Eutsuk Lake Rainbow Trout: Biology, Population Significance and Fishery Management

prepared by:

Joseph S. De Gisi
Box 2518
Smithers, BC
V0J 2N0

for:

BC Parks Skeena District
Box 5000
Smithers, BC V0J 2N0

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1. Introduction

Eutsuk Lake is located near the headwaters of the Nechako River, on the eastern margin of the Coast Mountain ranges within North Tweedsmuir Provincial Park. The lake supports rainbow trout which grow as large as 6.5 kg. These fish are the basis of a quality recreational fishery during the summer months.

Available information suggests "trophy" rainbow trout in Eutsuk Lake are pelagic predators which grow large by consuming kokanee. The size of these piscivorous rainbow trout allows them to forage widely in search of suitable food. They attack aggressively, from long reactive distances, to capture large prey which are capable of escape. These components of their feeding behavior increase their angling catchability.

Elsewhere in British Columbia, individuals of this form of rainbow trout typically attain body sizes which make them harvestable by angling at age 3 years. However, reproductive maturity may not occur until age 5 years or later. Their angling catchability and years of vulnerability before first reproduction make this type of trout particularly prone to decline due to fishing.

Eutsuk Lake is the largest lake in British Columbia not presently road accessible, but is subject each year to angling pressure from camping visitors who reach the lake by motorized boat through the adjacent Nechako Reservoir. Guided and unguided angling clients of two fishing lodges located in the on Eutsuk Lake arrive by air or by boat, and constitute a substantial additional component of angling exploitation.

The possible rarity of pelagic piscivorous rainbow trout populations within the province, and their vulnerability to angling impacts, require that BC Parks develop an appropriate framework for management the Eutsuk Lake sport fishery. Management objectives should include maintaining characteristics of abundance and population size structure of Eutsuk Lake rainbow trout, and the quality recreational experience of angling for these large fish.

In support of the development of a management framework for Eutsuk Lake, this document attempts to answer the following five questions using available information.

1. What is the relative rarity of piscivorous rainbow trout populations in British Columbia and elsewhere?

2. How do the life history characteristics of the Eutsuk Lake population and apparent productivity of Eutsuk Lake compare to other British Columbia populations of this ecotype and the lakes where they occur?

3. Are there known habitats or habitat attributes of this rainbow trout population, located within or adjacent to the park, which may require focused management?

4. How are sport fisheries exploiting other populations of this type managed in British Columbia?

5. What information about post-release angling mortality of trout and salmon is available from published studies?

Contingent on the answers to the first five questions, information is interpreted to provide responses to three additional questions about the present and future management of the Eutsuk Lake fishery.

6. Based on available information, is it possible to confidently assess whether the current management of Eutsuk Lake rainbow trout angling will provide long-term sustainability of both population abundance and size of angled trout?

7. If available information is insufficient, what supplementary data should be sought to allow management of the population?

8. In the absence of supplementary data, what would be a prudent approach to management of the rainbow trout fishery?

1.1. Document Organization

This document is intended to be useful to readers with a wide variety of backgrounds in fish biology and resource management. In order to maintain readability, some technical information and analyses are confined to appendices. Definitions for terms which may not be general knowledge for non-biologists, and explanation of other concepts specific to the field of recreational fishery management are provided in the following section of this introduction.

1.2. Concepts and Definitions

The *pelagic piscivorous rainbow trout ecotype*, particularly as it occurs in Eutsuk Lake, is the subject of this report. A lake's p*elagic* zone is the open water away from the influence of the lake shore and bottom -- the term *limnetic* is also sometimes used in this context. *Piscivorous* refers to animals which feed extensively upon fish[1], but does not imply that fish alone are eaten. All rainbow trout begin their life consuming small insects and other invertebrates but become omnivores as they grow, in the sense that other prey items such as fish eggs and fry may also be ingested. Conversely, insects and plankton are still consumed at least occasionally by even the largest piscivorous rainbow trout. In fact, stomachs of large piscivorous trout often contain only insects when examined by anglers (Parkinson et al. 1989); these trout may seasonally specialize on surface insects for a brief period when abundance is high. What distinguishes the pelagic piscivorous rainbow trout ecotype from other lake-dwelling insectivorous or omnivorous rainbow trout ecotypes is that an annual budget of the caloric intake of piscivorous rainbow trout would be dominated by fish prey, which would not be the case for other ecotypes.

An *ecotype* is a population which differs from adjacent populations of the same species in terms of quantitative characteristics such as morphology, coloration, physiology or life history (Taylor and Haas 1996). The term *life history* is applied fairly flexibly in population biology, but usually includes demographic traits as well as general behavioural ("lifestyle") characteristics. Demographic traits could include age or size at first

[1] Contrasted, for example with: *insectivorous*, referring to animals which consume mostly insects, or *omnivorous*, referring to animals which ingest a wide variety of food items.

reproduction, longevity, frequency of reproduction, and fecundity, to name but a few. For salmonid[2] fish, examples of lifestyle characteristics that are usually considered elements of life history would include anadromy or other regular migration patterns, pelagic or inshore habitat occupation, feeding specialization, and so forth.

The pelagic piscivorous rainbow trout ecotype occurs in widely scattered lakes in British Columbia. The ecotype has likely evolved independently in the lakes where ecological conditions have permitted it, in the millennia following post-glacial recolonization of these drainages by fish. Although the ecology of Eutsuk Lake pelagic piscivorous rainbow trout may be most comparable to the large piscivorous trout of Kootenay Lake or Okanagan Lake, the Eutsuk Lake piscivorous trout are almost certainly genetically more similar to their nearby non-piscivorous neighbors in other small lakes and streams of the upper Nechako drainage (McCusker 1999; Tamkee 2002; Docker and Heath 2002).

Piscivorous lake-resident rainbow trout are thought to have evolved morphology which is related to their specialization on fish as prey. For instance, piscivorous rainbow trout have larger heads and mouths, on average, when compared to similar-sized rainbow trout from non-piscivorous populations. A large head and mouth is presumably advantageous to trout feeding on large prey such as kokanee, but would be a disadvantage to those which specialize on smaller invertebrate foods. These differences in morphology between individuals of different rainbow trout populations are apparently due to genetics and rearing environment acting simultaneously (Keeley 2002). Experienced anglers generally are familiar with such differences in appearance between rainbow trout populations.

Multiple rainbow trout populations (also known as stocks) which spawn in distinct streams presumably coexist as older juveniles and adults in Eutsuk Lake. If typical, these stocks exhibit homing to their stream of origin for spawning, with some exchange of straying spawners reproducing elsewhere than their natal stream. The Eutsuk Lake stocks of distinct tributary origin may exhibit different life history characteristics including growth rate, size and age at maturity, and possibly dietary specialization. In other words, more than one ecotype of rainbow trout may occur in Eutsuk Lake, as has apparently been observed in other large rainbow trout lakes in British Columbia such as Babine, Kootenay, and Arrow.

Homing to distinct spawning streams with minimal straying maintains a degree of reproductive isolation between the stocks, allowing retention of a genetic component to specialized behaviors or demographic traits. When straying is common enough to potentially affect population dynamics in the short term, the population structure is known as a ***metapopulation*** (Cooper and Mangel 1999). The population structure of rainbow trout stocks in large British Columbia lakes has not been studied in detail. Given that rainbow trout mating tends to occur assortatively by body size and that some degree of genetic adaptation appears associated with pelagic piscivory, it seems unlikely that pelagic piscivorous stocks are typically elements of a lake-wide metapopulation.

Productivity of a lake usually refers to the biomass of a particular trophic level[3] which the lake can produce, per unit area and time. Other things equal, nutrient supply drives aquatic productivity in temperate lakes, and phosphorus or nitrogen are most often the limiting nutrients. Conductivity or total dissolved solids of a water sample are more easily

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[2] Salmonids include fish of the family *Salmonidae*: salmon, trout, char, whitefish and grayling
[3] for example planktonic plants, or invertebrates, or fish

determined and provide a rough index of lake productivity. Lakes in British Columbia vary widely in terms of their nutrient concentrations and productivity, largely due to the surrounding bedrock and soils along with climate. At a given level of nutrient supply, deep lakes tend to be less productive because the nutrients sink out of the biologically-active upper layer of the lake. Coastal lakes also tend to be less productive as the granitic bedrock in their watersheds is nutrient-poor. Organic staining and glacial turbidity reduce productivity by interfering with light penetration and photosynthesis. The maximum size of fish produced by a lake has no connection to the lake's productivity, as some of the least-productive lakes yield the largest freshwater fish. In such cases, however, the large fish are not abundant and require many years' growth to reach large body size. It is important to recall that when they return to freshwater to spawn, salmon and sea-run trout have incorporated into their biomass the biological production of huge areas of coastal and open ocean. Freshwater-resident salmonids do not have the opportunity to "mine" the productivity of the oceans, but must produce biomass in the relatively limited area of the lake in which they dwell.

The piscivorous rainbow trout ecotype is not the only non-anadromous rainbow trout ecotype capable of producing large-bodied individuals. Non-piscivorous rainbow trout can also regularly reach weights exceeding 3 kg in productive lakes, where invertebrate prey are abundant due to nutrient supply and fish population density is limited by other factors. Pothole lakes in the Kamloops area of British Columbia are an example of this type of situation. Rainbow trout also grow large in some North American lakes and streams by consuming salmon eggs and emerging salmon fry which are seasonally concentrated near spawning or smolting locations. As well, wherever rainbow trout exist, lakes do occasionally produce individuals which are much larger than average for the population. These unusual individuals may develop because of faster growth, extraordinary longevity, or both. Notwithstanding all of these situations, a variety of evidence suggests that a year-round diet of kokanee or young sockeye salmon is the general factor which allows non-anadromous rainbow trout to routinely grow to large size in deep unproductive lakes in British Columbia.

2. Sources and Methods

This report principally comprises a review and interpretation of prior sampling efforts, field studies, and visitor use data for Eutsuk Lake, and similar data for other lakes which may support the pelagic piscivore ecotype. A minor amount of additional information for Eutsuk Lake was obtained opportunistically during a fly-by of the area on 17 July 2002. Sources are detailed next, for each of the first five questions posed in the introduction.

2.1. Occurrence of the Large Lake Piscivore Ecotype

Interviews of one fishery biologist in each British Columbia Ministry of Water, Lands and Air Protection region were conducted by telephone. Biologists were provided with a description of the pelagic piscivorous rainbow trout ecotype and asked to provide a list of lakes which are believed to support the ecotype, and to comment on the biology and management of these populations. In Skeena Region, other persons with knowledge of regional fish populations were also questioned about the occurrence of this ecotype.

2.2. Life History of British Columbia Piscivorous Rainbow Trout

2.2.1. Eutsuk Lake Fish Population and Habitat Datasets

Due to its remote location and inaccessibility to anadromous salmon, Eutsuk Lake has received minimal attention from federal or provincial government agencies which compile information for the management of freshwater ecosystems in British Columbia. The lake's fish and fish habitat were investigated very superficially by the provincial Fish and Game branch, during a 1951 survey of Nechako River headwater lakes prior to the completion of the Kenney and Skins dams (Lyons and Larkin 1952). The next recorded sampling of Eutsuk Lake occurred in 1982, when aquatic inventory of a number of waters in North Tweedsmuir was undertaken by the provincial Water Management Branch (Norris and Grant 1982). The 1982 inventory was incomplete relative to the contemporaneous standard for lake survey. Substantial attention was given to fish population sampling with gillnets but water chemistry data were not collected, a full bathymetric survey was not made, and investigation of the adjacent stream reaches was not completed. During 1996 and 1997, Eutsuk Lake was sampled by fisheries and limnological consultants to the Skeena Region of Ministry of Environment, as a control lake for assessing the potential impact of submerged timber salvage on the Nechako Reservoir.

The following sections provide more detailed information about the rainbow trout datasets which resulted from pre-existing surveys and other sampling efforts on Eutsuk Lake.

2.2.1.1. Lake Survey 1982

B.C. Fisheries Branch standard multi-mesh sinking gillnets were utilized to sample Eutsuk Lake fish during the reconnaissance inventory conducted from August 24 to 27, 1982. Nine daytime sets of duration 3.4 to 5.9 hr and 3 overnight sets of 15.3 to 17 hr, for a total of 67.7 hr soak time, yielded 56 rainbow trout. For 41 of the rainbow trout and 2 additional angled fish, biological data including length, weight, sex, maturity and age were obtained. Ages were estimated by D. Bustard from scales.

Other fish species which were captured in Eutsuk Lake during this survey included kokanee (*Oncorhynchus nerka*), mountain whitefish (*Prosopium williamsoni*), northern pikeminnow (previously known as northern squawfish; *Ptychocheilus oregonensis*), longnose sucker (*Catostomus catostomus*), and largescale sucker (*Catostomus macrocheilus*). Burbot (*Lota lota*) and unspecified sculpins (family Cottidae) were mentioned to have been captured during a previous survey in 1951.

2.2.1.2. Angling Guides 1982

The Eutsuk Lake file at BC Environment Skeena Region provides biological data for 72 rainbow trout captured by guided anglers during July and August 1982. Length, weight, and sex were obtained by the angling guides. Ages were estimated by M. O'Neil from submitted scales. No other information about the equipment or methods used to obtain these data is present in the file.

2.2.1.3. MELP Tagging 1986

Between June 16 and June 18, 1986, four BC Fisheries (Smithers) staff visited Eutsuk Lake to assess the recreational fishery and gather additional biological data. Each member of the group angled for 2.5 days (total of 10 angler days), and the group captured 22 rainbow trout ranging in size from approximately 35 to 65 cm. Seven trout were tagged and released, 3 died, and scale samples were taken from 5 fish with ages estimated by S. Hatlevik and G. Schultze.

2.2.1.4. Anglers 1994

Scale sample envelopes for 24 rainbow trout angled from Eutsuk Lake during the summer of 1994 were obtained from Skeena District of BC Parks. Samplers included D. Sutherland, M. Cressy, S. McTague and M. Mueller. The circumstances of collection and affiliation of the samplers is not known. The type of information recorded on the envelopes varied considerably but always included length and occasionally weight, though units were inconsistent and methods and equipment not recorded so precision and accuracy are doubtful. Scales from this collection were aged in March 2002 by C. Lidstone.

2.2.1.5. Hatfield Consultants 1997

Hatfield Consultants sampled Eutsuk Lake fish populations near the mouth of Bone Creek in July 1997, to provide reference data for a study of the impact of submerged timber harvest in the Nechako Reservoir (Winsby et al. 1998; Hatfield Consultants Ltd. 1999; Winsby and Taylor 1999). B.C. Fisheries Branch standard multi-mesh floating and sinking gillnets were deployed to captured 369 fish, of which 66 were rainbow trout. Length, weight, sex, maturity, gonad weight, liver weight, stomach weight, and ages structures were collected. Ages for Eutsuk Lake rainbow trout are not given in any of the documents resulting from the study, and the present location of the age structures could not be determined (Winsby 2002).

2.2.1.6. Keeley 1999

A total of 85 rainbow trout ranging in size from fry to adults were captured primarily by MELP standard experimental gillnet, during fieldwork on Eutsuk Lake led by E. Keeley of the University of British Columbia (UBC) in May and June 1999. Length, weight, sex, maturity and age were obtained for all fish captured; ages were estimated from scales by J. Scroggie. Morphometric[4] data and tissue samples for genetic analysis were also collected. This fieldwork on Eutsuk Lake rainbow trout occurred during a province-wide study of rainbow trout ecotype diversity, which included smaller lakes in North Tweedsmuir and adjacent areas of the Nechako watershed (Keeley 2002; Tamkee 2002). Rainbow trout specimens were deposited in the UBC Fish Museum; data analysis and preparation of publications for the primary literature were ongoing at time of writing of this document.

2.2.1.7. Miscellaneous Fish Data

The earliest data for Eutsuk Lake rainbow trout comprise 7 individuals sampled for length, weight, sex, maturity, and age during a 1951 survey of the lake. Length, weight, sex and age were recorded for 8 rainbow trout angled in 1983 (Eutsuk Lake file, Skeena Region). Perrin et al (1997) provided biological data for 5 rainbow trout sampled for length, weight and age which were captured at Eutsuk Lake by angling and assayed for mercury content.

2.3. Habitats Of Importance to Eutsuk Rainbow Trout

2.3.1. Eutsuk Lake Physiochemistry

Prior to 1997, a minimal quantity of physiochemical data was available to describe Eutsuk Lake's potential for fish production. Lyons and Larkin (1952) reported a single temperature-oxygen profile and one estimate of total dissolved solids in 1951, along with 31 mapped individual depth soundings. Neither standard water chemistry sampling (including temperature-oxygen profiles), nor a complete bathymetric survey, were carried out during the reconnaissance survey of the lake in 1982 (Norris and Grant 1982).

The first detailed water chemistry data for Eutsuk Lake was collected at a single sample station[5] on two dates in August and September 1996, as reported by Perrin et al. (1997). The data do not capture the lake's longitudinal (west to east) variation in water chemistry related to parent geology and inflow (Perrin et al. 1997), but likely provide a representative late-summer average for Eutsuk Lake.

2.3.1.1. Comparable Physiochemical Data

Water chemistry data for many other large British Columbia lakes which support anadromous sockeye, including several lakes where the piscivorous rainbow trout ecotype also occurs, have been compiled by the Department of Fisheries and Oceans (Shortreed et al. 2001). These data provide good scope for comparison with data for Eutsuk Lake and the Nechako Reservoir reported by Perrin et al. (1997).

[4] Countable or measurable physical characteristics of individual fish, for example head length, mouth width, number of gill rakers
[5] Served as a control site in a study of the likely impact of submerged timber salvage on water chemistry of the Nechako Reservoir

2.3.2. Adjacent Stream Habitat

Stream habitat potentially accessible for spawning and rearing by Eutsuk Lake rainbow trout has been examined on three recorded occasions. Lyons and Larkin (1952) provide overview comments on streams of the Eutsuk basin based on field observations made in July 1950 and July-August 1951. During August 1982, aquatic biophysical inventories were conducted on the Chezko River and the St. Thomas River systems by the Inventory Operations Unit (Inventory Operations Unit 1982). The results of these inventories were recorded on stream site cards and summarized on Aquatic Biophysical Maps; copies of the stream cards are filed in the Resource Atlas maintained at BC Parks Skeena District office in Smithers. In 1999, Keeley (2002) sampled many of the inlet streams to Eutsuk Lake as well as the outlet Eutsuk River[6]. His field notes were made available for consultation. Following additional discussion about potentially important spawning habitat, the Chezko River from Eutsuk Lake to the Tesla Creek[7] confluence and Tesla Creek upstream to Tesla Lake were examined from the air on 17 July 2002. Notable features of both of these rivers were photographed from the air. High-altitude aerial photos (series BCC 99030 and BCC99033) were also examined to determine approximate channel width of the Chezko River and to confirm the position of notable habitat features.

2.4. Management of Piscivorous Rainbow Trout in British Columbia

During telephone interviews of one fishery biologist in each Ministry of Water, Lands and Air Protection (WLAP) region, comments were requested regarding the management of any piscivorous rainbow trout populations identified.

The 2002-2003 British Columbia Freshwater Fishing Regulations Synopsis was also examined to determine how lake angling for wild native rainbow trout is regulated in the WLAP regions of the province.

2.5. Post-Release Angling Mortality of Salmonids

A literature review was conducted to allow a summary of research about hooking mortality in recreational fisheries for salmonids. Neither a comprehensive review of the primary literature nor a complete compilation of the gray literature were possible within the scope of this study. WLAP Skeena Region (Beere 2002) has compiled a file of reported studies on the effects of angling on released fish. Reports present in this file were reviewed, and additional relevant studies cited in the reviewed reports were obtained. The most recent five years' issues of the prominent North American fisheries journals were also scanned for pertinent papers. Studies of salmonids were given particular attention, as were results relating to recreational angling using trolling gear.

