Sustainable Development and Sustainable Management: A Puget Sound Oyster/Eelgrass Case Study

John Marshall

MGIS

Geography 568 - Spring 2018

Sustainable Development/Management

- ‘Sustainable Development’ (SD): the paradox between environmental protection and economic development while insuring adequate resources and quality of life for future generations.

- ‘Sustainable Management’ (SM): the range of human strategies for achieving SD.

Sustainable Development

- Must benefit everyone;
- Must persist into foreseeable future;
- Can occur if:
  - Society redefines it; or
  - Societal behavior is altered to achieve it; or
  - Technology is altered to achieve it; or
  - A combination is used to achieve it; or
  - For many natural resources, a minimum partial recovery is achieved while simultaneously continuing on-going conservation practices.

Problem Statements

- Human constructs of socio-political and economic systems devised over the ages are collectively treated by societies as immutable reality (ontology).

- Consequently societies often knowingly and sometimes unknowingly allow the constructs to control us rather than the other way around.

- This is OK if they are working as intended, but if one or more breaks, we should never feel compelled to allow their failures to harm us.

The First Erroneous Assumption

"Currency used in economic transactions is separate from environmental capital."

SD/SM will not be completely achievable until this assumption is collectively abandoned worldwide. Simply put, currency has no meaning outside the context of the foundational existence of the natural resources it represents.

The Second Erroneous Assumption

"Evolutionary-Darwinism" inherently justifies a paradigm of social-Darwinism."

Is used to justify winners and losers in natural resource allocations and permeates out of our tribal ancestry, which basically facilitates a human condition that is predilected toward each human demographic feeling they are superior to every other human demographic and therefore "*more entitled."* Entitlement seems to be a hard-coded human attribute.

The Third Erroneous Assumption

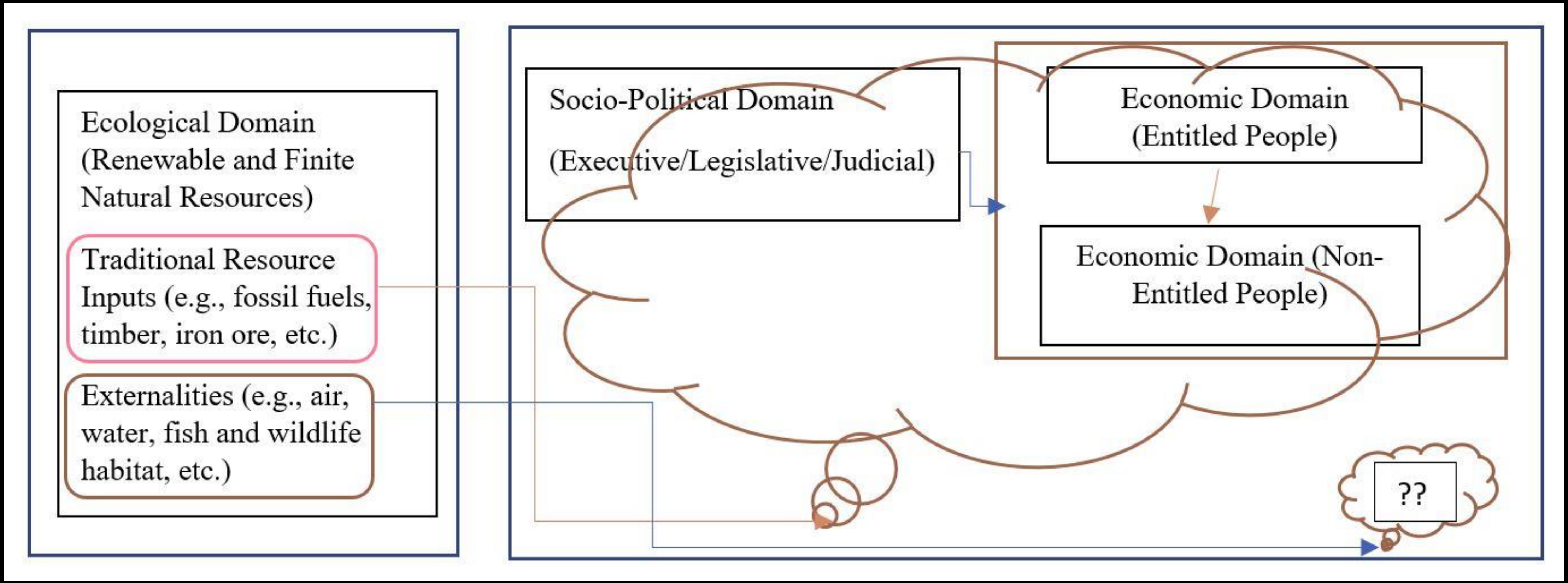
"As our knowledge and technologies improve, our efficiencies and overall abilities to develop more environmentally compatible economies will also improve."

- Legacy interests resist innovation and transition;
- Knowledge and technology are not evenly distributed;
- Environmental concerns are not universally shared;
- Legacy beneficiaries may only transition after decimating the resources they now want others to conserve;
- Expectations of new knowledge and technical innovations may be unrealistic;
- Sustainability thresholds are not universally agreed upon; and
- New technical innovation is often followed by its own unforeseen direct and indirect environmental impacts.

Developing A Conceptual Framework Analysis (CFA) For SD/SM

Traditionally markets treated natural resources as ‘externalities.’

