Delaware's Inland Bays Seagrass Reestablishment Project

&

SAV as an Environmental Indicator

Inland Bays' SAV

- History of SAV in the Inland Bays
- Introduction to SAV
- Restoration/Project History
- Results to Date
- Lessons Learned
- SAV as an Environmental Indicator

Historical Context

- Anecdotal information
- Indian River Power Plant 316 report-Swan cr.
- UD Class Field Trip Report- August 1968
- Academy of Natural Sciencies-1988 report
- IBEP CCMP SAV Recommendations
- USDA Arial Photos-Potential historical sites
- Increased flow volume of Indian River Inlet

Inland Bay's SAV Restoration

- **Goal**- To establish sustainable and reproductive Submerged Aquatic Vegetation (SAV) beds to the Inland Bays of Delaware
- Last known SAV beds were last seen in the late 1960 to mid 1970s
- Loss was attributable to poor water quality due to increased nutrient loads to the watershed

Seagrass Definition

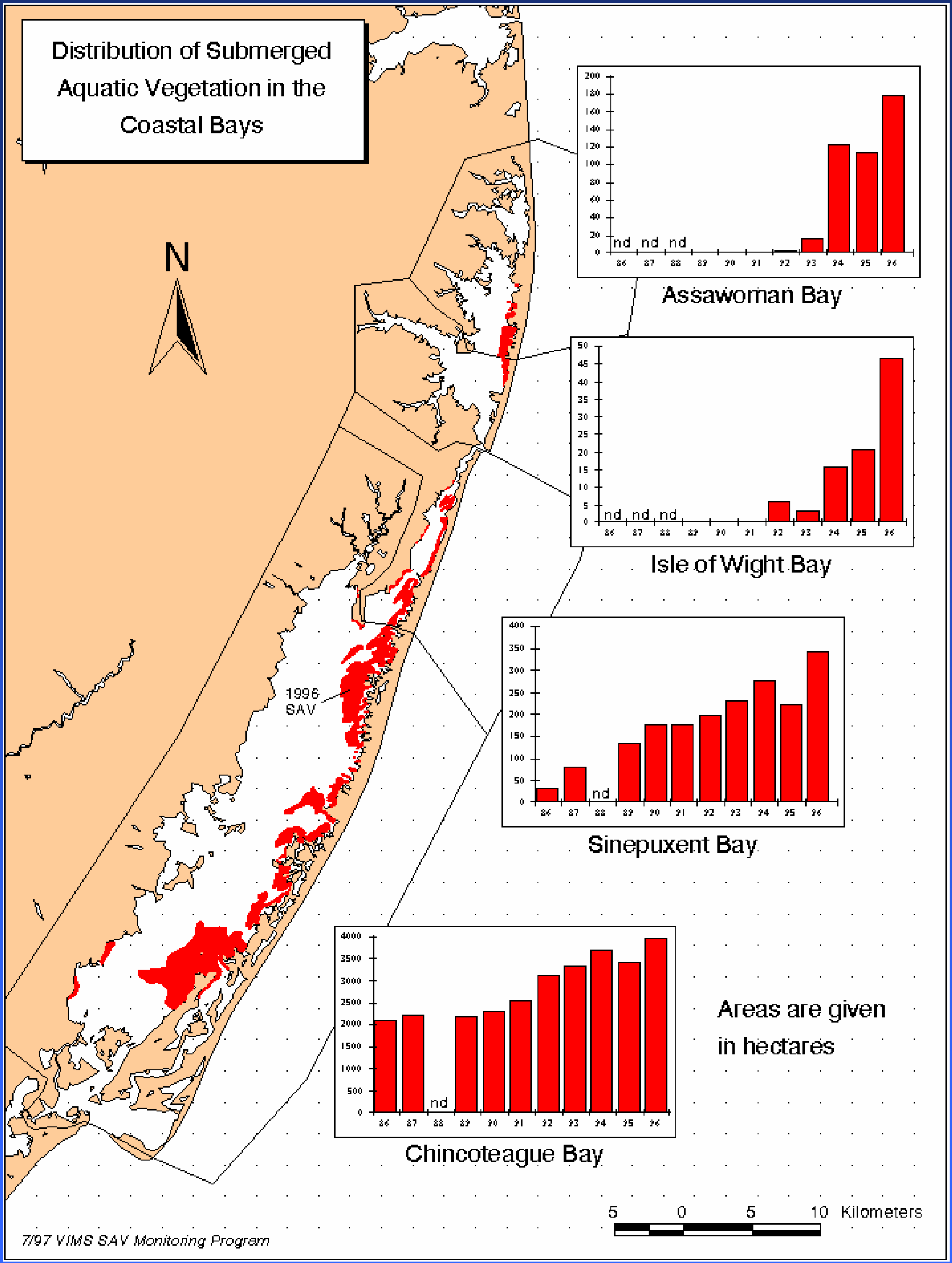
Seagrasses are flowering, rooted, vascular plants. Unlike algae, seagrasses have complex specialized parts, such as leaves, stems, rhizomes, and roots.

Unlike marsh plants, most seagrasses live completely submerged in saline water during the entire life cycle (including reproduction) and are fully adapted to life underwater.

Usually found in salinities greater than 20 ppt (psu).

