An Integrated Biophysical Assessment of Estuarine Habitats in British Columbia to Assist Regional Conservation Planning

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Pacific and Yukon Region

Technical Report Series Number 476
2007

Ducks Unlimited Canada
CANADA'S CONSERVATION COMPANY

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Catalogue No. CW69-5/476E
ISBN 0-662-45252-2

This series may be cited as:

Ryder, J.L., J.K. Kenyon, D. Buffett, K. Moore, M. Ceh, and K. Stipec. 2007.
An integrated biophysical assessment of estuarine habitats in British Columbia to assist regional conservation planning.
Technical Report Series No. 476. Canadian Wildlife Service,
Pacific and Yukon Region, British Columbia.

Copies may be obtained from:
Canadian Wildlife Service
Pacific and Yukon Region
5421 Robertson Road, RR #1
Delta, British Columbia
Canada V4K 3N2

Abstract

Estuaries in British Columbia comprise less than 3% of the province's coastline (Pacific Estuary Conservation Program 1999) but these productive and diverse habitats are seasonally or annually important to a variety of species. Despite their importance and rarity, approximately 43% of the province's estuaries are threatened by coastal development, modification, and pollution (CWS, unpublished data). Effective conservation of estuaries requires the achievement of two long-term goals: a) an objective, landscape-level scientific assessment to identify important areas for sustaining waterbird populations and b) timely and efficient allocation of resources to conserve priority sites. To address the first goal, this project identified and mapped 442 of B.C.'s estuaries on behalf of the Pacific Estuary Conservation Program (PECP) using standardized criteria and Geographic Information System (GIS) tools. The project provided a quantifiable regional overview of estuary habitats that links existing biophysical data and attributes to assist conservation planning. Individual estuaries were ranked for their biological importance to waterbirds (ducks, geese, swans, loons, and grebes) using data and metrics of estuary size, habitat type and rarity, herring spawn occurrence, waterbird use, and intertidal biodiversity.

Estuaries that ranked high in this assessment tended to be large estuaries (minimum size 356 ha) with relatively large areas of intertidal delta or adjacent saltmarsh. Within these high ranking estuaries, intertidal vegetation such as *Ulva*, *Zostera*, *Salicornia*, or kelp was common, and/or mussels are prevalent. Many of these estuaries have also experienced large and frequent herring spawn events. In most cases, the high ranking estuaries also had high densities of wintering waterbirds. Estuaries receiving a low ranking were usually small and were missing data for at least one or more attributes. A lack of data for some sites highlighted important information gaps in this exercise.

Such an integrated assessment will assist conservation agencies in directing resources to habitat securement or restoration activities and to further population and habitat monitoring where existing data are deficient. As the assessment is provided at a regional level, the results can also be used in the identification of a network of biologically representative sites to contribute to the conservation of biodiversity in British Columbia. The assessment also provides a valuable tool for regional and sub-regional land use planning, environmental assessment, emergency response, cumulative effects assessment, support for sustainable development initiatives, and provides an information base with which to conduct further research or studies in landscape ecology.

Résumé

Les estuaires de la Colombie-Britannique représentent moins de 3 % de la ligne de côte de la province (Programme de conservation des estuaires du Pacifique, 1999), mais ces habitats productifs et diversifiés sont, de façon saisonnière ou annuelle, essentiels pour de nombreuses espèces. Malgré leur importance et leur rareté, environ 43 % des estuaires de la province sont menacés par le développement, l'altération et la pollution des côtes (SCF, données inédites). Deux objectifs à long terme doivent être atteints dans le cadre d'une conservation efficace des estuaires : a) une évaluation scientifique objective à l'échelle du paysage visant à identifier les zones principales qui soutiennent les populations d'oiseaux aquatiques; b) une distribution juste et efficace des ressources visant à conserver les sites prioritaires. Dans la poursuite du premier objectif, 442 estuaires de la Colombie-Britannique ont été identifiés et cartographiés pour le Programme de conservation des estuaires du Pacifique (PCEP) au moyen de critères normalisés et de systèmes d'information géographique (SIG). Le projet a permis un survol régional quantifiable des habitats estuariens, qui lie les données biophysiques existantes aux caractéristiques des habitats pour faciliter la planification de la conservation. Chaque estuaire a été classé en fonction de son importance biologique pour les oiseaux aquatiques (canards, oies, cygnes, plongeons et grèbes) à partir de données et de paramètres concernant la taille des estuaires, le type et la rareté des habitats, la présence d'œufs de harengs, l'utilisation des habitats par les oiseaux aquatiques et la biodiversité intertidale.

Les estuaires classés aux premiers rangs dans le cadre de cette évaluation étaient généralement de vastes estuaires (d'une superficie minimale de 356 ha) comportant des zones relativement grandes de deltas intertidaux ou de marais salés attenants. Au sein de ces estuaires, les végétaux intertidaux du genre *Ulva, Zostera* et *Salicornia,* les laminaires ou les moules étaient abondants. Un bon nombre de ces estuaires sont aussi le lieu de longues et fréquentes périodes de fraye des harengs. Dans la majorité des cas, les estuaires classés aux premiers rangs présentaient aussi une forte densité en oiseaux aquatiques en hivernage. Les estuaires classés aux derniers rangs étaient généralement petits, et toutes les données n'ont pas pu être mesurées pour au moins une des caractéristiques évaluées. Le manque de données sur certains sites met en relief les importantes lacunes en termes d'information de cet exercice.

Une telle évaluation intégrée appuiera les organismes de conservation dans leur gestion des ressources pour la protection ou la restauration des habitats, et pour la surveillance future des populations et des habitats dans les régions où les données sont incomplètes. Comme l'évaluation est effectuée au niveau régional, les résultats pourront aussi être utilisés dans l'identification d'un réseau de sites biologiquement représentatifs, qui contribuera à la conservation de la biodiversité de la Colombie-Britannique. L'évaluation constitue aussi un outil précieux pour la planification de l'utilisation des sols, les évaluations environnementales, les interventions d'urgence, les évaluations des effets cumulatifs et l'appui d'initiatives de développement durable aux niveaux régional et infrarégional, et fournit des renseignements sur lesquels peuvent se fonder les recherches ou les études futures sur l'écologie du paysage.

Acknowledgements

The undertaking of a project such as this is not possible without the support of many organizations and individuals. Many staff members from the Canadian Wildlife Service lent their expertise to this project including Andre Breault, Michael Dunn, Ken Brock, Sean Boyd, Neil Dawe, Rob Butler, Ken Morgan, Dan Esler, and Doug Bertram. Statistical support was provided by Barry Smith of the Canadian Wildlife Service and Laura Cowen and Carl Schwarz of Simon Fraser University, Department of Statistics and Actuarial Sciences. Additional geo-spatial help was provided by Steven Shisko, Carrie Robb, Jason Komaromi, Betty Ling, and Susan Jesson of the Canadian Wildlife Service. Anders Wong aided in creation of the map figures.

Many people and groups provided access to data and provided much needed analytical advice. The Ministry of Agriculture and Lands (Carol Ogborne, Rick Deegan, and Mark Zaccharias), Ministry of Environment, Parks Canada, and Department of Fisheries and Oceans (Colin Levings, Bruce McCarter, Brad Mason, and Melody Farrell) provided biophysical data, digital orthophotos, and constructive feedback. Ducks Unlimited Canada also provided digital orthophotos. Bird survey data, and accompanying advice, was graciously supplied by the Comox-Strathcona Natural History Society, the Squamish Estuary Conservation Society, Bird Studies Canada (in particular Stephanie Hazlitt, Jeanne Roy, and Tasha Smith), and Ramunas Zydelis of Simon Fraser University/Centre for Wildlife Ecology. Interpretation of the shorezone dataset was aided by Archipelago Marine Research. Airphotos and airphoto support was provided by Western Forest Products Limited and Ian Norie & Associates. Mapping of eelgrass beds in the Nanaimo River estuary was conducted by the Snuneymuxw First Nation.

Earlier versions of this technical report were enhanced by reviews by Robin W. Baron, Michael Dunn, and members of the Pacific Estuary Conservation Program and Pacific Coast Joint Venture.

Financial support was provided by the Canadian Wildlife Service, Ducks Unlimited Canada, Georgia Basin Action Plan, and Ministry of Environment.

Table of Contents

List of Tables

List of Figures

Introduction

Estuaries are among the most biologically productive and threatened ecosystems in the world. The sustainability of estuarine ecosystems is in question due to coastal development pressures, human population growth, and the increasing extraction of nearshore resources. Estuary habitats support a wide diversity of marine and terrestrial species and net primary production rivals that of tropical rain forests (Ricklefs 1990). Estuaries provide important ecological roles and services such as water filtration, nutrient enrichment and recycling, detritus processing, and energy provisioning to support near-shore food-webs (Fox and Nowlan 1978; Simenstad 1983).

There are many threats to estuaries including habitat loss, alteration, eutrophication, resource extraction, freshwater diversion, chemical contamination, pollution, introduced non-native species, coastal subsidence, sea level rise, and debris and litter overload (Nichols *et al.* 1986; Mahaffy *et al.* 1994; Rogers and McCarty 2000; Wasson *et al.* 2001; Bollens *et al.* 2002; Deegan 2002; Elliott and de Jonge 2002; Kennish 2002; Scavia *et al.* 2002).

In British Columbia, anthropogenic impacts on estuaries are most conspicuous in the southern portion of the province, particularly the Georgia Basin (Figure 1). The British Columbia Nearshore Habitat Loss Working Group reported for the Georgia Basin that “approximately 23% of the nearshore has already been urbanized” and “less than 4% of coastal wetlands and estuaries are protected under federal and provincial legislation” (BCNHLWG 2001). Habitat loss associated with rapidly increasing human populations has been substantial in some areas of the Fraser River delta and Vancouver Island (Butler and Campbell 1987; Campbell-Prentice and Boyd 1988). Human population growth is expected to intensify the development pressures on British Columbia’s estuaries.

Estuaries in British Columbia are categorized primarily as fjord estuaries created by glaciation, or as drowned river valleys created as a result of river valleys flooding when sea levels rose after the last ice age (Emmett *et al.* 2000). In the Georgia Basin, Mahaffy *et al.* (1994) reported that the single greatest threat to shoreline birds was habitat destruction. In British Columbia, it is estimated that hundreds of thousands of waterfowl over-winter in coastal areas and that these populations are dependent on estuary habitats for survival (Butler *et al.* 1989; Mahaffy *et al.* 1994). Continental

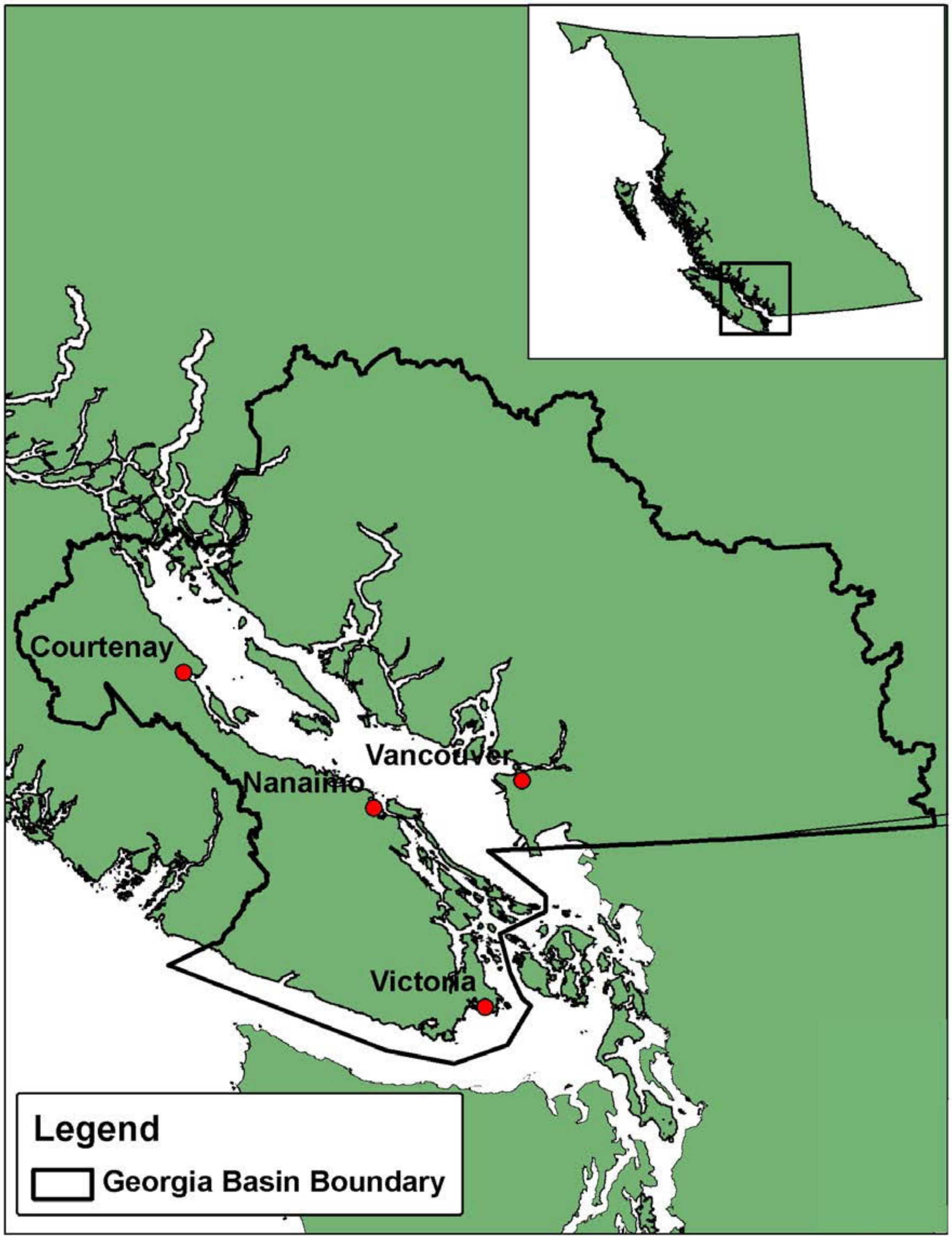

Figure 1: The Georgia Basin, located in southwestern British Columbia, has many anthropogenic activities that threaten its estuaries. Boundary designates the area of the Georgia Basin Action Plan (GBAP 1998).

declines of waterfowl populations in the 20th century have been linked with human destruction of wetland habitats needed for breeding, feeding, migration, and over-wintering (Sanderson 1980). Thus the sustainability of waterfowl, and waterbirds in general, is in part dependant on the conservation of important estuarine habitats that support wintering waterbird populations.

Conservation of Estuaries in British Columbia

Given the importance of wetlands and variety of habitat threats, the North American Waterfowl Management Plan (NAWMP) was initiated in 1986 to achieve landscape conditions that could sustain waterfowl populations. The Plan relies on regionally based joint ventures to implement objectives on a local scale (NAWMP 2004). A 2004 update to the NAWMP calls for partners to set habitat objectives in terms of specific and measurable goals for landscapes and to institute habitat monitoring approaches that can be used to address specific waterfowl conservation actions within particular landscapes (NAWMP 2004).

West coast conservation activities are administered through the Pacific Coast Joint Venture (PCJV), a partnership of government and non-government conservation agencies in California, Oregon, Washington, British Columbia, Alaska, and Hawaii, which aims to maintain coastal wetland ecosystems. In British Columbia, the PCJV has an overall goal to ensure the long-term protection of wetland-dependent wildlife and to sustain natural ecological processes within coastal wetland ecosystems (PCJV 2005). This represents a significant challenge because reliable estimates of populations for most marine species are unavailable and there is a poor understanding of the amount of habitat required to sustain populations.

Under the PCJV, the Pacific Estuary Conservation Program (PECP) is responsible for the securement and enhancement of estuarine habitats of conservation importance in British Columbia. The Pacific Estuary Conservation Program (PECP) began in 1987 as a coalition of government and non-government agencies intent on conserving important estuaries along British Columbia's Pacific coast. It is currently a partnership between Environment Canada (Canadian Wildlife Service), Fisheries and Oceans Canada, BC Ministry of Environment, BC Habitat Conservation Trust Fund, Ducks Unlimited Canada, Nature Conservancy of Canada, The Nature Trust of British Columbia, and The Land Conservancy of BC. To achieve optimum results for estuary habitat securement and conservation, the PECP is designed to be a mechanism to pool both financial and technical resources amongst the partners.

Conservation Planning

Effective conservation planning requires detailed information regarding the location, size, and relative biological importance of habitat units. As a first step, ecosystems must be formally described as spatially explicit areas with mappable units (Lackey 1998; Carpenter *et al.* 1999; Haufler *et al.* 2002). Ecosystem mapping is a complex and imprecise task because natural boundaries are not always apparent (Christensen *et al.* 1996; Simberloff 1998, BCLUCO 1999). However, given the rapid pace of environmental change and limited funds to implement conservation initiatives, some indication of the relative value of a habitat unit derived from biophysical mapping is essential to provide a foundation for landscape planning. Modern approaches to landscape ecology, Geographic Information System (GIS) mapping, and remote sensing can provide the tools to quantify ecosystem size and ecological patterns (O'Neill *et al.* 1995; Klemas 2001).

Estuary ecosystems and physical boundaries of such systems have been variously defined and interpreted, but Kjerfve (1989) defined estuaries as "coastal indentations that have restricted connections to the ocean and remain open at least intermittently". The author further stated that estuarine systems can be subdivided into three areas: 1) a tidal river, 2) a mixing zone of freshwater and saltwater, and 3) a nearshore zone. This definition, however, does not describe the functional aspects of estuaries and their role in transporting biotic and abiotic materials between terrestrial freshwater and marine systems.

A number of previous attempts were made to map and/or rank estuaries in British Columbia to assist conservation planning (Hagen 1984a,b; Hunter *et al.* 1985; Remington 1993; MacKenzie *et al.* 2000). However, these attempts were inadequate in meeting the current broad regional needs of the PECP for conservation planning. Mapping conducted by Hagen (1984a,b), Remington (1993), and Mackenzie *et al.* (2000) was done at a regional level or targeted specific estuaries exposed to development threats. Hunter *et al.* (1985) did examine estuaries province-wide, however, there was no standardized and objective method for determining what an estuary was; the assessment relied largely on expert opinion to identify priority sites. As well, there was a number of nearshore wetland sites included that were not estuaries but were known to have high numbers of waterfowl.

To help with strategic planning of conservation activities, the PECP partners in 2002 collaborated to identify, describe, map, and rank estuaries at the regional scale of British Columbia by making use of existing GIS datasets (Appendix 1). Identification and mapping of estuaries was based upon existing datasets. The estuaries identified are not a complete census of estuaries on British Columbia's coast but rather those defined by the criteria described in Appendix 1. Rankings reflect the relative biological importance of the identified estuaries to waterbirds (defined as ducks, geese, swans, loons, and grebes) in British Columbia. The project provided a necessary first step to identify relative biophysical values of estuaries using various regionally applicable and biologically relevant databases. Identified and mapped estuaries were ranked, with the exception of the Fraser River (see Discussion) based upon these biophysical attributes as surrogate measures of their biological importance. The intent was to use the rankings as objective, scientifically defensible sources of information to assist the PECP in the timely and effective allocation of scarce conservation resources to conserve important estuaries.[1] Biophysical attributes include data on estuary size, habitat rarity, herring spawn occurrence, waterbird use, and intertidal species rarity.[2] A Biological Importance Score for an estuary was estimated by combining the relative rank of an estuary for each of the five attributes. Each estuary was grouped into one of five importance classes based upon the Biological Importance Score relative to all other estuaries. The Fraser River estuary was not assigned to any importance class due to a lack of data consistent with the methodologies employed for determining biological importance. Despite the lack of appropriate data, it is well documented and recognized that the Fraser River remains one of the most important estuaries in British Columbia for waterfowl (FREMP 2003). Please see the discussion for further details regarding the importance of the Fraser River estuary and how it was treated in this assessment.

It must be noted that ranking and grouping of estuaries according to their relative biological importance scores provides only a portion of the information required to make appropriate conservation decisions. Socio-economic goals, objectives, and values are

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[1] This analysis includes only the 442 PECP Identified Estuaries (Appendix 1), which are generally the larger estuaries in British Columbia. It *does not* include the approximately 101 additional estuaries identified in Hunter *et al.* (1985) which consisted of many smaller estuaries or important waterfowl locales that could not technically be defines as an estuary (i.e. Tofino Mudflats)..

[2] For this report, rarity refers to the abundance of a species or habitat type at an estuary relative to other estuaries.

equally important considerations in conservation site prioritization initiatives. Although these were not considered here, knowledge of the biological values and relative importance of estuaries provides an ecological foundation that can be integrated with socio-economic considerations to support decision-making, consistent with the principles of sustainable development. The biological assessment also provides a benchmark for future resource assessments, environmental assessment, and landscape level land-use planning; a tool for directing resources for estuary securement or restoration; and as a baseline for assessing the success of future conservation initiatives.

Methods

Identifying and Mapping Estuaries

A detailed description of the standardized protocol used for identifying, describing, classifying, and mapping estuaries using the available GIS input data, including references, is provided in Appendix 1. Briefly, estuaries were identified as the intersection of large rivers with the coastline. Large rivers were defined by double-lined rivers (≥20m width) from existing datasets such as the Terrain Resource Inventory Mapping (TRIM I&II) basemaps (1:20,000 scale) (BCMSRM 2002) and fourth order rivers from the British Columbia Watershed Atlas basemaps (based on National Topographic Series maps at a 1:50,000 scale) (BCMELP 1996). Estuaries located with this criteria were mapped as discrete areas from a variety of input datasets (described below) using Arcview v.3.2 and ArcInfo GIS software (ESRI 1999).

Estuary boundaries were defined to include the intertidal (below coastline to lowest normal tide) and supratidal (above coastline) zones as well as habitat features connected to each river or stream above the coastline to an upstream distance of 500m.[3] The 500m upstream limit was established based on a study in the Campbell River estuary which determined the maximum upstream distance surface salinity could be detected (Colin Levings, Department of Fisheries and Oceans, pers. comm. 2002). This distance was also recommended by Durance (2001). Estuary extent was determined by capturing polygons for physiographic features such as marsh, swamp, islands, river/streams, ditches, sand/gravel bars, and lakes from TRIM. Intertidal areas (shown as mudflat, rock, gravel, and/or sand substrate) and some supratidal or intertidal marsh

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[3] Estuaries that were exceptions to this rule include the three largest estuaries: the Fraser River, Skeena/Ecstall/McNeil River complex, and the Nass/Ksi'Higinx/Burton/Iknouk/Chambers/Kincolith River complex

features not shown in TRIM were digitized and added as polygons. These physiographic features were obtained, captured, and verified from a wide variety of datasets including the provincial TRIM I&II basemaps, digital orthophotos (1:20,000 scale), airphotos (1:15,000 to 1:40,000 scale), Canadian Hydrographic Service (CHS) digital marine charts of varying scales, and 1:50,000 scale NTDB Watershed Atlas. Digital chart products were obtained from Nautical Data International (2002). Estimates of the areal extent of each estuary and associated features (measured in hectares) were derived from these procedures. Figure 2 provides an example of the different habitat types that comprise an estuary.

Ranking PECP Identified Estuaries

Estuary rankings were conducted following procedures presented by Turpie *et al.* (2002) for ranking South African estuaries. Data for biologically important attributes to waterbirds, summarized in Table 1, were used to rank estuaries by estimating a Biological Importance Score. Attributes of importance to waterbirds were chosen to focus the assessment on the needs of the PECP/PCJV partners. These attributes were chosen based on discussions with waterbird species biologists with expert knowledge of the habitat and forage requirements of waterbirds (A. Breault, CWS; S. Boyd, CWS; and R. Butler, CWS, pers. comm. 2003). These attributes are not an exhaustive list of data that could be used in determining a Biological Importance Score but were chosen due to their wide regional spatial coverage, compatible mapping scale, quality of data, and their likely correlation with quality waterbird habitat.

Following Turpie *et al.* (2002), estuaries were scored for each attribute with the resulting distribution of scores being transformed to a normal distribution where necessary. The estuary with the highest score for an attribute was indexed to a value of 100 and then each successive estuary was scaled as a proportion of the highest score to normalize the scores. Estuaries were then categorized into percentiles: 0-10%, 10-20%, 20-30% … 90-100% with a corresponding final index value of 10, 20, 30…90, or 100 being assigned to each estuary. Use of differing scales of the TRIM and marine charts data lead to uncertainties in the size of mapped polygons, therefore, categorization into percentiles was used to dampen the effects of these uncertainties in an estuary’s score.

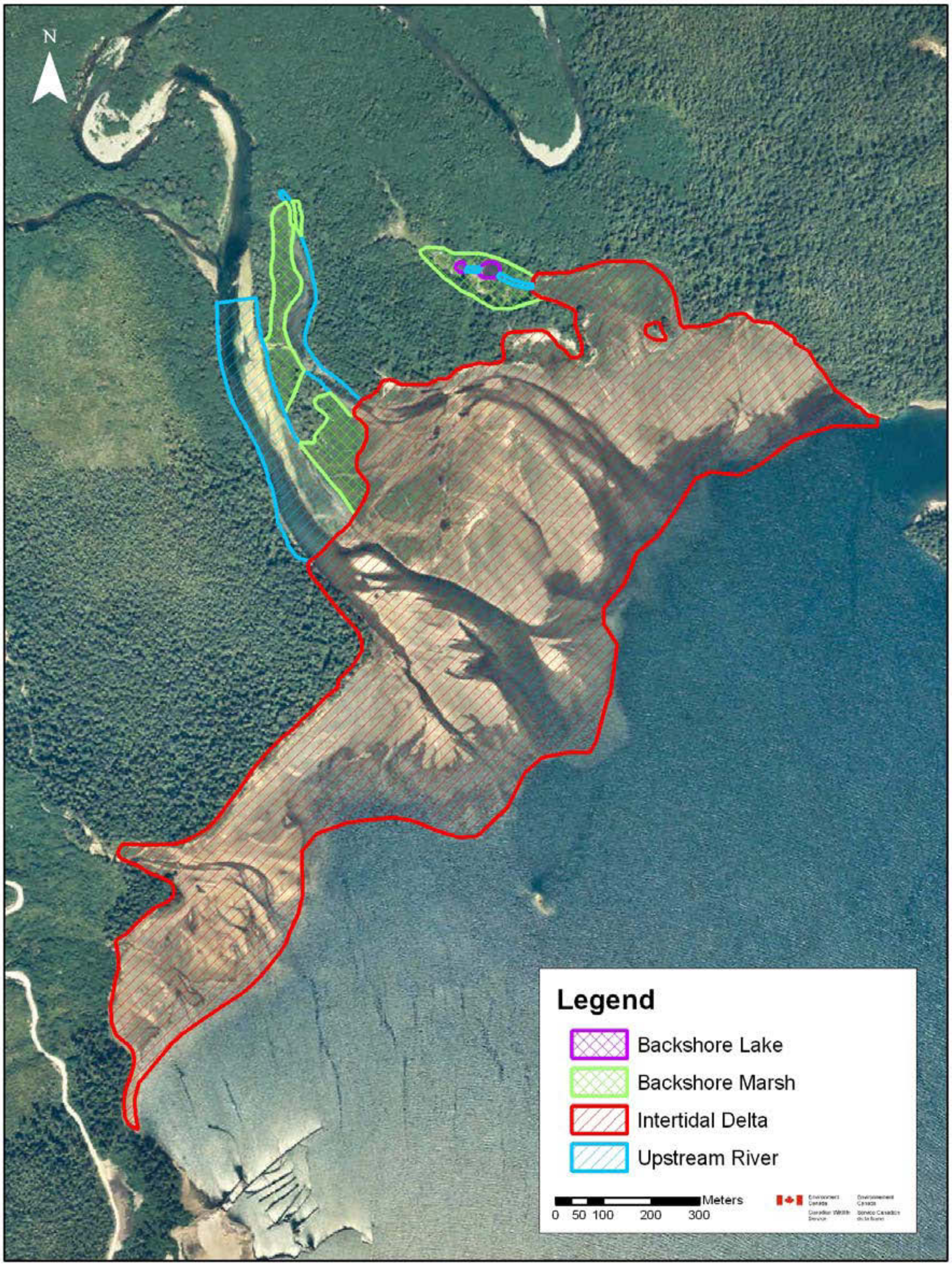

Figure 2: An example of the different habitat types that make up an estuary using the Toquart River estuary in Barkley Sound on the west coast of Vancouver Island as an example.

Table 1: Summary of attributes used to estimate a Biological Importance Score for each estuary.

Attribute	Name	Description
Estuary Size	Estuary Size Index (ESI)	Overall size of estuaries obtained from the mapping procedure
Habitat Type	Habitat Rarity Index (HRI)	An estuary's contribution to the provincial total for intertidal area and saltmarsh and swamp habitat
Intertidal Species	Species Rarity Index (SRI)	An estuary's contribution to the provincial total for the following intertidal species: mussels, kelp, *Salicornia*, *Ulva*, and eelgrass
Waterbird Density	Waterbird Density Index (WDI)	Density of over-wintering waterbirds using an estuary
Herring Spawn Events	Herring Spawn Index (HSI)	Frequency and size of herring spawn events occurring at an estuary

The Biological Importance Score for each estuary was then calculated by combining the rankings for each category and weighting the categories based upon biological importance and confidence in the data such that:

$$Importance = 0.3(ESI) + 0.15(HRI) + 0.2(SRI) + 0.1(WDI) + 0.25(HSI).$$

Figure 3 presents a diagrammatic view of the generalized steps taken to calculate the Biological Importance Score for an estuary.

Input Data Used in Biological Importance Score Calculations

The following sub-sections describe in detail the methodology employed to estimate the index value for each category used in calculating the Biological Importance Score.

Estuary Size Index

The distribution of estuary sizes was skewed because four estuaries contributed >63% to the total area for the province.[4] Due to the wide range in estuary sizes and the distribution of estuary sizes being non-normal, probit scores were used instead of the measured estuary size. Probit scores are based upon a categorical variable; in this case the rank of the estuary's size (i.e. 1, 2, 3 … 440, 441, 442). Probit analysis of a

[4] The four largest estuaries are the Fraser River, Skeena/Ecstall/McNeil River complex, Nicomekl/Serpentine River complex, and Nass/Ksi'Higinx/Burton/Iknouk/Chambers/Kincolith River complex.

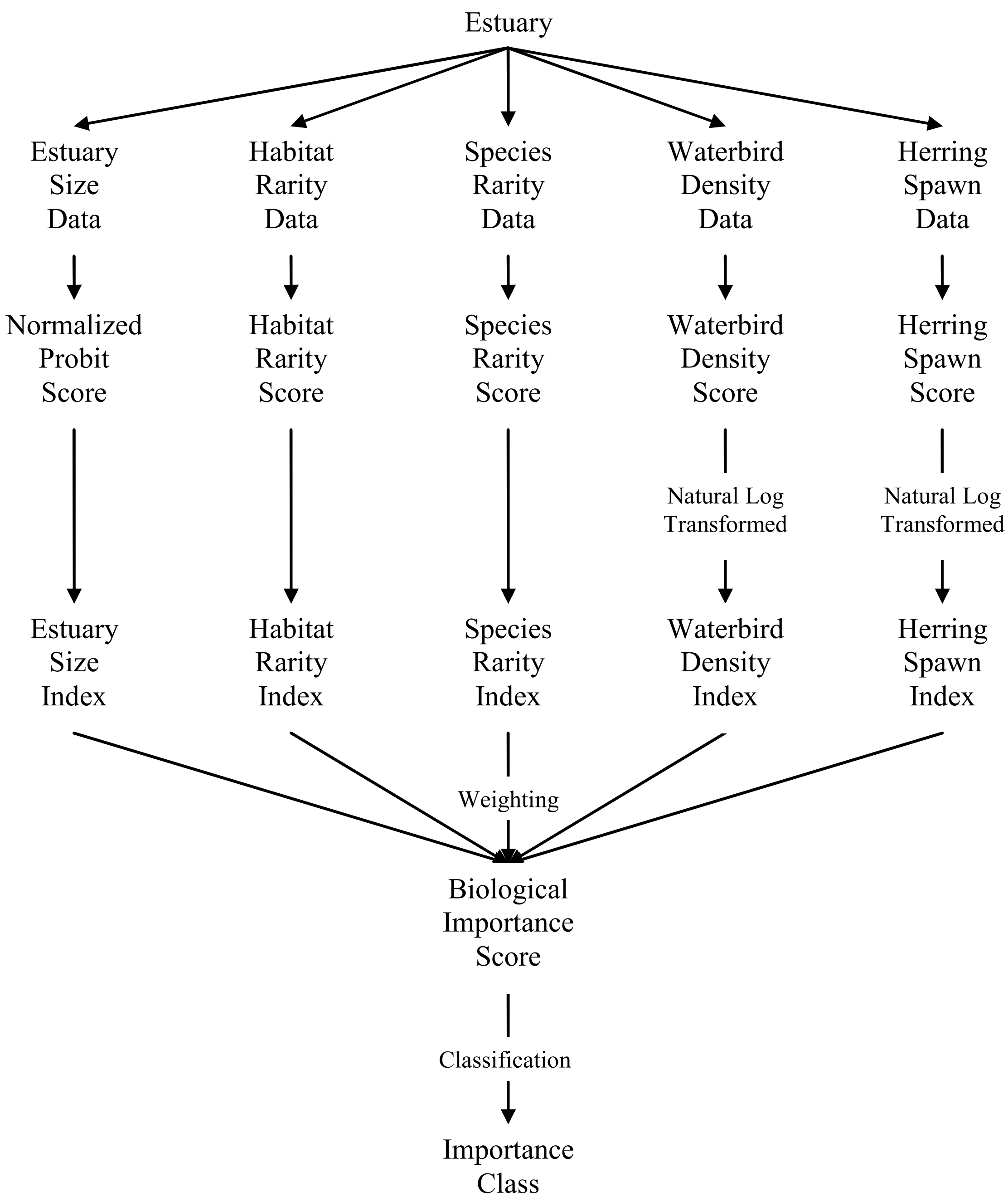

Figure 3: Flow diagram outlining the analytical process used to assign each estuary to an importance class. Data for each of the five variables was analyzed by various methods to calculate a score for each estuary. Each score was indexed based upon an estuary's relative score to the maximum scoring estuary. Index values of each of the five variables were combined to calculate the Biological Importance Score. Each estuary was assigned to an Importance Class based on its Biological Importance Score relative to the maximum Biological Importance Score.

categorical variable assumes a normal, or log-normal, distribution. To validate this analysis method, estuary size was natural log transformed to allow z-values to be calculated. The relationship between the calculated probit values and the z-values was a strong 1:1 relationship, supporting the assumption of a log-normal distribution. These normalized probit values of estuary rank were then scored on a scale of 0-100 as the proportion that each site contributed relative to the highest and lowest probit scores. Each estuary was then categorized as the Estuary Size Index by the percentile that it fell within (0-10%, 10-20%, 20-30% … 90-100%).

Probit analysis is a good proxy for estuary size because a categorical variable (rank) is used instead of the actual physical size for determining a relative score. Using probit analysis for estuary size then allows an analysis of the amount of rare habitats in each estuary without habitat rarity being nested under estuary size, thus minimizing a likely correlation between the two variables.

Habitat Rarity Index

The habitat rarity index (HRI) was calculated based on an estuary's contribution to the provincial total of two general habitat types: intertidal delta (mainly physical substrate characteristics and some vegetation) and saltmarsh (habitats with distinctive plant communities). Estuary habitat composition was determined from the specific habitats captured at each estuary from TRIM and the digital marine charts. Intertidal delta area includes intertidal features interpreted from digital marine charts and TRIM data. Saltmarsh was captured from TRIM marsh habitats in the intertidal or supratidal zones of each estuary. Digital TRIM and marine charts were used to quantify rare habitat types because there is no other comprehensive mapping of vegetation communities and intertidal features that cover all of the PECP Identified Estuaries. Although habitat estimates using TRIM and marine charts are coarse[5], it is a standardized way of examining and comparing vegetation across all identified estuaries.

[5] Habitat estimates of intertidal and salt marsh areas for each estuary are coarse because they were interpreted from TRIM and marine charts of varying accuracy. Backshore marsh chart only (BMC) is categorized as physical habitat but it is impossible to discriminate BMC accurately as supratidal, intertidal marsh habitat, or intertidal delta habitat because of the problem of the TRIM coastline not being digitized at a standardized tidal height. Also, some plant cover may have been present but was categorized as physical habitat and vice versa. The Serpentine/Nickomekl River Complex and Campbell River (1) estuary's habitats were partially derived from 1:2,500 Fraser River Estuary Management Plan (FREMP 1998) mapping. Thus, the saltmarsh category is biased toward higher saltmarsh estimates because more area was considered in the delineation of backshore marsh and backshore swamp polygons from TRIM.

Habitat rarity scores (HRS) were assigned to each estuary by relating the amount of each habitat type in an estuary to the total amount of those habitats in all identified estuaries so that:

$$HRS = 1000\sum_{i=1}^{n}\frac{a_i}{A_i}$$

where a_i is the area of the i^{th} habitat in the estuary and A_i is the total area of the i^{th} habitat in all estuaries.

The three largest estuaries (Skeena/Ecstall/McNeil River complex, Nass/ Ksi'Higinx/ Burton/Iknouk/Chambers/Kincolith River complex, and Nicomekl/Serpentine River complex; the Fraser River estuary was excluded) had the top HRS scores and were greatly different than the HRS for all other estuaries. Therefore these three estuaries were assigned an HRI value of 100. The estuary with the next highest HRS was then used as a base for scoring the remaining estuaries. Each HRS was then categorized as the HRI based upon the proportion of this estuary's score and grouped into percentiles (0-10%, 10-20%, 20-30% … 90-100%).

Species Rarity Index

The dataset used to estimate the Species Rarity Index for each estuary was the Physical and Biophysical Shorezone Mapping (version 1.0.0 Draft) dataset from the Ministry of Sustainable Resource Management (BCMSRM 2005; see Howes [2001] for details of data collection). Five intertidal vegetation and invertebrate classes of importance to waterbirds were examined to estimate presence and relative coverage of intertidal species at each estuary. The intertidal species classes used in near shore estuary habitat analyses were: 1) Mussels - California and Blue Mussels (MUS), 2) Kelp - *Macrocystis*, giant kelp and *Nereocystis*, nearshore bull kelp (KEL), 3) salt tolerant plants - *Salicornia*, goose grass, marsh grass and dune grass (SAL), 4) *Ulva* - sea lettuce (ULV) and 5) *Zostera* - eelgrass (ZOS). These were considered to be important species for supporting dabbling and diving ducks as well as other waterbird species in the nearshore environment.

This dataset does not include data for the Cowichan and Courtenay River estuaries so additional information regarding vegetation and invertebrate data was obtained from the Coastal Resource Folio compiled in 1981 (Moore *et al.* 1981). For a detailed methodology of the GIS steps used in this analysis, please see Appendix 2.

Determining the shorezone data that corresponded with a PECP Identified Estuary required generating points at 100m intervals (see Appendix 2 for details). For each point, a “nearest neighbour analysis” was performed to capture the relevant species attributes from the shorezone dataset. Many duplicate records were generated using this approach for long shorezone segments, and only one record for each species was retained for the summary. The 100m interval was chosen because this distance was tested and demonstrated to select even the smallest shorezone segments adequately without generating redundant data for a given shorezone feature.