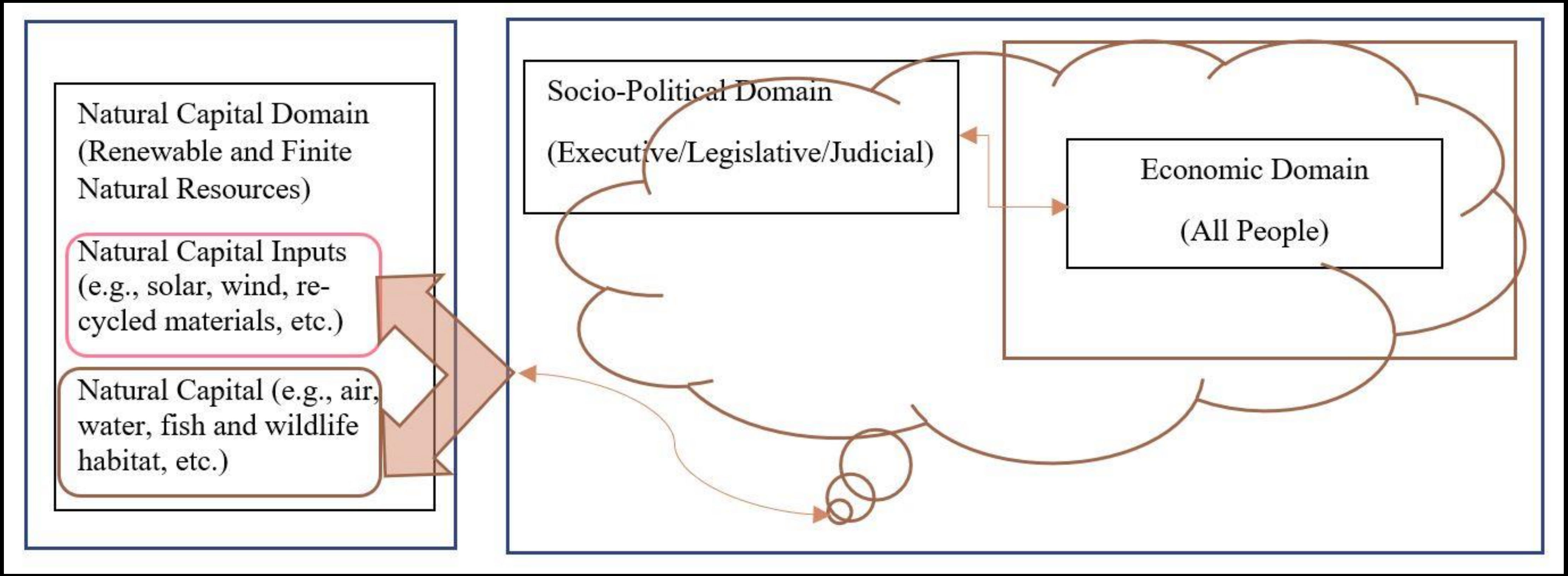
Traditional Paradigm



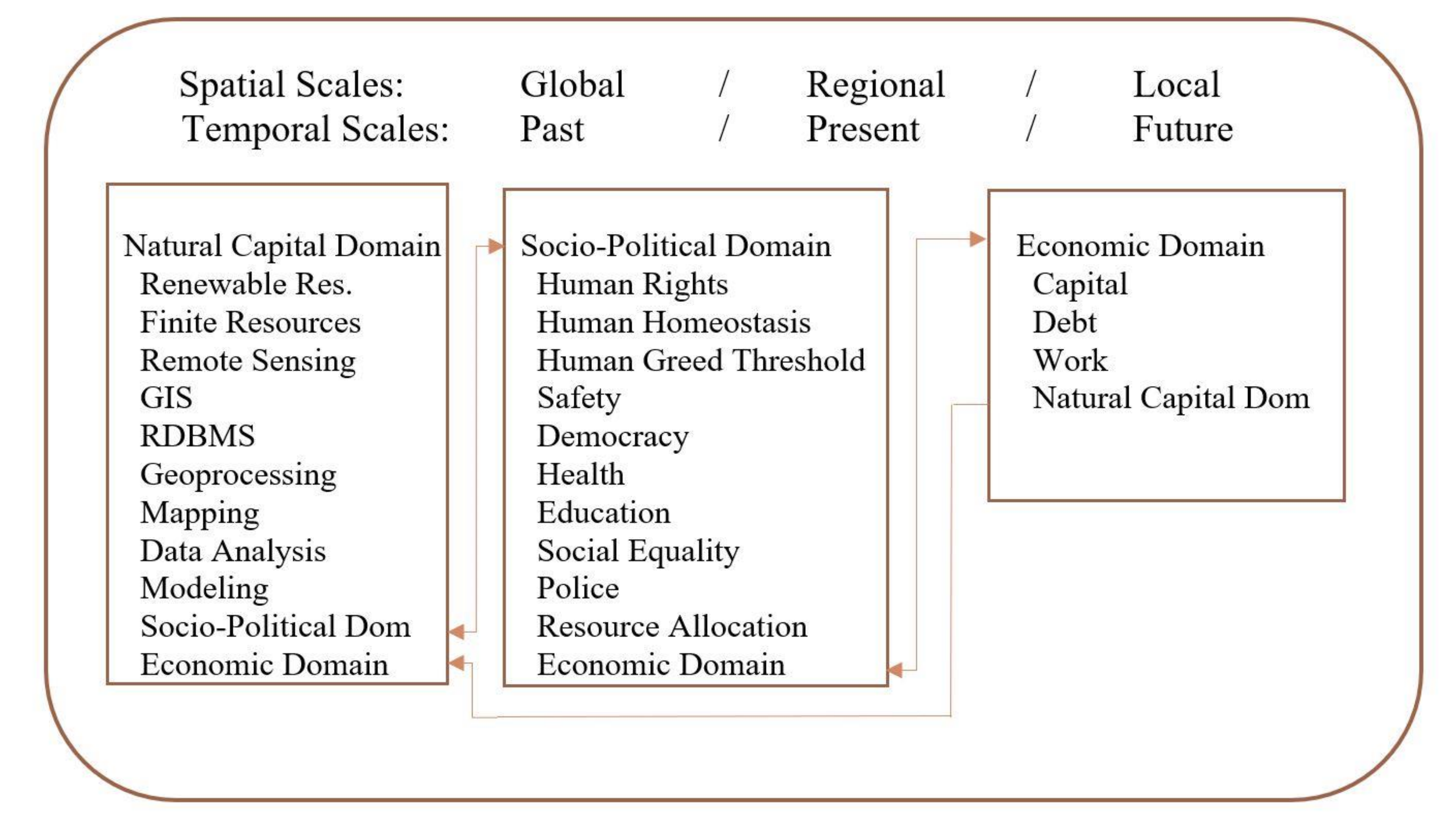
Developing A Conceptual Framework Analysis (CFA) For SD/SM

Reformed markets internalize ‘externaties.’

Reforming View



Macro CFA Entity Framework



Get a Handle on Entitlement

Find ways to democratically reign in the greed factor.

Remind citizens we share a commons of natural capital and that we need to collectively avoid those classic ‘commons’ tragedies inherent in incidents of over exceedance by individuals and/or corporations.

Judge Homeostasis Relative To Human Needs While Protecting The Environment

- Do you have food and freshwater?
- Do you have adequate shelter?
- Do you have adequate healthcare?
- Do you have access to an education?
- Do you have a job or advocation?
- Are you safe and free from discrimination or harassment of any kind?

Judge Homeostasis Relative To Human Needs While Protecting The Environment

- Do you feel free to practice and express your non-violent religious and / or social beliefs without fear of discrimination or reprisal?
- Do you have adequate clothing to meet your personal and professional needs?
- Do you have access to adequate transportation to get you to the places where you need to be in a reasonable amount of time?
- Are you able to manage your debt and still have enough financial resources remaining to meet your basic needs?

Judge Homeostasis Relative To Human Needs While Protecting The Environment

- Do you have family and/or community support?
- Do you feel your natural resources are being properly managed and protected?
- Has the best available science been used to establish sustainable development benchmarks in your local area and surrounding region?
- Has the best available science been used to monitor and ensure these benchmarks are being met?
- Are your basic freedoms (freedom of speech, freedom of religion, etc.) intact?
- Do you have access to a political process that allows your concerns, views, and ideas to be heard and given a fair chance for enactment?

Macro-Micro Linkage to Case-Study SD / SM

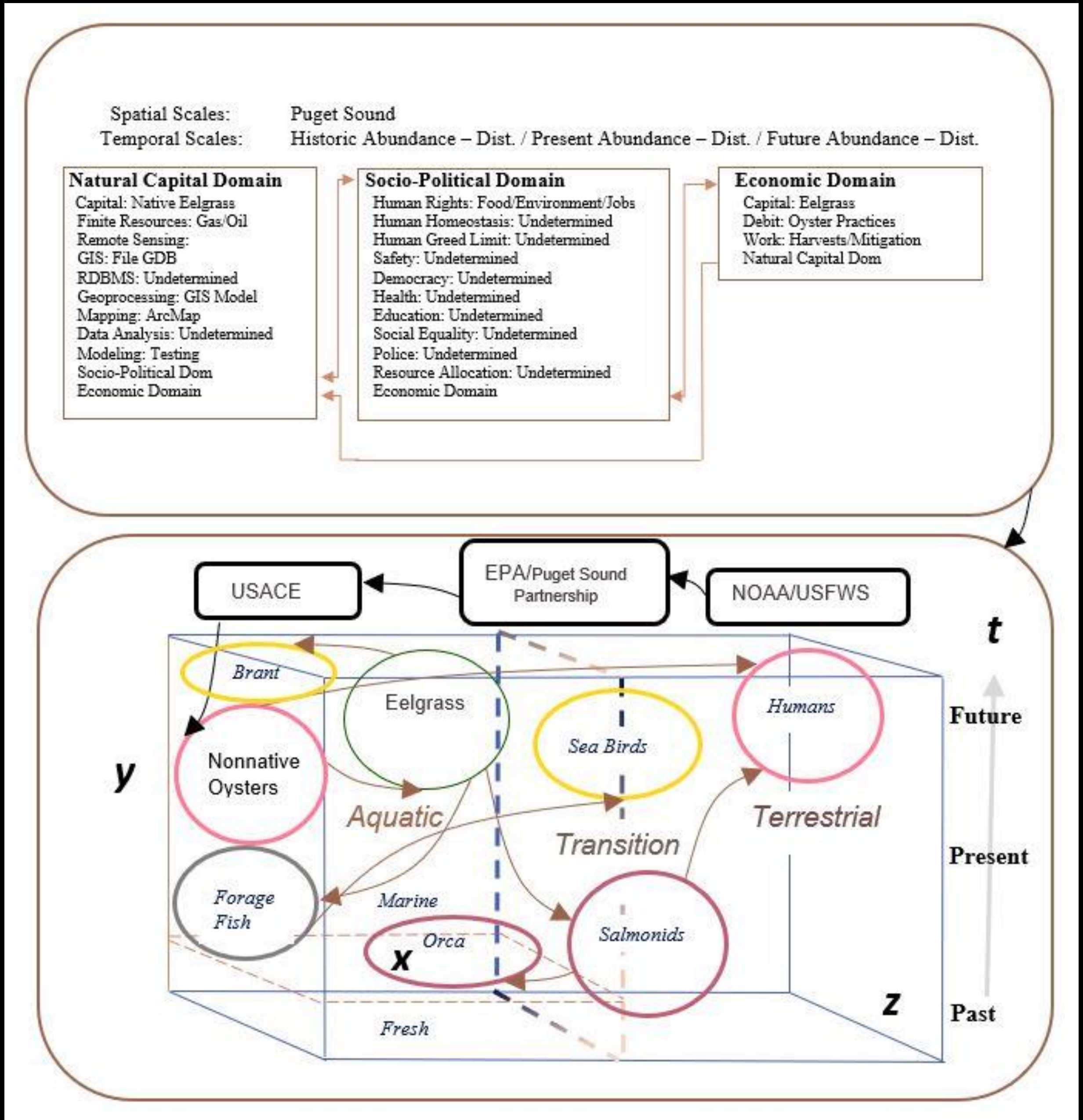
Micro (Case-study) CFA inherits the entities, relationships, and methods of the Macro (Umbrella) SD / SM CFA and in a sense can be considered an instantiation of the larger CFA. In this stage of the case-study characterization, the CFA might be best considered an ecological socio-political aspect and an intermediate phase of a more optimistic view of the ‘micro-macro’ linkage problem as compared to Coulter 2001.

Case-Study Problem Ontology/ GIS-Ontology

Significant portions of intertidal habitat in the Puget Sound are dedicated to oyster aquaculture operations under the premise that they are 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.


gettyimages
Rodger Jackman

Case Study CFA



Natural Capital (Native Eelgrass)

Currency: Credits / Debits

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.

Natural Capital (Native Eelgrass)

Currency: Credits / Debits

CREDITS

Production: 0 to 500
+
Food Chain: 0 to 500
+
Cover: 0 to 500

DEBITS

Structural Displacement: 0 to -300
Structural Impairment: 0 to -300
Lethal Direct: 0 to -250
Lethal Indirect 0 to -250
Sublethal Direct: 0 to -200
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

