Summary of Aquatic Resource Information for Gwaii Haanas

A Compilation and Synthesis of Aquatic Inventories for Lakes and Streams

Prepared for: Parks Canada
Gwaii Haanas / South Moresby National Park Reserve

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ABSTRACT

A review of available inventory and assessment information pertaining to streams and lakes within Gwaii Haanas National Park Reserve was completed. The status of aquatic biophysical information was summarized, data gaps were identified and recommendations for future monitoring and research are made.

Gwaii Haanas encompasses 147,271 ha of land along the southern portion of Haida Gwaii/Queen Charlotte Islands, including much of Moresby Island plus many smaller islands. This region consists of rugged terrain associated with the San Christoval Mountain Range along the length of Gwaii Haanas. Of the 779 watersheds found in the Protected Area, almost half are 50-100 ha in size. Over 1,400 streams exist, the majority being small, 1^{st} order streams without lakes in the watershed. Nine fish species have been recorded from streams along both coasts. Three species of adult Pacific salmon (chum, pink, sockeye) are only found in streams during the fall spawning migrations, and their young return to the ocean soon after hatching each spring. Coho salmon fry and juveniles remain within streams and lakes for longer periods.

There are 118 lakes ranging in size from 1-228 ha, plus hundreds of open-water areas under 1 ha. Eight fish species are known to reside within Gwaii Haanas lakes, mainly at lower elevations of 50 m or less above sea level. Threespine stickleback occur within low elevation lakes and stream reaches. Dolly Varden is the most common salmonid in these lakes, and is frequently the only fish species found at higher elevations or above major obstructions such as water falls. Rainbow trout are known to live year-round within several lakes, but migratory steelhead trout are also present at certain times of the year.

Salmon abundance estimates from spawning streams supports the general decline in salmon numbers observed for west coast fisheries. Chum salmon use the vast majority of Gwaii Haanas streams for fall spawning, while coho and pink salmon use less than one-third of these streams. Within the last five years, chum salmon numbers have dropped to 10% of their abundance from the late 1940s. The number of spawning pink salmon increased by the late 1960s and remained relatively high until a steady decline began in 1988.

The overall productivity of Gwaii Haanas lakes and streams is quite low. The biomass input to these freshwater systems via migratory salmon may be vital to continued survival of fish, invertebrates, certain birds and mammals, as well as overall productivity in riparian areas.

Currently, only three of 118 lakes have been surveyed, and another 32 lakes have limited information available. Recent surveys also exist for 22 of over 1,400 streams and similar information is available for another 166 streams, but has not been summarized for comparison with recent surveys. In either case, a very small number of lakes and streams have appropriate information to properly compare and summarize the aquatic

resources of Gwaii Haanas. Future inventory and monitoring is needed on a seasonal basis to understand temporal biophysical dynamics for these waters.

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ACKNOWLEDGEMENTS

I would like to thank Todd Golumbia and Patrick Bartier for their help in locating much of the background information and providing valuable comments after reviewing one or more drafts of the report. Patrick also created numerous figures portraying spatial summaries of species distributions. Tom Reimchen supplied additional insight into the status of research and inventory information for Gwaii Haanas lakes and streams. Current salmon escapement data were made available by Victor Fredette, who kindly put this into context with historical findings. Gordon Oliphant shed valuable light on historical stream inventory data collected by the Ministry of Environment, as well as the history and status of the British Columbia Watershed Atlas.

1.0 INTRODUCTION

The Queen Charlotte Islands/Haida Gwaii are an island archipelago located approximately 100 km off of the northern coast of British Columbia. This island complex consists of two large islands (Graham, Moresby) plus many smaller islands. Gwaii Haanas National Park Reserve/Haida Heritage Site (herein referred to as Gwaii Haanas or the Protected Area) covers the southern half of Moresby Island and adjacent islands, covering a land mass of approximately 1,470 km^2 and 1,600 km of shoreline (Figure 1).

Major summaries for Gwaii Haanas resources currently include a biophysical inventory of the coastal resources (Harper *et al* 1994) plus ecological land classification of the terrestrial biophysical resources (Westland Resources Group 1994).

Most of Gwaii Haanas falls within the biogeoclimatic zone known as Coastal Western Hemlock (CWH), covering elevations from sea level to approximately 550 m (Figure 2). It is differentiated into biophysical ecoregions identified as wet hypermaritime (CWHwh) and very wet hypermaritime (CWHvh)(Westland Resource Group 1994). Haida Gwaii/ Queen Charlotte Islands contains three Ecoregions (Queen Charlotte Lowland, Skidegate Plateau, Windward Queen Charlotte Mountains) which have been identified by the province based on landform and climate (Prince Rupert RPAT 1996). The line separating CWHvh and CWHwh ecoregions closely follows the border between the Skidegate Plateau and the Windward Queen Charlotte Mountains Ecoregion (Figure 2). The Queen Charlotte Lowland Ecoregion lies to the north and east of the Skidegate Plateau Ecoregion, and consists mainly of low lying, poorly drained soils. The CWHwh ecoregion encompasses most of the islands to the east of Moresby Island, plus a portion of Moresby Island south of Skincuttle Inlet. The remainder of Moresby Island plus Kunghit Island comprise the CWHvh ecoregion. Soils tend to be relatively well-drained and precipitation is lower in the CWHwh ecoregion, leading to very productive tree growth. The CWHvh ecoregion receives much more precipitation, with estimates in excess of 5,000 mm annually (Banner *et al* 1989). Super-saturation of the ground occurs producing many bogs where terrain permits, which in turn supports abundant wetland flora (Westland Resource Group 1994). There is a continuous buildup of decomposed organic matter on the CWHvh soil surface wherever runoff does not remove soil burdens.

Above elevations of approximately 500 m, two additional biophysical ecoregions exist. The Mountain Hemlock (MH) ecoregion occurs to elevations of 650 m and includes a relatively small part of Moresby Island within Gwaii Haanas. The dominant tree species is mountain hemlock (*Tsuga mertensiana*) within subalpine forests, but the landscape also includes open areas. The Alpine Tundra (AT) ecoregion is situated above 650 m, and contains abundant exposed bedrock, scrub trees and heaths (Westland Resource Group 1994).

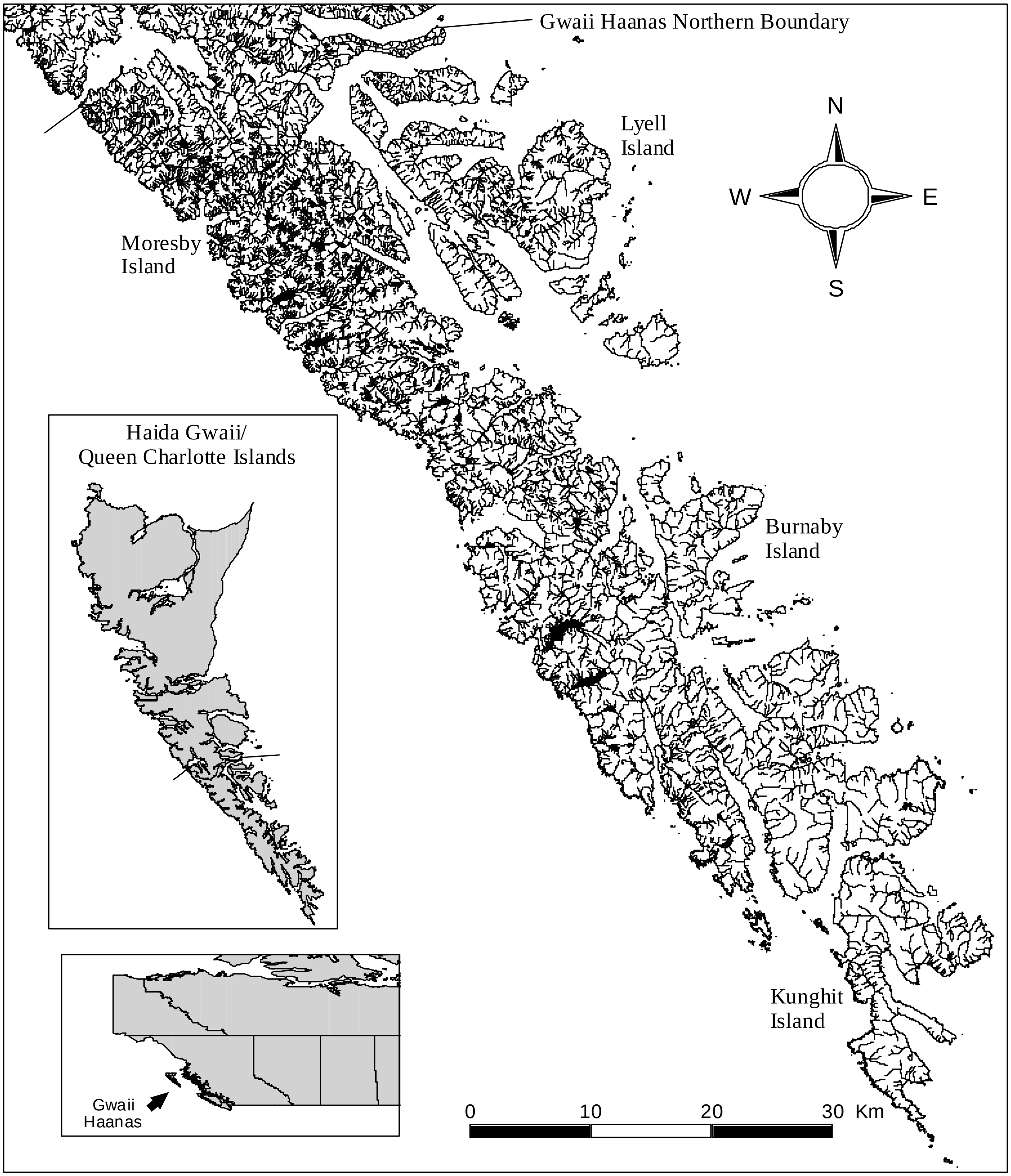


Figure 1. Locations and boundaries of Gwaii Haanas National Park Reserve/Haida Heritage Site in relation to Haida Gwaii/Queen Charlotte Islands and mainland British Columbia.

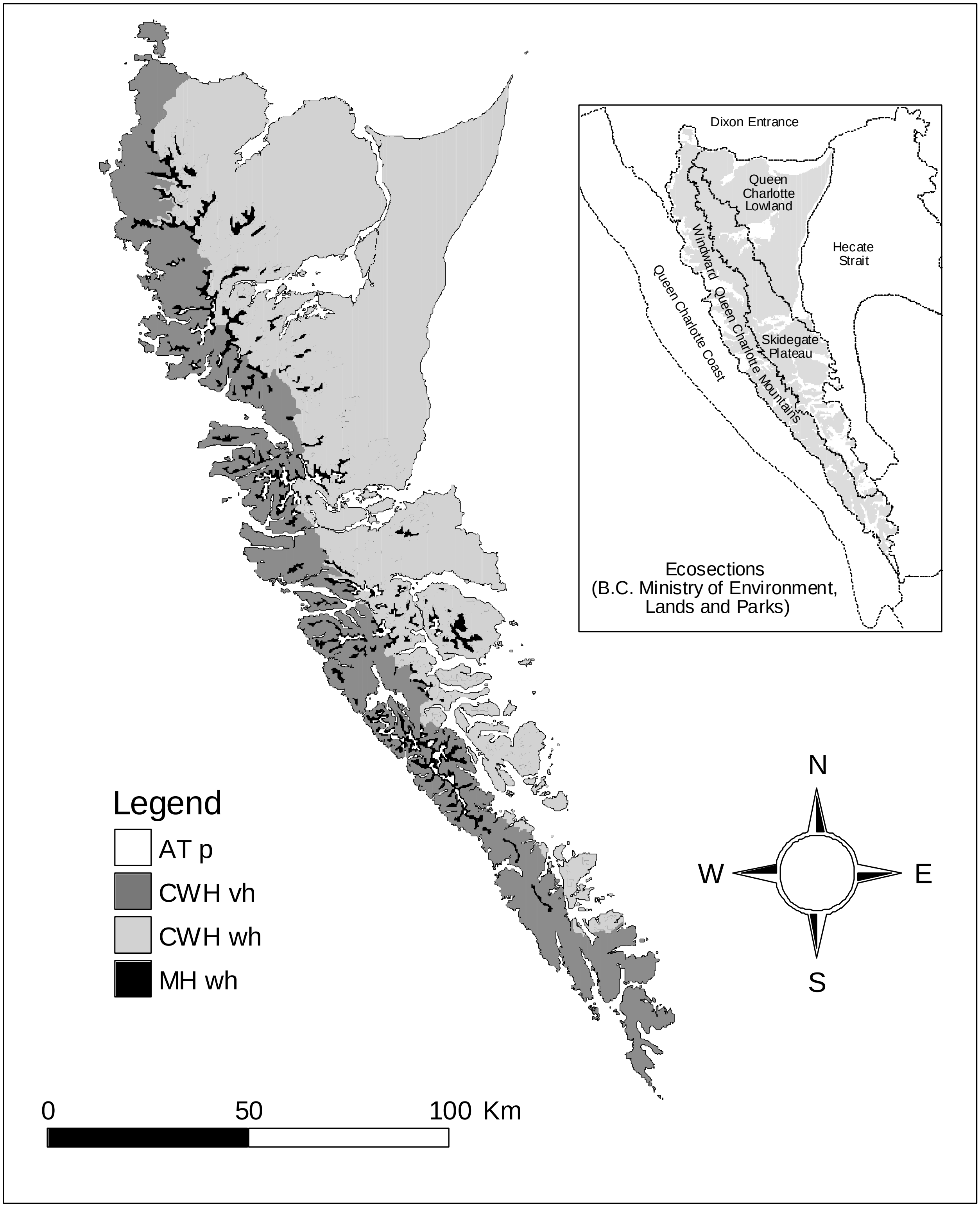


Figure 2. Biogeoclimatic zones of Haida Gwaii/Queen Charlotte Islands (from Banner *et al.*, 1989)

Several geological formations dominate the landscape within Gwaii Haanas (Figure 3), and are briefly described below according to Sutherland Brown and Yorath (1989). The Karmutsen Formation is volcanic rock consisting mainly of basaltic lava that was accumulated over 200 million years ago. It is a fine grained, dark green rock commonly having a pillowed texture. Following this period of volcanic activity, the Kunga Formation was created via massive limestone accumulations (from shells and organic debris) plus sedimentary deposition of fine sand and silt. Intrusive masses of granitic rock (syntectonic Plutons) and quartz diorites (tertiary Plutons) also occurred within the area at different times as magma cooled and solidified below the surface.

The current report focuses on the freshwater aquatic resources, and provides a synthesis of available inventory information. Aquatic resources within Gwaii Haanas include approximately 120 lakes and over 1,400 streams plus many bogs, swamps and other wetland habitats. Groundwater is an important component of existing aquatic systems, but is not reviewed here.

This report concentrates on freshwater habitats which have the potential to sustain fish, since these waters may contain valuable or unique populations in need of protection. Bogs and other wet areas abound within parts of Gwaii Haanas, but these sites are not expected to support fish populations. Of the 35 lakes where biophysical information exists, only three lakes (Escarpment, Lower Victoria, Upper Victoria) have more detailed data on record (Reimchen 1994a). Seven hundred and seventy-nine streams were identified from a series of maps known as the British Columbia Stream Atlas which were produced by the (then) British Columbia Ministry of Environment (MOE). The inventory status for streams included 191 Ministry of Environment, Lands and Parks (MELP) field surveys, and improved during 1993-94 when 22 streams were surveyed by Parks Canada. Sixteen of the 22 streams were originally inventoried by MELP, and the remaining six streams were previously unsurveyed.

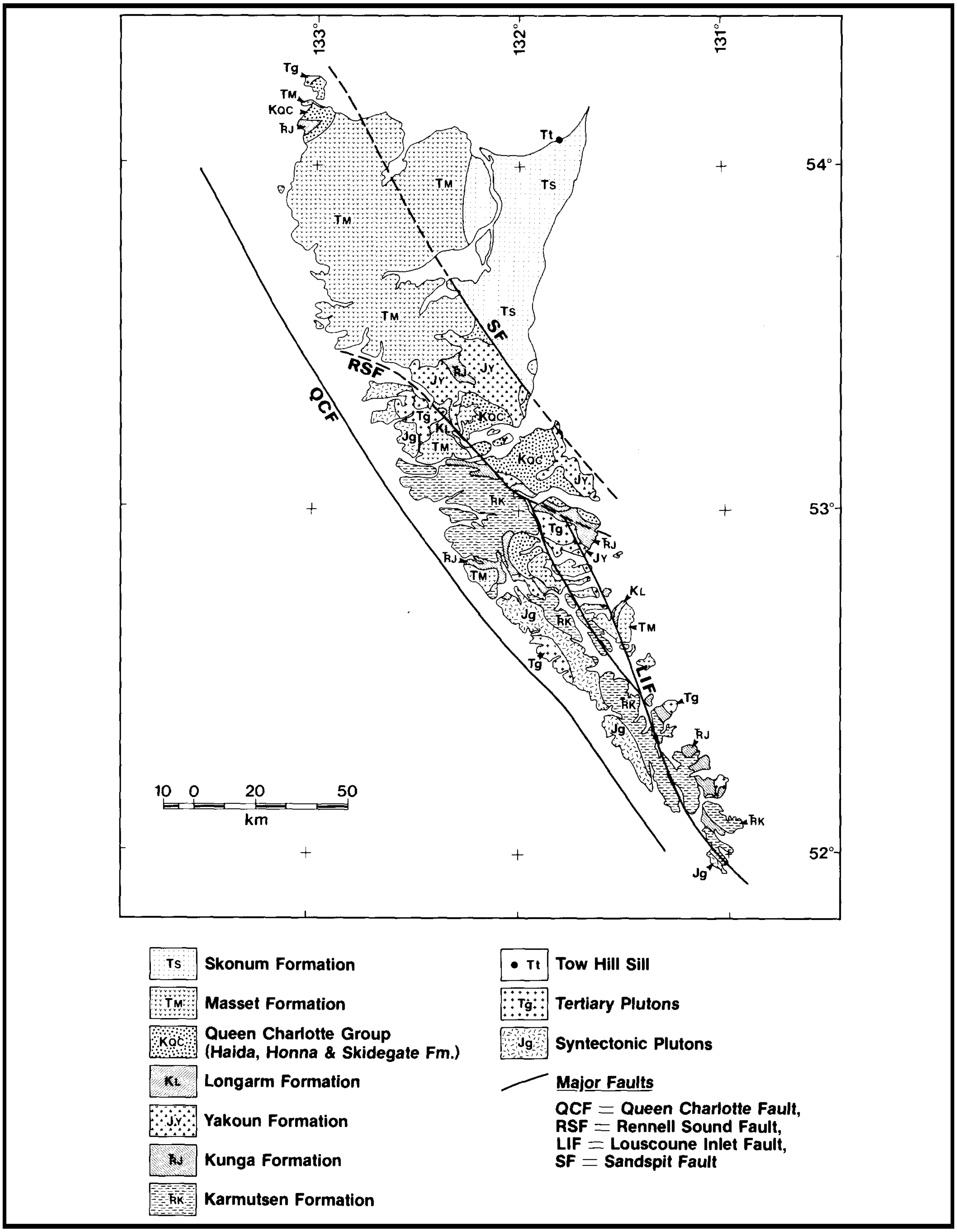


Figure 3. Generalized geology of Gwaii Haanas identifying the underlying geological formations, plus provincial ecosection boundaries.

2.0 METHODS

2.1 General Approach

The approach taken with this report was to provide a summary of the biophysical data for freshwater lakes and streams within the boundaries of Gwaii Haanas. Historical information (Table 1) was largely gleaned from Reimchen (1992a) which compiled information from 1) 1979 stream inventory data partially compiled as the British Columbia Stream Atlas (MOE 1986), 2) unpublished data from research activities within Haida Gwaii/Queen Charlotte Islands, and 3) Federal Department of Fisheries and Oceans (DFO) annual salmon escapement estimates dating back to 1947. Several years of recent survey information were also collected for three lakes plus 22 streams (Reimchen 1994a, Reimchen *et al* 1994). Updated escapement data (1991-96) were obtained directly from annual DFO Record of Management Strategies (RMS) reports for salmon and then appended to the existing database (see Appendix A).

Table 1. Major data sources used for compilation of aquatic resource information.

Data	Year(s)	Details	Source
Lake Surveys	1976-87	35 lakes inspected	Reimchen 1992a
	1993	3 lakes surveyed	Reimchen 1994a
Stream Surveys	1979	191 streams surveyed	MOE (unpublished)
	1993	14 streams surveyed	Reimchen 1994a
	1994	8 streams surveyed	Reimchen *et al* 1994
Salmon Escapement	1947-90	Up to 71 streams inspected annually	DFO escapement data
	1991-96	Estimates for 71 streams appended	DFO annual RMS reports

The following descriptions of collection methods provide an overview of how various data were obtained. More detailed summaries of field methods are given for the 1993-94 lake and stream surveys completed for Parks Canada (see Appendix B for complete text of methods provided by Reimchen 1994a and Reimchen *et al* 1994). Recommendations for revisions to future surveys will also be included where required.

2.1.1 Lake Surveys

Biophysical data collection for most low elevation lakes plus several others were competed during 1976-87 in conjunction with research activities related to endemic forms of threespine stickleback (*Gasterosteus aculeatus*) (T. E. Reimchen, Univ. of Victoria, pers. comm.). The number of lakes having information varied with the descriptor, but general categories were noted for most of the 35 lakes (Table 2). Sampling dates varied from lake to lake, but collections were made between May and August. The primary collection gear was the minnow trap since most sites had sharp dropoffs, but beach seines were used where site conditions allowed. Forage fish were collected using standard (6.3 mm mesh) minnow traps set for 6 hours, or in some cases, overnight. The netting objective was to capture target species in a habitat-dependent manner rather than index fish species abundance. Gillnets (5 m x 1 m panel, 40 mm mesh) were also set for periods of 8-24 hr in five lakes. Details concerning the number of collections, locations, dates plus other information (e. g. plankton, aquatic invertebrates, substrates, shoreline vegetation) were archived but are currently unavailable.

Table 2. Biophysical descriptors available from 1976-87 research work on 35 lakes. The number of lakes depends on the descriptor.

Biophysical Descriptor	Comments
Water chemistry	15 elements, pH, conductivity
Physical	Watershed codes (old, new), area, elevation, substrate, spectra
Fish	Presence, parasites, diet
Amphibians	Sightings and comments
Birds	Sightings and comments
Mammals	Sightings and comments
Aquatic plants	Species presence and abundance comments
General remarks	Surrounding terrain or forest types

The value of the 1976-87 data lies with sightings for flora and fauna distributions, plus limited chemical, physical and fish diet information. There is little opportunity for comparisons with standardized assessment surveys.

Sampling methods for the three lakes surveyed during 1993 are detailed in Appendix B, and are summarized below. Bathymetric maps were constructed using a minimum of 15 sounding transects per lake, and enabled the creation of hypsographic curves. Mid-day water temperature and dissolved oxygen readings were taken at three sites per lake. Values were recorded at 1 m intervals to a maximum depth of 15 m. Conductivity and pH were also measured from surface waters at these sites. Surface water samples were collected from the center of each lake for chemical analysis of 15 elements. Secchi disk readings were taken at two sites per lake, and light transmission was determined.

General abundance estimates were made for aquatic vegetation based on boat circumnavigation of the littoral zone, plus wading within representative areas. Substrate composition was visually categorized into six groups based on particle size, and assigned percentages within each site. The presence/absence of submerged trees and branches were also noted.

Zooplankton and benthos samples were obtained from each lake. Mid-day and midnight zooplankton samples were collected from three sites per lake using a plankton net. Duplicate samples were taken at each sampling occasion. The contents were preserved, and later processed for counts and general identification. Several bottom sediment samples were collected per lake using an Eckman dredge, and any macroinvertebrates found were preserved for classification. Macrobenthos were also obtained using dipnets at several littoral sites. Representative specimens of zooplankton and macroinvertebrates were forwarded to the Museum of Nature (Ottawa) for positive identification, but results are not available since the samples were not processed.

Fish were captured using Fyke nets and gillnets. Fyke nets set perpendicular to shore permitted live capture of fish which were identified and measured for standard length (SL). Rainbow trout (*Oncorhynchus mykiss*) and Dolly Varden (*Salvelinus malma*) over 10 cm were individually marked by either clipping the adipose fin of small fish (10-13 cm), or dorsal attachment of a Floy tag to larger individuals (>13 cm). Gillnets were used both at the surface and on bottom within open water habitats, and each gillnet contained multiple mesh sizes (from 1-10 cm). Live fish from gillnets were processed and released, while stomach contents were also examined from dead fish.

Amphibian, bird and mammal sightings were recorded throughout each day, with observation periods frequently starting at 0515 h to include potential early morning activity.

Lake morphometrics were calculated using 1:20,000 base map information plus bathymetric data. These values included lake area, volume, shoreline length, shoreline development factor, maximum length and width, plus several depth estimates (maximum, mean, relative).

Survey data for both lakes and streams were compiled as a series of Microsoft™ Access database files (Appendix C) containing the biophysical information. These data were used to review and compare results.

2.1.2 Stream Surveys

The British Columbia MOE, precursor to MELP, undertook to inventory 191Gwaii Haanas streams in 1979. Most of the streams are located along the eastern coast of the islands. Basic descriptors included physical and biological parameters for several reaches per stream where possible. Field data were recorded on cards which were the early version of the stream cards used today to record stream survey information in a standardized fashion. Details concerning the site specific data collected in 1979 are unavailable at this time since the information has been archived. Watershed boundaries were superimposed on 1:50,000 maps containing digitized stream inventory information, and are part of the B. C. Stream Atlas. The spatial information for provincial streams is being compiled by MELP as part of the British Columbia Watershed Atlas, and will be available for GIS applications by April 1997 (G. Oliphant, MELP, Victoria, pers. comm.).

Two years of more recent stream inventories exist from 1993-94. These surveys were contracted out by Parks Canada, and 1993 represented the first year where this agency was collecting biophysical data from streams in a standardized fashion. Further refinements to the sampling strategy occurred during 1994, and were based on the success of 1993 surveys in achieving inventory goals set out by Parks Canada.

Significant changes in sampling strategy among the two years included the increased number of sites per stream, an absence of fish abundance estimates from stream reaches, plus more detailed riparian vegetation and bird identification during 1994.

Biophysical survey methods for July 1993 are fully described in Appendix B, and are summarized here. Stream discharge was estimated at a relatively uniform section of the lower mainstem which lacked side channels. The time (T) taken for a partially submerged float to travel a measured distance (M), the average depth (D) across the wet width (W) of the stream transect, plus a bottom roughness factor (R) were used to calculate the discharge rate (in $m^3 s^{-1}$) using the equation provided by Wetzel (1983):

$$\text{Discharge Rate} = \frac{L * W * D}{T * R}$$

Catchment areas were determined by digitizing stream watersheds from 1:50,000 maps and calculating the area within each watershed boundary.

Two representative sites (close to mouth, further upstream) were sampled per stream, recording various physical and biological parameters. Stream temperature, time of day, and weather conditions were recorded at each site. Table 3 lists the measurements of stream morphology, following standard stream survey guidelines (DFO/MOE 1987).

Table 3. Stream morphological measurements and their sampling frequencies.

Stream Morphology	No. of Sites (samples)	Technique	Categories
Length of hydraulic units	2 (as required)	Tape measure	Riffle, cascade, pool, glide
Channel/wetted widths	2(3)	Tape measure	None
Maximum pool depth	2(as required)	Measure	None
Streambed substrate	2(1)	Visual percentages	Fines (<2 mm particles) Small gravel (2-16 mm) Large gravel (16-64 mm) Larges (over 64 mm) Bedrock
Streambed compaction	2(1)	Kicking gravel areas	Low, medium, high
Total cover for fish	2(1)	Visual percentage	% of wetted area
Composition of the cover	2(1)	Visual percentages	Cutbank, boulders, large organic debris (LOD), overhanging vegetation, instream vegetation

Stream confinement (between valley walls or terraces)	2(1)	Visual	Entrenched, confined, frequently confined, occasionally confined, unconfined

Riparian vegetation was classified as a percentage of crown cover over the stream bed and ranked by dominance for the major tree species. Presence/absence of 12 shrub and 34 herb species were also recorded.

Duplicate water samples were taken at one lower mainstem site per stream, and were sent to the Northern Forest Research Centre (Natural Resources Canada, Canadian Forest Service, Edmonton) for chemical analysis of 15 elements.

Various groups of fauna were collected or recorded during stream surveys (Table 3). Macroinvertebrate samples were collected before other instream work was completed at each site, and were later sorted into five categories to estimate numbers. Representative invertebrates were kept for expert identification, but no results have been received. Sightings of amphibians, birds and mammals were recorded along with additional notes concerning numbers or other information.

Table 4. Biological sampling for 1993-94 stream surveys.

Fauna	Number of Sites (no. of samples)	Technique	Categories/Comments
Macroinvertebrates	2(variable) in 1993 5(variable) in 1994	Surber sampler (25.4 cm x 25.4 cm)	Ephemeroptera, plecoptera, diptera, trichoptera, others
Fish	2(2) in 1993 max. 5(1) in 1994	Backpack electroshocker	All fish identified, measured and combined weights
Other vertebrates (amphibians, aquatic birds, mammals)	In stream or along stream edges	Visual counts when possible otherwise noted presence	Included animal signs (e.g. droppings, tracks)

The technique used to collect fish within selected sites was similar for both survey years, but the number of samples per stream varied. In 1993, fish were collected from two sites along each stream by using a backpack electroshocker within confined areas of the stream. Fish movement to/from the sample areas was restricted by using block nets to limit escapement. Two separate catches were made, with each electroshocking run starting from the downstream net to the upstream net and back again. Fish from each catch were anaesthetized, sorted by species, individually measured for standard length, and a combined species weight was recorded. Fish were then revived and released. When sample size and numbers allowed, fish abundance within a stream section was estimated using the removal method described by Seber and LeCren (1967) where:

$$n = \frac{(Catch1)^2}{(Catch1 - Catch2)}$$

A revised method was used in 1994 to determine which sites would be sampled for fish, and also to simplify each sample collection. Since more sites were being surveyed per stream (5 vs. 2) in 1994, the lower elevation sites were always electroshocked, but sampling of sites above the first high waterfall depended upon the presence of fish at the first site above the obstruction. If fish were present at this site, the remaining upstream sites were also electroshocked, otherwise no further fish collections were attempted. Unlike the 1993 collection method of making one upstream and one downstream electroshocking run within the confines of barrier nets, a single upstream electroshocking run was made at each site in 1994. This method eliminated the opportunity to estimate fish population sizes within sampled reaches. Collected fish were handled in the same manner as the previous year.

2.1.3 Salmon Escapement

The Federal Department of Fisheries and Oceans (DFO) has a long history of monitoring selected streams during salmon spawning runs. A subset of 24 streams have annual escapement estimates (defined as the number of mature fish that reach the spawning beds) dating from 1947 to the present, and DFO currently assesses up to 71 streams annually within Gwaii Haanas. Briefly, the method involves weekly inspections of each stream from the coastline to the known (or potential) upstream limits for salmon migration. Trained staff walk along the lengths of streams where salmon presence is known or suspected, recording estimated numbers for each species as the various salmon runs progress. They check for the presence of chum (*Oncorhynchus keta*), coho (*O. kisutch*), pink (*O. gorbuscha*) and sockeye salmon (*O. nerka*), and are able to determine new arrivals to the stream based on fish condition. Weekly numbers per species are recorded, and escapement estimates are derived from the maximum number of each species observed per stream.

DFO has designated certain streams as “key streams” since they historically or currently support significant runs of one or more salmon species. Three streams (Flamingo Inlet Creek, Goski Bay Creek, Louscoone Inlet Creek) are currently designated within DFO Management Area 2 West (2W) on the west coast of Gwaii Haanas, and nine others (Bag Harbour Creek, Cresent Creek, Echo Harbour Creek, Salmon River, Gate Creek, Matheson LH Creek, Sedgwick Bay Creek, Windy Bay Creek, plus Skaat Harbour LH Creeks) are identified as key streams on the east coast in Management Area 2 East (2E). Naming conventions for DFO escapement data assume that streams are named as Creek unless otherwise noted. Creek names may also have coding to indicate left-hand (LH), right-hand (RH), first right (FR), second right (SR), or head (HD) as the location of certain streams along identified channels (e.g. Hutton Inlet HD, Burnaby Narrows FR).

Annual escapement data for key salmon species have been collected by DFO staff for many years, and in some cases as far back as 1946 (Marshall *et al* 1978a, 1978b). The number of inspected streams has varied over the years, but lengthy trends are available in many cases. The reliability of escapement estimates for coho salmon is lessened due to the natural lateness of their runs relative to the other species. DFO inspections within Gwaii Haanas normally do not coincide with peak spawning periods for coho (V. Fredette, DFO, Queen Charlotte, B. C., pers. comm.). Even so, the strength of annual coho runs may be reflected in escapement estimates even though counts were not completed during peak periods.

Reimchen (1992a) also reviewed annual DFO field records for salmon escapements from 1953-90 and compiled sighting records for bird and mammal activity during the spawning runs. Indices were constructed based on the annual frequency of species sightings for each stream and the total number of years when the species was observed (Appendix D). Unfortunately, no further information or formulae were available to describe actual derivation of these values. The apparent variability of records among observers and streams limited the value of the DFO data, but still provided a coarse measure of stream use by predators at this time of the year.

3.0 RESULTS

3.1 Lakes

3.1.1 General

Gwaii Haanas has approximately 500 waterbodies ranging in size from 0.02 - 228 ha. Lakes larger than one hectare make up less than 21% of the waterbodies, and most of these lakes are found at elevations of 50-100 m above sea level (Figure 4).

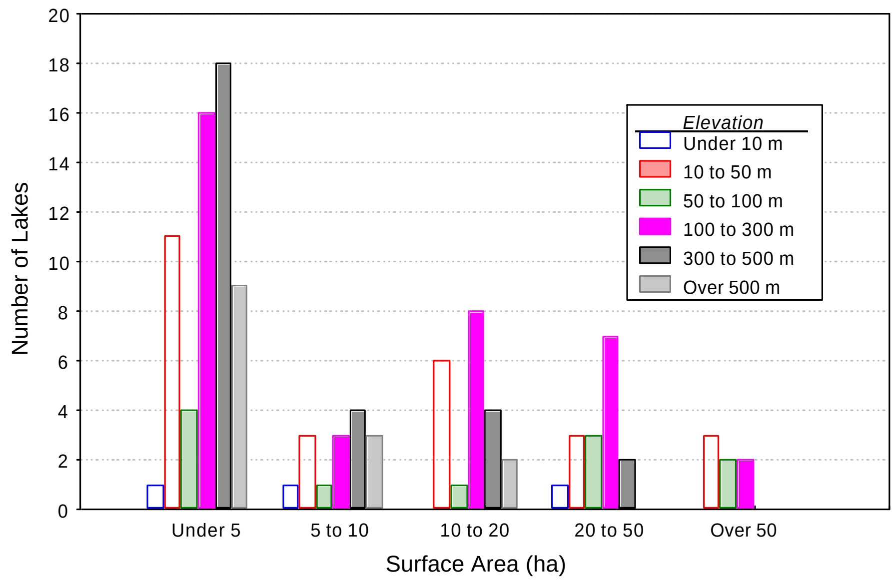


Figure 4. Distribution of Gwaii Haanas lakes based upon lake size and distribution.

