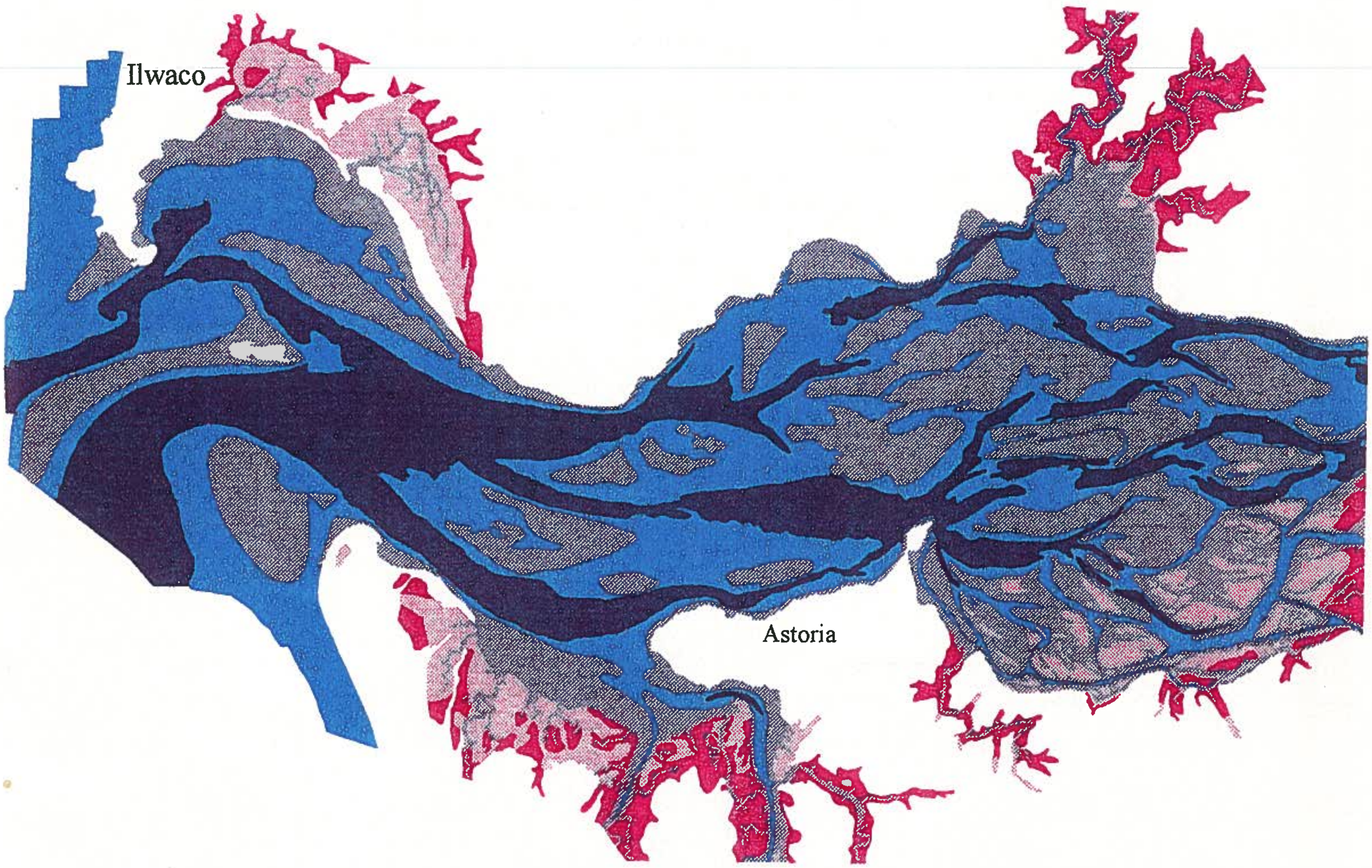
GIS-2

Historic Habitats of the Lower Columbia River



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Introduction

Background

Estuaries, like many other natural systems, undergo both gradual and catastrophic changes in topography, physical processes and the structure of floral and faunal communities. This project strives to show some of the changes that have occurred in the lower Columbia River over the past century.

