

Development of an Ecosystem Classification System for the Columbia River Estuary



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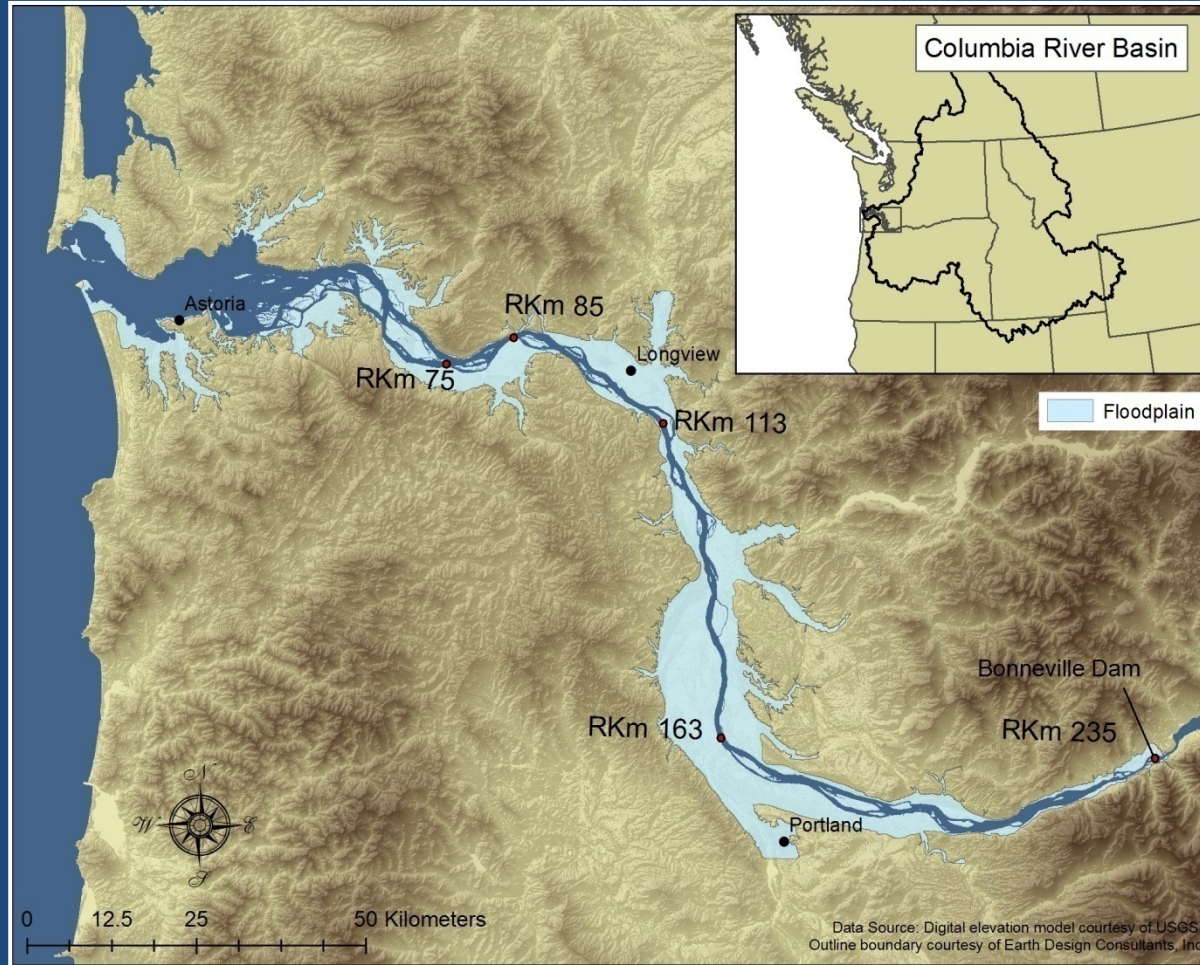
September 10, 2009

Columbia River Estuary



“an inlet of sea reaching into a river valley as far as the upper limit of tidal rise...” (Fairbridge 1980)

Columbia River Estuary



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Objective of Classification System

- Provide a hierarchical framework to aid understanding of:
 - the organization of the highly variable and dynamic ecosystems
 - the underlying processes that create the dynamic structure of this system
- Support planning and management activities
 - Research
 - Monitoring
 - Restoration
 - Preservation



Outline for Today's Talk



- Impetus and Rationale
- Classification Framework
 - Application
 - Timeline

Impetus for Classification System

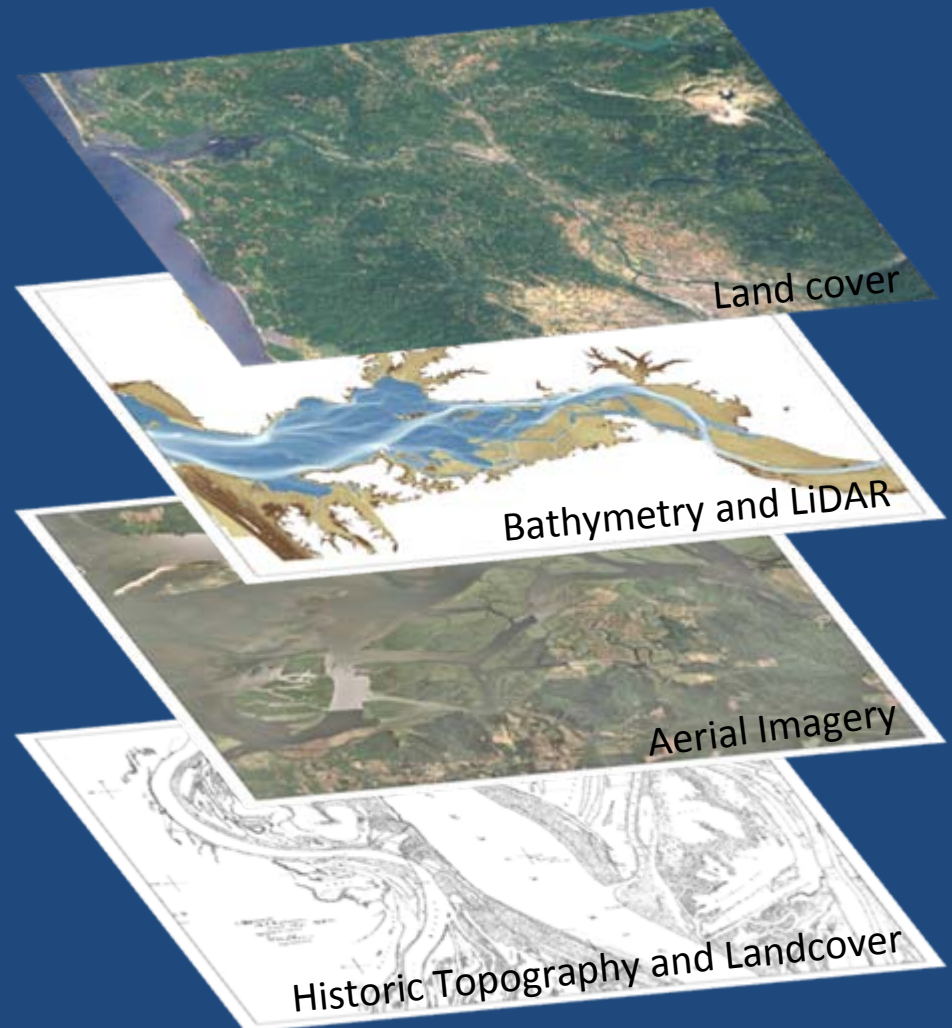
- Initial conceptualization of classification system
 - Lack of a clear accounting of the types and spatial organization of the diverse ecosystems that comprise the estuary
- Lower Columbia River Comprehensive Conservation and Management Plan (LCR-CCMP)
 - Habitat monitoring
- 2008 FCRPS BiOp
 - Establish a hierarchical classification system

