Amphibian and Reptile Surveys in Riparian and Wetland Habitats in the Gulf Islands National Park Reserve

Prepared for Parks Canada

Coastal British Columbia Field Unit

Victoria, BC

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August 2004

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ACKNOWLEDGMENTS

We thank Todd Golumbia for initiating and supporting this project. Ann Chan-McLeod generously lent us minnow traps. Ira Willey helped in the field. Funding for this project came from Parks Canada.

Cover photo: Red-legged Frog (*Rana aurora*), Greenburn Lake, South Pender Island, April 2004

EXECUTIVE SUMMARY

The Gulf Islands National Park Reserve contains riparian and wetland habitats suitable for several species of amphibians and reptiles. Here we present the results of surveys conducted in April and June 2004 at three locations within the Park: Roe Lake on North Pender, Greenburn Lake on South Pender, and McLean Lake/Lyall Creek on Saturna. The methods included visual encounter surveys of wetlands, riparian habitats, and littoral zones of lakes, and trapping in aquatic habitats. The objectives were to characterize amphibian and reptile faunas of these areas through surveys and review of existing information, and to identify important habitats.

At Roe Lake, we detected three species of native amphibians, the Rough-skinned Newt, Red-legged Frog, and Pacific Treefrog, and the introduced Bullfrog. All three species of garter snakes present in British Columbia occur at this site, but only two were detected during the surveys. The best habitats for amphibians include a large shallow bay and associated marshlands at the south end of the lake. Smaller bays at the north end of the lake, and a small pond and inlets along the west side of the lake also provide amphibian habitat. All these habitats provide foraging areas for garter snakes. This property is of particular value for amphibians and reptiles because it consists of a relatively large, undisturbed area and encompasses both terrestrial forest habitat and a variety of aquatic habitats.

At Greenburn Lake, we detected two species of native amphibians, the Rough-skinned Newt and Red-legged Frog, and the introduced Bullfrog. Wetland habitats at this site are disturbed and extensively modified by human activities and introduced plants. Both visual encounter surveys and trapping suggest that the densities of the Rough-skinned Newt are exceedingly high both in the lake and in the outlet creek/ditch within a wet meadow. In contrast, we detected few signs of the Red-legged Frog (found at the wetland adjacent to the lake only). We found all three species of garter snakes at this site. A rocky slope on the north shore of the lake provides excellent breeding and nursery habitat, and the lake and wet meadow provide foraging habitat. Potential habitat for the Sharp-tailed Snake is present on the rocky slope.

At McLean Lake, we found four species of amphibians, all native: the Rough-skinned Newt, Long-toed Salamander, Red-legged Frog, and Pacific Treefrog. This shallow lake with abundant emergent vegetation provides exceptional breeding habitat for amphibians and likely represents a source of recruits for a much wider area in the surrounding landscape. Lyall Creek and its tributaries provide important foraging habitat and movement avenues, but we found no signs of breeding by amphibians in the creeks. The Red-legged Frog was particularly abundant in and along the main channel. Of reptiles, we detected only the Common Garter Snake, at Lyall Creek, but all three garter snakes may well be present.

Recommended management measures consist of (1) prevention of the spread/control of Bullfrog populations, (2) maintaining hydrological patterns that facilitate the survival of

native species of amphibians, and (3) habitat enhancement/restoration at the Greenburn Lake site.

The Bullfrog poses a serious threat to native amphibians, and it is imperative that its introduction to McLean Lake is prevented through public education, including distribution and display of interpretive materials and signage at the lake. At present no evidence exists that this species occurs on Saturna. An experimental control and eradication program at Roe Lake and Greenburn Lake could be attempted.

At McLean Lake, hydrological patterns should be left undisturbed to preserve this important amphibian breeding habitat in its natural state. At Roe Lake, any drawing of water should be restricted in spring and early summer so that shallow water areas of the lake and adjacent ponds and inlets are maintained as amphibian breeding habitat. At Greenburn Lake, consideration should be given to controlling water levels at the dam site to mimic natural hydrological patterns of small lakes on the Gulf Islands and restoring the wet meadow west of the lake into a wetland suitable for native amphibians.

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1.0 INTRODUCTION

The Gulf Islands National Park Reserve contains riparian and wetland habitats suitable for several species of amphibians and reptiles but has never been surveyed specifically for these groups. Knowledge of their distributions and important habitats provides essential information for the management of these special areas and contributes to a database of biological resources of the Park. We carried out reconnaissance (presence/"not detected") level surveys for amphibians and reptiles at three larger riparian/wetland areas within the Park in the spring and early summer of 2004: Roe Lake on North Pender, Greenburn Lake on South Pender, and Lyall Creek/McLean Lake on Saturna. The surveys were designed to complement other biodiversity surveys that are in progress within the Park (for the endangered Sharp-tailed Snake, *Contia tenuis*, and for rare species of terrestrial gastropods).

Six native species of amphibians and six reptiles are known from the southern Gulf Islands (amphibians: Pacific Treefrog, *Pseudacris regilla*; Red-legged Frog, *Rana aurora*; Long-toed Salamander, *Ambystoma macrodactylum*; Northwestern Salamander, *A. gracile*; Rough-skinned Newt, *Taricha granulosa*; Wandering Salamander, *Aneides vagrans*; reptiles: Painted Turtle, *Chrysemys picta*; Northern Alligator Lizard, *Elgaria coerulea*; Northwestern Garter Snake, *Thamnophis ordinoides*; Western Terrestrial Garter Snake, *T. elegans*; Common Garter Snake, *T. sirtalis*; Sharp-tailed Snake, *Contia tenuis*; additional species that occur on Vancouver Island may be present, but we are aware of no records. With the exception of plethodontid salamanders (represented by the Wandering Salamander on the Gulf Islands), all the above amphibians are semi-aquatic and depend on the availability of suitable aquatic habitats for the completion of their lifecycles. All three species of garter snakes may use riparian or wetland habitats for foraging; the Western Terrestrial Garter Snake (despite of its common name) and the Common Garter Snake, in particular, use these habitats extensively.

2.0 OBJECTIVES

The objectives of the study were as follows:

- Characterize amphibian and reptiles faunas of three wetland/riparian areas within the Park through reconnaissance level surveys
- Review existing information on amphibians and reptiles for the three properties
- Identify important wetland/riparian habitats for these groups based on above surveys
- Provide management recommendations for the above areas with respect to amphibians and reptiles

3.0 METHODS

3.1 Study areas

We surveyed the following sites (see Appendix A for details of the sites):

- Roe Lake on North Pender Island
- Greenburn Lake on South Pender Island
- Lyall Creek/McLean Lake on Saturna Island

The surveys focused on the shallow littoral zone, perimeter, and wetlands associated with Roe Lake and Greenburn Lake, and on the channel, banks, and wetlands associated with Lyall Creek, including McLean Lake.

Roe Lake (5.2 ha) is located near the southwestern shore of North Pender Island at an elevation of 120 m asl (Figure 1). The lake drains into a small wetland to the southeast and then into ocean at Port Browning. This natural waterbody is relatively deep and the bottom drops off quickly near the shore. A narrow zone of emergent vegetation (mainly sedges) extends about 5 m from shore. An exception is a shallow littoral zone at the south end of lake and two inlets on the west side, which contain extensive areas of shallow water and emergent vegetation (sedges and marsh grasses). Floating and submerged logs are common along the lake edges. Water clarity is moderate.

Greenburn Lake (6.4 ha) is located on the southeastern end of South Pender Island at an elevation of 120 m asl (Figure 1). The lake drains to the west into the ocean at Bedwell Harbour. A dam at the outlet of the lake maintains artificially high water levels in the lake. A narrow, grassy wetland extends along the outlet creek for about 300 m. The lake is elongated, and the bottom drops off quickly especially on the north side. The zone of emergent vegetation is very narrow (< 5 m) and consists of sedges and an exotic species of iris (Yellow-flag, *Iris pseudoacorus*). Water clarity is very low, and the lake is eutrophic. Extensive beds of water lily extend 20 – 75 m from the shore. Floating and submerged logs and flooded timber occur along portions of the shoreline.

The main stem of Lyall Creek on Saturna Island flows from its headwaters near Narvaez Bay (about 100 m asl) west to the ocean at Lyall Harbour, a distance of about 3.7 km. A tributary flows in from the north (see description of McLean Lake and its outlet below). Two other tributaries flow in from the south. The creek varies in width form 5 – 10 m and consists of both riffles and small pools. Pool depths range from about 0.2 – 1 m, and emergent vegetation (mainly sedges) is occasionally present along the edges. The vegetation adjacent to the stream consists of second-growth mixed-wood forest.

McLean Lake (1.1 ha) is located about 640 m north of the main stem of Lyall Creek on Saturna Island (Figure 1). This small, natural waterbody is at 220 m asl and drains south to Lyall Creek via a small ephemeral stream. The lake is shallow and emergent vegetation, consisting of sedges and rushes, covers most of the lake. Lily pads and pondweeds occur in deeper areas, and floating and submerged logs are scattered along the lake edge. The lake is likely subject to periodic draw-down; during this study, water levels declined markedly from April to June. The shallow water depth, warm water, and

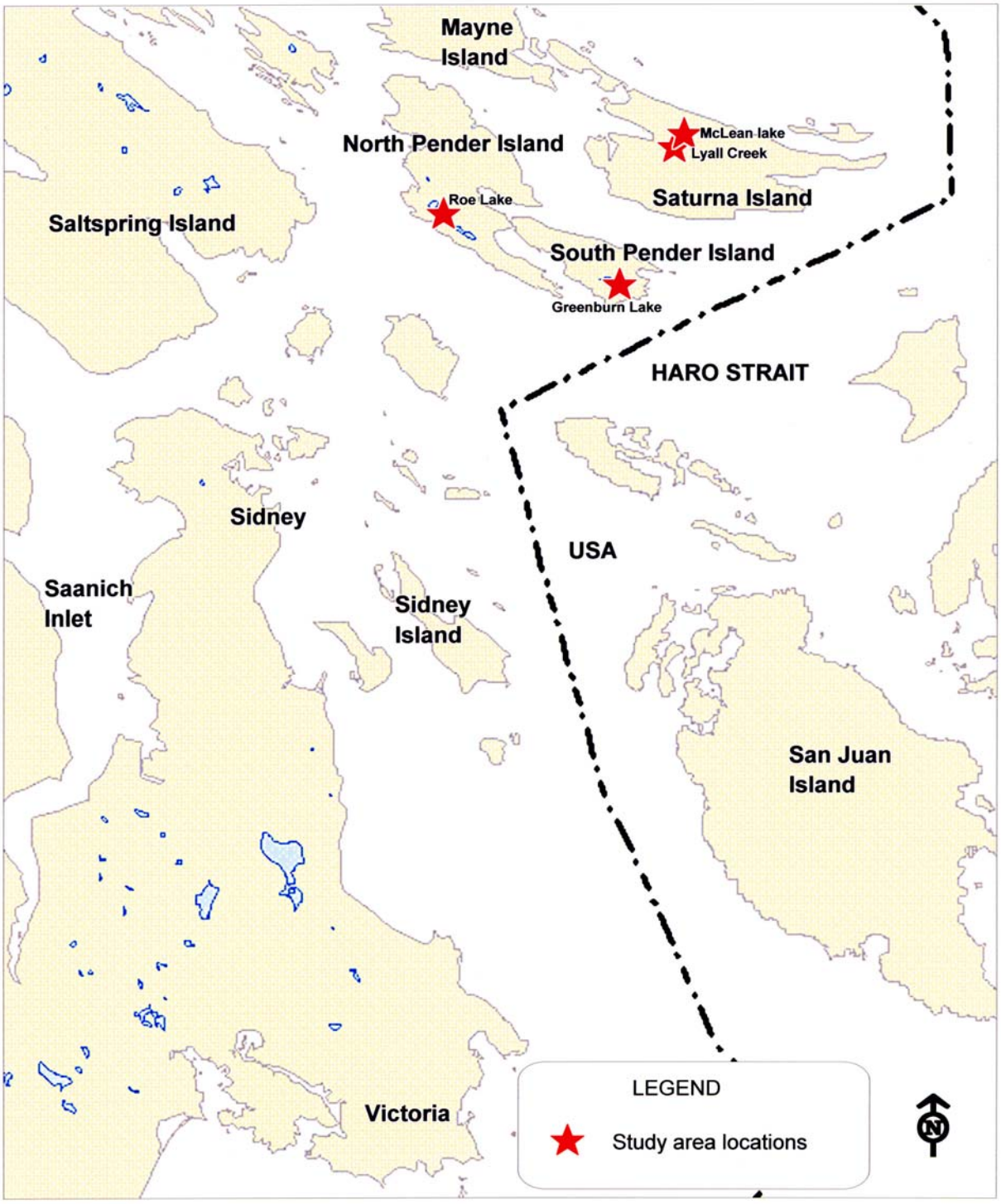

Figure 1. Location of study sites within the Gulf Islands National Park Reserve.

abundant emergent vegetation result in near ideal conditions for breeding amphibians. Water clarity is moderate.

3.2 Survey methods

The survey methods followed standard procedures for amphibians at the "present/not detected" level (Heyer et al. 1994, Olson et al. 1997). The surveys focused on amphibians, but we also recorded all reptiles encountered in riparian/wetland habitats. We used a combination of methods to increase the probability that all species present were detected. The methods consisted of the following:

- Visual encounter surveys along the perimeter of the lakes (shore line and littoral zone), creek channels and banks, and wetlands along meandering survey routes
- Trapping in water bodies with minnow traps
- Night-time visual encounter surveys of the forest floor

In addition, we recorded opportunistic observations of amphibians and reptiles while setting traps or moving between sites.

Visual encounter surveys of water bodies and associated wetlands consisted of observers walking through the habitats of interest and scanning the shoreline and water for the presence of amphibians (adults, larvae, egg-masses) and reptiles. We also used a boat to access all potential habitats within lakes. Along the shoreline, the observers opportunistically turned over cover-objects (logs and rocks) to detect animals that might be sheltering underneath and waded through the shallow water. To avoid disturbance to the habitat, we carefully replaced all cover-objects after inspection and did not take decaying logs apart.

Trapping is an effective method for detecting adults and larvae of several species of amphibians. Many species of semi-aquatic salamanders, in particular, are secretive but can often be detected by trapping larvae or adults in the aquatic habitat. We used funnel traps (minnow traps) at each of the sites surveyed. The traps were set near the shoreline in shallow (< 1 m in depth) water; traps set in deeper water are unlikely to produce additional species (Olson et al. 1997). Most traps were resting on the bottom of the water body and partially exposed to provide a source of air for adult amphibians and reptiles; a small, inflated plastic bag was placed in those traps that were in deeper water to create an air pocket. We left the traps in place overnight and inspected them the following day, about 18 – 24 hours after setting. To avoid contamination and possible spread of amphibian diseases, we cleaned all traps in a bleach solution and dried them thoroughly in the sun between their deployments at different sites.

Night-surveys consisted of the observers walking through likely habitat after dusk and were intended to detect nocturnal animals, such as terrestrial salamanders, active on the forest floor. The observers carefully scanned the ground and vegetation using light from headlamps or 12 volt flood-lights for illumination. We conducted a night survey in the Lyall Creek area only.

Identification and vouchers

We identified all amphibians and reptiles found and recorded their relative size/age class, including developmental stage of amphibians. Animals were identified either from a distance, or when handling was necessary, released at their original locations after inspection. An exception was the tadpoles of the introduced Bullfrog that were caught in traps at Roe Lake, which we removed from the site (voucher is deposited at the Royal BC Museum, RBCM 1951.00; remaining tadpoles were donated for research at the Department of Biochemistry, University of Victoria). We also collected three small salamander larvae from McLean Lake for identification purposes, and two voucher specimens of tadpoles of the Red-legged Frog that had sustained injuries in traps (deposited at the Royal BC Museum as vouchers, RBCM 1949.00). Two of the salamander larvae were raised to confirm identification (RBCM 1951.00).