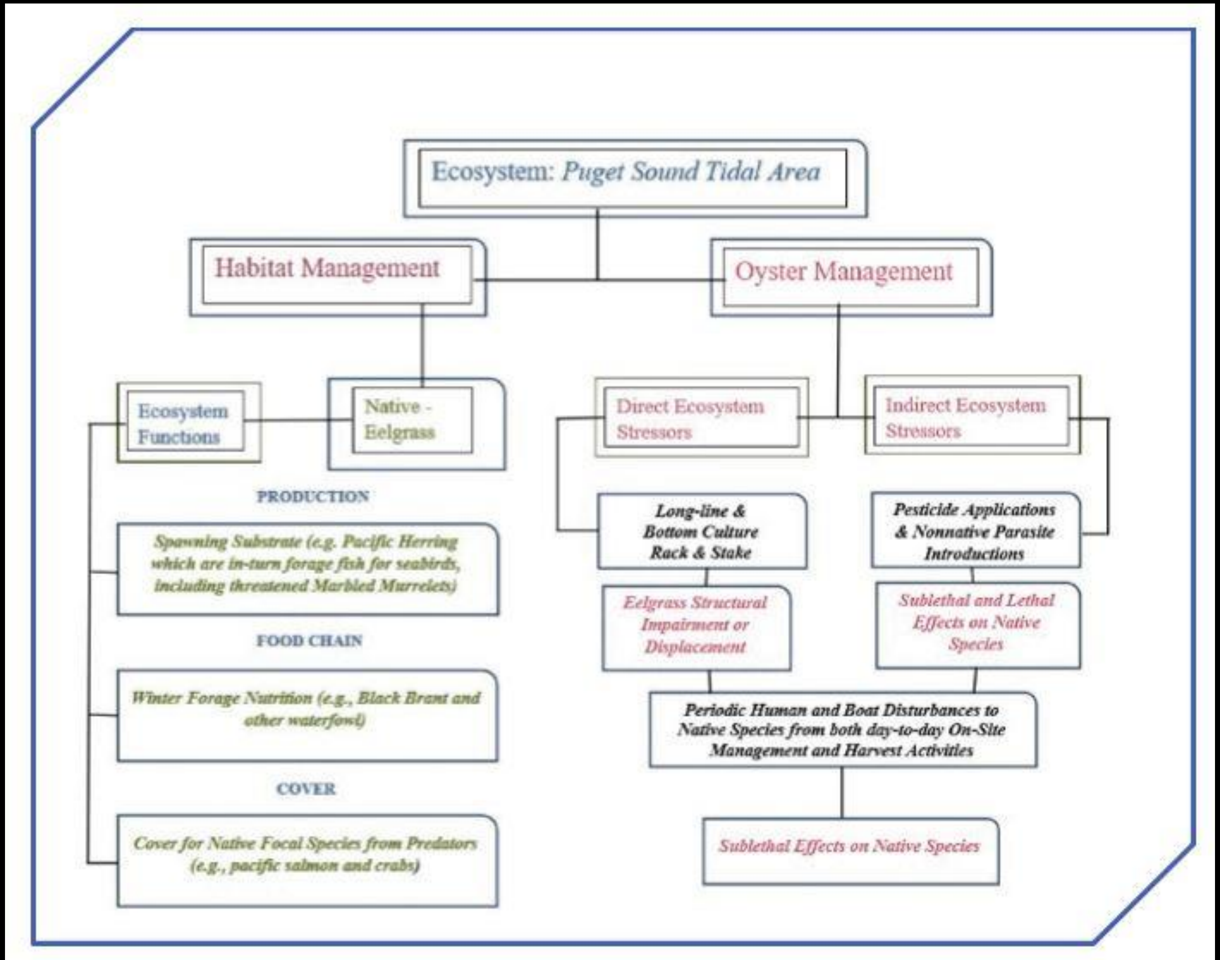
NET CREDIT: Total Potential Credit Value + Total Potential Debit Value

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

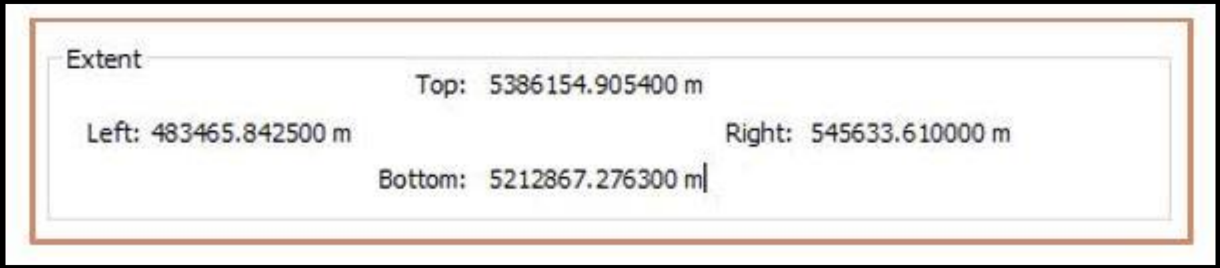
Natural Capital
(Native Eelgrass)

Currency: Credits / Debits

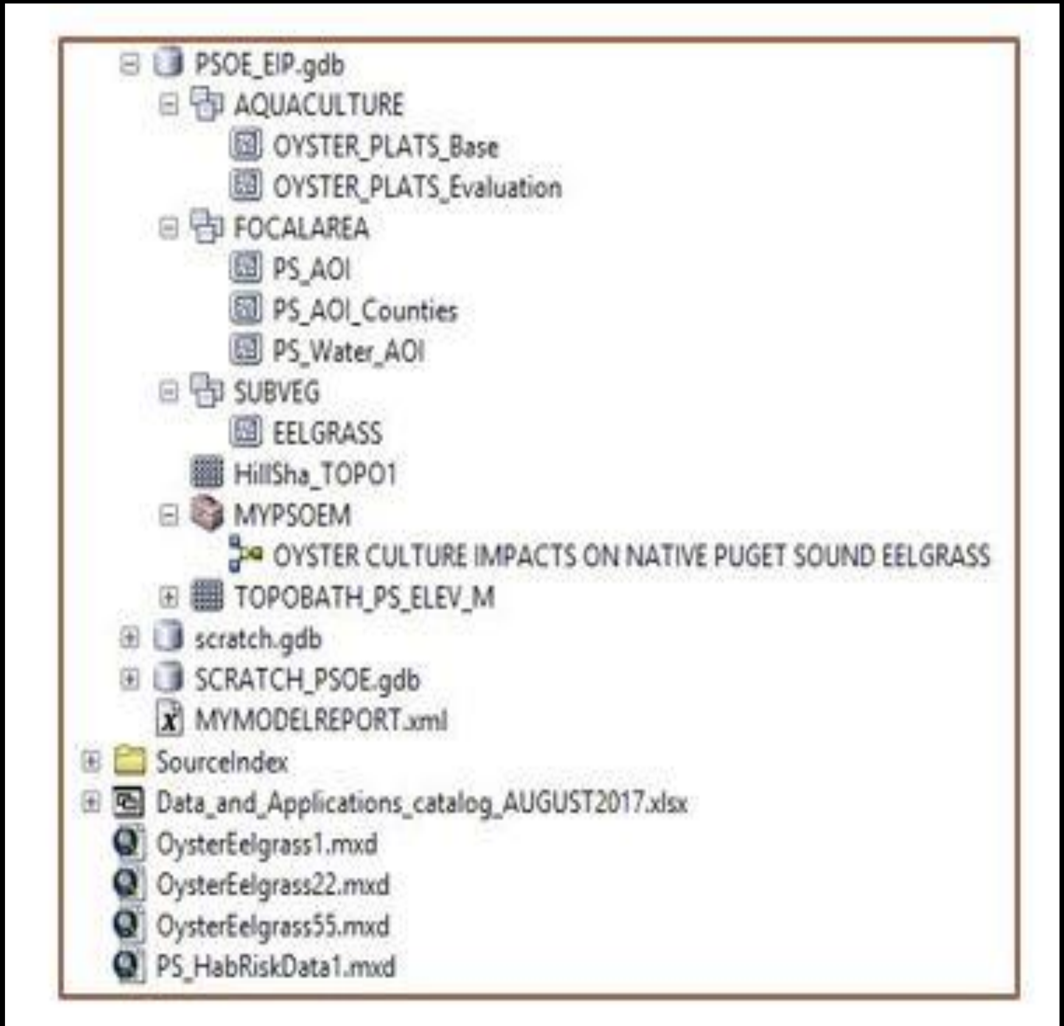


Extent

Since the focus of the problem addresses oyster culture direct and indirect impacts to native eelgrass *and the species with life-cycle requirements dependent on eelgrass*, the geographic extent of hypothetical indirect impacts by oyster plats was adopted to delimit the extent of the AOC .



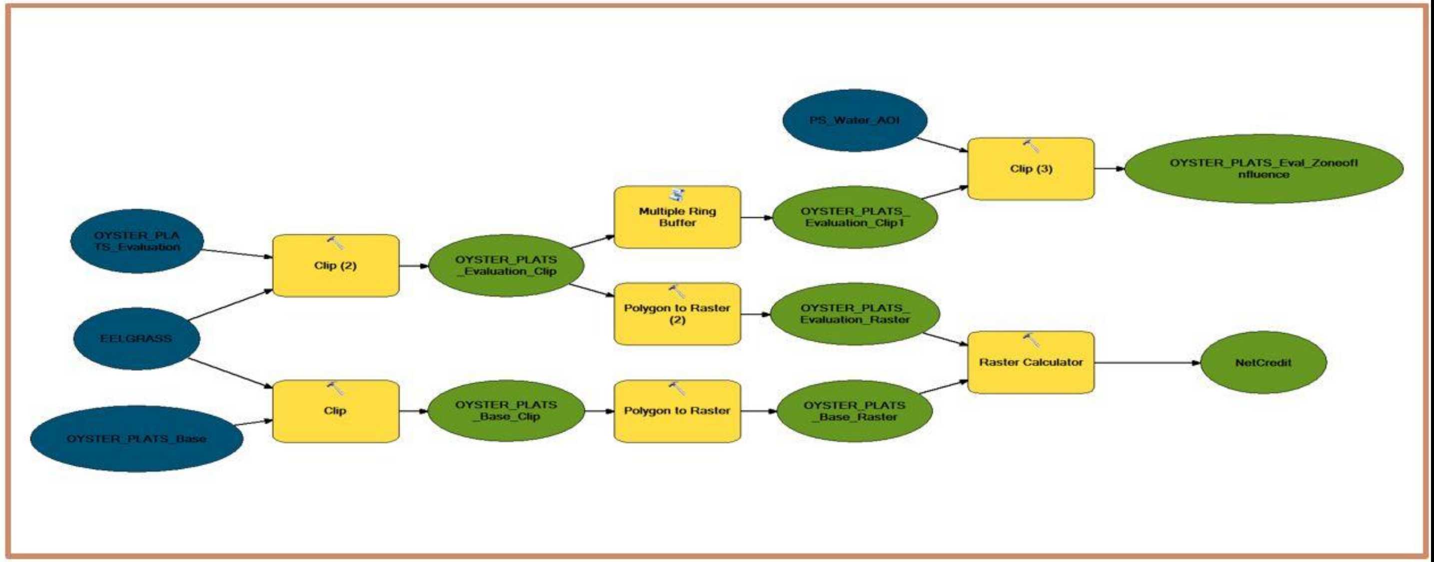
Geodatabase



Feature Datasets	Feature Classes	Definitions of Feature Classes	Data Sources
Aquaculture	Oyster Plats	Polygons delineating oyster culture operations.	Washington Department of Natural Resources
FocalArea	Puget Sound Area of Interest, Counties, Aquatic Areas	Polygons delineating the regions containing oyster culture activities.	Washington Department of Natural Resources
SubVeg	Native Eelgrass	A set of polygons delineating native eelgrass beds.	Washington Department of Natural Resources
Bathymetry/Topography	Elevation Hill-shade	Raster DEM	USGS/NOAA

