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Using *In situ* Fluorometry to Quantify Seston Removal Rates by Oyster Reefs

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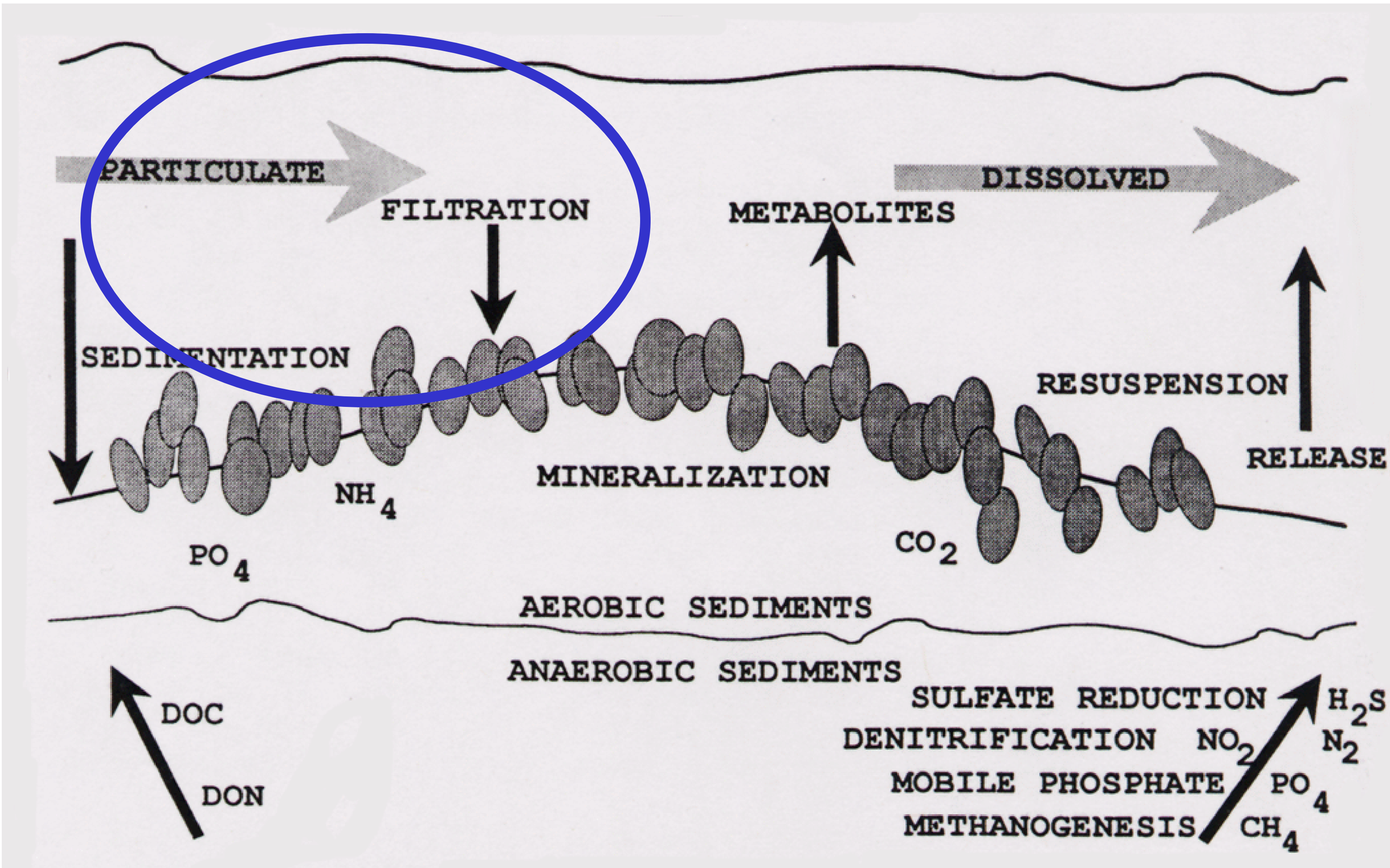
Materials Processing Overview



(Dame 1993)

Background

Bivalves in general…

- Seston uptake (removal of suspended particulates via the pumping/filtration/feeding process) has been demonstrated theoretically and in the laboratory for many species of suspension-feeding bivalve molluscs.