3.3 Timing of surveys and sampling effort

Visual encounter surveys took place on 23 and 30 April 2004 and trapping on 8 – 9 and 15 – 16 June 2004 (see Appendix B for details of survey timing and conditions). Night surveys on Saturna and additional, opportunistic observations took place during the trapping sessions in June.

We timed each visual encounter survey to obtain an estimate of the search effort. There were a total of 11.1 person-hours of search time at Roe Lake, 7.6 person-hours at Greenburn Lake, and 10.5 person-hours at McLean Lake/Lyall Creek; we spent an additional 5.2 person-hours for a night search of the forest floor in the Lyall Creek area (see Appendix B for details). There were 36 traps in Roe Lake, 20 traps in Greenburn Lake, 29 traps in McLean Lake, and 14 traps in Lyall Creek.

3.4 Review of existing information

We reviewed results of previous surveys of park lands in the Gulf Islands (Engelstoft and Ovaska 1997, Elgelstoft et al. 2002, Engelstoft 2004). These surveys focused on habitats suitable for the Sharp-tailed Snake, primarily on rocky slopes, but some riparian areas were also surveyed, including the vicinity of Roe Lake. In addition, we searched databases at the Royal British Columbia Museum (RBCM) and the BC Ministry of Water, Land and Air Protection (MWLAP) for records for reptiles and amphibians from Pender and Saturna Islands. The database at MWLAP, compiled by Laura Friis, contains records from various museum collections, the BC Frog Watch Program, and observations contributed by researchers.

4.0 RESULTS AND DISCUSSION

4.1 Overview of existing information

The Roe Lake property has been surveyed previously for reptiles as a part of efforts to locate the endangered Sharp-tailed Snake (Engelstoft and Ovaska 1997, Engelstoft et al. 2002, Engelstoft 2004). To our knowledge, no surveys specifically for amphibians or reptiles have been conducted at the Greenburn Lake or Lyall Creek/McLean Lake properties. All three species of garter snakes that occur in southwestern British Columbia, as well as the Northern Alligator Lizard, were located during previous surveys of the Roe Lake property. These surveys focused on the periphery of the lake (in 1997) and on rocky slopes with southern aspect, especially at the base of a large cliff-face east of the lake, in 2002 – 2004. The Sharp-tailed Snake was not found during any of the surveys, but continued efforts to locate this species are in progress (C. Engelstoft, unpublished data). In addition to four snakes and one lizard, the Painted Turtle occurs on the Gulf Islands, including North Pender Island.

The following native amphibians appear to be widespread on the Gulf Islands: Long-toed Salamander, Rough-skinned Newt, Red-legged Frog, and Pacific Treefrog. . There is only one confirmed record for the Northwestern Salamander (from Saltspring Island); another sight record exists from Galiano Island. The Wandering Salamander is known from a few islands (Thetis and Portland). Curiously, there are no records for the Western Red-backed Salamander, a common species on Vancouver Island. We know of no records for the Western Toad from the Gulf Islands south of Lasqueti Island.

4.2 Survey results

During surveys of the wetland and riparian areas at the three sites in 2004, we located five species of amphibians (four native species and the introduced Bullfrog) and three species of snakes (Table 1). Observations during gastropod surveys conducted concurrently (in spring 2004) in nearby terrestrial habitats produced no additional species: We detected the Rough-skinned Newt, Pacific Treefrog, and Northwestern Garter Snake at Roe Lake, and the Red-legged Frog at Lyall Creek during surveys for gastropods.

The introduced Bullfrog was found at two sites, at Roe Lake and Greenburn Lake. These records represent the first documented records from Pender Islands (P. Govindarajulu, pers. comm.).

Table 1. Amphibians and reptile species detected in wetland and riparian habitats within the Gulf Islands National Park Reserve in April and June 2004.
Survey methods included visual encounter surveys, trapping (with minnow traps), and opportunistic observations. X – found during this study; P – found previously during other studies. See Tables 2 & 3, and Appendices C & D for details of observations.

Species	Roe Lake, North Pender	Greenburn Lake, South Pender	McLean Lake, Saturna	Lyall Creek, Saturna
Amphibians:				
Rough-skinned Newt (*Taricha granulosa*)	X	X	X	X
Long-toed Salamander (*Ambystoma macrodactylum*)			X	
Pacific Treefrog (*Pseudacris regilla*)	X		X	X
Red-legged Frog (*Rana aurora*)	X	X	X	X
Bullfrog (*Rana catesbeiana*)	X	X		
Reptiles:				
Common Garter Snake (*Thamnophis sirtalis*)	X	X		X
Western Terrestrial Garter Snake (*T. ordinoides*)	P*	X		
Common Garter Snake (*T. elegans*)	X	X		

*Engelstoft and Ovaska 1997

Overall, the visual encounter surveys produced a similar array of species to what was found through trapping (Tables 2 & 3). Exceptions included the Bullfrog at Greenburn Lake, detected only during visual encounter surveys, and species composition of garter snakes found at particular sites. The visual encounter surveys in April also resulted in the detection of egg masses of the Pacific Treefrog and the Red-legged Frog, and mating pairs of the Rough-skinned Newt. However, the mating season of the Red-legged Frog, an early breeding species, had already been completed, and all egg-masses found had hatched and were decaying. Raw data of all observations are presented in Appendices C (visual encounter surveys and opportunistic observations) and D (trapping results).

The surveys were not intended to provide detailed information on relative abundance, but preliminary information on overall patterns of abundance and differences among the sites can be inferred. Both the visual encounter and trapping data suggest that (1) the Rough-skin Newt is particularly abundant at Greenburn Lake, and (2) the shallow McLean Lake provides excellent breeding habitat for a number of native species of

amphibians (see Tables 2 & 3, and Figure 2). Each of the areas surveyed contains interesting amphibian and reptile habitats, as discussed in the following sections. The location of observations and routes taken during the surveys are shown in Figures 3 – 10.

Figure 2. Number of amphibians caught per trap at three localities within the Gulf Islands National Park Reserve in June 2004. Note that the Y-axis is truncated; the number above the column for *Taricha granulosa* at Greenburn Lake denotes the actual value of this outlying data point.
Trapping took place on 7 – 8 June (Roe Lake and Greenburn Lake) and on 14 – 15 June (McLean Lake and Lyall Creek). TAGR-*Taricha granulosa*; AMMA-*Ambystoma macrodactylum*; PSRE-*Pseudacris regilla*; RAAU-*Rana aurora*; RACA-*Rana catesbeiana*

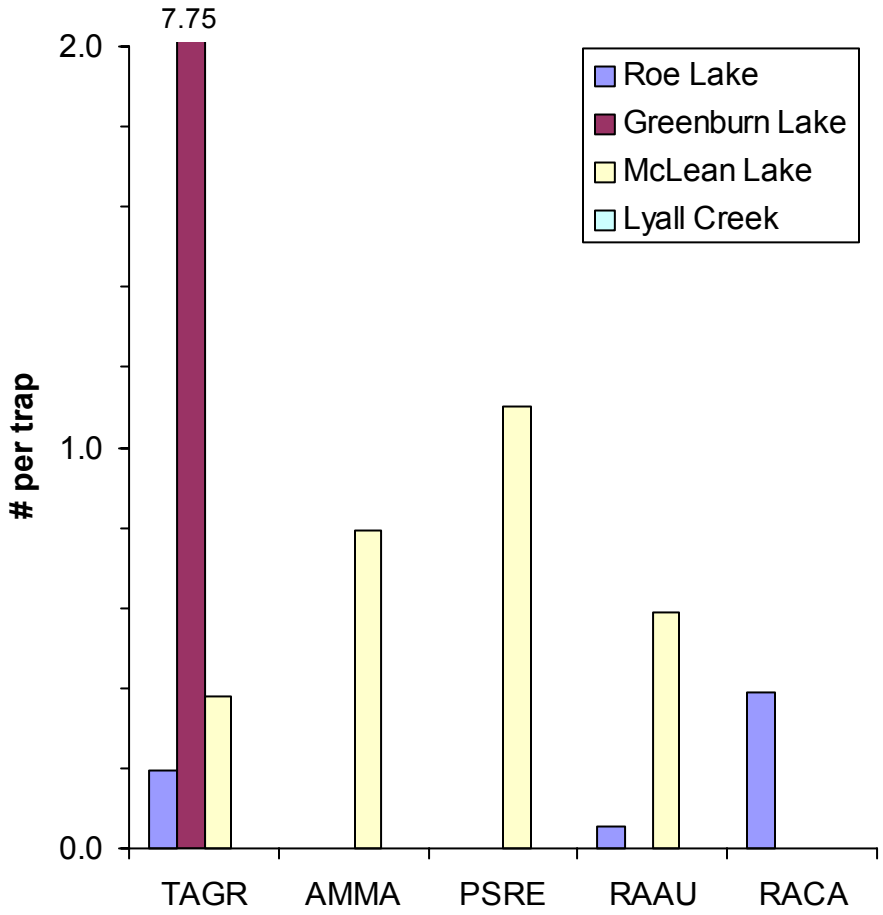

Table 2. Number of amphibians and reptiles located in wetland and riparian habitats during visual encounter surveys within the Gulf Islands National Park Reserve in April 2004.
See Figures 3 – 6 for locations of survey routes and Appendix C for details of the observations. For amphibians, juvenile refers to metamorphosed young.

Island	Locality name	Route ID	Habitat type	Search time (p-hour)	Rough-skinned Newt	Long-toed Salamander	Pacific Treefrog	Red-legged Frog	Bullfrog	Common Garter Snake	NW Garter Snake
North Pender	Roe Lake	1, 2	Lake	8.3	8 adults			2 egg-masses	2 tadpoles		
North Pender	Roe Lake	3	Creek, marsh	0.5							1 adult
North Pender	Roe Lake	4	Pond & creek (inlet)	2.0				1 juvenile; 1 adult			
South Pender	Greenburn Lake	1*	Lake	6.0	24 adults				1 tadpole		
South Pender	Greenburn Lake	2	Marsh & creek	1.6	19 adults			1 egg-mass; 2 adults		1 adult	
Saturna	McLean Lake	1, 1a	Lake	3.4	4 adults	7 larvae	>200 tadpoles; 3 adults	>60 tadpoles; 3 juveniles; 2 adults			
Saturna	Lyall Creek (trib. 1)	2	Creek	1.5			1 juvenile	1 adult			
Saturna	Lyall Creek (main channel)	3, 4	Creek	5.6	1 adult		4 juveniles; 6 adults	35 juveniles; 15 adults			

* includes a portion of Route 2 in the lake

Table 3. Amphibians and other vertebrates found in minnow traps at three localities within the Gulf Islands National Park Reserve in June 2004.
Trapping took place on 7 – 8 and 14 – 15 June 2004. See Figures 7–10 for detailed locations of traps and Appendix D for details of the observations. For amphibians, juvenile refers to metamorphosed young.

Locality name	# of traps	Rough-skinned Newt	Long-toed Salamander	Pacific Treefrog	Red-legged Frog	Bullfrog	Common Garter Snake	Western Terrestrial Garter Snake	Stickle-back	Coho Salmon
Roe Lake, North Pender	36	7 adults			1 tadpole; 1 juvenile	14 tadpoles	1 adult		422	
Greenburn Lake, South Pender	20	155 adults					1 adult	2 adults	32	
McLean Lake, Saturna	29	11 adults	23 larvae	29 tadpoles; 1 juvenile; 2 adults	17 tadpoles				4	
Lyall Creek, Saturna	14									9

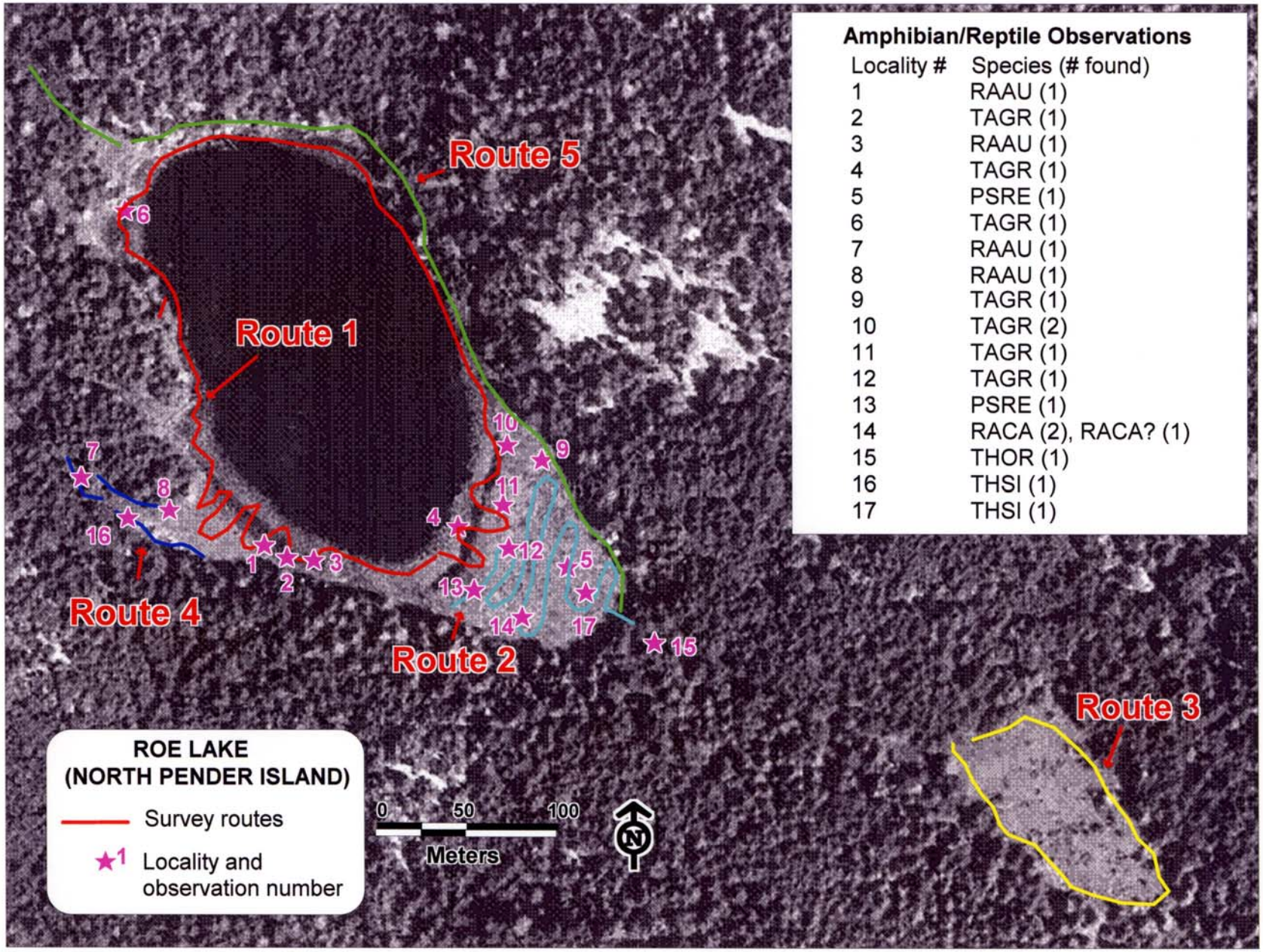

Figure 3. Location and number of amphibians and reptiles observed during visual surveys of Roe Lake, North Pender Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

