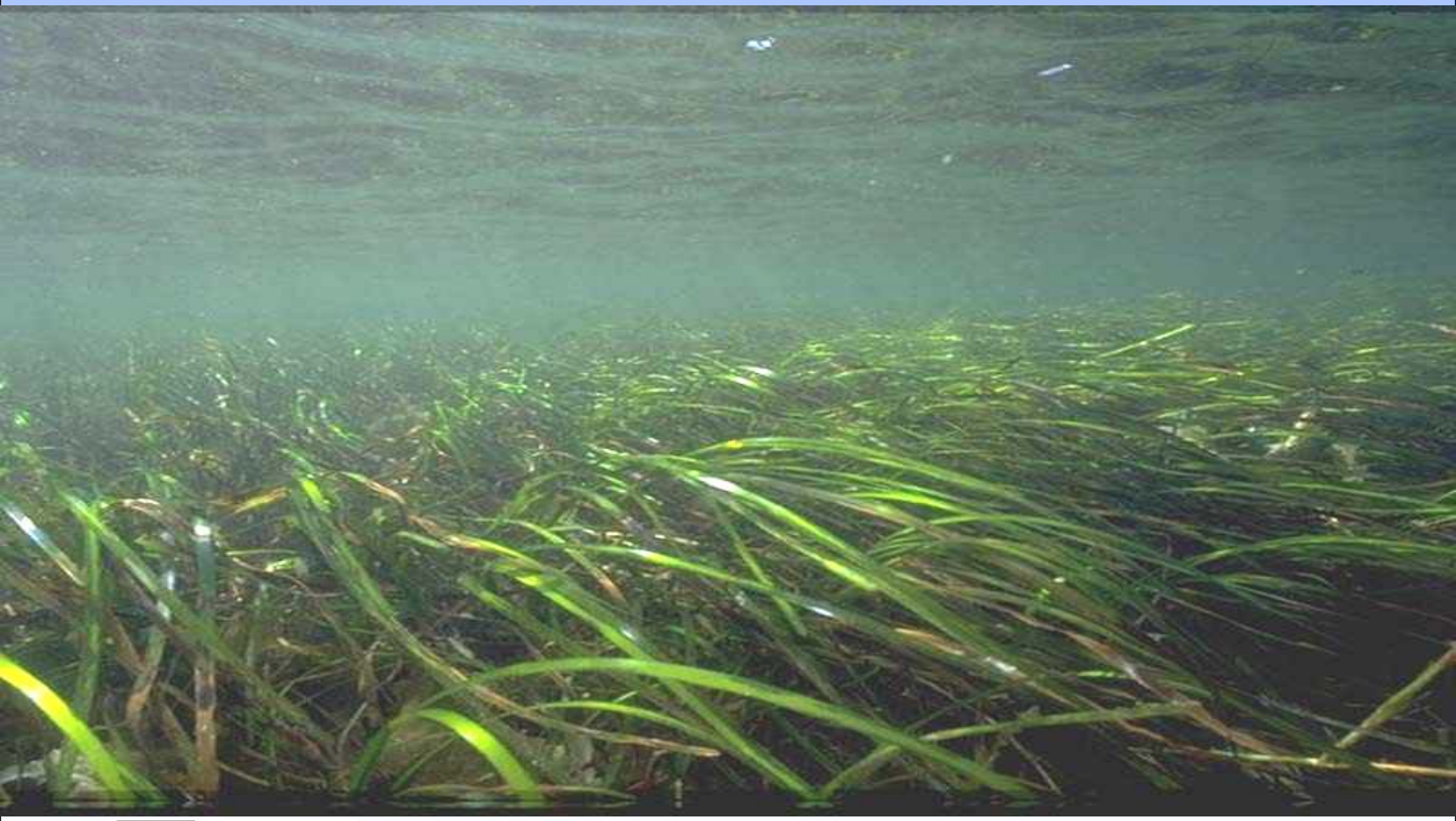
Massachusetts Seagrass Monitoring Program



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Zostera marina

•Primary Producer of Estuarine Habitats

•Robust system of Rhisomes- stabilizing the bottom

•Shoots float above bottom providing safe haven for larval scallops and other shellfish

•Highly stressed from macro-algal competition in enriched embayments

•In some embayments 2-3% areal decline per year

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Stabilizing Influence

Shellfish Habitat

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This is the problem

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Land Use in Estuarine Zone

Poor Water Quality

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Epiphytes – Additional Light Attenuation

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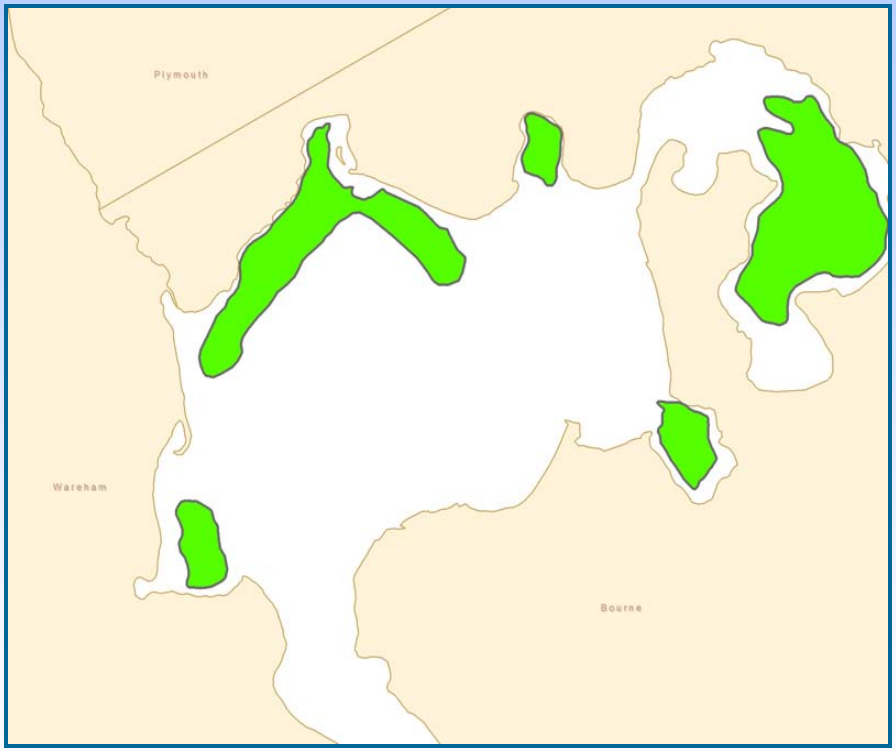
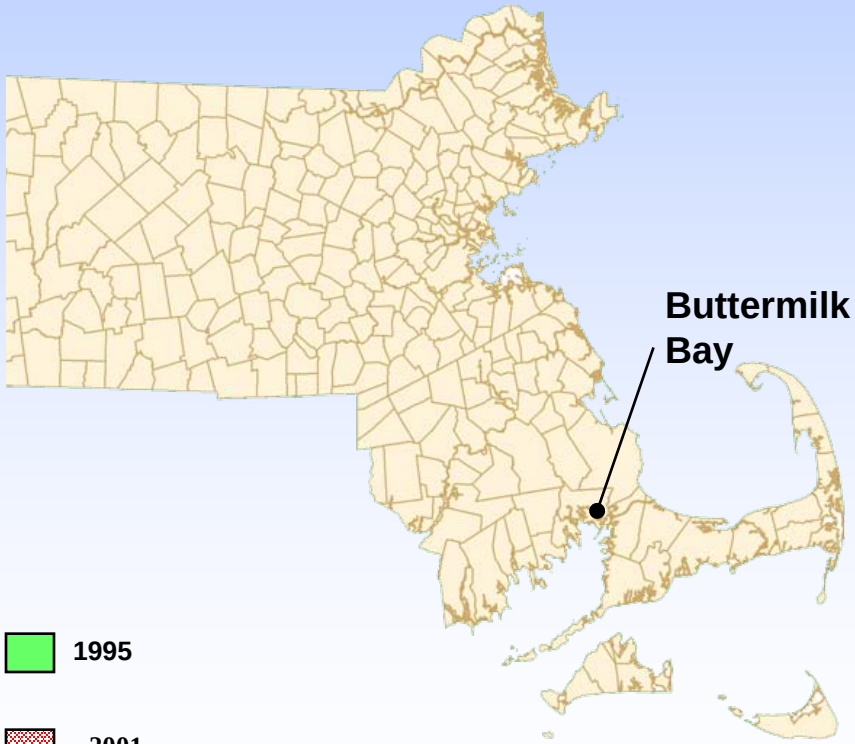
Buttermilk Bay -- The First Alarm –94.6 acres





1995

2001

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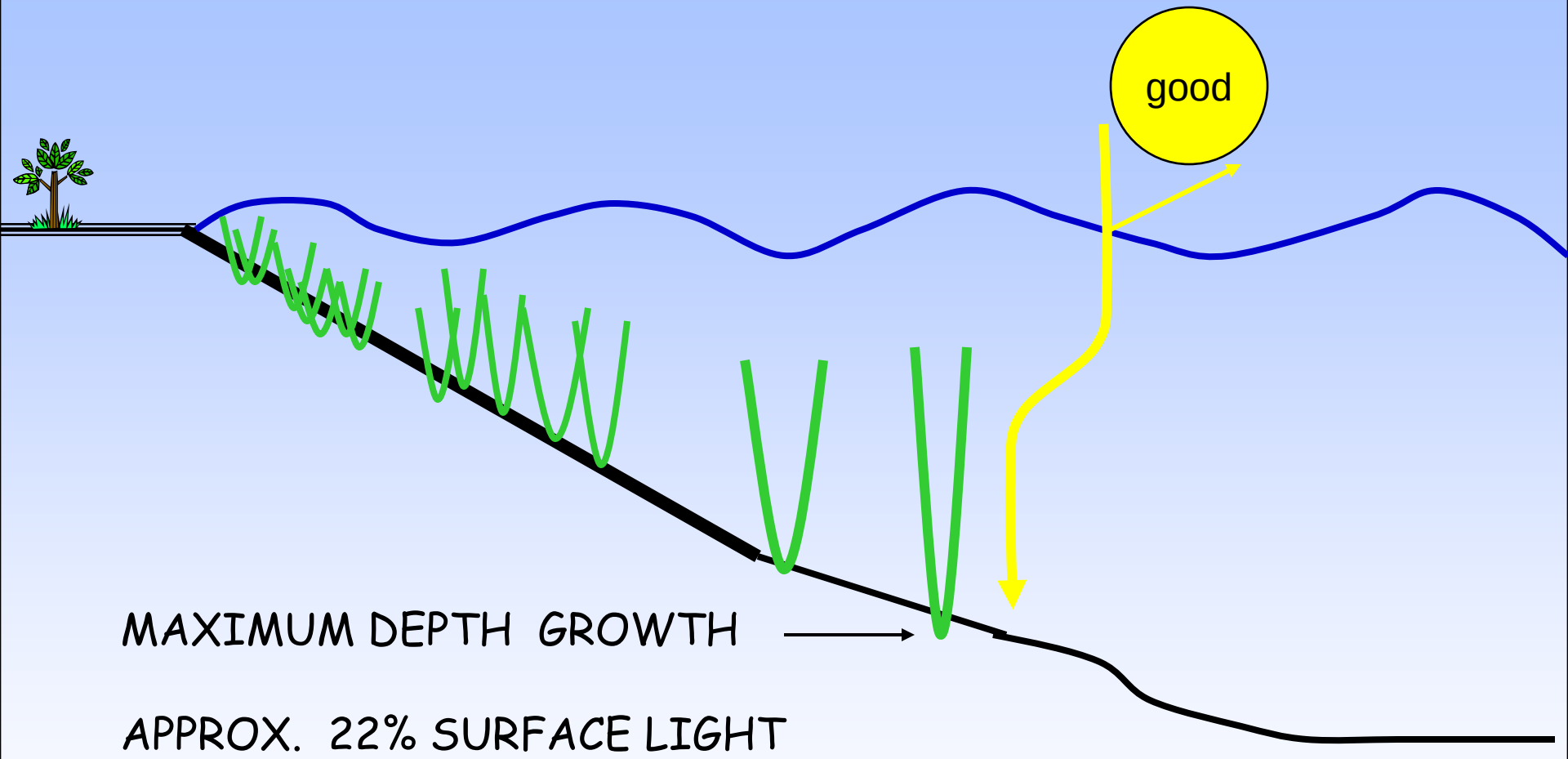
SEAGRASS DEPTH DISTRIBUTION



