KITSUMKALUM FISHERIES DEPARTMENT

FINAL REPORT ON 2010 SURVEY OF EULACHON ADULT SPAWNER AND EGG DISTRIBUTION IN THE LOWER SKEENA RIVER AND TRIBUTARIES

Report Document
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KITSUMKALUM

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EXECUTIVE SUMMARY

Eulachon, *Thaleichthys pacificus* (AKA ooligan, oolichan, hooligan, oolachan, uthlecan, ulichan) are an ecological cornerstone for regional coastal ecosystems (Marston et al. 2002), and a culturally important species to many First Nations on the British Columbia coast.

Starting in 1994, there was a sudden simultaneous drop in returns to many rivers, most notably in the Fraser, Columbia and Klinaklini Rivers (Hay 1996). Since then, many First Nations have reported that fish are absent or at very low levels in many British Columbia eulachon spawning rivers including: the Kemano, Kitimat, Wannock, Bella Coola, Nass, Skeena, Chilcoot, Unuk, Kitlope and Stikine (Moody 2007, Hay 2007).

In past few years, due to these declines in populations coast-wide; Canadian researchers have requested that COSEWIC (Committee on the Status of Endangered Wildlife in Canada) evualuate the eulachon's status; while in the USA, NOAA's (National Oceanic and Atmospheric Administration) National Marine Fisheries Service (NMFS), has recently listed the southern population of eulachon as threatened as of May 17, 2010. under the US Endangered Species Act since their scientific review found that this stock is indeed declining throughout its range.

The reasons for this decline are unknown, but may in part, be due to impacts to critical spawning habitat in some watersheds. Acquiring habitat-based data is important for fish and land management uses. Without understanding what the eulachon spawning, egg incubation and larval rearing habitat requirements are and subsequently mapping their location; it is problematic to provide direction to managers in order to protect the habitat.

In response to this need for better data on critical habitat utilized by eulachons for different aspects of their life history; funding was provided by the *World Wildlife Fund Canada* and *Fisheries and Oceans Canada* (FOC). The intent of this project was to provide accurate, dependable geo-referenced data on the substrate and location requirements of critical spawning habitat for the eulachon in the Skeena River, including estuarine larval rearing areas.

This report details the activities and findings of the Kitsumkalum Fisheries Department during March through May 2010 while surveying the Skeena River and associated tributaries, including the Khyex, Ecstall, Kasiks and Scotia Rivers.

Information on run timing and reproductive effort of spawning adult eulachon was collected through the use of gill nets; collecting data on sex, lengths, weights, and gonad mass. Information on critical spawning habitat was collected through the simultaneous use of a tethered camera to view spawning adults, and a ponar dredge to collect freshly deposited eggs. Information on larval densities was collected using a 0.5m diameter conical plankton net (130 micron mesh) with a General Oceanics

Inc. Model 2030R standard flowmeter to estimate volume of water filtered with the plankton net.

The positions of gill net, egg and larvae sampling sites as well as associated eulachon habitat, were recorded using a *Garmin 60Cx* GPS unit and plotted using Garmin *Mapsource*® software, while water depths were recorded using a *Garmin Fishfinder 90* depth sounder.

Corrected depths were then used to reconstruct the bottom profile of the spawning habitat using *Surfer Demo®* software Version 9.8.669 (Golden Software, Inc) for sites with adequate depth soundings.

The average fork length of male eulachons was 17.9 ± 1.05 cm (n=176), where the females were slightly smaller at 17.2 ± 0.96 cm (n=57). The ratio of females to males found in the sampled population generally varies from a larger proportion of females at the presumed start of a new run of eulachons, to a very small percentage of females remaining at the end of the run. In total, over the whole 2010 sampling period, only 20.67% of the eulachons caught were female.

Moderate to high density spawning sites (30,000-2,700,000 eggs m^{-2}) were found in corrected water depths of -3.16±1.9 m (n=13) on the mainstem of the Skeena River, but not the tributaries. Low to moderate egg density (0-30,000 eggs m^{-2}) sites were also found on the mainstem and in the Ecstall River at shallower depths of between 2m and 3.6m, but also found in as shallow as 0.8m (Kelson, 2010).

In the maximum turbidity zone in the lower Skeena estuary, densities of eulachon larvae ranged from 46.05 larvae m^{-3} (waypoint 580 Top) to 59.11 larvae m^{-3} (waypoint 583). Eulachon larvae densities in the remainder of the mainstem above this area ranged from 0.32 larvae m^{-3} (Waypoint 582) to 14.26 larvae m^{-3} (waypoint 572), but averaged 4.95 ± 4.83 larvae m^{-3} (n=8).

This would indicate that there is a mechanism for larval retention at the lower end of the Skeena estuary that facilitates the increases in larval densities that we observed, since the densities are increased tenfold from the mainstem.

Details of recommendations for future studies are given, including recommendations for modeling and stock assessment methods.

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Acknowledgements

The Kitsumkalum Fisheries Department would like to thank the World Wildlife Fund Canada and the Aboriginal Fisheries Strategy personnel of the Department of Fisheries and Oceans (DFO) for providing the financial resources to make this survey possible.

We would like to thank Chief Don Roberts for his assistance during this project, and acknowledge the assistance of Russell and Kirk Bolton for operating the vessel used in this survey, and to Jim Roberts for providing administrative support. Laboratory samples and data were analysed by Dave Rolston, as well as writing the report.

We would also like to thank the Metlakatla Fisheries Program (MFP); specifically William Beynon (MFP Manager), Vince Van Tongeren (MFP Technician) and John Kelson (biologist), for their assistance during the egg sampling on the Ecstall and Khyex Rivers, and to BC Hydro for providing accommodations.

INTRODUCTION

Project Rationale

The eulachon (*Thaleichthys pacificus*) is an anadromous smelt, one of nine species of smelt found off the Pacific Coast, that spawns within a number of mainland rivers within the Province of British Columbia, and is blue-listed within the provinces "*species at risk*" designation process (http://a100.gov.bc.ca/pub/eswp/esr.do?id=14828). Taxa listed as BLUE are sensitive or vulnerable; indigenous (native) species that are not immediately threatened but are particularly at risk for reasons including low or declining numbers, a restricted distribution, or occurrence at the fringe of their global range.

Eulachon (AKA ooligan, oolichan, hooligan, oolachan, uthlecan, ulichan) are an ecological cornerstone for regional coastal ecosystems (Marston et al. 2002).

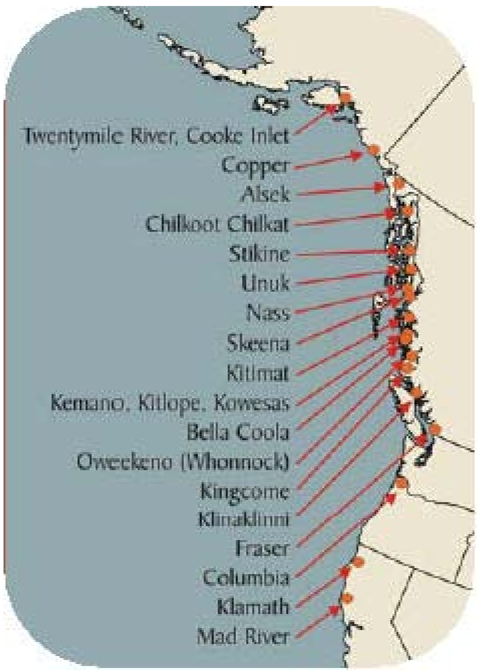

Figure 1 - Eulachon Rivers in western North America

Eulachon are a culturally important species to many First Nations on the British Columbia coast, where the fish are rendered down to extract the oil or grease. Eulachons are composed of about 20% oil content, which is found to be the highest level of oil by all species examined in a comparative study of Pacific forage fish (Payne et al. 1999). This oil product is an important food source, and was bartered among First Nations communities and given as gifts at potlatch ceremonies. There are many historical "grease trails" along the coast and inland that facilitated trade between many First Nation groups. Eulachon are also eaten fresh, smoked and dried.

Historically, the distribution of eulachon ranged from California through to Alaska (Figure 1).

Within British Columbia, 33 rivers are documented to have spawning eulachon populations of which 14-15 watersheds are consistently utilized, while the other watersheds appear to be used for spawning only in years of large eulachon abundance. Of these dependable stocks, the major river systems where eulachon return to spawn in BC are the Fraser, Skeena, Nass, and Klinaklini (Figure 2).

Starting in 1994, there was a sudden simultaneous drop in returns to many rivers, most notably in the Fraser, Columbia and Klinaklini Rivers (Hay 1996). Since then, many First Nations have reported that fish are absent or at very low levels in many British Columbia eulachon spawning rivers (Figure 2) including: the Kemano, Kitimat, Wannock, Bella Coola, Nass, Skeena, Chilcoot, Unuk, Kitlope and Stikine (Moody 2007, Hay 2007). Rivers which experienced virtually no returns in 2000 were: Stikine, Unuk, Skeena, Kitimat, Kemano, Kitlope, Bella Coola, Kimsquit, Owikeeno, and Kingcome Rivers.

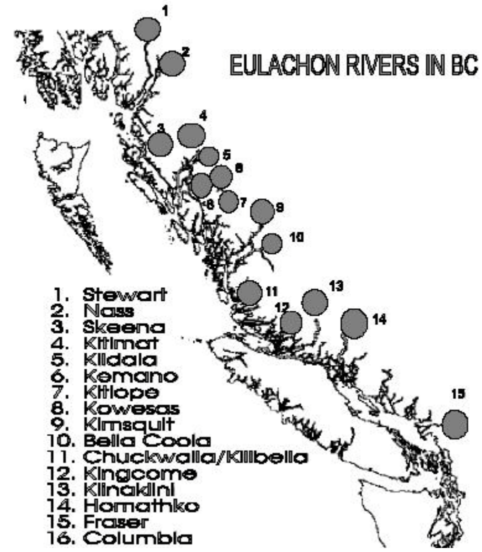

Figure 2 - Eulachon Rivers in British Columbia (Hay *et al*., 1997)

In past few years, due to these declines in populations coast-wide; Canadian researchers have requested that COSEWIC (Committee on the Status of Endangered Wildlife in Canada) list the eulachon as a *threatened* species; while in the USA, NOAA's (National Oceanic and Atmospheric Administration) National Marine Fisheries Service (NMFS), has recently listed the southern population of eulachon as threatened as of May 17, 2010. under the US Endangered Species Act since their scientific review found that this stock is indeed declining throughout its range.

NOAA found that eulachon in rivers south of the Skeena River (inclusive) in British Columbia, Canada, to the Mad River (inclusive) in California, are "*likely to become endangered within the foreseeable future*" (http://www.nwr.noaa.gov/Other-Marine-Species/Eulachon.ctm). NOAA looked at eulachon spawning habitat within the range of the southern Distinct Population Segment (DPS) that was present in the past, but may have been lost over time; and has to now determine the extent of the fish's remaining critical habitat.

Due to poor data and lack of rigid stock abundance assessments in Canada, it is difficult to accurately know what the exact stock status is within most rivers, most years. Fisheries and Oceans Canada (FOC) does not conduct annual stock assessments on most eulachon rivers, and there has been limited funding available coast-wide for eulachon research. Typically, most stock assessment data is anecdotal. In fact, very little is currently known about even the life history of this important fish species.

The intent of this project was to provide accurate, dependable geo-referenced data on the substrate and location requirements of critical spawning habitat for the eulachon in the Skeena River, including freshwater larval rearing areas.

Acquiring these data is important for fish and land management uses. Without understanding what the eulachon spawning/egg incubation/larval rearing habitat requirements are and subsequently mapping their location, it is problematic to provide direction to managers in order to protect the habitat. If egg abundance data is available at the river scale then adaptive management experiments may be performed to understand how to minimize the impacts of land/water management actions (Pickard and Marmorek. 2007).

Project Objectives

Initially, the intent of this 2010 study was to replicate the sampling protocol of the 2005 Skeena River Eulachon River Study completed by the Kitsumkalum Fisheries Department, under the direction of Chief Don Roberts.

However in early June 2007, the Skeena River had exceptional flood conditions which dramatically altered the hydrology of the lower river, including the main and secondary channels (thalwegs) and changed the location of the previously-identified, associated eulachon spawning habitat. This meant that the eulachon spawning habitat on the lower Skeena River had to be re-identified, and mapped.

The objectives of this 2010 study were to:

Identify and geo-reference areas of eulachon habitat in the lower Skeena River, specifically:

1. Identify eulachon spawning areas and describe habitat parameters,
2. Identify egg incubation areas and describe macro- and micro-habitat,
3. Collect population data of spawning adult eulachon (i.e. sex ratio, length, spawning condition),
4. Collect water temperature data for incubation determination purposes,
5. Identify boundaries of spawning areas through determination of salt water intrusion,
6. Identify spatial and temporal boundaries of spawning and larval rearing areas.

Funding Sources

This project was generously supported by both the World Wildlife Fund Canada, and the Department of Fisheries and Oceans Canada (DFO), with both in-kind and logistical support from the Kitsumkalum Fisheries Department.

Project Location

Skeena River (watershed code 400-000000) is a large river located on the North Coast of British Columbia, that drains an area of 54,500 km^2 (Figure 3), in DFO Fisheries Statistical Area 4. The co-ordinates of the mouth of the Skeena River are: Latitude and Longitude 54° 08' N, 130° 05' W (NAD 27), UTM 09/428416E 5999641N (NAD 83).

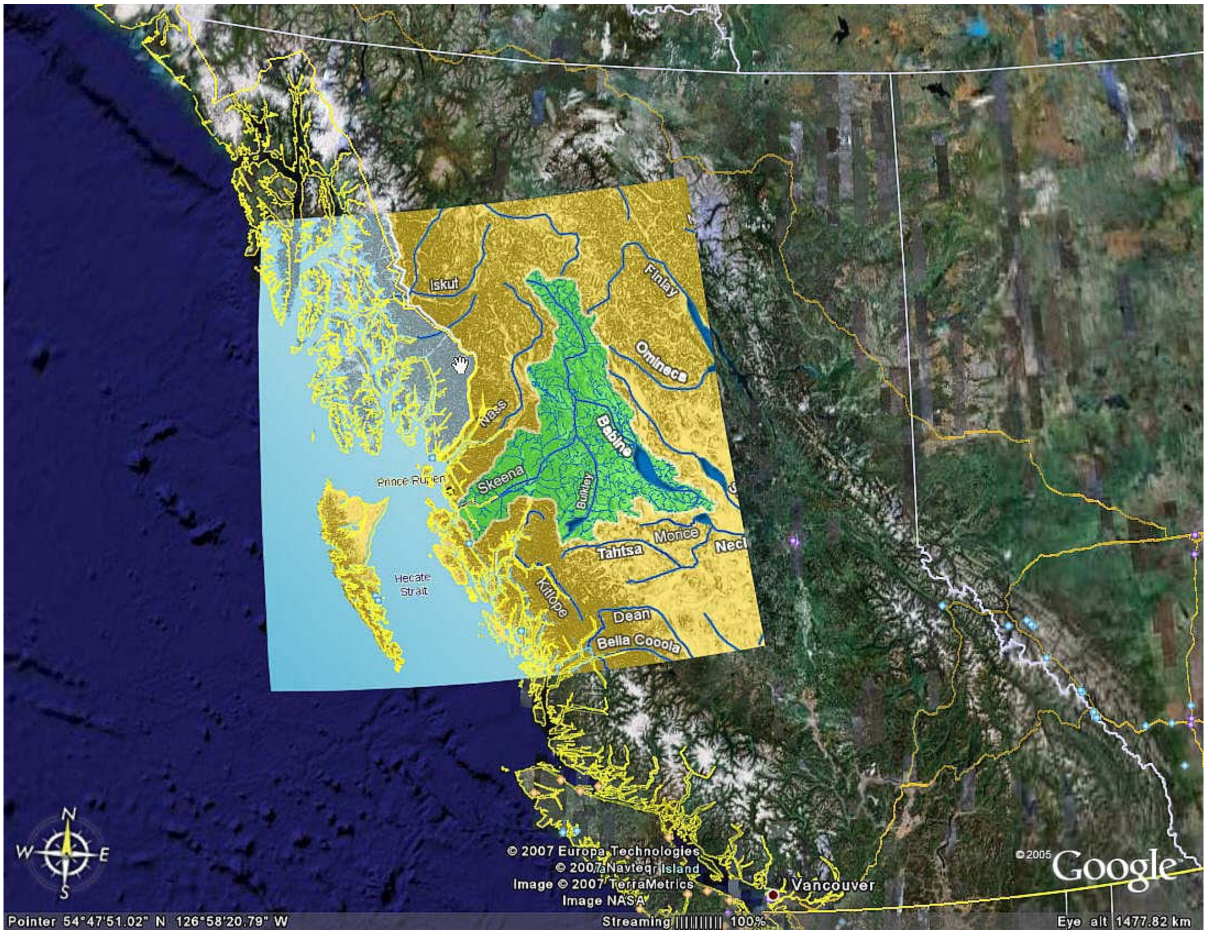

Figure 3 - Skeena River Watershed

There are also a number of large tributaries located in the lower reaches of the lower Skeena River (Figure 4), some of which support eulachon runs, some years. The more dependable eulachon runs typically include the Khyex (watershed code 400-036100) and the Ecstall Rivers (watershed code 400-18200). Both of these rivers were also investigated for location of spawning eulachon substrate in conjunction with the research team from the Metlakatla Fisheries Department. John Kelson authored a report (Kelson, 2010) for the Metlakatla Fisheries Department and DFO which described those activities in detail.

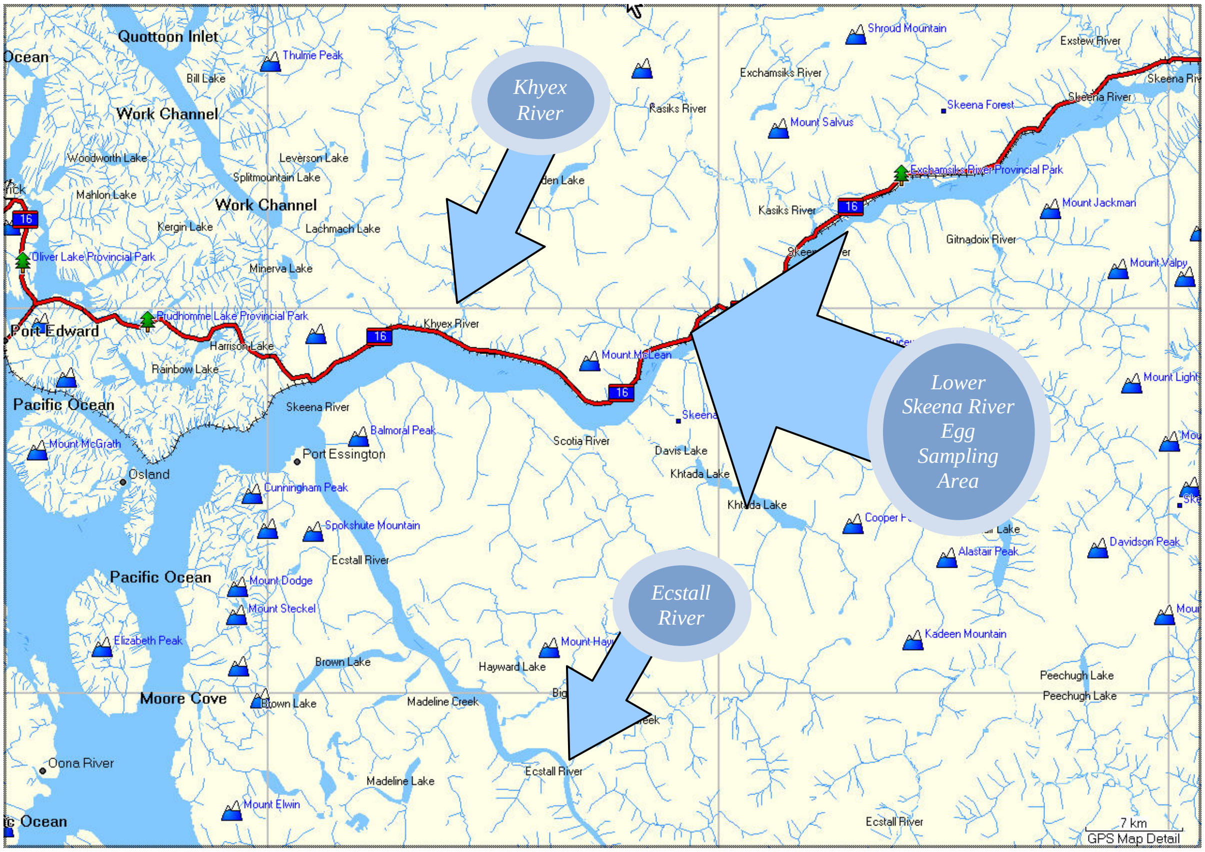

Figure 4 - Overview of the Lower Skeena River

METHODOLOGY

The very first run of eulachons came into the river at the end of January 2010 (D. Roberts, pers. comm.). Fisheries technicians Russel and Kirk Boulton began sampling adult eulachons by gillnetting on March 01, 2010. Biologist Dave Rolston was contacted and subsequently contracted to assist with the field work by March 10, 2010.

During the first week, Mr. Rolston took an inventory of field equipment, and ordered in a *YSI 85* meter, a tethered camera, *Tidbits*®, *Tidbits*® reader and *HOBO*® software, an Ohus CS200 weigh scale, flowmeter and egg preservative. With the assistance of Chief Don Roberts, Mr. Rolston was able to locate the grab sampler, plankton net and sediment containers.

By the end of the second week (18th March), the field sampling crew had equipment needed to adequately sample the eulachon spawning areas, just before the end of the high densities of the later eulachon run and the allotted field sampling days. The positions of gill net, egg and larvae sampling sites as well as associated eulachon habitat, were recorded using a *Garmin 60Cx* GPS unit and plotted using Garmin *Mapsource*® software, while water depths were recorded using a *Garmin Fishfinder 90* depth sounder.

Gill Netting Methodology

Initially, before the inclusion of Mr. Rolston on this project, the Kitsumkalum Fisheries Department field crew set gill nets daily on 2-3 selected suites on the Skeena, returned the next day (~24 hours later) and retrieved the saturated gill nets, then picked the nets clean of eulachons and distributed those eulachons to the village of Kitsumkalum.

Figure 5 - Fisheries Technicians Russel and Kirk Boulton Cleaning Gillnet of Eulachons

Under the direction of Mr. Rolston, a change in gill-netting protocol was affected during the second week. Shorter (i.e. 2-8 hour) gill net sets were carried -out, rather than the 24 hour sets previously maintained by the field sampling crew.

This was due to the fact that a true measure of catch per unit effort (CPUE) could not be accurately assessed with saturated gill nets. Additionally, the field crew was also then directed to accurately weigh the total catch using a reliable bathroom scale so that an accurate CPUE could be estimated.

A subsample of 20 fish from each set was also retained and frozen for later sampling for lengths and weights. A standard smelt net (7m length x 1.5 m depth, 1¼" [3 cm] mesh) was used at each sampling site.

Egg Sampling Methodology

A standard (13 x 17 cm) Ponar grab sampler was located by March 12, 2010, and sampling for eulachon egg masses started immediately. Spawning sites identified in the 2005 eulachon study (Gordon, D. 2005) were resampled for eulachon egg densities.

