Investigation of Restoration and Protection Options for Juvenile Salmonids in the Courtenay Estuary

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EXECUTIVE SUMMARY

The Comox Valley Project Watershed Society is a non-profit group working in the Comox Valley to promote "community stewardship of Comox Valley watersheds through information, education and action" since 1993 (Project Watershed, n.d.). In their efforts to achieve this mission, they have identified the Courtenay River estuary as a critical area of interest, partly due to its importance in sustaining healthy salmon runs. The Courtenay River estuary has experienced past and ongoing impacts from human population growth and development and there was a need to understand how these impacts affect salmon in the estuary.

The goal of this study was to provide a foundation for future activities that will help to restore and protect important habitats in the estuary for salmon, including the food webs of which they are a part and the processes that support them. In consideration of the highly complex nature of the Courtenay River estuary, reaching this goal required an ecosystem management approach. Key aspects to ensuring the success of this project were to include ecological principles into the methodology; to identify critical ecological processes that supported healthy salmon populations in the estuary; to include the knowledge and expertise of stakeholders; and finally, to ensure that the results could be interpreted and applied, and were adaptable as new information arose.

This study resulted in an overall ecological characterization of the estuary and the development of a comprehensive list of restoration and protection options. Estuary characterization involved a field investigation of habitat requirements of juvenile salmonids from the upper to the lower estuary over the spring and summer of 2010. In alignment with ecosystem management principles, this project used chinook (*Onchorhynchus tshawytscha*) and coho (*O. kisutch*) fry (under-yearling) as indicator species. Fry stages of these species were marked and monitored for recaptures, fish were identified and counted, water conditions were recorded, snorkel counts were conducted and habitats were mapped. Data from past studies were analyzed to identify changes in the residency period and size classes of these salmon. The results helped to identify important habitat requirements of these species, and aided in the development of a comprehensive list of restoration and protection options.

The development of restoration and protection options was a multistage process that involved information from past strategy reports, meeting minutes from the Estuary Working Group[2] (EWG), and input from various experts and stakeholders. After initial compilation, EWG technical committee members participated in a detailed review of the options. Some of the results were then discussed with three interviewees that had government, non-profit, and expert associations. Finally they were formally presented on March 17th, 2011 to an audience made up of potential stakeholders and project participants (volunteers, EWG members, government staff, experts, etc.).

[2] A committee of the Project Watershed Society that met regularly to discuss and strategize around the protection, conservation and restoration of the estuary.

Overall, the estuary provided the necessary ecological requirements for chinook and coho fry to survive and benefit from their residence over the spring and summer of 2010. Chinook and coho fry stages were more dependent on the estuary than the smolts, which moved through the estuary quickly. Chinook and coho fry were in the estuary by early spring when sampling began. Coho fry were found as late as December, while most of the chinook fry had left by the beginning of July.

The mark-recapture component of the study revealed that chinook frequently migrated between habitats while coho had high site fidelity. Visible Implant Elastomer (VIE) tagging made it possible to track fry movements between habitats. In total, there were 742 chinook fry tagged, and 446 coho fry. Despite the greater number of marks, there was only one recapture of chinook, compared to eight of coho. This indicated a greater movement between habitats of the chinook fry compared to coho. Only one of the eight coho recaptures had moved from the place it was marked. The recaptured chinook fry had migrated between the Courtenay Slough and Dyke Slough (below the tide gates), and the coho had migrated from the Airpark Lagoon to the Dyke Slough. This coho also had the longest minimum estuarine residency period of 125 days.

The Tsolum River relic channel, the Courtenay River above the mudflats, the Courtenay Slough at Simms Park, the Airpark Lagoon, and the Dyke Slough pool below the tide gates all provided important estuary habitats for juvenile salmon. Chinook fry were present in greater densities at most sites than coho fry, though they experienced poorer growth rates in backwater areas that had good refuge compared to habitats more exposed to the river. Coho fry appeared to be more sensitive to predation based on their patchy distribution that confined them to areas of good refuge. However, these habitats evidently had good food conditions for coho as reflected by high growth rates later in the season despite higher temperatures than in other habitats.

Food production and salmonid diet had important links with detrital and riparian sources. Gammarid amphipods were important food items for chinook fry and smolts and coho smolts. The fry stages of both species were highly dependent on insects, especially from May through July. The invertebrate-based diet of trout captured with the chinook and coho indicated that good invertebrate food production could decrease the potential for trout predation on the fry. During April, potential competition with chum fry in the same habitats as the coho and chinook was alleviated by differences in diet. Forage opportunities for these salmonids are closely linked to habitats that support their invertebrate diets, including healthy marsh and riparian ecosystems.

Chinook fry would benefit from restoration projects that improved food production and habitat connectivity throughout the upper and lower estuary by naturalizing hardened shorelines, creating deep water refuge habitat adjacent to upper intertidal marsh habitats, and ensuring frequent velocity refuge opportunities along the estuarine continuum for all tide heights. Coho fry would benefit from restoration projects in the upper estuary that

increased the area and quality of refuge habitat by restoring riparian habitats for improved insect production and creating and restoring off-channel habitats. Similarly, protection projects that ensure existing areas with these features for coho and chinook remain healthy will benefit both the salmon and their ecosystems.

There were 41 restoration options and 33 protection options identified for the estuary[3]. The greatest number of restoration options fell under the "Off-channel Habitat Enhancement" and "Riparian Restoration" project types. "Channel complexing" and "Saltmarsh Planting" were also common. As such, the restoration options would mostly benefit refuge requirements for juvenile salmonids. The majority of protection option types identified were "Education" (15), followed by "Land Protection" (11). There were also important projects identified under the "Voluntary Incentives" and "Regulatory incentives" project types, such as an Estuary Valuation Program, and a comprehensive Coastal Shoreline Protection Management Plan for the estuary.

The restoration and protection options were prepared to serve as a baseline for planning projects in the estuary that could be used by various stakeholders and adapted over time. To be adaptable, there must be a periodic review that involves stakeholders that have an interest in, or have been involved in, project implementation. Adaptation is important because project priorities will change over time depending on the circumstances, the people involved, and the available information. Ensuring continuity in the planning process will save time that might otherwise be spent researching similar problems of the past. In this way, we can move towards the goal of achieving a healthy thriving estuary ecosystem for salmon and other species that rely on it.

[3] These options are provided in Appendix, or excel versions may be obtained by contacting the author, or Project Watershed.

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1 INTRODUCTION

1.1 Background

Human activities have impacted juvenile salmonid habitat in the Courtenay River estuary. These activities include altered flow regimes from hydroelectric operations, historical dredging and log storage, dike development, shoreline hardening, riparian development, recreational boat use, and point and non-point source pollution. The resulting impacts to the habitats used by juvenile salmon can affect both their survival and fitness as they migrate from freshwater habitats to the marine environment. These salmon require a healthy ecosystem with interconnected habitats throughout the estuary continuum (upstream to downstream, high water to low water) that will provide seasonal refuge from predators, adverse water quality and extreme flows (Thorpe, 1994). Implications of habitat loss to local salmon populations include a decrease in genetic diversity and reduced ability to withstand environmental perturbations (Hilborne et al, 2003). Impacts to juvenile salmon habitats reflect impacts to the overall health of the estuary, including the ecological communities and processes linked to salmon.

A diversity of management interests affect the Courtenay River estuary, making it difficult to measure or predict the outcomes of any one management action on estuary health. Multiple organizations, jurisdictions and levels of government make decisions that affect the estuary. Three local governments border the estuary, and four local governments have jurisdiction over watersheds that drain into it. Both federal and provincial governments have administrative powers that can influence estuary health. Treaty negotiations are underway with the K'omox First Nation, which will likely result in further divisions of management authority. Non-governmental management initiatives, such as restoration and education programs, can also influence estuarine health. Many of these agencies divide the estuary into different management units and/or have management responsibilities that extend beyond the estuary. The management body that oversees the Courtenay River Estuary Management Plan is the only one that regards the estuary as a comprehensive management unit. Furthermore, while most of these agencies have planning and management objectives related to ecosystem health, measures to assess impacts to these objectives are not always known or provided (LeBlanc et al 2010).

1.2 Ecosystem Based Management

An opportunity to overcome diverse management objectives involves the application of ecosystem based management (EBM) principles where the objectives include achieving estuarine health (Meffe et al, 2002). EBM models are similar to other management models in that they involve the development of policy and goals, a planning component, and project implementation, monitoring and evaluation (Figure 1). Ecosystem principles can be incorporated into this basic model by ensuring that indicators of ecosystem health are used to monitor and evaluate ecosystems, and that there are feedback mechanisms that allow the model to become adaptable as new conditions and information arise.

The planning stage of an EBM system involves monitoring the status of a system, and modelling it to identify gaps to achieving management goals and objectives. This typically involves collecting data to tell a story about the system, identifying gaps to achieving management goals and objectives, and identifying indicators to monitor the success of management actions. Indicators that relate to ecosystem structure, function and composition can be used to monitor the status of estuarine ecosystems and can also be used in the project monitoring and evaluation components of an EBM to determine the success of management actions (Noss, 1990). Under-yearling chinook and coho salmon (referred to as "fry" in this report) in the Courtenay River estuary make good candidates as indicator species due to their high sensitivity to environmental conditions, their reliance on the estuary as a linkage between their freshwater and marine life stages, as well as their intrinsic cultural and provisional values to society. Puntledge summer chinook are particularly sensitive, as their population has experienced dramatic declines since the development and operation of the Comox Dam (Trites et al, 1996). Coho salmon populations are also considered sensitive due to region-wide declines (Fisheries and Oceans Canada, 2009). Furthermore, coho that rear in the estuary represent a unique life history type different from freshwater rearing that can contribute to population's diversity and resilience to withstand environmental disturbances (Koski, 2009).

1.3 Habitat Requirements

Habitats can be characterized by measuring their contribution towards the survival and fitness of juvenile stages of coho and chinook as they rear and migrate in the estuary. Simenstad and Cordell (2000) introduced three measures of habitat attributes: capacity, opportunity, and realized function, to assess the ecological and physiological responses of juvenile salmonids to restored estuarine habitat. Measures of capacity include habitat attributes that promote fish production. Measures of opportunity indicate how well fish can access and benefit from the habitats they occupy. Measures of realized function are directly related to the response of fish to capacity and opportunity habitat attributes, and indicates how these have affected fitness and survival (Simenstad and Cordell, 2000). While these measures can be applied to monitor restored habitat as Simenstad and Cordell (2000) propose, they can also be applied to monitor the status of existing habitats, to help characterize an estuary and provide baseline information for future monitoring, and to assist in identifying management actions.

1.4 Mapping

The use of mapping to communicate habitat information helps to facilitate understanding and cooperation among stakeholders. It can be a useful tool for making decisions about restoration and protection (Fraser, 2001; Johannes et al, 2002). Furthermore, mapping can promote positive action among stakeholders to protect and restore habitats even without the threat of regulation or fines (Serveiss, 2002).

1.5 Stakeholder Involvement

Restoration and protection planning involves decisions based on more than just the requirements of target species and communities. It involves a complex decision making process that has political, social and economic roots as well as the requirement for scientific understanding (Rapport et al., 1998). Restoration projects must not only improve habitat for

the target species, but be financially feasible and not create unresolvable conflicts. For example, the removal of tidal gates that prevent saltwater intrusion and fish access to a tidal slough might be of great benefit for juvenile salmonids and associated predators, but it may also ruin valuable farmland.

Inclusion of stakeholders into resource management decisions is critical to successfully achieve goals (Meffe et al, 2002). Stakeholders are people whose personal and professional lives are directly affected by the estuary and those that have an overall or individual interest in restoration and protection options (Meffe et al., 2002). This includes First Nations rights-holders, elected officials, government staff, consultants, landowners, community groups, and funders of protection and restoration projects.

In this study, ecosystem management planning principles are applied to assess the status of the Courtenay River estuary and to make recommendations for restoring and protecting its health. Social realities of achieving restoration and protection options were addressed by including the knowledge and expertise of stakeholders in the development of these options, and by developing maps to communicate the results with managers.

2 GOALS AND OBJECTIVES

The goal of this study is:

To provide a foundation for future salmon habitat restoration and protection activities that will ensure a healthy thriving estuary ecosystem for salmon and other species that rely on it.

The objectives of this study are:

1. To characterize the estuary based on the habitat requirements for juvenile coho and chinook; and
2. To develop a comprehensive list of restoration and protection options from ecological information and past assessments of the estuary.

3 STUDY AREA

The Courtenay River estuary is a large salt wedge estuary located along the east coast of Vancouver Island (Map 1). Its main tributaries are the Tsolum and Puntledge Rivers, which collect and deliver a mean annual discharge of 53.7m^3 to the estuary from approximately 842 km^2 of watershed area (Morris et al 1979). Other smaller tributaries enter the estuary at various locations, and include the Glenn Urquhart Creek, Mallard Creek, and Brooklyn Creek along its northeastern shoreline, and Millard Creek, Roy Creek and Trent River along its southwestern shoreline.

The estuary is highly important both culturally and ecologically. Historically, the Courtenay River was a very productive salmon system. Evidence for this is provided in the

approximate 150,000 stakes that make up the ancient weirs of a traditional K'omox First Nation's salmon fishery that dates back at least 1200 years (Nancy Greene, personal communication). The estuary has over 2000 hectares of river channel, mudflat, saltmarsh, and riparian habitats that support a diverse array of plants, fish, birds, and mammals. There are five species of salmon that use the estuary, including a severely depressed population of summer chinook (Trites et al, 1996). The estuary is internationally recognized as an Important Bird Area for Trumpeter Swans, and nationally recognized for waterfowl concentrations (IBA Canada). Seals are evident in the estuary, and have historically used booming areas as haul outs (Olesiuk et al, 1996). Morris et al (1979) and Asp and Adams (2000) provide detailed lists of the plant and animal life recorded or known to occur in the estuary.

The Courtenay River estuary is defined for the purposes of this study as extending from the confluence of the Tsolum and Puntledge Rivers at the upper end to Goose Spit and the Trent River estuary at the lower end, and is inclusive of the estuaries of smaller systems that occur between these boundaries. The upper ecotone refers to the tidally influenced, channelized river section that is bordered on both sides by terrestrial vegetation. The lower ecotone begins where at least one bank of the main channel is bordered by mudflats. The outer estuary refers to the area where the mudflats transition to subtidal.

The estuary can be characterized by several main features that have significance related to both fish habitat and historical and current human uses. In the main channel, approximately 500 meters below the Tsolum/Puntledge confluence (the section referred to as the Courtenay River), there is a tidally inundated channel that was historically fed by the Tsolum River (referred to as the Tsolum relic channel). Further downstream within the upper ecotone is Simms Park, where a Courtenay Slough branches off of the main channel along with some constructed off-channel fish habitat. Other features of the upper ecotone include shoreline armouring along both the Lewis Park riverbank near Simms Park, as well as along the historical Fields Sawmill site. Immediately adjacent and downstream of the Field Sawmill site is Hollyhock Flats, a natural area where rare plant species and diverse bird fauna occur (Lacelle, personal communication).

Near the transition between the upper and lower ecotones, there is a constructed lagoon along the south side of the river channel, and Dyke Slough on the north side. The lagoon on the south side once functioned as a sewage lagoon for the City of Courtenay, but has since been restored as fish habitat. The Dyke Slough was historically cut off from upper tidal habitats by tide gates, and continue to prevent saltwater intrusion to upstream farmland. There is a large wetland-slough above the tide gates, and a deep pool below with a tidal channel that leads to the river.

Fringing the lower ecotone and outer estuary are eelgrass beds made up of *Zostera japonica* and *Zostera marina*. At the southeastern boundary of the mudflats is the Royston Wrecks, a jetty composed of rip-rap, fill and sunken ships that was constructed in 1911 as a breakwater for a historical booming ground in the mudflats that operated until 1978 (Wild, 2006). At the northeastern tip of the outer mudflats there is a large marina (the Comox

Marina), and a sand spit (Goose Spit) where there is a military site, a K'omox First Nations reserve, and a popular recreational area. Goose Spit curls around to create a lagoon, into which Brooklyn Creek drains.

4 METHODS

Characterizing the habitat requirements for juvenile coho and chinook salmon in the Courtenay River estuary involved 2010 field data collection and analysis with historical fish capture data. The development of the restoration and protection options and associated concept models involved the compilation of historical analysis, habitat requirement characteristics from the 2010 study, input from stakeholders, and the mapping of potential restoration locations.

4.1 Habitat Requirements: Data Collection

Methods of characterizing habitat requirements for juvenile salmonids involved fish and water quality sampling in 2010 and comparison to historical fish capture data, snorkel surveys in 2010, lower river sampling in the late summer of 2010, and mapping of habitat features at specific locations in the estuary.

4.1.1 Fish and Water Quality Sampling

Sampling for fish and water quality took place between March 30th to August 19th, 2010 at 20 estuary sites. Sampling of three lower river sites began in early-mid July and ended in late August. Sample site descriptions are provided in Table 1, and map locations in Map 2. Sampling involved the capture of fish, marking under-yearling coho and chinook, measuring the lengths and weights of chinook and coho, recording species and numbers encountered, collecting information on diet and food availability, and collecting water quality information.

Fish captures were carried out using beach seining, pole seining, minnow trapping, and to a small extent, mini-purse seining techniques. Sampling was done from shore or assisted with a boat. Boat sampling involved beach seining during high tides in the upper river, and during low tides in the lower estuary. Most shore-based sampling involved beach seining during mid to low tides.

Where beach seining was done, the area covered by each seine was estimated at the time of sampling. The beach seine was 14m in length, 3m deep and made up 3 panels. The middle panel, or bunt, was 1/8" mesh size. The wing panels were 3/8" mesh size. Seining involved spreading the net across a habitat, pulling it in to shore from both ends, then pulling in the bunt to corral the fish. The pole seine was 1.5m in width with a ¼" mesh size. Use of the pole seine involved two people spanning the net over a section of habitat and periodically scooping it up to retrieve fish. All minnow traps were ¼" wire mesh and were set from 1 hour to overnight in pools and backwaters.

Most age 0+ coho and chinook were marked with Visible Implant Elastomer (VIE) tags, colour coded for each site. Marking of 446 coho fry and 742 chinook fry took place throughout the estuary from March 30 to June 24, 2010. A tag retention test was undertaken on chinook

fry at the Puntledge River hatchery that found some occurrences where colour codes were misidentified or miscounted, however, the results were consistently close (Table 2).

Depending on the size of the catch either a subsample or all of the coho and chinook captured were measured for length and weight. Fork length was collected to the nearest millimetre using a fish ruler, and weight to the nearest tenth of a gram using an Ohaus Scout SC4010 scale.

All captured fish were identified to species when possible, or sub-sampled for species composition for very large catches. Sub-sampling involved using the dipnet to collect a known volume of fish for counting and measuring, then counting the number of dipnet scoops as the remaining fish were released. The subsample was then extrapolated by the appropriate number of scoops to estimate the total catch. Species identification was done by a qualified biologist or a technician trained in identification techniques.

Benthic and stomach samples were collected to characterize the diet of fish. Benthic samples were collected along a cross section of habitat using a D-net. An area of 30cm x 30cm was disturbed above a D-net of 500 micron mesh over 3 locations representative of the habitat type for a total benthic area of $0.27m^2$. Benthic samples were stored in plastic bottles. Stomach samples from fry and smolt stages of chinook and coho were collected, along with samples from four steelhead ranging from 151 to 219 fork length, and one cutthroat with a length of 181mm. Stomach sampling involved either the collection and preservation of the entire fish or their dissected stomachs. Stomach samples were typically only collected when there were accidental mortalities as a result of sampling stress. Where there were no mortalities yet a stomach sample was desired, the fish were anaesthetized with MS222 until they perished. Both stomach and benthic samples were fixed with 10% formalin which was later decanted and replaced with ethyl alcohol to preserve the samples.

Water conditions were measured with a YSI 556 MPS multi-meter at each site prior to fish sampling. Salinity and temperatures were collected at the surface, and when possible, at 0.5m at each site.

Length and temperature data from 2001 (Hamilton et al, 2008) were also analyzed in this study.

4.1.2 Snorkel Surveys

The upper ecotone (3.1 km) was snorkelled once per week from May 11 to August 16th, 2010. Fish observations were recorded at six transect sites that were delineated above the high water line with flagging ribbon placed 25m apart. Prior to snorkelling, the underwater visibility was determined using a measuring tape. A total of five snorkelers participated in the snorkelling, with two snorkelers during each snorkel event. Tides during snorkelling ranged from 0.3m to 3.5m, with an average tide of 1.5 $^{+}/_{-}$ 0.5m (95 % confidence intervals). Counts were used to estimate densities per unit area, and general observations during the swim were used to help characterize fish usage of the upper ecotone.

4.1.3 Lower River Sampling

Late summer sampling of the Puntledge River Condensory side-channel and lower Mallard and Glen Urquhart Creeks was carried out to identify if marked fish re-entered the lower rivers later in the season, and to compare the size of fish found in the freshwater with those captured in estuary sample sites. Techniques involved the use of pole seines and minnow trapping. Fish were identified to species, counted, measured for fork length, and examined for VIE tags.

4.1.4 Habitat Mapping

Six areas that spanned the estuary from the upper ecotone to the outer estuary were chosen for detailed habitat characterization. Polygons were initially delineated using 2007 aerial photos. The plant communities, substrates, and important features such as fish and wildlife habitat, exotic species, and anthropogenic influences that fell within these polygons were assessed in the field. Transects and field observations were geo-referenced using a Trimble. The results were later used to compile species lists for each site, and to prepare habitat maps for presentation purposes. The data was stored in the Project Watershed Mapping Centre data base for application to future monitoring and restoration projects.

4.2 Characterization of Habitat Requirements

Habitats were characterized based on their contribution towards the survival and fitness of juvenile stages of coho and chinook as they reared and migrated in the estuary by incorporating measures of opportunity, capacity, and realized function (Simenstad & Cordell, 2000). Table 3 outlines the criteria, measures, and the associated habitat attributes used to characterize the estuary in this study.

4.2.1 Fish presence

Catch per unit effort (CPUE) was estimated temporally and between sites to infer the opportunity for fish to access and use sites over the season and throughout the estuary. Sites were assessed for relative use by coho and chinook based on the CPUE using beach seine methods only. CPUE was calculated for each site by dividing the number of fish caught per day by the number of sets. All size classes of chinook and coho that were captured were included in the CPUE estimates.

4.2.2 Life history composition

Life history composition was assessed to determine the temporal opportunities for fish of various size classes to use the estuary over the sampling period. Fork length data from unclipped chinook and coho captured in 2001 and 2010 were compiled by species and month for each sample year. Size classes were then visually estimated based on their length/frequency distributions. The size classes were interpreted as age classes, and are referred to as cohorts in this report. Cohorts were numbered based on their size and time of detection in the estuary. Cohort 1 represented the largest size class and was representative of the smolt stage (age 1+ or under-yearling smolts). Cohort 2 was the next size class down and was representative of the fry stage (age 0+). Cohort 3 entered the estuary later in the season, and was also representative of

the fry stage (age 0+). The modal lengths for cohort 2 of each species were used to estimate growth rate (see section 4.2.6).

The data were analyzed for significant differences between size classes where the sample sizes were large enough. The type of statistical analysis that was done depended on the number of size classes being compared and the distribution of data. For two normally distributed size classes, the student's t-test was used to compare means. Where there were two non-normal distributions, medians were compared using the Mann-Whitney test. Where there were multiple size classes being compared, ANOVA was used for normally distributed data and the Kruskall-Wallis was used for non-parametric data. The statistical software package Graphpad Prism Version 5.01 (GraphPad Software Inc., San Diego, CA) was used in the analysis of fork length data.

4.2.3 Proximity to migration routes

To further assess the opportunities for juvenile coho and chinook to access and use habitats in the estuary, habitats were categorized based on their proximity to the freshwater influence of the Puntledge and Tsolum Rivers. This resulted in the identification of areas that were numbered consecutively from upstream to downstream to reflect the net movement of migrating salmonids from freshwater to saltwater.

Area delineation of the estuary was based on the following:

- the upper extent of tides and the influence of normal high tides.
- characteristics of the upper and lower ecotone and their associated access to high and low water habitats
- salt wedge characteristics measured and interpreted in 2001 (Hamilton et al, 2008)
- distinct habitat features of the lower ecotone and outer estuary, including subtidal confluence with the mainstem channel, Comox Bay Marina, Goose Spit, and Royston Wrecks.

The rationale to applying this system was that it reflected the relative importance of habitat to juvenile salmonids along an upstream to downstream gradient and over the season, with Area 1 being of the greatest importance early in the season, and subsequent areas increasing in importance as the season progresses. This assumes that early in the season, under-yearling salmonids are most vulnerable as they first enter the estuary due to their small size and the osmotic stress associated with physiologically adapting to increasing concentrations of saltwater. These assumptions are supported by a study by Otto (1971), who found that coho smolts survived longer than fry when rapidly exposed to higher salinities, and that the under-yearling coho required more time in dilute salinities to survive the freshwater/saltwater transition. Other studies also support the importance of upper estuarine areas to early rearing of chinook fry (Healey, 1991).

4.2.4 Diet

Fish diet can be used to estimate the capacity of specific habitats to promote fish production (Simenstad and Cordell, 2000). Three sites and five species of salmonids were analyzed for benthic invertebrates and stomach contents from April through to July of 2010.

Diets were analyzed by comparing prey items in the gut to those found in the habitat where the fish were captured. This information was applied to the Strauss index to determine the selectivity of fish for each prey item (Bowen, 1996). The results ranged from -1 to +1, with values below zero indicating high selection, and above zero indicating less selection.

Laboratory analysis of the benthic and stomach samples was done by Zotec Environmental Services. The methodology used to analyze the benthics involved first rinsing samples through a 250um mesh with tap water, then draining them for 10-15 minutes. Samples were then weighed prior to collection of a random subsample for analysis, which was also weighed. Organisms were identified to characterize the diet of the salmonids, and included identifications to class, family and genus.

Stomach content analysis was done by pooling stomach contents from the same species caught at the same day and site. Stomach contents were retrieved by cutting the stomachs and scraping out the contents into a petri dish. Total volume was collected from the individual and/or pooled stomachs. Water was added to each sample before analyzing under a dissecting microscope. All taxa were identified and counted, and the total proportion by volume of each taxa observed was estimated for each sample.

4.2.5 Water Quality

Temperature was used to indicate the physico-chemical capacity of estuarine habitats to support juvenile salmon rearing. The upper and lower thresholds that identify ideal conditions for rearing coho and chinook (12-14°C), as well as the lethal temperatures (>25°C) were taken from Bjornn & Reiser (1991). Linear regression was used to analyze for trends in surface temperatures during similar ranges in tides in Areas 4 and 6 for 2001 and 2010. Temperature differences between these years were visually compared. Tidal ranges for the 2001 and 2010 comparison are provided in Table 4.

4.2.6 Growth

Growth rate and condition factor of chinook and coho juveniles were analyzed to characterize the contribution of different habitats to survival and fitness. Growth rate was determined for the dominant fry coho and chinook cohorts (cohort 2) by comparing the mean fork length differences that occurred over time. Growth rate was calculated from the difference between the mean monthly fork lengths of each species over the season.

Condition factors of the chinook and coho fry captured in 2010 were compared for each species between sites to provide a relative comparison of fish health. The statistical software package Graphpad Prism Version 5 (GraphPad Software Inc., San Diego, CA) was used in the

analysis condition factor data. The statistical analysis approach was the same as was done for the length analysis (4.2.2).

A size comparison of coho fry captured in the estuary and lower river sites involved comparing the mean fork length of late season (July and August) captures.

4.2.7 Residence time

Residence time was used as a measure of realized function to reflect the behavioural response of fish to habitat attributes that promote survival. Residence time was estimated from mark-recapture results. The potential residency periods were calculated for specific sites and for the estuary as a whole from the difference between the recapture date and the potential marking dates.

4.2.8 Density

Density was used as a measure of realized function to reflect the behavioural response of fish to habitat attributes that promote survival. Snorkel survey observations provided an estimate of densities per square meter of shoreline throughout the sample areas.

4.3 Mapping

Habitat mapping of specific sites involved a photo interpretation of habitat units, followed by ground-truthing during low tides to prepare habitat maps that were accompanied by information on plant assemblages, substrates, exotic species presence, and anthropogenic features. Table 5 provides a list of sites mapped and the dates they were mapped. Results were used to compare the diversity of trees, shrubs, herbs and algae at each site, and to compare the relative numbers of exotic plants that had established there. Exotic plants were determined based on information from the BC Ministry of Environment Conservation Data Centre[4].

4.4 Restoration and Protection Options

The restoration and protection options were compiled into a comprehensive list that included information on the project names and descriptions, location, rationale, opportunities and constraints, information requirements, key people to involve, and potential resources. This involved discussions with stakeholders early on in the process to identify potential information sources and key people, compilation of historical and current ecological information on the estuary. Once the tables were compiled, they underwent a review process that involved more discussions with stakeholders and experts that had insight into all or specific projects. Once the tables were at or near finalization, there were three interviews where ideas in the tables were brought up to assess feasibility and to provide more information on techniques and opportunities. The final results were the comprehensive lists of restoration and protection options and accompanying concept models to provide a brief overview of the contents.

4.4.1 Stakeholder Involvement

During the planning phase for this project, there were many groups that were consulted on the project and were made aware of opportunities for them to be involved:

[4] BC Species and Ecosystems Explorer: http://www.env.gov.bc.ca/atrisk/toolintro.html

- **The Estuary Working Group (EWG) and affiliated subcommittees** on restoration and land protection provided an opportunity to gather input from various stakeholders on these options.
    - *The EWG and its sub-committees were organized by the Comox Valley Project Watershed Society. They involved a variety of people from different backgrounds and representing different groups, including government and non-profit, and areas of varying expertise from historical, technical, biological and career oriented. This information was gathered from the direct attendance of EWG and subcommittee meetings, or from the minutes provided from these meetings.*

- **Several key people were sought for opinions on specific projects**, including expert staff from Fisheries and Oceans Canada, a local biologist with vast experience working on the Puntledge River watershed, a member of the Naturalists' Society, and a local historian.

- **Three formal interviews** were conducted with the new environmental planner for the City of Courtenay, the vice-president of the Fish and Game Protective Association, and an expert on coastal eelgrass research and restoration.

- **Anecdotal information was also gathered during the course of field** work in this project, as many of the volunteer assistance came from people involved in various stewardship groups and government organizations, and varying backgrounds of expertise.
    - *Volunteers ncluded streamside landowners, volunteers from the Tsolum River Restoration Society, the Fish and Game Protective Society, the Millard/Piercy Watershed Stewards, the Brooklynn Creek Stewards, the British Columbia Conservation Federation, and in-kind assistance from Fisheries and Oceans Canada and the Ministry of Agriculture, Food and Fisheries.*

4.4.2 Process

Development of restoration and protection options was a multi-stage process:

- A table of restoration options (referred to as the Restoration table) was initially compiled from three documents. The first document was the minutes from a February, 2003 workshop for federal and provincial government employees on knowledge gaps and future directions to manage fisheries resources in the Courtenay River estuary (Courtenay River Estuary Workshop Minutes, 2003). The second document provided the results of a reconnaissance tour undertaken on February 25th, 2004 of potential restoration sites in the estuary (E. Guimond & D. Poole, personal communication, Feb. 25th, 2004). The third document was another summary of a field tour of potential restoration sites carried out on October 1st, 2009 (D. Davies, personal communication, October 1st, 2009). Further information and new sites were added to the Restoration table following the 2010 field sampling season. This information was based on direct observations and experience of the project biologist and from ideas and perspectives found in the EWG and sub-committee meeting minutes.

- A table of protection options (referred to as the Protection table) was compiled from discussions provided in the minutes of 2009 and 2010 EWG meetings, and the land acquisition sub-committee (EWG, n.d.).

Both the restoration and protection options tables that resulted were subsequently reviewed by representatives of the EWG and the respective sub-committees. In addition, specific sections were further refined based on input from people with site-specific knowledge, the method proposed, the history of the site, and the social and political conditions surrounding the project.

Mapping of the restoration options involved pinpointing them in Google Earth[5], and creating an electronic .kmz file that could be easily uploaded by anyone who has the Google Earth program on their computer.

4.4.3 Concept Model

The purpose of the concept model was to create a visual diagram of the connections between project goals and anticipated outcomes. This was to facilitate understanding of where, why and how for each project. It was also done to highlight the emphasis of particular project types over others. The concept models are not stand-alone; they are meant to provide an initial overview of projects that are provided in detail in the Restoration and Protection tables.

Concept model development for the Restoration Options began with an overall goal of restoring the estuary to achieve greater health for chinook and coho salmon. As mentioned in section 4.2.3, the estuary was partitioned into areas based on a conceptual migration route of juvenile chinook and coho salmon. The restoration concept model was also organized in this way. The areas that occurred in the outer estuary (Areas 6, 7, 8 and 9) were combined to reflect the later stages of migration of fish from the Courtenay River, though still considering the importance of these habitats to salmon from tributary creeks. Another section, “Lower river restoration”, refers to restoration of freshwater habitat in the lower sections of smaller creeks that may provide rearing habitat to juvenile salmonids both prior to and following estuarine rearing. Each Area shown in the Restoration concept model was connected to restoration project types. In this way, the relative importance of project types for each area could be inferred. The relative contribution of the all the project types to the refuge, water conditions and forage potential for juvenile salmonids was indicated pictorially by applying different weights to the arrows that pointed to these descriptors on the concept model.

