Reconnaissance 1:20,000
Fish and Fish Habitat Inventory
of
Lower Campbell River Watershed

Downstream of Strathcona Dam
Upstream of Quinsam River

Watershed Code: 920-627900

Prepared for:

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Project Reference Information

MELP Project Number	01-CAMP-0000-0001-1998
FRBC Project Number	N917655-08
FDIS Project Number	01-CAMP-0000-0001-1998
FRBC Region	Vancouver Region
MELP Region	01
MELP District	Campbell River
FW Management Unit	1-10
Fisheries Planning Unit	Campbell Oyster
DFO Sub-District	13
Forest Region	01
Forest District	Campbell River
Forest Licensee and Tenure #	n/a
First Nations Claim Area	Campbell River and Cape Mudge Bands

Watershed Information

Watershed Group	Campbell
Watershed Name	Lower Campbell
Watershed Code	920-627900
UTM at Mouth	10.338168.5545896
Watershed Area	26,399 ha (Lower Campbell study area)
Total of All Steam Lengths	189 km (Lower Campbell study area)
Stream Order	7
NTS Map	92K/3, 92K/4, 92F/13, 92F/14
TRIM Map	092F.092, 092F.093, 092F.094, 092K.002, 092K.003, 092.004, 092K.012, 092K.013
Biogeoclimatic Zone	CWH
Air Photos	BCB91039:42-46, 73-80, 102-119 BCB91031:33-37, 91-99, 144-162, 192-208, 256-270 BCB91024:168-172, 199-205, 273-275

Sampling Design Summary

Total Number of Reaches	322 (Lower Campbell study area)
Random Sampling Sites	25
Discretionary Sample Sites	19
Total Sample Sites	44
Field Sampling Dates	August 17 – October 23, 1998

Contractor Information

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Disclaimer

This product has been accepted as being in accordance with approved standards within the limits of Ministry quality assurance procedures. Users are cautioned that interpreted information on this product developed for the purposes of the Forest Practices Code Act and Regulations, for example stream classifications, is subject to review by a statutory decision maker for the purposes of determining whether or not to approve an operational plan.

Acknowledgments

Forest Renewal BC provided funding for this inventory.

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1.0 Introduction

1.1 Project Scope and Objectives

- This report documents the findings of a 1:20,000 Fish and Fish Habitat Reconnaissance Survey conducted in the Lower Campbell River Watershed (downstream of the Strathcona Dam to the mouth of the Quinsam River). MJ Lough Environmental Consultants surveyed the streams in this watershed between August 17 and October 23, 1998 as part of the Sayward Landscape Unit Fish and Fish Habitat Inventory Project that was conducted between 1996 and 1998.
- Separate watershed reports have been prepared for each of the 5 watersheds in the Sayward Landscape Unit:
    - Amor de Cosmos
    - Lower Campbell
    - Menzies
    - Mohun
    - Pye
- The primary objective of this inventory project is to describe fish populations, distributions and fish habitat characteristics of project watersheds. This information will be used to guide fisheries management decisions and to indicate where further inventory work is required in the Sayward Landscape Unit.
- Many of the lakes (and their tributaries) in the Lower Campbell Watershed were surveyed during reconnaissance inventories in 1996 and 1997. Where appropriate, information from those surveys is summarized in this report. Complete lake inventory information is included in the individual lake reports that were produced as part of the 1996-97 lake inventory project (MJ Lough and others 1998).

1.2 Location

- The Campbell River flows east on Central Vancouver Island and enters the ocean in Discovery Passage, at the town of Campbell River. The study area for this inventory is the portion of the Campbell River watershed between the Strathcona Dam (at the outlet of Upper Campbell Lake) and the Quinsam River confluence, about 4 km upstream of the mouth of the Campbell River (Figure 1).
- Much of this watershed is located in the Sayward Provincial Forest, with a small section in MacMillan Bloedel's TFL 39 and another portion in private land held by Timberwest Forest Company. It lies between Mohun Creek Watershed to the north, Salmon River Watershed to the west, Upper Campbell Watershed and Quinsam River Watershed to the south, and the town of Campbell River and Discovery Passage to the east.

1.2.1 Access

- The lower Campbell River, downstream of the BC Hydro powerhouse, is in the town of Campbell River and is accessible for most of this length by paved road.
- Between the powerhouse and the John Hart Dam, the river flows through a canyon and is only accessible on foot via a hiking trail along the north side of the river.

- The Campbell River watershed has been logged since the late 1800's, and as a result, an extensive network of logging roads exists throughout the watershed. Much of the area is presently an active working forest with maintained roads for logging access. This network of active and overgrown logging roads provides access to, or near most of the sites in the study area.
- Although none of the streams and lakes in the study area are far from roads, there are a few small lakes and stream sites that are only accessible by foot or helicopter (e.g. Lukwa Lake) (Appendix 2, Project Maps).

2.0 Resource Information

2.1 First Nations Issues

- The Sayward Forest is included in the traditional claims to land title by the Campbell River and Cape Mudge Bands. The Kwakiutl Laich-kwill-Tach Council of Chiefs represents these and other bands in land claim issues, and have included the area in their *Statement of Intent* documents which were accepted by the BC Treaty Commission in February, 1997. Negotiations with the Federal and Provincial governments are currently proceeding through the BC Treaty Commission (Armstrong pers. comm.).

2.2 Development, Land and Water Use

- Man has had a profound effect on the fish habitat throughout the Campbell River Watershed (Lough and others 1992)
- It has been heavily logged, in many places for the second time. It has been mined and dammed. Streams from 3 neighboring watersheds have been diverted into the Campbell Watershed, and stream flows are artificially regulated to suit the operational requirements of the power generation facilities.
- Urban and industrial developments in the lower reaches have encroached upon fish habitat with much of the lower river now channelized, with alienated streambanks. An extensive network of logging roads and paved highways now exists throughout the watershed.
- In addition, the watershed is in one of the most popular outdoor recreation areas on Vancouver Island, and therefore contains numerous parks and British Columbia Forest Service Recreation Campsite facilities. This has resulted in an active sport fishery with game fish harvests that now require hatchery augmentation in several of the more popular lakes.

2.2.1 Logging

- The primary resource based activity in the Lower Campbell Watershed is logging. Most of the Sayward Forest was logged in the early 1900's (BCMOF-CRD undated). The extensive logging resulted in a network of old railway grades and gravel roads in the Sayward Forest, particularly in the Lower Campbell Watershed.

- In 1938, 35,000 hectares (ha) of forest from Campbell River to Courtenay was destroyed in the Bloedel Forest Fire (BCMOF-CRD undated). After the fire a large artificial reforestation program was initiated to plant trees on Crown and private land.

2.2.1.1 Sayward Provincial Forest

- Most of the Lower Campbell Watershed lies in the Sayward Provincial Forest which is a public forest managed by the British Columbia Ministry of Forests (MOF), Campbell River Forest District.
- In 1938, the Bloedel fire burned approximately 5,200 ha of the Sayward Provincial Forest, between Boot Lake and the north shore of what is now John Hart Lake (BCMOR-CRD undated). The timber in these areas is currently approaching merchantable size, and harvest of many of these trees is proposed during the next 10 years, either as commercial thins or clear-cuts (BCMOF-CRD 1998).
- The Snowden Demonstration Forest lies just north of Campbell Lake. This is an active forest where silviculture systems are integrated with environmental concerns, recreation, education, research, and wildlife management, to raise public awareness about Integrated Resource Management of Provincial Forests (Snowden Demonstration Forest, undated).

2.2.1.2 MacMillan Bloedel TFL 39

- The 2 northwest inlet streams to Brewster Lake originate in MacMillan Bloedel's TFL 39. The headwater lakes of these inlets are Beaver, Sedge, Lawnchair, and Pocket; all of which were surveyed by MJ Lough and Associates in 1997. The MacMillan Bloedel 1996 – 2000 Forest Development Plan shows no planned logging or road development in this area (MacMillan Bloedel 1996).

2.2.1.3 Timberwest Forest Company Land

- The area to the southwest of Campbell Lake, including Beavertail, Gooseneck, Snakehead, Reginald, Bottle and Highland Lakes, and their tributaries, lies in land owned by Timberwest Forest Company. All of these lakes were included in the 1997 lake and stream inventory performed by MJ Lough & Associates.
- The upstream half of Greenstone Creek was included in this inventory project and is also in Timberwest Forest Company land. There is no planned logging or road development for the next 5 years in the Timberwest land southwest of Campbell Lake (Gibson pers. com.).

2.2.1.4 Impacts of Logging

- Specific examples of the effects of logging in the Campbell Watershed are as follows:
  - The entire study area has been intensively logged during the last century, and some areas have been logged again in a second pass. One of the impacts of this is an extensive network of logging roads and old rail grades. Many of these roads are currently maintained as active logging roads, and have had a pronounced impact by opening up access to virtually all of the watershed.

- Culvert blockages, washouts, and siltation problems associated with the extensive network of logging roads have been documented throughout the watershed (BCMELP-FB-VIR 1998).
- Brewster and Snakehead Lakes were historically used for log dumps and sorts. Gooseneck Lake still has many drifting logs that are remnants from when the lake was used as a log dump. Logs left in the lakes have now accumulated at the outlets, creating large debris jams which obstruct or restrict flows from the system and deposits an organic mat of water-logged debris on the lake bottom.
- During the early 1900's, a logging railway network was used throughout the Campbell Watershed. Remnants of the large trestles and numerous stream crossings still exist today. Although the railway is now derelict and the steel has been removed, the old rail grade was never properly deactivated, and occasional washouts or blockages are evident at tributary crossings such as the south shore of Campbell Lake (Lough and others 1998).

2.2.2 Hydroelectric Development

- The Campbell River Watershed has a large BC Hydro hydroelectric development on it, which provides more that 240 MW of power (Hirst 1991).
- The hydro development consists of 3 main reservoirs that are used to store water for power generation. The lowermost dam in the system, John Hart, was built in 1947 and impounds John Hart Lake. Upstream, Campbell Lake is impounded by the Ladore Dam, which was completed in 1949 and modified in 1957. The Strathcona Dam, completed in 1958, forms the highest reservoir, Upper Campbell Lake which is connected to Buttle Lake (Hirst 1991).
- Flows from the Heber, Quinsam and Salmon Rivers were diverted into the Campbell watershed in 1958 to provide more water to the three reservoirs. Crest Creek and the Heber River headwaters are diverted into Upper Campbell Lake. The Quinsam diversion supplies water to Campbell Lake via Gooseneck Lake on Miller Creek, and the Salmon River diversion supplies water to Campbell Lake via the southwest inlet to Brewter Lake (Figure 2) (Hirst 1991).
- Penstocks carry water from John Hart Dam to the BC Hydro powerhouse, 1 km downstream (Hirst 1991).

2.2.2.1 Impacts of Hydroelectrical Developments

- Some of the largest changes that man has made to the Campbell Watershed have been associated with the development of the hydroelectric facilities; which includes reservoir impoundment, penstock and power generation facilities, and diversion of stream flows from the Heber, Quinsam and Salmon Rivers. The affects of these changes to fish habitat has been extensively studied, and the following is a summary of key findings.

2.2.2.1.1 Anadromous Waters

- Before the John Hart power generating facility was completed in 1947, the Campbell River flowed from Campbell Lake for about 5 km before it went over the Elk Falls, 5.6 km from the ocean (there was no John Hart Lake) (Figure 3).

