

Bella Coola Eulachon Study 2001

Final Report

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EXECUTIVE SUMMARY

Eulachon have high cultural and economic value, particularly to the First Nations that harvest them. The Bella Coola River supports a spawning population that has sustained a fishery by the Nuxalk Nation, however this run has been little studied. The objective of this study was to collect basic but specific information on life history and habitat use by eulachon in the Bella Coola River. This included describing the run timing, incubation period, distribution of spawning, body size, fecundity, and age structure, and to estimate spawning escapement based on larval and egg abundance.

Daily flow data were obtained electronically from the Water Survey of Canada and compiled to estimate the flow through the study area. Spot temperatures were taken daily with a hand-held thermometer. Continuous recording thermographs were anchored in the river near a staff gauge placed in early March, however, the site was vandalized and both the temperature and water level gauges were lost.

Adult eulachon distribution and abundance was assessed by gill net sampling. Adult field sampling began on 25 March, 2001 and continued until 18 April, 2001. In total 43 adult eulachon were captured during the 52 gillnet sets in the Bella Coola and Paisla Creek. Samples of adult eulachon collected were lost when the storage freezer in Bella Coola failed.

Eulachon egg and larval sampling generally followed the methodology typically used for eulachon larvae studies: sampling of eggs and larvae using a plankton net suspended from a boat, with a current meter set at the net entrance to measure the volume of water sampled. Plankton net tows were made in the Bella Coola River near the boat launch on N. Grant Road. A total of 476 samples were collected; 144 in March, 258 in April, and 74 in May. Quality assurance of the data identified significant recording or transcription errors in 82 (17%) samples.

A total of 1570 eulachon eggs were collected during plankton net tows. From these 676 eggs were identified as dead; 894 were identified as live. Additionally, 81 sculpin eggs were identified from the samples. In total, only 18 larval eulachon were captured in 2001. Over 99% (34,406) of the larval fish captured were prickly sculpin. In addition 954 pink salmon fry and 237 chum salmon fry were captured and identified. Eulachon larvae density averaged 0.0019 m^{-3} , was highest on 16 April (0.034 m^{-3}), but most commonly was zero. Sculpin larvae density averaged 3.14 m^{-3} .

Eulachon larvae were captured in March, April and May. The capture of larvae during March was earlier than reported in the literature for any other river. This finding may be an error, but regardless, is not significant as only nine larvae were captured, less than 1/1000th of the fecundity of a single eulachon. The bulk of the larvae migrated during the second half of April, four weeks after adults were captured and presumably spawned in late March. The duration of incubation is consistent with that predicted from the accumulated thermal units required to hatch eulachon in laboratory studies.

To calculate eulachon larvae and egg densities, individual catches were divided by the volume of water fished. The total number of eggs and larvae transported downstream was calculated by multiplying average weekly density by average weekly river flow, and summing the weekly estimates. Approximately 311,000 larvae and 10,283,000 eggs were produced. The total adult population was back calculated from eulachon egg and larval abundance, assuming standard fecundity and sex ratio, as 0.030 tonnes of eulachon.

The Bella Coola River in 2001 had the lowest productivity reported among several similar studies made on other rivers in other years. Larval and adult catch, larval density, estimated run size, and fishery activity all support a conclusion of a small run in the Bella Coola River in 2001. Considering the trend of declining catches, concurrent with low returns throughout Nuxalk territory, the run should be classified as Code 2, intense protective action of uncertain duration, consistent with the status assessed by Hay and McCarter (2000).

1. INTRODUCTION

The eulachon, *Thaleichthys pacificus*, belongs to the smelt family Osmeridae, a group of fishes restricted in distribution to the northern hemisphere. Their scientific name derives meaning from *Thaleichthys*-oily fish, and *pacificus*-of the Pacific. Eulachon are anadromous, spawning in freshwater and living as adults in the sea. Eulachon spawn in the spring, generally between February and April. Although many die after spawning (Hart and McHugh 1944) some adults have been found to survive (Barraclough 1964), suggesting that eulachon are iteroparous. They spawn at night in riffles with gravel substrate, where they broadcast their eggs and milt. The eggs adhere to the substrate and lie in interstitial spaces for six weeks, before hatching in May and June. The larvae average 4 mm in length and are passively transported to sea by river flow upon hatching.

Eulachon have high cultural and economic value, particularly to the First Nations that harvest them. In British Columbia the Fraser River supports a commercial and food fishery, and the Klinnaklini, Nass, Stikine Kitimat, Kemano, and Kitlope Rivers have substantial spawning populations of eulachon. All of these populations have been studied to varying extents. The Bella Coola River supports a spawning population that has sustained a fishery by the Nuxalk Nation, however this run has been little studied. Data on annual catch and run timing have been collected by Fisheries and Oceans Canada (pers. comm., Russ Hilland, Hatchery Manager, Fisheries and Oceans Canada, Bella Coola), however, there has been no study of eulachon eggs or larvae.

1.1. Objectives

The objective of this study was to collect basic but specific information on the life history and habitat use by eulachon in the Bella Coola River. The specific objectives of this year's study were to:

1. Describe the run timing, the incubation period, and the distribution of spawning eulachon for the lower Bella

Coola River and the variability in these parameters over the life of the project;

2. Describe the size, fecundity, and age structure of the spawning population of Bella Coola eulachon and the variability in these parameters over the life of the project; and
3. Estimate the annual adult eulachon spawning escapement based on larval abundance and the other biological parameters described above.

1.2. Study Area and Dates

The Bella Coola River drains 5,130 square kilometres. Lying just north of 52 degrees N latitude between 127 and 126 degrees W longitude, the river begins where the Talchako and Atnarko rivers converge and drains much of the western edge of Tweedsmuir Park South. The Bella Coola system is dominated by a coastal climate, although also influence by interior hydrological patterns.