In the shorezone dataset, coverage for each species class for each mapped coastline segment was scored as 0 (not present), 1 (partial coverage), or 2 (continuous coverage). Where there was duplicate information for a shorezone segment (i.e. both intertidal and subtidal presence of the species) the band with the highest score (i.e. continuous coverage) was used. Segments missing data were assigned a missing value to indicate that there was no data recorded. All estuaries were manually checked to ensure that anomalous shorezone segments were not included. As well, missed shorezone segments were manually included in the database. Shorezone segments incapable of being linked to any attribute data (due to an invalid physical identifier, i.e. unique identification code) were removed from the analysis. Some areas were not interpreted for intertidal species rarity because poor quality video imagery precluded accurate assignment of vegetation bands within the shorezone dataset (Appendix 2).

For each estuary, a rarity score (q_i) for each species (mussels, kelp, *Salicornia*, *Ulva*, and *Zostera*) was calculated based upon the species presence and estimated coverage within each shorezone segment found within the estuary. These rarity scores were used to determine the total rarity score for each species across all estuaries (Q_i). The species rarity score (SRS), based upon Turpie *et al.* (2002), for each estuary is defined as the sum of the proportional contributions an estuary makes to the provincial total of each of the five intertidal species

$$SRS = 100 * \sum_{i=1}^{n} r_i$$

where: r_i is the proportional contribution an estuary makes to the provincial total of the i^{th} species:

$$r_i = \frac{q_i}{Q_i}.$$

Below is an example of the SRS calculation for estuary x:

$$SRS_x = 100 * \begin{bmatrix} KEL & & SAL & & ULV & & ZOS & & MUS \\ \frac{3}{149} & + & \frac{7}{1198} & + & \frac{7}{916} & + & \frac{0}{414} & + & \frac{0}{164} \end{bmatrix}$$
$$= 100 * [0.02013 + 0.00584 + 0.00764 + 0 + 0]$$
$$= 3.361$$

One estuary had an SRS value much higher than all other estuaries and was therefore assigned a value of 100. The estuary with the next highest species rarity score was then considered as the estuary with the highest score. The species rarity index (SRI) for an estuary was calculated by determining the proportion its SRS is of the highest scoring estuary and then categorized by the percentile it fell within (0-10%, 10-20%, 20-30% … 90-100%).

Waterbird Density Index

Historical waterbird survey data was compiled from numerous databases including the Coastal Waterbird Inventory (CWI), West Coast Vancouver Island (WCVI) surveys, Bird Studies Canada (BSC) Coastal Waterbird Surveys, Baynes Sound surveys, and other CWS surveys. These surveys were conducted using air, ground, or boat survey methodologies.

The Coastal Waterbird Inventory[6] dataset is a compilation of many waterbird surveys conducted by the Canadian Wildlife Service, Ducks Unlimited Canada, and the Ministry of Environment from the 1960's to the 1980's. Surveys within the Coastal Waterbird Inventory had differing goals and objectives and employed aerial, boat, and ground survey methodologies to acquire data. These surveys include the entire coast of British Columbia except for a few estuaries that were too narrow to be flown.

The West Coast Vancouver Island surveys were aerial waterbird surveys conducted 3 times a year by Canadian Wildlife Service (CWS) biologists on the west coast of Vancouver Island in 1999 and 2000 (see Zydelis *et al.* 2005 for details).

The Bird Studies Canada Coastal Waterbird Surveys[7] contain data mainly for Vancouver Island and Lower Mainland estuaries. Bird Studies Canada, through

[6] Aerial observations were conducted using Otter or Beaver aircraft which have sufficiently slow flight speeds such that counts should be reasonable; generally the aircraft was positioned such that the birds were on the right hand side of the aircraft at all times. In most cases only 1 observer was present in the cockpit with one recorder. Of benefit, estuaries were circled in a clockwise fashion to count all birds present within the field of view so there was no left-side visibility bias for these surveys.

[7] All habitat stratifications (offshore, nearshore, and inland) were included in the analysis.

naturalist organisations and individual volunteers, collected this data. These surveys began in 1999 across a range of sites and are still ongoing. Only data up to 2002 is used in this report. All BSC surveys were conducted using ground-based counts.

A number of other datasets collected by CWS biologists using ground-based surveys provided data for estuaries on Vancouver Island and the Lower Mainland. Most of the surveys are reported in CWS Technical Reports and Occasional Papers (Butler *et al.* 1989; Comox-Strathcona Natural History Society 1994; Dawe *et al*. 1994a,b; Dawe and Buechert 1995; Dawe *et al*. 1995a,b,c; Dawe *et al*. 1997; Dawe and Buechert 1998; Vermeer and Morgan 1992a,b, Vermeer 1994, Vermeer *et al.* 1994). Waterbird surveys were conducted in Baynes Sound on Vancouver Island from 1980-81 by CWS and involved volunteers from the Comox-Strathcona Natural History Society (Dawe *et al*. 1997).

Data from an individual waterbird survey was only included if it was estuary specific and covered a suitable portion of the supratidal, intertidal and upstream interface of the estuary to give a representative count of the number of birds in the estuary. Data also were only included if the transect end point fell within three kilometres[8] of the estuary shoreline and within the lateral limits of the estuary[9]. This area was considered to be within the “sphere of influence” of an estuary and waterbird abundance could be ascribed to the estuary’s influence within this area.

Differences in the scale and spatial resolution of each dataset did not allow direct comparisons of the bird densities (birds/km versus birds/km^2) between the various datasets employed in this analysis. Therefore, all datasets were converted from polygons to linear polyline transects based upon the 1:250,000 coastlines. This allowed bird densities to be expressed as a birds/km measure for all datasets.

Only data from October 1 to March 31 when waterbirds are present on estuaries were considered for analysis. This time period is liberal but includes the migrating and wintering period of migratory birds and roughly corresponds to peak numbers reported in Butler and Vermeer (1994). Surveys were included as long as there was at least 1

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[8] Derived from a 1:250,000 base map.

[9] Two exceptions to the 3 km cut-off were: (1) a survey transect of approximately 5 km in length (2 km outside the 3 km buffer) from the southwest side of Skeena River estuary was included because the survey covered a substantial portion of that portion of the Skeena River estuary, and (2) a survey transect of approximately 25 km in length (6 km outside the 3 km buffer) from the east side of the Nass/Ksi’Higinx/Burton/Iknouk/Chambers/Kincolith River complex was included because the survey covered a substantial portion of the Nass/Ksi’Higinx/Burton/Lknouk/ Chambers/Kincolith River complex. These are two of the largest estuaries in B.C., outside the Fraser River estuary, so exceptions were made to identify bird use of these important sites.

record per month, regardless of the temporal continuity of the data, although most waterbird surveys were one-time inventories. This allows data that was collected within a calendar year (January to December) to be included even though data was collected over two separate winters.

Only a handful of species groups were used in this analysis and are referred to as waterbirds throughout this text. For our purposes, waterbirds were defined as ducks (both dabbling ducks and diving ducks), geese, swans, loons, and grebes. Specific species that are contained within each of these groups are listed in Table 2. Records that were identified to a known group (e.g. scoter, goldeneye) that would fall within one of the five above groups were also included in density estimates at an estuary.

Data was screened for potential bias, therefore incomplete records or surveys were omitted from the analysis. Records that could not be spatially identified were also omitted. Data from surveys that were targeting only a select few species were omitted. Only records that had a specific date were included in order to avoid monthly or yearly counts. See Appendix 3 for details regarding the specific records removed from this analysis.

Estuary use by waterbirds (waterbird importance score) was calculated as the sum of waterbirds of all species per kilometre per estuary per day. For estuaries with more than one transect or had surveys conducted over multiple days, the average waterbirds per kilometre per day was calculated so there was only a single estimate for each estuary.

Waterbird importance scores were skewed toward lower densities. Therefore, a natural log transformation was conducted and found the data to be approximately log-normally distributed. The normalized estuary data was classified on a scale of 0-100, relative to the estuary with the highest waterbird density. These scores were then classified by percentile (0-10%, 10-20%, 20-30% … 90-100%) to calculate the Waterbird Density Index.

Table 2: List of waterbird species used to calculate the Waterbird Density Index. Generic species groups (e.g. scoters, goldeneyes) were also used in the analysis.

Diving Ducks	Dabbling Ducks	Geese/Swans	Loons	Grebes
Barrow's Goldeneye	American Wigeon	Brant	Common Loon	Eared Grebe
Black Scoter	Blue-winged Teal	Canada Goose	Pacific Loon	Horned Grebe
Bufflehead	Cinnamon Teal	Greater White-fronted Goose	Red-throated Loon	Pie-billed Grebe
Canvasback	Eurasian Wigeon	Snow Goose	Yellow-billed Loon	Red-necked Grebe
Common Goldeneye	Gadwall	Trumpeter Swan		Western Grebe
Common Merganser	Green-winged Teal	Tundra Swan		
Greater Scaup	Mallard			
Harlequin Duck	Northern Pintail			
Hooded Merganser	Northern Shoveler			
Lesser Scaup	Wood Duck			
Long-tailed Duck				
Red-breasted Merganser				
Redhead				
Ring-necked Duck				
Ruddy Duck				
Surf Scoter				
White-winged Scoter				

Herring Spawn Index

The importance of estuaries as herring spawn areas, which provide important seasonal forage for waterbirds, was evaluated using data collected by the Department of Fisheries and Oceans (DFO) throughout coastal B.C. from 1928 to 2004[10] (McCarter *et al.* 2005). The surveys are used for herring stock assessment. The herring spawn index is used as a measure of habitat sensitivity because it takes into account both long-term frequency and magnitude of recorded herring spawn events over time.

Each year, coastal areas were surveyed by DFO if they had documented herring spawn events in previous years or if they were considered to be important areas. Available human resources affected the areas that were surveyed in a given year (Bruce McCarter, DFO, pers. comm. 2005). Spot spawns were not always recorded in the database. Points were placed along the coast at approximately 1 km intervals and a cumulative spawn habitat index (SHI) was calculated for each site (McCarter and Hay 2006) by summing an index for each year where the index is the length of spawn multiplied by the median of spawn width and egg layer thickness. This index estimates the frequency and magnitude of herring spawn events along a portion of coast. Due to limitations in the data, the SHI can only be considered a minimum cumulative estimate.

The SHI, as calculated by DFO, was used to determine each estuary's relative usage as a site for herring spawn events. Herring spawn points were assigned to an estuary if it fell within three kilometres of the shoreline and were within the lateral limits of the estuary. Half of the sites were manually verified to ensure that the appropriate attributes were associated with each estuary (See Appendix 4 for details of the GIS methodology). For estuaries with no herring spawn events it was assumed that either DFO considered the area to have no herring spawn events or that minor herring spawn events were missed at these sites, therefore these sites were adjusted to be scored in the lowest percentile for the herring spawn index (HSI). For estuaries with multiple herring spawn point locations, SHI scores were added together to calculate a cumulative herring spawn score for each estuary.

The distribution of herring spawn scores was not normally distributed; therefore, a natural log transformation of the data was used to (approximately) normalize the distribution prior to classification. To calculate the HSI, the normalized cumulative SHI scores for each estuary were classified on a scale of 0-100, relative to the highest

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[10] Data found at http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/cumulati.htm

cumulative herring spawn score and categorized by percentile (0-10%, 10-20%, 20-30% … 90-100%).

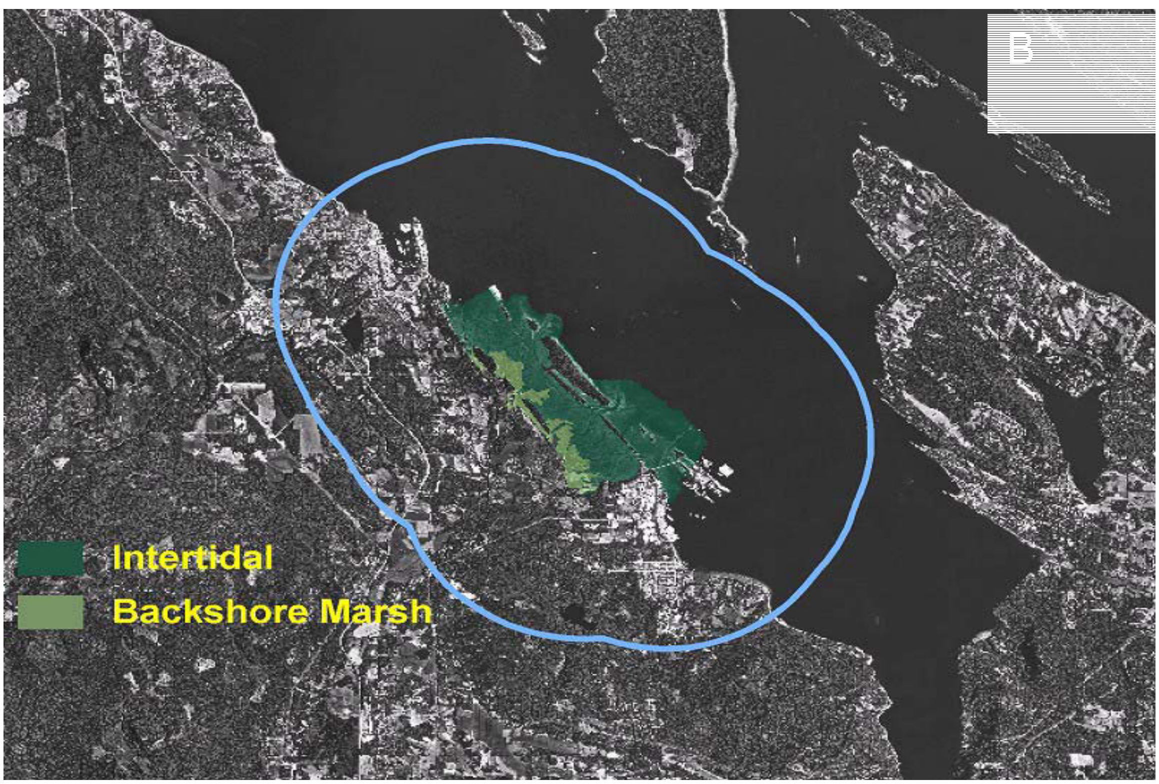
Classification into Importance Class

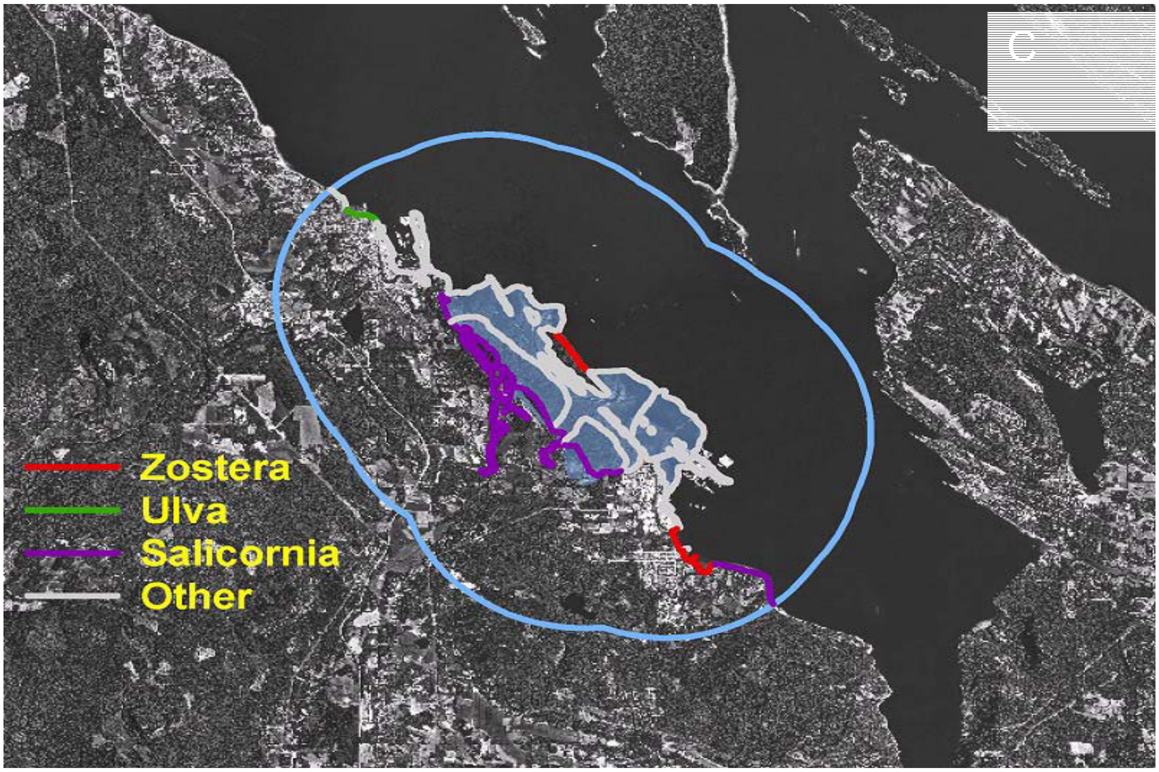
For some estuaries, estimates for one or both of the SRI (11.8% of all estuaries) and WDI (59.3% of all estuaries) variables were not available due to a lack of suitable surveys having been conducted at these estuaries. In these instances, the value was left blank and the importance score was estimated without the missing data. While assigning an average ranking value for each missing dataset was considered, this would have: a) obscured the data and b) provided an artificial value that may have either overestimated or underestimated the estuary score. Therefore, the rankings can be considered conservative for those estuaries missing data. This approach also highlights important data gaps that could be addressed in the future to improve the rankings for estuaries lacking relevant information.

Data used to determine each index value (for all but the estuary size index and habitat rarity index) included data that was collected within the bounds of the estuary itself and within a 3km zone of influence around the estuary. Estimates for species rarity, waterbird density, and herring spawn for an estuary are highly influenced by the amount of data available for an estuary. Figure 4 gives an example for the Chemainus River estuary ranking for a relatively data rich estuary. Although not discernable in the figure, differences in map scale between datasets was also a source of potential error in estimates of an estuary's biological importance.

The variables used in this equation, although distinct, may be correlated. The weightings of the variables were chosen to minimize any correlation and reflect the relative amount of rigor, spatio-temporal coverage, and confidences in the data sources. The Waterbird Density Index had the least amount of spatial coverage with many estuaries missing data, therefore, this variable was given a low weighting of 0.1. Of the remaining 90%, half was assigned to habitat factors (Estuary Size Index and Habitat Rarity Index) and half to biological factors (Species Rarity Index and Herring Spawn Index). Since the amount of rare habitat is likely to be correlated with estuary size and estimates of the amount of rare habitat in each estuary was coarse, more weighting was given to Size over the Habitat Rarity Index (0.3 versus 0.15). A slightly higher weighting was given to the Herring Spawn Index over the Species Rarity Index (0.25 versus 0.2) due to its lengthy temporal coverage and extensive spatial coverage.


A


B
Intertidal
Backshore Marsh


C
Zostera
Ulva
Salicornia
Other

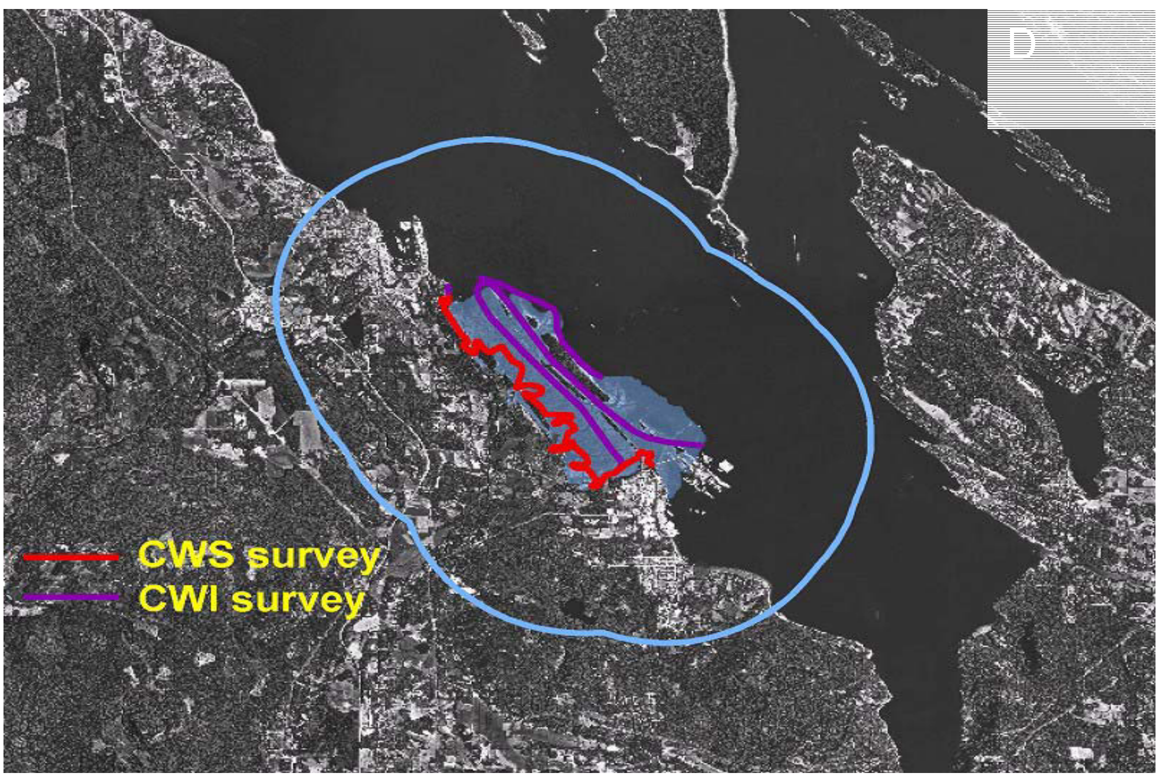

D
CWS survey
CWI survey

Figure 4: Example of the amount of data available at a data rich estuary for estimating the biological importance of an estuary (Chemainus River estuary, shown in solid blue). Data was present for estuary size (A), habitat rarity (B), species rarity (C), waterbird density (D), and herring spawn (E). The circle around the estuary represents the 3 km buffer within which relevant data were included in the rankings for the estuary.

Estuaries were classified into one of five Importance Classes based upon their relative importance score to the top scoring estuary. Each class represents 20% of the maximum Biological Importance Score and therefore does not represent 20% of the number of estuaries. Estuaries that had Biological Importance Scores ≥80% of the highest scoring estuary were classified as Importance Class 1; estuaries scoring 60-80% of the highest scoring estuary were classified in Importance Class 2 and so on (Figure 3).

Results

Estuary Statistics

The PECP estuary mapping project identified and mapped 442 estuaries along the coast of British Columbia (Figure 5). Appendix 1 details the estuary mapping specifications and guidelines. The majority of estuaries were found in the Coastal Gap

Figure 5: Location of the 442 PECP Identified Estuaries in British Columbia.

(140 estuaries), Pacific Ranges (73 estuaries), and West Vancouver Island (124 estuaries) ecoregions (see Figure 6 for location of ecoregions in British Columbia and Figure 7 for distribution of estuaries across ecoregions).

In total, the PECP Identified Estuaries cover 74,585 ha ranging in size from <1 ha to the 21,694 ha Fraser River estuary. Most estuaries in British Columbia are small (i.e. <10 ha) with four exceptionally large estuaries (i.e. >1,000 ha) located in the Lower Mainland and Coastal Gap ecoregions: Fraser River, Nicomekl/Serpentine River complex, Nass/Ksi'Higinx/Burton/Iknouk/Chambers/Kincolith River complex, and Skeena/Ecstall/ McNeil River complex. The largest estuaries (>1,000 ha) account for >63% of all estuarine area. Although the Lower Mainland ecoregion contains only a small proportion of all estuaries (Figure 7a), it contains 39% (Figure 7b, Table 3) of all estuarine area due to the presence of two of the largest estuaries: the Fraser River and the Nicomekl/Serpentine River complex. Figure 8 shows the distribution of estuary sizes in British Columbia as well as how much each of these size classes contributes to the total area of estuaries. Estuaries are comprised of a number of identifiable habitat types, such as intertidal flats, marsh/swamp, rivers/lakes, and islands. Intertidal flats make up the majority (~71%) of estuary habitat while river/lake (~19%) and marsh/swamp (~8%) habitats are the other most significant habitat types (Table 3).

Biological Importance Classes

Each of the 442 estuaries was placed in one of five Importance Classes (Table 4) based upon the biological attributes of the estuary (listed alphabetically). Importance Class 1 contains the highest ranked estuaries with relative rankings of 80-100% of the maximum scoring estuary, Importance Class 2 are estuaries with relative rankings of 60-80% and so on. Classification of estuaries into five Importance Classes, as determined by their Biological Importance Scores, results in only a few estuaries in the highest Importance Class (Figure 9, Table 4). In total, 49 estuaries are in the top two Importance Classes, representing all but one ecoregion (Figure 10). However, estuaries of high importance are not distributed equally across the province. The East Vancouver Island and West Vancouver Island ecoregions have the most high-ranked estuaries (14 and 11 estuaries in Importance Class 1 and 2 combined respectively) but few low-ranked estuaries. Figure 11 shows that top ranked estuaries are concentrated along the east and northwest coast of Vancouver Island and the Lower Mainland of British Columbia. Smaller concentrations are seen within some inlets along the central coast as well as the

Figure 6: Ecoregions of British Columbia (Demarchi 1995) containing estuaries.

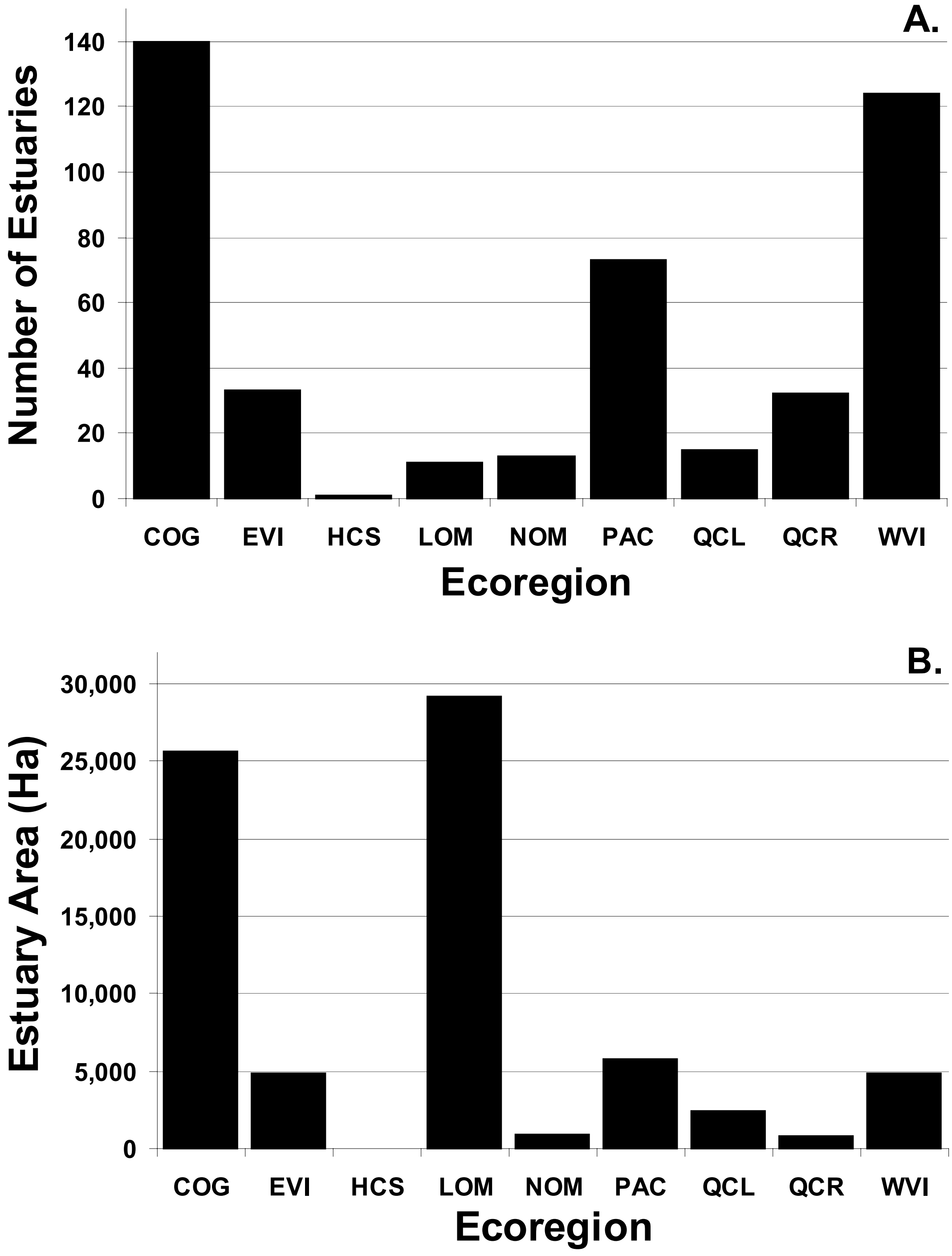


Figure 7: Distribution of (A.) estuaries across ecoregions and (B.) estuary area in each ecoregion. Definition of ecoregion acronyms are: COG= Coastal Gap, EVI= East Vancouver Island, HCS= Hecate Continental Shelf, LOM= Lower Mainland, NOM= Northern Coastal Mountains, PAC= Pacific Ranges, QCL= Queen Charlotte Lowland, QCR= Queen Charlotte Ranges, and WVI= West Vancouver Island.

Table 3: Breakdown of estuaries into component habitat types (measured in hectares) for each of the nine ecoregions. Included is the total area of each habitat type in British Columbia as well as the total estuarine area in each ecoregion.

	Ecoregion									
Habitat Type	**COG**	**EVI**	**HCS**	**LOM**	**NOM**	**PAC**	**QCL**	**QCR**	**WVI**	**TOTAL**
Intertidal Flats	14,768	4,065	<1	22,847	717	3,813	2,327	768	3,967	53,270
River/Lake	9,776	120	<1	3,525	75	373	57	62	387	14,374
Marsh/Swamp	934	675		2,773	161	1,041	12	24	427	6,047
Island	129	111		<1	<1	557	4	1	88	890
Unidentified		<1		1					3	4
TOTAL	25,607	4,863.1	<1	29,145	952	5,783	2,400	855	4,871	74,585

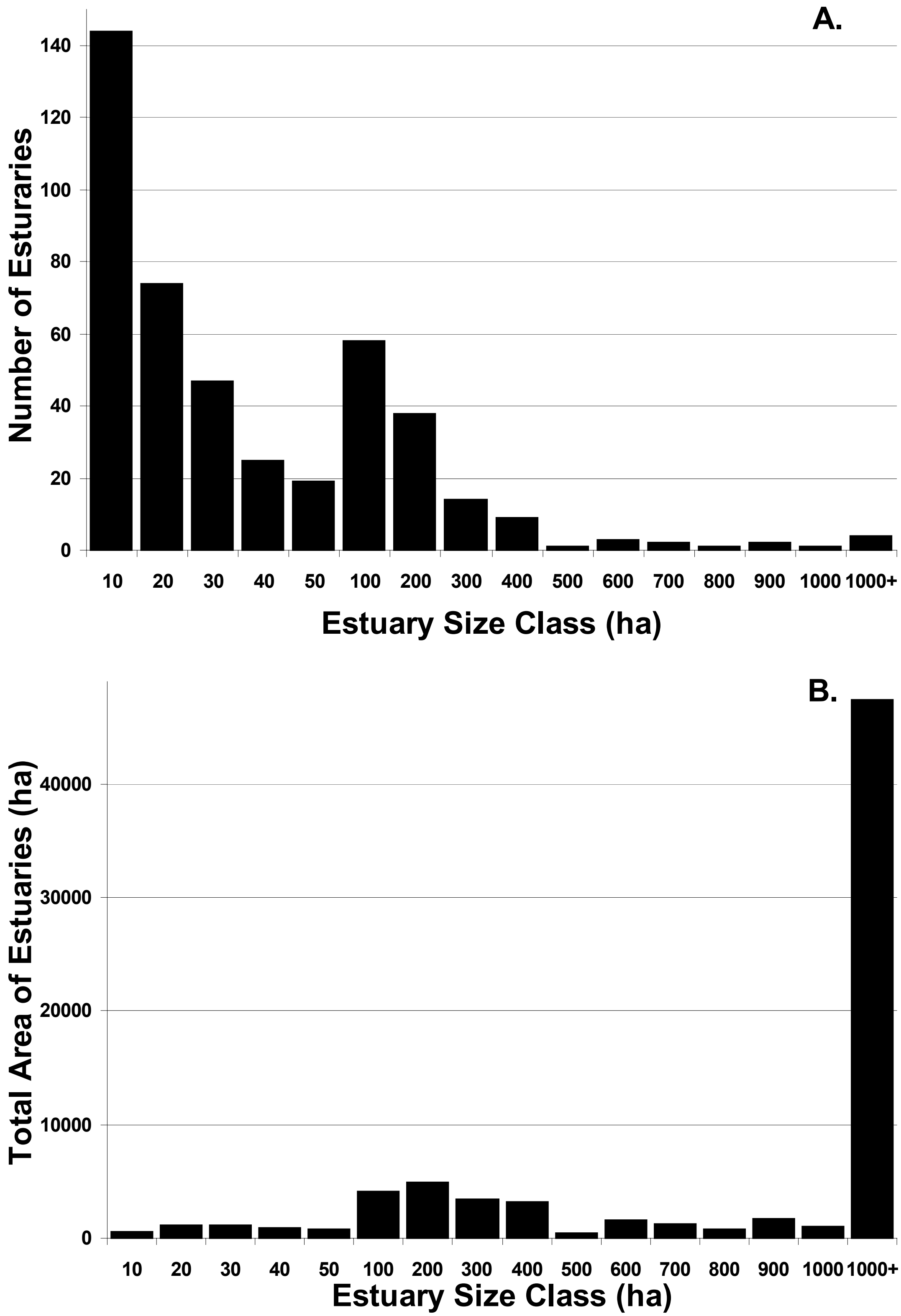


Figure 8: Distribution of estuaries by size class (A.) and contribution of each size class to the total 74,585 ha of estuarine area in British Columbia (B.).

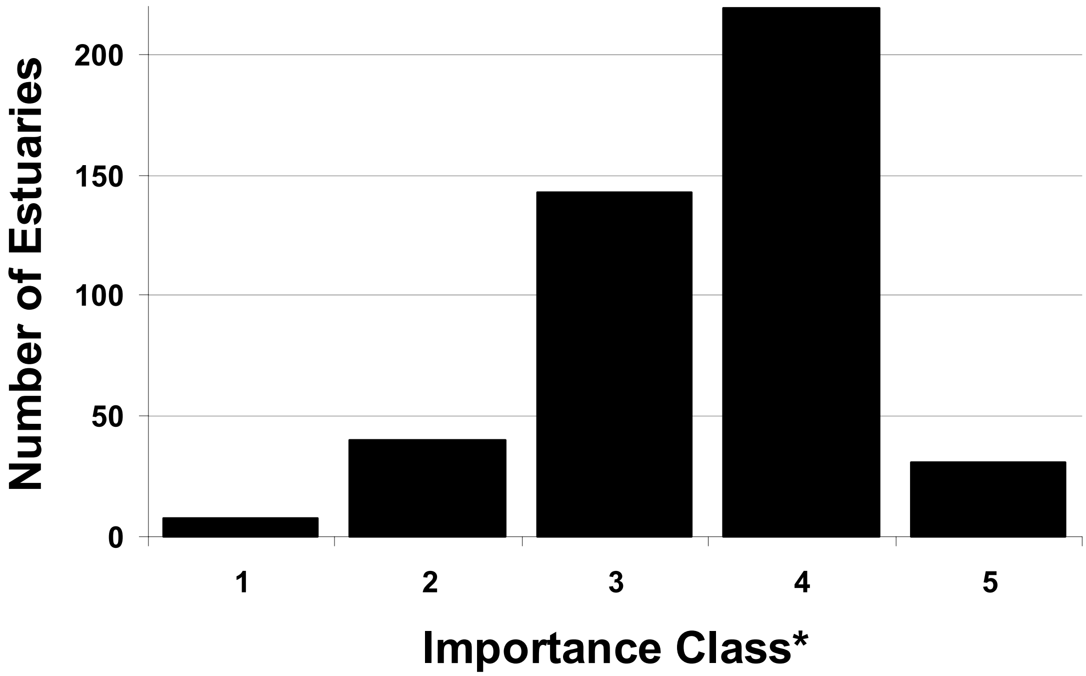


Figure 9: Distribution of estuaries across the five Importance Classes (* as defined by the PECP). Importance Class 1 corresponds to estuaries ranked 80-100% of the top scoring estuary, Importance Class 2 corresponds to estuaries ranked 60-80%, and so on. Please note that this analysis did not include the Fraser River estuary.

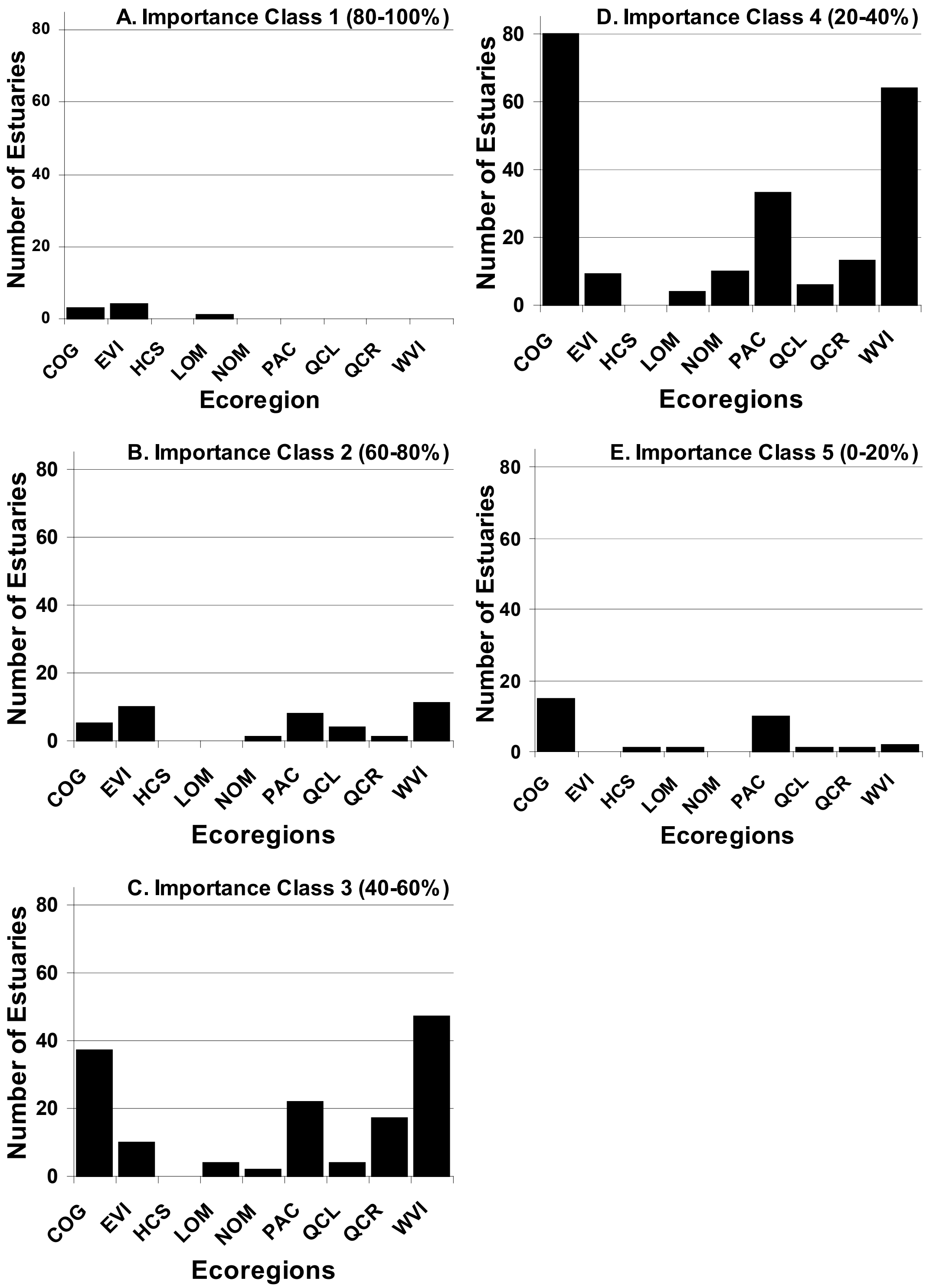


Figure 10: Distribution of estuaries across ecoregions for each Importance Class. Graph A. shows estuaries ranked in Importance Class 1 (80-100%), B. is Importance Class 2 (60-80%), C. is Importance Class 3 (40-60%), D. is Importance Class 4 (20-40%), and E. is Importance Class 5 (0-20%). Please note that this analysis did not include the Fraser River estuary

Table 4: All PECP Identified Estuaries, with the exception of the Fraser River, were placed in one of 5 Importance Classes based upon the biological attributes of the estuary (listed alphabetically). Importance Class 1 contains the highest ranked estuaries with relative rankings of 80-100% of the maximum scoring estuary, Importance Class 2 are estuaries with relative rankings of 60-80% and so on. Estuaries marked with a (†) are missing a score for the Species Rarity Index (SRI), those marked with a (††) are missing a score for the Waterbird Density Index (WDI), and those marked with a (†††) are missing a score for both the SRI and WDI.