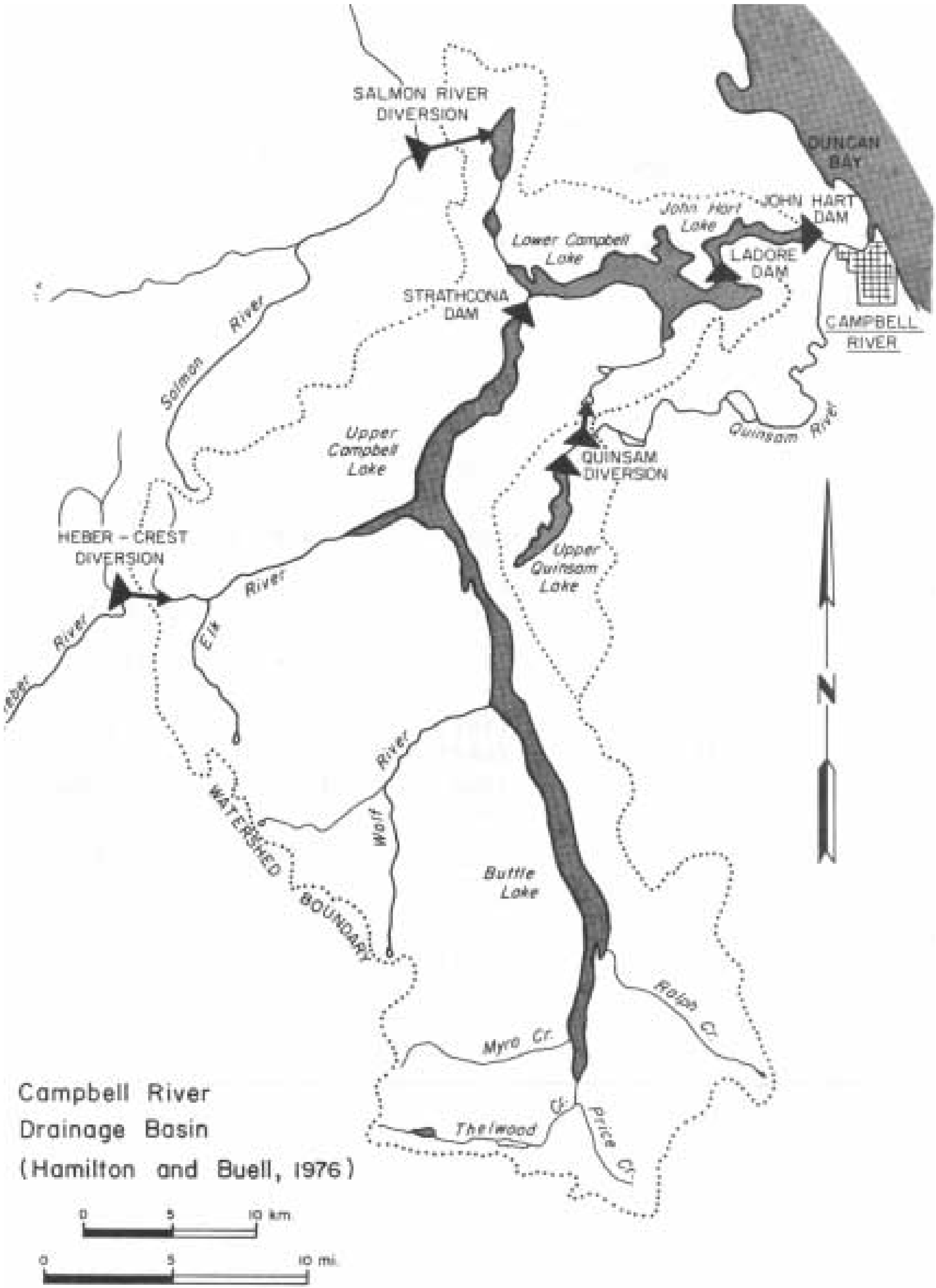

Figure 2 The Campbell River watershed, showing hydroelectric dams and diversions from the Salmon, Quinsam and Heber Rivers (*from* Hamilton and Buell 1976)

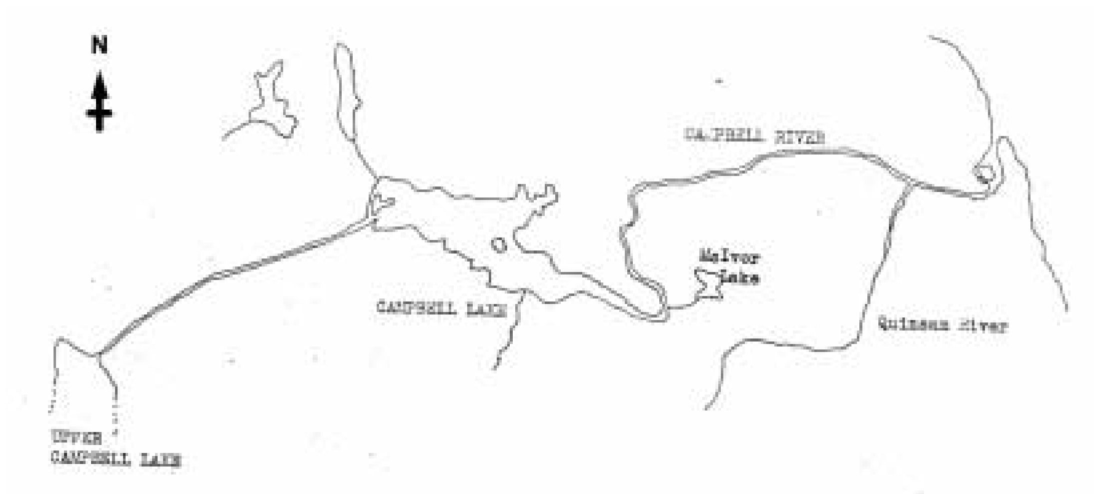

Figure 3 Drawing of the Lower Campbell River Watershed in 1937, prior to the construction of the John Hart, Ladore and Strathcona dams. The free-flowing reaches of the Campbell River were inundated when the John Hart and Ladore reservoirs were created (*from* Carl 1937)

- Historically, anadromous fish were able to access the lower 5.6 km of the Campbell River. However, construction of the John Hart Dam resulted in a loss of 600 m of river that was previously accessible to fish (Bell and Thompson 1977).
- Elk Falls remains a total barrier that blocks the upstream access of all anadromous species.
- The flows in the Campbell River downstream of John Hart Dam are regulated by discharge from the John Hart powerhouse, which has a major impact on fish habitat in these anadromous reaches. Detailed investigations of these impacts on salmon (steelhead were not considered) in the Campbell River were done by Hamilton and Buell in 1976. Results of this work indicated that post-construction impacts have been occurring on a continual basis, due to the flow regimes of the John Hart facility. Bell and Thompson (1977) found that the large and frequent changes to flow releases from the John Hart Reservoir affected the river in several different ways as follows:

    1. Water depths and velocities were frequently beyond the tolerance range of adult spawners, and limited the amount of spawning area available.
    2. Spilling during the spawning period likely inhibited the extent and success of spawning and egg deposition.
    3. Rapid fluctuations in discharges probably caused flooding of preferred rearing areas, and flushed out juveniles; and when flows were reduced, many juveniles were left stranded.
    4. Increased mortality of incubating eggs and alevins occurred as a result of substrate displacement by high spill discharges.
    5. The reduction of aquatic vegetation and stream banks due to high discharges limited the amount of juvenile rearing habitat, and hence fish production of the system.

6. Extreme discharges caused scouring of the substrate and loss of fines and gravels from the river. This limited the amount of spawning habitat available to fish.

- As a result of these findings, a key recommendation of the study was to regulate the releases from John Hart to provide for minimum flows of 56 cubic metres per second (cms), or preferably 70 cms. Maximum flows should not exceed 120 cms, and changes in flow rates should be made gradually to reduce stranding and sudden flushes.
- Negotiations between BC Hydro and DFO later resulted in an informal agreement to maintain flows lower than those recommended by Hamilton and Buell (1976) as follows:

1. Minimum flows of 34 cms.
2. Preferred minimum flows of 50 cms
3. Reduction and increase in flows from 50 cms to 34 cms should be done gradually over an 80 minute period to avoid the stranding and flushing of rearing juveniles.

- A more recent fish habitat study by BC Hydro found that prior to 1995, the preferred base flows of 34 cms were only achieved about 1% of the time during the critical juvenile rearing period of July through October (Burt and Burns, 1995). The study concluded that significant gains in rearing habitat could be realized if flow releases were maintained at 34 cms, and that additional gains would be achieved if the flows could be maintained at 27 cms.

2.2.2.1.2 Non-anadromous Waters

The affects of the hydroelectric development on the inland waters of the Campbell Watershed are summarized as follows:

<u>Construction of dams and reservoir impoundment</u>

- The Ladore and Strathcona dams have no fish passage facilities, and are complete barriers to upstream fish migration, which has essentially isolated populations and restricted movement throughout the watershed.
- Historically, the Campbell River was a 7^{th} order stream that connected Campbell, Upper Campbell and Buttle Lakes, flowing for many kilometers through the valley bottom (Figure 3) (Carl 1937). With the impoundment of the John Hart, Ladore and Strathcona Reservoirs, the smaller lakes and free-flowing stream reaches in the valley bottom were entirely inundated. The valley bottom is now dominated by these large reservoirs and the only remnants of the free-flowing river upstream of John Hart Dam are the outflows below the Strathcona and Ladore dams.
- One of the affects of impoundment has been a loss of stream habitat, and the associated loss of trout spawning and juvenile production capability (McMynn and Larkin 1953).

<u>Diversion of stream flows from adjacent watersheds</u>

- The BC Hydro Salmon River diversion has impacted fish habitat in the Campbell Watershed in the following way. Studies found that up to 97% of the coho salmon and steelhead smolts, from a headwater colonization program on the upper Salmon, were being diverted into the flume, and eventually into Brewster Lake in the Campbell watershed (BCMELP-FB-VIR 1998). Similarly, steelhead kelts from the upper Salmon River have been recovered from Campbell Lake (Law pers. com.). In 1986, BC Hydro and British Columbia Ministry of Environment, Lands and Parks (MELP) installed a screening apparatus in the diversion flume to recover fish that were being diverted from the Salmon River into the Campbell (Lough and others 1993).

Operational impacts

- The effects of regulated stream flows in the Campbell Watershed up-stream of the John Hart Dam, are most pronounced just downstream of the Ladore and Strathcona dams and where the 3 diversions flow into the Campbell Watershed. These effects have apparently not been studied in detail, and little information is available regarding the nature of the impacts.

Impacts of reservoir drawdown

- Reservoir drawdown, or lowering of the water level, also affects the production capability of the aquatic system. Although there is a potential benefit resulting from the increased surface area of the reservoir after impoundment, this is offset by the negative impacts of drawdown. When the reservoir water levels are drawn down, the normally productive littoral zone is reduced to a relatively narrow band below the lower limits of the drawdown. This has the overall effect of lowering the productivity of the lake if compared to pre-impoundment conditions (Sinclair 1965).
- Fluctuating water levels in reservoirs also impacts trout spawning in tributary streams. When reservoir levels are low, and trout spawn in the lower reaches of a stream, the spawning sites are vulnerable to inundation if the reservoir levels are increased.

2.2.3 Mining

- Although there are no mines in the Lower Campbell Watershed study area, leeched tailings from the Westmin lead, zinc and copper mine at Buttle Lake has had a dramatic impact on downstream waters, including Campbell Lake, John Hart Lake and the Campbell River as far as the estuary (BCMELP-FB-VIR 1998).
- A second mine, the Quinsam Coal Mine is an open pit mine located 3 km southeast of Gooseneck Lake, just outside of the Lower Campbell Watershed.

