EFFECTS OF OYSTER CULTURE ON NATIVE EELGRASS AND RELATED NATURAL RESOURCES IN THE PUGET SOUND

A Geographic Information System Based Model

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Geography 562 GIS Coastal Resources - Final Project: Fall 2017

University of Washington

PUGET SOUND AREA OF INTEREST

PROBLEM STATEMENT AND RESEARCH QUESTION

- Research Problem:

  Significant portions of intertidal habitat in the Puget Sound are dedicated to oyster aquaculture operations under the premise that they are inherently biologically and ecologically compatible with undisturbed estuarine and marine structure and function. However, history informs us that aquaculture is a type of agriculture that can have serious direct and indirect adverse impacts on native species and the natural habitats they depend on.

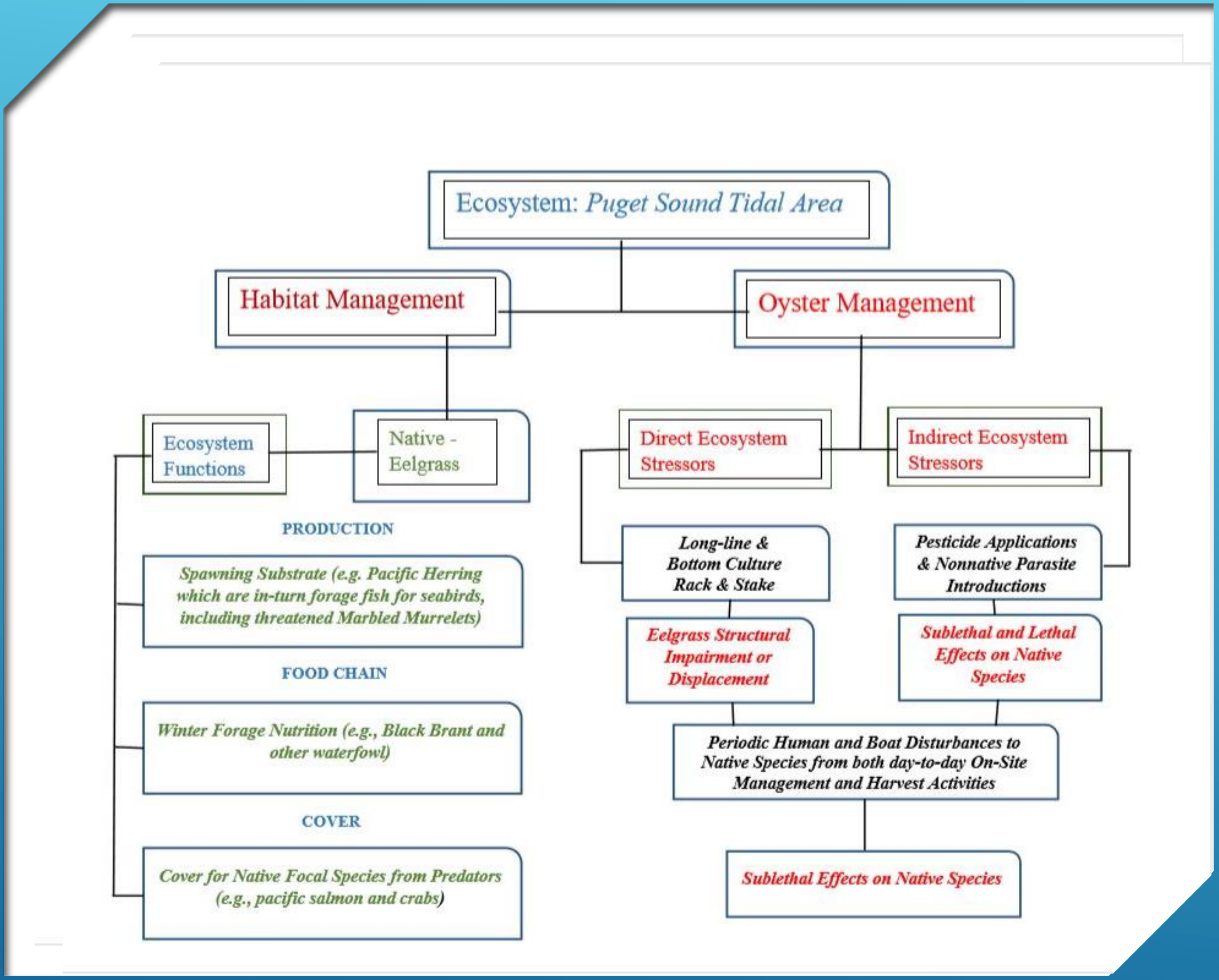
- Research Question:

  What are the focal stressors on native eelgrass (*Zostera marina*) and associated native eelgrass dependent species that stem from oyster aquaculture operations in the Puget Sound and what is the ordinal magnitude and geographic distribution of these stressors?

- Research Task:

  This project attempts to isolates one key habitat type, native eelgrass, itemize focal stressors, and use a Geographic Information System (GIS) based model to spatially evaluate the geographic distribution and relative magnitude of these stressors in the Puget Sound area of Washington State.

