The Use of Geospatial Data to Support Vulnerability Mapping of the Oregon Coast

by

Kelvin L. Raiford

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Committee in Charge:

Dawn Wright, Geosciences
Peter Ruggiero, Geosciences
Laurence Becker, Geosciences

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Dedication

I would like to dedicate this body of work to my wonderful sister Melanie Raiford Griggs who lost a hard fought struggle to breast cancer in 2008. She left behind a loving husband, two beautiful children and her immediate family. I love you Melanie and I feel your spirit leading and guiding me every day.

The Use of Geospatial Data to Support Vulnerability Mapping of the Oregon Coast

Abstract

This research considers the availability of the appropriate geospatial data in support of vulnerability mapping of the Oregon coast. An online experiment, Voicing Climate Concerns, was developed to give community stakeholders, researchers and other interested parties the opportunity to voice their concerns on climate change and their perceived vulnerability to it. The results of the experiment produced a synthesized list of only the most salient of concerns, as well as indicators and units of measurement for data sets that might represent these concerns. A detailed search of actual geospatial data was conducted based on these concerns and summarized in a list of geospatial data websites. The list was then used to develop a database of GIS data sets which were then used in conjunction with a web-based tool called MapChat2. MapChat2 was used as part of an online tool developed at the University of Washington called Deliberative Mapping of Vulnerability (DMV). The geospatial data sets were used as layers in a GIS environment for the creation of maps. Finally, users held interactive chat fora to discuss vulnerable areas of concern, which informed some concluding ideas on how best to locate and use GIS data sets for mapping concerns about climate change.

Introduction

The use of geospatial data and information in decision support is becoming widespread with governments, businesses, city planners and resources managers. Key methods of accessing spatial data now include the use of a geospatial data infrastructure comprised of several different components, such as data clearinghouses and geospatial consortia that provide services such as web-feature, web-coverage and web-mapping services through a uniform interface are becoming key methods in accessing spatial data. The evaluation and development of web based tools can be vital to decision makers and community stakeholders in understanding environmental impacts in a particular region.

Coastal ecosystems are pressured by population growth, leaving them vulnerable to pollution, habitat degradation and loss, overfishing, invasive species, and increased coastal hazards such as sea-level rise (Hinrichsen, 1998; National Safety Council, 1998; World Resources Institute, 2000). According to the United States Census Bureau (Perry, 2003), an estimated 153 million people lived in coastal communities in 2003. These same coastal ecosystems help fuel America's economy by providing employment, recreation, energy and tourism to a growing population. As the population continues to increase, the management of coastal resources will become more challenging.

Climate change and its affects are becoming of great interest to coastal resource managers and stakeholders in the Pacific Northwest. Historically, natural patterns have been discovered in climate variability such as El Nino and La Nina that drastically affect the climate of the region (Intergovernmental Panel on Climate Change, 2007). Climate change refers to any significant change in measures such as temperature, precipitation, or wind, lasting for an extended period (decades or longer). It may result from natural factors such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; natural processes within the climate system (e.g., changes in ocean circulation); human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g., deforestation and urbanization). Regardless of what might be causing climate change, assessments about community resource vulnerability are a key component of adaptation planning for climate change and variability (Füssel and Klein, 2006). These vulnerability assessments provide an opportunity to create a database of community based concerns when developing adaptation planning for climate change.

Increasingly, geospatial decision support tools are being used by coastal and city managers to aid in more detailed analysis for adaptation planning and vulnerability assessments. The vulnerability of these areas due to climate change is one of the key foci of this research paper. In assessing vulnerability, the properties of different receptors and the expected change or variability of future climate conditions are vital for adaptation planning. Questions driving the research include: How might concerns about climate change be represented as maps to give policy and decision maker’s tools to develop better strategies for management of these vulnerable areas? And further, what geographic information system (GIS) data sets are most effective for creating such maps?

This study will attempt to identify the appropriate data sets for mapping climate concerns in a Pacific Northwest estuary (South Slough Reserve and Coos Bay, Oregon) shown in Figure 1. Initially, the study was to encompass the entire Oregon coastline but was later scaled down to the area around Coos Bay. The South Slough National Estuarine Research Reserve (NERR) is the nation’s first estuarine research reserve established in 1974 under Section 315 of the federal Coastal Zone Management Act. The 4,800-acre reserve is made up of open water channels, riparian areas with freshwater and tidal wetlands. The South Slough NERR was selected for this study because of the active research and community involvement in the area. They also provide educational and stewardship programs to better inform decision makers in their efforts to understand the anthropogenic affects on coastal environments. Researchers and staff from South Slough NERR participated in an online experiment described below, along with students from the University of Washington and community stakeholders interested in how climate change and variability will affect this region.

Figure 1a. Region of interest, Coos Bay, Oregon. Red box indicates the boundary of the South Slough National Estuarine Research Reserve, shown in Figure 1b.

Figure 1b. South Slough National Estuarine Reserve within Coos Bay.

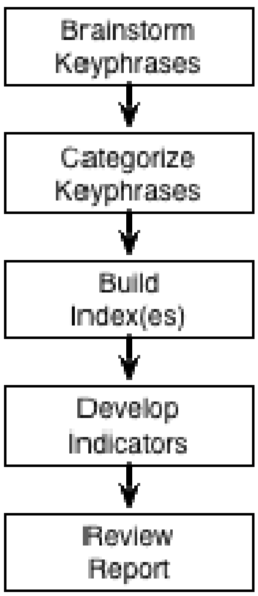
This study is an outcome of the project "Geospatial Decision Support Tools for Coastal Resource Management: Vulnerability Maps Characterizing regional Climate Variability and Change Impacts," funded by the NOAA Sectoral Applications Research Program, Climate and Coastal Resource Management Division. The overall research goal was to develop and evaluate web tools used by stakeholders for exploring and understanding coastal climate variability and change. A series of tasks was developed to help achieve the research objective, they include: online tool development, data integration, vulnerability to climate change workshop and synthesize collaborative process. In a primary task, the website Voicing Climate Concerns (VCC) was established at the University of Washington to create an environment for "an online activity, in which participants brainstorm concerns about climate change and variability along the Oregon Coast and analysts produce maps depicting those concerns contingent on availability of data" (http://www.climateconcerns.org, Figure 2).