SAV Recovery in the Coastal Bays of Maryland and Virginia

1987-1997



SAV Light Requirement

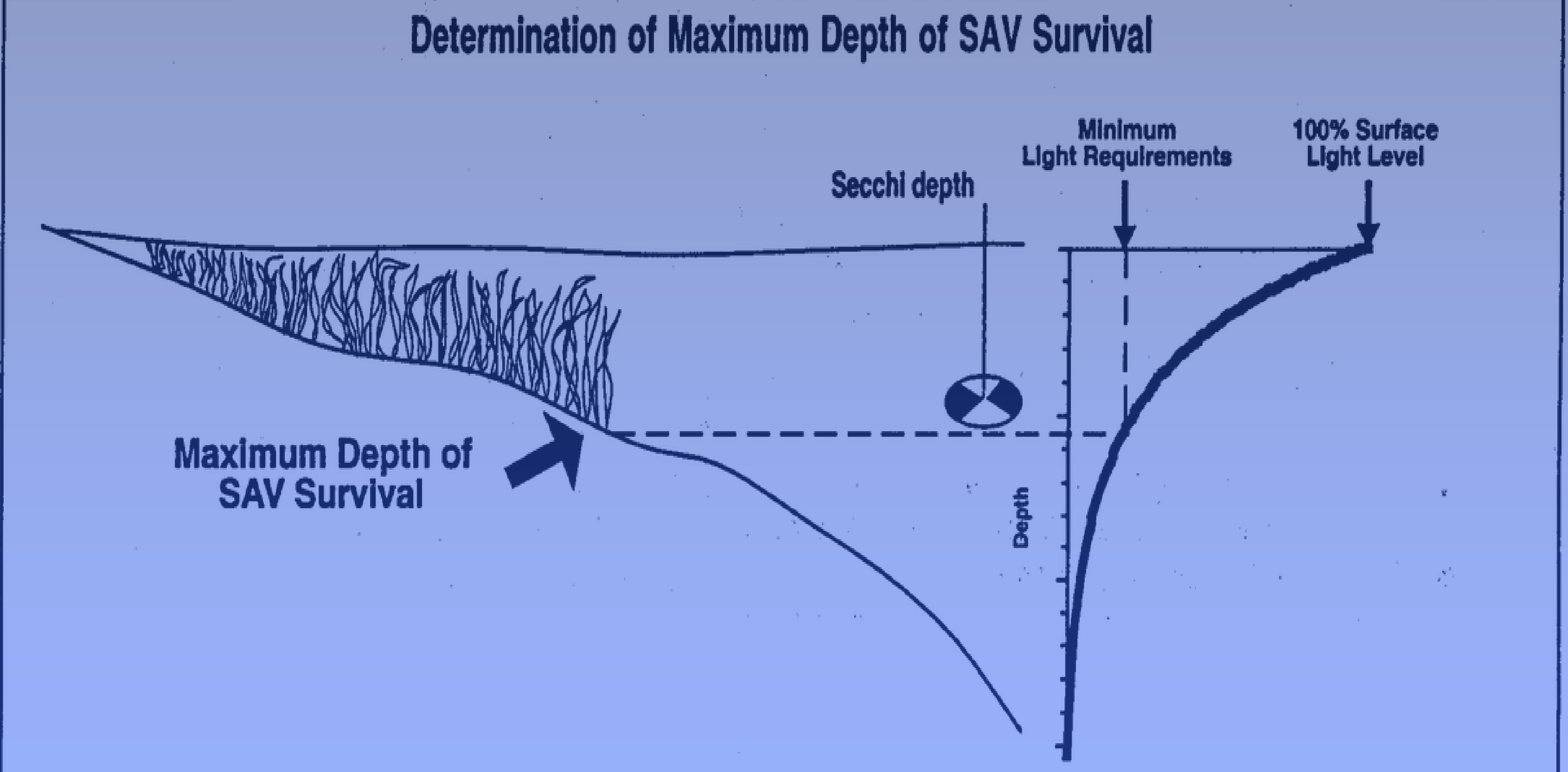


Figure 2. The interrelationships between light attenuation, SAV minimum light requirement, Secchi depth and the maximum depth of SAV survival depicted schematically. The intersection of the minimum light requirement and the light attenuation curve determines the maximum depth of SAV survival.

Chesapeake Bay Program

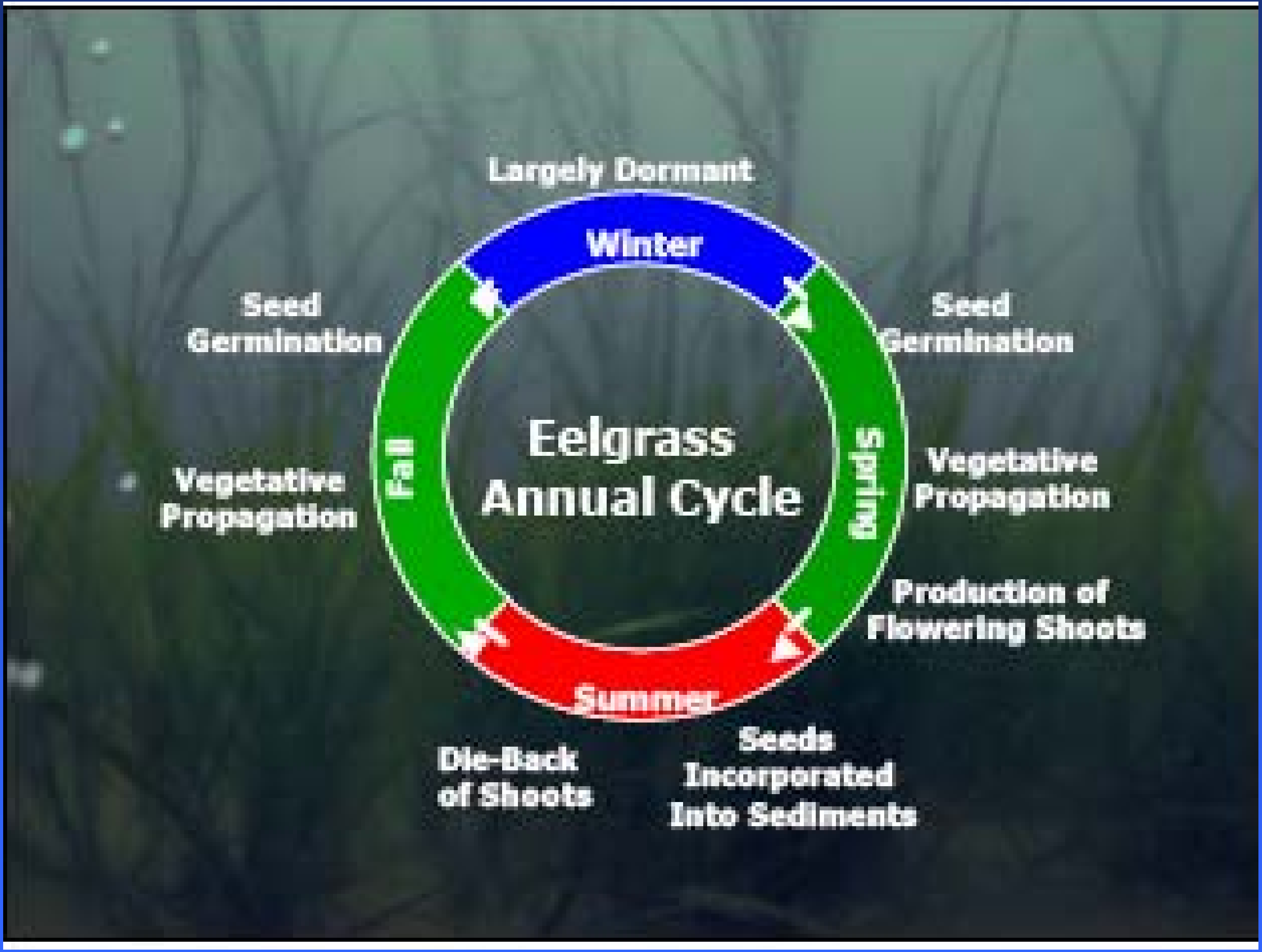
Polyhaline SAV Living Resource Habitat Requirements- Water Quality

Dissolved Inorganic Nitrogen (DIN)	<0.15 mg/l
Dissolved Inorganic Phosphorus (DIP)	<0.01 mg/l*
Total Suspended Solids (mg/l)	<15 mg/l
Chlorophyll *a* (ug/l)	<15 ug/l
Light Attenuation Coefficient (Kd; m-1)	<1.5
Secchi Depth (m)	>1.0 m

Critical Life Period-- March - May, September-November

* Covers both Mesohaline and Polyhaline portions of bays (5-35 ppt)

