***Assessing anthropogenic injury, modeling recovery, computing lost interim services and scaling compensatory action in seagrass ecosystems***

***Hydrodynamics and the forecasting of Ecological Characteristics of Seagrass Ecosystems***

# *Assessing anthropogenic injury, modeling recovery, computing lost interim services and scaling compensatory action in seagrass ecosystems*

**Mark S. Fonseca[1], Brian E. Julius[2] ,**
**W. Judson Kenworthy, Paula E. Whitfield[1]**
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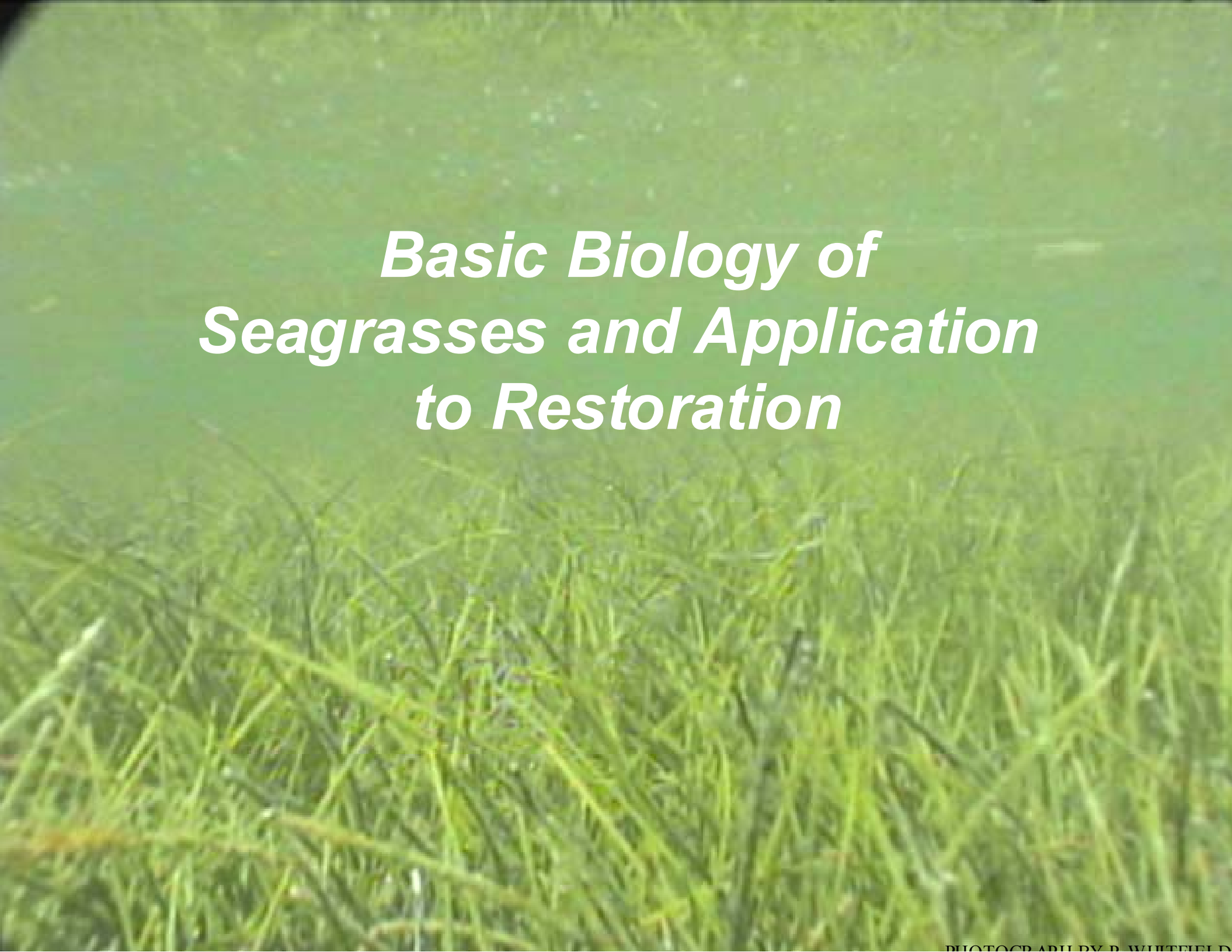
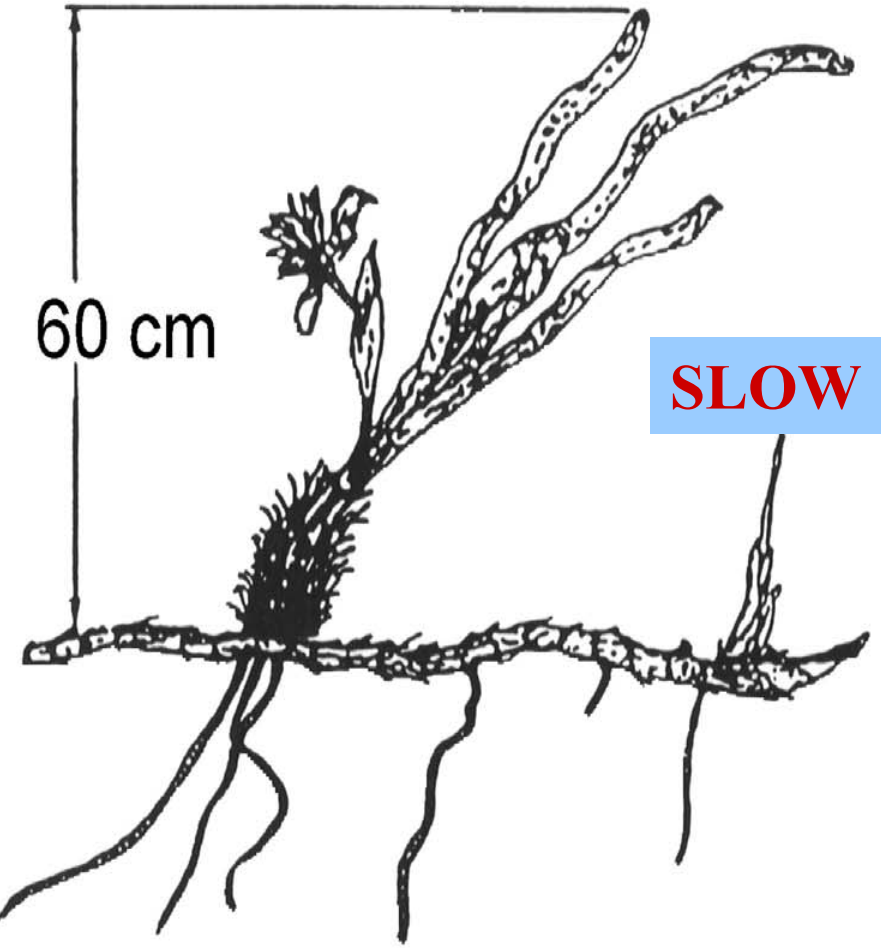
**[2]NOAA, National Ocean Service, Damage Assessment Center, SSMC4 Room 10218, 1305 East-West Highway, Silver Spring, MD 20910, USA**

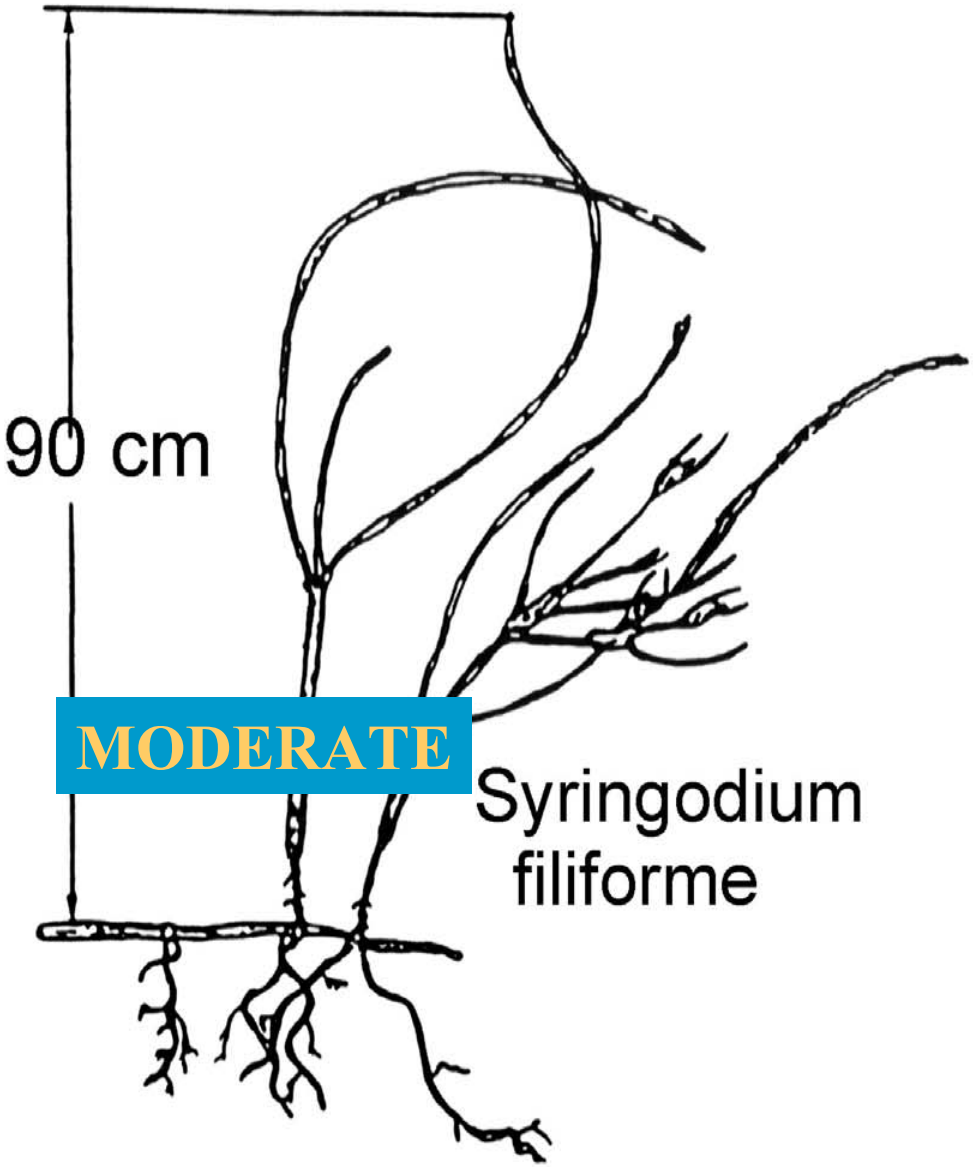
*Coastal Ecosystems and Their Modification:*
*A Technical Symposium for FWS Biologists*


Basic Biology of
Seagrasses and Application
to Restoration

Thalassia testudinum



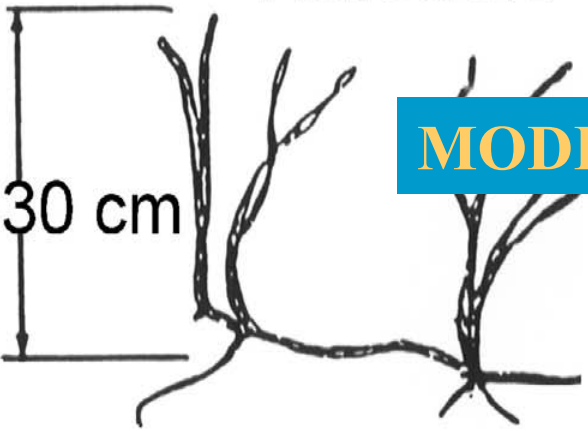

SLOW




MODERATE

Syringodium filiforme

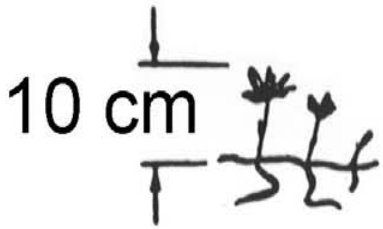
Halodule wrightii

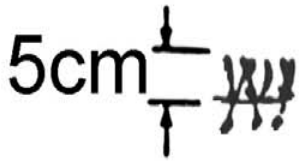



MODERATE

Halophila speci

FAST



# GENERIC QUESTIONS FOR RESTORATION PROJECTS

Michener 1997

- *What was done?*
- *Did it work?*
- *How well did it work?*
- *Why did it work/not work; next time?*
- *How much did (will) it cost?*
- *Social, legal, or political constraints?*