In general eulachon spawn near or at the upstream extent of tidal influence, particularly in steep rivers with high water velocities (Lewis *et al.* 2002). Accordingly, study effort was concentrated in the lower river within the zone of tidal influence. The study began on 21 March, 2001 and continued through to 27 May, 2001. Two methods of sampling were used: gill netting for sampling of adults from 25 March to 18 April, and plankton net tows for sampling of eggs and larvae from 21 March through 27 May.

2. METHODS

2.1. River Flow and Temperature

The Water Survey of Canada has gauged the Bella Coola River just upstream of Burnt Bridge Creek since 1965. Their archived records are available to the public on CD-ROM (Environment Canada 1992). Daily flow data were obtained electronically and compiled to estimate the flow in the study area.

The Bella Coola basin at Above Burnt Bridge creek drains an area of 3,730 km². At its mouth the estimated drainage area is 5,130 km². Flow in the upper Bella Coola River was described by station 08FB007 (Bella Coola River Above Burnt Bridge Creek). There is no gauge at the mouth, or anywhere on the Bella Coola River downstream of Burnt Bridge Creek. To estimate the flow in the study area, we multiplied the daily run-off coefficient obtained from the flow measured at Above Burnt Bridge Creek by the drainage area estimated for a former gauging station at the mouth (5130 km²). The estimated flow at the mouth was 37.5% higher than the flow measured at 08FB007. We originally intended to sum the flows from sub-basins within the drainage, however, flow data for these tributaries streams are unavailable.

Spot temperatures were taken daily with a hand-held thermometer. Continuous recording thermographs were anchored in the river near a staff gauge placed in early March, however, the site was vandalized and both the temperature and water level gauges were lost.

2.2. Distribution and Abundance

2.2.1. Adult

Adult eulachon distribution and abundance was assessed by gill net sampling. Adult eulachon were captured with monofilament mesh gillnets deployed from shore and suspended mid-river at two sites (Figure 1). A 'smelt gill net' was used; a 4 m long by 2 m deep net panel with 3.5 cm mesh. Smelt gill nets were ganged in three to create a net length of 12 m. The net was anchored by two lead weights to the substrate and marked by a single scotchman to allow retrieval.

All adult eulachon captured were sacrificed and frozen for examination in the laboratory. In the laboratory adult eulachon were to be thawed, sex was to be identified, and eulachon were to be weighed to the nearest gram and measured for fork length (mm). The otoliths were to be extracted and placed in 50 ml vials with glycerine and stored for aging as required. Unfortunately samples were lost due to breakdown of the freezing unit at the storage facility. The samples were unusable.