MODEL OVERVIEW



MODEL OYSTER PLAT RECORD CREDIT / DEBIT METHODS AND CLASSES

CREDITS		DEBITS	
Production:	0 to 500	Structural Displacement:	0 to -300
+		Structural Impairment:	0 to -300
Food Chain:	0 to 500	Lethal Direct:	0 to -250
+		Lethal Indirect	0 to -250
		Sublethal Direct:	0 to -200
Cover:	0 to 500	Sublethal Indirect:	0 to -200

= Total Potential Credit (1500) x Acres | = Total Potential Debit (0 to -1500) x Acres
= Total Potential Credit Value | = Total Potential Debit Value

NET CREDIT: Total Potential Credit Value + Total Potential Debit Value

Pre-Record Net Credit Classification Table

Range	Value
<=500	Low
> 500 and <=750	Moderate Low
> 750 and <=1000	Moderate
>1000 and <=1275	Moderate High
>1275	High

Credits

Production	Native eelgrass provides spawning substrate for Pacific Herring.	
Food Chain	Pacific Herring are forage fish for sea birds and marine mammals. Wintering Black Brant feed almost exclusively on eelgrass	**Diatoms**, bacteria, and detritus gathers **on eelgrass** leaves providing **food** for many invertebrates; including some clams.
Cover	Juvenile salmon use eelgrass to avoid predators.	Native crabs use eelgrass to avoid predators.