# THOUGHTS ON SEAGRASS RESTORATION

1) ASSESSING INJURY

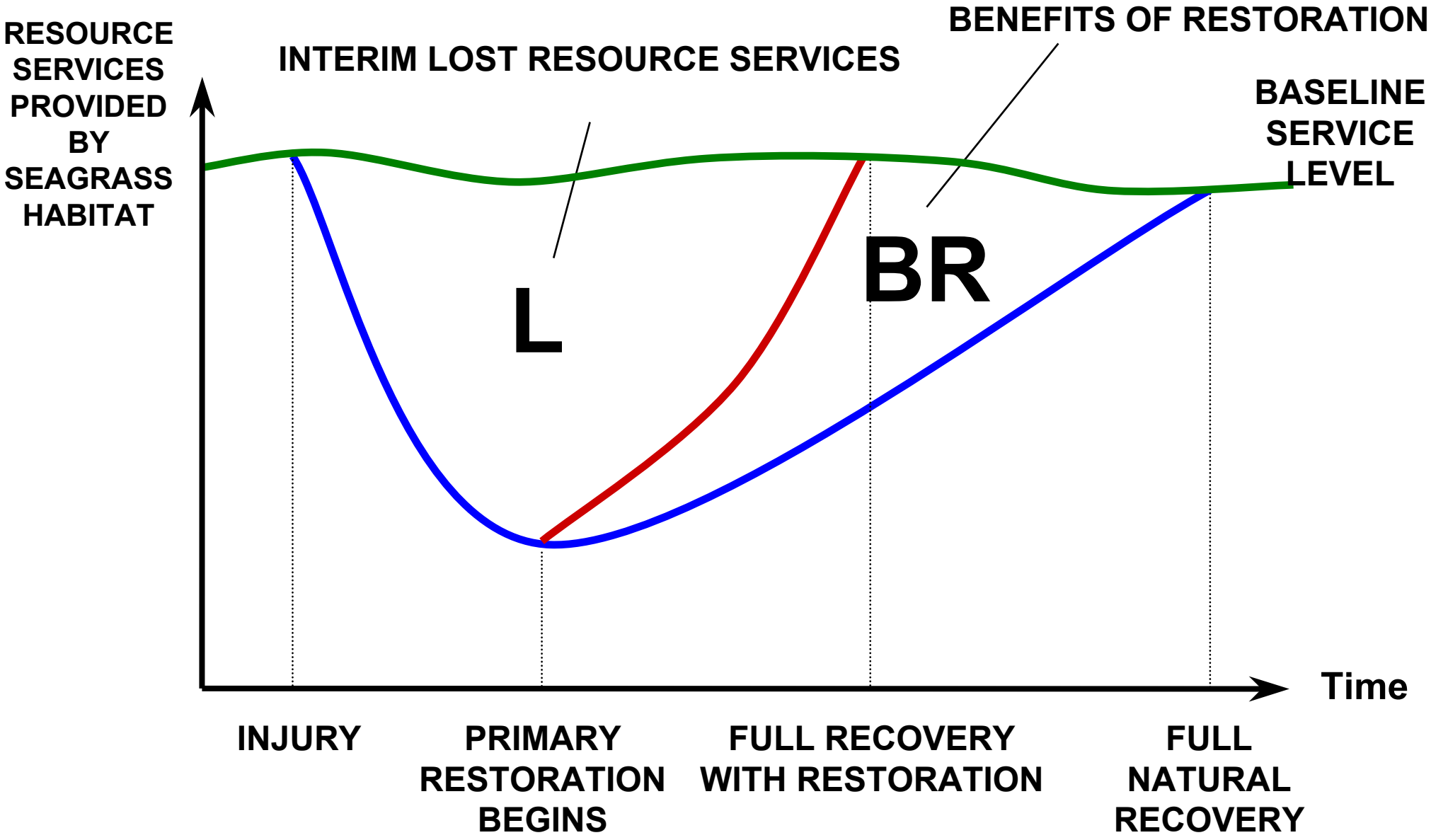
2) SITE SELECTION

3) PLANTING ISSUES

4) DETERMINING SUCCESS

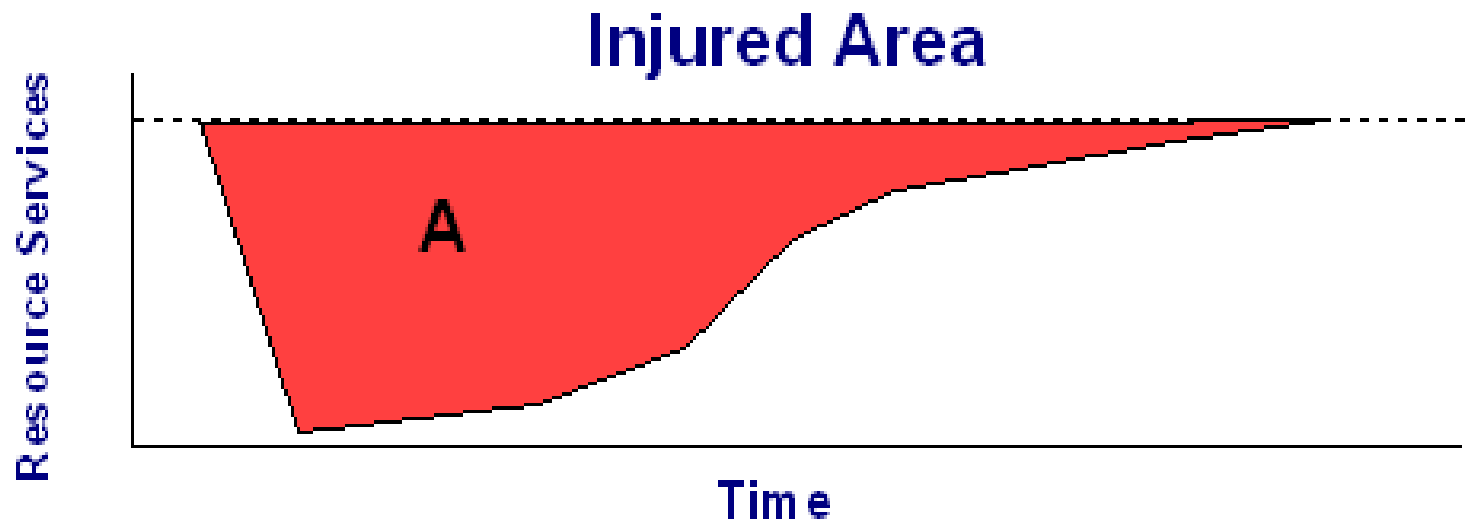
5) COST

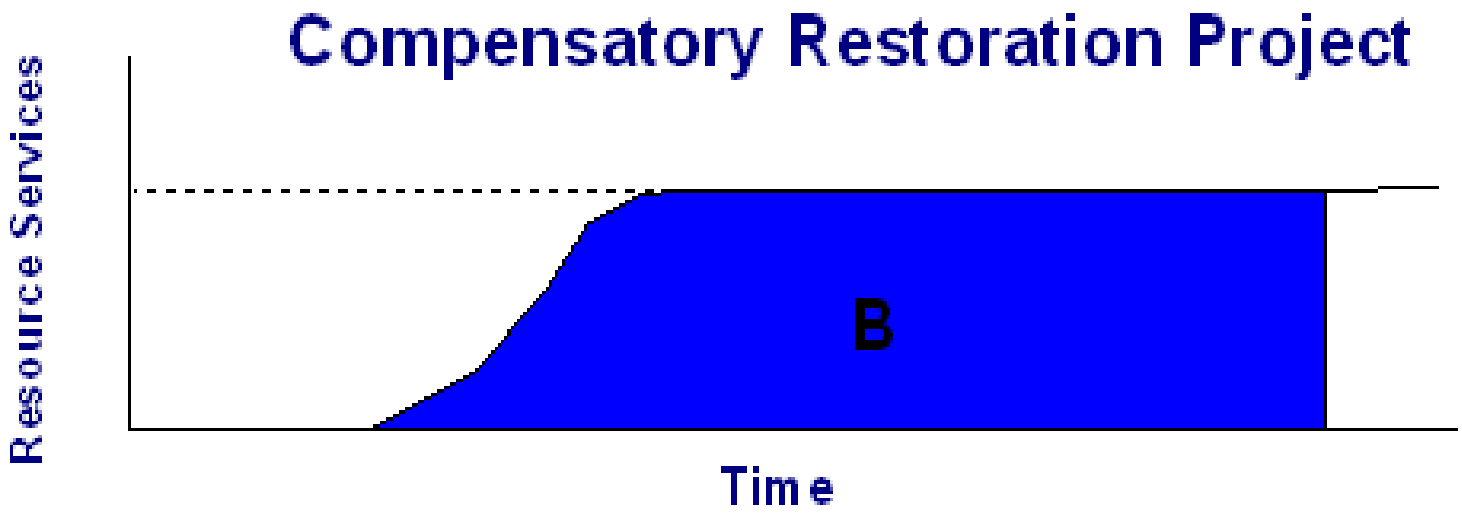
# Graphical Depiction of Interim Loss of Resource Services




COURTESY B. JULIUS

# Graphical Representation of HEA




COURTESY B. JULIUS

# THOUGHTS ON SEAGRASS RESTORATION

1) ASSESSING INJURY

2) SITE SELECTION

3) PLANTING ISSUES

4) DETERMINING SUCCESS

5) COST

**First Question that must be answered:**

**"If seagrass does not grow there now, what makes you think it can be successfully established?"**

***Fredette et al. 1985***

# Planting Site Selection

***(follows Addy 1947)***

- Depth is similar to nearby natural beds
- Anthropogenically disturbed
- Not subject to chronic storm disturbance
- Not undergoing rapid and extensive natural recolonization
- Not among patches of existing seagrass
- Restoration successful at similar sites
- Sufficient acreage to achieve goals
- Similar quality habitat restored as was lost

# THOUGHTS ON SEAGRASS RESTORATION

1) ASSESSING INJURY

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5) COST

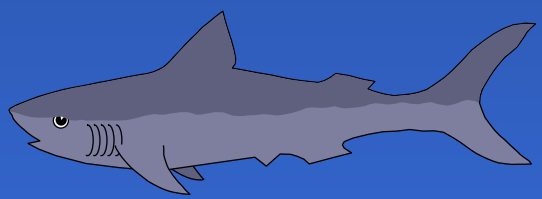
# Planting Stock Selection

***(follows Addy 1947)***

- Select planting stock from as many beds as possible (maintain genetic structure of the population)
- Select plants from sites with conditions like the planting site (depth, sediments, temp. salinity)
- Handle plants carefully - keep cool and soaked
- Spread the effort (min. donor bed impact)

# Problem animals & solutions

- Rays , Crabs and Fish: can be excluded by an number of devices, including:
- cages
- poles
- planting in dense plots
- artificial decoys (birds of prey, predator fish)



# Issues involving recovery of injuries to seagrass beds

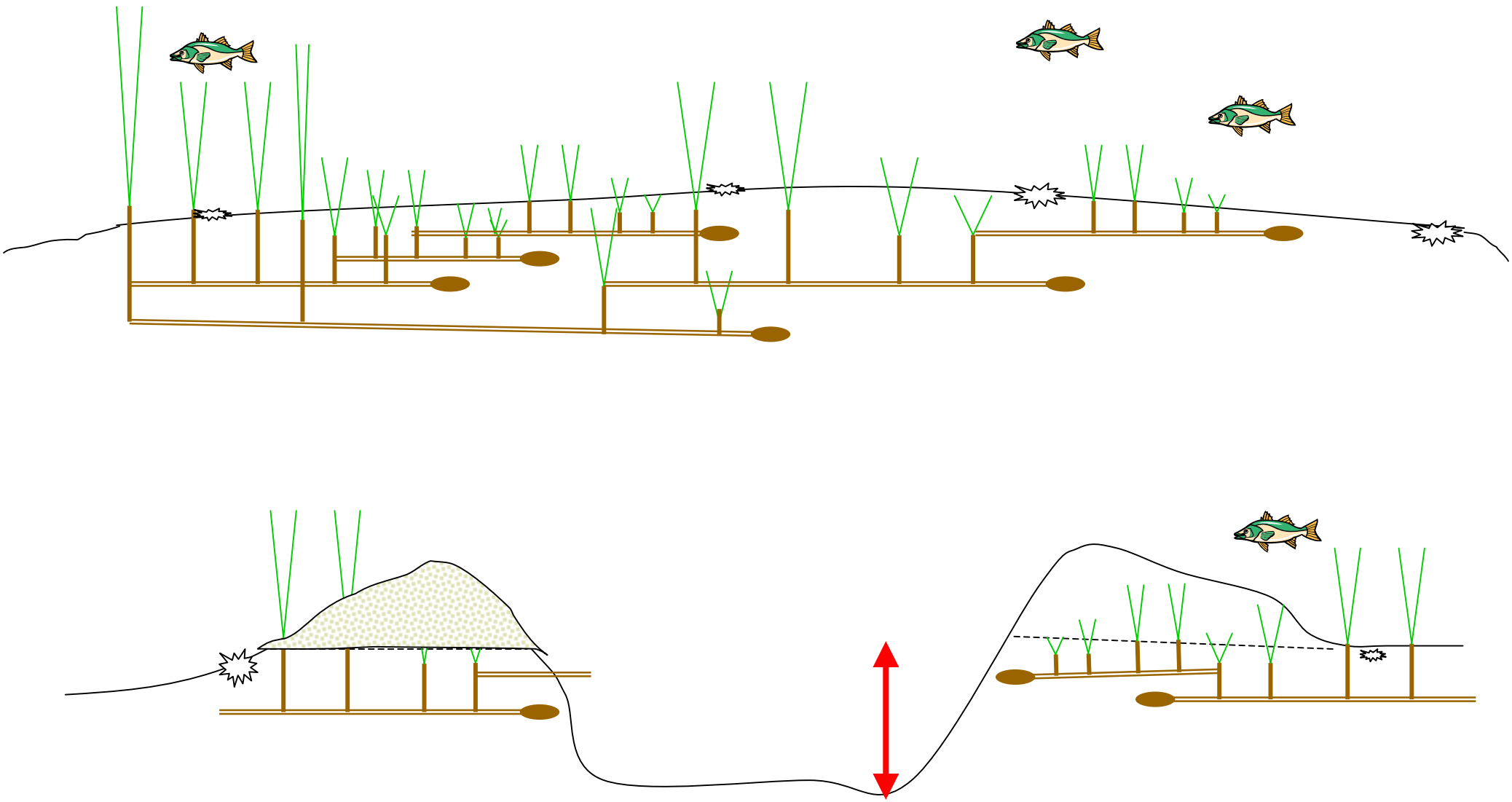

COURTESY J. KENWORTHY

LARGE HOLE WHERE VESSEL GROUNDED (TIME 0)

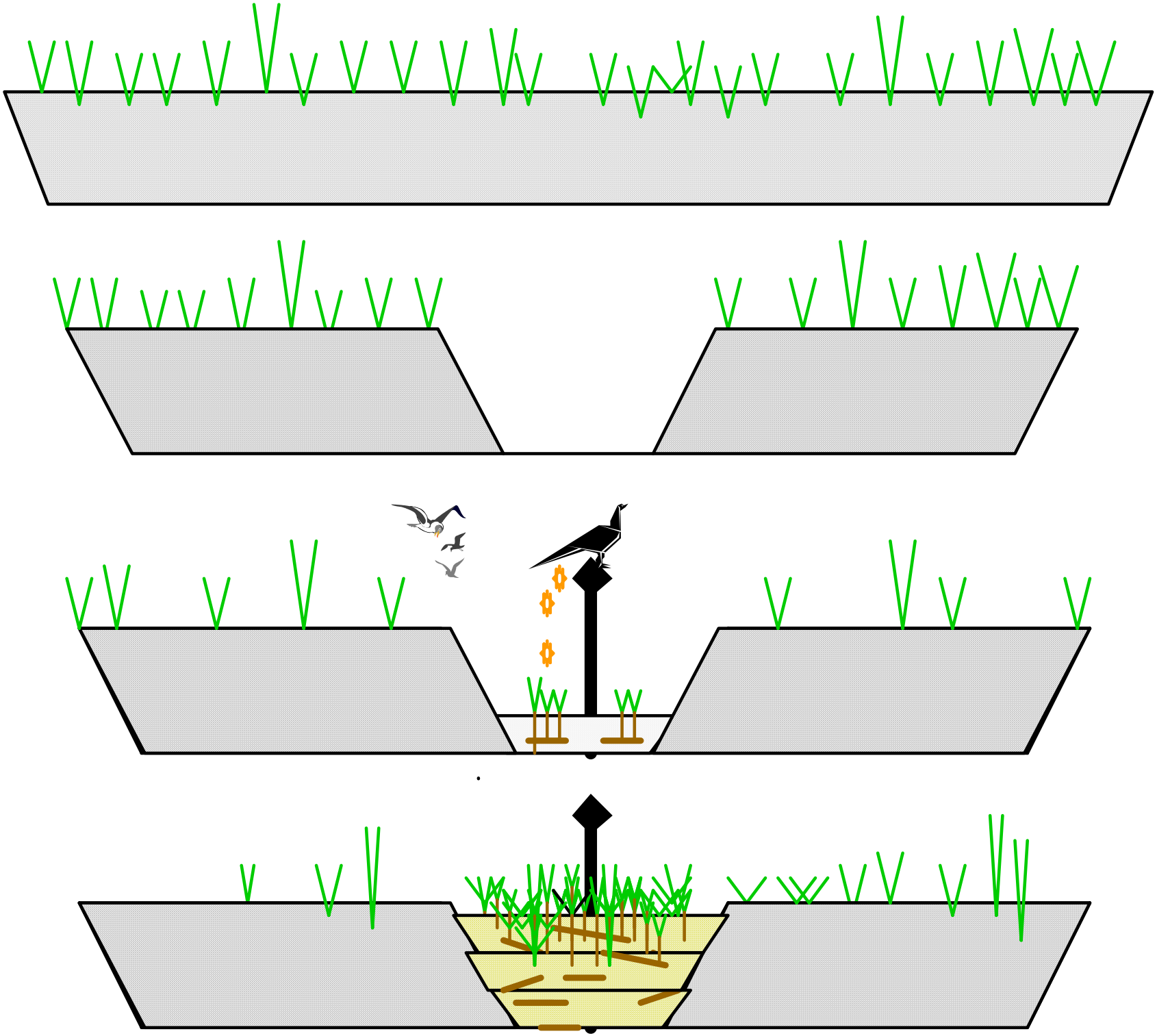
TWIN PROPELLER SCARS IN SEAGRASS BED


SAME LARGE HOLE WHERE VESSEL GROUNDED (TIME 1 YEAR)