Concept model development for the Protection Options highlighted the main categories and the cub-categories for protection. This is a simplification of the process required to plan protection projects, and as such, some important connections are not explicit, such as the need for fundraising in order to implement all of the protection project types. To avoid the complexity that would result if all interconnections between the options were shown in the concept model, it was designed to provide a clear path for achieving this connections, while

[5] Google Earth can be downloaded for free from http://www.google.com/earth/index.html

keeping in mind the interrelated benefits of one type of action on another. For example, though it is not explicit in the concept model, achieving support for land acquisition may require financial incentives for landowners to transfer title to public ownership for conservation. These types of details are instead provided in the Protections Table. However, the importance of communications and education as encompassing all protection options is highlighted in the concept model.

5 RESULTS

5.1 Habitat Requirements

Chinook and coho fry stages were more dependent on the estuary than the smolts, which moved through the estuary quickly. Chinook and coho fry had already entered the estuary by late March of 2010 when sampling started. The residency of chinook fry in the estuary peaked in June, and most had left by July. Coho fry remained into the estuary for the entire summer, and were still found during two post-study sampling sessions in October and December of 2010. The smolt stages of these species were more abundant, but left the estuary sooner. By July, there were very few chinook fry or smolts captured in the estuary.

There was only one recapture of chinook, compared to eight of coho. Only one of the coho recaptures had moved from the place it was marked. The recaptured chinook fry had migrated between the Courtenay Slough and Dyke Slough (below the tide gates), and the coho had migrated from the Airpark Lagoon to the Dyke Slough. This coho also had the longest minimum estuarine residency period of 125 days. All of the other coho recaptures stayed in the habitats in which they were marked (Table 15).

Chinook fry had a preference for habitats in the upper ecotone and near freshwater sources throughout the season. Areas 1, 2 and 4 were particularly important to chinook throughout the 2010 sampling season (Figure 2). They were found in pools and alcoves bordered by sedge habitats, near large woody debris, among large rocks and pilings, near eelgrass beds, and in areas where there was a strong influence of freshwater.

Coho fry that reared in the Courtenay River estuary occupied habitat with good refuge and a reliable source freshwater inflow. They remained in the estuary throughout the spring and summer and during this time experienced better growth than their freshwater counterparts (Figures 18 and 19).

Early season (May-June) growth rates were low for chinook fry compared to coho fry in the Dyke Slough pool below the tide gates (site 4). Growth rates of chinook were <0.4mm/day compared to up to 1.43mm/day for coho. The diet of chinook during this time indicates a preference for insects, though these were not prolific in the benthic samples. In comparison, coho fry appeared to select for gammarid amphipods which were prolific.

5.1.1 Fish Presence

CPUE results indicated high fish densities in Areas 1, 2, and 4 for both chinook and coho. May had the highest CPUE of the sampling period for both chinook and coho in Areas 1 through 4. Area 4 had the highest CPUE for both species. Area 2 was important for both chinook and coho in the Courtenay Slough as well as along mainstem channel margins where there were deep water alcoves and sedge habitat. CPUE for all sites and sampling days are provided in Figure 2 for chinook and Figure 3 for coho.

Other species that were encountered in the estuary included steelhead (*O. mykiss*) and sea-run cutthroat (*O. clarkii*) trout, sculpins (*Leptocottus armatus* and *Cottus spp.),* threespine stickleback (*Gasterosteus aculeatus*) and perch, amongst smaller numbers of other species. As the sampling season started at the tail end of the pink salmon migration, very few of this species were encountered. Figure 4 identifies the relative catches of each species.

5.1.2 Life History Composition

Length frequency distributions indicated multiple age classes (cohorts) of chinook and coho utilizing the estuary during certain periods of the study. In 2001, the length frequency distributions for chinook indicated two size classes[6] in July and August. In 2010, there was slight evidence of a third size class in July for chinook (captures in August were too small to compare). There were two statistically different size classes ($P<0.0001$) detected for chinook in May, June and July in 2001, and in June for 2010. Two size classes of coho were detected in May and June of 2001, and in April and May of 2010 ($P<0.0001$ for all). The June of 2001 cohort 1 chinook had a similar mean length as the hatchery chinook that were identified with an adipose clip, and therefore may represent hatchery stock (Table 6).

Figure 5 and Figure 6 provide the length-frequency distributions for chinook in 2001 and 2010, respectively. A box plot indicating significant differences in size classes for each species, year and month is provided in Figure 7. Tables 7 and 8 provide information on the statistical results where significant differences in size class were found.

5.1.3 Proximity to migration routes

The map indicating the sample sites and Areas is provided in Map 2. A description of each area and the associated 2010 sampling sites is provided in Table 9.

5.1.4 Diet

Results from the stomach analysis of five species of fish over three sites indicated dietary differences between species and sites over the season. In April, chum salmon (*O. keta*) had a diet dominated with copepods (mostly harpactacoid), and chinook fry with gammarid amphipods. Subdominant food items indicated that copepods were also important for chinook fry, and likewise amphipods for chum.

[6] These are referred to as cohorts 1 and 3, based on their size classes. There were not enough data to statistically test for a difference in the middle (cohort 2) size class.

In May, there were dietary differences detected between chinook and coho fry and smolts at the Dyke Slough below the tide gates. The fry had a diet almost entirely of insects, while smolts had a diet dominated by gammarid amphipods. Steelhead trout and sea-run cutthroat had diets dominated by gammarid amphipods and isopods, respectively, without evidence of predation on other fish found in their guts.

In June, chinook fry diet was almost entirely composed of insects. Coho fry diet was also dominated by insects, with a substantial component (20-25%) of gammarid amphipods. In July, insects were also an important dietary component for coho fry.

While gammarid amphipods made up the dominant part of the diet of chinook fry through April and May, dietary overlap analysis did indicate them to be a preferred item due to their high abundance in the benthic samples (Figure 8). They were found to be a preferred food item for coho, however. In May, chinook demonstrated a strong selection for insects, and coho for copepods. Insects were also strongly selected for in June by coho.

The dominant and sub-dominant prey items found in the stomachs of fish sampled are provided in Table 10. The composition of invertebrates found in benthic samples in the estuary in 2010 is shown in Figure 8. Dietary overlap indicating selection for (positive values) and selection against (negative values) food items by coho and chinook are shown in Figure 9 and 10, respectively.

5.1.5 Water Quality

Figure 11 compares temperatures at four sample sites to ideal and lethal levels for salmonids (Bjornn & Reiser, 1991). Temperatures during sampling of Areas 1-3 were typically below the optimal conditions until approximately mid-June, when they exceeded optimal levels. Area 4 exceeded optimal levels by the third week of May. There were no recorded instances where temperatures reached lethal levels.

There was a general increase in surface temperatures in Areas 4 and 6 over the season, with higher late-season (post-June) temperatures detected in 2010 compared to 2001 (Figure 12 and 13).

5.1.6 Growth

Growth of chinook and coho fry (cohort 2) varied between Areas and sampling period. The highest short term growth rate for chinook was estimated at 0.79mm/day in late May in Area 1. There was negative growth detected at Area 4 in early May for chinook. Coho demonstrated very good growth early in the season in Area 4, while coho in Area 1 experienced negative growth in late July (-0.57 mm/day). Figure 14 and Figure 15 compare seasonal (~1-2 months) growth between Areas for chinook and coho fry, respectively.

Tables 11 and 12 provide estimated growth rates for different areas over narrow time periods (~ 1-4 weeks) for chinook and coho fry, respectively.

Area 2 had significantly higher condition factors ($P<0.05$, Table 13 and Table 14, Figure 16 and Figure 17) than Area 3 for both chinook and coho fry in April. Differences between Areas 1, 2 and 4 were also similar for both species in May, with Areas 1 and 4 having greater condition factors than Area 2. Condition increased overall in June, with all areas and both species exceeding a condition factor of 1. The greatest condition factors for chinook occurred at Area 4 in June. Area 5 had coho fry with consistently high condition factors throughout the season.

End of the season size analysis indicated that coho captured in Areas 4, and in the lower river areas that fed into Area 4 (Glen Urquhart and Mallard Creeks) were of greater size than for the lower Puntledge River upstream of the upper ecotone, and in Areas 1 and 2 (Figure 17 and Figure 18). Coho captured in August in Area 5 were of greater size than those captured in the Condensory side-channel.

5.1.7 Residence Time

Overall 742 chinook fry and 446 coho fry were marked with VIE tags between March 30 and June 24, 2010. There were 1 chinook and 8 coho recaptures between May 6 and October 7, 2010.

Mark-recapture data indicated site fidelity of coho fry in Areas 2, 4, and 5. During the period from April to May, coho fry in Area 2 (captured in site 2a, Courtenay Slough) had a minimum residency period of 8 days. Recaptures at this site in June found an increase in the minimum residency period to 23 days. Known mark and recapture dates of a coho in Area 4 (site 4, Dyke Slough pool below the tide gates) found a residency period of exactly 41 days. Recaptures in Area 5 (Millard estuary) indicated a coho had resided there for at least 66 days.

The longest estuarine residency period was at least 125 days for a coho that was marked in Area 3 (Airpark lagoon) and recaptured on October 7, 2010 at site 4. One chinook fry was recaptured; it had a minimum residency period of 20 days and had moved from Area 2 to site 4.

Lower river sampling did not find any VIE tagged fish.

Table 15 provides details of species recaptured in the estuary and potential marking dates along with calculated ranges in residency periods.

5.1.8 Density/Snorkel observations

Density estimates of juvenile chinook and coho (fry and smolts combined) during the 2010 sampling period ranged from 0 to 4 salmon per m^2. Greatest densities were detected from June through to early July, particularly at Snorkel Site 2. Site 2 was located in a back eddy along a rip rap/boulder shoreline along the left bank of the river ~230m below the Tsolum/Puntledge confluence. Chinook made up the majority (87%) of juvenile salmon observations in June. Observations in early July were not identified to species. The lowest densities were detected at Snorkel Site 6. However, snorkelers observed difficulty in viewing fish at this site especially at the lowest tides due to a shallow sandy slope.

General observations noted by snorkelers are provided in Table 16. Map 5 provides an overview of salmon and trout densities for each of the six transects assessed weekly from May 11 to August 16th, 2010 along the 3.1km of the upper ecotone. Figure 20 provides a chart of overall densities from the Tsolum/Puntledge confluence to the end of the upper ecotone (beginning of the mudflats).

5.1.9 Mapping

Detailed habitat mapping of six different sites in the estuary provides a comparison of the diversity in aquatic and riparian vegetations that occurred from the upper ecotone to the lower estuary, and an indication of the relative numbers of exotic plants that have established in these areas. Maps were created for the Tsolum Relic Channel (Map 6), Simms Park (Map 7), the shoreline and mudflats adjacent to the river channel and Airpark Lagoon (Map 8), the Dyke Slough below the tide gates (Map 9), Millard estuary (Map 10), and the areas north and south of the Royston Wrecks (Map 11 and Map 12, respectively).

The greatest overall diversity of tall (>10m) and short (<10m) riparian vegetation and aquatic herbaceous vegetation occurred at the Tsolum Relic Channel in Area1. There was also the least number of different exotic plant species at this location. Millard Creek estuary also had a high diversity of native vegetation, but had the highest number of exotic plant species. Site comparisons of the riparian, herbaceous aquatic, and exotic vegetation is provided in Figure 21. Table 17 and Table 23 provide plant species lists for each of these sites.

5.2 Restoration and Protection Options

5.2.1 Restoration Options

In total, there were 41 restoration options, including 12 project types identified for the estuary (Figure 22, Appendix 6). The majority of these projects were located in Area 2 along the upper ecotone. There were 15 projects listed as “Other” that were wither not within one of the delineated areas or they spanned multiple areas. The greatest number of options fell under the “Off-channel Habitat Enhancement” and “Riparian Restoration” project types. “Channel complexing” and “Saltmarsh Planting” were also common. As such, most of these projects were determined to benefit refuge requirements for juvenile salmonids.

5.2.2 Protection Options

In total, there were 33 protection options identified that spanned the categories of “Education”, “Land Protection”, “Voluntary Incentives” and “Regulatory Incentives” (Figure 23 23, Appendix 7). The majority of project types identified were “Education” (15), followed by “Land Protection” (11).

The final Restoration and Protection options are provided in Appendices 6 and 7, respectively. The respective concept models are provided in Figures 22 and 23. An Excel spreadsheet of these options and the Google Earth map file (.kmz) is also available from the author or from Comox Valley Project Watershed Society.

5.2.3 Stakeholder Involvement

Results from stakeholder interviews and comments following presentation of the results to stakeholders are provides in Appendices 6 and 7, respectively. These summaries provide insight from various stakeholders of the results of this study and the feasibility of implementing restoration and protection options in the estuary.

6 DISCUSSION

This study provides current knowledge of habitats that are important to rearing salmonids in the Courtenay River estuary and possible solutions to ensuring the long term health of the estuary for all species. The application of an ecosystem-based management approach ensured that the results can be applied widely across the estuary and by different stakeholders. Key ecological linkages between juvenile salmon and their habitats were identified and applied to the development of the restoration and protection options along with stakeholder input. The restoration and protection options that resulted from this study identified 74 potential projects that could benefit estuary health to varying degrees.

Measures of opportunity, capacity and realized function introduced by Simenstad and Cordell (2000) were applied in this study to assess the ecological and physiological responses of juvenile salmonids to estuarine habitats. Overall, the estuary provided the necessary habitat requirements to support the survival and fitness of juvenile salmonids in 2010 to varying degrees. In particular, the opportunity for salmon to access and benefit from the habitats in the estuary was provided by the two different size classes of chinook and coho found in the estuary. Life history diversity has been linked to both ecological and genetic diversity within salmon populations, and can promote resilience to disturbance similar to the resilience provided by a diverse stock portfolio (Waples et al, 2009, Schindler et al, 2010). Likewise, the long residence time of coho fry in the estuary provides evidence that estuary habitats were functioning to promote the survival of this life stage (Simenstad and Cordell, 2000).

6.1 Habitat Requirements

The Tsolum River relic channel, edge and large woody debris habitat along the upper ecotone of the Courtenay River, the Courtenay Slough at Simms Park, the Airpark Lagoon, and the Dyke Slough pool below the tide gates all provided important estuary habitats for juvenile salmon. These areas were located mostly in the upper and mid-ecotones, they all had a combination of shallow and deep water refuge, and at least some intact riparian areas. These habitat characteristics have been identified as important estuarine habitats for both species (Healey, 1982; Kjelson et al 1982; Aitkin, 1998; Simenstad and Cordell, 2000).

Chinook had a preference for habitats that provided both high and low water refuge, and provided good refuge from predators and poor water conditions. These habitat preferences reflect chinook behaviour observed by Healey (1982) in the Nanaimo River estuary where they did tidal migrations between low tide refugia and high water marsh habitats. Areas

1, 2 and 4[7] were particularly important to chinook throughout the 2010 sampling season. They were found in pools and alcoves bordered by sedge habitats, near large woody debris, among large rocks and pilings, near eelgrass beds, and in areas where there was a strong influence of freshwater. There was only one chinook recapture compared to eight for coho, and that recapture had migrated in May or June between Simms Park (Area 2) and Dyke Slough (Area 4) over a minimum period of 20 days. This is likely due to a seaward migration later in the season, which was also found for chinook in the Nanaimo River estuary (Healey, 1982).

Coho fry that reared in the Courtenay River estuary had a long residency period in habitats of the upper ecotone that provided good refuge and feeding opportunities. Their preference for backchannels and sloughs despite poor water quality conditions encountered at these sites later in the summer season indicated they were sensitive to predation. They also grew relatively well in higher temperatures compared to chinook. High food conversion efficiencies have been reported for salmonids at higher temperatures where there are good food opportunities[8] (Wurtsbaugh & Davis, 1977; Bjornn & Reiser, 1991). During their estuarine residency in the spring and summer, coho fry experienced better growth than their freshwater counterparts, with some reaching the same size as smolts found in the estuary the previous April. Tschaplinski (1988) also found that the coho grew much faster in the Carnation Creek estuary than their freshwater counterparts. This could provide estuarine reared coho with an advantage over freshwater reared coho, as larger size upon entry to the marine environment has been attributed to greater survival when overall marine conditions are poor (Holtby, et al., 1990). Coho tended to stay in the same habitats for long periods of time, as indicated by the mark recapture results. These results indicated a range in residency periods in the same habitats that lasted at least 23 days in Area 2, 41 days in Area 4, and 66 days in Area 5. Only one of the eight coho recaptures had moved from the place it was marked. This coho also had a minimum estuarine residency period of 125 days, the longest of all the recaptures.

While this study did not find any indication of coho that moved to the marine environment after their spring and summer residency period, Tschaplinski did find that Carnation Creek coho were able to tolerate salinities up to 19 $^{0}/_{00}$ [9] by the end of the summer, therefore this scenario is possible. The survival of these fish to return to spawn is indicated in an otolith sample taken from a mature adult coho in 2009 from the Puntledge River Hatchery that had an estuarine rearing signature (Tryon, unpublished). As such, there is some evidence that this life history provides a contribution to coho survival in the Puntledge River system, however the proportion of estuarine reared coho that survive to spawn is unknown. Furthermore, whether this life history results from early displacement of fry from the rivers and creeks, or if there is an active migration to the estuary is also unknown (Koski, 2010).

[7] For a description of the Areas, see Map 2.

[8] Up to a maximum temperature threshold, after which conversion efficiency declines despite good food conditions.

[9] Seawater is typically 30 $^{0}/_{00}$

It is important to distinguish between salmon use of a habitat and the ability of that habitat to support salmon. Although chinook were found in high numbers at the Dyke Slough (Area 4), monthly length comparisons indicate low growth rates (>0.4mm/day) early in the season (May-June). This may be due to immigration and emigration to the site, or to the low composition of preferred diet items in the benthic environment. Habitats that have the capacity to provide preferred prey items to juvenile salmonids have been identified as important contributors to their survival (Simenstad and Cordell, 2000), and lack of preferred prey items, despite the presence of other food, can lead to reduced energetic efficiency for growth (Higgs et al, 1995). Gammarid amphipods had the greatest relative densities in the benthic samples and dominated chinook diet at this site, however, dietary overlap analysis indicated a preference for insects, which were not prolific in the benthic samples. This may be due to the sampling method not encountering the insects, or the interpretation may have large errors (error analysis of the Strauss Index was not undertaken). This argument is plausible as chinook fry had significantly higher condition factors ($P<0.05$) at this site compared to other sites. However, if insects were indeed limiting at the Dyke Slough site, this could explain the low growth rates of chinook during this time. In comparison, coho fry at this site grew very well (up to 1.43mm/day) from April through June, during which time they fed mainly on amphipods and insects. Coho fry appeared to select for both diets, therefore may have been better able to take advantage of the greater densities of amphipods in the environment than chinook fry.

Food production and salmonid diet had important links with detrital and riparian sources. Gammarid amphipods and copepods were important components of salmonid diet in this study. They are epi-benthic organisms, and likely lived in the same habitats where they were consumed (Pauley et al, 1988). Furthermore, amphipods in general are sensitive to environmental changes and their presence and abundance can be used as indicators of environmental quality (Gross and Pauley, 1989). Harpacticoids are also important dietary components for salmonids due to their high food conversion efficiencies (Coull, 1990). Insects were an important dietary component for chinook and coho fry in the upper ecotone throughout the spring and summer. Riparian vegetation provides an important contribution for insect production, both indirectly as an organic source of insect food, or directly from insect fall from surrounding riparian areas (Brennan et al 2009). The upper ecotone had intact riparian areas with a healthy diversity of tree and shrub species (Figure 21), which may have contributed to insect production in this area. Chinook were found to feed preferentially on insects in this study. In May in the Tsolum relic channel (Area 1), insects dominated chinook fry diet and they also experienced high growth rates. High growth rates have been linked to a diet on preferential food items that meet salmonid energy requirements (Higgs et al, 1995).

6.2 Restoration and Protection Options

This study identified habitat restoration and protection options that could benefit chinook and coho fry that rear in the estuary. Chinook fry would benefit from restoration projects that improved food production and habitat connectivity throughout the upper and lower estuary by naturalizing hardened shorelines, creating deep water refuge habitat adjacent to upper intertidal marsh habitats, and ensuring frequent velocity refuge opportunities along the estuarine continuum for all tide heights. Coho fry would benefit from restoration projects in

the upper estuary that increased the area and quality of refuge habitat by restoring riparian habitats for improved insect production and creating and restoring off-channel habitats. Similarly, protection projects that ensure existing areas with these features for coho and chinook remain healthy will benefit both the salmon and their ecosystems.

Other management actions that affect salmon include hatchery management, watershed development, and flow regulation. These are not directly addressed in the restoration and protection options, however they are in other management systems such as the Wild Salmon Policy (Fisheries and Oceans Canada, 2005), Nature Without Borders (Fyfe, 2008) and the Puntledge River Water Use Plan (BC Hydro, 2003). These actions can and do impact salmon in the estuary in different ways, therefore the estuary should be considered in these decisions as well.

6.3 Study Limitations

The characterization of and development of restoration and protection options involved a comprehensive process that brought in information from many sources. Given the high complexity of the estuary ecosystem and the myriad of perspectives amongst stakeholders on how to achieve a healthy estuary ecosystem, there were some limitations associated with this study. In the ecological characterization of the estuary, information gaps associated with data and budget limitations were addressed by referring to past studies. For example, Healey (1982) provided a good description of chinook and coho use of the Nanaimo and Nitnat river estuaries that helped to attribute importance of similar habitat features found in the Courtenay River estuary. Tschaplinski (1988) provided a detailed account of coho fry rearing in the Carnation Creek estuary that contributed to identifying the benefits of this unique life history trait in coho fry from this study. Water temperature interpretation required drawing upon conventional stream habitat requirements for salmon provided by Bjornn and Reiser (1991). This approach was supported by Tschaplinksi (1988) who identified that freshwater thresholds were similar for estuarine reared coho. Significant differences in habitat types based on salinity in the Courtenay River estuary in 2001 (Hamilton et al. 2008) helped with Area delineation in this study. Finally, the investigation into measures of capacity, opportunity and realized function by Simenstad and Cordell (2000) formed a basis for characterizing estuarine health. While these measures were developed to monitor restoration projects, their value in assessing existing habitats and establishing a baseline for future monitoring was recognized for this study.

Further challenges were associated with the development of the restoration and protection options. These included time and budget limitations that prevented input from all stakeholders, in particular First Nations rights-holders. However, by including the diverse group of stakeholders that make up the Estuary Working Group (EWG) in the process, and by conducting the three interviews across three different stakeholder types, there was a healthy cross-section of input from non-profit, government and expert associations. Furthermore, the adaptive nature of the final outcomes partially address these limitations by making them applicable to different management systems and by providing an opportunity for involvement at a later date during periodic reviews.

7 RECOMMENDATIONS

Cooperation and communication are essential to achieving management actions. To ensure the greatest value of the effort and resources that many people have put into this study and into past research, restoration and protection projects, it is important to:

1. clearly recognize a common goal amongst stakeholders; and
2. to ensure ongoing efforts related to the estuary strive to meet that goal.

In this study, the goal was to provide a foundation for future salmon habitat restoration and protection activities that will ensure a healthy thriving estuary ecosystem for salmon and other species that rely on it. The outcomes provide a broad overview of estuary conditions and the current social systems that affect its management.

The next steps require stakeholders of the estuary - environmental organizations, First Nations rights holders, politicians, government staff, landowners, professionals, funding organizations – to assess how their goals and objectives align with the results of this study, and then, their involvement in reaching a common goal of a healthy estuary. Assessment of goals and objectives may involve the confirmation or redefining of the meaning of estuary health and how it is measured. Involvement can include different levels of support, including verbal and written support, financial support, and active support in project implementation. It can also include taking charge of a particular project, including its proposal, design, implementation and monitoring.

The protection and restoration options in this report provide a guide to stakeholders to assess their potential involvement in future projects that affect the estuary. These can be used in existing management planning systems used by different organizations, or applied to new systems. The implementation of specific projects will require greater scrutiny and likely more detailed and site specific research. There will also be requirements for broader scale research into the Courtenay River estuary, including:

- Ecological prioritization of specific restoration projects to help with management decisions
- Periodic (ex. annual) reviews of restoration and protection options to add new projects ideas, and update or remove current projects
- Periodic (ex. annual) reviews of social and economic conditions that affect the health of the estuary and feasibility of implementing specific projects
- Development of more habitat maps of specific areas not covered in this study
- Further analysis of existing data to compare annual trends in habitat requirements for juvenile salmonids beyond what was done in this study
- Continued monitoring of salmonid use of estuarine habitats

Finally, the most important element to ensure that the Courtenay River estuary remains a healthy system for all species, including humans, is to include a strong communications

component in all management planning. This will help to foster cooperation amongst stakeholders, facilitate information sharing, identify opportunities and constraints, access resources, and ensure continuity and long term success in reaching management objectives and goals.

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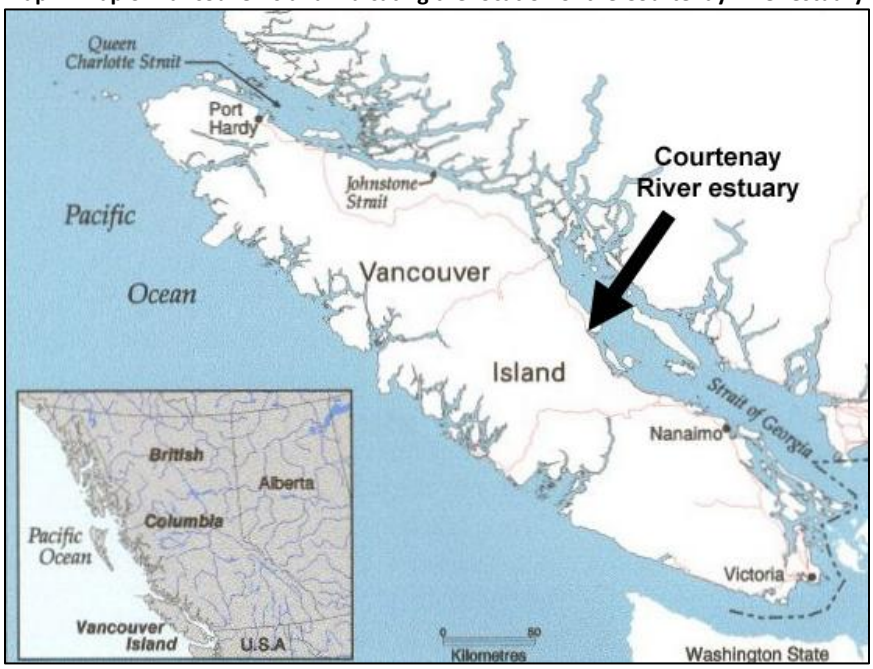
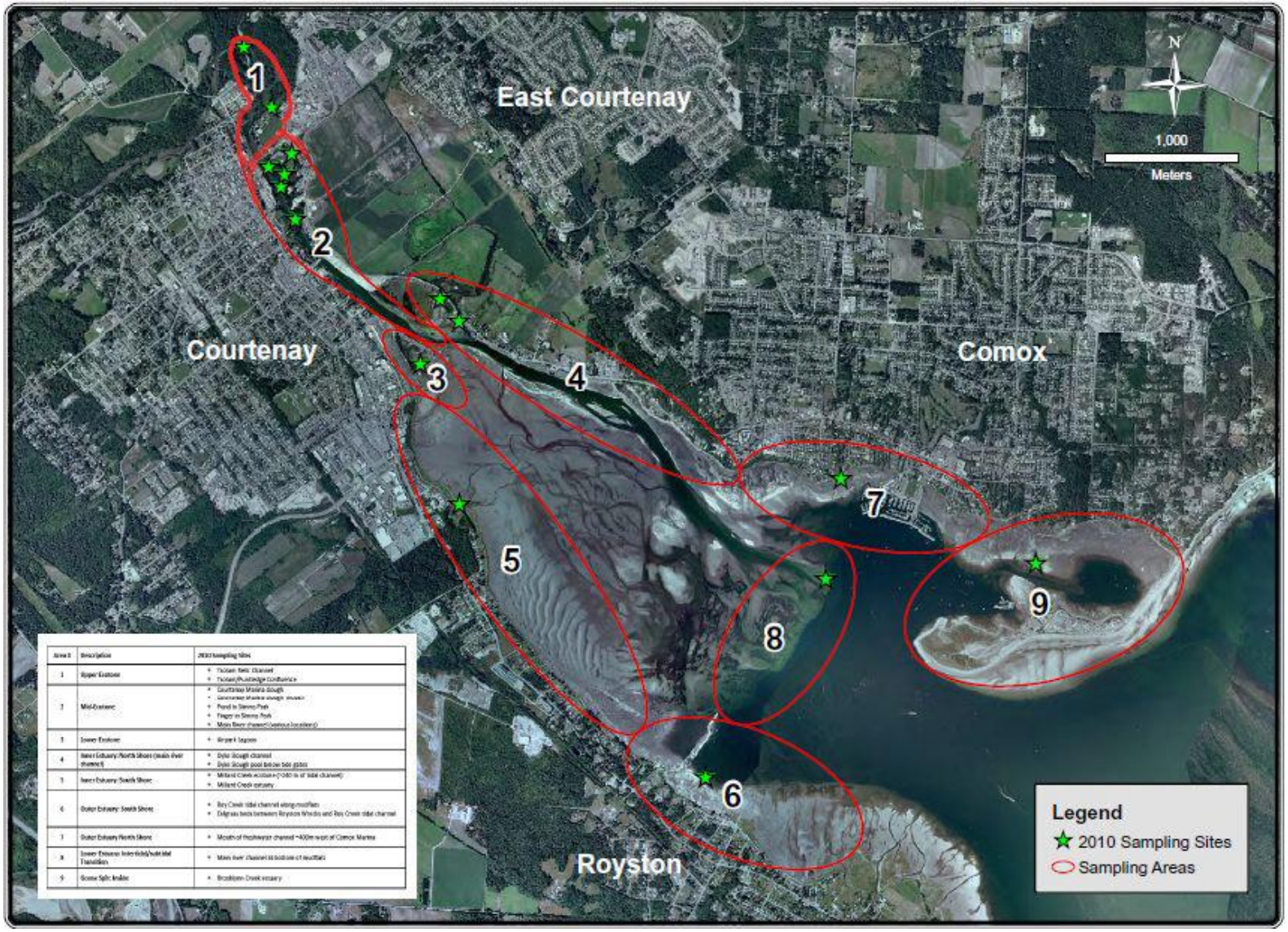
APPENDIX 1: MAPS

Map 1: Map of Vancouver Island indicating the location of the Courtenay River estuary.



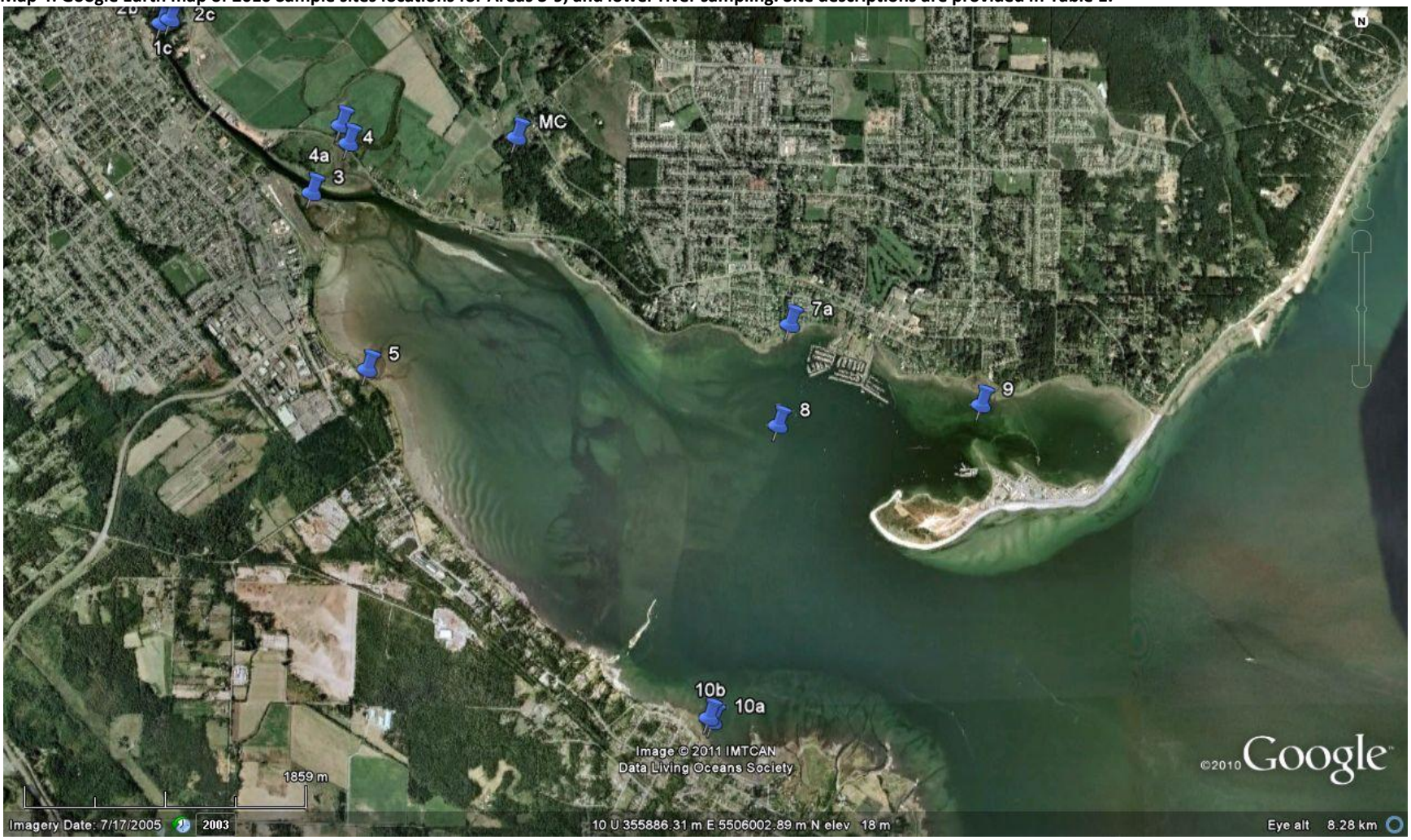
Map 2: Area delineation of the estuary, numbered consecutively to indicate conceptual migration route of anadromous salmonids[10].