Importance Class	PECP Identified Estuaries within each Importance Class
1	Chemainus River/Bonsall Creek Complex, Courtenay River, Cowichan River, Georgetown Creek, Kitimat River, Nanaimo River, Nicomekl/Serpentine River Complex†††, Skeena/Ecstall/McNeil River Complex††
2	Bella Coola/Necleetsconnay River Complex, Big Qualicum River, Billy Creek, Clanninick Creek, Cypre River, Denad Creek, East Creek, Englishman River, Fanny Bay/Cowie Creek, Franklin River, Hansen/Rasmus/Fisherman River Complex, Hart Creek, Homathko/Teaquahan River Complex, Kilbella/Chuckwalla River Complex, Kingcome River, Kitlope/Tsaytis River Complex††, Kitsault/Illiance River Complex, Klinaklini River, Kumdis Creek, Kwatleo Creek††, Lignite Creek, Little Qualicum River, Maggie River, Malksope River, Mud Bay/Rosewall/Waterloo Creek Complex†, Naden River/Davidson Creek Complex††, Nanoose/Bonell Creek Complex†, Nasparti River, Nekite River, Oyster River, Quaal River/Kitkiata Creek Complex, Seal Inlet, Stanley Creek, Toquart River, Trent River, Tsable River, Wakeman River, Wannock/Nicknaqueet River Complex, Wathl Creek, Yuquot Point
3	Adam River, Ahta River, Amor de Cosmos Creek, Apple River††, Artlish River, Asseek River, Atleo River††, Beano Creek††, Bear River [2††], Bedwell Creek, Beresford Creek††, Bilston Creek, Bish Creek, Black Creek, Braverman Creek, Campbell River (1) †††, Campbell River (2), Canton Creek, Cayaghis Creek, Christie River, Clayton Falls Creek††, Cluxewe River, Clyak River, Coates Creek††, Colquitz River, Conuma River, Cow Bay, Dala River, Dass Creek††, Dean River††, Deena Creek††, Empetrum Lake††, Evader Creek, Falls River, Fulmore/Shoal Creek Complex††, Gilttoyees River, Glenlion River, Goldstream River††, Goodspeed River, Gorge Waters/Craigflower Creek, Grant Bay††, Hana Koot Creek††, Hankin Point††, Hathaway Creek, Hesquiat River††, Ickna Creek††, James Bay††, Kainet Creek, Kakushdish Harbour Area††, Kakweiken River, Kaouk River, Kapoose Creek††, Kdelmashan Creek††, Kemano/Wahoo River Complex††, Keogh River, Khutze River††, Khutzeymateen River††, Kildala River, Kimsquit/Hoam Creek Complex, Klaskish River††, Klekane River, Klootchlimmis Creek, Koeye River, Koprino River, Kowesas River††, Kromann/Moore Cove Creek Complex, Kshwan River†††, Kutcous Point, Kwatna River, Kwinamass River, Leiner River, Lipsett Creek††, Lois River†, Lucky Creek††, Mace Creek††, Mackenzie Cove††, Marble River, Marvinas Bay††, McClinton/Unnamed Creek Complex††, McKay Cove††, Mercer Lake††, Mill Stream††, Millar Channel, Mosquito Bay††, Mountain Creek, Nass/Ksi'Hlginx/Burton/Iknouck/Chambers/Kincolith River Complex†††, Neekas Creek††, Nimmo Bay, Nimpkish River, Noeick River††, Nooseseck River, Nordstrom Cove††, Oona River, Orford River, Otard Creek††, Otun Creek††, Ououkinsh/Unnamed River Complex, Powell River†††, Power River, Quatlena River, Quatse River/Boyden Creek Complex, Salmon River, San Josef River, Sarita River, Security Cove, Seymour River (2), Shushartie River, Sialun Creek††, Sim River††, Skopun

Importance Class	PECP Identified Estuaries within each Importance Class
	River††, Skowquiltz River, Sliammon Creek†, Somas River, Sombrio Creek††, Southgate River, Squamish River†, Stafford River, Stranby River, Tahsish River, Takush River, Taleomey River, Tankeeah River††, Tartu Inlet, Tasu Creek, Toba/Tahumming River Complex††, Tom Browne Creek, Toon River, Tsowwin River††, Tsulquate River††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Viner Sound††, Wahkash Creek, Wanokana Creek††, Wathlsto Creek††, Waukwaas Creek, Weeteeam Bay Area††, Western Lake Chain††, Yakoun River, Youghpan Creek††, Zeballos River
4	Aaltanhash River††, Ada Cove††, Ahnuhati River††, Ain River††, Amos Creek††, Arnoup Creek††, Barrie Creek††, Battle Bay, Bazett Island Area††, Bear River [1] ††, Belowe Creek††, Betteridge Inlet Area, Blind Creek††, Bloomfield Lake††, Bolivar Islet, Bonanza Creek††, Bottleneck Inlet†††, Brem River, Brim River/Owyacumish Creek Complex††, Brittain River†††, Bulson Creek, Burman River, Camper Creek††, Canoona River††, Capilano River†, Captain Cove, Carmanah Creek, Carter River††, Cascade Creek††, Cave Creek††, Chambers Creek†, Charles Creek††, Cheewhat River††, China Creek, Clesklagh Creek††, Coeur d'Alene Creek††, Cohoe Creek††, Coleman Creek††, Cornwall Inlet†††, Cous Creek, Crab River††, Cullite Creek††, Datlamen Creek††, Doc Creek, Donahue Creek††, Draney Creek†, Dunn Point Area††, Easy Inlet, Effingham River†, Ellerslie Lagoon, Ensheshese River††, Escalante River††, Espinosa Creek, Evelyn Creek††, Flat Creek, Foch Lagoon, Frederick Arm†††, Furry Creek†††, Georgie River††, Gibraltar Point††, Gilford Creek††, Goat River††, Gold River, Gordon River, Green Lagoon†††, Gudal Creek††, Gustafson Bay†, Haines Creek††, Hans Point††, Head of Kootenay Inlet††, Heydon Creek††, Hiellen River††, Hird Point††, Holti Point††, Hosu Cove††, Hot Springs Creek††, Houston River††, Ice River†††, Indian River†††, Ingram Creek††, Irony Creek, Jacklah River††, Jalun River††, Jordan River††, Jump Across Creek††, Kashutl River, Kauwinch River, Keecha Creek††, Keith River††, Kennedy River, Keswar Inlet††, Kewquodie Creek, Keyarka Cove†††, Kiltuish River††, Kingfisher Creek, Kingkown Inlet††, Kirby Creek††, Kiskosh Creek, Klanawa River††, Kleeptee Creek††, Kloiya River††, Kokish River, Kooryet Creek††, Kootenay Inlet††, Kumealon Creek†††, Kwalate River††, Lagins Creek, Lard Creek††, Lime Creek††, Link River††, Little Zeballos River††, Logan Creek††, Lombard Point††, Loss Creek††, Lull Creek, Macjack River††, Mackenzie Lake††, Macktush Creek, MacNair Creek††, Mahatta Creek††, Mamin Creek††, Mamquam River†††, Marmot River††, Mathieson Channel††, McCurdy Creek††, McNab Creek†††, Megin River, Milton River, Moh Creek††, Mohun Creek, Moneses Lake††, Mooyah River, Moyeha River, Muir Creek††, Mussel River††, Nahmint River, Nahwitti River††, Naka Creek, Nascall River†, Nitinat River, Nootum River, Nusash Creek††, Oeanda River††, Oih Creek††, Oyster Bay††, Pa-aat River††, Pachena River, Paril River††, Phillips River††, Pike Creek††, Poison Cove Creek††, Price Cove††, Pye Creek††, Quartcha Creek††, Quatam River, Quigley Creek††, Rainbow Creek††, Restless Bight††, Restoration Bay††, Riley Creek††, Roscoe Creek††, Salter Lake††, San Juan River††, Schmidt Creek††, Scott Cove††, Scow Bay††, Sechelt Creek†, Seymour River (1) †, Silverado Creek††, Skwawka River†††, Snass Lake††, Snug Basin††, Songhees Creek††, Sooke River†, Spiller Inlet††, Stagoo Creek††, Stakawus Creek†††, Stannard Creek††, Stawamus River†††, Sucwoa River, Surf River††, Sutslem Creek††, Swallop Creek††, Sydney River, Taaltz Creek††, Tahsis River, Theodosia River††, Thulme River††, Tlell River††, Tlupana/Nesook River Complex††, Tofino Creek, Tranquil River†, Triumph River††, Tsitika River††, Tyler Creek††, Tzoonie River†, Unnamed†, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Unnamed††, Vancouver River/High

Importance Class	PECP Identified Estuaries within each Importance Class
	Creek Complex[†], Walbran Creek[††], Walt Creek[††], Waterfall Inlet[††], Waump Creek[††], Weewanie Creek[††], Whitly Point[††], Woodcock Islands Area[††], Yeo Lake[††]
5	Banks Lakes[††], Clowhom River[†], Earle Creek[†††], Farquhar River[††], Four Lakes[††], Grand Creek[†††], Henderson Lake[†††], Hevenor Lagoon[†††], Huaskin Lake[††], Jermaine Point Area[††], Jesse River[†††], Kumdis Slough[††], Kumowdah River[††], Kwakwa River[†††], Long Lake[†††], Lynn Creek[†††], Mill Creek[†††], Misery Creek[†††], Rainy River[†††], Roderick Cove[††], Shade Island area[††], Treat Creek[†††], Tsimtack Lake[†††], Unnamed[††], Unnamed[††], Unnamed[††], Unnamed[††], Unnamed[††], Unnamed[††], Upper Victoria Lake Chain[††], Village Bay[††]

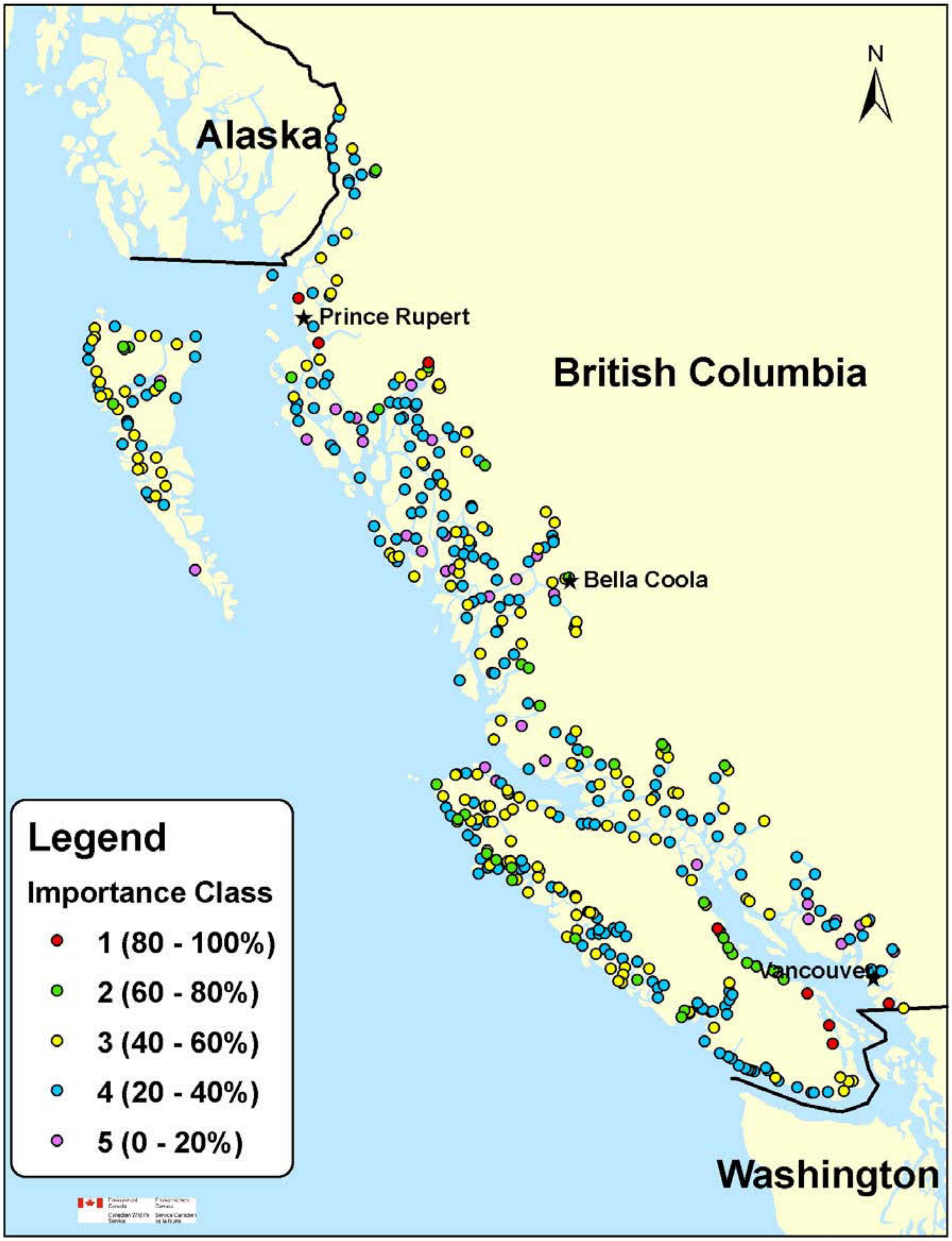


Figure 11: Importance Class of each estuary. The lower mainland, the east coast of Vancouver Island, and the northwest coast of Vancouver Island have concentrations of estuaries ranked in the top two classes while other top ranking estuaries are distributed across the central coast and Queen Charlotte Islands. Please note that this analysis did not include the Fraser River estuary.

northern Queen Charlotte Islands. Many estuaries had very similar importance scores which resulted in many estuaries being placed in the third and fourth (20-40% and 40-60% classes) Importance Classes. Similar importance scores arise due to actual similarity between estuaries, missing data, and/or the interplay of the five attributes used to rank estuaries (i.e. small estuary with high species diversity and/or herring spawn has a similar score to a larger estuary with lower values of other attributes). Unlike the third and fourth Importance Classes, Importance Class 1 and 5 have estuary distributions across ecoregions that differ from the overall distribution of estuaries across ecoregions (Figure 7 versus Figure 10).

Discussion

The main goal of the estuary mapping project was to provide PECP partners with an objective, scientifically defensible, regional biophysical assessment of estuaries along the British Columbia coast. Program partners expressed interest in the development of a comprehensive approach to identify and map estuaries, and to determine the biological importance of estuaries to support strategic conservation planning and decision making. The assessment described here enables partners to evaluate and compare the relative biological importance of estuaries for waterbirds, derived from a suite of spatially explicit attributes with the results available to identify securement or restoration opportunities.

The first step identified and mapped 442 of the largest estuaries in British Columbia. In addition to mapping the size, location, and habitat attributes of the estuaries, other existing datasets were used to rank the relative biological importance of each estuary, defined according to the planning requirements of the PECP. While 442 estuaries were identified, mapped, and ranked based on relative biological importance, many smaller estuaries, and many estuaries identified by Hunter *et al*. (1985), were not considered or evaluated in this assessment.

As mentioned, the Fraser River estuary was not ranked following the same methodology as the other estuaries. Existing datasets for the Fraser River estuary were unavailable or inconsistent with the standardized requirements used in our analysis. Due to its immense size and adjoining land uses (e.g. Vancouver International Airport); many waterbird surveys only examined portions of the estuary, not the entire estuary. The shorezone dataset used for calculating the Species Rarity Index had no data for the Fraser River estuary. This resulted in an inability to develop scores for the relevant indices and the Fraser River would have been ranked in Importance Class 2. However, the high biological value of the Fraser River estuary has been substantiated. The significance of the Fraser River estuary, relative to other estuaries in British Columbia and western North America, has been documented (FREMP 2003). The

Fraser River estuary has been designated as an Important Bird Area due to its high waterbird abundances (McKelvey 1986; McKelvey and Summers 1990; Butler and Campbell 1987; Butler and Cannings 1989; Butler *et al.* 1989; Butler and Vermeer 1994; Summers *et al.* 1994, 1996).

Estuaries in Importance Classes 1 and 5 can be contrasted in terms of their characteristics. Estuaries in Importance Class 1 are typically large with high index values for at least two other attributes. Although two of the top ranking estuaries have missing data, they do score in the top percentile in three categories in which they do have data. Estuaries that were ranked in Importance Class 5 were typically quite small, scored very low in the Habitat Rarity Index and Herring Spawn Index, and were missing data for at least one of the Species Rarity Index or Waterbird Density Index. Estuaries in Importance Class 2 through 4 can best be described as a continuum between Importance Class 1 and 5. For example, general trends include a decrease in size and an increase in the frequency of missing data where 25% of estuaries in Importance Class 1 are missing data while 7%, 47%, 79%, and 100% of estuaries in Importance Classes 2 through 5 respectively are missing data (Table 4). This outcome highlighted a major limitation of ranking procedures where data are deficient at a given site; the utility of the rankings would be considerably strengthened if these data gaps were addressed with additional survey effort. For the purpose of this assessment, interpretation of the estuary scores should be interpreted with caution and then used only for the purposes of strategic landscape planning. The PECP partners recognize the inherent values of all estuaries along the British Columbia coast and will continue to develop innovative strategies to secure estuary habitat throughout British Columbia.

Uses of Mapped and Ranked Estuaries

For the PECP, mapping estuaries at a scale suitable for strategic landscape planning, with the subsequent ranking of estuaries based upon their biological importance, now provides a versatile tool for conservation purposes. Firstly, mapping estuaries in such detail provides a spatially explicit foundation upon which to accumulate future information, such as understanding habitat use by waterbirds. The baseline or benchmark status or condition of biological or physical resources can be combined with waterbird species population information to develop habitat-species associations at a landscape level for predictions of the spatial distribution of a species. Secondly, the process of ranking estuaries also highlights data gaps. For instance, the high number of estuaries (>59%) that are missing waterbird surveys that are at an estuary-specific spatial scale is a substantial data gap. Therefore this information could be used to direct future efforts for surveys. Thirdly, it provides knowledge of the current biological attributes or biological potential of an estuary, which can be combined with an estuary's current conservation and socio-economic status (Gilkeson *et al.* 2006), to create a prioritization list for conservation initiatives (e.g. Guikema and Milke 1999; Turpie *et al.* 2002).

Ranking of estuaries also has more general applications than the specific needs of the PECP. The product has great potential to identify areas of interest for current and future coastal land and resource management planning, owing to its broad regional applicability and the fact that it is spatially explicit. In addition, the assessment could be used as an aid in environmental assessment (EA). Although it has limited utility for site specific EA, and is intended for application at a regional level, the rankings provide broad context for large developments (e.g. pipelines or aquaculture) and estimating cumulative response impacts and/or effects in areas with multiple, concurrent development pressures. Mapping and ranking of estuaries is also important for preparation and response to ecological emergencies such as oil spills.

Many studies have suggested identifying representative sites in order to ensure conservation of ecological processes across a large landscape (e.g. Turpie *et al.* 2002; Beazley *et al.* 2005). The data and calculations used here could possibly be used in a similar analysis, thereby directing conservation efforts to establish a network of representative estuaries to maintain ecological integrity.

Appropriate Uses and Limitations

There are several limitations with respect to how the mapping and ranking results can be used for other purposes. Many are a result of limitations with the source datasets used to produce the maps and rankings. These limitations include: a) varying scales of map input data, b) varying quality and resolution of input data, c) substantial data gaps (lack of spatial and temporal coverage), and d) used existing data only with no mapping from new air photos or field work included. Additionally, the results and comparisons are applicable only at a regional, landscape level scale, not at a site-specific scale.

In addition to these systemic limitations, the use of the rankings is limited to the stated purposes and goals of this project. The results are intended to provide a value-added product for application toward strategic conservation planning for the PECP. Although many of the province's larger estuaries were likely identified and mapped in this exercise, many of the smaller estuaries would not have been identified using these queries and therefore was not a complete census of British Columbia's estuaries. Many of these smaller estuaries may have high biological values and require separate identification and assessment of importance. It is highly recommended that the reader acknowledge these limitations before applying the results of this report to their own needs.

The issue of mapping scale has several implications in this report. Estuaries are mapped at a 1:10,000 scale. However, as documented in Appendix 1, some data used to define boundaries of an estuary, or habitat within, were originally mapped at a coarser scale leading to potential errors in the location of boundaries (e.g. airphotos at scales ranging from 1:15,000 to 1:40,000). The multitude of datasets that were overlaid and used to map estuaries also increases the probability that interpretation errors of habitat types occurred. It must be recognized that no ground-truthing or verification of the mapping results using other sources of images or maps has been conducted. Considering that the dataset is intended for strategic planning only, it is highly recommended that the mapped estuaries not be used for applications at a scale finer than 1:20,000.

The biological data used in determining the estuary rankings, such as the waterbird densities and herring spawn index, came from a variety of datasets and sources of varying spatial scales. The scale of the shorezone dataset also varied, depending on the geographic location of the linework along the British Columbia coast. These differences in scale between inputs may cause some inaccuracies in the estimated index values and the overall Biological Importance Score for some estuaries. Appendices 2-4 have detailed notes about limitations and errors encountered during the compilation and analyses of the biophysical datasets.

As noted above, ranking estuaries is meant to be used for strategic landscape-level assessment, and can be used to draw broad inference with respect to the spatial arrangement and patterns of estuary importance. The results could also be used toward regional or sub-regional identification of areas of interest. These rankings cannot be used for site-specific assessment or as a site-specific ranking tool, as they use index values to compare estuaries relative to each other. Relative rankings are appropriate for comparison across sites. Estuaries that currently have low importance scores do have considerable ecological value and as new data becomes available this value will be substantiated. The estuary rankings reported here do not replace site-specific assessments or the need for detailed monitoring of resource status and trend.

Although data for the Species Rarity Index, Waterbird Density Index, and Herring Spawn Index was included and used in the estuary rankings if the observations fell within a 3km area surrounding an estuary, the mapping extent covers only the intertidal and nearshore environments. Therefore, little extrapolation of the value of adjacent marine or terrestrial habitat can be inferred from this data. It must also be stressed that the type of adjacent marine (e.g.

subtidal areas of upwelling) or terrestrial (e.g. farmland) habitat played no direct role in this analysis in determining the biological importance of an estuary. The influence of any adjacent habitat features or activities is an important factor to review in any site-specific analysis.

Only a few datasets contained sufficient data at a consistent scale required for the rankings. These datasets have differences that need to be considered in the interpretation of the rankings. Few of the input datasets have current survey information and estimates. The time of data capture for most of the datasets may not reflect the current attributes of an estuary, and therefore the estuary score may not reflect an estuary's present state or condition. For example, an estuary may become degraded over time with resulting negative effects on nearshore organisms that are not reflected in the available data; alternatively, conservation efforts (e.g. planting of eelgrass) may have improved habitat conditions and the condition of nearshore resources.

Also, populations of waterbirds typically fluctuate over time, possibly resulting in one estuary being ranked relatively higher or lower than another estuary compared with current conditions. This outcome may be an artefact of the timing of past surveys at various estuaries rather than a true change in the relative status of waterbird populations. Many of the datasets used for the Waterbird Density Index calculations contained records collected as early as the 1970's while the most recent data is from 2002. Due to the variety of datasets used in calculating the WDI, there were different methodologies employed in conducting waterbird surveys including aerial, boat, and ground surveys. Estuaries where boat or ground surveys were conducted may have waterbird densities that differ from estimates gathered had aerial surveys been conducted. Additionally, many of the estuary surveys were one-time inventories of waterbirds collected across a range of sites and in different years. Most of the estimates reported here may not reflect site-specific trends or current status of waterbird populations.

There are significant data gaps in the waterbird data and the species rarity data. Estuaries with low Biological Importance Scores were often estuaries with missing data (Table 4). Missing data results in an underestimate of the importance of some estuaries, as a result, some estuaries may be placed in a lower importance class. This is particularly true for estuaries that have missing data but are just below the threshold for being placed in a higher importance class; estuaries missing more than one dataset will likely have grossly underestimated importance scores. These rankings must be considered as conservative estimates of an estuary's importance because missing data were left blank instead of inserting a minimal or average value. Estuaries of specific interest that have missing data could be evaluated separately using additional sources of data through either the collection and analysis of additional survey data or expert opinion of an estuary's biological values where data are entirely lacking.

Confirmation of Estuary Rankings

This report presents the details of the mapping and analytical tools and approaches used to develop Biological Importance Scores and ranking of PECP Identified Estuaries. A number of limitations were identified and discussed above with respect to the process of ranking estuaries. The most important of these limitations is the scale of the data and its representation of the current attributes of the estuary. Filling the identified data gaps, conducting up-to-date surveys on the status and trends of nearshore biological resources, and ground-truthing the boundaries of the estuaries and their habitats against other data sources will help to minimize these limitations and increase the rigour, relevance, and accuracy of the results.

Validation that the highest ranked estuaries are indeed the most biologically important estuaries is needed. Three ways of testing the predicted rankings are to 1) examine the weightings used for determining the Biological Importance Score and 2) compare the rankings to other independent ranking schemes, and 3) continue to monitor the status and/or trend of the biological resources used in this ranking exercise and compare to the baseline condition. The weightings chosen for each attribute in the ranking procedure were subjective and based upon expert opinion. To validate the results of the ranking procedure, sensitivity analysis of the weighting values could be conducted to determine how much the Biological Importance Score, and subsequently an estuary's ranking changes. A second test could involve comparing these rankings to rankings based on, for example, importance to fisheries or predictors of shorebird presence such as estuary wave exposure and substrate type.

Monitoring of the biological status and trend of the resources used in this ranking exercise should be conducted. As conservation measures are implemented in the future, monitoring of waterbird abundance, herring spawn, and prevalence of intertidal species (e.g. *Zostera* or *Salicornia*), will allow for program evaluation to be conducted and adaptive management strategies to be put in place through comparisons to this baseline data. A current state assessment of these resources and comparisons to baseline conditions is the only way that the success or failures of conservation efforts can be measured, tracked, and reported effectively.

Summary

As outlined above, a formal spatial description of an ecosystem is needed for effective conservation planning (Lackey 1998; Carpenter *et al.* 1999; Haufler *et al.* 2002). With respect to the PECP and their needs for conserving estuaries in British Columbia, developing criteria to map and rank 442 identified estuaries provides an important piece of information to assist decision making. This assessment provides a foundation that enables agencies to quantify the location, amount, and status of biophysical resources present at estuaries across the region. The findings reported here provide valuable information that can be used to direct scarce conservation resources toward securing the most important estuaries, should opportunities become available.

In combination with other pertinent information regarding estuaries, such as conservation tenure status, development threats, additional wildlife values, and socioeconomic attributes, the PECP can focus future efforts on a strategic assessment of estuaries for effective implementation of conservation initiatives (see Gilkeson *et al.* 2006 for an example). Such an assessment requires a multi-disciplinary approach to prioritize estuaries based on multiple ecological and socio-economic decision criteria, and is consistent with meeting the principles of sustainable development that most resource management agencies are now striving to achieve.

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Acronyms

BCNHLWG	British Columbia Nearshore Habitat Loss Working Group
BCMELP	British Columbia Ministry of Environment, Land, and Parks
BCMSRM	Ministry of Sustainable Resource Management
BMC	Backshore marsh chart only
BMU	Blue Mussel
BSC	Bird Studies Canada
CHS	Canadian Hydrographic Service
COG	Coastal Gap
CWI	Coastal Waterbird Inventory
CWS	Canadian Wildlife Service
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
ESI	Estuary Size Index
ESRI	Environmental Systems Research Institute
EVI	East Vancouver Island
FREMP	Fraser River Estuary Management Plan
GBAP	Georgia Basin Action Plan
GIS	Geographic Information System
HCS	Hecate Continental Shelf
HRI	Habitat Rarity Index
HRS	Habitat Rarity Score
HSI	Herring Spawn Index
KEL	Kelp
NAWMP	North American Waterfowl Management Plan
NDI	Nautical Data International
NOM	Northern Coastal Mountains
NTDB	National Topographic Database
NTS	National Topographic Series
PAC	Pacific Ranges
PCJV	Pacific Coast Joint Venture
PECP	Pacific Estuary Conservation Program
QCL	Queen Charlotte Lowlands
QCR	Queen Charlotte Ranges
SAL	*Salicornia*
SHI	Spawn Habitat Index
SHIM	Sensitive Habitat Inventory Mapping
SRI	Species Rarity Index
SRS	Species Rarity Score
TRIM	Terrain Resource Inventory Mapping
ULV	*Ulva*
WCVI	West Coast Vancouver Island Surveys
WIS	Waterbird Importance Score
WDI	Waterbird Density Index
WVI	West Vancouver Island
ZOS	*Zostera*

Appendix 1: Mapping Specifications and Guidelines for PECP Identified Estuaries in British Columbia

Mapping specifications and guidelines for PECP identified estuaries in British Columbia

(includes supratidal and intertidal features derived from 1:20,000 TRIM I&II provincial basemaps and digital orthophotos, 1:50,000 NTS Watershed Atlas, 1:variable scale CHS/NDI digital marine charts, 1:2,500 FREMP v.1.0 August 1998 maps, and 1:variable scale airphotos)

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Version April 2004

PACIFIC ESTUARY CONSERVATION PROGRAM

Table of Contents

Section I: Intertidal zone mapping criteria

I. Estimation of estuary intertidal area

The intertidal zone features for each estuary system or complex are captured as polygons within the area found below the provincial Terrain Resource Inventory Mapping (TRIM) 1:20,000 coastline or island shoreline (<Mean higher high water mark) and above the 0 chart datum contour line (>Lowest normal tide) depicted on Canadian Hydrographic Service (CHS) charts. Estuary complexes include multiple river/streams flowing into a shared intertidal zone. The TRIM coastline or island shoreline is used to separate the backshore/intertidal zones and the CHS charts are used to separate the intertidal/subtidal zones. Subtidal features below 0 chart datum contour are not included in this version of the mapping.

II. Mapping layers and features used for querying, verifying, capturing and digitizing of intertidal polygon boundaries

Mapping data sources: 1:20,000 TRIM I & II provincial basemaps, 1:variable scale CHS charts, 1:variable scale NDI digital raster charts (BSB v.3.0 2000), 1:50,000 NTS mapsheets (Watershed Atlas), 1:20,000 TRIM orthophotos (various years, where available), and 1:variable scale airphotos (various years, where available).

Relevant feature codes and descriptions for intertidal mapping:

TRIM layer (twtr coverage): GA90000110 (left bank), and GA90000120 (right bank), GA24850000 (river/stream "definite"), GA24850140 (river/stream "indefinite"), GA24850150 (river/stream “intermittent”), GG05800000 (coastline "definite"), GG95800130 (coastline "indefinite"), GE25850000 (sand/gravel bar), GC17100000 (Marsh area outline), GC30050000 (Swamp area outline), GE14850000 (island to scale), GE09400000 (dyke), GE03050110 (breakwall/breakwater-large), GE26250000 (seawall), GA08450000 (dam-section.top), GA98450100 (dam-section.bottom).

CHS/NDI raster layer: coastline, 0 chart datum, river/stream/creek, lake, marsh, islands, swamp, jetty, peninsula, stones/gravel, rocky area, mud, sand (features may be depicted above or below TRIM coastline dependent on map scale).

NTS layer (Watershed Atlas coverage): WA21100000 (coastline), WA21100111 (construction line, coastline), WA24100110 (single-line blueline, mainflow), WA24100120 (single-line blueline, mainflow through wetland), WA24100130 (single-line blueline, secondary flow), WA24100140 (single-line blueline, secondary flow through wetland), WA24111110 (construction line, mainflow), WA24111120 (construction line, double-line river, main flow), WA24111130 (construction line, secondary flow), WA24111150 (construction line, double-line river, secondary flow), WA24200110 (double-line blueline, right bank), WA24200120 (double-line blueline, right bank shared with wetland), WA24200130 (double-line blueline, left bank), WA24200140 (double-line blueline, left bank shared with wetland).

III. Estuary location queries (river/stream intersection with coastline)

Each estuary system was identified from one or both of the following queries:
a) query of 1:20,000 TRIM double-lined river/stream (>20m width) intersection of left bank with (i) coastline or (ii) island shoreline (for estuaries on nearshore/offshore islands), or b) query of 1:50,000 NTS Watershed Atlas (WSA) for ≥ 4th order river/stream intersection with coastline. For the TRIM query, hanging double-lined river/streams near the coastline, that would normally intersect the coastline if they continued, were included as estuaries. Queried estuaries that were also located by Hunter *et al.* (1985) should be noted in the database (see Appendix 1 below for description). Each river/stream located from these queries is referred to below as the primary river/stream.

Secondary river/stream(s) or ditches either: a) flow into the primary river/stream channel(s), within a maximum upstream distance of 500m from the primary river/stream mouth(s), or b) intersect the coastline, within the limits of the intertidal zone, for the primary river/stream (see mapping criteria below for intertidal boundaries). Secondary river/streams were not located using the above queries, and were not considered as estuaries for this exercise.

IV. General polygon capture and digitizing rules

1) Capture and digitize all relevant intertidal estuary features at a scale of 1:10,000. Capture or digitize common area boundaries for each estuary feature/polygon only once.
2) TRIM and CHS charts are the primary reference layers for capturing and digitizing relevant intertidal features as polygons. Use TRIM twtr layer to locate primary single or double-lined river/stream intersection points with TRIM coastline (identified from TRIM and/or WSA query). For double-lined river/stream(s) the left-bank feature code is used to close the coastline in TRIM, but this may not be the river/stream mouth (see below for river/stream mouth definition). For the TRIM layer, verify coastline features with 1:50,000 Watershed Atlas layers and CHS charts. Consult CHS charts for intertidal zone, coastline, and intertidal features (i.e. marsh, swamp, and islands) that may not have been captured in TRIM.
3) Where there is a discrepancy between the CHS coastline/0 chart datum linework relative to 1:20K TRIM coastline, owing to problems of scale or otherwise, consider the TRIM coastline to be the true coastline depiction since it was digitized at 1:20,000. This is

a better scale compared to most of the CHS charts. DO NOT shift CHS chart images to match TRIM linework unless they are of similar scale and there is an obvious projection problem. Some interpretation and interpolation of features will be necessary in some areas.

4) The boundaries of the intertidal zone for a given estuary should not generally extend into another bay, delta, mudflat, fjord, etc. that is outside the approximate geographic “zone” of the delta or bay where the primary river/stream enters that delta or bay. If an airphoto or orthophoto is available, the forward and lateral boundaries of the intertidal zone for a given estuary can be approximately verified from the extent of the freshwater plume extending from the primary river/stream into the delta or bay.
5) All intertidal zone features for a given primary river/stream estuary system or complex are captured within the area where the 0 chart datum contour line (from CHS charts/NDI digital chart layers) intersects with the TRIM coastline at ≥ 2 locations to form a closed intertidal delta polygon. The intertidal zone is present between the subtidal zone and the TRIM coastline or island shoreline. For a double-lined river/stream in TRIM, the intertidal zone is below the primary river/stream mouth(s) which is/are generally, but not always, delineated by the apparent high water mark.
6) The mouth(s) of a primary river/stream(s) are located where a river/stream or associated channels open into the nearshore bay or delta (based on TRIM map layer features) as follows: a) for a single-lined river/stream, the point(s) at which they intersect the coastline, b) for a double-lined river/stream with one channel, the point at which the left/right banks open toward the ocean, whereby a breakline can be drawn to connect the banks to close the coastline, and c) for a double-lined river/stream with ≥ 2 channels, with islands present between the channels, the points at which each channel opens toward the ocean. ***Note that the TRIM apparent high water mark is often, but NOT always, the mouth of the estuary for b and c. It is not applied consistently and accurately enough to define the mouth of an estuary in all cases.**

   DO NOT use training walls or dykes (TRIM fcode GE09400000) to identify/delineate river/stream mouth(s), only islands and other natural geological features. Mouth(s) may be present below the upstream extent of the intertidal delta/marsh depicted on CHS charts. The charts often do not show the primary river/stream channel where it flows through the delta.
7) The intertidal boundaries of the primary river/stream should not overlap the intertidal zone of another primary single or double-lined river/stream(s) unless the primary

river/stream(s) flows into a shared delta, bay or section of coastline as the primary river/stream being digitized. In this case, the primary river/stream(s) and intertidal zone forms part of an estuary complex comprised of ≥ 2 primary river/stream(s), the intertidal zone, and all backshore/ supratidal or upstream features associated with the primary river/stream(s).

8) Where the 0 chart datum contour line is parallel and continuous below the coastline, for a given primary river/stream, and does not intersect the coastline, digitize an intertidal breakline where the distance between the 0 chart datum contour line and the TRIM coastline narrows to **120m**. Owing to the variety of available CHS chart scales, on an earlier version of the mapping project we used a narrowing distance of 2mm to digitize a breakline(s), corresponding to where the coastline and 0 chart datum distance narrowed to 2mm. The 120m cutoff point is used because the majority of chart scales are either at 1:40,000 or 1:80,000, so the average CHS map scale is 1:60,000. The breakline distance has been standardized, whereby 2mm=120m at the average scale; this becomes the minimum distance to close continuous coastline and 0 chart datum contours.

   *** If the 0 chart datum line and the coastline features are continuous and the distance between the coastline and the 0 chart datum line is already <120m at the primary river/stream mouth proceed to step 3 of mapping/digitizing criteria below.**

9) Where step 3 is used, shoreline habitat changes can include a change from mudflat to rocky shoreline, sandbar, sand/gravel bars, anthropogenic alteration (piers, docks, etc.) as per features found on CHS charts, NTS, or where present in TRIM, above or below the coastline. Use the best chart scale available to verify shoreline habitat changes in each area, in combination with other map layers. Consider the first shoreline habitat change as the relevant location to digitize a breakline where step 3 is used, provided that the habitat change occurs at the periphery of the approximate intertidal boundaries of the bay or delta of the primary river/stream. Do not arbitrarily create a breakline from habitat changes where they occur within the lateral limits of the intertidal zone if the intertidal zone can otherwise be closed using steps 1 and 2.