All lakes within Gwaii Haanas are located on Moresby Island except for three lakes on Lyell Island and one lake on Burnaby Island (Table 5, Figure 5). The four largest lakes are found along the west coast. The majority of lakes are located within the northern half of Gwaii Haanas, interspersed throughout the San Christoval Mountain Range. Those watersheds which contain lakes frequently have three or more lakes within the drainage system. Lakes rarely occur on 1st order streams, and if so, are quite small.

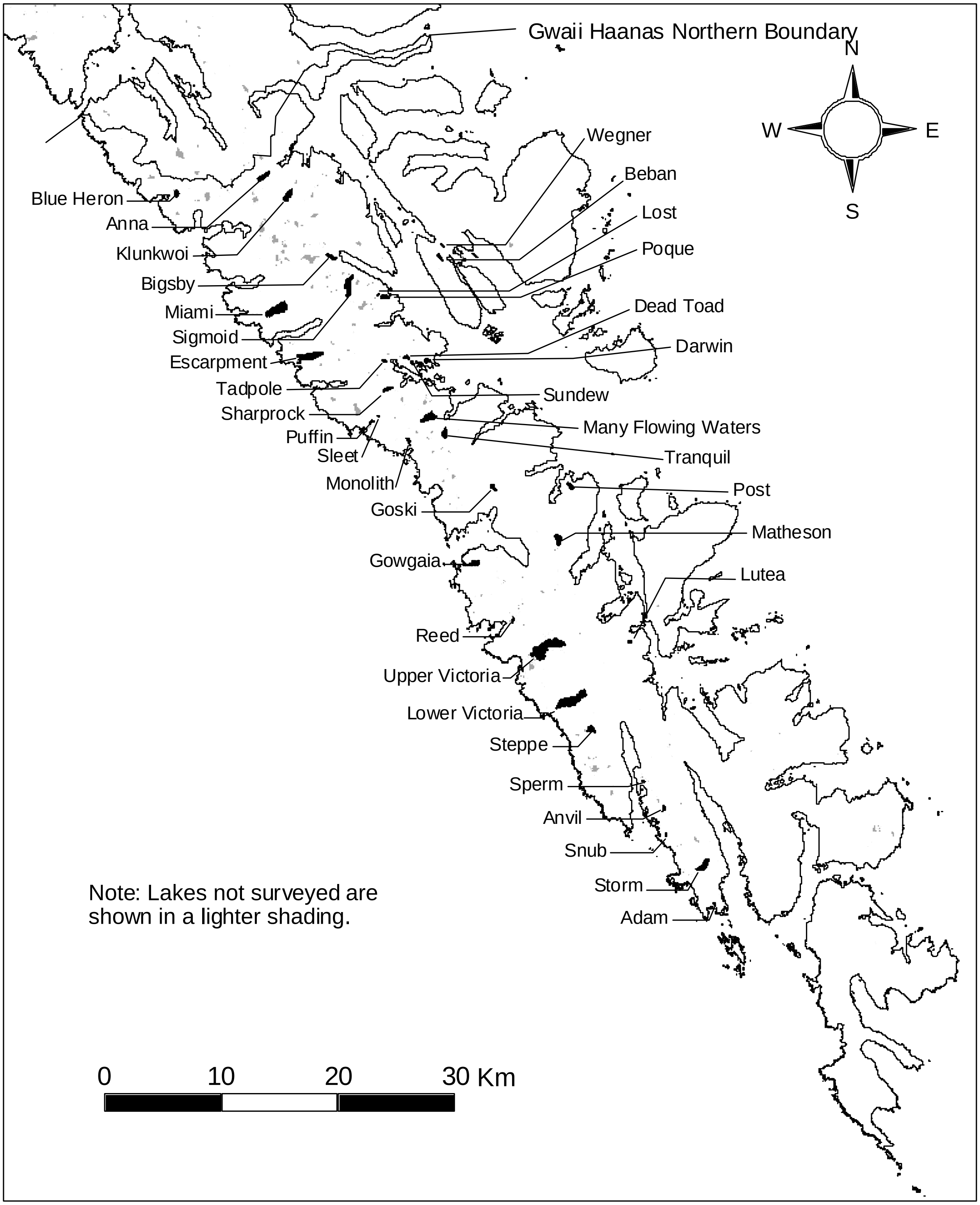


Figure 5. Location of surveyed lakes which have biophysical data available from recent assessment surveys or research activities from 1976-87.

Island(s)	Surface Area (ha)	Shoreline Perimeter (km)	% of all Watersheds	No. of Lakes (≥1ha)	Total Lake Area (ha)	Lake Perimeter (km)
Burnaby	6,463	69	5.8	1	3.5	0.7
Kunghit	12,700	151	6.5	0	0	0
Lyell	17,300	140	11.6	3	25.3	3.9
Moresby	102,171	780	71.9	114	1,398.4	15.6
Others	8,636	588	4.2	0	0	0
TOTAL	**147,271**	**1,728**	**100.0**	**118**	**1,427.2**	**20.2**

3.1.2 Physical

Only 35 lakes possess basic descriptors other than lake area, shoreline perimeter and elevation. This subset includes lakes from 1.8-228.3 ha in size and elevations of 5-229 m (Table 6).

A cursory evaluation of littoral substrates is available for 27 lakes. Of these, four lakes (Anvil, Sharp Rock, Sigmoid, Tranquil) were described as having angular rock substrates, along with boulder, bedrock or coarse gravel depending on the lake. Goski Lake and Wegner Lake had soft substrates, while silt and bark were noted for Tadpole Lake. Exposed bedrock was the only substrate given for Blue Heron Lake, but was one of several substrates listed for Klunkwoi Lake and Many Flowing Waters Lake. The remaining lakes had substrates consisting mostly of coarse gravel and sand. Angular rock and bedrock were frequently noted for lakes located above 50 m elevations.

The only lakes which have detailed substrate information are those lakes surveyed in 1993 (Lower Victoria, Upper Victoria, Escarpment). Reimchen (1994) provided figures illustrating substrate dominance within 24-33 sectors per lake, and the information is summarized in Table 6. The Upper Victoria Lake littoral habitat contains mostly sands, gravels and cobbles, except for exposed bedrock near the outlet plus one other section of the lake. Relatively gentle slopes provide sections up to 30 m wide with an exposed sand and gravel shoreline during summer low-water periods.

The shoreline surrounding much of Lower Victoria Lake has a much steeper profile. Coarse sands and gravels dominate the littoral substrate along the north and east shores, and the west is mainly bedrock. Major landslides have moved trees from shoreline slopes into the lake basin in several areas, creating tree spires originating at depths to 25 m.

Escarpment Lake contains a narrow shoreline, with littoral substrates varying frequently between bedrock and boulders along most of the south shore. Larger sections of coarse sands and fine gravels occur to the north. Landslides within the outlet bay and along portions of the south shore have placed tree trunks within the water.

Table 5. Summary of selected physical and chemical data, plus fish species presence for Gwaii Haanas lakes. Known fish species are listed, and probable species are noted within brackets. Fish species include coho (CO), Dolly Varden (DV), rainbow trout (RT), threespine stickleback (TS), coastrange sculpin (CS), prickly sculpin (PS), Pacific staghorn sculpin (SS) and starry flounder (SF).

Lake	Area (ha)	Perimeter (km)	Elevation (m)	% Spectra (at 400 nm)	pH	Fish Species
Adam	2.2	0.7	41	82.5	6.3	(DV)
Anna	34.3	2.9	158	-	-	None collected
Anvil	7.7	1.5	55	83.1	6.6	None collected
Beban	11.4	1.7	24	95.0	-	DV TS (CO RT)
Bigsby	20.9	2.5	8	92.8	-	CS PS RT TS (CO)
Blue Heron	18.8	1.8	117	-	-	None collected
Darwin	14.6	1.9	7	90.0	-	CO PS TS (DV RT)
Dead Toad	13.3	1.5	46	94.1	6.7	CS
Escarpment	109.8	6.8	14	96.3	6.3	CO DV RT TS
Goski	13.4	1.7	24	88.1	7.3	CO TS (DV RT)
Gowgaia	28.8	3.3	6	77.9	-	CO DV PS SS TS (RT)
Klunkwoi	43.4	3.2	64	-	-	None collected
Lost	2.8	0.7	50	-	-	None collected
Lower Victoria	160.3	7.6	40	94.8	7.0	DV RT TS
Lutea	7.1	1.1	17	93.9	6.8	CO TS (DV RT)
Many Flowing Waters	57.6	4.4	78	-	6.7	DV
Matheson	35.3	2.6	76	-	6.7	DV
Miami	120.0	5.3	63	-	-	CO
Monolith	11.3	2.0	30	-	-	None collected
Poque	21.0	2.3	25	90.8	6.0	CS DV TS (CO RT)
Post	19.8	2.0	17	87.0	-	CO RT TS (DV)
Puffin	6.9	1.4	5	82.7	-	CO PS RT TS (DV)
Reed	6.0	1.5	27	-	7.3	DV
Sharp Rock	17.6	2.3	158	-	-	None collected
Sigmoid	69.6	5.1	103	-	6.2	(DV)
Sleet	1.9	0.6	50	-	-	None collected
Snub	4.0	1.0	25	82.5	6.7	DV TS (CO RT)
Sperm	3.8	0.9	30	-	-	None collected
Steppe	24.4	2.5	115	-	-	None collected
Storm	47.8	3.8	62	88.5	6.6	(DV)
Sundew	4.7	1.2	24	86.4	-	TS (CO DV)
Tadpole	6.4	1.2	24	86.1	7.3	DV (CO)
Tranquil	26.8	2.3	229	86.9	6.8	None collected
Upper Victoria	228.3	9.8	43	92.4	7.1	DV
Wegner	2.0	0.8	5	93.9	-	CO SS TS

Table 6. Dominant substrates within the littoral zone of three lakes.

Lake	Substrates	% of Shoreline	Comments
Upper Victoria	Coarse sands, gravels	55	Most common substrate type
	Bedrock	25	Along both shores near outlet, plus along east central area
	Coarse gravels, cobbles	20	Mainly along northeast and northwest shores
Lower Victoria	Coarse gravels, cobbles	60	Largely along north and east shores
	Bedrock	30	Southwest portion of lake
	Coarse sands, gravels	10	Four small sections around lake
Escarpment	Coarse sands, gravels	35	Mainly along north shore
	Bedrock	25	Scattered sections throughout lake
	Boulders	20	Along south central shore and outlet
	Coarse gravels, cobbles	20	Isolated areas along south shore

3.1.3 Chemical

Temperature and dissolved oxygen profiles for three lakes (Figure 6) are quite similar, with the top 15 m layer of water being well oxygenated and thermally stratified. Dissolved oxygen measurements were not taken at greater depths, but Eckman grab samples from Escarpment Lake indicated anoxic conditions did exist.

Analysis of water chemistry is very sporadic for Gwaii Haanas lakes (Table 8). Lake water was relatively neutral with pH values averaging 6.8. Conductivity was in the 35-80 µmhos cm^{-1} range, except for several lakes which were affected by saltwater incursion or salt spray, producing much higher readings. Most waters also had high clarity based on spectrophotometric measurements.

Table 7. Availability of water chemistry data from 35 Gwaii Haanas lakes.

Parameter	No. of Lakes	Range	Comments
pH	18	5.65 - 7.3	Acidic to slightly alkaline
Conductivity	10	35 - 4150	Extreme highs due to marine incursions
Spectra	21	77.9 - 95.0	Clarity typical of mountain lakes
15 elements	8	variable	Values depend on specific elements

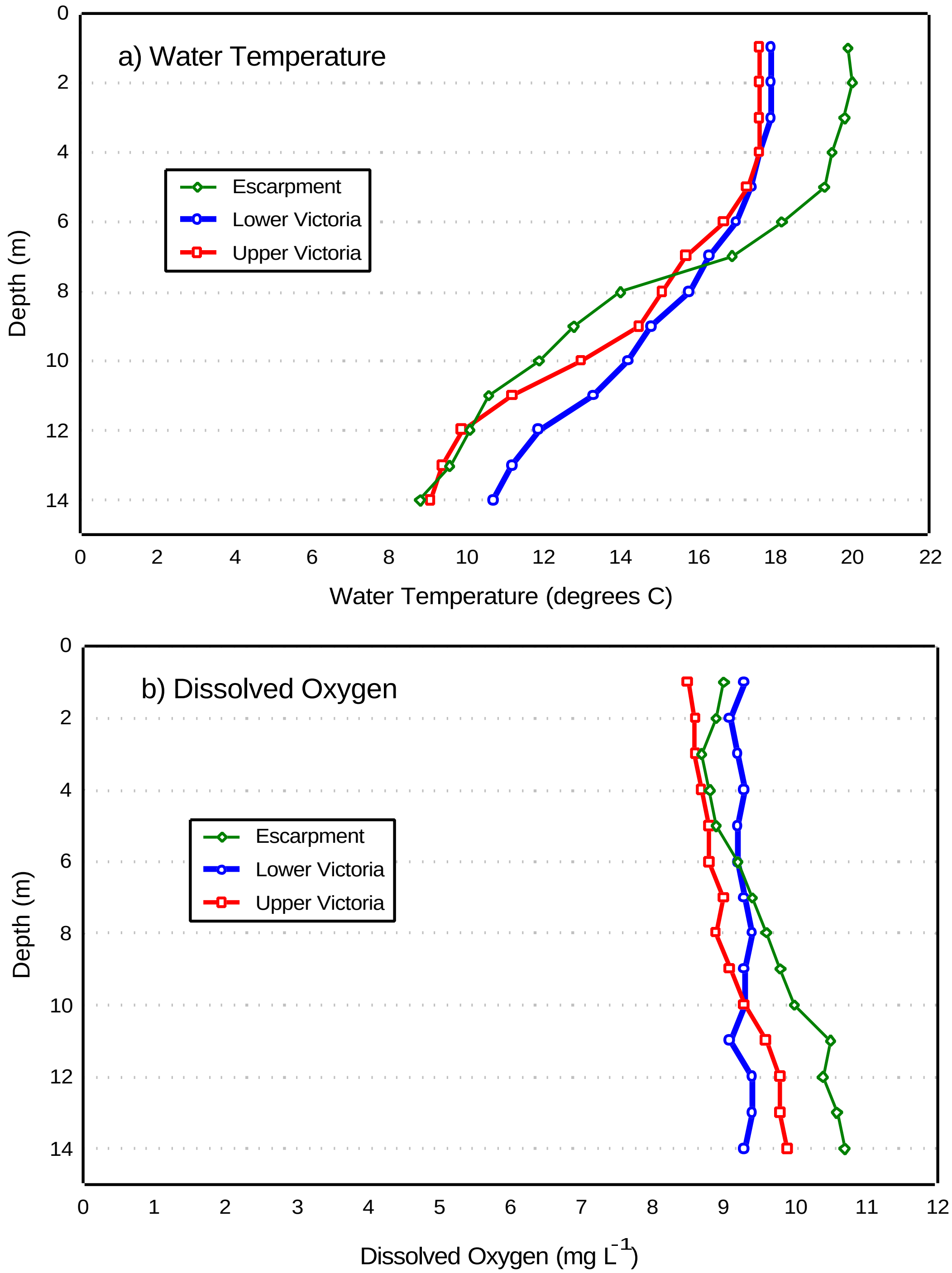


Figure 6. Profiles for a) water temperature and b) dissolved oxygen measurements from the deepest basin in Escarpment Lake, Lower Victoria Lake and Upper Victoria Lake.

The 8-lake subset for which 15 chemical elements have been analyzed (Table 8) show several interesting features of Gwaii Haanas lakes. Based on element concentrations, three lakes (Adam, Gowgaia, Lutea) are susceptible to contributions from seawater, leading to unusually high concentrations of numerous elements. Gowgaia Lake is low enough (6 m elevation) to experience direct marine incursions during extreme weather conditions, but the other two lakes are more likely receiving added elements via salt spray during wind storms and subsequent runoffs. Bigsby Lake (8 m above sea level) shows no chemical sign of salt spray additions, likely due to its sheltered location within Bigsby Inlet. Other lakes such as Darwin, Puffin, and Wegner have elevations of 5-7 m, but water analyses have not been completed to indicate marine incursions even though a tide influence has been noted for Wegner Lake. Potassium, iron and phosphorus levels in Adam Lake and Lutea Lake are very high compared with the other six lakes.

Table 8. Summary of 15 element concentrations in lake waters. Values for certain elements were recorded as below detectable limits (BD) for the 1993 analyses.

Lake	Ca	Mg	Na	K	Al	Ti	Pb	As	Cu	Fe	Mn	Zn	Ni	P	S
Adam	198.6	58.6	383.6	692.2	1.70	0.01	0.14	0.10	0.03	2.33	5.42	1.50	0.07	205.1	101.0
Bigsby	0.6	0.8	6.3	2.1	0.40	0.02	0.37	0.25	0.02	0.02	0	0.03	0.17	0.40	0.25
Escarpment (1976)	0.6	0.2	4.1	0	0.03	0.03	0.03	0.02	0	0	0	0.03	0.02	0.04	0.44
Escarpment (1993)	1.1	0.6	5.1	0.8	0.22	BD	0.01	0.02	0.18	BD	0	0.02	BD	0.04	0.64
Goski	2.2	0.7	5.4	1.3	0.03	0	0.03	0.02	0	0.08	0	0	0.01	0.59	0.51
Gowgaia	15.2	39.7	344.5	12.9	0.14	0.01	0.01	0.10	0.01	0.01	0	0.01	0.07	0.16	27.50
Lower Victoria	1.4	0.7	4.7	0.7	0.07	BD	0.01	0.01	0.01	BD	0	0.02	0.02	0.01	0.60
Lutea	124.6	20.3	150.7	298.8	0.94	0	0.07	0.05	0.13	1.44	21.63	0.54	0.06	31.41	33.33
Puffin	0.9	0.4	6.3	1.2	0.16	0	0.03	0.02	0	0.05	0	0	0.01	0.03	0.42
Reed	2.4	0.8	6.7	1.0	0.21	0	0.03	0.02	0.01	0.04	0	0	0.01	0.31	0.49
Upper Victoria	0.8	0.4	4.9	0.9	0.08	BD	0.01	0.12	0.02	BD	0	0.03	BD	0.20	0.41

3.1.4 Fauna

3.1.4.1 *Fish*

There have been eight fish species reported from the limited number of lakes inventoried within Gwaii Haanas (Table 9). All eight species are diadromous even though freshwater populations are common for threespine stickleback as well as several salmonids and cottids. Elevation and stream gradient are important factors associated with fish distribution. The 14 lakes which contain fish are less than 30 m above sea level, while the five lakes above 110 m lacked fish populations. Fourteen of the 35 lakes have no fish species indicated. Dolly Varden probably occurs in three of these lakes and more complete sampling is required to fill in the data gap or confirm their absence. It is quite possible that many of the smaller lakes do not contain fish, and the preponderance of stream obstructions due to the rugged terrain certainly limits lake usage by migratory species.

Highlights of the 1993 fish sampling results show that Fyke nets were the more efficient gear for collecting available species within lakes (Table 10). Threespine stickleback was the most abundant species, and was only caught using Fyke nets. This was expected since gill net mesh sizes were selected to capture larger fish species. Dolly Varden was the only species caught in Upper Victoria Lake and was very abundant. Dolly Varden was also dominant whenever more than one salmonid species was present in the lake.

Table 9. Fish species observed in lakes. Values in brackets indicate the number of additional lakes where the species probably occurs (from Reimchen 1992a).

Fish Species	Taxonomic Name	No. of Lakes	Comments
Dolly Varden	*Salvelinus malma*	11(+9)	Only species found at higher elevations
Rainbow trout	*Oncorhynchus mykiss*	5(+7)	Probably in at least another 7
Coho salmon	*O. kisutch*	9(+4)	Probably in at least another 4
Threespine stickleback	*Gasterosteus aculeatus*	14	Low elevation lakes
Prickly sculpin	*Cottus asper*	4	Low elevation lakes
Coastrange sculpin	*C. aleuticus*	3	Catadromous species
Pacific staghorn sculpin	*Leptocottus armatus*	1	Incidental marine species
Starry flounder	*Platichthys stellatus*	2	Incidental marine species

Table 10. Summary of catch and size information for fish collected from Fyke net and gill net samples for three lakes.

Lake	Species	Total Catch	Mean Catch (fish/net) by Gear			Standard Length (cm)	
			Combined	Fyke Net	Gill Net	Mean	Range
Escarpment	Dolly Varden	100	3.4	4.8	2.4	10	6-23
	Rainbow Trout	24	0.9	1.3	0.4	18.5	8-31
	Threespine stickleback	4450	159	318	0	7	3-9
Lower Victoria	Dolly Varden	317	11.7	16.4	3.9	14	5-22.5
	Rainbow Trout	107	4.0	5.9	0.7	16	7.5-29
	Threespine stickleback	718	26.6	41.9	0.6	5	N/A
Upper Victoria	Dolly Varden	844	60.3	74.5	8.3	9	4-21.5

Attempts to estimate population sizes using mark-recapture techniques failed to produce reliable estimates within the brief sampling period during lake surveys. Reimchen (1994) did estimate species abundance, but noted a lack of confidence since several estimates relied upon only one recaptured fish. Also, other basic assumptions for population estimates were not met (Ricker 1975).

Five major parasitic groups (trematodes, cestodes, nematodes, acanthocephalans, copepods) were identified from seven fish species (Table 12). Six of the 18 parasites require either birds or mammals as definitive hosts. The presence of *Corynosoma* in the starry flounder (*Platichthys stellatus*) from Gowgaia Lake supports the theory that this fish species recently lived in marine waters. Eleven parasitic species were found in threespine stickleback, compared with 3-5 for most other fish. Extensive use of Lower Victoria Lake by diving birds was suggested by Reimchen (1992a) due to 100% occurrence of *Schistocephalus solidus* in threespine stickleback.

Table 11. Parasites identified from coho salmon (CO), coastrange sculpin (CS), Dolly Varden (DV), prickly sculpin (PS), rainbow trout (RT), starry flounder (SF), and threespine stickleback (ST). Data are from Reimchen (1992a).

Parasite	Fish Host							Definitive Host
	CO	CS	DV	PS	RT	SF	ST	
Trematoda								
Diplostomum sp.							✓	Bird
Bunadera sp.				✓			✓	Fish
Crepidostomum farionis	✓		✓					Fish
tetracotyle metacercaria		✓					✓	Bird
Cestoda								
Diphyllobothrium sp.				✓			✓	Mammal
Schistocephalus solidus		✓					✓	Bird or mammal
Proteocephalus sp. (larva)							✓	Fish
Nematoda								
Eustrongylides sp.				✓			✓	Bird
Capillaria sp.		✓						Fish
Truttaedacnitis truttae	✓				✓			Fish
Cystidocoloides tenuissima			✓	✓			✓	Fish
Salvelinema salmonicola			✓					Fish
S. walkeri	✓							Fish
Acanthocephala								
Neoechinorhynchus sp.	✓		✓				✓	Fish
Echinorhynchus sp.	✓						✓	Fish
Corynosoma sp.						✓		Marine mammal
Copepoda								
Ergasilus sp.				✓				Fish
Thersitina gasterostei							✓	Fish

Dolly Varden

Dolly Varden is the most common salmonid species among lakes within the Protected Area. Anadromous populations are common within its natural range (Scott and Crossman 1973), but the migratory nature of most Gwaii Haanas lake populations is uncertain unless major obstructions are evident downstream to restrict movement (e.g. Upper Victoria Lake). This is the only species found in the higher elevation lakes (Many Flowing Waters (78 m), Matheson (76 m)) which still contain fish. Large-bodied Dolly Varden (>40 cm SL) are known to migrate inland and over-winter in lakes on Graham Island before returning to offshore waters come spring, and similar movements are expected within Gwaii Haanas (Reimchen 1992a).

The size distribution for Dolly Varden collected from Escarpment Lake shows an abundance of fish between 8.5-11 cm, and was similar to the peak size within Upper Victoria Lake (Figure 7). The mean size of Dolly Varden in Escarpment Lake was slightly larger, but in all three lakes, abundance rapidly declined above 14.0 cm. Since the sampling gear effectively caught larger fish such as rainbow trout, the sharp declines seen in these histograms should reflect the maximum sizes for Dolly Varden in the lakes. A larger mean size of fish was collected from the eastern basin of Upper Victoria Lake.

This basin contains a greater amount of littoral area compared to the western basin, and may contain more benthic invertebrates which are suitable forage for larger fish. Sea-run fish which migrate from coastal waters are identified by the presence of marine parasites and tend to be much larger fish. Several individuals were collected during stream surveys, but none were observed during the lake surveys.

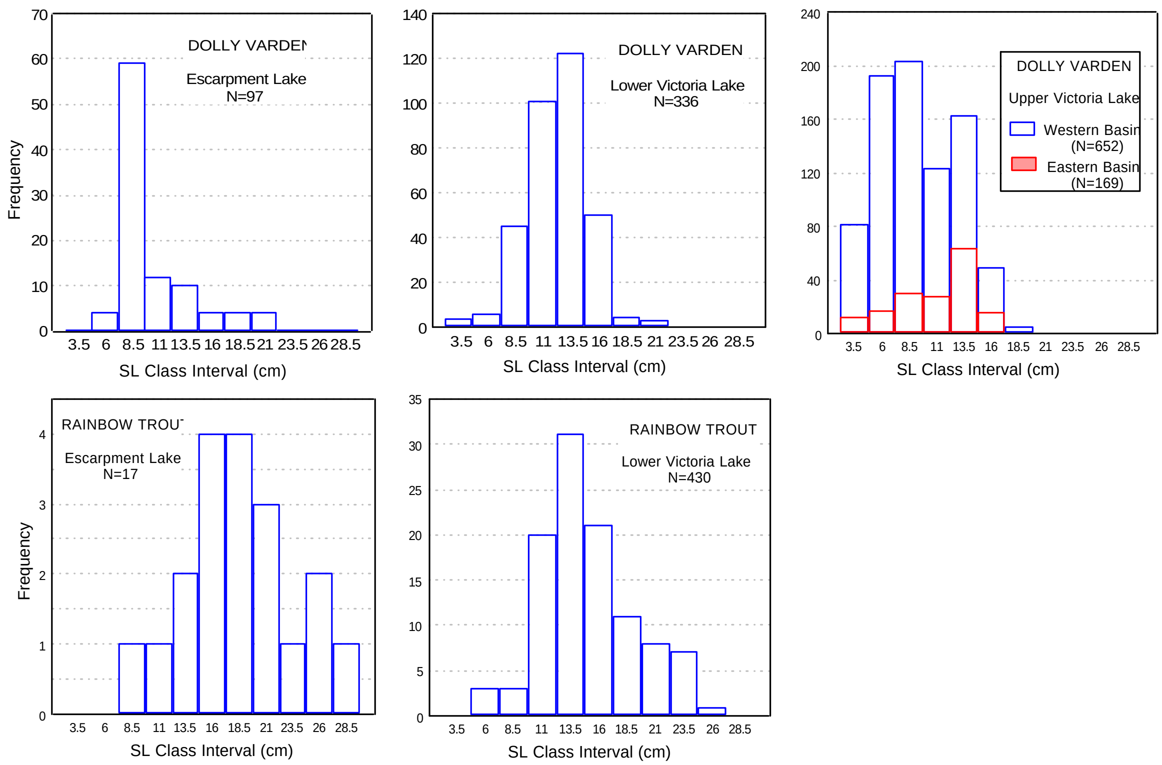


Figure 7. Size distributions for Dolly Varden and rainbow trout from Escarpment, Lower Victoria and Upper Victoria Lakes.

Dolly Varden may compete with fall spawning salmon for food, and are considered a serious predator on young salmon (Scott and Crossman 1973). Diet information for Dolly Varden (45-220 mm SL) collected from lakes in Gwaii Haanas indicated that numerous insect groups (odonata, trichoptera, coleoptera, diptera) were common food items, along with amphipods and threespine stickleback (Figure 8). Fourteen categories of food items were identified in Dolly Varden stomachs (Appendix E).

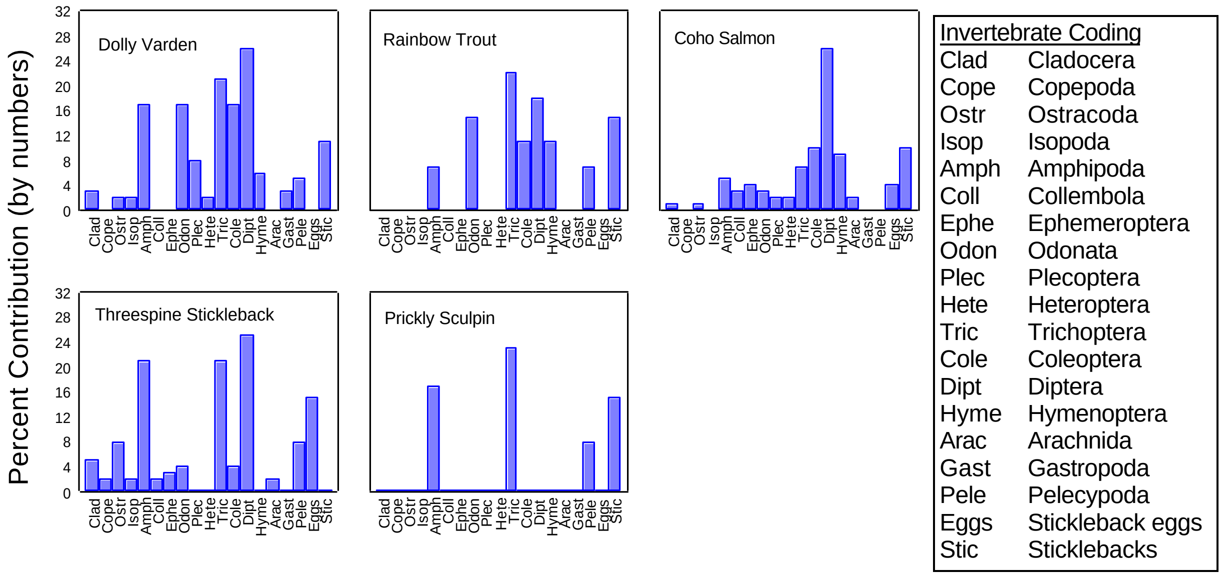


Figure 8. Summary of diet composition for five fish species collected from Gwaii Haanas lakes.

Rainbow Trout

Rainbow trout have been collected from five lakes having elevations under 40 m. It is probably found in another seven of the low elevation lakes known to contain fish, but was not collected during brief sampling periods (Reimchen 1992a). Like the Dolly Varden, rainbow trout populations may be restricted to freshwater and attain a smaller size (<30 cm SL) than its sea-run form known as steelhead trout. Unlike salmon, steelhead trout do not die following a spawning run and are able to return in future years to continue reproducing. Rainbow trout is considered a resident population in Lower Victoria Lake due to the steep outflow gradient which is impassible for migratory steelhead trout.

Rainbow trout were not caught during fish sampling in Upper Victoria Lake, but limited samples were obtained for Escarpment and Lower Victoria Lakes. Mean size of rainbow trout in Escarpment Lake was larger than for Lower Victoria Lake (Table 10, Figure 7), suggesting that the population in Escarpment Lake consists of both rainbow and steelhead trout.

The diet of rainbow trout is less diverse than that of Dolly Varden, even though trichoptera and diptera are the most common food groups for both species (Figure 8). Reimchen (1994) noted that the low zooplankton density for Escarpment Lake may be associated with the presence of rainbow trout and threespine stickleback which feed on both zooplankton and benthos.

Coho Salmon

This species was confirmed in ten of 35 lakes, but coho fry presence in most low elevation lakes is expected as adults migrate upstream through lakes to spawn at higher elevations. High numbers of coho fry were noted historically from Lutea Lake (Reimchen 1992a). Coho fry normally rear within streams but have been known to inhabit littoral areas of lakes (Mason 1974). Coho were absent from all three lakes surveyed in 1993, but its occurrence within stream reaches was evident from recent mid-summer surveys. Coho appear in relatively small numbers within many Gwaii Haanas streams during the late fall spawning season, but peak numbers for this species may not be observed during the period where salmon escapement is monitored by DFO.

Preliminary diet analyses from coho collected during earlier lake surveys (Reimchen 1992a) showed that four categories (diptera, coleoptera, hymenoptera, threespine stickleback) comprised 60% of the coho diet by numbers. The remaining 40% consisted of another ten invertebrate groups plus stickleback eggs (Appendix E).

Threespine Stickleback

This species is known to exist in 14 of 35 inventoried lakes. With the exception of Lower Victoria Lake, all lakes were less than 25 m above sea level, and lake size ranged from 1.6-157 ha. Older lake surveys indicated that threespine sticklebacks were very abundant in Lutea Lake, and also that this species matured at a very small size in Darwin Lake (Reimchen 1992a). Based on the 1993 surveys (Reimchen 1994a), this was the most common fish in Lower Victoria and Escarpment Lakes but it was absent from Upper Victoria Lake (Table 10). Very few details related to these particular lake populations were reported.

Threespine stickleback from the Queen Charlotte Islands exhibit considerable morphological and genetic variation resulting in unique populations within the archipelago (Moodie and Reimchen 1973, Reimchen 1990). Threespine stickleback populations among Gwaii Haanas lakes appear relatively undifferentiated compared to their counterparts on Graham Island. However, Reimchen (1992a) noted the resemblance of Bigsby Lake stickleback to its ancestral marine form, the presence of large-bodied females in Escarpment Lake, and the smaller size at first maturity (28 mm) in Darwin Lake compared to the typical female maturity at 40 mm or more (Moodie and Reimchen 1976).

Fourteen food categories were identified from threespine stickleback diet summaries from historical information (Appendix E). Just over half of the food items consisted of dipterans, trichopterans or amphipods. Stickleback eggs made up 12% of the diet. Coho was the only other fish species to consume these eggs.

Sculpins

The coastrange sculpin (*Cottus aleuticus*) characteristically resides in fast water, but does occur within lakes (Scott and Crossman 1973). It was present in three lakes (Bigsby, Dead Toad, Poque) situated in the northern portion of Gwaii Haanas. These lakes are all less than 20 m above sea level. This species is the only fish collected from Dead Toad Lake. Prickly sculpins (*C. asper*) occurred in four lakes, but Bigsby Lake was the only location to support two cottid species. Unlike the coastrange sculpin, prickly sculpins prefer the quieter waters found in lakes. Aquatic invertebrates are the major food source for both species throughout much of the year, but salmon eggs and fry are seasonally important (Scott and Crossman 1973). These species may also form part of the diet for Dolly Varden and other salmonids (Carl *et al* 1959). The Pacific staghorn sculpin (*Leptocottus armatus*) is a marine species which is commonly found near shore. It inhabits coastal bays and estuaries, and sometimes enters the mouth of coastal streams (Eschmeyer *et al* 1983). It was noted in Wegner Lake, and may have arrived via marine incursion.

Starry Flounder

The starry flounder is typically a marine species which is able to tolerate extreme salinity changes, and has frequently been found in the lower reaches of streams (Carl *et al* 1959). Its presence in Gowgaia Lake is not surprising since the lake is only 6 m above sea level and may be inundated with seawater during severe storms. Regular movement of the species between this lake and the coastal waters is not possible due to waterfalls at the mouth of the outlet. Higher sea levels during the past 5,000-10,000 years may have allowed starry flounder to enter other lakes which are currently at higher elevations, but the species would not have reproduced and established populations in a strictly freshwater environment.