2.2.3.1 Impacts of Mining

- Heavy metal contamination from tailings at the Westmin Mine, starting in 1966, resulted in high heavy metal levels from Buttle Lake to the Campbell River estuary. Elevated heavy metal levels in fish (exceeding sub-lethal stress levels), and a resulting decline in fish abundance were documented during the following years (Deniseger and others 1988). Corrective measures imposed by the BC Government resulted in declines of heavy metal levels in fish by 1986 and increased fish abundance (Deniseger and Erickson 1991).

- The Quinsam Coal Mine, south of Gooseneck Lake, extracts water from Gooseneck Lake for use in the mining process and work camps (BCMELP-WQB-VIR 1999).

2.2.4 Recreation

- The Sayward Provincial Forest is a popular Recreation destination. It offers a variety of recreational opportunities, from fairly rustic to fully developed. The network of old railway grades and gravel roads in the Sayward Forest allow good access to almost all areas. Some of these old grades have been converted into hiking trails, and a large network of trails is being developed by MOF to link the entire Sayward Forest (Cornfield pers. com.).
- The Lower Campbell Watershed provides a freshwater sport fishery for steelhead and salmon downstream of the John Hart Dam. Effort by steelhead anglers has declined from a high of 4,878 angler days in 1989 to 870 angler days in 1998 (BCMOF 1999).
- MELP has conducted angler surveys to determine sport fishing activity on lakes in the study area. It was found that in 1989 an estimated 9,164 angler days were spent in pursuit of the resident cutthroat trout, rainbow trout and Dolly Varden char in large, named lakes in the Lower Campbell Watershed (BCMELP-FB-VIR 1999). Survey data did not consider the additional activity on the numerous small lakes in the study area.
- There are 18 BC Forest Service Recreation Sites in the Lower Campbell Watershed, all located on the shores of lakes, with several on Campbell Lake (Campbell River Forest District 1995). These recreation sites offer rustic camping facilities with fishing, swimming and boating.
- The Sayward Forest Canoe Route is a popular 50 km, circular canoe route through several lakes in the Sayward Forest. It includes 7 lakes in the Lower Campbell Watershed (Campbell, Fry, Whymper, Gray, Brewster, Higgins and Gosling). MOF has constructed portage trails, which join the lakes. As well, there are numerous Forest Service Recreation sites and rustic camping areas along the route (Sayward Forest Canoe Route 1995).
- The southern half of the Snowden Demonstration Forest lies within the Lower Campbell Watershed. The MOF is promoting recreational use of the Snowden Forest through public awareness programs such as the “Hike and Bike the Snowden” initiative. This includes posters that display the trails and lakes in the area. Approximately 30 km of mountain bike and hiking trails have been constructed along old, abandoned railroad grades throughout the Snowden Demonstration Forest (Snowden Demonstration Forest undated).
- There are 2 provincial parks in the Lower Campbell Watershed, Loveland Bay and Elk Falls. Loveland Bay Provincial Park is a 30 ha parcel on the north side of Campbell Lake, at the head of Loveland Bay. It offers camping, picnicking, a boat ramp, swimming, and fishing. Elk Falls Provincial Park is an 81 ha area at the mouth of the Quinsam River. It offers camping, picnicking, swimming, fishing and hiking (PTC Phototype Composing Ltd. 1993).
- McIvor Lake Regional Park lies on the north shore of McIvor Lake and is managed by the town of Campbell River. It offers picnicking, hiking, swimming and water skiing. The Campbell River Waterski Club uses this lake during the summer (Cornfield pers. com.).

- The entire Sayward Provincial Forest has been inventoried at the 1:50,000 level with regards to recreation use, and divided into biophysical feature polygons. These Recreation Resource Inventory maps are available for viewing at the Ministry of Forests, Campbell River District Office. They indicate that hunting, fishing, hiking, mountain biking, camping and canoeing are major recreational pursuits in the Lower Campbell Watershed (Brewster Lake 1987, Quadra Island 1987).
- Several undeveloped limestone karst formations in the Campbell River Watershed are popular with spelunker groups (Campbell River Forest District 1995).
- Several “swimming holes” in the Lower Campbell Watershed are used during the summer, including the canyon area on the Campbell River downstream of Elk Falls. In addition, commercial recreation tours provide river swim and drifting trips from the powerhouse to tidal waters.
- Commercial mushroom picking is a common activity in the forests of the Lower Campbell River Watershed (Cornfield pers. com.).

2.2.5 Water Licences

- There are currently 27 water licenses on the Lower Campbell Watershed that are registered with MELP (BCMELP-WQB-VIR 1999).
- The town of Campbell River takes its domestic water from John Hart Lake.
- Fletcher Challenge operates the Elk Falls Pulp and Paper Mill at Duncan Bay. The mill draws water from Campbell River, just upstream of the Quinsam River mouth, for use in the pulping process.
- MOF obtains water from John Hart Lake, for their nursery north of Campbell River.
- Quinsam Coal draws water from Gooseneck Lake for washing coal and for work camps.
- There are several more private interests and residences that draw water from the Lower Campbell River.

2.3 Water Quality and Flow Data

- Gosling, Merrill and Reginald Lakes were fertilized during a MELP lake fertilization study conducted on 8 lakes in the Sayward forest from 1993 to 1996. Detailed water chemistry sampling was conducted during the study years, with data available at Fisheries Branch, MELP, Nanaimo (BCMELP-FB-VIR 1998).

2.3.1 Water Quality Testing

- Table 1 summarizes historical water quality testing on lakes in the Lower Campbell River Watershed.
- A thorough historical review and summary of water quality testing in the Campbell Watershed, prior to 1977, is described in *The Campbell River Estuary-Status of Environmental Knowledge to 1977* (Bell and Thompson 1977).
- Several of the lakes in the Sayward Forest were surveyed in the late 1970’s by a group of Campbell River Junior Secondary School students. These lake surveys were performed under the guidance of the BC Fish and Wildlife Branch, and included field water chemistry sampling. These studies are located in the MELP Lake Inventory files (BCMELP-FB-VIR 1998).

Table 1 Summary of historical water quality testing in lakes in the Lower Campbell Watershed

Lake or Stream	Survey Date	Performed by	Type of Survey
Beaver Lake	June 13, 1991	MELP	Reconnaissance Lake Survey (lab and field water chemistry)
Beavertail Lake	May 13, 1975	MELP	Reconnaissance Lake Survey
	February 1977	MELP	Lab water chemistry
	May 26, 1981	MELP	Field water chemistry
	December 31, 1981	EVS Consultants	Lab water chemistry
	September 1988	BCFP	Lab Water chemistry
Boot Lake	July 12-17, 1978	students	Field water chemistry
Brewster Lake	May 21, 1960	MELP	Field water chemistry
	August 1-3, 1978	students	Field water chemistry
Campbell Lake	September 15, 1937	G.C. Carl	Field water chemistry
	September 29-30, 1951	MELP	Reconnaissance Lake Survey
	1953	McMynn and Larkin	lab water chemistry
	1965	Sinclair	lab water chemistry
Campbell River near John Hart	1967 – 1987	Environment Canada, Water Quality Branch	lab water chemistry
Fry Lake	July 21-24, 1978	students	Field water chemistry
Garrett Lake	July 10, 1986	MELP	Field water chemistry
	July 20, 1990	MELP	Field water chemistry
Gooseneck Lake	July 17, 1956	MELP	Field water chemistry
	1984	Environment Canada	Lab water chemistry
	August 24, 1990	MELP	Field water chemistry
Gosling Lake	July 24-25, 1978	students	field water chemistry
Gray Lake	July 20, 1978	students	field water chemistry
Hayes Lake	August 27, 1969	MELP	field water chemistry
Lawson Lake	July 9, 1986	MELP	field water chemistry
McIvor Lake	June 3-10, 1987	MELP	Reconnaissance Lake Survey (lab water chemistry)
Reginald Lake	June 21-22, 1989	MELP	Reconnaissance Lake Survey (lab water chemistry and sediment sample)
Snakehead Lake	July 23, 1985	MELP	Reconnaissance Lake Survey (lab water chemistry)
Whymper Lake	July 20, 1978	students	field water chemistry

Source: (BCMELP-FB-VIR 1998).

- MJ Lough and Associates collected water samples from 11 lakes in the Lower Campbell Watershed for lab water chemistry analysis, as part of the 1996 and 1997 Reconnaissance Inventory. As well, field water chemistry testing was performed on these, and 8 additional lakes in the study area. See the individual lake reports for this data (Lough and others 1998).

2.3.1.1 EMS Sites

- MELP Water Quality Branch records data from Environmental Monitoring System (EMS) air and water sampling stations (previously SEAM sites). Table 2 lists the EMS sites in the Lower Campbell Watershed.
- MJ Lough and Associates obtained EMS numbers for limnology stations established at the 19 lakes in the Lower Campbell Watershed that were included in Reconnaissance Lake Inventories in 1996 and 1997 (Lough and others 1998).

Table 2 EMS sites in the Lower Campbell Watershed

Location	EMS/SEAM Site Number
Campbell River near John Hart Dam	0130600 (03)
McIvor Lake	0130140(03)
North of McIvor Lake	E212054
South of McIvor Lake	E217140
Campbell Lake near Ladore Dam	0130141 (03)
Gooseneck Lake	1132502
Upper Campbell Lake near Strathcona Dam	0130142 (02)
Upper Campbell Lake	0130143 (03)
Beaver Lake	E225630
Bootmar Lake	E226914
Bottle Lake	E225650
Buck Lake	E225649
Davis Lake	E225631
Hayes Lake	E225632
Higgins Lake	E225633
Higgins Bog	E226913
Lawnchair Lake	E226910
Lawson Lake	E225634
Lost Lake	E225635
Lukwa Lake	E225636
Pocket Lake	E226912
Reed Lake	E225246
Riley Lake	E226828
Sandhill Lake	E225652
Sedge Lake	E225648
Swan Lake	E225651
Trestle Lake	E226915

Source: BCMELP-WQB-VIR 1998

2.3.2 Waste Permits

- Table 3 lists the Waste Permits that are held in the Lower Campbell Watershed.

Table 3 Waste Permits in the Lower Campbell Watershed

Location	Permit Number	Permit Holder	Type of Waste
North of Campbell River near John Hart powerhouse	PR0567601(15)	--	dry refuse
Outlet of small lake south of John Hart Lake	PR0594701(15)	--	dry refuse
McIvor Lake	PA0624104(11)	--	air discharge
North of McIvor Lake	PA0398401-03(11)	Tayco Paving Ltd.	air discharge from asphalt plant
East of McIvor Lake	PR0240101(15)	District of Campbell River	dry refuse at townsite dump
East of McIvor Lake	PE0389001(18)	Island Redi-mix Ltd.	effluent from gravel washing

Source: BCMELP-WMB-VIR 1998

2.3.3 Flow Data

- A Water Survey of Canada gauging station at the Ladore Dam (8HD001) was operated from 1910 to 1949 (DFO-BCMELP 1998).
- Another Water Survey of Canada gauging station, downstream of the study area, and just downstream of the Quinsam River mouth (WSC8HD003) was monitored from 1949 to 1971 and then from 1991 to the present (Burt and Burns 1995).
- BC Hydro maintains records of the discharge through the John Hart Generating Station turbines, and John Hart Dam releases (Burt and Burns 1995).

2.4 Wildlife

- The Campbell River Watershed is in the Coastal Western Hemlock Biogeoclimatic Zone (British Columbia 1996), which is reported to be potentially the most productive region on Vancouver Island for blacktail deer (*Odocoileus hemionus columbianus*) and Roosevelt elk (*Cervus canadensis roosevelti*) (Diggle and Addison, 1977).
- Several Forest Ecosystem Networks (FEN's) have been identified in the Lower Campbell Watershed (BCMOF-CRD 1998). FEN's recognize areas that require a long term landscape management approach to better protect riparian zones, wildlife migration routes, and maintain or restore natural connectivity within the larger landscape unit (BCMOF 1995a). The FEN's identified in the Sayward Forest indicate areas that are critical ungulate habitat (BCMOF-CRD 1998).

