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A LIMNOLOGICAL INVENTORY OF SELECTED B.C. LAKES TO EVALUATE SUITABILITY FOR NUTRIENT ADDITIONS

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INTRODUCTION

There is overwhelming evidence that the productivity of some freshwater environments is only a fraction of production rates in marine ecosystems. Photosynthetic indices in oligotrophic lakes seldom exceed 0.8 mg C/ mg Chl a/hr and are typically less than 0.5 (Ichimura and Aruga 1964). On the other hand, Takahashi et. al (1972) have shown that the photosynethetic index for waters of the Western North Pacific vary between 1.4 and 2.0 mg C/ mg Chl a/ hr. Nutrient limitation, shorter growing season and greater temperature extremes in fresh water environments undoubtedly contribute to this difference.

The high fecundity of Pacific Salmon that spend their underyearlying year in freshwater has been given as evidence of the severe conditions for survival of juvenile salmon in freshwater relative to those in the sea (Foerster 1968). There is sufficient evidence, however, that primary productivity of oligotrophic lakes can be substantially increased by the addition of nutrients (Parsons et. al 1972, Schindler 1974) partially compensating for the reduction in that natural fertilization process which relies on the decomposition of salmon carcasses (Krokhin 1967), salmon which have been harvested by the commercial fishery. Reports on Pacific coastal lakes which have been the subject of fertilization programs indicate that juvenile sockeye salmon were larger at the time of seaward migration than in years when nutrients were not added (Barraclough and Robinson 1972, Nelson and Edmondson 1955). Since there is a positive correlation between smolt size and survival (Ruggles 1965, Johnson 1965), the potential benefits to the commercial fishery and escapement in future years are clear. The results of studies conducted in Great Central Lake also indicate that the numbers of seaward migrants also increased after fertilization (Barraclough and Robinson 1972) and escapement increased in subsequent years.

Increases in the size and number of juvenile sockeye following additions of plant nutrients clearly indicates that increases in fish production are an economic feasibility and that with careful management, these results can be achieved without altering biological properties of the system such as phytoplankton and zooplankton species composition (Parsons et. al. 1972, LeBrasseur and Kennedy 1972) and stability (McAllister et. al. 1972). There is also little doubt that in many cases some of the benefits derived by anadromous salmonids would be passed along to resident salmonids increasing their productivity and enhancing the sports fishery at the same time.

The present investigation was initiated to assess the suitability of a number of B.C. lakes for nutrient enrichment. The evaluation of any lake as a candidate for enrichment must consider many factors including biological, chemical, climatological and morphometric parameters as well as economic considerations such as accessibility, public and industrial utilization. To facilitate the simultaneous evaluation and relative importance of a larger number of objective and subjective considerations in defining the suitability of a given lake, an 'Enhancement Suitability Index (ESI)' has been derived for each lake. The justification and computation of this index is described in detail in the discussion.

MATERIALS AND METHODS

Study Areas

During the last week of September and throughout October 1975, limnological and morphometric observations were completed at 27 lakes in coastal British Columbia watersheds. The survey was conducted from a float-equipped De Havilland 'Beaver' chartered from West Coast Air Services. The locations and sampling sequence of lakes included in the program are given in Table O-1.

These lakes are located in the following watersheds: Fraser R. (1-3,27); Nitinat Lake watershed (4); Nanaimo R. (5); Henderson R. (6); Kennedy R. (7); Somass R. (8-10); Salmon R. (11); Campbell R. (12); Puntledge R. (13); Gold R. (14); Nimpkish R. (15); Smith Inlet (16); Rivers Inlet (17); Bella Coola R. (18); Masset Inlet (19); Skeena R. (20-24,26) and Nass R. (25).

Field Program

During the approach to and departure from each lake, comments regarding industrial and public utilization, local topography, obstructions, upland vegetation, accessibility and quality of spawning grounds were recorded on cassettes and supplemented with aerial photographs. In situations where a hydrographic map was obtained from the files of the Fish and Wildlife Branch and sounding was unnecessary, a single sampling station was located near the deepest portion of the lake; two stations were located in large lakes comprised of more than one basin (Table O-1). An echo sounding program was conducted if the morpho-metric features and depth of a lake were unknown.

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TABLE 0-1

Locations and Sampling Sequence of Lakes

Region and Lake	Latitude	Longitude
REGION 2: LOWER MAINLAND		
1. Chilliwack Lake	49° 03' N	121° 25' W
2. Silver Lake	49° 18' N	121° 24' W
3. Widgeon Lake	49° 27' N	122° 40' W
REGION 1: VANCOUVER ISLAND		
4. Hobiton Lake	48° 45' N	124° 49' W
5. Nanaimo Lakes	49° 05' N	124° 13' W
6. Henderson Lake	49° 05' N	125° 02' W
7. Kennedy Lake (2 stns)	49° 03' N	125° 33' W
8. Sproat Lake (2 stns)	49° 16' N	124° 57' W
9. Great Central Lake	49° 22' N	125° 15' W
10. Dickson Lake	49° 24' N	125° 05' W
11. Paterson Lake	50° 03' N	125° 39' W
12. Upper Quinsam Lake	49° 52' N	125° 33' W
13. Comox Lake	49° 37' N	125° 08' W
14. Muchalat Lake	49° 53' N	126° 11' W
15. Nimpkish Lake	50° 25' N	126° 57' W
REGION 5: COAST CARIBOO		
16. Long Lake (2 stns)	51° 14' N	127° 10' W
17. Owikeno Lake	51° 40' N	127° 00' W
18. Lonesome Lake	52° 15' N	126° 44' W
REGION 6: SKEENA		
19. Ian Lake	53° 45' N	132° 35' W
20. Alastair Lake	54° 05' N	129° 11' W
21. Morice Lake	54° 00' N	127° 40' W
22. Kitwanga Lake	55° 22' N	128° 06' W
23. Johanson Lake	56° 36' N	126° 10' W
24. Babine Lake (2 stns)	54° 45' N	126° 00' W
25. Meziadin Lake	56° 02' N	129° 15' W
26. Swan Lake	55° 47' N	128° 40' W
REGION 5: CHILCOTIN		
27. Chilko Lake	51° 15' N	124° 05' W

1. Echo Sounding Programs

Each program consisted of several transects with transducer of a Furuno Model F-701 50-khz echo sounder mounted to the substructure of the aircraft. Transect locations were marked on topographic maps and taxi time recorded for calculation of average speed. Taxi speed was maintained at 6 kph to avoid movement of the transducer or fracture of the mounting clamps. In some instances, it was impossible to sound extremely shallow areas (< 3 m) due to interference of the aircraft with shoreline vegetation or shoals and emergent littoral vegetation; however, in general sounding from the aircraft was satisfactory and permitted flight from transect to transect in larger lakes without removal of the transducer from the aircraft substructure. The following lakes were sounded during the program: Widgeon L., Hobiton L., Henderson L., Kennedy L., Sproat L., Dickson L., Paterson L., Upper Quinsam L., Nimpkish L., Long L., Ian L., Swan L. and Johanson L.

2. Vegetation

In most cases the shoreline, upland and littoral vegetation was examined from the beach. Major upland species were noted and recorded on cassettes while minor species and littoral emergent and submergent flora were collected or photographed for subsequent indentification. In situations where the beach was inaccessible or particularly marshy, vegetation was photographed with a 135 mm or 400 mm telephoto lens. Kodak High-Speed Ektachrome (160 ASA) was used for all photography during the lake survey.

3. Flow Rates

In many instances, flow rates and dimensions of inlet and outlet streams and rivers were available in the lake survey files of the Fish and Wildlife Branch. In some lakes where such data did not exist, flow rates were measured in the following manner. For each stream, the mean depth, mean width and the nature of the bottom (eg. sand, coarse gravel, large rocks), were recorded and a 20-50 m straight section located. The time required for 3-5 corks to travel this distance was measured and flow rates computed with the following formula.

$$\text{CMS} = \frac{[W][D][A][L]}{T}$$

where W = mean width in meters
D = mean depth in meters
A = constant for correction of stream velocity
L = length of a straight section (m)
T = mean time in seconds for floats to cover distance "L"

and A = 0.8 for rough bottom streams such as rocks or coarse gravel

or A = 0.9 for smooth bottom streams such as mud, sand, hardpan or bedrock

It must be emphasized that flow rates are extremely variable in most coastal lakes and rates determined in this manner may not be representative of mean values. However, calculations of flushing rate based on drainage basin area, lake volume and precipitation records are presented elsewhere in this manuscript and supplement flow rate measurements.

4. Temperature Profiles

Each sampling program began with the measurement of a temperature profile to delineate the epilimnion and hypolimnion. Temperature profiles were measured with a bathythermograph lowered slowly to a depth of 60 m using a hand winch and 3 mm (diam.) steel cable mounted to the steps of the aircraft. When wind or surface conditions were severe, the bathythermograph was weighted with a 9 kg lead ball to prevent an angle of ascent and descent in the water column. The B-T slide was removed and temperatures recorded after calibration to surface water temperature measured with a glass thermometer; the depth of the thermocline was noted and depths for subsequent sampling determined. The thermocline was defined as the depth of maximum temperature change (°C/m) in lakes where the 1°C/m standard was not observed. B-T slides were stored and subsequently photographed using extension tubes and Kodak Tri-X film.

5. Vertical Hauls

A zooplankton sample was collected from each lake or station by towing a 1 m diam. SCOR net from a depth of 50 m. A hand winch was used in the manner previously described and in all cases the net was weighted with the lead ball to prevent capture of zooplankton during the descent. The net was towed vertically at a rate of approximately 15 m/min to minimize avoidance reactions and turbulence. Zooplankton were rinsed into labelled 120-ml glass jars and preserved with 10 ml or formalin for subsequent indentifaction and enumeration. In several lakes, 10-20 kph winds caused an unavoidable wire angle of 10-15°; in these cases the aircraft engine was used to maintain a fixed position on the lake. In lakes where the maximum depth was less than 50 m, vertical hauls were made from lesser depths and appropriately note .

6. Transparency

Transparency of the water column was determined by lowering a seechi disc from the shaded side of the aircraft, recording the depth at which the disc disappeared and reappeared. Water colour was observed during the descent. The depth of the euphotic zone or compensation depth, equivalent to approximately 1% of the surface radiation, was calculated as 2.19 [seechi depth] as described by Parsons and Takahashi (1973). In those lakes where water colour suggested the presence of glacial silt, electron microscopy (see Laboratory Analyses) was used to determine the nature of particles contributing to light extinction.

7. Collection of Water Samples

Water samples were collected from six depths in the epilimnion and hypolimnion with a 7-l Van Dorn bottle; typically samples were taken at the surface, 5, 10, 20, 30 and 50 m although this varied to some extent with the thermal structure of the water column and maximum depth of the lake. For each depth, two subsamples were siphoned into rinsed 500-ml nalgene bottles for subsequent phosphate, nitrate, chlorophyll a and particle biomass analyses. An additional 100-ml aliquot of water was drawn from each 5 m sample and preserved with 5 ml of formalin for phytoplankton identification and enumeration. Nutrient Samples were frozen after each flight and returned to Vancouver the following day for storage at -15°C.

Laboratory Analyses

1. Phytoplankton and Zooplankton Identification and Emumeration

Phytoplankton in samples collected from 5 m were identified to genus and 100 microscope fields examined to determine the cell number/ml for individual genera. Total standing crop and percentage composition of Chlorophyta, Cyanophyta, Pyrrophyta, Chrysophyta and Bacillariophyceae were determined for each sample.

Zooplankton collected in vertical hauls were identified to species in most cases and number/m^2 for Size Groups I + egg to VII determined after samples were split by a factor of 1/5 to 1/200. The settled volume for each sample was also determined although in some cases the animals were not fully compacted. Sex ratios were calculated for major species but are not presented here. Total standing crop and percentage composition of Cladocera, Rotifera, Calanoid and Cyclopoid Copepoda were calculated for each lake or station. Shannon-Weiner species diversity indices were computed for phytoplankton and zooplankton communities of each lake using the expression:

$$D = 3.322\ (\log_{10} n - [1/n\ \Sigma n_i\ \log_{10} n_i])$$

where n = total number of individuals of all species
n_i = number of individuals in the ith species
D = Shannon-Weiner Diversity Index

2. Determination of Phosphate, Nitrate and Chlorophyll *a*

Water samples collected for nutrient analysis were completely thawed and filtered through Millipora HA (o.45 μ) filters to remove particulate matter. Reactive inorganic phosphorus was determined by the low-level method of Strickland and Parsons (1972) and absorbance measured with a Beckman DU Spectrophotometer.

