CARING FOR THE ENGLISHMAN RIVER ESTUARY

a Bio-Inventory and Volunteer Monitoring Project (draft)

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Introduction

Goals of the Project

In 2007 and 2008 an investigation of the Englishman River Estuary was undertaken with two goals in mind. One was to increase understanding of this unique and biologically important place. The Mid Vancouver Island Habitat Enhancement Society undertook to:

- compile what is known about the estuary
- identify gaps in baseline data and help to fill them
- develop methods suitable for long-term monitoring by an informed public
- continue comparison studies of patterns in the ecosystem over time and space
- involve public in the process of research and planning, as well as in management activities
- enhance connections between the public at large, the landowners in and around the estuary, and various volunteers, staff, professionals and elected officials working to protect the estuary
- increase a feeling of 'ownership' of the estuary and its management by the local population
- shift human behaviour patterns that affect the estuary so that what is normal and acceptable moves toward understanding, respect and protection of the estuary
- The other goal was to increase involvement of local citizens, professionals, landowners, and decision-makers, in the ongoing process of monitoring, protecting the estuary and its related nearshore areas. It was decided to involve as many people as possible in order to:
- compile what is known about the estuary
- elevate interest and responsibility for the estuary among the community as a whole
- get individual people looking closely and learning about the estuary, especially those living adjacent
- give long term continuity to the various monitoring projects
- incorporate local citizens knowledge in the planning process
- create a broad level of public acceptance and support for management recommendations

Estuary management planning requires data about plant and animal communities in order to manage for protection of remaining intact ecosystems and endangered species, as well as to rebuild all communities to their historic state. We believe there is positive correlation between the number of people informed *and* involved, and the potential for long-term success of any component of a management plan.

Estuary Location and Study Area

The Englishman River Estuary (49o 20' N, 124o 17'; UTM Zone 10: 406100 5464500) is located on the northeast side of Vancouver Island, British Columbia, entirely within the Regional District of Nanaimo. The western portion is within the City of Parksville and the eastern portion is in Electoral Area G of the Regional District. The estuary is at the mouth or delta of the Englishman River where it flows northwards into the tidal saltwater of the Strait of Georgia.

An estuary is a low-lying flat area where one or more rivers and streams enter tidal waters and where tidal saltwater enters the river mouth(s). The word estuary often refers to a semi-enclosed body of water. As such, the Englishman River Estuary is affected by the flows of the river and by the tides and currents of the strait, which has limited connections to the Pacific Ocean through Johnstone Strait to the northwest and the Strait of Juan de Fuca to the south.

The study area of this report is the delta of the Englishman River and it includes all the river channels, their streambeds, banks, bars, and islands; the tidal flats, marshes, foreshores, beaches, spits and dykes; and all of the forested floodplain downstream from the point where river water during a flood may overtop the banks and enter tidal water without returning to the river channels. All of the areas on the river that are likely to be influenced by flooding, currents, waves, accretion, erosion, or salt from the tidal waters of the strait are within the study area. For convenience, the study area was defined as spanning the area from just below the Island Highway Bridge down to the subtidal limits of where vascular plants like eelgrass grow.

In addition, shorelines, eelgrass beds and forage fish habitat that interact with the Englishman River estuary go far beyond the delta of the river, so it was decided that, for these parts of the inventory, the study area would include the nearshore area between Little Qualicum River and Craig Creek. Use of the term *nearshore* captures the backshore, intertidal and the subtidal zone out to 20-30 metres below datum, and so includes more than the word *foreshore.* It reflects an ecosystem approach to discussing shorelines and their interactions with life in the estuary.

Topography, Surficial Geology and Hydrology of the River System

The Englishman River system drains the northeastern slopes of a ridge from Mount Arrowsmith (1817 metres elevation) to Mount Moriarty; this ridge is approximately 27 kilometres from the Strait of Georgia. The watershed catchment area is approximately 324 square kilometres which includes the following tributaries and their catchment areas: the Englishman River mainstem 179 sq km), Morison Creek (36 sq km), the South Englishman River (83 sq km) plus Centre Creek (21 sq km), and Shelly Creek (5 sq km). The mean annual discharge of the river is 13.7 cubic metres per second. Flows vary from mean monthly summertime flows as low as 1.26 cubic metres per second (August) to mean monthly flows as high as 29.25 cubic metres per second in the cold and rainy season (December).

The river "displays large changes in flow, and maximum daily discharges can reach three times the highest mean monthly flow" (Blood, 1976). Clermont (1995) reports "an extreme high of 393 cubic metres per second" recorded on 26 December 1980. In November 2007, the authors noted the reverse side of this hydrological 'flashiness' when the water depth at the upstream end of the estuary dropped more than one vertical meter in the 16 hours following a rainfall event that may have been coupled with snowmelt at higher elevations. Plummer Road, where this anecdotal measurement was made, was just above the peak water level that was observed on that day. Upstream, in an almost annual event, fast moving floodwaters can make parts of Martindale Road unsafe to walk or drive.

The largest 7 lakes within the watershed have a combined total of 6.3 square kilometres which allows only limited regulation of flows between rainfall events and between wet and dry seasons. The largest tributaries of the system are described under Fish Use below.

In addition to surface water inputs from rain and snowmelt, the river is connected year round with groundwater, especially where it crosses unconsolidated glacial gravels and sands. Water that enters the river through springs and seepage is cooler than the river water in summer and warmer in winter, an effect that is important to fish. In other areas water is likely moving from the river into the ground (Blood, 1976; Fyles, 1963).

To understand why the river is intimately connected to groundwater requires some understanding of the contribution of glaciation to the surficial geology of the area. At the time of the most recent glaciation (the Fraser glaciation), ice covered the entire Englishman River area, except perhaps the summit of Mount Arrowsmith (Fyles, 1963) and an active glacier flowed down the Englishman River Valley (Holden, 1989). This ice laid down the Vachon Till and the Capilano Sediments, in many areas on top of the Quadra Sands which had been laid down earlier. The Englishman River valley now has roughly 30 m of glacial, marine, and fluvial deposits which are being eroded and transported to the coastal zone by the river (Fyles, 1963 cited by Holden, 1989). Some of these layers are permeable to water and others are less so. As the river moves to the coast, it cuts across these layers and, depending on the permeability, slope and hydrological pressures at each location, groundwater may enter the river as springs in one area and leave the river as groundwater recharge in another area.

During summer drought, which is common on the estuary, many plants are likely relying on groundwater. The water table over much of the estuary fluctuates, probably affected by rainfall, river flows and tides. A map of water table patterns on the estuary is included in the Tera report (1990). Recent mapping and modeling of aquifers indicate that complexity of aquifers increases closer to the estuary, and that there are three levels of aquifer at the estuary (Wendling, 2009. pers. comm.)

The gradient on the Englishman River averages under 1% slope from the tide line to the falls. Above that, the slope is often much steeper.

"It is possible that the Englishman River has been transporting greater volumes of material to the coastline. Increased logging activities in the watershed area will increase the runoff volumes and the rate of runoff; hence greater land erosion and greater volumes of material will be transported to the coastal zone. The offshore bars that have developed or grown may be an accumulation of extra river material which has not yet been relocated by the littoral process." (Holden, 1989)

At the estuary, inundation period and salinity regimes have significant effects on estuarine life including plants and fish. Water levels at any point on the river can change, mostly due to the river's response to the weather. Fluvial processes, such as flooding, erosion, and deposition, affect the volume of water flowing through any of the channels on the estuary. A side channel one day can be the main channel the next day. Changes can be gradual such as when gravel deposits build up and block one channel, or the change can be sudden, such as when the start of rapid erosion is triggered by a weather event.

Abandoned river channels can best be identified on older air photos because the channels have not yet been obscured by urban development. In 1949, the channel immediately below and east of the tower was the main river channel. In the period since then, the main channel of the river has been moving primarily east, away from what is now the viewing tower. In 1962, the large channel further east, which now bisects the central marsh, was at that time, the main river channel. In 1975, parts of the river were continuing to erode and meander east from that channel. By 1984, the main river channel appears to be split and in the process of switching channels again. Sometime after that, the switch occurred and, ever since then, the main channel has been near its present location in line with the tip of the present day spit on the east side of the river mouth. Meanwhile, erosion continues eastward from the new channel, carving at the estuarine marshes of the Big Island. (see photo)

Marine water levels, like river levels, are affected by meteorological factors. Atmospheric pressure and wind, rather than precipitation, cause increases in the marine water levels in the form of storm surges and wind setup. Marine water levels are also affected by the positions of the sun and the moon which can create exceptionally high "spring" tides. In addition, marine water levels can be affected by large climatic cycles such as El Nino events. For example, a temporary water level increase of about 20 centimeters lasted for several months on the north Pacific coast during the 1982 - 1983 El Nino event (Holden, 1989).

Some archeological evidence suggests that Vancouver Island may be rotating on its long axis. This large scale geological process might be creating a total change between west and east coasts of approximately 1 mm per year (Holden, 1989). Global warming might already be creating a difference of 1 mm of higher water per year through the associated rise in sea levels, although no reference was found to confirm this as a measurement . On any location which is flat and near sea level, such as the Englishman River Estuary, an increase of only 1 mm in the marine water level relative to the adjacent lands can, at times, mean longer inundation over a large area of mud flats and marsh.

Regional Climate

The climate is characterized by wet winters that are warm for this latitude and dry summers that are relatively cool because of the heat moderating influence of the Pacific Ocean. The mean annual temperature is 9.9°C. The mean temperature for January is 2.6°C and for July the mean is 17.8ºC. The average total bright sunshine is 1,913 hours annually. There are, on average, 295 frost-free days annually.

The actual temperature and rainfall measurements for any date and the average for any month can vary as frontal pressure systems move into this region from different directions. The mean annual precipitation totals 926.6mm (Anonymous, 1977). Boom and Bryden (1994) and Barnard (1990) used higher precipitation figures (963.9mm and 952.5mm

respectively) but none of these figures are specific to the estuary. On average, approximately 8% of the precipitation falls as snow (from Barnard, 1990) but it does not usually stay on the ground at the estuary for more than a few days. Precipitation occurs on an average of 168 days each year.

As a result of global climate trends, the study area is likely to become drier in the summer for decades or centuries into the future (Hebda, pers com, 2005). This would be expected to put stresses and limits on the growth of some native plant species, especially trees.

Oceanography

Because of the shape of the Straight of Georgia, "the prevailing winds over open water at Parksville are from the east and southeast; therefore, the dominant wave direction and resulting net littoral drift is toward the west and northwest" (Holden, 1989). Wind, waves and the resulting littoral drift also occur in other directions, but the net movement of material on the beaches and spits on both sides of the estuary is from the east and southeast to the west and northwest.

The ongoing river erosion of roughly 30 metres of glacial deposits (described in Topography above) is important to the formation and maintenance of the substrates of the estuary (the Englishman River fan). The Englishman River and its fan are now the principle source of littoral material that maintain the famous broad sandy beaches of Parksville Bay to the west of the estuary, states Holden (1989), but that littoral transport processes are sometimes relatively slow and the complete cycle of erosion and accretion which directs the movements of gravel bars and beach sand may take longer than a lifetime. In other words, as material moves down the river and into the tidal parts of the fan, it may take many years before the littoral transport processes of the strait can move it away.

Severe storms are infrequent at the estuary. The most likely period for them to occur is November to January. Storms that occur in December have the highest likelihood of causing coastal erosion because of the certainty of high "spring" tides for a few days every two weeks in December.

Vegetation

The Englishman River estuary is entirely within the Coastal Douglas Fir moist maritime (CDFmm) biogeoclimatic zone (Green and Kinka, 1994). As the estuary receives material from the watershed, the land surface there is expected to be slowly elevated and the land area to be expanded into what was once tidal water through the process of accretion. It appears likely that the vegetation continuously undergoes a natural succession of plant communities moving northward towards the straight over hundreds and perhaps thousands of years . This create bands of vegetation, the forest, shrub, and estuarine marsh, which can be further subdivided into high, mid and low marshes, with a subtidal zone below that. Each band or zone can be described and mapped separately.

The climax plant community on the floodplain/upland is coniferous forest with Douglas-fir (*Pseudotsuga menziesii*), Grand Fir (*Abies grandis*), Western Redcedar (*Thuja plicata*) and some Sitka Spruce (*Picea sitchensis*) dominant in the forest canopy. However, the forest canopy also includes Bigleaf Maple (*Acer macrophyllum*) and Black Cottonwood (*Populus balsamifera ssp trichocarpa*) and it will likely continue to do so as part of the disclimax (or possibly edaphic) climax plant community that is created on the floodplain by disturbances

from the river, from wind, and from ocean storms. Since the estuary is within the Coastal Douglas-fir Biogeoclimatic Zone, it can be assumed that disturbance by fire is another important process that has prevented succession in the flood plain forest from moving towards a climatic climax.

The shrub layer within the forest zone is dominated by one or more of Salal (*Gaultheria shallon*), Oregon Grape (*Mahonia nervosa*), Oceanspray (*Holodiscus discolor*), and Snowberry (*Symphoricarpos albus*). Near the river channels, Pacific Ninebark (*Physocarpos capitatus*) and Red-osier Dogwood (*Cornus stolonifera*) are common shrubs. Some early seral forest stands on the Englishman River Estuary are dominated by Red Alder (*Alnus rubra*) and Salmonberry (*Rubus spectabilis*).

A distinct shrub zone (or shrub/graminoid mosaic) exists between the forest and the marsh, where there is no canopy of full size trees. This area is dominated by Pacific Crabapple (*Malus fusca*) and Nootka Rose (*Rosa nutkana*), often growing side by side.

As one moves north towards the strait, the shrubs give way to patches of graminoids and forbs which coalesce into the treeless, shrubless, open areas of the estuarine marsh. The zones of marsh vegetation on the Englishman River Estuary can be described as High, Mid, and Low Salt Marsh, categories which primarily reflect elevation and salinity, based on the classification of MacKenzie and Moran (2004). For details about the plants and plant communities on the estuary, refer to the *Vascular Plants, Plant Communities and Ecosystems* section in this report.

As one moves east or west along the shoreline from the river mouth, the observed vegetation changes. The backshore continues to be Coastal Douglas Fir moist maritime biogeoclimatic zone with forests and native shrubs that overhang and provide shade and organic material to intertidal species.

On the beach itself, Dune Grass (*Leymus mollis*) and other grasses, and forbs such as Gumweed (*Grindelia integrifolia*) or Silver Burweed (*Ambrosia chamissonis*) are present which are adapted to, and stabilize the often well drained, dry and sandy soils above the intertidal zone.

The intertidal areas support plants adapted to a life spent in and out of salt water. The estuary and coastline areas within a few kilometres include Strait of Georgia beach habitat types from mud and sand to gravel and bedrock adjacent to deep water. Common forbs include American Saltwort (*Salicornia virginica,* knas sea asparagus when it is harvested for human consumption), and marine intertidal algae such as Rockweed (*Fucus spp.).*Common Eelgrass (*Zostera marina*) can be found on sand/mud substrates within the intertidal zone, and more so in the subtidal areas of the Strait. *Zostera japonica*is an introduced species of eelgrass that was not observed on the estuary but was found in nearby intertidal areas.

Fish Use

Fish species are termed anadromous if their life cycle includes migration from the tidal saltwater of the ocean into the freshwater of rivers, streams and lakes to spawn. To complete the migration, different species of fish depend on the estuary to varying degrees. Many anadromous fish species need the estuary to be accessible, clean and populated with food and also to provide opportunities for a gradual transition from fresh to salt and salt to fresh.

The Englishman River provides accessible habitat to anadromous fish up to the lower falls at Englishman River Falls Provincial Park, a distance of approximately 15 kilometres. Each of the larger tributaries also have their own fish barriers (Morison Ck has Triple Falls; Englishman River South fork has South Fork Rapids; Shelly Creek has the falls on Shelly Farm) thereby restricting anadromous fish to the lower reaches of this river system (Bravender et al. 1996). Shelly Creek is often effectively impassible to fish beyond the Martindale Road culvert, except during a flood. Nevertheless, the Englishman River system supports 7 anadromous species of salmonid. In addition, 2 of these species also have resident populations that exist both above and below the river's barriers to migration.

In the last 30 years, there have been significant changes in the use of the river by salmonids, including Steelhead (*Oncorhynchus mykiss*). Blood (1976) stated that, "The Englishman ranks as one of the top 30 steelhead streams in B.C. (based on angler catch)." Today, Steelhead numbers are very low, and of "extreme conservation concern" (Lill, 2002, cited by Lanarc, 2003). Salmonid enhancement projects have also affected the numbers and species proportions of other salmonid fish using the river and the estuary. An evaluation of the changes in fish use of the West Marsh Lagoon was done by Tutty et al. (1983).

Most of the shoreline near the estuary provides excellent spawning areas for Pacific Herring (*Clupea pallassi*).Fisheries and Oceans Canada have been conducting annual surveys regarding herring populations and spawning locations. The annual herring spawn plays a significant role in the ecosystem of the region. The spawn is a major seasonal food source for gulls, waterfowl, seabirds and marine mammals. Juvenile and adult herring provide food for larger birds and marine mammals.

Pacific Sand Lance (*Ammodytes hexapterus*), and other forage fish use the nearshore areas for living and spawning. Because there has not been a commercial fishery, little information was available on these species in general, especially habitat and seasonal use within the study area.

For details about the use of the estuary by salmonid and other fish species, refer to the chapters of this report entitled *Fish Survey and Water Sampling Reports 2007/2008* and *Nearshore Studies*.

Terrestrial Fauna

A variety of land animals use the Englishman River estuary. One group, the birds, has been

listed and counted on the estuary study area; the numbers give an indication of the diversity of all animals present. Dawe et al. (1994) found 113 species of birds and made reference an additional 49 species recorded on the Englishman River Estuary from other sources, including the authors' field notes, a study of passerine use by Martin and Fortune (1993), and Christmas Bird Counts by local naturalists up to that time.

In the latest management plan for the PQBWMA (Lanarc, 2003), the list of other species is mostly hypothetical based on data from the Little Qualicum River Estuary. Almost no information about terrestrial invertebrates on the Englishman River Estuary was found in the literature.

For a list of the species of invertebrates, amphibians, reptiles, birds and mammals (including slug, frog, snake, shrew, mouse, vole, beaver, rabbit, deer, otter, bear, domestic dog, domestic cat, human) observed during this study period, see the section on Terrestrial Fauna in the body of this report.

Dawe et al (1994) noted, "Domestic animals, particularly dogs and cats running free are invariably a significant threat to wildlife."

Some of the larger mammals such as beavers, otters, deer and bears are unlikely to remain on the estuary throughout their lives. Those with larger territories, such as bears, would likely enter and leave the study area more than once in a season; their place on the estuary dependent on their ability to move along wildlife corridors. The river bed itself remains available to animals but the riparian strip in some areas is narrow, unvegetated and close to human activity. East of the river, there are nearly contiguous forest areas stretching upstream to the Regional Park and beyond, but a potential barrier exists when wildlife moves from this defacto corridor and tries to cross the highway or moves under the highway bridge.

History of Estuary

Before written records, the natural boundaries of the estuary appear to have changed as the river changed its course many times over the millennia since the glaciers. Fluvial or glacio-fluvial deposits seem to be present from Parksville Bay to Craig Bay. "The active channel of the Englishman River has meandered over time from Rathtrevor Park to Parksville Bay" (Holden, 1989).

First Nations use of the estuary is recorded by the documented presence of an archeological site (DhSb-004), which is a midden in the vicinity of Shelly Road and Mills Road in Parksville. LeBaron also mentions an archeological site near the dyke. Although this study was not looking for signs of first nations use, there appears to be evidence of what might be another midden exposed by erosion in the estuary forest. The estuary of the Englishman River and all the major estuaries in the area were likely important to the inhabitants of that time (Dawe, 2004, pers.comm; Lanarc, 2003 sites Dawe, 1977).

At the time of first European settlement, approximately 150 years ago, the estuarine floodplain would likely have extended from somewhere in what is now the Parksville Community Park to somewhere in San Pareil or Rathtrevor Provincial Park. The first major efforts to alter the natural state of the estuary began in 1870 when 64.75 ha in the west half of the estuary were pre-empted for the purpose of agriculture. A farm house was build on the Flats in 1874. Fencelines from later farming efforts are still visible on the Big Island of the estuary.

The Community Park was conceived in 1925 and, through a grand cooperative effort, the period from 1947 to 1952 saw the clearing and development for the Community Centre and ball park (Parksville Museum, 2009) at the western edge of the estuary. These developments were early steps towards alteration and alienation of the western parts of the marsh, beach and spit habitats of the estuary, but at the same time, they were forerunners of the trend towards a broad public recognition and interest in the public values embodied in the privately owned waterfront properties of the area.

The Dogleg Slough separates the access road to the western spit from the natural estuary. Construction on it continued over a period starting around 1954 for the purpose of creating a Venice-like housing development (Ryan, 1991. pers.comm.). By 1962, it is obvious on an air photo (B.C. 5047 No.95, 1962). However, work on it must have continued. The Dogleg Slough appears to be in its present form on a 1975 air photo (B.C. 7760 No. 175, 1975) but the tidal connection from the Dogleg Slough to the big western tidal channel appears to be still changing.

The construction of the dyke that isolated the western portion of the estuary occurred in 1969, apparently to prevent tidal intrusion and reclaim the land from the sea. In 1979, that dyke was breached and the gap was spanned by a bridge. This reopened the entire western part of the estuary to the influences of tide and salt water and with them came the fish (Tutty, et al., 1983) and the estuarine marsh plants (Dawe and McIntosh, 1993). The bridge has since been removed and the gap widened.

The construction of the Mine Road Dyke, which started the process of alienating the eastern side of the estuary, was apparently done to facilitate the dumping and booming of logs, with all the associated habitat disturbance and debris on the estuary. The road/dyke and adjacent log booms are visible in airphotos of 1949 and 1962 (B.C. 814, No. 95 1949 & B.C. 5047 No. 95 1962). The dyke also has kept tidal and river water from entering 8.3 ha of shrub land that was once estuarine marsh. A study by Summers and McKenzie (1990) proposed that this dyke could be breached to increase habitat values but this has never been done.

The start date of the subdivision and development of San Pareil and Shorewood neighbourhoods on the western part of the estuary is not known but the marks of the present road network are visible in a 1962 airphoto (B.C. 5047 No.95) and a line of houses on the beach at the junction of San Malo Road and Mariner Way is apparent on the 1975 airphoto (B.C. 7760 No. 175, 1975).

The central forest area of the estuary appears to have been logged before 1900. Regrowth of a mixed deciduous/coniferous forest appears to have been well under way by 1949. Already at that time, the Shelley Road access through the forest was present, perhaps as a driveway to what appears to be building sites near the present location of the viewing tower; the exact location of the Hirst homestead and the fate of the buildings is not known to the authors. The forest area was operated as a campground for many years; a few camping stalls and the fire hydrants are still obvious among the regrowth.

The area of the estuary is now approximately 164 hectares of undeveloped land. The size before European settlement would likely have been closer to 275 hectares. Dyking and other human changes started reducing its size in around 1870 when it became one of the first parts in the entire region to be settled for agriculture. A line of fenceposts of unknown age is still conspicuous on Big Island in the estuary. A portion of the Parksville Community Park would likely have been the western part of the estuary at one time. Today the intact

estuary is separated from the alienated lands to the west (the community park) by the "Dogleg Slough" (4.5 metres in depth) which was dug in preparation for a Venice-like housing development planned for the 1950's or 1960's and by a filled area that was reported as 3.9 ha by Clermont (1995).

As a result of these developments, the sandy spit and beach habitat that once occupied both sides of the river mouth is now largely occupied by permanent houses and RV yards. This plant community has the least total area of any of the sensitive ecosystems in the Regional District of Nanaimo (Ward et al., 1998). In the forested part of the estuary, a campground was operated; the roads, fire hydrants and camping stalls can still be seen among the trees and shrubs.

Legal Descriptions, Ownerships and Tenures

The Englishman Estuary is known affectionately as the Parksville Flats, and thought of by many as the 'Stanley Park of Parksville', even though most of the land is not publicly owned. A comprehensive explanation of the legal details of the remaining intact Englishman River Estuary properties can be found in Clermont (1995) and earlier in Barnard (1990) and LeBaron (1976).

The Parksville - Qualicum Beach Wildlife Management Area "is managed by the Wildlife Program (Vancouver Island Region) of BC Environment." "Under the Wildlife Act, BC Environment has legal authority to use WMA's to protect critical fish and wildlife habitat." (Clermont, 1995).

Disclaimer

In this report, descriptions of activities undertaken and places visited are for information only. They do not constitute any kind of permission to enter private land and they are not a recommendation for anyone else to do these things. The reader is entirely responsible to obtain permission to enter private property, even to do research or control invasive species on the estuary lands. And of course, the reader is entirely responsible for their own safety.

Overview of Project Methodology

The goals of the project were to increase understanding of the estuary and to increase local community involvement. The rationale for these two goals is outlined in the *Introduction* section under *Goals of the Project*. Towards these goals, MVIHES decided to undertake an ecological inventory of the Englishman River estuary and some aspects of the related nearshore, in cooperation with volunteers. A report would present what was learned in a way that would be easily accessible to a variety of people. The report would consider changes that have occurred up to now, and expand the baseline of data for comparison with monitoring efforts in the future. This information would give practical ideas for managing human impacts on the estuary.

A planning meeting was held on 8th June 2007 for the purpose of discussing the proposed project with the major agencies and the Nature Trust of BC, the landowner organization. The usefulness of inventory work to add to the baseline data on the estuary and the possibility of long-term volunteer-based studies was discussed. Various methodologies were considered.

Gaps were identified in the baseline data that had been collected up to that point and plans were made to fill some of these. A priority was also given to any opportunities for collection of data that would allow scientific comparisons with the past. For example, an attempt was made to locate various vegetation transect lines that had been used 20 years earlier (Dawe and McIntosh, 1993). A copy of the relevant parts of the Kennedy thesis (1982) were obtained. Other data that might have been useful was not available such as vegetation data reportedly collected on the Englishman River by students in connection with the Pacific Biological Station.

Mid Vancouver Island Habitat Enhancement Society (MVIHES) decided to focus the estuary inventory work on the following: the quality of freshwater inputs, fish use, forage fish habitat, native vascular plants and plant communities, invasive plants and animals, eelgrass distribution, bird use, and special places on the estuary.

Work was to be done mostly by volunteers guided by paid MVIHES staff/contractors. The project was overseen by a project coordinator. Separate sections in this report include rationale, methods, results and discussion for each of the following sections:

Section 1 Fish Survey and Water Sampling Reports 2007/2008
Section 2 Vascular Plants, Plant Communities and Ecosystems
Section 3 Terrestrial Fauna
Section 4 Mapping Special Places and Features on the Estuary
Section 5 Invasive Species
Section 6 Nearshore Studies - Shoreline Inventory, Forage Fish and Eel Grass Mapping
Section 7 Public Involvement

Inventory work that began through literature review, consultations with experts, and field work in the summer of 2007, increased through early 2008 and reached a climax of field work in the summer of 2008. By October 2008, most of the data was in and the process of data entry, mapping and writing was foremost.

Section 1 ENGLISHMAN RIVER ESTUARY FISH SURVEY AND WATER QUALITY REPORT

1.1 Fisheries Goals And Objectives.

The Fisheries Goal is to make recommendations for a future Estuary Management Plan.

The Englishman River estuary has long been the subject of harmful human development. Its mudflats were scoured by historic log boom and sorting operations. Agricultural development added dykes, fill, pastures and non-native plants. More recently there have been several resort developments that scar the natural landscape with excavated ponds, building foundations, rip rap and removal of vegetation. The City of Parksville has designed several storm drains to enter the lagoon area while withdrawing river water just upstream of the estuary. Upland logging, farming and urbanization continue to influence the water quality and quantity that is delivered to the estuary.

There has not yet been a Management Plan to address these development impacts.

The Fisheries Objectives to accomplish this task are:

1. *Conduct a fisheries inventory of the estuary over the 2007 and 2008 period.*
2. *Incorporate public participation, education and awareness of the estuary fisheries resource.*

These objectives will bring information on the estuary to light as to what fish species are using the estuary. Determination of the fish species will provide direction on the habitat requirements, which leads to the activities required for habitat restoration in an Estuary Management Plan. The second objective will create the public interest in the estuary and help answer the question of how and who will get the Estuary Management Plan implemented. Training volunteers from the local community to be stewards of the estuary creates the support we need for a long-term approach.

SALMONIDS

Historically Chum (*Oncorhynchus keta*) and Coho (*O. kisutch*) salmon have been the two most dominant species. The Englishman River watershed is also inhabited by Chinook (*O. tshawytscha*), Pink (*O. gorbuscha*) and Sockeye (*O. nerka*) salmon. Steelhead Trout, Resident Rainbow (*O. mykiss*), sea run and resident Cutthroat (*O. clarki clarki*) are also present[1]. Steelhead populations are currently at severely reduced levels[2]. The provincial government has classified the Englishman River as a sensitive stream.

Salmon and some trout are anadromous species. These fish begin their lives in freshwater, migrate to estuaries as juveniles then on to various feeding areas in the Pacific Northwest while maturing, finally returning to the estuary to ready for their spawning entry to lay their eggs in fresh water and die. All use the estuary for varying periods for development as juveniles and returning adults

ESTUARIES

Estuaries are transitional areas between fresh and salt water. This environment is a place where salt water is diluted by freshwater flow. Fish species found here come from both fresh and salt water ecosystems and can tolerate these varying saline conditions. The chemical and physical characteristics of an estuary can change dramatically from day to day, week to week, and month to month. Because of that, it is important that the fish in these conditions can tolerate an ever changing environment. Consequently, this limits the number of fish species that can live in an estuary. Although the number of species inhabiting an estuary is limited, the high abundance of nutrients found there can support a large concentration of individuals.

Estuaries typically act as staging areas for anadromous fish, causing them to remain there for several days or weeks before finally moving upstream. Estuaries can also act as a nursery for young allowing some fish to spend the first few months to a year of their life in estuaries before heading off into the ocean.

True estuarine fish spend their entire life cycle in estuaries. The Shiner Perch (*Cymatogaster aggregate)*, Three-spine Stickleback (*Gasterosteus aculeatus)* and Sculpin species (*Leptocottus armatus, Oligocottus maculosus, Clinocottus embryum,* and *Ascelichthys rhodorus)* are able to survive in areas of varying salinity. The variety and high concentration of food found in an estuary creates an inviting ecosystem for these fish [3]. The Staghorn Sculpin (*L. armatus)* and Shiner Perch are two species that are considered estuarine - nondependent marine fish. These fish are commonly found near the oceanic mouth of estuaries but do not depend on it to complete their life cycles. Usually nondependent marine fish make up about half the species found in an estuary and are typically abundant seasonally or in areas with high salinity[4]. Estuarine dependent marine fish spend at least one stage of their life cycle in estuaries, using them as spawning grounds, as nurseries for young, or as feeding grounds for adults. Starry flounder (*Platichthys stellatus)* spawn adjacent to the estuary, so when their young hatch they will migrate into the nutrient rich estuary where they will feed and grow [5].

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[1] Brown et al. 1977
[2] Wightman et al. 1998
[3] Annand et al. 1993
[4] Moyle &Cech, 2004
[5] Moyle & Cech, 2004

1.2 Methods

1.2.1 Survey Area:

The Estuary was broken into areas determined by their physical differences with respect to tide and location. Four sample sites were chosen for this study (Figure 1.1) These sites included the Beach, Dyke, River, and Lagoon.

Beach Site: Located on the east shore of the estuary, the gravel beach is adjacent to the exit of the Englishman River. The beach has a flat aspect with a wide tidal area. The slope of the survey area is less than 1% gradient resulting in a long beach line that extends over 300m at low tide in the survey area. The substrate is primarily gravel and cobble with sandy pockets throughout. We sampled this site at low tides only. Access was through San Pareil to the beach parking lot at the end of the spit.

Dyke Site: A man-made fill of gravel, cobble and sand, built over 40 years ago, that bisected the upper intertidal marsh with the lower river and estuary. The Dyke was breached in 1981 and the opening is now approximately 30 m wide. Approximately 100 m of Dyke remains deflecting water away from the upper lagoon. The Dyke is partially vegetated (Crab Apple, Nootka Rose) and gradually eroding, resulting in areas only 2-3m wide on the top. The substrates of the adjacent wetted area are made up of a cobble/gravel edge with a flat sandy bottom approximately 15-20 m wide. The site was sampled at moderate to high tides.

River Site: The lower river channel is 25-30 m wide. It has a gravel/cobble substrate with shallow pools and glides when sampled at low tide. At low tide, all fresh water flows through this site. The bank edges are gravel and sand and there is virtually no instream cover other than the occasional boulder.

Lagoon Site: This area receives most of its upland water from Mills and Bagshaw Street storm culverts located 1.5km upstream at the top of the intertidal area. It has a 10m wide channel that tapers to 2m up at the storm culverts. Shallow perennial pools that are flooded every high tide, remain at low tide. The lagoon has a muddy substrate with a grassy sedge perimeter. We sampled fish at rising to high tide levels. There are large man-made pools excavated west of the Lagoon that are connected at high tide. These pools are perennial but not sampled due to limitations on access and equipment. Access to the Dyke, River and Lagoon was through the park gate at Shelly Road.

Figure 1.1 Map of the Fish Seining Sites of the Englishman River Estuary.

1.2.2 Survey Methods

Schedule: The survey schedule was determined in advance by selecting dates when we could begin at the Beach Site at Low Tide and then work our way up to the River, Dyke and finally, Lagoon sites at High Tide. The schedule was then published and emailed to the MVIHES Project Coordinator, Faye Smith.

Volunteer Coordination: Once field days were established, the sampling was lead by the project Biologist (Dave Clough, RPBio) or another environmental professional (Brad Remillard, BSc B.I.T, Boone Barber BSc, Jack Newman, Fisheries Technician). The MVIHES Volunteer Coordinator, Ronda Murdock, contacted volunteers before the sampling date. Faye was on-site to meet and greet the volunteers and direct them to survey areas. She distributed equipment among volunteers, provided drinks and snacks, as well as recorded data and took photographs.

A typical sample day would begin at the Beach at low tide. The number of volunteers ranged from 5 to 15 persons per sample site. They ranged in age from students to retirees, all with strong personal convictions about environmental stewardship. Volunteers were offered responsibilities before work was undertaken for duties such as; carrying the equipment, setting the net, removing the fish, recording data, taking pictures and water quality measures. The voluntary jobs were generally kept by the same people through the study. Training was done before sampling to familiarize volunteers on equipment and safe sampling techniques. Careful fish handling was stressed (maintain wet hands, avoid exposure of fish to sunlight, air or dropping on to ground).

Equipment: In 2007 we used a 6.1m wide rectangular shaped beach seine. In 2008 we had a larger net custom made that had an 11.2m wide opening that had a V shape to taper to a collection sock. Equipment used is listed below:

- Small Net - 6.1m wide & 1.2 m ht. ¼ inch mesh (green) with lead and cork lines.
- Big Net - 11.2m wide & 1.82 m ht. ¼ inch mesh (green) with lead and cork lines.
- Tow ropes – floating ½ inch nylon, tied to either net end, 4m long
- Wading staffs (2) – 2.0m by 1.5 inch diameter to support ends of net from folding in and for lifting lead line over debris while in tow. Also used as wading staffs.
- Large Collection Tub (50 l), with grass, leaves or kelp to calm fish.
- Fine mesh dip nets for sorting fish – 4-10 inch (4)
- Sorting tubs, buckets, length boards and viewing tanks
- Battery powered aerator, oxygen meter, thermometer
- Chest waders and PFD's for everyone near water
- Waterproof Camera, data sampling papers, GPS

Sampling: Sampling at each site took between 40 minutes and 2 hours depending on weather, tide, number of sets and fish captured. The sampling was undertaken by first running the net perpendicular to shore to the end or to the point the lead line is still attached to bottom. The shorter net (6m) was walked along the beach for the length of the net then turned to shore, essentially catching a 6m square area. The longer net (11.7m) was set perpendicular to shore. The deep end was swept in an arc back to shore around the shallow end pivot. Care was taken not to disturb the sample area prior to setting the net.

The net was retrieved slowly to ensure the lead line stayed on the bottom and the float side of the net stayed at the surface. Net pulling required 4-6 persons to maintain the opening and pull against the drag of bottom and current. We used wading staffs to support the sides of the net and push the lead line down as we hopped it over rough surfaces such as boulders. We also placed cobbles in the net to ensure the net stayed flush to bottom and had a bag in it rather than a tight stretch from lead to float line. The net was closed at the shore with the lead line and edges beached first. A belly of net mesh ballasted by rocks remained in the water to keep fish alive while being picked from the net. The net was picked by a row of 6 to 8 volunteers along the net opening, using their hands and soft mesh dip nets to remove the fish into the collection tub.

A large fish capture tub (50L), and several collection pails (20L & 4L) were filled with water just prior to sorting the fish. A volunteer assistant was designated responsible for the buckets being ready. They had clean water with seaweed for cover ready for arrival of fish. The water was monitored for oxygen and temperature to ensure it was kept at ambient conditions. We changed the water at 5 minute intervals with buckets so our battery powered aerators were never used.

Captured fish and invertebrates were identified, recorded, photographed and then released. We returned the fish to suitably deep water preferably located near cover habitat (plants or rocks). Depending on capture efficiency another set was done if the count was very low. Faye, or sometimes a volunteer, recorded on a data sheet the number of fish and species captured at each set and site.

1.3 Results

1.3.1 Total Fish Captured in 2007 and 2008 surveys.

The 2007 estuary survey resulted in a total of 326 fish captured during the sampling period of June and July. Table 1 shows the results with areas and times not surveyed left blank.

Table 1) Total Fish Captured in 2007 Sampling Period.

Year:	**2007**						
Site	**March**	**April**	**May**	**June**	**July**	**August**	**Total**
Beach				58.0	18.00		76
Dyke				6.0	97.00		103
River				42	39.00		81
Lagoon					66.00		66
Total:				106.0	220.0		**326**

In 2008 the sampling was conducted during the months of March to August and yielded a total 1329 fish captured in the estuary (Table 2).

Table 2) Total Fish Captured in 2008 Sampling Period.

Year:	**2008**						
Site	**March**	**April**	**May**	**June**	**July**	**August**	**Total**
Beach		20.0	111.0	124.0	15.0	16.0	286
Dyke	34.0	313.0	126.0	53.0	9.0	111.0	646
River	81.0	19.0					100
Lagoon	62.0		46.0	36.0	19.0	134.0	297
Total:	177.0	352.0	283.0	213.0	43.0	261.0	**1329**

1.3.2) Species Captured in 2007 and 2008.

We captured 20 different species of fish in the 2007 and 2008 surveys. They have been grouped into five fish categories according to the 1993 study . We captured fewer fish in 2007 than 2008 due to the shorter sampling period and frequency. Fish species are identified by location and date of capture in Appendix 1 for 2007 and Appendix 2 for 2008.

All Salmon captured were juveniles smolts with parr marks faint or non-existent. As noted, Sculpin species were the most common, with Staghorn Sculpins by far the most abundant (see Sculpins below). Fish were identified using several reference keys (Hart 1973)[6] and

[6] J.L. Hart. 1973. Pacific Fishes of Canada, Fisheries Research Board, Ottawa

(Lamb & Edgell, 1986)[7] and photos taken of any difficult to identify species for later confirmation. The Midshipman, Gunnels, Buffalo Sculpin and Tube Snouts were perhaps the most striking in colour and shape.

There was little mortality in fish handling. One Midshipman was stepped on as well as a few crushed shrimp from the rocks at the net bottom. All fish appeared otherwise to be in good health upon release shortly after capture (between 5 –20 minutes). No parasites or disease were observed on fish examined.

Table 2.1). Species Captured, Englishman River Estuary, 2007 & 2008.

Common Name	Species	2007	2008
Staghorn Sculpin	*Leptocottus armatus*		
Tidepool Sculpin	*Oligocottus maculosus*		
Calico Sculpin	*Clinocottus embryum*		
Rosy Lip Sculpin	*ascelichthys rhodorus*		
Buffalo Sculpin	*Enophrys bison*		
Total Sculpin		86	792
Shiner Perch	*Cymatogaster aggregata*	18	121
Three Spine Stickleback	*Gasterosteus aculeatus*	123	48
Starry Flounder	*Platichthys stellatus*		
Juvenile Sole	*Pleuronichthys sp.*		
Arrow Goby	*Clevelandia ios*		
Kelp Greenling	*Hexagrammos decagrammus*		
Pipe fish	*Syngnathus griseolineatus*		
Cling Fish	*Gobiesox maeandricus*		
Plainfin Midshipmen	*Porichthys notatus*		
Tube snout	*Aulorhynchus flavidus*		
Rockweed Gunnel	*Apodichtys fucorum*		
Total Other Fish Species		96	277
Pink Salmon	*Oncorhynchus gorbuscha*	0	71
Chum Salmon	*Oncorhynchus keta*	0	8
Chinook Salmon	*Oncorhynchus tshawytscha)*	2	12
Coho Salmon	*Oncorhynchus kisutch*	1	0
Total Salmon		3	91
Total Fish		326	1329

2.1 Sculpins

Sculpins were the dominant species captured at every site, comprising of over 45% of the total individuals captured in both survey years. Staghorn Sculpins comprised the majority of this group, with Tidepool, Rosy Lip, Calico and Buffalo found in low numbers. Amongst the survey areas, Sculpins were found in highest numbers at the River with 29 found in 2007

[7] Lamb, A. & P. Edgell, 1986. Coastal Fishes of the Pacific, Northwest.Harbour Publishing, Madeira Park, B.C.

and 497 found at the Dyke in 2008. The fewest Sculpins were found at the Dyke in 2007, with 3 found and 66 found in 2008 at the Lagoon. Sculpin numbers were highest earlier in the spring than the other top species. In 2007, the highest number of Sculpins found was in June with 55 individuals captured. In 2008, the highest number of Sculpins was in April with 342 captured.

2.2 Shiner Perch

Shiner Perch were not distributed evenly throughout the estuary. These fish were found in the open tidal areas. The highest numbers were found at the Beach in both survey years with 18 in 2007 and 65 captured in 2008. In 2007, Shiner Perch were not captured at the River nor the Lagoon. In 2008, the fewest Shiner Perch were found at the Dyke and the Lagoon with zero and two captured respectively. In 2008, 54 were captured in one set at the Dyke during high tide.

2.3 Three Spine Stickleback

Three Spine Stickleback were captured at every site, however their populations were not evenly distributed. Three Spine Stickleback were found in highest numbers at the Dyke with 75 found in 2007 and 44 captured in 2008. In 2007, the fewest number of Stickleback found was at the Lagoon with 8 captured. In 2008, the Lagoon and the River each captured a single Stickleback. Three Spine Stickleback were found in highest numbers in July in both years, as the new brood of the year emerged.

