Overview Assessment of the Fish and Fish Habitat of Kunlin and Donner Lakes Vancouver Island, BC

Kunlin Lake, Vancouver Island. August 2021

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April, 2022

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Introduction

Located within the rugged mountain wilderness of central Vancouver Island lies Strathcona Park, the oldest park in BC, and the largest on Vancouver Island. One of more than 120 provincial parks on the Island, Strathcona Park was created in 1911 and is a critical part of Vancouver Island's protected wilderness (BC Parks 2001). Considered the wilderness heart of the Island, BC's first provincial park comprises more than 250,000 ha and includes Canada's highest falls, the only glaciers on the Island, and numerous rivers and lakes, some of which are renowned for their salmon and trout fisheries.

Donner and Kunlin Lakes are two of the roughly 50 lakes within the borders of Strathcona Park. Both lakes lay in the steep valleys that typify the Western ranges of the Vancouver Island Mountains on the West side of the park. Donner Lake is the largest lake on the Ucona River and was named after trapper Julius Donner or his brother Charles Donner both of whom resided at the lake after the turn of the century (Coombs 1988a). As with most lakes in the Vancouver Island region, Donner and Kunlin Lakes are clear, insular, coastal mountain lakes characterized by low standing populations of fauna and fish (Northcote and Larkin 1956).

Donner and Kunlin and Donner Lakes were referenced in the 1993 *Strathcona Park Master Plan* which defined the role of the park, and established objectives and actions to guide its management and development (Ministry of Environment Lands and Parks 1993). BC Parks relies on zoning to apply uniform and consistent management objectives to provincial parks. To that end, the *Master Plan* included Donner Lake in the Wilderness Recreation Zone, the objective of which is to protect remote, undisturbed natural landscapes and provide backcountry recreation opportunities within a pristine environment. The road-accessible areas of Kunlin Lake were included in the Intensive Recreation Zone and are managed to provide for a variety of readily accessible, facility-oriented outdoor recreation opportunities in as natural a setting as possible.

The *Strathcona Master Plan* outlined the public expectation for Strathcona Park and strong support for the preservation of its wilderness characteristics (Ministry of Environment, Lands and Parks 1993). However, there was also stated public need for access to recreational opportunities within the park and to that end the plan committed to improving roads and access, and establishing day use areas at Kunlin Lake, and improving roads and providing new vehicle-accessible campgrounds at the North end, and a new canoe-accessible campground at the South end of Donner Lake. Recommendations pertaining to conservation and preservation of fishing opportunities for native fish species at both lakes were outlined in the *Sport Fishery Management Plan for Strathcona Park and Recreation Area* (Paish and Associates 1989) and reiterated in the *Master Plan*. Specifically, Donner and Kunlin Lakes were recognized as two of seven key fishing opportunities in the park and recommendations were made for managing inventory and monitoring needs including preparing management plans for fish, monitoring angler use and demand, and undertaking general surveys of all fish species (Ministry of Environment Lands and Parks 1993).

The objective of this study was to survey fish populations and record observations about the lake and stream fish habitat at Donner and Kunlin Lakes, and provide information to inform decisions by BC Parks when considering management recommendations for these lakes as proposed in the *Strathcona Master Plan*.

Study Sites

Donner and Kunlin Lakes are located on the West side of Strathcona Park (Figure 1). Both lakes are in the submontane moist maritime variant of the Coastal Western Hemlock (CWHmm1) Biogeoclimatic Ecosystem Classification (BEC) zone[1] (Green and Klinka 1994). Kunlin Lake is located ~ 6.5 km East of Gold River and access to the West end of this lake is via the Ucona Mainline for ~8 km, and a 4X4 spur road for an additional ~5 km. Donner Lake is ~10 km East-Southeast of Gold River and access is via the Ucona Mainline to a junction ~9 km from Gold River. All Terrain Vehicles (ATV) are required to travel the additional ~9 km to the North end of Donner Lake at the Ucona River outlet.

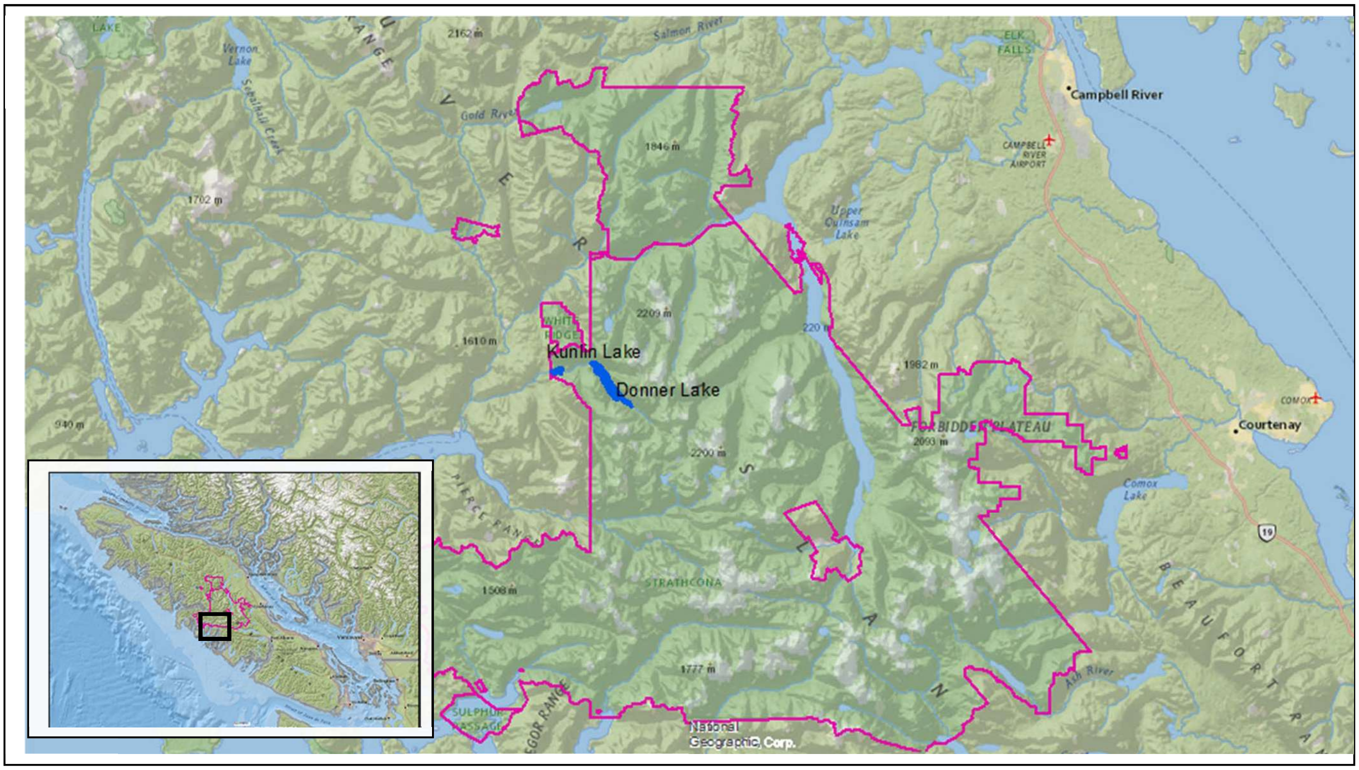

Figure 1. Location of Donner and Kunlin Lake on the West side of Strathcona Park on Vancouver Island

At ~400 ha, Donner Lake is characterized by a shoreline of rockfall rubble or bedrock, many slides, well-developed avalanche tracks, and steep drop offs into a deep, cold lake (Table 1, Figure 2). The lake sits at 563 m elevation in a basin within a steep glacial-cut valley in the insular mountains where volcanic and granitic rocks have produced thin, rocky and poor soils. Although vegetation includes both climatic climax forest and a riparian fringe, avalanche tracks and regenerated logged and burnt areas define the Donner Lake basin vegetation (Coombs 1988a). The high elevation and cool temperatures, sudden squalls and stiff winds that produce high, steep waves as a result of the long fetch at this lake add to what is likely a short growing season for fish. Cutthroat Trout (*Oncorhynchus clarkii*) are the only salmonids documented in Donner Lake (Appendix 2) although Coombs (1988a) also sampled Sculpins (*Cottus sp.*) during his fish assessment in 1988.

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[1] The Biogeoclimatic Ecosystem Classification (BEC) delineates ecological zones (biogeoclimatic units) by vegetation, soils, and climate, and is commonly used in forestry and conservation to classify ecosystems in BC.

Table 1. Physical attributes of Donner and Kunlin Lakes, Vancouver Island (Coombs 1988a, Coombs 1988b).

Lake	Elevation (m)	Lake Drainage Area (ha)	Lake Area (ha)	Maximum Depth (m)	Mean Depth (m)
Donner	563	5,960	397	164	76
Kunlin	264	7,860	55.8	22.7	12.6

Figure 2. Photograph of Donner Lake looking South toward the Ucona River inlet. Photograph shows Donner Lake within a deep glacial-cut valley within the Vancouver Island Mountains.

Less than 5 km downstream past an imposing series of falls, cascades and chutes is small (<60 ha), shallow (~12 m average depth) Kunlin Lake (Table 1). Apart from a steep drop-off along some shores, littoral shoals and beach areas formed by wave action on the alluvial soils characterize this lake (Coombs 1988b). Kunlin Lake is located at ~260 m elevation and is oriented almost perpendicular to Donner Lake in a Southwest aspect, and although it is a small lake, the basin drains a partially logged steep mountainous and rolling terrain of >7,000 ha. (Figure 3) Cutthroat Trout are documented in Kunlin Lake (Appendix 2), and Rainbow Trout (*Oncorhynchus mykiss*) have been observed in the Ucona River above and below the lake (Tripp Biological Consultants Ltd 1997).

Figure 3. Photograph taken August 27, 2021 of Kunlin Lake from the 4X4 road leading to Donner Lake. This picture was taken looking at the South and West shores of Kunlin Lake.

Donner and Kunlin Lake were surveyed in 1988 by the Recreational Fisheries Branch of the Ministry of Environment (Coombs 1988a, Coombs 1988b). Physical data, fish and water chemistry were sampled at both lakes and the resulting reports provide general recommendations regarding fisheries management and monitoring, fish data and bathymetric surveys (Appendix 3) and are available at Aquatic Report Catalogue (gov.bc.ca). Tripp Biological Consultants (1997) conducted surveys on the Ucona River and their fish observation data is available at HabitatWizard - Province of British Columbia (gov.bc.ca).

Methods

Field Methods

Staff from the Ministry of Forests Lands Natural Resource Operations and Rural Development (FLNRORD[2]), The University of BC (UBC), Vancouver Island Transport, and volunteers conducted water quality, fish habitat and fish assessments at Donner and Kunlin Lakes August 23 – August 27, 2021. Mainline and secondary logging roads from Gold River provided access close to both lakes,

[2] Now Ministry of Forests

and Vancouver Island Transport conveyed the project team and equipment the remainder of the way (Figure 4).

Figure 4. Side-by-side transport of pontoon boat by Vancouver Island Transport to the North end of Donner Lake August 25, 2021.

Fish Habitat. Team members made general observations and took photographs of the first reach of inlet streams at Donner and Kunlin Lakes. We have presented our results with those of Coombs (1988a, 1988b) to characterize the Donner and Kunlin Lakes habitat as completely as possible.

Water Quality. We recorded temperature, dissolved oxygen, Total Dissolved Solids (TDS) and pH using calibrated YSI probes (YSI™ Pro 1030 and ProODO) and took secchi disc readings at the centres of both lakes.

