HABITAT ASSOCIATIONS, PHENOLOGY, AND BIOGEOGRAPHY OF AMPHIBIANS IN THE STIKINE RIVER BASIN AND SOUTHEAST ALASKA

REPORT OF THE 1991 PILOT PROJECT

Nick Dana L. Waters

U.S. Fish and Wildlife Service

California Cooperative Fishery Research Unit

Humboldt State University

Arcata, CA 95521-4957

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Please direct email correspondence to the author at nickdwaters@gmail.com

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Abstract

Herpetofauna were sampled during the 1991 pilot project phase at aquatic habitats within US territory of the Stikine River basin, Southeast Alaska (USFS Stikine Area, Stikine-Le Conte Wilderness), and outlying areas for the purposes of determining the distribution of herpetofauna in the region, habitats used for breeding, phenology, to gather baseline data on abundance/occurrence, to establish permanent monitoring stations, and to establish a frozen tissue collection of herpetofauna from the study area. Working definitions of aquatic habitats, based on qualitative geomorphic features, were developed. The aquatic habitats were ranked in order of least to most suitable (favorable to amphibian breeding) using the criteria of hydrologic stability and water temperature to gauge whether amphibian abundance/occurrence correlate. Five amphibian species were previously reported from the Stikine Area. A sixth species, the Northwestern Salamander (Ambystoma gracile) is reported for the first time. A previous report of the Valley Garter Snake (Thamnophis sirtalis) in the Stikine River basin was not confirmed despite three months of fieldwork in areas that appeared to be excellent summer foraging habitat. The six herpetofauna species known to occur in the Stikine Area, the Western Toad (Bufo boreas), Spotted frog (Rana pretiosa), Wood frog (Rana sylvatica), Northwestern Salamander (Ambystoma gracile), Long-Toed Salamander (Ambystoma macrodactylum), and Rough-Skinned Newt (Taricha granulosa) depend on aquatic habitat to reproduce. Out of a total of 18,413 amphibian observations, 82 percent of the observations (eggmasses, larvae, and adults) were of the Western Toad and 17 percent were of the Spotted Frog. The remaining 1 percent were comprised of the Rough-Skinned Newt (the majority) and the Northwestern Salamander. Long-Toed Salamanders were not observed in the field despite previous reports of their being observed from Twin Lakes in mid-Summer. They were observed at Mallard Slough prior to my arrival in the study area by a reliable observer (I saw the living specimens). Suitable aquatic habitat appears to be the critical limiting factor affecting all amphibian species in the Stikine River basin. Data from 86 sites show that amphibians seasonally occur throughout the Stikine River basin but are locally abundant in only a few areas possibly due to the scarcity of suitable breeding habitat. Aquatic habitats, ranked in order of least to most suitable (favorable to amphibian breeding) based on the criteria of hydrologic stability and water temperature are: Stikine River (least suitable), streams, backwater slough, mountain lake, backwater lake, beaver pond, muskeg, and outwash pond (most suitable). Breeding activity and amphibian occurrence appear to correlate with this ranking of habitats, with no breeding activity observed in the most hydrologically active and coldest habitats.

Acknowledgements

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Introduction

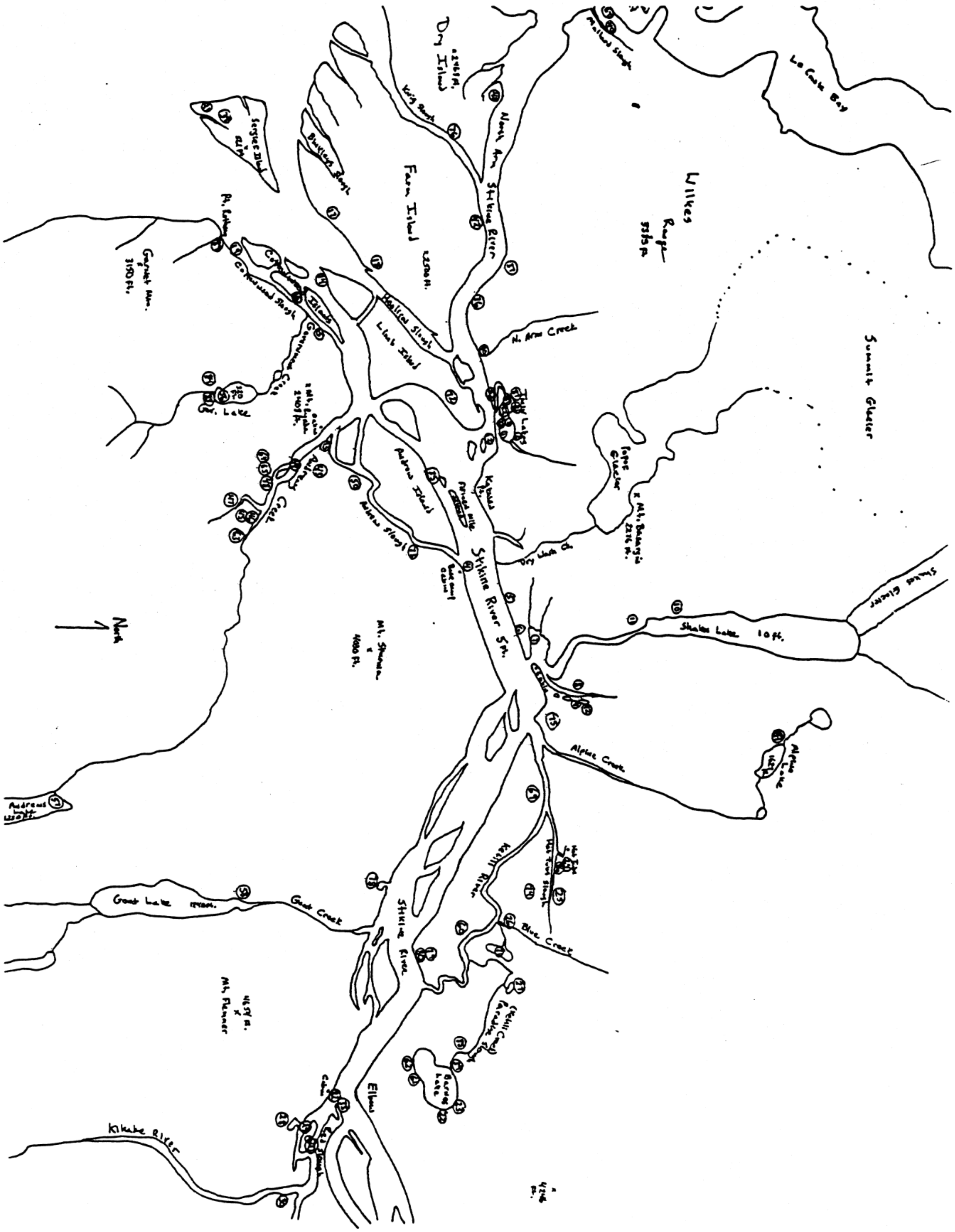
The Spotted Frog has disappeared from large portions of its range in Oregon and Washington. Close relatives of the Spotted frog, the Cascades Frog (Rana cascadae) and the Red-Legged Frog (Rana aurora), whose ranges interdigit each other, have also declined or become extinct in portions of their respective ranges (Hayes and Jennings, 1986; Blaustein and Wake, 1991). Factors for their respective declines are complex, with different factors contributing to the decline of each species. These frogs share similar habitat requirements, breeding in wetlands, lakes, and the margins of slow moving streams, although each species is behaviorally and physiologically adapted to low, mid, and high elevation conditions (Licht, 1971 & 1975; Briggs, 1987). It is alarming that these closely related species have declined throughout their ranges, and at apparently all elevations. Possible phenomena contributing to their population decline are 1) habitat loss due to encroachment by man, 2) climatic change, including prolonged drought which produces a host of secondary conditions such as changes in water chemistry, 3) lake acidification, possibly due to air pollution through acid rain or snow (Harte and Hoffman, 1989) or natural lake acidification (Tolonen, et al. 1986) as a consequence of climate change or succession, 4) UV-B radiation increases due to recent ozone depletion in the upper atmosphere (Blaustein and Wake, 1991), and 5) competition with introduced species, such as the Bullfrog (Rana catesbeiana; Hayes and Jennings, 1986). The status of the Spotted Frog and uncertainty over the factors which affect amphibian populations stimulated the initiation of a pilot research program in Southeast Alaska to gather baseline data on the Spotted Frog and other herpetofauna species.

Stikine River Basin Habitat Sampling

Study Area

The pilot study took place in the Stikine Area of the Tongass National Forest, Wrangell, Southeast Alaska. The principle study area was on the mainland within the Stikine River basin, from the mouth of the river to the Canadian border (Figure 1). Additional forays were made on Wrangell Island (DLW), Etolin Island (DLW), Onslow Island (H. Hall, K. Smyth, DLW), Zarembo Island (K. Smyth, DLW), Vank Island (R. Clair, S. Ryll, DLW), Sokolof Island (S. Wise-Eagle), areas on the mainland immediately south of the Stikine River (Anan Creek and Frosty Creek: J. Stoneman, B. Trauffer; Crittenden Creek: L. Murray, K. Smyth, DLW), and to areas elevated above the Stikine River basin (DLW).

Figure 1. Stikine River basin. Circled numbers are sample sites. Crittenden Creek and Virginia Lake are south of the river (See Figures 11 & 12 for more readable maps).



Duration of Sampling

The field investigator (DLW) arrived in the study area on May 23, 1991. Field observations began on Wrangell Island the same day. Field work within the Stikine River Basin did not begin until June 4 and continued up to August 30. The field investigator left the study area on August 19 whereupon fieldwork was carried out by Sharon Ryll and Kevin Smyth.

Proposed Pilot Study Objectives

Seven objectives were proposed during the planning stage of the pilot project:

1. Delineate herpetofauna habitat relationships within the Stikine River basin.
2. Determine the distribution and relative abundance of herpetofauna within the Stikine River basin;
3. Identify species specific phenology patterns.
4. Establish reference point sampling areas as permanent monitoring sites.
5. Relate ground temperature to herpetofauna activity.
6. Collect voucher specimens for the University of Alaska - Fairbanks.
7. Collect specimens for a tissue collection of Southeastern Alaskan herpetofauna at the University of California - Berkeley.

Refinement of Objectives

Conclusions regarding objective 2 should be weighed against the following considerations: (1) the breeding season was entirely missed, when amphibians congregate and are easily observed, (2) the herpetofauna data is marginal for most sites (3) the abundance of amphibians is likely to be related to the quantity and suitability of aquatic habitat, and (4) the types of habitat and quantity vary throughout the study area. To properly assess this objective an inventory of the available habitat in the Stikine River basin would have had to be undertaken in addition to sampling evenly among the habitats, which was not logistically feasible in 1991.

Objectives 3 and *5* can be considered as a single “phenology” objective with “ground temperature” being a controlling variable of spring emergence and fall hibernation. Due to our late start the amount of data gathered was minimal although the information collected from observers in the field prior to my arrival was sufficient.

Objective 6 was minimally implemented due to time and logistic restraints. Objective 7 was not feasible due to logistical considerations. It was learned that the University of Alaska, Fairbanks, had established a tissue collection and herpetofauna specimens sent to UAF were preserved in this fashion, thus fulfilling the spirit of Objective 7. It was judged to be inappropriate to gather voucher specimens throughout the study area due to the uncertain population status of the herpetofauna species. Limited numbers of specimens were collected from localities that represented range expansions or from areas where herpetofauna were clearly abundant (Table 1).

Table 1. Amphibian species collected in 1991, Southeast Alaska. Specimens deposited at the University of Alaska, Fairbanks, Vertebrate Museum. UAF refers to accession number and AF to frozen tissue collection.

Species	**No.**	**Date Collected**	**Locality**	**Disposition**	**Sex**	**Age**	**Breeding Condition**
Bufo boreas	1	July 3, 1991	Vank Island	UAF 1992-7 AF 0013	Unknown	Subadult	None
Bufo boreas	1	July 3, 1991	Vank Island	UAF 1992-7 AF 0014	Unknown	Subadult	None
Hyla regilla	1	June 15, 1991	Ward Creek, Ketchikan	UAF 1992-5 AF 0010	Male	Adult	Active Calling
Hyla regilla	1	June 15, 1991	Ward Creek, Ketchikan	UAF 1992-5 AF 0011	Female	Adult	Gravid
Rana pretiosa	1	July 3, 1991	Vank Island	UAF 1992-5 AF 0019	Male	Adult	Active
Rana pretiosa	1	July 3, 1991	Vank Island	UAF 1992-5 AF 0020	Female	Adult	Gravid
Rana pretiosa	1	Aug 14, 1991	Mallard Slough, Stikine River	UAF 1992-8 AF 0015	Male	Adult	Unknown
Rana pretiosa	1	Aug 14, 1991	Mallard Slough, Stikine River	UAF 1992-8 AF 0016	Female	Adult	Unknown
Rana sylvatica	1	Aug 14, 1991	Mallard Slough, Stikine River	UAF 1992-8 AF 0017	Unknown	Subadult	None
Rana sylvatica	1	Aug 14, 1991	Mallard Slough, Stikine River	UAF 1992-8 AF 0018	Unknown	Subadult	None

Final Objectives - 1991 Field Season

The objectives were reduced to the following:

1. Delineate herpetofauna habitat relationships within the Stikine River basin.
2. Determine the distribution of herpetofauna within the Stikine River basin.
3. Identify species specific phenology patterns.
4. Establish reference point sampling areas as permanent monitoring sites.
5. Establish a herpetofauna tissue collection at the University of Alaska Fairbanks.

Research Approach

The research approach stressed quantification of the vegetation community adjacent to aquatic habitat coupled with the assessment of qualitative geomorphic factors that directly form the habitat. This approach carries with it the assumption that the vegetation reflects historical patterns of climatic and physiographic conditions that are relevant to herpetofauna. Complete assessment of the data will take place after completion of field activities.