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[6] The British Columbia Geographic Names Information System (http://www.gdbc.gov.bc.ca/~bcnames/) does not provide a gazetted name for the short river which flows from Eutsuk to Tetachuck Lake. Lyons and Larkin (1952) refer to this river as the Eutsuk River so that name will be used herein. Redfern River is also occasionally used locally, but is not apparently an official name either.

[7] Tesla Creek is also shown on some maps as "Tesla River" but the latter name has been rescinded in favor of the former, according to the BC Geographic Names Information System

3. Results and Discussion

3.1. What is the relative rarity of this ecotype in the province?

At least 13 natural lakes in British Columbia and one lake in Washington state appear to support indigenous populations of the pelagic piscivorous rainbow trout ecotype (Table 1). Two hydroelectric reservoirs in British Columbia, Nechako and Arrow Lakes, are also known to support the ecotype as a result of flooding of large natural lakes where pelagic piscivorous rainbow trout occurred before impoundment (Table 1). Another 10 or more natural lakes and two flooded-lake reservoirs may also support indigenous populations of this ecotype not yet confirmed (Appendix I), though one or more of these populations may have been extirpated. In British Columbia, WLAP regions which appear to lack indigenous rainbow trout populations of this ecotype include Region 7B (Peace: Burrows 2002), Region 1 (Vancouver Island: Rimmer 2002), and Region 2 (Lower Mainland: Jesson 2002).

Firm categorization of lakes supporting the pelagic piscivorous rainbow trout ecotype is problematic for several reasons. Anecdotal reports of very large rainbow trout captured by angling are often the only evidence about the possible presence of this ecotype in a particular lake. Without data on the abundance and diet of large trout resident in a lake, the presence of significant number of pelagic piscivorous fish constituting a distinct stock cannot be assumed and alternative explanations must also be considered. Rainbow trout may be occasionally growing large by other mechanisms mentioned previously: seasonal feeding on salmon eggs and fry in riverine or littoral habitats, abundant invertebrate prey, or simply anomalous growth and longevity. In some cases, large trout could represent irregular adoption of the pelagic predator niche by a small subset of population members. Such fish would not represent a distinct ecotype if their life history was not typical of the stock, and different conservation and management issues would come into play as a result. Theory and available empirical evidence do not suggest that this latter scenario is common, but rainbow trout populations do appear to display polymorphic life histories in some cases[8], and general biology is still poorly known for many of the apparent examples of pelagic piscivorous stocks. In this document, pelagic piscivore lakes were characterized as 'confirmed' or 'unconfirmed' with these issues in mind, reflecting the subjective opinions of the biologists involved.

An additional difficulty in assessing the rarity of this ecotype is that no accepted classification of lake-resident rainbow trout ecotypes is presently available for British Columbia. Research is currently establishing a framework for this process (Parkinson and Rosenfeld 1996; Taylor and Haas 1996; Keeley 2002). Even if categories were established, inventory of lakes in the province is incomplete and it is unlikely that reconnaissance surveys will provide the data needed to distinguish ecotypes. Consequently, an objective assessment of the rarity of pelagic piscivory relative to other rainbow trout ecotypes cannot be made. Lake-spawning rainbow trout may be even less common than are pelagic piscivores, as may ecotypes with non-standard spawn timing. Other unusual ecotypes with recreational importance could also exist. Subjectively, the pelagic piscivore ecotype would appear to be rare relative to other recreationally significant rainbow trout ecotypes, including summer and

[8] for instance non-anadromous and anadromous life histories within the same rainbow trout populations (Zimmerman and Reeves 2000)

winter steelhead each of which is represented by hundreds of distinct populations in North America.

Information on possible indigenous occurrences of this ecotype outside of British Columbia was difficult to obtain. It does not appear that rainbow trout were native piscivores in the large natural lakes of Idaho, Oregon, Nevada and eastern Washington though Gerrard-origin rainbow trout have apparently naturalized in Lake Pend Oreille (Idaho) following outplants beginning in 1941. Stocked rainbow trout may have naturalized and occupied the pelagic piscivore ecotype in other such lakes and reservoirs in those states as well, and have certainly done so in the Laurentian Great Lakes and elsewhere introductions have occurred.

Rainbow trout are also native to Pacific drainages in Alaska as far northwest as the Kuskokwim drainage north of Bristol Bay. Sockeye nursery lakes in the Bristol Bay region appear to be candidates for additional occurrences of the ecotype. Iliamna Lake is known to support several rainbow trout stocks including a population which feeds on sockeye eggs and fry in the outlet river of the lake and grows to 9 kg. The degree to which any of the Alaskan populations has adopted pelagic piscivory is unknown (Haas 2002; Hasbrouck 2002).

Table 1. North American lakes with 'confirmed' indigenous populations of the pelagic piscivorous rainbow trout ecotype. Surface area unit is hectares, depth unit metres.

Lake	WLAP Region	Watershed	Drainage	Surface Area	Mean Depth	Max Depth
Nechako Res.	6	Fraser	Nechako	120,000	?	>300
Arrow Res.	4	Columbia	Columbia	52,600	83	287
Babine	6	Skeena	Babine	49,000	55	186
Kootenay	4	Columbia	Kootenay	40,700	102	154
Okanagan	8	Columbia	Okanagan	36,009	70	232
Shuswap	3	Fraser	Thompson	29,000	62	162
Quesnel	5	Fraser	Quesnel	26,400	158	530
Eutsuk	**6**	**Fraser**	**Nechako**	**24,500**	**106**[9]	**323**
Kamloops	3	Fraser	Thompson	6,203	74	151
Mabel	8	Fraser	Thompson	5,986	120	201
Bonaparte	3	Fraser	Thompson	3,901	40	98
Isaac	5	Fraser	Quesnel	3,273	60	174
Crescent	[Wash.]	Lyre	N/A	2,008	101	191
Tesla	6	Fraser	Nechako	1,903	41	108
Nadina	6	Fraser	Nechako	905	15	35
Khtada	6	Skeena	Khtada	605	66	158

[9] rough estimate only, from Lyons and Larkin (1952)

3.2. How do the characteristics of Eutsuk Lake piscivorous rainbow trout, and fish production environment of Eutsuk Lake, compare to other occurrences of this ecotype?

3.2.1. Life History

Life history characteristics of known pelagic piscivorous rainbow trout populations, including Eutsuk Lake, are summarized in Table 2. Length at age for Eutsuk Lake samples, several other such populations of this ecotype, and other non-piscivorous lacustrine rainbow trout populations in Skeena Region are given in Table 3 and depicted in Figure 1. Compiled data for Eutsuk Lake rainbow trout are provided in Appendix IV.

As mentioned previously, the multiple rainbow trout stocks which share Eutsuk Lake likely exhibit different life history characteristics. These may include growth rate, size and age at maturity, and possibly even dietary specialization. Gillnetting and angling of the lake have provided the only samples to date, and may have collected a mixture of the stocks rather than solely the pelagic piscivorous population. Means of distinguishing stocks cannot be applied to the existing Eutsuk Lake data. The minimal life-history information available must be interpreted with caution, and substantial uncertainty acknowledged.

Common elements of life history for this ecotype include reproductive maturity at age 5 to 7 yr or later, and weight at maturity in excess of 1.5 to 2 kg and occasionally much greater (Table 2). Maximum age is typically 9 to 10 years or older. Maximum size appears roughly correlated to lake surface area. In other words, the largest pelagic piscivorous rainbows tend to come from the largest natural lakes but there is considerable variation presumably driven by other factors.

Eutsuk Lake rainbow trout are longer at age than non-piscivorous populations in Tweedsmuir Park and elsewhere in Skeena Region (Figure 1). Babine Lake piscivore spawners exhibited mean length at age which was similar to Eutsuk Lake, but Kootenay Lake piscivores appear to grow more rapidly from age 4 yr onward. Differences in methods of collection of these data, and in the persons conducting the ageing, constrain the comparability.

Age at maturity for the Eutsuk Lake population of this ecotype must be considered highly uncertain at present. Nearly all of the large individuals for which scale samples have been collected to date were captured by angling, and no assessment of their gonadal maturity was made. Analysis of the scale samples showed that several individuals appeared to display patterns indicative of first spawning at age 5 (1 fish), age 6 (3 fish) or age 7 (2 fish). Other individuals, some as old as 9 years, showed no apparent spawning checks. Keeley (2002) netted relatively few large individuals in May/June of 1999 (Appendix IV), but did capture 4 females he classified as mature: age 4 (1 fish), age 5 (2 fish), and age 7 (1 fish). The dates which he netted may have fallen during the spawning period, in which case many of the mature fish could have already migrated to streams in preparation.

Estimated spawning numbers for populations of the ecotype in other lakes range from 70 to 1200. These spawning numbers comprise escapements after several years' exposure to recreational fisheries in the lakes. Where information exists, it appear that some pelagic piscivorous stocks withstand exploitation rates of up to 90% (total, not annual) from their entry to the fishery to their age of first reproduction (Parkinson 2002).

When spawning locations are known, pelagic piscivores are believed to originate from one or two spawning streams despite the presence of a large number of other inlets to the lakes they inhabit. The spawning sites utilized by these stocks are occasionally located below lake outlets, and usually in watersheds with several lakes upstream. Additional information exists about the spawning and rearing areas utilized by some of the populations. The desirability of collecting equivalent information for Eutsuk Lake is discussed in greater detail in Section 3.4.

3.2.2. Fish Production Environment

Fish community characteristics of lakes supporting pelagic piscivorous rainbow trout are summarized in Table 4. Kokanee are present in all lakes known to support the ecotype. Pelagic piscivorous rainbow trout co-exist with pelagic piscivorous large-bodied char such as bull trout and lake trout in 8 of the lakes, and anadromous fish access occurs or historically occurred to about half of the lakes as well. The Eutsuk Lake fish community is depauperate relative to many of the lakes with pelagic piscivores. Eutsuk supports few fish species and no piscivorous char or anadromous fish access.

Limnological data for pelagic piscivorous rainbow trout lakes are presented in Table 5, along with surface area, mean and maximum depth which were given in Table 1. Histograms of selected parameters are displayed in Figure 2 . Eutsuk Lake is intermediate in surface area, but among the most nutrient-poor of the lakes supporting the ecotype: though Eutsuk drains to the interior, the parent geology of the area leads to water chemistry which is more representative of coastal lakes. Chlorophyll-a concentration is also very low, indicating a low standing biomass of phytoplankton suggestive of ultra-oligotrophic status. Eutsuk Lake's extreme water clarity (euphotic zone depth) results from the relative lack of phytoplankton biomass as well as other factors such as minimal staining or non-organic turbidity. The combination of light penetration and deep thermocline does give Eutsuk Lake a large epilimnetic volume for primary production to occur, which could partially compensate for the poor nutrient supply.

Summary of biophysical characteristics presented here neglects the thermal budget of the lakes. Insufficient comparable data were available. Eutsuk Lake is colder than many of the other lakes supporting the pelagic piscivorous ecotype, but temperature by itself is probably relatively unimportant in determining the production characteristics of these lakes.

Considerable information exists about kokanee abundance and life history in several other lakes which support the pelagic piscivorous rainbow trout ecotype. Data for kokanee in Eutsuk Lake are presently lacking. The utility of better physiochemical and biological information about the fish production environment of Eutsuk Lake is also discussed in greater detail in Section 3.4.

In addition to the character of the lacustrine environment, in some situations the quantity of accessible spawning and stream rearing habitat can also limit the production potential of lake-dwelling rainbow trout stocks. This type of data is currently unavailable for Eutsuk Lake but is needed for a full understanding of the lake's fishery potential.

Table 2. Life history characteristics of North American indigenous populations of the pelagic piscivorous rainbow trout ecotype, in descending order of lake surface area. UN = value unknown due to insufficient data; blanks indicate data is likely available elsewhere. Weight unit is kg, ages are years. Two values given in a particular cell on distinct rows (e.g., Quesnel Lake) correspond to two distinct stocks in a given lake.

Lake	**Typical Age at First Maturity**	**Typical Weight at First Maturity**	**Max Weight To Date**	**Max Age To Date**	**Estimated Spawning Number**	**Primary Known Spawning Location(s)**
Nechako Res.	UN	UN	7	UN	UN	UN
Arrow Res.	UN	UN	14	UN	~ 1000 (pre-impound)	Camp Ck, Tonkawatla Ck, Columbia R?
Babine	>5	>1.5	12	10+	500	Sutherland R and its tributary Duncan Ck
Kootenay	5 to 6	2 to 4	14	9+	800-1200	Lardeau R at Trout Lk outlet; Duncan R (now inundated)
Okanagan	5 to 6	3 to 7	10		300-500	Mission Ck
Shuswap	5 to 7	3.5	9	9?	500-1000	Eagle R; Scotch Ck
Quesnel	6 to 7 5	4;	>12			McKinley Ck; Mitchell R
Eutsuk	**UN**	**UN**	**7**	**10+**	**UN**	**UN**
Kamloops	5 to 6	2.5 - 3	5.5	UN	low 100s	Barriere R (outlet of North Barriere Lk)
Mabel	5 to 6	UN	>4.5	UN	200-400	Duteau Ck
Bonaparte	UN	UN	4	UN	UN	Bonaparte R (Bonaparte Lk outlet)
Isaac	6	UN	7.5	UN	UN	Cariboo R (outlet of Isaac Lk)
Crescent	4 to 6[10]	2.5	10.4	9+	70-318	Lyre R
Tesla	UN	UN	6	UN	UN	UN
Nadina	UN	UN	UN	UN	UN	UN
Khtada	7 to 8	2	5.5	9+	UN	Khtada R

[10] ages questionable, probably low by one year or more based on later data

Table 3. Length at age data for selected piscivorous and non-piscivorous rainbow trout populations. The first three rows (in italic font) are not believed to include pelagic piscivorous populations. Lake Crescent data were converted from total length by the formula FL = 0.87 TL. A variety of means (e.g. creel survey, gillnetting, enumeration weirs) were used to collect the fish from which these data were estimated, and aging was conducted by a large number of different individuals, so comparisons should be cautious.

Water	Reported		Age (yr)							
			3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Region 6 non-piscivore lakes	*unpublished*	Fork Length (cm)	*23*	*27*	*30*	*32*	*35*	*40*		
Tweedsmuir lakes (non-piscivore)	*Keeley 2002*		*22*	*27*	*30*	*35*		*35*		
Babine (all stocks; back-calculated from scales)	*Griffiths 1968*					*38*	*44*	*47*	*51*	*55*
Babine (Sutherland)	David Bustard and Associates 1990					50	53	62	72	74
Eutsuk	Appendix V of this document		31	38	45	52	59	65		76
Nechako Res.	Perrin et al. 1997		36	42	46	57	64			
Arrow Res.	Sebastian et al. 2000		27	38	42	53	66	88		
Kootenay (back-calculated from scales)	Cartwright 1961		27	43	58	70				
Khtada	unpublished		17	26	35	38	50	58	59	
Lake Crescent 1949-52	Meyer and Fradkin 2002		40	44	58	66				
Lake Crescent 1996-99	Meyer and Fradkin 2002			34	41	45	58	53	54	

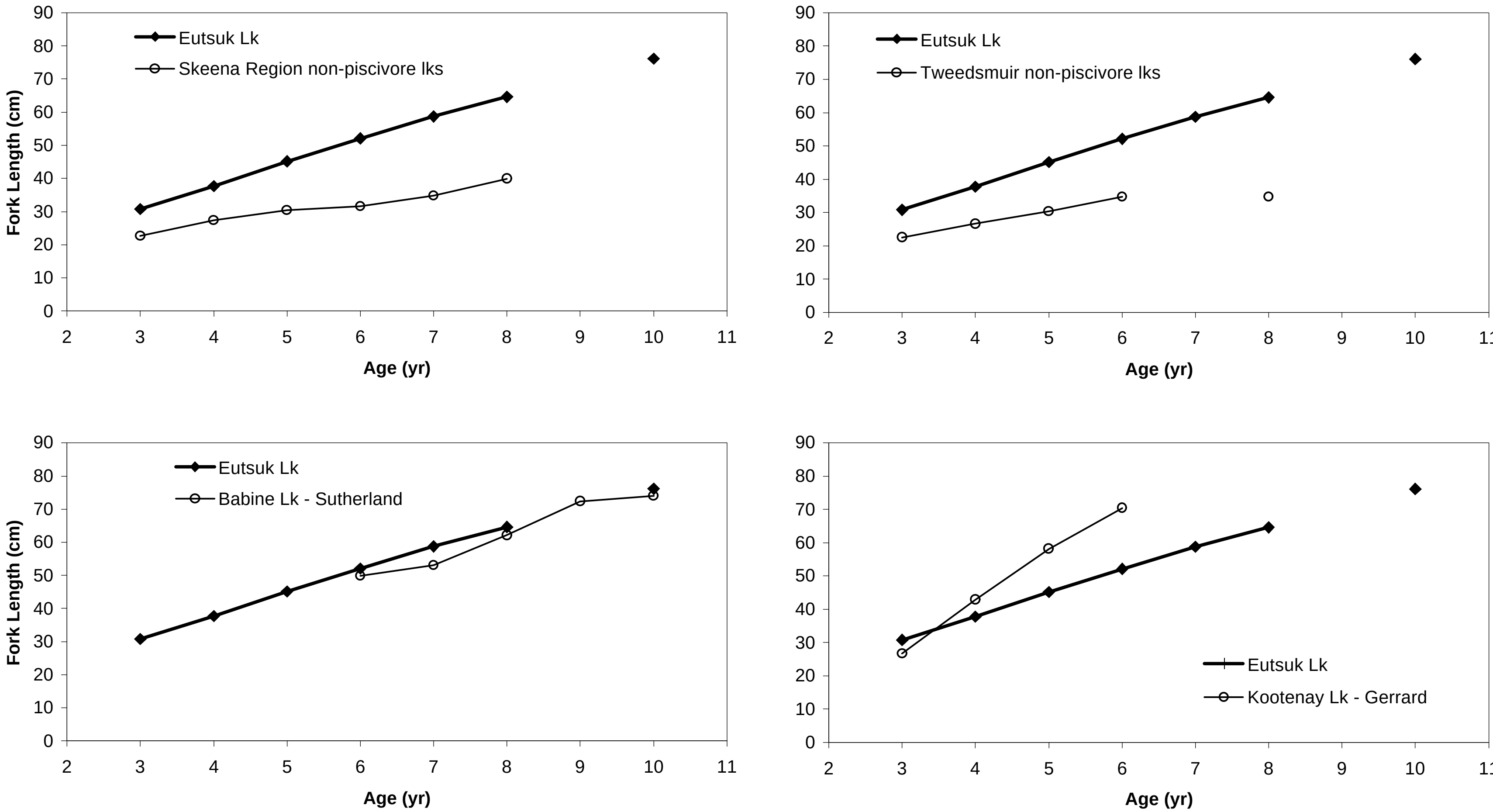

Figure 1. Mean length at age for Eutsuk Lake rainbow trout in comparison to other British Columbia populations. Eutsuk Lake rainbow trout are longer at age than non-piscivorous populations in Tweedsmuir Park and elsewhere in Skeena Region (top two panels). Babine Lake piscivore spawners exhibited mean length at age which was similar to Eutsuk Lake, but Kootenay Lake piscivores appear to grow more rapidly from age 4 onward. Data for these populations and others are also presented in Table 3.