2.5 Fish

- Table 4 lists the fish species, and the species codes that are referred to in this report.

Table 4 Fish species and species codes used in this report

Fish Species	Latin name	Species Code
anadromous cutthroat trout	*Oncorhynchus clarki*	ACT
chinook salmon	*Oncorhynchus tshawytscha*	CH
chum salmon	*Oncorhynchus keta*	CM
coastal cutthroat trout	*Oncoryunchus clarki clarki*	CCT
coastrange sculpin	*Cottus aleuticus*	CAL
coho salmon	*Oncorhynchus kisutch*	CO
cutthroat trout (general)	*Oncorhynchus clarki*	CT
Dolly Varden char	*Salvelinus malma*	DV
Pacific lamprey	*Lampetra tridentata*	PL
pink salmon	*Oncorhynchus gorbuscha*	PK
prickly sculpin	*Cottus asper*	CAS
rainbow trout	*Oncorhynchu mykiss*	RB
sculpin general	*Cottus* spp.	CC
sockeye salmon	*Oncorhynchus nerka*	SK
steelhead	*Oncorhynchu mykiss*	ST
threespine stickleback	*Gasterosteus aculeatus*	TSB
western brook lamprey	*Lampetra richardsoni*	BL

2.5.1 Anadromous Waters

- All 5 species of salmon; chinook, coho, chum, pink and sockeye, as well as steelhead, anadromous coastal cutthroat trout and a small population of Dolly Varden char occur downstream of the John Hart dam. In addition, threespine stickleback, sculpins and Pacific lamprey occur above and below tidal limits (Hamilton and Buell 1976, Bell and Thompson 1977, DFO-BCMELP 1998).

2.5.2 Inland (non-anadromous) Waters

- Rainbow trout, accidental and stocked steelhead trout, coastal cutthroat trout, Dolly Varden char and accidental coho salmon occur in the lakes and streams upstream of the John Hart dam. In addition, threespine stickleback, prickly sculpin, coastrange sculpin, and western brook lamprey, are found in the non-anadromous waters of this watershed (BC MELP-FB-VIR 1998). “Accidental” occurrence refers to the wild steelhead and coho smolts from the Salmon River that have been inadvertently introduced into the Campbell Watershed via the BC Hydro diversion.

2.5.3 Historical fish sampling

- MJ Lough and Associates conducted fish sampling in 19 lakes in the Lower Campbell Watershed as part of the Sayward Landscape Unit Reconnaissance Lake

Inventory during 1996 and 1997 (Table 5). As well, lake tributary surveys were conducted at 9 additional lakes, and many of these were sampled for fish. The fish data collected during the 1996 - 1997 surveys is summarized in this report (Section 4.0).

Table 5 Lakes in the Lower Campbell Watershed surveyed during Reconnaissance Lake and Tributary Inventories in 1996 and 1997

Lake Name	Survey Date	Type of Survey
Beaver	September 1996	Lake Inventory
Beavertail	June 1997	Tributary Inventory
Boot	May 1997	Tributary Inventory
Bootmar	August 1997	Lake Inventory
Bottle	October 1996	Lake Inventory
Brewster	June 1997	Tributary Inventory
Buck	August 1997	Lake Inventory
Campbell	December 1996, March, April, June 1997	Tributary Inventory
Davis	September 1996	Lake Inventory
Gooseneck	June 1997	Tributary Inventory
Gosling	June 1997	Tributary Inventory
Gray	May 1997	Tributary Inventory
Hayes	April 1997	Lake Inventory
Higgins	September 1996	Lake Inventory
Higgins Bog	August 1997	Lake Inventory
Lawnchair	September 1997	Lake Inventory
Lost	July 1997	Lake Inventory
Lukwa	August 1997	Lake Inventory
Pocket	September 1997	Lake Inventory
Pothole	August 1997	Lake Inventory
Reed	October 1996	Lake Inventory
Reginald	June 1997	Tributary Inventory
Riley	August 1997	Lake Inventory
Sandhill	July 1997	Lake Inventory
Sedge	April 1997	Lake Inventory
Snakehead	June 1997	Tributary Inventory
Swan	April 1997	Lake Inventory
Trestle	July 1997	Lake Inventory

- Several lakes and streams in the Sayward Forest were surveyed in the late 1970’s by a group of Campbell River Junior Secondary School students, who carried out the field surveys with guidance from the BC Fish and Wildlife Branch. The surveys included gillnetting of the lakes and detailed stream habitat description and mapping. Stream bank stability, discharge, substrate type, riparian vegetation and obvious constraints to fish (e.g. waterfalls, debris jams, etc.) were recorded, however, fish sampling was not performed in streams (BCMELP-FB-VIR 1998). These lake reports are located in the regional MELP Lake Inventory files in Nanaimo (BCMELP-FB-VIR 1998).
- Historical fish sampling data for the Lower Campbell Watershed, prior to 1996, is summarized in Table 6.

Table 6 Summary of historical fish sampling results in the Lower Campbell Watershed prior to 1996

Lake or Stream	Survey Date	Performed by	Type of Survey	Species
Beaver Lake	June 13, 1991	MELP	gillnet	CT
Beavertail Lake	May 12-13, 1975	MELP	2 floating gillnets, 2 sinking gillnets	CT, DV, RB
	June 22-23, 1977	MELP	2 gillnets	CC, CT, DV
	April 5-6, 1979	MELP	2 gillnets	CT, DV
	July 31-August 1, 1979	MELP	3 gillnets	CC, CT, marked RB, DV
	May 25-26, 1988	MELP	Sinking gillnet	CT, DV, RB
Boot Lake	1975	MELP	Creel census	CT
	July 12 –17, 1978	students	3 floating gillnets, 3 sinking gillnets	CC, CT, RB, DV
Boot Lake inlet and outlet	July 3, 1975	MELP	Visual observation	trout
Brewster Lake	1975	MELP	Creel census	CT, DV, RB
	August 1-3, 1978	students	3 floating gillnet, 3 sinking gillnet	CT, DV, RB
Campbell Lake	September 15, 1937	G.C. Carl	unknown	CC, RB, SB
	1951	MELP	unknown	CT, RB, SB
	1953	MELP	unknown	CT
	1957	MELP	unknown	RB, DV, CT
	1960, 1961, 1962	MELP	floating and sinking gillnets	CC, RB, DV
Campbell River below John Hart	1976	Hamilton and Buell	various methods	CH, CM, CO, PK, SK, ST, CT,
Campbell River below John Hart	1995	MELP	Snorkel surveys	ST, PK, CH, RB, CT, CO
Campbell River below John Hart	1996	MELP	Snorkel surveys	ST, CT, CO, CH, PK, CM
Campbell River below John Hart	1997	MELP	Snorkel surveys	SK, CM, CH, CO, PK, ST, RB, CT
Fry Lake	July 21-24, 1978	students	gillnet	CT, DV, RB,
Garrett Lake	July 10, 1986	MELP	gillnet	CT
	July 20, 1990	MELP	gillnet	CT
Gooseneck Lake	July 17, 1956	MELP	gillnet	CT
	1975	MELP	Creel census	CT
Gosling Lake	July 24-25, 1978	students	gillnet	CT
	May 13, 1988	MELP	gillnet	CT
Gray Lake	July 20, 1978	MELP	sinking gillnet, floating gillnet	CT, DV, RB, TSB
Hayes Lake	August 27, 1969	MELP	gillnet	RB
Lawson Lake	July 9,1986	MELP	floating gillnet, 2 minnow traps	CT, RB, TSB, CC
McIvor Lake	June 3-10, 1987	MELP	2 sinking gillnets, 1 floating gillnet, 2 minnow traps	CC, CT, DV, TSB
Merrill Lake	1975	MELP	Creel census	CT, RB
	July 26, 1978	students	Gillnet	CT, RB
Reginald Lake	September 9, 1988	MELP	Gillnet	CT
	June 21-22, 1989	MELP	F&S gillnets,	RB
Snakehead Lake	July 23, 1985	MELP	2 sinking gillnets	CT
Whymper Lake	July 20, 1978	students	gillnet	CT, RB, TSB

Source: BCMELP-FB-VIR 1998, DFO-BCMELP 1998

2.5.4 Fish Stocking

- Fish stocking in the Lower Campbell Watershed is summarized in Table 7.

Table 7 Summary of fish stocking in the Lower Campbell Watershed

Lake or Stream	Stocking Date	Performed by	Species
Beavertail Lake	1979 , 1981-1987, 1989-1998	MELP	RB
	1976, 1978	DFO[1]	ST
Boot Lake	1986-1988, 1990-1998	MELP	RB
Brewster Lake	1986, 1987, 1992, 1994-1998	MELP	CT
	1988-1991, 1996, 1997	MELP	RB
Campbell Lake	1992	DFO	ST
Campbell River	1936, 1937	unknown	RB
	1937, 1957, 1982-1994, 1996	DFO	ST
	1989-1991, 1994-1998	DFO	ACT
	1996, 1997	DFO	CO
Gooseneck Lake	1987-1998	MELP	CT
Gosling Lake	1978, 1981, 1982, 1984, 1985-1988, 1990, 1992, 1994, 1996, 1998	MELP	CT
Gray Lake	1986-1988, 1992-1998	MELP	CT
McIvor Lake	1989-1994, 1996	DFO	ST
Merrill Lake	1987	MELP	CT
	1988-1998	MELP	RB
Miller Creek	1982	MELP	ACT
Reed Lake	1992	DFO[2]	ST
Reginald Lake	1988, 1991, 1993, 1995, 1997	DFO	ST
Snakehead Lake	1986, 1987, 1990-1992	MELP	CT

Source: BCMELP-FB 1998
[1] VanTyne pers. com.
[2] Law pers. com.

3.0 Methods

3.1 Standards

- This survey was conducted according to standards described in MELP *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures, Resource Inventory Committee (RIC) Manual, Version 1.1* (BCMOF-FIS 1998a).
- The field data was entered into the BC Fisheries Field Data Information System (FDIS) Version 6.5 using IBM compatible personal computers (Attachment 6).
- The *Phase 1-3 Pre-field Project Planning Report Sayward Fish Inventory* refines the project objectives and describes the project plan (Attachment 1).

3.2 Equipment and Procedures

3.2.1 Equipment List

- Table 8 lists the equipment used during the field inventory.

3.2.2 Stream Site Sampling

- A stadia (survey) rod, 50 m tape, meter stick and a hip chain were used for depth and length measurements of stream channels and obstructions. An Abney level (Chicago Steel Tape and Berger Instruments, IL) or a Suunto clinometer (Suunto Instruments, Finland) were used for measuring stream gradients.
- Site data was recorded on the FDIS Site Card (April 1998 version) and entered into the FDIS Version 6.5 data entry system. The FDIS Summary Reports and site photographs are included in Appendix 1.

3.2.3 Fish Sampling

- A 2-person field crew used electrofishing and visual observations to collect fish information. Open site electrofishing was conducted using a Smith-Root Model 12B-backpack electrofisher (Smith-Root Inc., Vancouver, WA).
- Sampled fish were anesthetized in a bucket with Alka-Seltzer, measured for fork-length on a fish board, then released at the capture site.
- Scale samples were collected from representative fish.
- Representative examples of each fish species captured, were photographed prior to release.
- Where required, representative fish were kept as voucher specimens (generally 1 per species per watershed). As well, diseased or abnormal fish were kept as voucher specimens. Voucher specimens were submitted to Liparis Biological Services for confirmation of species identification (Attachments).
- DNA samples were taken from cutthroat trout and Dolly Varden that had a fork length greater than 100 mm, and submitted to Sue Pollard, Fish Geneticist, BC Fisheries (Attachments).
- Fish data was recorded on the FDIS Fish Card (April 1998 version) and entered into the FDIS Version 6.5 data entry system. The FDIS Summary Reports and fish photographs are included in Appendix 1.