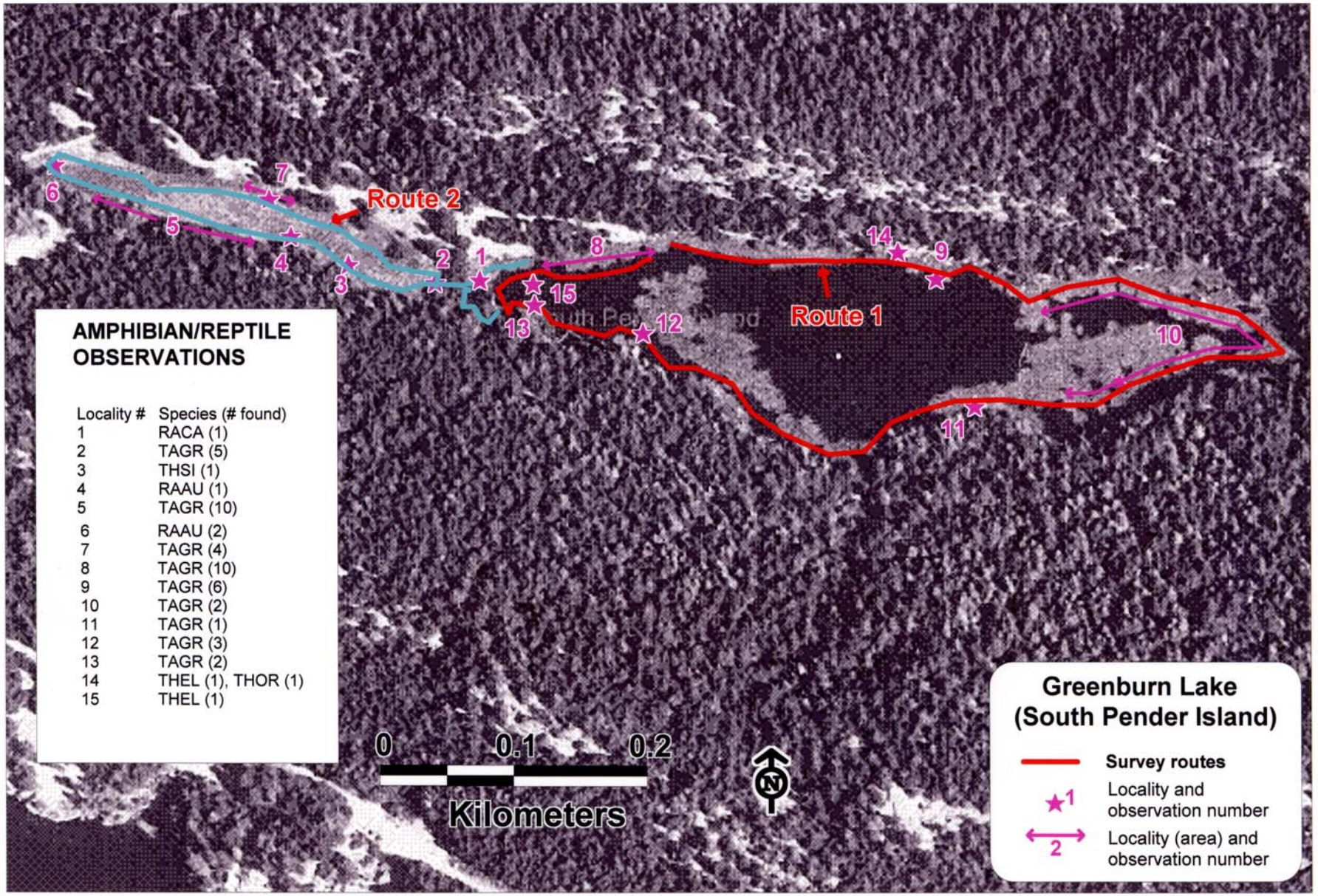

Figure 4. Location and number of amphibians and reptiles observed during visual surveys of Greenburn Lake, South Pender Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

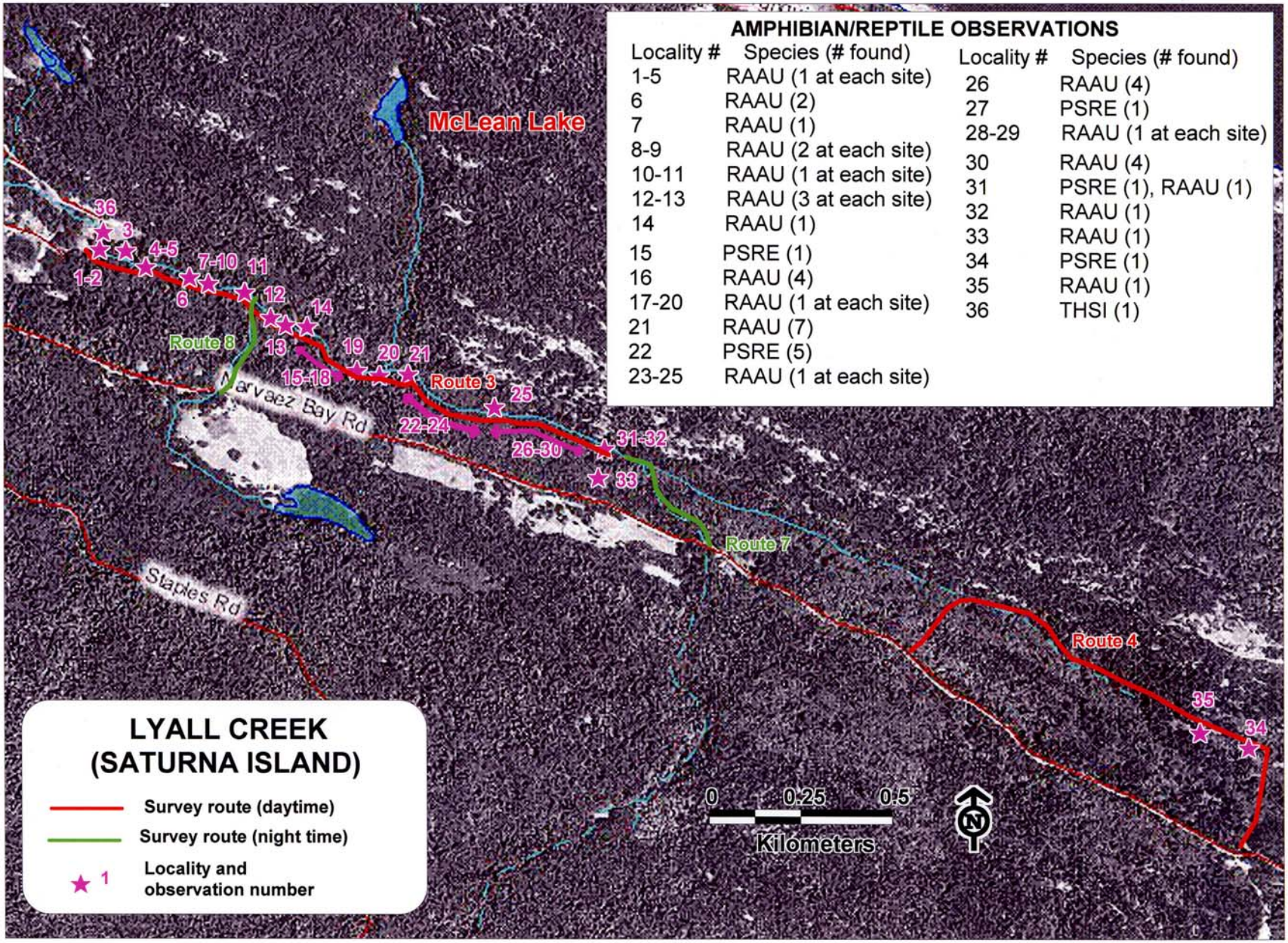

Figure 5. Location and number of amphibians and reptiles observed during visual surveys of the main stem of Lyall Creek, Saturna Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

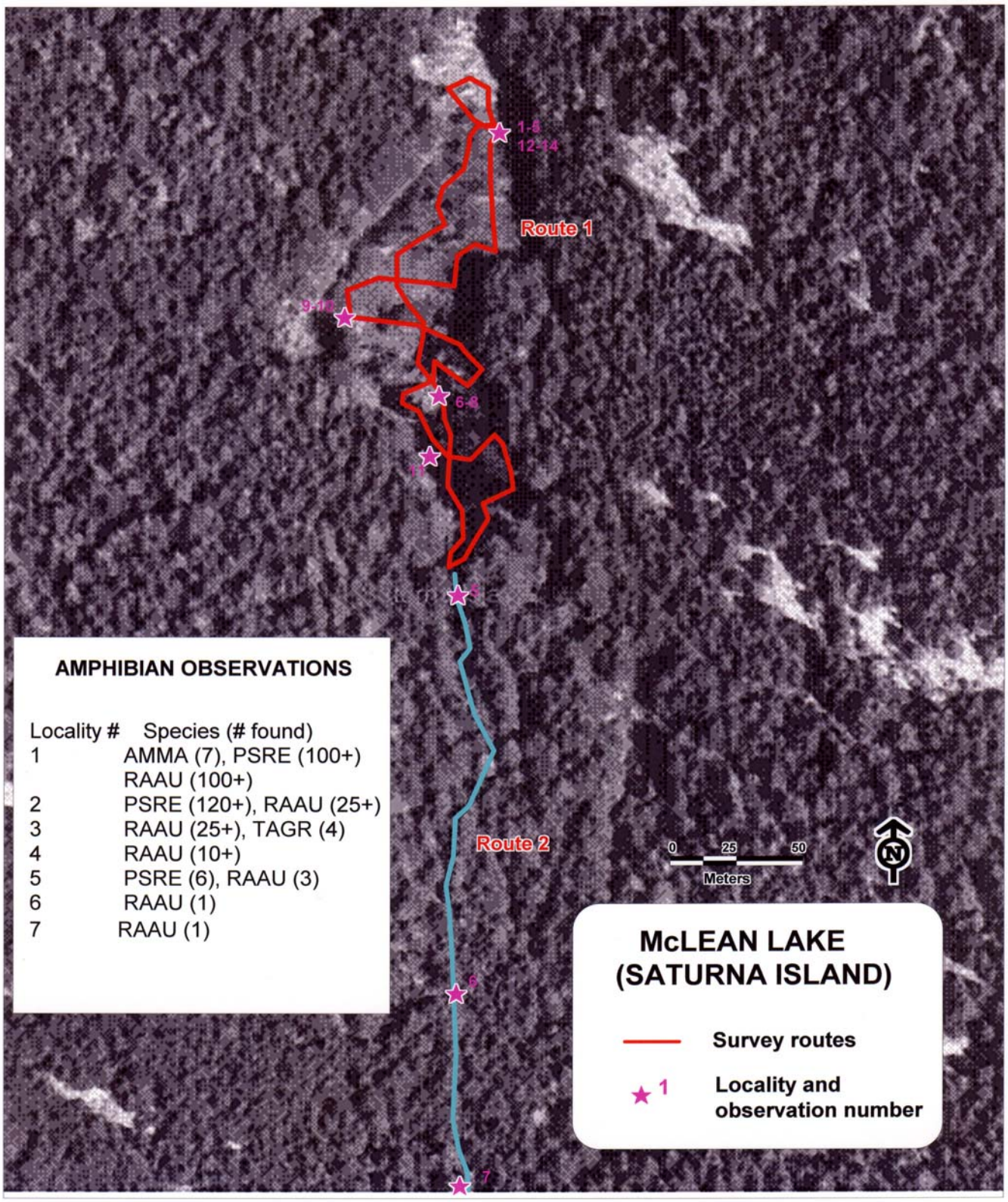

Figure 6. Location and number of amphibians and reptiles observed during visual surveys of McLean Lake and outlet creek, Saturna Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

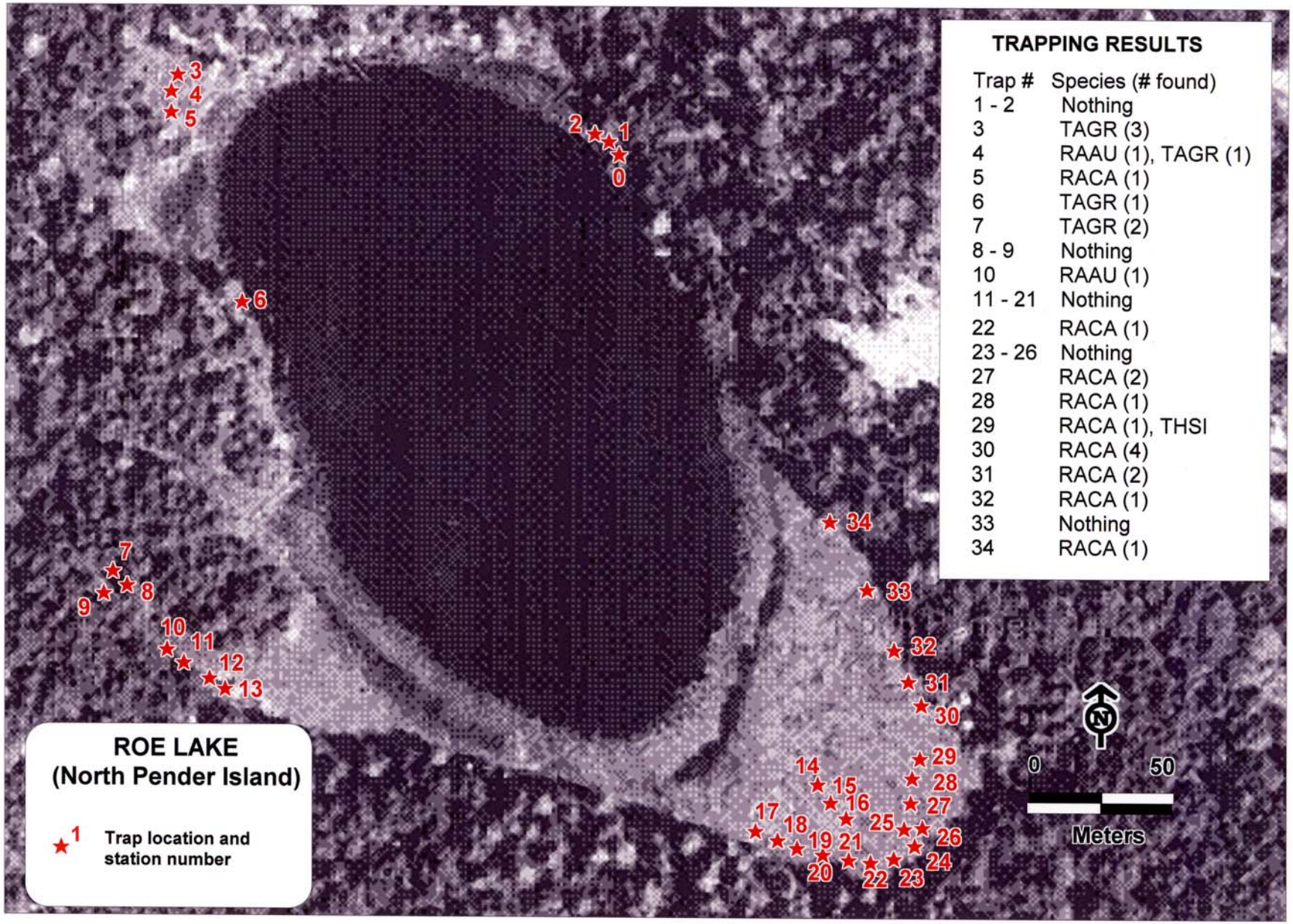

Figure 7. Location of minnow traps and number of amphibians and reptiles captured at Roe Lake, North Pender Island.
Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

