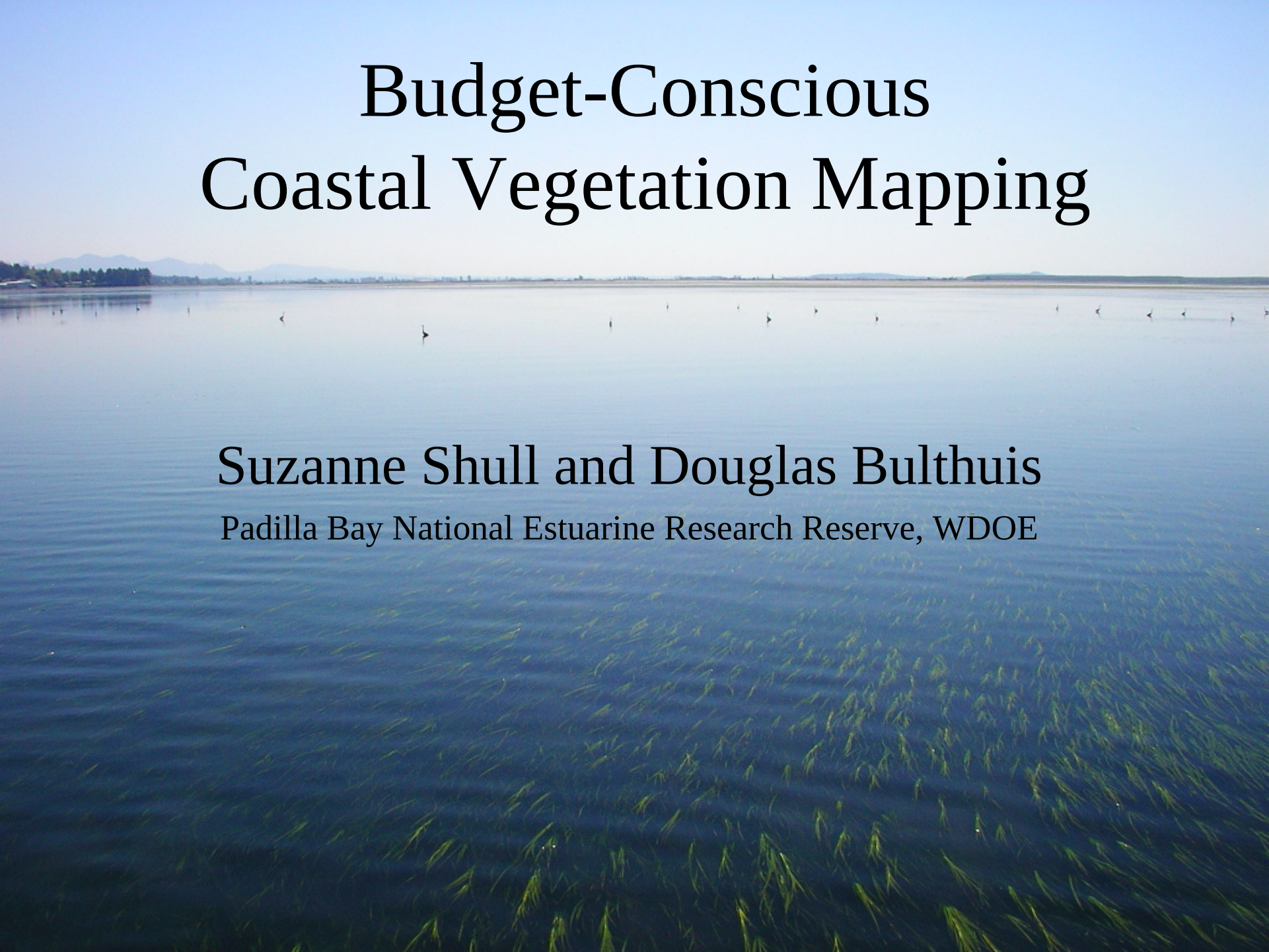
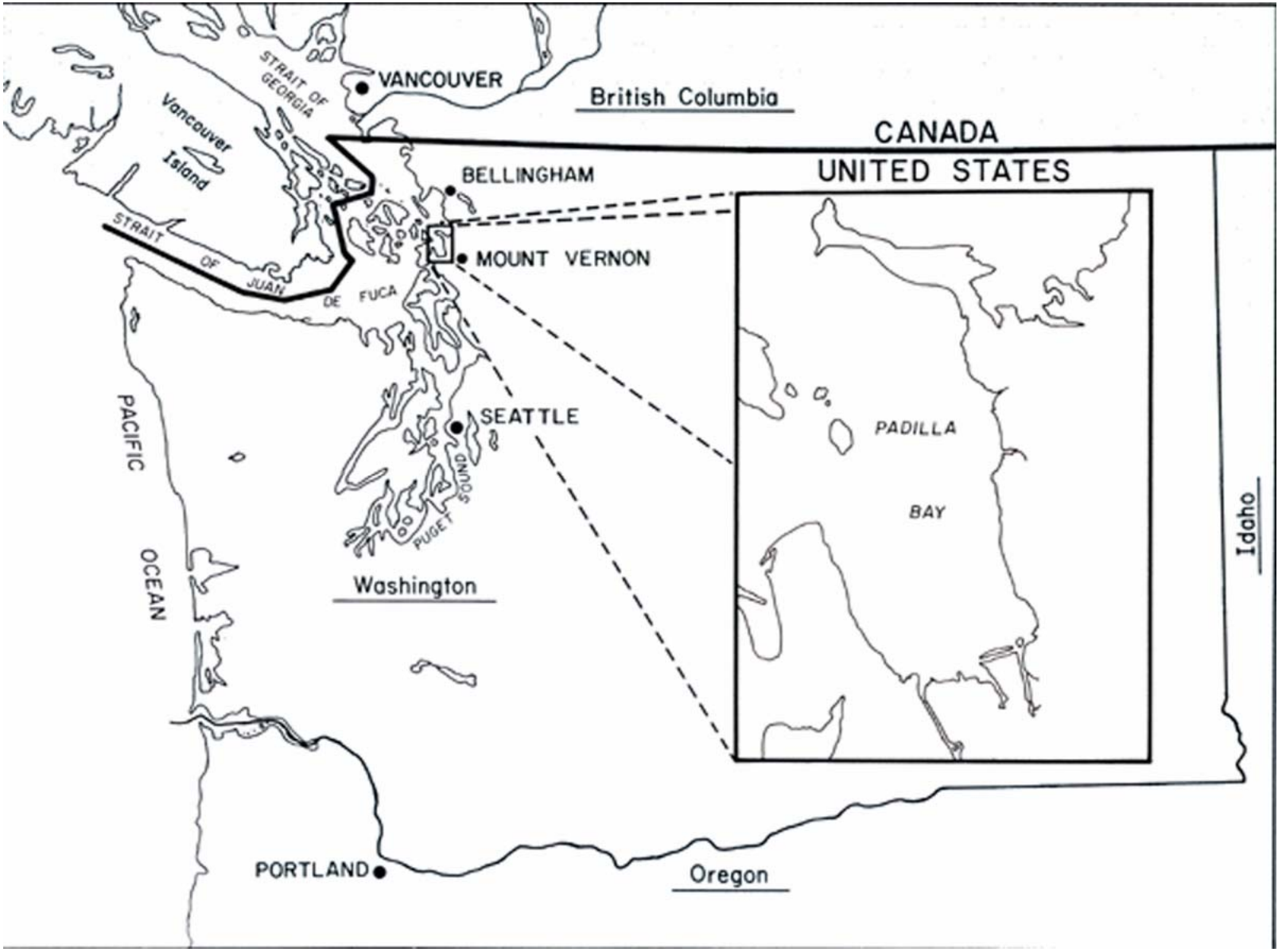
Budget-Conscious Coastal Vegetation Mapping



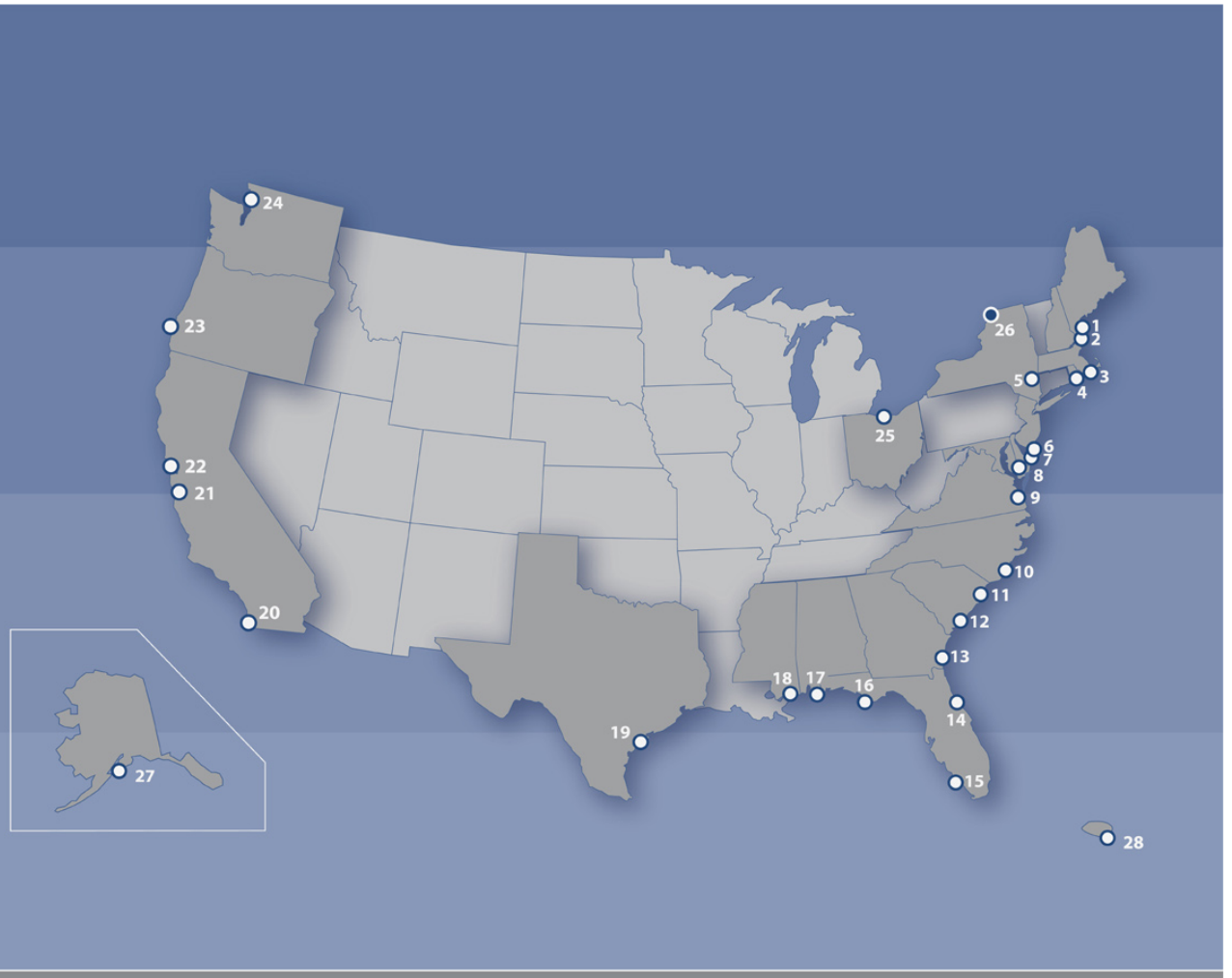
Suzanne Shull and Douglas Bulthuis

Padilla Bay National Estuarine Research Reserve, WDOE


STRAIT OF GEORGIA
VANCOUVER
British Columbia
CANADA
UNITED STATES
Vancouver Island
BELLINGHAM
STRAIT OF JUAN DE FUCA
MOUNT VERNON
PACIFIC OCEAN
SEATTLE
PUGET SOUND
PADILLA BAY
Washington
Idaho
PORTLAND
Oregon

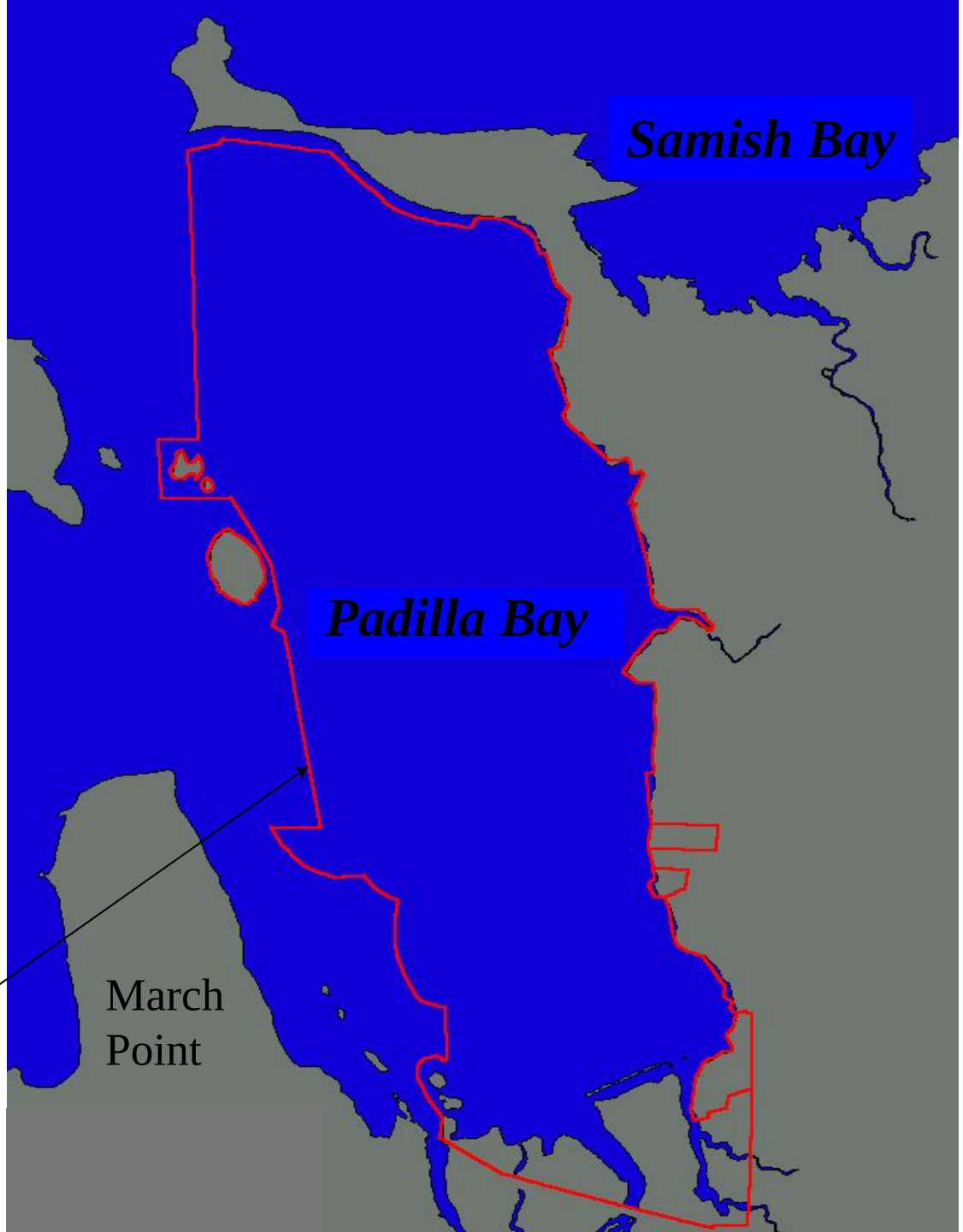
NATIONAL ESTUARINE RESEARCH RESERVES

A network of 27 protected areas

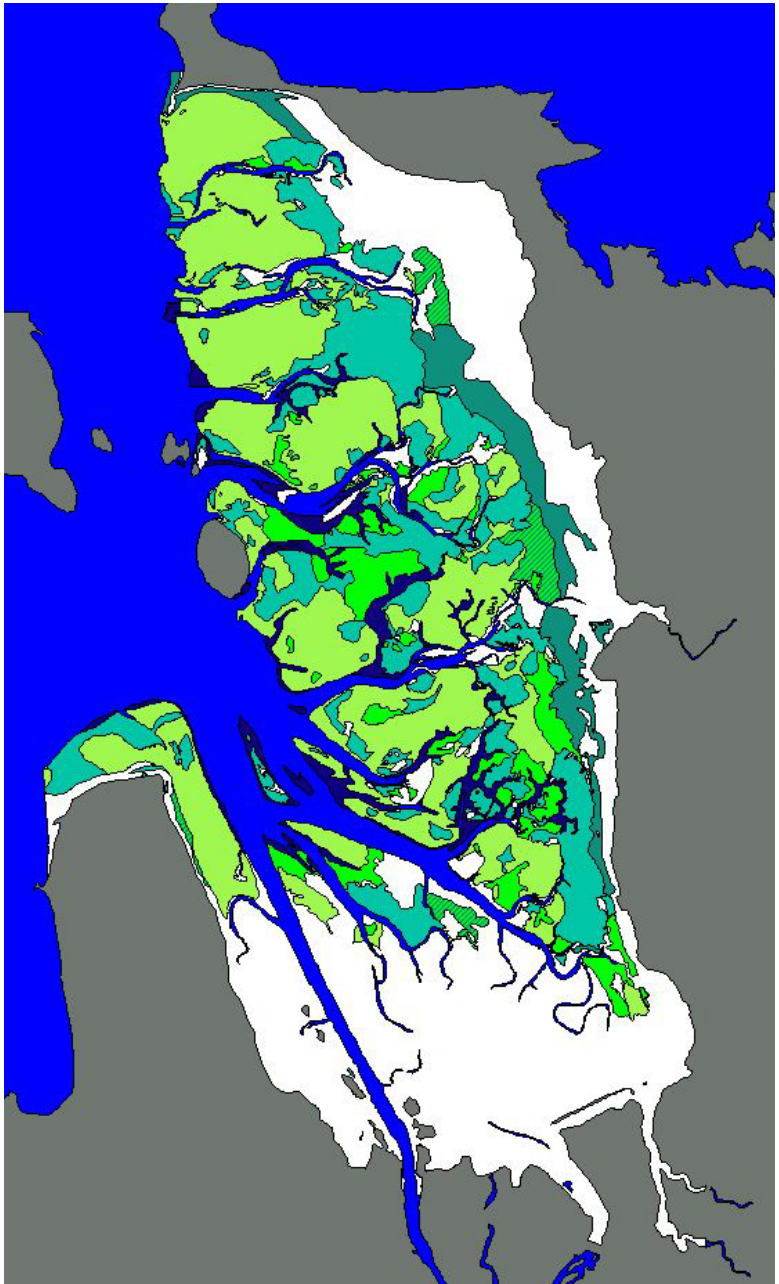


1. Wells, Maine
2. Great Bay, New Hampshire
3. Waquoit Bay, Massachusetts
4. Narragansett Bay, Rhode Island
5. Hudson River, New York
6. Jacques Cousteau, New Jersey
7. Delaware
8. Chesapeake Bay, Maryland
9. Chesapeake Bay, Virginia
10. North Carolina
11. North Inlet-Winyah Bay, South Carolina
12. ACE Basin, South Carolina
13. Sapelo Island, Georgia
14. Guana Tolomato Matanzas, Florida
15. Rookery Bay, Florida
16. Apalachicola, Florida
17. Weeks Bay, Alabama
18. Grand Bay, Mississippi
19. Mission-Aransas, Texas
20. Tijuana River, California
21. Elkhorn Slough, California
22. San Francisco Bay, California
23. South Slough, Oregon
24. Padilla Bay, Washington
25. Old Woman Creek, Ohio
26. Proposed—St. Lawrence River, New York
27. Kachemak Bay, Alaska
28. Jobos Bay, Puerto Rico

Education And Research



Intertidal Habitats of Padilla Bay



Macroalgae
and
Eelgrass

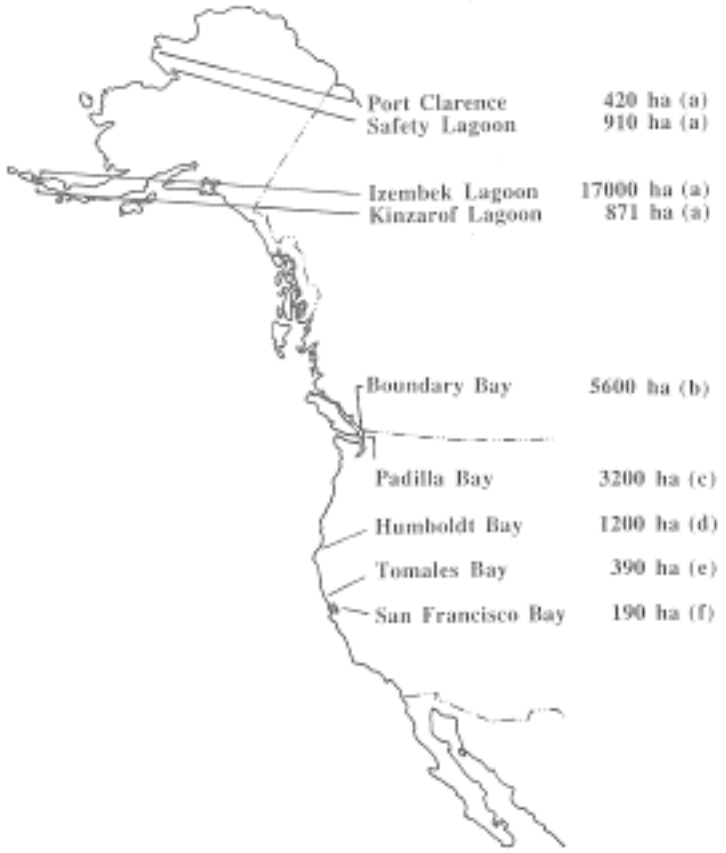
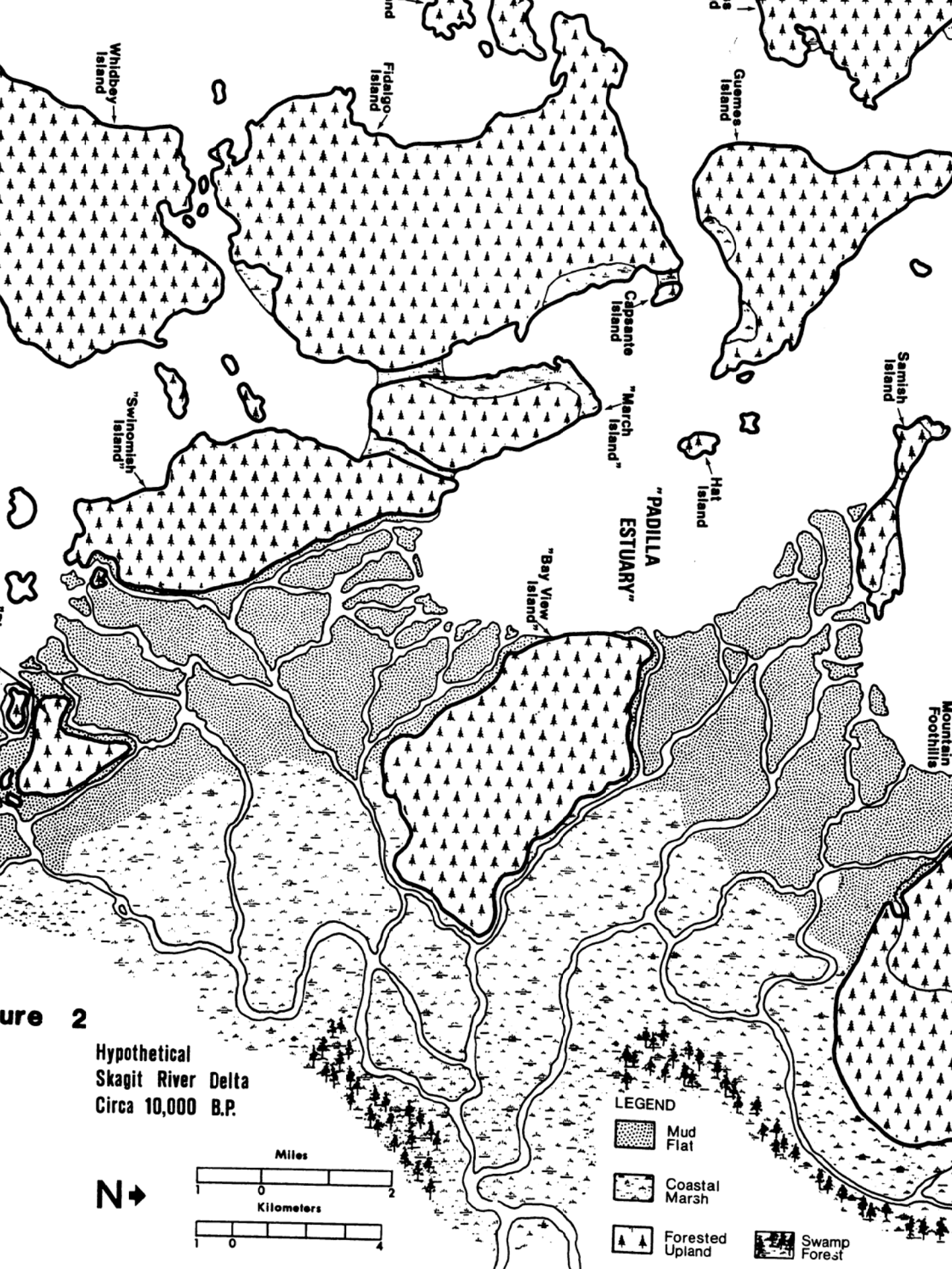


Fig. 2. Area covered by seagrasses in nine bays along the Pacific coast of North America for which published estimates exceed 100 ha. Sources are: (a) McRoy (1970); (b) Baldwin and Lovvorn (1994); (c) present study; (d) Harding and Butler (1979); (e) Spratt (1989); (f) Wyllie-Echeverria (1990).