2.4 Other Fish Species

This grouping of fish was not distributed evenly throughout the estuary. The “other fish species” were found in highest numbers at the Lagoon in both survey years with 50 captured in 2007 and 165 captured in 2008. They consisted of Flounder, Sole, Midshipmen, Arrow Goby, Greenling, Tubesnout, Clingfish and Gunnel. The fewest number of “other fish species” was found at the Beach in 2007 with 11 captured, and at the River in 2008 with 2 captured. The highest number of “other fish species” found in 2007 was in July with 81 captured. In 2008, the highest number of “other fish species” found was in August with 120 captured.

2.5 Salmonids

Chum: In 2007, there were no Chum captured at any of the sites. In 2008, Chum were found only at the Beach site. A total of 8 individuals were captured in May (3) and June (5).
Chinook: Chinook were only found in two locations, the Beach and the Dyke. In 2007, two Chinook were found, one at each of the above sites. In 2008, Chinook were found only at the Dyke, with 12 captured. In 2007, one fish was found in each of the survey months, June and July. In 2008, the highest number of Chinook captured was in June with 10 captured.
Pink: Pink were found at every site, with a higher population at the Lagoon. The Pink salmon captured during the survey period were all found in 2008. In 2008, the highest number of Pink salmon was found at the Lagoon with 62 captured. In 2008, the highest number of Pinks captured was in March with 65 found. No Pink salmon were captured in 2007 which largely due to the short sample season and lack of a hatchery release in 2007.
Coho: Coho were not found throughout the estuary, with only one Coho was captured. This Coho was found at the Beach in June of 2007. In 2008, no Coho were captured at any of the sites.

1.3 Spatial Distribution of Fish within Sample Areas, 2007.

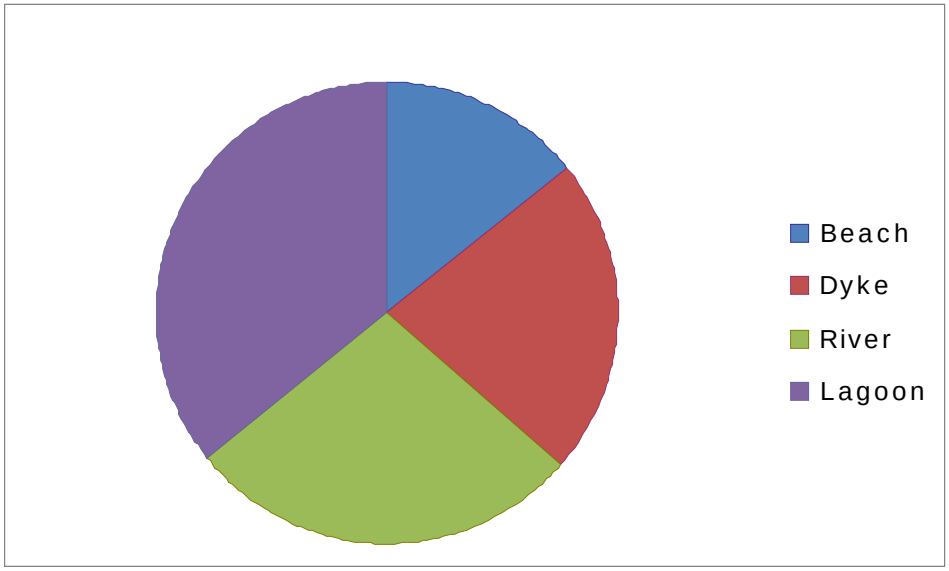
The sampling methods resulted in fish being captured by single or repeated net passes with the swept area calculated to determine the number of fish captured per square meter. The density of fish per square meter of net area for each location in 2007 is shown in Table 4 and Figure 2 below.
The average density of fish was 0.412 fish per square metre in 2007. The density of fish fluctuated between the two months surveyed with the overall trend towards increased fish in July over June.

Table 3.1) Fish density (F/m^2) at each site in 2007.

Site	March	April	May	June	July	August	Avg.
Beach				0.390	0.081		0.235
Dyke				0.081	0.652		0.366
River				0.564	0.349		0.457
Lagoon					0.591		0.591
Avg:				0.345	0.418		0.412

The Lagoon location had the highest fish density (primarily Sculpins). The lowest density of fish was at the Beach in 2007. Ease of fish capture may have played a role in the high numbers for the Lagoon site. We were able to stretch the net from bank to opposite bank blocking off the outside escape route of fish.

Figure 3.1) Total Fish Density (F/m^2) by Location, 2007.



1.4 Spatial Distribution of Fish within Sample Areas, 2008.

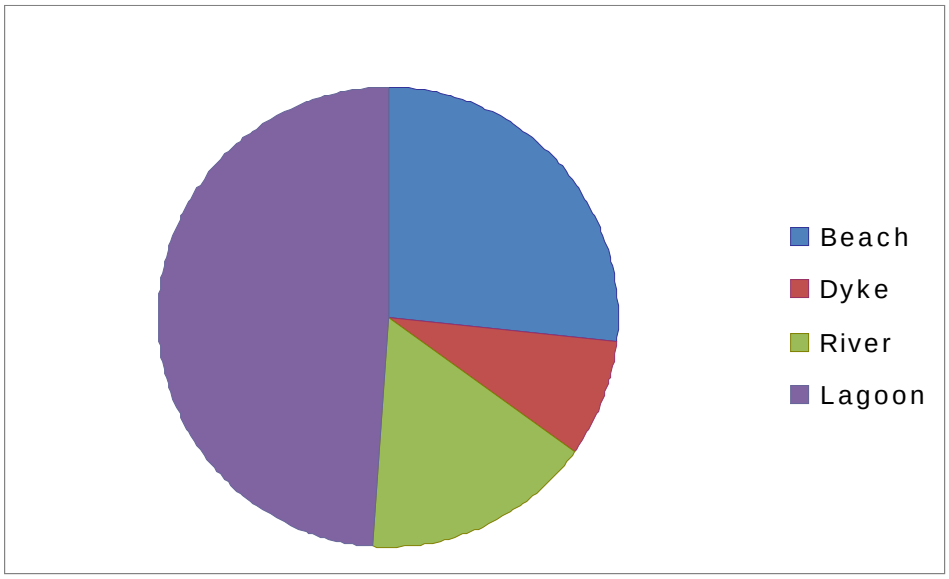
March and August were the months of highest fish abundance and the overall density was higher than the 2007 year. Figure 4 overleaf identifies the breadth of the salmon habitat distribution in the estuary.

Table 4.1) Fish density (F/m^2) at each site in 2008.

Site	March	April	May	June	July	August	Avg.
Beach		0.537	0.818	0.457	0.076	0.054	0.388
Dyke	0.152	2.804	0.320	0.269	0.046	1.127	0.786
River	0.544	0.170					0.357
Lagoon	1.666		0.467	0.183	0.193	1.361	0.774
Avg:	0.788	0.170	0.535	0.303	0.105	0.847	0.576

The 2008 results show the density of fish was greatest at the Dyke (Table 5 & Figure 3). The lowest density was with the River scoring the fewest fish. The Dyke is actively eroding and one day will wash away as the river takes its toll. This will likely change conditions in the lagoon area, which the Dyke segregates from the River.

Figure 4.1). Total Fish Density (F/m^2) by Location, 2008.

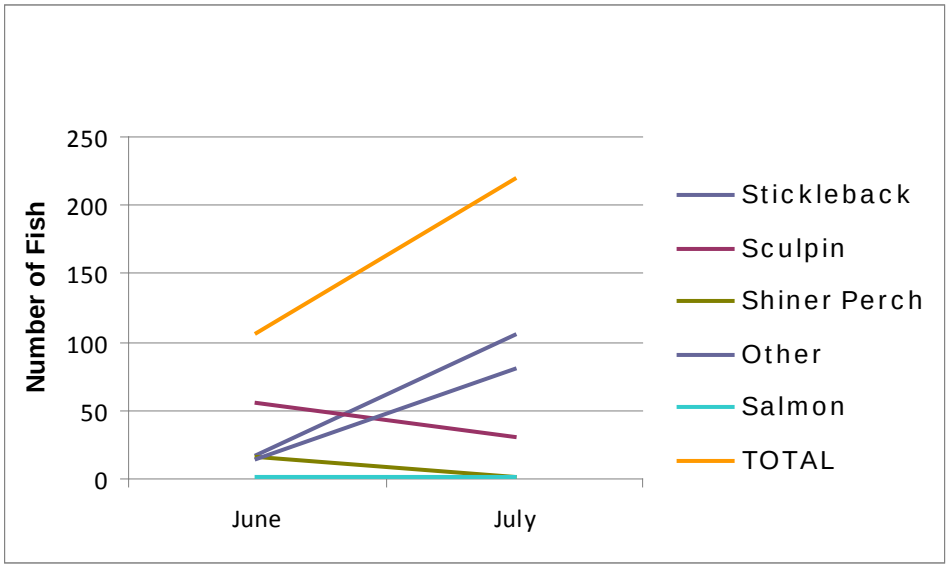


1.5 Temporal Distribution of Fish within Sample Areas, 2007 & 2008.

In 2007, only 5 sample days in June and July were done. The total number of fish at each site varied over time. The changing numbers reflected our observation of one species

becoming prevalent in the capture site. Stickleback or Sculpins would typically dominate one site over other species. It may be tied to their growth and maturity rates. Salmon juveniles (Coho & Chinook) were only captured in the June surveys.

Figure 5.1) Monthly Fish Abundance trends over survey period, 2007.



In 2008, there was sampling from March to August. The salmon juveniles were all captured from March to June with none captured in April, July or August. The highest number was Pink Salmon found on the March 30 set (62). The highest Chum count was on June 2 (5). The highest number of Chinook was on June 29 (10). No Coho were captured in 2008. In 2008 the highest single capture of fish was found at the Dyke in April with a total of 313 individuals captured. This 2008 sample consisted of four species: Threespine Stickleback, Sculpins, Starry Flounder and Arrow Gobies. A complete distribution of fish capture results is in Appendix 1 (2007) and Appendix 2 (2008).

Figure 5.2) Monthly Fish Abundance trends over survey period, 2008.

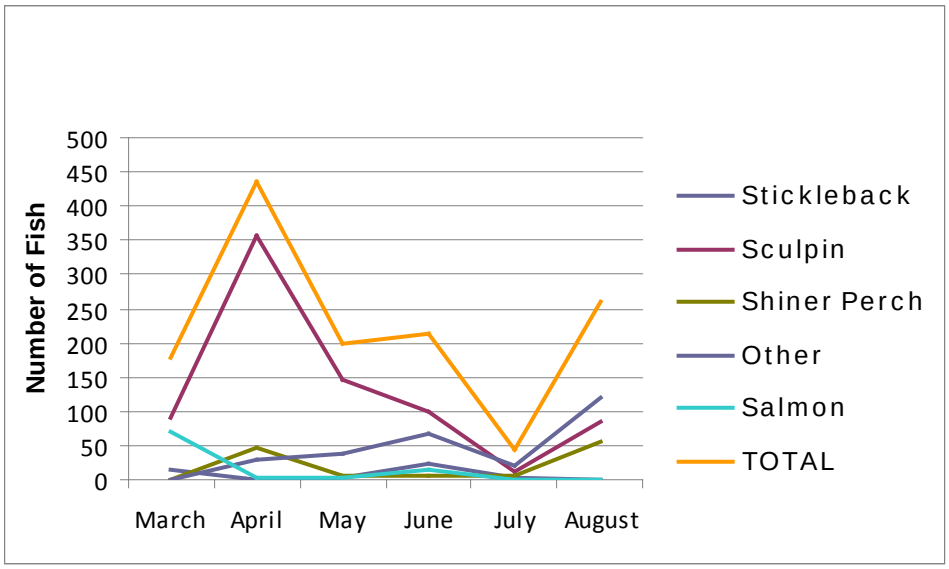


Figure 1.4.0: Salmon Habitat Distribution.

1.6 Water Quality

Water quality was sampled in the field with instruments during our fish captures, from grab samples examined by labs and Environment Canada monitoring in the river.

6.1) Field Water Sampling.

Our field water quality collections sampled each site for: Temperature, Conductivity, Dissolved Oxygen and Salinity in 2008. Only Temperature was sampled in 2007 due to lack of equipment.
The table below identifies the averaged values taken from multiple dates at each site, each sampling period. The results were highly variable and generally based on the tide and time of day. Generally we observed that 2008 was cooler than 2007. The Beach site with direct connectivity to Georgia Strait was coolest with highest salinity. The Dyke site had the lowest salinity as it was the highest site up the River and most influenced by fresh water. The Lagoon always had the highest Temperature and lowest Oxygen levels, again expected given that it was located in a semi–isolated area (behind the dyke).
No location had lethal water quality. The range of temperature varied from 7C to 23.5C with the seasons and tides. Oxygen, taken just below the surface, ranged from 7.1 to 11.6 ppm. The Salinity depended on tides, we had a high of 25% to a low of 0.5%. Conductivity generally followed Salinity levels except in the Lagoon, where Conductivity measures remained above 200*uS* when Salinity was 5%. This may be the result of retention of conductive elements (dissolved ions, particulates) behind the Dyke or influence from the two Storm Water discharge sources from city streets found above this location.

Table 6.1) Field Water Quality Measurements 2007 & 2008

	Temperature (C)		Oxygen (ppm)	Conductivity (*u*S)	Salinity (%)
Year	**2007**	**2008**	**2008**	**2008**	**2008**
Beach	15.60	14.14	9.50	212.5	17.31
Dyke	17.96	14.16	NA	74.5	9.0
River	18.10	16.17	9.70	222.0	18.4
Lagoon	20.50	16.92	8.90	241.0	16.3

6.2) Laboratory Analysis of Water Samples

In 2008, bottles of water from storm outfalls that enter the Lagoon area and the River were sent to laboratories for analysis. The complete data set is in the Appendix 3. The September 25 samples were an attempt to collect “First Flush” samples that would have the accumulations of the summer period rinsing into the watershed. The extensive water parameters are summarized in the Table 6.2 below for Nutrients, Coliform, Metals and PAH’s. The table shows which general parameters were below or above B.C. Standards for water quality for fish or drinking water.

Table 6.2) Summary of Storm Water Quality per B.C. Standards.

Site	Nutrients	Coliform	PAH	Metals
Bagshaw	Pass	Fail	Fail	Fail
Turner	Pass	Fail	N/a	Fail
Mills	Pass	Fail	Fail	Fail
Martindale	Pass	Fail	N/a	N/a

The Nutrients in the water quality results show no concerns for lack of or over-loading. The pH, Nitrate and Nitrite were measured. Additional readings of Ammonia, Nitrogen, Ortho-phosphate and Phosphorous could determine limitations or excesses in productivity.
The Coliform samples were very high in all sites. The sources can only be speculated on as sampling to determine the source was not done. The high inputs at the street drainages at Bagshaw, Turner and Mills are likely from urban garden runoff of manure or cross connections of sewage lines. The Martindale site receives Shelly Creek runoff from an agricultural area where unfenced cattle may be a source. Addressing the Coliform inputs could attenuate nutrient overloading and its attendant problems of anoxia in shallow, low flush areas.

The Poly Aromatic Hydrocarbons (PAH) are a concern from oils and industrial sources; Pyrene was the biggest concern exceeding the standards with Benzo-Pyrene and Benzo-anthracene at detectible levels. PAH were only measured at Bagshaw and Mills culverts, which drain urban streets in Parksville.

There were many Metals over the limit in all four sites. Aluminum, Cadmium, Copper, Iron, and Zinc were the biggest concern. Sources of Metals from the City Streets were not known. This would involve tracing upstream to source the elements if possible.

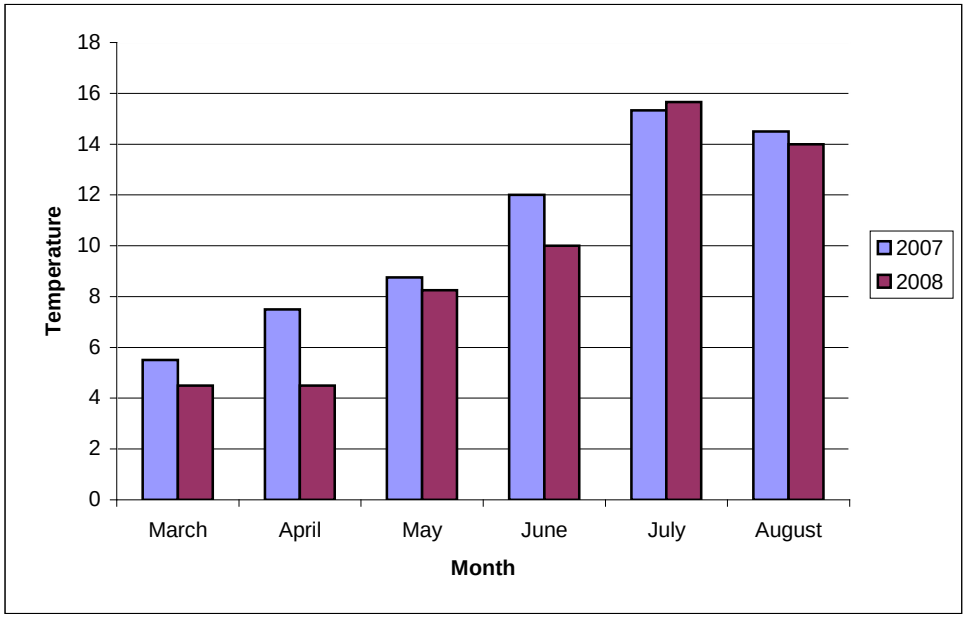
6.3) River Water Temperature

This data was taken from Water Survey Canada web site for the Englishman River at the old highway bridge. We found that during our March to August sampling period, the river was warmer in 2007 than 2008 (Table 6.3.). The 2008 year was noticeably cooler, something that was felt by the volunteers as well. The warmer temperatures result in faster growth and earlier departure of salmon smolts from the estuary.

Table 6.3) Average River Water Temperature , 2007 & 2008.

Year	2007	2008
Average Temperature	**10.6**	**9.5**

Figure 6.3) Average Monthly River Water Temperature, 2007 & 2008



The MVIHES has also taken water quality samples over many years at storm water outlets that lead into the Lagoon as well as samples at the River (Appendix).

1.7 Volunteers

The volunteers ranged in age from pre-school to retirees. Most were from the surrounding area. There were some with science background but for most this was a first time experience with the project.

Table 7.1) Volunteer Effort 2007 & 2008 Fish Sampling.

Month/Year	Number Of Volunteers	Volunteer Effort (hours)
June 2007	16	64
July 2007	13	96
March 2008	4	32
April 2008	32	128
May 2008	16	108
June 2008	17	104
July 2008	9	52
August 2008	11	64
Total	**118**	**648**

The Volunteers contributed 118 person days and 648 hours to the project. This is an

invaluable contribution by the citizens of the area. Large scale sampling programs could be prohibitively expensive if not for the community donating their personal time to environmental stewardship.

The Volunteers learned scientific collection protocols of;

- Fish Identification through hands on learning, fish guidebooks and keys
- Fish Capture skills through proper net setting, fish handling, storage and measuring
- Water Quality Sampling was trained using field instruments in Oxygen, Conductivity, Salinity, Temperature.

Many of the participants had previous training with a certificate from Pacific Streamkeepers Federation. Many had experience with sampling, restoration or education programs undertaken by area Societies in past projects.

1.4 Discussion

Comparisons with 1993 Study

The intent of this study was to compare our fish sampling results with the 1993 survey. The Pacific Estuary Conservation Program (P.E.C.P.) sponsored the report: The Englishman River Estuary by C. Annand, A. Hillaby and J. Naylor, published in September 1993. The survey covered Fish, Benthos, Epibenthos, Water Chemistry, Vegetation and Birds. They were assisted by a team of field of study experts from various agencies on Vancouver Island[8]. We have attempted to imitate the same methods where possible within the resources available, to compare ecological values of then and now. This report looks only at the Fish Populations and Water Chemistry conducted in 2007 and 2008. Further areas of studies are being undertaken by other authors on behalf of the MVIHES; Estuary Vegetation characteristics by Ron Beuchert, Eel Grass, Shoreline mapping and Pelagic Fish by Michele Deakin.

Sampling Methods

The 2007 and 2008 Fish surveys are compared to the earlier estuary study. There were some differences. In 1993, only May and June were sampled. They primarily used a boat-towed seine net and surveyed in most of the same areas of our study. In 1993, the survey was conducted for only May and June but 97 samples were taken covering an area of over 18,300m^2. The 2007 – 2008 study was during an eight month period, with 72 seines conducted and less sample area 4030m^2 with the smaller nets. Thus in 1993, with only two months they covered over four times as much area as the later samples.

Although the 1993 study was conducted for a shorter period, the result of more fish captured was due to a larger area being seined, with more seines set. Each seining period used two different nets. In 1993, a large beach seine (area of 232m^2) and a stick seine (area of 84m^2) were used. In the latter survey, two beach seines were used (areas of 98m^2 and 37m^2).

The later samples with smaller nets are easier for volunteers to sample with. They can be belayed by 4 people (two in a pinch) and require no boat. We found we could carry the 11.1m wide net to the site with two people and deploy the equipment in less than 30 minutes at any site. Pop up nets were considered for the estuary studies. They would have a better element of surprise for more wary fish species. These nets were considered too technical to assemble and operate for the project.

The 11.1m net appeared to work well as a collection device; fishing all the habitat types and depths and catching more fish species than the 1993 study. We feel this size net is well suited to the activity objectives of sampling and community involvement.

The two studies did not seine at the same sites, resulting in the presence and absence of some species. The 1993 survey exhibited higher weighted densities in sites that were not utilized by the 2007-2008 survey and vice versa.

[8] Bruce Hillaby -DFO, Neil Dawe- CWS, Bill Austin- Koyhotan Labs, Bev Bravender -DFO, Bruce Bennett CWS, Judy Hillaby, RPBio, Rusty Joerin -Nature Trust, Dave Carriage -field studies, Ken Ryan -historian, Margaret Wright –DFO.

Fish Population Changes

There were 5,256 fish captured in 1993 with 326 (Table 1.1) and 1329 fish (Table 1.2) in 2007 and 2008 respectively. Fewer fish are the result of less sampling rather than less fish as described below.

The variety of species increased from 15 in the 1993 study, to 20 in the 2007-2008 study (Table 2.1). The 2007-2008 study had a longer survey period. This longer period allowed the opportunity to capture fish that make use of the estuary at different times of year. The latter study caught the migration of Pink Salmon smolts through the estuary in the months of March and April that the 1993 study missed.

The 2007-2008 project surveyed slightly different areas than the 1993 study which may also explain the different species. A Plainfin Midshipman, Kelp Greenlings and Rockweed Gunnels were captured only at the Beach site in the 2007-2008 study. None of these fish were captured in the 1993 study which surveyed on the north side of the river only. The Beach site is unique with its long flat tidal area that has a sandy substrate for most of its area. Having the same sampling locations and consistent methods between the two studies would have allowed for better comparisons of results. Other species of fish we did not capture known to migrate through the area are Searun Cutthroat and Steelhead. These fish enter the estuary as large smolts and likely are too few and fast to capture easily with this method.

Total Fish Densities:

The fish densities were generally higher in 2007/2008 than in the 1993 study. We compared the five groups of fish used in the 1993 study with the later study (Sculpins, Stickleback, Shiner Perch, “Other fish species” and Salmon).

Table 8.1: Fish capture results 1993, 2007 & 2008.

Year	Total Fish (N)	Survey Area (m^2)	Density Fish/m^2
1993	5256	18364	0.286
2007	326	1042	0.313
2008	1329	3046	0.436

It is hopeful that the estuary fish population is increasing as the sample results indicate. This result is a gross average of all species of fish. We may have skewed the numbers with a lucky capture of a large school of Stickleback, Sculpin or Goby. There is not enough data to determine any trends in the gross data yet. More sampling is required.

Further understanding of individual fish life history patterns with respect to the Englishman Estuary is required to determine population trends. There is a lack of knowledge on their time of emergence as foraging fish and their habitat preferences throughout their life history. Species-specific studies with sampling at different life stages are required. Knowing we have 20 fish using the estuary is the tip of the iceberg with respect to knowledge. We now need to break out the individual habitat requirements through their life history to determine population trends.

Individual Species Densities

The highest weighted densities were spread evenly throughout the study years. No specific study year tended to exceed the others. For instance, the 1993 study had the highest fish densities for Chinook (0.008 f/m^2), Chum (0.021 f/m^2) and Stickleback (0.130 f/m^2). The year 2007 had the highest densities of Coho (0.0010f/m^2) and “other fish species” (

0.092f/m^2). In 2008 were the highest densities of Pink (0.23 f/m^2), Sculpins (0.260 f/m^2) and Perch (0.040 f/m^2). These results show the spread of sampling results over all years indicating presence and a variety of abundances that are not understood.

Salmonid Species Distribution

We suspect the 1993 and 2007 studies captured no Pink Salmon as they started too late (May and June respectively). The Pink Salmon may have left the estuary before net sampling in 1993 and 2007, as we captured them all in March and May during 2008. The Pink Salmon numbers are also be tied to the timing and number of hatchery releases that have been done every year since 1992. The emergence of Pink Salmon at the hatchery is tied to water temperature and egg take dates. Given they are emerging at similar dates as native stocks the timing appears normal.

Chum usually emerge and enter the estuary after Pink. They were captured only in the months of May and June at the estuary.

Coho are next to migrate; usually leaving the river from April to June with peak migration in mid May. These fish were found in the estuary from May to July.

Chinook are last to leave the river, they migrate in May and June. They were captured in the estuary in May, June and July. Again hatchery releases have occurred since 1992 where pre-smolts are fed in rearing channels as they grow and acclimatize from Big Qualicum to Englishman. The release timing is similar to the native pattern targeted to leave as smolts generally between May 25-June15.

Less is known about the life history of other species of fish in the estuary. It was obvious during the six month long 2008 study that the common fish such as Stickleback, Perch and Sculpins, were growing in size and weight. With the equipment and resources, a length and weight study is recommended in any future studies of all fish. This extra handling aspect was deemed too lengthy for the volunteer based program we had at the time. There was also much scrutiny over our methods during the permit applications from at least three agencies concerned about sampling disturbance or mortality. With all of the volunteers now skilled in fish capture and handling (and the agency confidence in volunteers hopefully improved) it could be used in the near future using these experienced people.

While more research is required, it is important to note that the residency period in the Englishman Estuary by juvenile salmonids is at least from March to July. We surveyed on two dates in three locations in August 2008 and captured no salmonids. It appears the majority of juveniles have left the area by then. There are other life stages of Salmonids[9] that remain in the estuary or arrive through the early summer. Sea-run cutthroat are year round estuary residents. Steelhead adults leave the river after post-spawn feeding as late as June. Pink Salmon adults arrive in July. Coho adults arrive in August and Chinook are at the beach in September. Historically, there may have been more overlap of species age classes of salmonids with abundance and diversity.

The Lagoon, Dyke and Beach had the majority of fish populations including salmon. The Dyke had the lowest fish densities. The gravel fill is rapidly eroding along the Dyke and the opening to the Lagoon could easily be doubled at any flood event. This will cause additional flushing to the Lagoon area, which will change the dynamics considerably. Fish will likely benefit as this was the historic condition of the estuary before a farm and park were attempted over the last 40 years. The vegetation, insect community, water quality will likely change as more fresh water enters at low tide and more salt water enters at high tide.

[9] Unpublished & published swim surveys and assessments, D.R. Clough 1981-1998

Water Quality Comparisons

Field sampling was done in 1993 and in 2007 and 2008 (Table 6.1).The Temperature, Salinity, Conductivity and Oxygen were taken. No significant concern was observed in these results. All were found to represent best the daily cycle of tide movement and almost always in the range tolerable for Salmonids and other estuarine fish species. No grab samples of storm water culverts were done in 1993.

The 2008 results (Table 6.2) indicate toxic water is entering the estuary. It is likely a direct result of growing urbanization of the watershed contributing unacceptable levels of Coliform, PAH and Metal. It is important to continue the monitoring of water quality in future years in order to protect the estuary from one of the most direct ways to kill off all aquatic life. This sampling information is invaluable in determining the sources of pollutants and developing a point source reduction plan. Our field sampling did not routinely include the storm water culverts. These sites should be surveyed with field equipment regularly as it is a fast and cheap indicator of water quality issues. Grab samples sent to laboratories for full spectrum analysis are still important to verify any field sampling concerns. We recommend grab samples continue be done at first flush every fall at the storm drain sites. Further sampling through other seasons and a control site in the river above the storm pipes is also recommended if funding permits. Continued pressure on water protection agencies is needed to get their expertise and budgets involved. Both the Ministry of Environment and Fisheries and Oceans have assisted or done their own studies in the past. It is important to coordinate this activity. It may be in the best interest of the City of Parksville as their water intake is located just above the estuary in the river. Urban run off impacts at Shelly Creek will influence the City drinking water. The knowledge of this concern may encourage the City planning and engineering staff to promote greener roads and subdivisions using grass swales and rain gardens for biofiltration. Remediation at the existing outfalls could also be done; engineered filters are available that can remove metals and PAH's.

The Water Survey Canada site had no temperature records for 1993 to compare with the later dates. The WSC site did have discharge data that could be compared with the later study years. The data shows that 2007 had the highest discharges and 1993 the lowest for the survey period.

Table 8.3) Mean Discharge 1993 compared to 2007 & 2008

Month/Year	1993	2007	2008
March	21.80	29.90	11.30
April	14.20	11.90	7.20
May	11.10	10.30	14.70
June	6.17	6.65	7.90
July	1.34	3.63	2.80
August	0.95	1.74	1.80
Total	**55.56**	**64.12**	**45.70**

1.5 Conclusions

Goals and Objectives Achievements

The Fisheries Objectives of this study were:
1.) Conduct a fisheries inventory of the estuary over the 2007 and 2008 period.
2.) Incorporate public participation, education and awareness of the estuary fisheries resource.
The fisheries survey and public participation were rolled into a major two-year study. The survey results will offer a baseline for understanding the fish species dynamics in the estuary. Over 650 hours of public participation was involved in addition to possibly equal time by society members and staff involved in the project. It was not a small task to complete; thanks goes to the MVIHES members, volunteers, staff and agency people whom assisted. The success will be measured in the usefulness of this effort in continued protection of the estuary.

Summary Conclusions

- There were 20 species of fish found in the Englishman Estuary during the sample period.
- Three Spine Stickleback, Staghorn Sculpin and Shiner Perch were the most common fish.
- Pink were the most common salmon. Chinook, Coho and Chum were also captured.
- All fish were evenly distributed through the Beach, Lagoon and Dyke with fewest along the River.
- Salmon juveniles were captured in the estuary from March to July but not in August.
- There appeared to be no changes in fish population abundance since the 1993 study although methods for sampling were different.
- Water quality from the City storm drains that enter the estuary is poor in terms of Coliform, Metals and PAH.
- Volunteers contributed approximately 650 hours towards the fish surveys. These surveys could not have been done without their help.

1.6 Fisheries Recommendations

1. More sampling of the estuary fish populations is needed. Fish samples should continue with a more directed intensity to distribution, residence period and growth. Directed species specific studies should be encouraged for key abundance species such as Stickleback, Sculpins and Salmon.

2. Water Quality sampling should continue at the storm drain outfalls to monitor the toxins entering the estuary.

3. Water quality management needs to be done to address the current level of pollution entering the estuary.

4. Encourage continued volunteers and stewardship with the project. Establish training courses on estuarine surveys for the volunteers.

5. Involve other agencies in the surveys, analysis and plans.

6. Establish a management plan for the estuary to ensure its integrity.

1.7 References

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Appendix 1.1 2007 Fish Species Summary, Englishman Estuary Seine Net Results.

Site	DATE:	Stickleback	Sculpin	Shiner Perch	Starry Flounder	Sole	Midship men	Pink	Chum	Coho	Chinook	Arrow Goby	Greenling	Pipe fish	Gunnel	Tubesnout	Clingfish	Total
Beach	June 28/07	15	23	16	2					1	1							58
Beach	July 22/07		1		6							1						8
Beach	July 29/07	1	5	2										1	1			10
Total:		**16**	**29**	**18**	**8**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**76**
Dyke	June 28/07	3	3															6
Dyke	July 8/07		1		2													3
Dyke	July 15/07				2													2
Dyke	July 15/07	74	2		14													90
Dyke	July 22/07	1									1							2
Total:		**78**	**6**	**0**	**18**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**103**
River	June 28/07	0	29		2							11						42
River	July 8/07	17	5															22
River	July 22/07	4	9		2							2						17
Total:		**21**	**43**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**0**	**0**	**0**	**0**	**81**
Lagoon	July 8/07		5		12							13						30
Lagoon	July 15/07	8	3		21							4						36
Total:		**8**	**8**	**0**	**33**	**0**	**0**	**0**	**0**	**0**	**0**	**17**	**0**	**0**	**0**	**0**	**0**	**66**

Appendix 1.2 2008 Fish Species Summary, Englishman Estuary Seine Net Results.

Site	DATE:	Stickleback	Sculpin	Shiner Perch	Starry Flounder	Sole	Midship men	Pink	Chum	Coho	Chinook	Arrow Goby	Greenling	Pipe fish	Gunnel	Tubesnout	Clingfish	Total
Beach	April 20		20															**20**
Beach	May 5		14	47	1	6		1	1					2	11			**83**
Beach	May 25	1	14	7	3				2					1				**28**
Beach	June 2		11			3			5				7		13			**39**
Beach	June 8		48			1							2		1			**52**
Beach	June 16		13	6									10		1	3		**33**
Beach	July 14		4	4			1						3	3				**15**
Beach	August 18		13	1									1				1	**16**
Total:		**1**	**137**	**65**	**4**	**10**	**1**	**1**	**8**	**0**	**0**	**0**	**23**	**6**	**26**	**3**	**1**	**286**
Dyke	March 30		14															**14**
Dyke	March 31	14	3					3										**20**
Dyke	April 21	1	304		2							6						**313**
Dyke	May 12		63		10						2	15						**90**
Dyke	May 26	3	33															**36**
Dyke	June 29	24	18		1						10							**53**
Dyke	July 27	2	5											2				**9**
Dyke	August 10		57	54														**111**
Total:		**44**	**497**	**54**	**13**	**0**	**0**	**3**	**0**	**0**	**12**	**21**	**0**	**2**	**0**	**0**	**0**	**646**
River	March 30	1	74					5				1						**81**
River	April 20		18		1													**19**
Total:																		
Lagoon	March 30							62										**62**
Lagoon	May 26		37		6							3						**46**
Lagoon	June 29		10		20	6												**36**
Lagoon	July 27	2	3	2	2							10						**19**
Lagoon	August 10		16		3							115						**134**
Total:		**2**	**66**	**2**	**31**	**6**	**0**	**62**	**0**	**0**	**0**	**128**	**0**	**0**	**0**	**0**	**0**	**297**

Appendix 1.3 Englishman River Storm Water Quality Samples 2008

	Parameters	BC Water-Drinking (1)	BC Water Aq. Life	Bagshaw		Bagshaw		Bagshaw		Turner		Mills		Mills		Mills		Martindale	
	Site																		
	Date			25-Sep-08	P/F	06-Nov-08	P/F	12-Dec-08	P/F	25-Sep-08	P/F	25-Sep-08	P/F	06-Nov-08	P/F	12-Dec-08	P/F	06-Nov-08	P/F
	Temperature																		
	Salinity																		
Turbidity	TDS -FR	500	1000	94	P			122	P	70	P	42	P			15	P		
	Non FR	10% incr	10% incr																
	Turbidity	5-10%incr	5-10%incr							4.5	P	18	P						
	Colour	15 Pt-Co	0-300																
Oxygen	Oxygen																		
	BOD			<5.0	P					<5.0	P	<5.0	P						
Nitrogen	Total Ammonia (NH3+NH4)		0.10																
	Nitrate (NO3-)	10	200	0.2	P					<0.1	P	0.1	P						
	Nitrite (NO2-)	1	0.06	<0.1	P					<0.1	P	<0.1	P						
	Organic Nitrogen																		
	Kjeldahl Nitrogen																		
	Total Nitrogen																		
	Ortho-phosphate (PO4-3)																		
	Phosphorus (P)	0.10	.05-0.15																
pH	pH	6.5-8.5	6.5-9	7.5	P					7.5	P	7.5	P						
Carbon	Carbon, Organic TOC																		
	Carbon, Inorganic																		
Hardness	Ca Mg							46.9	P							74	P		
	CaCo3	200	500					47.6	P	30	P	15	P			75.2	P		
	Alkalinity		<20																
Coliform	Total Coliform			>20000	F					>20000	F	>200000	F						
	Fecal Coliform			>2000	F	2200	F			>200	F	>2000	F	1700	F			2500	F

PAH	Acenaphthene	0.01ug	0.1ug	<0.1	P							<0.1	P						
2-7 rings	Acenaphthylene			<0.1	P							<0.1	P						
	Acridine		.05ug	<0.05	P							<0.05	P						
	Anthracene			<0.1	P							<0.1	P						
	Benzo(a)anthracene		.1ug	0.01	P							<0.01	P						
	Benzo(a) pyrene	.01ug		0.02	C							0.01	C						
	Benzo(b)Flouranthene			0.02	C							0.02	C						
	Benzo(g,h,I) perylene			<0.1	P							<0.1	P						
	Benzo(k)flouranthene			<0.02	P							<0.02	P						
	Chysene			<0.1	P							<0.1	P						
	Dibenzo(a,h)anthracene			<0.01	P							<0.01	P						
	Flouranthene		.2ug	<0.1	P							<0.1	P						
	Flourene			<0.1	P							<0.1	P						
	Ideno(123-c,d,)pyrene			<0.1	P							<0.1	P						
	Naphthalene			<0.1	P							<0.1	P						
	Phenanthrene			<0.1	P							<0.1	P						
	Pyrene		.02ug	0.08	F						n/a	0.04	F						
	Quinoline			<3.4								<3.4							
Organics	Chlorophenyls/Dioxins	.06pg/l																	
PCB's	Polychlorinated biphenyls		.0001ug																
Halides	Chloride																		
	Flouride	1-1.5	0.2-0.3																
Metals	Aluminum	0.20	0.1	2.12	F			0.08	C	0.169	F	1.07	F			0.15	C		
	Antimony			0.0013	P			<0.05	P	<0.0002	P	0.0007	P			<0.05	P		
	Arsenic			0.0012	P			<0.05	P	<0.0002	P	0.0004	P			<0.05	P		
	Barium			0.018	P			0.009	P	0.007	P	0.01	P			0.006	P		
	Berylium			<0.0001	P			<0.001	P	<0.0001	P	<0.0001	P			<0.001	P		
	Bismuth																		
	Boron			0.22	C			0.02	P	0.016	P	0.014	P			0.02	P		
	Cadmium	5.00	.017ug	0.00009	C			<0.005	F	<0.00001	P	0.00002	F			<0.005	F		
	Calcium			8.5	P			13	P	9.8	P	4.3	P			18.9	P		
	Chromium		0.0089	0.0133	F			0.009	F	0.0013	F	0.004	C			<0.005	P		
	Cobalt			0.0012	P			<0.005	P	<0.0001	P	0.0006	P			<0.005	P		

Copper	500ug	2 ug @ 50mg	0.029	F			<0.005	C	0.002	C	0.012	F			<0.005	C		
Iron		0.3	2.52	F			0.105	C	0.2	C	1.21	F			0.243	C		
Lead	10ug	3ug @ 8mg	0.0076	P			<0.05	P	0.0003	P	0.0033	P			<0.05	P		
Lithium			0.002	P					0.003	P	<0.001	P						
Magnesium			2.6	F			3.5	F	1.3	F	1	F			6.5	F		
Manganese			0.84	F			0.033	C	0.012	P	0.042	P			0.052	P		
Mercury	1ug	.02ug																
Molybdenum	0.25	1.0	0.001	P			<0.01	P	<0.001	P	<0.001	P			<0.01	P		
Nickle			0.0034	P			<0.02	P	<0.0005	P	0.0017	P			<0.02	P		
Phosphorus		0.01mg/l	0.12	C			<0.1	P	<0.05	P	0.09	C			<0.1	P		
Potassium			1.1	P			1	P	<0.4	P	0.6	P			1	P		
Selenium			<0.0002	P			<0.05	P	<0.0002	P	<0.0002	P			<0.05	P		
Silicon			4.76				2.28		2.25		2.34				4.74			
Silver	.05ug	0.1ug @100mg	0.00005	P			<0.01	P	<0.00001	P	0.00002	P			<0.01	P		
Sodium			5.6	P			61.6	C	5.5	P	3.2	P			13.6	P		
Strontium			0.034	C			0.041	P	0.046	C	0.02	C			0.064	C		
Sulphur							1.62								1.85			
Thallium			<0.00005	P					<0.00005	P	<0.00005	P						
Tin			0.001	P			<0.05	P	<0.001	P	0.001	P			<0.05	P		
Titanium			0.159				0.004		0.0089		0.0736				0.008			
Vanadium			0.0086	P			<0.01	P	0.0009	P	0.0051	P			<0.01	P		
Zinc	5.00	7ug@90mg	0.085	F			<0.05	C	0.004	C	0.043	F			<0.05	P		

Section 2 VASCULAR PLANTS, PLANT COMMUNITIES AND ECOSYSTEMS

2.1 Vegetation Survey - Rationale and Methodology

A review of the literature was done to determine what baseline data was missing for the Englishman River Estuary and what studies could be initiated or repeated to produce the most useful data from a management perspective. Various methodologies of inventory were reviewed and compared including Resources Inventory Committee (Howes et al. 1999), Sensitive Ecosystems Inventory (Ward et al. 1998), Site Inventory and Conservation Evaluation (Kirkby 2003, unpubl.; Buechert 2004, unpubl.), inventories of federal lands under the Species At Risk Act (Dawe et al. 2004), Photopoint Monitoring (Lucey and Barraclough 2001), releves at regular intervals along transects (Dawe and McIntosh, 1993) and Community Based Mapping (Harrington ed. 1996). Assessment of the appropriate inventory methodology was done in light of the project's goal of involving a broad diversity of people in the inventory process.

On this basis, it was decided to initiate the following:

- catalogue and map invasive species on the estuary for use in designing an invasive species management plan
- research what has been done to manage invasive species and begin experimenting with control measures
- map vascular plant communities on the estuary for comparison with plant communities in 1976 based on the map of Kennedy (1982)
- develop easy to use methods such as sample points and transects that help to map the plant communities now and, at the same time, allow return visits to the same polygons over many years, allowing comparisons far into the future
- add to the list of species and plant communities known to be present on the estuary and note those that are designated rare or threatened.
- map special places and features on the estuary that are likely to be important for consideration in management planning

Why quantify, map and photograph native plant communities, special places and invasive species? Why not just get out there and cut broom or rescue fry? The rationale for each one is different and can be understood from the description under each section below. However, an overview of the assumptions is useful here.