3.1.4.2 *Mammals*

Four mammal species which are commonly associated with lacustrine habitats are the black bear (*Ursus americanus*), river otter (*Lutra canadensis*), pine marten (*Martes americana*) and raccoon (*Procyon lotor*). Species presence near Gwaii Haanas lakes was often detected from telltale tracks and/or droppings rather than by actual sightings.

Signs of black bear were observed near nine of the 35 lakes during 1976-87. Five of the nine sightings occurred along the central portion of the west coast, and the remaining signs were scattered along the east coast of Moresby Island. Most lakes were below 50 m elevation, except for Many Flowing Waters Lake (78 m) and Sharp Rock Lake (158 m). The true distribution of this species is unclear within Gwaii Haanas. Black bear sightings from the smaller islands are very rare, presumably because limited resources are unable to sustain permanent populations (Westland Resource Group 1994). This species is more readily observed along streams during the fall salmon migrations (Reimchen 1992a). Use of the lower elevation riparian habitat may be seasonal. Salmon is an important food resource during the fall, but herbaceous forage and berries are important indicators of black bear habitat during the spring and summer months (Westland Resource Group 1994).

The river otter was observed near three lakes (Darwin, Goski, Reed) according to available survey information. Within Naikoon Provincial Park, river otters are found in the larger lakes containing fish populations. The diet consisted almost entirely of stickleback even though fry of other fish species were present as potential food sources (Reimchen 1992b). River otters are present along the coastal shorelines of Gwaii Haanas, but remain closely associated with marine or stream shorelines which support fish (Westland Resource Group 1994). The suspected lack of fish resources within many of the Gwaii Haanas lakes would limit their suitability for river otters.

Raccoon were introduced into the Masset area of Graham Island by the 1940s (Summers and Rodway 1988), and are found throughout the island now. Numerous sightings are reported for raccoon on Moresby Island plus others within Gwaii Haanas, and the animal or its signs have been documented from numerous islands. Raccoon are opportunistic feeders which have fed on the abundance of western toads (*Bufo boreas*) during breeding season at several lakes (Reimchen 1992a), but the impact on toad populations is unknown. In Gwaii Haanas, the species is more closely associated with coastal habitat, feeding mainly on crabs, clams and intertidal invertebrates (Westland Resource Group 1994).

The pine marten was seen near three lakes (Lost, Many Flowing Waters, Reed). This species of marten is known to forage regularly along island beaches of the Queen Charlotte Islands (Cowan 1989), but the extent of lake shore usage is unknown due to its secretive and nocturnal habits (Westland Resource Group 1994).

3.1.4.3 *Avifauna*

Numerous avian species which were identified from inventoried lakes prior to 1993 all are typically associated with aquatic environments (Table 12). One additional bird sighted was the blue grouse. It is not an aquatic species, but it was seen at eight of the 35 lakes. The 1993 survey of three lakes (Reimchen 1994a) included sightings for all birds regardless of habitat preferences, adding another 15 species to the list. All species listed in Table 13 have also been identified by various other sources (see Westland Resource Group 1994).

Common species included both the common and hooded mergansers, red-throated loons and Canada geese. None of these species were observed at more than seven of the 35 lakes. Red-throated loons are known to breed in Gwaii Haanas, but nesting sites have only been identified at Beban Lake, Sperm Lake, and near Gowgaia Bay (Reimchen 1992a, Douglas and Reimchen 1988).

During the 1993 lake surveys, sandhill cranes were associated with open bogs adjacent to Upper Victoria Lake, while Canada geese were observed both in a nearby *Sphagnum* bog and along the shore of Lower Victoria Lake. Bird activity on or immediately over these lakes was often limited to the occasional sighting of species such as loons or belted kingfishers. Tree swallows frequently foraged on insects above *Nuphar* plants on Upper Victoria Lake.

Most of the bird activity occurred either in the forest canopy or on the forest floor. The calls of marbled murrelets were very common from the slopes surrounding Escarpment Lake but were less frequent near the Victoria Lakes. The species was also heard regularly while flying high above Escarpment Lake at dawn.

Table 12. Bird species associated with Gwaii Haanas lakes. Sightings orginate from A) 1976-87 lake studies (Reimchen 1992a) or B) the 1993 lake surveys (Reimchen 1994a).

Common Name	Taxonomic Name	Lakes	Habitat	Sightings
American dipper	*Cinclus mexicanus*	5	shore	A B
American robin	*Turdus migratorius*	1	terrestrial	B
Bald eagle	*Haliaeetus leucocephalus*	2	coastal	B
Barrow's goldeneye	*Bucephala islansica*	1	aquatic	B
Belted kingfisher	*Ceryle alcyon*	1	shore	B
Blue grouse	*Dendragapus abscurus*	1	terrestrial	A B
Canada goose	*Branta canadensis*	7	aquatic	A B
Chestnut-backed chickadee	*Parus rufescens*	2	terrestrial	B
Common loon	*Gavia immer*	4	aquatic	A B
Common merganser	*Mergus merganser*	6	aquatic	A B
Common raven	*Corvus corax*	1	terrestrial	B
Glaucous-winged gull	*Larus glaucescens*	5	coastal	A B
Great blue heron	*Ardea herodias*	2	shore	A
Harlequin duck	*Histrionicus histrionicus*	1	aquatic	A
Hermit thrush	*Catharus gluttatus*	2	terrestrial	B
Hooded merganser	*Lophodytes cucullatus*	7	aquatic	A
Mallard duck	*Anas platyrhynchos*	3	aquatic	A B
Marbled murrelet	*Brachyrhamphus marmoratus*	3	coastal	B
Northern flicker	*Colaptes auratus*	2	terrestrial	B
Red crossbill	*Loxia curvirostra*	1	terrestrial	B
Red-throated loon	*Gavia stellata*	6	aquatic	A B
Sandhill crane	*Grus canadensis*	2	shore	A B
Townsend's warbler	*Dendroica townsendi*	1	terrestrial	B
Tree swallow	*Tachycineta bicolor*	1	terrestrial	B
Varied thrush	*Ixoreus naevius*	1	terrestrial	B
Western flycatcher	*Empidonax difficilis*	3	terrestrial	B
Winter wren	*Troglodytes troglodytes*	2	terrestrial	B

3.1.4.4 *Aquatic Macro-invertebrates*

The list of known aquatic macroinvertebrates has been compiled from diet analyses for fish species collected since the benthic invertebrate samples sent to the Museum of Nature in Ottawa have not been identified (Table 13). Most macro-invertebrate classes are represented, but identification of organisms rarely reaches the level of genus and species. This list is by no means exhaustive and simply summarizes identified genera, and in some cases species, present within Gwaii Haanas lakes.

Table 13. Invertebrates identified from stomach contents of Coho (CO), Dolly Varden (DV), prickly sculpin (PS), rainbow trout (RT), staghorn sculpin (SS), and threespine stickleback (ST).

Class or Order	Taxonomic Name	Fish Species Stomach					
		CO	DV	PS	RT	SS	ST
Amphipoda	*Anisogammarus sp.*						✓
	Hyalella azteca	✓	✓				✓
Odonata	*Aeshna sp.*				✓		
	Cordulia shutleffi						✓
	Enallagma sp.		✓				✓
	Lestes sp.		✓				
	Libellula sp.				✓		
	Limnepilus sp.						✓
Coleoptera	*Agabinus sp.*	✓			✓		
	Gyrinus sp.						✓
	Heliophorus sp.		✓				
	Hydroporus sp.					✓	
	Ilybius sp.						✓
Diptera	*Ablabesmyia sp.*	✓	✓				✓
	Limnonia sp.	✓					
	Phaenopsectra sp.						✓
	Plecia americana				✓		
	Procladius sp.	✓					✓
	Rhamphomyia sp.	✓	✓		✓		
	Trichonta sp.				✓		
Trichoptera	*Ecclisomyia sp.*		✓				✓
	Lepidostoma sp.			✓	✓		
	Mystacides sp.				✓		
	Ocetis sp.				✓		
Isopoda	*Exosphaeroma sp.*		✓			✓	✓
Acarina	*Hydrozetes sp.*	✓					
Ostracoda	*Candona sp.*						✓

3.1.4.5 *Zooplankton*

Zooplankton samples were collected from Escarpment, Lower Victoria and Upper Victoria Lakes during 1993 (Table 15). Density estimates were much higher for Upper Victoria Lake compared to the other lakes, indicating that it is a more productive waterbody. Cladocerans dominated (by numbers) for Escarpment and Upper Victoria Lakes. Results from detailed taxonomic identifications have not been received, but may provide insights into the structure of these plankton communities at some point in the future.

Zooplankton samples were also collected from an undetermined number of the 35 lakes referenced by Reimchen (1992a), but these data are not summarized and are currently archived (T. E. Reimchen, pers. comm.).

Table 14. Estimated zooplankton density and dominant groups for three lakes.

Lake	No. of Samples	Mean Density (number m^{-3})	Range of Values (number m^{-3})	Comments
Escarpment	6	172	61 - 473	Estimated 71% cladocerans and remainder were copepods
Lower Victoria	6	425	91 - 1209	92% cyclopoid copepods and remainder were cladocerans
Upper Victoria	6	1778	1097 - 3275	Estimated 60% cladocerans and remainder mostly cyclopoid copepods

3.1.4.6 *Amphibians*

The Queen Charlotte Islands currently has two amphibian species documented. The western toad (*Bufo boreas*) is native to these islands, and has been observed at 12 lakes within Gwaii Haanas by 1993. High toad densities have been observed in the littoral zone of several lakes during the breeding season (late May to early June). Raccoon predation on the toad was evident at Dead Toad Lake, where many everted toad skins were found along a stretch of shoreline (Reimchen 1992a). The raccoon is able to peel and discard toad skins which contain toxins that normally affect other predators (Green and Campbell 1984).

The Pacific treefrog (*Hyla regilla*) was introduced onto Graham Island around 1963. It has expanded its range throughout much of Graham Island and onto the northern portion of Moresby Island (Reimchen 1991). This species has not yet been documented Gwaii Haanas other than a single sighting near Anna Inlet in 1982 (a personal communication from K. Moore noted by Reimchen (1992a)), and will likely spread south in the future. Its impact on the native toad is uncertain, but these two species do have diet overlaps at various life stages, leading to potential competition for food resources (Reimchen 1992c).

3.1.5 Flora

3.1.5.1 *Aquatic Macrophytes*

The distribution of aquatic macrophytes within Gwaii Haanas lakes is limited to initial data for the 35-lake subset. A rough quantitative measure of yellow pond-lily (*Nuphar luteum*) abundance in these lakes indicates that this species covered 80% or more of the lake surface in five lakes (Goski, Gowgaia, Lutea, Sleet, Sperm) found at elevations of 50 m or less. These lakes are all under 30 ha in size. The productivity of these waters may be reflected in the abundance of yellow pond-lily, or other aquatic macrophytes (e.g. *Fontinalis* was extensive at Adam Lake). Yellow pond-lily was still found in lakes located 160 m above sea level, but its abundance dropped to less than 1% of surface area in lakes at elevations above 60 m. Higher nutrient concentrations for potassium and phosphorus resulting from marine incursion or salt spray may account for greater macrophyte productivity in Adam, Gowgaia and Lutea Lakes.

Bladderworts (*Utricularia*), the lesser spear-leaved buttercup (*Ranunculus flammula*), the needle spike-rush (*Eleocharis acicularis*) were some of the more common aquatic plants associated with the lakes, but numerous others were also identified (Table 15).

Table 15. Aquatic macrophytes recorded from 35 lakes, where frequency of occurance was rated as common (6 or more lakes, limited (2-5 lakes) or unique (1 lake) based on the number of lakes within the lake set having the species present.

Common Name	*Scientific name*	Frequency
Bristle-like quillwart	*Isoetes echinospora muricata*	Limited
Buckbean	*Menyanthes trifoliata*	Unique
Chara	*Chara* sp.	Limited
Diverse-leaved water-starwort	*Callitriche heterophylla*	Unique
Flat-leaved bladderwort	*Utricularia intermedia*	Common
Floating-leaved pondweed	*Potamogeton natans*	Limited
Fontinalis	*Fontinalis* sp.	Limited
Greater bladderwort	*Utricularia vulgaris*	Common
Lesser spear-leaved buttercup	*Ranunculus flammula*	Common
Mountain mare's-tail	*Hippuris montana*	Unique
Needle spike-rush	*Eleocharis acicularis*	Common
Northern bur-reed	*Sparangium hyperboreum*	Limited
Pondweed	*Potamogeton* sp.	Limited
Spreading rush	*Juncus oreganus*	Limited
Water club-rush	*Scirpus subterminalis*	Limited
Western lilaeopsis	*Lilaeopsis occidentalis*	Unique
Yellow pond-lily	*Nuphar luteum polysepalum*	Common

Several lakes contained other aquatic species which were unique in their abundance. Adam Lake (1.7 ha) contained extensive growths of common water moss (*Fontinalis antipyretica*) which normally occurs in flowing waters attached to rocks or logs (Pojar and MacKinnon 1994). Gowgaia Lake was the only other lake where this species was recorded. The spreading rush (*Juncus oreganus*) was quite abundant in Reed Lake and Lower Victoria Lake, but was not recorded elsewhere within lake inventories.

3.1.5.2 *Terrestrial Plants*

Available descriptions of shoreline vegetation from historical lake surveys were very cursory. Simple descriptors included mixed forest, (not) forested, open, or open bog whenever terrestrial vegetation was mentioned. Recent lake surveys mentioned dominant species for shorelines, but the level of detail was much less than for streams surveys.

The shortage of information from shoreline descriptions limits discussion. As more lake surveys and associated terrestrial vegetation data are compiled, future comparisons with the Gwaii Haanas Ecological Land Classification (Westland Resource Group 1994) will be possible.

Seventeen species of terrestrial vegetation were noted during the 1993 lake surveys (Table 17). Yellow cedar (*Chamaecyparis nootkatensis*), lodgepole pine (*Pinus contorta*) and sitka alder (*Alnus viridis*) were the tree species common to these lakes, and one or more of these species dominated along portions of the lakeshore. Western yew (*Taxus brevifolia*) and yellow cedar were common along the main inlet to Lower Victoria Lake. Large areas of *Sphagnum* bog exist near Upper Victoria Lake and along the north shore of Escarpment Lake. Six species of shrubs were associated with the inlet of Escarpment Lake.

Table 16. Terrestrial vegetation identified during the 1993 lake surveys for Escarpment, Lower Victoria and Upper Victoria Lakes.

Common Name	Taxonomic Name	Escarpment	Lower Victoria	Upper Victoria
Copperbush	*Cladothamnus pyrolaeflorus*	✓		
Devil's club	*Oplopanax horridus*	✓		
Hellebore (Indian)	*Veratrum viride*			✓
Lodgepole pine	*Pinus contorta*	✓	✓	✓
Mountain hemlock	*Tsuga mertensiana*			
Red alder	*Alnus rubra*	✓		
Red cedar	*Thuja plicata*	✓		✓
Red elderberry	*Sambucus racemosa*	✓		
Red huckleberry	*Vaccinium parvifolium*	✓		
Salmonberry	*Rubus spectabilis*	✓		
Sitka alder	*Alnus viridis*	✓	✓	✓
Sitka spruce	*Picea sitchensis*	✓		
Sphagnum	*Sphagnum* sp.	✓		✓
Stink currant	*Ribes bracteosum*	✓		
Western hemlock	*Tsuga heterophylla*	✓	✓	
Western Yew	*Taxus brevifolia*		✓	
Yellow cedar	*Chamaecyparis nootkatensis*	✓	✓	✓

3.2 Streams

3.2.1 General

As mentioned previously, the whole of Gwaii Haanas lies within the geological region of the Queen Charlotte Islands known as the Queen Charlotte Ranges. The rugged terrain within this region dictates the features characteristic of local streams. Elevations of over 1,100 m are reached along the northwestern coast of Gwaii Haanas, dropping rapidly to sea level and then continuing to depths of over 1,000 m within 10-20 km of the coastline.

Terrain along the east coast is much less extreme but still quite rugged compared the rest of the Queen Charlotte Islands.

Much of Gwaii Haanas consists of terrestrial ecosections that are not strongly differentiated, creating a sense that habitat diversity is relatively low compared to mainland sites (Westland Resource Group 1994). The climate is generally cool and wet, while the terrain quickly becomes rugged proceeding inland. Similarly, stream characteristics provide limited support for fish populations, particularly at higher elevations where slope and flow rates prevent most species from surviving extreme conditions.

Comparisons of stream biophysical data focus largely on geology, lake resence, and coastal location. Streams have been grouped by proximity to the east or west coast of Gwaii Haanas based on flow patterns and exposure to either the Pacific Ocean or Hecate Strait. The location of streams which were surveyed during 1993-94 are shown in Figure 9.

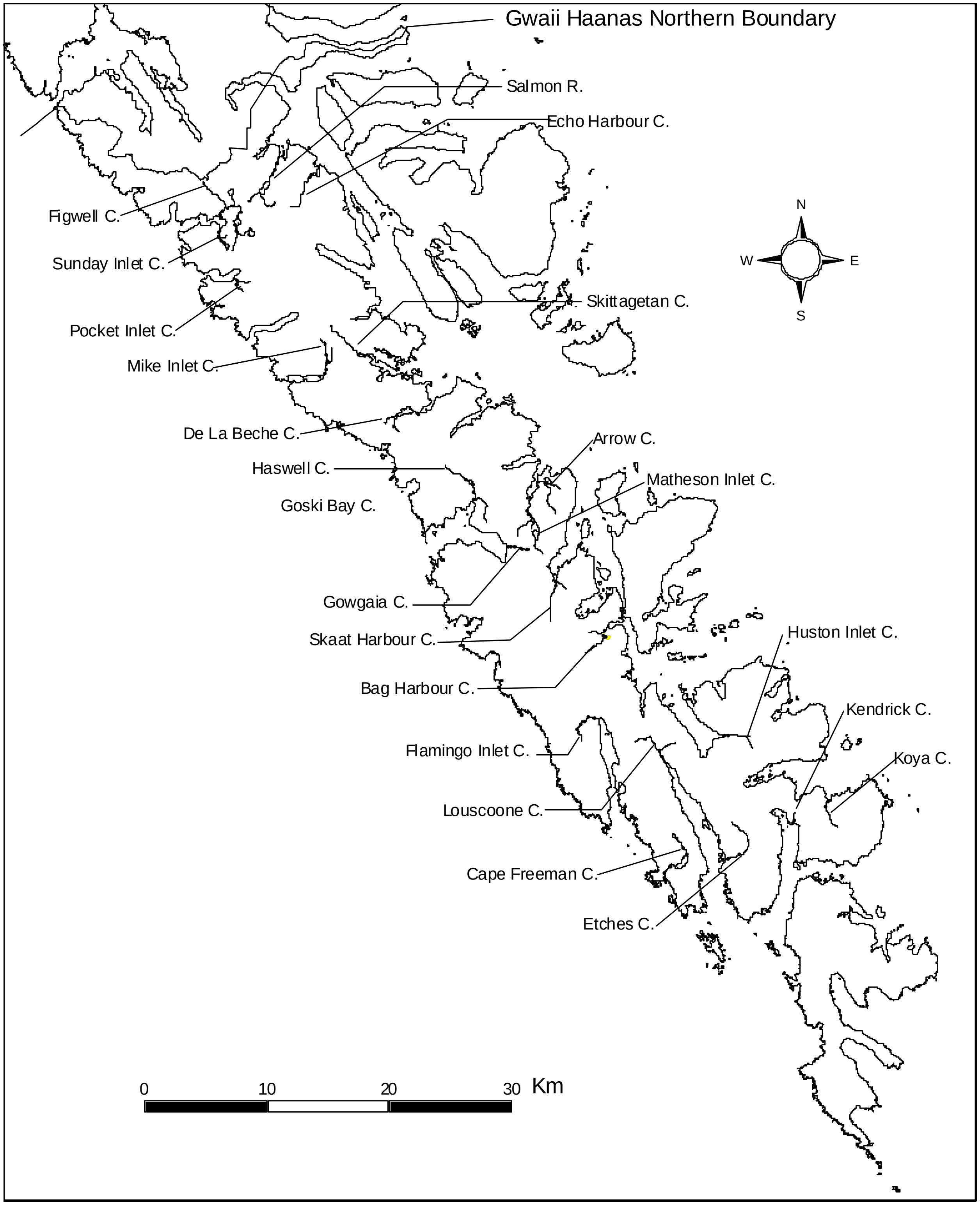


Figure 9. Location of Gwaii Haanas streams which were surveyed during 1993-94.

3.2.2 Physical

The geography of the Gwaii Haanas area precludes that many streams possess high gradient headwaters, changing to low gradient sections near the coast. Spatially, most of the 779 watersheds noted by Reimchen (1992a) are situated on the largest land mass in Gwaii Haanas which is Moresby Island (Table 18). About one quarter of the watersheds are situated on the other larger islands (Lyell, Kunghit, Burnaby), and the remainder were found on the numerous smaller islands. The same watershed set contained 433 1^{st} order (55.6%), 292 2^{nd} order (37.5%), 51 3^{rd} order (6.5%), and three 4^{th} order streams (0.4%).

Reimchen (1992a) used 1:50,000 maps based on aerial photographs to determine that 779 streams existed in Gwaii Haanas. A tally of the streams based on Terrain Resources Information Management (TRIM) data originating from 1:20,000 maps provides a significantly higher count of 1,475 streams (Table 18). The number of streams for each of the major islands is roughly proportional to their land mass. Moresby Island contains 67% of the streams within the Protected Area, followed by Lyell Island with just under 14%.

When stream order classification is summarized, 72.3% of all streams are 1^{st} order streams. Relatively more 1^{st} order streams are found on the smaller islands (81%) compared to Moresby Island (70%). Only the larger islands (Moresby, Lyell) have 4^{th} order streams, and the combined proportions of 3^{rd} and 4^{th} order streams on these islands are almost double those of the smaller islands.

Table 17. Distribution of streams and stream orders among the major Gwaii Haanas islands. Values are approximate based on manual counts of streams appearing within the Parks Canada GIS stream overlay.

Island(s)	Surface Area (ha)	% of all Watersheds	First Order	Second Order	Third Order	Fourth Order	Total
Burnaby	6,463	5.8	41	8	3	0	52
Kunghit	12,700	6.5	98	18	5	0	121
Lyell	17,300	11.6	145	37	16	2	200
Moresby	102,171	71.9	693	216	71	12	992
Others	8,636	4.2	89	16	5	0	110
TOTAL	**147,271**	**100.0**	**1066**	**295**	**100**	**14**	**1475**

The subset of 191 watersheds surveyed during 1979 varied in size from 4.3 - 3,767 ha, with a mean watershed area of 294 ha (Reimchen 1992a). A breakdown of this information showed that 36.1% of the watersheds were under 100 ha in size, 48.7% were 100-500 ha,10.5% were 500-1,000 ha, and 4.7% covered over 1,000 ha of the land base. Channel width measurements from the lowest reaches of these streams averaged 6.5 m, with a maximum value of 25 m for Gate Creek on Lyell Island. Other creeks with channel widths of 20 m or greater include Beresford Bay Creek (22 m), Marshall Inlet Head Creek (20 m), and Windy Bay Creek (20 m). Stream gradients near the mouth averaged 9.6% and one creek within Burnaby Narrows had the highest recorded slope of 33%.

Approximately 4% of Gwaii Haanas streams contain one or more lakes which are 1 ha or larger in size (Table 19). Moresby Island is the only island that has streams with more than one lake in the system. In one case, 17 lakes are located within a complex 4th order stream flowing into the head of Bigsby Inlet. Thirty-nine of 57 streams on Moresby Island contain a single lake.

Table 18. Summary of the number of streams, by island group, which contained one or more lakes within the stream system.

Island(s)	Numbers of Streams		Numbers of streams having 1 or more lakes				Lake
	Total	with Lakes	1 Lake	2 Lakes	3 Lakes	4 or More	Total
Burnaby	52	1	1	0	0	0	1
Kunghit	121	0	0	0	0	0	0
Lyell	200	3	3	0	0	0	3
Moresby	992	57	39	6	2	10	114
Others	110	0	0	0	0	0	0
TOTAL	**1475**	**61**	**44**	**6**	**2**	**10**	**118**

Stream Temperatures

It is apparent that the presence of lakes within a watershed noticeably increased the downstream water temperatures (Table 19). Streams having lakes present were warmer by 2.5-4.7 ^{o}C depending on the year and sampling time. The 1994 mean stream temperatures were also cooler than during the previous year. Reimchen (1994) noted the colder streams were those which had a northerly aspect and where lakes were absent. Daily stream temperatures are given in Appendix F.

Table 19. Summary of daytime stream temperatures (^{o}C) for watersheds with and without lakes. Morning temperatures were taken from 0800-1200 hr, and afternoon values covered the 1300-1800 hr period. Average temperatures were estimated for 8-11 values per period.

Watershed Type	1993 Surveys		1994 Surveys	
	Morning	Afternoon	Morning	Afternoon
Without lakes	11.5 (10.5-12.8)	12.8 (11.2-15.1)	11.0 (7.8-14.8)	11.8 (8.9-14.8)
With lakes[1]	15.4 (10.6-18.9)	17.5 (11.2-22.4)	13.5 (11.4-16.8)	14.2 (11.9-17.2)

[1]excluding stream temperatures taken above lakes

Stream Discharge

Stream discharge estimates were made for 22 streams during 1993-94 using a relatively uniform channel near the stream mouth for measurements (Appendix G). Few differences were noted when catchment area and discharge rate were compared with respect to lake presence, geology or coastal location. Summer discharge rates were frequently below 0.20 $m^3\ s^{-1}$ with three exceptions - Salmon River (2.67), Mike Inlet Creek (0.60), and Figwell Creek (0.72, 1.56), all of which have lakes within the watershed (Figure 10). Most of the streams having larger catchment areas also contain lakes.

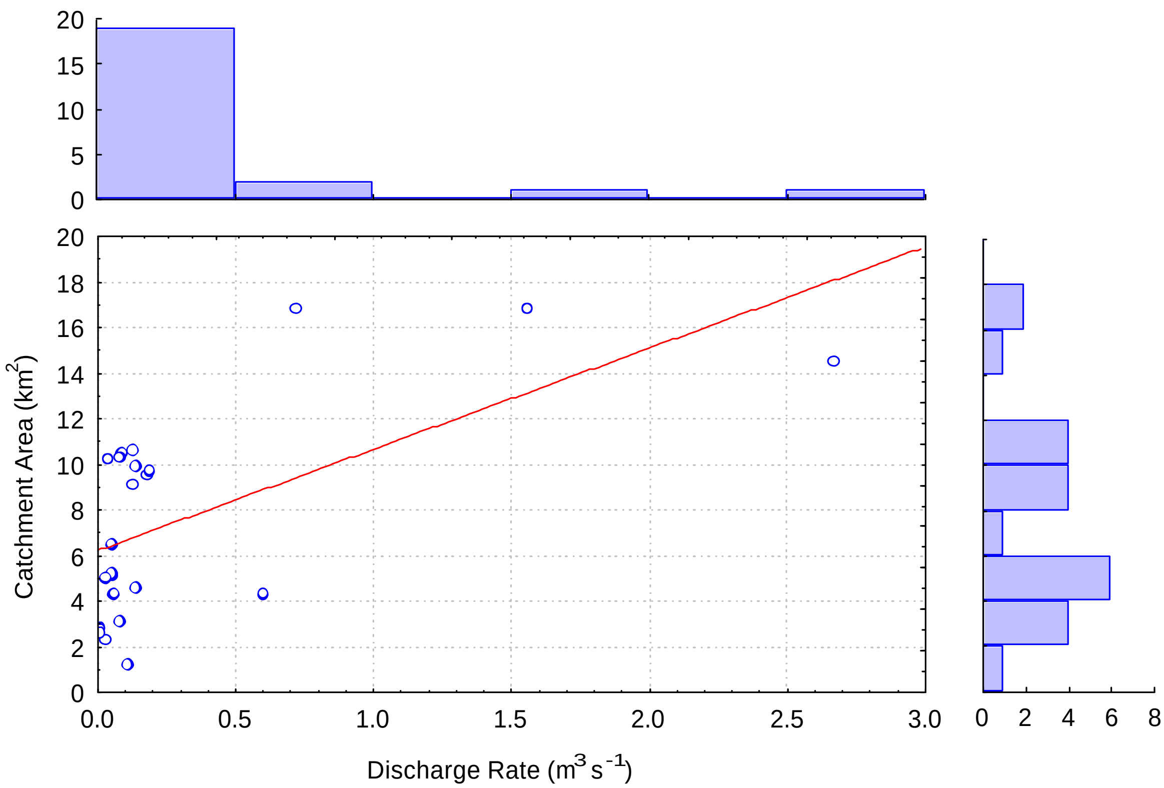


Figure 10. Relationship of stream flow and catchment area for 22 Gwaii Haanas streams, plus frequency plots for each variable.

Estimates for discharge rates were made during July when rainfall, and therefore stream discharge, is at a seasonal low (Hogan and Schwab 1990; Harper *et al* 1994). Heavy rainfall during July 16-17, 1994 no doubt increased discharge estimates for four streams (Figwell Creek, Mike Inlet Creek, Pocket Inlet Creek, Sunday Inlet Creek), but no baseline information exists to quantify expected increases. Even though Figwell Creek has the largest catchment area of all streams surveyed during 1993-94, rainfall impacts on its discharge rate would be buffered by the presence of six lakes within the watershed.

Salmon River had an unusually high discharge compared with other streams. Heavy rains just prior to the survey did not appear to seriously alter discharge though. Stream levels rose only slightly, and periphyton growth in the stream was close to existing water levels during the survey. Upon further investigation by Parks Canada in 1993, the outlet from the sizable headwater lake (98.7 ha) was blocked by landslide materials which appeared permeable. The Klunkwoi Lake water level was approximately 12 m below the high water mark at this time, and no surface flow was evident at the outlet. This feature would help moderate downstream surges in water flow via steady underground discharge throughout much of the year. Support for this theory was obtained by Parks Canada in September 1993 by comparing discharge rates for Salmon River and Echo Harbour Creek in the neighbouring watershed. The catchment area for Salmon River was 30% larger than that of Echo Harbour Creek, but the discharge rate was found to be five times greater (0.56-0.65 $m^3 s^{-1}$ vs. 0.11-0.12 $m^3 s^{-1}$).

Channel Morphology

Stream gradients appeared to differ with underlying geology and coastal location. Streams on the west coast had higher mean gradients from lower mainstem sites (sites 1 and 2) compared to the east coast (3.7% and 2.1% respectively).

Underlying geology plays an important role in defining channel characteristics of Gwaii Haanas streams. Of the three geological formations common to this area (Karmutsen, Kunga, Pluton), the Pluton formations are most resistant to weathering. Pluton sites have granitic or dolomitic rock as a foundation, Karmutsen sites commonly contain basaltic pillow lava, and Kunga sites consist of either limestone or sedimentary deposits (Sutherland Brown and Yorath 19889). Gradients from Pluton sites were much more variable than for Kunga or Karmutsen sites on either coast, and were also much higher on average. Lower mainstem gradients for Kunga and Karmutsen sites were quite similar with one exception - mean gradients were lower for east coast Karmutsen sites with lakes in the watershed (Arrow Creek, Bag Harbour Creek, Echo Harbour Creek, Matheson Inlet Creek, Salmon River).

The ratio of channel width to wet width provides a measure of stream flow stability. Low ratios generally indicate stable flows, and are characteristic of spring-fed streams or those watersheds having suitable lake capacity to buffer rainfall extremes. Generally, ratios were lower for the Pluton streams, or when lakes occurred in the watershed. Lakes are more prevalent within watersheds from Pluton formations. Kendrick Point Creek and Koya Bay Creek are east coast streams located on Kunga formations. Both streams lack lakes in the watersheds, and have higher ratios than the Pluton streams which also tend to have greater stream channel confinement. The absence of lakes for west coast Karmutsen streams corresponds with higher ratios than either west coast streams with lakes, or Pluton streams without lakes from the east coast.

Substrate composition for stream sites was not significantly correlated with geology or stream gradient, but did vary with channel width, wet width and their ratio for certain substrate classes. The percentage of large gravels increased with greater channel widths, while mean wet width was positively correlated with the amount of larges. Unlike substrates such as large gravels and larges which were evenly distributed among the levels of relative abundance, stream sites often had either low or high bedrock abundance. Bedrock appeared less prevalent as channel width increased, corresponding with the greater bedrock presence from Pluton streams which also had lower channel widths. Fines represented less than 10% of the substrate on average, but the lower mainstem site on De la Beche Inlet Creek (east coast Plutons) had 50% fines. Small gravels often represented 5-10% of the substrate, but were more abundant on the Kunga streams (Kendrick Point Creek, Koya Bay Creek).

Channel confinement ratings for stream reaches corresponded to standards provided by the DFO/MELP Stream Survey Field Guide (1987). Data were only available from stream sites surveyed in 1993. East coast sites were often occasionally confined for stream reaches on Karmutsen and Kunga formations, but most Pluton sites were classified as confined. Only two sites (Etches Creek, Arrow Creek) were considered totally confined and were found on the Plutons.

3.2.3 Chemical

Chemical characteristics of the surveyed streams are largely based on the underlying geological formations. Sodium was the most abundant element in 15 of the 22 streams, while calcium was most abundant in the remaining seven streams (Table 20). The lowest sodium values were obtained from streams located at the head of well sheltered inlets on the west coast (Mike Inlet, Sunday Inlet) which are protected from salt spray due to surrounding topography. Cape Freeman Creek had a relatively exposed lower mainstem, and also had the highest sodium values from the 1994 surveys. Overall, Kendrick Point Creek and Koya Bay Creek had the highest sodium levels, and both creeks reside on limestone substrates of the Kunga formation. Huston Inlet Creek and Gowgaia Creek each had concentrations for the 15 major elements totaling over 30 mg L^{-1}, and in both cases, calcium represented 67% of the total amount.

Table 20. Water chemistry results for 22 streams, plus coastal location, geology and lake presence within watersheds.