COURTESY P. WHITFIELD

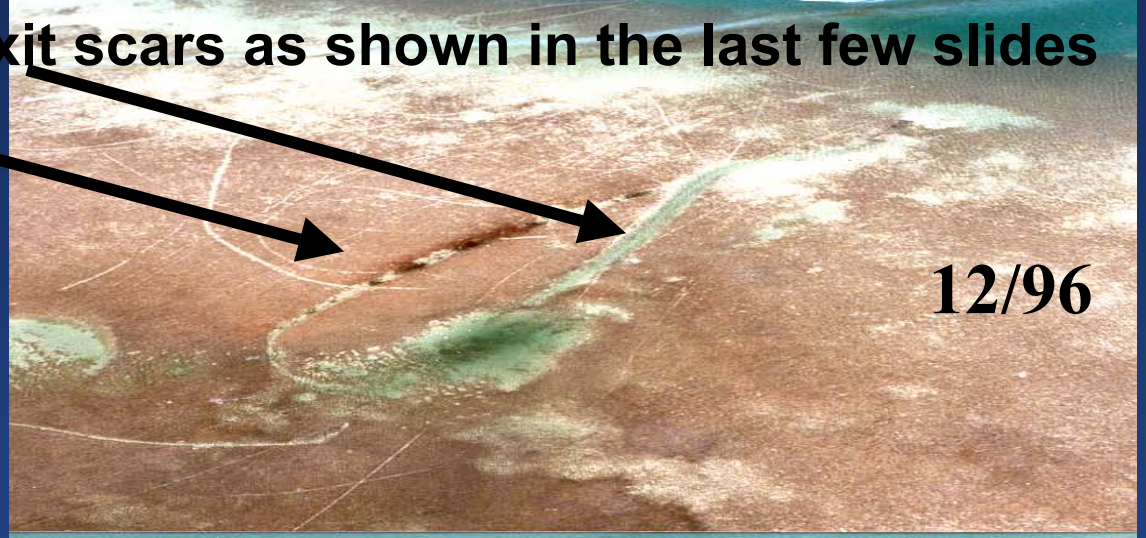


COURTESY J. KENWORTHY



COURTESY J. KENWORTHY

Entry and Exit scars as shown in the last few slides




42% Cover


60% Cover

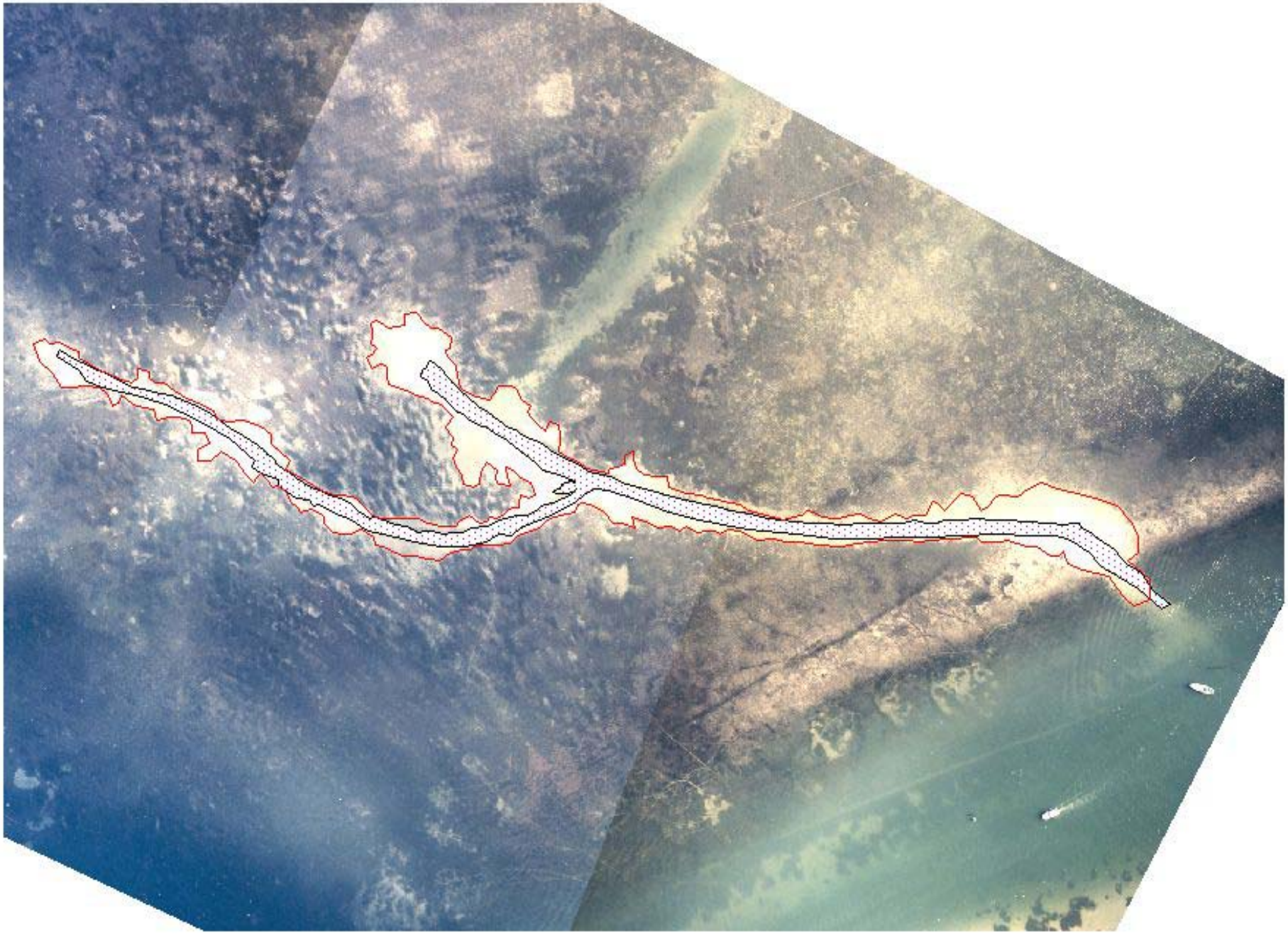

85% Cover

COURTESY J. KENWORTHY

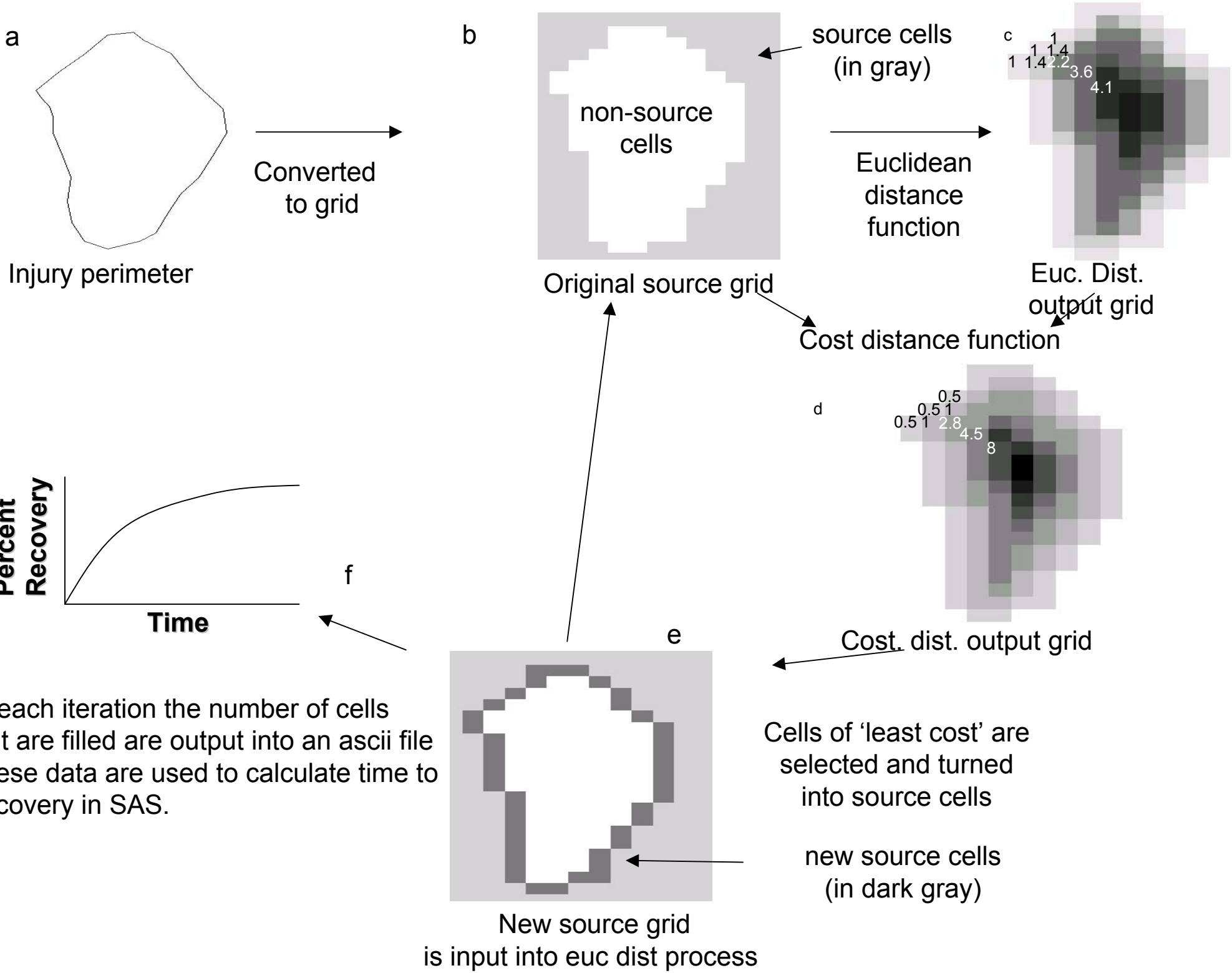
# Applied research on injury geometry modeling -

- Injury extent varies f (length, width, depth)
- Injuries also vary f (shape)
  - ↗ perimeter/area ratio
  - ↗ eccentricity (L/W)

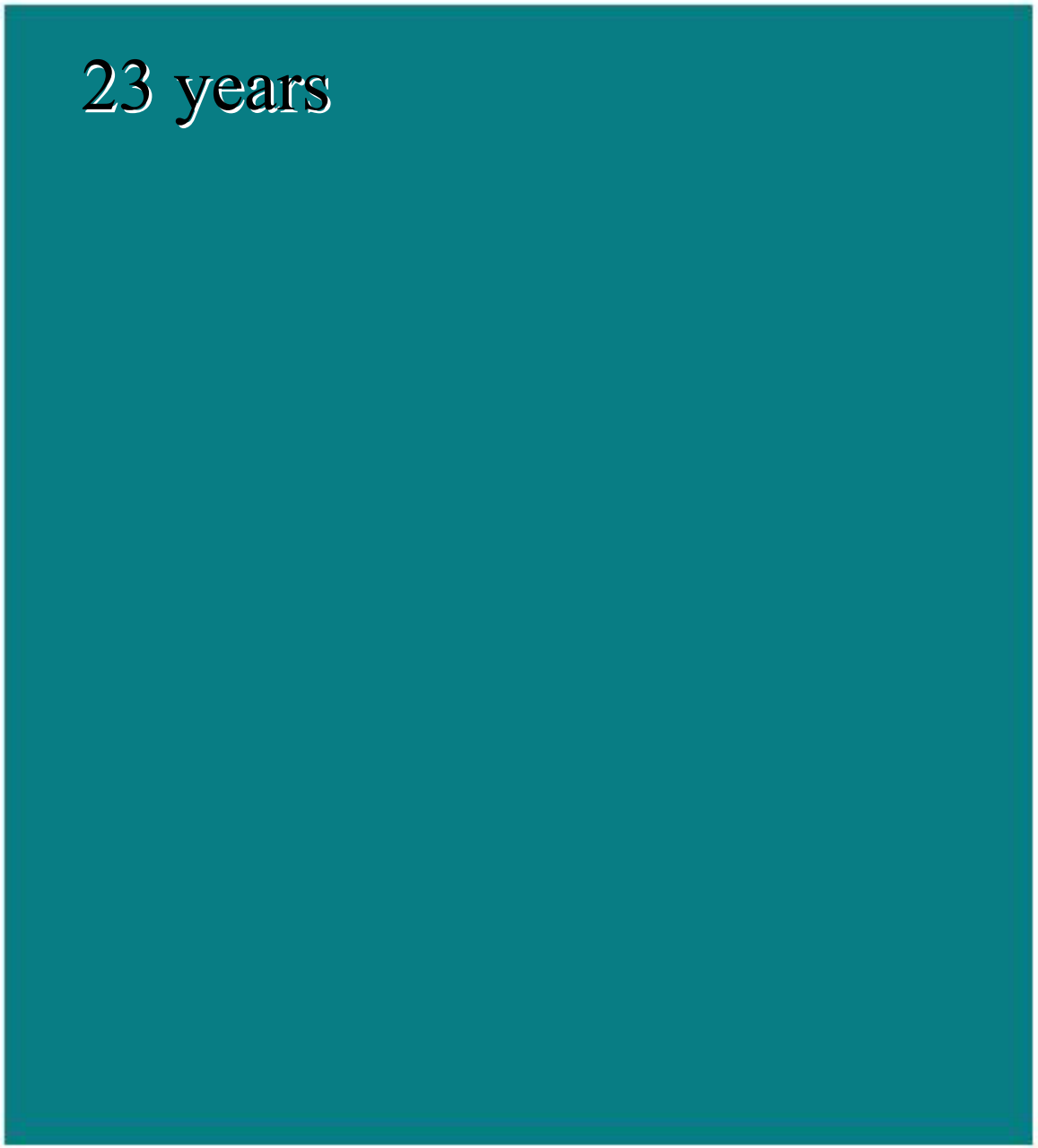
- Models of recovery must include shape, not just physical extent and degree of injury (%)


berm area = 5267 sq meters
trench area = 2863 sq. meters
0
30
60 Meters

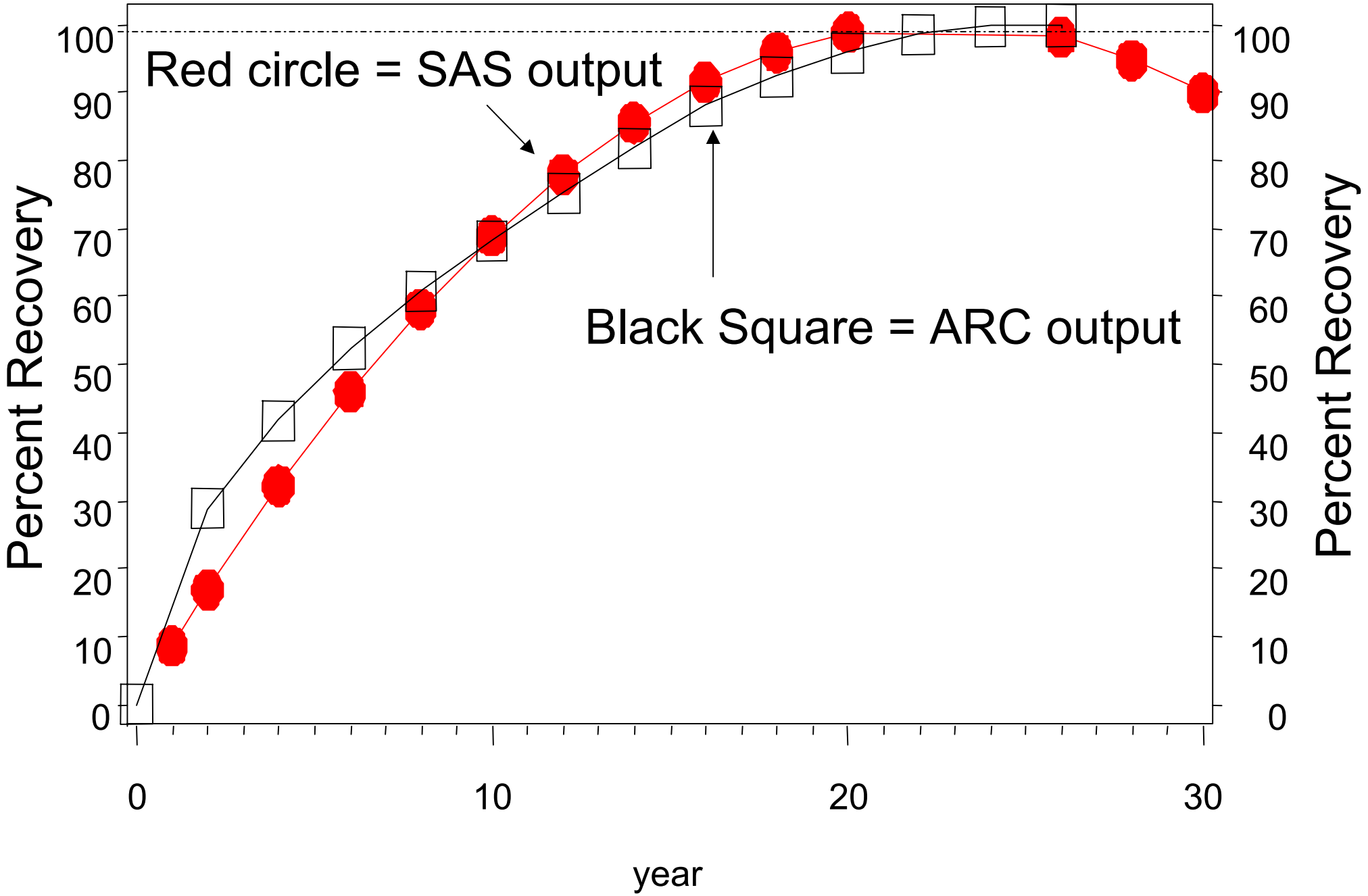
Flowchart of Deterministic Modeling Process Process



# Arc-Info Spatial Model




COURTESY P. WHITFIELD


Red circle = SAS output
Black Square = ARC output
Percent Recovery
Percent Recovery
year
0
10
20
30
0
10
20
30
40
50
60
70
80
90
100

# TAKE HOME POINT

All the restoration tricks and models of recovery were based on a strong empirical data set in the form of applied experimental manipulations.

# THOUGHTS ON SEAGRASS RESTORATION

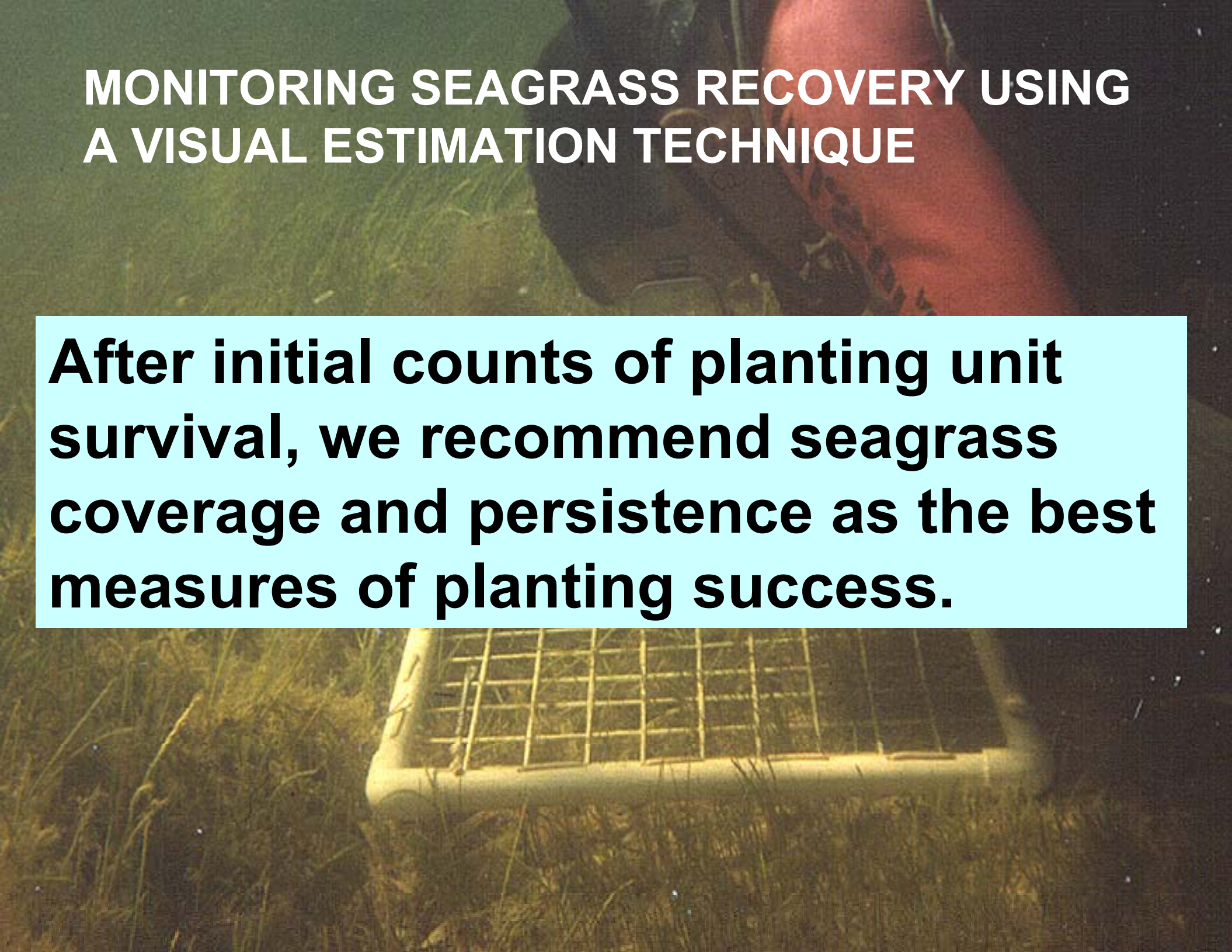
1) ASSESSING INJURY

2) SITE SELECTION

3) PLANTING ISSUES

4) DETERMINING SUCCESS

5) COST



# MONITORING SEAGRASS RECOVERY USING A VISUAL ESTIMATION TECHNIQUE

**After initial counts of planting unit survival, we recommend seagrass coverage and persistence as the best measures of planting success.**