1) Each plant community is a marker for a larger community of plants and animals including some that are less apparent but significant or critical to the ecological functioning of that community. A record of the proportions of ground covered by each plant species *within a plant community* and also the areas covered by each plant community *within the estuary* as a whole, gives an indication of what other species are likely to be present at a particular time and place.

2) Each plant community is an indication of the presence of the abiotic conditions required for survival of each of the plant and animal species present.

3) The record of plant communities can be compared with earlier records (such as the Kennedy map from 1976) in order to monitor changes that have occurred. For example, one carefully documented photograph of a tidal channel on the Little Qualicum River estuary has provided

startling evidence of the changes that have occurred to the vegetation patterns on that estuary over a 30 year period.

4) By monitoring changes in vegetation patterns over time, we can detect changes that may be affecting human values such as fisheries resources, endangered species, ecosystem services, and special places within the estuary. Anthropogenic trends may be revealed and altered, but only if we have the knowledge in time. For example, plant communities provide an easy way to monitor the period and salinity of inundation which in turn may indicate changes in watershed hydrology, channel characteristics, licenced or unlicenced water removals, erosion and deposition patterns, sea level rise and climate change.

5) The new plant community map is more comprehensive and more detailed than Kennedy's work, primarily because of the use of GPS technology and higher resolution digital orthophotos. The western dyke isolated the lands behind it from 1969 to 1979, the period in which Kennedy did her vegetation work. This project begins the process of creating a new community map that covers the entire estuary, including the western marsh and the forest. Thus, the new map allows for comparisons now and it provides improved baseline data for comparison and identification of trends far into the future.

6) Invasive species data can be used to show to neighbouring landowners, planners and the public at large the size and immediacy of the threat to the estuary. Maps assist in planning the spatial component of any campaign for control or removal. Future maps can be compared with our invasive species baseline to show trends. This helps to plan allocation of scarce resources to the most needed campaigns. It also helps to highlight successes, which is a necessary part of motivating people whether they are volunteering or being paid.

7) Maps are generally more accessible and memorable to the general public and to planners than words in a report that sits on a shelf. Information and involvement moves everyone towards buying into the plan. Maps of special places can capture the imagination, motivate inquiry, help to plan an outing, trigger involvement, and create a feeling of ownership.

2.2 Vegetation Survey - Plant Community Mapping and Point Sampling Methods

The project had initially identified 32 spatial study units for which vegetation data would be collected for the purpose of mapping the ecosystems at that scale. In addition, three permanent new transects had been established and two more were being planned to repeat earlier studies on the West Marsh of the estuary (Dawe and McIntosh, 1993). Data on percent plant cover by species would be collected from 1- metre square quadrats at 5-metre intervals along the transects. It was thought that the percent vegetation cover data might be more comparable and consistent if it was performed by a single person, an ecologist, while volunteers would take a standardized series of photographs (adapted from photopoint monitoring methods) and handle documentation of the transect. The volunteers would then have the experience necessary to continue doing photographic records of the transect quadrats every few years.

Moving to finalizing the plant community mapping methodology involved experimentation with equipment and volunteers, and consultation with experts. At a meeting on 6 May 2008, Nature Trust representative Tom Reid announced that transect data would not be useful to them because they unexpectedly had a specialized crew collecting similar data in an area that included the Englishman River Estuary. Furthermore, MVIHES was having difficulty locating the transects in the West Marsh/Lagoon area that we intended to repeat from Dawe and McIntosh (1993) because the

landmarks described were either no longer present, or no longer visible. Finally, by this time we already had one field season on the estuary, and it was becoming apparent that major changes had occurred to the vegetation on the eastern and central parts of the marsh since Kennedy mapped the plant communities there in 1976. At this point, it was decided to expand the ecosystem mapping component to greatly increase that level of detail (from 32 spatial study units to over 400), while reducing the number and complexity of the transect data. Because the large changes we had already observed, we decided at that time to give priority to mapping the eastern and central marshes of the estuary, including San Pareil Lagoon, Big Island Marsh and Centre Marsh, in order to make a detailed comparison with the plant communities that Kennedy mapped in 1976. The task of creating a baseline of Biogeoclimatic Ecosystem Classification (BEC) based primarily on Mackenzie and Moran (2004) and on the British Columbia Conservation Data Centre (2008; BCCDC) for the remainder of the estuary would be initiated in those areas that had not been mapped by Kennedy and then expanded later to include the entire estuary.

The final methodology chosen for plant communities involved 5 basic procedures: delineation, sampling, data management, classification and mapping. The steps taken are given below.

2.2.1 DELINEATION OF GEOGRAPHIC STUDY UNITS

- obtained recent high quality digital colour orthophotos of the study area.
- using GPS on the study area, recorded the locations of what appeared to be an occurrence of a consistent plant community (a point) or a vegetation transition (a line) that could be plotted on a computer as a layer over the orthophoto.
- used these lines and points to help interpret the meaning of the patterns visible on the orthophoto.
- delineated geographic study units (GSUs), as many as needed, with the idea of making each polygon represent a uniform vegetation pattern such as a single plant community or a uniform mosaic of plant communities. On the Englishman River estuary, over 400 GSUs were delineated.
- visited different kinds of polygons in different areas and defined the transitions in terms of plant species visible (ideally, plants easily visible to volunteers).

An ecologist accompanied volunteers in exploring the estuary with GPS, camera and high quality air/ortho photos. They identified and recorded the locations of some of the plant communities and some transitions between plant communities. They familiarized themselves with how the transitions varied. For example, in a brackish area, the species and transitions at a particular elevation (tidal level) were different from a more saline area. In an area disturbed by erosion or grazing, the species and transitions differed from areas that were not disturbed.

The creation of new geographic study unit (GSU polygon) boundaries was done by an ecologist using ArcView on digital 2007 colour orthophotos (.gif format) with an effective pixel size of 20cm X 20cm (i.e. 25 pixels per square metre). With this resolution, photo interpretation could be done at scales as large as 1:300 (and even greater in some cases). To assist in orthophoto interpretation, the ecologist plotted UTM coordinates of some vegetation transitions that had been recorded on the ground using a GPS (Garmin GPSMAP 76CSx). To do this, the points were downloaded onto the computer, plotted as a theme on the orthophoto, and in most cases, the dots were joined to create free floating lines using ArcView 3.1. The lines observed and plotted on the ground could then be compared directly with patterns visible on the orthophoto.

In some cases, the entire line of waypoints thus created appeared out of alignment due to a consistent error by the GPS unit on that day. When it was clear the error was consistent, it was corrected by moving the entire line to match features on the orthophoto.

The points recorded in the field were based on selected vegetation transitions between various plant communities. Which transitions were chosen for mapping was not deemed to be critical to the success of the method because their only purpose was to help in the photo-interpreted delineation of GSUs, with each GSU intended to represent a consistent vegetation pattern within its boundaries. However, to be useful, each line or group of GPS points had to have a clear definition of what was being observed and recorded and that definition had to be adhered to consistently until a new line with a new definition was started. Because this was often done by volunteers, it was helpful if the GPS points represented a feature that was easily observable on the ground. For example, the volunteers might be asked to use a GPS to record the UTMs of a line marked by yellow flowers if there was only one species of yellow flower open at that time.

It was helpful, but not essential, if the feature or the vegetation transition being mapped turned out to be something that was also discernible on the orthophoto. Lines of GPS points with a consistent meaning were expected to enhance interpretation of the patterns visible on the ortho photos and ultimately make it easier for an ecologist to delineate the GSUs in a way that would make it simpler to describe and map the plant communities on the ground.

Vegetation transitions were defined by an ecologist to meet these criteria. Some examples of how the transitions were defined include: the edge of a species range that had conspicuous flower heads, or the edge of the area where a single species comprised more than 95% of the vegetative ground cover in a square metre, or a line formed by mapping where two species could be found separated by one metre or less. The definitions of vegetation transitions could be different from one area to another to accommodate differences in vegetation patterns (due to variations in salinity, inundation, wave action, sedimentation, erosion, grazing pressures etc) providing that the mapping of each line of points represented a consistent definition and a set of clear observations on the ground. Teams of two volunteers or paid summer students working closely with an ecologist in the field used a GPS unit to record the locations of these transitions.

When mapped, this combination of photo interpretation and data collected in the field was at a level of detail that allowed the remaining natural estuary to be divided into more than 400 GSU polygons to assist in the long term study of plant communities.

2.2.2 SAMPLING OF VEGETATION COVER BY SPECIES AND LAYER

- in each GSU polygon, chose one or more sample sites (using non-random SEI methodology) to represent the plant community or communities of that GSU polygon.
- set the GPS unit to average the readings at the centre of the chosen sample site, and left it there to record the position to within 5 meters (+ or -). Sometimes an antenna was used to improve GPS accuracy.
- estimated and recorded the vegetation by percent cover for each species in each structural (vertical) layer for a plot that can range in size and shape depending on the shape of the plant community. The ideal plot was 10m by 10m for forb areas and 20m by 20m for forested areas.
- created a photo record of the sample site by systematically facing each of 4 (or 8) compass directions and taking a photo that included the horizon and/or the edge of the plant community being documented.
- photographed the vegetation looking downward being careful to include some size reference such as a 20 cm ruler (or the photographer's foot or the GPS unit).
- oblique angles were sometimes photographed to include special features that would otherwise not be recorded but it was found that this was rarely necessary.
- photographed the face of the GPS unit showing the waypoint number, date, UTM

coordinates, and elevation (elevation was optional).

Initially, potential sample sites were identified on the orthophoto within each study unit as possibly typical of that unit and then the UTM coordinates of that potential sample site were recorded. A number of the GSUs, especially those that were difficult to find on the ground, were visited by using the GPS to get to the UTM coordinates that had been pre-chosen remotely on the computer. However, it was found that the pre-chosen coordinates were sometimes unsuitable for sampling because they appeared to be not typical of the surrounding vegetation. Furthermore, it was learned that finding a location using pre-chosen coordinates could be time consuming. A laptop computer was brought into the field during good weather to assist with this.

In the end, as much as possible, the sample sites were visited by sampling any place where a different plant community could be discerned on the ground. Printed copies of the GSU polygon maps cased in plastic were carried in the field to minimize duplications. When incoming data was plotted indicating a GSU or plant community was being overlooked, then the sample crew would revert back to the method of targeting a specific UTM coordinate as a sample location to fill in the oversight.

Sampling of vegetation was done using non-random methods similar to those developed for the Sensitive Ecosystems Inventory (Ward et al. 1997). On 118 of the GSU polygons, the vegetation was sampled in a formal plot of a size and shape appropriate to the polygon. Ideally the plots were 10m X 10m on forb and shrub dominated sites and 20m X 20m on fully forested sites. Each sample plot location was chosen by an ecologist from the GSU polygon to be representative of the polygon as a whole and to avoid transition areas where the vegetation would be less uniform. The objective is for the sample site to be typical of the GSU polygon. The percent cover by species was visually estimated for the sample plot. Digital photographs (equivalent to a 35mm camera with a 55mm lens) were taken in four compass directions (usually E, N, W, S) using the camera angle to record as much of the polygon as possible and also the edge of the polygon or the horizon for reference. One or more photographs were also taken pointing downwards from a height of approximately one metre with some object on the ground included for scale, such as a compass or a GPS unit or part of the photographer's foot. In addition, oblique angle photographs were used to record features like vegetation, logs or reference points that might otherwise not be recorded.

The sample plot data consisted mainly of a GPS file (date, time, waypoint number, and UTM-NAD83 coordinates, and sometimes elevation in metric), handwritten field notes (date, waypoint number, UTM coordinates, field surveyors and percentage cover by plant species) and photographic data (photos facing E, N, W, S, DOWN, and a photo of the face of the GPS showing date, waypoint number, and UTM coordinates, and sometimes elevation. The sample plot data also included the camera-assigned number for each photo which was not available until photos were downloaded onto a computer.

Photographing the GPS was an innovation that started part way through the project to help demarcate the end of the photos for one sample site and to provide an independent cross-referenced link for the photographic data that was recorded on the camera's chip and later downloaded in a file separate from the GPS data.

The sampling that was done east of the Shelly Road Dyke was aimed at creating a map for comparison with the Kennedy (1982) map from 1976. The sampling that was done west of the Shelly Road Dyke (the West Marsh) began the process of baseline mapping the vegetation of the estuary using the biogeoclimatic classification (Mackenzie and Moran,2004; BCCDC, 2009). For this purpose, a soil pit was dug from 20cm to 60cm deep to sample the substrate, primarily to look at soil textures down to the first impervious or slow draining layer. The full field data script that was used for vegetation plot samples in the West Marsh is shown in Appendix 2.1**.**

Plant species identifications were done using *Plants of Coastal British Columbia* (Pojar and MacKinnon 1994) but with reference to the *Illustrated Flora of British Columbia* (Douglas et al. 1989).

2.2.3 DATA MANAGEMENT

- downloaded the data from the GPS as a txt file and manipulated it to form the basis of a spreadsheet file (open document spreadsheet) into which data from the field notes and photography were entered by keyboard
- this spreadsheet was saved as a dbf file for input into the GIS program ArcView. The dbf file was never edited or altered in any way. All edits were done to the ods spreadsheet, saved over as an ods file and then saved again as a dbf file which is then immediately closed to avoid confusion.

Downloading the data was done daily in order to keep the three components of the data together. Organizing that data was done within a week. It involved putting the data into a database for the following categories: form of data such as waypoint number (wp#) or a photograph number (J~), yyyy/mm/dd, time, UTM-NAD83 zone, x and y spatial coordinates (easting and northing respectively), elevation, species codes (7-capital letters for plants, 4-capital letters for birds, italicized scientific names or English names in some cases) and notes which is intended to include the initials of the people doing the sampling.

The GPS data was downloaded as a txt file, manipulated to remove some idiosyncrasies that the computer would read incorrectly, and then it was saved as an ods file (open document spreadsheet). Open Office (copyright 2000 to 2006 by Sun Microsystems Inc.) software allowed the option of working in a Microsoft Excel-compatible environment that could be saved as a dbf file at the end of each session. The dbf format is readable by the GIS program ArcView 3.1. Unfortunately, the dbf file would often truncate column entries that were too long. Data remained accessible in the ods format where it was first imported or entered because all modifications to the data file were done and saved first in the ods format and then it was saved again in dbf format. However, each time the data was moved from ods to dbf and then into ArcView, some of the data under species and notes was sometimes truncated.

A better system was needed. Ideally, we needed to get an extension to ArcView that allowed it to accept other formats such xls (or ods which seems highly compatible with xls). In this way, the ease of entering data in the spreadsheet format would allow more columns with more specific data requirements such as a place for each of the ten most abundant species, a place for the percentage cover for each of those ten species, a place for the initials of those persons sampling and a place for field notes, etc. Alternatively, the data could be entered directly into ArcView, but for most people this seems to be a less user-friendly environment.

Consulting a GIS or data management expert would have been very useful and cost effective in this process but the timing is important. Because the consultants may not address these issues, the consultation needs to occur after decisions have been made in answer to the following questions:
what kinds of data does the project need - what figures and maps will be produced?
what kinds of data can volunteers collect and process?
what is needed from a database - size? compatibility? should it handle all of the data?
who will do the data entry?
who will check the data, and manipulate it in preparation for GIS?
who will do the mapping?

Ideally, the database structure needs to be finalized before much data is collected or entered into a database. Part of the purview of this study was to explore and develop those data collection methodologies and decide what data is possible to collect with volunteers and what is useful to have accessible in a database for presentation in figures, maps and text. As a result, the development of the final database structure had to wait for answers to these questions which came late in the project.

2.2.4 CLASSIFICATION OF OBSERVED PLANT COMMUNITIES

- decided what plant community classification system to apply to the data that had been collected and would continue to be collected. On the Englishman River estuary east of the Shelly Road Viewing Tower, it was decided to facilitate comparisons by using the 19 plant communities that Kennedy defined and mapped in 1976, with 7 plant communities added to represent those observations in 2008 within the same area that Kennedy mapped but which did not seem to fit within Kennedy's plant community descriptions.
- decided to begin the process of classifying and mapping the estuary using the BEC system on the Englishman River estuary west of the Shelly Road Viewing Tower.
- used sample plot data consisting of GPS file (date, waypoint number, and UTM coordinates), field notes (date, waypoint number, UTM coordinates and percentage cover by plant species); and photographic data (photos facing E, N, W, S and DOWN and the camera-assigned numbers of the photos) to decide what layer (theme) best represented the plant community observed at that location.

On the east and central sections of the Englishman River estuary, it was decided to use the same classification system that Kennedy (1982) used, based on 19 plant communities that Kennedy had mapped in 1976, plus an additional 7 plant community descriptions that we added to represent plant groupings that were observed in 2008 in the same areas that Kennedy mapped, but that did not seem to fit the descriptions Kennedy had developed 32 years earlier. Descriptions are given below of the 7 plant hypothetical communities that were added to Kennedy's list.

As in Kennedy's work, the community descriptions in this report are intended to help an ecologist understand the vegetation patterns on the estuary and in particular, the changes that have occurred. They are not intended as a formal classification scheme based on a statistical analysis of large numbers of vegetation plot data.

Sea Milkwort (*Glaux maritima*) - early seral
This is a community near the low marsh - mid marsh boundary dominated by Sea Milkwort (.01% to 50% cover), usually on a firm inorganic substrate. In association with the Sea Milkwort, we found small amounts of Canadian Sand-spurry (*Spergularia canadensis*) and American Saltwort (*Salicornia virginica*). Some of the sites that we mapped in 2008 as "Sea Milkwort - early seral" were in 1976 supporting one of the communities dominated by Lyngbye's Sedge. The sedge was gone from the "Sea Milkwort - early seral" sites we mapped, but also absent was the organic layer and root mass of the marsh platform usually associated with Lyngbye's Sedge.

American Saltwort (*Salicornia virginica*) - 95 to 100
In this mid-marsh community, the American Saltwort is typically at least 10 cm tall and it accounts for 95% to 100% of vegetative cover. There is little or no bare ground - if American Saltwort was less than 100% of the vegetative cover, the remainder of the area was usually covered by Orache (*Atriplex patula*). The substrates have not been sampled yet, but it is likely that the "American Saltwort - 95 to 100 Community" is a form of the CDFmm Em02 *Salicornia virginica-Glaux*

maritima Ecosystem which is RED-listed by the Province of BC (BCCDC, 2009).

Dunegrass (*Leymus mollis*)
Based on Kennedy's species description of the Dunegrass community, it likely included areas that were dominated by Dunegrass as well as sandy beach and spit areas where Dunegrass was sparse or absent. We decided to map areas dominated by dunegrass separately from other sandy beach and spit communities.

Seacoast Bulrush (*Bolboschoenus maritimus*)
MacKenzie and Moran (2004) describe additional estuarine site associations for which no BEC code had been assigned. One of these is a monospecific stand of Seacoast Bulrush in saline depressions in the high marsh. These occur on the Englishman estuary so we decided to map them separately, even though they do not appear in Kennedy's classification table, probably because of their small areal extent. For convenience in mapping, we also included in this classification that part of the Jamieson Marsh which was nearly monospecific Seacoast Bulrush, even though its features are different and its origins include recent human intervention.

Tule (*Scirpus lacustris*)
Patches of a community of near monospecific Tule occur in the Jamieson Marsh. We mapped these separately even though their origins are recent and not entirely the result of natural processes.

Low Clubrush (*Isolepis cernua*) - Wigeongrass (*Ruppia maritima*)
This community consists of low marsh areas, usually with Low Clubrush, Canadian Sand-spurry and/or Wigeongrass growing on mud substrate. In mapping this community, we included areas where these species occurred at very low densities. Other species of vascular plants are generally absent. These intertidal areas are low elevation so they are flooded most of the time and, where the tidal water cannot drain, they are flooded all of the time. This community is not the same as the American Saltwort - Sea Arrow-grass Community (K1) that Kennedy described, even though K1 is the only community in which Kennedy listed Wigeongrass. However, this community is likely a form of the CDFmm Em01 *Ruppia maritima* Site Association; both grow on muddy substrates. The only difference appears to be that Canadian Sand-spurry was present in this community on the Englishman estuary but it is not listed for the CDFmm Em01 Site Association, as described by MacKenzie and Moran (2004)

Unvegetated or Nearly Unvegetated Sands and Gravels
Some areas that had supported middle marsh and possible high marsh communities in 1976, now appeared to be lower in elevation and almost barren of vegetation. In order to represent this major change in vegetation on the maps, it would be inappropriate to leave them unclassified, so we created this mapping category.

The classification system of Kennedy required a few other minor modifications in order to be usable. Cattail (*Typha latifolia*) and Pacific Water-parsley (*Oenanthe sarmentosa*) were not found on the saline and brackish marshes of the Englishman estuary in 2008, which is to be expected because they are not salt tolerant. Therefore, any references to these two species in the plant communities defined by Kennedy were not considered when classifying the estuarine plant communities that were observed in 2008, during this study.

A few species required nomenclature transcriptions. *Agrostis alba* in Kennedy (1982) is referred to as Creeping Bentgrass (*Agrostis stolonifera*) in this report. *Agropyron repens* in Kennedy is referred to as Quackgrass (*Elymus repens*) in this report.We assume that *Hordeum murinum* in Kennedy is the same species we refer to as Foxtail Barley (*Hordeum jubatum*) in this report, since Kennedy also refers to *Hordeum brachyantherum* in her report. We assume that *Juncus balticus* in

Kennedy is the same species that we refer to as Arctic Rush (*Juncus arcticus*) in this report. *Elymus mollis* in Kennedy is Dunegrass (*Leymus mollis*) in this report. *Potentilla pacifica* in Kennedy is Silverweed (*Potentilla egedii*) in this report. *Pyrus fusca* in Kennedy is Pacific Crabapple (*Malus fusca*) in this report.

On the area west of the Shelly Road Viewing Tower (the West Marsh), the process was started to classify and map the entire estuary using the BEC system (MacKenzie and Moran, 2004; BCCDC, 2009).

2.2.5 MAPPING OF PLANT DATA BY COMMUNITY

- copied that GSU as a feature from the GSU map and pasted it into the layer (theme) appropriate for that community.
- used ortho/air photo interpretation (Quads 07, 08, 11, 12 and 13; 2007) and ground photos to map GSU's that did not have sample plots
- decided for the area west of the Shelly Road Viewing Tower (the West Marsh) to start the process of mapping the entire estuary using the Biogeoclimatic Ecosystem Classification (BEC) system because this area had not been mapped by Kennedy

On the eastern marshes, the purpose was to make a comparison of old and new maps. To aid comparisons at a similar scale, the Kennedy map from 1976 was scanned into a digital file, the geographic data made to fit (i.e. rubber sheeted) the projection of the 2007 ortho/air photos (Quads 07, 08, 11, 12 and 13; 2007) and then digitized by a GIS technologist directly from the hardcopy of the 1976 polygons.

The decision about what plant community was represented by (or typical of) each GSU polygon was made primarily on the basis of air/ortho photo interpretation on the computer. This was greatly aided by the vegetation sample plot data and the ground photos both at the plot locations and at any other location where a photo was taken and the location was recorded with a GPS.

The result is two comparable maps of the same estuarine areas (San Pareil Lagoon, San Pareil High Marsh Finger, East River Channel, Big Island, the current (2007) Main River Channel, and the Centre Marsh) separated by a period of 32 years. One map is the plant communities on the estuary in 1976 and the other is of the vegetation in 2008 using our interpretation and modification of the plant communities as Kennedy described them (Kennedy, 1982).

2.3 Vegetation Survey - Transect Sampling Methods

The transect component of this project was reduced to one permanent photographic transect 55m long designed to cross an area that appeared to be heavily grazed. The transect was surveyed using a GPS (Garmin GPSMAP 76CSx) and its end points were marked with 70cm U-shaped re-bar pounded like a staple into and below the surface of the marsh. Orange flagging tape was attached to the re-bar staple during the work and then removed later. During the process, a reeled tape measure was stretched and tied from the start of the transect to its finish, along the south side of the transect. The tape was removed later.

Moving from west to east, and walking on the right (south) side of the transect, a photo was taken every five metres, being careful to include the tape (and a boot) in the picture but not to step across the tape measure into the sample area. The camera was consistently held at lower chest level, approximately 110 centimetres off the ground surface, but this is not particularly important as long as a one-metre square of untrampled vegetation and the tape measure are both clearly visible

in each photograph. It was assumed that this method would require modification for areas where the vegetation was too high to photograph easily for a person on the ground so a sturdy wooden box was brought for standing on. (A step ladder, stool or chair would sink into the substrate.) However, as it turned out, the box was not needed on this particular transect.

2.4 Vegetation Surveys - Results and Discussion

The changes in vegetation on the Englishman River estuary over the 32 years from 1976 to 2008 are described here from east to west, based on the map from 1976 (Kennedy 1982) and the plant community map that is based on the 2007 and 2008 data collected in this project. Each of the two plant community maps is superimposed on the same ortho photo from 2007 to aid in comparison, but it is important not to attempt interpreting the 1976 map from this report as if the features on the 2007 ortho basemap were present in 1976. The plant community definitions used were those developed by Kennedy but with the modifications described under the Methods - Mapping section above.

2.4.1 Behind the Mine Road Dyke

The south end of the Mine Road Dyke starts where a vehicle on Plummer Road entering San Pareil - Shorewood subdivision would first encounter houses as the road turns suddenly northeast. Behind the Mine Road (San Pareil) dyke, alienated from most of the influences of the river and the ocean, the terrestrial plant communities have shown an increase in the total area covered by shrubs and trees. Kennedy recorded two plant communities: K6 in which 5 species of shrubs occur but none are dominant or subdominant, and K7, which does not include any shrubs at all. Much of the area that had a few shrubs in 1976 (K6), is now dominated by shrubs (K16 and K17), although approximately half of the K6 remains today as a mosaic of shrub patches and grass/forb patches. The area that was formerly occupied by K7 (no shrubs) is now almost completely covered by shrubs and small trees (K16, K17, K19).

The terrestrial communities behind the dyke appear to be moving through a process of natural succession towards a forest cover. Unless there are changes in land use, such as livestock grazing, increased pedestrian or bicycle traffic, or a breach in the dyke, it is likely that the area will become a forest within another 20 to 50 years. If this occurs, most of the meadow grasses and forb species will be shaded out and disappear because they are early seral and depend on an abundance of light; this includes most of the invasive species present at that location including Quack Grass (*Agropyron repens*), Common Velvet Grass (*Holcus lanatus*), Orchard Grass (*Dactylis glomerata*), Reed Canary Grass (*Phalaris arundinacea*), Creeping Thistle (*Cirsium arvense*), and Bull Thistle (*Cirsium vulgare*). The invasive shrubs Scotch Broom (*Cytisus scoparius*) and Armenian Blackberry (*Rubus armeniacus*) will also likely disappear, except at the edges of the forest. Continued succession towards a forest would also result in eventual reduction of some native species as well, such as Nootka Rose (*Rosa nutkana*) and Western Terrestrial Garter Snake (*Thamnophis elegans*).

This area suffers a serious threat from new invasive species being introduced adjacent to San Malo Drive, in the vicinity of the bicycle park. It appears that several introductions to the area have already come from dumped yard waste, prunings, flower pots and planters. Our observations of yard waste dumped in this area in 2008 indicate that the potential for disastrous introductions is ongoing. (see photo #)

2.4.2 Jamieson Wetland

Within the dyked area, there is also a wetland at the northern end. In 1976 the wetland supported a community with Lyngbye's Sedge (Carex lyngbyei) in association with 15 or more other vascular plant species (K8 plant community). In 2008, much of the area has become nearly monospecific stands of Tule (*Scirpus lacustrus*) or Seacoast Bulrush (*Bolboschoenus maritimus*). The remainder is still a Lyngbye's Sedge community but most of that area has moved from K8 to K4 as shown by an increase in the proportion of Seashore Saltgrass (*Distichlis spicata*) and a decrease in overall plant diversity.

It is uncertain to the authors, what perturbations and introductions occurred during and after residential construction near the wetland since 1976, but whatever their influences, the wetland now seems stable and likely to remain a wetland into the foreseeable future. If the dyke is breached at some time in the future (Summers and McKenzie, 1990), this wetland will likely become brackish again and the Lyngbye's Sedge can be expected to expand in area.

2.4.3 San Pareil Spit

The northeastern corner of the estuary just south of the sandspit area is referred to as San Pareil Lagoon in this report. There are three plant communities/natural habitat types centred around the San Pareil Lagoon.

The locations of the sandy beach and spit areas at the northeastern corner of the estuary have moved and changed over time, based on the air photo records. Beach and spit plant communities (K11), often typified by Dunegrass (*Leymus mollis*) and Silver Burweed (*Ambrosia chamissonis*) depend on this natural instability; if the sandy areas become stable for a sufficient length of time, other plant communities begin to take over from K11. It is likely that the edges of the K11 community have been destroyed and re-established many times as the beach and spit areas moved and changed. Although changes are occurring, the equivalent of ecological stability can be present if the total area of beach and spit habitat remains relatively constant over time.

If we make an estimate of the historic area of K11 community on the east side of the Englishman River and we base the estimate on the size and appearance of the spit in a 1954 air photo (BC 1667 No.49), the beach and spit community would likely have occupied approximately 7 hectares at that time. Unfortunately, these plant communities were not mapped in 1976 so the changes since then are difficult to assess. If we base the estimate on the size of the spit in the 2007 air/ortho photo, as if the residential development of the spit had never occurred, we get an estimate of 3.5 to 5 hectares of potential beach and spit community. The actual size of the remaining intact beach and spit community on the east side of the Englishman River, near its mouth, is approximately 0.75 hectares.

The beach and spit areas in the vicinity of San Pareil support some invasive species such as Scotch Broom and a small amount of pedestrian traffic, but otherwise they are in a relatively natural state.

Today beach and especially spit communities are some of the rarest on the east coast of Vancouver Island (Ward et al. 1998, McPhee et al. 2000). The Regional District of Nanaimo area was found to have an approximate total of 8 hectares of intact beach and spit community in around 1997. Therefore, 10% (0.75 hectares) of the remaining intact beach and spit community in the entire regional district is located in that little patch of intact sandy beach vegetation on the east side of the mouth of the Englishman River.

Thin soils make them vulnerable, even to pedestrian traffic. They could also be altered by erosion

patterns as the river's main channel appears to be continuing its move eastward.

2.4.4 Mudflats - Low to Middle Marsh of San Pareil Lagoon

The intertidal lagoon consisted of a sparsely vegetated mud flat ringed by some saltwater and brackish marsh communities in 1976 and it is still that today. The mudflats are often coated with a thin layer of algae and many areas are sparsely occupied by Low Clubrush (*Isolepis cernua*) often coated with algae. Approximately 10 plants of Widgeongrass (*Ruppia maritima*) were encountered during an inspection of the mudflats in 2008. This is probably similar to what was present in 1976, however, there have been some changes which are described below.

The band of American Saltwort (*Salicornia virginica*) on the east side of the lagoon where the boardwalk is today has become narrower and it occupies a fraction of the area that it did in 1976, assuming similar mapping definitions then and now. A slight difference in the density of plants that is required to qualify for inclusion could make large difference in the geographic area that gets mapped as this particular community. In the field, there appeared to be an obvious and natural edge to the community, but Kennedy may have defined it otherwise so we can only draw tentative conclusions. This location is an exception, in most places on the estuary, these kinds of definitional differences are unlikely to make any significant difference to the outcome of mapping.

Based on Kennedy's plant community definition for K1, we would have expected to see Sea Arrowgrass (*Triglochin maritimum*) as the codominant with American Saltwort, but in 2008 we found Sea Arrowgrass almost absent. Instead Sea Milkwort (*Glaux maritima*) was present and often codominant in 2008 and at the lower elevations, the Sea Milkwort was often the most abundant species, below the edge of the American Saltwort and as an early seral plant community on vegetated *island* remnants surrounded by a *sea* of more sparsely vegetated mud. Note that the early seral Sea Milkwort community was not mapped by Kennedy but in this study it was mapped as a separate layer.

On the north side of the lagoon, the plant community typified by Seashore Saltgrass and American Saltwort (K2) appears to have been heavily grazed right up to the beach. Part of it appears to have been replaced by an early seral community of Sea Milkwort. Waterfowl feces and goose footprints were observed and abundant in the area in 2007.

On the south side of the lagoon, the large area of Seashore Saltgrass (K3) that was present in 1976 is mostly gone, replaced by 'islands' of the early seral Sea Milkwort plant community surrounded by mud.

2.4.5 San Pareil High-Marsh Finger

The peninsula of high marsh that borders the south side of San Pareil Lagoon was classified in 1976 and again in 2008, as K4 at the eastern base and K5 at the northwestern tip. Assuming similar definitions then and now, the area has for more than 32 years supported plant communities that are more densely vegetated (higher biomass) and biologically diverse (more plant species) than the other plant communities at lower elevations in and around the San Pareil Lagoon. This is partly because the East River Channel has been relatively stable over that period of time, based on historic airphotos.

However, one major change appears to be underway in the last few years. All the stages of waterfowl grazing, from changing species composition through disintegrating marsh platform and finally to bare mud slumped into the low marsh, appear to be present in the area closest to the San Pareil viewing tower at the northeast corner of the high marsh finger. (See photo # ; for more

detail about the stages of waterfowl grazing on the Englishman River estuary, see the *Invasive Species* section of this report under *Canada Goose*) This suggests that parts of the high marsh finger were being grazed intensively. The goose grazing probably depends on easy and safe access to the high marsh from San Pareil Lagoon.

In 1976, the presence of one Canada Goose on the Englishman River estuary would have been an unusual sight. If numbers of the Canada Goose have been grazing the area intensely for 5 or more years, this might explain the loss or transformation of some of the other plant communities around San Pareil Lagoon. Geese using the lagoon might have grazed the Seashore Saltgrass, the Sea Arrowgrass and the American Saltwort, thus creating the conditions suitable for the early seral Sea Milkwort community to become dominant on the higher ground that was, through grazing, stressed or denuded of vegetation.

2.4.6 Mid and High Marsh Between Mine Road Dyke and East River Channel

In this area, north of the Plummer Road Forest, the plant community seems to have diversified over the last 32 years. It has transformed from a community where Arctic Rush (Juncus arcticus) and Seashore Saltgrass were abundant 32 years ago and Lyngbye's Sedge was absent (K18), to a community where Lyngbye's Sedge is now present on approximately half the area, usually on the lower elevations and often that sedge comprises more than 20% of the vegetative cover. This area is one of only 3 places in the study area (the others are the south end of the Centre Marsh area and the southwest corner of the estuary, near Golden Dawn Trailer Park) where Lyngbye's sedge appears likely to have expanded its distribution. Furthermore; these 3 areas support the only remaining pockets of tall Lyngbye's Sedge channel edge community which appears to match the description of the CDFmm Em05 *Carex lyngbyei* Herbaceous Vegetation Site Association. In that case, it is likely an occurrence of the BLUE-listed ecosystem of the same name (BCCDC, 2008). Sampling of the substrate would be necessary to confirm these 3 occurrences.

Although the Canada Goose was observed nearby on the water of the East River Channel, and there were two nests for two consecutive years just across the channel, geese were not seen using the area between the Mine Road dyke and the channel. This may be because of the frequent presence of dogs, usually with pedestrians or bicyclists during daylight hours.

2.4.7 Big Island Marsh

From 1976 to 2008, the main channel of the river has been moving east while the East River Channel appears to have changed little during that period. This report refers to the area between these two river channels as the Big Island of the Englishman River estuary. In 1976, the Big Island Marsh was a mosaic of many plant communities and it remains that today. The changes over time can be seen when comparing Kennedy's map of the plant communities in 1976 (Map, Figure 2.1) with the mapping that was done 32 years later as part of this project. (Map, Figure 2.2). The two plant community maps are superimposed on the same ortho photo from 2007 to aid in comparison but it is important not to attempt interpreting the 1976 map as if the features on the 2007 ortho basemap were present in 1976.

Natural succession has occurred at the edge of the marsh as shrubs colonize the graminoid areas and trees colonize the shrub areas.

Erosion from 1976 to 2007 appears to have removed approximately 65 to 75 metres all along the western edge of Big Island Marsh as the main channel of the river continued to move east. Of the Lyngbye's Sedge community (K8) that was once there, only a few tiny pockets remain; they can still be identified by the species present (Lyngbye's Sedge, Tufted Hairgrass *Deschampsia*

cespitosa, and Sea Plantain *Plantago maritima*). They are growing on steep sided islands among the large woody debris deposited by the river but now their location is on the opposite side of the river channel from where they were 32 years ago because the main channel has moved.

In contrast to the Centre Marsh, most of the marsh on Big Island appears to have been protected from active river erosion. During the study period two flood events were observed in which the river water levels were exceptionally high; the depth of the water in parts of the Big Island forest was sufficient to plaster sticks and leaves 5 to 100 cm up the tree trunks, depending on the elevation of the tree and its location in relation to old channels in the forest. However, the force of the water seems to have been insufficient to tear at the ground surface or topple trees in the forest. In fact, the opposite was observed; new depositions of fine alluvium were present in some broad areas after the flood. Deposition suggests that the water was moving relatively slowly with low turbulent energy, in spite of the flood. It seems likely that the trunks of the trees dissipated the energy of the river's flood water.

Except for erosion near the main river channel, active erosion on Big Island from 1976 to 2008 appears to have been confined to sediment at the edge of a steep-sided bowl, over one metre deep, which has formed at the southern tip of the main tidal channel. This bowl probably looks like a small waterfall when floodwater moving northward exits the forest during 1-year to 5-year flood events.

2.4.8 Main Tidal Channel on Big Island

In spite of what appears to be protection from erosion, the plant communities centered around the main tidal channel on Big Island seem to have undergone major changes since Kennedy mapped the area as being dominated by Lyngbye's Sedge in K8 and K4 plant communities. In 1976, the K8 community occupied the length of the main tidal channel (Big Island) across a width ranging from 10 to 20 metres and it had a large contiguous appendage running from the main tidal channel onto higher ground to the northwest; the total area of this polygon of K8 community in 1976 was approximately 0.6 hectares. Surrounding this K8 polygon, Kennedy's map shows four K4 polygons.

One of these is the K4 polygon fronting on the East River Channel. The K4 areas that are situated north of the K8 polygon and fronting onto the East River Channel are excluded from this analysis because their existence is hypothetical. In 1976, the K4 plant community that Kennedy mapped there would have required marsh-like conditions with frequent, almost daily flooding by brackish water. Today that area appears to be a mound of material rising more than a metre above the marsh and the river. The mound appears to be a continuation of the levee that lies southeast of it, but that levee was already in existence in 1976. Why would the levee have expanded over the last 32 years? Where would the gravel and sand have come from?

Air photo interpretation (B.C. 7760 No. 175; date=1975) at a scale of approximately 1:10000 suggests three hypothetical possibilities.

1) A natural process may have created the levee and that same process is continuing to act periodically or seasonally on the East River Channel and Big Island, burying the sedge marshes there and extending the levee northwards.

Sometime between 1976 and 2007, the river bed of the East River Channel may have been dredged, perhaps to enhance log booming or to channel floodwater, and then the dredged material was filled on top of the K4 marsh community, creating a mound of gravel where, in 1976, there used to be a marsh dominated by Lyngbye's Sedge.

Perhaps, a simple transcription error was made by Kennedy. On the 1975 air photo, the areas on both sides of the entrance to the main tidal channel of Big Island appear to have some upland vegetation that Kennedy did not seem to record on her map. Perhaps the areas in question never were K4 brackish marsh communities and Kennedy knew that; her intent was to label the plant

community on the levee as K17 or K16 but for some reason it was labeled K4 by mistake.
No single hypothesis seems to explain the observations. More time would be needed to research the history of dredging in that location before that area could be included in an analysis of the vegetation changes, natural or anthropogenic, that have occurred there in the last 32 years.

- areal extent of the changes
Excluding those areas that are now a mound of gravel, the three other K4 polygons surrounding the main tidal channel on Big Island in 1976 had a total area of approximately 0.6 hectares (.02ha + 0.1ha + .55ha - .07). Thus, the total area occupied by plant communities with Lyngbye's Sedge as a dominant or codominant species (one K8 polygon and three K4 polygons) in and around the main tidal channel on Big Island in 1976 was approximately 1.2 hectares. In 2008, only .24 hectares (20%) of sedge communities remained in that area, and all of it was K4. In 2008, the K8 community was gone completely including the tall Lyngbye's Sedge channel-edge community that was likely present there as part of the K8 polygon that was mapped in 1976.

- the changing shape of tidal channels
However, two-dimensional mapping does not tell the whole story; the 32-year transformation of this 1.2 hectare area has more than two dimensions. What was likely a narrow, steep-sided channel with permanent water in it, even at low tide, is now a broad flattened channel that is low relief (like the cross section of a saucer). In 1976, the tall Lyngbye's Sedge channel-edge community would likely have overhung the steep channel edges providing shade and cover for aquatic animals in the channel and the roots would have provided stability for the steep sides. Today, the centre of the saucer lacks standing water at low tide, so it is no longer suitable for fish.

- what replaced the sedge communities?
Approximately 80% of the sedge community (K8 and K4 combined) at this location had been replaced by 2008. The highest elevation parts of the sedge communities were replaced by a community that we described in 2008 as 'Simplified K4&K8-b.' It is typified by some native species like American Saltwort and Silverweed cinquefoil (Potentilla egedii) that are likely remnants of the community that has been modified by grazing (see photos # for Sample Plot wp# 167, photos 0801 to 0811, 2008_09_26), but it also includes invasive species like European Annual Saltwort, Brass Buttons and Creeping Bentgrass (Agrostis stolonifera) which seem to be more tolerant of, or less targeted by, the grazing. The total vegetative cover for many parts of this Modified K4&K8 area is less than 50%, and the plants that are present appear to be cropped short and often depauperized. Compare this with the greater height and density of the plant cover on the area beyond the grazing edge (mostly community K14).

At lower elevations, the sedge communities were replaced by the early-seral Sea Milkwort community and at the lowest elevations near the channel, the sedge communities were replaced by a community comprised of mud, mud-surface algae and sparse Low Clubrush (*Isolepis cernua*). Widgeongrass (*Ruppia maritima*) was probably present in the centre of the channel for the length of the main tidal channel on Big Island in 1976, but in 2008 its occurrences were few and sporadic in the lower half of the main tidal channel on Big Island. For understanding the changes over time, it is unfortunate that Kennedy did not map the K1 (or similar) community in the narrow channel as separate from the K8 community that would have likely overshadowed it in 1976.

- the grazing front
The active grazing front follows the edges of the this same area where Lyngbye's Sedge was once dominant or codominant and most of the area that lies below (i.e. lower in elevation from) this active grazing line no longer supports Lyngbye's sedge.

