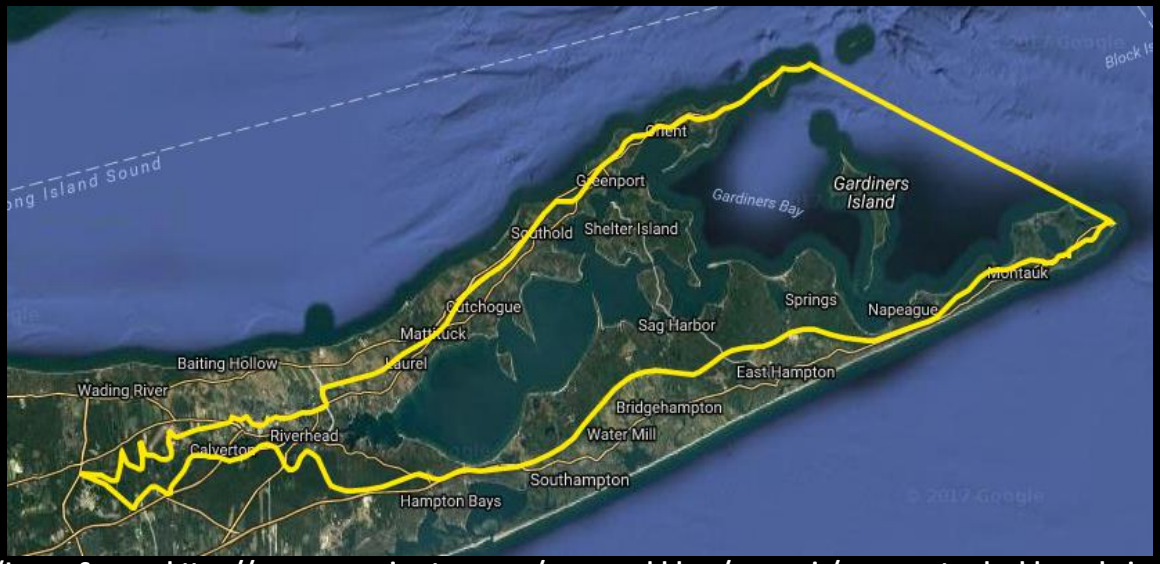
Peconic Estuary Seagrass Bio-Optical Model Project

Kaitlyn O'Toole

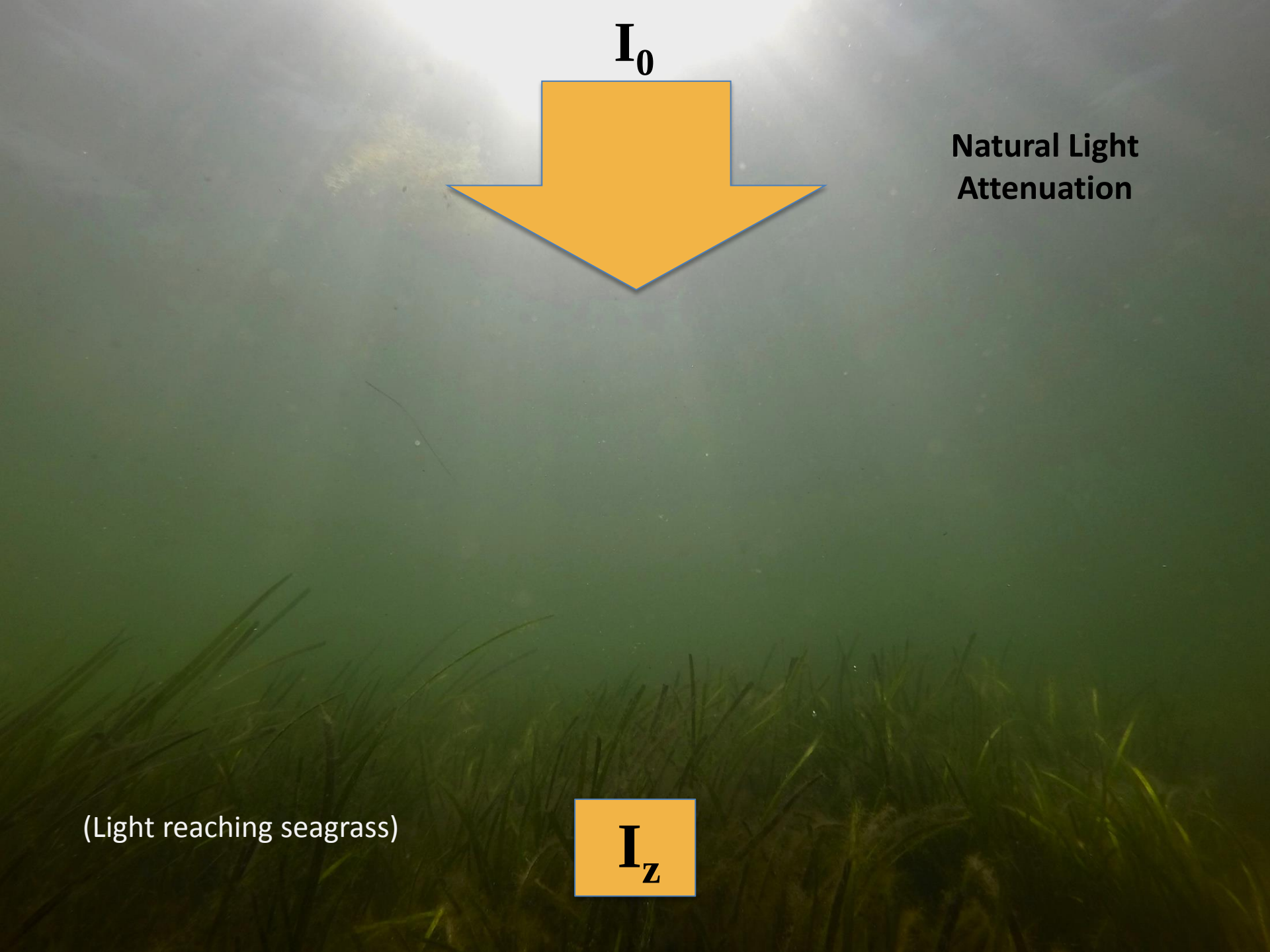
SUNY Stony Brook University

Peconic Bay

- In Peconic Bay, eelgrass (*Zostera marina*) has declined by approximately 50% from 2000 to 2014 (Pickerell and Schott 2017).
- Nutrient levels are below established criteria in eastern Peconic Bay for a majority of the year, according to the PEP.
- Eelgrass beds have continued to decrease and are considered outside of optimal temperature range west of Shelter Island.
- So why are eelgrass beds declining?



(Image Source: https://www.peconicestuary.org/news-and-blogs/maps-gis/maps-watershed-boundaries/)


I_0
Natural Light Attenuation
(Light reaching seagrass)
I_z

Natural Light Attenuation

Chlorophyll (chl-a)

(Light reaching seagrass)

I_z

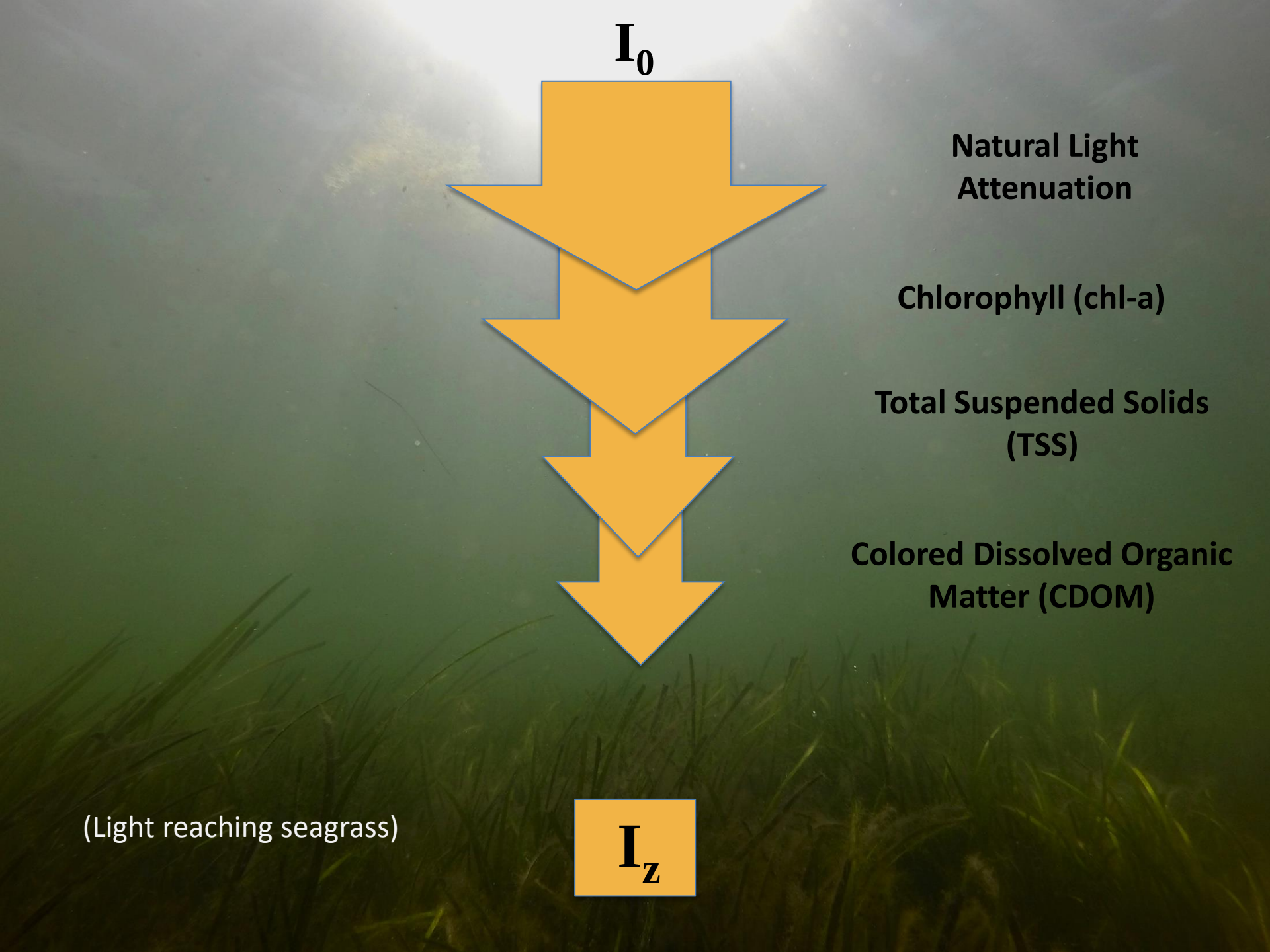
Natural Light Attenuation

Chlorophyll (chl-a)

Total Suspended Solids (TSS)

(Light reaching seagrass)

I_z


I_0
Natural Light Attenuation
Chlorophyll (chl-a)
Total Suspended Solids (TSS)
Colored Dissolved Organic Matter (CDOM)
(Light reaching seagrass)
I_z

Natural Light Attenuation

Chlorophyll (chl-a)

Total Suspended Solids (TSS)

Colored Dissolved Organic Matter (CDOM)

Epiphyte Growth

(Light reaching seagrass)

Creation of the bio-optical model

- Utilizes the chlorophyll-a, TSS, and CDOM values collected for calculation of predicted Kd.

$$K_d = K_{(W+DOC)} + k_C[Chl] + k_S[TSS]$$

Creation of the bio-optical model

- Utilizes the chlorophyll-a, TSS, and CDOM values collected for calculation of predicted Kd.

$$K_d = K_{(W+DOC)} + k_C[Chl] + k_S[TSS]$$

- Calibrated with observed Kd values calculated from Li-Cor PAR measurements.

$$I_Z = I_0 \exp[-Kd(\Delta Z)]$$

Creation of the bio-optical model

- Utilizes the chlorophyll-a, TSS, and CDOM values collected for calculation of predicted Kd.

$$K_d = K_{(W+DOC)} + k_C[Chl] + k_S[TSS]$$

- Calibrated with observed Kd values calculated from Li-Cor PAR measurements.

$$I_Z = I_0 \exp[-Kd(\Delta Z)]$$

- Kd values used to determine % light to bottom.

$$PLW = \exp(-Kd * Z_{max}) * 100$$

Why create a light model?