Nitrate was determined with a Technicon Autoanalyzer and chlorophyll a by the fluorometric technique of Strickland Parsons (1972). Nitrate and phosphate levels were expressed as μg-at N/ℓ and μg-at P/ℓ respectively; chlorophyll a was calculated as mg/m^3.

3. Determination of Particle Biomass

Samples collected at each depth were thawed and 10 ml of saturated KNO_3 electrolyte solution added to 100-ml aliquots. Samples were continuously agitated to prevent settling and particle counts determined with a Model B Coulter Counter and Model M Volume Converter following the method of Parsons et. al. (1961). Particle number / ml, particle biomass (μ^3/ml) and mean particle volume (μ^3) were computed for each of 11 size classes corresponding to $\log_2$ stepwise increases in mean particle volume from 7.1 to 7258 μ^3 with the following expression:

$$PB = \Sigma_{sc=1}^{n} [F]\overline{RB}_{sc=1}$$

where $$F = \frac{[\text{abs. no. part/ml @ SCM}][\text{MPV @ SCM}]}{\overline{RB}\text{ @ SCM}}$$

and $MCV = [K]\ [S]60$

sc = particle size class (max=16) where MCV of each successive size class (sc) increases logarithmically ($\log_2$)

n = total number of size classes used for distribution

$\overline{RB}_{sc=1,n}$ = mean relative biomass for each size class

F = Absolute biomass conversion factor

SCM = size class with highest relative count

MPV = mean particle volume (μ^3)

K = calibration factor for Coulter Counter aperature tube

S = sensitivity of Coulter Counter

For spherical particles this range corresponded to an increase in particle diameter from 3.8 to 38.7 μ. Total particle biomass and particle number were calculated for each sample and mean values determined for the water column.

4. Measurement of pH, Conductivity and Total Dissolved Solids

Measurements of pH and conductivity were completed in the laboratory because field instruments did not operate in a satisfactory manner. However, since laboratory measurements were consistent with those values given for a number of lakes surveyed by the Fish and Wildlife Branch, this was not considered a serious shortcoming. The pH of thawed water samples from each lake was determined with a Radiometer Model 22 pH meter calibrated with pH 6.00, 7.00 and 8.00 buffer solutions. Resistance (Ω) of samples at 20°C was determined in a platinum-electrode glass cell with a John Fluke Model 710B impedance bridge and conductivity (μmhos/cm^2) calculated. Total dissolved solids (ppm) was computed from conductivity using the expression, TDS = 0.60 [conductivity].

5. Determination of the Nature of Particulate Matter

To determine the inorganic or organic nature of particles in silted lakes, a 10-ml aliquot of each 5 m water sample was filtered through a Nucleopore 0.4 μ filter and attached to metal mounting pins with silver paint. Samples were plated with a thin layer of gold and examined with an ETEC Autoscan Model U-1 scanning electron microscope. Those samples indicating the presence of inorganic particles were photographed and the size of particles noted.

6. Mean Surrounding Elevation

The mean surrounding elevation (m) of each lake was calculated from 1:50,000 or 1:250,000 scale topographic maps (Dept. of Mines and Technical Surveys). Depending on lake size, 500 or 1000 m increments were marked on the shoreline perimeter and elevations recorded at distances 1 km away from and perpendicular to the shore. Mean surrounding elevation was calculated and the mean angle of inclination determined from the following expression:

$$\text{Inclination } (°) = \tan^{-1} \frac{[\text{mean surr. elev} - \text{lake elev}]}{1000}$$

7. Climatological Parameters

Monthly precipitation, temperature and sunligh records for weather stations near to each lake were obtained from various files and publications of the Atmospheric Environment Service, Department of the Environment. The growing season for each lake was defined as the number of days where the mean daily temperature exceeded 10°C (Northcote and Larkin 1956) and calculations of climatological parameters related to growing season were based on this value.

8. Depth Related Parameters

Hydrographic maps were drawn for each lake using existing hydrographic maps from Fish and Wildlife Lake Survey files (redrawn in metric units and reduced to 22 x 88 cm page size) or from depths measured during echo sounding programs. Hydrographic maps for Morice and Owikeno lakes were drawn from maps provided by the Fisheries Operations Branch of the Department of the Environment. Surface areas (km^2) were computed from topographic maps with a Keuffel and Esser compensating polar planimeter.

Total lake volume (m^3) was calculated as the summation of the volumes of component depth strata from hydrographic maps using the expression:

$$V_i = hA_2 + \tfrac{1}{2}h\,[A_1 - A_2]$$

where V_i = volume (m^3) of the ith strata

h = difference in depth (m)

A_1 = surface area of upper depth contour (m^2)

A_2 = surface area of lower depth contour (m^2)

The volumes of the epilimnion and hypolimnion were determined in a similar manner. Mean depth (m) was calculated as total lake volume (m^3) / surface area (m^2).

9. Shoreline Parameters

Shoreline perimeter (km) was determined from topographic maps using calipers set at an interval of 500 m compensating for slight irregularities in shoreline configuration. The shoreline development factor (SDF) for each lake was computed from the expression:

$$SDF = \frac{P}{2\sqrt{\pi A}}$$

where P = shoreline perimeter in km

A = surface area in km^2

10. Flushing Rate

The theoretical water residence time for each lake was calculated as

$$WRT=\frac{V}{[MAP][DA][SR][10^4]}$$

where WRT=theoretical water residence time

MAP=mean annual precipitation (cm)

DA =drainage area (Km^2)

SR =%surface runoff/100%

10^4 =a conversion factor from cm x Km^2 to m^3

V = total lake volume (m^3)

and the percent of the epilimnion flushed during the growing season and following the maximum twenty-four precipitation during the growing season were calculated as

$$PF=\frac{[P][DA][SR][10^6]}{EV}$$

where PF = the percent of the epilimnion flushed

P = precipitation (cm)

EV = epilimnion volume (m^3)

where precipitation is for the growing season and the twenty-four hour maximum precipitation during the growing season respectively, and where percent surface runoff is calculated as

$$\%SR = 20 + [2 \times I]$$

where I = mean angle of inclination as defined in section 6 above.

This relationship was chosen without consideration of geological formation, soil type, or extent of vegetation cover due to time constraints. It is considered adequate since in no case is it expected to underestimate surface runoff.

11. Fish Stocks and Spawning Facilities

Escapement of anadromous salmonids and information concerning spawning facilities were obtained from Fisheries Operations Branch Spawning Files. Mean annual escapement was calculated for each species based on observations during the last 15 years. Information pretaining to resident fish stocks was obtained from Fish and Wildlife Branch files and publications and in some cases personal communications with Regional Fish and Wildlife Branch Biologists, local anglers and John Lightbown, our pilot, who was exceedingly familiar with fish of B.C. lakes and willing to sample fish stocks during the lake surveys.

RESULTS

Due to the volume of data presented for each lake in this survey, the results section of this manuscript must follow an unconventional format. The results and supportive documentation are presented alphabetically in individual files for each lake. Each file is organized in a similar manner and contains basically parallel information. Comments regarding noteworthy results and comparisons of present data with previous studies will be made in the discussion as will any comparisons drawn between lakes. Each file is organized in the following manner where 'n' is the number of the lake.

A. FIGURES

n-1: Hydrographic map

n-2: Topographic map illustrating:
  a. drainage basin
  b. spawning areas of anadromous salmonids using the following code:
    A = Sockeye Salmon
    B = Coho Salmon
    C = Spring Salmon
    D = Chum Salmon
    E = Pink Salmon
    F = Steelhead

n-3: Nitrate (μg-at N/l) and Phosphate (μg-at P/l) at various depths.

n-4: Size Distribution of Particle Biomass versus Depth where:

Abscissa = mean particle volume (mcv) without units; reader is referred to Table n-9 containing actual mean particle volumes.

Ordinate = particle biomass ($\mu^3 \times 10^{-5}$) for each size class (ie. mean particle volume).

B. TABLES

n-1: Phytoplankton species composition and standing crop 5 m.

n-2: Zooplankton species compostion and standing crop from a depth of 'x' meters. This table also includes % Cladocera, Rotifera, Calanoid and Cyclopoid Copepoda.

n-3: pH, Conductivity (μmhos/cm^2) and Total Dissolved Solids (ppm) at various depths.

n-4: Total Particle Number, Particle Biomass (μ^3) and Chlorophyll a for various depths.
NOTE: chlorophyll a data is not complete at this time and will be provided when analyses are finished. Chlorophyll a units should read mg/m^3 not mg/l as stated in tables.

n-5: Anadromous salmonid escapement history for each watershed. This table also includes mean annual escapement for each species during the last 15 yrs.

n-6: Resident Fish Stocks

n-7: Upland, Shoreline and Littoral Vegetation

n-8: Climatological Data

n-9: Particle Number and Particle Biomass for various depths (Computer print-outs)

C. PLATES

n-1: Temperature Profile taken from Bathythermograph

n-2: Photographs

n-3: Electron miscroscope photograph to illustrate nature of particulate matter (only given for silted lakes)

D. DATA SHEETS

Comprehensive summaries of information including:

1. location data
2. sampling information
3. topography
4. climatology
5. drainage information
6. depth related parameters
7. shoreline information
8. accessibility
9. public and industrial utilization
10. discharge rates
11. temperature
12. pH, Conductivity and TDS
13. nutrient levels
14. transparency
15. particle analysis
16. vegetation
17. phytoplankton
18. zooplankton
19. fish stocks
20. miscellaneous notes and comments

E. SLIDES

A collection of slides showing local topography, vegetation, industrial and public utilization, and streams.

Following the data sets for each lake, a series of comparative tables are presented for rapid comparison of climatological, morphometric, chemical and biological parameters in each of the lakes. These table are identified as follows:

TABLE NO.	CONTENTS
28A	Comparison of phytoplankton communities (a)
28B	Comparison of phytoplankton communities (b)
29	Comparison of zooplankton communities
30	Summary of fish stocks
31	Comparitive Climatological Data
32	Comparison of Euphotic Zone Depths, Thermocline Depths, pH, Total Dissolved Solids and Nutrient Levels
33	Comparison of Standing Crops, Taxonomic Composition and Species Diversity Indices for Phytoplankton Communities
34	Comparison of Standing Crops, Taxonomic Composition and Species Diversity Indices for Zooplankton Communities
35	Mean Escapements for Anadromous Salmonids
36	Flushing Rates of Various Lakes
37	Comparison of Secchi Disc Readings
38	Comparison of Sockeye Population Parameters
39	Comparison of 'Enhancement Suitability Indices'

DISCUSSION

The potential suitability of a lake for nutrient enrichment must consider a variety of parametric and non-parametric factors of varying importance. Some factors are obviously more important than others; nutrient limitation in the final analysis undoubtedly deserves greater attention than say mean summer epilimnion temperature or frost-free period. Yet a number of paramount consideration are difficult to quantify or in many ways become somewhat subjective in arriving at a final evaluation. For example, the fact that a certain lake has an open-pit mine discharging trailings into the epilimnion or has an obstruction preventing the migration of anadromous salmonids may be of equal or greater importance than the fact that the same lake is silted or perhaps nutrient limited.

Consequently, an 'Enhancement Suitability Index (ESI)' is proposed to allow evaluation of each lake in terms of a number of biological, chemical, climatological, morphometric and economic considerations with varying degrees of emphasis. It is essential to stress at the outset, however, that ESI is an arithmetic formulation designed to augment the evaluation process; it is not intented as a general model nor is it the only mathematical approach that could be taken. It is also noteworthy that there are undoubtedly other factors which could be included in the definition of ESI; for example, the size of smolts leaving a lake is an important parameter but this information is unavailable for most lakes in the survey.

The 'Enhancement Suitability Index' contains two classes of parameters. The first class is those which are additive in effect; important in combination with other factors in this class but without the individual power to cause rejection of a lake.

Most but not all climatological parameters fall into this category. The second class of parameters is far more important; these factors are multiplicative in effect and a single factor, when unacceptable and assigned a value of zero can cause rejection of the lake ('REJECT') irrespective of the suitability of the lake in other ways; Factors assigned values < 1 adversely affect the final suitability index and conversely factors given values greater than 3 promote high ESI values when not negated by other unfavourable multiplicative parameters.

At this point in the discussion each factor contained in the derivation of the 'Enhancement Suitability Index' will be considered in some detail.