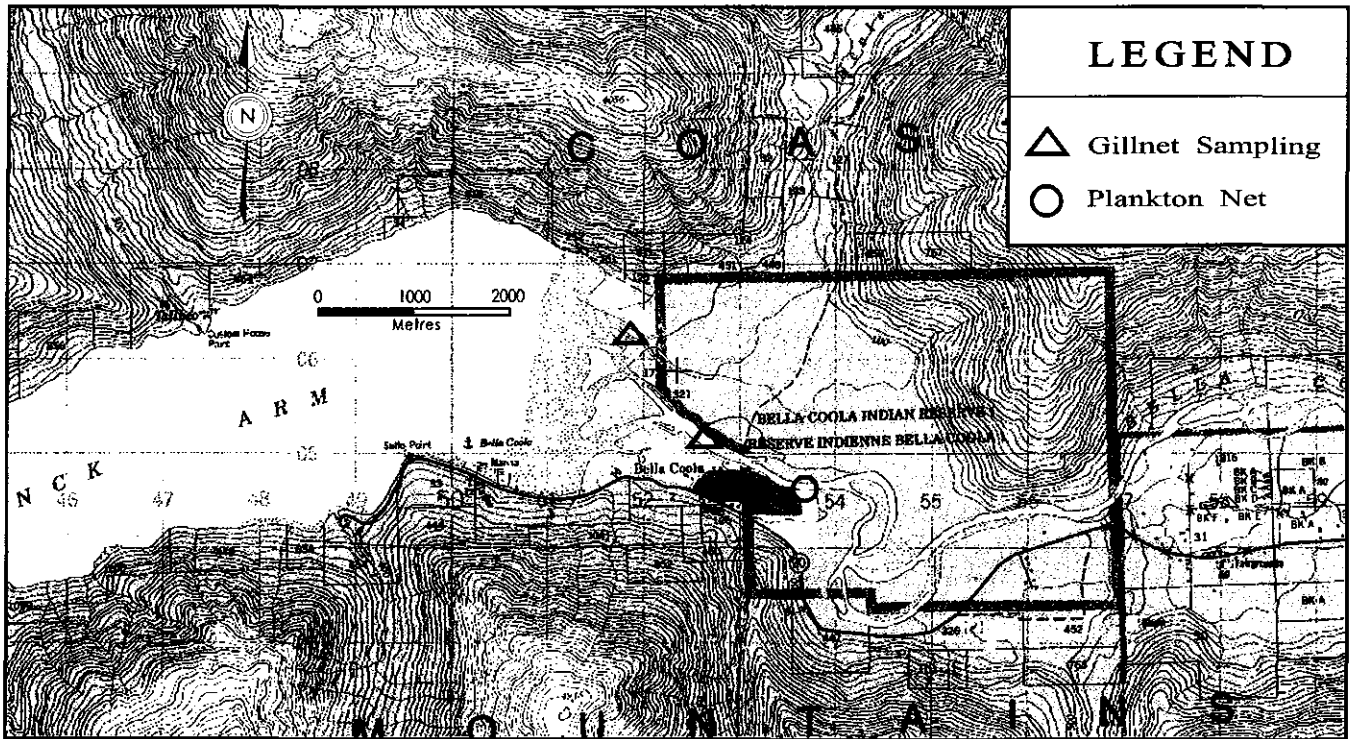
2.2.2. Eggs and Larvae

Eulachon egg and larval sampling generally followed the methodology of Pedersen et al. (1995). Eulachon egg and larval sampling was done with a plankton net suspended from the stern of a 7 m boat. The net was 4 m long with a 0.5 m diameter hoop mouth with an area of 0.196 m², and was panelled with 320 µm mesh. A mechanical flow meter (General Oceanics Ltd.) was attached at the centre of the net mouth. The meter value was recorded when the net was deployed and retrieved. The net was attached to the boat with 6 mm steel cable and the bottom of the hoop was weighted with a 5 kg lead weight. Towing time depended on current velocity and debris loading; increases in either necessitated a reduction in sampling time.

In the laboratory each sample was examined thoroughly by parts. A portion of the sample was placed in a ~2 L rectangular glass dish and picked with forceps and tweezers over a light table. All eggs and larval fish were removed from the sample and stored in a 10 mL glass vial in isopropyl alcohol. The sample vial was labelled with the site name, date and time of sample collection. After all samples had been picked they were examined under a dissecting scope to identify and enumerate by species (larvae). Larval fish keys from the literature were used to assist in larval identification (Matarese *et al.* 1989). Once examined, sample contents were returned to the sample jar for storage.

Eggs of sculpin and eulachon were differentiated by size (sculpin eggs have twice the diameter) and color (sculpin eggs are orange-hued).

Figure 1. Location map showing gill net and plankton sampling sites.



Egg and larval densities were estimated for each sample by dividing the number of larvae in a sample by the volume of water fished by the plankton net.

The water volume sampled was estimated by multiplying the distance recorded on the digital flow meter by the area of the net mouth.

2.2.3. Fishery

The lower Bella Coola River is traditionally fished by members of the Nuxalk Nation. The study sampling sites were located adjacent to areas preferred for eulachon harvesting. Given this, we are confident that no eulachon harvesting occurred in 2001. During each field trip, historic fishing sites were visited and any fishing activity was documented, and a data form was provided to record catches. In addition, an informal survey of Nuxalk Band members was made to identify any fishing activity that may have occurred on days between field trips.

3. RESULTS AND DISCUSSION

3.1. River Flow and Temperature

Pro-rating daily flow records from the Bella Coola River at Burnt Creek Bridge by drainage area size, flow in the Bella Coola River at the mouth was estimated to range from a minimum daily flow of 15.4 m³/s on 14, 15, & 16 March 2001, to a maximum daily flow of 187 m³/s on 25 May, 2001 (Table 1, Figure 2). Mean monthly flow increased from 15.8 m³/s in March, to 19.5 m³/s in April, and 69.6 m³/s in May.

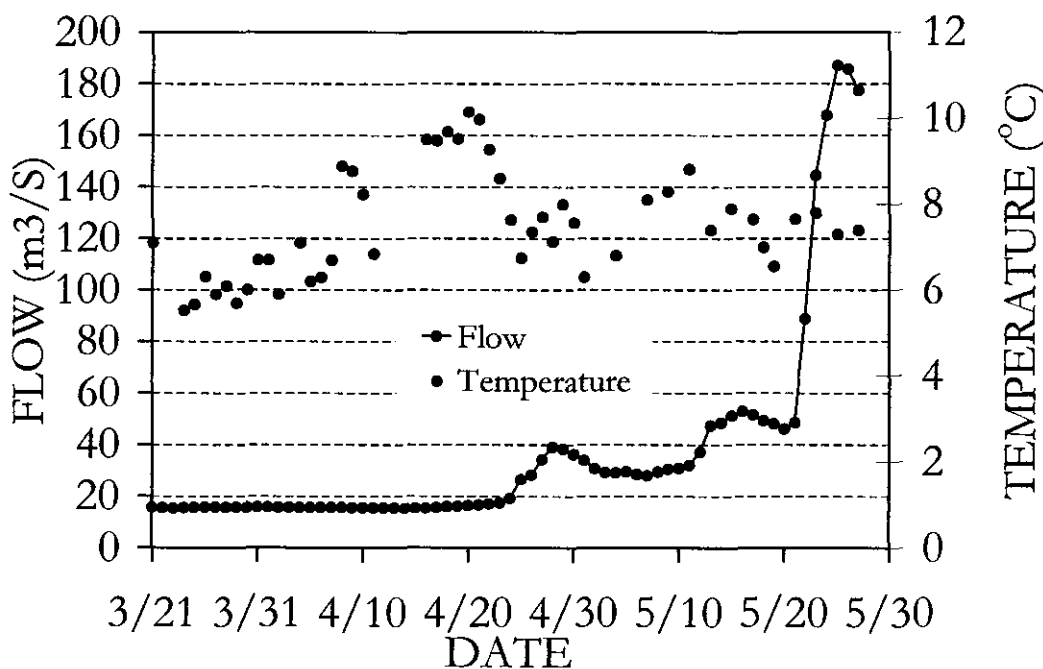
Spot water temperatures in the Bella Coola ranged from 4.1 to 11.9 °C during the March to May 2001 study period. Mean monthly water temperatures increased from a low of 6.0 °C in March, to a high of 8.2 °C in April, but declined again to 7.5 °C in May coincident with an increase of flow.

Daily temperature and flow data are provided in Appendix A.

Table 1. Mean monthly flow and spot temperatures in the Bella Coola River at the mouth for March, April, and May 2001.