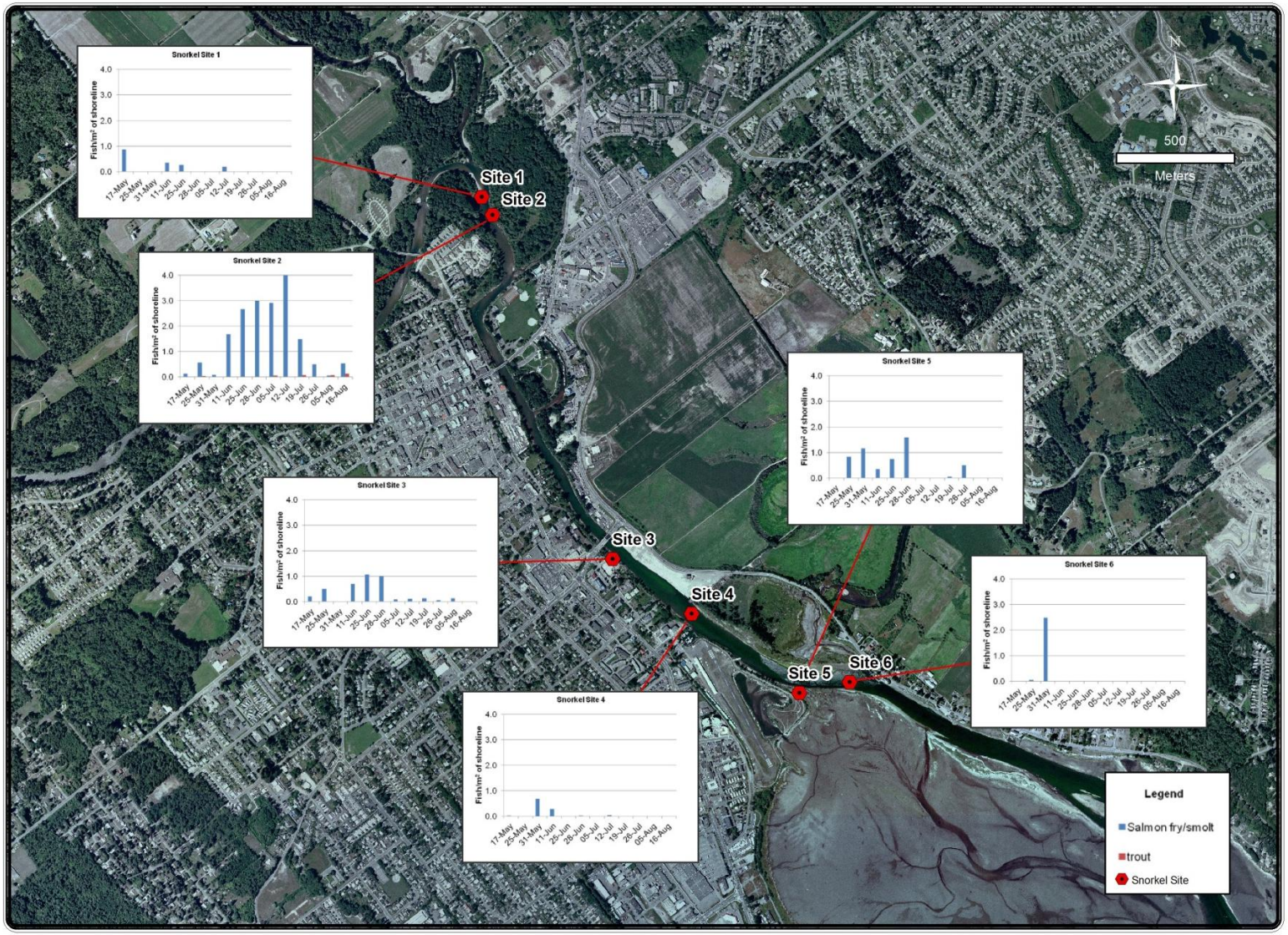
[10] Refer to methods section 4.2.3 for details. Inset table also provided in Table 9.

Map 3: Google Earth map of 2010 Sample sites locations for Areas 1 and 2 and lower river sampling. Site descriptions are provided in Table 1.

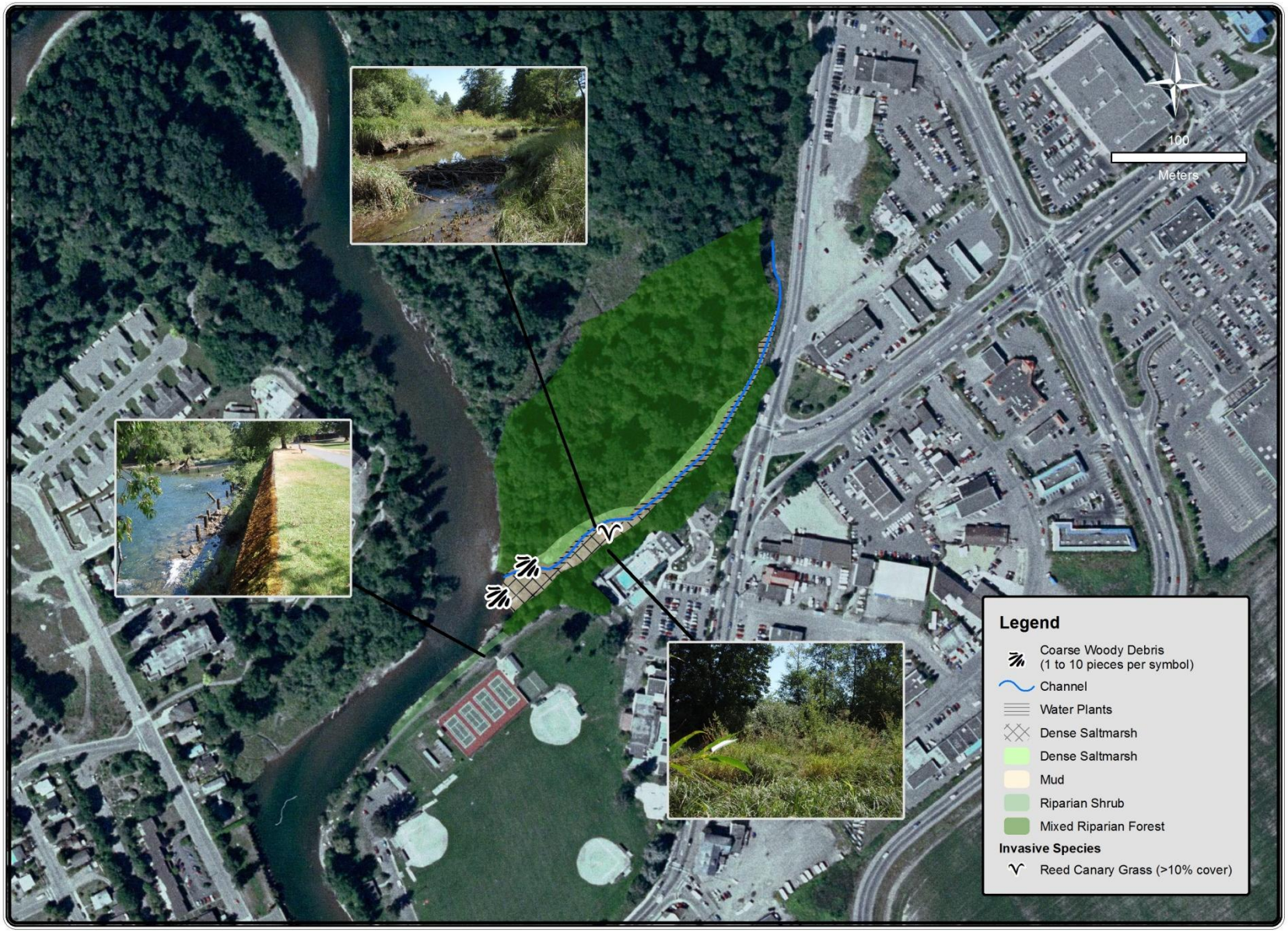
Map 4: Google Earth map of 2010 Sample sites locations for Areas 3-9, and lower river sampling. Site descriptions are provided in Table 1.



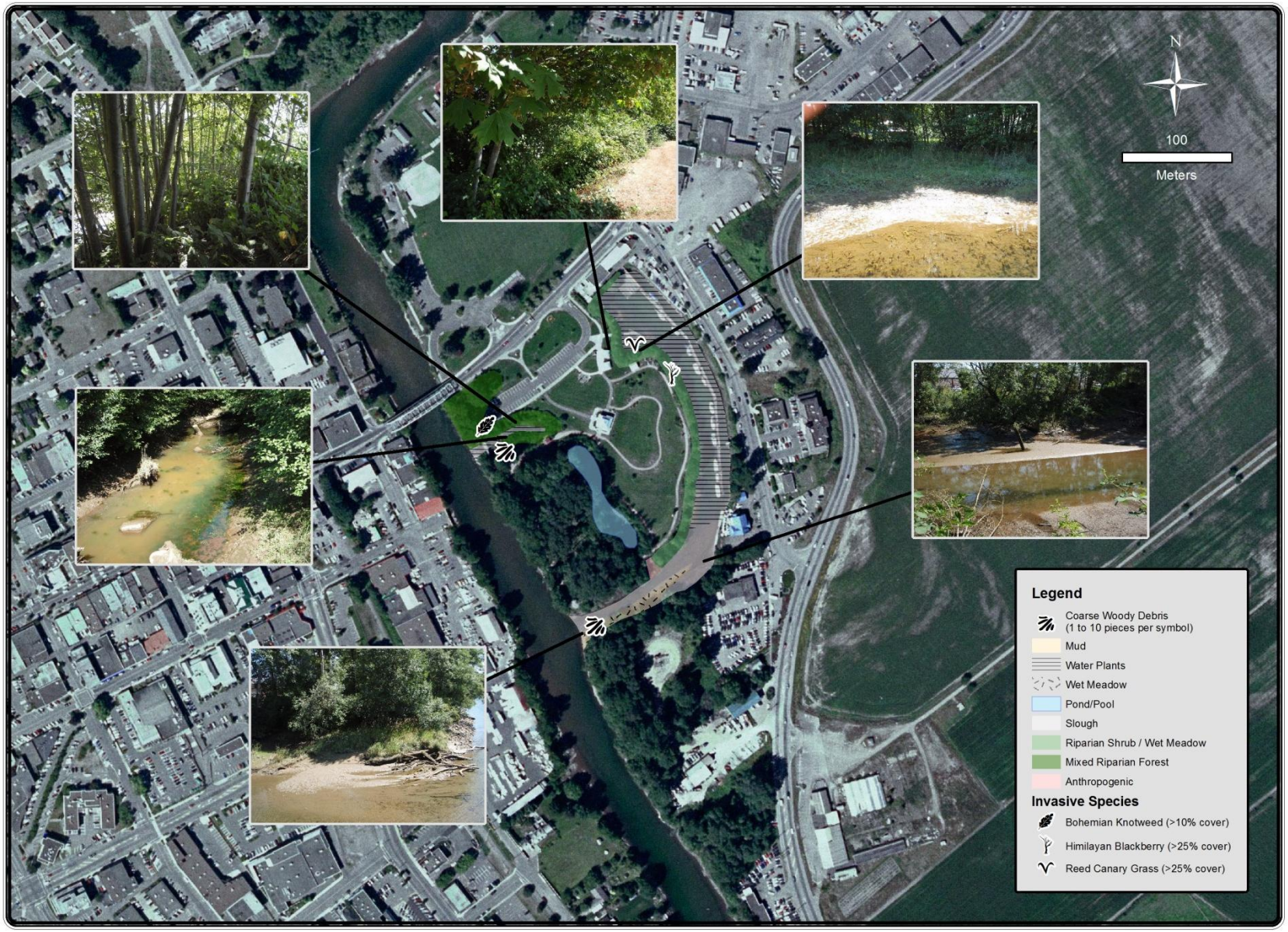
Map 5: Snorkel sites where density transects were located and assessed on a weekly basis between May 11 to August 16th, 2010.



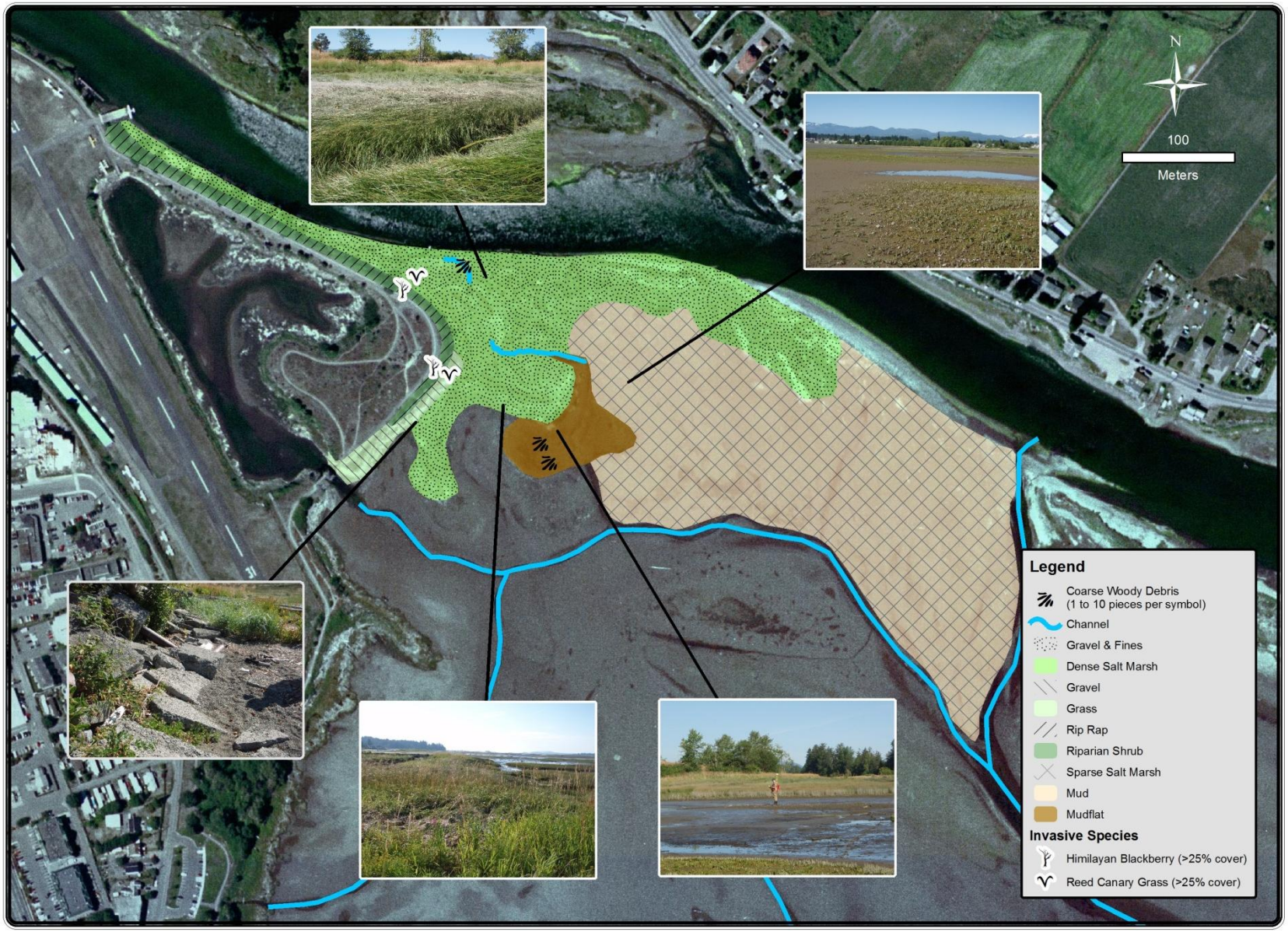
Map 6: Habitat map of site 1a, the Tsolum Relic Channel.



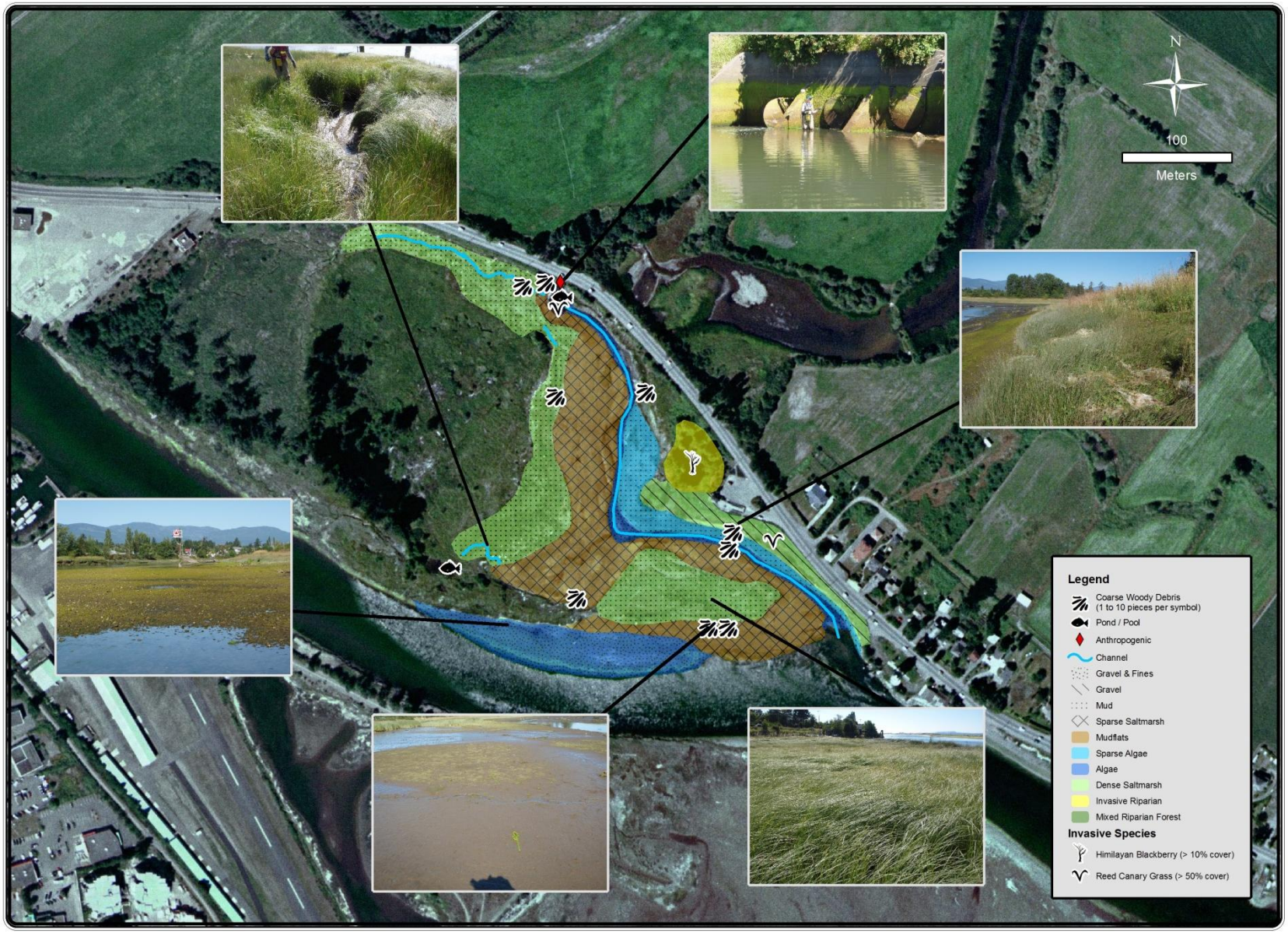
Map 7: Habitat map of Simms Park and Courtenay Slough.



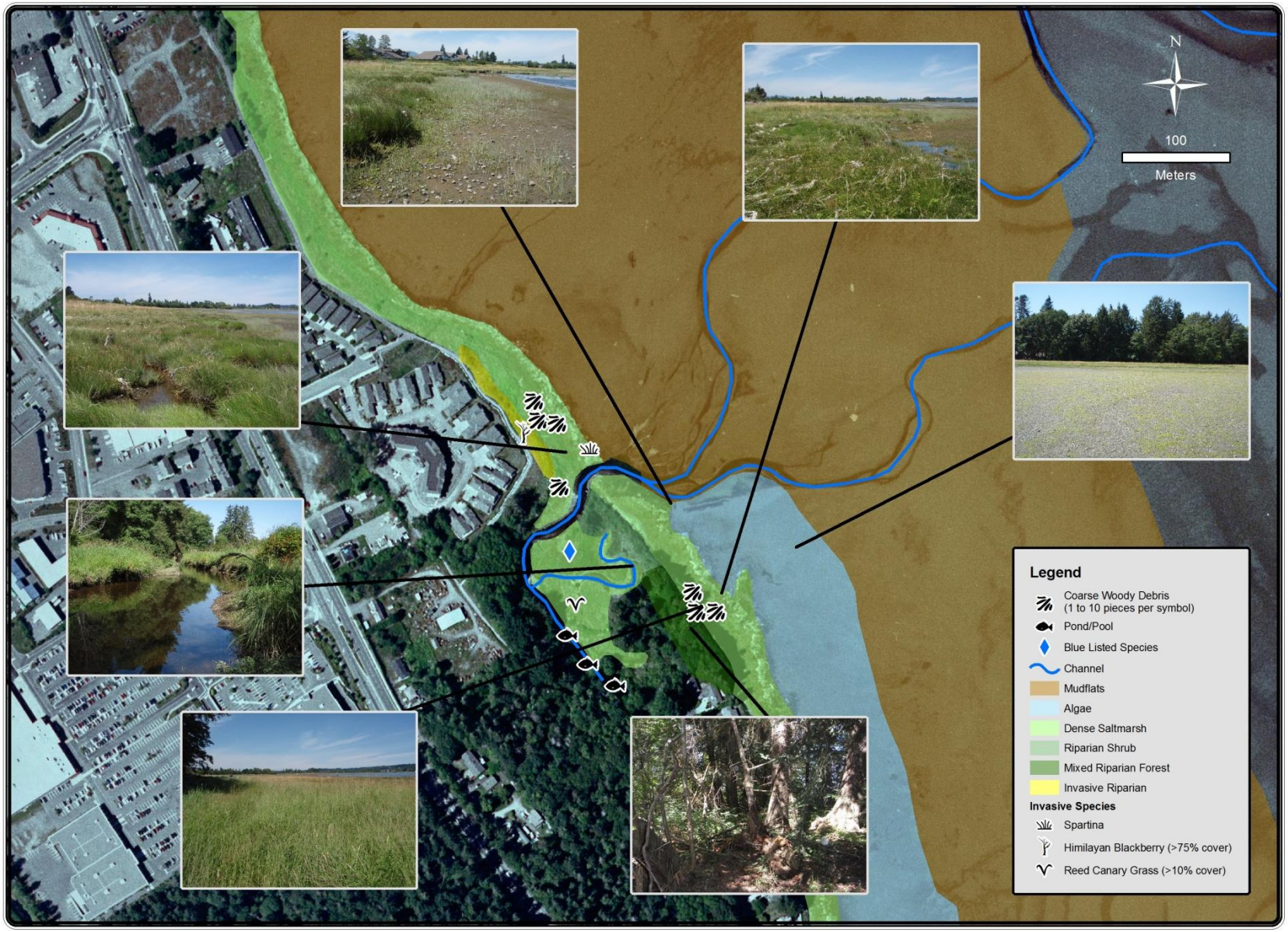
Map 8: Habitat map of the upper and lower ecotone transition located adjacent to the Courtenay Airpark.



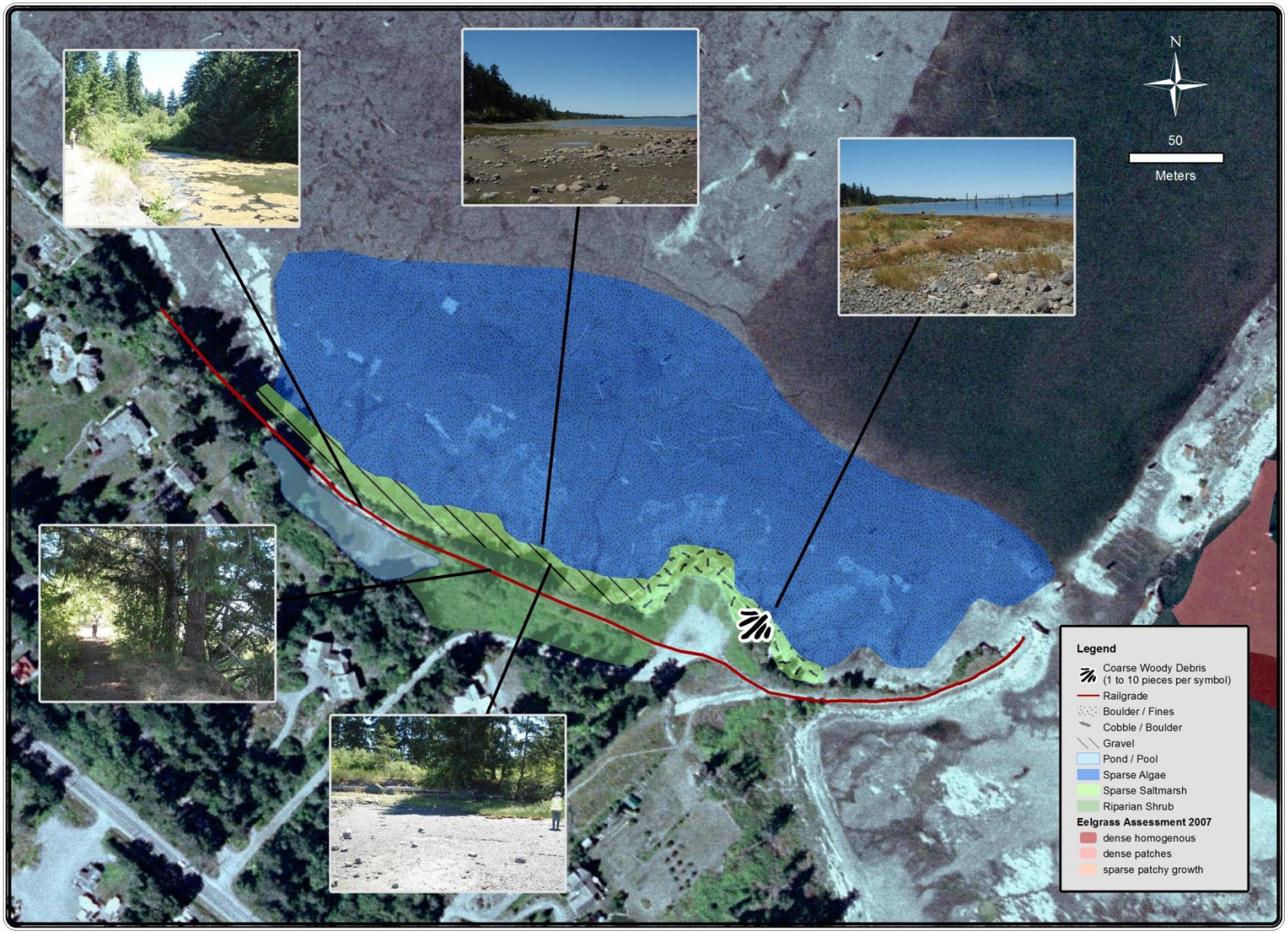
Map 9: Habitat map of Dyke Slough downstream of the Comox Ave. tide gates.



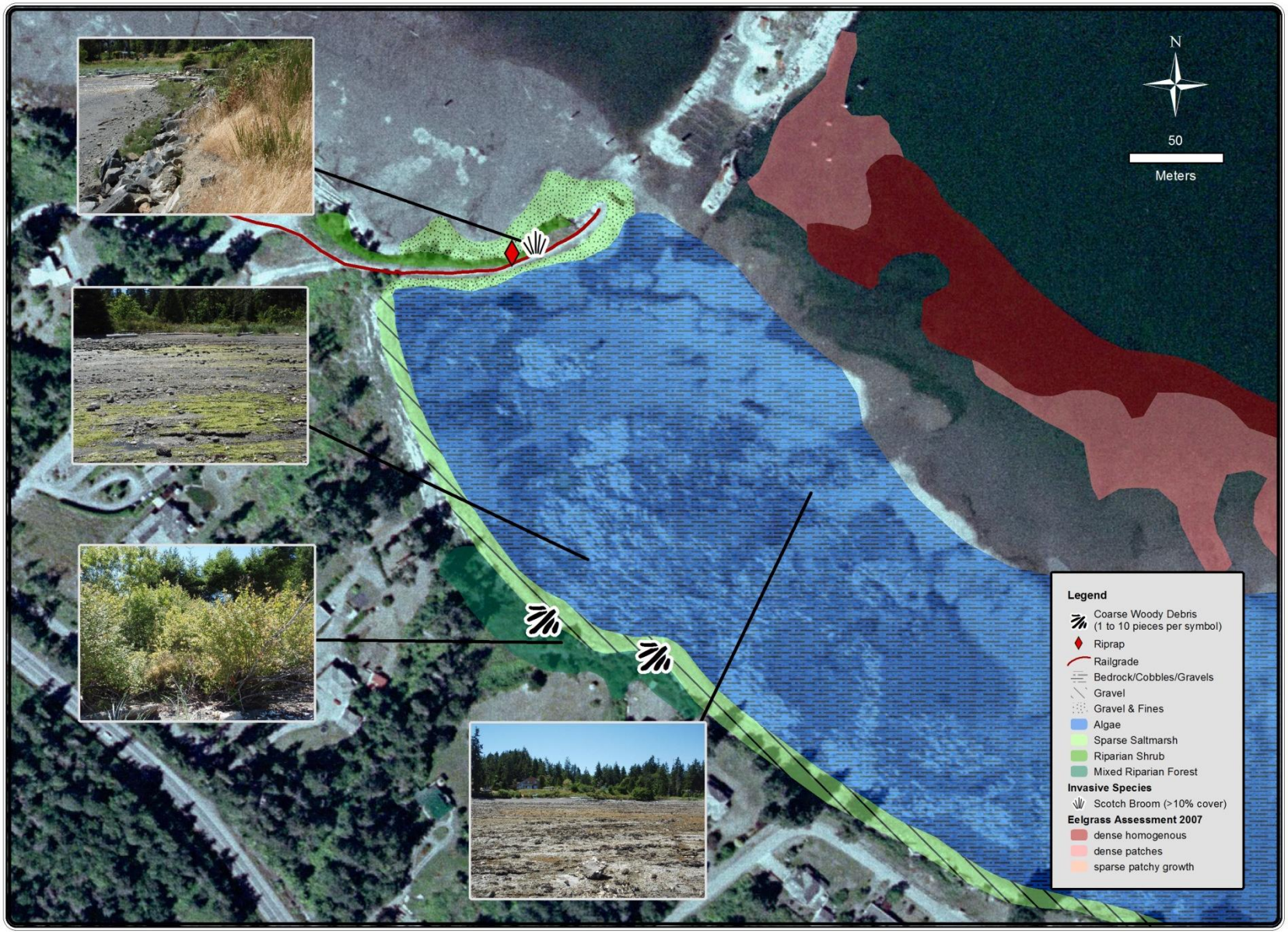
Map 10: Habitat map of the Millard estuary (site 5).



Map 11: Habitat Map of the Royston shoreline north of Royston Wrecks.



Map 12: Habitat map of the Royston shoreline south of Royston Wrecks.



APPENDIX 2: FIGURES

Figure 1: Basic ecosystem based management (EBM) model (adapted from Meffe et al, 2002). The green circle indicates where this study fits into this management system approach.