- Easily collected parameters

Why create a light model?

- Easily collected parameters
- Calculate % light to bottom

Why create a light model?

- Easily collected parameters
- Calculate % light to bottom
- Parameters can be modified for future scenarios.
  - Useful for whole plant carbon balance and eelgrass productivity

Why create a light model?

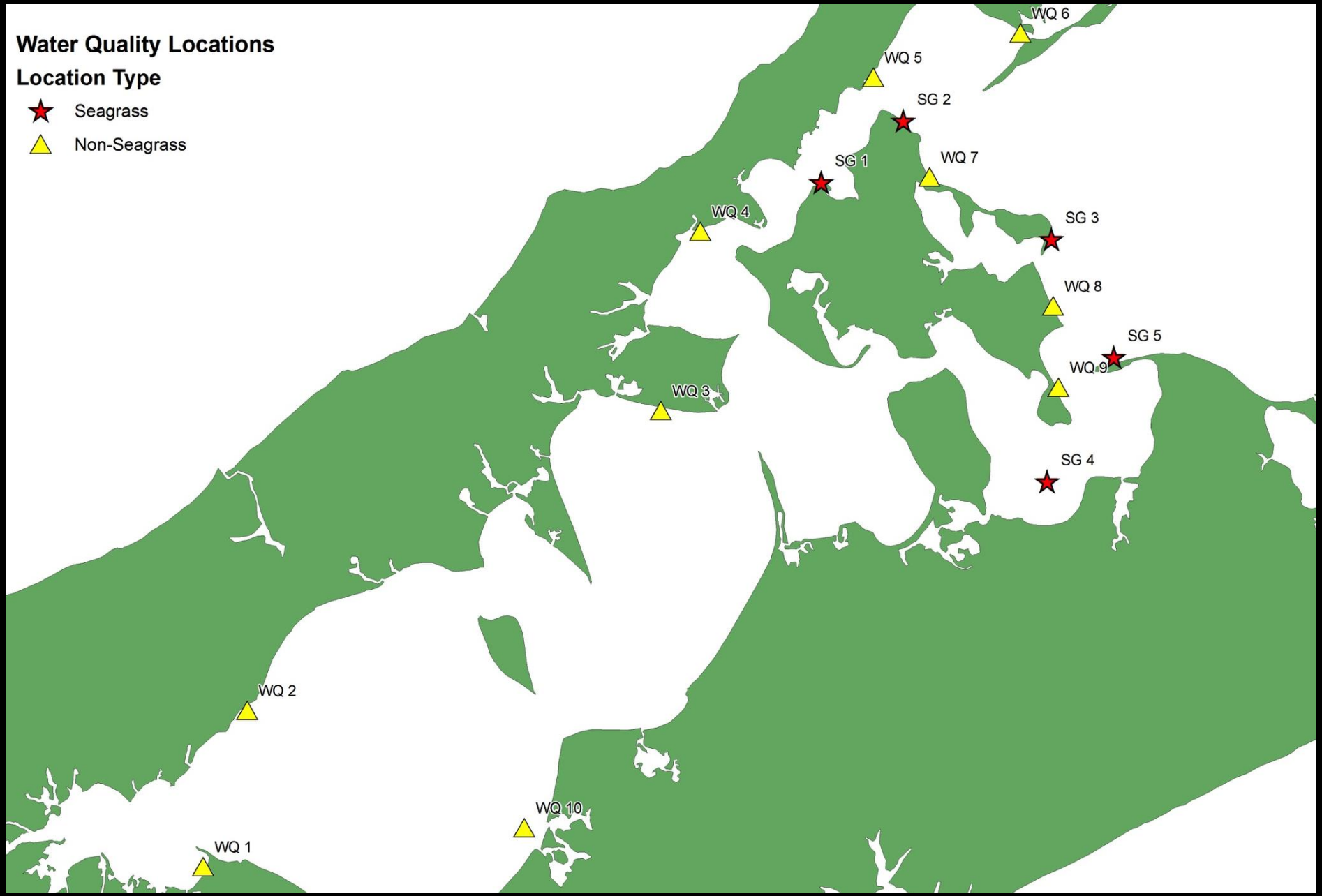
- Easily collected parameters
- Calculate % light to bottom
- Parameters can be modified for future scenarios.
  - Useful for whole plant carbon balance and eelgrass productivity
- Can be used with other models.

Why create a light model?

- Easily collected parameters
- Calculate % light to bottom
- Parameters can be modified for future scenarios.
  - Useful for whole plant carbon balance and eelgrass productivity
- Can be used with other models.
- Includes light-limiting effects of epiphytes

Why create a light model?

- Easily collected parameters
- Calculate % light to bottom
- Parameters can be modified for future scenarios.
  - Useful for whole plant carbon balance and eelgrass productivity
- Can be used with other models.
- Includes light-limiting effects of epiphytes
- Determines what is decreasing light availability to eelgrass.
  - Nitrogen loading, suspended sediment, and/or other factors should be managed


Water Quality Locations
Location Type
Seagrass
Non-Seagrass
WQ 6
WQ 5
SG 2
SG 1
WQ 7
WQ 4
SG 3
WQ 8
SG 5
WQ 9
WQ 3
SG 4
WQ 2
WQ 10
WQ 1

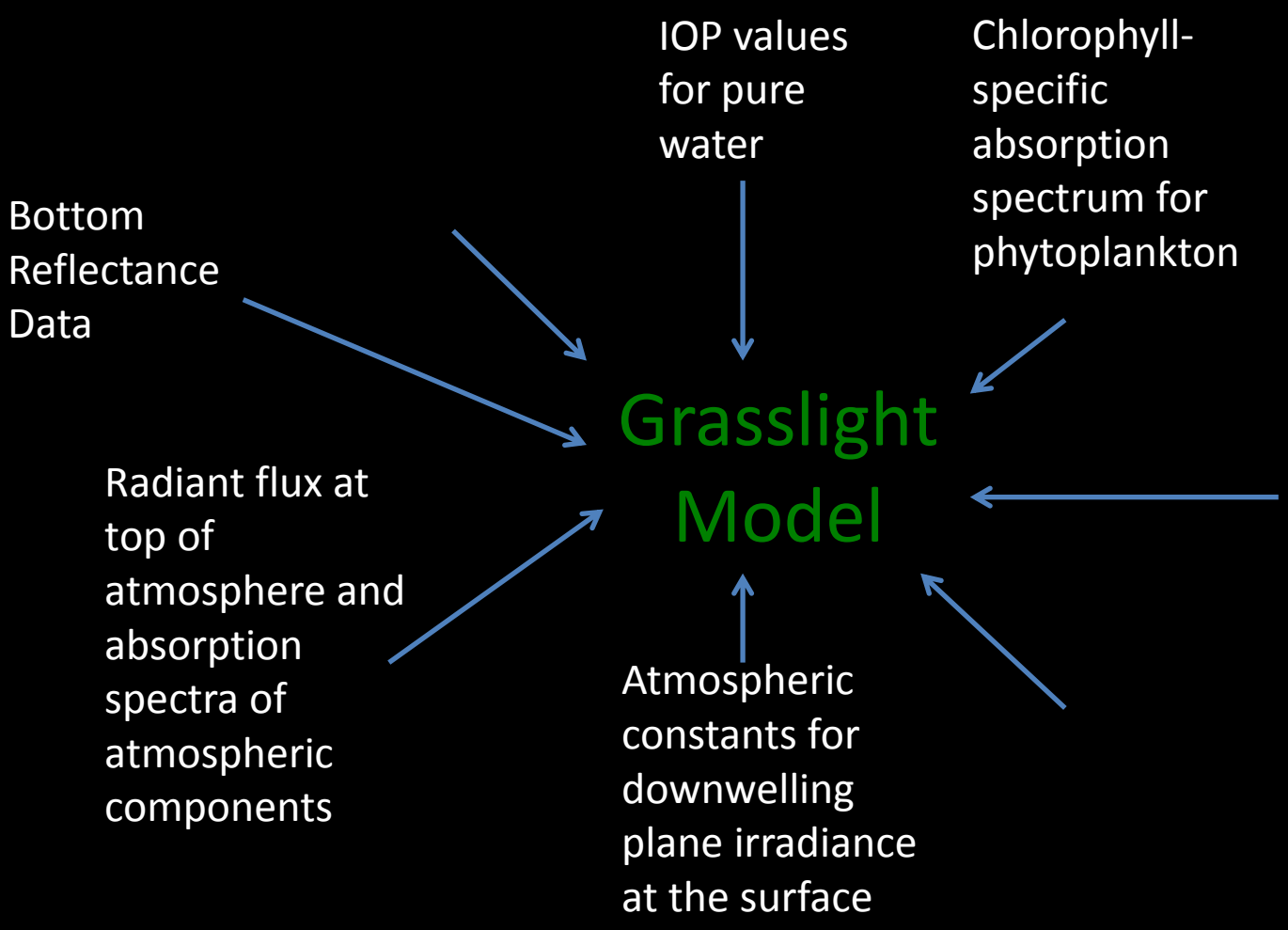
Continuous monitoring

- HOBO Dataloggers
  - Measure temperature every 15 minutes
  - Deployed May 31, 2018
  - Data offloaded monthly
  - Will be retrieved in late early October
  - Used to determine limits of the populations
  - Deep vs. shallow