Fish Sampling. Our team set mini-fyke nets at three lake sites in Donner and Kunlin Lakes, four stream inlet sites (lake deltas) at Donner Lake and three lake delta sites at Kunlin Lake (Figure 5). Initially, nets were set for four-hour periods, however, after no fish were captured in successive sets at either lake, nets were re-set and left to fish overnight. In addition to capturing fish in fyke nets we sampled young-of-the-year (age-0) Cutthroat Trout by dipnet at the Ucona River outlet at Donner Lake, and in the Ucona River inlet at Kunlin Lake. All fish were anesthetized using Tricaine-S (MS-222), weighed, measured, and sampled for scales. We used the lavage method (Meehan and Miller

1978, Culp et al. 1988, Haley 1998) to collect stomach contents for all but the 0+ fish. Fish were revived in fresh lake water and returned to the lake or stream of origin (Figure 6).

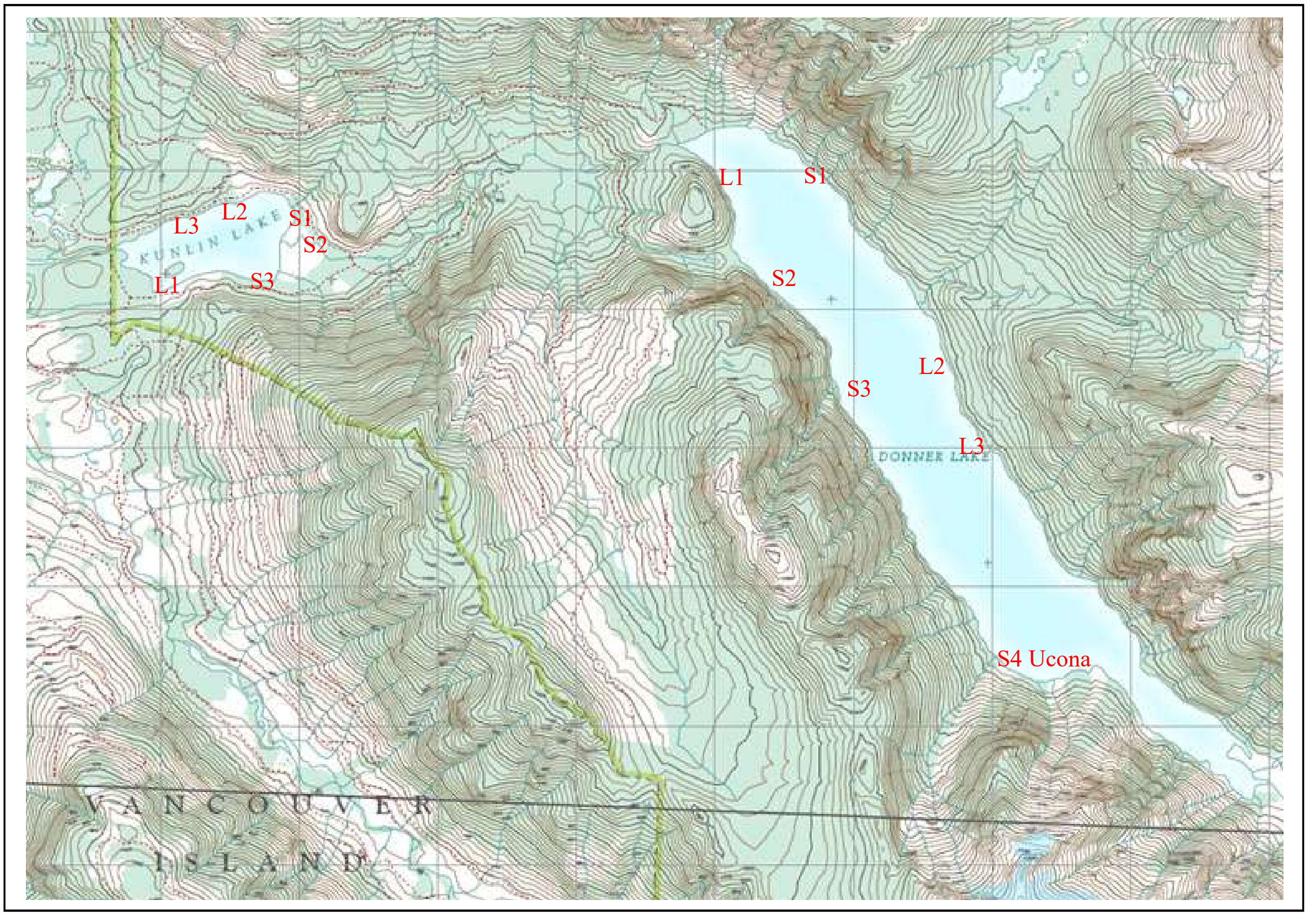


Figure 5. Fyke net set locations at Donner and Kunlin Lake August 2021. Notations show three lake littoral sites and four stream inlet sites at Donner Lake and three lake littoral and three stream inlet sites at Kunlin Lake.

Figure 6. Ministry staff, UBC and members of Vancouver Island Transport sampling fish at Donner Lake August 25 2021. Photo shows stomach contents of Cutthroat Trout being flushed into collecting tray.

Data Summary and Analyses

Data and Information Search. We searched Ministry databases including the Ecocat Ecological Reports Catalogue (Aquatic Report Catalogue (gov.bc.ca), Cross-Linked Information Resources (CLIR) Cross-Linked Information Resources (CLIR) - Province of British Columbia (gov.bc.ca), Fish Inventories Data Queries (FIDQ) (Fish Inventories Data Queries (gov.bc.ca)) and Habitat Wizard (Habitat Wizard (gov.bc.ca) to locate fish or lake reports in addition to Coombs (1988a, 1988b) for Donner and Kunlin Lakes. We also searched the Freshwater Fisheries Society of BC (FFSBC) (Freshwater Fisheries Society of BC - Freshwater Fisheries Society of BC (gofishbc.com)) to determine if either lake has been stocked.

Stomach Contents and Fish Ageing. Preserved fish stomach contents were sent to invertebrate taxonomists at Cordillera Consulting in Summerland, BC for analyses. Identifications were made at the genus/species level for all insect organisms found including *Chironomidae*. Non-insect organisms were identified to genus/species where possible and to a minimum of family level with intact and mature specimens (Cordillera Consulting Inc 2017). Fish were aged by Ministry staff who mounted scales on glass slides, photographed each scale then annotated and counted annuli on each photograph.

We summarized fish, stream habitat and stomach contents using descriptive statistics. We also performed a Students t-test using RStudio (RStudio Team 2022) to test for differences in average length and condition factor (K) (Williams 2000) for each age group (i.e. age-1+ Kunlin vs. age-1+ Donner) and between these populations and Cutthroat sampled in 2020 at Twaddle Lake (i.e. age-1+ from Kunlin and Donner vs. age-1+ from Twaddle) also located in the Gold River watershed on the West Coast of Vancouver Island.

Results

Donner Lake

Lake and Stream Habitat

Donner Lake has a steep drop-off underwater around most of the margin and much of the shoreline at the centre and South end of the lake is rockfall rubble or bedrock with many slide areas and well-developed avalanche tracks (Figure 7, Figure 8). We noted numerous small, steep sided streams at the South end of the lake, many of which were dry at the time of our survey (Figure 9).

Figure 7. Photograph of Donner Lake at South end of the lake showing steep mountain drop-off into the lake.

Figure 8. Photograph of Donner Lake approximately mid-way between the South and North ends. Red arrow shows steep debris trail entering lake.


Figure 9. Photograph of steep, dry stream entering in the South end of Donner Lake

We observed only a few shoals along the Donner Lake shore (Figure 10), however, inlet streams, some of which were dry, became less steep toward the North end of the lake (Figure 11).

Figure 10. Photograph of Lake Site 3 (L3), one of few large beach and shoal areas approximately half-way along the length of Donner Lake.

Figure 11. Photograph of dry stream inlet at North end of Donner Lake

The Ucona River inlet provides much of the stream habitat available to the Donner Lake fish population (Figure 12, Figure 13), however, Coombs (1988a) pointed out that even during his assessment in July this stream was still cold (4.5^0C). We observed that Reach 1 of the Ucona River inlet was large with an average bankfull width of 19 m with much of the habitat in the upper part of the reach dominated by boulder riffles, and that the habitat in Reach 2 was dominated by chutes and rapids over bedrock (Table 2).

Figure 12. Photograph looking South toward the Ucona River lake delta (marked with the red arrow). The lake delta in front of the inlet is large and shallow, however, immediately adjacent areas have large drop-offs with heavily forested beaches.

Figure 13. Accessible netting site close to the Ucona River lake delta (S4). The inlet stream (noted with red arrow) is small with little flow, however, the lake delta provided some shoal area for fish.

Table 2. Summary of fish habitat parameters recorded by Coombs (1988) at Reach 1 of the Ucona River inlet at Donner Lake. Substrate values for Reach 1 do not add to 100%.

Reach	Bankfull Width (m)	Wetted Width (m)	Average Depth (m)	Gradient (%)	Substrate	Observations
1	19.0	17.0	0.7	2	boulder (10%) cobble (50%) gravel (30%) fines (5%)	habitat in upper part of reach dominated by boulder riffles
2	General observations: habitat in Reach 2 dominated by chutes and rapids over bedrock with substrate of cobbles and boulders					

During his assessment, Coombs (1988a) noted many minor stream systems draining into Donner Lake, but he suggested that they offered little or no fish habitat of any sort. Coombs also observed that in a few cases some potential salmonid spawning habitat exists where alluvial fans reach the lake (Figure 14).

We did not assess the Ucona River outlet because there is a large drop-off ~120 m past the end of Donner Lake and this prevented our access to the area. In his report, however, Coombs (1988a) noted that the fish habitat available at this outlet is quite small.

Figure 14. Photograph of Stream Site 1 (S1) at the North end of Donner Lake. Photograph shows the low gradient and wetted area of Reach 1 as it enters the lake.

Water Quality

The surface temperature of Donner Lake was 18.5^{0}C, the thermocline[3] was between 6 – 8 m and the TDS was <10 ppm on August 25 (Table 3, Appendix 1).

Table 3. Water quality measurements at Donner Lake (August 25, 2021) and Kunlin Lake (August 23, 2021).

Lake	Date	Temperature (^{0}C)	TDS (ppm)[1]	pH	Secchi Depth (m)	Thermocline Depth (m)[2]
Donner	25-Aug-21	18.5	8.38	6.34	10	6 - 8
Kunlin	23-Aug-21	21.8	9.66	6.32	8	8 - 13

[1] converted from Siemens/cm at: Conductivity convertor, Siemens into TDS PPM and MHO (lenntech.com)
[2] see Appendix 1

Fish Sampling

Cutthroat Trout We captured 53 Cutthroat Trout ranging from 53 mm and 1.2 g. to 305 mm and 250.6 g. at Donner Lake (Figure 15). Fish ranged in age from the single age-0 fish captured in the Ucona River outlet, to age-4+ (Figure 16, Figure 17).

[3] the steep temperature gradient marked by a layer above and below which the water is at different temperatures.