Projected Coordinate System:	NAD_1983_UTM_Zone_10N
Projection:	Transverse_Mercator
False_Easting:	500000.00000000
False_Northing:	0.00000000
Central_Meridian:	-123.00000000
Scale_Factor:	0.99960000
Latitude_Of_Origin:	0.00000000
Linear Unit:	Meter
Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Model Builder

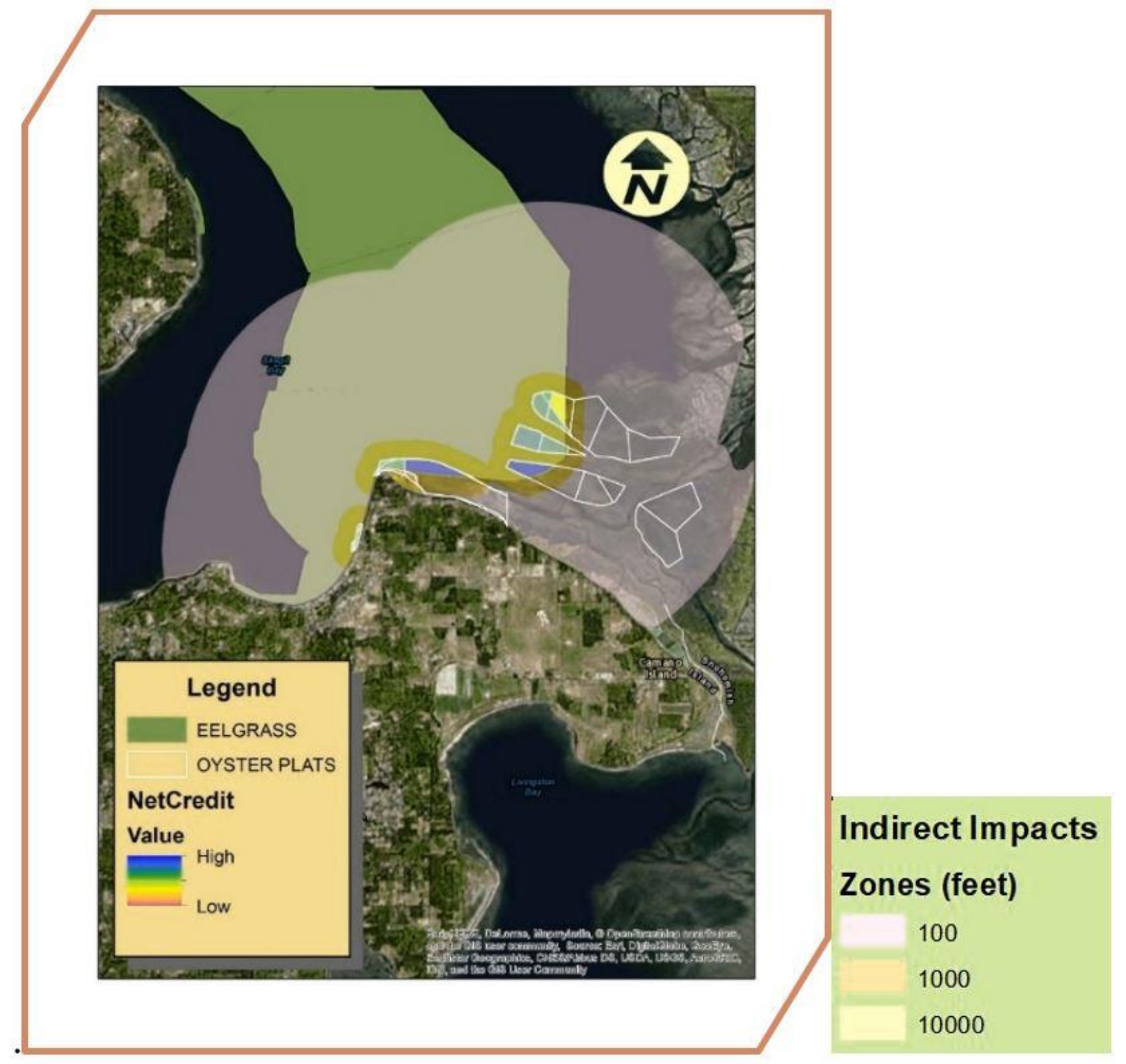


902.5	-546.25	356.25
59611.75	-34867.25	24744.5
5901.5	-1073	4828.5

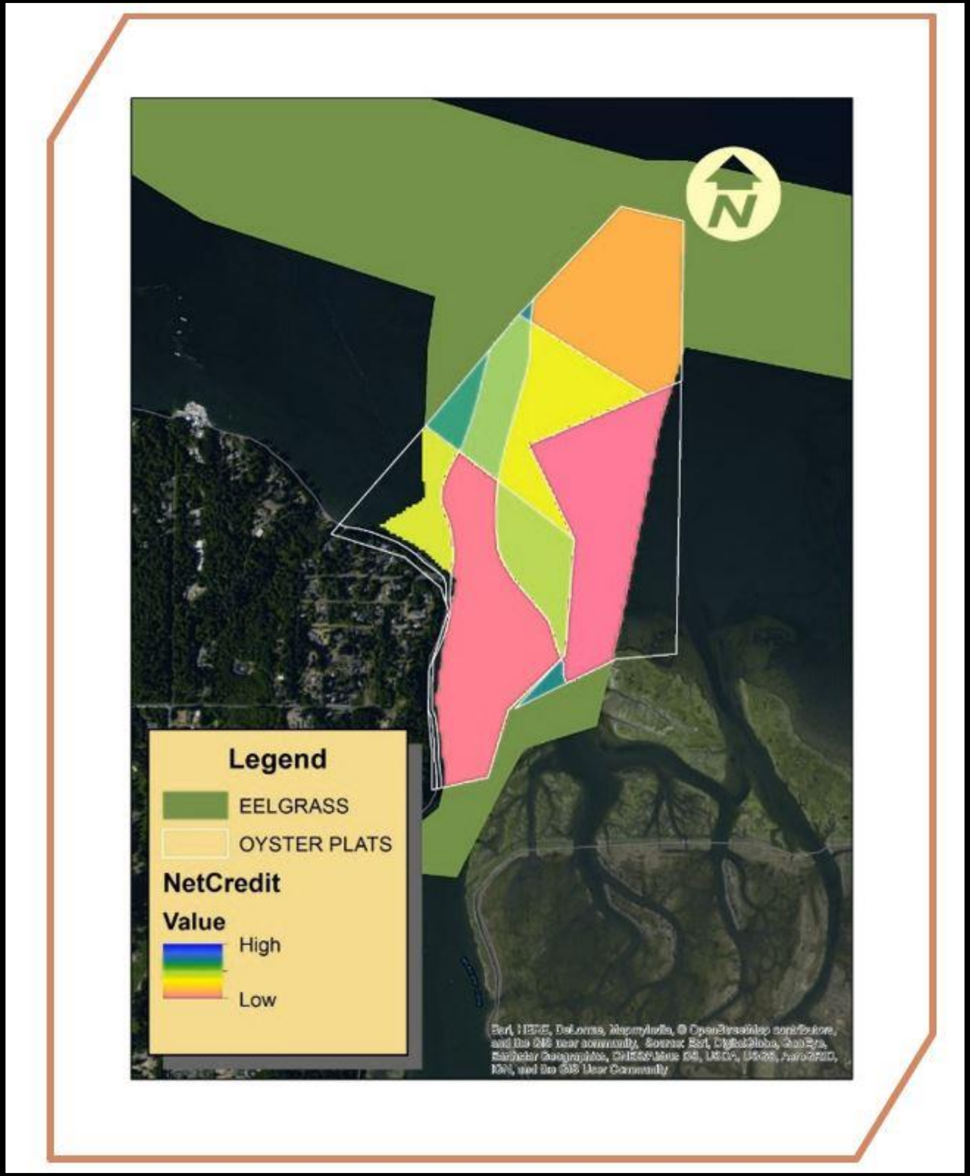
OID	Production	FoodChain	Cover	TotalCredit	Acres	TotalCreditVal
1	400	300	250	950	0.95	902.5
2	500	450	375	1325	44.99	59611.75
3	100	100	75	275	21.46	5901.5