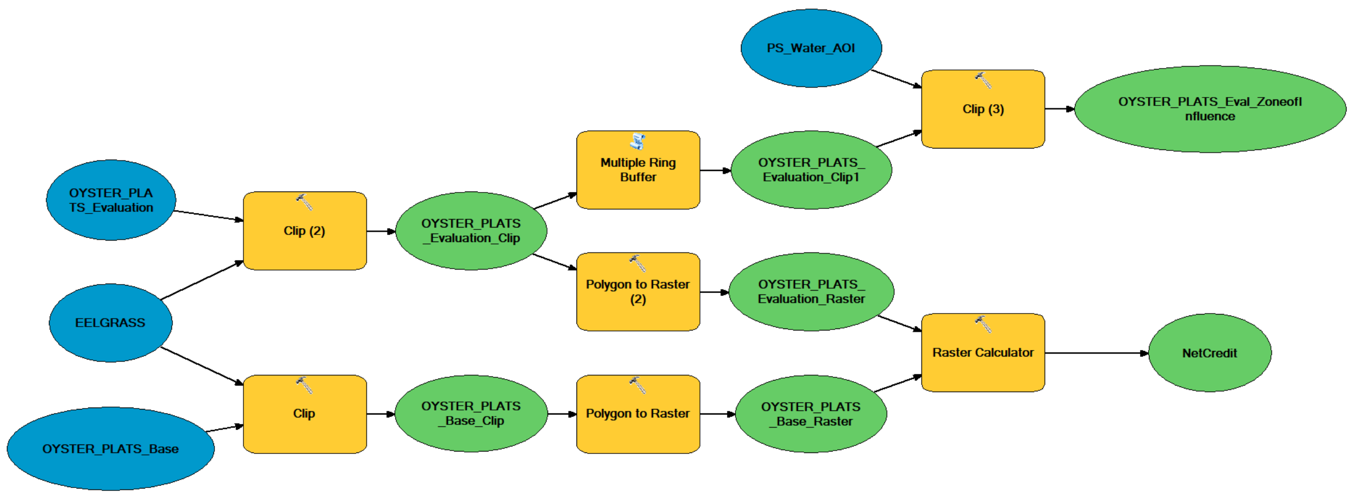
Debits

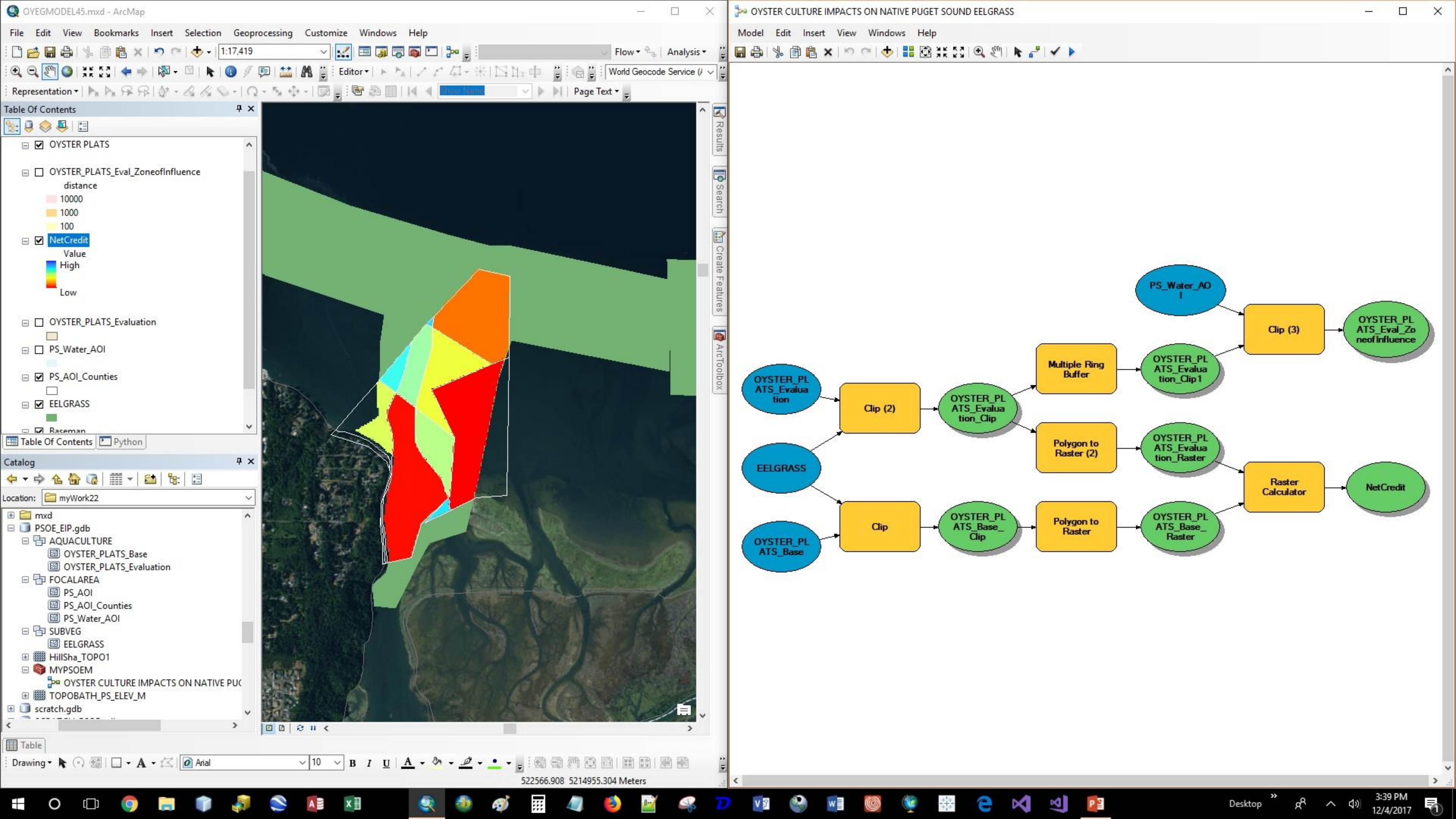
Structural Displacement	Oyster bottom culture, longline, and rack and stake can result in mechanical tearing of fragile eelgrass blades eliminating them from an entire plat. The reduction in light from shellfish bed structures can be associated with reduced eelgrass presence.	Oyster bottom culture, longline, and rack and stake can result in prevention of new eelgrass growth over an entire plat. High-density structures may increase sediment deposition, reducing eelgrass growth. Digging and dredging activities immediately reduce eelgrass presence.
Structural Impairment	Oyster bottom culture, longline, and rack and stake can result in mechanical tearing of fragile eelgrass blades decreasing blade density or eliminating it from entire sections of a plat.	Oyster bottom culture, longline, and rack and stake can result in prevention of new eelgrass growth over significant sections of a plat.
Lethal Direct	Pesticides used to control native burrowing shrimp kill these important estuarine species utilizing areas inside oyster plats.	Pesticides used to control burrowing shrimp likely expose and kill other 'non-target' native species (e.g., juvenile salmon and crabs) when they use eelgrass in oyster plats.
Lethal Indirect	Pesticides can persist and drift from the application areas into other estuarine areas indiscriminately killing many organisms in its path.	Nonnative parasites on native burrowing shrimp hosts may be decimating their hosts over large areas in Pacific Northwest estuaries.[i]
Sublethal Direct	Oyster boats transporting growers and growers walking in their plats tending and / or harvesting oysters disturb black brant off their feeding areas diminishing their winter reserves for the spring migration.	Pesticides used to control native burrowing shrimp may impair these important estuarine species utilizing areas inside oyster plats and make them more susceptible to disease and predation.
Sublethal Indirect	Oyster boats and growers travelling to their plats and walking on their plats disturb nearby black brant off their feeding areas diminishing their winter reserves for the spring migration.	Pesticides can persist and drift from the application areas into other estuarine areas indiscriminately impairing numerous organisms in its path, making them more susceptible to other perturbations.

[i] This is highly speculative consequence of oyster culture.

