Lecture 21 Applications of GIS to Coastal Change

Learning Objectives
21.1 What data types would be useful for nearshore and coastal/shoreline analysis?
21.2 What levels of analysis does the Puget Sound Nearshore Ecosystem Restoration Program suggest?
21.3 How might Envision, OpenNSPECT and SUSTAIN tools work together?
21.4 What are the most significant challenges facing you in your final project?

GIS is an important tool for understanding and proposing actions for coastal change in general, and habitat conservation and restoration in particular. Looking at this issue from different scales provides a broad and deep understanding of different concerns.

21.1 What data types would be useful for nearshore and coastal/shoreline analysis?

Scoping conceptual data types (feature categories), logical data types (data structure primitives), and physical data types (data structure primitives as formatted and stored) for analysis can take advantage of broad and in-depth perspectives on a problem topic.

Scope of Puget Sound watershed influences: see Figure 1 Georgia Pacific Puget Sound Basin p.7 of this report (.pdf p. 11) for geographic scope.

Conceptual specification of data types…
Examples of shore-zone (and shore type) mapping are at
- Physical Shore-Zone Mapping System for British Columbia; particularly section 2.0 shore-zone mapping concept in context of British Columbia resources.
- In context of FEMA Nearshore diagram (Fig 2.1 p 14) in Beatley Ch 2.
- In context of PSP the Coastal Data Model paper table 4 provides a list of data types.

When we adopt a dataset, we face adopting the data structure of the dataset, plus the measurement units and their format. Alternatively, we can restructure and reformat data to meet specific needs of the problem at hand. We discussed data structure transformations for PLAS x PLAS in a previous lecture; thus, should be cognizant that different levels of potential information reside within different data structures. This is particularly relevant if moving from one scale of analysis to another.

21.2 What levels of analysis does the Puget Sound Nearshore Ecosystem Restoration Program suggest?

The Puget Sound Nearshore Ecosystem Restoration Program (PSNERP) suggests a nearshore change analysis at four levels (scales) of GIS data analysis. The main thrust of the analysis is to characterize shoreform process units (SPU). SPU’s are shore zones that change over time in a manner that can be characterized (based on GIS data analysis), but unique to the particular place along the near shore.
Level 1 – Shoreform transition analysis

Shoreform analysis is based on characterizing shoreforms that compose process units as the basis for understanding how shore areas change over time. The shoreforms approach is based on a National Research Council Report (NRC) from 2005 titled “Mitigating Shore Erosion Along Sheltered Coasts”. The report was developed from research performed in the Puget Sound region, and it continues.

The NRC framework was used as the basis for Historic Characterization of WRIA 9 Shoreline Landforms (See report .pdf page 18, Fig 14, for river and waterway watercourses, see page.pdf p. 6 for data set references if interested in data).

<table>
<thead>
<tr>
<th>Shoretype</th>
<th>Confidence level</th>
<th>Total number of segments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High segments</td>
<td>Medium segments</td>
</tr>
<tr>
<td>Bluff-backed beach</td>
<td>166</td>
<td>31</td>
</tr>
<tr>
<td>Barrier beach</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Open coastal inlet</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Barier estuary</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Barrier lagoon</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Closed lagoon/marsh</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>River-dominated Estuarine Delta</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Rocky Ramp/Platform</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total number of segments</td>
<td>251</td>
<td>35</td>
</tr>
</tbody>
</table>

The prototype application of GIS was used as a basis to classify nearshore landforms of nearshore Puget Sound within eight sub-basins as related to geomorphic systems (see Figure 2, and table 1 in .pdf; datasets described in Appendix B). It was a major GIS project effort called Puget Sound Nearshore Ecosystems Restoration Program. A geodatabase from PSNERP study results is available in WAGDA.

Level 2 – Shoreline Modification Analysis (information excerpted from DNR site)

Shoreline modification such as bulk-heading, filling and dredging can lead to direct habitat loss by destroying high intertidal habitat used for spawning and other activities. Indirectly, it can lead to changes in the sediments and wave energy on a beach and adjacent subtidal areas. The degree of shoreline modification can also reflect development intensity. For these reasons, shoreline modification is recognized as an important indicator of change in intertidal and nearshore habitats.
In 1995, scientists estimated the extent of shoreline modification by surveying 325 stratified random sites throughout the Puget Sound. This research filled an information gap: previous shoreline modification estimates did not consider the entire Sound.
- 33% of Puget Sound's shorelines, approximately 800 miles, have been modified.
- 25% of the intertidal zone -- areas that are regularly covered by tides -- has been modified.
- 8% of the shoreline is modified only in the supratidal zone -- areas directly above the extent of tides.
- Modifications in supratidal zones characteristically have less severe impacts on shoreline processes; however, they continue to affect sediment supply and natural shoreline configuration.