Figure 15. Example of a Cutthroat Trout captured at Donner Lake August 26, 2021

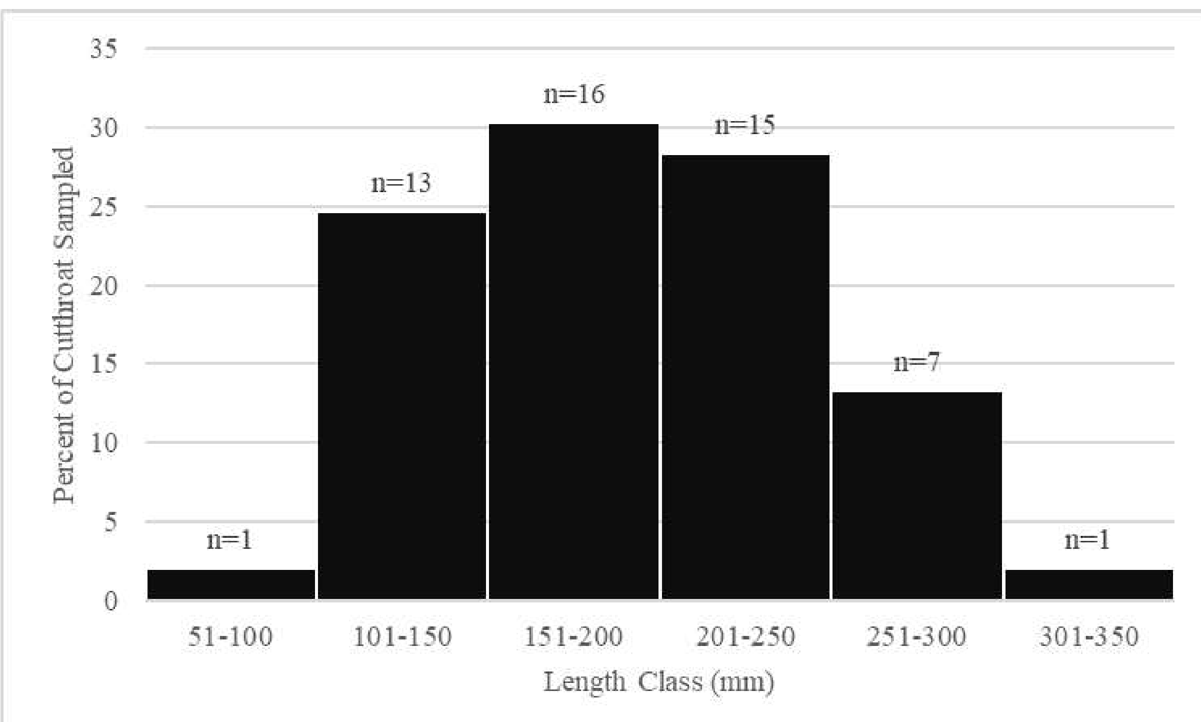
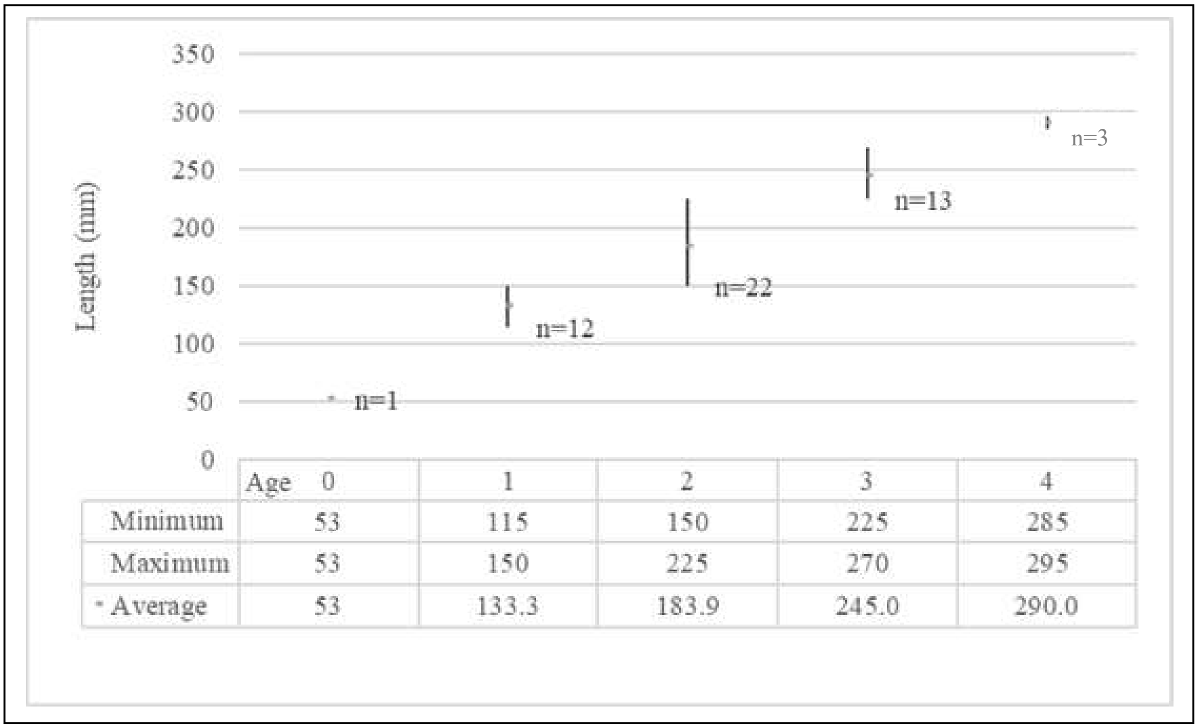


Figure 16. Length frequency of Cutthroat Trout Sampled at Donner Lake August 25 and 26, 2021 showing most fish we captured were 151 – 250 mm (N=53).



Age	0	1	2	3	4
Minimum	53	115	150	225	285
Maximum	53	150	225	270	295
Average	53	133.3	183.9	245.0	290.0

Figure 17. Length-at-Age of Cutthroat Trout Sampled at Donner Lake August 25 and 26, 2021 showing the majority of fish captured were age-2+ (N=51).

Seventy percent of the Cutthroat we sampled were captured at the lake shoal site L1 and the stream site S3 both located on the West side of Donner Lake (Figure 5, Table 4).

Table 4. Number and minimum and maximum sizes of Cutthroat Trout sampled at each site in Donner Lake August 25 and 26, 2021 (N=53).

Site	Number Sampled (n)	Size	
		Minimum (mm)	Maximum (mm)
L1	21	115	255
S3	16	130	285
S1	4	135	240
S2	4	130	295
S4	4	130	200
L3	3	290	305
Ucona Outlet	1	53	

<u>Rainbow Trout</u> We also captured two Rainbow Trout (Figure 18) at Donner Lake. These fish were 202 mm in length, 81.9 g., and age-2+, and 272 mm long, 81.9 g., and age-3+(Table 5).

Figure 18. Example of a Rainbow Trout captured at Donner Lake August 25, 2021.

Table 5. Length (mm), weight (g) and age of Rainbow Trout captured at Donner Lake August 25, 2021

Length (mm)	Weight (g)	Age
202	81.9	2
272	194.3	3

Fish Diets

Table 6 summarizes the most common and most abundant invertebrate prey groups found in fish captured at stream and lake sites in Donner Lake. Dipterids (true flies), which include chironomids, were by far the most abundant prey items in fish sampled at lake sites and were also the most commonly found prey item although amphipods and members of the *Coleoptera* (beetles) were found in fish stomachs from lake locations. *Ephemeroptera* (mayflies) were the most abundant prey items found in stomachs sampled from fish at stream sites, and while Dipterids and amphipods were common, they were much less abundant in fish from these sites.

Table 6. Summary of the most common vs. the most abundant invertebrate prey groups found in fish captured at lake and stream sites in August 2021 at Donner Lake. Numbers beside prey groups represent the number of individuals counted in all fish stomachs sampled.

Lake Sites	
Most Common	Most Abundant
Diptera (9)	Diptera (23)
Amphipoda (5)	Amphipoda (9)
Coleoptera (3)	Coleoptera (7)
Ephemeroptera (1)	Ephemeroptera (1)
Hymenoptera (1)	Hymenoptera (1)
Trichoptera (1)	Trichoptera (1)
Stream Sites	
Diptera (12)	Ephemeroptera (33)
Ephemeroptera (11)	Diptera (14)
Amphipoda (7)	Amphipoda (11)
Coleoptera (4)	Coleoptera (7)
Trichoptera (4)	Trichoptera (6)
Veneroida (1)	Veneroida (1)

Kunlin Lake

Lake and Stream Habitat

Although there are some steep drop offs along the North and South shores, the Kunlin Lake shoreline also has numerous shoals (Figure 19, Figure 20).

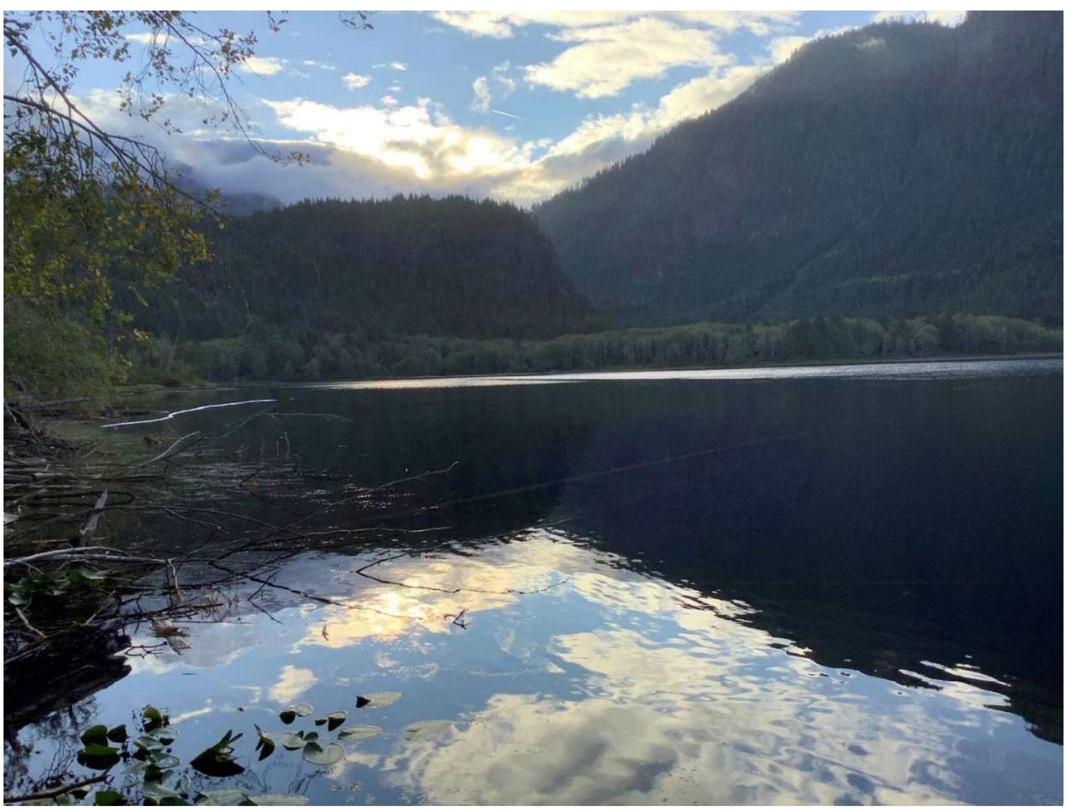


Figure 19. Photograph of Kunlin Lake looking toward the Ucona River inlet and showing the steep, mountainous terrain on East side of the lake. Photograph taken August 27, 2021.

Figure 20. Photograph of Kunlin Lake looking toward more moderate sloped terrain on the West side of the lake August 23, 2021.