A. ADDITIVE FACTORS

1. Nearest Habitation

Any lake selected for nutrient enhancement should be within reasonable reach of a center of habitation for acquisition of supplies. However, this is not a critical consideration since the fertilization crew will in all probability reside at the lake and a second crew to monitor temporal changes in biological and chemical parameters require a maximum of 1-2 days every week or perhaps two weeks. In situations where the nearest habitation is so close, 'public interest' may actually hinder the progress of the program. Our minimal concern with this parameter is reflected in its contribution to ESI; the effect is additive and assigned a range of values from 2.50 for lakes an optimum of 40-50 km from habitation to 1.00 for lakes <10 km or >200 km from nearest habitation. For example, Alastair L. is 58 km from Terrace and is assigned a value of 2.4 whereas Silver L. is only 7.5 km from Hope and assigned a value of 1.0.

Distances from nearest habitation are given in the 'Location Data' section of each set of data sheets.

Distance Range (km)	Rating
0-10	1.00
10-20	1.50
20-30	2.00
30-40	2.30
* 40-50	2.50
50-60	2.40
60-80	2.25
80-100	2.00
100-125	1.75
125-150	1.50
150-200	1.25
>200 km	1.00

2. Frost-Free Period

Frost-free period is one of a number of climatological parameters which influence the growing season in lakes. In general, the frost-free period and growing season are shorter for lakes in northern latitudes and become progressively shorter with distance inland. Longer day-length with increasing latitude compensates for this decrease to some extent but nonetheless frost-free period may limit the potential productivity of lakes such as Johanson L. which has a frost-free period of only 127 days in contrast to Chilliwack L. with a 308 day frost-free period.

Frost-Free Period (days)	Rating
>300	1.35
245-300	1.30
250-275	1.25
225-250	1.10
200-225	1.00
150-200	0.75
<150	0.50

3. Day-Degree Units

The number of day-degree units like frost-free period is a climatological parameter which may be correlated with the growing season of a lake. However, this index considers the number of degree units by which the mean daily temperature exceeds the 10°C limit delineating the growing season (Northcote and Larkin, 1956) and as such provides more precise information regarding the thermal suitability of a lake throughout the growing season. The following table indicates the range of values assigned for this parameter.

Day-Degree Units	Rating
>900	1.75
800-899	1.70
700-799	1.60
600-699	1.50
500-599	1.40
400-499	1.35
300-399	1.30
200-299	1.20
100-199	1.10
<100	1.0

4. Mean Epilimnion Temperature

It is well documented that the growth rates of phytoplankton and zooplankton are temperature dependent; in general, growth rates increase with temperature up to some maximum value which varies with species, season and acclimation state but generally lies in the range of 15-20°C. Beyond this 'optimum' growth range, productivity is expected to decrease sharply; however, since neither mean summer epilimnion temperatures nor surface temperature exceeds 20°C for the lakes in this investigation, high temperatures are not expected to reduce productivity and growth rates of phytoplankton and zooplankton. Lower epilimnion temperatures, on the other hand, are expected to limit the growth of primary and secondary producers in some lakes, particularly those located in northern latitudes. For example, the mean epilimnion temperature in Johanson L. was 5.9°C and this will undoubtedly have a marked effect on the generation time of phytoplankton and zooplankton. The contribution of mean epilimnion temperature to ESI is nonetheless additive and formulated in the following manner.

Temperature (°C)	Rating
≥15.0	1.55
14.0-14.9	1.50
13.0-13.9	1.45
12.0-12.9	1.35
11.0-11.9	1.15
10.0-10.9	1.00
9.0--9.9	0.85
8.0--8.9	0.60
<8.0	0.50

5. Mean Hypolimnion Temperature

The mean hypolimnion temperature is of importance to juvenile sockeye which spend the greatest proportion of the day below the thermocline (see for example Barraclough and Robinson, 1972) and feed in warmer plankton-rich surface waters at dawn and dusk. Energy expenditure is clearly related to temperature and has been suggested (McLaren, 1963, Biette MS) that energy derived from increased feeding in surface waters may be channeled into increased growth in the hypolimnion by virtue of lower energy expenditures (McLaren, 1963, Biette MS). Consequently, low hypolimnetic temperatures are essential for increased sockeye productivity.

Temperature (°C)	Rating
>10.0	0.50
9.0--9.9	0.85
8.0--8.9	1.00
7.0--7.9	1.15
6.0--6.9	1.35
5.0--5.9	1.45
4.0--4.9	1.55

6. Total Dissolved Solids

Several authors have shown positive correlations between the mean settled volume of zooplankton and total dissolved solids (Northcote and Larkin, 1956, Rawson, 1953). Similar relationships have been demonstrated for total dissolved solids and biomass of fish collected in gill-net sets (Northcote & Larkin, 1956). There is little doubt that conductivity and total dissolved solids bear a strong relationship to nutrient concentrations in the hypolimnion, although the parameter does not define the components of the nutrient pool which in many cases is dominated by calcium. However, since silicate is also a major component of Total Dissolved Solids and has been shown to become limiting at concentrations below 0.S ppm (F.P. Healey, pers. comm.) Total Dissolved Solids may limit primary production of diatoms when exceedingly low (<10 ppm) and ultimately affect production at other trophic levels. For example, both Long L. and Widgeon L. have <10 ppm TDS and in both cases the standing crop of Bacillariophyceae is <6% of the total phytoplankton standing crop.

TDS (ppm)	Rating
<5	0.2
5-10	1.0
10-30	1.25
>30	1.5

7. Percent Dinobryon

The Chrysophyte, Dinobryon has been shown to occur in dense bands near the compensation depth in certain lakes at E.L.A (E.J. Fee, pers. comm.); numbers increase slowly throughout the growing season to a maximum just before turnover. It has also been suggested that zooplankton are unable to ingest Dinobryon and consequently dense blooms occur until fall turnover disperses the alga into the water column and high light intensities inhibit the photosynohetic apparatus. Lakes containing an abundance of Dinobryon may also be characterized by an extremely low efficiency of energy transfer from the first to second trophic levels.

Dinobryon (%)	Rating
>50	0.25
30-49	0.50
10-29	1.00
<10	1.25

8. Percent Rotifera

Rotifers, because of their size, are not a particularly suitable food source for salmonids (LeBrasseur and Kennedy 1972). Consequently, those lakes showing an exceedingly high proportion of rotifers may be unsuitable nurseries for salmonids. Silver Lake, for example, has a zooplankton community composed of >90% Rotifera. The following rating is suggested for this parameter.

Rotifera (%)	Rating
>50	0.25
40-50	0.85
30-40	1.00
20-30	1.25
10-20	1.40
<10	1.50

9. Zooplankton Species Diversity Index

Shannon-Weiner species diversity indices were calculated for the zooplankton communities of each lake. Although less important than the phytoplankton species diversity index in assessing the potential reduction in stability, when a system is subjected to nutrient enrichment, a high species diversity index for zooplankton minimizes the possibility that an undesirable zooplankter in terms of salmonid food (eg. Holopedium) may become the dominant species.

Zooplankton S.D.I.	Rating
>2.5	2.0
2.0-2.5	1.8
1.5-2.0	1.6
1.0-1.5	1.4
0.5-1.0	1.2
<0.5	1.0

10. Presence of Anadromous Salmonids Other Than Sockeye

Where the watershed of a sockeye-producing lake has runs of other anadromous salmonids (with the possible exception of coho, discussed below), increased sockeye returns could cause problems in the management of the fishery. Increased fishing pressure in response to enhanced sockeye returns may well result in the overfishing of well-established runs of other species, or conversely, drastically increased escapements may cause competition and possible exclusion of other less abundant salmonids which share limited spawning areas.

Other Anadromous Salmonids	Rating
Other anadromous salmonids present in drainage system	1.0
No other anadromous salmonids present in drainage system	2.0

11. Presence of Coho Salmon in Lake Watershed

Increasing the rates of primary and secondary production in a nutrient-enhanced system may also provide downstream benefits to juvenile coho salmon who spend their underyearling year in stream nurseries. The Great Central Lake fertilization program was designed specifically to increase the productivity of sockeye, however, our analyses show that coho escapement in the Somass R. for 1973 and 1974, the first two years of increased sockeye escapement, was significantly greater than before fertilization ($3.204 > 3.012$ @ $p < 0.01, df=13$). Whether the increased coho escapement in the Somass R. will persist or not remains to be seen but nonetheless early trends suggest that downstream effects on coho may be an added 'bonus' to lake fertilization. Consequently, the following scheme is utilized to consider the possibility of downstream effects.

Coho	Rating
Coho present in drainage system	2.0
Coho not present in drainage system	1.0

B. MULTIPLICATIVE EFFECTS

1. Ratio of Euphotic Zone Depth/Thermocline Depth

The first multiplicative factor used in the computation of ESI is the ratio of the euphotic zone depth to thermocline depth. As previously outlined, this class of parameter, when totally unfavorable for successful nutrient enrichment, can cause rejection of a lake even though it may be suited to nutrient enrichment in other ways. The ratio EZD/TCD was used to reject lakes with shallow euphotic zones when this ratio was < 0.5. The rationale for excluding lakes of this type is as follows. In lakes with a euphotic zone of less than 50% of the epilimnion, primary producers will experience light intensities below the compensation level more than half the time; consequently, such communities are more likely to be light-limited than nutrient-limited. This situation is found in lakes which are either heavily silted or contain large quantities of humic acids which cause a characteristic brown stain. In the present survey, two lakes were found to have EZD/TCD ratios < 0.5. Owikeno L. has a secchi disc depth < 3 m. with the mixed layer extending to 24 m. It is clear that in a light-limited water column nutrient enrichment would do little to stimulate productivity.

The second lake which was excluded on the basis of an unfavorable EZD/TCD ratio was Ian Lake, on the Queen Charlotte Islands. This lake is heavily stained with humic acids and has a secchi disc depth of 3.0 m. with the thermocline at 15 m.

EZD/TCD	Rating
> 0.5	1.0
< 0.5	0.0

2. Thermocline Depth

The success of a fertilization program will depend to a large extent on the volume of the epilimnion and as such is determined by thermocline depth. A lake with the thermocline at 2 m. is poorly suited for nutrient enrichment since an epilimnion of such low volume will be highly susceptable to rapid flushing, negating any increase in production and standing crop. A case in point is Widgeon L.

which is only stratified to a depth of 2 m. and is therefore rejected as a poor fertilization risk. As illustrated in the following table, thermocline depth has no further affect on the suitability index beyond a depth of 10 m.

Thermocline Depth	Rating
< 3	0
3.1 - 5.0	0.5
5.1 - 7.5	1.0
7.6 - 10.0	1.25
>10.1	1.5

3. Industrial Utilization

The extent and type of shoreline or watershed industry is very important in the assessment of the nutrient enhancement potential of a lake. The only type of industrial activity which we considered important enough to promote complete rejection of a lake as a potential site for nutrient enrichment programs were hydroelectric facilities without provisions for fish migration. Extensive logging operations in the lake watershed make the area less desirable in terms of the 'Enhancement Suitability Index' but certainly do not preclude enrichment programs, nor do mining operations unless they are discharging debris or chemicals which could alter the transparency or act as potential toxicants. Upper Quinsam Lake was rejected as a potential site for nutrient enrichment on the basis of unfavorable industrial activity. This lake is currently diverted via a sluice to Campbell Lake where it is used as an adjunct to the hydroelectric facility to maintain water levels in Campbell Lake. During certain periods water flow is completely stopped and the design of the system prevents migration of anadromous salmonids to Upper Quinsam Lake. In additon to this impass, the Quinsam R. which connects Upper Quinsam, Middle Quinsam and Quinsam Lake has several falls preventing upstream movement of salmonids.

Industrial Use	Rating
No industrial use	1.5
Extensive logging	0.75
Moderate logging	1.0
Shoreling industry returning water to lake	0
Hydroelectric facility without fish ladder	0
Hydroelectric facility with ladder	1.0
Mining operation	1.0

4. Public Utilization

Recreational use of a lake in no way detracts from its suitability as a site for nutrient enrichment. In fact, the existence of a well-established sports fishery may in many cases make the lake even more suitable when benefits of the enhancement program can stimulate the production of sports fishes in addition to sockeye populations. The only form of public utilization which decreases the suitability of a lake for nutrient enrichment are permanent private residences as found in many areas surrounding Sproat Lake.