Stream	P	S	Mg	As	Na	Al	Zn	Cu	Pb	Ti	Ni	K	Mn	Fe	Ca	Total	Coast	Geology	Lakes
Arrow	.00	.58	1.7	.00	5.3	.01	.01	.01	.00	.00	.00	.6	.00	.00	3.2	11.3	E	KA	Y
Bag Harbour	.02	.46	1.8	.00	5.2	.03	.04	.01	.00	.00	.00	.6	.00	.00	3.5	11.7	E	KA	Y
De la Beche Inlet	.01	.45	1.1	.00	4.1	.00	.02	.01	.00	.00	.00	.5	.00	.00	6.7	13.0	E	PL	Y
Echo Harbour	.00	.52	1.2	.01	3.8	.00	.03	.00	.01	.00	.00	.8	.00	.00	5.9	12.4	E	KA	Y
Etches	.00	1.11	2.0	.00	7.8	.04	.03	.01	.01	.00	.00	.6	.00	.00	4.6	16.3	E	KA	N
Haswell	.03	.36	.5	.00	4.5	.05	.03	.01	.01	.00	.00	.6	.00	.00	1.5	7.5	E	PL	Y
Huston Inlet	.01	1.66	1.5	.00	6.3	.05	.04	.01	.00	.00	.00	.5	.01	.00	20.2	30.2	E	KA	N
Kendrick Point	.02	.81	1.3	.00	9.5	.16	.08	.06	.02	.00	.00	1.7	.00	.00	4.5	18.1	E	KU	N
Koya Bay	.00	1.47	1.9	.01	9.3	.02	.03	.01	.01	.00	.00	1.0	.00	.00	4.7	18.4	E	KU	N

Louscoone Inlet	.01	.96	2.1	.01	6.4	.09	.04	.02	.01	.00	.01	.7	.01	.00	.7	11.1	E	KA	N
Matheson	.00	.52	3.7	.01	6.0	.00	.01	.01	.01	.00	.00	.5	.00	.00	8.6	19.3	E	KA	Y
Salmon R.	.00	.25	.5	.00	2.9	.00	.04	.01	.01	.00	.00	.8	.00	.00	1.2	5.8	E	KA	Y
Skaat Harbour	.00	.80	2.7	.01	5.4	.02	.03	.04	.01	.00	.00	.6	.00	.00	5.3	14.9	E	KA	N
Skittagetan	.00	.35	.5	.00	3.9	.03	.02	.01	.00	.00	.00	.6	.00	.00	2.4	7.8	E	PL	Y
Cape Freeman	.09	1.81	1.4	.00	8.1	.13	.11	.01	.00	.00	.15	.5	.09	.03	2.7	15.2	W	KA	Y
Figwell	.00	.30	.3	.00	1.6	.21	.01	.00	.01	.00	.00	.2	.00	.00	.6	3.2	W	PL	Y
Flamingo Inlet	.05	.62	1.6	.02	5.6	.15	.03	.00	.00	.00	.00	.3	.00	.04	4.4	12.7	W	KA	N
Goski Bay	.00	.80	2.6	.00	6.3	.44	.01	.00	.01	.00	.00	.5	.00	.03	7.6	18.4	W	KA	Y
Gowgaia	.00	1.34	5.1	.00	5.6	.04	.01	.00	.01	.00	.00	.3	.01	.00	24.6	37.0	W	KA	N
Mike Inlet	.01	.22	.3	.01	1.9	.30	.03	.00	.00	.00	.00	.1	.00	.00	1.0	3.8	W	PL	Y
Pocket Inlet	.02	.48	1.1	.01	4.1	.13	.02	.00	.01	.00	.00	.5	.01	.09	4.5	10.9	W	PL	N
Sunday Inlet	.00	.25	.4	.00	2.6	.11	.02	.00	.00	.00	.00	.4	.00	.00	.7	4.4	W	PL	N

3.2.4 Fauna

3.3.4.1 *Fish*

There have been nine fish species observed within Gwaii Haanas streams to date (Table 21). The six salmonid species are all anadromous even though some populations of rainbow trout and Dolly Varden may reside in streams throughout the year. There is no evidence showing that coho remain in streams for their entire lives, but coho are known to exist within freshwater lakes (Sandercock 1991). Of the three cottid species, both prickly sculpin and coastrange sculpin are freshwater inhabitants. Three additional species also presumed to inhabit streams at certain times of the year include Pacific lamprey (*Entosphenus tridentatus*), western brook lamprey (*Lampetra richardsoni*), and starry flounder. Two streams on the west coast (Mike Inlet Creek, Pocket Inlet Creek) lacked fish, likely due to the relatively high gradients for these waters.

Table 21. Fish species observed in Gwaii Haanas streams, indicating the number of streams and species residency.

Fish Species	Taxonomic Name	Streams	Annual Presence
Dolly Varden	*Salvelinus malma*	62	Annual
Rainbow/steelhead trout	*Oncorhynchus mykiss*	20	Annual
Chum salmon	*O. keta*	67	Seasonal
Coho salmon	*O. kisutch*	81	Annual
Pink salmon	*O. gorbuscha*	40	Seasonal
Sockeye salmon	*O. nerka*	1	Seasonal
Threespine stickleback	*Gasterosteus aculeatus*	3	Annual

Coastrange sculpin	*Cottus aleuticus*	18	Annual
Prickly sculpin	*C. asper*	4	Transient

Dolly Varden, rainbow trout, coho salmon, and coastrange sculpins have widespread stream distributions in Gwaii Haanas (Figures 11-13). Most of the west coast streams inventoried in 1979 lacked Dolly Varden, rainbow trout and coho, even though these species were more commonly distributed along the eastern shores and islands. Sockeye salmon was absent from the west coast and was noted only from the Salmon River to the east. Electrofishing samples from 1993-94 on eight west coast streams (Table 23) suggest that Dolly Varden, rainbow trout and coho are more common along the western shores of Gwaii Haanas than previously thought. It is unclear whether these particular streams were electrofished by MELP during the older stream inventories, possibly explaining their absence at that time.

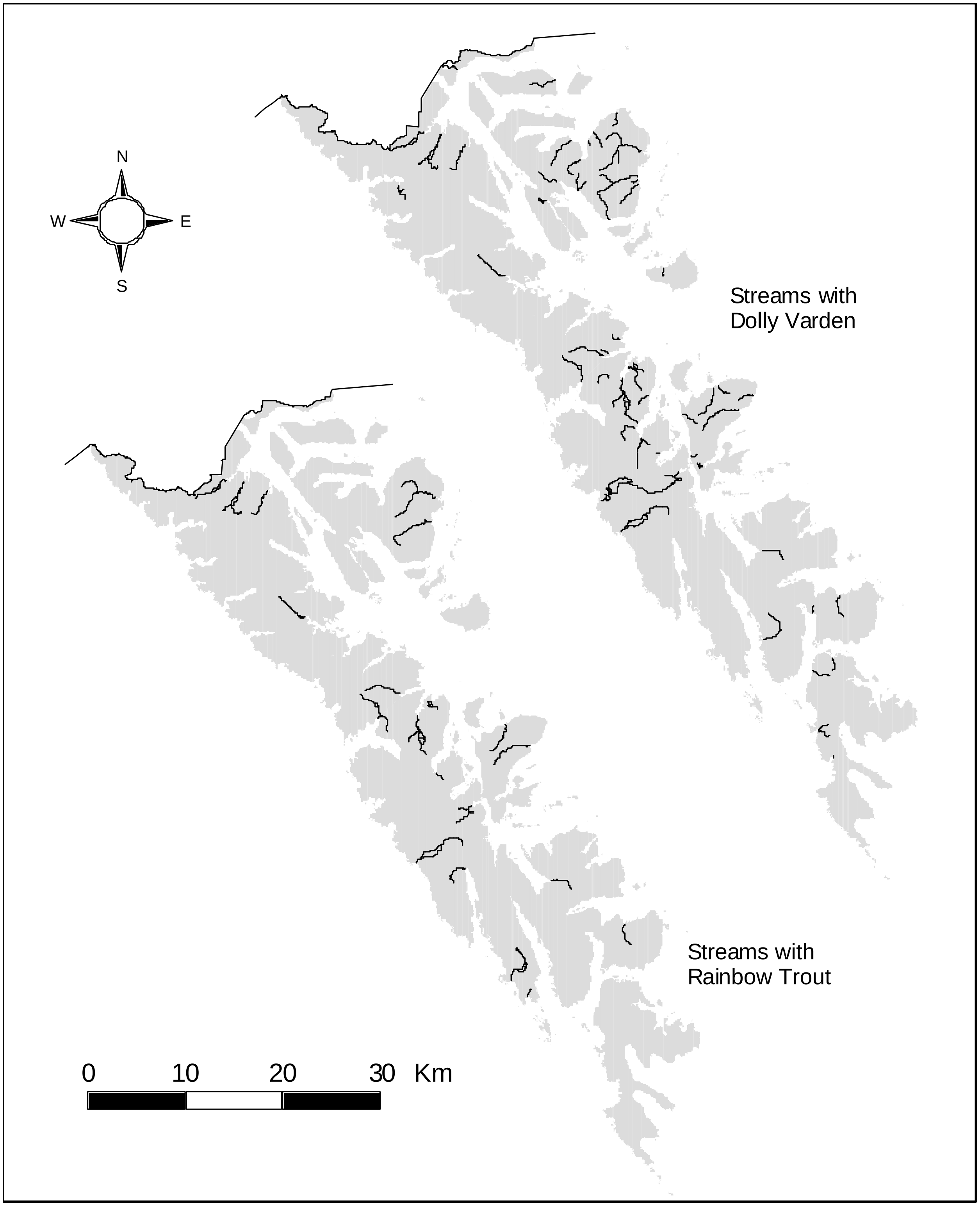


Figure 11. Distribution of Dolly Varden and rainbow trout from Gwaii Haanas streams, based on recent stream surveys plus MELP and DFO information.

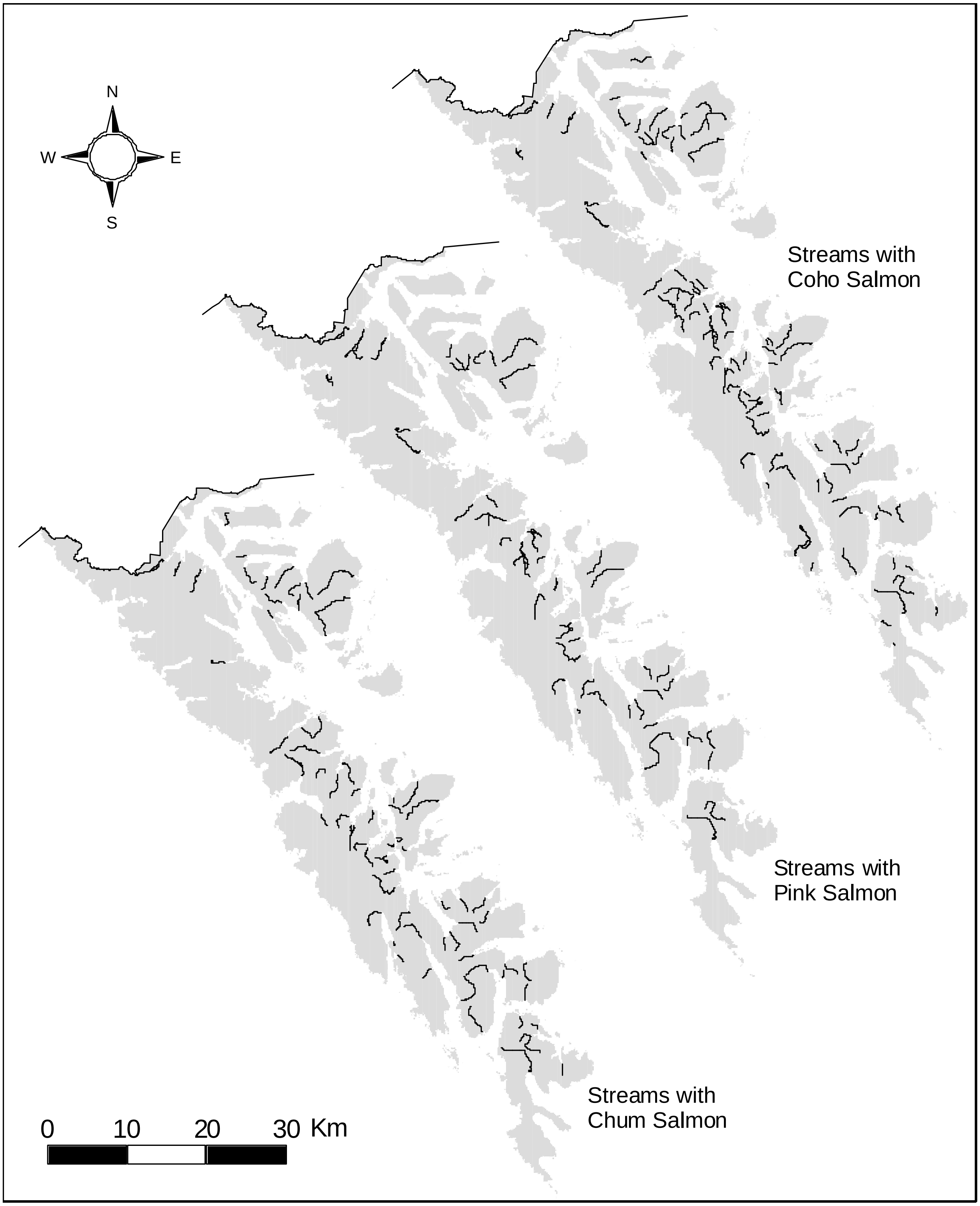


Figure 12. Distribution of Pacific salmon (chum, coho, pink) from Gwaii Haanas streams based on recent stream surveys plus MELP and DFO information.

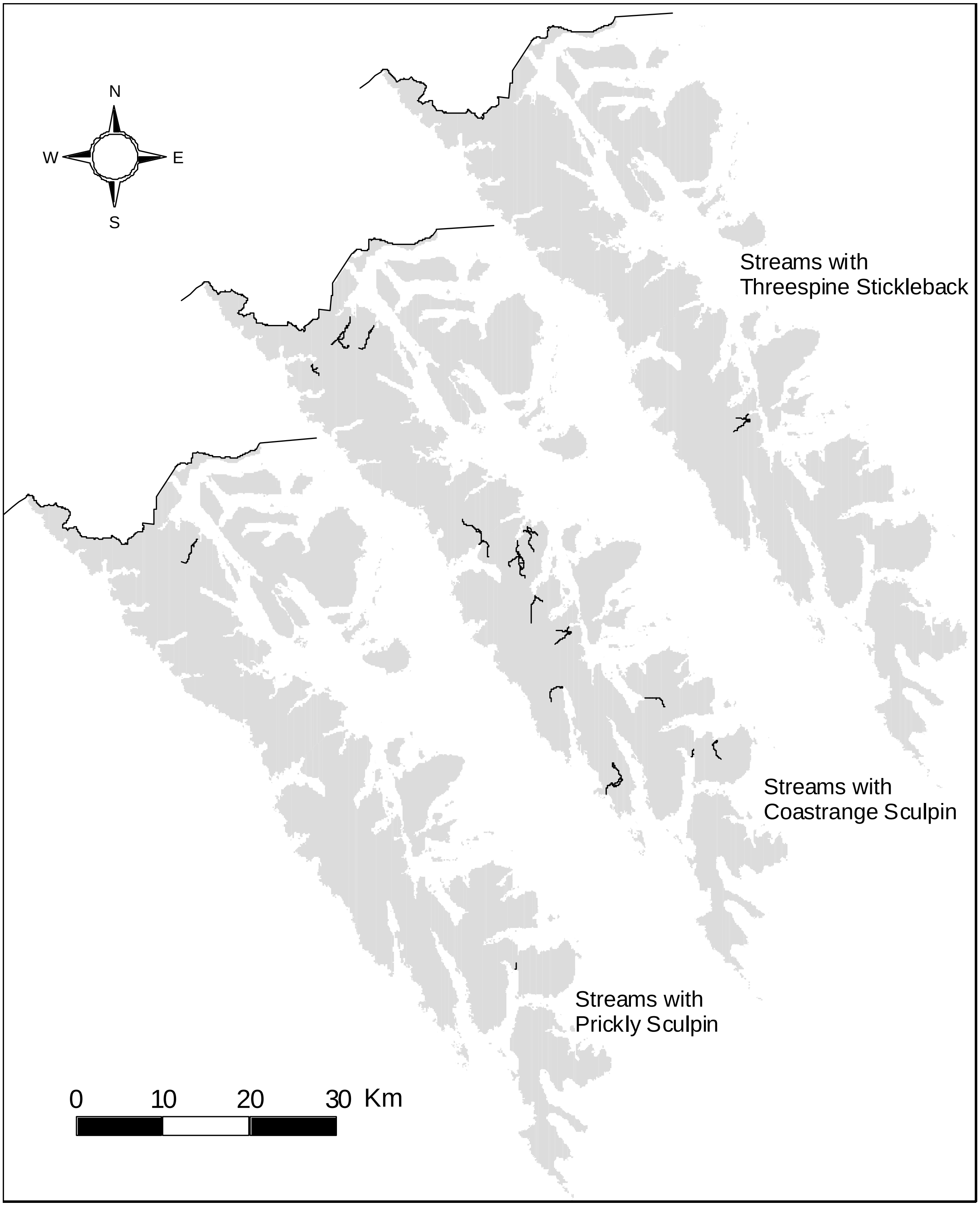


Figure 13. Distribution of prickly sculpin, coastrange sculpin and threespine stickleback from 22 Gwaii Haanas streams surveyed during 1993-94.

Table 22. Fish species relative abundance (%) and total catches based on all electrofishing samples from 22 streams. Fish species include Dolly Varden (DV), rainbow trout (RT), coho salmon (CO), coastrange sculpin (CS), prickly sculpin (PS) and threeslpine stickleback (TS). Coastal location and the presence of lakes in the system are indicated for each stream.

Stream	Coast	Lakes	DV	RT	CO	CS	PS	TS	Total
Arrow	East	Yes	7	16	56	17	-	2	123
Bag Harbour	East	Yes	9	9	47	21	-	14	426
Cape Freeman	West	Yes	-	70	5	25	-	-	61
De la Beche Inlet	East	Yes	56	14	30	-	-	-	71
Echo Harbour	East	Yes	12	18	40	23	8	-	78
Etches	East	No	100	-	-	-	-	-	36
Figwell	West	Yes	-	20	-	80	-	-	20
Flamingo Inlet	West	No	3	16	27	54	-	-	68
Goski Bay	West	Yes	2	23	16	59	-	-	112
Gowgaia	West	No	48	-	43	9	-	-	46
Haswell	East	Yes	4	4	-	92	-	-	25
Huston Inlet	East	No	3	17	14	66	-	-	160
Kendrick Point	East	No	66	-	27	5	2	-	56
Koya Bay	East	No	4	31	28	38	-	-	284
Louscoone Inlet	East	No	-	-	10	89	1	-	224
Matheson	East	Yes	1	16	22	62	-	-	224
Mike Inlet	West	No	-	-	-	-	-	-	0
Pocket Inlet	West	No	-	-	-	-	-	-	0
Salmon R.	East	Yes	3	4	2	91	1	-	137
Skaat Harbour	East	No	23	1	54	22	-	-	86
Skittagetan	East	Yes	1	-	-	18	-	81	72
Sunday Inlet	West	No	19	-	30	51	-	-	94

Coastrange sculpin

The coastrange sculpin was numerically dominant within most of the 18 streams it inhabited and was found in streams regardless of whether lakes were present or not. Fast flowing waters are the preferred habitat for this species (Scott and Crossman 1973), possibly explaining its relatively wide distribution within Gwaii Haanas. It prefers the large uncompacted substrates observed frequently during stream surveys. This species, like most others appears to limit upstream distribution to the first major obstruction such as high falls. An exception was noted for Skittagetan Creek where coastrange sculpins were collected above water falls. Reimchen (1994) suggested that these fish were able to maneuver over the obstruction using natural resting areas in the highly pitted bedrock common to this and other streams located on the Plutons.

The average size of coastrange sculpins was similar for fish collected from either coast of Gwaii Haanas (Figure 14). The average size was 59 mm overall, with means for the 18 streams ranging from a low of 54 mm in Figwell Creek and Matheson Inlet Creek, to 93 mm in Echo Harbour Creek (Appendix H). Mean size often increased for upstream sites from numerous streams, but exceptions were also common.

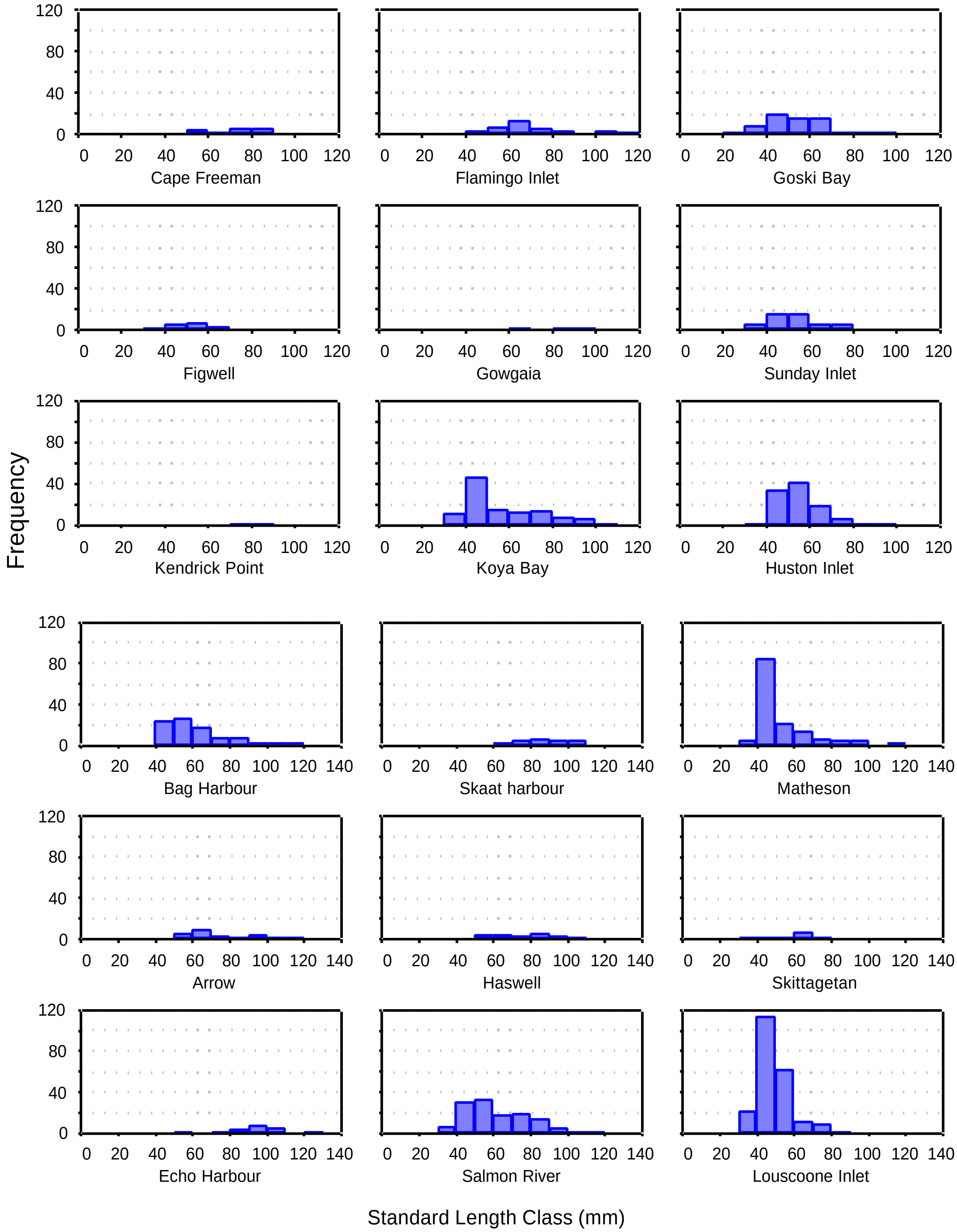


Figure 14. Size frequency distributions for coastrange sculpins collected from 18 Gwaii Haanas streams.

Coho salmon

Coho were widely distributed along both coasts of Gwaii Haanas, and they were normally the dominant salmonid based on numbers. There was no apparent preference for watersheds containing lakes. It was absent from two streams on either coast (Figwell Creek and Etches Creek on the west, Haswell Creek and Skittagetan Creek to the east) where either Dolly Varden or rainbow trout survived.

Many of the coho collected from De la Beche Inlet Creek had parr marks which were broader than those normally seen on coho from the other streams (Reimchen *et al* 1994). This difference in appearance will require further investigation to clarify the initial findings.

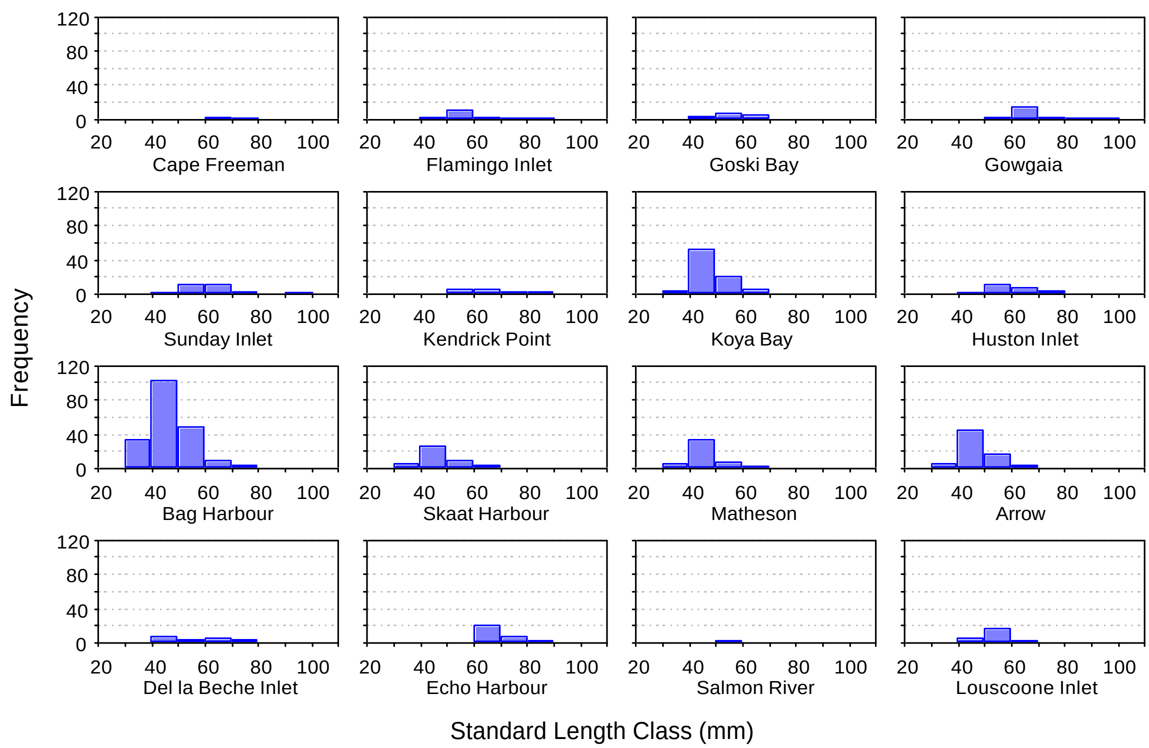


Figure 15. Coho salmon size frequency distributions from 16 Gwaii Haanas streams.

Mean size ranged from 47 mm in Matheson Inlet Creek to 68 mm in Cape Freeman Creek and Echo Harbour Creek, averaging 52 mm across all streams (Figure 15, Appendix H). Coho fry tended to be larger on the west coast (56 mm vs. 46 mm), possibly due to density-dependent effects similar to those observed on Vancouver Island (Holtby 1988). Reimchen *et al* (1994) suggested the mild winter of 1994 may have led to earlier emergence, resulting in a longer growth period before the 1994 surveys were completed.

Rainbow trout

Rainbow trout were frequently collected from east coast streams (10 of 14) and in only four of eight streams on the west side. In either case, the species occurred much more often in the stream systems containing lakes. Rainbow trout was the dominant species in just one stream (Cape Freeman Creek) which was different from other surveyed streams in having warmer stream temperatures, relatively stable flow and steep gradients. Fish access to Cape Freeman Creek was also limited to the lower 0.6 km due to waterfalls. This species slightly outnumbered coho in three streams (Goski Bay Creek, Huston Inlet Creek, Koya Bay Creek) where they coexisted.

Rainbow trout fry were similar in mean size from both coasts of Gwaii Haanas, having modal lengths of 30-35 mm (Figure 16, Appendix H). Cape Freeman Creek also contained the largest 0^+ fry of this species. Reimchen *et al* (1994) indicated the southerly aspect of this west coast stream may have produced warmer stream temperatures and more complete fry emergence before the stream was surveyed in mid-July, leading to the numerical dominance mentioned above.

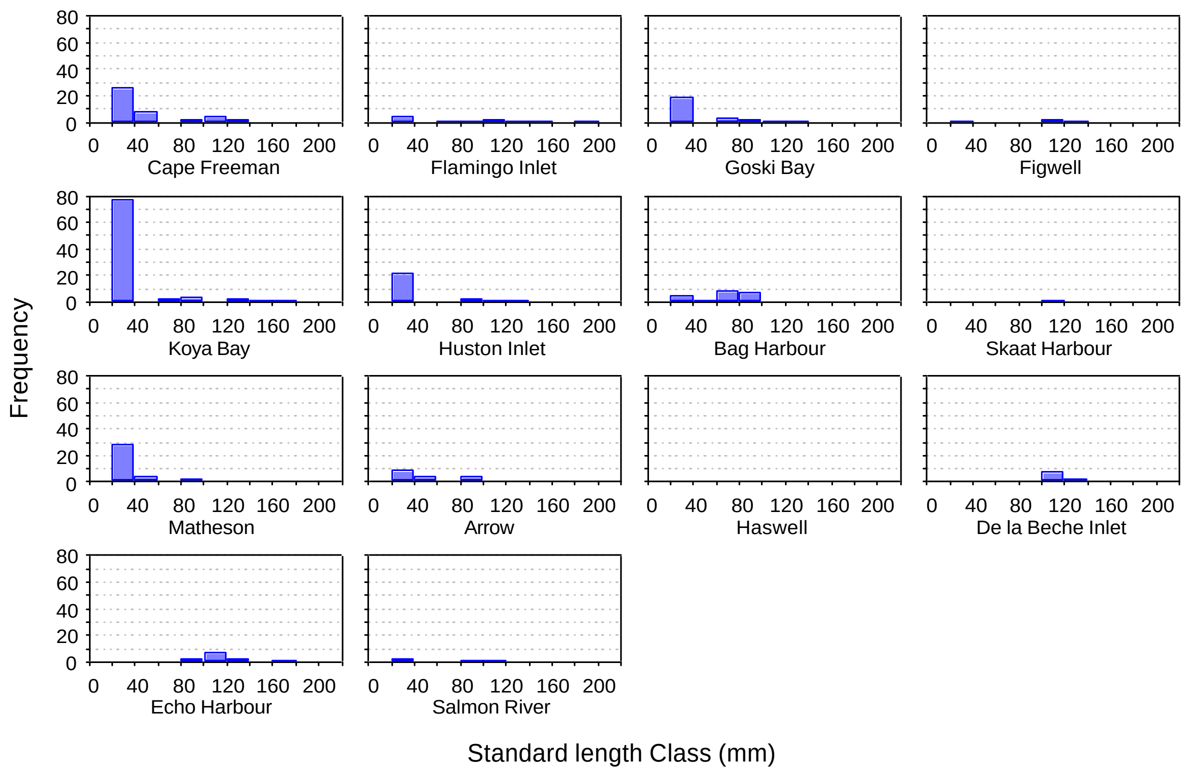


Figure 16. Rainbow trout size frequency distributions from Gwaii Haanas streams.

Dolly Varden

Dolly Varden was frequently the only species collected at higher elevation sites. It was the only fish species collected from Etches Creek, and appeared to dominate the fish communities in Kendrick Point Creek and De la Beche Inlet Creek. This species was never found at the same sites where rainbow trout were collected from the west coast streams even though both species existed within the same watersheds. On the west coast, relative abundance of Dolly Varden was higher in Gowgaia Creek and Sunday Inlet Creek where stream temperatures were cooler and rainbow trout did not occur. In contrast, these species often coexisted within sampled reaches from eastern streams. Accessibility and habitat preference guide the different abundance levels of Dolly Varden and rainbow trout, but the species exclusions noted for west coast streams requires further study to determine the reason why this occurs.

Dolly Varden fry were slightly larger in the west coast streams where the modal length was 45-50 mm compared with 35-45 mm on the eastern side of Gwaii Haanas (Figure 17, Appendix H). Five sea-run Dolly Varden (based on the presence of external marine parasites) were found in one upper reach of Sunday Inlet Creek on the west coast during 1993, and eleven more were collected from three streams (Bag Harbour Creek, Skaat Harbour Creek, Echo Harbour Creek) in 1994. Sea-run fish ranged in size from 140-290 mm.

Threespine stickleback

Threespine stickleback was only found in three east coast streams (Arrow Creek, Bag Harbour Creek, De la Beche Inlet Creek) which had lakes in the watershed (Figure 13), and none were collected from the western side of Gwaii Haanas even though the species is present in Goski Lake (Reimchen 1992a). Threespine stickleback was widely distributed among lakes based on lake survey information. The average size of threespine sticklebacks was smaller (35 mm) in De la Beche Inlet Creek compared with 50-53 mm in the other two streams, and was likely due to young-of-the-year fish within this sample (Appendix H).

Prickly sculpin

Prickly sculpin were rare with only nine fish were collected from four of 22 streams. One fish was found in Louscoone Inlet Creek in the southern part of the Park, and the remaining sculpins were caught from east coast streams. The Pacific staghorn sculpin normally lives in coastal waters, and was not found during stream surveys even though it sometimes enters lower stream reaches and was found in Wegner Lake (see pg. 25).

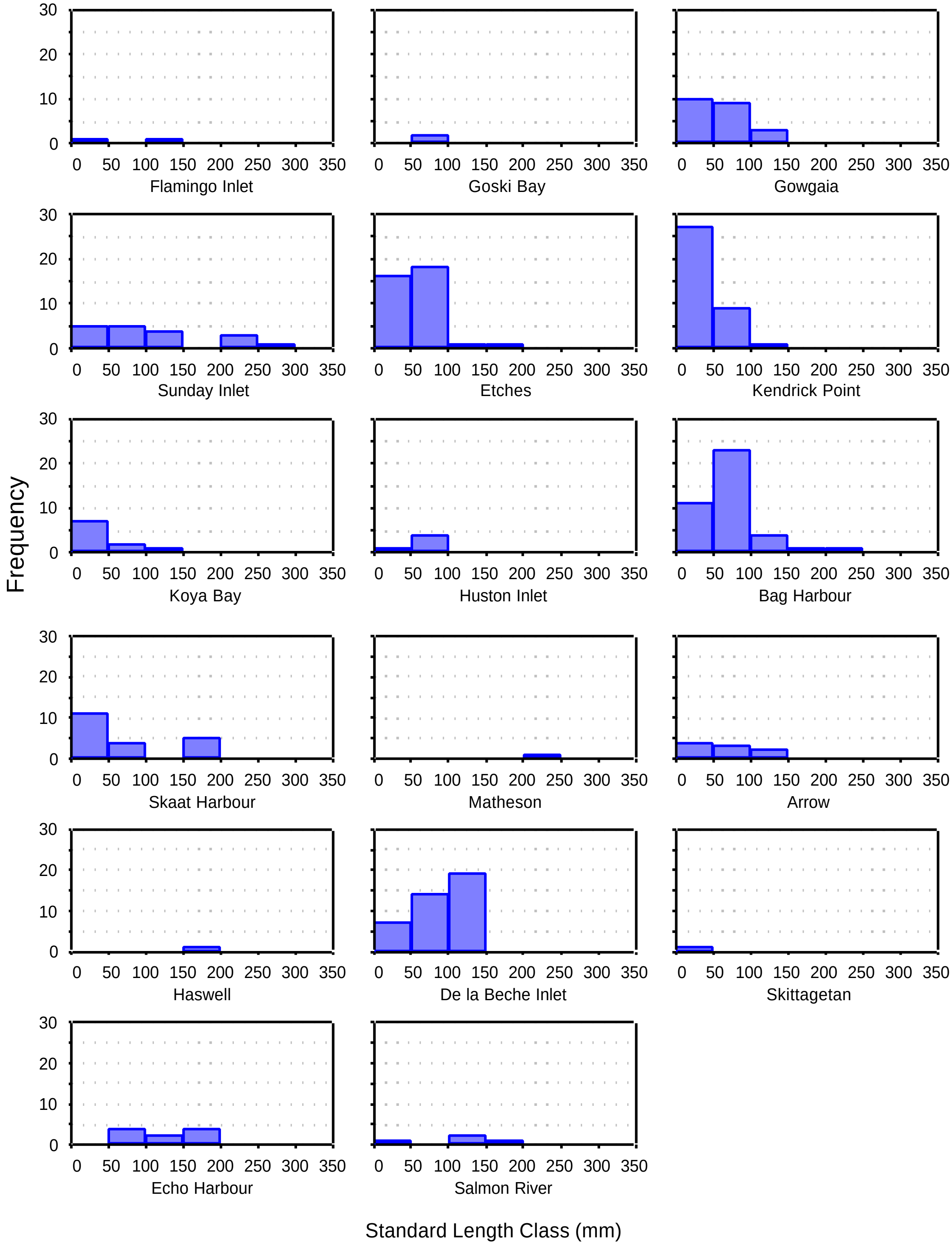


Figure 17. Dolly Varden size frequency distributions from 17 Gwaii Haanas streams.