Rationale

- Systematic approach to understand the organization of highly variable ecosystems
- Lacking an off-the-shelf estuarine classification scheme
 - None of sufficiently fine resolution to discriminate features of interest
 - Juvenile salmon habitat
 - None effectively address tidal freshwater regions

Approach

- GIS-based structure
 - Automated
 - Minimal manual classification
 - Repeatable
 - Historical and future spatial datasets
- Data Sources
 - Comprehensive
 - Entire landscape
 - Hydrogeomorphic
 - Hydrology
 - Ecoregions
 - Elevations (DEM, LiDAR)
 - Bathymetry
 - Adequate resolution
 - Relevance
 - Habitat requirements of biota of concern
 - Landscape ecology of tidal floodplain systems



Classification Framework

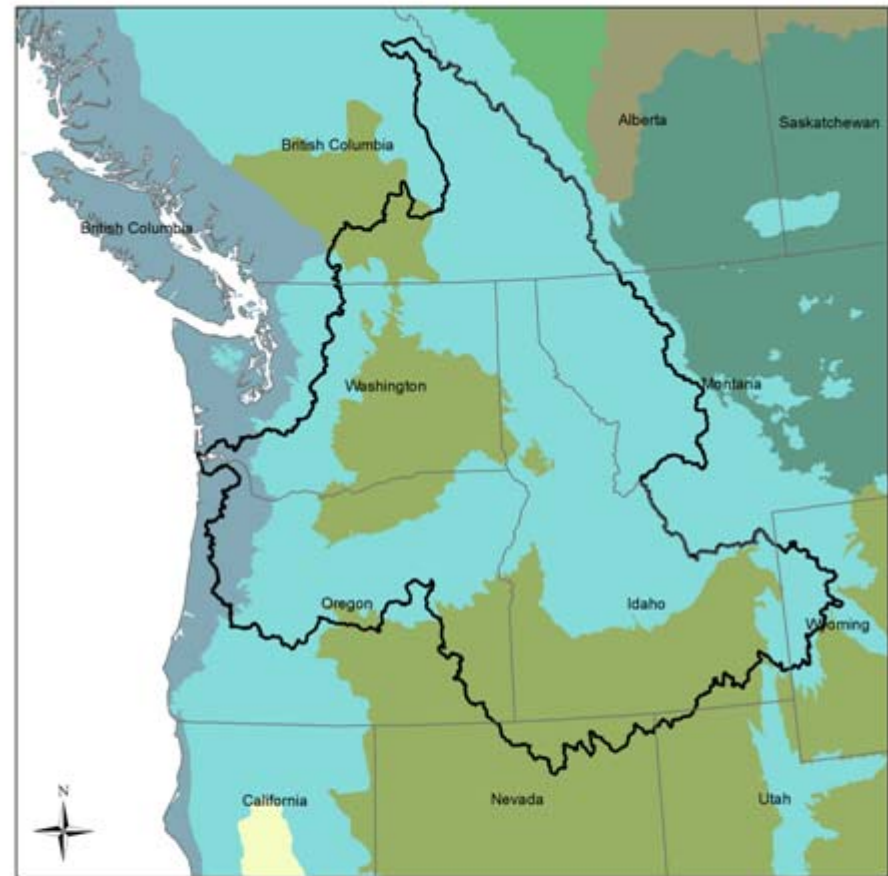
- 6 Hierarchical Levels
 - Level 1. Ecosystem Province
 - Level 2. Ecoregion
 - Level 3. Hydrogeomorphic Reach
 - Level 4. Ecosystem Complex
 - Level 5. Geomorphic Catena
 - Level 6. Primary Cover Class

Level 1. Ecosystem Province

EPA Ecoregion Level II

Ecoregion concept provides a broad-scale framework in which ecological regions are identified by patterns of abiotic and biotic phenomena:

- Climate
- Geology
- Physiography
- Hydrology
- Vegetation
- Soils
- Land use



□ Columbia River Basin

EPA Level II Ecoregions

- Marine West Coast Forest
- Western Cordillera
- Mediterranean California
- Cold Deserts
- West-Coast Semi-Arid Prairies
- Temperate Prairies
- Boreal Plain

Columbia River Estuary Ecosystem Classification Level 1 Ecosystem Provinces

Map created by M.F. Ramirez and C.A. Simenstad,
University of Washington, School of Aquatic and Fishery Sciences.
Data Source: Level II Ecoregions courtesy of Commission for
Environmental Cooperation, <http://fp.epa.gov/wed/ecoregions/ha/>

Level 2. Ecoregion

EPA Ecoregion Levels III & IV

Regional variability of watersheds exerts a strong peripheral effect on the structure of estuarine ecosystems