Public Use	Rating
No use	1.5
Camping or fishing without cottages	1.5
Private residences seasonal minimal - moderate	1.0
Private residences extensive seasonal use	0.75
Permanent private residences	0.5

5. Epilimnion pH

Epilimnion pH may have an important effect on stability of enriched algal communities. In situations where the epilimnion pH is either < 5.5 or > 8.5 increased rates of phosphate uptake favor the growth of Cyanophytes (F.P. Healey, pers. comm); this can cause a rapid decrease in the species diversity index as blue-greens rapidly reach bloom proportions and begin to exclude more 'favorable' species such as the Bacillariophyceae and Chlorophytes. These are the symptoms of eutrophication and such oscillations in abundance within a trophic level can lead to rapid decreases in the stability of the system and if the oscillation is not damped, total collapse may ensue. As pH values become ≤ 5.5 or ≥ 8.5 the probability of damping this reaction decreases and alternatively as pH values approach neutrality both the severity of the potential oscillation and the instability decrease.

pH	Rating
6.5 - 7.5	1.2
7.6 - 8.49	1.0
5.5 - 6.49	1.0
<5.49	0.5
>8.50	

6. Accessibility

A number of lakes examined during this survey are only conveniently accessible by float-equipped aircraft, although it is possible to reach Owikeno L. and Long L. by boat. Transportation of equipment and materials necessary for the actual mechanics of fertilizer could be extremely costly in lakes such a Swan L. Although a fertilization crew would probably stay at the camp throughout the growing season, scientific personnel must be able to access the lake on a regular basis to monitor or examine biological and chemical properties of the enriched system. The following scheme was used to consider this factor in the derivation of the 'Enhancement Suitability Index'. On the other hand, a lake which is accessible by a paved highway may promote extensive public use which could hamper progress of the project. The ideal form of access is a dirt or gravel road allowing reasonable access but discouraging extensive public use. The method of evaluation of this factor is given below.

Description	Rating
Inaccessible except by float plane	.8
Accessible by paved highway	1.0
Gravel road	1.35
Dirt or logging road	1.50

7. Littoral Vegetation

A lake which has virtually 100% of the bottom covered with aquatic macrophytes is not likely to be nutrient-limited nor is it likely to be very deep. In fact, the two lakes which had this extent of littoral coverage (Dickson L. and Silver L.) may even be classified as eutrophic. In fact, both Dickson L. and Silver L. had 100% littoral coverage and in many ways may be classified as eutrophic. In Silver L. the extent of decaying matter and aquatic macrophytes was so great that gas bubbles were continuously released to the surface. In the derivation of E.S.I. littoral vegetation was treated in the following manner.

Extent of Littoral Coverage	Rating
Minimal	1.25
Moderate (10 - 50%)	0.50
Extensive (50%)	0.25

8. Phytoplankton Species Diversity Index

Species diversity indices can be used to characterize an environment in much the same way as any other environmental parameter such as nutrient levels or thermal structures are used. In our computations the Shannon-Weiner derivation for species diversity was favored since its logarithmic computation is better suited to large ranges in standing crop. Margalef (1958) has shown that communities with high species diversity indices typically follow the spring stratification of the water column and nutrient depletion; on the other hand, fall and occasionally spring overturn inevitably cause a bloom in a single species leading to lower species diversity indices. Species diversity indices must therefore be used with some degree of caution since they vary considerably during the natural course of the growing season.

McArthur (1955) suggests that when a lake is obviously stratified and nutrient limited, a low phytospecies diversity index may be indicative of potential instability. As stated earlier, in discussion of epilimnion pH, eutrophication and enhancement programs may lead to oscillations in standing crop (Dunbar 1960) and potential collapse of the system. For this reason, species diversity indices were examined carefully throughout the lake survey. Of the lakes examined in the present survey, those which may be potentially unstable are: Alastair L., Chilko L., Great Central L., and Johanson L. The rating of phytoplankton diversity indices was determined as follows:

Species Diversity Index	Rating
< 0.500	0.50
0.5 - 1.000	1.00
1.000 - 1.500	1.25
1.500 - 2.000	1.50
2.000 - 2.500	1.65
> 2.500	1.75

9. Zooplankton Standing Crop

Zooplankton standing crop is ultimately the single-most important factor affecting the productivity of fish communities. The significance of this factor is reflected in magnitude of values used in computation of the 'Enhancement Suitability Index'. Lakes such as Babine and Chilko, with 150,000 zooplankters/m^2 undoubtedly provide sufficient ration to maintain a larger standing stock of fish; the sockeye production of both these lakes is sufficient evidence of this. Long L. and Nimpkish L., on the other hand, have less than 10,000 zooplankters/m^2 and relatively lower sockeye escapements. However, once again, caution must be exercised in the interpretation of zooplankton standing crops, since values determined during the lake survey may not be representative of levels throughout the growing season.

Standing Crop/m^2	Rating
> 100,000	0.50
80,000 - 100,000	0.75
60,000 - 80,000	1.00
40,000 - 60,000	1.15
20,000 - 40,000	1.35
10,000 - 20,000	1.60
< 10,000	1.75

10. Presence of Resident Salmonids

At this time there is insufficient evidence to suggest that nutrient enrichment programs would be a feasible approach to the enhancement of resident salmonid populations, at least not on a large scale. Cultivation of fish and small fertilization projects, in some cases using to advantage the natural runoff from agricultural land, is successful in small prairie ponds and lakes but it is difficult to extrapolate this limited success to enhancement of larger lakes. Resident salmonids may, however, benefit from enrichment programs geared to sockeye. Consequently, in the determination of lakes most suited to nutrient enrichment, we have excluded those lakes without sockeye runs as well as lakes with mean sockeye escapements of less than 100 individuals.

Although we have not completed an economic analysis to assess the minimum population which would justify fertilization, we have selected a figure of 6,000 fish, below which we apply a reduced weight in the calculation of the ESI (see following table). This value was calculated by estimating the cost of fertilizing a lake for five months at $30,000. Assuming a very conservative two-fold increase in return, at a price of $5 per fish, the cash return to the fishing industry would just equal the cost of fertilizing the lake.

It must be emphasized, however, that this figure is a very rough estimate, and is only used to indicate a size of run below which we consider a detailed economic analysis to be a prerequisite to any fertilization program.

Fishes - Part A	Rating
Sockeye present > 6,000	4.00
Sockeye present < 6,000	1.00
No sockeye (<100)	0

Fishes - Part B (additive)	
Anadromous salmonids in drainage system (other than S.E. Coho)	1.0
No other anadromous salmonids in drainage system	2.0

11. Nutrient Levels

The identification of nutrient deficiency in algae is an extremely difficult process (Healey 1975). The paucity of information describing levels of nutrient limitation in natural environments is evidence of this. A concentration of nitrate or phosphate inhibiting growth of one species in an algal community does not necessarily limit another; consequently at low nutrient levels the species composition of a phytoplankton community changes frequently. Since the precise definition of a limiting concentration under a given set of environmental circumstances in any lake is uncertain, we can only suggest that low levels of either phosphate or nitrate when accompanied with low phytoplankton standing crop may be indicative of nutrient limitation. On the other hand, higher nutrient levels, together with relatively high standing crops, probably suggest that the growth of a phytoplankton community is not nutrient limited. This is reflected in our derivation of ESI; under no circumstances do high nutrient levels cause rejection of a lake, particularly since in many cases the timing of the lake investigation corresponded with the timing of salmon escapement so the decomposition of carcasses may have contributed to the nutrient load.

Epilimnion - Phosphate	Rating
> 0.050	0.25
0.040 - 0.049	0.50
0.030 - 0.039	1.00
0.020 - 0.029	2.00
0.010 - 0.019	4.00

Epilimnion - Nitrate	Rating
> 2.00	0.25
1.00 - 2.00	0.5
0.75 - 1.00	1.0
0.50 - 0.75	1.5
0.25 - 0.50	2.0
< 0.25	2.5

Either nutrient can be limiting, therefore it is not necessary for both to be low.

12. Presence of Cyanophytes

As mentioned earlier, the presence of large numbers of blue-green algae is characteristically associated with process of eutrophication, either natural or induced by man. For example, Schindler (1974) reports that after addition of massive amounts of phosphate to one of the ELA lakes, 'the lake was transformed into a teeming, green soup' due to a rapid bloom of the blue-green alga, *Anabaena spiroides*. Although this type of fertilization study is clearly different in nature than nutrient enhancement, it does serve to point out an important consideration. Since cyanophytes have the ability to fix free nitrogen, their growth is usually limited by the level of available phosphate; in lakes where the proportion of cyanophytes is high prior to nutrient enhancement, the addition of even small quantities of phosphate may accelerate their growth to the point where they become the dominant species. This is obviously most undesirable even though the situation could not reach the state of some ELA lakes. Our concern with the presence of cyanophytes is reflected in the following multiplicative component of ESI.

13. Percent Epilimnion flushed during in the growing Season

The success of any nutrient enhancement program depends on the flushing rate of the lake, although flushing rate has little bearing on a lake's suitability between full overturn and stratification during the spring. The percent of the epilimnion flushed during the growing season is the parameter considered in the computation of ESI.

There is obviously little value in adding nutrients to a lake if they or the gains achieved by increased productivity cannot be transferred to the fish community. For example, the epilimnion (98% of the total lake volume) of Dickson L., which we earlier described as a wide portion of the Ash R., flushes at an average rate of once every 5.8 days throughout the growing season; in periods of intensive rainfall this value may increase to once every 10 hours. This lake may be rejected on the basis of flushing rate alone although the lack of anadromous salmonids and state of impending eutrophication does little to favor its position for nutrient enhancement.

% Epilimnion Flushed	Rating
< 50	4.00
50-75	2.50
75-100	1.25
100-200	1.00
200-350	0.50
> 350	0

At this point in our discussion, we would like to consider the relative merits and shortcomings of each lake in terms of potential enhancement of salmonids through nutrient enrichment programs. The reader is referred to comparative tables rather than the individual result sections since this readily facilitates lake to lake comparisons. Also throughout the discussion of each lake it will be useful to refer to Tables 39A and 39B, which summarize the additive and multiplicative components used in the computation of the Enhancement Suitability Index.

COMPUTATION OF ENHANCEMENT SUITABILITY INDEX

The enhancement suitability index is derived from the following expression using the natural

$$\text{S.D.I.} = \ln \left(\sum_{i=1}^{11} \text{Additive Para...} \right) (\text{Mult par}_1)(\text{Mult Par}_2) \ldots (\text{Mult Par}_{13})$$

logarithm to reduce the product of additive and multiiplicative components to a manageable size. Enhancement suitability components and final ESI values are given in Tables 39A and 39B.

ALASTAIR LAKE

One of the characteristic features of Alastair Lake is the distinct race of sockeye salmon found in its watershed; unlike other sockeye, adult spawners of this population are silvery green to blue with a distinctive red stripe along the lateral line.

The Gitnadoix system, of which Alastair L. is the headwater, possesses all five species of Pacific Salmon as well as anadromous and resident forms of Dolly Varden char, rainbow and cutthroat trout; it is also relatively inaccessible and therefore remains in a near natural state.

The lake is colored by glacial silt (Plate 1-3) but the water remains relatively transparent. The secchi disc depth (Table 37) measured during the present investigation (5.6 m) is consistent with values reported by others (Brett 1947, Northcote and Taylor 1972) and the presence of glacial silt is not considered a serious shortcoming.

Epilimnion nutrient levels are low (Table 32) suggesting that increased productivity could be achieved by nutrient addition. However, the mean escapement for sockeye is <2000 and therefore the cost of nutrient enrichment could well exceed the financial returns. In view of the uniqueness of the Gitnadoix sockeye population and apparent potential for nutrient enrichment, the authors feel that further investigation of Alastair L. is warranted, particularly in view of possible benefits to resident sports fish populations. One direction this investigation should take is to increase the ratio of fry:adults in order to increase the escapement of

Alastair L. to the level where nutrient enrichment would be economically feasible.

BABINE LAKE

Babine is a large and extremely productive lake presently supporting the largest sockeye run in B.C.; particularly since escapement has been increased 50-60% during the last 6 years by construction of two spawning channels.

Stockner and Shortreed (1975) have recently suggested that Babine L. is in a mixotrophic rather than oligotrophic state. Zooplankton standing crops (Table 34) and nutrient levels (Table 32) were also very high during our survey of Babine L., we must therefore conclude that nutrient enrichment would do little to increase the rate of production beyond its present level, particularly at the third trophic level. Stockner and Shortreed (1975) also suggest, however, that the northern end of the lake may be phosphorus limited; analyses of samples collects from the southern end of lake during our study, show no evidence of phosphate limitation.

CHILKO LAKE

Chilko Lake, though relatively transparent (secchi depth = 8.6 m) is colored by glacial silt (Plates 3-3A and 3-3B), has one of the lowest phytoplankton standing crops (15 cells/ml) observed during our survey. Epilimnion nutrient levels (N:0.75, P:0.022 µg-at/l respectively) may be indicative of some degree of limitation but given the high proportion of cyanophytes (>40%) and low phytoplankton species diversity index, nutrient enrichment would require a fair deal of caution to minimize the possibility of a blue-green bloom and instability as outlined in earlier discussion. The low standing crop of phytoplankton may, however, be a consequence of heavy grazing pressure since the standing crop of zooplankton is >170,000 individuals /m^2. As indicated by the thermal structure (Plate 3-1) and nutrient profiles (Fig. 3-3), fall turnover may have occurred before the survey, dispersing epilimnetic phytoplankton communities.