2.4.9 Centre Marsh

The river and tidal channel immediately east of the Shelly Road Viewing Tower was the main channel of the Englishman River in 1976. The area between it and the new (2008) main channel is referred to in this report as Centre Marsh. It is a mosaic of different plant communities, many of which appear to be in various stages of succession after the disturbance associated with flooding by fast flowing river water as the river destabilized and moved its location a number of times in that 32 year period. Changes in the plant communities can be seen by comparing the map from 1976 (Kennedy 1982) with the plant community map from 2008 that is based on data collected in this project. The two plant community maps are superimposed on the same ortho photo from 2007 to aid in comparison but, again, it is important not to attempt interpreting the 1976 map as if the features on the 2007 ortho basemap were present in 1976.

Changes to the vegetation have occurred in nearly every polygon of Centre Marsh since 1976. However, the largest changes have occurred in the communities where Lyngbye's Sedge was one of the dominant species (K10, K8 and K4).

- areal extent of transformation
In contact with the northwestern edge of the marsh, there were three polygons of Lyngbye's Sedge, one polygon of K10 plant community and two polygons of K8 plant community in 1976. These three sedge-dominated polygons with a combined total of approximately 2.2 hectares (1.5 + 0.6 + 0.2) are now completely gone, replaced by an archipelago of Early Seral Sea Milkwort Community with unvegetated or sparsely vegetated sand and pebbles in between the islands of Milkwort.

- changes in biomass, productivity, biodiversity and marsh platform
There appears to have been a major decrease in the biomass, productivity and diversity of that part of the estuary because Sea Milkwort does not grow as tall or a dense as the communities that were there in 1976. It is likely that this was accompanied by erosion of the rich alluvial silt and organic matter, sometimes more than a metre thick, that would normally be associated with the Lyngbye's Sedge plant communities, and held there by the roots of the sedges and other brackish marsh plants. As on Big Island, a few remnants of this marsh platform remain surrounded by the simpler early seral marsh typical of disturbed lower elevations.

A number of possible explanations can be hypothesized to explain the changes in the Centre Marsh:

1. Increased salinity -

Since Lyngbye's sedge seems dependent on brackish water, if an increase in salinity occurred, it might eliminate the sedge and the resultant loss of the rootmass might destabilize the whole marsh platform. Changes that could cause an increase in salinity include:

a) The changes in the location of the main river channel between 1976 and 2008 might have changed how the freshwater mixes with the salt.

The rising sea level from global warming makes estuaries particularly vulnerable because an increase of only a few millimeters might affect a large geographic area if it is low elevation and flat (low relief). The possible change in relative sea level from plate tectonics as Vancouver Island continues to rotate on its long axis, could complicate prediction of the sea levels resulting from global climate change. For more details and references, see section on *Topography, Surficial Geology and Hydrology of the River System* in the *Introduction* to this report.

The river may be carrying less water because of the increase in licenced removals that have been granted, and possibly an increase in unregulated uses (through new uses of riparian rights and groundwater, or possibly through illegal withdrawals).
Changes in other climatic or hydrological factors that affect the seasonal flow regime might create

an increase in salinity that occurs in summer only. For example, the deforestation of the watershed that has occurred over the last 150 years might have increased flows in winter and during floods, but at the same time decreased freshwater availability during summer and other periods of low flow because of an increased tendency for the river to discharge its water more quickly than in the past (For more details and references, see the *Introduction* to this report) .

2. Erosion by the river -

As the main river channel moved east, large amounts of fast moving water might have been crossed these polygons at times during the period from 1976 to 2008, disturbing and scouring the surface of the marsh.

3. Erosion by storms and large woody debris -

Note that all three areas where the sedge plant communities vanished are facing the open Strait of Georgia. Around some of the large woody debris scouring of the vegetation appears to have occurred in an arc around the tree, with root ball apparently acting like an anchor.

4. Grazing by waterfowl -

during the period from 1976 to 2008, Canada Goose numbers increased from between one and 10 seasonal visitors to hundreds of birds that appear to be resident (see *Canada Goose* in the section on *Invasive Species* below.

At the south end of the Centre Marsh in 1976 Kennedy delineated an area as Red Alder Plant Community (K19). This community's description does not include Lyngbye's Sedge. In 2008, approximately 25% of that area was unrecognizable because it lies within the new main channel of the river. To understand this, compare the same area in the maps in Figure 2.1 and Figure 2.2. Other areas appear to have developed a plant community on top of part of the log jam that occurred there years ago. Patches of the land that remained terrestrial since 1976 were occupied by Lyngbye's Sedge in 2008; in the 2008 map (Figure 2.2) this area is shown as unclassified polygons. The conditions suitable for Lyngbye's Sedge were probably created by an increase in the salinity of the water and substrate brought about by greater tidal inflows up the Western River Channel as the main flow of the river moved away from the Western River Channel. Comparing the records suggests that the south end of Centre Marsh is one of 3 areas where Lyngbye's Sedge has expanded its distribution on the Englishman River estuary during the last 32 years; in each case there appear to be pocket occurrences of the CDFmm Em05 *Carex lyngbyei* Site Association. These might represent occurrences of the BLUE-listed ecosystem of the same name (BCCDC, 2008). Substrate sampling would need to be done to confirm this presence.

2.4.10 West Marsh

In this report, the area referred to as the West Marsh is that part of the estuary lacking trees and shrubs that is situated west of the Shelly Road tower and the dyke which is a continuation of the drivable trail that runs north from Shelly Road. The dyke effectively closed the West Marsh to the influences of tide and saltwater from 1969 to 1979, with the possible exception of periods when the flapgate in the culvert under the dyke was in disrepair. Dawe and McIntosh (1993) comment that the culvert was almost blocked by Blue Mussels, so the influences of tide and salt may have been effectively excluded even when the flapgate was jammed open. In 1979, that dyke was breached and the gap was spanned by a bridge. This reopened the entire western part of the estuary to the influences of tide and salt water. The bridge has since been removed and the breach was widened to improve the connection between the West Marsh and the rest of the estuary, the Englishman River and with the Strait of Georgia.

Kennedy's mapping of the estuarine plant communities in 1976 did not include the Western Marsh, likely because at that time it was alienated and not functioning as part of the estuary. However,

numerical baseline data were collected on 9 transects starting in 1979, within 12 weeks after the breaching of the dyke, and it continued each year near the end of June until 1983, and then again in 1986. Vegetation cover data was collected using the Braun-Blanquet scale for each species within a one-metre square releve placed at five-metre intervals along the transects. From this, percent cover and frequency of occurrence data was calculated. The methods and the details of vegetation changes during that period are described by Dawe and McIntosh (1993).

They grouped the species present according to the changes in frequency of occurrence in their 200 releve sample plots within their period of observation:

- upland species that disappeared from the study area during the period from 1978 to 1986,

colonizing species that arrived after the dyke was breached in 1979,

ephemeral species that appeared and disappeared with irregularity, and

residual species that were present in the study area before and after the breaching of the dyke:

- species that increased in frequency of occurrence,

species that stayed the same and

species that declined in frequency of occurrence during the period of study.

The results indicated a sudden die-off of salt intolerant species followed by an invasion of the newly bare soil by salt-tolerant colonizing species that included some annuals and some non-native species. "By 1986 (the end of the study), the marsh was dominated by the *Distichlis - Salicornia virginica* community which included over 52% of all the releves; halophytic vegetation was now dominant," (Dawe and McIntosh 1993). Seashore Saltgrass (*Distichlis spicata*) and American Saltwort (*Salicornia virginica*) are perennial native species.

Dawe and McIntosh noted that a decline in both the frequency and percent cover of Lyngbye's Sedge on the study site had occurred just before and after the end of their study period. Some areas with 100% cover of Lyngbye's Sedge in 1983, were "devoid of vegetation or held only Spergularia canadensis (Canadian Sand-spurry) in 1986." They attributed this, at least in part, due to the increases in soil salinity that they measured along the transect. As a brackish marsh species, Lyngbye's Sedge is dependent on inputs of both fresh and saltwater and the soil salinity appeared to have moved above the level that the species could tolerate.

The major changes to the West Marsh since 1986 seem to be a continuation of the trends observed during their 1979 to 1986 study period. In 2008, communities dominated by Seashore Saltgrass and/or American Saltwort continued to cover the majority of the ground in the middle marsh area. Most of the area appeared to be CDFmm/Em03 *Distichlis spicata* Site Association which is likely an occurrence of the RED-listed ecosystem of the same name. Substrate sampling was done at 8 locations and the findings of fine-textured poorly drained sediments support the designation of these polygons as CDFmm/Em03. However, to classify other polygons where Seashore Saltgrass was observed or interpreted to be most abundant, it would be necessary to do substrate sampling at a typical location within each of those polygons.

In 2 of the polygons sampled, the CDFmm/Em03 Site Association appeared to be complexed with the CDFmm/Em02 *Salicornia virginica-Glaux maritima* Site Association. CDFmm/Em02 occurred at sites closer to the main tidal channel and, at the two locations sampled, the substrate of the CDFmm Em02 sites appeared to present less of a barrier to drainage than did the substrate at the

CDFmm/Em03 sites. Closest to the main tidal channel in the West Marsh, we found a vegetation cover that best matched the CDFmm/Em02 *Salicornia virginica-Glaux maritima* Site Association, but no substrate sampling has been done there yet to confirm this occurrence.

In the West Marsh, the main tidal channel itself appears to be an occurrence of the CDFmm/Em01 *Ruppia maritima* Herbaceous Vegetation Site Association with Widgeongrass and Low Clubrush present on mostly muddy substrates. Canadian Sand-spurry was also present in some areas of the channel - a species which is not listed as part of that Site Association in the description by MacKenzie and Moran (2004). This presence of CDFmm/Em01 *Ruppia maritima* Herbaceous Vegetation Site Association is likely an occurrence of the RED-listed ecosystem of essentially the same name (BCCDC, 2008)

Dawe and McIntosh provide baseline data on the distribution of Lyngbye's Sedge within their transects on the West Marsh during the period from 1979 to 1986. Unfortunately, baseline data on the distribution of that species on the remainder of the West Marsh is not available. By 2008, Lyngbye's Sedge appeared to be absent from the northern and central parts of the West Marsh. This matches the trend that Dawe and McIntosh noted on their transects by 1986, the end of their study period.

Lyngbye's Sedge was present in 2008 from near the Mills Road storm drain outfall, just downslope (west) of the area where Cattails (*Typha latifolia*) grow in freshwater, west to the southwestern corner of the study area, near the Golden Dawn Trailer Park. Within that area it is present on both sides of the main tidal channel of the West Marsh, but occurrences are patchy and not all contiguous. In some areas near the main tidal channel and in the southwest corner of the estuary near Golden Dawn Trailer Park, Lyngbye's Sedge is present as the most abundant species, 50 to 70 centimetres tall, in a channel edge plant community (see photos #) that is typical of brackish areas on other nearby estuaries such as the Little Qualicum River estuary. This appears to be one of 3 remaining occurrences on the Englishman estuary of the CDFmm Em05 *Carex lyngbyei* Herbaceous Vegetation Site Association described in MacKenzie and Moran (2004) and it likely represents an occurrence of the BLUE-listed ecosystem (BCCDC, 2008) of essentially the same name. However, confirmation of this classification would require sampling of the substrate which has not yet been done.

It is likely that Lyngbye's Sedge tall channel edge community did not occur this far upstream (upslope) on the West Marsh prior to the breaching of the Shelly Road dyke in 1979, however it may have been present as a stressed remnant from the time before the dyke was completed. The stormdrain outfalls at Mills Road and Bagshaw Road and the small creek that enters the southwest corner of the estuary near the Golden Dawn Trailer Park, would likely have been providing freshwater to the area 35 years ago, as they do today. However, Lyngbye's Sedge also requires the tidal input of saltwater to create the brackish conditions that it needs. This salt input would not have been available prior to breaching the dyke, so the southwestern corner of the estuary was more likely to support Cattails than support a thriving Lyngbye's Sedge community. Dawe and MacIntosh recorded the disappearance of Cattails from their study area.

Section 3 TERRESTRIAL FAUNA

In this study, records of native terrestrial fauna on the Englishman River estuary were made as they occurred during other work that was being done; the methodology of this project did not include a systematic survey of animal life. However, some volunteers were provided with field notebooks and field guides to animal tracks and birds (Sheldon and Hartson, 1999; Alden, 1987; Peterson, 1990) to encourage this kind of record keeping, as time permitted.

Bird use of the estuary was systematically surveyed in 1979 to 1980 and 1988 to 1989 and released as a Technical Report Series by the Canadian Wildlife Service; Dawe et al. (1994) included data from other surveys and field notes that had been made up to and including 1993. For an overview or their findings, see the section in this report entitled Introduction - Terrestrial Fauna.

The Arrowsmith Naturalists (2009) recorded the numbers of all birds that they observed with binoculars on the Englishman River estuary during a monthly bird survey along a regular route, usually between the hours of 9 and 11am, from March 2005 to February 2009. Two months were not surveyed during this period due to bad weather, June 2008 and January 2009. Birds that were so far out on the Strait of Georgia that they would have required a spotting scope to identify were not counted (Maggie Little, 2009, pers. comm.) The Arrowsmith Naturalists' bird surveys began before the Caring For the Englishman River Estuary study began, but the study periods overlap, so their data is presented in Appendix 2.2. The surveyors' names are listed under Arrowsmith Naturalists in the section of this report entitled Literature Cited and References.

As part of this study in 2007 and 2008, the following animals were recorded by a biologist or by volunteers and confirmed by a biologist using descriptions, field notes, photographs and/or site visits. It should be noted that many animals were observed but not recorded in this process; from an ecological perspective, some of these animals that went unrecorded, because they are commonplace, may have far more significance to the ecology of the estuary than those rarities that get recorded. However, the time constraints, the interests and skills of the people involved and the nature of this study limited the amount of data that was recorded about some of the most common animals on the estuary. Data entry is also a bottleneck in processing data collected by volunteers; what follows is only a fraction of the data that was collected during this study:

Some of the Terrestrial Animals Observed on the Englishman River Estuary, 2007 to 2008

Invertebrates

Banana Slug	(*Ariolimax columbianus*)
Reticulate Taildropper	(*Prophysaon andersoni*)

Amphibians and Reptiles

Pacific Treefrog	(*Pseudacris regilla* formerly known as *Hyla regilla*)
Red-legged Frog	(*Rana aurora*)
Western Terrestrial Garter Snake	(*Thamnophis elegans*)
Common Garter Snake	(*Thamnophis sirtalis*)

Birds

Dunlin	(*Calidris alpina*)
yellowlegs	(*Tringa spp.)*
Killdeer	(*Charadrius vociferus*)
Merlin	(*Falco columbarius*)
Peregrine Falcon	(*Falco peregrinus*),
likely Peale's Peregrine Falcon	(*Falco peregrinus pealei*)
Bald Eagle	(*Haliaeetus leucocephalus*)
Northern Harrier	(*Circus cyaneus*)
Band-tailed Pigeon	(*Patagioenas fasciata*)
Northwestern Crow	(*Corvus caurinus*)
Savannah Sparrows	(*Passerculus sandwichensis*)

Mammals

Blacktail Deer	(*Odocoileus hemionus*)
aka Columbia Blacktail Deer	(*O. hemionus columbianus*)
Raccoon	(*Procyon lotor*)
Black Bear	(*Ursus americanus*)
Northern River Otter	(*Lontra canadensis*)
aka North American River Otter	
Harbour Seal	(*Phoca vitulina*)
aka Common Seal	
Deer Mouse	(*Peromyscus maniculatus*); a dead specimen in forest
Townsend's Vole	(*Microtus townsendii*)
Red Squirrel	(*Tamiasciurus hudsonicus*)
American Beaver	(*Castor canadensis*)
shrew	(*Sorex spp.,* either one of two closely related species: *Sorex vagrans* or *Sorex monticolus*)

Unusual Sightings

Caspian Tern	(*Hydroprogne caspia* also or formerly known as *Sterna caspia*)
golden-plover,	
likely the American Golden-plover	(*Pluvialis dominica*)
Lark Sparrow	(*Chondestes grammacus*)

The fauna of the Englishman River estuary include a number of invasive species. For information and recommendations about these, see the section in this report entitled Invasive Species - Annotated List of Some Invasive Species Observed on the Englishman River Estuary, 2007 and 2008. The Canada Goose is also discussed in this report in the section entitled Invasive Species even though some subspecies of Canada Goose could be considered native because they were

recorded using the study area in small numbers on migration prior to the arrival (sometime after 1980) of hybrid forms that do not appear to migrate.

Section 4 MAPPING SPECIAL PLACES AND FEATURES

4.1 Rationale and Method

In the process of doing other work, volunteers were encouraged to make notes and photographs to record spatial information about special features and sightings on the estuary. They were supplied with some field guides (Sheldon and Hartson, 1999; Alden, 1987; Pojar and MacKinnon, 1994).The UTM coordinates were recorded afterwards, either on paper together with the notes, or on camera by taking a photograph of the face of the GPS unit. Normally, waypoints on the GPS were not used because that would slow down the process of data entry because each point would need to be entered separately.

Sometimes features and sightings important to some aspect of the ecology of the estuary came from a member of the public; volunteers and staff then went into the field to confirm those locations. Using various records of this sort, we were able to map special features and sightings with the intent that they will be included and considered in any planning or management activities that might have impacts on the estuary.

Special features for consideration in the management planning process should also include abiotic features. For example, it might be useful for managers to have a map of the areas where erosion, deposition and natural succession of the vegetation are dominant processes. This could be undertaken by volunteers as a project separate from any biological inventory work. What follows is a small fraction of the spatial data that was collected about special places and features during this study.

4.2 Results and Discussion - Spatial Data About Some Species

Northern Riceroot was observed in only a few areas, these are important as repositories of genetic material, likely remnants from a pre-agricultural population of this plant on the Englishman River estuary. **Indian Consumption Plant** was surprisingly limited in distribution on the estuary even though suitable habitat for it seemed abundant. This might be another effect of agricultural grazing that started in the 1800's. Volunteer mapping of these and other remnant native populations would be a very useful tool to assist in management decisions; this could be done using the GPS methods developed in this study for individual invasive species. As much as possible, without compromising the reproduction of the plants on site, restoration of the Englishman River estuary should be done using seeds from the same estuary.

Solitary bee condominiums, where large numbers of these insects bury pollen from Gumweed for their larvae to eat, are important areas for those bees, and possibly to the Gumweed and other native species that the bees pollinate in the fall. It is unknown whether the conditions required for the solitary bees to create a condos are highly specific or can they met easily at other locations on the estuary.

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The **Red-legged Frog** is listed as a species of special concern by the Committee on the Status of Endangered Wildlife In Canada (COSEWIC). It is also on the Province of B.C. BLUE-list (BCCDC, 2009). One Red-legged Frog was found on the estuary; the area where it was found, the pool and the surroundings should be excluded from any future plans for recreational use or habitat

enhancement. Existing trails should be diverted from that area, if human presence becomes damaging to the habitat of the Red-legged Frog.

Some shaded pools around Big Island on the Englishman River estuary supported schools of **juvenile salmonids** through the summer of 2007. At times, these pools of fish were trapped. Small schools of salmonids were also often observed using the small, permanently flooded tidal channels with steep banks and overhanging vegetation in the West Marsh / West Lagoon areas. No changes should be made to the estuary that do not take these uses into account.

The uppermost areas of the tidal channels sometimes supported **sticklebacks** of various sizes that appeared to move with the tides from the permanently flooded lower channels; the sticklebacks were distinguishable from other fish without sampling because of the way they sometimes hold their tail kinked to one side.

Two **Bald Eagle** nests were observed in this study. One in a Black Cottonwood on Big Island, had eagles around it during the spring of 2007. The other, in a conifer (possibly a Douglas-fir), appeared to be in active use on 15 February 2009. Bald Eagle nests have statutory protection in the province of B.C.

On one occasion, one **Peregrine Falcon** was observed in 2007 using the area from San Pareil Lagoon to the Centre Marsh for hunting. The ducks present took flight in flocks and seemed to be moving away from the falcon. It perched on a tall conifer near the Shelly Road Viewing Tower but the perch at the other end was not clear. Those perch trees, whether on the estuary or in the suburb, should be preserved. The Peregrine Falcon subspecies likely to present on the study area (*F. peregrinus pealei*) is BLUE-listed by the Province of B.C. (BCCDC, 2009).

One **Merlin** was often observed using an area in the high marsh of the West Marsh Lagoon during the summer of 2008. This "Merlin Runway" consisted mainly of a series of perching spots on tall stumps and upturned root balls. One Northern Cottonwood was also used which appears to be on the property of Surfside RV Park. The principle prey item that was being sought at that time seemed to be **Savannah Sparrows**; some close misses, but no kills, were observed. The sparrows would rise up, notice the high speed approach of the Merlin, and then dive dramatically into tall vegetation. **Sandpipers**, another common prey item for the Merlin, were observed using the tidal channels between the areas of high marsh, but none were observed under pursuit by the Merlin in this study. The stumps on the estuary and the surrounding trees, as much as possible, should be left as they are.

Two **Northern Harriers** were observed on three occasions, hunting for ground-based prey, probably voles, in one area of the Big Island marsh. They were observed using stumps and posts, although they also seemed to land on the ground surface. The presence of humans (in this case doing vegetation survey work) seemed to displace their activities to the edge of the area where the people were. We recommend that the goal for Big Island on the Englishman River estuary be that it is kept free of bridges and trails, that dogs (*Canis lupus familiaris*) and domestic cats (*Felis catus*) be excluded, that wildlife corridors for predators be maintained to connect it with other natural areas. We also recommend that signs be posted to marijuana growers know that many people know about their clearings among the Nootka Rose thickets and it will only take one person to prevent their hard work from paying off.

Dunlin, **yellowlegs** and **Killdeer** were common sights foraging in the muddy substrate of San Pareil Lagoon.

The **American Golden-plover** is BLUE-listed by the Province of B.C. (BCCDC, 2009). It was seen on the lowest intertidal bars at the mouth of the river during an exceptional low tide.

The **Great Blue Heron** occurs on intertidal areas of the estuary wherever there is some standing or flowing water with fish, and also but rarely on the intertidal marshes. The local subspecies is *Ardea herodias fannini,* which is a BLUE-listed species by the Province of B.C. (BCCDC, 2009).

The **Band-tailed Pigeon** is listed by COSEWIC as a species of special concern. It is also a BLUE-listed species by the Province of B.C. (BCCDC, 2009). In this study, flocks of up to 20 birds were observed using the area of forest on Big Island where the forest meets the broad shrub zone adjacent to the main river channel, and in similar habitat near where the forest meets the narrow shrub zone and marsh at the southwest corner of the estuary. This represents observations made in on different days spread out over two years, so it might represent the same group of up to 20 birds. However, in one survey on July of 2007, the Arrowsmith Naturalists team counted 33 Band-tailed Pigeons on the Englishman River estuary. The peak number from an earlier study (Dawe et al., 1994) was 49 Band-tailed Pigeons observed on 15 June 1980, in the upland area behind the Mine Road Dyke.

The success of Band-tailed Pigeons in an area seems to be linked with roosting sites and especially to their access to certain mineral supplements. "Mineral sites used by Band-tailed Pigeons should be included in the overall management scheme for maintaining stable breeding populations of this species (Sanders and Jarvis, 2000)." More information about Band-tailed Pigeon use of the Englishman River estuary would be needed before any changes were proposed to any of the areas used by these birds.

Hundreds of **Northwestern Crows** were often observed in the evenings flying east over the Centre Marsh and Big Island Marsh of the Englishman River Estuary. They seemed to be coming from the beaches of the Parksville area, where they are known to forage in numbers, and going to a roosting area in the vicinity of the Plummer Road Forest, the adjacent pasture lands or, more likely, further east in Rathtrevor Park. That roosting area should be located and protected by agreement if possible.

A group of approximately 5 **Northern River Otters**, with 2 large members and 3 smaller members, was observed frequently in 2007 and again in 2008 in the area from the entrance of San Pareil Lagoon up the main channel of the Englishman River estuary about half way upstream beside Big Island. The area is full of rest spots and trails, many with marking spots and piles of faecal matter, along the river's edge. A possible den location was found near the northern edge of the forest on Big Island in an area where the river is rapidly eroding the steep bank.

The otter's presence dominates the banks on Big Island but they share these swimming areas in the main channel of the river with the **American Beaver** and the **Harbour Seal**. The beavers seem to be cutting trees among the new growth of cottonwoods, willows and alders along the river near the south end of Big Island and also where the big log jam is buried at the south end of the Centre Marsh area, adjacent to the estuary forest and near to the Shelly Road Trail. No lodge was observed but, from the presence of canal work and beaver pathways and wood cutting in the latter area, it appears that they den in that area, where the former main river channel (1976) joins the channel that is the main river channel today (2009).

In the estuary study area, the areas of highest use by **Humans** are those with the easiest access. The most accessible and least vulnerable areas for human use are the two viewing towers and other viewing spots along the banks of the river, the Mine Road Dyke and Trail, the remnants of the Shelly Road Dyke and Shelly Road Trail, and the Forest Perimeter Trail. Any trend from the public, or plans from landowners or the municipal and regional governments, that would change

this pattern of human access should be considered carefully because it could have a large impact on the natural ecosystems of the estuary.

4.3 Understanding Estuary Ecology in Four Dimensions

Mapping special places and features gives another spatial dimension to this report about the Englishman River estuary. However, ecologically important information is not static; ecology is also about the timing of events. For example, each niche is often described by a species' place on the food chain, but the food of some organisms changes from week by week.

Seasonal changes in the ecology of the estuary appear to be dominated by a sequence of pulses in the availability of nutrients (essential elements, organic compounds, biomass) which overlays the yearly cycles of the availability of solar energy and fresh water. Some events that might function as pulses of nutrients were recorded in this study; it is likely that many others are not yet understood. A useful project for volunteers would be to work with biologists to develop criteria for systematically recording the timing of the onset, peak and closure of these nutrient peaks. Some of these examples need only a way of interpreting existing data; others would require new observations. The purpose would be to develop the kinds of information that would be required to show the complexity of the ecosystems, and the ecosystem changes that might result from any planned perturbation, including habitat restoration proposals.

As a record of the timing of these events is developed, it also might be possible to develop some understanding of how these events synchronize with each other in a way that meets the needs of the various species on the estuary. For example, it is impossible to understand the bird count data collected on the Englishman estuary by the Arrowsmith Naturalists without understanding that in March 2008, the main herring spawn on this part of the coast took place elsewhere (Deep Bay to French Creek) and so the birds that follow that abundant food supply were mostly gone from study area during that period.

Below are listed some examples of natural events which might be important to estuary ecology. A first step to understanding would be to monitor the timing of these events, and that would require clear definitions of onset, peak and closure for each event so that volunteers all mean the same thing when recording and sharing information:

- herring spawn (Are the year to year changes in location connected to changes in commercial harvest? How do these changes affect the estuary?)
- salmon run upriver for adults of each species (Who eats the fish before and after they spawn? What is the importance of this nitrogen to the estuary forest and marsh?)
- salmon smolt arrivals coming downstream (Who eats whom in the world of young salmon? Are there cycles in food availability for Belted Kingfishers, (*Megaceryle alcyon)?*
- alder pollen drop (What utilizes this layer of nitrogen rich organic material on the soil?)
- leaf drop of maples, cottonwoods and alders, and also deciduous shrubs that are abundant on the estuary (Has the soil of the estuarine forest been accumulating organic matter since the Ice Age?)
- first active insects (Who eats winter craneflies, springtails, midges and mayflies?)
- first flush of fungal fruiting bodies, such as Oyster Mushrooms (*Pleurotus ostreatus*) (The huge numbers of fungus gnats that emerge - are they important to the early success of young salmonids and young spiders?)
- first pollen and nectar sources such as: the flowers of Skunk Cabbage (*Lysichiton americanum*) (Is this important to the beetles and flies that attend?)
- - first flowers of Red-flowering Current (*Ribes sanguineum*) and Salmonberry (Are these important to Rufous Hummingbird, *Selasphorus rufus*, arrival times?)

- maple nectar and flower drop (Is this important to nectar feeding bees and other insects?)
- amphibian migration and occupation of ponds (Amphibian eggs, larvae and adults are food for pond insects, snakes and many other species. Is this important?)
- the huge increase in insects in mid April and May (How important is this to salmonids? Why were bluebirds not observed on the estuary in this study?)
- queen ant flights (How important is this to salmonids, hawking flycatchers, warblers and nighthawks, and salmonids, etc?)
- queen termite flights (How important is this to hawking flycatchers, warblers and nighthawks, etc?)
- algae (likely *Enteromorpha spp*) bloom in spring (Is this important to provide cover for fish?)
- arrival of earliest song birds, such as the Yellow-rumped Warbler (*Dendroica coronata*) (Is this important to the arrival times of some raptors?)
- goose moulting period (Does this change the feeding patterns of the geese on the estuary?
- Is the volume of high nitrogen feathers that wash onto the beaches and marshes significant?)
- the burst of growth (biomass increase) by marsh plants such as Lyngbye's Sedge (How quickly can the marsh platform replace itself if waterfowl grazing is reduced?)
- waterfowl feces as a form of available nutrients to plants and invertebrates
- waterfowl eggs (Is this an important seasonal food for carnivores? If not, why not?)
- shorebirds migrating through the estuary (Is this an important food for falcons? Why are there so few sightings of the Peregrine Falcon?)
- a burst of mycelial activity by fungi that seems to occur in Spring and Fall (Does this release nutrients to the soil? Where do these nutrients go?)
- arrival of leafy structures (How do changes in species composition over decades, as described in this report through When river erosion, goose grazing, natural succession, or the arrival of an invasive species changes the leaves available on the estuary, as described in this report, how does that affect the herbivores like geese and deer or caterpillars?)
- berries and fruit - salmonberries, Nootka Rose hips, pacific crabapples, bitter cherries (What eats them and when? What are the Band-tailed Pigeons eating throughout their spring, summer and autumn seasons on the estuary?)
- last pollen sources such as Gumweed (How important is this to solitary bees and their parasites and commensal insects within the same condominium?
- Are the bees important to Gumweed seed production? What eats Gumweed seeds?)

A few timelines that are locally applicable to the study area are available. Campbell (1990) presents biweekly changes in abundance of each species of bird in the Parksville/Qualicum Area. Her report draws on the work of Dawe (1976, 1980) in which baseline phenology data for this region is presented, primarily for bird and plant species on the Little Qualicum River estuary, but also for non-avian animals there including some invertebrates. However, it should be noted that each estuary is different and therefore unique.

Section 5 INVASIVE SPECIES

5.1 Introduction

Vancouver Island is unique in that its native ecosystems seem to lack many of the species present just across the water on the mainland such as the Grizzly Bear (*Ursus arctos*), Lynx (*Lynx canadensis*), Bobcat (*Lynx rufus*), Coyote (*Canis latrans*), Red Fox (*Vulpes vulpes*), Long-tailed Weasel (*Mustela frenata*), Fisher (*Martes pennanti*), all species of skunks (*Spilogale gracilis* and *Mephitis mephitis*), Snowshow Hare (*Lepus americanus*), Rocky Mountain Pika (*Ochotona princeps*), Porcupine (*Erethizon dorsatum*), Mountain Beaver (*Aplodontia rufa*), Flying Squirrel

(*Glaucomys sabrinus*), Bushy-tailed Woodrat (*Neotoma cinerea*), Douglas Squirrel (*Tamiasciurus douglasii*), all species of chipmunks (*Tamias townsendii* and *Tamias amoenus*) and a number of other species of rodents, all species of moles (*Scapanus orarius* and *Neurotrichus gibbsii*), Masked Shrew (*Sorex cinereus*), Black-capped Chickadee (*Parus atricapillus*) and Leopard Frog (*Rana pipiens*). It appears that Vine Maple (*Acer circinatum*) and the large birches native to B.C. (*Betula occidentalis* and *Betula papyrifera*) are two of the many mainland plants that are not native to the Island. The absence of each of these species means that the ecosystems present on Vancouver Island are different in ways that may be subtle or gross.

In addition, Vancouver Island supports a number of species or subspecies of plants and animals that occur nowhere else in the world. Each of these endemic taxa may have behaviour and morphology that is adapted, often through an expanded niche, to the unique situation on the Island. This means Vancouver Island, like Hawaii and New Zealand and many other biogeographic "islands" (islands, lakes, or mountain ranges that have been isolated) has some taxa, ecosystems and behavioural strategies that can only be viewed alive, in place, on that island.

In Australia, the concern about invasive species is high. If one species of rabbit and one species of cactus, to name just two examples, could cause major economic and ecological problems, the concern is about what else was possible. At one time, everything from the tires of the aircraft to the shoes of the air travelers were cleaned upon entry to prevent the unwelcome arrival of seeds and other organisms that might turn their whole ecological and economic picture upside down.

Meanwhile on Vancouver Island, people continue to import and cultivate those non-native species that have the capability of escaping and naturalizing, such as English Ivy, Lesser Periwinkle, Yellow Lamium and Common Carp (*Cyprinus carpio,* also known in English as koi), thereby creating potential ecological and economic problems that may grow ever bigger as people prepare to hand their home place on to the next generation. For example, in west Qualicum Beach, a new road expanded the distribution of an unknown number of species including Couchgrass (*Elymus repens*), Scotch Broom (*Cytisus scoparius*), the European Black Slug (*Arion ater*) and the Great Grey Slug, also known as the Leopard Slug (*Limax maximus*), all native to Europe. As a result of these arrivals, gardening, horticulture and opportunities for commercial vegetable production suddenly became more difficult and costly, and less economically viable.

In the USA, "4,500 nonnative species have established free-living populations, of which about 15 percent cause severe harm; looking at just 79 of those species, the OTA documented $97 billion in damages (US congressional Office of Technology Assessment, sited in Quammen, 1998)."

On the Englishman River estuary, well meaning people have planted packets of "wildflower" seeds that are native to California and the Ukraine but not native to Vancouver Island. Governments have introduced, or allowed the spread of, mixed-breed geese that do not seem to migrate (Campbell et al., 1990; Dawe, 2004, pers. comm.; Clermont 2009, pers. comm.). Domestic cats, whether they are pets or feral animals, roam the estuary. For centuries, songbirds have travelled hundreds of kilometres to nest on Vancouver Island which, until recently, had no small feline predators, neither Lynx nor Bobcat. Do the songbirds nesting on Vancouver Island have behaviour patterns suitable for avoiding the hunting styles of a small feline predator?

Thus, the Englishman River estuary, with its rare natural ecosystems and invasive species, is a microcosm of this issue which is both island-wide and global; some examples will be discussed

below. This project undertook to list the invasive species encountered, map the distribution of selected species within the study area, research and experiment with some control measures, and report findings and recommendations in an annotated list that prioritizes the invasive species seen based on the severity of the problems likely to be associated with them. Our objective was to contribute to realistic long-term planning that is specific to each invasive species and the location of its occurrence.

5.2 Invasive Species Mapping Methodology

The UTM coordinates of selected non-native vascular plant occurrences were recorded by trained volunteers onto a GPS unit (either Garmin etrex Legend or Garmin etrex Summit). The data from this was downloaded and mapped using ArcView 3.1 onto 2007 colour orthophotos (.tif format) for use at scales of 1:10000 to 1:300. For Scotch Broom, the distribution was determined by a combination of GPS-recorded occurrences and orthophoto interpretation of broom plants. The map of Scotch Broom distribution on the estuary (Map 2.3) shows these two forms of data separately to inform users about the accuracy of the points being shown. For English Ivy, which can be seen in trees at a distance, most occurrences were recorded using a GPS, but some locations were mapped by recording the approximate locations in relation to some landmarks that were later located on the 2007 orthophotos. Other non-native plant maps are based mostly or entirely on GPS field data. The range maps of invasive species were used to develop recommendations for management. To help with discussion and planning strategies, the broom management plans are area-specific through reference to broom management zones (Broom Zones A to H).

A list of invasive species observed during this study on the Englishman River estuary is provided in Appendix 2.3. Below is an annotated list of some of the observed invasive species arranged in a sequence from high to low priority; the species that seemed to present the most serious threats to native species and ecosystems on the estuary are at the top while those species that appear to be less threatening are nearer the bottom. Invasive species information and rankings from many sources were taken into consideration, but also the purpose of the ranking; a plant that is considered noxious or "invasive" in a farmer's field which is perpetually maintained in the early seral stage typical of modern agriculture may be a minimal threat within an established estuary ecosystem. The origin of some species that are present on the Englishman River estuary, such as Stinging Nettle (*Urtica dioica*), may be controversial. Another example, Saltmarsh Dodder (*Cuscuta salina*) is present in the study area; it is considered a native species in this report, based on E-Flora of BC (2009) and Wikipedia (2009), even though there may be some controversy about this.

Non-native species that have an observable impact on native ecosystems are ranked a higher threat than those that do not yet present impacts. In this report, the shade tolerant non-native species are considered a higher threat to native species and ecosystems in the forest than are early seral species that only live for a few years on freshly disturbed ground in open areas. A non-native species that has been present for decades and appears to have reached a stable population and distribution on the study area will be ranked as a lower threat, if all other factors are equal. Non-native species that are known to do well and spread quickly in this climate are considered a greater threat, and so on. Species native to Vancouver Island are not considered a potential threat unless there has been some kind of genetic or behavioural modification, as is the case with the Canada Goose and Reed Canarygrass, for example.

In Appendix 2.3 can be found a list of some vascular plant species or taxa introduced to Vancouver Island that were observed on the Englishman River Estuary during 2007 and 2008.

5.3 Annotated List of Some Invasive Species Observed on the Englishman River Estuary, 2007 and 2008

5.3.1 Overview

The purpose of this list is to help with a 6-step planning process for volunteers, land managers and for the Mid Vancouver Island Habitat Enhancement Society.
For each species:

1.) Know the subject species and its ecology. This will give clues about management options.
2.) Know its distribution in and around the estuary, and how long it has been there.
3.) Catalogue some techniques tried or observed; include details of what, where, when, why?
4.) Prioritize the work from first experiment to final outcome, then make a plan and act on it.
5.) Record results. Scientific methods of testing techniques give understandable and replicable results. If the testing appears a success, volunteers are likely to feel encouraged. If the testing shows a failure, it allows another, more refined attempt a through an adaptive process.
6.) Make further recommendations to modify the plan for controlling the invasive species and build a deeper relationship with partners.

The following annotated list of invasive species is not intended to be comprehensive. A more complete list of invasive species observed on the estuary is presented in Appendix 2.3. More species will be added to the list as new ones are found and as new species invade the area.

Each category is presented in approximate order of suggested priority; this same sequence is used in the annotated list below.

Shade-tolerant Invasive Plant Species of Forests and Forest Openings

(1) Lesser Periwinkle (*Vinca minor*)
English Ivy (*Hedera helix*)

Common Touch-me-not (aka Jewelweed or Impatiens) (*Impatiens noli-tangere*)

Yellow Archangel - variegated form (*Lamiastrum galeobdolon*)

Herb Robert (aka Robert Geranium) (*Geranium robertianum*)

Spurge Laurel (*Daphne laureola*)

European Holly (*Ilex aquifolium*)

Shade-Intolerant Invasive Shrubs and Trees

(2) birch (*Betula spp.* likely European White Birch, *Betula pendula*)
Scotch Broom (*Cytisus scoparius*)

Armenian Blackberry (aka Himalayan Blackberry) (*Rubus armeniacus*)

& Cut-leaf Evergreen Blackberry (*Rubus laciniatus*)

Salt-tolerant Invasive Plant Species of Brackish and Saline Marshes

(3) Creeping Bentgrass (*Agrostis stolonifera*)
European Saltwort (aka Common Glasswort, S*alicornia europaea* aka *Salicornia depressa*)

Brass Buttons (*Cotula coronopifolia*)

Couchgrass (*Elymus repens aka Agropyron repens, Elytrigia repens)*

Shade-intolerant Early Seral Plant Species

(4) knapweed (*Centaurea spp.* likely Spotted Knapweed, *C. maculosa* aka *C. biebersteinii*)

Canada Thistle (aka Creeping Thistle, *Cirsium arvense*)

Bull Thistle (*Cirsium vulgare*)

Common Tansy (*Tanacetum vulgare*)

Purple Deadnettle (aka Purple Lamium, (*Lamium purpureum*)

Some Other Non-native Plant Species

(5) Field Bindweed (*Convolvulus arvensis*)

(6) some buttercups (non-native *Ranunculus spp.* such as Creeping Buttercup, *Ranunculus repens*)

Early Hairgrass (*Aira praecox*)

(7) Perennial Sow-thistle (*Sonchus arvensis*)

Some Non-native Animal Taxa (Species, subspecies and crosses)

(8) European Black Slug (*Arion ater*)

Canada Goose (*Branta canadensis*), the non-migratory cross variant

Ring-necked Pheasant aka Common Pheasant (*Phasianus colchicus*)

California Quail (*Callipepla californica*)

(9) Barred Owl (*Strix varia*)

(10) European Starling (*Sternus vulgaris*)

House Finch (*Carpodacus mexicanus*)

Eastern Cottontail (*Sylvilagus floridanus*)

Domestic Cat (*Felis catus*)

Domestic Dog (*Canis lupus familiaris*)

Human (*Homo sapiens*), the industrialized cultural variant

Some Non-native Species To Prepare For

These species were <u>not</u> observed on or adjacent to the estuary in this study, but are known to occur in the area.

(1) Chervil or Wild Chervil (*Anthriscus sylvestris*)

Giant Hogweed (*Heracleum mantegazzianum*)

Great Grey or Leopard Slug (*Limax maximus*)

(2) Grey Squirrel (*Sciurus carolinensis*)

5.3.2 Shade-tolerant Invasive Plant Species of Forests and Forest Openings

Lesser Periwinkle (*Vinca minor*)

Lesser Periwinkle is present on the study area for a stretch along Plummer Road from the large Western Redcedar (*Thuja plicata*) shrine for Neil Robert Murison in the south to the roadside ditch just north of the main trail into the Plummer Road Forest. Periwinkle is a highly invasive ground cover from Europe that spreads vegetatively by above-ground trailing stems. Severed stems can root easily. Its evergreen leaves are vaguely reminiscent of English Ivy but, unlike the ivy which grows nearby, periwinkle does not climb. In spring, its showy periwinkle-blue five-petaled flowers are unmistakable. Because it is tolerant of shade, periwinkle could easily become a permanent part of the forest floor on southeastern Vancouver Island to the exclusion of many native species. In this study, periwinkle was observed competing successfully with a number of native species including Vanilla Leaf (*Achlys triphylla*) and Fringe Cup (*Tellima grandiflora*).

The authors consider this species to be of the highest possible concern and recommend immediate removal with the goal of eradication. Plummer Road is the only known occurrence in the study area; it is an area where the native vegetation is already impacted by invasive species and human recreational use of the narrow riverside strip. The advantage of this is that, although pulling of periwinkle will disturb the soil, this will likely have minimal impact the ecosystems present.