Estuarine processes are not stable in the classical sense. Geologically speaking, estuaries are a transition region between land and sea. Sea level rises and falls relatively quickly over geologic time. Large quantities of sediment are brought down the river into the estuary and other sediments are eroded from the open coast by wave action. Thus, estuaries are relatively transient phenomena, with a lifetime of a few thousand years or less. Recent information shows that estuarine processes vary in their dynamics. For example, tidal processes are relatively predictable, stream flow processes vary significantly from year to year following larger climatic cycles and stochastic weather patterns. Subduction and subsidence processes are rapid and dramatic, yet temporally infrequent as are volcanic eruptions. The Columbia River estuary responds and reflects all of these variations. For example, the Columbia River estuary is adjusting to the recent eruption of Mt. Saint Helens. Pulse loading of sediment from flood events and runoff from fire disturbed sites is a part of the history of the Columbia. Human intervention has both accelerated some processes and slowed some others. Dams have significantly altered the stream flow regime and sediment transport into the estuary. Dredging has also altered the sediment transport regime of the river. It is arguable whether human changes have uniformly accelerated changes to the estuary.

The historical charts are used to portray estuarine habitats at the time the surveys were conducted. Comparison with current conditions can illustrate the net change in habitats through the interval of time evaluated.

Approach

Several methods are available for identifying historical ecosystems. In San Francisco Bay, Krone (1979) uses historical bathymetric surveys to quantify changes due to shoaling and erosion, while Atwater et al. (1979) compared historical and modern maps augmented with an examination of fossil roots and stems to assess changes in tidal marshes. In the Puget Sound and the Fraser River Delta, Bortelson, et al. (1980) and North, et al. (1979) used 1880's shoreline data to map changes in wetland and shoreline habitats. This project maps the historic habitats of the lower Columbia River using historic US Coast Survey Navigation Charts but does not compare historical habitats to modern habitats (see appendix B for a comparison to modern habitats). The quality of historical information is clearly the limiting factor in mapping historical habitats.

Methods and Materials

Selection of Historical Database

Various kinds of historical documents were examined, such as old maps and navigational charts, photographs dating from the late nineteenth and early twentieth centuries, and historical accounts of the estuary. These were found in the archives of a number of institutions, principally the CREST map collection and library, the Clatsop County Historical Museum, and the Columbia River Maritime Museum, all located in Astoria, Oregon; additional information was obtained from the Oregon Historical Society map collection and library and the Army Corps of Engineers map collection, library, and photogrammetry department in Portland, Oregon.

After an examination of all these materials, six charts issued by the U.S. Coast Survey between 1870 and 1888, based on data from 1851-1887, were selected as the best available representation of the undeveloped estuary and lower river. The U.S. Coast Survey charts used are shown on Table 1 on the next page. The U.S. Coast Survey was later called the U.S. Coast and Geodetic Survey and is presently called the National Geodetic Survey.

Earlier charts such as those produced by Wilkes in 1841 show extensive soundings in the subtidal area, but the graphic representation of the floodplain was judged to be unreliable for quantitative measurement. The soundings shown on the U.S. Coast Survey charts are more complete than those of Wilkes, and the floodplain and upland vegetation are depicted graphically with symbols that suggest great attention to detail. These were the first charts to include most of the floodplain (Thomas, 1983).

Table 1: U.S. Coast Survey Charts Used

Sheet	Coverage	Publication	Field Work
1	Columbia Bar to Astoria	1870	1851-1869
2	Astoria to Tenasillahe Island	1875	1852-1871
3	Tenasillahe Island to Crims Island	1878	1871-1876
4	Crims Island to Kalama	1888	1873-1875
5	Kalama to False Landing (Campbell Lake)	1888	1873-1886
6	False Landing (Campbell Lake) to Portland	1888	1870-1887

Three methods were devised to test the accuracy of the information shown on the Coast Survey charts. Old photographs were compared with the vegetation shown on the charts, the current elevation of diked areas shown on the charts as marsh was compared with that of adjacent diked areas shown as swamp, and the current configuration of drainage ditches in diked areas was compared with the tidal channel systems for the same areas shown on the charts. The conclusion was drawn that the charts are an accurate representation of the floodplain vegetation, at least for distinguishing emergent marshes from forested and tall-shrub dominated swamps (Thomas, 1983). No method was found for checking the accuracy of the bathymetric data; the general observation that the survey was conducted with great attention to accuracy and detail led to the conclusion that the bathymetry could be accepted as reliable.