A tethered ***FISHTV®*** underwater camera was ordered and subsequently arrived by March 18, 2010, coinciding with the arrival of another new "run" of female eulachons into the Skeena and heavy concentrations of spawning eulachons were seen using this camera. Grab samples were taken at these dense spawning concentrations and other sites with sand substrate above the influence of salt water. Depth and water quality parameters including temperature, salinity and visibility, were also noted.

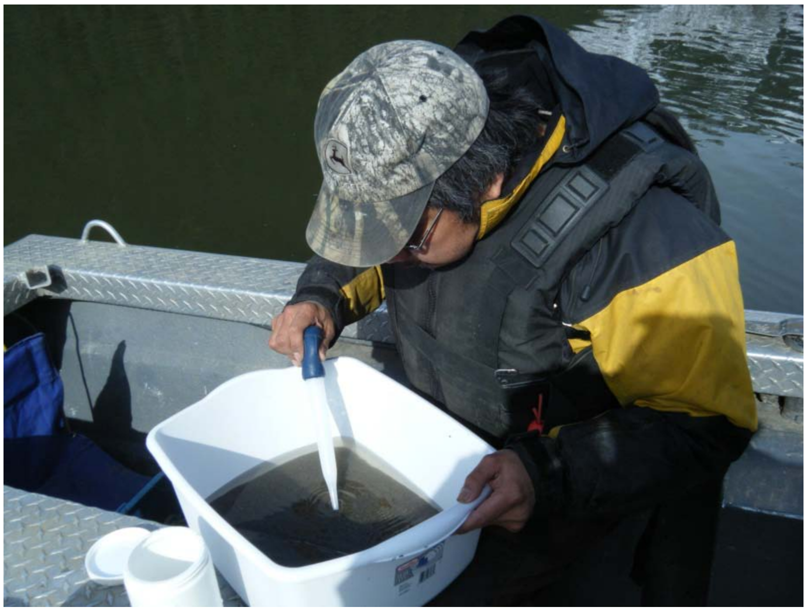

Figure 6 - Fisheries Technician Russel Boulton Sorting Grab Sample Onboard

Primary sorting was completed onboard after each grab sample (Figure 6). Sand substrate taken by the Ponar grab sampler was immediately deposited into a wash basin and sorted using a circular motion, similar to gold-panning methods. The lighter egg masses appeared as clumps of sand on the surface of the sampled substrate and were sucked-up using a turkey baster and placed in a labeled sample jar along with excess sand entrained by the suction of the baster.

Secondary and final sorting was later accomplished on land by adding hot water to the saved egg samples and waiting a minimum of 15 minutes. At that time, eggs concealed by attached sand died and turned white and dropped some of the sand, making identification easy. These eggs from the purified grab sample were again processed using identical methodology as the primary sorting, and then were weighed and preserved using Stockard's Solution preservative. High density samples were weighed and abundances estimated, while low density samples were counted.

Staff Gauge and Tidal Cycle Estimation Methodology

On March 10, 2010, a 10m fiber measuring tape was installed on the vertical wood pile at the launch site at Kwinitsa (Figure 7). At each launch and retrieval of the boat, water heights on the gauge and times were noted.

Figure 7 - Staff Gauge at Kwinitsa

On April 11, 2010, water height readings from this staff gauge were noted every 15-20 minutes and subsequently compared against the tidal cycle at Prince Rupert. The times and heights of low and high water were then estimated for the Kwinitsa area of the Skeena River during the previous egg sampling dates, and the water depths of the samples were then corrected to read as a low tide standard. These corrected depths were then used to reconstruct the bottom profile of the spawning habitat using *Surfer Demo®* software Version 9.8.669 (Golden Software, Inc) for sites with adequate depth soundings (i.e. "*Site 2*", "*Corner 73.7 km*" and "*Mud Creek*").

Automated Temperature Recorders

Without prior knowledge of current eulachon spawning sites, *Tidbits®* were placed initially at the launch site at Kwinitsa, downstream of the past known spawning sites, when the equipment arrived on March 16, 2010. This included 2 *Tibdits®*; one recording water temperatures, the other recording air temperatures.

Once the high density spawning sites were identified, the Kwinitsa *Tidbit®* recording water temperatures was relocated away from the potential conflicting influence of the discharge from the Kwinitsa Creek, 10 km upstream adjacent to the incubating egg masses (Table 1).

An additional *Tidbit®* was placed lower in the estuary on Raspberry Island to record rearing temperatures for the later hatching larvae on March 29, 2010 (Table 1).

Table 1 - Locations of Temperature-recording Tidbits

Name Site	*Latitude/Longitude*	*UTM Co-ordinates*
Kwinitsa staff gauge	54º 13.269’ N 129º 34.654’ W	9 U 462341 6008282
upstream km 80	54º 15.287’ N 129º 26.133’ W	9 U 471624 6011957
Raspberry Island	54º 10.755’ N 129º 56.943’ W	9 U 438059 6003881

Accumulated Thermal Units (ATUs)

Using a combination of sampled water temperatures, and the data from the placed *Tidbits®*, the water temperatures of the mainstem of the Skeena River were reconstructed so that Accumulated Thermal Units (ATUs) could be assessed and time of hatch of incubating eulachon eggs into larvae could be estimated and predicted.

This information was then used to plan timing of larval sampling trips, to assess the length of stay of larvae in larval holding and rearing habitat, and to assess the potential for retention processes for larvae within the Skeena Estuary. We used the estimate for the number of Accumulated Thermal Units (ATUs) required to hatch eulachon eggs as 369.6 (from Smith and Saalfeld 1955).

Larvae Sampling Methodology

A 0.5m diameter conical plankton net (130 micron mesh) was used to sample for eulachon larvae at the same depth that eggs were found (4m), unless the site was shallow. Sites in tributaries were sampled during a dropping tide, and above the limit of the entrained turbid Skeena water so that only larvae produced from that tributary (if any) were captured. A General Oceanics Inc. Model 2030R standard flowmeter was used to estimate volume of water filtered with the plankton net (Figure 8).

Figure 8 - Technician Kirk Boulton Sampling Larvae

Samples were preserved in 5% formaldehyde, and initial sorting of fish larvae from debris in the filtrate was accomplished using a 3x power diopter magnifier with a 22 watt light and a black pan which provided excellent contrast for lighter preserved larvae (Figure 9). Estimates were made of total sample jar larvae contents for samples with excessive debris and/or larvae. Purified samples were then later examined under a dissecting microscope for species ID. Various keys, such as Matarese et al. (1989) and Levesque (2008) were used in speciating larvae.

Figure 9 - Larval Sorting Equipment

RESULTS

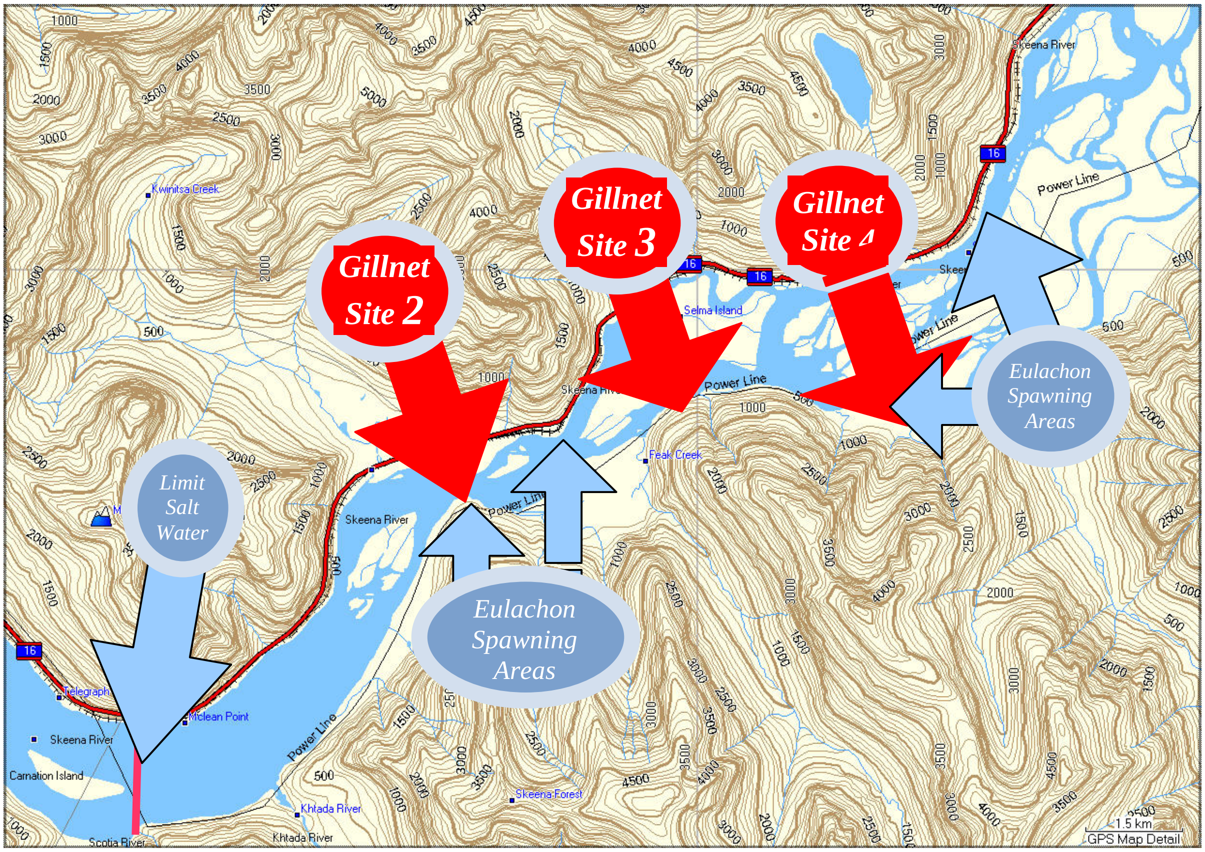

Figure 10 - Overview Map of Sampling Area, Lower Skeena

Figure 10 shows relative positions of gill net and spawning sites on the lower Skeena River.

Gill Netting Results

Table 2 gives the positions of the gill nets, while Table 3 shows results from the gill netting. Some samples from some sites were discarded due to mislabeling, so there are gaps in the data. However, note that the ratio of females to males found in the sampled population generally varies from a larger proportion of females at the presumed start of a new run of eulachons, to a very small percentage of females remaining at the end of the run. In total, over the whole 2010 sampling period, only 20.67% of the eulachons caught were female.

Table 2 - Positions of Gill Net Sites

Site #	Name	UTM	Lat/Long
2	Don's Cabin	9 U 463748 6007999	54°13.123'N 129° 33.358'W
3	Fike's Point	9 U 467532 6009561	54° 13.980'N 129° 29.886'W
4	Site 4	9 U 470473 6009359	54° 13.882'N 129° 27.179'W

Table 3 - Catch and Catch Effort of 2010 Gill-netting

	Soak Time			Catch Data		
Site #	**Time In**	**Time Out**	**Soak Time (hr:mm)**	**Totals**	**CPUE (# Fish/Hr.)**	**Ratio Females (%)**
All	01/03/2010 9:10	02/03/2010 9:10	24:00	1147	47.79	23
All	02/03/2010 9:10	03/03/2010 9:10	24:00	803	33.46	53
All	03/03/2010 9:10	04/03/2010 9:10	24:00	688	28.67	22
All	04/03/2010 9:10	05/03/2010 9:10	24:00	1090	45.42	20
All	05/03/2010 9:10	06/03/2010 9:10	24:00	975	40.63	16
All	06/03/2010 9:10	07/03/2010 9:10	24:00	918	38.25	11
All	07/03/2010 9:10	08/03/2010 9:10	24:00	803	33.46	14
All	08/03/2010 9:10	09/03/2010 9:10	24:00	631	26.29	14
3	09/03/2010 9:10	10/03/2010 10:45	25:35	459	17.94	5
2	09/03/2010 9:10	10/03/2010 9:10	24:00	654	27.25	4
All	***10/03/2010***		49:35	1113	22.45	4
2	10/03/2010 10:20	10/03/2010 12:28	2:08	390	182.63	7
3	10/03/2010 12:05	11/03/2010 10:05	22:00	389	17.70	7
All	***11/03/2010***		24:08	779	32.28	7
4	11/03/2010 12:00	12/03/2010 11:55	23:55	N/A	N/A	N/A
2	12/03/2010 10:10	12/03/2010 11:40	1:30	N/A	N/A	N/A
All	11/03/2010 9:10	12/03/2010 9:10	24:00	824	34.33	16
All	***12/03/2010***		49:25	824	16.67	16
2	15/03/2010 14:15	15/03/2010 15:20	1:05	54	49.85	4
2	15/03/2010 15:20	16/03/2010 9:50	18:30	275	14.88	3
3	16/03/2010 11:10	16/03/2010 14:21	3:11	507	159.26	6
All	***16/03/2010***		21:41	782	36.08	5
2	17/03/2010 9:10	17/03/2010 14:10	5:00	94	18.80	3
3	17/03/2010 9:25	17/03/2010 12:48	3:23	165	48.82	3
All	***17/03/2010***		8:23	833	99.36	N/A
3	17/03/2010 12:48	18/03/2010 10:40	21:52	906	41.44	87
2	18/03/2010 10:40	18/03/2010 13:40	3:00	N/A	N/A	N/A
All	***18/03/2010***		24:52	N/A	N/A	N/A
2	18/03/2010 13:30	19/03/2010 9:10	19:40	N/A	N/A	N/A
3	18/03/2010 13:40	19/03/2010 10:35	20:55	N/A	N/A	N/A
2	19/03/2010 9:10	19/03/2010 10:35	1:25	N/A	N/A	N/A
All	***19/03/2010***		42:00	N/A	N/A	N/A
3	22/03/2010 6:40	23/03/2010 9:10	26:30	238	8.98	0
		Totals:	**659:43**	**16342**	**24.77**	<Total Watershed CPUE

Table 4 lists the sampled lengths and weights of the sampled eulachons by date and site, while Figure 11 compares the fork lengths of captured eulachons by sex. The average fork length of male eulachons was 17.9 ± 1.05 cm (n=176), where the females were slightly smaller at 17.2 ± 0.96 cm (n=57).

Table 4 - Lengths and Weights of Gill Net-Caught Eulachons by site and Date

		Eulachon Fish Data – Males								Eulachon Fish Data – Females							
Site #	Date/Time Set	Average Length (cm)	Std Dev (cm)	Average Wt (g)	Std Dev (g)	Ave. Gonads Wts (g)	Std Dev (g)	GSI (% weight)	Std Dev	Average Length (cm)	Std Dev (cm)	Average Wt (g)	Std Dev (g)	Ave. Gonads Wts (g)	Std Dev (g)	GSI (% weight)	Std Dev
3	09/03/2010 9:10	17.75	0.90	39.01	6.29	0.97	0.52	2.48	1.33	17.88	1.36	41.88	8.69	7.80	3.42	18.78	7.81
2	09/03/2010 9:10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16.68	0.89	33.97	6.07	6.44	2.91	18.60	7.33
2	10/03/2010 10:20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17.05	0.65	36.75	3.52	7.43	1.38	20.15	2.90
3	10/03/2010 12:05	18.33	0.91	41.57	5.74	0.76	0.22	1.83	0.22	17.86	1.09	38.58	5.08	6.58	3.00	16.66	6.24
2	15/03/2010 14:15	17.65	1.20	38.45	7.60	1.48	0.93	3.72	1.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	15/03/2010 15:20	17.61	1.10	35.53	7.19	0.55	0.31	1.53	0.85	17.00	0.76	32.74	7.42	6.14	3.41	17.75	6.80
2	17/03/2010 9:10	17.66	0.77	31.27	5.30	0.45	0.35	1.19	0.80	17.60	1.85	29.17	7.09	4.13	1.50	14.13	4.43
3	17/03/2010 9:25	18.24	1.25	41.35	9.14	0.84	0.38	1.99	0.57	17.80	0.26	40.87	4.51	8.47	1.33	20.68	1.62
3	17/03/2010 12:48	17.83	1.24	36.20	9.40	0.96	0.56	2.65	1.57	16.44	0.96	31.84	4.15	7.20	1.16	22.57	1.29
3	22/03/2010 6:40	18.09	0.81	38.185	6.39	0.97	0.38	2.50	0.82	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes: Wt = Weight, GSI = Gonosomatic Index, cm = cemtimeter, g = grams.

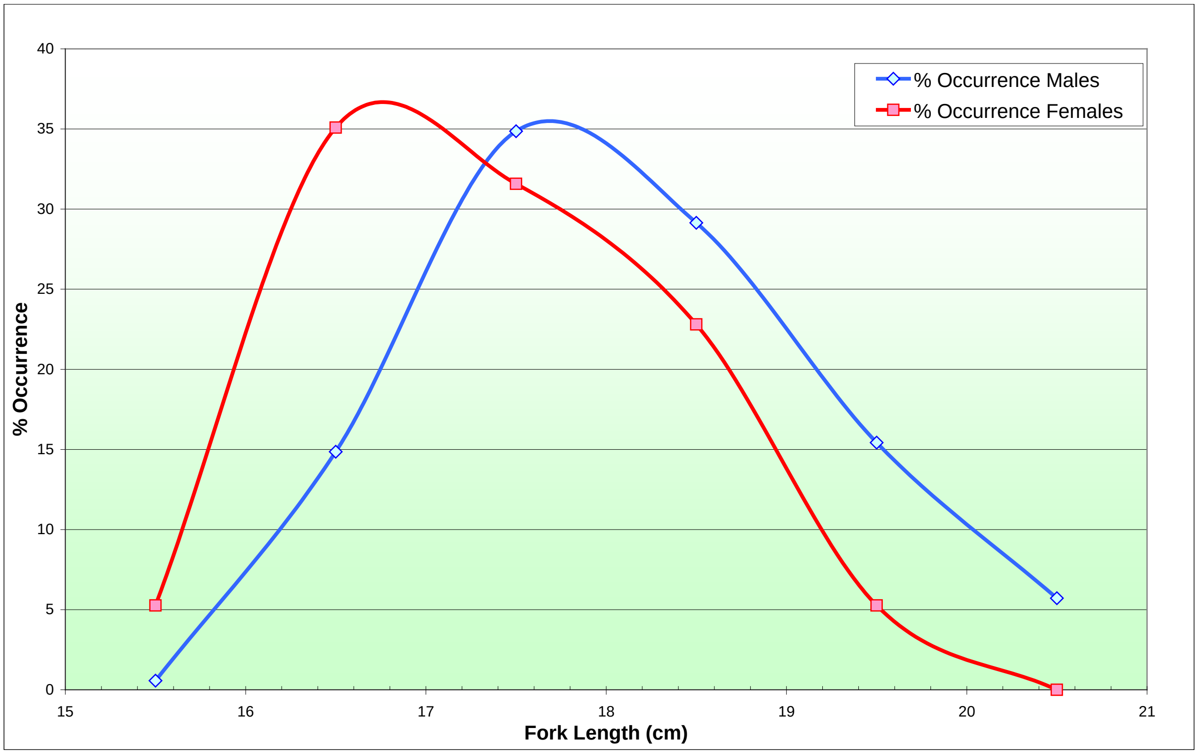

Figure 11 - Fork Lengths of Male and Female Eulachons

Egg Sampling Results

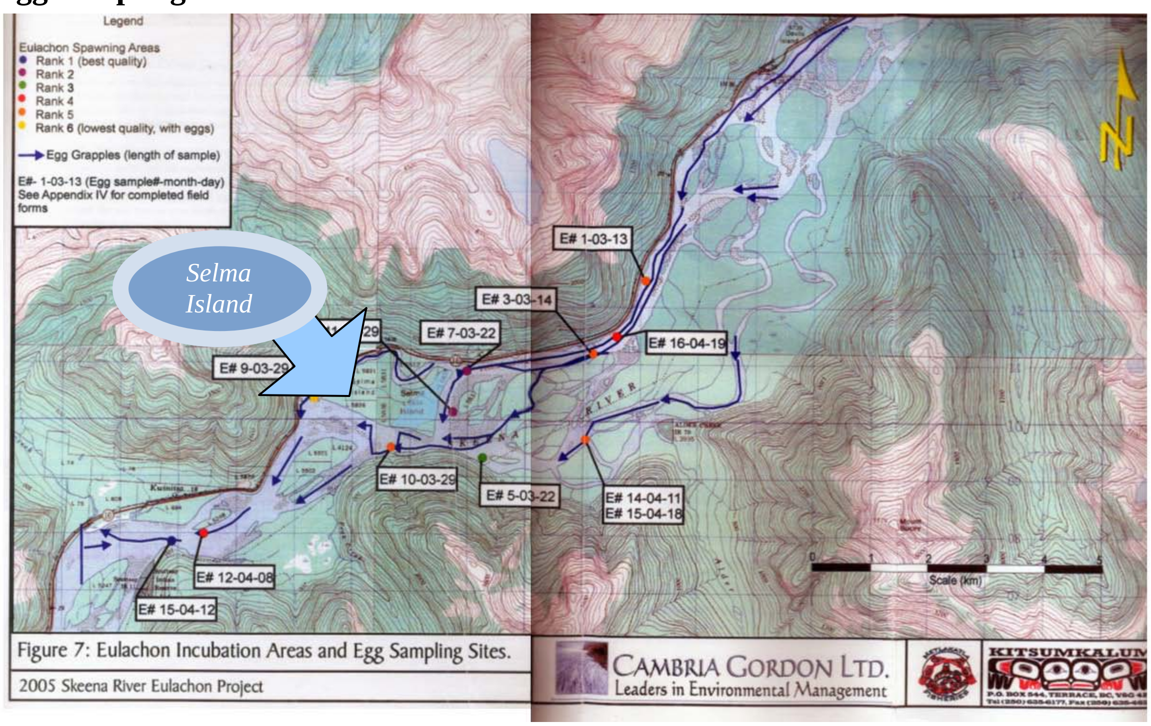

Figure 12 - Egg Sampling Sites 2005 (Gordon et al 2005)

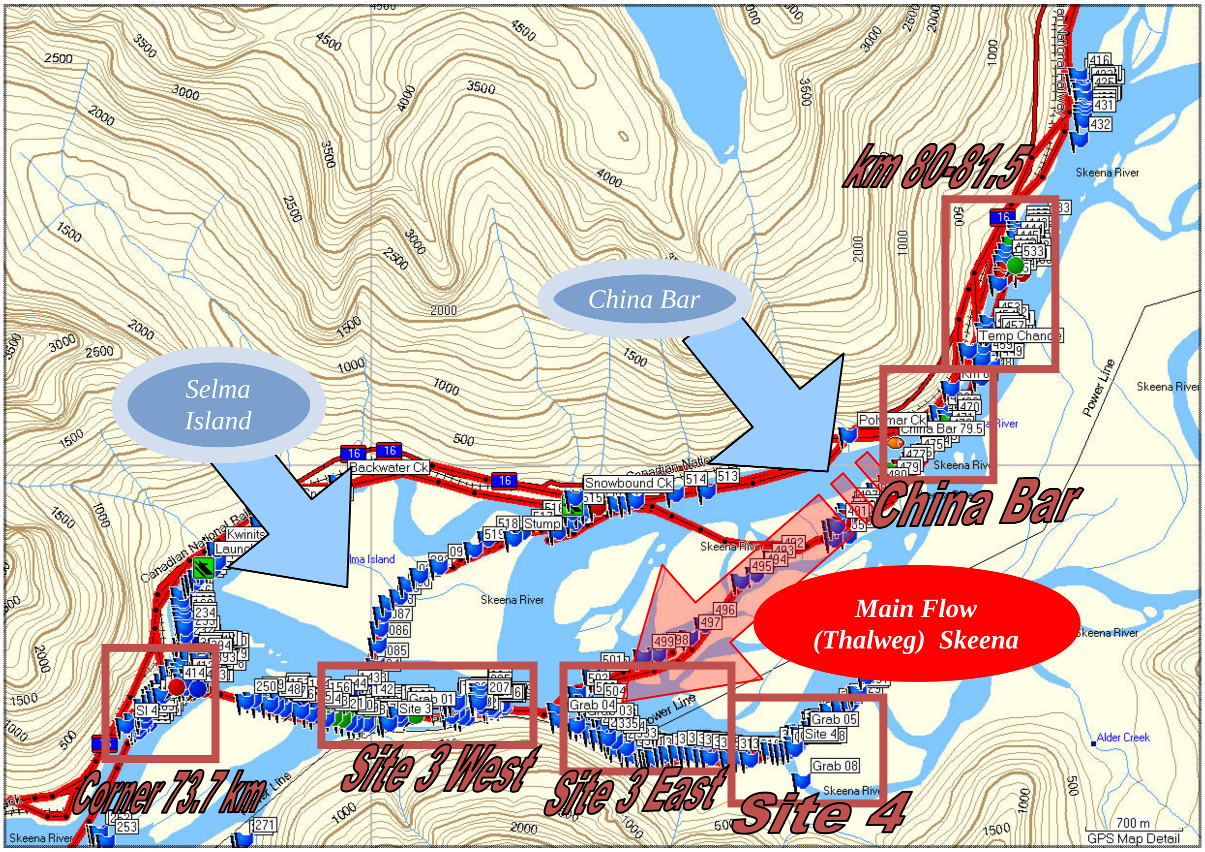

Figure 13 – Overview of Egg Sampling Sites 2010

Changes in eulachon spawning habitat induced by the 2007 flood conditions can be illustrated by comparing Figures 12 and 13. Figure 12 shows egg sampling done by Gordon et al (2005) in 2005. Figure 13 shows the results from 2010, where blue flags represent depth and/or egg sampling sites, and where the red lines show track lines where the boat has traveled in a thalweg (channel). Since 2005, the main thalweg has shifted, south of China Bar, and Selma Island has been cut in half.