- Seston uptake has been measured in the field in multiple study areas for a few species of bivalves (e.g. blue mussels, zebra mussels).

- Water flow variations, sediment re-suspension, and other factors complicate field measurements of seston uptake.

Background

Oysters in particular…

- The ability of oysters to remove substantial amounts of suspended particulates (seston uptake)—and thereby potentially improve water quality—is often cited as a reason for restoration projects.

- Empirical demonstration in the field of this ability for restored or natural oyster reefs, however, has not been convincingly demonstrated.

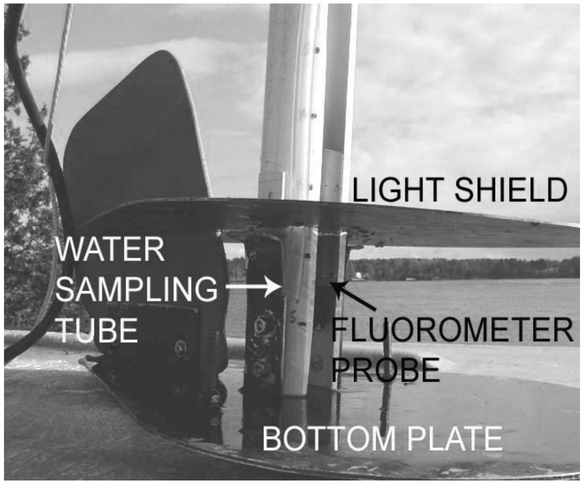
“Standard Methods” for Field Measurement of Seston Uptake by Oysters

- Dame et al. (1992): pumped water samples, laboratory analysis of seston
- Wilson-Ormond et al. (1997): pumped water samples, laboratory analysis of seston
- Cressman et al. (2003): dipped water samples, laboratory analysis of seston
- Nelson et al. (2004): dipped water samples, laboratory analysis of seston

Rationale for *In Situ* Methods

- Standard methods for measuring seston uptake are cumbersome and costly.
- *In situ* methods potentially represent substantial cost savings as well as <u>greatly increased spatial and temporal resolution</u> of uptake processes.
- Empirically quantifying seston uptake is needed as a success metric for ongoing restoration projects.

In Situ Fluorometry Apparatus



One of two identical units, total cost per unit ~$5,000.

Typical Set-up for Field Measurements

Pre-2005 Data for Three Bivalve Species, Four Different Localities

Table 1. Summary of environmental characteristics, bivalve population data, and other information for all study sites.

Species	Bivalve Density (#/m^2)	Mean Shell Size (mm)	Location	Site	Date	Tide	Sampling Duration (hr)	# of Samples: *In situ* Fluoro	# of Samples: Pumped Water	Water Depth Range (m)	Flow Length (m)	Flow Speed Range (cm/s)	*In situ* Fluoro (% uptake)	Laboratory Chloro *a* (% uptake)
Mytilus edulis	526	45.0	New Hampshire	Albacore Channel	11/13/01	Ebb	1.4	4	4	0.32-0.47	63	12.6-27.8	27.8	11.8
Mercenaria Mercenaria	285	19.4	Virginia	Clam Bed 1	6/5/02	Flood	0.8	5	4	0.35-0.42	9	10.0-13.0	35.3	16.1
Mercenaria Mercenaria	285	19.4	Virginia	Clam Bed 2	6/6/02	Ebb	0.4	3	0	0.61-0.65	44	3.0-5.0	62.3	
Crassostrea virginica	61	36.8	Florida	CANA Reef 1	6/10/02	Flood	1.0	7	0	0.28-0.34	12	12.0-17.0	11.4	
Crassostrea virginica	122	54.9	Florida	CANA Reef 2	6/10/02	Ebb	0.7	4	0	0.18-0.19	20	3.0-4.0	37.4	
Crassostrea virginica	76	50.5	Florida	CANA Reef 3	6/11/02	Ebb	1.8	8	6	0.40-0.50	20	4.0-6.0	10.7	11.9
Crassostrea virginica	134	47.0	Florida	CANA Reef 4	6/12/02	Flood	1.3	4	0	0.13-0.18	17	8.0	26.3	
Crassostrea virginica	2538	26.7	South Carolina	Palmetto Reef 1	10/18/04	Flood	1.7	11	3	1.0-1.5	6	3.5-11.5	-2.7	-5.3