Methods

Site Selection

The Stikine River basin was divided into 31 sections on the basis of physiographic features and by the logistics necessary to reach each section (see master topographic map) for the purpose of sampling evenly across the study area. From field reconnaissance and aerial photographs a number of sites, based on the diversity of habitat types (Appendix A) evident on the aerial photographs, were designated to each section. Sites were selected in the field on the basis of representative conditions or whether herpetofauna were present. We attempted to broadly cover the Stikine River basin without concentrating in any particular region.

Sampling Procedures: Objectives 1 & 2

Herpetofauna, vegetation, and microhabitat conditions were sampled within 50 x 10 meter transects, subdivided into five 10 x 10 meter sub transects (D.Rudis, pers. comm.). This yielded five replicate sub-transects per site, each of which has information that is independent of the other sub-transects.

From boat or foot, observers entered the site and kept track of herpetofauna. A 50 meter Keson tape was extended along the habitat (usually adjacent to a shoreline) and white flagging, marked with the transect number and either bottom or top, was hung at the ends of the tape. A compass bearing was taken from bottom to top aid in re-establishing transects if one of the flags was missing. This procedure permits observers to repeatedly sample a site through the field season. It remains to be seen whether the flagging allows observers to easily locate transects in following years. All systematic observations were made along the 50 meter transects and within 5 meters of the tape. An encoded aluminum tag (marked USF&WS & USFS Herp Survey, date, transect number) was placed near the bottom of the transect.

Within the sub-transects observers counted the number of herpetofauna by species, stage of development, sex, activity, substrate, cover, side of transect, and distance from transect. The abundance of individual plant species was recorded using the Braun-Blanquet (1932) technique. In addition to this, general microhabitat variables were collected (see Appendix B for details on methods and variables collected in association with the transect). The habitat type was determined following procedures outlined in Appendix A.

In addition to the sampling protocol stated here observations of amphibians were iven to the field investigator from individuals in the community and USFS office (see Acknowledgements). Observations were confirmed in the field whenever possible if a specimen was not collected. However, when no specimen was procured for inspection, I asked the observer to describe what they saw and showed them pictures of specimens portrayed by Stebbins (1985) and photographs in Behler and King (1979). At no time did I insinuate characters or suggest what something was before a full and satisfying description was given. Questionable observations are not included here. This procedure proved itself to be reliable.

Sampling Procedures: Objective 3

Sites were re-sampled when breeding was observed or when amphibians appeared to be abundant. Observations from knowledgeable eyewitnesses were garnered throughout the field season, especially on breeding activity in April and May. Taylor recording thermographs were installed at three sites within the Stikine River basin and at a single site on the south end of Wrangell Island. In addition, Taylor minimum-maximum thermometers were installed at locations throughout the Stikine River basin.

Recording thermographs were installed in late May and June and will record data through Spring of 1992. Taylor minimum-maximum thermometers were installed in August. These devices were installed evenly throughout the Stikine River basin and were buried immediately below the soil surface, at a maximum depth of 15 cm.

Weather data from Wrangell Airport, near the mouth of the Stikine River, was purchased from NOAA. This data, on IBM formatted *5* 1/4" floppy disks covers the period from 1949 to 1991. Data included are: maximum daily temperature, minimum daily temperature, daily precipitation, daily snowfall, and daily snow depth. These data can be supplemented in following years and analyzed to discern relatively recent weather patterns within the Stikine Area. This data is not dealt with here.

Objective 4

The majority of sample sites were delineated on aerial photographs and the aerial photo numbers and series were recorded in a field notebook. Aerial photos were not available for every area we sampled. Sample sites were also indicated on a topographic map. Aerial photographs are the property of the Tongass National Forest, Wrangell office, and are deposited there. The master topographic map will be deposited in the USF&WS office in Juneau (along with the report and original field data and notebooks). White flagging (as indicated above) was hung at most sites, and a coded aluminum tag was left near the top flag. The exceptions (sites 81-92) are sites which were visited but data was not collected on the spot due to time constraints. Locations of these sites have been clearly delineated on the topographic map and a drawing included with each data form to indicate their approximate location. Site locations are listed in Appendix C.

Objective 5

Limited numbers of amphibians, notably those representing range extensions or from areas where amphibians appeared to be abundant, were sent to the University of Alaska, Fairbanks. Two specimens were sent per species from certain localities (Table 1). Liver and leg muscle tissue are in ultra cold storage and the carcasses are in 95% ethanol.

Herpetofauna Sampling and Data Quality

Tadpoles tend to rest either along the shoreline or on aquatic vegetation near the surface because they are attracted to warmth. Due to this behavior, their presence in a particular habitat can be reliably quantified, provided aquatic vegetation is not too thick or the water too turbid. When tadpoles were observed we attempted to directly count the total number present per species. However, when they were too abundant to reliably count, we estimated their density per unit area using square plots. We calculated the total number present by multiplying the total area they inhabited (often very limited) by their mean density. Frogs are also attracted to warmth and were visible when present. We flushed them from vegetation by walking over as much of the transect area as possible and by searching crevices.

Salamanders were problematic due to their secretive habits. Rough-Skinned newts were the most visible salamander, usually found basking near the surface or along the shoreline. However, larvae and adults of the Northwestern Salamander are secretive hiding among debris at the bottom by day. Larvae and adults of the Long-Toed salamander are attracted to warmth and may be readily observable (Waters, pers. obs.; Hodge, 1973). However, no Long-Toed Salamanders were observed in the field, and at present caution is stressed regarding the nature of the 1991 data for this species. Adult Northwestern Salamander, Long-Toed Salamanders, and Rough-Skinned Newts migrate to breeding sites and subsequent to breeding retreat to forested cover. However, Northwestern Salamanders are known to maintain neotenic populations. Rough-Skinned Newts tend to linger in aquatic habitat through the summer.

We were only able to sample for salamander larvae along the shoreline, within 1m of the transect usually, because we lacked equipment to sample at depth where these species tend to occur during the day. Counts of salamanders, especially the Northwestern Salamander and Long-Toed Salamander are possibly unreliable.

Analysis

In-depth statistical analysis of the data is unwarranted with so few sites and observations at this time. Analysis here is limited to discerning which habitats are suitable for amphibians. The null hypothesis is that species occur evenly among all habitats. The test will consist of two parts: adult amphibian occurrence and larval amphibian occurrence.

Multiple visits were made to many of the sites. Data reported here reflect the maximum number of observations of a species within a transect, not an average or total. Comparisons will be made using one way ANOVA along with the Student-Newman-Keuls multiple comparison test if the ANOVA results in a rejection of the null hypothesis (p=0.10). Prior to analysis data will be tested for homogeneity of variance using Bartlett's test and transformed where needed. Normality will be graphically assessed (Zar, 1984).

Data represented in Figures 2-8 are species presence or absence within a site. Data from Table 3 (page 16-17) was converted to a table of 0's and 1's, summed across habitats, and averaged by dividing by the total number of sites sampled per habitat.

Results

Objective 1, 2, & 3: Habitat Relationships, Distribution, and Phenology

Exploratory data analysis of the habitat relationships of the various species of amphibians within the study site failed to detect any significant differences (p> *0.25).* This was due in part to the low sample size and to the high variability of species occurrence within all but one habitat type. Analysis of the breeding data set resulted in significant rejections ($p < 0.05$) between the outwash ponds and all other habitat types, indicating outwash ponds were the most suitable aquatic habitat for amphibian breeding in 1991. Raw captures of amphibians are presented in Table 3 and phenology in Table 4 below. Data are discussed by species.

Working definitions and physiographic interactions between these habitats were assessed during the early stages of this effort (Appendix A). An effort was made to determine which of the habitats are the least and most suitable to amphibians by two criteria: hydrologic stability and temperature. Although "hard" data are lacking to support these criteria, three months of observation within the study area and hack temperature measurements at sample sites do allow for more than speculation. Using these criteria the least suitable habitat was the Stikine River. A third supporting criteria was the aquatic plant richness (Table 2). The Stikine River was the most depauperate in aquatic vegetation compared to all other habitats. The following habitats, in order of increasing suitability (hydrologic and temperature only) are: streams, backwater sloughs, mountain lakes, backwater lakes, beaver ponds, muskegs, and outwash ponds. This ranking of habitats separated two hydrologic classes: lotic (flowing) and lentic (stillwater) habitats. Richness of aquatic vegetation increases with hydrologic stability, and warmer temperature (Table 2). The proportions of amphibian observations, using this ranking of habitats, follow a similar pattern (Figure 2).

Figure 2. Occurrence of amphibians at sites in aquatic habitats. Proportions expressed as the number of sites divided by the total sampled per habitat. Light bars represent amphibian presence. Dark bars represent evidence of amphibian breeding.

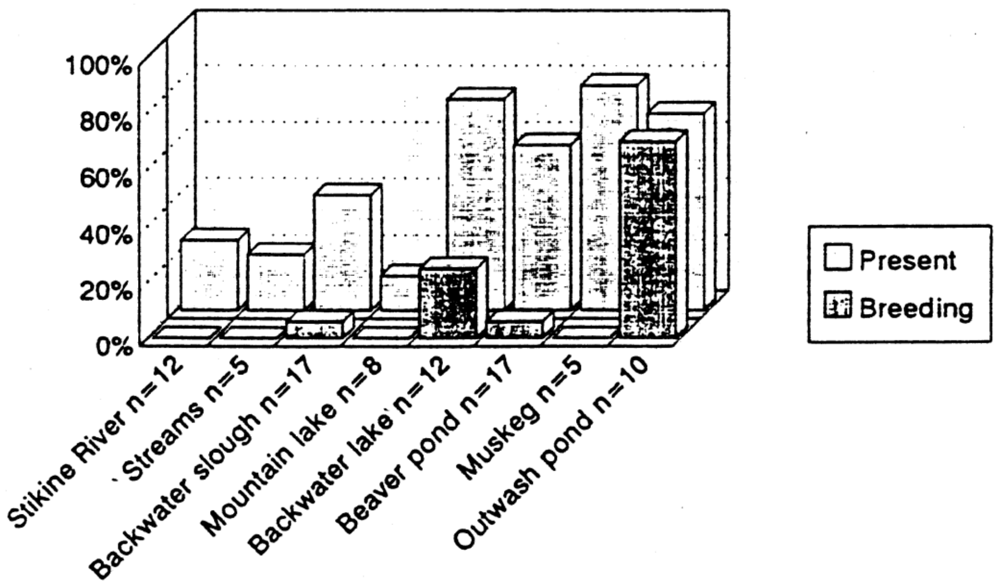


Table 2. Aquatic and semi aquatic plants encountered at aquatic habitats. Plants are arranged in descending order of most to least common. Names are either Genus or common name acc. Brayshaw (1985). Habitats are arranged least suitable (Stikine River) to most suitable (Outwash Pond).

Stikine River	Streams	Backwater Slough	Mountain Lake	Backwater Lake	Beaver Pond	Muskeg	Outwash Pond
Carex	Moss	Carex	Moss	Carex	Carex	Moss	Ceratophyllum
Equisetum	Carex	Grass	Carex	Equisetum	Equisetum	Buckbean	Potamogeton
Moss	Grass	Equisetum	Equisetum	Moss	Ceratophyllum	Algae	Nuphar
Grass	Caltha	Moss	Caltha	Grass	Potamogeton	Nuphar	Hippurus
Cotton Grass	Skunk Cabbage	Skunk Cabbage		Algae	Nuphar	Grass	Zostera
		Caltha		Caltha	Sparganium	Carex	Sparganium
		Algae		Skunk Cabbage	Moss	Sparganium	Potentilla
		Potamogeton		Potamogeton	Grass	Potamogeton	Algae
		Sparganium		Sparganium	Buckbean	Skunk Cabbage	Equisetum
					Potentilla	Potentilla	Carex
						Cotton Grass	Moss
							Juncus
							Grass
							Cotton Grass

Objective 4: Establish Permanent Monitoring Sites

Sites were indicated on aerial photographs and on a topographic map. Sites were delineated in the field by white flagging. A compass bearing of the transect line was recorded (bottom to top). Site location information, habitat type, and the number of visits to the site is presented in Appendix C. This information, in addition to the master topographic map, aerial photographs, and field notebook will allow one to return to the exact sampling points provided the flagging survives. It should be noted that on more than five occasions during the summer of 1991 we returned to sites where the flagging had been either removed or bitten and torn off, making us rely on memory to re-establish transect routes.

Objective 5: Establish Tissue Collection of Southeastern Alaskan Herpetofauna

Collection and maintenance of live amphibians was time consuming. Amphibians were only collected when the observation represented a range expansion or a large population was encountered. Amphibians that were collected are listed in Table 1.

Western Toad (Bufo boreas)

Distribution

Western Toads were observed throughout the Stikine River basin (master topographic map; Figure 1; Table 3). They were observed on Sergief Island (sites 39, 91), Dry Island (site 41), Cheliped Bay (site 67), Mallard Slough (opportunistic observation), North side of North Arm Stikine River (site 37), Limb Island (opportunistic observation), mouth of Andrews Creek (opportunistic observation), Twin Lakes (sites 1,2,3,77), top of Andrews Slough (adjacent to site 4), Shakes Slough (sites 6,7), Hot Tubs Slough (site 24,86), Blue Creek (site 26), Ketili Creek (site 27), top of Ketili River (site 79), Barnes Lake (sites 22,61,62), Mt. Flemer Cabin (site 82), Red Slough area (sites 33,70,29,28), and Kikake River (site 30). In addition, sightings of this species have been made at Crittenden Creek (mainland, site 21), Virginia Lake (mainland, site 88), Frosty Creek (mainland), Anan Creek (mainland), Wrangell Island, Mitkof Island, Etolin Island, Onslow Island, Zarembo Island, Vank Island, Sokolof Island, and Blashke Island (K. Smyth, pers. comm.).