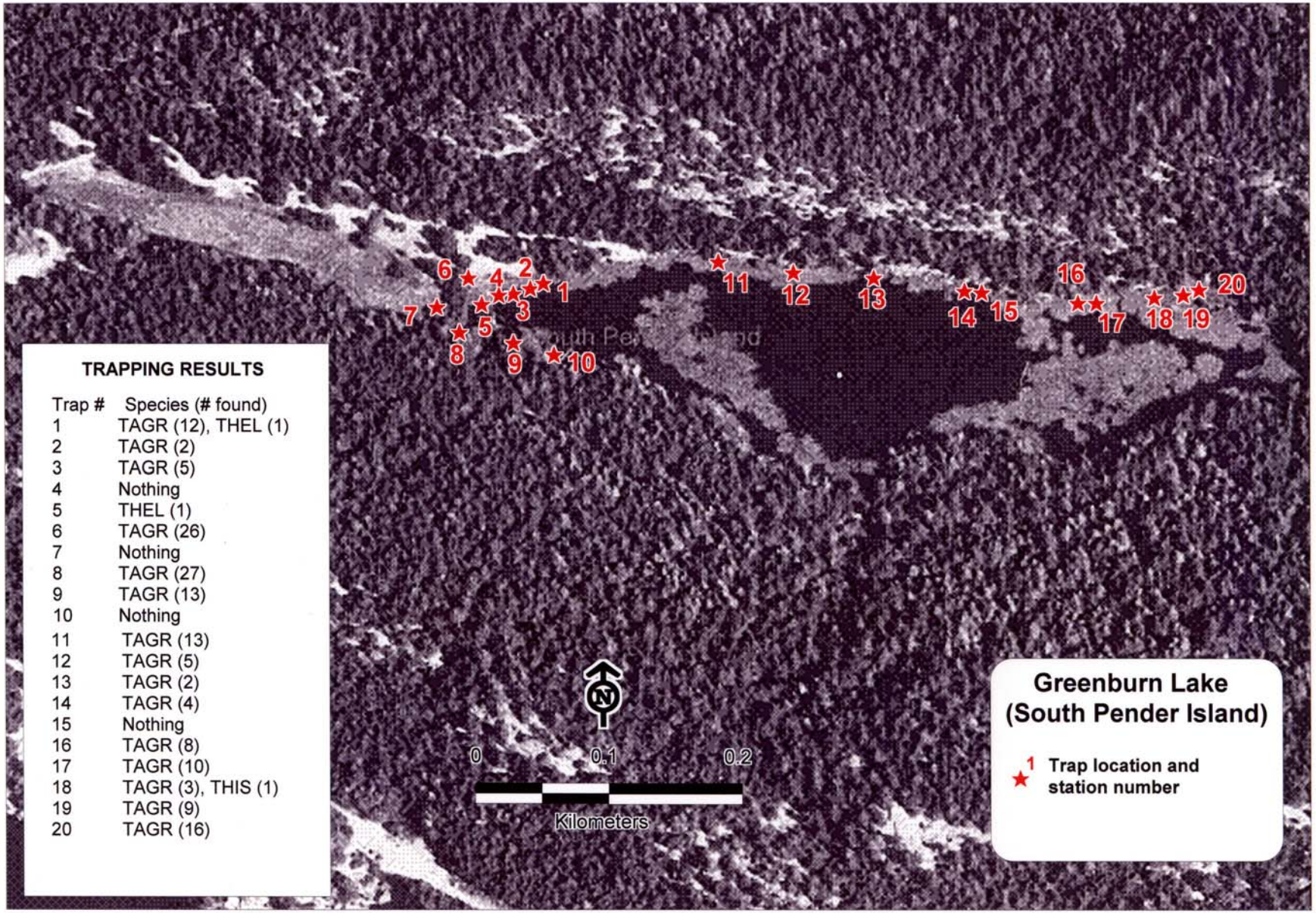

Figure 8. Location of minnow traps and number of amphibians and reptiles captured at Greenburn Lake, South Pender Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

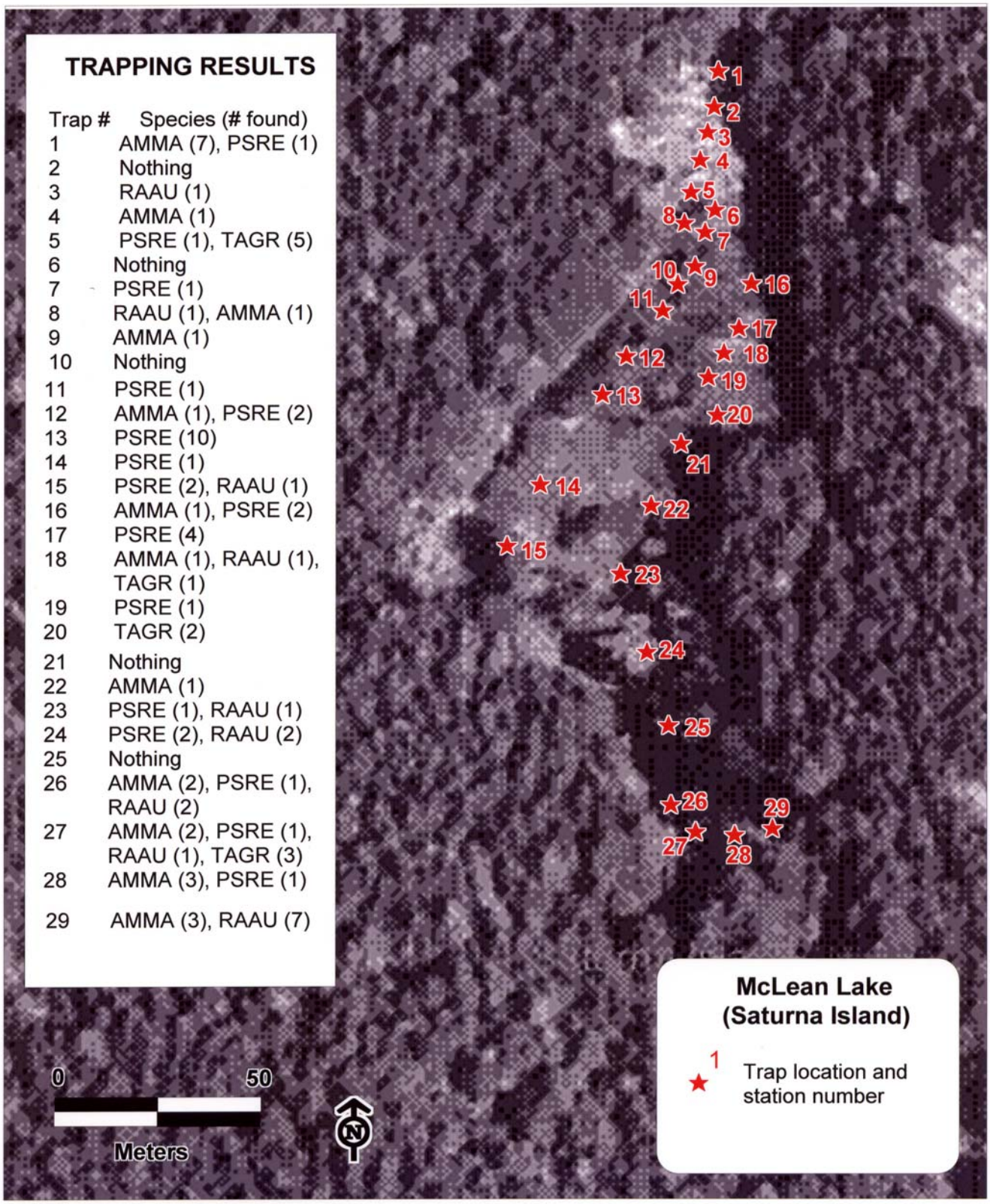

Figure 9. Location of minnow traps and number of amphibians and reptiles captured at McLean Lake, Saturna Island. Species codes: AMMA - Long-toed Salamander, PSRE - Pacific Treefrog, RAAU - Red-legged Frog, RACA - Bullfrog, TAGR - Rough-skinned Newt, THEL - Western Terrestrial Garter Snake, THOR - Northwestern Garter Snake, THSI - Common Gartersnake

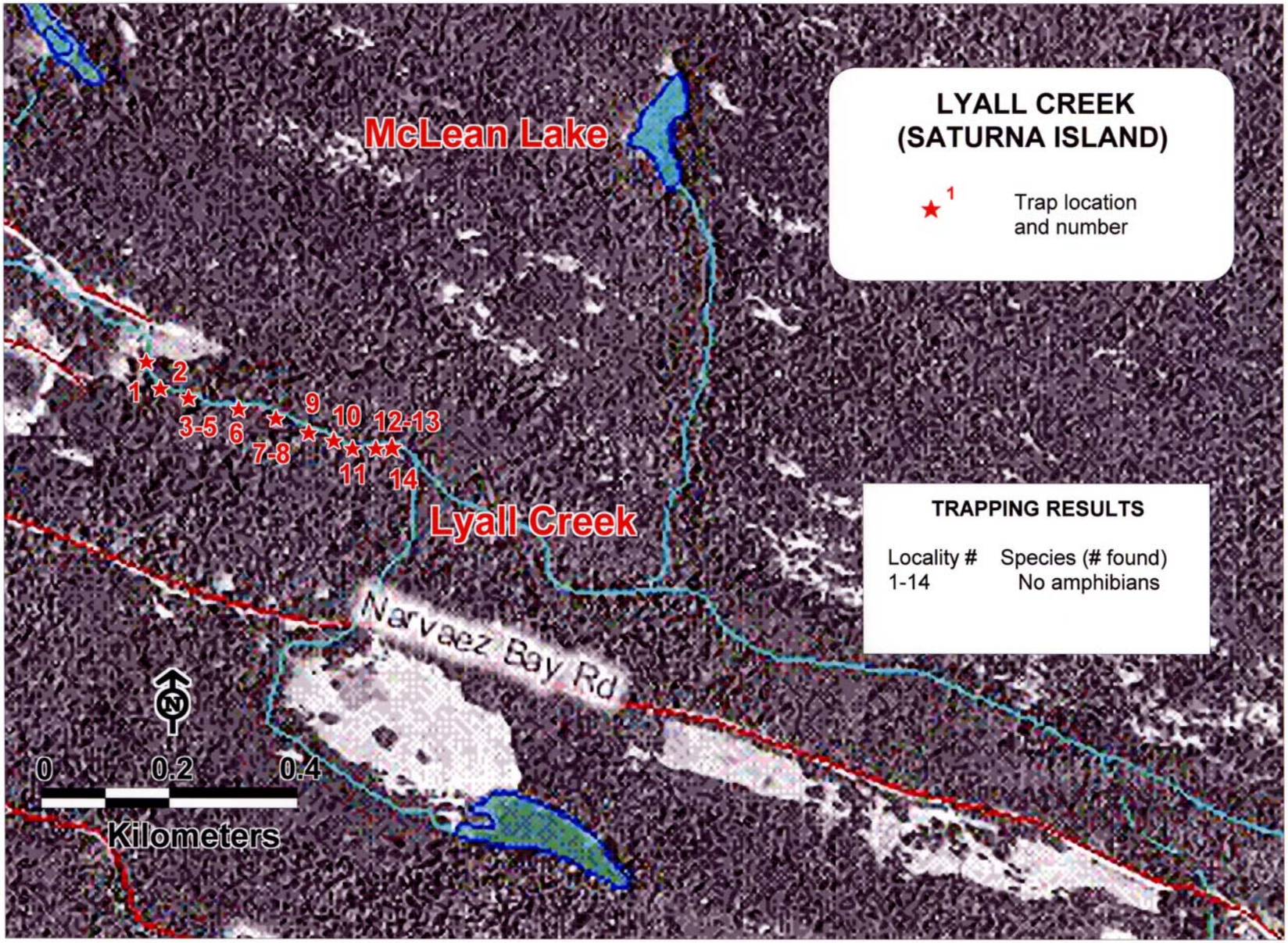

Figure 10. Location of minnow traps and number of amphibians and reptiles captured along the main stem of Lyall Creek, Saturna Island.

4.3 Roe Lake, North Pender

Amphibians

At this site, we detected three species of native amphibians (the Rough-skinned Newt, Red-legged Frog, and Pacific Treefrog) and the introduced Bullfrog (Tables 1 – 3). The observations included signs of breeding by the Red-legged Frog (egg-masses and tadpole) and the Rough-skinned Newt (mating pairs and egg-laying behaviour) in shallow bays of the lake with emergent and floating aquatic vegetation. Adults and metamorphosed juveniles of the Red-legged Frog were found at the north end of the lake and in a small pond and inlet adjacent to the egg-masses. This species breeds very early in the spring, and little evidence of egg-masses remained by the time of the surveys in April; both egg-masses found were old and decaying. The surveys were not designed to provide accurate information on densities, but interestingly we found only a few larvae (1 in a trap) and metamorphosed individuals (3 individuals, in total) of the Red-legged Frog. Similarly, we found few signs of the Pacific Treefrog (one individual heard calling at the shallow bay in the south end of the lake).

The Bullfrog is reproducing in the lake, as indicated by the presence of large tadpoles in advanced developmental stages (several with hind-limbs; voucher deposited to the RBCM). Tadpoles of this species usually require two years before metamorphosis, indicating that the species has been in the lake for multiple years. Most of our observations took place in the shallow, weedy bay at the south end of the lake, but we also found a few tadpoles in the north end of the lake. The Bullfrog poses a serious threat to native species of frogs, including the Red-legged Frog, in British Columbia (Govindarajulu, undated) (see Section 5.0 on Management Recommendations).

Reptiles

At this site, we detected two of the three species of garter snakes present in British Columbia. The third species (Western Terrestrial Garter Snake) also occurs in riparian habitats around the lake but was not found during this study (Engelstoft and Ovaska 1997).

Important habitats

Roe Lake and associated wetlands and forests represent a large area of relatively undisturbed habitat on the densely populated island and are therefore of special importance for a variety of wildlife. For most of our amphibians, the combination of aquatic breeding habitat and terrestrial forest habitat is particularly important.

The littoral zone is narrow with the exception of large bay in the south-east end of the lake. The best habitats for amphibians in this area include this bay and associated marshlands along the inlet, smaller bays in the north end of the lake, and a small pond and inlets at the west side of the lake (Figure 4). Shallow water depths and abundance of emergent vegetation make these areas high-quality habitat; the pond may also contain fewer predators. The presence of the Bullfrog in the lake is unfortunate, as it

reduces habitat suitability for native species. It is unknown whether the lake contains salmonid fish, which also are predators of amphibians. We trapped a large number of sticklebacks in the lake (Table 3). These native fish probably have few or no adverse effects on amphibians.

The lake shores and wetland areas provide excellent foraging habitat for garter snakes, and the adjacent rocky areas, particularly on the north and east sides of the lake, provide hiding places and hibernation habitat. Potential habitat exists for the endangered Sharp-tailed Snake, but to date the species has not been found there (Engelstoft et al. 2002, C. Engelstoft, unpublished data).

4.4 Greenburn Lake, South Pender

Amphibians

At this site, we detected two species of native amphibians (the Rough-skinned Newt and Red-legged Frog) and the introduced Bullfrog (Tables 1 – 3). The density of the Rough-skinned Newt appeared to very high both in the lake and in the adjacent slow-flowing creek/ditch within a wet meadow. During the April surveys, we observed several mating pairs and a mating ball (consisting of at least five individuals) in the lake and creek/ditch. In June, strikingly large numbers of adults entered our traps (Figure 8). Most likely the newts breed in both habitats, although we detected no larvae. This species is often quite aquatic and tends to prefer permanent water bodies, including sites where the water is very stained with rotting vegetation (Cochran and Toms 1996). We found only two adults of the Red-legged Frog, both along creek/ditch banks in the west end of the lake. We also found evidence of breeding (one disintegrating egg-mass) in the creek but detected no signs of the Red-legged Frog in the lake itself or its banks. The Pacific Treefrog, a common species on the island, may well occur at the site, although we failed to detect its presence.

The Rough-skinned Newt is a predator of amphibian eggs and small larvae (Calef 1973, Leonard et al. 1993), and it could be partially responsible for the lack of signs of breeding by other native amphibians. Predation by newts can account for a significant proportion of larval mortality of the Red-legged Frog during the first few weeks after hatching (Calef 1973). Also, the lack of well-developed littoral zone of the reservoir could contribute to lack of signs of breeding. It would be useful to conduct auditory surveys for calling frogs in early spring to confirm breeding or lack of thereof.

The Bullfrog is reproducing in the lake, as indicated by an observation of a very large tadpole in the west end of the lake. However, densities might be low; only one tadpole was sighted, and none were caught in the traps.

Reptiles

At this site, we detected all three species of garter snakes present in British Columbia. Interestingly, three individual snakes (one Common Garter Snake and two Western

Terrestrial Garter Snakes) entered our traps set in the lake. Both species often forage in water for fish and amphibians. One Western Terrestrial Garter Snake was observed on a floating log, which the snakes can use as foraging platforms and thermoregulation sites. We also opportunistically found garter snakes along a rocky slope on the north side of the lake.

Important habitats

Greenburn Lake appears to provide excellent habitat for the Rough-skinned Newt, judging from the large numbers of individuals found both within the lake itself and within its outlet. It may well be the best site for newts within the park.