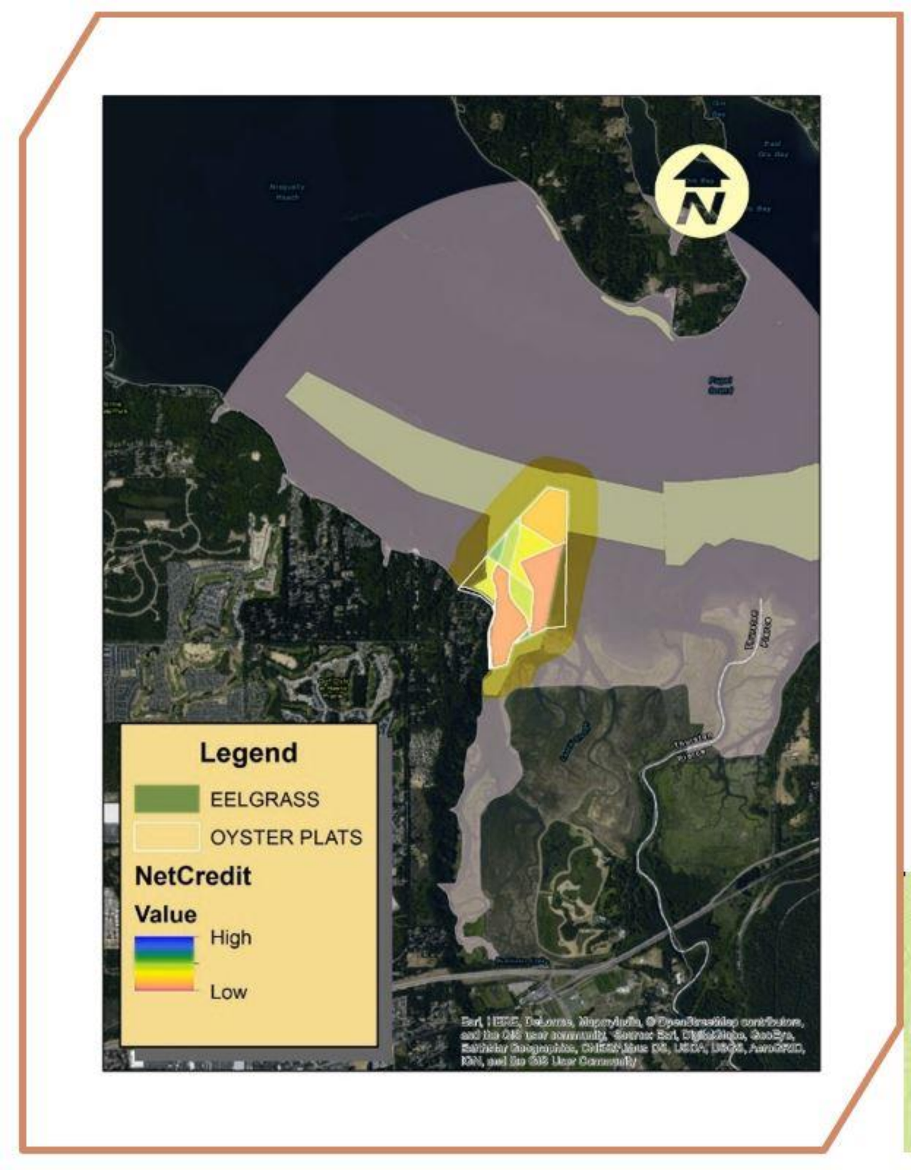
OID	StrucDisp	StrucImp	LethDir	LethIndir	SubLethDir	SubLethIndir	TotalDebit	Acres	TotalDebitVal
1	-25	-150	-250	-50	-75	-25	-575	0.95	-546.25
2	-100	-325	-125	-150	-50	-25	-775	44.99	-34867.25
3	0	0	0	0	-25	-25	-50	21.46	-1073