3.2.4 Fish Age and Growth

- Scale samples were aged and archived using a 3M Microfiche Viewer/Printer to produce enlarged printed images of the scales. The original scales were then replaced in the scale envelopes after the reading and attached to the photocopy enlargements for archival storage (Attachments).
- Fish age was determined through scale analysis or in the case of small juveniles, through length-frequency distribution methods described in *MELP Lake and Stream Inventory Standards and Procedures (DRAFT)* (BCMELP-FB-IU 1995).

- Table 8 Reconnaissance stream inventory equipment list

Access	Access maps Air photos compasses
Photodocumentation	cameras film white boards with marking pens
Stream Survey Kit	Site Cards Fish Collection Forms Individual Fish Data Forms Site card binders (Duksbaks) Pencils and omnichromes Hip chains and spare strings Stadia rods or metre sticks Abney level or Suunto clinometers
Boat	Boats and motors equipped to meet Coast Guard safety standards (PFV's, oars) Fuel for boat motor Tool-kits and spare parts Anchors with adequate line for deep lakes
Water Sampling Kit	YSI 85-10 Temp/DO/conductivity meter, spare membranes, and calibration solutions Hanna Instruments Model HI 9024C pH meter, spare probe and calibration solutions WTW MultiLine P3 pH/LF and SET meter and calibration solutions Secchi disc and 30 m marked line Hand-held mercury and alcohol thermometers
Fish Collection Gear	Federal and provincial fish collection permits Minnow traps with clips and lines Bait for minnow traps Dip-nets for handling fish Smith-Root Model 12-B Backpack Electrofishers Lineman's gloves Stop nets Buckets for handling fish
Fish Sampling Kit	Dissecting kits Scale envelopes Weigh scales Fish measuring boards DNA sample kits Zip-lock bags Anaesthetic for fish sampling (Alka-Seltzer)
Safety	VHF radios Emergency whistles Emergency Plan Level 1 First Aid Kits Survival gear

3.2.5 Photodocumentation

- Photographs were taken with a Yashica Microtec 35mm camera and an Olympus AF-10 35mm camera.
- The film was developed into negatives and transferred to CD. The FDIS Photo Documentation Report for the Lower Campbell Watershed is included in Appendix 1 as well as the Reach, Site, Feature and fish photographs. Attachment 5 contains the negatives and photo-CD index for the entire 1998 Sayward Inventory (all 5 watersheds).

3.2.6 Water Chemistry

- Either a Hanna Instruments Model HI 9024C pH meter (Hanna Instruments Inc., Wainsocket, RI) or a WTW MultiLine P3 pH/LF and SET meter (Wissenschaftlich-Technische Werkstatten, Weilheim, Germany) was used to measure pH in the stream, at the site. The WTW MultiLine P3 pH/LF and SET meter, or a YSI Model 85-10 Temp/DO meter (YSI Inc. Yellow Springs OH), was used to measure the temperature and specific conductance. When necessary, a standard limnology secchi disc (Wildco, Saginaw, MI) was used to obtain turbidity and water color information.

3.2.7 Digital Mapping

- GIS mapping was performed by Pacific International Mapping in Victoria, BC, according to MELP *Standards for Fish and Fish Habitat Maps Version 2.0* (BCMOF-FIS 1998b). The final project maps are included in Appendix 2.
- The information required for the site data and reach data symbols was extracted from the FDIS database and plotted on TRIM (Terrain Resource Information Management) 1:20,000 linework.
- Site and feature locations were digitized manually from the working maps.
- MicroStation 95 with MAP 3D software tools was used for data capture, labelling and plotting. Reach break, sample site, and feature locations were captured within 10 m at ground scale from the working maps.
- The ARC/INFO translation is as follows: ARC/INFO Version 7.0, double precision, BC Albers projection.

4.0 Results and Discussion

4.1 Logistics

4.1.1 Study Design

- The study design and hence reporting format of this watershed inventory is not entirely typical of 1998 FDIS and RIC standards. The primary difference is that the lakes in the watershed were independently surveyed by MJ Lough and Associates during 1996 and 1997. This affected the sampling design for 1998 in the following ways:

1. The process of randomly selecting lakes for survey was not done in 1998, and no lakes were sampled. This was because the lakes in the study area, and their tributaries had already been surveyed during the 1996 and 1997 lake inventories.
2. A review of historical data found that although numerous lakes in the study area had been surveyed previously, information about their tributaries was usually lacking. Therefore, these omitted tributaries were included in the lake inventories conducted by MJ Lough and Associates during 1997.
3. Many of these stream reaches that were sampled during 1996 and 1997 were randomly selected by FDIS for surveys during 1998. These reaches were not surveyed again, since the inventory data had already been collected. Therefore, the data from these reaches resides in the 1996 and 1997 inventories, and with the exception of some fish data, is not included in this report.

- The random sampling selection of sites in the project area selected 2 sites on the lower Campbell River in the anadromous waters (Reach 5 and Reach 7). These two reaches were included in a recent fish habitat survey of the lower Campbell River and therefor, were not included in this study (Burt and Burns 1995).

4.1.2 Waterbody Identifiers

- The waterbody identification numbers (WBID's) from the watershed atlas database were inadvertently changed by MELP after the lake surveys had been conducted. As a result, the field cards for the 1996 and 1997 surveys contain WBID's that are out-dated. We addressed this problem by naming all the unnamed lakes in the entire study area, a process administered by Geographic Data BC in Victoria. Henceforth, we have referred to these lakes by their new names, thereby avoiding the use of the unstable WBID's. The original WBID's in our field notes have not been changed to the new ones but the digital databases for the 3 years have been updated to reflect the current waterbody ID's.

4.1.3 Mapping Anomalies

- Identification of streams and lakes using watershed codes was often difficult due to the numerous mapping inaccuracies that were encountered during this project. The British Columbia Watershed/Waterbody Identifier System was originally based on the National Topographic System (NTS) 1:50,000 maps of the province. Although the system has been re-designed to allow for the identification of watersheds and waterbodies represented on TRIM (1:20,000), the original codes were assigned using the NTS maps. Since NTS maps were drawn from different aerial photography than was used to create TRIM maps, there is some variation in the stream lines between the maps. This has created 3 types of problems:

  1. Streams that are on NTS maps but are not on TRIM maps (these locations were field checked to see if streams actually existed and if so, they were surveyed)
  2. Streams that are mapped on TRIM maps but are not mapped on NTS maps (these streams did not have watershed codes and were assigned Interim Locational Points or ILP's)
  3. Streams that are mapped differently on TRIM maps than on NTS maps (these were identified as mapping anomalies, and usually had incorrect watershed codes)

- There are several areas in the Lower Campbell Watershed where streams are mapped incorrectly on NTS, but only 2 have resulted in incorrect watershed codes:

  1. Davis Lake and tributaries
  2. Hayes Lake and outlet stream

- The outlet stream of Davis Lake is shown incorrectly on the NTS map 92K/4 as flowing southeast into Campbell Lake. Although there is a stream shown in this location on the TRIM map 92K.003, it is not the outlet of Davis Lake, which actually flows south into Campbell Lake. Therefor, the watershed code for Davis Lake (920-627900-30700) is different from the watershed code of its outlet stream (920-727900-31800).
- Hayes Lake is shown on the NTS map 92K/4 as flowing south into Garrett Lake, and on the TRIM map 92K.002 it has no outlet. When this lake was field surveyed, an outlet stream was found at the north end of the lake, which flowed underground into a karst formation. This stream appeared to flow northwest into the Salmon Watershed. In any case, the watershed code for Hayes Lake (920-627900-35700-31200) is incorrect.

4.1.4 Fish Sampling

- Fish were sampled in the Lower Campbell Watershed over a 3 year period from 1996 to 1998.
  - During the 1998 survey, the streams sample sites that were flowing, were sampled for fish.
  - During the Reconnaissance Lake and Tributary Inventories performed in 1996 and 1997, MJ Lough and Associates surveyed 19 lakes in the Lower Campbell Watershed, all of which were sampled for fish; and the tributaries of 9 additional lakes, many of which were sampled for fish.
  - Fish sample data from the 3 years is combined in this report. The scales from fish sampled in 1998 are included with the Attachments to this report. The scales from the fish sampled from lakes in 1996 and 1997 are included as Attachments with each lake report, and are available at the MELP Regional office in Nanaimo.
- Precipitation in the study area during the late summer of 1998 was well below average. The Campbell River Airport Weather Station monthly mean temperature and precipitation for 1992 to 1998 and the 28-year means (1965 to 1992) are summarized in Table 9.
- Many of the small streams that were selected for sampling by the FDIS random sampling process were low or dry during the late summer of 1998. Initially, the larger streams that were still flowing were sampled, but as the end of the field season approached, even the small dry streams were surveyed in order to complete the project. It was not possible to check for fish in these dry streams, although the information that they do dry during long, dry summers provided some insight to the limitations of the fish habitat.
- Western brook lamprey were visually observed during sampling, while completing DFO/MOE Stream Survey Forms during 1996/97. Although they were clearly observed at close range, they were not electrofished since they were actively spawning. No voucher specimens were obtained.
- Four Dolly Varden char were captured in the Lower Campbell Watershed, but only 1 of these was large enough to provide structures for aging. Otoliths were not

collected from this fish, so scale analysis was used as a substitute method for aging the fish.

Table 9 Mean monthly temperature and precipitation at Campbell River Airport

Period	June		July		August		September		October		November	
	Temp (°C)	**Rain-fall (mm)**	**Temp (°C)**	**Rain-fall (mm)**	**Temp (°C)**	**Rain-fall (mm)**	**Temp (°C)**	**Rain-fall (mm)**	**Temp (°C)**	**Rain-fall (mm)**	**Temp (°C)**	**Rain-fall (mm)**
1992	16.8	69.4	18.3	6.0	17.3	45.1	12.2	47.4	9.6	167.3	5.2	209.2
1993	14.5	106.0	15.9	71.3	17.2	69.9	14.5	2.0	10.0	63.1	3.9	84.4
1994	14.0	98.8	18.5	10.0	17.4	80.5	14.9	39.2	8.2	188.8	3.3	217.1
1995	15.8	68.7	17.8	73.2	15.2	87.2	15.6	29.8	8.3	233.1	5.6	360.2
1996	13.6	25.7	17.9	45.7	16.9	49.8	12.1	101.8	7.7	173.6	2.5	167.6
1997	14.2	103.4	17.0	44.0	18.3	63.6	14.1	205.5	8.7	292.2	5.7	174.0
1998	16.1	64.7	18.9	54.4	17.8	15.4	16.6	6.4	9.0	184.6	6.0	352.7
28 year mean	14.3	50.3	16.8	38.9	16.7	44.6	13.0	59.3	8.1	152	4.2	228

Source: Environment Canada 1999

4.2 Habitat and Fish Distribution

- Fish species composition and fish habitat characteristics are markedly different in the Campbell River downstream of the John Hart Dam (accessible to anadromous fish), as compared to the waters upstream of the John Hart Dam (not accessible to anadromous fish). A summary of fish habitat for these waters will therefore be examined separately.