# THOUGHTS ON SEAGRASS RESTORATION

1) ASSESSING INJURY

2) SITE SELECTION

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## Based on aforementioned HEA -

To avoid conflict over differing strategies for assessing resource value, we now assess seagrass value on the basis of the cost to restore the habitat to pre-injury conditions

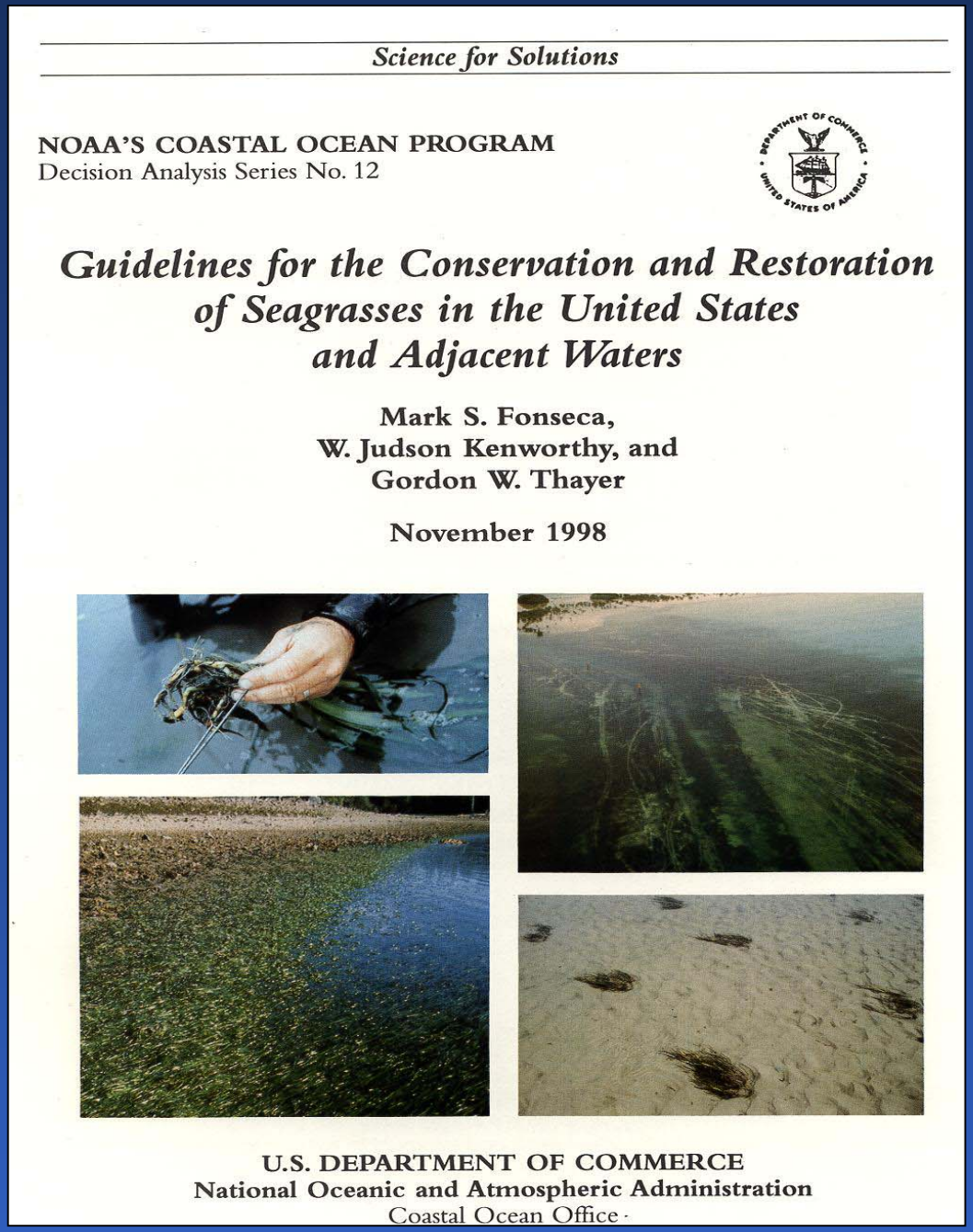
**In the United States, seagrass restoration costs for a 1.5 acre (0.607 HA) project:**

- **Map & Ground truth = 5.5%**
- **Planting = 18.5%**
- **Monitoring = 58.7%**
- **Contractor = 8.3%**
- **Gov't oversight = 9.1%**

- **TOTAL COST = $351,648 US**

**Source:** United States of America v. Melvin A. Fisher, et. al. 1997. 92-10027-CIV-DAVIS

Available over the web in .pdf format at:
http://shrimp.bea.nmfs.gov/library/digital.html
*and*
http://www.cop.noaa.gov/pubs/das.html



*Science for Solutions*

NOAA'S COASTAL OCEAN PROGRAM
Decision Analysis Series No. 12

# *Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters*

Mark S. Fonseca,
W. Judson Kenworthy, and
Gordon W. Thayer

November 1998

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Coastal Ocean Office

# Hydrodynamics and the forecasting of Ecological Characteristics of Seagrass Ecosystems

**Mark S. Fonseca[1] , Paula E. Whitfield [1] , Bradley D. Robbins[2,3], and Pat Clinton[4]**

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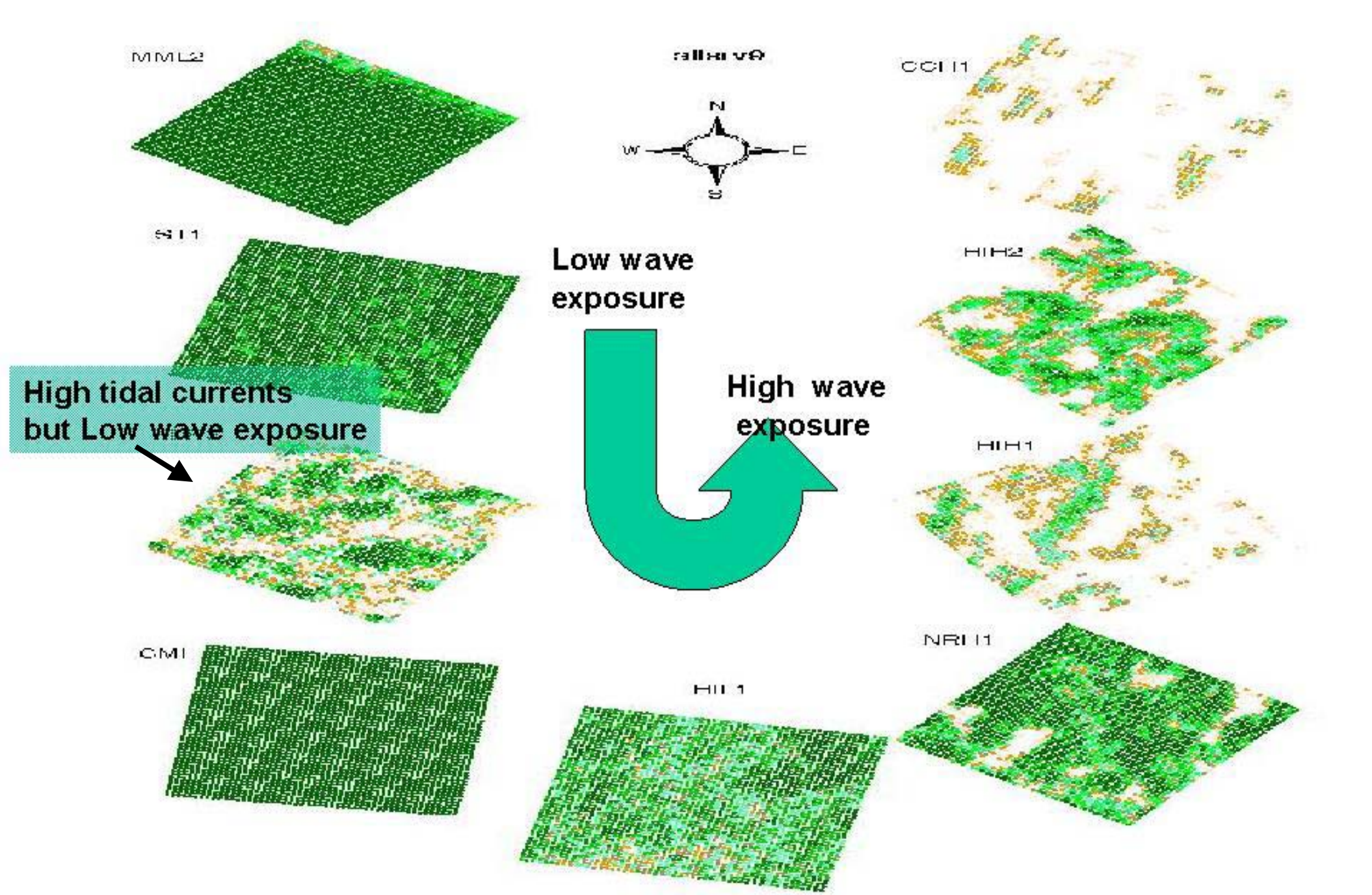
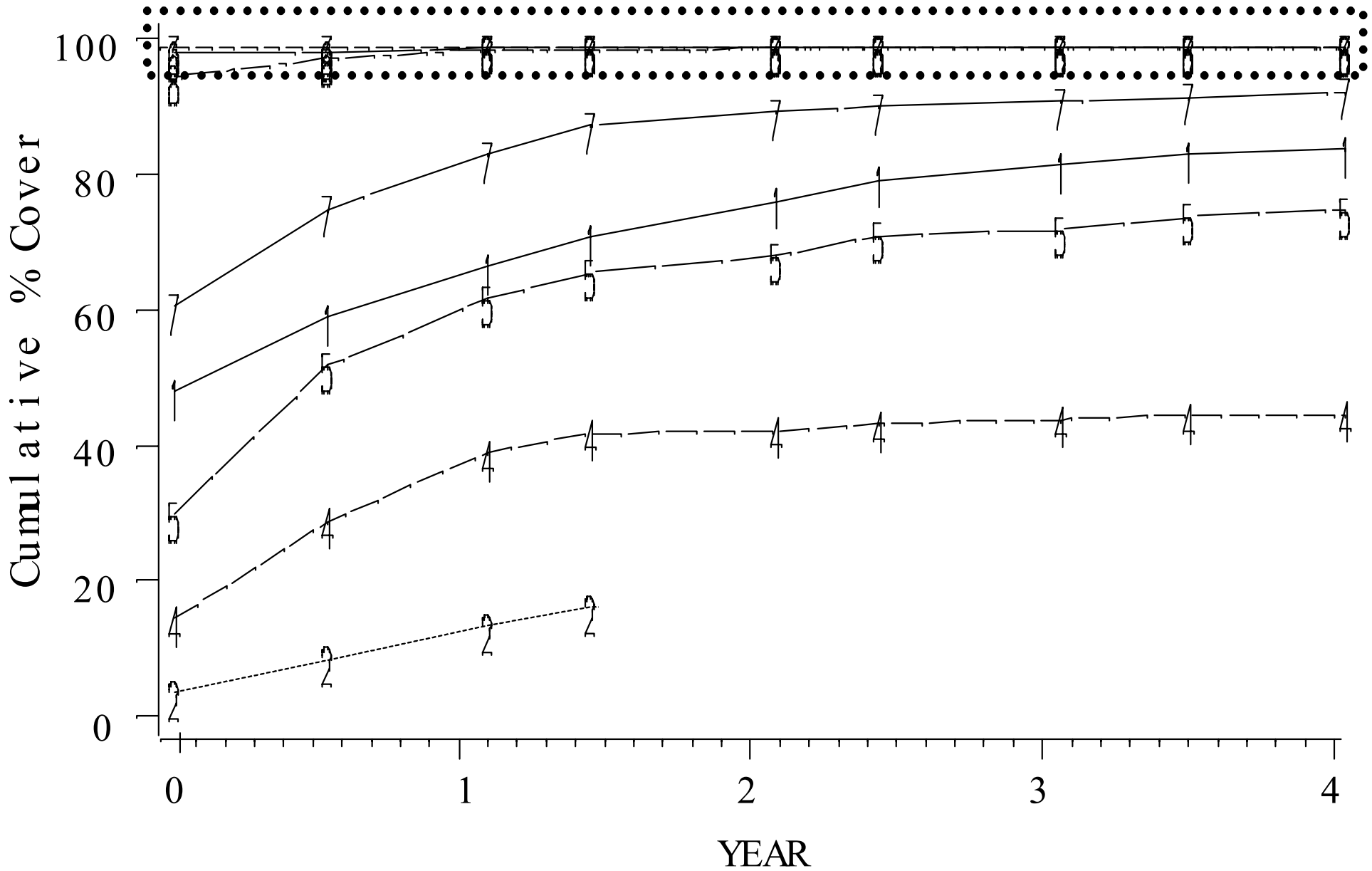
[2]Coastal Ecology Branch, WED/NHEERL/ORD U.S. EPA, 2111 SE Marine Science Center Dr., Newport, OR, 97365-5260, USA

[3] *Current Address*: Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota FL, USA 34236

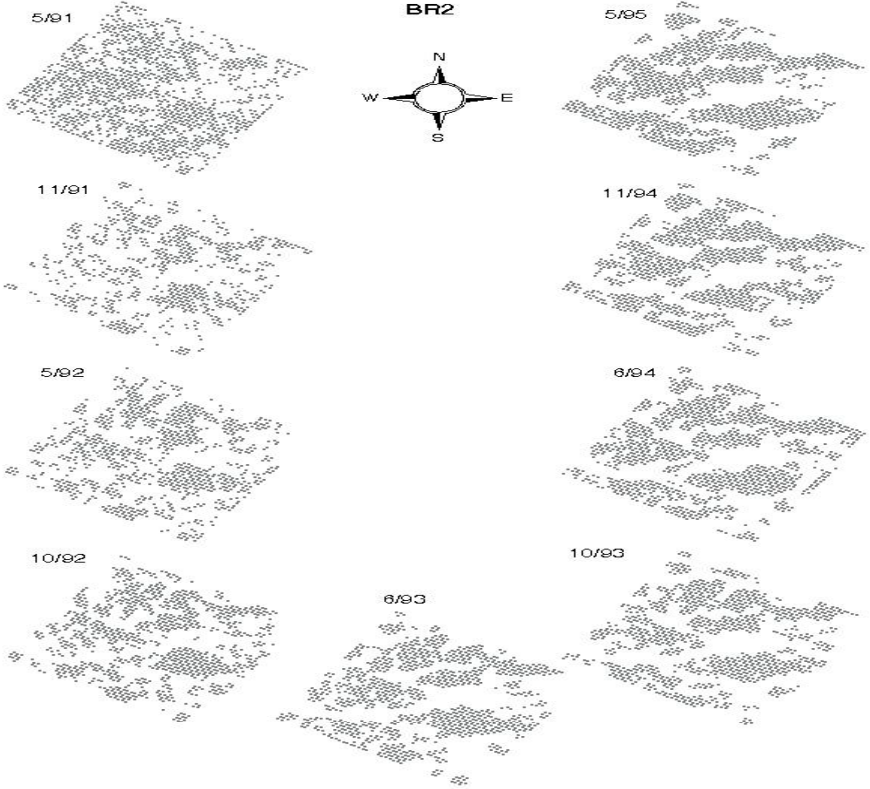
[4] OAO, WED/NHEERL/ORD U.S. EPA, 2111 SE Marine Science Dr., Newport, OR, 97365-5260,




**…seagrass beds in low wave and current areas are flat and exhibit continuous cover of the bottom…in high wave and current areas, beds are patchy, dune - like and migrate across the seafloor**




FROM FONSECA ET AL. 1998


BR2
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5/95
11/91
11/94
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6/94
10/92
6/93
10/93
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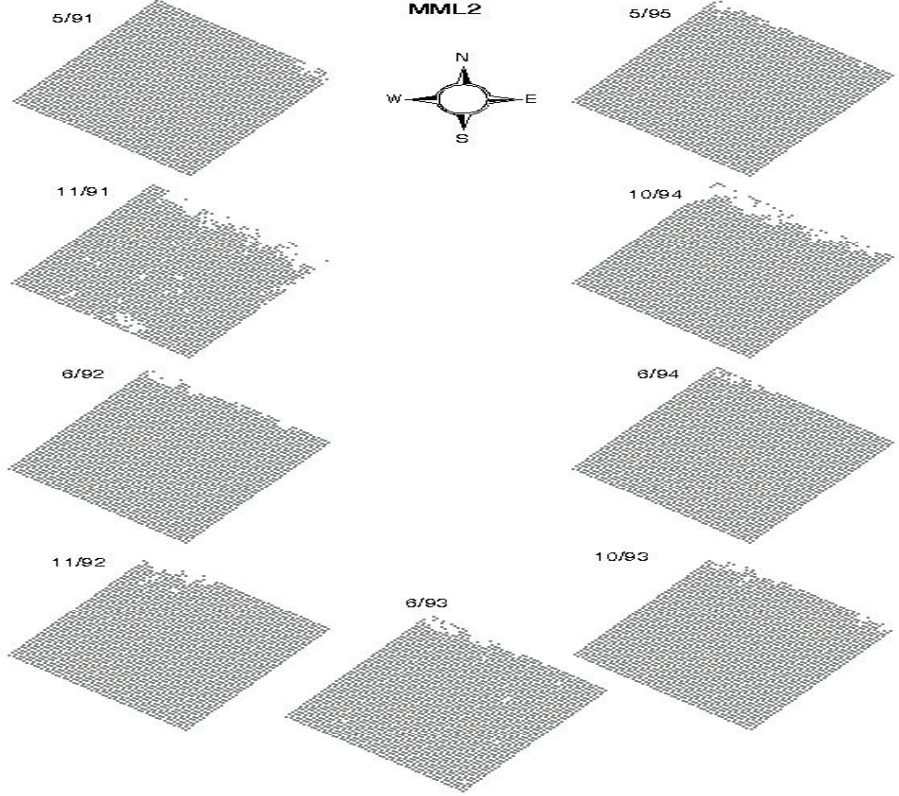
W
E
S