**Level 3 – Buffer analysis** – From NRC Report “Mitigating Shore Erosion Along Sheltered Coasts”

For the purposes of this study, four categories of commonly used techniques to address erosion are identified: (1) Manage land use, (2) Vegetate, (3) Harden, and (4) Trap and/or add sand. Each of these techniques has one or more specific type of technology or measure that can be used to meet its objective, discussed in the following sections. It is common for some combination of techniques to be applied at any particular location of a sheltered coast. For instance, if a decision is made to vegetate a site with a fringe marsh on a low to moderate wave energy coast, a combination of marsh plantings (vegetate) on sand fill (add sand), protected by a stone sill (harden) might be installed as a system. Although these techniques are discussed as separate topics, it is common for multiple methods to be used in combination.
Manage Land Use

Decisions on land use typically occur at the state and local levels. Land use measures have both spatial and temporal components. Spatial scales vary at the federal, state, regional and local levels. Historically, land use controls have been applied at the level of an individual lot without consideration of the system-level (e.g., littoral cell) processes that drive erosion. The temporal component derives from the requirement that the effectiveness of these measures depends on the consistency and longevity with which they are applied.

Management of land use varies greatly, from passive to active approaches. Measures to manage land use may be outlined as follows:

(1) planning
   • managed retreat
   • community visioning
   • green planning
   • education
   • technical assistance
   • restoration and reclamation

(2) regulation
   • buffers
   • setbacks
   • down-zoning
   • construction standards
   • perpendicular access
   • institutional reorganization and coordination

(3) incentives
   • current use tax
   • transfer of development rights
   • conservation easements
   • rolling easements

(4) acquisition
   • fee simple
   • conservation easements
   • rolling easement
   • lot retirement

Land use control and land management techniques transfer responsibility of shoreline management from the individual to the community and are often perceived as more difficult to implement than a single action by a property owner. The long-term individual and cumulative benefits of these measures extend beyond those produced by other methods, including: (1) reduced coastal infrastructure and development, (2) diminished water quality degradation, (3) improved ecological status of shorelands by avoidance of fragmentation, (4) no loss of recreational access, (5) increased property values, and (6) reduced property losses.
Level 4 – Watershed Drainage Flow Analysis

Geography 462/562 Exercise 6 was first set up to investigate…
- Gasoline tanker truck crash spill
- gasoline moves across land to water
- gasoline moves down stream to Puget Sound
- moves out into Puget Sound and mixes with other water.

ArcHydro could be used for the assignment, but it involves considerable work. As a final project, it would be a full time job across those weeks. What is missing from lab assignment 6 in regards to watershed process? The nonpoint aspect.

21.3 How might Envision, OpenNSPECT and SUSTAIN tools work together?

Lecture 22 was eliminated from Coastal GIS this quarter due to one less lecture day than in past winter quarters. Nonetheless, learning objective 22.5 (here provided as 21.3) provides interesting insight about how three GIS-enabled software programs (Envision, OpenNSPECT, and SUSTAIN) can be used to examine a challenging problem for Puget Sound recovery, i.e., land cover change linked to stormwater induced nonpoint source pollution runoff followed by stormwater runoff mitigation through best management practice. The three GIS-based software applications could be used for exploring investments in water quality improvement for sub-basins or watersheds as sustainable systems, that is, a collection of inter-relationships performing ecosystems services. Each of the applications is a GIS-enabled software system. Articulating the problem you want to address is a major part of knowing how to proceed with GIS-based analysis. Background investigation of what others have done is essential to understanding what you can do in the final project.


OpenNSPECT – compute nonpoint source contamination from stormwater run-off over land use / land cover alternatives; given rainfall factors, watershed elevation, soil factors, erosion factors using stochastic probability to compute stormwater accumulation.

SUSTAIN – computes optimal stormwater runoff mitigation alternatives in terms of green stormwater infrastructure best management practice solutions using cost-benefit analysis to prioritize investment options.
21.4 What are the most significant challenges facing you in your final project?
- Choosing a topic?
- Getting started through background research and forming question that addresses a gap in knowledge
- Finding the data for that topic?
- Understanding what operations to use to address the information need?
- Completing the project? In what way?

Addressing a gap in knowledge is important. Filling a gap in your own knowledge is important; but filling a gap in community knowledge is even more highly valued. Completing what was originally intended is great, but completing (learning about) an interesting project to a community of users is even more beneficial.