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Habitat Utilization and Improvement Opportunities in the Englishman River Estuary

Prepared by

LGL Limited
and
BC Conservation Foundation

Prepared for

BC Conservation Foundation

January 2012

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Acknowledgments

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1 Introduction

The Englishman River estuary has lost significant habitat complexity and productivity for rearing salmonids as a result of urban/agricultural encroachments, dyking, over-grazing of sedge vegetation by Canada Geese, and the historic conversion of upper watershed old growth forests to second and third growth conifer plantations (Buechert et al. 2009; C. Wightman, BC Conservation Foundation (BCCF) pers. comm.). Consequently, BCCF and other organizations are interested in rehabilitating the estuary and improving rearing habitat for juvenile salmonids. In support of this objective, a better understanding of the range of characteristics and habitat preferences of salmonids for available rearing space in the estuary is a prerequisite to development of a detailed rehabilitation plan.

In this project, the British Columbia Conservation Foundation (BCCF) investigated the distribution and habitat preferences of juvenile salmonids that rear in the Englishman River estuary. Their investigation sought answers to fundamental biological questions about the current habitat condition and complexity of the estuary, its utilization by salmonids of different species, and specific physical characteristics of the preferred habitat type(s). The questions included:

- Has the salmonid habitat of the Englishman River estuary changed from its historic condition?
- How would we characterize the health and condition of the existing habitat in the estuary?
- What species and life stages of salmonids use the estuary as rearing habitat?
- What types of habitat are the most and least preferred by salmonids?
- When and for how long is this habitat used by salmonids?
- What structural component(s) of the preferred habitat appear to be most important to salmonids?

This investigation is the first stage in a feasibility assessment examining the biological need, benefits, constraints and alternatives for improving habitat complexity in the estuary. If the feasibility assessment recommends that improvements to habitat are warranted, then the investigation and assessment will provide the biological basis, rationale and, potentially, design criteria for a rehabilitation plan to improve the quality of salmonid rearing habitat in the Englishman River estuary. Any rehabilitation plan that may be developed in the future must be multi-disciplinary and consider the current ecological uses of the lower river and estuary habitat by various native wildlife species. In addition, the plan must consider or comply with designated land uses, flood protection requirements, and other community priorities. Development of the rehabilitation plan will therefore involve working in close cooperation with organizations including City of Parksville, Guardians of Mid Island Estuaries Society, Mid Vancouver Island Habitat Enhancement Society (MVIHES), The Nature Trust of BC (TNT), Ministry of Forests, Lands and Natural Resource Operations (BC Fish & Wildlife Branch), Ministry of Environment (BC Parks), Regional District of Nanaimo, local First Nations and Fisheries and Oceans Canada.

1.1 Project Scope

This project investigated the distribution and habitat preferences of juvenile salmonids that rear in the Englishman River estuary. The responsibilities of LGL Ltd. in this investigation included:

1. Providing a statistical experimental design for assessing the preferred habitats of juvenile salmonid rearing habitat in the Englishman River estuary;
2. Summarizing the fish abundance data collected by BCCF and providing a statistical analysis; and
3. Preparing a report describing and discussing the results of the survey data analyses, and providing recommendations on next steps.

The following report documents the analyses, interpretations and conclusions relative to the three tasks described above.

2 Methods

2.1 Study Design

The estuary was divided into four survey quadrants that were differentiated by their hydraulic connection to Englishman River flows and their relative salinity at low tide (Table 1; Figure 1). Quadrants 1 and 2 were located in the western portion of the estuary near the community of Surfside. Quadrants 3 and 4 were located in the eastern portion of the estuary on the mainstem and a primary side channel of the Englishman River.

Table 1. Characteristics of the four survey quadrants (Q) in the Englishman River estuary.

Quadrant	Site Description
Q1	Small to medium-sized, dendritic channels with moderate residual pool depths near the estuary's western edge; only connected to freshwater flows from Englishman River at high tides; relatively high salinity at low tides;
Q2	Moderate to large, sinuous, open channels with generally shallow depths in the western half of the estuary; only connected to freshwater flows from Englishman River at high tides; relatively high salinity at low tides;
Q3	Mainstem channel and associated flats; connected to freshwater flows from Englishman River at all times; relatively low salinity at low tides; and
Q4	Secondary channel of river with associated flats; connected to freshwater flows from Englishman River at all times; relatively low salinity at low tides.

Within these quadrants BCCF fisheries staff determined the predominant types of cover and their locations in the Englishman River estuary. In addition, habitats without cover were also located. Four Habitat-type categories were characterized from their assessment (Table 2).

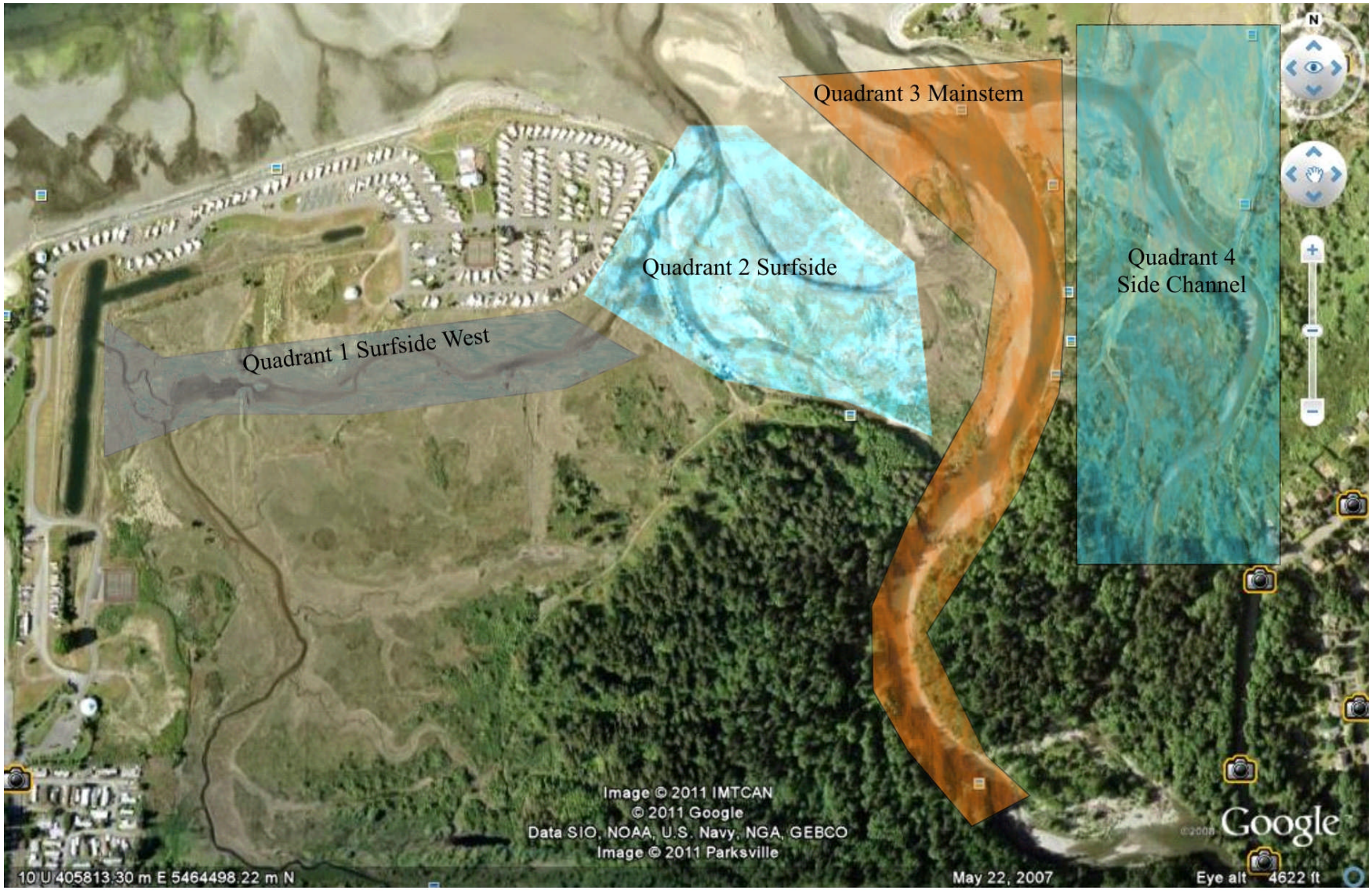

Figure 1. Map of Englishman River estuary showing the boundaries of four survey quadrants.

Table 2. Description of the four predominant Habitat-types assessed in the Englishman River estuary.

Habitat-type	Description
No Cover (Control)	Mainstem or secondary channel with banks of typically cobble or gravel; residual pools/flats/channels (3-10 m wide; <1 m deep) with little to no cover
Large Wood Debris (LWD)	Generally a low frequency of occurrence in the estuary; present primarily along the edges of the channel but some LWD situated mid-channel or on open flats; some LWD embedded into sediments while other pieces could potentially float away at high discharges
Overstream Vegetation	Generally a low frequency of occurrence in the estuary; located within 1 m of the water surface at low tide; includes overhanging shrubs, trees, and grass/sedge; typically found with some degree of eroding, undercut bank
Rip Rap	Associated with bank protection in the mainstem and secondary (east) channel of the Englishman River; large diameter (~0.7-1.1 m) with numerous, large voids between individual rocks

Where specific cover types were present within quadrants, survey sections were established that represented the four Habitat-types (Table 3; Figure 2). Each survey section was ~15 m in length and delineated by flagged wooden stakes or painted lines on the stream bank. Sections were generally no more than 3 m in width to maximize species identification.

Table 3. A description of the treated and control sites assessed within four quadrants of the Englishman River estuary.

Quadrant	Habitat-type	No. of Sites
Q1	No Cover (Control)	2
Q2	No Cover (Control)	2
Q3	No Cover (Control)	2
	LWD	3
	Riprap	1
Q4	No Cover (Control)	2
	Riprap	2
	Overhanging Vegetation	3
Subtotals	No Cover (Control)	8
	LWD	3
	Riprap	3
	Overhanging Vegetation	3
	Total	17

Snorkel swims were conducted by BCCF fisheries staff to assess fish utilization of the habitats at each site. Fish counts were recorded at 17 locations, during 11 snorkel surveys that occurred from 13 April to 24 August 2011. Surveys generally occurred weekly from mid-April to mid-June, then monthly to the end of August 2011. The

snorkel team was generally the same two biologists each survey. The team started at the western sites (Q1 and Q2) and worked their way eastward to the river's secondary channel (Q4). Observations and counts occurred within two hours of a low tide. Each section was swum slowly by one swimmer (same person each time) employing an LED dive light to look into crevices/riprap voids, etc. Swimmers surveyed in a downstream to upstream direction and, unless fish numbers changed substantially, attempted to spend the same effort on each site as they had on previous occasions. All fish were counted and speciated and their life stage identified (i.e., fry, parr, smolt). Salmonids that could not be confirmed to species were counted as 'unknown'. Presence and relative abundance of prey species and invertebrates were noted. Depth and water quality measurements that included temperature, pH, dissolved oxygen, specific conductivity, ortho-phosphate (ORP) and salinity were taken to characterize the 17 sites. Weather, tides, transparency (presence of salt water, lensing effects) were also noted each survey.

2.2 Statistical Analysis

An analysis was made to determine whether the differences in fish abundance between the four Habitat-types (i.e., LWD, Overstream Vegetation, Riprap and No Cover) were statistically significant. Differences were tested for each salmonid species and life stage observed and recorded during the snorkel surveys. Unknown fish were partitioned into known categories for the analysis. For example, if 60 unknown fish were observed, and proportions of 90% Chum and 10% Coho were estimated, then 54 Chum and 6 Coho were added. If no proportions were estimated, the relative proportions at the other sites during that week were used to partition the unknown fish to species.