On the basis of the present date, it is not possible to discern whether or not Chilko L. is nutrient limited during the growing season and since sockeye escapement to Chilko L. is already very high (mean = 195,000) the benefits that could be derived from a nutrient enhancement program are questionable at this time.

CHILLIWACK

There is little doubt that the epilimnion of Chilliwack L. is phosphate limited (P:0.015 µg-at /l) but probably contains an adequate supply of nitrate (Table 32). This is reflected in low standing crops of phytoplankton and zooplankton (61 cells /ml and 53,00 zooplankters/m^2) and a very high transparency (secchi depth = 17 m).

Two factors however discourage the initiation program at this time. Sockeye escapement to Chilliwack L. (mean = 128) is too low to balance the cost of a nutrient enhancement program, although the well-established sports fishery of the lake would undoubtedly be stimulated by increased productivity. The second consideration may be a relatively high flushing rate (81.5% epilimion flushed during growing season) which as mentioned earlier could cancel the effects of a fertilization program.

We would therefore recommend further investigation of the two aspects discouraging enhancement of this lake. Firstly, since flushing rates presented here are an estimate, this parameter should be measured more precisely. Secondly, and far more important is the sockeye escapement into Chilliwack L.; for a lake of its size and climatological suitability, the escapement is disappointingly low. We would recommend that a program be initiated to examine the potential for increasing the population from its present level prior to re-examination of the fertilization potential. Establishment of a hatchery or incubation boxes may be suitable in this case although it was not the intent of this program to consider this aspect of enhancement.

COMOX LAKE

Comox L. is totally unsuitable for nutrient enhancement due to presence of an obstruction to migration of anadromous salmonids. The Puntledge R. has a hydroelectric facility located below the lake and although provisions have been made to permit passage of anadromous salmonids, for some reason the system in ineffective at this time (pers. comm. F. Fraser). Since our results indicate that primary production may be nutrient limited we recommend examination of the restrictive nature of the Puntledge R. hydroelectric facility before further examination of this lakes potential for nutrient enrichment or other enhancement programs.

DICKSON LAKE

As discussed earlier, Dickson L. is totally unsuited to fish enhancement and nutrient addition; there are no anadromous salmonids present, there is virtually no hypolimnion, a high flushing rate is reflected in low nutrient levels, phytoplankton and zooplankton standing crops, and the lake is characterized by extensive submergent and emergent vegetation. We therefore recommend no further consideration of this lake.

GREAT CENTRAL LAKE

Great Central Lake has several desirable features which make it suitable for fertilization, not the least of which are the history of previous success with this type of program and proximity to the Pacific Biological Station. These characteristics include nutrient levels which are low (N:D 0.1 µg-at /l, limit of detection; P:0.014 µg-at /l), high transparency (S.D. = >14m), low flushing rate and a standing crop of zooplankton ($<9000/m^2$) which must restrict the productivity of sockeye salmon. This is reflected in a high Enhancement Suitability Index. We therefore suggest that G.C.L. is an excellent candidate for renewed nutrient additions. Our only word of caution would be to monitor the phytoplankton species composition very carefully to avoid possible instability since during our examination of G.C.L. the species diversity index was very low.

HENDERSON LAKE

Henderson L. is characterized by virtually all the

the desireable features of Great Central Lake including low nutrient levels (N:0.34 µg-at /l; P:0.03 µg-at /l), considerably lower phytoplankton standing crop (276 cells/ml) and low flushing rate (Table 36). In addition, it is not subject to extensive public use, has epilimnion pH values (7.14) which would not favor the growth of blue-green algae, and has a much higher phytoplankton species diversity index indicating potentially greater stability during enrichment. Henderson L. is dominated by a sizeable sockeye run and thus would not have the management problems inherent to many systems included in this survey.

The Enhancement Suitability Index computed for Henderson L. (Tables 39A and 39B) is the highest of all lakes examined. We would however, like to add one precautionary note; hypolimnion conductivity is extremely high (266 µmhos/cm^2) and the source of this conductivity should be determined even though epilimnion values are higher (101 µmhos/cm^2) than values shown for other lakes in this survey (Table 32). For example, Vollenweider and Frei (1953) have shown that marked increases in the conductivity of the hypolimnion of lakes is associated with a marked increase in bicarbonate. Consequently, dissolved oxygen and carbon dioxide concentrations should also be examined and if no negative aspects such as serious oxygen depletion are observed, we would strongly recommend a nutrient enrichment program be initiated in this lake.

HOBITON LAKE

Hobiton has many of the features desirable for a lake to be selected for nutrient enrichment; these include very low nitrate (0.1 µg-at /l, limit of detection) and phosphate (0.022 µg-at /l) levels in the epilimnion with a very high phytoplankton species diversity index (Table 33) yet low standing crop (285 cells/ml). Also favorable is a very high proportion of copepods and cladocerans to rotifers. However, it has two shortcomings which will require further investigation. These are an estimated flushing rate which would replace 72% of the epilimnion during the growing season although this may not be a serious shortcoming considering the duration of the growing season (Table 31).

Secondly, and more important, is that sockeye escapement to Hobiton L. average only 4660 fish. A run of this size may not produce great enough returns to exceed the cost of a nutrient enrichment program. However, we would like to point out that since the lake is relatively small (3.6 km^2), fertilization would be relatively inexpensive.

We feel that the trophic state of this lake is such that productivity could be substantially increased but without more detailed information regarding the flushing rate and potential cash value of feasible returns, a decision to fertilize would be premature.

IAN LAKE

As previously mentioned in the discussion of transparency, Ian Lake is characterized by stained waters of high humic acid content. This results in a secchi disc value of 3.0 m, a situation where the euphotic zone is only 44% of the mixed layer. This represents a condition where 44% of the primary producers are above the compensation depth at any particular time consequently, light is more likely to limit the rate of production than nutrients. Epilimnion nitrogen is relatively high (1.24 µg-at /l) and phosphate, although low (0.022 µg-at /l), exceeds the value in the hypolimnion. It is likely that nutrient additons would do little to increase to the productivity of this lake; we therefore recommend that it be given no further consideration.

JOHANSON LAKE

Johanson L. is not recommended for nutrient enrichment for the following reasons.

Primary production will undoubtedly be curtailed by mean epilimnion temperatures of < 8° c during the growing season (Falls and Beune 1974); surface temperature measured during the present investigation (Oct. 12, 1975) was 5.9°c. The growing season is also exceedingly short with only 188.5 day-degrees per year and rotifers represent 77% of the total zooplankton standing crop. However, the single-most undesirable feature of Johanson L. is the low sockeye escapement (mean=337) with a lack of other anadromous salmonids.

KENNEDY LAKE - CLAYOQUOT ARM

Clayoquot Arm of Kennedy L. has many features which make it a suitable candidate for nutrient enrichment. For example, the epilimnion levels of phosphate and nitrate are low (N: 0.13 µg-at /l; P: 0.04 µg-at /l) and pH (7.52) near neutrality. Sockeye escapement to Clayoquot Arm averages 16,463 with only coho represented of the other species of Pacific salmon. There is however, one factor which detracts from this suitability. The thermocline is located at only 4 m; consequently, the lake volume subject to increased productivity is relatively small and the flushing rate is high (98% / growing season). However, since this thermocline is rather shallow for lakes of this region and since the high calculated flushing rate a consequence of this value, we recommend that this should be the subject of further investigation.

KENNEDY LAKE - MAIN BASIN

The fertilization of the main basin of Kennedy L. would be of questionable merit. Epilimnion phosphate concentration is abnormally high (0.09 µg-at /l) but nitrate levels are below the limit of detection. One major shortcoming with respect to the main basin of Kennedy L. is the mean hypolimnion temperature of 10.9°c; as mentioned in earlier discussion, this may limit the productivity of vertically migrating sockeye fry due to relatively high energy expenditure in the hypolimnion throughout most of the day. This factor may contribute to the fact that the main basin of Kennedy L. has approximately the same sockeye escapement, phytoplankton and zooplankton standing crops as Hobiton L. (hypolimnion temp. 6.9°c) even though the latter supports the same size population with less than 10% the surface area. The level of public utilization with several permanent residences also discourages enhancement of this lake.

KITWANGA LAKE

Kitwanga L. at one time supported a substantial population of sockeye salmon (McConnell and Brett 1946); this is no longer the case. In 1945, the escapement was 6000-7000 fish; however, by 1960 escapement had decreased to 400 fish and since 1968 no spawning sockeye have been observed in the Kitwanga River system.

Godrey (1955) classified Kitwanga Lake as eutrophic. The high zooplankton standing crop (46,000/m^2) collected from a depth of only 5 m, the high proportion of rotifers, high light extinction (S.D. = 3.7 m) resulting exclusively from organic matter, and extensive littoral coverage observed during our study confirm the eutrophic nature of this lake. Hence nutrient addition is considered to be of questionable merit!

spawning

LONESOME LAKE -> stillwater.

Although escapement to the Bella Coola - Atnarko System averages 43,000 sockeye per year, the proportion utilizing the Lonesome Lake nursery is poorly documented. Fisheries Operations Spawning Files indicate that 70-90% of these fish spawn in the Atnarko watershed above Lonesome L. If one were to assume that 80% of the juvenile sockeye use the Lonesome L. nursery this would represent a smolt density 8.9 times greater than that of Babine L. Babine is reported to be the most productive sockeye producing lake in B. C. and it seems improbable that a lake with a mean depth of only 14 m, a mean water residence time of 99 days and an epilimnion flushing time of 47 hrs. during maximum growing season precipitation can approach an order of magnitude greater production than Babine Lake.

We suggest that only a small proportion of the fry produced by the Atnarko R. actually nurse in Lonesome L. and given the high flushing rate, poor accessibility and harsh climatological character of this lake (Table 31) recommend it be given no further consideration.

LONG LAKE

On the basis of the Enhancement Suitability Index, Long Lake is ranked second only to Henderson L. as a favorable candidate for enhancement by nutrient enrichment. The following features account for this high suitability: low phosphate levels (0.02-0.03 µg-at /l), an extremely low standing crop of phytoplankton (24 cells/ml) yet high species diversity index, an absence of Rotifera and Cyanophyta, and a low epilimnion flushing rate (32.8%). The lack of public or industrial utilization, presence of an existing Fisheries camp with a counting fence and finally a mean sockeye escapement of 91,000 also favor nutrient enrichment of Long L. However, there are two characteristics which detract slightly from the desirability of this lake. The first is its relative inaccessability; equipment would have to be transported to the lake by boat. The second consideration is a nitrogen to phosphorus ratio of approximately 350:1 (calculated from hypolimnion values), which would most certainly require careful consideration in the selection of a fertilizer. The higher levels of phosphate in the epilimnion relative to hypolimnion values observed during the present investigation are attributed to the nutrient load supplied by decaying salmon carcasses. Hypolimnion values probably more realistically reflect the phosphorus available to phytoplankton immediately following spring stratification.

MEZIADIN LAKE

Meziadin Lake is characterized by an abundance of nitrate (6.06 µg-at/l) but is probably phosphate limited (0.018 µg-at/l). The zooplankton standing crop (199,000/m^2) is the highest recorded during the lake survey; the low phytoplankton standing crop (55 cells/ml) may therefore be a consequence of heavy grazing pressure. The lake is relatively transparent (s.d. = 8 m) despite the presence of glacial silt (Plate 16-3).

During the mid-sixties a fishway was constructed to alleviate problems induced by changing water levels which caused erratic escapement patterns. Since construction of the fishway, sockeye returns have increased from approximately 20,000 (Withler 1956) to >100,000 in recent years and it is suggested that further increases may be limited by spawning facilities (pers. comm. P. D. Murray). In view of the high zooplankton standing crop, it is unlikely that productivity of young sockeye is limited by ration and we therefore suggest that nutrient enrichment of Meziadin Lake is of questionable merit. However, further investigations could be conducted to assess the feasibility of expanding current spawning facilities, particularly in view of the extensive forts fishery for Dolly Varden and Rainbow Trout.