Statistic	March	April	May
<i>FLOW (m³/S)</i>			
Mean Daily	15.3	19.5	77.7
Maximum Daily	16.1	39.1	187
Minimum Daily	14.6	15.4	27.9
N	43	41	43
<i>TEMPERATURE (°C)</i>			
Mean	6.0	8.2	7.5
Maximum	7.3	11.9	9.0
Minimum	4.1	5.4	6.1
N	140	248	74

Figure 2. Mean daily flow and daily spot temperatures in the Bella Coola River near the mouth from March to May 2001.



3.2. Distribution and Abundance

3.2.1. Adults

Adult field sampling began on 25 March, 2001 and continued until 18 April, 2001. A total of 17 days were sampled during this period, a sampling frequency of roughly 70%. A total of 52 net sets were made. The Bella Coola River was sampled each day during this period near the town of Bella Coola, just offshore of the boat launch on N. Grant Road. The nearby Paisla Creek was sampled at its mouth on eight different days. Individual set data are provided in Appendix B.

In total 43 adult eulachon were captured during the 52 nets sets in the Bella Coola and Paisla Creek (Table 2). The sex ratio was effectively 1:1 with totals of 22 males and 21 females captured.

Although adult eulachon captured were frozen for morphometric analyses in the laboratory, specimens deteriorated while in storage in Bella Coola because of a power failure, and no data are available.

3.2.2. Eggs and Larvae

Plankton net tows were made in the Bella Coola River site near the boat launch on N. Grant Road. A total of 476 samples were collected; 144 in March, 258 in April, and 74 in May. Number of plankton tows per day averaged 10.06 with a mode of 6. A maximum number of plankton tows (24) were taken on 29 March, a minimum (3) on 21 March, and 7 and 23 May (see Appendix C).

Quality assurance of the data identified significant recording or transcription errors. Of the 476 samples taken, 82 had apparent errors in flow meter counter recording, evidenced by excessively low or high elapsed counts, or asynchrony between the counter number and the time of sampling (samples are taken sequentially without zeroing the counter, therefore errors are indicated when the counter number does not increase with date of time of day).

Table 2. Adult eulachon catch and effort.

Date	Net Sets	Male Eulachon Captured	Female Eulachon Captured
25-Mar	3	4	7
26-Mar	3	5	6
27-Mar	3	1	0
28-Mar	5	1	0
29-Mar	2	1	3
30-Mar	3	1	0
31-Mar	3	0	0
1-Apr	3	0	0
2-Apr	3	0	0
4-Apr	3	0	0
5-Apr	3	3	2
6-Apr	3	0	1
7-Apr	3	0	0
8-Apr	3	0	0
9-Apr	3	6	1
10-Apr	3	0	1
11-Apr	3	0	0
Total	52	22	21

Overall, a human error rate of 17% was measured in data recording, considerably higher than the standard 5% expected in such studies. The 82 cases were excluded from the analysis of eulachon density and production.

A total of 1,570 eulachon eggs were collected during plankton net tows. From these 676 eggs were identified as dead; 894 were identified as live (Table 3). Additionally 81 sculpin eggs were identified from the samples, of which 33 were identified as dead, 48 as live. In addition to these drifting eggs captured in the plankton net sets, eggs are expected to have adhered to substrate and remained in the river. These eggs were not sampled hence we cannot calculate the total number of eggs deposited in the Bella Coola River.

Table 3. Eulachon eggs captured during plankton sampling on the Bella Coola River by collection date.

Date	No. samples	Live	Dead	Total	Date	No. samples	Live	Dead	Total
21-Mar	3	0	0	0	23-Apr	12	3	1	4
24-Mar	9	5	9	14	24-Apr	8	3	0	3
25-Mar	22	29	0	29	26-Apr	12	2	0	2
26-Mar	20	59	3	62	27-Apr	12	1	0	1
27-Mar	20	112	52	164	28-Apr	7	0	0	0
28-Mar	20	60	17	77	29-Apr	12	3	0	3
29-Mar	24	88	28	116	30-Apr	6	0	0	0
30-Mar	13	29	7	36	1-May	6	1	0	1
31-Mar	13	76	67	143	4-May	5	9	0	9
1-Apr	15	30	65	95	7-May	3	1	0	1
2-Apr	6	10	3	13	9-May	6	2	0	2
4-Apr	6	9	165	174	11-May	6	0	9	9
5-Apr	14	71	99	170	13-May	6	0	0	0
6-Apr	17	52	106	158	15-May	5	0	0	0
7-Apr	5	9	2	11	17-May	7	0	0	0
8-Apr	13	35	7	42	18-May	3	0	0	0
9-Apr	11	59	15	74	19-May	6	0	0	0
10-Apr	12	20	3	23	21-May	6	0	0	0
11-Apr	6	8	0	8	23-May	3	1	0	1
16-Apr	6	7	0	7	25-May	6	0	0	0
17-Apr	15	37	2	39	27-May	6	0	0	0
18-Apr	9	2	0	2	March	144	458	183	641
19-Apr	12	21	3	24	April	258	422	484	906
20-Apr	12	24	7	31	May	74	14	9	23
21-Apr	12	3	4	7	Total	476	894	676	1570
22-Apr	12	13	2	15					