Table 4. Fish community characteristics of lakes which appear to support indigenous populations of the pelagic piscivorous rainbow trout ecotype. Definitions of **Fish Species Codes** are provided in Appendix I; codes in parentheses in this table are species whose presence in the lake is suspected but unconfirmed, and ‡ indicates introduced species. **Anadr Access** = do anadromous fish access the lake, where Historic indicates access has been blocked by dams, and Recent indicates that barrier alleviation has created access; **Pisc Char** = are piscivorous char resident in the lake?; **RB plants** = have hatchery-produced rainbow trout been stocked in the lake at any time? **Species Complete** = is the list of species present likely a complete and accurate list?

Lake	Anadr Access	Pisc Char	RB Plants	Fish Species Present in Addition to Rainbow Trout	Species Complete
Nechako Res.	No	No	No	BB CAS CSU KO LKC LSU MW NSC	Yes
Arrow Res.	Historic	Yes	Yes	BB BSU BT CAS CCG CP CT CRH CSU CT EB‡ KO LKC LNC LSU LW‡ MW NSC PMC PW RSC WP WSG YP	Yes
Babine	Yes	Yes	Yes	BB BT CAS CH CO CT KO LSU LNC LT LW PMC MW NSC RSC SK WSU	Yes
Kootenay	No	Yes	Yes	BB BT CAS CSU KO LNC LSU PMC MW WSG	Unknown
Okanagan	Historic	No[11]	Yes	BB CAS CCG CMC CSU KO LNC LSU LT‡ LW MW NSC PMC PW RSC	Unknown
Shuswap	Yes	Yes	Yes	BB BT CAS CH CO CSU KO LNC LSU LT LW MW PW NSC PK PMC RSC SK SU WSG	Unknown
Quesnel	Yes	Yes	Yes?	BB BT CH CO KO LT LNC MW NSC PMC RSC SK SU	Unknown
Eutsuk	**No**	**No**	**No**	**BB CC CSU KO LSU MW NSC**	**Yes**
Kamloops	Yes	Yes	Yes	BB BT CH CAS CSU LSU MW NSC PMC RSC SK ST	Unknown
Mabel	Yes	Yes	Yes	BB BT CC CH CO CSU KO LT LNC LSU MW NSC PMC RSC SK	Unknown
Bonaparte	Recent	No	No	CSU KO LNC MW NSC PMC RSC	Unknown
Isaac	No	Yes	No	KO LT MW	Yes
Crescent	No	No	Yes	CT KO PW	Yes
Tesla	No	No	No	CSU KO LSU MW NSC	Yes
Nadina	Sporadic	No	No	KO LSU MW SK	Yes
Khtada	No	No	No	DV KO	Yes

[11] Although lake trout are very occasionally captured in Okanagan Lake, their abundance is apparently very low and it is unknown whether they represent a self-sustaining population or downstream migrants from Katamalka Lake where they were originally introduced.

Table 5. Water chemistry parameters for North American lakes which likely support indigenous populations of the pelagic piscivorous rainbow trout ecotype. Graphical depiction of this data is provided in Figure 2.

Lake	**Thermocline Depth (m)**	**Euphotic Zone Depth**	**TDS (ppm)**	**Mean Nitrate (mg/L)**	**Mean Phosphorus (mg/L)**	**Chlorophyll-a (ug/L)**	**Alkalinity**
Nechako Res.	~20.0	18.0	23	5.5	5.9	1.19	20.2
Arrow Res.		25.4	60	145.0	4.0	1.80	
Babine	11.3	6.9	~60	26.0	5.5	2.20	36.6
Kootenay		21.0		90.0	~10.0	2.50	
Okanagan	~20.0		160		~ 9.0	1.60	
Shuswap	10.0	12.3	80	18.0	5.1	1.81	35.7
Quesnel	12.4	15.5	88	68.0	2.8	1.03	46.4
Eutsuk	**19.0**	**29.1**	**19**	**20.0**	**2.3**	**0.75**	**14.5**
Kamloops			78		10.0		
Mabel			99				
Bonaparte	14.8	13.3		1.6	5.0		38.8
Isaac			~108[12]				
Trout			102				
Crescent	~25.0	>50.0		~1.0	3.0 to 21.0	0.08 to 0.67	49.1
Tesla			26				
Nadina			38				
Khtada	14.0	28.5	7		< 3.0	1.20	4.5
Young			78				

[12] No water chemistry data was accessible for Isaac Lake; the listed TDS is for Cariboo Lake downstream

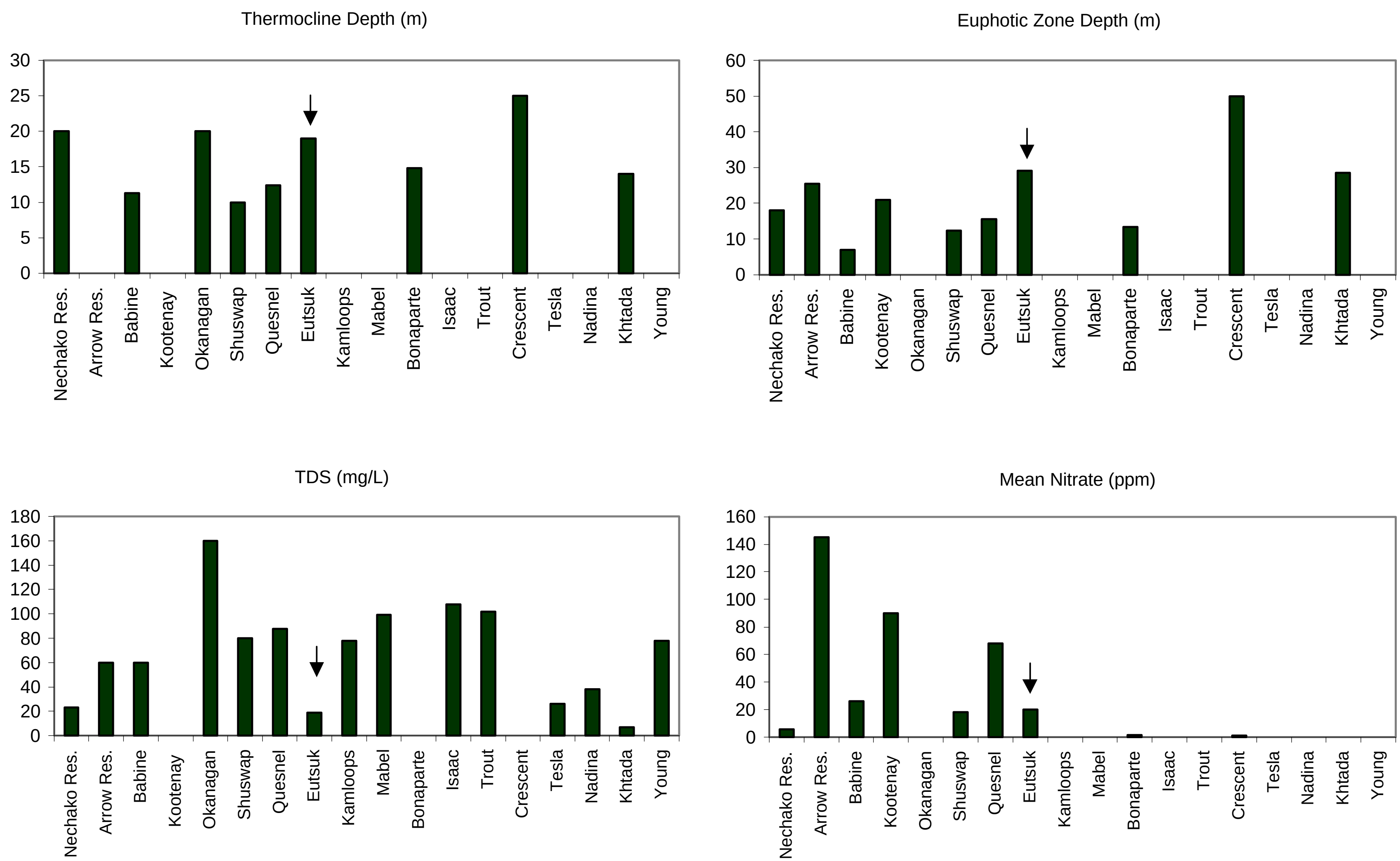

Figure 2. Limnological characteristics of lakes supporting the pelagic piscivorous rainbow trout ecotype. Parameter values are also provided in Table 5.

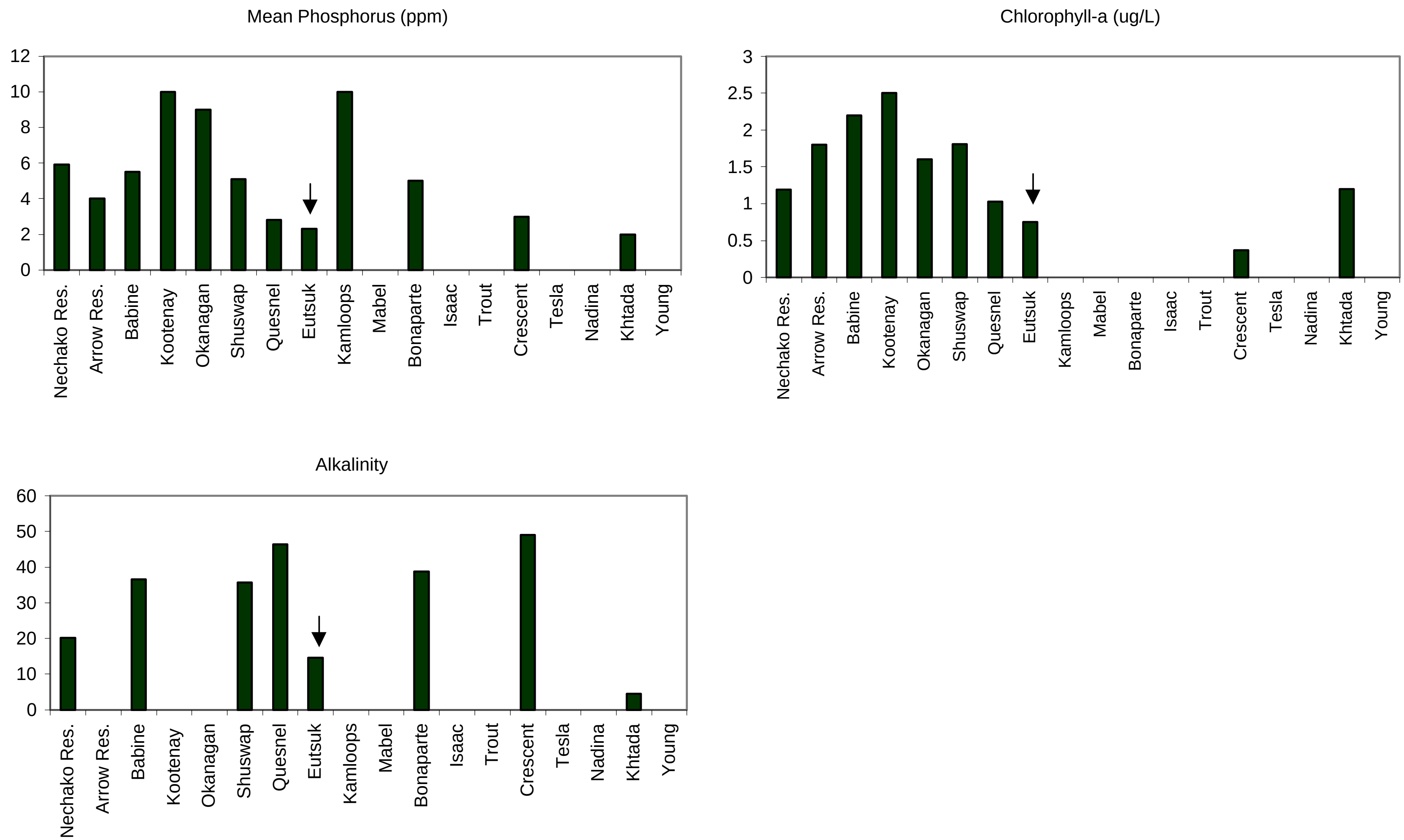

Figure 2 continued**.** Limnological characteristics of lakes supporting the pelagic piscivorous rainbow trout ecotype. Parameter values are also provided in Table 5.

3.3. Are there known habitats located within or adjacent to the park which may require focused management?

Habitat use of lake-dwelling rainbow trout in the upper Nechako watershed has not been thoroughly investigated. Studies of rainbow trout elsewhere show that life history varies widely, but with few exceptions spawning occurs in streams and rivers (Parkinson and Rosenfeld 1996). After hatching and emergence from the spawning gravel, young rainbow trout remain in their natal stream for a period of a few weeks to several years of rearing. When barriers do not exist, migration to rivers or lakes[13] often follows, presumably to take advantage of better growth opportunities in larger waters (Northcote 1969; Burrows 1993). After additional growth to reproductive maturity, rainbow trout migrate seasonally between their adult habitat where feeding occurs and their natal stream where spawning takes place.

In some cases, spawning areas utilized by pelagic piscivorous rainbow trout lie just downstream of lake outlets. These can include the outlet of the lake where the stock resides as adults, or lakes present on upstream tributary streams. In other cases, spawning areas are located on portions of tributaries distant from any lake. There is no easily discernable set of rules for identifying tributaries most likely to be used for spawning by large resident trout.

Two sets of methods are often used to infer the use of stream habitats for spawning and early-life rearing by lake-dwelling trout. The most reliable of these involves the marking and subsequent reobservation of fish in stream and lake habitats. There have been no reported projects of this type in lakes of the upper Nechako watershed. Secondarily, analysis of age structures such as scales or otoliths can provide information about fish life history, including periods of residency in various types of habitats though usually not the specific locations themselves. For example, Winsby and Taylor (1999) reported that scales of rainbow trout sampled in the Nechako Reservoir suggested most individuals spent two years in streams before entering the reservoir. Scale circuli patterns may display increased growth rate associated with lake entry, presumably the evidence examined by Winsby and Taylor (1999), but serious questions remain about the reliability of this method of inferring the timing of lake entry (Burrows 1993). Scale analysis for timing of lake entry is of debatable value without validation by sampling of lakeward migrating fish.

In the absence of detailed studies of fish movements, lacustrine rainbow trout life history as described in the first paragraph of this section is assumed applicable in the Eutsuk watershed. Accordingly, the following sections provide further detail about stream and lake habitats which are known to be used, or may be accessed, by trout present in Eutsuk Lake.

3.3.1. Stream Habitats Adjacent to the Eutsuk Basin

3.3.1.1. Eutsuk River (Eutsuk Lake Outlet)

Prior to flooding of Tetachuck Lake by the Nechako Reservoir, 4 to 7 km of riverine channel[14] (sixth-order[15] Eutsuk River) was present between the two lakes (Lyons and Larkin

[13] or the ocean, in the case of steelhead

[14] Lyons and Larkin (1952) present contradictory information about the length of the Eutsuk River between Eutsuk and Tetachuck Lake, prior to impoundment. On page 12, the channel length is given as "four to five miles", while on page 19 the length is "2.5 miles".

1952) which differed in elevation by roughly 7 m. At present, due to flooding of Tetachuck Lake which raised its mean surface elevation by 1.7 m, the riverine portion of the Eutsuk River channel appears to be about 3 km in length during early summer. Thus, depending upon the reservoir level, a loss of one or more kilometers may have occurred at the Tetachuck end of the Eutsuk River channel. Redfern Rapids (Figure 4 to Figure 7) would not likely represent a serious obstruction to fish passage in either direction except perhaps for very small juvenile fish.

No data are available to assess whether the Eutsuk lake outlet channel is presently or was historically used for spawning and juvenile rearing by pelagic piscivorous rainbow trout of Eutsuk Lake. Keeley (2002) snorkeled the Eutsuk River in early June 1999, but saw no spawning trout in the area. He observed that substrate was generally too large for rainbow trout redds, and that velocities in most areas were too high. Lyons and Larkin (1952) traversed the river in late summer, and noted that in the reach above Redfern Rapids only a small quantity of habitat suited to rainbow trout spawning occurred immediately downstream of the Eutsuk Lake outlet. However, they reported that the channel below the rapids appeared to provide excellent spawning habitat. Lyons and Larkin (1952) also reported that fish were observed spawning in the Whitesail River in July 1950, so it is possible that the Keeley visit in early June 1999 was too early in the year to observe spawning fish in the Eutsuk River.

Figure 3. Upstream view of Eutsuk River, 18 July 2002. The river mouth at Tetachuck Arm of the Nechako Reservoir is in the foreground, and Eutsuk Lake in the background.

[15] stream order is a hierarchical system of classifying channel position in the watershed and correlates roughly with discharge and channel width; first-order stream are headwater channels; second-order streams are formed by the joining of two first-order channels; third-order streams are formed at the confluence of two second-order streams, and so forth.

Figure 4. Aerial downstream view of Redfern Rapids on 18 July 2002.

Figure 5. Aerial upstream/lateral view of Redfern Rapids on 18 July 2002.

Figure 6. Downstream view of Redfern Rapids from river left bank, 29 July 2002. Rock outcrop on opposite bank at center left is also shown at center right in Figure 7 below.

Figure 7. Downstream view of Redfern Rapids from center of river, 29 July 2002.

3.3.1.2. Eutsuk Lake Tributaries

As mapped by the 1:50,000 BC Watershed Atlas[16], Eutsuk Lake receives tributary inflow from

- 58 first-order,
- 35 second-order,
- 9 third-order,
- 4 fourth-order, and
- 1 fifth-order

stream channels, of which most are unnamed. The fifth-order tributary is the Chezko River. The fourth-order streams include the St. Thomas River, Bone Creek, the outlet of Pondosy Lake, and the unnamed stream which enters Eutsuk Lake at Sand Cabin Bay.

No systematic inventory of the watershed's channels has been undertaken. Regarding rainbow trout spawning in inlet streams accessible from Eutsuk Lake, Lyons and Larkin (1952) suggested that

> *streams flooding into … the southwest portion of Eutsuk Lake are not considered to be ideal for spawning, due to the extreme temperature and silting occasioned by their glacier source. Of the streams flowing into Eutsuk Lake, only those draining the northern side, such as the St. Thomas River and Redfish Creek are considered to be of any importance as spawning areas.*

3.3.1.2.1. Fifth-Order Tributaries

Notwithstanding observations of Lyons and Larkin (1952) above, it appears that one or more locations within the fifth-order Chezko watershed could also offer ideal spawning conditions for large-bodied rainbow trout, particularly given the propensity for fish of this type to spawn downstream of lake outlets. The Chezko River mainstem, width generally 25 to 75 m in its lower reaches, is very cold and glacially turbid during the spring and early summer. In early June 1999, Keeley (2002) was able to access the lowest 5 km of the Chezko channel by boat from Eutsuk Lake; he captured juvenile rainbow trout in this reach of the river by electrofishing. Several tributaries to the Chezko are lake-headed and thus relatively clear and likely with stabilized flow and temperature regimes. In upstream order from Eutsuk Lake, these are: the unnamed second-order stream[17] which drains Tahuntesko Lake, the unnamed second-order stream[18] which drains Olaf and downstream lakes, and Tesla Creek which drains Wahla and Tesla lakes. The largest of the three is Tesla Creek, which provides approximately 0.8 km of fifth-order channel (width roughly 20 m) downstream of Tesla Lake and upstream of the confluence with the Chezko mainstem. The confluence of the two streams is shown in Figure 8. A chute roughly 0.7 km downstream of the confluence of the Tesla and Chezko channels (coordinates 126°30.346'W, 53°7.751'N; see Figure 9) is the first obstruction upstream of Eutsuk Lake on the Chezko mainstem channel. It is unknown whether this section is passable to fish in an upstream direction. Both Tahuntesko Lake outlet and Olaf Lake outlet streams are much narrower channels

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[16] The BC Watershed Atlas uses digitization of the 1:50,000 NTS series as a basemap
[17] Watershed code 180-639300-47200-18500
[18] Watershed code 180-639300-47200-33800

draining smaller drier watersheds, and thus appear less likely to offer abundant year-round rearing habitat for rainbow trout.

