application methodology (bait deflector bucket, coastal perimeter baiting at high tide), the likelihood of brodifacoum transfer at detectable concentrations into the marine ecosystem is low, and by extension, the likelihood of fish and marine invertebrate exposure is very low. The probability of exposure to otters through exclusively fish prey species is likely low to nil. The probability of river otters being exposed to brodifacoum concentrations that cause mortality, morbidity, or survivability-affecting sublethal effects via fish is anticipated to be negligible (USFWS, 2007), given the low likelihood of contamination of fish and very low likelihood of consuming the number of contaminated fish required to result in body burdens that cause these sublethal effects. However unlikely, any brodifacoum-caused mortality of individual river otters would not result in any population level effects to this group of animals. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. Taking into consideration the persistence of brodifacoum in the applicable environmental compartments, the already low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Zero risk is anticipated by one year following bait application, if not sooner.

Considering the potential to be exposed to bait via ingestion of marine invertebrates - following the planned mitigative measures that are part of the aerial bait application methodology (bait deflector bucket and coastal perimeter baiting at high tide), the likelihood of brodifacoum transfer at detectable concentrations into the marine ecosystem is low. An exposure scenario where bait enters a stagnant pool inhabited by invertebrates is possible, but associated wave/water action at high-tide would preclude the formation of stagnant pools. Although the accumulation of brodifacoum within the tissues of marine invertebrates is possible, it is improbable given this exposure scenario. Any river otters that are foraging for invertebrates in these areas (especially sessile invertebrates such as mussels) are at risk (albeit very low) of brodifacoum exposure. Taking into consideration the persistence of brodifacoum in marine invertebrates and the low likelihood of bait entering the marine environment, the overall likelihood of brodifacoum exposure is low to nil; any possible exposure would be highly localized. The likelihood of adverse effects therefore is very low, on the whole. Any brodifacoum-caused mortality of individual river otters, however unlikely, would not result in any population level effects to this group of animals. The spatial extent of any effects will obviously centre on the areas immediately surrounding Murchison and Faraday Islands, with probability of effects decreasing with increasing distance from these islands. The low risk of adverse effects is expected to be highest in the week following rodenticide application, decreasing through time. Given the potential for brodifacoum residues to persist in the tissues of filter-feeding invertebrates, zero risk is anticipated by two years following bait application as any brodifacoum residues present (however unlikely) in the tissues of longer-lived (>1yr) invertebrates would have had sufficient time to depurate.

Deer cull activities and associated ecosystem changes are not expected to have any negative or positive effects on river otters, given their predominantly marine diet and habitat use.

3.1.1.3 Amphibians

The western toad (*Anaxyrus boreas*) is the only native amphibian on Haida Gwaii and is currently designated under the federal Species at Risk Act as Special Concern (Conservation Data Centre, 2012). Current population estimates for this species is not available. However, COSEWIC (2002) suggests population levels are greater than the critical limits set for listing a species federally as threatened or endangered, (i.e., more than 10,000 individuals occupying an area > 5,000 km^2). It is not known whether there are any western toads on Murchison or Faraday Islands. Based on a map of known occurrences of Western Toad on Haida Gwaii, their distribution seems to be restricted to Graham and Moresby Islands (Burles et al., 2004). Islands located offshore within the archipelago either do not have toads or do not have data on toad presence.

This species is an opportunistic predator exploiting a range of invertebrates including worms, terrestrial and aquatic insects and spiders (COSEWIC, 2002). Based on their diet, any western toads present on Murchison and Faraday islands during the eradication would initially be at high risk for secondary poisoning resulting from ingesting invertebrates that have fed on the rodenticide baits. If present on Murchison and Faraday islands, dead or dying toads exposed to the rodenticide may also be preyed on or scavenged by one or more species mentioned under Birds and Mammals, leading to increased tertiary poisoning risk. Based on their physiology (skin permeability), fossorial habits and use of crevices/burrows as hibernacula (Duellman and Trueb, 1994), and the potential for bait to be cached in such places by rats and other small mammals that may be present, toads occupying contaminated hibernacula could passively accumulate brodifacoum residues directly from any intact bait (highly unlikely, given the local climate and insect activity that reduces the amount of time that the bait remains intact), or from soil that was contaminated by the bait. An aerial eradication operation on Murchison and Faraday islands would likely impact individual animals, if this species is present, but not result in any population level effects even in the unlikely event that mortalities occur as a result of the operation. Spatial extent of exposure is restricted to the eradication islands. Temporal extent of exposure is anticipated to be 6 months (conservatively), based on previously estimated half-life of brodifacoum in soil (see section 3.1.3).

Deer cull activities are not expected to have any effects on the Western Toad. Ecosystem changes (greater amount of understory vegetation) resulting from the reduction of deer numbers may have an indirect, beneficial effect resulting from an increase in the terrestrial invertebrate population, which forms their prey base, and increased cover/refugia. Spatial extent of these effects is anticipated to be centered on Murchison and Faraday Islands, extending as far as S. Lyell Island and Ramsay Island (wherever active culling reduces deer numbers). Temporal extent would be limited to the amount of time that the area maintains reduced deer numbers.

3.1.1.4 Invertebrates

Terrestrial, freshwater and marine invertebrates have the potential to be exposed to, and accumulate brodifacoum. During an unarmed bait trial, terrestrial invertebrates such as banana slugs, millipedes, carabid-like beetles, and small flies were observed feeding on the grain-based bait pellets (Parks Canada Agency 2012b; P. Bartier pers. comm. Jan. 24, 2013). As well, since brodifacoum is excreted largely unchanged in mammalian and avian feces (Eason et al. 2002), invertebrates may be exposed to brodifacoum through ingestion of contaminated feces. Invertebrates are not susceptible to the toxicant's mode of action, therefore they are not expected to experience mortality due to brodifacoum's mode of action (Morgan et al., 1996b). They may, however, accumulate brodifacoum within their tissues. There is a possibility that accumulated brodifacoum residues may cause lethal and sublethal effects to individual invertebrates via narcosis/toxicosis (Ogilvie et al., 1997). Sublethal narcosis may render the invertebrate more vulnerable to predation. As well, invertebrate attraction to bait pellets and contaminated feces may result in higher invertebrate densities in the vicinity of the bait or feces pellet, which may attract insectivores. More importantly, exposed invertebrates can act as vectors for secondary exposure/poisoning. Fortunately, once bait pellets and feces disintegrate, invertebrates that have fed upon them are likely to disperse, in essence diluting the presence of brodifacoum.

Within stagnant marine or freshwater habitats (e.g. tidal pools, ponds), contamination via non-intentional introduction of brodifacoum bait is expected to remain localized around the bait pellet (Fisher et al., 2012). Aquatic invertebrates (freshwater or marine) may feed on the grain-based bait, accumulating/mobilizing the toxicant within their tissues. These exposed organisms may then move to other areas, and/or be consumed as prey items, transferring their toxicant body burden to other locations and to higher trophic levels.

In aquatic environments that experience current, tidal, or wave action, bait is expected to rapidly disintegrate and disperse. Brodifacoum residues were not detected in starfish, crayfish, and crab collected 8-16 days following an accidental bait release into an intertidal environment in New Zealand (E. Coast of South Island) (Primus et al., 2005). Although not specifically published within this study, it is assumed that water temperatures at the site of the accidental release are likely warmer than that found around Murchison / Faraday Islands. However, depending on the feeding habit (specifically filter feeders), certain invertebrates (e.g. bivalves) may build a toxicant body burden, which can persist for quite some time. The detection of brodifacoum residues within certain intertidal marine invertebrate tissues (bivalves, abalone) two years following the same bait release (Primus et al., 2005) suggests a persistent contamination source that is moderately mobile and available for trophic transfer. The use of a deflector during bait application to the coastal perimeter of the islands will reduce bait entering the marine environment, and the likelihood of bait pellets remaining in stagnant pools and contaminating resident invertebrates is low, as wave and tidal action are expected to cause the bait to rapidly disintegrate and disperse.

Spatial extent of invertebrate contamination is expected to be restricted to the eradication islands and the immediate marine intertidal area. Contaminated invertebrates that are able to fly (i.e. insects) may reach S. Lyell Island and Ramsay Island; however, the dispersal of these insects has an environmental dilution effect, and it is highly unlikely that this dispersal will result in adverse effects. Given the potential persistence of brodifacoum residues in these organisms (especially marine bivalves; Primus 2005)), temporal extent is anticipated to be 2 years (conservatively).

3.1.1.5 Fish

Fish could be exposed to brodifacoum either through direct ingestion of bait, secondary exposure (e.g. consuming brodifacoum-contaminated prey), or through passive (e.g. gill or transdermal) uptake via direct contact with contaminated water or sediments.

None of the streams on Murchison and Faraday Islands have been identified as fish-bearing (Broadhead 2009; Krishka 1997; Department of Fisheries and Oceans' Fisheries Information Summary System). As well, no fish have been observed recently or historically (P. Dyment pers. comm. With R. Gautier; P. Dyment, pers. comm. December 11, 2012). Because these streams are not fish-bearing, any bait entering them during aerial broadcast operations is predicted to have little or no impact on fish habitat or fish life.

It is expected that any bait pellets entering the marine environment will rapidly disintegrate and be quickly dispersed by currents and tidal action. Given the sparing solubility of brodifacoum in water, it is not likely that fish will accumulate measurable concentrations of the rodenticide via passive uptake from water. Fish with benthic habits may be exposed via passive uptake from contaminated sediments; however, given the high likelihood of dispersal by wave action and currents, it is unlikely that measurable concentrations will be accumulated through this method of exposure.