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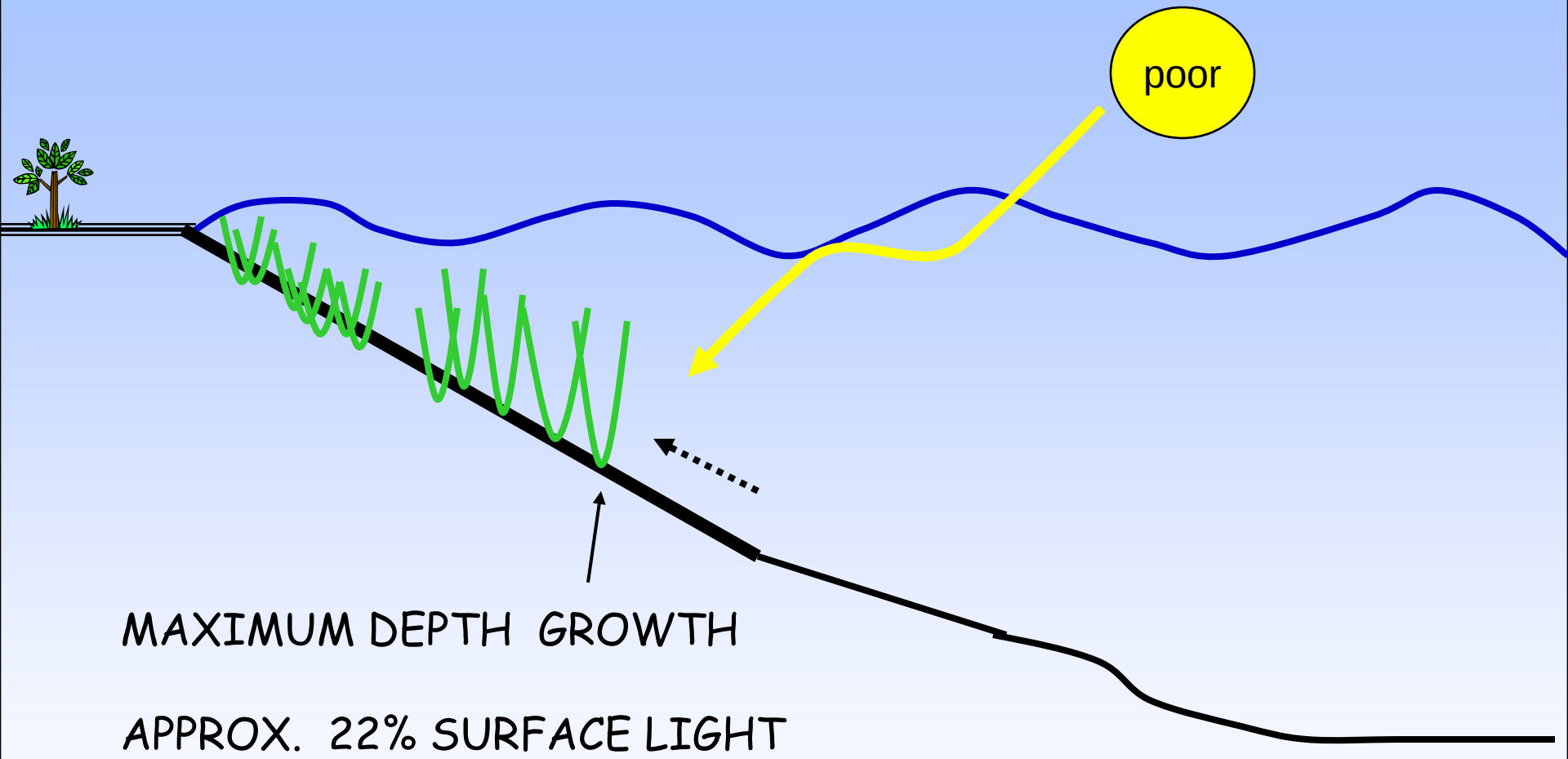
SEAGRASS DEPTH DISTRIBUTION



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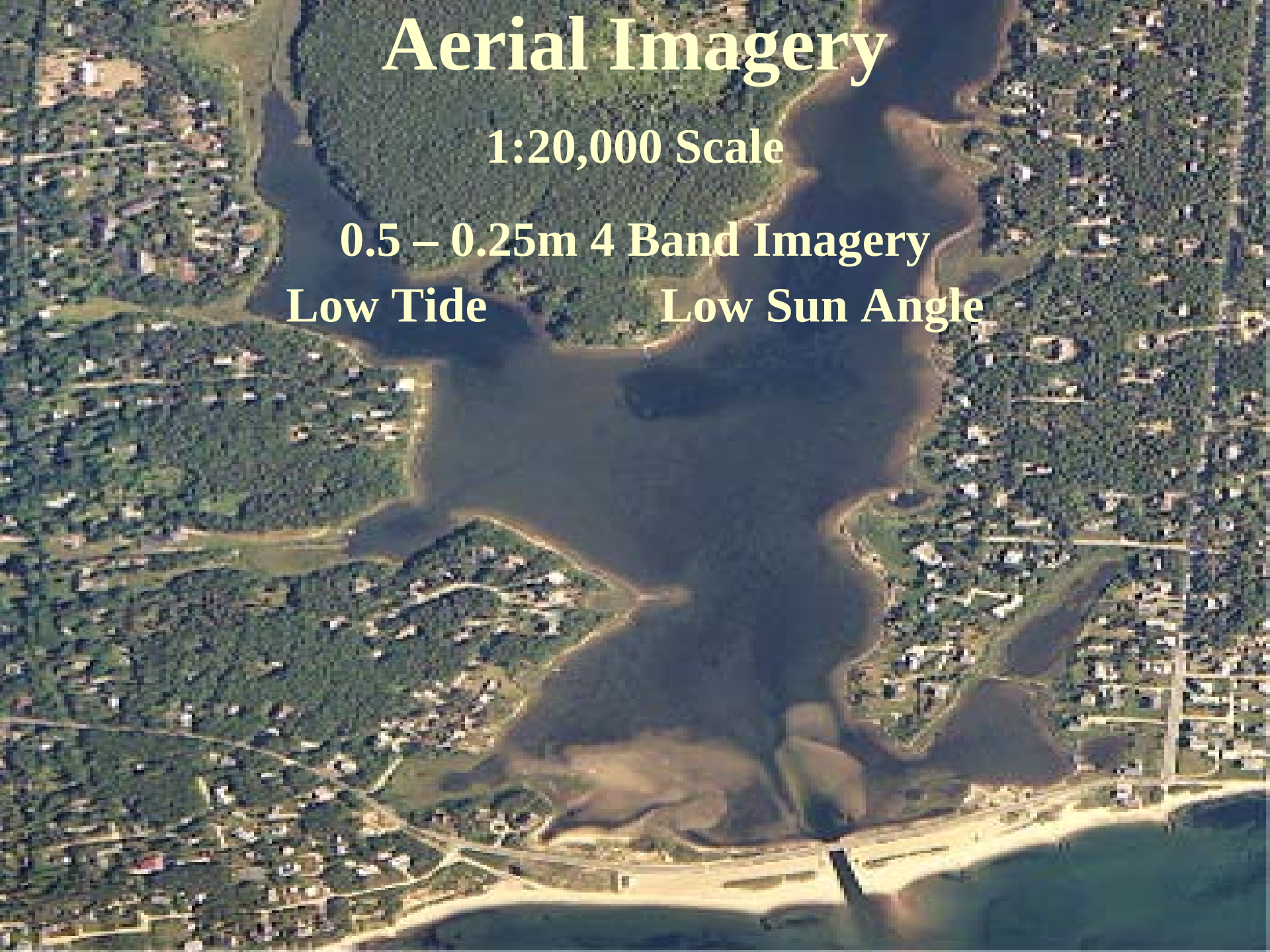
Aerial Imagery

1:20,000 Scale

0.5 – 0.25m 4 Band Imagery

Low Tide **Low Sun Angle**



Methods

- Acquire high resolution aerial imagery to the specifications of the NOAA-C-CAP program
- Photointerpret imagery
- Conduct fieldwork as required to verify photointerpretation
- Record field data
- Geo-reference analogue data to state digital map base

Brief History

- 1993- conducted pilot project to develop methods
- 1994-1996- completed first state coastal mapping. Made a digital coverage
- 2001 – completed 2nd state coast-wide mapping
- 2002-5 –monitored all waterbodies
- 2006/7 - conducted 3rd mapping of state's most stressed waterbodies