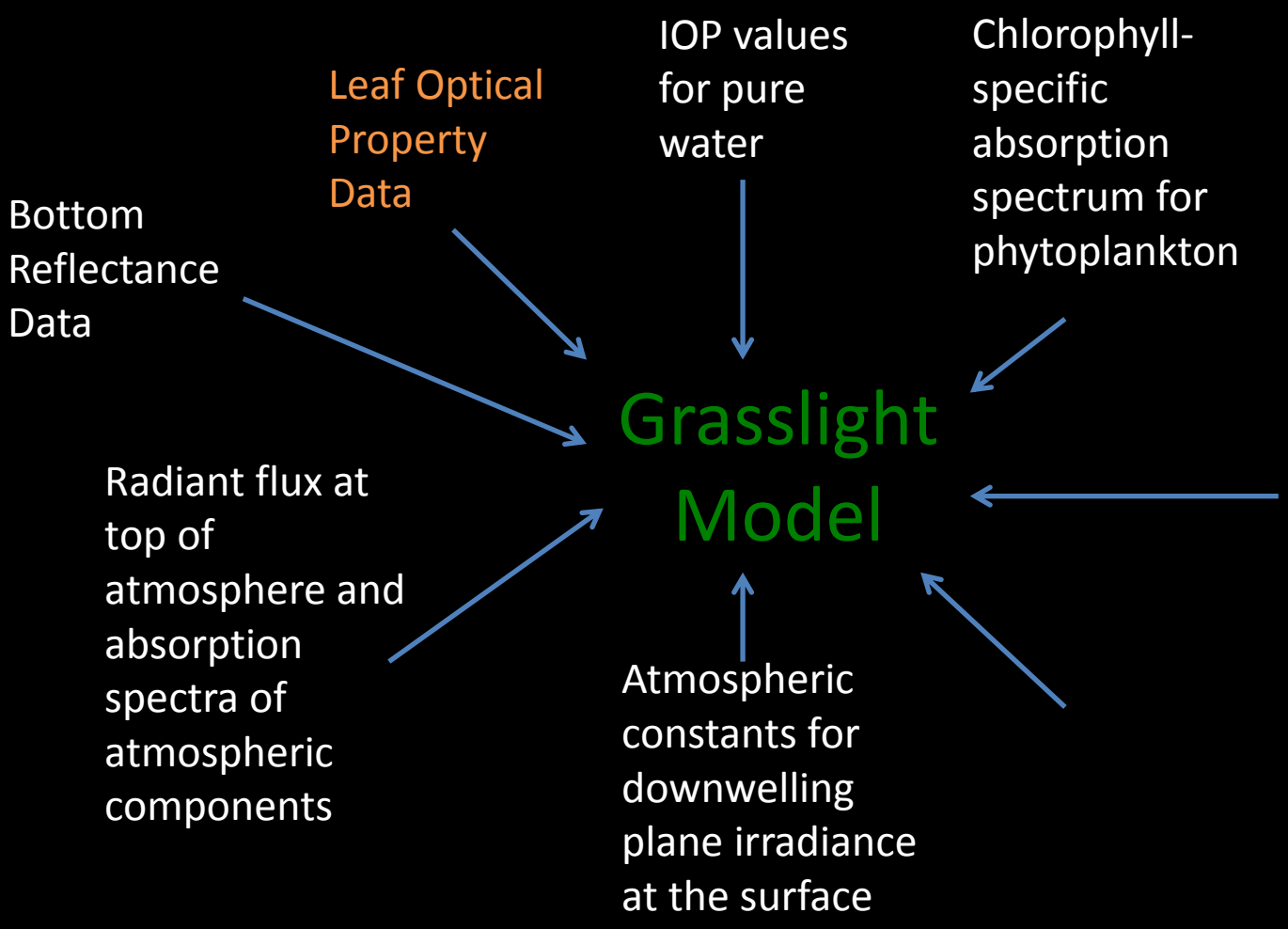
Water Quality Sampling

- Bi-Weekly:
  - Li-Cor:
    - Measures irradiance and % surface light through the water column at 0.1, 0.2, 0.4, 0.8, 1.4, 2.0, 3.0m
  - YSI Sonde:
    - Measures temperature, DO, salinity, conductivity, and turbidity within 0.5m of the bottom.
  - Whole water samples:
    - Chlorophyll-a and TSS (total suspended solids)
- Monthly:
  - CDOM
  - Nutrients (DIN, DIP)

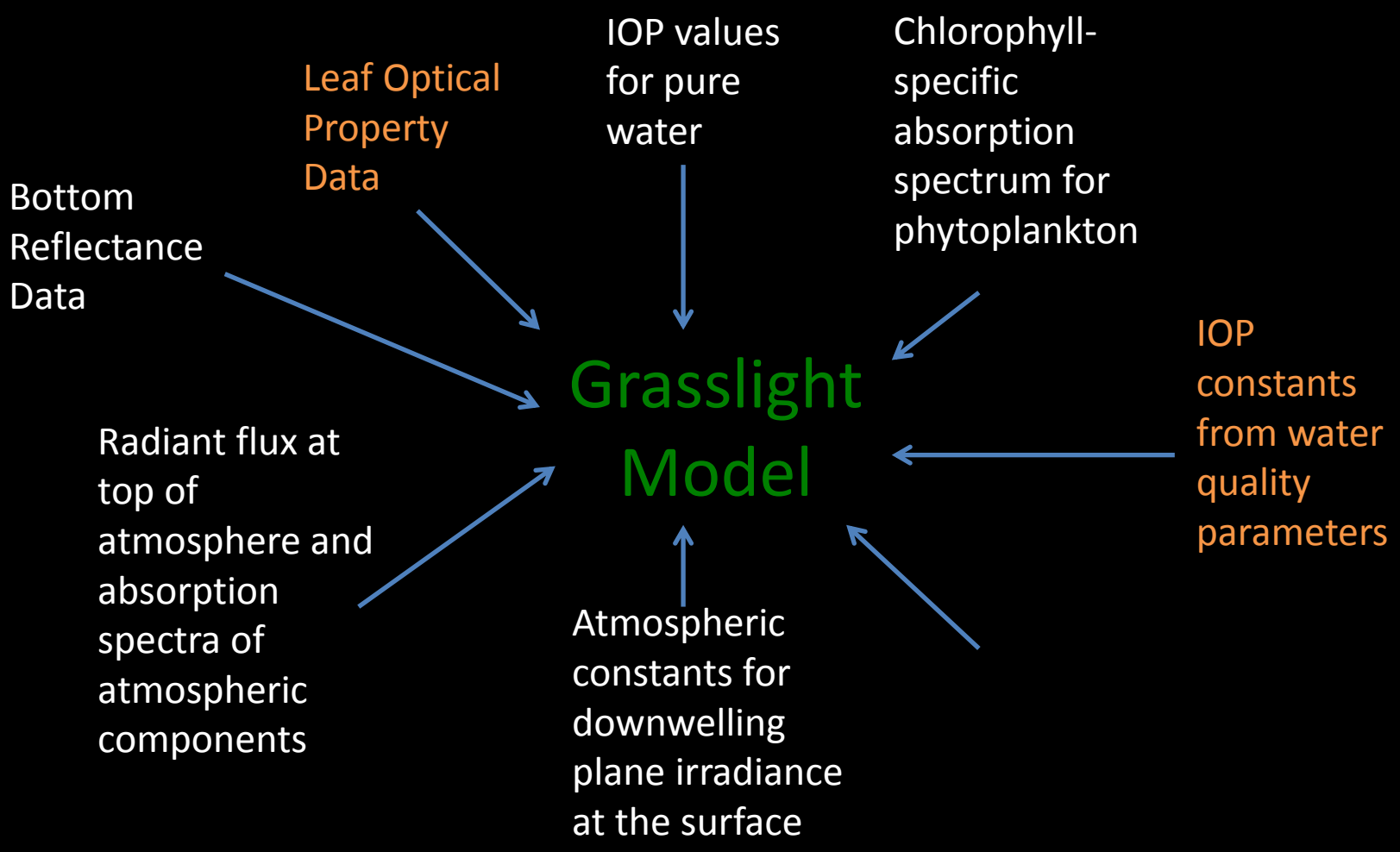
Grasslight Model, Zimmerman et al. 2015



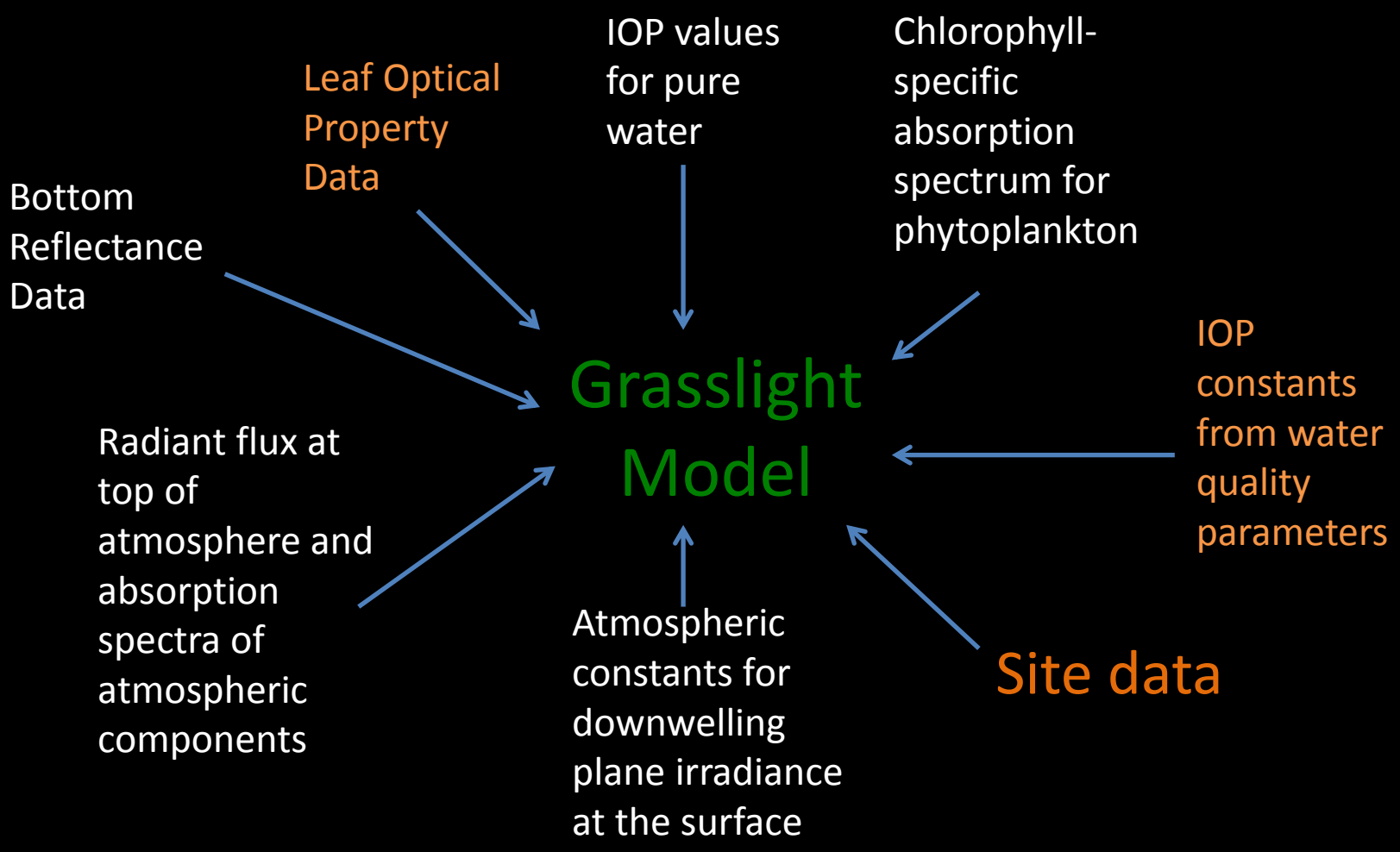
Grasslight Model, Zimmerman et al. 2015.