EPA Level III Ecoregions

- Coast Range
- Willamette Valley
- Puget Lowland
- Cascades
- Floodplain, Tidal Influence



EPA Level IV Ecoregions

- Coastal Lowlands
- Coastal Uplands
- Volcanics
- Willapa Hills
- Valley Foothills
- Prairie Terraces
- Willamette River/Tributaries
- Portland/Vancouver Basin
- Cowlitz/Chehalis Foothills
- Cowlitz/Newaukum Prairie Floodplains
- Western Cascades Lowlands and Valleys
- Western Cascades Montane Highlands
- Cascade Subalpine/Alpine
- Cascade Crest Montane Forest
- Grand Fir Mixed Forest
- Floodplain, Tidal Influence



Columbia River Estuary Ecosystem Classification Level 2 Ecoregions

Map created by M.F. Ramirez and C.A. Simenstad,
University of Washington, School of Aquatic and Fishery Sciences,
Data Source: Level II Ecoregions courtesy of Commission for
Environmental Cooperation, <http://ftp.epa.gov/wed/ecoregions/na/>

Level 3. Hydrogeomorphic Reach

Integrate broad scales of watershed influence (EPA Level IV Ecoregions) and tidal-fluvial interactions along the estuarine gradient to delineate 8 hydrogeomorphic reaches



Hydrogeomorphic Reach

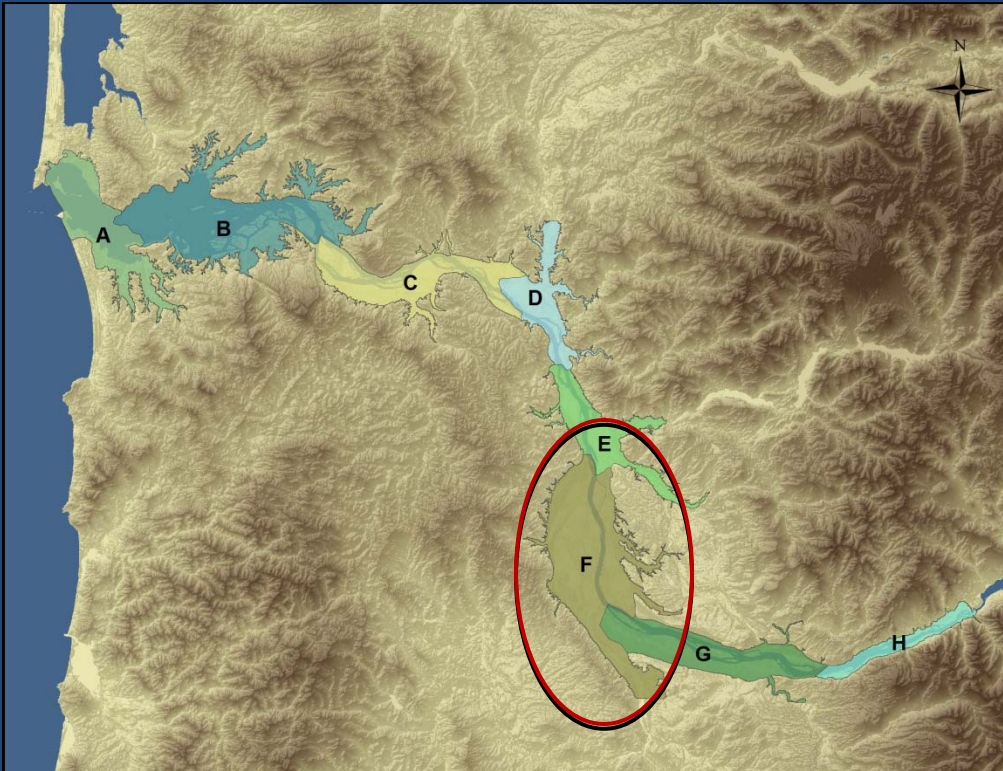
- A - Coastal Lowlands Entrance-Mixing
- B - Coastal Uplands Salinity Gradient
- C - Volcanics Current Reversal
- D - Western Cascades Tributary Confluences
- E - Tidal Flood Plain Basin Constriction
- F - Middle Tidal Flood Plain Basin
- G - Upper Tidal Flood Plain Basin
- H - Western Gorge

Columbia River Estuary Ecosystem Classification Level 3 Hydrogeomorphic Reaches

Map created by M.F. Ramirez and C.A. Simenstad,
University of Washington, School of Aquatic and Fishery Sciences,
Data Source: Digital elevation model courtesy of USGS,
Outline boundary courtesy of Earth Design Consultants, Inc.

Classification Framework

- Levels 1 – 3 of Classification complete
- Levels 4 – 6: examples from Reach F

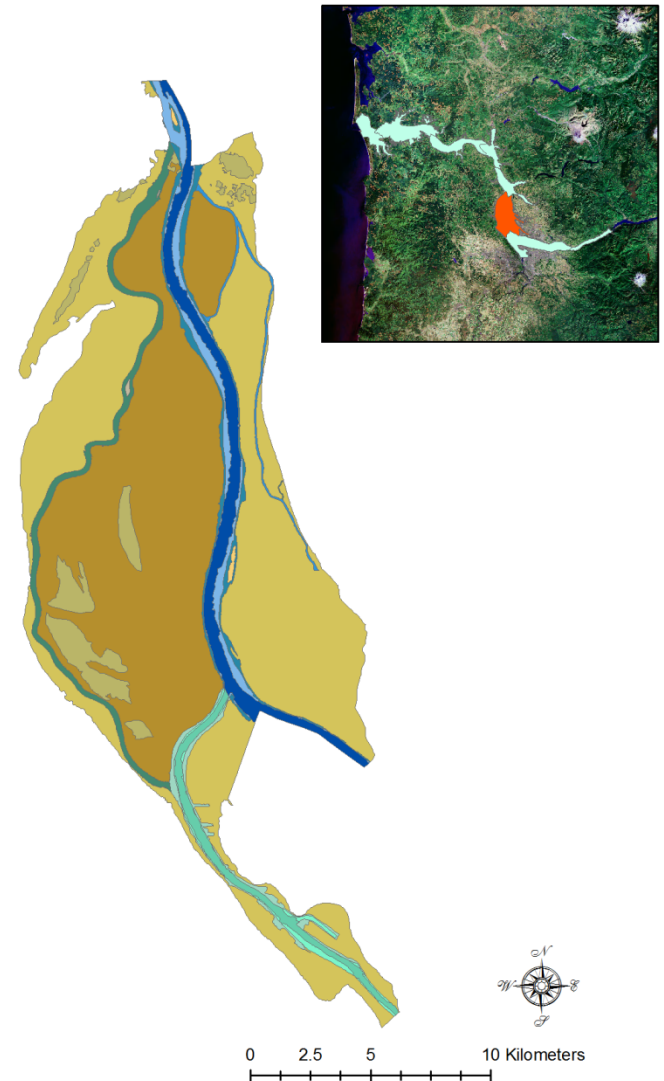


Reach F – portion of the Columbia and Willamette rivers (including Multnomah Slough) flood plains