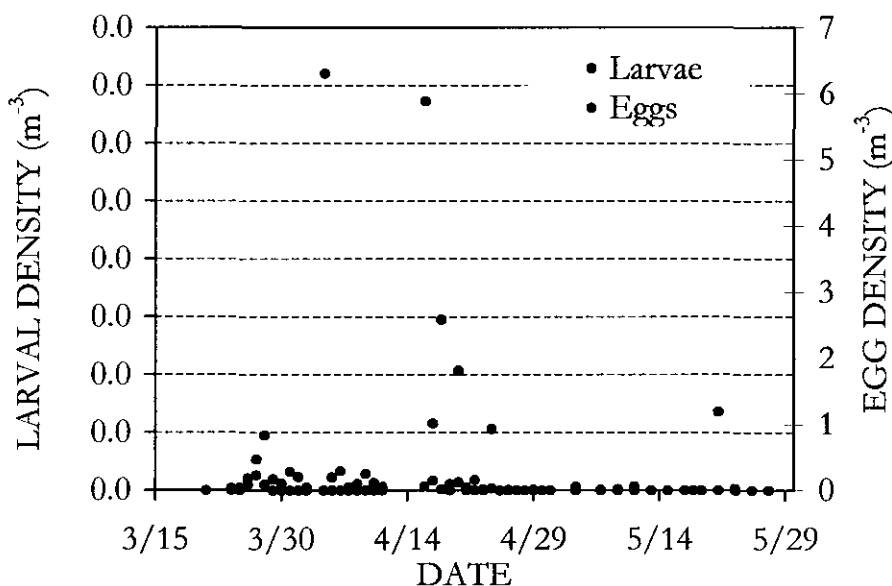
Eulachon larvae were collected during plankton net tows. Only 2.7 % (13 total) of the samples contained larval eulachon, while 95.2 % (453 total) contained larval sculpin.

In total, only 18 larval eulachon were captured in 2001. Over 99% (34,406) of the larval fish captured were prickly sculpin. In addition 954 pink salmon fry and 237 chum salmon fry were also captured and identified. All salmon fry were kept alive and returned to the river.

Table 4 lists eulachon larvae density by date. Eulachon larvae density averaged 0.0019 m^{-3} , but most commonly was zero. The highest mean daily density was on 16 April (0.034 m^{-3}). Sculpin larvae density averaged 3.14 m^{-3} .

Eulachon migration timing can be inferred from catch density information. Eulachon larvae density shows a somewhat bell-shaped distribution, although the small numbers captured make it difficult to make any substantial comments on migration timing (Figure 3). Larvae were captured on 26, 27, and 28 March, 16, 17, 18, and 24 April, and 21 May-01. All captures occurred on, or prior to, 24 April, except for the capture of one larva on 21 May.

Figure 3. Date versus eulachon larval density and egg density (m^{-3}) in the Bella Coola River.



The capture of larvae in April suggests early run timing on the Bella Coola during 2001. The samples have been checked and the early captures are indeed larval eulachon. In total, 9 larvae were captured during March: 4 on March 16, and 1 on March 17, and 4 on March 28. This suggests that eulachon were spawning in early February, unlike the March and April timing observed on other rivers in northern B.C.

Peaks of larval migration timing in the Kemano River were May 20 in 1990, and June 6 in 1997; on the Kitimat River 75% of larvae migrated between May 2 and May 15 in 1993 (Pedersen *et al.* 1993), and the midpoint of the migration was on May 25 in 1995 (Kelson 1996). In the Nass River, larval migration peaked between May 19 and June 8, 1983 (Orr 1984). However, during 2001 eulachon larvae were first captured on the Skeena River on April 12 and adults were observed on February 28, and similar early run timing was observed in 2002 (John Kelson, Smithers B.C., file data provided to the author). We are suspicious of the apparent early run timing on the Bella Coola during 2001, but cannot explain it other than as an error in sample labeling and identification. Even if not an error, the capture of larvae in March must be taken in context of absolute numbers: only 9 larvae were taken, less than $1/1000^{\text{th}}$ of the egg complement of a single female.

Table 4. Numbers and density of eulachon and sculpin larvae by date of capture. Each value is the daily average over a varying number of samples (ranging from a low of 3 samples on 21 March to a high of 24 samples on 29 March (mode = 6; median = 8.5). Eighty-one samples were excluded from the analysis because of suspected errors in recording the flow meter counter.

Date	No. Eulachon	Eulachon Density (m ⁻³)	No. Sculpin	Sculpin Density (m ⁻³)
3/21/2001	0	0.0000	10	0.0860
3/24/2001	0	0.0000	263	0.5915
3/25/2001	0	0.0000	919	1.1987
3/26/2001	1	0.0011	880	1.2684
3/27/2001	1	0.0027	1084	1.5878
3/28/2001	4	0.0048	894	1.5766
3/29/2001	0	0.0000	1046	1.7147
3/30/2001	0	0.0000	354	1.9396
3/31/2001	0	0.0000	597	2.4289
4/1/2001	0	0.0000	976	2.6807
4/2/2001	0	0.0000	476	5.0787
4/4/2001	0	0.0000	521	39.8980
4/5/2001	0	0.0000	841	10.6145
4/6/2001	0	0.0000	1929	4.9664
4/7/2001	0	0.0000	2178	9.7391
4/8/2001	0	0.0000	2001	6.2031
4/9/2001	0	0.0000	662	3.7881
4/10/2001	0	0.0000	627	3.9589
4/11/2001	0	0.0000	1629	9.2599
4/16/2001	4	0.0336	586	6.7365
4/17/2001	1	0.0058	836	6.7614
4/18/2001	2	0.0148	851	7.3565
4/19/2001	0	0.0000	820	4.2983
4/20/2001	3	0.0104	1579	5.2677
4/21/2001	0	0.0000	713	5.6703
4/22/2001	0	0.0000	765	8.9799
4/23/2001	0	0.0000	406	5.6120

Table 4 continued.