Two statistical models were constructed. The first test examined the effect of Habitat-type on the numbers of fish observed, with data restricted to those from the 'Flow' Zone (i.e., Quadrants 3 and 4). The restriction was imposed because only one Habitat-type (i.e., 'Control') was available to be surveyed in the 'Surfside' Zone (i.e., Quadrants 1 and 2). The second test examined the effect of Zone on the numbers of fish observed, with data restricted to those from the 'Control' Habitat-types.

Both statistical models were fully-factorial general linear models (GLM), with over-dispersed Poisson distributions (log links), using fish counts as the continuous response variable. Both models included Survey Date and its interaction with the factor of interest as categorical explanatory factors. Locations were treated as independent replicates. Separate analyses were run for the most commonly observed fish groups (Habitat effects: Coho, Chinook, Chum, and Coho smolts; Zone effects: Coho, Chinook, and Chum). Initially, the full model was run for each analysis. If the interaction term was significant, the analysis was re-run, examining the effect of the factor of interest for each Survey Date separately. If the interaction term was not significant, it was removed from the model, and the analysis was re-run. If there was evidence for an effect of Habitat-type, post-hoc tests were performed to examine the nature of the differences among habitats. Since alpha-controlled methods were not available under the GLM platform, all possible contrasts were examined, and experiment-wise alpha was controlled using the Bonferroni adjustment.

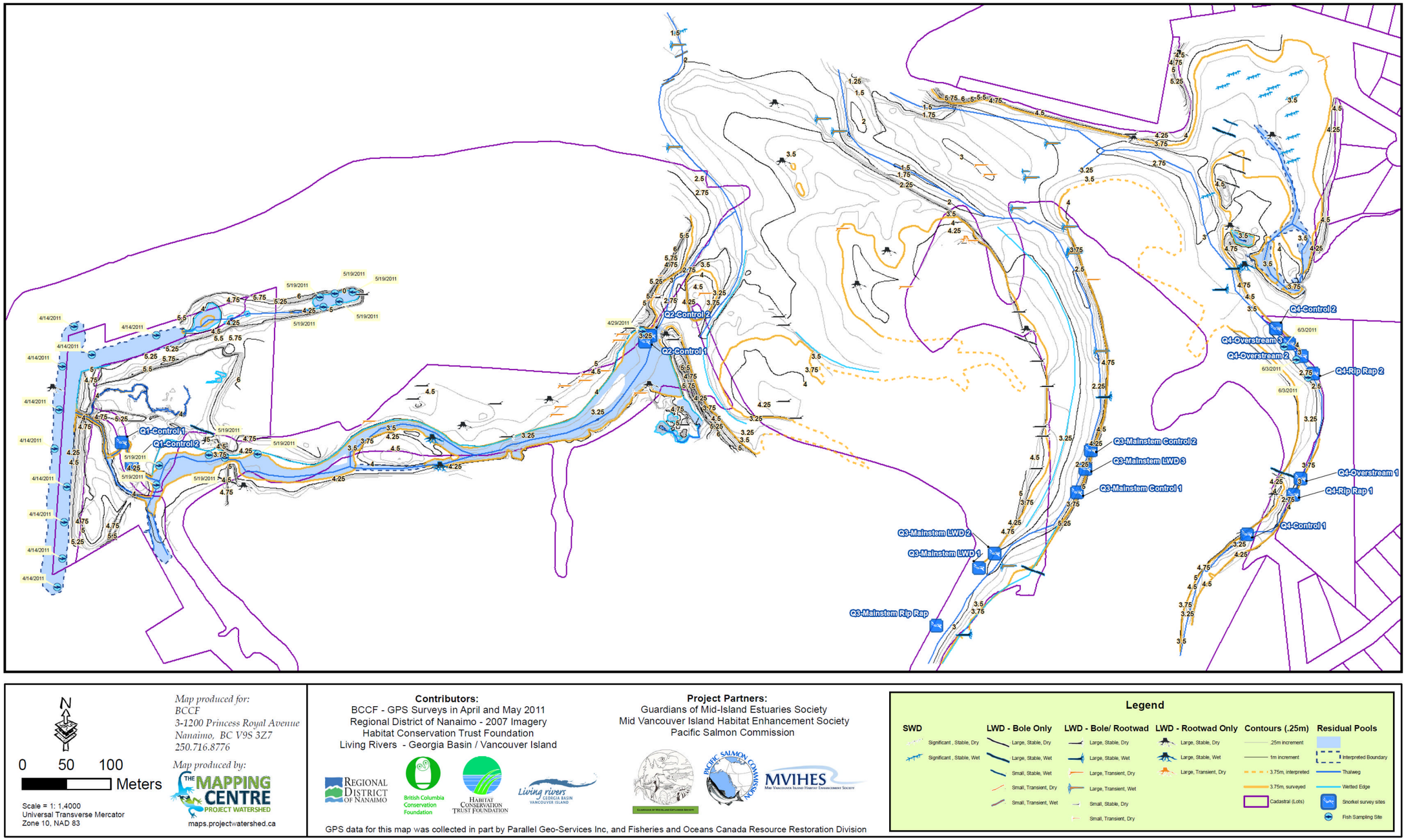

Figure 2. Map of Englishman River estuary showing the location of 17 survey sites within four quadrants.

3 Results

3.1 Site Water Quality

Water quality measurements taken at low tide in the Englishman River estuary showed that the shallower Quadrants 1 and 2 (Surfside area) had higher salinity and water temperatures than the generally deeper Quadrants 3 and 4 (Flow area) (Table 4). Salinities on 1 June 2011 averaged 12.86 ppt in Quadrants 1 and 2 but averaged 0.02 ppt in Quadrants 3 and 4. Water temperatures averaged 18.20^{0}C in Quadrants 1 and 2 but averaged 8.54^{0}C in Quadrants 3 and 4.

3.2 Fish Composition and Abundances

Snorkel surveys conducted in the Englishman River estuary between 13 April and 24 August 2011 observed a total of 7,992 Coho (CO) juveniles and smolts, 154 Chum (CM) fry, 2,525 Chinook (CH) juveniles, 24 Rainbow Trout (RB) juveniles, and 4 anadromous Cutthroat Trout (ACT) juveniles, but no Pink Salmon (PK) fry[1] or Steelhead (ST) smolts (Table 5; Appendix A to Appendix K; Photo 1 to Photo 15). It was apparent during the surveys that Chinook were comprised of two distinct size classes, suggesting that a large proportion of those observed originated from the community hatchery located in Reach 3 of the Englishman River. Approximately, ten times more fish were observed in the Sites with Cover than in the Control Sites, with all species and life stages preferentially selecting Sites with Cover. For Sites with Cover, Chum fry numbers peaked 5 May while the numbers of Coho and Chinook juveniles and smolts peaked on 24 May. No Rainbow Trout juveniles were observed until the last snorkel survey on 24 August. No distinct relationship was apparent between fish abundance and the date of survey for the Control Sites but the majority of fish were observed between 20 May and 17 June at the Sites with Cover (Table 6; Figure 3; Figure 4).

[1] Following a snorkel survey on April 13, low numbers of Pink fry were observed in a shallow, isolated residual pool adjacent to the mainstem.

Table 4. Summary of water quality measurements at survey sites.

Date: 1-Jun-11	Q1-Control 1	Q1-Control 2	Q2-Control 1	Q2-Control 2	Q3-Control 1	Q3-Control 2	Q3-LWD 1	Q3-LWD 2	Q3-LWD 3	Q3-Rip Rap	Q4-Control 1	Q4-Control 2	Q4-Overstream 1	Q4-Overstream 2	Q4-Overstream 3	Q4-Rip Rap 1	Q4-Rip Rap 2
Parameters	Bottom	Bottom	Bottom		Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom
Time	11:55	12:00	12:15		15:05	14:35	15:25	15:20	14:55	15:35	14:25	13:30	14:15	13:50	13:45	14:20	14:00
Depth (m)	0.15	0.1	0.3		0.2	0.4	0.8	0.8	1.1	1.1	0.2	0.2	0.4	0.5	0.6	0.5	0.6
Water Temperature (^{o}C)	17.34	17.23	20.04		8.41	8.51	8.25	8.57	8.49	8.23	8.52	8.73	8.61	8.69	8.69	8.6	8.7
pH	7.99	8.13	8.4		7.29	7.27	7.28	7.41	7.32	7.29	7.28	8.25	7.49	7.38	7.47	7.32	7.45
Dissolved Oxygen (mg/l)	9.76	9.97	12.17		11.99	12.02	12.07	11.91	12.02	12.05	12.06	12.35	12.05	12.24	12.28	12.04	12.19
Specific Conductivity	21119	21312	22154		74	89	41	41	87	41	41	109	44	84	104	44	73
ORP	337	330	325		379	378	401	396	386	408	374	309	357	354	355	367	363
Salinity (ppt)	12.6	12.74	13.24		0.03	0.03	0.01	0.01	0.03	0.01	0.01	0.04	0.01	0.03	0.04	0.01	0.02

Date: 13-May-11	Q1-Control 1	Q1-Control 2	Q2-Control 1	Q2-Control 2	Q3-Control 1	Q3-Control 2	Q3-LWD 1	Q3-LWD 2	Q3-LWD 3	Q3-Rip Rap	Q4-Control 1	Q4-Control 2	Q4-Overstream 1	Q4-Overstream 2	Q4-Overstream 3	Q4-Rip Rap 1	Q4-Rip Rap 2
Parameters			Bottom							Bottom	Bottom			Bottom			
Time			13:40							11:08	10:35			12:40			
Depth (m)			0.5							0.1	0.25			0.6			
Water Temperature (^{o}C)			16.97							6.2	5.73			7.19			
pH			8.72							7.29	7.05			7.37			
Dissolved Oxygen (mg/l)			18.45							12.97	13.01			13.11			
Specific Conductivity			31816							42	41			126			
ORP			346							384	378			385			
Salinity (ppt)			19.81							0.01	0.01			0.05			

Date: 29-Apr-11	Q1-Control 1	Q1-Control 2	Q2-Control 1	Q2-Control 2	Q3-Control 1	Q3-Control 2	Q3-LWD 1	Q3-LWD 2	Q3-LWD 3	Q3-Rip Rap	Q4-Control 1	Q4-Control 2	Q4-Overstream 1	Q4-Overstream 2	Q4-Overstream 3	Q4-Rip Rap 1	Q4-Rip Rap 2
Parameters			Bottom							Bottom	Bottom						
Time			-							10:00	11:03						
Depth (m)			0.44							0.4	0.3						
Water Temperature (^{o}C)			15.76							5.34	5.9						
pH			8.39							n/a	7.95						
Dissolved Oxygen (mg/l)			16.85							13.21	13.09						
Specific Conductivity			n/a							n/a	46						
ORP			n/a							n/a	n/a						
Salinity (ppt)			19.44							0.01	0.01						

Table 5. Fish species abundances at Control Sites and Sites with Cover in the Englishman River estuary.