We took notes and photographs at three stream sites in the Kunlin Lake basin including at the Ucona River inlet (Table 6). The bathymetric map of this lake created by the Recreational Fisheries Branch in 1988 shows the Ucona River with two inlets (Figure 21). We found one inlet with flow (S1), and a heavily vegetated second inlet (S2) with no discernable surface flow.

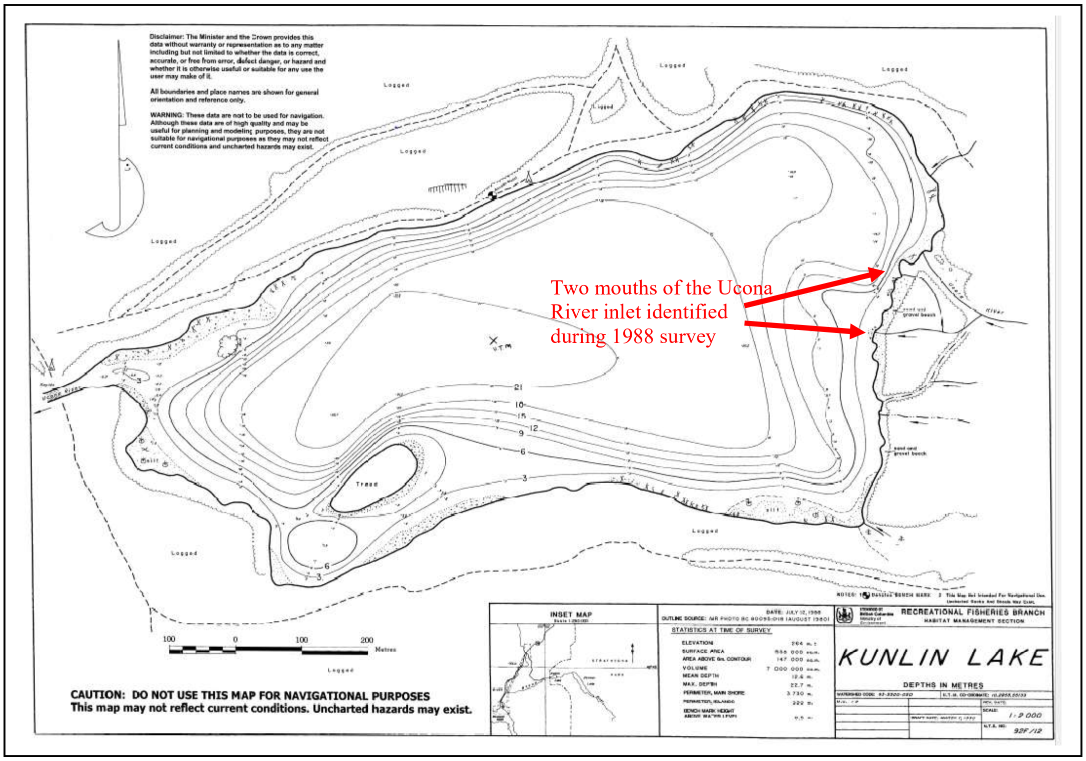


Figure 21. Bathymetric map of Kunlin Lake created by the Recreational Fisheries Branch (Ministry of Environment 1988) showing the two mouths of the Ucona River.

Reach 1 of the Ucona River inlet (S1) was a wide channel with a bankfull width of almost 16 m and a wetted width of ~12 m (Table 7, Figure 22). The lower ~100 m of the reach was <5% gradient and comprised of mostly cobble/gravel substrate with some deep pools (Figure 23). Upstream we noted large depositions of cobble, gravel and fines, with intermittent pools and sparse overhead cover (Figure 24).

Table 7. Summary of stream observations and of the Ucona River inlet (S1), historical Ucona River inlet (S2) and wetland (S3) August 24, 2021.

Site	Stream 1 (S1) Ucona River Inlet (2021 survey)	Stream 1 (S1) Ucona River tributary – 500 m up/stream of Kunlin Lake (Coombs 1988)	Stream 2 (S2) Historical Ucona River Inlet	Stream 3 (S3) Wetland
Gradient (%)	<5	1	<10%	
Wetted Width (m)	12	17	no wetted stream	0.4
Bankfull Width (m)	15.7	18	no channel	<1
Pool Depth (m)	0.7	2.0	no pools	0.3
Substrate	gravel/cobble	boulder/cobbles (90%)	gravel	fines
Instream Cover	overhanging vegetation		overhanging vegetation	overhanging vegetation/submerged vegetation
Comments	Large deposition zone at the bottom of reach at Kunlin Lake. S1 is correctly mapped; stream dries in summer but this is the only location of the Ucona inlet.		Stream is called Ucona River on government ArcGIS, but this is the old inlet (main inlet is S1). Flow here (S2) negligible and could be sub-surface.	Low gradient wetland characterized by grasses and skunk cabbage at mouth; thick grass cover comprises riparian zone; stream mouth is muddy; sediment/mud deposition zone. Upstream heavily vegetated.

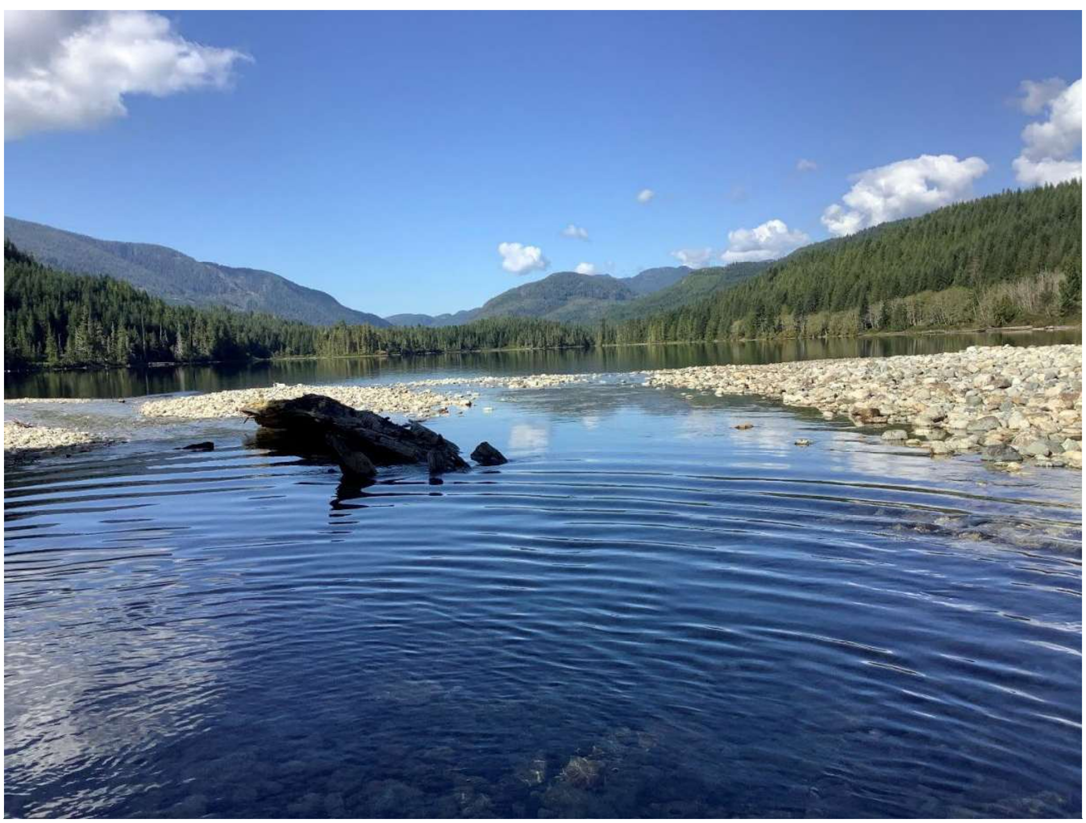


Figure 22. Mouth of the Ucona River outlet (S1). Photograph taken looking West into Kunlin Lake, August 24, 2021.

Figure 23. S1 Ucona River ~20 m upstream showing pool habitat and gravel substrate August 24, 2021.

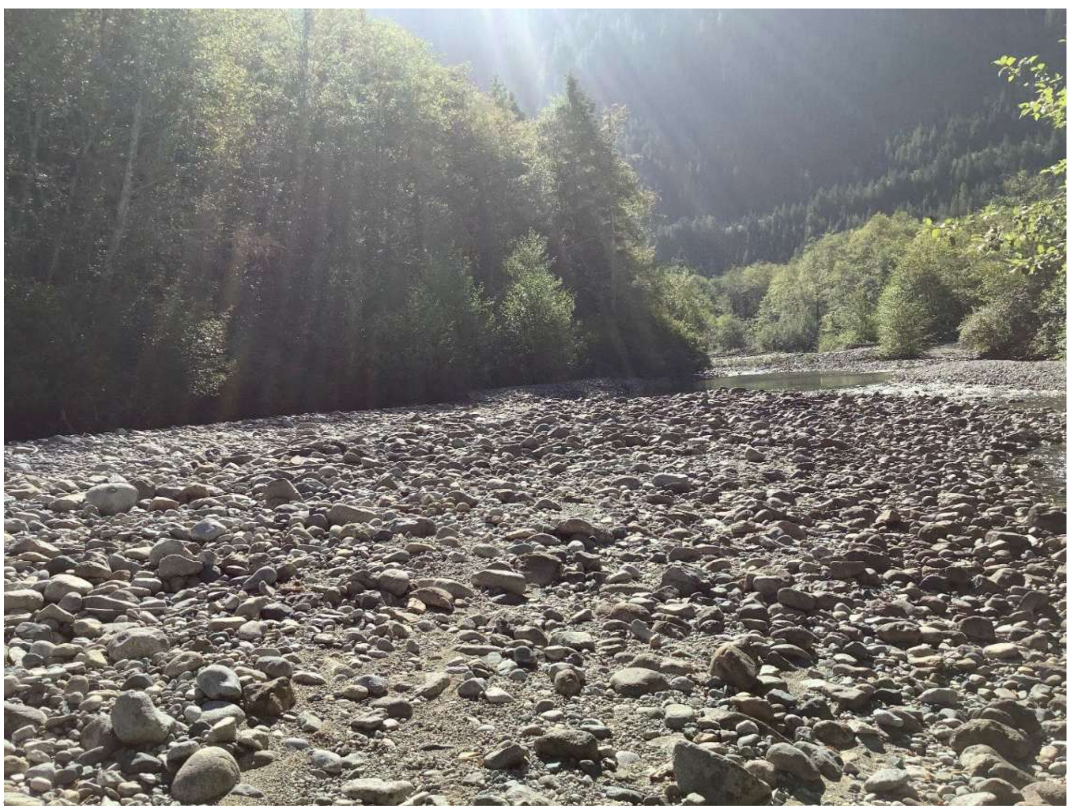


Figure 24. S1 Ucona River ~100 m upstream from mouth. This picture, taken August 24, 2021, shows the large deposition of cobble, gravel and fines, intermittent pool habitat and little overhead cover.

Coombs (1988b) surveyed Reach 1 of the Ucona River inlet and noted that the main channel had boulder substrate, and a large amount of vegetative cover in the stream delta including Red Alder (*Alnus rubra*), Hardhack (*Spiraea douglasii*), Ninebark (*Physocarpus spp*.), Thimbleberry (*Rubus parviflorus*) and Red Osier Dogwood (*Cornus sericea*). He also observed numerous tributaries with gravel beds, as well as a few minor dry tributaries and, at 500 m upstream of the mouth, one wetted, low gradient but large tributary with deep pools and boulder/cobble substrate (Table 6). He stated that the Ucona River was a lower gradient stream with side channels further upstream of the mouth and below a lower set of falls.