Level 4. Ecosystem Complex

Classes based on delineating mainstem and distributary channels using bathymetry data and wetlands/floodplain through analyses of floodplain geology and geomorphology

Patches and corridors that form the estuarine mosaic, created predominantly from Holocene disturbance regimes, but still modified by modern processes



**Columbia River Estuary Ecosystem Classification
Level 4 Ecosystem Complex**

Map created by J.L. Burke, M.F. Ramirez and C.A. Simenstad,
University of Washington, School of Aquatic and Fishery Sciences.
Data Source: Landsat (insert) courtesy of Earth Satellite Corporation (EarthSat)

Level 4.

Ecosystem Complex



























Ecosystem Complex	Brief Description	Formative Processes
Floodplain	Planar to sub-planar surfaces subject to occasional or periodic flooding	Holocene aggradation from sea level rise; Overbank deposition of Columbia River flood suspended load
Floodplain (wetland)	Floodplain with many areas of seasonal and permanent water bodies	Overbank deposition, peat accumulation, generally in areas protected from significant overbank flow velocities
Floodplain (bar and scroll)	Floodplain with ridge and swale topography	Lateral channel migration and bar building from sand deposition among riparian vegetation lining major flood channels
Primary channel thalweg	Columbia River thalweg	Fluvial erosion and transport
Floodplain channel	Sloughs and side channels	Abandonment of primary channels, crevasse splays through breached natural levees
Beach/shallow	Seasonally inundated and exposed river edge	Lateral erosion (floods and waves) and deposition
Terrace	Pre-Holocene gravel deposits within area of floodplain	Relic landforms from Pleistocene epochs of Columbia River aggradation and gravel transport; Locally capped by eolian deposits

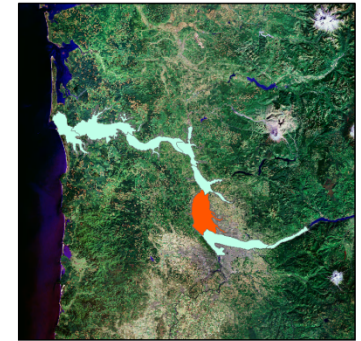
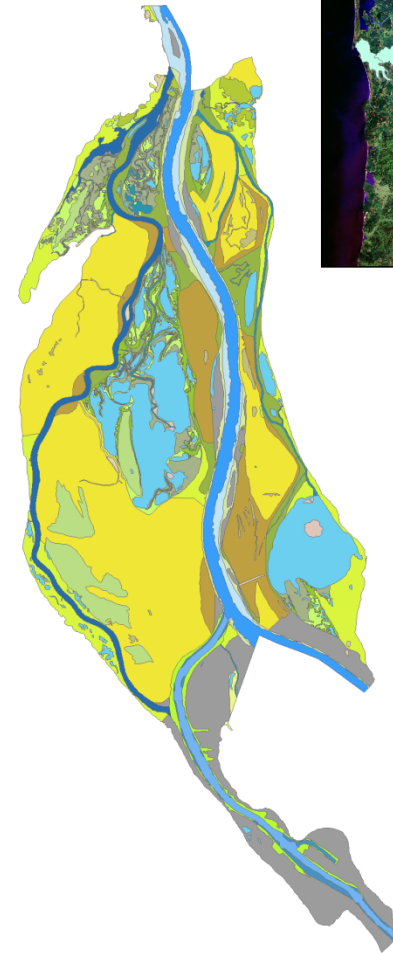
Level 5. Geomorphic Catena

Represent a shifting mosaic of features embedded within ecosystem complexes that changes over space and time

Variable and even ephemeral
 - dependent on more short-term, “snap-shot” datasets such as aerial photography, LiDAR and satellite remote sensing imagery
 - observe shifts in habitat structure over time

Geomorphic Catena

-  Primary channel thalweg
-  Primary channel permanently flooded
-  Floodplain channel
-  Floodplain secondary channel
-  Floodplain lake/pond
-  Tributary channel
-  Tributary channel thalweg
-  Tributary channel permanently flooded
-  Main beach/shallow
-  Floodplain (other)
-  Floodplain (bar and scroll)
-  Floodplain herbaceous low
-  Floodplain herbaceous high
-  Floodplain forested low
-  Floodplain forested high
-  Large tributary floodplain
-  Large tributary beach/shallow
-  Bedrock
-  Non-fluvial and terrace floodplain patch
-  Primary channel island
-  Tributary/secondary channel island
-  Floodplain lake island
-  Artificial lake/pond
-  Diked floodplain
-  Diked bar and scroll
-  Diked floodplain channel
-  Diked secondary floodplain channel
-  Diked lake/pond
-  Artificial fill