We were unable to record the images observed in the video from the tethered camera since there were no RCA jacks manufactured on the camera. However, notes were made of these observations which were geo-referenced using the GPS unit and subsequently displayed on the following detailed maps of each site (Figures 14-21).

Blue flags indicate no eulachons observed and also reflect depth soundings. Green flags indicate a few eulachons were observed, as well as making depth data. Red flags indicate heavy concentrations of eulachons, as well as depth readings. Blue circles indicate a grab sample with no egg found, as well as a depth sounding. Green and red circles indicate positions of eulachon spawning, with green circles indicating low to moderate amounts of eggs (0-30,000 eggs m^{-2}) and red circles indicating high density spawning sites (30,000-2,700,000 eggs m^{-2}). Moderate to high density spawning sites were found in corrected water depths of -3.16±1.9 m (n=13). Details of soundings, fish observations and egg sampling results are given in Table 5 in the Appendix, for each waypoint. The highest density spawning sites were at Site 2, the corner at 73.7 km, and km 80 – 81.5 of Highway 16.

Site 2 Spawning Area

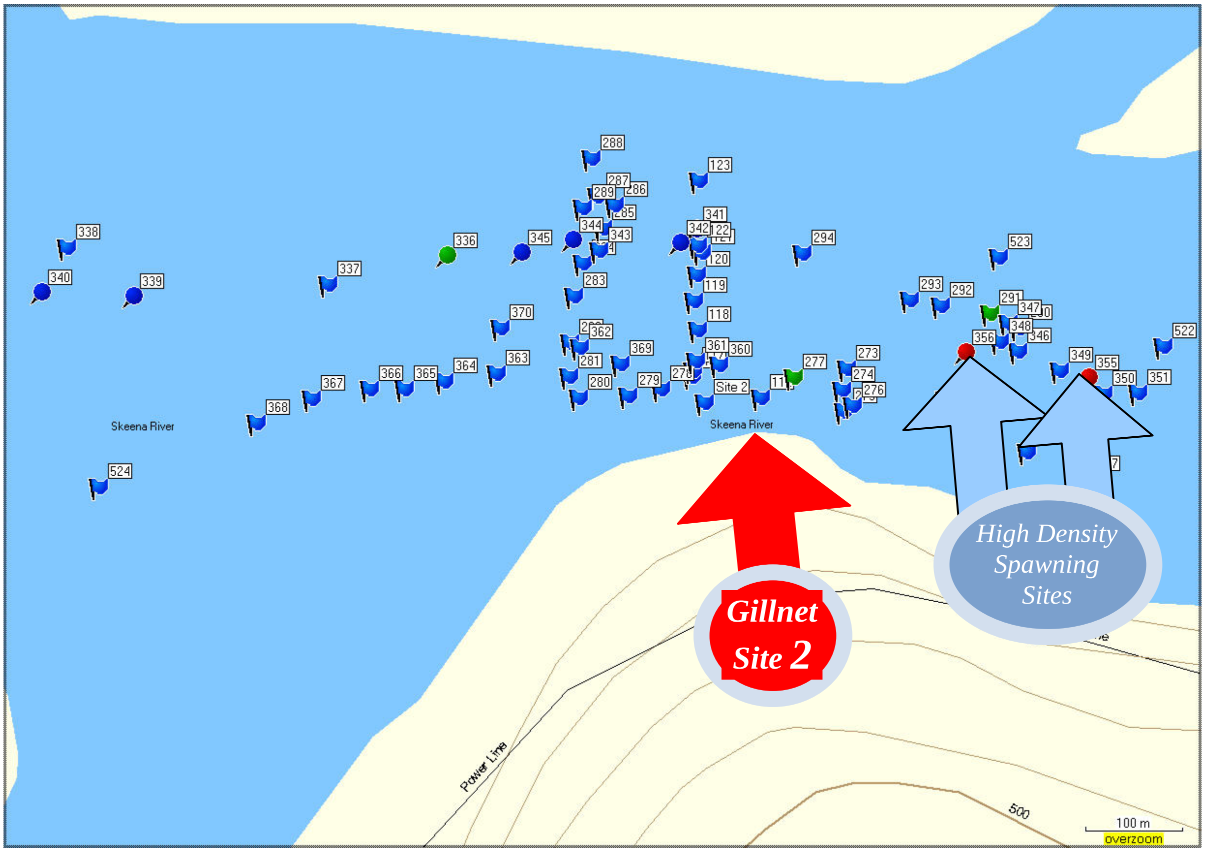

Figure 14 - Details of Spawning Area near Site 2

Figure 14 shows the results of both the egg sampling and observations using the tethered camera at site 2, where Figure 15 illustrates the bottom topography and the egg sampling results obtained using the Surfer software. Larger black circles in Figure 15 indicate the high-density spawning sites at waypoints 355 (189,036 eggs m^{-2}) and 356 (355,388 eggs m^{-2}). The deep area (~9m) immediately Northeast of the gill net site (*i.e.* waypoint 277) was noted as a holding area for spawning eulachons. Figure 16 shows bottom profile in a 3D aspect.

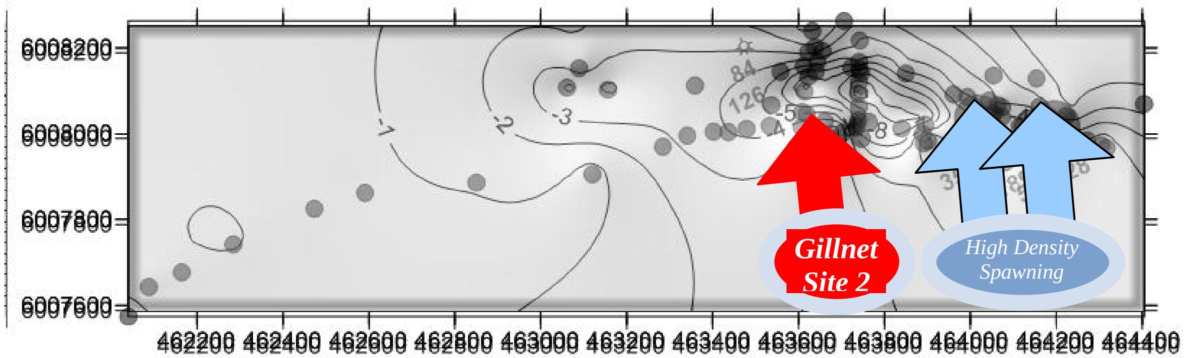

Figure 15 - Bottom Profile and Egg Sampling Results Site 2

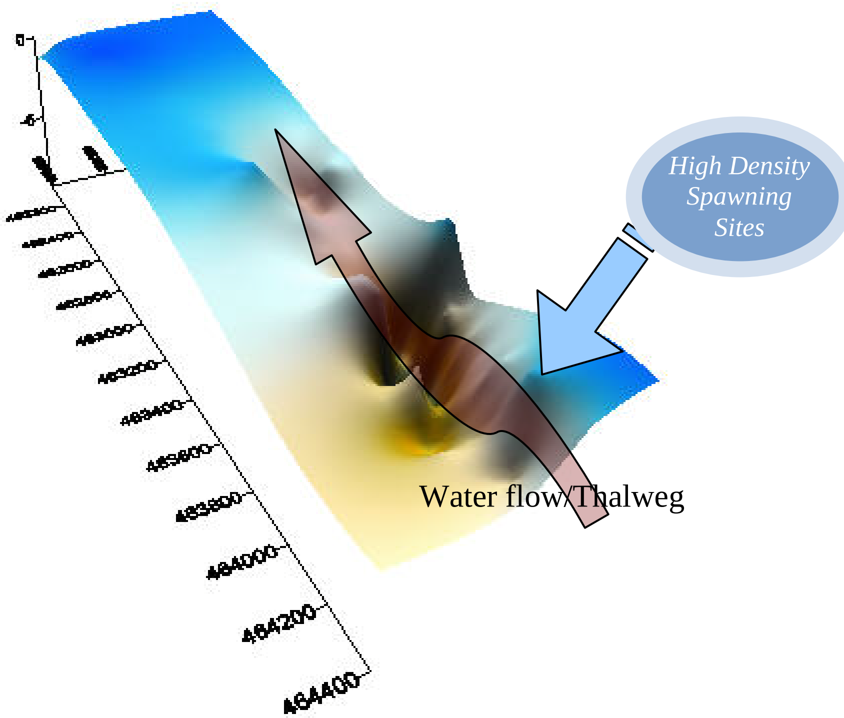

Figure 16 - 3D model of Spawning Habitat near Site 2

Site 3 Spawning Area

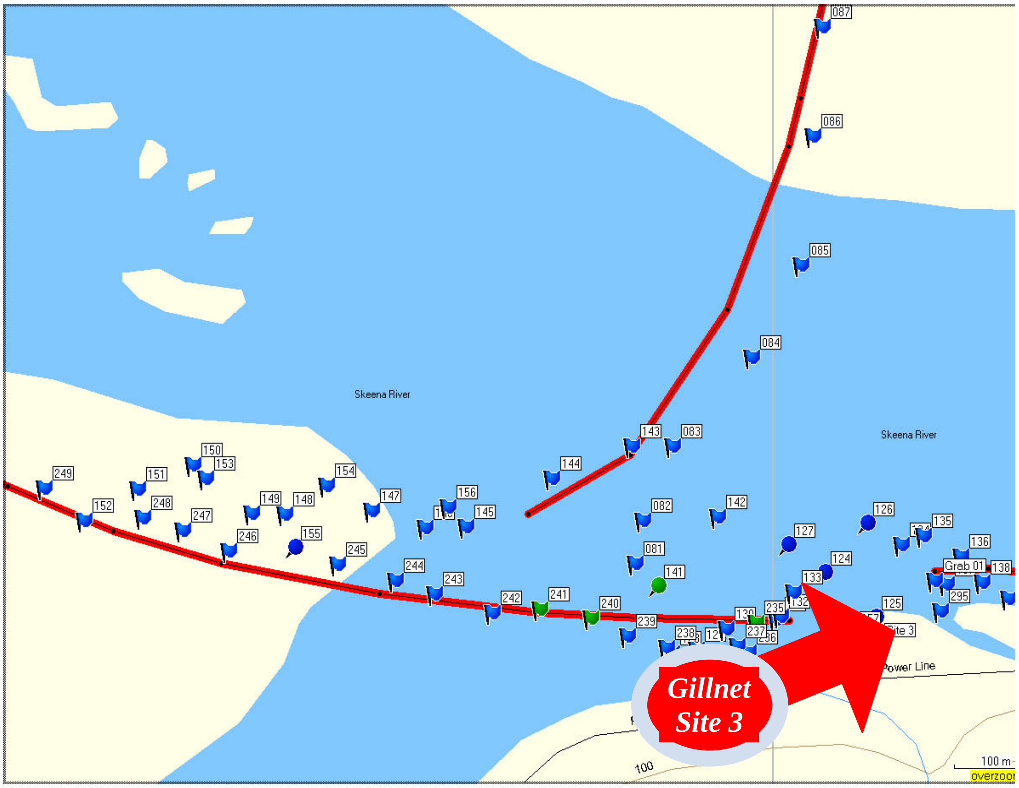

Figure 17 - Details of Spawning Area to the West of Site 3

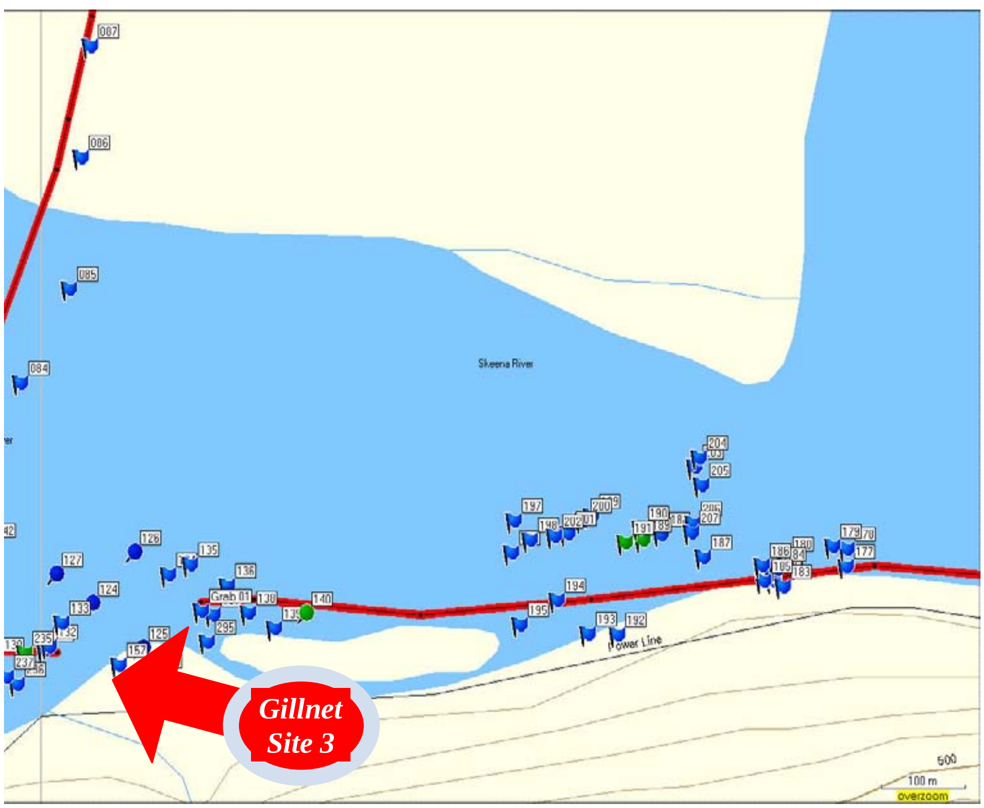

Figure 18 - Details of Spawning Area to the East of Site 3

No high density spawning sites were found near site 3 (Figures 17 & 18); only 2 low-density sites at waypoints 140 (420 eggs m^{-2}) and 421 (914 eggs m^{-2}).

Site 4 Spawning Area

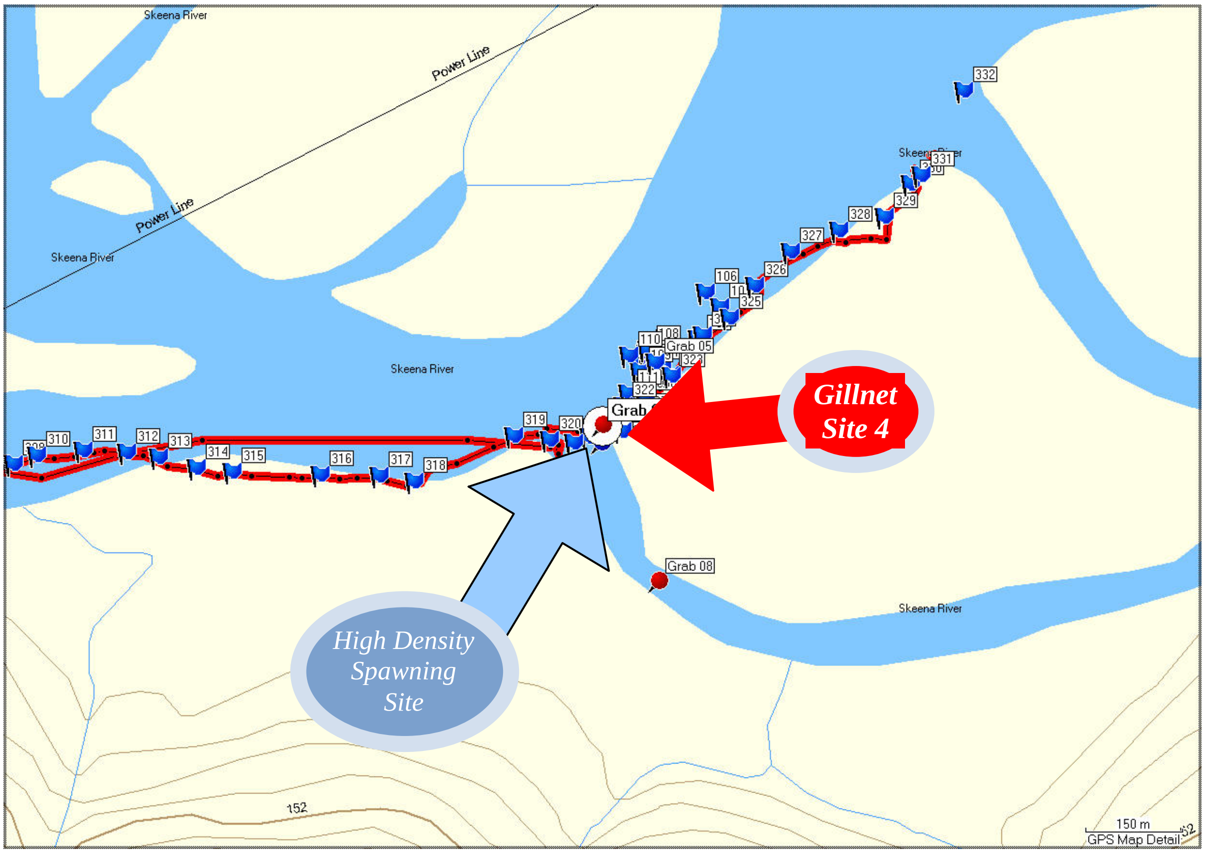

Figure 19 – Details of Spawning Area near Site 4

There was 1 high density spawning site near Site 4 (Figure 19); waypoint "Grab 02" (68,053 eggs m^{-2}), and 1 low-density site at waypoint "Grab 04" (7,561 eggs m^{-2}).

Corner at 73.7 km of Highway 16

Figure 20 shows the results of both the egg sampling and observations using the tethered camera at the site at the corner at km 73.7 of the highway, and Figure 21 illustrates the bottom topography and the egg sampling results obtained using the Surfer software. Larger black circles in Figure 21 indicate the high-density spawning sites at waypoints 223 (37,009 eggs m^{-2}), 371 & 372 (302,458 eggs m^{-2}), and 414 (37,807 eggs m^{-2}). There are also low- to moderate-density sites at waypoint 214 (17,476 eggs m^{-2}), 221 (8,224 eggs m^{-2}), and 373 (756 eggs m^{-2}). Figure 22 shows bottom profile in a 3D aspect.

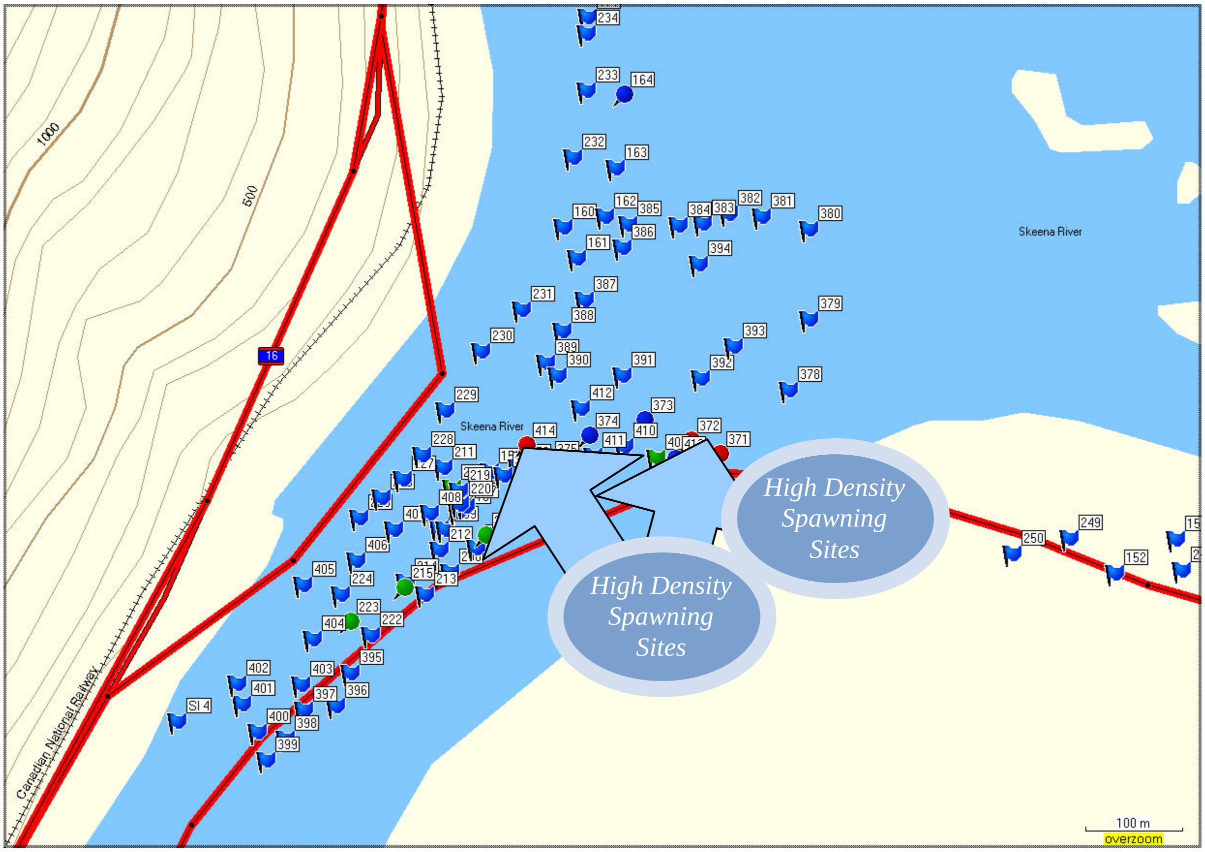

Figure 20 – Details of Spawning Area near km 73.7 of Highway 16.