ASSUMPTIONS SUPPORTING CREDITS AND DEBITS

MODEL APPLICATION DIAGRAM

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File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
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PS_AOI_Counties
EELGRASS
Basemap
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Location: myWork22
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PSOE_EIP.gdb
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OYSTER_PLATS_Evaluation
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PS_AOI_Counties
PS_Water_AOI
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EELGRASS
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Clip
OYSTER_PLATS_Evaluation_Clip
OYSTER_PLATS_Base_Clip
Multiple Ring Buffer
Polygon to Raster (2)
Polygon to Raster
OYSTER_PLATS_Evaluation_Clip1
OYSTER_PLATS_Evaluation_Raster
OYSTER_PLATS_Base_Raster
Clip (3)
Raster Calculator
OYSTER_PLATS_Eval_ZoneofInfluence
NetCredit
Desktop
3:39 PM
12/4/2017

SAMPLE MODEL RUN DOCUMENTATION

Name	Direction	Type	Data Type	Value
Input Features	Input	Required	Feature Layer	C:\University of Washington GIS\UOWFall2017\InVest\RESEARCH\myWork22 \SCRATCH_PSOE.gdb\OYSTER_PLATS_Evaluation_Clip
Value field	Input	Required	Field	TDValue
Output Raster Dataset	Output	Required	Raster Dataset or Raster Catalog	C:\University of Washington GIS\UOWFall2017\InVest\RESEARCH\myWork22 \SCRATCH_PSOE.gdb\OYSTER_PLATS_Evaluation_Clip3
Cell assignment type	Input	Optional	String	CELL_CENTER
Priority field	Input	Optional	Field	TDValue
Cellsize	Input	Optional	Analysis Cell Size	10

Messages:

WARNING 000258: Output C:\University of Washington GIS\UOWFall2017\InVest\RESEARCH\myWork22 \SCRATCH_PSOE.gdb\OYSTER_PLATS_Evaluation_Clip3 already exists (258)

Raster Calculator

Tool Name: Raster Calculator
Tool Source: c:\program files (x86)\arcgis\desktop10.4\ArcToolbox\Toolboxes\Spatial Analyst Tools.tbx\Map Algebra\RasterCalculator

Parameters:

Name	Direction	Type	Data Type	Value
Map Algebra expression	Input	Required	Raster Calculator Expression	"%OYSTER_PLATS_Base_Raster%" + "%OYSTER_PLATS_Evaluation_Raster%"
Output raster	Output	Required	Raster Dataset	C:\University of Washington GIS\UOWFall2017\InVest\RESEARCH\myWork22 \SCRATCH_PSOE.gdb\NetCredit

Messages:

MODEL SAMPLE PYTHON SCRIPT

```
ASS = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\PSOE_EIP.gdb\\SUBVEG\\EELGRASS"
STER_PLATS_Evaluation_Clip = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\SCRATCH_PSOE.gdb\\OYSTER_PLATS_Eva
OYSTER_PLATS_Evaluation_Clip1 = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\SCRATCH_PSOE.gdb\\OYSTER_PLATS_Ev
PS_Water_AOI = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\PSOE_EIP.gdb\\FOCALAREA\\PS_Water_AOI"
OYSTER_PLATS_Eval_ZoneofInfluence = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\SCRATCH_PSOE.gdb\\OYSTER_PLAT
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NetCredit = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\SCRATCH_PSOE.gdb\\NetCredit"

# Set Geoprocessing environments
arcpy.env.scratchWorkspace = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\SCRATCH_PSOE.gdb"
arcpy.env.workspace = "C:\\University of Washington GIS\\UOWFall2017\\InVest\\RESEARCH\\myWork22\\PSOE_EIP.gdb"

# Process: Clip (2)
arcpy.Clip_analysis(OYSTER_PLATS_Evaluation, EELGRASS, OYSTER_PLATS_Evaluation_Clip, "")

# Process: Multiple Ring Buffer
arcpy.MultipleRingBuffer_analysis(OYSTER_PLATS_Evaluation_Clip, OYSTER_PLATS_Evaluation_Clip1, "100;1000;10000", "Feet", "distance", "ALL", '

# Process: Clip (3)
arcpy.Clip_analysis(OYSTER_PLATS_Evaluation_Clip1, PS_Water_AOI, OYSTER_PLATS_Eval_ZoneofInfluence, "")