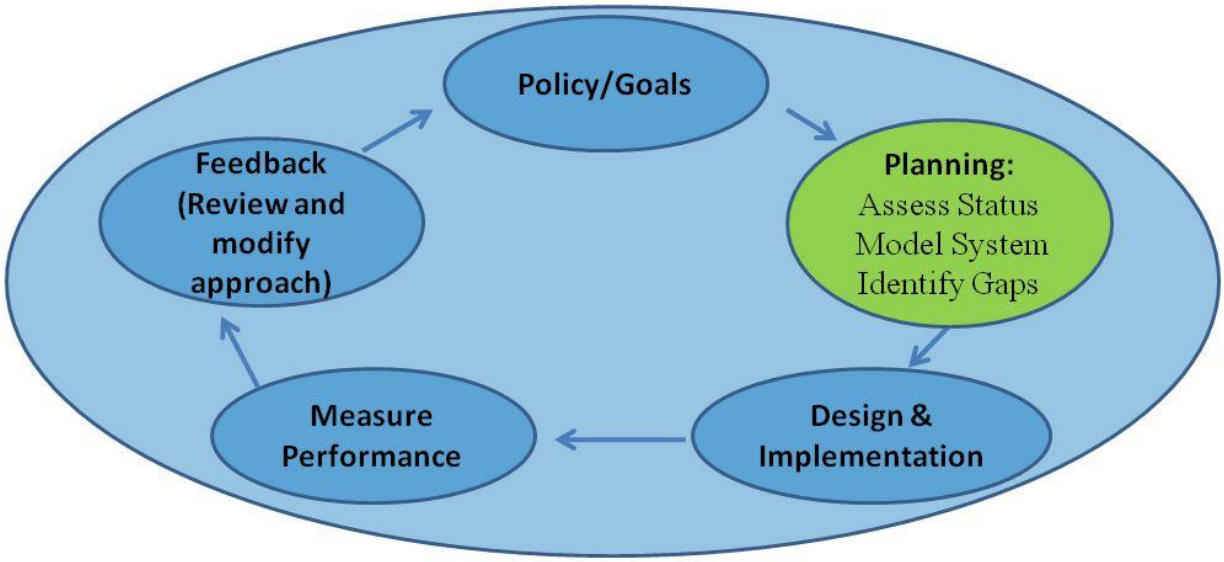


Figure 2: Catch Per Unit Effort by site for chinook (fry and smolt stages) captured over the 2010 sampling season.

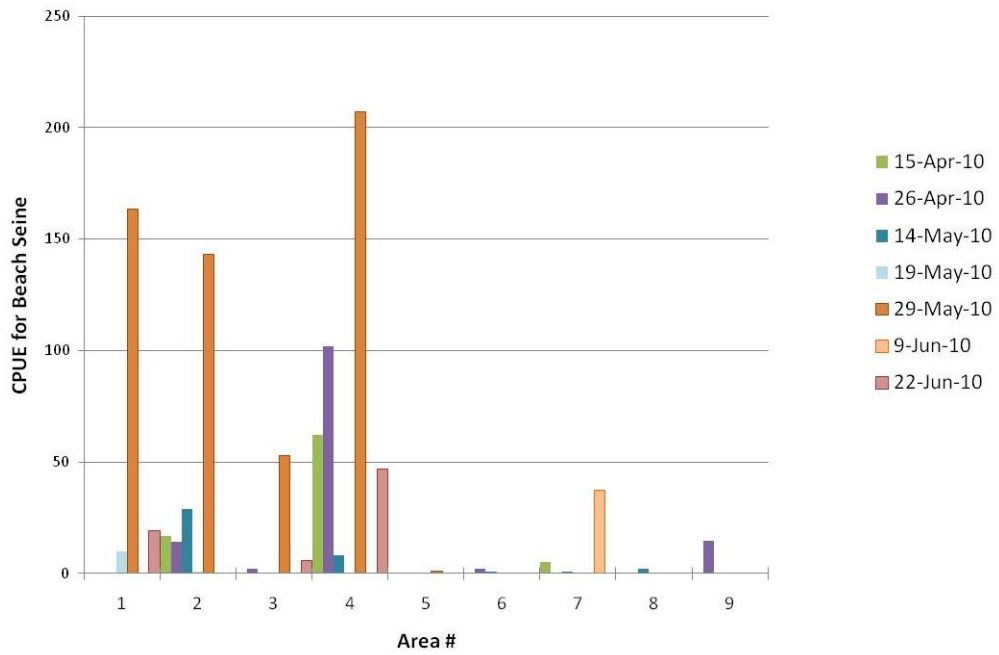


Figure 3: Catch Per Unit Effort by site for coho (fry and smolt stages) captured over the 2010 sampling season.

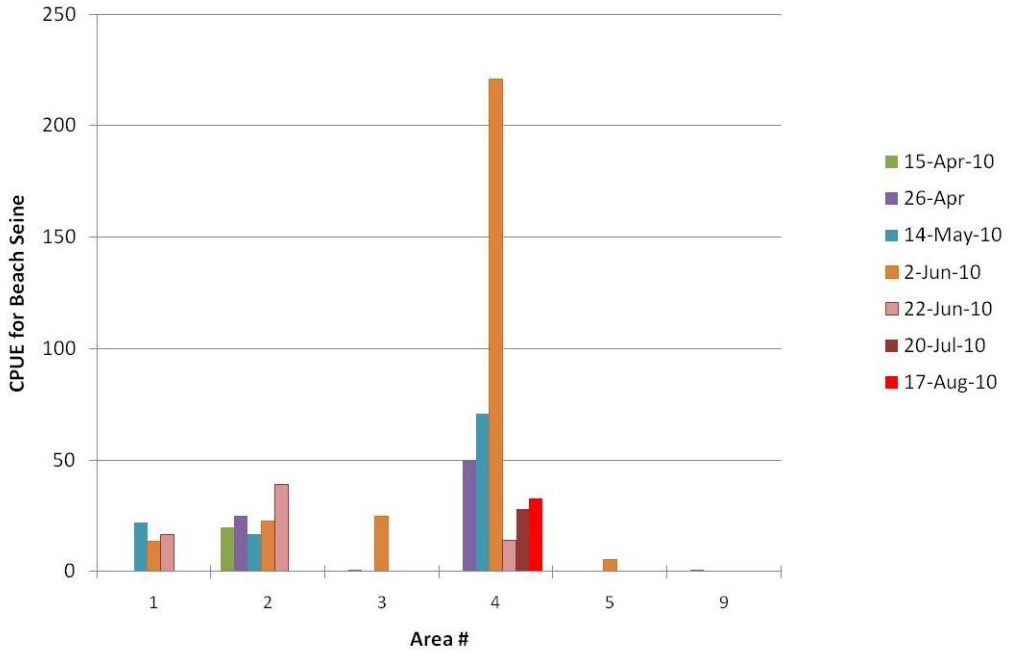


Figure 4: Relative captures of fish throughout March 30 to Aug 19, 2010 sampling period in the estuary.

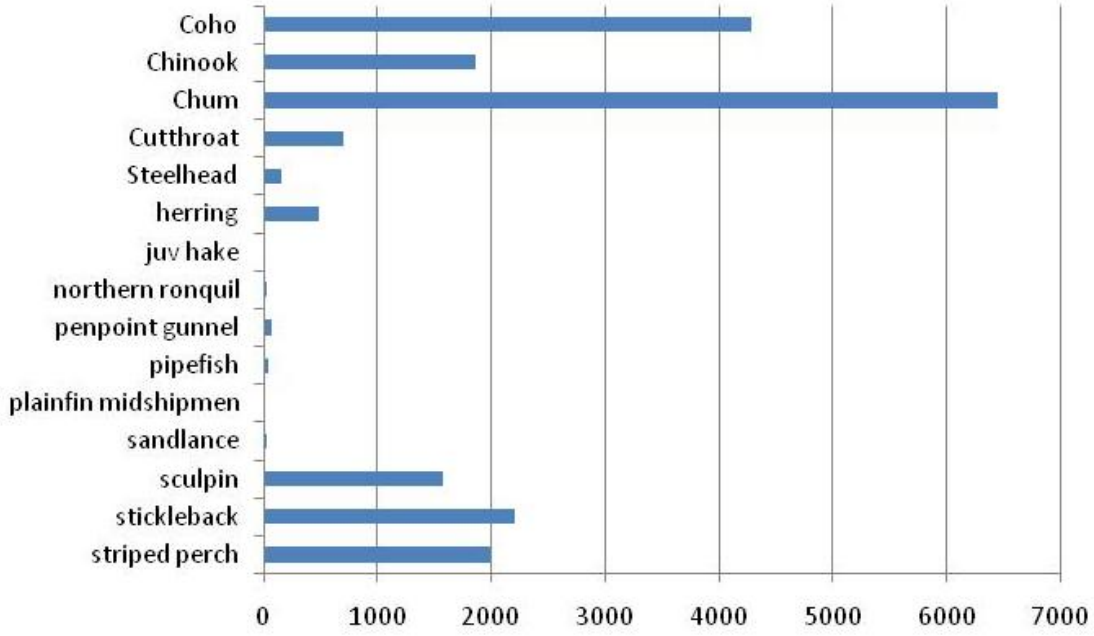


Figure 5: Length frequency chart of chinook captured in the estuary in 2001.

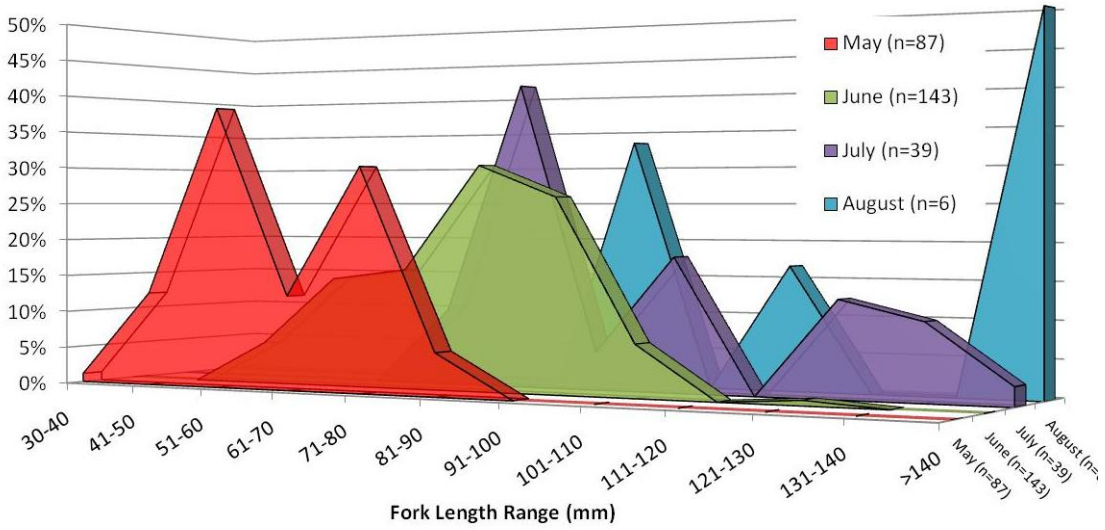


Figure 6: Length frequency chart of chinook captured in the estuary in 2010.

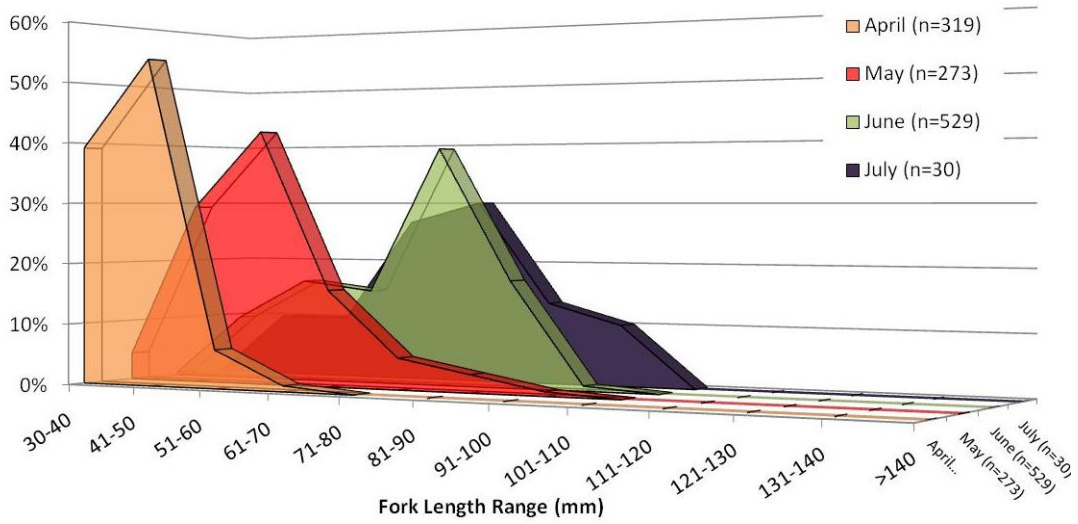


Figure 7: Box Plots comparing median fork lengths of chinook (CN) and coho (CO) cohorts sampled in 2001 and 2010. Size ranges were determined using length frequency analysis. Box plots indicate the max and minimum size ranges for each cohort, the boxes indicate the lower and upper 25th and 75th percentiles within which the majority of fish fork lengths reside, with the intersecting line indicating the median fork length for each cohort. Only samples with sufficient sample size were shown. Cohorts two and three were assumed to represent fry stages, while cohort one represented smolt stages for each species.

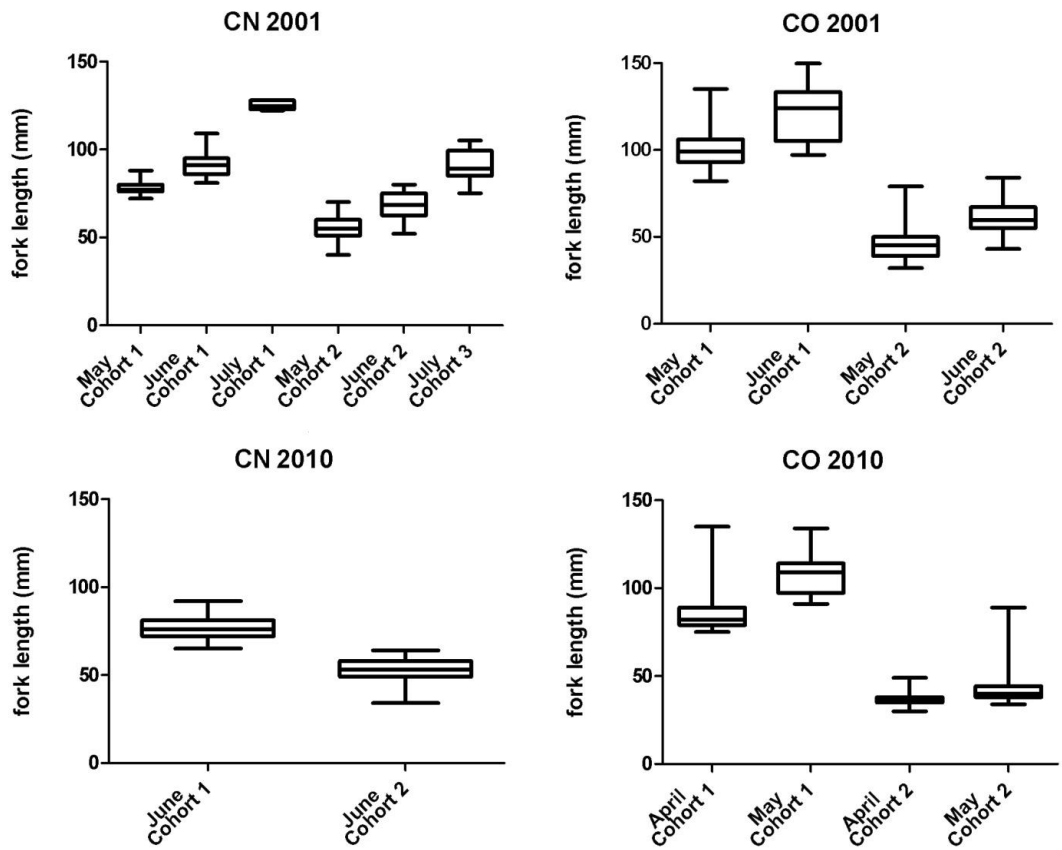


Figure 8: Composition of food items found in benthic habitats sampled in 2010.

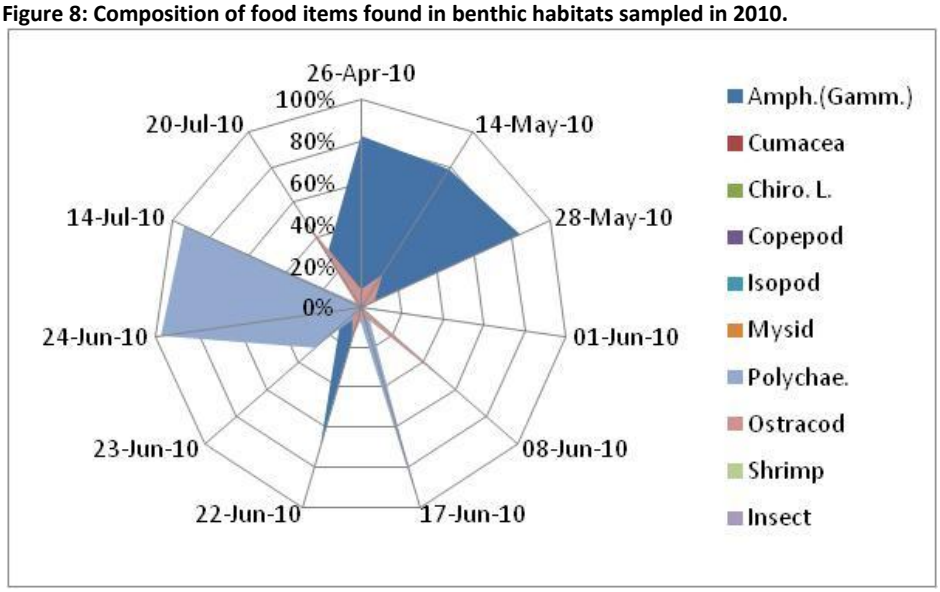


Figure 9: Strauss Index of forage selectivity for chinook fry in the Dyke Slough in 2010. Increasing negative values indicate increasing avoidance of the prey, and increasing positive values indicate increasing prey preference. Zero indicates random foraging without selection.

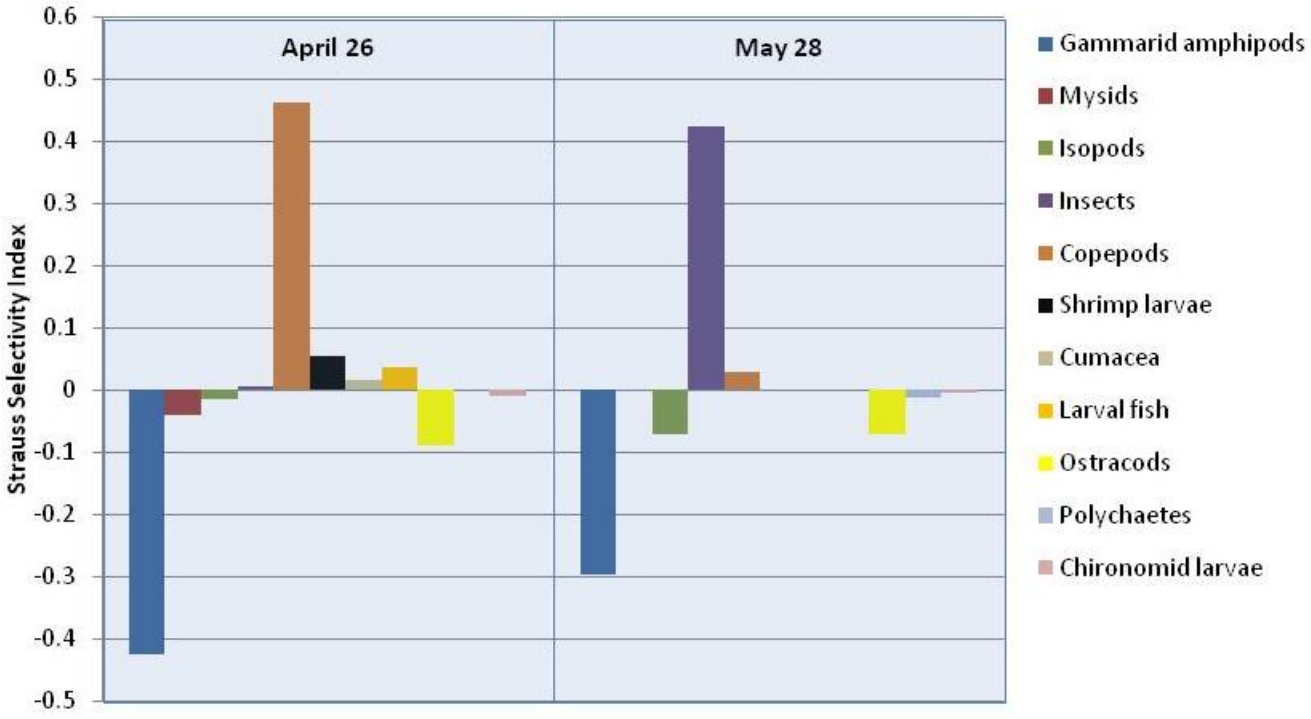


Figure 10: Strauss Index of forage selectivity for coho fry and smolts in the Dyke Slough in 2010. Increasing negative values indicate increasing avoidance of the prey, and increasing positive values indicate increasing prey preference. Zero indicates random foraging without selection.

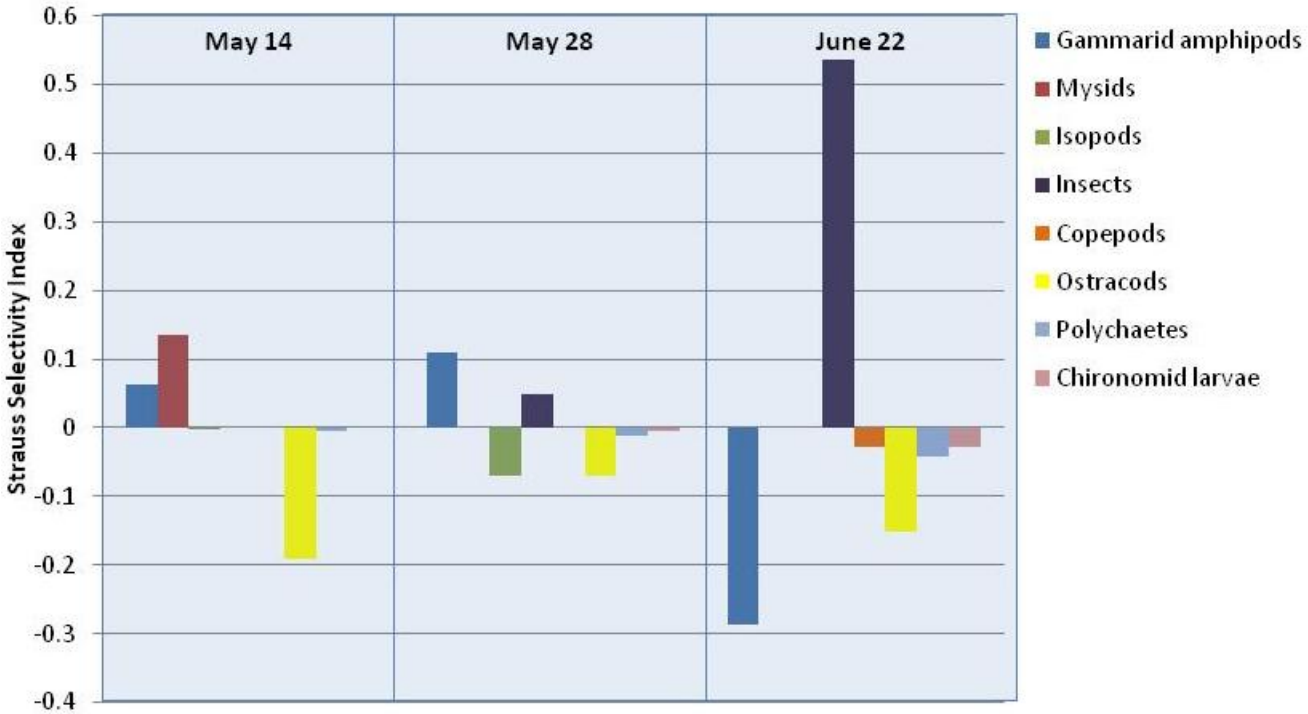


Figure 11: Seasonal temperatures and associated tide heights by Area during 2010 fish sampling. Purple lines indicate optimal forage temperatures for chinook and coho, red bands indicate lethal levels (from Bjornn & Reiser, 1991).

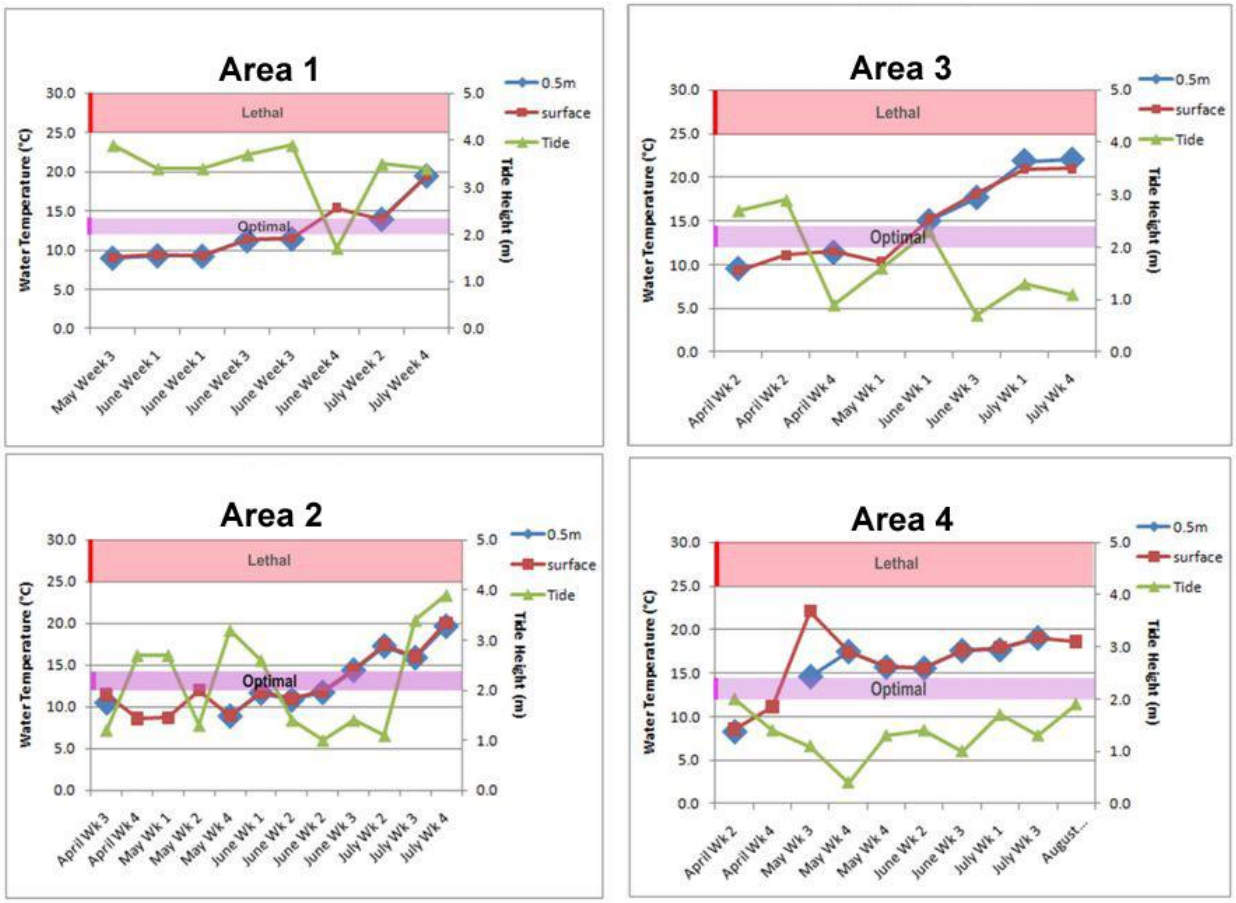


Figure 12: Comparison of 2001 and 2010 surface temperatures in Area 4. Tide ranges when temperatures were collected are provided in Table 4.

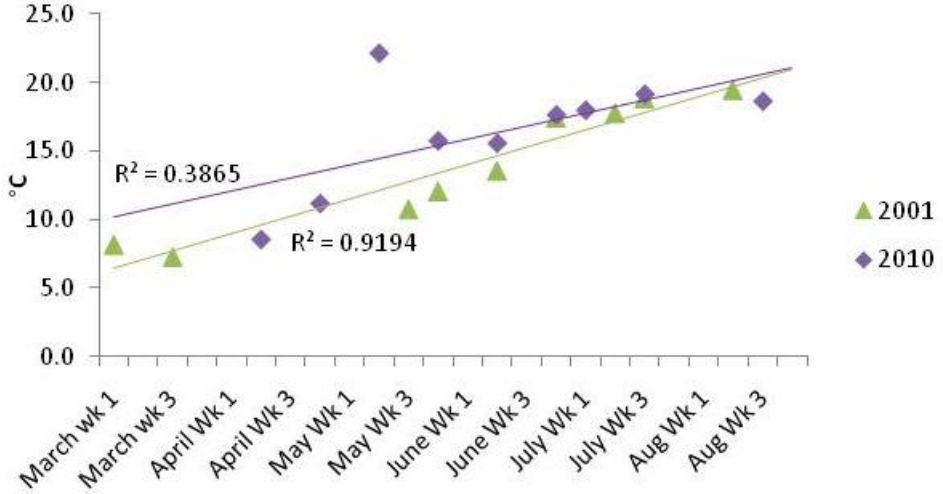


Figure 13: Comparison of 2001 and 2010 surface temperatures in Area 6. Tide ranges when temperatures were collected are provided in Table 4.

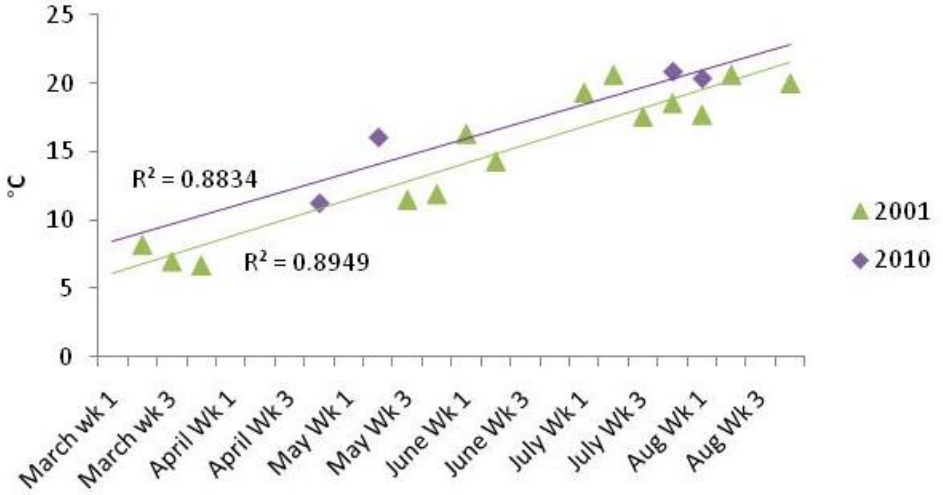


Figure 14: Chinook fry (cohort 2) growth rates for 2010 sampling by Area.

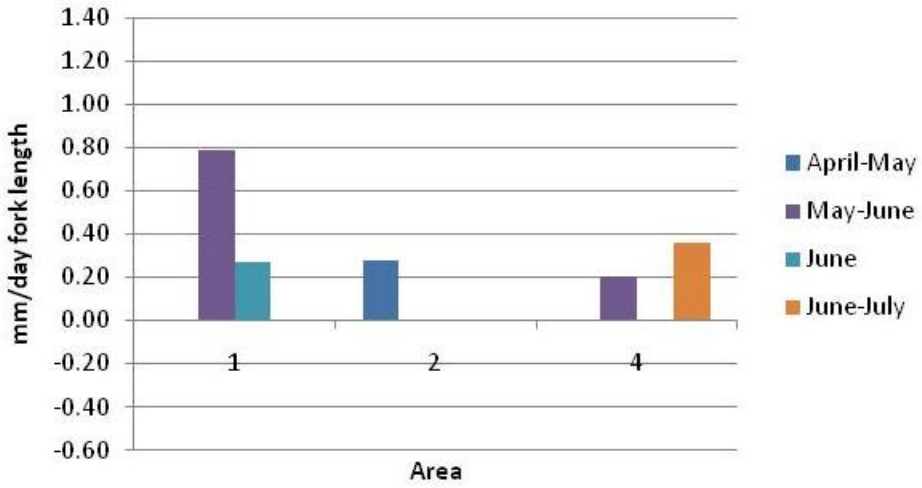


Figure 15: Coho fry (cohort 2) growth rates for 2010 sampling by Area.

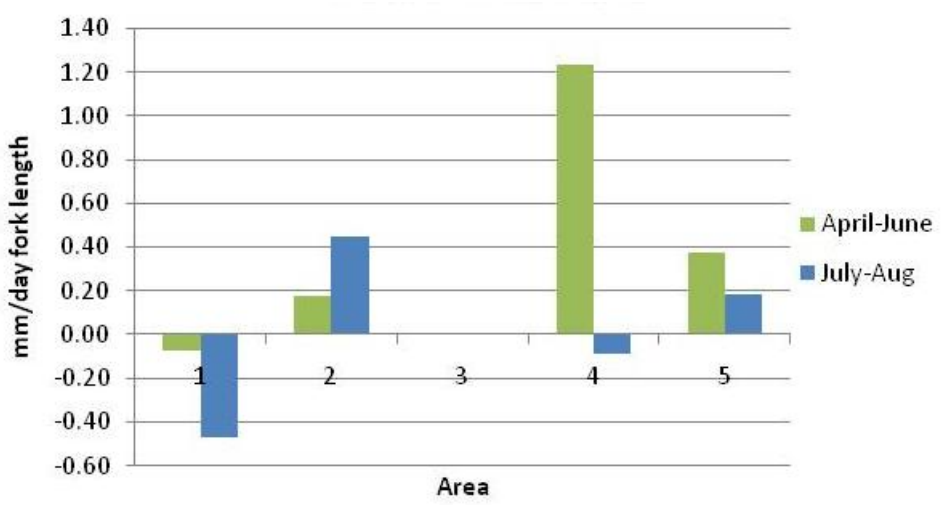


Figure 16: Comparison of between-site condition factors for chinook fry (cohort 2) in 2010 (site numbers = area numbers).