Figure 2. Front page of Voicing Climate Concerns website, http://climateconcerns.org

VCC allows participants to brainstorm over concerns about climate change and variability along selected regions of the Oregon coast. The site collects and synthesizes lists of concerns as entered by participants about the overlap between future climate conditions and receptors. A climate indicator is simply a specific measurement of change or variability in climate conditions. Examples of climate indicator are expected increase in temperature or precipitation at any location in the estuary over time. A receptor refers to any phenomenon (person, place, thing as in habitats, crops, animals etc.), that is potentially vulnerable to climate change. These indicators and receptors can then be mapped using GIS to identify any areas where exposures to vulnerability might occur. Once the appropriate GIS data sets have been located, they can be mapped out for the user. The map layers may further be used to analyze differences between indicators and receptors in a region of interest. The identification of the appropriate GIS data sets is a primary focus of this research.

Methodology

Online experiments within VCC were comprised of two phases. The first phase allowed users the opportunity to participate in an activity composed of five steps, each with a moderated discussion as per below. Researchers from South Slough NERR, and students from the University of Washington were the actual participants in this experiment.



Step 1. Participants brainstorm climate concerns plus keywords/phrases for annotating concerns.

Step 2. Participants specify indicator labels that best represent the entire collection of keywords/phrases.

Step 3. Participants select indicator labels that should move forward in the process, as well as identify indicator labels that help generalize climate indicators as appropriate.

Step 4. Participants assign units of measurement to indicator labels, thereby suggesting ways of measuring climate conditions and receptor impacts.

Step 5. Participants review a report listing the indicators.

An agenda was provided within the site including detailed instructions about what to do and when each step would be closed. VCC allowed users to translate their concerns into measurable indicators, including measurable indicators about climate conditions in general and about exposure of particular receptors. The first step of the experiment gave the participant the opportunity to brainstorm about their climate concerns using keywords or phrases. These keywords were then voted on by participants to represent their specific concerns on climate change and variability. A synthesized list of keywords and phrases was developed for the next step in the experiment. Participants categorized these keywords into indicator labels (i.e., biologic, sea level, roads), representing the most common climate concerns that participants had developed from the brainstorming activity. The next step of the experiment allowed users to assign units of measurement to the indicators developed in the previous step. The units of measurement represented how the concerns or indicators were to be specifically measured (i.e., feet, cm per year and bushels per acre) as seen in Table 1. Finally, the indicators with their specified units of measurement are reviewed by an analyst to direct the search for climate change data. A synthesized list of receptors and paths was also developed to direct the data analyst search as seen in Appendix A.

Table 1. List of indicators and units.

Indicators:	**Units:**
Biologic	count
Storm	low barometric pressure
Sea Level	cm per year
Roads	number of possible failures
Rainfall	cm per year
Reactions	number of changes per community
Water volume	acre feet per year
Property	feet per decade change
Species	count loss or gain
Agriculture	bushels per acre
Shore	change per decade
Ecosystem	sq km per year
Erosion	cm per year
Fresh water impact	cubic feet per sec
Marine water impact/economic	dollars lost
Public infrastructure impact	dollars per year lost
Private structures impact	dollars per year
Temperature	degrees
Fire	acres affected
Resource impact	dollars lost

In order to achieve the objective of locating the appropriate GIS data sets for this research, first a data management strategy was developed for access and storage. In this case, a Windows operating system file folder structure was used to create a database of downloaded data sets. The main folder for the receptors contained a filing system structured with three main headings representing climate concerns (i.e., community infrastructure, coastal natural systems and coastal economic sectors). Each heading contains subfolders of specific areas of interest (i.e., estuaries, agriculture, transportation, etc.). When conducting a search documentation was important for the creation of metadata. The main attributes recorded to create the metadata for the indicators consisted of file name, brief description, data source, file type and web address if available. The main attributes recorded for the receptors consisted of the same criteria as the indicators. Examples of Microsoft Excel spreadsheets are shown in Appendix B. Next, a systematic approach was used to identify relevant sources with geospatial data of the region. An initial keyword search for sources of geospatial data was conducted to locate the appropriate agencies and websites that provide users with geospatial data. Data clearinghouses were used as starting points for the initial GIS data search. There were certain sites identified by the data analysts as primary sources of data for the region. A list was synthesized of sources included websites from local, state and federal agencies. The Oregon Coastal Atlas, http://www.coastalatlas.net (Figure 3), Oregon Explorer, http://oregonexplorer.info, and the Geospatial One Stop http://www.geodata.gov were used as primary sources to initiate the search process for climate data shown in Table 2.

Table 2. List of geospatial data sources.

Geospatial Data Sources	**URL**
Oregon Coastal Atlas	www.coastalatlas.net
Oregon Explorer	www.oregonexplorer.info
Oregon Spatial Data Library	www.oregon.gov/DAS/EISPD/GEO/sdlibrary.shtml
Geospatial One Stop	www.geodata.gov/
Oregon Climate Service	www.ocs.orst.edu/
Oregon Hydrologic Data (USGS)	http://or.water.usgs.gov/data_dir/datapage.html
Oregon Department of Geology and Mineral Industries	http://www.oregongeology.org/sub/default.htm
National Geospatial Program	http://www.usgs.gov/ngpo/
NOAA National Estuarine Research Reserve System	http://cdmo.baruch.sc.edu/
NW Geodata Clearinghouse	http://nwdata.geol.pdx.edu/
USDA:NRCS:Geospatial Data Gateway	http://datagateway.nrcs.usda.gov/
National Atlas	http://nationalatlas.gov/mapmaker
US Census Bureau (Geography)	http://www.census.gov/geo/www/

Figure 3. Oregon Coastal Atlas website (http://coastalatlas.net).

A typical search was conducted by first accessing the data sources website, such as the Oregon Coastal Atlas. In the Oregon Coastal Atlas a search is performed by entering a keyword from the indicator or receptor databases or by choosing a specific data source by agency shown in Figure 4.