10) If criteria 1-3 below cannot be used to create a breakline(s) from the 0 chart datum contour line to the coastline, within the lateral limits of the “enclosed” area of a bay, delta, mudflat, or fjord, then criteria 4 or 5 can be used. **Criteria 4 and 5 are primarily applicable to the east coast of Vancouver Island and the Mainland coast where in many areas the 0 chart datum contour line parallels the TRIM coastline without intersecting the coastline**.

11) Within the intertidal zone, all TRIM marsh, swamp, lake, non-forested island and other unconfirmed linework are captured as separate and distinct intertidal polygons, as per Section II below. Intertidal areas that are not otherwise shown as distinct features in TRIM, between the TRIM coastline and the 0 chart datum contour line, should be captured as intertidal delta.
12) Sand/gravel bar linework present within the boundaries of the intertidal zone do not require separate polygons as they are a reflection of low water conditions and are captured adequately within the intertidal zone boundaries. These features <u>can</u> be used to digitize breaklines where habitat changes occur as per criteria 3.
13) If the mouth(s) of a primary river/stream intersects a marsh, swamp, or non-forested island (an island not confirmed as a wooded area feature in TRIM tcvr layer) polygon feature present between the primary river/stream channel(s) banks, where the majority of the polygon area is present <u>below</u> the river/stream mouth in the intertidal zone, code the entire polygon as intertidal (see codes in Appendix 1). If the feature is a forested island, see Section II, part IV, rule 8 of criteria below.
14) Exclude TRIM breakwall/breakwater, seawall, or dam features present in intertidal areas, as donuts (exclude linework with 10m buffer, 5m either side).
15) Use the lateral extent of the intertidal boundary for a given primary river/stream to determine the approximate extent of the area to search for backshore/upstream polygon features associated with the estuary being digitized (relevant to Part II of criteria below). The area to look for relevant features is within the limits of the intertidal zone up to a maximum upstream distance of 500m, the breakline for most primary river/stream(s).

V. Intertidal (below mean higher high water line or coastline to 0 chart datum) mapping/digitizing criteria

1. Single or double-lined primary river/stream located from query. Below the primary river/stream mouth(s), the 0 chart datum contour line intersects the TRIM coastline at ≥ 2 locations, and a closed intertidal polygon can be digitized and captured between 0 chart datum and coastline.

1a Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum contour line intersects with TRIM coastline at ≥ 2 locations. A closed intertidal delta polygon can be digitized/captured (see Fig. 1a below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, go to step 1 backshore digitizing criteria below, otherwise go to step 1b*

1b Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum contour line intersects with the TRIM coastline at ≥ 2 locations, but the outflow of the primary river/stream channel(s) shown on CHS charts splits the intertidal delta into one or more sections, or the intertidal flat has been dredged creating a channel that splits the delta into one or more sections. Digitize connector lines across channel(s) to form a continuous contour line along the 0 chart datum line. A closed intertidal delta polygon can be digitized/captured (see Figs. 1b and 1c below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and primary river/stream channel(s) or open water areas within the intertidal delta above the 0 chart datum contour, go to step 1 supratidal digitizing criteria below, otherwise for presence of continuous 0 chart datum contour line that cannot be used to close intertidal zone go to step 2*

2. Single or double-lined primary river/stream located from query. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline, and does not intersect the TRIM coastline at ≥ 1 location. Distance between 0 chart datum and coastline narrows to 120m.

2a Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline, does not intersect TRIM coastline at ≥ 1 locations, but the distance between 0 chart datum contour line to coastline narrows to ≤ **120m** (not dependent on chart scale) and a breakline can be digitized from the 0 chart datum contour line to the coastline at the 120m breakpoint. A closed intertidal delta polygon can be digitized/captured using steps 1 and 2 (see Fig. 2a and 2b below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and primary river/stream channel(s) or open water areas within the intertidal delta above the 0 chart datum contour, go to step 1 supratidal digitizing criteria below, otherwise for presence of continuous 0 chart datum contour line that cannot be used to close intertidal zone polygon go to step 3*

3. Single or double-lined primary river/stream located from query. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline, and does not intersect the TRIM coastline or narrow to 120m between 0 chart datum and coastline at ≥ 1 location. Coastline habitat changes are apparent at periphery of intertidal zone.

3a Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline and criteria 1-2 cannot be used to create breaklines. A coastline habitat change (i.e. from mudflat to rocky intertidal), above or below the coastline is depicted, and a breakline can be digitized from the 0 chart datum contour line to the new habitat feature. A closed intertidal delta polygon can be digitized/captured using steps 1-3 (see Fig. 3 below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and primary river/stream channel(s) or open water areas within the intertidal delta above the 0 chart datum contour, go to step 1 supratidal digitizing criteria below, otherwise for presence of continuous 0 chart datum contour line that cannot be used to close intertidal zone go to step 4*

4. Single or double-lined primary river/stream located from query. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline, does not intersect the TRIM coastline, does not narrow to 120m between 0 chart datum and coastline, and there are no coastline habitat changes at ≥ 1 location. Geographic features (peninsulas, spits, jetty's) are present that separate intertidal bays or deltas.

4a Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline and criteria 1-3 cannot be used to create breaklines, but a logical geographic breakpoint is depicted (i.e. peninsula, spit, jetty, etc.), and a breakline can be digitized from the 0 chart datum contour line to the geographic breakpoint. A closed intertidal delta polygon can be digitized/captured using steps 1-4 (see Fig. 4a and 4b below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and primary river/stream channel(s) or open water areas within the intertidal delta above the*

0 chart datum contour, go to step 1 supratidal digitizing criteria below, otherwise for presence of continuous 0 chart datum contour line that cannot be used to close intertidal zone go to step 5

5. Single or double-lined primary river/stream located from query. Below the primary river/stream mouth(s), the 0 chart datum contour line runs continuous and parallel to the TRIM coastline, does not intersect the TRIM coastline, does not narrow to 120m between 0 chart datum and coastline, and no habitat changes or logical geographic breakpoints are present. A named secondary river/stream is present (identified from any map source) above or below the primary river/stream being captured and digitized.

5a Single or double-lined primary "definite" river/stream(s) or channel(s) intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream. Below the primary river/stream mouth(s), the 0 chart datum intertidal/subtidal contour line runs continuous and parallel to the TRIM coastline and criteria 1-4 cannot be used to create breaklines, but a named secondary river/stream is present, and a breakline can be digitized at the mid-point between the secondary and primary river/stream. A closed intertidal delta polygon can be digitized/captured using steps 1-5 (see Fig. 5a below for example).

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and primary river/stream channel(s) or open water areas within the intertidal delta above the 0 chart datum contour, go to step 1 supratidal digitizing criteria below*

VI. Intertidal mapping/digitizing examples

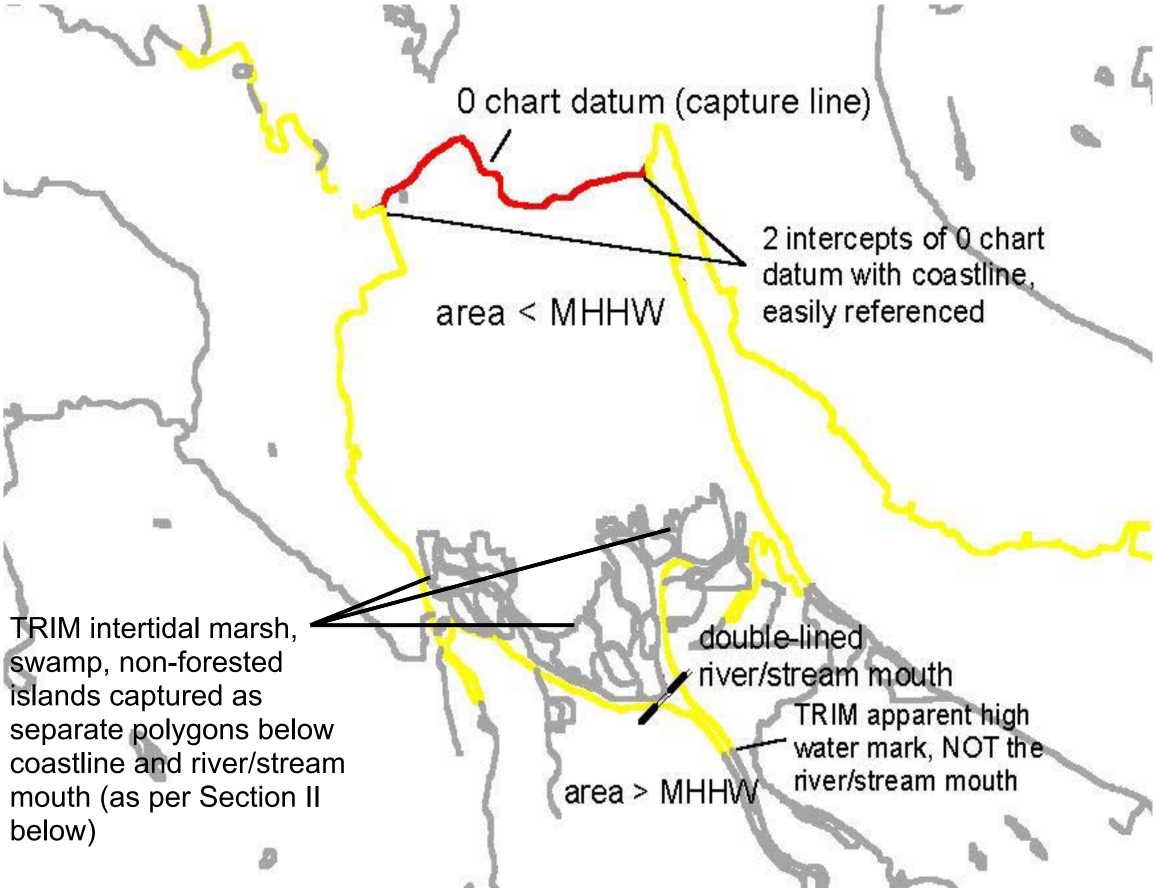

Fig. 1a. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum contour line intersects with coastline at ≥ 2 locations, intertidal zone can be captured from 0 chart datum/coastline intersection up to river/stream mouth (coastline or MHHW in yellow, 0 chart datum line in red, Nanaimo estuary shown).

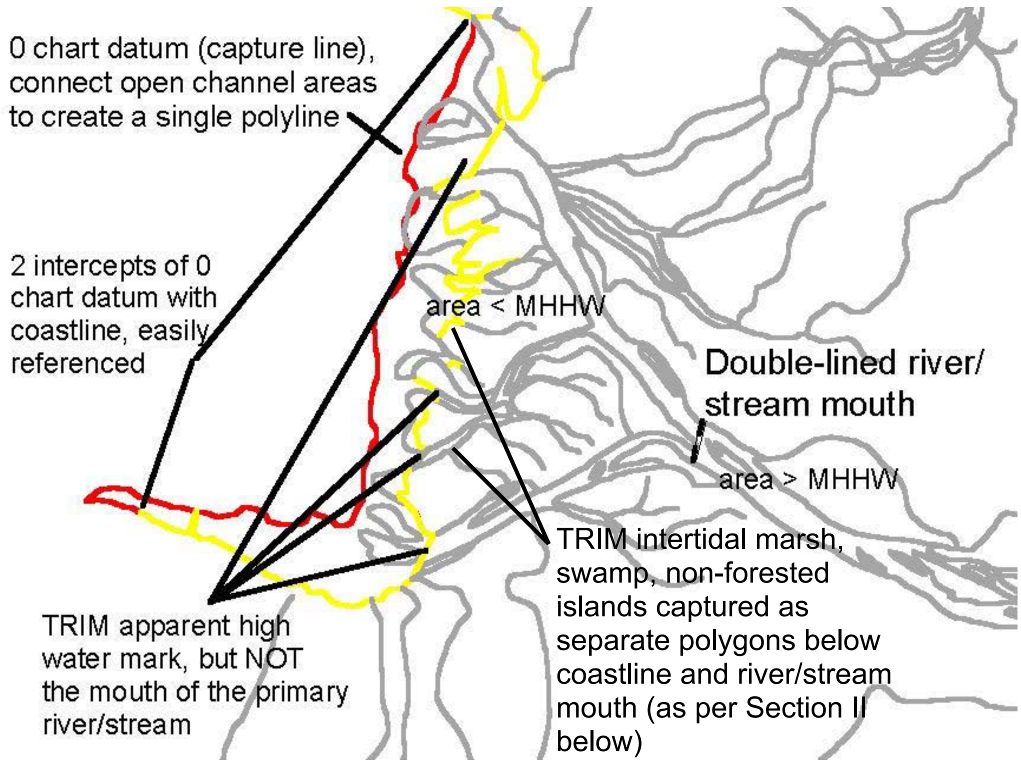

Fig. 1b. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum contour line intersects with coastline at ≥ 2 locations, but outflow of primary river/stream channel(s) splits intertidal delta into one or more sections or intertidal delta has been dredged, intertidal zone can be captured by digitizing connector lines across channels or dredged areas (coastline or MHHW in yellow, 0 chart datum line in red, Bella Coola estuary shown).

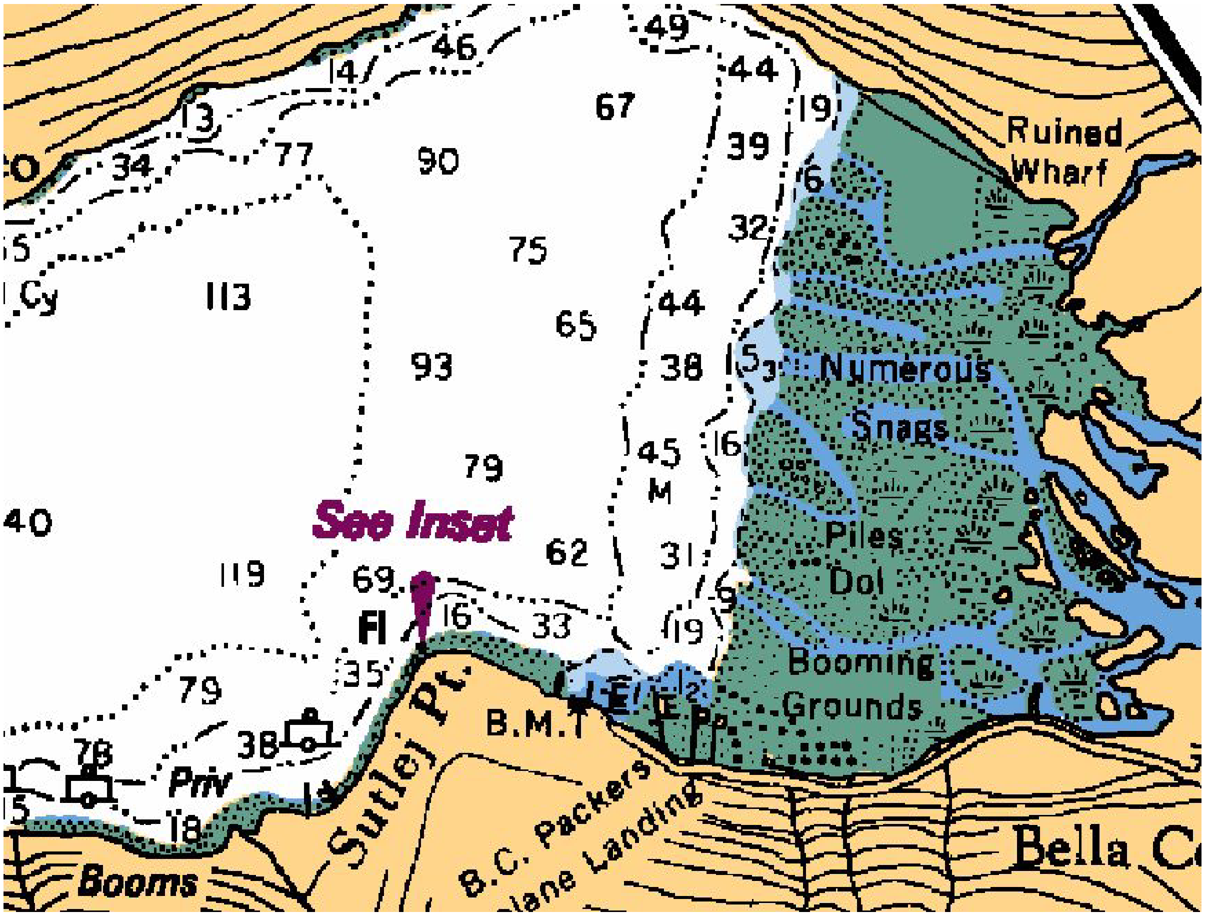

Fig. 1c. Bella Coola River estuary on CHS chart showing intertidal delta and outflow of primary river/stream channels that splits the delta (Canadian Hydrographic Service, 1996).

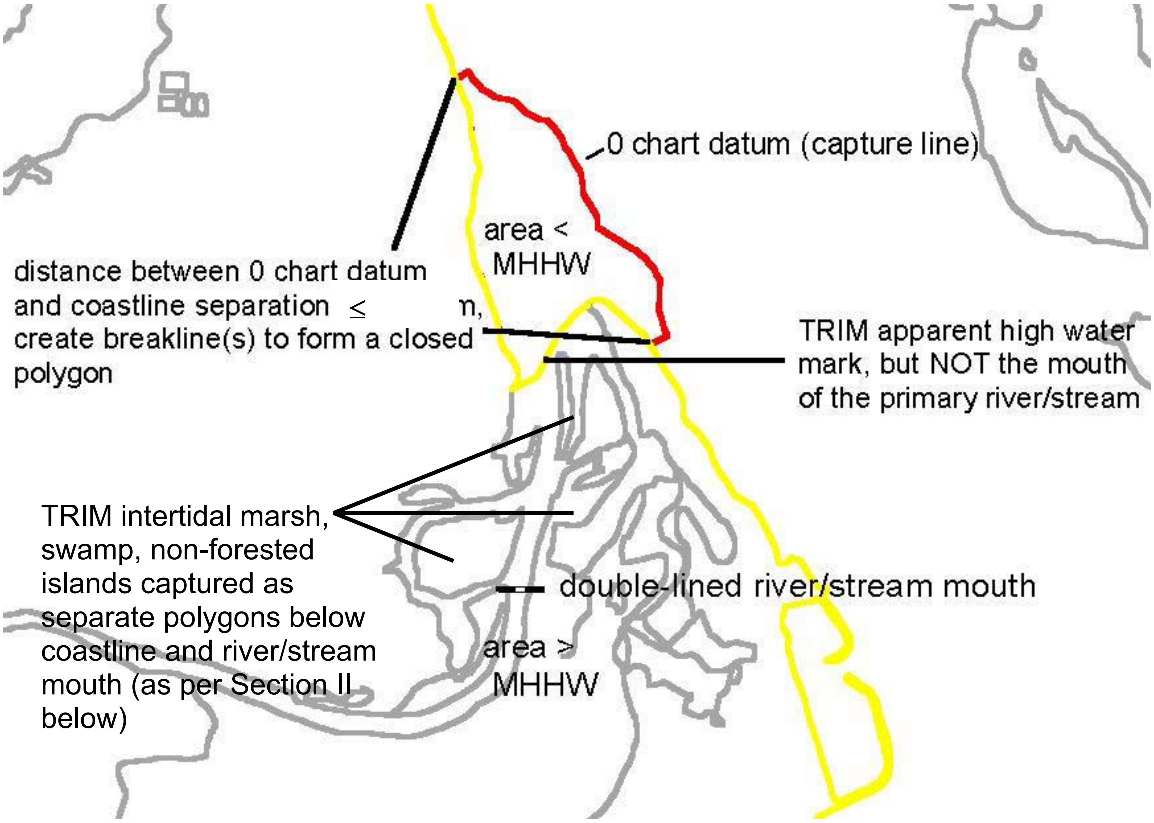

Fig. 2a. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum contour line <u>does not</u> intersect coastline at ≥ 1 locations and runs continuous parallel to the coastline, <u>but</u> distance between 0 chart datum and coastline narrows to ≤ 120m, intertidal zone can be captured by digitizing breakline(s) at 120m breakpoints (coastline or MHHW in yellow, 0 chart datum line in red, Campbell River estuary shown).

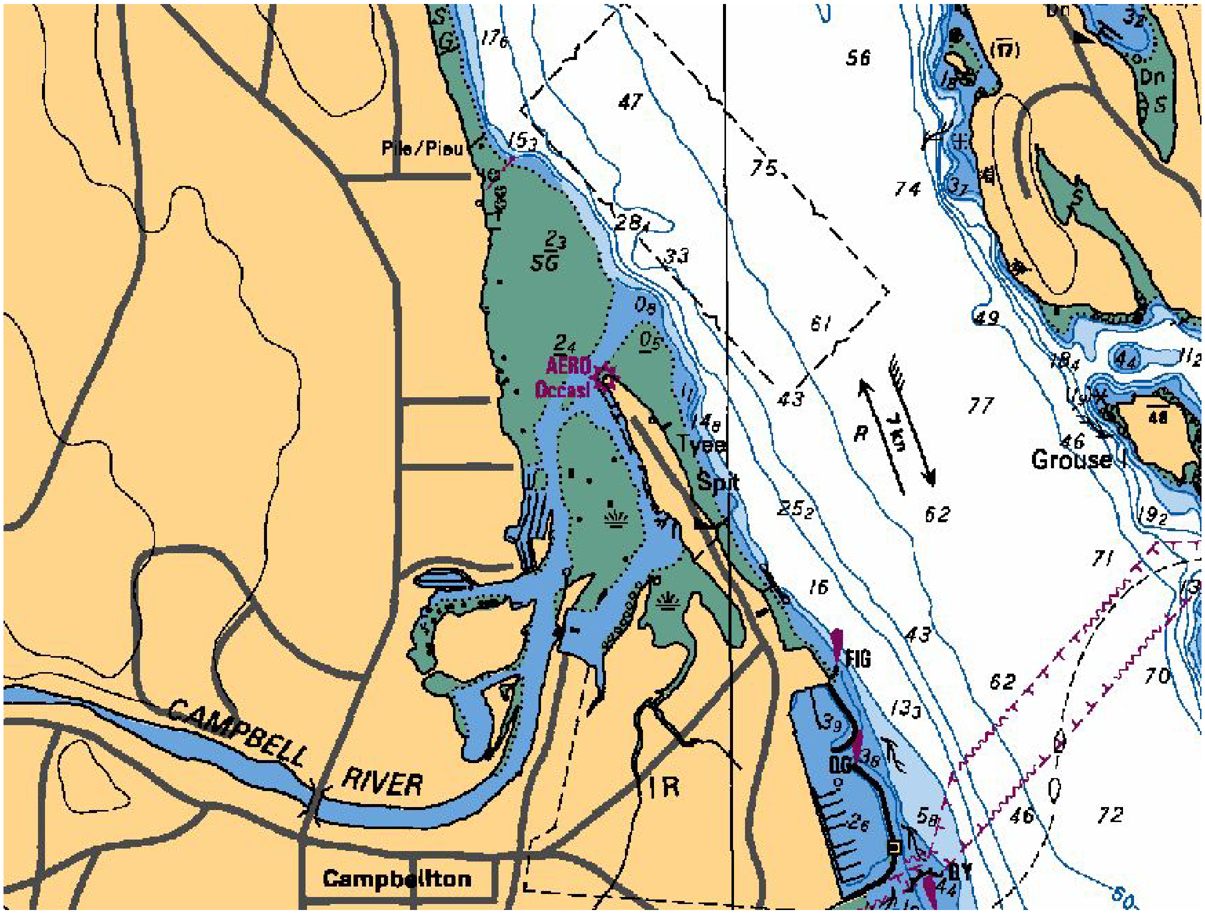

Fig. 2b. Campbell River estuary on CHS chart showing intertidal delta, outflow of primary river/stream channels that splits the delta, and narrowing of 0 chart datum/coastline to distance of ≤ 120m (Canadian Hydrographic Service, 1996).

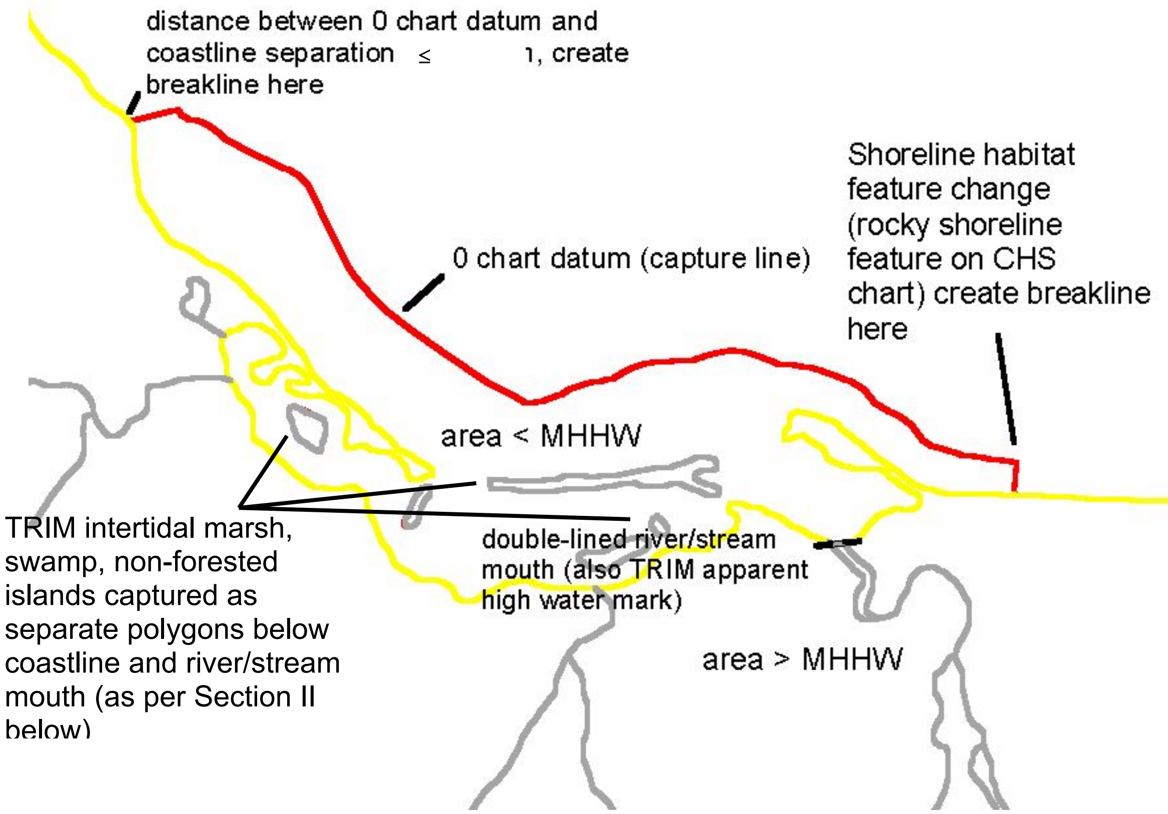

Fig. 3a. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum contour line <u>does not</u> intersect coastline at ≥ 1 locations and runs continuous parallel to the coastline, breaklines cannot be digitized as per criteria 2, <u>but</u> coastline habitat features change, intertidal zone can be captured by digitizing breakline(s) from the 0 chart datum to habitat feature and using criteria 1-2 above (coastline or MHHW in yellow, 0 chart datum line in red, Cluxewe River estuary shown).

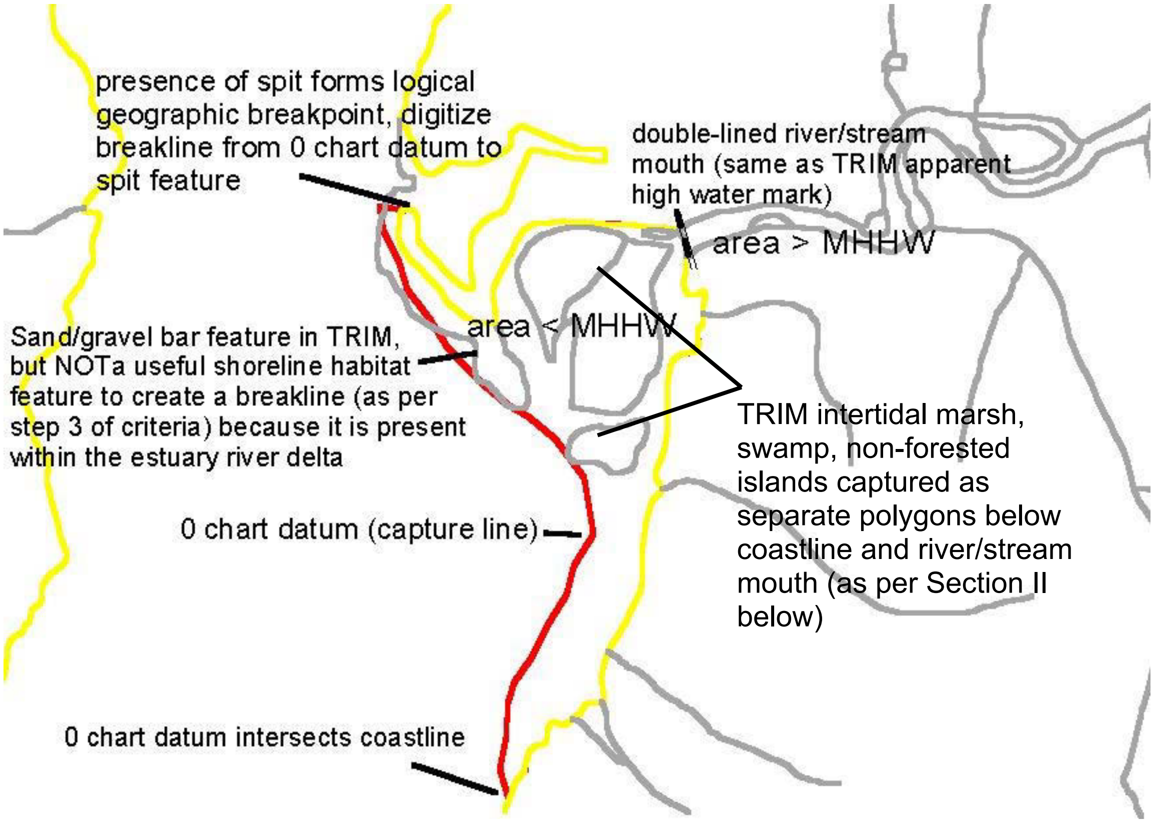

Fig. 4a. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum contour line <u>does not</u> intersect coastline at ≥ 1 location(s) and runs continuous parallel to the coastline, breaklines cannot be digitized as per criteria 1-3, <u>but</u> a peninsula, spit, jetty, etc. forms a logical geographic breakpoint, intertidal zone can be captured by digitizing breakline(s) from the 0 chart datum to breakpoint(s) and using criteria 1-3 above (coastline or MHHW in yellow, 0 chart datum line in red, Leiner River estuary shown).

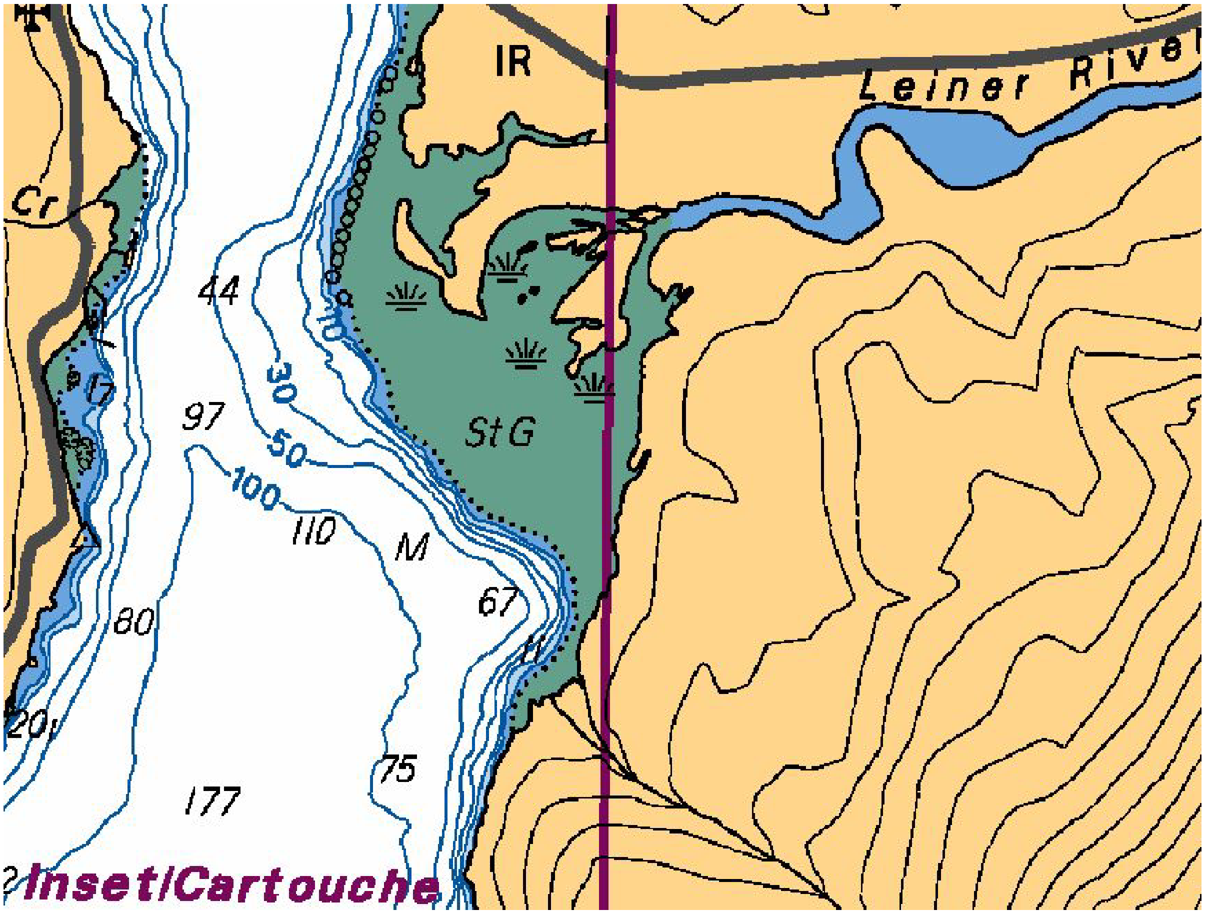

Fig. 4b. Leiner River estuary on CHS chart showing intertidal delta, outflow of primary river/stream channels that splits the delta, and presence of spit at north side of estuary (Canadian Hydrographic Service, 1996).

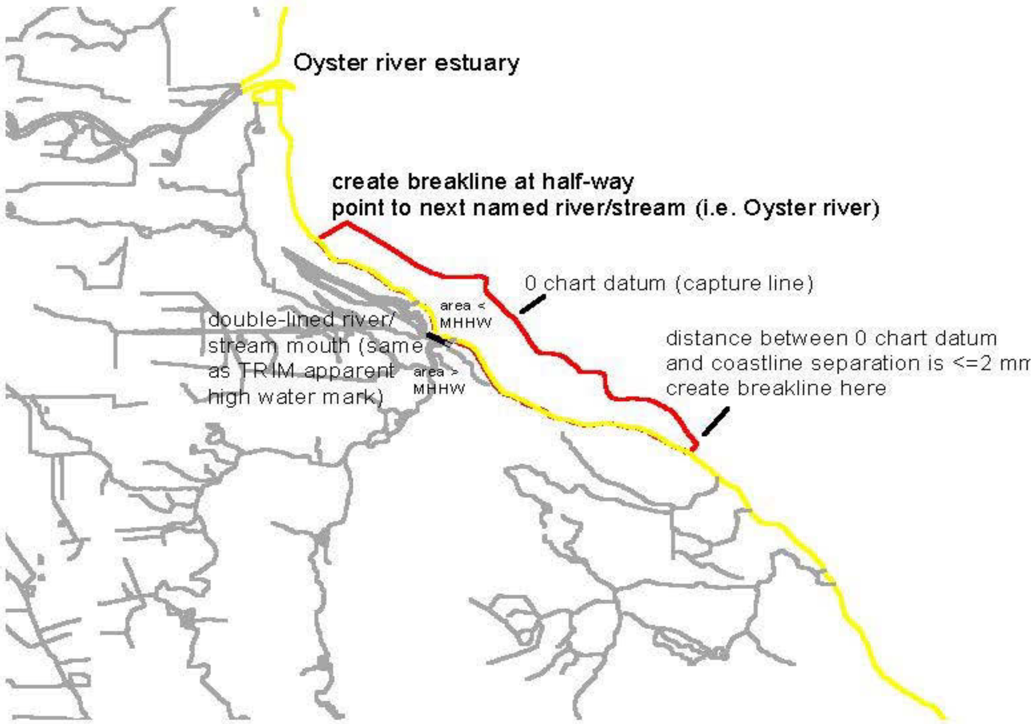

Fig. 5. Single or double-lined primary river/stream or channel(s) intersects with TRIM coastline, 0 chart datum does not intersect the coastline at ≥ 1 location(s) and runs continuous parallel to the coastline, breaklines cannot be digitized as per criteria 1-4, but a named secondary river/stream is present, above or below the primary river/stream estuary being digitized, and a breakline can be digitized at the mid-point between the secondary and primary river/stream (coastline or MHHW in yellow, 0 chart datum line in red).

Section II: Supratidal/backshore/upstream zone mapping criteria

I. Estimation of estuary supratidal/backshore and upstream area

The supratidal/backshore and upstream zone features for each estuary system or complex are captured as polygons within the area found above the provincial Terrain Resource Inventory Mapping (TRIM) 1:20,000 coastline or island shoreline (>Mean higher high water mark) and above the river/stream mouth(s). Estuary complexes include multiple river/streams flowing into a shared intertidal zone. The upstream extent of each estuary is delineated at the approximate limit of surface salinity intrusion from data collected at Campbell River (Vancouver Island). An upstream breakline of 500m distance from the river/stream mouth is used in most cases. The TRIM coastline or island shoreline is used to separate the backshore/intertidal zones. The inclusion of upstream features is dependent on where the river/stream mouth(s) are digitized/captured to separate the upstream from the intertidal sections of each estuary. The mouth is not necessarily the TRIM apparent high water mark. Upland and forested area features are not included in this version of the mapping.

II. Mapping layers and features used for querying, verifying, capturing and digitizing of supratidal/backshore and upstream polygon boundaries

Mapping data sources: 1:20,000 TRIM I & II Provincial basemaps, 1: variable scale CHS charts, 1:variable scale NDI digital raster charts (BSB v.3.0 2000), 1:50,000 NTS mapsheets (Watershed Atlas), 1:20,000 TRIM orthophotos (various years, where available), and 1:variable scale airphotos (various years, where available).