3.2.4.2 *Mammals*

Mammalian activity associated with Gwaii Haanas streams originated from three data sources. The stream surveys completed in 1993 (Reimchen *et al* 1994) and 1994 (Reimchen 1994a) recorded recent sightings during July, while historical observations from DFO escapement field records provided a indexed measure of annual predator occurrences during salmon migrations in the late fall (Appendix D).

Mammals observed during the 1993-94 streams surveys included the black bear, river otter, raccoon, red squirrel (*Tamiasciurus hudsonicus*), and black-tailed deer (*Odocoileus hemionus columbianus*). Black bear were fairly common during 1993 surveys and were observed at eight of 14 streams. This species was only noted for one of eight streams (Sunday Inlet Creek) in 1994. Bear usage of streams is seasonal in nature, coinciding with salmon migrations in the fall, and its presence has been recorded frequently by DFO staff during salmon escapement monitoring. Only three of 48 streams (Beresford Bay Creek, De la Beche Inlet Creek, Moore Creek) lacked bear sightings during annual salmon migrations, and black bear was the most frequently observed species of all mammals and birds along the spawning streams.

The river otter appeared at only four east coast streams, and was not seen during the west coast stream surveys in 1994. It was observed during DFO salmon escapement monitoring for 26 of 48 streams in the past, but was much less common compared to bear sightings during the same period (Reimchen 1992a).

Three species (raccoon, black-tailed deer, red squirrel) introduced to the Queen Charlotte Islands are now well established throughout the archipelago (Cowan 1989). Raccoon sightings along streams were infrequent due to the animal's nocturnal nature, but raccoon signs (e.g. tracks or droppings) were found near seven of 12 streams along the east coast during 1993. West coast sightings showed signs of raccoon in only three of eight surveyed streams. Black-tailed deer and red squirrels were common on both coasts within Gwaii Haanas, but deer sightings were more frequent along the east coast.

Sea lions (*Eumetopias jubata*) and Pacific harbour seals (*Phoca vitulina*) were two marine mammals seen either within the lower reaches of streams or in coastal waters at river mouths during the fall salmon migrations (Appendix D). Sea lions were associated with 16 of 48 streams. Seal presence was noted for the same 16 streams plus 12 others.

3.2.4.3 *Avifauna*

Seventeen avian species were identified during the 1993-94 stream surveys (Table 23). Species such as the Canada goose and sandhill crane are more commonly associated with lakes, and marbled murrelets were only observed flying high over streams. Many of the species noted in 1994 inhabited terrestrial vegetation such as shrubs and trees.

Bald eagles (*Haliaeetus leucocephalus*) were found along the lower mainstem of many east coast streams during the summer, and appeared less frequently on the western streams. Spring observations of bald eagle abundance and nesting sites within Gwaii Haanas (Westland Resource Group 1994) supported the species preference for east coast versus west coast shores, and found that bald eagles were also more abundant along the various islands adjacent to the east coast of Moresby Island. There is an autumn shift in habitat preference to streams from the usual coastal waters as bald eagles exploit abundant salmon resources. Eagles were often seen along streams during fall salmon migrations (37 of 48 streams), and was the most frequently observed bird during this season (Appendix D).

Table 23. Avian species sightings during the 1993-94 stream surveys, plus preferred habitats for each species.

Common Name	Scientific Name	No. of Streams	Preferred Habitat
American dipper	*Cinclus mexicanus*	4	Mountain streams or ponds
Bald eagle	*Haliaeetus leucocephalus*	11	Lakes and streams
Belted kingfisher	*Ceryle alcyon*	3	Lakes and riparian area
Canada goose	*Branta canadensis*	1	Lakes and marshes
Chestnut-backed chickadee	*Parus rufescens*	1	Forested and open areas
Common raven	*Corvus corax*	6	Varied but often near water
Golden-crowned kinglet	*Regulus satrapa*	1	Coniferous forests
Hermit thrush	*Catharus guttatus*	2	Woodlands
Marbled murrelet	*Brachyramphus marmoratus*	2	Marine, nesting inland
Red-breasted sapsucker	*Sphyrapicus ruber*	6	Woodlands
Rufous hummingbird	*Selasphorus rufus*	2	Varied terrestrial
Sandhill crane	*Grus canadensis*	1	Shallow wetlands
Townsend's warbler	*Dendroica townsendi*	2	Coniferous forests
Tree swallow	*Tachycineta bicolor*	1	Forested, feeding over water
Western flycatcher	*Empidonax difficilis*	12	Shady woodlands and streams
Winter wren	*Troglodytes troglodytes*	6	Woodlands

Sightings of common raven and American dipper were fairly common along the east coast streams during 1993, but neither species was observed along the west coast in 1994 even though numerous other terrestrial species were noted.

Other species such as glaucous-winged gulls, mallards, common mergansers and common ravens are also found near streams during the fall, but the common raven was the only species observed during the mid-summer stream surveys.

3.2.4.4 *Aquatic Macro-invertebrates*

Invertebrate catches varied considerably among stream sites. The lower mainstem site for Louscoone Inlet Creek was ignored during comparisons since this sample contained a large number of marine amphipods.

Streams on the east coast averaged 700 invertebrates m^{-2} which was significantly higher than 236 m^{-2} for the western streams (F=11.82, P=0.01 ANOVA). Lake-fed sections of streams appeared to contain more invertebrates than sites located above lakes, but the differences were not significantly greater (F=1.19, P=0.29, ANOVA). Reimchen (1994) suspected that unusual drought conditions during the 1993 surveys may have concentrated macroinvertebrates within reduced areas and artificially increased density estimates.

Fish were present at all invertebrate sampling sites on the east coast streams, but were absent from 14 of 34 west coast sites. The presence of fish at a sampling site corresponded with fewer invertebrates in the Surber samples. Thirty-seven invertebrates per Surber sample (N=14) were collected from those sites lacking fish compared with a mean of 12 per sample (N=20) for sites containing fish.

Table 24. Mean number of stream invertebrates (numbers per m^{-2}) summarized by coast, lake presence and geology.

Feature	Category	Plecoptera	Ephemeroptera	Trichoptera	Diptera	Other	Total
Coast	East	45	350	59	518	101	1073
	West	28	167	11	102	39	347
Lakes	Present	43	200	40	177	53	513
	Absent	23	301	19	403	79	825
Geology	Karmutsen	40	302	36	349	60	787
	Kunga	88	315	0	423	109	935
	Pluton	23	174	30	180	64	470
Combined		34	243	31	274	64	646

Surber sample collections for 59 sites within 22 streams indicated the dominance of ephemeroptera (mayfly) larvae from west coast streams, compared with diptera larvae as the primary stream macroinvertebrate found on the east side of Gwaii Haanas (Figure 18). The relatively steep gradients characteristic of the west coast streams provide faster stream flows more suitable for ephemeropterans. Many ephemeropteran species are functionally designed to live in swift waters, and are frequently found in riffles (Needham 1969).

Geology may also influence stream invertebrate composition to a degree. Invertebrate catches were higher on Kunga sites compared to sites on the other formations. No significant differences in numbers were found for the major invertebrate categories even though diptera were much less abundant on the Pluton sites. Plecoptera (stoneflies) were absent from six west coast sites located on Plutonic rock, and ephemeropterans were relatively scarce, but the situation did not repeat on the west side of Gwaii Haanas where ephemeropterans were abundant and plecopterans were common. The ability of these taxa to accommodate high stream velocities may override the geological influences observed on the east coast.

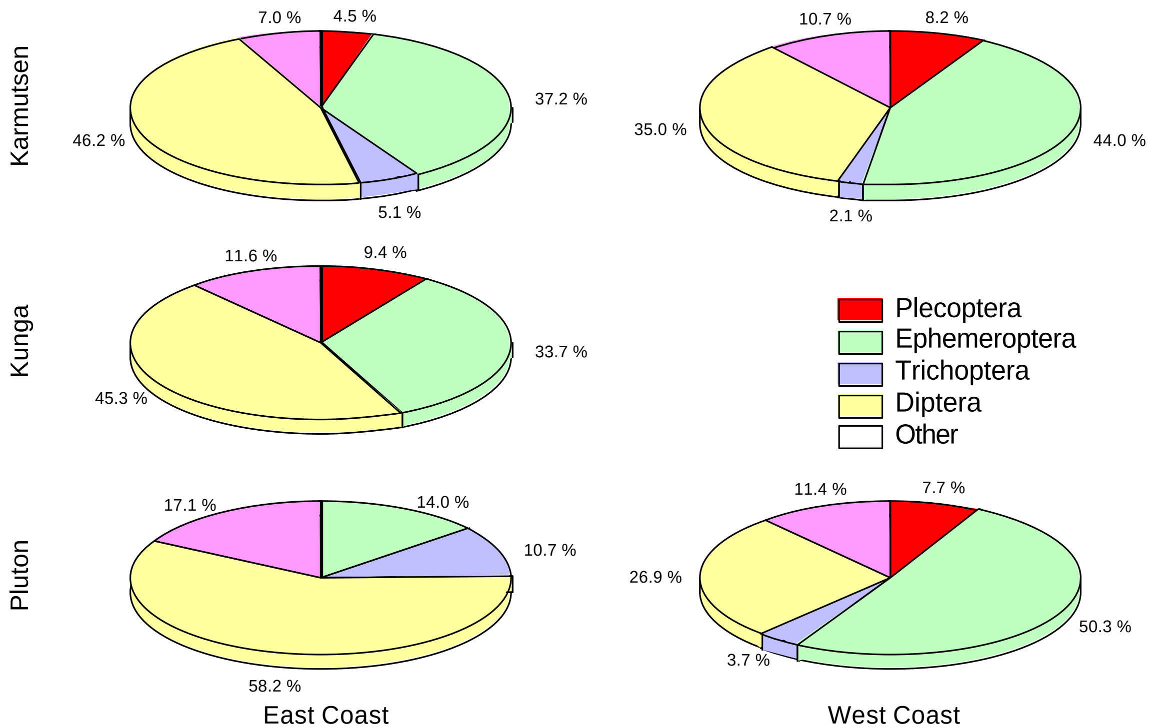


Figure 18. Relative abundance of the major macroinvertebrate groups among streams from either coast and associated with underlying geology.

3.2.4.5 *Amphibians*

The only amphibian noted during stream surveys was the northwestern toad. It is the only indigenous amphibian on the Queen Charlotte Islands. It was seen in three watersheds on the east coast (Bag Harbour, De la Beche Inlet, Skittagetan) and two others (Mike Inlet, Figwell) on the west side of Gwaii Haanas. This native toad has also been observed near 12 lakes within Gwaii Haanas including De la Beche Lake.

No signs of the introduced treefrog were noted during the stream surveys, but the species is well established throughout northern Moresby Island and Graham Island (Reimchen 1991a).

3.2.5 Flora

Vegetation surveys within the riparian zone of Gwaii Haanas streams identified nine tree species, 15 shrub species, plus 47 types of herbaceous plants (Appendix I).

Table 25. Dominance ranking for the top three tree species identified from stream sites. Values in brackets indicate the number of sites where the species ranked first, and the total number of sites where the species was present.

Mean Dominance	Karmutsen (33 sites total)	Kunga (4 sites total)	Plutons (25 sites total)
First	Western Hemlock (18 of 32 sites)	Western Hemlock (4 of 4 sites)	Yellow Cedar (11 of 21 sites)
Second	Yellow Cedar (5 of 19 sites)	Sitka Spruce (0 of 4 sites)	Western Hemlock (8 of 21 sites)
Third	Red Cedar (4 of 26 sites)	Red Alder (0 of 4 sites)	Lodgepole Pine (5 of 16 sites)

Tree dominance varies among the geological sites (Table 25), but the validity of apparent differences will require integrated spatial analysis using terrestrial biophysical data and the ecological land classification proposed by Westland Resource Group (1994). Western hemlock (*Tsuga heterophylla*) and red cedar (*Thuja plicata*) tended to dominate within lower stream reaches. Western hemlock was the dominant tree species found within 30 of 62 sites, including all four Kunga sites. The species was present at all lower mainstem sites and was found at all but five sites that were assessed. Freeman (3) was on the Karmutsen formation and Flamingo Inlet (4/5), Mike Inlet (3/5) sites were on Plutons.

Comparisons between streams sites from 1993-94 included all sites per stream. Most sites were below 100 m elevation, and most upper reach sites were under 200 m. None of the sites were at elevations reaching the mountain hemlock biogeoclimatic zone beginning around 550-600 m (Banner *et al* 1989). Yellow cedar survived at many west coast sites regardless of geology, but was less frequently found on east coast Karmutsen sites, and was absent from Kunga sites. Mountain hemlock was identified from 20 sites, 15 of which were located on Plutons. This species was not found at sites on the Kunga formation, and was also absent from east coast Karmutsen sites. Western yew was absent from sites on the Kunga formation, and was rarely observed at Karmutsen or Pluton sites. If present, this species ranked 6^{th}-8^{th} in dominance and is not common anywhere on the islands.

Trunk diameter provides a measure of tree size for comparisons among tree species and stream sites. Trees found on the west coast were generally smaller than their counterparts to the east. Mean trunk diameter was equal or higher from east coast sites for all species. Also, wherever a species was recorded from all three geological formations, trunk diameter was always greatest on the Kunga sites, and often lowest for the Plutons.

In most cases, the dominant tree species at west coast sites had average trunk diameters of under 0.3 m, except for Flamingo Inlet (5) where yellow cedar was the dominant species with trunk diameter in the 0.3-1 m class. Only three sites on the west coast contained trees with a mean trunk diameter greater than 1 m (Gowgaia-1(RC,SS), Figwell-5(SA), Sunday-5(SS)). In contrast, the east coast sites frequently contained trees with larger trunks. Diameters over 1 m were common for red cedar (Huston Inlet, Kendrick Point, Koya Bay, Matheson, Skaat Harbour), sitka spruce (*Picea sitchensis*)(Huston Inlet, Kendrick Point, Koya Bay, Salmon, Skaat Harbour), western hemlock (Louscoone Inlet, Salmon) and yellow cedar (Arrow). Similar to the west coast, the dominant tree species had smaller trunk diameters than the other species. Those species which ranked 2nd or 3rd for dominance tended to have the largest mean trunk diameters.

Crown cover varied considerably, but was lower on the east coast Pluton sites at Haswell, De la Beche Inlet and Skittagetan Creeks where mean trunk diameters were smaller for most species.

A total of 15 shrub species were identified during 1993-94 stream surveys (Table 26). Salal, red huckleberry, rusty Pacific menziesia and salmonberry were very common shrubs along both coasts. Salal was found at all sites except for Mike Inlet Creek (site 2) on the west coast, while only site 2 on De la Beche Inlet Creek lacked red huckleberry. Rusty Pacific menziesia was absent from four Plutons sites.

Table 26. Occurance of dominant shrubs, total number of species plus underlying geology for 22 streams (61 sites) in Gwaii Haanas. Frequency of sightings among sites fore each stream is indicated as one (O), several (S), or all (A) sites, otherwise it is left blank. Shrubs are identified as AB (Alaskan blueberry), BB (bog blueberry), BC (black crowbery), DC (Devil's club), LT (Labrador tea), NR (Nootka rose), OB (oval-leafed blueberry), PC (Pacific crabapple), PM (false azalea), RE (red elder), RH (red huckleberry), SA (salal), SL (swamp laurel), SY (salmonberry), WT (western thimbleberry).

Stream	DC	SY	WT	NR	PC	SA	RH	OB	AB	PM	LT	RE	SL	BB	BC	Total	Geology
Arrow		A	O			A	A	O	O	A						7	Karmutsen
Bag Harbour		A		O	O	A	A	S	S	A	O	S				10	Karmutsen
Cape Freeman		S				A	A	O	O	O	S		S	O	S	10	Karmutsen
De la Beche Inlet		A		O		A	O	O	O	O	A	O				10	Plutons
Echo Harbour	A	O	A			A	A	A	A	A		O				9	Karmutsen
Etches		O				A	A			A						4	Karmutsen
Figwell		S				A	A	A	A	A				S		7	Plutons
Flamingo Inlet	O	S				A	A	S	S	S	S	S	O		S	11	Plutons
Goski Bay		A				A	A	A	A	A	O	S				8	Karmutsen
Gowgaia		S	O			A	A	S	S	A		S		O		9	Karmutsen
Haswell		A				A	A			O	O					4	Plutons
Huston Inlet		A				A	A			A						4	Karmutsen
Kendrick Point		O				A	A	O	O	A						6	Kunga
Koya Bay		A				A	A			A		A				5	Kunga
Louscoone Inlet		A				A	A			A		A				5	Karmutsen
Matheson		A				A	A	O	O	A		A				7	Karmutsen
Mike Inlet		O				S	A	A	S	A	S		S	A	O	10	Plutons
Pocket Inlet						A	A			A	A		A	A		6	Plutons
Salmon R.	A	A	O	O		A	A	A	A	A		A				11	Karmutsen
Skaat Harbour		A				A	A	A	A	A						6	Karmutsen
Skittagetan		A				A	A				O					5	Plutons
Sunday Inlet		A				A	A	A	A	A		S				7	Plutons

Alaskan blueberry (*Vaccinium alaskaense*) and oval-leafed blueberry (*V. ovalifolium*) were common, having identical distributions among the east coast stream sites, and very similar distributions on the west coast. Devil's club was only observed on the Salmon River, Echo Harbour Creek, plus one site on Flamingo Inlet Creek. Other rare shrubs included the Pacific crabapple (1 eastern site), western thimbleberry (1 western and 4 eastern sites), Nootka rose (3 eastern sites). Swamp laurel, bog blueberry and black crowberry were only found on the west coast and are often associated with alpine or bog terrain (Douglas 1991). Red elder tended to inhabit the lower elevation sites from half of the streams surveyed on each coast.

Forty-seven herbaceous plant species were recorded from stream reaches. Twenty-eight species were found on the west coast and 35 were identified from east coast sites, 16 of which were recorded from both coasts. *Cornus unalaschkensis* was the most common west coast herb, followed by the false lily of the valley (*Maianthemum dilatatum*) which was also the most widely distributed species on the east coast. The presence of alpine bogs on the west coast accounted for herbs such as *Anaphalis margaritacea and Pedicularis ornithorhynchus*. *Veratrum escholtzii* was commonly found growing in *Sphagnum* bogs adjacent to the west coast sites. It was much less abundant along the eastern coast where herbs such as *Aparagidium* and Douglas gentain (*Gentaina douglasii*) were also associated with this type of bog (Calder and Taylor 1968).

Inspection of three additional sites per stream during 1994 lead to the identification of more herb species per stream (mean = 14.6, range of 10-18 species) compared with 7.6 species per stream from the east coast (range of 4-15 species). The two streams (Kendrick Point, Koya Bay) located on the Kunga formation had fewer herbs identified than most other streams.

Bryophytes (true mosses) were found at all west coast stream sites checked in 1994, and were more abundant on the forest floor compared to the tree canopy within riparian areas. Total moss cover decreased at higher elevations and where crown closure was reduced (Reimchen 1994a).

Lichen abundance was ranked for six groups (club, crusty, hair, leaf, scale, shrub) from the west cost riparian areas. Leaf and crusty lichens were the more frequently noted groups of the six. The only sites considered to have abundant lichen were two sites on Cape Freeman Creek, otherwise lichen groups were ranked as either common or sparse if present. Scale lichens were absent from all sites. Hair lichen was rarely observed, being found only four of 35 sites.

3.3 Salmon Escapement

Salmon had been a source of food for human populations on the Queen Charlotte Islands long before the appearance of European traders and settlers. As increased pressure on island resources developed along with the establishment of commercial fisheries, mining and logging operations, human impacts on salmonid populations and habitat followed suit. For example, Dalzell (1968) noted the loss of salmon from Gate Creek on Lyell Island after construction of a dam at the mouth of the creek.

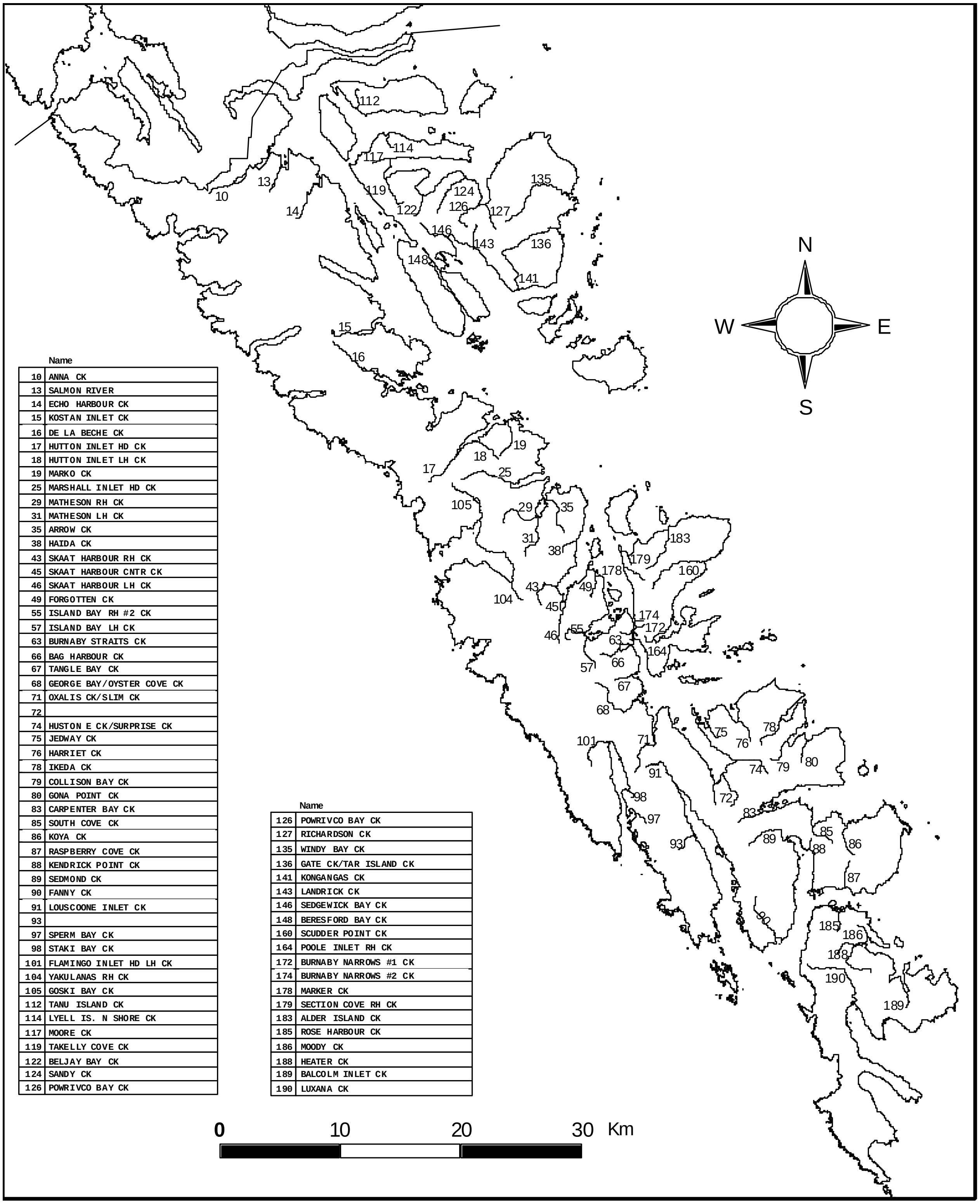
Commercial salmon fishing began around the 1900s within the current Gwaii Haanas boundaries, but DFO did not establish a regime to allow annual salmon abundance estimates until the 1930s. By 1947, 20 Gwaii Haanas streams were being monitored and annual salmon estimates continue to be made. Reimchen (1992a) had included pre-1953 escapement information (see Marshall *et al* 1978a,b) to an existing DFO computer database such that salmon abundance estimates for 71 Gwaii Haanas streams (Figure 19) currently reside in the database (Appendix A). Updated escapement estimates for 1991-96 have been appended to this database for the present summary. Even though estimates cover from 1947-96 for approximately 30% of the streams monitored by DFO, very few streams have estimates for each year. Certain years (e.g. 1974) appear as data gaps within the time series for numerous streams, including those which are otherwise complete.

Of the four salmon species observed during escapement monitoring within Gwaii Haanas, chum are found in all monitored streams except for De la Beche Inlet, Fanny, Luxana Bay, Raspberry Cove and Tanu Island. Salmon River is the most productive chum stream in Gwaii Haanas, averaging 14,000 spawning adults over the past 17 years. Most of the other streams have much smaller annual runs of under 2,000 fish in recent years.

Pink salmon are present in 23 of 69 streams monitored for escapement estimates. Those stream which have noteworthy spawning runs are situated along the northeastern portion of Gwaii Haanas along Moresby and Lyell Islands. Gate Creek and Windy Bay Creek have historically been considered pink salmon streams as they both have relatively large spawning runs on even years. Also, this species now dominates spawning runs on three creeks (Marshall Inlet Head, Matheson (both RH and LH)) within Marshall Inlet after first appearing in the early 1960s. Pink salmon also became established south of Salmon River in Echo Harbour Creek by 1976.

The original 24 streams in the escapement database date back to 1947, and provide a basis for long-term trends within salmon stocks (Figure 20). It is necessary to qualify the data by noting that counting methods were not standardized over the past 50 years. Reliability of estimates has varied considerably with stream visibility, weather conditions and DFO staff experience from year to year. Even with ideal conditions, annual estimates for species such as coho may only provide a coarse measure of the annual runs. Coho spawning normally peaks well after the end of DFO stream inspections in late November or early December (V. Fradette, DFO, pers. comm.). Depending on the lateness of the coho runs, few or no fish may be observed within streams even though numbers may eventually peak well into December or January.

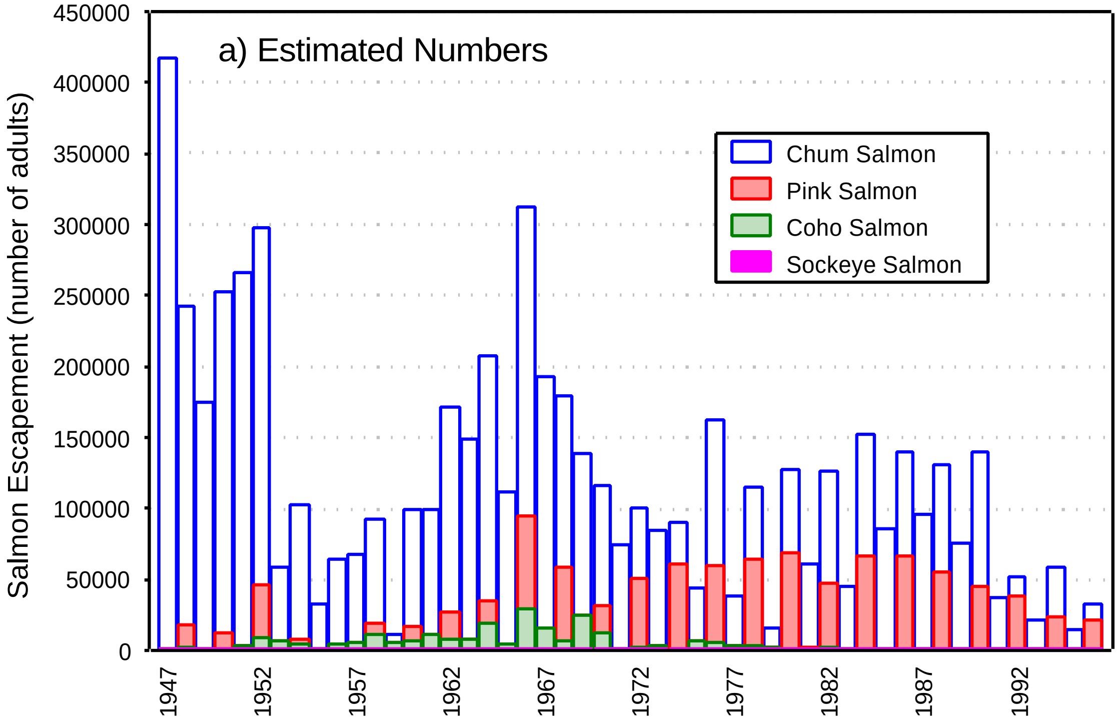
Chum salmon abundance consistently exceeded 150,000 fish up to 1952, followed by a rapid decline and a moderate recovery from 1962-69 before dropping below 50,000 for much of the 1970s (Figure 21). Since then, chum numbers increased very slowly to approximately 80,000 fish until 1991. Average combined escapement for 1991-96 decreased to about 20,000 fish annually for updated analysis of 24 streams. In contrast, pink salmon abundance within the same streams was normally under 20,000 fish during even years up to 1962. Escapement estimates after 1962 averaged over 50,000 pink salmon semi-annually with few exceptions, but has steadily declined since 1976. Relatively high numbers of both chum and pink salmon occurred in 1966.



	Name
10	ANNA CK
13	SALMON RIVER
14	ECHO HARBOUR CK
15	KOSTAN INLET CK
16	DE LA BECHE CK
17	HUTTON INLET HD CK
18	HUTTON INLET LH CK
19	MARKO CK
25	MARSHALL INLET HD CK
29	MATHESON RH CK
31	MATHESON LH CK
35	ARROW CK
38	HAIDA CK
43	SKAAT HARBOUR RH CK
45	SKAAT HARBOUR CNTR CK
46	SKAAT HARBOUR LH CK
49	FORGOTTEN CK
55	ISLAND BAY RH #2 CK
57	ISLAND BAY LH CK
63	BURNABY STRAITS CK
66	BAG HARBOUR CK
67	TANGLE BAY CK
68	GEORGE BAY/OYSTER COVE CK
71	OXALIS CK/SLIM CK
72	
74	HUSTON E CK/SURPRISE CK
75	JEDWAY CK
76	HARRIET CK
78	IKEDA CK
79	COLLISON BAY CK
80	GONA POINT CK
83	CARPENTER BAY CK
85	SOUTH COVE CK
86	KOYA CK
87	RASPBERRY COVE CK
88	KENDRICK POINT CK
89	SEDMOND CK
90	FANNY CK
91	LOUSCOONE INLET CK
93	
97	SPERM BAY CK
98	STAKI BAY CK
101	FLAMINGO INLET HD LH CK
104	YAKULANAS RH CK
105	GOSKI BAY CK
112	TANU ISLAND CK
114	LYELL IS. N SHORE CK
117	MOORE CK
119	TAKELLY COVE CK
122	BELJAY BAY CK
124	SANDY CK
126	POWRIVCO BAY CK

	Name
126	POWRIVCO BAY CK
127	RICHARDSON CK
135	WINDY BAY CK
136	GATE CK/TAR ISLAND CK
141	KONGANGAS CK
143	LANDRICK CK
146	SEDGEWICK BAY CK
148	BERESFORD BAY CK
160	SCUDDER POINT CK
164	POOLE INLET RH CK
172	BURNABY NARROWS #1 CK
174	BURNABY NARROWS #2 CK
178	MARKER CK
179	SECTION COVE RH CK
183	ALDER ISLAND CK
185	ROSE HARBOUR CK
186	MOODY CK
188	HEATER CK
189	BALCOLM INLET CK
190	LUXANA CK

Figure 19. Location of Gwaii Haanas streams which have been monitored by DFO for annual salmon escapement estimates.



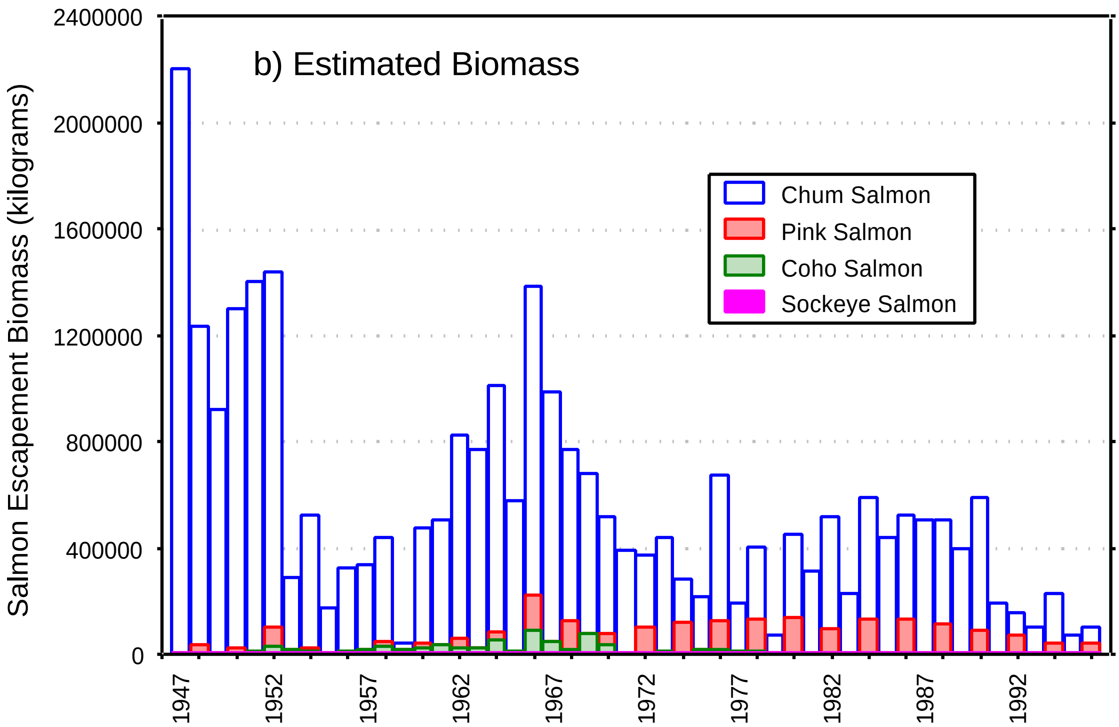


Figure 20. Estimated a) numbers and b) biomass of Pacific salmon from 24 Gwaii Haanas streams having long-term data from 1947-96.

A relationship between escapement estimates for chum and pink salmon was suggested by Reimchen (1992a). When escapements for these species are compared for the subset of streams having long term data, various changes in relative abundance occurred (Figure 21). Pink salmon numbers definitely increased and remained higher for certain creeks (Echo Harbour, Matheson RH/LH) during the 1960-70s, but peaked and declined in others (Hutton HD/LH). Historically, these streams did not exhibit high numbers of chum even before pink salmon appeared. In other cases such as Staki Creek, chum escapement remained fairly stable following peaks in pink salmon numbers during the 1960s. Chum salmon also had similar or greater decreases on streams where pink salmon runs did not appear (e.g. Skaat Harbour, Island Bay RH/LH). The inverse relationship for chum and pink salmon may certainly be true on a broader scale, but is not apparent from the limited number of streams used by both species for spawning during the past 50 years. Further investigation is needed to determine whether conditions have changed on the historical chum spawning sites to the benefit of pink salmon.