(from Grizzle et al. 2006)

Recent (2005-06) Studies on SC Reefs

Seston Uptake Model Predictions and Measured (*in situ* fluorometry) Uptake - Summary of 2004-2006 SC Studies

Date	Site	Mean Bivalve Density (A; #/m^2)[1]	Mean Bivalve Size (Shell L or H, mm)	Assumed Individual Clearance (B; L/ind/hr)[2]	Reef Bottom Area (C; m^2)[3]	Water Column Cross-Section Over Reef (D; m^2)[4]	Water Flow Speed (E; cm/s)[5]	Total Water Flow Rate (DxE; m^3/hr)	PREDICTED Total Clearance (AxBxC; m^3/hr)	PREDICTED % Cleared (Seston Uptake)	MEASURED % Cleared (Seston Uptake)
				"low gear"							
10/18/04	Palmetto Restored R1	2538	26.7	0.6	15	3.4	8.2	1004	23	2.3	-2.8
10/19/04	Palmetto Restored R1,R2,F	2909	31.7	0.7	234	3.1	13	1451	476	32.8	6.9
05/16/05	Woodland Ck	1662	39.6	0.8	75	1.90	4.7	321	100	31.0	22.1
05/17/05	Oak Ck SCORE (2003)	1100	28.0	0.6	15	0.80	8.5	245	10	4.0	3.5
05/17/05	Oak Ck SCORE (2001)	1500	44.0	0.9	15	1.10	13.5	535	20	3.8	1.9
05/19/05	ACE Clam Pen	412	39.4	0.8	46	1.40	5.0	252	15	6.0	23.1
05/19/05	ACE Recycled Shell	2931	22.5	0.5	28	1.60	10.0	576	41	7.1	14.9
06/07/06	Store Ck#1-Natural	217	31.8	0.7	72	1.28	2.2	101	11	10.8	-9.8
06/07/06	Store Ck#2-Natural	922	31.7	0.7	72	1.56	8.5	477	46	9.7	20.2
06/08/06	Bailey Ck-Natural	820	51.4	1.1	75	1.85	2.8	186	68	36.3	27.9
	"low gear" MEANS:	**1501.1**	**34.7**	**0.7**	**64.7**	**1.8**	**7.6**	**514.9**	**81.0**	**14.4**	**10.8**
	"high gear" MEANS:	**1501.0**	**34.7**	**3.0**	**64.7**	**1.8**	**7.6**	**514.9**	**291.3**	**56.6**	**10.8**

[1]Measured mean density of all suspension feeding bivalves in modeled area; usually determined from quadrat counts or similar method.

[2]Assumed/predicted individual clearance rate based on literature values; e.g. Powell et al. (1992).

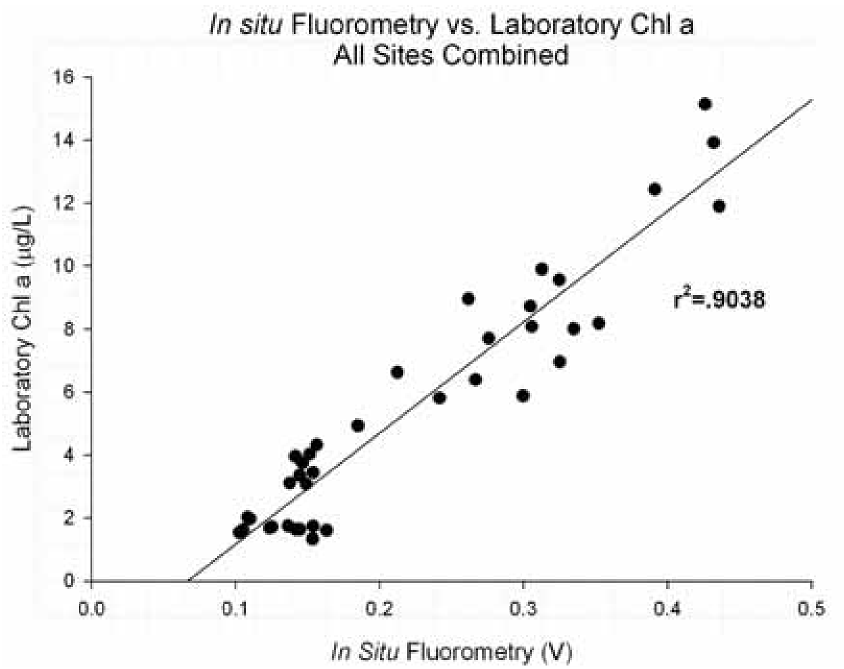
[3]Measured length and width of the reef.