# Process: Clip
arcpy.Clip_analysis(OYSTER_PLATS_Base, EELGRASS, OYSTER_PLATS_Base_Clip, "")

# Process: Polygon to Raster
arcpy.PolygonToRaster_conversion(OYSTER_PLATS_Base_Clip, "TCVAL", OYSTER_PLATS_Base_Raster, "CELL_CENTER", "TCVAL", "10")

# Process: Polygon to Raster (2)
arcpy.PolygonToRaster_conversion(OYSTER_PLATS_Evaluation_Clip, "TDValue", OYSTER_PLATS_Evaluation_Raster, "CELL_CENTER", "TDValue", "10")

# Process: Raster Calculator
arcpy.gp.RasterCalculator_sa("\"%OYSTER_PLATS_Base_Raster%\" + \"%OYSTER_PLATS_Evaluation_Raster%\"", NetCredit)
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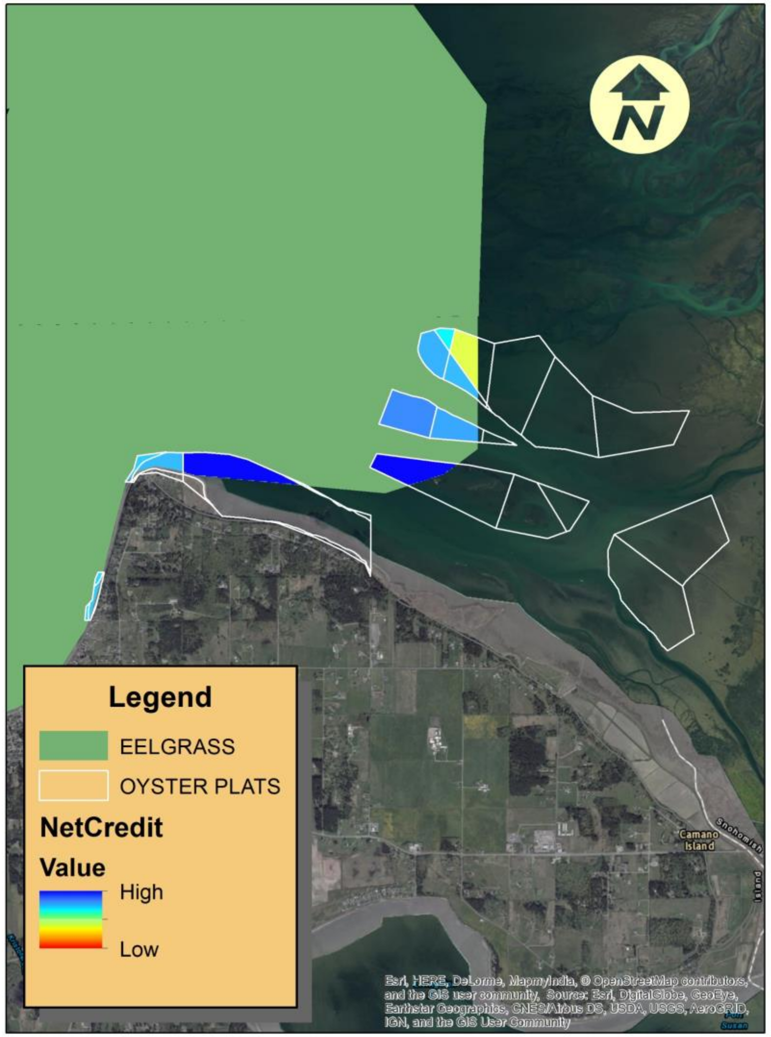
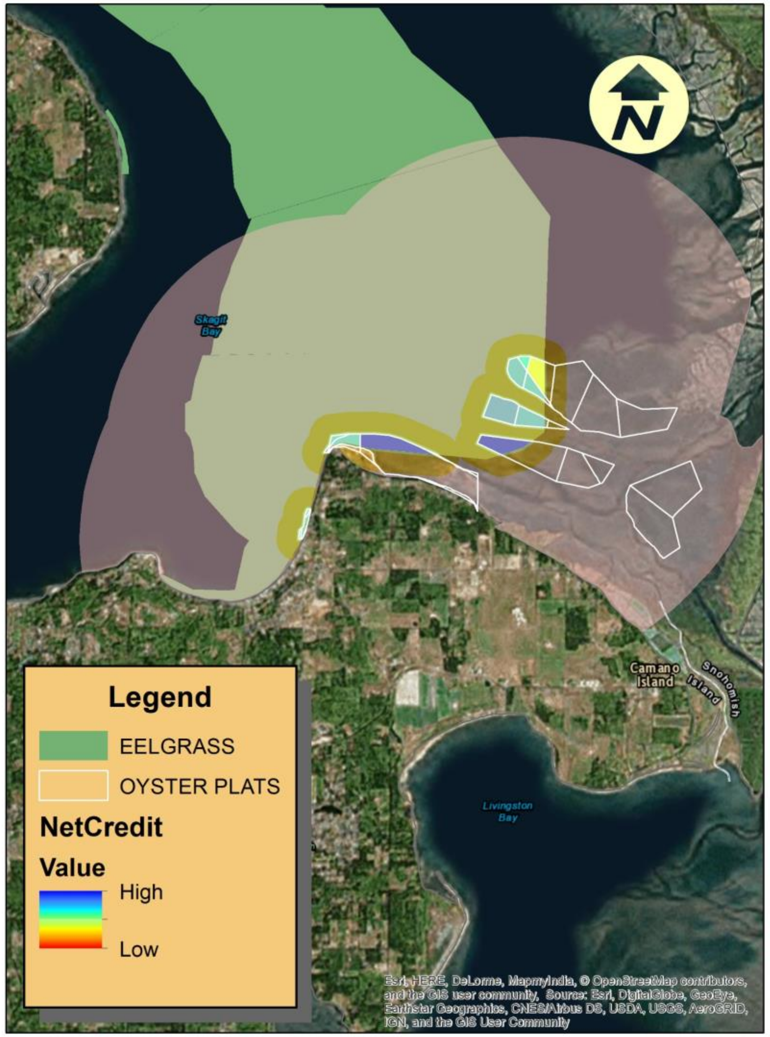
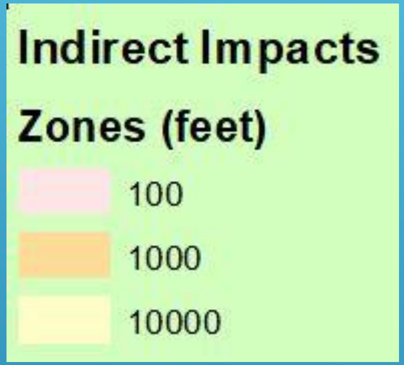
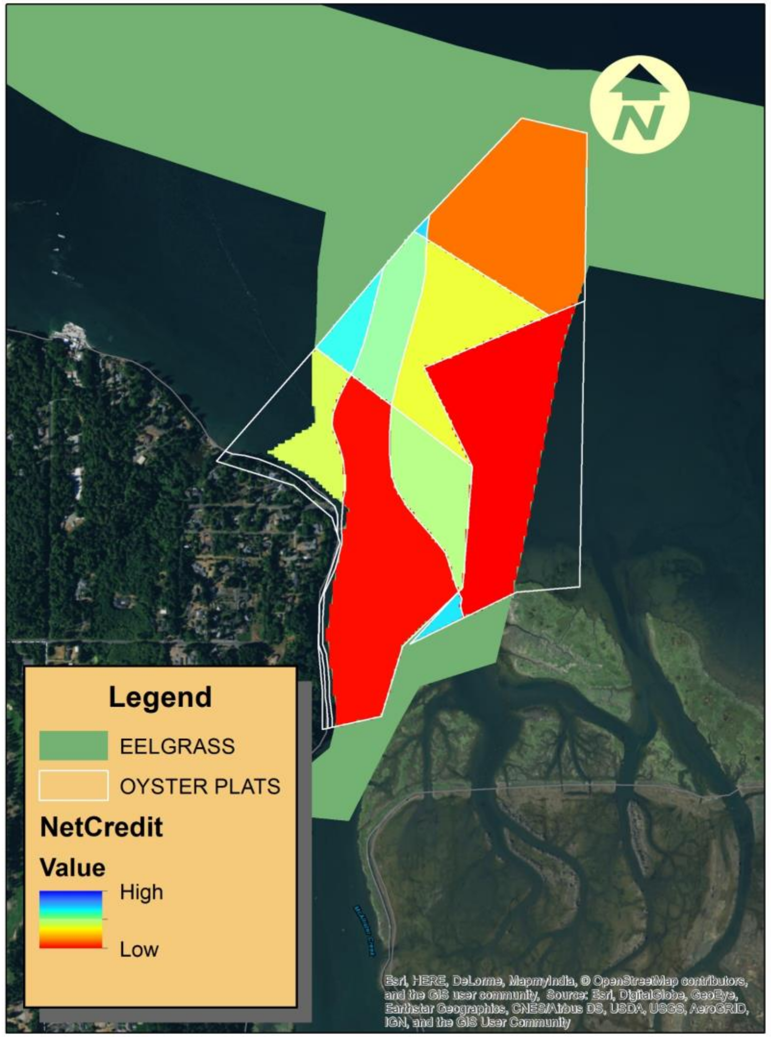


PRELIMINARY TRIAL CLASSIFICATION TEST SITE A

PRELIMINARY TRIAL CLASSIFICATION TEST SITE A2 (ZONE OF INFLUENCE)

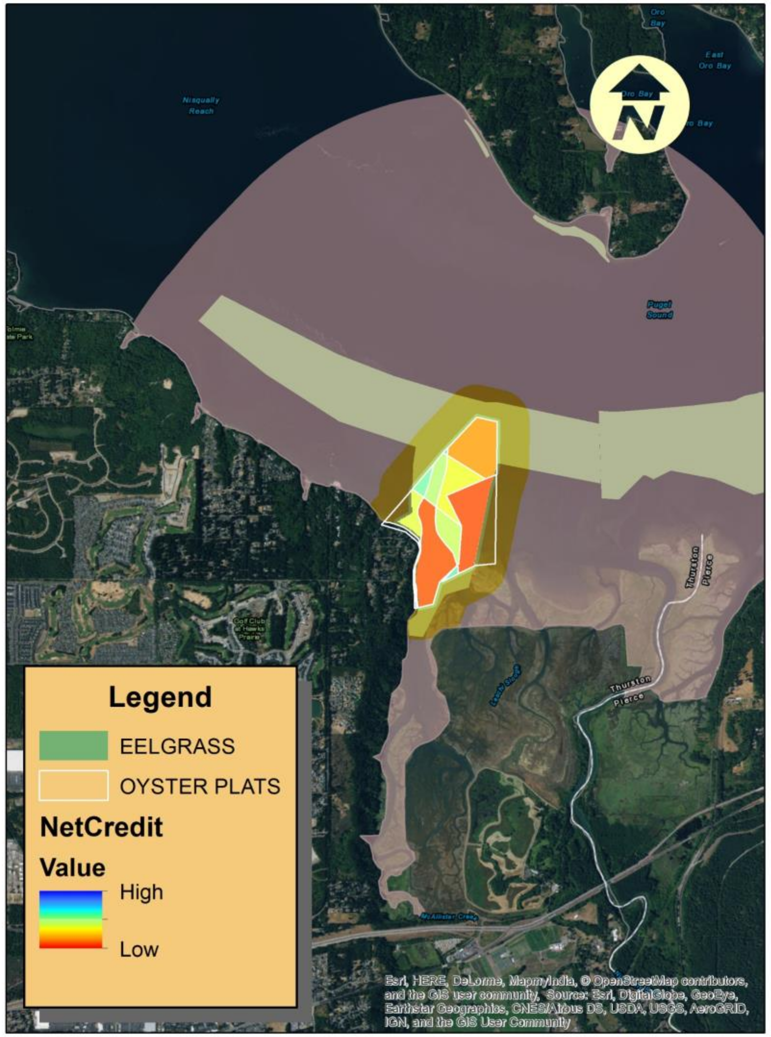


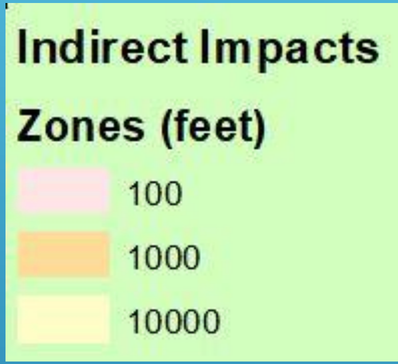




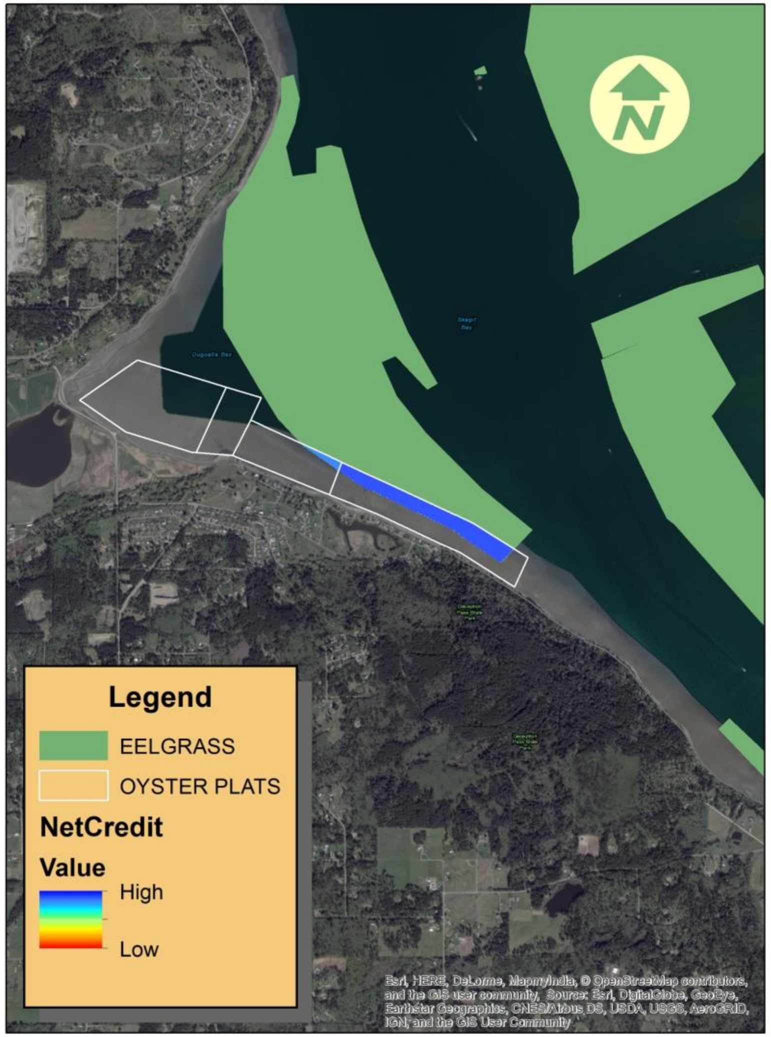
PRELIMINARY TRIAL CLASSIFICATION TEST SITE B1

PRELIMINARY TRIAL CLASSIFICATION TEST SITE B2 (ZONE OF INFLUENCE)

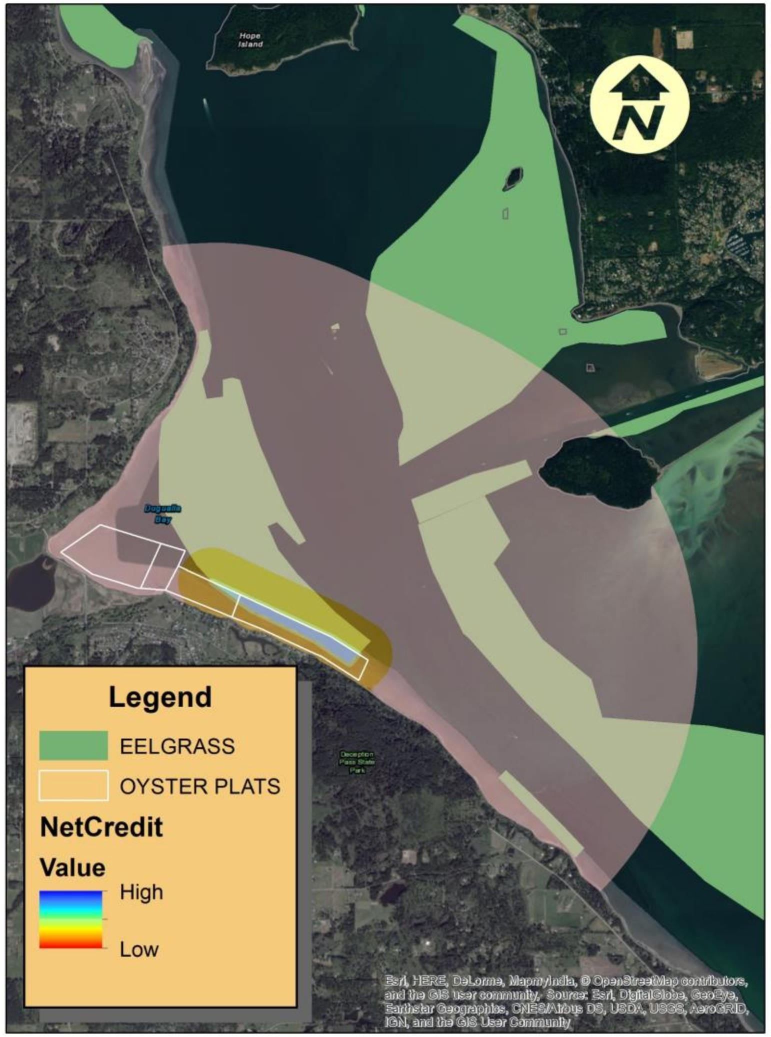


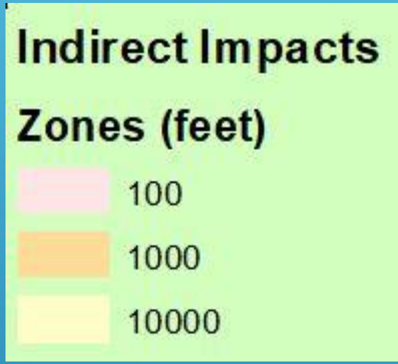


PRELIMINARY TRIAL CLASSIFICATION TEST SITE C1



