Prince of Wales Island Amphibian Survey, 2013
Preliminary Results

Kelly Walton, Tracey Gotthardt, Timm Nawrocki, and Jesika Reimer

March 2014

Alaska Natural Heritage Program
University of Alaska Anchorage
707 A Street
Anchorage, Alaska 99501

This page intentionally left blank.

Table of Contents

Figures

Abstract

Despite low diversity and relatively restricted ranges, little is understood about amphibian distribution and population status in Alaska. Although there have been several surveys designed to gather baseline amphibian data at various locations in the state, few studies have actually implemented long-term monitoring strategies. In 2004, Pyare et al. conducted a pilot study in the Prince of Wales Island, Admiralty Island, and the Upper Lynn Canal regions of southeast Alaska to establish monitoring sites that could be used to calculate initial occupancy rates for western toads (*Anaxyrus boreas*), a species thought to be declining in the southern part of its range. To our knowledge, the western toad breeding sites identified during this pilot survey have not been resurveyed. Pyare et al. also reported a high incidence of rough-skinned newts (*Taricha granulosa*) during the Prince of Wales amphibian surveys.

Pyare et al. focused their entire survey effort of Prince of Wales Island on the central part of the island, where wetlands are relatively abundant. In contrast, large wetland complexes in the northern portion of Prince of Wales Island have never been systematically surveyed for amphibians. These wetlands are highly influenced by underlying karst features and formations. Because they are highly productive systems, timber harvest has been disproportionally higher in this habitat type because of the presence of large, dense forest stands. To our knowledge, the implication of karst topography on amphibian occurrence and habitat suitability has not been studied.

Given the known occurrence of western toads and rough-skinned newts on Prince of Wales Island, as well as the high abundance of karst topography, we initiated a pilot study to investigate amphibian distribution and usage of the unique and productive karst wetlands. Our project will fill basic information voids on distribution, habitat requirements, and potential threats.

During year one, we resurveyed 34 sites on Prince of Wales Island where Pyare et al. recorded amphibians during the summers of 2005 and 2006. We located rough-skinned newts at 71% and western toads at 32% of the sites where Pyare et al. had previously observed each species in non-karst habitats. In karst habitats, amphibians were recorded in 23% of the wetland sites (n = 71) surveyed. Rough-skinned newts were captured during all major life-stages and were recorded in a wide variety of habitats including beaver ponds and sloughs, emergent aquatic beds, and needleleaf forest peatlands. Western toads were also recorded in a variety of habitats including, needleleaf forest and herbaceous peatlands, beaver pond and sloughs, lower riverine or aquatic beds, and were captured as either adults or subadults.

Our initial survey results show that amphibians utilize wetlands of relatively high pH and conductivity, which is characteristic of karst topography in northern Prince of Wales Island. We suggest surveying additional wetlands in karst landscapes to increase the sample size and then compare occupancy rates between karst and non-karst landscapes to determine if amphibians are more likely to occur in karst and to determine what environmental variables are correlated with amphibian occurrence. Our ultimate goal is to better define the distribution and habitat requirements for western toads and rough-skinned newts on Prince of Wales Island, so that this information can be used to support amphibian conservation.

This page intentionally left blank.

Introduction

The herpetofauna of Alaska is depauperate relative to temperate and tropical regions. Only six amphibian species are native to Alaska. These include the western toad (*Anaxyrus boreas*), wood frog (*Lithobates sylvaticus*), Columbia spotted frog (*Rana luteiventris*), rough-skinned newt (*Taricha granulosa*), northwestern salamander (*Ambystoma gracile*), and long-toed salamander (*Ambystoma macrodactylum*). Only two of these species have been documented outside the southeast region of the state. The wood frog, which is the most hardy and widespread species of frog in North America, has been found from the mainland of Southeast Alaska northward to the Brooks Range. Alaska's single toad species, the western toad, has been recorded throughout the southeast Panhandle and along the mainland coast to Prince William Sound. There have also been localized introductions of two non-native species, the Pacific chorus frog (*Pseudacris regilla*) and red-legged frog (*Rana aurora*). These non-native species apparently have viable but restricted populations in the Alexander Archipelago of Southeast Alaska on Revillagigedo Island and Chichagof Island (ADF&G 2006).

Despite such low diversity and relatively restricted ranges, little is understood about amphibian distribution and population status in Alaska. Previous surveys have been limited to small geographic areas of interest with little or no systematic resampling over time. Accurate statewide abundance and population trends are unknown, which is a cause of concern as amphibians are rapidly declining and disappearing from other parts of their range. Anecdotal reports have suggested western toads may be declining throughout their range from Ketchikan to Haines (ADF&G 2006), yet these claims have not been substantiated.

Furthermore, amphibians are good indicators of significant environmental changes. They are sensitive to environmental factors such as habitat destruction, fungal infection, intensified predation by introduced fish and nonnative frogs, climate change, increased presence and diversity of pathogens, and combinations of these factors. Amphibians in many parts of North America, including some areas of Alaska, have unusually high occurrences of malformed limbs (Reeves et al. 2013). In light of these growing conservation concerns and the importance of their habitats for other fish and wildlife species, there is a need for basic information about amphibians in Alaska. This will require an understanding of species distribution, habitat needs, current status, and population trends of specific species (AFG&G 2006).

Although there have been several surveys designed to gather baseline amphibian data in Alaska, few studies have actually implemented long-term monitoring strategies. In 2004, Pyare et al. drafted a monitoring protocol for western toads in Southeast Alaska. The protocol was intended to develop a standardized procedure to survey breeding sites, as well as to establish a baseline distribution of western toads based on occupancy of ponds, and to characterize breeding habitat. Survey procedures closely followed methods developed by the U.S. Geological Survey (USGS) Amphibian Research and Monitoring Initiative (ARMI) to monitor amphibians across the contiguous United States. This method estimates the Proportion of Area Occupied (PAO) to measure the fraction of the landscape occupied by a species based on occupancy rates (not abundance), which includes a correction for the probability of detecting a species (MacKenzie et al. 2002, Bailey and Adams 2005).

Pyare et al. (2004) conducted a pilot study in the Prince of Wales Island, Admiralty Island, and the Upper Lynn Canal regions of southeast Alaska to establish monitoring sites that could be used to calculate initial occupancy rates. To our knowledge, the western toad breeding sites identified during this initial survey on Prince of Wales Island have not been resurveyed.

Pyare et al. focused their entire survey effort of Prince of Wales Island on the central part of the island, where wetlands are relatively abundant and generally neutral to acidic. In contrast, large wetland complexes in the northern portion of Prince of Wales Island have never been systematically surveyed for amphibians (Carstensen et al. 2013). These wetlands are highly influenced by underlying karst features and formations. Karst refers to the chemically eroded landscape that develops on soluble bedrock, usually composed primarily of calcium carbonate ($CaCO_3$) such as limestone or marble. Karst wetlands develop unique hydrologic dynamics and water chemistry of a higher alkalinity compared to non-karst wetlands. An increase in forest productivity is often seen on karst topography as a result of soil nutrients and the formation of well-developed drainages.

While surface water is much less abundant on the internally-drained karst topography, streams and ponds on karst are exceptionally productive for invertebrates and fish, and we expect them to be productive for amphibians as well. On northern Prince of Wales Island, streams in karst landscapes had higher alkalinity, as well as higher densities and larger sized coho salmon parr compared to streams in landscapes lacking karst (Bryant et al. 1998). Because they are highly productive systems, timber harvest has been disproportionally higher in karst landscapes because of the presence of large, dense forest stands (Baichtal and Swanston 1996). To our knowledge, the implication of karst topography on amphibian occurrence and habitat suitability has not been studied (Carstensen et al. 2013).

Objectives

Given the known occurrence of rough-skinned newts and western toads on Prince of Wales Island, as well as the high abundance of karst topography, we initiated a pilot study to investigate amphibian distribution and usage of the unique and productive karst wetlands. Our project will fill basic information voids on distribution, habitat requirements, and potential threats.

The specific objectives of Year I (2013) were to:

1) Gather baseline data on amphibian distribution, species composition, and habitat use, with a focus on wetlands within or downstream of karst topography.
2) Resurvey monitoring sites established by Pyare et al. (2004-2006) to document continued presence or absence of amphibians in non-karst habitats.
3) Compare the extent to which amphibians utilize karst and non-karst habitats and the suitability of site characteristics as it relates to amphibian occupancy between the two habitat types.
4) Collect specimens for future use in research, teaching, and outreach, and for inclusion in a national bio-contaminants database.

This study is intended to occur during the amphibian breeding seasons of 2013 (Year I) and 2014 (Year II), with the potential for continuation in 2015 (Year III) depending on the results of the first two years. During Year I we intend to identify potential monitoring areas in karst habitats to gain a better understanding of occupancy levels, habitat conditions, and feasibility. During Year II (and Year III, if deemed necessary) we will revisit a subset of sites of known occurrence to document occupancy rates, as well as continue to expand baseline distribution surveys in karst habitats. This report summarizes the methods and results of Year I of the study.