The river itself seems to provide a barrier to the spread of periwinkle but that is an illusion; one stem of periwinkle broken off on Plummer Road and tossed into the river might have a fair chance of landing on Big Island where it could easily root and create a severe impact on the intact native ecosystems there.

We recommend experimentation with hand pulling coupled with careful record keeping so that the most efficient method of removal can be identified. Everyone would need to be informed of the importance of not spreading the broken stems anywhere, especially not in the river. The plant contains vincamines which have some human metabolic effects. Hand washing after hand pulling is important, and the periwinkle plant parts should be meticulously removed for shredding and composting rather than attempting to dispose of them by dumping or burning.

English Ivy (*Hedera helix*)

English Ivy, also known as Common Ivy, is present in a few locations on the estuary. However, in contrast with broom and blackberry which are shade-intolerant and generally dependent on disturbance, ivy can spread and become dominant within a mature forest, even a mature (Structural Class 6) riparian forest. For example, near the mouth of the Sooke River there exists an occurrence of what appeared to be a Douglas Fir - Salal forest several hundred years old. It might have been classified as an occurrence of a RED-listed ecosystem but the ground and the tree trunks were so overgrown with thousands of square metres of English Ivy that the native plant community was almost unrecognizable. For this reason, the presence of English Ivy on the Englishman River Estuary is an acute threat to native ecosystems.

The good news is that the occurrences on the Englishman River estuary appear to be spreading slowly and their total number and size allow them to be managed immediately for containment. The goal with ivy on the Englishman River Estuary should be complete eradication of this serious invasive species as soon as possible. Even for a volunteer group, and especially with the help of paid labour in the summer, there seems to be a reasonable expectation of success.

Ivy is both a ground cover and a climber, which in one area of the estuary has achieved 50 to

100% coverage on the forest floor and a high percent cover in the canopy. It climbs with use of sucker-like pads comprised of aerial rootlets. Ivy has two types of leaves, the familiar palmate 5-lobed "juvenile" leaves of the climbing vines and the "mature" leaves associated with the black clusters of berries. The leaves and stems contain biologically active chemicals which have medicinal and toxic qualities that should not be carelessly ingested or breathed as smoke. Gloves are recommended for handling. Each person working with ivy should take care at first to see if they have any reaction because "The leaves can cause severe contact dermatitis in some people." (Jøhnke, H & Bjarnason, B. (1994). and Boyle, J. & Harman, R. M. H. (2006) cited by Wikipedia, 2009) Disposal of cuttings by fire is probably not a safe option unless a facility is available that allows special precautions to vent the smoke.

The largest occurrence is on the Big Island near an area that ranks as one of the oldest and most undisturbed natural forest areas on the entire estuary. Seven large tree trunks (3 trees were approaching one metre diameter at breast height, approximately) were found to be completely covered by ivy stems. The ivy stems were overlapping on the trunk three or four layers deep for a total of up to 20 centimetres so that no part of the tree's bark was visible near the ground. The largest ivy stems were over 10 cm thick and, if the annular growth rings on ivy are annual, the ages of the largest stems were more that 50 years. The growth of ivy leaves on these trees could easily be seen as part of the forest skyline from 300 metres away. Uncounted smaller trees and shrubs were also supporting a mass of ivy and there was at least 700 square metres of ground surface completely covered by living ivy leaves. Two other separate, relatively minor, ivy occurrences were found on the Big Island, one on the west side near the main channel of the river and the other in the heart of the forest.

Another large occurrence of ivy involves 7 tree-trunks between the east bank of the river and Plummer Road. A few plants can be also be seen beside the forest perimeter trail where it passes the straight-sided pond near the Mills Road entrance.

With the concerted effort of four men over 3 days at the worst infestation on the estuary, the ivy stems were completely removed from the seven largest trees. The tools used were machete, sharpened mattock, long-handled loppers with a compounded mechanical advantage, and hand pruners. It was thought that a chainsaw would be more likely to damage the tree and be a danger to the removal crew, if not from accident, then from exhaust fumes, hand vibration and noise. From the other two outbreaks on Big Island, all upright stems of any size were cleared of ivy. A month later at the site of the most dense occurrence, thousands of ivy leaves had fallen from high in the conifers that had been cleared of ivy stems. This created an unexpected windfall -- a layer of mulch 10 to 20 centimetres deep which appeared to be suppressing the layer of living ivy that had been covering the ground surface beneath the infested trees.

Another goal of anyone working on the ivy problem (or invasive species in general) could be legislative change. Volunteers and paid students that had been returning for several days of physical labour at the most ivy-dominated site to rescue some of the largest Douglas-firs on the estuary, decided to take a lunch break in Parksville. At the shop, ivy in small pots was on sale - special that day (see photo #). The sale or import of English Ivy is banned in Oregon, and it is on the list of noxious weeds of 45 other states of the USA. (USDA, cited by Wikipedia, 2009). We will probably be battling to save native ecosystems on Vancouver Island from ivy for many decades to come - it is time we stopped planting and cultivating it.

Common Touch-me-not (*Impatiens noli-tangere*)

Common Touch-me-not, also known as Jewelweed or Impatiens, is an annual, possibly from Eurasia. The only known occurrence near the Englishman estuary is from one backyard adjacent to the waterline right-of-way trail on the southern edge of the estuary study area. This species had

been very successful in conditions similar to the Englishman Estuary, such as throughout Burnaby Lake Regional Park on the Lower Mainland in the early 1980's, where it sometimes dominated a solid 100 square metre area of ground. It spreads by seeds dispersed by a spring-like mechanism in the ripe seedpods. Unfortunately for those trying to prevent the spread of this serious invasive species, the seedpod-popping is a dramatic tactile, auditory and visual experience which can be almost irresistible to children (and adults).

Touch-me-not is not established on the Englishman River estuary and so the management plan for this species would be monitoring, education and various actions to prevent that from happening. With the cooperation of adjacent landowners, and a few years of pulling these rather frail plants before they seed, a buffer zone free of Touch-me-not could be established and kept completely clear of this species.

Yellow Archangel - variegated form (Lamiastrum galeobdolon)

A wild form of this sprawling, soft-bodied forest plant in the Mint Family is common in Europe (Wikipedia, 2009). It is sometimes known as Yellow Lamium even though it is no longer classified in that genus. Spreading easily by runners, as well as by abundant seed production, Yellow Archangel, with its showy yellow flowers from April to June, has become a popular ornamental groundcover in gardens and yards on Vancouver Island and the Lower Mainland. Yellow Archangel occurs on the southern edge of the Englishman River estuary, on the waterline right-of-way and in the adjacent forest, near the forest edge. Dumping sites for garden trimmings and yard waste were observed there in 2007, so it is likely that it escaped from a similar source at some time in the recent past.

This species has various forms or cultivars, and all are serious threats to native ecosystems on Vancouver Island. The form on the Englishman estuary has leaves that are bright green but dominated by obvious large white blotches known as variegated. This form has covered some forested creek bank areas from Nanaimo to Qualicum Beach. A similar form has become one of the top six priority invasive species in Surrey, B.C. and control strategies are being developed in Coquitlam and Langley (Evergreen Invasive Plant Profile, 2009). The same species, but a different cultivar, is a serious pest in the Seattle area.

Removal is recommended immediately to stop vegetative spread, and each year thereafter before seeds are produced. Since the species is just getting established on the estuary, the aim should be eradication combined with education of neighbouring residents. Removal techniques usually involve some kind of hand pulling, often with a rake. Evergreen Invasive Plant Profile (2009) warns against trying to compost this plant material because it can grow in the composter. It is important to be careful to avoid allowing stray plant parts to root, but composting can be achieved using a power mulcher, lawn mower or machete to chop the soft plant tissues before composting in black plastic bags or garbage containers placed in an exposed location so solar energy helps to warm it and compost it. Even some haphazard chopping or breaking of the tissues creates more infection sites for bacteria and fungi so that the plant tissues cannot survive a period of warm incubation.

Because the plant is so popular, it may be effective to develop a package of suggestions for alternative groundcovers that can be used locally. The Evergreen Invasive Plant Profile (2009) suggests *Tiarella trifoliata*, *Hosta spp*., *Euonymus fortunei*, *Epimedium spp*., and *Oxalis oregana*.

Herb Robert (*Geranium robertianum*)

Herb Robert, a native of Eurasia, is common on the Englishman River estuary, primarily in forested areas near openings or stream banks, where there is sufficient moisture and nutrients and shade. A taprooted annual (Pojar and MacKinnon, 1994) with the option of biennial growth, Herb Robert seems to spread by relatively large seeds which germinate easily in this climate, often producing an carpet of crowded seedlings. Only a few of the seedlings seem to make it to maturity each year.

Herb Robert is listed as blooming from April until the autumn but, on the Englishman Estuary, it was observed to bloom in almost every month of the year. It is unknown if viable seeds were produced from flowers during cold months.

This showy flower has been so fully naturalized for such a long time in some areas of North America that several states in the USA claim it as a native plant. On Vancouver Island, it is still expanding its range; the authors noted its arrival in west Qualicum Beach with the expansion of the road network into an otherwise undeveloped area.

As a shade-tolerant species, there appear to be no barriers against it becoming the dominant ground cover in suitable areas of the estuary; it was observed competing successfully with some native forest forbs like Siberian Miner's Lettuce (*Claytonia sibirica*) and Foam Flower (*Tiarella trifoliata*). In the State of Washington website for plant communities, Chappell (2006) states that Herb Robert "is another threatening non-native because of its potential impacts on the forb layer" within certain endangered forested plant associations similar to those occurring on the Englishman River estuary (such as Western Redcedar-Grand Fir-Sword Fern). To accept Herb Robert (or any invasive species) as fully naturalized on Vancouver Island and therefore beyond the scope of control measures might be a decision to accept extirpation of one or more native species on the Englishman estuary and on the whole of Vancouver Island.

The first step in developing a realistic management plan would be to map the distribution of Herb Robert on the Englishman River estuary. Pairs of volunteers could do this using the GPS-to-computer methods developed in this project. A management plan might include either control or eradication from the estuary, or from part of the estuary, based on how difficult it is remove the plants. A quick trial of hand removal from a small area showed that the roots of the adult plants come out easily and completely, it seemed. If it is true that the seeds germinate easily, this could be an advantage for control because there is not likely to be a large seed bank present in the soil. It would be useful to design careful experiments to compare different methods of hand pulling and in particular the timing - is it better to pull the numerous little seedlings in spring or to pull fewer plants later when they are mature? If a suitable method can be developed, the initial management objective might be to prevent extirpation of those species with which Herb Robert competes, and to eliminate Herb Robert from one area, such as Big Island on the Englishman River estuary.

The plant has a long history of uses to humans, including as an effective mosquito repellent (Pojar and MacKinnon, 1994; Wikipedia, 2009); perhaps harvesting for some purpose can be encouraged. Experienced naturalists could be pulling it as they encounter it. At the very least, we recommend that care be taken to avoid spreading it. In the state of Washington, it is known as Stinky Bob because of the distinct geranium smell and it is legally classified as a noxious weed. We would recommend that anyone concerned about this encourage the governments of British Columbia and Canada to follow suit by adding it to their lists of legislated weeds.

Spurge Laurel (*Daphne laureola*)

Spurge Laurel is a small evergreen shrub native to Europe including England. It has glossy, leathery leaves and black berries in late summer. Its leaves tend to be whorled around the end of each branch and the berries under them, giving young plants an overall shape that is vaguely reminiscent of a coconut palm tree, although the leaves and stems do not look like palm. Spurge laurel is tolerant of sun but it thrives in shade; this and its ability to spread by seeds in the berries and by suckers makes it a serious threat to the native forest ecosystems of Vancouver Island. In Washington State, USA, it is classified as a noxious weed (Wikipedia, 2009). On the Englishman River estuary, it has a scattered distribution throughout the forest and shrub areas but over time as the density and abundance are likely to increase, the occurrences may coalesce forming stands that are nearly monospecific, such as occur in Qualicum Beach.

Control is possible by hand pulling but care must be taken to wear gloves because the plant tissues contain toxins and caustic sap. Wikipedia (2009) suggests that plants too large to pull, can be cut off at or below the ground level.

European Holly (*Ilex aquifolium*)

European Holly is a non-native shrub or small tree that is well established in the Parksville - Qualicum Beach area, probably because of escapes from commercial holly farms where for the prickly evergreen foliage with red berries is grown to to meet the demand at Christmas, and for the hard, white wood which is used for piano keys, chess figures, wood inlay and many other uses. Holly is common on the Englishman River estuary, but occurrence is scattered throughout the forest areas and forest edges because its main form of dispersal seems to be through consumption of the berries by birds. However, under a mature berry-producing bush there may develop a jungle of 50 to 100 young holly saplings.

European Holly grows well in the temperate areas of Australia, New Zealand and western North America and every case it is a concern as an invasive species. It is shade tolerant, which makes it a serious threat to native forest ecosystems on Vancouver Island however, its abundance and growth rate tend to be low so the threat is not as acute as some other species. Nevertheless, its removal is recommended, initially by cutting it when time and resources permit. At times when the wood has economic value, it might be possible to find a commercial collector who will exploit it with the goal, not of managing it, but of extirpating it from the estuary.

5.3.3 Shade Intolerant Invasive Shrubs and Trees

Birch (*Betula spp.*)

A patch of more than 20 birch trees (*Betula spp.*), likely European White Birch (*Betula pendula*) or a cross, occurs near Mills Road on the southern edge of the estuary. A few of them, those with the trunks roughly 20 centimetres in diameter, have bright white bark that peels horizontally in fine layers. Female catkins are 2 to 2.7 cm long and 0.6 to 0.8 cm wide. The male catkins are longer, approximately 4cm long, but narrower, only 0.3 cm wide. The leaves are not hairy or glandular; they are approximately 3cm X 4.5cm with a petiole that appears to be always less than 1 cm long. Many of the finer twigs appear pendulous; some more so than others. The species most like this description is *Betula pendula*, however many of the species of *Betula* hybridize freely, which might account for the differences in form as seen from a distance.

These birch trees appear to be thriving and spreading on the Englishman River estuary. Pojar and MacKinnon (1994) list no native birch trees on Vancouver Island, however E-Flora of BC (2009) shows occurrences of both *Betula papyrifera*, a BC species that is not native to Vancouver Island, and *Betula pendula*, a native from Europe which is an invasive species in BC but available in nurseries because of its beautiful pendulous branches. Both species are invasive on the Englishman River estuary. Brayshaw (1996) reports that the European White Birch is "now escaped and becoming abundant on the Lower Mainland and to a lesser extent on southern Vancouver Island; now the commonest birch on the Fraser River delta." The removal of all birch trees from the estuary is recommended as soon as possible. However, further research and experimentation is advised to see if anyone knows what is the most effective way to do this without regrowth from the stumps (coppicing). For example, is it better to cut the stumps or girdle them, and what time of year is best? Copper nails might be effective against coppicing under certain conditions, but care must be taken to avoid any unwanted side effects.

When undertaking control of the birch, care and skill at identification is required. Even experienced people can confuse the bark of birch with the native tree, Bitter Cherry (*Prunus emarginata*) which

is present in the same vicinity on the estuary. The colours and lenticel patterns of the two species can be similar. Ideally, a person experienced in tree identification on Vancouver Island would go through first and flag all the trunks to be cut and this would be checked by someone else, before any cutting begins.

Scotch Broom (*Cytisus scoparius*)

Scotch Broom (Photo #) is a native of Europe. It has gained a high profile as an undesirable species since its introduction to Vancouver Island in 1850 in the form of 3 seeds from Hawaii that germinated. "Broom has been so successful over much of its (new) range that it has endangered much of our region's distinctive rainshadow flora." (Pojar and MacKinnon, 1994). In the Parksville - Qualicum Beach area, a "Cut Broom in Bloom" campaign was started by the "Broombusters" in 2006 (Murdoch, 2008); it is a popular broad-based community project that involves many different groups and hundreds of individuals as well as volunteered resources, including an entry in the Qualicum Beach Family Day parade to promote awareness.

However, letters to the editor in the local newspapers have hotly debated the desirability and effectiveness of broom control. Although a large segment of the public is aware of broom related issues, there still seems to be much misinformation.

Like many rugged plants, broom has alkaloid poisons in its branches, leaves and seeds (Pojar and MacKinnon, 1994). It is toxic to humans and livestock and burning of any broom tissue is not recommended, especially where inhalation of smoke cannot be avoided. It can produce 10,000 seeds per plant and the seeds may last in the soil for 5 to 60 years (King County Department of Natural Resources and Parks, 2004?).

Broom distribution and abundance on the estuary seems to be related to three factors: shade, saltwater and soil disturbance. Broom appears stressed and unlikely to succeed in places with shade from a canopy above it, or where soil moisture is high, especially if the roots are exposed to brackish or salt water. Broom appears to survive and compete successfully in open locations on disturbed soils , even if nutrients are low and drainage is rapid, such as on gravelly or sandy deposits where summer drought can be severe. Broom seems to thrive as an early seral stage on gravel and sand with a freshwater table nearby, such as on gravel bars and other areas of recent deposition on the river's floodplain. Its ability to thrive on poor soils is, in part, due to the symbiotic relationship it has with nitrogen fixing bacteria concentrated in nodules that are easily visible on the roots. The plant tends to hold most of the nitrogen it fixes in it tissues so the branches, leaves and roots all make effective compost material, especially if they are shredded or chipped.

Scotch Broom appears to have reached its potential peak in abundance and distribution on the Englishman River estuary. It was already a major component of several plant communities in 1976, based on plant community descriptions from Kennedy (1982). Today it appears in almost every location where it can survive.

The mapping shows that attempts to prevent its spread would have little effect at this time. However, leaving it in its current state of abundance might continue to accumulate undesirable effects such as:

- the gradual degradation of native plant communities and the displacement or loss of native species that are currently struggling to compete with it, such as those species that would normally be associated with Dunegrass or Nootka Rose.
- the increased difficulty of restoring native vegetation on sites with broom.
- the potential for creating or increasing a long-lived broom seed bank in the soil
- possible fire hazard

From an understanding of the ecology of Scotch Broom, different strategies for ongoing management or eradication can be developed specific to each situation where broom is found on the estuary. Much information is available. The key is careful planning of the limited time and resources and then an unbiased evaluation of the success or failure of each technique so that, through adaptive management, the effectiveness of broom control can be increased over time. After mapping the distribution of broom on the estuary, it was possible to identify eight different Broom (management) Zones to assist campaigners to plan a strategy to suit each situation.

1) raised islands and fingers near tidewater
2) sandy beach and sandspit communities including accretion areas near tidewater
3) mixed shrub and graminoid areas between forest and marsh
4) areas of natural succession on ground recently deposited by the the river
5) forest, forest trails and forest clearings
6) disturbed areas around towers and kiosk, dykes and the 'Levee' on Big Island
7) buffers around edge of estuary
8) the shrub and graminoid area alienated by the Mine Road Dyke

We recommend that each campaign to control broom be specific to a location (or broom management zone) and that time and space be allowed for some scientifically designed experiments or test plots that compare some of the methods available to volunteers and managers. Much can be learned about broom control through careful experimentation.

We recommend that the objectives of broom control on the estuary be focused first on those areas with two characteristics:

1) the greatest benefit to native plant communities

the highest likelihood of eradication, if available resources and effort is focused

This would provide the best return for effort and it has the potential of providing some much needed victories for those volunteers who have been working on this problem year after year.

With the objective of getting the most ecological benefits in return for our efforts and, at the same time getting the best likelihood of eradication in one area at a time, we recommend three Broom Management Zones to become the top priority for broom control on the estuary:

Zone A - raised islands and fingers near tidewater
Zone B - sandy beach/sandspit communities including accretion areas near tidewater
Zone C - mixed shrub and graminoid areas between forest and marsh

Each broom management zone is considered separately below.

The task of a restoration project in any of these areas would be to make sure that appropriate native species were present to replace the void left by the broom. Cutting the broom can help the existing vegetation compete successfully. If the native species that can compete (mostly shrubs) are absent or if the broom is going to be dug up or pulled for some other reason, we recommend planting with the appropriate native species for the zone under consideration. Some native species that compete with broom under estuarine conditions are:

Pacific Crabapple	*Malus fusca*
Nootka Rose	*Rosa nutkana*
Black Hawthorn	*Crataegus douglasii*
Tall Oregon Grape	*Mahonia aquifolium*
Dunegrass	*Leymus mollis*

Broom Zone A - raised islands and fingers near tidewater
On the little islands of high ground in the estuary, the broom is often under physiological stress. Annual cutting while the broom is in bloom would likely push the competitive advantage towards native species within a few years, as long as the native species were not damaged in the process of cutting the broom. This could be a quick job with big returns, but it would require some agility; the islands are often steep and the terrain is rough and unstable because of overhanging edges. After the first repetition of the cutting process, we would recommend an evaluation of the project the following year to see what comes back.

Among the shrub fingers on the west side of the estuary (Broom Zone A), the rose and other native shrubs are often so dense that it would be very difficult to cut the broom. A motorized blade would be effective at the edges and a long handled pruner can be used horizontally to some effect. In the centres of these thickets, beyond where it is easy to cut, the options of building trails for crawling through the rose to attack the broom might be self defeating because the disturbance, although killing broom plants, would also create improved broom habitat. Unless a method without disturbance can be devised, we suggest cutting the broom at the edges and simply monitoring the areas in the centre for a few years to see if the broom is succeeding under conditions where they are crowded by native species like Nootka Rose.

The salinity of the soil in the western marsh areas has increased since the dyke was breeched in 1979. In some marginal areas the broom is already dead or in decline (photo #). It is likely that the broom cover in some of those areas will continue to give way to competition from more salt tolerant native shrubs.

Broom Zone B - sandy beach and sandspit communities including accretion areas near tidewater
The broom on the sandspit and beach area on the east side of the river mouth (in Broom Zone B) was recently cut (2008); this might have been part of the work of a paid crew of young people employed by Nature Trust of BC. Their efforts seem to have released some parts of the sandspit habitat from shading and crowding by broom. The broom was not thriving there in any case, likely because of summer drought on the sandy soil, and because of salt from wave-spray and tidal water entering the pervious sandy substrate. Continuing to cut the broom each year can be expected to stress it further so that it will be replaced by native shrubs or shrub-like herbs such as Silver Burweed (*Ambrosia chamissonis*), and by Dunegrass (*Leymus mollis*).

The people cutting need to be informed of the fragility and rarity of that ecosystem, if they were not already. A thin skin of bryophytes (mosses and lichens) growing on the surface of loose sand dominates the vegetative cover and it is vulnerable to even a few careless, twisting or running footsteps. An evaluation of the 2008 broom control effort is needed that also considers any damages done, especially to the bryophyte layer. If this kind of evaluation guided training and preparation for a followup attack in 2009, the effort would likely show big results on the surviving broom because it is already under stress.

Broom Zone C - mixed shrub and graminoid areas between forest and marsh
The shrub and graminoid areas between the marsh and the forest support some large (300 square metres or more) stands of broom. As one moves towards the marsh, the broom is stressed similar to the situation in Broom Zone A. As one moves towards the forest, the broom is stressed by shade and other forms of competition (see description of Broom Zone E). If the stressed broom at either end of this gradient was cut (in bloom) one or two years in a row, it might never recover.

However, removal of broom from the large infestations of the intermediate area (between forest

and marsh) would not likely be as easy. In spite of the size of the task, we recommend that broom removal from the intermediate areas of Broom Zone C (between the forest and the marsh) be a high priority for restoration because the broom there is in competition with, or has an adverse affect upon, many plant species in communities marked by Pacific Crabapple, Nootka Rose and Dunegrass.

In these intermediate areas where broom is a strong competitor, planting of native species will likely be needed to succeed. Planting and the associated disturbance of the soil creates the opportunity to dig out some of the broom, roots and all; an option that is not recommended for Broom Zones A and B.

Conversely, if digging of broom is undertaken on any site, it is important that the disturbed ground be replanted with native shrubs as soon as practical. Pacific Crabapple is likely an effective first choice on natural sites near the forest especially on the Big Island in the estuary. It is unlikely that alder or conifers could be used to replace broom in open undisturbed areas like on the Big Island because the ecological conditions there seem unsuitable for them; alder and conifers would be growing there already if they could survive. Nootka Rose would be suitable for planting at the edge of existing thickets and in the shrub zone beyond the edge of the forest.

However, in the disturbed areas at the edge of the forest near the Shelly Road Viewing Tower, there are some areas where Red Alder would likely be the ideal species to plant to replace the broom that has been cut or dug. Alder might be able to grow and compete with cut broom on poor sites because, like broom, it produces its own nitrogen through a symbiotic relationship with soil bacteria. Once the alder, rose or crabapples get tall enough to shade the broom, it is expected that the last broom plants will die.

Strategies appropriate for broom control in areas where people (or the management plan) call for maintaining openness are discussed under Broom Zone F.

Broom Zone D - areas of natural succession on ground recently deposited by the the river
Unless the broom at the edge of the river is providing seeds for the re-invasion of areas downstream, Broom Zone D would probably be a low priory for broom removal. Gravel bars and low bench areas on the annual flood plain of the river are undergoing natural succession to forest without any help from humans. These areas seem ideal for broom right now, but as natural succession proceeds on this newly deposited ground, trees such as cottonwood and alder would get taller and the broom would decline, as can be seen on Big Island (photo #). Cutting the broom in these areas once would be helpful to hurry the succession and reduce the numbers of seeds dumped into the river, but repeated cutting would produce diminishing returns for the effort; we recommend this be a low priority for broom control and restoration dollars.

Broom Zone E - forest, forest trails and clearings
In the forest, the situation is similar to the river bench. Broom is virtually absent from old established native forest areas and it appears to be in decline where the native canopy has been reestablished . However, broom is present along old roads and throughout clearings in the forest. Cutting the broom one or more times coupled with the planting of Douglas-fir has already almost eliminated the broom from one area (Photo # and Tom Reid, 2008, pers. comm.). We would suggest planting Red Alder with the conifers because it provides faster growth to overshadow the broom and, like the broom, it fixes nitrogen so it can be a strong competitor for broom on poor soils.

Broom Zone F - disturbed areas around towers and kiosk, dykes and the 'Levee' on Big Island
A special management problem exists near the tower and kiosk and west along the edge of the

forest. These areas appear to be open and shrubby because of disturbance. Broom removal has been done in some of these areas for years. If the management objective is to keep the area open around the tower and the junction of trails, a low growing competitor for broom needs to be found. We suggest continued cutting or, if the energy and tools are available, pulling and digging of the broom while planting Dunegrass among the stumps and disturbed ground. For those shrub areas closer to the forest, if the management objectives allow it, we would suggest continuing to pull or cut the broom while planting Nootka Rose, and in the areas closest to the forest, planting Red Alder and Douglas-fir. If the existing or planted trees look stressed, plant Pacific Crabapple, Saskatoonberry (*Amelanchier alnifolia*) or native Black Hawthorn (*Crataegus douglasii*). To avoid the similar, but invasive species Common Hawthorn (*Crataegus monogyna*), question carefully any nursery stock and refer to Pojar and MacKinnon (1994).

Those areas that are kept in grass and forbs by trampling of mammalian feet (people, deer, rabbits) should be left as is. In these areas, if broom sprouts, it is better to cut it that to dig it or pull it so that the ground with many viable broom seeds in it remains undisturbed as much as possible. In planning any land use, care should be taken to leave special features alone and unplanted if that is what is there now. Near the Shelly Road Viewing Tower there is a south-facing bare area where hundreds of solitary bees burrow and lay eggs creating a condominium of individual nests. Other barren locations around the estuary appear to be kept bare by many birds returning there to bath in dust. These areas are small but important to the ecology of the estuary so it would be unfortunate to destroy them in an effort to control broom, unless it is known that they can be easily and quickly replaced.

Broom Zone G - buffers around edge of estuary

The Sensitive Ecosystems Inventory Conservation Manual (McPhee et al, 2000) emphasizes the importance of buffers for a variety of purposes, including invasive species control. Suitable broom management buffers would include the roadsides and properties of Shorewood Drive and San Malo, including the 'bicycle park,' the roadsides and river edge along Plummer Road, around the highway bridge and the river side down to the Parksville Waterline Trail, the Parksville Waterline Trail including Shelley Road parking lot, forest and shrub areas from the north end of Mills Road to Golden Dawn facility, the west side of the estuary including Golden Dawn facility and the roads and filled areas near Surfside RV facility, the entire Surfside RV area and the beaches, walls and dykes that border it.

If part of the estuary study area gets cleared of broom, the adjacent buffer zones become very important, either as sources of seeds and future infestation, or as broom-free areas that can be maintained as such because they are already disturbed. The idea is that drastic measures like digging, ploughing, bulldozing or machine cutting of invasive species can be implemented in the buffer zones without hazard to the estuary ecosystems.

For example, near the parking lots and waterline trail on the southern edge of the Parksville Flats property, broom is in competition mainly with non-native grasses. The removal of broom and other non-native species (Armenian Blackberry, Comfrey, Common Tansy, Jewelweed, etc) along that edge is not a priority in itself. However, as a buffer zone removal of these species there becomes important because that is the gateway and the last line of defence against the introduction of those species or the reintroduction of a species that has been eliminated from adjacent areas. Mowing is sometimes being done along the Parksville Waterline Trail and we recommend that be encouraged or reinforced as a way of controlling broom and other non-native species along that frontier.

Broom Zone H - the shrub and graminoid area alienated by the Mine Road Dyke

We recommend that the area that is protected from the influences of the river and tidal water by

the Mine Road Dyke in San Pareil be a low priority for broom control measures. If the dyke is breached (Summers and McKenzie, 1990) and the area becomes accessible to river and saltwater once again, the broom will likely die, as it did on the west side of the estuary. On the other hand, if the area is left as it is, natural succession will likely overtake the broom within 30 years, except at the edges: the roadsides, the backyards and on the dyke. If there is a shortage of time and energy and money, we recommend that this area be considered last for broom control. If an adjacent area is made broom-free, such as the dyke, then the area behind the dyke should be a considered a buffer zone (see Broom Zone G) and cleared of broom as time and money allow.

Permission Required
Note that some private property has been included in or near the broom management zones and buffers. Suggestions about broom control on private land are for discussion purposed only. Anyone planning broom removal on private land, including the Englishman River estuary, needs to obtain prior permission of the landowners.

Armenian Blackberry (*Rubus armeniacus*) & Cut-leaf Evergreen Blackberry (*Rubus laciniatus*)
Two species of non-native blackberry are present on the estuary. The Armenian Blackberry is commonly known locally as the Himalayan Blackberry, despite the fact that it originated in the Caucasus region (Wikipedia, 2009) and is a long-time resident of Europe and around the Mediterranean (Invasive Species Net, 2009). The Cut-leaf Evergreen Blackberry can easily be distinguished from the Armenian Blackberry by its deeply and finely cut leaves; the berries of Cut-leaf Evergreen Blackberry usually ripen in August-September whereas the Armenian Blackberries ripen in July- August, in most years. Both species are thorny perennial shrubs with stems that are thick and stiff rather than limp, they are usually elevated off the ground and often arching, and they are biennial. The first year stems produce rapid vegetative growth and the second year they bear fruit and usually die back.

The Trailing Blackberry (*Rubus ursinus*), a perennial trailing shrub native to Vancouver Island, is also present on the estuary. Its stems are limp, like string with thorns, and never more than a few millimeters thick, and the thorns of the invasive species are usually thicker than the whole stem of the native species. Nevertheless, care should be taken to distinguish Trailing Blackberry from its invasive counterparts because all three species of blackberries on the estuary have similar black fruits that consist of a compound structure call a drupe which, when picked, take the central support structure with them, attached to the berry. Other related native berries on the estuary such as Salmonberry (*Rubus spectabilis*) and Thimbleberry (*Rubus parviflorus*) have yellow or red (seldom dark) drupes (berries) that come come off the parent plant with the central support structure attached to the fruit.

These species, especially the Armenian Blackberry, have been introduced to many parts of the world where they have become invasive pests. At the same time, their fruit is much valued and often collected and even celebrated in various harvest festivals by people unconcerned about the invasive qualities. On the Englishman River estuary, the Armenian Blackberry is more abundant than the Cut-leaf Evergreen Blackberry, but this may not always have been the case. Kennedy (1982) lists *Rubus laciniatus* as a dominant component of one of the plant communities that she observed on the estuary in 1976; *Rubus armeniacus* /*Rubus discolor* is not mentioned.

Because of their long history and easy dispersal by birds, these two invasive blackberries have probably reached their peak in terms of abundance and distribution on the estuary. The first step in creating an integrated pest management strategy would be completing the inventory and mapping of these two species which was started by volunteers in this project. Removal by cutting with pruners or a motorized blade (or mowing with flail mounted on a backhoe or tractor, if budget allows), is recommended, but not as a high priority at this time. On farmland, goats tied to a tire will

eat blackberries almost to the ground, but goats on an estuary is probably not an ecologically sound idea.

The largest numbers of these two invasive blackberry species occur behind the Mine Road Dyke. If the dyke is breached; they would be decimated in that area because they are not salt tolerant. On the other hand, if the dyke is not breached, they would likely fall into decline through succession because they are not tolerant of shade from forest trees and other shrubs.

5.3.4 Salt-tolerant Invasive Plant Species of Brackish and Saline Marshes

Creeping Bentgrass (*Agrostis stolonifera*)

Creeping Bentgrass is a native grass of Europe that appears to have naturalized in almost every province, territory and state of Canada, the USA and Greenland (USDA, 2009). It is popular for moist pastures and as a turf grass for short-cut lawns, and especially for the greens of golf courses, because it "aggressively produces horizontal stems, called stolons, that run along the soil's surface. These (characteristics) allow Creeping Bent to form dense stands under conducive conditions and outcompete..." other species of grass and forbs. (Wikipedia, 2009). The presence of stolons and long ligules helps to identify this species, but Pojar and MacKinnon (1994) point out some ambiguity in nomenclature; *Agrostis alba* is often used as a synonym for *Agrostis stolonifera* (see Kennedy, 1982) but *Agrostis alba* is also used as a synonym for *Agrostis gigantea* which has rhizomes but not stolons, and therefore occupies a different niche.

Creeping Bentgrass is almost ubiquitous on the brackish marshes of the Englishman River estuary down to the edge of the tidal channels. Under the name of Agrostis alba, Kennedy (1982) recorded its presence in 12 of the 19 plant communities she described on the estuary in 1976 and it was a dominant species in 4 of those 19 plant communities at that time. It is one of the few species that sometimes grows among the dense stands of Lyngbye's Sedge in the tall channel-edge community; as such it has invaded likely occurrences in the study area of CDFmm Em05 Lyngbye's Sedge Herbaceous Vegetation Ecosystem which is BLUE-listed (BCCDC, 2008). Mackenzie and Moran (2004) state that Creeping Bentgrass "now forms the dominant component of the high marsh in many estuaries of the Georgia Depression."

Elimination or reduction of this invasive species from the study area seems unlikely at this time unless an insect enemy or a plant competitor arrives, but that could bring with it other unwanted impacts. On the contrary, it appears that Creeping Bentgrass may be going through another phase of expansion in response to grazing pressures from waterfowl. Creeping Bentgrass appears to be heavily grazed by the Canada Goose in the study area but ironically, the bentgrass appears to thrive under these conditions; it takes on the appearance of a golfing green while the other species that were competing with it disappear completely under the intense grazing pressure. To control the recent spread of Creeping Bentgrass, it would be likely necessary to control the Canada Goose, either its population or its use of the estuary.

European Saltwort (S*alicornia europaea* aka *Salicornia depressa*)

European Saltwort (also known as Common Glasswort) is a non-native annual species that is well established on the ERE. It typically has colonized areas on the ERE that have been left barren of plants by grazing, erosion, or a sudden change in salinity, as described by Dawe and McIntosh (1993). As a colonist and an early seral plant, it helps to stabilize bare ground but it gives way easily to later seral species such as Sea Milkwort and American Saltwort, a related perennial species in the same genus. No control measures are recommended for this species at this time. It is edible and considered choice but the process of collecting a sufficient quantity of this tiny plant without disturbing and eroding the vulnerable unvegetated substrate where it grows would be a

challenge; collecting is not recommended.

Brass Buttons (*Cotula coronopifolia*)

Brass Buttons is a salt tolerant species native to South Africa but it has spread to shorelines in many places throughout the world. The tough leaves have a distinctive shape and the bright yellow rayless flowers can sometimes be seen at a distance. Its niche is as a colonist and an early seral plant often associated with European Saltwort at the edges of tidal channels and at the lowest edge of the middle marsh, often on surfaces where a substrate is exposed. It was not observed to be competing with any native vascular plant.

Brass Buttons may have arrived on the Englishman River estuary between 1976 and 1980; it is not mentioned by Kennedy (1982) and it appears as one of the first species that colonized the areas exposed by the die-off of salt intolerant species after the Shelly Road Dyke was breached in 1979 (Dawe and McIntosh,1993). The abundance and distribution of Brass Buttons appears to be expanding at this time in response to barren substrate created by intense waterfowl grazing pressures on the native vegetation. Therefore, the first step to controlling this expansion would be to control the impacts of grazing Canada Geese. No direct control measures are recommended at this time.

Couchgrass (*Elymus repens* aka *Elytrigia repens*; *Agropyron repens*)

Couchgrass is native to Eurasia and northwest Africa (Wikipedia, 2009) but it is a species many people are familiar with in gardens and on roadsides and almost anywhere in the world where European descendants have altered the landscape. Perhaps as a result, it has many names both in English (Quickgrass and Quackgrass) and in scientific nomenclature (*Elytrigia repens, Agropyron repens*). It is highly invasive on Vancouver Island; spread occurs easily by underground white rhizomes. Control is difficult in early seral situations such as gardens where digging and tilling often help to increase its abundance by destroying competition while breaking up the Couchgrass rhizomes so that each piece can form a new plant. Couchgrass competes successfully in open meadows, especially young meadows, but it is not usually able to withstand succession to a more shady situation; Couchgrass is not tolerant of deep shade.

On the Englishman River estuary, Couchgrass has been established for at least 30 years. In 1976, Kennedy (1982) named Couchgrass in 3 of the plant communities she described, including one where she considered it to be one of the dominant species. Today it occurs in the area from the shrub-to-meadow transition zone, where it grows in the open meadow patches between the groups of shrubs, down into parts of the high marsh where it appears to show some degree of salt-tolerance. Couchgrass on the study area sometimes presents as a monospecific patch of more than one hundred square metres. This indicates that it is likely suppressing some native species in, what would otherwise be, a species-rich habitat. It is unknown if the species is still expanding on the study area.

Partial control of Couchgrass can usually be achieved with impervious ground covers like black plastic or plywood. Mulches of wood chips or straw can also control it if there is no opportunity for the grass to push up through the mulch but this is usually impractical because the mulch needs to be very deep and dense to have an effect. Control of Couchgrass is desirable from an ecological perspective but how to do this on a significant scale is not known. The first step would be to map the monospecific patches of Couchgrass on the estuary using the volunteer-based techniques developed in this study, and then monitor the patches over a period of years. If they are expanding, Couchgrass should be a priority for control and restoration; otherwise not. If the Couchgrass areas are shrinking, it might be a indication that later seral species have an advantage over Couchgrass if the situation remains stable enough for succession to occur. More research is urgently needed into ecological niche and distribution of Couchgrass on the estuary and what control measures used successfully elsewhere, but no control action is recommended at this time.

5.3.5 Shade-intolerant Early Seral Plant Species

Knapweed (*Centaurea spp.*)

Knapweed (likely Spotted Knapweed, *Centaurea maculosa* a.k.a *Centaurea biebersteinii*) is established on the Englishman River estuary south of the Shelly Road Viewing Tower in the vicinity, and east, of the kiosk sign. Spotted Knapweed is a biennial from Eastern Europe which can sometimes live more than 2 years. Several species of *Centaurea* can be serious invasive species on dry rangelands especially where overgrazing has reduced the viability of the native grass community, but its potential impact on the wet coast of B.C. is not known. Spotted Knapweed and some other *Centaurea* species are statutory (noxious) weeds under many legislative jurisdictions, including the Province of B.C.

The Arrowsmith Naturalists seem to have *Centaurea spp.* clear in their minds and their efforts to selectively hand pull it before it sets seeds each year seems to be an effective campaign strategy. (see photo # .) If it ever happens that pulling does not occur before seed set begins, it is important to bag the pulled plants and mulch and compost in a secure manner to prevent the dead plants from setting seeds.

At first the campaign may seem to be limited to stopping its spread but eventually, assuming the level of manual control effort continues, it is expected that the seed bank will sprout and diminish over a period of up to 8 years and eradication will be achieved. Careful scientific monitoring of some sample plots of knapweed, might provide volunteers an incentive to continue because science might provide clear evidence of declining numbers of this species coincident with the Arrowsmith Naturalists' efforts at control. The Invasive Plant Council of B.C. (2008) warns that monitoring (and control, if necessary) should continue for several years after eradication seems to have been achieved.

Canada Thistle aka Creeping Thistle (*Cirsium arvense*)

Canada Thistle, in spite of the name, is an invasive species on Vancouver Island. The name Creeping Thistle is more descriptive of the way it spreads by long, white, underground rhizomes which can produce a new clonal plant at each node. Close inspection reveals that flowers can be male or female, and what looks like an area of ripe seed heads might actually contain little of no viable seed.

In 1976, this species was listed as present in 3 of the plant communities on the Englishman River estuary and it was considered dominant in one of them. Today the plant is able to thrive in the open near the Shelly Road Viewing Tower and kiosk and along some of the old dykes, but it also tolerates partial shade well, such as where the forest trails pass through an opening in the forest. Pulling the plant and digging the roots is difficult and usually counterproductive; the result is often more thistle plants than there were at the start because of regrowth from the rhizomes. However, Creeping Thistle has a major weakness - it is intolerant of repeated mowing. A scythe or a motorized rotating line can be used to give other plants that are more tolerant of mowing, especially native grasses, a competitive edge over Creeping Thistle. Unfortunately, it often takes several mowings a year for several years to see success.

Bull Thistle (*Cirsium vulgare*)

Bull Thistle is a common biennial (or sometimes an opportunistic annual) in open disturbed areas and on old dykes in the study area where it can be an aggressive competitor for a short while after

disturbance. However, it cannot survive succession processes for more that a few years so the density and abundance of this species appears to be stable. If management or restoration objectives require that an area be cleared of Bull Thistle, a scythe or a motorized rotating line can be effective if used to cut it off in the week or two before its flowers are open (usually in its second year of life). At that stage, the exposed interior of the hollow stem will often turn brown and rot right down into the taproot after it is cut. The cut stems do not seem to have the ability to re-root, but it can regrow from a healthy tap root. It is recommended that Bull Thistle be a low priority in an invasive species budget.