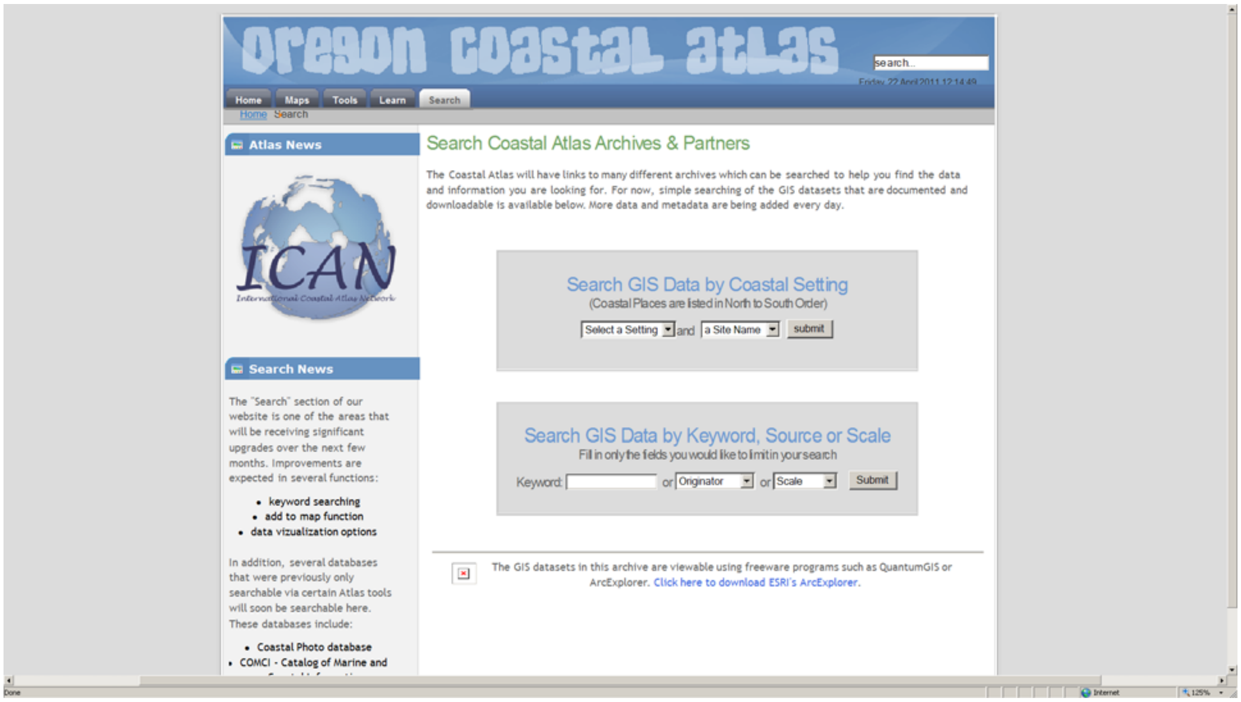


Figure 4. Search interface for GIS data sets within the Oregon Coastal Atlas.

This procedure was used for each data source identified in the VCC experiment. Once the list of indicators had been exhausted for each data source, the process was then repeated to locate data sets for receptors.

The synthesized list of indicators was used first to direct detail searches for the availability of GIS data sets. An indicator and its specified unit of measurement were selected and a search was conducted using each data source. Once a data set was located for an indicator, the unit of measurement would be checked. If the criteria were met for that particular indicator it was downloaded and saved to the database. An example of a geospatial data set for an indicator was erosion, with a unit of measurement as amount per year, file type of vector. Specified indicators that were located but did not meet the unit of measurement criteria were reviewed for unit conversions. If these criteria were met, then the data set was downloaded and saved to the database. Once each indicator was researched at a particular data sources website, the process was then repeated using the next data source.

The same methodology was used in conducting searches for receptor data sets. First a data source was identified and then the synthesized list of receptors was used to locate geospatial data sets (e.g., roads in Coos County, Oregon, vector shapefile). These data sets were then downloaded and added to the database.

If a data set was located but did not meet the specified unit of measurement it was still documented. These data sets may have required some conversions to meet unit specifications. If no data sets were available, the next data source was then explored for the same criteria until all known data sources were exhausted.

Next, another indicator was selected and the process was repeated until finally all desired indicators were explored through each data source. The data sets were downloaded and placed in folders for use in Phase 2 of the experiment.

The second phase of the experiment uses another web-based tool called Deliberative Mapping of Vulnerability (DMV) which featured MapChat. MapChat is an open source tool for integrating maps in a real time setting allowing discussion between multiple participants. The tool allows users to create windows on the map to directly comment on locations within the study area. The chat dialog window is used to open up discussions on any climate topic at any geographic location on the map. This study uses MapChat2, the newest version of the tool offering better features for integrating resources (Figure 5).

Figure 5. MapChat2 user login.

The DMV tool enabled participants to visualize the indicators developed by the group in Phase 1 as a combination (overlay) of climate condition map layers and receptor may layers, while at the same time deliberating about exposure and vulnerability (Nyerges, 2010). The user interface of MapChat with the region of interest, map layers and chat dialog box is shown in (Figure 6).