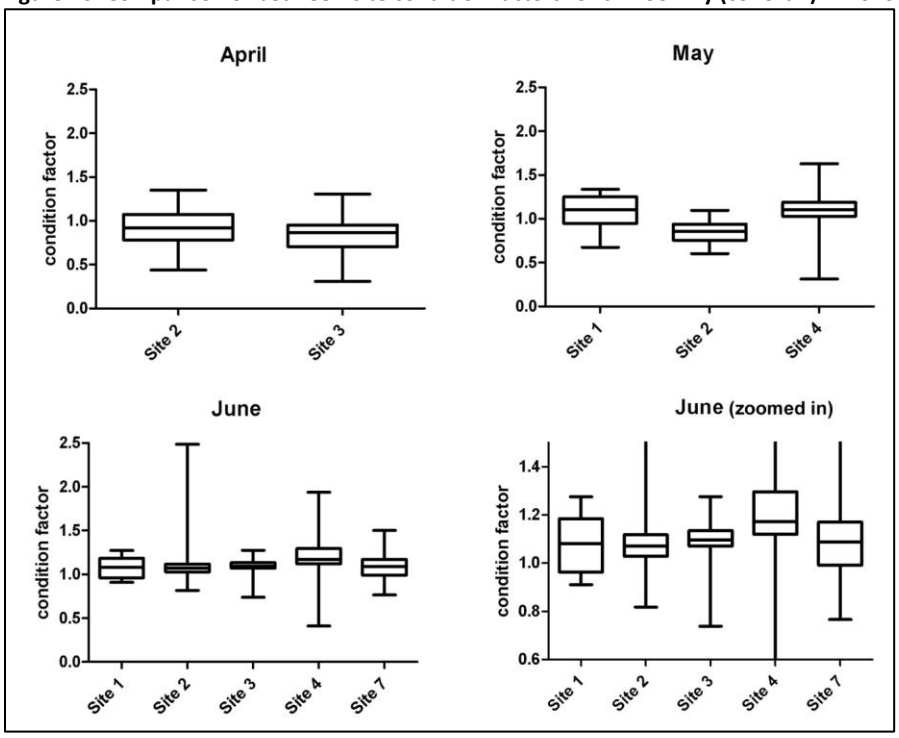


Figure 17: Comparison of between-site condition factors for coho fry (cohort 2) in 2010 (site numbers = area numbers).

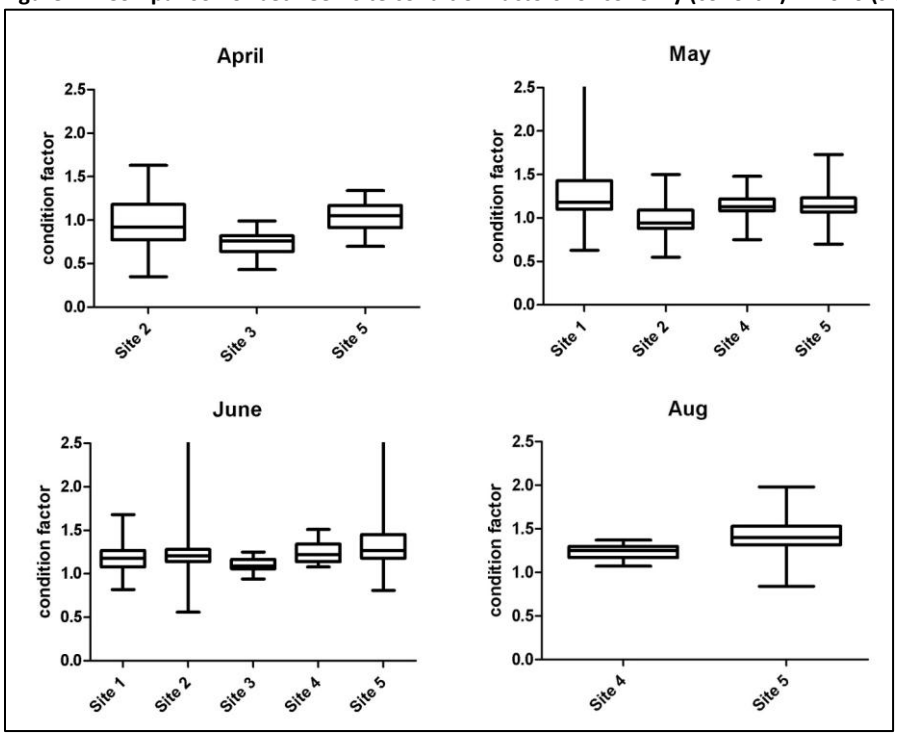


Figure 18: Comparison of mean fork lengths of coho fry captured in lower river (Condensory, Mallard and Glenn Urquhart) and estuary sites in July, 2010.

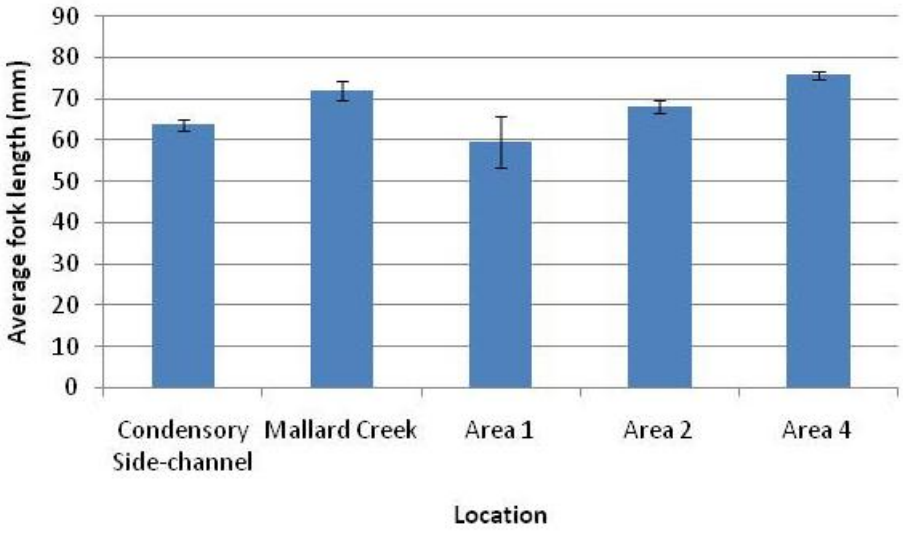


Figure 19: Comparison of mean fork lengths of coho fry captured in lower river (Condensory, Mallard and Glenn Urquhart) and estuary sites in August, 2010.

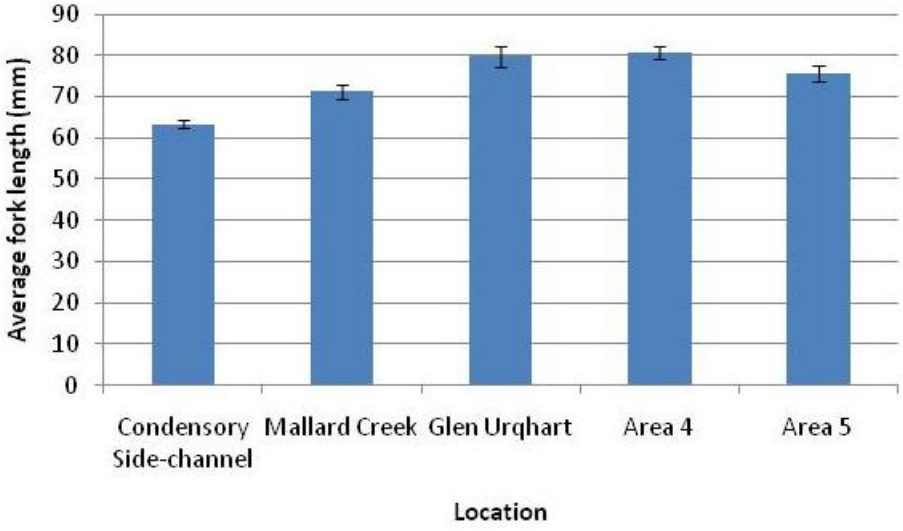


Figure 20: Salmon fry/smolt densities and trout densities estimated for the upper ecotone from snorkel observations in 2010.

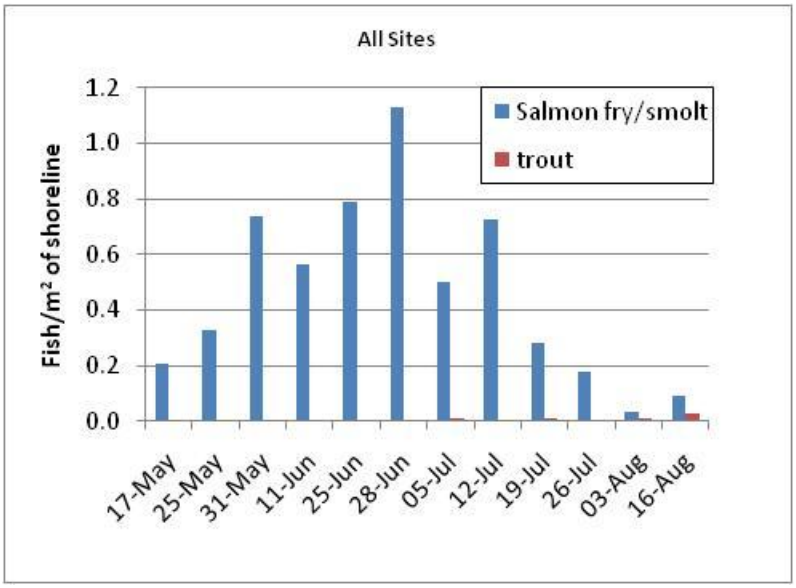


Figure 21: Site comparisons of vegetation found at seven sites mapped in August, 2010.

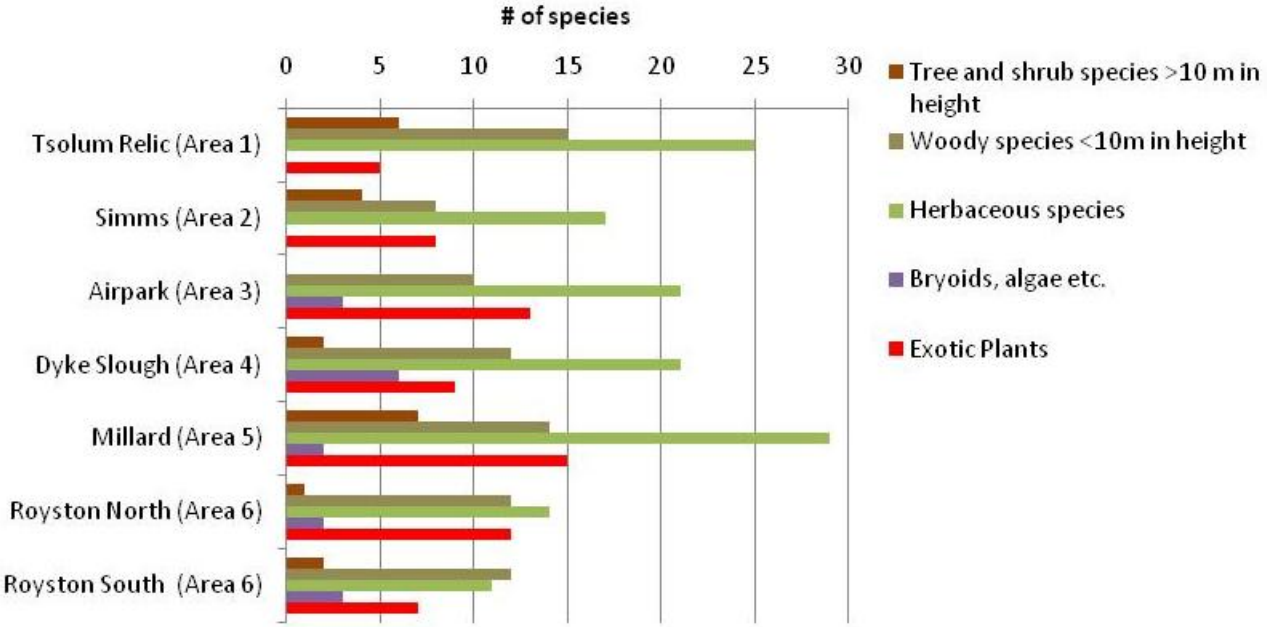


Figure 22: Concept Model for Restoration Options provided in Appendix 6.

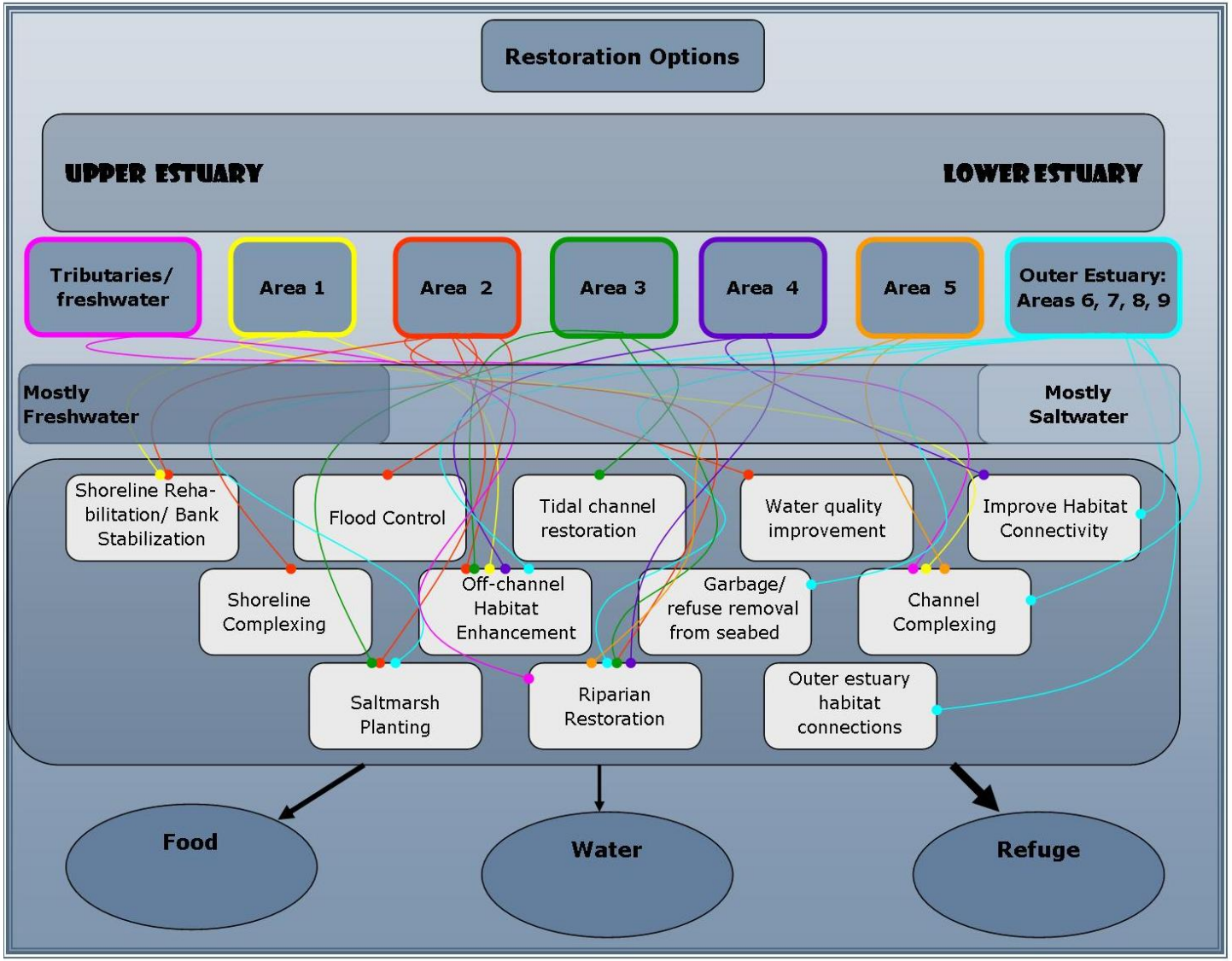
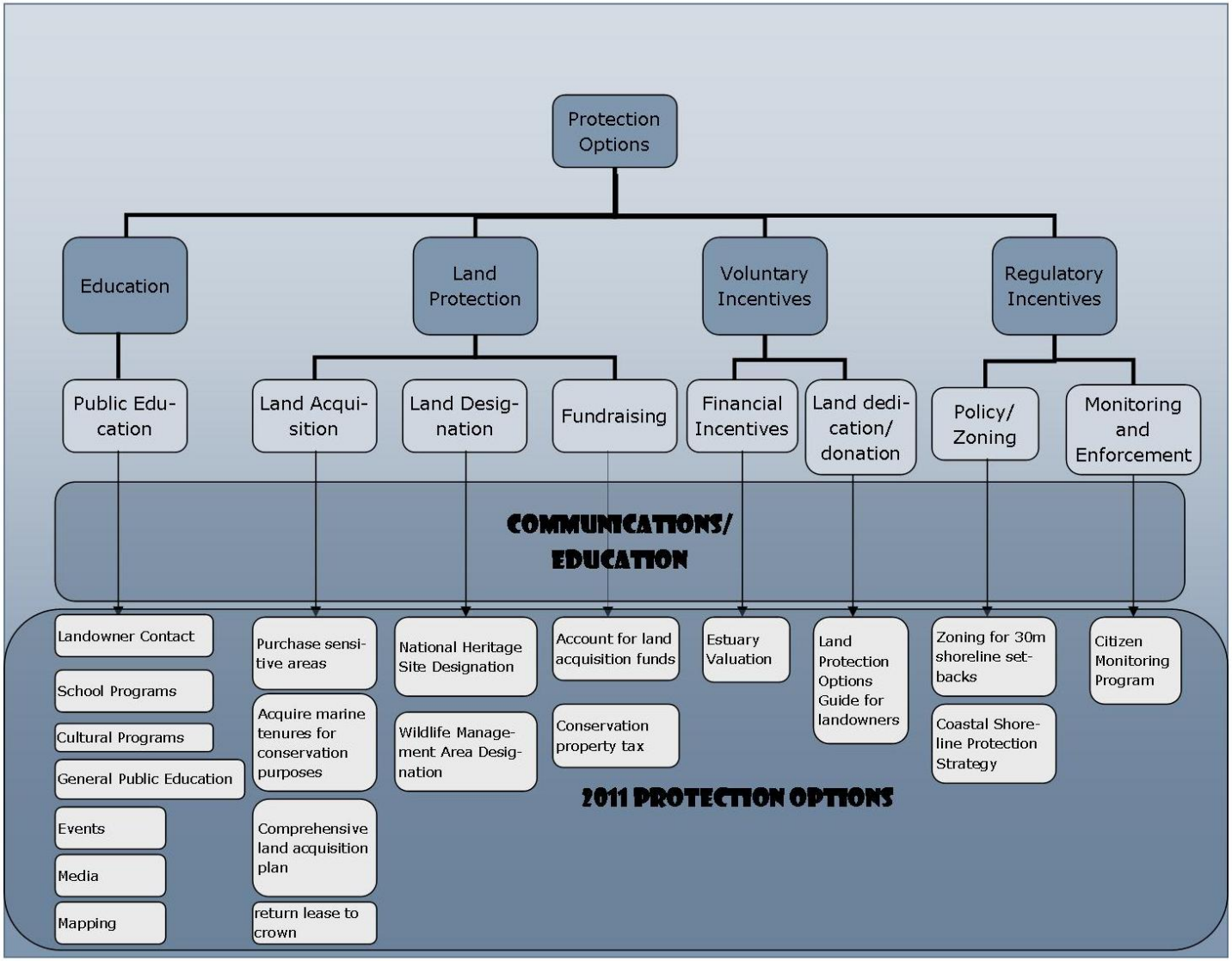


Figure 23: Concept Model for Protection Options provided in Appendix 7.



APPENDIX 3: TABLES

Table 1: Sites sampled and habitat notes for 2010 estuary sampling. Site locations can be found on Maps 2 and 3 of this report.

Area #	2010 site names	Site Description	Habitat Notes	Vegetation Map #
1	A	Tsolum/Puntledge Confluence	Sandy/gravel point bar immediately downstream of confluence. High usage in summer by recreational swimmers.	
1	1a	Tsolum Relic Channel near river mainstem	Shallow sand/mud habitat with riparian shrub and wet meadow. Complex habitat with LWD, alcoves, slow water next to swifter mainstem.	Map 4
2	1b	Lewis Bend	Concrete wall along shoreline, sparse riparian vegetation, cobble/sand substrate with relic pilings, immediately downstream of relic channel outflow. Location of dense fish observations during 2010 snorkel surveys	Map 4
2	1c	Courtenay River - d/s corner of central builders on right bank	near concrete bulkhead for Central Builders. Sparse riparian habitat, some sedges.	
2	2a	Courtenay Slough marina (Simms Park)	Shallow sloping shoreline, mostly mud. Heavy summer algae growth. Riparian vegetation, dock and pilings for marina. Freshwater seepage through gravel/mud substrate throughout length of slough. High captures of coho early in season, some chinook fry.	Map 5
2	2b	Simms Park Finger	Constructed channel with anchored LWD. Sparse sedge habitat along margins, deep slow moving water. Small numbers of coho captured near entrance to the river, mostly stickleback further up.	Map 5
2	2c	Simms pond	Constructed pond with anchored LWD. Sparse sedge habitat along margins. Isolated at low tides. Thick mud, noted infilling since original construction (2001). High numbers of coho captured here in December.	Map 5
2	2d	Simms at mouth of Slough	Moderately sloping thick wet meadow/sedge habitat. LWD clusters nearby. Near influence of main river.	Map 5
2	2e	Courtenay River - various locations between Simms Park and 17th sty. street bridge	High tide sampling along river margin in slow-water alcoves bordered with sedge benches and riparian vegetation.	
3	3	Lagoon	Deep water habitat with brackish sedge habitat along margins. Gravels and fines throughout most of lagoon. Tidal channel outflow with sand and cobbles.	(adjacent to Lagoon- Map 6)
4	4	Dyke Slough pool below tide gates.	Deep water habitat with eelgrass and brackish marsh habitats. Freshwater influence from above tide gates.	Map 7
4	4a	Dyke Slough tidal channel	Tidal channel with substrate of fines/mud bordered by brackish marsh habitat. Fish concentrated near scour pools created from LWD.	Map 7
5	5	Millard estuary. Includes ~240 m of tidal channel	Riffle/pool habitat along ecotone with gravels and fines with infrequent LWD. Large saltmarsh habitat along right bank, dense overhanging riparian along left bank. Deep pool at mouth before mudflats.	Map 8
6	10a	South side of Royston Pier (south-east of Roy Creek)	Gently sloping sandy/mud habitat over dense eelgrass.	Map 9 (north of this site on other side of wrecks- Map 10)
6	10b	Roy Creek estuary channel	fine sands and mud, sparse LWD.	Map 9
6	10c	Immediately south of Royston wrecks	Dense eelgrass at low tide over sandy/cobble habitat.	Map 9
7	7a	Beach with freshwater stream west of the Comox Marina	Sandy/gravel substrate over gentle slope. Small freshwater influence near tidal channel outflow at low tide. Eelgrass beds further offshore, but not directly at sample site.	
8	8	Mouth of river where it drops off south of Comox marina	eelgrass habitat along shallow sandy slope adjacent to mainstem Courtenay river where it enters the subtidal.	
9	9	Brooklynn Crk estuary tidal channel at low tide	Sandy, gently sloping habitat. Small freshwater influence near tidal channel outflow at low tide.	
Lower River	CSC	Condensory side-channel	margins of side-channel and small alcoves with small woody debris, sandy substrate and overhanging riparian vegetation	
Lower River	MC	Mallard Creek	Small Creek (~1-2m channel width) with scour pool habitat, dense riparian vegetation, and some open pond habitat.	
Lower River	GU	Glenn-Urquhart Creek	Wide constructed, low gradient open channel with muddy substrate. Little riparian vegetation: mostly grasses and Himalayan blackberry. Small section of creek with higher gradient downstream of Williams Rd., with gravel/cobble habitat and overhanging riparian vegetation.	

Table 2: Tag retention test at Puntledge Hatchery

Date Tagged	April-01-10	
Time	12:30	
Date recovered	April-09-10	
Time	12:00	
Species:	CN	
Colour	**# Tagged**	**# Recovered**
Yellow	39	47
Red	47	53
Not tagged	50	39
morts	1	0
Totals	137	139

Table 3: Ecological assessment criteria and habitat attribute association used to characterize the habitat requirements of juvenile coho and chinook salmon in the Courtenay River estuary.

Survival success criteria	Measures	Habitat Association
Fish presence	CPUE (beach seine)	Opportunity
Life history composition	Cohort (size class) analysis	Opportunity
Proximately to migration routes	Distance from FW	Opportunity
Diet	Stomach content analysis	Capacity
	Diet overlap with invertebrate assemblage	Capacity
Water quality	optimal temperatures	Capacity
Growth	Growth rate	Realized Function
	Condition factor	Realized Function
Residence time	Mark/recaptures	Realized Function
Density	Snorkel counts	Realized Function

Table 4: Summary of tide ranges that occurred during sampling events when temperatures were collected to compare 2001 and 2010 seasonal trends (refer to Figure 12 and 13).

	Site 4		Site 6	
	2001	2010	2001	2010
Avg (m)	2.7	1.5	3.0	1.4
Max (m)	3.2	2.0	4.4	2.1
Min (m)	1.3	1.0	0.8	0.5
Std Dev (m)	0.7	0.3	1.1	0.7
N	10	9	19	4

Table 5: Summary of locations and dates where habitat mapping occurred. Details of exact locations provided in Table 1 , Map 3 and Map 4.

Location	Date Sampled
Tsolum Relic Channel	July 27th, 2010
Simms Park	July 27th, 2010
Courtenay Airpark	July 19 & 21, 2010
Dyke Slough below tide gates	July 23rd, 2010
Millard Creek estuary	July 21st, 2010
Royston Wrecks: north	July 23rd, 2010
Royston Wrecks: south	July 23rd, 2010

Table 6: Comparison of central tendencies of fork length (mm) for chinook salmon cohorts captured in Courtenay River estuary in 2001, compared to marked hatchery captures.

	June Cohort 2	June Cohort 1	June Hatchery CN
Number of values	52	91	17
Minimum	52	81	70
25% Percentile	62.5	86	98
Median	68.5	91	89
75% Percentile	75	95	83
Maximum	80	109	117
Mean	68.69	91.49	90.76
Std. Deviation	7.848	6.578	12.88
Lower 95% CI of mean	66.51	90.12	84.64
Upper 95% CI of mean	70.88	92.86	96.89

Table 7: Statistical summary of cohort fork length analysis for chinook (CN) and coho (CO) in 2001 indicating significant (P<0.05) differences in size classes.

						Mann-Whitney		Unpaired t-test	
Species/Month	Cohort A vs B	Test	P value	Are medians signif. different? (P < 0.05)	Are means signif. different? (P < 0.05)	Sum of ranks cohort A	Sum of ranks cohort B	t-ratio	DF
CN May	**1** vs **2**	Mann-Whitney	< 0.0001	Yes	-	2232	1596	-	-
CN June	**1** vs **2**	unpaired t-test	< 0.0001	-	yes	-	-	18.57	141
CN July	**1** vs **3**	Mann-Whitney	< 0.0001	Yes	-	189	406	-	-
CO May	**1** vs **2**	Mann-Whitney	< 0.0001	Yes	-	18250	3486	-	-
CO June	**1** vs **2**	Mann-Whitney	< 0.0001	Yes	-	635	1711	-	-

Table 8: Statistical summary of cohort fork length analysis for chinook (CN) and coho (CO) in 2010 indicating significant (P<0.05) differences in size classes.

						Mann-Whitney		Unpaired t-test	
Species/Month	Cohort A vs B	Test	P value	Are medians signif. different? (P < 0.05)	Are means signif. different? (P < 0.05)	Sum of ranks cohort A	Sum of ranks cohort B	t-ratio	DF
CN June	**1** vs **2**	unpaired t-test	< 0.0001	Yes	yes	-	-	18.57	141
CO April	**1** vs **2**	Mann-Whitney	< 0.0001	Yes	-	47945	5356	-	-
CO May	**1** vs **2**	Mann-Whitney	< 0.0001	Yes	-	5226	2775	-	-

Table 9: Description of Areas and associated sampling sites described in this report and depicted in Map 2.

Area #	Description	2010 Sampling Sites
1	Upper Ecotone	Tsolum Relic Channel, Tsolum/Puntledge Confluence
2	Mid Ecotone	Simms Park: slough and mouth, pond & finger, Main River channel, various locations
3	Lower Ecotone	Lagoon
4	Inner Estuary: North Shore (main river channel)	Dyke Slough channel and pool below gates
5	Inner Estuary: South Shore	~240 m of tidal channel and pool at mouth
6	Outer Estuary: South Shore	mouth of freshwater tidal channel, Eelgrass beds between Wrecks and Roy Creek tidal channel
7	Outer Estuary North Shore	mouth of freshwater tidal channel
8	Lower Estuary: Intertidal/subtidal Transition	Main river channel at bottom of mudflats
9	Goose Spit: Inside	mouth of freshwater tidal channel

Table 10: Dominant, sub-dominant, and other prominent food items found in the guts of fish sampled in the Courtenay River estuary during 2010 (CN=chinook, CM=chum, CO=coho, RT=rainbow trout, CT=cutthroat trout).

Place	Month	Species	Dominant food item	Sub dominant food item	Other
Dyke Slough	April	CN fry- April	Gammarid amphipods	copepods	shrimp, cumacea, larval fish
Dyke Slough	April	CM- April	copepods	Gammarid amphipods	euphasids, cumacea
Dyke Slough	May	CO smolt- May	Gammarid amphipods	Mysids	isopod
Dyke Slough	May	RT-May	Gammarid amphipods	Insects	mysids
Dyke Slough	May	CT-May	Isopods		Gammarid amphipods
Dyke Slough	May	CN-May-smolt	Gammarid amphipods		
Dyke Slough	May	CN-May-fry	Insects		Gammarid amphipods
Dyke Slough	May	CO- may cohort 2	Insects	Gammarid amphipods	
Dyke Slough	June	Co June	Insects	Gammarid amphipods	
Tsolum Relic	June	CN fry June	Insects		fish eggs
Simm's Slough	July	Co July	Insects		

Table 11: Estimated growth rates of chinook fry (cohort 2) during 2010 sampling period.

Area 1	Date:	19-May	02-Jun	17-Jun	
	Growth Rate (mm/day)	0.79	0.27		
Area 2	Date:	15-Apr	24-Apr	12-May	
	Growth Rate (mm/day)	0.00	0.28		
Area 4	Date:	14-May	27-May	22-Jun	20-Jul
	Growth Rate (mm/day)	-0.31	0.31	0.36	

Table 12: Estimated growth rates of coho fry (cohort 2) during 2010 sampling period.

Area 1	Date:	19-May	02-Jun	16-Jun	13-Jul	27-Jul	
	Growth Rate (mm/day)	-0.79	0.64	0.63	-1.57		
Area 2	Date:	15-Apr	24-Apr	05-May	12-May	03-Jun	24-Jun	14-Jul
	Growth Rate (mm/day)	-0.11	0.09	0.29	0.23	0.38	0.45	
Area 3	Date:	13-Apr	04-Jun					
	Growth Rate (mm/day)	0.00						
Area 4	Date:	27-May	22-Jun	06-Jul	20-Jul	17-Aug		
	Growth Rate (mm/day)	0.35	1.43	-0.50	0.32			
Area 5	Date:	23-Apr	06-May	15-Jun	19-Aug			
	Growth Rate (mm/day)	0.23	0.53	0.18				

Table 13: Statistical summary of chinook (CN) (cohort 2) condition factors in 2010.

Species/Month	Sites Analyzed	Test	P value	Are medians signif. different? (P < 0.05)	Are means signif. different? (P < 0.05)	Number of groups	Kruskal-Wallis Statistic	Unpaired t-test t-ratio	Unpaired t-test DF
CN April	2, 3	Unpaired t test	0.0425	-	yes	2		1.747	73
CN May	1, 2, 4	Kruskal-Wallis	< 0.0001	Yes	-	3	56.39	-	-
CN June	1, 2, 3, 4, 7	Kruskal-Wallis	< 0.0001	Yes	-	5	43.42	-	-

Table 14: Statistical summary of coho (CO) (cohort 2) condition factors in 2010.

Species/Month	Sites Analyzed	Test	P value	Are medians signif. different? (P < 0.05)	Are means signif. different? (P < 0.05)	Number of groups	Kruskal-Wallis Statistic	One-Way ANOVA F-ratio	One-Way ANOVA R square	Mann-Whitney Sum of ranks (one-tailed)
CO April	2, 3, 5	One-way analysis of variance	0.0008	-	Yes	3	-	7.61	0.1344	-
CO May	1, 2, 4, 5	Kruskal-Wallis	< 0.0001	Yes	-	4	33.62	-	-	-
CO June	1, 2, 3, 4, 5	Kruskal-Wallis	< 0.0001	Yes	-	5	56.46	-	-	-
CO Aug	4, 5	Mann Whitney test	< 0.0001	Yes	-	2	-	-	-	503 , 3413

Table 15: Estimated residence times in 2010 for chinook (CN) and coho (CO) fry recaptures in 2010.