A secondary, historical inlet for the Ucona River is at S2 (Figure 3). Discharge here was low and intermittent the day we did our survey, while upstream was heavily vegetated with no discernable surface flow (Figure 25, Figure 26).

Figure 25. Historical Ucona River inlet (S2) now heavily vegetated with little or no discernable surface flow. Photograph was taken looking West into Kunlin Lake August 24, 2021.

Figure 26. Historical Ucona River inlet (S2) at ~10 m upstream of the heavily vegetated mouth. Photograph is looking upstream and East at densely vegetated wetland August 24, 2021.

S3 was a low gradient, heavily vegetated wetland with grasses and skunk cabbage at the mouth which was inundated with deep mud and a large accumulation of sediment (Figure 27). There was no stream channel or wetted habitat upstream of the mouth, and the area became heavily vegetated with grasses and a thick riparian zone (Figure 28).

Figure 27. Mud/silt deposition zone at the mouth of S3. Photograph was taken looking West toward Kunlin Lake August 24, 2021.


Figure 28. Looking West from the mouth of S3. Photograph showing no stream channel or wetted habitat and heavy vegetation on mud substrate August 24, 2021.

We did not survey the Ucona River outlet at the West end of the lake (Figure 5), however, Coombs (1988b) noted there is a falls at the outlet of the mouth which is an obstruction but not a barrier to fish movement. Downstream of the falls there is a low gradient stream which flows for ~1.3 km before reaching the Ucona Mainline, falls, rapids, chutes and finally the Gold River (Coombs 1988b).

Water Quality

The surface temperature of Kunlin Lake was 21.8^{0}C, the thermocline was between 8 – 13 m and the TDS was <10 ppm on August 25 (Table 3, Appendix 1).

Fish Sampling

We sampled 14 Cutthroat Trout at the Ucona River inlet and in Kunlin Lake on August 24 and 27, 2021. Fish ranged from 32 mm and 0.4 g. to 295 mm and 273.5 g (Figure 29). Most fish were between 170 – 205 mm and age-2+, however, we did sample age-0 fish in both the Ucona River inlet, and in Kunlin Lake (Figure 30).

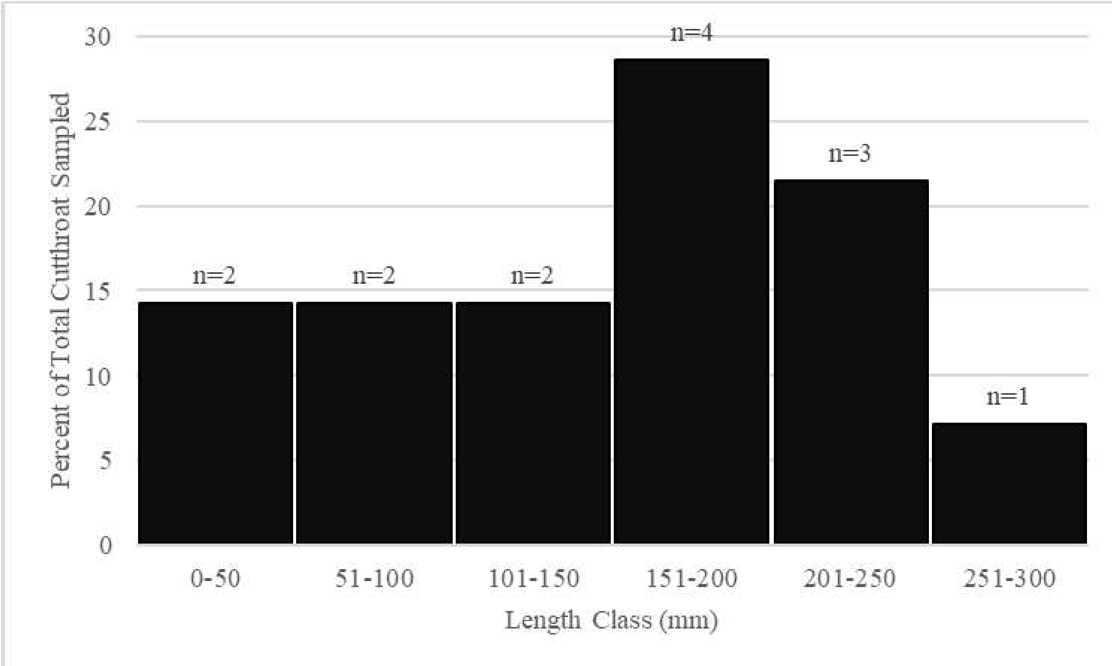
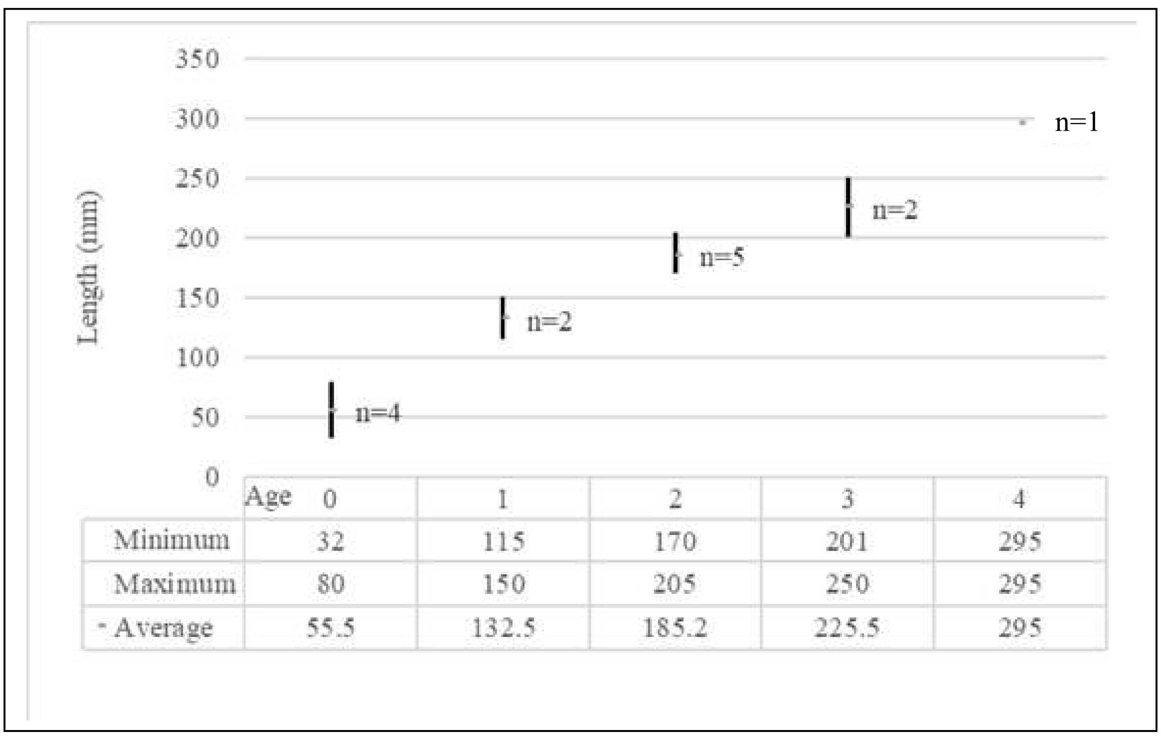


Figure 29. Length frequency of Cutthroat Trout sampled at Kunlin Lake August 24 and 27, 2021 (N=14).



Age	0	1	2	3	4
Minimum	32	115	170	201	295
Maximum	80	150	205	250	295
Average	55.5	132.5	185.2	225.5	295

Figure 30. Length-at-age of Cutthroat Trout sampled at Kunlin Lake August 24 and 27, 2021 showing most fish captured were age-2+ years old (N=14).

We captured almost equal numbers of Cutthroat Trout at the lake (L1) and the Ucona River inlet (S1) sites, although we sampled more young fish at the stream inlet (Table 8).

Table 8. Number and minimum and maximum sizes of Cutthroat Trout sampled at each site in Kunlin Lake August 24 and 27, 2021 (N=14).

Site	Number Sampled (n)	Size (mm)		Modal Age
		Minimum	Maximum	
L1	7	115	250	2+
S1	6	32	295	0+
S3	1	75		N/A

Fish Diets

Members of the order *Odonata* (dragonflies, damselflies) were slightly more abundant and common than other invertebrate prey items in fish sampled at lake sites and were found in stomachs in roughly the same numbers as were dipterids from fish sampled at stream sites (Table 9).

Table 9. Summary of the most common vs. the most abundant invertebrate prey groups found in fish captured at lake and stream sites in August 2021 at Kunlin Lake. Numbers beside prey groups represent the number of individuals counted in all fish stomachs sampled.

Lake Sites	
Most Common	Most Abundant
Odonata (3)	Odonata (5)
Amphipoda (2)	Ephemeroptera (3)
Diptera (2)	Amphipoda (2)
Trichoptera (2)	Diptera (2)
Ephemeroptera (1)	Trichoptera (2)
Stream Sites	
Diptera (2)	Odonata (3)
Odonata (2)	Diptera (2)

Comparison Between Kunlin & Donner Lakes and Twaddle Lake

We compared the mean lengths and condition factors (K) of age-1+, age-2+ and age-3+ Cutthroat Trout captured in Donner versus Kunlin Lakes and found no significant difference between these populations by age class. We then grouped the data for Donner and Kunlin Lakes and compared the grouped data for length and condition for each age class to Cutthroat captured in Twaddle Lake.

We found no difference in the mean length of age-1+ fish between Donner/Kunlin and Twaddle Lakes, but significant differences in the condition of these fish (t (53) = -3.48, P=0.0010) with the Twaddle Lake fish having a higher average condition than the Donner/Kunlin fish (Appendix 4).

We found a significant difference in the average length of age-2+ Cutthroat (t(63) = 2.72, P=0.008) between the two systems with the mean length of Donner/Kunlin Cutthroat ~20 cm larger than Twaddle lake fish (Appendix 4). Although the Donner/Kunlin Cutthroat were on average larger than the Twaddle Lake Cutthroat, the Twaddle Lake fish were in significantly better condition (t(63) = -2.30, P=0.025) (Appendix 4).

Age-3+ Cutthroat (Appendix 4) in Donner/Kunlin were significantly larger than Twaddle fish (t(24) = 4.57, P=0.00013); however, age-3+ year old Cutthroat in Twaddle Lake had (nonsignificantly) higher condition factors vs. those sampled in Donner/Kunlin Lakes.

Discussion

Donner and Kunlin Lakes are very different biophysically, however, the habitat constraints limiting fish production in these lakes are similar. For example, at Donner Lake the majority of the spawning and rearing habitat for the resident fish population is provided by the Ucona River inlet and outlet and a small number of streams at the North end of the lake. While other small inlet streams exist in the basin, many of these are steep and likely inaccessible in the upper reaches, and/or dry at the mouth with limited lake delta habitat to provide critical nutrients and resource subsidies to the resident Cutthroat population.

Similarly, the majority of stream habitat at Kunlin Lake is provided by the Ucona River on the Northeast shore of the lake. Although as Coombs (1988b) concluded, neither the Ucona inlet nor outlet offer much potential spawning or rearing habitat for salmonids at this lake. Additionally, we documented large depositions of cobble, gravel and fines in the lower reach of the Ucona River inlet suggesting this reach is an active channel under high flows thus limiting its suitability for spawning and early rearing, while further upstream limited pool habitat adds an additional constraint for rearing fish.