Date	No. Eulachon	Eulachon Density (m ⁻³)	No. Sculpin	Sculpin Density (m ⁻³)
4/25/2001	0	0.0000	24	0.3072
4/26/2001	0	0.0000	129	0.6325
4/27/2001	0	0.0000	76	0.3148
4/28/2001	0	0.0000	71	0.7430
4/29/2001	0	0.0000	194	0.7231
4/30/2001	0	0.0000	173	0.9561
5/1/2001	0	0.0000	32	0.2307
5/4/2001	0	0.0000	807	12.8669
5/7/2001	0	0.0000	94	1.1352
5/9/2001	0	0.0000	46	0.2517
5/11/2001	0	0.0000	52	0.3311
5/13/2001	0	0.0000	13	0.1664
5/15/2001	0	0.0000	25	0.2347
5/17/2001	0	0.0000	27	0.2252
5/18/2001	0	0.0000	36	0.4094
5/19/2001	0	0.0000	2	0.0119
5/21/2001	1	0.0068	71	0.4218
5/23/2001	0	0.0000	0	0.0000
5/25/2001	0	0.0000	12	0.2542
5/27/2001	0	0.0000	16	0.0840
Average		0.0019		3.1392

The bulk of the larvae migrated during the second half of April, four weeks after adults were captured and presumably spawned in late March. This suggests that the eggs hatched three to four weeks post-spawning. This is faster than in the Kemano River, however, water temperatures in the Bella Coola are relatively warmer and more rapid hatching would be expected. In fact, at an average temperature of 8.2 °C during April, eulachon would be expected to hatch within 25 days, based on the 205 ATU's required to hatch Cowlitz River eulachon eggs (Smith and Saafeld 1955).

To calculate eulachon larvae and egg densities, catches were divided by the volume of water fished, which was estimated from current meter readings taken concurrently with each sample. The results of each step in the calculation for each individual sample are detailed in Appendix C.

The total number of eulachon transported by the river can be estimated from eulachon density, weighting the mean density each sampling week by the corresponding mean river flow. Larval and egg densities in m^{-3} are multiplied by river flow in m^3/s , to yield larval and egg productivity in s^{-1} . Egg and larval productivity is expanded to production by multiplying productivity by mean river flow over a known period (in this study, by week). Other eulachon researchers have used this method (Petersen *et al.* 1995, Hay *et al.* 1997).

Through such calculations we estimate that approximately 311,000 larvae and 10,283,000 eggs were produced (Table 5). Note that this estimate is based on the capture of only 18 larvae and 1,570 eggs, thus river flow accounts for an extrapolation of >17,000 in larval production and >6,500 in egg production.

Total adult population can be back calculated from eulachon egg and larval abundance, assuming standard fecundity and sex ratio. Based on relative fecundity of 350 eggs/g of spawning fish, as per Hay *et al.* 1997, we estimate that 0.030 tonnes of eulachon would be required to produce the estimated 10.6 million eggs and larvae produced in the Bella Coola in the 2001 spawning period.

The density of eulachon larvae measured in this study is lower than any other reported in the literature. Published estimates of larval density for the Skeena Kemano, Kitimat, and Nass Rivers are provided in Table 6. Previous to this study, the lowest reported density was $0.0078 m^{-3}$ (from the Skeena River in 1997), four times higher than measured here.

Larvae density reflects the abundance of eulachon larvae abundance, but also river flow, which dilutes the larvae. To account for the effects of dilution, eulachon productivity has been calculated, a measure of the number of eulachon larvae and eggs transported by a river per second. The Bella Coola River in 2001 has the lowest productivity of the studies examined by 1000 fold.

3.2.4 Fishery

No eulachon fishing activity was observed on the Bella Coola River during 2001.

Fisheries and Oceans Canada staff have observed the eulachon fishery of the Nuxalk people on the Bella Coola River for over 40 years (data provided by Russ Hilland). Based on direct observation, total eulachon catch in tonnes is reported for most years from 1944-2000 (Appendix D). These catch statistics provide a longer-term picture of adult presence and fishery activities in the Bella Coola. Historically, the Bella Coola has supported catches as high as 70 tonnes, but more typically 10 tonnes or higher (Figure 4). The most recent catches were made in 1999 when 1.5 tonnes were taken.

The status of the Bella Coola eulachon stock in 2001 can be assessed by considering both larval and adult catches. Adults catches were very low (52 individuals), larval densities were low ($0.0019 m^{-3}$), estimated run size was negligible (0.030 tonnes), and there were insufficient eulachon to support a fishery. All sources of information support a conclusion of a small run in 2001.

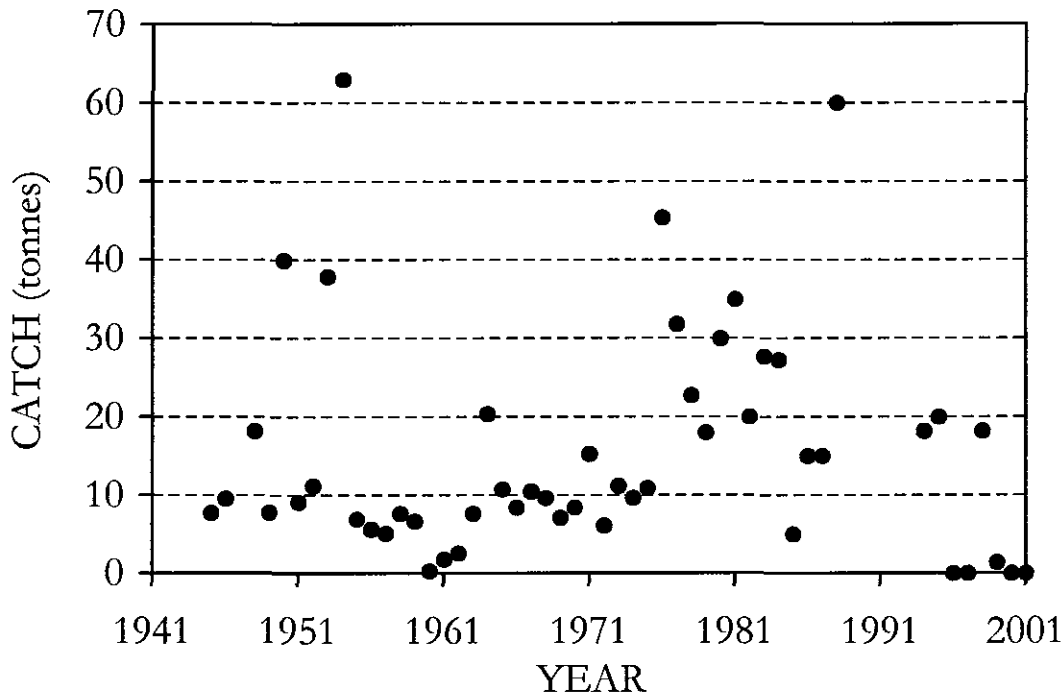
Table 5. Bella Coola River flow, eulachon egg and larval density, and production of eggs and larvae by week during 2001.