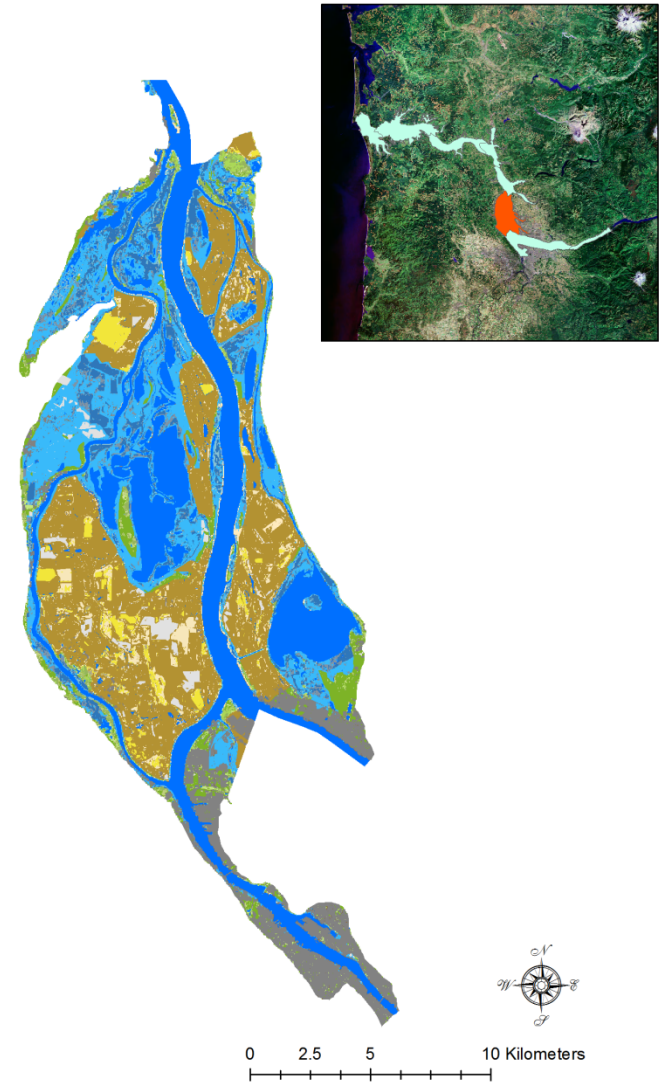
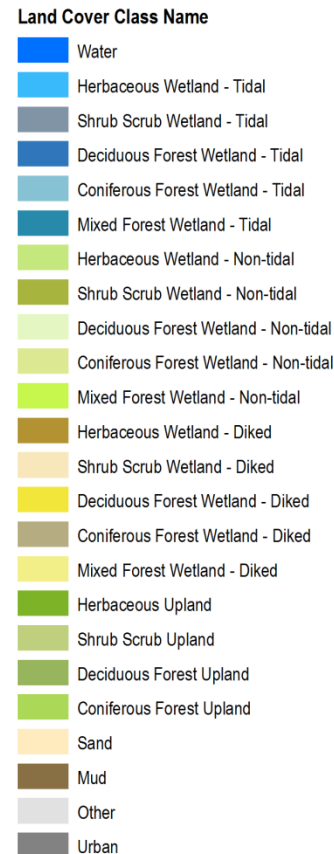
Columbia River Estuary Ecosystem Classification Level 5 Geomorphic Catena

Map created by M.F. Ramirez, J.L. Burke and C.A. Simenstad,
 University of Washington, School of Aquatic and Fishery Sciences.
 Data Source: Landsat (insert) courtesy of Earth Satellite Corporation (EarthSat)

Level 6. Primary Land Cover

Currently using the 2000 LANDSAT 7 TM because it provides the most recent information and is supported by extensive training data in some regions of the system.

Anticipate that updated (2007-2009) remote sensing imagery will be analyzed and classified to facilitate finer resolution catena delineation in the future.



**Columbia River Estuary Ecosystem Classification
Level 6 Primary Land Cover**

Map created by M.F. Ramirez and C.A. Simenstad,
University of Washington, School of Aquatic and Fishery Sciences.
Data Source: Landsat (insert) courtesy of Earth Satellite Corporation (EarthSat)

Classification Framework

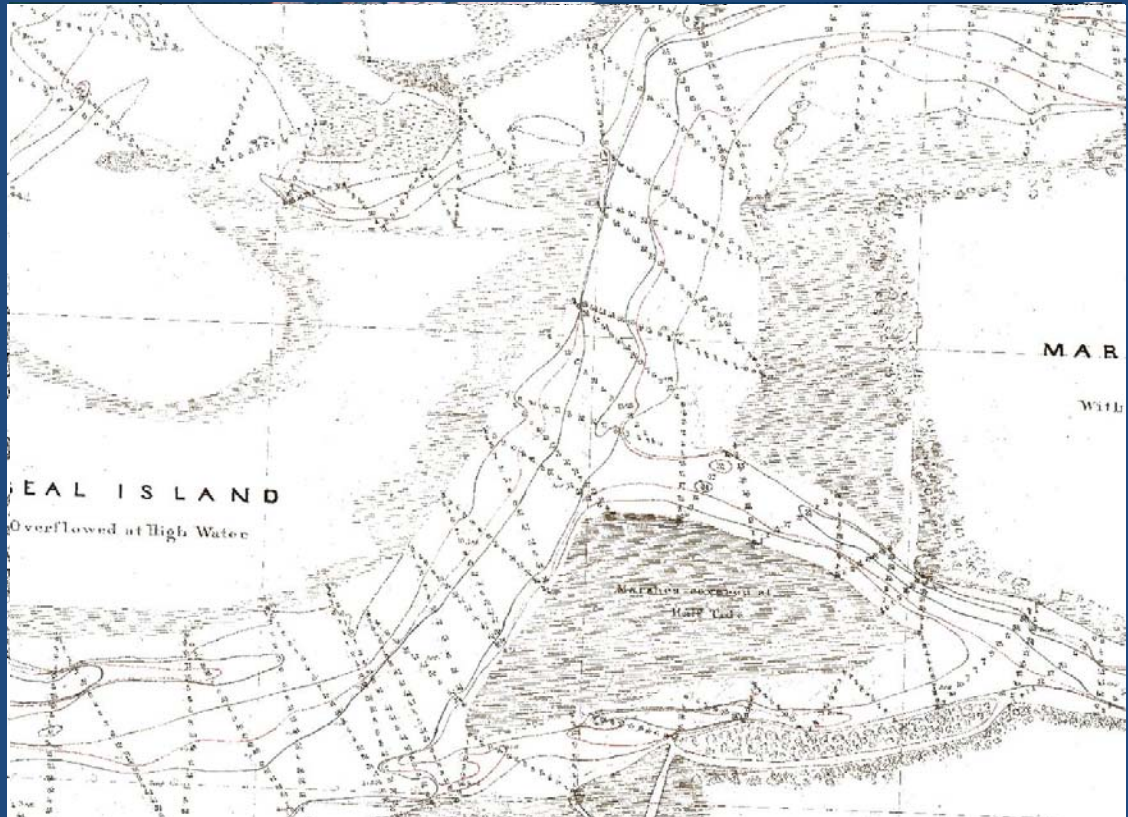
- 6 Hierarchical levels
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Application of Classification