Coombs (1988b) noted that both Donner and Kunlin Lakes have been impacted by natural events such as avalanches and rockfall and anthropogenic impacts including forest harvest. Avalanches, landslides, and debris flows can all result in materials such as rocks, wood and silt moving into lakes while forest harvesting might contribute to materials entering the lake both directly, or by increasing the rates or severity of the other, natural processes. We documented large depositions of sediment at one small inlet stream, and a now heavily vegetated lake delta at a one-time Ucona River inlet resulting in diminished lake delta habitat at Kunlin Lake.

In addition to physical limits to fish habitat, Donner and Kunlin Lakes are, like many lakes on Vancouver Island, oligotrophic with low nutrients and, therefore, low primary productivity. Island lakes generally have low nutrients because of rapid flushing rates and lake basins may completely renew their water supply within a few days. Thus, plankton crops are carried out of the lakes and the incoming water is nutrient poor. Total Dissolved Solids (TDS), which comprise inorganic salts and small amounts of organic matter dissolved in water is an important predictor of the general level of lake productivity and lakes with TDS<50 ppm are particularly unproductive with respect to fish size (Northcote and Larkin 1956). The TDS in Donner and Kunlin Lakes is <10 ppm which is symptomatic of the hyper-oligotrophic nature of these lakes (Coombs 1988a).

It is possible that the nutrient-poor water of Donner and Kunlin Lakes, combined with the limited physical habitat explains why we found a lower condition factors for age-1+ and age-2+ Cutthroat at Donner and Kunlin Lakes compared to the same aged Cutthroat from nearby Twaddle Lake. Condition factor of a fish reflects physical and biological circumstances and, through interactions with other factors, feeding conditions (Le Cren 1951, Surjya et al 2013). While our fish survey was not comprehensive it suggests that although fish in some age categories at Donner/Kunlin Lakes were, on average, larger, their condition was not as high as fish from Twaddle Lake. Given Twaddle Lake also has low nutrients (TDS~6 ppm) (Becu, 2020 unpublished data) other factors including the minimal amount of critical stream and lake delta habitat we observed could be limiting fish condition at Donner and Kunlin Lakes.

The *Strathcona Master Plan* recognizes a stated public need for improved access to Strathcona Park. and proposes that roads to Donner and Kunlin Lakes be improved. The effects of roads on freshwater fish habitat have been well documented and include morphological alterations of stream channels, bank and channel erosion, bedload movement, infilling of critical pool habitat, removal of large wood, and depositions of high levels of sediment including sedimentation of spawning and rearing habitats (Gibbons and Salo 1973, Iwamoto et al. 1978, Cederholm and Reid 1987, Everest et al. 1987, Megahan 1987, Bilby et al 1989, Tschaplinski 1992, Forman and Alexander 1998, Jones et al., 2000). Inputs of sediment in particular have been shown to result in significant decreases in salmonid egg and alevin survival, physiological stress of fry, smolts and adults, reduction in macroinvertebrate prey resources, and direct mortality of fish (Campbell 1954, Ziebell 1960, Beschta 1978, Cederholm et al 1978, Culp and Davies 1983, Reid and Dunne 1984, Culp et al 1986, Tschaplinski, 1992). Increased and improved access to Donner and Kunlin Lakes (e.g. road improvements, additional campsites and day use areas) could increase sediment inputs to sensitive lakes shore habitat and impact the limited amount of stream and lake delta habitat available to Cutthroat at both lakes (Figure 31) (Figure 32).

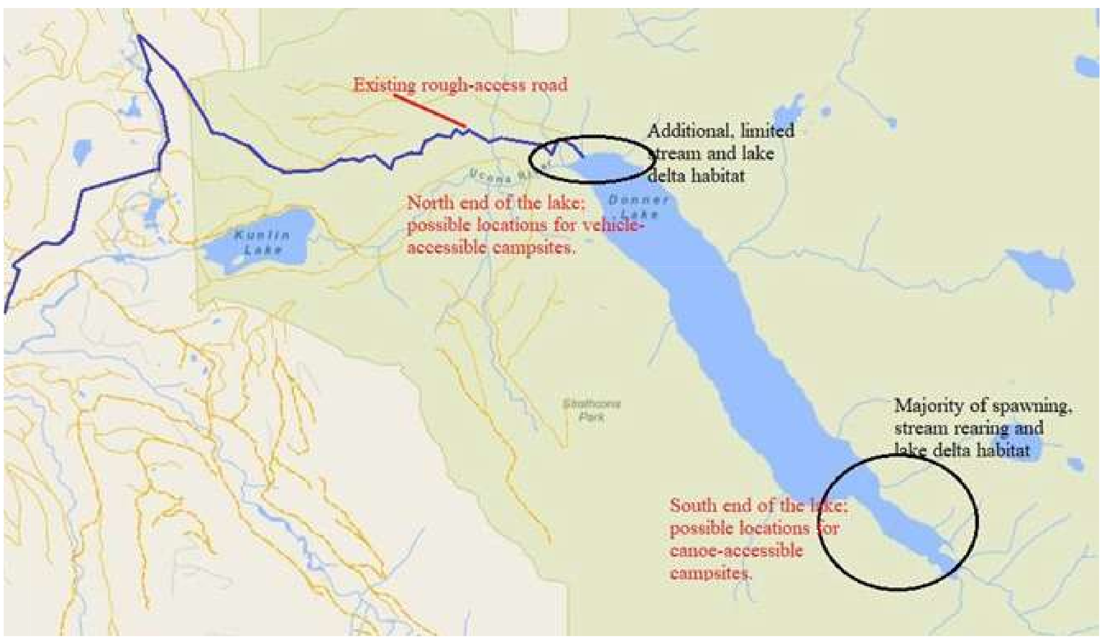


Figure 31. Sketch of road accessible areas, location of stream spawning, rearing and lake delta fish habitat at the North and South end of Donner Lake. No specific locations for improved road access and canoe-accessible campgrounds are provided in the *Plan*; however, the Plan does note the road improvements will be at the North end, and the campgrounds at the South end of the lake.

Figure 32. Sketch of location of stream spawning, rearing and lake delta fish habitat and of existing rough boat launch and roads at Kunlin Lake that could provide access to a variety of readily accessible, facility-oriented outdoor recreation opportunities as noted in the *Strathcona Master Plan*. Note, no specific locations for these facilities are *Plan*; the areas shown in this figure are provided only to give an idea of the relationship between locations of major fish habitat and general locations of existing road networks.

In addition to impacts due to road construction, the effects of additional angler effort resulting from improved access should also be considered when contemplating recommendations in the *Master Plan*. Angler effort is still relatively low compared to effort at other nearby West Coast lakes. For example, the last time the Vancouver Island Angler Questionnaire was completed there were ~40 angler days per year estimated at Donner and Kunlin Lakes together[4] compared to roughly double the effort estimated for nearby Star and Antler Lakes (Kehler 2013). Improved road access may increase angler effort at Donner and Kunlin Lakes, particularly if that access is accompanied by the opportunity to camp.

As angler effort increases and a fishery builds changes to fish stocks occur. In the early phases of a fishery, total yield is low, and angler success is high as larger, older individuals are harvested with a modest amount of fishing effort. As angler effort builds, the yield rises but success drops due to declining standing crops and a population of fish becomes significantly reduced and harder to catch (Schlesinger and McCombie, 1983). Fisheries affect not only a change in stock levels, but also stock composition. Ricker's (1946) work demonstrated that a fishery will substantially increase the mortality of fish for many years and when enough years have elapsed to spread those effects through the stock there is a marked decrease in the relative number of the oldest and largest fish.

Despite the foregoing, an increase in angler effort can be beneficial as there is evidence of a positive association between outdoor recreational participation and pro-environmental behavior (Theodori et al 1998). However, fisheries must be monitored to ensure stocks are stable and regulations keep pace with angler effort. In addition to considering the potential effects of increased angler effort it is important to note that unlike many fishing lakes on Vancouver Island, Donner and Kunlin Lakes are not stocked; the Cutthroat populations in these lakes are wild. Currently the fisheries at Donner and Kunlin are managed with only general regional fishing quotas so anglers may harvest 4 trout/day[5]

[4] Angler effort was estimated in 2011 at 28 angler days/year at Kunlin Lake, and 14 angler days/year at Donner Lake. Angler effort was estimated at 42 angler days/year at Star Lake and 42 angler days/year at Antler Lake (Kehler 2013).

[5] Region 1 Daily Quotas (excluding Haida Gwaii): Trout: 4, but not more than 1 over 50 cm (2 hatchery steelhead over 50 cm allowed), 2 from streams (must be hatchery). Anglers must release: all wild steelhead, all wild trout from streams and all char

(Ministry Forests, Lands, Natural Resource Operations and Rural Development 2021). It is possible these general regulations will not protect wild stocks if improved access and camping bring more angling pressure to these nutrient-poor and habitat limited lakes.

Our overview assessments suggest that the Cutthroat at Donner and Kunlin Lakes are limited by nutrient-poor water and limited stream and lake delta habitat. The majority of available habitat is in the vicinity of existing road and access points which may be the most logical areas to improve and expand. Fisheries at both lakes are regulated with only general regulations and, to our knowledge, fisheries management and monitoring plans suggested by Paish and Associates (1989) have not been completed. We suggest the following be considered during decision-making regarding recommendations for Donner and Kunlin Lakes as outlined in the *Strathcona Master Plan*:

- Protect the limited fish habitat in the watershed. Our survey corroborated the findings of Coombs (1988a and 1988b) and documented the effects of both natural events and historic land use to Donner and Kunlin Lakes including sediment depositions and infilling of important and limited lake delta habitat. Moreover, our fish assessment, albeit cursory, suggests Donner and Kunlin Lake Cutthroat stocks may be limited by naturally low productivity and limited stream and lake delta habitat. We suggest BC Parks consider that improvements to existing roads, which are located at or in the vicinity of limited critical stream and lake delta habitat, could result in impacts to fish habitat and further limit the wild Cutthroat stocks at these lakes.

- Conduct a comprehensive fish population assessment and angler creel survey to determine fish abundance and current angler effort. Knowledge of the abundance of fish in a stock is a component of the information used in management of fisheries (Ney 1999) and fish abundance estimates, along with angler creel surveys can be used first to determine, then monitor the status of fish stocks and the fishery. There are numerous methods to estimate fish abundance, however, many of these are expensive. Index of abundance assessments using catch per unit effort (C/*f*) can be relatively inexpensive and are acceptable methods for monitoring the stock and fisheries, and identifying population levels and/or angler catch rates below which protective measures such as limiting access and/or introducing restrictive regulations are implemented.

- Evaluate current angling regulations. Anglers at Donner and Kunlin Lakes can currently harvest 4 trout/day, however, more restrictive regulations such as catch-and-release may be warranted to protect the wild stocks at these lakes. Surveys to determine if more restrictive regulations are required should include determining fish population age structure, size classes in the angler catch, catch rates, and angler fishing habits, preferences and opinions. Results of these surveys can be used to design regulations and provide baseline data against which to compare the results of future surveys.

- Integrate ecological objectives into long-term management plans. Ecological objectives aimed at preserving ecological values can be part of an effective framework for long term management of lakes, fish stocks and fisheries within protected areas (Gaston 2008, Watson et al. 2021). In the case of Donner and Kunlin Lakes, these objectives might include establishing no-access riparian buffers to protect stream, streamside and lake delta habitat,

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(includes Dolly Varden). There is no general minimum size limit for trout in lakes or hatchery origin trout in streams. Possession Quotas (i.e. the number of fish allowed to possess when staying away from a permanent residence = 2 daily quotas.

and maintaining fish populations within a range of natural variation identified through comprehensive fish assessments. Objectives should also recognize the connection of Donner and Kunlin Lakes to the larger Gold River watershed as landscape-level pressures, for example land use and development and expansion of road networks within the basin, can have far-reaching, trans-boundary impacts on ecological processes and can threaten biodiversity within the protected area boundaries (Hansen and DeFries 2007, Wilson et al 2014).