Trial 1a and 1b

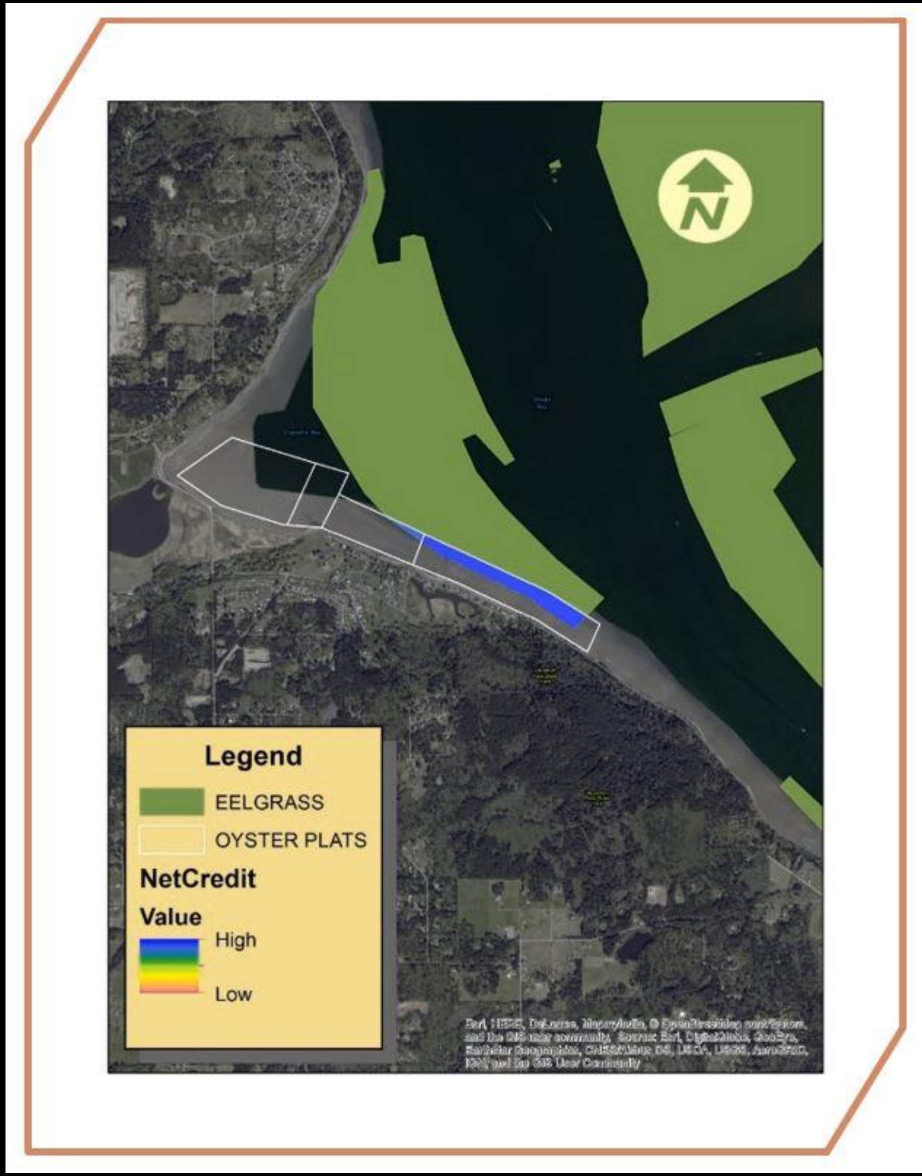


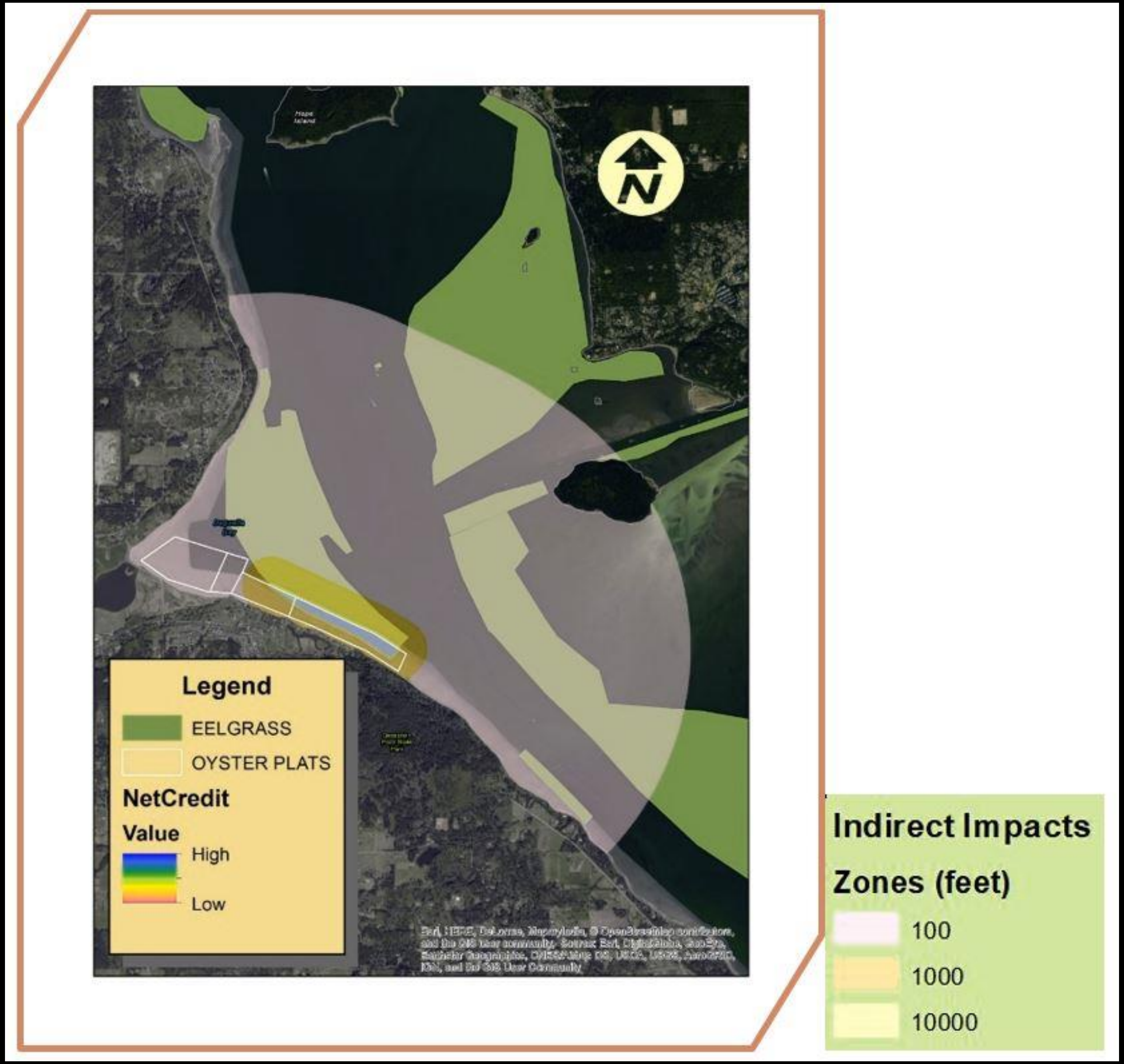
Trial 2a and 2b





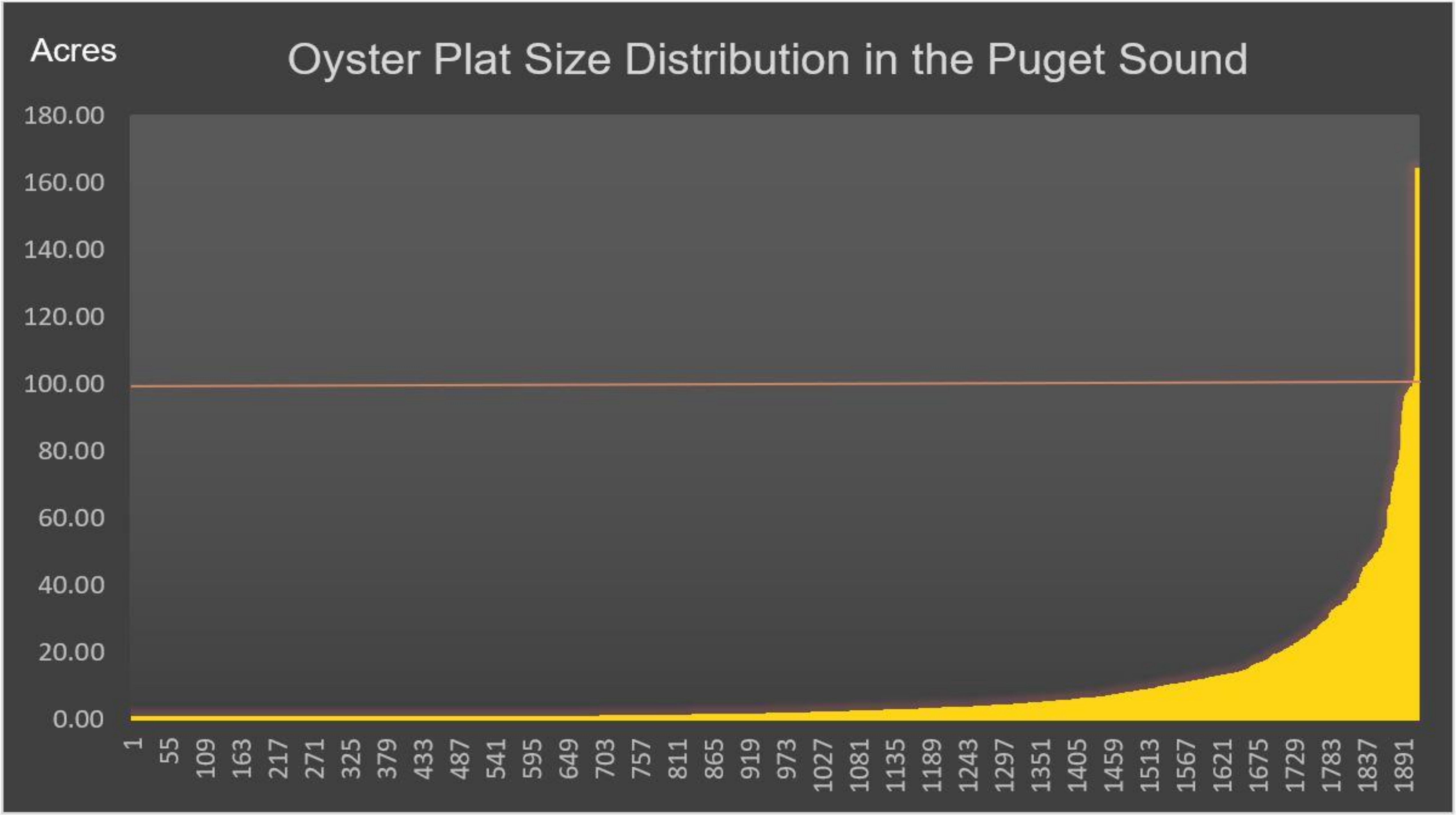
Trial 3a and 3b





Regulation Constraints

Agency / Tribe	Authority	Constraints
U.S. Army Corps of Engineers	Sec. 404 Clean Water Act - 33 USC 1344; Sec. 10 Rivers and Harbors Act – 33 USC 403; National Environmental Policy Act – USC 4321et seq.	Does not authorize activities affecting more than 1/2-acre of eelgrass in plats that have not been used for oyster aquaculture during the past 100 years (insecticides and other pesticides not regulated by Corps so not considered in affects analysis). If the operator will be conducting commercial shellfish aquaculture activities in multiple contiguous project areas, he or she can either submit one PCN for those contiguous project areas or submit a separate PCN for each project area.
U.S. National Marine Fisheries Service	Endangered Species Act – 16 USCA 1531 et seq.; Fish and Wildlife Coordination Act – 16 USC 661 et seq.	Does not authorize the “take” of a threatened or endangered species. DE must require PCN if project greater than 100-acres[§] or substantial change in type or location(s) of BMPs. If take is determined, DE must reinitiate consultation with NMFS case-by-case.
U.S. Fish and Wildlife Service	Endangered Species Act – 16 USCA 1531 et seq.; Fish and Wildlife Coordination Act – 16 USC 661 et seq.; MBTA – 16 USC 703 et seq.	Determined there is no “take” of a threatened or endangered species. No constraints are required.
Washington Department of Ecology	Sec. 401 Clean Water Act - 33 USC 1251 et seq.;	Does not authorize new operations, or expansions of existing operations with direct impacts to eelgrass beds nor activities affecting more than 1/2-acre of eelgrass in plats that have not been used for oyster Aquaculture during the past 100 years (insect-icides and other pesticides not regulated by Corps so not considered in affects analysis).
Puget Sound Tribes	Sec. 401 Clean Water Act - 33 USC 1251 et seq.;	NWP 48 Section 401 CWA WQ Certification is denied without prejudice by Confederated Tribes of the Lummi Nation, Makah Tribe, Port Gamble S’Klallam, Puyallup Tribe of Indians, Swinomish, and Tulalip Tribes over activities on their respective tribal lands.


Acres
Oyster Plat Size Distribution in the Puget Sound
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1
55
109
163
217
271
325
379
433
487
541
595
649
703
757
811
865
919
973
1027
1081
1135
1189
1243
1297
1351
1405
1459
1513
1567
1621
1675
1729
1783
1837
1891

Concerns

- There are no criteria by which to measure eelgrass performance;
- There are no criteria by which to measure oyster-culture stresses on eelgrass performance;
- There are no thresholds that can be used to objectively determine if eelgrass performance has been substantially compromised; and
- There are no data collected at the oyster-plat level that can be tested in the context of a criteria / threshold based decision framework.

Inheriting Actors from Umbrella CFA

Native Eelgrass Habitat Value

- Habitat Production
- Habitat Cover
- Habitat Forage

Native Eelgrass Stressors

- Direct Oyster-Culture Stressors
- Indirect Oyster-Culture Stressors

Populate Each Category With Relevant Key Species

Native Eelgrass Habitat Value

Habitat Production Beneficiary

- Pacific herring - *Clupea pallasii*

Habitat Cover Beneficiary

- Dungeness crab - *Metacarcinus magister*
- Tube-snout - *Aulorhynchus flavidus*
- Bay pipefish - *Syngnathus leptorhyncus*
- Shiner perch - *Cymatogaster aggregate*
- Saddleback Gunnel – *Pholis ornate*
- Chinook - *Oncorhynchus tshawytscha*
- Coho salmon - *Oncorhynchus kisutch*
- Bull trout - *Salvelinus confluentus*

Populate Each Category With Relevant Key Species

Native Eelgrass Habitat Value

- Habitat Forage Beneficiary
  - American wigeon - *Mareca Americana (Primary consumer native eelgrass)*
  - Black brant - *Branta bernicula (Primary consumer native eelgrass)*
  - Marbled murrelet - *Brachyramphus marmoratus (Secondary consumer Pacific herring)*
- Important Forage Prey Species
  - Ghost shrimp - *Neotrypaea spp.*
  - Mud shrimp - *Upogebia pugettensis*

Populate Each Category With Eelgrass Stressors

Native Eelgrass Stressors

- Direct Oyster-Culture Stressors
  - *Bottom Culture*
  - *Rack Culture*
  - *Stake Culture*
  - *Rack and Stake Culture*
  - *Long-line Culture*
  - *Nursery Shell Bags*

- Indirect Oyster-Culture Stressors
  - *Boat Traffic*
  - *Foot Traffic*
  - *Raking Oysters*
  - *Neurotoxin Applications*
  - *Predator Nets*

Preliminary Key Geodatabase Schema Designs

A theory for natural currency (credits/debits) at the plat level scale is needed. The logic being the data needed to inform the methods used to apply the theory strongly dictate the fields required to contain that data. Based on the nature of the research problem ontology, it was determined the theory should:

Preliminary Key Geodatabase Schema Designs

- be spatially and temporally explicit;
- reflect the relationships between native eelgrass and native eelgrass interdependent species; and
- reflect the effects oyster-culture related stressors have on native eelgrass and eelgrass interdependent species values.

Preliminary Key Geodatabase Schema Designs

Each species receives a calculated credit score based on:

1. their relative abundance or habitat suitability ;
2. their importance or focal weight; and
3. the amount of undisturbed focal habitat (native eelgrass) available to them.

The credit scores for each species are summed to derive a total credit score for the portion of the management unit (reference site or oyster plat) containing native eelgrass.