Table 3. Summary of Stikine Area Total Observed Herpetofauna Within 50 Meter by 10 Meter Transects.

	Adults & Subadults[1]						Juveniles & Larvae						Eggmasses					
Site	BUBO	RAPR	RASY	AMGR	AMMA	TAGR	BUBO	RAPR	RASY	AMGR	AMMA	TAGR	BUBO	RAPR	RASY	AMGR	AMMA	TAGR
01	2	2																
02	4	4																
03	1	1																
04																		
05																		
06	1[2]																	
07	1																	
08		1																
09																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21							9195											
22	2	3																
23		3																
24	23	4																
25																		
26																		
27	6	1																
28	66	1																
29	14	5																
30	21																	
33	7																	
34		1																
35																		
36																		
37	2																	
39	1						4500											
40		21	2					2666	2									
41	1		1				553											
42																		
43		2				3												
45																		
46		7																
47																		
48																		
49																		
50		2																

	Adults & Subadults[1]						Juveniles & Larvae						Eggmasses					
Site	BUBO	RAPR	RASY	AMGR	AMMA	TAGR	BUBO	RAPR	RASY	AMGR	AMMA	TAGR	BUBO	RAPR	RASY	AMGR	AMMA	TAGR
51																		
52																		
53																		
54																		
55																		
56																		
57																		
58																		
59																		
60																		
61	1	2					450											
62	2	6																
63																		
64		2																
65																		
67		6					1	450										
69																		
70	1																	
71																		
72																		
73																		
74		1	1[2]															
75																		
76																		
77	3	1					150											
78																		
79		1					120											
80																		
81						2								1				
82	25																	
83		1				6												
84						20												
85						1												
86													1					
87																1		
88	4																	
89																		
90																		
91							15											
92		6																
Total	188	84	4	0	0	32	14984	3116	2	0	0	0	1	1	0	1	0	0

[1] Adult & Subadult indicate frogs and salamanders at least 1 year old (post metamorphosis).
[2] Observation made adjacent to transect.

BUBO = Western Toad (Bufo boreas), RAPR = Spotted Frog (Rana pretiosa), RASY = Wood Frog (Rana sylvatica), AMGR = Northwestern Salamander (Ambystoma gracile), AMMA = Long-Toed Salamander (Ambystoma macrodactylum), TAGR = Rough-Skinned Newt (Taricha granulosa)

Phenology

Toads deposited their eggmasses in May and early June (later in higher elevation and colder sites). Metamorphosis occurred in mid-July and proceeded through August (Table 4). Nine breeding sites were observed. The approximate time for eggmass deposition was determined by giving two weeks for development and one week for every 4-5 millimeters of growth (based on observations at Crittenden Creek). The only eggmass observed was at Hot Tubs Slough (site 86), on June 4. Tadpoles and young of year juvenile toads were observed at Cheliped Bay (Juveniles, August 14: site 67), Dry Island (Tadpoles, June 25; Juveniles, August 14: site 41), Sergief Island (Tadpoles, June 21; Tadpoles, July 26: site 39; Tadpoles, July 26: site 91), Crittenden Creek (Tadpoles, June 3; Tadpoles, June 17; Tadpoles and Juveniles, July 15: site 21), Twin Lakes (Tadpoles, August 7: site 77), Hot Tubs Slough (Eggmass, June 4: site 86), top end of Ketili River (Juveniles, August 29: site 79), and Barnes Lake (Tadpoles, July 24: site 61). Very young tadpoles were observed at the headwaters muskeg at Long Lake, Wrangell Island, in the third week of June (none were observed on May 24).

Table 4. 1991 Phenological Reconstruction, Stikine Area, Tongass NF. Note incomplete data on timing of metamorphosis.

	Northwestern Salamander[1]	**Long-Toed Salamander**[2]	**Rough-Skinned Newt**[3]	**Western Toad**[4]	**Spotted Frog**[5]	**Wood Frog**[6]
January			HIBERNATION			
February			HIBERNATION			
March			EMERGENCE			
April		BREEDING			BREEDING	BREEDING
May	BREEDING		BREEDING	BREEDING		
June			BREEDING	BREEDING		META-MORPHOSIS
July				META-MORPHOSIS	META-MORPHOSIS	META-MORPHOSIS
August				META-MORPHOSIS		
September						
October			HIBERNATION			
November			HIBERNATION			
December			HIBERNATION			

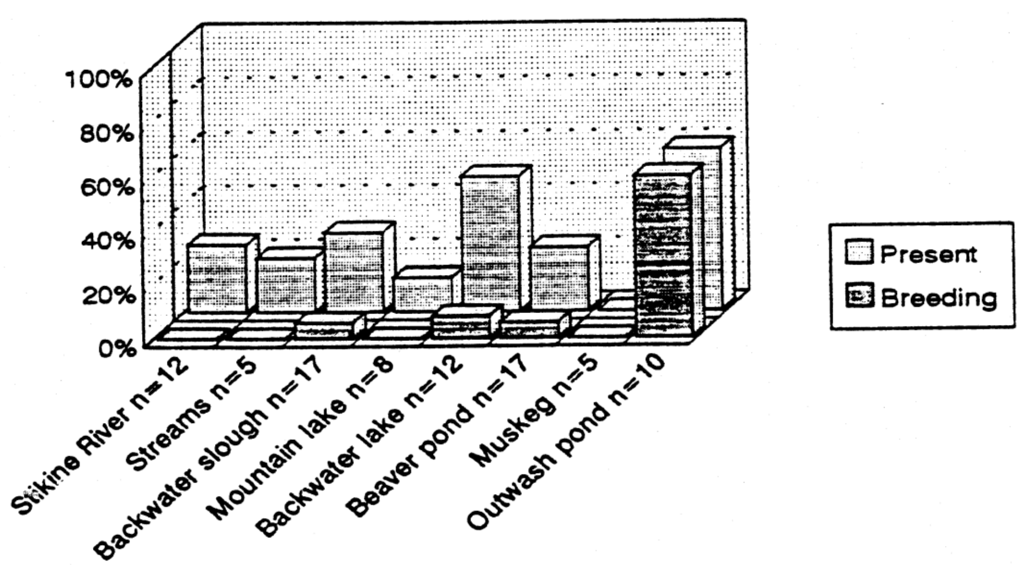
[1] Northwestern Salamander (Ambystoma gracile)
[2] Long-Toed Salamander (Ambystoma macrodactylum)
[3] Rough-Skinned Newt (Taricha granulosa)
[4] Western Toad (Bufo boreas)
[5] Spotted Frog (Rana pretiosa)
[6] Wood Frog (Rana sylvatica)

Habitat Associations

The Western Toad displays a broad range of habitat use (Figure 3). Toads were predominantly observed breeding in outwash ponds, and also in a backwater slough, backwater lake, and beaver pond. Western toads breed in muskegs (as was observed on Wrangell Island) though none were observed in muskegs within the Stikine River basin, possibly due to the small sample size. Sub-adult toads were observed at a single mountain lake (site 88, Virginia Lake). Many observations were made in areas that appeared to be marginal breeding habitat (such as site 4,26,30,82,88; Table 3). This species probably spends much of its time wandering during its non-reproductive years. The sample most likely reflects the dispersal capability of this species. Toads overwinter in forested cover adjacent to aquatic habitat.

Of the amphibians observed, the Western toad demonstrated the most variability in habitat use and environmental tolerances. Western toads bred in saline outwash ponds which were periodically inundated by tides. These ponds include: Crittenden Creek (site 21), Sergief Island (site 39,41), and Dry Island (site 91). No other amphibians were observed in saline ponds. Tadpoles and juveniles were observed at an alkaline outwash pond (site 41; pH= 10.3 on June *25,* pH= 10.2 on August 8), and in a slightly acidic beaver pond (site 61; pH=6.2 on July 24).

Figure 3. Occurrence of Western Toads (Bufo boreas) at sites in aquatic habitats.



Spotted Frog (<u>Rana</u> <u>pretiosa</u>)

Distribution

Spotted frogs were observed throughout the study area (master topographic map; Figure 1; Table 3). They were observed at Cheliped Bay (site 67), Mallard Slough (site 41), Government Lake (site 83), Andrews Creek (site 43,46,64), Twin Lakes (site 1,2,3,77,81), Shakes Slough (site 8,92), Hot Tubs Slough (site 24,86), Ketili Creek (site 27), top end of Ketili River (site 79), Barnes Lake (site 22,23,34,61,62), and Red Slough (site 28,29). In addition, sightings of this species have been made on Vank Island and several locations on Mitkof Island (C. Iverson, pers. comm.).

Phenology

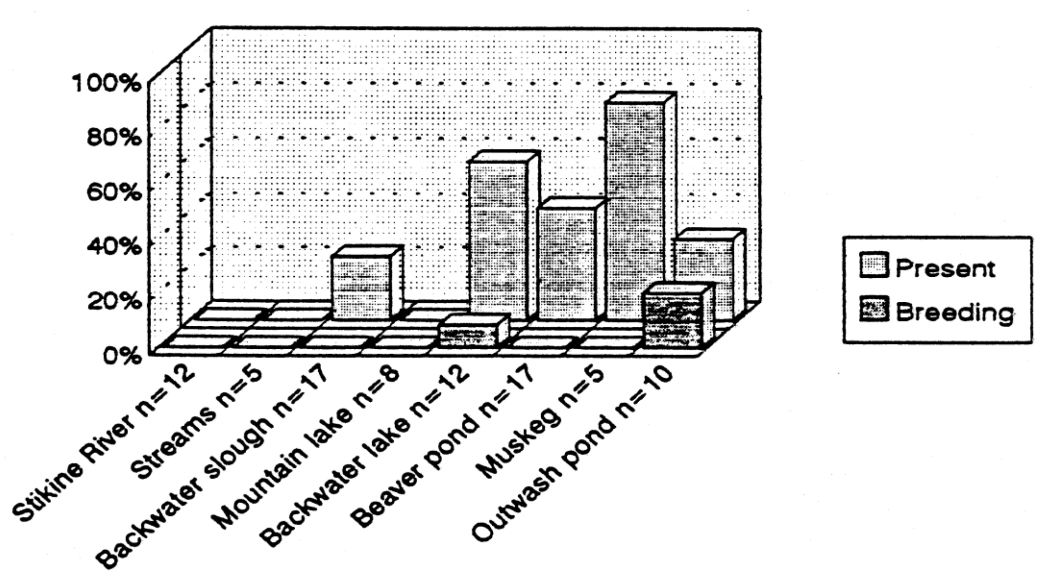
Breeding probably commenced in April and continued through mid-May. Metamorphosis began in late July and continued through August (Table 4). Three breeding sites of the Spotted frog were observed. A single eggmass was observed at Twin Lakes on June 4. Tadpoles and young of year juveniles were observed at Cheliped Bay (Tadpoles and Juveniles, August 14: site 67), and Mallard Slough (Tadpoles, June *25;* Tadpoles and Juveniles, August 1: site 40), Twin Lakes (Eggmass, June4: site 81).

Habitat Associations

Spotted frogs were predominantly observed breeding in outwash ponds and in a backwater lake. It is likely they breed in muskegs and beaver ponds, which can be surmised from the high incidence of sites that had frogs (Figure 4). Spotted frogs were always observed in close proximity to aquatic habitat. Spotted Frogs ranged up to a muskeg adjacent to Government Lake, at an elevation of 320 feet above the river valley. Many observations of this species were made in areas that appeared to be good breeding habitat (site 1, 2, 3, 22, 23, 24, 27, 28, 29, 43, 46, 51, 52, 61, 62, 64, etc.) yet no breeding was observed. The situation is not clear. This species overwinters in aquatic habitat.

Note: Three dead sub-adult Spotted Frogs were observed at Hot Tubs Slough on June 19. They were in the interface between the hot spring inlet and the Stikine River backwater channel. All were moderately decayed. No evidence of “red leg” disease was present. Cause of death is not known, although thermal shock is a possible candidate.

Figure 4. Occurrence of Spotted Frogs (<u>Rana</u> <u>pretiosa</u>) at sites in aquatic habitats.



Wood Frog (Rana sylvatica)

Distribution

The distribution of Wood frogs in the Stikine River basin is not clear. Four Wood frogs were observed at three sites (master topographic map; Figure 1 ; Table 3): Mallard Slough (site 40), Dry Island (site 41), and Shakes Slough (site 74). Previous reports of this species have been made at Mallard Slough, Twin Lakes, and Hot Tubs Slough (Hodge, 1976). Sightings of this species have been made on Mitkof Island (Hodge, 1976) and possibly Wrangell Island (Pat's Lake, March 1991, H.Hall, pers. comm.).