Eelgrass Growth Cycle

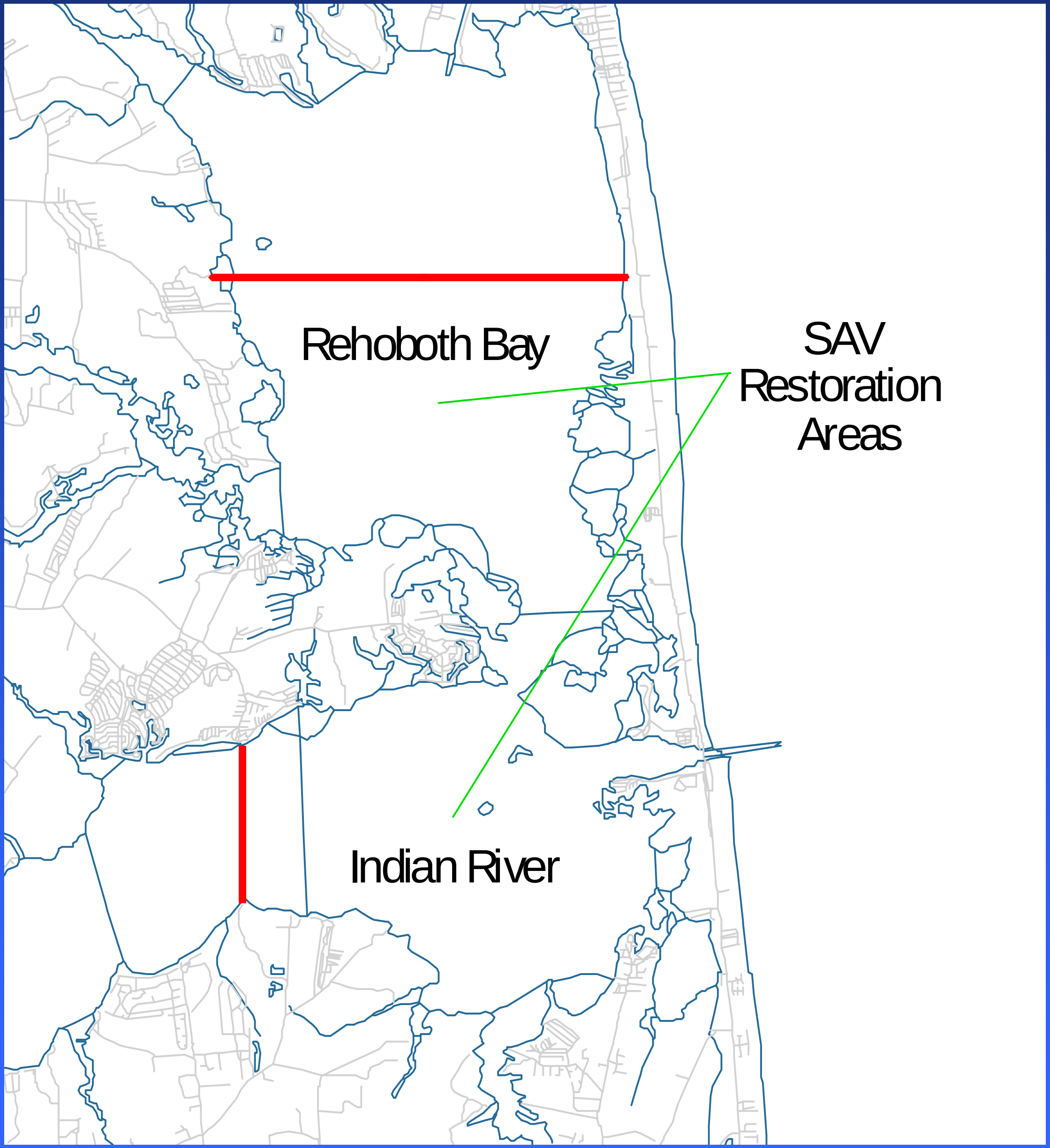


PROJECT DESIGN CRITERIA

Site Selection

- **Site History-Previous SAV Growth Locations**
- **Hydrology Dynamics**
  - **Tidal Range**
  - **Current Flow Velocity**
  - **Wave Energy/Exposure**
- **Benthic Sediment Characteristics**
  - **Grain Size-fine to medium**

Targeted SAV Restoration Areas



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Proposed restoration areas that currently meet Chesapeake Bay SAV restoration goals.

Indian River Bay

SAV Establishment Methods

- Staple transplants
- Peat Pot transplants
- Seed broadcasting

October 1990-Chincoteaque Bay

Eelgrass Roots & Shoots

Eelgrass Staple Method

3 Day process:

1-Collect eelgrass in Chincoteaque

2-Assemble eelgrass plants into planting bundle

3- Assemble dive teams to plant in Inland Bays

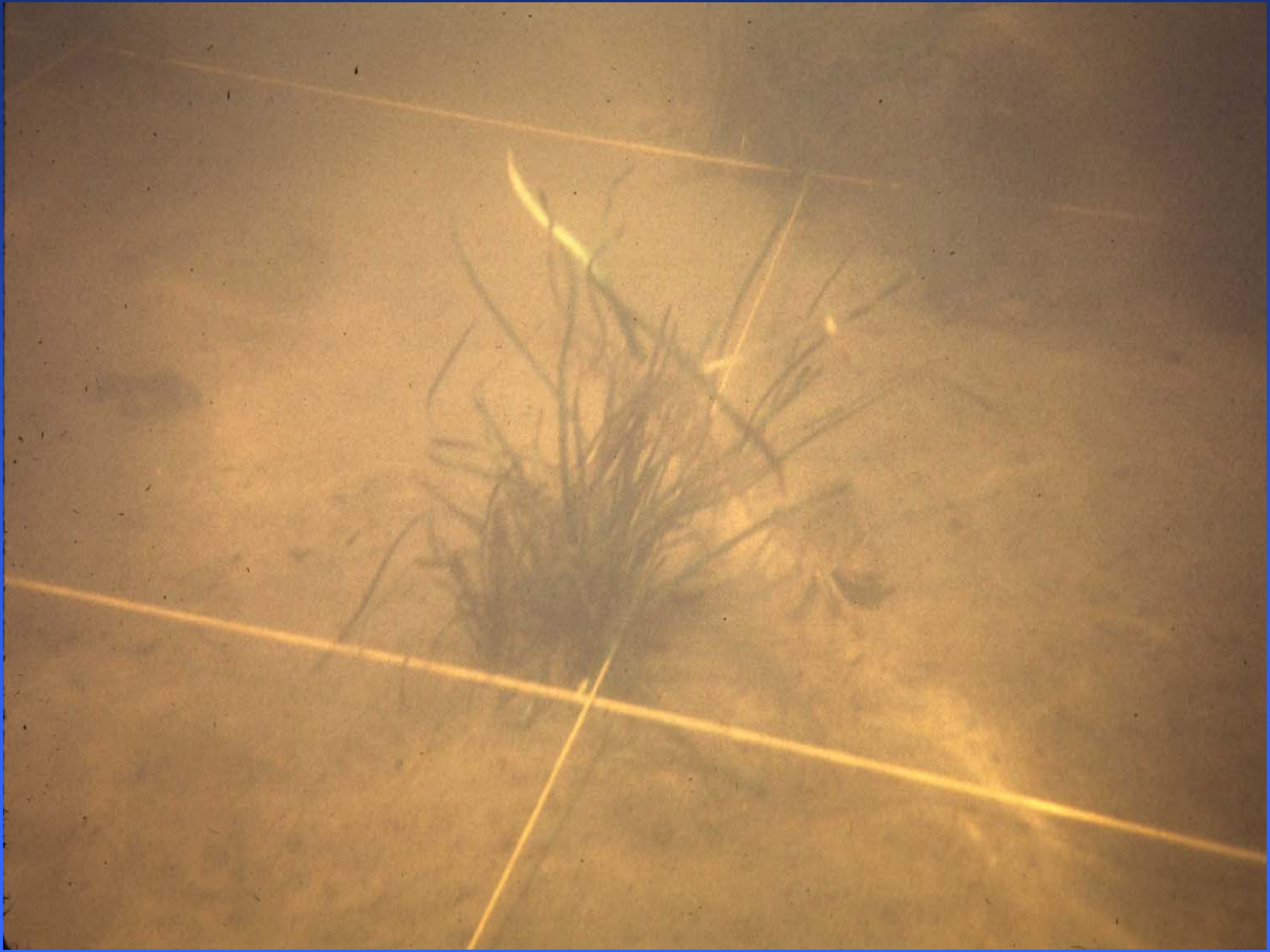
Time consuming and very volunteer intensive