Species	Source	Destination	Recovery Date	Potential tagging dates	Residence time range (days)
CO	Area 2 (Courtenay Slough)	Area 2 (Courtenay Slough)	12-May	15-Apr, 24-Apr, 5-May	8-28
CO	Area 2 (Courtenay Slough)	Area 2 (Courtenay Slough)	12-May	15-Apr, 24-Apr, 5-May	8-28
CO	Area 2 (Courtenay Slough)	Area 2 (Courtenay Slough)	03-Jun	15-Apr, 24-Apr, 5-May, 12-May	23-50
CO	Area 2 (Courtenay Slough)	Area 2 (Courtenay Slough)	03-Jun	15-Apr, 24-Apr, 5-May, 12-May	23-50
CN	Area 2 (Courtenay Slough)	Area 4 (Dyke Slough)	22-Jun	5-May, 12-May, 3-June	20-82
CO	Area 3 (Airpark Lagoon)	Area 4 (Dyke Slough)	07-Oct	13-Apr, 29-Apr, 4-June	125-177
CO	Area 4 (Dyke Slough)	Area 4 (Dyke Slough)	06-Jul	27-May	41
CO	Area 5 (Millard)	Area 5 (Millard)	06-May	23-Apr	14
CO	Area 5 (Millard)	Area 5 (Millard)	19-Aug	23-Apr, 6-May, 29-May, 15-June	66-118

Table 16: General observations from the snorkel surveys conducted during the in 2010. "T" refers to the transect snorkel sites, u/s and d/s refer to upstream and downstream, respectively.

Date	Location	Observation
25-May	between powerlines d/s to 17th st bridge	200 juvenile salmon observed
31-May	~50m u/s snorkel T5	40CNS observed around some LWD
31-May	immediately u/s 17th st bridge	70 CNS observed along RB
11-Jun	between T1 and T2	observations of ~1500+ fry, large CT (12"), 1 adult CN
25-Jun	between T2 and T3	~300+ fish seen in riprap at Lewis Park side of river
28-Jun	on pUN upstream Puntledge/Tsolum confluence	1 adult CN with contusions
28-Jun	between T2 and T3	~500 observations
05-Jul	between T2 and T3	~1500 juvenile salmon observed
19-Jul	T1	1 jack (sp UK) observed
03-Aug	T6	1 adult pink observed
16-Aug	T1	Many tubers/swimmers near site 1
16-Aug	T1	1 pink adult observed
16-Aug	T5	300 perch observed

Table 17: Tsolum Relic Channel plant list.

Tree and shrub species >10 m in height	Woody species <10m	Herbaceous species	Bryoids, algae etc.	Exotic Plants
bigleaf maple	bigleaf maple	American speedwell		European mountain-ash
black cottonwood	black hawthorn	American water-plantain		common St. John's-wort
Cherry	coastal red elderberry	bur-reed		Himalayan blackberry
Garry oak	common snowberry	common silverweed		orchard-grass
Pacific willow	hardhack	cow-parsnip		reed canarygrass
red alder	Pacific ninebark	dock		
	Pacific willow	false bugbane		
	red alder	false lily-of-the-valley		
	red-osier dogwood	mannagrass		
	salmonberry	Pacific bleeding heart		
	Scouler's willow	purple-leaved willowherb		
	Sitka willow	reedgrass		
	thimbleberry	rushes		
	western flowering dogwood	sedges		
	willows	Sitka sedge		
		skunk cabbage		
		slough sedge		
		small-flowered bulrush		
		small-flowered forget-me-not		
		spike-rush		
		springbank clover		
		sweet-scented bedstraw		
		water lobelia		
		water-starwort		
		yellow monkey-flower		

Table 18: Simms Park plant list.

Tree and shrub species >10 m in height	Woody species <10m in height	Herbaceous species	Bryoids, algae etc.	Exotic Plants
Acer macrophyllum	Alnus rubra	Alisma triviale		Fallopia x bohemica
Alnus rubra	Physocarpus capitatus	Athyrium filix-femina		Rubus armeniacus
Populus balsamifera ssp. trichoca	Rosa nutkana	Callitriche sp.		Convolvulus arvensis
Prunus sp.	Rubus parviflorus	Carex spp.		Geranium robertianum
	Rubus spectabilis	Epilobium angustifolium		Hypochaeris radicata
	Sambucus racemosa var. arbore	Equisetum arvense		Mycelis muralis
	Spiraea douglasii ssp. douglasii	Glyceria sp.		Phalaris arundinacea
	Taxus brevifolia	Lysichiton americanus		
		Mimulus guttatus		
		other grasses		
		Polystichum munitum		
		Potentilla anserina		
		Rumex sp.		
		Schoenoplectus tabernaemontani		
		Scirpus microcarpus		
		Stachys chamissonis		

Table 19: Courtenay Airpark plant list.

Tree and shrub species >10 m in height	Woody species <10m	Herbaceous species	Bryoids, algae etc.	Exotic Plants
Populus balsamifera ssp. trichoca	Acer macrophyllum	Ambrosia chamissonis	Enteromorpha sp.	Rubus armeniacus
	Alnus rubra	Carex lyngbyei	Ulva sp.	Cytisus scoparius
	Crataegus douglasii	Deschampsia cespitosa	Fucus sp.	Rubus armeniacus
	Physocarpus capitatus	Distichlis spicata		Phalaris arundinacea
	Populus balsamifera ssp. trichoca	Eleocharis sp.		Atriplex patula
	Rosa nutkana	Glaux maritima		Cirsium vulgare
	Rosa sp.	Grindelia integrifolia		Convolvulus arvensis
	Rubus spectabilis	Juncus breweri		Dactylis glomerata
	Sorbus sitchensis	Juncus sp.		Daucus carota
	Symphoricarpos albus	Lathyrus japonicus		Lotus corniculatus
		Leymus mollis		Melilotus alba
		Mimulus moschatus		Phalaris arundinacea
		Plantago maritima		Symphytum officinale
		Potentilla anserina		
		Rumex sp.		
		Schoenoplectus pungens		
		Schoenoplectus tabernaemontani		
		Sidalcea hendersonii		
		Trifolium spp.		
		Trifolium wormskioldii		
		Triglochin maritima		

Table 20: Dyke Slough Plant list.

Tree and shrub species >10 m in height	Woody species <10m	Herbaceous species	Bryoids, algae etc.	Exotic Plants
Alnus rubra	Crataegus douglasii	Carex lyngbyei	Enteromorpha sp.	Rubus armeniacus
Populus balsamifera ssp. trichoca	Alnus rubra	Deschampsia cespitosa	Brown algae	Rubus laciniatus
	Crataegus douglasii	Eleocharis sp.	Eleocharis sp.	Dactylis glomerata
	Lonicera involucrata	Equisetum arvense	Enteromorpha sp.	Cirsium arvense
	Malus fusca	Glaux maritima	Green algae	Convolvulus arvensis
	Physocarpus capitatus	Grindelia integrifolia	Ulva sp.	Lythrum salicaria
	Prunus emarginata	Hordeum brachyantherum		Melilotus alba
	Ribes divaricatum	Juncus spp.		Phalaris arundinacea
	Rubus spectabilis	Leymus mollis		Rubus armeniacus
	Rubus ursinus	Phleum sp.		Sonchus asper
	Salix lucida ssp. lasiandra	Plantago maritima		
	Symphoricarpos albus	Potentilla anserina		
		Rumex sp.		
		Ruppia maritima		
		Schoenoplectus pungens		
		Sidalcea hendersonii		
		Trifolium wormskioldii		
		Triglochin maritima		
		Typha latifolia		
		Zostera marina		

Table 21: Millard Creek estuary plant list.

Tree and shrub species >10 m in height	Woody species <10m	Herbaceous species	Bryoids, algae etc.	Exotic Plants
Alnus rubra	Abies grandis	Bolboschoenus maritimus	Enteromorpha sp.	Rubus armeniacus
Abies grandis	Acer glabrum	Calamagrostis sp.	Ulva sp.	Hedera helix
Acer macrophyllum	Cornus stolonifera	Carex lyngbyei		Rubus armeniacus
Alnus rubra	Crataegus douglasii	Deschampsia cespitosa		Convolvulus arvensis
Picea sitchensis	Ilex aquifolium	Distichlis spicata		Agropyron sp.
Prunus sp.	Mahonia nervosa	Eleocharis sp.		Atriplex patula
Pseudotsuga menziesii var. menzi	Malus fusca	Epilobium angustifolium		Convolvulus arvensis
	Picea sitchensis	Galium triflorum		Cotula coronopifolia
	Prunus sp.	Glaux maritima		Geranium robertianum
	Rhamnus purshiana	Grass species		Lotus corniculatus
	Rosa nutkana	Grindelia integrifolia		Phalaris arundinacea
	Rubus spectabilis	Hordeum brachyantherum		Plantago major
	Rubus ursinus	Juncus breweri		Sonchus asper
	Symphoricarpos albus	Juncus spp.		Spartina patens
		Lathyrus japonicus		Spergularia salina
		Leymus mollis		
		Myosotis laxa		
		other grasses		
		Plantago maritima		
		Poa sp.		
		Polystichum munitum		
		Potentilla anserina		
		Rumex sp.		
		Schoenoplectus pungens		
		Schoenoplectus tabernaemontani		
		Sidalcea hendersonii		
		Symphyotrichum subspicatum		
		Trifolium wormskioldii		
		Triglochin maritima		

Table 22: Royston Wrecks: north plant list.

Tree and shrub species >10 m in height	Woody species <10m in height	Herbaceous species	Bryoids, algae etc.	Invasive Plants
Pseudotsuga menziesii var. menzi	Acer glabrum	Achillea millefolium	Fucus sp.	Atriplex patula
	Acer macrophyllum	Carex lyngbyei	Brown algae	Cirsium vulgare
	Crataegus douglasii	Distichlis spicata		Cytisus scoparius
	Mahonia nervosa	Eleocharis sp.		Dactylis glomerata
	Malus fusca	Glaux maritima		Daucus carota
	Physocarpus capitatus	Grindelia integrifolia		Hedera helix
	Pseudotsuga menziesii var. menzi	Juncus spp.		Hypericum perforatum
	Rhamnus purshiana	Leymus mollis		Leucanthemum vulgare
	Rosa nutkana	other grasses		Malus pumila
	Rubus parviflorus	Plantago maritima		Phalaris arundinacea
	Rubus spectabilis	Potentilla anserina		Rubus armeniacus
	Sambucus racemosa var. arboree	Salicornia virginica		Spergularia salina
		Triglochin maritima		
		Typha latifolia		

Table 23: Royston Wrecks: south plant list.

Tree and shrub species >10 m in height	Woody species <10m in height	Herbaceous species	Bryoids, algae etc.	Exotic Plants
Pseudotsuga menziesii var. menzi	Acer macrophyllum	Ambrosia chamissonis	Ulva sp.	Atriplex patula
Abies grandis	Amelanchier alnifolia	Epilobium angustifolium	Brown Algae	Cirsium arvense
	Amelanchier alnifolia	Glaux maritima	Fucus sp.	Convolvulus arvensis
	Holodiscus discolor	Grindelia integrifolia		Cytisus scoparius
	Mahonia nervosa	Leymus mollis		Hypochaeris radicata
	Pseudotsuga menziesii var. menzi	other grasses		Rubus armeniacus
	Rosa nutkana	Plantago maritima		Tanacetum vulgare
	Rubus parviflorus	Polystichum munitum		
	Salix sp.	Rumex sp.		
	Sambucus racemosa var. arboresc	Salicornia virginica		
	Sorbus sitchensis	Triglochin maritima		
	Symphoricarpos albus			

APPENDIX 4: INTERVIEWS

Interview #1

Stakeholder Interview #1 with Ron Wantanabe (1st Vice President, Courtenay and District Fish and Game Protective Association) conducted by Lora Tryon on January 24th, 2011.

Interview #1 was conducted with Ron Watanabe of the Courtenay and District Fish and Game Protective Association (CDFGPA). The purpose of this interview was to identify the potential role of the CDFGPA in the planning and implementation of restoration projects in the estuary. After a review and discussion of the proposed project restoration options Lora (LT) explained the rationale for prioritizing the identified restoration options in the Courtenay River Estuary (CRE). LT and Ron (RW) discussed examples of how the CDFGPA has been involved in past restoration projects, and the potential for their involvement in future projects. As a follow up to the interview (after RW had some time to review the restoration options spreadsheet on his own), he provided a letter outlining the potential capacity of the CDFGPA to be involved in the future and an estimate of their level of future involvement. A summary of both or these communication events are provided below.

Prioritization of Restoration Options

The face-to-face interview began with LT giving an overview of the restoration options identified in her study. As an aid in this interview, LT provided a print-out of the restoration option matrix spreadsheet along with a map of the corresponding sites in the CRE.

Given the many restoration options identified in this study, RW suggested prioritizing to one single, most important option so that he (and other CDFGPA members) could focus on a single issue in detail, to improve the likelihood of improving important fish habitat in the estuary. LT responded that the lower river (and estuary) is a corridor for migration through which fish encounter many hazards that are effectively preventing functional refuge and feeding, and that a single project will not remediate this larger issue within the corridor. As an alternative, LT proposed a system of prioritization that identified one priority option for each segment or reach of the corridor, so that habitat connectivity throughout the rearing and migration phases of young salmonids can be more effectively addressed. She emphasized the relative importance of each segment of an estuary/river interface during advanced juvenile phases of development for saltwater adaption, as well as the necessity for interconnection between feeding areas and areas of refuge from predators.

RW responded that it would make sense (from the perspective of juvenile anadromous fish) to tackle such restoration projects in an upstream to downstream direction, given that the transition from freshwater to saltwater appears to be the largest bottleneck in their survival.

Past CDFGPA Protection and Restoration Projects

The discussion turned towards what the traditional capacity of the CPFGPA has been with regards to habitat restoration. RW provided examples of members involvement in hatchery programs, members volunteering in fish studies (including previous work in the data collection stage of this project), the organization donating money to other groups for restoration works, and an annual program where volunteers transported chum carcasses to the upper Puntledge watershed for nutrient enrichment. As well, RW mentioned that the CPFGPA have been active in writing letters to lobby specific issues, or provide support for particular projects.

Future Involvement of the CPFGPA in CRE Restoration Projects
LT asked RW what level of involvement CPFGPA would take in future restoration work in the CRE? RW responded by saying that he wanted more time to review and digest the options being proposed. A couple days after this meeting, RW responded further with the following comments:

"I believe that there are multiple opportunities for the Courtenay and District Fish and Game Protective Association to assist in varying degrees in all of the projects listed. All that is needed are formal requests for volunteers to do the physical work, letters of support, financial contributions, participating in meetings with government officials and other NGO's, are all activities that are doable by members of my Association." (Watanabe, email communication).

In Summary
RW stressed that his group would likely support 'in principle' any enhancement or restoration projects for juvenile salmonids as long as they are supported by strong scientific evidence.

Interview #2

Stakeholder Interview #2 (by phone) with Cynthia Durance of Precision Identification (Seagrass Restoration Specialist) conducted by Lora Tryon on January 26th, 2011.

The purpose of this interview was to discuss the past, present and future conditions of eelgrass habitats in the Courtenay River Estuary (CRE). Lora Tryon (LT) initiated the discussion by giving a brief overview of the condition of eelgrass beds she has encountered in the CRE through field investigations for this and other recent projects. She then asked Cynthia (CD) to describe any past assessment or restorative work she was aware of in the CRE, as well as opportunities for restoration in the near future.

Historical Restoration on CRE

CD began by reviewing a restoration project that took place approximately 20 years ago. She described an unsuccessful effort to transplant eelgrass into a degraded habitat area adjacent to the Comox Marina. She explained that the initial lack of success of this transplant effort was likely due to unfavourable conditions (chemical or physical) within the site locale. She further explained that this site restored itself approximately 10 years after the initial transplant effort was made, indicating that it is possible that some eelgrass shoots torn from the sediment by boats were able re-establish without being washed away by currents and tides. CD indicated that this incidence is an interesting anomaly because eelgrass beds in this region usually expand through vegetative means (which is a very slow process at approximately 0.5m/year).

Potential Restoration of CRE

CD mentioned that (at the time of the interview) she was in the process of preparing to deliver an eelgrass restoration workshop in the CRE (hosted by the Comox Valley Project Watershed Society). This workshop would introduce volunteer stewards to habitat identification, transplant and monitoring techniques. She followed by saying that the next step was to find a suitable location for a pilot eelgrass transplant project in the estuary.

Present and Future Threats to Restoration of CRE

LT asked CD to identify the greatest adverse impact to eelgrass beds in an estuary environment (such as that found in the CRE). CD said that recreational boat use in shallow water is likely the most adverse. She said that prop wash often breaks or dislodges eelgrass vegetation and rhizomes in shallow habitats. It was suggested that public education in the form of signage, and/or creating 'no go' zones for boaters near shore (i.e., use buoys and floats to delineate newly restored areas) may be effective ways of preventing this kind of degradation in the CRE in the future. Recreational boaters are likely to respond positively if they are informed of potential impact to the ecosystem, and that public response to travel restrictions will be based on effective modes of education and voluntary compliance.

CD identified that point and non-point source water pollution were also important threats to consider, as they can contribute to eelgrass bed degradation. She mentioned that this is a much more difficult issue to tackle - but important to identify and mitigate wherever possible.

Restoration Techniques

LT asked whether bed restoration through transplantation or seed broadcast would have a higher success rate in an environment like CRE? CD responded that seed collection and broadcast is the most cost-effective method (as long as restoration work is done by trained professionals), however the success of this method has been poor in past endeavours. She said that though transplanting is more labour intensive it can be cost effective (as long as experts are used to do the work), and there is greater chance for success than seeding. She went on to explain that many seeds will germinate but few can grow roots fast enough to avoid being washed away by tides and currents (a situation that is very different in the Atlantic where many populations of eelgrass have developed an annual lifecycle).

CD mentioned that she has developed a transplant technology that has met with very high success in most of the pilot study areas where she has done restorative work. In her experience with transplanting, a lack of success is usually related to planting in areas of excessive erosion and poor water quality. She said that it is important to cluster the plants together in patches of 10 or more to protect the centre of the patch long enough to allow good rhizome establishment. She also recommended that steel washers be used to anchor plants (1 per shoot). The steel is known also to assist in sediment remediation by chelating excess sulfide molecules that are often found in estuarine sediments.

CD went on to say that if seed collection and broadcast is going to be used, seeds are easy to harvest without adversely impacting parent stock, and broadcast technique(s) are inexpensive. She suggested that if a seeding project were undertaken locally, it should be done on a pilot project basis, and at a site with minimal influence from tides and waves. Seeding projects have not met with high success on the Pacific Coast as they have on the Atlantic Coast, and that there are reproductive differences between east and west coast eelgrass beds. She emphasized that since local eelgrass beds typically reproduce through the slow process of vegetative branching, leaving nature to expand on existing eelgrass beds without intervention can take a very long time.

Remedial Potential of Eelgrass in Estuaries

CD explained that eelgrass has an incredible physiology because it can derive nutrients either from the water column or from sediment depending on the optimal source. As well, eelgrass will sequester oxygen from the water column and pump it into sediment through its rhizomes. This introduction of oxygen into the sediment will often have a remedial effect on buried toxins. CD mentioned that there are possibly areas within the CRE where toxic 'hotspots' may be a limiting factor for eelgrass bed survival, but eelgrass is quite tolerant of many toxins including heavy metals. Toxic hotspots therefore might be good candidates for restoration as the eelgrass could potentially remediate the sediment now that many of the impacting industries (e.g., log storage) have been phased out within the CRE.

Interview #3

Stakeholder Interview #3 with Nancy Hofer, Environmental Planner, City of Courtenay conducted by Lora Tryon on February 10th, 2011.

The purpose of this interview was to identify opportunities within the governance structure of City of Courtenay to implement and support estuarine protection and restoration programs on the Courtenay River Estuary (CRE). Lora (LT) started by giving a brief overview of the BCRP study to-date and a review of the relationship(s) between the various groups involved in local estuary stewardship.

LT began by asking what (if any) current initiatives or policy exist to support estuary protection and/or restoration within the City of Courtenay? Nancy (NH) responded that there is interest internally to acquire lands (i.e., protection interest) along the estuary shoreline (e.g., the Field Sawmill site), but this will require partnership(s) to secure funding as no funds currently available within City budget. LT inquired whether there were changes being made within the OCP to increase shoreline protection? NH showed a recent map illustrating protective buffers along the CRE shoreline (i.e., riparian areas protection), and explained that she is in the process of working with senior staff to flag sensitive habitats such as these within Environmental Development Permit Areas. LT emphasized the sensitive and complex nature of such estuarine shoreline habitats and the resulting problems that can arise when defining high water marks in a tidal environment. NH agreed and mentioned that she has been working to update the definition(s) of sensitive areas within the OCP (and using the recently published Nature Without Borders document extensively, along with provincial Riparian Areas Regulation literature and the past work on a Sensitive Ecosystem Inventory by the CVRD).

LT continued by asking what (if any) opportunities exist to create a sustained dialogue between city staff and groups with expertise, knowledge and active involvement in estuary protection? NH responded that since she started this position with the City (6 months prior to this interview), she has been given the opportunity to attend meetings amongst local conservation groups so she could learn more about local environmental issues and network with the people involved with these issues in the community. NH emphasized that her position as a municipal Environmental Planner requires that she does not form political alliances, however. She said that there are already systems in place for the planning staff to make referrals to local stewardship groups in the Development Permit process. She mentioned that the City recently hosted a meeting with the local development community to help applicants streamline their applications by addressing the necessary environmental protection measures during the design phase of their development proposal.

LT asked about the level of importance that public recognition plays when staff and/or council implement environmental protection measures? NH responded that she is not aware of any obvious drive by staff or council to gain community recognition for environmental initiatives. She said that there are incentives, however, from the province to gain future municipal resources through implementing innovative environmental initiatives.

LT asked whether the system of applying dollar values to Ecosystem Goods and Services (EGS) is an effective way of educating staff, council and the public about the necessity of investing in a new environmental initiative? NH confirmed that she felt this has the potential to be an effective strategy as the single message of 'protecting because it's valuable' doesn't connect to everyone. Economics of a decision grab a larger audience. She gave the example of the local Cycling Task Force that is working to change the perception that the development of a bike lane network around the city is expensive. She said that over the long term such investments actually save money by reducing car infrastructure costs, and reducing health care costs as people have low-cost opportunities to exercise more. There are also growing costs associated with global warming that are not being accounted for within a fossil fuel based economy, of which transportation is a central issue. LT asked whether the Estuary Working Group (a committee of the Comox Valley Project Watershed Society) could help bridge the information gap regarding such issues? NH affirmed that the language that is used is very important. She said that accurate economic evaluation of ecosystem services would likely be key to bridging the communication gap between municipal government and those working to protect the natural environment. LT asked if there was any particular style of communication that should be avoided when proposing such initiatives to staff and council? NH indicated that the current council is very practical and would likely respond positively to proposals for environmental protection if a valid case was made showing a benefit to the local taxpayers.

LT asked how committed the City is to idea of land protection either through opportunities for direct acquisition, a legislated designation (such as a National Historic Site or a Wildlife Management Area), or through a land conservation type property tax? NH reiterated that the City is interested in acquiring land(s) but requires financial partnership(s) to do so because there is currently no budget for such purchasing. NH expressed hesitation about the City aligning themselves with land protection initiatives that are based on external designations such as those suggested by LT, possibly because she doesn't know enough about them and some sound quite onerous to obtain. She followed by saying public pressure reaches staff through council sensitivity to a public issue. In regards to the idea of implementing a land conservation property tax (similar to the one described by LT that was recently implemented in the Regional District of East Kootenay), NH said that the intent would likely have to appeal to 'parks and recreation' and 'quality of life' interests as well as for land conservation in order to get enough public support

LT asked what regulatory incentives exist within the City for estuary shoreline protection? More specifically, LT asked what level of involvement or interest the City has for the current Courtenay River Estuary Management Plan (CREMP) initiative? NH replied that she thinks staff and council are tentative about getting involved with such a multi-jurisdictional issue. LT mentioned that she had obtained feedback from one of the original participants in the CREMP process, who felt that the City may have not supported it due to it being highly controlled by the federal government, leaving little room for collaboration. LT went on to say that her source had told her that the current atmosphere within this second round with CREMP

is one of collaboration. NH replied that she was given the most recent CREMP version and plans to review it and sit in on a future CREMP meeting but will likely stay non-committal, due to the uncertainty among city staff of the CREMP outcomes. LT asked if the Estuary Working Group took time to inform staff and council of the recent developments within the CREMP process, could this result in increased involvement by CoC in this process? NH replied that it is possible.

LT asked what voluntary incentives exist for the City to protect the estuary, such as carbon offsets, etc.? NH responded that the BC Climate Action Charter involves complex accounting that deals with large-scale, internationally based offsets. Blue carbon offsets such as those potentially found in the CRE are an emerging field that do not seem to be accounted for by the Pacific Carbon Trust. Until the province recognizes such initiatives, there is not a financial incentive for the CoC to pursue this particular avenue to help protect the estuary.

Regarding restoration projects on municipal lands, LT asked what level of involvement could be expected from the City for the restoration of shorelines along the Courtenay River? LT provided an example of a problem shoreline along the old Field Sawmill site where the corrugations in the sheet metal pilings are used by seals to trap fish. LT then went on to inform NH that the $5,000 requested for investigation of fish habitat enhancement opportunities at the City's Simms Park was conditionally approved, and asked if the City would be interested in future involvement in similar restoration or enhancement projects? NH replied that the City would likely support similar restoration work on municipal lands as long as the appropriate level of planning has taken place. LT inquired what level of involvement the City might have in the necessary removal and naturalizing hardened shorelines such as that mentioned at the old Field Sawmill site? NH responded that a floodplain study is being planned by the City for the Lewis Park area to determine constraints on present and future use, and that there may be more support for shoreline "softening" projects once this is complete. For example, it may be decided that some City buildings that are on the existing floodplain may be inappropriately placed, and their removal may facilitate other opportunities for shoreline restoration in the area. LT asked about municipal support for invasive plant removal in riparian areas along the CRE? NH said that if there were money available from the province for invasive plant removal the City would likely support such an initiative financially. Otherwise, support will likely only be verbal and in the form of access to municipal lands.

APPENDIX 5: MARCH 17TH, 2011 PRESENTATION DISCUSSION

Project Presentation at the Courtenay & District Museum on March 17, 2011

"Investigation of Restoration and Protection Options for Juvenile Salmonids in the Courtenay Estuary – A Study by Lora Tryon, R.P.Bio."

Question & Answer Period(s) Summary

1. Methodologies Q & A:

Ensalmo Q: Why were upstream areas determined to have priority over downstream areas as indicated by the Areas 1-9 labelling for the study area?

Lora Tryon A: The criteria used in this study were habitat condition(s) for juvenile Chinook and Coho. This includes food and refuge requirements during outmigration, which were determined to be the more critical at higher reaches of the system where the physiology of anadromous fish must change from freshwater to saltwater dwelling. This priority ranking is not meant to discount other priority areas downstream – it is just one way of categorizing the importance of restoration and protection on this system.

2. Restoration and Protection Options Q & A:

Brett Knight Q: Why are invasive plants in riparian areas a problem in terms of fish habitat?

Lora Tryon A: Some of the key functions of riparian area vegetation for fish habitat are what's called the "insect drop" and "litter fall". Native plant species evolved through time with native species of fish, and the fish rely on the insects and detritus inputs provided by specific types of plants in the riparian zone. Non-native species of plants often won't recruit the same kinds of insect larvae and may not provide the same sorts of litter fall into a stream – which will negatively impact the fish in that habitat.

Shane Johnson Q: Was a Large Woody Debris (LWD) inventory a part of this estuary study?

Lora Tryon A: LWD complexing is important to fish habitat in the estuary, and LWD at particular habitats were mapped, but an detailed inventory was not done. LWD is limited to the lower estuary as a result of tidal inputs. Some LWD comes downstream, but logging and dams are limiting factors in this system.

Wayne White Comment: The Tsolum and lower Puntledge do provide a significant amount of LWD to the estuary that is constantly being buried in soft sediments. This is important in terms of carbon sequestration.

Unknown Person Q: Why was there no mention of Pink salmon juveniles in your study results?

Lora Tryon A: There were a handful of Pink juveniles sampled, but these were not included because so few. Most of the pinks out-migrated before the sample period.

Unknown Person Q: Did you compare the temperature data from this study to historical data for this system?

LoraTryon A: There was no comparison made but it would be interesting to compare current average air temperatures to those of the past as a way to monitor climate change. The challenge with water temperature comparisons in an estuarine system is replicating tidal influx and discharge within a specific period in a season.

Wendy Kotilla Comment: Studies from the Carnation Creek research area have shown a clear correlation between increasing instream temperatures and logging within the riparian areas upstream within a watershed.

Ensalmo Comment: Another factor that results in increased water temperatures in any system is dropping summer flows. This is compounded in systems with poor shoreline habitat complexity such as the Courtenay River Estuary.

Ensalmo Q: How would you rate the overall health of the Courtenay River Estuary – stable, increasing or decreasing?

Lora Tryon A: If salmonid species are indicators of this, then I would say that the estuary and the watershed as a whole are in decline. For salmon, the overall decrease in stream habitat complexity in this watershed is clearly a factor.

Wayne White Comment: I believe the health of the estuary is actually slowly increasing. If you consider that the old dredged channel in the lower river is slowly infilling and most of the old industries that were a source of toxins in the river system are now gone – these factors can only be an overall benefit to the ecology of this system!

Kathryn Clousten Q: Your study has identified the Dyke Slough as great refuge habitat for juvenile salmonids migrating out to the estuary. Have you found other sites that have potential to provide a similar level of quality refuge and possibly feeding habitat for outmigrating salmonids?

Lora Tryon A: The Airpark Lagoon has a lot of potential. In it's current state, there is not much freshwater input. This could be mitigated by creating a high (tide)

water breach between the Courtenay River and the lagoon through a culvert under the pedestrian walkway. This modification will presumably also enhance the downstream tidal flat as increased flows result in increased channel braiding. Channels in estuarine tidal flats provide critical summer refuge for salmonids. It is important to note that is some concern still for the potential release of toxins from this lagoon with increased flows as it used to serve as a sewage lagoon.

Wayne White Comment: There is record of excavation within the lagoon to remove contaminated sediments, so this may not be an issue.

Wayne White Comment: The current strategy at the hatchery is to release the Chinook smolts in the high pulse flows of spring in an effort to essentially blow them past the hungry seals waiting downstream. This is known to be hard on the fish as they don't have much time to acclimatize to the saline conditions. It is critical that shoreline refuge habitats be restored to allow these fish safe holding habitat out of reach of seals.

Lora Tryon Q: How many property owners in the audience today would be willing to pay a kind of conservation tax levied to restore and/or protect the estuary?

Audience response: Approximately 8 of the 30 odd participants put up their hands. One person commented that he would be more willing if this levy wasn't called a "tax".

Lora Tryon Q: Of the municipal staff present, how many would be willing to try to convince their respective Council members to enact such a levy?

Response: 1 of the 2 Municipal Planners present put up her hand.

Janine Bond Q: How is this study tied to the current CREMP process?

Lora Tryon A: The ecosystem based management structure of this study model should make it easy for such a group to integrate components of the study from areas applicable to the work they are doing.

Janine Bond Q: I guess I'm wondering if this study is already part of a larger, comprehensive management plan for the estuary?

Don Castledon A: An emphasis of this recent version of CREMP has been to develop a more inclusive consultation process that integrates a wider range of information and values.

Wayne White Comment: The current CREMP process is not necessarily taking a site specific approach. There will be overarching goals such as reducing shoreline hardening that will overlap directly with this study – but not site specific objectives within CREMP.

Brett Knight Q: You mentioned a priority restoration project as the removal of hardened shoreline structures along Lewis Park. Is this feasible?

Lora Tryon A: There have been similar studies implemented in the US that have been successful. The risks associated with potential loss of private land are difficult to manage, however. There are substantial resource and capacity hurtles to overcome to implement such a project (e.g., engineering requirements, public support, long-term management, etc.).

Brett Knight Comment: Shoreline softening in public areas such as Lewis Park could actually add value in terms of beach creation, increased biodiversity and natural habitats that many people appreciate.