[4]Measured water depth over the reef taken for each set of measurements of flow, fluorometry, etc. x width of the reef. NOTE: 1 m reef width can be assumed for C and D if width not

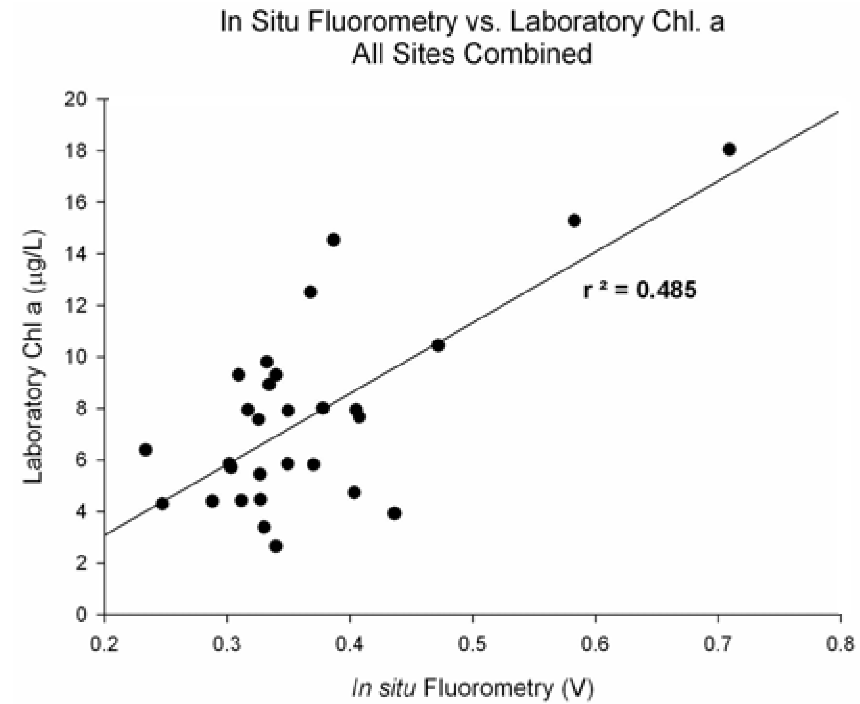
[5]Measured water flow speed (usually at same height as fluorometry) taken for each set of measurements of fluorometry, etc.