MORICE LAKE

Morice Lake is the fourth-rated lake in terms of the ESI dispite the fact that it has a sockeye escapement of <4000 fish. The lake shows signs of phosphate limitation (0.018 µg-at/l), standing crop of phytoplankton is not particularly high (55 cells/ml) and the standing crop of zooplankton is low (<38,000/m^2). Like Meziadin, Morice Lake is silted (Plate 17-3) but nonetheless is relatively transparent (s.d. = 7.7 m) with the mixed layer extending to 27 m. Other desirable features include an~~d~~ exceedingly low flushing rate during the growing season (17.3%) with only 4.4% of the epilimnion flushing in periods of maximum precipitation, extensive gravel beaches highly suited to beach spawners, very little public utilization and virtually no industrial activity. Since the sockeye escapement is presently so low (Mean escapement = 3700) we would not recommend fertilization at this time but strongly suggest that programs be initiated to increase the egg-fry survival rate and if this is successful, initiate a fertilization program.

MUCHALAT LAKE

We do not advise fertilization of Muchalat L. primarily on the basis of low sockeye escapement and extensive industrial utilization of the lake watershed. We do however, submit that further investigations be completed to assess the feasibility of future enhancement programs since the lake has several desirable qualities, not the least of which is the presence of sizeable populations of Dolly Varden Char and Cutthroat Trout.

This lake is also characterized by an exceedingly low standing crop of phytoplankton (18.2 cells/ml) and although nitrate (1.385 µg-at/l) does not appear to be limiting, phosphate (0.011 µg-at/l) undoubtedly is low. The flushing rate is also suitably low with 33.2% of the epilimnion flushing throughout the growing season. The euphotic zone extends slightly beyond the thermocline which is located at 12 m, insuring adequate light throughout the entire epilimnion. It is also noteworthy that total dissolved solids are relatively low (11 ppm) but nonetheless diatoms are abundant indicating sufficient silicate supply.

The surface area of Muchalat Lake is relatively small suggesting that stimulation of present sockeye populations would be relatively inexpensive in comparison with lakes of larger size. We therefore feel that the first step in any subsequent investigation should be a cost-benefit analysis in terms of potential sockeye increases.

NIMPKISH LAKE

In terms of the Enhancement Suitability Index, Nimpkish Lake was the third most suitable lake examined, surpassed only by Henderson and Long L. respectively; however, in this particular case we cannot recommend nutrient enrichment until an additional investigation is completed.

The lake is characterized by the lowest zooplankton standing crop observed during the entire study; zooplankton numbers were <3500. Phytoplankton standing crop was also unusually low and in all probability limited by the low phosphate level (0.023 µg-at/l); nitrate on the other hand, is not considered a limiting factor since epilimnion levels exceeded 2 µg-at/l and were even higher in the hypolimnion.

The thermocline of Nimpkish L. was located at 24 m, with the euphotic zone extending to 20.5 m. This suggests that the phytoplankton community is not light limited throughout the majority of the mixed layer. The flushing rate of Nimpkish L. is also acceptably low with only 31.2% of the epilimnion flushed during the growing season; this corresponds to a water residence time of 3.87 years.

The justification for not recommending fertilization of this lake at the present time centers on ambiquity in the fate of sockeye entering the Nimpkish Watershed.

Although the mean annual escapement exceeds 98,000 fish, there is no evidence that the juvenile sockeye spend their underyearling year in Nimpkish Lake. A large proportion of the sockeye enter Woss Lake (Anon 1958), 20 km upstream of Nimpkish. Since this run is a large one and Nimpkish L. appears to be a favorable lake for nutrient enrichment, we recommend that the locations of these nurseries be established as soon as possible and in the event that a significant proportion of the run utilize Nimpkish, this lake would be an excellent prospect for nutrient enrichment. Alternatively, if Woss Lake represents the major nursery, we further recommend evaluation of its prospects for nutrient enrichment.

OWIKENO LAKE

The rate of primary production in Owikeno Lake is entirely light limited. The euphotic zone extends to only 6.4 m due to the presence of glacial silt (Plate 20-3) while the epilimnion extends to 24 m in Basin IV and 44 m in Basins I and II. Consequently, only 14.5-26.7% of the phytoplankton community is above the compensation depth at any particular moment. The results of Narver and Anderson (1968) indicate that rates of primary production in Owikeno L. decrease exponentially with depth, following a pattern similar to that of vertical light extinction. Further evidence that primary production is light limited is apparent from the epilimnion nutrient levels; epilimnion nitrate levels exceed 0.9 µg-at/l and phosphate levels exceed 0.03 µg-at/l.

In spite of the obvious light limitation in Owikeno Lake, it supports the second largest population of sockeye among the lakes in the survey. In view of the high nutrient levels, the high rate of sockeye production, and the ratio of euphotic zone depth to thermocline depth, we suggest that Owikeno L. would not benefit from nutrient enrichment.

PATERSON LAKE

Paterson Lake is rejected as a candidate for nutrient enrichment since it does not support runs of anadromous salmonids.

SILVER LAKE

Although anadromous salmonids spawn in the Silverhope River, Silver Lake contains no sockeye, has no hypolimnion, is not nutrient limited, and is in the process of natural eutrophication. We therefore recommend no further study of this lake.

SPROAT LAKE - TAYLOR ARM

Taylor Arm of Sproat Lake has several positive features favoring nutrient enrichment. These include a deep euphotic zone (s.d. = 12.7 m), absence of cyanophytes, exceedingly low flushing rate (11.4% of the epilimnion during the growing season), definite nitrate and possible phosphate limitation (Table 32), relatively low phytoplankton standing crop (Table 33) and a sizeable run of sockeye (mean annual escapement = 35,000).

However, there are a number of other features which detract from this suitability. Standing crop of zooplankton is already relatively high (Table 34), there is a moderate density of all-season cottages and there is insufficient information regarding the proportion of sockeye utilizing Taylor Arm.

We recommend that further studies be completed to determine the extent of the sockeye nursery in Taylor Arm but given the level of public utilization caution must be exercised in any enrichment program in this lake.

SPROAT LAKE - MAIN BASIN

The main basin of Sproat Lake has all of the desirable described for Taylor Arm and in addition has greater transparency (s.d. = 16.5 m), lower standing crops of phytoplankton and zooplankton and lower phosphate levels. However, this portion of the lake has such extensive public utilization including numerous permanent residences that we submit that fertilization of this basin would be of questionable merit and perhaps political suicide.

SWAN LAKE

Irrespective of the fact that this lake has transparency, nutrient levels and phytoplankton and zooplankton standing crops which all indicate that nutrient addition could substantially enhance primary and secondary production, the very low sockeye escapement (mean = 1229) and its extreme inaccessibility make it a very unfavorable fertilization prospect at this time.

UPPER NANAIMO LAKE

Upper Nanaimo Lake similarly shows some potential for increased primary and secondary production through nutrient enrichment programs. However, no sockeye are found in this system and although coho spawn downstream of the Nanaimo Lakes, Lower Nanaimo Lake is nearing a state of eutrophication and it is therefore unlikely that any effects of nutrient addition would benefit downstream populations.

UPPER QUINSAM LAKE

Upper Quinsam Lake has low nutrient levels in the epilimnion, particularly nitrate (0.1 µg-at/l), a low phytoplankton standing crop (57.6 cells/ml), but a relatively high zooplankton standing crop ($67{,}000/m^2$). The presence of a hydroelectric facility without a fishway however, prevents migration of anadromous salmonids into the lake. Although downstream coho populations could benefit from nutrient enrichment, the small size the run (mean = 3700) indicates that this would not balance the cost of enrichment.

WIDGEON LAKE

Widgeon Creek which drains Widgeon Lake has a waterfall of at least 100 m height within a few hundred meters of the lake; consequently anadromous salmonids do not reach the lake. There is however, a limited sports fishery at this time and due to the proximity of this lake to Vancouver and its exceptionally esthetic qualities the lake would be more suitably stalked with Kokanee or some other resident salmonid.

SUMMARY AND RECOMMENDATIONS

Of the twenty-seven lakes included in this survey, only three can be positively recommended for nutrient enrichment at this time. In order of merit, these are: Henderson Lake, Long Lake and Great Central Lake.

All of these lakes have substantial sockeye runs as well as very low epilimnion phosphate levels and relatively low flushing rates. Henderson L. and GCL are also characterized by low nitrate levels in the epilimnion, while Long L. has an absence of cyanophytes and rotifers.

Henderson and Long Lake also have very low phytoplankton standing crop and high species diversity indices indicating a high degree of stability, similarly, neutral pH of Henderson Lake is unfavorable to the growth of blue-green algae.

There are relatively few shortcomings to discourage fertilization of these lakes. Great Central Lake has a low phytoplankton species diversity index; consequently any fertilization program must include assessment of changes in this index to avoid any possibility of instability at this trophic level. The only major shortcoming of Long Lake is its relative inaccessibility, however the existence of a permanent Fisheries Operation camp will offset transportation expenses to some extent.

The fertilization of a lake to increase sockeye production is only economically feasible when the size of the original run is large enough that the cash value of increased returns exceeds the cost of fertilization. On the basis of preliminary calculations an escapement of 6000 fish was selected as a minimum.

Lakes which are not recommended on this basis are Alastair, Chilliwack, Hobiton, Muchalat and Morice. The sockeye production of Alastair, Chilliwack, Morice and perhaps Hobiton may however be limited by spawning area. Since these lakes have a potential for increased production through nutrient enrichment, we suggest that the spawning capacity be determined in these lakes and when feasible artificial methods of increasing egg capacity examined and initiated with nutrient enrichment programs when the size of the run reaches a level that would be economically feasible.

Clayoquot Arm of Kennedy Lake is also a potential candidate for nutrient enrichment; however, its shallow thermocline and high flushing rate detract from its otherwise suitable nature. Since this shortcoming may be an anomaly of the particular time of our analysis, we recommend that the thermal structure of Clayoquot Arm be examined in further detail.

There is some possibility that Chilko Lake may have been in the process of fall turnover during our investigation and results obtained not representative of those during the growing season. We recommend that this lake be examined in a similar manner during the next year.

Nimpkish Lake is one of the strongest candidates for for a nutrient enrichment program. However, the proportion of sockeye using Nimpkish and Woss Lake nurseries must be examined befor enrichment can be recommended. A similar ambiquity exists for Taylor Arm of Sproat Lake. The results of our survey indicate that the productivity of this lake could be substantially increased by nutrient addition, however the distribution of fry throughout the lake and the location of spawning areas must be resolved before any programs can be initiated.

The main basin of Sproat Lake is probably even better suited to an enhancement program than Taylor Arm. However in view of the political implications of adding fertilizer such a highly developed residential and recreation area, nutrient addition is of highly questionable merit.

Babine Lake already has a high rate of primary productivity, and since nutrients are not limiting and standing crops of phytoplankton and zooplankton very high, this is little merit in initiating a fertilization program.

Although Swan Lake could benefit from a nutrient enhancement program, its small sockeye escapement and the extreme inaccessibility make it a very poor candidate at this time.

Dickson, Silver and Kitwanga are all shallow, eutrophic and lack anadromous salmonids and are rejected as candidates for nutrient enrichment.

Ian and Owikeno Lakes both have very restricted euphotic zones due to presence of humic acids and glacial silt respectively and are light-limited not nutrient limited.

Comox, Upper Quinsam and Widgeon lakes all have obstructions which prevent migration of anadromous salmonids and are therefore not recommended for enhancement programs. Similarly both Paterson and Upper Nanaimo lakes are without runs of anadromous salmonids and not worthy of further consideration.

Lonesome Lake and Johanson Lake are both unsuited to nutrient enhancement programs due to unfavorable climatological factors.