Padilla Bay


Whidbey Island
Fidalgo Island
Guemes Island
Capsante Island
Samish Island
"Swinomish Island"
"March Island"
Hat Island
"PADILLA ESTUARY"
"Bay View Island"
Mountain Foothills
Hypothetical
Skagit River Delta
Circa 10,000 B.P.
Miles
1 0 2
Kilometers
1 0 4
N
LEGEND
Mud Flat
Coastal Marsh
Forested Upland
Swamp Forest

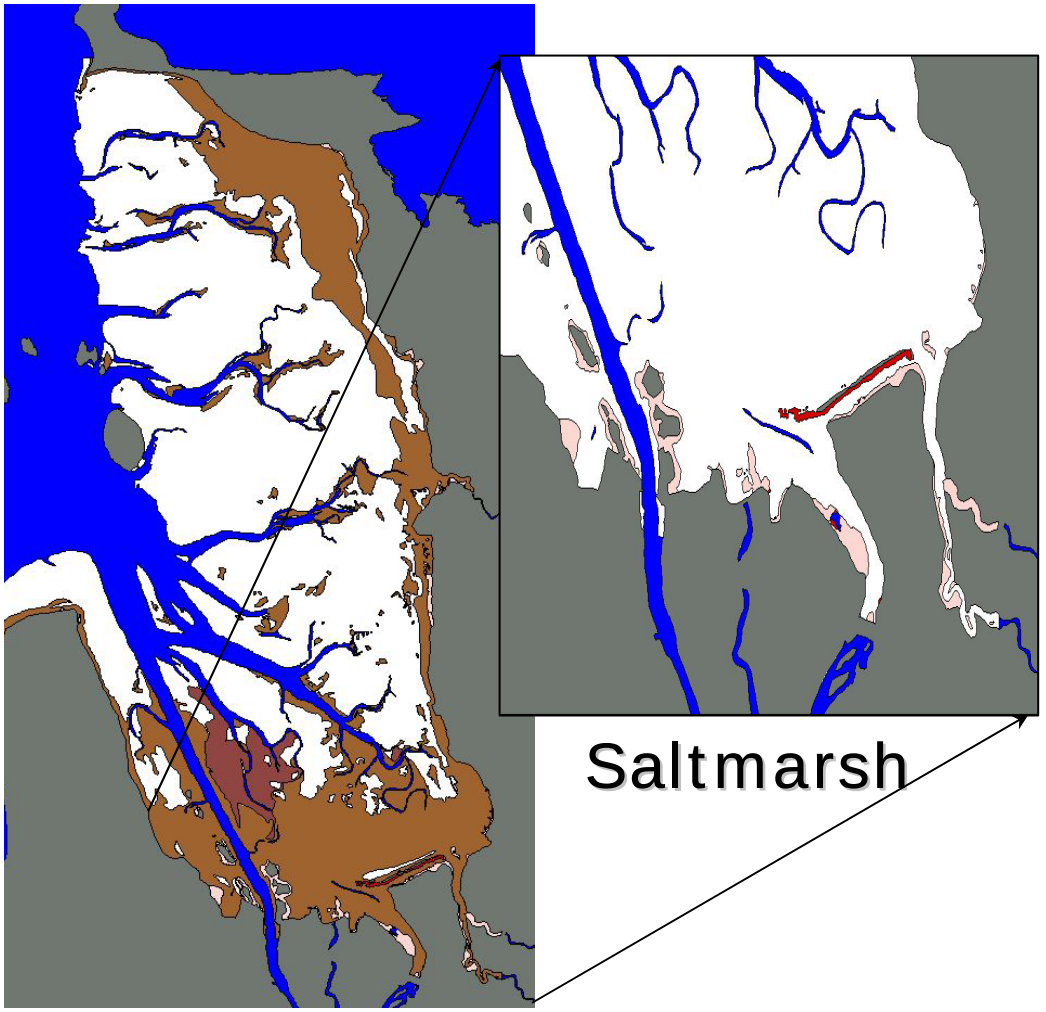
ure 2

One of the largest eelgrass meadows in North America

YSI Water Quality Instruments

Other Habitats of Padilla Bay

Bare
Subtidal



Bare Intertidal
(mud and sand flats)

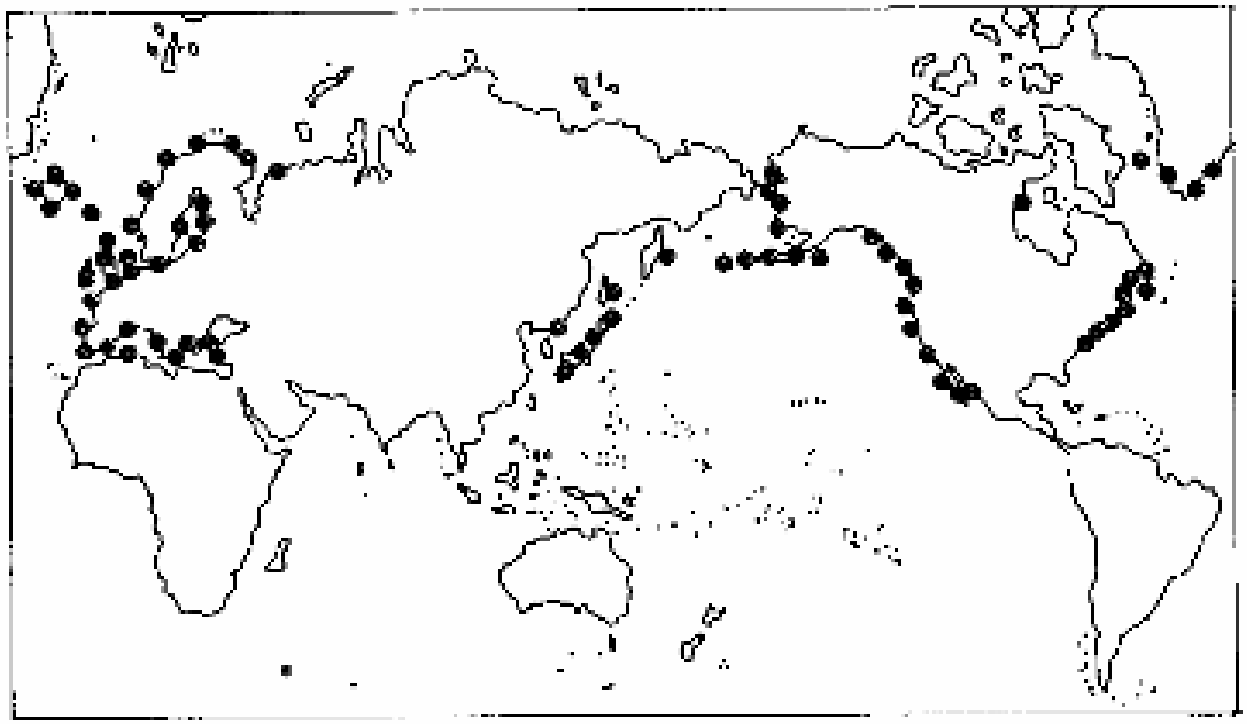
Padilla Bay Eelgrass

– **Zostera marina** (native species)
found in subtidal to mid-upper intertidal

•**Zostera japonica** (introduced species)
found in upper intertidal

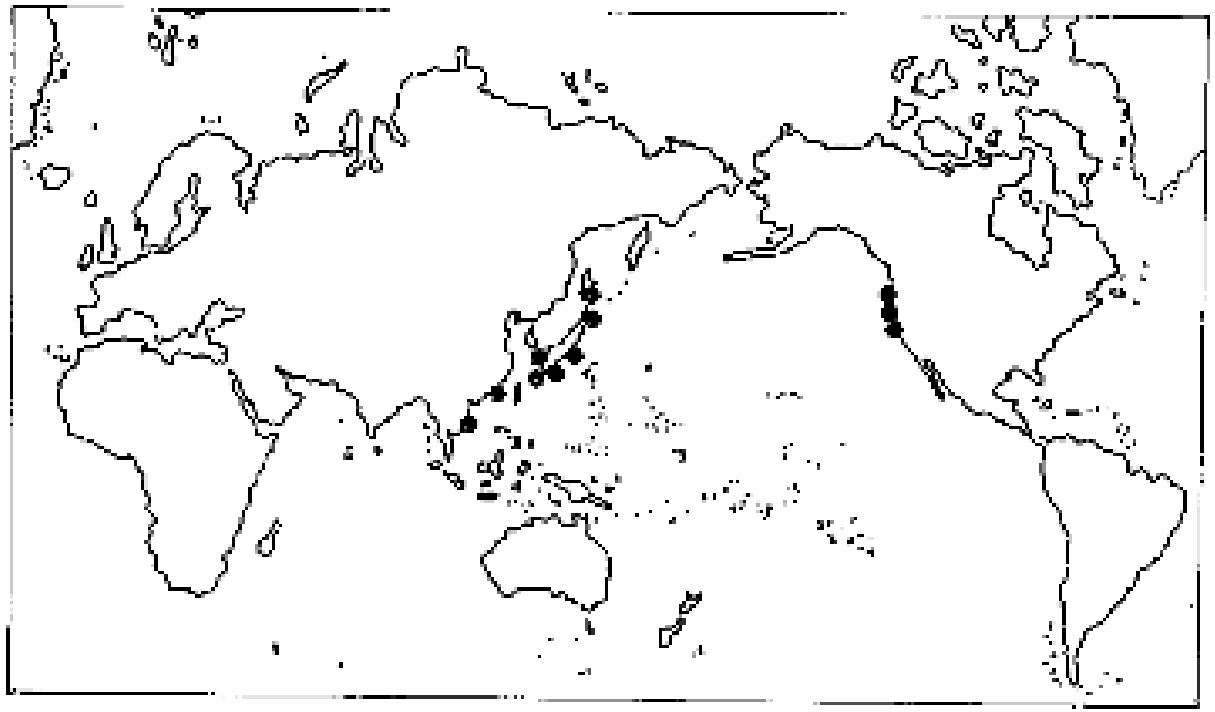
Zostera marina distribution

MAP 3
Zostera marina



Zostera japonica distribution

MAP 6
Zostera japonica

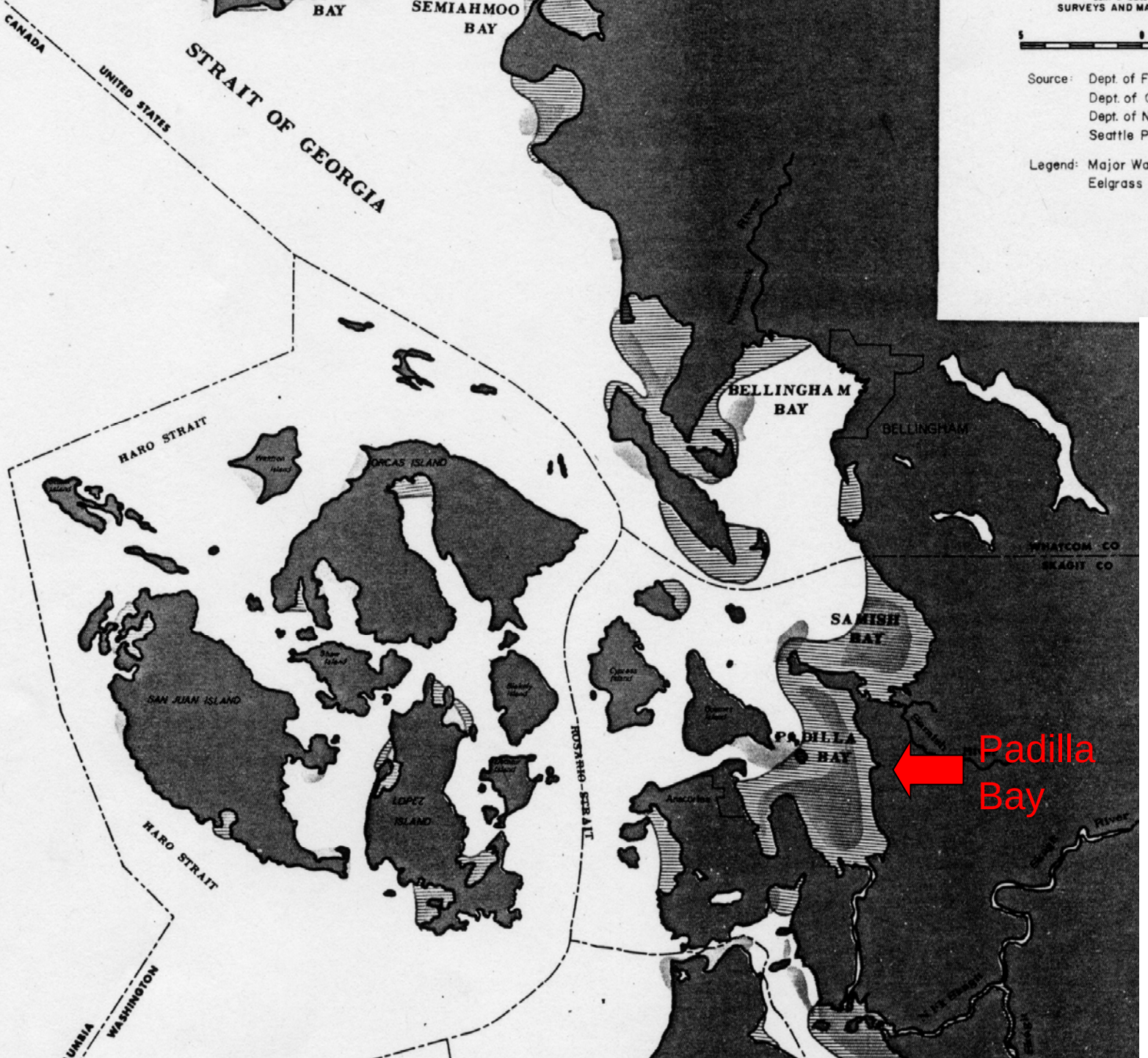


Importance of Eelgrass

- Provides food and/or shelter for:

- juvenile herring
- juvenile salmon
- Dungeness crab
- Black brant

Previous Mapping



Washington Marine Atlas

1974

Landsat 1986

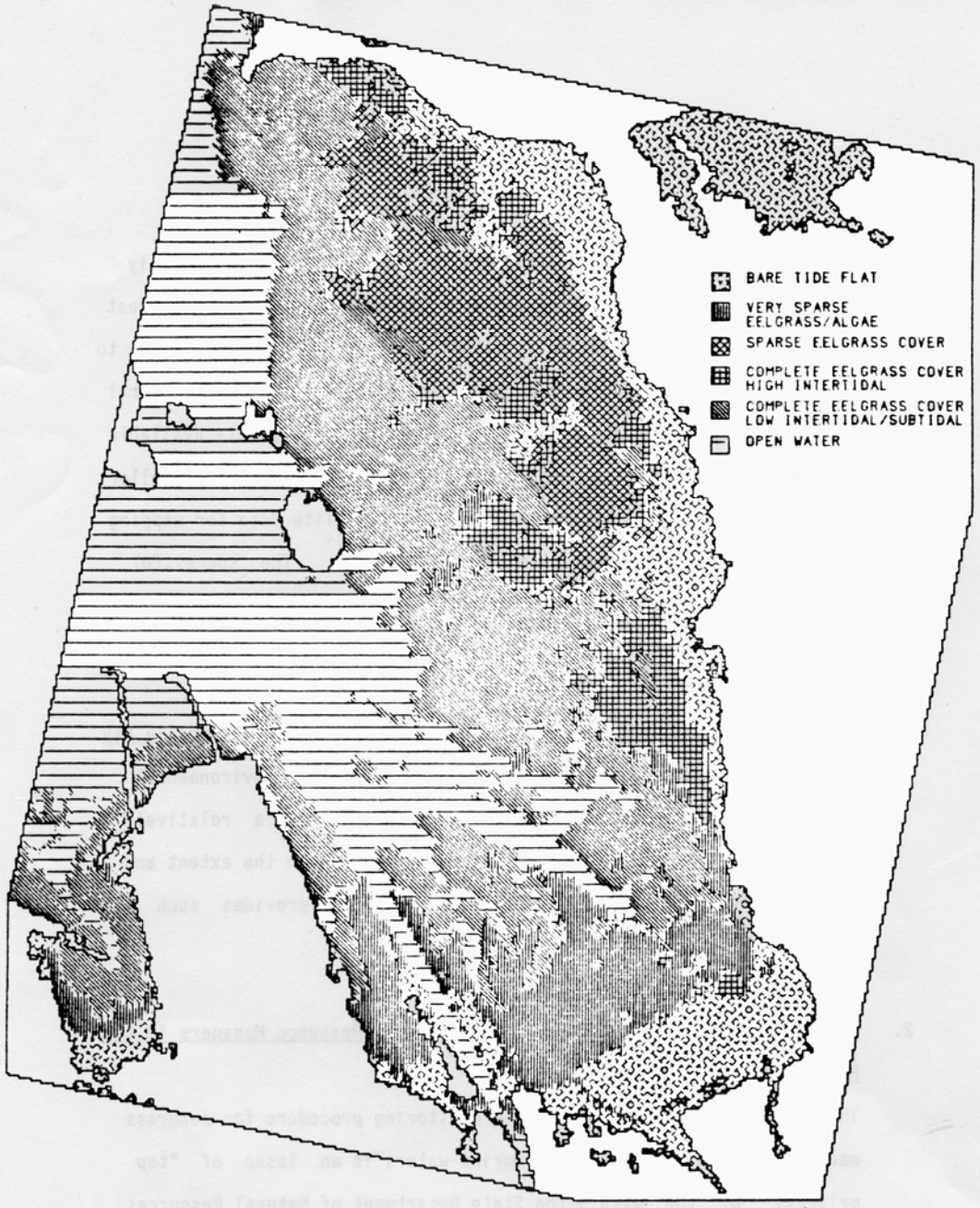


Figure 18

Black and white reduction of the 1:2,4000 map showing the distribution of seagrass cover types in Padilla Bay.