Previous study has shown that marine fish species show almost no interest in the bait pellets (References cited in Parks Canada Agency 2012b). However, there were detectable brodifacoum concentrations in butterfish gut and liver 9 days after an accidental discharge in a tidal marine environment (Primus et al., 2005). It is not definitively known whether the exposure of fish was through direct ingestion or ingestion of contaminated food; however, the detection of brodifacoum residues in marine invertebrate tissues (bivalves, abalone) two years following the spill (Primus et al., 2005) suggests a persistent contamination source available for trophic transfer.

Within stagnant marine habitats (e.g. tidal pools), contamination via non-intentional introduction of brodifacoum bait is expected to remain localized around the bait pellet (Fisher et al., 2012). Aquatic invertebrates (freshwater or marine) may feed on the grain-based bait, accumulating/mobilizing the toxicant within their tissues. Through movement, these exposed organisms may then move to other areas, and/or be consumed as prey items, transferring their toxicant body burden to higher trophic levels. However, given mitigative measures to minimize introduction of bait with rodenticide into the marine environment (use of a deflector and coastal perimeter bait application at high tide), bait pellets that enter the marine environment will be subject to current and wave action and are not be expected to remain intact for long, in essence diluting the rodenticide and preventing any appreciable accumulation within the tissues of marine invertebrates or fish.

Spatial extent of contamination is expected to be restricted to the marine areas immediately surrounding the eradication islands. Temporal extent of contamination is not expected to extend beyond the subsequent high tide (up to 12 hours).

Concerning the deer cull and associated terrestrial-based ecosystem effects, there are no effects anticipated.

3.1.2 Vegetation

Taking into account all of the activities associated with this project, there is expected to be some trampling of understory vegetation associated with any human presence and movement, including but not limited to carcass searches, deer culls, and manual baiting. Given the low anticipated impact of these activities, trampled vegetation is expected to recover by the subsequent growing season.

Field tests have shown no significant transfer of brodifacoum from soil to grass, even at applications rates 15 times higher than normal rates of application on rangelands. No brodifacoum was detected in samples of grasses collected post eradication on East Anacapa Island (Howald et al., 2010). Plants are not known to be susceptible to toxic effects of brodifacoum.

The culling of deer may result in the recovery of understory vegetation, which may be of benefit to forest insects and songbirds (Allombert et al., 2005 a&b). The spatial extent of this effect is limited to areas where deer are eliminated or substantially reduced. The temporal extent of this effect is for as long as reduced deer numbers are maintained.

3.1.3 Soils and landforms

Taking into account all of the activities associated with this project, there is expected to be some ground compaction associated with human activity related to the project (including, but not limited to carcass searches, deer culls, and manual baiting). This is expected to be very minor and localized, with recovery anticipated by the subsequent growing season.

Humic and surficial materials will come into direct contact with the rodenticide brodifacoum, localized to the area immediately surrounding the bait pellets (USEPA, 1998). Brodifacoum is not soluble in water and will not migrate from the land to the water supply or ocean. It binds strongly to organic or non-polar soil constituents, rendering it immobile, except in the case of erosion of these substrates (USEPA,1998). It would remain adsorbed to organic material and settle out into the sediment, which would be widely dispersed and diluted by waves and current action. Degradation of brodifacoum by soil microbes results in non-toxic metabolites in microorganisms, and eventual reduction to its base components of CO_2 and H_2O. Soil-bound brodifacoum degrades slowly. The environmental half-life of brodifacoum in soil (26 – 178 days) depends on soil type, ambient temperature, and the presence of soil micro-organisms (USEPA, 1998). Given the cool climate and employing the precautionary approach, the half-life of brodifacoum in the soils of Murchison and Faraday Islands is deemed to be closer to the 178 days time period.

3.1.4 Aquatics/hydrological resources

During an aerial eradication operation, bait pellets will drift into the marine environment during baiting along the coastline due to winds and to the fact that coastlines are convoluted. However, the bait application techniques described in this document include mitigation measures to minimize bait drift into water bodies. Based on previous studies, bait drift into the marine environment will have no measurable long term negative impact to intertidal invertebrates, fish, or water (e.g. Primus et. al., 2005). Furthermore, brodifacoum is not water soluble and will likely not be detectable in the water column (Olgilvie et al., 1997). The pellets also sink if they drop into the water (G. Howald pers. comm.).

Freshwater features are considered optimal rat habitat. It is therefore critical to ensure that there are no baiting gaps in the vicinity of the temporary streams on Murchison and Faraday Islands. Creating a “no bait” buffer around these streams would be extremely challenging due to difficult terrain, and the extent of vegetation cover – this may result in baiting gaps, which will increase the risk of eradication failure.

Brodifacoum-armed bait is unlikely to contribute to detectable concentrations of brodifacoum in the water column. Its low solubility in water / high log K_{ow} causes strong binding to non-polar environmental compartments such as organic sediments. Within stagnant marine or freshwater habitats (e.g. tidal pools, ponds), contamination via non-intentional introduction of brodifacoum bait is expected to remain localized around the bait pellet (Fisher et al., 2012). Bait pellets that fall directly into flowing freshwater bodies or marine environment will likely disintegrate rapidly and become dispersed owing to wave action and/or currents. The brodifacoum, in turn, is expected to bind to organic material and slowly degrade.

Brodifacoum contamination may be localized to the area immediately surrounding the bait pellets. Depending on precipitation events, a bait pellet or its disintegrated “cloud” within surface water (e.g. creek) may be transported/dispersed by currents and re-settle elsewhere downstream. Within the marine environment, brodifacoum-bound sediments may settle out of the water column, but could become re-suspended by wave action.

The potential for groundwater contamination is low, given brodifacoum’s high binding affinity to soils.

The deer cull may have a minor, but beneficial effect on stream habitat, based on recovery of understory vegetation.

3.1.5 Pollution

Details/effects of pollution/contamination related to the introduction of rodenticide (brodifacoum) bait is discussed in sections 3.1.1 to 3.1.4. There is a risk of accidental spill of rodenticide bait into marine, freshwater, or terrestrial environment (e.g. Primus et al., 2005; Fisher et al., 2012) owing to helicopter bucket failure, human error, accident, etc. A bait spill response plan is in place and will be posted, in the event of accidental introduction of large amounts of rodenticide bait into the environment. All personnel will be oriented to bait spill response procedures during project start-up.

The use of motorized watercraft and helicopters, specifically the risk of accidents, may result in the introduction of fuels and lubricants into the environment. The extent and severity of these effects depends on the location, nature and amount of substance spilled. Secondary containment of fuels will be provided, including use of a pan to capture any small volume spillage associated with helicopter and hopper refueling. Containment booms and spill pads will be kept on hand for rapid deployment in the event of a fuel spill. Staff that will be present have already taken Canadian Coast Guard fuel spill response training.

There will be wastewater produced from personnel accommodations that will be on site. However, these facilities will be equipped with a peroxide-based marine sanitation device that conforms to international and Transport Canada marine pollution standards. The marine sanitation device will be treating wastewater from toilets. In the unlikely event that the sanitation device malfunctions, is not operating optimally, or the treatment capacity is overwhelmed, temporary portable toilets should be kept on hand to capture human wastes. Any untreated wastewater that enters the marine environment is not expected to have a significant effect on the surrounding marine environment, given the time of year, dilution from tidal currents, and the relatively short period of time that the facilities and human occupants will be on site.

3.2 Valued Components: Cultural Resources

3.2.1 Heritage Values

Humans have occupied Haida Gwaii for at least the last 10,000 years before present, and today in excess of 600 archaeological sites are known within Gwaii Haanas (D. Fedje, pers. comm., undated). Most of the known sites occur along shorelines, but because of sea level fluctuations, many sites are now either inland or beneath the sea. Murchison and Faraday islands were historically inhabited by the Haida. A number of archaeological sites (i.e. shell middens, cultural modified trees (CMTs)) are present on the islands and require consideration in planning and implementing the eradication; these are listed below. The remains of a settler's cabin are also present on Faraday Island and a more recently constructed cabin located on the small island lagoon on the eastern end of Murchison are not considered historical sites.

Known archaeological sites on Murchison and Faraday Islands include shell middens, CMTs, house depressions and other sensitive cultural features. The location of these is known by Parks Canada Agency for management purposes, however locations are not outlined here because of the cultural sensitivity of this information.

3.2.2 Character-defining elements

Seabirds have played a significant cultural role in Haida life pre-contact and throughout the early 20th century. Oral history interviews (Blackman 1979; Ellis, 1991) and archaeological excavations (Acheson, 1998; Fedje et. al, 2001) have documented the use of seabirds by the Haida for the purposes of dietary and ceremonial use. Seabirds feature largely in the story-telling and songs of the Haida people. Historically, seabirds and their eggs provided seasonally abundant food sources. Small alcids such as ancient murrelets and Cassin's auklets dominated the diet during the nesting season, and nesting colony locations were well known. Birds were dug out of the burrows at night, and fires were used to disorient birds (B. Wilson, pers. comm. undated). Glaucous-winged gulls were of sufficient importance that nesting sites were inherited property of specific lineages. Today, the collection of gull eggs still occurs at some sites in Skidegate (B. Wilson, pers. comm. undated).

The raven (*Corvus corax*) and the bald eagle (*Haliaeetus leucocephalus*) are culturally significant birds to the Haida. All Haida persons are born into the Raven or the Eagle moiety, which are further divided into lineages or families. Marriage takes place between Eagles and Ravens, rather than within the same moiety. Haida children become members of the same moiety as their mother. Because of the cultural significance of these animals to the Haida, there will be a high level of scrutiny on the well-being of these species during, and as a result of, the eradication.