MML2
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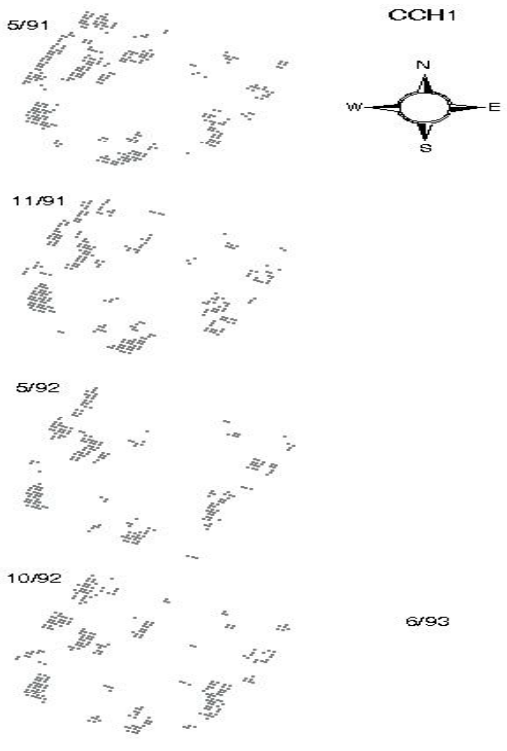
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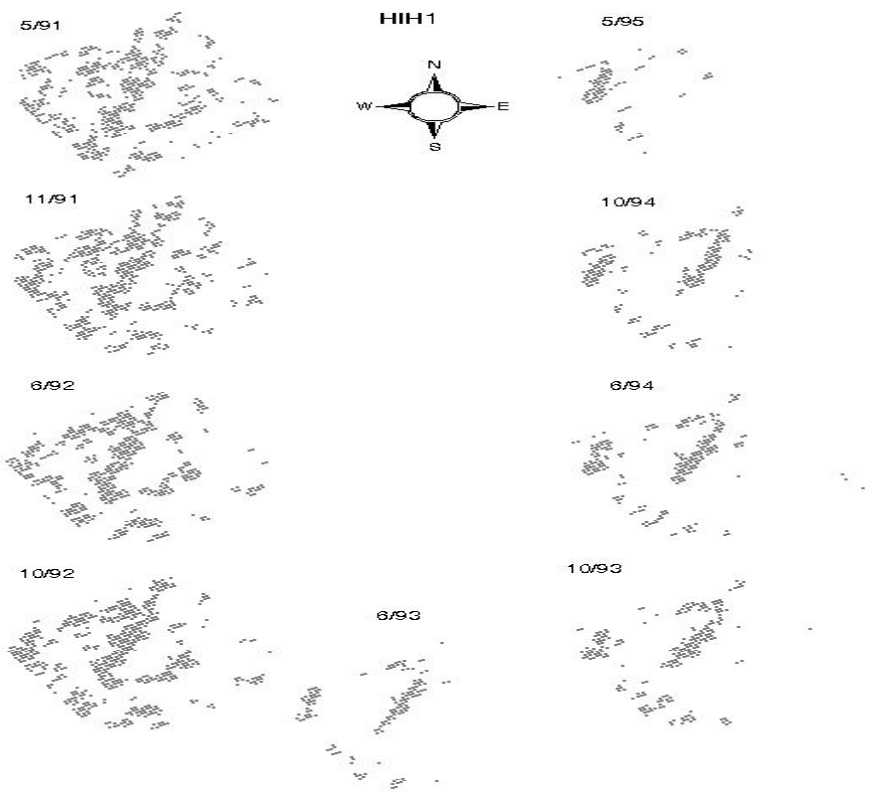
HIH1
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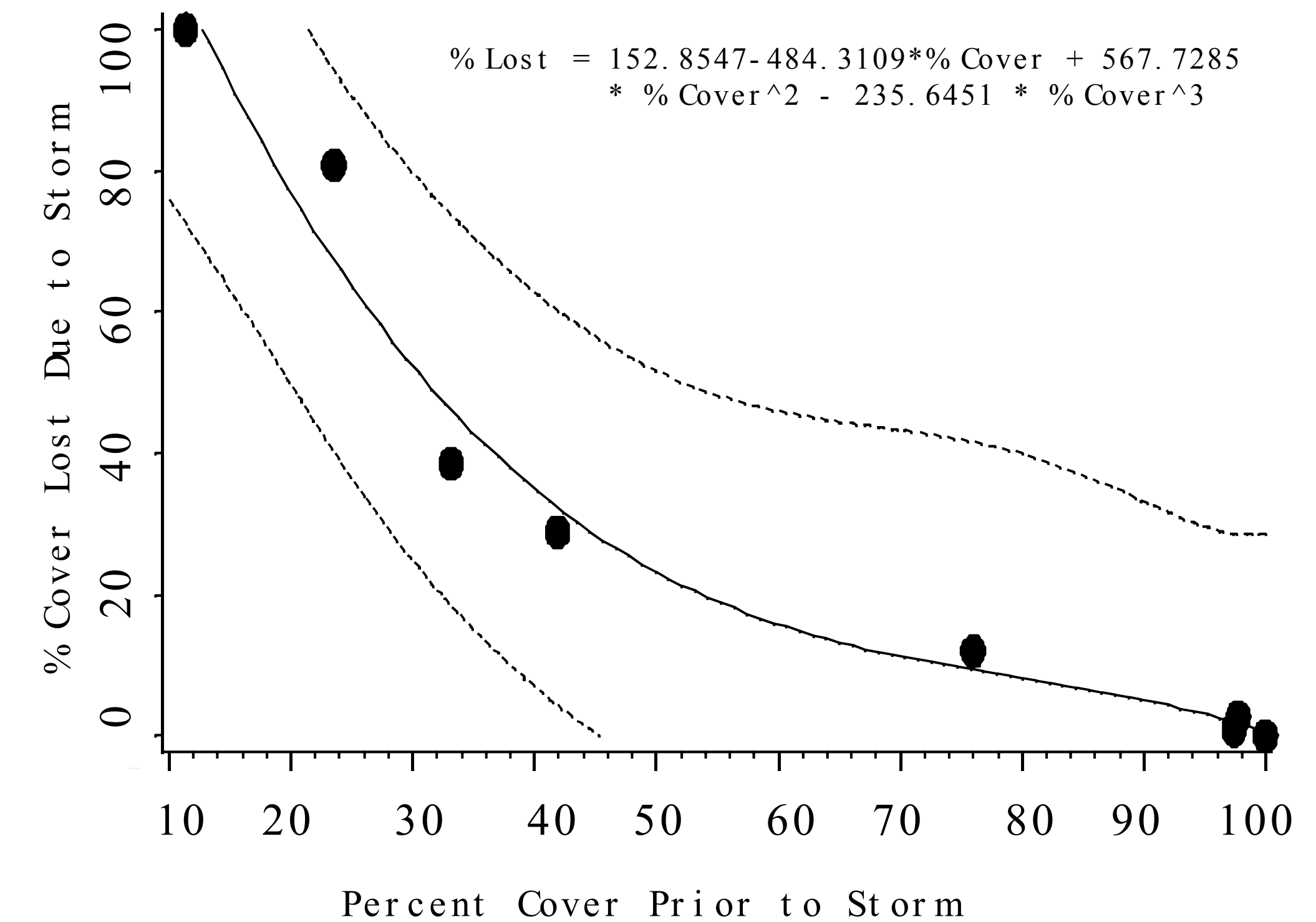
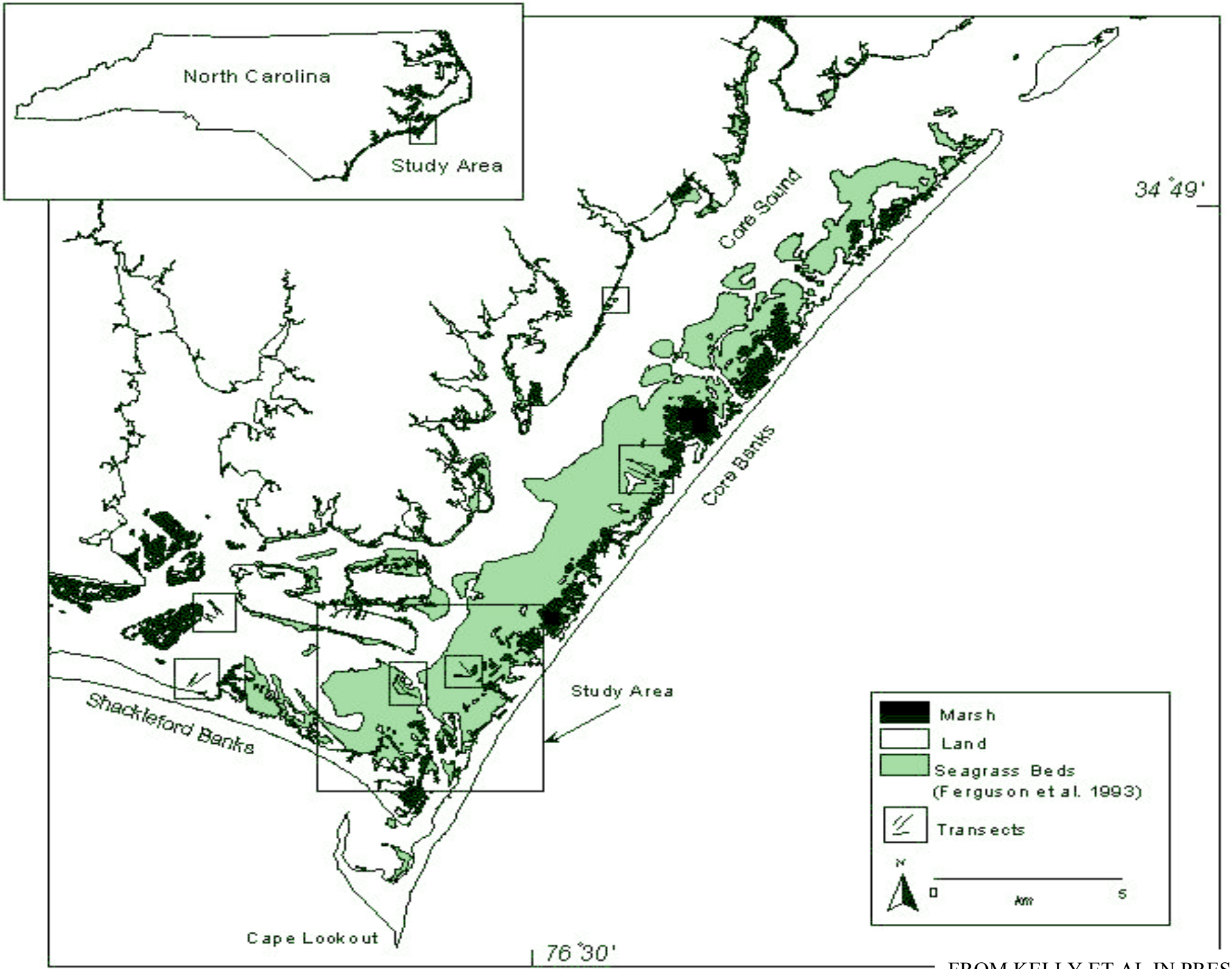