TABLE 28A

KEY

◯ > 500 cells / ml
○ 100-500 cells / ml
• < 100 cells / ml

	Alastair	Babine A	Babine B	Chilko	Chilliwack	Comox	Dickson	G.C.L.	Henderson	Hobitan	Ian	Johanson	Kennedy A	Kennedy B	Kitwanga	Lonesome	Long A	Long B	Meziadin	Morice	Muchalat	Nimpkish	Owikeno	Paterson	Silver	Sproat A	Sproat B	Swan	U. Nanaimo	U. Quinsam	Widgeon
CHLOROPHYTA	•	•	•		•				•	•	•	•	•	•	•		•	•		•			•	•		•	•	•	•	•	
Ankistrodesmus	•	•	•						•	•	•	•	•		•					•			○					•	○		
Axthrodesmus										•				•			•	•						•							
Cosmarium																				•											
Nannochloris					•				•																				•		
Oocystis										•										•											
Spondylosium													•	•			•														
Staurastrum															•																
Westella		•	•						•				•							•				•		•	•			•	
CYANOPHYTA		•	•	•	•	•			•	•			•	•														•	•	•	•
Anacystis					•																										
Arthrospira		○	•																												
Chroococcus			•	•		•			•	•			•	•														•	•	•	•
PYRROPHYTA	•				•	•	•	•	•	•		•	•	•	•	•	•	•						•	•	•	•				•
Ceratium								•		•			•	•	•	•								•		•	•				•
O. Peridinales	•				•	•	•	•	•	•		•	•	•			•	•							•	•	•				
CHRYSOPHYTA	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Chrysophaerella																								•						•	
Crucigenia										•				•																	
Dinobryon	•			•	•	•	•	•	•	•		•	•	•	•	•		•	•	•	•	•	•	•	•	•	•		•	•	
Mallamonas		•	•												•	•							•								
Scenedesmus									•			•	•	•						•											
Schroederia					•	•							•	•			•	•			•								•		
FLAGELLATES		•	•		•		•		•	•		•	•	•	•	•	•	•			•		•		•		•		•		
CILIATES		•	•				•					•				•	•			•			•	•	•	•			•	•	

TABLE 28B

KEY

◯ >500 cells / ml
○ 100-500 cells / ml
∘ <100 cells / ml

	Alastair	Babine A	Babine B	Chilko	Chilliwac	Comox	Dickson	G.C.L.	Henderson	Hobitan	Ian	Johanson	Kennedy A	Kennedy B	Kitwanga	Lonesome	Long A	Long B	Meziadin	Morice	Muchalat	Nimpkish	Owikeno	Paterson	Silver	Sproat A	Sproat B	Swan	U. Nanaim	U. Quinsa	Widgeon
BACILLARIOPHYCEAE	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘		∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	
Asterionella		○	∘			∘					∘	∘		∘	∘	∘								∘						∘	
Cyclotella		∘	∘	∘		∘	∘	∘			∘				∘	∘			∘	∘				∘						∘	
Cymbella			∘																												
Diploneis						∘																									
Fragilaria										∘					∘																
Frustulia							∘																								
Gomphoneis							∘																								
Gyrosigma							∘							∘																	
Melosira							∘	∘	∘	∘				∘										∘		∘		∘	∘		
Meridion	∘																														
Navicula							∘	∘			∘			∘										∘					∘		
Nitzschia	∘	∘	∘					∘								∘			∘	∘	∘	∘							∘		
Rhizosolenia	◯	∘	∘	∘		∘		◯	○	∘		∘	○	○								∘	∘			∘	∘		○		
Stauroneis																∘															
Stephanodiscus															∘					∘											
Surirella																							∘								
Synedra		∘	∘		∘		∘					∘			∘				∘						∘			∘			
Tabellaria		∘	∘										∘		∘		∘				∘										
UNKNOWNS		∘	∘		∘	∘	∘	∘	∘	∘			∘	∘	∘	∘	∘	∘	∘	∘				∘	∘	∘	∘	∘	∘		
U 14								∘	∘	∘			∘																		
U 16					∘					∘			∘	∘		∘								∘		∘		∘	∘		
U 18																∘								∘				∘			
U 21		∘	∘												∘	∘															
U 25										∘			∘			∘		∘	∘	∘				∘			∘				
U 30			∘			∘											∘	∘		∘				∘		∘	∘				
U 41																				∘											
U 42																									∘						
U 43							∘		∘																						

TABLE 29

KEY

>15,000 / m^2

1500-15,000 / m^2

<1500 /m^2

	Alastair	Babine A	Babine B	Chilko	Chilliwack	Comox	Dickson	G.C.L.	Henderson	Hobitan	Ian	Johanson	Kennedy A	Kennedy B	Kitwanga	Lonesome	Long A	Long B	Meziadin	Morice	Muchalat	Nimpkish	Owikeno	Paterson	Silver	Sproat A	Sproat B	Swan	U. Nanaimo	U. Quinsam	Widgeon
LADOCERA																															
lona affinis							●															●									
osmina coregoni	○	●		○	●	○	○	●	◯	●	○	○	○	◯	●	○	○	◯			●	●	●	○	●	◯	○	●	○	○	●
eriodaphnia quadrongulata							●																	○							
eriodaphnia sphaercus																●					●										
aphnia ambigua						○			●	●															●			●			
aphnia longiremis		●	●									●						●								●	●				
aphnia pulex	○			●	◯		●				○				○	◯			○	●	○		●	○					○	○	
eptidora	●														●	●													●	●	
olyphemus pediculus					●	●	●		●							●								●		●				●	●
caphaloberis kingi					●		●		●																						●
ida cristalina														●										●					●	●	
ALANOID COPEPODA																															
iaptomus ashlandi		○	◯	◯																			◯							◯	
iaptomus kenai																	●	●					●								
iaptomus oregonensis						○	○		●	○			○	○				●			○	●		○					○		
iaptomus tyrelli																												●			
iaptomus 'A' pribilofensis		○	○		○										●	●								○	●						◯
iaptomus 'C' signicauda																			○												
pischura nevadensis		●					●	●			○						●	●		●		●				●	●				
eterocope septentrionalis		●	●																												
YCLOPOID COPEPODS																															
yclops bicuspidatus	◯			◯		◯	○	○	●	◯	◯	○	◯	○	○	○		●		◯	◯	●		○	●	◯	○	○	○	◯	
yclops scutifer		◯	◯	●																											
yclops vernalis	○				◯	●		●	●				●	●			○	○	◯		○	●	○		●	●	●				○
yclops 'A' modesta																									●						
OTIFERA																															
splanchna	○	●				○			●			○	○	●				●	○	○		●					●				
onchilius unicornis	●	○				○	●	○	○			◯	●	●		●						●		○	○	●		●	○		○
ilinia																●							●	●							
astropus						○			●				●								●								○		
ellicottia spp.	○	○	○	○	○	○	●	●		●	●	○	●	●	○	○			○	○	○	●		○	●	○	●	●	○	○	○
eratella cochleas								●								●			●		○			●							●
aked Rotifers												●			○										○			●			●
leosoma ludsoni															●	●											●		●		
leosoma truncatum									●																						
olyarthra											●			●	○																
ompholyx			○		○					●					○	○						●		●				●	●	●	
HIRCHIMIDS						●	●					●						●			●		●					●	●		
ITES						●	●		●						●	●	●							●	●				●	●	
olopedium ... erum (Clad)				●		●	○	●									●	●		●				●		●	●	●			○

TABLE 30

	Alastair	Babine	Chilko	Chilliwack	Comox	Dickson	G.C.L.	Henderson	Hobiton	Ian	Johanson	Kennedy A	Kennedy B	Kitwanga	Lonesome	Long	Meziadin	Morice	Muchalat	Nimpkish	Owikeno	Paterson	Silver	Sproat	Swan	U. Nanaimo	U. Quinsam	Widgeon
SALMONIDAE																												
Sockeye	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O
Spring	O	O	O	O	O		O	O					O	O	O	O	O	O	O	O	O	O		O	O	O	O	
Coho	O	O		O	O		O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Chum	O	O		O	O		O	O	O	O			O	O	O				O	O	O	O	O	O			O	O
Pink	O	O		O	O		O	O		O				O	O		O	O	O	O	O	O	O	O			O	
Kokanee		O		O	O																		O	O	O			
Steelhead	O	O	O	O	O		O	O						O	O			O	O	O	O	O	O	O		O	O	
Rainbow Trout	O	O	O	O	O	O					O			O			O	O	O				O	O		O		O
Cutthroat Trout	O	O		O	O	O			O					O	O				O	O	O	O		O		O	O	
Dolly Varden	O	O	O		O	O					O			O	O		O	O	O	O	O		O		O	O		
Lake Trout		O																O							O			
COREGONIDAE																												
Common Whitefish		O																										
Mountain Whitefish	O	O	O								O			O	O		O	O							O			
CYPRINIDAE																												
Peamouth Chub	O	O												O			O											
Northern Squawfish		O												O														
Redside Shiner														O			O											
CENTRARCHIDAE																												
Black Crappie				O																								
GASTEROSTEIDAE																												
Threespine Stickleback	O				O															O				O				
GADIDAE																												
Burbot		O																										
COTTIDAE																												
Prickly Sculpin	O													O						O				O				
Slimy Sculpin																				O								
Aleutian Sculpin					O																							
CATOSTOMIDAE																												
Largescale Sucker	O													O	O		O											
Northern Sucker		O													O		O	O						O				
White Sucker		O																O										

COMPARATIVE CLIMATOLOGICAL DATA								
Lake	Frost Free Days	Daily Mean Temp	Annual Ppt (cm)	Day-Degree Units	Grow. Seas. Mean Temp.	Grow. Seas. Ppt. (cm)	Grow. Seas. Max. 24 h Ppt.	Hours Sun
Alastair	236	6.61	237.6	580.9	13.79	46.18	5.53	923
Babine	127	1.11	60.1	188.5	12.04	14.73	4.80	643
Chilko	151	4.11	28.2	306.3	12.61	12.38	5.26	1080
Chilliwack	308	10.22	134.0	959.7	15.22	50.95	7.24	na
Comox	288	9.33	110.1	768.0	15.01	18.91	6.91	na
Dickson	272	9.11	191.6	810.5	15.29	24.89	7.04	1184
G.C.L.	272	9.11	191.6	810.5	15.29	24.89	7.04	1184
Henderson	316	9.17	302.0	466.0	12.54	87.41	15.42	na
Hobitan	310	9.06	268.3	443.9	12.42	71.31	18.59	na
Ian	302	7.89	118.2	401.6	13.28	13.66	4.85	676
Johanson	127	1.11	60.1	188.5	12.04	14.73	4.80	643
Kennedy	(316)	9.17	302.0	466.0	12.54	87.41	15.42	na
Kitwanga	170	4.33	49.0	411.1	12.68	23.55	3.86	1002
Lonesome	105	0.37	32.3	15.5	9.75	5.00	3.20	na
Long	(303)	(7.94	173.0	347.6	12.84	31.22	9.63	na
Meziadin	170	4.33	49.0	411.1	12.68	23.55	3.86	1002
Morice	229	6.67	188.7	584.1	13.81	40.06	10.16	923
Muchalat	288	9.33	110.1	768.0	15.01	18.91	6.91	na
Nimpkish	303	7.94	173.0	347.6	12.84	31.22	9.63	na
Owikeno	303	7.94	273.0	347.6	12.84	45.68	9.62	na
Paterson	280	8.94	154.0	739.0	14.82	25.49	5.08	1164
Silver	200	7.83	112.5	867.4	15.65	21.00	4.19	na
Sproat	272	9.11	191.6	810.5	15.29	24.89	7.04	1187
Swan	170	4.33	49.0	411.1	12.68	23.55	3.86	1002
U. Nanaimo	322	10.56	93.0	945.0	15.14	27.51	6.30	1305
U. Quinsam	280	8.94	154.0	739.0	14.82	25.49	5.08	1164
Widgeon	285	8.94	221.2	513.0	14.65	47.90	10.92	994

TABLE 32

Comparison of Euphotic Zone Depths, Thermocline Depths, pH, Total Dissolved Solids and Nutrient Levels