Methods

Study Area

Prince of Wales Island (6,674 km^2) is located in the coastal temperate rainforest in the southern portion of the Alexander Archipelago in southeast Alaska. The climate is characterized by high annual precipitation (average ~250 cm in Craig) with mild winters (January average temperate range is -1 to 4°C) and cool summers (July average range is 10 to 17°C) (WRCC 2013). The coniferous rainforest on Prince of Wales Island is dominated by Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*), interspersed with western red cedar (*Thuja plicata*), yellow-cedar (*Callitropsis nootkatensis*), red alder (*Alnus rubra*), and shore pine (*Pinus contorta* var. *contorta*) (Harris et al. 1994). Elevations range from 0 - 1,092 m above sea level. Most of the island is managed by the USDA Forest Service, Tongass National Forest.

Amphibian Survey Methods

Northern Prince of Wales Island: wetlands influenced by karst topography

We selected the northern portion of Prince of Wales Island as the focal area for our survey of karst habitats, as this region contains the highest density of surficial karst features on the island (Albert et al. 2008; Figure 1). To identify potential survey sites, we extracted wetland types that contained potential breeding habitat for amphibians from the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) GIS data layer (Figure 2). Extracted wetland types included lacustrine littoral wetlands (primarily aquatic bed) and palustrine wetlands (primarily unconsolidated bottom, aquatic bed, emergent, scrub-shrub, and forested). Using ArcGIS 10.1, we overlaid the NWI GIS data layer with the Alaska Department of Natural Resources (ADNR) 1:63,600 Roads layer (containing primary, secondary, and logging roads) and applied a 2 km buffer to it so that any wetlands greater than 2km distance from roads were removed. This excluded wetlands from our study area that would have been potentially difficult to access. We then overlaid the accessible wetlands layer with a map of surficial karst features (Albert et al. 2008) to prioritize wetlands downstream of karst formations, which we considered most likely to be impacted by karst topography.

Based on the selection criteria described above, our survey area was focused in two distinct areas of high karst feature density that were road accessible. The first area surveyed was near Port Protection, Jansen Creek, Baker Creek, and Flicker Creek in the northwestern corner of the island. We then surveyed habitats in the vicinity of Neck and Twin Island Lakes. Surveys in the northern region of Prince of Wales were conducted from July 3 to 10, 2013. We sampled all accessible wetlands that we were able to gain access to within that 7 day timeframe. All watersheds surveyed were impacted by past logging activities. Some wetlands that were originally mapped as potential survey sites were not visited because of decommissioned logging roads that prevented vehicle access (and thus substantially increased the hiking distance), extreme topography, or impassable logging slash. In addition, we opportunistically surveyed several wetlands that were not mapped by NWI, likely due to their more recent formation from changes in hydrology.

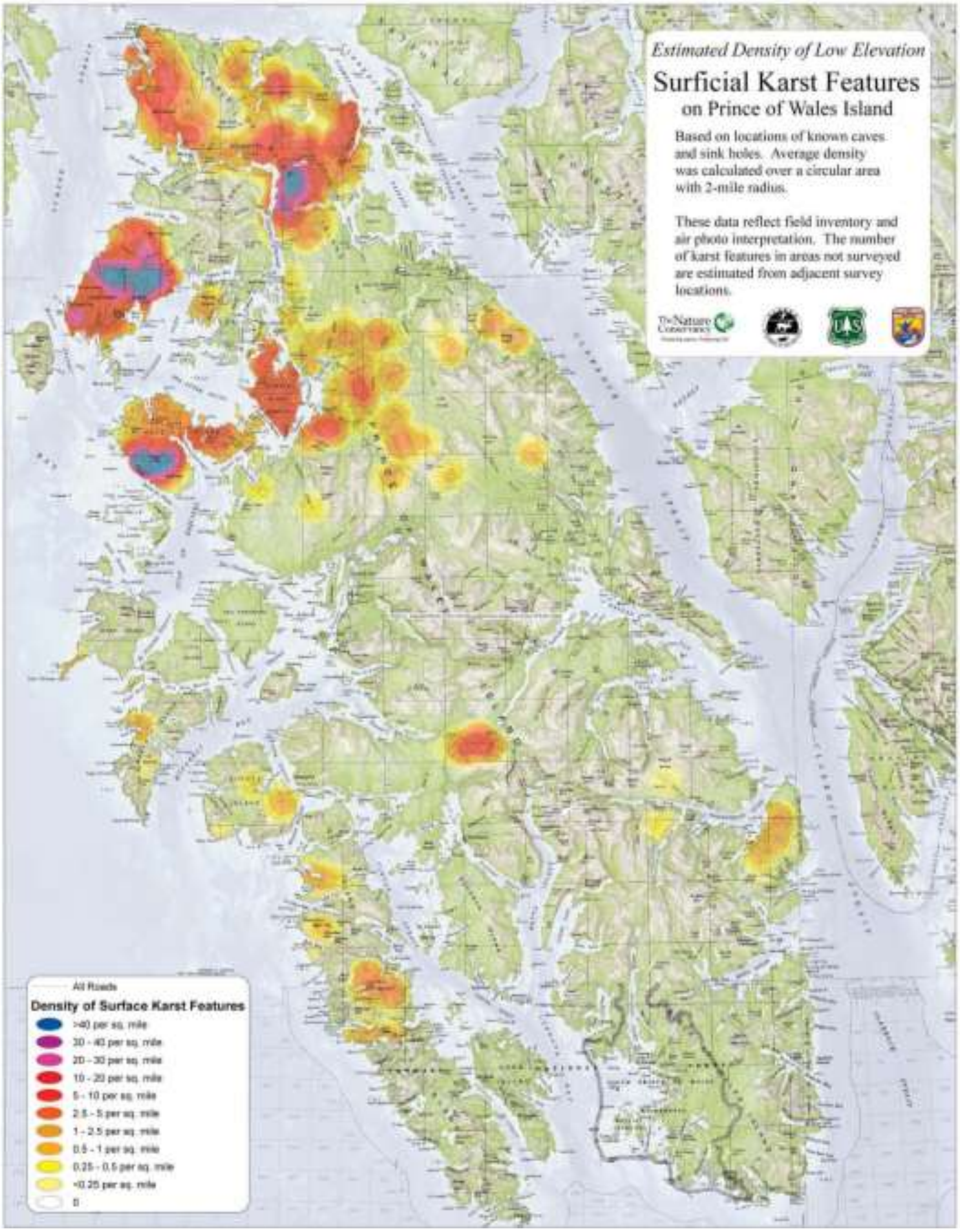

Figure 1. Estimated density of surface karst features on Prince of Wales Island. Map produced by The Nature Conservancy, Alaska Department of Fish and Game, U.S. Forest Service, and the U.S. Fish and Wildlife Service (Albert et al. 2008).

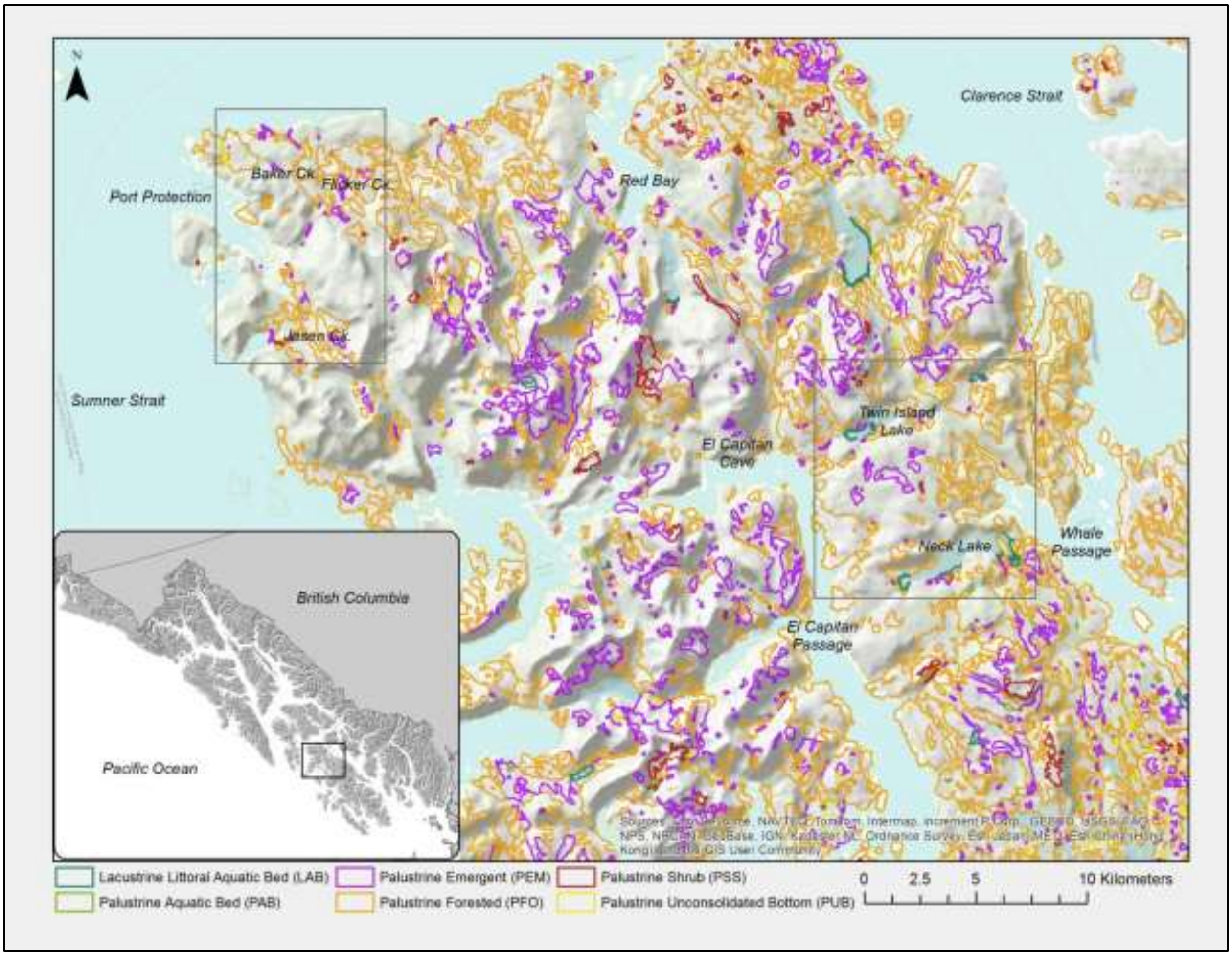

Figure 2. Locations of lacustrine and palustrine wetlands extracted from the National Wetlands Inventory (NWI) database on northern Prince of Wales Island. Surveys were focused in wetland areas downstream of karst topography in the two focal areas: near Port Protection and in the vicinity of Neck and Twin Island Lakes.