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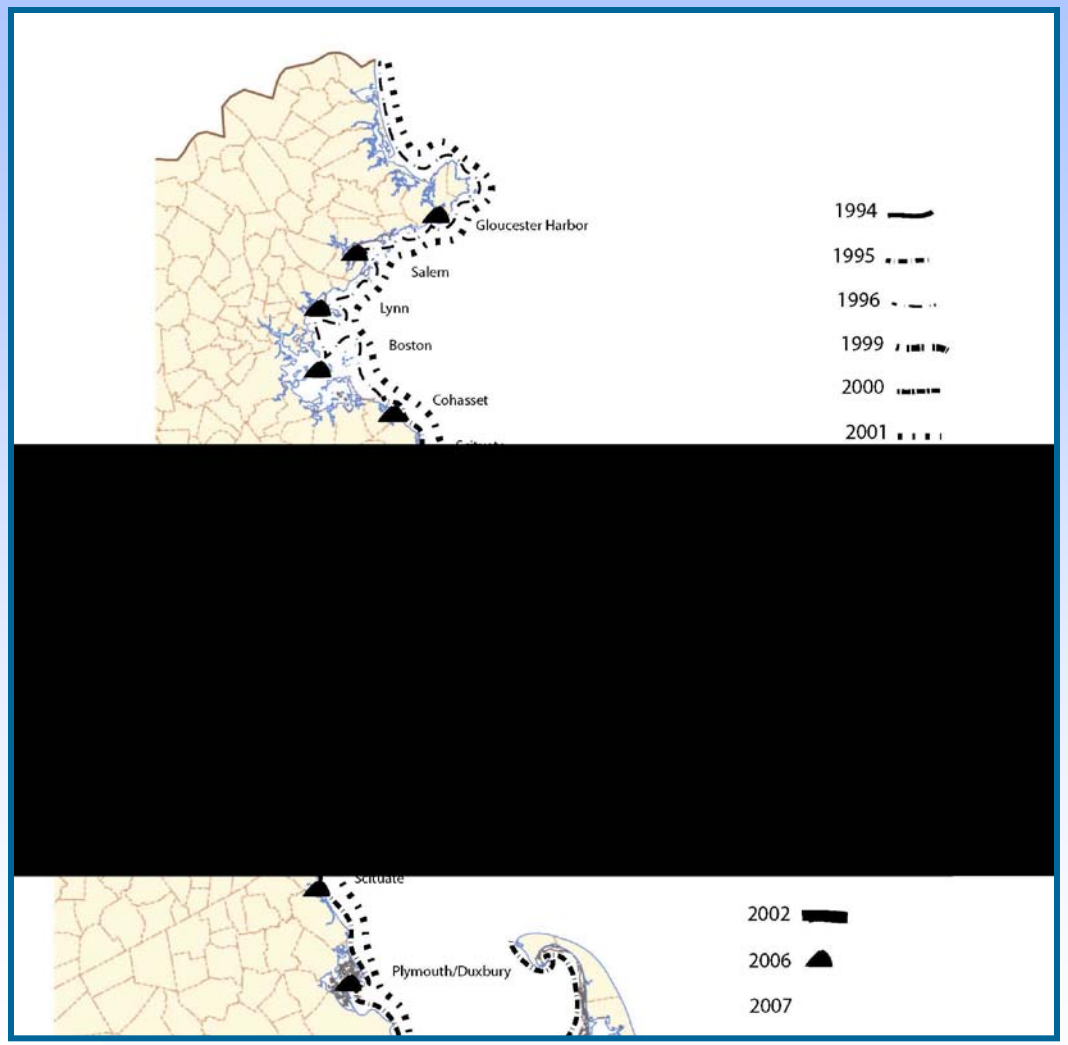
DEP Seagrass Aerial Photo Missions



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Field Boat Console

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Efficient Observer

Underwater Video Camera System

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-Comprehensive Report –

In Preparation for Publication

TWELVE YEAR MAPPING AND CHANGE ANALYSIS OF EELGRASS (ZOSTERA MARINA) DISTRIBUTION IN MASSACHUSETTS (USA) IDENTIFIES STATE WIDE DECLINES

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Massachusetts Department of Environmental Protection
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Boston, MA 02108

W. Judson Kenworthy
Center for Coastal Fisheries and Habitat Research
NCCOS, NOS, NOAA
101 Pivers Island Road
Beaufort, NC 28516

I. INTRODUCTION

Massachusetts has approximately 2400 km of coastline, extending from the eastern border of Rhode Island Sound (71° 7' 13.9938" N, 41° 29' 50.3952" W) north to the state line of New Hampshire (70° 48' 57.5136" N, Long 42° 52' 19.3512" W), including a series of large offshore islands along the south coast and numerous smaller islands distributed throughout the state (Fig. 1). The Elizabeth Island chain forms the southeastern boundary of Buzzards Bay. Martha's Vineyard, Nantucket and Monomoy partially enclose the waters of Nantucket and Vineyard Sounds protecting the south shore of Cape Cod from the open waters of the Atlantic Ocean.

Ten Year Eelgrass Bed Areal Trends

LOCATION	REGION	YEAR	YEAR	CHANGE (acres)	% CHANGE	RATE
		1996	2006			(% per yr.)
Boston Harbor	North Shore	201.33	116.27	85.06	42.25	4.22
Cohasset Harbor	North Shore	112.71	111.99	0.73	0.64	0.06
Duxbury\Plymouth Harbors	North Shore	2249.32	1904.42	344.90	15.33	1.53
Gloucester Harbor	North Shore	45.84	59.60	13.76		
Lynn Harbor	North Shore	715.18	672.16	43.01	6.01	0.60
Salem Harbor	North Shore	103.61	31.00	72.61	70.08	7.01
Scituate Harbor	North Shore	11.97	10.30	1.67	13.92	1.39
Region Mean		*3439.96*	*2905.74*	*561.73*	24.71	*2.47*
		1994	2006			
Hambln/JhuPds&Grt/LitRs	South Shore	73.91	14.92	58.99	79.81	6.65
Lower Pleasant Bay	South Shore	1279.07	1068.29	210.78	16.48	1.37
Morris Island	South Shore	169.82	153.62	16.19	9.54	0.79
RydersCove/Crow/Bassing	South Shore	155.87	121.51	34.36	22.05	1.84
Stage Harbor System	South Shore	261.00	155.93	105.07	40.26	3.35
Upper Pleasant Bay	South Shore	312.73	193.93	118.80	37.99	3.17
Region Mean		*2252.40*	*1708.21*	*544.20*	*34.35*	*2.86*
		1996	2006			
Cuttyhunk Harbor	Buzzards B.	13.25	31.00	17.75		
Hadley Harbor	Buzzards B.	55.48	52.87	2.61	4.71	0.47
Inner Sippican Harbor	Buzzards B.	158.79	80.48	78.31	49.32	4.93
New Bedford Outer Hbr	Buzzards B.	105.59	121.88	16.29		
Pocasset Harbor	Buzzards B.	41.35	30.82	10.52	25.45	2.54
Quisset Harbor	Buzzards B.	51.72	36.38	15.35	29.67	2.97
Wareham Harbor	Buzzards B.	11.22	2.20	9.02	80.39	8.04
West Cape Cod Canal Area	Buzzards B.	390.40	232.28	158.13	40.50	4.05
West Falmouth Harbor	Buzzards B.	55.72	50.60	5.11	9.18	0.92
Westport R-E&W Branch	Buzzards B.	677.04	513.23	163.82	24.20	2.42
Weweantic River	Buzzards B.	51.71	22.96	28.75	55.60	5.56
Wild Harbor	Buzzards B.	20.53	13.48	7.05	34.34	3.43
Region Mean		*1632.81*	*1188.18*	*512.71*	*35.33*	*3.53*
		1994	2006			
CapPogue\Pocht\CalebsPds	Islands	546.83	528.69	18.14	3.32	0.28
Lagoon Pond	Islands	164.56	51.36	113.20	68.79	5.73
Lake Tashmoo	Islands	91.16	37.89	53.27	58.44	4.87
Madaket Harbor	Islands	673.31	605.14	68.16	10.12	0.84
Menemsha	Islands	427.98	319.43	108.55	25.36	2.11
Region Mean		*1903.84*	*1542.51*	*361.33*	*33.21*	*2.77*
LOCATION TOTAL		9229.01	*7344.00*	1885.00	20.4	*3.01*

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Massachusetts Estuary Program – WQ Monitoring

Monitoring - multi-year embayment nutrient sampling

- **Hydrodynamics -**
  - **embayment bathymetry**
  - **site specific tidal record**
  - **current records (in complex systems only)**
  - **hydrodynamic model**
- **Watershed Nitrogen Loading**
  - **watershed delineation**
  - **stream flow (Q) and nitrogen load**
  - **land-use analysis (GIS)**
  - **watershed N model**
- **Embayment TMDL - Synthesis**
  - **linked Watershed-Embayment N Model**
  - **salinity surveys (for linked model validation)**
  - **rate of N recycling within embayment**
  - **D.O record**
  - **Macrophyte survey**
  - **Infaunal survey**

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Massachusetts Estuaries Project