Calibration of *in situ* Fluorometers

2005

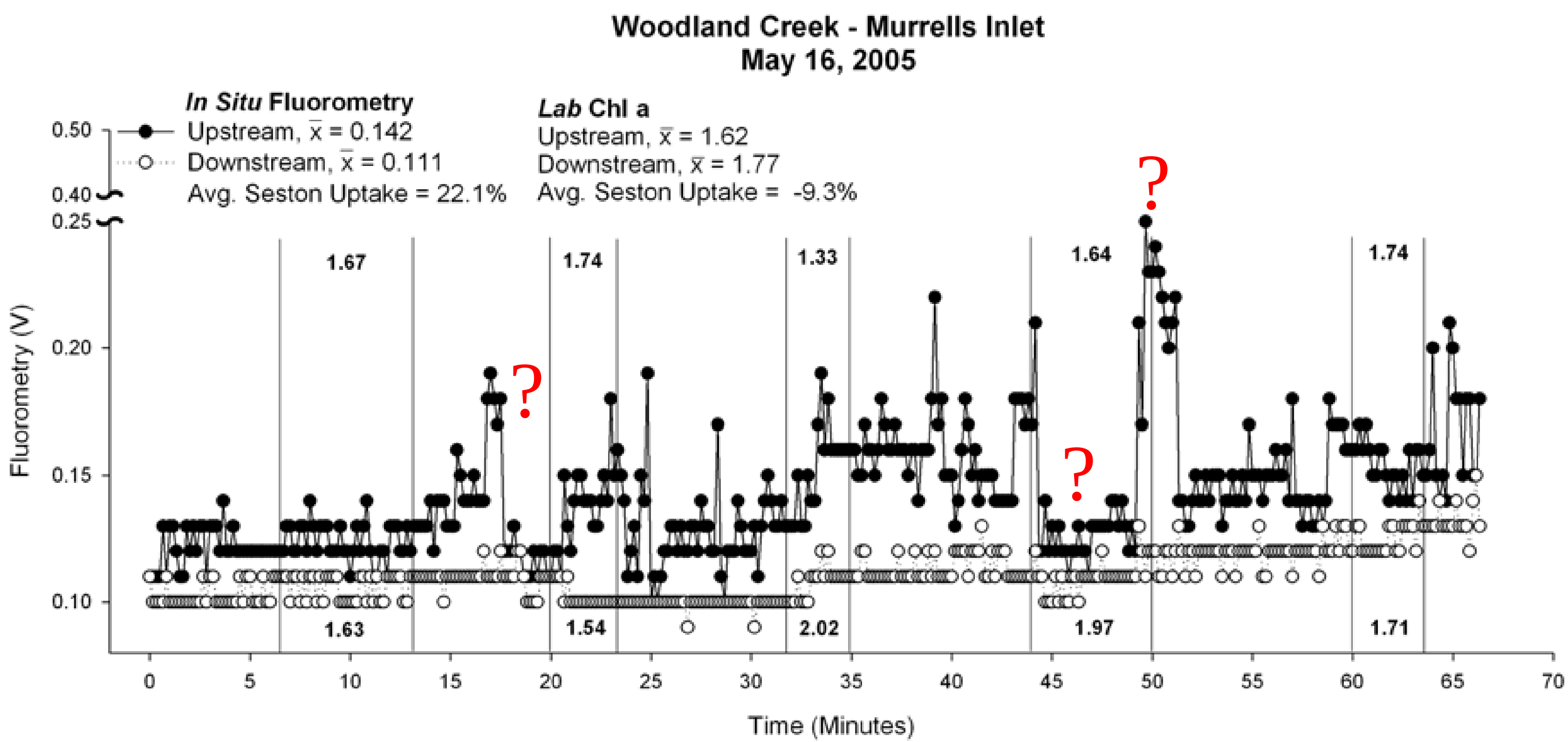


2006



- Relation between *in situ* fluorometry and Chl *a* affected by several factors: plankton composition and condition, ambient light, dissolved material, etc.
- Key question: Does this affect the use of *in situ* fluorometry for quantifying seston removal rates?