We used diurnal Visual Encounter Surveys (VES) to search for both western toads and rough-skinned newts at each sample location. VES is an efficient survey technique for pond breeding anurans and tends to establish occupancy reasonably well (Crump and Scott 1994; Carstensen et al. 2004). We searched the shoreline and near-shore habitat for evidence of amphibians using visual scans and net sweeps (using dip-nets). We scanned the shallow aquatic zone for larvae of both species, emerging toadlets, and adult rough-skinned newts. We scanned the terrestrial near-shore habitat for emerging toadlets, subadult and adult toads, and adult rough-skinned newts. Additionally, we used a long-handled dip-net to sample for rough-skinned newts in small, deep (or mucky) ponds that could not be visually searched due to poor water clarity. We surveyed the entire near-shore zone of smaller lakes and wetlands. For larger lakes, we surveyed a subsection of the shoreline.

On large peatlands, we walked transects across the area to systematically scan the entire wetland. When 4 observers were available, we divided the peatland into either four or five rectangular transects with the minimum possible width (i.e. long edges of rectangles parallel to long axis of survey area) to cover the entire survey area. We then walked one person to a transect at the same pace until we reached the end of the survey area. When only two observers were available, we generally walked lines perpendicular to the long axis of the survey area, moving approximately 5 to 10 m along the edge of the survey area parallel to the long axis between each perpendicular segment. Net sweeps in the waterbodies were completed after walking transects.

At sites where amphibians were detected, we recorded standard measurements (snout-vent length, total length) for individuals captured and checked for deformities. In addition, we recorded detailed location, weather (air temperature, precipitation, and wind), wetland size and dimensions (length, width, surface area, and stream connections), water quality (pH, temperature, conductivity, % shallow, and clarity), habitat (terrestrial and aquatic vegetation, and aquatic substrate), and disturbance information, as well as site photographs in each cardinal direction. At sites without amphibian detections, we filled out an abbreviated datasheet describing the basic characteristics of the site including date, location, air temperature, water pH, conductivity, and temperature, and wetland type (i.e., forested, emergent, etc.). We also took site photographs in each cardinal direction.

The habitat was characterized in the immediate vicinity of the wetland. For peatland wetland complexes with a series of small pools, the habitat was characterized for the entire peatland area, thus the terrestrial vegetation was a major component of the habitat. For ponds and lakes, we characterized the vegetation within the waterbody, as well as the terrestrial habitat bordering the shoreline (within approximately 5 m). As a result, the habitat often included a large water component (with or without aquatic vegetation) and a much smaller terrestrial component.

Central Prince of Wales Island: non-karst influenced wetlands

To provide context to our findings, the second half of our survey focused on revisiting sites of known amphibian occurrence (Pyare, unpubl. data) in non-karst habitats. Pyare et al. (2004) identified 200-400 wetlands with potential western toad habitat using NWI and aerial photographs within a designated monitoring area in each region of southeast Alaska (i.e., Prince of Wales, Admiralty Island, Upper Lynn Canal, etc.). On Prince of Wales Island, monitoring sites were concentrated within watersheds in the central portion of the island (Figure 3). When Pyare et al. initially surveyed monitoring sites on Prince of Wales Island, they recorded the presence of amphibians and microsite characteristics. In addition, they determined a detection probability by re-surveying a subset of the wetlands using a second field team of observers. They also recorded the location of amphibians seen while traversing between sites. Since our survey was not focused exclusively on western toads, we resurveyed several of Pyare et al.'s toad monitoring sites, as well as many incidental sites where they recorded rough-skinned newts.

Surveys in the central part of Prince of Wales were conducted from July 9 to 17, 2013. We used the VES methods (described above) to resurvey known sites of amphibian occurrence. At each site, we recorded detailed site characteristic data including location, weather, wetland size and dimensions, water quality, habitat, and disturbance (also described above).

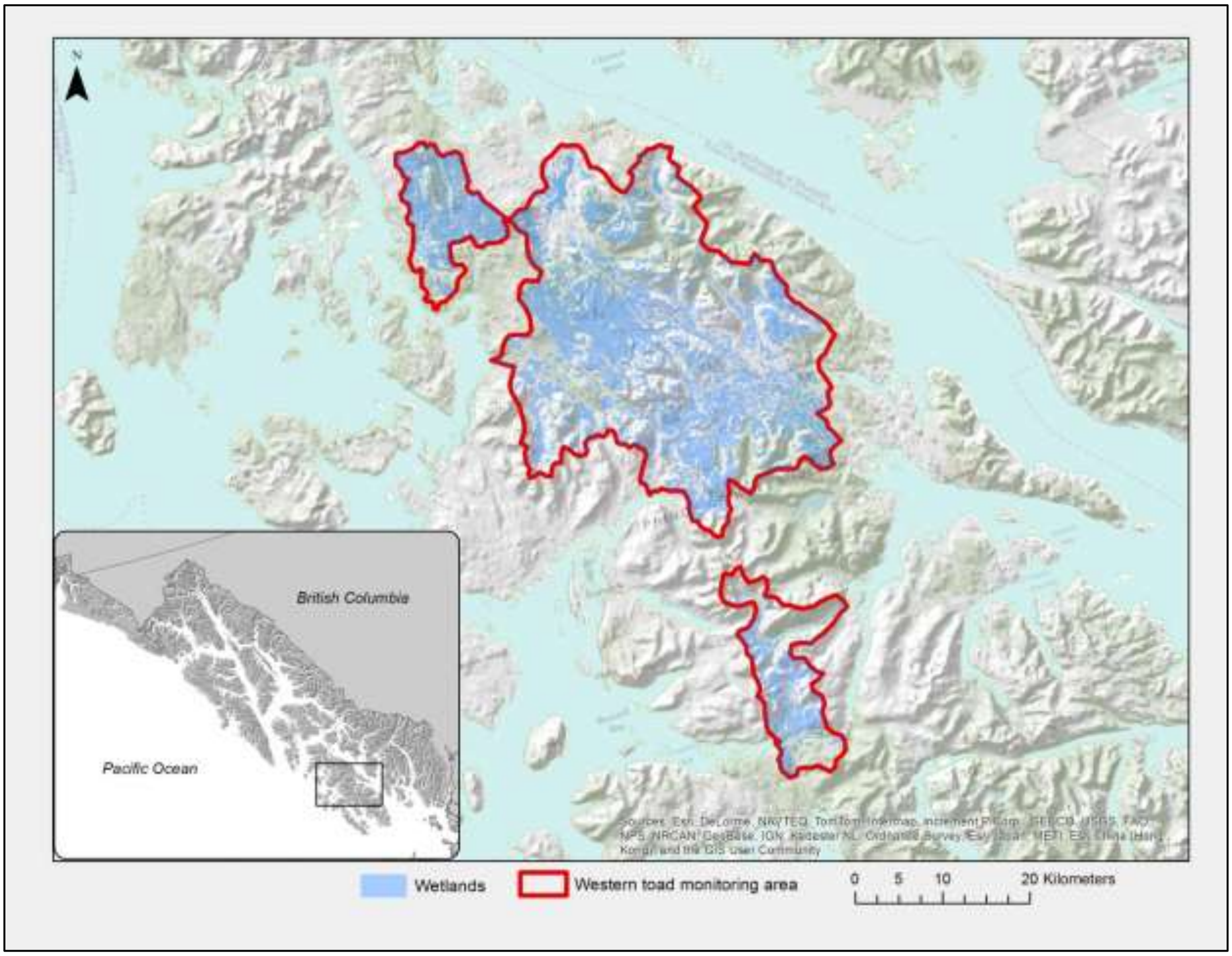

Figure 3. Location of Pyare et al.'s western toad monitoring area (watersheds) on Prince of Wales Island, southeast Alaska (modification of a map of survey sites produced by Dr. S. Pyare).

Specimen collection

The Alaska Comprehensive Wildlife Conservation Strategy identifies the preservation of scientific samples for future morphological, genetic, and epidemiological studies as a conservation need (ADF&G 2006). Few amphibian voucher specimens have been collected and archived in Alaska for future use in research, teaching, and outreach. We collected a limited number of specimens using a buffered overdose of MS-222 to euthanize up to 10 western toad tadpoles (not subadults or adults) per site and up to 10 rough-skinned newts (of any life stage) per site. No more than 10% of the observed population was euthanized at any site. Specimens of western toad were only collected at sites with estimated or observed populations of over 100 tadpoles. Specimens were submitted to the Fishes Collection at the University of Alaska Museum (UAM) in Fairbanks, Alaska or the U.S. Geological Survey (USGS) Rangeland and Ecosystem Science Center in Corvallis, Oregon for inclusion in a bio-contaminants database. All specimens were frozen immediately after collection and during transport to their deposition location.