The littoral zone of the lake is relatively narrow with a steep drop within less than about a meter from the shore throughout most of its perimeter. This bottom configuration reduces the suitability of the lake for many amphibians, including the Red-legged Frog and Pacific Treefrog, which prefer shallow water areas with abundant emergent vegetation as breeding areas. The abundant population of the Rough-skinned Newt, the presence of the Bullfrog and, possibly, also of predatory fish reduce habitat suitability of this permanent lake for native frogs. The ditch/creek that flows through the adjacent wet meadow at the outlet of the lake provides some breeding habitat for the Red-legged Frog. Much of the outlet was dry during our visit in mid-June, but some depressions still retained water. However, we detected no tadpoles. Efforts to enhance habitats for native species of amphibians should focus on this disturbed wet meadow (see Section 6 on Management Recommendations).

Both the lake and wet meadow provide excellent foraging habitat for garter snakes, particularly for the Common Garter Snake and the Western Terrestrial Garter Snake. A rocky slope on the north side of the lake has a suitable southern exposure and loose talus to provide excellent breeding and nursery habitat for a variety of snakes. We found several garter snakes sheltering under the rocks there. This area also provides potential habitat for the endangered Sharp-tailed Snake and should be investigated further.

4.5 Lyall Creek and McLean Lake, Saturna

Amphibians

In McLean Lane, we found four species of amphibians, all native: the Rough-skinned Newt, Long-toed Salamander, Red-legged Frog, and Pacific Treefrog. During both the April and June surveys, we found larvae of each of these species (with the exception of the Rough-skinned Newt). Tadpoles of both the Pacific Treefrog and Red-legged Frog were particularly abundant (Tables 2 and 3). Adults and juveniles of the Long-toed Salamander are secretive, possibly fossorial (living underground for much of the time), and difficult to locate in the terrestrial habitat. The shallow lake (mostly < 1m in depth in mid-June 2004) with abundant emergent vegetation provides warm water and abundant hiding places for amphibian larvae, facilitating their development and survival. The lake

may be largely ephemeral (with the possible exception of deeper pools at its south end), so reducing pressure from predators such as fish that require permanent water.

Surveys in and along Lyall Creek and its tributaries resulted in the detection of the Red-legged Frog, Pacific Treefrog, and Rough-skinned Newt. Adults and metamorphosed juveniles of the Red-legged Frog appeared to be abundant along the main channel of Lyall Creek throughout its length. The frogs were observed perching along the shoreline or on the forest floor within the riparian zone; a few individuals were in pools within slow-flowing portions of the creek. We observed no breeding activity by this or other amphibians within the creek. Concentrations of the Pacific Treefrog occurred within herbaceous vegetation along portions of the creek shore. Night surveys, carried out to detect nocturnal salamanders in the terrestrial habitats, produced no observations of amphibians, although such surveys are very effective on Vancouver Island (Beasley et al. 1996, unpublished data by KO & LS).

Reptiles

We detected few reptiles during the surveys. Only the Common Garter Snake was found, at Lyall Creek. The Western Terrestrial Garter Snake and the Northwestern Garter Snake are probably also present in these habitats although not detected. Newly metamorphosed amphibians provide a good food source for garter snakes, and concentrations of these snakes often occur at amphibian breeding sites such as McLean Lake later in the summer. Surveys in July – early August when metamorphs emerge in large numbers would be a good time for surveys at McLean Lake to confirm these types of predator-prey dynamics.

Important habitats

The shallow McLean Lake's provides exceptional breeding habitat for a number of native amphibians and might be a source of recruits for a relatively large area in the surrounding landscape. It is imperative to protect this area from artificial fluctuations in water levels and from the introduction of exotic species, including the Bullfrog and predatory fish. In contrast, Lyall Creek overall provides poor breeding habitat for amphibians due to the relatively cool water and the abundance of juvenile salmon (the creek is a salmonid breeding site). However, pools in small forest gaps along the creek could provide some breeding habitat for the Red-legged Frog.

Lyall Creek and its tributaries provide dispersal routes and riparian foraging areas for the Red-legged Frog and other amphibians. Amphibians could use the creek flowing out of McLean Lake, including the channel and intermittent pools during dry periods, to disperse to foraging areas in the forest. The Red-legged Frog can move several kilometers between aquatic breeding sites and terrestrial foraging areas (reviewed in Ovaska and Sopuck 2004). Streams and creeks provide important travel routes for this species, especially during periods of dry weather that curtails overland movements. Dispersal movements of young away from breeding sites are poorly documented, but water courses are likely to be important. In the summer, adults of the Red-legged Frog

maintain small foraging ranges, often along forested stream banks (Chan-McLeod 2003).

Many amphibian populations are organized as metapopulations (a number of subpopulations linked by dispersal). Some degree of connectivity among these subpopulations is essential to maintain the dynamics of the system. In systems with source/sink dynamics larger habitat patches or those with particularly suitable breeding sites produce large numbers of young that then disperse into the surrounding area, supplementing poor natal recruitment in less productive sites and allowing recolonization of vacant habitat patches, including those that have suffered local extinctions. Metapopulation dynamics of the Red-legged Frog and other native frogs in British Columbia are poorly studied, but it is conceivable that exceptional breeding sites such as McLean Lake act as source populations in such systems. A multi-year mark-recapture study would be needed to confirm source/sink dynamics of these habitats.

In addition to facilitating movements of native amphibians, the outlet creek from McLean Lake could be used by the Bullfrog to enter the lake, if the species was introduced at Lyle Creek or elsewhere within the drainage system. This creek was already almost dry in early June and has high gradient sections; consequently salmonid fish, which are predators of amphibians, are unlikely to enter the lake using this route.

5.0 SPECIES AT RISK

Of the species located during the surveys, only the Red-legged Frog is considered to be at risk. It is listed as “special concern” by the Committee on the Status of Endangered Species In Canada (COSEWIC) and is on the provincial blue list of species at risk. Threats to populations include fragmentation of forest habitats, loss and degradation of breeding sites, and competition and predation by introduced species, such as the Bullfrog (Ovaska and Sopuck 2004). Protected areas that are sufficiently large to contain both breeding sites and terrestrial foraging habitat, such as within parks, are especially important for this species. A large portion of its range overlaps with populated areas on Vancouver Island and the Lower Mainland and suffers from extensive fragmentation.

The Red-legged Frog is present at each of the sites surveyed. The Roe Lake and MCLean/Lyall Creek properties are likely to provide important refuges for this species: The Roe Lake area represents a relatively large protected area with a variety of terrestrial and aquatic habitats required by the species. McLean Lake constitutes excellent breeding habitat, and Lyall Creek and its tributaries provide movement and dispersal routes and foraging habitats. These latter areas are particularly important as they appear to be free of the invasive Bullfrog.

6.0 MANAGEMENT RECOMMENDATIONS

Recommended management for wetland habitats at the three sites consist of (1) prevention of the spread/control of Bullfrog populations, (2) maintaining natural

hydrological patterns to facilitate the survival of native species of amphibians, and (3) enhancing/restoring habitat for native amphibians at the Greenburn Lake site. Recommendations for habitat enhancement/restoration should focus on Greenburn Lake and its vicinity, because this site is disturbed by human activities, and opportunities exist to substantially improve the habitat for native amphibians. At Roe Lake and McLean Lake efforts should focus on preserving existing, relatively unmodified habitats in their natural state – both sites provide important breeding habitat for native amphibians and are among few such sites that are protected.

6.1 Managing hydrology and vegetation at amphibian breeding sites

The best option is to retain or restore natural hydrological patterns at amphibian breeding sites. If drawing of water is required for other purposes, special care should be taken to maintain hydrological patterns that do not impede reproductive success of native amphibians, from egg-laying to metamorphosis. Similar considerations apply to habitats that are restored or enhanced. The duration of water (hydro-period), current velocity, water depth, water level fluctuations, and water quality all are important considerations when managing wetland habitats for amphibians (Richter 1997). Hydrology, in turn, contributes to vegetation cover by aquatic and semi-aquatic plants, which are an important feature of amphibian breeding requirements.

The principles of management consist of (1) avoiding fluctuations in water levels during the egg-laying period; (2) maintaining water in shallow zones throughout larval rearing period; (3) avoiding premature drying of the habitat (i.e., before larvae have had a chance to complete their development and metamorphose); and (4) maintaining natural patterns of drying in ephemeral habitats, avoiding their conversion into permanent water bodies.

Duration of hydro-period:
Most amphibians that occur on the Gulf Islands can use either temporary or permanent water bodies for breeding; the Northwestern Salamander is an exception and requires permanent water for larval development that spans over more than one year. The Rough-skinned Newt also tends to be rather aquatic and reaches high densities in permanent water bodies, although it also breeds in temporary water bodies at low elevations. In contrast, the Red-legged Frog and Pacific Treefrog prefer ephemeral water bodies, where periodic drying reduces predation pressure, especially from fish, other amphibians (Bullfrog, Northwestern Salamander), and some invertebrate predators. In the Puget Lowlands, Washington State, survival of tadpoles of these two species was greater in temporary than in permanent ponds (Adams 2000). Amphibian larvae that develop in predator-free habitats can attain a relatively large body size at metamorphosis, which in turn tends to increase their subsequent survival (Alford 1999, Ultsch et al. 1999). Creating shallow pools adjacent to a permanent water body can be used to effectively increase habitat diversity for amphibians and reptiles (Kingsbury and Gibson 2002).

The periods of egg-laying and early development are highly species-specific but their exact timing varies among localities and years in response to environmental conditions.

In southwestern British Columbia, the Red-legged Frog breeds early in the spring, in February – March, over a period of 2 – 3 weeks (Licht 1969, 1974). The eggs typically hatch after 6 – 7 weeks, by early May, and tadpoles metamorphose by July – early August. However, tadpoles may continue to metamorphose until October at some sites (Calef 1973). The Pacific Treefrog begins to breed in early spring (February – March), but egg-laying continues for several months, until June at some localities (Leonard et al. 1993). Most individuals, however, are ready to metamorphose in June at low elevations. At low elevations the Rough-skinned Newt breeds from February to April, and larvae metamorphose towards the end of the summer (Leonard et al. 1993). The Long-toed Salamander breeds very early (as early as December in the Puget Sound) and is the earliest breeding species in our area. The eggs hatch rapidly (within a few weeks when water temperatures are favourable), and larvae metamorphose in early summer (Leonard et al. 1993). Metamorphosis probably takes place in July on the Gulf Islands, but little data on the timing of development for this or other species of amphibians from this area are available. At high elevations, larvae of both the Rough-skinned Newt and Long-toed Salamander transform in their second year.

Current velocity:
All amphibians found on the Gulf Islands are lentic-breeding species and spawn in standing or slow-moving water. Mating either fails to take place in fast water or fertilization success might be reduced. High water velocities after egg-laying can dislodge egg-masses and physically damage eggs (Richter 1997). Richter (1997) suggested that flow-rates greater than 5 cm/sec are detrimental to the breeding success of the Red-legged Frog and Northwestern Salamander and recommended that currents through restored wetlands should be well below this threshold. However, some slow movement of water is beneficial as moving water resists freezing in early spring when several amphibian species breed and also provides oxygenated water to the eggs.

Water depth:
Shallow shoreline areas with emergent vegetation provide important egg-laying sites for many amphibians and feeding areas for their larvae. These areas may be lost if water levels are either increase (as a result of damming) or decrease (as a result of drawing of water). Sufficient water depths in amphibian breeding habitats should be maintained at levels that allow egg-laying by different species at preferred depths in the water column. The egg-masses of the Red-legged Frog are attached to submerged vegetation relatively deep in the water column and are typically at least 30.5 cm (12”) below the surface (Licht 1969). However, the attachments to vegetation are weak, and the egg-mass often floats to surface later in the development (Leonard et al. 1993). Egg-masses of the Pacific Treefrog and Long-toed Salamander are laid in small clusters and attached to submerged vegetation in shallow water, usually less than 50 cm deep (Corkran and Thoms 1996). The eggs of the Rough-skinned Newt are laid singly and often wrapped in a leaf of submerged plants at varying depths.

Richter (1997) suggested that water depths of 10 – 50 cm should be available at restored wetlands throughout the egg-laying and embryonic development period to facilitate successful breeding by amphibians found in the Puget Sound Basin area in

Washington State. He suggested terraced shores for restored ponds at three depths (10 – 20 cm, 30 – 40 cm, and 50 – 60 cm) or very gradual slopes to a total depth of 50 cm (with gradients of 10 horizontal to 1 vertical or shallower) to provide suitable spawning conditions for a variety of species.

Amphibian larvae tend to prefer shallow water and often select the shallowest areas possible. Water in the shallow zone is warmer than in the rest of the water body, resulting in more rapid development. It is important that the full extent of shallow areas at amphibian breeding sites is maintained. Shrinking of the shallow zone as a result of drawing of water is likely to cause concentration of amphibian larvae into the remaining shallow areas. Predation risk increases when larvae are concentrated within small areas, and food may be in short supply. Decreased larval survival or premature metamorphosis at a small body size (with decreased subsequent survivorship) may result under such conditions.

Water level fluctuations:
Water levels should be maintained relatively stable from egg-laying to hatching to avoid direct mortality and decreased habitat complexity through simplified plant communities that result from fluctuating water levels (Richter 1997). Direct mortality can result from the dislodgement of eggs and from their exposure to the elements (drying, UV-b radiation, temperature fluctuations). In southwestern British Columbia, this sensitive period for most native amphibians extends from early February to late May. Mean fluctuations greater than 20 cm correlated with reduced amphibian species richness in wetlands in Washington State (Richter and Azous 1995). However, even smaller fluctuations (>7 cm) resulted in embryonic mortality of the Northwestern Salamander (Richter 1997); this threshold depth corresponded to the average depth of egg-mass attachment by this species in field experiments. Egg-masses of the Red-legged Frog are somewhat buffered by fluctuations by their location relatively deep in the water column.

While fluctuations in water depth during the egg-laying and hatching period can be detrimental to amphibians, periodic drawdowns in late summer can be beneficial by increasing the productivity of a wetland and preventing the establishment of predators (see Section 6.1: Duration of hydro-period).

Vegetation cover:
Submerged and emergent aquatic vegetation provide attachment sites for amphibian eggs and shading, refuges from predation, and foraging areas for larvae. Vegetation structure rather than specific species composition appears to be important for most species (Richter 1997). The Red-legged Frog, Long-toed Salamander, and Northwestern Salamander tend to deposit their eggs on thin-stemmed, emergent plants (Richter 1997, Richter and Azous 1995 and references therein). Suitable plant species include Water-Parsley (*Oenanthe sarmentosa*), rushes (*Juncus* spp.), sedges (*Scirpus* and *Carex* spp), and other thin-stemmed (with average stem diameter 3 – 4 mm) plants (see Table 3 in Richter 1997 for a more comprehensive list of suggested plant species). Richter (1997) suggested that plants to be avoided at restored amphibian breeding sites

include Hardhack (*Spiraea douglassii*), willows (*Salix* spp.), and other woody plants. Aggressive smartweeds (*Polygonum* spp.), Cattail (*Typha latifolia*), and exotic species (including the Yellow Flag common at the Greenburn site) are unsuitable for most native amphibians and should be avoided.

An interspersion of open water with vegetation cover is favourable for amphibians, as many species tend to avoid large expanses of both open water and densely vegetated areas. Richter (1997) suggested ratios of 50:50, 25:75, or 75:25 of open water to vegetated area for restored amphibian breeding sites.

6.2 Recommendations for specific sites

McLean Lake/Lyall Creek:
McLean Lake provides exceptional breeding habitat for a number of native amphibians, and maintaining the lake in its natural state is a priority. We suggest the following measures:

1. *Public education to prevent the introduction of the Bullfrog.* At present there is no evidence that this species occurs on Saturna Island. Making interpretive materials available and placing signage on park properties should be used to ensure that residents and visitors to the island are aware of the problem and preventative measures, which include a prohibition to move or release tadpoles or frogs of any species.
2. *Establish an early Bullfrog detection and eradication program* to ensure that Saturna Island remains Bullfrog-free. Such a program would entail monitoring wetlands during the summer breeding season when male Bullfrogs are vocal (in June – July).
3. *Maintaining natural drainage of the lake*. This lake is very shallow and, with the exception of some deeper pools, might dry out regularly by late summer. While the ephemeral nature of the lake is beneficial to amphibians by reducing predators and should be maintained, drawing water from the lake during the spring or early summer could result in premature drying and hence reduced survivorship of amphibian larvae. The natural drainage pattern of the lake should be left unaltered, and any drawing of the water from the lake should be prohibited to preserve this exceptional site.
4. *Clean-up of outlet creek from McLean Lake.* There is an old logging road and human-deposited debris along the outlet creek, possibly obstructing water flow. Cleaning of the debris and rehabilitating the road should be considered to restore the creek to its natural state.