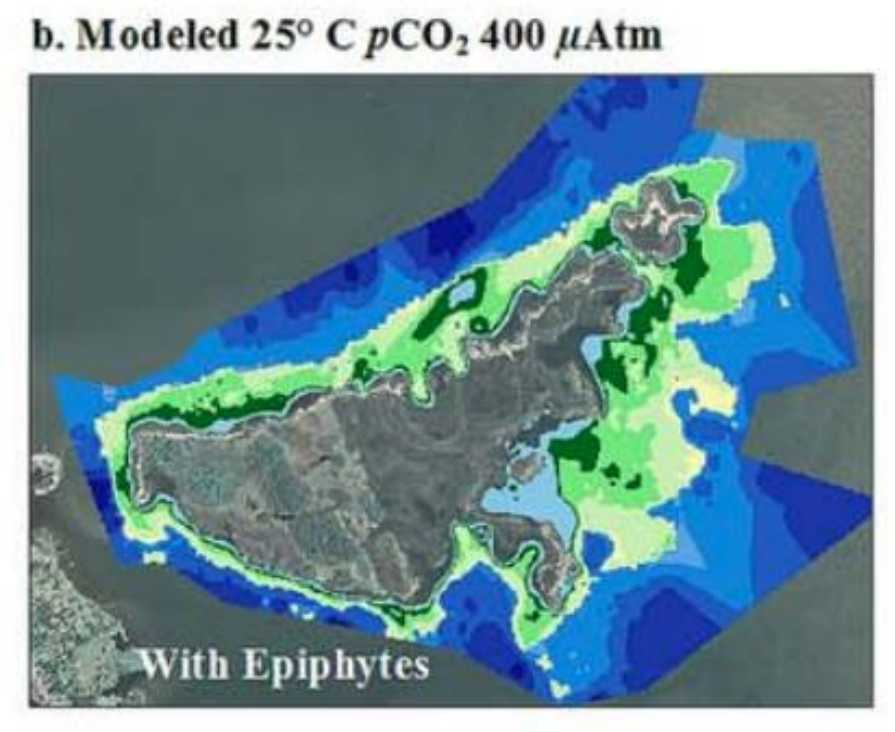
Grasslight Model, Zimmerman et al. 2015

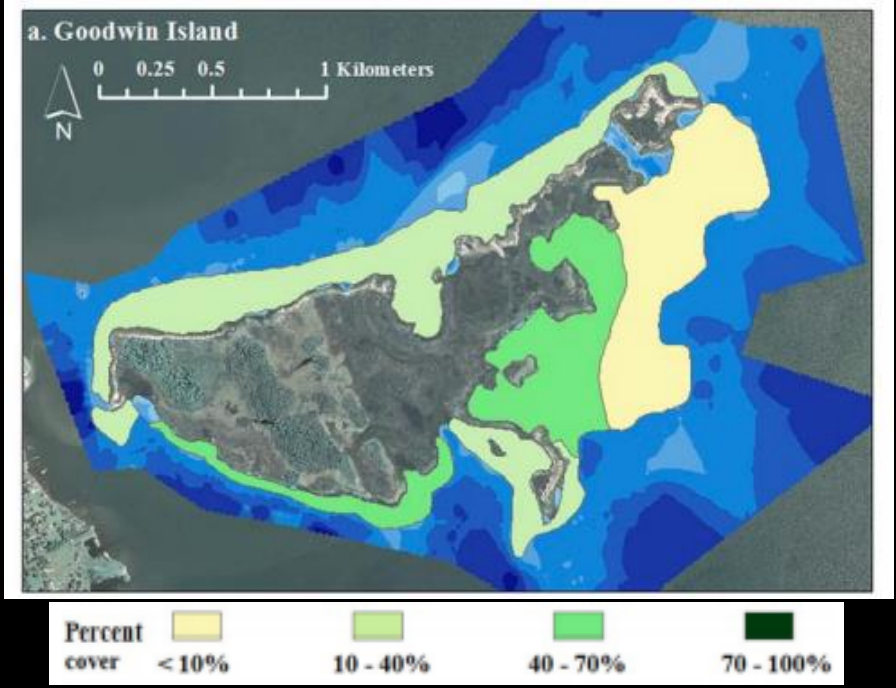


Grasslight Model, Zimmerman et al. 2015



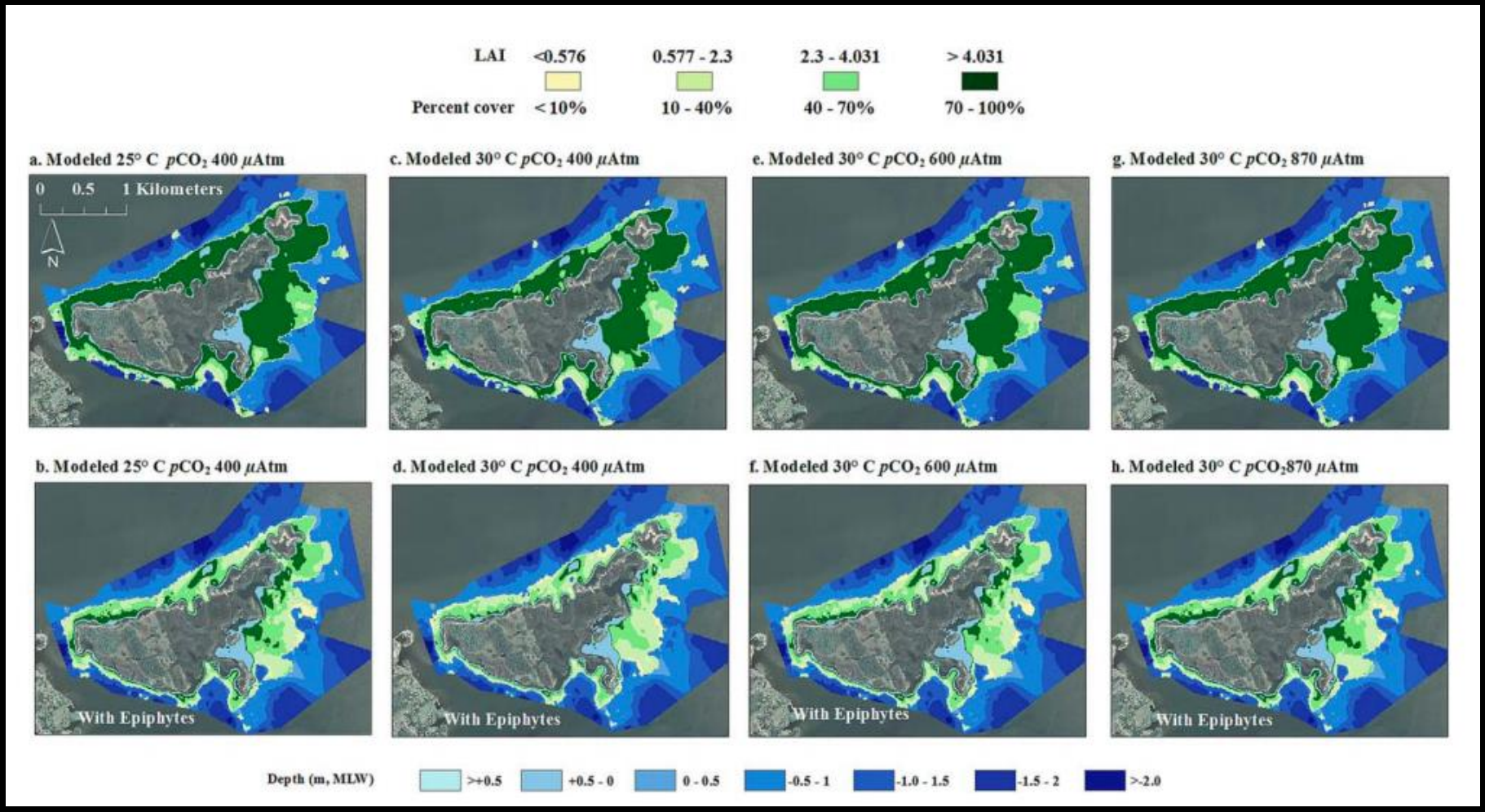
Grasslight Model, Zimmerman et al. 2015





a. Presence/Absence	Measured		
Modeled	Present	Absent	Row Sum
Present	11,228 (99%)	12,430 (37%)	23,658
Absent	75 (1%)	22,254 (63%)	21,329
Column Sum	11,303	33,684	44,987

Grasslight Model, Zimmerman et al. 2015



Other Sampling

- Deep Edge Analysis:
  - Productivity and epiphyte analysis

Other Sampling

- Deep Edge Analysis:
  - Productivity and epiphyte analysis
  - Eelgrass shoot counts