Date	Sites	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total
13-Apr-11	Control Sites	0	0	0	0	0	0	0	0	0	0	0	0
	Sites with Cover	10	0	5	50	0	0	0	0	0	0	0	65
19-Apr-11	Control Sites	0	0	0	0	0	0	0	0	0	0	60	60
	Sites with Cover	0	0	0	0	0	0	1	0	0	0	97	98
5-May-11	Control Sites	5	0	0	0	0	0	0	0	0	0	120	125
	Sites with Cover	242	4	52	54	0	0	0	0	0	0	0	352
13-May-11	Control Sites	28	0	7	6	0	0	0	0	0	0	0	41
	Sites with Cover	74	5	8	0	0	0	0	0	0	0	228	315
20-May-11	Control Sites	107	0	7	64	0	0	0	0	0	0	0	178
	Sites with Cover	201	69	9	26	0	0	0	0	0	0	1104	1409
24-May-11	Control Sites	47	0	0	10	0	0	0	0	0	0	1	58
	Sites with Cover	2346	118	20	829	0	0	0	0	0	0	0	3313
1-Jun-11	Control Sites	87	1	10	203	0	0	0	0	0	0	0	301
	Sites with Cover	843	75	25	664	0	0	0	0	0	0	748	2355
7-Jun-11	Control Sites	148	0	0	40	0	0	0	0	0	0	6	194
	Sites with Cover	1406	93	11	395	0	0	0	0	0	0	369	2274
17-Jun-11	Control Sites	123	0	0	31	0	0	0	0	0	0	0	154
	Sites with Cover	1510	45	0	149	0	0	0	0	0	0	335	2039
19-Jul-11	Control Sites	38	0	0	0	0	0	0	0	0	0	0	38
	Sites with Cover	189	0	0	0	0	0	0	0	0	0	0	189
24-Aug-11	Control Sites	16	0	0	0	0	0	0	0	0	0	0	16
	Sites with Cover	162	0	0	4	0	3	6	14	0	4	0	193
Total	Control Sites	599	1	24	354	0	0	0	0	0	0	187	1165
	Sites with Cover	6983	409	130	2171	0	3	7	14	0	4	2881	12602

Table 6. Summary of total fish observed at each site on each survey date.

Site Number	Site	13-Apr	19-Apr	5-May	13-May	20-May	24-May	1-Jun	7-Jun	17-Jun	19-Jul	24-Aug	Total
1	Q1-Control 1	0	0	0	0	1	8	6	10	8	0	0	33
2	Q1-Control 2	0	0	0	0	5	1	0	0	0	0	0	6
3	Q2-Control 1	0	0	120	1	0	0	0	0	0	0	0	121
4	Q2-Control 2	0	60	0	0	2	0	0	1	0	0	0	63
5	Q3-Control 1	0	0	0	2	63	0	175	90	20	1	0	351
6	Q3-Control 2	0	0	0	0	2	0	28	16	1	0	0	47
11	Q4-Control 1	-	0	5	38	105	49	85	71	105	37	16	511
12	Q4-Control 2	0	0	0	0	0	0	7	6	20	0	0	33
7	Q3-LWD 1	0	1	3	41	58	405	39	64	131	34	4	780
8	Q3-LWD 2	0	0	69	42	198	512	61	229	291	105	115	1622
9	Q3-LWD 3	0	11	41	135	208	652	312	651	214	37	25	2286
10	Q3-Rip Rap	0	0	0	0	23	36	46	76	47	0	2	230
13	Q4-Overstream 1	0	0	56	0	226	362	318	281	214	1	16	1474
14	Q4-Overstream 2	65	86	136	87	554	631	594	176	230	7	24	2590
15	Q4-Overstream 3	0	0	0	0	66	324	687	551	590	0	3	2221
16	Q4-Rip Rap 1	0	0	15	3	45	89	120	102	91	2	4	471
17	Q4-Rip Rap 2	0	0	32	7	31	302	178	144	231	3	0	928
	Totals	65	158	477	356	1587	3371	2656	2468	2193	227	209	13767

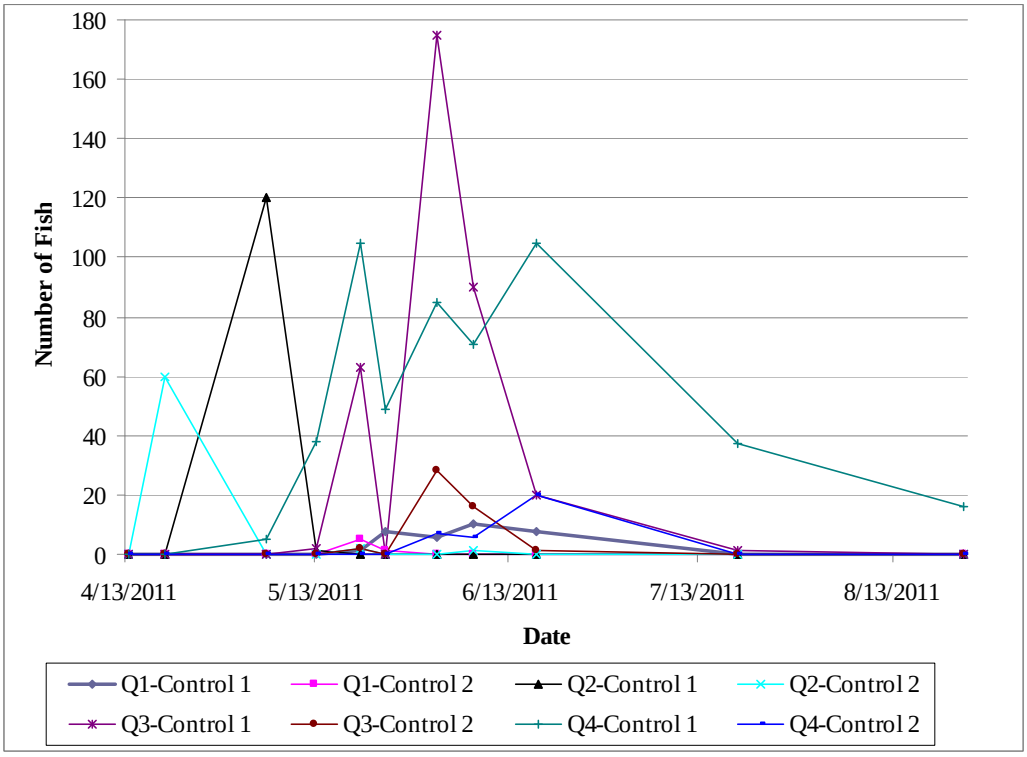

Figure 3. Number of fish observed between 13 April and 24 August 2011 during snorkel surveys at Control Sites in Quadrants (Q) 1-4 of the Englishman River estuary.

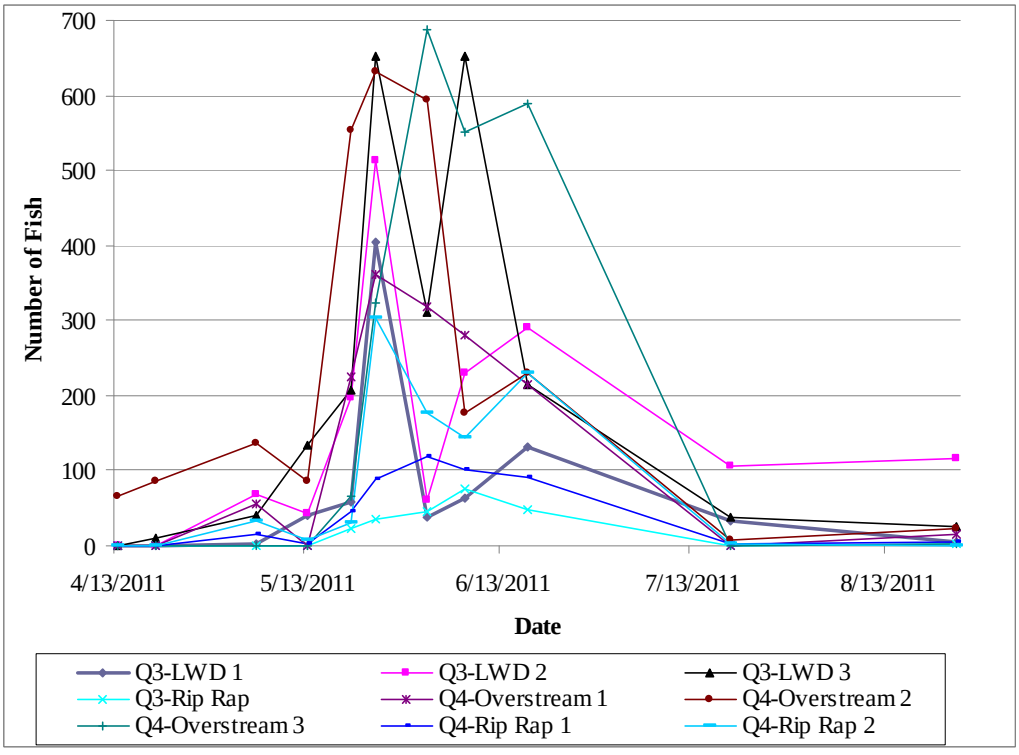

Figure 4. Number of fish observed between 13 April and 24 August 2011 during snorkel surveys at Sites with Cover in Quadrants (Q) 3 and 4 of the Englishman River estuary.

3.3 Effects of Habitat-type

An examination of species preferences for the various Habitat-types in the Englishman River estuary found that habitats with LWD and Overstream Vegetation cover were, on average, inhabited with more Coho, Chinook and Chum than habitats without cover (Control) or with Rip Rap cover (Figure 5).

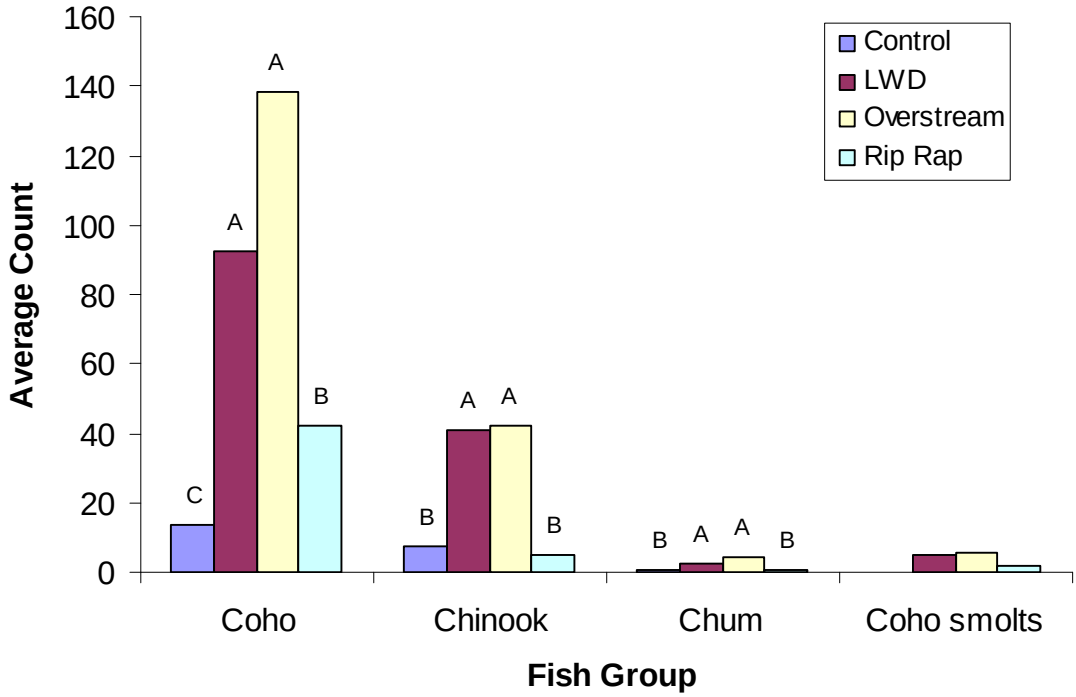

Figure 5. The average counts of fish observed in each of four Habitat-types, by fish group. Within a fish group, letters are shown above the bars to indicate statistically significant differences (i.e., Habitat-types that share a letter in common are not significantly different).