The Council of the Haida Nation, through the Archipelago Management Board and its cooperative management of Gwaii Haanas, is supportive of reducing and/or eliminating the negative impacts of rats on culturally significant seabird populations and on other natural and cultural resources of Gwaii Haanas (including totemic animals such as Ravens and Eagles). The Gwaii Haanas Management Plan calls on Parks Canada and the Haida Nation to "*prepare and implement [plans] to manage introduced species in order to minimize their impact on indigenous species and their habitats*" (Archipelago Management Board, 2003). The Council of the Haida Nation, through the Archipelago Management Board, has been closely involved in the development of the rat eradication project outlined here and has been closely consulted on operational matters and potential impacts, both positive and negative.

Rat eradication is likely to result in a positive (in the case of seabirds) or a nil effect (i.e. cultural sites) on cultural resources, provided that mitigative measures are followed.

3.3 Valued Components: Characteristics Important to Visitor Experience Objectives

3.3.1 Viewscapes and aesthetics

The project will have only minimal short-term negative impacts on visitor experience objectives in that rat eradication activities will be conducted during the last month (September) of the visitor season. The floathouse and barge will be anchored at Murchison Island and helicopter activity on the target islands may pose a disruption to visitors at nearby islands (i.e. Hotsprings).

However, in the long-term, visitor experience objectives of the area will be enhanced as a result of rat eradication. No change to the viewscape or aesthetics of the site is anticipated.

3.3.2 Visitor appreciation and access

Visitor appreciation of the site will be enhanced as rat eradication will result in rat-free camping on the target islands.

Visitor access to these islands will be closed temporarily to ensure public safety during the eradication (April 1, 2013 to October 31, 2013) and during periods of deer culling. Some visitors to nearby areas will witness project activities related to the eradication (i.e. helicopter activities) and associated monitoring programs.

A visitor orientation program is delivered to all visitors to Gwaii Haanas prior to their visiting the park reserve. It includes targeted messaging about invasive species, ecological restoration and this proposed project. Educating visitors to Gwaii Haanas about park reserve management, including the management and eradication of invasive species, is a key part of the Parks Canada mandate. It is anticipated that many visitors will be interested and supportive of park management activities to restore ecological integrity.

3.3.3 Recreational and other opportunities for enjoyment

In both the short-term and long-term, rat-free camping opportunities will be available to visitors to the area.

3.3.4 Public Safety

There is potential for adverse short-term public safety concerns associated with deer culling activity (use of firearms). There is a low potential for humans to be exposed to brodifacoum, through indirect exposure (i.e. consuming brodifacoum-contaminated meat, likely deer) although hunting by Haida First Nations is limited in the area and hunting restrictions will be implemented until sampling of deer tissues show no further detection of rodenticide (approx 2 years).

Positive, long-term effects of rat eradication will improve public and visitor safety by providing visitors with opportunities for rat-free camping on Murchison and Faraday Islands and reduce human exposure to rats and associated concerns with hygiene, disease, and food contamination.

3.3.5 Unique character and connection to place

No effects, adverse or positive, on the unique character and connection to place are anticipated.

3.4 Additional Values

3.4.1 Socio-Economic Impacts

No socio-economic impacts are associated with this project.

4 Mitigating Measures

4.1 Mitigating Measures to Reduce Non-target Risk

Mitigative measures will be employed to minimize potential non-target impacts on native wildlife. The mitigation measures described below are designed to protect individual animals even if expected impacts are not considered significant to the population while still ensuring eradication success. Eradication of rats from Murchison and Faraday islands is anticipated to have long term positive impacts for non-target species, even those populations that may experience some level of mortality as a result of rodenticide bait application.

4.1.1 Eradication Timing

The eradication is proposed for the fall months from September to mid-October 2013. This period corresponds to the time when migratory birds have left the islands for their wintering grounds and hence, will reduce the potential of primary and secondary poisonings. Timing the operation for the late fall also minimizes the potential for physical and noise disturbance of native species including birds and marine mammals.

4.1.2 Bait Pellet Design

The cylinder-shaped bait pellets are approx 2 grams in weight (mass) and are approximately 17mm long and 13mm in diameter. The pellets are too large for small passerines such as sparrows to easily consume and are dyed blue/green which may make them less attractive to some birds (Pank 1976, Tershy and Breese 1994, Buckle 1994). Chaff, the dry, scaly protective casings of the seeds of cereal grain is minimized with the bait pellet which should further reduce attractiveness of the bait to small birds (P. McClelland pers. comm. undated). The bait is sterile and non-viable hence will not risk introducing new seeds into the environment.

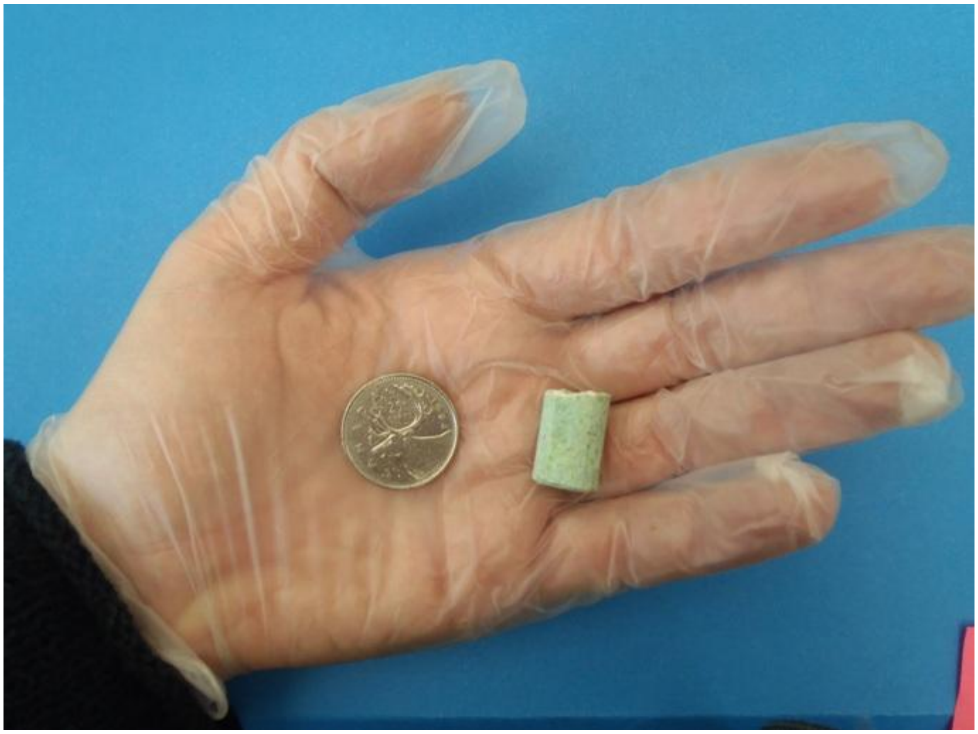

Figure 9: Bait pellet size and scale.

4.1.3 Carcass Searches

During the eradication operation field crews will conduct searches on both islands and remove any target and non-target wildlife carcasses found in order to minimize the risk of secondary poisoning. Generally, most rats die below ground, which can reduce but not eliminate the risk of secondary poisoning during eradication operations targeting this species (Kaiser et. al., 1997). However, less is known about the behaviour of black rats exposed to lethal or sublethal levels of a rodenticide (P. McClelland pers. comm. undated). A. Wegman (pers. comm.) suggests that a majority will likely die in their nest based on previous black rat eradication operations. Therefore, if their preferred nesting habitat is in burrows, which is likely the situation with Murchison and Faraday islands, then it is likely that most rats will die underground. If this is not the case with the Murchison and Faraday islands eradication it is possible that a larger number of rat carcasses may be present during and after the eradication operation thereby increasing the risk of secondary poisoning to non-target species. This necessitates the need for thorough carcass searches both during and after the aerial broadcast operations.

4.1.4 Supplemental Feeding of Avian Scavengers

Sitka deer carcasses (“clean” i.e. not exposed to brodifacoum) could be placed as a supplemental food source at strategic points of land near Murchison and Faraday islands in order to draw Bald Eagles, Common Ravens, Northwestern Crows, and other scavengers away from the project site during the aerial eradication operation. This mitigative measure was successfully implemented during the Bischofs and Arichika eradications in 2011 (Parks Canada Agency, 2012).

4.1.4 Introduced Sitka Black-tailed Deer Cull

Prior to eradication implementation a Sitka deer cull on Murchison and Faraday islands will be undertaken in order to reduce the potential for secondary poisoning from scavengers feeding on deer carcasses. A deer reduction plan has been prepared by Parks Canada in line with the Management of Hyperabundant Wildlife Populations Directive. This plan is being evaluated as part of this DEIA, in accordance with the Guide to the Parks Canada Environmental Impact Analysis Process under CEAA 2012. Evaluation of the effects of the deer cull on valued components is included as part of the overall evaluation of the project on valued components.

Public safety, and the humane treatment of animals must be assured for this component of the project. Parks Canada's Western and Northern Animal Care Task Force recommends that the most humane way of killing deer is by a shot to the head or heart/lung region with a high powered rifle (T. Shury, pers. comm. undated). Only hunters who have qualified in marksmanship and firearm safety should be allowed to participate in culls. Cull islands must be closed to the public during culls and this closure must be properly advertised. A clear strategy and protocol should be established for this cull, which could include wearing high visibility clothing (if appropriate for the cull technique being used), being in radio contact, restricted zones of movement / shooting, and reporting of all shots fired and deer shot. Briefings should be held prior to all culls that emphasize firearm safety, the need for good marksmanship and adherence to all procedures and protocols, including Environmental Assessment mitigating measures. Where the animals are to be used for human food, it is strongly recommended that non-lead (Pb-free) ammunition be used, so as to avoid human consumption and exposure to lead.