Eelgrass Harvested from Beds

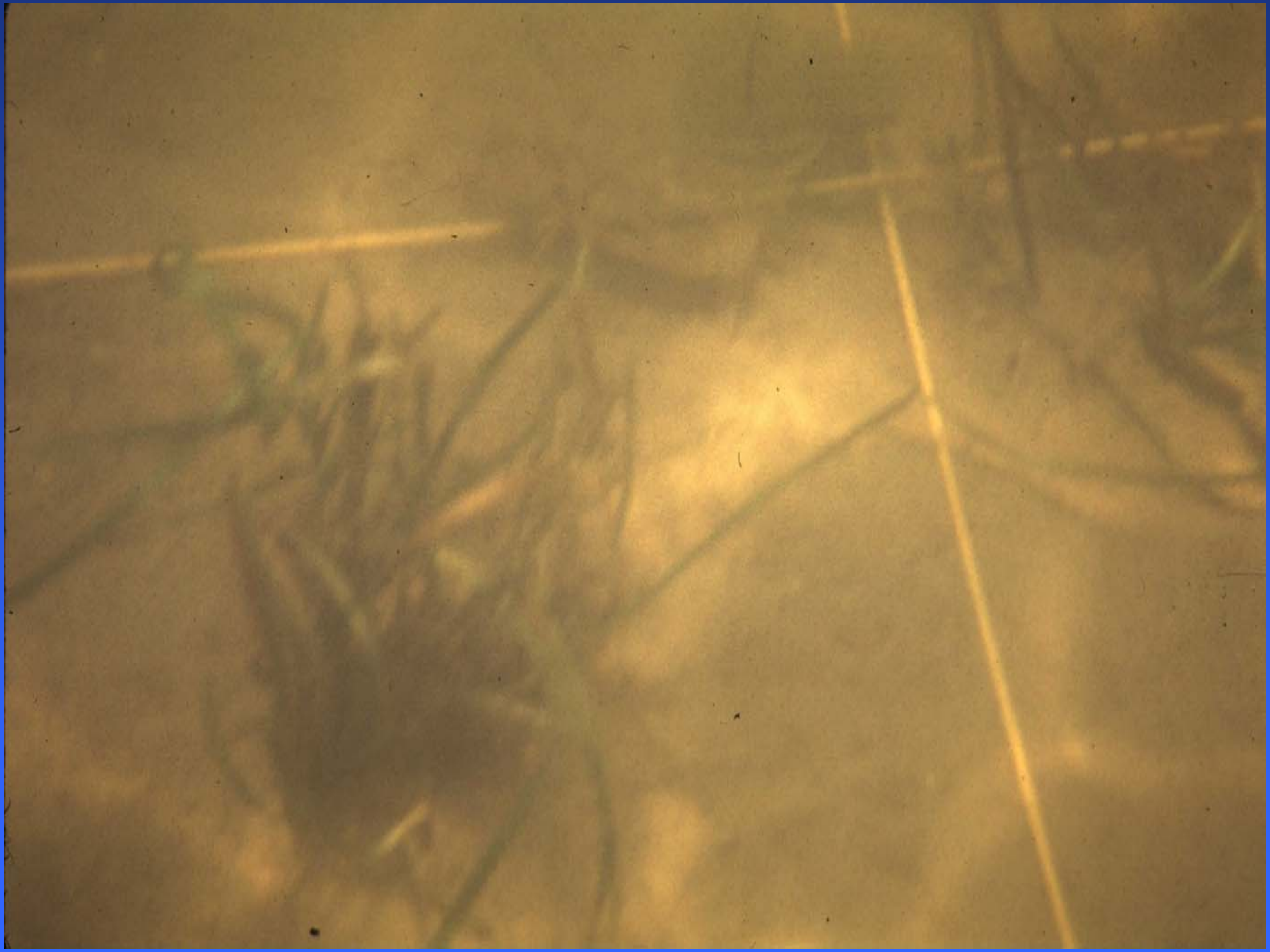
Wire Staple Method

2 Meter/25 Point Planting Grid

Freshly Planted Eelgrass



Crabby Intruder



Packing Peat Pots

Eelgrass Potting Unit

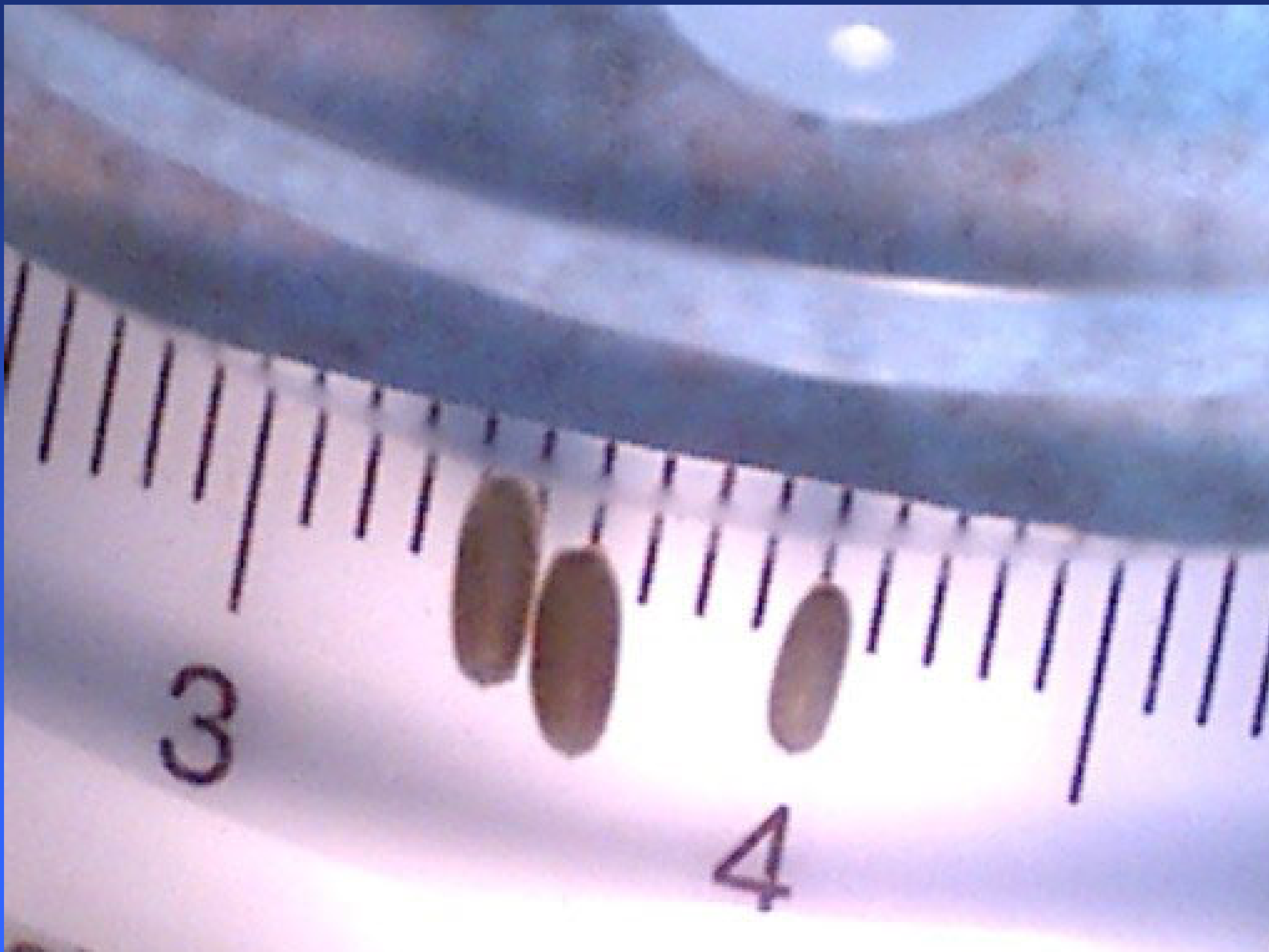
Potting Units Stacked in Trays

1999 Crew and Gear

2003 SAV Pilot Project
Seeds to Augment Transplanting

- Less labor intensive
- No permits required
- Proven technique
- Requires large indoor tanks-1,000 gals.

Germinating Eelgrass Seed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SAV Tank

Eelgrass Seeds

Plankton Counting Wheel

1ml=
66
Zm
seeds

Buoy Deployed Seeds

Christopher H. Pickerell, et al.