Embayment Information

About the Program

Progress Map

Completed Reports

Project Highlights

Contacts

Home

Nauset Marsh
Orleans/Eastham, MA

Teaming Partners: Town of Orleans/Eastham

- **Status:** Initiated During 2003
- No Report Available at this Time

Back to Location Map

2001 Aerial Photo
Courtesy of Massachusetts Geographic Information Systems (MASSGIS)

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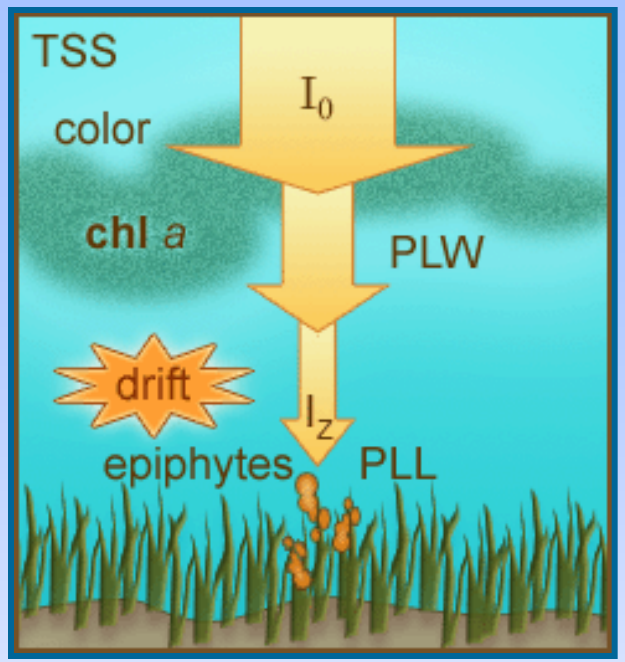
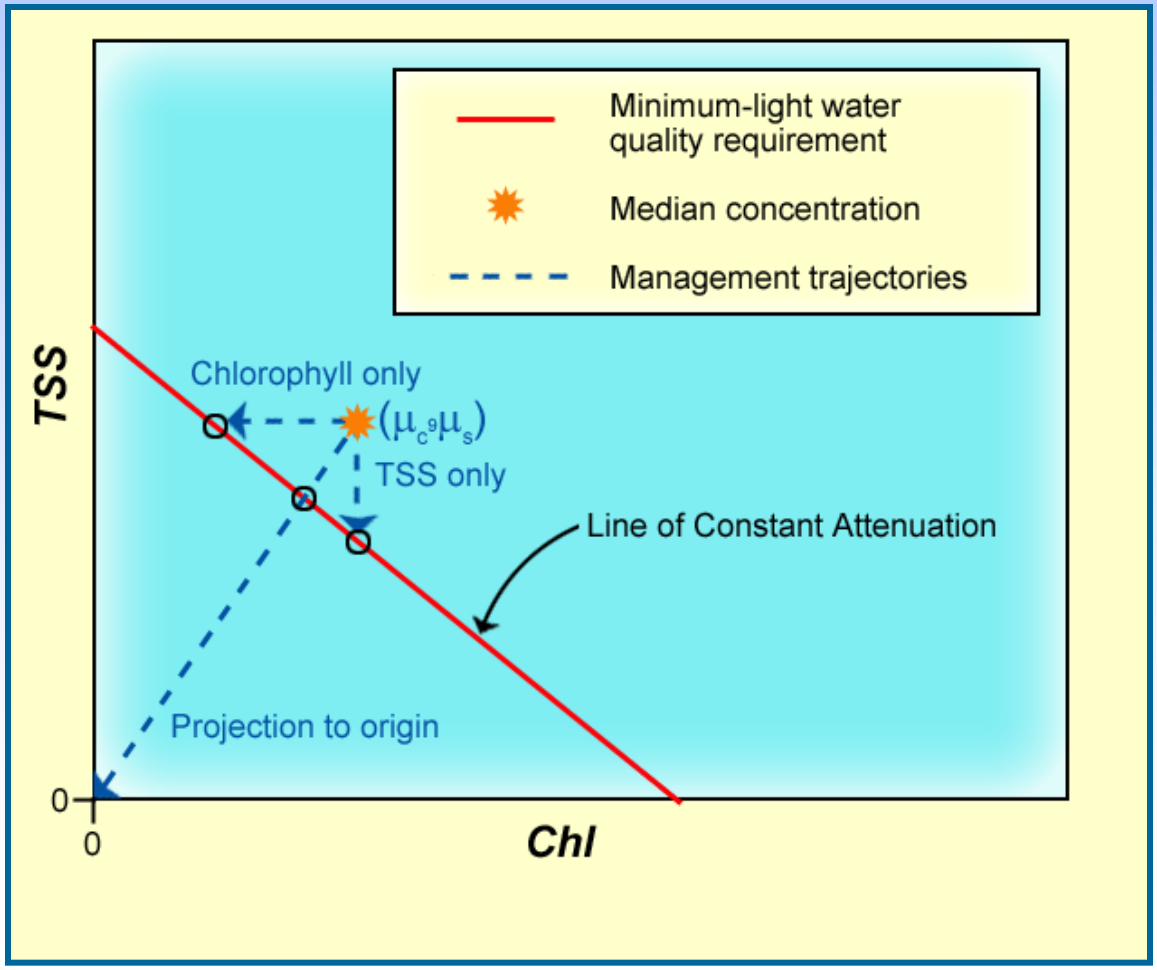


Bio-Optical Model



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Outline

- **Field activities**
  - Calibration of bio-optical model
  - Survey of eelgrass deep edges
- **Model application**
  - Eelgrass light requirements
  - Water quality requirements
- **New insights**
  - Eutrophication and eelgrass light requirements
  - Management implications

Light Sensor

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AC – 9 Sensor

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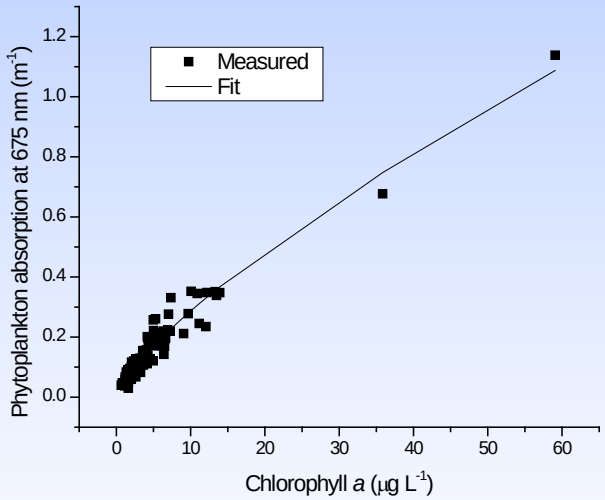
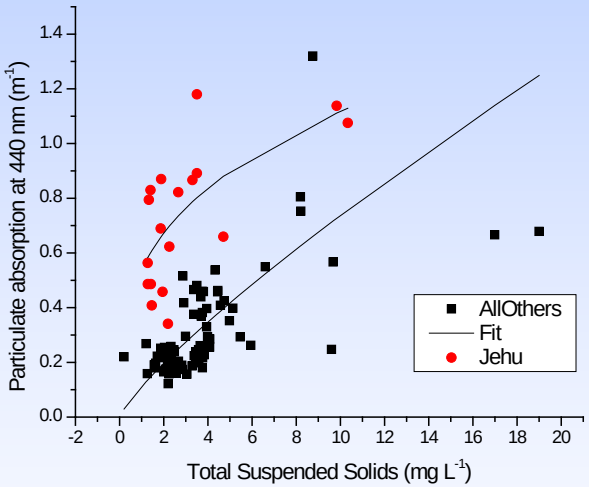
Calibration of Bio-Optical Model

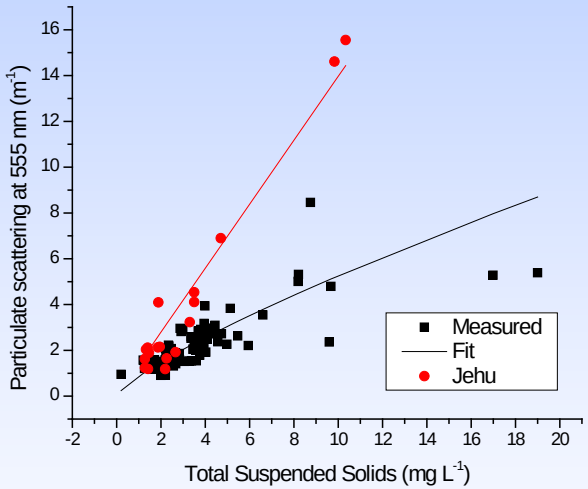
Phytoplankton Absorption



Particulate Absorption



Particulate Scattering



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Surveys of Eelgrass Deep Edges

LOCATION	DATE	TIME	SAMPLING DEPTH (m)	OPUS DEPTH (m)
West Falmouth	9/10/07	12:50 pm	1.4 / 1.3	1.75
Pogue Pond	9/11/07	12:50 pm	3.6 / 3.3	3.62
Jehu Pond	9/12/07	12:25 pm	1.6 / 1.8	1.4
Lagoon Pond	9/13/07	11:50 am	2.7 / 2.8	2.59
Pleasant Bay*	9/15/07	12:50 pm	1.8 /2.1	1.51

*—Bed appeared to be accreting, and probably not reflective of actual water quality at the site, due to recent opening of new inlet in April 2007.

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Eelgrass Light Requirements

Location	OPUS Depth (m)	Mean K_d(PAR) (s.d.)	% Surface Irradiance
Jehu Pond	1.4	0.84 (0.12)	30.8
Pogue Pond	3.62	0.55 (0.15)	13.5
Lagoon Pond	2.59	0.53 (0.11)	25.4
West Falmouth	1.75	0.63 (0.09)	33.1
Pleasant Bay*	1.51	0.69 (0.23)	35.3

*—Eelgrass bed at Pleasant Bay appeared to be expanding, and not in equilibrium with existing water quality.

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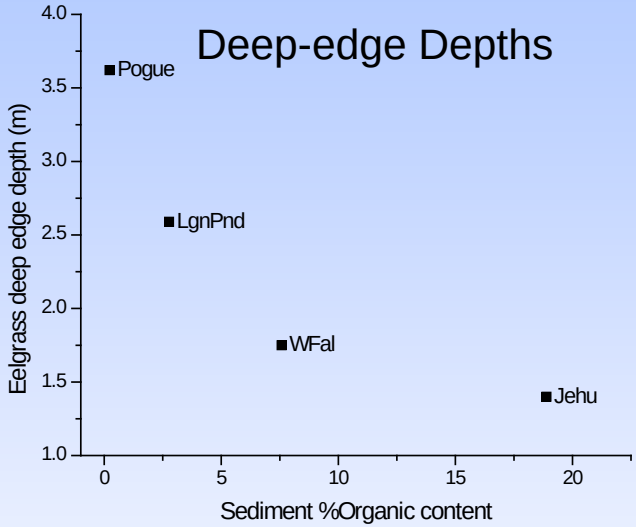
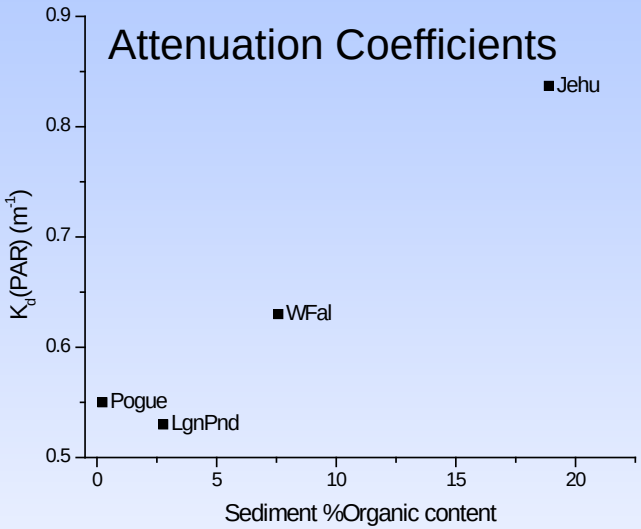
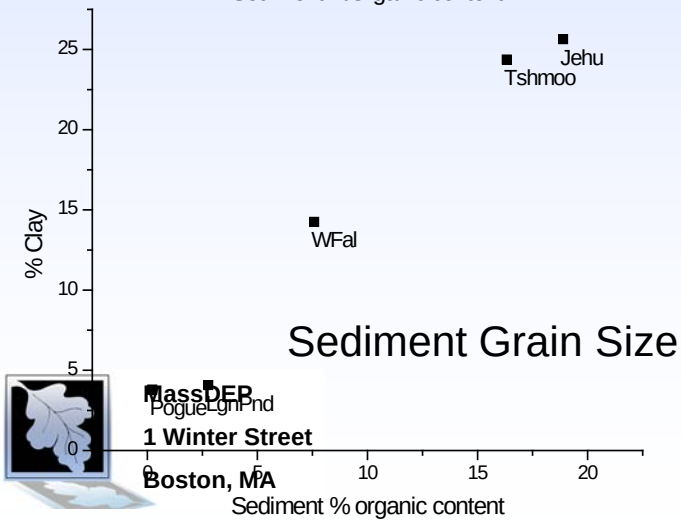
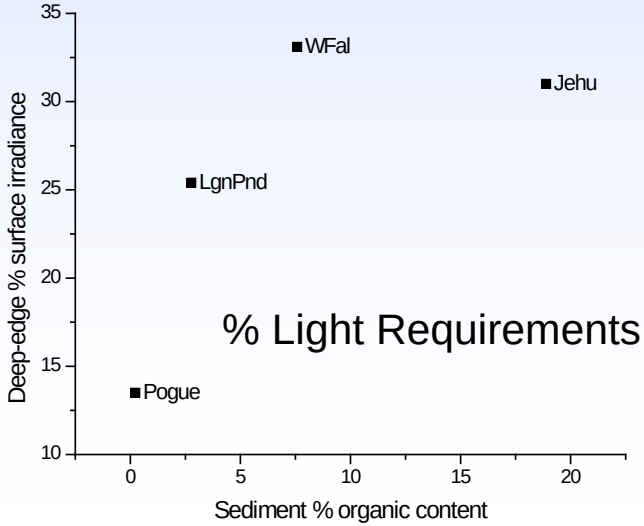
Eutrophication and Eelgrass Light Requirements