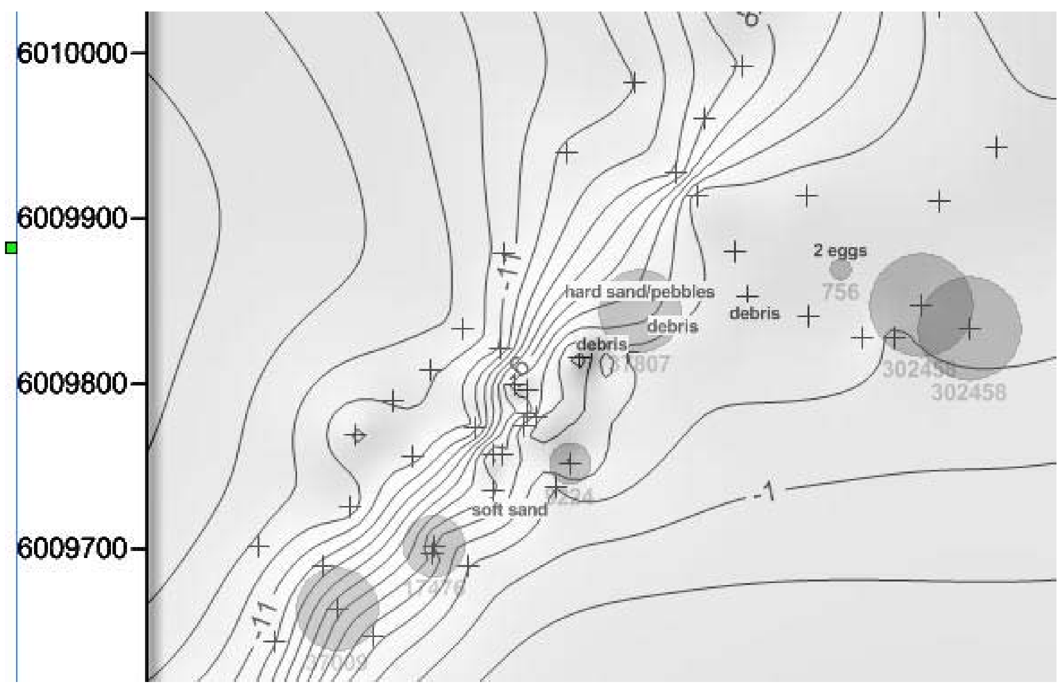

Figure 21 –Bottom Profile and Egg Sampling Results from Corner at 73.7 km

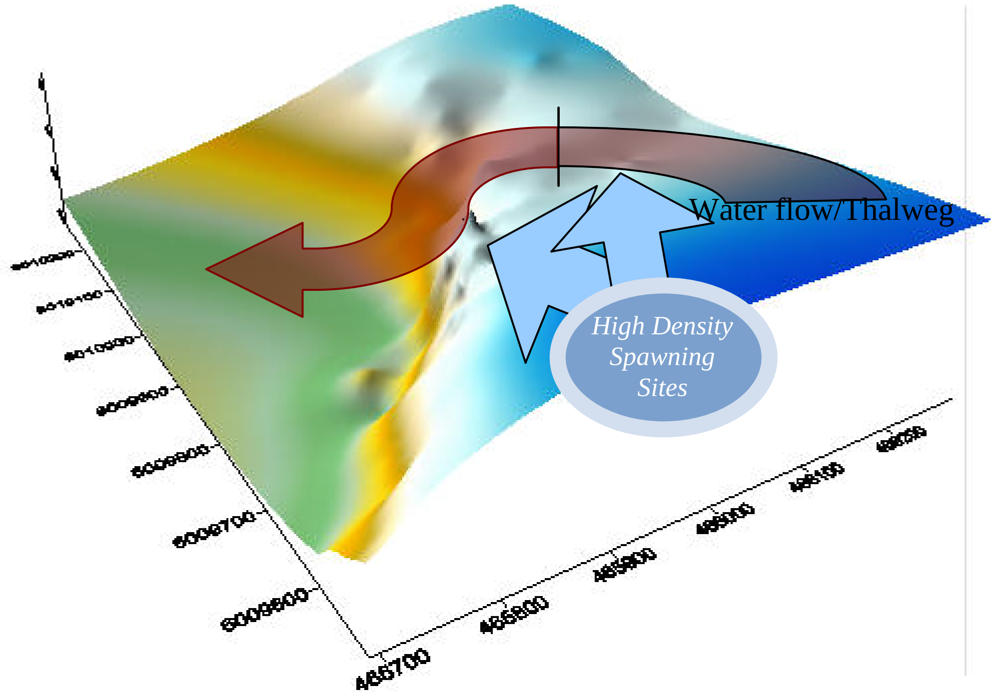

Figure 22 - 3D model of Spawning Habitat near km 73.7 of Highway

China Bar

Figure 23 shows the results of both the egg sampling and observations using the tethered camera at China Bar. The area immediately to the Southeast of China Bar (i.e. waypoints 473-476, 479, 488, 490) was noted as a holding area for spawning eulachons. No spawning was observed, and no eggs were found near the bar.

Figure 23 – Details of Holding Area near China Bar

Km 80 – 81.5 Highway 16 (above China Bar)

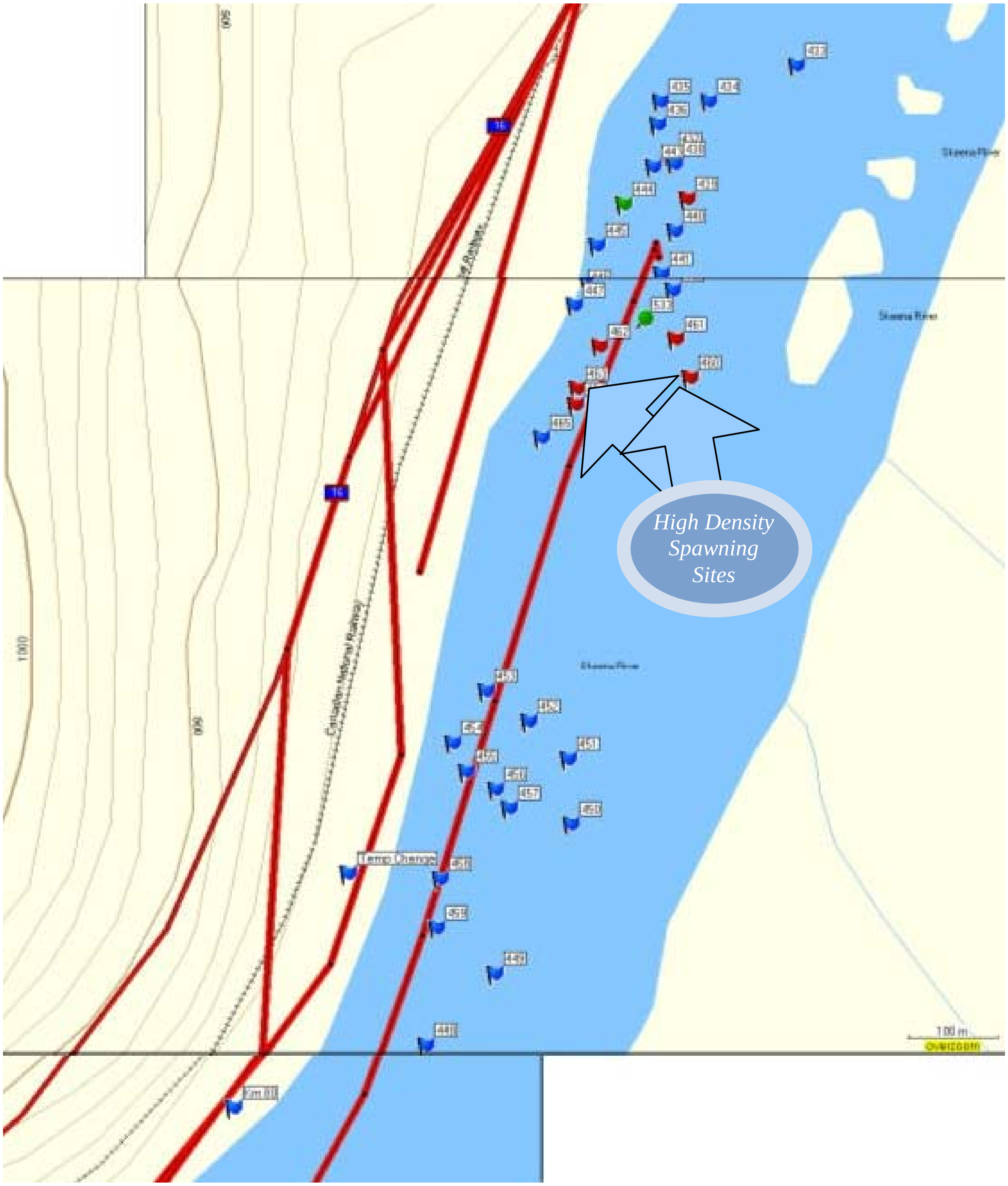

Figure 24 – Details of Spawning Area near km 80 – 81.5 of Highway 16

Figure 24 shows the results of both the egg sampling and observations using the tethered camera at the site between km 80 and 81.5 of Highway 16. High-density spawning sites were found at waypoints 439 (81,213 eggs m^{-2}) and 462 (2,744,803 eggs m^{-2}). Waypoint 462 contained the highest density of eggs of all the spawning sites that we found, with eggs in a layer covering 2.5 cm in depth.

Ecstall River

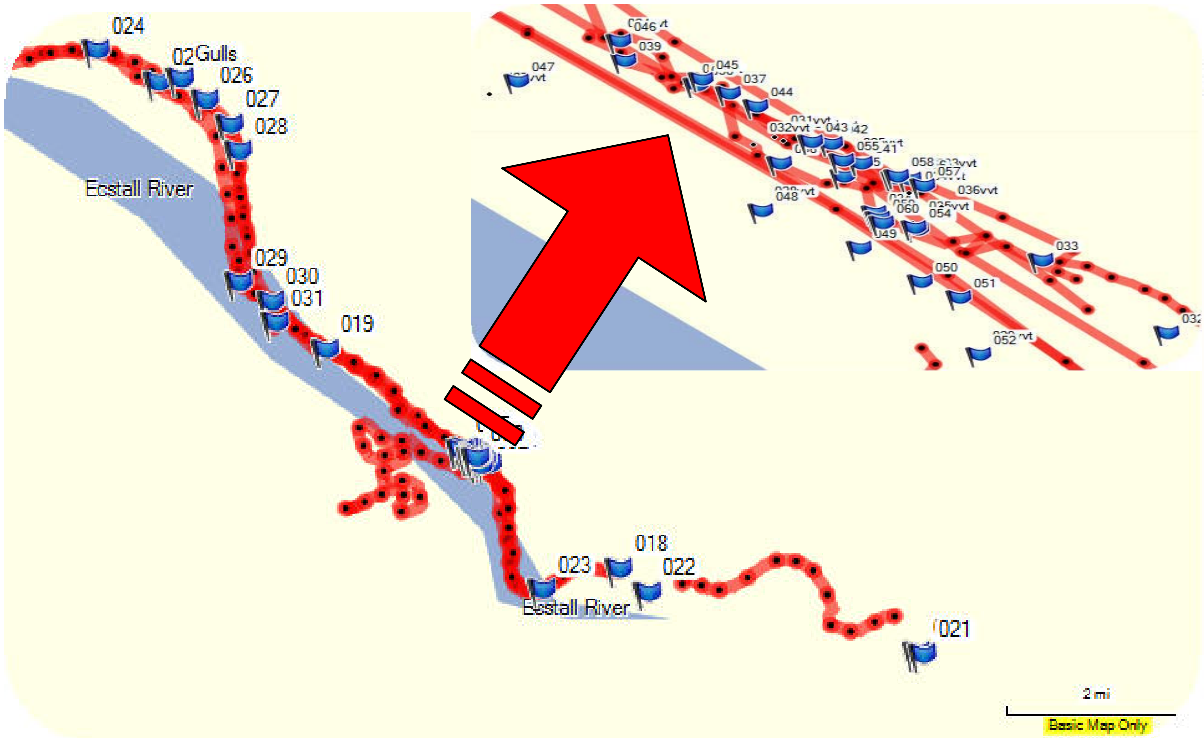

Figure 25 – Details of Spawning Area near Mud Creek on the Ecstall River.

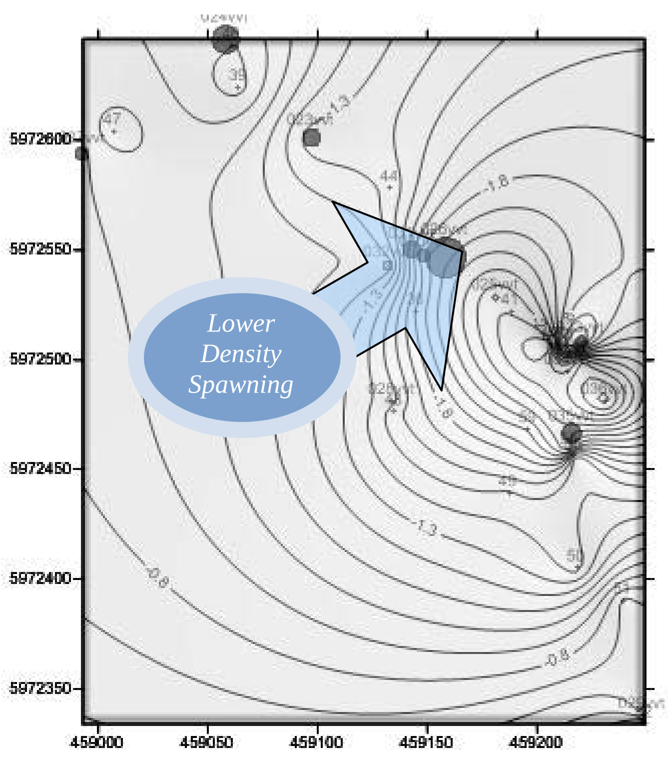

Figure 26 –Bottom Profile and Egg Sampling Results from Mud Creek/Ecstall

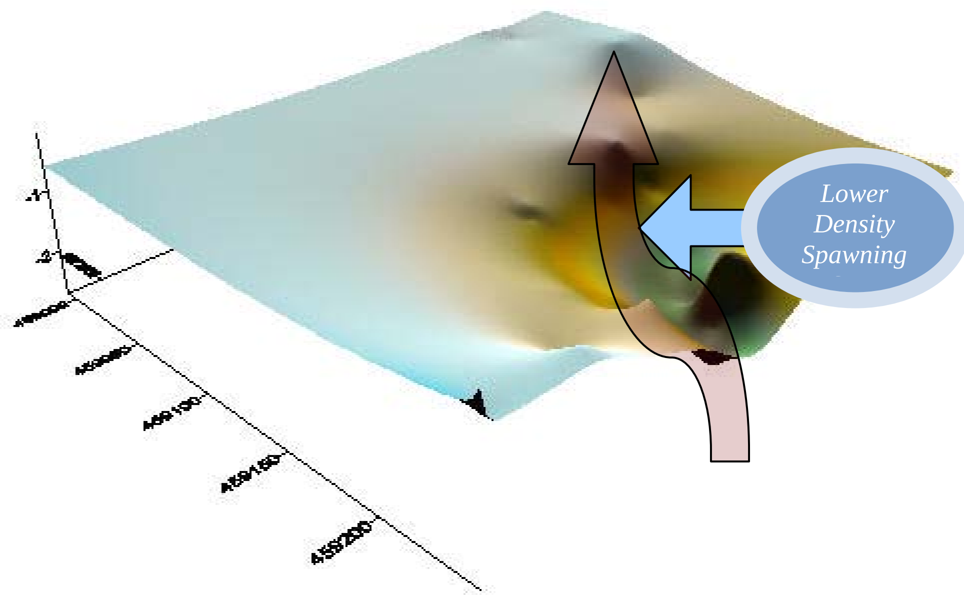

Figure 27 - 3D model of Spawning Habitat near Mud Creek, Ecstall River

Figure 25 shows the results of both the egg sampling and observations using the tethered camera at the spawning site near Mud Creek in the mainstem of the Ecstall River, where Table 6 in the Appendix lists the waypoints in detail.

Low-density spawning sites were found at waypoints 06vvt (6,044 eggs m^{-2}), 024vvt (2,304 eggs m^{-2}), 035vvt (826 eggs m^{-2}), 023vvt (696 eggs m^{-2}), 031vvt (522 eggs m^{-2}), 030vvt (304 eggs m^{-2}), 027vvt (261 eggs m^{-2}), 025vvt (87 eggs m^{-2}), and 32vvt (47 eggs m^{-2}).

Egg density in this area of the Ecstall varied with depth. Eggs were generally more abundant in the deeper section of the pool near the mouth of Muddy Creek between 2m and 3.6m but eggs were found in as shallow as 0.8m (Kelson, 2010).

Figure 26 illustrates the bottom topography and the egg sampling results obtained using the Surfer software. Larger black circles in Figure 26 indicate the low-density spawning sites at waypoints 024vvt to 032vvt. Figure 27 shows the bottom profile in a 3D aspect.

Small-Scale Spawning Habitat Requirements

Figure 28 is an example of "typical" high-density eulachon spawning substrate as observed using the tethered camera. Eulachons were observed spawning at the upstream end of sand bars during the day, in the pans of sand found behind clumps of cobble and rock, at a water depth where there is boundary between the turbulent fast-flowing water and the slower-moving water in the deeper pools that accumulated debris, such as leaves. In the mainstem of the Skeena River, this was at a depth of -3.16±1.9 m (n=13), corrected for tides.

Figure 28 - Example of "Typical" High-Density Eulachon Spawning Substrate

In the Ecstall River, with reduced flows and velocities as compared to the mainstem of the Skeena, this type of high-density spawning habitat was not found. Instead, eulachons were found utilizing a lower-density spawning habitat, with respect to both much reduced egg numbers, as well as a lesser number of spawners. Eggs were found at shallower depths of between 2m and 3.6m but also found in as shallow as 0.8m (Kelson, 2010).

In the Ecstall River, instead of using small pans of sand behind cobble/rock structure, eulachons were spawning in the troughs between the crests in submerged sand dune substrate. Figure 26 illustrates the type of habitat utilized by the eulachons for spawning in the Ecstall River, except that the sand dunes shown in the photograph would be too shallow for spawning eulachon to successfully utilize since these sand dunes are actually dry at low tide (as shown in the photograph).

Figure 29 - Example of "Typical" Low-Density Eulachon Spawning Substrate

Staff Gauge and Tidal Cycle Estimation Results

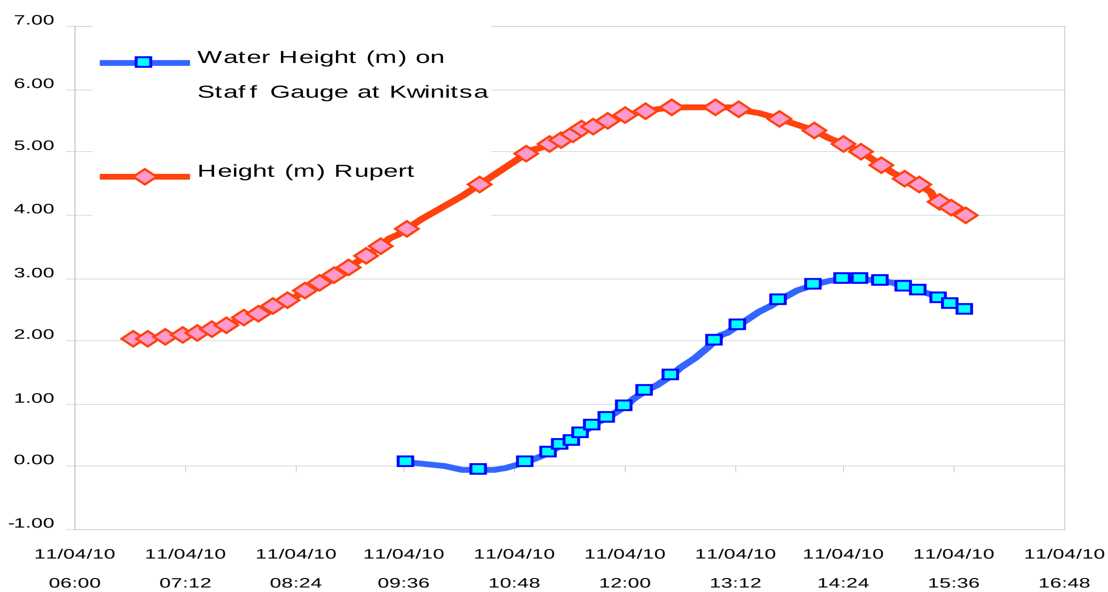

Figure 30 - Comparison of Kwinitsa and Prince Rupert Tides and Heights

It was found that high tide occurred at Kwinitsa 1h35m past high tide in Prince Rupert (Figure 30), while low tide at Kwinitsa occurred 3h47m past the time of low tide in Prince Rupert. The overall tidal heights at Kwinista were 82% of Prince Rupert heights for that sampling date.

Automated Temperature Recorder Results

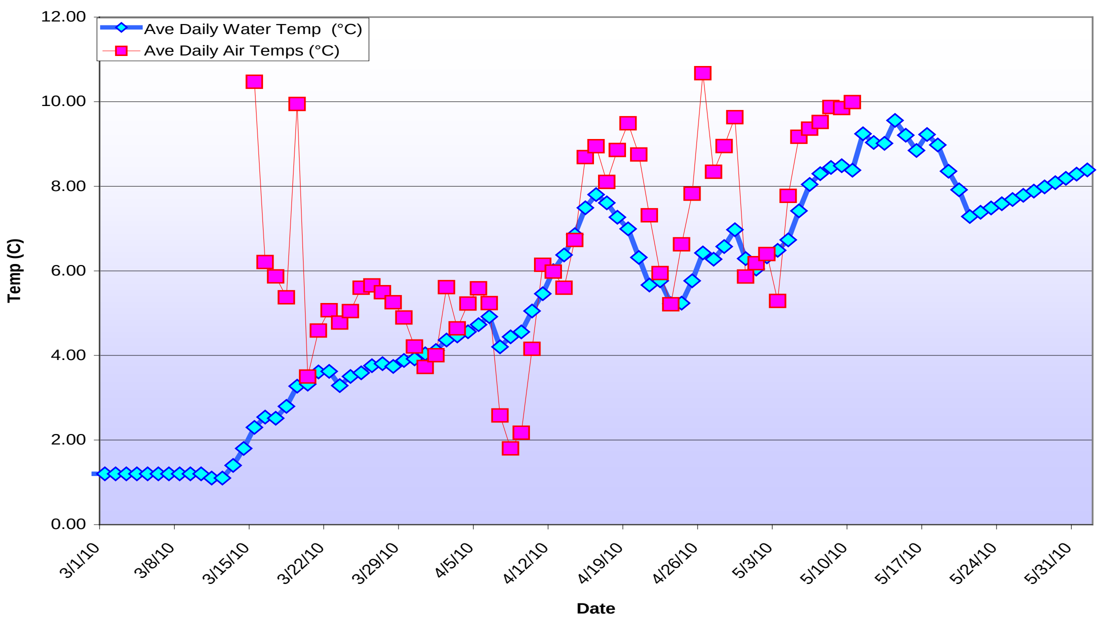

Figure 31 - Kwinitsa 2010 Winter/Spring Water and Air Temperatures

Figure 31 shows the temperature data from the *Tidbits*® near Kwinitsa. The battery died in the *Tidbit*® at Raspberry Island, and that data was lost. It should be noted that the water temperatures followed the trends in the air temperatures, gradually warming from 1.2ºC to 8.4ºC over the three month period of March to end of May.