Lake	EZD (m)	TCD (m)	pH (E)	pH (H)	TDS (E)	TDS (H)	NO_3 (E)	NO_3 (H)	PO_4 (E)	PO_4 (H)	Seechi
Alastair	12.3	11.0	6.57	5.81	6.3	8.0	0.145	7.180	0.010	0.019	5.6
Babine A	12.0	16.0	8.40	7.97	51.0	50.3	3.830	5.530	0.055	0.059	6.0
Babine B	16.1	25.0	8.64	8.56	49.5	49.0	3.295	5.490	0.047	0.024	7.3
Chilko	18.9	16.0	7.17	7.17	31.3	31.7	0.750	1.003	0.022	0.026	8.6
Chilliwack	37.4	8.0	7.14	6.83	14.3	15.7	2.607	5.220	0.015	0.043	17.0
Comox	22.0	18.0	7.70	7.79	22.0	22.0	1.030	3.170	0.034	0.032	10.0
Dickson	15.4	8.0	7.92	6.89	23.0	26.0	0.160	0.780	0.048	0.019	7.0
G.C.L.	32.6	8.0	7.96	8.44	19.3	19.0	0.100	2.270	0.014	0.024	14.8
Henderson	18.7	16.0	7.14	6.54	60.5	159.5	0.338	1.850	0.030	0.024	8.5
Hobitan	19.8	7.0	6.82	6.24	16.0	14.0	0.100	1.885	0.022	0.048	9.0
Ian	6.6	15.0	6.10	5.86	18.5	19.0	1.240	1.860	0.029	0.010	3.0
Johanson	35.9	16.0	7.73	8.77	30.0	32.0	0.126	3.470	0.010	0.026	16.3
Kennedy A	19.8	4.0	7.52	7.23	23.0	20.5	0.133	2.255	0.010	0.040	9.0
Kennedy B	13.2	8.0	7.60	6.98	19.0	17.0	0.100	1.600	0.090	0.121	6.0
Kitwanga	8.1	8.0	7.79	--	64.7	--	0.100	--	0.065	--	3.7
Lonesome	28.2	13.0	7.52	7.26	22.7	28.7	0.100	0.870	0.023	0.045	12.8
Long A	14.1	16.0	6.33	6.04	5.7	6.6	0.978	5.535	0.024	0.015	6.4
Long B	10.8	16.0	6.21	5.93	5.7	7.2	0.490	4.300	0.033	0.013	4.9
Meziadin	17.6	8.0	7.68	8.48	51.0	53.3	6.060	15.050	0.018	0.039	8.0
Morice	16.9	27.0	7.56	8.43	23.4	23.0	1.388	3.620	0.014	0.030	7.7
Muchalat	14.7	12.0	6.79	6.11	11.5	11.0	1.385	2.465	0.011	0.025	6.7
Nimpkish	20.5	24.0	7.39	7.26	17.5	18.0	1.950	2.620	0.023	0.022	9.3
Owikeno	6.4	44.0	6.35	6.12	9.3	41.0	0.938	13.300	0.034	0.065	2.9
Paterson	15.6	6.0	7.57	6.84	36.0	34.5	1.020	2.640	0.036	0.032	7.1
Silver	20.5	--	7.20	--	39.0	--	3.640	--	0.018	--	6.0
Sproat A	27.9	9.0	8.35	8.19	34.8	34.0	0.108	2.380	0.031	0.053	12.7
Sproat B	36.3	9.0	8.12	8.10	32.5	33.0	0.133	1.255	0.015	0.022	16.5
Swan	20.5	11.0	8.38	7.49	22.7	22.0	0.163	1.490	0.042	0.037	9.3
U. Nanaimo	16.5	11.0	6.96	6.90	24.3	24.0	0.239	0.700	0.011	0.011	7.5
U. Quinsam	24.2	8.0	7.16	7.27	29.3	28.0	0.100	0.220	0.025	0.052	11.0
Widgeon	41.8	2.0	5.60	5.28	3.4	3.7	5.060	7.560	0.013	0.176	19.0
MEAN	20.0	13.3	7.34	7.13	26.4	29.4	1.220	3.725	0.028	0.040	9.0

Comparison of Standing Crops, Taxonomic Composition and Species Diversity Indices for Phytoplankton Communities

Lake	% Chlorophyta	% Cyanophyta	% Pyrrophyta	% Chrysophyta	% Bacillariophyceae	Cells / ml	S.D.I.
Alastair	13.4	----	1.1	1.1	84.4	5432.7	0.875
Babine A	30.5	40.5	----	0.7	23.7	397.5	2.556
Babine B	31.7	30.5	----	2.5	26.8	248.8	3.071
Chilko	----	40.1	----	----	59.9	15.2	1.519
Chilliwack	20.0	35.0	10.1	15.0	5.0	60.6	2.646
Comox	----	+	5.0	20.0	55.0	60.5	2.599
Dickson	----	----	4.7	19.0	47.8	63.6	3.247
G.C.L.	----	----	1.8	2.7	93.6	953.9	0.533
Henderson	25.3	+	3.3	2.2	64.8	276.1	1.827
Hobitan	20.2	31.9	5.3	10.6	9.6	285.5	3.172
Ian	33.5	----	----	----	66.5	18.2	1.496
Johanson	1.5	----	3.0	19.4	71.7	203.2	2.433
Kennedy A	1.0	20.6	10.3	11.3	45.4	294.3	2.464
Kennedy B	5.5	13.7	4.1	20.5	50.7	221.5	2.599
Kitwanga	28.3	----	1.0	11.1	49.5	300.2	2.217
Lonesome	----	----	+	42.4	18.1	100.0	2.678
Long A	23.6	----	35.3	11.8	5.8	51.6	2.714
Long B	12.4	----	37.8	12.4	----	24.1	2.402
Meziadin	----	----	----	44.5	38.6	54.6	2.016
Morice	12.6	----	----	67.9	13.8	263.9	1.753
Muchalat	----	----	----	50.0	50.0	18.2	1.915
Nimpkish	----	----	----	7.6	92.4	39.4	1.138
Owikeno	91.1	----	----	2.5	1.2	239.7	0.594
Paterson	5.8	----	+	20.7	61.8	103.0	2.761
Silver	----	----	+	84.3	3.1	97.1	0.863
Sproat A	2.1	----	4.2	25.0	50.0	145.6	2.113
Sproat B	8.4	----	8.2	16.6	58.3	72.8	1.862
Swan	27.3	9.0	----	----	27.3	33.3	2.660
U. Nanaimo	25.0	5.2	----	14.7	45.7	880.2	2.829
U. Quinsam	31.6	10.6	----	10.4	42.2	57.6	2.403
Widgeon	----	+	+	----	----	5.0	0.000

Comparison of Standing Crops, Taxonomic Composition and Species Diversity Indices for Zooplankton Communities

Lake	% Cladocera	% Calanoid Copepods	% Cyclopoid Copepods	% Rotifera	Standing Crop / m^2	Settled Vol. (ml)	Spec. Div. I
Alastair	10.0	-	81.2	8.8	72,713	4	1.305
Babine A	1.1	15.4	76.0	7.5	102,040	18	1.304
Babine B	-	27.7	60.6	11.6	164,960	24	1.649
Chilko	5.9	36.1	56.4	1.4	170,800	21	1.398
Chilliwack	36.8	20.4	31.4	11.4	53,500	18	2.160
Comox	29.8	15.4	31.5	23.3	55,020	12	2.880
Dickson	61.0	17.6	27.2	3.6	8,891	2	2.597
Great Central	14.0	0.3	38.8	46.9	7,327	3	3.569
Henderson	49.5	5.3	4.4	40.8	36,104	5	1.618
Hobitan	1.3	9.5	85.7	3.4	46,480	5	0.860
Ian	19.0	6.1	71.4	3.4	29,400	6	1.432
Johanson	7.6	-	15.6	76.8	33,750	2	1.658
Kennedy A	28.8	19.8	40.9	10.4	40,215	30	2.166
Kennedy B	47.6	14.8	33.0	4.6	34,947	15	1.767
Kitwanga	23.7	1.5	29.4	45.4	45,990	7	2.469
Lonesome	67.2	4.7	9.0	19.1	27,803	15	2.094
Long A	76.2	8.6	15.2	-	9,880	2	1.086
Long B	68.0	7.1	24.7	-	24,372	2	1.368
Meziadin	6.6	5.3	71.9	16.3	199,200	12	1.437
Morice	2.1	0.1	56.2	35.2	38,129	6	1.637
Muchalat	19.6	4.8	55.6	20.1	48,938	6	2.194
Nimpkish	21.2	29.5	39.6	9.7	3,491	1	2.375
Owikeno	1.7	58.9	38.2	1.1	28,170	6	1.369
Paterson	36.8	19.2	23.6	20.4	30,570	14	3.161
Silver	2.1	0.2	6.1	91.6	15,292	2	1.596
Sproat A	40.7	-	55.4	4.0	56,687	6	1.824
Sproat B	18.2	0.4	49.7	18.7	9,830	3	2.217
Swan	3.1	35.4	53.9	7.5	3,727	1	1.549
U. Nanaimo	12.8	34.2	27.8	25.3	42,369	12	2.768
U. Quinsam	25.3	25.0	41.9	7.8	67,072	21	2.461
Widgeon	12.7	60.8	8.0	18.6	35,537	24	1.921

TABLE 35

MEAN ESCAPEMENTS FOR ANADROMOUS SALMONIDS

LAKE	SOCKEYE	SPRING	COHO	CHUM	PINK	STEELHEAD
ALASTAIR	1,637	318	7,465	667	2,841	+
BABINE	515,853	2,651	3,935	31	61,876	481
CHILKO	195,000	3,767				571
CHILLIWACK	128	215	4,543	31,667	130,000	2,608
COMOX[a]	20	954	5,607	36,280	1,843	1,500
DICKSON						
G.C.L.	38,793⊕	+	+	+	+	+
HENDERSON	46,600	523	1,227	2,977	400	350
HOBITON	4,660		61	4,647		
IAN	2,298		3,802	29,321	2,863	
JOHANSON	337					
KENNEDY A	16,463		3,267			
KENNEDY B	5,050	443	1,388	205		
KITWANGA	130	71	357	158	115,267	50
LONESOME	43,000	22,033	34,333	44,400	781,200	+
LONG	91,033	493	1,011			
MEZIADIN	107,515	958	3,460		80	
MORICE	3,667	6,378	2,873		2,878	917
MUCHALAT	3,281	1,490	4,317	3,300	973	3,500
NIMPKISH	98,667	5,977	17,847	22,464	5,435	+
OWIKENO	482,458	2,911	2,179	10,290	1,173	+
PATERSON[a]	20	717	3,953	1,053	10,340	578
SILVER			51	179	869	324
SPROAT	34,784⊕	+	+	+	+	+
SWAN	1,229	47	565			
U. NANAIMO[a]		1,353	2,550	25,833		1,075
U. QUINSAM[a]	54	36	3,700	503	2,197	+
WIDGEON[a]	760		573	415		

⊕ Combined numbers for other species are available for the whole of the Somass River system in Table 7-5A.

[a] The runs listed for these lakes run into the systems draining the lakes but spawn below the lakes.

TABLE 36

	DRAINAGE AREA (Km^2)	DEGREES INCLINE	EPILIMNION VOLUME (10^6 M^3)	TOTAL VOLUME	WATER RESIDENCE TIME (Yr.)	% EPI. FL. IN GR. SEASON	MAX. 24 % EPI. FL. IN G.S.
ALASTAIR	85.8	31.0	67.5	175.	1.05	48.1	5.70
BABINE	10,000.	3.9	7,435.	27,010.	16.2	5.5	1.80
CHILKO	1952.	19.4	2,557.	23,082.	71.3	5.6	2.36
CHILLIWACK	225.	22.7	92.	703.	3.56	81.5	11.58
COMOX	437.6	18.3	255.	892.	3.27	18.4	6.72
DICKSON	267.	5.3	2.45	2.5	0.016	830.	234.
G.C.L.	308.	15.5	408.	10,200.	33.9	9.6	2.71
HENDERSON	144.	24.5	259.	1,845.	6.15	33.5	5.91
HOBITON	47.7	15.4	24.	129.	1.98	71.9	23.2
IAN	243.	10.2	215.	615.	5.30	6.2	2.22
JOHANSON	42.3	15.3	17.4	22.9	1.78	18.1	5.90
KENNEDY A	128.	18.5	65.	848.	3.85	98.1	17.3
KENNEDY B	363.	9.5	311.	1,166.	2.73	39.8	7.02
KITWANGA	516.4	8.5	38.	52.	0.56	118.	19.3
LONESOME	825.	26.0	37.	52.	0.27	80.3	51.4
LONG	369.	23.7	237.	1,160.	2.70	32.8	10.1
MEZIADIN	674.	9.8	233.	1,399.	10.7	27.0	4.43
MORICE	1,843.	20.3	2,579.	10,327.	4.90	17.3	4.39
MUCHALAT	162.6	21.9	59.	183.	1.60	33.2	12.1
NIMPKISH	1,648.	14.8	817.	5,471.	3.87	31.2	9.63
OWIKENO	3,621.	27.8	3,755.	16,510.	2.21	21.8	17.1
PATERSON	32.3	3.9	7.94	15.5	1.12	28.8	5.74
SILVER	241.	27.3	4.17	4.1	0.021	905.	181.
SPROAT	327.	21.9	456.	3,208.	8.03	11.4	3.22
SWAN	145.	1.4	266.	636.	39.3	2.9	0.48
U. NANAIMO	240.	20.5	18.5	40.3	0.296	218.	49.9
U. QUINSAM	65.9	8.8	28.8	52.3	1.37	21.9	4.36

TABLE 37

COMPARISON OF SEECHI DISC READINGS

LAKE	SEECHI DISC DEPTH (m)
Alastair	5.6
Babine A	6.0
Babine B	7.3
Chilko	8.6
Chilliwack	17.0
Comox	10.0
Dickson	7.0
Great Central	14.8
Henderson	8.5
Hobitan	9.0
Ian	3.0
Johanson	16.3
Kennedy A	9.0
Kennedy B	6.0
Kitwanga	3.7
Lonesome	12.8
Long A	6.4
Long B	4.9
Meziadin	8.0
Morice	7.7
Muchalat	6.7
Nimpkish	9.3
Owikeno	2.9
Paterson	7.1
Silver	6.0
Sproat A	12.7
Sproat B	16.5
Swan	9.3
U. Nanaimo	7.5
U. Quinsam	11.0
Widgeon	19.0

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