Common Tansy (*Tanacetum vulgare*)

Common Tansy is native to Eurasia where it is called simply Tansy, but the presence in BC of native species in the same genus requires a more precise usage here. Common Tansy is present mostly at the edges of the ERE where it appears to thrive but never in abundance. It appears as if the population of Tansy might be expanding. The tissues of Tansy are toxic and can cause contact dermatitis (and fatal poisoning if consumed in sufficient quantity) but these same toxins have made it useful as an insecticide and a de-worming medicine. The unforgettable strong smell of the leaves when crushed are described as "similar to that of camphor with hints of rosemary." in Wikipedia (2009). It is recommended that people familiarize themselves with this plant and pull it (with gloves on, for those with allergies or skin sensitivities) or cut it off whenever it is encountered and especially before it sets seeds. Because numbers are low, it may be possible to eradicate Common Tansy from the estuary.

Purple Deadnettle (*Lamium purpureum*)

Purple Deadnettle grows in a few open, well drained areas of the estuary, especially on parts of the old dykes. Its appearance is somewhat similar to Self Heal (*Prunella vulgaris*) but on Vancouver Island the flowers of Purple Deadnettle seem to be more pink than purple (see photo typical of Vancouver Island in Wikipedia, 2009). This species is invasive but it appears to have little chance of becoming a major threat to native ecosystems because it does not seem to tolerate forest shade or competition from taller plants on rich moist ground. It is recommended that Purple Deadnettle be a low priority for invasive species control budget at this time, unless the species is observed to be expanding. Therefore, inventory, mapping and monitoring is recommended using the volunteer GPS methods developed in this report. If a survey crew is doing inventory of this species, care should be taken to map Common Deadnettle (*Lamium amplexicaule*) separately; it is another non-native species with a somewhat similar appearance that might also be present on the Englishman estuary.

5.3.6 Some Other Non-native Plant Species

Bindweed (Convolvulus spp.)

In this study, only one occurrence of an invasive bindweed species was observed; it was on the east side of Mine Road Dyke, near the junction of the dyke and Plummer Road. By the size of its showy white flowers, it is likely Hedge Bindweed (Convolulus sepium). Immediate hand removal from the dyke is recommended to prevent the bindweed from getting established on the west side of the dyke. Pojar and MacKinnon (1994) note that a similar species, Field Bindweed (Convolulus arvensis) is difficult to eradicate because of the deep rhizomes. A control plan for bindweed on the estuary would need to include a bindweed-free buffer in the adjacent backyards and for that, close cooperation with the adjacent landowners would be essential.

Buttercups (Ranunculus spp)

The invasive species Creeping Buttercup (*Ranunculus repens*) appears to be present on the estuary but confirmation of this was not a part of this study. In hindsight, it is recommended that it be a priority to key out the species of Ranunculus present on the estuary and then, using the people thus trained, map the distribution of Creeping Buttercup throughout the study area. A

management plan would need to take into account the difficulty volunteers might have in distinguishing it from a number of native flowers on the estuary that are more or less buttercup-like such as Little Buttercup (*Ranunculus uncinatus*), Large-leaved Avens (*Geum macrophyllum*) and *Potentilla egedii*.

Early Hairgrass (*Aira praecox*)

Early Hairgrass is an abundant annual invasive grass in the high marsh and meadow areas of the Englishman River estuary. It is likely that it has fully occupied all of the locations (niches) suitable to it. Mapping and monitoring would be useful but volunteer GPS monitoring would probably be impractical due to the seasonal nature of this species and the difficulties with identification. It is recommended that this species be a low priority for control at this time.

Perennial Sow-thistle (*Sonchus arvensis*)

Perennial Sow Thistle (Sonchus arvensis) is a native of Eurasia that is now present in high marsh and meadow areas of the Englishman River estuary. It is one of the few plants that can become established and survive among a dense stand of Dunegrass (Leymus mollis). In 1976, Kennedy (1982) listed it as present in 10 of the 19 plant communities she used to describe the Englishman River estuary at that time, and it was a dominant or subdominant component of two of the plant communities she identified. It is classified as a noxious weed in the states of Washington and Alaska.

Because this invasive species spreads easily by wind and it has been present for at least 32 years on the study area, it is likely that it has already reached its peak of distribution and abundance on the estuary. As such, it can be considered s a low priority for invasive. It is recommended that no action to manage this species be taken unless it can be done without disturbing the soil or creating other undesirable impacts.

5.3.7 Some Non-native Animal Taxa (species, subspecies and crosses)

European Black Slug (*Arion ater*)

This species was observed near the suburban backyards on the southern edge of the study area and on Big Island of the Englishman River estuary. Its population on the estuary is likely increasing as it moves into new areas on the estuary. It is recommended that the options for management be researched.

Canada Goose (*Branta canadensis*)

The Canada Goose is a native species on Vancouver Island. However, in the 1940's, the species "was mainly a migrant and a summer visitant in British Columbia" (Campbell et al. 1990). At that time, few Canada Geese spent summer or winter anywhere in B.C. Counts of wintering birds in five locations around the Lower Mainland, including Ladner and Vancouver, totaled approximately 300 or fewer Canada Geese up until 1972.

The Canada Goose most likely to be seen on the Englishman River estuary at that time was probably one of three subspecies *Branta canadensis fulva*, *Branta canadensis minima* and *Branta canadensis occidentalis*, passing through, either in the spring on the way to its northern breeding grounds, or in the fall while making the return pass through the area. Then, as now, large numbers of the Canada Goose are thought to have been migrating annually up and down the length of Vancouver Island, but mostly staying offshore on the west side of the island. At that time, relatively few Canada Geese visited the east side of the Island for any reason.

Seeing even one Canada Goose on the Englishman Estuary during the breeding season would have been unusual - likely a non-breeding bird. Bird counts done on the Englishman River estuary four times per month, from 17 June 1979 to 29 June 1980, created a record of all of the Canada Geese observed by the surveyors during a one year period. (Dawe et al. 1994). The first Canada

Goose seen in that study was a single bird on 21 October 1979. Later, 5 birds were seen on 10 February 1980 and 8 birds were seen on 29 May1980. The Canada Goose was not seen at all in the summer months.

During the 1960's and 1970's, the most common behaviour seemed to be changing toward remaining year round in the same local area. Campbell et al (1990) note that the species has a high natural adaptability, but they consider the change in behaviour to be "primarily because of transplants of flightless young and breeding stock from a wide variety of races." The races of geese that were brought to the coast were not native to coastal British Columbia, so the larger form of Canada Goose that feeds and breeds on the Englishman River estuary today, and does not appear to migrate, is in effect, a non-native cross that has become an invasive "species" because its behaviour and its numbers are not in balance with the productivity of the estuary.

Instead of seasonal migration, during some parts of the year at least some of the birds engage in daily movements, often to farms, golf courses, parks and lawns during the daylight. During this study, flocks of Canada Geese were often observed arriving at the Englishman Estuary and other local estuaries in the twilight of dusk. Other geese with similar diurnal movement patterns, may be returning to freshwater marshes like Hamilton Marsh. During breeding, in April, May and June, many Canada Geese seem to remain with their young of the year on the Englishman Estuary around the clock. During the four to five week moulting period, possibly in July or August after breeding, the geese may be out on the Strait of Georgia to avoid predators while their feathers regrow (Maggie Little, 2009. pers. comm.) but these geese may be returning to the estuary at night to feed, preen, and sleep. In fact, this may be a period of heavy feeding because the geese need to eat much nitrogen-rich vegetation to replace the protein in the feathers that they have shed. In this study, we observed masses of goose feathers in the estuary, often on the tideline near the end of June 2007. The movements or migrations of the local Canada Geese might soon be better understood as observations accumulate of the leg bands that are being attached to Canada Geese by volunteers under the auspices of a Canadian Wildlife Service permit (Tim Clermont, 2009. pers. comm.).

The population of the Canada Goose appears to have grown exponentially in the Parksville - Qualicum Beach area since around 1980 or shortly thereafter (Neil Dawe, 2006. pers. comm.). The numbers of all the Canada Geese observed on the Englishman River estuary during one monthly bird survey along a regular route, usually between the hours of 9 and 11am, were recorded by the Arrowsmith Naturalists (2009) from March 2005 to February 2009. The highest number of Canada Geese counted on any one survey within each year is shown below; surveys seek to avoid counting the same bird twice so these numbers indicate that at least that many Canada Geese were using the estuary for some part of that year:

June 2005:	220 adults and 16 juveniles
June 2006:	85 adults and 0 juveniles
April 2007:	95 adults and 0 juveniles
December 2008:	194 adults and 0 juveniles
February 2009:	53adults and 0 juveniles

Although the Arrowsmith Naturalists had already undertaken counting the birds, some incidental observations of Canada Goose numbers were made as part of this study. Notably on 29 September 2008, approximately 109 Canada Geese were observed taking flight at the north end of Centre Marsh on the Englishman Estuary (photo). The numbers of goslings that hatched on the Big Island in 2008 appeared to be similar to the number of eggs (6, 7 , and 8) that had been observed in each of the 3 nests that were close to the vegetation work being done at that time. A fourth nest in an exposed location was also observed but its 6 eggs were all predated the day after some of the eggs were handled briefly to look for markings. Predation might have happened while

the adults delayed returning to the nest after the human intrusion, or it might be the result of a predator such as a mustellid smelling human presence on the eggs (Clermont, 2009. pers. comm). Many other nests were encountered but no time was spent recording them or observing their degree of success. Clermont (February 2009, pers. comm.) clarified that they (Nature Trust) had not done egg addling in 2008 at that location.

On 19 April 2009, the number of nests observed by MVIHES volunteers on the Big Island of the Englishman estuary was 26 and an additional 5 nests were seen on the San Pareil High Marsh Finger, including the little islands in San Pareil Lagoon. Of these, a total of 7 nests had all unmarked eggs and 3 nests had some marked eggs and some unmarked eggs. The remainder of the eggs were marked, either as addled eggs or as cold eggs that should be addled once incubation starts and egg-laying stops.

The Canada Goose is unlike many other waterfowl in that it is almost exclusively herbivorous and it feeds primarily on land. Further research might reveal a formula or rule of thumb for farmers about how many acres does it take to raise a goose.

In this study, casual observation of nest sites suggested that they were chosen for the view, "giving the incubating female a clear line of sight to detect approaching predators" (Hanson, Bailey and Hughes, 2003). We found a two nests in thickets, and one was in a forest, on top of an old river bank. Although the exact locations of goose nests usually changed from year to year, the same general areas were often used again. "Female Canada Geese always return to nest in the same area where their parents nested and often use the same nest site year after year" (Hanson, Bailey and Hughes, 2003).

On the Englishman River estuary during 2008, it appeared that the majority of eggs were laid in April and by 20 April, most of the eggs were being incubated. Most of the active nests observed in this study seemed to have four to eight eggs. The literature reports that the female sits while the male often stands guard, but sometimes it seemed that the males (presumably) vacated the nest area and the female stretched her head down to avoid detection. Hatching occurs after 25 to 28 days of incubation (Hanson, Bailey and Hughes, 2003), which seems to be mostly in May on the Englishman River estuary. Sometimes when a nest was predated or destroyed, it seemed that a second, smaller clutch was produced in a smaller nest.

Coinciding with the increasing resident goose population, we can see transformations occurring on the estuaries in the Parksville - Qualicum Beach area. In particular, Lyngbye's Sedge often appears mowed or it is has disappeared completely from some areas that have easy and safe access for geese. The channel edge plant community, where Lyngbye's Sedge often grows in a nearly monospecific stand approximately one metre tall, appears to be one of the first targets of grazing geese. In some plant communities that were once dominated by sedge, the tops have been eaten down to the ground and the roots grubbed out. In other parts, the roots seems to have died after their tops were overgrazed. Either way, the result seemed to be a disintegration of the marsh platform as the unattached fine sediments start to wash into the low marsh and, in some cases the whole marsh platform develops pits, gullies and mounds, or it breaks off and slumps down in chunks.

For descriptive analysis, the effects of intensive grazing can be seen as distinct stages.

A reduction in the height of plants
In some spots where geese could not get to easily, for example behind a narrow log, we observed the same plant community as was present a few centimeters away, but the height of the inaccessible plants was higher and the leaves did not have squared ends. Often, where accessibility of the forage plants decreased, the heights of the plants gradually decreased, creating

tapered or windswept effect.

A shift in plant species composition
The geese seem to selectively remove Lyngbye's Sedge and, to a lesser degree, Sea Arrowgrass, Seashore Saltgrass, Sea Plantain and American Saltwort. The plant community appears to shift towards a much lower total biomass and a higher proportion of plants that the geese do not seem to like, such as Sea Milkwort and Silverweed.

A boundary separating vegetated from unvegetated ground
The grazing seems to be most intense in areas where the geese have easy access to and from the water, a clear view of potential threats, and few regular disturbances that they consider to be unsafe. In many of these areas, we find a boundary separating, on the one side, severe grazing down to eroding mud, and on the other side, a plant community where grazing may be present and the species composition may have been altered, but the marsh platform of roots and sediment is still intact and alive. This line is referred to in this report as the active grazing front.

Pits, hummocks and gullies
In some areas, the edge of the grazing may not be a sharp line but rather an area of pits, hummocks and gullies just above the receding line of vegetation, as if the geese return to grub and burrow with their heads below ground at individual spots where they have broken through the tough surface sod into the edible root layer of the marsh platform. This seems more likely to occur in areas that meet the needs of the geese for easy access and safety.

Collapsing marsh platform or collapsed segments nearby
The receding edge of vegetation is, in some spots, also the location of a sharp drop in elevation that varied in height but which was, in some places, more than a vertical metre. At the edge, what remains of the marsh platform is an overhanging mat that may have been undermined by grazing from below and/or by erosion as the receding roots release the organics and fines of the substrate into the water. Near the San Pareil Lagoon and at the north end of the Big Island, there were chunks of marsh platform that sometimes formed islands of lush high or mid-marsh vegetation towering above the flats on a sheer bank of silt. They seemed to be intact and connected at the base to their original location, but completely isolated by a sharp line of vegetation atop a vertical bank of silt.

Remnant sediments
In some areas after the marsh platform of roots and sediment has disintegrated, and slumping has occurred, the finer sediments like silt and organic mud get eroded away leaving pebbles or compacted silt/clay. This appears to be habitat suitable for Sea Milkwort and two non-native species, European Common Saltwort and Brass Buttons.

Mud-filled channel
The final stage in some areas, especially where the marsh platform has collapsed into a tidal channel, is a trough of unvegetated or sparsely vegetated mud that fills in those parts of the channel that would formerly have provided shaded and hidden pools for invertebrates and fish during low tide. Some of these areas seem to be suitable the native species Low Clubrush and Canadian Sand-spurry (*Spergularia canadensis*) as well as the invasive low marsh plant, Brass Buttons.

The Canada Goose Issue - What Are the Options
At the centre of the issue, the options with regard to the Canada Goose appear to be few. If the non-native subspecies and crosses that do not migrate continue to grow in population, then the habitats they depend on, including the Englishman River estuary, will simplify until they are not

suitable to meet the needs of these geese. Science provides us with tools to hypothesize about natural laws and test these hypotheses; unending growth of any population within a finite world would contradict several of the laws of physics (i.e. thermodynamics) which have never been found false. Whether we as humans take responsibility for our earlier actions which modified local Canada Goose behaviour and genetics, or let natural processes solve the imbalance in its own unpredictable way -- that is the only real question at hand. In any case, the population cannot keep growing forever.

The local carrying capacity for the Canada Goose is not known, but based on the area of the plant communities that have disappeared or changed into an early seral form, it appears that the geese have already exceeded the practical size limit of a stable population in balance with its habitat.

The management plan could propose to:

1. do nothing, and let habitat destruction from grazing and natural population control take its course.
2. delay the issue and hope that casual egg addling and fencing will become more effective over time.
3. increase human hunting of geese by making it easy for bow hunters and others. It would useful to monitor this to see if hunting actually limits the population.
4. increase access by predators by buying or securing sufficient wildlife corridors to allow easy access to the estuary by big predators such as bears, wolves and cougars. Regular use by Minks and Otters was observed on the spit area at the mouth of the Little Qualicum River, but that did not prevent the geese from producing a high density of goose nests in the same area in 2009. It would appear that these smaller predators might not be interested in goose eggs or adults as prey at nesting time, possibly because the geese are too powerful. Therefore a larger predator would be needed
5. lower the goose population by some kind of cull.

So the choice is not whether the goose population will be controlled, the choice is how. If natural processes are allowed to prevail, the observed conversion of the lush sedge marshes to Sea Milkwort and bare substrate will likely continue. Some species will disappear from any location where geese feel safe. The banks of the tidal channels will continue to slump making unusable for fish during low tide. In order to have an estuary with the highly productive sedge plant communities intact, it would appear that it is necessary to take steps to control the geese, even though control of Canada Goose was not historically necessary, before the introduction of the mixed birds that do not appear to migrate.

Ring-necked Pheasant or Common Pheasant (*Phasianus colchicus*)

The Ring-necked Pheasant is present in low numbers on the Englishman estuary. In this study, their vocalizations were frequently heard from the shrub and high marsh areas around the Western Marsh. The population appears to be low and stable so no control measures are recommended.

California Quail (*Callipepla californica*)

This exotic species is well established on the estuary, although it was not seen during this study. There is no evidence that its population is increasing so no control measures are recommended at this time.

Barred Owl (*Strix varia*)

The Barred Owl was observed by the Arrowsmith Naturalists (2009) in June and July 2007, and in this study, it was heard during the day in June 2007. The Barred Owl is not native to Vancouver Island, however sightings of this species on the Englishman estuary go back at least as far as 26 October, 1993 (Dawe et al., 1994 cites Keith Fortune).

Its presence on the estuary is of some concern, partly due to the possibility that it might be feeding on the smaller owls, and in particular, the Vancouver Island subspecies of the Western Screech Owl (*Megascops kennicottii kennicottii* BLUE-listed, BCCDC 2009 and the Northern Pygmy Owl (*Glaucidium gnoma swarthi* BLUE-listed, BCCDC 2009). Anecdotal evidence by the authors of this study suggests that the Western Screech Owl on Vancouver Island might be in decline in some areas such as west Qualicum Beach where the distinctive "bouncing ball" rhythm of the owl's call used to be heard regularly in 1986 and 1987. Habitat changes from natural succession could also account for this hypothetical decline of Western Screech Owl on Vancouver Island.

Control of the Barred Owl on the estuary is not recommended at this time, however no effort should be made, for example through nest boxes, to encourage it.

European Starling (*Sturnus vulgaris*)

In downtown Courtenay in the autumn of 2000, the authors observed starlings in flight occupying one quarter of the sky; a crude estimate of their numbers at that time put the total at approximately 30,000 starlings in view at one time. In this study, flocks of several hundreds of European Starlings were seen using the Western Marsh of the estuary in 2008. (photo #). This is similar to the peak number of 363 starlings reported by Dawe et al. (1994). That report also noted the species numbers were highest on the western part of the estuary and in the trees just beyond the western boundary of the study area.

It appears that the numbers of the European Starling have stabilized on the estuary. No control is recommended at this time, but every effort should be made to ensure that the needs are met of raptors that feed on starlings, such as the Merlin, Coopers Hawk and Sharp-shinned Hawk. As new information becomes available, or if the population of Starlings increases, it might be necessary to use control measures. In Spain, nets are used to capture starlings as a seasonal delicacy for human consumption in some large cities.

House Finch (*Carpodacus mexicanus*)

Although the House Finch it is native to Mexico, it appears to be completely naturalized since it arrived on Vancouver Island in 1937 and started over wintering around 1951 (Campbell et al., 2001, cites Cowan, 1937, and Clay, 1952). The House Finch has been present on the Englishman River estuary since at least as far back as 1979 (Dawe et al.,1994) when a peak of 34 birds was seen in December. The Arrowsmith Naturalists (2009) recorded a peak of 71 birds in October, 2008. Thus, it appears that the population of the House Finch on the Englishman River estuary has been long established and is likely stable, so no control measures are recommended at this time.

Eastern Cottontail (*Sylvilagus floridanus*)

This exotic species of rabbit was introduced to Vancouver Island by an intentional release near Sooke in 1964 (Nagorsen, 1990 cited in RISC, 2009) and its range has been expanding northwards ever since. There may have been earlier releases as well. The species was present in the Parksville / Errington area in 1986 but it did not appear to have reached Qualicum Beach at that time. Today it is present on the east side of the island from Victoria to Campbell River and Sayward. In spite of the recent expansion following its arrival, its population appears to have been stable on the Englishman River estuary over the last 10 years of casual observations. No control measures are recommended at this time.

Domestic Cat (*Felis catus*)

Three domestic cats were seen roaming the estuary during the study period. The local impact of this species on the estuary is not known. Birds may not have any defense against small feline predators because none were present on Vancouver Island until the arrival of people of European decent. As part of a comprehensive public outreach campaign, the problems with roaming cats could be discussed, and cat owners encouraged to keep their pet inside or, at least, bell the cat.

Domestic Dog (*Canis lupus familiaris*)
We recommend that dogs be kept on a leash throughout the estuary. If there are many complaints about this, a local dog club has the option of organizing an "Off the Leash but Under Control" training course for dogs and their owners. The Greater Vancouver Regional District operated a similar system at Campbell Valley Regional Park.

Human (*Homo sapiens*)
The human species is native to this area; middens and burial grounds suggest that human presence may have been continuous for thousands of years. However, the humans that occupied the Englishman River estuary did not have motorized quads and chainsaws. Today these and other tools, although not welcome on the estuary properties, find their way in. The tracks a quad made on middle and high marsh areas within the estuary were still visible in a ground photograph taken from a distance 7 months later. The chainsaw cuts on some Broad-leaf Maple joints, likely to obtain burl-grained or bird's-eye wood, are still visible 10 years later. Last year's ground cleared clean of Nootka Rose on Big Island to grow marijuana (*Cannabis spp.*) and the campground full of garbage that growers used is still present not far from this year's new clearing. A wildlife manager's biggest task is not managing the wildlife; it is managing the people (Neil Dawe, 1997, pers. comm.). Controls on this species' activities on the estuary is recommended.

For Nature Trust and others, it must be a continuous burden to maintain fences and keep in contact with the problems occurring at the local scene. It is the hoped that this report will contribute to public knowledge and awareness and, in this way, make the task of management a little easier.

5.3.8 Some Non-native Species To Prepare For

A large number of invasive species are present on the east side of Vancouver Island. Here are a few examples of species that were not observed on or adjacent to the Englishman River estuary study area, but are known to occur within the region and would likely find suitable conditions for rapid expansion there, if given a chance to become established. It is recommended that people concerned about the estuary become knowledgeable and prepared for the controversy that might arise if these and other animals come into conflict with the delicate native fauna and flora of Vancouver Island.

Chervil or Wild Chervil (*Anthriscus sylvestris*)

is present on the estuaries of the Little Qualicum River estuary and Nanoose/Bonell Creek estuary.

Giant Hogweed (*Heracleum mantegazzianum*)

is abundant on French Creek.

The Great Grey or Leopard Slug (*Limax maximus*) occurs in Qualicum Beach.

The Eastern Grey Squirrel (*Sciurus carolinensis*) is a highly invasive species that usually appears in its fully black phenotype on Vancouver Island. One was observed during the study period near French Creek in 2007 and one black squirrel was seen near the E&N railway station in Qualicum Beach in 2008.

The final list of all invasive species that has been identified on the ERE in this project will be forwarded to the BCCDC. This will add to their data about species, occurrences and ranges.

Section 6 NEARSHORE STUDIES

The Nearshore area is part of the Englishman River estuary. It is vital to survival of many plant and animal species including salmon. The Nearshore ecosystem includes the backshore, intertidal, and subtidal zones out 20 to 30metres. It's described as; "the aquatic interface between freshwater, land, air and the marine environment" (Wright/Deakin, 2009). These critical marine areas include upland and backshore areas that both directly influence shoreline conditions. They are sensitive to adverse land uses such as; run-off from agricultural lands, roadways and landscaped areas.

These zones provide critical habitats for the underlying structure of the marine food chain. For example they provide spawning and rearing habitat for Sand Lance, Pacific Herring and Surf Smelt populations, which are an important in the food chain for juvenile and adult salmon. They also provide the means for fisheries and recreation economies. Natural vegetation along the interface between the upper intertidal and the backshore, buffers pollutants from entering marine waters and provides food for young salmon. Large woody debris generated from the native vegetation helps to break up the wave energy and reduce shore erosion." (Wright/Deakin, 2009)

An ecosystem approach is needed to watershed management. It is not enough to care for an estuary if we are to ensure survival of salmon and other species. Once fish have left the estuary, sufficient habitat and food are required in order to ensure marine survival. These survivals then connect to the marine fish, mammals and birds that depend on these smaller fish to survive.

Eighty percent of ocean pollution comes from land-based activities (National Ocean Service, 2008). Understanding our nearshore and how we impact it and the areas adjacent, will show us how to manage our activities in order to protect the marine environment, and the ecosystem services we receive from a healthy marine area. These services include currents that determine our weather and temperatures, carbon sinks in the form of eelgrass, food, quality of life, recreation, tourism and commercial fishery industries, cultural and spiritual connections. In a time of climate change, ocean acidification, an increase in dead zones, over fishing, global shortages of forage fish and extreme species declines, shoreline communities must do what they can to reverse these trends and ensure the continuation of the functions of this thin strip, to help ensure long term ocean health and marine survival, and a continuation of ecosystem services needed by humans.

In this case we have examined the nearshore area from the Little Qualicum River to Craig Bay. This is in keeping with the understanding that when working with shorelines, human actions in one area can impact the nearshore further along the shoreline, and so to limit the study to only the estuary would not necessarily capture the issues.

6. 0 Goals and Objectives

The goal of this inventory was to collect information on key species to indicate the health and complexity of the nearshore area. The information should be useful to land managers in decisions regarding planning and management. We also expect stakeholder groups to use the information for education, awareness, and support for any changes in policy, regulation or management of the area.

Originally the study was intended to only collect the information on hardening vs. natural areas. But as the group mapped the shoreline the decision was made to add notes on potential forage fish habitat, and also the health of the marine riparian areas. It was realized that this would mean an inconsistency of data, but the information was collected as indicators only and follow-up would be needed regardless, and by collecting this information now, it was hoped that this would speed up a future process of determining the health of the marine riparian more fully.

The nearshore section contains information focused on

1. inventory and mapping of natural vs. hardened Shoreline
2. inventory and mapping of Marine Riparian Areas
3. Inventory and mapping of Eel Grass
4. inventory and mapping of Forage Fish utilization.,
5. comparison of key shellfish populations over time,

Discussion will include the correlation of declines in native plants and animals with respect to alteration by man to this environment.

6.1 Shoreline Inventory

6.1 Introduction

Healthy shorelines are constantly changing. Currents pick up sediments off some beaches and deposit it on others. Cliff areas are a key part of a natural shoreline process, providing the nourishment to the beaches. New sediment must come from somewhere, or the beach will turn to cobble. Some beaches are meant to be cobble, but in other areas the sands and fine gravels must come from above or up current from the particular beach. If this nourishment does not happen, then the fines are washed away, and gravel and cobble remain.[1]Winter storms move sediments around within bays, create gravel bars, and take them apart, sometimes in different areas of foreshore, and also within the same area over time. Foreshore accretes and then erodes, constantly changing the shape and depth of the waterfront.

With population growth, there is now primarily private ownership of the east coast Vancouver Island shoreline from Victoria to Campbell River. The result of private ownership has seen significant changes to the natural shoreline structure; land is cleared and shorelines filled to hardened edges made typically of concrete, rock and/or piles. Property owners, often new to the coastal areas are unfamiliar with an ocean environment. They are easily concerned and view the process from a short-term window, and usually move to harden the foreshore in an attempt to maintain the size and shape of their waterfront property. Other modifications are made due to a lack of understanding related to legal access to shorelines and the high tide marks (e.g. boat ramps from residential yard to point below high tide). Other modifications are installed by local governments putting in sewer lines, storm drains, public access points, boat ramps and harbours.

These hardened areas change the natural dynamic of the shoreline, often creating unintended erosion. Due to beach dynamics, hardening a shoreline typically creates erosion at either end of the hardening. This often results in a spin-off where the neighbours to the original hardening then feel they must armour their beach, and so on down the beach areas[2]. Hardened beaches can

also change the substrate from a sandy beach to a gravel and/or cobble beach, removing vital habitat (Emmett, Brian, 2007) .

6.1 Objectives

The shore line study was done to; quantify the amount of natural nearshore within the greater estuary area, the types and amounts of shoreline hardening that currently exist, and locations of the storm drains and other anthropogenic impacts.

Determination of the types and level of modification should provide direction on the habitat requirements, which will lead to the activities required for education and habitat restoration in an updated Estuary Management Plan, including additional components regarding the nearshore area.

6.1 Methodology

Schedule: Shorelines were mapped throughout the summer of 2008. Since mapping was done at the highest high tide point, there was no need to follow a strict schedule set by tides, though times were selected to ensure a beach area large enough to walk safely.

Volunteer Coordination: Volunteers were used to help on days that summer students were not available to help. Volunteers were coordinated by Ronda Murdock (MVIHES) on behalf of coordinator Michele Deakin (MVIHES). Volunteers were given training on the reasons for the mapping of our shorelines, use of the equipment. They were given responsibilities that ranged from carrying equipment, using a rangefinder, using a GPS, taking photos of shoreline areas, recording data.

Equipment: Garmin GPS 76, Opti-Logic 800XL Rangefinder , Canon camera,

Mapping Methods: The survey area was from the Little Qualicum River, across the mouth of the Englishman River to Craig Bay, a length of approximately XXX m. A minimum crew of two was used. One person would stay at a point where shoreline treatment changed. The other person would take a GPS reading at that point and then walk forward until even with the next change, and stay there, taking a GPS point again. The person behind would use the rangefinder on that front person and get a reading on distance in metres, and walk forward to join that front person. Data was recorded, including the GPS location of the two points. Photos were taken parallel to the beach and towards the water and then if needed from the water to the seawall or land area. The data was then uploaded by the Project Watershed Mapping Centre for entry into a GIS data base where it was portrayed on maps as well as its content analyzed.

6.1.1 Results - Natural vs. Hardened

The shoreline was divided into units determined by the approach to shoreline management taken in any one stretch. The range of options for shoreline management included natural or softshore, rip rap, wood wall, piled rock, cement block, cement wall, combination, and other. The length of beach used for each shore zone could be one lot, a part of a lot, or several lots together if they had followed the same approach Figure 1 illustrates the placement of various types of armouring along the study area.

Most of the natural areas are those in protected areas including Rathtrevor Provincial Park, the Little Qualicum River Estuary Regional Conservation Area, and the Marshall-Stevenson Unit, Qualicum National Wildlife Area. The softshore beach in the Community Park in the City of Parksville is not included in these protected areas.

6.1.2 Results - Anthropogenic or Human Made Impacts

Anthropogenic changes like storm drains, groynes, culverts, docks, boat ramps, public access points, were noted within each shore area differentiated by a change in hardening type or a change between natural and hardened shoreline. Figure 2 overleaf illustrates the anthropogenic changes.

After reviewing the data, an anthropogenic feature that shows up in some areas but is not on the list for the mapping is a pathway created in cobble. People move back cobbles to create a path wide enough for either walking or pulling boats to the water. We were unable to create new categories outside the SHIM listing and so this has been noted but not mapped. Considering there were 6-8 of these pathways, the impact to overall results will not be significant.

Lines of boulders running perpendicular to the beach were another anthropogenic noted, but not mapped. It is unclear what some of these lines were for. Some seemed to be associated with storm drains, but others had no such association.

6.1.3 Results - Natural vs. Modified

Most of the shoreline has been modified. Hardening has effected the shoreline from anthropogenic alterations (storm drains, culverts, stairways, etc.). The protected areas make up a significant portion of the natural shoreline within the mapping area. It should be noted that the area known to be restored was considered a natural beach and not modified. The reason for this was that the intent of the study is to quantify the hardening, and of other negative human impacts. Restoration of a beach through softshore approaches does not fit within these parameters and so needed to be treated as natural.

Figure 6.1 Map – Parksville-Qualicum Beach Shoreline Inventory – Shoreline Hardening

Figure 6.2 Map – Parksville-Qualicum Beach Shoreline Inventory Anthropogenic Features

Figure 6.3 Parksville-Qualicum Beach Shoreline Inventory Natural vs. Modified

6.1 Discussion

The study was stopped at a small creek east of Craig Creek, and so in order to complete this mapping to the WMA boundaries, and to match it to the area covered by eelgrass mapping, the section between this point and Craig Creek must be finished - a total of 1710 metres, and a small distance on the east side of the Little Qualicum River. This distance should be covered as soon as possible.

Though photographic images have been collected of each unit of shoreline, they are not available at this time to be matched in an orderly fashion to information on specific parcels of land, due to time needed to work out map production challenges. This should be addressed as soon as possible.

The slope of the shoreline facing a given property was a good predictor of whether hardening had occurred or not. Usually houses at the top of a rise would not have a wall of any kind, but those houses on a slope would have a hardened shoreline.

Older homes tended to have a natural shoreline, but new homes had obviously armoured their shore as part of the building project or soon after construction.

Some homes attempted to use a softshore approach that may or may not have been part of their plan. The placement of driftwood, for example, was seen throughout the shoreline, possibly as one approach to managing erosion.

Other information available regarding shoreline modifications are two videos of the region. One was done in March 2009 by helicopter, and another collected several years ago. The comparison of these two videos would indicate a change in the shoreline and habitat, and highlight trends in development. It could also provide the initial indication of where to start researching shoreline variances.

Shoreline variance reports are becoming common in the Georgia Basin, Puget Sound area. These include a review of shoreline modifications and a collection of the history of the number of variances that have been granted and how; but also a review of the modifications to see if they are being kept up and if they are still legal. This information is useful to help develop OCPs, and related zoning, planning policies, and education of elected officials and community. It is also useful as a tool to help bylaw staff and others to follow up with landowners to ensure proper care is taken of any modification that has been approved.

Overall there is significant modification of the shoreline in Parksville-Qualicum Beach. Currently there are no bylaws to prevent further hardening of the shoreline and though the Fisheries Act should provide protection for these areas, the resources don’t exist to proactively review all shoreline modification projects in one of the fastest growing areas of BC.

Alternatives to armouring need to be presented to residents, developers, planners and elected officials. Restoration of softshores would be expected to improve the natural function of the nearshore, and would be most effective on a community-wide planning effort.

6.1 Conclusions

The hardening and modification of the shoreline is greatly altering and so having a negative effect on the ecological functions of the shore of the Parksville-Qualicum Beach area, and the Englishman River estuary.

- We need to educate the public, developers, elected officials and property owners about alternatives to armouring a shoreline.
- We need to review the possibilities for restoration of softshores within the study area.
- We need to have laws to protect our nearshore including local bylaws and enforcement of the Fisheries Act.
- We need to review our shoreline variances in order to understand how shoreline modifications are approved and then develop tools and/or a revised process to assist in better decisions regarding nearshore health.

6.2 Marine Riparian Areas

6.2 Goals and Objectives

Similar to the riverine riparian areas, the marine riparian provides many important ecosystem services including nourishment of beaches, shade and cooling, insects and other nutrients. This inventory was developed informally, to provide a visual indicator of marine riparian health, to use as tool until a more formal and complete analysis of riparian health can be developed.

6.2 Methodology

Native species provide a better riparian function, though in some cases having some type of vegetation there, even if an introduced species can help provide some function. (R. Russell, 2009) Vegetation was classified using the SHIM database. Vegetation with a high value for a natural riparian area was rated and coloured for High Value (e.g. Dune grass, Gumweed, coniferous forest, etc.). Other vegetation was rated Low (e.g. English Ivy, California Poppies, Berries). Each line on the map with the corresponding colour indicates the presence of a species with a high or low rating. Together this rating shows those areas with the riparian area more intact than others.

Anywhere a group of seagrass was noted, the group was assigned "Dunegrass" to fit with the SHIM database so that there would be some vegetation of value, or some function, recognized on the map, but Native Dunegrass (*Elymus mollis*) may not be present in all places it is mentioned-though it is in most and possibly all locations.

6.2 Results

Figure 4 shows that the most healthy riparian areas are in protected areas. It also illustrates that some spots along the coast have some riparian element. Most areas are developed and have little or no riparian function. The map also indicates that most vegetation in the riparian zone is of high value. As the process was used to develop only a visual indication of riparian health, there was no numbered rating system applied.

6.2 Discussion

Because the map provides a line of appropriate vegetation colour for each different species (e.g. Gumweed), or group noted (e.g. mixed forest), it only indicates presence and not quantity. There is no capture of health of the vegetation, or area covered. Not all species were noted. For example more than one species of grass was noted in some areas, but only Dunegrass was used to indicate the function, as the project did not allow the time to key out the variety of species actually found.

A more complete study would be useful. This study should note the variety of substrates in sections of the shore, and the number and variety of species within a section of shore and into the backshore.

A review of species that should be in the riparian area but no longer exist would also be useful. Many landowners are becoming interested in planting native species in an effort to save water, and be more environmentally responsible. This information could be provided to land managers, real estate agents, local gardening clubs and other stakeholders, and some instruction given regarding the planting and growing of these species.

In an area that is a thin ribbon of potential vegetation, the marine riparian area in a developed area can not support invasives. The impact of the invasives on this small area, and on an island like Vancouver Island, would be more significant than in a larger area, or on the mainland. In those areas where invasive species are found, removal should be encouraged through public education where possible. Bylaws should be considered to prevent further introductions of known invasives, and to encourage removal of those that currently exist.

6.2 Conclusions

- The marine riparian area has been impacted by development. It provides important biological function to the nearshore and to humans.
- A more complete study of the marine riparian area should be conducted.
- A study of the marine riparian vegetation that is not in existence but should be needs to be completed. Information from such a study should be shared through education programs, and incentives given to plant and restore the riparian zone.
- Bylaws to prevent introductions of known invasives and encourage removal of existing invasives should be considered.

Figure 6.4 Map – Parksville-Qualicum Beach Shoreline Inventory Marine Riparian Areas

6.3 Eel Grass Mapping

Eelgrass (*Zostera marina*), when healthy, helps buffer the shoreline as it slows the wave action down. The rhizomes of the plant, help hold the sediment in place and prevent erosion of the foreshore. The swaying motion of the eelgrass also helps clean the water thereby reducing turbidity. As a green, photosynthesizing plant it provides us with both oxygen, and effective carbon sinks.

Eelgrass is often equated to the coral reefs or tropical rainforest, due to the amount of biodiversity that seasonally moves through the beds. 80% of commercial fish and shellfish species depend on *Z. marina* at some point in their lifecycles. This can be for protection from predation, sunshine and fresh water. Eelgrass also provides nursery grounds for some and hunting grounds for others. It also supplies nutrients to salmonids and other fish, shellfish, waterfowl and about 124 species of faunal invertebrates. The plants offer surface area for over 350 species of macroalgae and 91 species of epiphytic microalgae. It is an extremely important part of ecosystem health. (Wright/Deakin, 2009)

Eelgrass is a fairly flexible plant, but does have some preferred habitat requirements. It prefers to grow in mudflats, and/or sandy substrate, needs a certain level of sunlight, a particular range of wave action, and a range of salinity (BC Coastal Eelgrass Mapping Network, 2003). The area of the Englishman River Estuary and the shorelines of Parksville-Qualicum Beach provide exemplary habitat for eelgrass. Whereas most of the coast consists of small eelgrass beds, tucked between rocky shores, the extensive beaches of the Oceanside area provide stretches of potential habitat that are several kilometres long.

6.3 Goals and Objectives

This mapping and monitoring of eelgrass is intended to collect information to show the location of eelgrass beds, quantify the amount of eelgrass and the carbon being sequestered. Comparison to historic mapping efforts will give some indication of any change in location or size of beds. These results can be used to indicate water quality issues, changes in sea level, or visitor management issues.

6.3 Methodology

Schedule: Due to limited resources and the extent of *Z. marina* in this area, multi-year mapping has been necessary. Mapping efforts were focused on areas that were more susceptible to human impact. Intertidal eelgrass was mapped at low tides over the last 4 years. Some sites were repeated as monitoring sites. Subtidal eelgrass was mapped at close to low tides over the last 3 years.

Volunteer Coordination: Once field days were established, the mapping was led by the project coordinator, Michele Deakin. For the first 3 years, volunteers were solicited and coordinated by Michele. Through this project, Ronda Murdock found volunteers. The number of volunteers ranged from 2 to 6 persons per sample site, though in the case of Rathtrevor Provincial Park special groups of volunteer geocachers were brought in totalling from 10-20 each time. Most volunteers were adults and retirees, though some children were involved. Two school groups were involved

including one which conducted a separate 3 year study regarding growth rates of *Z. marina* vs. *Z. japonica*.

Volunteers were offered responsibilities before work was undertaken for duties such as; carrying the equipment, laying the transect, recording data, running the GPS units, counting densities. Training was done before to familiarize volunteers with the species and its significance to the ecosystem and humans. Volunteers were also trained each outing on equipment and proper mapping techniques. Careful movement in and around eelgrass beds was also stressed to reduce the impact to the habitat and wildlife.

Equipment: 60m transect tape, quadrats 0.25 sq. metres, GPS, camera.

Mapping Methods: Eelgrass is mapped using the methodology developed by Precid Identification for Canadian Wildlife Service, Environment Canada. This 41 page manual is located at www.stewardshipcentre.bc.ca/eelgrass/methods.pdf.

The most basic approach is to use a GPS to record points and walk the outside of the bed, so that the location and size are noted, while completing a standard data collection sheets. If there is the opportunity to map at a higher level (i.e. collect details regarding density), then the intertidal methodology involves the laying of a 60 metre tape parallel to the beach at low tide in the middle of an eelgrass bed. 30 quadrats are then counted for number of plants, number of reproducing, and leaf area index is calculated. Other flora and fauna found in the bed are also noted. A Garmin GPS is used to note the ends of the transect, but also the outline of the bed.

Subtidal mapping of eelgrass involves a boat, GPS, underwater camera and viewer. The beds are located with the viewer and then the camera is used to keep the boat on track along the outside edge of the beds. GPS points are entered along the route which will then provide a polygon outlining the bed on the atlas.

Where possible, divers can be included to apply the same methodology as the intertidal mapping, underwater to calculate densities and health of the bed.

Whether it is intertidal or subtidal information, this data is downloaded and entered onto the Community Mapping Network site in the Eelgrass Mapping Atlas for the coast of BC. Data entry includes cleaning up of GPS points, creating points, lines, and polygons to indicate locations and size of eelgrass beds. Attribute data is also entered and connected to the features.