Relevant feature codes and descriptions for backshore and upstream mapping:

TRIM layer (twtr coverage): GA90000110 (left bank), and GA90000120 (right bank), GA24850000 (river/stream "definite"), GA24850140 (river/stream "indefinite"), GA24850150 (river/stream “intermittent”), GA08800110 (ditch), GA08800130 (indefinite ditch), GG05800000 (coastline "definite"), GG95800130 (coastline "indefinite"), GE25850000 (sand/gravel bar), GC17100000 (Marsh area outline), GC30050000 (Swamp area outline), GE14850000 (island to scale), GB15300000 (lake definite), GB15300130 (lake indefinite), GB15300140 (lake intermittent), GA10450000 (Falls – to scale), GA11500000 (Flume), GE09400000 (dyke), GE03050110 (breakwall/breakwater-large), GE26250000 (seawall), GA08450000 (dam-section.top), GA98450100 (dam-section.base)

TRIM layer (tcvr coverage): JA33750000 (wooded area)

NTS layer (Watershed Atlas coverage): WA21100000 (coastline), WA21100111 (construction line, coastline), WA24100110 (single-line blueline, mainflow), WA24100120 (single-line blueline, mainflow through wetland), WA24100130 (single-line blueline, secondary flow), WA24100140 (single-line blueline, secondary flow through wetland), WA24111110 (construction line, mainflow), WA24111120 (construction line, double-line river, main flow), WA24111130 (construction line, secondary flow), WA24111150 (construction line, double-line river, secondary flow), WA24200110 (double-line blueline, right bank), WA24200120 (double-line blueline, right bank shared with wetland), WA24200130 (double-line blueline, left bank), WA24200140 (double-line blueline, left bank shared with wetland)

CHS/NDI raster layer: coastline, 0 chart datum, river/stream/creek, lake, marsh, islands, swamp, jetty, peninsula, stones/gravel, rocky area, mud, sand (features may be depicted above or below TRIM coastline dependent on map scale)

III. Estuary location queries (river/stream intersection with coastline)

Each estuary system was identified from one or both of the following queries:

a) query of 1:20,000 TRIM double-lined river/stream (>20 m width) intersection of left bank with (i) coastline or (ii) island shoreline (for estuaries on nearshore/offshore islands), or b) query of 1:50,000 NTS Watershed Atlas (WSA) for ≥ 4th order river/stream intersection with coastline. For the TRIM query, hanging double-lined river/streams near the coastline, that would normally intersect the coastline if they continued, were included for capture and digitizing. Queried estuaries that were also located by Hunter *et al.* (1985) should be noted in the database (see Appendix 1 below for description). Each river/stream located using these queries is referred to below as the primary river/stream.

Secondary river/stream(s) or ditches either: a) flow into the primary river/stream channel(s), within a maximum upstream distance of 500m from the primary river/stream mouth(s), or b) intersect the coastline, within the limits of the intertidal zone, for the primary river/stream (see Section I mapping criteria above for intertidal boundaries). Secondary river/streams were not located using the above queries, and were not considered as estuaries for this exercise.

IV. General polygon capture and digitizing rules

1) Capture and digitize all relevant backshore (supratidal) and upstream estuary features as polygons at a scale of 1:10,000. Capture or digitize common area boundaries for each estuary feature/polygon only once.
2) TRIM is the primary reference layer for capturing and digitizing relevant backshore and upstream features as polygons. Use TRIM twtr layer to locate primary single or double-lined river/stream intersection points with TRIM coastline (identified from TRIM and/or

WSA query). For double-lined river/stream(s), the left bank feature code is used to close the coastline in TRIM, but this may not be the river/stream mouth (see below for river/stream mouth definition). From the TRIM layer, verify marsh, swamp, lake, islands or wooded area features with 1:50,000 Watershed Atlas layers. Consult CHS charts for intertidal zone, coastline, backshore, and upstream estuary features (i.e. marsh and swamp) that may not have been captured in TRIM. Use airphotos or orthophotos for additional feature verification.

3) Where there is a discrepancy between the CHS coastline/0 chart datum linework relative to 1:20K TRIM coastline, owing to problems of scale or otherwise, consider the TRIM coastline to be the <u>true coastline</u> depiction since it was digitized at 1:20,000. This is a better scale compared to most of the CHS charts. DO NOT shift CHS chart images to match TRIM linework <u>unless</u> they are of similar scale and there is an obvious projection problem. Some interpretation and interpolation of features will be necessary in some areas.

4) Use the primary river/stream(s) intertidal zone boundaries (see Section I intertidal zone mapping criteria) to determine the approximate lateral extent of the coastline to locate relevant backshore and upstream features for each estuary. The search area is within the lateral limits of the primary river/stream intertidal zone to a maximum upstream curvilinear distance of 500m from the primary river/stream mouth(s). The 500m upstream cut-off distance is based on the maximum upstream distance that surface salinity could be detected from the mouth of Campbell River on Vancouver Island (C. Levings, DFO, personal communication, 2002). In the absence of salinity data for most systems, the area of the single or double-lined river/stream, between the left/right channel banks, to the 500m cut-off point is the upstream portion of the river/stream estuary system for most systems. **See upstream breakline exceptions for Fraser, Skeena, and Nass estuaries in supplemental mapping criteria below**.

5) The <u>mouth(s)</u> of a primary river/stream(s) are located where a river/stream or associated channels open into the nearshore bay or delta (based on TRIM map layer features) as follows: a) for a single-lined river/stream, the point(s) at which they intersect the coastline, b) for a double-lined river/stream with one channel, the point at which the left/right banks open toward the ocean, whereby a breakline can be drawn to connect the banks to close the coastline, and c) for a double-lined river/stream with ≥ 2 channels, with islands present between the channels, the points at which each channel opens toward the ocean. ***Note that the TRIM apparent high water mark is often, but NOT always, the**

mouth of the estuary for b and c. It is not applied consistently and accurately enough to define the mouth of an estuary in all cases, and may require separate digitizing in some areas.

DO NOT use training walls or dykes (TRIM fcode GE09400000) to identify/delineate river/stream mouth(s), only islands and other natural geological features. Mouth(s) may be present below the upstream extent of the intertidal delta/marsh depicted on CHS charts. The charts often do not show the primary river/stream channel where it flows through the delta.

6) There may be multiple single or double-lined primary river/stream(s) that intersect the coastline, within a shared intertidal zone, thus forming an estuary complex. Where this occurs, each primary river/stream and associated feature(s) are to be captured and digitized as part of a single connected estuary complex.
7) Some backshore or upstream features are shown on CHS charts (i.e. marshes and swamps) that are not depicted in the TRIM layer. Verify these features on ortho/airphotos where available and digitize/capture relevant CHS/NDI chart raster images as estuary polygons provided that a) they intersect or overlap with relevant estuary features and linework in TRIM, as per criteria below, b) they have not already been partially or completely captured from TRIM linework as different feature types (coded as different features in TRIM than indicated on CHS charts)
8) Wooded areas are excluded as donuts. Verify TRIM wooded area/island features by comparing twtr layer with tcvr layer. DO NOT capture wooded area linework from tcvr layer <u>if</u> the feature boundaries can be completely verified by the twtr layer. Wooded area features have a crown closure of $\geq$ 6% of the polygon area and cover >1 hectare area (BCMELP Geographic Data BC, 1992). If the wooded area boundaries in the tcvr layer do not completely match island linework present in the twtr layer, capture as relevant estuary polygons based on the twtr feature codes.
9) TRIM sand/gravel bar linework present within the left/right banks of double-lined primary river/stream(s) or channels do not require separate polygons as they are captured within the river bank(s)/channel(s) and are a reflection of low water flow or tidal conditions.
10) For primary single or double-lined river/streams, and their associated channel(s), digitize a breakline at 500m upstream distance between river/stream banks to close the upstream estuary polygon. Use the maximum 500m curvilinear distance measured from the river/stream mouth(s), from either the left or right bank, to create the 500m breakline. If relevant TRIM or CHS estuary features are present at the 500m breakline [features

overlap, intersect, or are present within the river channel(s)] capture the ENTIRE polygon feature(s) as part of the estuary and digitize the breakline where the feature(s) end upstream (breakline will be at an upstream distance >500m from primary river/stream mouth(s)). **This rule does NOT apply to wooded area linework verified from the tcvr layer or sand/gravel bar linework from twtr layer. These features do not affect the placement of breakline(s).**

11) If the source watershed (lake) is present at a distance of ≤ 500m from: a) the river/stream mouth(s) of a primary single or double-lined river/stream, or b) a secondary single-lined river/stream present within the lateral extent of the intertidal delta of a primary river/stream (disconnected from primary river/stream, as per criteria 3f below), create the breakline at the point where the outflow of the primary river/stream begins from the source watershed. **Do not capture the entire source watershed**. Capture primary or secondary river/stream(s) boundaries and features below the breakline(s) as above. Verify watershed lake feature(s) as to whether they are water sources for the primary or secondary river/stream from CHS and NTS charts. If there is ambiguity as to whether the lake is a water source, and it cannot be verified as such, capture the lake feature as a polygon that is part of the estuary.
12) If a TRIM falls feature is present at a distance of ≤ 500m from the primary river/stream mouth(s) of a double-lined river/stream or a secondary double-lined river/stream, create the breakline at the location of the falls feature. Capture primary or secondary river/stream(s) boundaries and features below the breakline(s) as above.
13) Secondary river/stream(s) or ditches to be captured either: (a) flow into the upstream portion of the single or double-lined primary river/stream, or one of its channels, at ≤ 500m curvilinear distance from the primary river/stream mouth(s), or (b) are disconnected from the primary river/stream but intersect the coastline, within the intertidal boundaries of the primary river/stream(s) being digitized, and connect relevant features (i.e. marsh or swamp) to the coastline at ≤ 500m curvilinear connection distance.
14) Backshore/supratidal or upstream features for capture or digitizing, within the 500m upstream search area for each estuary system or complex, must be directly/indirectly connected to and/or intersect TRIM: a) coastline within the limits of the digitized intertidal zone, b) the primary single or double-lined river up to the 500m upstream breakline, c) secondary single-lined features that connect to the coastline or the primary river/stream being digitized, d) other feature(s) that themselves overlap or connect to the primary river/stream being digitized. Features present within the channel(s) of a double-lined river,

provided they are not wooded areas, are also included. ***Features disconnected from: a) the primary river/stream(s), or b) the coastline, within the lateral extent of the intertidal zone for each estuary, are not included.**

15) For single-lined primary or secondary river/stream(s) features or ditches that are part of the estuary system, digitize a 10m buffer (5m either side) around the feature to the next polyline intersection point (as per criteria below). The 10m buffer for single-lined features is half the width of the minimum distance for a double-lined river/stream (double-lined river/stream defined in TRIM as >20m width).

16) DO NOT use anthropogenic features such as roads, dykes, training dyke walls, etc. from TRIM, NTS, or CHS charts as a basis for splitting what would otherwise be continuous estuary features. Capture the entire features as polygons where they are present within the estuary supratidal/backshore or upstream zones.

17) DO NOT capture secondary single-lined river/stream or ditch features flowing through marsh, swamp, lake, wooded area, island, or intertidal marsh areas separately if they are captured adequately within these feature boundaries. Capture all primary single-lined river/stream features as per rule 10 and 15 above regardless of whether they flow through marsh, swamp, lake, wooded area, island, or intertidal marsh areas; capture the areas outside the river/stream bank buffers as separate polygons. ***IF double-lined river/stream linework is present within marsh/swamp (CHS or TRIM), lake, wooded area, island, or intertidal marsh features, capture as double-lined river (upstream) features to where the feature ends upstream, and capture the areas outside the left/right bank as separate polygons.**

18) Exclude TRIM breakwall/breakwater, seawall, or dam features present between left/right banks or above coastline, as donuts (exclude linework with 10m buffer, 5m buffer either side).

19) If the mouth(s) of a primary river/stream intersects a marsh, swamp, or non-forested island (an island not confirmed as a wooded area feature in TRIM tcvr layer) polygon feature present between the primary river/stream channel(s) banks, where the majority of the polygon area is present above the river/stream mouth in the upstream zone, code the entire polygon as backshore (marsh or swamp) or upstream (island areas only).

V. Backshore and upstream (above mean higher high water line or coastline to 500m upstream breakline) mapping/digitizing criteria

1. Single or double-lined primary river/stream located from query. No marsh, swamp, sand/gravel bars, islands, wooded areas, lakes, or CHS features present within the approximate lateral boundaries of the intertidal zone, above or below the TRIM coastline, to an upstream curvilinear distance of ≤ 500m from the mouth of the primary definite single or double-lined river/stream. No definite, indefinite, or intermittent secondary river/stream(s) connect relevant features to the primary river/stream, at or below 500m breakline. No islands are present within double-lined river/stream channel(s). Continuous forest cover or other non-estuarine features are present from the TRIM coastline upland to 500m breakline.

Examples:

1a Single-lined primary "definite" river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single-lined river/stream to curvilinear distance of 500m from mouth. Digitize breakline at 500m distance, digitize 10m buffer (5m either side) around river/stream to coastline intersection and capture area as polygon (see Fig. 1a below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and buffered polygon area below upstream breakline, otherwise go to step 1b

1b Single-lined primary "definite" river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single-lined river/stream, becomes a double-lined river/stream at <500m curvilinear distance from mouth. Digitize breakline at 500m distance, digitize 10m buffer (5m either side) around single-lined river/stream section to where it intersects the double-lined river/stream, capture double-lined river/stream area as polygon (see Fig. 1b below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon area, and double-lined river/stream area(s) below upstream breakline, otherwise go to step 1c

1c Double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as double-lined river/stream, becomes single-lined river/stream upstream at <500m curvilinear distance from mouth. Digitize breakline at 500m distance, digitize 10m buffer (5m either side) around single-lined river/stream section to where it intersects the double-lined river/stream, capture double-lined river/stream area as polygon (see Fig. 1c below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon area, and double-lined river/stream area(s) below upstream breakline, otherwise go to step 1d

1d Double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as double-lined river/stream to curvilinear distance of 500m from mouth. Digitize breakline at 500m distance, using the maximum 500m curvilinear distance measured from either the left or right bank to create the breakline, capture double-lined river/stream area as polygon (see Fig. 1d below for example)

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, and double-lined river/stream area(s) below upstream breakline, otherwise go to step 1e*

1e Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth. Secondary single or double-lined river/stream(s) or ditch(es) flowing downstream intersect the primary river/stream below the 500m breakline. Digitize breaklines at 500m distance, for both the primary river/stream and each intersecting secondary feature, using the maximum 500m curvilinear distance measured from either the left or right bank of the primary river/stream mouth to create breaklines. Digitize 10m buffer (5m either side) around single-lined primary or secondary river/stream sections. Capture double-lined river/stream areas as polygons (see Fig. 1e below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, and double-lined river/stream area(s) below upstream breakline(s), otherwise go to step 1f

1f Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth. Secondary single or double-lined river/stream(s) or ditch(es) flowing downstream intersect the primary river/stream below the 500m breakline. Other secondary single-lined indefinite or intermittent river/stream(s) or ditches intersect or overlap with the secondary single or double-lined features flowing into the primary/river stream, at <500m curvilinear distance, but they DO NOT connect to the primary river/stream OR the coastline.

DO NOT include other secondary single-lined features that intersect with secondary branch(es) being digitized if they do not directly connect to the primary river/stream or the coastline. Digitize 500m breaklines and capture single or double-lined river/stream areas as polygons (see Fig. 1f below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, and double-lined river/stream area(s) below upstream breakline(s), otherwise go to step 1g

1g Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth. Other secondary features may intersect the primary river/stream below the 500m breakline, or additional secondary features may intersect secondary river/stream features entering the primary river/stream (as above).

If one or more secondary single-lined definite, indefinite, or intermittent river/stream(s) or ditches branch from the primary river/stream and flow directly to the coastline, at or below the 500m breakline of the primary river/stream, within the lateral limits of the intertidal zone, capture the entire length of the single-lined feature to the upstream point where it intersects the primary river/stream. If the single-lined feature intersects the coastline outside the lateral limits of the intertidal zone, digitize the upstream breakline as per criteria 1e above. DO NOT include the entire single-lined segment. Digitize 500m breaklines and capture single or double-lined river/stream areas as polygons (see Fig. 1g below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, and double-lined river/stream area(s) below upstream breakline(s)

…. for presence of marsh, swamp, islands, sand/gravel bars, or wooded area polygons BELOW coastline go to step 2

…. for presence of marsh, swamp, islands, sand/gravel bars, lake, or wooded area polygons ABOVE coastline go to part 3

2. Single or double-lined primary river/stream located from query. Marsh(es), swamp(s), island(s), sand/gravel bar(s), or wooded area(s) features present below and/or intersect the TRIM coastline (<MHHW), within the lateral boundaries of the digitized intertidal zone, between the coastline and the 0 chart datum line. No definite, indefinite, or intermittent secondary river/stream(s) connect relevant features to the primary river/stream, at or below 500m breakline. No islands are present within double-lined river/stream channel(s). Continuous forest cover or other non-estuarine features are present from the TRIM coastline upland to 500m breakline.

Examples:

2a Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are present between the coastline and the 0 chart datum layer and do not extend below the intertidal zone. Capture linework as distinct estuary polygons (island, marsh, etc.) unless the polygon(s) are confirmed as wooded area features in the tcvr layer. Wooded area features should be excluded as donuts. Digitize 500m breaklines and capture single or double-lined river/stream areas as per criteria 1 above (see Fig. 2a below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, and double-lined river/stream area(s) below upstream breakline(s), and relevant polygon(s) between coastline and 0 chart datum, otherwise go to step 2b

2b Single or double-lined primary river/stream intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are present between the coastline and the 0 chart datum layer but these extend below the intertidal into the subtidal zone. DO NOT capture polygons where the boundary(ies) extend below the intertidal zone. Capture or digitize relevant polygons as per 2a. Digitize 500m breaklines and capture single or double-lined river/stream areas as per criteria 1 above (see Fig. 2b below for example)

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), and relevant polygon(s) between coastline and 0 chart datum, otherwise go to step 3

3. Single or double-lined primary river/stream located from query. Marsh(es), swamp(s), island(s), sand/gravel bar(s), wooded area(s), or lake(s) features present above the TRIM coastline (>MHHW), within the lateral boundaries of the digitized intertidal zone, at or below the 500m upstream breakline(s). No definite, indefinite, or intermittent secondary river/stream(s) connect relevant features to the primary river/stream, at or below 500m breakline. Islands may be present within double-lined river/stream channel(s). Polygon(s) present below the coastline were captured as per 2 above.

Examples:

3a Single or double-lined primary river/stream intersects with “definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are present above the coastline to ≤ 500m breakline, but do not connect to the coastline or to the primary river/stream being digitized, either by a secondary single-lined river/stream, ditch, or intersection with the coastline or primary river/stream. DO NOT include disconnected features. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1 and 2 above.

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), and relevant polygon(s) between coastline and 0 chart datum, otherwise go to step 3b

3b Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, a relevant lake feature that has been verified from other map layers as being the source watershed for the primary river/stream is present and connects the primary river/stream to the coastline at ≤ 500m distance from the coastline. Digitize the upstream breakline at the intersection of the source watershed with the primary river/stream. DO NOT include verified source watershed features as part of the estuary system. If the lake feature cannot be verified as the source watershed, go to step 3c. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1 and 2 above.

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), and relevant polygon(s) between coastline and 0 chart datum, otherwise go to step 3c

3c Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, all or a portion of island features at ≤ 500m distance above the mouth are present within the river/stream channel(s), above the coastline. Capture island linework as estuary polygons unless the polygon(s) are confirmed as wooded area features in the tcvr layer. Wooded area features should be excluded as donuts. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1 and 2 above.

If the 500m breakline intersects a portion of an island feature present within the double-sided river/stream, digitize the breakline at the upstream limit of the island and capture the entire feature as a polygon (breakline will be > 500m distance). If the island feature is a wooded area, digitize 500m river/stream channel(s) breaklines to the island intersection point(s) and exclude the island as a donut.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, and relevant island features above the coastline within the river/stream channel(s), otherwise go to step 3d*

3d Double-lined primary river/stream intersects with “definite” or “indefinite” coastline or island shoreline, continues upstream as double-lined river/stream to curvilinear distance of 500m from mouth, but splits into ≥ 2 channels above the coastline intersection point(s), and island(s) are present between the channels. Digitize breakline(s) for each channel at farthest 500m curvilinear distance measured upstream from river/stream mouth, using either left or right banks, or at the upstream limit of relevant island features. Capture island linework as estuary polygon(s) between the channel(s) as per 3c. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1 and 2 above.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, and relevant island features above the coastline within or between river/stream channel(s), otherwise go to step 3e*

3e Single or double-lined primary river/stream intersects with "definite" or "indefinite" coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant feature(s) boundary(ies) (i.e. marsh, swamp, etc.) either a) overlap/intersect the coastline within the limits of the digitized intertidal zone (where they may extend into the intertidal zone; in which case a portion were captured in Step 2 above), or b) overlap/intersect primary river/stream left/right channel(s)/bank(s) at ≤ 500m breakline distance. Other relevant features may overlap these feature(s) boundary(ies). Capture all relevant linework as polygon(s), and additional overlapping polygon(s), unless they are wooded area features from the tcvr layer. Secondary single-lined river/stream(s) may flow through feature(s) connected to the coastline or the primary river/stream. DO NOT digitize separate buffers for single-lined features where they are captured adequately within existing polygon(s). Capture or digitize upstream polygons and polygons below the coastline as per criteria 1,2, and 3a-d above.

As per 3c, if the 500m breakline(s) intersects a portion of a feature (that is not a wooded area) that overlaps/intersects the double-sided river/stream channel(s)/bank(s), digitize the breakline at the upstream limit of where the polygon(s) overlap with the bank(s) and capture the entire feature(s) (breakline will be >500m distance). If the feature is a wooded area, digitize 500m river/stream channel(s) breaklines to the feature intersection and exclude the feature as a donut.

If a portion of a feature (that is NOT a wooded area) overlaps/intersects the coastline and extends laterally beyond the intertidal coastline intercepts, capture the entire polygon as part of the estuary.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, relevant island features above the coastline within the river/stream channel(s), relevant polygon(s) overlapping/intersecting the primary river/stream channel(s)/bank(s) or the coastline, and any additional overlapping polygons connected to these, otherwise go to step 3f*

3f Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant feature(s) are connected to the coastline, within the lateral limits of the digitized intertidal zone, by a secondary single-lined river/stream or ditch, but are not connected to the primary river/stream channel(s)/bank(s).

Capture features and secondary single-lined connecting features if the single-lined feature connecting polygon(s) to the coastline is ≤ 500m in length, and the feature is not a wooded area from the tcvr layer or a source watershed for the secondary river/stream. If a source watershed is present at ≤ 500m from coastline, capture the single-lined feature below the watershed to the coastline intersection.

Capture additional overlapping/intersecting features if present. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1, 2, and 3a-e above.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, relevant island features above the coastline within the river/stream channel(s), relevant polygon(s) overlapping/intersecting the primary river/stream channel(s)/bank(s) or the coastline, any additional overlapping polygons connected to these, and polygon(s) connected to the coastline within the limit of the intertidal zone by secondary single-lined features that do not connect to the primary river/stream, otherwise go to step 4*

4. Single or double-lined primary river/stream located from query. Marsh(es), swamp(s), island(s), sand/gravel bar(s), wooded area(s), or lake(s) features present above the TRIM coastline (>MHHW), within the lateral boundaries of the digitized intertidal zone, at or below the 500m upstream breakline(s). Above the coastline, definite, indefinite, or intermittent secondary river/stream(s) connect relevant features to the primary river/stream, at or below 500m breakline. Polygon(s) present above and below the coastline were captured as per 1-3 above.

Examples:

4a Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are connected to the primary river/stream by secondary river/stream(s) or ditches at ≤ 500m distance from the primary river/stream mouth(s) (these features may also be connected to and/or intersect/overlap the coastline).

Capture or digitize feature(s) and secondary single-lined features connecting these to the primary river/stream if all or a portion of the feature(s) are connected to the primary river/stream within 500m of the primary river/stream mouth(s), and the feature is not a wooded area from the tcvr layer. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1-3 above.

…. Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, relevant island features above the coastline within the river/stream channel(s), relevant polygon(s) overlapping/intersecting the primary river/stream channel(s)/bank(s) or the coastline, any additional overlapping polygons connected to these, polygon(s) connected to the coastline within the limit of the intertidal zone by secondary single-lined features that do not connect to the primary river/stream, and polygon(s) connected to the primary river/stream by secondary single-lined river/stream features above the primary river/stream mouth(s), otherwise go to step 4b

4b Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are connected to the primary river/stream by secondary river/stream(s) or ditches at ≤ 500m distance from the primary river/stream mouth(s) (these features may also be connected to and/or intersect/overlap the coastline). Other relevant features overlap/intersect these polygon(s) boundary(ies).

Capture or digitize feature(s) and additional features that overlap/intersect these (not wooded areas from the tcvr layer), and secondary single-lined features connecting polygon(s) to the primary river/stream (as per 4a). Capture or digitize upstream polygons and polygons below the coastline as per criteria 1-3 above.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s),* *relevant polygon(s) between coastline and 0 chart datum, relevant island features above the coastline within the river/stream channel(s), relevant polygon(s) overlapping/intersecting the primary river/stream channel(s)/bank(s)* <u>*or*</u> *the coastline, any additional overlapping polygons connected to these, polygon(s) connected to the coastline within the limit of the intertidal zone by secondary single-lined features that do not connect to the primary river/stream, polygon(s) connected to the primary river/stream by secondary river/stream features above the primary river/stream mouth(s), and all relevant polygons overlapping/intersecting these, otherwise go to step 4c.*

4c Single or double-lined primary river/stream intersects with "definite" or "indefinite" TRIM coastline or island shoreline, continues upstream as single or double-lined river/stream to curvilinear distance of 500m from mouth, relevant features are connected to the primary river/stream by secondary river/stream(s) or ditches at ≤ 500m distance from the primary river/stream mouth(s) (these features may also be connected to and/or intersect/overlap the coastline). Other relevant features are connected to the first feature, by other secondary river/stream(s) or ditches, within the 500m upstream limit, forming a link or chain of features, all of which are present at or below the 500m upstream limit.

Capture <u>only</u> the first feature present in the chain (not wooded areas from the tcvr layer), connected to the secondary river/stream, <u>not</u> additional features in the chain. Capture or digitize upstream polygons and polygons below the coastline as per criteria 1-3 and 4a-b above.

…. *Estuary includes intertidal zone and features above 0 chart datum to coastline intercepts, buffered polygon areas, double-lined river/stream area(s) below upstream breakline(s), relevant polygon(s) between coastline and 0 chart datum, relevant island features above the coastline within the river/stream channel(s), relevant polygon(s) overlapping/intersecting the primary river/stream channel(s)/bank(s)* <u>*or*</u> *the coastline, any additional overlapping polygons connected to these, polygon(s) connected to the coastline within the limit of the intertidal zone by secondary single-lined features that do not connect to the primary river/stream, polygon(s) connected to the primary river/stream by secondary river/stream features above the primary river/stream mouth(s), and all relevant polygons overlapping/intersecting with these*

VI. Backshore and upstream mapping/digitizing examples

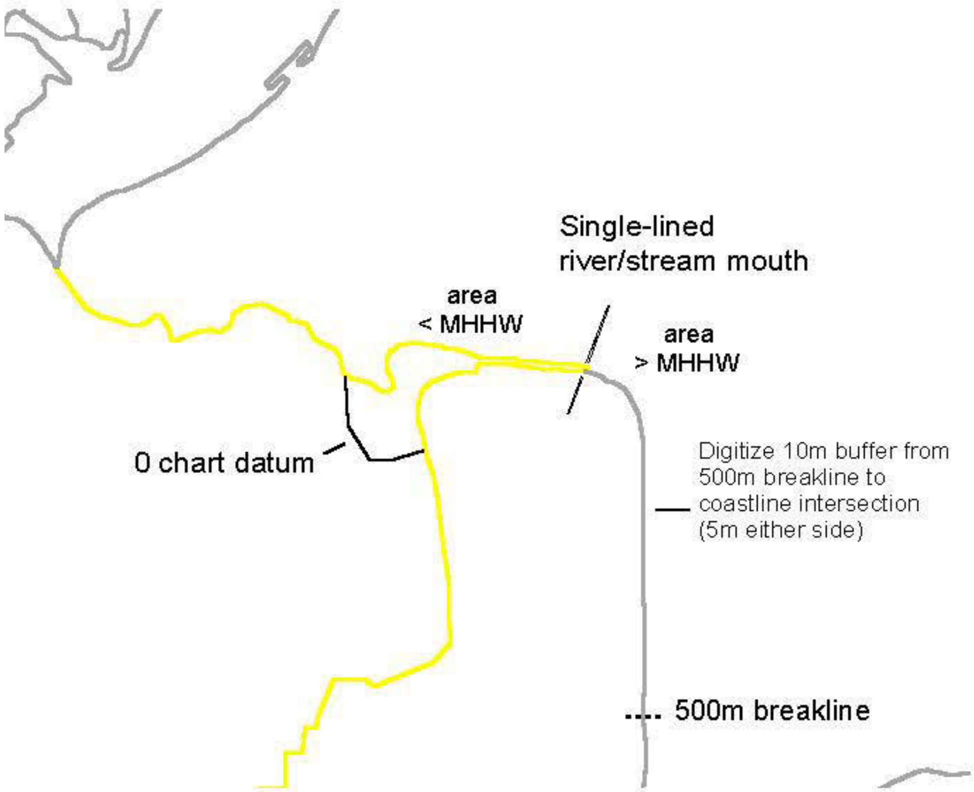

Fig 1a. Single-lined primary river/stream intersects with TRIM coastline, continues upstream as single-lined river/stream to 500m distance, no other features present, upstream zone can be captured as polygon above river/stream mouth to 500m breakline (coastline or MHHW in yellow).

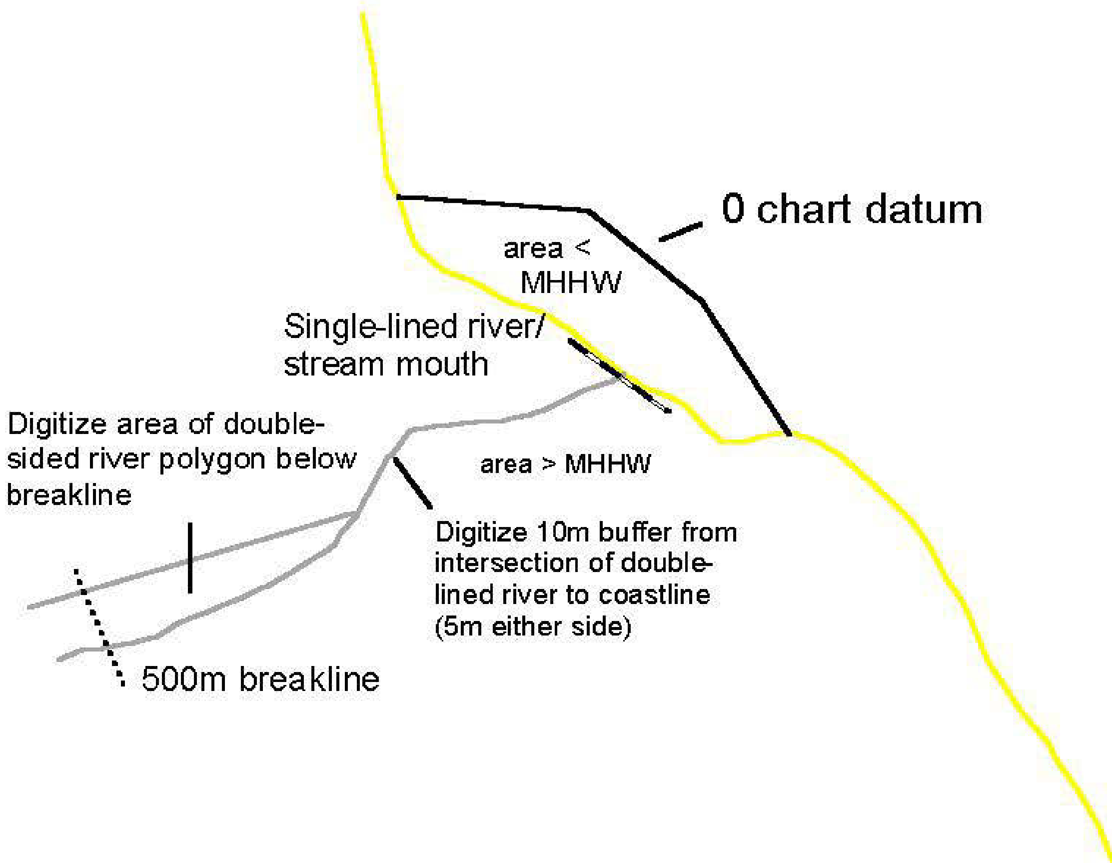

Fig 1b. Single-lined primary river/stream intersects with TRIM coastline, continues upstream as single-lined river/stream <u>but</u> becomes double-lined river/stream at <500m distance from mouth, no other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breakline (coastline or MHHW in yellow).

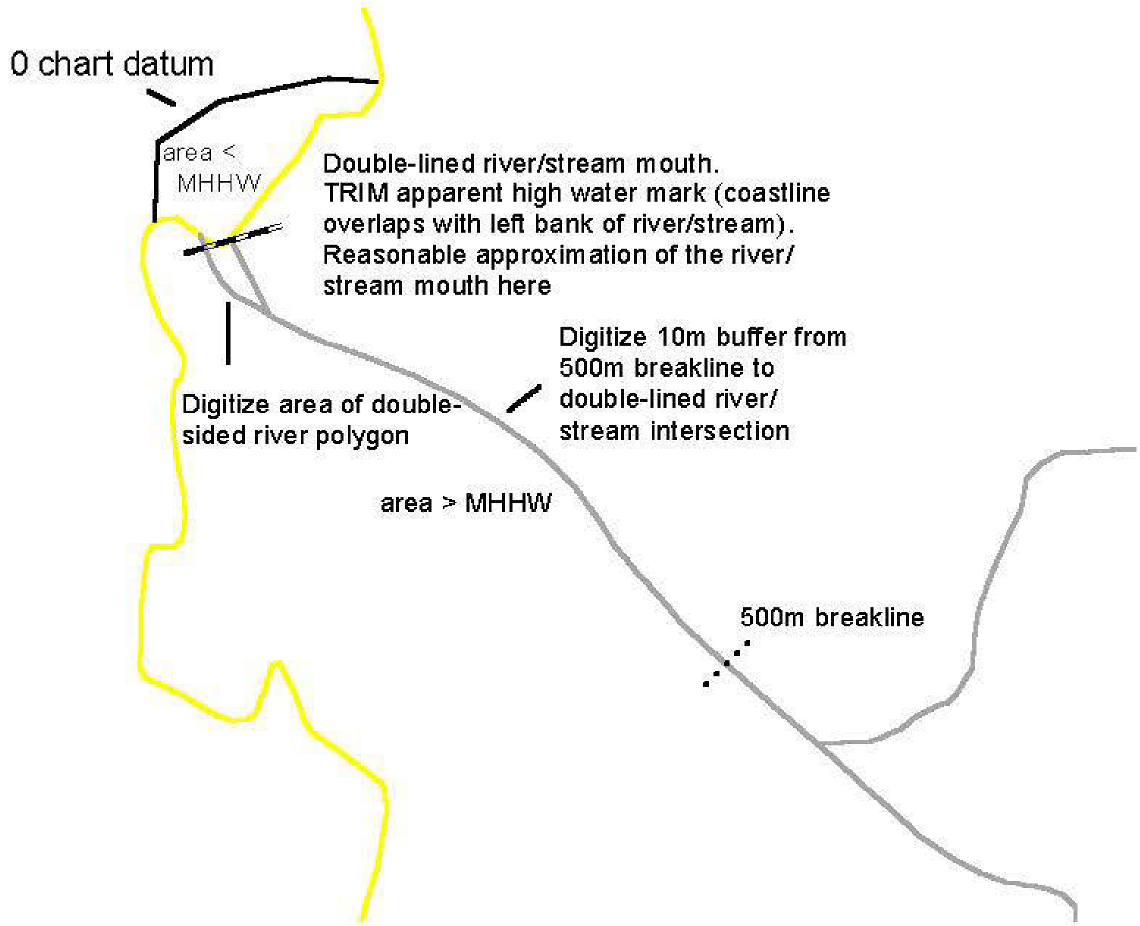

Fig 1c. Double-lined primary river/stream intersects with TRIM coastline, continues upstream as double-lined river/stream <u>but</u> becomes single-lined river/stream upstream at <500m distance from mouth, no other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breakline (coastline or MHHW in yellow).

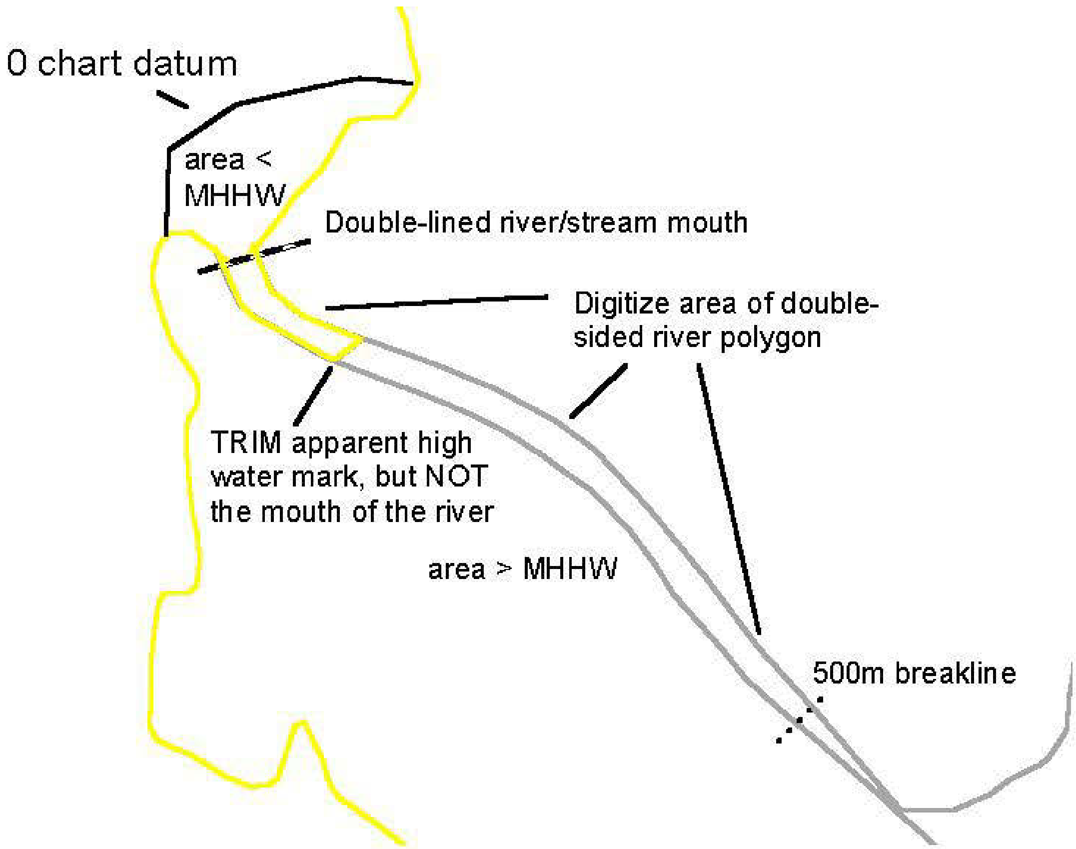

Fig 1d. Double-lined primary river/stream intersects with TRIM coastline, continues upstream as double-lined river/stream to 500m distance, no other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breakline (coastline or MHHW in yellow).