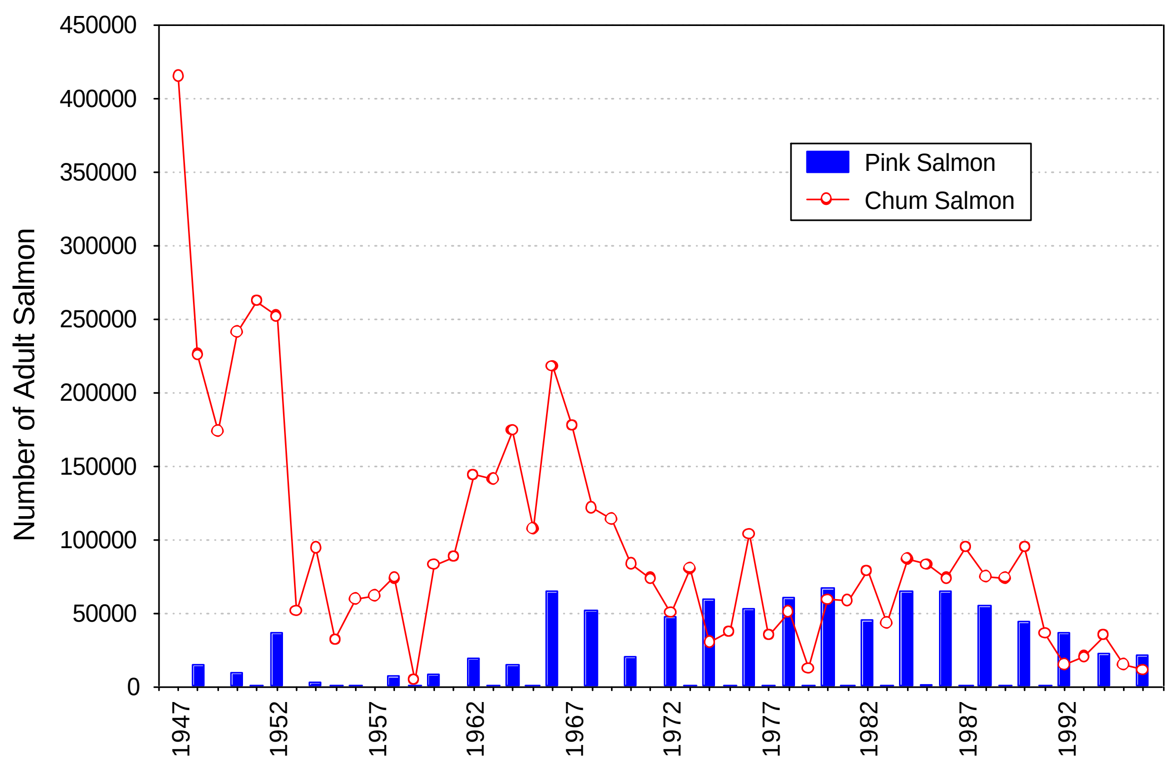


Figure 21. Trends in estimated abundance of chum and pink salmon from 24 streams in Gwaii Haanas from 1947-96.

As of 1995, chum salmon escapement was about 30-50% below DFO targets for the east side of Moresby Island to the north of Gwaii Haanas, but fell well below 10% for many of the streams along the east coast within the Protected Area (Anon. 1995). Chum salmon returns increased slightly for 1996 in Area 2E, but remained poor for streams along the west coast of Gwaii Haanas (Anon. 1996). A suggested explanation for the decline in coho stocks considers the influences of very mild winters and extreme high water events (Anon. 1995). Even-year pink salmon returns for 1996 were not strong on the west side of Gwaii Haanas, but did exceed DFO targets for many key producing streams north of Gwaii Haanas on the eastern shores (Anon. 1996). Most of the streams monitored by DFO have estimates from 1980 to the present. When estimated numbers from 50 streams are summarized for 1980-96 (Figure 22), the same decline is observed as seen in the long-term trend from 24 streams.

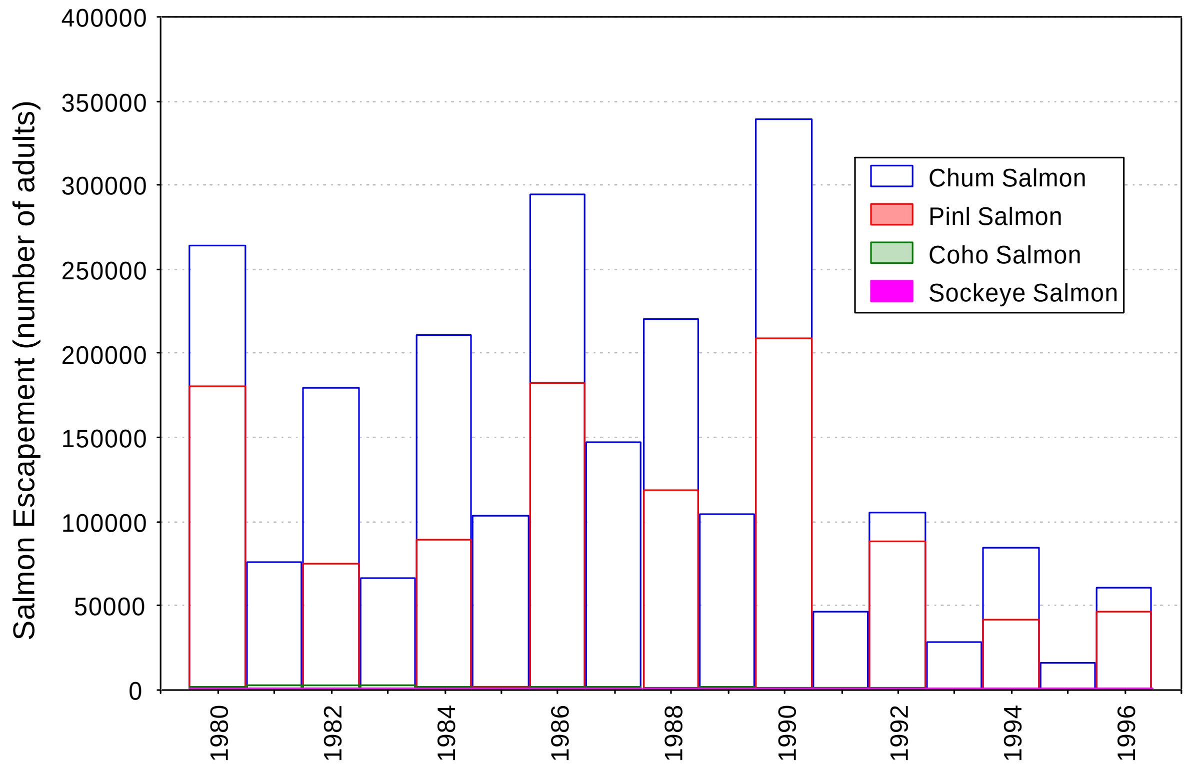


Figure 22. Estimated numbers of Pacific salmon from spawning sites on 50 Gwaii Haanas streams since 1980.

4.0 Discussion

4.1 Lakes

4.1.1 Comparative Results

Gwaii Haanas resides entirely within the ecosection known as the Queen Charlotte Ranges which consists of two ecoregions. The west coast of Gwaii Haanas has a very rugged shoreline, rising quickly to elevations of 500 m and reaching extremes of over 1,000 m along the northern portion of Moresby Island. Stream gradient is much higher than along the east coast, restricting size and availability of potential lake basins. The creation of small lakes is a possibility due to mass movement and landslide deposition. Much of northern Moresby Island within Gwaii Haanas has moderate-to-high mass movement potential even though the potential for landslide deposition is low or nil within most of the Protected Area (Westland Resource Group 1994).

Gwaii Haanas lakes are generally very small, and have quite clear water with pH near neutrality, being characteristic of most lakes on the Ranges (Northcote *et al* 1989). The portion of the Skidegate Plateau to the north of Gwaii Haanas contains numerous larger lakes. Four lakes, each over 500 ha in size, account for almost one third of the total lake surface area for the Queen Charlotte Islands. Heavily stained, acidic waters are characteristic of the poorly drained soils of the Queen Charlotte Lowlands in the northeast part of Graham Island. Here, small lakes and ponds occur along with a multitude of seasonal bog pools which lack surface flow or dry up during the summer months. A lake inventory for Naikoon Provincial Park on the northwestern part of Graham Island showed that most lakes had pH values of 4-5 and light transmission averaging 60% at 400 nm (Reimchen 1992b).

Most of the lakes within Gwaii Haanas are small waters with fish species distributions unknown. The eight fish species and four families found in Gwaii Haanas lakes is lower than species counts from Vancouver Island (8 families, 20 species) or the British Columbia mainland (16 families, 66 species)(Carl *et al* 1959). Cutthroat trout (*Oncorhynchus clarki*) are found in low elevation lakes on Graham Island and the northern part of Moresby Island, but their presence within Gwaii Haanas is uncertain.

Upstream fish migrations are effectively limited to reaches below major obstructions since large waterfalls, cascades and organic debris physically prevent fish from passing over or though the barrier. The occurrence of fish at higher elevations resulted from the post-glacial era when sea level was considerably higher than it is today. Dolly Varden is the only species found so far in the higher elevation lakes. Seasonal use of spawning streams occurs for most Pacific salmon species, but coho is the only one of these species found within Gwaii Haanas lakes.

Littoral substrates are predominantly coarse gravel and sand based on cursory descriptions provided by Reimchen (1992a), while angular rock and bedrock were more common for lakes at higher elevations. This increased substrate size coincides with the increased potential for mass transfer and landslides as elevation rises.

Indicators of lake productivity were rarely encountered from the information provided by Reimchen (1992a), the most consistent measure being the amount of *Nuphar* coverage for each lake. Of the five lakes that had extensive (over 80%) coverage, only the two lakes smaller than 3 ha (Sleet, Sperm) did not contain fish. Productivity indicators from the 1993 surveys included the rarity of benthic invertebrates and aquatic macrophytes within the narrow littoral zone of each lake.

Fish density appears to be very low in all three lakes surveyed during 1993. Based on fish biomass estimates using the morphoedaphic index (MEI) derived by Ryder (1974), the lakes could provide 0.51-0.56 kg ha^{-1} annually. Reimchen (1992a) also estimated the total salmonid biomass to be approximately 1.0 kg ha^{-1} (Upper Victoria Lake), 1.8 kg ha^{-1} (Lower Victoria Lake) and 1.6 kg ha^{-1} (Escarpment Lake) based on netting effort and mark-recapture information from the surveys. These values are relatively low compared with estimates made by Ryder (1965) for other north-temperate lakes of similar size. Indirect evidence from the 1993 surveys supporting low productivity of the three Gwaii Haanas lakes includes a general paucity of aquatic birds and mammals and limited aquatic vegetation.

4.1.2 Data Gaps

The low number of surveyed lakes, and the variable information associated with many surveys, limits the value of existing data to adequately describe the characteristics of lakes and their resident biota. Considerable survey work is required to bring existing lake inventory information up to MELP or similar standards for reconnaissance surveys. Only three lakes (Escarpment, Lower Victoria, Upper Victoria) currently have this level of information. Of the 35 older lake inventories, none currently possess suitable descriptions for most, if not all, trophic components of the aquatic community. Ideally, most of the 35 lakes which possess limited information should be properly surveyed to the appropriate MELP standards.

Basic lake descriptors such as mean and maximum depths, basin morphometry, water chemistry, temperature and oxygen profiles are nonexistent for most lakes. General information concerning shoreline slopes, inflow/outflow features, geology and terrestrial vegetation can be obtained from maps of the proper scale, but this does not replace the finer detail possible from ground surveys.

A number of additional lakes within Gwaii Haanas should also be inventoried. Lakes with suspected (or known) fish populations should be a priority before sport fish harvests are allowed since there is the potential to damage unique fish stocks. A very cautious “no harvest” strategy is appropriate until survey results indicate otherwise.

The status of historic sport fisheries on Gwaii Haanas lakes is unclear even though fishing pressure is expected to be very low. Sport fishing is currently prohibited within Gwaii Haanas. Before anglers are allowed to harvest fish from lakes, the size and characteristics of the fish populations should be assessed. The potential loss of unique fish populations is great when little is known about genetic diversity among lakes.

The existing "snapshot" of biophysical resources within a brief sampling period on each lake supplies relatively static descriptors such as lake bathymetry and most water chemistry characteristics. The initial survey also begins to catalog the taxa associated with this habitat. Unfortunately, a one-time survey neither describes seasonal fluctuations in the water regime, nor changes in species abundance and composition of biotic communities.

The influence of marine incursions on low elevation lakes is unclear. Lakes such as Darwin, Puffin, and Wegner have elevations of 5-7 m, but lack water analyses. Seasonal variation in water chemistry should be investigated for those lakes that are susceptible to marine incursion. A subset of the remaining lakes should have water chemistry sampled seasonally to observe the effects of salt spray, particularly during the fall when offshore winds are normally much higher.

Age, weight and size distributions are basic biological information needed to evaluate and compare Gwaii Haanas fish populations with those elsewhere on the Queen Charlotte Islands and mainland British Columbia.

A significant amount of aquatic information exists for 35 lakes in Gwaii Haanas, but little has been compiled in a format comparable with standard lake surveys. The benefit in trying to recover existing research data must be weighed with the cost of completing standardized surveys on the same lakes. Sampling gear, methods and collection sites are often quite different for research studies compared with inventory and assessment surveys. In the case of Gwaii Haanas lakes, the primary research focus was endemism in threespine stickleback. As such, collections were generally biased toward stickleback habitat.

The absence of fish species should not preclude assessment of other lakes, since biophysical information will improve the understanding of aquatic ecosystem dynamics within Gwaii Haanas and the Queen Charlotte Islands. Insight into plankton and benthos communities of higher elevation lakes will aid comparisons with lower elevation lakes regardless of resident fish populations.

A review of the Gwaii Haanas lake set is needed to provide reconnaissance survey coverage of lakes across coastal locations, elevation and geology. Currently, all three surveyed lakes are found on the west coast and reside on Pluton formations. The underlying geology of the remaining 32 lakes studied by Reimchen (1992a) is not known but could be determined to assist with lake selection for future surveys. Eighteen of the 32 lakes are found on the east coast, including two lakes on Lyell Island.

4.2 Streams

4.2.1 Comparative Results

Gwaii Haanas has many streams located within its boundaries. The high percentage of 1st order streams is expected since the mountainous landscape throughout this area allows for little stream complexity due to steep slopes, particularly along the west coast. Even though higher order streams exist, they are relatively rare when compared to the Skidegate Plateau or Queen Charlotte Lowlands regions of Haida Gwaii (Northcote *et al* 1989). High order streams from the Lowlands exhibit meandering channels characteristic of streams with low gradients. In contrast, Gwaii Haanas streams are much more confined by the terrain, and low gradients are generally limited to the lower mainstem portions of the system. Channel width is a product of stream confinement by adjacent slopes. Most streams within Gwaii Haanas are not very wide, even near sea level. Stream flow is concentrated within relatively narrow channels and heavy rainfall significantly increases flows since the confined stream banks prevent the additional water from dispersing laterally. This leads to further effects on stream bed composition and sediment loads since higher flow rates are capable of moving larger particles.

Lake presence resulted in higher stream temperatures from either coast, and may be a factor in the presence of rainbow trout in the warmer streams. Based on the observed ratios of channel width to wet width, lakes also appeared to moderate extreme flows, possibly enhancing upstream migration for most species that are unable to manage strong currents.

Differences in abundance of aquatic invertebrates were observed depending upon the presence of lakes or proximity to either coast. More invertebrates were collected within stream systems containing lakes, and the lower rainfall, more productive forests of the east coast likely contributed more nutrients into the waters.

Coastal location also influenced the composition of riparian vegetation, where the greater amounts of precipitation along the west coast lead to less productive tree species. The dominant trees along both coasts were similar, but trunk diameter was noticeably smaller along the west coast streams. Subalpine bogs were also more prevalent on the western side of Gwaii Haanas where herbaceous plants such as swamp laurel, bog blueberry and black crowberry were found.

The number of fish species is much lower within Gwaii Haanas (3 families, 9 species) than for the entire Queen Charlotte Islands (5 families, 15 species) or the British Columbia mainland (16 families, 64 species)(Northcote *et al* 1989). Cutthroat trout, Pacific lamprey and western brook lamprey are common for the Queen Charlotte Islands, but their presence within Gwaii Haanas is uncertain. Seasonal use of Gwaii Haanas spawning streams occurs for most Pacific salmon species, even though sockeye are only observed in the Salmon River. The eulachon (*Thaleichthys pacificus*), a member of the smelt family (Osmeridae), is considered rare for the Queen Charlotte Islands and appears limited to the mouth of the Yakoun River.

High stream gradients and obstructions such as waterfalls, cascades and log jams are common features of many streams in Gwaii Haanas. Fish distribution is naturally restricted to reaches below these barriers with few known exceptions. Even though species distributions may indicate that a particular fish species can be found in most streams at some time during the year, access to upper reaches is often impossible. Dolly Varden is an aggressive swimmer and is often found at higher elevations. The occurrence of this species above major impasses is not a recent phenomenon. Dolly Varden distribution within Gwaii Haanas was likely aided by relatively high sea levels thousands of years ago, explaining why this species is found where no other fish currently exist. It is also more common from west coast streams compared with other species.

Avian and mammal sightings along stream reaches certainly varies with the season. Species such as bald eagles and black bears were frequently observed during salmon migrations, but during the summer months, sightings decreased and bald eagles were more common along coastal waters and lower mainstem sites. Summertime inhabitants of east coast riparian areas include the American dipper and common raven.

The underlying geology influenced the physical characteristics of streams such as channel confinement and resultant stream flows. Streams located on Pluton formations tended to have lakes which provide higher downstream water temperatures and more stable flow for stream inhabitants. Stream substrates also varied with geology to some extent. Bedrock was more common in Pluton streams, while Kunga sites often had abundant small gravels.

It is apparent that coastal location, lake presence and geology affect different components within Gwaii Haanas stream ecosystems. The degree to which these factors act together or independently will require additional stream surveys for each stream category before reliable comparisons are possible.

4.2.2 Data Gaps

The major data gaps which exist for Gwaii Haanas streams include: 1) the limited number of surveyed streams in the Parks Canada database; 2) the seasonal nature of existing inventories; 3) the need to relate precipitation and stream flow to stream community dynamics; 4) assessment of seasonal migrations for fish species beyond the salmon escapement information provided by DFO; and 5) improved monitoring to describe seasonal resource use by birds and mammals.

Twenty-two streams have recently been surveyed, and are the basis for most of the biophysical comparisons covered in this report. The number and diversity of stream systems within this area dictate that considerably more surveys are required before a critical mass of inventory data is available to adequately describe Gwaii Haanas stream resources. Recent surveys do provide relatively complete descriptions for representative stream reaches in the limited time allowed for field data collection.

The majority of sampling sites are found at lower elevations yet many streams originate well above sea level. The value of including one or more sites above designated elevations should be considered, as these sites will enable biophysical comparisons of riparian and stream biota which are influenced by elevation. These sites will certainly be useful when attempting to describe stream systems which contain significant lakes at higher elevations, such as those found in the northern interior of Gwaii Haanas. The inclusion of three additional sites per stream during 1994 was an attempt to deal with the original bias towards low elevation (lower mainstem) sites, but most sampled reaches were still below 100 m levels. Careful review of existing information is needed before upstream sites are considered for future surveys.

Stream inventory information has been summarized for 22 watersheds surveyed during 1993-94, but considerable biophysical data exists from the 1979 MOE stream inventories for approximately 190 additional watersheds. Some of this older information was used to create the series of biophysical maps, but considerable data still resides only as paper copies of the stream survey cards. There are no plans for MELP to construct databases with the archived information from Gwaii Haanas.

Future stream surveys should continue to be completed during the summer months as a common sampling period for most biophysical descriptors. Logistically, this is the most opportune time to access most areas of Gwaii Haanas, particularly along the more rugged west coast. The relatively dry conditions at this time of year also permit a more thorough description of substrate plus other stream features. What is lacking is a seasonal description of stream dynamics specific to Gwaii Haanas. Changes in precipitation, stream flow, primary and secondary productivity, plus fish presence and abundance vary widely within Gwaii Haanas, but are often only generally described.

Precipitation and stream flow variation must be monitored throughout the year to assess their influence of stream community dynamics within Gwaii Haanas. General knowledge of relative rainfall characteristics for the east and west coasts must be quantified and linked with concurrent biotic sampling where conditions allow. Macroinvertebrate and fish collections from selected reaches should be made seasonally.

Seasonal sampling of plankton and macroinvertebrates for stream systems containing lakes will help to quantify the influence that lakes have on stream productivity. The potential additional biomass available from lakes without fish populations may be substantial since certain species in Gwaii Haanas (e.g. rainbow trout, threespine stickleback) are capable of reducing plankton density through forage activities.

Bird and mammal use of in-stream and riparian habitat are briefly captured in the presence/absence data collected during the summer stream surveys. Reimchen (1992a) extracted similar information from DFO sightings during salmon escapement monitoring. What is needed is quantifiable data allowing a measure of bird and mammal utilization for aquatic resources not only during the fall spawning period for salmon, but also covering Dolly Varden and spring runs for species such as steelhead trout.

Continued difficulty in relating certain stream characteristics to the physical landscape results from an absence of basic watershed knowledge such as the number and size of watersheds in the Parks Canada GIS database. This information will be available from MELP within several months as part of the B. C. Watershed Atlas, and should help to describe and compare more effectively. Additional analysis of Ecological Land Classification data (e.g. soils, vegetation, geology) is also needed to investigate relationships with aquatic biophysical data.

4.3 Ecological Synthesis

Lakes and rivers should be considered integral parts when attempting to provide an ecological synthesis of aquatic resources for Gwaii Haanas. Climate, topography and geology are underlying factors which characterize the many watersheds. The whole of Gwaii Haanas lies within the physiographic region of the Queen Charlotte Ranges, with underlying geology mainly consisting of very old rock formations. These are frequently exposed due to lack of surface soil on steeper slopes and along stream channels.

The climate of Gwaii Haanas and the Queen Charlotte Islands is moderated by the surrounding marine environment and distance from mainland British Columbia. Seasonal precipitation varies widely throughout the year, with typical mid-summer lows and extremely high amounts during the fall and early winter months, particularly along the west coast of Gwaii Haanas. Annual fluctuations regulate stream flows, altering stream flow dynamics and substrate composition. These changes in turn allow migrating fish to move upstream through reaches which were impassable during the summer months.

Lower elevation lakes are more likely influenced by coastal processes while terrestrial ecoregions are more suitable for describing the higher elevation lakes. The Queen Charlotte Islands are located in one of the windiest parts of Canada, and this area is know for its frequent and intense storms (Thomson 1989). This often violent weather produces large waves which lead to marine incursions of salt water into low elevation lakes near the coast. The steady, strong winds present along the west coast of the Queen Charlotte Islands each fall carry salt water spray well inland, potentially affecting lake and stream chemistry within these watersheds.

The importance of lakes within a watershed is considerable since they may provide important buffering capacity. Smaller lakes generally do not provide the same protection as larger lakes, and without sizable lakes in the system, stream flow can increase sharply immediately after significant rainfall events. The buffering capacity of lakes will be lower during the wetter winter months since soils are already saturated and lake levels will be at or near their maxima. During the dry summer period, significant rain may simply eliminate low water levels for lakes which were well below high water marks, without increasing downstream flow significantly.

Within lakes, increased water temperatures normally lead to higher productivity of plankton, benthos, fish and aquatic macrophytes. Depending upon the lake characteristics, a portion of the lake biomass may be transported downstream, either on a regular basis (e.g. plankton) or during extreme flow conditions (e.g. fish). The result is additional biomass in downstream reaches which can be utilized by stream inhabitants.

The additional solar energy absorbed by lakes in turn raises downstream water temperatures. Fish species have optimal and preferred temperatures for survival, which influences species distributions. For example, rainbow trout in Gwaii Haanas appeared to be more abundant in streams with higher water temperatures. The combination of high altitude headwaters and the absence of high summertime air temperatures prevent stream water from warming considerably before entering the Pacific ocean. Any unique features of the watershed (e.g. lakes, exposure to winds, rain, sun) which help to capture solar energy are expected to enhance stream productivity.

Many of the lakes and higher elevation streams reaches are expected to be void of fish. The relatively high stream gradients of upper reaches prevent most species from migrated much above the lower mainstem. Dolly Varden is capable of maneuvering faster waters and is often the only species found furthest upstream. Natural obstructions such as waterfalls and steep stream gradients effectively restrict migrating species to stream sections below the barrier.

The presence of Dolly Varden in lakes and rivers above such obstructions illustrates the influence that ancient sea levels and glaciation have had on present day species distributions. Upper Victoria Lake, at an elevation of 44 m, is a good example where a major obstruction prevents further upstream migration of fish, yet Dolly Varden is the only fish species above this location. The most plausible answer is a speculation of higher sea levels and the added weight of glaciers on Haida Gwaii that occurred thousands of years ago which made the current obstruction less difficult to overcome.

Salmon spawning migrations influence the use of streams by birds and mammals, and their importance cannot be underestimated. The additional food resources available from streams at this time of year attract numerous species which are otherwise associated with coastal or terrestrial habitats. Seals, sea lions, bald eagles and glaucous-winged gulls are the more common coastal species to congregate along migratory paths or at spawning sites. Black bears alter their spring and summer diet of herbaceous forage and berries, and are drawn to salmonid streams each fall to feast on the concentrated food resource (Westland Resource Group 1994). Marine mammals such as sea lions and Pacific harbour seals forage on salmon as the fish approach stream mouths, and these mammals have been within freshwater reaches in pursuit of prey.

Reductions in spawning salmon abundance have been evident from Gwaii Haanas streams for some time. Estimated numbers of the most abundant salmon species is currently far below historical values. Since 1990, the number of chum salmon reaching Gwaii Haanas spawning grounds appears to be about 10% of that estimated for 1947-

52. In turn, salmon numbers were likely much higher before commercial salmon fisheries became established compared to the late 1940s. Pink salmon became relatively abundant by the late 1960s in the limited number of Gwaii Haanas streams known to contain this species, but began to decline by the late 1980s. The shift from an overall abundance of large-bodied fish (chum) to smaller-bodied ones (pink salmon) from streams within Gwaii Haanas is characteristic of trends seen globally in commercial fisheries (Welcomme 1991).

The influx of biomass into streams during spawning periods is considered a vital energy source for stream inhabitants. Seasonal egg deposition and decomposition of salmon carcasses is expected to enhance the naturally low productivity of most Gwaii Haanas streams. Aquatic invertebrates, resident fish species and riparian biota will benefit from the added nutrients (Reimchen 1994b). Relatively large salmon runs in the Salmon River and Bag Harbour Creek correspond with greater fish densities during the summer months (Reimchen 1994a), even after most salmonid offspring have returned to the ocean.

Stream productivity generally increases with stream complexity. Most streams within Gwaii Haanas are 1st order streams which tend to have high stream gradients and no lakes. They are relatively unproductive compared with other streams on the Queen Charlotte Islands or mainland British Columbia. Streams within Gwaii Haanas and much of the Queen Charlotte Islands must rely largely on riparian vegetation for energy inputs (Cummins 1974; Vannote *et al* 1980).

Genetic and morphological diversity of fish species has been studied on the Queen Charlotte Islands during the past 30 years. Threespine stickleback occur in many low elevation lakes on the major islands (Graham, Louise, Lyell, Moresby), but are absent from Langara Island, plus most lakes having steep outflow gradients (Northcote *et al* 1989). Populations of morphologically distinct threespine stickleback have been studied extensively on the Queen Charlotte Islands (Moodie 1972a,b; Moodie and Reimchen 1973; Reimchen 1984; Reimchen *et al* 1985), and extremely divergent forms occur in the north-east portion of Graham Island (Reimchen 1984). Some variation is also evident within Gwaii Haanas. The question of similar genetic variability in other resident species such as rainbow trout and Dolly Varden exists but cannot be answered until much more work is done with these fish populations in the Protected Area.

Many recent human impacts within Gwaii Haanas were curtailed when Gwaii Haanas National Park Reserve was established. Historically, mining and logging have occurred within the current Gwaii Haanas boundaries (Sutherland Brown and Yorath 1989; Dalzell 1973). Commercial fishing focuses on migrating salmonids in the lower stream reaches, but has not occurred in lakes. Since the Protected Area was created, the demand for general recreational opportunities increased considerably, creating potential impacts for lake habitat and fish populations.

Introductions of new fish species is certainly possible, but not very probable at this time. The isolated location of most lakes will inhibit unauthorized transfers, and there are certainly no plans for authorized introductions of new species within Gwaii Haanas. Even so, natural dispersion of species such as cutthroat trout is possible since this species is currently found to the north of the Gwaii Haanas boundary on both Moresby and Louise islands (Northcote *et al* 1989).

5.0 Research and Monitoring Issues and Priorities

Seasonal monitoring of lake levels, stream flows, fish movements, plus plankton and benthos community changes are needed to quantify the dynamics of aquatic resources in Gwaii Haanas. A subset of lakes and streams should be selected and assessed seasonally to estimate productivity of these waters throughout the year. Hydrological information for Gwaii Haanas is still absent, but is required to better understand lake and stream dynamics. The climate station network of hydrological stations throughout the Protected Area, as recommended by Seel *et al* (1990), has not been established to provide the type of data (e.g. stream flow, sediment transport, water quality, flood hazards) which can be linked to biotic information to better understand aquatic ecosystems.

Groundwater studies are needed to understand the importance and dynamics this particular component in the complete water cycle for Gwaii Haanas. Even though lakes and streams appear to be influenced heavily by precipitation and runoff, groundwater may also play an important role in the overall dynamics of aquatic ecosystems.

Research into the taxonomic diversity of plankton and benthos is needed since expertise and suitable identification keys are not available to properly identify most invertebrate below the genus or family level. Invertebrate collections from selected lakes and streams throughout all seasons would aid taxonomists with specific and sub-specific identification. Endemic forms are only identifiable after taxonomy is properly defined at the species level. The value of benthos and plankton collections during reconnaissance surveys would increase considerably beyond coarse measures of productivity at this trophic level.

The morphological diversity among threespine stickleback populations on the Queen Charlotte Islands is evident from research activities during the past 30 years. Future population studies for Gwaii Haanas lakes would inventory existing (and newly discovered) populations to determine the extent of variability for salmonids. Rainbow trout, for example, is considered a very plastic species, and was known under various scientific names within its native range (Scott and Crossman 1973). The distinction still remains with common names for riverine (rainbow), lacustrine (Kamloops) or migratory (steelhead) forms of the species. The close proximity of cutthroat trout to the northern border of Gwaii Haanas is also of interest since it is known to hybridize with rainbow trout. Another example of potential variation and a research need are the wider parr marks observed on coho salmon from De la Beche Inlet Creek.

Additional insight is required into the pink salmon expansion within streams previously dominated by chum salmon. Inspection of current and historical spawning sites for both species may indicate if and why spawning habitat has been altered in some way to benefit one species over the other.

6.0 Summary and Recommendations

This section provides a status summary for Gwaii Haanas aquatic resource information to identify and suggest future survey needs. Recommendations are highlighted in bold to ensure their identification within the text.

There needs to be a balance between filling in data gaps for lakes having partial information, and completing standardized surveys on new waters. Even though considerable additional data pertaining to the 35 lakes surveyed during 1976-87 exists as archived information, the value in pursuing this information is doubtful. It would certainly mean some overlap with archived research data, but new reconnaissance surveys on many of the same lakes would facilitate comparisons using standardized data. Three of the largest lakes were surveyed in 1993, which is more time consuming than surveys on lakes that are many times smaller.

Future surveys within Gwaii Haanas should focus on watershed assessment, such that all lakes and streams within selected watersheds should be surveyed during the same year if possible. There should be little difficulty in selecting from the small, simple watersheds which are abundant. Considerably more complex systems consisting of 3^{rd} or 4^{th} order streams and multiple lakes are relatively rare, but would require much more effort to properly assess.

The information pertaining to Gwaii Haanas aquatic resources is at best limited, and considerable inventory work is required simply to provide reasonable distribution maps for both fauna and flora. Recommendations for data collections are listed separately for lakes and streams to fill in some of the more important data gaps which currently exist. These include revisions to field sampling methods for individual lakes or stream surveys, plus the identification of spatial information gaps for Gwaii Haanas.

Lakes:

A priority for Gwaii Haanas lakes is the need to add further surveys to the inventory base. The three lakes surveyed during 1993 are a start in the right direction. These surveys include the three largest lakes within Gwaii Haanas, there are currently no smaller lakes to compare and contrast information. The somewhat incomplete data for many of the 35 lakes that do contain information should be used to guide the selection of lakes for future surveys. Reimchen (1994) recommended surveys on four small, shallow lakes (Lutea, Post, Many Flowing Waters, Hidden) with varying levels of conductivity to contrast with the large, low productivity waters surveyed in 1993.

Water chemistry data exist for only 10 lakes within Gwaii Haanas at this time, while temperature and dissolved oxygen profiles have been determined for only three lakes. Cessation of temperature and oxygen readings below 15 m is unfortunate. **Rapid**

collection of water samples and temperature/oxygen profiles from numerous lakes may be possible using helicopters plus Hydrolab™ equipment. Plankton hauls should be made at the same time to begin monitoring plankton community dynamics for selected lakes.

Basic fish sampling is needed from more of the 35 inventoried lakes since 14 of these lakes currently show no fish present. The origins of coho salmon, Dolly Varden and rainbow trout populations needs further investigation to determine if they are resident or migratory. In the mean time, the lake populations should be considered unique within Gwaii Haanas, and in need of protection.

Based on population estimates from the 1993 lake surveys, fish marking should be ignored during reconnaissance surveys since the numbers of marked and/or recaptured fish will be too low for reliable estimation of population size. The added time to mark and check fish could be better spent by the field crew with other components of the survey**. Mark-recapture work should be considered low priority for preliminary lake surveys since netting results still provide a relative measure of species abundance**. If initial findings suggest the presence of a unique population, further assessment (including mark-recapture) is warranted to confirm its status.

Fish descriptors from each lake should include abundance, size, weight, parasites and diet data for each species where possible. Reported results should include a measure of sample variance when means and ranges are reported. The collection of aging structures from fish would allow the age structure to be determined for the larger individuals. The length-weight relationship should be presented both graphically and as an equation for future reference and comparison.

Standardized data formats are being used to archive Gwaii Haanas survey data for lakes and streams. As the survey design evolves, **custom software which is designed to enter and archive such information should be considered**.

Bathymetric mapping of lakes should continue, as this information will provide further insight into the influence lakes have within these watersheds. Currently, information as basic as maximum depth is not available for most Gwaii Haanas lakes.

The benthic invertebrate and zooplankton communities of lakes require further evaluation at seasonal intervals to determine their roles in supporting lacustrine and riverine fish species. The selection should include a cross section of those lakes which have: 1) no fish, 2) no planktivorous fish, 3) planktivorous fish, 4) a range of nutrient levels, and 5) a range of aquatic macrophyte growth**. Relative and absolute measures of benthos and plankton abundance should be obtained by taxonomic group to follow community dynamics throughout the year. Invertebrate species distributions within Gwaii Haanas may also be resolved by providing samples for expert identification**.

Seasonal observations of avian and mammal activity will add to the sporadic knowledge related to lake use within Gwaii Haanas. In particular, short-term observations of bird activity during the winter may indicate important winter habitat for some species near Escarpment Lake.