The data collected by Haegle for the Department of Fisheries and Oceans in the 1970s and early 1980s was gathered together into a digital database by the Department in 2003. The area of Parksville-Qualicum Beach was inventoried in 1977. Haegle collected the data through the “use of low-level colour infrared and colour aerial photographs. In cases where no distinct uni-species vegetation zones was evident, vegetation zones were plotted according to either the:

• Single dominant type (if it occupied not less than 80% of the total area)

• Mixed vegetation zones (if two or more vegetation types each occupied more than 20% of the total area) Vegetation types covering less than 20% of a zone were not included in zone identification.” (Bennett, K. 2003)

Some ground-truthing was completed with the use of divers. In the Deep Bay area, the presence of vegetation “was identified for 72% of transect samples, and 60% of transect samples were correctly mapped from the aerial photographs. Shoreline vegetation incorrectly mapped as bare from aerial vegetation was almost exclusively (90%) beyond the outer edge of vegetation identified in photographs and in deep water. Many of these areas exhibited patchy vegetation.” (Bennett, K., 2003) Despite the correspondence, Haegele recommended in his report that analysis of the data should emphasize total area of each species type, not the positional location of the polygon itself.

The Haegle data was included to illustrate the complexity of our beds, but also provides some useful comparisons about eelgrass bed locations and size. Since the mapping work of Haegle, the

introduced Sargassum (?) has apparently been spreading (according to anectdotal evidence) and so the vegetation zones will have changed in some areas. Sargassum presented challenges to mapping the subtidal eelgrass as it is mixing in and around the beds, making it difficult to see exact boundaries on the eelgrass locations.

Data gaps: There are still some gaps regarding the outside edge of the subtidal beds. Also some beds were such a mix of marina and sargassum that it was not possible to differentiate between them given the tides and weather during mapping. Several mapping attempts were cancelled due to wind.

Subtidal mapping did not include density counts. Despite efforts in the past, a team of qualified volunteer divers was not found. A group of free divers however have been working in other locations on the mainland and Gulf Islands the last two years and so would be a resource to use to get some baseline densities of the subtidal *Z. marina* in this region.

The eelgrass atlas is hosted on a publically accessible network of community mapping efforts, CMN Network. This allows the efforts of many volunteers to be displayed. The benefit of the atlas is that part of the mapping process can be done online without the maintenance of expensive software and base maps. The atlas also presented some challenges. Digitizing lines was time consuming because the start and finish of the lines was confined to the screen size available, so numerous lines had to be digitized to create a polygon for example. In addition, an attribute form had to be filled out for each line. It was discovered part way through the project that in order to show consecutive year data (with different coloured lines) a GIS technician would have had to have been paid, which was not in the budget. As it stands the viewer must click on each line to open a report to view the date of survey. Visually, this is not ideal.

The atlas has recently been transferred into new software that will eventually make the online mapping more user friendly, but it is in its infancy. More funds are needed to add useful features and bugs are still being ironed out. Leanna Boyer, Seagrass Conservation Working Group and Gordon Luckett, Arrow Geomatics Inc., have volunteered many hours to get the data and maps together for this project to export to Project Watershed and then in final clean up.

Figure 6.5: Map – Parksville-Qualicum Beach Eelgrass (Haegle)

6.3 Results

Figure 6.6 illustrates the locations of eelgrass both intertidal and subtidal along the shoreline of Parksville-Qualicum Beach area, including the Englishman River estuary. In those areas where a polygon is shown, it is known that the bed has been mapped in its entirety. Many areas show a line of eelgrass indicating a narrow bed, or a fringing bed that crosses from intertidal into subtidal. In some cases a line indicates a subtidal bed left incomplete due to wind and/or visibility issues. Other single points indicate locations of eelgrass that are approximately a metre in size but not large enough to create a polygon or a line.

The map shows the seagrass and seagrass/mixed areas captured by Haegle, compared to the eelgrass mapped between 2004-2008 in Parksville-Qualicum Beach. In some areas, eelgrass mapped by Haegle is sea-ward of the current locations, or lower on the beach. This indicates that the Z. marina is noticeably moving up the beach. Eelgrass moves up a beach in response to changing water quality, and/or rising sea levels.

Figure 6.6 Map – Parksville-Qualicum Beach Eelgrass (MVIHES)

Figure 6.7 Map – Parksville-Qualicum Beach Eelgrass (MVIHES and Haegle)

6.3 Discussion

We have chosen to inventory some key plant species to indicate overall health of the nearshore. Eelgrass is a key indicator species. It is the central element in the discussion of healthy shorelines and healthy salmonid populations. If eelgrass meadows are healthy and resilient to changes, including those of climate, so too is there a higher likelihood of juvenile salmonids growing robust and surviving the open ocean. Healthy nearshore habitats increase marine survival of salmonids, forage fish, such as herring and sand lance and other important fish species. None of this nearshore can exist sustainably if the natural process of formation and maintenance of the shoreline has been interrupted by human impact.

Anecdotal information on changes to eelgrass since 2004 include the reduction of bed size in the Qualicum Beach and Rathtrevor Beach areas. This could be due to trampling but should be reviewed.

Along the Parksville Bay area, the movement of pebble and cobble, likely due to altered shorelines is likely impacting the growth of eelgrass. Historic photos and a discussion with a coastal engineer confirm that the beach in front of Surfside used to be a sandy beach. It is understood by coastal engineering experts that creating of the rip rap along that beachfront has altered the current significantly and created the gravel bars in the area. There is a large gravel bar that has come and gone naturally over time, but now seems to be permanent and continuing to grow. Mapping of eelgrass shows the cobble mixing with eelgrass along this area and it seems that we are monitoring the continued decline of this habitat.

This area has traditionally been an important area for herring spawn and for migratory birds including the Black Brant goose. Resident birds like the listed Great Blue Heron use it regularly for feeding, standing in the eelgrass beds to fish.

Other changes we are seeing occur in eelgrass in this study area and other areas of the Georgia Basin include the earlier development of ephiphytes. A typical cycle of diatoms on eelgrass is that in late July/August Z. marina would “turn off” the chemical that prevents epiphytes from attaching to the plant. This then permits the diatoms to attach and this is in time to feed the copepods and other zooplankton that are arriving in the area, and that this then ensures that there is a food source for salmon smolts coming out of the streams and rivers. The question we have been asking is, does this upset the cycle of diatoms to copepods to salmon? The relationship of one to the other is significant.

Recent research shows that diatoms feed copepods that are needed to sustain salmon. Will there be enough left for movement of salmon into the nearshore from river? Is this a result of climate change and warming of the water, or a water quality issue? A form of sun screen? Research needs to be done on this trend.

Water quality samples were taken last year by the Tribal Journey canoe trip to Duncan. Collection of that data and mapping of the results might help indicate where changes are occurring due to water quality issues. Other sampling should be undertaken in an organized study to quantify water quality in areas where eelgrass has moved up the beach, or where significant decline has been noted. Attempts should be made to determine whether any water quality issue is due to local influence, or a regional issue or concerns the whole of Georgia Basin.

In some areas of the Georgia Basin this year, eelgrass has suddenly disappeared and there is not yet an explanation. The San Juan Islands have also been experiencing sudden losses of eelgrass and further research is needed into the reasons. But it highlights the importance of maintaining the eelgrass we do have as any remaining eelgrass becomes even more significant as other areas

experience losses of the habitat.

Wasting disease is a potential factor in these sudden disappearances that should be researched in the Georgia Basin. In the 1930's a widespread collapse of eelgrass occurred on the Atlantic coast. So far the Pacific coast has not experienced that collapse, but wasting disease is present in Puget Sound. It is thought that *Zostera marina* is always infected with the fungi *Labyrinthul* (Short, F.T, L.K. Muehlstein, L.K. & D. Porter, 1987). There are different theories about how this pathogen is triggered. Some suggest it is set off by a change in salinity, or light levels or temperature and that pollution is the most likely trigger of all these changes. Others suggest that the fungi is actually a saprophyte and only feeds on dead eelgrass cells. Still another suggestion is that the eelgrass meadows only seem to be a monoculture and so susceptible to widespread wasting disease, but in fact each meadow is actually full of a variety of smaller plants and animals that provide the antibiotics necessary (Kruckeberg, A. 1995). The Bamfield Marine Science Centre is currently researching wasting disease and will work with the Seagrass Conservation Working Group to promote partnerships in research and management in the Georgia Basin and West Coast of Vancouver Island.

Once reasons for decline have been identified, consideration of transplants would be possible. Given the substrate in this region, it is likely that there was more eelgrass in the area than we currently have. A transplant would help increase the habitat and support its adaptation to climate change, but also increase the potential biodiversity of the area, and is a very useful tool to educate and involve the community in understanding and protecting their nearshore environments.

Zostera japonica (japonica) was introduced to the coast several years ago, traveling with oysters from Japan. This plant was studied about 10 years ago and at that time it was determined that it is not an invasive. It tends to grow high up on the intertidal and is an annual and so does not compete with the *Z.marina*. Some mapping projects however are catching a possible change in behaviour. It is possible that *Z. japonica* is evolving and adapting to its new environment. This inventory and others have found japonica mixed into beds of *Z. marina*. This could mean that the japonica is moving down the beach as it adapts to its new environment, the *Z. marina* is moving up the beach due to water quality issues, or that sea levels have changed and forced the *Z. marina* further up the beach.

Mapping of Zostera Japonica would be worthy of consideration as well. Some biologists consider japonica as increased habitat, and other biologists are concerned about the spread of japonica impacting habitat for migratory birds that feed intertidally. Mapping of the introduced eelgrass would indicate the level of growth, and likely indicate if there has been a change in behaviour in the plant. This may then answer concerns for some, or indicate a need for management considerations.

A more detailed study comparing growth rates of Z. Marina to Z. Japonica should be undertaken to determine if there has been a change in japonica behaviour. This would help answer the questions regarding whether Z. Marina is moving up the beach or Japonica moving down, and so indicate changes in water quality and/or sea level. If it is a change due to sea level increase, then the results would indicate the ability of the Z. Marina to adapt to a changing sea level and what else occurs in the changing habitat.

Eelgrass vs hardening? Eelgrass can be severely impacted by hardening of shorelines. Because eelgrass spreads most successfully by rhizome, one bed can consist essentially of one plant. The rhizomes are dug out of the substrate by wave action that is created and/or increased in response to the armouring of a beach. Hardening alters the pattern of the current from a travel route along the beach and forces it to come in straight, almost perpendicular to the beach. The wave action then "bounces" down the beach until it finds a soft spot to absorb the impact – usually at the end of the seawall or structure, where the energy creates erosion of the shoreline. At the same time, this "bouncing" is done in a circular motion that digs out the finer substrate in front of the armoured

section, and thus will dig out and remove sand and mud leaving cobble behind. This reduces the ability of the beach to support a level of biodiversity. It also removes habitat important for birds, wildlife, fish, marine vegetation and wildlife.

Figure 6.1 illustrates the hardening on the shoreline by hardening type. The selection of hardening situations was drafted based on the variety of armouring found most often above the high tide line. Those types include natural, indicating no hardening and can include some restoration work; rip rap which is the large sharp rocks brought in and piled; piled rocks which describes the areas where natural rounded rock has been piled; wood wall which indicates those areas where a wall is constructed of wood and may indicate a driftwood structure, wooden fence, or wooden posts, etc.. Cement block describes those sections hardened with large blocks that have been put together to make a wall; cement wall indicates areas armoured by poured concrete; combination highlights those areas where homeowners have installed more than one wall in front of each other; and other is a category to capture what has not been captured above.

In addition to the above categories it was noted where driftwood had been placed which is similar to a softshore approach using logs and trees. Other alterations were also noted.

Figure 6.8 Map – Parksville-Qualicum Beach Shoreline Inventory Eelgrass vs. Hardening

The map comparing eelgrass to forage fish distribution highlights areas where there is overlap. There has been some discussion about whether herring actually prefer eelgrass or kelp or whether they just spawn as they are ready. This map shows an overlap with high use areas by Pacific herring and larger eelgrass beds. The Fisheries and Oceans manual for Herring Spawn Surveys recognizes the role of seagrasses in the spawn site selection by herring.

The manner in which Zostera marina holds the shoreline and protects habitat for various forage fish also is important. Looking at those areas indicate potential for forage fish spawning sites,

6.4 Forage Fish

Forage fish are those fish that are preyed upon by larger species. In our area, these include Sand Lance (*Ammodytes hexapterus*), Surf Smelt (*Hypomesus pretiosus)*, Shiner Perch (*Cymatogaster aggregate)*, Pacific Herring (*Clupea pallasii)*, and juvenile salmonids. Not a lot of information exists on some of these species, where there has not been a commercial fishery.

Forage fish species are declining around the world at alarming rates. As larger species disappear, commercial fisheries move down the food chain. Also, the aquaculture industry harvests forage fish to feed their captive fish. A global decline in marine mammals and seabirds has been attributed directly to the decline in forage fish (Oceana, 2009). As the basis for several food chains it is vital we maintain the habitat for forage fish.

Both Sand Lance and Smelt spawn in the intertidal areas. For at least part of their life cycle, Sand Lance remain in the upper intertidal even after the tide recedes, and this seems to be the area in which they spawn, making them very susceptible to impacts from human use of the shoreline.

Given the extent of sand and fine gravel intertidal areas, the beaches of the Oceanside area present substantial potential habitat for both Sand Lance and Smelt.

The upper intertidal area is easily impacted by human use. By determining locations of potential habitat, existing habitat and potential for change through human modification of the shoreline, land managers should have basic information to work with in order to develop policies, planning approaches, and restoration projects needed to ensure a functioning forage fish population.

6.4 Methodology

Schedule: Sand Lance was the initial focus of the study and so low tides during the winter spawning window were chosen to initiate a presence and absence study. The identification of potential forage fish habitat was noted during the mapping of shoreline modifications.

Volunteer Coordination: Volunteers were coordinated by the project coordinator, Michele Deakin, and Ronda Murdock. They ranged in age from students to retirees, and were given responsibilities that included carrying equipment, laying a transect, collecting samples, recording data and sorting the sample and looking for eggs.

Equipment: 60 m transect tape, trowel, GPS, camera, stick (name),

Mapping Methods: As per training by Pam Thuringer, MSc, Fisheries Biologist who has worked with Sand lance for 20 years. This approach is based on that used by Thuringer under the advice of Dan Pattilla of the Washington State Department of Fish and Wildlife.

At tides low enough to expose the potential spawning sites, 60 m transects were laid parallel to the beach, in areas of substrate matching description of potential habitat. Samples were taken within 5 feet of each side of the transect. Trowels were used to dig down up to 2 cm deep at random points along both sides of the transect. Though random, attempts were made to spread the samples out evenly in the sample area, regardless of substrate types. (e.g. if some of the area was sand, and some was pebble, the sample would not focus on the sand substrate but would also include sample from the pebble area) A total of 2 litres of sample is collected for each transect.

Data sheets are completed during the transect regarding wind and fetch, compass readings taken. Samples are labeled to match the data sheets and kept refrigerated until reviewed within a 4-day period.

To review the samples, they are rinsed with water through specially designed filters that reduce the size of the sample but leave those sections most likely to contain spawn. Gold panning techniques are used to winnow the sample down further and examine each few tablespoons at a time under a microscope and bright lights. The first time through a sample the sediment is saved and then 500 ml of that sample are passed onto another reviewer to look through in the same manner as a double-check.

Any possible spawn is put into sample bottles with preservative and then sent to Pam Thuringer to confirm identification.

Data gaps: The potential habitat on the study area is quite extensive. This study focussed on Sand Lance choosing some sample beaches in the area. The potential habitat in winter will look different than during the summer as a result of natural beach processes. For this reason, the study gives some indication of places to check for presence/absence but some of the beaches identified may have different substrate in winter.

Only a handful of transects were attempted based on the funding, and so the presence/absence does not represent the potential of the whole area. Also as the eggs are the same size or smaller than a grain of sand, it takes a practiced eye to find the eggs. As capacity is increased in the volunteers, it will be likely more eggs will be found.

Also, similar to Pacific Herring, Sand Lance move spawning areas. Spawn is also moved around in the water column by the tides, between beaches. So data from one year is an indicator, but similar to herring several years of information are needed in order to determine the habits of Sand Lance and their need for habitat.

Also, the original intent of the shoreline study was to quantify modifications and not forage fish habitat. This was added in after the study was begun as the potential to easily add this factor in was realized. For this reason some areas of potential habitat have not been included in the study.

Since the shoreline changes seasonally, it would be important to capture the potential habitat year-round. A photo-point monitoring program should be considered to cover one year once/ month, or a program covering a wider selection of beaches 4 times/year may be enough.

Mapping for Pacific Smelt should be completed as well. These fish spawn in summer also in the upper intertidal area, and so are subject to the same issues as Sand Lance. A similar methodology is used for Pacific Smelt, except for the requirement of laying of transects a little lower in the intertidal.

Forage Fish – Sand Lance

Potential habitat for Sand Lance exists throughout the nearshore area of the study area. Several transects were done within the study area to sample for possible spawning sites for Sand Lance. One egg was found on December 31st, 2008 in one sample and that location is highlighted on the map.

Finding of one egg indicates that Sand Lance do use these beaches to spawn. Given the date of the sample, it also indicates that samples need to be collected earlier in the year, likely early December or in November. Because Sand Lance are similar to herring and may not use the same beach in subsequent years, not finding eggs does not necessarily mean that the beach is not a spawning beach, or used at some other time in the life cycle of this fish.

The eggs are the size of a grain of sand, and so volunteers need to develop an eye for them. As this capacity increases it is expected that the number of eggs found will also increase.

Most of the shoreline was noted for potential forage fish habitat.

6.4 Herring

Pacific herring, (*Clupea pallasii)* is another forage fish important as an adult to other fish and marine mammals. The spawn of this fish supports a high marine biodiversity contributing to health of Brant geese, other seabirds, and sea mammals including migrating whales, and sea lions.

Clupea pallasii is sometimes considered a keystone species because of its very high productivity and interactions with a large number of predators and prey. Pacific herring spawn in variable seasons, but often in the early part of the year in intertidal and subtidal environments, commonly on eelgrass or other submerged vegetation; however, they do not die after spawning, but can breed in successive years.

Central in the marine food web, Pacific herring are a key fish prey contributing 30 to 70% to the summer diets of Chinook salmon, Pacific cod, lingcod, and harbour seals in southern B.C. waters.

Herring eggs constitute an important part of the diets of migrating seabirds and gray whales, and invertebrates. It contributes 58% of the diet for Coho Salmon = 58% oand 53% for Pacific Halibut.

Pacific herring spawn in coastal areas, requiring abundant algal beds and uncontaminated waters. A growing concern is a threat by coastal development to the spawning habitat of Pacific herring.

The data to create this map was collected through the Pacific Biological Station. It is at this station that Fisheries and Oceans Canada conducts ongoing surveys on herring populations and spawning areas.

T he geographical distributions of Pacific herring (*Clupea pallasi*) spawning sites have been estimated each year since 1928. The analysis was based on approximately 30,000 spawning events recorded mostly by fishery officers and diver teams in six regions of the British Columbia (BC) coast. For each of 101 geographical *sections* of BC, time-series maps were constructed to delineate annual herring spawn depositions along each kilometre of shoreline from 1930 to 2001. Total cumulative egg deposition from 1928 to 2008 was also mapped using proportionately sized, multi-coloured, bubble plots which rank and classify each kilometre of herring spawning habitat according to the long-term frequency and magnitude of spawns over time. Cumulative spawn analysis was conducted coast-wide so that any kilometre on the BC coast could be easily compared with any other BC coastal kilometre.

Approximately 5,260 km (or 18 %) of British Columbia's extensive 29,500 km coastline have been ranked and classified as herring spawning habitat. An estimated 400 to 600 kilometres of BC coastline or about 1.8 % of BC's total shoreline length are intensively utilized by spawners in a typical year. (DFO website) The area of this study then represents three to four percent of potential spawning area for herring in BC.

According to Fisheries and Oceans Canada, sea grasses, are used coast-wide by spawning herring more often than other vegetation types. Two forms are found, both in shallow water. The most common grows on mud/sand flats in protected locations while the other prefers rocky crevices exposed to surf. (DFO website – herring spawn survey manual, 2009). The first type of grass would likely be eelgrass and the latter would be surf grass. Also the female travels back and forth along the substrate to lay her eggs in layers. It would seem then that the fish generally look for vegetation to lay their eggs on. In this area, Sargassum and Zostera Marina provide extensive areas for herring to spawn.

Annual fluctuations of herring spawners may indicate migratory movements (to some degree) between adjacent regions. Tagging evidence presented by Hay, D.E. et al, 2001 suggests that approximately 10 to 20 percent of the spawning biomass in any region may move to adjacent regions in subsequent years. Considerably greater inter-area movements occurs between smaller spatial units such as statistical areas, herring sections or locations. Migratory movements of tagged herring (1936 to 1992) are shown in detail, on tag, origin and recovery maps. (DFO website, April 2009)

The study area is quite close to the Bowser Bay area which is the “most significant herring spawn location in BC” (Penn, B., 2009), but concerns about the scallop aquaculture industry in the Bowser area have been raised regarding health of the herring fishery. Doug Hay, retired herring fishery biologist has stressed the need to “limit future industrialization of the Bowser area coastal zone, and adjacent areas. These areas support very important herring habitat.” (Penn, B., 2009)

The herring populations in the study area then are of a provincial concern. Monitoring of the fishery

vs. the habitat should continue, and a forage fish policy pursued similar to that in the state of Washington.

It is clear that the nearshore area within Parksville-Qualicum Beach is important to the population of herring in BC. Herring use most of the study area for spawning but mapping by DFO shows that some particular areas are used more than others.

The Forage Fish map shows the area used by herring in the study area for spawning. A colour code has been applied so that the darker the pink, the higher the use in that area.

Fisheries and Oceans, on their website, have indicated that if regular information can be collected in order to contribute as an indicator to herring management decisions they would consider adding that indicator to their decision-making framework. Considering the acknowledged value of seagrasses to herring, continued monitoring of eelgrass and the addition of mapping kelp in the area would be of value to forage fish management.

Acknowledgement of the value of the local nearshore to the herring and the many food chains dependent on herring, needs to occur. This information should be included in a variety of education programs.

There should also be further development of policies and regulations to protect and restore the fisheries habitat.

Aggregate maps show the complexity of the nearshore area, and the interaction actual and potential between elements of this zone.

Figure 6.8 Map – Parksville-Qualicum Beach Shoreline Inventory Aggregate Map

6.5 Shellfish

In 1999, the Shorekeepers conducted intertidal surveys along the shoreline including one location in the ER estuary, and one location on the nearby beach in Parksville Bay. The location within the estuary matches one of the locations used for beach seining by this study. The Parksville Bay site matches where intertidal survey work has been done before and after construction of a softshore beach in 2008.

A review of these studies will provide a comparison of populations of key species, useful as another indicator of nearshore health and how it has been changing over the years. Clam species to be compared include the manila and littleneck. Varnish clams will also be noted in order to capture the impact of the invasive species in this region.

At time of writing of this report, the final report from the bio-inventory of the City of Parksville softshore beach is not available, and so the comparison is not possible at this time. When the report comes out, a comparison will be done.

6.6 Looking at the Nearshore -- a Discussion

Several recommendations come about through looking at the interrelationships in the nearshore area, and considering an ecosystem approach.

An issue that exists in this region and others is the increasing interest in using natural products to fertilize gardens. This is also happening as an influx of non-coastal people move to waterfront property and do not understand the importance of the wrack line to maintaining life on the beach. Many of these new residents find the beach messy and hire others to clean it up for them.

The combination of harvesting eelgrass and kelp for gardening and cleaning up the “messy” beaches are stripping beaches of important nutrients. Rusty Feagin, Coastal Restoration Specialist at Texas A&M University points out that “the wrack line influences the system. A beach doesn’t get a lot of nutrients, so whatever can get in is very significant” (Feagin, R., 2009). An education program focused on both the coastal home owner, and the avid gardener would be a useful next step.

A more detailed review of the marine riparian area would be extremely useful to indicate health of the whole nearshore, and possible management actions and best practices to suggest to property owners.

The issue of Canada Geese was raised under the vegetation section. Canada geese are also a threat to the eelgrass meadows. They rip out the whole plant and can destroy large sections of a bed at a single feeding. There is a need to raise the profile of these issues and create an understanding and support or potential solutions through development and implementation of a public education program. This would include presentations to public, mainstream animal rights groups and other key audiences.

The role of groundwater in the estuary and nearshore areas is an area that has not been well studied. We know that the most complexity in aquifers exists at the estuary. Three layers of aquifer are found there. The amount of groundwater that naturally flows into a healthy estuary has not been quantified. Also in the nearshore area it is not unusual to find trickles of water running down

the beach to the sea and this raises the question of function for those trickles some of which would be surface water and some groundwater. Without a target amount needed to keep an estuary and nearshore functioning, this could not be considered properly in a water management plan for the watershed. And so studies need to be done in order to determine the role of groundwater in an estuary and nearshore areas generally and the ER estuary and nearshore specifically.

Also the estuary area has been rated very vulnerable in the water vulnerability mapping project developed by Ministry of Environment, Regional District of Nanaimo and the Vancouver Island University and others. This should signal some real concern over the future of water supplies to the estuary and nearshore. Studies should be done to clarify flow, salinity and DO within the estuary to better understand what levels are required and set baselines in different areas of the estuary.

This study has shown some of the complexity of the nearshore and this information should be communicated to the public, land managers and politicians. A communications/education program would help increase understanding and support for various management approaches and protection of the nearshore. This would include guided tours of the softshore beach in Parksville and workshops for property owners regarding softshores. It would also include development of tools for local government to use to help protect their shorelines, including case studies and examples of potential bylaws and other policies and regulations to protect their nearshore.

As public understanding and support grow, a regional shoreline planning process would be a strong step towards a wide-ranging healthy nearshore.

Section 7 PUBLIC PARTICIPATION

7.0 Goals and Objectives

There were several reasons to involve the public in this project. Goals included the expanding the awareness and understanding of the role and function of an estuary in community life in those living in the City of Parksville and surrounding communities; and to encourage public participation in public planning about the future of the estuary and other ecosystem-based issues.

Objectives included:

- Speaking to most residents living within the estuary area about their values around the estuary and any future management, their water use and pesticide use
- Providing information to all residents of the Englishman River estuary regarding estuary function, ecosystem services received from a healthy estuary, and how to enjoy the estuary on a seasonal basis
- Increasing the number of residents participating in conservation projects in the region, and especially the estuary area including observation, photography, recording, mapping, and helping with hands-on management.
- Increasing the number of residents understanding of estuary role and function through workshops, and media coverage.
- Increase the number of members of MVIHES, Arrowsmith Naturalists and other ENGOs in the area and especially those working on the estuary
- Change the behaviour of residents within the estuary to reduce impacts related to introduced and invasive species, recreational and water use, and even habitat enhancement.

7.1 Methods of Public Involvement

Public were involved through a multi-faceted approach including a free workshop, hand-on training sessions, team membership in actual mapping and monitoring, education at community events, media coverage, and a door-to-door encounter which included provision of a brochure, a survey and assistance getting further information.

Estuary Workshop
The project began with a free public workshop regarding estuaries. It was a “beginner” course and advertised as such, clearly stating there was no pressure to volunteer by attending. Topics covered included definition of an estuary, description of some of the ecosystem services that we get, location of the Englishman River Estuary and identification of some of the issues known to exist in the protected area. The audience of almost 30 were also advised about who the various land managers were in different areas of the estuary. They were then introduced to the coordinators of the various elements of the project from MVIHES and Arrowsmith Naturalists, and a quick explanation provided about the different kinds of mapping to be done, and why that approach to mapping was thought to be useful.

Audience members were invited to sign up for volunteer monitoring and to indicate their areas of interest. An afternoon training session was offered regarding use of a GPS. Twenty-five audience members signed up immediately to help out, and almost half returned for the afternoon training session.

Hands-On Training Sessions
Much of the training of volunteers was done as they joined individual mapping and monitoring activities. Due to the straightforward approaches to the mapping and design for the layperson, this was much more efficient and effective. Most volunteers once trained would return to complete further work on the same mapping project and so capacity and effectiveness was increased.

Reliability of information was ensured by coordinators checking operation of any technology as the data collection proceeded. Coordinators also checked that information made sense as it was entered. Follow-up checks on GPS points and related data ensured a high level of accuracy.

Special hands-on training sessions were provided a few times on operating a GPS to give volunteers a chance to ask many questions, and have repeated tries with supervision to ensure a comfort level with the technology.

Other special training sessions included water flow monitoring.

Mapping and Monitoring
Ninety-one stewards signed up to volunteer. Given a variety of schedules, 68 were able to participate in the program. They ranged in age, including Middle School students to retired individuals.

Activities for volunteers included mapping estuary vegetation with GPS; photography of plant and marine species and of volunteer activities; eelgrass mapping; forage fish mapping; recording beach seine data on forms; assisting with beach seines by holding nets and safely transporting marine life from nets to buckets and to ocean after identification; shoreline mapping; birding; storm drain marking; pulling broom; assisting with a special Rivers Day event for children; and water flow monitoring.

A total of 286 volunteer hours were contributed to these studies and events.

Community Events
Several community events were attended and/or offered in order to increase the profile of the estuary, this project and its funders. These events included Rivers Day 2007 and 2008, KidsFest 2008, Oceans Day 2007, a Girl Guides storm drain marking event, a guided tour for a special student group from Oceanside Middle School, and a Junior Streamkeepers course.

A total of 345 people were contacted through these events.

Door-to-Door, Brochure and Survey
Maps of all the residences within the estuary area were gathered from local and regional governments. Also provided were the maps to show which homes were serviced by city water, sewer, well, and septic system.

A simple survey (see Appendix ?????) was developed to gather information regarding their use of, and value placed on, the estuary to residents, their knowledge of their own water supply, their use of water, water conservation and pesticides, and their willingness to change behaviour and/or need of further information.

A brochure was developed to explain the role and function of the estuary to residents, offer a seasonal breakdown of some estuary highlights, and describe some simple actions home-owners can take at home and play to help keep their estuary functioning (see attached, Appendix ?????)

Each of the 458 homes in the estuary was contacted by Ronda Murdock. Due to project budget, surveys were completed if someone was at home and willing. Where people were not at home, one follow-up visit was made in order to try and contact them again. Regardless of availability, each home received a brochure.

7.2 Results and Discussion of Public Survey

In order to help open the doors, advertising of Ronda's photo and explanation of the project was done in both local newspapers. Most people contacted were pleased to see Ronda, and happy to know that someone was concerned about the estuary.

Of the 458 homes visited, 218 people were contacted and 215 surveys were completed. The return rate on this survey is 98.6%, and 46.9% of potential respondents were contacted and completed the survey. Most surveys were completed in San Pariel (123 of 215), compared to 69 in Parksville and 23 in Surfside.

Six new volunteers for the monitoring project were found as a result of this door-to-door effort.

Highlights of the results show that the community wishes to protect their estuary, with 98 percent giving the highest rating possible to the need to protect the estuary. Three respondents (1.4%) gave it a medium ranking and 2 respondents, or 0.9%, rated protection as a low priority. One person felt that his property by being developed protected the estuary and that rock walls also protect the estuary.

Water conservation is clearly a priority for the residents in the estuary. Thirty-eight percent (37.6%) have only a low flow toilet, 25.6% have a low flow showerhead only, and an additional 29.3% have both a low flow toilet and a showerhead, showing 92.6% of residents taking action to conserve water.

Also regarding water conservation, 75% take short showers, 54.4% do not water their lawn and 8% do not have a lawn. Seventy-eight percent sweep rather than hose their driveway, while 22% have a powerwasher. Fifty-one percent plant drought resistant native species in their garden. There was some comment that a minimum water charge is unfair and is not an incentive to conserve water.

Fifty-five percent do not use pesticides or herbicides. Regarding amount actually being used in different areas of the estuary it was difficult. In many cases the person being surveyed was not the person in the home that would be responsible for that function. Some felt that they were only using the products in small amounts and so felt that any effect they had was only a minimal negative impact. Others eliminated pesticide use when they began having pets, children/grandchildren around. There was some interest amongst those using pesticides and herbicides for alternatives for additional information and workshops.

Only 6% of residents had never been into the estuary. In all neighbourhoods surveyed, most respondents visited the estuary once a week or more (58.6% overall). The next frequency level was again the same in all neighbourhoods at one time per month (18.6%). Thirteen percent of residents visit the estuary 2-3 times per year, and 3.7% visit once per year.

There was a range of comments on some issues from respondents. These included recognition that the numbers of people in the estuary have increased since pay parking was established in Rathtrevor Provincial Park. Others were concerned about possible inputs to the water system from City of Parksville trucks, car maintenance in Surfside, and vehicle dealerships. Powerwashing of driveways, the roadway and trailers was mentioned by a variety of respondents.

Based on the results of this survey it is clear that the estuary is of real importance to the people who live there. Most who live there spend time in the estuary, and wish to see it protected from further development. The comment regarding rock walls protecting the estuary may indicate a need for further public education about the efficiency of rock walls and their impacts on shorelines , and a look at alternatives.

Though rates of water conservation are good, there is room for improvement. More detailed information about the vulnerability of water within the estuary and the benefits of conservation could be of value.

The runoff from pesticides, herbicides and fertilizers this close to the estuary could be significant to the growth of various aquatic, estuarine and marine plant species, and should be the target of some public education programming. The City of Parksville should consider the passing of a bylaw similar to other municipalities across the country to remove the use of pesticides and herbicides. Alternatives to chemical fertilizers should also be considered for a public education program and research done regarding a potential ban of these chemicals as well.

7.3 Conclusions

There is definitely an interest in the community in participating in citizen science, or the stewardship of their ecosystems. By using a variety of methods to contact the community and engage them, a range of resident type and a good number of residents were reached with messaging and/or a chance for a hands-on experience.

- Given the value placed on the estuary by the community, it is important that upcoming OCP reviews consider these values. Bylaws protecting estuary and nearshore areas should be reviewed
- Public education programs regarding the function of their estuary and nearshore and how to care for them should be offered. Topics could include invasive plants and how to remove them, alternatives to seagrasses and algae in the garden as fertilizer, role of the wrack line on the beach, alternatives to hardening, etc.
- Continued opportunities for stewardship and monitoring should be offered. Topics could include alternatives to pesticides, herbicides and fertilizers; continued monitoring of the estuary and nearshore elements of this study such as vegetation, fish distribution, water flow monitoring, etc.

Section 8.0 CONCLUSIONS

Section 1 Fish Survey and Water Sampling

- There were 20 species of fish found in the Englishman Estuary during the sample period.
- Three Spine Stickleback, Staghorn Sculpin and Shiner Perch were the most common fish.
- Pink were the most common salmon. Chinook, Coho and Chum were also captured.
- All fish were evenly distributed through the Beach, Lagoon and Dyke with fewest along the River.
- Salmon juveniles were captured in the estuary from March to July but not in August.
- There appeared to be no changes in fish population abundance since the 1993 study although methods for sampling were different.
- Water quality from the City storm drains that enter the estuary is poor in terms of Coliform, Metals and PAH.
- Volunteers contributed approximately 650 hours towards the fish surveys. These surveys could not have been done without their help.
- There were 20 species of fish found in the Englishman Estuary during the sample period.
- Three Spine Stickleback, Staghorn Sculpin and Shiner Perch were the most common fish.

Section 2 Vascular Plants, Plant Communities and Ecosystems

A method was developed and tested for mapping vascular plants, plant communities and ecosystems based on 5 steps: delineation, sampling, data management, classification, and mapping. This project was made possible because enthusiastic volunteers put in the many hours of training and field work required to complete delineation and sampling of that part of the estuary that existed in 1976. This method would be easily transferable to other estuaries and to any natural area that is close to an interested and involved population. To facilitate comparisons over time, the classification system used to map the estuary in 2008 was similar to that in 1976, but in 2008 the system was based on 26 observed plant associations -- the 19 used in 1976 plus 7 more. A map entitled "Some Plant Communities of the Englishman River Estuary in 2008" was produced based primarily on several hundred polygons classified by the vegetation cover observed at over 100 sample sites and several thousand UTM data points that marked edges and transitions.

It was found that major changes had occurred during the period from 1976 to 2008, especially in areas where Lyngbye's Sedge had once been described as dominant in terms of species cover/abundance. Most of the areas that supported plant communities with Carex Lyngbyei in 1976

were, by 2008, simplified to the point where Lyngbye's Sedge was gone from much of it. In that time, the plant biomass appeared to have decreased to a fraction of what it would have likely been in 1976, based on the volume of plant matter usually associated with the plant communities that Kennedy (1982) described.

Observations of footprints, feces, cut stems, leaves and roots of vegetation, patterns where the vegetation cutting either has or has not occurred in relation to access and disturbance, selective disappearance of certain species (possibly preferred food species) from some areas over time, and some direct observations of waterfowl grazing during the day, indicated that some parts of the estuary vegetation, and often the substrate as well, have been dramatically affected by the Canada Goose.

If the substrate was involved, it was pitted, or eroded at the edges, or slumping down into the tidal channels, or in some cases, it was gone altogether. Slumping of the marsh substrate into the tidal channel made the channel more shallow and it changes its shape and elevation so that standing water was absent at low tide, in some locations. Slumping also seemed to have removed the overhanging vegetation that would otherwise have shaded the channel waters and helped to hide the inhabitants from predation. These changes can be expected to have a major impact on fish.

Another force for change has been the river moving its main channel on the estuary further east since 1976. However important this powerful current of water may be to the vegetation patterns observed, it does not explain the transformation in vegetation that occurred in areas where the river flow patterns appear to have remained unchanged since 1976, based on ortho photo interpretation and field observation of erosion and deposition. Other possible processes for change were also considered.

In summary 3 factors appear to account for the vegetation changes observed since the Kennedy made her observations in 1976:

1) movement of the river's main channel in an easterly direction
2) breaching of the dyke
3) grazing by Canada Geese

In the areas where the natural estuary vegetation had expanded since 1976 because the western dyke was breached in 1979, a similar volunteer-based method was used to delineate and sample vegetation as the first steps in the process of creating a Biogeoclimatic Ecosystems Classification map of the entire estuary.

It was found that a large area of the western part of the estuary (the West Marsh/ Lagoon) supported a plant community that is a likely occurrence of the CDFmm/Em03 *Distichlis spicata* Ecosystem which is RED-listed (equivalent to "endangered" or "threatened") by the Province of BC. Near the tidal channels, this ecosystem appeared to be complexed with the CDFmm/Em02 *Salicornia virginica-Glaux maritima* Ecosystem which is also RED-listed. Two other plant communities were identified thus far with likely correspondence to existing BEC classifications: the CDFmm/Em01 *Ruppia maritima* Herbaceous Vegetation Ecosystem which is also RED-listed, and the CDFmm Em05 *Carex lyngbyei* Herbaceous Vegetation Ecosystem which is BLUE-listed. This volunteer work is ongoing.

This project confirmed many plant species presence on the estuary and it added at least 3 new plant species to previous lists: Shore Buttercup (*Ranunculus cymbalaria*), Brass Buttons (*Cotula* coronopifolia), Hazelnut (*Corylus spp.,* either Beaked Hazelnut (*Corylus cornuta*), a native species, or European Hazelnut (*Corylus avellana*), an introduced species that has naturalized.

Section 3 Terrestrial Fauna

The confirmed observations that volunteers and staff in this study made of terrestrial animals produced records that totaled 24 species. Many of the observations were recorded with UTM coordinates from a GPS unit so these records added to the mapping of animal uses as part of mapping special places and features on the estuary. The observations are presented in text form for management purposes and are in the process of being developed into maps for easier visual interpretation.

The team of Arrowsmith Naturalists that undertook a systematic monthly bird survey from 2005 to 2009 observed 143 species of birds. They have generously allowed us to share their data. Of the birds that were observed, either by the naturalist or as part of this study, the Western Grebe and Short-eared Owl are RED-listed and the Peregrine Falcon (local *pealei* subspecies and the Great Blue Heron (local *fannini* subspecies) are BLUE-listed. A number of other listed (endangered, threatened, of special concern) animal taxa, such as the Vancouver Island subspecies of Common Water Shrew or Navigator Shrew (*Sorex palustris brooksi*) and the Vancouver Island subspecies of Ermine or Short-tailed Weasel (*Mustela erminea anquinae*) are likely present on the estuary but their presence was not confirmed in this study.

Section 4 Mapping Special Places and Features on the Estuary

The purpose of this part of the project was to record some of the places that might be of special importance to someone trying to make a ecosystem-based management decision about the estuary. The concept was introduced to volunteers and the results suggest that some understanding and appreciation has been developed. Thus, this technique is a useful tool to bring together the public, the land owners and the land managers. The results documented 26 locations on the estuary that are of particular importance to certain species. It is expected the list will grow to many times that number as the photographs and records are processed by volunteers and, as new data is collected.. The result will be a map where these features will be conveniently visible to anyone making decisions that might affect the estuary.

In addition, this field-based process coupled with a review of the literature, highlighted the need for some specific spatial data. For example, the Band-tailed Pigeons that were recorded using the estuary in this study are likely to be dependent on a mineral resource whose geographic location is not known. Similarly, the roosting spot that hundreds of Northwestern Crows depend on is on or near the estuary but not yet located. In another example, a few solitary bee condominiums were located that might be important to many species of plants and animals, but a careful inventory of the estuary in the autumn would be needed to locate the remainder of these condominiums.

The process of doing inventory, as described in the section on Vascular plants, Plant Communities and Ecosystems, and the section on Invasive Species, has created a database of occurrences of listed (endangered, threatened) plant communities, thus providing another layer of information that could be useful to guide decisions about the estuary. The information will be mapped to make it conveniently accessible.

Section 5 Invasive Species

The presence of more than 30 invasive plant species was confirmed on the Englishman River estuary. This number is expected to rise as confirmation found for many other invasive species.

This part of the project involved the greatest amount of volunteer effort: approximately 34 people were involved in various training activities, 9 volunteers and 2 students were involved in walking the estuary and marking the locations of invasive species with a GPS, either as part of a volunteer field work team or working with a biologist. Experiments with control of some species, especially English Ivy, involved 2 volunteers and 2 students spending 4 days of physical labour clearing the vines off of 7 large trees and approximately 20 shrubs. In total, approximately 684 hours of unpaid volunteer time was given to the invasive species part of this project, not including the many hours that the Arrowsmith Naturalists spent pulling Scotch Broom and knapweed.

Another result was maps of Scotch Broom, English Ivy and Lesser Periwinkle distributions on the estuary using a combination of ground records and orthophoto interpretation. Maps of occurrences of knapweed, Armenian Blackberry, European Holly, Spurge Laurel and Yellow Archangel were also made and these are still being added to. This project has identified a need for distribution maps of Robert Geranium, Quackgrass and Field Bindweed but volunteers have not yet started on these tasks.

From the maps, recommendations for inclusion in a detailed management plan for those species was developed, starting with Scotch Broom.