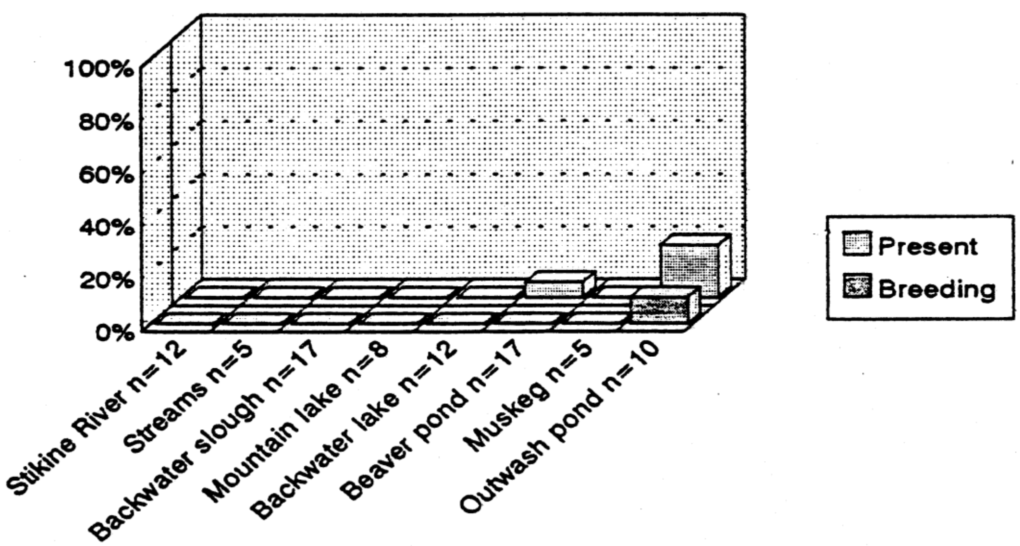
Phenology

A single Wood Frog breeding site was observed at Mallard Slough (Juveniles, August 14: site 40). In mid-April an interagency team of biologists conducting a shorebird census at Mallard Slough and Cheliped Bay (along the North Arm of the Stikine River) heard what was described as "the quacking of ducks" which turned out to be frogs calling. This description matches the literature descriptions of the mating call of the Wood Frog (Stebbins, 1985; Conant and Collins, 1991). The Wood Frog is known to initiate breeding even when ponds are still partially ice covered. In the Stikine River basin, this would have corresponded in 1991 to the spring break-up period of March, April, and early May. Time of metamorphosis is not clear, but growth probably takes two months, and metamorphosis would likely occur in July, and possibly in June (Table 4). This species is known to be highly migratory and may traverse significant distances like the Western Toad.

Habitat Associations

The habitat associations of this species are not clear (Figure 5). Wood frogs were principally observed adjacent to outwash ponds (site 40, 41) and near a beaver pond (site 74). It is likely this species uses muskegs and backwater lakes. This species uses forested cover adjacent to aquatic habitat for foraging and overwintering habitat.

Figure 5. Occurrence of Wood Frogs (Rana sylvatica) at sites in aquatic habitats.



Northwestern Salamander (<u>Ambystoma</u> <u>gracile</u>)

Distribution

One observation of this species was made at Twin Lakes (site 87; master topographic map; Figure 1; Table 3). This represents the first report of this species in the Stikine Area. This species has previously been reported from Chichagof Island (Pelican; Hodge, 1986) and Mary Island (Hodge, 1976). The distribution of this species within the Stikine River basin is unclear.

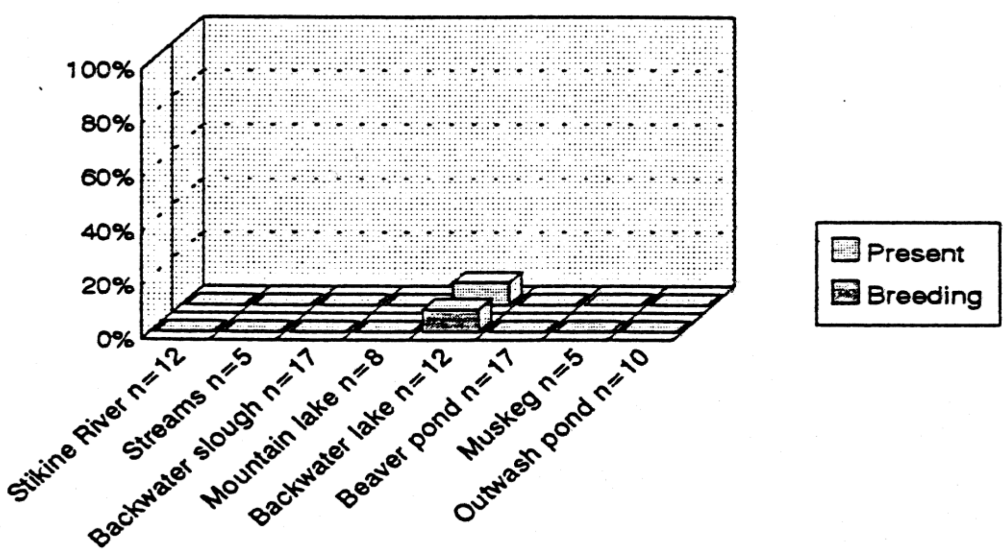
Phenology

An eggmass of the Northwestern Salamander, containing approximately 150 eggs in a solid 3” x *5”* globular mass, was observed at Twin Lakes (site 87) on June 12. It was lying ashore next to a hot spring. Apparently something had detached it from its submerged position, dragged it ashore, and had eaten part of the eggmass. We re-submerged the remaining eggs a short distance away. No specimens were collected. The embryos had reached stage 8-9 (pg. 130 Duellman and Trueb, 1986) indicating it had recently been deposited, probably the first week of June (Table 4). The terrestrial adults of this species are migratory, spending only a short time at breeding sites before leaving. However, neotenic forms may be present in hydrologically stable environments, as is the case at the Pelican population (Hodge, 1986).

Habitat Associations

Habitat associations of this species are unclear (Figure 6). Twin Lakes, a backwater lake, is the only known site this species occupies in the Stikine Area. No other habitat associations, aside from their occurrence in muskegs (Hodge, 1976; Hodge, 1986), are known. It is likely they breed in outwash ponds and beaver ponds, and possibly mountain lakes. The terrestrial form of this species uses forested cover adjacent to aquatic habitat for foraging and overwintering habitat. Observations of this species in California show they are capable of migrating at least 1 mile to breeding sites (Waters, pers. obs.). Larvae are capable of metamorphosing within 1 season, but can require up to three seasons to metamorphose, requiring a permanent or semi-permanent source of water.

Figure 6. Occurrence of Northwestern Salamanders (Ambystoma gracile) at sites in aquatic habitats.



Long-Toed Salamander (Ambystoma macrodactylum)

Distribution

No field observations of this species were made (Table 3). Four specimens were brought from Mallard Slough to Wrangell Island in mid-May and shown to the author. This species was previously reported from Twin Lakes (master topographic map; Figure 1; Hodge 1973; Hodge 1976).

Phenology

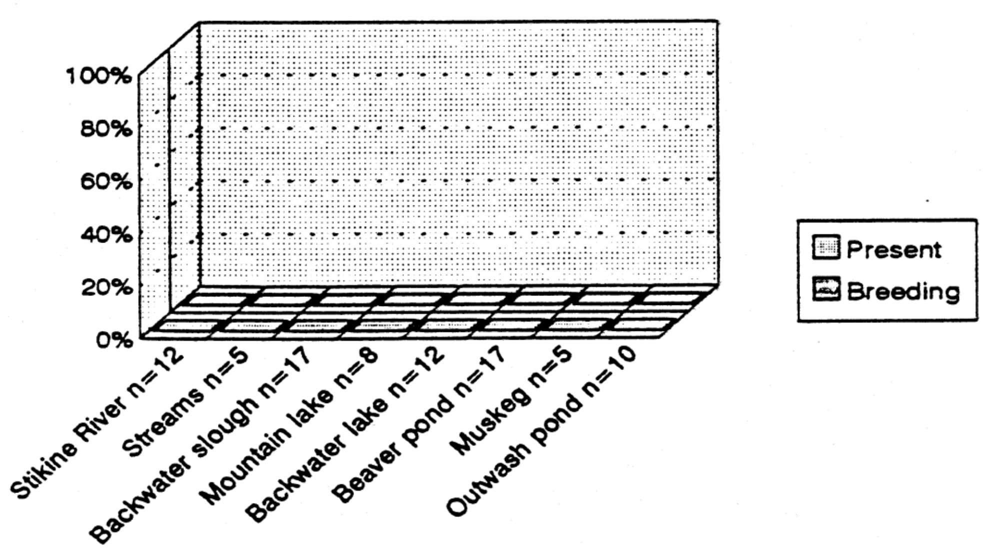
Spent female Long-Toed Salamanders were among the specimens brought to Wrangell in mid-May. It is reasonable to conclude that this species breeds in May and probably in April (Table 4), because this species, like the Wood frog, is known to enter ponds before they are ice free (Beneski, et al. 1986). Time of metamorphosis can be highly variable, depending on altitude (Howard and Wallace, 1985) with populations at low elevation being capable of metamorphosing within one season, and at higher elevations up to three seasons. This species migrates to breeding sites and leaves shortly after breeding. The salamanders that were brought to Wrangell were found under wood a short distance from a pond.

Habitat Associations

No sightings of this species were made during the field season, leaving habitat associations uncertain (Figure 7). Long-toed salamanders were brought from Mallard Slough prior to my arrival in the study area. Hodge (1973) made the first recorded sighting of this species at Twin Lakes. The habitats at Mallard Slough are predominantly outwash ponds whereas Twin Lakes is a backwater lake. It is likely this species also breeds in beaver ponds and muskegs. Mountain lakes may also be used by Long-Toed Salamanders (Stebbins, 1985). This species uses forested cover adjacent to breeding ponds for foraging and overwintering habitat. Larvae are capable of metamorphosing within one season, but can take up to three seasons to metamorphose, requiring a permanent or semi-permanent source of water.

Note: Hodge (1973) published the first observation of the Long-Toed Salamander in Alaska at Twin Lakes on the Stikine River, an area we heavily sampled. He visited the area in July and August (Hodge, pers. comm.) and found salamanders near shore where we would have expected to observe them. We failed to observe any Long-Toed Salamanders, raising the possibility that the species has become locally extinct in the Twin Lakes area, and possibly throughout the lower Stikine River basin.

Figure 7. Occurrence of Long-Toed Salamanders (<u>Ambystoma</u> <u>macrodactylum</u>) at sites in aquatic habitats.



Rough-Skinned Newt (Taricha granulosa)

Distribution

Newts were observed in only a few areas (master topographic map; Figure 1; Table 3). They were observed at Government Lake (site 83,84), Twin Lakes (site 81), Andrews Creek (site 43), and Paradise Slough (site 85). In addition sightings of this species were made on Sergief Island (Stikine River; B.Messmer), Vank Island, Zarembo Island, Wrangell Island, Etolin Island, and Mitkof Island. This species is widely distributed throughout the Stikine River basin and surrounding areas.

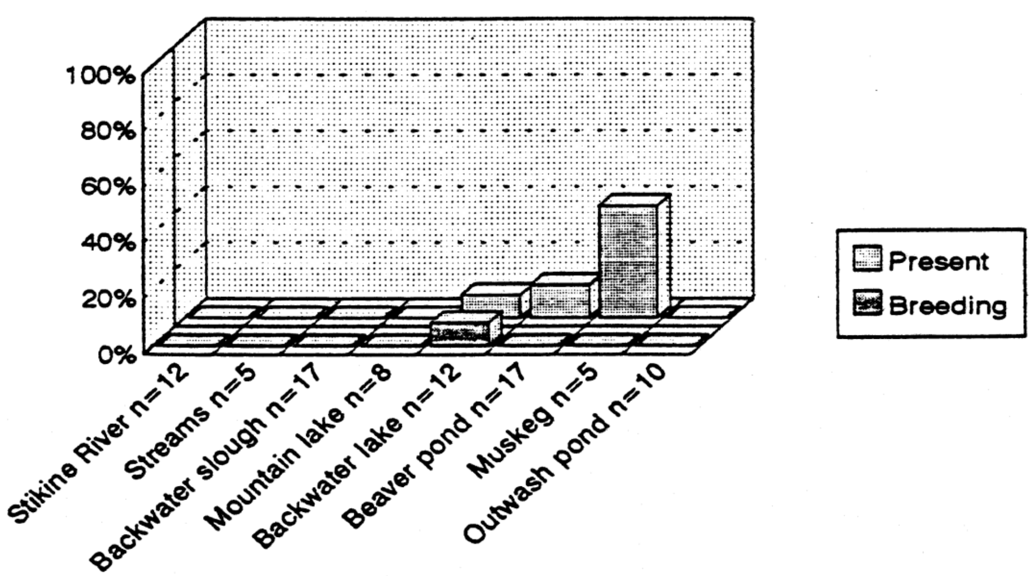
Phenology

Breeding probably commenced in May and continued into June (Table 4). Amplecting pairs of newts were observed the last week of May on Wrangell Island and at Twin Lakes (site 81) the first week of June. Metamorphosis may range from I season to 2 seasons, depending on altitude and site conditions. Larvae were observed in a muskeg pond on Wrangell Island the last week of May. These larvae were relatively large (25 mm SVL) indicating they were 2 seasons old but showed no sign of impending metamorphosis. It is possible the larvae metamorphose in July and August. The eggs of this species are difficult to observe because they are deposited individually among aquatic vegetation (each egg is about 8 mm in diameter). This species develops secondary sexual characters during the breeding season. A mixture of males and females at a site could be used to determine whether the site was used for breeding.

Habitat Associations

Habitat associations of this species are sketchy (Figure 8). Rough-Skinned Newts were observed breeding in a backwater lake and in muskegs on Wrangell Island. Concentrations of newts were observed at a muskeg and beaver pond adjacent to Government Lake (site 83, 84). A single newt with breeding characters was observed in a backwater slough (site 85). Newts may not spend the summer in cold and hydrologically unstable habitats. In these situations they migrate to breeding sites in the spring but leave soon after the breeding season (this was observed at Twin Lakes). Mountain lakes may be used by this species. Newts were abundant in several mountain lakes on Wrangell Island. Newts were not observed in outwash ponds, but they probably use them. This species uses forested cover adjacent to aquatic habitat for foraging and overwintering habitat.

Figure 8. Occurrence of Rough-Skinned Newts (Taricha granulosa) at sites in aquatic habitats.



Discussion

This project resulted in three notable range expansions for three species: the first sighting of the Pacific Tree-Frog (Hyla regilla) in Alaska (Ketchikan), a new island locality of the Spotted Frog (Rana pretiosa), Vank Island, and an interior range expansion of the Northwestern Salamander (Ambystoma gracile) at Twin Lakes, Stikine River basin. Many recorded sightings of amphibians were made in the study area and in adjacent areas that significantly increased the knowledge of amphibians in Southeast Alaska, a relative void among zoologists, wildlife managers, scientific literature, and vertebrate museum records.