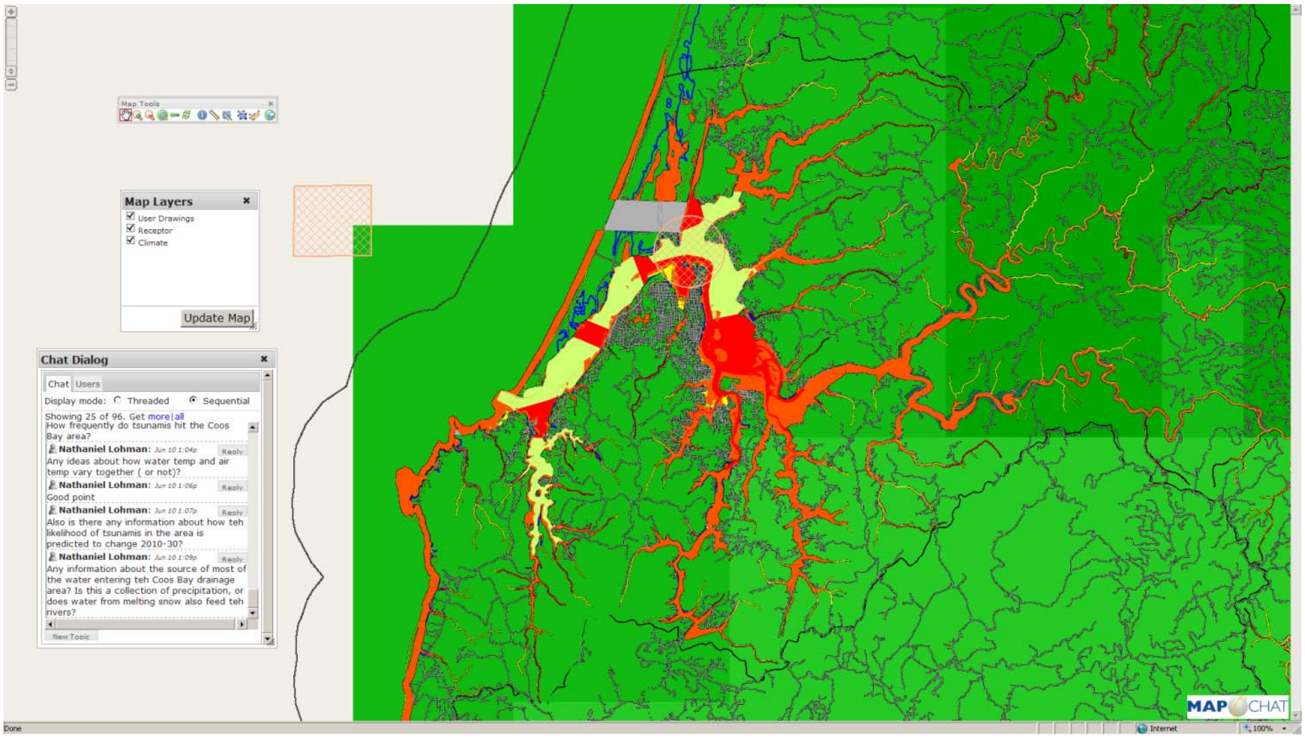


Figure 6. MapChat2 chat dialog box, map layers, toolbar and region of interest.

Results

The five tasks from the VCC experiment produced a synthesized list of indicators and receptors specified by participants for the research of available data sets as shown in Appendix A. Table 3 shows a final list and resulting database of geospatial data sources developed for conducting the searches for the appropriate GIS data to represent the concerns indicated by participants in the experiment.

Table 3. Resulting map layers used in MapChat2.

Resulting Map Layers used in MapChat	
<u>Receptors</u>	**<u>Climate</u>**
Shellfish	**Tsunami Inundation**
Approved	
Conditionally approved	**Air Temperature Change**
Prohibited	
Restricted	**Precipitation Change**
Unclassified	**Sea Level**
Flood zone	
100 year	
500 year	
Not classified	

Salinity zones	
Tidal fresh zone	
Seawater zone	
Mixing zone	
River Water Quality	
Chinook	
Rearing	
Spawning	
Migration	
Unknown	
Coho	
Rearing	
Spawning	
Migration	
Unknown	
Steelhead	
Rearing	
Spawning	
Migration	
Unknown	

Road Network	
Highways	
Others	
Shoreline erosion	
Very Low	
Low	
Moderate	
High	
Very High	
Land Use-Cover	
Water	
Unconsolidated shore	
Snow-Ice	
Shrub	
Pasture - Hay	
Palustrine Scrub - Shrub	
Wetlands	
Palustrine Forested Wetland	
Palustrine Emergent Wetland	
Palustrine Aquatic Bed	
Mixed Forest	

Medium Intensity Developed	
Low	
High	
Grassland	
Evergreen Forest	
Estuarine Emergent Wetland	
Estuarine Aquatic Bed	
Developed Open Space	
Deciduous Forest	
Cultivated	
Bare land	

In Phase 2 of the experiment, the appropriate GIS data sets specified from Phase 1 of the experiment were imported into ArcGIS. This action creates the layers and they are displayed in the table of contents shown in Figure 7. After users were able to use the MapChat 2 dialog box shown in Figure 7 to engage in discussion on climate change and variability, the following receptor layers were chosen as most appropriate for overlaying with climate layers in order to display areas of vulnerability shown in Table 4.

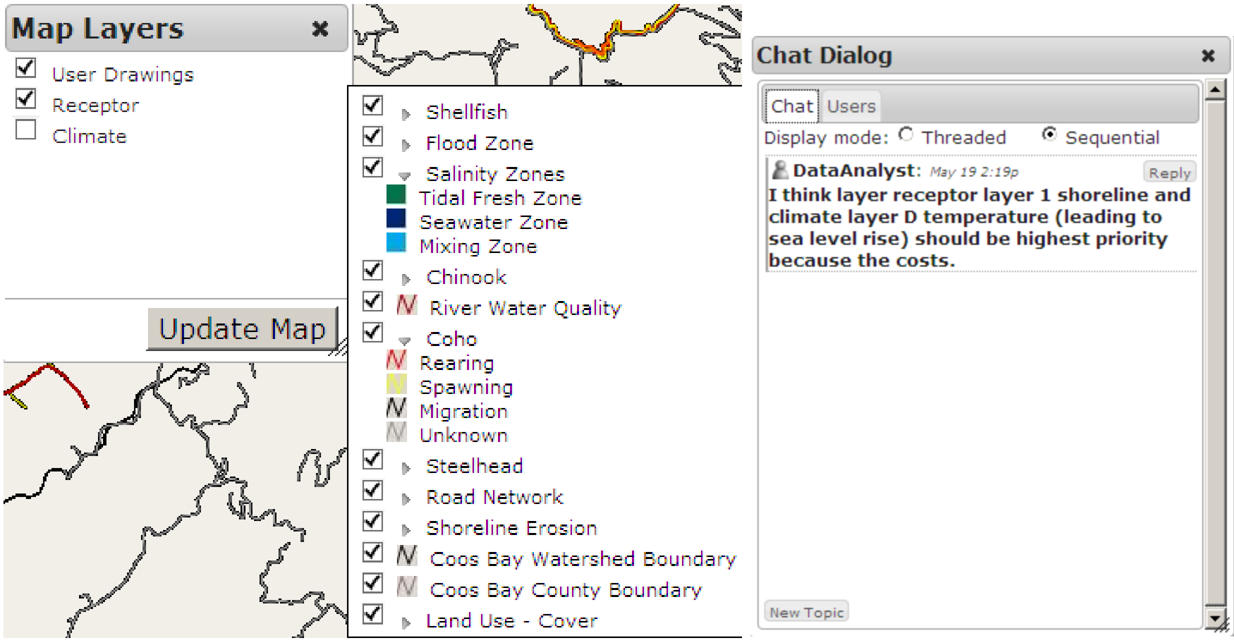


Figure 7. Map layers window and the table of contents and chat- window for text (deliberation).