In this study, the Canada Goose was considered an invasive species because the local population of the Canada Goose is recently established and still growing, and already it appears to exceed the carrying capacity of the estuary. In addition, the genetics and behaviour of these birds appears to be different from any of the smaller, native migratory Canada Geese that would sometimes visit the Englishman River estuary in small numbers for a brief period. Further conclusions about the Canada Goose and how it may be affecting vegetation and fish are presented under the heading Conclusions Section 2 -- Vascular Plants, Plant Communities and Ecosystems.

In the process of advertising, in door to door delivery of brochures, and in public events such as Rivers Day, many people were exposed to the problems of invasive species, how they spread and the how everyone can help to control and eradicate some of them. At the end of the project, it appears that there are enough interested people forming a network to complete many more of these tasks in the near future.

Section 6 Nearshore Studies - Shoreline Inventory

THE HARDENING AND MODIFICATION OF THE SHORELINE IS GREATLY ALTERING AND SO HAVING A NEGATIVE EFFECT ON THE ECOLOGICAL FUNCTIONS OF THE SHORE OF THE PARKSVILLE-QUALICUM BEACH AREA, AND THE ENGLISHMAN RIVER ESTUARY.

- ☐ We need to educate the public, developers, elected officials and property owners about alternatives to armouring a shoreline.
- ☐ WE NEED TO REVIEW THE POSSIBILITIES FOR RESTORATION OF SOFTSHORES WITHIN THE STUDY AREA.

WE NEED TO HAVE LAWS TO PROTECT OUR NEARSHORE INCLUDING LOCAL BYLAWS AND ENFORCEMENT OF THE FISHERIES ACT.

- ☐ WE NEED TO REVIEW OUR SHORELINE VARIANCES IN ORDER TO UNDERSTAND HOW SHORELINE

MODIFICATIONS ARE APPROVED AND THEN DEVELOP TOOLS AND/OR A REVISED PROCESS TO ASSIST IN BETTER DECISIONS REGARDING NEARSHORE HEALTH.

Section 6 Nearshore Studies – Marine Riparian Areas

The marine riparian area has been impacted by development. It provides important biological function to the nearshore and to humans.

- ☐ A more complete study of the marine riparian area should be conducted.
- ☐ A study of the marine riparian vegetation that is not in existence but should be needs to be completed.
- ☐ Information from such a study should be shared through education programs, and incentives given to plant and restore the riparian zone.
- ☐ Bylaws to prevent introductions of known invasives and encourage removal of existing invasives should be considered.

Section 6 Nearshore Studies - Eel Grass Mapping

The eelgrass beds of Parksville-Qualicum Beach cover a significant distance of shoreline. Changes in behaviour seem to be occurring – movement up the beach, possible stabilization of *Z. japonica,* change in timing of ephiphytes.

We need to:

- More research is needed to explain these changes and potential impacts on food chains in the ocean.
- Water quality may be an issue, contributing to changes in behaviour of the Z. marina. Attempts should be made to determine whether any water quality issue is due to local influence, or a regional issue or concerns the whole of Georgia Basin.
- The Bamfield Marine Science Centre is currently researching wasting disease and will work with the Seagrass Conservation Working Group to promote partnerships in research and management in the Georgia Basin and West Coast of Vancouver Island. MVIHES and land managers should continue to work together on this research.
- Once reasons for decline have been identified, consideration of transplants would be possible.
- Mapping of *Zostera Japonica* should be undertaken to monitor the area it has taken, but also any changes in behaviour that may be significant. This would include a detailed study comparing growth rates of *Z. Marina* to *Z. Japonica.*
- ***AN ECOSYSTEM APPROACH MUST CONTINUE IN MONITORING OF EELGRAS, RELATING THE HABITAT TO OTHER SPECIES THAT BENEFIT FROM HEALTHY EELGRASS BEDS, AND HUMAN ACTIONS THAT CAN IMPAIR THE HEALTH OF THE SYSTEM***
- ***MAPPING OF KELP IN THE AREA WOULD BE USEFUL AND HELP COMPLETE THE PICTURE OF NEARSHORE FUNCTION***

Section 6 Nearshore Studies - Forage Fish Mapping

The beaches of Parksville-Qualicum Beach seem to offer a selection of locations for Sand Lance and Surf Smelt habitat.

- Mapping for Pacific Smelt should be completed as well, using a methodology similar to that used for Sand Lance.
- Sand Lance spawning sampling need to be collected in November, and early December.
- Several years of data collection should occur in order to capture the movement of Sand Lance use of different beaches over time.
- A photo-point monitoring program to identify and monitor forage fish habitat should be considered to cover one year once/ month, or a program covering a wider selection of beaches 4 times/year may be enough.

THIS SECTION OF COASTLINE CONTRIBUTES 3-4 PERCENT OF HERRING SPAWN HABITAT FOR THE PROVINCE. OF THE HERRING SPAWN MAPPING DONE WITHIN THE STUDY AREA, THERE ARE MANY AREAS THAT INDICATE A HIGH USE ZONE.

- Considering the acknowledged value of seagrasses to herring, continued monitoring of eelgrass and the addition of mapping kelp in the area would be of value to forage fish management.
- Acknowledgement of the value of the local nearshore to the herring and the many food chains dependent on herring, needs to occur. This information should be included in a variety of education programs.
- There should also be further development of policies and regulations to protect and restore the fisheries habitat.

Section 6 Nearshore Studies – Looking at the Nearshore

As expected before the study was done, the nearshore is a complex zone as a result of many interrelationships, some of which are still not well understood. In order to ensure a healthy nearshore in the study area a multi-faceted approach will be necessary.

Actions should include:

- The combination of harvesting eelgrass and kelp for gardening and cleaning up the “messy” beaches are stripping beaches of important nutrients. An education program focused on both the coastal home owner, and the avid gardener would be a useful next step.
- A more detailed review of the marine riparian area would be extremely useful to indicate health of the whole nearshore, and possible management actions and best practices to suggest to property owners.
- There is a need to raise the profile of the Canada Goose issues and create an understanding and support or potential solutions through development and implementation of a public education program. This would include presentations to public, mainstream animal rights groups and other key audiences.
- The role of groundwater in the estuary and nearshore areas is an area that has not been well studied. Further research is needed in order to determine the role of groundwater in an estuary and nearshore areas generally and the ER estuary and nearshore specifically. This needs to be completed before further water management planning is conducted for the area.

- There are some real concern over the future of water supplies to the estuary and nearshore. Studies should be done to clarify flow, salinity and DO within the estuary to better understand what levels are required and set baselines in different areas of the estuary. Similar work should be done within the nearshore as well.
- This study has shown some of the complexity of the nearshore and this information should be communicated to the public, land managers and politicians. A communications/education program would help increase understanding and support for various management approaches and protection of the nearshore.
- As public understanding and support grow, a regional shoreline planning process would be a strong step towards a wide-ranging healthy nearshore.

Section 7 Public Involvement

There is definitely an interest in the community in participating in citizen science, or the stewardship of their ecosystems. By using a variety of methods to contact the community and engage them, a range of resident type and a good number of residents were reached with messaging and/or a chance for a hands-on experience.

- Given the value placed on the estuary by the community, it is important that upcoming OCP reviews consider these values. Bylaws protecting estuary and nearshore areas should be reviewed
- Public education programs regarding the function of their estuary and nearshore and how to care for them should be offered. Topics could include invasive plants and how to remove them, alternatives to seagrasses and algae in the garden as fertilizer, role of the wrack line on the beach, alternatives to hardening, etc.
- Continued opportunities for stewardship and monitoring should be offered. Topics could include alternatives to pesticides, herbicides and fertilizers; continued monitoring of the estuary and nearshore elements of this study such as vegetation, fish distribution, water flow monitoring, etc.

Management Recommendations

1) Establish invasive species plan for each species including specific goals for management - acceptance, control or eradication? Refer to the annotated invasive species list that forms a part of this report.

Work with neighbouring land owners on the estuary to establish buffers for cooperative control of invasive species around the estuary.

2) Control Canada Goose population before it controls itself by exceeding its carrying capacity and simplifying the estuary, thereby lowering the ability of the estuary to produce food for Canada Geese. Openly involve the public in the information and decision making process from the outset of the debate. Also include at the discussion table the interests of the migratory Canada Geese and all the other species of waterfowl that would soon find no food available at the Englishman River estuary if the non-migratory population Canada Goose continues on its current path.

Use a poster or brochure with photographs to inform the public about what species are invasive and what the problems of invasive species are. Describe invasive species method of entry and exactly how anyone can help to prevent it. Many neighbouring people chose their house because they care about their estuary and they want to help.

Remove all Birch (*Betula spp*) from the estuary. The goal is complete eradication near Mills Road.

Remove all Periwinkle (*Vinca minor*) from the estuary. The goal is complete eradication near Plummer Road.

Start broom removal in areas of highest ecological benefit and highest chance of success. This report concludes that Broom Management Zones A, B and C satisfy these two conditions.

Limit access to Big Island with no bridges and no new trails.

The careful approach that was taken when removing broom from the spit area adjacent to San Pareil Lagoon should be continued in all management planning of that area to protect the thin layer of bryophytes and forbs there. Ideally there could be sings or some other technique to let neighbours know that this area represents the rarest of the ecosystems in the Regional District of Nanaimo that were mapped in the Sensitive Ecosystems Inventory (McPhee et al. 2000).

Maintain fencing and gates to block access for motor vehicles, especially quads and motorcycles access at Shelly Road.

Continue posting "no camping/no garbage" signs, especially up high on trees in Plummer Road Forest and at edges of Big Island.

Post a sign that lets marijuana growers know that they are under observation and, as a result, they might lose their crop. Let burl cutters know that they can be prosecuted.

Establish a procedure for reporting incidents and let the public know. Report to whom? -- The volunteer warden? the land manager? the land owner? a recording device?

Ask an MVIHES representative to sit again on the Parksville - Qualicum Beach Wildlife Management Area (PQBWMA) steering committee. Help to resurrect the PQBWMA committee as an important voice for the river and the estuary.

Use a poster or brochure to explain the problems of hardening river banks and water front. Get the message out that riprap might make their life more exciting in ways that no one really wants.

Keep the database of people contacted in the project. Facilitate neighbourhood meetings where all the landowners in and around the estuary can explain their situations and maintain contact with one another. Use a brochure or a card to maintain contact. Record the time spent on this to see if it is cost effective over not staying in contact and fixing fencing instead.

Build trust with the public by aiming for broad public involvement in every issue, even those issues like the Canada Goose, where the situations are sometimes awkward. Offer training for staff and volunteers in effective interpersonal communication such as Non-violent Communication (Rosenberg, 2003).

Leave the fire hydrants intact and operational. Low pressure for fighting fires is probably better than no water at all, in the face of global warming and increased use. Humans start many forest fires, brush fires and grass fires, accidentally or otherwise.

Allow people to use the estuary lands in a non-consumptive way. Develop methods to shift liability to the individual user and away from the land owner or manager. Find a lawyer with the expertise to create "wild lands" status so that the land owner is not liable for anyone who enters their land

Put up a permanent sign post that allows easy-to-change signs. Change the signs to inform people about issues like the snail from Port Alberni estuary and how to prevent its spread.

Secure wildlife corridors in river and along riparian zones using covenants and purchase if necessary, especially so that predators can become inexpensive labour to help with the Canada Goose problem. Calculate the cost of the program and the value of the effects.

Move systematically towards breaching of the San Pareil dyke and "reclaiming" the alienated lands for use by wildlife including fish, and by native plants. Follow the recommendations of the report on breaching the San Pareil Dyke, if they meet with public approval at regular public meetings.

Consider the entire estuary community from the condominiums of the solitary bees to the nest in the eagle trees when looking at suggestions for side channel opportunities, habitat enhancement or restoration. The estuary landscape seems to be packed with many experiments at enhancement that are difficult to distinguish from the industrial uses and alterations of the generation before.

Continue to work with the Arrowsmith Naturalists at developing some clearly defined projects for volunteers, such as mapping Robert Geranium distribution (using the methods that were developed in this study), pulling up Lesser Periwinkle on Plummer Road with the help of school children, or recording the timings of the onset, peak and closure of the ecological events listed in the Mapping Special Places section of this report.

3) Lobby as individuals (not as MVIHES) to change the laws about what are invasive species at the federal and provincial levels. Use the wording of laws in nearby jurisdictions like Washington, USA to make it illegal for people to wholesale, retail or cultivate plants like Scotch Broom, English Ivy, Lesser Periwinkle and Yellow Lamium **(***Lamiastrum galeobdolon***).**
4) Lobby as individuals (not as MVIHES) to change the laws of accretion and flood plains so that the Crown claims any land that is accreted and anyone buying on a flood plain must sign a statement acknowledging that they are aware of the hazards to life and property present on floodplains. Ask that the Regional District of Nanaimo and the City of Parksville use municipal bylaws and building codes to make development of accreted land impossible and to discourage development on floodplains.
5) Lobby as individuals (not as MVIHES) that water licensing and allocation should recognize the political reality that, in any shortage situation, people will probably come first because people have political power whereas rivers, ecosystems and native species do not vote or make donations. This means that river water should not be licensed to a human if there is insufficient water to ensure that the allocation will not result in the perception that people and other users of the resource such as fish are in competition for water.

Global warming and climate change would need to be considered in any discussion of water allocation and releases from a hypothetical future dam. It is recommended that the principle that there will be one dam and one dam only on the Englishman River be upheld unless all the connected factors can be taken into account and assessed, including the instability of the climate. Estuaries need fresh water; less fresh water would likely mean a smaller, more saline estuary.

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Note: Other references can be found in a bibliography of research done on the Englishman River Estuary provided by Lanarc (2003).

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APPENDICES

Appendix 2.1

Field Data Sheet for Vegetation Sample Plots

Project: English River Estuary
Date: 2008_09_19ERE
Surveyors: RB, TA, CS

LOCATION
Location Description: West Marsh near small tidal channel just beyond second dyke opening
waypoint (or photo) number: wp#72
UTM NAD83 Zone: 10
x UTM easting:
y UTM: northing:
Photo Sequence: E, N, W, SW, S, DOWN, GPS, oblique south, species photos, GPS
Photo Numbers: J1011 to J1023

ECOLOGICAL DESCRIPTION OF PLANNED POLYGON:
slope/aspect: level
exposed substrate (root platform, organic mud, silt, sand and/or gravel): not visible
graminoid, forb, shrubland or forest: forb/grass on mid saltmarsh
salt/brackish/fresh: salt
level (low, mid or high): mid marsh
erosion: LWD movement created furrow nearby but not in plot
deposition: not visible
grazing: not visible

NOTES
Is the vegetation of the sample plot uniform?
yes
How far does the vegetation pattern of the sample plot continue beyond the plot boundaries?
10m EW&S, > 100m to the N
If this was a polygon, what plant species (occurrence or absence or percent cover) might be used to mark its boundaries?
GRININT occurrence marks a change

SAMPLE PLOT SIZE: 10 X !0m

VEGETATION COVER
layer assessed in sample plot ---(algae, bryophyte, graminoid&forb, low shrub, tall shrub, tree canopy): graminoid&forb
total vegetation cover for layer: 100% graminoid and forb (no bare ground, no other layers)
vegetation cover for major species:

Layer	GENUSPE	Percent Cover
	SALIVIR	75%
	DISTSPI	20%
	ATRIPAT	4%
	HORDBRA	0.1%

other species observed in plot: SAVS flew up as we arrived,

species nearby:
bare mud&algae, sparse SCIRCER elevations below plot
GRININT elevations above plot
ROSANUT, MALUFUS, CYTISCO occurs above GRININT

Appendix 2.2

Monthly Bird Surveys on the Englishman River Estuary, March 2005 to February 2009 by the Arrowsmith Naturalists (2009)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
WATERFOWL													
Trumpeter Swan			1										2005
	10											8	2006
											2	3	2007
	-----	3											2009
Canada Goose adults	-----	-----	58	63	48	220		92	54	14	3	1	2005
goslings	-----	-----				16							2005
adults	30	31	71	79	36	85	2		11	4	55	56	2006
goslings							5						2006
adults	19	39	70	95	86	60	40		4	26	11	4	2007
goslings					8		8						2007
adults	12	3	11	88	93	-----	65	20	3	3	98	194	2008
goslings					39	-----							2008
adults	-----	53	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2009
goslings	-----		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2009
Brant				30	6								2005
				485									2006
	30		55	106		6							2007
		24		520	80	-----							2008
	-----	17											2009
American Wigeon			71	67	18				3	48	100	45	2005
	56	15	38	63	40	3					125	10	2006
	14	36	62	465	12	2				40	113	79	2007
	35	101	155	219	60	-----			13	1117	500	294	2008
	-----	55											2009
Eurasian Wigeon			1	1							1		2005
				4							1	6	2006
		1		1								1	2007
		2	1	2		-----					2		2008
Mallard			188	156	21	57		15	21	22	52	80	2005
	46	23	18	37	30	22			4		130	75	2006
	49	75	60	460	73	16	6		7	40	327	138	2007
	173	248	71	164	10	-----		2	19	199	150	370	2008
	-----	76											2009
Northern Pintail			22	11					25	12	14	2	2005
			3	19	1						14	1	2006
		1	14	68	2						40	12	2007
	2	35	37	8	1	-----			12	275	11	24	2008
	-----	4											2009
Green-winged Teal			39	84	10				59	13		5	2005
			3	47	35						22		2006
		16	42	159	2					2	101		2007
		61	6	85	25	-----			18	144	40	102	2008

	-----	37											2009
Bufflehead			2	23	25						41	21	2005
	20	5	17	31	22						3	6	2006
	6	11	24	29	6						37	31	2007
	7	36	4	20	5	-----					6	5	2008
	-----	25											2009
Common Merganser			2	2	2	17		4	3	17		15	2005
	7	1	13	5		3					12	1	2006
	2	9	3	19	1		15				23	11	2007
	2	3	2	2	3	-----	20	18	23	21	7	16	2008
	-----	10											2009
Red- breasted Merganser										2		2	2005
						3							2006
	1				1	11			3			17	2007
		1		6		-----				2	1		2008
	-----	4											2009
Hooded Merganser			2					1	2	4		4	2005
	6			2					1		10	2	2006
	1	3								2	4		2007
						-----				8	2	1	2008
	-----	1											2009
Common Goldeneye				11									2005
	5		4	14								24	2006
	11	2			7							9	2007
	2	9	22	38		-----							2008
	-----	9											2009
Barrow's Goldeneye											12	5	2005
												2	2006
	2											13	2007
	2	2				-----						5	2008
Surf Scoter										3		4	2005
			19	9							60	30	2006
				34									2007
		42				-----				34	50		2008
	-----	43											2009
White-winged Scoter										3		14	2005
				15							5	40	2006
				30									2007
	106	5		10		-----				12	15		2008
Black Scoter												105	2005
				2								5	2006
				7									2007
	40	11				-----				5		20	2008
Mixed Scoters											10		2005
Harlequin											5		2005
Greater Scaup			1	2									2006
				2									2007
	7	21				-----							2008
Lesser Scaup				1									2005
	1												2006
Blue-winged Teal												1	2005
	3					-----							2008
Gadwall	3			4									2007

		2	2			-----							2008
Long-tailed Duck				22								2	2007
	1					-----							2008
Wigeon Hybrid			1			-----							2008
White-fronted Goose						-----				18			2008
Northern Shoveller						-----				7			2008
	7											200	2007
LOONS													
Pacific Loon												1	2005
												7	2007
		11				-----							2008
	-----	11											2009
Common Loon												2	2005
												1	2006
	2									2		6	2007
		7		1		-----				1	3		2008
	-----	5											2009
												3	2006
						-----				9	4		2008
GREBES													
Horned Grebe										1			2005
												1	2006
										1		8	2007
		6				-----							2008
	-----	1											2009
Red-necked Grebe										1			2005
												7	2007
		16				-----				1			2008
	-----	2											2009
Western Grebe												2	2007
ALCIDS													
Common Murre		1				-----					4		2008
CORMORANTS													
Double-Crested Cormorant										2			2005
	2		1						1			3	2006
												1	2007
	6	1				-----		15	1		2		2008
	-----	1											2009
Pelagic Cormorant												1	2006
				1								4	2007
						-----				2			2008
	-----	10											2009
Brants Cormorant		25				-----							2008
HERONS													
Great Blue Heron			2	2	2	2	2	2	4	1	4	8	2005
	2		2	4	3	11	1	2	2		1		2006
	2	9	9	4	4	4	4	1	4	1	5	3	2007
	2	5	3	1	3	-----	1	1	2	2	2	1	2008
	-----	1											2009
GULLS													
Gull species			7-	75	50	2	7	8	108	354	418	459	2005

including – Mew,			10Th										
– Glaucous wing,Western,	180	7	6Th	157	55	25	6	20	27	31	1150	47	2006
– Herring, Thayers, California,	807	75	16Th	1600	340	17	21		100	164	817	300	2007
– Bonapartes,Ring-billed,	66	300	269	275	21	-----	1	100	1000	300	300	100	2008
– Heermans	-----	120											2009
SHOREBIRDS													
Black Oystercatcher												1	2006
			2										2007
Black Turnstones								12				2	2005
												1	2006
										10		15	2007
	3	8				-----				6			2008
	-----	11											2009
Black-bellied Plover												3	2005
												2	2006
	41												2007
	3					-----		1			37		2008
	-----	12											2009
Killdeer			8	2	1	21			4	19		2	2005
				2	3			1	4				2006
					2			1	1				2007
	1	12				-----		9	15		6		2008
Lesser Yellowlegs					1								2005
						-----			1				2008
Greater Yellowlegs					2				1				2005
				5									2007
						-----			1	1			2008
Dunlin					25							48	2005
											32		2006
		30			1						57	25	2007
	150					-----				18	77		2008
Long-billed Dowitcher			2					7		4			2005
						-----				2			2008
Short-billed Dowitcher											2		2007
Western Sandpiper					20			8	7				2005
					10		65						2007
						-----		51	56				2008
Least Sandpiper					5			3	1				2005
					20								2006
					2		2						2007
						-----			11				2008
Semi-palmated Plover						-----			4				2008
Wilson's Snipe						-----				1			2008
Long-billed Curlew			1										2005

CRANES & COOTS													
Sandhill Crane			**5**										**2005**
RAPTORS													
Bald Eagle adult			**6**	**3**	**3**	**4**	**5**	**1**			**6**	**4**	**2005**
immature											**1**	**5**	
adult	**3**	**2**	**10**	**4**	**10**	**3**	**2**			**1**	**2**	**8**	**2006**
immature			**7**		**7**	**1**	**1**					**6**	
adult	**2**	**6**	**10**	**7**	**5**	**5**	**3**	**1**		**2**	**3**	**6**	**2007**
immature					**2**	**3**	**3**				**1**	**10**	
adult	**2**	**6**		**1**	**4**	**-----**		**1**		**1**	**6**	**3**	**2008**
immature	**2**	**1**		**3**	**3**	**-----**						**1**	
adult	**-----**	**4**											**2009**
immature	**-----**	**1**											
Osprey						**1**		**2**					**2005**
Merlin								**1**	**1**	**2**	**1**		**2005**
					1		**1**	**1**	**1**				**2006**
									1				**2007**
					1	**-----**			**1**				**2008**
Red- tailed Hawk										**1**		**2**	**2005**
	1	**1**		**1**						**1**		**1**	**2007**
		1				**-----**					**1**	**1**	**2008**
	-----	**1**											**2009**
Sharp- shinned Hawk				**1**							**1**		**2005**
								1					**2006**
					1						**1**		**2007**
						-----					**2**		**2008**
Peale's Peregrine										**1**			**2005**
						-----				**1**	**1**		**2008**
Swainson's Hawk											**1**		**2005**
Cooper's Hawk						**1**			**1**	**1**			**2005**
					1								**2006**
			1										**2007**
		1				**-----**							**2008**
Northern Harrier												**1**	**2006**
						-----				**1**			**2008**
Turkey Vulture						**1**		**3**					**2005**
						-----	**1**	**1**					**2008**
CHICKEN-LIKE BIRDS													
Ring-necked Pheasant				**1**									**2006**
						3							**2007**
					1	**-----**							**2008**
California Quail					**2**	**4**	**1**			**1**			**2005**
				1		**2**		**6**		**6**			**2006**
		15	**1**	**1**	**4**	**3**	**3**			**2**			**2007**
			2	**2**	**4**	**-----**	**1**						**2008**
OWLS													
Short-eared Owl												**1**	**2006**
Barred Owl						**1**	**1**						**2007**
HUMMINGBIRDS													

Rufous Humming Bird			**1**			**5**	**2**	**1**		**1**			**2005**
				3	**3**	**3**	**1**						**2006**
				9	**3**	**2**	**4**						**2007**
				2	**12**	**-----**	**1**						**2008**
SWIFTS													
Black Swift						**27**	**1**						**2007**
KINGFISHER													
Belted Kingfisher			**1**	**1**	**1**		**1**	**2**	**5**	**2**	**2**	**2**	**2005**
			2	**2**	**2**		**1**		**1**	**2**	**1**	**1**	**2006**
	1	**1**	**3**	**2**		**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2007**
		1			**1**	**-----**	**2**	**2**	**1**	**4**	**4**		**2008**
	-----	**2**											**2009**
WOODPECKERS													
Northern Flicker			**2**	**2**	**2**	**3**		**6**	**3**	**11**	**8**	**8**	**2005**
		3	**6**	**14**	**2**	**8**	**1**	**2**	**7**	**3**	**5**	**1**	**2006**
	6	**14**	**11**	**6**	**1**	**2**	**8**	**4**	**6**	**4**	**4**	**5**	**2007**
	5	**12**	**7**	**7**		**-----**	**3**	**2**	**3**	**13**	**9**	**7**	**2008**
	-----	**26**											**2009**
Pileated Woodpecker					**2**					**1**	**2**	**1**	**2005**
				1		**1**		**1**	**1**				**2006**
		1	**1**	**1**					**1**	**1**			**2007**
		1				**-----**	**1**		**1**			**2**	**2008**
	-----	**2**											**2009**
Downy Woodpecker			**1**	**1**		**1**				**3**	**1**	**1**	**2005**
			1	**1**									**2006**
				1						**1**			**2007**
				1		**-----**	**1**			**1**			**2008**
Hairy Woodpecker			**1**		**1**					**1**	**1**	**1**	**2005**
						1		**1**					**2006**
		1										**1**	**2007**
		2	**1**			**-----**				**1**	**1**		**2008**
Red-breasted Sapsucker				**1**						**1**			**200?**
DOVE-LIKE BIRDS													
Band-tailed Pigeon			**3**			**10**	**3**						**2005**
					4	**2**			**4**				**2006**
						2	**33**						**2007**
					16	**-----**	**2**		**1**				**2008**
Rock Dove					**4**								**2007**
					10	**-----**							**2008**
PASSERINES													
Raven			**3**	**2**					**3**	**2**		**1**	**2005**
		1	**4**	**2**	**2**	**2**		**1**	**2**				**2006**
		1	**1**	**3**	**1**		**1**		**2**	**4**		**1**	**2007**

		3	2	1	5	-----	1		2	7	1	1	2008
	-----	1											2009
Northwestern Crow			14	35	11	67	15	22	14	20	8	10	2005
	26	10	52	30	11	29	12	2	5	34	4		2006
	17	33	19	45	28	8	30	4	10	5	155	8	2007
	1	29	8	41	11	-----	9	11	7	50	34	18	2008
	-----	44											2009
Steller's Jay			1							2	12	6	2005
			2	1					8	4	2		2006
	1	2	6	3	1								2007
						-----			5	3	2	2	2008
	-----	4											2009
American Robin			7	15	27	13	28	1	8	48	3	1	2005
	2	8	44	17	15	28	7		1	36	4		2006
	6	3	24	48	22	22	34		33	20	30	1	2007
	2	3	24	39	32	-----	6	1		99			2008
	-----	35											2009
European Starling			48	20	17	184	30	207	6	129	53	48	2005
	26		3	25	1	104					50		2006
	14	25	68	11	8	63	115		10	26	210	5	2007
		17	5	19	15	-----	8	30	2	218	20		2008
	-----	81											2009
Brewer's Blackbird			6			3	3		10	12	6		2005
					2								2006
		32	24	12		12	7			11	23	17	2007
		22	2	19	4	-----				14			2008
	-----	79											2009
Red-winged Blackbird			2		6	44	10			6	6		2005
		1	20		7			1					2006
	150	54	3	13	5	9	2		2		1		2007
		18		20	3	-----				17	1		2008
	-----	62											2009
Northern Shrike				1									2007
						-----					1		2008
	-----	1											2009
Hermit Thrush						1							2006
						-----							2008
Varied Thrush			1	1						1		8	2005
				4	1								2006
		2	1	2	2						3	2	2007
		7				-----				2			2008
	-----	2											2009
Swainson's Thrush						2	4	2					2005
						10	3						2006
						3	8	1					2007
							3	2					2006
Brown-headed Cowbird					2	3			1				2005
					2	1							2006
			1		7	3							2007
					6	-----							2008

Black- headed Grosbeak						**1**							**2007**
Evening Grosbeak						**-----**				**1**			**2008**
White-crowned Sparrow				**3**	**1**				**1**	**12**		**1**	**2005**
			2	**1**	**2**	**7**	**1**		**2**	**1**		**4**	**2006**
		4		**6**	**1**	**14**	**5**	**1**				**1**	**2007**
				12	**3**	**-----**	**1**			**5**	**3**		**2008**
Golden-crowned Sparrow				**3**						**10**	**18**	**37**	**2005**
					9					**1**	**4**	**5**	**2006**
		4		**4**						**9**	**2**	**5**	**2007**
		10		**11**	**9**	**-----**			**7**	**98**	**9**		**2008**
	-----	**4**											**2009**
Song Sparrow			**5**	**7**	**3**	**4**	**5**	**4**	**3**	**8**	**11**	**23**	**2005**
		1	**7**	**9**	**6**	**5**	**2**		**6**	**1**	**9**	**5**	**2006**
	3	**9**	**7**	**8**	**9**	**12**	**9**	**1**		**7**	**11**	**7**	**2007**
	1	**4**	**5**	**6**	**6**	**-----**	**4**	**1**	**1**	**50**	**9**	**14**	**2008**
	-----	**8**											**2009**
Chipping Sparrow							**3**						**2005**
						1							**2006**
							1						**2007**
						-----	**1**		**1**				**2008**
Fox Sparrow										**4**	**3**	**3**	**2005**
			3								**2**		**2006**
	1	**2**	**2**	**5**						**1**	**2**		**2007**
		3	**2**			**-----**				**4**	**4**	**2**	**2008**
Savannah Sparrow									**7**				**2005**
					2								**2007**
					2	**-----**			**1**	**104**	**1**		**2008**
Lincoln 's Sparrow										**1**			**2005**
												1	**2007**
					1	**-----**				**13**			**2008**
House Sparrow												**6**	**2005**
		8		**6**	**2**	**2**	**4**				**7**		**2007**
		6		**8**	**7**	**-----**				**6**	**2**		**2008**
Spotted Towhee			**6**	**12**	**18**	**5**	**18**	**4**	**8**	**15**	**14**	**21**	**2005**
	2	**4**	**26**	**14**		**10**	**8**		**10**	**9**	**6**	**2**	**2006**
	3	**11**	**9**	**19**	**16**	**12**	**17**	**4**	**10**	**20**	**1**	**9**	**2007**
	5	**18**	**7**	**19**	**9**	**-----**	**6**	**8**	**8**	**17**	**8**	**14**	**2008**
	-----	**7**											**2009**
Cedar Waxwing							**3**	**2**					**2005**
							2	**1**					**2006**
							3	**1**					**2007**
						-----	**1**	**3**		**182**			**2008**
Western Tanager								**1**					**2005**
									1				**2006**
							2						**2007**
Red Crossbill												**2**	**2005**
								5	**10**	**8**	**4**		**2007**
		12	**8**	**4**	**8**	**-----**							**2008**
Berwick's Wren			**3**	**1**	**3**	**2**	**2**	**2**	**3**	**3**	**4**	**1**	**2005**

			3	5	4	1	3	1	2			3	2006
		6	6	2	2	?	11	2	3	2		5	2007
	2		3		3	-----	2	6	5	6	2	2	2008
	-----	2											2009
Winter Wren			3	1	8	3	3		1	3	6	10	2005
	7	3	5	6	3	5	3		2		6		2006
		1	4	5	2	5	3		1	4	5		2007
	2	3	8	5	6	-----			1	4	4	10	2008
	-----	1											2009
Marsh Wren		1											2007
American Pipit						-----			15	2	2		2008
American Dipper			1										2005
Violet -green Swallow			3	2	1	13	3						2005
					2	7	4						2006
					4	10	8						2007
					4	-----							2008
Barn Swallow						3	9						2005
								12					2006
						1							2007
Northern Rough winged Swallow					3	2							2007
					1	-----							2008
Chestnut-backed Chickadee			28		4	2	17	14		5	4	21	2005
	5	16	6	1	3	3	2		19	4			2006
	5	5	28	6	2	17	12	4	16		33	20	2007
	5	16	8	7	7	-----	5	1	1	35	26	20	2008
	-----	4											2009
Common Bushtits			15										2005
				2		3		17		2			2006
	9	2	8	2			6	1	2	11			2007
			2	2	2	-----	2		8	2		10	2008
Pine Siskin				3			2	1	6				2005
				1	30	2			2	4	60	50	2007
	275	126	26	62	28	-----			8	60	1	22	2008
Oregon Junco				8	2				1	19	78	68	2005
	8	21	32	6		1				16	9	23	2006
	12	46	19	15	4				1	50	38	45	2007
	18	66	8	9	1	-----		1		149	135	26	2008
	-----	41											2009
Brown Creeper											2	1	2005
	1		1						1				2006
		2		1		1							2007
		1	3		1	-----	1			3	2	5	2008

House Finch			**2**		**1**		**1**		**5**	**24**	**23**	**3**	**2005**
			13		**2**		**2**			**5**			**2006**
	2		**11**	**6**	**12**	**14**	**7**		**1**	**25**	**29**	**7**	**2007**
		5		**20**	**2**	**-----**	**12**	**2**	**4**	**71**	**8**	**12**	**2008**
	-----	**33**											**2009**
Purple Finch				**4**	**1**			**2**	**45**	**4**	**6**	**10**	**2005**
				3	**1**	**4**			**3**				**2006**
		5	**14**	**4**	**3**	**4**	**3**	**31**		**6**	**44**	**62**	**2007**
	112	**27**	**6**	**44**	**5**	**-----**	**1**	**3**	**35**	**59**	**6**		**2008**
	-----	**2**											**2009**
Orange-crowned Warbler			**1**	**1**	**8**	**1**	**5**		**1**				**2005**
					6	**3**			**1**				**2006**
				1	**3**	**2**			**2**				**2007**
					14	**-----**				**3**			**2008**
Yellow-rumped Warbler				**1**									**2005**
				3									**2006**
				2					**3**				**2007**
					8	**-----**				**3**			**2008**
Black-throated Grey							**1**		**3**				**2006**
Warbler													
Wilson's Warbler						**1**		**1**			**1**		**2005**
								2					**2007**
						-----	**1**						**2008**
Yellow Warbler					**1**	**3**	**3**	**4**					**2005**
						5							**2007**
Townsend's Warbler							**2**						**2005**
					2								**2007**
Myrtle-rumped Warbler					**1**	**-----**							**2008**
Ruby- crowned Kinglet			**2**							**2**	**6**	**8**	**2005**
			6	**9**					**2**		**2**		**2006**
			6	**11**	**2**		**2**			**3**	**2**	**12**	**2007**
	2	**1**	**2**	**5**	**3**	**-----**				**22**	**7**	**24**	**2008**
Golden-crowned Kinglet			**4**							**4**	**10**	**11**	**2005**
	7	**1**	**15**							**3**			**2006**
		5		**12**						**2**	**10**	**16**	**2007**
	2	**4**	**2**		**2**	**-----**					**24**	**55**	**2008**
Hutton's Vireo					**1**								**2006**
			1	**1**		**-----**				**1**			**2008**
Pacific Slopes Flycatcher					**3**	**3**	**6**	**3**					**2005**
							3	**3**					**2006**
					1	**5**	**4**						**2007**
					4	**-----**	**1**						**2008**
Willow Flycatcher						**2**	**2**	**6**					**2005**
						7	**2**						**2006**
						7	**4**	**4**					**2007**
						-----	**1**	**4**					**2008**
Western Wood Pee Wee						**-----**				**1**			**2008**

Red-breasted Nuthatch							**2**	**5**	**2**	**5**	**2**	**1**	**2005**
	1	**3**	**3**		**1**		**1**		**3**				**2006**
	1	**1**		**5**			**1**	**1**	**2**	**1**	**4**	**2**	**2007**
		2			**3**	**-----**	**1**	**2**	**3**		**1**		**2008**
	-----	**2**											**2009**
Common Yellowthroat								**2**	**2**				**2005**
American Goldfinch								**9**	**1**		**1**		**2005**
					4								**2006**
					6	**4**			**4**		**5**		**2007**
				1	**2**	**-----**			**8**	**3**			**2008**
Warbling Vireo						**3**							**2006**
						1	**1**						**2007**
						-----	**2**						**2008**
Cassin's Vireo					**2**	**1**							**2007**
Lapland Longspur										**1**			**2007**
Total Species - 143													
Bird species: totals/month			**46**	**45**	**43**	**35**	**34**	**38**	**40**	**54**	**44**	**53**	**2005**
	24	**22**	**38**	**47**	**41**	**36**	**27**	**20**	**30**	**19**	**29**	**35**	**2006**
	35	**46**	**40**	**60**	**52**	**44**	**43**	**17**	**29**	**40**	**41**	**50**	**2007**
	36	**59**	**37**	**46**	**57**	**-----**	**34**	**28**	**40**	**63**	**54**	**34**	**2008**
	-----	**47**											**2009**

Appendix 2.3

Some vascular plant species or taxa introduced to Vancouver Island that were observed on the Englishman River Estuary, Parksville, B.C., 2007 to 2008

Agrostis stolonifera	Creeping Bentgrass
Aira praecox	Early Hairgrass
Betula sp (likely *Betula pendula* or *Betula X*)	birch (likely European White Birch, or a cross)
Bromus tectorum	Cheatgrass
Centaurea sp. likely *C. maculata* aka *C. biebersteinii*	knapweed (likely Spotted Knapweed)
Cichorium intybus	Chicory
Cirsium arvense	Canada Thistle (aka Creeping Thistle)
Cirsium vulgare	Bull Thistle
Convolvulus sp. likely Convolvulus sepium	bindweed (likely Hedge Bindweed)
Cotula coronopifolia	Brass Buttons
Cytisus scoparius	Scotch Broom
Dactylus glomerata	Orchard Grass
Daphne laureola	Spurge-laurel
Elymus repens (aka *Agropyron repens*; *Elytrigia repens*)	Quackgrass
Eschscholzia californica	California Poppy
Geranium robertianum	Herb Robert (aka Robert Geranium)
Hedera helix	English Ivy
Holcus lanatus	Velvet Grass (aka Yorkshire Fog)
Hordeum jubatum	Foxtail Barley
Ilex aquifolium	English Holly
Lamium purpureum	Purple Deadnettle
Lamiastrum galeobdolon *Lamium)*	Yellow Archangel (variegated) (aka Yellow Lamium)
Phalaris arundinacea **	Reed Canarygrass (**either native or hybridized)
Plantago major	Broad-leaved Plantain
Ranunculus sp. (likely R. repens)	*buttercup (likely Creeping Buttercup)*
Rubus armeniacus	Armenian Blackberry (aka Himalayan Blackberry)
Rubus laciniatus	Cut-leaf Evergreen Blackberry
Rumex acetosella	Sheep Sorrel
Salicornia europaea (aka *Salicornia depressa)*	European Annual Saltwort (aka Common Glasswort)
Sonchus arvensis	Perennial Sow-thistle
Tanacetum vulgare	Common Tansy
Vinca minor	Lesser Periwinkle

The list of invasive species that we have confirmed on the ERE will be forwarded to the BCCDC. The list in this report is not intended to be comprehensive; as new species are found, mostly by volunteers, and then confirmed by a biologist, we will continue to update the list and forward the results to others working to compile the information. When this report is released, it will contribute to province-wide efforts to understand and manage invasive species; several of the species we observed were not on invasive species lists for the province as of 21 January 2008 (http://www.geog.ubc.ca/~brian/florae/invasive_sp_list.html)

Appendix 2.4

Non-native species or taxa likely to be present on Englishman River estuary now or in the near future because of occurrences observed nearby, 2007-2008. Actual occurrence on the estuary would need confirmation.

Arctium sp.	Burdock
Anthriscus sylvestris	Chervil (aka Wild Chervil)
Bidens cernua	Nodding Beggarticks
Capsella bursa-pastoris	Shepherd's Purse
Chenopodium album	Lamb's-quarters
Digitalis purpurea	Foxglove
Erodium cicutarium	Stork's-bill
Galium aparine	Cleavers
Heracleum mantegazzianum	Giant Hogweed
Hypericum perforatum	Common St. John's-wort
Hypochaeris radicata	Cat's-ear
Leucanthemum vulgare (aka *Chrysanthemum leucanthemum*)	Oxeye Daisy
Plantago lanceolata	Narrow-leaved Plantain
Poa annua	Annual Bluegrass
Ranunculus repens	Creeping Buttercup
Stellaria media	Common Chickweed
Thlaspi arvense	Field Pennycress

Appendix 2.5
Invasive plant species and taxa to watch on the Englishman River estuary

Avena fatua	Wild Oat
Cardaria draba ssp. draba	Heart-podded Hoary-cress\
Dipsacus sp.	Teasel
Echinochloa crusgalli	Barnyard Grass
Madia sativa	Coast Tarweed
Matricaria sp.	Pineapple weed
Melilotus sp.	Yellow and White Sweet-clover
Poa compressa	Canada Bluegrass
Poa pratensis	Kentucky Bluegrass
Polygonum convolvulus (aka *Fallopia convolvulus*)	Wild Buckwheat (aka Black bindweed)
Polygonum cuspidatum	Japanese Knotweed
Polygonum sachalinense	Giant Knotweed
Potamogeton crispus	Curly Pondweed
Rumex crispus	Curled Dock
Senecio jacobaea	Tansy Ragwort
Senecio vulgaris	Common Groundsel
Solanum sp.	Nightshade
Solanum americanum	Black Nightshade
Solanum dulcamara	Climbing Nightshade
Sonchus asper	Prickly Sow-thistle
Sonchus oleraceus	Common Sow-thistle
Sorbus aucuparia	European Mountain-ash
Verbascum thapsus	Great Mullein

Appendix 2.6
Some invasive plant species recommended for provincial and federal legislation such as inclusion on the (noxious) weed list

Cytiscus scoparius	Scotch Broom
Geranium robertianum	Herb Robert
Hedera helix	English Ivy
Heracleum mantegazzianum	Giant Hogweed
Impatiens noli-tangere	Touch-me-not
Lamiastrum galeobdolon	Yellow Archangel (aka Yellow Lamium)
Vinca minor	Lesser Periwinkle