For amphibian habitat along Lyall Creek and its tributaries we have no specific recommendations, apart from preventing the introduction of the Bullfrog, which could use these creeks to access McLean Lake. Any new trails should be constructed away from the creek and the immediate vicinity of the riparian zone that is used by frogs for

foraging to prevent compaction of the substrate and trampling of the shoreline vegetation.

Roe Lake:
This area is important for amphibians and reptiles because of its large size and the variety of relatively undisturbed habitats that it contains. We suggest the following management measures:

1. *Control of the Bullfrog population present in the lake*. Eradication measures should be attempted, although the large size of the lake makes control difficult. Assessing the magnitude of the problem, including the proximity of possible source populations, would be a first step. Control efforts are likely to be more efficient on the periphery of the species' distribution and/or where the potential for recolonization is low. Control measures could include the removal of egg-masses and other life-history stages, and trapping of dispersing frogs at the inlets and outlets of the lake.
2. *Public education to prevent new releases of the Bullfrog*. (see recommendations for McLean Lake/Lyall Creek, above)
3. *Maintaining shallow water areas of the lake undisturbed during spring and early summer*. Drawing of water from the lake should be restricted during egg-laying and larval periods of native amphibians (from early spring to about mid-summer) if it results in the loss of shallow water areas, particularly in the large bay on the south side of the lake. Fluctuations in water level, especially by more than 20 cm, should be avoided during the early developmental periods (from egg-laying to hatching), as such fluctuations can be detrimental to hatching success of a number of native species (see Section 6.1: Managing hydrology and vegetation at amphibian breeding sites" for details). Lowering of the water level can leave eggs stranded or reduce the shallow water zone preferred by amphibian larvae. If water has to be drawn from the lake, restricting it to periods from late summer to winter (from about mid-August to January) would be optimal. If water must be drawn during the breeding period of amphibians (February – early June), the magnitude of fluctuations and depth of water should be closely monitored throughout this period to ensure that both remain within acceptable limits.
4. *Ensuring that the drainage of small ponds, inlets and tributary creeks remain undisturbed.* Special attention should be paid to the inlets and ponds on the west and northwest side of the lake, which might provide important breeding habitat for the Red-legged Frog. Natural patterns of drainage should be maintained to the extent possible. Similar to the shallow water areas within the lake itself, fluctuations in water level should be avoided during the periods of egg-laying and embryonic development (from February to early June). The pond and shallow water areas should be maintained until larvae have metamorphosed in August. Monitoring of water levels (depth and magnitude of fluctuations) should be undertaken, if any water is withdrawn during developmental period of amphibians.

Greenburn Lake:
Wetland habitats at this site have been heavily modified by human activities and also by introduced vegetation; modifications include a dam, clearing of forest, apparent channeling of the outlet creeks, and introduction of the exotic plants, including the Yellow-flag prevalent along margins of the lake. The lake provides excellent habitat for the Rough-skinned Newt, but its suitability for other native amphibians appears to be limited. We suggest the following management measures:

(1) *Control of the Bullfrog population*. Limited information from our surveys suggests that although the Bullfrog is present in the lake, densities might be low. An experimental eradication program could be attempted at this site, which is relatively small and isolated.

We suggest the following strategy:

a. conduct night surveys to gain information on the densities and distribution of calling males

b. assess the potential for recolonization through dispersal from other areas

c. device a control plan if deemed feasible and cost-effective

d. implement suitable eradication measures. Such measures could include the collection and removal of egg-masses from territories of males, concurrent targeting of other life history stages, and experimental male sterilization program (adult males hold breeding territories, and their sterilization could potentially be effective).

(2) *Public education to prevent new releases of the Bullfrog*. (see recommendations for McLean Lake/Lyall Creek, above)

(3) *Consideration should be given to controlling water levels at the dam site to mimic natural hydrological patterns of small lakes on the Gulf Islands*. For example, pronounced draw-downs in late summer followed by flooding in winter/spring may increase natural biodiversity of the system. The wet meadow and creek downstream of the lake would likely benefit from seasonal flooding in winter and spring by release of water from the lake, again mimicking natural patterns of water flow.

(4) *Restoration/enhancement of the wet meadow by the outlet of the lake.* This area provides an excellent opportunity for breeding habitat enhancement for native amphibians: forested foraging habitat exists immediately adjacent to the site, and the natural drainage pattern is disturbed. The existing dam facilitates control measures for water levels and periods of inundation. The Red-legged Frog already uses this habitat but in apparently low densities. Habitat enhancement is likely to benefit populations of this and other native amphibians. A drawback is the presence of the introduced Bullfrog in the lake. Any habitat enhancement measures are likely to be futile is the Bullfrog population is not controlled or eradicated.

We recommend remodeling the wet meadow and its drainage by constructing a meandering channel and a series of several shallow ponds and by filling in the existing channeled ditches at each side of the meadow. Water can be released from the dam to inundate the meadow and the ponds, as needed. Complete removal of the dam may not be feasible, especially if drawing of the water for other purposes is required, and would considerably lower water levels and result in the shrinking of the lake. The ponds would prevent premature drying of the restored wetland in July – early August; however, the ponds should be allowed to dry up in late summer to prevent the establishment of the Bullfrog, which cannot develop to metamorphosis within one season. The ponds should have shallow, gradual slopes, a suitable interspersion of vegetated areas and open water, and irregular, convoluted edges to maximize the extent of the shoreline. The establishment of thin-stemmed plants, such as rushes and sedges, should be encouraged (see Section 6.1 “Managing hydrology and vegetation at amphibian breeding sites” for more detailed requirements). Monitoring of the use of the restored habitat by amphibians and reptiles should be undertaken to assess the effectiveness of the measures and possible needs for refinements.

(5) *Protection of the cliffs and talus areas on the north side of the lake from disturbance, such as trampling and rock climbing.* Rocky areas along the slope provide excellent cover and nursery habitat for garter snakes and potentially also for the Sharp-tailed Snake. These areas should be surveyed for the latter species and protected from disturbance.

7.0 LITERATURE CITED

Adams, M. J. 2000. Pond permanence and the effects of exotic vertebrates on anurans. Ecological Applications April 10:559–568.

Alford, R. A. 1999. Ecology: resource use, competition, and predation. Pp. 240–278. *In:* R.W. McDiarmid, and R. Altig (eds.). Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, London.

Beasley, B., C. Addison, and K. Lucas. 2000. Clayoquot Sound Amphibian Inventory, 1998–1999. Unpublished report prepared by The Long Beach Model Forest Society and the BC Ministry of Environment, Lands and Parks.

Calef, G. W. 1973. Natural mortality of tadpoles in a population of *Rana aurora*. Ecology 54:741–758.

Chan-McLeod, A. C. A. 2003a. Refining the funnel trapping protocol for monitoring amphibians and movement patterns of red-legged frogs. Unpublished progress report prepared for Weyerhaueser Company, Nanaimo, BC.

Corkran, C. C. and C. Thoms. 1996. Amphibians of Oregon, Washington, and British Columbia. Lone Pine Publishing, Vancouver, BC.

Engelstoft, C. 2004 (*draft*). Sharp-tailed snake habitat assessment and survey on Coast Guard, DND and Parks Canada properties in the Capital Region, BC, 2003-04. Unpublished report by Alula Biological Consulting for Parks Canada.

Engelstoft, C. and K. Ovaska. 1997. Sharp-tailed Snake inventory within the Coastal Douglas Fir Biogeoclimatic Zone, June-November 1996. Unpublished report prepared for the Ministry of Environment, Lands and Parks, Vancouver Island Region, Nanaimo, BC. Project # PA-96-242-IN.

Engelstoft, C., L. Sopuck, and K. Ovaska. 2002. Assessment of Sharp-tailed Snake habitats in the proposed Gulf Islands National Park – Phase 1. 2002. Unpublished report prepared for Parks Canada, Coastal British Columbia Field Unit, Victoria, BC.

Govindarajulu, P. (undated). Survey of Bullfrogs *Rana catesbeiana* in British Columbia http://web.uvic.ca/bullfrogs/page2.htm (accessed June 2004).

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L-A. C. Hayek, and M. S. Foster. 1994. (editors). Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington DC. 364 pp.

Kingsbury, B.A., J. Gibson, and contributors. 2002. "Habitat Management Guidelines for Amphibians and Reptiles of the Midwest." A PARC Publication. ISBN 0-9667402-1-1. 57 pp.

Leonard, W. P., H. A. Brown, L. L. C. Jones, K. R.McAllister, and R. M. Storm (coordinating editors). 1993. Amphibians of Washington and Oregon. Seattle. Seattle Audobon Society.

Licht, L. E. 1969. Comparative breeding behavior of the red-legged frog, (*Rana aurora aurora*) and the western spotted frog (*Rana pretiosa pretiosa*) in southwestern British Columbia. Canadian Journal of Zoology 47:1287–1299.

Licht, L. E. 1974. Survival of embryos, tadpoles, and adults of the frogs *Rana aurora aurora* and *Rana pretiosa* sympatric in southwestern British Columbia. Canadian Journal of Zoology 52:613–627.

Olson, D. H., W. P. Leonard, and R. B. Bury (editors). 1997. Sampling Amphibians in Lentic Habitats. Northwest Fauna 4. Society for Northwestern Vertebrate Biology, Olympia, Washington. 134 pp.

Ovaska, K. and L. Sopuck. 2004. Update COSEWIC Status Report on the Red-legged Frog *Rana aurora* in Canada. Unpublished report prepared for the Committee on the Status of Endangered Species in Canada.

Richter, K. 1997. Criteria for the restoration and creation of wetland habitats of lentic-breeding amphibians of the Pacific Northwest. Pp, 72–94. *In*: K.B. Macdonald and F. Weinmann. (eds.). Wetland and Riparian Restoration: Taking a Broader View. Contributed Papers and Selected Abstracts, Society for Ecological Restoration, 1995 International Conference, September 14-16, 1995, University of Seattle, WA. Publication EPA 910-R-97-007, USEPA, Region 10, Seattle, WA.

Richter, K. O. and A. L. Azous. 1995. Amphibian occurrence and wetland characteristics in the Puget Sound Basin. Wetlands 15:305–312.

Ultsch, G.R., D.F. Bradford, and J. Freda. 1999. Physiology: coping with the environment. Pp. 189-214. *In*: McDiarmid, R. W., and R. Altig (eds.). Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, London.

Appendix A. Localities surveyed for amphibians April and June 2004 within the Gulf Islands National Park.

Route ID: Survey route travelled by observers by boat or foot (see Figures 3-6 for locations)

UTM: Zone 10; NAD 83; for estimated center of area surveyed; obtained from maps.

Habitat type: lake pond seepage stream river marsh swamp bog

Vegetation (aquatic):

Substrate: silt clay sand gravel cobble boulder bedrock wood organic debris

Drainage: permanent ephemeral unknown

Origin: natural human-made unknown

Surrounding landscape: forest marsh/swamp meadow other (describe)

Island	Locality Name	Route ID	UTM Easting; Zone 10U	UTM Northing; Zone 10U	Habitat type	Vegetation	Substrate	Drainage	Origin	Surrounding landscape	Photo frame	Comments
North Pender	Roe Lake	1	477634 (start), 477831 (middle), 477632 (end)	5403343 (start), 5403236 (middle), 5403348 (end)	Lake	Locally abundant emergent & aquatic vegetation	Organic debris	Permanent	Natural	2nd growth mainly coniferous forest		Beaver activity
North Pender	Roe Lake	2	477809 (start), 477857 (middle), 477912 (end)	5403193 (start), 5403262 (middle), 5403183 (end)	South bay of lake & adjacent marshy riparian area	Abundant emergent vegetation in bay; Skunk Cabbage marsh (adjacent)	Organic debris	Permanent	Natural	2nd growth mixedwood forest	CE digital photos; LS: 20-22 (prints)	
North Pender	Roe Lake	3	478102 (start), 478236 (middle), 478114 (end)	5403109 (start), 5403026 (middle), 5403115 (end)	Marsh/bog	Mostly sedges; some Hardhack, Willow, Skunk Cabbage			Natural			Little standing water
North Pender	Roe Lake	4	477580 (start), 477636 (middle), 477666 (end)	5403276 (start), 5403247 (middle), 5403218 (end)	Pond & creek (inlet of lake)		Organic debris	Permanent	Natural	2nd growth mainly coniferous forest; some Alder		Beaver activity
North Pender	Roe Lake	5	477522 (start), 477762 (middle), 477904 (end)	5403503 (start), 5403397 (middle), 5403188 (end)	Swamp at north shore of lake							Dried up
North Pender	Roe Lake	6 (trapping)	See Figure 7 for trap locations		Lake edges, pond				Natural	2nd growth mainly coniferous forest; some Alder		Trapping with minnow traps
South Pender	Greenburn Lake	1	484645 (start), 485103 (middle), 484628 (end)	5398912 (start), 5398833 (middle), 5398900 (end)	Lake	Locally abundant emergent & aquatic vegetation	Organic debris	Permanent	Enhanced (human-made dams & beaver activity)	2nd growth mixed-wood forest		
South Pender	Greenburn Lake	2	484539 (start), 484176 (middle), 484516 (end)	5398899 (start), 5398968 (middle), 5398860 (end)	Lakeshore & marsh		Organic debris	Lake: permanent; Marsh: unknown	Enhanced (human-made dams & channeling)	Meadow; 2nd growth mixed-wood forest		Route followed a U-shaped channed creek or ditch
South Pender	Greenburn Lake	3 (trapping)	See Figure 8 for trap locations		Lake, littoral zone		Organic debris	Permanent	Enhanced (human-made dams &			Trapping with minnow traps
Saturna	McLean Lake	1a,b	488537 (start), 488527 (middle), 488535 (end)	5404954 (start), 5404773 (middle), 5404949 (end)	Lake	Abundant throughout lake; almost 100% coverage); sedges, pond lilies, Bullrush, Milfoil	Organic debris	Permanent	Unknown	2nd growth mixed-wood forest	1-11 (LS prints)	Shallow; most of lake 6" - 18" deep.
Saturna	Tributary of Lyall Creek (1) near McLean Lake	2	488528 (start), 488535 (middle), 488546 (end)	5404771 (start), 5404615 (middle), 5404517 (end)	Stream	Sedges in seepage areas only	Silt & clay	Permanent near inlet; then ephemeral	Natural	2nd growth mixed-wood forest		
Saturna	Lyall Creek, main channel	3	487690 (start), 488490 (middle), 489110 (end)	5404520 (start), 5404170 (middle), 5403940 (end)	Stream	Patches of wet riparian vegetation (sedges, grass) along portions of the shoreline	Gravel (silt in some pools)	Permanent	Natural	2nd growth mixed-wood forest (Western Redcedar dominant by creek)	CE photos (7144-7145); 7140	Juvenile fish abundant; salmonid habitat projects
Saturna	Lyall Creek, headwaters	4	489930 (start), 490510 (middle), 490830 (end)	5403410 (start), 5403320 (middle), 5402880 (end)	Stream, swamp		Organic debris	Ephemeral	Natural	2nd growth mixed-wood forest	CE photos (7146-7148)	Swamp at valley bottom: UTM (start/end of route)
Saturna	McLean Lake	5 (trapping)	See Figure 9 for trap locations									
Saturna	Lyall Creek	6 (trapping)	See Figure 10 for trap locations									
Saturna	Tributary of Lyall Creek (2)	7	489150 (start), 489270 (middle), 489380 (end)	5403930 (start), 5403800 (middle), 5403700 (end)	Forest floor & riparian zone along creek							Towards headwaters of Lyall Cr.; creek and tributary mostly dry; UTM (start/end of route)
Saturna	Lyall Creek Trail	8	488130 (start), 488120 (middle), 488040 (end)	5404360 (start), 5404220 (middle), 5404110 (end)	Forest floor & riparian zone along creek							UTM (start/end of route)

Appendix B. Dates and conditions during surveys for amphibians in April and June 2004 within the Gulf Islands National Park.