- Management
 - Levels 3 – 5 have particular relevance to estuarine resource management issues/actions
 - i.e. release of river flows; removal or setback of dikes
- Research
 - Organize large, dynamic systems into manageable, discrete units for intensive and/or spatially extensive study
 - Quantification of processes that form and maintain individual complex or catena classes
- Monitoring
 - Spatially balanced sampling design
- Restoration and Preservation Planning
 - Identify/prioritize specific ecosystems for restoration actions.
 - Select projects that establish refuge habitats, or “stepping stones” along estuarine and tidal freshwater corridors.

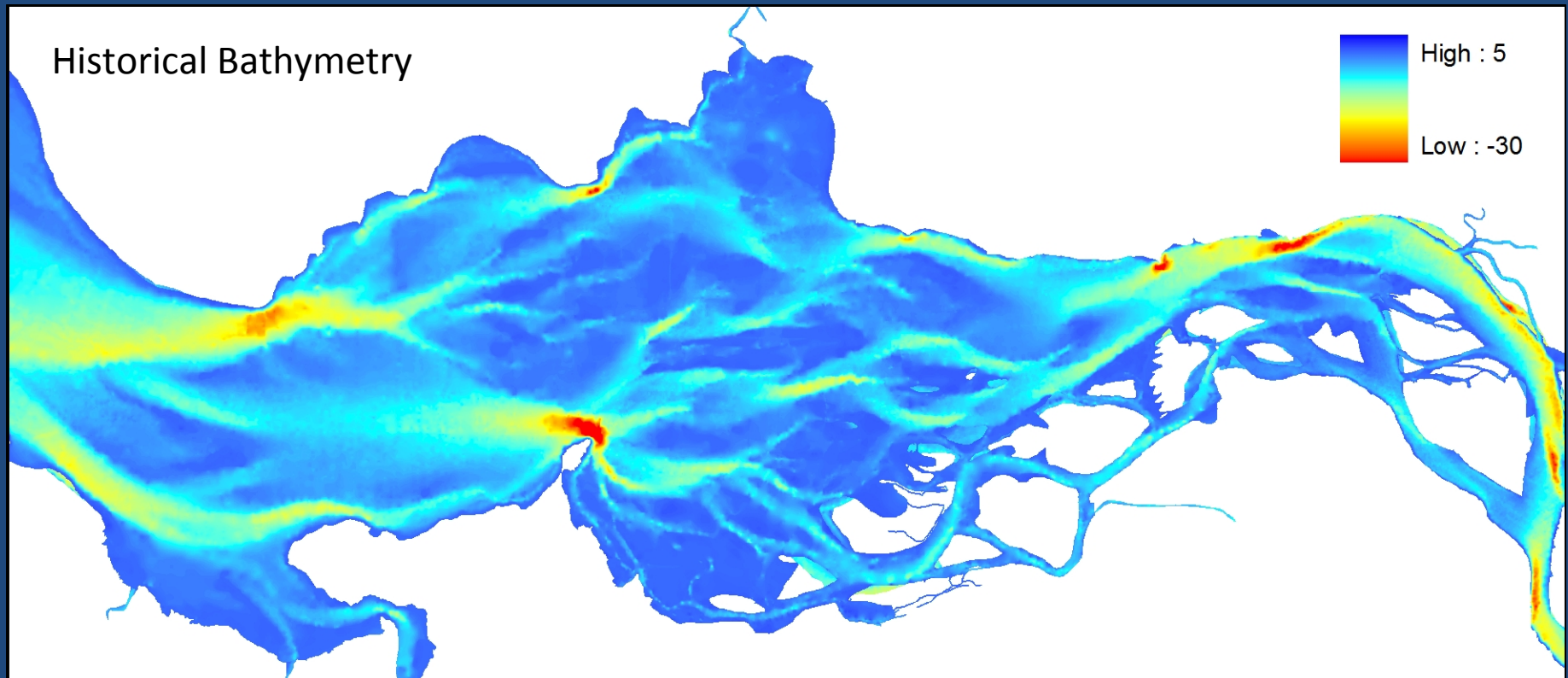
Change Analysis

- Historical datasets (1866-1901)
 - U.S. Coast and Geodetic topographic and bathymetric survey maps
- Reconstruct change in the landscape from a historic baseline



Change Analysis

- Bathymetric change



Application of Classification

- Landscape ecology metrics
 - Categories of landscape metrics
 - Non-spatial
 - Composition – quantify patch area
 - Diversity and richness
 - Spatial
 - Configuration
 - » Physical distribution
 - » Spatial arrangement/character
 - Multiple scales
 - Comparisons within and between systems
 - Historic to current change analysis
 - Provide the basis for assessments of the complexity and diversity of complexes and/or catena

Application of Classification

Habitat Capacity Example



- Habitat opportunity (access)
 - Connectivity of habitat critical for juvenile salmon performance
- Habitat capacity (quality)
 - What does the system produce?
 - How has the system changed over time?