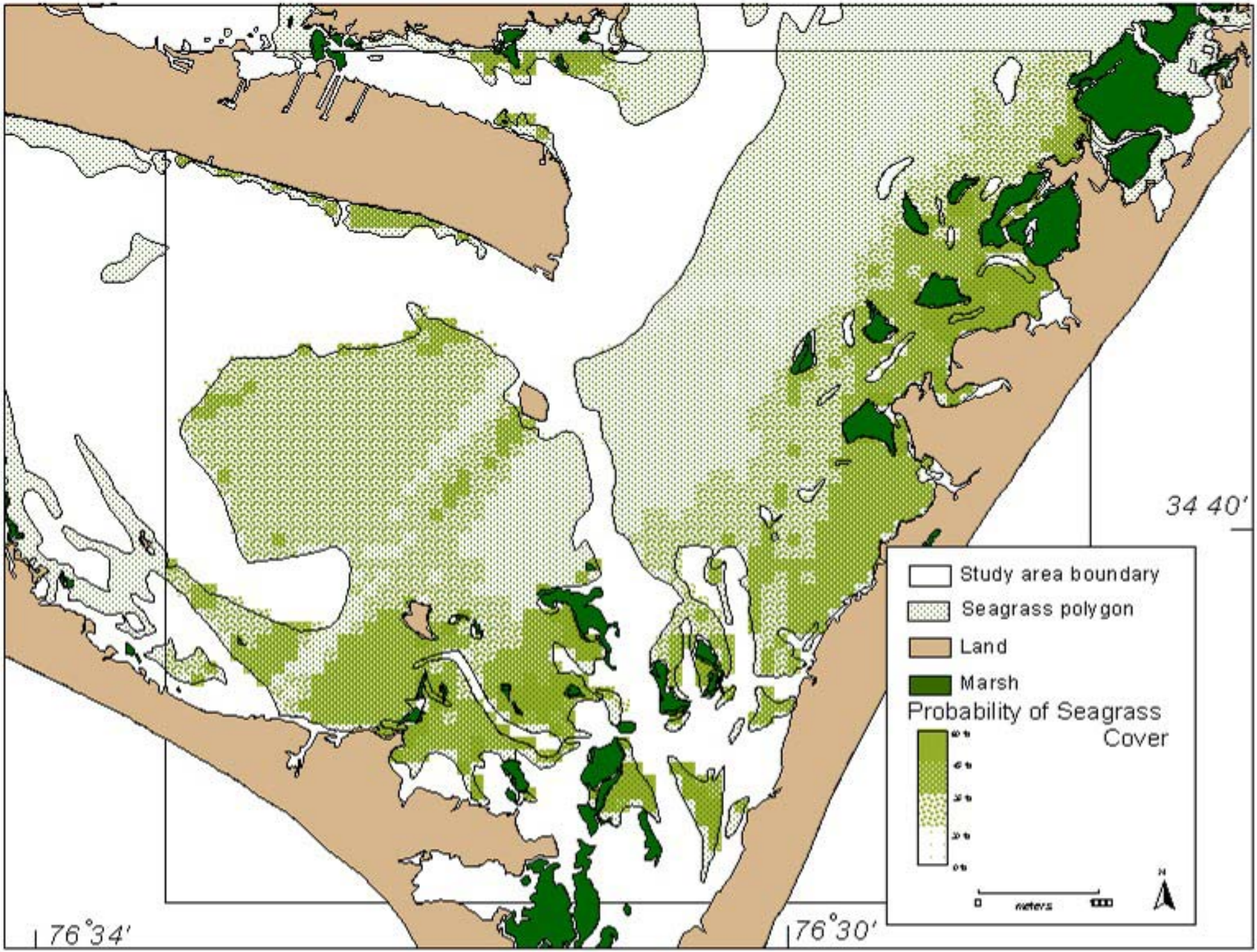

FROM FONSECA ET AL 2000

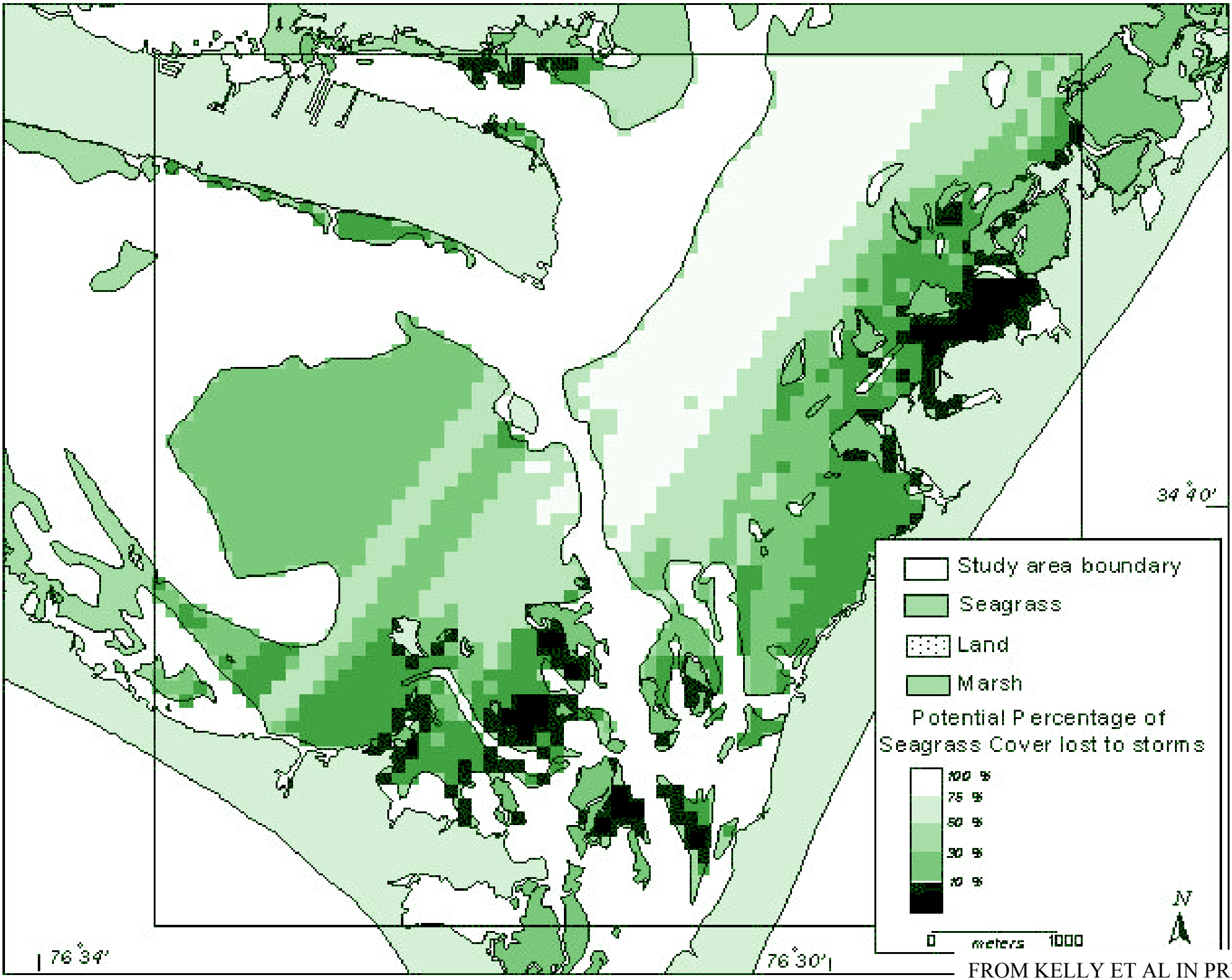
# *Take - home points:*

- **seagrass beds migrate - unvegetated spaces between seagrass patches must be considered part of the seagrass habitat**
- **seagrass habitat is therefore the sum of both patchy seagrass and the unvegetated sea floor among those patches**
- **if the effects storm events are not recognized in interpretation of seagrass surveys, injuries by humans may be impossible to detect**
- **restoration is difficult in high wave and current areas as there is little experience with planting in high wave and current conditions**
- **high disturbance areas are candidates for special protection from injury.**




FROM KELLY ET AL IN PRESS


34 40'
76°34'
76°30'
Study area boundary
Seagrass polygon
Land
Marsh
Probability of Seagrass Cover
meters
N

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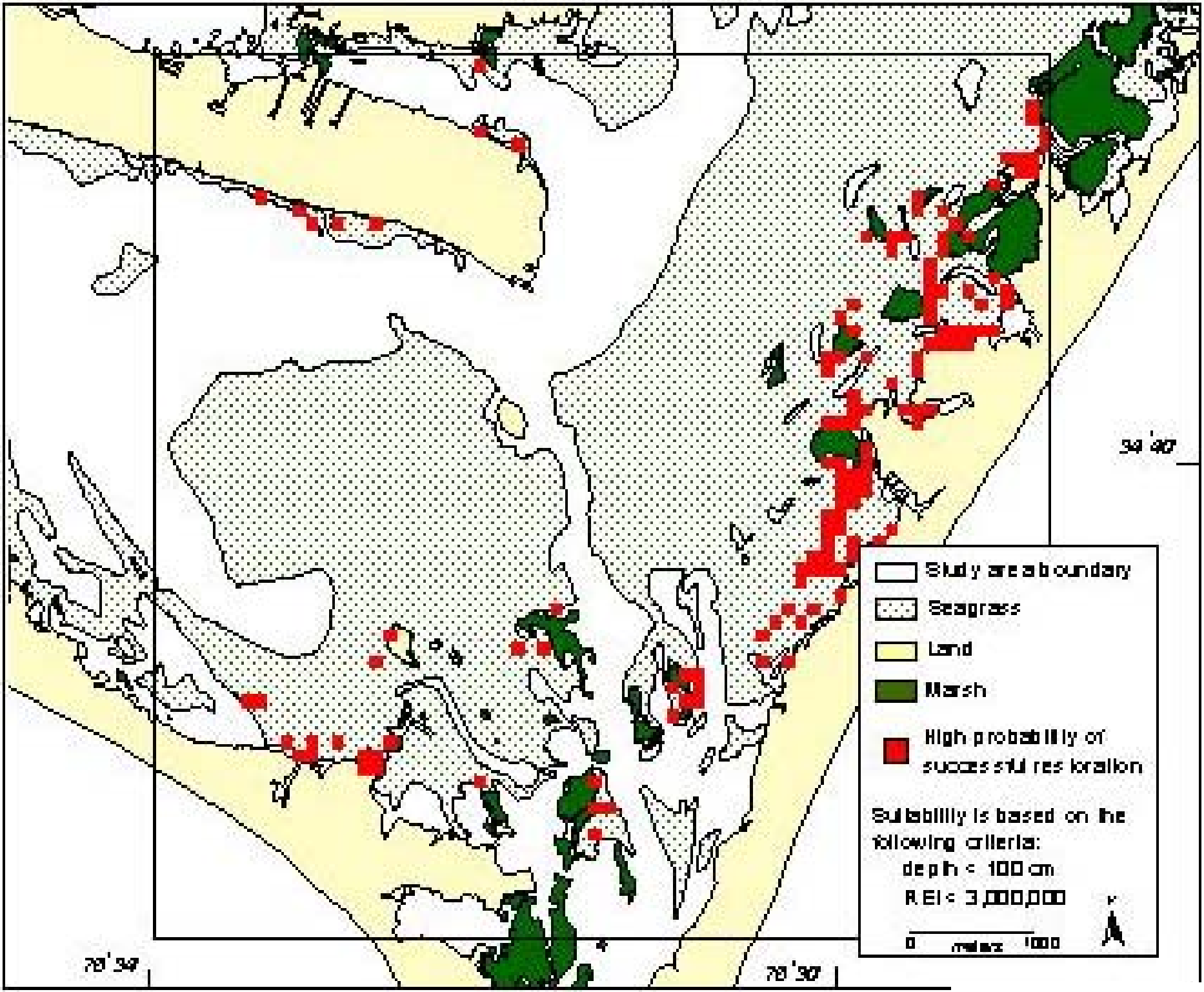
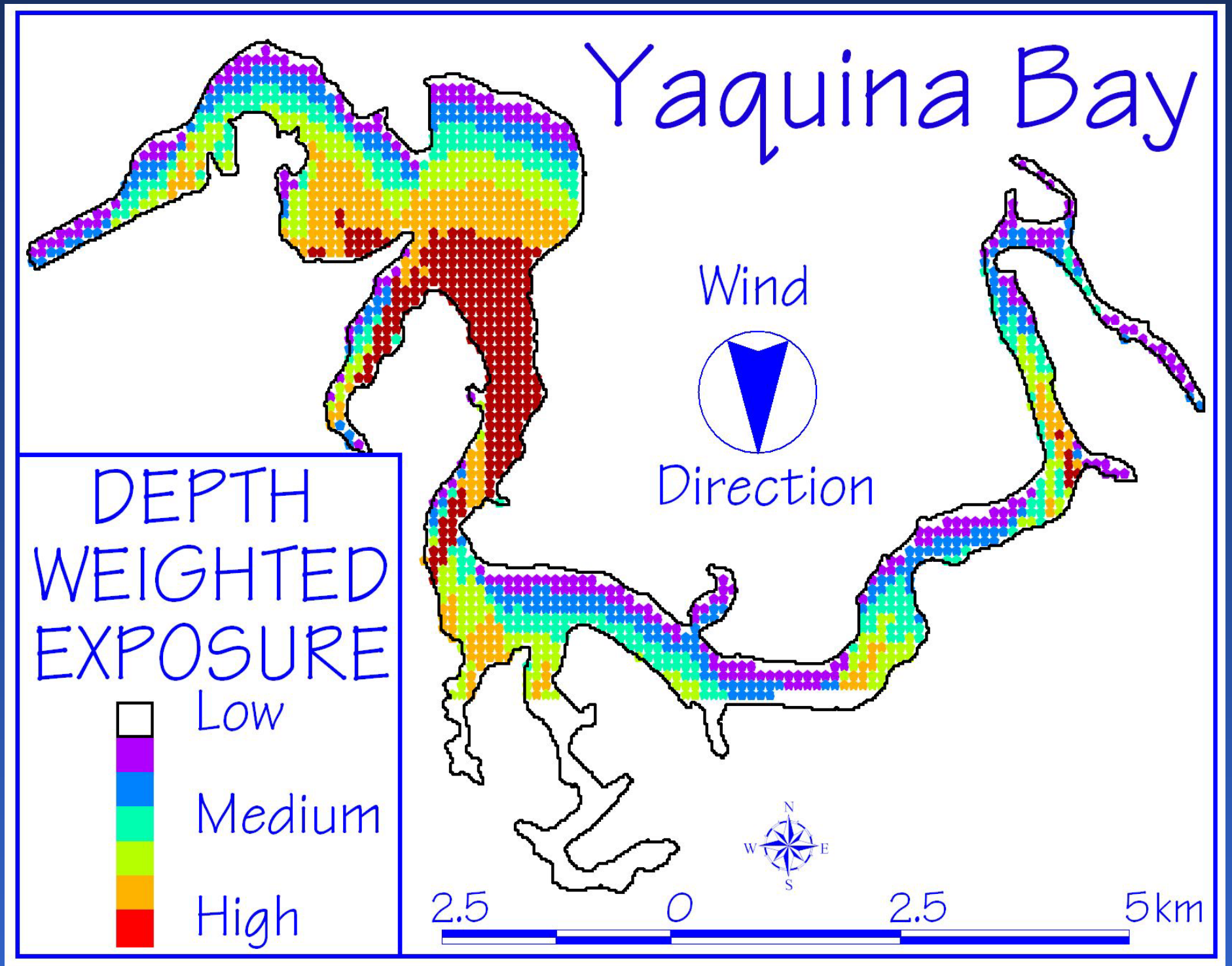


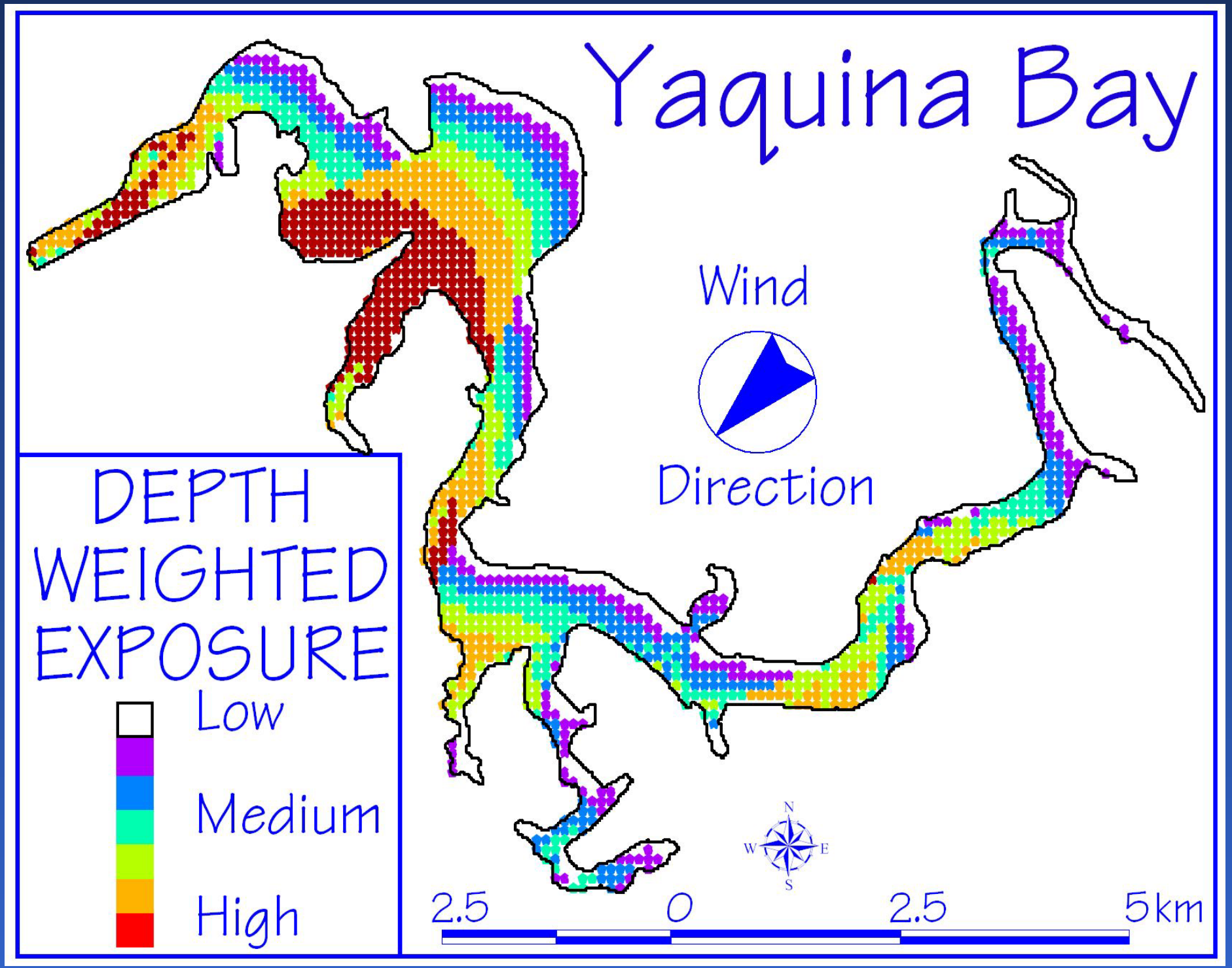

FROM KELLY ET AL IN PRESS

Initial computations of REI (Relative [wave] exposure index): **REI = sum (effective fetch X wind speed X wind duration) for each of those directions**

However, when first applied elsewhere (Chesapeake Bay) - the model was not sufficiently sensitive to shoaling effects and worked poorly

The model has now been refined to use use an Inverse Distance Weighting function to incorporate the not only water depth, but the proximity of shallow water with respect to a chosen point


Yaquina Bay
Wind
Direction
DEPTH
WEIGHTED
EXPOSURE
Low
Medium
High
N
W
E
S
2.5
0
2.5
5km


Yaquina Bay
Wind
Direction
DEPTH
WEIGHTED
EXPOSURE
Low
Medium
High
N
W
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0
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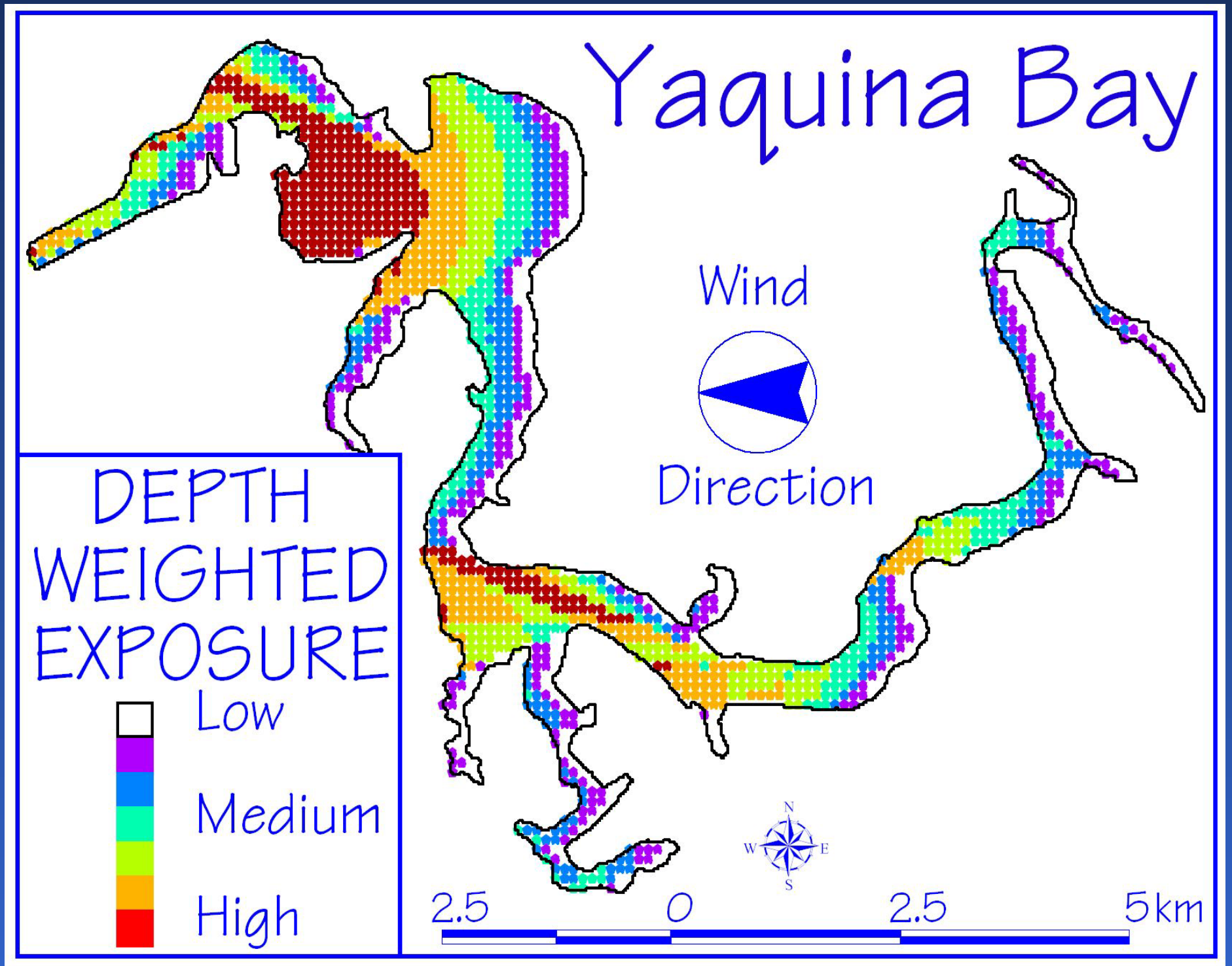
5km