4.2.1 Anadromous Waters

- The Campbell River is accessible to anadromous fish for the lower 5.6 km of the river, with the upstream limit being Elk Falls in the canyon just below the John Hart Dam (Hamilton and Buell 1976). Our study area for the anadromous portion of the watershed includes the Campbell River upstream of the Quinsam River confluence and downstream of Elk Falls. All fish populations here are confined to stream habitat, since there are no lakes.
- Fish habitat in the waters downstream of the John Hart Dam have been examined and described in numerous studies, and were not re-examined as part of this inventory. Fish distribution and detailed habitat descriptions are available in several reports including Hamilton and Buell 1976, Bell and Thompson 1977, and Burt and Burns 1995.

4.2.2 Inland Waters

4.2.2.1 Habitat and Fish Distribution

- The remainder of the study area is not accessible to anadromous fish. The watershed has a glacial piedmont setting, and exhibits the typical characteristics of gently rolling hills with low gradient, lake-headed streams. There are 33 lakes in the study area downstream of the Strathcona Dam, that range in size from Campbell Lake at 2,694 ha to several small lakes that are less than 5 ha. In general, the size of these lakes is an indicator of the general abundance of fish in the lake (Lough and others 1992). The largest fish populations therefore occur in the large lakes such as Campbell, Brewster, Beavertail and Gooseneck Lakes.
- The production capability of lakes is related to their total dissolved solid (TDS) levels (Ryder and others 1974). Most lakes in the study area have TDS levels of approximately 10 to 30 mg/l, which is relatively low compared to the more productive lakes in the southern interior of BC, where TDS levels can range from 300 to 500 mg/l (Ryder and others 1974). Theoretical fish yield of lakes in the study area is therefore lower than that of lakes in the BC interior.
- The streams in the study area are typically 3rd order or smaller, stable systems with clear water. This is due largely to the influence of the numerous lake-headed, low gradient streams.
- An exception to the low gradient generalization is the Greenstone River, which flows into the west end of Campbell Lake. Instead of the typical rolling hills found throughout most of the study area, this stream drains the steep mountain terrain at the western limit of the study area. The higher gradient and lack of lakes to buffer runoff patterns have combined to make this a more volatile stream. These conditions have been aggravated by intensive and environmentally poor logging practices that have affected the stream channel and fish habitat. A 12 m falls near the mid-point of the drainage is a complete barrier, limiting fish presence to the lower reaches of the stream. High-gradient reaches and degraded fish habitat resulting from logging impacts limit the quality of fish habitat upstream of the barrier.
- Fish populations have generally penetrated the watershed up into the headwaters of the small 1st order streams or lakes throughout the study area.
- In general, the adult fish populations in the watershed (dominated by coastal cutthroat and rainbow trout) occur in the lakes, although the numerous lake tributaries are required for spawning and juvenile production. Many of the small 1st or 2nd order streams in the watershed dry up during warm, dry summers, forcing fish into the limited number of larger streams or, more commonly, the lakes. The trout populations therefore rely upon the streams during the spring and early summer for spawning and juvenile rearing, and rely on the lakes more for growth during the summer.
- The larger streams that do not dry up during the summers provide important rearing habitat for all fish species in the study area, but these streams are a minor component of the fish habitat in this lake-dominated watershed. Brewster Lake to Campbell Lake is a 4th order system, and the largest stream in the study area is the 7th order Campbell River, now seen only as the short remnants of the original river. Presently, the only free-flowing reaches that remain in the Campbell River are just below the Ladore, Strathcona and John Hart Dams. MELP snorkel surveys have found that trout populations from John Hart Lake and Campbell Lake, utilize these areas as spawning and juvenile rearing habitat (BCMELP-FB-VIR 1998).

4.2.2.2 Obstructions

- Elk Falls at Km 5.6 of the Campbell River was a barrier to anadromous fish before the John Hart Dam was constructed. Neither the falls nor the John Hart Dam now have facilities for upstream or downstream passage. Other major barriers in the study area are the Ladore and Strathcona hydroelectric dams which also have no facilities for upstream or downstream fish passage. Some downstream passage occurs as fish pass through the turbines or pass over the spillways, but the dams generally restrict fish movements throughout the watershed.
- Two other man-made barriers also prevent upstream fish migration. These are located where the Salmon Diversion flows into Brewster Lake and where the Quinsam Diversion flows into Gooseneck Lake. The barriers are falls at the mouth of the stream that were purposely designed to prevent upstream fish movement from the Campbell Watershed into the Quinsam or Salmon watersheds.
- A summary of barriers described in historical data is found in Table 10. Appendix 3 summarizes all barriers to fish migration in the Lower Campbell Watershed that were found during this inventory project in 1996, 1997 and 1998.

Table 10 Summary of historical barriers to fish migration found in Campbell River Watershed

Stream	Watershed Code	TRIM map #	Reach #	Barrier Type	Barrier height (m)	Verified in Field	Description of Barrier
Campbell River	920-627900	92K.004	5	F	6	N	Elk Falls, barrier to all fish
Campbell River	920-627900	92K.004	5	F	7	N	Deer Falls, barrier to all fish
Campbell River	920-627900	92K.004	5	F	8	N	Moose Falls, barrier to all fish
Campbell River	920-627900	92K.004	5	D	20	Y	John Hart Hydroelectric Dam, barrier to all fish
Campbell River	920-627900	92K.004	7	D	37	Y	Ladore Hydroelectric Dam, barrier to all fish
Campbell River	920-627900	92F.093	9	D	53	Y	Strathcona Hydroelectric Dam, barrier to all fish

Source: DFO-BCMELP 1998

- Lakes in the study area that are upstream of barriers to fish migration are summarized in Table 11.

4.3 Fish Age, Size and Life History

- MJ Lough and Associates collected biological information regarding the fish populations in the study area during 1996, 1997 and 1998. Fish sample data for all three years have been combined. Fish age, size and life history information from the three years is summarized in the following sections.

Table 11 Lakes in the study area that are upstream of barriers to fish migration.

Lake upstream of barrier	**Lake downstream of barrier**	**Fish population in lake upstream of barrier**
Bottle	Beavertail	CCT, DV, CAS
Davis	Campbell	barren
Garrett	Gray	CCT
Gosling	Campbell	CCT,
Hayes	Gray	barren
Lost	John Hart	TSB
Lukwa	Campbell	barren
Pocket	Brewster	CCT
Reed	Campbell	ST (stocked)
Reginald	Campbell	ST (stocked)
Riley	John Hart	barren
Sandhill	Gooseneck	barren
Swan	Campbell	barren

4.3.1 Anadromous Fish Populations

- No sampling was conducted downstream of the John Hart Dam, since the reaches accessible to anadromous fish have been closely examined during other studies (*see* Section 2.5.1). Thorough reviews of the fish species and their life histories are found in Hamilton and Buell 1976, Bell and Thompson 1977, and Burt and Burns 1995. Those studies have documented the presence of the following species:

  chinook salmon
  coho salmon
  sockeye salmon
  pink salmon
  chum salmon
  sculpin
  rainbow and steelhead trout
  anadromous cutthroat trout
  Dolly Varden Char
  threespine stickleback
  Pacific lamprey

4.3.2 Inland Fish Populations

- Fish sampling performed by MJ Lough and Associates in the inland waters of the study area (upstream of John Hart Dam) during 1996, 1997 and 1998 documented the presence of the following species:

  coastal cutthroat trout
  rainbow trout
  steelhead trout (stocked)
  threespine stickleback
  prickly sculpin
  coastrange sculpin
  Dolly Varden char
  brook lamprey

4.3.2.1 Coastal Cutthroat Trout

- Wild and hatchery origin coastal cutthroat trout are found in the study area. Stocking records also indicate that there was a release of anadromous cutthroat trout into Miller Creek in 1982 (BCMELP-FB 1998).

- Historical studies indicate that an indigenous population was present in the watershed prior to development of the hydroelectric facilities and reservoirs (McMynn and Larkin 1953). As road access to the watershed improved, and fishing pressure increased, some of the wild trout populations were augmented with hatchery fish to maintain populations to provide for angler harvest (*see* Section 2.5.3).
- Fish sampling during this study indicates that the populations generally reside in the lakes of the study area, but they require access to streams for spawning and juvenile rearing habitat.
- Coastal cutthroat trout, rainbow trout and Dolly Varden char co-exist in several of the larger lakes in the study area, but sampling found that the cutthroat trout dominate the small lakes, wetlands and streams of the headwaters.
- Field observations indicate that spawning generally occurs during the spring, with fry emergence starting in late May and peaking through June. Juveniles may remain in the streams for their first year, but many of the small 1st and 2nd order spawning streams dry up during the late summer, forcing the juvenile trout into the lakes or larger streams.
- Examination of scales and gonads from sampled fish indicates that fish generally spawn following their 2nd winter (just prior to age 3). Spawning checks observed during scale analysis indicate that repeat spawning can take place each following year.
- The age and growth data for coastal cutthroat trout sampled from the inland waters of the Campbell Watershed study area, shown in Table 12, includes fish that were sampled in 1996, 1997 and 1998. All of the fish summarized in Table 12 were aged using scales. Fish scales for the 1996 and 1997 fish are included as attachments with the individual lake inventory reports (Lough and others 1998).

Table 12 Summary of length-at-age data for aged coastal cutthroat trout sampled from the inland waters of the Campbell Watershed study area during 1996, 1997 and 1998 (n=153)

Species	Age	Number of Fish	Mean Length (mm)	Range (mm)
CCT	0+	1	95	95
	1+	45	167	110-199
	2+	56	208	158-250
	3+	20	260	215-340
	4+	24	305	241-380
	5+	5	379	334-405
	6+	2	385	378-391

- The fork lengths of all of the coastal cutthroat trout sampled from the Lower Campbell Watershed in the three years ranged from 37 mm to 405 mm. This size range is probably not representative of the entire population in the study area since only small lakes and streams were sampled during this survey. Historical data from larger lakes such as Campbell Lake documents cutthroat trout up to 570 mm in fork length (BCMELP-FB-VIR 1998).
- The length-frequency histogram for coastal cutthroat trout sampled from the inland waters of the Lower Campbell Watershed study area includes all of the fish that were measured during sampling in 1996, 1997 and 1998 (Figure 4).

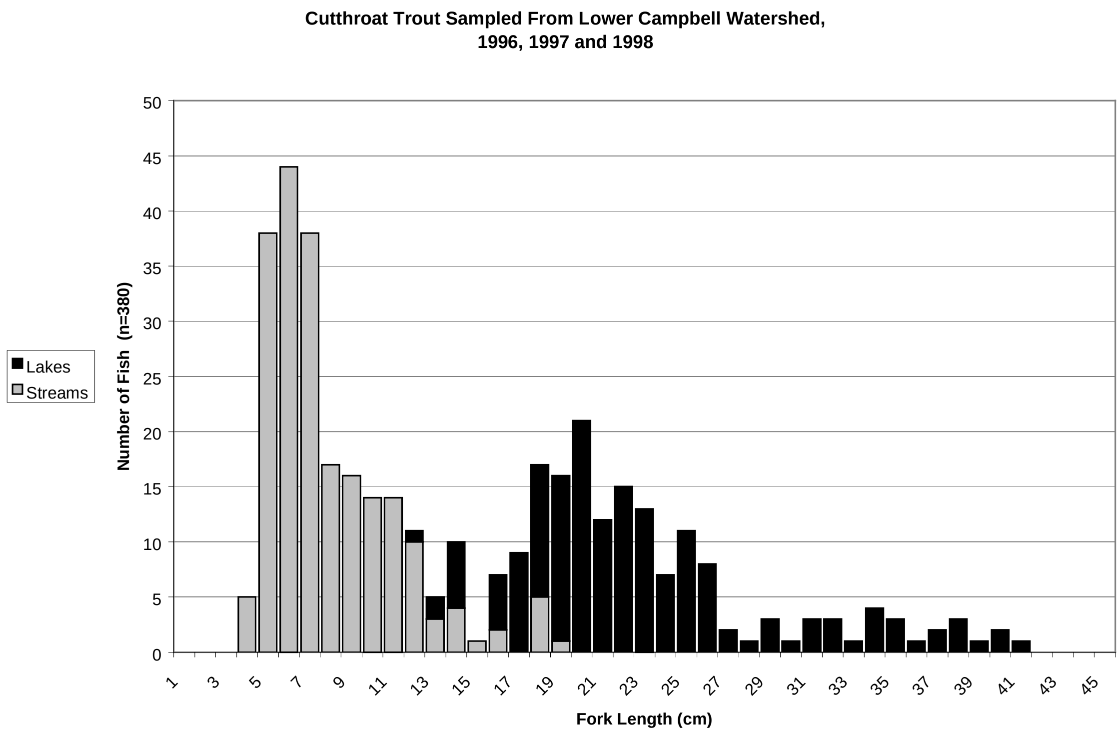

Figure 4 Length-frequency histogram for coastal cutthroat trout sampled from the inland waters of the Lower Campbell watershed study area during 1996, 1997 and 1998

4.3.2.2 Rainbow Trout and Steelhead

- The age and growth data for rainbow trout sampled from the inland waters of the Lower Campbell watershed study area shown in Table 13, includes fish that were sampled in 1996, 1997 and 1998.