3.3.1.2.2. Fourth-Order Tributaries

Of the fourth-order tributaries to Eutsuk Lake, two of four have received sampling attention. First, the St. Thomas River was sampled during biophysical surveys conducted in 1982. A waterfall downstream of Reid Lake prevents access by Eutsuk Lake fish to all but the lowest 2 km of the mainstem river. However, the watershed is not glacial, and contains lakes and wetlands which would buffer the downstream flow regime. Second, Keeley (2002) sampled the lowest reach of Bone Creek, noting its low gradient and fine sediment composition poorly suited to rainbow trout reproduction. The reaches upstream on the flanks of Bone Mountain have not been examined; the watershed lacks significant lakes to moderate its discharge and temperature regimes. Third, Pondosy Lake drains to Eutsuk Lake via a short (length <0.5km) section of fourth-order channel which is lacustrine in character but could support spawning by rainbow trout. No reported biophysical survey of this channel has been made, although this section of stream is traversed repeatedly by guided anglers accessing Pondosy Lake from the lodge in Pondosy Bay, and no observations have been reported of spawning fish in the channel. Keeley (2002) examined the lower reaches of tributaries to Pondosy Lake and did not consider them particularly suited to rainbow trout reproduction. Finally, the unnamed fourth-order stream which flows into Eutsuk Lake through a wetland at Sand Cabin Bay has not received any recorded sampling attention. Its watershed is relatively small for its order, and contains only a few small lakes.

3.3.1.2.3. Third- and Lower-Order Tributaries

Other inlets to Eutsuk Lake which have received at least one sampling visit include those listed in Table 6; typically only the portion of the stream proximate to Eutsuk Lake was accessed. Except where barriers are present, neither the absence of high-quality habitat nor relatively low abundance of rainbow trout juveniles in the sampled sections precludes the use of upstream reaches for reproduction by large-bodied Eutsuk Lake rainbow trout. Any such preclusion could only be based on more extensive surveys or other data.

Table 6. Third- and lower-order tributaries to Eutsuk Lake which have received fish sampling attention. Watershed codes begin with 180-639300 which has been truncated. Sampling efforts were conducted by Keeley (2002) in the reach closes to Eutsuk Lake, the outlet of Redfish Lake which was also sampled by Inventory Operations Unit (1982).

Channel	**Code**	**Comments**
outlet of Redfish Lake	70000	Captured one juvenile rainbow trout
outlet of Mink Lake	49900	Captured 2 juvenile rainbow trout
outlet of unnamed lake in Pondosy Pass	71500	Captured sculpins
outlet of Cam McEwen Lake	62800	Captured several juvenile rainbow trout
inlet to Eagle Bay	67600	
outlet of Musclow Lake	99600	Waterfall very near to Eutsuk Lake
outlet of Surel Lake	98700	Waterfall very near to Eutsuk Lake

Figure 8 (above)**.** Aerial upstream view of Tesla Creek showing its confluence with glacially-silty Chezko River, 29 July 2002. Chezko River (foreground) flows left to right.

Figure 9 (above)**.** Aerial upstream view of Chezko River rapids roughly 0.7 channel km downstream of the Tesla Creek confluence, 29 July 2002. Note extensive beetle-killed trees.

3.3.1.3. Potential Impacts to Streams in the Eutsuk Lake Drainage

The entire watershed of Eutsuk Lake lies within North Tweedsmuir Provincial Park. Spawning and rearing habitat are seemingly well-protected from human disturbances such as mining, logging, grazing and roading. The most extensive environmental perturbation occurring or foreseen for the near-term future in North Tweedsmuir Park is mountain pine beetle infestation (Gawalko 2002). Fuchs (1999) reviewed the literature on the effects of bark beetle outbreaks on hydrology which can include:

- increased base flow and peak runoff especially during the snowmelt period,
- higher summer water temperatures as a result of reduced vegetative shading,
- increased erosion and siltation, and
- organic materials in streams including large woody debris leading to logjams.

The impact of beetle outbreaks on aquatic habitat may also be mediated through fire. Again according to Fuchs (1999), intensive fires can increase the density of soil and decrease soil infiltration rates. These changes can contribute to increased flooding, surface erosion, stream sedimentation, and debris flows.

Despite the extensive and intensive effects of beetle outbreaks on the terrestrial ecosystems, many potential impacts to aquatic habitat could be short in duration and minimally disruptive. Depending on whether crowning fires occur, existing understory vegetation may "green" the impacted areas fairly rapidly, minimizing the effects on soils, hydrology and erosion. Streams within the Eutsuk watershed tend to be cold and nutrient-poor, so moderate increases in these parameters would probably not produce a major negative impact on rainbow trout rearing suitability. However, an increase in large woody debris entering stream channels could lead to logjams which might create obstructions to spawning migration. For example, logs which have collected above the rapids shown in Figure 9 could impede the upstream passage of spawners in the smaller (river left) channels at this location. As the spawning areas of Eutsuk Lake piscivorous rainbow trout are not presently known, monitoring for debris jams is not practical. If subsequent investigation does suggest likely spawning areas, lodge operators and others who regularly fly within the park could be enlisted to assist in monitoring.

Beaver impoundment also has the potential to interfere with seasonal migrations of fish. The intensity of beaver activity within a particular drainage can vary due to a number of factors related to climate, vegetation stage, mortality including trapping, and dispersal. Fish movements in small channels are most vulnerable to disruption. The lack of information about spawning location of Eutsuk Lake piscivorous trout again prevents prediction or monitoring of possible impacts of beaver impoundment.

Although at present the global climate appears to be warming on average, regional changes in cloudiness may lead to cooling and increased mean precipitation in some locales. Climate variation has the potential to significantly alter runoff and stream flow regimes, and thus nutrient inputs, water temperature, and channel form. All of these can impact the suitability of streams for spawning and rearing of fish, including rainbow trout.

3.3.2. Eutsuk Lake Physiochemistry

As discussed in the report sections addressing stream habitat, the entire watershed of Eutsuk Lake lies within North Tweedsmuir Provincial Park so the physiochemistry of the lake is well-protected from human disturbances. The large volume of the lake suggests that small-scale perturbations, such as waste from lodges and campgrounds and pollution from outboard motors and floatplanes, are unlikely to produce a detectable impact on the lake's ecology. Beetle outbreaks may lead to short-term effects on the hydrology and nutrient budget of the lake but again are unlikely to significantly alter the lake's productivity. Regardless of its origin, variation in climate is also a driver of change in lake productivity. A better understanding of the biology of Eutsuk Lake piscivorous rainbow trout is needed before predicting their response to large-scale long-term perturbations.

3.3.3. Nechako Reservoir

It remains unknown whether rainbow trout commonly move between Eutsuk Lake and downstream basins of the Nechako watershed. The Eutsuk River is a large channel with abundant deep water and boulder cover for larger fish, and Redfern Rapids between Eutsuk and Tetachuck Lake probably has not represented an obstruction to fish passage either before or after impoundment of the Nechako Reservoir. However, the physical possibility of round-trip migration through the river does not suggest whether it routinely occurs.

Prior to impoundment, just downstream of Tetachuck Lake the Tetachuck River traversed a series of rapids and drops including Tetachuck Falls (photo in Lyons and Larkin 1952). This reach of the Tetachuck River imposed a major obstruction if not a complete barrier to fish passage, and it seems very unlikely that Eutsuk rainbow trout would have utilized any habitats downstream of the Tetachuck Lake outlet. Tetachuck Lake itself was only about 20% of the surface area of Eutsuk, and relatively shallow (mean depth estimated as 15m; Lyons and Larkin 1952). Consequently, migration of pelagic piscivorous Eutsuk Lake rainbow trout through the Eutsuk River into Tetachuck Lake would not appear to have been an obviously profitable behavior in terms of feeding and energetics.

At present water levels, the Tetachuck River falls and rapids are inundated. Eutsuk rainbow trout which traversed the Eutsuk River into the Tetachuck reach of the reservoir would not be constrained from feeding throughout the much more extensive adjacent pelagic habitats which are currently flooded by the Nechako Reservoir. Assuming migration out of the Eutsuk basin was not particularly energetically attractive before the reservoir existed, an unknown period of years might be needed for this behavior to evolve under the present conditions of impoundment if in fact feeding opportunities are better in the reservoir than in Eutsuk Lake itself.

Forty years after the completion of impoundment, Perrin et al. (1997) reported similar levels of mercury content in the flesh of rainbow trout captured in Eutsuk Lake and those sampled from the reservoir, despite expecting that concentrations would be higher in the reservoir fish. They suggested that movement of fish between the two waterbodies provided a plausible explanation. However, an equally credible and more parsimonious interpretation is that concentrations of methyl mercury in the reservoir trophic web have returned to levels similar to Eutsuk Lake (Odense 2002). If so, the results of Perrin et al. (1997) do not imply anything about fish migration between the two waterbodies.

Tracking of fish movements by tagging could provide a definitive answer to whether piscivorous rainbow trout routinely leave and re-enter the Eutsuk watershed, but to date that type of study has not been undertaken on a large scale. Of the seven trout tagged at Eutsuk Lake by biologists in 1986, one individual was re-angled two months later in the same area where it had been tagged near Sand Cabin Bay, and a second fish was recaptured in 1990 by an angler also near Sand Cabin Bay (Hooton 1990). Though both fish were recaptured very near to their tagging location, the small sample size precludes any conclusions about movement, particularly since the presence of the campground nearby means that the Sand Cabin Bay area is probably angled more heavily than other areas of Eutsuk Lake. Nevertheless, in some cases elsewhere, pelagic piscivorous rainbow trout may tend to remain in the portion of the lake closest to their spawning stream (Irvine 1978; David Bustard and Associates 1990).

The Nechako Reservoir water level fluctuates with natural inflow and management of outflow, on a variety of time scales. Log salvage within the reservoir was begun in the late 1990s, but has been discontinued due to the harvestable abundance of beetle-kill wood within the watershed. Potential effects on Eutsuk Lake pelagic piscivorous rainbow trout, of any of these perturbations in the Nechako Reservoir and its watershed, cannot be assessed without definitive information about whether Eutsuk fish commonly utilize habitat within the reservoir.

3.4. How are sport fisheries exploiting other populations of this ecotype managed in British Columbia?

3.4.1. Monitoring

Two important issues are faced in policy design for fisheries management, when harvest is allowed: choosing an optimum fishing mortality rate, and setting an allowable harvest given the optimum fishing mortality rate and the current population size (Cox and Walters 2002). For most freshwater recreational fisheries in British Columbia where harvest is allowed, neither fishing mortality rates nor total allowable harvests are quantitatively estimated (Cox and Walters 2002). But even when regulatory decisions are made by intuition or professional experience rather than quantitative models, fish population size and the amount of angling and harvest are considered fundamental information for management.

Estimates of fish population size are made by stock assessment. Effort and harvest are quantified by angling use studies often called creel surveys. Occasionally, angling use studies can also provide information useful to stock assessment: life history samples may be obtained from anglers, and angling catch rate is one potential (albeit risky) index of fish population abundance. Lake ecosystem[19] studies also provide a valuable and occasionally necessary tool for fisheries management, particularly for waters where external-source disturbances are extensive: residential and industrial development, impoundment downstream or upstream, other nutrient perturbations, introductions of exotic species, and enhancement of anadromous species. Even in the absence of current perturbations, ecosystem studies can provide important information about a lake's fish production capacity, useful in the context of stock assessment and harvest regulation.

The combinations of these management elements (angling use surveys, rainbow trout population assessment, and lake ecosystem monitoring) which have been applied to lakes supporting the pelagic piscivorous rainbow trout ecotype are summarized in Table 7. Five of the lakes are receiving ongoing monitoring in at least two of the three categories (Table 7). Lakes with ongoing programs tend to be those where ecosystem perturbations or angling exploitation, or both, have created the perception of potential crisis.

Eutsuk Lake is one of four lakes with no formal program or history in any of these categories. Stock assessment, lake ecosystem studies and creel surveys are expensive particularly on large waters with spatially and temporally diffuse fisheries. Regional freshwater fisheries management in British Columbia often cannot obtain the resources necessary to pursue such data. In its absence (as for Eutsuk Lake), reconnaissance inventory data combined with anecdotes about effort and catch from anglers and conservation officers often comprises the information available.

3.4.2. Method and Harvest Regulation

Fisheries managers can use a variety of methods to attempt to modify the number and size of fish captured and harvested in recreational fisheries. Angling regulations, including

[19] including stream channels with high biological or physiochemical connectivity to the lake

harvest quotas and method restrictions, are most often applied. In British Columbia, each WLAP region imposes a set of general region-wide angling regulations which may be modified by water-specific restrictions. General daily catch quotas throughout the province include quotas for "trout and char[20]" combined. Regions 1 to 3 apply a daily quota of 4 trout/char; regions 5 to 7 allow 5 per day; the daily quota for region 4 is 6 per day. General regulation in all regions allow harvest of only one trout/char over 50 cm in fork length per day, and possession limits are typically twice the daily quotas. Provincially, each angler is allowed to fish only one line[21] with a single lure, fly, or baited hook attached. Aquatic invertebrates and live or dead fin fish or fish parts (except roe) are prohibited as angling bait in lakes.

Angling method regulations and quotas currently in place on known pelagic piscivorous rainbow trout stocks are summarized in Table 8. Regulations for four of the lakes impose restrictions on angling within certain zones at some or all times, presumably relating to concentrations of fish before and during spawning. Angling method restrictions have been enacted on 5 of the 16 lakes. Single barbless hooks are mandated on 4, and bait bans are in place on 2 lakes. Use of downriggers is effectively banned by the 2 oz weight limit on Crescent Lake angling.

Eleven of the 16 lakes impose no retention quotas more stringent than the general regional quotas. Of the 5 lakes with restrictive harvest quotas, only Lake Crescent (WA) has a non-retention regulation at present. Two lakes (Shuswap and Kootenay) require the purchase of a special annual licence by anglers who wish to retain rainbow trout over 50 cm, and an annual quota of 5 rainbow trout over 50 cm is applicable on both. Shuswap Lake regulations prohibit retention of any trout under 50 cm, while Kootenay Lake allows retention of 4 fish under 50cm which is a reduction of 2 from the general regional regulations. A daily quota of two trout is in place for Okanagan Lake; an open slot limit on Quesnel Lake allows the retention of only two rainbow trout daily, both of which must be greater than 30 cm but less than 50 cm.

The sale of special tags on Shuswap and Kootenay lakes also allows the regional fisheries section to conduct annual mail-out surveys of activity and success in the fishery. This is a specialized form of angling use study, subject to a different set of weaknesses than are field-based creel surveys (De Gisi 1999).

[20] rainbow trout, cutthroat trout, brown trout, brook trout, lake trout, bull trout and Dolly Varden
[21] a person who is alone in a boat on a lake may angle with two lines

Table 7. Approaches to management of pelagic piscivorous rainbow trout populations. In the column headed **Fishery**, 'Ongoing' indicates a regular program of angling use studies, 'Historic' indicates that at least one year of creel survey has been completed in the past but there is no commitment to a regular program, and 'No' indicates there have been no angling use studies and none are planned. In the column headed **Fish Population,** 'Ongoing' indicates a regular program of stock assessment using means such as spawner counts or fry surveys, 'Historic' indicates that at least one year of fish population assessment has been completed but there is no commitment to a regular program, and 'No' indicates there has been no stock assessment attempted and none is planned. The column headed **Lake Ecosystem** indicates whether attempts have been made to understand the biophysical basis for the productivity of the stock, including physical and chemical limnology, kokanee population dynamics, and so forth. Values listed in this column have meanings (with respect to lake ecosystem monitoring) analogous to those in the Fish Population column.

Lake	**Monitoring / Assessment**		
	Fishery	**Fish Population**	**Lake Ecosystem**
Nechako Res.	No	No	No
Arrow Res.	Ongoing	No	Ongoing
Babine	Historic	Historic	Historic
Kootenay	Ongoing	Ongoing	Ongoing
Okanagan	Historic	Historic	Ongoing
Shuswap	Ongoing	Historic	Ongoing
Quesnel	Ongoing	Ongoing	Ongoing
Eutsuk	**No**	**No**	**No**
Kamloops	No	Historic	No
Mabel	Historic	Historic	No
Bonaparte	No	Historic	No
Isaac	No	No	No
Crescent (WA)	Historic	Ongoing	Ongoing
Tesla	No	No	No
Nadina	No	No	No
Khtada	No	No	Historic

Table 8. Recreational angling harvest quotas and method regulations in place on confirmed pelagic piscivorous rainbow trout lakes. T/C = combined trout and char quota; RB = rainbow trout, BT = bull trout. (T/C) indicates that the quota is a combined trout and char quota but char are not present in the lake or are not retained by anglers. Regulations which differ from regional standard regulation for trout/char in lakes are indicated by *italic typeface*. For these lakes, and for general regional regulations, all possession quotas are double the daily quotas.

Lake	**Regulation**
Nechako Res.	• (T/C) daily quota 5, only 1 over 50cm
Arrow Res.	• T/C daily quota 6, only 1 over 50cm
Babine	• T/C daily quota 5, only 1 over 50cm • *no fishing within ~10 km of mouth of Sutherland River*
Kootenay	• *T/C daily quota 4,* only one RB over 50 cm and 1 BT any size • *annual quota 5 RB over 50 cm from main body of lake (not lake west arm)* • *conservation surcharge to retain RB over 50 cm*
Okanagan	• *RB daily quota 2, only 1 over 50cm* • *single barbless hook*
Shuswap	• *RB daily quota 1 (none under 50 cm)* • *RB annual quota 5 over 50 cm* • *conservation surcharge to retain RB over 50 cm* • *no fishing areas near major inlets and outle*t
Quesnel	• *T/C daily quota 2, no T/C under 30 cm, no RB over 50 cm* • *bait ban* • *single barbless hook* • *no fishing areas during spawning season Mar 1 - May 31*
Eutsuk	• (T/C) daily quota 5, only 1 over 50cm
Kamloops	• T/C daily quota 6, only 1 over 50cm
Mabel	• T/C daily quota 6, only 1 over 50cm • *single barbless hook* • *no fishing within 0.8km of mouth of Shuswap River inlet*
Bonaparte	• T/C daily quota 6, only 1 over 50cm
Isaac	• T/C daily quota 5, only 1 over 50cm
Crescent (WA)	• *RB daily quota 0* • *bait ban* • *single barbless hook* • *downriggers prohibited (2 ounce weight restriction)*
Tesla	• RB daily quota 5, only 1 over 50cm
Nadina	• RB daily quota 5, only 1 over 50cm
Khtada	• (T/C) daily quota 5, only 1 over 50cm

3.5. Is post-release mortality an important consideration in regulating angling on Eutsuk Lake?

Survival of fish released following angling capture has been of research interest since the 1930s. The subsequent literature on the topic is very extensive: more than 100 experimental studies have been published in the primary literature during the last seventy years. A greater quantity of the information on this topic is unpublished or has been summarized only in the grey literature, and is thus inaccessible except through extensive inter-agency contact.

Capturing a fish by angling and releasing it alive involve a large number of interacting processes and variables which may affect the survival of the animal. These may include factors related to

(a) the fish themselves:
- species, ecotype, and race,
- size,
- physiological condition;

(b) the capture and recovery environment:
- flowing or still water;
- temperature and water chemistry;

(c) the angling method:
- type of bait or lure,
- hook anatomy (single or multiple point, barbed or barbless, hook dimensions);
- passive or active presentation of the lure or bait,
- time interval of playing (between hooking and landing),
- post-landing treatment.