Other Sampling

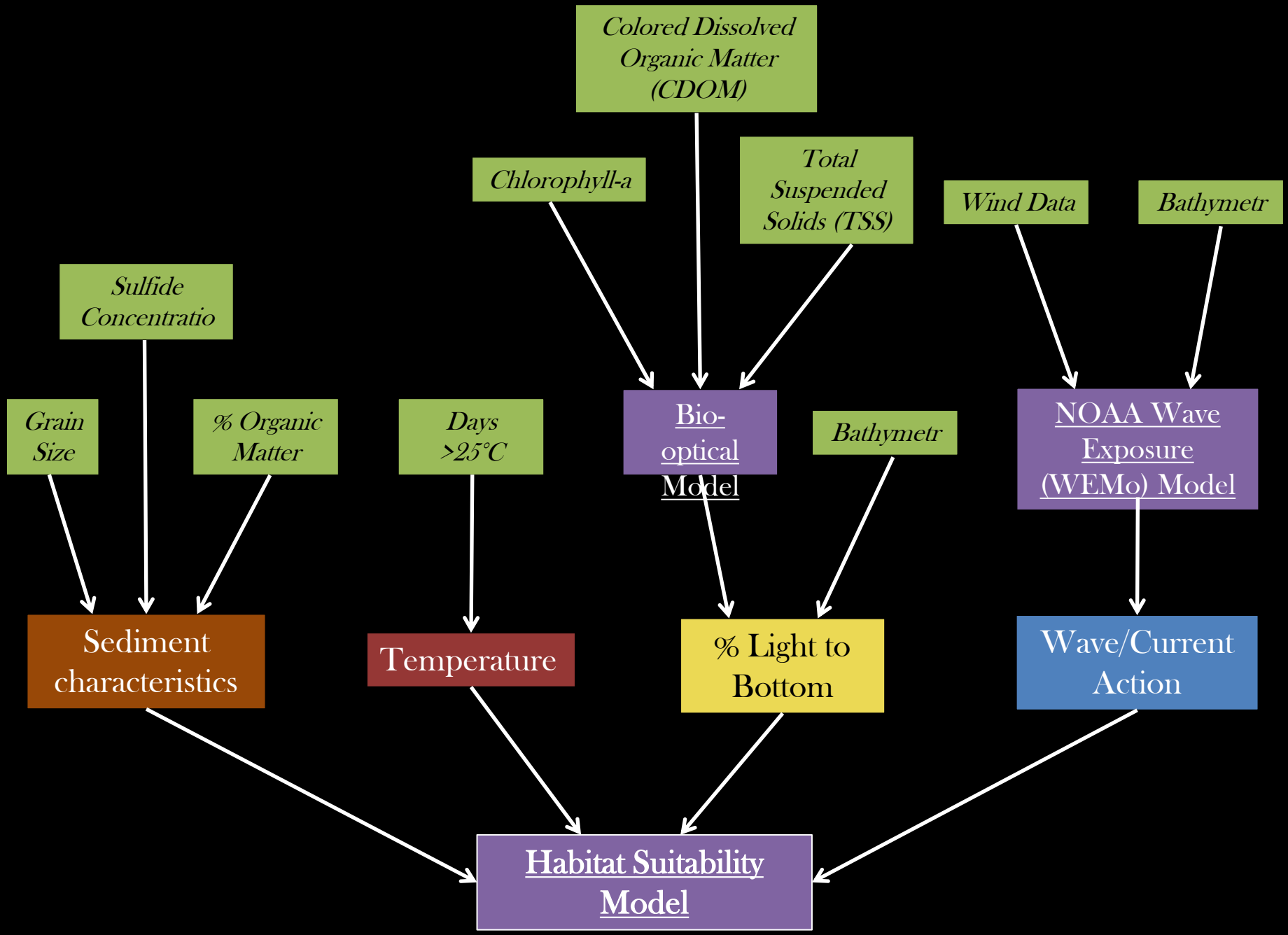
- Deep Edge Analysis:
  - Productivity and epiphyte analysis
  - Eelgrass shoot counts
  - Macroalgae/eelgrass % coverage
  - Depth

Other Sampling

- Deep Edge Analysis:
  - Productivity and epiphyte analysis
  - Eelgrass shoot counts
  - Macroalgae/eelgrass % coverage
  - Depth
- Sediment Analysis:
  - Grain Size

Other Sampling

- Deep Edge Analysis:
  - Productivity and epiphyte analysis
  - Eelgrass shoot counts
  - Macroalgae/eelgrass % coverage
  - Depth
- Sediment Analysis:
  - Grain Size
  - Organic Matter
  - Sulfide Sampling


Colored Dissolved Organic Matter (CDOM)
Chlorophyll-a
Total Suspended Solids (TSS)
Wind Data
Bathymetr
Sulfide Concentratio
Grain Size
% Organic Matter
Days >25°C
Bio-optical Model
Bathymetr
NOAA Wave Exposure (WEMo) Model
Sediment characteristics
Temperature
% Light to Bottom
Wave/Current Action
Habitat Suitability Model

Habitat Suitability Calculated Parameters

- Minimum water depth
- Maximum water depth (PLW)
  - Bio-optical
- Wave Energy (REI/WEMo)
  - Wave mixing depth

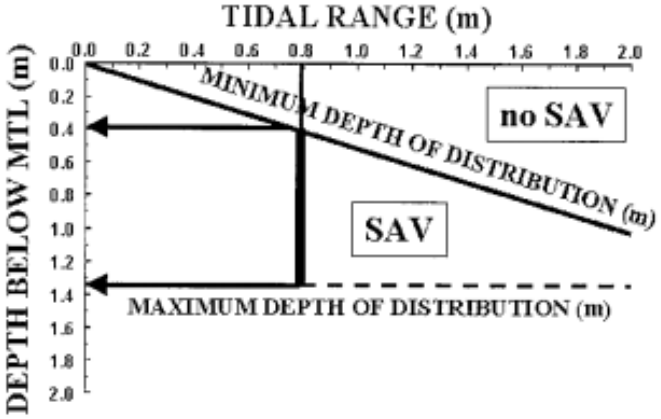


Fig. 3. An example of how the vertical distribution of SAV (Z_{max}—Z_{min}) can be predicted. A tidal amplitude of 0.8 m (see x-axis), a light requirement of 14% and a K_d = 1.5 m^{-1} are assumed. Z_{max} is determined by using the Lambert-Beer equation (depth is the only unknown). Z_{min} is determined by plotting a diagonal line passing through the origin and half the tidal range. A line is then drawn vertically from the 0.8-m tidal range. The depth at which it intersects the diagonal line determines Z_{min}. In this case, SAV has the potential to grow in a 0.9-m fringe between 0.4 and 1.3 m depth.

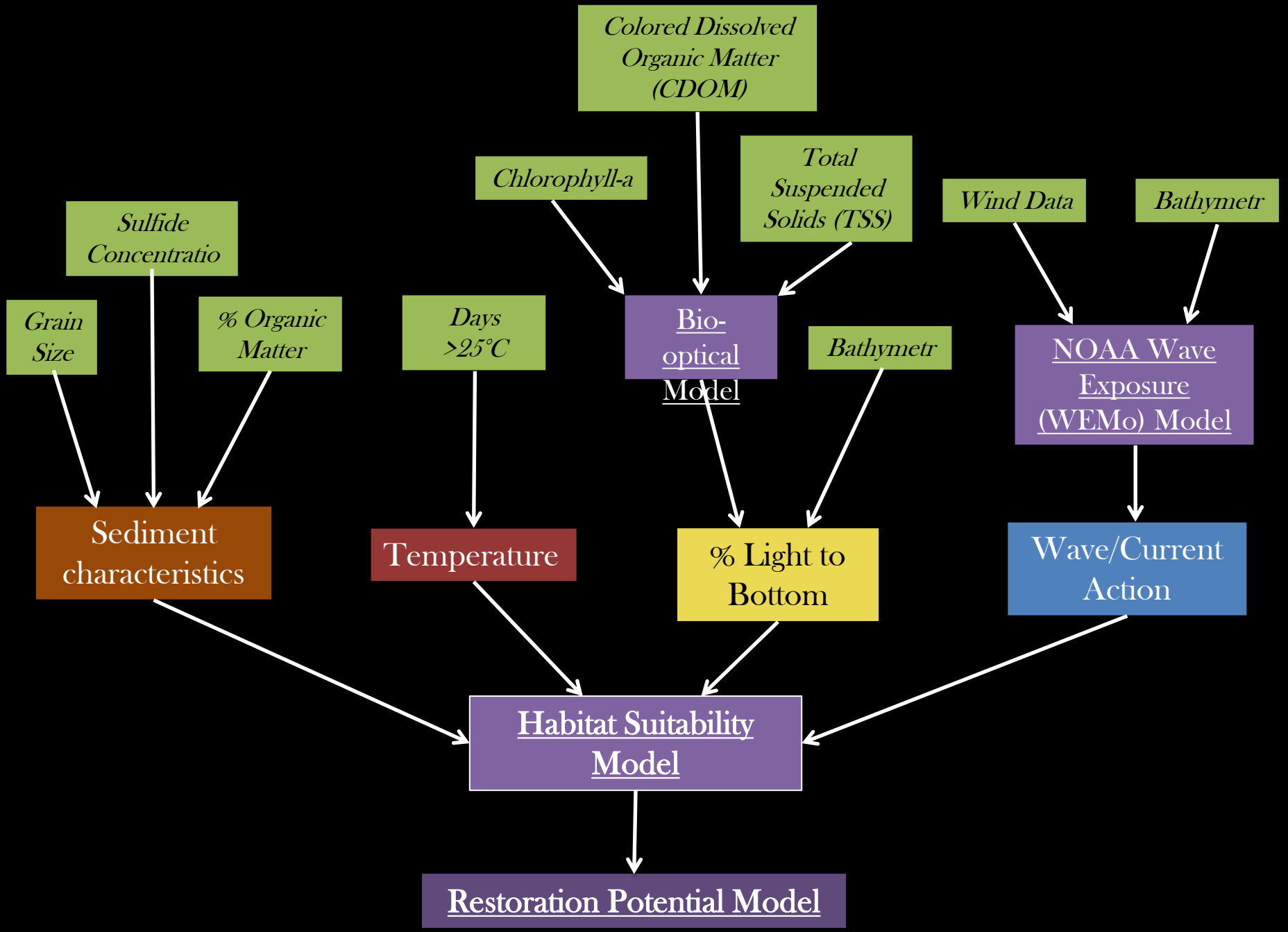
Koch, E. (2001). Beyond Light: Physical, Geological, and Geochemical Parameters as Possible Submersed Aquatic Vegetation Habitat Requirements. *Estuaries.* 24(1), p. 1-17.

Habitat Suitability Calculated Parameters

- Minimum water depth
- Maximum water depth (PLW)
  - Bio-optical
- Wave Energy (REI/WEMo)
  - Wave mixing depth
- Current Velocity
  - DBL, self-shading, sediment suspension, sulfide suspension, epiphytes
- Temperature
  - Days over 25C, 27C, 30C
  - Length of time of each temperature

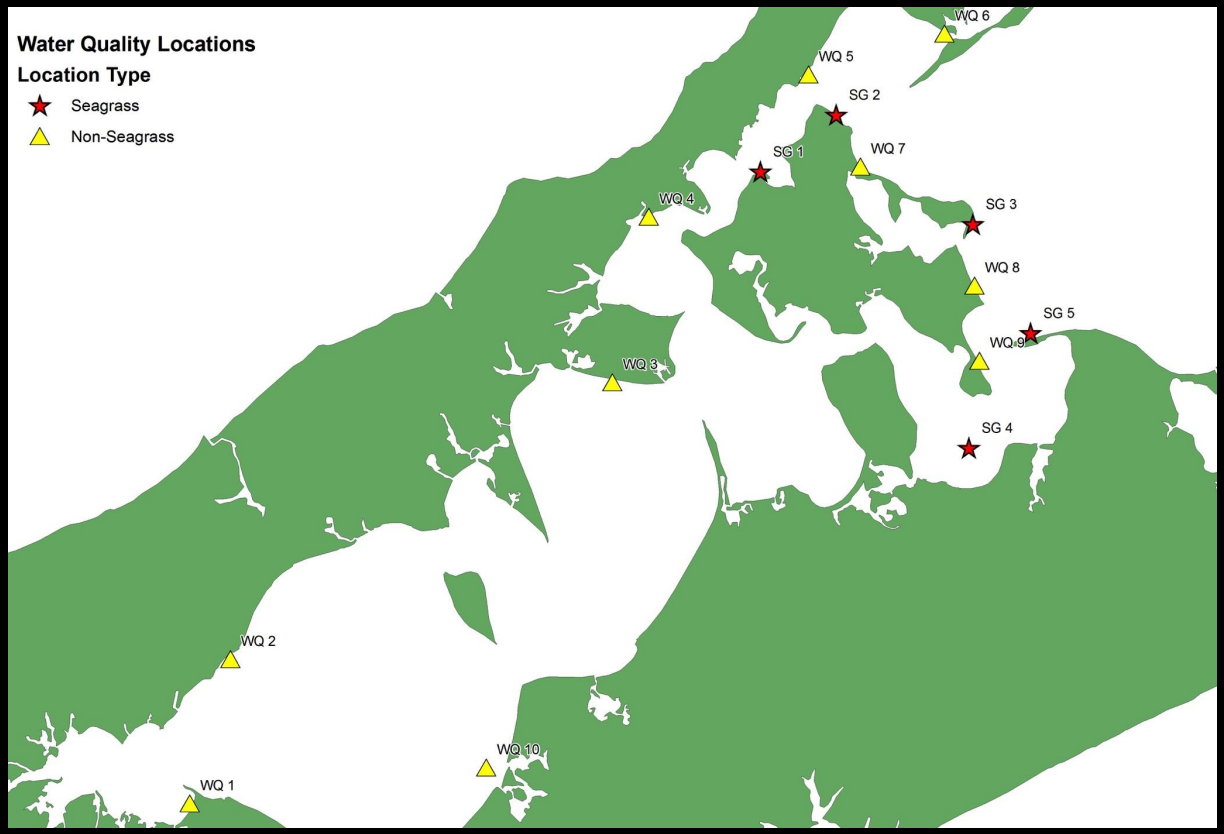
Habitat Suitability Collected Parameters