Deer carcasses that will not be used for human consumption should not be left near or upstream of any drinking water sources. These carcasses should be removed from Murchison and Faraday Islands so that rats will not feed on them (and expand their populations by doing so). Uncontaminated deer carcasses can be left on exposed points of land that are removed from eradication activities, as this practice has successfully drawn aerial scavengers away from eradication areas during the 2011 Bischofs Island rat eradication. Another disposal option for deer carcasses is to dispose of them in the offshore marine environment – for this option, a carcass condition that encourages rapid decomposition and marine scavenging (e.g. cutting open the body cavity) is recommended.

To minimize / mitigate any trampling effects, specifically to seabird burrow habitat, people participating in the deer cull should be made aware of the location of this habitat via staking / flagging these areas and/or delineating these areas on a map. Shoreline culls should take place by boat.

One of the several cull methods that will be used involves baiting. Use of bait should be judicious to limit introduction of new food sources for rats and should not be a vector for the introduction of invasive plants.

Major effects identified are associated with the use of firearms. Noise associated with shots fired has the potential to disturb wildlife. For this reason, as well as to keep the local deer population naïve, firearms equipped with sound suppressors will be used. Culling of deer will be suspended for the last week of May and throughout June to reduce stress on deer during peak fawning times (the first two weeks of May) and to reduce stress on any pups at known nearby pinniped haul outs.

4.1.5 Minimizing Bait Drift into the Marine Environment

A broadcast deflector will be attached to the hopper for all treatment passes of coastal bluffs and cliffs, and will be used on a perimeter swath around the islands. The deflector directs bait within approximately 180° of the onshore side of the helicopter to minimize bait drift entering the ocean on the opposite, or seaward, side. Baiting of the perimeter swath will take place during high tide to minimize bait drift into the marine environment. Supplemental hand-broadcasting may be required in areas where aerial application is not feasible (i.e. small islets) in order to minimize accidental bait drift into the marine environment.

4.1.6 Mitigating Human Health Impacts

When working with the bait in a planned and controlled environment the risks to human health are very low. Personal Protective Equipment (PPE) will be worn by all personnel that handle bait and will meet or exceed all requirements described on the PMRA label for the rodenticide bait. Furthermore all personnel that will come in contact with the bait or monitor bait application in the field will receive training in bait handling protocols and procedures and successfully obtain their Provincial Pesticide Applicators Certification.

Washing/decontamination of hands/containers will be in a location where wash water is not accessing streams or other freshwater/marine environments directly or through surface run-off. The use of hand sanitizer as a means of decontamination is not recommended. All bait will be stored in appropriate bait containers as indicated by law. Bait spill kits will be available to contain any spills. Access to the project site is to be limited to Parks Canada personnel and contractors associated with the project.

A temporary hunting closure will be implemented for Murchison Island, Faraday Island, Southeast Lyell Island, Hotsprings Island, House Island, and Ramsay Island to ensure that any deer sub-lethally exposed to the rodenticide bait can depurate the toxin before being potentially consumed by humans. Deer on the project islands and adjacent shores of Lyell Island should be tested for brodifacoum exposure before the hunting closure is lifted. This hunting closure should be maintained until deer tissue testing confirms that rodenticide is not detected in deer tissue (approx 2 years), or present at non-toxic concentrations if detected[7], based on analytical detection limits of the laboratory protocol being used. As well, marine invertebrate harvesting should be closed for at least 1 year following the eradication to allow marine invertebrate tissue the chance to depurate any rodenticide that may have accumulated. Marine invertebrate tissues should be analyzed for brodifacoum residues prior to resuming this activity (i.e. through sampling of bivalves).

4.2 Mitigative Measures for the Protection of Cultural Resources

Extreme care must be taken when hunting in or near cultural features. Personnel should be oriented to locations of sensitive cultural features. Those that are that are not conspicuous should be flagged or maps provided to personnel. Whenever possible, shots should be directed away from important cultural areas.

[7] Current analytical protocols offer a limit of detection of 0.5 parts per million for brodifacoum residues in animal tissue. New analytical protocols are currently being developed that can detect brodifacoum residues in animal tissues to a limit of detection of a few parts per billion (Nick Schrier, Animal Health Laboratory – University of Guelph, pers. comm. April 5, 2013), which is far below tissue concentrations that can cause a toxic response in mammals.

Should human remains be uncovered or discovered at any of these sites during the course of the project, the coordinates of the location should be noted and Gwaii Haanas Cultural Resource Management Advisor should be notified so that the appropriate course of action can be determined.

Visible cultural features should be noted on maps for personnel and personnel should avoid walking through house depressions and/or exposed middens to avoid contributing to erosion. If located, CMTs should be flagged and care should be taken to maintain the integrity of these cultural features as they can be subject to stray bullets. Digging or other ground disturbance should be avoided. Additionally, any other visible cultural features not already mapped should be flagged and reported to the Cultural Resource Management Advisor.

4.3 General Mitigative Measures

All participants in fieldwork will (or will have within the last 3 years) attend a Gwaii Haanas orientation. Disturbing wildlife will be avoided (outside of deer cull activities). Wildlife will not be allowed access to lunches, other foods and food garbage. Wastes will be appropriately managed to reduce opportunities for rats and other wildlife. The Parks Canada Wildlife Conflict Specialist will be notified of all human–bear encounters as soon as possible after they occur. If the bear shows any sign of aggression, the work area will be vacated immediately. All garbage will be packed out of the area and eventually disposed of in town. Fueling of chainsaws or other motors (except boats) shall be at least 5 m away from a stream bank. Funnels will be used for refueling to minimize spillage. Fuels will be stored in containers approved for gasoline or oils. The fuel line between fuel tanks and generators will be inspected for leaks no less than twice per week, and absorbent material will be kept on hand to manage leaks and spills, if necessary. Aviation fuel for helicopters should be stored with a means of approved secondary containment, and fueling of helicopters and hopper should be done while using a spill pan to capture any small volume spillage associated with refueling. Containers will be sealed immediately after refueling. A spill protocol will be posted for all personnel to see. All spills will be reported to the appropriate contact person.

Vessel speeds should be kept low while approaching the floating accommodations to minimize shoreline disturbance from wakes, and vessels should safely avoid kelp patches. Disposal of food scraps through kitchen sink should be avoided – food scraps should be thoroughly scraped off plates etc. prior to washing dishes. Food scraps and other biodegradable refuse can be disposed of offshore and well away from land. The use of environmentally friendly, biodegradable soap and cleaning products (dish soap, hand soap, shampoo, cleaners, etc.) is encouraged.

The floatcamp is equipped with a marine sanitation device that will treat wastewater from toilets. In the unlikely event that the sanitation device malfunctions, is not operating optimally, or the treatment capacity is overwhelmed, temporary portable toilets or other options should be available for proper disposal of human wastes.

Disposal of solvents, paints or other environmentally deleterious substances will be done through appropriate storage and transport back to town.

5 Cumulative Environmental Effects

Cumulative assessment of effects for this project will be restricted to the areas where the rat eradication and deer cull activities will take place, and the surrounding marine areas.

The primary cumulative environmental effect and goal of this project is the eradication of black rats from Murchison and Faraday Islands. Rats are a non-native, invasive species that have devastating effects on seabird colonies. Elimination of rats will make predator-free breeding habitat available for a number of marine birds and raptors, including species-at-risk. The absence of rats may encourage native small mammals to establish populations in newly rat-free areas, which, in turn, would provide a prey base for SAR-listed Northern Goshawk and Northern Saw-whet Owl.

After careful consideration by project planners, the aerial application of a brodifacoum rodenticide pelleted bait formulation was deemed to be the best manner in which to successfully eradicate rats. However, this does result in the temporary presence of a potent rodenticide, and open access of a variety of wildlife to that rodenticide. This poses a risk of primary non-target poisoning to a variety of wildlife identified in Section 3, which can lead to indirect poisoning via scavenging. Wherever possible and without compromising bait availability to rats, mitigative measures have been designed to decrease this risk. A bait deflector will be used to minimize bait drift into the marine environment. The fall timing of the eradication is outside of the breeding season of most of the area's wildlife to minimize disturbance and noise-related impacts. The bait pellets that will be used are sized, coloured, and formulated to be less attractive to smaller bird species (i.e. songbirds) and to not present a risk of introducing seeds into the environment (grain-based matrix of the bait is sterile). Carcass searches will be conducted in order to reduce the risk of secondary poisoning , and to provide tissues for brodifacoum residue analysis. Some non-target effects owing to the presence of rodenticide are anticipated; on the whole, these are not likely to result in population-level effects for any affected non-target species.

To control and minimize human/occupational exposure to the rodenticide, PPE will be used by personnel that handle the bait, such that PMRA label requirements are met or exceeded. Handlers will have their Provincial Pesticide Applicator's Certification. Procedures and locations pertaining to handwashing will be clearly outlined. Bait will be contained and stored as per the PMRA label requirement, and personnel on site will be restricted to those who are involved in some aspect of the project.

Also to minimize human exposure to rodenticide, the islands and surrounding area will be closed to deer hunting and marine invertebrate gathering for defined periods post-eradication. Testing for rodenticide residues in these species will be undertaken prior to lifting hunting and harvesting closures.

A deer cull is proposed as a mitigative measure. Deer are likely to be attracted to the bait, and will compete with rats for the bait, creating bait gaps and potentially jeopardizing eradication success by reducing bait availability to rats. The deer cull will increase likelihood of eradication success, and also reduce risk of secondary poisoning for species that will predate deer carcasses. As deer are an introduced, hyperabundant species in Gwaii Haanas, their removal from the target islands will have beneficial impacts on vegetative communities.