Results

Northern Prince of Wales Island: wetlands influenced by karst topography

Survey effort and conditions

Between July 3 and 10 we surveyed 71 wetlands within or adjacent to areas of high karst feature density in northern Prince of Wales Island. Of the 71 wetlands visited, 2 (3%) were classified as seasonally flooded needleleaf forest wetlands (no waterbodies), 3 (4%) as seasonally flooded needleleaf forest wetlands (with waterbodies), 11 (15%) as beaver ponds and sloughs, 6 (8%) as lacustrine littoral (emergent – aquatic bed), 3 (4%) as riverine lower perennial (emergent – aquatic bed), 9 (13%) as palustrine (emergent – aquatic bed), 15 (21%) as needleleaf forest peatlands, and 9 (13%) as herbaceous peatlands. The remaining 13 (18%) wetlands were unclassified because we only performed cursory checks for amphibians at those sites and did not classify the site or record site data unless amphibians were observed. See Appendix I for explanations and photographs of the habitat classes.

Water flow and drainage patterns were highly variable between wetlands. Wetlands with large waterbodies (more than several m^2 in area) ranged from very slow moving water in river bends to stagnant water in lakes and ponds. Depth of water ranged from several centimeters in the shallowest littoral zones of lakes to several meters in abruptly deep beaver ponds and sloughs. Wetlands with small waterbodies (several m^2 in area) or no waterbodies ranged from poorly drained, saturated soils interspersed with small pools in needleleaf forest peatlands to moist soils without obvious surface water in seasonally flooded needleleaf forest wetlands (no waterbodies).

The weather in July 2013 was abnormally dry and warm, resulting in partial drying of some wetlands and generally drier than normal conditions, with below average water levels. For example, moist soils dominated some seasonally flooded needleleaf forest wetlands (no waterbodies) in micro-topography that are likely usually saturated (as inferred from the NWI and vegetation). In addition, the warmer than average air temperatures may have reduced amphibian activity during the daytime, when we were actively conducting surveys. During several afternoons when air temperatures exceeded 25°C, we noticed rough-skinned newts were found only buried within the cool sediments of ponds instead of on the surface of the sediment.

Air temperature ranged from 13.7 to 25.2°C (average 17.3°C) during the July 3 to 10 survey period. Water temperature was highly variable depending on the water source and canopy coverage. Water temperature ranged from 11.1 to 24.9°C (average 17.5°C). In shallow ponds, water temperature was often higher than the air temperature. Both pH and conductivity were often positively correlated with each other and likely influenced in part by the surrounding geology. pH levels were significantly higher in core karst areas (mean ± SE: 7.0 ± 0.16) than in areas less influenced by karst (mean ± SE: 6.47 ± 0.14) (t-test, $t = 2.24$, $df = 87$, $p = 0.01$). Water conductivity measures the ability of the water to pass electrical current and is affected by the presence of inorganic dissolved solids. Conductivity values were highly variable, likely due to the water source (precipitation vs. groundwater) and surrounding geology, and ranged from 13.1 to 322.0 µS/cm (average 127.2 µS/cm; Table 1).

Table 1. Summary of air temperature, water temperature, water pH, and conductivity values (with standard error) between all karst sites and sites where specific amphibians were observed, northern Prince of Wales Island, July 2013.

Physical parameters	All karst sites (n = 71)	Sites with western toads (n = 6)	Sites with rough-skinned newts (n = 8)
Air temperature (°C)	17.3 ± 0.4	16.8 ± 1.0	18.5 ± 1.1
Water temperature (°C)	17.5 ± 0.4	18.7 ± 1.4	18.1 ± 0.6
Water pH	7.0 ± 0.2	7.2 ± 0.6	7.3 ± 0.3
Water conductivity (µS/cm)	127.2 ± 14.3	119.2 ± 42.6	161.0 ± 36.6

Distribution and habitat characteristics

Amphibians were recorded in 16 (23%) of the 71 wetland sites surveyed in karst habitats. Of the 16 sites where amphibians were recorded, 8 (11%) sites had rough-skinned newts and 8 (11%) sites had western toads. Observations of these two species did not overlap at any of the karst survey sites (Figure 4).

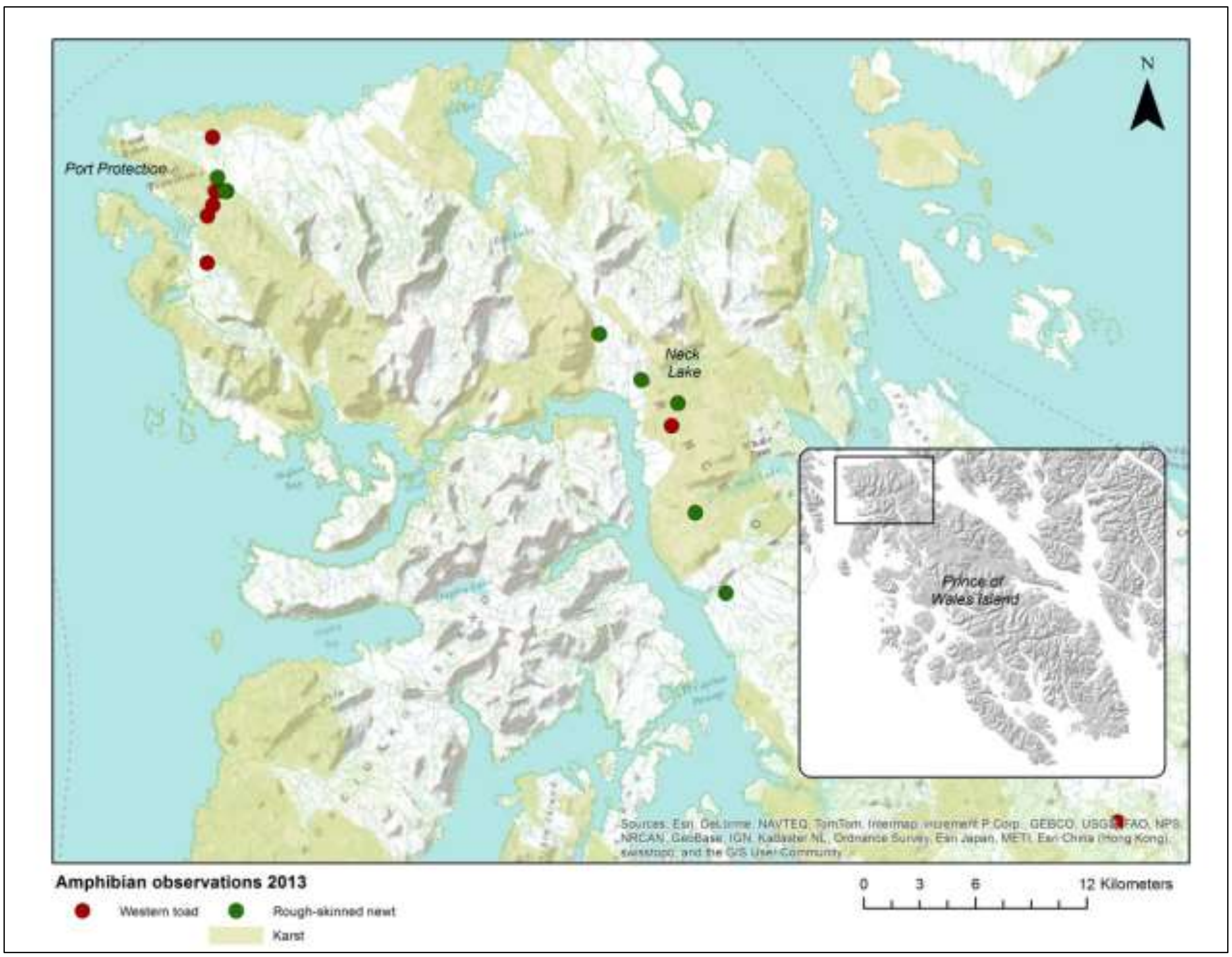

Figure 4. Location of western toad and rough-skinned newt detections in karst habitats, northern Prince of Wales Island, Alaska, July 2013.

Table 2. Habitat characteristics of wetlands, defined by percent cover (%) of vegetation (with standard error), for sites where specific amphibians were observed, northern Prince of Wales Island, July 2013.