An example of a receptor layer used in the study would be Chinook or Coho salmon. The attributes associated with the layer would be spawning, rearing, migration and unknown. Salinity zones with attributes such as tidal fresh zones, seawater zones and mixing zones. The climate layers represented concerns of tsunami inundation, precipitation and air temperature changes.

Discussion and Conclusion

There are several limitations to this project and more work needs to be done to consider these in order to make an accurate assessment of the complete situation. The broad scope of the project presented a major challenge. There were several challenges faced in conducting the VCC experiment. Initially the scope of the project was extremely broad trying to map climate concerns for the entire Oregon coast. Participation from concerns individuals was low resulting in a small data set. The next issue was how to increase participation? This issue was partly resolved by recruiting researchers and staff from South Slough NERR who were interested in the project from a coastal management perspective, as well as students from the University of Washington..

Data mining was a challenging and daunting task. A systematic approach was used by first developing a list of geospatial data sources. There were hundreds of websites offering geospatial data in a variety of formats. The problem arises on which one to choose and which data source best fits the needs of the study. Several hours were spent just searching for relevant data sources before actual searching for data sets could begin. The Oregon Coastal Atlas, Oregon Explorer and Geospatial One Stop were extremely valuable resources with geospatial data sets more specific to the geographic region of the study. The USGS, NOAA and USDA's NRCS Geospatial Data Gateway were extremely valuable as well as data sources.

Another challenge faced while conducting data searches was finding duplicate data sets, finding the same data set from the same data source on multiple websites. Deciding when to terminate a search for data set was also an issue. A lot of time can be spent searching for a data set that does not exist. Locating data sets with specified units of measurements was another daunting task. In managing the data some conversions and transformation are required to achieve the desired data set.

The original research questions posed were: How might concerns about climate change be represented as maps to give policy and decision maker’s tools to develop better strategies for management of these vulnerable areas? And further, what geographic information system (GIS) data sets are most effective for creating such maps? In conclusion concerns about climate change can be mapped by using a structured set of web based tools with input from researchers, policy makers and community stakeholders. The most effective way to do this may be via the

MapChat2 approach previously described. This allows for a better understanding of the science through interactive dialog and discussion. The GIS data sets that were found to be most effective in creating such maps were derived from the VCC experiment. The climate data sets were temperature, storms-tsunami inundation, sea level, and precipitation. The most effective receptor data sets were shellfish, flood zones, salinity zones, river water quality, chinook salmon, steelhead salmon, coho salmon, road networks, shoreline erosion, land use cover and wetlands. These data sets were found to be most appropriate when used in MapChat 2 to display areas of vulnerability and to allow interactive discussions between participants.

Geospatial data can be used effectively to support vulnerability mapping. A key issue encountered while conducting this research was the divide between geospatial data sources and available data sets. Most data sources offer a wide array of data but they could be categorized in a more effective manner. Transformations and conversions need to be performed on data sets before becoming available to end users. A final suggestion would be to allow for end users specify all of the parameters when requesting data sets. Specifying parameters such as scale, file format and unit of measurement would also be helpful. This would be an advantage to any user searching for specific data.