We established permanent monitoring stations (sites where flagging was hung) at 74 sites. The exceptions are areas we visited only briefly while en route to other areas, were under a time constraint due to changing weather conditions, or scheduling (such as the float plane). Sites where we did not establish permanent monitoring stations are 81-92.

Concentrating Future Efforts Within The Stikine River Basin

Several areas demonstrated themselves to be consistently productive for amphibian observations and involved but few logistical hardships. Cabins are available in close proximity to most of these areas as well. Mallard Slough and Cheliped Bay are highly productive areas for amphibians, as are Crittenden Creek, Sergief Island, Dry Island, Twin Lakes, Andrews Creek area, Hot Tubs Slough, Barnes Lake area, and Red Slough area. Of these sites Barnes Lake represents the most difficult area to reach, but is worth the time due to its productivity.

Protocol Development

A prototype habitat typing method was developed for use in the Stikine River basin along with working definitions of the habitats. Amphibian occurrence appeared to be related to hydrologic stability and water temperature, which varies by habitat type. These are objective criteria that allow habitat types to be sorted into the order of least to most suitable for amphibian breeding. The assumption of this procedure is that lentic adapted amphibians (which includes all the species known to occur in Alaska) prefer productive, warm, and stable environments.

Aquatic plant richness increases with increasing hydrologic stability and warmer water temperatures. These three factors are interrelated. The diversity of the aquatic plant community would probably be a very strong indicator of the suitability of a particular site for amphibian reproduction. Hydrologic stability and water temperature regime are expensive variables to measure, requiring equipment and personnel to monitor habitats on a continual basis, but they can be reasonably estimated or ranked in the correct order based on hack measurements and visual observations. Assessing the aquatic plant species is an economical alternative.

The majority of aquatic plant species that occur in British Columbia and Southeast Alaska require warmth and hydrologic stability (Brayshaw, 1985). Sites that are constantly under the pressure of physiographic change are difficult situations to prosper in because they demand a species to be highly tolerant, which itself is a specialization and a limiting factor on local species richness. Amphibians, as with many organisms in general, are highly specialized for a specific range of ecological conditions. However, the extant ecological conditions and species specific habitat preferendum are poorly understood in Southeast Alaska.

Habitat Sampling Recommendations

I suggest that future fieldwork concentrate on lentic habitats. In particular: outwash ponds, muskegs, beaver ponds, and backwater lakes. Aquatic plant diversity is greatest in these habitats, and the great majority of amphibian observations (accounting for all species) were made in them (Figure 2). Amphibians were not observed breeding in any other habitat type other than backwater sloughs. This does not rule out amphibian breeding activity in mountain lakes. However, the difficulty of reaching mountain lakes when amphibians may be breeding is probably insurmountable because float planes can only land on very large lakes and they must be ice free. Landing sites for helicopters are also not available.

The principle problem with sampling backwater sloughs arises when river level fluctuations are taken into account. Many backwater sloughs that would be desirable to sample within are impassible much of the time. Amphibians breed in early and mid-spring and most channels would be impassible during that time. When the river rises, it is likely larvae would have dispersed or become virtually unnoticeable. Funnel traps deployed in the channels, or sweep-net surveys would probably enable observers to detect them.

Additional sightings of amphibians throughout the Alexander Archipelago were gathered during the 1991 field season. The ranges of amphibians that occur in the Alexander Archipelago and in adjacent areas are presented in Appendix D. Biogeographical analysis of the ranges of amphibians that occur in or near the Alexander Archipelago indicate the possibility of several species of herpetofauna that may as yet be undetected in the area

(Appendix D). Streams should be cursorily surveyed for amphibians, in particular mountain torrents, on the western edge of the Alexander Archipelago and the Ketchikan area, for the tailed frog (Ascaphus truei). The sampling procedure involves overturning stones in riffles and holding a dipnet downstream to catch the dislodged amphibians. Tadpoles and frogs will be swept into the dipnet if present in the stream. The nearest known population to Alaska is Kitimat, BC.

Protocol Modifications

At the selected areas (mentioned above) two continuous days should be spent sampling a particular area. At pre-established sites and new sample sites a funnel trap should be set to detect salamanders. This trap should be deployed for 24 hours and placed in the center transect section, or in a place the observer feels salamanders are likely to be encountered. This may involve some mortality of amphibians, but would add a measure of robustness to the sampling effort. The two day visit would allow observers to sample a site twice within 24 hours for amphibians thus adding more strength to the observers ability to detect amphibians.

Ecological measurements that probably should be incorporated into the sampling protocol are conductivity (EC), a more direct and reliable way of measuring salinity than the “taste test” we employed out of necessity, and would enable other ecological interactions to be discerned. Turbidity (using a Nephelometer) would complete the water chemistry data.

If long-term monitoring of amphibians is an objective that meshes with the needs of the funding agencies, I recommend an additional level of sampling from the transect approach. This would involve gathering ecological data, mapping aquatic habitat, and thoroughly sampling each habitat. The current sampling approach was designed to determine which habitats are primarily used by amphibians. A mark-recapture program could be initiated at Mallard Slough, an area that deserves attention. This area has gentle topography, open grassland, and numerous ponds, relatively easy access, a good cabin, and apparently a large population of amphibians.

Timing of Sampling

The project would have yielded more herpetofauna observations if the fieldwork had begun in April when amphibians were actively breeding. Data that are reported here are biased in that they may give the *possibly* false impression that amphibians are scarce within the project area. Working in Alaska presents several limitations upon performing fieldwork within the Stikine River basin, such as foul weather during the early spring, and ice in the river. However, the Mallard Slough and Cheliped Bay areas are on the edge of the basin and are reachable throughout the spring. Fieldwork could begin there and progress upriver as conditions improve.

Suitable Breeding Habitat as a Limiting Factor to Amphibian Populations

Preconceived notions, prior to entering the field, led me to believe that the study area, being a wilderness with abundant wetlands, and being relatively unimpacted, ought to support a large population of amphibians. Several observations indicate that this is not the case at this time. Initiating field work in June, as was done in 1991, strongly affected our ability to locate eggmasses, but should not have adversely affected our ability to observe larval amphibians, especially tadpoles (as stated on page 12). Adult amphibians do tend to linger in aquatic habitats for a time subsequent to breeding. We tested the idea that amphibians were more active at night and conducted a midnight survey of Twin Lakes, a touted amphibian “hotspot” , and found fewer amphibians than during the day (using a spotlight looking for eyeshines, sweep-net samples, and on the ground transect surveys, sampled the same day prior to night work, and the day after). This leads to the assertion that the data, although apparently “sparse” in the number of amphibian observations in general, especially of breeding populations, reflect the local conditions present at the site and are not an artifact of a poorly executed survey.

A second observation is of the distribution of aquatic habitats in the Stikine River basin. Seven of the eleven habitats (not individual “sites”) where breeding populations were observed were in outwash ponds, judged here to be the most suitable breeding habitat available. Outwash ponds predominate in Mallard Slough, Cheliped Bay, and in the tidal flats on Sergief Island, Dry Island, and elsewhere along the coastline. Few, if any outwash ponds, exist further up the Stikine Basin, which indicates that amphibians would be most abundant in the lower Stikine River basin. The majority of suitable aquatic habitat higher up the basin consists of muskeg, beaver ponds, backwater lakes, backwater sloughs, and mountain lakes. The distribution of these habitats is highly variable. Clusters of suitable breeding habitat are to be found throughout the Stikine River basin, and in these pockets substantial numbers of amphibians and breeding sites were observed (Table 3, Appendix C, Figure 1, master topographic map). These areas were pointed out on page 31.

A third observation is of possible importance. Large numbers of recently metamorphosed (in 1990) juvenile Western toads were observed in several localities, but breeding was not observed in those localities in 1991. Do these pockets of juvenile toads indicate the presence of a breeding site used the year before or did they disperse from another site? The Red Slough area deserves a closer look, as several sites contained large numbers of juvenile toads, but several of the sites were clearly unsuitable (isolated on sand spits, along the Stikine River). The most parsimonious explanation is that they dispersed from another locality.

The data, aside from observations of larval amphibians and eggmasses, probably contains a large number of sites that were occupied by amphibians for part of the year, but were not used for reproduction. This view is supported by the “typical” number of observations made at a site, usually one or two individual amphibians. A breeding population would contain a diverse mixture of age-classes and sexes: adults, sub-adults, juveniles, larvae, and eggmasses. These conditions were observed in only a few instances (Table 3).

The nature of the salamander data could be construed as poor, at best. This is probably due to their scarcity within the Stikine River basin. Hodge (1973) discovered the Long-toed salamander at Twin Lakes, observing several in June-July. Specimens were brought from Mallard Slough in 1991 and shown to the author. We failed to observe any Long-toed salamanders despite extensive surveys in Mallard Slough and elsewhere in the basin throughout the summer of 1991. This raises the possibility that Long-toed salamanders have declined. Wrangell residents and long employed USFS employees recall in the mid-1970’s of seeing numerous amphibians at Twin Lakes, yet we only managed to observe a very limited number, possibly indicating that amphibian populations have been depressed.

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Appendix A. Habitat Types and classification

Table 5. Field Classification of Aquatic Habitats.

	BL Backwater Lake	BS Backwater Slough	ML Mountain Lake	BP Beaver Pond	M Muskeg	OP Outwash Pond	SR Stikine River	S Streams
Aquatic[1]	+[2]	+	+	+	+	+	+	+
Tidal Influence	-	-	-	-	-	+/-	+/-	+/-
Stikine waters	-	-	-	-	-	-	+	-
H_20 contained by plants	-	-	-	-	+	-	-	-
H_20 controlled by Stikine	+	+	-	-	-	-	-	-
H_2O controlled by Beavers	-	-	-	+	-	-	-	-
H_2O controlled by Geology	-	-	+	-	-	+	-	+
Substrate Alluvium	+	+	-	+/-	+/-	+/-	+	-
Substrate Glacial	-	+	-	+/-	+/-	+/-	-	-
Broad	+	-	+	+/-	+/-	+	-	-

[1] Criteria are described on page 42.

[2] + = Yes - = No +/- = Both Yes and No possible

Working Definitions of Habitat Types

Backwater Lake-BL

A "backwater lake" is a broad expanse of water that is backed up by hydraulic force, in this case the Stikine River. The water level in the lake depends on the volume in the Stikine River, which changes on a daily basis.

Backwater Slough-BS

A "backwater slough" is a narrow expanse of backed up water, in this case a backed up stream channel. The major difference between a "backwater lake" and a "backwater slough" is the slough flows at a noticeable rate, backfilling as the river rises, and flowing outward as the river drops. Beavers favor these habitats and dam up sections of channels which backflood extensive areas, especially adjacent to Ketili Slough.

Mountain Lake-ML

A "mountain lake" is a cirque lake, or a similar lake formed by glaciation. Bedrock serves as the limiting depth factor in cirque lakes whereas a moraine (boulders, cobbles, and sediment) may be the limiting depth factor in some situations.

Beaver Pond-BP

"Beaver ponds" (lentic) are built adjacent to the Stikine River in backwater sloughs, streams, backwater lakes, and higher upslope in and adjacent to mountain lakes. Beaver ponds are a very important source of stillwater habitat (Naiman, 1988; Naiman et al., 1988).

Muskeg-M

"Muskegs" (more commonly known as "heath" or "raised bog") are formed by the interactions of two varieties of sphagnum moss, one which rots quickly, the other slowly. The result is a pockmarked microtopography which has depressions filled with water (hollows) and elevated areas (hummocks; Johnson and Damman, 1991). Muskegs develop in areas of fairly constant moisture, such as on exposed bedrock shelves carved by glaciation, cirque lakes, or through a variety of factors that lead to increased ground moisture retention. Muskegs have elements of both lentic and lotic systems.

Outwash Pond-OP

"Outwash ponds" originate in two patterns, one similar to the formation of oxbow lakes and the other through outwash erosion. Artificial ponds, closely resembling natural ponds, were blasted (see Regional Physiography section, below). Outwash ponds could be split into several classes, including "glacial outwash pond", "alluvial outwash pond" , "oxbow pond" , and "tidal pond" . These pond types superficially resemble each other, although different physicochemical processes operate within them and the vegetation communities are distinct. Outwash ponds typically appear to be lentic with no surface water exchange occurring during the summer, however, some ponds, notably in the tidal zone, have a single outlet through which marine water enters and exits during tidal shifts.

Stikine River-SR

The Stikine River is the dominant force on the landscape. The river level changes on a daily basis and carries tremendous amounts of sediment. The ever-changing water level makes the margin of the Stikine River chaotic and ill suited for aquatic plant colonization.

Streams-S

A "stream" is a free-flowing body of water that is not controlled by any factor other than the bedrock beneath it and the absence of hydraulic control by the Stikine River. Otherwise it would be called a "backwater slough".

Habitat Typing Methods

Sites were classified into several categories based on ten subjective criteria that yield explicit yes or no answers. Habitat types were classified according to criteria that were mutually exclusive and allowed one to discriminate habitat types in the field based on visual observations.

1. Aquatic? (At least 2% water in transect)
2. Regular tidal influence? (At least once a month, based on proximity to ocean, salinity, and seaweed)
3. Water source is Stikine River? (From the headwaters)
4. Water depth is botanically controlled? (Vegetation traps water, i.e. moss in muskeg)
5. Water depth is hydraulically controlled? (Water from Stikine River backs up stream outlet)
6. Water depth is beaver dam controlled? (Beaver dam traps water)
7. Water depth is geomorphically controlled? (Sediment, moraine, or bedrock traps water)
8. Substrate is alluvial deposit? (Sediments deposited by Stikine River)
9. Substrate is glacial outwash deposit? (Glacial terminus deposits)
10. Water expanse is broad? (Length to width ratio)

The method is based on a no answer implying the logical alternative. If a “no” answer is given to “aquatic?” , the logical alternative is that it is “not aquatic” , and therefore a terrestrial environment. Successive answers indicate the forces that affect the local environment of the site.