Vegetation type	Sites with western toads (n=6)	Sites with rough-skinned newts (n=8)
Emergent aquatic vegetation cover (%)	3.9 ± 2.7	7.3 ± 2.1
Floating aquatic vegetation cover (%)	3.3 ± 2.5	11.3 ± 4.1
Submerged aquatic vegetation cover (%)	11.3 ± 7.3	21.3 ± 9.5
Terrestrial herbaceous cover (%)	58.5 ± 11.9	69.9 ± 6.8
Terrestrial shrub cover (%)	2.0 ± 1.6	1.8 ± 0.8
Terrestrial tree cover (%)	16.9 ± 3.7	14.3 ± 3.4

Western toads were observed in the following habitats in the northern part of the island: beaver ponds and sloughs (3 sites), riverine lower perennial (emergent - aquatic bed) (1 site), needleleaf forest peatlands (2 sites), and herbaceous peatlands (2 sites). Only adult and subadult life stages were detected, likely due to the late timing of our survey. All toads were found on land within close proximity to the water, but not physically in the waterbody. Water temperature ranged from 13.3 - 24.3°C (average 18.7°C), pH ranged from 4.34 - 8.65 (average 7.2), and conductivity ranged from 27.1 - 282.0 µS/cm (average 119.2 µS/cm; Table 1). Waterbody substrate was variable and included muck, gravel, cobble, boulders, and woody debris. All wetlands were either bordered by forest on at least one side or within 20 m of forest cover. Wetlands had no clear dominant aquatic vegetation. Forest coverage was primarily *Tsuga heterophylla* and *Picea contorta* var. *contorta*, with lower coverage of *Picea sitchensis* and *Callitropsis nootkatensis*. Herbaceous cover was relatively high (averaged 58.5%) and was dominated by *Carex sitchensis*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, and *Juncus ensifolius* (Table 2). Invasive reed canarygrass (*Phalaris arundinacea*) was recorded at two sites.

Rough-skinned newts were recorded in the following habitats in the northern part of the island: palustrine (emergent – aquatic bed) (3 sites), needleleaf forest peatlands (3 sites), and herbaceous peatlands (2 sites). Water temperature ranged from 16.0 - 19.8°C (average 18.1°C), pH ranged from 5.9 - 8.9 (average 7.3), and conductivity ranged from 33.7 - 324.0 µS/cm (average 161.0 µS/cm; Table 1). The bottom substrate of the waterbodies was primarily muck, except for an anthropogenic pond that was formed by water filling in a human made gravel/quarry pit on the side of the road. Wetlands with rough-skinned newts had 0 – 20% emergent plant cover (average 7%) of primarily *Menyanthes trifoliata* and *Carex sitchensis*, 0 -30% floating plant cover (average 11%) of primarily *Potamogeton* spp. and *Nuphar polysepala*, and 0 - 70% submerged aquatic plant cover (average 21%) of primarily *Chara* spp. (algae) and *Myriophyllum sibiricum*. All wetlands were either bordered by forest on at least one side or were within 10 m of forest cover. Dominant tree species included *Picea sitchensis*, *Picea contorta* var. *contorta*, *Thuja plicata*, and to a lesser degree *Alnus rubra* and *Callitropsis nootkatensis*. Herbaceous cover within the immediate vicinity of the wetlands was relatively high (average 69.9%), with a wide variety of co-dominant species including *Carex sitchensis*, *Trichophorum cespitosum*, *Juncus ensifolius*, and *Eriophorum angustifolium* (Table 2). Invasive reed canarygrass (*Phalaris arundinacea*) dominated the herbaceous cover at one site. We captured rough-skinned newts of all major life-stages, including larvae, metamorphs, and adults. See Appendix 2 for photographs of the different life stages we observed.

Central Prince of Wales Island: non-karst influenced wetlands

Survey effort and conditions

Between July 9 and 17, we surveyed 34 wetland complexes where Pyare et al. had previously recorded the presence of rough-skinned newts and western toads, and 1 additional site where we observed rough-skinned newts. Of the 35 wetlands visited, 2 (6%) were classified as seasonally flooded needleleaf forest wetlands (no waterbodies), 4 (11%) as seasonally flooded needleleaf forest wetlands (with waterbodies), 3 (9%) as beaver ponds and sloughs, 4 (11%) as lacustrine littoral (emergent – aquatic bed), 4 (11%) as riverine lower perennial (emergent – aquatic bed), 7 (20%) as palustrine (emergent – aquatic bed), 6 (17%) as needleleaf forest peatlands, and 5 (14%) as herbaceous peatlands.

Air temperatures ranged from 12.4 to 29.8°C (average 17.1°C) during the July 9 to 17 survey period. Water temperature was highly variable depending on the water source and canopy coverage. Water temperatures ranged from 9.0 to 24.9°C (average 16.8°C). pH was also highly variable, ranging from 4.2 to 8.7 (average 6.8). Conductivity values ranged from 13.2 to 282.0 µS/cm (average 98.8 µS/cm; Table 3).

Table 3. Summary of air temperature, water temperature, water pH, and conductivity values (with standard error) between all non-karst sites and sites where specific amphibians were observed, central Prince of Wales Island, July 2013.

Physical parameters	All non-karst sites (n = 34)	Sites with western toads (n = 7)	Sites with rough-skinned newts (n = 13)
Air temperature (°C)	17.1 ± 4.4	17.1 ± 2.9	17.2 ± 4.4
Water temperature (°C)	16.8 ± 4.0	16.5 ± 2.7	16.8 ± 3.9
Water pH	6.8 ± 1.1	6.7 ± 1.1	6.8 ± 1.1
Water conductivity (µS/cm)	98.8 ± 82.4	97.5 ± 66.8	99.5 ± 83.0

Distribution and habitat characteristics

Amphibians were recorded in 18 (51%) of the 35 wetland sites surveyed in the central part of the island. We recorded the presence of rough-skinned newts at 14 (40%) sites and western toads at 5 (14%) sites (Figure 5). We did not detect western toads at 17 sites where Pyare et al. had recorded them previously. We captured rough-skinned newts of all life-stages, ranging from larvae to adults. We observed western toad tadpoles at only two sites and metamorphs at only one location. Tadpoles captured on July 10th 2013 averaged 31 mm in total length with only hind limbs developed and those captured on July 15th averaged 29 mm, some of which had developed both fore and hind limbs. Metamorphs captured on July 15th at the same pond as the tadpoles, averaged 16 mm in length and were in varying stages of resorbing their tails. At the remaining sites at which we observed western toads, we captured subadults or adult life-stages. We recorded both western toads (adult) and rough-skinned newts (larvae) at one site; at all other sites only a single species was present (Figure 5).

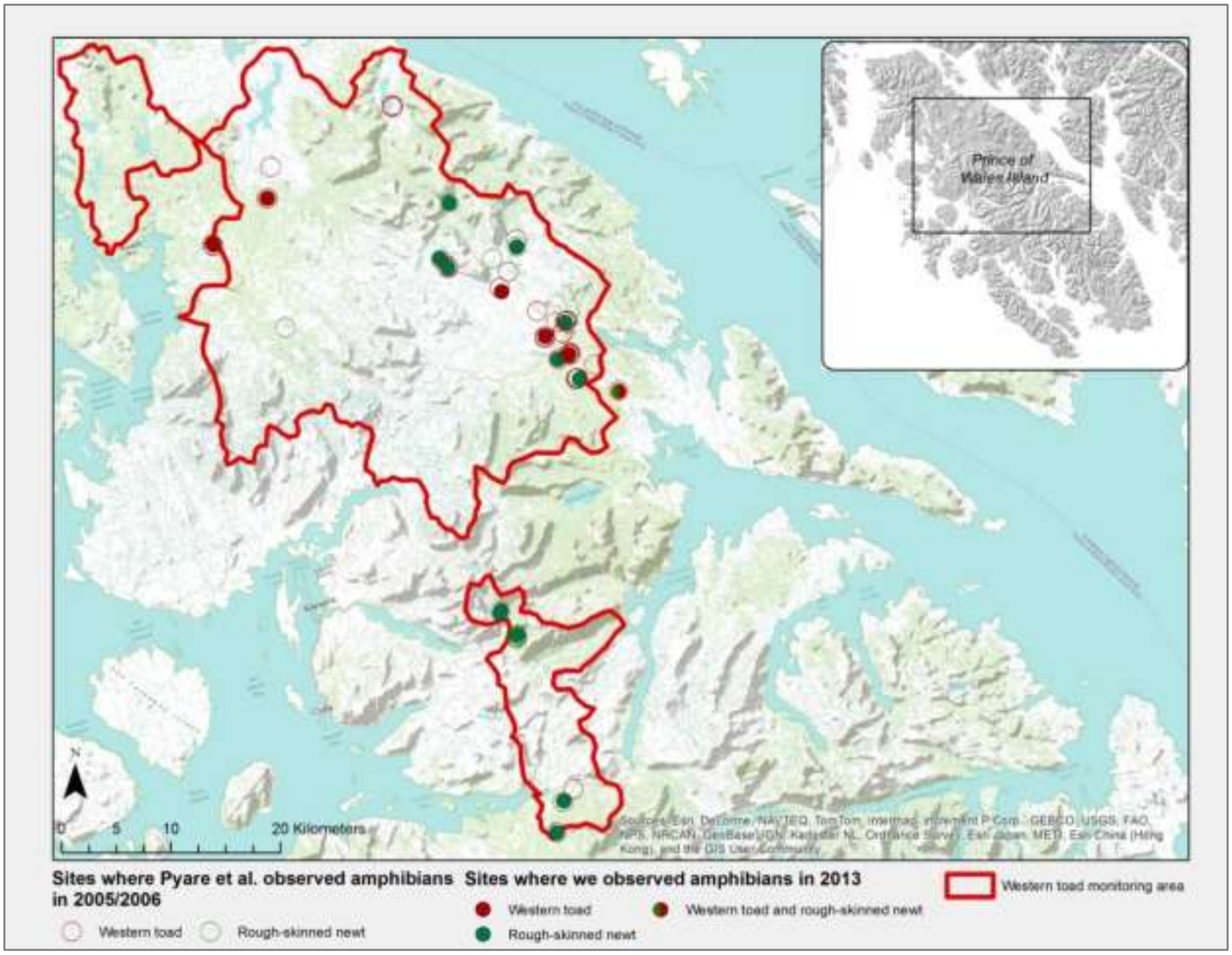

Figure 5. Location of survey sites where Pyare et al. (2007) observed western toads and rough-skinned newts during 2005/2006 compared to sites where amphibians were observed during July, 2013 on Prince of Wales Island, Alaska.