Accumulated Thermal Units (ATUs) Results

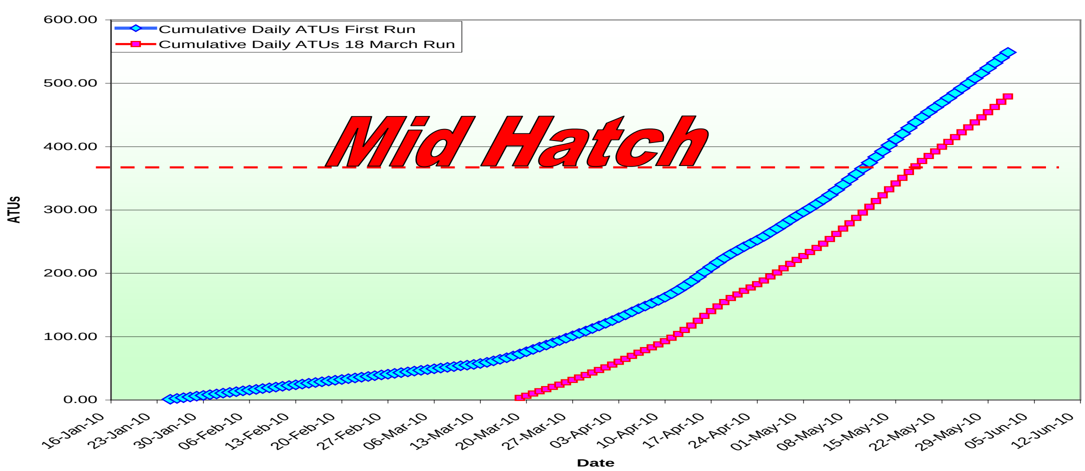

Figure 32 - 2010 Accumulated Thermal Units

Using the water temperature data to plot Accumulated Thermal Units (ATUs), it can be seen (Figure 32) that it was estimated that the middle of the eulachon egg hatching was estimated to have occurred between the 11-18th May, 2010. This estimation focused the few remaining field days for eulachon larvae sampling to occur just after the peak, on the 20th of May, 2010.

Larvae Sampling Results

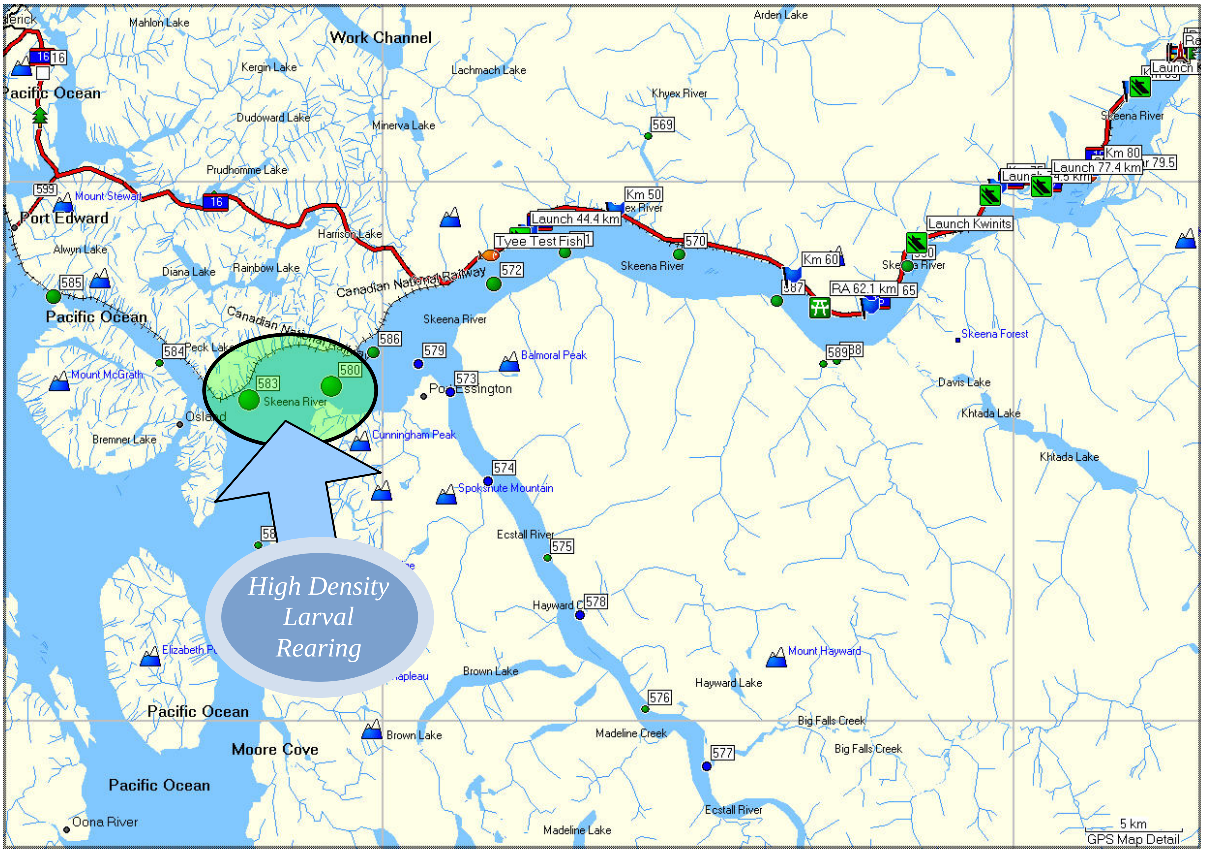

Figure 33 - Larvae Sampling Results

Figure 33 illustrates the results of the 2010 larval sampling, where Table 8 in the Appendix displays the details. Larger diameter green circles mark highest densities of eulachon larvae, and blue circles represent where no eulachon larvae were found.

It should be noted that an area containing high densities of eulachon larvae was found near the mouth of the Skeena River, just above the influence of salt water near the area referred to as the “boneyard”, and the East end of Inverness Channel.

In this area, densities of eulachon larvae ranged from 46.05 larvae m^{-3} (waypoint 580 Top) to 59.11 larvae m^{-3} (waypoint 583). Eulachon larvae densities in the remainder of the mainstem above this area ranged from 0.32 larvae m^{-3} (Waypoint 582) to 14.26 larvae m^{-3} (waypoint 572), but averaged 4.95 ± 4.83 larvae m^{-3} (n=8).

This meant that the high density area contained approximately 10 times the number of larvae found in other parts of the mainstem of the Skeena River.

Additionally at waypoint 580, sampling was conducted not only at 4m depth, but also at the bottom (9.1 m) to compare vertical distributions of eggs and larvae.
Eggs were found only on the bottom at waypoint 580 (0.54 eggs m^{-3}), where larvae were 17.8 times more abundant at 4m depth than the bottom, when comparing larval densities of 2.59 larvae m^{-3} (Bottom) to 46.05 larvae m^{-3} (Top).

Other results of interest include:

- No eulachon larvae were found in the Khyex River in 2010, nor were any eggs found during grab sampling, although eggs were found in a few sites in 2001 (Kelson 2010) in the 100s per sample, and usually in the 1 to10s per sample. Scouring and changes in stream structure from the previous summer period (2009) were noted; as a LWD jam let go at 6.9 km upstream from the mouth (UTM 449463 6015129). Additionally, the severe flood of 2007 may have changed the habitat of the mainstem of the Skeena, making it more attractive to use for spawning by eulachons, so that lower density sites in the tributaries were less utilized.

- No eulachon larvae were found in two tributaries of the Ecstall River; Hayward Creek (waypoint 578) and Big Falls Creek (waypoint 577). However, eulachon larvae were found in the mainstem of the Ecstall in front of Madeline Creek (waypoint 576) at densities of 0.20 larvae m^{-3}, and eggs were found to be dispersed throughout the mainstem of the Ecstall, especially near Mud Creek and in the Sparkling Creek tributary, but not in Madeline Creek or Muddy Creek (Kelson 2010).

- Eulachon larvae were found in the Scotia River (waypoints 588 and 589) in low densities of 0.01 larvae m^{-3}, and in the Kasiks River in low densities of 0.13 larvae m^{-3}, indicating eulachon had spawned in these tributaries.

- Eulachon larvae were found in high densities along the North side of the Skeena at the mouth, not the South side.

- Inverness Passage appeared to retain older larvae, and may be an important rearing and feeding area for eulachon larvae.

- Pictures of potential competitors and predators of eulachon larvae shown in Table 9, in Appendix.

DISCUSSION & RECOMMENDATIONS

Gill Netting Results

Many authors have reported a sex bias in the greater numbers of male eulachons caught when compared to female eulachons, when caught spawning in freshwater (*e.g*. Smith and Saalfeld 1955; Kubik and Wadman 1977, 1978; Franzel and Nelson 1981; Higgins et al. 1987; Lewis 1997; Lewis et al. 2002; Moffitt et al. 2002; Spangler 2002; Spangler et al. 2003) . Ratios from the Skeena include Gordon et al. (2005) – 21% female, and our own results similarly indicating that only 20.67% of the eulachons caught in the Skeena in 2010 were female.

There are a number of potential reasons for the observations of skewed sex ratio bias of spawning eulachon stocks coast-wide, including:

1. Biases in sampling methodologies,
2. Differences in survival rates of males and females of spawning eulachons in the watersheds (called residence time),
3. Skewed estuarine/oceanic survival rates between male and female eulachons,
4. Genetic predetermination of sexes at time of either fertilization or during egg development.

Yet, the potential reasons for the observations of skewed sex bias have not been systematically investigated, which is particularly concerning given the real threat that current and future climate change could potentially play in the determination of sex ratios in populations of eulachons, coast-wide.

Moffit et al. (2002) postulated that as spawning commences, females may avoid the river bank and disperse to the center of the river, thus skewing sex ratios as calculated from sampling using dip nets along river banks.

However, we sampled using gill nets in the middle of the river, and observed distinct changes over the spawning season (Table 4). Our data do not support Moffit's hypothesis, but instead concur with Langer et al. (1977) that eulachon females numbers increase at the start of a new "run", but probably die sooner than the accompanying males, as those numbers drop gradually, but noticeably. Mc Hugh (1939) and Hart and McHugh (1944) similarly reported that during the fishing season in 1939 and 1941 in the Fraser River, males predominated in the early part of the eulachon run, but in the latter part females came to predominate.

This observation also concurs with the suggestion of Lewis (1997) that sex ratios skewed in favor of males may be due to longer residence time of male eulachon in freshwater compared to females. An instream tagging program could prove/disprove this hypothesis.

Other authors hypothesize that genetic predetermination of sex ratios is fixed at fertilization. Smith and Saalfeld (1955) first hypothesized "*that the type of spawning of smelt may necessitate an excess of males*.", where Moffitt et al. (2002) postulated that broadcast-spawn eggs and sperm in fast moving rivers, "*a large number of males upstream may increase the probability of egg fertilization*.", and Spangler et al. (2003) concurred.

If through genetic analysis (*i.e.* a genetic sex marker for the Y chromosome), the sex of all life stages of eulachons could be determined; then a sampling program that properly preserved eggs and larvae could determine whether sex determination happens at fertilization, or later through external environmental influences (such as temperature, or pollution from pseudoestrogenic and endocrine disrupting chemicals) over the incubation period; or instead through skewed estuarine/marine survival rates.

If the observed skewed sex ratios are a product of external factors (such as temperature, or chemical pollution), or due to gender-biased marine survival rates related to gender differences in life history strategies; there are serious, long-term and coast-wide implications to these hypotheses.

The reason for the seriousness of the implications is that these potential external factors operate on large scales and potentially affect the population-level health of the species of eulachon across multiple watersheds along its range.

Climate change and global warming, for example, affect the water temperatures of the incubating eggs, typically raising the incubation temperatures. Ospina-Álvarez and Piferrer (2008) found that in those fish species that actually have temperature-dependent sex determination; "*sex ratio response to increasing temperatures invariably results in highly male-biased sex ratios, and that even small changes of just 1–2°C can significantly alter the sex ratio from 1:1 (males:females) up to 3:1 in both freshwater and marine species*".

The implications of this finding are obvious, and illustrate the critical need to determine the mechanisms that drive the skewed sex ratios of spawning stocks.

Other potential reasons for skewed sex ratios include the effects of pollution from pseudoestrogenic and endocrine disrupting chemicals and sex-skewed estuarine/marine survival rates.

Since the effects of pollution from pseudoestrogenic and endocrine disrupting chemicals typically feminize the phenotype of male fish (*e.g.* Gross-Sorokin, Roast, and Brighty, 2006) – it is unlikely that this is the reason for the high male bias in samples, but could be affecting sex ratios in polluted rivers, such as the Kitimat.

Sex ratio bias during early juvenile development and in adults during ocean migration could also be of concern and may be associated with gender specific foraging behavior and age-at maturation in saltwater. If females mature later than males, they may be exposed to more predation due to geographic and/or temporal differences in location. Accurately aging spawning eulachons could shed light on this hypothesis.

Again, we need to understand the processes that determine the sex ratio bias we observe when sampling eulachon stocks at spawning time.

Another interesting and related observation from our data; is the comparison of mass of the gonads of the male and female eulachons in proportion to the overall mass of the organism, expressed as the *Gonosomatic Index* or GSI. Our data (Table 4) indicate that the female eulachons we sampled had a GSI of from 14.13 to 22.57%, where the males had a GSI of only 1.19 to 3.72%.

The female eulachon GSI corresponds well to the energy reserves that adult sockeye salmon females contribute to egg production, with a GSI of 19 to 24% (Groot and Margolis 1991). Male eulachons, on the other hand, only put approximately a tenth the energy into gonads (*i.e.* only up to 3.72%) as did the female eulachons. This male eulachon GSI percentage, however, also corresponds well with the 3% GSI reported by Gilhousen (1980) for male Fraser River sockeye salmon.

So, eulachons invest approximately equal amounts of energy on a body-size basis, as do other anadromous fish species such as sockeye salmon; but exhibit a male sex bias in the sampled population.

If retention of sperm or milt (verses eggs) in fast moving rivers is a factor in successful eulachon spawning events (as mentioned by Smith and Saalfeld, 1955 and others); then having a means to increase the amount of sperm available during spawning; by either increasing the male gonad size, or by increasing the numbers of males at spawning time - could be an adaptation to spawning in these fast moving rivers.

The fact that male eulachons possess a longer pelvic fin and a rougher texture than females, with nuptial tubercles on the skin, and a large mass of muscle that develops along the lateral line with concave sides; may be additional adaptations to finding females and successfully spawning in these fast moving rivers.

The hypotheses of Smith and Saalfeld (1955) and Lewis (1997) on the reasons for the skewed male sex ratios, are not mutually exclusive suggestions. Having a longer residence time would potentially allow males to participate in multiple spawnings, while still exhibiting a skewed male sex ratio.

Egg Sampling Results

Various authors have commented that eulachons spawn mainly at night (*e.g* Smith and Saalfeld 1955, Parente and Snyder 1970, Lewis 1997) or under low light conditions (Spangler 2002). However, the effects of turbidity and visibility on predation risk and spawning behaviour is rarely mentioned, if at all.

For both the mainstem of the Skeena, and for the Ecstall River; the discharge water held heavy loads of suspended solids, and was very turbid (visibility from 0.3 to 2.8 m).

Eulachons were noted in heavy concentrations in areas on the mainstem of the Skeena, and when the grab sampler was deployed and the substrate sampled at these locations – heavy concentrations of eggs were found. This suggests that the heavy concentrations of eulachons viewed were actually spawning during the daylight hours.

The effects of turbidity on predation risk of juvenile salmon has been well studied (*e.g.* Gregory 1993, 1994; Gregory and Northcote 1993; Gregory and Levings 1998), and would be expected to provide similar protection for spawning eulachons.

It is likely that observed phenomenon of spawning at night by eulachons is a behavioral adaptation by eulachons for shallow and/or clear waterbodies only, but in highly turbid rivers, where high turbidity reduces the risk of capture by visual predators such as marine mammal and avian predators enough so that daylight spawning is common.

One of the more critical challenges is to understand what set of physical and hydrodynamic conditions constitute critical eulachon spawning habitat, and then to extrapolate those conditions to other watersheds so that changes to those habitats can be assessed and critical spawning processes protected.

We feel that we have identified both high- and low-density spawning habitats for the Skeena River and its tributaries. The criterion noted in recognizing and identifying critical spawning habitat includes a substrate-based physical component (*i.e.* non-compacted sand of a certain grain size), a bio-physical component (*i.e.* above the influence of salt water, but within the effects of tidal flow), and a hydrodynamic/ hydraulic component (*i.e.* dependent upon the velocity of the flow and in relation to internal shear zones).

Sand substrate is a critical physical component for the fertilized adhesive eulachon eggs, creating an anchoring sand collar around the eggs shown in Table 9, in the Appendix. Only when the egg is fertilized, will the outer membrane rupture and encapsulate the surrounding sand. Only sand grains of a certain size are capable of being trapped by the outer egg membrane, which then keep the egg from being immediately swept downstream in the fast water currents, but instead allow the fertilized egg to roll on top of the sand during its incubation period.

If large construction projects change the hydrodynamics of a rivers bed, so that sand is transported downstream into the high salinity zone (*e.g.* the Alcan Kemano/Nechako diversion project), then that critical sand substrate would become unavailable for spawning and population-level effects to eulachon stocks may ensue.

The development of a habitat suitability model linked with a spatially explicit stochastic population model would provide resource managers with a timely tool to assess potential changes to eulachon stocks. This potential model development is particularly applicable due to the various proposed run-of-river hydroelectric projects in eulachon-bearing watersheds in B.C, and their potential effects on eulachon spawning substrates (Kelson, 2010).

Staff Gauge and Tidal Cycle Estimation

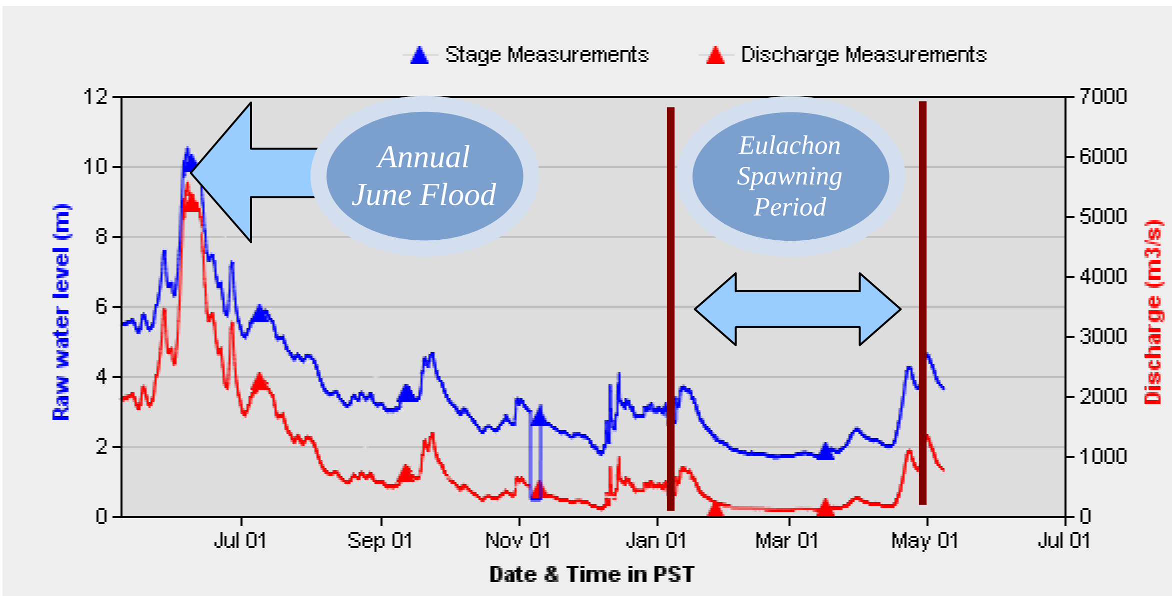

Figure 34 - Annual Hydrograph of Skeena River at Usk for May 2009-2010

Figure 34 illustrates the annual hydrograph of the Skeena River at Usk (Station EF001 at 54° 37' 50'' N, 128° 25' 55'' W), 92 km upstream of the eulachon spawning sites (http://www.wateroffice.ec.gc.ca/graph/graph_e.html?stn=08EF001).

Note that eulachons spawn during the lowest flow conditions of the year, where the salt water intrusion from oceanic waters would be expected to be entrained as far up the estuary as possible.

It is also interesting to note that eulachons spawn near the timing of the largest spring tides (*i.e.* the "*Equinoctial*" spring tides) which occur around the spring equinox on the 21st of March. This is also when the salt water intrusion from oceanic waters would be expected to be entrained as far up the estuary as possible due to tidal effects.

Since eulachons spawn above the influence of the salt water at the time of the year that saline water would be expected to be entrained as far upstream as possible; then the eulachon eggs would be expected to be protected from the influence of salt water during the remainder of their incubation period. This is important because eulachon egg survival is reduced upon exposure to salinities of 16 ppt and greater (Armstrong and Hermans 2007).

Another observation to note is that most eulachon eggs hatch BEFORE the yearly June flood, when scouring and large-scale changes to the stream bed may occur.

Larvae Sampling

Since we did not have the financial resources to sample and track the larval densities over the weeks of the hatching and outmigration, we cannot estimate total run size.

However, we can compute absolute peak larval production by multiplying peak densities with water discharge estimates for the lower Skeena near the Kasiks River, during our sampling date of on May 20th, 2010 (assuming we sampled at or near the peak of larval production).

The discharge of the Skeena River at Usk was estimated to be ~3000 m^3sec^{-1} on May 20th, 2010. The station at Usk is the lowest downstream hydrometric gauging station on the Skeena, but there are many tributaries which empty discharge into the Skeena mainstem farther downstream of Usk.. The watershed area upstream of the Usk station is 42,200 km^2, but it is estimated that there is 51,917 km^2 of watershed drained at the mouth of the kasiks River – an increase of 23% by area.

This would mean that the discharge estimate of the Skeena River at Kasiks should be at least 23% more than the discharge at Usk, since the watershed systems nearer the coast typically receive more precipitation than those systems more inland.

A more accurate approach developed by Lewis (1998), is to include discharge information from the Zymoetz River (Station EF005) and Exchamsiks Rivers (Station 08EG011), and using these stations as a indicator of discharge of their sub-basins, scale-up the discharge of their respective sub-basins, and then add these monthly estimates to the mainstem discharge estimate from Usk.

These estimates then add ~50% to the discharge estimate from Usk, so that the total discharge at Kasiks is estimated to be 4500 m^3sec^{-1} on May 20th, 2010. If the average mainstem eulachon larvae density was sampled as 4.95 ± 4.83 larvae m^{-3} (n=8); then 388,800,000 larvae hatched daily from eggs during the peak of the hatch in 2010. This is assuming the hatch at night was at least as dense as the daytime hatch, while some authors claim hatching is often more dense early morning and late at night (Lewis 1997).