Noise disturbance owing to firearms use is a concern – the use of noise suppressors will reduce this disturbance. Culling will be temporarily suspended to reduce stress on animals during peak fawning and pinniped birthing/pupping in June.

Procedures to ensure public and hunter safety are tantamount. At the time of publication, the use of non-lead (e.g. copper) ammunition is being considered to eliminate lead contamination of the meat, especially in instances where the meat will be used for human consumption. Deer carcasses should be removed from Murchison/Faraday Islands to reduce food availability to rats.

To reduce the potential for damage and disturbance to seabird burrowing habitat, shoreline culls should take place by boat. To increase cull efficiency, deer attractants will be used. Attractants must be sterile (i.e. not contain viable seeds) and must be used in a manner that new food sources are not introduced for rats.

Sitka-black tailed deer are a non-native, invasive species on Haida Gwaii that has a profound effect on the forest plant community. There are other corollary benefits to reducing deer numbers. There is expected to be a recovery of understory vegetation in areas where deer browse has suppressed plant growth. This benefits forest songbirds, small mammals and invertebrates, as well as any wildlife that use these as a prey base. The culling of deer also provides for mitigation of secondary poisoning to avian scavengers.

Protection of cultural resources is an important consideration in Gwaii Haanas. Extreme care must be taken when hunting in or near cultural features. Personnel will be oriented to locations of sensitive cultural features. Those that are that are not conspicuous will be clearly marked on maps or flagged as appropriate. Personnel should avoid walking through cultural features such as middens and house depressions, where possible.

There are a number of generalized mitigative measures that address day-to-day conduct in these areas, such as not allowing wildlife access to human food and garbage, not littering, proper fueling techniques, and having fuel spill response materials on hand.

Ecological integrity is expected to improve on a local and regional scale as a result of this project. Invasive mammals are a stressor on a number of Gwaii Haanas' ecosystem, as reflected in the "Forests" and "Coastal" Ecological Integrity indicators (Gwaii Haanas 2007). Invasive rat presence, as well as seabirds breeding, feed into the "Coastal" EI indicator – reduction of the number of rat-infested islands and an increase in seabird breeding activity will result in improvements to the "Coastal" indicator. The culling of deer that is associated with the project will improve the forest's plant diversity, and decrease the impact of deer on forest vegetation, within the local areas where deer culling takes place.

The persistence of brodifacoum residues in this particular environment is a relative unknown. Environmental or biological half-life can be inferred from other studies; however, given the potential risk of exposure to humans (Aboriginal harvesters have the right to hunt deer and harvest marine resources in Gwaii Haanas) testing for rodenticide residues prior to lifting harvest restrictions will be conducted. See section 8 for a complete description of monitoring programs associated with the proposed project.

6 Residual Impacts

As addressed in various sections above, the net environmental change is the elimination of rats on two islands in Gwaii Haanas, along with the resulting cascade of change to the associated ecosystem and habitats of a number of wildlife species, including species at risk. These "residual impacts" are net benefit improvements to the ecosystem.

There may be minor residual impacts from non-target exposure to rodenticide; however, these are expected to be temporary, and not result in population-level effects.

7 Site Inspection Requirements

Parks Canada will designate an Environmental Assessment Surveillance person to ensure implementation of environmental protection measures outlined in this DEIA for the duration of project activities.

8 Monitoring Requirements

Monitoring is required to determine that the eradication is effectively targeting rats, and to determine both positive and negative impacts on non-target species. The monitoring associated with the eradication consists of three main types including:

- efficacy monitoring
- non-target species monitoring (including rodenticide sampling)
- post-eradication ecosystem recovery monitoring.

8.1. Efficacy Monitoring

Efficacy monitoring of the rat population will be conducted to evaluate eradication of invasive black rats. Prior to the eradication adult rats (n=20 on Murchison, n=20 on Faraday) will be captured and fitted with radio collars. Directional Yagi antennas and digital receivers will be used to locate radio collared rats prior to eradication to ensure they are alive and active. Beginning 5-7 days after first baiting application, rats will be tracked until found and confirmed dead where feasible. While the proportion of the island's rat population marked with radio collars is small, the results should provide an index of eradication progress and may indicate whether problems have occurred (e.g. rat mortality has not occurred or has taken longer than expected in some areas).

Remote cameras (Reconyx Infra-red wildlife cameras) will be deployed during the eradication on both islands and will remain in place for the winter months. Data will be downloaded at 3 months, 6 months and one year post-eradication to confirm rat absence. Tomahawk traps, baited with sardines, rat and squirrel attractants will be deployed 3 months, 6 months and 1 year post-eradication to confirm rat absence. Traps will be deployed on the coastal perimeter where rat densities are likely to be highest.

After the 1 year period, efficacy monitoring will consist of periodic live trapping and remote camera deployment with sardine and attractant baits to confirm rat absence. This monitoring will be targeted to summer and early fall months when rat numbers are likely to be at an annual high. Following standard practice for rodent eradication, success will not be declared before two breeding seasons after the eradication has been completed. This time lag will allow any population recovery to reach a detectable level if the eradication is unsuccessful.

8.2 Non-target Monitoring

Risk to non-target species has been assessed in the Feasibility Study (Parks Canada Agency, 2012b) which identifies a number of priority species that are at higher risk of consuming rodenticide baits or rat carcasses. The following section outlines broadly the monitoring programs for these priority non-target species.

8.2.1 Bald Eagle

Long-term monitoring for bald eagles (*Haliaeetus leucocephalus*), including population surveys and nest success monitoring, has been underway in Gwaii Haanas for more than 10 years.

Monitoring to date has confirmed that nest success is higher on rat-free islands vs. rat-infested islands. All eagle nests on Murchison and Faraday Islands will be monitored monthly for occupancy beginning in May through to September, and occupied nests will be checked during peak fledging time at the end of July. This monitoring will be conducted using boat-based surveys using an established protocol for non-target species monitoring. Eagles are a culturally significant animal to the Haida hence are earmarked for specific monitoring because of potential level of interest from local communities.

8.2.2 Raven

Ravens are at particular risk of consuming rodenticide bait and individual mortalities are expected. All raven carcasses will be collected and analyzed for rodenticide residue. Ravens will be monitored using boat based surveys for presence and absence pre and post-eradication.

8.2.3 Species-at-Risk

While key Species-at-Risk, such as Northern Saw-whet Owl, *brooksi* subspecies (*Aegolius acadicus brooksi*) and Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*) will ultimately benefit from rat eradication (i.e. rats are having detrimental impacts on their prey base), individuals may be at-risk of secondary poisoning over the short-term, if they prey on rat carcasses. Pre-eradication monitoring led to the discovery of one adult goshawk active in the southern end of Murchison but it is suspected that this individual is foraging here and returning to a nest on the southern part of Lyell Island (C. Bergman pers. comm.). No goshawk nests have been found on Murchison and Faraday islands to date. Monitoring will consist of pre-eradication and post-eradication monitoring to determine presence/absence using call play backs. Acoustic Recording Units (ARUs) will also be used to determine presence or absence of Saw-whet Owl. In addition, listening counts along the shoreline using call playbacks will be conducted during March during the peak of vocalizations for this species. Opportunistic monitoring of this species will be conducted using call playbacks prior to the eradication. ARUs will be used to determine presence or absence post-eradication and an index of abundance can be inferred from this data.

8.2.4 Sooty Grouse

Sooty grouse (*Dendragapus fuliginosus*) are an important prey species for Northern Goshawk and are potentially at risk from consuming bait pellets. Attempts to radio collar grouse for a wider population study on Haida Gwaii have met with varying success with two individuals radio collared presently. In late April/early May, listening transects using call playbacks, will be employed. ARU data will also be used to provide an index of abundance. Radio collared grouse can be monitored during the eradication to determine mortality. Post-eradication monitoring will employ ARUs and listening transects.

8.2.4 Great Blue Heron, fannini subspecies

Murchison Island is a key area for Great Blue Heron (*Ardea herodias fannini*) in Gwaii Haanas. Although the risk to this species is likely low because they are an intertidal forager, they may opportunistically consume baits and be at risk. ARUs will be used to detect presence or absence pre and post-eradication. This species will also be monitored as part of the boat-based surveys of non-target species.

8.2.5 Rodenticide Sampling

Sampling of relevant environmental matrices will be conducted as per the PMRA requirements and Parks Canada Environmental Impact Assessment to assess potential exposure pathways for native species as well as humans and also to monitor the movement of the rodenticide in the ecosystem. A detailed sampling strategy is being developed for sampling environmental matrices (water), as well as biological matrices such as mammal carcasses.

Environmental matrices to be sampled include freshwater (from streams), and near shore/intertidal water using accepted sampling protocols. These samples will be collected from pre-determined sites around the Murchison / Faraday Islands. Water samples will be obtained prior to the initial bait application, within two days following the initial bait application, within two days following the second bait application, and periodically thereafter (approximately weekly) for 3 to 4 weeks.

Biological sampling will focus on abundant or hyperabundant organisms, especially those that are common food sources for humans such as deer, crabs, and fish. Prior to aerial application of rodenticide bait, a carcass search and collection will be conducted on the islands, focusing on mammals and birds. The livers of any fresh carcasses will be analyzed for brodifacoum residues, which would serve as baseline (pre-eradication) rodenticide concentrations (in essence, to confirm that there is no rodenticide detected prior to bait application). As well, this would assure that the cause of mortality was likely not rodenticide, which would be important in the case of culturally important and charismatic fauna such as Bald Eagles. Following rodenticide application, carcass searches will be conducted and all carcasses collected. Livers will be analyzed for brodifacoum residues to confirm whether or not mortality was due to rodenticide exposure[8].