Sediment organic content appears to be a "master variable" that correlates with many system attributes









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Management Implications

- **Reduction of nitrogen loading to curtail macroalgal blooms and organic C loading to sediments remains the advisable restoration strategy**
- **Response times of key variables are unknown**
  - Sediment percent organic content?
  - Sediment grain size?
  - Re-suspension of fine-grain particulate matter?

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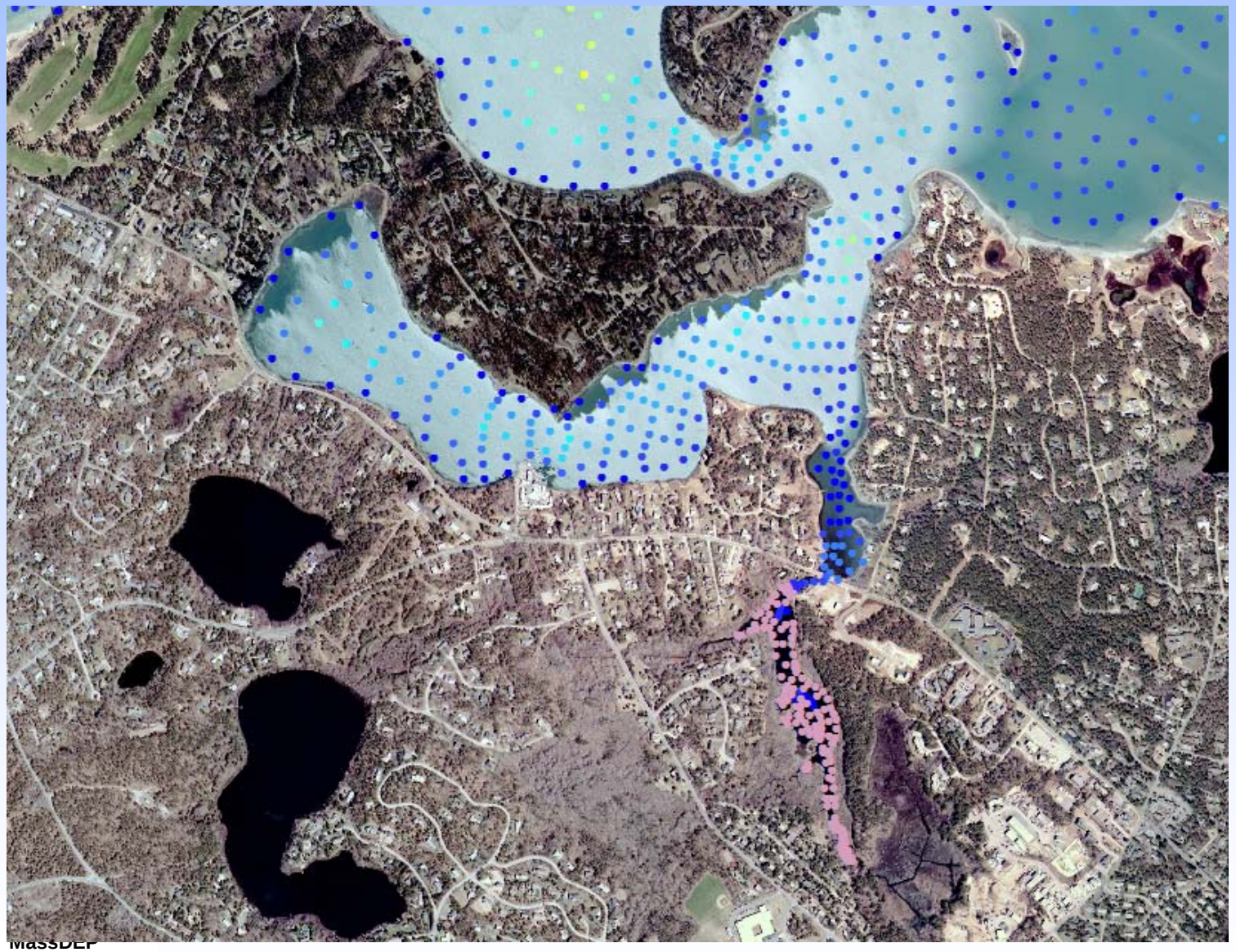
Ryder's Cove, Chatham



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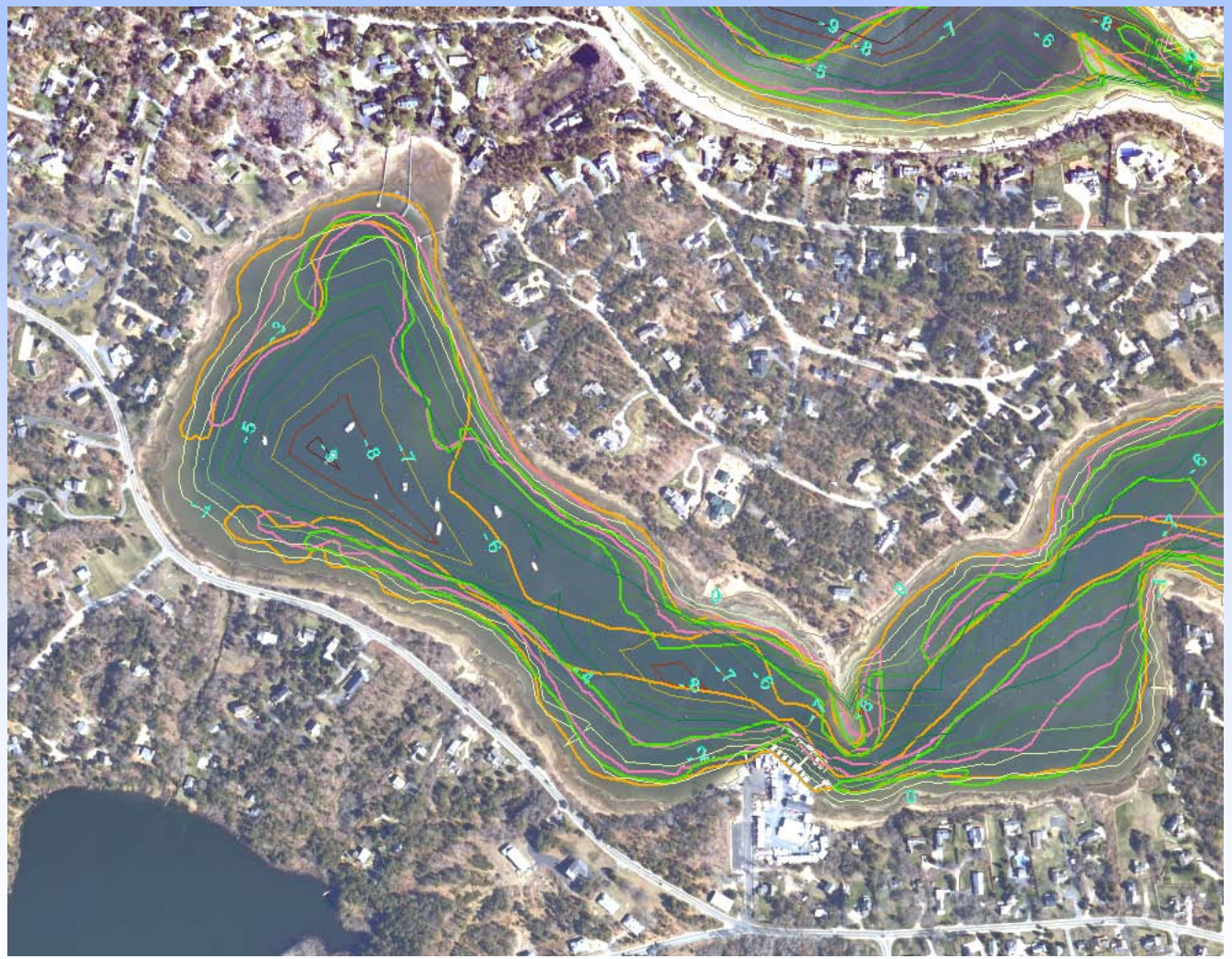
Raw Bathymetric Points obtained from UMD SMAST Partners