- Sediment Characteristics:
  - Grain size (% clay and silt)
    - Porewater exchange
    - SG1, 2, 3 vs. SG4, 5
  - Organic matter (%)
  - Sulfide Concentration
- Dissolved oxygen (mg/L)


Colored Dissolved Organic Matter (CDOM)
Chlorophyll-a
Total Suspended Solids (TSS)
Wind Data
Bathymetr
Sulfide Concentratio
Grain Size
% Organic Matter
Days >25°C
Bio-optical Model
Bathymetr
NOAA Wave Exposure (WEMo) Model
Sediment characteristics
Temperature
% Light to Bottom
Wave/Current Action
Habitat Suitability Model
Restoration Potential Model

Methodology

- Obtain water quality data throughout Peconic Bay from summer 2017 (May-October) and 2018.

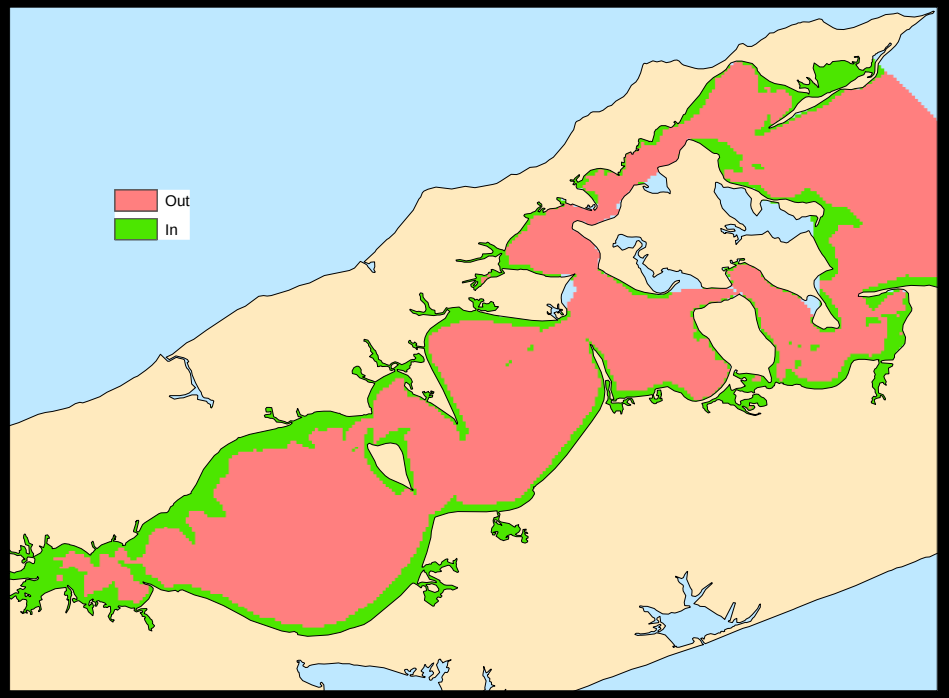


Methodology

- Interpolate data across the bay through Inverse Distance Weighting (IDW)

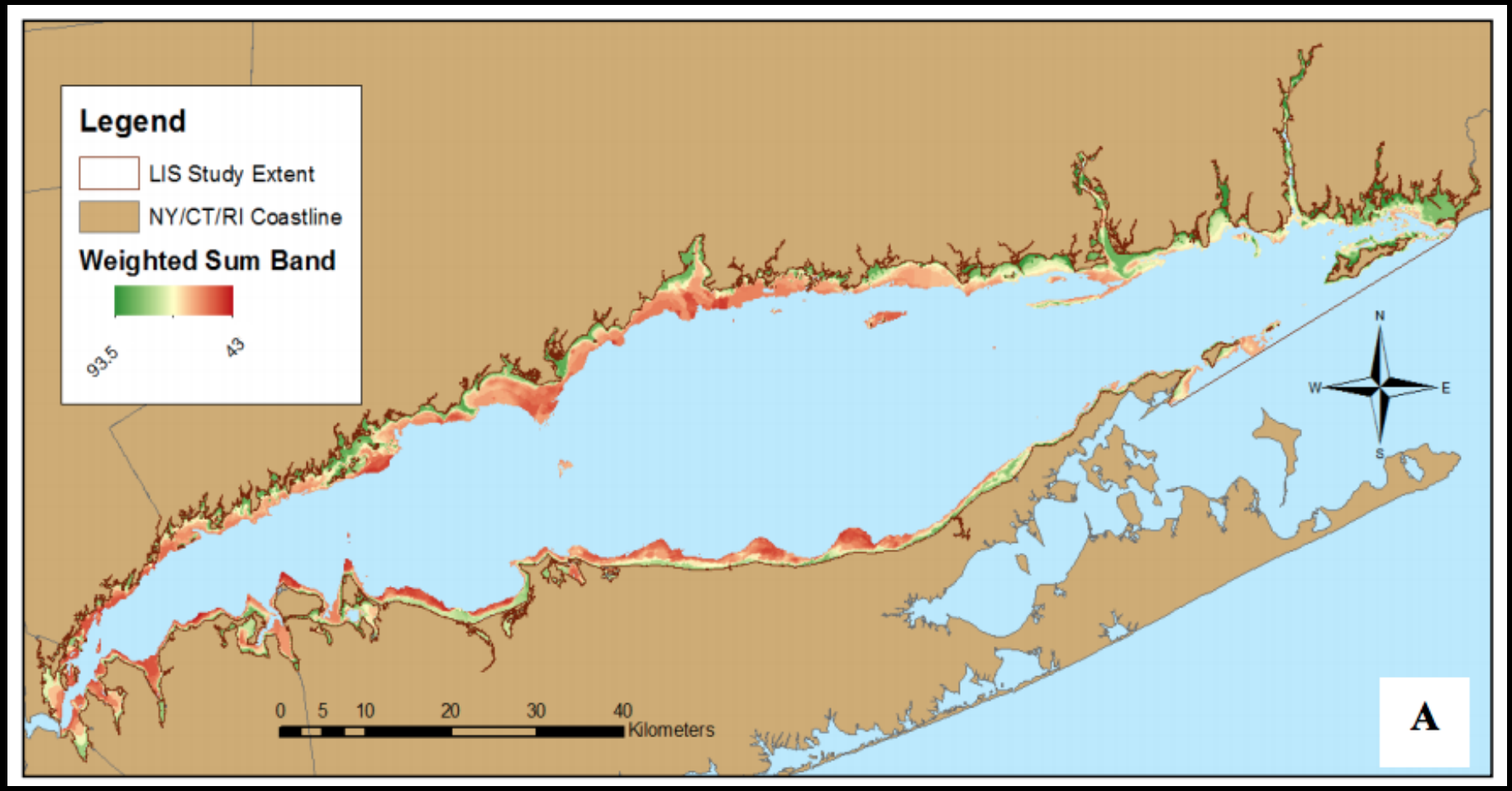
Methodology

- Reclassify and determine areas of in/out range of seagrass parameters and cross-check with current seagrass distribution for accuracy.



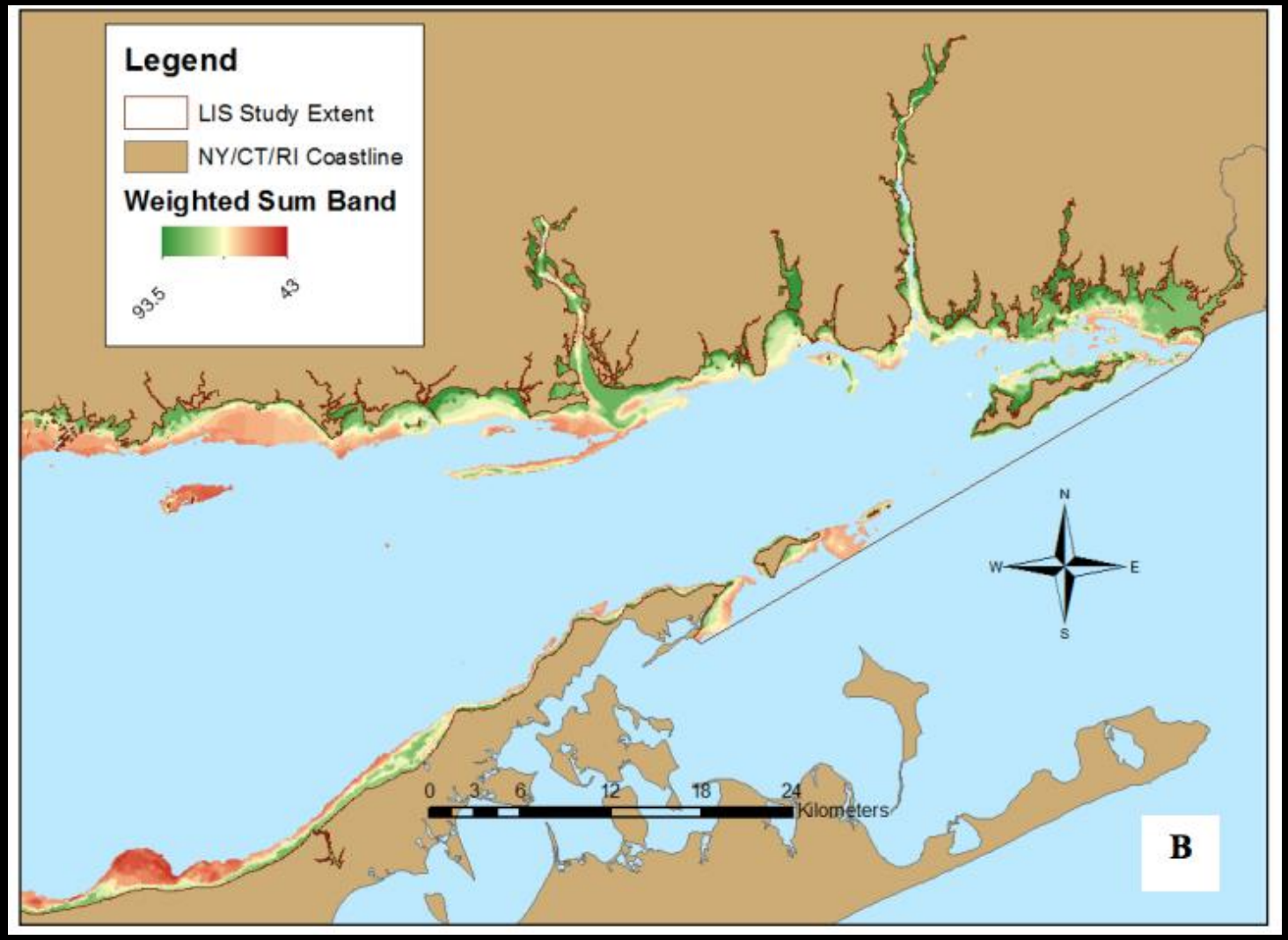
Example in LIS

Justin Eddings, Geographic Information Systems Eelgrass (*Zostera marina)* Habitat Restoration Suitability Model