Experimental studies of post-angling release mortality have usually differed from each other by several of these factors simultaneously. As a consequence, results have varied widely and are often contradictory. To attempt to find a general pattern among the diverse outcomes, several studies in the last three decades have synthesized all or a portion of the literature to date (Wydoski 1977; Mongillo 1984; Schill and Scarpella 1997), including the use of statistical meta-analyses[22]. Taylor and White (1992) and Schill and Scarpella (1997) provide meta-analyses dealing with studies specific to freshwater-resident salmonids. The results of their work will be discussed in the paragraphs which follow, but the issue of experimental time frame warrants discussion first.

3.5.1. Experimental Time Frame

Experimental time frame is important if fish which are angled and released could experience detrimental effects which do not become evident until after the termination of the experiment. Insufficient length of experiment could thus lead to underestimation of the impact of non-retention angling on survival, growth and reproduction. Immediate mortality

[22] Statistically robust process of synthesizing results of several other studies from the available literature.

due to hooking injury can usually be attributed to wounds causing excessive bleeding and/or neurological damage, or simply exhaustion and its effects on physiology. Delayed effects might include infection, or simply disruption of physiology and behavior due to exhaustion and trauma. Sub-lethal effects of the latter factors might then include lessened growth and fecundity.

A few studies have documented substantial delayed mortality of rainbow trout after exhaustive exercise or angling (Bouck and Ball 1966; Wood et al. 1983; Ferguson and Tufts 1992). In contrast, other investigators have found little association between exhaustive exercise and post-exercise mortality (Wydoski 1977; Tufts et al. 1991). Studies which have shown substantial delayed mortality have been laboratory experiments with extensive sampling of blood chemistry, typically using hatchery or farmed trout. Given the substantial genetic and physiological differences between domesticated and wild trout, domestic strains are a poor surrogate for wild populations. The weight of evidence suggests that exhaustion typically does not kill wild angled fish either immediately or later, and that most mortality attributable to angling happens within four hours of capture due to bleeding or neurological damage from wounds sustained.

A few studies have attempted to determine the long-term sub-lethal effects of angling capture and release on rainbow trout, but the results are usually confounded by other factors. Fish captured by angling are typically the more aggressive individuals in a population, and their later survival may be influenced by their aggressiveness which would be difficult to separate from the effects of angling.

In short, there is no convincing evidence that studies using wild fish have generally under-estimated mortality by releasing fish too early. Exhaustion does not appear to cause mortality for angled wild fish, except when water temperatures are high or oxygen concentrations low relative to the range of tolerance of the species, neither of which is likely ever the case at Eutsuk Lake. As well, evidence does not suggest that fish experience substantial delayed effects on survival or reproduction related to angling capture, though the results are not convincing.

3.5.2. Experimental Evidence About Post-Release Mortality

This discussion of post-release mortality will be limited to methods which are typically used by anglers in the Eutsuk Lake fishery. Much of the angling in Eutsuk Lake is done by trolling, with spoons and plugs probably the most common terminal gear (Van Tine 2002). Downriggers are often but not always used. Many parties of anglers simultaneously troll two or more lines at different depths from a single boat (Van Tine 2002).

Many of the available studies on post-angling mortality involve comparison of bait, flies, and other artificial lures, often with barbed versus barbless hooks as an additional factor. Bait typically produces the highest mortality rates because it often produces hooking locations deep in the oral cavity, closer to vital organs, nerves and blood vessels. Wydoski (1977) reported hooking mortality rates of 25% for bait; barbed lures 6.1%, and flies 4.0%. Bait is not typically used to angle for rainbow trout on Eutsuk Lake, so additional studies of release mortality rates associated with bait angling will not be reported here. Mongillo (1984) summarized the results of roughly 30 previous studies. For wild rainbow trout, he found no statistically significant difference between barbed flies, barbless lures and barbed lures, which tended to produce mortality between 5 and 7%. Schill and Scarpella (1997) summarized results of a number of studies on hooking mortality of resident (nonanadromous) salmonids. Weighted mean hooking mortality for lures was 7.3% for barbed and 6.6% for barbless hooks; for flies it was 1.4% for barbed and 1.7% for barbless.

Unlike smaller invertebrate foods, prey fish such as kokanee are able to visually detect approaching predators and attempt escape. As a consequence, piscivorous rainbow trout probably attack trolled lures which simulate prey fish more aggressively than other rainbow trout strike smaller lures imitating invertebrates which are presented by drifting or casting. Eutsuk Lake rainbow trout strike trolled lures with great force (Van Tine 2002). This may result in hooking locations for troll-captured Eutsuk lake rainbow trout that tend to be deeper within the oral cavity, and possibly deeper penetration of hook points as well. Such locations and wounds are more likely to result in damage to critical organs and blood vessels (Gjernes et al. 1993). No study of post-angling mortality for rainbow trout captured by recreational trolling gear has appeared in the literature to date. Gjernes (1990) reported a study of post-angling survival of young coho captured by sport trolling. Average fork length of angled fish varied between 37 cm in March to 45 cm in May; mortality for coho caught on single 1/0 hooks was 3.3%; barbed and barbless single-hook mortality rates were similar; barbed treble hooks produced 18.2% mortality. More coho escaped after hookup with treble hooks, as it was more difficult for them to engulf the hook completely; the coho which were landed had usually engulfed the hook and the higher mortality rate reflects the filling of the buccal cavity by the hook and thus greater chance of damage to gills or blood vessels. Gjernes (1990) also reported a study of post-release mortality of chinook salmon 35 to 82 cm in fork length angled by sport trolling using downriggers. A total of 152 chinook were landed, 50 coho were landed, and 40 salmon of unknown species were hooked but escaped. A total of 15 fish died, suggesting a 10% mortality rate. Smaller and larger fish died at fairly similar rates; most fish that died did so within a half hour of landing.

Gjernes et al. (1993) also discuss how hook size and shape can interact with fish size to affect the probability of a severe wound. Other than barbed / barbless, and single or multiple points, British Columbia does not regulate the size or anatomy of hooks used in angling. The interaction of hook anatomy with fish size in affecting the probability of mortality implies that careful consideration of intent (protect immature fish versus protect broodstock) would be needed in designing the regulation. Enforcement staff generally resist complex regulations, and restriction of the size and shape of hooks would certainly be seen in this way.

3.5.3. Other Considerations

The use of barbless hooks also reduces the rate of hook-up and landing of fish (Gjernes et al. 1993). The survival of fish that are hooked but not landed, by barbless or barbed hooks, has not apparently been reported in the literature and would be very difficult to quantify.

Except by fishery closures, British Columbia does not regulate the number of fish which can be caught and released, though such regulations are implemented as daily limits in a very few fisheries elsewhere in Canada (Government of Newfoundland and Labrador 2002; Government of the Yukon 2002). The latter type of regulation is relatively new in North

America, but can be expected to become more prevalent with time. Although compliance with such regulations would be difficult to enforce, public education is a dominant component of the success of any regulation. Full compliance may not be required in order to achieve management objectives.

3.5.4. Summary

Additional effort in compiling post-release mortality study results from the literature would not be likely to significantly reduce the uncertainty around this issue for the Eutsuk Lake fishery. Differences in species, fish physiology, lake conditions and angling methods imply that uncertainty about post-release mortality could only be substantially reduced by an experimental study on site or on a very similar lake in the region, using the gear and methods typical of the fishery.

Based on results reported in the literature, the mortality rate of released troll-caught Eutsuk Lake rainbow trout is likely in the range of 7 to 15 percent. Voluntary creel card results for Eutsuk Lake (presented in Section 3.6.2) suggest that the typical angler on the lake harvests one trout per day and releases two. If these estimates are approximately correct, under current regulations post-release mortality accounts for 12 to 23 percent of all rainbow trout mortality related to the fishery, with the remaining 77 to 88 percent attributable to harvest. Thus although average daily catch rates (harvested plus released fish, per angler day) in the Eutsuk fishery are apparently higher than for most lake fisheries in the province, rainbow trout mortality related to angling on the lake is probably still dominated by harvest rather than release mortality. Recreational fishery managers balance the relative social values of the opportunity to angle and the opportunity to harvest when implementing regulations intended to limit fish mortality. In most British Columbia lake fisheries, the opportunity to angle appears to be valued more highly than the opportunity to harvest. In addition, except in the case of complete fishery closure, harvest-related mortality is more easily regulated.

Despite the fact that the angling public has warmly embraced barbless hooks as reducing angling impacts, evidence indicates that the reduction in harm is minimal. Barbless hooks are easier to remove following landing of a fish, but critical injury usually occurs before landing. Although the results presented here suggest that single hooks are less likely than treble hooks to cause angling mortality, the situation is perhaps not that simple. The mortality rate appears to depend on the size of the hook and the size of the fish (mouth); some studies have suggested that multi-point hooks are more likely to catch in the outer part of the mouth where wounding of a critical organ or blood vessel is less likely. However, the balance of information appears to suggests that single hooks may cause lower mortality among released sport-trolled fish, and consideration of a single-hook regulation may be warranted for Eutsuk Lake.

3.6. Based on available information, is it possible to confidently evaluate whether the current management of Eutsuk Lake rainbow trout angling will provide long term sustainability of both population abundance and size of angled trout?

As detailed in Section 3.4, evaluation of the sustainability of a fishery is best accomplished by a combination of fish population assessment and fishery monitoring. Limnological analyses to date suggest that Eutsuk Lake is areally[23] unproductive, when compared to other lakes with pelagic piscivorous rainbow trout stocks. Life history data imply that the Eutsuk Lake piscivorous rainbow trout population is typical of the ecotype: growth to large size is accomplished by longevity and late sexual maturity. If accurate, all of these factors would tend to create vulnerability to overexploitation as angling harvest increases through time. Anecdotally, some long-time anglers of Eutsuk Lake have suggested to B.C. Parks that catch rates and the average size of fish caught from the lake is decreasing (Macdonald 2002). Others maintain that angling success has always varied interannually, but conditions now are similar to those of past decades (Van Tine 2002). Conflicting anecdotal information is of low value. Current numbers and any trends in abundance of the pelagic piscivorous population(s) are key components of stock assessment presently unknown.

In terms of fishery monitoring, no formal angling use study has been conducted on Eutsuk Lake, but several types of information have been collected to help in evaluating visitor impacts. Among these are visitor use statistics, volunteer creel cards, and angling guide reports from commercial lodges.

3.6.1. Visitor Use Statistics

Prior to 1999, B.C. Parks' estimates of visitor days in North Tweedsmuir Park relied on an unmonitored traffic counter at Chikamin Portage. Hatlevik (1987) and De Gisi (1998)[24] each naively calculated the potential annual number of angler days in the fishery on Eutsuk Lake based on these visitor statistics. The counts are now known to have been highly inaccurate. Their use would have resulted in severe overestimation of activity in the fishery (Macdonald 2002).

Beginning in 1999, implementation of park fees at the Chikamin Bay rail portage resulted in record keeping which could reflect park use more accurately. Four categories of entries dominate the fee records:

(1) entry/exit of parties in their own watercraft with destination Pondosy Bay Lodge,

(2) entry /exit of parties in their own watercraft who do not state their destination as Pondosy Bay Lodge (likely camping visitors),

(3) transit of parties in watercraft who are making a "circle tour", and

(4) entry or exit of watercraft belonging to Pondosy Bay Lodge or West Coast Resorts conveying staff, supplies and/or clients; or of provincial government staff.

[23] i.e. per hectare of surface area
[24] also cited in Cichowski et al. (2001)

Recording of craft serial numbers and owner names allows the collation of entry and exit records for visitors travelling in their own craft. Because the party size and duration of their visit is also recorded on entry, the annual number of visitor days represented by parties in categories (1) to (3) can be calculated. Collation allows the length of the visit to be corrected from the date of entry and exit if the party stayed longer than was stated at entry. Each year there are a number of parties for which an entry record is available but no exit record; these parties either exited by the Eutsuk River or their exit was simply unrecorded but the person days associated with their visit can still be estimated from their entry record.

Greater uncertainty is associated with the fourth category. Records of provincial government staff can be eliminated, and West Coast Resorts does not utilize watercraft to transport their clients so their entries can be removed as well. However, Pondosy Bay Lodge entries are difficult to collate because:

- Pondosy Bay Lodge makes many entries and exits each season with more than one craft,
- the number of lodge staff versus guests are not discernible from the records,
- the length of visit or party size (or both) is often unrecorded, *and*
- *it is unknown whether the visitors are accounted as guided or unguided clients in the annual report from the lodge.*

Notwithstanding these difficulties, Table 9 presents a summary of the number of person-days represented by entries each year at Chikamin Bay of visitors in their own watercraft. Table 10 summarizes person-days indicated by Chikamin Bay record entries of Pondosy Bay Lodge vessels. Aside from missing information for some entries and the difficulty of interpreting entries for Pondosy Bay Reports, there are other issues in converting these summary statistics to an estimate of annual activity in the sport fishery on Eutsuk Lake. Some visitors are en route to Pondosy or Surel lakes rather than Eutsuk, an unknown number of parties enter and exit the park via the Eutsuk River without any use of the Chikamin Portage, and an unknown proportion of visitor days do not involve angling. However, in the absence of better information, these data provide a starting point. Leaving aside for now the question of how to account for visitors associated with entry/exit of Pondosy Bay Lodge craft, in the three years 2000 to 2002 the records suggest 687 to 1331 park visitor days per annum by parties who entered Tweedsmuir Park in their own vessels through Chikamin Portage (Table 9). Assuming that a day each at the start and end of all party visits are occupied by travel rather than recreation, these visitors conducted approximately 407 to 836 angler days yearly (Table 9).

3.6.2. Volunteer Creel Cards

Volunteer creel cards have been distributed and collected at the boat launch in Andrews Bay Provincial Park as well as at Chikamin Portage. An unknown proportion of visitors complete cards, so the data are of no use in estimating activity in the fishery, but do provide a potential source about catch and harvest rates[25]. Table 11 presents a summary of catch and catch-per-day information from volunteer creel cards. Occasionally, returned cards

[25] 'catch' refers to the total of fish harvested and fish released; the catch rate is the number of fish caught per angler day, and the harvest rate is the number of fish retained per angler day

fail to report details of the catch and were then excluded from analysis. For a few cards, recorded comments state that the catch represents the activity of multiple anglers; estimates of total angler days represented by the data were adjusted to reflect this.

A total of 364 usable cards representing 1485 angler days were available for the period 1990 to 2000 (Table 11). On average, 3 rainbow trout were reportedly caught per angler day, and 29% were killed for an average harvest of 0.87 trout per angler-day. Catch rates were lowest for fish over 50 cm in length, at 0.47 fish per angler-day, and highest for fish in the 30 to 50 cm class at 1.29 fish per angler-day. However, anglers were more likely to kill larger fish. Roughly half (49%) of angled fish over 50 cm were harvested, giving an average harvest rate for this size class of 0.23 fish per angler day.

The most problematic aspect of volunteer creel census is that results of such surveys are typically biased upwards (De Gisi 1999). Anglers who return cards are often the most active and successful participants, so their responses tend to be non-representative and usually overestimate the angling catch. Without other information, the magnitude of the bias cannot be estimated.

3.6.3. Angling Guide Reports

Angling effort and catch by guided clients of the two angling lodges located on Eutsuk Lake are summarized in Table 12, for the operational years 1999 through 2001. Information was compiled from annual reports submitted to B.C. Parks, and entries in the WLAP Skeena Region Angling Guide Management System (AGMS) database.

All clients of West Coast Resorts lodge on Eutsuk Lake are guided, so their reports should reflect the full scope of the lodge participation in the fishery (except staff). West Coast Resorts' clients also enter and exit the park exclusively by floatplane, so there is no concern for overlap between their reports and the entry/exit records at Chikamin Portage in terms of estimating effort in the fishery. For the period 1999 through 2001, the lodge conducted from 87 to 135 guided angler days annually on Eutsuk Lake. Their clients reportedly harvested less than 10 fish per year, and the average catch rate of (released) rainbow trout was roughly 2.5 to 4 fish per day, fairly similar to catch rates reported by unguided anglers on voluntary creel cards.

The clientele of Pondosy Bay Lodge includes guided guests as well as parties who are simply renting accomodation from the lodge. Pondosy Bay Lodge's reports provide catch and effort for guided parties, but catch information only for unguided clients. Most of the lodge's clients enter and exit the lake via Chikamin Portage, though some do travel to the lodge by floatplane (Van Tine 2002). Pondosy Bay Lodge reported conducting 52 to 90 guided angler days per annum in the period, and these clients killed 11 to 27 rainbow trout annually. Guided client catch rates were 0.9 to 2.5 fish per day. The harvest reported for unguided clients was 86 rainbow trout in 2000 and 10 in 2001.

3.6.4. Fishery Totals

Using the information presented, it is possible to make a rough estimate of the total activity and catch in the Eutsuk Lake fishery in the years 1999 to 2001 and compare the estimates to angling use studies for other pelagic piscivorous rainbow trout lakes. Some of the sources of error in the Eutsuk information were discussed in section 3.6.1. Overlap between the Chikamin Portage records and Pondosy Bay Lodge's guide report can be alleviated by assuming that all entry/exits of craft belonging to the resort were related to transportation of supplies, staff, or guided clientele only; this is an assumption of questionable accuracy but appears the most straightforward approach to the problem. Thus to obtain an estimate of effort in the fishery, the estimates of visitors entering the park at Chikamin portage *in their own crafts*[26] would be added to the reported *guided* angler activity of the two lodges. By this accounting, a total of 587 to 1023 angler days occurred annually on Eutsuk Lake between 1999 and 2001. Using the average harvest rate from voluntary creel cards of 0.87 fish killed per angler day, 511 to 890 rainbow trout were harvested per year. This suggests 2.4 to 4.2 angler days per square kilometre of lake surface area per year in the Eutsuk fishery, and a harvest of 2.1 to 3.6 rainbow trout per km^2 per year.

Selected angling use studies for other pelagic piscivorous rainbow trout lakes are presented in Table 13. Adjustment of effort and catch by lake surface area is provided in Table 14. On an area-adjusted basis, effort in the Eutsuk Lake fishery is in the range of 1% to 10% of the other fisheries presented. Harvest at Eutsuk, in terms of numbers of rainbow trout only, is less 10 % of the other fisheries shown. Comparison of catch rates (total of harvested and released fish) shows that the Eutsuk Lake catch of 3 rainbow trout per angler day is 3 to 5 times higher than rates for Babine (roughly1 fish per angler day) or Kootenay (0.6 fish per angler day).

3.6.5. Summary

The information presented in this section should not give a false sense of security about present levels of activity and harvest in the Eutsuk Lake fishery. Eutsuk Lake angling activity and harvest, when adjusted for the surface area of the lake, does appear much lower than for road-accessible lakes with fish populations of this ecotype. Catch rates per angler day are apparently higher, suggesting that relative abundance of trout at Eutsuk Lake is likely greater under the lower exploitation rates. However, two major notes of caution are warranted. First, the estimates of effort and catch in the Eutsuk fishery are highly speculative, based on a variety of information which cannot be considered reliable. Second, Eutsuk Lake may be much less productive per unit area than the comparison lakes, and/or the size of the pelagic piscivore stock much different. For both of these reasons, the answer to the question posed by the heading of the section must be negative: available data is insufficient to allow confident assessment of the status of the Eutsuk Lake fishery and additional information is needed.