Western toads were observed in the following habitats in the central part of the island: lacustrine littoral (emergent – aquatic bed) (2 sites), riverine lower perennial (emergent – aquatic bed) (1 site), palustrine (emergent – aquatic bed) (1 site), and needleleaf forest peatland (1 site). Water temperature ranged from 13.3 – 18.5°C (average 17.1°C), pH ranged from 4.75 - 8.65 (average 6.7), and conductivity ranged from 30.8 - 282.0 µS/cm (average 97.5 µS/cm; Table 3). Waterbody substrate was variable and included muck, gravel, woody debris, and sand.

Rough-skinned newts were observed in the following habitats in the central part of the island: beaver ponds and sloughs (1 site), lacustrine littoral (emergent – aquatic bed) (1 site), palustrine (emergent – aquatic bed) (4 sites), needleleaf forest peatland (4 sites), and herbaceous peatland (4 sites). Water temperature ranged from 14.4 – 24.9°C (average 16.8°C), pH ranged from 5.4 – 7.3 (average 6.8), and conductivity ranged from 13.2 – 192.2 µS/cm (average 99.5 µS/cm; Table 3). The bottom substrate of the waterbodies was primarily muck and woody debris.

Specimen collection

We collected a total of 76 voucher specimens: 20 western toads and 56 rough-skinned newts. All 20 western toad specimens were tadpoles, collected from 2 sites (10 tadpoles per site). Of the 56 rough-skinned newts, 34 were adults, 1 was a metamorph, and 21 were larvae. All western toad specimens and 29 rough-skinned newt specimens were sent to the Fishes Collection at the University of Alaska Museum in Fairbanks, Alaska. The remaining 27 newt specimens were sent to the USGS Rangeland and Ecosystem Science Center in Corvallis, Oregon for analysis.

Discussion

During July 2013, we surveyed over 100 wetlands for amphibians on Prince of Wales Island, in both karst and non-karst influenced habitats. To our knowledge, our pilot study in karst topography is first study in southeast Alaska to investigate habitat usage of karst influenced wetlands by amphibians. We recorded amphibians at 22.5% of wetlands surveyed within karst habitats, with rough-skinned newts and western toads observed at an equal number of sites. These occurrence rates are not corrected for by a probability of detection rate. Our goal with this first year of surveys was to identify known breeding sites for western toads and rough-skinned newts in karst habitats, with the intention of revisiting a subset of these sites in future years to document occupancy rates and draw general conclusions from.

In the northern part of the island, we encountered larval, metamorph, and adult aged rough-skinned newts, but only found adult and subadult western toads. Although each waterbody was extensively searched for western toad tadpoles, it is possible that our survey occurred too late in the year to capture toads at these life stages. Due to project funding constraints in 2013, it was not possible to begin surveys before July 1st. Pyare et al. surveyed throughout the entire summer (May-August), with the majority of sites visited in May and early June. During Year II of this survey, we intend to arrive earlier in the breeding season to capitalize on the larval period shortly after hatch.

We had relatively high re-survey encounter rates for amphibians in non-karst habitats. We detected rough-skinned newts at 71% of sites where they were previously described by Pyare et al. in 2005 and 2006 (again, these rates of encounter are not corrected for by a probability of detection rate). We also found newts at 3 additional sites where Pyare et al. had previously recorded the presence of western toads. Conversely, we only encountered western toads at 32% of resurvey sites.

Although we present results of habitat characteristics used by each species in both karst and non-karst habitats, these are very preliminary, and should be treated as such. Our initial survey results show that amphibians utilize wetlands of relatively high pH and conductivity, which is characteristic of karst topography in northern Prince of Wales Island. During the next field season we intend to expand our survey area in the northern part of the island to collect additional baseline data on amphibian distribution in karst habitats. During that same time period, we intend to revisit a subset of known occurrences, in both karst and non-karst habitats, to document occupancy rates. Increasing our sample size will allow us to compare the occupancy rate between karst and non-karst landscapes to determine if amphibians are more likely to occur in karst and to determine what environmental variables are correlated with amphibian occurrence. Our ultimate goal is to better define the distribution and habitat requirements for western toads and rough-skinned newts on Prince of Wales Island, so that this information can be used to support amphibian conservation.

Acknowledgements

Funding was provided by the Alaska Natural Heritage Program (AKNHP) - University of Alaska Anchorage and the Alaska Department of Fish and Game (ADF&G) Wildlife Diversity Program. Specimens were collected under Alaska state fish resource permit number SF2013-241 and IACUC approval was received under permit number 473406-1. We thank Dr. Sanjay Pyare for his western toad monitoring site locational data from Prince of Wales Island. We thank M. Kohan (ADF&G), T. Nawrocki (AKNHP), M. Snively (ADF&G), and J. Willacker (AKNHP and University of Alaska Fairbanks [UAF]) for assistance in the field. We thank B. Logan and T. Cady, U.S. Forest Service, for providing logistical support and transportation on Prince of Wales Island. Dr. A. López (UAF) provided advice on amphibian preservation techniques for specimens.

Literature Cited

Alaska Department of Fish and Game (ADF&G). 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. A Comprehensive Wildlife Conservation Strategy. Alaska Department of Fish and Game. Juneau, Alaska. xviii+824 pp.

Albert, D., L. Baker, S. Howell, K. Koski, and R. Bosworth. 2008. A framework for setting watershed-scale priorities for forest and freshwater restoration on Prince of Wales Island. The Nature Conservancy, Juneau, AK.

Aley, T., C. Aley, W. Elliot, and P. Huntoon. 1993. Karst and cave resource significance assessment, Ketchikan Area, Tongass National forest, Alaska. Prepared for the Ketchikan Area of the Tongass National Forest.

Baichtal, J. F., D. N. Swanston, and A. F. Archie. 1995. An ecologically based approach to karst and cave resource management. In: Proceedings of the 1995 National Cave Management Symposium12. October 25-28, 1995. Mitchell, IN.

Baichtal, J. F. and D. N. Swanston. 1996. Karst landscapes and associated resources: a resource assessment. Gen. Tech. Rep. PNW-GTR-383. Portland, OR: US Forest Service, Pacific Northwest Research Station.

Bailey, L. and M. Adams. 2005. Occupancy models to study wildlife. USGS Patuxent Wildlife Research Center and USGS Forest and Rangeland Ecosystem Science Center.

Boggs, K., T. Boucher, and T. Kuo. 2013. Vegetation Map and Classification: Southern Alaska and Aleutian Islands. Alaska Natural Heritage Program, University of Alaska Anchorage. Anchorage, Alaska. Available: http://aknhp.uaa.alaska.edu/ecology/vegetation-map-southern-alaska-and-the-aleutian-islands/

Brinkman, T. J. 2009. Resilience of a deer hunting system in southeast Alaska: integrating social, ecological, and genetic dimensions. Dissertation, University of Alaska Fairbanks, Fairbanks, AK.

Brew, D. A., T. Overshire, S. M. Karl, and S. J. Hunt. 1984. Preliminary reconnaissance geologic map of the Port Alexander and Sumdum 1:250,000 quadrangles, south-eastern Alaska. File rep. 84-405. Washington, DC: US Geological Survey.

Bryant, M. D., D, N. Swanston, R. C. Wissmar, and B. E. Wright. 1998. Coho salmon populations in the karst landscape of North Prince of Wales Island, Southeast Alaska. Transactions of the American Fisheries Society 127: 425-433.

Carstensen, R., M. Willson, and R. Armstrong. 2003. Habitat use of amphibians in northern Southeast Alaska. Report to the Alaska Department of Fish and Game written by Discovery Southeast. Juneau, AK.

Crump, M.L. and N.J. Scott. 1994. Pp. 84-91 in Measuring and monitoring biological diversity: standard methods for amphibians (W.R. Heyer et al., eds). Smithsonian Institution. Washington, D.C.

Davis, T. M. 2000. Ecology of the Western Toad (*Bufo boreas*) in forested areas on Vancouver Island. Final Report. Forest Renewal B.C. Ministry of Forests, Victoria, B.C

Gehrels, G. E. and H. C. Berg. 1992. Geologic map of southeastern Alaska. Misc. Invest. Ser. Map 1-1867. US Geological Survey, Menlo Park, CA.

Harris, A. S., O. K. Hutchison, W. R. Meehan, D. N. Swanston, A. E. Helmers. J. C. Hendee, and T. M. Collins. 1984. The forest ecosystem of southeast Alaska: 1. The setting. US Forest Service General Technical Report. PNW-12. Portland, OR.

Jones, M. S. 1999. Henderson/Urad boreal toad studies. In, Jones, M.S. (ed.). Boreal toad research progress report 1998. Colorado Division of Wildlife, Fort Collins, CO.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A, Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83: 2248-2255.