Application of Classification

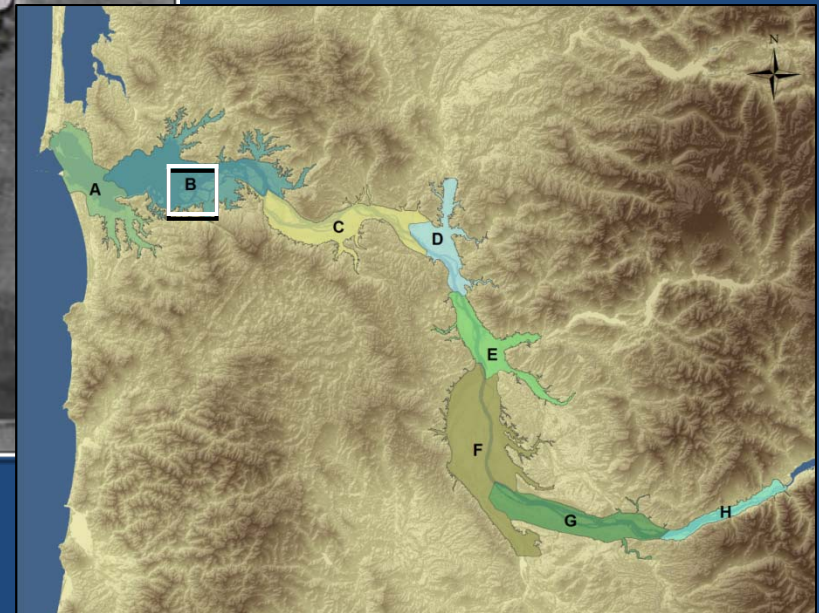
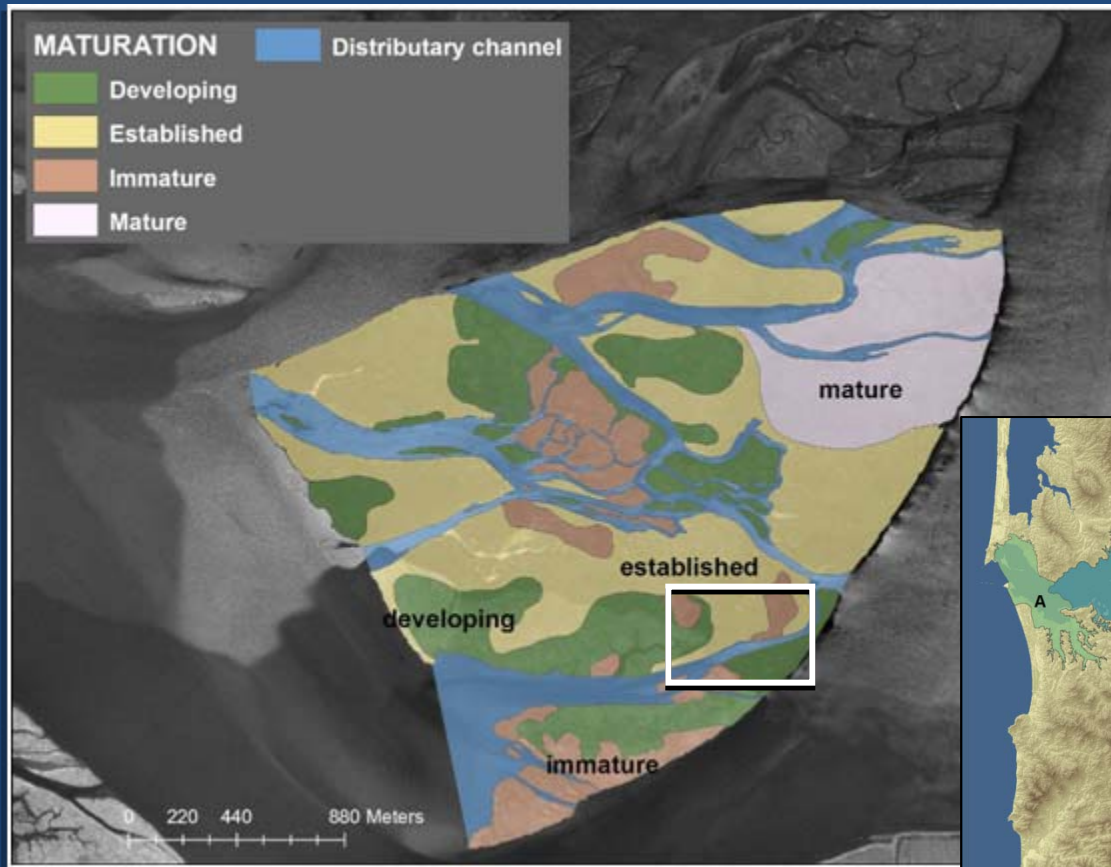
Habitat Capacity Example

Habitat Opportunity

Connectivity of habitat through tidal channel system

Habitat Capacity

Maturation level of marsh likely affects the habitat's capacity to support juvenile salmon