Questions 4-7 are mutually exclusive. It is an “either or” chain of questions. If “no” is given to all, then provided “yes” was given to “aquatic?” , the logical conclusion is that the aquatic habitat is lotic (flowing).

Question 8 and 9 are also mutually exclusive. A “no” answer to both questions implies a sedimentary origin apart from either the direct action of glaciers or the Stikine River (where in both situations the sediment has been transported), in that the sediment is endemic. This situation tends to occur in “streams”.

Question 10 is directed at separating “backwater sloughs” from “backwater lakes”. The relative water expanse is the most significant physical distinction between the two habitats. It could be argued that the Stikine River, fully a half mile across in some places, should be called broad. However, if it is considered that the river is several hundred miles long, then it turns out to be rather “narrow” when the scale of the river is considered.

Regional Physiography

Stikine River Physiography

The Stikine River basin is a glacial valley 2 to 2.5 miles wide on average. During peak summer flows the river occupies 0.5 miles or more of the valley floor. Within the valley the Stikine River tends to braid between islands formed by depositional sediments. Extensive alluvial and outwash plains bound the main channel. Glacial rock flour is the bulk of the material deposited within the basin, forming extensive alluvial plains and sand bars, some of which eventually become islands. Beavers (Castor canadaensis) are very abundant and construct dams which backflood extensive areas throughout the basin. Muskegs are limited chiefly to areas above the flood level of the river. The outlets of many streams that empty into the Stikine River become inundated during peak spring and summer flows.

Island Physiography

Many of the islands in the river basin, particularly near the mouth, are elevated in places from 5-20 meters above the peak summer flow level. Many appear to be tilted. However, when the summer flows subside, sand bars and the margins of islands become exposed to the atmosphere. Sand dunes develop in the river bottom, the most exposed of which can be observed on Andrew Island and Limb Island. The tilted appearance of the islands can be accounted for by dunes only developing immediately along the river. If the dune and sand bar persist and additional sediment is deposited, an island will develop. The erosional pattern that develops on the leeward side of the island is akin to an outwash plain, where numerous stream channels carve through the sediment and interconnect. These riparian areas are colonized by beavers and dams built at the outlets form ponds. However, not all areas are conducive to beavers (such as in the tidal zone) or the hydrology changes and the site becomes less favorable. Small “outwash ponds” can form when the outflowing channels become blocked by sediment (notably on upper Limb Island).

Tidal Flat Physiography

Tidal flats of the Stikine River delta lie adjacent to Sergief Island, Farm Island, and Dry Island. Tidal flats north of Dry Island (Mallard Slough and Cheliped Bay) are classified as glacial deposits, independent of deposition by the Stikine River. Runoff from the parent island flows onto the alluvium and erosion proceeds similarly to the outwash plain pattern. The tidal flats on Sergief Island, Farm Island, and Dry Island are elevated above the peak summer flows by approximately one foot. However, during the tidal surge, depending on the magnitude, portions of the flats are inundated. Consequently, the vegetation growing on the flats is adapted to brackish conditions. Many small ponds dot the tidal flats. Most are natural, however, a limited number (at least 80) were blasted during the early 1970's as part of a waterfowl enhancement project. Check dams were constructed in several of the sloughs and continue to function today. The blasted ponds can be distinguished from the natural ponds by the presence of sediment mounds on the perimeter, material that was blasted out. Otherwise, no other differences are readily noticeable.

Recent Glaciation

A significant influence upon the physiography of the Stikine River basin is the lingering effect of the "little ice age" (Bradley, 1985). During this time the Le Conte, Shakes, and Popof Glaciers advanced into the river valley, as evidenced by their enduring terminal moraines. The Le Conte glacier experienced two periods of advancement or a single advancement with a delayed ablation. The oldest moraine is represented by the remains of a lobate terminus at Mallard Slough. The slough itself is an outwash plain from this terminus. A more recent moraine is represented by a smaller terminus close to the opening of Le Conte Bay. "Cheliped Bay" (just north of Mallard Slough) is the outwash plain of the most recent terminus. Shakes Glacier advanced as far as the current position of the Stikine River. The lobate terminus has been colonized by beavers and is clearly delineated on aerial photos and on the topographic map of the area. The region behind the terminus is known as Shakes Slough. Popof Glacier is a hanging glacier that may have only advanced as far as the river valley adjacent to Shakes Slough. The outflow from Popof Glacier is Dry Wash Creek and forms an outwash plain. Mallard Slough, Cheliped Bay, and Shakes Slough have important geomorphic features which are conducive to the formation of lentic habitat.

Beaver Influence

An empirical estimate of the percentage of the lentic habitat in the Stikine River valley that was created by beavers is 90 percent (surface area). Beavers exert a great influence on the habitat potentially available to herpetofauna (Naiman et al., 1988). Where beaver dams tend to be constructed has been discussed to some length. There are some features of beaver dams and the activity of beavers that need elaboration. Beavers are herbivorous and forage on aquatic vegetation. They are most active in the vicinity of the dam, repairing leaks and building up the dam. Areas near dams show signs of disturbance including substrate disruption and devegetation both in and out of water. These areas also tend to be deep (excess of 1 meter). For these reasons it is likely amphibians favor areas outside of the immediate vicinity of beaver dams, Towards the rear where water levels are shallow and beavers spend less time due to their being more exposed.

Habitat Suitability Assessment

The goal of the assessment is to rank the habitats in order of their degree of overall suitability (favorable to amphibian breeding), as a function of, and affected by, environmental factors. While this particular assessment is crude in its approach, it does achieve the objective of separating clearly unsuitable habitat from the most suitable. This can serve to at least help stratify the sampling effort.

The assessment can be simplified if we consider the factors important to lentic adapted amphibians: they require habitat that is relatively stable year to year in order to persist. The ideal amphibian habitat, for lentic adapted forms, is a shallow (30-50 cm deep), warm, and richly vegetated environment that is minimally disturbed by environmental forces during the larval period. As a further example, the Spotted frog is dependent on aquatic habitat not only to satisfy breeding requirements but also for overwintering habitat.

This assessment only involves hydrologic stability and temperature. Analysis of aquatic vegetation diversity is reported in the results (Table 2).

Table 6. Summer Hydrologic Stability

Habitats ranked least to most stable	
1.	Stikine River
2.	Backwater Slough
3.	Backwater Lake
4.	Streams
5.	Beaver Pond
6.	Mountain Lake
7.	Muskeg
8.	Outwash Pond

“Hydrologic stability” involves flowrate and depth (volume) variability through time. A habitat such as the Stikine River is clearly unstable. Streams also flow at reasonable velocity, but are not nearly as volumetrically variable as the river. Backwater sloughs flow at a slow rate and change their depth on a daily basis, although not as pronounced as the Stikine River. Backwater lakes flow at a very slow rate and depth changes on a daily basis, but less so than sloughs due to their removal from the river and the volume they hold. Mountain lakes are very stable and change seasonally, as do beaver ponds (aside from dam bursts) which receive stream inflow. Muskegs receive groundwater and stream inflow whereas outwash ponds are probably the most stable, receiving only groundwater inflow.

Table 7. Summer Water Temperature

Habitats ranked least to most stable		
1.	Mountain Lake	5 – 10 C
2.	Streams	7 - 9 C
3.	Stikine River	8 – 9 C
4.	Backwater Slough	8 – 12 C
5.	Backwater Lake	9 – 15 C
6.	Beaver Pond	9 – 25 C
7.	Muskeg	12 – 37 C
8.	Outwash Pond	15 – 35 C

These rankings are based on hack water temperatures taken on site and on the following qualitative criteria: Higher elevation sites will be colder, lentic habitats concentrate heat better than lotic environments, and shallow bodies of water are warmer than deep bodies of water.

Mountain lakes are very large, deep, and ice-covered much of the year. Streams generally flow from higher elevations (concentrating groundwater subsurface flow or draining lakes) and are canopied, keeping ambient water temperature low. The Stikine River, though warmer than streams on average due to the accumulation of solar radiation, is kept cold by streams entering it. Backwater sloughs are slow flowing and warm somewhat. They are nearly as cold as the Stikine River because the river and streams directly influence them. Backwater lakes are broad and very slow flowing and can become relatively warm. However, they are invariably connected to backwater sloughs, streams, and the Stikine River, and are kept relatively cool. Beaver ponds are separated from the Stikine River and backwater sloughs. However, they can be connected to streams. The ponds are usually broad and become warm due to the lack of water movement distributing the heat. Muskegs can get very warm (as high as 37 C as measured on Wrangell Island on several occasions). Some muskegs have stream courses through them, or ponds will be interconnected. This habitat varies depending on the season and rainfall. Outwash ponds are relatively large with water movement restricted to tidal influenced ponds. Temperatures are stable day to day and can reach into the 30-35 C range or higher.

Table 8. Hydrologic Stability and Water Temperature Combined

Mean rank lowest to highest suitability	
1.	Stikine River
2.	Streams
3.	Backwater Slough
4.	Mountain Lake
5.	Backwater Lake
6.	Beaver Pond
7.	Muskeg
8.	Outwash Pond

Note that lotic (flowing) and lentic (stillwater) habitats are separated from each other, and they are in a general sequence from coldest to warmest. The same is true of the lentic environments. The "assessment" divided the eight habitats into two hydrologic classes and thermally arranged them. Herpetofauna occurrence (presence/absence) and breeding occurrence is reported per species and habitat type using this ranking of habitats in Figures 2-8.

Appendix B. List of variables and methods used in collection of data within 50 x 10 meter transects at 86 sites in the Stikine Area of the Tongass National Forest.

Transect Information

Transect number. unique identifier per transect.

Visit number: indicates the particular visit for repeat sampling.

Habitat type: ordinal classification of aquatic habitats (Appendix A).

Habitat number: accounting number given per habitat type.

Township, range, section: determined from topographic maps showing approximate location of site.

Aerial photo location: organized by flight, photo, and series. Exact location of transect indicated on photo.

Aspect: direction of travel, from the bottom of the transect to the top.

General Site Characteristics

Time: time of day data was recorded.

Water temperature (C): measured in the center subtransect with a Quik-reading thermometer.

Soil temperature (C): measured in the center subtransect with a Quik-reading thermometer.

Water turbidity: ordinal rating (clear, algal, tannic, iron flock, slightly silty, moderately silty, very silty).

Water pH: measured with an Oakton PhEP+ in center subtransect.

Water salinity: strength rating from 0-2 (none, weak, strong).

Visibility right: effective herpetofauna sampling area to right of transect, upto *5* meters. Right/left determined by looking toward top end of the transect.

Visibility left: effective herpetofauna sampling area to left of transect, upto *5* meters. Right/left determined by looking toward top end of the transect.

Cloud cover: clear, intermittent cloud cover, partly cloudy, very cloudy.

Precipitation: not precipitating, intermittent rain, light rain, moderate rain, heavy rain, snow, hail, sleet.

Air ternperature. freezing (<0 C), cold (<15 C), cool (~20 C), warm (~25 C), hot (>25 C).

Wind: none, intermittent breeze, light wind, moderate wind, heavy wind, gale.

Braun-Blanquet (1932) Vegetation/Cover Estimates

A list of the vegetation species (some to just the genus) and cover types that were encountered in the field was assembled and each given a unique identifier from 00-99. Ocular estimates of the categories were made per subtransect.

Table 9. Braun-Blanquet Cover Scale

Code	Proportion	Mean Percent
0	0%	0.0%
1	<= 1%	0.5%
2	<= 10%	4.5%
3	<= 25%	17.5%
4	<= 50%	37.5%
5	<= 75%	62.5%
6	< 100%	87.5%

Cover/Substrate Categories (rock categories after Lane, 1947)

98: Ground

99: Ice/snow

00: Open water

01 : Bedrock/boulder (> *256mm)*

02: Boulder/cobble/gravel (> 256mm, > 64mm, > 2mm)

03: Cobble/gravel (> 64mm, > 2mm)

04: Gravel/sand (> 2mm, < 2mm)

05: Sand (<2mm)

06: Organic sediment/mud (< < < 1mm)

07: Soil

08: Leaf litter/branches (< 10cm diameter)

09: Log(>10cm diameter)

Angiosperm Tree Categories (Terrestrial plants after Hulten, 1968)

10: Young black poplar (Populus sp.), (< 2m height)

11: Mature poplar (< 5m height)

12: Old poplar (> 5m height)

13: Young alder (Alnus sp.), (< 2m height)

14: Mature alder (< 5m height)

15: Old alder (> 5m height)

16: Young willow (Salix sp.), (< 2m height)

17: Mature willow (< 5m height)

18: Old willow (> 5m height)

19: Young apple (Malus diversifolia), (< 2m height)

20: Mature apple (< 5m height)

21 : Old apple (> 5m height)

95: Sitka mountain ash (Sorbus sitchensis), (any height)

Gymnosperm Tree Categories

22: Seedling Sitka spruce (Picea sitchensis), (< 1m height)

23: Young Sitka spruce (< 5m height)

24: Mature Sitka spruce (< 15m height)

25: Old Sitka spruce (> 15m height)

26: Young Western hemlock (Tsuga heterophylla), (< 5m height)

27: Old Western hemlock (> 5m height)

28: Young mountain hemlock (Tsuga mertensiana), (< 2m height)

29: Old mountain hemlock (> 5m height)

96: Shore pine (Pinus contorta), (any height)

97: Alaska cedar (Chamaecyparis nootkaensis), (any height)

Shrub Categories

30: Devils club (Echinopanax horridum)

31: Strawberry (Fragaria sp.)