Literature Cited

BC Parks. 2001. Master Plan Amendment for Strathcona Park. BC Parks Strathcona District. June 2001.

Beschta, R. L. 1978. Long-term pattern of sediment production following road construction and logging in the Oregon coast range. Water Resource. Res. 14: 1011 – 1016.

Bilby, R.E., Sullivan, K. and S.H. Duncan. 1989. The generation and fate of road-surface sediment in forested watersheds in Southwestern Washington. Forest Science 35(2):453-468.Cederholm, C.J., Lestelle, L.C., Edie, B.G., Martin, D.J., Taggart, T.V., and E.O. Salo. 1978. Observations on the effects of landslide siltation on salmon and trout resources of Stequaleho Creek and the main Clearwater River, Jefferson County, Washington, 1972 - 1975. Final Report: Part 2. FRI-UW-7804. Fisheries Research Institute, University of Washington, Seattle. 53 p.

Campbell, H. J. 1954. The effect of siltation from gold dredging on survival of rainbow trout and eyed eggs in Powder River, Oregon. Oregon State Game Commission Report. 3p.

Cederholm, C. J. and L. M. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations in the Clearwater River, Washington. In Streamside management: Forestry and fishery interactions. Edited by E. O. Salo and T. W. Cundy. University of Washington, Institute of Forest Resources Contribution No. 57. pp. 373 – 398.

Cederholm, C. J., Lestelle, L.C., Edie, B.G. Martin, D.J., Taggart, J.V., and E.O Salo. 1978. Observations on the effects of landslide siltation on salmon and trout resources of Stequaleho Creek and the main Clearwater River, Jefferson County, Washington, 1972 - 1975. Final Report: Part 2. FRI-UW-7804. Fisheries Research Institute, University of Washington, Seattle. 53 p.et al., 1978

Coombs, D.M.V. 1988a. A Reconnaissance Survey of Donner Lake. Recreational Fisheries Branch Ministry of Environment. Aquatic Report Catalogue (gov.bc.ca).

Coombs, D.M.V. 1988b. A Reconnaissance Survey of Kunlin Lake. Recreational Fisheries Branch Ministry of Environment. Aquatic Report Catalogue (gov.bc.ca).

Culp, J.M., Boyd, I., and N.E. Glozier. 1988. An improved method for obtaining gut contents from small, live fishes by anal and stomach flushing. Copeia Vol. 1988, No. 4 (Dec 28 1988) pp 1079 – 1082.

Culp, J.M., Wrona, F.J. and R.W. Davies. 1986. Responses of stream benthos and drift to fine sediment deposition versus transport. Can. J. Zool. 64: 1345 – 1351.

Culp, J. M. and R. W. Davies. 1983. An assessment of the effects of streambank clear-cutting on macroinvertebrate communities in a managed watershed. Canadian Technical Report of Fisheries and Aquatic Sciences 1208: 116 p.

Cordillera Consulting Inc. 2017. Methods and QC Report 2017. Project ID: Cutthroat Ecology 2017 March/April Fish Stomach. Cordillera Consulting Inc., Summerland, BC..

Everest, F. H., Beschta, R.L., Scrivener, J.C., Koski, K.V., Sedell, J.R., and C.J. Cederholm. 1987. Fine sediments and salmonid production: A paradox. In Streamside management: Forestry and fishery interactions. Edited by E. O. Salo and T. W. Cundy. University of Washington, Institute of Forest Resources Contribution No. 57. pp. 98 – 142.

Forman RTT, Alexander LE (1998) Roads and their major ecological effects. Annual Review of Ecological Systems 29:207–231.

Gaston, K. J., Jackson, S. F., Cantú-Salazar, L., & Cruz-Piñón, G. (2008). The ecological performance of protected areas. Annual Review of Ecology, Evolution, and Systematics, 39(1), 93–113. https://doi. org/10.1146/annur ev.ecols ys.39.110707.173529

Gibbons, D. R. and E. O. Salo. 1973. An annotated bibliography of the effects of logging on fish of the western United States and Canada. USDA For. Serv. Gen. Tech. Rep. PNW-10. Pac. Northwest For. and Range Exp. Stn., Portland Oregon. 145 p.

Green, R.N. and K. Klinka. 1994. A field guide for site identification and interpretation for the Vancouver Forest Region. Land Management Handbook 28. Ministry of Forests Research Program 1994.

Haley, N. 1998. A gastric lavage technique for characterizing diets of sturgeons. North American Journal of Fisheries Management 18:978 – 981.

Hansen, A.J.; and R. DeFries. 2007. Ecological mechanisms linking protected areas to surrounding lands. Ecological Applications 17: 974–988.

Iwamoto, R. N., Salo, E.O., Madej, M.A.,, and R. L. McComas. 1978. Sediment and water quality: A review of the literature including a suggested approach for water quality criteria. U.S. Environmental Protection Agency, Region 10, Seattle. 151 p.

Jones, J. A., Swanson, F.J., Wemple, B.C., and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology 14(1): 76 – 85.

Kehler, M.L. 2013. Results of the 2011 Vancouver Island Lakes Angler Questions Survey. BC Ministry of Forests, Lands and Natural Resource Operations Fish and Wildlife Branch 2080 A Labieux Road Nanaimo, BC. April 2013.

Le Cren ED (1951) The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 20:201–219.

Meehan, W.R. and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. Journal of the Fisheries Research Board of Canada 35: 1359 – 1363.

Megahan, W.F. 1987. Effects of forest roads on watershed function in mountainous areas. *In*: Jones, J. A., Swanson, F.J., Wemple, B.C., and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology 14(1): 76 – 85.Ministry of Environment and Climate Change Strategy. 2022. Ecocat Ecological Catalogue:https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/libraries-publication-catalogues/ecocat Fish Inventory Data Queries Website: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/search-fish-fish-habitat-data-information/fisheries-inventory-data-queries

Ministry of Environment Lands and Parks. 1993. Master Plan for Strathcona Provincial Park. April 1993. Prepared by Strathcona District South Coast Region North Vancouver, BC.

Ministry of Forests Lands, Natural Resource Operations and Rural Development. 2021. BC Fishing Regulations Synopsis Region 1 Vancouver Island. https://www2.gov.bc.ca/assets/gov/sports-recreation-arts-and-culture/outdoor-recreation/fishing-and-hunting/freshwater-fishing/region_1_vancouver_island.pdf

Ney, J.J. 1999. Practical use of biological statistics. *In*: Inland Fisheries Management in North America Second Edition. C.C. Kohler and W.A. Hubert editors American Fisheries Society, Bethesda Maryland.

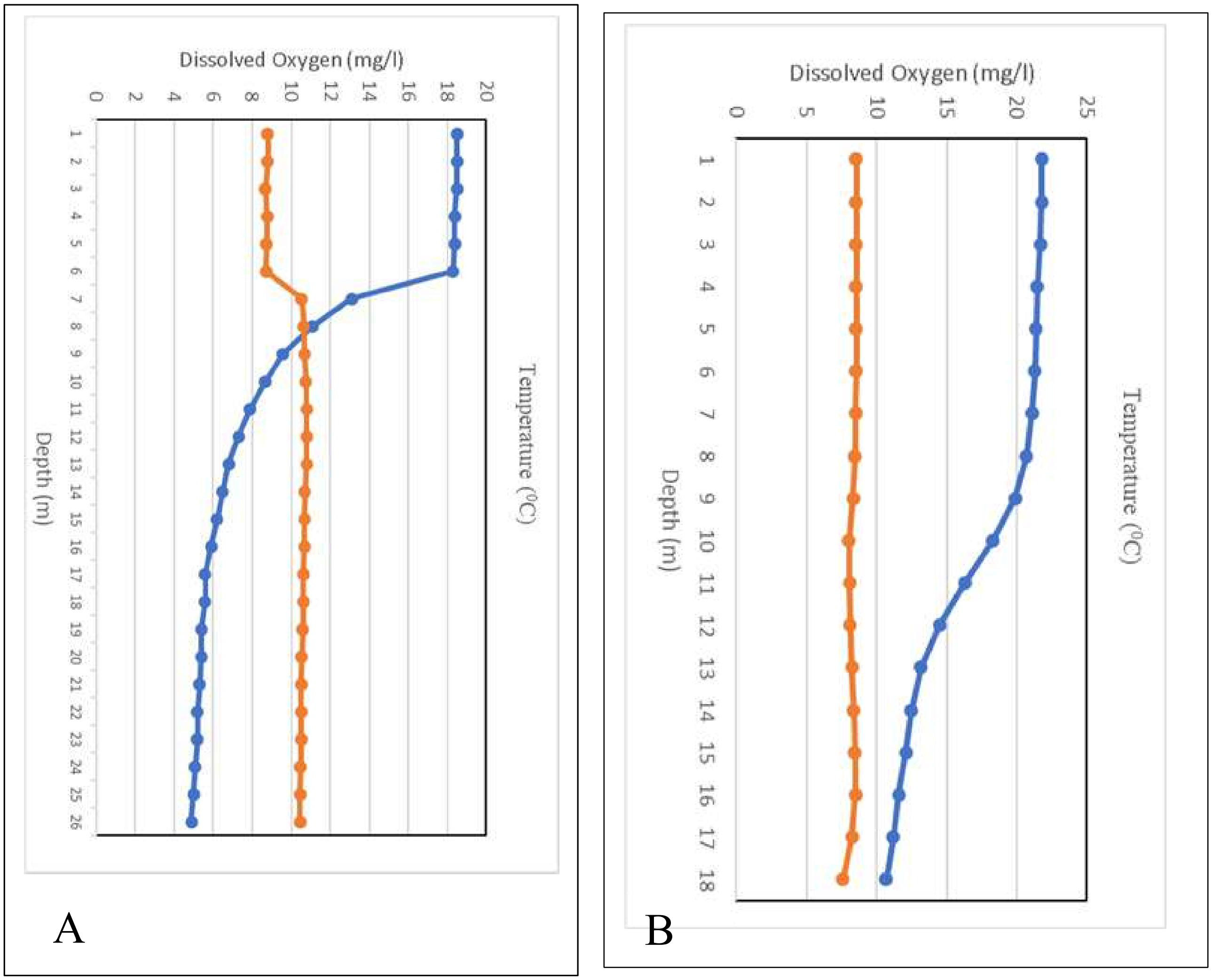
Northcote, T.G., and Larkin, P.A. 1956. Indices of Productivity in British Columbia Lakes. Journal of the Fisheries Research Board of Canada: 13(4) 515-540.

Paish and Associates. 1989. Sport Fishery Management Plan for Strathcona Park and Recreation Area. Prepared for BC Ministry of Parks. Parks Library Government of British Columbia Victoria, BC.

Reid, L.M. and T. Dunne. 1984. Sediment production from forest road surfaces. Water Resources 20(11): 1753 – 1761.