Ryder’s Cove, Chatham



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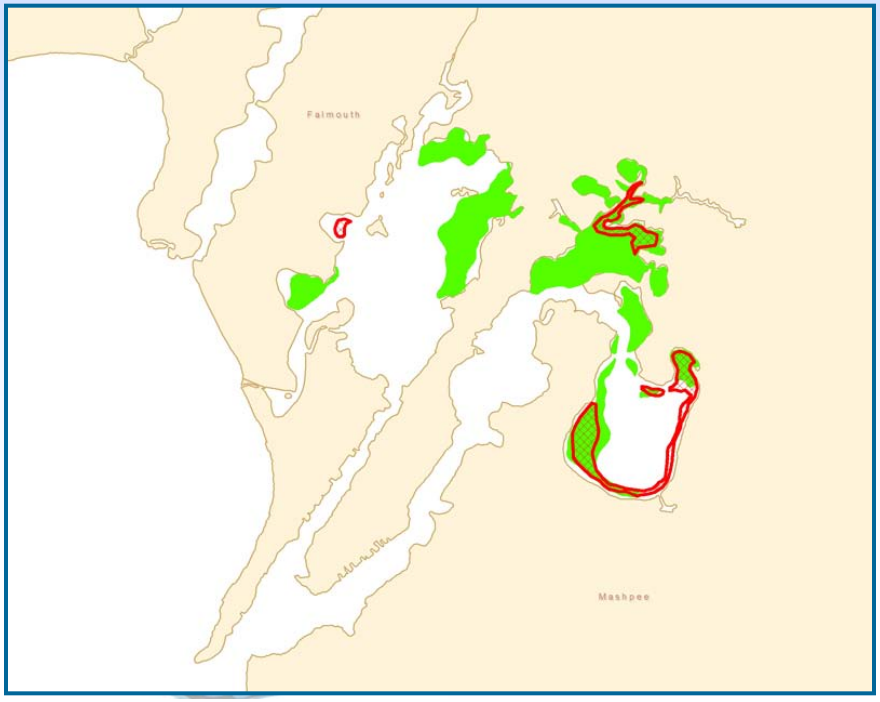
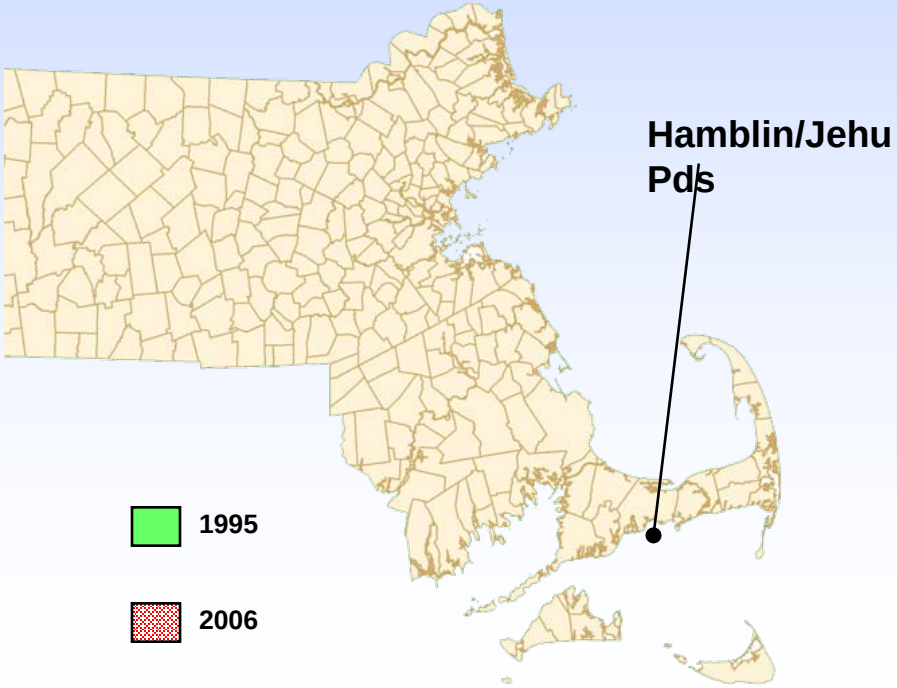
Application of Bathymetry and EG Coverage

LOCATION	REGION	ACRES MAPPED				ACRES CHANGE	% CHANGE	RATE (%/y)
		Initial Year	Baseline	2001	2006	Initial - Final		
Hambln/JhuPds&Grt/ LitRs	S. Shore	1994	73.91	17.2	14.92	-58.99	-79.81	-6.65
Lower Pleasant Bay	S. Shore	1994	1288.98	1,170.64	1,075.15	-213.83	-16.5	-1.37
Morris Island	S. Shore	1994	170.87	142.51	155.77	-15.1	-8.84	-0.73
RydersCove/Crow/Bassing	S. Shore	1994	158.86	119.15	124.11	-34.75	-21.87	-1.82
Stage Harbor System	S. Shore	1994	261	161.53	155.93	-105.07	-40.26	-3.35
Upper Pleasant Bay	S. Shore	1994	299.89	188.63	182.03	-117.82	-39.29	-3.27
Waquoit Bay	S. Shore	1994	25.29	14.7	0	-25.29	-100	-8.33