Lewis (1997) reported very low larval densities of 0.02 to 0.09 (average 0.08) larvae m^{-3} during the peak of larval densities for the Skeena in 1997, but estimated the total run size to be only 2.0 to 4.4 tonnes, and only caught 6 eulachons by gillnetting. In the appendix, information shows that the larvae were sampled at 0-1m depths.

Understanding at what depths that eulachon larvae are found at the highest densities, verses actual sampling depths is necessary in comparing results. Various authors give seemingly contradictory information on location and feeding depths of eulachon larvae.

Spangler (2002) states that the highest densities of larval eulachon are found near the bottom of the water column, with peak larval drift occurring at night.

However, McCarter and Hay (2003) state that: "*Most eulachon larvae have been captured in the surface waters between 0 and 15 m depth. Considerably fewer larvae were caught at depths of 15 to 35 m and almost none below 35 metres.*"

Yet, a study of larval distribution in the lower Columbia River found that eulachon larval density was greater in the lower portion of the water column (Howell et al. 2002).

While, Robinson et al. (1968) determined that almost all eulachon larvae in the Strait of Georgia, off the Fraser River during daylight on 6 June 1967, were distributed in the top 6.5 m of the water column, with the greatest density (50–150 larvae m^{-3}) occurring between 1.7 and 3.5 m depth. This description most closely parallels our findings.

All of these descriptions may be correct, but illustrate that they do not fully describe the various physical and biotic factors that may be affecting where eulachon larvae can be found.

No mention is commonly made of physical processes that move water, such as river discharge and tides; nor of processes that create currents and segregate water masses, such as density and salinity gradients; nor of processes that potentially initiate behavioural responses in eulachon larvae, such as light and turbidity; nor of the developmental stage and swimming ability of the larvae.

In short, we need to understand these processes that affect eulachon migration, growth and survival since very little is known about the early estuarine/marine life history of the eulachon species where much of population-level mortality may occur.

If we can understand both the hydrodynamic processes within the estuary, and the behavioural responses of the eulachon larvae to those processes; then we can develop models (*e.g.* Lynch and Werner, 1991; and Lynch et al., 1996) to predict such things as retention, advection, growth and mortality of the pre- and post-flexion stages of larval development. This estuarine model could potentially be linked to the habitat suitability model for critical eulachon spawning habitat, previously described in the discussion on egg sampling results.

These coupled habitat/hydrodynamic models could potentially allow us to assess annual changes in those processes, and how they would affect recruitment of larvae into later stages of the populations of eulachons. Then these results could be coupled to spatially explicit stochastic population models (*e.g.* Ault et al. 1999) to assess population-level fluctuations and extinction risks for the purposes of COSEWIC listings.

More field survey work needs to be completed on critical feeding areas and growth of larval eulachons in conjunction with studies on estuary current speed, salinity, temperature, turbidity, bottom composition grain size, and lunar/tidal phases. A study utilizing an *Acoustic Doppler Current Profiler* (ADCP) could provide some of these physical data. The other necessary research involves understanding the behavioural responses of the eulachon larvae to external stimuli, and how these responses may change through the various developmental phases.

Blaber and Blaber (1980) observed the highest densities of juvenile fishes in the most turbid reaches of estuaries; negative phototropism may be involved in accumulation in such areas.

Negative phototaxic responses to light were noted by captured eulachon larvae in jars before being preserved during our sampling. With their large reflective eyes (see Table 9 in Appendix), eulachon larvae may swim down vertically in the water column to where light levels allow feeding opportunities in an area of increased production (Grimes and Kingsford 1996), but dark enough to decrease predation on the larvae due to decreased visibility (De Robertis et al. 2003). This behavioural response to light levels could facilitate larvae being found closer to the surface waters at night, as reported by some authors (*e.g.* Spangler, 2002). Correlating turbidity to preferred light levels at depth, may accurately describe and explain both larval densities and retention mechanisms.

Since the high density area we observed in the high turbuidity zone of the Skeena estuary contained approximately 10 times the number of larvae found in other parts of the mainstem of the Skeena River - This would indicate that there is a mechanism for larval retention at the lower end of the Skeena estuary that facilitates the increases in larval densities.

Depth of transport of eulachon larvae in the water column could be mediated not only by swimming vertically in response to light levels, but also salinity; and balances between these contrasting cues.

Larvae may be forced upwards through contact with the more saline ocean water entrained along the estuary bottom, until a set stage or size is reached. This assumed preference for lower salinity river water would be expected to promote transport of early-stage larvae downriver.

However, there may also ontogenetic shifts in these responses, as larvae grow and mature. Once larvae arrive at the lower (*i.e.* seaward) end of an estuary and need to remain in the maximum turbidity zone for feeding purposes, they may be attracted to a higher salinity level so that they remain entrained within the estuary.

Development of Natural Tags

In order to:

1. follow, study and understand the full life-cycle of eulachons,
2. assess migratory routes and components of connectivity and larval transport,
3. assess critical feeding and rearing areas of larval, sub-adult and adult eulachons, and
4. quantify and apportion population-level removal amounts to bycatch and capture fisheries so that population-level changes in numbers of eulachons can be understood on a watershed-by-watershed basis.

There is a critical need to develop a methodology to determine watershed of origin for eulachons (of every age and stage), when found outside of their spawning rivers.

In addition to these needs, it is also important to determine boundaries of meta-populations, and to determine if eulachon are a single stock, or not. If eulachons form a single stock, then any declining returns may be attributed to changes in distribution, not a decrease in overall abundance; but may indicate that the area of occupancy is becoming severely fragmented

Thus by-catch of eulachon may not be as significant a factor in the decline of numbers, but processes such as global warming that may precipitate changes in distribution instead need to be understood.

However, if each eulachon-bearing river contains a distinct population of eulachon, even a small by-catch of eulachon may significantly impact the returns because “the size of the by-catch may be very large relative to the size of some small runs” (Hay et al. 1999).

Understanding these stock dynamics is crucial to Fisheries and Oceans Canada in managing bycatch in various fisheries in a risk-adverse fashion, and in giving COSEWIC (Committee on the Status of Endangered Wildlife in Canada) accurate advice on the status of eulachon stocks.

In fact, Fisheries and Oceans Canada has stated (2010/2011 Eulachon Integrated Fisheries Management Plan) that Management goals have been defined for eulachon fisheries in accordance with the following guiding principals:

"*To ensure conservation and protection of fish stocks and their habitat through the application of scientific management principles applied in a risk averse and precautionary manner based on the best scientific advice available.*" (Sec. 4.1.1, p. 9).

Luckily, there are now a number of scientific techniques and methodologies that have been developed that could potentially be utilized to determine natural tags or markers that would identify watershed of origin for eulachons caught outside of their spawning rivers.

These techniques include:

1. DNA determinations (including mitochondrial DNA or mtDNA),
2. Laser ablation of core areas of eulachon otoliths collected from various watersheds, coupled with mass spectrometry, and linear discriminant function analysis,
3. Counts of meristic characters, such as vertebrae (*e.g.* DeLacy and Batts, 1963).
4. Fatty acid signatures (*e.g.* Rossi at al. 2006, Elsdon 2010)

The technique of mtDNA genotyping has already been completed on eulachon stocks, but McLean (2002) was not successful in determining watershed of origin between stocks, but only suggesting possible regional population structure.

However, using microsatellite loci rather than mtDNA, (Beacham et al. 2005) found that eulachon do display genetic differentiation among spawning aggregations of major rivers. More work needs to be completed in this area.

Laser ablation has been already used successfully in determining differences between closely-related stocks of delta smelt *Hypomesus transpacificus* from within a single estuary (Hobbs et al. 2007). Yet, this technique remains yet to be successfully utilized on eulachon stocks coast-wide.

Stock Assessments

Acquiring stock assessment data for eulachon stocks coast-wide on a watershed-by-watershed basis is critically important for the simple reason that we need to know the yearly trends in population numbers (*i.e.* a stock trajectory).

If we do not know the annual population size, then we cannot assess yearly (and historical) trends in stock abundance. We then cannot assess risks and impacts to eulachon stocks, nor determine the scale of potential impacts to eulachon populations, nor of the interactions of cumulative impacts.

Yet, accurate and reliable stock assessment information on eulachons in the various watersheds in British Columbia is rare, despite the federal government's Section 35 constitutional, fiducary responsibility to First Nations to facilitate and protect aboriginal rights to fish for food, social and ceremonial purposes – which certainly includes eulachon harvesting, given the historical and economic significance of the eulachon oil trade prior to European colonization.

Under the fishery decision-making framework instituted by Fisheries and Oceans Canada, which incorporates the *Precautionary Approach* (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm); a comprehensive risk management framework for decision-making includes the following elements:

- reference points linked to stock and ecosystem indicators;
- objectives for desirable resource and fishery outcomes; and
- resource use strategies to scale resource use to its condition in a manner that avoids undesirable outcomes

Without current, accurate and annual stock assessments of eulachon on a watershed-by-watershed basis – it is impossible to develop reference points, objectives and strategies.

Eulachon is also under COSEWIC (Committee on the Status of Endangered Wildlife in Canada) consideration for inclusion of ranking within candidate lists, with a status report in preparation. In order to identify candidate wildlife species for inclusion of ranking within candidate lists developed by COSEWIC ; specific data on the following criteria are necessary:

- Decline in Total Number of Mature Individuals,
- Canadian population size and trends in the population, and
- Threats, either ongoing or likely to occur, that are likely to affect a large percentage (>50%) of population.

These criterion/indicators explicitly require accurate and dependable stock assessment information that is normally the responsibility of Fisheries and Oceans Canada to provide to COSEWIC.

Yet, unlike funding for salmon stock assessments; funding for eulachon stock assessments is extremely limited, ad-hoc, and most often originates from the *Aboriginal Fisheries Strategy* program monies through separate agreements with individual First Nation bands. Occasionally, non-governmental organizations (*e.g.*

World Wildlife Fund Canada) may also contribute funding, as is the case with our study.

However, Fisheries and Oceans Canada does not commit annual, dependable funding for eulachon stock assessments, as it does for salmon stock assessments.

There is a critical need to develop dependable, multi-year funding for eulachon stock assessments so that population sizes and trends can be assessed on a watershed-by-watershed basis. It is possible that some of these monies could be developed through the COSEWIC processes.

Concurrently, there is a critical need to develop effective and economic methodologies for eulachon stock assessments, coast-wide.

To date, the only methodology developed for eulachon stock assessments has been larval zooplankton surveys. The question of whether these sporadic surveys are the most cost-effective and/or accurate methodology to determine annual population numbers, is still unanswered.

There are unresolved difficulties in comparing larval plankton studies without first resolving larval transport and retention mechanisms that may operate very differently in different estuaries, with differing flow velocities, turbidities and salinities. These are also dynamic processes.

There are also other methodologies commonly used to determine biomass of other species of forage fishes (*e.g.* herring); such as trawl/acoustic surveys, and mark and recapture surveys. These methodologies appear not yet attempted on eulachon stocks.

The most cost-effective strategy in the development of long-term monitoring program for eulachons, that includes stock assessment; would be to develop an intensive, accurate methodology to determine stock size (*e.g.* larval sampling, acoustic surveys, etc.) in conjunction with assessment of another less-intensive, dependable stock size indicator that could be used as an annual surrogate for the intensive sampling program.

An example of the development of a dependable indicator might be the simultaneous sampling utilizing CPUE (Catch per Unit Effort) and gill nets during the adult spawning period, followed by an intensive larval sampling program.

We did not have adequate funding to carry-out an intensive larval sampling program for weeks following the weeks-long adult spawning period; so we instead concentrated on a habitat-based spawning evaluation.

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APPENDIX

Table 5 - Soundings, Camera Observations and Egg Sampling Results for Each Waypoint on the Skeena River

Waypoint Name	Site Name	Date/Time (PST)	Position UTM Eastings	Position UTM Northings	Corrected Depths (m)	egg density (No./m2)	Water Vis (m)	substrate	Fish Observations
70	Site 4	12/03/2010 10:24	468937	6009525	-2.39				
71	Site 4	12/03/2010 10:24	468974	6009542	-2.27				
72	Site 4	12/03/2010 10:24	468984	6009550	-0.75				
73	Site 4	12/03/2010 10:24	468999	6009563	-0.06				
74	Site 4	12/03/2010 10:25	469020	6009574	0.41				
75	Site 4	12/03/2010 10:26	468995	6009518	-1.41				
76	Site 4	12/03/2010 10:27	469037	6009499	-0.82				
77	Site 4	12/03/2010 10:28	469078	6009531	-0.43				
78	Site 4	12/03/2010 10:28	469105	6009525	0.29				
79	Site 4	12/03/2010 10:32	468767	6009587	-5.82				
80	Site 4	12/03/2010 10:38	468755	6009654	0.00				
81	Site 3	12/03/2010 10:47	467250	6009654	-3.71				
82	Site 3	12/03/2010 10:48	467259	6009701	-0.75				
83	Site 3	12/03/2010 10:48	467295	6009784	-1.60				
84	no site	12/03/2010 10:49	467388	6009883	-1.34				
85	no site	12/03/2010 10:49	467447	6009985	-0.79				
86	no site	12/03/2010 10:50	467463	6010129	-0.99				
87	no site	12/03/2010 10:51	467475	6010251	-1.80				
88	no site	12/03/2010 10:52	467496	6010354	-1.18				
89	no site	12/03/2010 10:52	467544	6010433	-0.81				
90	no site	12/03/2010 10:53	467621	6010477	-0.62				
91	no site	12/03/2010 10:54	467682	6010569	-0.34				
92	no site	12/03/2010 10:54	467770	6010629	-0.06				
93	no site	12/03/2010 10:55	467905	6010691	-0.05				
94	no site	12/03/2010 10:57	468054	6010748	0.00				
95	no site	12/03/2010 10:58	468180	6010797	0.00				
96	no site	12/03/2010 10:59	468310	6010837	0.00				
97	Site 4	12/03/2010 11:59	470493	6009380	0.00				
98	Site 4	12/03/2010 11:59	470508	6009409	0.33				
99	Site 4	12/03/2010 12:00	470504	6009456	-1.04				

100	Site 4	12/03/2010 12:00	470498	6009472	0.83	
101	Site 4	12/03/2010 12:01	470510	6009479	2.07	
102	Site 4	12/03/2010 12:01	470531	6009461	-0.41	
103	Site 4	12/03/2010 12:01	470535	6009457	0.13	
104	Site 4	12/03/2010 12:02	470546	6009446	0.06	
105	Site 4	12/03/2010 12:03	470591	6009501	0.32	
106	Site 4	12/03/2010 12:04	470603	6009573	1.07	
107	Site 4	12/03/2010 12:04	470624	6009551	0.95	
108	Site 4	12/03/2010 12:07	470511	6009484	-0.30	
109	Site 4	12/03/2010 12:08	470499	6009452	-0.90	
110	Site 4	12/03/2010 12:09	470482	6009476	1.35	
111	Site 4	12/03/2010 12:17	470481	6009417	-0.64	
112	Site 4	15/03/2010 13:19	463806	6008004	-8.14	2.8
113	no site	15/03/2010 13:36	460768	6003680	-0.58	0.5
114	no site	15/03/2010 13:44	458760	6003067	-7.54	0.4
115	no site	15/03/2010 13:48	456951	6003461	-4.04	0.3
116	Site 2	15/03/2010 14:31	463735	6008026	-9.04	
117	Site 2	15/03/2010 14:31	463736	6008032	-9.37	
118	Site 2	15/03/2010 14:32	463741	6008074	-9.52	
119	Site 2	15/03/2010 14:32	463738	6008104	-9.86	
120	Site 2	15/03/2010 14:32	463741	6008131	-8.79	
121	Site 2	15/03/2010 14:33	463746	6008154	-7.39	
122	Site 2	15/03/2010 14:33	463742	6008161	-5.15	
123	Site 2	15/03/2010 14:33	463743	6008228	-4.12	
124	Site 3	16/03/2010 9:10	467472	6009643	-6.35	0.6
125	Site 3	16/03/2010 9:34	467532	6009593	0.00	
126	Site 3	16/03/2010 10:22	467523	6009698	-4.71	
127	Site 3	16/03/2010 10:39	467430	6009674	-3.01	
128	Site 3	16/03/2010 10:46	467292	6009553	-1.54	
129	Site 3	16/03/2010 10:46	467321	6009556	-3.42	
130	Site 3	16/03/2010 10:47	467357	6009580	-3.33	
131	Site 3	16/03/2010 10:48	467415	6009591	-3.79	
132	Site 3	16/03/2010 10:48	467421	6009594	-4.31	
133	Site 3	16/03/2010 10:49	467436	6009620	-5.83	
134	Site 3	16/03/2010 10:50	467564	6009672	-3.47	

135	Site 3	16/03/2010 10:51	467589	6009682	-2.03			
136	Site 3	16/03/2010 10:51	467634	6009659	-2.34			
137	Site 3	16/03/2010 10:52	467616	6009628	-6.86			
138	Site 3	16/03/2010 10:53	467659	6009629	-2.56			
139	Site 3	16/03/2010 10:53	467689	6009611	-3.80			
140	Site 3	16/03/2010 10:54	467726	6009630	-3.26	420		
141	Site 3	16/03/2010 11:01	467275	6009629	-4.06	914		
142	Site 3	16/03/2010 11:03	467348	6009705	-0.65			
143	Site 3	16/03/2010 11:05	467247	6009784	-1.06			
144	Site 3	16/03/2010 11:05	467153	6009749	-1.61			
145	Site 3	16/03/2010 11:06	467051	6009696	-3.85			
146	Site 3	16/03/2010 11:06	467002	6009695	-4.73			
147	Site 3	16/03/2010 11:12	466939	6009714	-3.78			
148	Site 3	16/03/2010 11:20	466837	6009711	-3.43			
149	Site 3	16/03/2010 11:20	466798	6009713	0.00			
150	Site 3	16/03/2010 11:21	466729	6009767	-2.71			
151	Site 3	16/03/2010 11:21	466664	6009741	-2.92			
152	Site 3	16/03/2010 11:22	466601	6009706	-2.75			
153	Site 3	16/03/2010 11:26	466744	6009752	-2.50			
154	Site 3	16/03/2010 11:27	466887	6009743	-2.06			
155	Site 3	16/03/2010 11:30	466848	6009675	-4.79			
156	Site 3	16/03/2010 11:35	467030	6009718	-1.02			
157	Site 3	16/03/2010 11:40	467503	6009573	-1.50			
158	corner	16/03/2010 11:52	465955	6009816	-1.03			
159	corner	16/03/2010 11:53	465902	6009757	-3.09			
160	corner	16/03/2010 12:00	466033	6010067	-7.43		mud	dead eulachons
161	corner	16/03/2010 12:00	466046	6010035	-5.67		mud	dead eulachons
162	corner	16/03/2010 12:00	466076	6010078	-4.43		mud	dead eulachons
163	corner	16/03/2010 12:01	466087	6010128	-2.43		mud	dead eulachons
164	corner	16/03/2010 12:05	466095	6010205	-2.55		mud	dead eulachons
165	no site	16/03/2010 12:18	466033	6010501	-0.32		mud	dead eulachons
166	no site	16/03/2010 12:19	466031	6010429	-1.61		mud	dead eulachons
167	no site	16/03/2010 12:20	466038	6010370	-3.25		mud	dead eulachons
168	no site	16/03/2010 12:20	466043	6010357	-2.87		mud	dead eulachons
169	no site	16/03/2010 12:21	466043	6010326	-2.60		mud	dead eulachons

170	no site	16/03/2010 12:30	466108	6010573	-0.20	mud	dead eulachons
171	no site	16/03/2010 12:32	466129	6010595	0.28	mud	dead eulachons
172	no site	16/03/2010 12:33	466161	6010628	-0.04	mud	dead eulachons
173	no site	16/03/2010 12:41	466199	6010686	-0.21		
174	no site	16/03/2010 12:42	466269	6010685	-2.75		
175	no site	16/03/2010 12:43	466300	6010736	0.82		
176	no site	16/03/2010 13:16	466059	6010284	-3.46		
177	Site 3B	17/03/2010 10:02	468371	6009675	-3.69		
178	Site 3B	17/03/2010 10:04	468372	6009694	-4.25		
179	Site 3B	17/03/2010 10:04	468356	6009697	-5.31		
180	Site 3B	17/03/2010 10:05	468298	6009684	-9.01		
181	Site 3B	17/03/2010 10:05	468285	6009660	-7.21		
182	Site 3B	17/03/2010 10:06	468284	6009666	-6.27		
183	Site 3B	17/03/2010 10:07	468295	6009654	-5.45		
184	Site 3B	17/03/2010 10:08	468289	6009673	-8.24		
185	Site 3B	17/03/2010 10:08	468273	6009660	-7.82		
186	Site 3B	17/03/2010 10:09	468271	6009677	-7.15		
187	Site 3B	17/03/2010 10:12	468201	6009686	-4.85		
188	Site 3B	17/03/2010 10:13	468151	6009712	-4.82		
189	Site 3B	17/03/2010 10:14	468129	6009706	-5.85		eulachons
190	Site 3B	17/03/2010 10:14	468126	6009718	-4.63		eulachons
191	Site 3B	17/03/2010 10:15	468108	6009703	-4.15		eulachons
192	Site 3B	17/03/2010 10:19	468098	6009602	-2.00		
193	Site 3B	17/03/2010 10:21	468063	6009604	-1.76		
194	Site 3B	17/03/2010 10:23	468027	6009640	-2.82		
195	Site 3B	17/03/2010 10:25	467982	6009614	-2.88		
196	Site 3B	17/03/2010 10:26	467972	6009693	-3.04		
197	Site 3B	17/03/2010 10:26	467975	6009728	-0.98	cobble	
198	Site 3B	17/03/2010 10:28	467995	6009707	-1.58	boulders	
199	Site 3B	17/03/2010 10:30	468068	6009732	-2.76		
200	Site 3B	17/03/2010 10:31	468058	6009727	-2.58	cobble/sand	
201	Site 3B	17/03/2010 10:32	468040	6009713	-2.04		few eulachons
202	Site 3B	17/03/2010 10:33	468024	6009710	-1.92		few eulachons
203	Site 3B	17/03/2010 10:37	468192	6009785	-1.92	soft sand	
204	Site 3B	17/03/2010 10:38	468196	6009795	-2.74		