[26] neglecting the over-estimation resulting from some visitors spending days on other lakes, and the underestimation resulting from craft entering and exiting via the Eutsuk River (Redfern Rapids) being uncounted-- these factors would act in opposite directions on the total estimate, although their magnitude is unknown

Table 9. Collation of Chikamin Bay portage records to estimate Eutsuk Lake visitorship for the calendar years 1999 to 2001, for visitor-owned vessels only. **Visitor Days** include all days (or portions thereof) spent in the park; estimation of **Angler Days** assumes that a day each at the start and end of visits are devoted to travel rather than angling. **Record Status**

Year	Destination	Record Status	Number of Vessels	People	Visitor Days	Angler Days
1999	Pondosy Bay Lodge	In & Out	26	82	423	259
	Other	In & Out	40	105	552	342
	Pondosy Bay Lodge	In Only	3	16	76	44
	Other	In Only	18	53	272	176
	Other	Transit	1	2	8	4
Total	**All - 1999**		**88**	**258**	**1331**	**825**
2000	Pondosy Bay Lodge	In & Out	24	74	421	273
	Other	In & Out	27	83	502	336
	Pondosy Bay Lodge	In Only	5	24	141	93
	Other	In Only	11	29	160	102
	Other	Transit	3	12	56	32
Total	**All - 2000**		**70**	**222**	**1280**	**836**
2001	Pondosy Bay Lodge	In & Out	12	44	199	111
	Other	In & Out	21	61	319	197
	Pondosy Bay Lodge	In Only	7	23	117	71
	Other	In Only	5	12	52	28
	Other	Transit	-	-	-	-
Total	**All - 2001**		**45**	**140**	**687**	**407**

Table 10. Collation of Chikamin Bay portage records for the calendar years 1999 to 2001, for vessels owned by Pondosy Bay Lodge. Park entry records only (not exits) are included. **Visitor Days** include all days (or portions thereof) spent in the park. Pondosy Bay Lodge average visit length of 4.3 days and average party size of 3.3 persons were applied to estimate visitor days when either the number of persons or the length of visit was not recorded; in these cases where data were missing, estimates are in parentheses. Because Chikamin records do not distinguish lodge staff from recreational visitors or guided from unguided clients, these entries were not used in estimation of angling activity at Eutsuk Lake.

Year	Number of Entries	Data Recorded	People	Visitor Days
1999	*8*	*Days and Persons*	*22*	*68*
	1	*Days Only*	*UN*	*(15)*
	3	*Persons Only*	*13*	*(56)*
Total 1999	***12***			***(139)***
2000	*5*	*Days and Persons*	*20*	*121*
	2	*Days Only*	*UN*	*(28)*
	6	*Persons Only*	*20*	*(86)*
Total 2000	***13***			***(235)***
2001	*3*	*Days and Persons*	*10*	*36*
	4	*Days Only*	*UN*	*(57)*
	15	*Persons Only*	*47*	*(202)*
Total 2001	***22***			***(295)***

Table 11. Angling effort and catch from volunteer creel cards distributed and collected by B.C. Parks at Chikamin Portage. Reported catch where length was unspecified is reflected in the Total column only. See report text for explanation of the limitations of the information.

Year (# cards)	**Anglers**	**Angler Days**	**Rainbow Trout Catch**	**< 8"**	**8"-12"**	**12"-20"**	**>20"**	**Total**
1990 (n=44)	44	183	Killed	2	30	81	36	**149**
			Released	55	86	86	18	**245**
			Percent killed	4	26	49	67	**0.38**
			Killed per day	0.01	0.16	0.44	0.20	**0.81**
1991 (n=73)	73	360	Killed	15	41	160	96	**312**
			Released	78	113	216	109	**516**
			Percent killed	16	27	43	47	**0.38**
			Killed per day	0.04	0.11	0.44	0.27	**0.87**
1992 (n=45)	45	180	Killed	22	21	82	54	**179**
			Released	93	106	124	77	**400**
			Percent killed	19	17	40	41	**0.31**
			Killed per day	0.12	0.12	0.46	0.30	**0.99**
1994 (n=6)	6	35	Killed	0	6	22	4	**32**
			Released	6	14	5	6	**31**
			Percent killed	0	30	81	40	**0.51**
			Killed per day	0.00	0.17	0.63	0.11	**0.91**
1996 (n=7)	7	21	Killed	7	6	8	3	**24**
			Released	5	5	14	0	**24**
			Percent killed	58	55	36	100	**0.50**
			Killed per day	0.33	0.29	0.38	0.14	**1.14**
1997 (n=101)	98	369	Killed	7	30	175	56	**268**
			Released	376	341	442	37	**1196**
			Percent killed	2	8	28	60	**0.18**
			Killed per day	0.02	0.08	0.47	0.15	**0.73**
1998 (n=56)	56	216	Killed	12	36	102	51	**201**
			Released	60	107	247	48	**474**
			Percent killed	17	25	29	52	**0.30**
			Killed per day	0.06	0.17	0.47	0.24	**0.93**
2000 (n=32)	33	121	Killed	7	14	59	47	**127**
			Released	42	54	88	62	**246**
			Percent killed	14	21	40	43	**0.34**
			Killed per day	0.06	0.12	0.49	0.39	**1.05**
All (n=364)	**362**	**1485**	**Killed**	**72**	**184**	**689**	**347**	**1292**
			Released	**715**	**826**	**1222**	**357**	**3120**
			Percent killed	**9**	**18**	**36**	**49**	**0.29**
			Kill per day	**0.05**	**0.12**	**0.46**	**0.23**	**0.87**

Table 12. Reported annual Eutsuk Lake angling activity associated with commercial lodges located on the lake. Information was compiled from annual reports submitted to B.C. Parks, and entries in the WLAP Skeena Region Angling Guide Management System (AGMS) database. Where both sources were available, the AGMS totals are shown in parentheses; the larger of the two values was used for totals. **RB** = **r**ain**b**ow trout.

Year	Lodge	Status	Angler Days	RB Killed	RB Released
1999	West Coast	Guided	90 (87)	5	224
	Pondosy Bay	Guided	90 (90)	17	66
		Unguided	*UN*	*UN*	*UN*
	Total - Lodges	**Guided**	**180**	**22**	**290+**
2000	West Coast	Guided	121 (135)	2	512
	Pondosy Bay	Guided	52 (52)	11 (11)	67 (67)
		Unguided	*UN*	*86*	*320+*
	Total - Lodges	**Guided**	**187**	**13**	**832**
2001	West Coast	Guided	120 (106)	6	360
	Pondosy Bay	Guided	60 (60)	27	130
		Unguided	*UN*	*10*	*38+*
	Total - Lodges	**Guided**	**180**	**33**	**490**

Table 13. Angling effort, catch and harvest on selected lakes supporting pelagic piscivorous rainbow trout. **Catch Per Year** includes killed and released rainbow trout; if harvest is known, it is included in parentheses. **CPE** = **C**atch **P**er **E**ffort, in number of fish per unit of angling time, where **Annual Effort** unit is **d**ay or **hr**.

Lake	**Years**	**Annual Effort**	**Catch Per Year**	**CPE**	**Comments**
Arrow Res.	1976-1979	21,800 hr	1839	0.07 /hr	Upper Arrow only; all rainbow stock(s)
Babine	1985	20,905 d 102,835 h	20,000 (~15,000 killed)	~1.0/d	entire lake as well as Nilkitkwa Lake; all rainbow stock(s)
Kootenay	1990 - 2001	44,200 d 244,000 h	28,000 (11,200 killed)	0.63/d	only special tag purchasers (see text)
Okanagan	1985	~ 60,000 d		0.05/hr	all rainbow stocks
Shuswap	early 1990s	~55,000 d			all rainbow stocks
Crescent	1976	11,000 hr	900 killed	> 0.08	released fish not tallied

Table 14. Area-adjusted annual angling effort and harvest on selected lakes supporting pelagic piscivorous rainbow trout. **Annual Effort Per Km^2** unit is angler days per square kilometer of lake surface area per year. **Annual Harvest Per Km^2** unit is number of individual trout harvested per square kilometer of lake surface area per year, not adjusted for fish body size.

Lake	**Years**	**Annual Effort**	**Annual Effort Per Km^2**	**Annual Harvest**	**Annual Harvest Per Km^2**
Babine	1985	20,905 d	43	~15,000	31
Kootenay	1990 - 2001	44,200 d	109	11,200	28
Okanagan	1985	~ 60,000 d	166		
Shuswap	early 1990s	~55,000 d	190		
Crescent	1976	11,000 hr (day length unknown)	75 to 150	900	45

3.7. If available information is insufficient, what supplementary data should be sought to allow management of the population?

As detailed in previous sections, a formal and accurate angling use study of Eutsuk Lake is needed, using a statistically defensible design. Given the access structure of the Eutsuk Lake fishery, this type of study will be much less expensive and likely more precise than could be accomplished for a lake of this size anywhere else in the province.

Previous sections also make a strong case for beginning the process of rainbow trout population assessment. This would include identifying the location of spawning and rearing habitat used by pelagic piscivorous rainbow trout of Eutsuk Lake, and investigation of possible means of enumerating or indexing spawner numbers. Such assessments are expensive, but the data will ensure conservative management at present and provide a baseline for future monitoring efforts.

3.8. In the absence of supplementary data, what would be a prudent approach to management of the rainbow trout fishery?

Given the following circumstances in the Eutsuk Lake fishery:

- likelihood of increasing non-commercial visitor access,
- probable request for additional guided angler days by lodges on the lake who have recently expended considerable funds in upgrading their facilities,
- the unique aspects of the Eutsuk Lake fishery including the apparent rarity and high value of the ecotype,

there would appear to be no prudent approaches to continuing to manage without better data. Information needs are suggested in Section 3.7; B.C. Parks and stakeholders should seek funds to collect the needed information as soon as possible.

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Appendix I. Unconfirmed Natural Lake and Reservoir Populations

Natural Lakes

Takla, Trembleur and Stuart Lakes

Takla, Trembleur and Stuart lakes drain southward in that sequence to the Stuart River, tributary to the lower Nechako River. Very minimal information is available concerning large rainbow trout present in these three lakes. Hartman (1969) listed Stuart Lake in his table of population characteristics of large rainbow trout; he noted that fish of 7 kg had been recorded, and provided dimensions of the spawning creek (length 9.7 km, width 10-15 m, depth 0.6 to 1.0 m) but did not name the stream. Zimmerman (2002) reviewed data in the Omineca Region lakes files for these waters. The Stuart Lake file contains data from 1952 showing rainbow trout up to 70 cm in length and 5.5 kg in weight captured by unknown method. Similarly, datasheets from 1950 in the Trembleur Lake file show rainbow trout to 77 cm in length and 6.7 kg in weight, method again unrecorded. The Takla Lake file did not indicate any rainbow trout longer than 40 cm, but conservation officers patrolling the lake in August 2002 reported the largest angled rainbow trout checked was 53 cm in length and 2.1 kg in weight.

Further investigation of rainbow trout populations of these lakes has remained a low priority regionally. The lakes are relatively remote from population centers, and apparently lightly exploited (Zimmerman 2002), due both to their remoteness and the challenging boating conditions often encountered on the lakes.

Available limnological data was extracted from Shortreed et al. (2001) and FISS (2002).

Adams Lake

Bison (2002) reported the likely presence of pelagic piscivorous rainbow trout in Adams Lake. He based this contention on observations of large rainbow trout with appropriate body form captured at the lake, but stated that very little is presently known about the population including life history or spawning locations. The fishery exploiting the population is minimal at present. The classification of this stock as unconfirmed results from the paucity of data relating to diet, life history, spawning location and population size.

Adams Lake limnological data were reported in Shortreed et al. (2001). Fish species presence was extracted from FISS (2002).

Trout Lake

Bell (2002) reported the probable occurrence of an indigenous population of pelagic piscivorous rainbow trout in Trout Lake. It is unknown whether Trout Lake rainbow trout originally spawned in the Lardeau River downstream of the lake, habitat which is currently utilized by Gerrard rainbow trout of Kootenay Lake. A fish fence operated at the Trout Lake outlet between 1914 and 1949 would have eliminated any such downstream spawning run. Current spawning location is unknown but may be Wilkie Creek or the Lardeau River upstream of the lake (Bell 2002). The number of large piscivores residing in Trout Lake is apparently not high at present, as reports of large fish (up to 9 kg) captured by angling each year are relatively infrequent.

The lake was also stocked with several different strains of hatchery rainbow trout between 1914 and 1953, including Gerrards; the FISS (2002) database does not show any stocking records for Trout Lake after 1953 so it is presumed that current reports of large trout angled in the lake do represent a self-sustaining population. However, in theory such fish might be Gerrard strays; lack of specific life history data and spawning location information for Trout Lake suggests that this stock should be classified as unconfirmed at present.

Limnological data for Trout Lake were obtained from FISS (2002).

Slocan Lake

The presence of an indigenous pelagic piscivorous rainbow trout population in Slocan Lake is considered probable, at least historically, by Bell (2002). Before impoundments on the Columbia system, Slocan Lake was accessible to anadromous fish. The lake drains via the Slocan River to the Kootenay River downstream of Bonnington Falls. The falls formed the natural upstream extent of anadromy in the Kootenay watershed, prior to construction in the early 1940s of Brilliant Dam on the Kootenay River downstream of the Slocan confluence.

There is very little recent anecdotal information, in the form of creel surveys or public feedback, about large rainbow trout captured in the sport fishery on Slocan Lake. The lake has received outplants of 20,000 Gerrard yearlings for each of the past 10 years (FISS 2002). Rainbow trout in the 3 to 4.5 kg size range spawn in the Slocan River below the outlet of Slocan Lake (Bell 2002); the timing of their arrival is later than the smaller riverine fish from Brilliant Pool which also spawn at the Slocan Lake outlet. Whether the larger later fish comprise a self-sustaining pelagic piscivorous rainbow trout population resident in Slocan Lake remains unknown. Wilson Creek is also considered a likely spawning location for large rainbow trout from Slocan Lake (Bell 2002).

Limnological data for Slocan Lake were obtained from FISS (2002).

Wahla Lake

Wahla Lake drains via an unnamed second-order stream, length 1 km and mean gradient 1%, which enters the north shore of Tesla Lake adjacent to the fishing camp owned by Lakes District Air. The company also keeps a boat on Wahla Lake, and guests can hike to Wahla Lake from the Tesla camp via a short trail which follows the Wahla Lake outlet creek. The lake is reputed to regularly produce large rainbow trout (Boudreau 2002), apparently verified by photos on the cover of Lakes District Air's brochure showing three very large trout captured there in early summer of 2001. No information is available about the stomach contents of large trout is available, nor is it known whether their capture has been in the lake's pelagic or littoral areas.

Wahla Lake received a reconnaissance inventory in 1978, including limnological data (Osmond-Jones 1978b). Two sinking gillnet sets captured all fish species which were also present in Tesla Lake, with the exception of kokanee. As is typical, survey gillnetting did not yield any of the very large rainbow trout reportedly present in the lake. Production of large rainbow trout in Wahla Lake in the absence of kokanee prey (but abundance of competing fish species) would be a puzzling phenomenon. Kokanee may be present in Wahla Lake and were simply not captured during the lake survey. It is also possible that large rainbow trout travel to Wahla lake from Tesla Lake via the Wahla outlet stream, although movement among lakes via small streams is thought to be generally uncommon for resident rainbow trout (Parkinson and Rosenfeld 1996).

Union Lake

Union Lake drains via Union Creek to Union Inlet at the north end of Chatham Sound near Prince Rupert, B.C. Waterfalls on Union Creek downstream of the lake are presently a complete barrier to anadromy. Fish species captured in the lake during a 1996 reconnaissance inventory included only rainbow trout, kokanee, and prickly sculpin. Angling at the lake reportedly yields rainbow trout to at least 3.5 kg (Pierce 2002). The largest rainbow trout captured by gillnet during the 1997 inventory was 56 cm in length, 1.9 kg in weight and aged 7 yr; the oldest fish captured were aged 10 yr (Mason 1997). No notes of stomach contents were recorded during the inventory, so pelagic piscivory cannot be confirmed but is strongly suspected.

Limnological data for Union Lake were obtained from Mason (1997).

Young Lake

Bison (2002) reported the possible presence of pelagic piscivorous rainbow trout in Young Lake, which lies downstream of Bonaparte Lake on the mainstem Bonaparte River. During gillnetting on the lake in 2002, rainbow trout were observed attacking kokanee captured in the net; the trout were similar in form to pelagic piscivores elsewhere in the region though smaller in size. The sport fishery on the lake captures rainbow trout to about 60 cm in length and 2.3 kg in weight. This stock is categorized as unconfirmed pelagic piscivores due to the lack of data relating to diet, life history, spawning location and population size.

Limnological data and fish species presence for Young Lake were obtained from FISS (2002).

Reservoirs

Seton Reservoir / Anderson Lake

Seton Reservoir was created during the middle 1950s with the construction of a dam downstream of the natural outlet of Seton Lake. The project was accompanied by diversion of cold turbid water through a tunnel from Carpenter Reservoir (Bridge River) to Seton Lake. Seton Dam caused only a very moderate change in the water level and surface area of Seton Lake. Fish ladders have allowed passage for most migratory fish species, though the dam did flood some fluvial spawning habitat at the outlet of the lake. The reservoir is presently considered to offer very good rearing habitat for sockeye and kokanee, including a unique form of kokanee known as oneesh. Anderson Lake lies upstream and drains to Seton Lake by the 2-km-long Portage River. The large resident rainbow trout of the Seton watershed are believed to spawn in the Seton River downstream of Seton Lake, in Portage River, in the Gates River which is the major tributary to Anderson Lake, and in at least one other smaller tributary (Bison 2002). It is unknown whether Anderson Lake supports distinct population(s) of rainbow trout. Diet analysis has not confirmed that these lake-resident rainbows feed pelagically on kokanee or sockeye juveniles (Hebden 2002).

Duncan Reservoir

Duncan Reservoir was formed in 1967 by a dam constructed downstream of the natural outlet of Duncan Lake. The lake (now reservoir) drains via the Duncan River to the north arm of Kootenay Lake. The Duncan River supported spawning by kokanee and large rainbow trout of Kootenay Lake origin prior to creation of the impoundment; the Meadow Creek spawning channel, near the mouth of the Duncan River, was created to attempt to mitigate fish habitat losses due to the Duncan Dam.

Bell (2002) considered it probable that Duncan Lake supported a pelagic piscivorous rainbow trout population before impoundment. Additional information is lacking, and the present status of the population is unknown. Duncan Lake has also received outplants of several strains of hatchery rainbow trout between 1918 and the present, most recently Gerrards stocked between 1987 and 1989 (FISS 2002).

Table 15. North American lakes and reservoirs which potentially support native populations of the pelagic piscivorous rainbow trout ecotype. Column headings correspond to those in Table 1 and Table 4.