SAV Reestablishment Results

Bill McAvoy

May 2007

Natural Seed Distribution Pattern

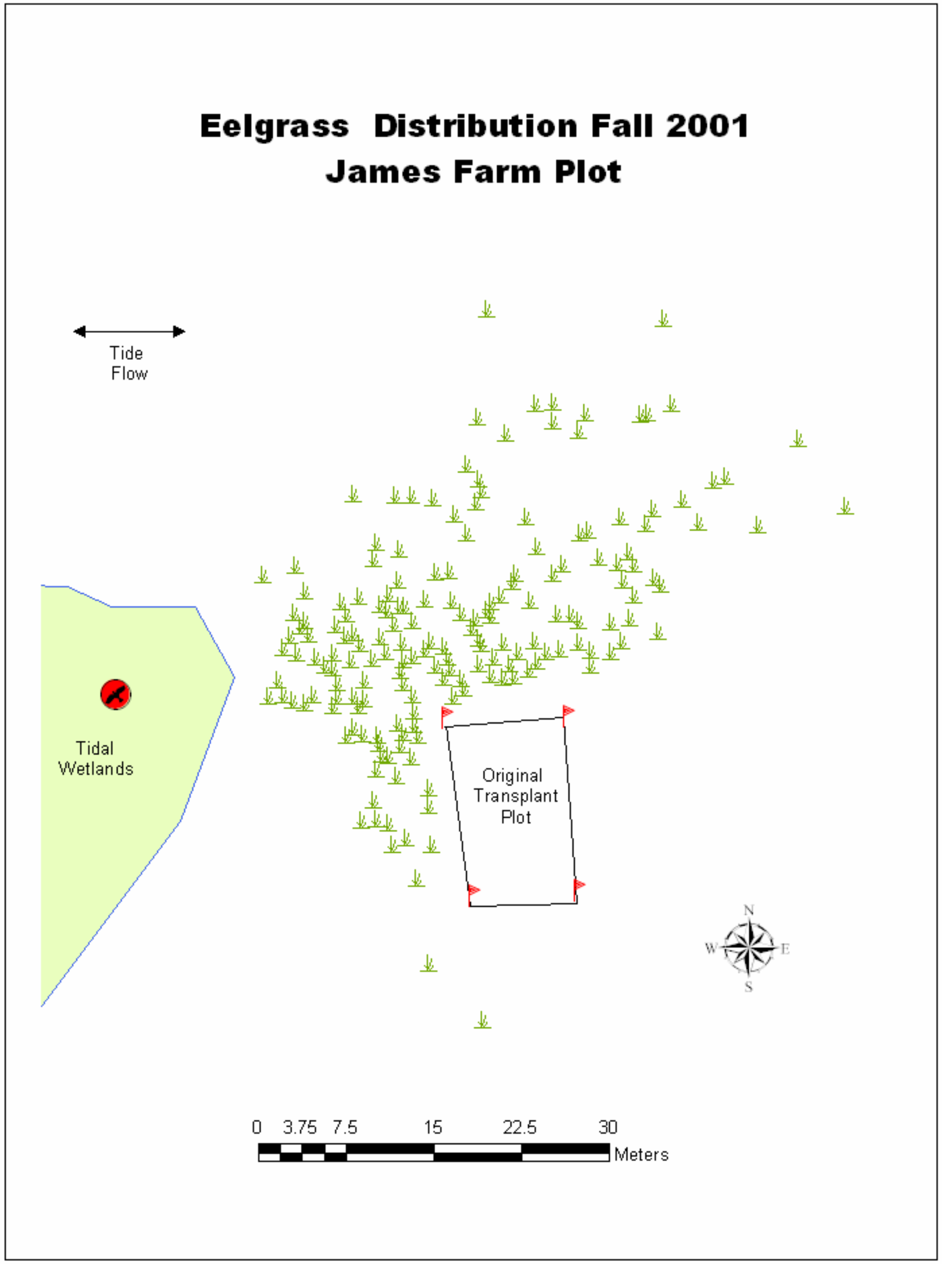
Planted 28 July 1999-

400 planting units

First seeds produced in spring 2000

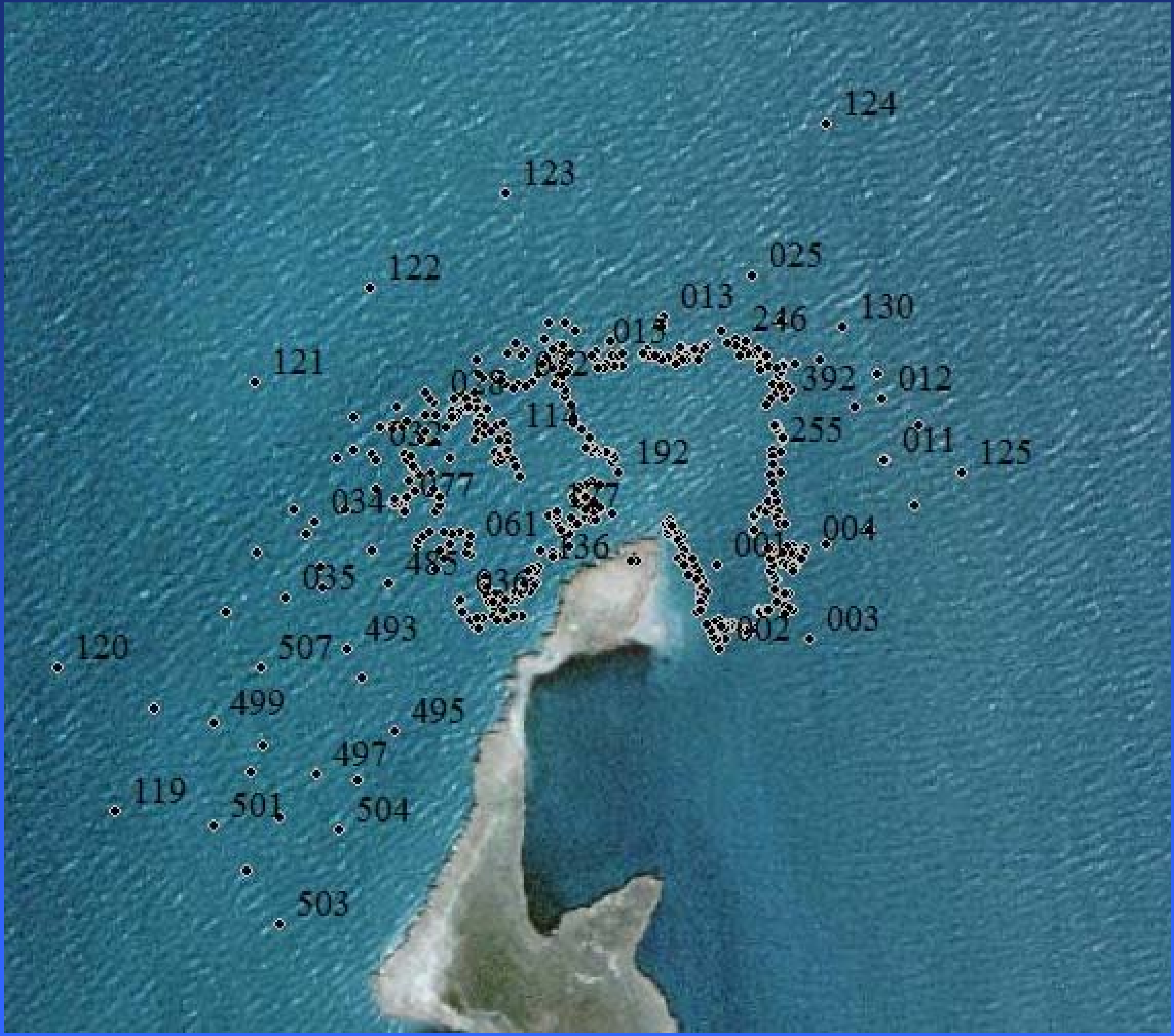
Seeds germinated fall 2000 and spring 2001

Additional seeds produced in spring 2001 by original transplant units-not germinated



Pasture Point 2004

Fall 2004



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SEAGRASS RECOVERY AREA
VERY SENSITIVE AREA
DO
NOT ENTER
DELAWARE DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL
FOR INFORMATION CALL 302-739-4590

Threats to Seagrass Beds

- Episodic Events-Storms, Hurricanes (Dennis & Floyd Sept ’99)
  - Bed Erosion, Burial, uprooting
- Ice-Sheet and Slush
- Wind Blow-out-Desiccation
- Disease
- Eutrophication
  - Macroalgae, Phytoplankton, Epiphytes
- Clam Harvesting
- Prop Scarring
- Dredging
  - Bed/Habitat Elimination-Light, Sediments
  - Habitat Modification

Natural Threats to Seagrasses

- Outbreaks of diseases can cause diebacks or eradication-1930s pandemic eelgrass decline
- Overgrazing can decimate seagrass beds (cownose rays)
- Storms can uproot or bury seagrass beds
- Salinity/temperature changes resulting from extreme weather patterns can shift or eliminate seagrass beds

Ulva Blooms & Harvesting

Summer 2000

Human Threats to Seagrasses

- Reckless boating can contribute to prop scars
- Docks and piers shade seagrass beds
- Dredging destroys seagrass habitat
- Sediment runoff buries seagrasses and clouds water
- Certain shellfish harvesting methods destroy seagrass beds
- Excess nutrient runoff reduce water clarity by stimulating phytoplankton, macroalgae, epiphytic and epizootic growth

Lessons Learned

Signage and post perimeter

Fencing and macroalgae don’t mix!