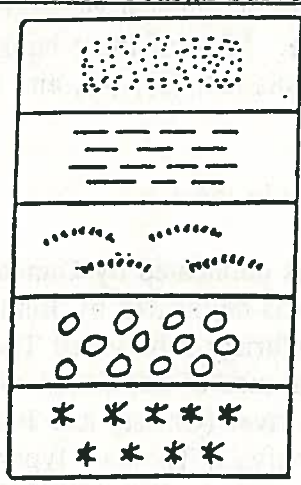
Interpretation of the U.S. Coast Survey Charts

Neither the charts nor the annual reports have keys defining the symbols used to delineate vegetation. Shalowitz (1964) provided a key to some of the symbols, while others are more or less intuitive; leaving little doubt as to their interpretation.

Soundings in deep water are shown without any symbols. Table 2 shows the symbology used on the US Coast Survey Charts. Soundings to a depth of eighteen feet are shown by numerals indicating feet below mean lower low water (MLLW) superimposed on symbol (1). The zero, six, and twelve foot bathymetric contour lines are indicated by artful shadings of symbol (1), which extends above MLLW. Where soundings are absent, symbol (1) was interpreted as unvegetated flats. Abbreviations such as "hrd" and "sft" occasionally appear superimposed on symbol (1) to indicate the nature of the sediment. Symbol (2) is shown extensively, always in combination with symbols (3), (4), and/or (5); it was therefore interpreted as an illustration of water, indicating the limits of tidal inundation. Symbols (3), (4), and (5) appear both with and without symbol (2) superimposed. Their meaning as pictorial representations seemed clear; thus symbol (3) in combination with symbol (2) would indicate emergent marsh, and symbols (4) and/or (5) in combination with symbol (2) would indicate forested and tall-shrub dominated swamps. These interpretations produced a portrait of the estuary that was recognizable and corresponded to the patterns one would expect to find.

Since the original field maps from which the charts were drafted are in the Oregon Historical Society collection in Portland, together with reports from the survey teams, the content and quality of these were reviewed by Thomas (1983). The original survey work was carried out under the supervision of Cleveland Rockwell (topography) and Edward Cordell (hydrography). Rockwell and Cordell produced charts in the field at a scale of 1:10,000. From these field studies, the six Coast Survey charts were later drafted at a scale of 1:40,000. The reports from the survey teams indicate that their work on the lower Columbia River was carried out meticulously. The Annual Reports of the Superintendent of the U.S. Coast Survey, 1868-73 contain accounts based on these reports (Thomas, 1983).

Table 2: U.S. Coastal Survey Chart Symbology from Thomas 1983



1.	Unvegetated flat and subtidal area to eighteen feet below mean lower low water
2.	Vegetated wetlands, floodplain area
3.	Grassland; emergent marsh if in floodplain
4.	Deciduous trees and shrubs
5.	Coniferous Trees

Habitat Types

Thomas (1983) delineated seven tidal and non-tidal habitats types from the U.S. Coast Survey charts. The habitat types were defined as follows:
(1) Deep water: below the eighteen foot bathymetric contour.

(2) Medium depth water: from the eighteen foot up to the six foot bathymetric contour line.

(3) Shallows and flats: from the six foot bathymetric contour line up to the edge of tidal marsh or swamp vegetation, or mean higher high water (MHHW) where vegetation is absent. These limits were selected for practical reasons since the MLLW contour was incompletely mapped and three feet below MLLW, which is the lower limit of wetlands defined by Cowardin et al. (1979), is seldom shown as a contour on charts, preventing the use of what is otherwise the preferred datum. Although various sediment properties such as grain size and organic content are critical factors in determining the community structure and abundance of organisms in shallows and flats, the abbreviations shown on the U.S. Coast Survey charts were insufficient to delineate sediment types.

(4) Tidal Marshes: areas dominated by emergent vegetation and low shrubs; that is, areas shown with a combination of symbols (2) and (3) on the historical charts. Tidal marshes are found from MLLW to slightly above MHHW, although they are rare at the lowest elevations.

(5) Tidal swamps: shrub and forest dominated wetlands, extending up to the line of non-aquatic vegetation (i.e., the line at which excess water ceases to be a factor controlling the composition of the vegetation). On the historical charts, areas shown with symbol (2) in combination with symbols (4) and/or (5) were interpreted as tidal swamps. These swamps may be of sufficiently high elevation that they are inundated only during spring tides, but they may also extend down below MHHW.