32: Salmonberry (Rubus spectabilis)

33: Thimbleberry (Ruhus parviflorus)

34: Blackberry/Nagoonberry (Rubus sp.)

35: Elderberry (Sambucus sp.)

36: Currant (Ribes sp.)

37: Goatsbeard (Aruncus sp.)

38: Dwarf dogwood (Cornus sp.)

39: Dogwood (Cornus stolenifera)

40: Blueberry (Vaccinium sp.)

41: Cranberry (Vaccinium sp.)

84: Labrador tea (Ledium groenlandicum)

Grass Categories

42: True grasses (Gramineae sp.)

43: Sedges (Carex sp.)

44: Rushes (Juncus sp.)

45: Cotton grass (Eriophorum sp.)

46: Salt reeds (Juncus sp.)

Herb Categories

47: False hellebore (Veratrum viride)

48: Salt marsh plantain (Triglochin maritimum)

49: Weed plantain (Plantago sp.)

50: Lupine (Lupinus sp.)

51: Yarrow (Achillea sp.)

52: Shooting star (Dodecatheon sp.)

53: Indian paint brush (Castilleja sp.)

54: Marsh five-finger (Potentilla palustris)

55: Silverweed (Potentilla anserina)

56: Chocolate lily (Fritillaria camschatcensis)

57: Violet (Viola sp.)

58: Iris(Iris sp.)

59: Orchid (Orchidaceae sp.)

60: False lily of the valley (Maianthernum dilatatum)

61 : Solomon seal (Streptopus sp.)

62: Bedstraw (Galium sp.).

63: Buttercup (Ranunculus sp.)

83: Fleabane (Erigeron sp.)

Moss/Heather Categories

64: Clubmoss (Lycopodiaceae sp.)

65: Moss (general)

94: Heather (Cassiope sp.)

Fern Categories

69: Bracken fern (Pteridium aquilinum)

70: Sword fern (Polystichnum sp.)

71: Lady fern (Athyrium sp.)

Aquatic and Bog Plant Categories (Hulten, 1968; Brayshaw, 1985)

66: Horsetail (Equisetum sp.)

67: Marestail (Hippurus sp.)

68: Skunk cabbage (Lysichiton americanum)

72: Buckbean (Menyanthes trifoliata)

73: Yellow marshmarigold (Caltha sp.)

74: Yellow pond-lilly (Nuphar polysepalum)

75: Butterwort (Pinguicula vulgaris)

76: Roundleaf sundew (Drosera rotundifolia)

77: Burr-reed (Sparganium sp.)

78: Pond weed (Potamogeton sp.)

79: Ceratophyllum sp.

80: Eel grass (Zostera japonica)

81 : Algae (general)

82: Seaweed (marine species in general)

85: Aquatic grass (Gramineae sp.)

Subtransect Physical Variables

Bank-aquatic interface length (m): ocularly estimated

Mean water depth (m): measured with depth probe

Herpetofauna Data

Subtransect: 1-5

Herpetofauna species: species were identified using Stebbins (1985) and abbreviated to the first two letters of the genus and species.

Stage of development: eggmass, larval, newly metamorphosed juvenile, subadult, and adult. Differences used to classify age classes stage in the field are the distinct mass difference evident between classes.

*Sex***:** determined only for adults. In frogs the male foreli.mbs are swollen and the trunk triangular, whereas the female has diminished forelimbs and a rotund body. In salamanders the male has swollen vent lobes and a narrow body compared to the female body which tends to be swollen with diminished vent lobes. Other secondary sexual characters are described by Stebbins (1985).

Activity: ordinal variable describing action of amphibians prior to disturbance. Categories include no action, moving towards water, moving away from water, jumping (diving), swimming, floating in water, breeding, calling, eating, and schooling.

Substrate: same as Braun-Blanquet vegetation/cover categories above.

Cover: same as Braun-Blanquet vegetation/cover categories above.

Number seen: number of amphibians observed per species in similar situations that are the same sex and stage. When many of the same species were observed the activity, substrate, and cover was generalized.

Transect side: side of transect where observation of amphibians was made (see General Site Characteristics, Visibility etc., for description of "side").

Distance from transect: estimated distance from transect.

Procedure: protocol or opportunistic. If herpetofauna were observed outside of the transect, but were within the same habitat, they were recorded as opportunistic observations.

Appendix C. Location of transects in the Stikine River basin.

Table 10. Transect Habitat Type, Visitations, Locality and Aerial Photograph Information

Site	Habitat Type	Number of Visits	Area	Locality	Township	Range	Section	Flight Line	Aerial Photo	Series
01	BL	6	10	Twin Lakes	60S	83E	01	22	205	1073
02	BL	6	10	Twin Lakes	60S	83E	01	22	205	1073
03	BL	6	10	Twin Lakes	60S	83E	01	22	205	1073
04	SR	2	12	Andrews Slough	60S	84E	03	24	94	2073
05	SR	2	13	Dry Wash	60S	84E	02	25	32	2073
06	SR	2	14	Shakes Slough	60S	84E	02	25	32	2073
07	BS	2	14	Shakes Slough	59S	84E	36	26	11	2073
08	BS	2	14	Shakes Slough	59S	85E	30	26	11	2073
09	BP	2	14	Shakes Slough	59S	85E	30	26	11	2073
10	ML	2	14	Shakes Slough	59S	84E	14	25	29	2073
11	BP	2	14	Shakes Slough	60S	84E	23	25	29	2073
12	SR	2	9	Limb Island	60S	84E	06	22	205	1073
13	BS	2	11	Andrews Creek	60S	84E	18	23	110	1973
14	SR	2	9	Limb Island	60S	83E	27	21	191	1073
15	SR	1	8	Cottonwood Slough	60S	83E	26	21	191	1073
16	SR	2	8	Cottonwood Slough	60S	83E	35	21	191	1073
17	BS	2	5	Farm Island	60S	83E	17	19	102	2173
18	BS	2	5	Farm Island	60S	83E	28	19	102	2173
19	SR	2	8	Cottonwood Slough	61S	84E	07	19	105	2173
20	OP	2	30	Crittenden Creek	62S	84E	14	22	221	1073
21	OP	2	30	Crittenden Creek	62S	84E	14	22	221	1073
22	BP	2	20	Barnes Lake	60S	86E	17	31	203	0573
23	BP	2	20	Barnes Lake	60S	86E	08	31	203	0573
24	BS	2	17	Hot Tubs Slough	59S	85E	34	28	114	1273
25	BS	2	17	Hot Tubs Slough	59S	85E	34	28	114	1273
26	S	2	17	Hot Tubs Slough	59S	85E	35	29	39	0673
27	BL	2	20	Barnes Lake	60S	85E	01	29	39	0673
28	BL	2	22	Kikake River	60S	86E	33	32	161	1273

Site	Habitat Type	Number of Visits	Area	Locality	Township	Range	Section	Flight Line	Aerial Photo	Series
29	BS	2	22	Kikake River	60S	86E	28	32	161	1273
30	S	1	22	Kikake River	60S	86E	27	32	161	1273
33	SR	1	22	Kikake River	60S	86E	29	32	161	1273
34	BP	2	20	Barnes Lake	60S	86E	08	31	203	0573
35	SR	2	12	Andrews Slough	60S	84E	08	23	107	1073
36	SR	2	6	North Arm of the Stikine River	60S	83E	16	19	100	2173
37	BS	2	6	North Arm of the Stikine River	60S	83E	17	19	99	2173
39	OP	2	1	Sergief Island	61S	83E	15	17	67	2173
40	OP	2	7	Mallard Slough	59S	82E	32	15	17	2173
41	OP	2	4	Dry Island	60S	82E	15	15	15	2173
42	BS	2	6	North Arm of the Stikine River	60S	83E	18	18	121	2173
43	M	1	11	Andrews Creek	60S	84E	20	23	110	1973
45	BP	1	11	Andrews Creek	60S	84E	29	23	110	1973
46	BP	1	11	Andrews Creek	60S	84E	28	23	110	1973
47	BS	1	11	Andrews Creek	60S	84E	29	23	110	1973
48	BS	1	11	Andrews Creek	60S	84E	20	23	110	1973
49	BS	1	11	Andrews Creek	60S	84E	20	23	110	1973
50	BS	1	12	Andrews Slough	60S	84E	17	23	110	1973
51	BL	1	10	Twin Lakes	60S	83E	01	22	205	1073
52	BL	1	10	Twin Lakes	60S	83E	01	22	205	1073
53	BS	1	10	Twin Lakes	60S	83E	01	22	205	1073
54	ML	1	12	Virginia Lake	62S	85E	21			
55	ML	1	13	Virginia Lake	62S	85E	22			
56	ML	1	14	Government Lake	61S	84E	2			
57	ML	1	14	Andrews Lake	61S	86E	7			
58	ML	1	14	Goat Lake	60S	85E	35			
59	ML	1	14	Alpine Lake	59S	85E	8			
60	BP	1	14	Ketili River	60S	85E	11	29	38	0673
61	BP	1	14	Barnes Lake	60S	86E	17	31	203	0573
62	BP	1	9	Barnes Lake	60S	86E	17	31	203	0573
63	S	1	11	Andrews Creek	60S	84E	28	23	110	1973

Site	Habitat Type	Number of Visits	Area	Locality	Township	Range	Section	Flight Line	Aerial Photo	Series
64	M	1	9	Andrews Creek	60S	84E	20	23	110	1973
65	M	1	8	Andrews Creek	60S	84E	20	23	110	1973
67	OP	1	8	Cheliped Bay	59S	82E	32	15	17	2173
69	BP	1	5	Ketili River	59S	85E	32	28	115	1273
70	BP	1	5	Kikake River	60S	86E	28	31	205	0573
71	BP	1	8	Ketili River	60S	85E	2	30	189	0573
72	OP	1	30	Limb Island	60S	85E	12			
73	BS	1	30	Andrews Creek	60S	84E	9	24	94	1973
74	BP	1	20	Ketili River	59S	85E	34	28	115	1273
75	BP	1	20	Ketili River	59S	85E	31			
76	OP	1	17	King Slough	60S	82E	23	17	72	2173
77	BL	1	17	Twin Lakes	60S	83E	1	22	205	1073
78	BL	1	17	Goat Creek	60S	85E	14	29	36	0673
79	OP	1	20	Ketili River	60S	85E	13	29	36	0673
80	BL	1	22	Ketili River	60S	85E	13	29	36	0673
81	BL	2	22	Twin Lakes	60S	83E	1			
82	SR	1	22	Mount Flemer Cabin	60S	86E	29			
83	M	1	22	Government Lake	61S	84E	2			
84	BP	1	20	Government Lake	61S	84E	2			
85	BP	1	12	Paradise Slough	60S	86E	8			
86	BS	3	6	Hot Tubs Slough	59S	85E	34			
87	BL	2	6	Twin Lakes	60S	83E	1			
88	ML	1	1	Virginia Lake	62S	85E	21			
89	S	2	7	Point Rothsay	61S	84E	7			
90	S	1	4	North Arm Creek	60S	83E	11			
91	OP	1	6	Sergief Island	61S	83E	15			
92	M	2	11	Shakes Slough	59S	85E	30			

Total of 86 transect sites. All sites are marked on the master topographic map, and the majority on aerial photographs and Figure 1. Map and aerial photos stored at the USFS Wrangell, Alaska office. Duplicates stored at the USF&WS Juneau, Alaska office.

Appendix D. Herpetofauna Distribution

Southeastern Alaskan Herpetofauna

Little is known of the northerly distributed non-marine herpetofauna that occur in Alaska and British Columbia. To date, a limited number of publications (Hodge, 1976; bibliography of Hodge, 1976; Hodge, 1986; Norman, 1988; Waters, 1992; Waters, this study) have described the Southeastern Alaskan herpetofauna. Much of the literature reported by Hodge (1976) was generated about the Wood Frog (Rana sylvatica) regarding its distribution, morphologic variation, and physiology.

Seven species of herpetofauna have been reliably documented from Southeast Alaska (Hodge, 1976; Waters, 1992). These species are the Northwestern Salamander (Ambystoma gracile), Long-Toed Salamander (Ambystoma macrodactylum), Western Toad (Bufo boreas), Pacific Tree-Frog (Pseudacris = {Hyla} regilla), Spotted Frog (Rana pretiosa), Wood Frog (Rana sylvatica), and Rough-skinned newt (Taricha granulosa). Of the seven species, six are known to occur in the Stikine Area. An eggmass of the Northwestern Salamander (Ambystoma gracile) was observed at Twin Lakes and represents the first sighting of this species in the Stikine Area (the eggmass exactly matched the description given in Stebbins, 1985). The Pacific Tree-Frog (Pseudacris regilla) has not been observed in the Stikine Area.

Species in Contention

Controversy surrounds two species of herpetofauna, the Alaskan Worm Salamander (Batrachoseps caudatus), and the Valley Garter Snake (Thamnophis sirtalis). Opinion varies on the status of the Alaskan Worm Salamander whereas the garter snake has been positively identified within the borders of Alaska along the Stikine River and possibly the Unuk River and Taku River (R.Hodge, pers. comm.). A specimen of the Valley Garter Snake from the Stikine River was collected and deposited in the University of Fairbanks collection, but was subsequently lost. The record of its presence in the museum still exists (R.Hodge, pers. comm.). Several other species of herpetofauna may presently occur in Alaska in relictual populations, or may have historically occurred there. The most likely species are the Wandering Garter Snake (Thamnophis elegans), which occurs in an apparently isolated population in the Skeena River basin, British Columbia, and the Tailed Frog (Ascaphus truei), a species adapted for extremely cold environments, which occurs at Kitimat (Stebbins, 1985).