Calculations

Species x: $[\text{Credit}_1] = [\text{Abundance}] \times [\text{Focal Weight}] \times [\text{Acres}]$

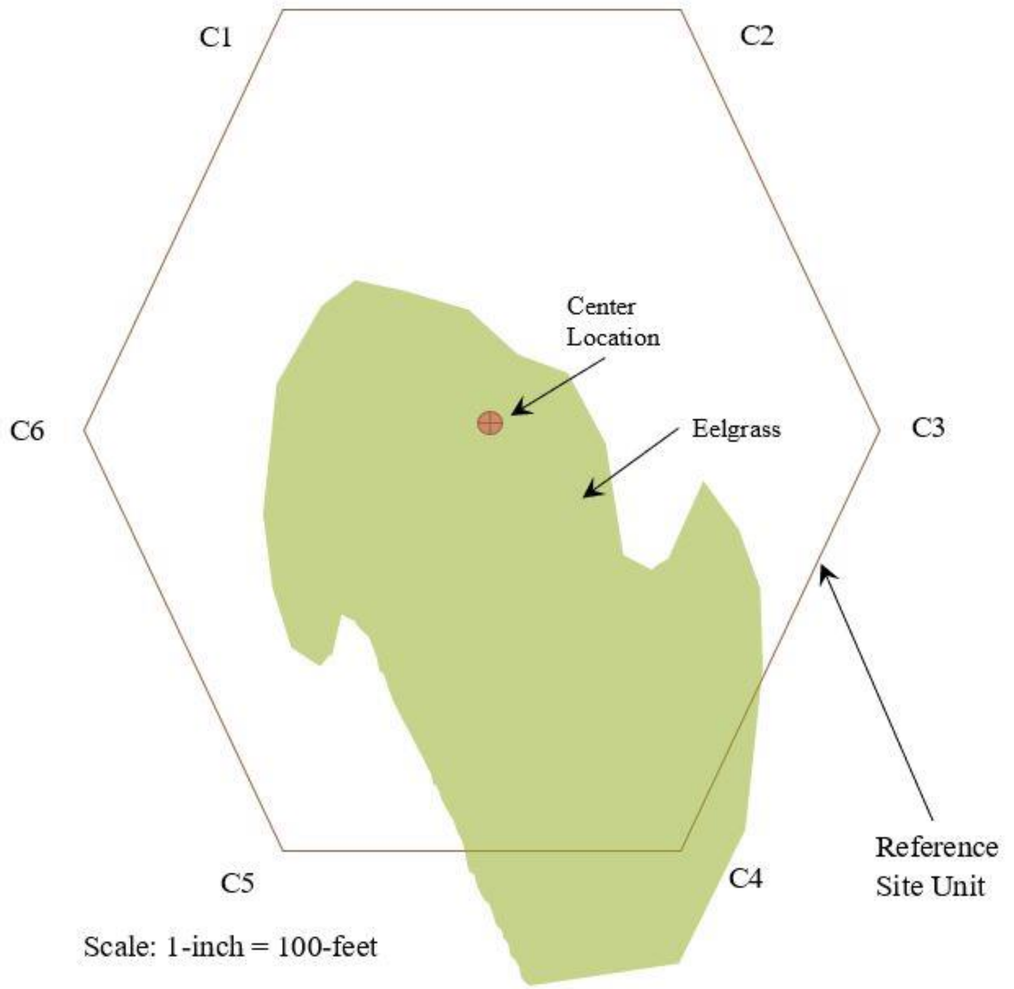
Species y: $[\text{Credit}_2] = [\text{Abundance}] \times [\text{Focal Weight}] \times [\text{Acres}]$

Species z: $[\text{Credit}_3] = [\text{Abundance}] \times [\text{Focal Weight}] \times [\text{Acres}]$

$$\text{Total Credit} = \text{Credit}_1 + \text{Credit}_2 + \text{Credit}_3$$

Example 1

Undisturbed Reference Site



Reference Site Unit Corner Locations

UID	C1 - Lat	C1 - Lon	C2 - Lat	C2 - Lon	C3 - Lat	C3 - Lon	C4 - Lat	C4 - Lon	C5 - Lat	C5 - Lon	C6 - Lat	C6 - Lon
1	48.291476	-122.4067	49.291430	-122.4016	48.288234	-122.3991	48.284985	-122.4016	48.285071	-122.4069	48.288226	-122.4090
2												
3												
4												
5												
6												

Example 1

Undisturbed Reference Site Credit Score

Model Assessment Reference Site Application.

Reference Site Credit Score Card – Based on Species Associations (Generalized from Dethier 1990)									
UID	Genus	Species	Present	Density	HSI	Population	Focal Weight	Acres	Credits
1	*Zostera*	*marina*	x	10			10	100	10000
2	*Metacarcinus*	*magister*	x		10		5	100	5000
3	*Neotrypaea*	*spp*	x		10		5	100	5000
4	*Upogebia*	*pugettensis*	x		10		5	100	5000
5	*Clupea*	*pallasii*	x		10		8	100	8000
6	*Aulorhynchus*	*flavidus*	x		10		5	100	5000
7	*Syngnathus*	*leptorhyncus*	x		10		5	100	5000
8	*Cymatogaster*	*aggregata*	x		10		5	100	5000
9	*Pholis*	*ornata*	x		10		5	100	5000
10	*Blepsias*	*Cirrhosis*	x		10		5	100	5000
11	*Clinocottus*	*acuticeps*	x		10		5	100	5000
12	*Oncorhynchus*	*tshawytscha*	x		10		10	100	10000
13	*Oncorhynchus*	*kisutch*	x		10		10	100	10000
14	*Salvelinus*	*confluentus*	x		10		10	100	10000
15	*Pleuronectes*	*vetulus*	x		10		5	100	5000
16	*Mareca*	*americana*	x		10		3	100	3000
17	*Branta*	*bernicula*	x		10		5	100	5000
18	*Brachyramphus*	*marmoratus*	x		10		10	100	10000
	Total								116000

Credit Score Schema (Informed by Hypothetical Field Data).

Species x: $[Credit_1]$ = [Abundance] x [Focal Weight] x [Acres]
Species y: $[Credit_2]$ = [Abundance] x [Focal Weight] x [Acres]

Total Credit = $Credit_1 + Credit_2$ . . .

Credit Ranks			
UID	Credit Criteria	Ordinal	Numeric
1	Highly Functional System	H	116000
2	Moderately High Functional System	MH	null
3	Functional System	M	null
4	Moderately Low Functional System	ML	null
5	Low Functional System	L	null

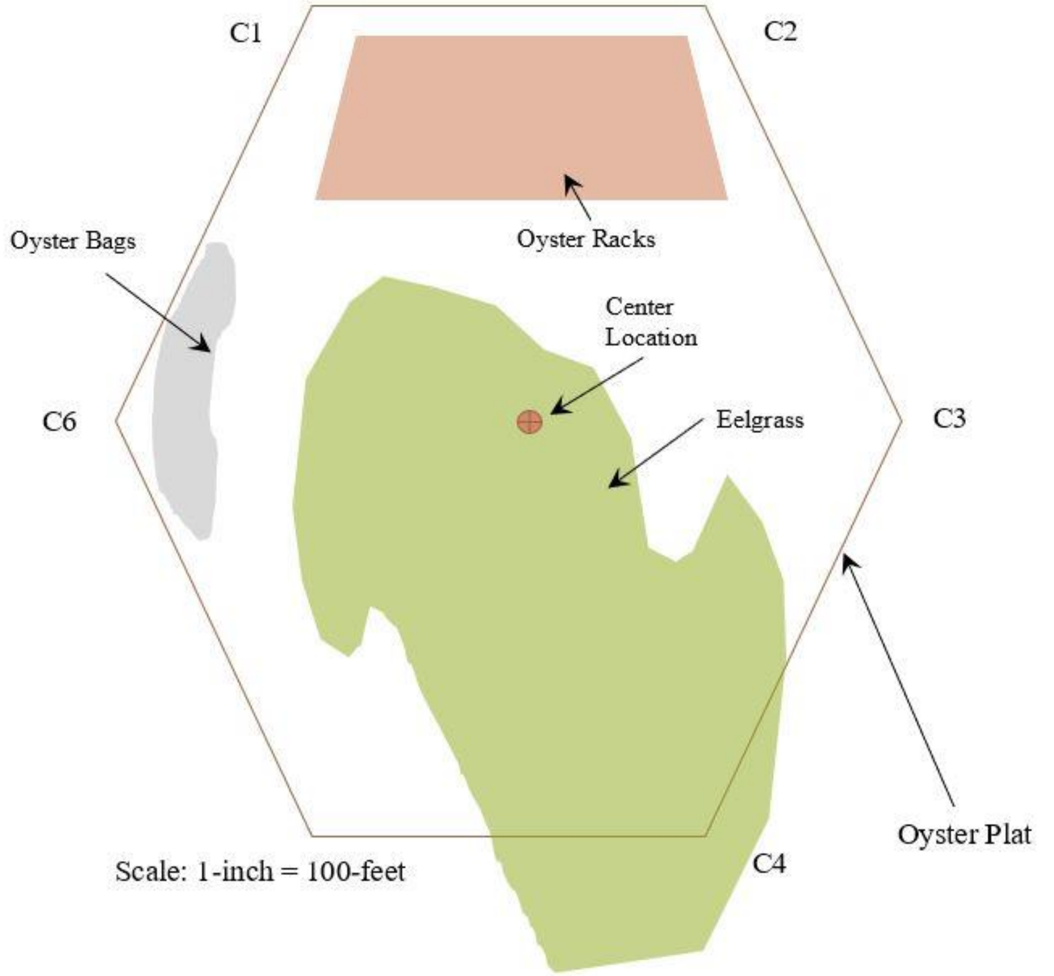
Hypothetical Credit Score for Reference Site Unit.

Puget Sound Reference Site							
UID	Date	Disturbance Type	Elevation (ft < MLLW)	Acres	Total Credit	Latitude	Longitude
1	5/23/2018	None	0 -10	100	116000	48.288240	-122.404113
2							
3							
4							
5							
6							

Hypothetical Summary Credit Score for Multiple Reference Site Units (Only One of Many Potential Records is Displayed in this Table).

Example 2

Undisturbed Oyster Plat Site



Oyster Plat Corner Locations

UID	C1 - Lat	C1 - Lon	C2 - Lat	C2 - Lon	C3 - Lat	C3 - Lon	C4 - Lat	C4 - Lon	C5 - Lat	C5 - Lon	C6 - Lat	C6 - Lon
1	48.291476	-122.4067	49.291430	-122.4016	48.288234	-122.3991	48.284985	-122.4016	48.285071	-122.4069	48.288226	-122.4090
2												
3												
4												
5												
6												

Example 2

Relatively Undisturbed Oyster Plat Site Credit Score

Model Assessment Relatively Undisturbed Oyster Plat Application.