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Appendices

Appendix A: List of Indicators

Appendix B: List of Climate Receptors

Appendix A

List of Indicators

No	Path	Name	Unit	Votes_No	Source Layer	Type	Color	Receptor-Climate No.	MapChat Group	MapChat Layer Name
1	1	Path: **Damage to coastal barriers | rate of erosion**			USGS Coastal Vulnerability Index for shoreline	Line	Green to red scale from "Very Low" to "Very High" rate of erosion in "EROSION"	Receptor 2.4 Coastal Shorelands; Receptor 1.2 Shore Protection and Flood Control	Receptor	**Shoreline_Erosion_MetersPerYear**
2	1	Indicator: Recommend none of the following	Unit:	Votes:3						
3	1	Indicator: erosion	Unit: amount eroded per year	Votes:2						
4	2	Path: **Deforestation Rates | forest density**			OR 2006 Land use/land cover	Raster	Colored by land use/cover class "Class_Name"	3.3 Forestry	Receptor	**Land Use/Cover 2006**
5	2	Indicator: Recommend none of the following	Unit:	Votes:3						
6	2	Indicator: forest density	Unit: %	Votes:0						
7	2	Indicator: forest	Unit: decrease in trees per year	Votes:1						
8	3	Path: **Capacity of wastewater system | change in pollution from runoff**			OR streams water quality	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including dissolved oxygen, pH, fecal	2.1 Rivers and streams; 2.2 Estuaries	Receptor	**River Water Quality**
9	3	Indicator: surface pollution runoff	Unit: ppm	Votes:1						
10	3	Indicator: Recommend none of the following	Unit:	Votes:5						
11	4	Path: **Changes in environmental chemistry | pH of estuaries**			OR streams water quality (pH is only readily available for streams, not the estuary itself)	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including dissolved oxygen, pH, fecal coliform, etc.	2.2.5 Acidification	Receptor	N/A
12	4	Indicator: Recommend none of the following	Unit:	Votes:3						
13	4	Indicator: acidity	Unit: pH level	Votes:1						
14	4	Indicator: PH	Unit: N/A	Votes:0						
15	5	Path: **change maximum rainfall**			Precip Change 2010-2030 from Coastal Impacts Group	Raster	Greyscale by precipitation change in mm	Climate D Precipitation	Climate	**Precip Change 2010 to 2030**
16	5	Indicator: Recommend none of the following	Unit:	Votes:4						
17	5	Indicator: precipitation	Unit: centimeters per year	Votes:0						
18	5	Indicator: rain	Unit: cm per year	Votes:1						
19	6	Path: **Land use issues | susceptibility to flooding**			Oregon Coastal Atlas FEMA Q3 flood map (see also Path 6)	Line	Colored by "ZONE" in three classes: "A" is red, "ANI" is grey, and "X500" is yellow.	(across all receptors); 1.2 Shore protection and flood control structures	Receptor	**Flood Zone**
20	6	Indicator: Recommend none of the following	Unit:	Votes:2						
21	6	Indicator: elevation	Unit: meters above sea level	Votes:2						
22	6	Indicator: flooding	Unit: susceptibility index	Votes:1						
23	7	Path: **Changes in environmental chemistry | Water Quality**			OR streams water quality (see Path 3)	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including dissolved oxygen, pH, fecal	2.1 Rivers and streams; 2.2 Estuaries	Receptor	**River Water Quality**
24	7	Indicator: Recommend none of the following	Unit:	Votes:3						
25	7	Indicator: oxygen	Unit: BOD changes	Votes:0						
26	8	Path: **Changes in environmental chemistry | salinity of estuaries**			NOAA Sailinity Zones	Polygon	Greenish-blue to blue by three salinity zone classes in "SZNAME"	2.2 Estuaries	Receptor	**Salinity Zones**
27	8	Indicator: Recommend none of the following	Unit:	Votes:0						
28	8	Indicator: salinity	Unit: Practical Salinity Unit	Votes:0						
29	8	Indicator: Change in Salinity	Unit: parts per thousand (grams per liter)	Votes:5						
30	9	Path: **Changes in fauna | salmonid rearing habitat**			Oregon Department of Fish and Wildlife fish habitat use	Line(s)	Separate layer for each fish species, colored by habitat use in value field "fhdUseTy": "Rearing" is red, "Spawning" is yellow, "Migration" is black, and "Unknown" is grey.	Receptor 3.1.1 Salmonids	Receptor	**[Three layers]: Coho, Chinook, Steelhead**
31	9	Indicator: Recommend none of the following	Unit:	Votes:0						
32	9	Indicator: Change in Salmonid Rearing Habitat	Unit: meters squared per year	Votes:1						
33	9	Indicator: salmonids	Unit: births per season	Votes:2						
34	9	Indicator: habitat	Unit: meter squared habitat (nearshore, grassbeds, etc)	Votes:2						
35	10	Path: **change in average temperature | change**			Precip Change 2010-2030 from Coastal Impacts Group (see also Path 5)	Raster	Greyscale by precipitation change in mm	Climate D Precipitation	Climate	**Precip Change 2010 to 2030**
36	10	Indicator: Recommend none of the following	Unit:	Votes:2						
37	10	Indicator: rainfall	Unit: cm per year	Votes:5						
38	10	Indicator: rain	Unit: inches per year	Votes:1						
39	11	Path: **health of marine ecosystem | shellfish beds**			NOAA shellfish zones	Polygon	Red and green by "SHELLCLASS" as to whether shellfishing is approved or prohibited based on point and non-point source pollution	2 Coastal natural systems (various)	Receptor	**Shellfish**
40	11	Indicator: Recommend none of the following	Unit:	Votes:3						
41	11	Indicator: shellfish beds	Unit: % of 2000 level	Votes:1						
42	11	Indicator: habitat	Unit: coverage area in square miles	Votes:0						
43	12	Path: **change in average temperature | Average ocean temperature**			(Not considered at this time because offshore and out of range of Coos Bay watershed.)	N/A	N/A	2.3 The Pacific Ocean	Receptor	N/A
44	12	Indicator: temperature	Unit: Celsius per year	Votes:2						
45	12	Indicator: Recommend none of the following	Unit:	Votes:4						