3.3.1 Coho

Coho counts were initially modeled as a function of Habitat-type, Survey Date, and the Habitat-type × Survey Date interaction. The interaction term was not significant (Chi sq = 37.4, df = 30, $P = 0.17$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Habitat-type (Figure 5; Figure 6; Chi sq = 117.8, df = 3, $P < 0.0001$) and of Survey Date (Chi sq = 211.2, df = 10, $P < 0.0001$). Post-hoc examination of Habitat-type effects revealed:

- LWD counts were not significantly different from Overstream Vegetation counts;
- LWD and Overstream Vegetation counts were greater than Rip Rap and Control counts; and
- Rip Rap counts were greater than Control counts.

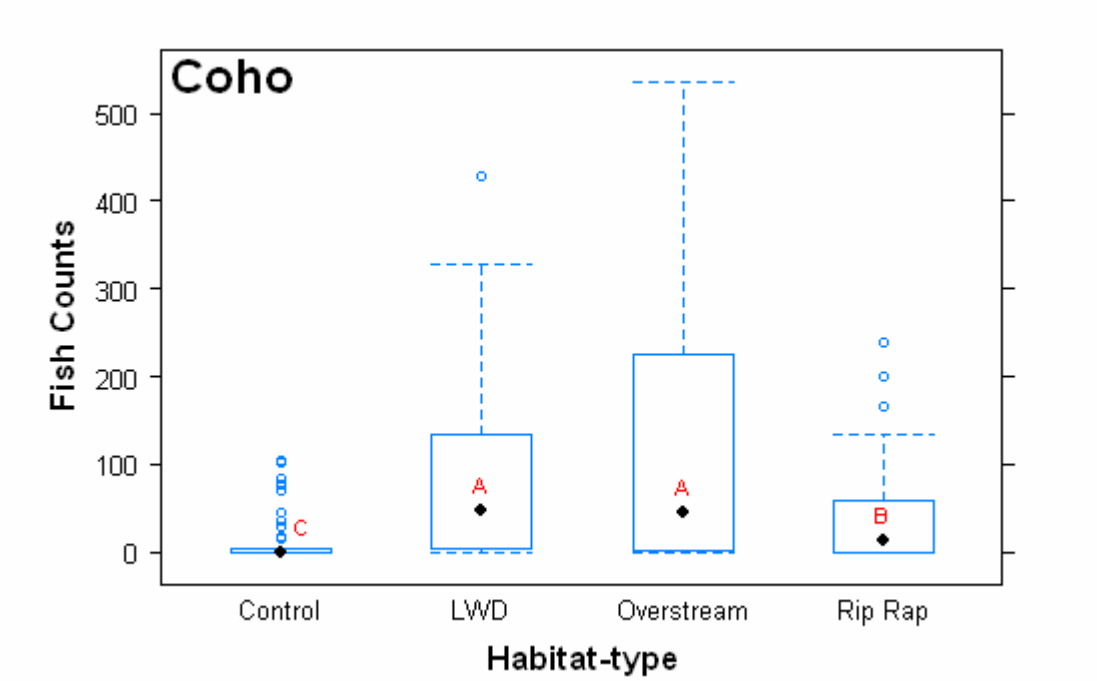

Figure 6. The distribution of coho counts observed in each of four Habitat-types. Black diamonds represent median values. Boxes extend from the 25th to the 75th percentiles. Vertical 'whiskers' extend to 1.5 × the interquartile range. Extreme values shown as open circles. Letters are shown to indicate statistically significant differences (i.e., Habitat-types that share a letter in common are not significantly different).

3.3.2 Chinook

Chinook counts were initially modeled as a function of Habitat-type, Survey Date, and the Habitat-type × Survey Date interaction. The interaction term was not significant (Chi sq = 37.5, df = 30, $P = 0.17$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Habitat-type (Figure 5; Figure 7; Chi sq = 73.1, df = 3, $P < 0.0001$) and of Survey Date (Chi sq = 164.9, df = 10, $P < 0.0001$). Post-hoc examination of Habitat-type effects revealed:

- LWD counts were not significantly different from Overstream Vegetation counts;
- Rip Rap counts were not significantly different from Control counts; and
- LWD/Overstream Vegetation counts were greater than Rip Rap/Control counts.

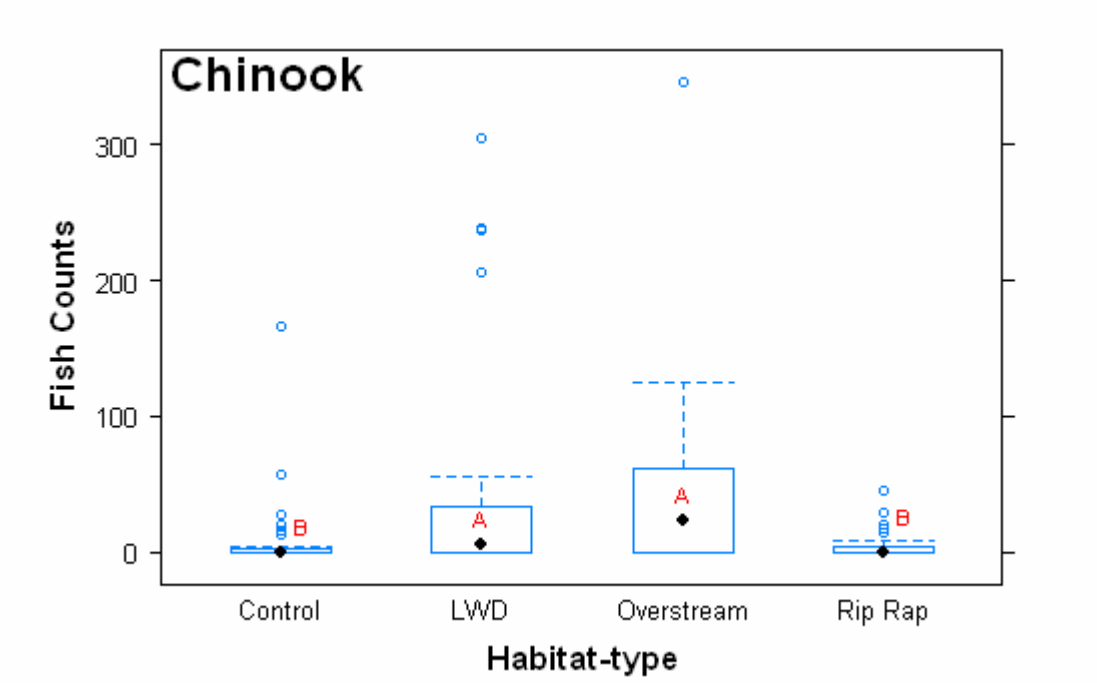

Figure 7. The distribution of Chinook counts observed in each of four Habitat-types. See Figure 6 legend for further details.

3.3.3 Chum

Chum counts were initially modeled as a function of Habitat-type, Survey Date, and the Habitat-type × Survey Date interaction. The interaction term was not significant (Chi sq = 26.9, df = 30, $P = 0.63$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Habitat-type (Figure 5; Figure 8; Chi sq = 53.6, df = 3, $P < 0.0001$) and of Survey Date (Chi sq = 86.8, df = 10, $P < 0.0001$). Post-hoc examination of Habitat-type effects showed their pattern to follow that found for Chinook:

- LWD counts were not significantly different from Overstream Vegetation counts;
- Rip Rap counts were not significantly different from Control counts;
- LWD/Overstream Vegetation counts were greater than Rip Rap/Control counts.

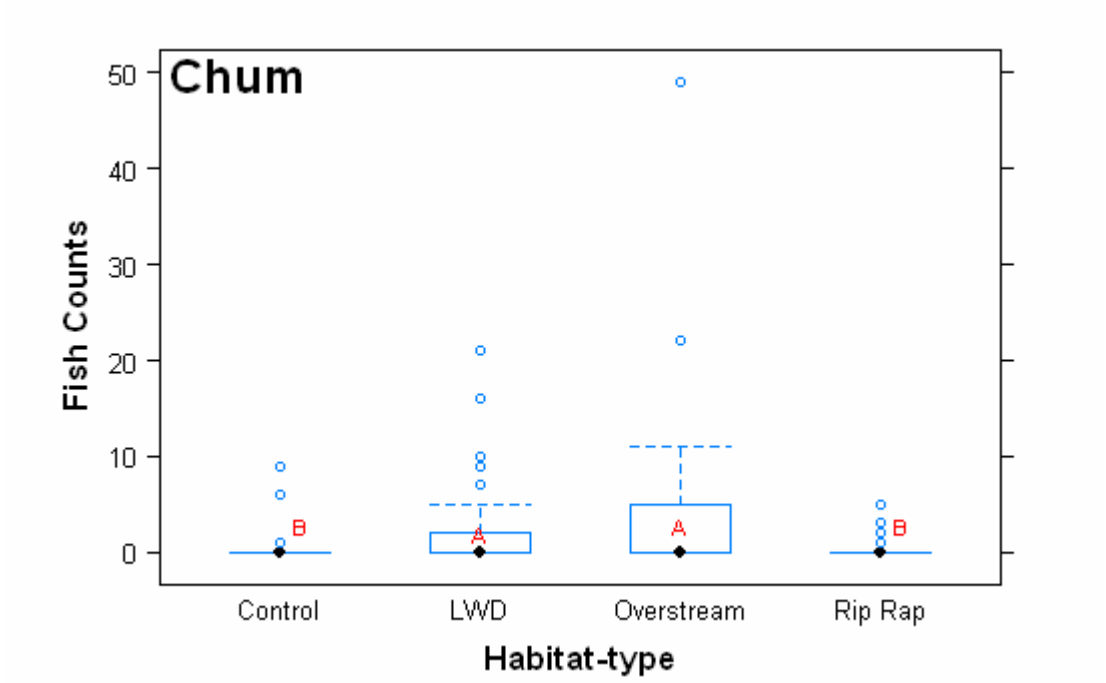

Figure 8. The distribution of chum counts observed in each of four Habitat-types. See Figure 6 legend for further details.

3.3.4 Coho smolts

Coho smolt counts were initially modeled as a function of Habitat-type, Survey Date, and the Habitat-type × Survey Date interaction. The interaction term was significant (Chi sq = 67.8, df = 30, $P < 0.0001$). Thus, the effect of Habitat-type was examined for each Survey Date separately (Table 7; Figure 9).

Table 7. Summary of results for statistical tests of the effect of Habitat-type on coho smolt counts, by Survey Date.

Survey Date	Chi Sq	*P*	C-L-O-R *	Conclude
13 Apr	.	.	.	.
19 Apr	.	.	.	.
5 May	16.3	**0.0010**	B-B-A-AB	O > C and L
13 May	13.2	**0.0042**	B-A-AB-AB	L > C
20 May	13.2	**0.0042**	B-AB-A-AB	O > C
24 May	15.9	**0.0012**	B-A-B-AB	L > C and O
1 Jun	8.4	**0.0387**	A-A-A-A	no differences
7 Jun	18.3	**0.0004**	C-A-AB-BC	L and O > C; L > R
17 Jun	6.3	0.0987	A-A-A-A	no differences
19 Jul	.	.	.	.
24 Aug	.	.	.	.