Cove planting sites and macroalgae don mix!

Claming and SAV beds don’t mix!

Volunteers vs. Paid Help

Seasonal Planting Guidelines

Get real about Expectation Management-

it’s a long haul!

Set Realistic and Achievable Goals

Next Steps

- Protect beds through legislation, administrative order or other means
- Develop MOA between States for SAV restoration source plants and seeds
- Develop additional methods to reestablish SAV
  - Seed Broadcasting
  - Lab or aquaculture applied techniques

SAV as an Indicator?

Monitoring a resource or a vital sign

MD Coastal Bays Seagrass Status

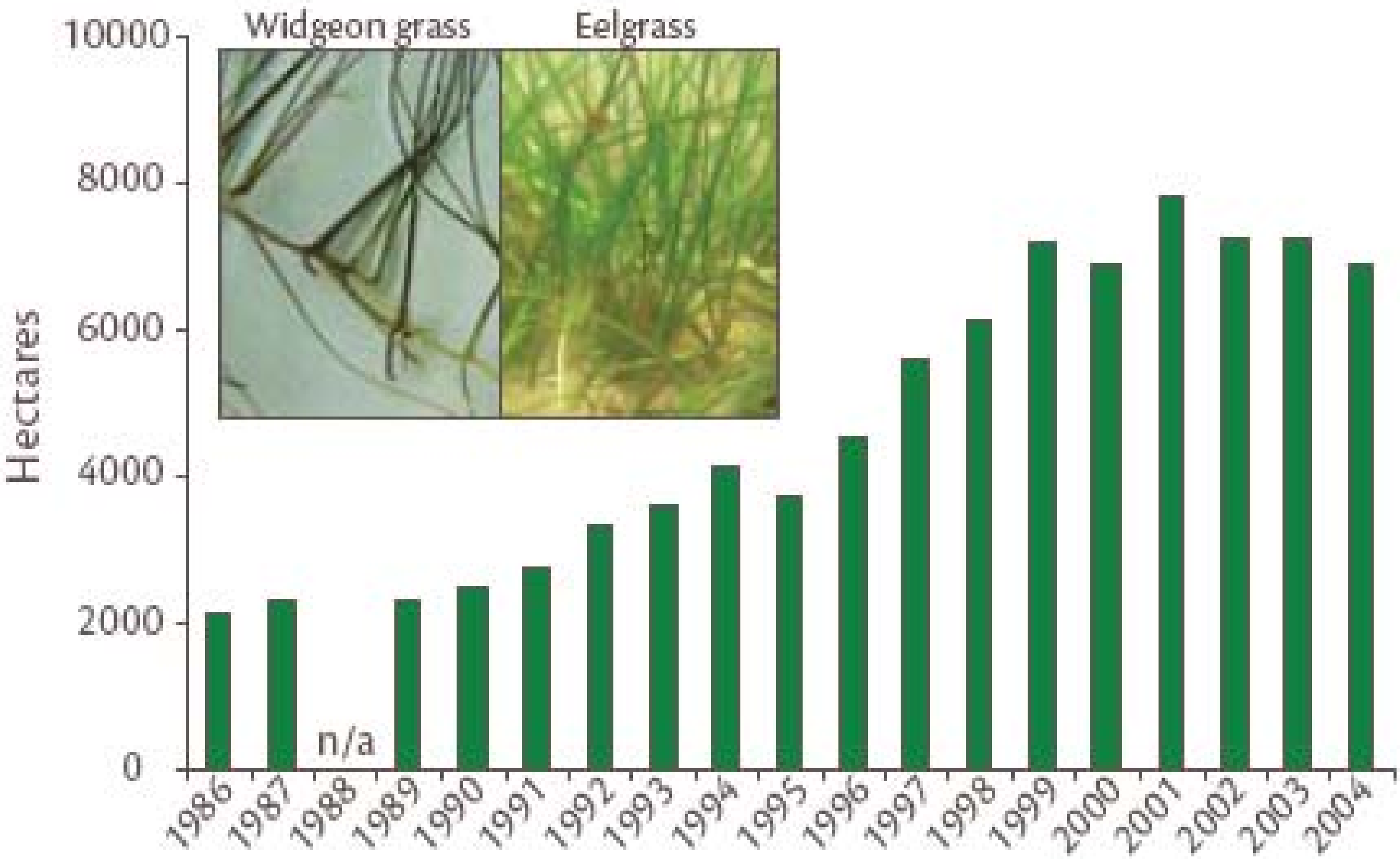
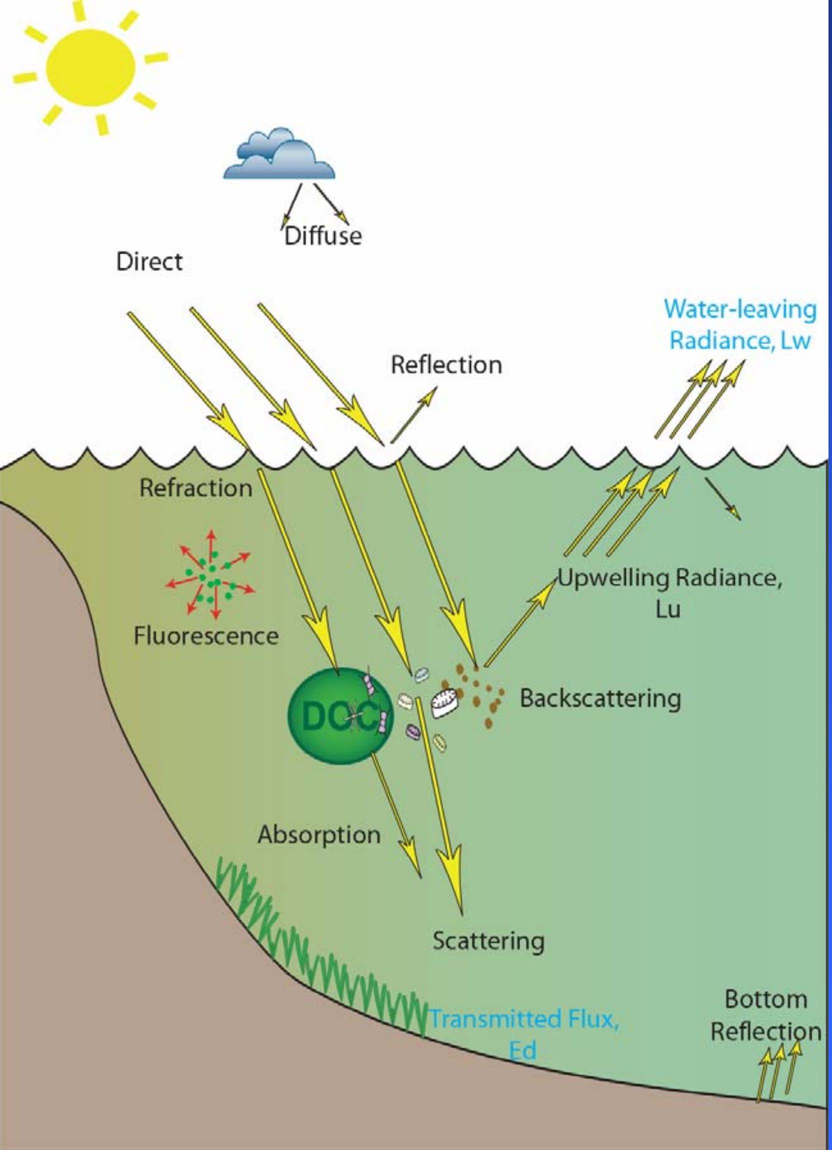


Figure 3: Aquatic grass abundance over time in Maryland's Coastal Bays. (Data: www.vims.edu/bio/sav. Widgeon grass photo: USDA, eelgrass photo: P. Tango, MD DNR)