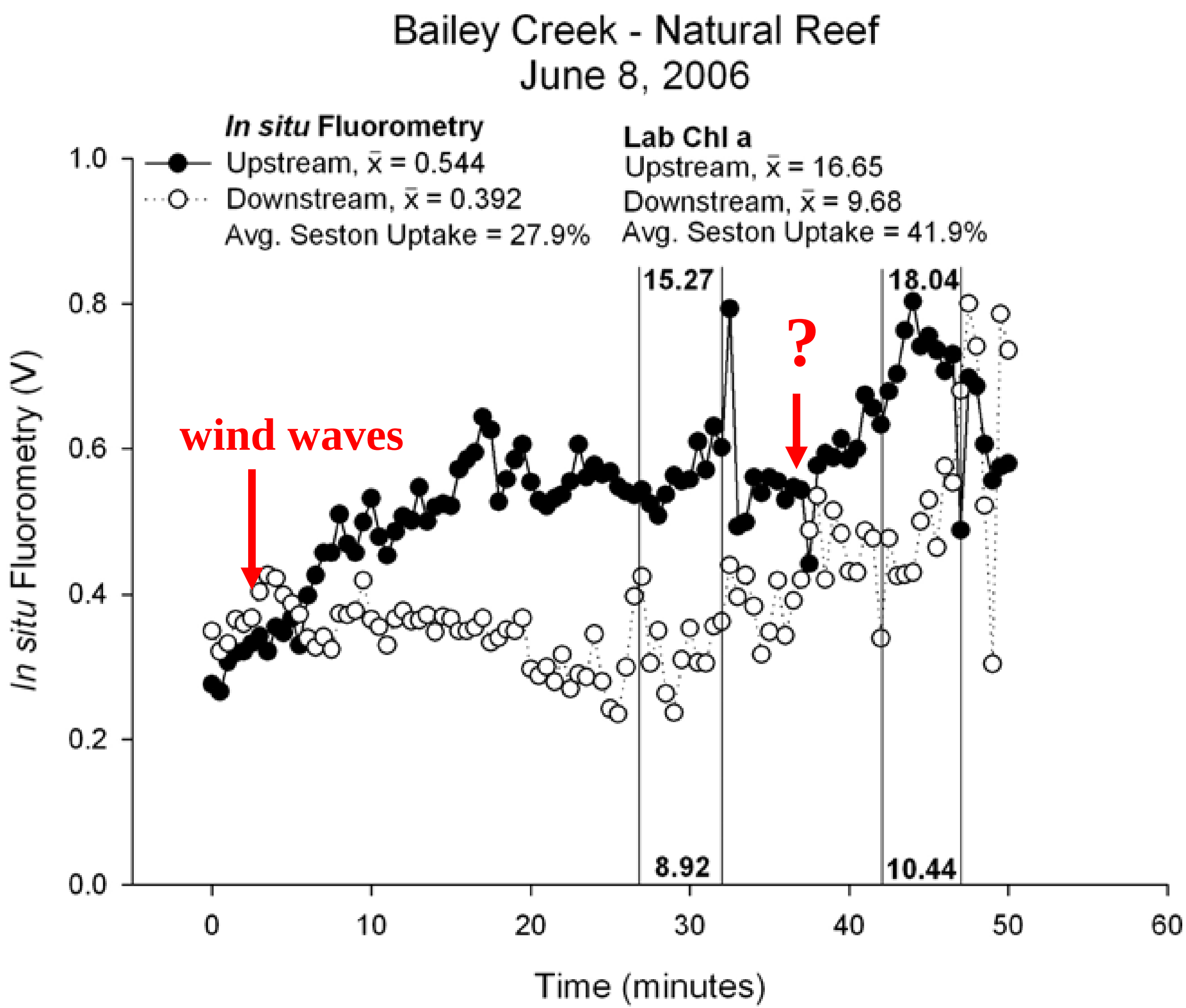
Widely Variable Seston Removal (or ?) by Reef – Unknown Causes