Week Starting	Flow (m ³ /s)	Eulachon Egg Density (m ⁻³)	Weekly Egg Production	Eulachon Larvae Density (m ⁻³)	Weekly Larval Production	Total Production
18-Mar-01	15.7	0.0245	232,323	0.0000	0	232,323
25-Mar-01	15.8	0.1381	1,316,092	0.0013	12,374	1,328,465
1-Apr-01	15.7	0.5012	4,752,277	0.0000	0	4,752,277
8-Apr-01	15.5	0.1348	1,267,411	0.0000	0	1,267,411
15-Apr-01	15.9	0.0877	844,184	0.0089	85,327	929,511
22-Apr-01	26.0	0.0377	592,490	0.0006	9,595	602,085
29-Apr-01	32.4	0.0120	236,222	0.0000	0	236,222
6-May-01	30.9	0.0335	625,935	0.0000	0	625,935
13-May-01	49.8	0.0000	0	0.0000	0	0
20-May-01	124	0.0055	416,184	0.0027	203,742	619,926
27-May-01	165	0.0000	0	0.0000	0	0
TOTAL	(rounded)		10,283,000		311,000	10,594,000

Table 6. Eulachon larvae density, river flow, and larvae production per second in the Bella Coola, Skeena, Nass, Kitimat, and Kemano Rivers.

River	Year	Eulachon Density (m ⁻³)	Data Source	Flow (m ³ /s)	Productivity (larvae/s)
Bella Coola	2001	0.0017	this study	38.9	0.0035
Skeena	1992	17.73	DFO data in Lewis 1997	3,677	65,179
Skeena	1993	0.060	DFO data in Lewis 1997	3,803	228
Skeena	1997	0.0778	Lewis 1997	3,936	31
Kitimat	1995	3.54	Kelson 1996	217	769
Kitimat	1993	6.42	Pedersen <i>et al.</i> 1995	161	1,034
Kemano	1990	1.86	Lewis <i>et al.</i> 2002	257	478
Nass	1983	131.63	Orr 1984	1,100	144,793

Figure 4. Times series of eulachon catches (tonnes) from the Bella Coola River. Data provided by Russ Hilland, Hatchery Manager, Fisheries and Oceans Canada.



An assessment of population status must be considered in the context of our understanding (and lack thereof) of eulachon population structure. Eulachon show little variation in mitochondrial DNA between populations (McLean *et al.* 1999), suggesting that they may not return to the natal river. Viewed in this context, the absence of significant eulachon runs may not reflect a decline but rather a change in spawning location. On the other hand, recent evaluation of nuclear DNA shows some differences between rivers (pers. comm. Terry Beacham, DFO, 2001), supporting a salmon-like population structure. Under this hypothesis, the multi-year decline of Bella Coola eulachon suggests a serious decline in population size. Given this conflicting evidence and consistent differences between rivers in run timing (a heritable trait in other species of smelt) the most parsimonious explanation is that eulachon populations home to distinct marine

areas (inlets, sounds) but then may vary in the individual streams selected for spawning (Hay and McCarter 2000). Given this, declines in eulachon populations in a single river are of concern, but may not reflect critical status.

Marine surveys of eulachon larval density by DFO in 1997 showed presence of larvae in the Kimsquit River estuary and at the head of Cascade Inlet. Eulachon were captured along Dean Channel, North and South Bentinck arms, and in Burke Channel. In 2001 no reports of eulachon runs in other rivers in Nuxalk territory were made to us by Nuxalk fishers, however, the other rivers were not sampled for larvae and may not have been examined for adults with more than cursory effort. Accordingly, we cannot conclude the runs to Burke and Dean channels were as low as those to the Bella Coola River. It is possible that runs of eulachon returned to other parts of the Nuxalk territory in 2001, however, these runs were probably small.

Hay and McCarter (2000) define levels of concern for eulachon and corresponding levels of remedial action. For the Bella Coola River, based on the low abundance in 2001, and considering the decline in catches, concurrent with low returns throughout Nuxalk territory, the run would be classified as Code 2: intense protective action of uncertain duration. The low densities sampled in 2001 may constitute an unsustainable population. At very low levels of abundance, the viability of a population a forage fish species like eulachon is at risk, given the high depensatory mortality typically experienced at low population levels (Myers *et al.* 1995).

4. RECOMMENDATIONS

4.1. Sampling Location and Intensity

The location of spawning by Bella Coola River eulachon and the area of egg incubation are presently unknown. Detailed research on other rivers has shown that the eggs tend to be clustered in specific areas, and that regions influenced by the saline wedge are not productive egg incubation areas (Lewis *et al.* 2002). Data specific to the Bella Coola River would help define areas sensitive to instream disturbances that include instream construction, sediment transport from upstream instream activities, and boat and wading activity within spawning areas.