McClellan, M.H., T. Brock, and J.F. Baichtal. 2003. Calcareous fens in Southeast Alaska. Research Note PNW-RN-536. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Pyare, S., R. Carstensen, B. Christensen, and M. J. Adams. 2004. Draft study plan: inventory and monitoring for western toad in Southeast Alaska: Documenting regional and distribution and habitat occupancy; baselines for detection of future change. Unpublished study plan.

Pyare, S., R.E. Christensen III, R. Carstensen, and M. J. Adams. 2005. Preliminary assessment of breeding site occupancy and habitat associations for western toad (*Bufo boreas*) monitoring in Glacier Bay. In J. F. Piatt and S. M. Gendem (eds) Proceedings of the Fourth Glacier Bay Science Symposium, 2004. U.S. Geological Survey, Information and Technology Report USGS/BRD/ITR-2005-00XX, Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 2009. National Wetlands Inventory, Alaska Region. Fish and Wildlife Service, U.S. Department of the Interior. Available: http://www.fws.gov/wetlands/

Western Regional Climate Center (WRCC). 2013. Cooperative climatological data summary for Craig, Alaska. Available at: http://www.wrcc.dri.edu/climatedata/climsum/ (Accessed on 9 September 2013).

Wissmar, R. C., D. N. Swanston, M. Bryant, and K. McGee. 1997. Factors influencing stream chemistry in catchments on Prince of Wales Island, Alaska. Freshwater Biology 38: 301-314.

Appendix 1. Habitat Classes and Characteristics

Wetland habitat types surveyed on Prince of Wales Island included predominantly terrestrial sites and predominantly aquatic sites. Habitat classes for the predominantly terrestrial sites were derived from the vegetation classes of the Vegetation Map and Classification: Southern Alaska and Aleutian Islands (Boggs et al. 2013). Habitat classes for the predominantly aquatic sites were derived from the subclasses of the U.S. Fish and Wildlife Service National Wetlands Inventory (USFWS 2009). The seasonally flooded needleleaf forest wetland class of the Boggs et al. 2013 map was subdivided into those with waterbodies and those without waterbodies, since the presence of waterbodies potentially has a profound effect on suitability for amphibians. The beaver ponds and sloughs class was separated out from the palustrine (emergent – aquatic bed) subclass of the NWI because beaver activity often produces unique waterbodies that are abruptly deep and lack shallow water for much of the shoreline.

During the 2013 field season, we surveyed the following habitats for amphibians:

- Seasonally flooded needleleaf forest wetland (no waterbodies)
- Seasonally flooded needleleaf forest wetland (with waterbodies)
- Beaver ponds and sloughs
- Lacustrine littoral (emergent – aquatic bed)
- Riverine lower perennial (emergent – aquatic bed)
- Palustrine (emergent – aquatic bed)
- Needleleaf forest peatland
- Herbaceous peatland

The descriptions of habitat classes provided in this appendix are based on the descriptions of coarse scale vegetation classes from Vegetation Map and Classification: Southern Alaska and Aleutian Islands (Boggs et al. 2013), but have been modified to more closely identify the sites that we surveyed in 2013 on Prince of Wales Island. The common vegetation listed for each habitat class therefore reflects the vegetation that we observed at survey sites rather than vegetation common to the vegetation classes across southern Alaska.

Seasonally flooded needleleaf forest wetland (no waterbodies)

The seasonally flooded needleleaf forest wetland (no waterbodies) includes freshwater wetlands in open to closed needleleaf forests that lack streams, ponds, or other significant bodies of water (Figure 6). Soils are poorly drained and typically saturated. There may be some shallow standing water but there are no permanent waterbodies or large ephemeral waterbodies. Total canopy cover of trees is normally 25% or higher and needleleaf trees dominate.

Tsuga heterophylla and *Picea sitchensis* are usually dominant or codominant in the forest canopy. *Thuja plicata* and *Callitropsis nootkatensis* are also common. Common shrubs include *Vaccinium ovalifolium*, *Oplopanax horridus*, *Menziesia ferruginea*, and *Rubus spectabilis*. Common forbs include *Lysichiton americanus*, *Gymnocarpium dryopteris*, *Phegopteris connectilis*, and *Thelypteris quelpaertensis*. *Sphagnum* moss is common. The presence of *Lysichiton americanus* is indicative of soils that are usually saturated or inundated.

Figure 6. Seasonally flooded needleleaf forest wetland (no waterbodies) from site TAGR79-SP. Tree cover was dominated by *Tsuga heterophylla* and *Picea sitchensis* at this site. *Lysichiton americanus* grows in areas with typically saturated or inundated soils, although because of warm weather in 2013 these areas were drier than usual.

Seasonally flooded needleleaf forest wetland (with waterbodies)

The seasonally flooded needleleaf forest wetland (no waterbodies) includes freshwater wetlands in open to closed needleleaf forests that lack streams, ponds, or other significant bodies of water (Figure 7). Soils are poorly drained and typically saturated. There may be some shallow standing water in addition to permanent waterbodies or large ephemeral waterbodies. Total canopy cover of trees is normally 25% or higher and needleleaf trees dominate.

Tsuga heterophylla and *Picea sitchensis* are usually dominant or codominant in the forest canopy. *Thuja plicata* and *Callitropsis nootkatensis* are also common. *Alnus rubra* is sometimes present. Common shrubs include *Vaccinium ovalifolium*, *Oplopanax horridus*, *Menziesia ferruginea*, and *Rubus spectabilis*. Common forbs include *Lysichiton americanus*, *Gymnocarpium dryopteris*, *Phegopteris connectilis*, and *Thelypteris quelpaertensis*. *Sphagnum* moss is common. The presence of *Lysichiton americanus* is indicative of soils that are usually saturated or inundated.

Figure 7. Seasonally flooded needleleaf forest wetland (with waterbodies) from site TAGR78-SP. Small ponds and creek were present in this forested wetland complex. Tree cover was dominated by *Tsuga heterophylla* and *Picea sitchensis*. *Lysichiton americanus* grows in areas with typically saturated or inundated soils and at the edges of waterbodies.

Beaver ponds and sloughs

This class consists of seasonally flooded needleleaf forest wetlands (with waterbodies) or palustrine (emergent – aquatic bed) sites that have been modified by beaver activity (Figure 8). Both active and inactive damns are included. The beaver ponds and sloughs class has been separated out from the two previously mentioned habitat classes because beaver activity often creates networks of abruptly deep channels and ponds. Beaver damns span small ponds to lake-sized waterbodies.

Vegetation is usually the similar to the vegetation described for seasonally flooded needleleaf forest wetlands (with waterbodies) or palustrine (emergent – aquatic bed). Common tree species include *Picea sitchensis*, *Tsuga heterophylla*, *Thuja plicata*, and *Alnus rubra*.

Figure 8. Beaver ponds and sloughs with typical standing dead trees and tall graminoid terrestrial vegetation. An adult western toad was found on the woody debris of the large beaver pond at site BUBO-2013-10 (left). Beaver sloughs are often abruptly deep, such as this beaver slough from northern Prince of Wales Island (right).

Lacustrine littoral (emergent – aquatic bed)

Lacustrine littoral (emergent – aquatic bed) consists of lake littoral zones and the adjacent terrestrial shorelines and includes terrestrial, emergent, floating, and submerged vegetation (Figure 9). This class does not include peatlands (lakes in peatlands are included within the needleleaf forest peatland or herbaceous peatland classes). Vegetation at these sites is usually a combination of the herbaceous (wet-marsh) coarse vegetation class and herbaceous aquatic coarse vegetation class from the Boggs et al. 2013 map.

Herbaceous (wet-marsh) vegetation dominates the terrestrial shorelines and shallow littoral zones of lakes. The water table for most of the growing season ranges from just below the ground surface, to at the ground surface, to above the ground surface in shorelines with emergent wetlands. Soils are mineral soil or muck over mineral soil, or have an organic layer less than 40 cm thick. Organic material may be composed of *Sphagnum* moss, *Carex* spp., or other plant material and can occur over mineral soil or may be a floating root mat.

Along shorelines where the water table is typically above the ground surface (i.e. marsh or emergent wetland), common plants include *Carex sitchensis*, *Carex utriculata*, *Comarum palustre*, *Equisetum fluviatile*, and *Menyanthes trifoliata*. Species diversity is often low. Along drier shorelines where the water table is typically below the ground surface (i.e. terrestrial shorelines), common plants include *Carex sitchensis*, *Comarum* *palustre*, and *Nephrophyllidium crista-galli*. The invasive grass *Phalaris arundinacea* is present or common at some sites.

Herbaceous aquatic vegetation occurs in the deep littoral zone of lakes and is dominated by floating and submerged vegetation. *Nuphar polysepala* is often present. Other common species include *Callitriche* spp., *Isoetes* spp., *Myriophyllum sibiricum*, *Potamogeton* spp., and *Sparganium angustifolium*. *Chara* spp. (algae) are common.

Figure 9. Lacustrine littoral (emergent – aquatic bed) shorelines are often dominated by *Carex sitchensis*. *Nuphar polysepala* is common in the deep littoral zone of the lake at site ABS-2013-124 (left). *Equisetum fluviatile* is common in the shallow littoral zone of the lake at site ABS-2013-25 (right).

Riverine lower perennial (emergent – aquatic bed)

Riverine lower perennial (emergent – aquatic bed) consists of river littoral zones and the adjacent terrestrial riverbanks of rivers with year-round flow (perennial) at low elevations (does not include headwater streams). These sites include terrestrial, emergent, floating, and submerged vegetation (Figure 10). This class does not include peatlands. Vegetation at these sites is usually a combination of the herbaceous (wet-marsh) coarse vegetation class and herbaceous aquatic coarse vegetation class from the Boggs et al. 2013 map. The riverine lower perennial sites that we surveyed generally had slow moving waters or included protected waters.