BARE TIDE FLAT
VERY SPARSE EELGRASS/ALGAE
SPARSE EELGRASS COVER
COMPLETE EELGRASS COVER HIGH INTERTIDAL
COMPLETE EELGRASS COVER LOW INTERTIDAL/SUBTIDAL
OPEN WATER

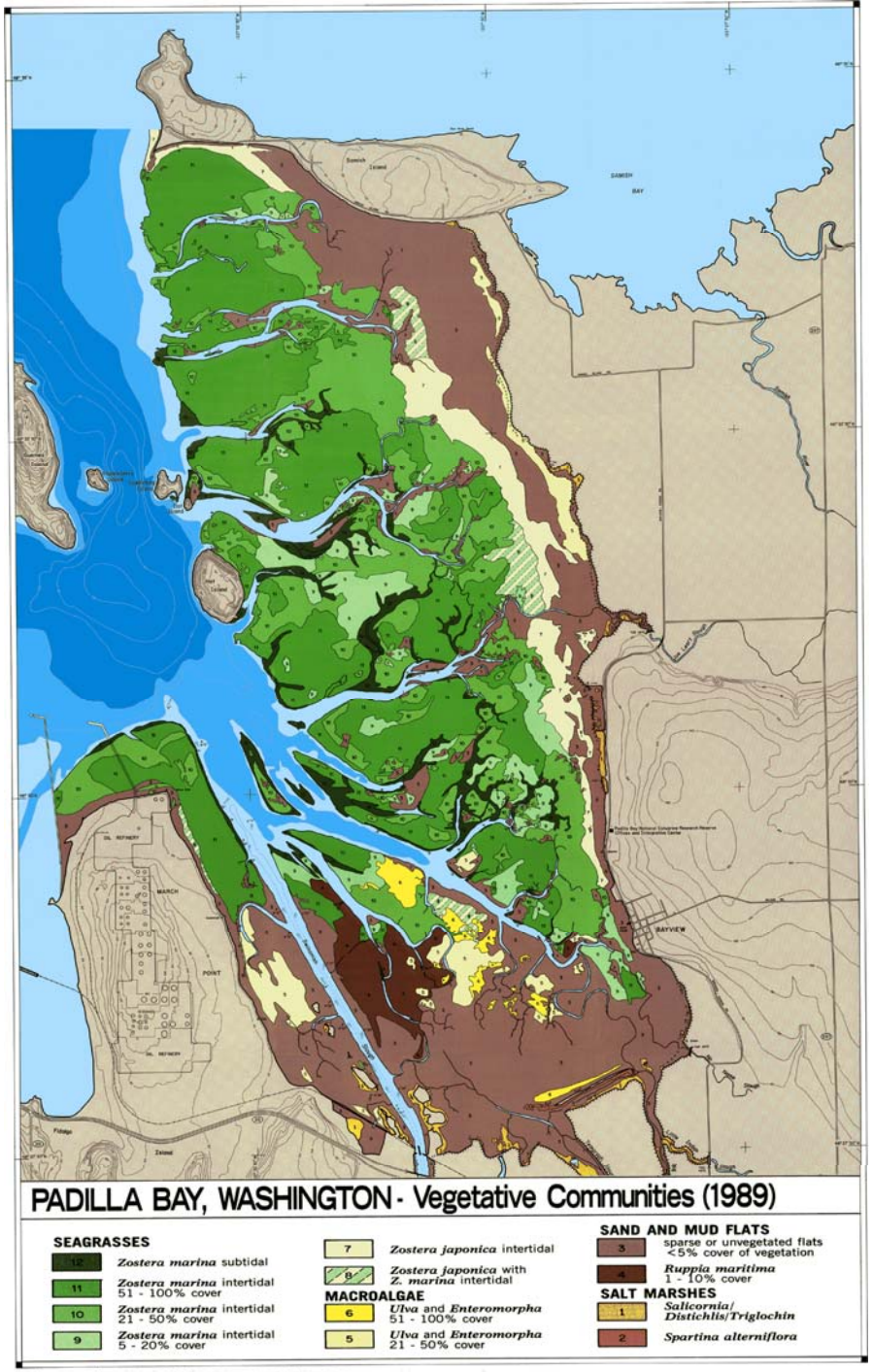
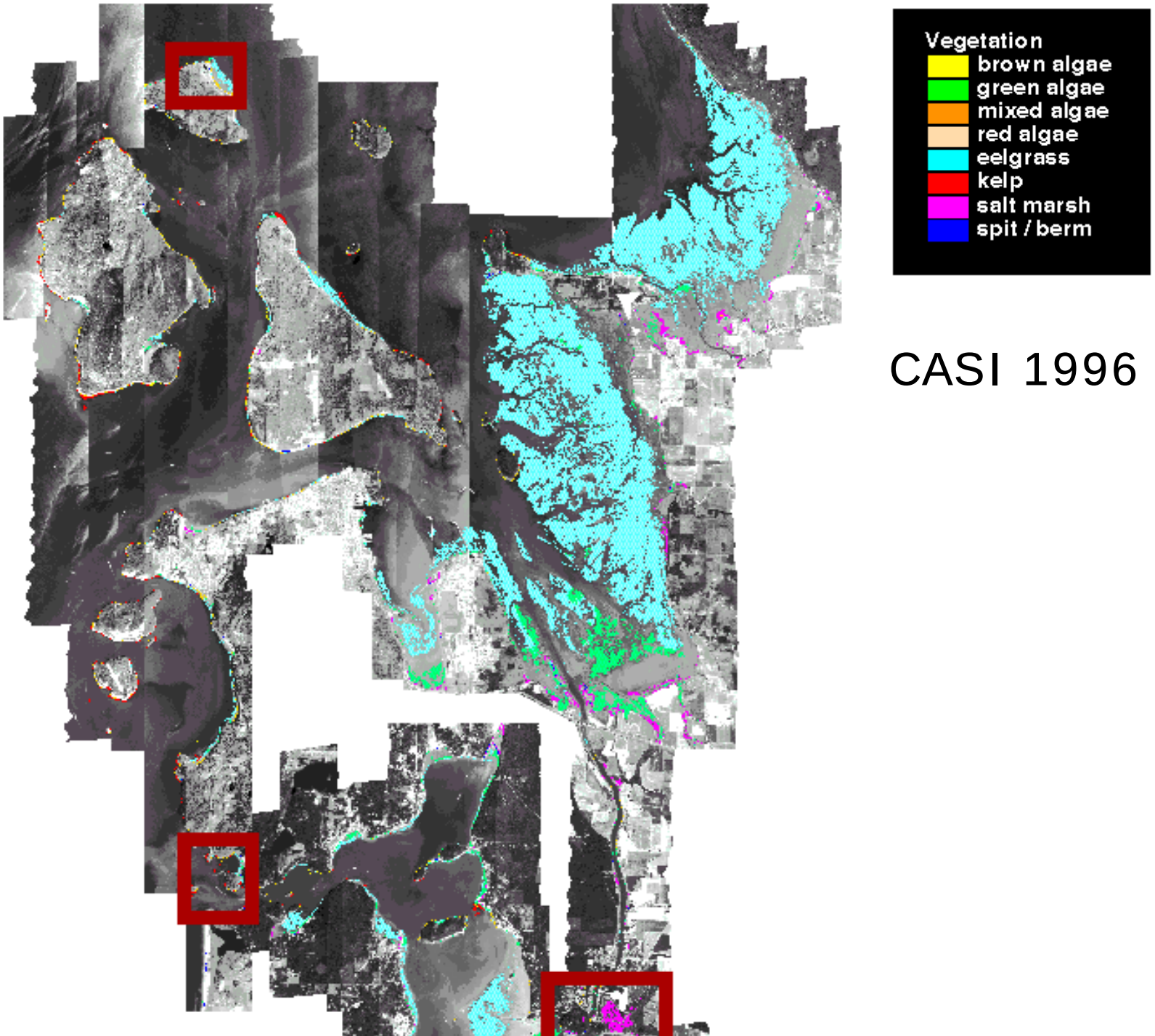


Figure 1. Padilla Bay Habitat Map.


Vegetation
brown algae
green algae
mixed algae
red algae
eelgrass
kelp
salt marsh
spit / berm

CASI 1996

Objectives in 2004

Methods for annual monitoring of distribution of SAV in Padilla Bay

SAV distribution in Padilla Bay in 2004

- Is Zostera japonica areal coverage increasing?
- Is there evidence of interannual variation?

Methods

Image acquisition: true color aerial photography

Image processing: an orthorectified photomosaic

Geodatabase and classification scheme in ArcGIS 9

Ground reference data collection

On-screen delineation

Change detection

Photo Specifications:

1:12K and 1:42K contact prints
30% Sidelap
60% Overlap
narrow tidal window

Orthophotography

June 4, 2004

-3.9’ Tide

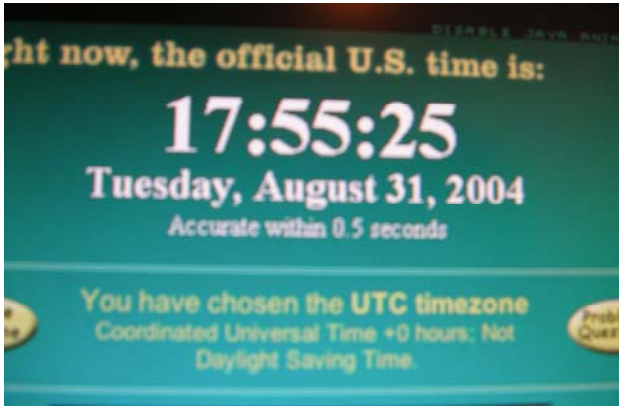
0.5’ resolution

Equipment:

- ArcGIS 9 (ESRI)
- Dual Xeon 2.66 GHz Processor
- Touchscreen display
- Dual monitor
- Trimble GeoXT & Garmin

Extensions:

- Red Hen Systems Pixpoint

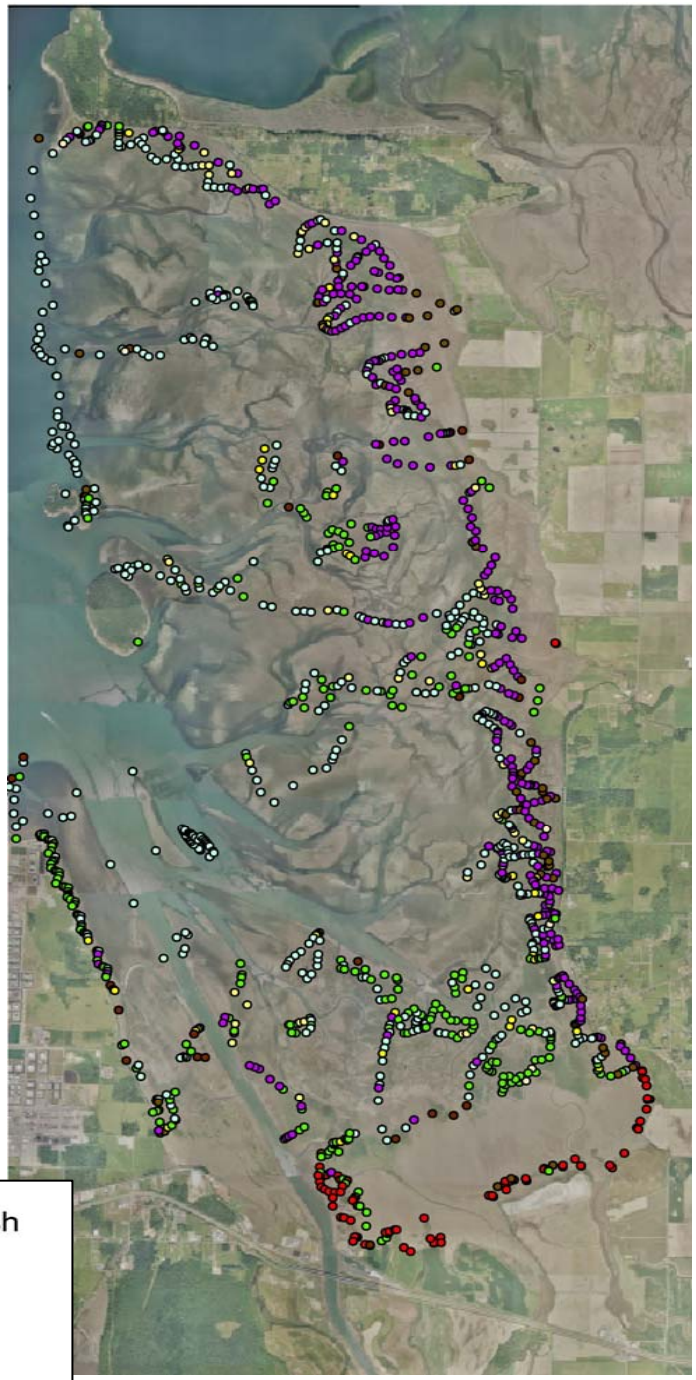


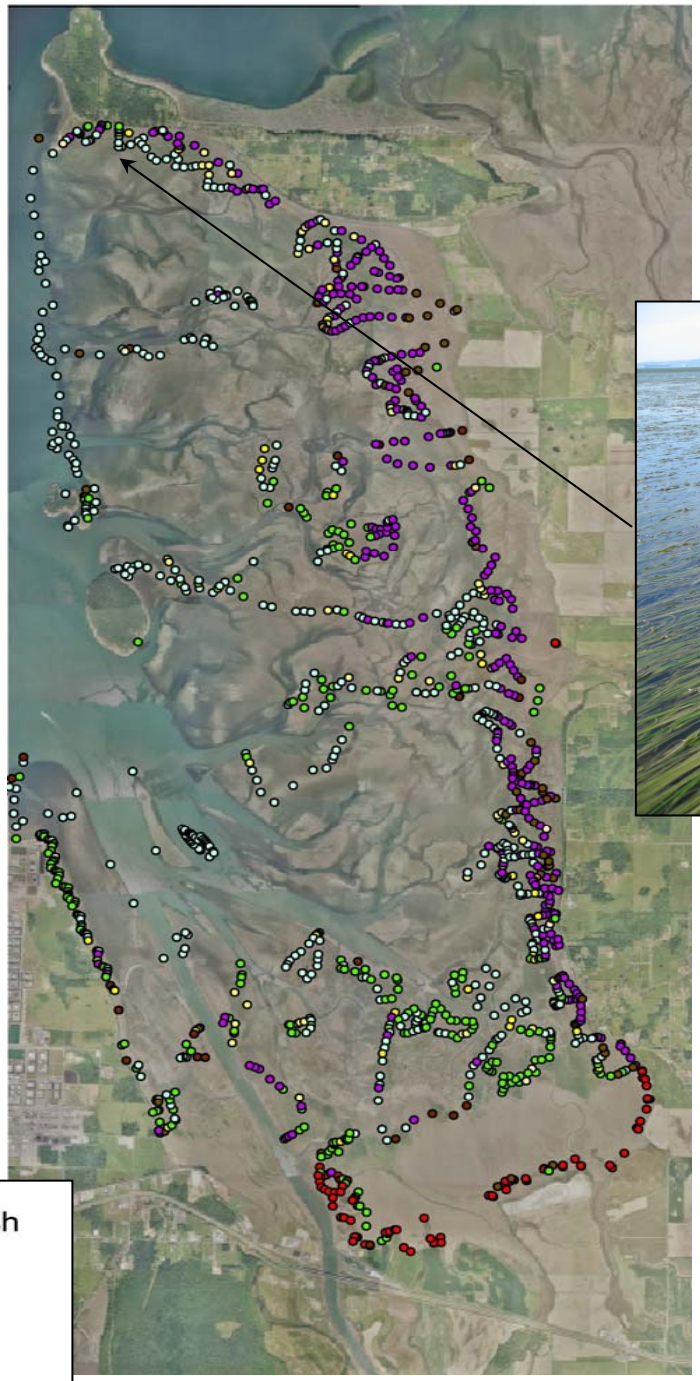
Groundtruth

Date	Time	Site	Observer	Lat._degre	Lat._minut	Lon._degre	Lon._minut	%_category	%_composit	Trans._vs.	Comments
20000731	930	G96	Karen Wetso	48	29	122	32	>10%	Mostly ZJ, some G. Al	WH	Patchy with large bare areas
20000731	931	G97	Karen Wetso	48	29	122	32	11-50%	mix of ZJ and ZM	WH	Even, thin cover, not as patchy as site 96
20000731	1030	G98	Karen Wetso	48	29	122	31		almost all ZJ	Transition	>10% to the west, 51-100% to east, transition with bare to west and ZJ < 50% to east
20000731	1033	G99	Karen Wetso	48	29	122	31	51-100	100% ZJ	WH	90% cover
20000731	1040	G100	Karen Wetso	48	29	122	31	51-100	60% Ulva, 40% Entero.	WH	much softer sediment than previous sites, lots of sediment on top of algae
20000731	1043	G101	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	algae about 3 inches deep with ZM floating on surface
20000731	1055	G102	Karen Wetso	48	29	122	31	51-100	80% ZM, 20% G. Algae	WH	90% cover, strip of ZM along channel about 30-40 meters wide from site 101 to 102
20000731	1100	G103	Karen Wetso	48		122					Edge of channel, west edge in line with north edge of channel flowing east
20000731	1105	G104	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	Similar to site 101
20000731	1112	G105	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	Same as site 101
20000731	1120	G106	Karen Wetso	48	29	122	32	51-100	80% Ent., 20% ZM	WH	
20000731	1126	G107	Karen Wetso	48	29	122	32	Full Cover	90% ZM, 10% G. Algae	WH	
20000731	1135	G108	Karen Wetso	48	29	122	32				Marking channel that comes out by channel marker #18, on east shore by tributary channe
20000731	1145	G109	Karen Wetso	48	29	122	32	Full Cover	70% ZM, 30% G. Algae	WH	Meter long ZM
20000731	1150	G110	Karen Wetso	48	29	122	32	Full Cover	60% ZM, 40% G&B Algae	WH	Meter long ZM, midway between 2 channels
20000731	1155	G111	Karen Wetso	48	29	122	32			Transition	Transition between site 110 type and site 112 type
20000731	1157	G112	Karen Wetso	48	29	122	32	Full Cover	100% Ulva	WH	about 4 inches deep
20000731	1203	G113	Karen Wetso	48	29	122	31			Transition	West is similar to site 112, east is 100% cover w/ 90% ZM(1m tall), appears same to ch
20000731	1207	G114	Karen Wetso	48	29	122	31			Transition	To south and east is full cover tall ZM, west and toward Hat Island is like site 112
20000731	1215	G115	Karen Wetso	48	29	122	31			Transition	wider than other places, tall full cover ZM to east and Ulva to west
20000731	110	G116	Karen Wetso	48	29	122	32	11-50%	mixed ZM, ZJ and bare		Marking edge of Swinomish channel between Edna 6 and site, strip about 30-40ft wide, an
20000731	120	G117	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	Even, thin covering of ZJ
20000731	124	G118	Karen Wetso	48	28	122	31			Transition	Similar to site 117 to line west and bare to east, SE appears very bare, north looks pa
20000731	130	G119	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	East of 119 bare band about 30 meters wide on channel edge
20000731	140	G120	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	90% cover, occasional green algae
20000731	147	G121	Karen Wetso	48	28	122	31	11-50%	75% G. Algae, 25% ZM	WH	
20000731		G122	Karen Wetso	48	28	122	31	Full Cover	60% ZM, 40% G. Algae	WH	ZM tall (about 1 meter), green algae is Ulva and Enteromorpha
20000731	157	G123	Karen Wetso	48	28	122	31				Junction of tributary channel

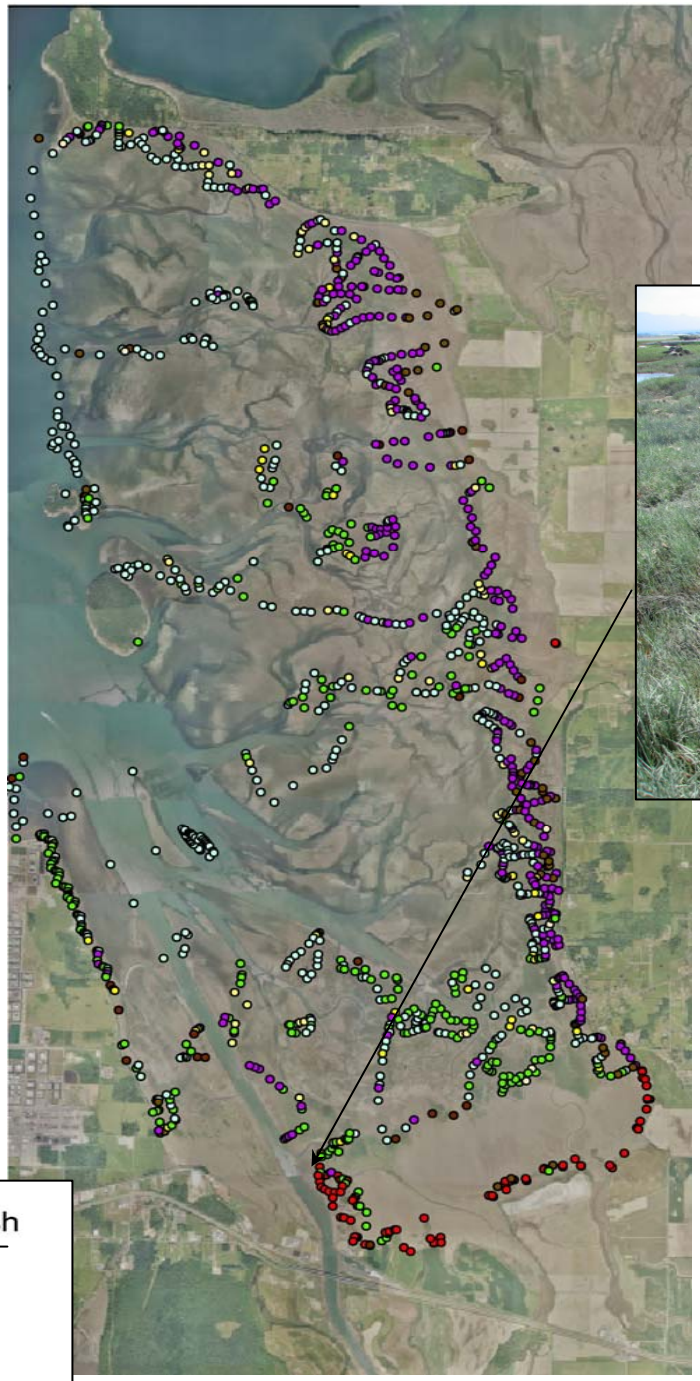
% Category	% Composition	Trans. Vs. WH	Comments
>10%	Mostly ZJ, some G. Algae	WH	Patchy with large bare areas
11-50%	mix of ZJ and ZM	WH	Even, thin cover, not as patchy as site 96
	almost all ZJ	Transition	>10% to the west, 51-100% to east, transition with bare to w
51-100	100% ZJ	WH	90% cover
51-100	60% Ulva, 40% Entero.	WH	much softer sediment than previous sites, lots of sediment c
Full Cover	10% ZM, 45/45 Ulva/Ent.	WH	algae about 3 inches deep with ZM floating on surface