* C-L-O-R (Control-LWD-Overstream-RipRap). Levels that share a letter in common are not significantly different

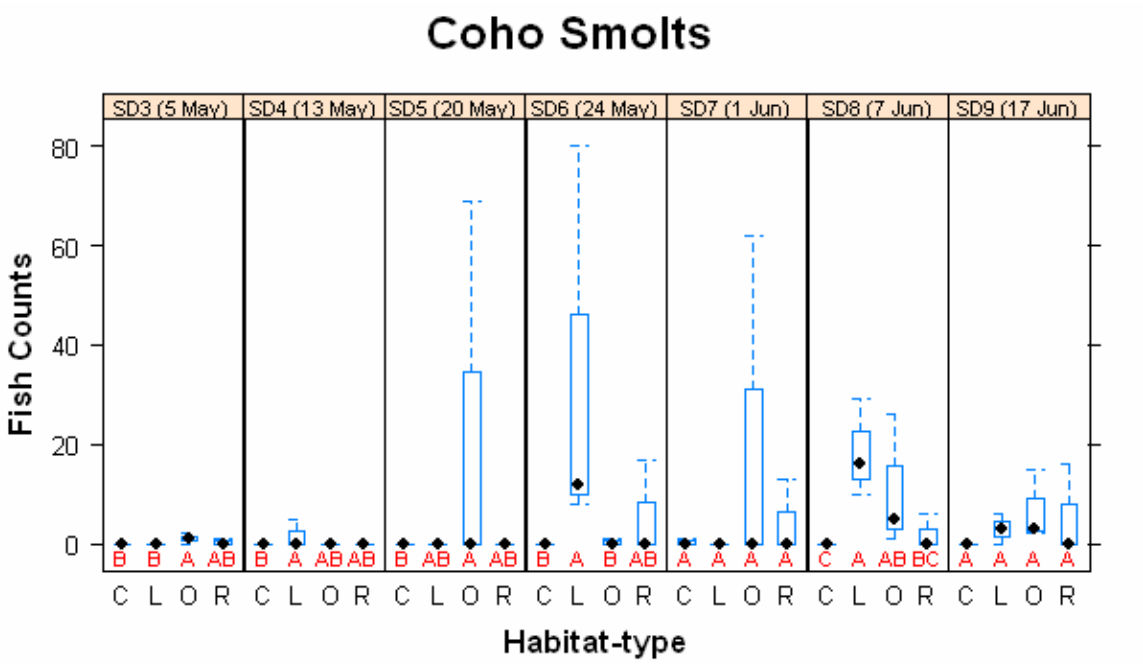

Figure 9. The distribution of Coho smolt counts observed in each of four Habitat-types, by survey date (SD). See Figure 6 legend for further details.

3.4 Effects of Zone

Coho, Chinook and Chum fry and juveniles were observed in both Zones of the estuary. However, an examination of species preferences for the two Zones in the Englishman River estuary found that Coho and Chinook were more abundant in Quadrants 3 and 4 (Flow) habitats while Chum were more abundant in habitats without cover in Quadrants 1 and 2 (Surfside) (Figure 10).

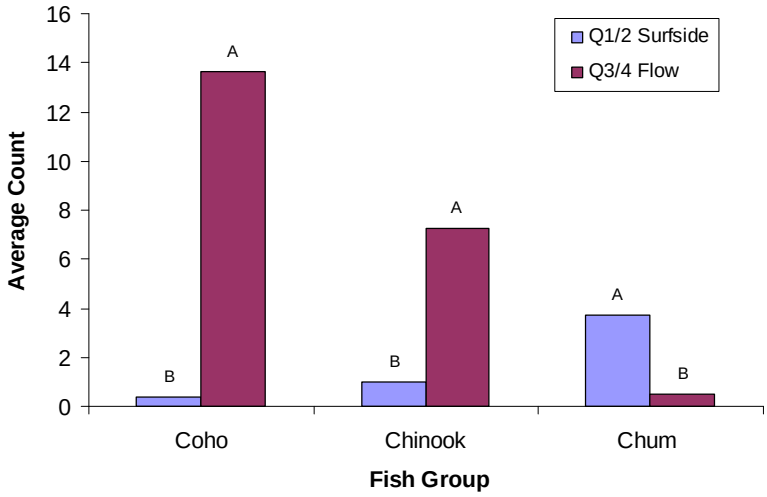

Figure 10. The average counts of fish observed in each Zone, by fish group. Within a fish group, letters are shown above the bars to indicate statistically significant differences (i.e., Zones that share a letter in common are not significantly different).

3.4.1 Coho

Coho counts were initially modeled as a function of Zone, Survey Date, and the Zone × Survey Date interaction. The interaction term was not significant (Chi sq = 3.8, df = 10, $P = 0.95$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Zone (Figure 10; Figure 11; Chi sq = 22.7, df = 1, $P < 0.0001$), but not of Survey Date (Chi sq = 17.9, df = 10, $P = 0.056$). Coho counts in the 'Flow' Zone were significantly greater than those in the 'Surfside' Zone.

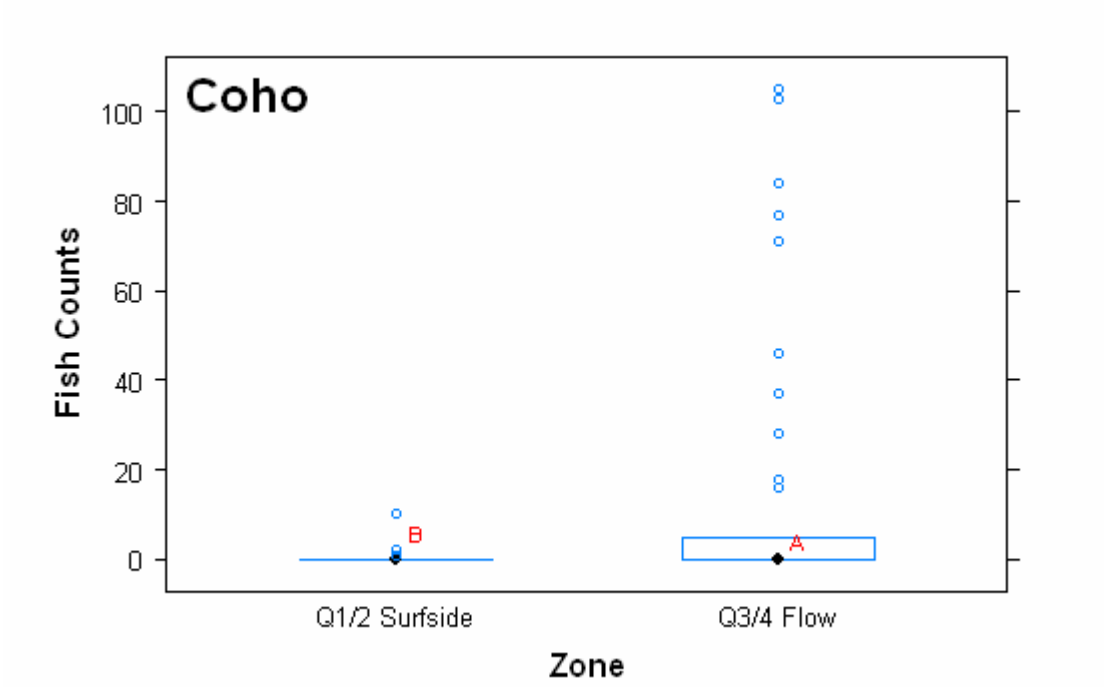

Figure 11. The distribution of Coho counts observed in each Zone. See Figure 6 legend for further details.

3.4.2 Chinook

Chinook counts were initially modeled as a function of Zone, Survey Date, and the Zone × Survey Date interaction. The interaction term was not significant (Chi sq = 8.1, df = 10, $P = 0.62$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Zone (Figure 10; Figure 12; Chi sq = 14.8, df = 1, $P = 0.0001$) and of Survey Date (Chi sq = 47.2, df = 10, $P < 0.0001$). As observed for coho, Chinook counts in the 'Flow' Zone were significantly greater than those in the 'Surfside' Zone.

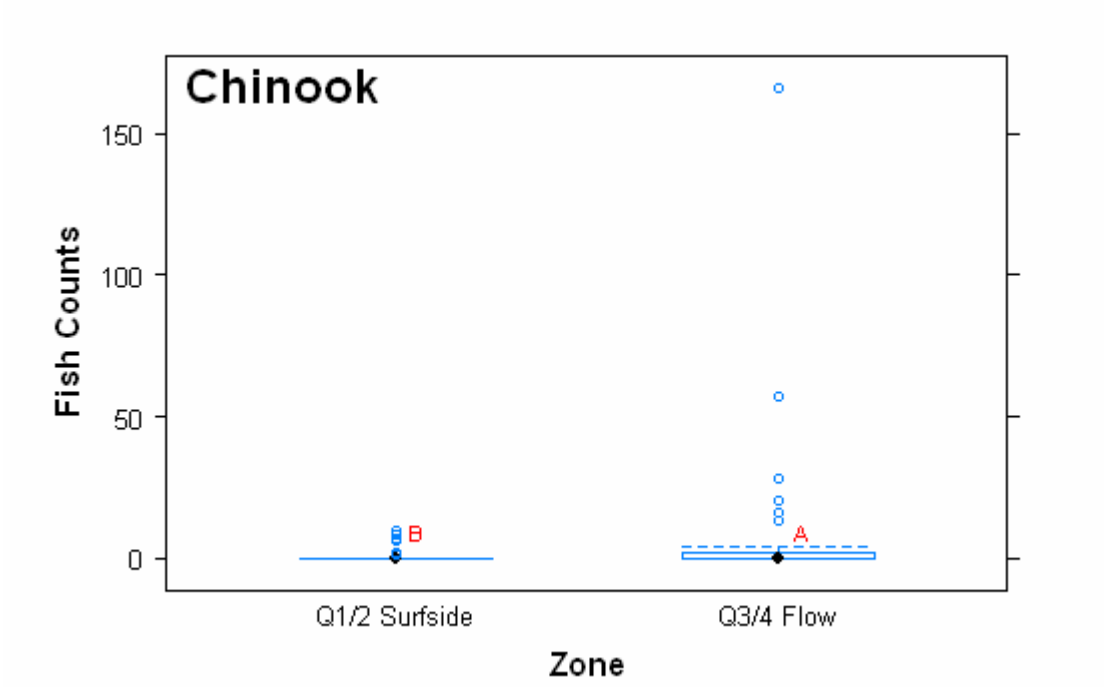

Figure 12. The distribution of Chinook counts observed in each Zone. See Figure 6 legend for further details.

3.4.3 Chum

Chum counts were initially modeled as a function of Zone, Survey Date, and the Zone × Survey Date interaction. The interaction term was not significant (Chi sq = 14.8, df = 10, $P = 0.14$), thus it was removed from the model parameterization, and the reduced model was re-run. The reduced model showed a significant effect of Zone (Figure 10; Figure 13; Chi sq = 7.9, df = 1, $P = 0.005$) and of Survey Date (Chi sq = 31.7, df = 10, $P = 0.0004$). Opposite to that observed for Coho and Chinook, Chum counts in the 'Surfside' Zone were significantly greater than those in the 'Flow' Zone.