Sitka Black-tailed Deer

Muscle and liver samples will be obtained from introduced, non-native Sitka black-tailed deer. Because this species is being actively culled prior to and following rodenticide application to reduce bait competition with rats, samples can easily be obtained for brodifacoum residue analysis both prior to and following rodenticide application. Because deer can swim and are not restricted to the islands targeted for eradication, samples will also be collected from deer culled from nearby Hotsprings and Lyell Island in order to determine if rodenticide residues are detectable. Because there is limited hunting by Aboriginal persons within Gwaii Haanas, Parks Canada will advise the Haida Nation of restrictions on hunting of deer within the area and surrounding islands during the eradication and for 2 years post-eradication. Sampling will occur after the second rodenticide application, within one month, 6 months, and one year post-application, potentially extending to two years post-application to monitor for presence of brodifacoum, prior to lifting the hunting restrictions.

Invertebrates

Invertebrates (terrestrial and marine) that have the potential to be exposed to bait will be included in the pre- and post- bait application rodenticide monitoring, especially those which species which have been directly observed consuming placebo bait pellets during the application rate and biomarker trials in September 2012. Invertebrates that are sampled should be plentiful, and of a size where a number of them can be collected within a reasonable time frame to obtain sufficient tissue for analysis.

Recommended marine invertebrates for rodenticide sampling include crab that can be used for human consumption (rock crab or Dungeness crab), and locally abundant and easily obtained bivalves such as mussels, which have the propensity to accumulate and retain detectable concentrations of environmentally persistent compounds such as brodifacoum.

Recommended terrestrial invertebrates include carabid beetles (Family Carabidae), millipedes, and slugs, as these have been frequently observed feeding on placebo bait during the 2012 trials (P. Bartier & L. Wein, pers. comm.).

Fish

Fish that are harvested for human consumption (e.g. ling cod) will be collected from different locations around Murchison and Faraday islands prior to the initial rodenticide bait application, within two days following the initial bait application, within two days following the second bait application, and periodically thereafter (approximately weekly) for 3 to 4 weeks.

8.3 Post-eradication Monitoring (Ecosystem Response)

Parks Canada Agency has implemented a number of monitoring programs to measure long-term recovery of the ecosystem in the post-eradication recovery phase. These monitoring programs are being managed by Parks Canada Agency, and are included in the agency-wide Ecological Integrity program which tracks indicators of ecosystem health over time. Some monitoring programs are conducted in collaboration with academic institutions. Methodologies include:

1) Establishing baseline for measuring populations over several years after rat eradication
2) Conducting BACI (Before-After, Control-Impact) design to determine impacts to native species on target islands, and also on islands where eradication has not taken place

Parks Canada Agency's long-term ecological integrity monitoring program tracks key indicators of ecosystem health over time. Indicators are monitored annually and/or periodically (every 2 to 5 years). Specific indicators of this park-wide monitoring program that will be used to determine success of this project include:

- Rat absence on restored islands (eradication islands), as well as control (rat-free) islands;
- Presence/absence of Ancient Murrelets, Cassin's Auklets, Fork-tailed and Leach's Storm-Petrels and other ground nesting seabirds on restored islands and control islands;
- Nesting shorebird abundance (using Black Oystercatcher as a keystone species);
- Breeding songbird abundance and species diversity;
- Native small mammal presence/abundance;
- Intertidal algae & invertebrate diversity and abundance.

Monitoring methods include the use of remote wildlife cameras (for rats, small mammals, and other species), the use of acoustic recording units (seabirds vocalizations), and seabird and shorebird surveys.

All of the above metrics, with the exception of abundance of nesting seabirds, are part of a broader program of long-term monitoring established by Parks Canada to monitor landscape-level indicators of ecological integrity. These metrics are reported on every 5 years through the Parks Canada Agency's State of the Park reports which showcase trends in ecosystem health through the tracking of key ecological indicators.

9 Knowledge Deficiencies

The persistence of brodifacoum residues in this particular environment is a relative unknown (e.g. half-life in certain terrestrial invertebrates, deer liver, local soils). Some environmental or biological half-life can be inferred from other studies; however, given the potential risk of exposure to humans (Aboriginal harvesters have the right to hunt deer and harvest marine resources in Gwaii Haanas) testing for rodenticide residues prior to lifting harvest restrictions will be conducted. See section 8 for a complete description of monitoring programs associated with the proposed project.

It is reasonable to conduct brodifacoum residue sampling within potentially exposed environmental matrices as a means of evaluating the effectiveness of certain mitigation measures. Sampling of key species is addressed in section 8.2.6, Rodenticide Sampling.

Sampling results will help inform the design and execution of future rodenticide treatments as part of an adaptive management approach.

10 References

Acheson, S.R. 1998. In the wake of the *ya'aats' xaatgaay* [Iron People]: a study of changing settlement strategies among the Kunghit Haida. British Archaeological Reports International Series 711: 209 pp.

Allombert, S., A.J. Gaston, and J.L. Martin. 2005a. A natural experiment on the impact of overabundant deer on songbird populations. Biological Conservation 126: 1-13.

Allombert, S., S. Stockton, and J.L. Martin. 2005b. A natural experiment on the impact of overabundant deer on forest invertebrates. Conservation Biology 19: 1917-1929.

Andrews, C. 1909. On the fauna of Christmas Island. Proceedings of the Zoological Society of London:101-103.

Archipelago Management Board, 1998. *Gwaii Haanas National Park Reserve and Haida Heritage Site: Management Plan for the Terrestrial Area*. Government of Canada and the Haida Nation.

Atkinson, I. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effect on island avifaunas. Pages 35-81 in P. J. Moors, editor. Conservation of Island Birds. International Council for Bird Preservation, Cambridge, UK.

Blackburn, T. M., P. Cassey, R. P. Duncan, K. L. Evans, and K. J. Gaston. 2004. Avian extinction and mammalian introductions on oceanic islands. Science 305:1955-1958.

Blackman, M.B. 1979. Northern Haida land and resource utilization: a preliminary overview. Pp. 43-55. In: *Tales from the Queen Charlotte Islands*. Vol. 1. Senior Citizens of the Queen Charlotte Islands, Masset, BC.

Blood, D.A. and G.G. Anweiler. 1994. Status of the bald eagle in British Columbia. B.C. Environment, Lands and Parks, Victoria, B.C. Wildlife Working Report No. WR-62.

Bremner, A., C. Butcher, and G. Patterson. 1984. The density of indigenous invertebrates on three islands in Breaksea Sound, Fiordland, in relation to the distribution of introduced mammals. Journal of the Royal Society of New Zealand 14:379-386.

Broadhead J, 2009. Riparian Fish Forest on Haida Gwaii – A Portrait of Fish Distribution and Riparian Forests on Haida Gwaii (the Queen Charlotte Islands). Unpublished Technical Report. 51pp.

Buckle, A.P. 1994. Control methods, chemical. Pp. 127-160 in A.P. Buckle and R.H. Smith (eds.) Rodent pests and their control. Cab International, Oxford, UK.

Bullock, D. 1986. The ecology and conservation of reptiles on Round Island and Gunner's Quoin, Mauritius. Biological Conservation 37:135-156.

Burles, D.M. 1999. Bats of Gandl K'in. In: L. M. Darling, editor. 2000. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C. Volume One. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 490pp.

Burles D.W., A. G. Edie and P. M. Bartier, 2004. Native Land Mammals and Amphibian of Haida Gwaii with Management Implications for Gwaii Haanas National Park Reserve and Haida Heritage Site. Parks Canada Technical Reports in Ecosystem Science Report. 116 pp.

Burles, D. 2009. Rat Management Strategy for Gwaii Haanas National Park Reserve and Haida Heritage Site. Unpublished Report.

Campbell, D., H. Moller, G. Ramsay, and J. Wait. 1984. Observations on foods of kiore (*Rattus exulans*) found in husking stations on northern offshore islands of New Zealand. New Zealand Journal of Ecology 7:131-138.

Campbell, E. 1991. The effect of introduced roof rats on bird diversity in Antillean Cays. Journal of Field Ornithology 62:343-348.

Campbell, D. J. and I. A. E. Atkinson. 2002. Depression of tree recruitment by the Pacific rat (Rattus exulans Peale) on New Zealand's northern offshore islands. Biological Conservation 107:19-35.

Campbell, R. W. and H.M. Garrioch, 1979. Seabird colonies of the Queen Charlotte Islands. British Columbia Provincial Museum, Victoria, BC.

Chiba, S. 2010. Invasive rats alter assemblage characteristics of land snails in the Ogasawara Islands. Biological Conservation 143:1558-1563.

Conservation Data Centre. 2012. BC species and ecosystem explorer. Accessed online on 03/31/2012 at: http://a100.gov.bc.ca/pub/eswp/

COSEWIC 2000. COSEWIC assessment and update status report on the Northern Goshawk *Laingi* subspecies *Accipiter gentilis laingi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 36 pp.

COSEWIC 2002. COSEWIC assessment and status report on the western toad *Bufo boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 31 pp.

COSEWIC. 2003a. COSEWIC assessment and update status report on Keen's long-eared bat Myotis *keenii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 35pp.

COSEWIC 2006. COSEWIC assessment and status report on the Northern Saw-whet Owl *brooksi* subspecies *Aegolius acadicus brooksi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 23 pp.

COSEWIC. 2007. COSEWIC assessment and update status report on the Peregrine Falcon *Falco peregrinus* (*pealei* subspecies -*Falco peregrinus* and *pealei anatum/tundrius* - *Falco peregrinus anatum/tundrius*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 45 pp.

COSEWIC. 2008. COSEWIC assessment and update status report on the Great Blue Heron *fannini* subspecies *Ardea herodias fannini* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 39 pp.