APPENDIX 6: RESTORATION OPTIONS

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
1a	Off-channel Habitat Enhancement	Puntledge Side-channel	1 Upper Ecotone (Tsolum Relic Channel, Tsolum / Puntledge Confluence)	Construct a side-channel through floodplain along right side of river across the bend between the Condensory Rd bridge and the Tsolum/Puntledge confluence.	Unchanged- some of this work could be undertaken when new two lane Condensory Rd. bridge is being constructed. Medium priority.	Potentially highly valuable rearing habitat, similar to that provided to coho along the condenser side-channel.	Construct a side-channel across existing floodplain along low area where flood flows have already scoured a route and connect to river below Tsolum/Puntledge confluence.	Unknown ownership of land, likely some private land issues and negotiations required. Constructed side-channels can be difficult to maintain, and are prone to plugging with materials. A side channel of this scale would have to have major engineering and design studies completed prior to any construction. DFO may not accept liability for the future maintenance of side channels. Possible low flow problems from splitting flow. Possible stranding issues in summer.	Consultations with DFO, City of Courtenay, BC Hydro, K'omox First Nation, neighbouring landowners; clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes. Hydrological and fish habitat survey.	Fisheries and Oceans, City of Courtenay, K'omox First Nation, BC Hydro, landowners	BC Hydro gauging information
1b	Mainstem Complexing	Courtenay River Mainstem	1 Upper Ecotone (Tsolum Relic Channel, Tsolum / Puntledge Confluence)	Channel complexing along 200m of riffle/rapids in river below Tsolum/Puntledge confluence.	Unchanged. High Priority.	This is a swift section of creek that could pose a velocity barrier to upstream migrating fish, and can flush downstream fry into saline waters at high tides and flows. Sampling in an eddy just below this section of river found coho, chum and pink fry mortalities and contusions and scale loss on live fish after a storm event. Reasons unknown but possible related to high velocities and lack of velocity refuge through this section.	Create velocity refuge habitat through shoreline complexing, and benching with Carex spp..	Access to this section with machinery difficult due to private property along left bank and natural impediments along left bank. Structures placed in mainstem may pose a trapping hazard to recreational boaters and tubers.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes. Hydrological and fish habitat survey.	DFO, landowners, City of Courtenay, BC Hydro;	BC Hydro gauging information
1c	Off-channel Habitat Enhancement	Tsolum Relic Channel	1 Upper Ecotone (Tsolum Relic Channel, Tsolum / Puntledge Confluence)	Clear out current channel to accommodate lower flows	Unchanged. Low priority - see constraints.	Opportunity for creation of high value off-channel habitat	Already a channel there that is slowing infilling and heavily vegetated	*Constraints to this project, especially low flows in the Tsolum, make this project low priority.* Private land ownership, not enough flows from the Tsolum to feed this channel during low summer flows, current ecosystem is thriving, provides good chinook and coho fry rearing habitat near mouth where it meets the Courtenay River during high tides. Current aggradation processes may hinder constructed channel integrity. DFO previously considered this option and found that splitting flow of Tsolum River through this old channel may compromise mainstem Tsolum fish habitat during low flows.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes. Hydrological and fish habitat survey.	Fisheries and Oceans, Tsolum River Restoration Society, Ministry of Environment: Water Stewardship, Landowners affected by flow diversion	Jack Minard of TSSR; Mel Sheng, DFO
1d	Shoreline Rehabilitation/Bank Stabilization	Courtenay River: Left Bank	1 Upper Ecotone (Tsolum Relic Channel, Tsolum / Puntledge Confluence)	Concrete wall removal and re-contouring of channel banks, restoring them to provide greater ecological function.	Unchanged. Medium priority - lower priority only because difficult to get political will due to park facilities.	This section of river is highly channelized, providing little in the way for refuge from flows and predators.	Natural engineering options are available so that flood risk is minimized while habitat values are maximized. Public space provides opportunities for access to do the works. Opportunities to educate public while works underway.	Walkway and park facilities near the banks may be restrictive when re-grading channel banks. Downstream flooding concerns if project constricts channel beyond capacity. Concerns over bridge downstream and impacts to infrastructure from changes in channel hydraulics.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	Fisheries and Oceans, City of Courtenay	
1e		Courtenay River: Right Bank	1 Upper Ecotone (Tsolum Relic Channel, Tsolum / Puntledge Confluence)	Removal of sheet piling and replacement with engineered options that provide more fish habitat.	Unchanged. Medium priority - City of Courtenay recently (Aug. 2016) armoured this section with rip-rap as the piling was failing.	Section along Puntledge with sheet piling creates marginal conditions for fish migration and refuge. Seals use sheet piling to trap juvenile salmonids, including Puntledge summer chinook and prey on them. Removal of sheet piling and replacement with more natural habitat feature would provide increased fish habitat.	Natural engineering options are available so that flood risk is minimized while habitat values are maximized.	Private land along this section could make access and permissions a challenge. Building occurs close to shore, limiting bank stabilization options. Softer engineering options in channel may decrease capacity of channel to convey flood flows.		Fisheries and Oceans, City of Courtenay, landowners	

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
2a	Shoreline Rehabilitation/Bank Stabilization	Central Builders shoreline	2	Remove hard shorelines and replace with sloping natural shorelines. shoreline complexing and replanting	Unchanged. High priority. There is potential to implement some of these suggestions with the new Tiger Lily seniors community development. Unchanged. High priority there is potential to implement some of these suggestions with the new Tiger Lilly development.	Existing shoreline habitat along this section marginal due to concrete wall and rip-rap.	Good access from Central Builders lot, opportunity to involve local business	Private property. Limited opportunity for riparian planting at top of slope. Can have high velocities from upstream shoreline hardening. Erosion a consideration.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	City of Courtenay DFO	
2b	Off-channel Habitat Enhancement	Simms Park Pond and Finger	2	Pull back the slope to create benches at elevations that marsh habitat will thrive. Remove the culverts at both ends of the pond to daylight tidal exchange areas. Lower the invert at each end to facilitate tidal exchange between the marina slough, the pond and the finger.	On-going. High Priority. Project Watershed is currently working on a restoration design for the site, but saltmarsh benches are not part of this plan.	Both the pond and the finger are currently used by fish, however habitat quality is low, and tidal flushing is restricted due to the elevations of the culverts at either side of the pond. Project will improve access for salmonids, refuge from predators, improved forage potential, and improve water quality.	Opportunities for public involvement and education, and partnerships with City of Courtenay. Easy access through Simms Park.	Temporary disturbance in a public park during construction will require a strong education and community involvement component to gain public support.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	City of Courtenay, Fisheries and Oceans	As built drawings available. Fish sampling studies in area done 1998, 1999, 2000 and 2010.
2c	Saltmarsh Planting	Courtenay Marina Slough (Simms)	2	Construct saltmarsh benches along margins of slough channel	Unhcanged. High Priority. Project Watershed is currently working on a restoration design for the site. If funding can be secured, the work is planned to take place the summer of 2017.	Cessation of dredging activities has likely resulted in the slow infilling of the Courtenay slough marina. Saltmarsh creation is a natural process of an aggrading channel, though slow. By constructing saltmarsh benches, this will speed this process, and help create valuable habitat.	2010 Project Watershed vegetation survey identified locations and plant assemblages of existing saltmarsh benches. Boat access to site possible, or from new Honda dealership. Possible to involve Honda dealership to help voluntarily mitigate for indirect impacts of development on estuary.	Courtenay marina slough still active with boats, though access is possible only during high tides. Must ensure that new benches do not interfere with navigation. Also, a weir built across slough channel should be considered for current usefulness and possible removal prior to benching and planting, as this may change sediment transport processes.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	City of Courtenay, Fisheries and Oceans, Comox Harbour Authority	Fish sampling studies in area done 1998, 1999, 2000 and 2010.
2d	Off-channel Habitat Enhancement/Riparian Planting Saltmarsh Planting	14th Street (Standard Park)	2	Expand the existing pond, possibly reconstruct as a wetland to filter contaminated runoff from storm drain. Remove blackberry, native planting. Add salt marsh benches where appropriate.	Unchanged. Medium priority. Unchanged. Medium priority.	Current habitat for appears marginal with potential room for improvement (site assessment required). Potential contamination of estuary from storm water, wetlands will help to filter any polluted runoff. Dense growth of invasive Himalayan Blackberry preventing natural riparian vegetation establishment. Small manageable project that will address salmon issues such as refuge from predators and water quality improvement. Public lands improve chances for approval and improved access for machinery to do works. Saltmarsh habitat highly utilized by trout and juvenile salmon in this area during spring and early summer.	Partner with City, involve the community in the blackberry removal and riparian planting and saltmarsh bench planting.	Sediments may be contaminated as used historically to store bulk fuels. This ceased when it was purchased in 1985 by the City of Courtenay. Lack of baseline information on fish use and current habitat attributes.	Consultations, clear identification of goals and objectives, site survey, design options, assessment of risks of project failure and potential impacts from changes.	City of Courtenay Fisheries and Oceans, Ministry of Environment	
2e	Shoreline Complexing	Field Sawmill(a)	2	Install and anchor structures along sheet piling as a temporary measure until future of site is determined.	Unchanged. Medium priority. Prefered option is acquistion and restoration.	Approx 430m of shoreline along left bank modified with sheet piling. Major impact on habitat connectivity as fish are exposed through this section during migration. Seals have been observed using the corrugations in the pilings to trap and eat juvenile salmon.	Provides a high valued temporary measure to provide migrating salmonids with refuge from seals.	Will require permission of current owners. Anchoring can be complex- possible to use existing sheet piling. Must ensure that materials behind sheet piling, if exposed to the water from anchoring, are free from contaminants. Placement of structures in water way constrict flows, causing flooding issues.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	Interfor (landowners), Fisheries and Oceans.	Design of LUNKERS (National Engineering Handbook).
2f	Shoreline Rehabilitation/Bank Stabilization	Field Sawmill(b)	2	Site rehabilitation through removal of concrete, sheet piling and rehabilitation planting.	On-going. High Priority. Project Watershed is working on acquisition of this site for the purposes of restoration and long-term conservation.	Approx 8.3 acres of riverbank with 1400 feet frontage covered in concrete and shored up by sheet piling from recently ceased sawmill operation there. Site is on Project Watershed priority list for land acquisition (see protection options)	Highly visible site with large public support for rehabilitation. High interest from multiple partners to do a joint purchase for protection. Indications from realtor that the site soils are not contaminated. Certificate of Compliance to Residential Standards is available. Price is dropping. Adjacent pristine Hollyhock flats provides a template for riparian plantings. Opportunity to cut a channel from river across site to Dyke Slough side channel to deliver water and provide refuge for fish from seal predation.	Constraints to land acquisition (see protection options). High cost to carry out rehabilitation. Though soil tests indicate site is clean, digging may reveal problems and resulting in waste disposal considerations. Area of historic fill placement, and with pump house station active next to site, there are limited opportunities to reduce elevations to historic levels characteristic for the site.	Purchase and acquire foreshore lease, and prepare detailed plans and budget for rehabilitation.	Interfor (landowners), DFO, Naturalists (Re adjacent property concerns), Ducks Unlimited & CVRD (if channel is constructed), City of Courtenay, Ministry of Environment (Re Waste Management), other purchases.	Results of preliminary consultations available through EWG meeting minutes and/or through Wayne White (EWG). Soil testing results (owner has these). Certificate of Compliance to the Residential Standards is available from owner. Vegetation assessment carried out by Naturalists.
2g	Water quality improvement Shoreline Rehabilitation	19th Street (Below Service Canada)	2	Expand and re-contour existing pond to create a wetland complex for filtering polluted runoff. Build saltmarsh benches near river.	No longer and option, as Riverstone condo development has proceeded and filled in this wetland. Unchanged. Medium priority. Riverstone development has severly impacted the site. The site would have to be reassed to determine feasilbity of saltmarsh benches.	Current habitat for appears marginal with potential room for improvement (site assessment required). Potential contamination of estuary from storm water, wetlands will help to filter any polluted runoff. Small manageable project that will address salmon issues such as refuge from predators and water quality improvement. Saltmarsh habitat highly utilized by trout and juvenile salmon in this area during spring and early summer	Site is under scrutiny by Fisheries and Oceans and Ministry of Environment for water quality issues, where oil slicks regularly observed coming from storm drain, therefore should be high priority by all levels of government to implement a project that deals with this issue. Can expand wetland complex into private property south of walkway, currently (2010) unoccupied and for sale. Update - property sold and City of Courtenay approved Riverstone condo development.	Private property south of walkway. Permission to undertake project on private land or land acquisition funding constraints. History of dispute with private property owners and City of Courtenay where the trail access was blocked, therefore may create roadblocks to partnership. Consideration of enhancing habitat near an area that has water quality issues- may be attracting fish to harmful area.	Consultations, clear identification of goals and objectives, initial survey, design options, assessment of risks of project failure and potential impacts from changes.	City of Courtenay Fisheries and Oceans, Ministry of Environment, private landowners	site history, survey may already exist.

Updated estuary restoration options Sept. 2016

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
3a	Habitat Enhancement/ Saltmarsh Planting	Airpark Lagoon	3	Open up top (north) end of lagoon to river flows during high tide conditions by creating a breach across the Courtenay walkway.	**COMPLETED.**	Past fish sampling in estuary revealed areas that received regular flushing with freshwater were more productive for coho and chinook fry, especially in the spring. By introducing freshwater at high tides to the lagoon, tidal mixing will improve water quality and fish access from the upper end, and will encourage tidal channel formation in the mudflats below the lagoon, which has been severely reduced since the lagoon and airpark were constructed and blocked off flows from main river.	City park, partnership opportunities. community education, potential access from airpark.	Potentially toxic materials in lagoon from active storm drain and historic use as a sewage lagoon may get flushed into estuary with increased flows. Access issues may interfere with public use during construction. Many aspects to consider- public use and access after the project, disturbance to existing habitat, funding.	Testing of lagoon sediments for contaminants, and flow/tide modeling that includes sediment transport and opportunities for saltmarsh bench construction. Vegetation community survey, elevation survey. More information on fish use throughout the year, bird survey.	Fisheries and Oceans, City of Courtenay, BCRP, Airpark managers, Comox Valley Naturalists Society	2010 report by Patrick Walshe: Lagoon Restoration feasibility Study.
			3	Construct saltmarsh benches along margins of lagoon	**COMPLETED.**	Saltmarsh habitat highly utilized by juvenile salmon in this area during spring and early summer	Refuge from seals for adults and juveniles close to areas of high impact from seals.				
3b	Restore tidal channel network in the mudflats.	Seaward side of old sewage lagoon and airpark	3	Open up mudflats to more flow by breaching the blind end of a tidal channel that currently is extended to a ~5m berm that's blocking flow to the mudflats.	Unchanged. Medium priority.	This will accelerate a process that's occurring naturally. Tidal channel network density is much less than historic due to channelization and shoreline modification in the estuary. Tidal channel networks, especially through vegetated marsh areas, are important for juvenile salmon refuge and food production. Unknown, but the berm materials may be artificially placed.	Opportunities for a low-cost project with high volunteer involvement, low environmental impact and high benefit for salmon and other species. The project could potentially be accomplished using hand digging methods, therefore reducing or eliminating the need for machinery over sensitive tidal marsh. The excavated materials could be used to encourage growth of existing vegetated patches. Project can be coupled with the removal of invasive estuarine plants identified during the 2010 PW assessment.	More information is required to estimate the rate of natural erosion and thus determine project feasibility for intervention vs. allowing nature to do the work. If machinery is used, there could be some short term impact on the marsh vegetated along an access route through compaction and direct disturbance.	Assessment of rate of natural erosion. Project plan that estimates volume of materials to excavate, methods, and the best disposal/use of excavated materials (ex. saltmarsh bench design). Archaeological risk assessment.	City of Courtenay, Fisheries and Oceans, Project Watershed Mapping Centre (vegetation maps), Comox Valley Naturalists Society	Vegetation maps and landform features from 2010 Project Watershed assessment

Map Label	Project Type	Location	Area #	Description	Status - June 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
4a	Improve Habitat Connectivity	Dyke Slough tide gates. Located along Comox Ave 240m north of wildlife viewing area. Characterized by 2 culverts with side-hinged tide gates that restrict movement of saltwater into floodplain area, known as "Dyke Slough", and a 3rd culvert with a top-hinged tide gate provides flood relief.	4	Two options considered: 1. Install baffles that will allow for fish to move through culverts during higher velocities, and 2. To increase the height of the downstream invert so that the downstream pool backwaters the culverts, thus lowering velocities through culverts and increasing opportunities for fish migration to slough. Second option can be tied into restoration option 4b, below. Both options can are linked with restoration options LR1, 2 and 3, and FC 1 and 2.	Unchanged. High Priority. The CVRD are currently working with a metal fabrication shop to get the tide gates in better working order. They have also convened a stakeholder committee to look at changing the operation of the gates to benefit fish and wildlife.	The tide gates were constructed during the 1930's and restricted the intrusion of saltwater to farmland and marsh area above. The area is currently, and has historically been, an important rearing area for salmonids. Slough habitat above and below the gates highly valuable for food production, and has year-round flows from Glen Urquhart and Mallard creeks. The construction of the tide gates likely decreased salmon production dramatically by isolating the upstream areas. Project will improve access of juvenile and adult salmonids between the estuary, Dyke Slough and associated creeks.	There is a high interest on part of the Ministry of Environment, Ministry of Transportation and Highways, Fisheries and Oceans Canada, and the British Columbia Conservation Foundation to improve access to productive upstream habitats. Work can build on a study of fish migration potential and habitat use carried out in 2010.	Options 1 and 2: High summer temperatures above gates limit utility for salmonid use during this time. If fish access improved past gates, project should be coupled with other projects that improve habitat in lower creek systems above gates so there are suitable upstream habitats during the summer. Option 2: Increases in H2O elevations and salinities above gates may result in changes to freshwater dominated marsh ecosystem and impact cropland. Modeling of the change in elevations and migration of the saltwater wedge above the tide gates would be required to determine impact, if any.	Cost/Benefit analysis of different options. Concept plans and modeling of resulting migratory success of juvenile and adult salmonids. Model changes in H2O elevations in slough and magnitude, frequency and duration of saltwater intrusion. Consultations with upstream property owners/land managers. Archaeological risk assessment.	Ministry of Environment, Ministry of Transportation and Highways, Ducks Unlimited (Tom Reid), Nature Trust of BC, British Columbia Conservation Foundation, Esther Guimond, Fisheries and Oceans, farmers	2011 Guimond report on tide gate study, PW SHIM study on Glen Urquhart Creek (2000)
4b	Off-channel Habitat Enhancement	Dyke Slough downstream tide gates	4	Create and enhance pool and riffle channel habitat through lower intertidal portion.	Unchanged. High Priority.	Current habitat is highly productive from introduction of flows and nutrients from Dyke Slough, but the size and structure of habitat compared to historical is highly diminished.	Opportunity to combine project with CVRD's plans to improve Dyke Road Slough Park area, and with tide Gate project (4a). Channel and pool excavations can be designed to benefit fish and be located over intertidal southern section of area.	The area has some high valued saltmarsh habitat which would require compensation if disturbed during construction. Highly visible to public, and constructed phase may be negatively perceived. Splitting flow is a concern.	Initial consultations and risk analysis. Archaeological risk assessment.	Naturalists, Comox Strathcona Regional District, K'omox First Nation, Ministry of Environment, Fisheries and Oceans	Project Watershed project results from tide gate study (water levels), and 2010 vegetation mapping.
4c		Hollyhock Flats	4	Create a channel that connects the pool below the tide gates to the main river channel	Unchanged. Medium priority.	New channel will provide enhanced forage and refuge habitat for salmonids and benefits to associated food webs. Improved water quality from introduction of river flows.	Large natural area provides opportunity to create a side channel that will divert water from top end of Hollyhock flats to the pool below the tide gates and connect to an existing blind channel that extends into Hollyhock Flats from tide gate pool. Constructed channel can be made with features that benefit fish (ex pools, LWD complexing).	*The constraints for this project have been highlighted by the Comox Valley Naturalists Society, and therefore this project is considered to be of low priority.* Channel construction will impact some of the last remaining intact healthy upper intertidal ecosystem in the estuary. Highly visible to public, and construction phase may be negatively perceived. Blue listed plant Henderson's Checkered Mallow found in this area. Potentially some archaeological artefacts and ethnobotany features that could be damaged if not located and avoided. Many years of efforts by the Naturalists to remove invasives and undertake native plantings in this area, which could be disturbed with this project.	Initial consultations and risk analysis. Archaeological and ethnobotany risk assessment.	Comox Valley Naturalists Society, Comox Strathcona Regional District, K'omox First Nation, Ministry of Environment	Comox Valley Naturalists Society vegetation mapping of Hollyhock Flats

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
5a	Channel complexing	Millard Creek Estuary	5	Complexing along upper ecotone	Unchanged. Medium priority. Funding has been secured for an estuary signage project this year and the site could be included for signage.	Development in the watershed has reduced the input of Large Woody Debris and resulted in high sediment loads becoming deposited in the estuary ecotone (tidal channel above the mudflats). As such, there are long stretches of uniform habitat along this section where fish are exposed to high temperatures and predation. Although Chinook do not spawn in this system, the fry utilize the estuary during the spring and early summer as fry, along with coho, chum, and pink salmon from this, and possibly adjacent, systems.	Access ecotone from pedestrian bridge crossing at Rotary walkway downstream to mudflats using the Riverway walkway, which follows adjacent to left bank of channel. Area highly used by recreationists and is also a nature viewing area for people that require alternative means of transportation (eg wheelchairs, scooters), therefore opportunity to include a public education component and to create wilderness viewing locations that are wheelchair/scooter accessible.	Highly visible to public, and constructed phase may be negatively perceived, though this can be addressed through public involvement and education as discussed in opportunities. Although access possible from public walkway, restrictive to large machinery which could damage trail system and intact riparian areas. High flood flows and tides in system would require anchoring of habitat complexing features (eg LWD)	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	Millard/Piercy Watershed Stewards, City of Courtenay, Fisheries and Oceans Canada, K'omox First Nation (possible midden sites)	Millard/Piercy Watershed Management Plan, 2006 assessment notes of lower estuary (check with author)

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
6a	Pond Habitat Enhancement/Salt marsh planting	Railway pond	6	Open up and enhance riparian pond of ~1000m2 as a tidal lagoon adjacent to mudflats. Divert potentially fish bearing ditch into south end of pond. Enhance saltmarsh habitat around pond.	Partially completed. Low Priority. The Royston Seaside trail has been and the railway dike was partially breached to reconnect the pond to the marine environment at very high tides. The railway bed continues to erode and will completely breach over time.	Pond ecosystem is in the process of change, as old railway grade that forms the seaward shoreline of the pond is eroding and threatening to breach. Pre-emptive action can potentially improve both fresh and saltwater flushing into the pond and ensure the long term integrity of the pond to hold water.	Pond has marine inflow through a small culvert under rail line, some freshwater inflow from a ditch to the north and an opportunity to introduce more freshwater from a nearby ditch to the south that is possibly fish bearing. Pond could be enhanced as a brackish lagoon with a stable tidal channel and saltmarsh benches constructed with railgrade fill material. Regional District is planning a trail system in the future therefore project partnership opportunity exists.	Access along railway grade not possible as it is degrading. Opportunities for access will have to be investigated. Introduction of freshwater ditch to the south of pond could accelerate the degradation of the rail line. *This project should be postponed if breaching of the wrecks (#6c below) goes ahead, which may cause changes in sediment process that could affect this site.*	Consultations with CVRD and DFO regarding partnership and integrating with public trail plans. Clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes. Archaeological risk assessment.	Comox Valley Regional District, Fisheries and Oceans, Ministry of Environment.	Brief by Esther Guimond on project feasibility from Feb. 25, 2004 assessment.
6b	Saltmarsh Planting	Royston Beach: North of Wrecks	6	Build saltmarsh habitat along shoreline north of wrecks	COMPLETED	Saltmarsh is important habitat for juvenile salmon and other species during spring and early summer	The presence of existing saltmarsh vegetation and the landforms in the area indicate an opportunity to expand saltmarsh areas. 2010 vegetation assessment of saltmarsh areas along site 6 provides a planting template for selection of vegetation species to enhance. Possible to access from the end of Hilton Rd. Materials for building up saltmarsh benches may be provided if done in conjunction with CVRD's trail project (materials from old rail line), or with the Royston Wrecks jetty breaching project (Project # 6c).	Abundant materials required to build up elevations suitable for saltmarsh planting. May be some access issues, and ecological impacts with the delivery of materials to beach areas. *This project should be postponed if breaching of the wrecks (#6c below) goes ahead, which may cause changes in sediment process that could affect this site.*	Delineation of existing and potential saltmarsh vegetation and scoping of project area. Elevation survey. Consultations with CVRD and DFO. Archaeological risk assessment.	Comox Valley Regional District, Fisheries and Oceans, Ministry of Environment.	2010 Project Watershed vegetation mapping for site 6.
6c	Improve Habitat Connectivity	Royston Wrecks	6	Open up tidal flow to lower estuary by breaching riprap jetty in one or more locations.	Low priority. The wrecks are a listed archaeological site, so removal of the jetty and reusing the rock to create a reef would require working through a lot of red tape. The wrecks are also breaching on their own over time as they erode.	of the estuary except at higher tides, where a breach (~80m) in the intertidal allows some movement. Above the jetty are the remains of an old booming ground, where bark debris has accumulated in the sediments creating anoxic benthic conditions. The seaward side of the jetty is deeper and highly productive, with healthy eelgrass beds utilized by large and diverse schools of fish. Breaching the jetty will help to improve circulation in the southwest side of the estuary, oxygenate anoxic sediments, and possibly allow for expansion of the eelgrass beds further along the shoreline.	Using both a barge and truck, remove rock from jetty and use it to create a shallow subtidal reef adjacent to existing eelgrass beds to the south (see project # S2). Finer materials can be used to construct saltmarsh benches nearby (see project # 6b). Historic wrecks may be left in situ. Once project is done and a sediment transport processes have reached an acceptable state of equilibrium, new areas on the estuary side of the jetty can be assessed for eelgrass restoration (see Project S1). Possibility to partner with Interfor and/or the BC government as part of remediation requirements for Interfor lease.	lease for the jetty itself, Pentlatch seafood's has a license for the area to the south of the wrecks, and Interfor holds the now inactive lease for the booming ground to the north of the wrecks. Therefore project implementation would require involvement from multiple stakeholders and possibly varying interests in the project. A change in circulation patterns may impact part of the exiting eelgrass bed to the south of the wrecks. Bark contaminants in the sediments may have harmful effects if increased circulation cause transport of contaminants beyond current extent.	Identify interest from all land managers/leaseholders on project implementation, arrange for meeting of those who would be responsible for funding and implementing it to develop goals and scope. Cost/benefit analysis and initial concept plan. Initial surveying of site, sediment sampling. Archaeological risk assessment.	K'omox First Nation, Comox Valley Regional District, Interfor, Fisheries and Oceans, Ministry of Environment	Project Watershed eelgrass mapping study (to be completed in 2011). Historic surveys of jetty. Information from Interfor on potential sediment contaminants from booming grounds.

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
9a	Channel complexing	Restoration at the mouth of Brooklyn Creek	9	complexing of upper ecotone	Unknown - Brooklyn Creek Watershed Society may have taken on some of this work. Low priority.	Development in the watershed has reduced the input of Large Woody Debris and resulted in high sediment loads becoming deposited in the estuary ecotone (tidal channel above the mudflats). As such, there are long stretches of uniform habitat along this section where fish are exposed to high temperatures and predation.	Opportunity to partner with Town of Comox as there are plans to build a new boardwalk in area. Also, area will soon be park and land protected by the Town of Comox. Opportunity to include a public education component.	Highly visible to public, and construction phase may be negatively perceived, though this can be addressed through public involvement and education as discussed in opportunities. Access issues.	Consultations, clear identification of goals and objectives, design options, assessment of risks of project failure and potential impacts from changes.	Brooklynn Creek Watershed Society, Town of Comox, Fisheries and Oceans Canada, K'omox First Nation, Rupert Wong.	