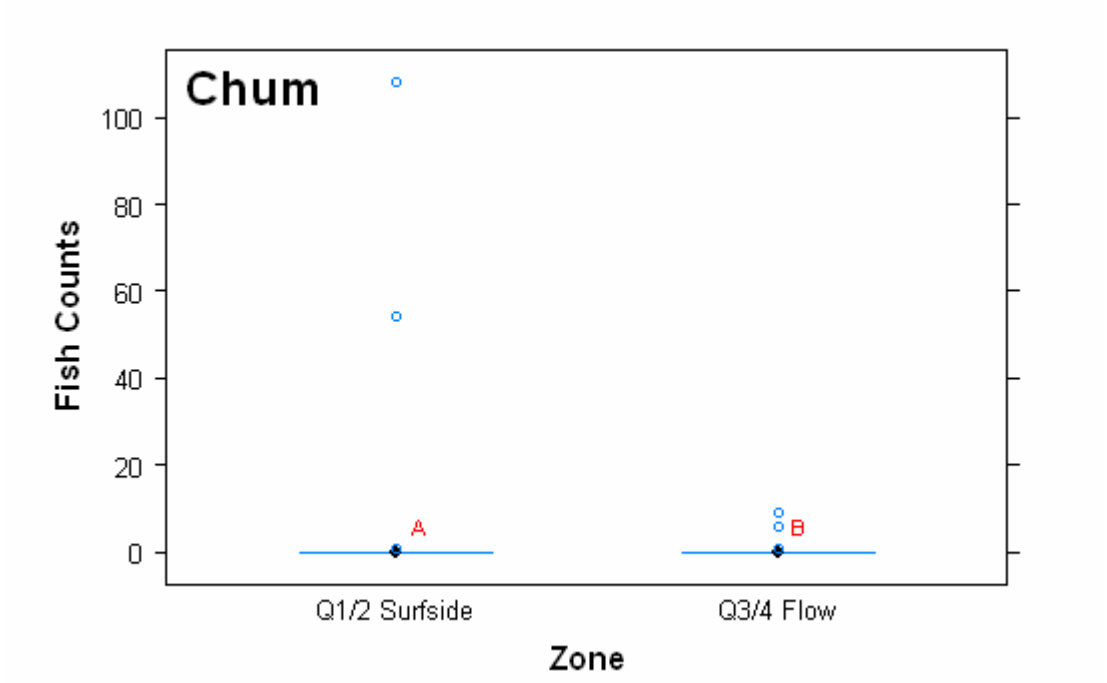

Figure 13. The distribution of Chum counts observed in each Zone. See Figure 6 legend for further details.

4 Discussion

4.1 Habitat Preferences of Salmonids in the Estuary

Behaviour of salmonid juveniles and smolts in the Englishman River estuary has not been intensively studied to date. However, from this study it is apparent that the estuary is used for rearing by Coho and Chinook juveniles from April to at least late August, by Coho smolts in May and June, and by Chum fry from April to June. Also, we found that Coho, Chinook and Chum preferentially selected habitats with cover rather than habitats without cover. The results of our statistical analyses on fish utilization of the various Habitat-types showed that abundances for all three salmon species were significantly greater in habitats with cover provided by Large Woody Debris (LWD) or Overstream Vegetation than for Rip Rap or No Cover habitats. Furthermore, for Rip Rap and No Cover habitats the abundance of Coho juveniles was significantly greater in Rip Rap habitats whereas for Chinook and Chum the differences in abundance were not significant. It is important to note, however, that observer efficiency likely varied with habitat type but was not examined during this study. This could have potentially biased the results presented here.

Our results corroborate the findings of other researchers in BC and Pacific Northwest. Quinones and Mulligan (2005) found significant differences between the relative densities of juvenile Chinook salmon and trout observed in habitats with and without cover along stream margins of the Smith River estuary, California. They determined that in estuaries with little instream cover, juvenile salmonids appeared to preferentially use habitats with overhanging riparian vegetation. However, only 10% of the lower reaches they studied contained forms of instream cover such as

LWD, undercut banks and large boulders. Similarly, McMahon and Holtby (1992) found that LWD functions as cover habitat for Coho during smoltification and seaward migration in Carnation Creek, near Bamfield on Vancouver Island. During their underwater counts in Carnation Creek and its estuary, 82% of the 1,260 smolts observed were found within 1 m of LWD. They suggested that woody debris creates the preferred habitat features for Coho juveniles of slow current velocities and low light intensity.

4.2 Opportunities for Increasing the Amount of Cover

The quantity and quality of estuary and nearshore habitats for salmonid fry and juveniles during early rearing has been linked to the viability of salmon populations in the Pacific Northwest (Clancy et al. 2009; Fresh 2006; Gonor et al. 1988; Quinones and Mulligan 2005). Estuaries can provide juvenile salmonids with foraging habitats, refuge from predators, and areas in which smoltification and orientation for return migrations can occur (Simenstad et al. 1982; Iwata and Komatsu 1984; Moser et al. 1991). Therefore, restoring and protecting estuary and nearshore habitats must be considered a part of efforts to rebuild salmonid populations.

The Englishman River estuary is now approximately 164 ha in size, having lost about 40% of its estimated historic area (~275 ha) as a result of urban/agricultural encroachments and dyking (Buechert et al. 2009). In addition to the loss of available estuary area, significant reductions in habitat complexity and productivity for rearing fish have occurred as a result of over-grazing of sedge vegetation by Canada Geese, armouring streambanks with riprap, and the historic conversion of upper watershed old growth forests to second and third growth conifer-managed forests (C. Wightman, BCCF pers. comm.). Concerning the latter point, recruitment of large woody debris (LWD) from younger managed forests does not provide the same quality of habitat because wood entering streams tends to be smaller, more mobile, and decays faster (McHenry et al. 1998). This is especially true in the Englishman River estuary where existing large logs and stumps are now in an advanced state of rot, with most small trees carried directly into Georgia Strait during winter floods, and not retained by estuary channels and benches. Over time, this has resulted in greatly reduced escape cover for young salmonids that depend on estuary habitats for critical rearing and smolt transformation prior to full ocean residence.

As demonstrated in this study, the significant and preferential use of cover, primarily LWD and Overstream Vegetation and secondarily Riprap, by juvenile salmonids suggests that increasing the amount and diversity of cover within the estuary could be an important step to rebuilding Englishman River salmonid populations. It is important to note, however, that increasing the amount of functional instream LWD and riparian overstream vegetation in estuaries has broader ecological benefits beyond providing fish cover. For example, placements of LWD and overstream vegetation provide habitat for nesting, foraging, perching and feeding for a number of bird species, and food and habitat for wood degrading (boring) organisms (Clancy et al. 2009). Some of the biological and geomorphic benefits of LWD have been succinctly summarized by Gonor et al. (1988) as follows:

> "Fallen trees influence the estuarine portion of the ecosystem, mainly through their physical properties as large masses; they form heavy, solid objects and firm substrates in an environment where the bottom consists mainly of fine sediment. Fallen trees in the tidal river segment of coastal stream systems create riffles and provide shelter from

predators for upper reach fishes. Examples of common fishes in this section of Pacific Northwest estuaries are stickleback, sturgeon, starry flounder, and juvenile and adult salmonids. Fallen trees can also affect local waterflow patterns by creating turbulence and thereby affecting the sedimentation pattern and the formation of bars or mudbanks. Emergent parts of fallen trees stranded in the channel or partly or wholly on tidally exposed banks are used by water birds as refuge perches during daily rest cycles, or by predatory birds, such as herons and eagles, as hunting perches" (http://www.fs.fed.us/pnw/pubs/229chpt4.pdf).

4.2.1 Recommended Next Steps

The recommended steps to developing and implementing a project to increase the amount and diversity of cover in the Englishman River estuary are as follows:

1. The specific goals and objectives relating to protection and restoration of the Englishman River estuary, and in particular to the proposed project's objective(s), should be confirmed with various landowners and stakeholders prior to initiating estuary restoration activities;

Meetings, workshops and public information sessions could be organized by BCCF to include the relevant organizations such as City of Parksville, Guardians of Mid Island Estuaries Society, Mid Vancouver Island Habitat Enhancement Society (MVIHES), The Nature Trust of BC (TNT), Ministry of Forestry, Lands and Natural Resource Operations (BC Fish & Wildlife Branch), Ministry of Environment (BC Parks), Regional District of Nanaimo, local First Nations, and Fisheries and Oceans Canada.

2. Assuming that increasing the amount of cover in the estuary is an objective and action item of the restoration plan, identify and evaluate specific sites where overstream vegetation and LWD could potentially be placed;

Subject sites should be evaluated to determine if LWD and/or overstream vegetation are appropriate and if there are potential constraints that could limit the likelihood of project success. Based on our study results, all four Quadrants and all four Habitat-types in the estuary held salmonids. As Coho, Chinook and Chum juveniles all preferred habitats with cover over habitats without cover and with fewer salmonids being found in habitats without cover, it seems reasonable to propose that LWD or overstream vegetation treatments would be appropriate within all four Quadrants, and that treatments could be applied to sites without cover to improve their rearing habitat function. The recommended order of priority for the installation of LWD or overstream vegetation treatments is: Quadrant 1, 3, 2 and 4.

The selection of treatment sites should recognize species-specific habitat preferences for salinities and water depths, velocities and temperatures. For example, Chum were found in Quadrants 1 and 2 where salinities and water temperatures were higher and water velocities and depths were lower than Quadrants 3 and 4. Therefore, LWD or overstream vegetation treatments in Quadrants 1 and 2 would likely target Chum more than Coho or Chinook.

Determining the feasibility of a potential cover treatment typically includes many aspects that are also critical to design. For example, a feasibility assessment for a LWD placement should in all cases incorporate a thorough understanding of river hydraulics, the existing channel migration and bank erosion rates, existing habitat use by fish, birds and other wildlife, tidal effects on water levels and salinities, and the potential to successfully deliver, place and anchor the LWD. For an overstream vegetation project it is important to assess such elements as bank height, planting site moisture characteristics, existing plant community, bank erosion rates and the potential need for bank protection measures to reduce erosion.

3. Based on each site's configuration and characteristics, develop specific designs and/or specifications for treatment implementation;

Plant species, stock size and planting densities are considerations that should be included in the design specifications. As a potential alternative, LWD could be placed in complexes of $\geq$3 rootwads to produce the scale of structure that functions best as cover for instream rearing salmonids (Figure 14). The rootwads would be ballasted with large boulders to prevent dislodgment. Conifers, particularly Douglas fir and western red cedar, should be used as the source of the LWD to extend longevity in wet environments. Construction specifications should include the source and sizes of the LWD, the equipment and method of delivering the LWD to the proposed sites, and the tools and equipment that will be used to construct and anchor the structures. Procedures must be in place to prevent the introduction of invasive alien plant species via imported LWD or riprap material.

4. Review designs with environmental regulators, landowners and stakeholders and seek approvals on design and siting of structures and treatments;
5. Obtain regulatory approvals and implement LWD placement and overstream vegetation treatments on approved projects; and
6. Monitor effectiveness of cover treatments at meeting site-specific objectives for a minimum of three years.