Fish collections made during the winter months may also indicate the residency status of salmonids from lakes which are along the migratory paths of anadromous species. Escarpment Lake is an example where steelhead trout and salmon spawn upstream of the lake to spawn, but winter use of the lake is unknown.

Streams:

The 1993-94 surveys provide a good start at assembling aquatic biophysical information, however, **additional streams should be surveyed to adequately sample all watershed types within Gwaii Haanas**. Just over 70% of the watershed are located on Moresby Island, suggesting that surveys are needed from the other large islands as well. The distinctive geology of Lyell Is. in particular provides a useful comparison with Moresby Island. The underlying geology of Lyell Island includes the relatively young Skonum and Masset Formations.

Careful review of watershed information from the B. C. Watershed Atlas (MELP 1996) plus other data sources will guide priorities for future stream inventories. For example, surveys completed for streams which are monitored for salmon escapement by DFO should be considered worthwhile to tie in with historical information.

Inspection of representative stream survey cards used for the 1979 MOE stream inventories of Gwaii Haanas streams will determine the value in creating digital data sets for selected biophysical information. Since these data were supposedly collected in a standardized fashion, the opportunity exists to compare the streams surveyed in 1979 and 1993-94 after compiling and entering the raw data from the original stream survey cards.

The trade-off made by electrofishing more sites per stream in 1994 was the absence of abundance estimates within stream reaches. Relative abundance of fish species should suffice for preliminary surveys**. Aging structures should be collected from larger fish to determine ages of older fish such as sea-run Dolly Varden**.

Seasonal measures of such stream properties as discharge rates, water temperatures, and selected chemical elements are needed. Biological attributes requiring seasonal monitoring include fish presence and abundance, vertebrate usage and macroinvertebrate assemblages. The lack of salmon fry emergence and migration information is a shortfall of the current sampling regime for streams.

Gwaii Haanas staff and visitors should be encouraged to aid in mapping species distributions by recording and reporting sightings. Obviously, there is some error expected as amateur taxonomists misidentify species and confidence ratings for reports must be established. Development of such a program is underway and should be implemented quickly. This type of information will also be useful in guiding future assessment or research work based on a more complete knowledge of species distributions.

Fish species distribution for chum salmon is certainly incorrect in the Parks GIS data and DBase file (S92DATA.DBF) provided for the 1979 MOE stream inventories (Reimchen 1992a). Species presence appears to be correct based on DFO escapement data, but chum is a glaringly absent species for these streams. MELP is indicated as a second source of species presence, but exactly what this source was is unclear. Fish Inventory Summary (FIS) maps produced in 1986 by MELP also indicate that chum is present in many streams, but again, the information is absent from the DBase file. **Careful review of the species recorded from DFO escapement data, FIS maps plus any other sources is required before distributions are to be considered accurate**.

Comparisons among the many lakes and streams within Gwaii Haanas if further complicated by the lack of similar information outside of the Gwaii Haanas boundary**. An effort should be made to compile DFO salmon escapement data and other biophysical information to compare and contrast**. Considerably more data have been collected within areas destined to be logged, and the information may provide a better understanding of species distribution and habitat.

The impact of raccoons on indigenous toad populations is unknown, but considerable predation on toads had been observed. **Future surveys should actively check for these species to improve existing knowledge of distributions and interactions**. These species may also require research and monitoring to determine relationships.

The recommendation to conduct future surveys on a watershed basis should also encompass the collection of estuarine data. Estuaries are an important link between the freshwater and saltwater environments used by migratory species in Gwaii Haanas, but very little is currently known.

Finally, **spatial analysis of integrated information from terrestrial, coastal and freshwater aquatic resources is required to investigate interactions which are not readily apparent**. Unknown relationships among the various flora and fauna of aquatic and riparian areas may be identified using this approach, but considerable effort is required to properly complete the task.

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8.0 APPENDICES

Appendix A. General description of the salmon escapement database (SMSALMON.DBF) and field descriptors.

Contents:

This database contains DFO salmon escapement estimates for 71 streams within Gwaii Haanas. The earliest estimates included in the database occurred in 1947 even though sporadic values existed from the 1920s and 1930s for certain streams. Only 24 streams have annual data for most year beginning in 1947, and the remaining streams have annual estimates for shorter time spans. There are 2488 records in the database.

Fields:

STREAM	- stream code
YEAR	- year of the estimates
SOCKEYE	- estimated number of sockeye salmon
COHO	- estimated number of coho salmon
PINK	- estimated number of pink salmon
CHUM	- estimated number of chum salmon
LOCAL	- local name for the stream (8 characters)

Codes:

0 - stream was inspected for this species but no fish were observed
-2 - species presence was unknown, or the stream was not inspected for this species

Appendix B. Detailed sampling methods for 1993 lake surveys and 1993-94 stream surveys, extracted from original reports and included here to fully document the sampling methods.

1993 Lake Survey Methods (from Reimchen 1994a):

Surveys were carried out in July 1993 (Upper Victoria Lake, July 7-11; Lower Victoria Lake, July 12-17; Escarpment Lake, July 18-24). Field crew (2) and equipment were transported to the lakes by float-plane.

Bathymetry transects were conducted by boat using a depth sounder with digital readout. On each transect, depths close to shore were recorded at 15 m and 30 m from shore and thereafter, at fixed time intervals (10 s) across the lake with boat speed held constant. A minimum of 15 transects were conducted at each lake yielding from 300 to 600 depth measurements per lake. Hypsographic curves were plotted for each lake.

Oxygen and temperature profiles were carried out at mid-day at three diverse sites with a dissolved oxygen meter (YSI Model 58). Measurements were recorded every meter for the length of the cable (15m).

Water samples, collected from the surface at the center of the lake, were chemically analyzed for 15 elements (Northern Forestry Centre, Department of Natural Resources Canada, Edmonton, Alberta). Conductivity and pH were measured with a digital meter at three sites for each lake. A Secchi disk was used to determine transparency at two open water sites during full sunlight at mid-day. A water sample was also taken and percent light transmission at 400 nm was measured on a Digispec spectrophotometer.

Dominant aquatic vegetation and substrate composition was surveyed from a boat during circumnavigation of the lake littoral region. Representative littoral areas were examined in more detail by wading in the shallows during which all macrophytes were identified, their general abundance estimated (rare:<20% cover, common:20-50% cover, abundant:>50% cover) and substrate defined. Substrate was visually categorized and placed into standard groups (sands <2 mm, small gravels 2-16 mm, large gravels 16-64 mm, small cobbles 64-128 mm, large cobbles 128-256 mm, boulders >256 mm, bedrock). General proportions of each were estimated. Presence/absence of submerged trees and branches were recorded at all sites.

Zooplankton samples were obtained at mid-day and midnight at three sites per lake. Conditions were sunny with light winds for the mid-day sample and calm at midnight. The plankton net (hoop diameter 12 cm) was lowered to the bottom with the hoop entrance facing upwards and then raised from the bottom at constant rate (0.5 m s^{-1}) to the surface. Two replicate samples were made. Zooplankton was preserved in 10% formalin and later counted under a dissecting microscope (40X).

Bottom sediment was sampled with an Ekman dredge at several sites in each lake. The sediment was later examined for macroinvertebrates. Littoral macrobenthos was collected with dip nets at several localities around the lake. All of these samples, as well as the replicate zooplankton samples, were sent to taxonomists for classification (Museum of Nature, Ottawa). Lake bottom in the lake center was often hardpan on which the dredge did not penetrate and as such no samples could be obtained.

Three Fyke nets were used for live capture of fish and these were set in littoral areas perpendicular from shore. During shoreline movement, fish confront the netted barrier and are directed outwards where they enter hoops and are trapped. Conventional design, which primarily allows capture from a single direction, was modified by attaching the seine to the center of the hoop to allow bi-directional capture. The Fyke nets were set in diverse localities around the lake shore to identify major intra-lake variability in fish species. All fish captured were identified to species and measured for standard length (SL). Rainbow trout and Dolly Varden were individually marked, small individuals (SL 10-13 cm) with a clip of the adipose fin and large fish (>13 cm) with a numbered Floy tag inserted into the musculature at the base of the dorsal fin. The smallest fish (<10 cm) were released unmarked.

Gillnets were set to sample fish from open water habitats. Multiple-mesh sizes, ranging from 1 cm to 10 cm, were used. These were set both at the lake surface and at the bottom (>20 m) and were checked every 12 hours. Very few fish were captured and those in good condition were measured for SL, marked and released. The remaining were examined for stomach contents.

Records were made of any amphibians, mammals and birds on the lake surface or on the shoreline. Observation periods were usually begun at 0515 h which allowed potential sightings of species active at crepuscular periods such as Marbled Murrelet.

I used 1:20000 scale base maps (Surveys and Resource Mapping Branch, Province of British Columbia) which provided lake outline, stream channels and contour lines. Watershed boundary, lake perimeter, major stream channels and depth contours were digitized on a 30.5 X 30.5 cm Numonics graphics tablet using CAD software. Area, perimeter and width were determined with mapping software (Quikmap 3.0).

The following standard lake morphometrics were calculated based on Wetzel (1983):

Lake area (A) - derived from digitized map

Volume (V_1) - cumulative sum of volumes from each contour interval (midpoint depths between adjacent contours multiplied by the area between adjacent contours).

Volume (V_2) - lake basins can be simplified to an inverted truncated cone and volume calculated as follows:

$$V = \frac{h}{3}(A1 + A2 + \sqrt{A1xA2})$$

where h is lake depth, A1 is the total lake area and A2 is the area of the lake over the deepest depth contour.

Maximum length (l) - greatest staightline distance across the lake

Maximum width (b) - maximum breath across lake at right angle to length

Maximum depth (z_m) - maximum depth

Mean depth (z) - volume divided by surface area (A_o)

$$z_r = \frac{50\, z_m \sqrt{p}}{\sqrt{A_0}}$$

Relative depth (z_r) can be calculated:

Shoreline (L) - total perimeter is:

$$D_L = \frac{L}{2\sqrt{p\ A_0}}$$

Shoreline development (D_L) - where higher values represent progressive departures from a circle.

1993 Stream Surveys (from Reimchen 1994a):

Stream surveys were conducted July 8-22, 1993. At each of the 14 streams, two representative sites were surveyed, one close to the mouth and a second further upstream. At each site, a variety of physical and biological parameters were measured. Stream discharge was estimated in the lower mainstem by selecting a section of stream without side channels and with a reasonably uniform width, depth and substrate. The time (T, seconds) was recorded with a stopwatch, for a partially submerged float to travel over a measured distance (L, meters) between two hand held poles. The average depth (D, metres) was calculated by measuring the depths ¼, ½ and ¾ of the way across the wet width (w, metres) of the transect, and then dividing the sum of these depths by four. Discharge was calculated as $m^3 s^{-1}$=(L*W*D)÷(T*R) where R is a bottom roughness factor, using 0.8 for boulders or coarse gravel and 0.9 for fine gravel.

Stream temperatures were recorded with a hand held thermometer at each sampling site along with the time of day and weather conditions. Except for the last two days of the surveys (21 & 22 July), when it was overcast and raining, the weather was sunny.

For analyses of water chemistry, two simultaneous water samples were taken at one site in each stream and collected in 10 ml plastic containers, which had been rinsed six times in stream water. These were analyzed for 15 elements (Northern Forestry Centre, Department of Natural Resources Canada, Edmonton, Alberta).

For classification of riparian vegetation, crown closure by overhanging branches was estimated as percent cover over the streambed. Dominance rank (1-8 with 1 most dominant) was recorded for the nine major tree species. Maximum size (trunk diameter) of each species was classified into one of three groups (<1 m, 1 - 3 m, ≥3 m). Presence/absence of 12 major species of shrubs and 34 species of herbs were recorded at each locality.

Stream macroinvertebrates were sampled from riffle areas with a surber sampler prior to any other collecting activity on the stream. The surber sampler (25.4 cm x 25.4 cm), was set on the streambed and the stones within the frame, down to a depth of about 15 cm, were removed and placed in a bucket of water; any animals which were dislodged in the process drifted down into the cone of the net and retrieved. The stones were scrubbed, rinsed clean in the bucket of water, and then discarded. Contents of the bucket were then strained through the cone of the surber sampler net (mesh size: 1.5 meshes mm^{-1}) and the sample was preserved in 5% formalin. These samples were later sorted under a dissecting microscope into 5 categories: Ephemeroptera, Plecoptera, Trichoptera, Diptera and 'Others'. Representatives of each were sent to taxonomists for identification.

At each sampling site, measurements were made of the channel morphology. Length of stream between the stopnets used for electrofishing was measured with a 20 m tape. Length of each hydraulic unit (riffle, cascade, pool, glide) was recorded. Three measurements of channel width and wetted width were made within each site. If side channels were present, their length was measured, and their wet width included with that of the main flow. The maximum depth of the pools was measured. Composition of the streambed substrate in the wetted area of the sampling site was estimated to the nearest 5% in 5 categories: fines (< 2 mm particle size), small gravel (2 - 16 mm diameter), large gravel (16-64 mm diameter), larges (> 64 mm), and bedrock. Compaction of the streambed was subjectively rated as low, moderate or high by kicking an area of gravel in the substrate. Total cover for fish was estimated as a percentage of the wetted area of the streambed. The composition of the cover was estimated as a percentage in each of five components: cutbank, boulders, large organic debris (L.O.D.), overhanging vegetation (< 1m above the stream), and instream vegetation. Confinement of the stream between the valley walls or terraces for each sampling site was rated as: entrenched, confined, frequently confined, occasionally confined, or unconfined - according to the guidelines in the Stream Survey Field Guide published by the Department of Fisheries and Oceans and the British Columbia Ministry of the Environment (1987). Any significant obstructions to the upstream movement of fish - waterfalls, cascades or log jams - which were encountered, were noted.

At each sampling site, stopnets (size 2.8 meshes cm^{-1}) were placed across the stream at the upstream and downstream boundaries blocking access for fish into or out of the sampling site. Using a backpack electroshocker (Model BP - 1C) the enclosed section of stream was electrofished from the downstream net to the upstream net, and then immediately back down in the opposite direction. This catch, 'Catch 1', was put aside, while the rest of the sampling and recording was completed at the sampling site. Then the electrofishing method was repeated to give a second catch, 'Catch 2', in a separate bucket.

For each catch the fish were anaesthetized, using alkaseltzer tablets, separated by species, measured individually (fork length), and weighed collectively; all of the individuals of a species were placed in a light plastic container with a soft mesh bottom, which was towel-dried before weighing with hand-held spring scales calibrated to 5 g intervals. The fish were then tipped back into water, and the weight of the empty container deducted.

Numbers of fish for each sampling site (n) was estimated by the removal method (Seber and Le Cren 1967) using the formula:

$$n = \frac{(Catch1)^2}{(Catch1 - Catch2)}$$

At three sites only one catch (Catch 1) was obtained (due to breakdown of the electroshocker). For the other 24 sites electrofished, the average proportion (p) of the estimated population (n) which was obtained in the first catch was calculated (p = 0.62). For the three sites where there was only one catch, the population was estimated using the formula n = Catch 1÷0.62.

Each fish sampling site was photographed in an upstream direction from below the bottom net, and in a downstream direction from above the top net, using an Asahi Pentax camera with wide angle (35 mm) lens and 400 ASA colour print film. A polarizing filter was used, except when light conditions were marginal. A single photograph was taken at sites where only a surber sample was taken.

Any amphibians, mammals and aquatic birds observed on the stream or stream edge during the surveys were recorded. This included evidence from droppings such as that of black bear or black-tailed deer. Bird and mammal surveys require extended periods at each site to obtain any confidence in results and these could not be obtained in the time available at each stream.

The majority of streams in Gwaii Haanas do not have formal names and for purposes here will be referred to by number or by location.

1994 Stream Survey Methods (from Reimchen *et al* 1994):

Of the eight streams between Cape Freeman in the South and Sunday Inlet in the North (Figwell) which were initially selected for survey in 1994, two were omitted because sea conditions did not allow for safe access to the stream mouths. Two other streams were surveyed instead, one in Pocket Inlet, stream 6, which represented two adjacent streams which joined at the tideline, and an additional stream in Sunday Inlet, Stream 8. Surveys were conducted from July 11 to July 24, 1994.

General survey techniques follow that described for the 1993 season (Reimchen 1994a). Several changes were made in the design of the 1994 surveys. Rather than examining two reaches in each stream, as was done in 1993, more sites per stream were surveyed extending further into the headwaters although this was at the expense of detail on some parameters, such as fish biomass, within each reach. At six of the eight streams, five sites representative of different reaches on the stream were surveyed. At stream 4, only three sites were sampled due to heavy rain on the second day, and at stream 6, only two sites were surveyed due to time constraints.

A torrential rainstorm July 16th/17th, while we were anchored in Gowgaia Bay, resulted in flood conditions (bankful discharge) in the neighbouring streams, which made Surber sampling for invertebrates and electrofishing of the mainstems impossible for the following two days and difficult for the remainder of the trip.

Stream discharge was estimated in the lower mainstem of each stream by selecting a section of stream without side channels and with a reasonably uniform width, depth and substrate. The time (T, seconds) was recorded with a stopwatch, for a partially submerged float to travel over a measured distance (L, meters) between two hand held poles. The average depth (D, meters) was calculated by measuring the depths at ¼, ½, and ¾ of the way across the wet width (W, meters) of the transect, and then dividing the sum of these depths by four. Discharge was calculated as m^3s^{-1}=(LxWxD)/(TxR) where R is a bottom roughness factor, using 0.8 for boulders or coarse gravel and 0.9 for fine gravel.

Stream temperatures were recorded with a hand held thermometer at each sampling site along with the time of day and weather conditions.

For analyses of water chemistry and water colour, two simultaneous water samples were taken at one site in each stream and collected in 10 ml plastic containers, which had been rinsed six times in stream water. These were analyzed for 15 elements (Northern Forestry Centre, Department of Natural Resources Canada, Edmonton, Alberta). Water colour (% transmission at 400nm) was measured on a Digispec spectrophotometer in the laboratory. Conductivity and pH were determined with handheld digital meters on water samples from each stream.

For classification of riparian vegetation, crown closure by overhanging branches was estimated as percent over the streambed. Dominance rank (1-8, with 1 most dominant) was recorded for the nine major tree species. Maximum size (trunk diameter) of each species was classified into one of three groups (<0.3 m, 0.3 -1.0 m, >=1 m). Presence/absence of 13 major species of shrubs, 33 species of herbs and six groups of lichens were recorded at each locality. Percent moss cover was estimated for the canopy and for the forest floor. Plant classification and common names follow Calder and Taylor (1968).

Stream macroinvertebrates were sampled from riffle areas with a Surber sampler prior to any other collecting activity at the site. The Surber sampler (25.4 cm x 25.4 cm), was set on the streambed and the stones within the frame, down to a depth of about 15 cm, were removed and placed in a bucket of water; any animals dislodged in the process drifted down into the cone of the net and were retrieved. The stones were scrubbed, rinsed clean in the bucket of water, and then discarded. Contents of the bucket were then strained through the Surber sampler net (mesh size: 2.5 meshes mm^{-1}) and the sample was preserved in 5% formalin. The samples were later sorted under a dissecting microscope into 6 categories: Diptera, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, and Other.

At each sampling site two measurements of channel width and wetted width were made. If side channels were present, their wet width was included with that of the main flow. Composition of the streambed in the wetted area of the sampling site was estimated to the nearest 5% in the categories: fines (2 mm particle size), small gravel (2-16 mm diameter), large gravel (16-64 mm diameter), larges (>64mm), and bedrock. Compaction of the streambed was subjectively rated as low, moderate, or high by kicking an area of gravel in the substrate. Total cover for fish was estimated as a percentage of the wetted area of the streambed. The composition of the cover was estimated as a percentage in each of five components: cutbank, boulders, large organic debris (LOD), overhanging vegetation (<1m above stream), and instream vegetation.

The lower sampling sites of each stream were electrofished. If no fish were captured or seen at the first site above a high waterfall, electrofishing was not carried out at sites further upstream. Using a Coffelt backpack electroshocker (Model BP-IC), fitted with a 16m lead, approximately 32m length of stream at each site was electrofished in a single upstream direction. Stopnets were not used. The time period in which electrofishing was carried out was recorded. The last two streams (in Sunday Inlet) were electrofished with the back up unit provided by Parks Service; a battery operated backpack electroshocker fitted with a timer which recorded the number of seconds the electrofisher was in use.

The fish caught were anaesthetized, using alkaseltzer tablets, separated by species, and measured individually (fork length). After recovery from the anesthetic, they were released back into the stream.

Each sampling site was photographed in both upstream and downstream direction using an Asahi Pentax camera with a wide angle (35 mm) lens and 400 ASA colour print film. A polarizing lens was used, except when light conditions were marginal. The camera and film were affected by humidity on July 17th which damaged the photographs of Goski stream and Gowgaia Inlet.

Any significant obstructions to the upstream movement of fish, such as, waterfalls, cascades, or log jams were noted and photographed.

Any amphibians, mammals, and birds observed on the stream or stream edge during the surveys were recorded. This included evidence from droppings such as those of black bear or black-tailed deer. Bird and mammal surveys require extended periods at each site to obtain any confidence in results and these could not be obtained in the time available at each stream.

The majority of streams in Gwaii Haanas do not have gazetted names and for purposes here will be referred to by number and by location. All stream mouths, survey sites, major obstructions and tributaries were geo-referenced with a handheld GPS meter (Garmin 45). Plotted GPS coordinates were from 60m to 140 m (average 85m) offset from geographical reference points on TRIM maps.

All data were entered into a geo-referenced database. Data were analyzed with cross-correlation matrices and multiple regression (Statistica™).

Appendix C. Database descriptions for lake and stream surveys data sets available from Parks Canada.

L92ANIML.DBF (LAKE ANIMALS)

Field	Type	Description
Key	Numeric	1:1 link to lakes
COTALE	Logical	Presence/absence of Coast range sculpin
GASCAU	Logical	Presence/absence of Threespine stickleback
LEPARM	Logical	Presence/absence of Pacific sculpin
ONCFRY	Logical	Presence/absence of unidentified salmon fry
ONCKIS	Logical	Presence/absence of Coho salmon
ONCMYK	Logical	Presence/absence of Rainbow trout
ONCSAL	Logical	Presence/absence of unidentified salmonid
PLASTE	Logical	Presence/absence of Starry Ffounder
SALMAL	Logical	Presence/absence of Dolly varden
BEAR	Logical	Presence/absence of Black bears
MART	Logical	Presence/absence of Pine martens
OTTE	Logical	Presence/absence of River otters
RACC	Logical	Presence/absence of Raccoons
WETO	Logical	Presence/absence of Northwestern toads
AMDI	Logical	Presence/absence of American dippers
CAGO	Logical	Presence/absence of Canada geese
COLO	Logical	Presence/absence of Common loons
COME	Logical	Presence/absence of Common mergansers
GBHE	Logical	Presence/absence of Great blue herons
GWGU	Logical	Presence/absence of Glaucous-winged gulls
HADU	Logical	Presence/absence of Harlequin ducks
HOME	Logical	Presence/absence of Hooded mergansers
MADU	Logical	Presence/absence of Mallard ducks
RTLO	Logical	Presence/absence of Red-throated loons

Notes:
1. A "T" indicates that evidence for the species was observed.
2. A blank cell indicates no evidence was observed.
3. Only those animals for which evidence was found are listed.

L92CHEM.DBF, L93CHEM.DBF (LAKE CHEMISTRY)

Field	Type	Description
Key	Numeric	1:1 link to lakes
Stream	Text	Stream Identifier
Watershed	Text	Watershed Identifier
Name	Text	Lake Name
Year	Numeric	Year of data collection
AL	Numeric	Aluminum
AS	Numeric	Arsenic
CA	Numeric	Calcium
CU	Numeric	Copper
FE	Numeric	Iron
K	Numeric	Potassium
MG	Numeric	Magnesium
MN	Numeric	Manganese

NA	Numeric	Sodium
NI	Numeric	Nickel
P	Numeric	Phosphorous
PB	Numeric	Lead
S	Numeric	Sulphur
TI	Numeric	Titanium
ZN	Numeric	Zinc

Notes:
1. All chemistry values are in parts per million.
2. A “-2" indicates that the measurement is below detectable limits.
3. A “-1" indicates that no data is available.
4. The "Year" field is not present in L92CHEM.DBF.

L92PLANT.DBF (LAKE PLANTS)

Field	Type	Description
Key	Numeric	1:1 link to lakes.
Lake_name	Text	Gazetted or Common Lake Name
CALHET	Logical	Presence/absence of Callitriche heterophylla
CARSP	Logical	Presence/absence of Carex sp.
CHARA	Logical	Presence/absence of Chara sp.
ELEACI	Logical	Presence/absence of Eleocharis acicularis
EPIRAM	Logical	Presence/absence of Epihydrus ramosus
FONSP	Logical	Presence/absence of Fontinalis sp.
HIPMON	Logical	Presence/absence of Hippuris montana
ISOECH	Logical	Presence/absence of Isoetes echinospora
JUNSP	Logical	Presence/absence of Juncus sp.
LILOCC	Logical	Presence/absence of Lilaeopsis occidentalis
MENTRI	Logical	Presence/absence of Menyanthes trifoliata
NUPLUT	Logical	Presence/absence of Nuphar luteum
POTSP	Logical	Presence/absence of Potamogetam sp.
RANSP	Logical	Presence/absence of Ranunculus sp.
SCISUB	Logical	Presence/absence of Scirpus subterminalis
SPAHYP	Logical	Presence/absence of Sparganium hyperboreum
UTRINT	Logical	Presence/absence of Utricalaria intermedia
UTRSP	Logical	Presence/absence of Utricalaria sp.
UTRVUL	Logical	Presence/absence of Utricalaria vulgaris

Notes:
1. A “T” indicates that the species was observed.
2. A blank cell indicates that the species was not observed.
3. Only those species observed are listed.

L93ANIML.DBF (LAKE ANIMALS)

Field	Type	Description
Key	Numeric	1:1 link to lakes
BAT	Logical	Presence/absence of Bats
BEAR	Logical	Presence/absence of Black bears
BTDE	Logical	Presence/absence of Sitka black-tailed deer
RACC	Logical	Presence/absence of Raccoons
RESQ	Logical	Presence/absence of Red squirrels
WETO	Logical	Presence/absence of Northwestern toads
AMDI	Logical	Presence/absence of American dippers
AMRO	Logical	Presence/absence of American robins
BAEA	Logical	Presence/absence of Bald Eagles
BAGO	Logical	Presence/absence of Barrow's goldeneyes
BEKI	Logical	Presence/absence of Belted kingfishers
BLGR	Logical	Presence/absence of Blue grouse
CAGO	Logical	Presence/absence of Canada geese
CBCH	Logical	Presence/absence of Chestnut-backed chickadees
COLO	Logical	Presence/absence of Common loons
COME	Logical	Presence/absence of Common mergansers
CORA	Logical	Presence/absence of Common ravens
GWGU	Logical	Presence/absence of Glaucous-winged gulls
HETH	Logical	Presence/absence of Hermit thrushes
MADU	Logical	Presence/absence of Mallard ducks
MAMU	Logical	Presence/absence of Marbled murrelets
RSFL	Logical	Presence/absence of Red-shafted flickers
RTLO	Logical	Presence/absence of Red-throated loons
SACR	Logical	Presence/absence of Sandhill cranes
TOWA	Logical	Presence/absence of Townsend's warblers
TRSW	Logical	Presence/absence of Tree swallows
VATH	Logical	Presence/absence of Varied thrushes
WEFL	Logical	Presence/absence of Western flycatchers
WIWR	Logical	Presence/absence of Winter wrens
WWCR	Logical	Presence/absence of White-winged crossbills

Notes:
1. A “T” indicates that evidence for the species was observed.
2. A blank cell indicates no evidence was observed.
3. Only those animals for which evidence was found are listed

L93FISH.DBF (LAKE FISH)

Field	Type	Description
Key	Numeric	1:1 link to lakes
SALMAL_N	Numeric	Number of Dolly Varden
SALMAL_MD	Numeric	Dolly Varden modal weight, g
SALMAL_LO	Numeric	Dolly Varden low weight, g
SALMAL_HI	Numeric	Dolly Varden high weight, g
ONCMYK_N	Numeric	Number of Rainbow trout
ONCMYK_MD	Numeric	Rainbow trout modal weight, g
ONCMYK_LO	Numeric	Rainbow trout low weight, g
ONCMYK_HI	Numeric	Rainbow trout high weight, g
GASCAU_N	Numeric	Number of Threespine stickleback
GASCAU_MD	Numeric	Stickleback modal weight, g
GASCAU_LO	Numeric	Stickleback mean low weight, g
GASCAU_HI	Numeric	Stickleback high weight, g

Notes: 1. A blank cell indicates that no data is available.

L93OXYG.DBF; L93TEMP.DBF (LAKE OXYGEN, TEMPERATURE PROFILES)

Field	Type	Description
Key	Numeric	1:1 link to lakes
D1	Numeric	1 metre reading
D2	Numeric	2 metre reading
D3	Numeric	3 metre reading
D4	Numeric	4 metre reading
D5	Numeric	5 metre reading
D6	Numeric	6 metre reading
D7	Numeric	7 metre reading
D8	Numeric	8 metre reading
D9	Numeric	9 metre reading
D10	Numeric	10 metre reading
D11	Numeric	11 metre reading
D12	Numeric	12 metre reading
D13	Numeric	13 metre reading
D14	Numeric	14 metre reading

Notes: 1. Oxygen readings are in milligrams per litre.
2. Temperature readings are in degrees Celsius.

L93PHYS.DBF (LAKE PHYSICAL)

Field	Type	Description
Key	Numeric	1:1 link to lakes
Date1	Date	Start date of sample collection
Date2	Date	End date of sample collection
W_Area	Numeric	Watershed area in hectares
Elevation	Numeric	Lake elevation
Volume	Numeric	Lake volume (m3)
Mx Length	Numeric	Maximum length
Mx Width	Numeric	Maximum width
M_Width	Numeric	Mean width
Mx_Depth	Numeric	Maximum Depth
M Depth	Numeric	Mean depth
Rel Depth	Numeric	Relative depth
SD Index	Numeric	Shoreline development index
pH	Numeric	Lake pH
Conductivity	Numeric	Conductivity of water samples
Penetration	Numeric	Light penetration
Spectra	Numeric	% light transmission @ 400 nm

L93PLANT.DBF (LAKE AQUATIC VEGETATION)

Field	Type	Description
Key	Numeric	Provides a 1:1 link to lakes
ALGAE	Logical	Presence/absence of Algae
CALHET	Logical	Presence/absence of Callitriche heterophylla
CARSP	Logical	Presence/absence of Carex species
CHARA	Logical	Presence/absence of Chara species
ELEACI	Logical	Presence/absence of Eleocharis acicularis
ISOECH	Logical	Presence/absence of Isoetes echinospora
JUNORE	Logical	Presence/absence of Juncus oreganus
LILOCC	Logical	Presence/absence of Lilaeopsis occidentalis
LIVERW	Logical	Presence/absence of Liverwort
NUPLUT	Logical	Presence/absence of Nuphar luteum
POTNAT	Logical	Presence/absence of Potamogetam natans
RANFLA	Logical	Presence/absence of Ranunculus flammula
SPAHYP	Logical	Presence/absence of Sparganium hyperboreum
SPONGE	Logical	Presence/absence of Sponge
UTRINT	Logical	Presence/absence of Utricalaria intermedia
ZOOPLA	Numeric	Number of Zooplankton

Notes: 1. A "T" indicates that the species was observed.
2. A blank cell indicates that the species was not observed.
3. Only those species observed are listed.

L93VEG.DBF (LAKE VEGETATION)

Field	Type	Description
Key	Numeric	1:1 link to lakes
ALNCRI	Logical	Presence/absence of Sitka alder
ALNRUB	Logical	Presence/absence of Red alder
CHANOO	Logical	Presence/absence of Yellow cedar
CLAPYR	Logical	Presence/absence of Copperbush
MENTRI	Logical	Presence/absence of Buckbean
OPHLOR	Logical	Presence/absence of Devil's club
PICSIT	Logical	Presence/absence of Sitka spruce
PINCON	Logical	Presence/absence of Lodgepole pine
RIBBRA	Logical	Presence/absence of Stink currants
RUBSPE	Logical	Presence/absence of Salmonberry
SAMRAC	Logical	Presence/absence of Red elderberry
SPHSP	Logical	Presence/absence of Sphagnum bog
TAXBRE	Logical	Presence/absence of Yew
THUPLI	Logical	Presence/absence of Red cedar
TSUHET	Logical	Presence/absence of Western hemlock
TSUMER	Logical	Presence/absence of Mountain hemlock
VACPAR	Logical	Presence/absence of Red huckleberry
VERVIR	Logical	Presence/absence of Indian hellebore

Notes: 1. Dominance is ranked from 1 - 8, where 1 is most dominant
2. Sizes represent trunk diameter and are code using:
a: <0.3m
b: 0.3 - 1m
c: >1m
3. A"0" value indicates the species was not observed.
4. A blank cell indicates that no data is available.

S92DATA.DBF (191 MOE STREAM SURVEYS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams
Name	Text	Gazetted stream name
Streamcode	Numeric	MOE stream code
Watershed	Numeric	MOE watershed code
Width	Numeric	Stream width
Slope	Numeric	Stream Slope
ONCGOR	Logical	Presence/absence of Pink salmon
ONCKIS	Logical	Presence/absence of Coho salmon
ONCMYK	Logical	Presence/absence of Rainbow trout
ONCNER	Logical	Presence/absence of Sockeye salmon
SALMAL	Logical	Presence/absence of Dolly Varden
Other	Logical	Presence/absence of other fish
UNID	Logical	Presence/absence of unidentified fish
Source	Text	Source of information

Notes: 1. A "-1" indicates that the fish is present (all fish fields).
2. A blank cell indicates that no data is available.
3. In the Source field, 3 identifies DFO, 4 identifies MOE.

S94ANIML.DBF (STREAM ANIMALS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams
BEAR	Logical	Presence/absence of Black bear
BTDE	Logical	Presence/absence of Sitka black-tailed deer
DUSH	Logical	Presence/absence of Dusky shrew
OTTE	Logical	Presence/absence of River otter
RACC	Logical	Presence/absence of Raccoon
RESQ	Logical	Presence/absence of Red squirrel
WETO	Logical	Presence/absence of northwestern toad

Notes: 1. A "T" indicates that evidence for the species was observed.
2. A blank cell indicates no evidence was observed.

S94BIRD.DBF (STREAM BIRDS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
AMDI	Logical	Presence/absence of American dippers
BAEA	Logical	Presence/absence of Bald eagles
BEKI	Logical	Presence/absence of Belted Kgingfishers
CAGO	Logical	Presence/absence of Canada geese
CBCH	Logical	Presence/absence of Chestnut-backed chickadees
CORA	Logical	Presence/absence of Common ravens
GCKI	Logical	Presence/absence of Golden-crowned kinglets
HETH	Logical	Presence/absence of Hermit thrushes
MAMU	Logical	Presence/absence of Marbled murrelets
RBSA	Logical	Presence/absence of Red-breasted sapsuckers
RUHU	Logical	Presence/absence of Ruffous hummingbirds
SACR	Logical	Presence/absence of Sandhill cranes
TOWA	Logical	Presence/absence of Townsend's warblers
TRSU	Logical	Presence/absence of Tree suckers?
TRSW	Logical	Presence/absence of Tree swallows
WEFL	Logical	Presence/absence of Western flycatchers
WIWR	Logical	Presence/absence of Winter wrens

Notes: 1. A "T" indicates that evidence for the bird was observed.
2. A blank cell indicates that no evidence was observed.