46	12	Indicator: oceans	Unit: degrees Celsius	Votes:0						
47	13	Path: **change in fishing revenue**			Statistical table "56_Monthly_value_Charleston.pdf" on fishing revenue by species for Port of Charleston (Coos Bay)	Table	http://www.dfw.state.or.us/fish/commercial/landing_stats/2009AnnRep/56_Monthly_value_Charleston.pdf	3.1 Ocean fisheries	Receptor	N/A
48	13	Indicator: fish revenue	Unit: annual revenue in $	Votes:0						
49	13	Indicator: Fisheries	Unit: Annual $	Votes:0						
50	13	Indicator: fishing revenue	Unit: dollars	Votes:0						
51	13	Indicator: Recommend none of the following	Unit:	Votes:3						
52	13	Indicator: economic	Unit: dollars per year	Votes:0						
53	13	Indicator: Fishing revenue	Unit: dollars per year	Votes:4						
54	13	Indicator: fishing	Unit: dollars in tax revenue	Votes:0						
55	14	Path: **dissolved oxygen levels**			OR streams water quality	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including dissolved oxygen, pH, fecal coliform, etc.	2.1 Rivers and streams; 2.2 Estuaries	Receptor	**River Water Quality**
56	14	Indicator: Recommend none of the following	Unit:	Votes:5						
57	14	Indicator: dissolved oxygen	Unit: milligrams oxygen per liter water	Votes:0						
58	14	Indicator: decreased dissolved oxygen	Unit: oxygen molarity	Votes:0						
59	15	Path: **infrastructure | transportation | roads**			Census TIGER roads for Coos County (FIPS 41011)	Line	Grey or black but different line thickness by value field "ROAD_TYPE" where "Highway" are thick lines (line thickness 2)	1.1.1 Coastal roads, highways, and rail lines	Receptor	**Roads**
60	15	Indicator: Recommend none of the following	Unit:	Votes:2						
61	15	Indicator: roads damaged	Unit: average hourly capacity loss	Votes:2						
62	16	Path: **infrastructure | Watershed management | susceptibility to flooding**			Oregon Coastal Atlas FEMA Q3 flood map (see also Path 6)	Polygon	Colored by "ZONE" in three classes: "A" is red, "ANI" is grey, and "X500" is yellow.	(across all receptors); 1.2 Shore protection and flood control structures	Receptor	**Flood Zone**
63	16	Indicator: Recommend none of the following	Unit:	Votes:3						
64	16	Indicator: watershed flooding	Unit: flood events per year	Votes:2						
65	16	Indicator: floods	Unit: floods per year	Votes:0						
66	16	Indicator: flooding	Unit: Flood damage per year in dollars	Votes:2						
67	17	Path: **Indicator 'weather patterns' | Seasonal rainfall in mm**			Precip Change 2010-2030 from Coastal Impacts Group (see also Paths 5 and 10)	Raster	Greyscale by precipitation change in mm	Climate D Precipitation	Climate	**Precip Change 2010 to 2030**
68	17	Indicator: Recommend none of the following	Unit:	Votes:3						
69	17	Indicator: rain	Unit: Total seasonal rainfall in cm	Votes:3						
70	18	Path: **Changes in environmental chemistry | Ocean pH level**			(Not considered at this time because offshore and out of range of Coos Bay watershed.)	N/A	N/A	2.3.5 Ocean acidification	Receptor	N/A
71	18	Indicator: Recommend none of the following	Unit:	Votes:3						
72	18	Indicator: ocean pH	Unit: pH	Votes:2						
73	18	Indicator: acidification	Unit: pH per year	Votes:0						
74	18	Indicator: acidity	Unit: pH level	Votes:0						
75	18	Indicator: PH	Unit: N/A	Votes:0						
76	19	Path: **Changes in fauna | Biological productivity of estuary**			NOAA shellfish zones	Polygon	Red and green by "SHELLCLASS" as to whether shell fishing is approved or prohibited based on point and non-point source pollution.	2.2 Estuaries	Receptor	**Shellfish**
77	19	Indicator: Recommend none of the following	Unit:	Votes:1						
78	19	Indicator: Biological productivity	Unit: kcal/ squared meters/ year	Votes:4						
79	20	Path: **Changes in the overall economy | change in agricultural production**			OR 2006 Land use/land cover	Raster	Colored by land use/cover class "Class_Name"	Receptor 3.2 Agriculture	Receptor	**Land Use/Cover 2006**
80	20	Indicator: Recommend none of the following	Unit:	Votes:3						
81	20	Indicator: agricultural production per acre, 2010 dollars	Unit: $	Votes:1						
82	21	Path: **Changes in the overall economy | change in fishing revenue**			Statistical table "56_Monthly_value_Charleston.pdf" on fishing revenue by species for Port of Charleston (Coos Bay)	Table	http://www.dfw.state.or.us/fish/commercial/landing_stats/2009AnnRep/56_Monthly_value_Charleston.pdf	3.1 Ocean fisheries	Receptor	N/A
83	21	Indicator: Recommend none of the following	Unit:	Votes:3						
84	21	Indicator: Change in Fishing Revenue	Unit: dollars per year	Votes:2						
85	21	Indicator: business	Unit: Fisheries revenue in dollars	Votes:0						
86	21	Indicator: fishing	Unit: $ per year	Votes:0						
87	21	Indicator: local fishing revenue, 2010 dollars	Unit: $	Votes:1						
88	22	Path: **Changes in environmental chemistry | dissolved oxygen levels**			OR streams water quality	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including	2.1 Rivers and streams; 2.2 Estuaries	Receptor	**River Water Quality**
89	22	Indicator: Recommend none of the following	Unit:	Votes:2						
90	22	Indicator: Change in Dissolved Oxygen	Unit: grams per liter	Votes:0						

91	22	Indicator: dissolved oxygen	Unit: milligram per liter	Votes:4			dissolved oxygen, pH, fecal coliform, etc.	2.2 Estuaries		
92	22	Indicator: decreased dissolved oxygen	Unit: percentage	Votes:0						
93	23	Path: **change in average temperature | Storm strength and frequency**								
94	23	Indicator: Recommend none of the following	Unit:	Votes:6	Tsunami inundation zone line	Line	Red	B Storms	Climate	**Tsunami Inundation**
95	23	Indicator: storm	Unit: Wind speed in miles	Votes:0						
96	24	Path: **Changes in environmental chemistry | Deforestation Rates**								
97	24	Indicator: deforestation	Unit: hectares per year	Votes:2						
98	24	Indicator: Recommend none of the following	Unit:	Votes:2						
99	24	Indicator: Deforestation	Unit: meters squared per year	Votes:0	OR 2006 Land use/land cover	Raster	Colored by land use/cover class "Class_Name"	3.3 Forestry	Receptor	**Land Use/Cover 2006**
100	24	Indicator: timber	Unit: trees felled per acre	Votes:1						
101	24	Indicator: degradation	Unit: acre per year	Votes:1						
102	24	Indicator: forest	Unit: forest density (% of area coverage)	Votes:0						
103	25	Path: **coastal and estuary damage | wave height**								
104	25	Indicator: Recommend none of the following	Unit:	Votes:2	USGS Coastal Vulnerability Index for shoreline (see also others)	Line	Green to red scale from "Low" to "Very High" wave heights in "WAVES"	2.4 Coastal Shorelands	Receptor	**Shoreline_MeanWaveHeight_m**
105	25	Indicator: wave height	Unit: average meters	Votes:2						
106	26	Path: **Effects on infrastructure | Damage to coastal barriers**								
107	26	Indicator: Recommend none of the following	Unit:	Votes:3	USGS Coastal Vulnerability Index for shoreline (see also Path 1)	Line	Green to red scale from "Low" to "Very High" composite vulnerability in "CVI"	1.2 Shore Protection and Flood Control Structures	Receptor	**Shoreline_CoastalVulnerabilityIndex**
108	26	Indicator: replacement costs-damage to coastal barriers	Unit: $	Votes:4						
109	26	Indicator: damage	Unit: dollars per year	Votes:0						
110	26	Indicator: Loss Due to Damage to Coastal Barriers	Unit: dollars per year	Votes:1						
111	27	Path: **Capacity of wastewater system | change in pollution from sewer overflows**								
112	27	Indicator: Recommend none of the following	Unit:	Votes:3	OR streams water quality	Line	No stream segments in Coos Bay watershed are in Category 1 for all parameters, including dissolved oxygen, pH, fecal	1.3 Municipal services	Receptor	**River Water Quality**
113	27	Indicator: sewer overflows	Unit: ppm	Votes:6						
114	28	Path: **Indicator 'weather patterns' | Storm strength and frequency**								
115	28	Indicator: Recommend none of the following	Unit:	Votes:3	Tsunami inundation zone line (see also Paths 23 and 25)	Line	Red	B Storms	Climate	**Tsunami Inundation**
116	28	Indicator: storm	Unit: counts per year	Votes:2						
117	29	Path: **Indicator 'weather patterns' | peak rainfall**								
118	29	Indicator: Recommend none of the following	Unit:	Votes:2	Precip Change 2010-2030 from Climate Impacts Group (see also Paths 5, 10 and 17)	Raster	Greyscale by precipitation change in mm	D Precipitation	Climate	**Precip Change 2010 to 2030**
119	29	Indicator: rain	Unit: Highest recorded rainfall per year in cm	Votes:4						
120	30	Path: **Effects on infrastructure | wastewater facilities | Capacity of wastewater system**								
121	30	Indicator: Recommend none of the following	Unit:	Votes:3	(Location and capacity of Coos Bay wastewater treatment plants as point file not currently available)	N/A	N/A	1.2.3 Water supply and wastewater treatment	Receptor	N/A
122	30	Indicator: Capacity of wastewater system index	Unit: % of demand	Votes:1						
123	30	Indicator: Capacity of Wastewater System	Unit: gallons per day	Votes:3						
124	30	Indicator: wastewater	Unit: gallons per year	Votes:0						
125	31	Path: **Effects on infrastructure | Structural integrity**			USGS Coastal Vulnerability Index for shoreline (see also Paths 1 and 26)	Line	Green to red scale from "Low" to "Very High" composite vulnerability in "CVI"	1.2 Shore Protection and Flood Control Structures	Receptor	**Shoreline_CoastalVulnerabilityIndex**
126	31	Indicator: Recommend none of the following	Unit:	Votes:5						
127	31	Indicator: total infrastructure damages	Unit: $	Votes:1						
128		Reference Layer			Coos Bay Watershed	Polygon	Grey or black		Receptor	**CoosBayWatershed**
129		Reference Layer			Coos County	Polygon	Grey or black		Receptor	**CoosCounty**