Yaquina Bay
Wind
Direction
DEPTH
WEIGHTED
EXPOSURE
Low
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High
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W
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2.5
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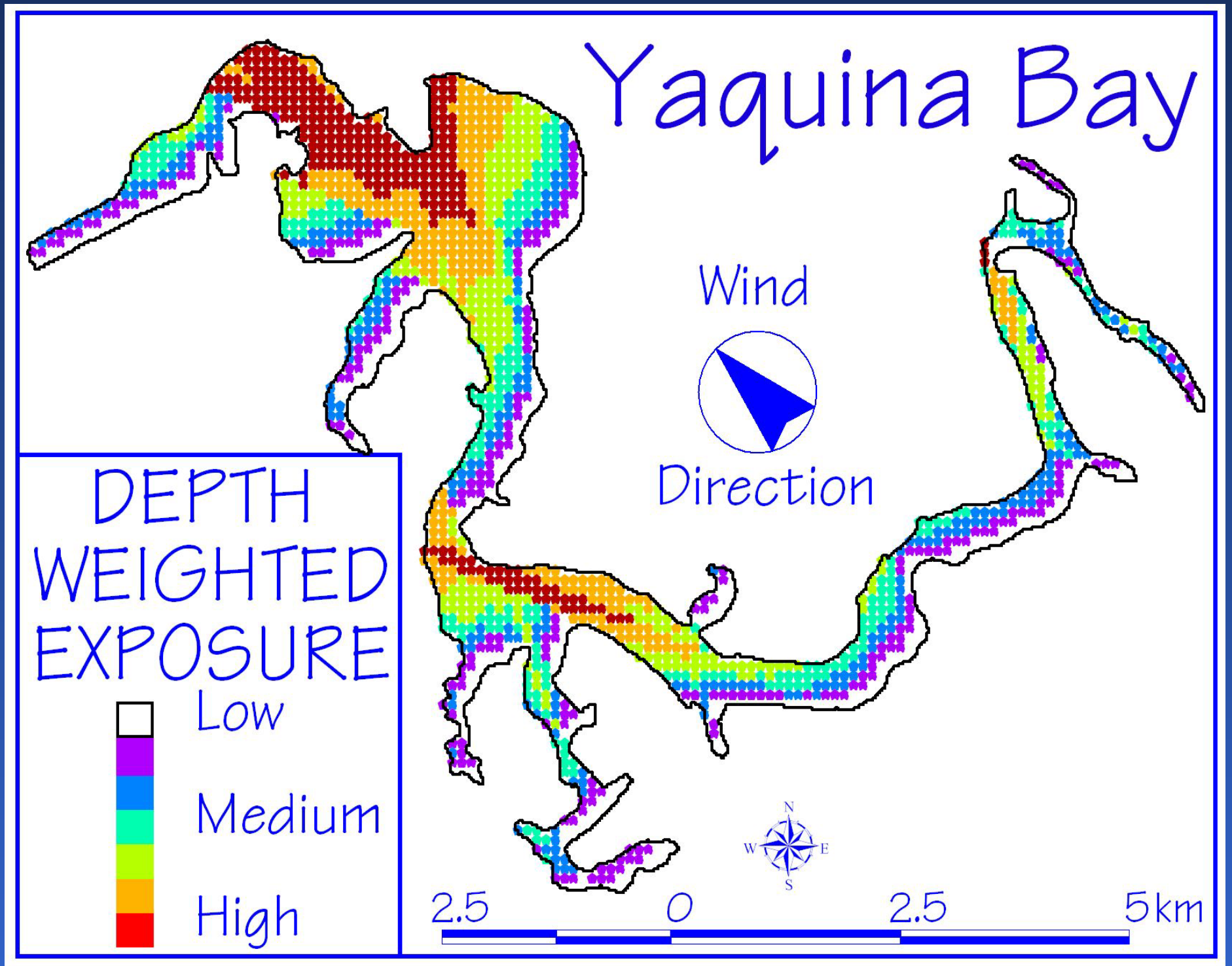
Yaquina Bay
Wind
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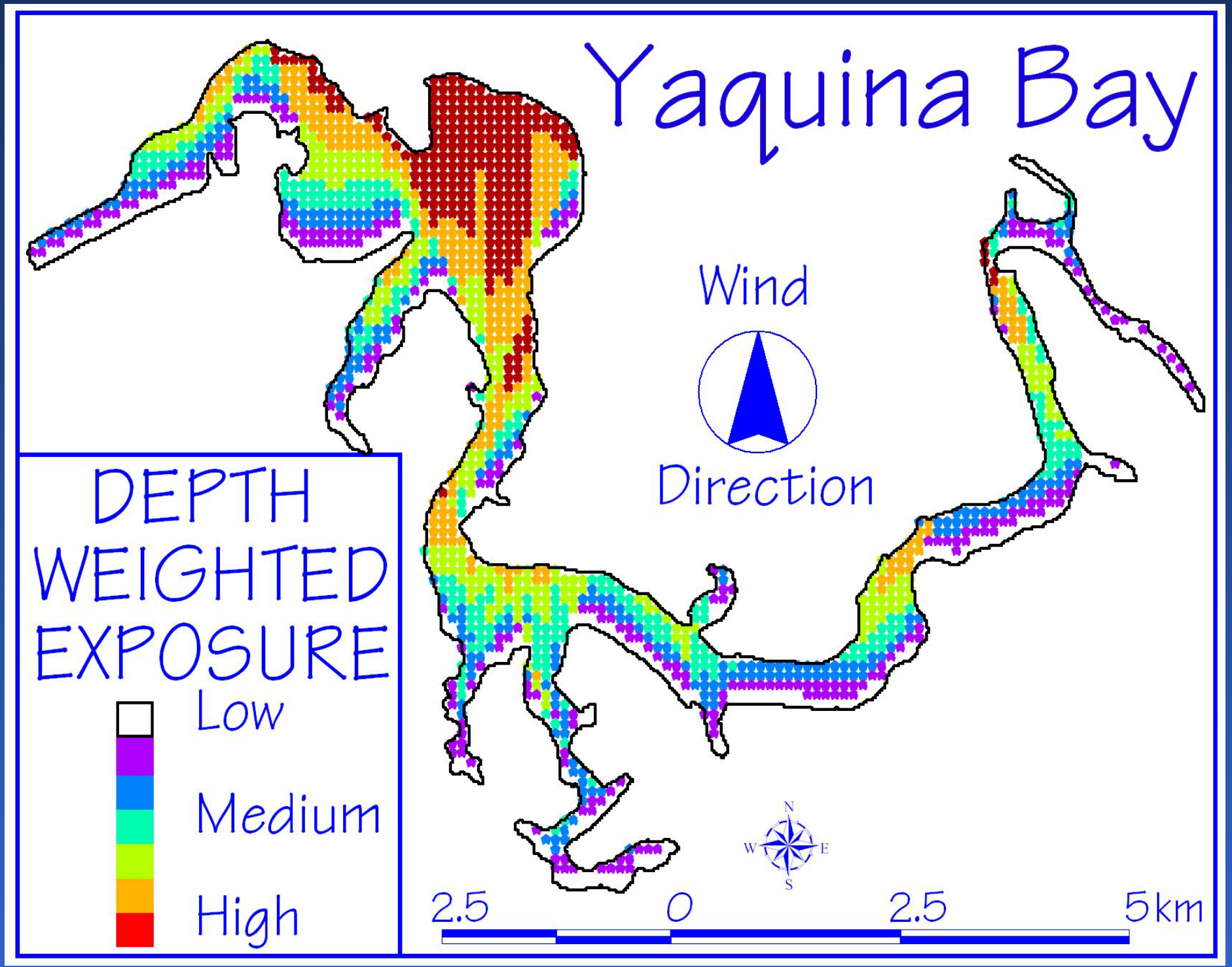
Yaquina Bay
Wind
Direction
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WEIGHTED
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Low
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0
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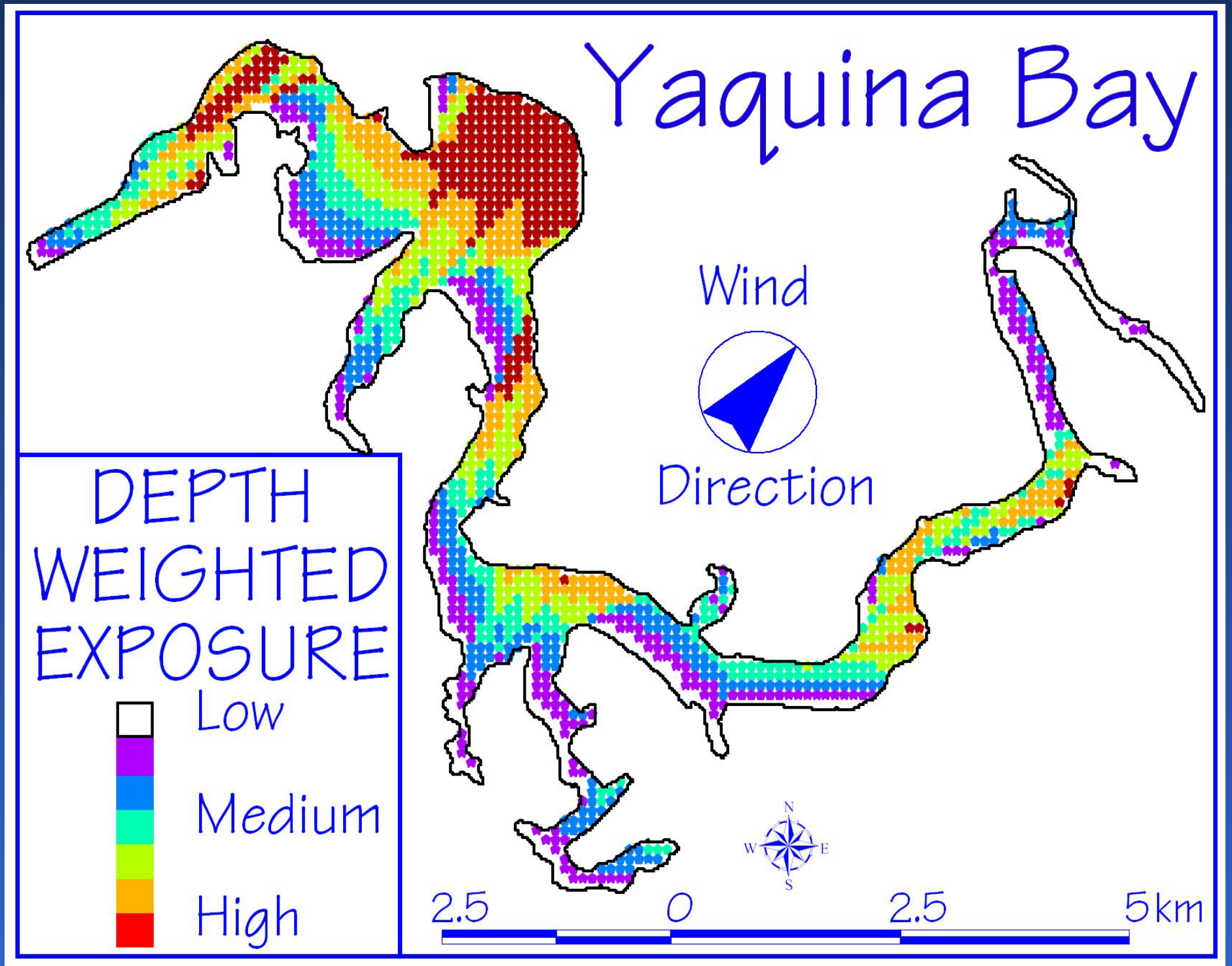
5km