Route ID: Survey route (a) travelled by observers or (b) trap locations (see Figures 3-10 for locations of routes)

Observers: Biolinx Environmental Research Ltd: Christian Engelstoft (CE), Kristiina Ovaska (KO), Lennart Sopuck (LS), Ira Willey (IW); Parks Canada: Todd Golumbia (TG), Kevin Taylor (KT), Leila Hanslit (LH)

Cloud cover (predominant): 1 - clear; 2 - <50% cloud; 3 - >50%; 4 - 100% ; Rain (predominant): none, drizzle, light, moderate, heavy; showers; Temperature (air); Temperature (water) - measured near surface)

Date	Island	Locality Name	Route ID	Survey method	Start time (route)	End time (route)	Total search time by route (person-min)	Observers	Cloud-cover	Rain	Air temp. (C)	Water temp.	Comments
23-Apr-04	North Pender	Roe Lake	1	Boat (visual & netting)	10:15	12:25	260	LS, KO	3	None	11.0	14.0	
23-Apr-04	North Pender	Roe Lake	2	Foot (visual & netting)	10:28	12:28	240	CE, IW	3	None	11.0	14.0	
23-Apr-04	North Pender	Roe Lake	3	Foot (visual day seach)	13:10	13:25	30	CE, IW	3	None			Nothing found
23-Apr-04	North Pender	Roe Lake	4	Foot (visual day seach)	13:45	14:15	120	LS, KO, CE, IW	2	None			
23-Apr-04	North Pender	Roe Lake	5	Foot (visual day seach)	10:00	10:08	16	CE, IW	3	None			Nothing found
23-Apr-04	South Pender	Greenburn Lake	1	Boat (visual & net)	15:56	17:36	360	LS, CE, IW	2	None	9.0	17.0	
23-Apr-04	South Pender	Greenburn Lake	2	Foot (visual & net)	15:51	17:35	94	KO	2	None			
30-Apr-04	Saturna	McLean Lake	1b	Boat & foot (visual & netting)	10:35	13:21	166	LS	1	None			
30-Apr-04	Saturna	McLean Lake	1a	Foot (visual day search & netting)	16:35	16:55	40	LS, KO	1	None	18.0	21.0	Bay of lake; portion of route 1
30-Apr-04	Saturna	Tributary of Lyall Cr. (1)	2	Foot (visual day search)	13:25	14:55	90	LS	1	None			
30-Apr-04	Saturna	Lyall Creek	3	Foot (visual day search)	10:31	15:16	285	CE, KO	1	None	18.0	10.0	
30-Apr-04	Saturna	Lyall Creek,	4	Foot (visual day search)	16:14	17:04	50	CE	1	None			
08-Jun-04	North Pender	Roe Lake	6	Trapping	9:45	12:15	NA	LS, KO	1	None		16-19	36 minnow traps
08-Jun-04	South Pender	Greenburn Lake	3	Trapping	13:00	14:40	NA	LS, KO	1	None		18 -20	20 minnow traps
15-Jun-04	Saturna	McLean Lake	5	Trapping	11:05	13:10	NA	KO, CE, TG, KT, LH	2	None		20.0	29 minnow traps
15-Jun-04	Saturna	Lyall Creek	6	Trapping	14:15	14:44	NA	KO, TG, KT	1	None		12.0	14 minnow traps
15-Jun-04	Saturna	Tributary of Lyall Cr. (2)	7	Foot (visual night search)	23:00	0:14	148	KO, CE	1	None	10.0		
16-Jun-04	Saturna	Lyall Creek Trail	8	Foot (visual night search)	0:25	1:45	160	KO, CE	1	None	9.0		

Appendix C. Observations of amphibians in April and June 2004 within the Gulf Islands National Park (raw data for visual encounter and opportunistic surveys).

Route ID: Survey route travelled by observers (see Figures 3-6 for locations of routes)

Locality ID: Refers to numbered locality within a route as shown in maps

Species code: Amphibians: A-PSRE - *Pseudacris regilla*; A-RAAU - *Rana aurora*; A-RACA - *Rana catesbeiana*; A-TAGR - *Taricha granulosa*; Reptiles: R-THEL - *Thamnophis elegans*; R-THOR - *T. ordinoides*; R-THSI - *T. sirtalis*

Developmental stage: egg; larva; juvenile (metamorph or young); adult

Observation type: aud-auditory; vis-visual; net-scooping with net; trap-with minnow-trap

Microhabitat: water - within water column; surface - exposed on surface of ground; bank - shore of water body

Terrestrial microhabitats: LOG-decaying log or piece of log >10 cm in greatest diameter; WOOD-block of decaying wood; BARK-pieces of bark on forest-floor; BARKLOG-loose bark on log; ROCK-rock, STICK-diameter < 10 cm; LITTER-leaf/needle litter, humus; MOSS-moss on forest floor

Prefices used with above codes: U-underneath; W-within; S-on surface

Date	Site name	Route ID	Locality ID	UTM east; Zone 10U	UTM north; Zone 10U	Species code	Egg-masses (#)	Larvae (#)	Juveniles (#)	Adults (#)	Obervation type	Habitat type	Micro-habitat	Comments
07-Jun-04	Greenburn Lake	0		484865	8398890	A-TAGR				1	vis	lake	water	Swimming near trap #14
07-Jun-04	Greenburn Lake	0	14	484814	5398906	R-THEL				1	vis	rocky slope	under rock	Opportunistic observation during trapping; North shore btw traps 13 - 16
08-Jun-04	Greenburn Lake	0	15	484542	5398881	R-THEL				1	vis	lake	floating log	In west bay near traps 5-9
07-Jun-04	Greenburn Lake	0	14	484814	5398906	R-THOR			1	1	vis	rocky slope	under rock	Opportunistic observation during trapping; North shore btw traps 13 - 15
23-Apr-04	Greenburn Lake	1	8	484592	5398891	A-TAGR				10	vis			
23-Apr-04	Greenburn Lake	1	9	484843	5398886	A-TAGR				6	vis			
23-Apr-04	Greenburn Lake	1	10	ca.485087	ca.5398837	A-TAGR				2	vis			Pair in amplexus
23-Apr-04	Greenburn Lake	1	11	484873	5398792	A-TAGR				1	vis			
23-Apr-04	Greenburn Lake	1	12	484623	5398846	A-TAGR				3	vis			Pair in amplexus
23-Apr-04	Greenburn Lake	1	13	484542	5398865	A-TAGR				2	vis			Pair in amplexus
23-Apr-04	Greenburn Lake	2	6	484181	5398969	A-RAAU				2	vis	ditch/creek	bank	KO slides (1-4)
23-Apr-04	Greenburn Lake	2	4	484359	5398916	A-RAAU	1				vis	ditch/creek	water	Very disintegrated egg-mass
23-Apr-04	Greenburn Lake	2	1	484500	5398884	A-RACA		1			vis	lake	water	Bay with abundant emergent/aquatic vegetation
23-Apr-04	Greenburn Lake	2	2	484468	5398881	A-TAGR				5	vis	ditch/creek	water	Mating ball involving 4 animals (photos of pair, later. By CE & KO)
23-Apr-04	Greenburn Lake	2	5	ca.484272	ca.5398935	A-TAGR				10	vis	ditch/creek		Observations throughout ditch (both sides of "U")
23-Apr-04	Greenburn Lake	2	7	ca. 484343	ca. 5398944	A-TAGR				4	vis	ditch/creek		
23-Apr-04	Greenburn Lake	2	3	484403	5398894	R-THSI				1	vis	marsh	surface	
30-Apr-04	Lyall Creek	3	15	ca.488320	ca.5404210	A-PSRE				1	vis	stream side	under ferns	
30-Apr-04	Lyall Creek	3	27	ca.488920	ca.5404010	A-PSRE				1	vis	stream side	under ferns	
30-Apr-04	Lyall Creek	3	29	ca.488920	ca.5404010	A-PSRE				1	vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	31	489097	5403925	A-PSRE			1		vis	stream side	edge of large pool	habitat photos by CE (7144, 7145)
30-Apr-04	Lyall Creek	3	22	ca.488630	ca.5404060	A-PSRE			2	3	vis	stream side	grassy shore	Moist meadow with Stinging Nettle, Bedstraw
30-Apr-04	Lyall Creek	3	1	487710	5404500	A-RAAU			1		vis	stream side	under ferns	Near NW boundary of park
30-Apr-04	Lyall Creek	3	3	487790	5404516	A-RAAU				1	vis	stream side	on litter	
30-Apr-04	Lyall Creek	3	5	487840	5404450	A-RAAU			1		vis	stream side	creek bed	
30-Apr-04	Lyall Creek	3	7	488004	5404450	A-RAAU			1		vis	stream side	creek bed	

Date	Site name	Route ID	Locality ID	UTM east; Zone 10U	UTM north; Zone 10U	Species code	Egg-masses (#)	Larvae (#)	Juveniles (#)	Adults (#)	Obervation type	Habitat type	Micro-habitat	Comments
30-Apr-04	Lyall Creek	3	9	488010	5404400	A-RAAU			2		vis	stream side	creek bed	Ca. 20 m after 1st stream fork (west)
30-Apr-04	Lyall Creek	3	11	488117	5404395	A-RAAU				1	vis	stream side	under ferns	
30-Apr-04	Lyall Creek	3	13	488220	5404290	A-RAAU			1	2	vis	stream side	under ferns	
30-Apr-04	Lyall Creek	3	17	ca.488320	ca.5404210	A-RAAU				1	vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	19	488423	5404152	A-RAAU			1		vis	stream side	grassy shore	With Stinging Nettle
30-Apr-04	Lyall Creek	3	21	488559	5404172	A-RAAU			7		vis	stream side	grassy shore	With Stinging Nettle, Horsetail
30-Apr-04	Lyall Creek	3	23	ca.488630	ca.5404060	A-RAAU				1	vis	stream side	grassy shore	Ca. 10 m upslope from stream in moist meadow with Stinging Nettle
30-Apr-04	Lyall Creek	3	25	488794	5404093	A-RAAU				1	vis	stream side	grassy shore	With Stinging Nettle, Horsetail, Sword Fern
30-Apr-04	Lyall Creek	3	32	489080	5403950	A-RAAU			1		vis	forest	under ferns	on slope towards road, after end of route
30-Apr-04	Lyall Creek	3	2	487772	5404405	A-RAAU				1	vis	stream	small pool	
30-Apr-04	Lyall Creek	3	6	487972	5404411	A-RAAU			2		vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	8	488028	5404424	A-RAAU			1	1	vis	stream side	under ferns	Ca. 15 m from creek in forest
30-Apr-04	Lyall Creek	3	10	488010	5404400	A-RAAU				1	vis	stream side	creek bed	
30-Apr-04	Lyall Creek	3	12	488178	5404349	A-RAAU			3		vis	stream side	grassy shore	In patch of Stinging Nettle
30-Apr-04	Lyall Creek	3	14	488269	5404334	A-RAAU			1		vis	stream side	seepage	Grass patch Horsetail, Stinging Nettle
30-Apr-04	Lyall Creek	3	16	ca.488320	ca.5404210	A-RAAU			4		vis	stream side	grass/sedge patch	
30-Apr-04	Lyall Creek	3	18	ca.488320	ca.5404210	A-RAAU				1	vis	stream side	creek bed	
30-Apr-04	Lyall Creek	3	20	488480	5404150	A-RAAU			1		vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	24	ca.488630	ca.5404060	A-RAAU				1	vis	stream side	grassy shore	With Stinging Nettle, Horsetail, Sword Fern
30-Apr-04	Lyall Creek	3	26	ca.488920	ca.5404010	A-RAAU			2	2	vis	stream side	grassy shore	Stinging Nettle patch; habitat photo by CE (7140)
30-Apr-04	Lyall Creek	3	28	ca.488920	ca.5404010	A-RAAU			1		vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	30	ca.488920	ca.5404010	A-RAAU			4		vis	stream side	grassy shore	
30-Apr-04	Lyall Creek	3	31	489097	5403925	A-RAAU			1		vis	stream side	edge of large pool	
30-Apr-04	Lyall Creek	3	4	487831	5404518	A-TAGR				1	vis	stream side	crack in log	
30-Apr-04	Lyall Creek	3	33	489070	5403870	A-RAAU			1					
30-Apr-04	Lyall Creek	3	36	487720	5404540	R-THSI				1	vis			Near NW boundary of park within the restored grassland habitat
30-Apr-04	Lyall Creek, headwaters	4	34	490850	5403140	A-PSRE			1		vis	swamp	surface	
30-Apr-04	Lyall Creek, headwaters	4	35	490720	5403190	A-RAAU				1	vis	swamp	surface	
30-Apr-04	McLean Lake	1b	1	488537	5404953	A-AMMA		1			net	lake	water	Ca. 5 cm (LS photo)
30-Apr-04	McLean Lake	1b	2	488537	5404953	A-PSRE				?	aud	lake		Many individuals
30-Apr-04	McLean Lake	1b	3	488537	5404953	A-PSRE	5+	5+			net, vis	lake	water	attached on sedge stems; some old and hatched; others new
30-Apr-04	McLean Lake	1b	4	488537	5404953	A-PSRE				3	vis	lake	water	Glimpse of several others also seen
30-Apr-04	McLean Lake	1b	5	488537	5404953	A-PSRE	20+				vis	lake	water	Several new but most old and hatched
30-Apr-04	McLean Lake	1b	6	488519	5404845	A-PSRE		100+			vis	lake	water	
30-Apr-04	McLean Lake	1b	7	488519	5404845	A-RAAU			2	1	vis	lake	water	