In addition to these five estuarine habitat types, two non-tidal habitats exist.

(6) Non-tidal water/wetland: areas of floodplain lakes and non-tidal emergent or forested wetlands. These areas are dominated by either emergent, shrub or forested wetland vegetation in areas that are beyond the extent of tidal influence. Most of these habitats are upriver from Longview, Washington. A combination of symbols (2), (3), (4), and (5) on the historic charts are used to identify these habitats.

(7) Upland: areas that were uplands without wetland vegetation in them.

Vegetation between the river mouth to Puget Island was delineated by Duncan Thomas (1983), and coverage from Puget Island to Portland was delineated by John Christy, wetlands ecologist at the Oregon Natural Heritage Program. Christy subdivided Thomas' seven categories into 18 categories, based largely on the appearance of additional symbology upriver from Puget Island, and extensive field work along the river (Christy and Putera 1993). In order to match the two classifications for overall analysis, Thomas' types were adopted as a coarse filter. Christy's classification provides a more detailed delineation for habitats above Puget Island, and is stored as a separate database within the ARC/INFO digital coverage. The symbology that John Christy used to interpret the U.S. Coastal Survey charts up river from Puget Island is shown in Appendix A. Equivalent habitat types are listed below, with Thomas' types underlined. Time and evidence did not permit subdividing Thomas' habitat types to match Christy's classification, which would provide an overall fine-filter delineation for future analyses.

Figure 1: Hierarchical Habitat Classification

Deep Water
Water deep, greater than 18 ft. (WD)

Medium Depth Water
Water shallow, 6 - 18 ft. (WS)

Shallows and Flats
Tidal flats and shallow (water < 6 ft. deep) (FS)
Sand bank, unvegetated (S)

Tidal Marshes
Tidal marsh (TM)

Tidal Swamps
Tidal cottonwood swamp (TSC)
Tidal willow swamp (TSW)
Tidal spruce swamp (TSS)

Uplands
Upland (U)
Oak and fir forest (OF)
Prairie and Pasture (PW)
Oak, fir, ash savannah (SOF)
Urban (URB)

Non-tidal Water/Wetland
Floodplain Lake (FL)
Emergent marsh, isolated from tidal influence (EM)
Willow swamp, isolated from tidal influence (SW)
Cottonwood and ash riparian forest (RCA)

Procedures

The project was divided into two parts: (1) interpreting the U.S. Costal Survey 1870's charts and (2) digitizing, attributing and georeferencing the interpreted data. John Christy delineated habitats using the U.S. Coast Survey maps and CREST digitized, attributed, and georeferenced the maps create by Christy. Since the mouth of the Columbia River to Puget Island was delineated by Thomas (1983), only conversion from hard copy map to digital coverage was needed for that map. For the areas upriver from Puget Island, Christy used an overhead projector to project the historical U.S. Coastal Survey charts onto mylar overlaying a United States Geological Survey 7.5 minute quadrangle. The projected image was adjusted until the mainstem and tributaries of the river lined up with the USGS map. Habitats were drawn onto the mylar which had the coordinates of the USGS quad map drawn onto it.

Once the historical habitats had been delineated onto 7.5 minute USGS quadrangle maps, the habitat types were digitized using an Altek data tab lite line digitizer with ± 0.001 inch accuracy using PC ARC/INFO software. Once the line work was digitized, it was projected into a Universal Transverse Mercator (UTM) Zone 10 projection with meters as the units. The PC ARC/INFO coverage was then attributed with habitat types and joined to the adjacent habitat map.

Results

The results of the mapping described in the preceding section are shown on the attached map (figure 2) and the following table (table 3) of acreage of historical habitat types. ARC/INFO coverages of this digital data are available from CREST and DEQ.