Processes Affecting the Propagation of Light Underwater



- Absorption
  - Photon extinguished
  - Energy converted to heat or photochemistry
- Scattering—a change of direction
- Reflection and refraction at air-water interface
  - Mostly forward
  - Small percentage of backscattering can have large effect on penetration
- Bottom reflection
  - Depends on water clarity
  - Composition of the bottom
- Phytoplankton fluorescence

Light Requirements

Percent Light Through Water (PLW)

Inputs

- K_d measured directly

or

- K_d calculated from Secchi depth: $K_d = \frac{1.45}{\text{Secchi depth}}$

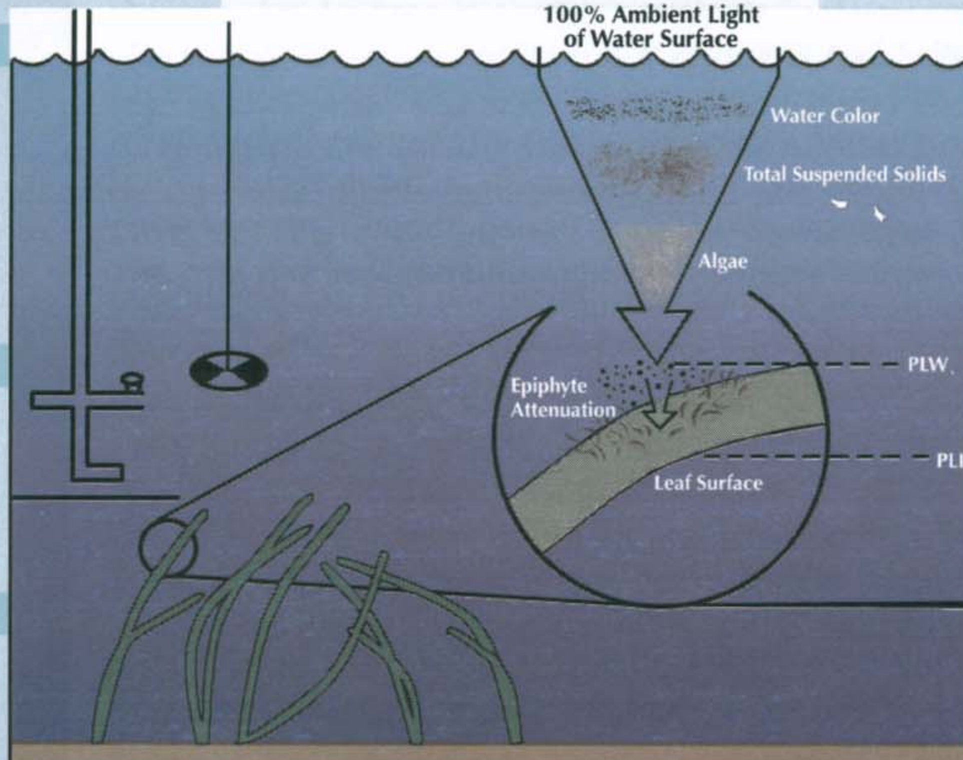
Calculation

$PLW = e^{(K_d)(Z)}100$

where
- z = depth
- e = 2.71828

Evaluation

PLW vs. water-column light requirement (see column 4 in table 1–1)



Percent Light at the Leaf (PLL)

Inputs

- K_d
- TSS
- DIN
- DIP

*Calculation**

$PLL = [e^{-(K_d)(Z)}][e^{-(K_e)(B_e)}]100$

where
- K_e = epiphyte attenuation
- B_e = epiphyte biomass
- e = 2.71828

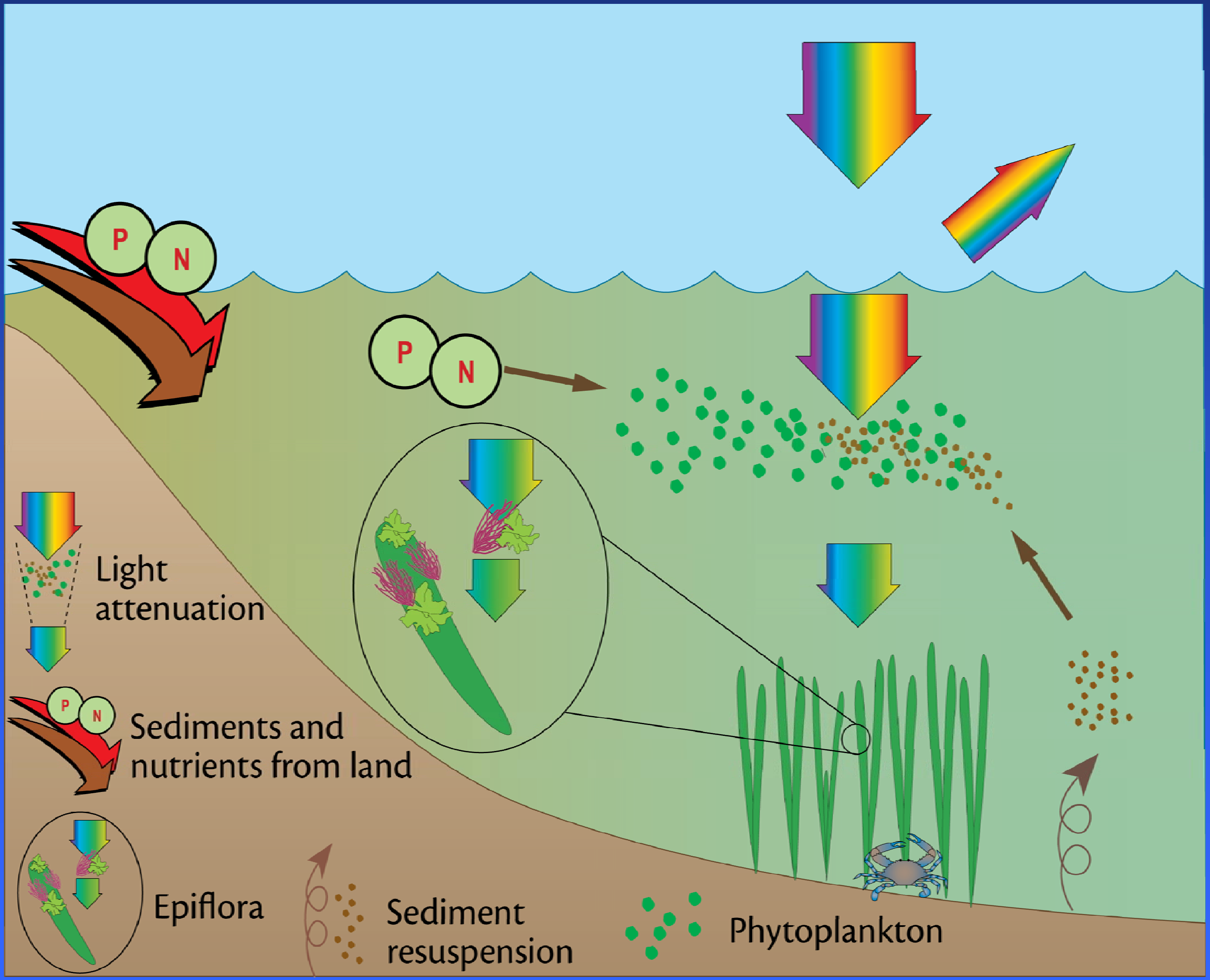
Evaluation

PLL vs. minimum light requirement (see column 3 in table 1–1)

* A PLL calculator is provided at http://www.chesapeakebay.net/cims, under Tools/Standalone Applications/Percent Light at Leaf Calculator. This model calculates PLL from four water quality variables: DIN, DIP, TSS, and either diffuse downwelling ***PAR*** (photosynthetically active radiation) attenuation coefficient (K_d) or Secchi depth.

Figure 3–1. Calculation of PLW and PLL and comparisons with their respective light requirements. SOURCE: BATIUK ET AL. 2000

SAV as Integrated Indicators



Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.