Example in LIS

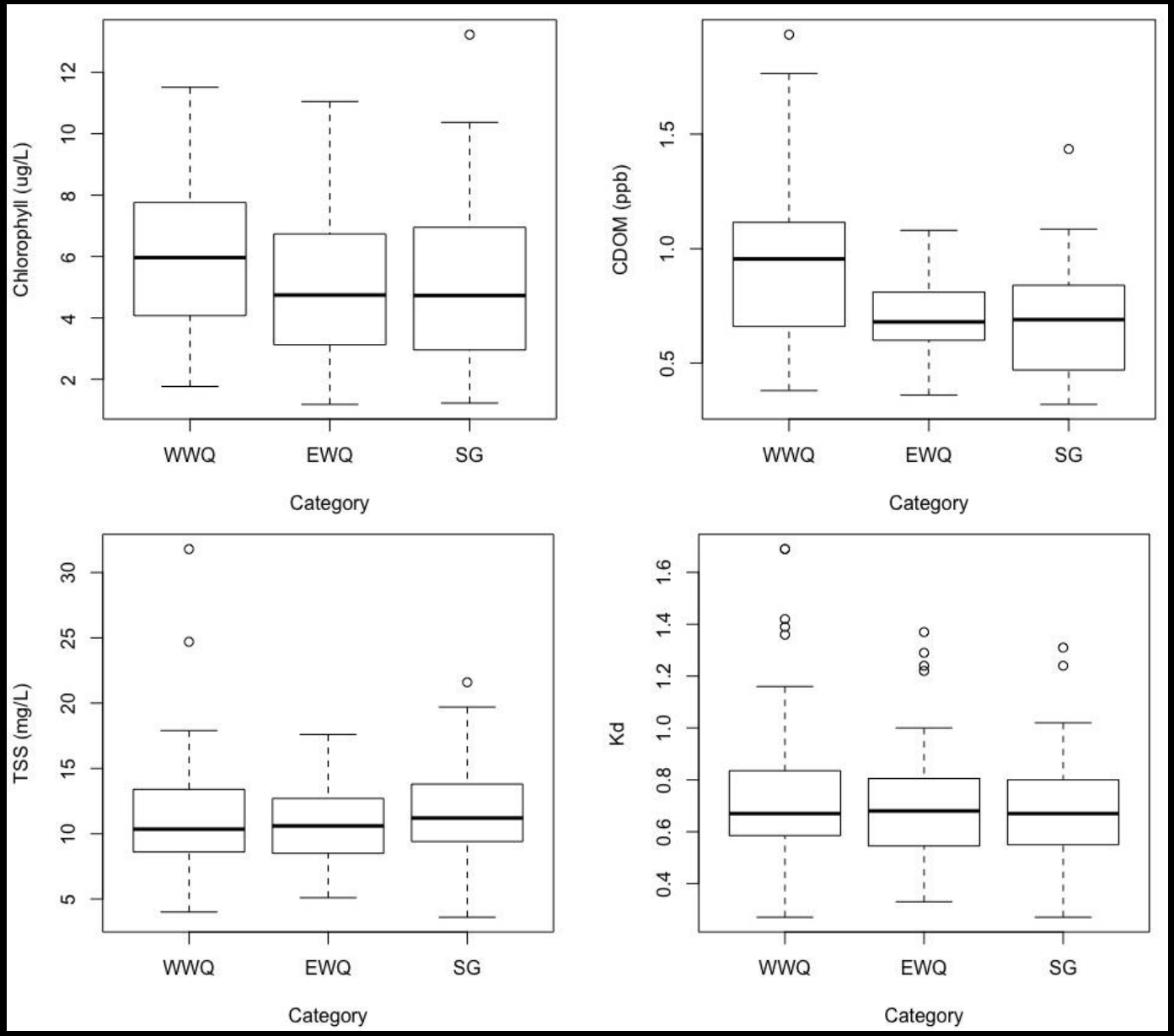
Justin Eddings, Geographic Information Systems Eelgrass (*Zostera marina)* Habitat Restoration Suitability Model