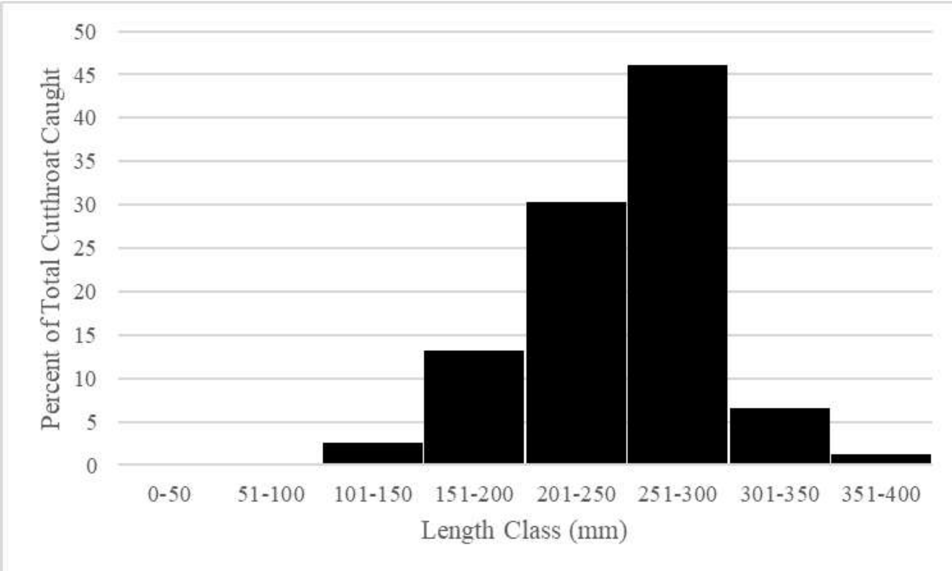
Ricker, W.E. 1946. Production and utilization of fish populations. Ecological Monographs 16(4): 373-391.
RStudio Team (2022). RStudio: Integrated Development Environment for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/
Schlesinger, D.A. and A.M McCombie. 1983. An evaluation of climatic, morphoedaphic and effort data as predictors of yields from Ontario sport fisheries. 1983 Ontario Fisheries Technical Report Series No. 10. Ministry of Natural Resources, Ontario.
Surjya Narayan Datta, S.N., Kaur, V.I., Dhawan, A., and G. Jassa. 2013. Estimation of length-weight relationship and condition factor of spotted snakehead Channa punctata (Bloch) under different feeding regimes Springer Plus 2013. http://www.springerplus.com/content/2/1/
Theodori, G.L., Luloff, A.E. and F.K. Willits. 1998. The association of outdoor recreation and environmental concern: re-examining the Dunlap-Heffernan these. Rural Sociology 63(1): 9 - 108.
Tschaplinski, P.J. 1992. Effects of roads on freshwater fish habitats and fish production. BC Ministry of Forests, Victoria, BC.
Tripp Biological Consultants Ltd. 1997. Project ID/Name: 294/Gold River Fish Inventory (VI) – 1997. Habitat Wizard (gov.bc.ca)
Watson, A.S., Hickford, M.J., and D.R. Schiel 2021. Freshwater reserves for fisheries conservation and enhancement of a widespread migratory fish. Journal of Applied Ecology 58.10 2135-2145.
Williams, J.E. 2000. Manual of Fisheries Survey Methods II January 2000. Michigan Department of Natural Resources. James C. Schneider, Editor.
Wilson, T.S. , Sleeter, B.,M., Sleeter, R.R. and C.E. Soulard. 2014. Land-use threats and protected areas: a scenario-based, landscape level approach. Land 3: 362-389 doi:10.3390/land3020362.
Ziebell, C.D. 1960. Problems associated with spawning and growth of salmonids in Northwest watersheds. Proceedings, seventh symposium on water pollution research. United States Department of Health, Education, and Welfare,

Appendix 1 Dissolved Oxygen/Temperature at Donner and Kunlin Lakes August, 2021



Dissolved Oxygen/Temperature at (A) Donner Lake and (B) Kunlin Lake, August 2021

Appendix 2 Coombs 1988 Fish Sampling Data

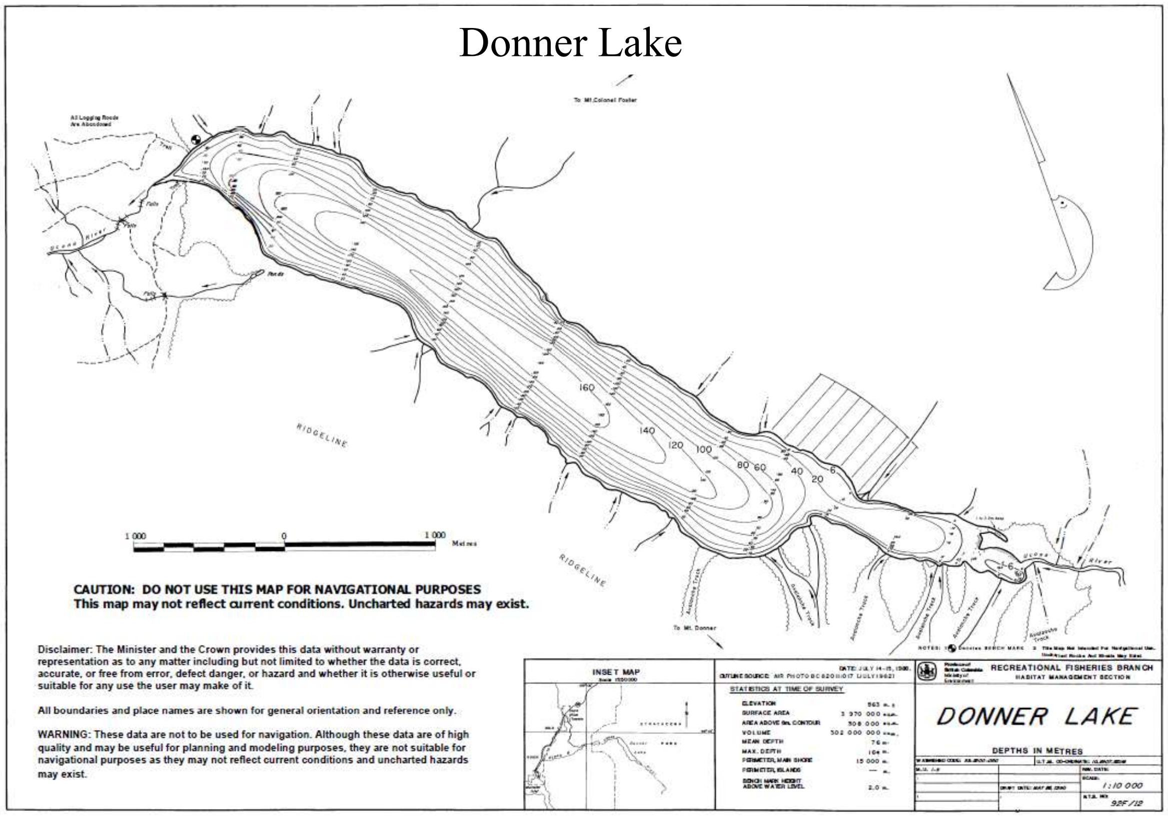


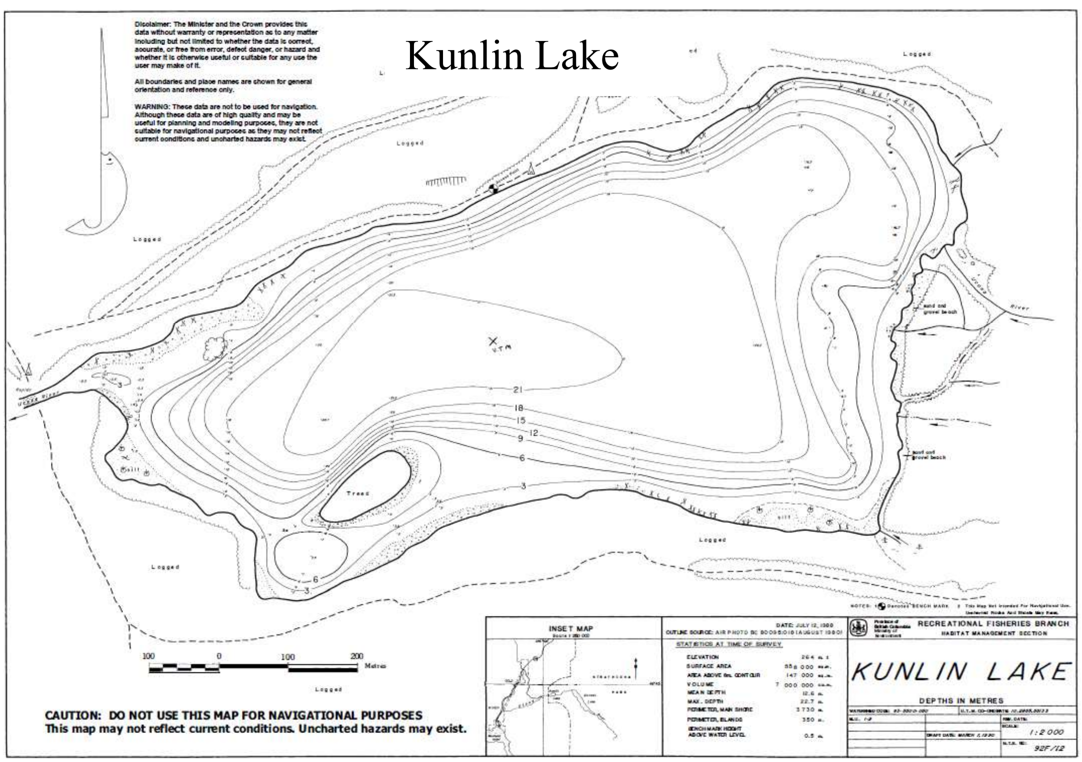
Donner Lake Cutthroat Trout Sampling (Coombs 1988) N=76

Kunlin Lake Cutthroat Trout Sampling (Coombs 1988) N=30

Length Class (mm)	Number (n)	Percent
0-50	0.0	0.0
51-100	0.0	0.0
101-150	10.0	33.3
151-200	10.0	33.3
201-250	10.0	33.3

Appendix 3 Bathymetric Maps of Donner and Kunlin Lakes





Appendix 4 Results of Students t test Comparing 1+, 2+ and 3+ Year Old Cutthroat Trout Sampled in Kunlin/Donner Lakes to Cutthroat Trout Sampled in Twaddle Lake.

One Year Old Cutthroat Trout

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Fish Length.
t = -0.27343, df = 53, p-value = 0.7856
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval: -10.920211 8.300002
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
135.7143	137.0244

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Condition factor
t = -3.4832, df = 53, p-value = 0.001002
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval:
-0.0006873712 -0.0001850172
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
0.0009544356	0.0013906299

Two-Year-Old Cutthroat Trout

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Fish Length.
t = 2.7182, df = 63, p-value = 0.008468
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval: 4.604596 30.169284
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
186.5185	169.1316

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Condition factor
t = -2.3006, df = 63, p-value = 0.02473
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval: -9.757168e-05 -6.861039e-06
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
0.0009687215	0.0010209378

Two-Year-Old Cutthroat Trout

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Fish Length.
t = 4.5663, df = 24, p-value = 0.0001251
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval: 24.44821 64.77603
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
242.0667	197.4545

Two Sample t-test – Lake (Donner/Kunlin, Twaddle) vs. Individual Condition factor
t = -1.9764, df = 24, p-value = 0.05971
alternative hypothesis: true difference in means between group Kunlin_Donner and group Twaddle is not equal to 0 95 percent confidence interval: -8.664596e-05 1.876654e-06
sample estimates:

mean in group Kunlin_Donner	mean in group Twaddle
0.0009628248	0.0010052095