PRELIMINARY TRIAL CLASSIFICATION TEST SITE C2 (ZONE OF INFLUENCE)





MODEL WEAKNESSES

Model Weaknesses

1. The model base assumptions are coarse and nonspecific about the management practices contributing to perturbation (debit) ranges as well as the ecological foundation for the process and function (credit) ranges.

2. No attempt was made to research specific management plans by oyster plat and individual oyster plat credit and debit values were selected arbitrarily for model test runs.

3. The model does not provide a graphical user interface (GUI) for users to input new data into the model as it becomes available.

4. Model net credit values only addresses areas where native eelgrass and oyster plats overlap.

5. The algorithm used to evaluate the carrying capacity (credit) and oyster plat related perturbations (debit) to subsequently derive the remaining carrying capacity (net credit) is highly simplistic and likely unrepresentative of actual adverse effects of cited perturbations on a specific area's carrying capacity.

6. The model's evaluation focus on areas of eelgrass overlapped by oyster plats does not account for the overall size of the eelgrass patches or their positions and geometric shapes relative to one another and other natural resources.

7. Zone of influence distances are arbitrary and not based on documentation, nor is there any attempt to assign them a credit or debit value.

PRELIMINARY SOURCE INFORMATION

EELGRASS

- ORIGINATOR: Washington State Department of Ecology
- PUBLICATION DATE: April 2011
- TITLE: Aquatic Unit
- GEOSPATIAL DATA PRESENTATION FORM: vector digital data

PRELIMINARY SOURCE INFORMATION

OYSTER TRACTS AND RESERVES

- Originator: Washington Department of Natural Resources
- PUBLICATION DATE: Unknown
- TITLE: AQUATIC PARCEL
- GEOSPATIAL DATA PRESENTATION FORM: vector digital data

PRELIMINARY SOURCE INFORMATION

GENERALIZED PUGET SOUND EELGRASS POLYGONS

- Originator: Washington Department of Natural Resources, Aquatic Resources Division, Nearshore Habitat Program
- PUBLICATION DATE: October 3, 2017
- TITLE: Submerged Vegetation Monitoring Program 2000-2015 Database
- GEOSPATIAL DATA PRESENTATION FORM: vector digital data

PRELIMINARY SOURCE INFORMATION

PUGET SOUND TOPOGRAPHIC/BATHYMETRIC DEM:

https://topotools.cr.usgs.gov/topobathy_viewer/dwndata.htm

- ORIGINATOR: U.S. GEOLOGICAL SURVEY, NOAA National Ocean Service, Coastal and Marine Geology Program - USGS
- PUBLICATION DATE: July 14, 2005
- TITLE: Puget Sound topographic/bathymetric DEM
- GEOSPATIAL DATA PRESENTATION FORM:

  raster digital data
- Spatial Reference: NAD 1983 Lambert Conformal Conic

  North American Horizontal Datum of 1983

  North American Vertical Datum of 1988