Map Label	Project Type	Location	Area #	Description	Status - Sept. 2016	Status - Sept. 2016	Rationale	Opportunities	Constraints	Preliminary work required	Key People	Resources
LR1	Fish Habitat Enhancement, lower rivers and Creeks	Glen Urquhart creek ponds	n/a	Reconfigure and complex these constructed ponds to improve on current fish habitat	On-going. High Priority. Preliminary detailed survey work to take place this year in order to identify potential restoration opportunities.	Unchanged. High Priority, Ducks Unlimited on board.	Current fish habitat appears to be highly marginal, though apparently utilized by fish. As previously constructed habitat, it is not highly naturalized and provides a low-impact opportunity to improve on fish habitat, especially if fish access through downstream tide gates is improved (Project 4a).	Habitat improvement that increases the complexity of this area for fish will be a large improvement over existing conditions. Easy access (behind Superstore), and public lands make logistics for this project manageable.	Current habitat condition analysis anecdotal- though past reports such as the Project Watershed SHIM or consultant's monitoring of the ponds may provide information on this. Site receives stormwater runoff from urban area- possible pollution concerns.	Some basic assessment required to determine if current habitat is indeed marginal for fish. Water quality monitoring during extreme low flows and after first flush events also required to ensure potential pollution concerns area are addressed in habitat design.	Fisheries and Oceans, City of Courtenay, landowners	PW SHIM survey report on GU Creek (2000); Ken Bond Consulting- monitoring reports.
LR2		Lower Mallard Creek	n/a	In-stream habitat enhancement projects	On-going. High Priority. Preliminary detailed survey work to take place this year in order to identify potential restoration opportunities.	Unchanged. High Priority, Ducks Unlimited and Nature Trust on board.	Mallard Creek has a combination of cool, reliable water flows, and impacts from headwater development and channelization. Restoring salmon habitat along lower section accessible to salmon can help mitigate impacts.	At least 1 landowner has expressed interest in having a stream enhancement project on his property (for details check with author). Can integrate with a landowner contact program that helps to educate landowners on stream protection.	Development in headwaters (urbanized area along Valley View Drive, Comox) has resulted in altered hydrology and sediment introduction to lower sections. New development also has the potential to cause problems. If not addressed, may compromise habitat enhancement projects.	Identification of potential areas for improvement, landowner contact, stream assessment, and concept plan for approval.	landowners, stewardship groups, Town of Comox (for ensuring headwater protection and necessary permits), Fisheries and Oceans, Ministry of Environment.	results from PW's lower river sampling in 2010
LR3		Dyke Slough above tide gates	n/a	Enhance Slough habitat above tide gates	On-going. High Priority. Stakeholder group has been brought together by the CVRD to determine options.	Unchanged. High Priority.	Some fish currently migrate past the tide gates, and more may do so if the tide gates are modified (project 4a) therefore important to ensure good quality habitat available above the gates.	Complex the pond and channelized section above the gates to provide habitat for fish during spring and fall and possibly winter. Deepen the pond above the gates to provide refuge from high summer temperatures similar to that provided by the pool below the gates.	Must find a balance in the trade-off between creating fish-specific habitat and altering existing wetland habitat that has many benefits to both fish and wildlife. Extreme warm temperatures in summer in Slough despite sections with abundant riparian cover, difficult to mitigate for.	Riparian and wetland mapping of area targeted for habitat enhancement. Concept plans for improving habitat for fish. Risk analysis of impacts to other species and farmland.	Ministry of Environment, Ducks Unlimited (Tom Reid), Nature Trust of BC, Esther Guimond, Fisheries and Oceans (Mel Sheng); CVRD - maintenance of tide gates	Chatwin Engineering Ltd. 1989. Courtenay Flats Drainage Operation and Maintenance Manual (CVRD)
S1	Outer estuary habitat connections	Lower intertidal/upper subtidal areas in estuary with suitable substrate and conditions	n/a	Eelgrass restoration	COMPLETED. A follow-up monitoring assessment of all the eelgrass transplant projects undertaken by Project Watershed is currently underway; this will determine whether or not more transplanting is necessary.	Onn-going.	Eelgrass is a high valued habitat for salmonids as well as other species. It provides food, refuge from predators, and is a crucial habitat link between the estuarine and adjacent marine habitats. Its presence in the estuary indicates it can survive here, though impacts from past development may have reduced the extent of eelgrass beds. Since much of the high-impacting development has ceased (ex log booming) there are opportunities to accelerate their recovery.	Update historical eelgrass habitat maps with current eelgrass bed locations, and identify areas that are suitable for planting. Carry out a pilot transplant project using methods known to have high success. Potential to use seeding as a low-cost method of restoration in areas of low exposure to currents on a trial basis.	Need to ensure that eelgrass beds used as donor stock for transplant projects are sufficient in size and density so they will not be impacted in process. Cost of eelgrass transplant can be high in subtidal areas where scuba divers are required. Seeding has not met with much success in other areas along the BC coast, and projects of this type should be done on a small scale, experimental basis. Newly planted areas can be disturbed by high recreational boat use in the area.	Continue mapping eelgrass habitats in estuary to identify potential areas for transplanting. Identify a suitable area to transplant eelgrass on a pilot project basis that will increase local capacity to undertake this type of project.	Project Watershed Mapping Centre, Fisheries and Oceans, Cynthia Durance (eelgrass expert)	Project Watershed has historical eelgrass maps of the estuary from 1995 imagery collected during for the Baynes Sound Fish Habitat Atlas. A 2010-11 PW study is underway that will use aerial images to map existing eelgrass bed extent, including groundtruthing, and identify gaps between historical and current coverage. The Squamish River Watershed Society and Seachange carried out a similar project that was successful (contact = Edith Tope)
S2		Subtidal area adjacent to eelgrass beds near Royston	n/a	Subtidal reef construction	Unchanged. Low Priority.	Unchanged. Low Priority.	Subtidal reefs provide surface area for invertebrate and marine plant growth, and provide cover and forage habitat for a variety of fish species. Where reefs are located close to nearshore habitats, such as eelgrass beds, they can provide important linkages for migratory species.	Possible to integrate with breaching Royston Wrecks and utilizing those materials.	Large volumes of clean materials required. High costs associated with marine transportation of these materials and deployment. Criticism of artificial reefs includes making fish more vulnerable to human predation.	Consultations with Fisheries and Oceans and Environment Canada to identify reef design opportunities to achieve habitat linkages. Concept designs and risk analysis.	Fisheries and Oceans, Interfor	Past research that investigates ecological opportunities and impacts of artificial reef construction.
S3		Comox Bar	n/a	Kelp bed restoration	Underway. High Priority. Kelp research and restoration is being undertaken by Bill Heath for Project Watershed in partnership with the Nyle Creek Stewardship Group.	Unchanged.	According to local knowledge, Bull Kelp growth along the Comox Bar was extensive until an experiment harvest that nearly decimated it. It has slowly been coming back, but could be helped along using kelp restoration techniques.	Techniques include dropping netted bags of spores weighted with rocks at suitable depths. Opportunities for volunteer involvement and education component.	Bull Kelp requires hard substrate, therefore sandy sections of the Comox Bar may not be suitable, or rock would have to be introduced. Growth of the invasive Japanese Wireweed may result in competition with Bull Kelp establishment, therefore work should be done on a pilot project basis to start. Some ecological concerns with the use of outside spore stock that may not be genetically adapted to this area.	Survey during summer growth season that identifies current extent of Bull Kelp on the Comox bar, depth range of where it occurs and identification of suitable areas for reestablishment. Community composition in both established areas and areas proposed for restoration, including potential predators. Identification of pilot project area and research into propagation techniques.	Project Watershed Mapping Centre, Fisheries and Oceans Canada	Nile Creek Enhancement Society has carried out similar projects nearby. Louis Druehl expert in marine plants helped with Nile Creek projects. Local Hornby resident has also done research on restoring kelp beds around Hornby Island (check with author).
FC1	Flood control	Lewis Park-Highway 19a ditch	n/a	Regrade roadway so that floodwaters that flow across Lewis Park are directed under Old Island highway and across the natural floodplain on other side.	Unchanged. High Priority. Benefit to community for flood relief and for fish and wildlife habitat.	Unchanged. High Priority.	This project would provide flood protection to the property owners in the Tsolum and Puntledge Roads area. Hydraulic relief on downstream fish habitats, private property will be better protected due to minimized flood route through urban areas, less polluted surface runoff will enter the estuary, and natural flooding processes will be returned to floodplain ecosystems on east side of Highway 19A.	Flood protection for the property owners, a return of natural flood flows to the water channels which flow into Dike Slough and reconnect sediment delivery processes to the estuary floodplain.	Alteration of urban landscape can be expensive and will require a public education component to gain support for project. While many areas will benefit from flood relief, risk to those adjacent to the proposed water route should be identified.			
FC2		Lewis Park-Simms Park-Farmland across from Highway 19a	n/a	Opportunity to reconnect some of the river water to the floodplain through a pipeline or creating a channel along low lying areas across Lewis park to farmland on other side of Highway 19A, possible utilizing Marina Slough at Simms.	Unchanged. High Priority (see above).	Unchanged. High Priority.	This project will have multiple benefits to people, infrastructure and the environment. It will provide flood relief, water to farmers fields, reconnect fish passage to the estuary floodplain (around the main seal predation areas), and improve water quality and flows for fish through Dyke Slough. If fish access is included in the plan, more habitat for fish higher up in the estuary will also be possible.	Use the newly updated City of Courtenay Floodplain map to identify low lying areas and opportunities for connections between the river and the Dyke Slough/lower Glen Urquhart area. Involve local farmers and explain benefits of floodplain connection to their activities and gain support. Option to use a pipe (restricting fish passage) or open channel- both will provide benefits to varying degrees with different associated costs.	Requires support from a variety of stakeholders to implement including different municipalities, farmers, businesses, harbour authority, non-profits. High costs associated, likely public dollars, therefore will require educational component that indentifies ecosystem values of project - a concept not well understood by the public.	Complete floodplain mapping (CoC), concept plan based on floodplain maps, consultations with landowners/managers, cost/benefit analysis (taking into account ecosystem values), investigation of opportunities to fund project.	CVRD (Area B), CoC, farmers, Ducks Unlimited, affected private landowners (ex old Courtenay house), Fisheries and Oceans, Ministry of Environment	new floodplain mapping currently underway by CoC.
M1	Garbage/refuse removal from seabed	Seabed under Courtenay Slough marina (Simms)	2	Removal and proper disposal of refuse from the seabed under marinas	Unchanged. Low Priority.	Unchanged. Low Priority.	Marinas typically accumulate large amounts of garbage that has been purposefully or inadvertently tossed into the water. This refuse could cause harm through smothering habitat and leaching harmful chemicals into the water.	Hire a dive team to manually remove debris, with the help of surface support equipped with a line. This type of work is fairly easy, quick and of relatively low cost, with great environmental benefit. Where it occurs in highly visible areas, it has an educational component where people observe how much refuse can accumulate on the seabed. Possible to partner with the Comox Harbour Expansion Project as habitat compensation.	Some of the materials removed from the seabed may be regulated under the BC's Environmental Management Act, which have standards for the transportation and disposal of harmful wastes with associated permitting requirements. Safety issues with diving in high boat use areas.	Consultations with public/private marina managers/owners, budgeting and implementation plan, including waste disposal considerations. Funding applications and implementation.	Comox Harbour Authority, private marina operators, Coast Guard (if divers in water), Ministry of Environment: Environmental Protection Division (Re Waste Management)	Local boat owners that can provide boats to do the work.
M2		seabed under Airpark marina (government)	2		Unchanged. Low Priority.	Unchanged. Low Priority.						
M3		seabed under Comox Marina	7		Unchanged. Low Priority.	Unchanged. Low Priority.						
M4		seabed under Goose Spit lagoon	9		Unchanged. Low Priority.	Unchanged. Low Priority.						
R1	Riparian Mapping and Restoration	Right bank* of river from Airpark to Tsolum/Puntledge Confluence	3, 2, 1	Invasive species removal and riparian planting	Unchanged. Medium Priority.	Unchanged. Medium Priority.	Healthy estuarine habitat contributes dramatically to shoreline habitat stability, food production, and is supportive of forage fish habitat	Document the width and composition of estuarine riparian habitats in this area, as well as important areas where it contributed to forage fish habitat. Involve landowners in restoring the riparian areas along their private shorelines. Vegetation mapping in 2010 provides species lists that can be used for restoring specific areas, including invasive species for removal. The Comox Valley Naturalists have already been involved in invasive removal and riparian plantin in the airpark for over 20 years, and may be a good resource for similar projects.	More information on status of riparian habitat in the area required. Requires landowner involvement and permissions to achieve tangible results. Many facets to the program: data gathering, community involvement strategy, funding acquisition. Possible to simplify with a pilot project for a small area.	Preparation of a riparian restoration plan that includes goals and objectives for planting, funding sources, landowners to contact, & information needs (i.e. locations of invasives, high priority areas, etc), and seasonal schedule for restoration and monitoring activities.	Project Watershed Mapping Centre, local stewardship groups, K'omox First Nation, private landowners, public lands management staff	2010 vegetation mapping data from Project Watershed for certain areas in the watershed, local stewardship groups landowner contact databases, volunteers. Invasive plants in the estuary; map available online through the Community Mapping Network. The Comox Valley Naturalists have already been involved in invasive removal and riparian planting in the airpark for over 20 years, and may be a good resource for similar project
R2		South-west shoreline of estuary from Trent River estuary to Airpark	6, 5, 3		Unchanged. Medium Priority.	Unchanged. Medium Priority.						
R3		Northern shoreline from inside of Goose Spit Lagoon to Dyke Slough	9, 7, 4		Unchanged. Medium Priority.	Unchanged. Medium Priority.						

*when facing downstream

APPENDIX 7: PROTECTION OPTIONS

Project ID	Project Type	Description	Rationale	Opportunities	Status - Sept. 2016	Constraints	Preliminary work required	Key People	Resources
E1		Eco-neighbourhood	Raise awareness among estuary residents of their responsibilities to ensuring a healthy estuary and shoreline through a process that creates community-based stewardship with aspects of community accountability	Pamphlet/flyer on eco-neighbourhoods developed: Outlines what it means, what it is, people responsibilities in an eco-neighbourhood	Unchanged. Although Betty Donaldson did complete an Estuary Residents Survey "The Gathering Place" in 2011: https://drive.google.com/file/d/13o26hGdwOFSclNgfutkoV1dyTZPUDxXHsBOJS_XyGH8K_iXI408NeW5Yxa5F/view				
E2	Landowner Contact	involvement of farmers	Farmers, especially those that operate on the estuary flood[plain, have the potential for huge impacts on estuary function, both positive and negative. Positive in that their land use prevents encroachment of higher impacting land uses to the area, and negative when their operation disturbs the estuarine ecosystems (ex land clearing, fertilizer use, water withdrawal). Therefore increasing their awareness of the estuary and their influences on it is of high importance.	There is a Fish, Farm, and Forest Forum that brings together people of shared and sometimes conflicting views to help resolve issues around the environment and fish and farming industries. Since there is legislative powers that can limit farmers (and foresters) ability to carry out their business, there is an interest on their part to learn more about their responsibilities and prevent charges under the Fisheries Act.	Unchanged.	The Right to Farm Act helps to protect farmers interests, and sometimes comes into conflict with environmental protective measures such as riparian buffer protection. There is a history of conflict between environmental protection organizations and farmers, which can make it a challenge to come to a consensus for both farmers and conservation interests.	Participate in, and encourage farmers participation in, the Fish , Farm and Forest forums as they come up.	Estuary Working Group, other conservation organizations in the Comox Valley, farmers that operate in watersheds of the Courtenay River estuary, especially those located along the estuary floodplain.	
E3	School Programs	Build relationship with schools	Children in schools are future residents, business leaders, and politicians of the Comox Valley and other areas that also have estuaries. By helping to develop understanding and awareness in schoolchildren, the future health of the estuary will be better represented by them. In addition, teaching children also teaches the community, through their families and schools.	Mix music and learning about the estuary through an "Estuary Ensemble" course in Schools.	In progress. Students from Royston Elementary were invited to help out with the saltmarsh planting at Royston in 2015. Project Watershed is looking at developing a broader education initiative.			Local Conservation groups, elementary and high school educators.	
E4		Fish Trap Recreation	This is an educational endeavour for all participants, including the organizers. By re-creating the technology of an ancient fish traps in the estuary, people will learn about this ancient technology and gain appreciation for the historical importance of the salmon resource in culture and food. This will help foster greater stewardship through connecting culture, technology and biology.	Partner with K'ómoks First Nations to build and operate a fish trap (link with National Heritage Site, option # LA7)	Completed. A model fish trap was built as part of the 2016 "Keeping it Living" campaign.	This project will require special permits and support from various agencies to implement. Planning will need to ensure that any structures built in the estuary do not cause harm or death to fish and fish habitat. Any waste (e.g. nets) must be handled carefully so it is not left in the environment following the activity.	Consultations and partnership building. Research into design and methodologies. Site selection. Public relations.	K'ómoks First Nation, Fisheries and Oceans Canada, experts on ancient fish traps (i.e. KFN Traditional knowledge, Nancy Green)	K'ómoks Traditional knowledge, Nancy Green. Fish collection permit processes.
E5	Cultural Programs	Designation of the estuary as a National Historic Site	The historic fish weirs are very extensive in this estuary, and are the main driver for achieving a heritage site designation. This designation would result in better protection and national/international awareness of the estuary. It could increase the economic value of the estuary in terms of the tourism dollars it would bring into the community.	Possible goals could include the establishment of a museum, interpretative and research centre and the restoration of some of the fish traps. Opportunity to partner with the Economic Development Council.	Inactive. National Historic Site committee was formed in 2011, but is no longer meeting.	A heritage site designation could limit opportunities for restoration projects that may have an initial disturbance on the estuary, though are meant to restore and/or enhance estuary function.	Obtain support from the K'ómoks First Nation, and write to the National Heritage Board.	K'ómoks First Nation, Estuary Working Group, all levels of government.	
E6	General Public Education	Estuary Interpretative Centre	Education of citizens and tourists, Increased eco-tourism and tourism dollars (dollar value of estuary more quantifiable for community)	CVNS is interested in ethnobotany and is looking for legacy projects so they may be interested in being involved in this sort of idea. This centre could provide training and job possibilities for Comox Fist Nation people. Getting the Estuary recognized as a historical site would help build the profile of this centre.	Unchanged.	High costs and energy associated with acquiring appropriate land to do this (ideally near estuary), and to build.	Identify support for this project through joint partnerships and dedication of money/resources. Clear identifications of goals and objectives. Conceptual ideas and committee dedicated to carry through with project once partnerships are established.	K'ómoks First Nation, Estuary Working Group, local government.	
E7		Gala Evening		Build on the past success of gala events by hosting one on a biannual basis.	On-going. Gala events happen once a year as part of the Keeping it Living campaign.	High organizational commitment, funding requirements	Review successes/problems associated with past events and organize based on these and on opportunities for ensuring the greatest success of anticipated outcomes. Have an organizing committee dedicated to delivery of Gala event.	Estuary Working Group, Businesses (for donations), community	Reports on past gala events, estuary projects recently complete or underway, "crowd draw-ers" (ex entertainers, artists), volunteers
E8		Walkabout		Host regular "walkabouts" that identify key areas of interest for protection and restoration in the estuary to people that will support it in some capacity.	On-going. Estuary tours have been put on for the BC Nature AGM, the North Island College - Emily Carr program, and occasionally as part of the Keeping it Living campaign. However we have not specifically targeted people that will support the estuary in some capacity.	Moderate organizational commitment and follow up essential (reporting of activities and results)	Through regular EWG or other meetings, identify where there is a need for a walkabout, and key people to deliver and report on it.	Various estuary stakeholders, Estuary Working Group	Sites of high priority for restoration and protection
E9		Shoreline event (shoreline cleanup)		Join in on annual shoreline clean up events that occur across Canada, advertised and facilitated by Loblaw's Inc. "Great Canadian Shoreline Cleanup ", based on the global shoreline cleanup event, the "International Coastal Cleanup".	On-going. Organized by Bill Heidrick (Project Watershed Outreach Director) each year.	Will involve an organization committee to deal with volunteer recruitment, media, organization of locations and activities, and garbage disposal. Some expenses will apply.	Register to become part of the national cleanup event at http://shorelinecleanup.ca . Set up an organizing committee. 2010 shoreline clean-up took place in September.	Stewardship groups, local government, community groups, Estuary Working Group	Great Canadian Shoreline Cleanup website and resources
E10		Workshops	Events that engage the public will help to raise awareness of the estuary and how people can protect and restore it. Outcomes include building volunteer capacity, gaining revenue for project implementation through direct donations, purchases, and prizes, and increased awareness and support of other protection programs such as land acquisition, voluntary incentives and regulatory incentives, and increased support for restoration projects. Indirect outcomes may include citizen monitoring and reporting of issues in the estuary.	Deal with issues such as the invasive plant problem in the estuary by hosting workshops that teach community members how to identify the problem and deal with it/monitor it.	This work can be taken on by the Coastal Invasive Species Committee.	Moderate organizational commitment and follow up essential (reporting of activities and results)	Identify experts to teach workshops, areas/species to focus on for removal. Logistics (dates, locations, etc.)	Estuary Working Group	Coastal Invasive Plant Committee, Ducks Unlimited (Janine Bond), local experts (ex Michele Jones)
E11	Events	Awareness Forum		Opportunity to bring together all of the various estuary programs in one place to achieve the goal of community involvement and awareness. Since projects change and develop from year to year, this could be an annual event that will help maintain and spark new interest in the estuary. It will also be an opportunity to bring together organizers and participants of the various programs and projects together in one place to share ideas and experiences. Participants, including politicians, can make official pledges at the forum to take action to protect and restore the CRE.	On-going. Estuary Symposium follow-up event planned for 2018.	High organizational commitment	Review successes/problems associated with past events and organize based on these and on opportunities for ensuring the greatest success of anticipated outcomes. Have an organizing committee dedicated to delivery of the Awareness forum.	Estuary Working Group, Businesses (for donations), community	
E12		Keeping It Living campaign	Through regular postings on the Keeping it Living website and media releases, the estuary can be kept in the radar of the public with relatively little effort. This helps to involve/inspire a broad spectrum of people through art and creative writing.	Regular media releases of programs, projects, estuary art, creative writing and estuary facts.	On-going via Project Watershed outreach.	Moderate organizational commitment and follow up essential (reporting of activities and results)	Already underway by Project Watershed. Continue to seek funding through agency and individual donations and grants to ensure programs are sustained.	Project Watershed, Estuary Working Group	Project Watershed
E13		Videos	Visual education of the estuary and the programs out there to restore and protect it.	Develop videos to be presented on social media websites (ex. you tube), on the Keeping it Living website, on Shaw TV, and at various public events.	On-going. Three new videos produced through the Emily Carr "Pieces of an Estuary" program. CVAG Youth Media participant is currently working on a new video for the estuary.				
E14	Media	Website	Website is a gateway for all of the projects and programs. Monitoring visits to the website provides a measure of interest in the estuary, which can be valuable when applying for funding.	Continue to maintain existing "Keeping it Living" website, get feedback from users of the website, and keep it active and interesting with new postings and artwork.	On-going.				
E15	Mapping	Regular updating of marine resource and features, tenure mapping, and plant communities.	Mapping provides a method to identify restoration and protection needs, a visual educational tool, and a way to monitor impacts of development and evaluate the success of various conservation programs. It also is an effective way to present information essential for land use planning, and the designation of the estuary as a Wildlife Management Area and as a National Heritage Site.	Project Watershed has established the Mapping Centre (MC) at the Stewardship Centre to provide community mapping services. The MC has up to date maps and has collected a wealth of information on estuarine habitats, development, streams, up to date aerial photos and other mapping resources that provide a foundation for future projects. Some mapping and inventory can be done by volunteers.	On-going. The eelgrass and shoreline vegetation mapping has been completed. This mapping information is now housed in the interactive map of the estuary. Funding is needed for on-going maintenance and updating.	Maintaining and updating maps requires consistent, reliable funding to maintain the overhead and staff, as well as the cost associated with collecting up to date information.	Currently (2011), there are several gaps identified and prioritized for mapping requirements in the estuary. These include up to date shoreline vegetation maps, and detailed eelgrass bed mapping.	Project Watershed Mapping Centre, Estuary Working Group	Project Watershed Mapping Centre, Community Mapping Network, CVRD's i-map

Project ID	Project Type	Description	Rationale	Opportunities	Status - Sept., 2016	Constraints	Preliminary work required	Key People	Resources
LA1				Billie Brothers property(beside the Nickel Brother's): they may accept less than market value if they could get a tax receipt for the difference	Unchanged.	cost	Identify opportunities for providing a tax receipt for purchase, identify site priority in relation to other opportunities for purchase (i.e. environmental value of site)	Billie Brothers, Estuary Working Group Land Acquisition Task Force, Revenue Canada	
LA2				Field Saw Mill: City of Courtenay interested in purchasing this site for protection with help of partners	On-going. Project Watershed is working towards the acquisition of the site.	cost, site has been heavily impacted by past development so there will be future costs with its remediation.	establish a partnership in the purchase of this site, prepare a Terms of Reference for its purchase and subsequent restoration goals and acceptable/unacceptable use of the property following restoration.	City of Courtenay (Peter Crawford), Estuary Working Group Land Acquisition Task Force.	Comox Valley Land Trust , City of Courtenay, BC Hydro
LA3		Purchase sensitive areas that are up for sale around the estuary (linked to Project #LA7)	Will ensure sensitive lands around the estuary protected from future development impacts, and allow for previously impacted areas to be restored	LaFarge property: barge dock and adjacent land owned by currently unoccupied by Lafarge. Lafarge has a history of restoring land to viable habitat and may be open to do so for this site.	Unchanged. Although the Estuary Working Group, through Don Castleden, have recently been in touch with Lafarge about this property.	Lafarge is a large company based out of France, which makes communications difficult. Currently for sale, therefore time is of the essence in case purchased for interests other than restoration and protection.	open up communications with Lafarge to express concerns/hopes for the site	Lafarge, Estuary Working Group Land Acquisition Task Force, Revenue Canada	Letter sent to Lafarge from EWG January 28th 2011
LA4		Acquire public control of unused private marine tenures for restoration and protection	Many leases that have yet to expire and have historically impacted the health of the estuary but are not longer active. Acquiring responsibility of these areas will ensure they are not returned to active use and will provide an opportunity to remediate them.	Apply for and acquire lease, get funding, restore or remediate the site, and once lease is up, return it to crown . Would facilitate provincial funding for restoration of previously impacted marine areas. Nature Conservancy looking for an opportunity for a pilot project to do this type of project. Various inactive Interfor leases make good candidates for this.	These have been applied for under the Wildlife Management Area application.	Government held tenures have the reputation that they should be looked after by the government other funders don't want to put funds towards this. High costs of remediation, as sediments heavily impacted by bark and possibly other contaminants.	Consultations with Land Conservancy and provincial government, identification of priority sites to target for this type of project, research into requirements for marine tenure application/transfer.	Katie Blake, Nature Conservancy. Scott Northrup (Fisheries and Oceans)	BC crown land tenure application process.
LA5		Comprehensive land acquisition plan	An adaptive comprehensive plan required to establish goals and objectives for land acquisition and guide its process.	Large interest in the estuary by various land and water managers, important to involve them in this process and to ensure that all parties are assigned and held accountable to specific tasks and to be a part of a regular (ex annual) review process.	Unchanged.	Many demands on different levels and forms of government that would be involved in this, with lack of funding to carry out activities for many. Therefore important to keep the spotlight on the estuary for both the public and the politicians (linked to education programs)	Bring together all the players and develop a terms of reference for plan development, including scope, goals and objectives. Compile available information on the estuary to develop an overview and formative background as to drainage, rain, sea level rise, ecosystem values etc.	Will Marsh, Alison Mewitt, Graham Fowler (Ducks Unlimited), Art Martel and Ernie Sellentin (Comox Valley Naturalists). a hydro geomorphologist , the Agricultural Land Commission, The Nature Conservancy, The Nature Trust of BC, BC Hydro	
LA6	Land Acquisition	Return to Crown any leases which are no longer used.	Will prevent future impacts associated with operation of leases, such as log storage, dredging, etc.	Designate the estuary as a Wildlife Management Area, which will protect any unoccupied Crown Land. As the leases retire to crown land the protection would extend to these areas as well. (see Project # LA8)	These have been applied for under the Wildlife Management Area application.	K'ómoks First Nation has an interest in expanding its shellfish leases in the estuary.	The process has been started to have the estuary declared a Wildlife Management Area. K'ómoks First Nation agreement needed.	Ministry of Environment, K'ómoks Fist Nation, local governments	
LA7		Designation of the estuary as a National Historic Site	The historic fish weirs are very extensive in this estuary, and are the main driver for achieving a heritage site designation. This designation would result in better protection and national/international awareness of the estuary. It could increase the economic value of the estuary in terms of the tourism dollars it would bring into the community.	Possible goals could include the establishment of a museum, interpretative and research centre and the restoration of some of the fish traps. Opportunity to partner with the Economic Development Council.	Unchanged. National Historic Site committee is no longer meeting.	A heritage site designation could limit opportunities for restoration projects that may have an initial disturbance on the estuary, though are meant to restore and/or enhance estuary function.	Obtain support from the K'ómoks First nation, and write to the National Heritage Board.	A committee has been established as part of the Estuary Land Acquisition Task Force to begin this process and includes Project Watershed, Comox Valley Regional District, City of Courtenay, Town of Comox, K'ómoks First Nation, Comox Valley Economic Council, Chamber of Commerce, local and federal politicians, and other experts	
LA8		Designation of estuary as a Wildlife Management Area	Will afford greater protection through access to additional tools under Section 4 of the Wildlife Act.	Courtenay River estuary is the highest priority site on Vancouver Island for a Wildlife Management Area designation.	On-going. A Wildlife Management Area application for the K'ómoks Estuary has been submitted to Front Counter BC by Tim Clermont.	May restrict recreational use that may disturb migratory wildlife, thus may not receive full community support.	Currently in process, with Nature Trust's Tim Clermont (Crown Land Securement Partner Program Coordinator) heading actions to achieve this designation on behalf of the Ministry of Environment and/or the Ministry of Natural Resource Operations and conservation partners (DU, CWS, HCTF, MoE, and TNT).	Ministry of Environment, Ministry of Agriculture and Lands, and the Ministry of Natural Resource Operations: all three local governments, K'ómoks First Nation, and The Nature Trust BC	BC website on Wildlife Management Areas: http://www.env.gov.bc.ca/bcparks/explore/wma/
LA9	Land Designation	Complete and implement the new Courtenay River Estuary Management Plan presently under development by the Comox Valley Regional District.	Will provide an overall plan for land use and protection of sensitive habitats.	Provide a long term development plan to guide the community in regard to properties in the area of the estuary.	On-going. The K'ómoks Estuary Management Plan has not yet been ratified, and it's ratification and implementation is now being led by the K'ómoks First Nation.	The support of the community, local politicians, K'ómoks First Nation will all be needed to see this plan implemented.	This plan is already well developed and nearing expected completion in 2011.	Oceans Canada, Ministry of Environment, Ministry of Agriculture and Lands, The Nature Trust of BC and Ducks Unlimited, Project Watershed, Courtenay and District Fish and Game Protection Association, Town of Comox,	ECL Envirowest Limited original CREMP document from March, 2000: http://www.comoxvalleyrd.ca/cremp/
LA10		Establishing an account for land acquisition	Will provide an account dedicated to accept donations and funds dedicated to purchase of lands deemed sensitive to the estuary, and if in sufficient amounts will allow for purchases of these lands as they come up for sale, thus preventing their purchase by some one who might not use them to restore or protect the estuary.	Create a Estuary Land Acquisition Fund. Can acquire funds from different funding agencies (see "Resources"), or from donations from the public, including setting up the option for monthly direct deposits, raffles, and money raised during educational events. May also be used to collect funds collect as part of the "property tax" project (Project # LA7). May also use "Blue Carbon Credits" program as a funding source (see project #V1)	COMPLETED. Project Watershed has a designated land acquisition fund.	requires a significant amount of administration time and would require a person be dedicated for this. Where funds come from a tax base there is likely going to be some government control over the use and distribution of these funds.		Estuary Working Group Land Acquisition Task Force	Pan Munroe: administrator for the Comox Valley Land Trust, o subsection 149.1(8) of the Income Tax Act,
LA11	Fundraising for protection	Initiate a referendum for a new property tax to go towards the purchase land for preservation. Align with a strong education component.	The cost of land acquisition for protection will be shared by all property taxpayers, thus lowering the cost per person with benefit for all.	Combine this project with the Estuary Land Acquisition Fund as the manager of the funds.	Unchanged. Low Priority.	Commitment and will from the politicians to support this endeavour will be needed	look at the list of parcels of land that have been rejected from the parks plan by the CVRD. Linking these purchases to improvements like a walkway around the estuary will help build support in the community. Presentation to the various regional committees and councils as well as press releases.	Estuary Working Group Land Acquisition Task Force, Comox Valley Regional District, City of Courtenay, Town of Comox, Village of Cumberland	Potential funders include: Habitat Conservation Trust Fund, Canadian Wildlife Federation, Habitat Stewardship Program

Project ID	Project Type	Location	Description	Rationale	Opportunities	Status - Sept. 2016	Constraints	Preliminary work required	Key People	Resources
V1		Estuary-wide	Estuary Conservation Offset program	By attaching value to the estuary's capacity to absorb carbon dioxide, programs that acknowledge external environmental costs associated with development within and outside of the estuary can be implemented that focus on recouping those costs and applying them to the benefit of the environment.	Growing awareness of external costs of human's activities on the environment has created a market for carbon offsets, which could be used as a source of revenue to fund conservation activities such as eelgrass and saltmarsh protection and restoration. Potential to associate credits for the estuary with existing credit offset programs, such as the province's "Pacific Carbon Trust", or the Land Trust Alliance's "Living Carbon Investments Ltd." In addition, local government support likely as they have pledged through the BC Climate Action Charter to reduce GHG emissions to a defined target by 2012.	Unchanged. Medium priority.	An ethical consideration is that the sale of carbon offsets will support activities that result in environmental costs beyond that offset by the value of the credit.	Based on rationale in the Blue Carbon study by the Sierra Club, carry study that places values on key habitats in the estuary. In particular, consider an initial valuation of the eelgrass and saltmarsh habitats based on information from Sierra Club's "Blue Carbon" publication. Identify the Risks and Benefits of developing a carbon credit program from these values.	Land Trust Alliance Living Carbon Investments program, Sierra Club, Province of BC, local municipalities.	Land Trust Alliance document: "Conservation Offsets" (author Briony Penn), Sierra Club "Blue Carbon" publication (Colin Campbell), BC . BC Pacific Carbon Trust website.
V2	Financial incentives	Estuary-wide	Estuary Valuation program	By attaching a value to the services provided by the estuary the real worth of the estuary will be recognized by the community.	Growing awareness of the services provided by the estuary in its natural state which must be provided at cost by the community.	Unchanged. Medium priority.	The program only addresses the services directly provided by the estuary.	Ecosystem services evaluation by a competent authority (i.e.: University or Urban Studies School)	Partner institute, local municipalities, Province of BC	Ecosystem Services literature.
V3	Land dedication/donation	Estuary-wide	Guide landowners to protect their land through stewardship agreements, covenants, selling and bequests, and combinations of these options.	Many incentives, such as tax breaks and knowledge that lands will be protected in perpetuity exist, though not very well understood by landowners and land protection groups.	A very useful tool has been developed specific to the Comox Valley by the Millard/Piercy Watershed Stewards that helps to guide landowners on their options to protect their lands, along with benefits and issues	Unchanged. Medium Priority. Prephaps Nature Conservance of Canada could lead this initiative.	Mostly targeted for landowners that already value the natural features of their land and wish to conserve them. Some options for landowners that do not, such as tax breaks, but these are limited.	Identify people/committees that will familiarize with the land protection options, and develop a program that identifies candidate landowners, and educated them on their options.	Comox Valley Land Trust, Nature Trust of BC, Ducks Unlimited, The Nature Conservancy of Canada, Estuary Working Group, Land Protection consultant, Environment Canada Ecological Gifts Program.	Millard/Piercy Watershed Stewards Land Protection Options brochure (2009)

Project ID	Project Type	Description	Rationale	Opportunities	Status - Sept. 2016	Constraints	Preliminary work required	Key People	Resources
R1		establishment of a 30m riparian shoreline buffer around the estuary	zone for shoreline protection is essential to help both protect shorelines and ensure ecosystem processes and functions, such as sediment transportation and riparian shading, are maintained. The alternative is a piecemeal approach, where individual properties implement shoreline modifications which can impact both the environment and adjacent properties if not designed correctly.	Apply minimum estuary shoreline setbacks of 30m where no development can occur for all jurisdictions bordering the estuary through zoning bylaws. For this same area, develop a comprehensive shoreline protection plan. Possible to increase support for this by ensuring rights of way for public access are considered as part of this process.	Unchanged. High Priority. A 30 m riparian shoreline buffer has been modelled in the interactive map of the estuary. Recent negative impacts to the foreshore area by private landowners (cutting of Garry oaks, armouring) demonstrate the need for such shoreline protection.	Does not address already development shoreline areas, however a comprehensive plan will be able to identify the cumulative effects of these areas on the estuary.	Identify areas where there is still at least 30m buffer of intact shoreline and target these to prevent encroachment. Work with current policy development processes occurring at the local government level to ensure setbacks are included in zoning process. Include these setbacks in the updating of the CREMP.	Estuary Working Group Land Acquisition Task Force, Comox Valley Regional District, City of Courtenay, Town of Comox	
R2	Shoreline Protection	Develop a comprehensive coastal shoreline protection management plan for the estuary.	Individual property owners and developers are concerned with protecting shorelines, usually without regard to the direct and indirect effects of shoreline protection on adjacent shorelines and ecosystem functioning. These effects can include accelerated erosion on neighbouring shorelines, causing a chain reaction until entire shorelines are protected with hard structures.	Where there are reviews and changes to policy documents, a multi-jurisdictional Coastal Shoreline Protection Strategy that includes a shoreline management zone and permitting process should be incorporated . This could be included in the current updating of the Courtenay River Estuary Management Plan, and referred to in individual jurisdictional policy documents (i.e. OCP's, LAP's, etc.)	Unchanged. High Priority.	The development of a Coastal Shoreline Protection Strategy can take a long time, in the meantime there are properties that are under threat of erosion with reactions by landowners to continue with the hardening of these shorelines. This is exacerbated by the increasing frequency of and intensity of storms that are occurring in the region.	Include discussions of a comprehensive shoreline management plan in the CREMP. Model shoreline processes in the estuary and identify areas of high risk for modification through shoreline protection.	Local municipalities, non-profit sensitive land-use planning groups (CVLT, CVCS, EWG), CREMP, Fisheries and Oceans(Scott Northrup)	Shoreline Protection in the Sunshine Coast Regional District & Roberts Creek Shoreline Bylaws
R3	Citizen Monitoring Program	Involve citizens to monitor water quality, construction phases of development, fish and wildlife in the estuary. Include a reporting protocol that links monitoring to enforcement.	Fisheries and Oceans enforcement capacity is stretched. By involving citizens in monitoring, then more opportunity to correct problems before they get too large, and will also to raise awareness of everyone's responsibility to protect the estuary and abide by protective regulations.	Through the various education programs and workshops, train volunteers to monitor specific aspects of the watershed, including important cues to watch out for and report (ex dead fish, turbid smelly water, etc.)	Unchanged. Medium Priority.	Follow up of results requires efforts of people other than the citizens doing the monitoring, though is essential to give a citizen monitoring program value. Potential for conflicts with private landowners/industry and conservation groups depending on how volunteers and the conservation group react to issues.	Terms of Reference for a each volunteer monitoring group, equipment maintenance and regular calibration (ex water quality monitoring), funds to deliver program, volunteer training, site selection.	Local conservation and stewardship groups, Fisheries and Oceans Canada or Conservation Officers (enforcement).	Case Studies by the Canadian Environmental Assessment Agency of Citizen Monitoring in the Comox Valley at: http://www.ceaa.gc.ca/default.asp?lang=En&n=C7B298F5-1&offset=13&toc=show