1360 Sites

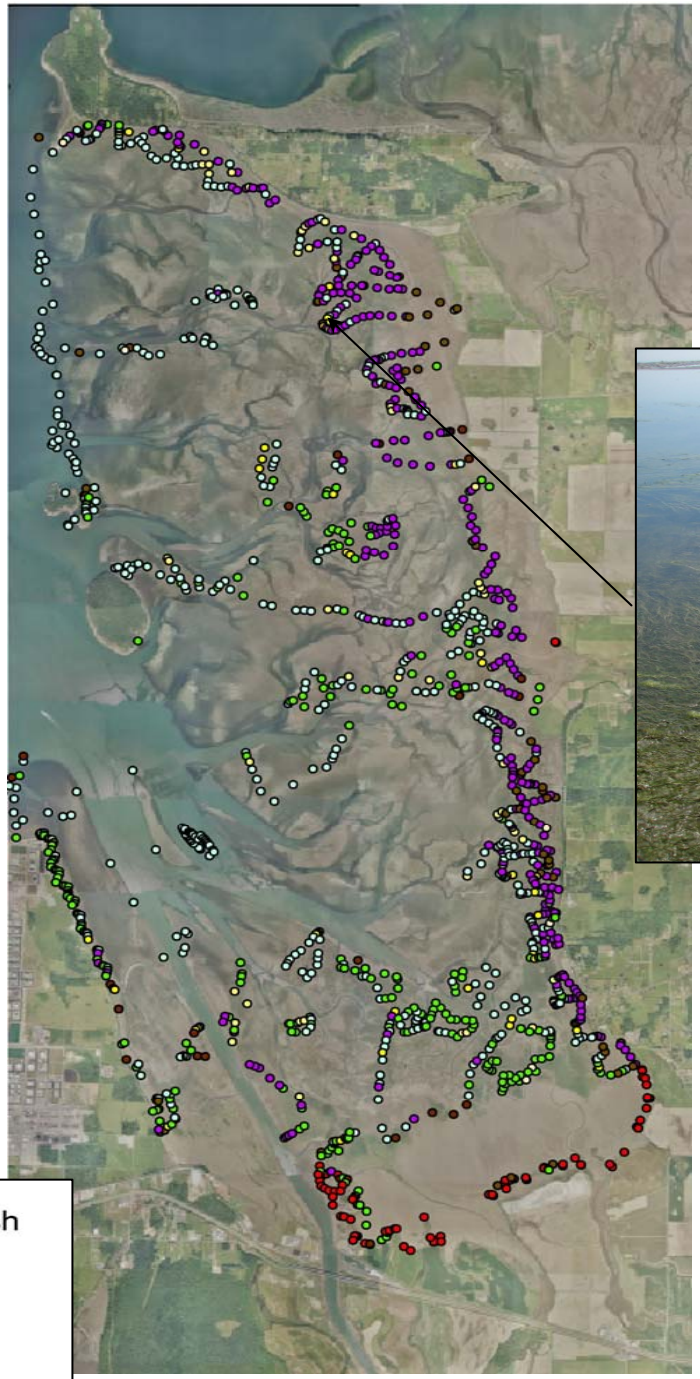

Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare

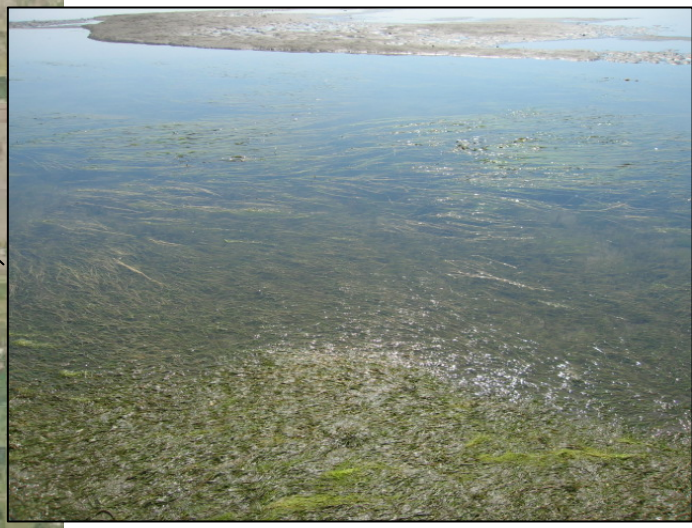

Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare

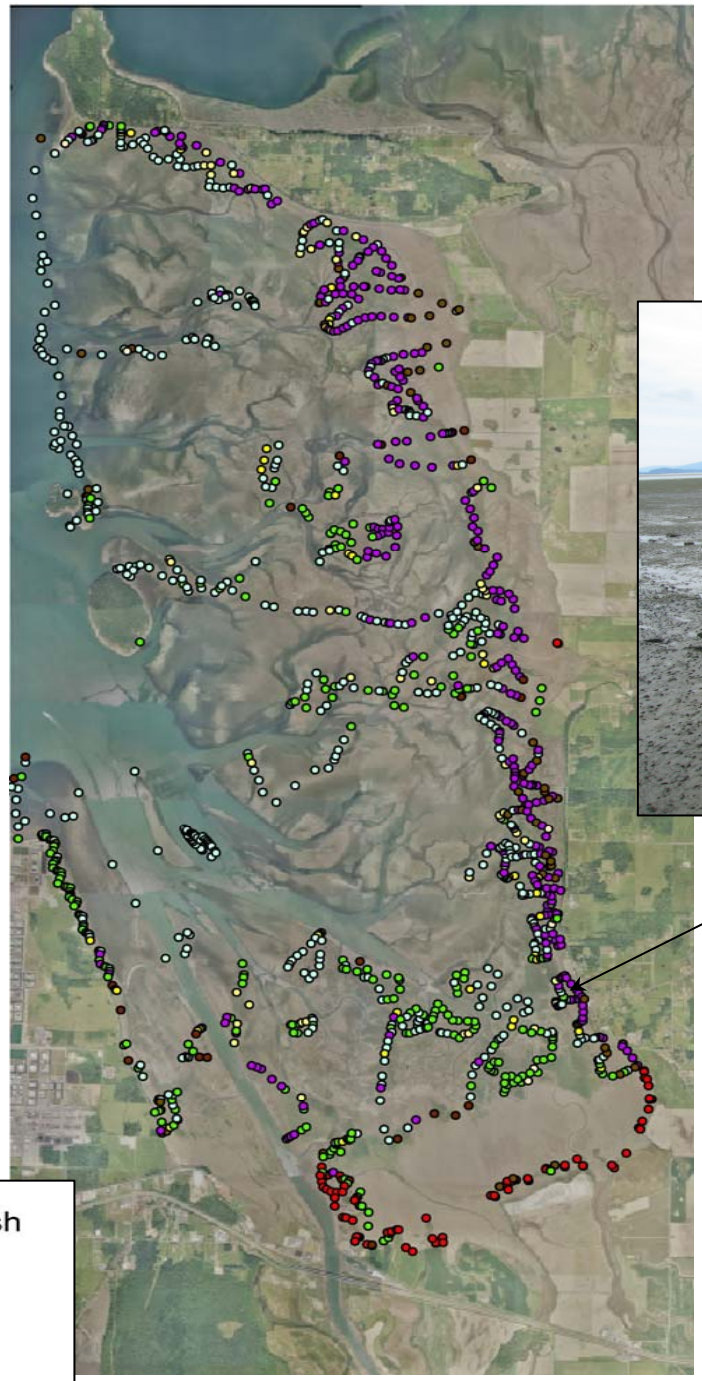
Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare



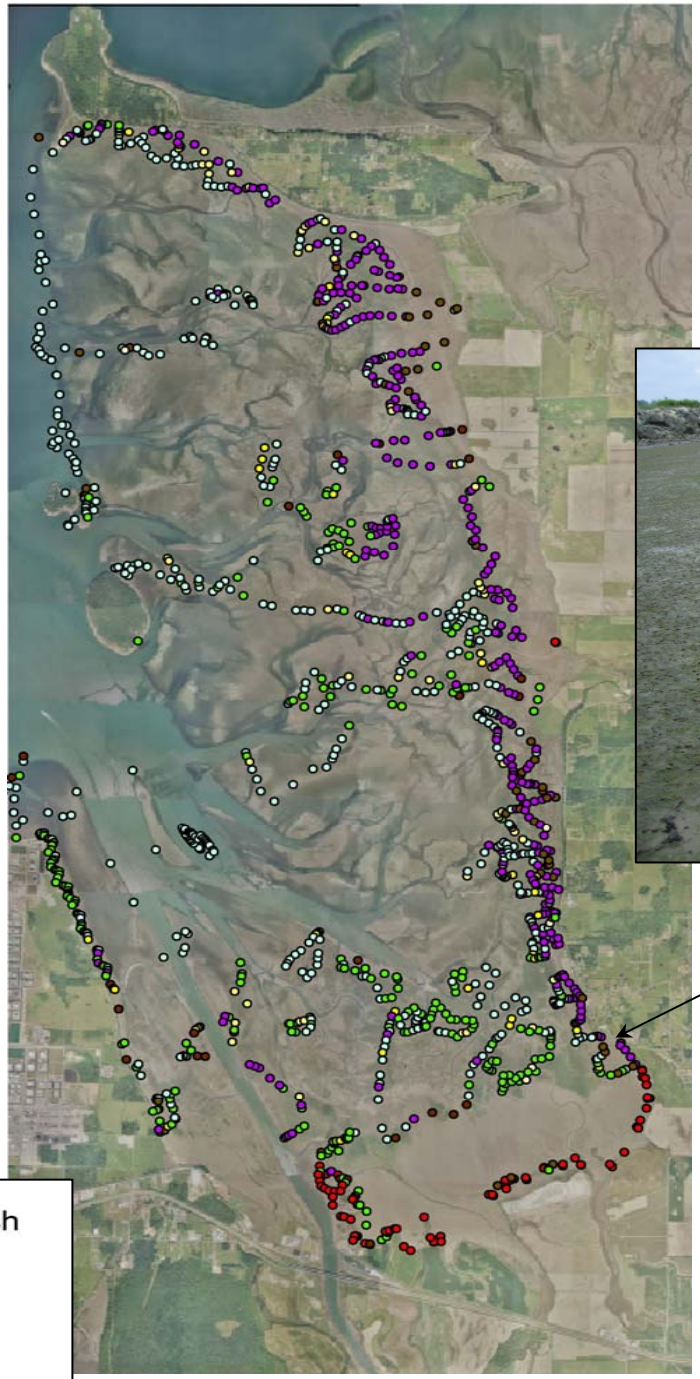
Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare


Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare





Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare


Z. marina
Z. japonica
Algae
Mixed
Salt Marsh
<=10%
Bare

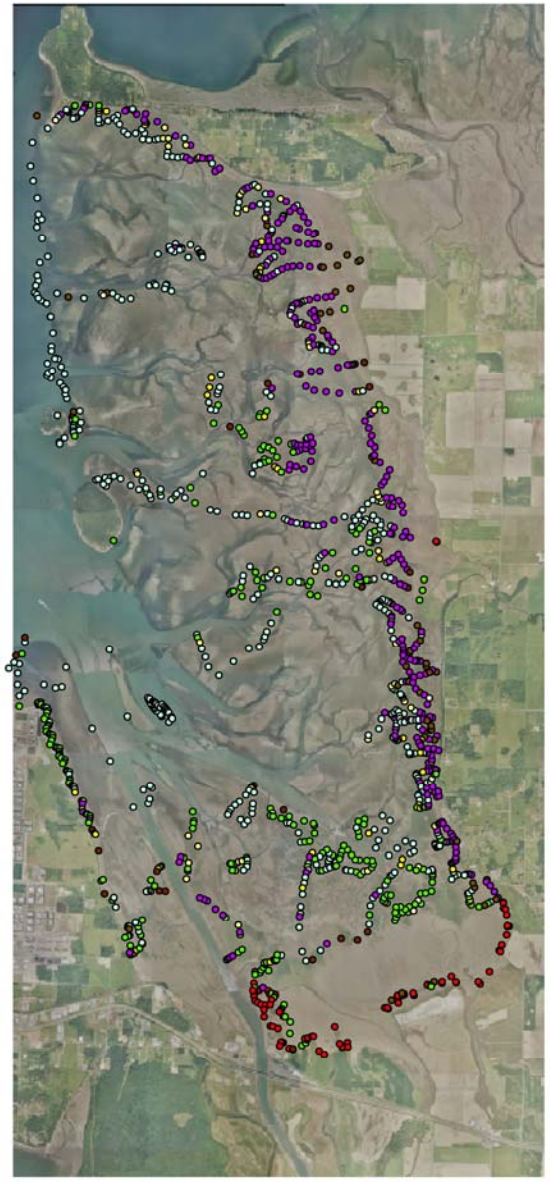
Random Point Selection

- Z. marina
- Z. japonica
- Macroalgae
- Bare
- Saltmarsh

20 points per category excluding Transition sites

2004

1360 Ground Reference Sites



100 Accuracy Assessment Sites

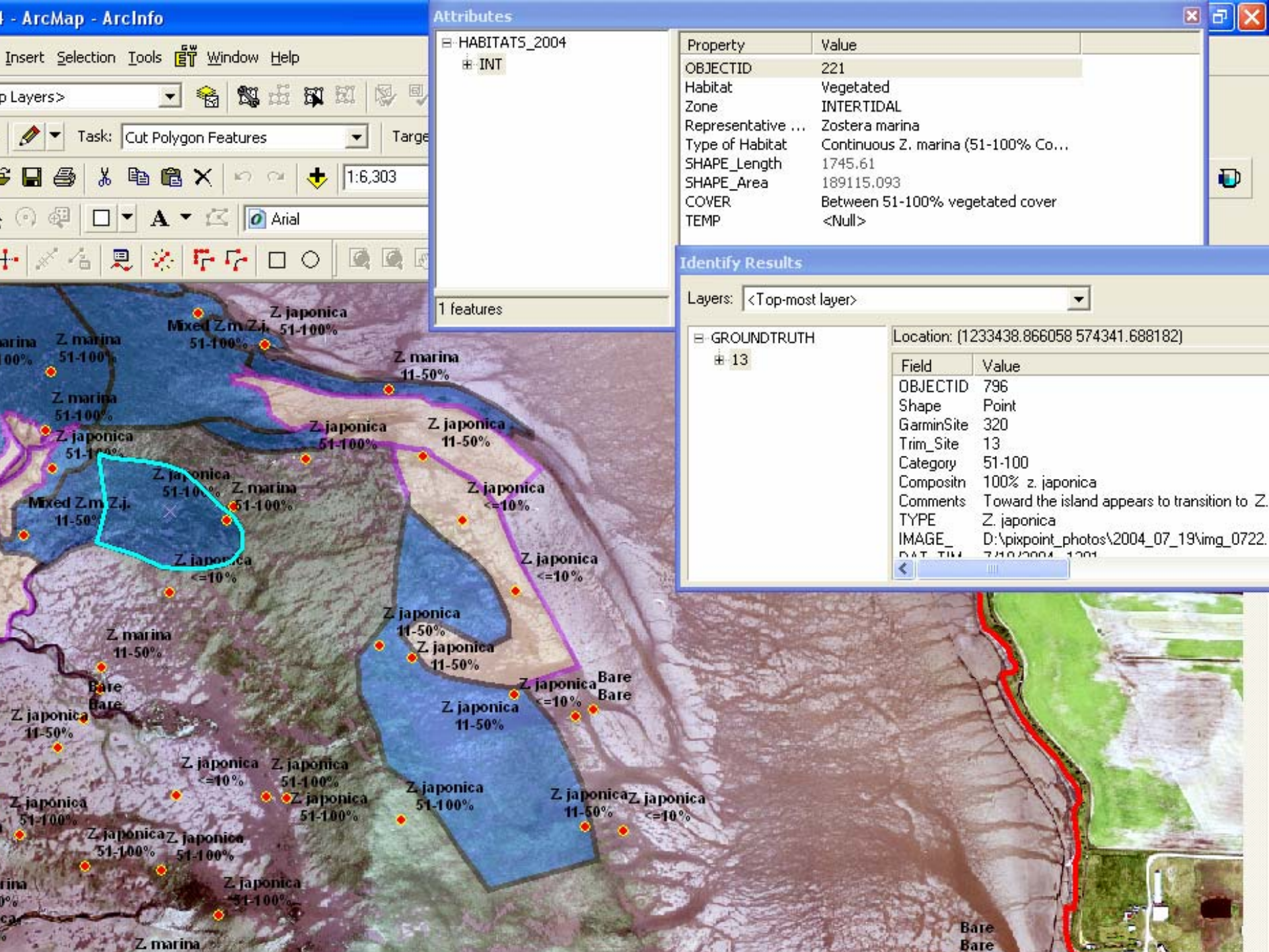
Geodatabase

- Schema
  - Subtypes
  - Domains

Based Habitat Digitizer Extension
by James Byrne (NOAA)