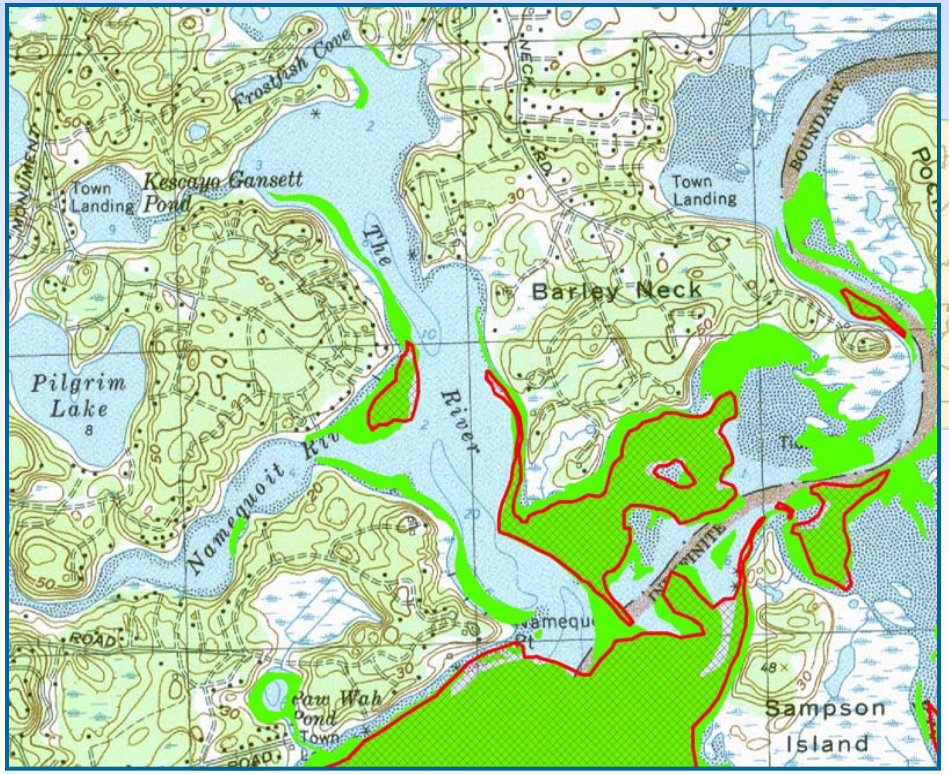


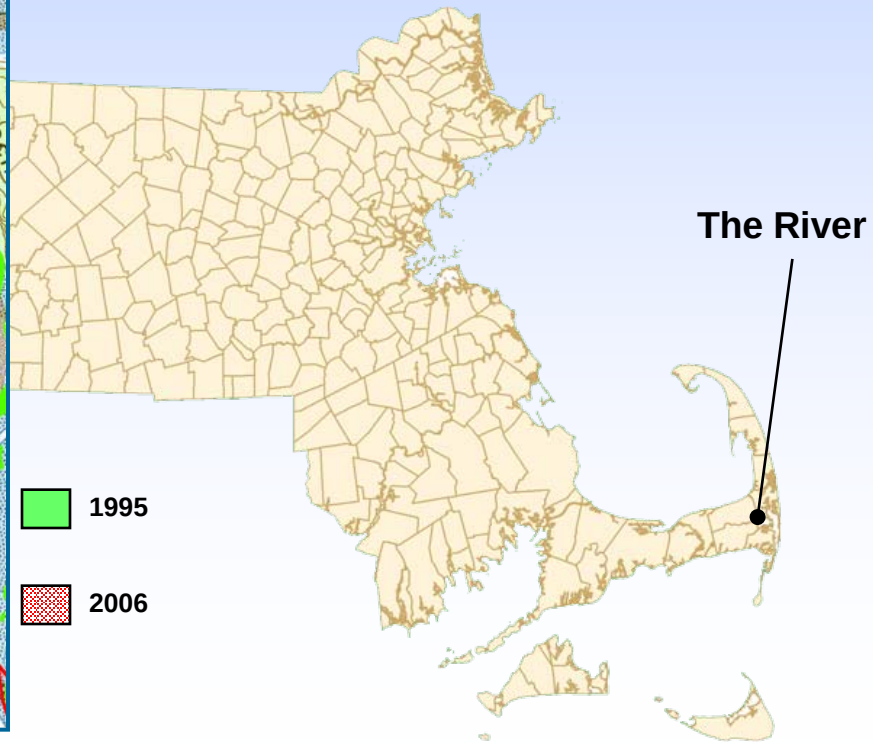


Eelgrass Mapping Areas

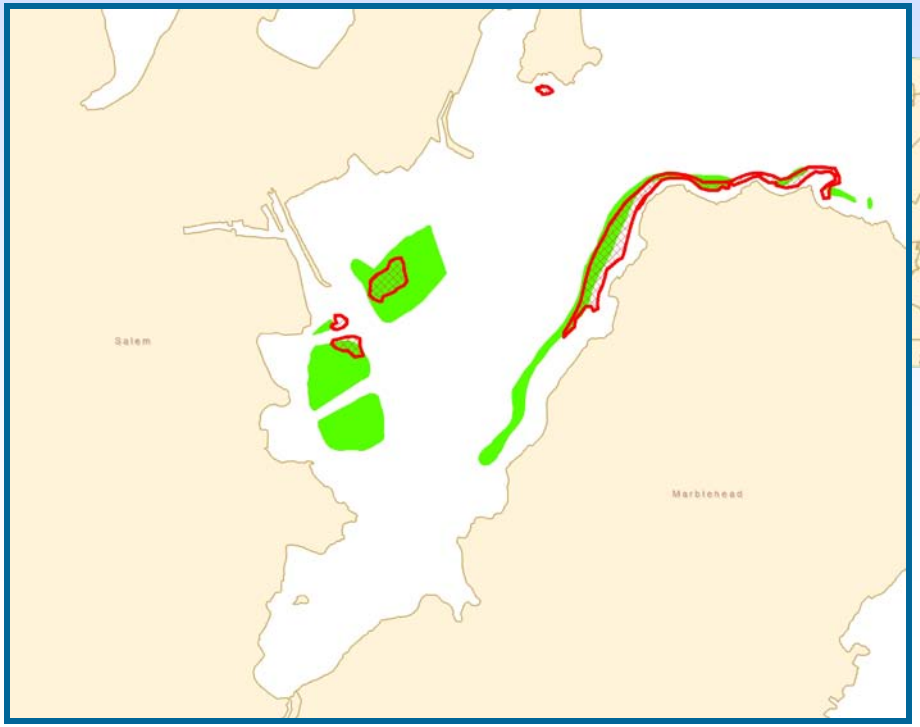
1995 45.3ac

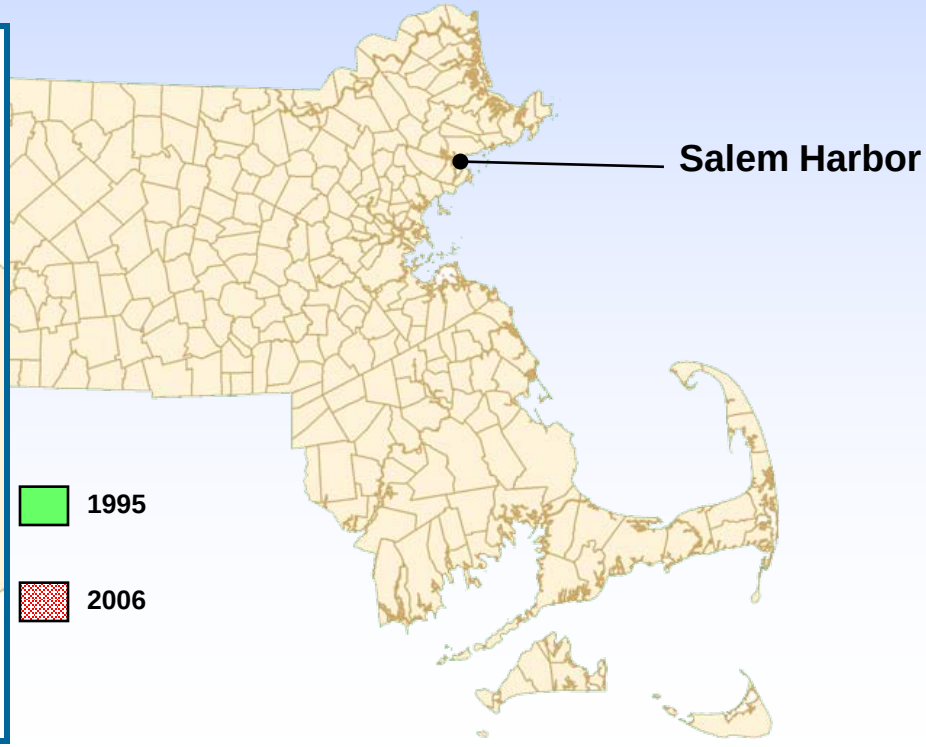
2006 16.0ac



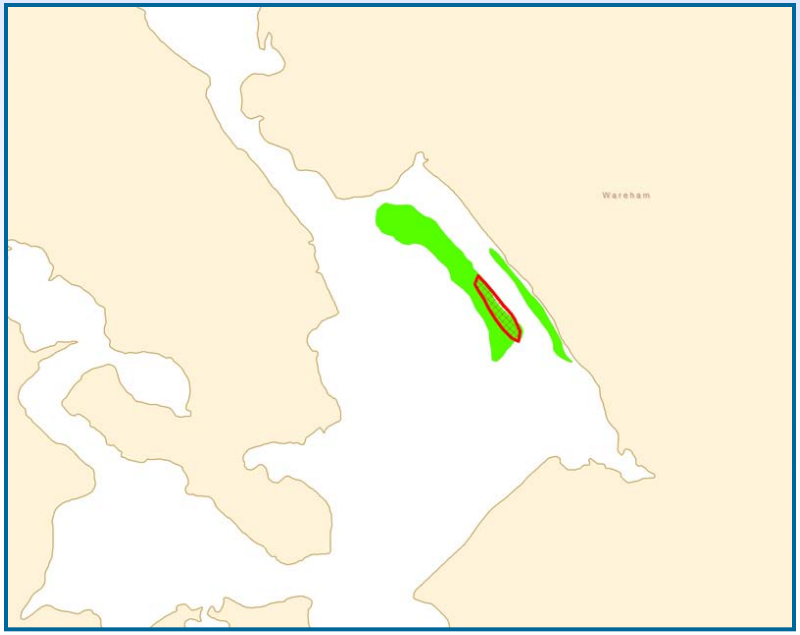


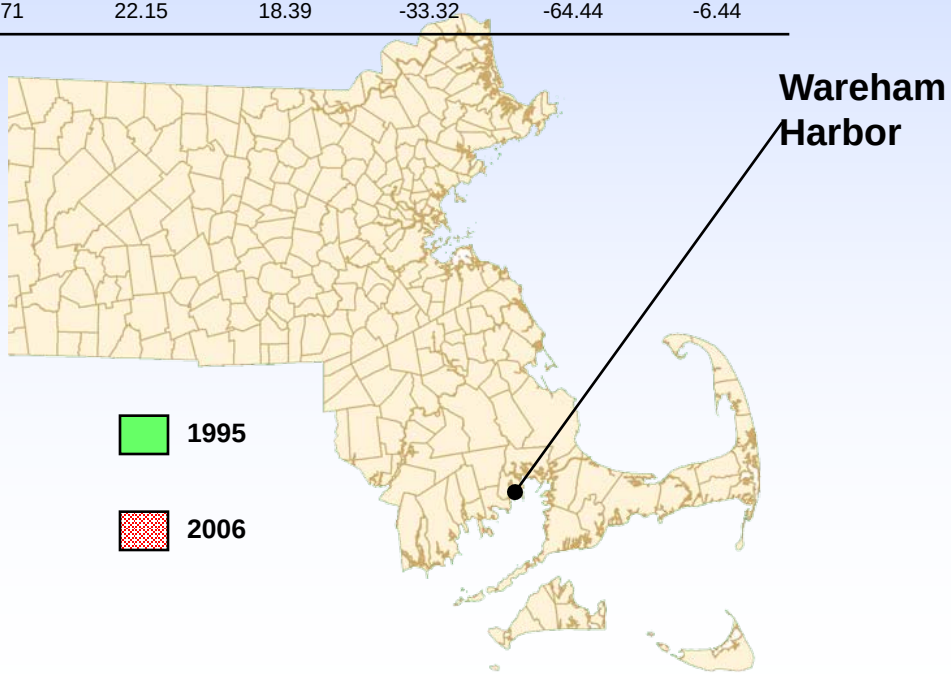
LOCATION	REGION	ACRES MAPPED				ACRES CHANGE	% CHANGE	RATE (%/y)
		Initial Year	Baseline	2001	2006	Initial - Final		
Boston Harbor	N. Shore	1996	201.33	66.64	116.27	-85.06	-42.25	-4.22
Cohasset Harbor	N. Shore	1996	112.71	117.48	111.99	-0.73	-0.64	-0.06
Duxbury\Plymouth Harbors	N. Shore	1995	2,249.32	1,958.17	1,909.52	-305.64	-13.5	-1.24
Gloucester Harbor	N. Shore	1996	45.84	37.13	**59.6**	**13.76**	**30**	**3**
Lynn Harbor	N. Shore	1996	715.18	640.49	672.16	-43.01	-6.01	-0.6
Salem Harbor	N. Shore	1996	103.61	19.06	31	-72.61	-70.08	-7.01
Scituate Harbor	N. Shore	1996	11.97	10.32	10.3	-1.67	-13.92	-1.39





LOCATION	REGION	ACRES MAPPED				ACRES CHANGE	% CHANGE	RATE (%/y)
		Initial Year	Baseline	2001	2006	Initial - Final		
Cuttyhunk Harbor	Buzz. Bay	1994	13.25	ND	**31**	**17.75**	**134**	**11.16**
Hadley Harbor	Buzz. Bay	1994	55.48	ND	52.87	-2.61	-4.71	-0.39
Inner Sippican Harbor	Buzz. Bay	1996	158.79	100.07	80.48	-78.31	-49.32	-4.93
New Bedford Outer Hbr	Buzz. Bay	1996	105.59	100.82	**121.88**	**16.2**	**15.2**	**1.54**
Pocasset Harbor	Buzz. Bay	1996	41.35	36.29	30.82	-10.52	-25.45	-2.54
Quisset Harbor	Buzz. Bay	1996	51.72	44.4	36.38	-15.35	-29.67	-2.97
West Cape Cod Canal Area	Buzz. Bay	1996	390.4	243	232.28	-158.13	-40.5	-4.05
West Falmouth Harbor	Buzz. Bay	1996	55.72	50.09	50.6	-5.11	-9.18	-0.92
Westend Pond	Buzz. Bay	1996	3.1	ND	1.34	-1.76	-56.77	-5.68
Westport R-E&W Branch	Buzz. Bay	1996	677.04	465.71	513.23	-163.82	-24.2	-2.42
Wild Harbor	Buzz. Bay	1996	20.53	17.39	13.48	-7.05	-34.34	-3.43
Wareham Harbor	Buzz. Bay	1996	11.22	2.54	2.2	-9.02	-80.39	-8.39
Weweantic River	Buzz. Bay	1996	51.71	22.15	18.39	-33.32	-64.44	-6.44