205	Site 3B	17/03/2010 10:39	468199	6009765	-1.92			
206	Site 3B	17/03/2010 10:40	468189	6009723	-3.77			
207	Site 3B	17/03/2010 10:40	468187	6009713	-5.17			
208	corner	17/03/2010 11:18	465913	6009712	-2.67		soft sand	
209	corner	17/03/2010 11:31	465908	6009757	-5.45			
210	corner	17/03/2010 11:32	465921	6009774	-3.00			
211	corner	17/03/2010 11:35	465907	6009821	-11.21			
212	corner	17/03/2010 11:37	465902	6009735	-5.42			
213	corner	17/03/2010 11:39	465887	6009690	-1.97			
214	corner	17/03/2010 11:40	465867	6009702	-3.33	17476		
215	corner	17/03/2010 11:42	465865	6009697	-5.17			
216	corner	17/03/2010 11:46	465940	6009737	-1.81			
217	corner	17/03/2010 11:46	465929	6009780	-2.81			
218	corner	17/03/2010 11:47	465916	6009799	-3.51			eulachons
219	corner	17/03/2010 11:48	465923	6009796	-5.03			debris
220	corner	17/03/2010 11:49	465923	6009782	-6.18			
221	corner	17/03/2010 11:54	465949	6009751	-4.26	8224		
222	corner	17/03/2010 12:26	465830	6009647	-3.31			
223	corner	17/03/2010 12:27	465808	6009663	-6.19	37009		
224	corner	17/03/2010 12:27	465799	6009690	-9.58			
225	corner	17/03/2010 12:28	465819	6009769	-10.73			
226	corner	17/03/2010 12:28	465842	6009790	-12.09			
227	corner	17/03/2010 12:29	465864	6009808	-12.09			
228	corner	17/03/2010 12:29	465884	6009833	-12.73			
229	corner	17/03/2010 12:30	465909	6009879	-11.58			
230	corner	17/03/2010 12:30	465947	6009940	-9.73			
231	corner	17/03/2010 12:31	465988	6009982	-10.06			
232	corner	17/03/2010 12:32	466043	6010139	-5.03			
233	corner	17/03/2010 12:32	466057	6010208	-5.03			
234	corner	17/03/2010 12:33	466058	6010266	-4.24			
235	Site 3	17/03/2010 13:08	467391	6009587	-4.00			eulachons
236	Site 3	17/03/2010 13:09	467383	6009553	-5.34		sand dunes	debris
237	Site 3	17/03/2010 13:10	467369	6009561	-4.79		rocks/cobble	
238	Site 3	17/03/2010 13:13	467287	6009560	-3.75		cobble	
239	Site 3	17/03/2010 13:14	467240	6009573	-4.30		cobble	few eulachons

240	Site 3	17/03/2010 13:15	467197	6009593	-4.39			eulachons
241	Site 3	17/03/2010 13:16	467137	6009603	-3.99			eulachons
242	Site 3	17/03/2010 13:16	467081	6009599	-3.72			
243	Site 3	17/03/2010 13:17	467013	6009621	-2.51			
244	Site 3	17/03/2010 13:19	466967	6009636	-2.08			
245	Site 3	17/03/2010 13:20	466900	6009655	-3.39		cobble/sand	
246	Site 3	17/03/2010 13:22	466771	6009671	-3.63		cobble/sand	
247	Site 3	17/03/2010 13:23	466717	6009694	-3.96			
248	Site 3	17/03/2010 13:25	466670	6009709	-3.14			
249	Site 3	17/03/2010 13:27	466555	6009742	-3.72			
250	Site 3	17/03/2010 13:28	466495	6009727	-3.54			
251	no site	17/03/2010 13:32	465413	6008795	-3.41			
252	no site	17/03/2010 13:32	465430	6008786	-2.32			
253	no site	17/03/2010 13:33	465478	6008719	-3.80		sand/sm cobble	
254	no site	17/03/2010 13:33	465517	6008675	-5.41	1.1	sand/cobble/snags	
255	no site	17/03/2010 13:34	465612	6008684	-4.20			
256	no site	17/03/2010 13:34	465729	6008671	-4.02			
257	no site	17/03/2010 13:35	465830	6008670	-2.92			
258	no site	17/03/2010 13:36	465961	6008663	-2.60			
259	no site	17/03/2010 13:37	466119	6008617	-3.85			
260	no site	17/03/2010 13:37	466181	6008550	-4.91			
261	no site	17/03/2010 13:38	466277	6008519	-6.73			
262	no site	17/03/2010 13:38	466321	6008562	-12.24			
263	no site	17/03/2010 13:38	466350	6008537	-14.18			
264	no site	17/03/2010 13:39	466404	6008525	-8.82			
265	no site	17/03/2010 13:39	466415	6008550	-7.45			
266	no site	17/03/2010 13:50	466399	6008616	-8.45			
267	no site	17/03/2010 13:52	466365	6008649	-6.09			
268	no site	17/03/2010 13:54	466342	6008635	-9.09			
269	no site	17/03/2010 13:56	466390	6008668	-0.95			
270	no site	17/03/2010 13:57	466454	6008706	-2.32			
271	no site	17/03/2010 13:58	466483	6008732	-2.92			
272	no site	17/03/2010 14:03	466363	6008585	-16.81			
273	Site 2	18/03/2010 10:05	463895	6008033	-9.36			
274	Site 2	18/03/2010 10:07	463890	6008011	-6.75			

275	Site 2	18/03/2010 10:07	463892	6007989	0.00			
276	Site 2	18/03/2010 10:07	463901	6007995	-3.78			
277	Site 2	18/03/2010 10:09	463840	6008024	-9.24			eulachons
278	Site 2	18/03/2010 10:12	463703	6008014	-3.05		cobble/snags	
279	Site 2	18/03/2010 10:14	463668	6008007	-2.45		cobble	
280	Site 2	18/03/2010 10:14	463617	6008005	-2.48			
281	Site 2	18/03/2010 10:15	463607	6008027	-3.89			
282	Site 2	18/03/2010 10:15	463609	6008062	-5.95			
283	Site 2	18/03/2010 10:16	463614	6008110	-8.32			
284	Site 2	18/03/2010 10:16	463623	6008144	-6.53			
285	Site 2	18/03/2010 10:16	463644	6008180	-3.65		sand dunes	
286	Site 2	18/03/2010 10:17	463656	6008204	-2.59			
287	Site 2	18/03/2010 10:17	463638	6008213	-1.77			
288	Site 2	18/03/2010 10:18	463632	6008251	-0.59		sand dunes	
289	Site 2	18/03/2010 10:19	463623	6008201	-2.19			
290	Site 2	18/03/2010 10:22	464074	6008073	-2.70		sand dunes	
291	Site 2	18/03/2010 10:23	464044	6008089	-3.52			eulachons
292	Site 2	18/03/2010 10:24	463993	6008097	-3.86			
293	Site 2	18/03/2010 10:25	463961	6008103	-4.06		sand/cobble	
294	Site 2	18/03/2010 10:28	463850	6008152	-4.43	1.1	sand/cobble/snags	
295	Site 3	18/03/2010 10:46	467609	6009598	-2.78		rocks	
296	Site 4	18/03/2010 10:51	469010	6009481	-2.27			
297	Site 4	18/03/2010 10:51	469061	6009454	-1.24			
298	Site 4	18/03/2010 10:52	469154	6009395	-1.27			
299	Site 4	18/03/2010 10:52	469192	6009371	-0.30			
300	Site 4	18/03/2010 10:53	469263	6009333	-2.20			
301	Site 4	18/03/2010 10:54	469310	6009312	0.00			
302	Site 4	18/03/2010 10:54	469311	6009316	-0.99			
303	Site 4	18/03/2010 10:54	469386	6009286	-0.44			
304	Site 4	18/03/2010 10:56	469407	6009299	-0.67			
305	Site 4	18/03/2010 10:57	469415	6009312	-0.50			
306	Site 4	18/03/2010 10:57	469441	6009291	-0.68			
307	Site 4	18/03/2010 10:58	469462	6009302	-0.40			
308	Site 4	18/03/2010 10:59	469526	6009314	-0.51			
309	Site 4	18/03/2010 11:00	469563	6009328	0.00			

310	Site 4	18/03/2010 11:00	469563	6009328	-0.64		
311	Site 4	18/03/2010 11:01	469634	6009334	-0.85		
312	Site 4	18/03/2010 11:02	469703	6009331	-0.68		
313	Site 4	18/03/2010 11:03	469752	6009323	-0.56		
314	Site 4	18/03/2010 11:03	469810	6009307	-0.66		
315	Site 4	18/03/2010 11:04	469865	6009301	-0.90		
316	Site 4	18/03/2010 11:05	470003	6009295	-0.69		
317	Site 4	18/03/2010 11:06	470094	6009292	-0.56		
318	Site 4	18/03/2010 11:07	470149	6009283	-0.41		
319	Site 4	18/03/2010 11:08	470304	6009353	-4.94		
320	Site 4	18/03/2010 11:09	470359	6009347	-6.01		
321	Site 4	18/03/2010 11:13	470421	6009351	-4.00		
322	Site 4	18/03/2010 11:13	470474	6009398	-2.07		
323	Site 4	18/03/2010 11:14	470549	6009445	-1.10		
324	Site 4	18/03/2010 11:15	470598	6009506	-0.84		
325	Site 4	18/03/2010 11:15	470639	6009533	-1.32		
326	Site 4	18/03/2010 11:16	470679	6009582	-0.53		
327	Site 4	18/03/2010 11:17	470734	6009634	-1.18		
328	Site 4	18/03/2010 11:18	470811	6009668	-0.52		
329	Site 4	18/03/2010 11:19	470881	6009687	-0.84		
330	Site 4	18/03/2010 11:20	470922	6009739	-0.50		
331	Site 4	18/03/2010 11:21	470939	6009752	-1.15		
332	Site 4	18/03/2010 11:28	471005	6009883	0.00		
333	Site 4	18/03/2010 11:51	469251	6009372	-1.58		
334	Site 4	18/03/2010 11:52	469167	6009426	-1.28		
335	Site 4	18/03/2010 11:52	469118	6009448	-1.37		
336	Site 2	18/03/2010 12:08	463481	6008154	0.00	126	
337	Site 2	18/03/2010 12:11	463359	6008124	0.00		
338	Site 2	18/03/2010 12:17	463089	6008164	-2.01		
339	Site 2	18/03/2010 12:18	463156	6008114	-4.21		
340	Site 2	18/03/2010 12:19	463061	6008119	-4.25		
341	Site 2	18/03/2010 12:24	463741	6008179	-4.21		
342	Site 2	18/03/2010 12:32	463723	6008165	-5.69		hard sand/pebbles
343	Site 2	18/03/2010 12:35	463640	6008157	-5.19		hard sand/pebbles
344	Site 2	18/03/2010 12:36	463612	6008169	-3.94		

345	Site 2	18/03/2010 12:41	463558	6008156	-4.21			hard sand/pebbles	
346	Site 2	18/03/2010 12:49	464073	6008050	-4.08				
347	Site 2	18/03/2010 12:50	464063	6008078	-2.46				
348	Site 2	18/03/2010 12:51	464054	6008060	-3.68				
349	Site 2	18/03/2010 12:51	464115	6008029	-4.10				
350	Site 2	18/03/2010 12:52	464161	6008005	-4.48				
351	Site 2	18/03/2010 12:52	464197	6008006	-3.79				
352	Site 2	18/03/2010 12:56	464305	6007984	-4.73				
353	Site 2	18/03/2010 12:57	464317	6007978	-4.41				
354	Site 2	18/03/2010 12:58	464272	6007996	-3.55				
355	Site 2	18/03/2010 12:59	464145	6008023	-4.65	189036			
356	Site 2	18/03/2010 13:07	464017	6008049	-4.61	355388			
357	Site 2	18/03/2010 13:23	464142	6007917	-4.88				
358	Site 2	18/03/2010 13:23	464081	6007945	-6.03				
359	Site 2	18/03/2010 13:25	464016	6007968	-7.15				
360	Site 2	19/03/2010 9:49	463763	6008038	-8.37				eulachons
361	Site 2	19/03/2010 9:49	463739	6008042	-5.60				lots eulachons
362	Site 2	19/03/2010 9:52	463619	6008057	0.00				lots eulachons
363	Site 2	19/03/2010 9:54	463533	6008030	-4.83				lots eulachons
364	Site 2	19/03/2010 9:55	463479	6008023	0.00			cobble/sand	lots eulachons
365	Site 2	19/03/2010 9:57	463437	6008015	-4.10				lots eulachons
366	Site 2	19/03/2010 9:58	463402	6008016	-3.71				eulachons
367	Site 2	19/03/2010 10:00	463341	6008007	-3.51		1.2		eulachons
368	Site 2	19/03/2010 10:02	463284	6007981	-2.71				no eulachons
369	Site 2	19/03/2010 10:12	463661	6008040	0.00				
370	Site 2	19/03/2010 10:18	463537	6008078	0.00				
371	corner	19/03/2010 10:39	466192	6009833	-2.48	302458			
372	corner	19/03/2010 10:39	466162	6009847	-2.97	302458			few eulachons
373	corner	19/03/2010 10:40	466114	6009869	-2.58	756		2 eggs	lots eulachons
374	corner	19/03/2010 10:41	466057	6009853	-2.53				eulachons
375	corner	19/03/2010 10:42	466012	6009823	-2.47			debris	few eulachons
376	corner	19/03/2010 10:43	465984	6009819	-2.69				
377	corner	19/03/2010 10:44	465969	6009812	-5.00			debris	
378	corner	19/03/2010 10:46	466265	6009897	-2.95				
379	corner	19/03/2010 10:47	466286	6009971	-1.98				

380	corner	19/03/2010 10:48	466287	6010063	-0.22			
381	corner	19/03/2010 10:49	466238	6010076	-0.82			
382	corner	19/03/2010 10:50	466204	6010080	-0.38			
383	corner	19/03/2010 10:50	466177	6010070	-1.80			
384	corner	19/03/2010 10:50	466152	6010068	-3.28			
385	corner	19/03/2010 10:51	466100	6010070	-4.72			
386	corner	19/03/2010 10:51	466094	6010046	-5.99			
387	corner	19/03/2010 10:52	466054	6009992	-6.94			
388	corner	19/03/2010 10:52	466031	6009960	-6.97			
389	corner	19/03/2010 10:53	466013	6009928	-8.28			
390	corner	19/03/2010 10:53	466026	6009914	-2.15			
391	corner	19/03/2010 10:54	466093	6009914	-2.31			
392	corner	19/03/2010 10:55	466173	6009910	-2.48			
393	corner	19/03/2010 10:55	466208	6009943	-2.14			
394	corner	19/03/2010 10:56	466173	6010028	-2.64			
395	corner	19/03/2010 11:00	465808	6009609	-2.75			
396	corner	19/03/2010 11:02	465794	6009575	-2.77		debris	
397	corner	19/03/2010 11:03	465761	6009571	-4.74			
398	corner	19/03/2010 11:04	465741	6009542	-4.41			
399	corner	19/03/2010 11:05	465721	6009520	-5.28			
400	corner	19/03/2010 11:05	465712	6009548	-8.33			
401	corner	19/03/2010 11:05	465696	6009577	-10.15			
402	corner	19/03/2010 11:05	465692	6009598	-12.36			
403	corner	19/03/2010 11:06	465758	6009597	-9.52			
404	corner	19/03/2010 11:06	465770	6009644	-10.15			
405	corner	19/03/2010 11:07	465760	6009701	-12.77			
406	corner	19/03/2010 11:07	465815	6009725	-12.71			
407	corner	19/03/2010 11:08	465854	6009756	-11.51			
408	corner	19/03/2010 11:08	465892	6009773	-11.05			
409	corner	19/03/2010 11:10	466127	6009828	-2.76			eulachons
410	corner	19/03/2010 11:11	466094	6009841	-2.79			few eulachons
411	corner	19/03/2010 11:12	466062	6009831	-2.74		debris	few eulachons
412	corner	19/03/2010 11:13	466049	6009880	-2.56			
413	corner	19/03/2010 11:53	466146	6009828	-1.66			
414	corner	19/03/2010 12:36	465992	6009844	-4.69	37807	hard sand/pebbles	

415	no site	22/03/2010 6:52	472542	6014167	0.81			
416	no site	22/03/2010 6:53	472565	6014208	2.10			
417	no site	22/03/2010 6:54	472578	6014126	-3.05			
418	no site	22/03/2010 6:55	472596	6014106	-4.23			
419	no site	22/03/2010 6:55	472626	6014091	-1.23			
420	no site	22/03/2010 6:55	472665	6014093	-0.47		cobble	
421	no site	22/03/2010 6:56	472641	6014115	-0.60		cobble/rock/sand	
422	no site	22/03/2010 6:57	472622	6014116	-2.97			
423	no site	22/03/2010 6:58	472593	6014105	-4.79			
424	no site	22/03/2010 6:59	472607	6014054	-0.37		sand	
425	no site	22/03/2010 7:00	472602	6014045	-3.32			
426	no site	22/03/2010 7:01	472638	6013987	-0.35		sand/cobble	
427	no site	22/03/2010 7:02	472631	6013974	-0.70		rocks	
428	no site	22/03/2010 7:03	472611	6013967	-2.79			
429	no site	22/03/2010 7:04	472600	6013947	-1.73		sand/cobble	
430	no site	22/03/2010 7:05	472601	6013916	-2.49		cobble/rock	
431	no site	22/03/2010 7:07	472597	6013887	-0.14			
432	no site	22/03/2010 7:08	472566	6013748	-4.63			
433	UCBU	22/03/2010 7:09	472271	6013146	-1.60			
434	UCBU	22/03/2010 7:10	472172	6013107	0.97			
435	UCBU	22/03/2010 7:11	472118	6013107	0.80			
436	UCBU	22/03/2010 7:11	472115	6013081	0.62		cobble	
437	UCBU	22/03/2010 7:11	472129	6013048	0.53		sand/cobble	
438	UCBU	22/03/2010 7:12	472134	6013036	0.46		sand/cobble	few eulachons
439	UCBU	22/03/2010 7:13	472148	6012998	0.00	81213	sand/cobble	lots eulachons
440	UCBU	22/03/2010 7:14	472133	6012961	-0.36		sm cobble	few eulachons
441	UCBU	22/03/2010 7:15	472118	6012914	-0.58		sand	no eulachons
442	UCBU	22/03/2010 7:16	472123	6012878	-0.71			
443	UCBU	22/03/2010 7:17	472110	6013034	0.32		sand/lg gravel	few eulachons
444	UCBU	22/03/2010 7:20	472076	6012992	0.37		sand/sm cobble	eulachons
445	UCBU	22/03/2010 7:21	472047	6012946	-0.25			
446	UCBU	22/03/2010 7:23	472027	6012895	-0.86		cobble/pebble/sand	few eulachons
447	UCBU	22/03/2010 7:24	472012	6012862	-1.41		cobble	
448	UCBL	22/03/2010 7:41	471841	6012034	-0.40			
449	UCBL	22/03/2010 7:42	471919	6012113	0.77			

450	UCBL	22/03/2010 7:43	472005	6012280	0.00			
451	UCBL	22/03/2010 7:44	472003	6012352	0.00			
452	UCBL	22/03/2010 7:45	471959	6012395	0.76			
453	UCBL	22/03/2010 7:46	471911	6012429	-0.79		sand/cobble	
454	UCBL	22/03/2010 7:46	471873	6012371	-1.49		debris	
455	UCBL	22/03/2010 7:47	471888	6012340	-0.99		sand/gravel/cobble	few eulachons
456	UCBL	22/03/2010 7:48	471921	6012320	-0.41			no eulachons
457	UCBL	22/03/2010 7:49	471936	6012298	0.14			
458	UCBL	22/03/2010 7:51	471858	6012220	-1.09			
459	UCBL	22/03/2010 7:53	471854	6012165	-1.47			
460	UCBU	22/03/2010 7:54	472142	6012780	-0.42			lots eulachons
461	UCBU	22/03/2010 7:55	472125	6012823	-0.60			lots eulachons
462	UCBU	22/03/2010 7:56	472041	6012816	-0.51	2744803	sand/cobble	lots eulachons
463	UCBU	22/03/2010 7:57	472016	6012769	-0.54		sand/cobble	lots eulachons
464	UCBU	22/03/2010 7:58	472013	6012750	-0.94		sand/cobble	lots eulachons
465	UCBU	22/03/2010 8:00	471975	6012714	-0.95			no eulachons
466	CB	22/03/2010 8:27	471522	6011709	0.28			
467	CB	22/03/2010 8:28	471459	6011634	0.48			
468	CB	22/03/2010 8:31	471539	6011784	0.95			
469	CB	22/03/2010 8:32	471600	6011747	-0.73			
470	CB	22/03/2010 8:33	471609	6011713	-1.19		sand/cobble	eulachons
471	CB	22/03/2010 8:35	471566	6011636	-1.06		sand/cobble	eulachons
472	CB	22/03/2010 8:36	471551	6011590	-0.83		sand/cobble	eulachons
473	CB	22/03/2010 8:39	471445	6011511	-0.91		sand/cobble	lots eulachons
474	CB	22/03/2010 8:39	471390	6011471	-0.85		sand/cobble	lots eulachons
475	CB	22/03/2010 8:41	471343	6011447	-0.32		dead eulachons	lots eulachons
476	CB	22/03/2010 8:42	471263	6011389	0.35			lots eulachons
477	CB	22/03/2010 8:43	471216	6011373	-0.53			eulachons
478	CB	22/03/2010 8:44	471187	6011299	-0.60			dead eulachons
479	CB	22/03/2010 8:45	471168	6011277	-0.09	14392		lots eulachons
480	CB	22/03/2010 8:48	471085	6011223	-0.71		cobble/dead eulachons	no eulachons
481	CB	22/03/2010 8:51	470980	6011123	-0.21			few eulachons
482	CB	22/03/2010 9:02	470758	6010950	0.00			
483	CB	23/03/2010 7:40	470881	6010907	-0.49		cobble	
484	CB	23/03/2010 7:40	470879	6010897	0.00			

485	CB	23/03/2010 7:43	470774	6010872	-0.61		cobble	
486	CB	23/03/2010 7:45	470859	6011048	-0.70			
487	CB	23/03/2010 7:45	470869	6011078	0.60			
488	CB	23/03/2010 7:46	470882	6011032	-0.78			lots eulachons
489	CB	23/03/2010 7:48	470848	6011012	-0.72		cobble/sand	
490	CB	23/03/2010 7:48	470831	6010982	-0.57		cobble/sand	lots eulachons
491	CB	23/03/2010 7:50	470793	6010964	-0.47		cobble	few eulachons
492	no site	23/03/2010 7:52	470326	6010737	-0.74		cobble	
493	no site	23/03/2010 7:52	470258	6010682	-1.35		sm cobble	
494	no site	23/03/2010 7:54	470201	6010618	1.20		cobble	
495	no site	23/03/2010 7:56	470092	6010572	-0.94			
496	no site	23/03/2010 7:57	469829	6010259	-0.61			
497	no site	23/03/2010 7:58	469722	6010170	-0.28		cobble	
498	no site	23/03/2010 8:01	469492	6010048	-0.24			
499	no site	23/03/2010 8:02	469384	6010028	-0.55		cobble	
500	Site 4	23/03/2010 8:06	469048	6009872	-1.98			
501	Site 4	23/03/2010 8:08	469010	6009899	-0.81			
502	Site 4	23/03/2010 8:09	468904	6009768	-1.88			
503	Site 4	23/03/2010 8:10	468962	6009707	0.44			
504	Site 4	23/03/2010 8:10	469028	6009678	-0.04			
505	no site	23/03/2010 8:19	468772	6010940	1.05			
506	no site	23/03/2010 8:20	468891	6011002	0.10			
507	no site	23/03/2010 8:21	468945	6011062	-1.03			
508	no site	23/03/2010 8:22	468998	6011092	-0.71		boulders	
509	no site	23/03/2010 8:22	469063	6011112	-1.93			lots eulachons
510	no site	23/03/2010 8:23	469200	6011135	-1.40			
511	no site	23/03/2010 8:24	469282	6011136	-0.29			
512	no site	23/03/2010 8:24	469338	6011161	0.05		sm cobble	
513	no site	23/03/2010 8:32	469852	6011225	1.20			
514	no site	23/03/2010 8:35	469621	6011208	0.32			
515	no site	23/03/2010 8:49	468868	6011076	-2.63		sand	dead eulachons
516	no site	23/03/2010 8:51	468608	6011017	-0.49	882		
517	no site	23/03/2010 8:54	468512	6010942	-0.83		snags	
518	no site	23/03/2010 9:04	468256	6010894	0.01			
519	no site	23/03/2010 9:05	468158	6010814	-0.85			