Proposed Historical Glacial Influence Model

The time from the Pleistocene glacial maxima (20,000 YBP) and present day encompasses a period during which radical environmental changes have occurred. During the Pleistocene, ice-sheets periodically covered the mountainous regions of Alaska, Canada, the northern United States, and mountain ranges throughout the world, profoundly affecting the distribution of fauna and flora (Bradley, 1985). In Southeast Alaska the ice-sheets extended across the Alexander Archipelago to the Pacific Ocean and southward across the Queen Charlotte Islands to Vancouver Island. During the glacial epochs the sea level lowered upto 120-150 meters (Morner, 1980). At the Pleistocene glacial maximum (20,000 YBP) much of Alaska, if not all of it, was probably uninhabited by herpetofauna.

After the glacial maximum, glacial recession proceeded most rapidly at the edges and fringe areas upto about 13,300 YBP (Morner, 1984). The Pacific edge of the ice-sheet probably receded comparatively rapidly compared to interior and highly elevated areas on account of the maritime influence. At this time the sea level remained fairly low and a coastal corridor, freed of glacial ice, opened along the coastline of British Columbia and Alaska, extending from Northern Washington through Vancouver Island, currently inundated areas of coastal British Columbia, the Queen Charlotte Islands, the Alexander Archipelago through Yakutat, and the South Coast of Alaska. As the glacial recession concluded, from 13,300 to 8500 YBP the sea level rose and isolated elevated regions of the Pacific Coast. Vancouver Island, the Queen Charlotte Islands, and the Alexander Archipelago were likely isolated by the early Holocene (~10,000 YBP). During this time the ice sheet had fully receded leaving mountain glaciers in its place. An interior corridor opened, through the Fraser River of interior British Columbia. The major rivers that originate in British Columbia that bisect the coast ranges, the Fraser River, Skeena River, Unuk River, Stikine River, Whiting River, and Taku River, could be crossed at the headwaters through a series of plains which contain numerous wetlands, during thermal maxima (Lamb, 1984) between Holocene glaciation events.

During the last 10,000 years several periods of glaciation occurred. The most recent and possibly the most severe, “the little ice age” ended only recently (Bradley, 1985). Glaciers that developed were primarily restricted to mountain valleys. River basins remained relatively unglaciated, though glaciers did reach into them. Ice fields likely developed in mountain passes that served as corridors between rivers.

Biogeographical Patterns

Glaciated areas preclude herpetofauna and many other vertebrate taxa. During the most recent glaciation, herpetofauna would have been restricted to refugia, adjacent to the coast ranges in extreme coastal and interior Washington. The ranges of the herpetofauna that occur in Southeast Alaska and Northern British Columbia follow two distinct distributional patterns. The Rough-Skinned Newt, Western Toad, and Northwestern Salamander are distributed west of the coast ranges, and it is likely they entered Alaska at the close of the Pleistocene (13,000-10,000 YBP) through the coastal corridor (Figure 9). The Spotted Frog, Wood Frog, and Long-Toed Salamander are principally distributed east of the coast ranges (re: Spotted Frog see Dumas, 1966) and likely entered Alaska in the early to mid-Holocene (> 10,000 YBP) through the major rivers that bisect the coast ranges (Figure 10; British Columbia distributional information from Stebbins, 1985; Alaskan distributional data from Hodge, 1976, and Waters, unpublished data).

Several other species of herpetofauna follow these two distributional patterns but have yet to be observed in Southeast Alaska. It is uncertain whether the Pacific Tree-Frog is native to Alaska (Waters, 1992) and assessment of this species is deferred until more distribution records become available.

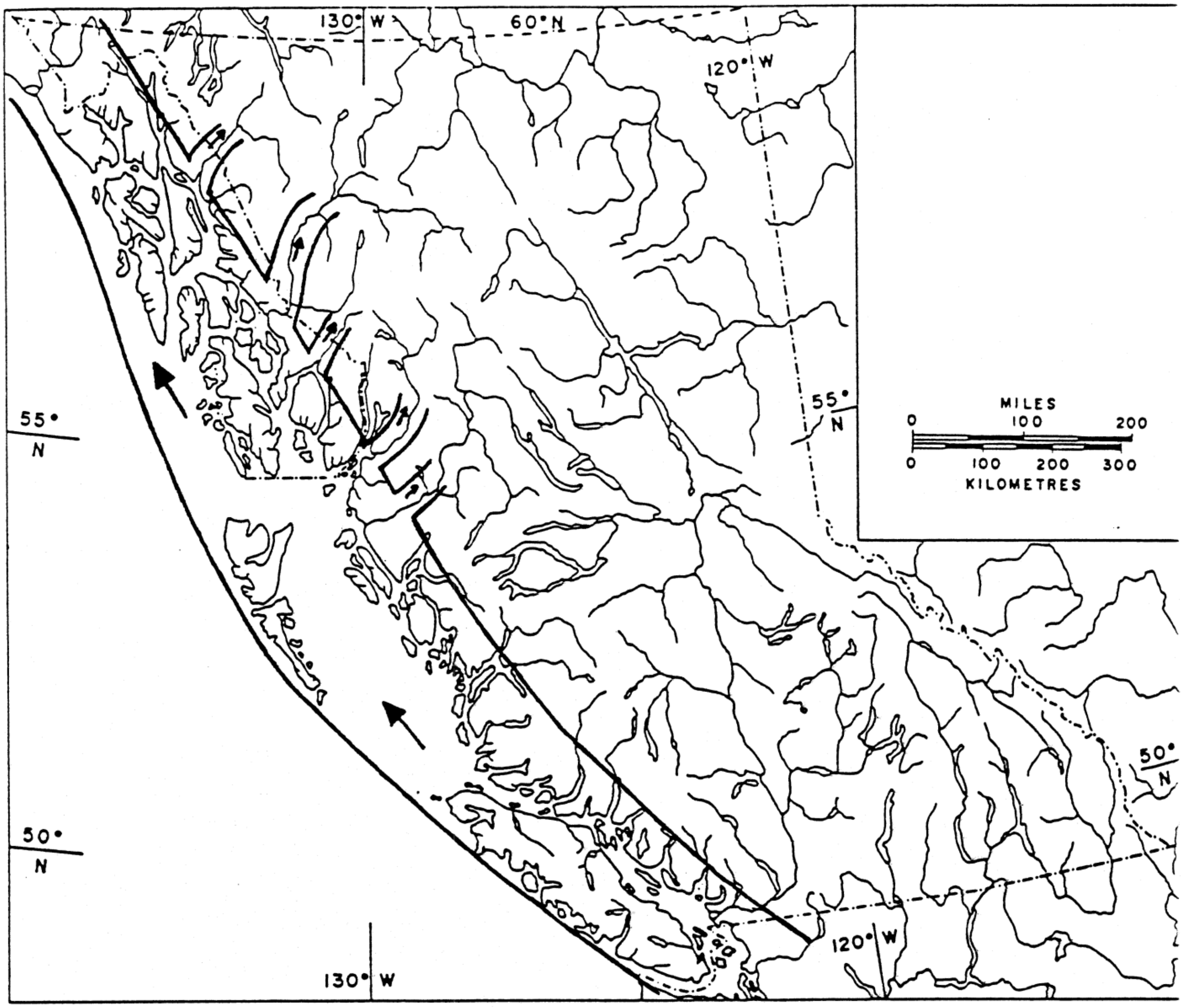

Figure 9. Coastal corridor. The Northwestern Salamander (Ambystoma gracile), Western Toad (Bufo boreas), and Rough-Skinned Newt (Taricha granulosa) are principally distributed on archipelago islands and coastal areas. Arrows indicate proposed directions of progressive colonization through time. Basemap reproduced from Brayshaw (1985) and used by permission of the Province of British Columbia - Queen's Printer. Not for resale, for educational purposes only, not an official copy.

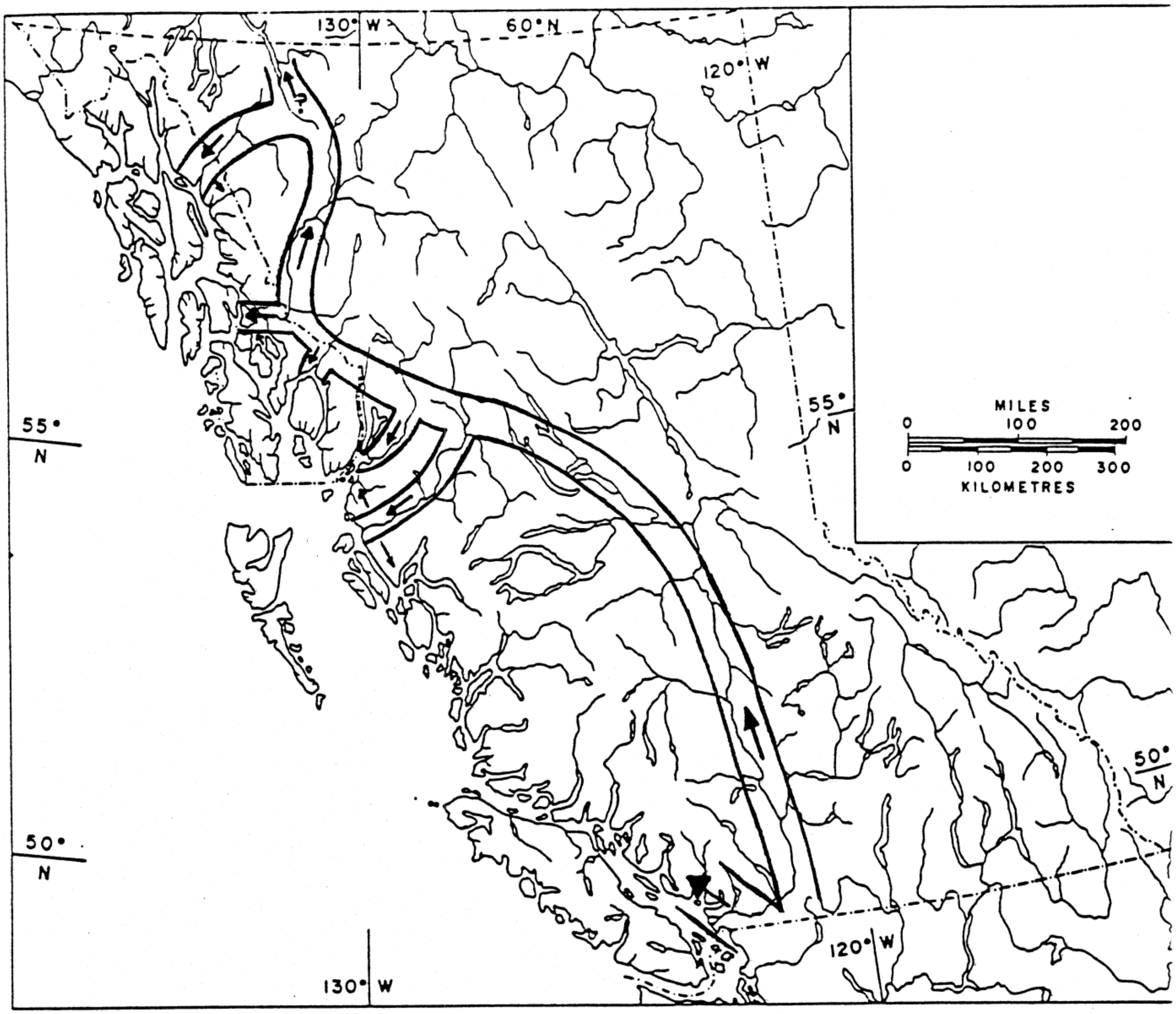

Figure 10. Interior corridor The Long-Toed Salamander (Ambystoma macrodactylum), Spotted Frog (Rana pretiosa), and Wood Frog (Rana sylvatica) are principally distributed within river basins and adjacent islands. Arrows indicate proposed directions of progressive colonization through time. Basemap reproduced from Brayshaw (1985) and used by permission of the Province of British Columbia - Queen's Printer. Not for resale, for educational purposes only, not an official copy.

Addendum

The original inter-agency report was faithfully converted to PDF. It was never the intention of the author to revise or update this document aside from minimal style considerations and address typographical errors. Pagination has been preserved. Much has been learned in the last 17 years, in particular the importance of disease negatively influencing populations of herpetofauna. Genetic analysis has revealed just how fragmentary the distribution of many herpetofauna species are which were once thought to be genetically contiguous.

All types of habitat described herein are represented in the photo collection stored at the USFS Wrangell Office, but are not shown in this document. Eight are presented to provide a sense of place.

Figures 11 and 12 are updated versions of Figure 1. Base maps provided courtesy of Google, Inc. See http://maps.google.com

Photograph 1. Spotted Frog (Rana pretiosa) from Vank Island, SE Alaska. 1991 Photo by Nick Waters; Kevin Smyth holding frog.

Photograph 2. Overlooking base camp (Site 4) at Stikine River, facing Mt. Basargin. Photo by Nick Waters.

Photograph 3. Western Toad (Bufo boreas) Juvenile. Photo by Nick Waters.

Photograph 4. The author at Twin Lakes (Site 1), a Backwater Lake. Photo by Kevin Smyth.

Photograph 5. The Stikine River facing upstream adjacent to Cottonwood Islands to the right. Photo by Nick Waters.

Photograph 6. Outwash Pond with tidal influence on the outskirts of Mallard Slough. Note the Hippurus sp. (Marestail). Photo by Nick Waters.

Photograph 7. Muskeg Habitat. Note the diversity of plant species within and surrounding the pond and microtopography typical of regions with muskeg. Photo by Nick Waters.

Photograph 8. Muskeg habitat. Note Nuphar sp. (Pond Lilly) as bio-indicator of long-term habitat stability. Photo by Nick Waters.

Figure 11. Terrain Map of US Side of Stikine River Basin with Place Names.

Figure 12. Satellite view of Stikine River study area with Site numbers in red.