Seagrass Response to Excess Nutrients

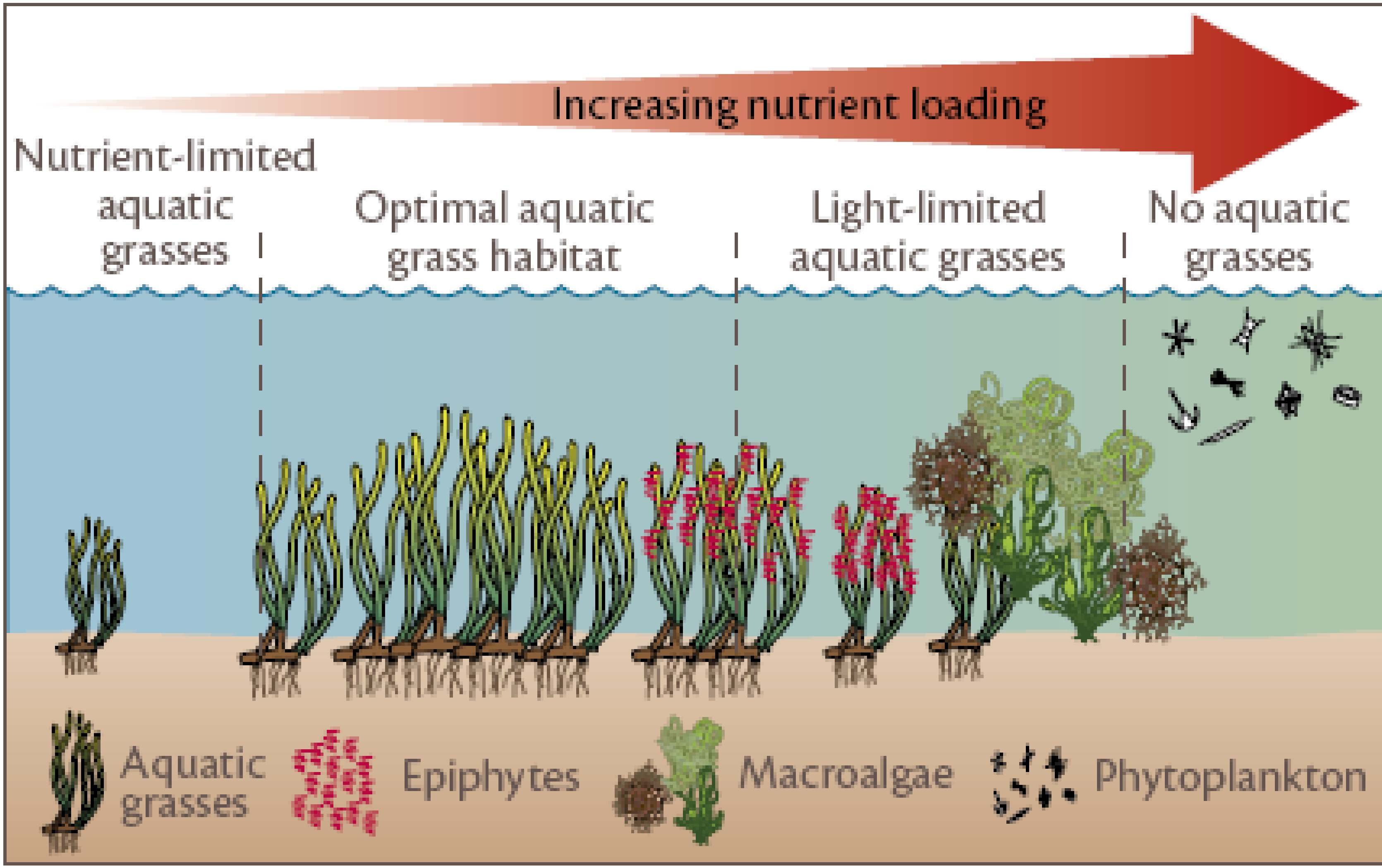


Figure 2: Diagram of aquatic grass responses to nutrients. (Data: Wazniak et al. in press)

SAV Habitat Monitoring/ Indicator Status

- Depth Range – Max/min
- Aerial Coverage-total, existing vs % potential coverage
- Sediment Types
- Associated Adjacent Habitats (structure, wetlands, discharges, impervious surfaces, etc.)
- Hydraulic Parameters
  - Wave height
  - Fetch
  - Current velocity
  - Turbidity

SAV Bed Monitoring/Indicator Status

- Shoot density, height
- Above and below ground biomass
- Spatial coverage
- Floral, faunal, infaunal assemblage/metrics
- Water quality (salinity, DO, temp, clarity, nutrients, chl *a*)
- Sediment dynamics-temporal changes
- Survival-3 to 5 year term
- Reproductive success-seed production/germination
- Site suitability- meets current thresholds?
- Additional standardized metrics ?

What is the question we are trying to answer?

- Define the question-What is impacting our Bays
- Main driver is Nutrients
  - Decisions for Delaware
  - Governor's IB Monitoring Committee- 1988
  - IBEP CCMP
  - TMDL
  - Various independent studies

“It’s the nutrients, stupid”

- National Park Service-Coastal Estuarine Nutrient Assessment
- Monitoring Protocols for the National Park Service North Atlantic Coastal Parks: Ecosystem Indicators of Estuarine Eutrophication

http://www1.nature.nps.gov/im/units/ncbn/products/Phase_III_Plan/NCBN_Phase3App_EstuarineEutrophProtocol_2004Dec14.pdf

Nutrient Status in the Inland Bays

- Objective 1: Determine if nutrient loads to Inland Bays estuaries are increasing (or decreasing);
- Objective 2: Determine if estuarine resources are changing in response to nutrient inputs.

Characteristics of effective monitoring variables

- Relevant to management concerns and ecological resources
- Applicable for use in a monitoring program
- Responsive to anthropogenic stresses
- Interpretable and useful to environmental decision-making

Characteristics of effective monitoring variables

- Relevant to management concerns and ecological resources
  - Address monitoring questions of interest
  - Have known linkage to ecological function or critical resource of interest
  - Are at appropriate scale to answer specific monitoring questions
    - Are integrative in space and time, so that the full suite of variables provides assessment of entire system of interest

Characteristics of effective monitoring variables (con't)

- Applicable for use in a monitoring program
  - Are easy and practical to measure
  - Are non-destructive or low impact to measure without disturbing monitoring site
  - Are measurable using standard, well-documented methods
  - Generate data that are compatible with other systems
  - Are cost-effective to measure

Characteristics of effective monitoring variables (con't)

- Interpretable and useful to environmental decision-making
  - Responsive to anthropogenic stresses
  - Have known sampling and measurement error
  - Have low natural variability
  - Have known variability in time and space
  - Are sensitive to anthropogenic stresses on the system or resource of interest, while having limited and documented sensitivity to other factors (i.e. to natural variation in ecosystem condition)

Characteristics of effective monitoring variables (con't)

- Interpretable and useful to environmental decision-making
  - Respond to stress in a predictable manner
  - Are anticipatory: signal impending change in ecosystem before substantial degradation occurs
  - Are linked to management decisions; predict changes that can be averted by management action, or document success of past actions
  - Have known or proposed thresholds of response that delineate acceptable from unacceptable ecological condition
  - Can be communicated to managers, legislatures and the public

Vital Signs and their measurement

- Estuarine Water Chemistry
  - Dissolved Oxygen
  - Temperature
  - Salinity

- Estuarine Water Quality
  - Chlorophyll a

- Estuarine Water Clarity
  - Attenuation of Photosynthetically Active Radiation (PAR)
  - Turbidity

Vital Signs and their measurement

- Seagrass Distribution (Mapping)
  - SAV bed size
  - SAV bed structure (cover class)
  - SAV bed location
- Seagrass Condition
  - Population based measurements
    - Density
    - Biomass
    - Canopy height
    - Percent cover
    - Seagrass depth limit
    - Shoot based measurements
    - Epiphyte cover
    - Wasting index
    - Grazing
    - Ancillary measurements of environmental suitability
      - Temp., Salinity, Light Attenuation, Sediment Parameters, etc.

In-house Volunteers