See This Link for More Information

http://www.ecy.wa.gov/programs/wq/303d/WQAssessmentCats.html

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http://www.dfw.state.or.us/fish/commercial/landing_stats/2009AnnRep/56_Monthly_value_Charleston.pdf

http://www.ecy.wa.gov/programs/wq/303d/WQAssessmentCats.html

http://www.dfw.state.or.us/fish/commercial/landing_stats/2009AnnRep/56_Monthly_value_Charleston.pdf

http://www.ecy.wa.gov/programs/wq/303d/WQAssessmentCats.html

q/303d/WQAssessmentCats.html

http://www.ecy.wa.gov/programs/wq/303d/WQAssessmentCats.html

Appendix B

List of receptors

Folder within Sub-Folder	Description (feature and extent)	File Name	Data Type	Name or Agency Source	URL (web address if available)
1.1.1 Coastal roads, highways, and rail lines	roads in Coos County, OR	tgr41011lkA.shp	vector line shapefile	Census TIGER	ESRI Census data http://arcdata.esri.com/data/tiger200
1.1.1 Coastal roads, highways, and rail lines	highways in State of Oregon	highways.shp	vector line shapefile	State of Oregon	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
1.1.1 Coastal roads, highways, and rail lines					
1.1.2 Airport runways					
1.1.3 Port facilities, jetties, and groins					
1.2.1 Dikes and levees					
1.2.2 Shore protection improvements	shoreline of the Pacific Coast (including 'vulnerability' rank)	pacific	vector line coverage	U.S. Geological Survey	http://pubs.usgs.gov/dds/dds68/htmldocs/data.htm
1.2.2 Shore protection improvements					
1.3.1 Stormwater systems					
1.3.2 Water supply and wastewater treatment					
1.3.3 Recreational facilities					
2.1.1 Coastal rivers					
2.1.2 Inland rivers	rivers and streams	rivers.shp	vector line shapefile	WDFW, IDFG, and ODFW, 1:100,000.	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
2.2.1 Estuarine wetlands	wetlands for State of Oregon	CONUS_wet_poly.shp	vector polygon shapefile	U.S. Fish and Wildlife Service National Wetlands Inventory	http://www.fws.gov/wetlands/Data/DataDownload.htm
2.2.1 Estuarine wetlands					
2.2.2 Estuarine benthic ecosystems					
2.2.3 Ocean spits					
2.2.3 Ocean spits					
2.2.4 Invasive species					
2.2.5 Acidification					
2.3.1 Ecosystem shifts					
2.3.2 Distribution of species					
2.3.3 Changes in upwelling					
2.3.4 Hypoxia					
2.3.5 Ocean acidification					
2.4.1 Ocean shore	beaches along the State of Oregon coast (location and other attributes)	beach.shp	vector point shapefile	State of Oregon	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
2.4.1 Ocean shore	shoreline of the Pacific Coast (including 'vulnerability' rank)	pacific	vector line coverage	U.S. Geological Survey	http://pubs.usgs.gov/dds/dds68/htmldocs/data.htm
2.4.2 Estuarine shores					
2.5.1 Habitat distribution and composition					
2.5.2 Non-native species					
3.1.1 Salmonids					
3.1.2 Harvest effects					
3.1.3 Ocean acidification					
3.2.1 Water supplies	Drinking Water, Surface Water Source Areas (2005)	sw_dwsa.shp	vector polygon shapefile	Oregon DEQ, 1:24,000.	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
3.2.2 Dikes, levees, and tidegates					
3.3.1 Forest mix					
3.3.2 Forest growth					
3.3.3 Forest resilience					
3.3.4 Fires	Wildfires; Communities at Risk data	populated_jurisdiction.shp	vector polygon shapefile	Oregon Department of Forestry	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm

3.4.1 Recreation	beaches along the State of Oregon coast (location and other attributes)	beach.shp	vector point shapefile	State of Oregon	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
3.4.1 Recreation	State parks in Oregon	OregonStateParks.shp	vector polygon shapefile	State of Oregon	http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtm
3.4.1 Recreation					
3.4.2 Tourism					
3.5.1 Growth and Development	Urban Growth Boundries	UGB_2009.shp	vector polygon shapefile	Dept. of Land Conservation and Development, 1:24,000 (2009).	Dept. of Land Conservation and Development, 1:24,000