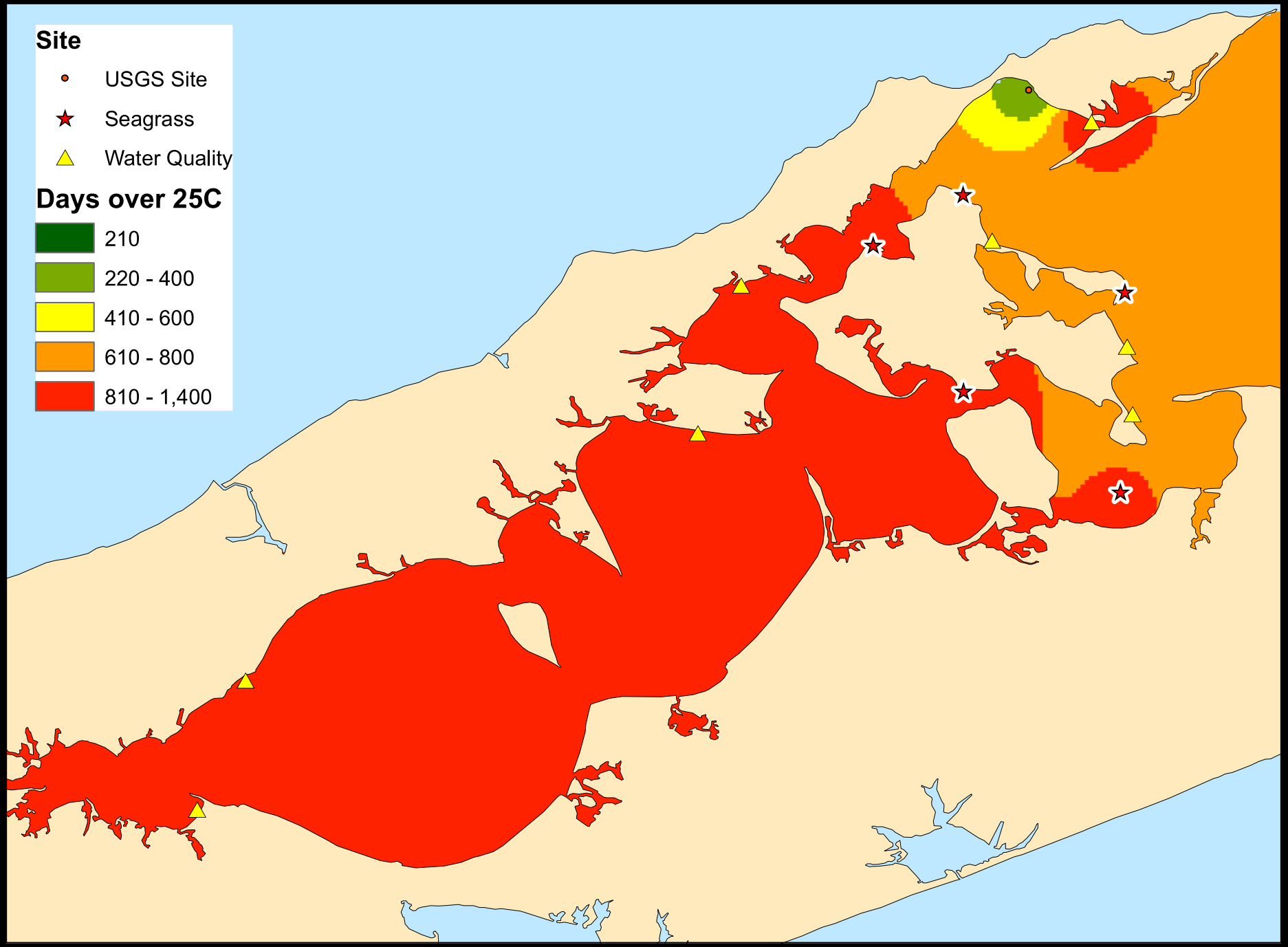
Habitat Suitability Model

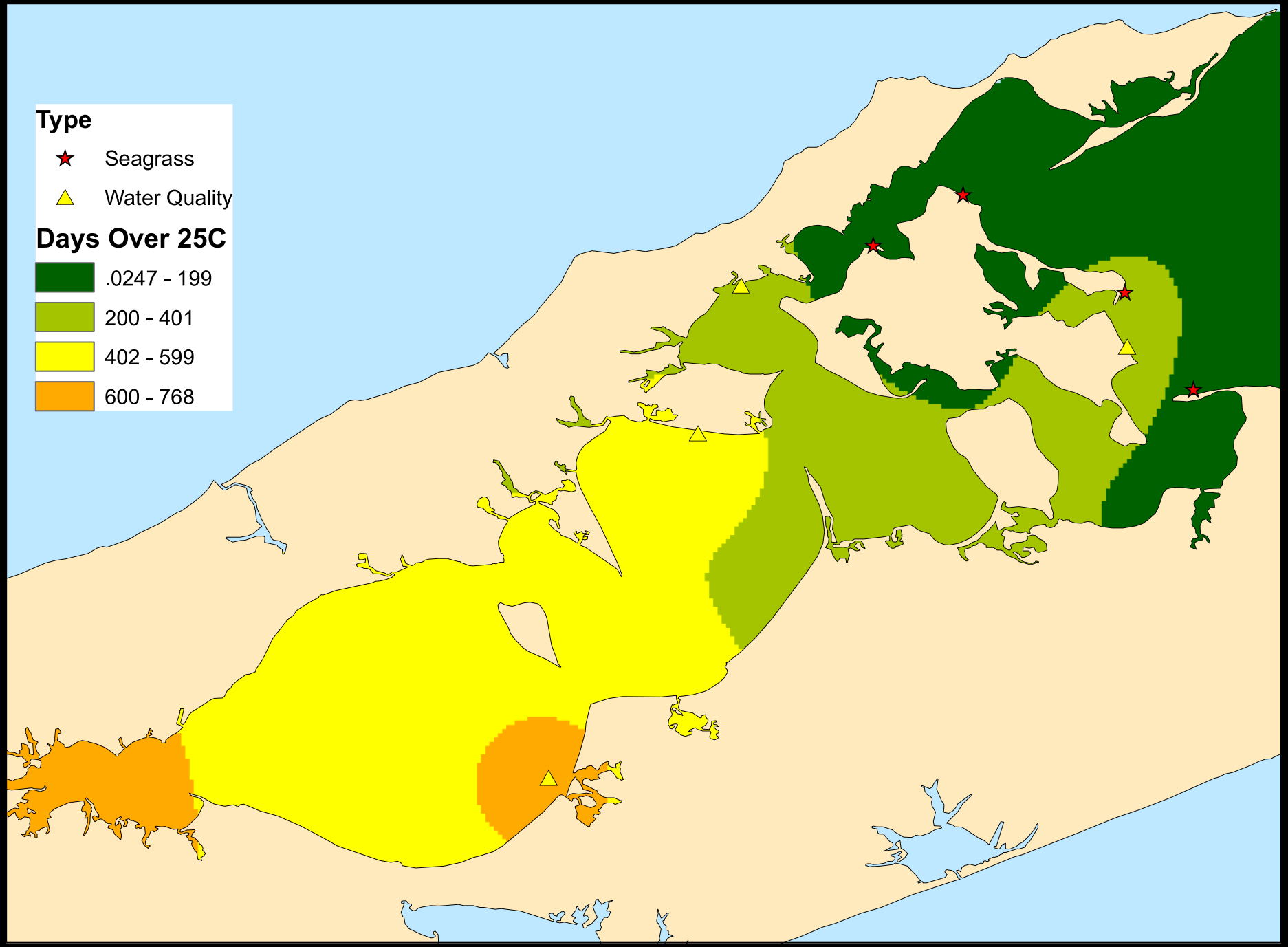
- Can be used to create areas of seagrass restoration potential.
  - Reveals different methodologies and challenges to each area.
- Future scenarios
  - Sea level rise
  - Increased temperature
  - Storm activity
  - Human activity
  - Combinations of above

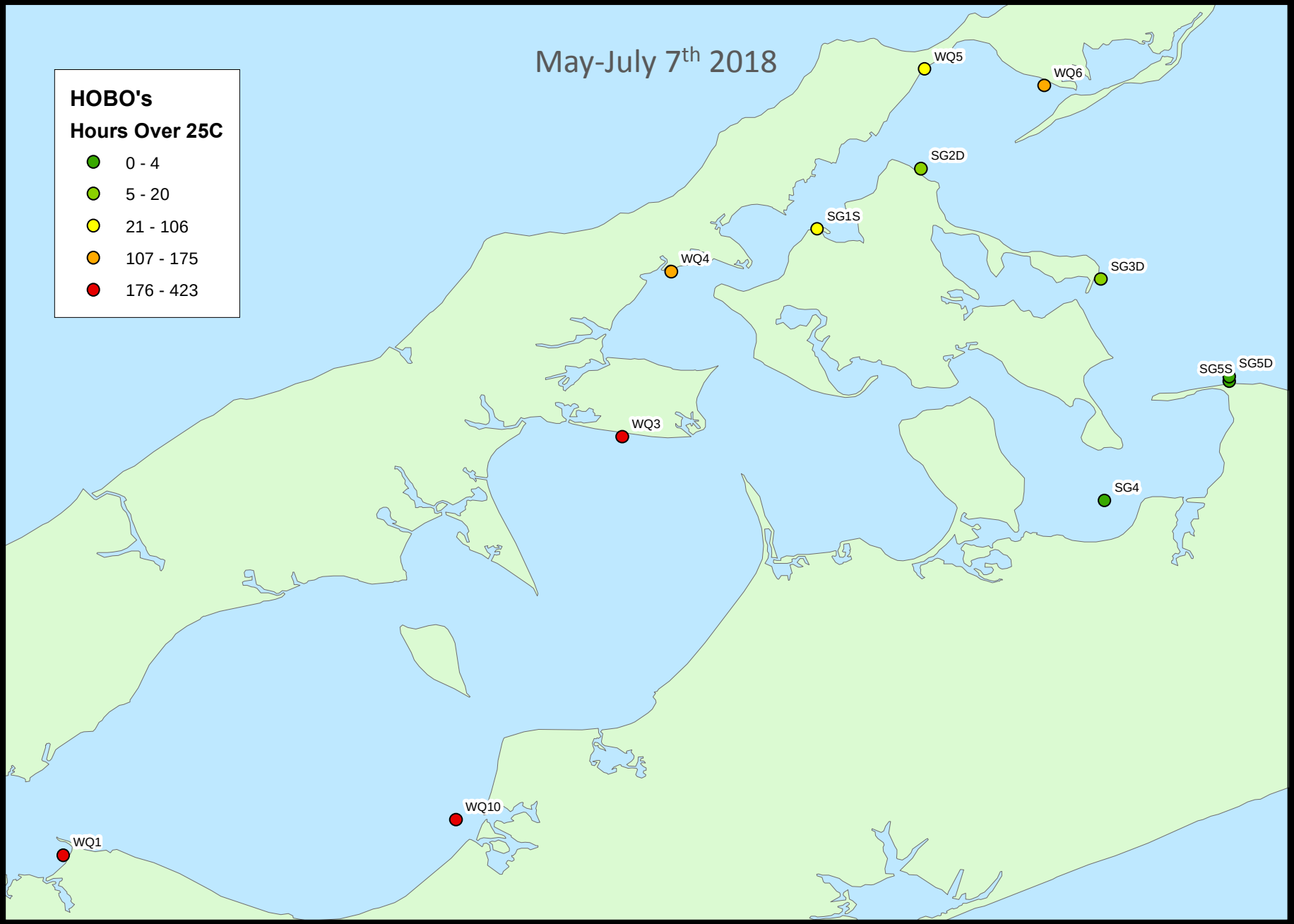
Peconic Bay 2017 Water Quality Data

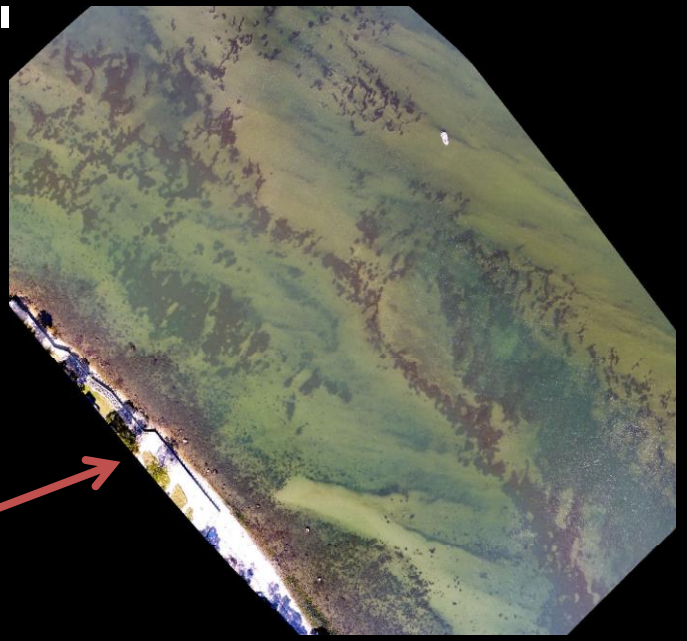


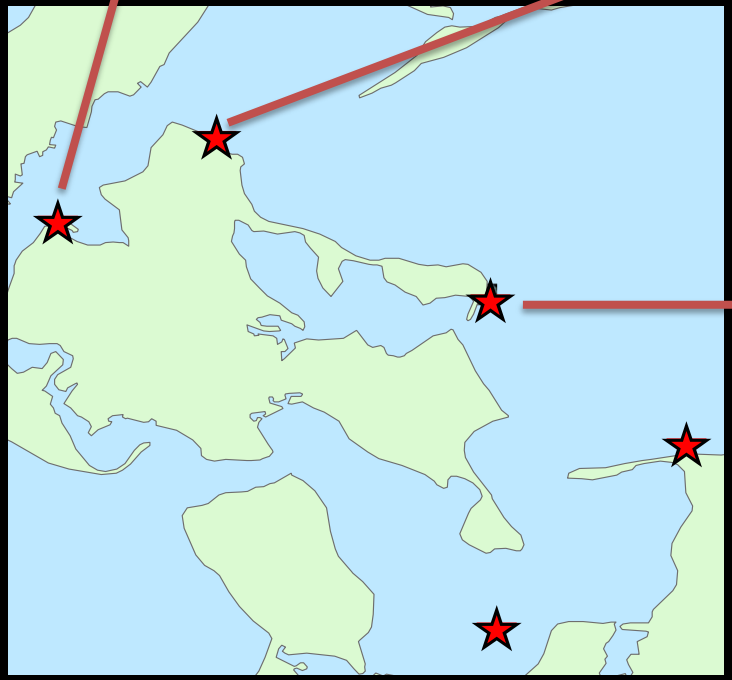
WWQ- western water quality EWQ- eastern water quality SG- seagrass


Site
USGS Site
Seagrass
Water Quality
Days over 25C
210
220 - 400
410 - 600
610 - 800
810 - 1,400

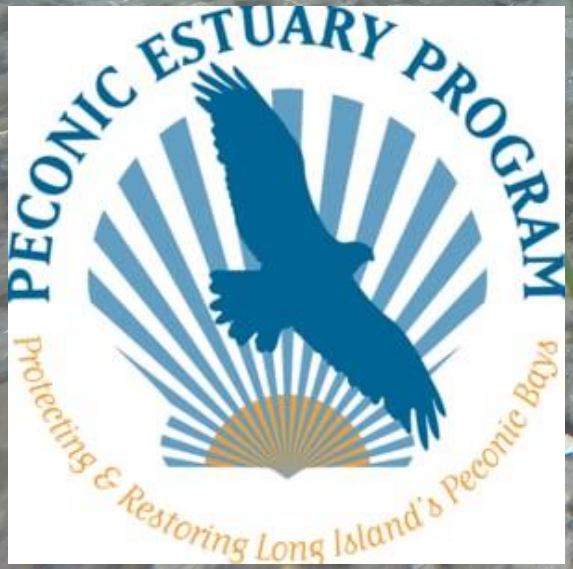

Type
Seagrass
Water Quality
Days Over 25C
.0247 - 199
200 - 401
402 - 599
600 - 768


May-July 7th 2018
HOBO's
Hours Over 25C
0 - 4
5 - 20
21 - 106
107 - 175
176 - 423
WQ5
WQ6
SG2D
SG1S
WQ4
SG3D
SG5S
SG5D
WQ3
SG4
WQ10
WQ1





Questions?



SoMAS
School of Marine and Atmospheric Sciences
STONY BROOK UNIVERSITY