Lake	WLAP Region	Watershed	Drainage	Surface Area [ha]	Mean Depth [m]	Max Depth [m]	TDS	Phosph	Chlor-a	Anadr	Pisc Char
Stuart	7A	Fraser	Nechako	36,402	20	97		7.4	1.92	Yes	Yes
Takla	7A	Fraser	Nechako	24,600	107	287		4.9	1.02	Yes	Yes
Adams	3	Fraser	Thompson	14,502	169	457	57	1.6	0.81	Yes	Yes
Trembleur	7A	Fraser	Nechako	11,704	41	103		8.1	1.40	Yes	Yes
Duncan Res.	4	Columbia	Kootenay	7,140	52	118				No	Yes
Slocan	4	Columbia	Kootenay	6,929	171	298	53			No	Yes
Trout	4	Columbia	Kootenay	2,874	128	234	102			No	Yes
Anderson	3	Fraser	Seton	2,832	140	214	97	5.8	1.04	Yes	Yes
Seton Res.	3	Fraser	Seton	2,403	85	150	83	7.2	1.49	Yes	Yes
Wahla	6	Fraser	Nechako	495	25	69	47			No	No
Young	3	Fraser	Thompson	343	29	66	78			No	No
Union	6	Union	(Coast)	240	48	80	18			No	No

Appendix II. Fish Species Codes

Species Code	Species Common Name
BB	Burbot
BSU	Bridgelip sucker
BT	Bull trout
CAS	Prickly sculpin
CBA	Mottled sculpin
CC	Unidentified sculpin (family Cottidae)
CCG	Slimy sculpin
CCN	Shorthead sculpin
CH	Chinook salmon
CO	Coho salmon
CP	Carp
CRH	Torrent sculpin
CSU	Coarsescale sucker
CT	Cutthroat trout
DV	Dolly Varden char
EB	Eastern brook trout (char)
KO	Kokanee
LDC	Leopard dace
LKC	Lake chub
LMB	Largemouth bass
LNC	Longnose dace
LSU	Longnose sucker
LT	Lake trout
LW	Lake whitefish
MW	Mountain whitefish
NSC	Northern pikeminnow (formerly northern squawfish)
PMB	Pumpkinseed sunfish
PMC	Peamouth chub
PW	Pygmy whitefish
RSC	Redside shiner
SK	Sockeye salmon
ST	Steelhead (rainbow trout)
SU	Unidentified sucker (family Catostomidae)
UDC	Umatilla dace
WP	Walleye
WSG	White sturgeon
WSU	White sucker
YP	Yellow perch

Appendix III. Sources and Other Relevant Information About Pelagic Piscivorous Rainbow Trout Populations

Nechako Reservoir

The Nechako Reservoir still supports an apparently healthy fishery for this ecotype with trout in excess of 4 kg regularly captured by trolling, and maximum size comparable to that of Eutsuk Lake (Perrin et al. 1997; Van Tine 2002). Kenney Dam created the reservoir by flooding a number of large lakes (Ootsa, Whitesail, Tahtsa, Tetachuck, and Natalkuz) in the 1950s. It is unknown how many distinct populations of this ecotype existed prior to impoundment of the upper Nechako drainage, or how many remain today. Present-day spawning locations have not been documented, though impoundment is known to have flooded some areas that were previously very important for rainbow trout spawning (i.e. Whitesail River: Lyons and Larkin 1952).

Limnological analyses were reported in detail for nine Nechako Reservoir sample stations in Perrin et al. (1997). The latter document also provides data from 45 rainbow trout of fork length 356 mm to 686 mm sampled from the reservoir angling catch between 31 August 1996 and 13 September 1996. These fish data were collected to assess mercury levels in tissues; length, weight and age[28] were recorded but gonadal maturity was not assessed. No other substantive dataset for larger pelagic piscivorous rainbow trout in the reservoir is known to exist. Winsby et al. (1998), Hatfield Consultants Ltd. (1999), and Winsby and Taylor (1999) present biological data for fish captured mainly by gillnet at a variety of Nechako Reservoir sites during further study of submerged timber salvage on fish and fish habitat. However, the latter 3 reports do not present age data and the study did not capture rainbow trout of length greater than 325 mm in the reservoir.

Arrow Lakes Reservoir

Available information for yellowfin rainbow trout and other fish species of the Arrow Lakes system is reviewed in Sebastian et al. (2000). One or more populations of large piscivorous rainbow trout began to decline soon after the construction of the Keenleyside dam which in the late 1960s inundated into a single reservoir the natural Upper Arrow Lake, Lower Arrow Lake, and the Columbia River between them. Reservoirs upstream on the Columbia River (Mica Dam created Kinbasket Reservoir in 1973, and Revelstoke Dam created Revelstoke Lake in 1983) apparently blocked access to spawning habitat in Camp Creek, Tonkawatla Creek, and/or other Columbia River tributaries upstream of Revelstoke (Sebastian et al. 2000; Bell 2002). Stocking of Gerrard rainbow trout in the Arrow Lakes reservoir possibly also contributed to the decline of the Arrow lakes native populations (Bell 2002) though such stockings were discontinued in 1997 due to concern for Arrow Lake kokanee stocks (Sebastian 2002). In any case, the native yellowfin trout are currently very low in abundance though rehabilitation efforts are ongoing.

Limnological information for Arrow Lakes Reservoir was reported in Matzinger (2000) and Pieters et al. (2002); Pieters et al. (1998) may present more detailed data but was not available for this summary. The reservoirs upstream on the Columbia River have

[28] by scales, aged by an unknown party

resulted in a reduction in nutrient loading to the Arrow Lakes and lowered their productivity; introduction of mysid shrimp (*Mysis relicta*) may also have negatively impacted kokanee populations. Due to concern for declining kokanee stocks, a fertilization program was initiated in 1999. Water chemistry data for Arrow Lakes Reservoir provided in this document were collected after the construction of upstream reservoirs but before the fertilization program, and thus do not reflect pre-impoundment conditions under which one or more thriving yellowfin rainbow trout populations existed.

Babine Lake

Rainbow trout rear in at least 34 tributaries to Babine Lake (David Bustard and Associates 1990). Individuals which spawn in the Sutherland River watershed may or may not comprise the entire pelagic piscivorous ecotype of the species residing as adults in Babine Lake (David Bustard and Associates 1990). For instance, rainbow trout residing in the northwest arm of Babine Lake[29] apparently are composed of one or more stocks distinct from the lake's pelagic piscivores. Their diet may include seasonal gorging on outmigrating sockeye fry and smolts, but the northwestern arm of the lake does not generally yield individuals of the size attained by Sutherland River spawners (David Bustard and Associates 1987). Though the evidence to date is suggestive, the stock structure in the lake and fishery remains unknown.

Life history characteristics of the pelagic piscivorous stock were extracted from David Bustard and Associates (1990) which reported a single-year study of spawners netted and radio-tagged in Babine Lake at the mouth of the Sutherland River. Because the Sutherland watershed spawners which were netted presumably included first-time as well as repeat spawners, the data provide only lower bounds for population characteristics such as size- and age-at-first-reproduction. Although the Sutherland River headwaters contain several small lakes, spawning did not appear to occur immediately below lake outlets. Nevertheless, these lakes and extensive beaver impoundment downstream in the reaches where spawning occurs both may moderate the discharge regime.

Basic characteristics of Babine Lake's limnology were obtained from Shortreed et al. (2001). More detailed information is presumably provided in Shortreed and Morton (2000) which was not available at time of writing.

The ecology of Babine Lake was altered significantly by the construction of sockeye spawning channels on Pinkut Creek and the Fulton River in the late 1960s. The resulting "enhanced" densities of sockeye fry in the lake may have competitively affected the lake's kokanee. Piscivorous pelagic rainbow trout stock dynamics are sensitive to characteristics of their food supply. Larger juvenile (post-yearling) kokanee are preferred prey for pelagic piscivorous trout (Parkinson et al. 1989) which appear to grow less rapidly when kokanee abundance is depressed by sockeye fry competition (Dolighan 2002). Pre-enhancement population data for Babine Lake pelagic piscivorous rainbow trout do not apparently exist, so possible changes in population abundance and size cannot be addressed.

[29] possibly including Nilkitkwa Lake and "Rainbow Alley" which is the short section of the Babine River downstream of the outlet of Babine Lake and upstream of Nilkitkwa Lake

Kootenay Lake

The present ecology of Kootenay Lake reflects substantial impacts of human activities, to the lake and its watershed, during the last 50 years. These have included upstream dam construction, nutrient inputs through fertilization, and introduction of exotic aquatic species (most notably the mysid shrimp *Mysis relicta*; Walters et al. 1991).

Prior to the 1960s, pelagic piscivorous rainbow trout of Kootenay Lake apparently spawned in both the Duncan and Lardeau rivers (Cartwright 1961) but Duncan River spawning habitat was eliminated by construction of the Duncan Dam in 1967 (Irvine 1978). Cartwright (1961) and Irvine (1978) summarize abundance and life history characteristics of the remaining Gerrard population, which spawns in a very limited area of the Lardeau River just downstream of the outlet of Trout Lake. The Gerrard stock has the longest history of investigation and manipulation of any such population of this ecotype in British Columbia, in part because it regularly produces the largest freshwater-resident rainbow trout known from the native range of the species. However, early mismanagement resulted in a public environment hostile to additional studies of the spawning fish (Irvine 1978); current life history data are lacking (Bell 2002).

Information on Kootenay Lake limnology was extracted from Thompson (1999); other sources such as Ashley et al. (1997) and Ashley et al. (1999) presumably provide greater detail but were not available. Operation and then decommission of an ammonium phosphate fertilizer plant on the Kootenay River at Kimberley, construction of the Duncan and Libby dams in 1967 and 1972 which serve as nutrient traps, and restorative fertilization of the lake begun in 1992 have led to wide fluctuations in the water chemistry of Kootenay Lake (Thompson 1999). The parameter values provided for Kootenay Lake in this document are intended to reflect the lake's limnology in the mid-1970s; this is an arbitrary choice but the available data do not suggest the lake's pre-industrial limnological condition. Abundance of Gerrard rainbow trout during the past 5 decades probably has roughly tracked the trends in nutrient loading to the lake, as mediated through the abundance and growth rates of kokanee (Redfish Consulting Ltd. 2002).

Okanagan Lake

The limnology and ecology of Okanagan Lake have been greatly impacted by human settlement in the watershed, and the introduction of exotic aquatic species including the mysid shrimp *Mysis relicta*. Agricultural and residential development have created direct and indirect impacts to fish habitat in the lake and its tributary streams, including but not limited to nutrient additions and hydrologic effects. The lake's kokanee populations have been in steep decline during the last decade or more, necessitating closure of the kokanee sport fishery and other measures including experimental trawl harvest of mysid shrimp.

Life history, population size and spawning location information for Okanagan Lake pelagic piscivorous rainbow trout was obtained by personal communication from Jantz (2002). Additional reports and data for the population and fishery exist at the Ministry of Water, Land and Air Protection office in Penticton, mostly dating from the 1980s. During the 1990s, the fisheries research and management emphasis for the lake shifted to kokanee. In particular, with the closure of the kokanee fishery during the last 5 years, recreational angling effort on the lake has declined such that precise monitoring of the rainbow trout fishery has not been a priority. As the Mission Creek rainbow trout spawning run is not monitored, the effect of the kokanee decline on rainbow trout size and abundance is not presently known.

Limnological data for Okanagan Lake were obtained from FISS (2002) and International Lakes Environment Committee (2002). The fish species presence list for the lake was extracted from FISS (2002).

Shuswap Lake

Life history and spawning location information on Shuswap Lake piscivorous rainbow trout was obtained by personal communication from Bison (2002). Additional reports and data for the population and fishery exist at the Ministry of Water, Land and Air Protection office in Kamloops (Bison 2002).

Shuswap Lake limnological data were reported in Hume et al. (1996) and Shortreed et al. (2001). More detailed information in Morton and Shortreed (1996), and Nidle and Shortreed (1996), was not available for this summary. The fish species presence list for the lake was extracted from FISS (2002).

Quesnel Lake

Information on Quesnel Lake piscivorous rainbow trout, including life history data and spawning locations, was obtained from Parkinson et al. (1989) and Dolighan (2002). Additional data and reports for the fish populations and fishery exist in the Ministry of Water, Lands and Air Protection office in Williams Lake (Dolighan 2002). The fishery is subject to an annual creel survey; the spawning run to the McKinley Creek is monitored by a video system and resistivity counter (Dolighan 2002). Quesnel Lake piscivorous rainbow trout have been decreasing in size during recent years; the current size of approximately 4 kg at first maturity is lower than historic values. A variety of evidence indicates that increased sockeye production has detrimentally affected the lake's kokanee, and that the declining kokanee numbers has created poorer growth conditions for large piscivores (Dolighan 2002).

Quesnel Lake limnological data were reported in Hume et al. (1996) and Shortreed et al. (2001); Nidle et al. (1994) was not available at time of writing. Additional limnological data and reports exist in the Cariboo Region office in Williams Lake. Fish species presence was extracted from FISS (2002).

Kamloops Lake

Telemetric evidence for the spawning location of Kamloops Lake piscivorous rainbow trout was reported by Bison (2002). General life history and abundance data for the population is not available.

Limnological data for Kamloops Lake were obtained from FISS (2002) and International Lakes Environment Committee (2002). Fish species information for Kamloops Lake in FISS (2002) is incomplete, so species possibly present were listed based on those occurring in upstream and downstream waters.

Mabel Lake

Information concerning Mabel Lake piscivorous rainbow trout, including life history data and spawning locations, was obtained by personal communication from Jantz (2002). Additional data and reports for the population exist in the Ministry of Water, Lands and Air Protection office in Penticton (Jantz 2002).

Limnological data and fish species presence for Mabel Lake were obtained from FISS (2002) which reflects a reconnaissance inventory of the lake in 1969.

Bonaparte Lake

Bison (2002) reported the presence of piscivorous pelagic rainbow trout in Bonaparte Lake, and provided the available information on life history and spawning location.

Two fishways were constructed on the Bonaparte River in the early 1990s; one is located 2 km upstream of the mouth of the Bonaparte River at the Thompson River, and the second is located near the outlet of Bonaparte Lake (Shortreed et al. 2001). These fishways have allowed coho, chinook and steelhead to access the lake and its tributaries. Sockeye have not been observed, but Fisheries and Oceans may consider fry outplants to the lake (Shortreed et al. 2002). The establishment of sockeye could have significant effects on kokanee population(s) and thus piscivorous rainbow trout in Bonaparte Lake.

Bonaparte Lake limnological data were reported in Shortreed et al. (2001). The fish species occurrence list for Bonaparte Lake was extracted from FISS (2002).

Isaac Lake

The presence of a population of pelagic piscivorous rainbow trout in Isaac Lake was reported by Dolighan (2002), who also provided the available life history information. Isaac Lake is one of the circle of lakes known as the "Bowron Lake chain" within Bowron Lake Provincial Park, accessible only by canoe. Further research on this population is of low priority regionally, due to the moderate angling exploitation rate engendered by non-motorized use only.

Limnological data and fish species occurrence for Isaac Lake were obtained from FISS (2002), which reflects the reconnaissance survey of the lake in 1970.

Lake Crescent

All information concerning Lake Crescent fish populations and limnology were obtained from Meyer and Fradkin (2002). The lake supports indigenous populations of both rainbow trout and cutthroat trout, each preying pelagically on kokanee salmon and growing to large size. The lake's rainbow trout population are known as Beardslee trout, while the cutthroat are know as Crescenti (Meyer and Fradkin 2002).

Crescent Lake is road-accessible, limnologically unproductive, and has been heavily angled for much of the last century. Despite decades of overexploitation and stocking of non-local hatchery rainbow trout, the Beardslee population appears to have persisted as a genetically unique form (Meyer and Fradkin 2002). Ongoing concern for the Beardslee population has led to a non-retention regulation and prohibition of downriggers for angling at the lake (Meyer 2002).

Tesla Lake

Anecdotal information about Tesla Lake rainbow trout was obtained from Dubuc (2002), but no life history data or other biological information has been collected for the population. Limnological data for Tesla Lake were obtained from a reconnaissance inventory of the lake in 1978 (Osmond-Jones 1978a). As is typical, the survey gillnetting associated with the inventory did not capture any specimens of the large pelagic rainbow trout known to occupy the lake (Osmond-Jones 1978a). Dubuc (2002) verified the presence of fish in the stomach contents as well as the angling capture of large trout by trolling in the lake's pelagic zone, so pelagic piscivory is considered to be confirmed despite the lack of biological data.

Nadina Lake

The occurrence of large piscivorous rainbow trout in Nadina Lake was reported by Bustard (2002), and confirmed by Sprado (2002) and Lacey (2002). Vanderstar (1998) noted kokanee in the stomach contents of two rainbow trout angled at the lake (fork length 45 cm and 49 cm, aged 5 and 6 yr respectively) in September 1998. During the reconnaissance inventory of the lake in September 1974, the largest rainbow trout captured by gillnetting was 49 cm fork length and 1.4 kg in weight; the survey notes stated that larger rainbow trout stomach contents comprised fish from 2.5 to 10 cm in length.

The Nadina River below Nadina Lake is the site of a spawning channel which provides the majority of sockeye fry recruitment to François Lake further downstream. A waterfall below Nadina Lake but upstream of the spawning channel is occasionally passable by anadromous fish, including sockeye. Nadina Lake's typical balance between kokanee and sockeye juveniles is unknown.

Limnological data and the fish species occurrence list for Nadina Lake were obtained from FISS (2002), reflecting the 1974 inventory of the lake.

Khtada Lake

The Khtada watershed is tributary to the lower Skeena River, but a set of cascades on the lower Khtada River prevent anadromy to the lake. Genetic markers confirmed that the large piscivorous trout of Khtada Lake are rainbow trout and not cutthroat. Dolly Varden char present in the lake do not adopt piscivory and occupy benthic habitat, maturing at very small size.

Fish life history and limnological data for Khtada Lake were obtained from the report of the reconnaissance inventory of the lake in 1985 (Norris 1985); an intensive inventory of the lake in 1998 (De Gisi unpublished) which included angling capture of a sample of the large piscivores and a hydroacoustic assessment of the lake's kokanee population; and unpublished data of Keeley (2002).

Appendix IV. Eutsuk Lake Rainbow Trout Data

Column headings : **No.** = sample number for the listed project; **FL** = fork length in cm; **Wt** = weight in grams; **Mat** = sexual maturity; **Spawn Check** = annuli which appear to display spawning checks if any; **Ager** = person who completed the scale examination.