Historical Habitats of the Lower Columbia River

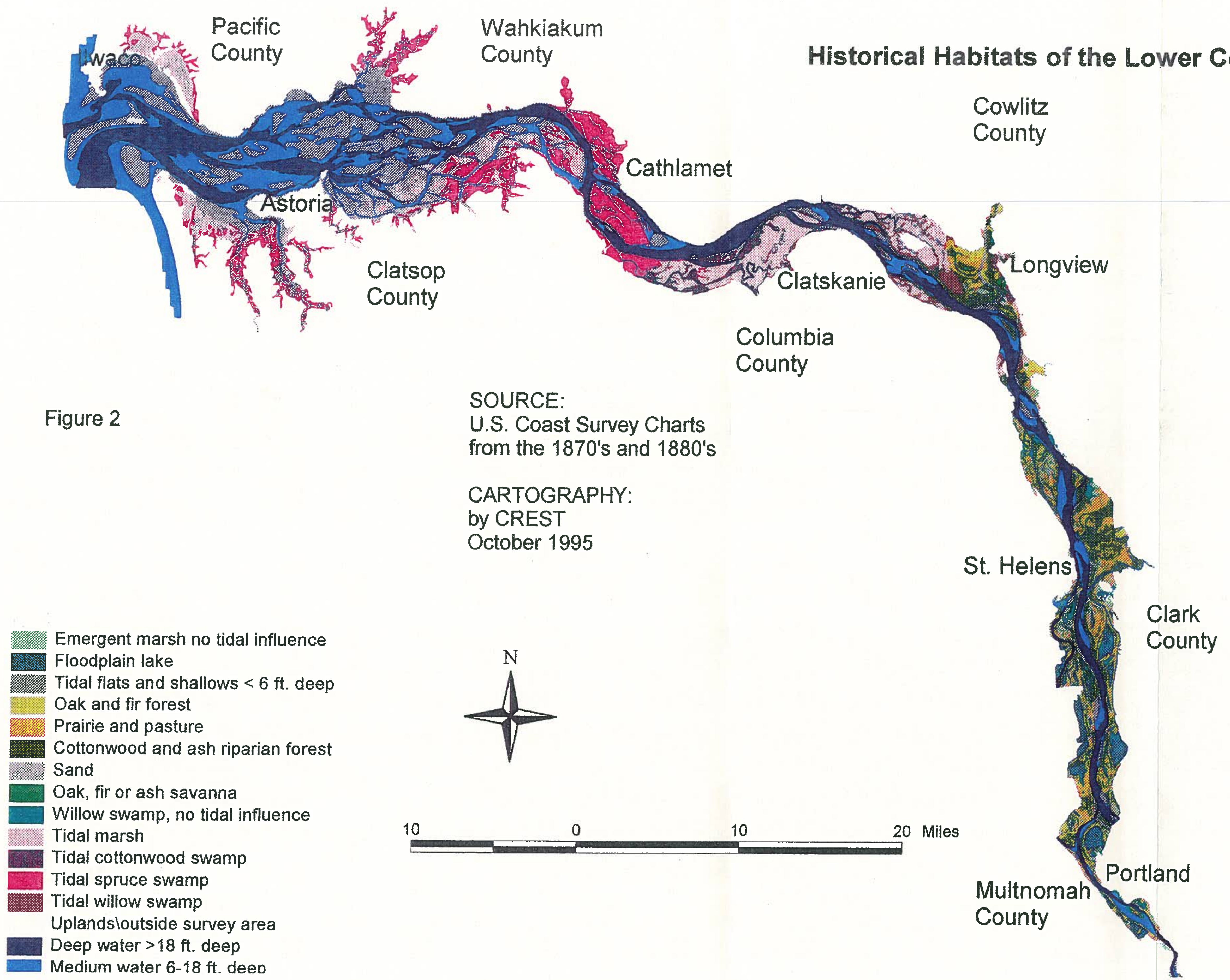
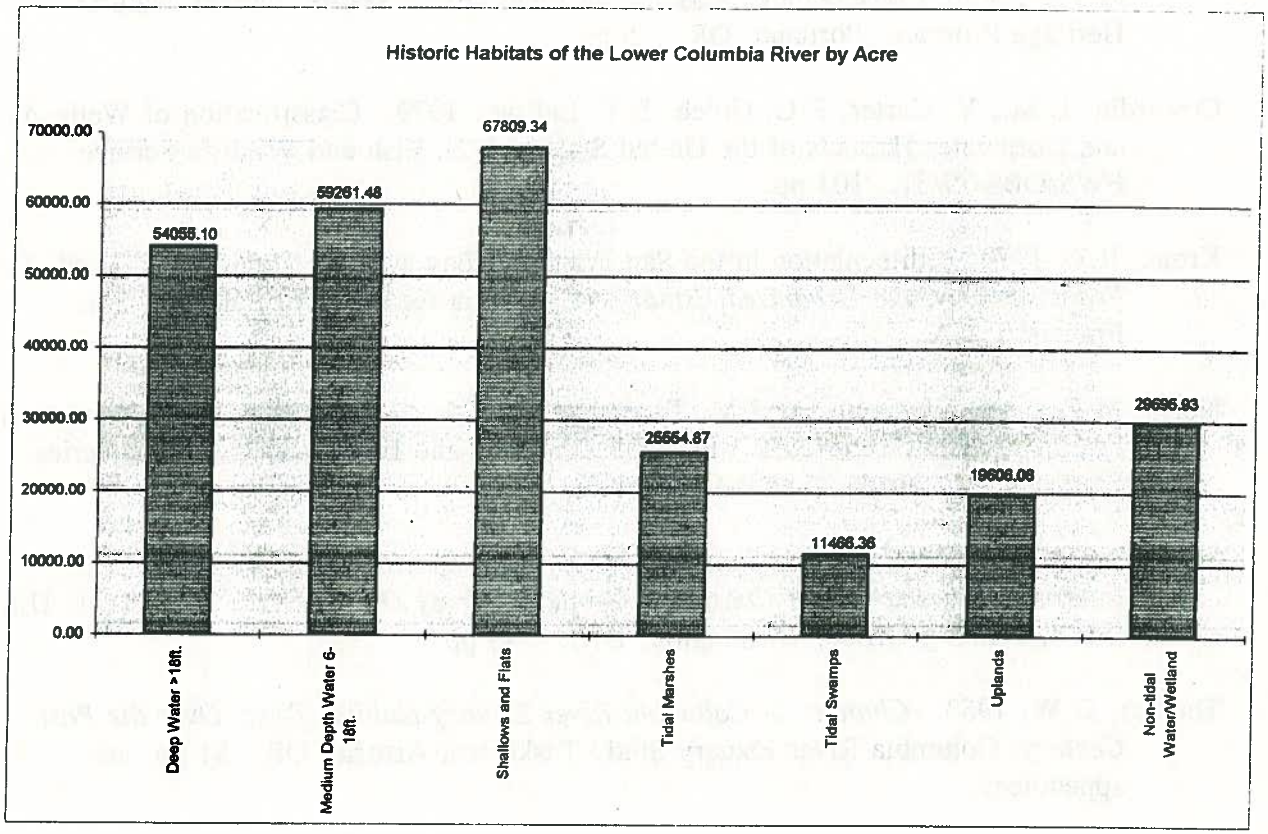