520	Site 2	23/03/2010 9:27	464565	6008183	-0.48			
521	Site 2	23/03/2010 9:30	464405	6008081	-1.29			few eulachons
522	Site 2	23/03/2010 9:33	464223	6008053	-0.89		sand	
523	Site 2	23/03/2010 9:39	464054	6008147	-2.29		soft sand	dead eulachons
524	Site 2	23/03/2010 10:14	463120	6007917	-0.68			
525	Site 2	23/03/2010 10:16	462850	6007898	-1.09		gravel	
526	Site 2	23/03/2010 10:19	462591	6007874	-0.83		gravel/sand	
527	Site 2	23/03/2010 10:21	462473	6007837	-0.47			
528	Site 2	23/03/2010 10:24	462284	6007754	0.06		gravel/cobble	
529	Site 2	23/03/2010 10:26	462164	6007689	-0.10		sand	
530	Site 2	23/03/2010 10:27	462088	6007655	-0.22		sand/cobble	
531	Site 2	23/03/2010 10:29	462040	6007586	-1.44		sm cobble	dead eulachons
533	CBU	24/03/2010 9:09	472091	6012847	0.00	25700		
534	no site	24/03/2010 10:10	461828	6006781	0.00	756		
535	no site	24/03/2010 10:10	461898	6006690	-2.66			
536	no site	24/03/2010 10:11	461931	6006644	-0.62			
537	no site	24/03/2010 10:13	461910	6006553	-0.31			
538	no site	24/03/2010 10:14	461910	6006529	-0.48			
539	no site	24/03/2010 10:16	461889	6006480	-0.70			
540	no site	24/03/2010 10:17	461879	6006424	-0.60			
541	no site	24/03/2010 10:23	461884	6006503	0.00			
542	no site	24/03/2010 10:26	461898	6006460	0.00			
543	no site	24/03/2010 10:37	461885	6005330	1.90			
544	no site	24/03/2010 10:37	461937	6005321	1.21			
545	no site	24/03/2010 10:38	462106	6005385	1.67			
546	no site	24/03/2010 10:39	462175	6005513	1.74			
547	no site	24/03/2010 10:41	462588	6006129	2.25			
563	Site 2	11/05/2010 13:19	463706	6008274	0.00		mud/fine sand	
564	Site 2	11/05/2010 13:27	463473	6008216	0.00	84	pebbles	
565	Site 2	11/05/2010 13:33	464154	6008140	0.00		gravel/rocks	
566	Site 2	11/05/2010 13:36	464161	6008074	0.00		rocks	
567	Site 2	11/05/2010 13:39	464195	6008029	0.00	503728	sand	
568	Khyex	20/05/2010 9:20	448626	6013932	0.00			
China Bar 79.5		12/07/2009 20:46	471213	6011584	0.00			
Grab 01	Site 3	11/03/2010 11:37	467603	6009632	0.00	302458	sand	

Grab 02	Site 4	11/03/2010 11:53	470440	6009369	0.00	68053	
Grab 03	Site 4	12/03/2010 10:21	468898	6009537	0.00		sand/mud
Grab 04	Site 4	12/03/2010 10:32	468766	6009579	0.00		mud
Grab 05	Site 4	12/03/2010 12:12	470523	6009465	0.00		
Grab 07	Site 4	12/03/2010 12:21	470397	6009342	0.00		
Grab 08	Site 4	12/03/2010 12:27	470526	6009128	0.00	7561	
Grab 09	Site 4	12/03/2010 12:23	470438	6009343			
Km 80		12/07/2009 20:47	471624	6011957			
Kwinitsa E Ck		21/08/2009 17:50	466296	6010827			
Launch 44.4 km		12/07/2009 20:48	441912	6008745			
Launch 74.5 km		12/07/2009 20:37	466205	6010721			
Launch 77.4 km		12/07/2009 20:42	468877	6011152			
Launch Ex 112		13/07/2009 6:50	496291	6028028			
Launch Ex 93.5		12/07/2009 21:13	480529	6020622			
Launch Ka 85.5		12/07/2009 20:54	473979	6016288			
Launch Kwin 69		12/07/2009 20:30	462406	6008327			
Margonish Ck		12/08/2009 17:17	444875	6010260			
Polymar Ck		21/08/2009 17:35	470879	6011625			
seals 1		11/03/2010 9:56	465018	6008426			
seals 2		16/03/2010 8:57	463997	6008000			
Site 2		10/03/2010 10:21	463748	6007999			
Site 3		10/03/2010 10:41	467532	6009561			
Site 4		11/03/2010 12:00	470473	6009359			

Table 6 - Egg Sampling Results for Ecstall River.

Waypoint No	Date/Time	Position UTM	Depth (m)	Temp ©	salinity (ppt)	substrate	Density Eggs (m^{-2})
18	29/03/2010 13:33	9 U 460998 5970496					
19	29/03/2010 15:51	9 U 457311 5974386		4.2	0		
20	29/03/2010 16:24	9 U 464770 5968992					
21	29/03/2010 16:33	9 U 464839 5968956					
22	29/03/2010 17:02	9 U 461358 5970075					
23	29/03/2010 17:25	9 U 460018 5970141					
24	30/03/2010 9:59	9 U 454455 5979687					
25	30/03/2010 10:03	9 U 455229 5979118					
26	30/03/2010 10:05	9 U 455829 5978790					
27	30/03/2010 10:06	9 U 456133 5978354					
28	30/03/2010 10:07	9 U 456239 5977894					
29	30/03/2010 10:11	9 U 456222 5975580					
30	30/03/2010 10:12	9 U 456628 5975239					
31	30/03/2010 10:16	9 U 456677 5974873					
32	31/03/2010 12:23	9 U 459349 5972354				sand & snags	
33	31/03/2010 12:26	9 U 459283 5972426	-1.48			sand dunes	
34	31/03/2010 12:28	9 U 459195 5972473				sand dunes	
35	31/03/2010 12:29	9 U 459178 5972509				sand/gravel	
36	31/03/2010 12:30	9 U 459145 5972522	-1.82			lg sand dunes	0
37	31/03/2010 12:32	9 U 459119 5972591				sm sand dunes	
38	31/03/2010 12:33	9 U 459101 5972599				pebble/gravel/debris	
39	31/03/2010 12:34	9 U 459064 5972624	-0.76			sand dunes	0
40	31/03/2010 12:40	9 U 459206 5972507	-2.58			sand/debris/rocks	0
41	31/03/2010 12:42	9 U 459188 5972522	-2.39			gravel/sand	0
42	31/03/2010 12:42	9 U 459173 5972541				sand dunes/gravel	
43	31/03/2010 12:43	9 U 459162 5972543				sand dunes/gravel	
44	31/03/2010 12:44	9 U 459133 5972578	-1.33			gravel	0

45	31/03/2010 12:46	9 U 459104 5972604				sand dunes/gravel	
46	31/03/2010 12:47	9 U 459061 5972643	-0.79			sand dunes	0
47	31/03/2010 12:49	9 U 459007 5972604	-1.06			fine sand	0
48	31/03/2010 13:13	9 U 459135 5972476	-1.58			sm sand dunes	0
49	31/03/2010 13:15	9 U 459187 5972439	-1.48				0
50	31/03/2010 13:15	9 U 459218 5972405	-1.45				0
51	31/03/2010 13:16	9 U 459239 5972390	-0.67				0
52	31/03/2010 13:19	9 U 459249 5972334	-0.06				0
53	31/03/2010 14:10	9 U 459217 5972456	-1.39				0
54	31/03/2010 14:11	9 U 459215 5972458	-2.30				0
56	31/03/2010 14:25	9 U 459213 5972506	-1.52			sm cobble	
57	31/03/2010 14:27	9 U 459220 5972500	-2.52			rocks/sand	0
58	31/03/2010 14:27	9 U 459207 5972508				edge rocks/sand	
59	31/03/2010 14:31	9 U 459196 5972468	-2.00			sand dunes	0
60	31/03/2010 14:31	9 U 459198 5972463					
61	01/04/2010 13:58	9 U 447396 6009336					
62	01/04/2010 14:15	9 U 448644 6010440		5.4	0.1		
63	01/04/2010 14:21	9 U 448410 6012677	-2.73	5.2	0		
64	01/04/2010 14:29	9 U 448711 6014588				grab sample	0
65	01/04/2010 14:34	9 U 449187 6015178				grab sample	0
66	01/04/2010 14:38	9 U 449150 6015182				grab sample	0
67	01/04/2010 14:46	9 U 449463 6015129				grab sample	0
68	01/04/2010 14:50	9 U 449451 6015149				grab sample	0
69	01/04/2010 14:52	9 U 449435 6015146				grab sample	0
70	12/03/2010 10:24	9 U 468937 6009525				grab sample	0
71	12/03/2010 10:24	9 U 468974 6009542				grab sample	0
72	01/04/2010 14:57	9 U 449454 6015109				grab sample	0
73	12/03/2010 10:24	9 U 468999 6009563				grab sample	0
74	12/03/2010 10:25	9 U 469020 6009574				grab sample	0
75	12/03/2010 10:26	9 U 468995 6009518				grab sample	0
76	12/03/2010 10:27	9 U 469037 6009499				grab sample	0

77	12/03/2010 10:28	9 U 469078 6009531		grab sample	0
78	12/03/2010 10:28	9 U 469105 6009525		grab sample	0
79	12/03/2010 10:32	9 U 468767 6009587		grab sample	0
80	12/03/2010 10:38	9 U 468755 6009654		grab sample	0
81	12/03/2010 10:47	9 U 467250 6009654		grab sample	0
82	12/03/2010 10:48	9 U 467259 6009701		grab sample	0
83	12/03/2010 10:48	9 U 467295 6009784		grab sample	0
84	12/03/2010 10:49	9 U 467388 6009883		grab sample	0
85	12/03/2010 10:49	9 U 467447 6009985		grab sample	0
86	12/03/2010 10:50	9 U 467463 6010129		grab sample	0
87	12/03/2010 10:51	9 U 467475 6010251		grab sample	0
88	12/03/2010 10:52	9 U 467496 6010354		grab sample	0
89	12/03/2010 10:52	9 U 467544 6010433		grab sample	0
90	12/03/2010 10:53	9 U 467621 6010477		grab sample	0
91	12/03/2010 10:54	9 U 467682 6010569		grab sample	0
92	12/03/2010 10:54	9 U 467770 6010629		grab sample	0
93	12/03/2010 10:55	9 U 467905 6010691		grab sample	0
94	01/04/2010 15:01	9 U 449439 6015129		grab sample	0
95	01/04/2010 15:03	9 U 449449 6015129		grab sample	0
96	01/04/2010 15:07	9 U 449442 6015130		grab sample	0
532	01/04/2010 15:26	9 U 449335 6015122		grab sample	0
533	01/04/2010 15:35	9 U 449067 6015085		grab sample	0
534	01/04/2010 15:36	9 U 449066 6015094		grab sample	0
535	01/04/2010 15:38	9 U 449045 6015064		grab sample	0
536	01/04/2010 15:42	9 U 449023 6014965		grab sample	0
023vvt		9 U 459097 5972601	-1.3636	grab sample	696
024vvt		9 U 459058 5972646	-0.8485	grab sample	2304
025vvt		9 U 459181 5972528	-2.3939	grab sample	87
026vvt		9 U 459158 5972546	-1.9697	grab sample	6044
027vvt		9 U 458993 5972594	-0.8788	grab sample	261
028vvt		9 U 459134 5972481	-1.4545	grab sample	0

029vvt	9 U 459248 5972338	-0.6061	grab sample	0
030vvt	9 U 459148 5972547	-1.8788	grab sample	304
031vvt	9 U 459143 5972550	-1.6667	grab sample	522
032vvt	9 U 459132 5972543	-1.1212	grab sample	43
033vvt	9 U 459220 5972508	-1.4848	grab sample	
034vvt	9 U 459214 5972495	-2.3939	grab sample	0
035vvt	9 U 459216 5972466	-2.1818	grab sample	826
036vvt	9 U 459231 5972481	-2.7576	grab sample	0

Table 7 - Egg Sampling Results for Khyex River (Kelson, 2010).

Grid UTM Datum NAD83 Waypoint Position (UTM)	Dates: 29-31 March, 2010 River	Depth (ft)	Temp ©	salinity (ppt)	substrate	Sample type	Eggs #	Density (#/m2)	Remarks
64 9 U 448711 6014588	Khyex	nr	nr	nr		grab	0	0	
65 9 U 449187 6015178	Khyex	nr	nr	nr		grab	0	0	
66 9 U 449150 6015182	Khyex	nr	nr	nr		grab	0	0	
67 9 U 449463 6015129	Khyex	nr	nr	nr		grab	0	0	
68 9 U 449451 6015149	Khyex	nr	nr	nr		grab	0	0	
69 9 U 449435 6015146	Khyex	nr	nr	nr		grab	0	0	
72 9 U 449454 6015109	Khyex	nr	nr	nr		grab	0	0	
94 9 U 449439 6015129	Khyex	nr	nr	nr		grab	0	0	
95 9 U 449449 6015129	Khyex	nr	nr	nr		grab	0	0	
96 9 U 449442 6015130	Khyex	nr	nr	nr		grab	0	0	
532 9 U 449335 6015122	Khyex	nr	nr	nr		grab	0	0	
533 9 U 449067 6015085	Khyex	nr	nr	nr		grab	0	0	
534 9 U 449066 6015094	Khyex	nr	nr	nr		grab	0	0	

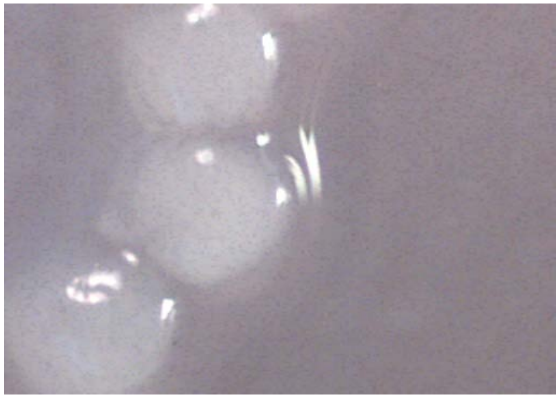
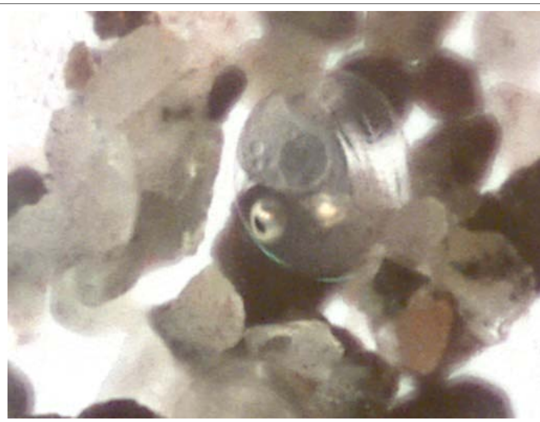
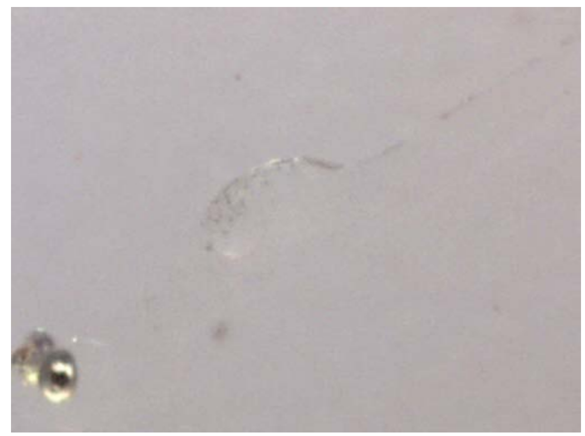
Table 8 - Results from 2010 Eulachon Larvae Sampling

Wpt Name	Place Description	Date/Time	Eastings	Northings	Depth (m)	Surface Salinity (ppt)	Bottom Salinity (ppt)	Temp (ºC)	Larval Density (no m^{-3})	Egg Density (no m^{-3})	Eulachon larval Density (no m^{-3})	Notes
569	Khyex River	20/05/2010 9:20	448625	6013932					0.13		0.00	mayfly casts
570	Ayton I, Skeena Main	20/05/2010 9:45	450160	6007839		0.0	0.0	8.7	8.70	0.3165	8.64	big mayfly, 1 sculpin larvae, rest eulachons
571	Windsor Pt., Skeena Main	20/05/2010 10:03	444228	6007998	9.091	0.0	0.0	8.8	4.09		3.95	1 sculpin, rest eulachons, some just hatched; odd isopod
572	Power Line, Tyee, Skeena	20/05/2010 10:15	440572	6006405	3.03	0.0	0.0	9.2	14.37	0.824	14.26	few amphipods, 1 sculpin, rest eulachons
573	Mouth Ecstall River	20/05/2010 10:49	438181	6000888	9.394	0.0	0.3	11.1	0.41		0.00	opossom shrimp (*Neomysis* spp.) w egg sacs, 1 pink juvie
574	Ecstall River	20/05/2010 11:12	440091	5996231		0.1		11.9	0.36		0.00	all sculpins, opossom shrimp (*Neomysis* spp.) w egg sac
575	Ecstall River	20/05/2010 11:28	443137	5992250	6.364	0.0		11.4	0.09		0.04	debris, isopods, *Americorophium* isopods, opossom shrimp (Neomysis spp.) w egg sacs, 1 sculpin
576	Madeline Ck, Ecstall River	20/05/2010 11:55	448109	5984386	5.152	0.0		9.0	0.22		0.20	1 sculpin larvae
577	Big Falls, Ecstall River	20/05/2010 12:14	451269	5981416					0.01		0.00	mayfly casts

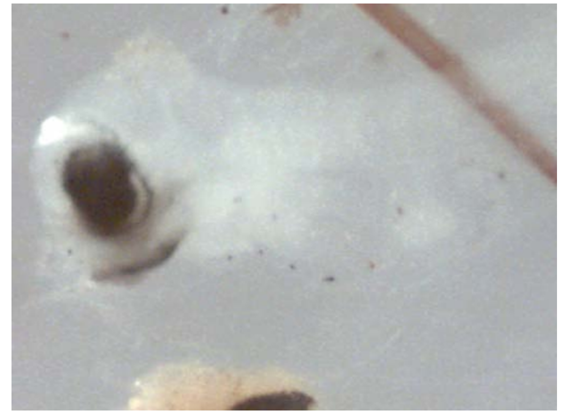
578	Hayward Ck, Ecstall River	20/05/2010 12:56	444779	5989297	2.485	0.1		11.9	0.00		0.00	debris/stoneflies
579	Port Essington	20/05/2010 13:35	436580	6002332					0.00		0.00	all sculpins, shrimps
580 Top	Veitch Pt, Skeena	20/05/2010 13:51	432025	6001245	9.697	0.0		9.0	46.49		46.05	1 sculpin, rest eulachons, w sm yolk sacs
580 Bottom	Veitch Pt, Skeena	20/05/2010 13:51	432025	6001245	9.697				2.59	0.5381	2.59	All eulachons, some freshly hatched
581	Hanmer Pt, Skeena	20/05/2010 14:19	429101	5997422	6.97	1.3	14.5	10.3	1.13		1.11	lots copepods: calanoids, few harpactacoid; medusae, 1 sculpin larvae
582	Clayton Cannery, Skeena	20/05/2010 14:42	428144	5993096	6.364	0.0	4.0	10.3	0.32		0.32	1 large (20mm) eulachon, rest large w no yolk sacs
583	Boneyard, Skeena	20/05/2010 15:04	427765	6000625	6.364	0.0	2.6	9.7	60.41		59.11	7 sculpins, rest eulachons
584	Inverness Passage East	20/05/2010 15:27	424035	6002105	8.182	2.8	6.3	10.4	0.06		0.06	all eulachons
585	Hicks Pt, Inverness Pass	20/05/2010 15:48	417807	6006111	12.12	1.8	25.2	11.5	1.61		1.61	All eulachon, lots harpactacoids, many calanoids, odd jellyfish, few crab larvae
586	Haysport, Skeena	20/05/2010 16:39	434269	6002994	8.182	0.0		9.7	7.56		7.56	all eulachons, assorted sizes, few larger larvae w full stomachs
587	Snag Point, Skeena	21/05/2010 11:12	455182	6005376					2.17		2.07	1 sculpin larvae, rest eulachon
588	Scotia River	21/05/2010 11:32	458224	6002264	0.909	0.0		6.7	0.01		0.01	

589	Scotia River	21/05/2010 11:48	457549	6002125	0.07	0.01	mayfly casts
590	Kwinitsa, Skeena	21/05/2010 12:25	461933	6007116	1.69	1.69	all eulachons
591	Kasiks River Mouth	21/05/2010 13:55	473918	6016388	0.13	0.13	

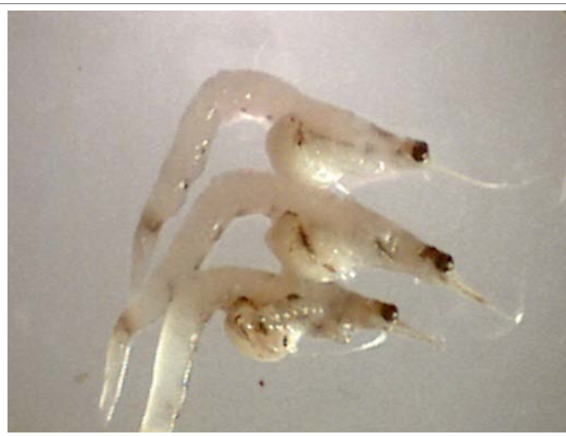
Table 9 - Pictures from the Microscope of the Planktonic/Benthic Organisms

 A - Unfertilized eulachon eggs	 B-Fertilized eulachon egg with attached sand
 C-Eulachon egg near hatch	 D-Live early-stage, transparent eulachon larvae

E-Preserved, translucent eulachon larvae

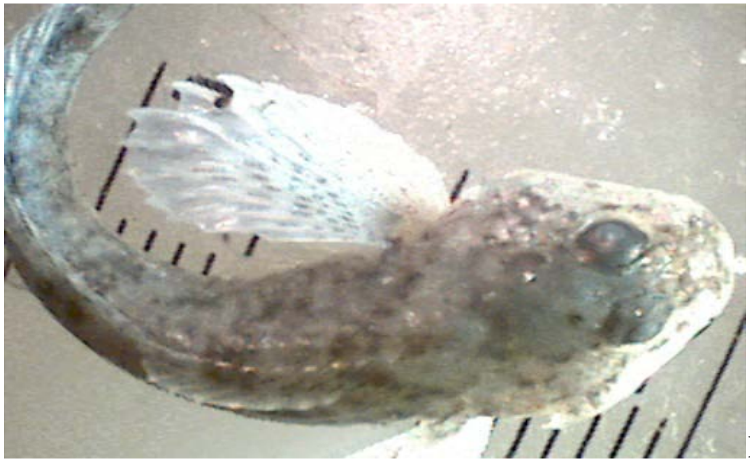


F-Preserved, unidentified (prickly?) sculpin larvae



G-Opossum shrimp *Neomysis* sp.

H-Unidentified amphipods

 I- Unidentified sculpin caught in grab sample	J- amphipod *Americorophium* spp *Amewricorophium* amphipod