J. Burke and C. Elliot (2004)

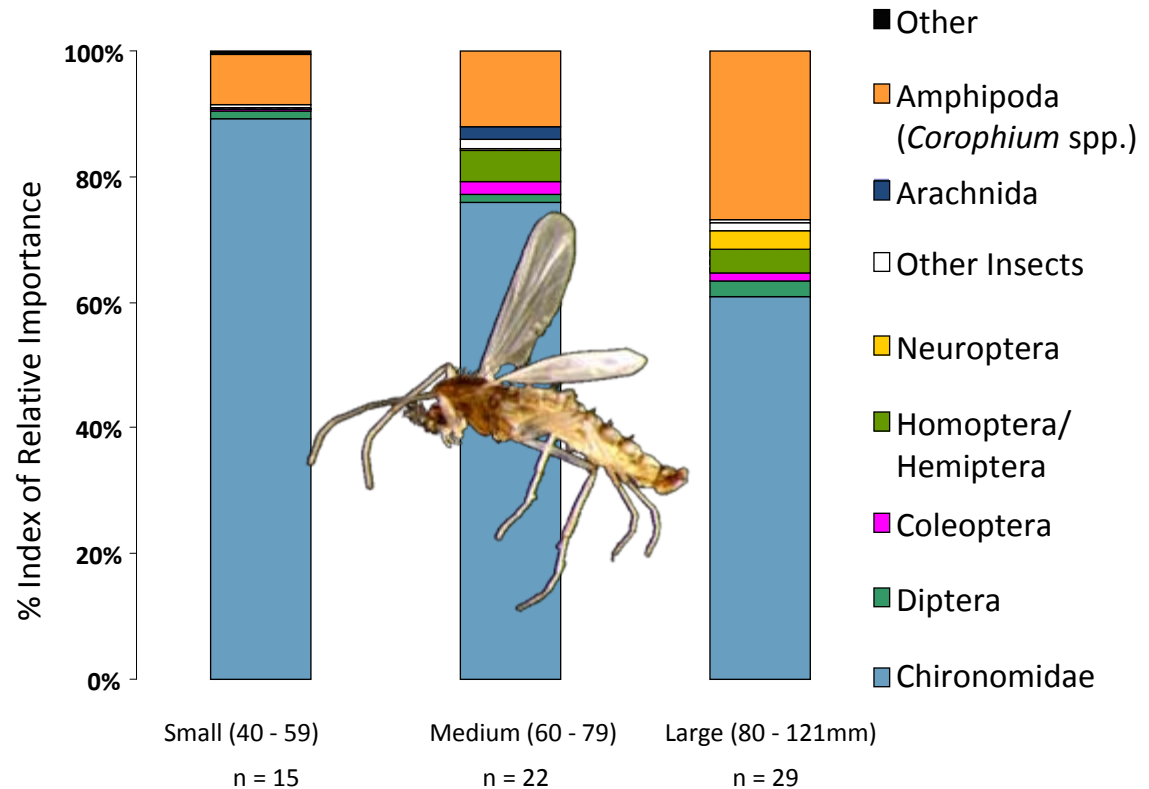
Application of Classification

Habitat Capacity Example

Emergent marsh insects major food source for fish in wetland habitats



JUVENILE CHINOOK DIET COMPOSITION Russian Island South Emergent Marsh, 2002

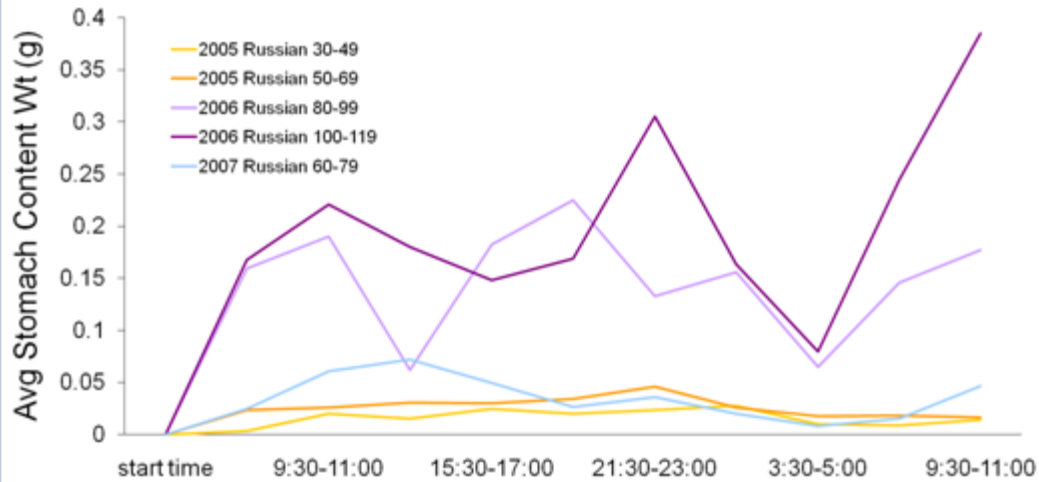


Application of Classification

Habitat Capacity Example

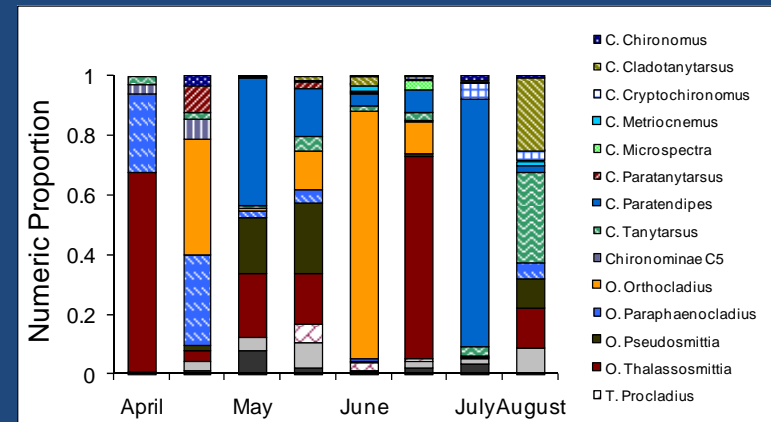
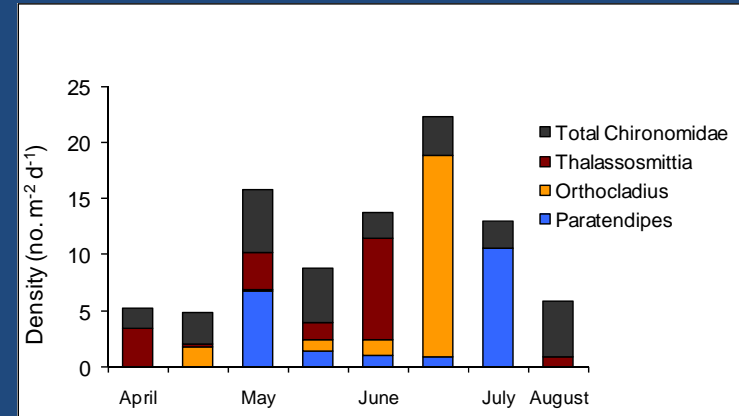
Daily consumption rates for juvenile salmon

	4/19/05	4/19/05	6/1/06	6/1/06	4/12/07	4/14/07	4/14/07
	Russian	Russian	Russian	Russian	Russian	Lord	Lord
FL (mm)	30-49	50-69	80-99	100-119	60-79	30-59	60-79
Evacuation (R)	0.40	0.37	0.40	0.40	0.41	0.34	0.30
Daily Meal (g/day)	0.16	0.28	1.33	1.74	0.37	0.17	0.25
Daily Ration (%)	16.99%	11.90%	14.40%	12.35%	8.94%	10.44%	6.04%



L. Stamatiou & C. Simenstad (unpublished)

Daily densities of emergent chironomid insects



Ramirez (2008)

Classification Timeline

- Levels 1 - 3 complete for entire estuary
- Levels 4 - 6
 - Application has been tested for Reach F
 - Acquiring necessary datasets to complete Classification
 - Bathymetry
 - Acquisition of data ongoing through Spring 2010
 - Land Cover
 - Anticipated collection for 2009-2011
 - **Anticipated date of completion for entire estuary**
 - Ecosystem Complexes: Summer 2010
 - Geomorphic Catena & Land Cover: Summer 2011

Acknowledgments

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Thank you