- Topology Rules
  - Must Not Overlap
  - Must Not Have Gaps

- Snapping Rules
  - Snap to shoreline layer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Insert Selection Tools Window Help
Task: Cut Polygon Features
1:6,303
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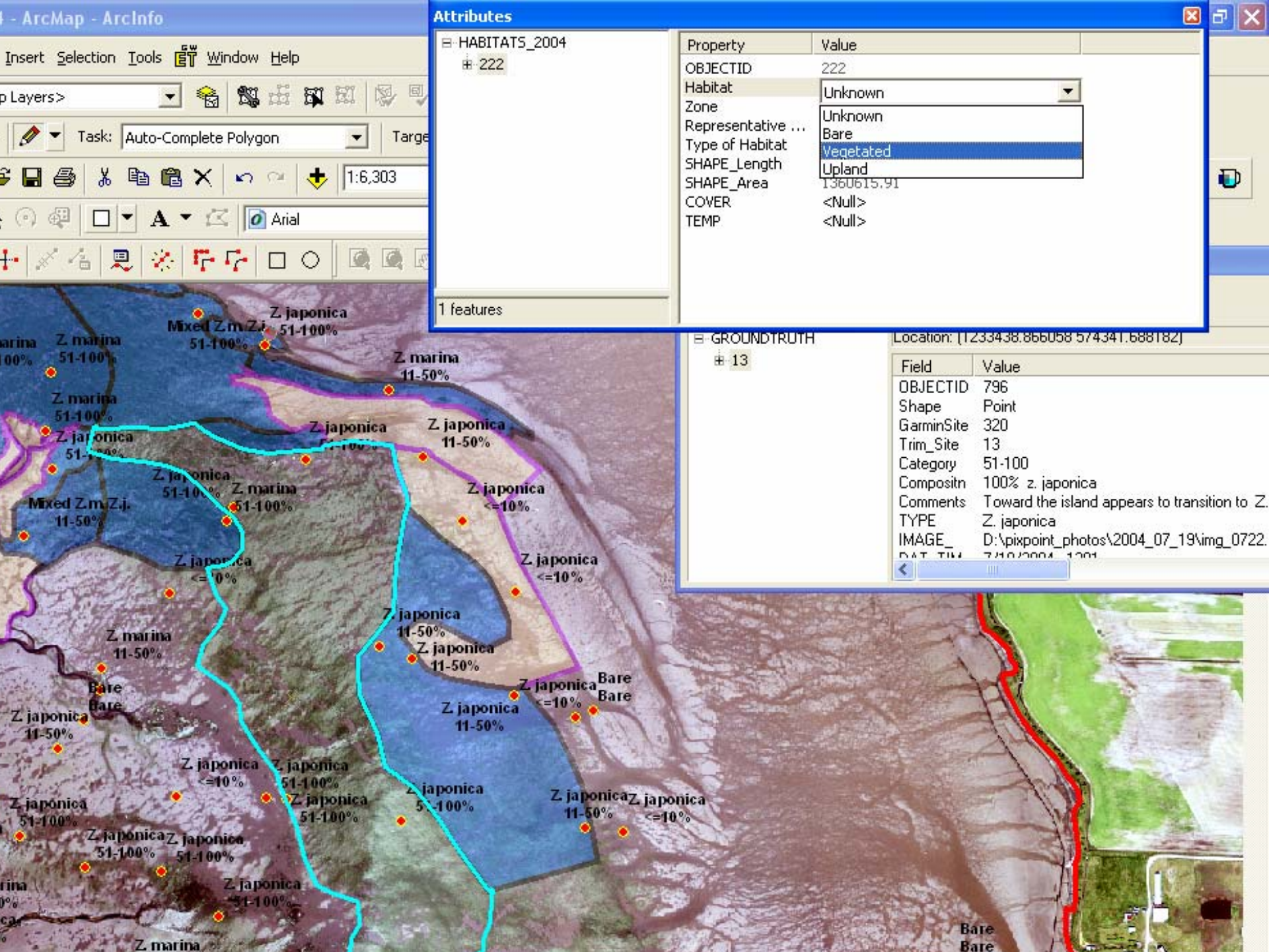
INT
1 features
Property Value
OBJECTID 221
Habitat Vegetated
Zone INTERTIDAL
Representative ... Zostera marina
Type of Habitat Continuous Z. marina (51-100% Co...
SHAPE_Length 1745.61
SHAPE_Area 189115.093
COVER Between 51-100% vegetated cover
TEMP <Null>
Identify Results
Layers: <Top-most layer>
GROUNDTRUTH
13
Location: (1233438.866058 574341.688182)
Field Value
OBJECTID 796
Shape Point
GarminSite 320
Trim_Site 13
Category 51-100
Compositn 100% z. japonica
Comments Toward the island appears to transition to Z.
TYPE Z. japonica
IMAGE_ D:\pixpoint_photos\2004_07_19\img_0722.
Z. japonica 51-100%
Z. marina 51-100%
Z. marina 11-50%
Z. japonica 11-50%
Z. japonica <=10%
Mixed Z.m/Z.j. 11-50%
Bare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222
1 features
Property Value
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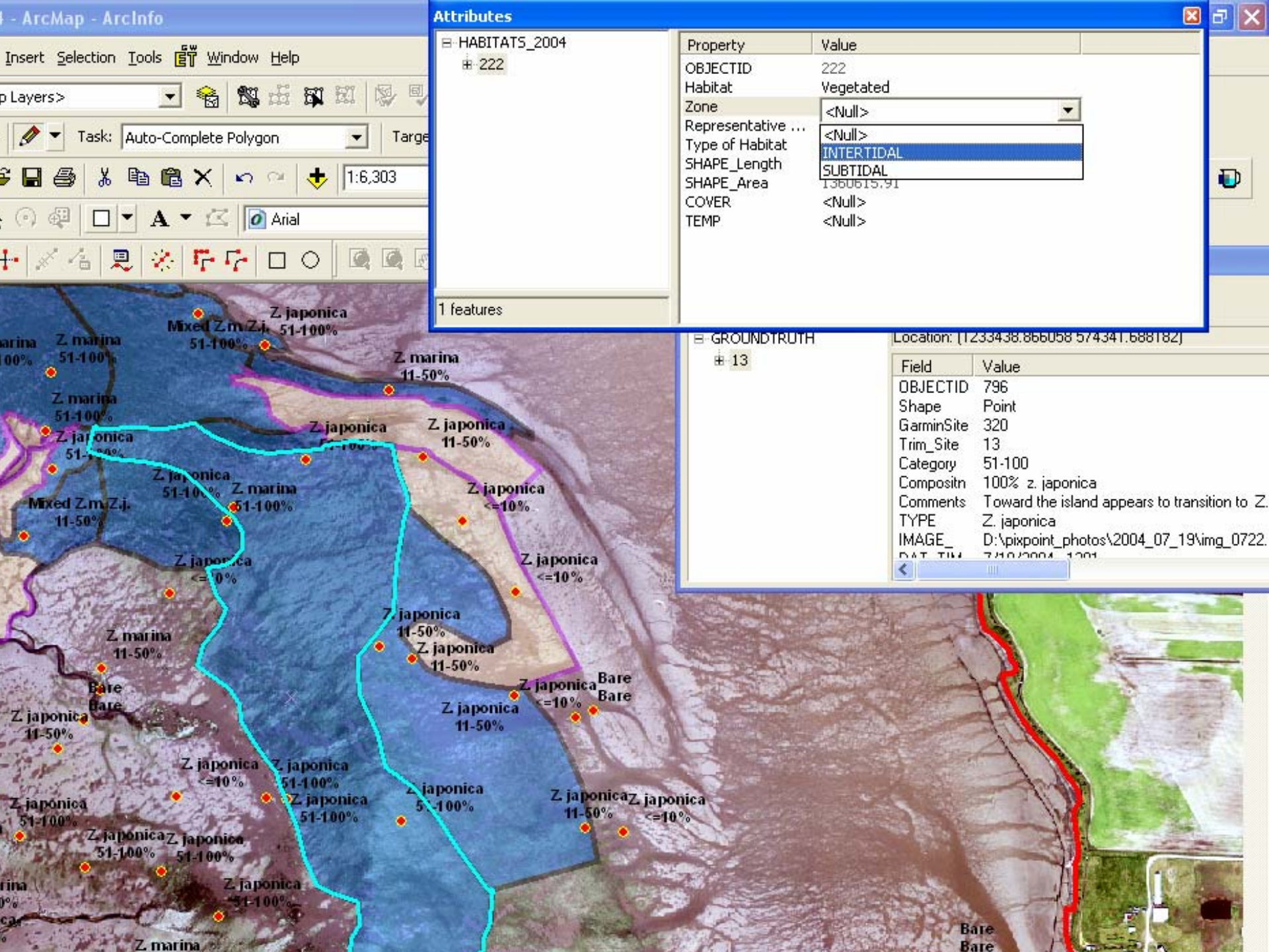
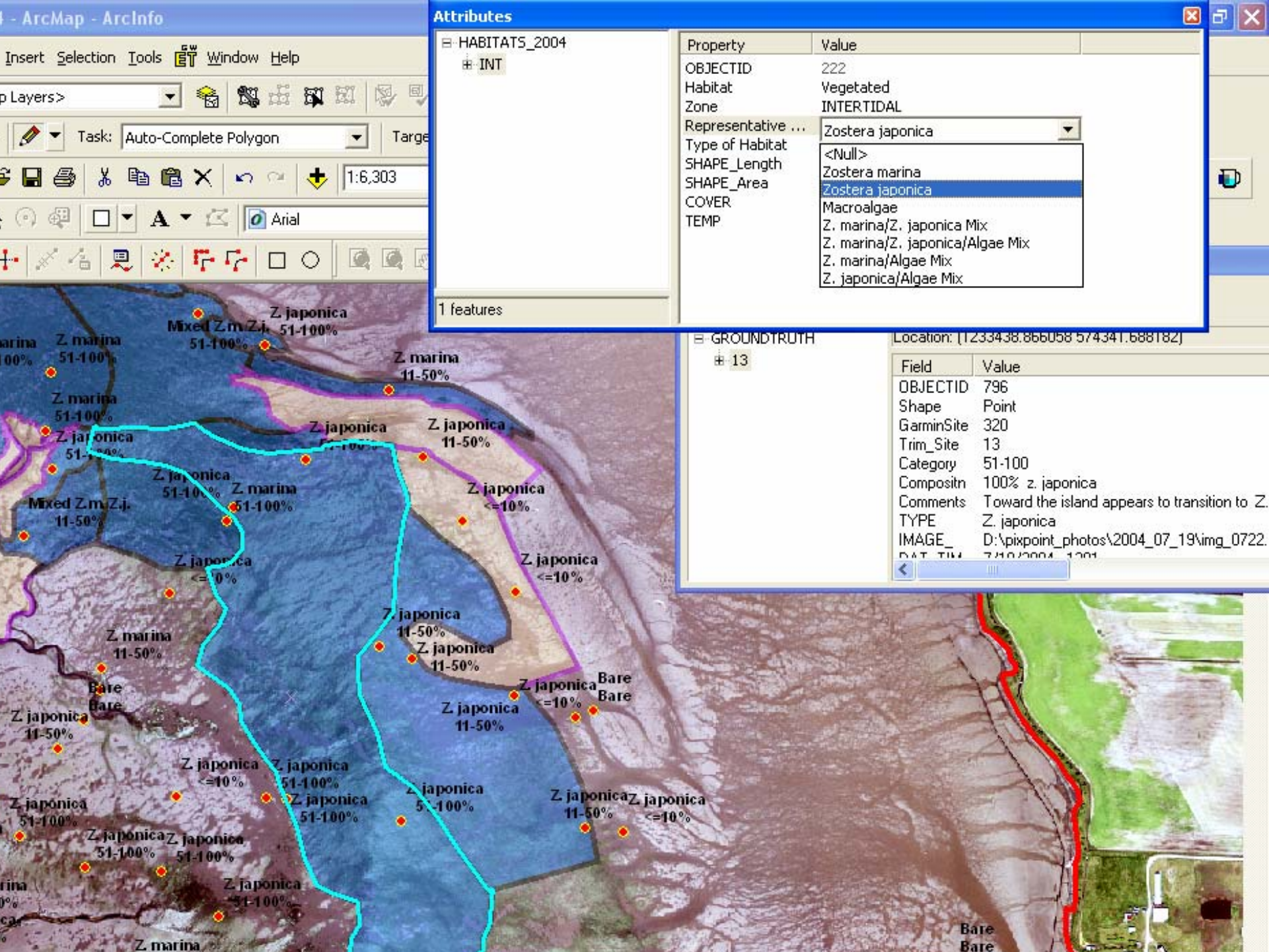
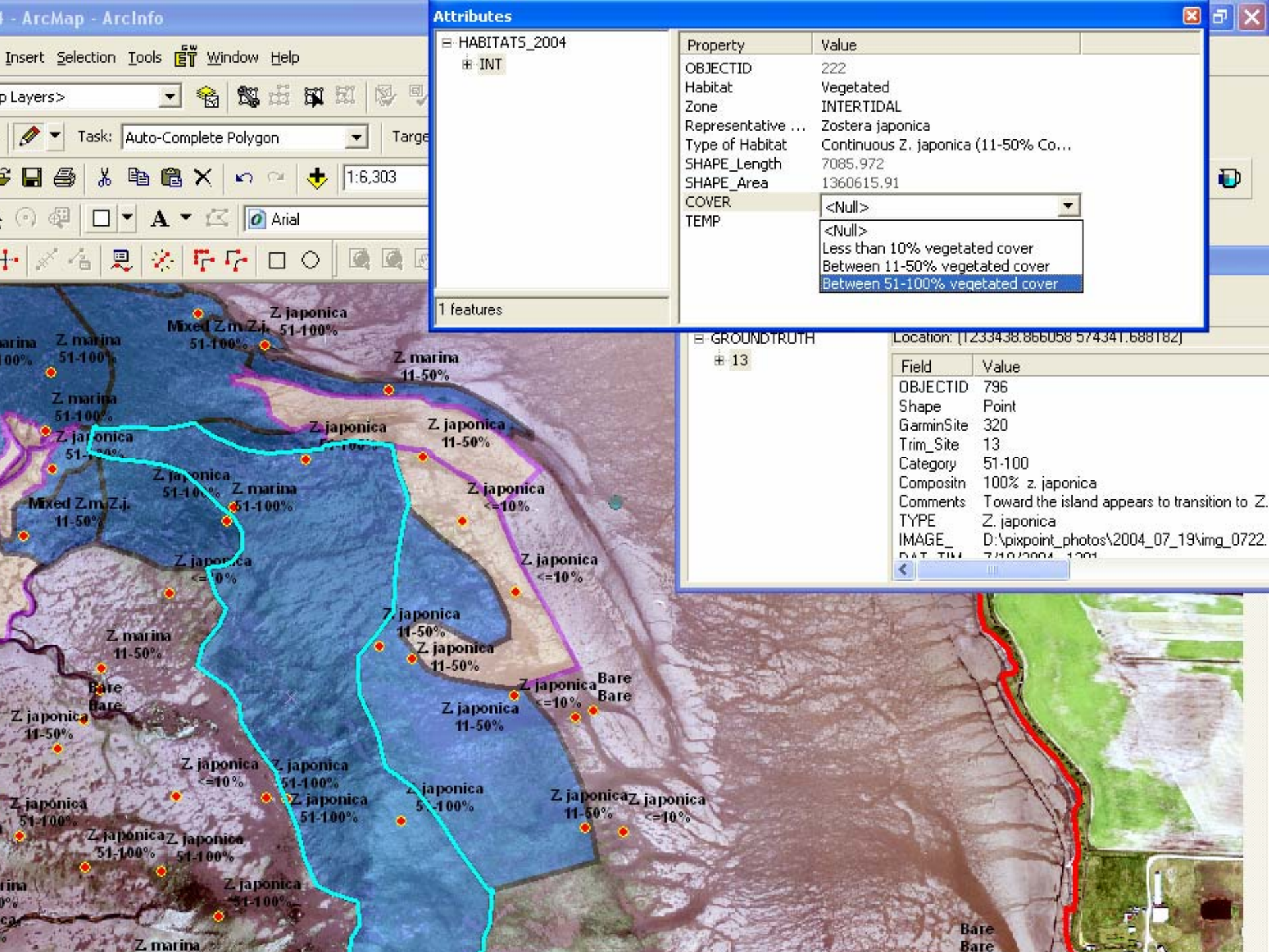
Zone
Representative ...
Type of Habitat
SHAPE_Length
SHAPE_Area 1360615.91
COVER <Null>
TEMP <Null>
Unknown
Bare
Vegetated
Upland
GROUNDTRUTH
13
Location: (1233438.866058 574341.688182)
Field Value
OBJECTID 796
Shape Point
GarminSite 320
Trim_Site 13
Category 51-100
Compositn 100% z. japonica
Comments Toward the island appears to transition to Z.
TYPE Z. japonica
IMAGE_ D:\pixpoint_photos\2004_07_19\img_0722.
Z. marina 51-100%
Z. japonica 51-100%
Mixed Z.m/Z.j. 11-50%
Z. marina 11-50%
Z. japonica 11-50%
Z. japonica <=10%
Bare
Z. marina


- ArcMap - ArcInfo
Insert Selection Tools Window Help
Task: Auto-Complete Polygon
1:6,303
Arial
Attributes
HABITATS_2004
222
1 features
Property Value
OBJECTID 222
Habitat Vegetated
Zone <Null>
Representative ... <Null>
Type of Habitat INTERTIDAL
SHAPE_Length SUBTIDAL
SHAPE_Area 1360615.91
COVER <Null>
TEMP <Null>
GROUNDTRUTH
13
Location: (1233438.866058 574341.688182)
Field Value
OBJECTID 796
Shape Point
GarminSite 320
Trim_Site 13
Category 51-100
Compositn 100% z. japonica
Comments Toward the island appears to transition to Z.
TYPE Z. japonica
IMAGE_ D:\pixpoint_photos\2004_07_19\img_0722.
Z. japonica 51-100%
Z. marina 51-100%
Mixed Z.m/Z.j. 51-100%
Z. marina 11-50%
Z. japonica 11-50%
Z. japonica <=10%
Mixed Z.m/Z.j. 11-50%
Z. marina 11-50%
Bare


- ArcMap - ArcInfo
Insert Selection Tools Window Help
Task: Auto-Complete Polygon
1:6,303
Arial
Attributes
HABITATS_2004
INT
1 features
Property Value
OBJECTID 222
Habitat Vegetated
Zone INTERTIDAL
Representative ... Zostera japonica
Type of Habitat
SHAPE_Length
SHAPE_Area
COVER
TEMP
<Null>
Zostera marina
Zostera japonica
Macroalgae
Z. marina/Z. japonica Mix
Z. marina/Z. japonica/Algae Mix
Z. marina/Algae Mix
Z. japonica/Algae Mix
GROUNDTRUTH
13
Location: (1233438.866058 574341.688182)
Field Value
OBJECTID 796
Shape Point
GarminSite 320
Trim_Site 13
Category 51-100
Compositn 100% z. japonica
Comments Toward the island appears to transition to Z.
TYPE Z. japonica
IMAGE_ D:\pixpoint_photos\2004_07_19\img_0722.
Z. japonica 51-100%
Z. marina 51-100%
Mixed Z.m/Z.j. 51-100%
Z. marina 11-50%
Z. japonica 11-50%
Z. japonica <=10%
Mixed Z.m/Z.j. 11-50%
Z. marina 11-50%
Bare
Z. japonica 11-50%
Z. japonica <=10%
Z. japonica 51-100%
Z. japonica 11-50%
Z. japonica <=10%
Z. marina


- ArcMap - ArcInfo
Insert Selection Tools Window Help
Task: Auto-Complete Polygon
1:6,303
Arial
Attributes
HABITATS_2004
INT
1 features
Property Value
OBJECTID 222
Habitat Vegetated
Zone INTERTIDAL
Representative ... Zostera japonica
Type of Habitat Continuous Z. japonica (11-50% Co...
SHAPE_Length 7085.972
SHAPE_Area 1360615.91
COVER <Null>
TEMP
<Null>
Less than 10% vegetated cover
Between 11-50% vegetated cover
Between 51-100% vegetated cover
GROUNDTRUTH
13
Location: (1233438.866058 574341.688182)
Field Value
OBJECTID 796
Shape Point
GarminSite 320
Trim_Site 13
Category 51-100
Compositn 100% z. japonica
Comments Toward the island appears to transition to Z.
TYPE Z. japonica
IMAGE_ D:\pixpoint_photos\2004_07_19\img_0722.
Z. japonica 51-100%
Z. marina 51-100%
Mixed Z.m./Z.j. 51-100%
Z. marina 11-50%
Z. japonica 11-50%
Mixed Z.m./Z.j. 11-50%
Z. japonica <=10%
Z. marina 11-50%
Bare
Z. japonica 11-50%
Z. japonica <=10%
Z. japonica 51-100%
Z. japonica 11-50%
Z. japonica <=10%

Results

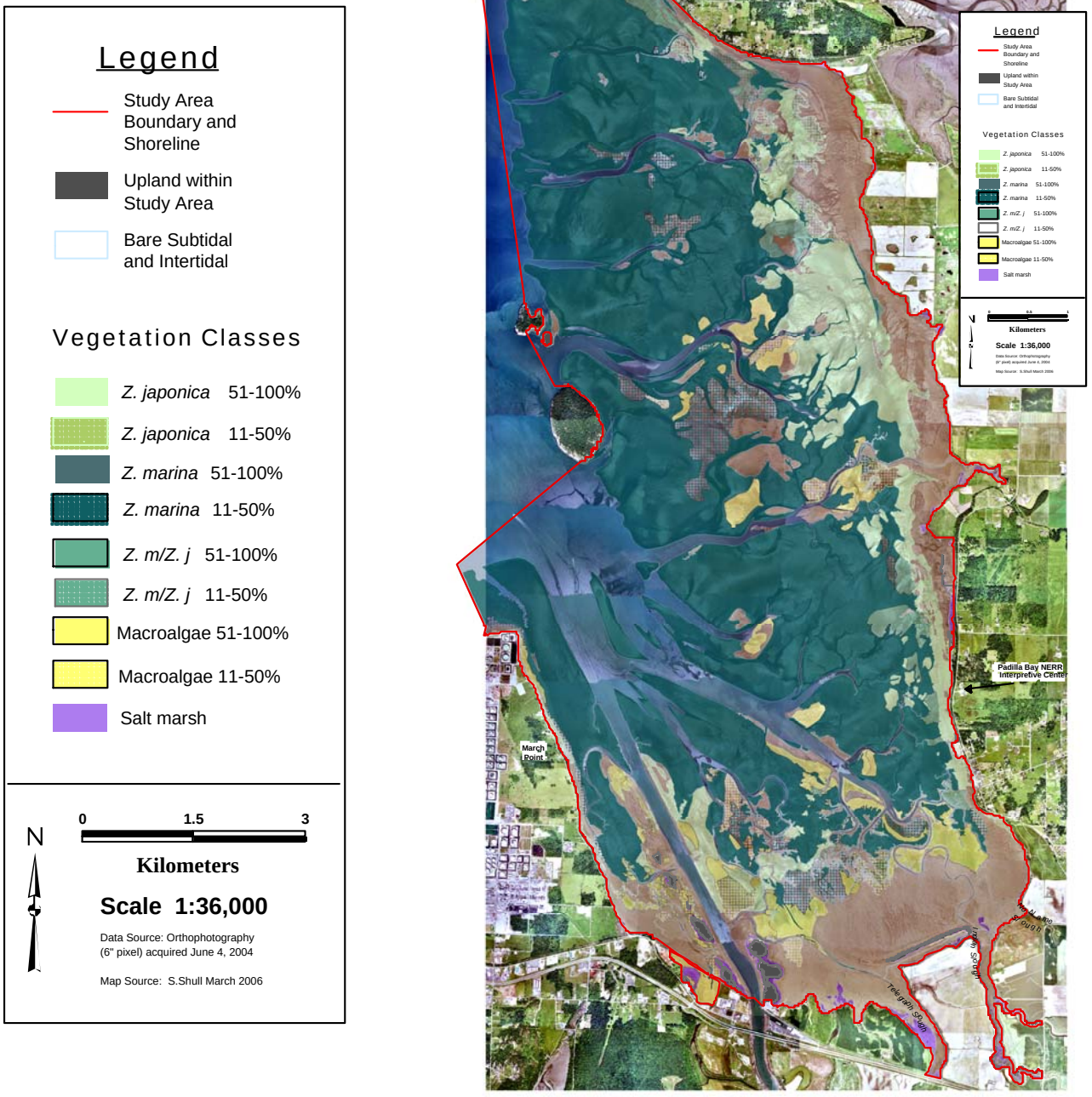
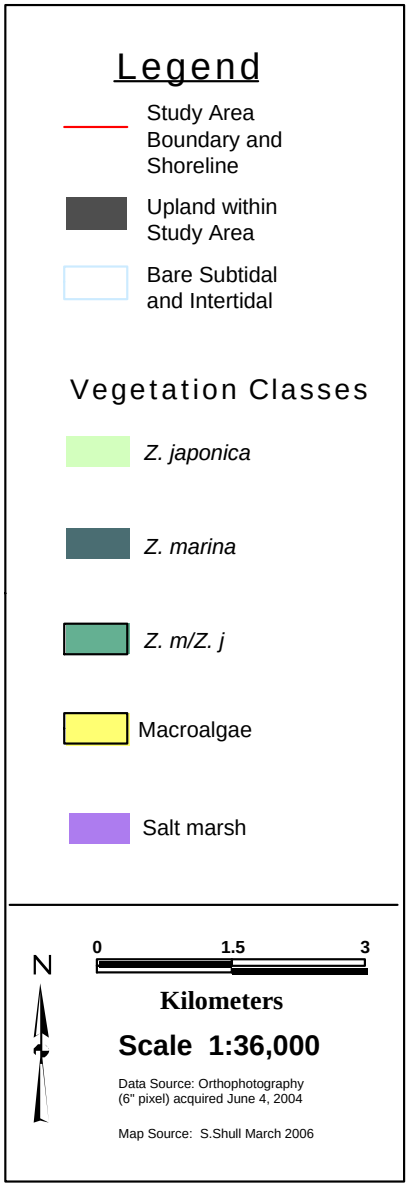


Figure 7. Distribution of all percent cover classes of eelgrasses, macroalgae, and salt marshes in Padilla Bay, Washington in June 2004.



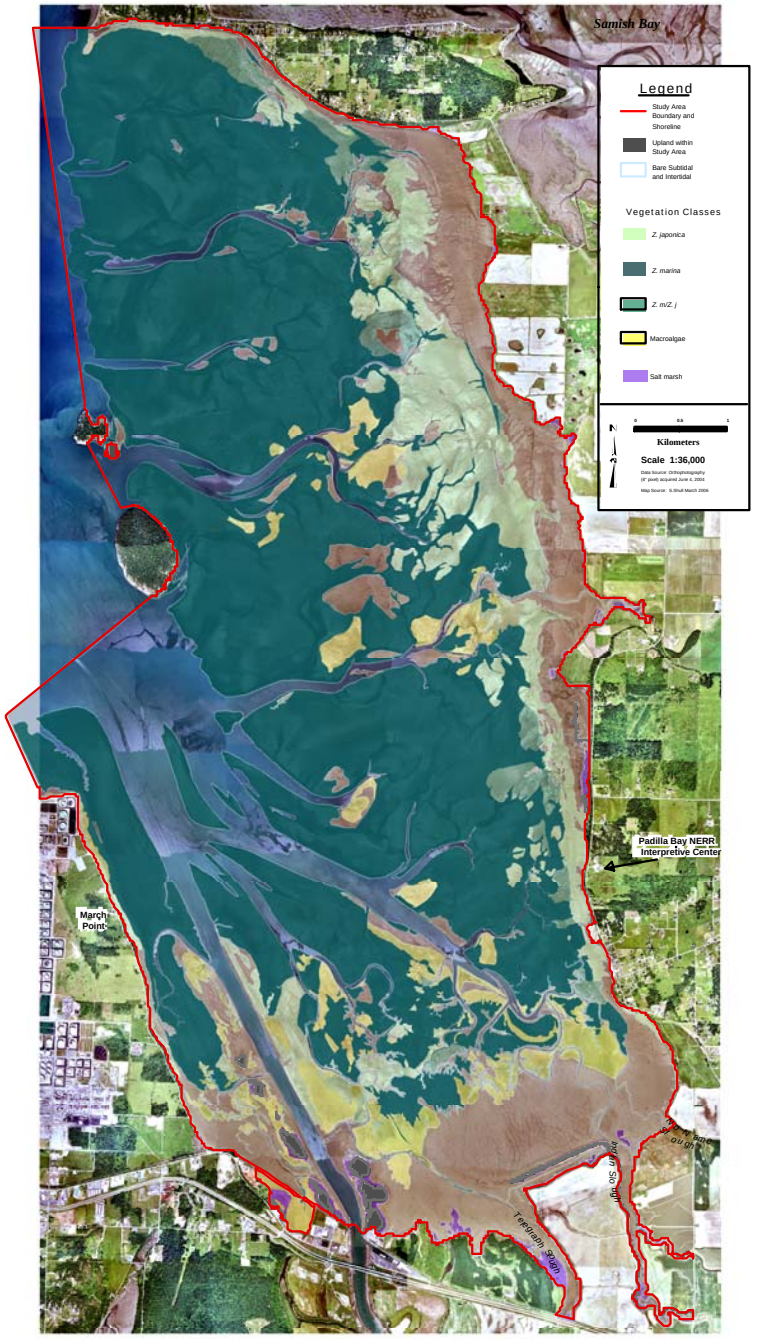


Figure 6. Distribution of eelgrasses, macroalgae, and salt marshes in Padilla Bay, Washington in June 2004.

2004

Interpreted Map Class

Ground Reference

	Z. marina	Z. japonica	Algae	Bare	Salt Marsh	N/A		Producer's Accuracy
Z. Marina	19	0	0	1	0	0	20	95.0%
Z. Japonica	1	14	0	5	0	0	20	70.0%
Algae	4	0	12	4	0	0	20	60.0%
Bare	1	2	1	16	0	0	20	80.0%
Salt Marsh	0	0	0	6	12	2	20	60.0%
	25	16	13	32	12	2	100	
User's Accuracy	76.0%	87.5%	92.3%	50.0%	100.0%			

Overall accuracy = 73%

Patterns of stability and change

1989 to 2004

- **Methods 1989**

- True color aerial photos 1:12,000
- Ground truth investigations at more than 100 sites
- Photointerpretation and mapping with Zoom Transfer Scope onto enlarged USGS quads
- Area of apparent vegetation units measured with planimeter

• Methods 2000

- Establish ground control points
- True color aerial photos 1:12,000
- Ground truth investigations at more than 250 sites
- Aerial photos scanned
- Georectification and mosaic of 1:12,000 photos with ArcView 3.x and extensions
- Delineation on screen with habitat digitizer
- Area of apparent vegetation units calculated with ArcView queries.