Example 1 Oyster Plat Credit Score Card – Based on Species Associations (Generalized from Dethier 1990)									
UID	Genus	Species	Present	Density	HSI	Population	Focal Weight	Acres	Credits
1	*Zostera*	*marina*	x	10			10	100	10000
2	*Metacarcinus*	*magister*	x		10		5	100	5000
3	*Neotrypaea*	*spp*	x		10		5	100	5000
4	*Upogebia*	*pugettensis*	x		10		5	100	5000
5	*Clupea*	*pallasii*	x		10		8	100	8000
6	*Aulorhynchus*	*flavidus*	x		10		5	100	5000
7	*Syngnathus*	*leptorhyncus*	x		10		5	100	5000
8	*Cymatogaster*	*aggregata*	x		10		5	100	5000
9	*Pholis*	*ornata*	x		10		5	100	5000
10	*Blepsias*	*Cirrhosis*	x		10		5	100	5000
11	*Clinocottus*	*acuticeps*	x		10		5	100	5000
12	*Oncorhynchus*	*tshawytscha*	x		10		10	100	10000
13	*Oncorhynchus*	*kisutch*	x		10		10	100	10000
14	*Salvelinus*	*confluentus*	x		10		10	100	10000
15	*Pleuronectes*	*vetulus*	x		10		5	100	5000
16	*Mareca*	*americana*	x		10		3	100	3000
17	*Branta*	*bernicula*	x		10		5	100	5000
18	*Brachyramphus*	*marmoratus*	x		10		10	100	10000
	Total								116000

Credit Score Schema (Informed by Hypothetical Field Data).

Species x: $[Credit_1] = [Abundance] \times [Focal\ Weight] \times [Acres]$

Species y: $[Credit_2] = [Abundance] \times [Focal\ Weight] \times [Acres]$

Total Credit = $Credit_1 + Credit_2$ . . .

Credit Ranks			
UID	Credit Criteria	Ordinal	Numeric
1	Highly Functional System	H	116000
2	Moderately High Functional System	MH	null
3	Functional System	M	null
4	Moderately Low Functional System	ML	null
5	Low Functional System	L	null

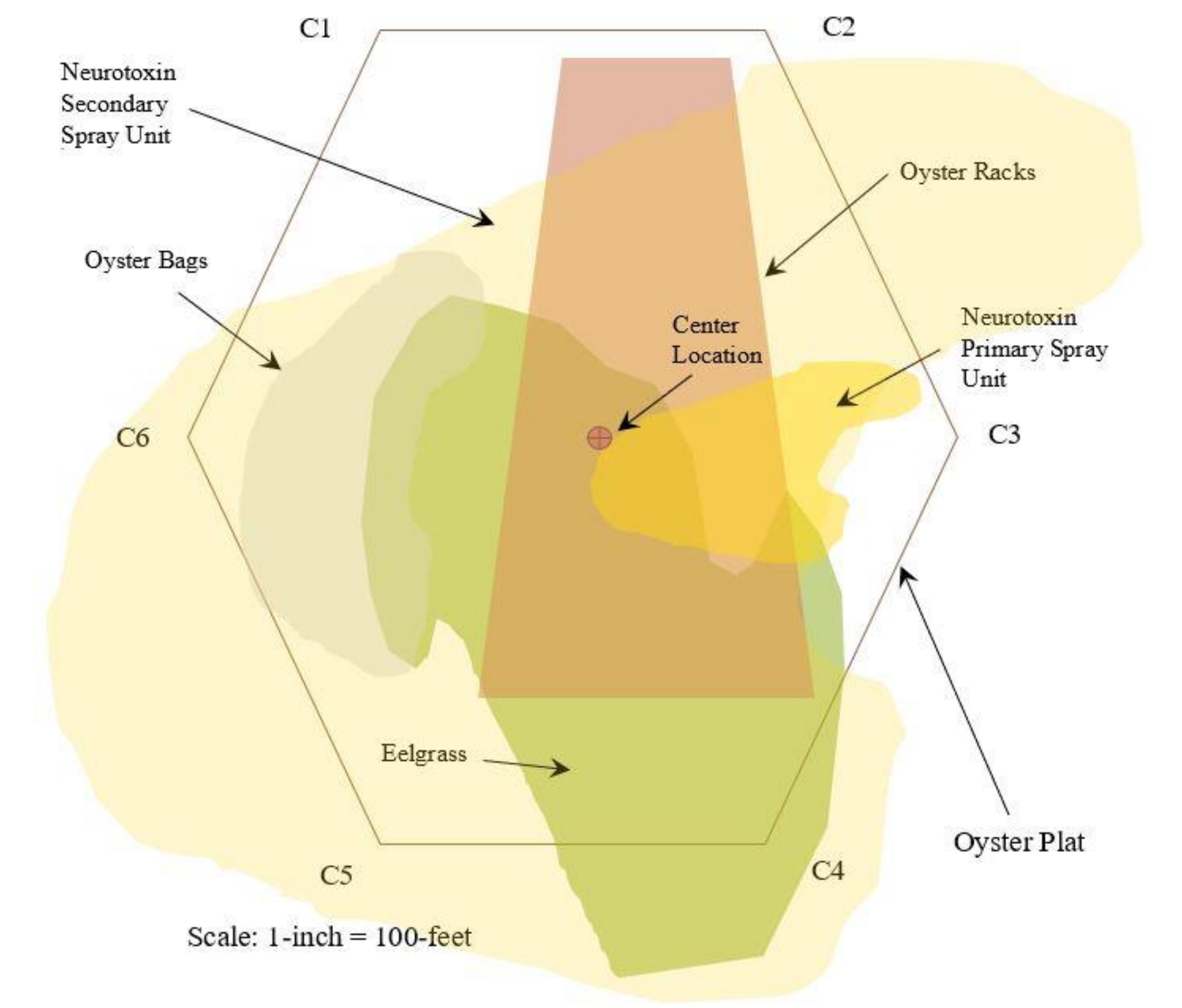
Hypothetical Credit Score for Oyster Plat Unit.

Puget Sound Oyster Plat Example 1							
UID	Date	Disturbance Type	Elevation (ft < MLLW)	Acres	Total Credit	Latitude	Longitude
1	5/23/2018	None	0 -10	100	116000	48.288240	-122.404113
2							
3							
4							
5							
6							

Hypothetical Summary Credit Score for Multiple Oyster Plat Units (Only One of Many Potential Records is Displayed in this Table).

Example 3

Disturbed Oyster Plat Site



Oyster Plat Corner Locations

UID	C1 - Lat	C1 - Lon	C2 - Lat	C2 - Lon	C3 - Lat	C3 - Lon	C4 - Lat	C4 - Lon	C5 - Lat	C5 - Lon	C6 - Lat	C6 - Lon
1	48.291476	-122.4067	49.291430	-122.4016	48.288234	-122.3991	48.284985	-122.4016	48.285071	-122.4069	48.288226	-122.4090
2												
3												
4												
5												
6												

Example 3

Disturbed Oyster Plat Site Credit Score

Model Assessment Disturbed Oyster Plat Application.

Example 2 Oyster Plat Credit Score Card – Based on Species Associations (Generalized from Dethier 1990)									
UID	Genus	Species	Present	Density	HSI	Population	Focal Weight	Acres	Credits
1	*Zostera*	*marina*	x	3			10	25	750
2	*Metacarcinus*	*magister*	x		3		5	25	375
3	*Neotrypaea*	*spp*	x		1		5	2	10
4	*Upogebia*	*pugettensis*	x		1		5	2	10
5	*Clupea*	*pallasii*	x		3		8	25	600
6	*Aulorhynchus*	*flavidus*	x		3		5	25	375
7	*Syngnathus*	*leptorhyncus*	x		3		5	25	375
8	*Cymatogaster*	*aggregata*	x		3		5	25	375
9	*Pholis*	*ornata*	x		3		5	25	375
10	*Blepsias*	*Cirrhosis*	x		3		5	25	375
11	*Clinocottus*	*acuticeps*	x		3		5	25	375
12	*Oncorhynchus*	*tshawytscha*	x		3		10	25	750
13	*Oncorhynchus*	*kisutch*	x		3		10	25	750
14	*Salvelinus*	*confluentus*	x		3		10	25	750
15	*Pleuronectes*	*vetulus*	x		3		5	25	375
16	*Mareca*	*americana*	x		3		3	25	225
17	*Branta*	*bernicula*	x		3		5	0	0
18	*Brachyramphus*	*marmoratus*	x		3		10	25	750
	Total								7595

Credit Score Schema (Informed by Hypothetical Field Data).

Species x: $[Credit_1]$ = [Abundance] x [Focal Weight] x [Acres]
Species y: $[Credit_2]$ = [Abundance] x [Focal Weight] x [Acres]

Total Credit = $Credit_1 + Credit_2$ . . .

Credit Ranks			
UID	Credit Criteria	Ordinal	Numeric
1	Highly Functional System	H	116000
2	Moderately High Functional System	MH	null
3	Functional System	M	null
4	Moderately Low Functional System	ML	7595
5	Low Functional System	L	null

Hypothetical Credit Score for Oyster Plat Unit.

Puget Sound Oyster Plat Example 2							
UID	Date	Disturbance Type	Elevation (ft < MLLW)	Acres	Total Credit	Latitude	Longitude
1	5/23/2018	Oyster Bags	0 - 5	20	10	48.288359	-122.407111
2	5/23/2018	Oyster Racks	5 - 10	45	25	48.288534	-122.403292
3	5/23/2018	Neurotoxin Direct	5 - 10	15	5	48.289079	-122.402677
4	5/23/2018	Neurotoxin Indirect	0 - 30	> 100	7555	48.288100	-122.404861
5							
6							

Hypothetical Summary Credit Score for Multiple Oyster Plat Disturbance Units.

Conclusion

- Making better and more defensible decisions based on reliable data is a cornerstone of sustainable development.
- Regulatory agencies stand to gain an increased confidence in their minimal individual and cumulative impacts findings and the regulated public has potential for a higher certainty their operational side-bars are bright lines and not foggy mazes subject to multiple interpretations.
- Also, by treating native eelgrass as natural capital, another important cornerstone of sustainable development, new regulatory tools become further enabled to help insure continued operational capacity of the oyster industry while providing additional means to help protect and recover vital Puget Sound natural resources.

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