Cowie, R. H. 2001. Decline and homogenization of Pacific faunas: The land snails of American Samoa. Biological Conservation 99:207-222.

Cree, A., C. Daugherty, and J. Hay. 1995. Reproduction of a rare New Zealand reptile, the tuatara *Sphenodon punctatus*, on rat-free and rat-inhabited islands. Conservation Biology 9:373-383.

Cromarty, P. L., K. G. Broome, A. Cox, R. A. Empson, W. M. Hutchinson, and I. McFadden. 2002. Eradication planning for invasive alien animal species on islands - the approach developed by the New Zealand Department of Conservation. p 85-91 in C. R. Veitch and M. N. Clout, editors. Turning the tide: the eradication of invasive species, Proceedings of the International Conference of Eradication of Island Invasives. International Union for the Conservation of Nature, Gland, Switzerland.

Daniel, M. and G. Williams. 1984. A survey of the distribution, seasonal activity and roost sites of New Zealand bats. New Zealand Journal of Ecology 7:9-25.

Doyle, F.I. 2003a. Biological review and recommended interim strategy direction for Northern Goshawks on Haida Gwaii/Queen Charlotte Islands. Wildlife Dynamics Consulting, Telkwa, BC. Unpublished report.

Doyle, F.I. 2003b. Managing for goshawks in TFL 39 on Haida Gwaii/Queen Charlotte Islands: goshawk nest monitoring and diet in 2003. Wildlife Dynamics Consulting, Telkwa, BC. Unpublished report.

Duellman, W.E. and L. Trueb. 1994. Biology of Amphibians. 2nd Edition. Johns Hopkins University Press. 696pp.

Duncan, R. and T. Blackburn. 2007. Causes of extinction in island birds. Animal Conservation 10:149-150.

Dyment, P., J. Brown, C. Johnson and L. Wein, 2013. Night Birds Returning Phase 2: Deer Population Reduction Plan for Murchison and Faraday Islands. Gwaii Haanas National Park, National Park Reserve, and Haida Heritage Centre. Skidegate, BC. 18pp.

Eason, C.T. & E.B. Spurr. 1995. Review of the toxicity and impacts of brodifacoum on non-target wildlife in New Zealand, New Zealand Journal of Zoology, 22:4, 371-379

Eason, C.T., E.C. Murphy, G.R.G. Wright and E.B. Spurr. 2002. Assessment of risks of brodifacoum to non-target birds and mammals in New Zealand. Ecotoxicology 11: 35-48.

E-Fauna. 2011. Bats of British Columbia. Accessed online at: http://www.geog.ubc.ca/biodiversity/efauna/BatsofBritishColumbia.html on 12/16/2011.

Ellis, D.W. 1991. The living resources of the Haida: birds. Unpublished manuscript on file with the Haida Gwaii Museum, Skidegate, BC. 67 pp.

Environment Canada. 2012. Management Plan for the Ancient Murrelet (*Synthliboramphus antiquus*) in Canada [Draft]. *Species at Risk Act* Management Plan series. Environment Canada, Ottawa. xx+XXpp.

Fedje, D.W., R.J. Wigen, Q. Mackie, C.R. Lake and I.D. Sumpter. 2001. Preliminary results from investigations at Kilgii Gwaay: an early Holocene archaeological site on Ellen Island, Haida Gwaii, British Columbia. Canadian Journal of Archaeology 25:98-120.

Fisher, P., E. Funnell, A. Fairweather, L. Brown, M. Campion. 2012. Accidental discharge of brodifacoum baits into a freshwater lake: a case study. Bull. Env. Contam. Toxicol. 88: 226-228.

Foster, J.B. 1965. The Evolution of the Mammals of the Queen Charlotte Islands, British Columbia. Occasional Papers of the British Columbia Provincial Museum. No. 14. Victoria, BC. 130 pp.

Fukami, T., D. Wardle, P. Bellingham, C. Mulder, D. Towns, G. Yeates, K. Bonner, M. Durrett, M. Grant-Hoffman, and W. Williamson. 2006. Above- and below-ground impacts of introduced predators in seabird-dominated island ecosystems. Ecology Letters 9:1299-1307.

Gaston, A.J., S. Sharpe, S.A. Stockton, T. Golumbia, and J. Martin, 2008. "Reduction in deer numbers on Reef Island and SGang Gwaay: progress, results and vegetation changes". In Gaston, A.J., T.E. Golumbia, J.-L. Martin and S.T. Sharpe (eds.) *Lessons from the islands: Introduced species and what they tell us about how ecosystems work.* Special publication of Canadian Wildlife Service. 206pp.

Golumbia, T. 2001a. Gwaii Haanas Terrestrial Ecosystem Conservation Strategy. Prepared for the Archipelago Management Board, Gwaii Haana National Park Reserve/Haida Heritage Site.

Graham, M. and C. Veitch. 2002. Changes in bird numbers on Tiritiri Matangi Island, New Zealand, over the period of rat eradication. Pages 120-123 in C. Veitch and M. Clout, editors. Turning the tide: the eradication of invasive species. IUCN SSC Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Gwaii Haanas, 2007. Technical Compendium to the 2007 State of the Protected Area Report. N. Sloan, ed. 83pp.

Gwaii Haanas, 2013. Murchison and Faraday Islands Deer Cull Plan and Capture/Kill Protocol. 17pp.

Hadfield, M., S. Miller, and A. Carwile. 1993. The decimation of endemic Hawai'ian tree snails by alien predators. American Zoologist 33:610-622.

Harfenist, A. 1994. Effects of introduced rats on nesting seabirds of Haida Gwaii. Technical Report Series 218: Canadian Wildlife Service, Pacific and Yukon Region, BC.

Harfenist, A., N.A. Sloan, and P.M. Bartier. 2002. Living Marine Legacy of Gwaii Haanas. III: Marine Bird Baseline to 2000 and Marine Bird-related Management Issues throughout the Haida Gwaii Region. Parks Canada Technical Reports in Ecosystem Science Report 036. 164pp.

Heise, K.A., N.A. Sloan, P.F. Olesiuk, P.M. Bartier, and J.K.B. Ford. 2003. Living Marine Legacy of Gwaii Haanas. IV: Marine Mammal Baseline to 2003 and Marine Mammal-related Management Issues throughout the Haida Gwaii Region. Parks Canada Technical Reports in Ecosystem Science Report 038. 150pp.

Hobson, K.A. and S.G. Sealy. 1991. Marine protein contribution to the diet of Northern

Saw-whet Owls on the Queen Charlotte Islands: A stable isotope approach. Auk 108: 437-440.

Howald, G. R., P. Mineau, J. E. Elliott, and K. M. Cheng. 1999. Brodifacoum poisoning of avian scavengers during rat control on a seabird colony. Ecotoxicology 8:431–447.

Howald, G.R., K.R. Faulkner, B.R. Tershy, B.S. Keitt, H. Gellerman, E.M. Creel, M. Grinnell, S.T. Ortega, and D.A. Croll. 2005. Eradication of black rats from Anacapa Island: Biological and social considerations. Proceedings of the Sixth California Islands Symposium, Ventura, CA, Institute for Wildlife Studies, Arcata, CA.

Howald, G., C.J. Donlan, J.-P. Galvan, J.C. Russell, J. Parkes, A. Samaniego, Y. Wang, D. Veitch, P. Genovesi, M. Pascal, A. Saunders, and B. Tershy. 2007. Invasive rodent eradications on islands. Conservation Biology online early edition accessed 18 August 2007.

Howald, G., J. Donlan, K.R . Faulkner, S. Ortega, H. Gellerman, D.A. Croll, and B.R. Tershy. 2009. Eradication of black rats *Rattus rattus* from Anacapa Island. Fauna & Flora International, Oryx, 44(1), 30–40.

Howald G., Donlan C.J., Faulkner K.R., Ortega S., Gellerman H., Croll D.A. & Tershy B.R. 2010. Eradication of black rats *Rattus rattus* from Anacapa Island. Oryx, 44, 30-40.

Hutton, I., J. Parkes, and A. Sinclair. 2007. Reassembling island ecosystems: the case of Lord Howe Island. Animal Conservation 10:22-29.

International Programme on Chemical Safety. 1995. Brodifacoum. Health and Safety Guide No. 93.

Jones, H., B. Tershy, E. Zavaleta, D. Croll, B. Keitt, M. Finkelstein, and G. Howald. 2008. Severity of the effects of invasive rats on seabirds: a global review. Conservation Biology 22:16-26.

Jouventin, P., J. Bried, and T. Micol. 2003. Insular bird populations can be saved from rats: a long-term experimental study of white-chinned petrels *Procellaria aequioctialis* on Ile de la Possession (Crozet archipelago). Polar Biology 26:371-378.

Kaiser, G.W., Taylor, R.H., Buck, P.D., Elliott, J.E., Howald, G.R. & Drever, M.C. 1997. The Langara Island Seabird Habitat Recovery Project: eradication of Norway Rats – 1993–1997. Technical Report Series No. 304. Delta, BC: Canadian Wildlife Service. 49 pp.

Krishka, B. 1997. Summary of aquatic resource information for Gwaii Haanas. A compilation and synthesis of aquatic inventories for lakes and streams. Prepared for: Parks Canada Gwaii Haanas / South Moresby National Park Reserve. Technical report. 115 pp.

Kurle, C. M., D. A. Croll, and B. R. Tershy. 2008. Introduced rats indirectly change marine rocky intertidal communities from algae- to invertebrate-dominated. PNAS 105:3800-3804.

Landcare Research. 2010. Environmental fate and residual persistence of brodifacoum in wildlife. Technical report. 28pp.