Yaquina Bay
Wind
Direction
DEPTH
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EXPOSURE
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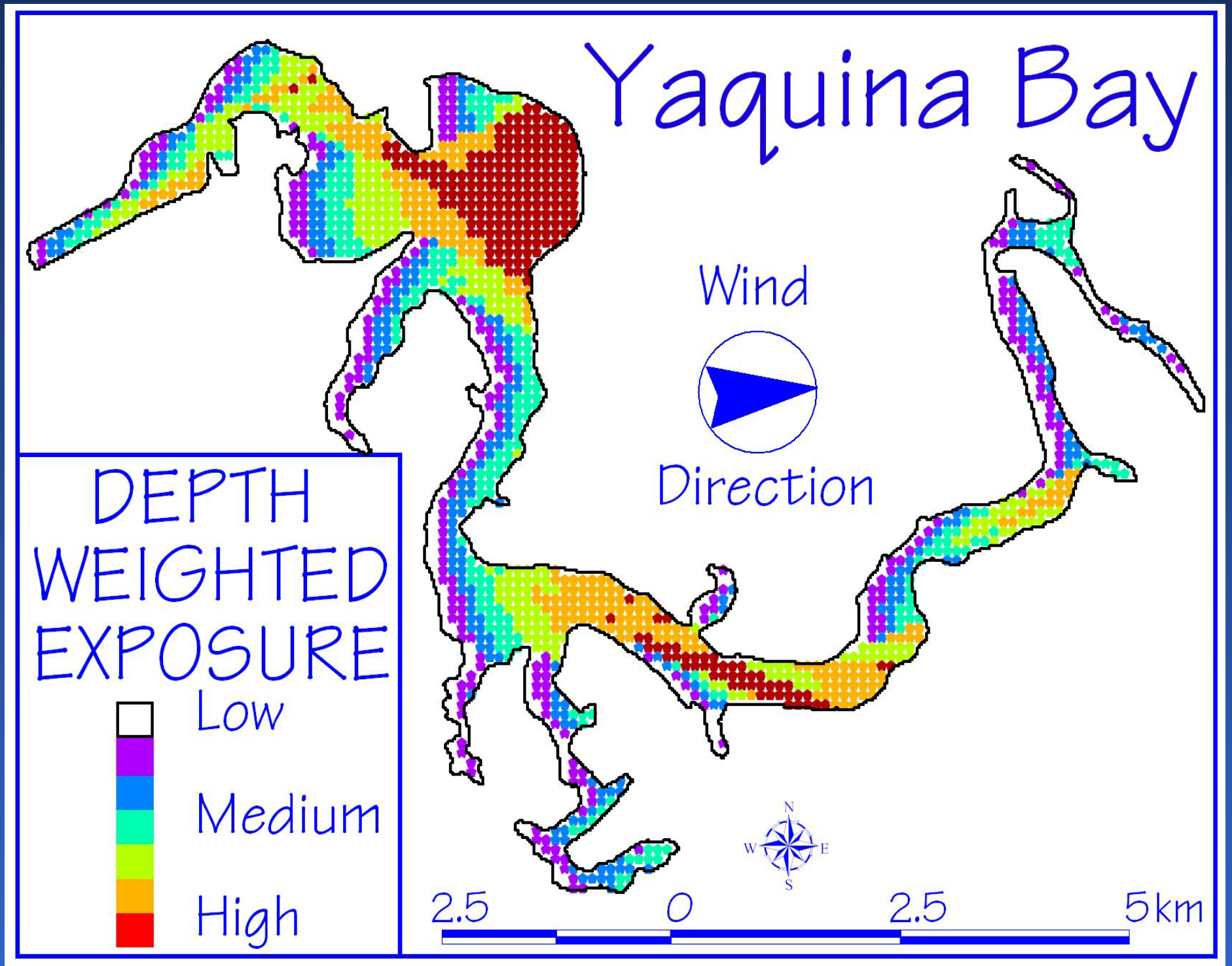
Yaquina Bay
Wind
Direction
DEPTH
WEIGHTED
EXPOSURE
Low
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High
N
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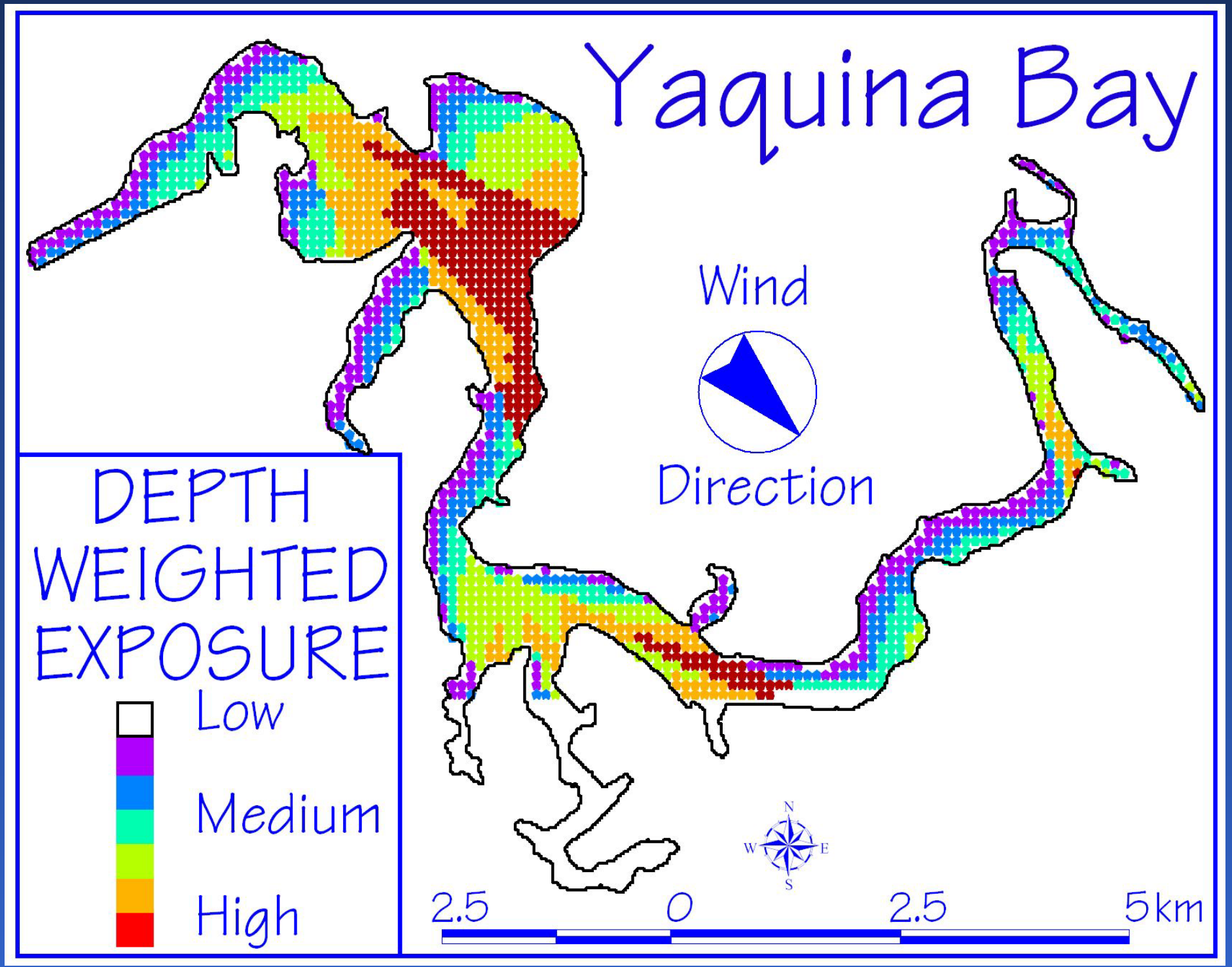
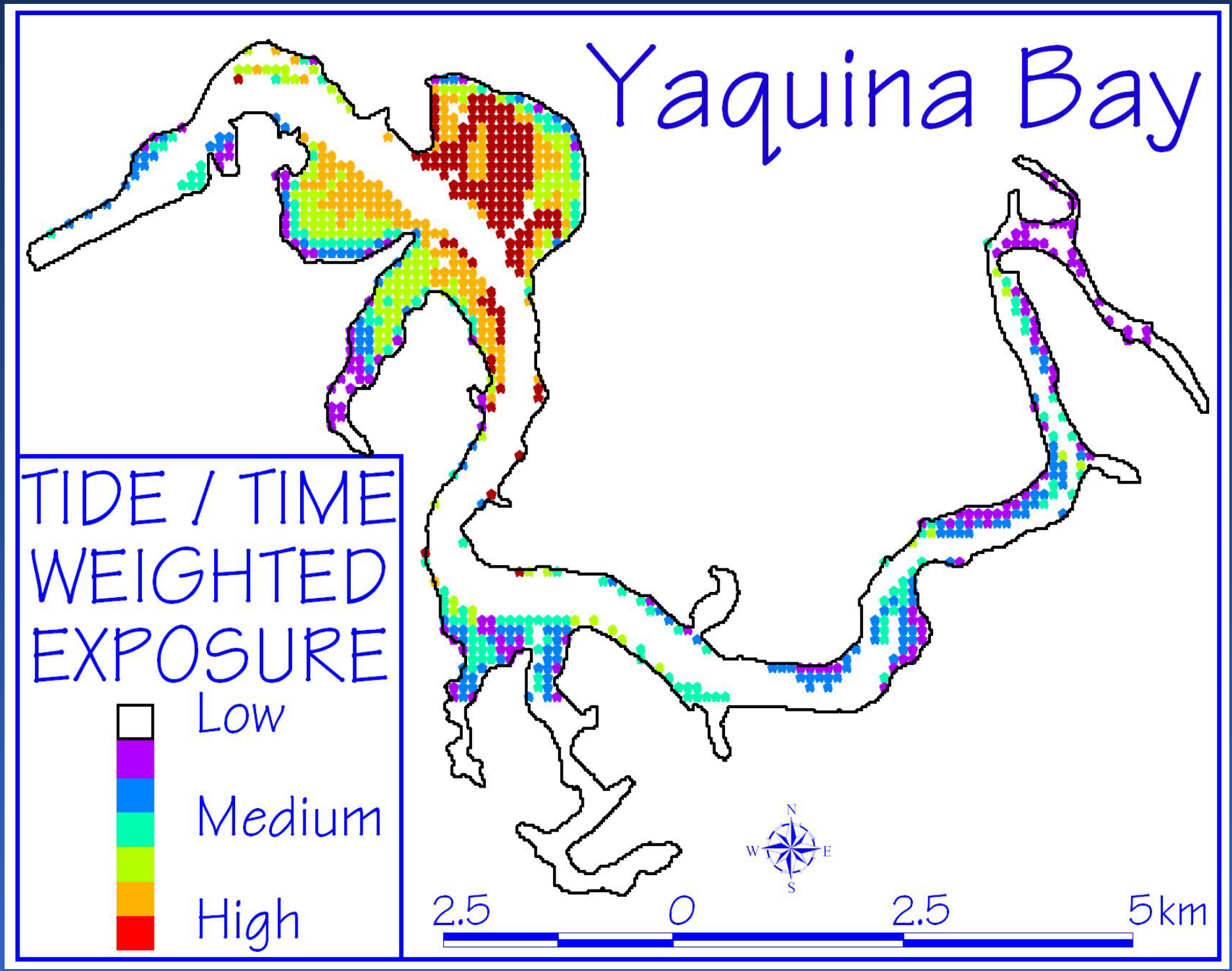
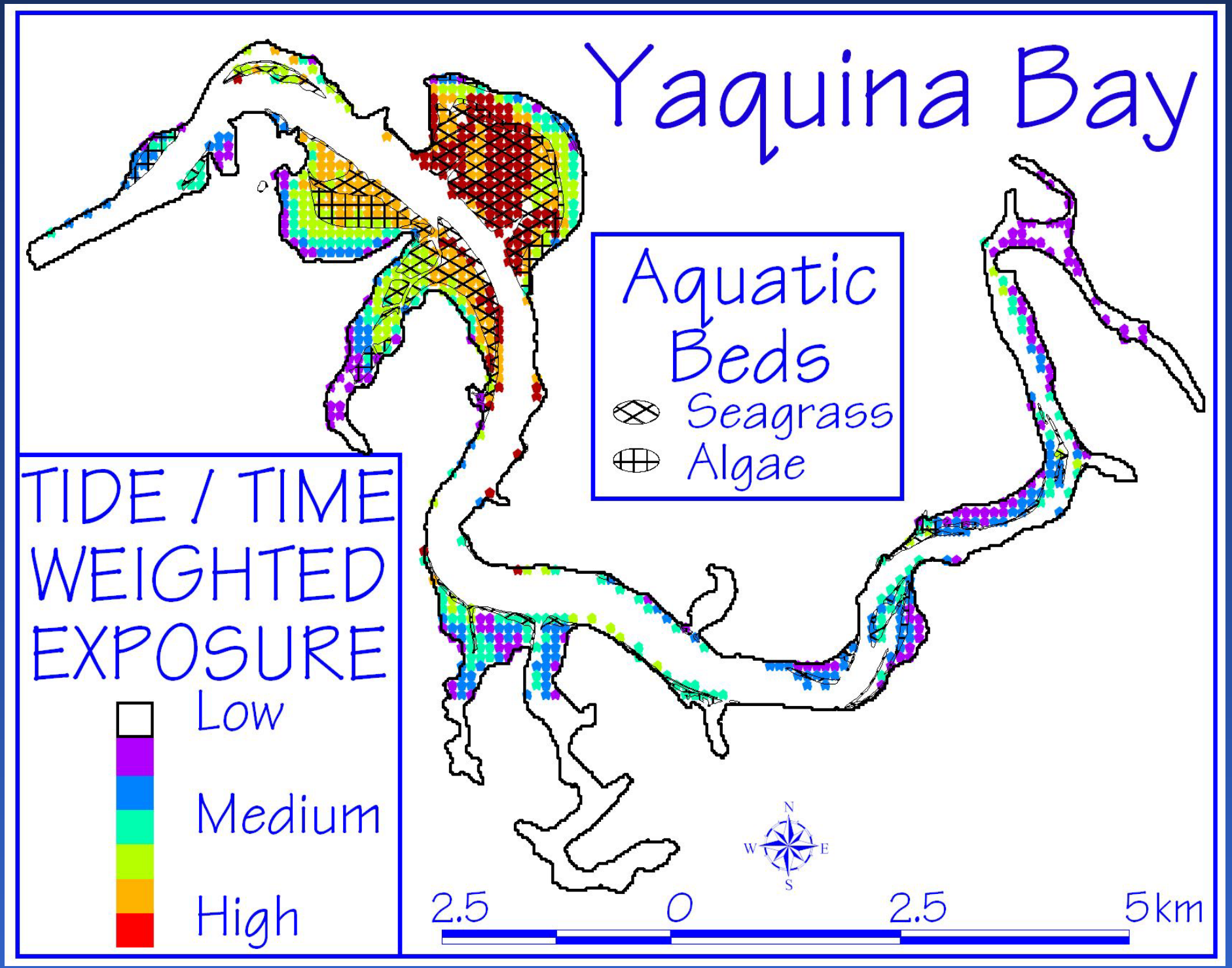

Yaquina Bay
Wind
Direction
DEPTH
WEIGHTED
EXPOSURE
Low
Medium
High
N
W
E
S
2.5
0
2.5
5km

After creating the Mean Depth - Weighted REI (shown previously), another product can be created by further weighting the index with the cumulative immersion of a any given point by the tide.

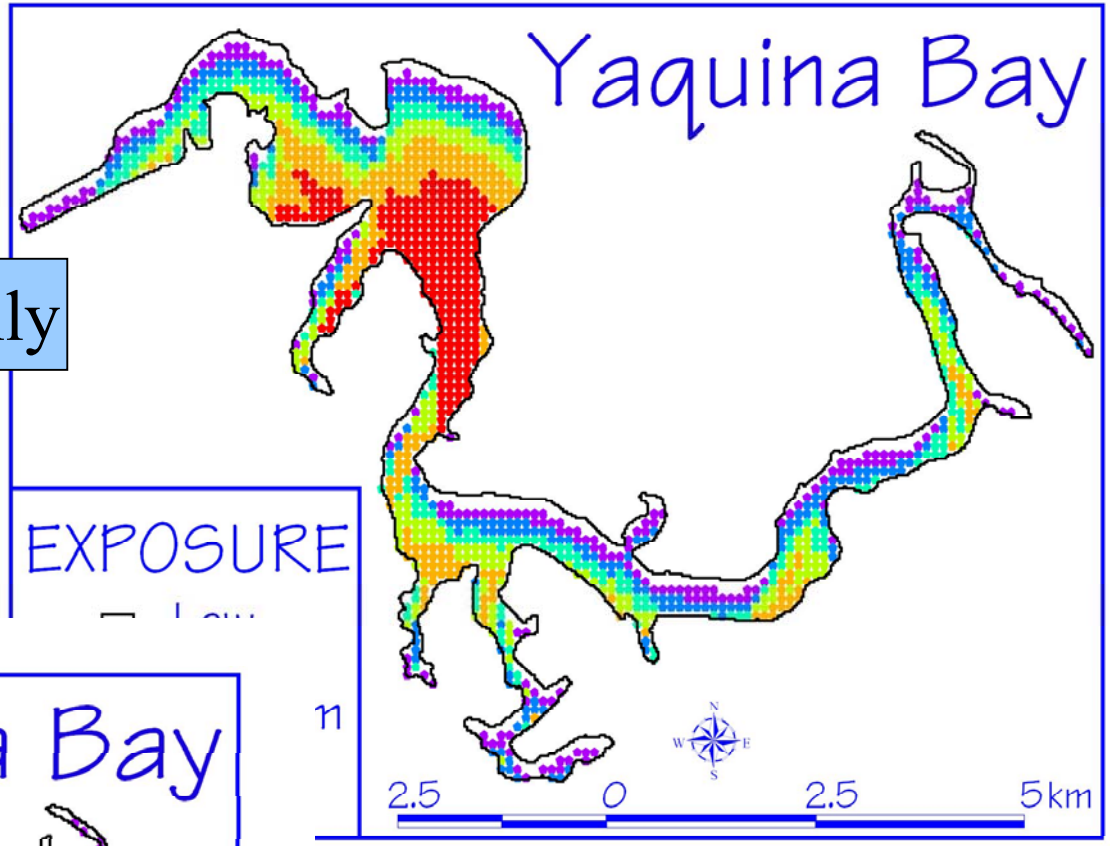


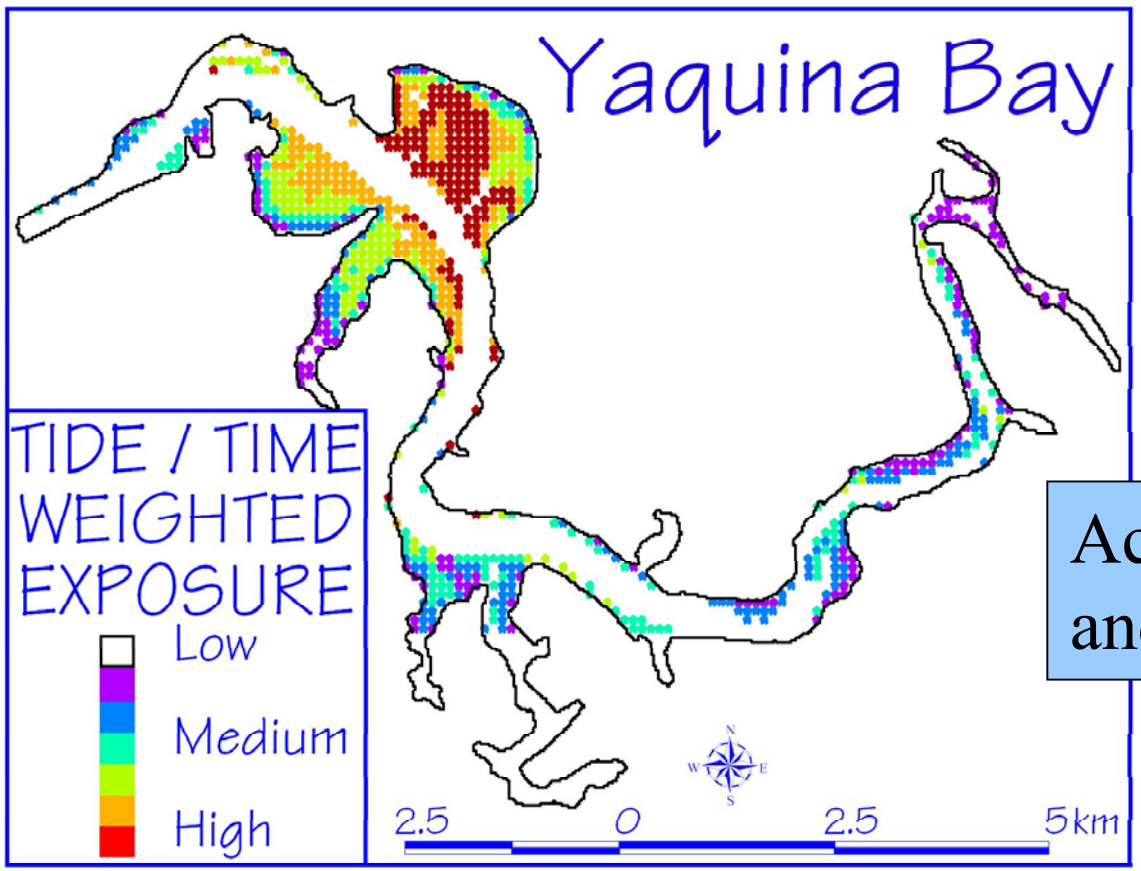

FROM ROBBINS ET AL PRESS




FROM ROBBINS ET AL PRESS

Accounts for REI only




Accounts for REI, shoaling, and period of inundation

# CONCLUSIONS

1) SPATIAL MODELING OF PHYSICAL FACTORS INFLUENCING SEAGRASS ECOSYSTEMS HAS BEEN DEVELOPED AND TESTED

2) THESE MODELS PROVIDE A PARSIMONIOUS MEANS OF BOTH HINDCASTING AND FORECASTING TRENDS IN SEAGRASS ECOSYSTEM STRUCTURE AND FUNCTION IN BOTH SPACE AND TIME