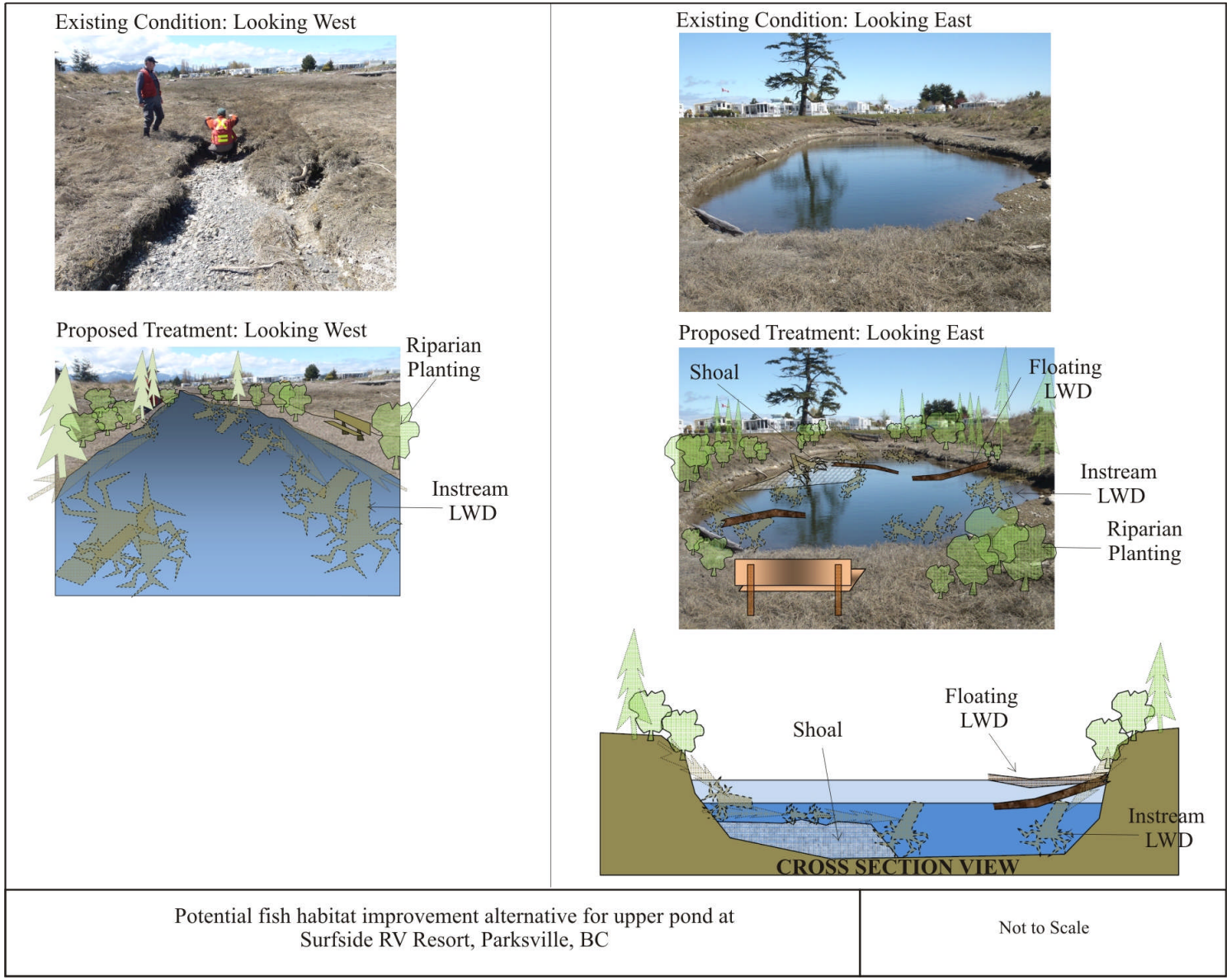

Figure 14. Potential fish habitat improvement alternative for upper pond at Surfside RV Resort.

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APPENDICES

Appendix A. Summary of fish observations during snorkel surveys in the Englishman River, 13 April 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	-	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	-	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	-	
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	-	
5	Q3-Control 1	-	-	-	-	-	-	-	-	-	-	-	-	
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	-	
7	Q3-LWD 1	-	-	-	-	-	-	-	-	-	-	-	-	
8	Q3-LWD 2	-	-	-	-	-	-	-	-	-	-	-	-	
9	Q3-LWD 3	-	-	-	-	-	-	-	-	-	-	-	-	
10	Q3-Rip Rap	-	-	-	-	-	-	-	-	-	-	-	-	
11	Q4-Control 1	-	-	-	-	-	-	-	-	-	-	-	-	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	-	
13	Q4-Overstream 1	-	-	-	-	-	-	-	-	-	-	-	-	
14	Q4-Overstream 2	10	-	5	50	-	-	-	-	-	-	-	65	
15	Q4-Overstream 3	-	-	-	-	-	-	-	-	-	-	-	-	
16	Q4-Rip Rap 1	-	-	-	-	-	-	-	-	-	-	-	-	
17	Q4-Rip Rap 2	-	-	-	-	-	-	-	-	-	-	-	-	
Total	All Sites	10	0	5	50	0	0	0	0	0	0	0	65	
	Control Sites	0	0	0	0	0	0	0	0	0	0	0	0	
	Sites with Cover	10	0	5	50	0	0	0	0	0	0	0	65	

Appendix B. Summary of fish observations during snorkel surveys in the Englishman River, 19 April 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	60	60	Est: 10%CH, 90%CM
5	Q3-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
7	Q3-LWD 1	-	-	-	-	-	-	1	-	-	-	-	1	holding in LWD
8	Q3-LWD 2	-	-	-	-	-	-	-	-	-	-	-	0	
9	Q3-LWD 3	-	-	-	-	-	-	-	-	-	-	11	11	Species not estimated. Holding tight in LWD
10	Q3-Rip Rap	-	-	-	-	-	-	-	-	-	-	-	0	
11	Q4-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
13	Q4-Overstream 1	-	-	-	-	-	-	-	-	-	-	-	0	
14	Q4-Overstream 2	-	-	-	-	-	-	-	-	-	-	86	86	Est: 50%CH, 10%CM, 38%CO, 2%PK
15	Q4-Overstream 3	-	-	-	-	-	-	-	-	-	-	-	0	
16	Q4-Rip Rap 1	-	-	-	-	-	-	-	-	-	-	-	0	
17	Q4-Rip Rap 2	-	-	-	-	-	-	-	-	-	-	-	0	
Total	All Sites	0	0	0	0	0	0	1	0	0	0	157	158	
	Control Sites	0	0	0	0	0	0	0	0	0	0	60	60	
	Sites with Cover	0	0	0	0	0	0	1	0	0	0	97	98	

Appendix C. Summary of fish observations during snorkel surveys in the Englishman River, 5 May 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	120	120	Large free swimming group, visibility made it difficult to ID to spp.'s., the dominant spp.'s were Chum
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
5	Q3-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
7	Q3-LWD 1	3	-	-	-	-	-	-	-	-	-	-	3	Some areas were difficult to survey as LWD was blocking line of sight
8	Q3-LWD 2	59	-	4	6	-	-	-	-	-	-	-	69	Some areas were difficult to survey as LWD was blocking line of sight
9	Q3-LWD 3	16	-	16	9	-	-	-	-	-	-	-	41	
10	Q3-Rip Rap	0	-	-	-	-	-	-	-	-	-	-	0	
11	Q4-Control 1	5	-	-	-	-	-	-	-	-	-	-	5	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
13	Q4-Overstream 1	45	1	10	-	-	-	-	-	-	-	-	56	1 CO smolt was observed
14	Q4-Overstream 2	73	2	22	39	-	-	-	-	-	-	-	136	2 CO smolts were observed
15	Q4-Overstream 3	0	-	-	-	-	-	-	-	-	-	-	0	
16	Q4-Rip Rap 1	15	-	-	-	-	-	-	-	-	-	-	15	
17	Q4-Rip Rap 2	31	1	0	0	0	0	0	0	0	0	0	32	1 CO smolt was observed and several fish were observed darting into the cracks of the rip rap
Total	All Sites	247	4	52	54	0	0	0	0	0	0	120	477	
	Control Sites	5	0	0	0	0	0	0	0	0	0	120	125	
	Sites with Cover	242	4	52	54	0	0	0	0	0	0	0	352	

Appendix D. Summary of fish observations during snorkel surveys in the Englishman River, 13 May 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	1	-	-	-	-	-	-	-	-	1	
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
5	Q3-Control 1	-	-	-	2	-	-	-	-	-	-	-	2	
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
7	Q3-LWD 1	35	-	-	-	-	-	-	-	-	-	6	41	
8	Q3-LWD 2	30	5	7	-	-	-	-	-	-	-	-	42	1 Adult salmon mort was found
9	Q3-LWD 3	-	-	-	-	-	-	-	-	-	-	135	135	Unknown=90%CO, 5%CM, 5%CH
10	Q3-Rip Rap	-	-	-	-	-	-	-	-	-	-	-	0	
11	Q4-Control 1	28	-	6	4	-	-	-	-	-	-	-	38	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
13	Q4-Overstream 1	-	-	-	-	-	-	-	-	-	-	-	0	
14	Q4-Overstream 2	-	-	-	-	-	-	-	-	-	-	87	87	Unknown=90%CO, 3%CM, 7%CH
15	Q4-Overstream 3	-	-	-	-	-	-	-	-	-	-	-	0	Some movement has occurred
16	Q4-Rip Rap 1	3	-	-	-	-	-	-	-	-	-	-	3	
17	Q4-Rip Rap 2	6	-	1	-	-	-	-	-	-	-	-	7	
Total	All Sites	102	5	15	6	0	0	0	0	0	0	228	356	
	Control Sites	28	0	7	6	0	0	0	0	0	0	0	41	
	Sites with Cover	74	5	8	0	0	0	0	0	0	0	228	315	

Appendix E. Summary of fish observations during snorkel surveys in the Englishman River, 20 May 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	1	-	-	-	-	-	-	-	-	-	-	1	
2	Q1-Control 2	2	-	1	2	-	-	-	-	-	-	-	5	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
4	Q2-Control 2	1	-	-	1	-	-	-	-	-	-	-	2	
5	Q3-Control 1	-	-	6	57	-	-	-	-	-	-	-	63	
6	Q3-Control 2	-	-	-	2	-	-	-	-	-	-	-	2	
7	Q3-LWD 1	49	-	-	9	-	-	-	-	-	-	-	58	
8	Q3-LWD 2	75	-	1	-	-	-	-	-	-	-	122	198	
9	Q3-LWD 3	-	-	-	-	-	-	-	-	-	-	208	208	Unknown=65% CO, 25% CH, 10% CM
10	Q3-Rip Rap	14	-	-	9	-	-	-	-	-	-	-	23	Took pics in site after swimming site over 60 salmonids seen, 1/2 CO, 1/2 CH
11	Q4-Control 1	103	-	-	2	-	-	-	-	-	-	-	105	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
13	Q4-Overstream 1	-	-	-	-	-	-	-	-	-	-	226	226	Unknown=77% CO, 20% CH, 3% CM
14	Q4-Overstream 2	-	69	-	-	-	-	-	-	-	-	485	554	Unknown=70% CO, 20% CH, 10% CM
15	Q4-Overstream 3	-	-	3	-	-	-	-	-	-	-	63	66	Unknown=10% CO, 90% CH
16	Q4-Rip Rap 1	34	-	3	8	-	-	-	-	-	-	-	45	
17	Q4-Rip Rap 2	29	-	2	-	-	-	-	-	-	-	-	31	
Total	All Sites	308	69	16	90	0	0	0	0	0	0	1104	1587	
	Control Sites	107	0	7	64	0	0	0	0	0	0	0	178	
	Sites with Cover	201	69	9	26	0	0	0	0	0	0	1104	1409	

Appendix F. Summary of fish observations during snorkel surveys in the Englishman River, 24 May 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	1	-	-	7	-	-	-	-	-	-	-	8	abundant crabs, variety of species. Vis good.
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	1	1	Vis relatively poor due to salt lens
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	No fish. Vis relatively poor, likely due to wind action & substrate disturbance
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	Bad visability, less than 1m
5	Q3-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	~86 euphausiids seen
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	there was euphausiids seen ~20
7	Q3-LWD 1	274	80	1	50	-	-	-	-	-	-	-	405	Vis good.
8	Q3-LWD 2	263	12	-	237	-	-	-	-	-	-	-	512	Vis good.
9	Q3-LWD 3	329	8	10	305	-	-	-	-	-	-	-	652	Vis good.
10	Q3-Rip Rap	32	-	-	4	-	-	-	-	-	-	-	36	Strong current
11	Q4-Control 1	46	-	-	3	-	-	-	-	-	-	-	49	Vis excellent
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
13	Q4-Overstream 1	316	-	2	44	-	-	-	-	-	-	-	362	Vis better than usual, salmondis found in overhang and before it
14	Q4-Overstream 2	535	1	-	95	-	-	-	-	-	-	-	631	Vis excellent
15	Q4-Overstream 3	285	-	7	32	-	-	-	-	-	-	-	324	bank
16	Q4-Rip Rap 1	72	-	-	17	-	-	-	-	-	-	-	89	all samonids found within the rip rap
17	Q4-Rip Rap 2	240	17	-	45	-	-	-	-	-	-	-	302	Vis excellent, but green sea lettuce (Ulva intestinalis?) afforded good cover
Total	All Sites	2393	118	20	839	0	0	0	0	0	0	1	3371	
	Control Sites	47	0	0	10	0	0	0	0	0	0	1	58	
	Sites with Cover	2346	118	20	829	0	0	0	0	0	0	0	3313	