Lloyd, B.D. 1994. Evaluating the potential hazards of 1080 aerial operations to short-tailed bat populations. Conservation Science Advisory Notes, vol. 108. Department of Conservation, Wellington, New Zealand.

Lloyd, B.D., and S.M. McQueen. 2002. Measuring mortality in short-tailed bats (*Mystacina tuberculata*) as they return from foraging after an aerial 1080 possum control operation. New Zealand Journal of Ecology, 26: 53-60.

Mackay, D. 1982. Correlation of bioconcentration factors. Environmental Science and Technology 16: 274-278.

Mackay, D. 1991. *Multimedia environmental models: the fugacity approach*. Lewis publishers, Celsea, MI. 257pp.

Martin, J.-L. and C. Baltzinger. 2002. Interaction among deer browsing, hunting, and tree regeneration. Canadian Journal of Forest Research 32: 1254-1264.

McChesney, G. and B. Tershy. 1998. History and status of introduced mammals and impacts to breeding seabirds on the California Channel and northwestern Baja California Islands. Colonial Waterbirds 21:335-347.

Meads, M., K. Walker, and G. Elliot. 1984. Status, conservation, and management of the land snails of the genus Powelliphanta (*Mollusca: Pulmonata*). New Zealand Journal of Zoology 11:277-306.

Moller, A. 1983. Damage by rats *Rattus norvegicus* to breeding birds on Danish islands. Biological Conservation 25:5-18.

Moors, P. and I. Atkinson. 1984. Predation on seabirds by introduced animals, and factors affecting its severity. Pages 667-690 in P. J. Moors, editor. Conservation of Island Birds.

Morgan, D.R., G.R. Wright, S.C. Olilvie, R. Pierce, P. Thompson. 1996b. Assessment of the environmental impact of brodifacoum during rodent eradication operations in New Zealand. Proceedings of the 17th Vertebrate Pest Conference, p. 213-219.

Mulder, C, W Anderson, D Towns, P Bellingham (eds). 2011. Seabird Islands: ecology, invasion and restoration. Oxford University Press.492 pp.

Navarrete, S. and J. Castilla. 1993. Predation by Norway rats in the intertidal zone of central Chile. Marine Ecology Progress Series 92:187-199.

New Zealand Department of Conservation. 2007. Key Facts about Brodifacoum. Accessed online at: www.doc.govt.nz on 12/16/2011.

Ogilvie, S.C., R.J. Pierce, G.R.G Wright, L.H. Booth and C.T. Eason. 1997. Brodifacoum residue analysis in water, soil, invertebrates, and birds after rat eradication on Lady Alice Island. New Zealand Journal of Ecology 21(2): 195–197.

Pank, L.F. 1976. Effects of seed and background colors on seed acceptance by birds. Journal of Wildlife Management 40(4): 769-774.

Parks Canada Agency, 2011. Recovery Strategy of the Ermine *haidarum* subspecies (*Mustela ermina haidarum*) in Canada. *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency. Ottawa iv+3pp+Appendices.

Parks Canada Agency. 2011b. A 20-year retrospective on trends in songbird diversity and abundance in Gwaii Haanas. Gwaii Haanas archive, Skidegate, BC.

Parks Canada Agency. 2012. Recovery Strategy for Northern Saw-whet Owl *brooksi* subspecies (*Aegolius acadicus brooksi*) in Canada [Draft]. *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency. Ottawa. vi + 41 pp.

Parks Canada Agency. 2012. Recovery Strategy for the Northern Goshawk *laingi* subspecies (*Accipiter gentilis laingi*) in Canada [Draft]. *Species at Risk* Act Recovery Strategy Series. Parks Canada Agency. Ottawa xx+X pp+ Appendices.

Parks Canada Agency, 2012. Night Birds Returning: Eradication of Norway Rats (Rattus norvegicus) from Bischof and Arichika Islands: Technical Report. Gwaii Haanas National Park Reserve and Haida Heritage Site, Skidegate, BC.

Parks Canada Agency 2012b. Night Birds Returning: Feasibility Study for Removal of Black Rats from Murchison and Faraday Islands. Gwaii Haanas National Park Reserve, National Marine Conservation Reserve and Haida Heritage Site, Skidegate, BC. Unpublished report.

Parks Canada Agency 2012c. Night Birds Returning Phase 2 Preparations: Application Rate & Biomarker Trials Report. Gwaii Haanas National Park Reserve, National Marine Conservation Reserve and Haida Heritage Site, Skidegate, BC. Unpublished report. 34pp.

Parks Canada Agency 2013. Murch / Fara Ops plan.

Primus, T, G. Wright, P. Fisher 2005. Accidental Discharge of Brodifacoum Baits in a Tidal Marine Environment: A Case Study. Bulletin of Environmental Contamination and Toxicology. Vol 74 (5)913–919.

Pye, T., R. Swain, and R. Seppelt. 1999. Distribution and habitat use of the feral black rat (*Rattus rattus*) on subantarctic Macquarie Island. Journal of Zoology (London) 247:429-438.

Reid, D.G., L. Waterhouse, P.E.F. Buck. A.E.Deroucher, R.Bettner, C.D.French, and C. Husband. 1999. Status and Management of Ermine on the Queen Charlotte Islands, British Columbia. Forest Research Extension Note EN-001. Ministry of Forests, Vancouver Forests, Region, Nanaimo, BC.

Roberts, A.M. 1997. Food habits of Northern Goshawks in the Queen Charlotte Islands and in the Kispiox Forest District 1996. B.C. Min. Environ., Lands and Parks, Smithers, BC. Unpublished report.

Rodway, M.S., M.J.F Lemon, and G.W. Kaiser. 1988. British Columbia Seabird Colony Inventory: Report 1 – east coast Moresby Island. Canadian Wildlife Service, Pacific and Yukon Region Technical Report Series 50: 276p.

Salmon T. & Paul E. 2010. The Rat Island Rat Eradication Project: a Critical Evaluation of Nontarget Mortality. Report of the Ornithological Council, Washington DC, USA.

Sealy, S.G. 1999. Further data on food items of Northern Saw-whet Owls (*Aegolius acadicus brooksi*) on the Queen Charlotte Islands, British Columbia. Western Birds 30: 200-205.

Soil Classification Working Group. 1998. *The Canadian System of Soil Classification*. Agric. and Agri-Food Can. Publ. 1646 (Revised). 187 pp.

Stone, W.B., J.C. Okoniewski, J.R. Stedelin. 1999. Poisoning of wildlife with an anticoagulant rodenticide in New York. Journal of Wildlife Diseases, 35(2):187–193

Tershy, B.R. and D. Breese. 1994. Color preference of the island endemic lizard *Uta palmeri* in relation to rat eradication campaigns. The Southwestern Naturalist 39(3): 295-297.

Thibault, J.-C. 1995. Effect of predation by the black rat Rattus rattus on the breeding success of Cory's shearwater *Calonectris diomedea* in Corsica. Marine Ornithology 23:1-10.

Tomich, P. 1986. Mammals in Hawai`i. 2nd edition. Bishop Museum Press, Honolulu, HI.

Towns, D. 1991. Response of lizard assemblages in the Mercury Islands, New Zealand, to removal of an introduced rodent, the kiore (*Rattus exulans*). Journal of the Royal Society of New Zealand 21:119-136.

Towns, D.R., and Broome, K.G. 2003. From small Maria to massive Campbell: forty years of rat eradications from New Zealand islands. N Z J Zool 30:377–398

Towns, D., I. Atkinson, and C. Daugherty. 2006. Have the harmful effects of introduced rats on islands been exaggerated? Biological Invasions 8:863-891.

Towns, D. R., D. A. Wardle, C. P. H. Mulder, G. W. Yeates, B. M. Fitzgerald, G. R. Parrish, P. J. Bellingham, and K. I. Bonner. 2009. Predation of seabirds by invasive rats: multiple indirect consequences for invertebrate communities. Oikos 118:420-430.

U.S. Environmental Protection Agency. 1998. EPA R.E.D. Facts: Rodenticide Cluster. EPA-738-F-98-004. 11pp.

U.S. Fish and Wildlife Service. 2007. Restoring Wildlife Habitat on Rat Island: Environmental Assessment. Alaska Maritime National Wildlife Refuge, U.S. Fish and Wildlife Service. Homer, Alaska.

Verbeek, N. A. M. 1993. Glaucous-winged Gull (*Larus glaucescens*). In The Birds of North America, No. 59 (A. Poole, and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Westland Resource Group. 1994. *Ecological Classification of Gwaii Haanas*. Gwaii Haanas Archipelago Management Board. 115 pp.

Whitaker, A. 1973. Lizard populations on islands with and without Polynesian rats *Rattus exulans* (Peale). Proceedings of the New Zealand Ecological Society 20:121-130.

World Health Organization – Food and Agriculture Organization. 2012. Data Sheet on Pesticides No. 57: Brodifacoum.

Wojtaszek, B.F. 2000. Quantifying Toxicological Stress in Amphibians: The Influence of Hydrophobicity on PAH and PCB Elimination Rates in Northern Leopard Frogs (*Rana pipiens*). M.Sc. thesis, University of Windsor, Windsor, ON, Canada. 117pp.

11 Detailed Environmental Impact Analysis Decision

☒	Assessment determined project is not likely to cause significant adverse environmental effects if mitigative measures are followed.
☐	Assessment determined project is likely to cause significant adverse environmental effects and will not proceed.
☐	Minister designated the physical activity under section 14(2).

12 Signatures and Approval

Author:		
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Peter Dyment	**Title**	**Date**

Decision Recommended By:		
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Steve Blake	**Title**	**Date**

Decision Approval:		
	Field Unit Superintendent	June 13, 2013
Ernie Gladstone	**Title**	**Date**

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Author:		
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