Date	Site name	Route ID	Locality ID	UTM east; Zone 10U	UTM north; Zone 10U	Species code	Egg-masses (#)	Larvae (#)	Juveniles (#)	Adults (#)	Obervation type	Habitat type	Micro-habitat	Comments
30-Apr-04	McLean Lake	1b	8	488519	5404845	A-RAAU		25+			vis	lake	water	
30-Apr-04	McLean Lake	1b	9	488482	5404877	A-RAAU		25+			net, vis	lake	water	
30-Apr-04	McLean Lake	1b	10	488482	5404877	A-RAAU		10+			net, vis	lake	water	In deeper end of lake with less emergent plants
30-Apr-04	McLean Lake	1b	11	488517	5404819	A-TAGR				4	vis	lake	water	
30-Apr-04	McLean Lake	1a	12	488537	5404953	A-AMMA		6			net	lake	water	3 collected for raising
30-Apr-04	McLean Lake	1a	13	488537	5404953	A-PSRE	15+	100+			net, vis	lake	water	
30-Apr-04	McLean Lake	1a	14	488537	5404953	A-RAAU		100+	1	1	net, vis	lake	water	
07-Jun-04	Roe Lake	0		477614	5403244	A-RAAU			2		vis	inlet to lake		Opportunistic observation during trapping by traps 10 - 11
07-Jun-04	Roe Lake	0	16	477619	5403242	R-THSI				1	vis	lake	water	Opportunistic observation during trapping by traps 10 - 11
08-Jun-04	Roe Lake	0	17	477883	5403199	R-THSI				1	vis	lake	water	Swimming over trap #29
23-Apr-04	Roe Lake	1	5	477871	5403213	A-PSRE				1	aud	lake	?	Heard in south bay; exact locality unknown
23-Apr-04	Roe Lake	1	1	477699	5403225	A-RAAU	1				vis	lake	water	All eggs had hatched; in small bay with abundant emergent vegetation (lily pads, grass) &
23-Apr-04	Roe Lake	1	3	477728	5403217	A-RAAU	1				vis	lake	water	All eggs had hatched; very disintegrated mass
23-Apr-04	Roe Lake	1	2	477713	5403218	A-TAGR				1	vis	lake	water	Probably laying eggs; twisting around a floating milfoil-type plant
23-Apr-04	Roe Lake	1	4	477805	5403236	A-TAGR				1	vis	lake	water	Swimming
23-Apr-04	Roe Lake	1	6	477589	5403421	A-TAGR				1	vis	lake	water	Swimming
23-Apr-04	Roe Lake	2	14	477849	5403185	RACA?		1			vis	lake	water	Unidentified tadpole; possibly RACA
23-Apr-04	Roe Lake	2	13	477821	5403200	A-PSRE				1	aud	lake		
23-Apr-04	Roe Lake	2	14	477849	5403185	A-RACA		2			vis	lake	water	
23-Apr-04	Roe Lake	2	9	477846	5403275	A-TAGR				1	vis	lake	water	Swimming
23-Apr-04	Roe Lake	2	10	477825	5403284	A-TAGR				2	vis	lake	water	
23-Apr-04	Roe Lake	2	11	477829	5403250	A-TAGR				1	vis	lake	water	
23-Apr-04	Roe Lake	2	12	477835	5403225	A-TAGR				1	vis	lake	water	
23-Apr-04	Roe Lake	3	15	477926	5403170	R-THOR				1	vis	marsh	surface	
23-Apr-04	Roe Lake	4	8	477643	5403245	A-RAAU			1		vis	inlet to lake	bank	
23-Apr-04	Roe Lake	4	7	477590	5403264	A-RAAU				1	vis	pond		
30-Apr-04	Tributary of Lyall Cr.	2	5	488530	5404762	A-PSRE				6	vis	wet sedge meadow		Ca. 5 m from lake outlet along stream
30-Apr-04	Tributary of Lyall Cr.	2	5	488530	5404762	A-RAAU			2		vis	wet sedge meadow		Ca. 5 m from lake outlet along stream
30-Apr-04	Tributary of Lyall Cr.	2	5	488530	5404762	A-RAAU			1		vis	stream	water	In permanent pool
30-Apr-04	Tributary of Lyall Cr.	2	6	488537	5404598	A-RAAU				1	vis	stream side		Ca. 5 m from dry stream bed
30-Apr-04	Tributary of Lyall Cr.	2	7	488543	5404518	A-RAAU			1		vis	stream side	grass	Just outside park boundary to NW

Appendix D. Results of trapping surveys in June 2004 (raw data). See Appendix A for details of localities and Appendix B for survey conditions.

See Figures 7-10 for the location of traps within a site.

# of minnow traps per site: Roe Lake (36), Greenburn Lake (20): traps were in place for 19 - 24 hours before inspection; McLean Lake (29), Lyall Creek (14): traps were in place 18 - 20 hours before inspection.

Species codes: **Amphibians**: A-AMMA - *Ambystoma macrodactylum*; A-RAAU - *Rana aurora*; A-RACA - *Rana catesbeiana;* A-TAGR - *Taricha granulosa*; **Reptiles**: R-THEL - *Thamnophis elegans*; R-THSI - *T. sirtalis*; **Fish**: F-GAS sp - *Gasterosteus* sp.; F-ONKI - *Oncorhynchus kisutch*)

Developmental stage: E- egg, L - larvae, J - metamorph or juvenile; A - adult

Date	Locality name	Route #	Trap #	UTM east; Zone 10U	UTM north; Zone 10U	Species code	No. found	Developmental stage	Comments
08-Jun-04	Greenburn Lake, S.	3	1	484548	5398896	A-TAGR	12	A	Photo, in bucket (KO)
08-Jun-04	Greenburn Lake, S.	3	2	484539	5398893	A-TAGR	2	A	
08-Jun-04	Greenburn Lake, S.	3	3	484525	5398889	A-TAGR	5	A	
08-Jun-04	Greenburn Lake, S.	3	6	484491	5398899	A-TAGR	26	A	Photos, in bucket (KO)
08-Jun-04	Greenburn Lake, S.	3	8	484485	5398859	A-TAGR	27	A	
08-Jun-04	Greenburn Lake, S.	3	9	484526	5398853	A-TAGR	13	A	
08-Jun-04	Greenburn Lake, S.	3	11	484680	5398913	A-TAGR	13	A	
08-Jun-04	Greenburn Lake, S.	3	12	484736	5398905	A-TAGR	5	A	
08-Jun-04	Greenburn Lake, S.	3	13	484797	5398901	A-TAGR	2	A	
08-Jun-04	Greenburn Lake, S.	3	20	485040	5398892	A-TAGR	16	A	
08-Jun-04	Greenburn Lake, S.	3	19	485028	5398889	A-TAGR	9	A	
08-Jun-04	Greenburn Lake, S.	3	18	485007	5398886	A-TAGR	3	A	
08-Jun-04	Greenburn Lake, S.	3	17	484964	5398882	A-TAGR	10	A	
08-Jun-04	Greenburn Lake, S.	3	16	484950	5398882	A-TAGR	8	A	
08-Jun-04	Greenburn Lake, S.	3	14	484866	5398890	A-TAGR	4	A	*Ranatra* sp. (Water Scorpion, 3)
08-Jun-04	Greenburn Lake, S.	3	1	484548	5398896	F-GAS	1		*Ranatra* sp. (Water Scorpion, 1)
08-Jun-04	Greenburn Lake, S.	3	2	484539	5398893	F-GAS	1		
08-Jun-04	Greenburn Lake, S.	3	3	484525	5398889	F-GAS	6		*Ranatra* sp. (Water Scorpion, 1)
08-Jun-04	Greenburn Lake, S.	3	4	484515	5398888	F-GAS	1		
08-Jun-04	Greenburn Lake, S.	3	8	484485	5398859	F-GAS	2		
08-Jun-04	Greenburn Lake, S.	3	11	484680	5398913	F-GAS	4		*Ranatra* sp. (Water Scorpion, 1)
08-Jun-04	Greenburn Lake, S.	3	12	484736	5398905	F-GAS	1		
08-Jun-04	Greenburn Lake, S.	3	13	484797	5398901	F-GAS	1		
08-Jun-04	Greenburn Lake, S.	3	20	485040	5398892	F-GAS	1		Dragonfly larvae
08-Jun-04	Greenburn Lake, S.	3	19	485028	5398889	F-GAS	3		
08-Jun-04	Greenburn Lake, S.	3	17	484964	5398882	F-GAS	1		
08-Jun-04	Greenburn Lake, S.	3	15	484877	5398887	F-GAS	10		
08-Jun-04	Greenburn Lake, S.	3	1	484548	5398896	R-THEL	1	A	
08-Jun-04	Greenburn Lake, S.	3	5	484502	5398881	R-THEL	1	A	
08-Jun-04	Greenburn Lake, S.	3	18	485007	5398886	R-THSI	1	J	Photo (LS)
15-Jun-04	Lyall Creek, Saturna	6	1	487710	5404520	F-ONKI	1	J	
15-Jun-04	Lyall Creek, Saturna	6	3	487770	5404460	F-ONKI	2	J	
15-Jun-04	Lyall Creek, Saturna	6	5	487770	5404460	F-ONKI	1	J	
15-Jun-04	Lyall Creek, Saturna	6	9	487960	5404410	F-ONKI	2	J	
15-Jun-04	Lyall Creek, Saturna	6	12	488070	5404390	F-ONKI	3	J	
15-Jun-04	McLean Lake, Saturna	5	1	488527	5404998	A-AMMA	7	L	
15-Jun-04	McLean Lake, Saturna	5	4	488524	5404974	A-AMMA	1	L	
15-Jun-04	McLean Lake, Saturna	5	9	488524	5404946	A-AMMA	1	L	
15-Jun-04	McLean Lake, Saturna	5	12	488509	5404922	A-AMMA	1	L	
15-Jun-04	McLean Lake, Saturna	5	16	488538	5404942	A-AMMA	1	L	
15-Jun-04	McLean Lake, Saturna	5	18	488532	5404923	A-AMMA	1	L	

Date	Locality name	Route #	Trap #	UTM east; Zone 10U	UTM north; Zone 10U	Species code	No. found	Developmental stage	Comments
15-Jun-04	McLean Lake, Saturna	5	22	488516	5404883	A-AMMA	1	L	*Physa* snails (2)
15-Jun-04	McLean Lake, Saturna	5	26	488525	5404803	A-AMMA	2	L	
15-Jun-04	McLean Lake, Saturna	5	27	488532	5404796	A-AMMA	2	L	
15-Jun-04	McLean Lake, Saturna	5	28	488541	5404795	A-AMMA	3	L	
15-Jun-04	McLean Lake, Saturna	5	29	488550	5404797	A-AMMA	3	L	
15-Jun-04	McLean Lake, Saturna	5	24	488517	5404844	A-PSRE	2	A	1 dead; also *Lethocerus americanus* (Giant Water Bug, 3)
15-Jun-04	McLean Lake, Saturna	5	23	488510	5404864	A-PSRE	1	J	Metamorphosed
15-Jun-04	McLean Lake, Saturna	5	1	488527	5404998	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	5	488522	5404966	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	7	488526	5404955	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	11	488517	5404934	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	12	488509	5404922	A-PSRE	2	L	
15-Jun-04	McLean Lake, Saturna	5	13	488503	5404912	A-PSRE	10	L	
15-Jun-04	McLean Lake, Saturna	5	14	488489	5404888	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	15	488482	5404872	A-PSRE	2	L	
15-Jun-04	McLean Lake, Saturna	5	16	488538	5404942	A-PSRE	2	L	
15-Jun-04	McLean Lake, Saturna	5	17	488536	5404930	A-PSRE	4	L	
15-Jun-04	McLean Lake, Saturna	5	19	488529	5404917	A-PSRE	1	L	Large dragonfly larva
15-Jun-04	McLean Lake, Saturna	5	26	488525	5404803	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	27	488532	5404796	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	28	488541	5404795	A-PSRE	1	L	
15-Jun-04	McLean Lake, Saturna	5	3	488525	5404982	A-RAAU	1	L	
15-Jun-04	McLean Lake, Saturna	5	8	488521	5404957	A-RAAU	1	L	Nearly metamorphosed (collected); also *Lethocerus americanus* (Giant Water Bug)
15-Jun-04	McLean Lake, Saturna	5	15	488482	5404872	A-RAAU	1	L	No legs (collected)
15-Jun-04	McLean Lake, Saturna	5	18	488532	5404923	A-RAAU	1	L	With hindlegs
15-Jun-04	McLean Lake, Saturna	5	23	488510	5404864	A-RAAU	1	L	
15-Jun-04	McLean Lake, Saturna	5	24	488517	5404844	A-RAAU	2	L	1 dead
15-Jun-04	McLean Lake, Saturna	5	26	488525	5404803	A-RAAU	2	L	Small hindlegs
15-Jun-04	McLean Lake, Saturna	5	27	488532	5404796	A-RAAU	1	L	
15-Jun-04	McLean Lake, Saturna	5	29	488550	5404797	A-RAAU	7	L	
15-Jun-04	McLean Lake, Saturna	5	5	488522	5404966	A-TAGR	5	A	
15-Jun-04	McLean Lake, Saturna	5	18	488532	5404923	A-TAGR	1	A	
15-Jun-04	McLean Lake, Saturna	5	20	488531	5404907	A-TAGR	2	A	
15-Jun-04	McLean Lake, Saturna	5	27	488532	5404796	A-TAGR	3	A	
15-Jun-04	McLean Lake, Saturna	5	10	488520	5404941	F-GAS	3		
15-Jun-04	McLean Lake, Saturna	5	14	488489	5404888	F-GAS	1		Dead
15-Jun-04	McLean Lake, Saturna	5	21	488523	5404899				*Lethocerus americanus* (Giant Water Bug)
08-Jun-04	Roe Lake, N. Pender	6	10	477612	5403247	A-RAAU	1	J	
08-Jun-04	Roe Lake, N. Pender	6	4	477579	5403451	A-RAAU	1	L	Large with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	5	477580	5403442	A-RACA	1	L	2nd year tadpole with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	22	477871	5403171	A-RACA	1	L	2nd year tadpole (no hind legs)
08-Jun-04	Roe Lake, N. Pender	6	30	477880	5403228	A-RACA	4	L	2nd year tadpoles with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	31	477873	5403237	A-RACA	2	L	2nd year tadpoles; 1 with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	32	477867	5403248	A-RACA	1	L	2nd year tadpole
08-Jun-04	Roe Lake, N. Pender	6	34	477836	5403295	A-RACA	1	L	2nd year tadpole with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	29	477882	5403208	A-RACA	1	L	2nd year tadpole with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	27	477881	5403192	A-RACA	2	L	2nd year tadpoles; 1 with small hind legs
08-Jun-04	Roe Lake, N. Pender	6	28	477880	5403202	A-RACA	1	L	2nd year tadpole (no hind legs)
08-Jun-04	Roe Lake, N. Pender	6	3	477580	5403456	A-TAGR	3	A	
08-Jun-04	Roe Lake, N. Pender	6	4	477579	5403451	A-TAGR	1	A	
08-Jun-04	Roe Lake, N. Pender	6	7	477587	5403275	A-TAGR	2	A	
08-Jun-04	Roe Lake, N. Pender	6	6	477617	5403373	A-TAGR	1	A	
08-Jun-04	Roe Lake, N. Pender	6	5	477580	5403442	F-GAS	3		*Lethocerus americanus* (Giant Water Bug)

Date	Locality name	Route #	Trap #	UTM east; Zone 10U	UTM north; Zone 10U	Species code	No. found	Developmental stage	Comments
08-Jun-04	Roe Lake, N. Pender	6	3	477580	5403456	F-GAS	6		
08-Jun-04	Roe Lake, N. Pender	6	4	477579	5403451	F-GAS	2		
08-Jun-04	Roe Lake, N. Pender	6	9	477585	5403267	F-GAS	34		
08-Jun-04	Roe Lake, N. Pender	6	17	477829	5403183	F-GAS	14		
08-Jun-04	Roe Lake, N. Pender	6	18	477837	5403179	F-GAS	9		
08-Jun-04	Roe Lake, N. Pender	6	19	477844	5403176	F-GAS	3		*Ranatra* sp. (Water Scorpion)
08-Jun-04	Roe Lake, N. Pender	6	20	477853	5403173	F-GAS	13		
08-Jun-04	Roe Lake, N. Pender	6	21	477863	5403172	F-GAS	49		
08-Jun-04	Roe Lake, N. Pender	6	16	477860	5403187	F-GAS	34		
08-Jun-04	Roe Lake, N. Pender	6	15	477853	5403192	F-GAS	47		
08-Jun-04	Roe Lake, N. Pender	6	23	477879	5403172	F-GAS	23		
08-Jun-04	Roe Lake, N. Pender	6	22	477871	5403171	F-GAS	17		
08-Jun-04	Roe Lake, N. Pender	6	26	477887	5403184	F-GAS	47		
08-Jun-04	Roe Lake, N. Pender	6	6	477617	5403373	F-GAS	3		
08-Jun-04	Roe Lake, N. Pender	6	1	477736	5403433	F-GAS	2		*Lethocerus americanus (Giant Water Bug* , 2); *Ranatra* sp. (Water Scorpion, 2)
08-Jun-04	Roe Lake, N. Pender	6	2	477729	5403436	F-GAS	21		*Ranatra* sp. (Water Scorpion, 1)
08-Jun-04	Roe Lake, N. Pender	6	11	477618	5403242	F-GAS	1		
08-Jun-04	Roe Lake, N. Pender	6	12	477628	5403237	F-GAS	65		
08-Jun-04	Roe Lake, N. Pender	6	13	477634	5403232	F-GAS	20		
08-Jun-04	Roe Lake, N. Pender	6	32	477867	5403248	F-GAS	2		*Lethocerus americanus (Giant Water Bug,* 1)
08-Jun-04	Roe Lake, N. Pender	6	33	477853	5403270	F-GAS	7		*Ranatra* sp. (Water Scorpion, 1)
08-Jun-04	Roe Lake, N. Pender	6	29	477882	5403208	R-THSI	1		2nd THSI swimming over trap