Figure 2

Table 3

Historic Habitats of The Columbia River Estuary

Historic Habitats	Acres	%
Deep Water >18ft.	54055.10	20.21
Medium Depth Water 6-18ft.	59261.48	22.16
Shallows and Flats	67809.34	25.35
Tidal Marshes	25554.87	9.56
Tidal Swamps	11466.36	4.29
Uplands	19606.06	7.33
Non-tidal Water/Wetland	29695.93	11.10
Sum	267449.14	100.00



References

Atwater, B.F., S.G. Conard, J.N. Dowden, C.W. Hedel, R.L. MacDonald and W. Savage. 1979. "History, Landforms, and Vegetation of the Estuary's Tidal Marshes." Conomos, T.J. ed. *San Francisco Bay: the Urbanized Estuary*. California Academy of Sciences San Francisco, CA.

Bortelson, G.C., M.J. Chrzastowski, and A.K. Helgerson. 1980. Historical Changes of Shoreline and Wetland at Eleven Major Deltas in the Puget Sound Region, Washington. Hydrilogic Investigation Atlas HA-617.

Christy, J.A. & J.A. Putera. 1993. Lower Columbia River Natural Area Inventory. Report to The Nature Conservancy, Washington Field Office Seattle. Oregon Natural Heritage Program, Portland, OR. 75 pp.

Cowardin, L.M., V. Carter, F.C. Goleb, E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31. 103 pp.

Krone, R.B. 1979, Sedimentation in the San Francisco Bay system. Conomos, T.J. ed. *San Francisco Bay: the Urbanized Estuary*. California Academy of Sciences, San Francisco, CA.

North, M.E.A., M.W. Dunn and J.M. Teversham. 1979. Vegetation of the Southwestern Fraser Lowland, 1858-1880. Fraser River Delta and Estuary Region Map Series. Environment Canada. Lands Directorate.