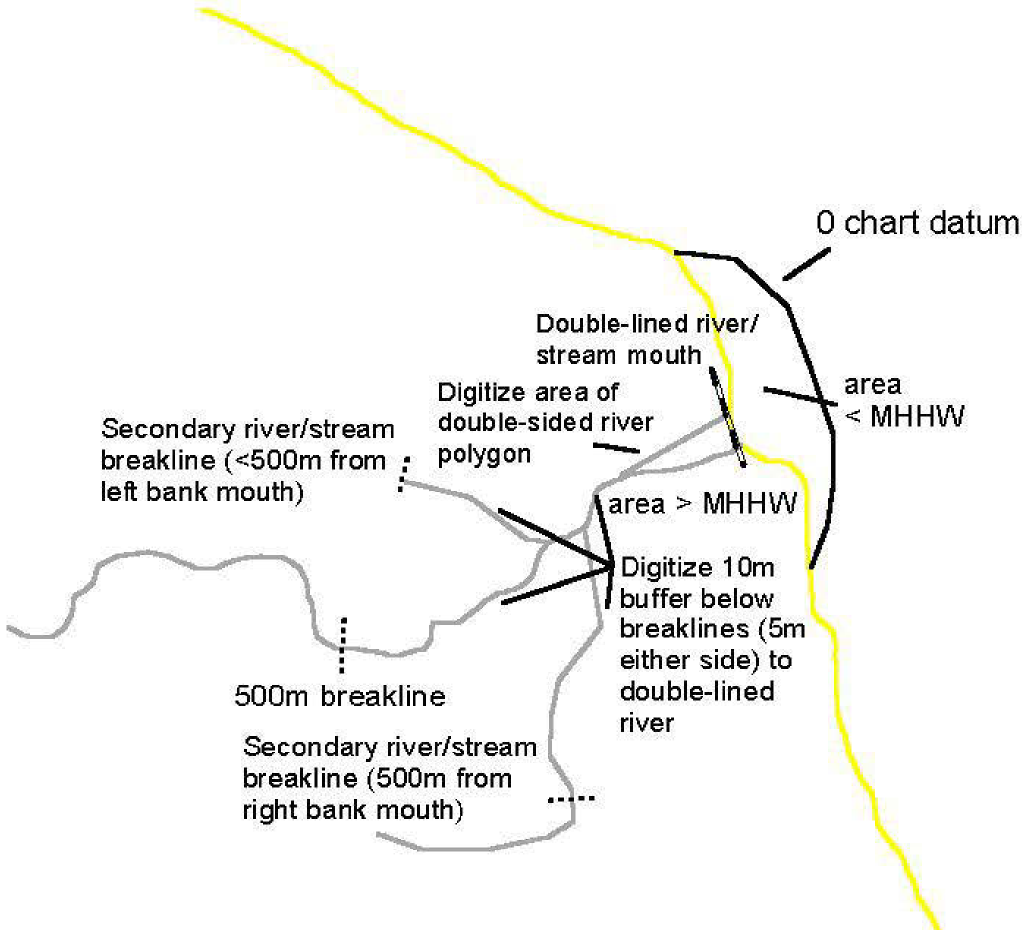

Fig 1e. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, secondary single or double-lined river/stream(s) or ditch(es) flow into the primary river/stream below the 500m breakline, no other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breaklines (coastline or MHHW in yellow).

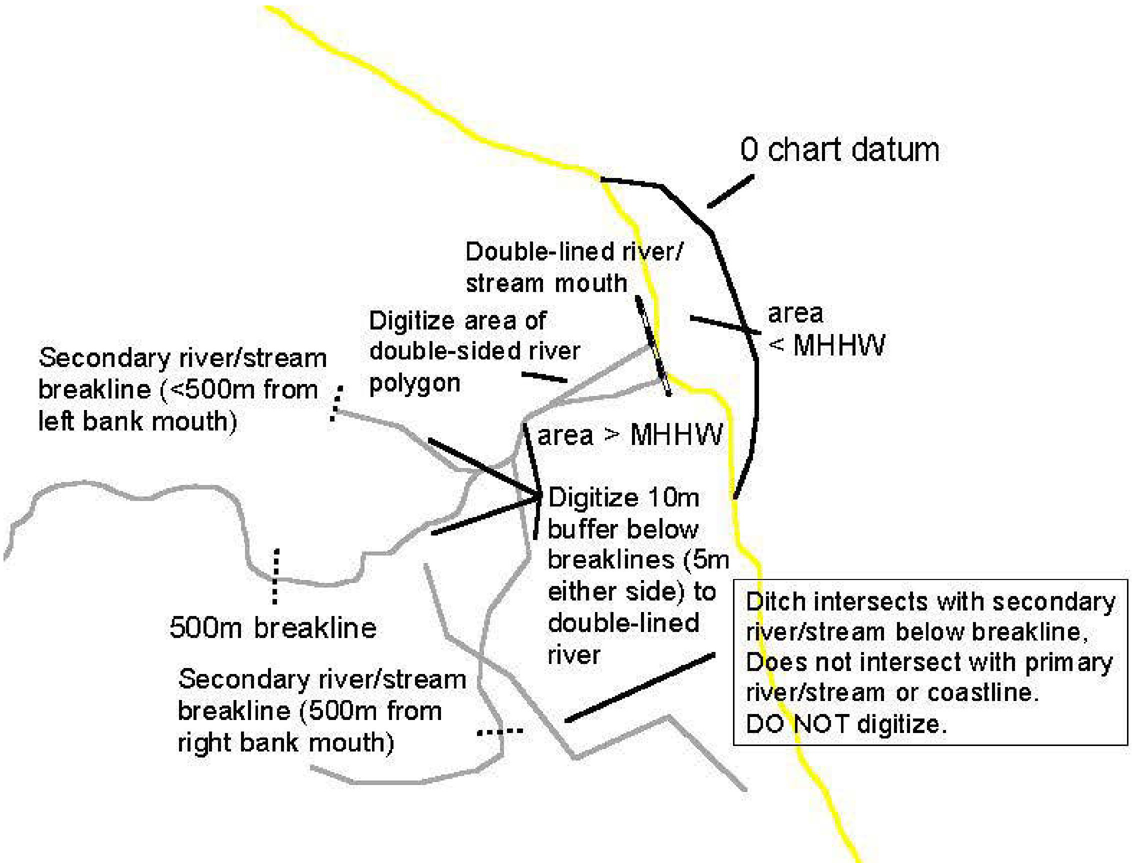

Fig 1f. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, secondary single or double-lined river/stream(s) or ditch(es) flow into the primary river/stream below the 500m breakline, other secondary single-lined features intersect secondary single-lined features that connect to the primary river/stream, no other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breaklines (coastline or MHHW in yellow).

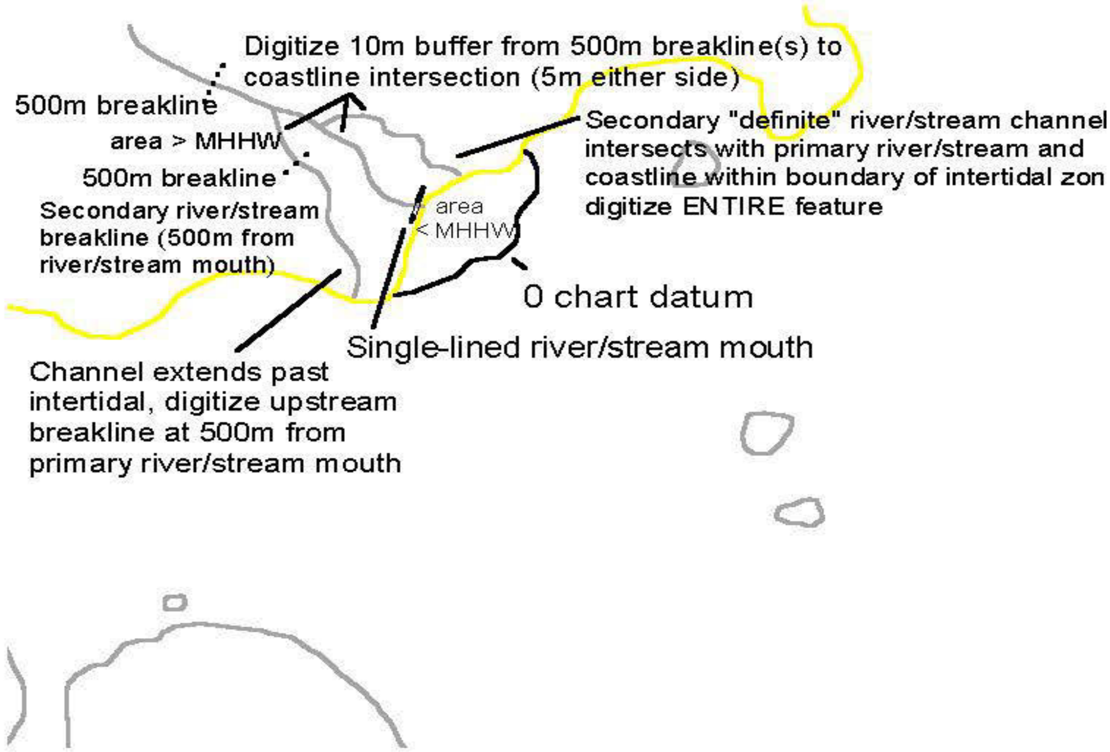

Fig 1g. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, secondary single-lined river/stream(s) or ditch(es) flow from the primary river/stream, below the 500m breakline, to the coastline, within the limits of the digitized intertidal zone. No other features present, upstream zone can be captured as polygons above river/stream mouth to 500m breaklines (coastline or MHHW in yellow).

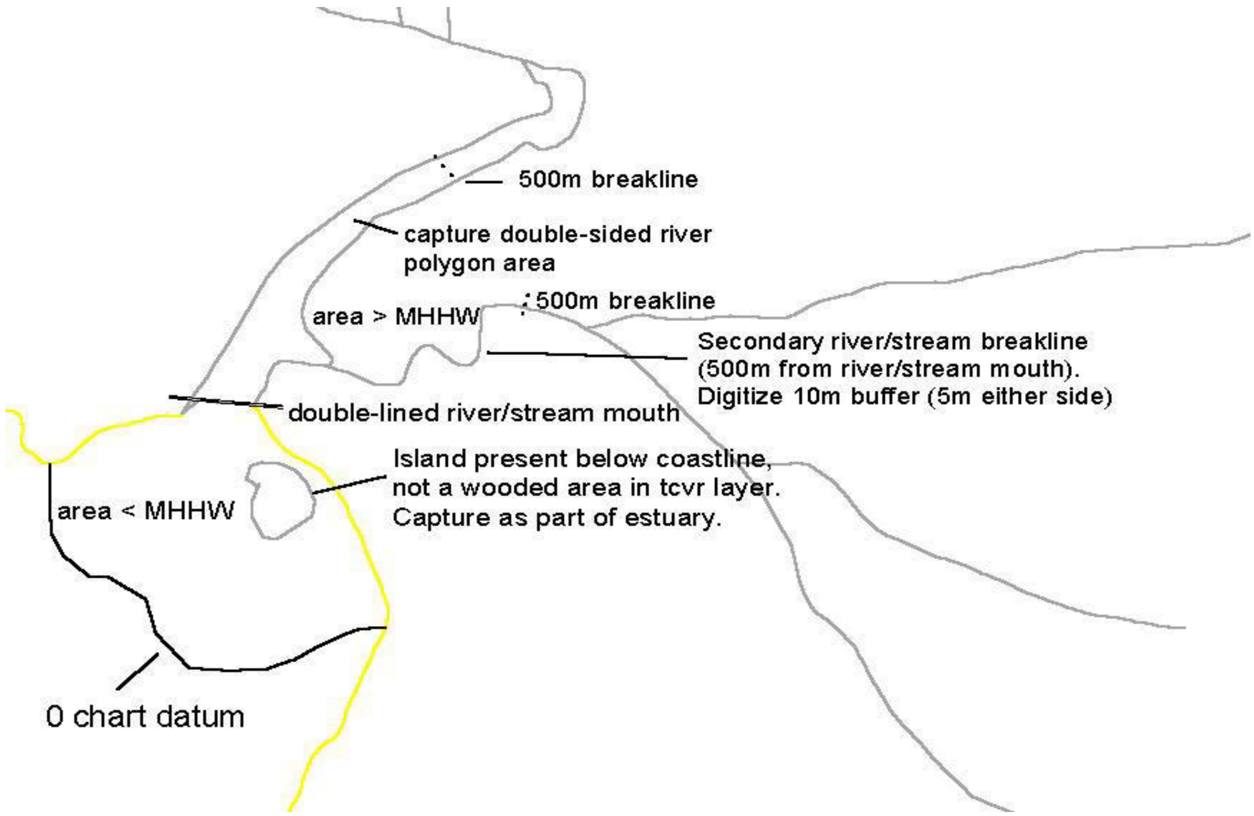

Fig 2a. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, relevant features are present between the coastline and the 0 chart datum line. Features in intertidal zone can be captured as polygons, upstream zone captured as above (coastline or MHHW in yellow).

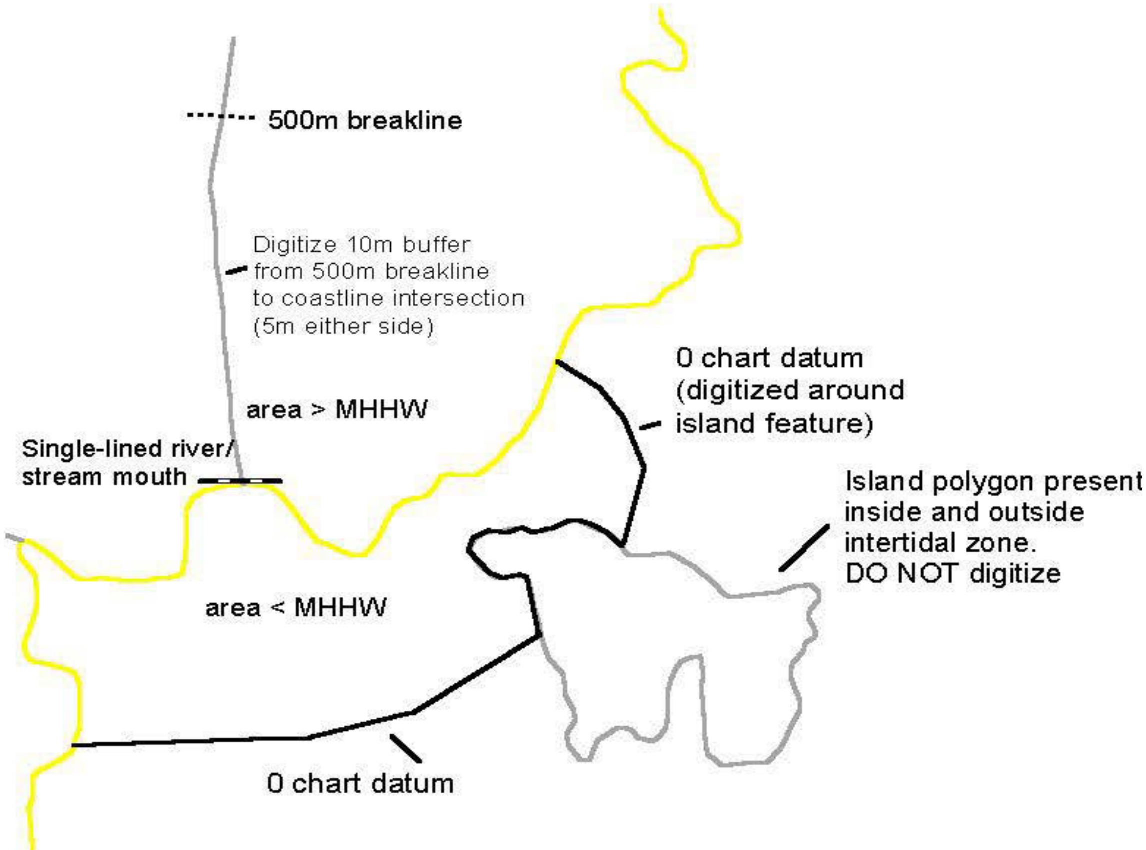

Fig 2b. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, relevant features are present between the coastline and the 0 chart datum line but extend below the intertidal zone. Features in intertidal zone can be captured as polygons, upstream zone captured as above (coastline or MHHW in yellow).

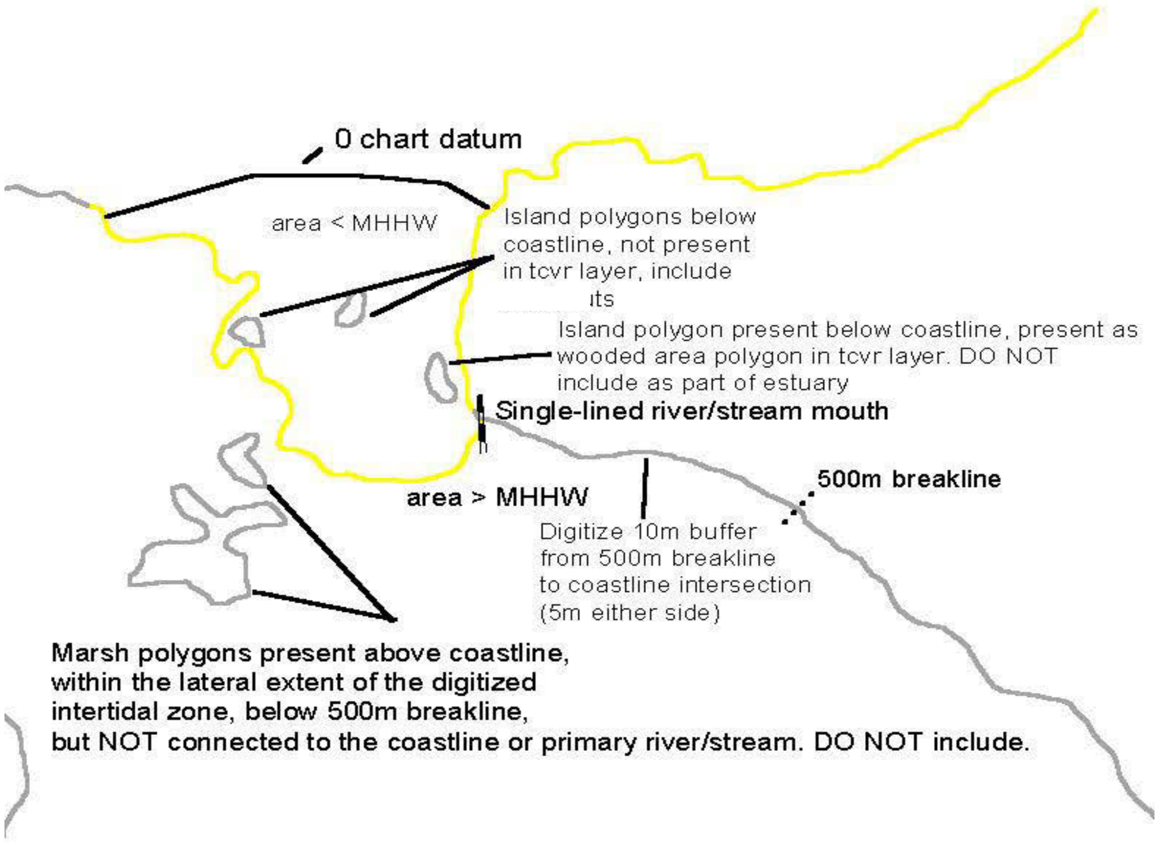

Fig 3a. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, relevant features are present in backshore zone above the coastline but do not connect to the primary river/stream or the coastline. Features in intertidal and upstream zones captured as above (coastline or MHHW in yellow).

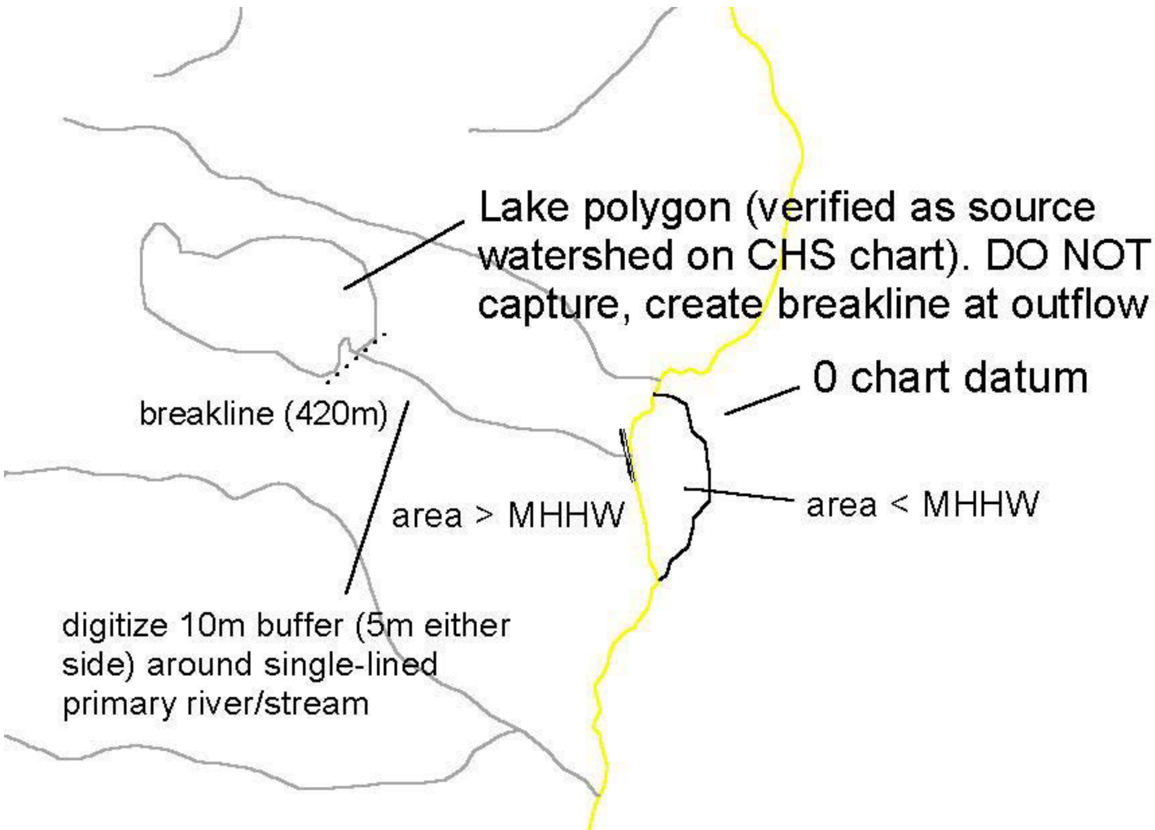

Fig. 3b. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, relevant lake feature verified from other map layers as the source watershed for the primary river/stream present and connects the primary river/stream to the coastline at ≤ 500m distance from the coastline. Features in intertidal and upstream zones captured as above (coastline or MHHW in yellow).

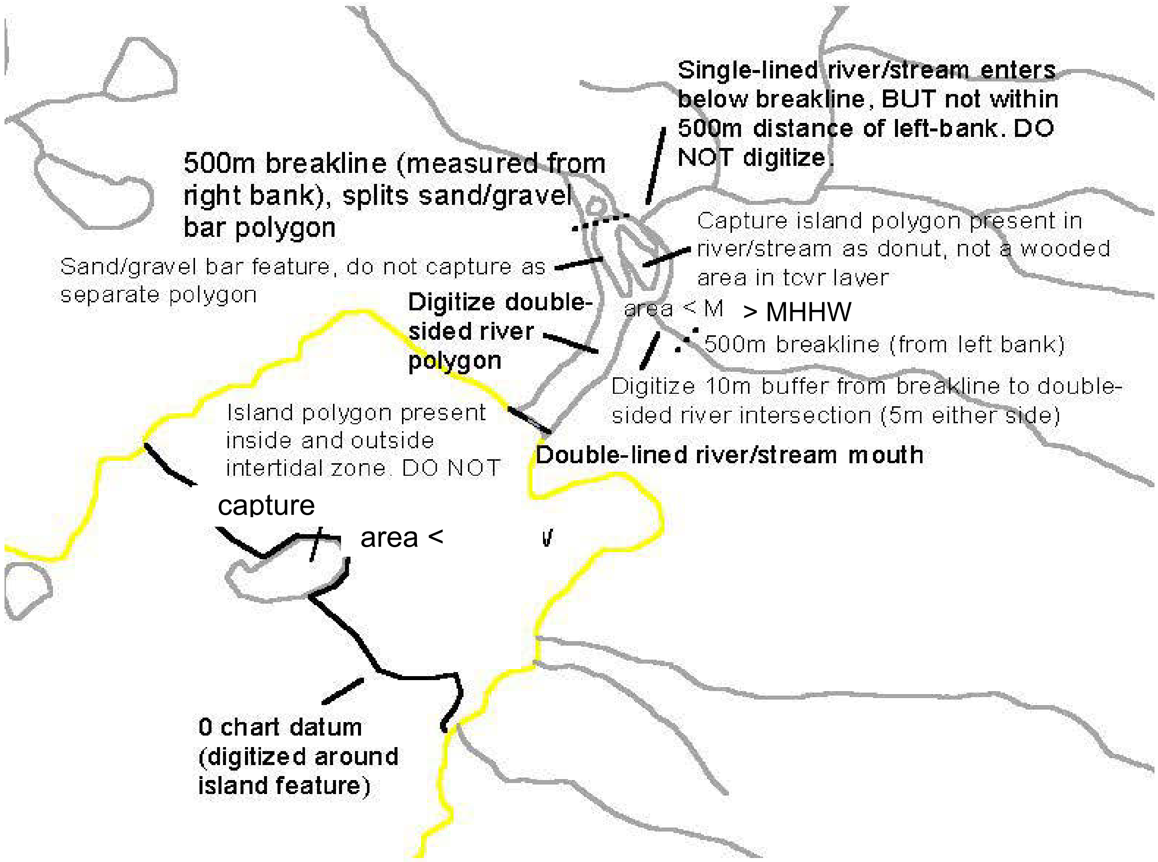

Fig. 3c. Single or double-lined primary river/stream intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance, relevant island features are present within the river/stream channel(s). Island features within river/stream channel(s) can be captured as upstream polygons. Features in intertidal and upstream zones captured as above (coastline or MHHW in yellow).

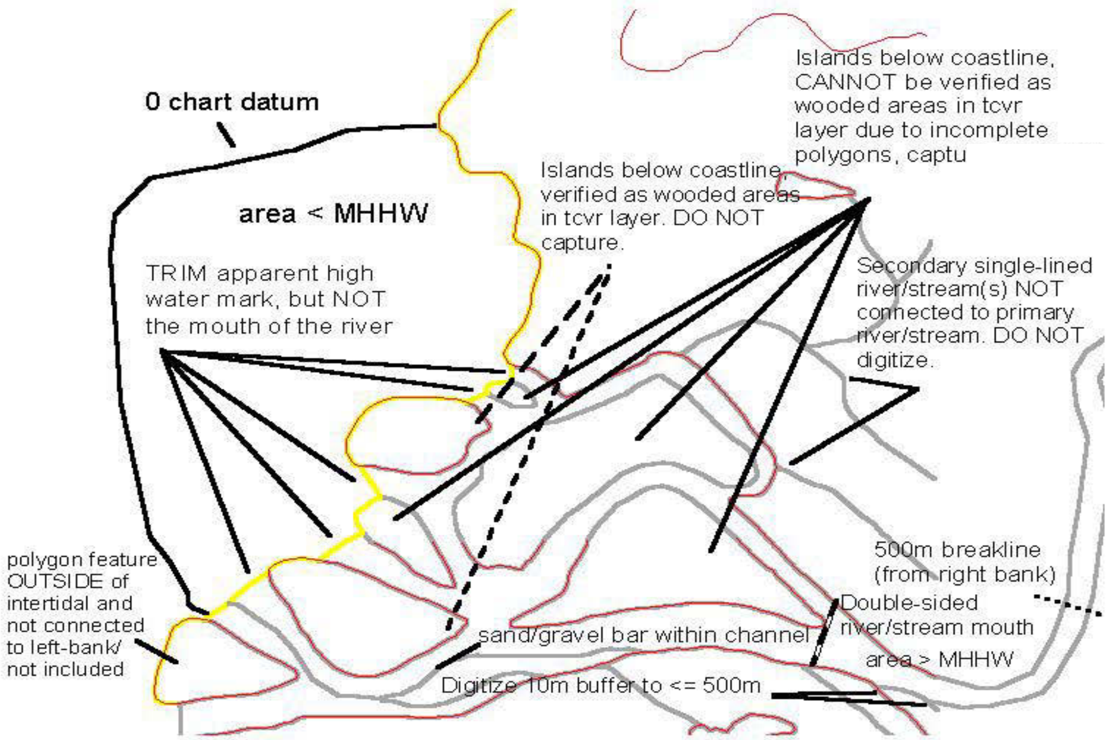

Fig. 3d. Double-lined primary river/stream intersects with TRIM coastline, splits into ≥ 2 channels above the coastline intersection point, island(s) present between channel(s), continues upstream as single or double-lined river/stream to 500m distance. Island features within or between river/stream channel(s) can be captured as upstream polygons. Features in intertidal and upstream zones captured as above (coastline or MHHW in yellow, wooded area features from tcvr layer in red).

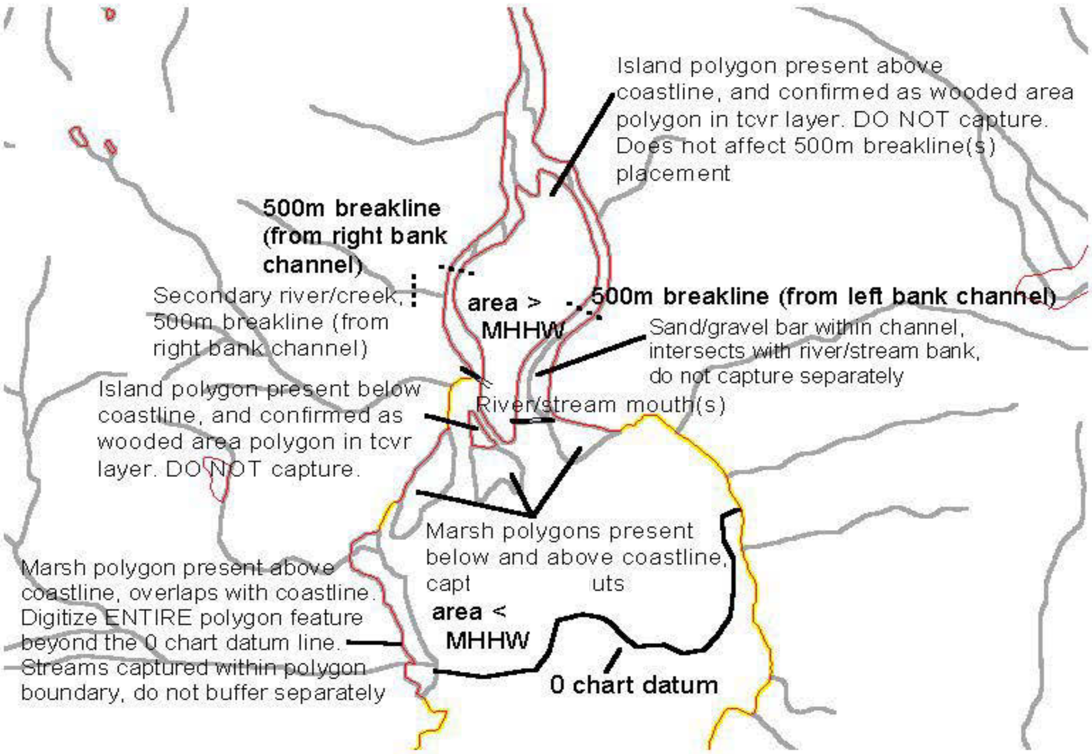

Fig. 3e. Single or double-lined primary river/stream channel(s) intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance. Relevant feature(s) overlap/intersect with the coastline or the primary river/stream channel(s)/bank(s). Features above the coastline or primary river/stream bank(s) can be captured as backshore polygons. Upstream islands, features in intertidal, and upstream zones captured as above (coastline or MHHW in yellow, wooded area polygons from tcvr layer in red).

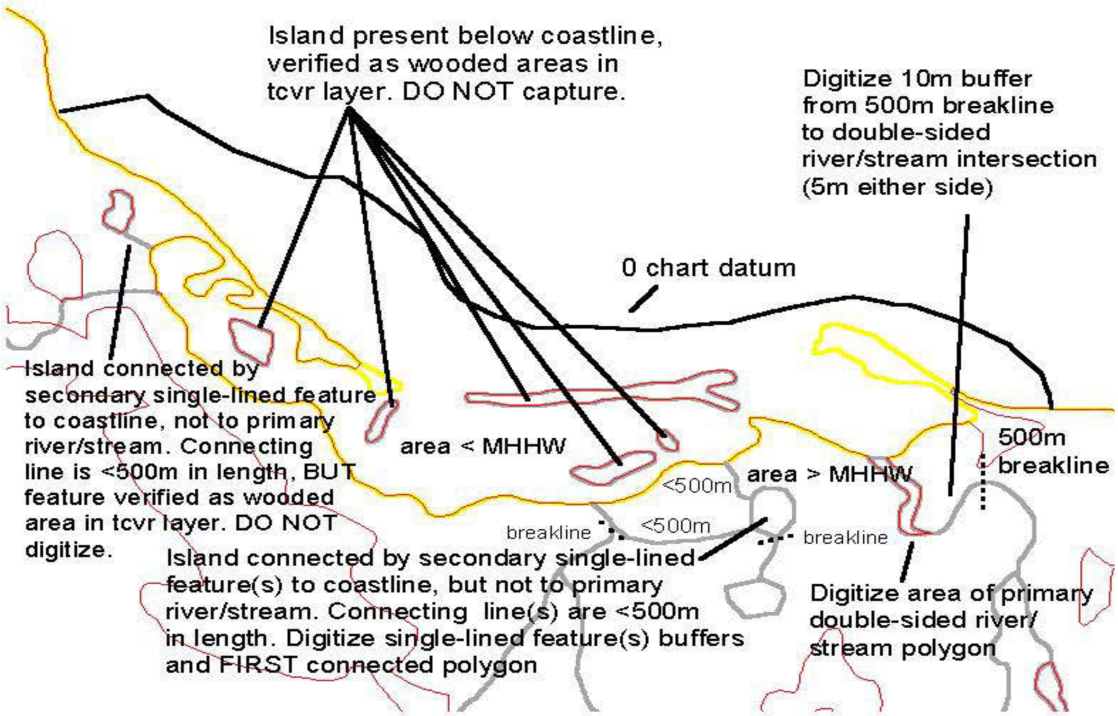

Fig. 3f. Single or double-lined primary river/stream channel(s) intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance. Relevant feature(s) are connected to the coastline by secondary single-lined features at ≤ 500m distance, within the limits of the intertidal zone, but are not connected to the primary river/stream. Features above the coastline can be captured as backshore polygons. Upstream islands, features in intertidal, and upstream zones captured as above (coastline or MHHW in yellow, wooded area polygons from tcvr layer in red).

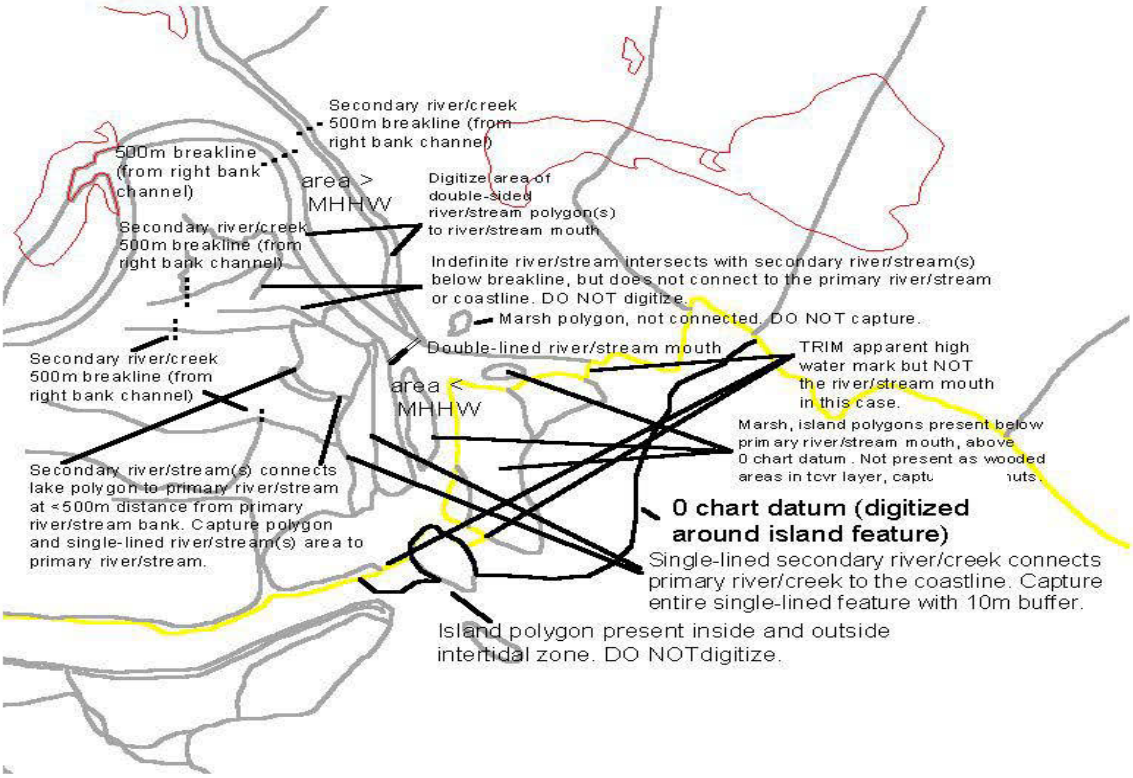

Fig. 4a. Single or double-lined primary river/stream channel(s) intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance. Relevant feature(s) are connected to the primary river/stream bank(s) by secondary single-lined river/stream(s) or ditches at ≤ 500m distance from primary river/stream mouth(s). Features connected to the primary river/stream bank(s) can be captured as backshore polygons. Features in backshore, upstream islands, features in intertidal, and upstream zones captured as above (coastline or MHHW in yellow, wooded area polygons from tcvr layer in red).

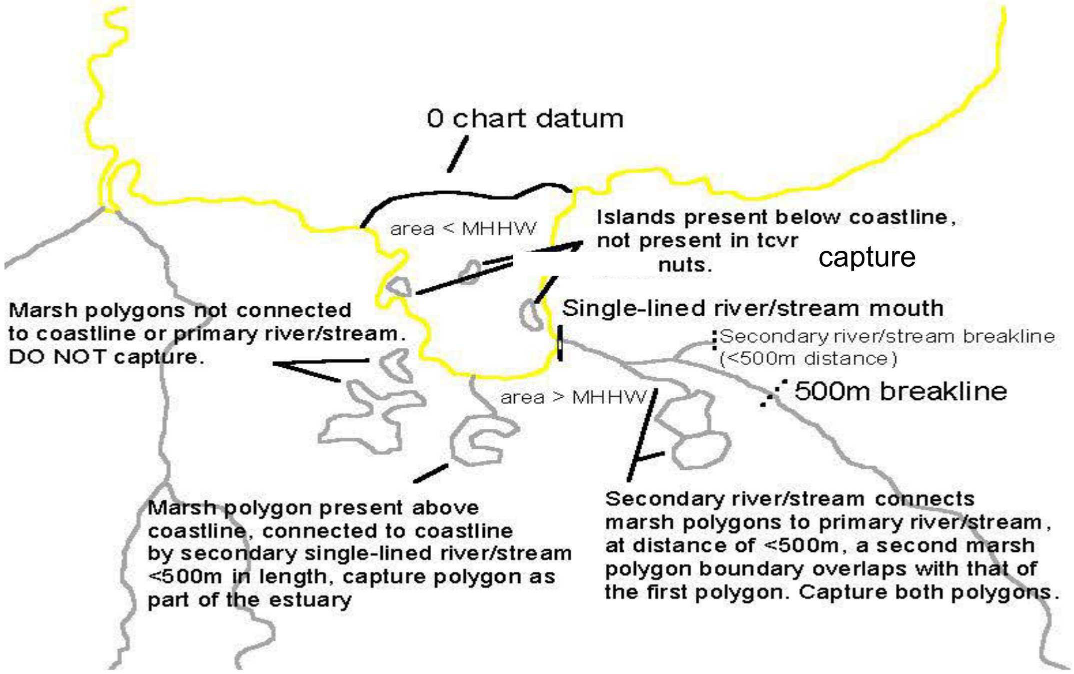

Fig. 4b. Single or double-lined primary river/stream channel(s) intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance. Relevant feature(s) are connected to the primary river/stream bank(s) by secondary single-lined river/stream(s) or ditches at ≤ 500m distance from primary river/stream mouth(s), additional feature(s) boundary(ies) overlap with the features connected to secondary river/streams. Additional features can be captured as backshore polygons. Features in backshore, upstream islands, features in intertidal, and upstream zones captured as above (coastline or MHHW in yellow, wooded area polygons from tcvr layer in red).