Herbaceous (wet-marsh) vegetation dominates the terrestrial riverbanks and shallow littoral zones of rivers. The water table for most of the growing season ranges from just below the ground surface, to at the ground surface, to above the ground surface in riverbanks with emergent wetlands. Soils are mineral soil or muck over mineral soil, or have an organic layer less than 40 cm thick. Organic material may be composed of *Sphagnum* moss, *Carex* spp., or other plant material and can occur over mineral soil or may be a floating root mat.

Along riverbanks where the water table is typically above the ground surface (i.e. marsh or emergent wetland), common plants include *Carex sitchensis*, *Carex utriculata*, *Ranunculus flammula*, and *Ranunculus trichophyllus*. Species diversity is often low. Along drier riverbanks where the water table is typically below the ground surface (i.e. terrestrial riverbanks), common plants include *Carex sitchensis* and *Carex utriculata*. *Calamagrostis canadensis*, *Rubus spectabilis*, and *Spiraea douglasii* are common at some sites. The invasive grass *Phalaris arundinacea* is present or common at some sites.

Herbaceous aquatic vegetation occurs in the deep littoral zone of rivers and is dominated by floating and submerged vegetation. Common species include *Callitriche* spp., *Isoetes* spp., *Nuphar polysepala*, *Potamogeton* spp., and *Sparganium angustifolium*. *Chara* spp. (algae) are common.

Figure 10. Riverine lower perennial (emergent – aquatic bed) site consisting of a shallow, heavily vegetated river bend at site BUBO-2013-36. Numerous western toad tadpoles were found in shallow waters protected from the river current by gravel bars.

Palustrine (emergent – aquatic bed)

Palustrine (emergent – aquatic bed) consists of small to large ponds and the adjacent terrestrial shorelines and includes terrestrial, emergent, floating, and submerged vegetation (Figure 11). This class does not include peatlands (lakes in peatlands are included within the needleleaf forest peatland or herbaceous peatland classes). Vegetation at these sites is usually a combination of the herbaceous (wet-marsh) coarse vegetation class and herbaceous aquatic coarse vegetation class from the Boggs et al. 2013 map.

Herbaceous (wet-marsh) vegetation dominates the terrestrial shorelines and shallow zones of ponds. The water table for most of the growing season ranges from just below the ground surface, to at the ground surface, to above the ground surface in shorelines with emergent wetlands. Soils are mineral soil or muck over mineral soil, or have an organic layer less than 40 cm thick. Organic material may be composed of *Sphagnum* moss, *Carex* spp., or other plant material and can occur over mineral soil or may be a floating root mat.

Along shorelines where the water table is typically above the ground surface (i.e. marsh or emergent wetland), common plants include *Carex sitchensis*, *Carex utriculata*, *Comarum palustre*, *Equisetum fluviatile*, *Equisetum palustre*, *Menyanthes trifoliata*, *Ranunculus flammula*. Species diversity is often low. Along drier shorelines where the water table is typically below the ground surface (i.e. terrestrial shorelines), common plants include *Carex flava*, *Carex livida*, *Carex sitchensis*, *Equisetum palustre*, *Juncus ensifolius*, and *Scirpus microcarpus*. The invasive grass *Phalaris arundinacea* is present or common at some sites.

Herbaceous aquatic vegetation occurs in the deep zone of ponds and is dominated by floating and submerged vegetation. Common species include *Callitriche* spp., *Isoetes* spp., *Myriophyllum sibiricum*, *Nuphar polysepala*, *Potamogeton* spp., and *Sparganium angustifolium*. *Chara* spp. (algae) are common.

Figure 11. Palustrine (emergent – aquatic bed) sites consisting of small ponds and emergent wetland. Numerous rough-skinned newt adults were found buried in the organic muck at the bottom of the shallow pond at site TAGR82-SP (left). One rough-skinned newt was observed hiding in *Sparganium angustifolium* and *Chara* sp. at site TAGR-2013-104 (right).

Needleleaf forest peatland

Peatlands include all sites with organic layers of more than 40 cm depth, composed largely of *Sphagnum* moss. Needleleaf forest peatlands have tree cover ranging from 10 to 30% and often include small ponds and channels (Figure 12). Needleleaf forest peatlands occur on low to mid elevation headlands, uplifted marine deposits, piedmonts, and ancient inactive outwash deposits. Sites are usually flat to low angle and poorly drained. Some needleleaf forest peatlands may develop on fairly steep sideslopes in areas with very high rainfall and low permeability. Soils are poorly drained and often saturated to the surface.

Pinus contorta var. *contorta* is usually the dominant needleleaf tree. *Tsuga heterophylla*, *Picea sitchensis*, *Callitropsis nootkatensis* are also common. Trees growing within peatlands are typically stunted. Common shrubs include *Empetrum nigrum*, *Juniperus communis*, *Rhododendron groenlandicum*, and *Vaccinium uliginosum*. Common herbaceous species include *Carex limosa*, *Carex livida*, *Eriophorum angustifolium*, *Nephrophyllidium crista-galli*, and *Trichophorum cespitosum*. Sphagnum moss is usually abundant in the ground layer. *Carex sitchensis*, *Menyanthes trifoliata*, *Nuphar polysepala*, and *Lysichiton americanus* are common in small ponds within needleleaf forest peatlands.

Figure 12. Needleleaf forest peatlands on Prince of Wales Island are dominated by *Pinus contorta* var. *contorta.* A single adult western toad was found in the saturated organic muck at site BUBO-2013-07 (left). This habitat class is often a complex of forested and non-forested peatlands, such as site ABS-2013-126 (right).

Herbaceous peatland

Herbaceous peatlands are well-developed peatlands (bogs and fens) dominated by herbaceous vegetation (herbaceous cover is greater than 25%) and an organic layer that ranges from over 2 m deep to approximately 0.4 m deep (Figure 13). The organic layer may be composed of *Sphagnum* moss, *Carex* spp., or other plant material and can occur over mineral soil or may be floating or submerged. Soils are poorly drained and often saturated to the surface. Tree cover is usually less than 10%, and shrub cover is usually less than 25%.

In bogs, *Carex livida*, *Carex pauciflora*, *Carex sitchensis*, *Eriophorum angustifolium*, and *Trichophorum cespitosum* are the dominant sedges. *Nephrophyllidium crista-galli*, *Microseris borealis* and *Drosera rotundifolia* are common forbs. Common shrubs include *Empetrum nigrum*, *Kalmia microphylla*, *Rhododendron groenlandicum*, and *Vaccinium ovalifolium*.

In fens, *Carex sitchensis* (McClellan et al. 2003) is typically dominant, although a variety of other sedges and forbs may be present, including *Eriophorum russeolum*. Ericaceous shrubs are uncommon.

Small ponds and channels are common in herbaceous peatlands. Within these small waterbodies, *Carex sitchensis*, *Menyanthes trifoliata*, *Nuphar polysepala*, and *Lysichiton americanus* are common.

Figure 13. Herbaceous peatlands are often dominated by *Carex* spp, *Eriophorum* spp., and *Trichophorum cespitosum*. A single adult western toad was found in the saturated organic muck at site BUBO-2013-131 (left). A single adult rough-skinned newt was found sheltering underneath a rotted log at site TAGR-2013-105 (right).

Appendix 2: Amphibian Life Stages and Photos in Habitat

Rough-skinned newts (*Taricha granulosa*)

Figure 14, Figure 15, and Figure 16 show the larvae, metamorph, and adult stages of rough-skinned newts that we observed in July, 2013 on Prince of Wales Island and list distinguishing traits between the life stages.

Figure 14. Rough-skinned newt larva captured on July 9, 2013. Larvae are distinguished from metamorphs by the presence of external gills, non-functional legs, and semi-translucent skin.

Figure 15. Rough-skinned newt metamorph captured on July 7, 2013. Metamorphs are distinguished from larvae by the lack of external gills, functional legs, and nearly opaque skin. Metamorphs are distinguished from adults by the presence of smooth skin, poorly differentiated dorsal and ventral coloration, and tail with large skin margins.

Figure 16. Rough-skinned newt adult captured on July 8, 2013. Adults are distinguished from metamorphs by the presence of small bumps on the skin, strongly differentiated dorsal and ventral coloration, and tail with minimal skin margins.

Western toads (*Bufo boreas*)

Figure 17, Figure 18, and Figure 19 show the tadpole, metamorph, and adult stages of western toads that we observed in July, 2013 on Prince of Wales Island and list distinguishing traits between the life stages.

Figure 17. Western toad tadpoles captured on July 15, 2013 (left) and July 10, 2013 (right). Tadpoles are distinguished from metamorphs by the absence of fore-legs, poorly developed hind-legs, and tail with large skin margins.

Figure 18. Western toad metamorphs captured on July 15, 2013. Metamorphs are distinguished from tadpoles by the presence of fore-legs, well-developed hind-legs, and tail without large skin margins. Metamorphs are distinguished from adults by the presence of tails.

Figure 19. Western toad adults vary considerably in size and coloration, from the small adult captured on July 13, 2013 (left) to the large adult captured on July 9, 2013 (right). Adults are distinguished from metamorphs by the lack of tails.