Methods 2004

Image acquisition: true color aerial photography

Image processing: an orthorectified photomosaic

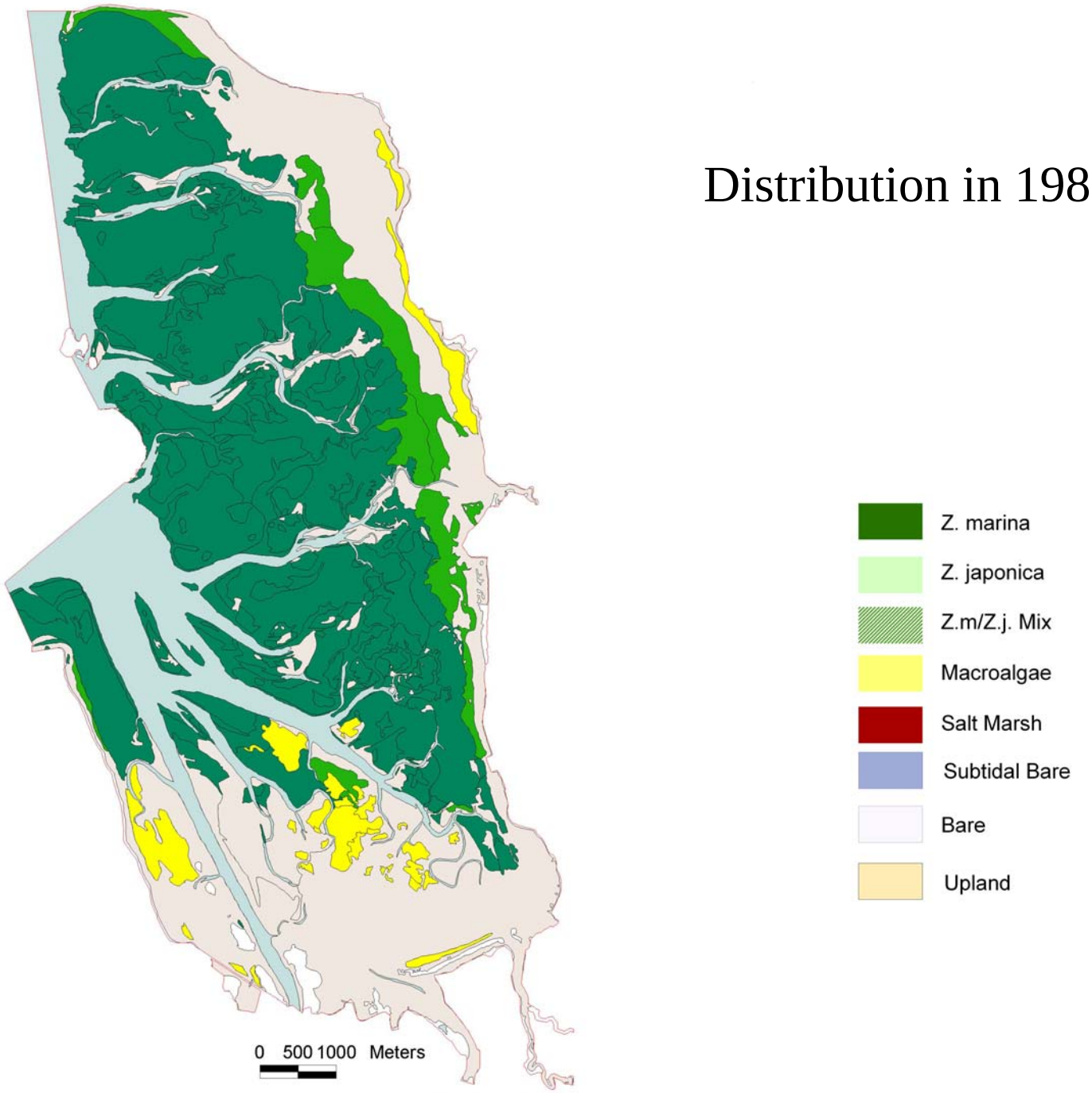
Geodatabase and classification scheme in ArcGIS 9

Ground reference data collection at 1360 sites

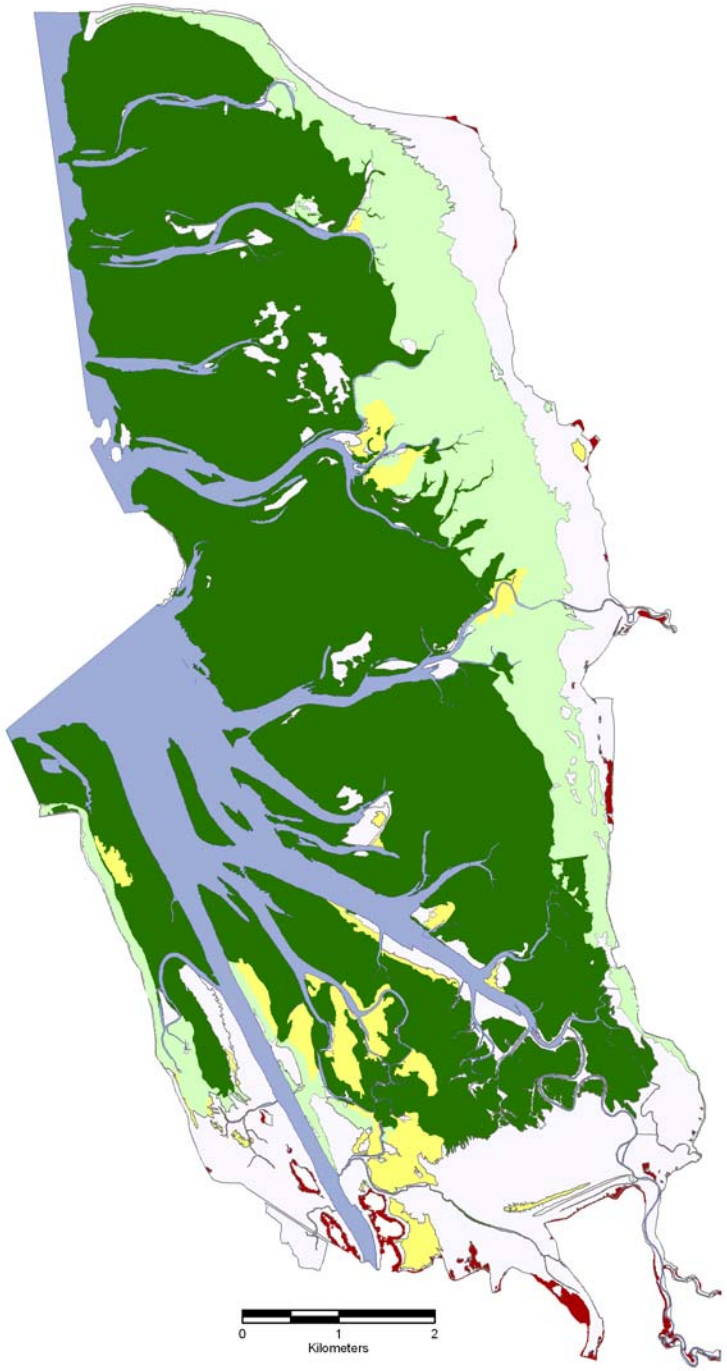
On-screen delineation

Change detection using ArcGIS 9

Distribution in 1989

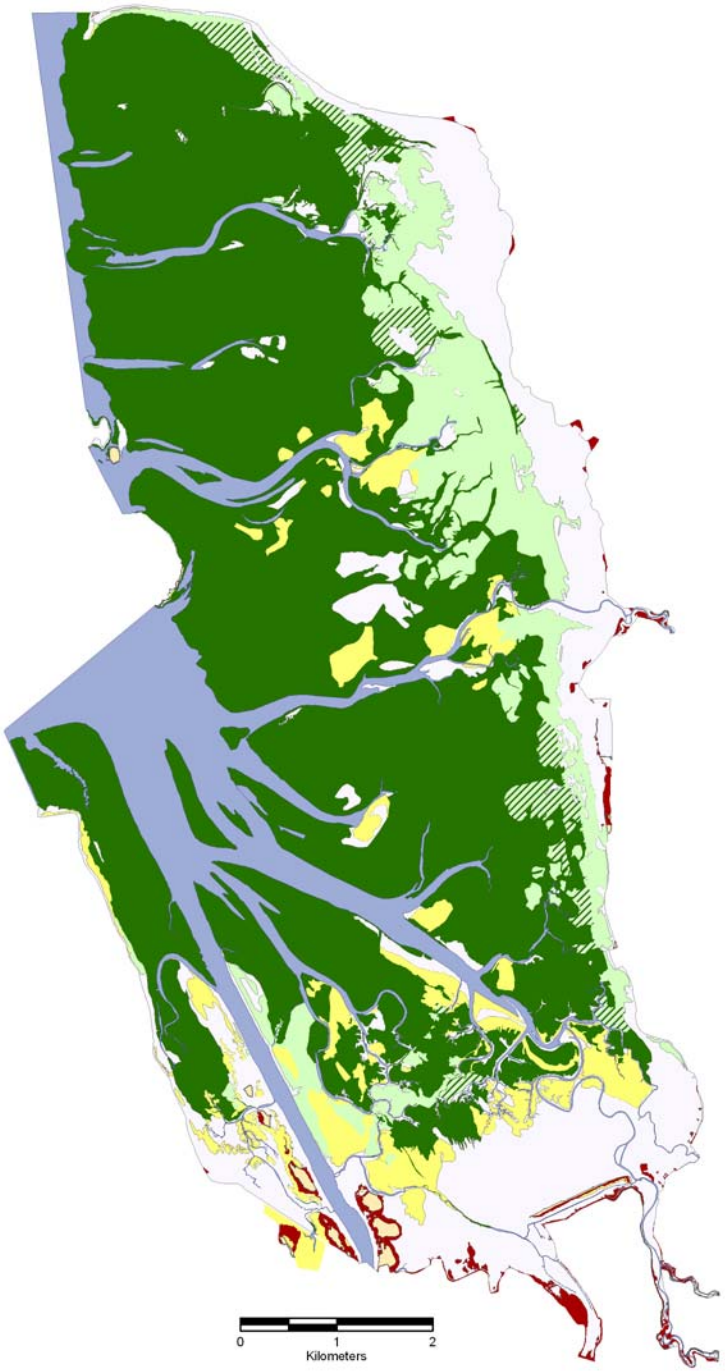


Distribution in 2000

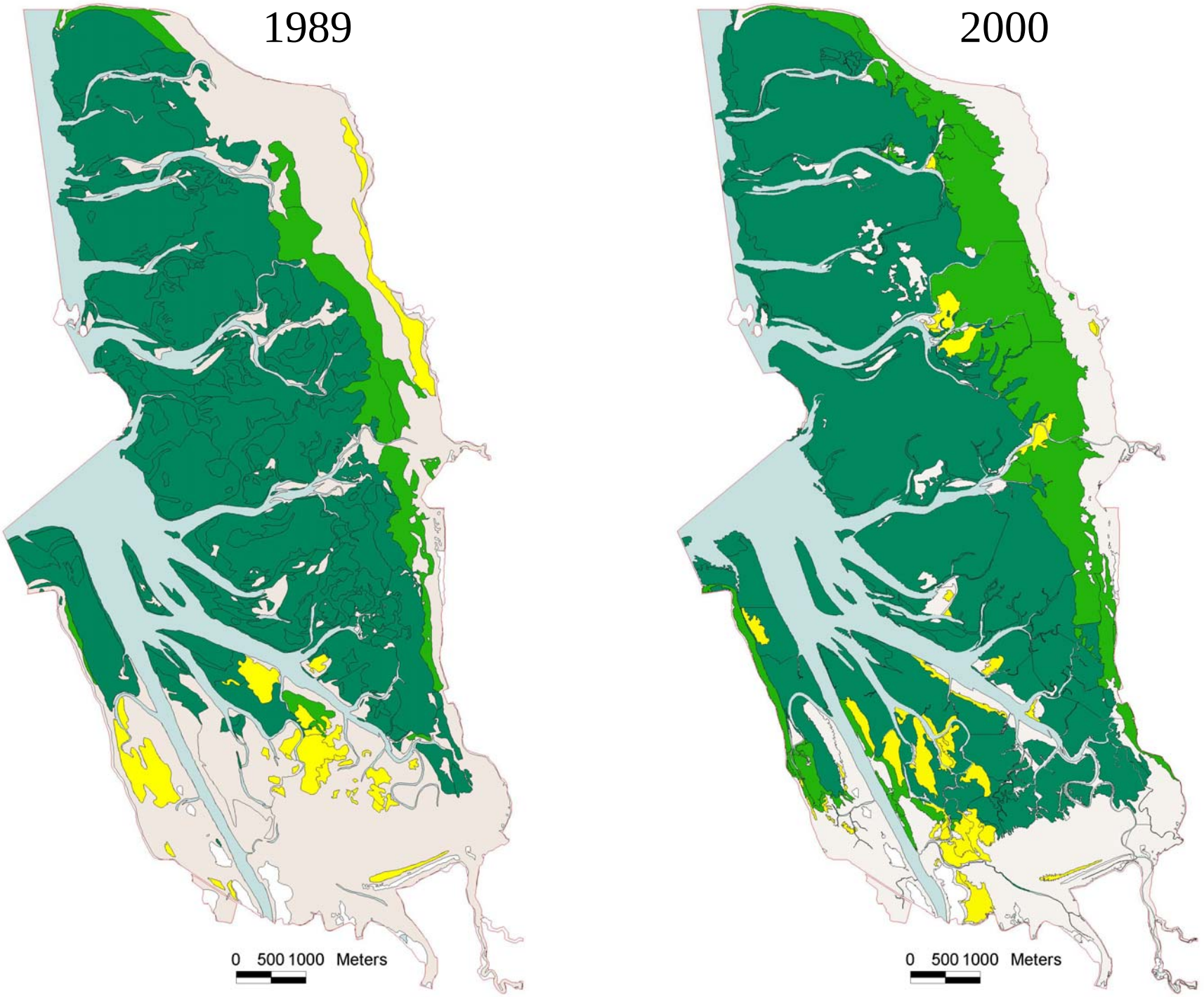


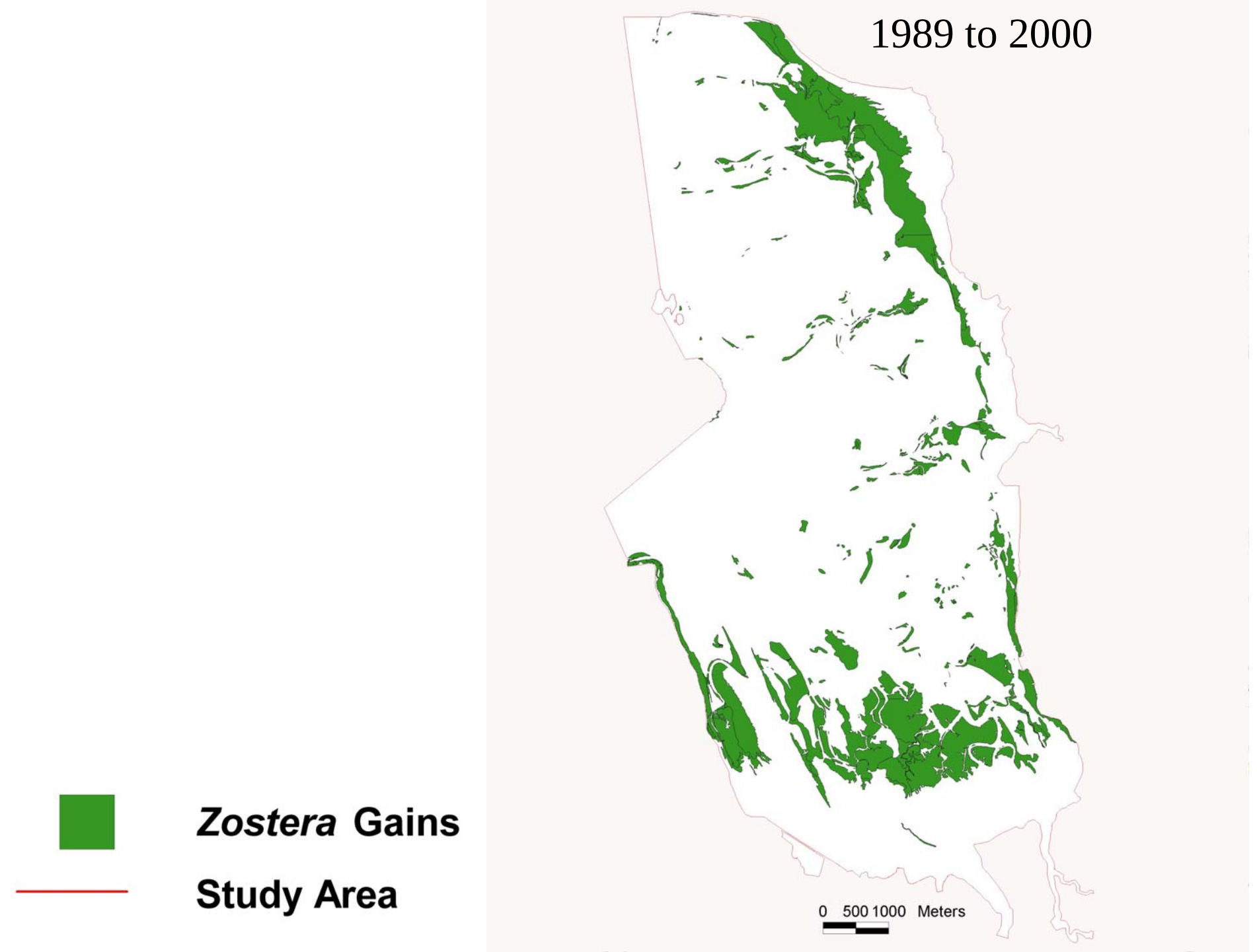
Z. marina
Z. japonica
Z.m/Z.j. Mix
Macroalgae
Salt Marsh
Subtidal Bare
Bare
Upland

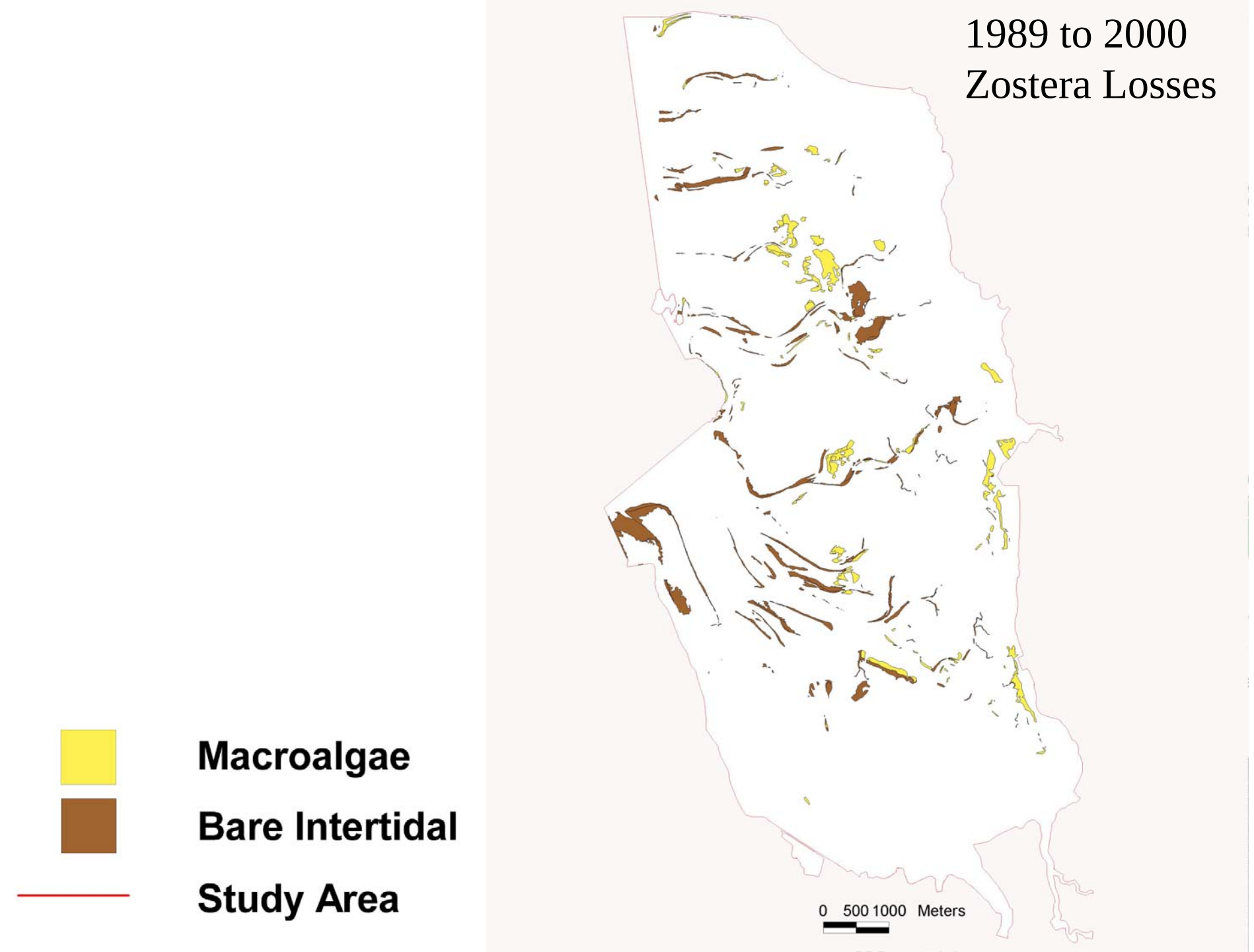
Distribution in 2004

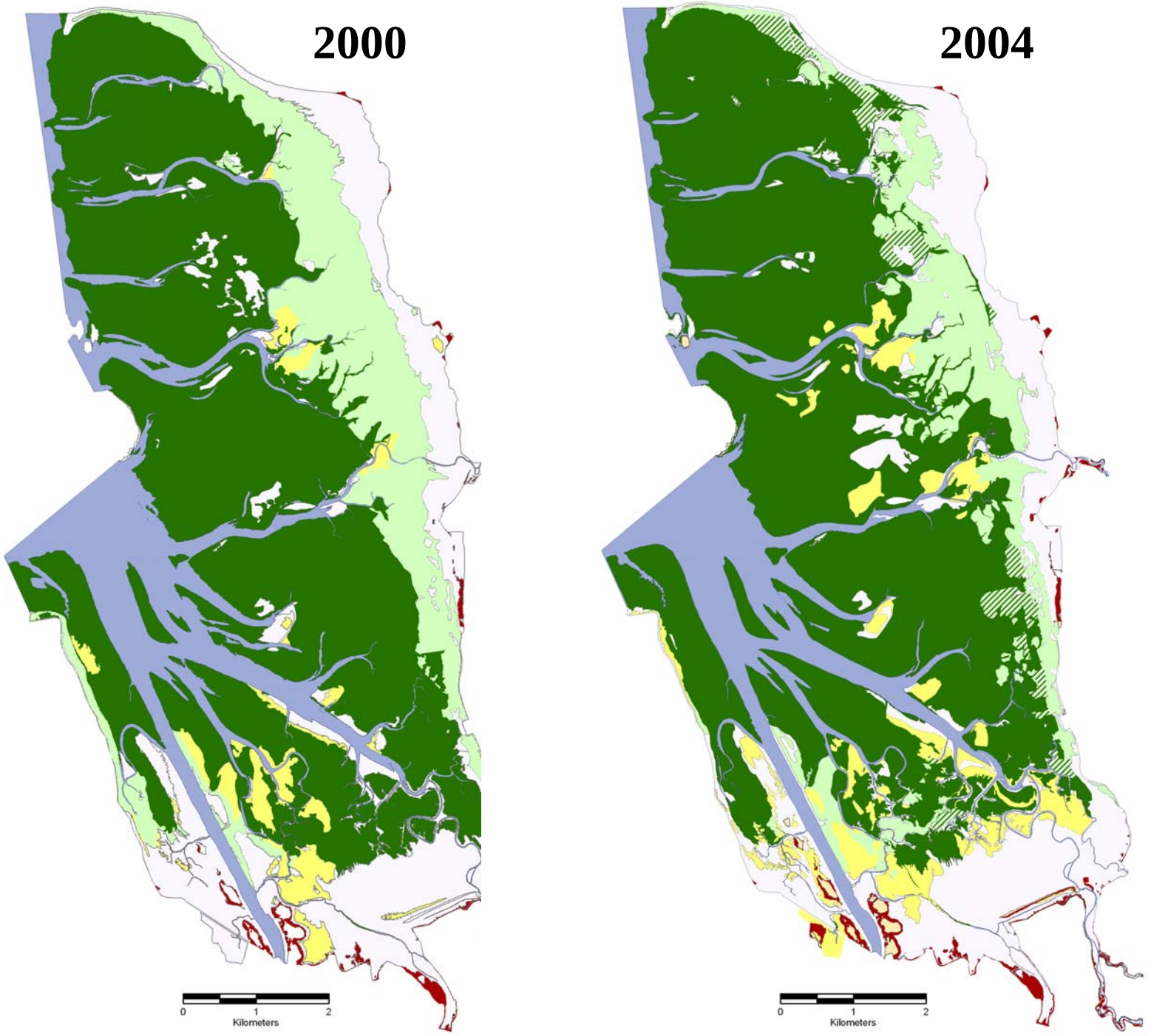


Z. marina
Z. japonica
Z.m/Z.j. Mix
Macroalgae
Salt Marsh
Subtidal Bare
Bare
Upland


1989
2000
0 500 1000 Meters
0 500 1000 Meters


1989 to 2000
Zostera Gains
Study Area
0 500 1000 Meters


1989 to 2000
Zostera Losses
Macroalgae
Bare Intertidal
Study Area
0 500 1000 Meters