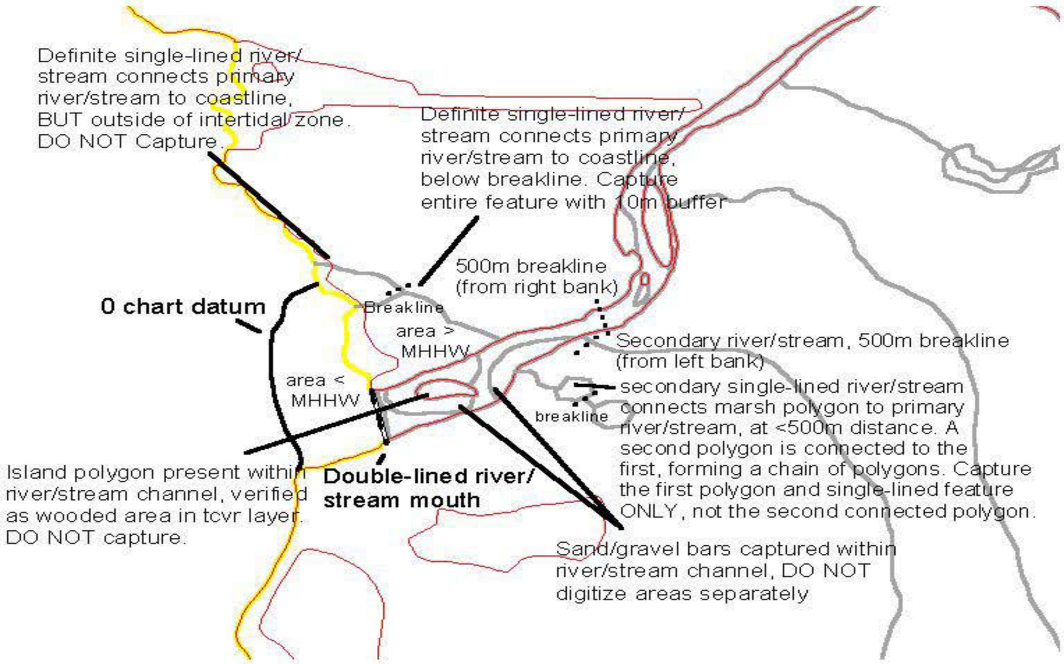

Fig. 4c. Single or double-lined primary river/stream channel(s) intersects with TRIM coastline, continues upstream as single or double-lined river/stream to 500m distance. Relevant feature(s) are connected to the primary river/stream bank(s) by secondary single-lined river/stream(s) or ditches at ≤ 500 distance from primary river/stream mouth(s). Other feature(s) are connected to the first feature by additional secondary single-lined features, within the 500m upstream limit, forming a link or chain of features. The first linked feature can be captured as a backshore polygon. Features in backshore, upstream islands, features in intertidal, and upstream zones captured as above (coastline or MHHW in yellow, wooded area polygons from tcvr layer in red)

Section III: Supplemental mapping criteria for Skeena River estuary

I. Additional guidelines for capturing relevant estuary features in intertidal and upstream areas

1) The Skeena is a unique estuary system in that it does not have a single distinct intertidal delta typical of most estuary systems. Suspended particles from the river system are deposited in banks or shoals along or in the lower river and channels connecting the estuary with the open ocean forming several intertidal deltas (Hoos, 1975). Intertidal zone digitizing rules applicable to other estuaries cannot be applied here.
2) There is no distinct mouth of the Skeena River system given the unique characteristics of the estuary. The mouth of an estuary is generally considered to be the Euhaline zone with >30 o/oo salinity content (Elliott and McLusky, 2002). Salinity samples collected by Fisheries and Oceans Canada in September 1948 (Trites, 1956) and September 1969 (M. Waldichuk, Pacific Oceanographic Group, Institute of Ocean Sciences, unpublished data) indicated that there was still considerable freshwater present at stations P28 Hicks Point (Oligohaline zone; 0.5-5 o/oo salinity) and 97 Hegan Point (Polyhaline zone; 18-30 o/oo salinity). Based on the freshwater outflow through several channels, and the presence of geographic breakpoints, create river mouth breaklines as follows:
   a) from Hicks point on Smith Island to north shoreline of Inverness Passage. The breakline intersects intertidal delta at both Hicks point and the north shoreline; the channel enters Chatham Sound from this location. For the north shoreline intersection, capture/digitize the intertidal delta below (west) of the breakline for the area known as Flora Bank (includes intertidal area around Lelu, Stapledon, and Kitson Islands). Capture/digitize the intertidal delta above (east) of the breakline to the coastline intersection point at the North Pacific Cannery Museum. For the Hicks point intersection, capture/digitize the intertidal delta below (west) of the breakline on the Northwest side of Smith Island to the coastline intersection point at the entrance to Tsum Tsadai Inlet. Capture/digitize the intertidal delta above (east) of the breakline to the coastline intersection point at Tatenham Point.
   b) from Georgy Point on Kennedy Island north to Gamble Point on CroasDaile Island AND from the westernmost point on CroasDaile Island to the South end of Smith Island (west of Neill Islets). The channel enters Marcus Passage at this location. Capture/digitize all intertidal delta (connected or disconnected from islands or

mainland coastline) areas above (east) of the breaklines adjacent to CroasDaile Island, between Smith and DeHorsey Islands, and east of Georgy Point. ***Additionally, capture/digitize the large intertidal area known as Base Sand, west of Georgy Point, as part of the estuary despite the fact it is present outside, and disconnected from, the Kennedy Island/CroasDaile breakline.**

c) from Clough Point on the mainland, north of Kromann/Moore Cove creek estuary, in a horizontal line to Kennedy Island. This is in the portion of the channel called Telegraph Passage. The breakline intersects intertidal delta at both Clough Point and Kennedy Island, capture areas above (north) and below (south) of the breakline as appropriate. ***Normally the breakline would be created at the south end of Kennedy island where the channel opens to the ocean, but the Kromann/Moore Cove creek estuary is present on the mainland, opposite the central portion of Kennedy Island, and it DOES NOT share an intertidal delta with the Skeena River system).**

3) Capture and digitize all intertidal areas above the breaklines, regardless of whether they intersect islands or the mainland shoreline, (i.e. capture/digitize such areas as Davies Bank, Robertson Banks, etc.) as part of the estuary (as described in Hoos, 1975). ***As the Skeena does not have a distinct river mouth, much of the intertidal deposits are present above the digitized river mouths, in contrast to other estuary systems where the intertidal delta is present below the primary river/stream mouth(s) and coastline.**

4) Code all intertidal areas, above or below the breaklines, whether they are connected or disconnected from islands or mainland coastline, as intertidal delta (ID).

II. Upstream limit of saltwater intrusion used to create breakline

1) The location with an average salinity measurement of <0.5 parts salt per unit mass of seawater (S o/oo), across sampling occasions, is generally used to estimate the upstream limit of an estuarine system. This is the beginning of the limnetic or non-tidal zone as defined by Elliott and McLusky (2002).

2) Salinity measurements for the Skeena were obtained by the Pacific Oceanographic Group in the Skeena River system in September 1948 (Hoos 1975). An estimated limit of saltwater intrusion for the Skeena cannot be precisely determined as the maximum upstream sampling station where measurements were taken (station 98 above confluence of Ecstall and Skeena River channels) had salinity measurements ranging from 1.0-8.1 from samples taken on September 7, 1948 (Trites, 1956). The range of measurements

corresponds approximately to what would be considered the oligohaline zone (Elliott and McLusky, 2002) which is located directly downstream of the limnetic zone. Additional maps and details can be found in Figure 5.5 from Hoos 1975.

3) Based on this estimate and in the absence of additional information, a breakline can be digitized parallel to sampling station 98 to delineate the upstream limit of the estuary. NOTE: the breakline intersects mud or sandflat areas between the TRIM left/right river banks according to CHS chart, but consistent with Section II, Part IV, rule 7b above these features are captured as sand/gravel bars in TRIM (the primary reference layer) and as per rule 9, sand/gravel bar features are not used to adjust breaklines.
   The breakline is approximately 22 km upstream of the mouth of the Skeena River estuary where it enters Marcus Passage. Digitize an additional breakline at the Ecstall River where it intersects the Skeena River to close the upstream polygon (distance from Skeena left bank/mouth intersection to Ecstall River confluence is >22 km).
4) Code all river channel or passage areas above (east) of the river mouth breaklines, below the upstream breakline, as Upstream River (UR).
5) All secondary single or double-lined river/stream(s) or ditches that connect to the Skeena, above the digitized river mouths and within the upstream distance of the digitized breakline, should be captured and/or buffered to an upstream point where the distance from the secondary feature intersection point with the Skeena left/right river banks is ≤ 500m.
6) All relevant features that connect to or intersect the banks of the Skeena, within the upstream distance of the digitized breakline, should be captured as per above mapping criteria. Capture relevant features connected to the Skeena by secondary river/stream features or ditches if the distance to the feature is ≤ 500m from the river/stream or ditch intersection with the Skeena left/right river banks.
7) As per above criteria, capture all relevant TRIM islands in twtr layer that are NOT verified wooded area features from tcvr layer.

Section IV: Supplemental mapping criteria for Nass River estuary

I. Additional guidelines for capturing relevant estuary features in intertidal and upstream areas

1) The Nass River forms a distinct intertidal delta below the river mouth, where the river channel splits the intertidal delta, that can be captured as per Part I, Section V, rule 1b above.
2) A large upstream area of the Nass River is not shown on CHS charts; Use NTS mapsheet to locate river mouth and upstream features.

II. Upstream limit of saltwater intrusion used to create breakline

1) The location with an average salinity measurement of <0.5 parts salt per unit mass of seawater (S o/oo), across sampling occasions, is generally used to estimate the upstream limit of an estuarine system. This is the beginning of the limnetic or non-tidal zone as defined by Elliott and McLusky (2002).
2) No data were available with respect to the upstream limit of saltwater intrusion for the Nass River estuary system. From the CHS charts and NTS mapsheet it was determined that the intertidal mudflats extended to approximately Black Point upstream from the mouth of the Nass River. The Ishkseenickh (AKA Ksi Hlginx) TRIM double-lined river enters the Nass River system above this location, and it is expected that this would likely be a point where freshwater inflow would significantly dilute any remaining saline content present in the Nass River.
3) Based on this, digitize a breakline from Black Point southwest to the opposite river bank to close the river mouth, and digitize a second breakline parallel to the confluence of the Ishkseenickh River with the Nass River to close the upstream polygon. This is approximately 3.5 km upstream from the mouth of the Nass River.
4) All secondary single or double-lined river/stream(s) or ditches that connect to the Nass, between the digitized river mouth and the upstream breaklines, should be captured and/or buffered to an upstream point where the distance from the secondary feature intersection point with the Nass left/right river banks is ≤ 500m.
5) All relevant features that connect to or intersect the banks of the Nass, within the upstream distance of the digitized breakline, should be captured as per above mapping criteria. Capture relevant features connected to the Nass by secondary river/stream features or ditches if the distance to the feature is ≤ 500m from the river/stream or ditch intersection with the Nass left/right river banks.

<u>Section V: Supplemental mapping criteria for Fraser, Serpentine/ Nickomekl and Campbell River(1) estuaries</u>

I. Additional mapping sources used for feature verification

1:2,500 scale Fraser River Estuary Management Plan (FREMP) estuarine habitat polygons (V.1.0 August 1998), in addition to the other mapping data sources used above. The FREMP polygons were digitized from 1996-98 using airphotos taken in 1986 and 1989.

<u>Relevant FREMP feature codes and descriptions for mapping:</u>

From Habinv.shp shapefile: estuarine marsh (EM), intertidal mudflat (IM), and intertidal sandflat (IS)

<u>Relevant additional TRIM feature codes and descriptions for river/stream or ditch intersections with dyke, roadway, or railway features:</u>

TRIM layer (ttrn coverage): DA25000110 (road loose undivided – 1 lane), DA25000120 (road loose undivided – 2 lane), DA25050180 (road paved divided – 2 lane), DA25100210 (road paved undivided – 4 lane), DA25050190 (road paved divided – 4 lane), DA25100220 (road paved undivided – 6 lane), DA25050200 (road paved divided – 6 lane), DA25050330 (road paved divided status unconfirmed – 6 lane), DA25100360 (road paved undivided status unconfirmed – 6 lane), DA25100350 (road paved undivided status unconfirmed – 4 lane), DA25050320 (road paved divided status unconfirmed – 4 lane), DA25050310 (road paved divided status unconfirmed – 2 lane), DA25000170 (road gravel undivided status unconfirmed – 2 lane), DA25000160 (road gravel undivided status unconfirmed – 1 lane), DA25100200 (road paved undivided – 3 lane), DA25100340 (road paved undivided status unconfirmed – 3 lane), DA25100190 (road paved one way – 2 lane), DA25100330 (road paved one way status unconfirmed – 2 lane), DA25150000 (road rough/unimproved), DA25100180 (road paved undivided – 1 lane), DA25100320 (road paved undivided status unconfirmed – 1 lane), DE22850000 (rail line double-track), DE22900000 (rail line multiple-track), DE22950000 (rail line single-track), DE22950001 (rail line abandoned track), DF28850000 (rail line spur).

II. Additional guidelines for capturing relevant estuary features in intertidal and upstream areas (includes downstream islands)

1) FREMP is the primary reference layer for capturing and digitizing features. Both FREMP with TRIM should be used as sources of input data. For the Fraser River, all relevant features present on the mainland or on islands (i.e. Lulu, Annacis, Westham, Sea Islands, etc.), between the river banks and below the digitized upstream breakline (see Section III below for upstream breakline location), should be captured as per above

mapping criteria. The relevant FREMP polygons to include as estuary features are estuarine marsh (EM), intertidal mudflat (IM), and intertidal sandflat (IS). The FREMP layer contains estuary polygons and does not generally show extensive coastline, island, or left/bank features. Use TRIM to depict and capture this linework (i.e. left/right river bank channel(s) and coastline). Reclassify FREMP polygons as per PECP mapping codes. **Where there is a discrepancy between polygons, linework and attributes between TRIM and the FREMP map layers, use the FREMP polygon boundaries to capture relevant features as they were mapped at 1:2,500 scale and should provide better detail relative to TRIM. If possible, verify features with 1m or 0.5m 1999 orthophotos.**

2) Owing to the size of islands present in the Fraser River estuary, the extent of urbanization/ industrialization on islands, and the availability of FREMP polygons for feature verification, the entire island features shown in TRIM below the upstream breakline <u>are not</u> captured as part of the estuary system. ***This is in contrast to Section II, Part IV, rule 8 above where all island areas, not be verified as wooded area features, were captured as part of the estuary. The former rule is not generally applicable to the large, deforested and otherwise modified islands within the Fraser estuary system where FREMP provides additional information on estuary features.**
3) Given the FREMP/TRIM scale discrepancies, capture all FREMP IM, IS, or EM polygons above 0 chart datum contour, even if they do not directly intersect or overlap TRIM linework (**in contrast to Section II, Part IV, rule 13 above**).
4) Exclude (clip and erase) FREMP polygons coded as riparian grass/shrubs (RG) or riparian trees (RT), regardless of their position relative to TRIM linework. Exclude areas as donuts where necessary.
5) Exclude all unidentified backshore areas <u>above</u> TRIM islands, left/right river/stream banks, and coastline that are not otherwise depicted as relevant estuary features in FREMP or TRIM.
6) For marsh, swamp, etc. features present above or below the TRIM island shoreline for Lulu, Annacis, Westham, and Sea Islands in the Fraser River estuary, code polygon features as backshore if the features are present above the Fraser river/stream mouth(s), between the river/stream channel(s), or above the shoreline.
7) Capture the intertidal delta (ID) area for the Fraser River, above 0 chart datum contour line, as depicted on CHS charts, including (2) small, isolated areas of intertidal delta at West side of Roberts Bank.

8) Capture the area of the (4) main outflow channels of the Fraser River below the digitized river/stream mouths, and digitize connector lines between the intertidal areas if the channels extend beyond the intertidal deltas shown on CHS charts (see Roberts and Sturgeon Banks). Code areas as intertidal delta (ID) consistent with Section I, Part V, rule 1b above.
9) If FREMP IS or IM polygons extend below 0 chart datum linework (applies to Campbell River(1) only) into the subtidal zone, only capture those portions of the polygons present in the intertidal zone above the 0 chart datum line.
10) If FREMP IM and/or IS polygons are fully contained <u>between</u> 0 chart datum and TRIM coastline and <u>below</u> river/stream mouth, dissolve polygon boundaries and include areas as intertidal delta. If IM or IS polygons are fully contained in the river channel(s), <u>below</u> TRIM left/right banks and <u>above</u> the river/stream mouth breaklines, dissolve polygon boundaries and include areas as upstream river. There is no need to identify intertidal mudflat and sandflat polygons as distinct areas if they are adequately captured within existing TRIM and CHS chart linework.
11) If all or portions of FREMP IM or IS polygons extend <u>above</u> TRIM coastline, AND are present <u>below</u> river/stream mouths, capture the entire polygon features, regardless of their position relative to TRIM linework, and include as intertidal delta (FREMP polygon overlaps occur primarily with TRIM coastline and island features).
12) If all or portions of FREMP IM or IS polygons extend <u>above</u> the TRIM left/right banks or upstream islands <u>above</u> river/stream mouths, capture the entire polygon features, regardless of their position relative to TRIM linework, and include as upstream river (FREMP polygon overlaps occur primarily with TRIM upstream islands, left/right banks, or dyke features).
13) If the river/stream mouth intersects FREMP IM or IS polygons, split the polygons using the river/stream mouth linework as the dividing line, and capture/code those portions <u>below</u> the river/stream mouth as intertidal delta, and those portions <u>above</u> the river/stream mouth as upstream river.
14) Where the river/stream mouths (derived from TRIM apparent high water mark or digitized separately) intersect relevant TRIM island features, not wooded areas in tcvr layer, that would otherwise split the island into backshore and intertidal sections, code the entire island feature as backshore island (above river mouth) or intertidal island (below river mouth) <u>dependent on</u> whether the majority of the polygon is present above or below the river/stream mouth.

15) Capture all FREMP estuarine marsh (EM) areas as distinct polygons. Assign unique id's to each polygon, regardless of position relative to TRIM linework. Code areas as intertidal marsh (present below coastline and river/stream mouth) or backshore marsh (present above river/stream mouth). If the majority of an EM polygon is present below TRIM coastline or river/stream mouth, code the entire polygon feature as intertidal marsh (IM). If the majority of an EM polygon is present above the coastline or river/stream mouth, code the entire polygon feature as backshore marsh (BM). All FREMP EM polygons upstream of the river/stream mouth should be coded as backshore marsh regardless of position relative to TRIM linework.

16) One swamp feature was captured by TRIM in the Fraser estuary; this area is partially covered by FREMP EM. Code that portion of the polygon covered by EM as backshore marsh (BM). The remainder of the TRIM swamp linework outside the EM boundary should be captured as a polygon and coded as backshore swamp (BS).

17) Capture all remaining upstream areas (above river mouth) between TRIM left/right banks and/or below upstream islands as upstream river (UR), if not otherwise excluded as donuts from FREMP comparison. Capture all remaining intertidal areas (below river mouth), below TRIM coastline, and above 0 chart datum contour as intertidal delta (ID) if not otherwise excluded as donuts from FREMP comparison. Associate these areas with existing UR or ID polygons to form multipart polygons.

18) Exclude TRIM breakwall/breakwater, seawall, or dam features present between left/right banks, or present in intertidal areas, as donuts (capture linework with 10m buffer, 5m buffer either side). FREMP polygons (all or portions) present within buffers are not excluded, provided they are not FREMP riparian polygons.

19) Label specific backshore, upstream and intertidal areas of the Fraser River system in the comments field (i.e. Roberts Bank, Sturgeon Bank, South Arm marshes, Lulu Island, etc.) for referencing.

III. Upstream limit of saltwater intrusion used to create breakline

1) The location with an average salinity measurement of <0.5 parts salt per unit mass of seawater (S o/oo), across sampling occasions, is generally used to estimate the upstream limit of an estuarine system. This is the beginning of the limnetic or non-tidal zone as defined by Elliott and McLusky (2002).

2) The upstream limit of saltwater intrusion for the Fraser River was obtained from measurements taken by Ages (1979, 1988) and Ages and Woollard (1994a,b). For the South/Main arm of the Fraser river, the recorded location where salinity measurements of

<0.5 parts salt per unit mass of seawater were detected was at the south end of Annacis Island; salinity measurements taken at ½ hour intervals for station S34 in February 1978 and June 1987 did not exceed 0.20-1.00 o/oo at this location (Ages, 1988, Ages and Woollard, 1994a,b). For the North arm of the Fraser river, a limited set of measurements indicated that the upstream extent of saltwater intrusion was approximately at the east end of Sea Island at the Arthur Laing bridge. Salinities >1.0 o/oo were not detected east of this sampling station from data collected in 1987 (Ages and Woollard, 1994a,b).

3) The points where breaklines would normally be delineated for the South/Main and North arms of the Fraser river intersect Lulu Island. Since this area cannot be verified as a wooded area feature in TRIM tcvr layer, the breakline is delineated at the upstream limit of the island polygon (east end of both Lulu and Annacis Island) where the Fraser separates into South and North arms.
4) For the Serpentine/Nickomekl and Campbell River (1) estuaries, a 500m upstream breakline should be delineated for each river/stream channel present above the mouths, consistent with the rule used for most estuaries.
5) All secondary single or double-lined river/stream(s) or ditches present on the mainland or on islands, that connect to the Fraser, Serpentine/Nickomekl, or Campbell River (1) estuaries, between the digitized river mouths and the upstream breaklines, should be captured and/or buffered to an upstream point where: a) they first intersect dyke, seawall, breakwall/ breakwater, dams, paved/unpaved road, or other features where it is assumed that water control structures would be present to interrupt the free flow of water, or b) where such structures are not present, to an upstream point where the distance from the secondary feature intersection point with the left/right river banks is ≤ 500m. For secondary single-lined features, digitize a 10m buffer up to these breakpoints (5m either side) consistent with existing criteria.
6) Capture other relevant TRIM features connected to the Fraser, Serpentine/Nickomekl, or Campbell River (1) estuaries, by secondary river/stream features or ditches (on the mainland or on islands), if a) there are no water control structures that impede the free flow of water between the feature and the secondary intersection point with the left/right river banks, b) the connection distance is ≤ 500m in length to the feature intersection point, and c) the features are otherwise not excluded as FREMP riparian area.

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Appendix 1. Field descriptions and codes used for estuary mapping

Shape	<polygon> is default
Area	polygon area in square metres
Perimeter	polygon perimeter in metres
Unique_id	unique numerical ID for each relevant estuary polygon in the database
Est_name	Name of the river/stream estuary system or complex using any map source (unnamed river/stream = Unnamed). River/stream names within a complex are separated by a backslash (/)
Est_no	unique numerical ID for each estuary system or estuary complex
Area_id:	B = Backshore (supratidal) I = Intertidal U = Upstream (above river/stream mouth)
Unit_id:	BI = Backshore Island BM = Backshore Marsh BMC = Backshore Marsh, derived from CHS chart only BS = Backshore Swamp BL = Backshore Lake BU = Backshore unconfirmed (unconfirmed/miscoded) II = Intertidal Island IM = Intertidal Marsh IS = Intertidal Swamp IL = Intertidal Lake (miscoded) ID = Intertidal Delta IU= Intertidal Unidentified (unconfirmed/miscoded) UI = Upstream Island UR = Upstream River UU = Upstream Unidentified (unconfirmed/miscoded)

Loc_method: 0 = Hunter *et al.* (1985)
1 = TRIM
2 = WSA
3 = TRIM & WSA
4 = TRIM (also found by Hunter *et al.* 1985)
5 = WSA (also found by Hunter *et al.* 1985)
6 = TRIM & WSA (also found by Hunter *et al.* 1985)
7 = CWS (estuary surveyed for waterbird abundance)
8 = TRIM & CWS
9 = WSA & CWS
10 = CWS (also found by Hunter *et al.* 1985)
11 = TRIM & CWS (also found by Hunter *et al.* 1985)
12 = WSA & CWS (also found by Hunter *et al.* 1985)
13 = TRIM & WSA & CWS
14 = TRIM & WSA & CWS (also found by Hunter *et al.* 1985)
15 = other location method

Spit_pres: presence of a spit beyond mouth of estuary, that shelters all or part of estuary from ocean influence [(y)es or (n)o]

M_int_dist: shortest connection distance (metres) from estuary mouth(s) to 0 chart datum line

Dig_crit: Criteria used to capture and digitize estuary polygons. Format is [backshore #, intertidal #] as follows:

<u>Backshore</u>

1 = No marsh, swamp, island, lake, or wooded area features present, within lateral extent of intertidal zone, above or below coastline. No secondary river/streams connect polygons to primary river/stream. No islands present between primary river/stream channel(s).

2 = Marsh, swamp, island, or wooded area features present, within lateral extent of intertidal zone, between coastline and 0 chart datum contour. No secondary river/streams connect polygons to primary river/stream. No islands present between primary river/stream channel(s).

3 = Marsh, swamp, island, lake, or wooded area features present, within lateral extent of intertidal zone, above coastline. No secondary river/streams connect polygons to primary river/stream. Islands may be present between double-lined river/stream channel(s).

4 = Marsh, swamp, island, lake, or wooded area features present, within lateral extent of intertidal zone, above coastline. Secondary river/streams connect polygons to primary river/stream. Islands may be present between double-lined river/stream channel(s).

Intertidal:

0 = << No intertidal zone present >>

5 = Below primary river/stream mouth(s), the 0 chart datum contour line intersects TRIM coastline at ≥ 2 locations, closed intertidal polygon can be digitized.

6 = Below primary river/stream mouth(s), the 0 chart datum contour line does not intersect TRIM coastline at ≥ 1 location, but distance between 0 chart datum and coastline narrows to 120m, closed intertidal polygon can be digitized.

7 = Below primary river/stream mouth(s), the 0 chart datum contour line does not intersect with TRIM coastline at ≥ 1 location, distance between 0 chart datum and coastline does not narrow to 120m at ≥ 1 location, but shoreline habitat has changed above or below coastline, closed intertidal polygon can be digitized.

8 = Below primary river/stream mouth(s), the 0 chart datum contour line does not intersect with TRIM coastline at ≥ 1 location, distance does not narrow to 120m at ≥ 1 location, shoreline habitat does not change, but spit, jetty or peninsula is present and forms logical breakpoint, closed intertidal polygon can be digitized.

9 = Below primary river/stream mouth(s), the 0 chart datum contour line does not intersect with TRIM coastline at ≥ 1 location, distance does not narrow to 120m at ≥ 1 location, shoreline habitat does not change, no spit, jetty or peninsula present, but secondary named river/stream is present upstream or downstream, breakpoint can be digitized midway between named secondary river/stream and primary river/stream, closed intertidal polygon can be digitized.

Code_let: Four letter/numeric ID code for estuary system/complex

Nts_used: NTS maps used for feature verification [(y)es or (n)o]

Ndi_chart: CHS chart reference number for estuary system/complex

Location: General location of estuary [Vancouver Island, Mainland coast, Queen Charlotte Islands]

A20k_tag: TRIM mapsheet reference number for estuary system/complex

Marsh_corr: Marsh/swamp area depicted on CHS chart but not captured in TRIM. Marsh area polygon digitized from CHS chart (above or below TRIM coastline) [(y)es or (na) not applicable]

photo_ver: estuary features verified from best available scale and most recent airphoto or orthophoto (where available) [(y)es, (n)o]

Comments: General comments about estuary system or complex

Hectares: Area of each estuary polygon (in hectares)

Gbei_est: Presence of estuary inside/outside Georgia Basin Ecosystem Initiative (GBEI) boundary [(Y)es, (N)o]

Ecoregion: B.C. Provincial Ecoregion in which estuary system or complex is located [COG = Coastal Gap, EVI = Eastern Vancouver Island, HCS = Hecate Continental Shelf, LOM = Lower Mainland, NOM = Northern Coastal Mountains, PAC = Pacific Ranges, QCL = Queen Charlotte Lowlands, QCR = Queen Charlotte Ranges, WVI = Western Vancouver Island]

Substrate: B.C. Provincial Marine Ecounit (Benthic Component, Substrate Class) in which estuary system or complex is located
[(H)ard, (M)ud, (S)and, (U)ndefined]

Exposure: B.C. Provincial Marine Ecounit (Benthic Component, Exposure Class) in which estuary system or complex is located
[(H)igh, (L)ow, (M)oderate]

Current: B.C. Provincial Marine Ecounit (Benthic Component, Current Class) in which estuary system or complex is located
[(H)igh or (L)ow]

Slope: B.C. Provincial Marine Ecounit (Benthic Component, Slope Class) in which estuary system or complex is located
[(F)lat, (S)loping, T = Steep]

Depth: B.C. Provincial Marine Ecounit (Benthic Component, Depth Class) in which estuary system or complex is located
[(D)eep, (M)id-depth, (P)hotic, (S)hallow]

Temp: B.C. Provincial Marine Ecounit (Benthic Component, Temperature Class) in which estuary system or complex is located
[(C)old, (W)arm, (U)ndefined]

Roughness: B.C. Provincial Marine Ecounit (Benthic Component, Roughness Class) in which estuary system or complex is located
[(H)igh, (L)ow, (M)oderate]

Appendix 2: Species Rarity Index GIS Methodology

Provincial Shore Zone dataset - references to methodology

SHORE ZONE DATASET USED: v.1.0.0 DRAFT (available prior to 3Mar05 when v. 2.0.0 was released by MSRM).

1. All PECP Estuary polygons excluding Unit_ID = "II" or "UI" were selected and converted from a shapefile to a geodatabase polygon feature class.
2. The resulting estuary polygons were then converted to a geodatabase polyline feature class governed by a topology rule disallowing any overlapping line segments (i.e. those generated by adjacent polygons).
3. The "Planarize Lines" tool was then used on the estuary polylines dataset to split all of the lines at their intersection point. This also eliminated any duplicate lines due to the existing topology rule. A spatial join was then performed to link the polylines with attributes from the original PECP Estuary polygon shapefile.
4. Shorezone records without a valid PHYIDENT (physical identifier) value were removed from the shorezone dataset. These included the following values of PHYIDENT: "" (null), "00", "00/00/0/00", any value where PHYIDENT < "01/01/0023/00" or PHYIDENT > "13/21/0178/00", any value of PHYIDENT that is less than 13 characters long (e.g. "10/21/0/00"). See Step 10 below for exceptions where the logical numbering of PHYIDENT was incorrect but the biobanding database contained records for what would have been the proper numbering; these errors were corrected prior to linking the shapefile to the biobanding data.
5. The shorezone shapefile was visually checked for any islands located near estuaries, but not intersecting an estuary at any point. These islands were removed from the dataset. This was to ensure that these islands were not selected in the nearest feature analysis. Shorezone segments from islands or mainland coast that did not intersect an estuary but could potentially be picked up in the nearest feature analysis were also removed (e.g. the coastline segments across an inlet from an estuary). However, this did not work in all cases (see Tasu Creek estuary for example).
6. Used the "Add points evenly along a line" tool at a distance of 100m to generate a series of points along the PECP Estuary polygon boundaries. The 100m interval was chosen because this distance was tested and demonstrated to pick up shoreline segments adequately without generating redundant data for a given shorezone feature. Attributes

from the PECP estuaries were then linked back to the 100m estuary points through a spatial join.

7. Used the “Find Nearest Features” tool to return the nearest shorezone segments from the estuary points in a database table.
8. The above procedure generates multiple hits for each section of shoreline found in the shorezone data. A SAS program was written to reduce the number of PHYIDENT hits to one for each estuary (keeps the first value of PHYIDENT returned by the PECP estuary linework to shorezone comparison and eliminates multiple hits for the same PHYIDENT segment). A total of 18 estuaries were checked to verify that the proper records were returned only once for each shorezone segment from this procedure.
9. 40 estuaries were initially checked to confirm that all shorezone segments within the extent of the estuary were detected in the analysis. While the analysis worked well for picking up all the shorezone units intersecting the estuary, some shorezone units outside of the estuary boundaries were also picked up if they were the nearest feature to one or more of the points in the 100m estuary point layer. Also, some significant shorezone segments were missed for estuaries that were offset from the shorezone linework. As a result, all estuaries were manually checked to eliminate those segments that were detected outside the estuary, including segments that were: a) in adjacent inlets, outside the estuary boundary, see Tasu Creek for example, b) anomalous “hits” that picked up segments that were not in the vicinity of the estuary, c) segments that were entirely present in another adjacent estuary, and d) segments that were >3 Km distance from the estuary intersection point(s) (same buffer as linework included from bird survey datasets). One exception to rule (d) was for est_no=400 (Southgate River) where shoreline segment 05/02/2248/00 was included because it extended >3 Km upriver instead of along the coastline (data for eelgrass, kelp, etc. should be robust as the intertidal portion of the segment was specific to the estuary).
10. There were a few duplicate PHYIDENTS from the shorezone file. These records were checked against the logical ordering of what the PHYIDENTS should have been for that section of coastline, and were checked against the bioband database to confirm that records existed. The following incorrectly assigned PHYIDENTS were changed in the database file to make the linkage back to legitimate biobanding records in the database.

Estuary Number	Estuary Name	PHYIDENT corrected #s
224	Unnamed	08/06/0272/00 assigned correctly to est_no 224, duplicate segment was deleted.
350	Koeye River	old prefix 07/02/****/** corrected to 07/01/****/**

There were also several PHYIDENTS that had incorrectly assigned numbers that were correctly assigned in the biobanding database and made sense in the logical ordering. These records were corrected in the database and were properly linked to the biobanding data (i.e. for Skowquiltz River estuary (est_no=317), PHYIDENTS 07/02/0981/00 and 07/02/0982 were not in the file and incorrect units 07/02/0/00 were assigned to these two segments; two segments were properly coded at the periphery of the estuary boundary in the shapefile and corresponded to the estuary, 07/02/0980/00 and 07/02/0982/00. PHYIDENTS 07/02/0981/00 and 0982 had data in the biobanding database, and logically these should have been the numbers assigned to these incorrectly coded segments in the shapefile). Incorrectly coded PHYIDENT segments from the shapefile were corrected as follows in the database to link the proper data from the biobanding database.