Table 13 Summary of age and growth data for rainbow trout sampled from the inland waters of the Lower Campbell Watershed study area during 1996, 1997, 1998 and aged using scale analysis (n=3)

Species	Age	Number of Fish	Mean Length (mm)	Range of Lengths (mm)
RB	0+	1	90	90
	1+	1	162	162
	5+	1	334	334

- Rainbow trout populations in the Campbell Watershed typically inhabit the large lakes that were not sampled, such as Campbell Lake (BCMELP-FB-VIR 1998). The only lake inhabited by rainbow trout that was gillnetted was Reed Lake, which had historically been stocked with steelhead juveniles. Two of the 3 rainbow that were large enough to age using scale analysis were hatchery steelhead from Reed Lake. The rainbow juveniles sampled during this study were collected from stream sample sites.

- Relatively few rainbow trout (n=14) were captured and measured during sampling in the study area, compared to coastal cutthroat trout (n=380). This is probably not an accurate reflection of the relative abundance of rainbow trout in the watershed, since most of the fish sampling was conducted in small streams or headwater lakes of the watershed. Such habitat in the Campbell is typically dominated by cutthroat trout.
- The length-frequency histogram for rainbow trout sampled from the inland waters of the Campbell Watershed study area includes fish that were measured during sampling in 1996, 1997 and 1998 (Figure 5).

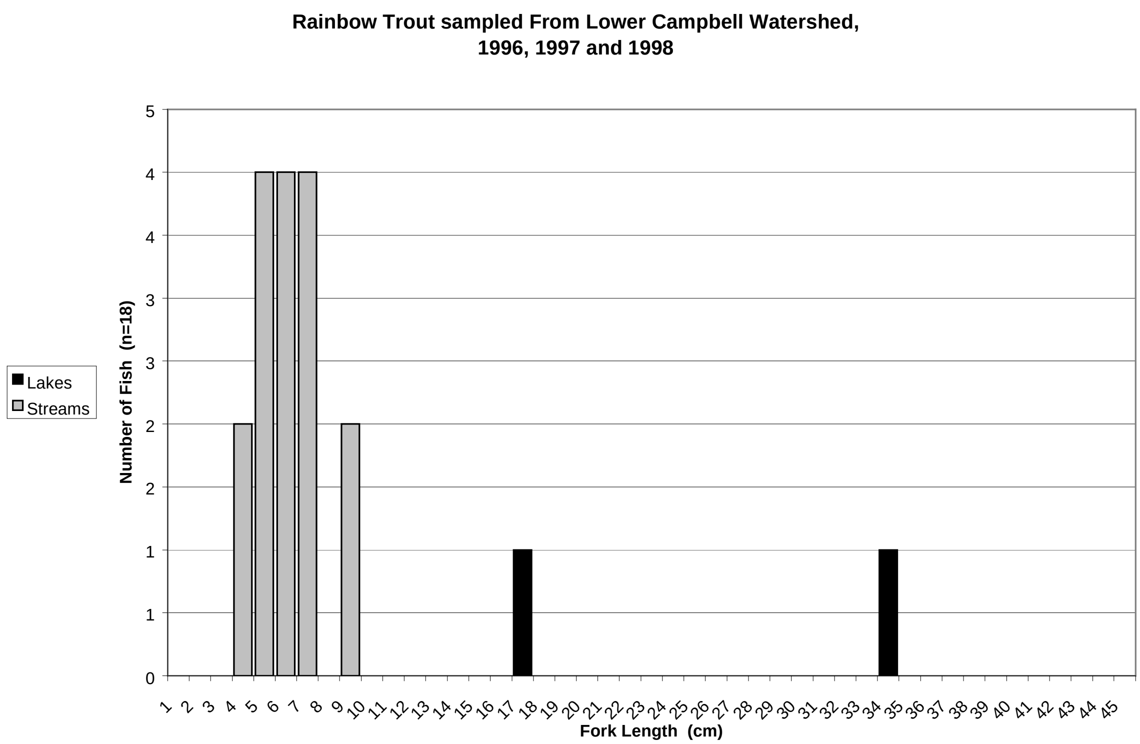

Figure 5 Length-frequency histogram for rainbow trout sampled from the inland waters of the Lower Campbell Watershed study area during 1996, 1997 and 1998

- Large lakes in the watershed such as Campbell, Beavertail and Brewster Lakes have documented rainbow trout populations, but fish sampling was not conducted in these lakes during this survey because they had been surveyed previously (BCMELP-FB-VIR 1998). Although fish sampling was conducted in numerous tributary streams to these lakes, only 2 rainbow juveniles were found.
- Historical data indicates that rainbow trout in the Lower Campbell Watershed are most abundant in the large lakes such as Campbell, John Hart, Brewster and Beavertail Lakes. Historically, fork lengths of rainbow trout sampled in the watershed rarely exceeded 325 mm, although fish up to 430 mm have been collected (BCMELP-FB-VIR 1998).

- Aggregations of large, spawning rainbow trout have been observed in the Campbell River immediately downstream of the Ladore and Strathcona Dams during MELP snorkel surveys in the spring (BCMELP-FB-VIR 1998). These findings indicate that the short remnants of the original 7th order river now provide substantial spawning habitat for large fish from the reservoirs.
- Steelhead trout have been introduced to the non-anadromous waters of Reed and Reginald Lakes through hatchery releases (*see* Section 2.5.3). In addition, wild steelhead kelts and smolts from the Salmon River have been diverted into Brewster Lake as they move downstream from the Salmon River headwaters. Tag recoveries indicate that these fish continue downstream through Gray, Whymper, Fry and Campbell Lakes. A smolt screen was installed at the diversion point in 1986 to minimize such fish diversions from the Salmon River watershed (BCMELP-FB-VIR 1998).

4.3.2.3 Dolly Varden Char

- A total of 4 Dolly Varden char were caught during sampling of lakes and streams in the Lower Campbell Watershed in 1996-1998. This is probably not an accurate reflection of Dolly Varden abundance in the watershed, since sampling was biased towards the smaller headwater lakes that are typically dominated by cutthroat trout. Historical sampling data indicates that the large lakes and reservoirs of the study area have Dolly Varden populations (BCMELP-FB-VIR 1998).
- The fork length of the 4 Dolly Varden sampled ranged from 45 mm to 285 mm.
- Only one Dolly Varden that was sampled was large enough to allow collection of scales. This fish was gillnetted in Bottle Lake and it was the only Dolly Varden sampled from the lake (Table 14).

Table 14 Length and age data for the Dolly Varden char aged during sampling in the Lower Campbell Watershed in 1996, 1997, 1998

Species	Age	Number of Fish	Mean Length (mm)	Range of Lengths (mm)
DV	3+	1	285	285

- Little information is available regarding spawning and juvenile rearing for Dolly Varden in the Campbell River watershed. Field studies are presently being conducted by MELP Fisheries Branch to improve the level of knowledge regarding Dolly Varden char in the Campbell Watershed (Rimmer pers. comm.).

4.3.2.4 Threespine Stickleback

- Threespine stickleback were found in many of the lakes and streams in the study area. Most of the fish were captured using baited minnow traps in lakes, although some were electrofished from large streams with low current velocities, such as the outlet stream of Gray Lake.
- An unusual population of extremely large threespine stickleback was found during the Reconnaissance Inventory of Higgins Lake in 1996. These stickleback attained lengths of 110 mm, and are therefore among the largest threespine stickleback

documented to date (McPhail pers. comm.). The mean length of threespine stickleback sampled from Higgins Lake was 85.8 mm, as compared to 51.1 mm from all other study lakes in the Lower Campbell Watershed combined (Table 15). A comparison of length-frequencies of stickleback from Higgins Lakes and all other samples combined is shown in Figure 6.

Table 15 Summary of threespine stickleback lengths sampled from Higgins Lake and from all other Lower Campbell Watershed samples combined, 1996 to 1998

Sample Source	**n**	**Mean length (mm)**	**Range (mm)**
Higgins Lake	40	85.8	36-110
Other Lower Campbell Watershed samples combined	37	51.1	28-79

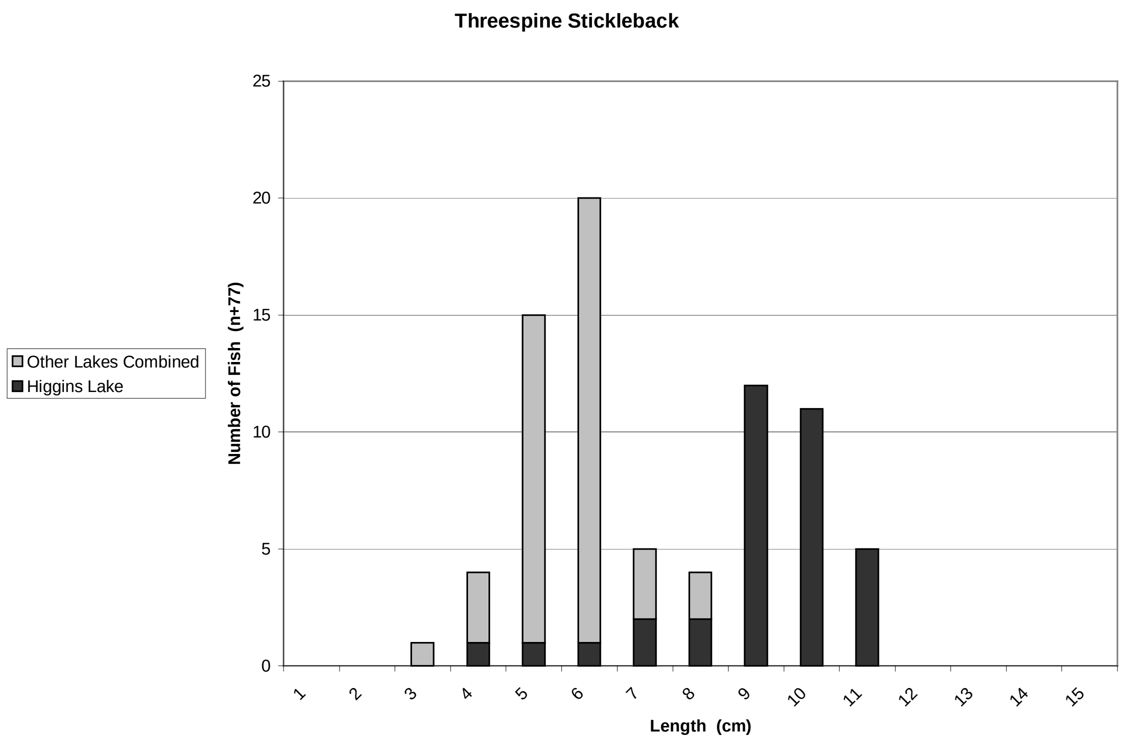

Figure 6 Length-frequency histogram for threespine stickleback sampled from study lakes in the Lower Campbell Watershed during 1996, 1997 and 1998. Dark shading indicates the unusually large stickleback from Higgins Lake.