S94CHEM.DBF (STREAM CHEMISTRY)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
Al	Numeric	Aluminum
As	Numeric	Arsenic
Ca	Numeric	Calcium
Cu	Numeric	Copper
Fe	Numeric	Iron
K	Numeric	Potassium
Mg	Numeric	Magnesium
Mn	Numeric	Manganese
Na	Numeric	Sodium
Ni	Numeric	Nickel
P	Numeric	Phosphorous
Pb	Numeric	Lead
S	Numeric	Sulphur
Ti	Numeric	Titanium
Zn	Numeric	Zinc
Total	Numeric	Total concentration for all elements combined

Notes:
1. All chemistry values are in parts per million.
2. A “-2" indicates that the measurement is below detectable limits.
3. A “-1" indicates that no data is available.

S94COVER.DBF (STREAM COVER)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
Crown	Numeric	% crown closure
Cover%	Numeric	% streambed cover
Cover C	Numeric	% cutbank
Cover B	Numeric	% boulder
Cover LD	Numeric	% large organic debris
Cover OV	Numeric	% overstream vegetation
FC	Text	Bryophyte cover in the forest canopy
FF	Text	Bryophyte cover on the forest floor

Notes:
1. Bryophyte cover (fields FF and FC) is coded using the following interval designations:
   - A: 0-20%
   - B: 21-50%
   - C: 51-80%
   - D: >81%
2. A “-1" indicates that no data is available.

S94FISH.DBF (STREAM FISH)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
SALMAL_N	Numeric	Number of Dolly Varden
SALMAL_W	Numeric	Dolly Varden weight, g
SALMAL_ML	Numeric	Dolly Varden Mean Length, mm
SALMAL_SN	Numeric	Number of Dolly Varden (sea run)
SALMAL_SW	Numeric	Dolly Varden (sea run) weight, g
SALMAL_SML	Numeric	Dolly Varden (sea run) mean length, mm
ONKMYK_N	Numeric	Number of Rainbow trout
ONKMYK_W	Numeric	Rainbow trout weight, g
ONKMYK_ML	Numeric	Rainbow trout mean length, mm
ONCKIS_N	Numeric	Number of Coho
ONCKIS_W	Numeric	Coho weight, g
ONCKIS_ML	Numeric	Coho mean length, mm
ONCNER_N	Numeric	Number of Sockeye
ONCNER_W	Numeric	Sockeye weight, g
ONCNER_ML	Numeric	Sockeye mean length, mm
COTALE_N	Numeric	Number of coast range sculpin
COALE_W	Numeric	Coast range sculpin weight, g
COTALE_ML	Numeric	Coast range sculpin mean length, mm
GASCAU_N	Numeric	Number of stickleback
GASCAU_W	Numeric	Threespine stickleback weight, g
GASCAU_ML	Numeric	Stickleback mean length, mm
COTASP_N	Numeric	Number of prickly sculpin
COTASP_W	Numeric	Prickly sculpin weight, g
COTASP_ML	Numeric	Prickly sculpin mean length, mm
ONCKET	Numeric	Presence/absence of chum salmon
ONCGOR	Numeric	Presence/absence of pink salmon

Notes: 1. “-1” indicates that no data is available.
2. “-3" indicates that the fish is known to be present from other sources of information (DFO or MOE).
3. A 4 in any of the “weight” fields indicates that the total weight is less than 5.

S94HERB (STREAM HERBS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams
ACHMIL	Logical	Presence/absence of Achillea millefolium
AMEALN	Logical	Presence/absence of Amelanchier alnifolia
ANAMAR	Logical	Presence/absence of Anaphalis margaritacea
AQUFOR	Logical	Presence/absence of Aquilegia formosa
ARUDIO	Logical	Presence/absence of Aruncus dioicus
ASTFOL	Logical	Presence/absence of Aster foliaceus
BLESPI	Logical	Presence/absence of Blechnum spicant
BOTMUL	Logical	Presence/absence of Botrychium multifidum
CAMALA	Logical	Presence/absence of Campanula alaskana
CAMROT	Logical	Presence/absence of Campanula rotundiflora
CIRSP	Logical	Presence/absence of Cirsium sp.
CLAPYR	Logical	Presence/absence of Cladothamnus pyroliflorus
CLASIB	Logical	Presence/absence of Claytonia sibirica
CONPAC	Logical	Presence/absence of Conioselinum pacificum
COPASP	Logical	Presence/absence of Coptis asplenifolia
CORUNA	Logical	Presence/absence of Cornus unalaskensis
DODJEF	Logical	Presence/absence of Dodecatheon jeffreyi
DROROT	Logical	Presence/absence of Drosera rotundifolia
GALTRI	Logical	Presence/absence of Galium triflorum
GENDOU	Logical	Presence/absence of Gentiana douglasiana
HERLAN	Logical	Presence/absence of Heracleum lanatum
LINBOR	Logical	Presence/absence of Linnea borealis
LISCAU	Logical	Presence/absence of Listera caurina
LISCOR	Logical	Presence/absence of Listera cordata
LIVERW	Logical	Presence/absence of Liverwort
LYCSP	Logical	Presence/absence of Lycopodium sp.
LYSAME	Logical	Presence/absence of Lysichiton americanum
MAIDIL	Logical	Presence/absence of Maianthemum dilatatum
MENTRI	Logical	Presence/absence of Menyanthes trifoliata
MICBOR	Logical	Presence/absence of Microseris borealis
MIMGUT	Logical	Presence/absence of Mimulus guttatus
MONUNI	Logical	Presence/absence of Moneses uniflora
NUPLUT	Logical	Presence/absence of Nuphar luteum
OPLHOR	Logical	Presence/absence of Oplopanax horridus
PEDORN	Logical	Presence/absence of Pedicularis ornithorhyncha
PETSAG	Logical	Presence/absence of Petasites sagittatus
PINVUL	Logical	Presence/absence of Pinguicula vulgaris
PLECON	Logical	Presence/absence of Plectritus congesta
RANFLA	Logical	Presence/absence of Ranunculus flammula
RANOCC	Logical	Presence/absence of Ranunculus occidentalis
SENTRI	Logical	Presence/absence of Senecio triangularis
SISLIT	Logical	Presence/absence of Sisyrinchium littorale
SORSIT	Logical	Presence/absence of Sorbus sitchensis
STRAMP	Logical	Presence/absence of Streptopus amplexifolius
TIATRI	Logical	Presence/absence of Tiarella trifoliata
VERVIR	Logical	Presence/absence of Veratrum viride
VIOSP	Logical	Presence/absence of Viola sp.

Notes: 1. A “T” indicates that the species is present.
2. A blank cell indicates that the species was not observed.
3. A”-1" indicates that data is not available.

S94INVERT.DBF (STREAM INVERTEBRATES)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
Coleoptera	Numeric	Number of Coleoptera
Diptera	Numeric	Number of Diptera
Ephemeroptera	Numeric	Number of Ephemeroptera
Plecoptera	Numeric	Number of Plecoptera
Trichoptera	Numeric	Number of Trichoptera
Other	Numeric	Number of other invertebrates

Notes: 1. A "0" values indicate that none were observed.
2. A "-1" indicates no data is available.

S94LICHEN.DBF (STREAM LICHENS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams
CL	Numeric	Club lichens
CR	Numeric	Crusty lichens
HA	Numeric	Hairy lichens
LE	Numeric	Leafy lichens
SC	Numeric	Scaly lichens
SH	Numeric	Shrub lichens

Notes: 1. A "-1" indicates that no data is available.
2. Field values indicate the following ranks:
1: abundant
2: common
3: sparse
4: absent

S94PHYS.DBF (STREAM PHYSICAL)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
Date	Date	Date of sample collection
Time	Time	Time of sample collection
Area	Numeric	Watershed area in hectares
Flow	Numeric	Stream discharge (m3/s)
Spectra	Numeric	% light transmission @ 400 ns
Temp	Numeric	Stream temperature (C)
Length	Numeric	Length of reach
Depth	Numeric	Stream depth
Conductivity	Numeric	Conductivity of water samples
Geology	Text	Stream geology
pH	Numeric	Stream pH
Confinement	Text	Stream confinement between valley walls or terraces
SubstrF	Numeric	% streambed fines (<2mm particles)
SubstrSG	Numeric	% streambed small gravel (2 - 16mm)
SubstrLG	Numeric	%streambed large gravel (16 - 64mm)
SubstrL	Numeric	% streambed larges (>64mm)
SubstrR	Numeric	% streambed bedrock
Compaction	Text	Stream compaction
Gradient	Numeric	Stream gradient
Width1	Numeric	First width measurement
Width2	Numeric	Second width measurement
Width3	Numeric	Third width measurement
MeanW	Numeric	Mean width
WetW1	Numeric	First wet width
WetW2	Numeric	Second wet width
WetW3	Numeric	Third wet width
MeanWW	Numeric	Mean wet width
W/WW	Numeric	Mean width to mean wet width ratio
Lakes	Numeric	Number of upstream lakes
Obstructions	Logical	Presence/absence of obstructions to upstream movement of fish

Notes: 1. A blank cell indicates that no data is available.

S94SITE.DBF (STREAM SITES)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
Name	Text	Gazetted stream name
Inlet	Text	Gazetted inlet name
Streamcode	Text	MOE stream code
Watershed	Text	MOE watershed code
Date	Date	Date of sample collection
Time	Time	Time of sample collection

S94SHRUB.DBF (STREAM SHRUBS)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
EMPNIG	Logical	Presence/absence of Empetrum nigrum
GAUSHA	Logical	Presence/absence of Gaultheria triflorum
KALMIC	Logical	Presence/absence of kalmia microphylla ssp. occidentalis
LEDGRO	Logical	Presence/absence of Ledum groenlandicum
LUPNOO	Logical	Presence/absence of Lupinus nootkatensis
MALFUS	Logical	Presence/absence of Malus fusca
MENFER	Logical	Presence/absence of Menziesia ferruginea
MIMGUT	Logical	Presence/absence of Mimulus guttatus ssp guttatus
OPLHOR	Logical	Presence/absence of Oplopanax horridus
RUBPAR	Logical	Presence/absence of Rubus parviflorus
RUBSPE	Logical	Presence/absence of Rubus spectablis
SAMRAC	Logical	Presence/absence of Sambucus racemosa ssp. Pubens var. arborescens
VACALA	Logical	Presence/absence of Vaccinium alaskenses
VACOVA	Logical	Presence/absence of Vaccinium ovalifolium
VACPAR	Logical	Presence/absence of Vaccinium parvifolium
VACULI	Logical	Presence/absence of Vaccinium uliginosum

Notes: 1. A “T” indicates that the species is present.
2. A blank cell indicates that the species was not observed.
3 A “-1" indicates that no data is available.

S94TREE.DBF (STREAM TREES)

Field	Type	Description
Key	Numeric	1:1 link to sample sites and to streams.
ALNCRI1	Numeric	Sitka alder dominance
ALNCRI2	Text	Sitka alder size
ALNRUB1	Numeric	red alder dominance
ALNRUB2	Text	Red alder size
CHANOO1	Numeric	Yellow cedar dominance
CHANOO2	Text	Yellow cedar size
PICSIT1	Numeric	Sitka spruce dominance
PICSIT2	Text	Sitka spruce size
PINCON1	Numeric	Lodgepole pine dominance
PINCON2	Text	Lodgepole pine size
TAXBRE1	Numeric	Yew dominance
TAXBRE2	Text	Yew size
THUPLI1	Numeric	Red cedar dominance
THUPLI2	Text	Red cedar size
TSUHET1	Numeric	Western hemlock dominance
TSUHET2	Text	Western hemlock size
TSUMER1	Numeric	Mountain hemlock dominance
TSUMER2	Text	Mountain hemlock size

Notes: 1. Dominance is ranked from 1 - 8, where 1 is most dominant
2. Sizes represent trunk diameter and are code using:
a: <0.3m
b: 0.3 - 1m
c: >1m
3. A”0" value indicates the species was not observed.
4. A blank cell indicates that no data is available.

Appendix D. Indices of mammal and bird activity on streams during salmon migration (from Reimchen 1992a). See Figure 19 in main document for localities.

Creek	Sea Lion	Pacific Harbour Seal	Black Bear	River Otter	Marten	Bald Eagle	Gull	Duck	Total	Years
Alder Island	0	0	.59	.06	0	0	0	0	.65	17
Anna Inlet	0	.06	.19	.06	.06	.06	.06	0	.49	16
Arrow	0	0	.31	.08	.04	.04	.04	.04	.55	26
Bag Harbour	.11	.11	.82	.08	0	.37	.29	.26	2.04	38
Balcolm Inlet	.30	.30	.30	0	0	.20	0	0	1.10	10
Beljay Bay	0	0	.03	0	0	.19	.08	.08	.38	36
Beresford Bay	0	0	0	.17	0	0	0	0	.17	6
Burnaby Straits	0	0	.44	0	0	.11	.22	0	.77	9
Carpenter Bay	.16	.20	.28	.08	0	.04	0	0	.76	25
Collison Bay	.03	.03	.29	.03	0	.06	.06	0	.50	31
De La Beche Inlet	0	0	0	0	0	0	0	0	0	5
Echo Harbour	0	.11	.46	0	0	.05	.05	0	.67	37
Flamingo Inlet	.05	.11	.47	.05	0	.24	.08	.05	1.05	38
Forgotten	0	0	.17	0	0	0	0	0	.17	24
Goski Bay	0	0	.23	0	0	.05	0	0	.28	22
Harriet	.14	.16	.46	.03	0	.11	0	.03	.93	37
Heater	.11	.11	.26	.33	0	.15	.11	.04	1.11	27
Huston Inlet	.03	.11	.16	0	0	.08	.08	.05	.51	37
Ikeda	.03	.08	.16	0	0	.05	.03	0	.35	37
Island Bay	0	.03	.03	0	0	0	0	0	.06	38
Jedway	.05	.08	.08	0	0	.05	.03	.03	.32	38
Kendrick Point	.20	.40	.40	0	0	.40	0	0	1.40	5
Kostan Inlet	0	0	.08	0	0	0	0	0	.08	24
Koya Bay	.04	.04	.25	.13	0	.04	.13	.04	.67	24
Louscoone Inlet	.13	.16	.58	0	0	.29	.11	.05	1.32	38
Luxana Bay	0	0	.05	0	0	.05	0	0	.10	19
Marko	0	0	.16	0	0	.05	0	0	.21	19
Marshall Inlet HD	0	.06	.61	0	0	.22	.03	0	.92	36
Matheson LH	0	0	.34	.05	.03	.08	.16	.11	.77	38
Matheson RH	0	.03	.51	.03	.03	.27	.14	.22	1.23	37
Moody	0	0	.09	.09	0	.09	0	0	.27	11
Moore	0	.11	0	.13	0	.05	.08	.05	.42	38
Oxalis	.21	.11	.66	.05	0	.26	.18	.34	1.81	38
Oyster Cove	.11	.14	.54	.03	.03	.43	.32	.38	1.98	37
Poole Inlet	0	.17	.75	.42	0	0	0	0	1.34	12
Powrivco Bay	0	.11	.21	.05	.03	.16	.13	.13	.82	38
Raspberry Cove	0	0	.29	0	0	.04	0	0	.33	24
Richardson	0	.03	.05	0	.03	.18	.13	.16	.58	38
Salmon River	0	.05	.68	.08	0	.32	.11	.21	1.45	38
Sandy Point	0	0	.16	.04	0	0	0	0	2..00	25
Scudder Point	0	.20	.60	.20	0	.33	.20	0	1.53	15
Section Cove	0	0	.33	.27	0	0	0	0	.60	15
Sedgwick Bay	0	.08	.03	.08	.03	.29	.18	.29	.98	38
Sedmond	.11	.16	.87	.08	0	.32	.18	.24	1.96	38
Skaat Harbour HD	0	0	.42	0	0	.21	.13	.16	.92	38
Skaat Harbour LH	0	0	.47	0	0	.10	.07	.07	.71	30
Skaat Harbour RH	0	0	.17	0	0	0	.10	0	.27	29
Yakulanas	0	0	.09	.09	0	0	0	0	.18	22

Appendix E. Percent contribution of food items to the diets of five fish species. Data originate from Figure 2.6 in Reimchen (1994).

Taxon	Dolly Varden	Rainbow Trout	Coho Salmon	Threespine Stickleback	Prickly Sculpin
Cladocera	2.1	0.0	1.1	4.1	0.0
Copepoda	0.0	0.0	0.0	1.6	0.0
Ostracoda	1.4	0.0	1.1	6.6	0.0
Isopoda	1.4	0.0	0.0	1.6	0.0
Amphipoda	12.1	6.6	5.6	17.2	27.0
Collembola	0.0	0.0	3.4	1.6	0.0
Ephemeroptera	0.0	0.0	4.5	2.5	0.0
Odonata	12.1	14.2	3.4	3.3	0.0
Plecoptera	5.7	0.0	2.2	0.0	0.0
Heteroptera	1.4	0.0	2.2	0.0	0.0
Trichoptera	15.0	20.8	7.9	17.2	36.5
Coleoptera	12.1	10.4	11.2	3.3	0.0
Diptera	18.6	17.0	29.2	20.5	0.0
Hymenoptera	4.3	10.4	10.1	0.0	0.0
Arachnida	0.0	0.0	2.2	1.6	0.0
Gastropoda	2.1	0.0	0.0	0.0	0.0
Pelecypoda	3.6	6.6	0.0	6.6	12.7
Stickleback eggs	0.0	0.0	4.5	12.3	0.0
Sticklebacks	7.9	14.2	11.2	0.0	23.8
Total %	100.0	100.0	100.0	100.0	100.0

Appendix F. Daily stream temperature recordings within hourly time intervals for those streams surveyed during July 8-22, 1993 (Reimchen *et al* 1994), and July 13-24, 1994 (Reimchen 1994a). Values with an asterix were taken above the lake. Streams were identified as having lakes absent (A) or present (P).

Coast	Stream (site#)	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	Date	Lake(s)
East	Arrow		12.8							14.5			17/93	A
	Arrow		16.7							20.2			17/93	P
	Bag Harbour			10.8				11.2					14/93	A
	Bag Harbour			17.1					16.9	16.8			13/14/93	P
	De la Beche Inlet			17.5						22.4			19/93	P
	De la Beche Inlet*				11.9								19/93	A
	Echo Harbour		10.6				11.2						21/93	P
	Etches		10.9				12.8			15.1			9/93	A
	Haswell				18.9					19.5			18/93	P
	Huston Inlet			11.3					13.8				12/93	A
	Kendrick Point		11.7					11.3					10/93	A
	Koya Bay			10.5						12.5			11/93	A
	Louscoone Inlet		11.0								11.2		8/93	A
	Matheson				12.8					14.4			16/93	P
	Salmon River			12.2					11.8				22/93	P
West	Figwell			13.6	13.0						14.8	14.6	21/94	P
	Figwell					11.9*		11.9*					22/94	P
	Flamingo Inlet		11.2		12.6			14.1		14.8			13/94	A
	Flamingo Inlet		12.3		12.9								14/94	A
	Cape Freeman		12.5			16.8			17.2				11/94	P
	Cape Freeman					16.6	16.9						12/94	P
	Goski Bay						14.0		14.2				16/94	P
	Goski Bay					12.5*							17/94	P
	Gowgaia							13.2			12.1	11.2	15/94	A
	Gowgaia		11.0	11.2		11.5							16/94	A
	Mike Inlet		11.5		11.4		11.9	12.1		12.0			19/94	P
	Pocket Inlet A			11.3									20/94	A
	Pocket Inlet B					12.6							20/94	P
	Skaat Harbour			12.5			13.1						15/93	A
	Skittagetan		17.5				21.9		19.7				20/93	P
	Sunday Inlet	9.1		10.1		7.8			8.9	9.6	10.1		24/94	A

Appendix G. Stream discharge and catchment area estimates for those streams surveyed in 1993 and 1994. The presence (P) or absence (A) of lakes within the watershed is indicated.

Stream	Date	Discharge ($m^3\ s^{-1}$)	Catchment Area (km^{-2})	Lake
Arrow	17/7/93	0.03	5.0	P
Bag Harbour	13/7/93	0.05	5.1	P
Cape Freeman	11/7/94	0.18	9.5	P
De la Beche Inlet	19/7/93	0.19	9.7	P
Echo Harbour	21/7/93	0.13	10.6	P
Etches	9/7/93	0.13	9.1	A
Figwell	21/7/94	1.56	16.8	P
Figwell	23/7/94	0.72	16.8	P
Flamingo Inlet	13/7/94	0.14	4.6	A
Goski Bay	16/7/94	0.09	10.5	P
Gowgaia	15/7/94	0.03	2.3	A
Haswell	18/7/93	0.08	10.3	P
Huston Inlet	12/7/93	0.06	4.3	A
Kendrick Point	10/7/93	0.01	2.8	A
Koya Bay	11/7/93	0.05	6.5	A
Louscoone Inlet	8/7/93	0.14	9.9	A
Matheson	16/7/93	0.04	10.2	P
Mike Inlet	19/7/94	0.60	4.3	P
Pocket Inlet	20/7/94	0.11	1.2	P
Salmon River	22/7/93	2.67	14.5	P
Skaat Harbour	15/7/93	0.05	5.2	A
Skittagetan	20/7/93	0.01	2.6	P
Sunday Inlet	24/7/94	0.08	3.1	A

Appendix H. Summary table of standard length (mm) statistics for fish species from 22 streams, collected by electrofishing.

Species	Local Stream Name	Mean Length (mm)	Sample Size	Standard Deviation	Variance
Dolly Varden	Arrow	68.9	9	36.72	1348.61
	Bag Harbour	77.0	40	39.02	1522.82
	De la Beche Inlet	94.5	40	31.48	990.77
	Echo Harbour	133.5	10	55.18	3044.72
	Etches	60.7	36	27.05	731.65
	Flamingo Inlet	82.5	2	60.10	3612.50
	Goski Bay	62.5	2	3.54	12.50
	Gowgaia	66.8	22	26.75	715.58
	Haswell	175.0	1	0.00	0.00
	Huston Inlet	76.0	5	18.51	342.50
	Kendrick Point	55.4	37	28.07	788.03
	Koya Bay	57.5	10	22.64	512.50
	Matheson	210.0	1	0.00	0.00
	Salmon R.	133.8	4	62.10	3856.25
	Skaat Harbour	77.2	20	66.40	4409.14
	Skittagetan	50.0	1	0.00	0.00
	Sunday Inlet	111.7	18	78.67	6188.24
Rainbow trout	Arrow	62.5	20	36.04	1298.68
	Bag Harbour	68.1	21	21.59	466.19
	Cape Freeman	54.4	43	32.72	1070.49
	De la Beche Inlet	118.5	10	8.18	66.94
	Echo Harbour	115.4	14	19.26	371.02
	Figwell	98.8	4	42.70	1822.92
	Flamingo Inlet	91.8	11	56.54	3196.36
	Goski Bay	48.1	26	28.50	812.15
	Haswell	140.0	1	0.00	0.00
	Huston Inlet	43.9	27	30.58	935.26
	Koya Bay	40.5	87	27.70	767.46
	Matheson	39.7	36	18.36	337.06
	Salmon R.	61.0	5	42.78	1830.00
	Skaat Harbour	105.0	1	0.00	0.00
Coho salmon	Arrow	47.4	71	6.34	40.14
	Bag Harbour	47.9	199	7.87	61.91
	Cape Freeman	68.0	3	4.58	21.00
	De la Beche Inlet	58.8	21	12.61	158.96
	Echo Harbour	68.4	31	6.51	42.38
	Flamingo Inlet	58.6	18	9.18	84.25
	Goski Bay	56.2	18	7.11	50.50
	Gowgaia	67.1	20	8.16	66.56
	Huston Inlet	60.9	22	7.67	58.75
	Kendrick Point	63.7	15	9.99	99.81
	Koya Bay	49.0	80	6.19	38.30
	Louscoone Inlet	55.2	25	6.13	37.58
	Matheson	47.0	49	5.84	34.15
	Salmon R.	58.3	3	11.85	140.33
	Skaat Harbour	47.8	46	6.98	48.67
	Sunday Inlet	62.0	28	8.95	80.04

Appendix H. (continued)

Species	Creek	Mean Length (mm)	Sample Size	Standard Deviation	Variance
Threespine stickleback	Arrow	52.5	2	0.71	0.50
	Bag Harbour	50.5	59	4.24	18.01
	De la Beche Inlet	34.5	58	12.15	147.69
Coastrange sculpin	Arrow	75.7	26	17.96	322.46
	Bag Harbour	62.9	87	16.70	278.95
	Cape Freeman	72.9	15	11.75	138.07
	Echo Harbour	93.2	18	15.57	242.42
	Figwell	53.8	16	7.47	55.80
	Flamingo Inlet	70.8	37	18.91	357.47
	Goski Bay	54.6	66	12.80	163.85
	Gowgaia	78.0	3	15.72	247.00
	Haswell	77.7	23	15.07	227.02
	Huston Inlet	55.8	101	9.45	89.27
	Kendrick Point	78.7	3	4.16	17.33
	Koya Bay	57.9	113	17.79	316.32
	Louscoone Inlet	50.2	216	8.51	72.48
	Matheson	53.9	139	14.66	215.01
	Salmon R.	62.1	124	17.10	292.58
	Skaat Harbour	88.6	19	11.02	121.36
	Skittagetan	58.0	13	13.71	188.00
	Sunday Inlet	54.4	48	11.59	134.28

Appendix I. Species listing for all vertebrates and flora identified during lake and stream surveys. Invertebrate species are listed within the main document.

Birds

Code	Genus	Species	Common Name
AMDI	*Cinclus*	*Mexicanus*	American Dipper
AMRO	*Turdus*	*Migratorius*	American Robin
BAEA	*Haliaectus*	*Leucocephalus*	Bald Eagle
BAGO	*Bucephala*	*islandica*	Barrow's Goldeneye
BEKI	*Ceryle*	*alcyon*	Belted Kingfisher
BLGR	*Dendragapus*	*obscurus*	Blue Grouse
CAGO	*Branta*	*Canadensis*	Canada Goose
CBCH	*Parus*	*rufescens*	Chestnut-Backed Chickadee
COLO	*Gavia*	*immer*	Common Loon
COME	*Mergus*	*Merganser*	Common Merganser
CORA	*Corvus*	*corax*	Common Raven
GBHE	*Ardea*	*herodias*	Great Blue Heron
GCKI	*Regulus*	*satrapa*	Golden-Crowned Kinglet
GWGU	*Larus*	*Glaucescens*	Glaucous-Winged Gull
HADU	*Histrionicus*	*histrionicus*	Harlequin Duck
HETH	*Catharus*	*guttatus*	Hermit Thrush
HOME	*Lophodytes*	*cucullatus*	Hooded Merganser
MADU	*Anas*	*platyrhynchos*	Mallard Duck
MAMU	*Brachyramphus*	*marmoratus*	Marbled Murrelet
NOFL	*Colaptes*	*auratus*	Northern Flicker
RBSA	*Sphyrapicus*	*ruber*	Red-Breasted Sapsucker
RTLO	*Gavia*	*stellata*	Red-Throated Loon
RUHU	*Selasphorus*	*rufus*	Rufous Hummingbird
SACR	*Grus*	*Canadensis*	Sandhill Crane
TOWA	*Dendroica*	*townsendi*	Townsends's Warbler
TRSW	*Tachycineta*	*bicolor*	Tree Swallow
VATH	*Ixoreus*	*naevius*	Varied Thrush
WEFL	*Empidonax*	*difficilis*	Western Flycatcher
WIWR	*Troglodytes*	*Troglodytes*	Winter Wren
WWCR	*Loxia*	*leucoptera*	White-Winged Crossbill

Fish

Code	Genus	Species	Common Name
COTALE	*Cottus*	*aleuticus*	Coastrange Sculpin
COTASP	*Cottus*	*asper*	Prickly Sculpin
GASCAU	*Gasterosteus*	*aculeatus*	Threespine Stickleback
LEPARM	*Leptocottus*	*Armatus ssp armatus*	Pacific Staghorn Sculpin
ONCCLA	*Oncorhynchus*	*Clarki ssp clarki*	Cutthroat Trout
ONCMYK	*Oncorhynchus*	*Mykiss*	Rainbow/Steelhead Trout
ONCGOR	*Oncorhynchus*	*Gorbuscha*	Pink Salmon
ONCKET	*Oncorhynchus*	*Keta*	Chum Salmon
ONCKIS	*Oncorhynchus*	*Kisutch*	Coho Salmon
ONCNER	*Oncorhynchus*	*Nerka*	Sockeye Salmon
ONCTSH	*Oncorhynchus*	*Tshawytscha*	Chinook Salmon
PLASTE	*Platichthys*	*Stellatus ssp stellatus*	Starry Flounder
SALMAL	*Salvelinus*	*malma*	Dolly Varden

Mammals and Amphibians

Code	Genus	Species	Common Name
BEAR	Ursus	americanus	Black Bear
BTDE	Odocoileus	hemionus	Black-tailed Deer
ERMI	Mustela	erminea	Ermine
BAT	Myotis		Bats
RACC	Procyon	lotor	Raccoon
RESQ	Tamiasciurus	hudsonicus	Red Squirrel
OTTE	Lontra	canadensis	River Otter
MART	Martes	americana	Marten
PATR	Hyla	regilla	Pacific Treefrog
WETO	Bufo	boreas	Western Toad

Plants

Code	Genus	Species	Subspecies	Variety	Common Name
ACHMIL	Achillea	millefolium			Yarrow
ALNRUB	Alnus	rubra			Red Alder
AMEALN	Amelanchier	alnifolia			Saskatoon
ANAMAR	Anaphalis	margaritacea			Pearly Everlasting
AQUFOR	Aquilegia	formosa			Red Columbine
ARUDIO	Aruncus	dioicus			Goat'sbeard
ASTFOL	Aster	foliaceus			Leafy Aster
BLESPI	Blechnum	spicant			Deer Fern
BOTMUL	Botrychium	multifidum			Leathery Grape-Fern
CALHET	Callitriche	heterophylla			Diverse-Leaved Water-Starwort
CALSP	Calliergon	sp.			
CAMALA	Campanula	alaskana			Alaskan Harebell
CAMROT	Campanula	rotundifolia			Common Harebell
CARSP	Carex	sp.			Sedge
CHANOO	Chamaecyparis	nootkatensis			Yellow-Cedar
CIRSP	Cirsium	sp.			Thistle
CLAPYR	Cladothamnus	pyroliflorus			Copperbush
CLASIB	Claytonia	sibirica			Siberian Miner's-Lettuce
CONPAC	Conioselinum	pacificum			Pacific Hemlock Parsley
COPASP	Coptis	aspleniifolia			Fern-Leaved Goldthread
CORUNA	Cornus	unalaschkensis			Cordilleran Bunchberry
DODJEF	Dodecatheon	jeffreyi			Jeffrey's Shootingstar
DROROT	Drosera	rotundifolia			Round-Leaved Sundew
ELEACI	Eleocharis	acicularis			Needle Spike-Rush
EMPNIG	Empetrum	nigrum		nigrum	Crowberry
EPIRAM	Epihydrus	ramosus			
FONSP	Fontinalis	sp.			Common Water Moss
GALTRI	Galium	triflorum			Sweet-Scented Bedstraw
GAUSHA	Gaultheria	shallon			Salal
GENDOU	Gentiana	douglasiana			Swamp Gentian
HEPGEN	Gen.				Liverwort
HERLAN	Heracleum	lanatum			Cow-Parsnip
HIPMON	Hippuris	montana			Mountain Mare's-Tail
ISOECH	Isoetes	echinospora			Bristle-Like Quillwort
JUNORE	Juncus	oreganus			Spreading Rush
JUNSP	Juncus	sp.			Rush
KALMIC	Kalmia	microphylla	occidentalis		Bog-Laurel
LEDGRO	Ledum	groenlandicum			Labrador Tea
LILOCC	Lilaeopsis	occidentalis			Western Lilaeopsis

Plants

Code	Genus	Species	Subspecies	Variety	Common Name
LINBOR	Linnea	borealis			Twinflower
LISCAU	Listera	caurina			Northwestern Twayblade
LISCOR	Listera	cordata			Heart-Leaved Twayblade
LUPNOO	Lupinus	nootkatensis			Nootka Lupine
LYCSP	Lycopodium	sp.			
LYSAME	Lysichiton	americanum			Skunk Cabbage
MAIDIL	Maianthemum	dilatatum			False Lily-of-the-Valley
MALFUS	Malus	fusca			Pacific Crab Apple
MENFER	Menziesia	ferruginea			False Azalea
MENTRI	Menyanthes	trifoliata			Buckbean
MICBOR	Microseris	borealis			Apargidium
MIMGUT	Mimulus	guttatus	guttatus		Yellow Monkey-Flower
MONUNI	Moneses	uniflora			Single Delight
NUPLUT	Nuphar	luteum	polysepala		Yellow Waterlily
OPLHOR	Oplopanax	horridus			Devil's-Club
PEDORN	Pedicularis	ornithorhyncha			Bird's-Beak Lousewort
PETSAG	Petasites	sagittatus			
PICSIT	Picea	sitchensis			Sitka Spruce
PINCON	Pinus	contorta		latifolia	Lodgepole Pine
PINVUL	Pinguicula	vulgaris	Macrocera		Butterwort
PLECON	Plectritis	congesta			Sea Blush
POTNAT	Potamogeton	natans			Floating-leaved pondweed
POTSP	Potamogeton	sp.			Pondweed
RANFLA	Ranunculus	flammula			Lesser Spearwort
RANOCC	Ranunculus	occidentalis			Western Buttercup
RANSP	Ranunculus	sp.			Buttercup
RIBBRA	Ribes	bracteosum			Stink Currant
RUBPAR	Rubus	parviflorus			Thimbleberry
RUBSPE	Rubus	spectabilis			Salmonberry
SAMRAC	Sambucus	racemosa	pubens	arborescens	Red Elderberry
SCICER	Scirpus	cernuus			Low Clubbrush
SENTRI	Senecio	triangularis			Arrow-Leaved Groundsel
SISLIT	Sisyrinchium	littorale			Shore Blue-Eyed-Grass
SORSIT	Sorbus	sitchensis			Sitka Mountain-Ash
SPAHYP	Sparganium	hyperboreum			Northern Bur-Reed
SPHSP	Sphagnum	sp.			Sphagnum
STRAMP	Streptopus	amplexifolius			Clasping Twistedstalk
TAXBRE	Taxus	brevifolia			Western Yew
THUPLI	Thuja	plicata			Western Red-Cedar
TIATRI	Tiarella	trifoliata			Three-Leaved Foamflower
TSUHET	Tsuga	heterophylla			Western Hemlock
TSUMER	Tsuga	mertensiana			Mountain Hemlock
UTRINT	Utricularia	intermedia			Flat-Leaved Bladderwort
UTRSP	Utricularia	sp			
UTRVUL	Utricularia	vulgaris			Greater Bladderwort
VACALA	Vaccinium	alaskenses			Alaskan Blueberry
VACOVA	Vaccinium	ovalifolium			Oval-Leaved Blueberry
VACPAR	Vaccinium	parvifolium			Red Huckleberry
VACULI	Vaccinium	uliginosum			Bog Blueberry
VERVIR	Veratrum	viride			Indian Hellebore
VIOSP	Viola	sp.			Viola