Estuary Number	Estuary Name	PHYIDENT Corrected Numbers	Estuary Number	Estuary Name	PHYIDENT Corrected Numbers
13	Chemainus River/Bonsall Creek Complex	01/09/0129/00	174	Deena Creek	10/18/0075/00
13	Chemainus River/Bonsall Creek Complex	01/09/0130/00	174	Deena Creek	10/18/0076/00
13	Chemainus River/Bonsall Creek Complex	01/09/0131/00	176	Lignite Creek	10/20/0098/00
14	Cowichan River	01/09/0161/00	176	Lignite Creek	10/20/0099/00
14	Cowichan River	01/09/0162/00	177	Naden River/Davidson Creek Complex	10/20/0111/00
15	Nanaimo River	01/09/0056/00	184	Dass Creek	10/17/0239/00
15	Nanaimo River	01/09/0057/00	197	Yakoun River	10/21/0143/00
18	Cypre River	03/04/0049/00	218	Nickomekl/Serpentine River Complex	01/07/0025/00
18	Cypre River	03/04/0050/00	218	Nickomekl/Serpentine River Complex	01/07/0026/00
18	Cypre River	03/04/0056/00	218	Nickomekl/Serpentine River Complex	01/07/0027/00

Estuary Number	Estuary Name	PHYIDENT Corrected Numbers	Estuary Number	Estuary Name	PHYIDENT Corrected Numbers
18	Cypre River	03/04/0057/00	218	Nickomekl/Serpentine River Complex	01/07/0015/00
19	Bedwell Creek	03/04/0126/00	218	Nickomekl/Serpentine River Complex	01/07/0016/00
19	Bedwell Creek	03/04/0127/00	218	Nickomekl/Serpentine River Complex	01/07/0017/00
20	Bulson Creek	03/04/0162/00	218	Nickomekl/Serpentine River Complex	01/07/0018/00
31	Marble River	12/04/0357/00	260	Klekane River	08/01/0136/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0640/00	260	Klekane River	08/01/0137/00
49	Clesklagh Creek	12/04/0252/00	261	Scow Bay	08/01/0133/00
50	Goodspeed River	12/04/0233/00	298	Khutze River	08/01/0025/00
51	Hathaway Creek	12/04/0199/00	298	Khutze River	08/01/0026/00
56	Koprino River	12/04/0117/00	312	Kimsquit/Hoam Creek Complex	07/02/0887/00
60	Kwatleo Creek	12/04/0014/00	313	Dean River	07/02/0859/00
60	Kwatleo Creek	12/04/0015/00	313	Dean River	07/02/0860/00
79	Waukwaas Creek	12/04/0326/00	317	Skowquiltz River	07/02/0981/00
85	Ououkinsh/Unnamed River Complex	12/02/0156/00	317	Skowquiltz River	07/02/0982/00
103	Keith River	12/03/0069/00	322	Ickna Creek	07/02/0460/00
106	Clanninick Creek	12/01/0720/00	328	Bella Coola/Necleetsconnay River Complex	07/02/0618/00
117	Cayaghis Creek	12/04/0434/00	336	Kwatna River	07/02/0242/00
117	Cayaghis Creek	12/04/0436/00	348	Nootum River	07/02/0042/00
118	Klaskish River	12/03/0239/00	355	Clyak River	06/05/0299/00
119	Irony Creek	12/05/0023/00	355	Clyak River	06/05/0300/00
120	Irony Creek	12/03/0251/00	357	Kilbella/Chuckwalla River Complex	06/05/0388/00
121	Kingfisher Creek	12/03/0288/00	374	Wakeman River	06/01/1137/00
124	Nasparti River	12/02/0274/00	374	Wakeman River	06/01/1138/00
125	Battle Bay	12/02/0184/00	380	Kingcome River	06/01/1195/00
126	Tahsish River	12/01/0465/00	380	Kingcome River	06/01/1196/00
126	Tahsish River	12/01/0466/00	390	Klinaklini River	05/04/3208/00
127	Kaouk River	12/01/0297/00	390	Klinaklini River	05/04/3209/00
165	Seal Inlet	11/07/0296/00	396	Phillips River	05/03/0813/00
165	Seal Inlet	11/07/0297/00	396	Phillips River	05/03/0814/00
166	Tartu Inlet	11/07/0410/00	406	Toba/Tahumming River Complex	05/01/1921/00
174	Deena Creek	10/18/0074/00	442	Asseek River	07/02/0466/00

11. Segments that were not picked up due to linework offset or limitations in the nearest feature analysis (where linework may have been missed because the points were at 100m intervals) were manually included in the database. Additional shorezone segments were included if: a) they intersected any part of the estuary at any point, or b) they would intersect if there were no offset between the estuary linework and the shorezone linework. The shorezone database file was updated accordingly and the file was joined back to the shorezone coverage.
12. The lower mainland from the U.S. border up to Theodosia River in Desolation Sound was NOT interpreted for biobands in this version of the shorezone mapping, largely owing to poor quality video imagery that precluded accurate assignment of vegetation bands (Carol Ogborne confirmed, BCMSRM, 24 September 2004 via correspondence from Mary Morris at Archipelago Marine Research Limited) and thus there are NO DATA for the following estuaries: 24, 26, 207, 208, 218 (partial data only), 273, 274, 361, 391 (partial data only), 408 (partial data only), 409, 410 (partial data only), 411, 412, 413, 414 (partial data only), 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427. These areas could not be ranked for their vegetative or invertebrate characteristics. Areas with no data were assigned missing values for: FK_ZONE_ID, FK_BIO_BND, and FK_BIO_DST fields. These records were removed from analysis using SAS to identify the missing records.
13. The following estuaries within the Strait of Georgia area on East Coast Vancouver Island had one or a few segments that could not be interpreted from the video imagery, which were recorded as missing, but had sufficient coverage (>75% of segments within the estuary were interpreted) to produce a ranking:

Estuary Number	**Estuary Name**	**Missing PHYIDENT**
1	Fanny Bay	01/10/0153/00
36	Tsable River	01/10/0154/00, 01/10/0155/00, 01/10/0158/00
6	Trent River	01/10/0175/00
13	Chemainus River	01/09/0123/00, 01/09/0126/00, 01/09/0128/00
34	Black Creek	01/10/0233/00, 01/10/0234/00
75	Oyster River	01/10/0234/00
147	Bilston Creek	01/11/0232/00

14. The following segments were also recorded as inferred "I" from the Strait of Georgia area, but had some bioband data information recorded for them. As the video imagery was poor for interpreted segments, these were also recorded as NO DATA (missing) despite the fact some biobands were noted. It was assumed that poor imagery would have precluded an accurate assessment of all biobands and that the ones that were mapped were biased toward those that could be easily identified from the poor image:

Estuary Number	Estuary Name	PHYIDENT
6	Trent River	01/10/0175/00
11	Nanoose/Bonell Creek Complex	01/10/0141/00
11	Nanoose/Bonell Creek Complex	01/10/0142/00
11	Nanoose/Bonell Creek Complex	01/10/0143/00
218	Nickomekl/Serpentine River Complex	01/07/0019/00
218	Nickomekl/Serpentine River Complex	01/07/0020/00
218	Nickomekl/Serpentine River Complex	01/07/0021/00
218	Nickomekl/Serpentine River Complex	01/07/0022/00
218	Nickomekl/Serpentine River Complex	01/07/0023/00
218	Nickomekl/Serpentine River Complex	01/07/0024/00
218	Nickomekl/Serpentine River Complex	01/07/0028/00
391	Fraser River	01/07/0001/00
391	Fraser River	01/07/0002/00
391	Fraser River	01/07/0004/00
391	Fraser River	01/07/0006/00
391	Fraser River	01/07/0009/00
391	Fraser River	01/07/0010/00
408	Sliammon Creek	01/01/0058/00
410	Lois River	01/01/0023/00
414	Vancouver River/High Creek Complex	01/03/0140/00

15. Two of the largest estuaries on Vancouver Island, Cowichan and Courtenay/Comox, were not interpreted in the shorezone mapping project. Given the obvious importance of these two sites for conservation planning and the absence of other vegetation data, it was decided to include data from the coastal resource folio/oil spill response atlas which was compiled in 1981 to supplement the shorezone mapping project data. Detailed vegetation data and invertebrate data are available for these areas from mylar maps, shown as polygons, for all seven classes used in the ranking (Moore *et al.* 1981). Both estuaries were plotted and overlayed on these mylar vegetation maps (same scale for interpretation) and a CWS GIS technician assigned the vegetation/invertebrate data to each PHYIDENT segment from the shorezone mapping project where they overlapped the coastal resource folio polygons. The same distribution codes were assigned as per the shorezone mapping project: P = patchy (intermittent distribution across the segment)

and C = continuous (continuous across the segment). This required some subjective determination where polygons were located close to, but not quite overlapping, the shorezone segments. There were some minor discrepancies between the shorezone classes and those found in the coastal resource folio as follows:

16. *Zostera* (ZOS) was pooled with *Ulva* (ULV) in the coastal resource folio habitat polygons; the eelgrass polygons for each site were consulted from the Sensitive Habitat Inventory Mapping (SHIM) coastal resource atlas to discriminate between these two habitat types to assign them properly to each PHYIDENT segment (http://www.shim.bc.ca/Coastal/Coastal_entry.htm). If the polygons from the coastal resource folio and SHIM overlapped for ZOS and ULV category and could not be separated, each was assigned as P or C for that shorezone segment.
17. *Ulva* (ULV) is also associated with *Enteromorpha* sp. which was inventoried in the coastal resource folio; therefore, where *Enteromorpha* was encountered it was recorded with ULV.
18. Mussel sp. were not distinguished in the coastal resource folio; it was assumed that the mussel species at these two sites would have been blue mussels (BMU) (Neil Dawe, CWS, pers. comm., 8 October 2004).
19. *Salicornia* were plotted as a genera for the Comox estuary; more detailed plant descriptions were available for Cowichan. The only *Salicornia* species at Cowichan was Salt Wort and where this was encountered it was recorded as *Salicornia* for that segment.
20. No Kelp species were present at either estuary, this was verified from the SHIM coastal resource atlas.
21. The following estuaries were not covered by any survey segments from the shorezone mapping project and thus there are NO DATA for these areas (estuary number in brackets): Chambers Creek (206), Mamquam River (274), Kwakwa River (290), Nascall River (320), and Nass/Ksi'Hlginx/Burton/Iknouck/Chambers/Kincolith River Complex (431). These were coded as per Step 12 above for missing values.

22. The following estuaries had incorrectly coded PHYIDENT segments in the shapefile that could not be manually corrected (logical sequence could not be interpreted) or linked to records in the biobanding database. There are no data for these locations:

Estuary Number	Estuary Name	PHYIDENT
40	Unnamed	03/02/0000/00
99	Effingham River	03/02/0000/00
100	Henderson Lake	00/00/0000/00
225	Keyarka Cove	08/03/0/00
240	Kumealon Creek	08/05/0/00
294	Hevenor Lagoon	08/06/0/00
301	Bottleneck Inlet	07/05/0/00
360	Draney Creek	06/05/0/00
436	Jesse River	08/07/0/00
438	Green Lagoon	07/06/0/00.

23. The following estuaries had duplicate PHYIDENT segments and FK_BIO_BND classifications in the bioband database, but had different across shore classifications (i.e. FK_ZONE_ID or FK_COMP_ID) therefore there were duplicate PHYIDENT segments, FK_BIO_BND, BUT different FK_BIO_DST codes (C and P); in these cases, one record with the highest score (C being best score) was retained for analysis. NOTE: these duplicate records are ONLY duplicated for PHYIDENTS and bio_bnd data, most are not true duplicates because for each PHYIDENT segment there are associated vertical zones (A=Supratidal, B=Intertidal, C=subtidal) and across shore components (1,2, or 3) within the PHYIDENT segment that have specific species assemblages assigned to them. To simplify the analysis, we took the highest band score for the (7) species of interest within the PHYIDENT segment (i.e. a given PHYIDENT segment may have had continuous *Zostera* for zone A component 1, and partial *Zostera* for zone B, component 1. We assigned a score of 2 for continuous *Zostera* in these instances to reflect the higher score, rather than developing a scoring index for each zone and component within a PHYIDENT segment). Additionally, the (7) species of interest were recorded in all zones and across all components which made this approach a more useful assessment of across-shore biobands.

Estuary Number	Estuary Name	PHYIDENT	Estuary Number	Estuary Name	PHYIDENT
7	Tahsis River	04/01/0226/00	90	Little Zeballos River	04/02/0169/00
7	Tahsis River	04/01/0226/00	90	Little Zeballos River	04/02/0170/00
8	Leiner River	04/01/0230/00	90	Little Zeballos River	04/02/0170/00
8	Leiner River	04/01/0230/00	90	Little Zeballos River	04/02/0170/00
8	Leiner River	04/01/0231/00	90	Little Zeballos River	04/02/0170/00
8	Leiner River	04/01/0231/00	91	Burman River	04/01/0606/00
20	Bulson Creek	03/04/0160/00	91	Burman River	04/01/0606/00
20	Bulson Creek	03/04/0160/00	91	Burman River	04/01/0606/00
20	Bulson Creek	03/04/0161/00	91	Burman River	04/01/0606/00
20	Bulson Creek	03/04/0161/00	92	Jacklah River	04/01/0635/00
22	Somas River	03/01/0870/00	92	Jacklah River	04/01/0635/00
22	Somas River	03/01/0870/00	92	Jacklah River	04/01/0635/00
23	Sarita River	03/02/0517/00	92	Jacklah River	04/01/0635/00
23	Sarita River	03/02/0517/00	93	Atleo River	03/05/0263/00
25	Kitimat River	08/07/0338/00	93	Atleo River	03/05/0263/00
25	Kitimat River	08/07/0338/00	94	Unnamed	03/05/0077/00
25	Kitimat River	08/07/0339/00	94	Unnamed	03/05/0077/00
25	Kitimat River	08/07/0339/00	108	Canton Creek	04/01/0386/00
25	Kitimat River	08/07/0340/00	108	Canton Creek	04/01/0386/00
25	Kitimat River	08/07/0340/00	108	Canton Creek	04/01/0386/00
25	Kitimat River	08/07/0341/00	108	Canton Creek	04/01/0386/00
25	Kitimat River	08/07/0341/00	108	Canton Creek	04/01/0386/00
29	Maggie River	03/02/0692/00	108	Canton Creek	04/01/0386/00
29	Maggie River	03/02/0692/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0692/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0692/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0694/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0694/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0694/00	108	Canton Creek	04/01/0387/00
29	Maggie River	03/02/0694/00	108	Canton Creek	04/01/0387/00
35	Skeena/Ecstall/ McNeil River Complex	09/02/0541/00	108	Canton Creek	04/01/0387/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0541/00	108	Canton Creek	04/01/0387/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0544/00	109	Sucwoa River	04/01/0381/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0544/00	109	Sucwoa River	04/01/0381/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0550/00	109	Sucwoa River	04/01/0381/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0550/00	110	Tlupana/Nesook River Complex	04/01/0416/00

Estuary Number	Estuary Name	PHYIDENT	Estuary Number	Estuary Name	PHYIDENT
35	Skeena/Ecstall/McNeil River Complex	09/02/0552/00	110	Tlupana/Nesook River Complex	04/01/0416/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0552/00	110	Tlupana/Nesook River Complex	04/01/0416/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0554/00	110	Tlupana/Nesook River Complex	04/01/0416/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0554/00	111	Gold River	04/01/0585/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0556/00	111	Gold River	04/01/0585/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0556/00	112	Megin River	03/05/0220/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0557/00	112	Megin River	03/05/0220/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0557/00	119	Irony Creek	12/05/0022/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0576/00	119	Irony Creek	12/05/0022/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0576/00	129	Espinosa Creek	04/02/0043/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0577/00	129	Espinosa Creek	04/02/0043/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0577/00	129	Espinosa Creek	04/02/0045/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0579/00	129	Espinosa Creek	04/02/0045/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0579/00	129	Espinosa Creek	04/02/0045/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0581/00	129	Espinosa Creek	04/02/0045/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0581/00	129	Espinosa Creek	04/02/0046/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0608/00	129	Espinosa Creek	04/02/0046/00
35	Skeena/Ecstall/McNeil River Complex	09/02/0608/00	129	Espinosa Creek	04/02/0046/00
39	Lucky Creek	03/02/0666/00	129	Espinosa Creek	04/02/0046/00
39	Lucky Creek	03/02/0666/00	130	Zeballos River	04/02/0158/00
39	Lucky Creek	03/02/0668/00	130	Zeballos River	04/02/0158/00
39	Lucky Creek	03/02/0668/00	130	Zeballos River	04/02/0158/00
44	San Josef River	12/05/0180/00	130	Zeballos River	04/02/0158/00
44	San Josef River	12/05/0180/00	130	Zeballos River	04/02/0159/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0114/00	130	Zeballos River	04/02/0159/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0114/00	130	Zeballos River	04/02/0160/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0115/00	130	Zeballos River	04/02/0160/00

Estuary Number	Estuary Name	PHYIDENT	Estuary Number	Estuary Name	PHYIDENT
45	Hansen/Rasmus /Fisherman River Complex	12/05/0115/00	131	Beano Creek	04/01/0006/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0116/00	131	Beano Creek	04/01/0006/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0116/00	200	Kloiya River	09/01/0009/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0117/00	200	Kloiya River	09/01/0009/00
45	Hansen/Rasmus /Fisherman River Complex	12/05/0117/00	200	Kloiya River	09/01/0009/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0117/00	200	Kloiya River	09/01/0009/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0117/00	217	Marmot River	09/04/0836/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0118/00	217	Marmot River	09/04/0836/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0118/00	219	Kromann/Moore Cove Creek Complex	09/02/0561/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0119/00	219	Kromann/Moore Cove Creek Complex	09/02/0561/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0119/00	219	Kromann/Moore Cove Creek Complex	09/02/0561/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0120/00	219	Kromann/Moore Cove Creek Complex	09/02/0561/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0120/00	221	Captain Cove	08/06/0361/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0121/00	221	Captain Cove	08/06/0361/00
45	Hansen/Rasmus/ Fisherman River Complex	12/05/0121/00	221	Captain Cove	08/06/0362/00
48	Stranby River	12/05/0027/00	221	Captain Cove	08/06/0362/00
48	Stranby River	12/05/0027/00	222	Hankin Point	08/06/0076/00
48	Stranby River	12/05/0027/00	222	Hankin Point	08/06/0076/00
48	Stranby River	12/05/0027/00	222	Hankin Point	08/06/0076/00
51	Hathaway Creek	12/04/0203/00	222	Hankin Point	08/06/0076/00
51	Hathaway Creek	12/04/0203/00	223	Keswar Inlet	08/06/0113/00
51	Hathaway Creek	12/04/0203/00	223	Keswar Inlet	08/06/0113/00
51	Hathaway Creek	12/04/0203/00	226	Kingkown Inlet	08/03/0255/00
55	Klootchlimmis Creek	12/04/0543/00	226	Kingkown Inlet	08/03/0255/00
55	Klootchlimmis Creek	12/04/0543/00	230	Wathlsto Creek	08/07/0322/00
55	Klootchlimmis Creek	12/04/0544/00	230	Wathlsto Creek	08/07/0322/00
55	Klootchlimmis Creek	12/04/0544/00	247	Crab River	08/07/0231/00
56	Koprino River	12/04/0118/00	247	Crab River	08/07/0231/00
56	Koprino River	12/04/0118/00	247	Crab River	08/07/0231/00
58	Nordstrom Cove	12/04/0093/00	247	Crab River	08/07/0231/00

Estuary Number	Estuary Name	PHYIDENT	Estuary Number	Estuary Name	PHYIDENT
58	Nordstrom Cove	12/04/0093/00	256	Kitlope/Tsaytis River Complex	08/07/0121/00
58	Nordstrom Cove	12/04/0093/00	256	Kitlope/Tsaytis River Complex	08/07/0121/00
58	Nordstrom Cove	12/04/0093/00	256	Kitlope/Tsaytis River Complex	08/07/0123/00
58	Nordstrom Cove	12/04/0093/00	256	Kitlope/Tsaytis River Complex	08/07/0123/00
58	Nordstrom Cove	12/04/0093/00	257	Unnamed	08/07/0148/00
58	Nordstrom Cove	12/04/0093/00	257	Unnamed	08/07/0148/00
58	Nordstrom Cove	12/04/0093/00	258	Kemano/Wahoo River Complex	08/07/0155/00
58	Nordstrom Cove	12/04/0093/00	258	Kemano/Wahoo River Complex	08/07/0155/00
58	Nordstrom Cove	12/04/0093/00	259	Goat River	08/04/0500/00
58	Nordstrom Cove	12/04/0093/00	259	Goat River	08/04/0500/00
58	Nordstrom Cove	12/04/0093/00	270	Unnamed	08/08/0024/00
58	Nordstrom Cove	12/04/0094/00	270	Unnamed	08/08/0024/00
58	Nordstrom Cove	12/04/0094/00	291	Stannard Creek	08/08/0404/00
58	Nordstrom Cove	12/04/0094/00	291	Stannard Creek	08/08/0404/00
58	Nordstrom Cove	12/04/0094/00	291	Stannard Creek	08/08/0405/00
58	Nordstrom Cove	12/04/0094/00	291	Stannard Creek	08/08/0405/00
58	Nordstrom Cove	12/04/0094/00	291	Stannard Creek	08/08/0406/00
59	Denad Creek	12/04/0038/00	291	Stannard Creek	08/08/0406/00
59	Denad Creek	12/04/0038/00	291	Stannard Creek	08/08/0409/00
59	Denad Creek	12/04/0038/00	291	Stannard Creek	08/08/0409/00
59	Denad Creek	12/04/0038/00	291	Stannard Creek	08/08/0410/00
59	Denad Creek	12/04/0039/00	291	Stannard Creek	08/08/0410/00
59	Denad Creek	12/04/0039/00	297	Dala River	08/07/0273/00
59	Denad Creek	12/04/0039/00	297	Dala River	08/07/0273/00
59	Denad Creek	12/04/0039/00	337	Marvinas Bay	04/01/0077/00
59	Denad Creek	12/04/0040/00	337	Marvinas Bay	04/01/0077/00
59	Denad Creek	12/04/0040/00	337	Marvinas Bay	04/01/0077/00
59	Denad Creek	12/04/0040/00	337	Marvinas Bay	04/01/0077/00
59	Denad Creek	12/04/0040/00	338	Yuquot Point	04/01/0025/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0025/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0029/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0029/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0029/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0029/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00

Estuary Number	Estuary Name	PHYIDENT	Estuary Number	Estuary Name	PHYIDENT
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	338	Yuquot Point	04/01/0031/00
65	Escalante River	04/01/0749/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	340	Kutcous Point	03/05/0126/00
65	Escalante River	04/01/0751/00	341	Cow Bay	03/05/0114/00
65	Escalante River	04/01/0751/00	341	Cow Bay	03/05/0114/00
65	Escalante River	04/01/0751/00	341	Cow Bay	03/05/0114/00
66	Mooyah River	04/01/0697/00	341	Cow Bay	03/05/0114/00
66	Mooyah River	04/01/0697/00	341	Cow Bay	03/05/0114/00
66	Mooyah River	04/01/0697/00	341	Cow Bay	03/05/0114/00
66	Mooyah River	04/01/0697/00	341	Cow Bay	03/05/0114/00
67	Silverado Creek	04/01/0681/00	341	Cow Bay	03/05/0114/00
67	Silverado Creek	04/01/0681/00	341	Cow Bay	03/05/0114/00
68	Houston River	04/01/0666/00	341	Cow Bay	03/05/0114/00
68	Houston River	04/01/0666/00	341	Cow Bay	03/05/0116/00
69	Kleeptee Creek	04/01/0524/00	341	Cow Bay	03/05/0116/00
69	Kleeptee Creek	04/01/0524/00	341	Cow Bay	03/05/0116/00
70	McCurdy Creek	04/01/0567/00	341	Cow Bay	03/05/0116/00
70	McCurdy Creek	04/01/0567/00	341	Cow Bay	03/05/0116/00
70	McCurdy Creek	04/01/0567/00	341	Cow Bay	03/05/0116/00
70	McCurdy Creek	04/01/0567/00	341	Cow Bay	03/05/0116/00
79	McCurdy Creek	12/04/0330/00	341	Cow Bay	03/05/0116/00
79	McCurdy Creek	12/04/0330/00	341	Cow Bay	03/05/0116/00
86	Ououkinsh/ Unnamed River Complex	12/01/0524/00	341	Cow Bay	03/05/0116/00
86	Ououkinsh/ Unnamed River Complex	12/01/0524/00	430	Donahue Creek	09/04/0775/00
86	Ououkinsh/ Unnamed River Complex	12/01/0524/00	430	Donahue Creek	09/04/0775/00
86	Ououkinsh/ Unnamed River Complex	12/01/0524/00	432	Kwinamass River	09/01/0500/00
90	Little Zeballos River	04/02/0168/00	432	Kwinamass River	09/01/0500/00
90	Little Zeballos River	04/02/0168/00	439	Unnamed	12/05/0423/00
90	Little Zeballos River	04/02/0168/00	439	Unnamed	12/05/0423/00
90	Little Zeballos River	04/02/0168/00	439	Unnamed	12/05/0423/00
90	Little Zeballos River	04/02/0169/00	439	Unnamed	12/05/0423/00
90	Little Zeballos River	04/02/0169/00	439	Unnamed	12/05/0423/00
90	Little Zeballos River	04/02/0169/00	439	Unnamed	12/05/0423/00

24) Several estuaries had all or portions of intersecting shorezone segments coded as bare beach (includes the following rtypes from physical shorezone mapping arc coverages, obtained from shore_alb83 and ncoast layers): (1) gravel beach, (2) rock with gravel beach, (3) rock with sand & gravel beach, (4) rock with sand beach, (5) sand & gravel beach, and (6) sand beach. Bare beach areas had no across shore bioband data and thus had no vegetative/invertebrate characteristics (0 values). This primarily applies to segments outside the Strait of Georgia area where the video interpretation was adequate, bare beach areas inside the Strait of Georgia often were coded as “I” for inferred and were assigned as NO DATA. Where these segments were encountered with no associated data in the biobanding database, 0 values (NONE code in FK_BIO_BND) were assigned to that segment provided that the segment was not also recorded as an inferred “I” segment found in Step 14 above (i.e. an “I” bare beach segment was assigned a missing value rather than a 0 score).

25. Several estuaries had all or portions of intersecting shorezone segments coded as man-made. Where these segments were encountered with no associated data in the biobanding database, 0 values (NONE code in FK_BIO_BND) were assigned to that segment PROVIDED that the segment was not also recorded as an inferred “I” segment found in Step 14 above, or present in the Strait of Georgia area which was generally not interpreted, in which case NO DATA was assigned to the segment.

26. All other segments with missing bioband data, that were not otherwise coded as bare beach or man-made as per Step 19 and 20 above, were assigned a missing value (blank fields for NO DATA) for this analysis and as per this version of the shorezone mapping; we could not reasonably determine if the segment was interpreted for biobands, or whether there were legitimate 0 values for vegetation/invertebrates across that segment. This applied to the following estuaries and shorezone segments: A problem is not all across shore segments with no data are bare beach, some are rock cliffs, etc.

Estuary Number	Estuary Name	PHYIDENT
17	Sooke River	02/01/0095/00
17	Sooke River	02/01/0096/00
17	Sooke River	02/01/0097/00
17	Sooke River	02/01/0104/00

Vegetation/invertebrate biobands included in the shorezone analysis and scoring:

27. The following (7) vegetation/invertebrate classes/types from the biobanding database were included for the nearshore estuary habitat ranking/analyses (3 letter code followed by description): 1) MUS -California mussel, 2) BMU - Blue mussel, 3) MAC – *Macrocystis*, giant kelp beds), 4) NER – *Nereocystis*, nearshore floating bull kelp, 5) SAL – *Salicornia*, goose grass, marsh grass, dune grass, salt tolerant plants, 6) ULV - *Ulva* (sea lettuce), and 7) ZOS - *Zostera* (eelgrass). These were considered to be important species for supporting dabbling/diving duck and other species in the nearshore environment. All other bioband records (i.e. algae, diatoms, barnacles, etc.) were excluded from the database. In addition, a NONE class was used to indicate that no vegetation/invertebrate classes/types were identified on that segment (0 score). Vegetation classes were also included by zone (FK_ZONE_ID); zone A is supratidal (above coastline) and zone B is intertidal (below coastline). Please note, NOT all species would be present in the supratidal zone A above the coastline OR the intertidal zone but all are recorded across zones A and B; to simplify the scoring. If the vegetation/ invertebrate was recorded more than once for zones A/B within a segment, we used the highest score for that segment regardless of zone (i.e. SAL zone A – Continuous, and SAL zone B – Patchy for same segment would have received a score of 2 for continuous presence in that segment)

28. For each vegetation class/type, each was assigned a score as follows, depending on the distribution of that vegetation type across the shorezone segment: not present = 0, patchy = 1 (distributed intermittently across the shorezone segment), continuous = 2 (continuous across the shorezone segment) (see http://srmwww.gov.bc.ca/risc/pubs/coastal/bioshore/shorezone-app-2.htm#shorezone.app.2)

    The scores for each bioband type were derived from the FK_BIO_BND_ID and FK_BIO_DSTRB_ID fields in the biobanding database; from FK_BIO_DSTRB_ID: P = patchy, C = continuous, and not present is not recorded in the database. This field also contains the following codes that were not relevant for this analysis: M = medium (applies only to *Verrucaria*, splash zone black lichen), N = narrow (applies to *Verrucaria* only), W = wide (applies to *Verrucaria* only), R = ? (likely a typo according to Carol Ogborne (BCMSRM, pers. comm. 2005), applies to 43 SAL records in the database), V = ? (likely a typo according to Carol Ogborne (BCMSRM, pers. comm. 2005), applies to *Verrucaria* only). NOTE: One R record was changed to P for SAL from Apple River estuary for segment 05/03/1461/00.

29. See paper by Turpie *et al.* (2002) pg. 196 for developing a biodiversity importance score. A CWS biometrician was consulted on 4 November 2004 for details on developing the species rarity index (SRI) for each estuary. The methodology chosen was to use total sum of scores for each estuary, by species, divided by the total aggregate possible score for the coastal estuaries.

Calculation of species rarity score (SRS):

$$SRS = 100 * \sum_{i=1}^{n} r_i$$

where: r_i is the proportional contribution an estuary makes to the provincial total of the i^{th} species and:

$$r_i = \frac{q_i}{Q_i}$$

where q_i is the rarity score for species *i* and Q_i is the total rarity score for species *i* across all estuaries.

For the (7) Species of interest, the scoring totals for all 442 estuaries combined (without duplicate segments) was as follows:

Species	Category	Total Score	Category Score
BMU	MUS	87	
MUS	MUS	77	164
MAC	KEL	58	
NER	KEL	91	149
SAL	SAL	1198	1198
ULV	ULV	916	916
ZOS	ZOS	414	414

* For the species rarity index, the low scores for the first (4) species, means that if an estuary contributes to the total score for these species, the SRI will be high; for this reason BMU was combined with MUS (species category=MUS), and MAC with NER (species category=KEL) for the SRI index. This approach would water down the importance that individual kelp and mussel species contribute to the index, which should better approximate an individual estuary's importance to the coast.

Example of scoring for estuary *x*:

$$SRS_x = 100 * \left[\frac{\overset{KEL}{3}}{149} + \frac{\overset{SAL}{7}}{1198} + \frac{\overset{ULV}{7}}{916} + \frac{\overset{ZOS}{0}}{414} + \frac{\overset{MUS}{0}}{164} \right]$$
$$= 100 * [0.02013 + 0.00584 + 0.00764 + 0 + 0]$$
$$= 3.361$$

The rankings for bioband scores follow the procedures for ranking South African estuaries outlined by Turpie *et al.* (2002) from semi-quantitative data. Under this procedure, bioband scores can be scored from 0-100 and every other estuary would be scaled down from that to normalize the scores. If an estuary was considered an outlier from the distribution, then it was assigned an SRI of 100 and the next highest scoring estuary was assigned a SRI of 100 and used as the estuary to relate all other estuaries to.

Estuaries were then further classified into the following categories: 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 as per Turpie *et al.* (2002); this classification would also dampen the problems we had with extracting the shorezone linework at 1:50,000 compared to the various scale marine charts and TRIM used for the estuary mapping, by grouping estuaries within size classes. If no biobands were present at an estuary, the estuary was given a SRI of 10.

Appendix 3: Waterbird Density Index Data Exceptions

For each estuary that has data for waterbird densities from datasets, with the exception of the Coastal Waterbird Inventory, the following details any aspects of the data that had to be handled in a unique fashion.

Estuary	Restrictions
BEDWELL	NONE
BULSON	NONE
CAMPBELL	Some unit14 counts were missing from Dawe *et al.* (1995c) but were in the database. Surveys conducted on 8 November 1982 and 28 January 1983 deleted due to missing units.
CHEMAINUS	NONE
CLUXEWE	Deleted 21 October 1990 survey due to missed unit3 counts due to high tide. Deleted transect with site_code="ECVI96" as it is forest strata unit 6.
COURTENAY	Deleted surveys on 11 October 1980, 18 October 1980, and 15 November 1980 due to missing units (recorded as survey coverage incomplete in the bias column) and deleted surveys on 14 February 1981(part coverage).
COWICHAN	NONE
CYPRE	NONE
ENGLISHMAN	Deleted site_code="ECVI12" because unit3 forest upland not surveyed in subsequent years.
FANNY BAY	Deleted the 3 December 1990 and 8 January 1991surveys because they were incomplete. Unit1 subtidal includes a north and a south survey strata that CANNOT be differentiated but the counts have been included here because this is generally a good survey design at this site. NOTE that unit1 south is really outside of the estuary though and this site should be flagged. Deleted site_code="ECVI37" as it is forest strata unit7.
GORGE	Data for unit1 estuary only included.

HART CREEK	Deleted the 11 October 1980 and 18 October 1980 surveys as survey units were undefined or missed.
KITIMAT	NONE
LITTLE QUALICUM	NONE
LEINER	Dataset includes November to May period 81-82 only.
NANAIMO	Guy Monty data deleted, not all species counted on all days. There were constant disturbance and visibility bias problems with Nanaimo estuary but no reason to preclude using all the data available. Vermeer data and BSC data used despite some discrepancy in strata size. Deleted site_code="ECVI8"; Guy Monty survey cannot determine area coverage adequately and different species groups surveyed on different days. BSC units VINN13 and VINN15 assigned to site_code=ECVI7 and unit_no=1 to combine both units prior to running macro. Deleted 14 January 2000 at unit2, 10 December 2000, at unit2, 14 January 2001 at unit1, 14 October 2001 at unit2 surveys due to no concurrent survey at each unit resulting in only partial survey coverage.
NANOOSE	All dates kept as most surveys are fractured.
QUATSE	Forest survey unit data deleted.
ROSEWALL CREEK/MUD BAY	No restrictions on data from Dawe. Deleted the 11 October 1980 survey due to undefined units, the 13 June 1981 unit42 survey was not done, and August 1981 surveys scattered across unit41 and 42 from the 1980-81 Baynes Sound survey.
SARITA	NONE
SOMAS	NONE
SQUAMISH	Squamish 1980 data includes January to April survey period only BUT included for analysis here as good coverage in 1990's. Deleted site_code="LMSQ2" or site_code="SCMA14" because the west delta stratum surveyed from across the river highly biased and site_code="LMSQ17" because this is an isolated marsh stratum that

is not part of the estuary. Stratum areas listed as Training dyke, EF2, SA deleted from the total area calculation since few seaducks were counted and areas are mostly forest cover along the river bank. Deleted the November 1991, April 1995, 26 April 1997, April/May 1999, 2 June 2000, and October 1999 surveys due to either incomplete survey coverage and/or survey coverage being split across days.

TAHSIS	NONE, however, dataset includes November to May period 1981-82 only and there were difficulties with Goldeneye identification on some surveys.
TRANQUIL	NONE
TRENT	No restrictions for the Comox-Strathcona Natural History Society (1994)1987 data. 1987 waterbirds recorded on all habitat types, including mixed forest-residential and cultivated fields, all data were included here for birds/km analyses due to the extremely fine habitat partioning used by the surveyors. 1980-81 Baynes Sound data restrictions include deleting the 11 October 1980 and 18 October 1980 surveys due to units being undefined or missed.
TSABLE	1980-81 Baynes Sound survey estuary data restrictions include deleting the 11 October 1980 survey due to units being undefined, deleting the 1981 May to July dates because unit 36 appears not to have been surveyed.

Appendix 4: Herring Spawn Index GIS Methodology

1. The cumulative herring spawn table was copied from http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/cumulati.htm into a text file and then converted to dbf format in Excel.

2. The dbf file was brought into ArcView as an event theme using the Lat and Long fields as y and x coordinates, respectively. The event theme was then saved as a shapefile.

3. PECP Estuaries were dissolved by est_no (intermed_shp_dissolved_estuaries) and buffered by 3 km (retained field est_no by selecting est_no as a dissolve field, dissolve type = none).

4. Points in dfo_herring_spawn_index that were within pecp_estuarypolys_18jun04_buf were selected and converted to a new shapefile.

5. A polygon clean tool was used to find the areas of overlap within the 3km buffer file. The herring spawn points that fell within the overlapping buffer area were selected and converted to a shapefile. These points were then removed from the shapefile created in Step 4 (using select by location) to maintain 2 separate point shapefiles: 1 with points that only fall within 1 buffer and therefore have only 1 associated est_no, and 1 with points that fall within multiple buffers and have to be manually attributed.

6. The shapefile with points that fell within only 1 estuary buffer was joined spatially to the 3 km buffer file to obtain the est_no field. The resultant shapefile was then joined to pecp_estuarypolys_18jun04 based on est_no to get the associated estuary attributes.

7. The field Est_no was added to the shapefile with points that fell within multiple estuary buffers. The herring spawn index points were spatially multiplied according to the number of overlapping estuary buffers. The est_no field was manually filled in for each point. The shapefile was then joined to pecp_estuarypolys_18jun04 based on est_no to get the associated estuary attributes.

8. The shapefiles created in Steps 7 and 8 were merged together to produce a final herring spawn shapefile to be used in the estuary ranking analysis. The fields retained in the attribute table are: point_id, section, sp_index, est_no, est_name, code_let, gbei_est, and ecoregion.

9. All estuaries with ≥2 overlapping buffers were quality assured/quality controlled to ensure that the proper herring spawn attributes were transferred from the database; this

was particularly important for estuaries where there were ≥3 overlapping 3 km buffers as correct assignment of attributes could get confusing in these cases.

The following sites were verified to determine that the correct attributes were transferred to the estuary.

Estuary Name	Estuary Name
Apple River	Mace/Mercer Creek
Artlish River	MacKenzie Cove
Asseek River	Maggie River
Atleo River	Mahatta Creek
Bazett Island Area	Mamquam River
Bear River [2]	Marmot River
Bella Coola/Necleetsconnay River Complex	McCurdy Creek
Beresford/Hana Koot Creek	McKay Cove
Blind Creek	Millar Channel
Burman River	Moneses Lake
Canton Creek	Moyeha River
Chemainus	Naden River
China Creek	Naden River
Clanninick Creek	Noeick River
Clayton Falls Creek	Nordstrom Cove
Coeur d'Alene Creek	Otard
Courtenay River	Ououkinsh River
Cow Bay	Oyster Bay
Cowichan	Pachena River
Cullite Creek	Powell River
Cypre River	Power River
Dala River	Price Cove
East Creek	Quatse/Boyden
Easy Inlet	San Juan River
Effingham River	Scow Bay
Empetrum Lake	Seal Inlet
Falls River	Security Cove
Franklin River	Silverado Creek
Georgetown Creek	Sliammon Creek
Gold River	Snug Basin
Grant Bay	Sooke River
Hathaway Creek	Southgate River
Henderson Lake	Spiller Inlet
Homathko/Teaquahan River Complex	Squamish River
Houston River	Stafford River
Ickna Creek	Stanley Creek
Ingram Creek	Stawamus River
Jacklah River	Sucwoa River
Kauwnich River	Tahsis River
Kdelmashan Creek	Tahsish River
Kelkane River	Taleomey River
Kemano/Wahoo River Complex	Tasu Inlet

Estuary Name	Estuary Name
Keogh River	Tlupana/Nesook River
Kildala River	Tofino Creek
Kiltope/Tsaytis River Complex	Tom Browne Creek
Kitimat River	Toquart River
Kitsault/Illiance River Complex	Tranquil River
Klaskish River	Unnamed = 167,168,169
Kleeptee Creek	Unnamed = 40
Klinaklini River	Unnamed = 83
Klootchlimmis Creek	Unnamed 257
Koprino River	Unnamed=162
Kumdis Creek	Wahtl Creek
Kumdis Slough	Wanokana Creek
Kutcous Point	Waterfall Inlet
Kwatleo Creek	Wathlsto Creek
Leiner River	Weeteeam Bay Area
Lignite Creek	Western Lake Chain
Lime Creek	Yakoun River
Little Zeballos River	Youghpan Creek
Lucky Creek	Zeballos River

Exceptions to including points within 3 km buffer for analysis:

In many cases the 3 Km buffer extended into another completely separate Bay/Inlet, etc., around a peninsula, where the points are outside the limits of the estuary intertidal zone; (see Hosu Cove in Queen Charlotte Islands for example); in these cases the points that were OUTSIDE the general lateral limit of the estuary bay, inlet, etc. were removed from the dataset. This applied to the following sites:

Estuary Name	Estuary Name
Banks Lakes	Mill Stream
Bazett Island Area	Mooyah River
Coates Creek	Mud Bay/Rosewall Creek
Colquitz River	Nanoose/Bonell Creek
Doc Creek	Neekas Creek
Dunn Point Area	Nooseseck River
Ellerslie Lagoon	Oyster Bay
Fanny Bay	Pachena River
Gorge Waters/Craigflower Creek	Quatlena River
Holti Point	Quigley Creek
Hosu Cove	Rainbow Creek
Ice River	Scott Cove
Kakushdish Harbour Area	Takush River
Kapoose Creek	Tankeeah River
Kdelmashan Creek	Tsable River
Klaskish River	Unnamed 94
Kutcous Point	Waterfall Inlet
Lucky Creek	Yuquot Point
McKay Cove	

* NOTE: the removal/addition of points for these estuaries was subjective and based on our interpretation of the approximate extent of the bay or inlet that the estuary was located in. The error in point locations is approx. +/- 1 Km and we used this approximation, all coastline line work from 1:20 to 1:250K, and the herring spawn historical polygon distributions dating to 1930 to interpret/include points that "generally" fell within the bay, inlet, etc. of the estuary, given the approximate error.

10. Extensive computations are performed to derive the "Cumulative Spawn Table" which should be considered as an extremely compacted and summarized version of the "database" and not the "database" (Bruce McCarter, DFO, pers. comm. 2005). The cumulative spawn habitat index is used as a measure of habitat sensitivity as this index takes into account both the long-term frequency and magnitude of recorded spawns over time; the index is calculated by the sum of the product of each measured spawn "shoreline length" and the median of the product of spawn width and eggs layers adjusted by percent cover and pooled geographically (McCarter and Hay 2006). The cumulative spawn index is calculated from the following metric:

$$SHI = \sum \text{Spawn Length}\,(m) * \text{Median Spawn Width}(m) * \text{Egg Layers},$$

adjusted by percent cover and pooled geographically.

For estuaries with multiple herring spawn point locations and SHI scores within the 3 Km buffer, we used the SUM of the SHI scores for all points that fell within the buffer to calculate the cumulative score for each estuary; this was considered appropriate by the herring spawn specialists at DFO (Bruce McCarter, DFO, pers. comm. 2005). The data are generally (precise geographical limits) considered to be accurate to within a kilometre.

Limitations of dataset:

a) Coastal survey coverage largely undocumented, relying on perceptions of DFO staff collecting the field data as to the importance of sites.
b) There are inaccuracies/biases in the ability of surveyors to interpret the length/width of herring spawn events across large estuary segments, or where spawn events are patchy, from historical data and these should be interpreted with caution.

The following websites are hosted by DFO and provide additional documentation on herring spawn data collection methods, digitizing methodology, and data summary procedures:

1. Cumulative spawn analysis page:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default1_e.htm
2. An associated documentation report:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/project_e.htm
3. Herring spawn shape files, for down load, for each year:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default6_e.htm
4. Mapping protocol used:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/mapspwn_e.htm
5. Raw data from the "database" can be viewed by clicking on successive maps starting here:
   http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default0_e.htm