Impacts Can't Be Hidden

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Scituate Harbor	North Shore	11.97	10.30	1.67	13.92	1.39
Region Mean		*3439.96*	*2905.74*	*561.73*	*24.71*	*2.47*
		1994	2006			
Hambln/JhuPds&Grt/LitRs	South Shore	73.91	14.92	58.99	79.81	6.65
Lower Pleasant Bay	South Shore	1279.07	1068.29	210.78	16.48	1.37
Morris Island	South Shore	169.82	153.62	16.19	9.54	0.79
RydersCove/Crow/Bassing	South Shore	155.87	121.51	34.36	22.05	1.84
Stage Harbor System	South Shore	261.00	155.93	105.07	40.26	3.35
Upper Pleasant Bay	South Shore	312.73	193.93	118.80	37.99	3.17
Region Mean		*2252.40*	*1708.21*	*544.20*	*34.35*	*2.86*
		1996	2006			
Cuttyhunk Harbor	Buzzards B.	13.25	31.00	17.75		
Hadley Harbor	Buzzards B.	55.48	52.87	2.61	4.71	0.47
Inner Sippican Harbor	Buzzards B.	158.79	80.48	78.31	49.32	4.93
New Bedford Outer Hbr	Buzzards B.	105.59	121.88	16.29		
Pocasset Harbor	Buzzards B.	41.35	30.82	10.52	25.45	2.54
Quisset Harbor	Buzzards B.	51.72	36.38	15.35	29.67	2.97
Wareham Harbor	Buzzards B.	11.22	2.20	9.02	80.39	8.04
West Cape Cod Canal Area	Buzzards B.	390.40	232.28	158.13	40.50	4.05
West Falmouth Harbor	Buzzards B.	55.72	50.60	5.11	9.18	0.92
Westport R-E&W Branch	Buzzards B.	677.04	513.23	163.82	24.20	2.42
Weweantic River	Buzzards B.	51.71	22.96	28.75	55.60	5.56
Wild Harbor	Buzzards B.	20.53	13.48	7.05	34.34	3.43
Region Mean		*1632.81*	*1188.18*	*512.71*	*35.33*	*3.53*
		1994	2006			
CapPogue\Pocht\CalebsPds	Islands	546.83	528.69	18.14	3.32	0.28
Lagoon Pond	Islands	164.56	51.36	113.20	68.79	5.73
Lake Tashmoo	Islands	91.16	37.89	53.27	58.44	4.87
Madaket Harbor	Islands	673.31	605.14	68.16	10.12	0.84
Menemsha	Islands	427.98	319.43	108.55	25.36	2.11
Region Mean		*1903.84*	*1542.51*	*361.33*	*33.21*	*2.77*
LOCATION TOTAL		9229.01	*7344.00*	1885.00	20.4	*3.01*

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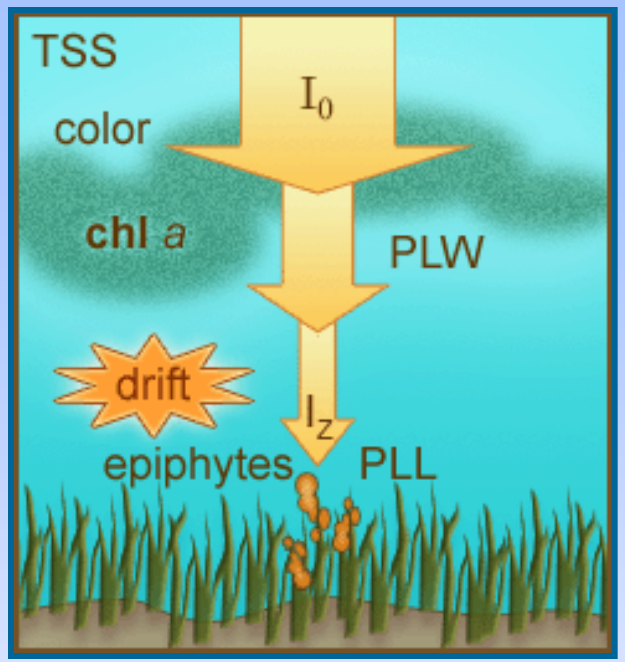
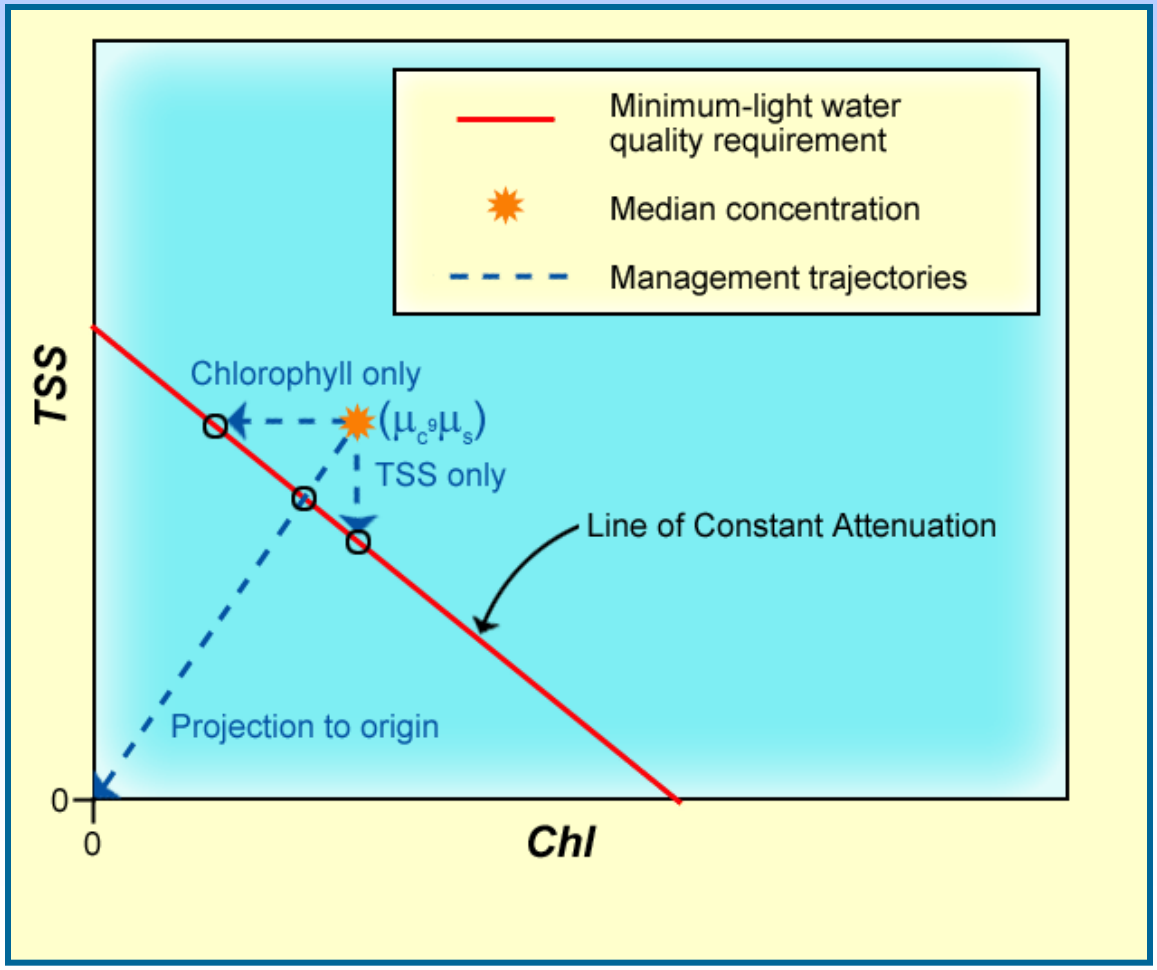
1 Winter Street
Boston, MA



Bio-Optical Model



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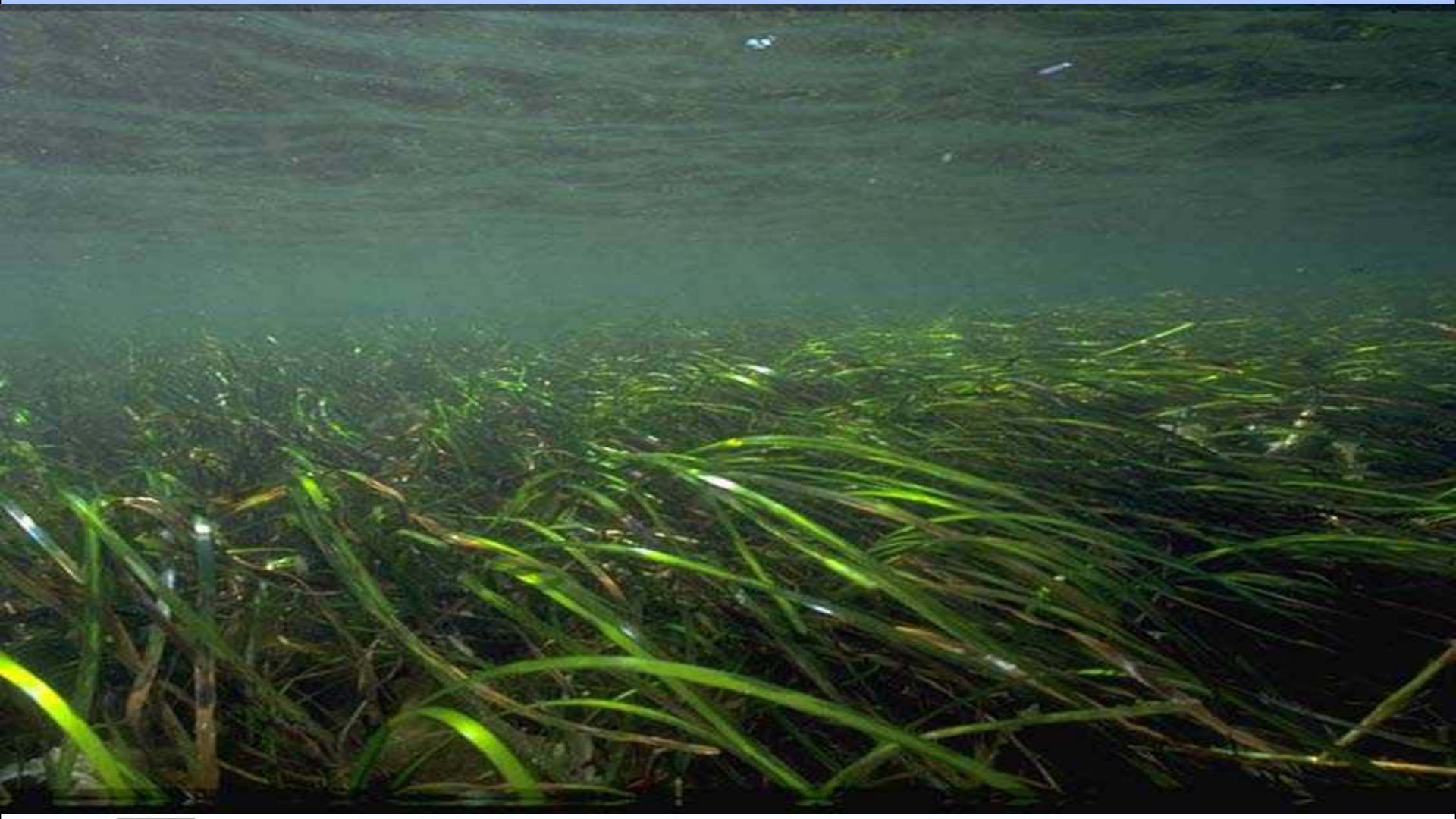

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