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
1	Aug-90	1990 angler	(11)	64.0	3178				Tetreau?
2	Jul-95	1994 anglers	10	76.2	5221				Tetreau?
1	02-Aug-94	1994 anglers	5	52.0			U		Lidstone
2	02-Aug-94	1994 anglers	7	48.5			U	6,7	Lidstone
3	July/Aug 94	1994 anglers	5	60.5			U		Lidstone
4	July/Aug 94	1994 anglers	4	44.0			U		Lidstone
5	21-Jul-94	1994 anglers	9	71.0	3405		U		Lidstone
6	UN	1994 anglers	4	32.0			U		Lidstone
7	22-Jul-94	1994 anglers	7	50.5			U		Lidstone
8	01-Aug-94	1994 anglers	9	81.3	4086		U		Lidstone
9	27-Jul-94	1994 anglers	7	58.4	1816		U		Lidstone
10	23-Jun-94	1994 anglers	4	48.0	1362		M		Lidstone
11	23-Jun-94	1994 anglers	5	49.0	1334		F		Lidstone
12	24-Jun-94	1994 anglers	5	45.0	1135		F		Lidstone
13	18-Jun-94	1994 anglers	6	64.0	4001		U	6	Lidstone
14	22-Jun-94	1994 anglers	5	56.0	2724		F		Lidstone
15	22-Jun-94	1994 anglers	7	63.0	2838		F	7	Lidstone
16	21-Jun-94	1994 anglers	7	65.5	4256		U	6,7?	Lidstone
20	30-Jun-94	1994 anglers	6	49.0			M		Lidstone
21	28-Jun-94	1994 anglers	3	39.0	900		M		Lidstone
22	30-Jun-94	1994 anglers	R	56.0			M		Lidstone
25	28-Jun-94	1994 anglers	3	38.0	350		M		Lidstone
26	27-Jun-94	1994 anglers	7	45.0	2951		F		Lidstone
27	27-Jun-94	1994 anglers	7	46.0	2951		F		Lidstone
28	25-Jun-94	1994 anglers	5	38.1	950		M		Lidstone
29	28-Jun-94	1994 anglers	4	39.0	400		M		Lidstone
30	Jul/Aug-2002	2002 anglers	8		2270		U		Lidstone
31	Jul/Aug-2002	2002 anglers	9		4086		U	7,8	Lidstone
32	Jul/Aug-2002	2002 anglers	7		3178		U	5 or 6	Lidstone
1251	10-May-99	Keeley 1999	4	38.5	695	IM	M		Scroggie
1252	10-May-99	Keeley 1999	4	36.2	440	MT	M		Scroggie
1253	10-May-99	Keeley 1999	5	43.6	910	MT	M		Scroggie
1254	10-May-99	Keeley 1999	4	36.0	390	MT	M		Scroggie
1255	10-May-99	Keeley 1999	3	31.5	280	MT	F		Scroggie
1256	10-May-99	Keeley 1999	3	31.8	295	MT	F		Scroggie
1257	10-May-99	Keeley 1999	3	31.9	310	MT	F		Scroggie

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
1258	10-May-99	Keeley 1999	4	33.4	340	IM	M		Scroggie
1259	10-May-99	Keeley 1999	2	28.7	205	MT	F		Scroggie
1260	10-May-99	Keeley 1999	3	31.0	300	MT	F		Scroggie
1261	10-May-99	Keeley 1999	2	21.8	96	IM	F		Scroggie
1262	10-May-99	Keeley 1999	2	18.6	67	MT	F		Scroggie
1263	10-May-99	Keeley 1999	5	43.9	1160	MT	M		Scroggie
1264	10-May-99	Keeley 1999	5	44.5	940	MT	F		Scroggie
1265	10-May-99	Keeley 1999	3	36.4	490	IM	F		Scroggie
1266	10-May-99	Keeley 1999	4	40.2	720	MT	F		Scroggie
1267	10-May-99	Keeley 1999	2	26.7	170	MT	F		Scroggie
1268	10-May-99	Keeley 1999	4	39.0	540	MZ	F		Scroggie
1269	7-Jun-99	Keeley 1999	7	56.2	2220	MT	M		Scroggie
1270	7-Jun-99	Keeley 1999	5	50.2	1650	MZ	F		Scroggie
1271	7-Jun-99	Keeley 1999	5	36.5	505	MT	F		Scroggie
1272	7-Jun-99	Keeley 1999	5	39.7	650	IM	M		Scroggie
1273	7-Jun-99	Keeley 1999	6	47.6	1250	IM	M		Scroggie
1274	7-Jun-99	Keeley 1999	5	42.6	825	IM	M		Scroggie
1275	7-Jun-99	Keeley 1999	6	37.6	540	MT	F		Scroggie
1276	7-Jun-99	Keeley 1999	4	35.4	470	MT	M		Scroggie
1277	7-Jun-99	Keeley 1999	7	64.8	3000	MZ	F		Scroggie
1278	7-Jun-99	Keeley 1999	4	41.5	705	IM	M		Scroggie
1279	7-Jun-99	Keeley 1999	5	47.6	1295	IM	M		Scroggie
1280	7-Jun-99	Keeley 1999	4	37.4	490	MT	F		Scroggie
1281	7-Jun-99	Keeley 1999	7	51.0	1610	MT	M		Scroggie
1282	7-Jun-99	Keeley 1999	5	44.2	1005	IM	M		Scroggie
1283	7-Jun-99	Keeley 1999	6	42.1	780	MT	F		Scroggie
1284	7-Jun-99	Keeley 1999	4	37.3	460	MT	F		Scroggie
1285	7-Jun-99	Keeley 1999	4	33.0	350	IM	M		Scroggie
1286	7-Jun-99	Keeley 1999	5	35.4	465	MT	F		Scroggie
1287	7-Jun-99	Keeley 1999	3	27.1	169	MT	F		Scroggie
1288	7-Jun-99	Keeley 1999	3	26.6	173	MT	F		Scroggie
1289	7-Jun-99	Keeley 1999	5	43.3	910	MT	M		Scroggie
1290	7-Jun-99	Keeley 1999	5	43.8	970	IM	M		Scroggie
1291	7-Jun-99	Keeley 1999	5	35.5	455	MT	M		Scroggie
1292	7-Jun-99	Keeley 1999	5	34.7	430	MT	F		Scroggie
1293	7-Jun-99	Keeley 1999	2	13.2	29	IM	M		Scroggie
1294	7-Jun-99	Keeley 1999	2	15.0	41	IM	F		Scroggie
1295	7-Jun-99	Keeley 1999	7	58.4	1970	MZ	F		Scroggie
1296	7-Jun-99	Keeley 1999	4	38.1	585	IM	M		Scroggie
1297	7-Jun-99	Keeley 1999	5	41.7	840	MZ	F		Scroggie
1298	7-Jun-99	Keeley 1999	3	28.4	195	MT	F		Scroggie
1299	7-Jun-99	Keeley 1999	3	30.4	240	IM	M		Scroggie
1300	7-Jun-99	Keeley 1999	0	5.6	2	IM	U		Scroggie

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
1301	7-Jun-99	Keeley 1999	2	16.8	52	IM	F		Scroggie
1302	7-Jun-99	Keeley 1999	2	17.6	59	IM	F		Scroggie
1303	7-Jun-99	Keeley 1999	2	14.9	40	IM	M		Scroggie
1304	7-Jun-99	Keeley 1999	0	4.4	1	IM	U		Scroggie
1305	7-Jun-99	Keeley 1999	0	4.4	1	IM	U		Scroggie
1306	7-Jun-99	Keeley 1999	0	4.7	1	IM	U		Scroggie
1307	7-Jun-99	Keeley 1999	5	43.1	940	MT	F		Scroggie
1308	7-Jun-99	Keeley 1999	6	39.5	625	MT	M		Scroggie
1309	7-Jun-99	Keeley 1999	4	37.0	580	IM	M		Scroggie
1310	7-Jun-99	Keeley 1999	4	34.3	420	IM	M		Scroggie
1311	7-Jun-99	Keeley 1999	4	35.6	360	MT	F		Scroggie
1312	7-Jun-99	Keeley 1999	5	35.4	430	IM	M		Scroggie
1313	7-Jun-99	Keeley 1999	3	27.6	184	MT	F		Scroggie
1314	7-Jun-99	Keeley 1999	5	48.3	1510	IM	M		Scroggie
1315	7-Jun-99	Keeley 1999	5	45.6	1000	MT	F		Scroggie
1316	7-Jun-99	Keeley 1999	6	46.8	1195	IM	M		Scroggie
1317	7-Jun-99	Keeley 1999	3	33.8	345	MT	F		Scroggie
1318	7-Jun-99	Keeley 1999	4	30.9	300	MT	F		Scroggie
1319	7-Jun-99	Keeley 1999	3	31.3	300	MT	F		Scroggie
1320	7-Jun-99	Keeley 1999	0	5.3	2	IM	M		Scroggie
1321	7-Jun-99	Keeley 1999	1	10.0	10	IM	F		Scroggie
1322	7-Jun-99	Keeley 1999	2	23.6	125	IM	M		Scroggie
1323	7-Jun-99	Keeley 1999	5	42.1	880	MT	M		Scroggie
1324	7-Jun-99	Keeley 1999	5	38.6	650	IM	M		Scroggie
1325	7-Jun-99	Keeley 1999	6	49.5	1325	MT	M		Scroggie
1326	7-Jun-99	Keeley 1999	5	45.5	1130	IM	M		Scroggie
1327	7-Jun-99	Keeley 1999	4	41.9	895	IM	M		Scroggie
1328	7-Jun-99	Keeley 1999	5	40.0	700	IM	M		Scroggie
1329	7-Jun-99	Keeley 1999	5	38.4	570	MT	F		Scroggie
1330	7-Jun-99	Keeley 1999	4	40.5	695	MT	F		Scroggie
1331	7-Jun-99	Keeley 1999	3	30.6	320	MT	F		Scroggie
1332	7-Jun-99	Keeley 1999	3	24.1	134	MT	F		Scroggie
1333	7-Jun-99	Keeley 1999	3	28.8	220	MT	F		Scroggie
1334	7-Jun-99	Keeley 1999	3	29.7	230	MT	F		Scroggie
1335	7-Jun-99	Keeley 1999	3	26.4	180	MT	F		Scroggie
1	25-Aug-82	1982 survey	2	13.5		IM	M		Bustard
2	25-Aug-82	1982 survey	2	15.2		IM	M		Bustard
3	25-Aug-82	1982 survey	3	23.1		IM	M		Bustard
4	25-Aug-82	1982 survey		23.2		IM	M		Bustard
5	25-Aug-82	1982 survey	3	25.0	150	IM	F		Bustard
6	25-Aug-82	1982 survey	3	25.5	100	IM	M		Bustard
7	25-Aug-82	1982 survey	3	27.0		IM			Bustard
8	25-Aug-82	1982 survey		27.5	100	IM	M		Bustard

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
9	25-Aug-82	1982 survey	4	28.0	200	IM	M		Bustard
10	25-Aug-82	1982 survey		28.5	225	IM	F		Bustard
11	25-Aug-82	1982 survey		29.5	150	IM	M		Bustard
12	25-Aug-82	1982 survey	3	29.7	250	IM	F		Bustard
13	25-Aug-82	1982 survey	3	30.7		IM	M		Bustard
14	25-Aug-82	1982 survey	3	30.8	250	IM	F		Bustard
15	25-Aug-82	1982 survey	3	31.2	250	IM	F		Bustard
16	25-Aug-82	1982 survey	3	31.3	250	IM	F		Bustard
17	25-Aug-82	1982 survey	4	31.5	250	MT	M		Bustard
18	25-Aug-82	1982 survey	4	31.8	200	IM	M		Bustard
19	25-Aug-82	1982 survey	4	31.8	200	IM	F		Bustard
20	25-Aug-82	1982 survey	4	31.8	300	IM	M		Bustard
21	25-Aug-82	1982 survey	4	31.9	200	IM	F		Bustard
22	25-Aug-82	1982 survey		32.0	200	IM	M		Bustard
23	25-Aug-82	1982 survey	4	32.3	250	IM	F		Bustard
24	25-Aug-82	1982 survey	4	32.8	200	IM	M		Bustard
25	25-Aug-82	1982 survey	5	33.0	250	IM	F		Bustard
26	25-Aug-82	1982 survey	4	33.0	250	IM	M		Bustard
27	25-Aug-82	1982 survey	4	33.4	250	IM	M		Bustard
28	25-Aug-82	1982 survey		33.5	250	IM	M		Bustard
29	25-Aug-82	1982 survey	4	33.8	250	MT	F		Bustard
30	25-Aug-82	1982 survey	5	36.0	350	MT	F		Bustard
31	25-Aug-82	1982 survey	5	37.0	450	IM	M		Bustard
32	25-Aug-82	1982 survey	5	38.8	450	MT	M		Bustard
33	25-Aug-82	1982 survey	5	39.4	500	IM	F		Bustard
34	25-Aug-82	1982 survey	5	41.0	700	MT	F		Bustard
35	25-Aug-82	1982 survey	5	41.4	700	MT	F		Bustard
36	25-Aug-82	1982 survey	5	42.2	500	MT	F		Bustard
37	25-Aug-82	1982 survey		46.5	1150	MT	M		Bustard
38	25-Aug-82	1982 survey	6	50.0	1100	ST	F		Bustard
39	25-Aug-82	1982 survey	6	51.5	1700	IM	M		Bustard
40	25-Aug-82	1982 survey	6	53.9	1450	ST	F		Bustard
41	25-Aug-82	1982 survey	5						O'Neil
1-1	Jul-Aug 82	1982 anglers	3	27.9	455		F		O'Neil
1-2	Jul-Aug 82	1982 anglers	3	29.5	227		M		O'Neil
1-3	Jul-Aug 82	1982 anglers	3	30.5	227		M		O'Neil
1-4	Jul-Aug 82	1982 anglers	3	30.5	364		M		O'Neil
1-5	Jul-Aug 82	1982 anglers	3	32.0	455		M		O'Neil
1-6	Jul-Aug 82	1982 anglers	3	34.5	455		M		O'Neil
1-7	Jul-Aug 82	1982 anglers	3	33.0	682		F		O'Neil
1-8	Jul-Aug 82	1982 anglers	3	33.0	364		M		O'Neil
1-9	Jul-Aug 82	1982 anglers	3	34.3	364		F		O'Neil
1-10	Jul-Aug 82	1982 anglers	3	34.3	818		F		O'Neil

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
1-11	Jul-Aug 82	1982 anglers	3	34.3	364		F		O'Neil
1-12	Jul-Aug 82	1982 anglers	3	34.3	818		M		O'Neil
1-13	Jul-Aug 82	1982 anglers	3	34.3	818		F		O'Neil
1-14	Jul-Aug 82	1982 anglers	4	36.8	818		M		O'Neil
1-15	Jul-Aug 82	1982 anglers	4	36.8	455		F		O'Neil
1-16	Jul-Aug 82	1982 anglers	4	36.8	818		M		O'Neil
1-17	Jul-Aug 82	1982 anglers	4	38.1	1000		M		O'Neil
1-18	Jul-Aug 82	1982 anglers	4	38.1	545		F		O'Neil
1-19	Jul-Aug 82	1982 anglers	4	38.1	682		M		O'Neil
1-20	Jul-Aug 82	1982 anglers	4	38.1	545		F		O'Neil
1-21	Jul-Aug 82	1982 anglers	5	40.6	682		M		O'Neil
1-22	Jul-Aug 82	1982 anglers	5	40.6	1000		F		O'Neil
1-23	Jul-Aug 82	1982 anglers	5	41.9	1136		F		O'Neil
1-24	Jul-Aug 82	1982 anglers	4	43.2	1364		M		O'Neil
1-25	Jul-Aug 82	1982 anglers	4	43.2	1000		UN		O'Neil
1-26	Jul-Aug 82	1982 anglers	4	43.2	909		M		O'Neil
1-27	Jul-Aug 82	1982 anglers	4	44.5	909		M		O'Neil
1-28	Jul-Aug 82	1982 anglers	4	44.5	1136		M		O'Neil
1-29	Jul-Aug 82	1982 anglers	4	44.5	909		F		O'Neil
1-30	Jul-Aug 82	1982 anglers	5	45.7	1364		F		O'Neil
1-31	Jul-Aug 82	1982 anglers	4	45.7	1364		M		O'Neil
1-32	Jul-Aug 82	1982 anglers	5	45.7	1818		M		O'Neil
1-33	Jul-Aug 82	1982 anglers	5	45.7	1727		M		O'Neil
1-34	Jul-Aug 82	1982 anglers	5	47.0	1591		M		O'Neil
1-35	Jul-Aug 82	1982 anglers	5	47.0	1364		M		O'Neil
1-36	Jul-Aug 82	1982 anglers	5	47.0	1591		M		O'Neil
1-37	Jul-Aug 82	1982 anglers	5	47.0	1727		F		O'Neil
1-38	Jul-Aug 82	1982 anglers	5	48.3	1818		M		O'Neil
1-39	Jul-Aug 82	1982 anglers	5	49.5	1364		F		O'Neil
1-40	Jul-Aug 82	1982 anglers	5	49.5	1364		M		O'Neil
1-41	Jul-Aug 82	1982 anglers	5	49.5	1364		F		O'Neil
1-42	Jul-Aug 82	1982 anglers	5	49.5	1818		F		O'Neil
1-43	Jul-Aug 82	1982 anglers	5	49.5	1818		M		O'Neil
1-44	Jul-Aug 82	1982 anglers	5	50.8	1818		UN		O'Neil
1-45	Jul-Aug 82	1982 anglers	5	50.8	1591		M		O'Neil
1-46	Jul-Aug 82	1982 anglers	5	50.8	2727		F		O'Neil
1-47	Jul-Aug 82	1982 anglers	5	50.8	1818		F		O'Neil
1-48	Jul-Aug 82	1982 anglers	6	51.3	2636		M		O'Neil
1-49	Jul-Aug 82	1982 anglers	5	52.1	1818		F		O'Neil
1-50	Jul-Aug 82	1982 anglers	5	52.1	1818		M		O'Neil
1-51	Jul-Aug 82	1982 anglers	5	53.3	2273		M		O'Neil
1-52	Jul-Aug 82	1982 anglers	5	54.6	1818		M		O'Neil
1-53	Jul-Aug 82	1982 anglers	6	55.9	2955		M		O'Neil

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
1-54	Jul-Aug 82	1982 anglers	6	55.9	2727		F		O'Neil
1-55	Jul-Aug 82	1982 anglers	5	55.9	2273		M		O'Neil
1-56	Jul-Aug 82	1982 anglers	5	55.9	1818		M		O'Neil
1-57	Jul-Aug 82	1982 anglers	6	55.9	2727		M		O'Neil
1-58	Jul-Aug 82	1982 anglers	6	55.9	2636		F		O'Neil
1-59	Jul-Aug 82	1982 anglers	6	57.9	3409		F		O'Neil
1-60	Jul-Aug 82	1982 anglers	6	58.4	2273		F		O'Neil
1-61	Jul-Aug 82	1982 anglers	6	58.4	2273		M		O'Neil
1-62	Jul-Aug 82	1982 anglers	6	61.0	2818		M		O'Neil
1-63	Jul-Aug 82	1982 anglers	7	61.0	3273		M		O'Neil
1-64	Jul-Aug 82	1982 anglers	7	63.5	2727		F		O'Neil
1-65	Jul-Aug 82	1982 anglers	6	63.5	3545		F		O'Neil
1-66	Jul-Aug 82	1982 anglers	7	64.8	4091		M		O'Neil
1-67	Jul-Aug 82	1982 anglers	7	64.8	4091		F		O'Neil
1-68	Jul-Aug 82	1982 anglers	7	66.0	3636		F		O'Neil
1-69	Jul-Aug 82	1982 anglers	8	67.3	4636		M		O'Neil
1-70	Jul-Aug 82	1982 anglers	7	68.1	3864		M		O'Neil
1-71	Jul-Aug 82	1982 anglers	7	68.6	4182		M		O'Neil
1-72	Jul-Aug 82	1982 anglers	8	76.2	4091		F		O'Neil
1	Aug-83	1983 anglers	4	38.1	500		F		Unknown
2	Aug-83	1983 anglers	4	40.6	500		M		Unknown
3	Aug-83	1983 anglers	4	40.6	485		F		Unknown
4	Aug-83	1983 anglers	4	43.2	900		F		Unknown
5	Aug-83	1983 anglers	4	43.2	900		M		Unknown
6	Aug-83	1983 anglers	5	48.2	1400		M		Unknown
7	Aug-83	1983 anglers	5	50.8	2000		F		Unknown
8	Aug-83	1983 anglers	6	55.9	2900		F		Unknown
1	20-Aug-51	1951 survey	6	52.5	1675		F		Unknown
2	20-Aug-51	1951 survey	6	51.5	1300		UN		Unknown
3	20-Aug-51	1951 survey	5	49.5	1225	IM	UN		Unknown
4	20-Aug-51	1951 survey	5	47.5	1000		F		Unknown
5	20-Aug-51	1951 survey	4	40.3	450	IM	UN		Unknown
6	20-Aug-51	1951 survey	5	38.5	550		F		Unknown
7	20-Aug-51	1951 survey	6	39.4	650		F		Unknown
1	Jun-86	1986 project	5	42.0			F		Tetreau?
2	Jun-86	1986 project	6	50.0			M		Tetreau?
3	Jun-86	1986 project	7	52.0			F		Tetreau?
4	Jun-86	1986 project	8	65.0			M		Tetreau?
5	Jun-86	1986 project	8	50.0			UN		Tetreau?
6	Jun-86	1986 project		50.0					N/A
7	Jun-86	1986 project		63.0					N/A
8	Jun-86	1986 project		55.0					N/A
E-1	Perrin	Perrin 1997	4	48.3	680				Unknown

No.	Date	Project	Age	FL	Wt	Mat	Sex	Spawn Check	Ager
E-2	Perrin	Perrin 1997	6	63.5	2947				Unknown
E-3	Perrin	Perrin 1997	4	35.6	567				Unknown
E-51	Perrin	Perrin 1997	3	30.5	283				Unknown
E-52	Perrin	Perrin 1997	4	41.9	453				Unknown
E-53	Perrin	Perrin 1997	4	37.5	453				Unknown
E-54	Perrin	Perrin 1997	5	41.9	680				Unknown
E-55	Perrin	Perrin 1997	6	46.4	1020				Unknown