2000
2004
0
1
2
Kilometers
0
1
2
Kilometers

2000 to 2004

Zostera losses

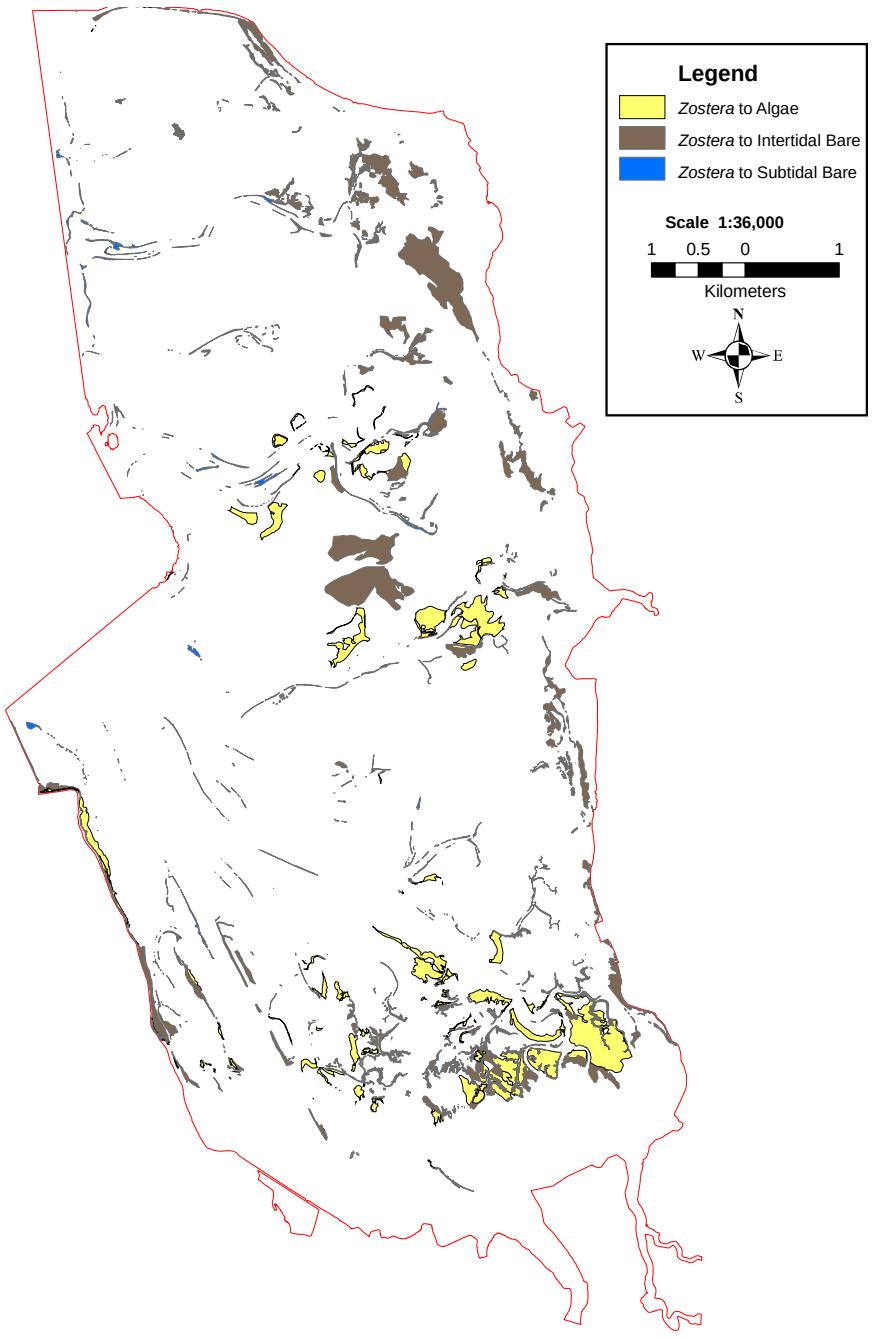


Figure 3. Areas of *Zostera* in 2000 that have been lost to areas of algae or bare substrate in 2004, Padilla Bay, WA.

2000 to 2004

Zostera gains

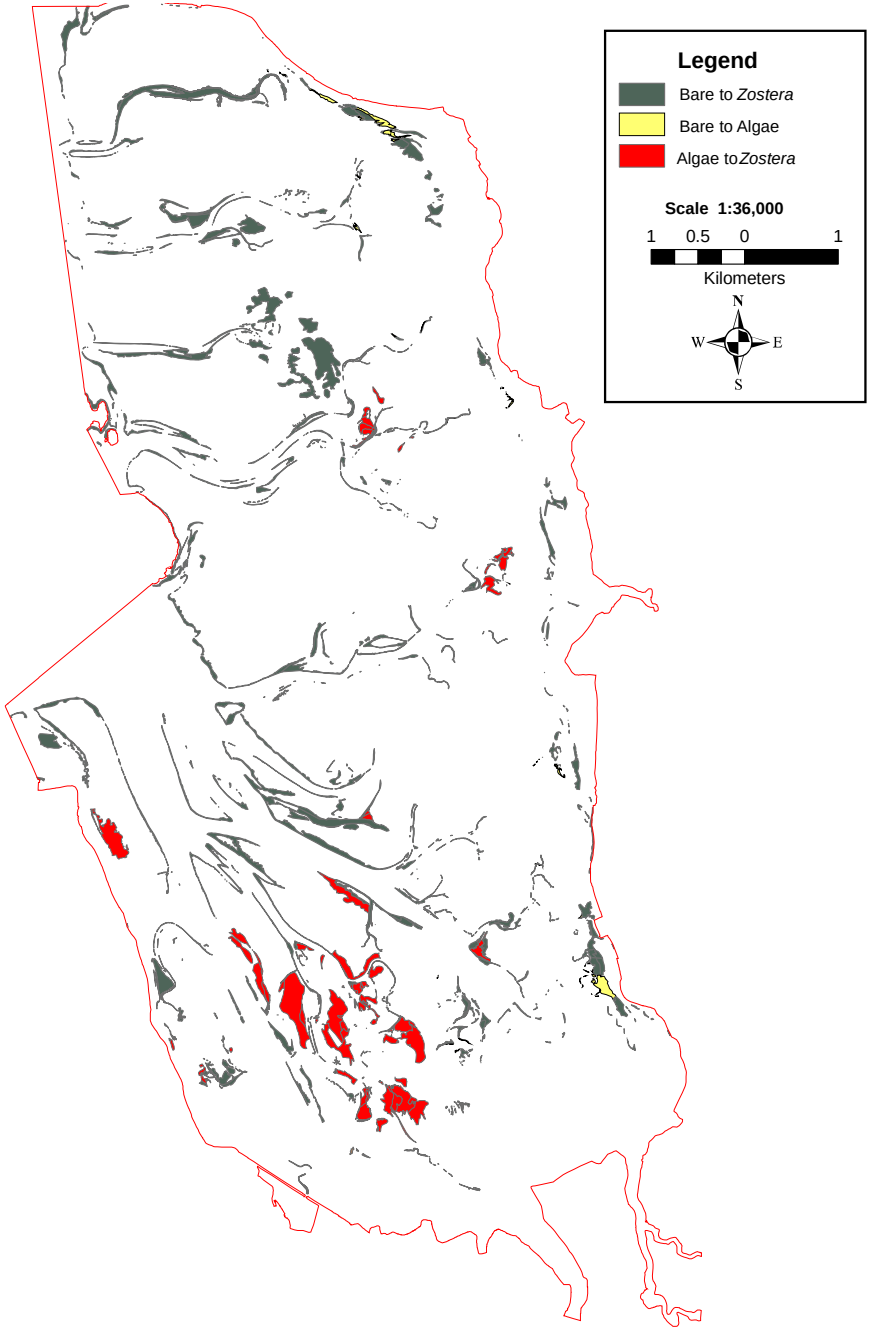


Figure 3. Bare or algae areas in 2000 that have become of *Zostera* areas in 2004, Padilla Bay, WA.

2000 to 2004

Zostera marina and

Z. japonica changes

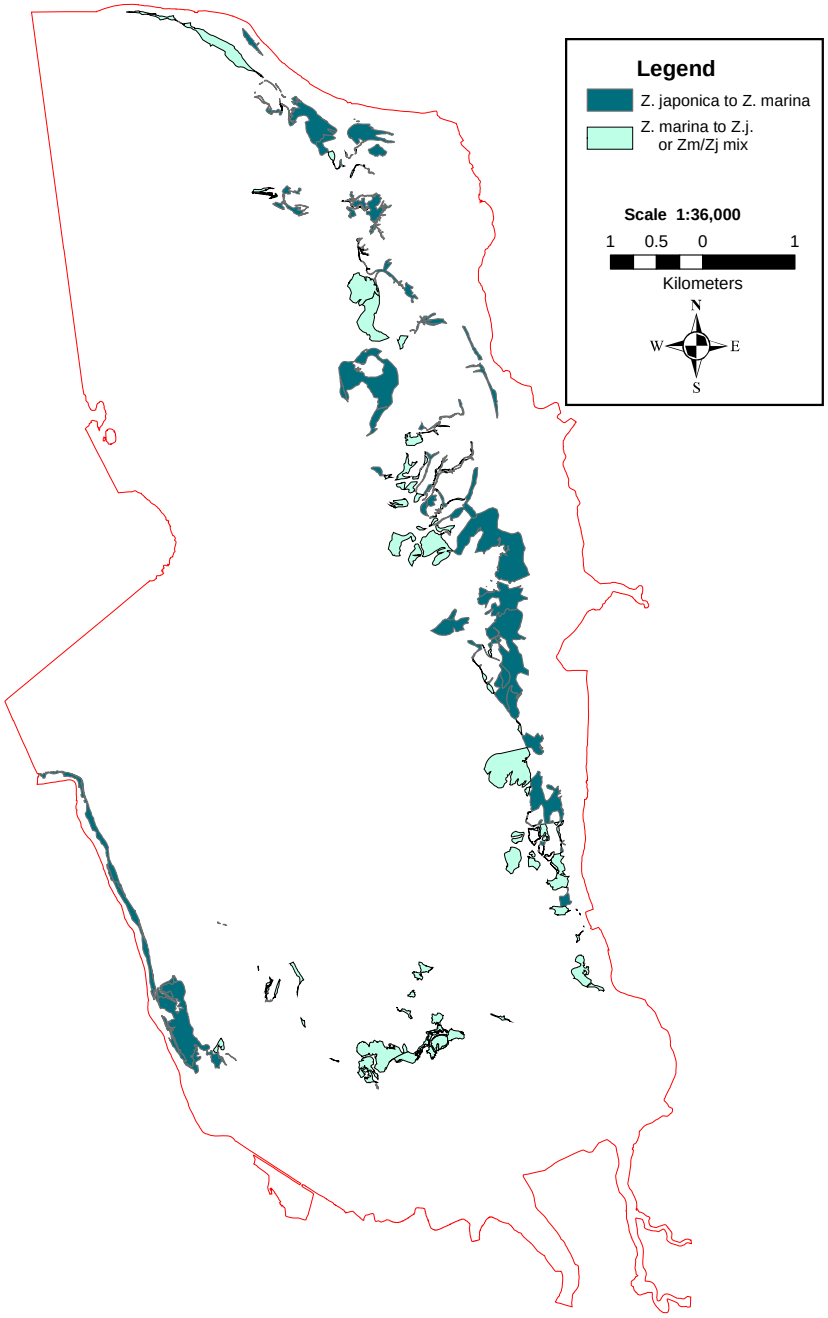
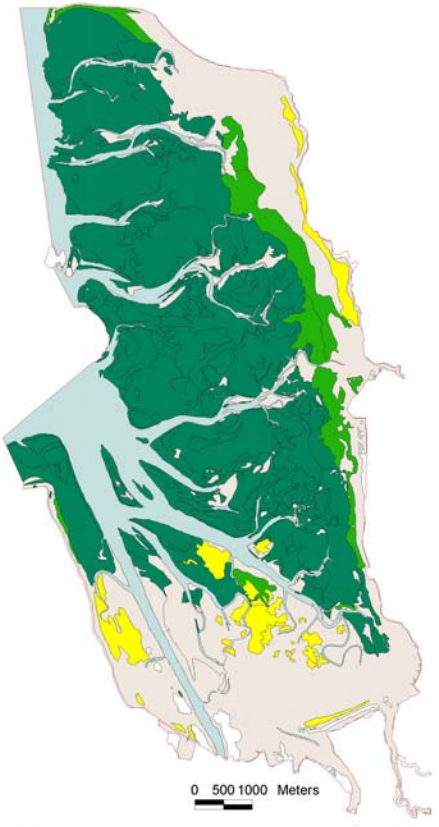
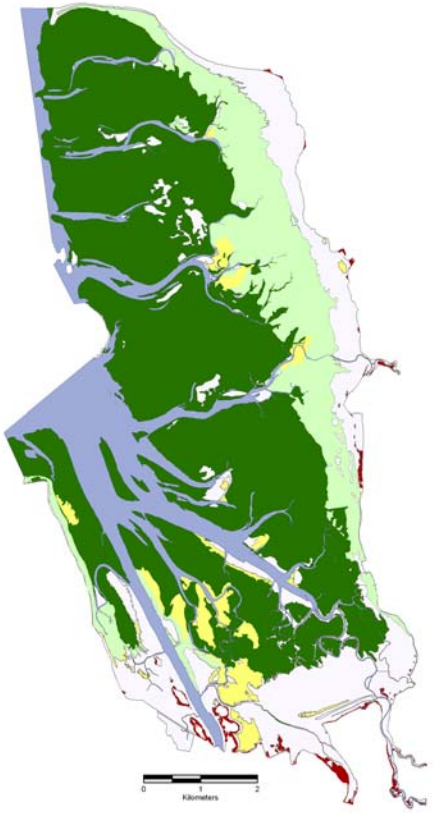


Figure 3. Areas of *Zostera* in 2000 that switched to the opposite species of *Zostera* in 2004, Padilla Bay, WA.

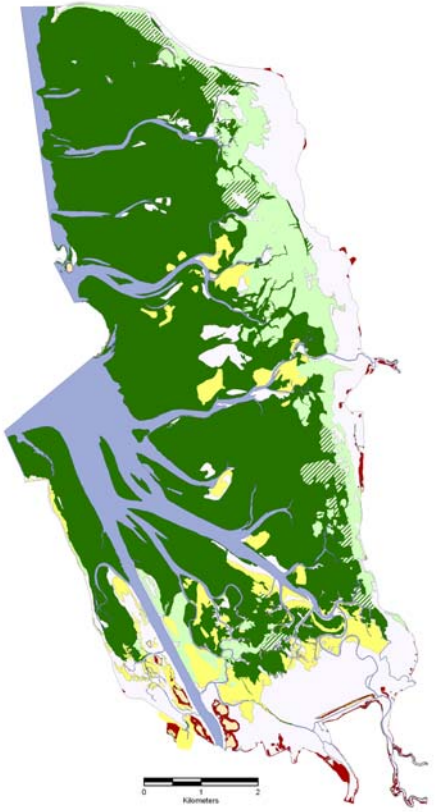
1989



2000



2004



Vegetation Classes	Area (hectares) 1989	Area (hectares) 2000	Area (hectares) 2004
Total *Zostera marina*	**2884**	**3030**	**3140**
Total *Zostera japonica*	**236**	**836**	**476**
Total *Zostera j/m* ***Zostera j/m/algae***	(88)	**-**	**(175)**
Total *Zostera sp*.	**3208**	**3865**	**3800**
Total macroalgae	**220**	**204**	**351**

Summary

Stability of mid and lower intertidal and subtidal *Z. marina*

Overall gains in *Zostera* spp. coverage over 15 years

Macroalgae highly variable year to year in location

Overall *Z. japonica* coverage increasing over 15 years

Z. marina and *Z. japonica* dominance shifting back and forth year to year

Results are not typical

- Westcott Bay, San Juan Island

posted 09/19/03 San Juan Islander

In 2000 approximately 45 acres of eelgrass (*Z. marina*) grew in Westcott Bay on San Juan Island. In 2003 it was virtually eliminated. Eelgrass is also gone from Garrison Bay. The areas include documented herring spawn sites. According to a recently released report: This sequence strongly suggests that the Z. marina population in Westcott Bay ceased to be self-sustaining at some point between 1998 and 2000, began to thin, and then crashed in 2003.