- During fish sampling in Higgins Lake, the small stickleback were captured primarily with minnow traps near shore, and the large stickleback were captured in gillnets set in deeper water, near the middle of the lake. This suggests that there may be 2 separate populations of threespine stickleback in Higgins Lake, a smaller littoral form, and the large limnetic form. The data for these and other fish sampled at Higgins Lake is found in the lake survey report for Higgins Lake (Lough and others 1998).

- There is nothing to prevent the large Higgins Lake stickleback from moving downstream into Gosling and Campbell Lakes, hence the distribution may not be confined to just Higgins Lake. Fish sampling was not conducted in Gosling and Campbell Lakes during this project.
- An unusual threespine stickleback monoculture population was found at Lost Lake. A barrier downstream of Lost Lake prevents other fish such as cutthroat trout from immigrating into Lost Lake from John Hart Lake.

4.3.2.5 Sculpin

- Prickly sculpin and coastrange sculpin are common throughout the Lower Campbell Watershed. Length information from sampled fish that were measured is summarized in Table 16.

Table 16 Summary of length information for sculpin sampled from the inland waters of the Lower Campbell Watershed, 1996 to 1998

Species	n	Mean length (mm)	Range (mm)
CAS	16	73	42 – 130
CAL	64	65	34 – 98

- Coastrange sculpin were widely distributed throughout streams in the watershed.
- The highest sample densities were encountered on September 2, 1998 at Site 33, in the 4th order stream that connects Gray and Whymper Lakes (Appendix 1).
- Prickly sculpin were found in lakes and streams throughout the study area. The species generally spawns between March and July (Scott and Crossman 1973), suggesting that many of the prickly sculpin sampled in the streams during May and June were probably spawning. The highest densities were encountered on June 10, 1997 at Site 40, in the small 1st order stream connecting Campbell Lake and Reed Lake (Appendix 1).

4.3.2.6 Western Brook Lamprey

- The non-anadromous western brook lamprey spends its life in lakes and enters tributary streams to spawn from April to July (Scott and Crossman 1973). Therefore, these fish are unlikely to be sampled in lakes with minnow traps and/or standard gillnets in the fall, and unlikely to be found in streams during the short spawning period. As a result, little information is available regarding their distribution in the study area (BCMELP-FB-VIR 1998).
- During this study, western brook lamprey were only encountered at Brewster Lake, although they probably inhabit other lakes of the watershed. Aggregations of spawners were visually observed in the small, 2nd order streams at Sites 10 and 13 on June 3, 1997 (Appendix 1).

4.4 Significant Features and Fisheries Observations

4.4.1 Fish and Fish Habitat

- An unusual population of extremely large threespine stickleback was found in Higgins Lake. These are among the largest stickleback on record, but further study is required to determine whether this is a unique or sensitive population. Development plans that could potentially affect the fish habitat or water quality of Higgins Lake might also affect this unusual population.
- Historical snorkel surveys have observed aggregations of large trout in the short river sections immediately downstream of the Ladore and Strathcona Dams. It is suspected that these areas are utilized as spawning habitat for trout populations from John Hart or Campbell Lake.
- Aggregations of spawning western brook lamprey were encountered in 2 tributaries to Brewster Lake (Sites 10 and 13). Little information is available regarding these populations, so careful protection of their spawning habitat would be a prudent precaution as more detailed information is collected. Any development plans that could potentially alter the stream or its water quality should be closely examined.

4.4.2 Habitat Protection Concerns

4.4.2.1 Fisheries Sensitive Zones

- One Fisheries sensitive zone was identified in the Lower Campbell Watershed during the surveys in 1996-1998, which is summarized in Table 17.

Table 17 Fisheries sensitive zones in the Lower Campbell Watershed identified in 1996-1998

Stream Name	Watershed Code	Survey Date	TRIM Map #	Reach #	Site #	Description
Miller Creek	920-627900-25200	1998/09/01	92F.093	2	20	high water refuge, 25 m long side channel

4.4.2.2 Fish above 20% Gradients

- In the 3 years of sampling in the Lower Campbell Watershed, no fish were found upstream of reaches steeper than 20% gradient, and there is no documentation in the historical data of fish occurring naturally upstream of reaches steeper than 20%.
- There are situations where barriers, such as chutes or waterfalls that exceed 20% gradient, are within a reach with an overall gradient of less than 20%. These situations are summarized in Section 4.2 and Appendix 3.

4.4.2.3 Restoration and Rehabilitation Opportunities

- Table 18 summarizes the potential restoration and rehabilitation opportunities that were identified during surveys in the Lower Campbell Watershed between 1996 and 1998.

Table 18 Restoration and rehabilitation opportunities in the Lower Campbell Watershed identified between 1996 and 1998.

Lake / Stream	Issue	Mitigation Options
Bottle Lake outlet	Lake outlet culverts at Elk River mainline are blocked and prevent fish passage	Rehabilitation of the outlet stream from Bottle Lake and culvert re-designed to allow for fish passage while maintaining the present water level in Bottle Lake
Buck Lake outlet	Obstruction at outlet	Debris removal and rehabilitate outlet
Higgins Lake outlet	Inadequate culvert at outlet of lake affects fish passage	Culvert modification to improve fish passage
Lukwa Lake outlet	Obstruction at outlet	Removal of bridge timbers and rehab outlet stream
Pocket Lake outlet	Obstruction at outlet	Repair/removal of culvert and rehabilitate stream
Sandhill Lake outlet	Obstruction at outlet	Re-install collapsed culvert and rehabilitate lake outlet
Sedge Lake inlet	Culvert plugged w/ sand and gravel	Improve culvert
Brewster Lake	Industrial debris near lake outlet and logs in lake	Remove debris and logs
Gooseneck Lake	logs in lake	Remove logs

- Bottle Lake, which flows into Beavertail Lake, has been partially created by blocked culverts at the Elk River Main logging road. If the culverts are cleared and improved, the drop in water level would dramatically affect the lake, and its population of Dolly Varden and coastal cutthroat trout. Culvert improvement plans should be carefully considered, but should provide for fish movement between the lakes.
- Debris from logging operations, such as tires and cable are clearly visible from the Menzies Mainline Bridge at the outlet of Brewster Lake. This detracts from the aesthetic quality of the area, and therefore from the quality of the sizable sport fishery at Brewster Lake. Removal of the debris and rehabilitation of the area would improve the ambience.
- Large amounts of logging debris continue to drift around Gooseneck Lake and to a lesser degree, Brewster Lake, which are some of the major sport fishing lakes in the study area. Although some logs could potentially provide cover for fish along the lake shore, large volumes of drifting logs often accumulate at the lake outlets, and appear to affect light penetration, aquatic productivity and flow patterns of the outlet streams. Removal of these logs and rehabilitation of the lake outlet areas should be investigated as a method of alleviating these impacts.

4.5 Fish Bearing Status

4.5.1 Non-Fish Bearing Reaches

- Even though no fish were caught in many of the sampled reaches, they were not designated as “non-fish-bearing” because the sites were only sampled once during late summer, when some of the viable fish habitat was dry.
- Specifications in the *Forest Practices Code Fish-stream Identification Guidebook* for assigning non-fish-bearing status to a stream reach with less than 20% gradient, require at least 2 thorough surveys at different times of the year to confirm fish absence (MOF 1995b).
- Reaches that were sampled for fish, but no fish were captured or observed, were labeled as “no fish caught” (NFC).

4.5.2 Follow-up Sampling Required

- Sites recommended for re-sampling are summarized in Table 19. These are sites where no fish were found or the streams were dry when sampled during 1998.
- Most of the sites that are recommended for re-sampling were dry at the time of survey, due to the extremely low flows in the late summer of 1998. Many of these streams are potential spawning and juvenile rearing habitat for trout, prior to low flows, which force the fish into lakes or larger streams.
- Field sampling found that trout fry emergence generally occurs during late May through June. The best period for detecting these fish would therefore be during late June and July, after fry emergence.
- Electrofishing and/or minnow trapping would probably provide the most efficient combination of sampling methods.

Table 19 Follow-up sampling required for classification of reaches where no fish were caught in the Lower Campbell Watershed during 1998 sampling

Stream Name	Watershed Code/ILP	Reach #	Timing	Methods	Comments
Miller Creek trib.	ILP 5	1	June-July[1]	EF / MT	intermittent
Beavertail Creek trib	ILP 6	1	June-July[1]	EF / MT	likely NFB [2]
Beavertail Creek trib	ILP 7	3	June-July[1]	EF / MT	dry/intermittent
Beavertail Creek trib	ILP 9	1	June-July[1]	EF / MT	dry/intermittent
Brewster Lake trib	ILP 24	1	June-July[1]	EF / MT	dry/intermittent
Greenstone Creek trib	ILP 25	1	June-July[1]	EF / MT	u/s of barrier, likely NFB
Greenstone Creek trib	ILP 25	3	June-July[1]	EF / MT	u/s of barrier, likely NFB
Campbell Lake trib	ILP 31	1	June-July[1]	EF / MT	dry/intermittent
Campbell River trib.	ILP 56	2	June-July[1]	EF / MT	intermittent
Campbell Lake inlet	ILP 57	1	June-July[1]	EF / MT	dry/intermittent
John Hart Lake inlet	920-627900-11600	1.2	June-July[1]	EF / MT	u/s of barrier, likely NFB
John Hart Lake inlet	920-627900-14300-51000	1	June-July[1]	EF / MT	intermittent
Miller Creek trib.	920-627900-25200-01100	1	June-July[1]	EF / MT	intermittent
Gooseneck Lake NW inlet	920-627900-25200-82200	6	June-July[1]	EF / MT	intermittent, u/s of barrier, likely NFB
Sandhill Lake outlet	920-627900-25200-92800	3	June-July[1]	EF / MT	intermittent
Trestle Lake inlet	920-627900-26800-44910	3	June-July[1]	EF / MT	dry/intermittent, probably NFB
Campbell Lake inlet	920-627900-31353	2	June-July[1]	EF / MT	dry/intermittent
Davis Lake outlet	920-627900-31800	2	June-July[1]	EF / MT	intermittent, u/s of barrier, likely NFB
Brewster Lake inlet	920-627900-35700-54091	3	June-July[1]	EF / MT	dry/intermittent
Brewster Lake inlet	920-627900-35700-54091	4	August	GN / MT	small lake, fish sampling only
Brewster Lake inlet	920-627900-35700-69500	3	June-July[1]	EF / MT	dry/intermittent
Brewster Lake inlet	920-627900-35700-69500	4	June-July[1]	EF / MT	dry/intermittent, gradient 14%
Brewster Lake inlet	920-627900-35700-75433	2	June-July[1]	EF / MT	intermittent
Brewster Lake inlet	920-627900-35700-80800	3	June-July[1]	EF / MT	intermittent
Beaver Lake inlet	920-627900-35700-86400-8860-7471	2	June-July[1]	EF / MT	dry/intermittent
Greenstone Creek	920-627900-35800	6	June-July[1]	EF / MT	u/s of barrier, likely NFB

[1] after trout fry emergence
[2] Non Fish Bearing

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