Shalowitz, A.L. 1964. *Shore and Sea Boundaries, With Special Reference to the Interpretation and Use of Coast and Geodetic Survey Data.* Vol.2. Publ. 10-1. U.S. Gov't. Printing Office, Washington, D.C. 749 pp.

Thomas, D.W. 1983. *Changes in Columbia River Estuary Habitat Types Over the Past Century*. Columbia River Estuary Study Taskforce, Astoria, OR. 51 pp. and appendices.

Appendix A

The symbology used by John Christy when interpreting the historic U.S. coastal Survey Charts follows in figure 3.

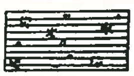
Figure 3: Symbols for Interpretation of Historic Vegetation of Lower Columbia River Floodplain


FS Tidal flats and shallows (water <6 ft. deep)


S Sand bank, unvegetated

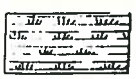

TM Tidal Marsh

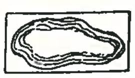

TSC Tidal cottonwood swamp

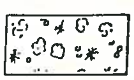

TSS Tidal spruce swamp

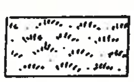

TSW Tidal willow swamp

Non-tidal, from Longview to Bonneville Dam:

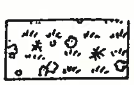

EM Emergent marsh, isolated from tidal influence


FL Floodplain lake


OF Oak and fir forest


PW Prairie and pasture


RCA Cottonwood and ash riparian forest


SOF Oak, fir or ash savanna


SW Willow swamp, isolated from tidal influence

As stated in the text Christy's mapping project used a more specific classification system than that of Duncan Thomas. This is a hierarchical classification in which Thomas used seven classes for habitat delineation. Christy took this classification system and broke out subclasses for areas from Puget Island upstream to Portland. Christy's classification system includes seventeen different habitat types. In three areas (Deep Water, Medium Depth Water, Tidal Marshes) Christy stuck with Thomas' classification scheme. In the four other Thomas habitat types Christy broke down Thomas' categories into subclasses. From Thomas' Shallows and Flats Christy derived: tidal flats and shallow water < 6 ft. deep (FS); and sand bank, unvegetated (S). From Thomas' Tidal Swamps habitat Christy derived: tidal cottonwood swamp (TSC); tidal willow swamp (TSW); and tidal spruce swamp (TSS). From Thomas' Upland category Christy derived: Upland (U); Oak and fir forest (OF); Prairie and Pasture (PW); Oak, fir ash savannah (SOF) and urban (URB). From Thomas' Non-tidal Water/Wetland Christy derived: floodplain lake (FL); emergent marsh, isolated from tidal influence (EM); willow swamp, isolated from tidal influence (SW); and cottonwood and ash riparian forest (RCA). In the following table the Christy and Thomas classification system are combined in one table to display the totals for both Christy and Thomas habitats on the same chart. It should be noted that there should be no Thomas habitat categories in the middle to upper reaches of the study area and conversely no Christy habitat categories will be found in the lower reach of the estuary.

Table 4

John Christy Habitats	Acres	%
EM Emergent Marsh	3791.05	1.42
FL Floodplain Lake	6396.69	2.39
FS Flats and Shallows <6ft.	44832.38	16.76
OF Oak and Fir Forest	1331.80	0.50
PW Prairie and Pasture	15438.78	5.77
RCA Riparian Forest	16051.39	6.00
S Sand Bank Unvegetated	44.71	0.02
SOF Oak,Fir,Ash Savannah	201.57	0.08
SW Willow Swamp no tidal influence	3456.80	1.29
TM Tidal Marsh	25554.87	9.56
TS Tidal Swamp	22932.26	8.57
TSC Tidal Cottonwood Swamp	4068.83	1.52
TSS Tidal Spruce Swamp	3140.42	1.17
TSW Tidal Willow Swamp	4257.11	1.59
U Upland	2552.84	0.95
URB Urban	81.08	0.03
WD Water Deep >18ft.	54055.10	20.21
WS Water Shallow 6-18ft.	59261.48	22.16
Total	267449.14	100.00

Appendix B

A correlation between the Corps of Engineers 1991 habitat mapping and the CREST Historic habitat mapping was performed and the results are presented in the following table.

Table 5: Habitat comparison between CREST historic habitat mapping and Corps of Engineers recent habitat mapping.

Table 5

COMPARISON BETWEEN
1880 AND 1991 HABITAT USING 1991 HABITAT
CLASSES