Appendix G. Summary of fish observations during snorkel surveys in the Englishman River, 1 June 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	6	-	-	-	-	-	-	-	6	abundant cottid's, Vis good.
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	No fish. Vis relatively poor, due to lensing
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	Bad visability, less than 1m
5	Q3-Control 1	-	-	9	166	-	-	-	-	-	-	-	175	lots of salmonids seen in veg and behind big dead plant
6	Q3-Control 2	-	-	-	28	-	-	-	-	-	-	-	28	there was euphausiids seen ~20
7	Q3-LWD 1	-	-	-	39	-	-	-	-	-	-	-	39	Vis good.
8	Q3-LWD 2	-	-	2	56	-	-	-	-	-	-	3	61	3 Unknown Trout parr
9	Q3-LWD 3	-	-	-	182	-	-	-	-	-	-	130	312	Vis good.
10	Q3-Rip Rap	46	-	-	-	-	-	-	-	-	-	-	46	Vis not great, ~60 CO seen 10' before site and 10 CH smolts
11	Q4-Control 1	84	1	-	-	-	-	-	-	-	-	-	85	Vis excellent
12	Q4-Control 2	3	-	1	3	-	-	-	-	-	-	-	7	
13	Q4-Overstream 1	33	-	4	41	-	-	-	-	-	-	240	318	Stronger flow then found in overstream 3; Unknown=80% CO, 20% CH
14	Q4-Overstream 2	345	62	3	79	-	-	-	-	-	-	105	594	Vis excellent
15	Q4-Overstream 3	168	-	11	238	-	-	-	-	-	-	270	687	Large rock at beginning of site used as current block 49 salmonids seen there; Unknown=60% CO, 40% CH
16	Q4-Rip Rap 1	86	-	5	29	-	-	-	-	-	-	-	120	
17	Q4-Rip Rap 2	165	13	-	-	-	-	-	-	-	-	-	178	Vis excellent, but green sea lettuce (Ulva intestinalis?) afforded good cover
Total	All Sites	930	76	35	867	0	0	0	0	0	0	748	2656	
	Control Sites	87	1	10	203	0	0	0	0	0	0	0	301	
	Sites with Cover	843	75	25	664	0	0	0	0	0	0	748	2355	

Appendix H. Summary of fish observations during snorkel surveys in the Englishman River, 7 June 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	10	-	-	-	-	-	-	-	10	High abundance of CC, ok vis.
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	Bad Vis, less then 1m
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	Poor vis. due to sediments in the water
4	Q2-Control 2	-	-	-	1	-	-	-	-	-	-	-	1	Vis ok ~1m, ~200 euphausiids seen
5	Q3-Control 1	77	-	-	13	-	-	-	-	-	-	-	90	Most fish found in the 2 root wads and behind the dead plant
6	Q3-Control 2	-	-	-	16	-	-	-	-	-	-	-	16	
7	Q3-LWD 1	47	10		7	-	-	-	-	-	-	-	64	High flows made it difficult to manoeuvre around site, poor vis. due to streaming light and sediments in the water
8	Q3-LWD 2	166	29	-	34	-	-	-	-	-	-	-	229	Fish were generally in tight to the banks, probably due to the higher flows
9	Q3-LWD 3	428	16	1	206	-	-	-	-	-	-	-	651	Fish were generally in tight to the banks, probably due to the higher flows
10	Q3-Rip Rap	58	-	-	18	-	-	-	-	-	-	-	76	~150 salmonids seen before the site beind 2 lage rocks
11	Q4-Control 1	71	-	-	-	-	-	-	-	-	-	-	71	Poor vis. due to streaming light and sediments in the water
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	6	6	
13	Q4-Overstream 1	73	1	2	21	-	-	-	-	-	-	184	281	Unknown=70% CO, 30% CH
14	Q4-Overstream 2	115	26	-	35	-	-	-	-	-	-	-	176	High abundance of SB, good vis.
15	Q4-Overstream 3	304	5	7	50	-	-	-	-	-	-	185	551	
16	Q4-Rip Rap 1	81	-	1	20	-	-	-	-	-	-	-	102	
17	Q4-Rip Rap 2	134	6	-	4	-	-	-	-	-	-	-	144	Good vis.
Total	All Sites	1554	93	11	435	0	0	0	0	0	0	375	2468	
	Control Sites	148	0	0	40	0	0	0	0	0	0	6	194	
	Sites with Cover	1406	93	11	395	0	0	0	0	0	0	369	2274	

Appendix I. Summary of fish observations during snorkel surveys in the Englishman River, 17 June 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	8	-	-	-	-	-	-	-	8	Probably same CH that I've seen over the last several weeks,. They have grown in size
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	Poor vis. Due to wind action
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	3 jellyfish were seen, vis not great
5	Q3-Control 1	-	-	-	20	-	-	-	-	-	-	-	20	More cadis fly larva seen in filamentous Ulva
6	Q3-Control 2	-	-	-	1	-	-	-	-	-	-	-	1	filamentous Ulva has thickened up
7	Q3-LWD 1	131	-	-	-	-	-	-	-	-	-	-	131	
8	Q3-LWD 2	270	3	-	18								291	Several large CC in the area
9	Q3-LWD 3	177	6	-	31	-	-	-	-	-	-	-	214	Most juveniles close to margins
10	Q3-Rip Rap	43	-	-	4	-	-	-	-	-	-	-	47	
11	Q4-Control 1	105	-	-	-	-	-	-	-	-	-	-	105	
12	Q4-Control 2	18	-	-	2	-	-	-	-	-	-	-	20	
13	Q4-Overstream 1	185	2	-	2	-	-	-	-	-	-	25	214	One smolt had a crooked spine
14	Q4-Overstream 2	165	15	-	20	-	-	-	-	-	-	30	230	
15	Q4-Overstream 3	248	3	-	59	-	-	-	-	-	-	280	590	Two smolts have a crooked spine; Unknown=95% CO, 5% CH
16	Q4-Rip Rap 1	91	-	-	-	-	-	-	-	-	-	-	91	
17	Q4-Rip Rap 2	200	16	-	15	-	-	-	-	-	-	-	231	Several fish free swimming in thalweg
Total	All Sites	1633	45	0	180	0	0	0	0	0	0	335	2193	
	Control Sites	123	0	0	31	0	0	0	0	0	0	0	154	
	Sites with Cover	1510	45	0	149	0	0	0	0	0	0	335	2039	

Appendix J. Summary of fish observations during snorkel surveys in the Englishman River, 19 July 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	salt lens visable
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	approximately 400 euphausiids seen
5	Q3-Control 1	1	-	-	-	-	-	-	-	-	-	-	1	approximately 200 euphausiids seen
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
7	Q3-LWD 1	34	-	-	-	-	-	-	-	-	-	-	34	
8	Q3-LWD 2	105	-	-	-	-	-	-	-	-	-	-	105	
9	Q3-LWD 3	37	-	-	-	-	-	-	-	-	-	-	37	
10	Q3-Rip Rap	-	-	-	-	-	-	-	-	-	-	-	0	Lots of algae covering the rocks, ~ 15 coho seen before site
11	Q4-Control 1	37	-	-	-	-	-	-	-	-	-	-	37	
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	Lots of green filamentous algae
13	Q4-Overstream 1	1	-	-	-	-	-	-	-	-	-	-	1	
14	Q4-Overstream 2	7	-	-	-	-	-	-	-	-	-	-	7	salt lens visable
15	Q4-Overstream 3	-	-	-	-	-	-	-	-	-	-	-	0	
16	Q4-Rip Rap 1	2	-	-	-	-	-	-	-	-	-	-	2	Lots of growth on the rocks
17	Q4-Rip Rap 2	3	-	-	-	-	-	-	-	-	-	-	3	
Total	All Sites	227	0	0	0	0	0	0	0	0	0	0	227	
	Control Sites	38	0	0	0	0	0	0	0	0	0	0	38	
	Sites with Cover	189	0	0	0	0	0	0	0	0	0	0	189	

Appendix K. Summary of fish observations during snorkel surveys in the Englishman River, 24 August 2011.

Site Number	Site Description	CO	CO Smolt	CM	CH	PK	RB 0+	RB 1+	RB 2+	ST Smolt	ACT	Unknown	Total	Comments
1	Q1-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
2	Q1-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
3	Q2-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
4	Q2-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	
5	Q3-Control 1	-	-	-	-	-	-	-	-	-	-	-	0	
6	Q3-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	5 euphausiids seen, lots of green filimentous algae
7	Q3-LWD 1	4	-	-	-	-	-	-	-	-	-	-	4	Low water made it challanging to get into LWD
8	Q3-LWD 2	85	-	-	3	-	3	6	14	-	4	-	115	Several RBT and some ACT observed
9	Q3-LWD 3	24	-	-	1	-	-	-	-	-	-	-	25	
10	Q3-Rip Rap	2	-	-	-	-	-	-	-	-	-	-	2	
11	Q4-Control 1	16	-	-	-	-	-	-	-	-	-	-	16	55 surf perch seen
12	Q4-Control 2	-	-	-	-	-	-	-	-	-	-	-	0	Lots of algae, hard to see anything
13	Q4-Overstream 1	16	-	-	-	-	-	-	-	-	-	-	16	Lots of surf perch in the middle of the channe
14	Q4-Overstream 2	24	-	-	-	-	-	-	-	-	-	-	24	400 surf perch seen
15	Q4-Overstream 3	3	-	-	-	-	-	-	-	-	-	-	3	Lots of algae, two types 1 green filimentous, the other creamy and cotton like
16	Q4-Rip Rap 1	4	-	-	-	-	-	-	-	-	-	-	4	Lots of surf perch in the middle of the channel, ~90
17	Q4-Rip Rap 2	-	-	-	-	-	-	-	-	-	-	-	0	
Total	All Sites	178	0	0	4	0	3	6	14	0	4	0	209	
	Control Sites	16	0	0	0	0	0	0	0	0	0	0	16	
	Sites with Cover	162	0	0	4	0	3	6	14	0	4	0	193	

PHOTOS

Photo 1. Control Site 1 in Quadrant 1, Englishman River estuary.

Photo 2. Control Site 2 in Quadrant 1, Englishman River estuary.

Photo 3. Control Site 1 in Quadrant 2, Englishman River estuary.

Photo 4. Control Site 2 in Quadrant 2, Englishman River estuary.

Photo 5. Control Site 2 in Quadrant 3, Englishman River estuary.

Photo 6. Control Site 2 in Quadrant 4, Englishman River estuary.

Photo 7. LWD Site 3 in Quadrant 3, Englishman River estuary.

Photo 8. Overstream Vegetation Site 1 in Quadrant 4, Englishman River estuary.

Photo 9. Overstream Vegetation Site 3 in Quadrant 4, Englishman River estuary.

Photo 10. Riprap Site 1 in Quadrant 4, Englishman River estuary.

Photo 11. Coho juveniles inhabiting riprap along streambank.

Photo 12. Chum fry inhabiting instream large woody debris habitat.

Photo 13. Coho juveniles inhabiting instream large woody debris habitat.

Photo 14. Coho and Chinook juveniles inhabiting instream large woody debris habitat.

Photo 15. Relative sizes of observed Chum (top) and Chinook (three lower) juveniles.