Changes in Distribution of *Zostera* in Northeast Section

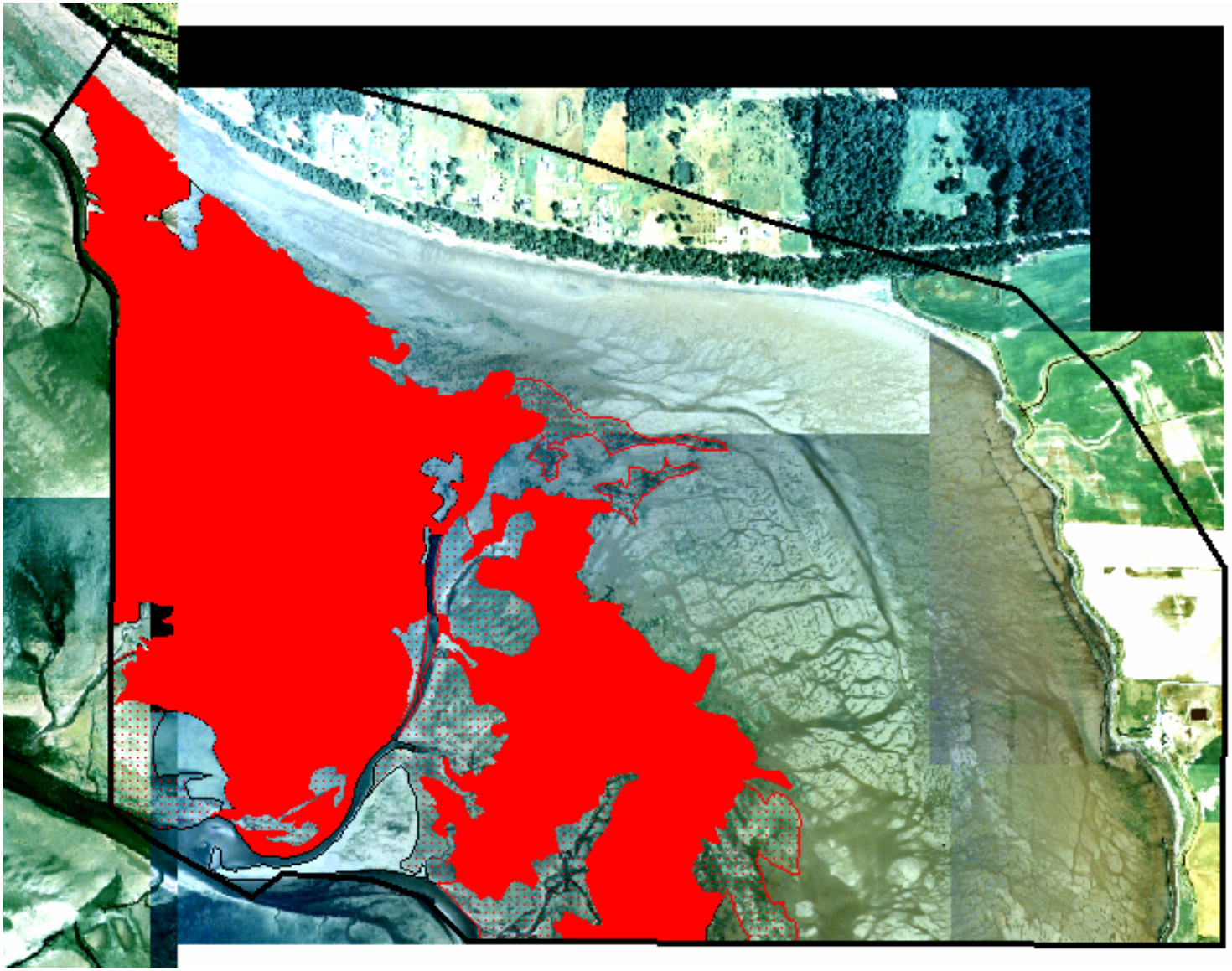
1989, 1992, 1996, 2000, 2004

SELECTION OF PHOTO SERIES

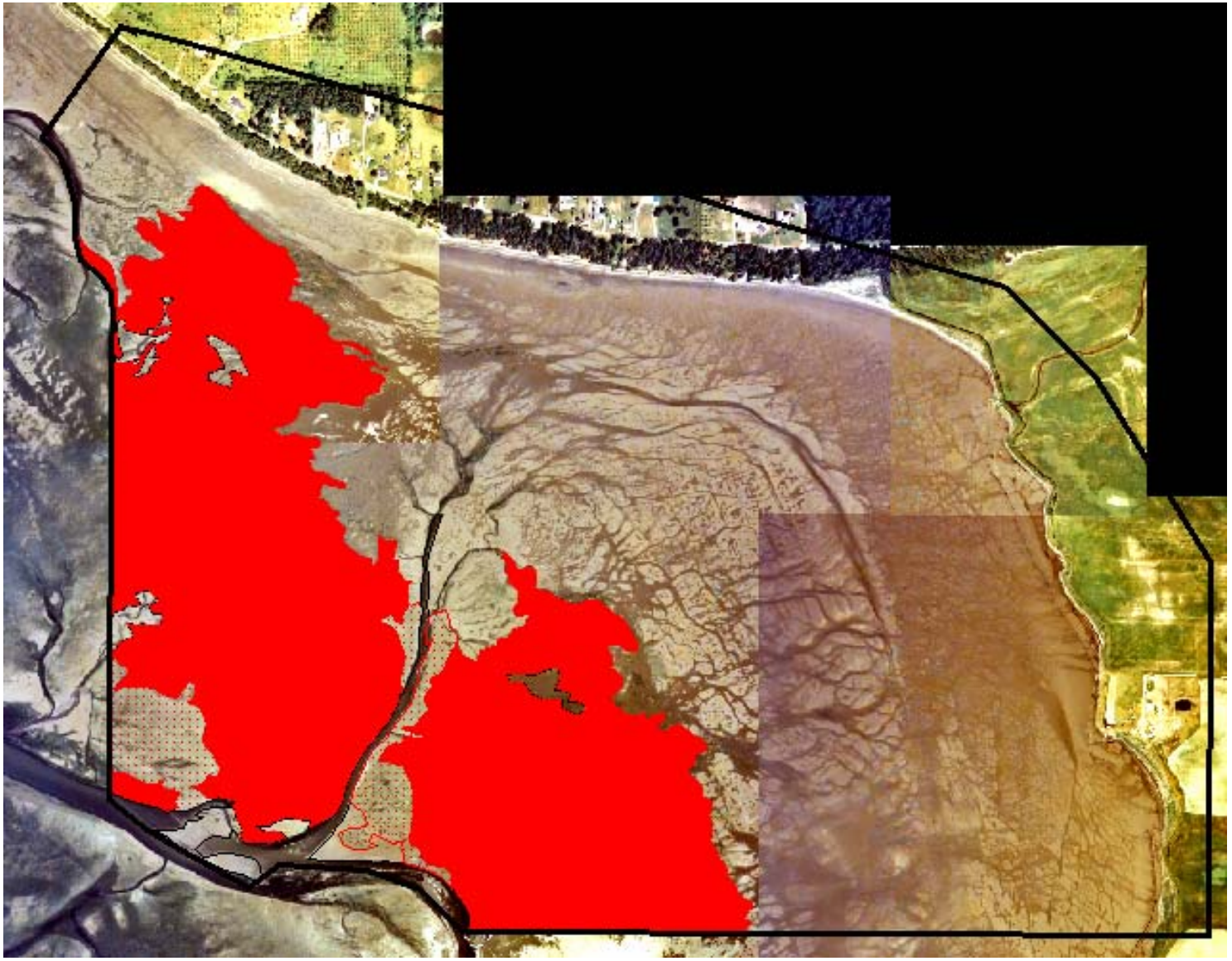
Year	1989	1992	1996	2000	2004
Scale	1:12,000 1:42,000	1:12,000 1:42,000	1:12,000 1:42,000	1:12,000 1:42,000	1:12,000 1:42,000
Number of Photos	58@12,000 7@42,000	85@12,000 7@42,000	76@12,000 7@42,000	61@12,000 5@42,000	60@12,000 5@42,000
Date Flown	June 3, 1989	July 28, 1992	July 1, 1996	July 30, 2000	June 4, 2004
Company	WSDOT	WSDOT	Sound Aerial Surveys	Sound Aerial Surveys	WSDOT
Tidal Height	**-2.5 @ 1342**	**-2.5 @ 1040**	**-3.0 @ 1159**	**-3.4 @ 1217**	**-3.9 @ 1217**

1989

1992



1996



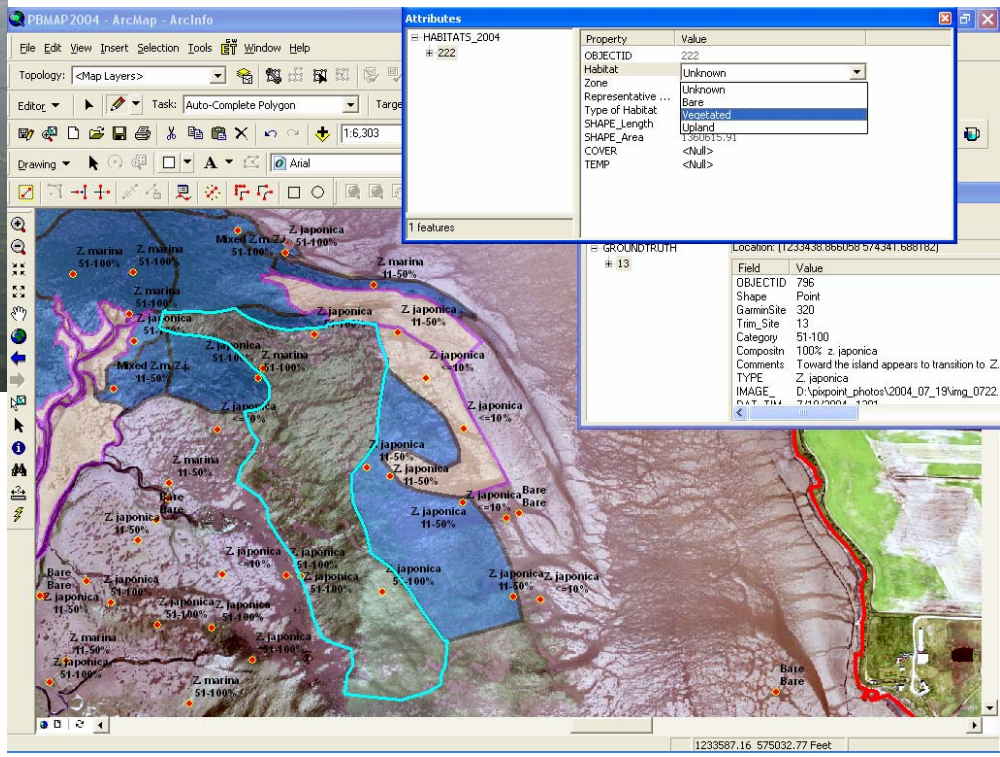
2000

2004

Northeast Study Area Results

Year	Continuous eelgrass (hectares)	Sparse eelgrass cover (hectares)	Total eelgrass cover (hectares)
1989	40.6	7.9	48.5
1992	107.3	27.4	134.6
1996	91.9	8.6	100.5
2000	107.3	61.1	168.3
2004	126.5	28.5	155.1

LESSONS LEARNED



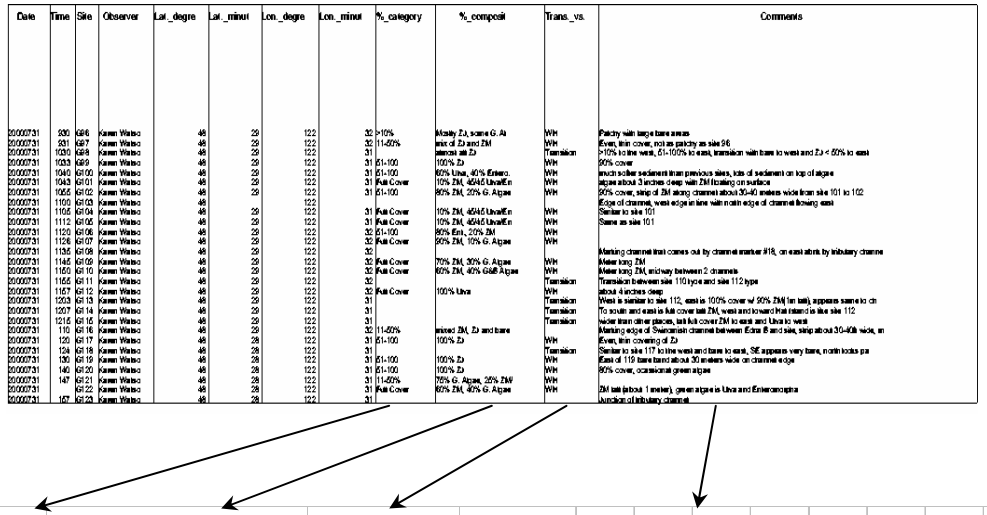
Ground reference data collection was critical.

The 315 budget did not cover costs.

The budget cycle did not fit the hiring and field work cycle.

Summer field staff were critical; two students for three months.

Vegetation was not stable over the summer months.



Date	Time	Site	Observer	Lat_degre	Lat_minut	Lon_degre	Lon_minut	%_category	%_composit	Trans_vs.	Comments
20000731	930	KR6	Karen Wetso	48	29	122	32	>10%	Mostly ZJ, some G. Al	WH	Patchy with large bare areas
20000731	931	KR7	Karen Wetso	48	29	122	32	11-50%	mix of ZJ and ZM	WH	Even, thin cover, not as patchy as site 96
20000731	1030	KR8	Karen Wetso	48	29	122	31		almost all ZJ	Transition	>10% to the west, 51-100% to east, transition with bare to west and ZJ < 50% to east
20000731	1033	KR9	Karen Wetso	48	29	122	31	51-100	100% ZJ	WH	90% cover
20000731	1040	KR00	Karen Wetso	48	29	122	31	51-100	60% Ulva, 40% Entero.	WH	much softer sediment than previous sites, lots of sediment on top of algae
20000731	1043	KR01	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	algae about 3 inches deep with ZM floating on surface
20000731	1055	KR02	Karen Wetso	48	29	122	31	51-100	90% ZM, 25% G. Algae	WH	90% cover, strip of ZM strong channel about 30-40 meters wide from site 101 to 102
20000731	1100	KR03	Karen Wetso	48		122				WH	Edge of channel, west edge in line with north edge of channel flowing east
20000731	1105	KR04	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	Similar to site 101
20000731	1112	KR05	Karen Wetso	48	29	122	31	Full Cover	10% ZM, 45/45 Ulva/En	WH	Same as site 101
20000731	1120	KR06	Karen Wetso	48	29	122	32	51-100	90% Ent., 10% ZM	WH	
20000731	1126	KR07	Karen Wetso	48	29	122	32	Full Cover	90% ZM, 10% G. Algae	WH	
20000731	1135	KR08	Karen Wetso	48	29	122	32				Marking channel limit comes out by channel marker #18, on east shore by tributary channe
20000731	1145	KR09	Karen Wetso	48	29	122	32	Full Cover	70% ZM, 30% G. Algae	WH	Meter long ZM
20000731	1150	KR10	Karen Wetso	48	29	122	32	Full Cover	60% ZM, 40% G&R Algae	WH	Meter long ZM, midway between 2 channels
20000731	1155	KR11	Karen Wetso	48	29	122	32			Transition	Transition between site 110 type and site 112 type
20000731	1157	KR12	Karen Wetso	48	29	122	32	Full Cover	100% Ulva	WH	about 4 inches deep
20000731	1203	KR13	Karen Wetso	48	29	122	31			Transition	West is similar to site 112, east is 100% cover w/ 90% ZM(1m tall), appears same to ch
20000731	1207	KR14	Karen Wetso	48	29	122	31			Transition	To south and east is full cover tall ZM, west and toward that island is like site 112
20000731	1215	KR15	Karen Wetso	48	29	122	31			Transition	wider than other places, tall full cover ZM to east and Ulva to west
20000731	110	KR16	Karen Wetso	48	29	122	32	11-50%	mixed ZM, ZJ and bare		Marking edge of Swanonish channel between Echo B and sea, strip about 30-40ft wide, in
20000731	120	KR17	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	Even, thin covering of ZJ
20000731	124	KR18	Karen Wetso	48	28	122	31			Transition	Similar to site 117 to line west and bare to east, SE appears very bare, north looks pa
20000731	130	KR19	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	East of 119 bare band about 30 meters wide on channel edge
20000731	140	KR20	Karen Wetso	48	28	122	31	51-100	100% ZJ	WH	90% cover, ocassional green algae
20000731	147	KR21	Karen Wetso	48	28	122	31	11-50%	75% G. Algae, 25% ZM	WH	
20000731		KR22	Karen Wetso	48	28	122	31	Full Cover	60% ZM, 40% G. Algae	WH	ZM tall (about 1 meter), green algae is Ulva and Enteromorpha
20000731	167	KR23	Karen Wetso	48	28	122	31				Junction of tributary channel

% Category	% Composition	Trans. Vs. WH	Comments
>10%	Mostly ZJ, some G. Algae	WH	Patchy with large bare areas
11-50%	mix of ZJ and ZM	WH	Even, thin cover, not as patchy as site 96
	almost all ZJ	Transition	>10% to the west, 51-100% to east, transition with bare to w
51-100	100% ZJ	WH	90% cover
51-100	60% Ulva, 40% Entero.	WH	much softer sediment than previous sites, lots of sediment c
Full Cover	10% ZM, 45/45 Ulva/Ent.	WH	algae about 3 inches deep with ZM floating on surface

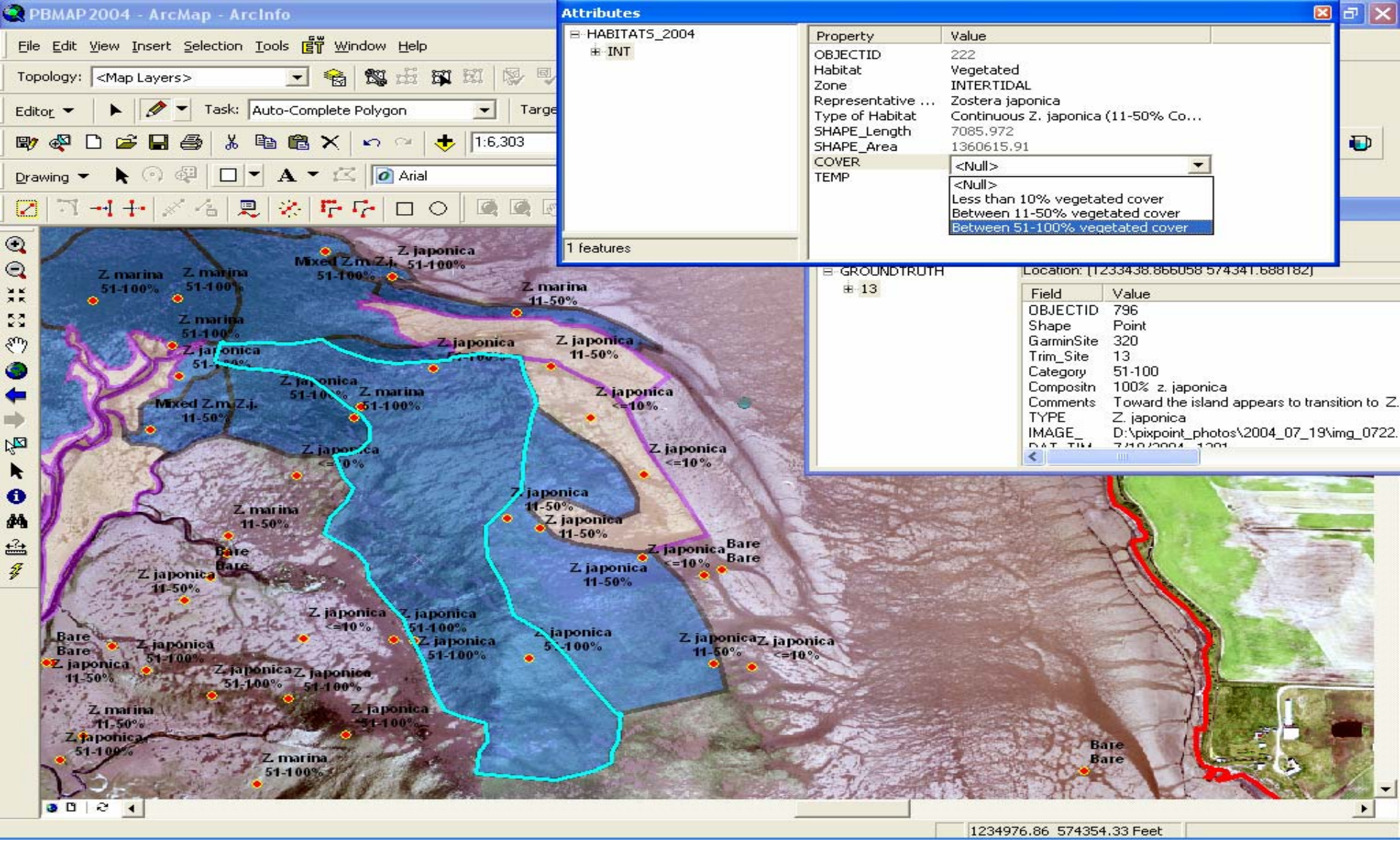
Automated data entry is most efficient.

Orthorectification of aerial photos was essential, but too costly for routine monitoring. In-house rectification works.

***Zostera marina* and *Z. japonica* could not always be distinguished on aerial photos.**

Infra-red ancillary photos were very helpful.

Ground photos of reference points were very helpful.



Advantages of Geodatabase format:

Topology, MMU restriction, classification drop down selection

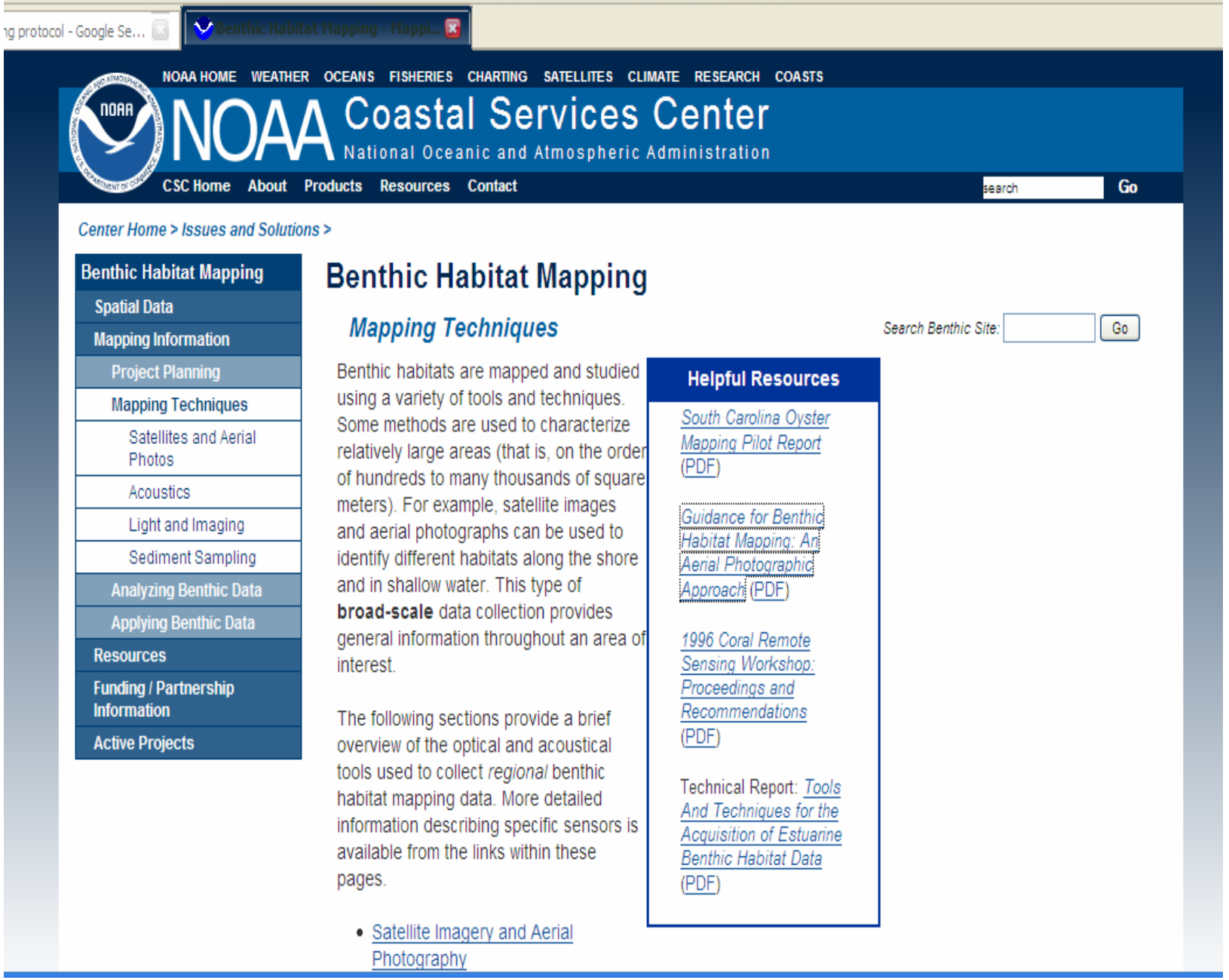
Summary

Methods (color aerial photos, ground reference data, on-screen digitizing) are appropriate for Padilla Bay.

Zostera marina and *Z. japonica* distribution is dynamic; the long-term trend is not known but *Z. japonica* appears to be expanding in Padilla Bay.

Interannual variation of eelgrasses is high in the mid-intertidal.

Annual monitoring of SAV is needed in Padilla Bay.



http://www.csc.noaa.gov/benthic/mapping/techniques/techniques.htm

Seafloor Mapping Workshop Alternatives

- Sidescan sonar (Smilk Bay)
- Green lidar (needs clear water and may not pick up eelgrass, better for elevations)
- Automated processing of aerial photos, hyperspectral sensors, or satellite imagery

For Comparison

- This method took approximately 1 year to complete.
  - what is the turnaround and repeatability?
- Project cost $50,000 plus $20,000 for orthophotos.
  - Have automated methods come enough down in price?
- Only method that can produce accuracy and detail we require.
  - What classification scheme and accuracy do you need?