Future sampling for eulachon on the Bella Coola River should include both the Bella Coola mainstem and the Necleetsconnay River. Adult sampling should continue to be conducted at the mouths of both rivers. Future larval sampling should be conducted on the Bella Coola at the existing site, but also, contingent on a minimum density of larval eulachon¹, 500 m and 1000 km further upstream for two days near the peak of larval emigration. In addition, should adult eulachon be captured at the mouth of the Necleetsconnay River, larval sampling should be undertaken for a minimum of five days within a two-week period around the peak of the run observed in the Bella Coola

River. The expansion of sampling areas, contingent on the appearance of a significantly large run of eulachon, would better define the geographic extent of eulachon spawning. However, the expansion of sampling area is not warranted if run size is small as there would be insufficient data to elucidate differences between areas.

Eulachon may be returning to rivers within Nuxalk territory undetected. The uncertainty in the status of Bella Coola eulachon highlights the need to survey in other rivers nearby. River population surveys are expensive, ranging from \$40,000 to \$80,000 to complete. Fortunately, marine surveys of eulachon larvae shortly after they have emigrated from the river provide a more cost effective (\$15,000), though less specific way of assessing eulachon populations in several estuaries. A marine survey should be undertaken two weeks following the peak of the run on the Bella Coola (mid-April) to determine the extent of eulachon returns to Dean and Burke channels. The sampling protocol and locations identified in McCarter and Hay (1999) should be repeated to allow comparison between years. Special attention should be given to estuaries and any rivers traditionally fished by the Nuxalk for eulachon should be sampled near their estuary.

4.2. Timing of Sampling

The capture of most larval eulachon in mid-April is of importance and should be considered in future sampling of eulachon. Given that eulachon egg incubation requires approximately six to eight weeks in the Kitimat and Kemano rivers (Pedersen 1995, Lewis *et al.* 2002), the present study indicates that adult eulachon migration peaked from mid-February to early March in the Bella Coola River. Given this, it is important that a watch for adult eulachon begin by mid-February in future studies.

Eulachon density on large rivers has reportedly not varied with time of day (Hay and McCarter 2000), however, on smaller rivers larvae are more abundant at night (Lewis *et al.* 2002). The difference between large and small rivers may reflect the distance between proximity of the sampling to eulachon spawning sites. On

¹ The minimum density is defined as 1 eulachon m⁻³.

small rivers like the Bella Coola, nighttime sampling of eulachon larvae is required to ensure unbiased estimates of the parent population. To balance this requirement with safety concerns, eulachon larval samples are taken at dawn. This is a critical feature of the sampling program and should not be varied. As the season progresses, dawn occurs earlier, therefore the samples should be collected earlier. During the peak of the run, sampling of the eulachon population should include sampling on some days every two hours from midnight to eight a.m. and sampling every four hours from eight a.m. to midnight. Again, safety concerns limit the feasibility of this approach, and careful planning will be necessary to ensure a safe and effective sampling program.

4.3. Sampling Protocol

If a medium or large run of eulachon returns in 2002, grab sampling should be used to identify areas of eulachon egg deposition, map egg density, and determine egg survival.

Eulachon eggs can be sampled from the substrate using a Mighty Grab mechanical benthic grab sampler with a 0.016 m² opening (see www.aquaticceco.com to order). Samples can then be stored in a 1 L plastic container, with isopropyl alcohol added at a ratio of 1 to 3 to preserve the samples. The sample bottle should be labelled with date and time of sample collection.

For larval sampling, more careful attention needs to be paid to sampling protocol each sampling day. During a quality assurance trip in May, several errors were identified, and a review of the data sheets shows frequent error. Key items are identified in point form below:

1. Flow meter counter measurement must be recorded at the beginning and end of each sample deployment. In addition, the time of deployment and retrieval should be recorded.
2. The plankton net must be washed externally to flush material adhering to the mesh into the cod end. This can be accomplished first by closing the mouth of the net and repeatedly immersing it in the river, then by washing the net with water from a spray bottle. Only when all visible material adhering to the inside of the net has been washed into the cod end should the cod end be removed.
3. Between sampling trips the plankton net should be washed and hung to dry.
4. Temperature and current flow meters should be stored in the dry (on countertops), not in wet containers (buckets).
5. The laboratory should be cleaned after each sampling day.
6. A boat certified by Transport Canada must be used when sampling. The boat used for part of the sampling during 2001 was unstable and had insufficient freeboard for this work.
7. A quick-release line must be used to connect the boat to any anchor. This allows rapid release in the event that debris or other waterborne objects threaten the boat.
8. Life jackets must be worn by all crewmembers when in the boat. Three oars, a bailer, and a first aid kit must be kept in the boat at all times. Failure to follow basic safety procedures violates regulations and compromises the future of the sampling program.
9. Adequate preservative must be added to each larval sample. 30% by volume of alcohol should be added to each sample.
10. Data transcription. A single data sheet should be used for field and laboratory data collection. Each data sheet should be initiated in the field, then transported along with the samples to the laboratory where they can be used to record the results of sample analysis. This procedure will avoid errors of association between the field and laboratory data.
11. Data sheets should be taken from the laboratory each sampling day and copied. The originals and the copies

should be stored in separate locations to reduce the risk of data loss.

12. Program quality will be increased if a formally trained science technician or biologist a) supervises the field sampling at least once a week, b) reviews the data sheets at the end of each sampling day; c) supervises the laboratory for 2 hours every week, and d) subsamples 5% of the laboratory samples to ensure quality.

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