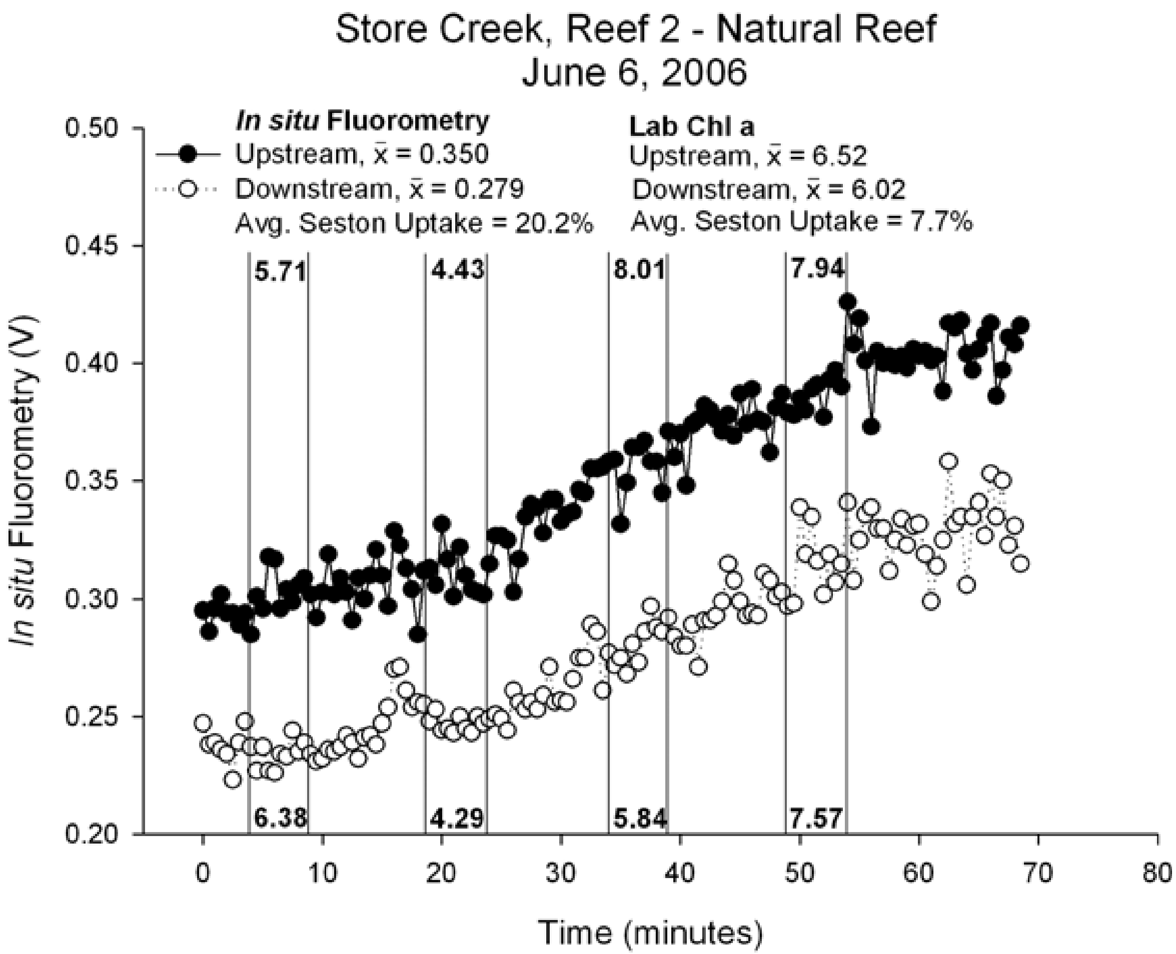
- Wide temporal variability shows advantages of *in situ* datalogging vs. laboratory analysis of pumped water samples

- Data suggest wide temporal variation in population-level oyster feeding rate

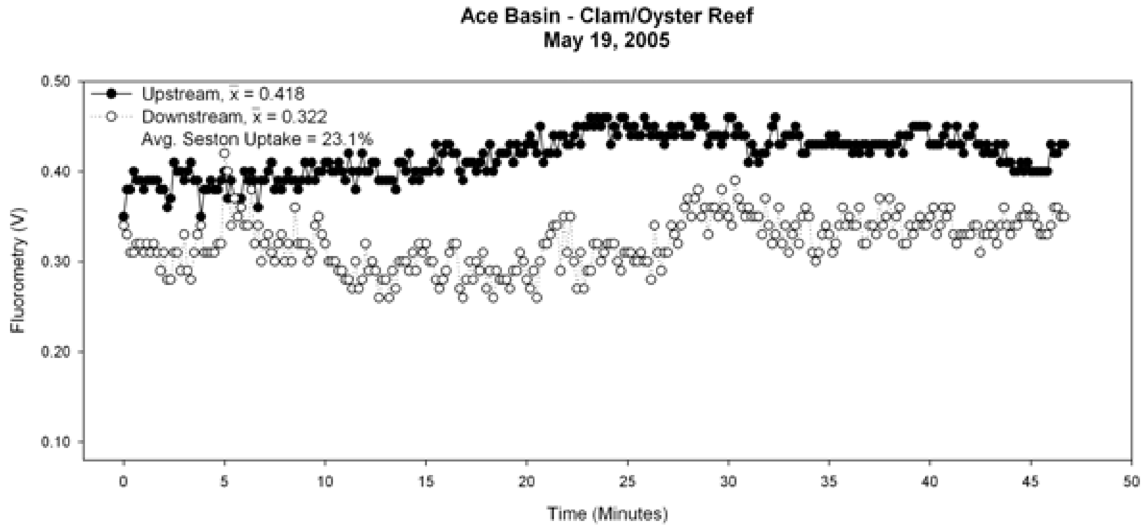
Widely Variable Seston Removal by Reef – Some Causes Identified

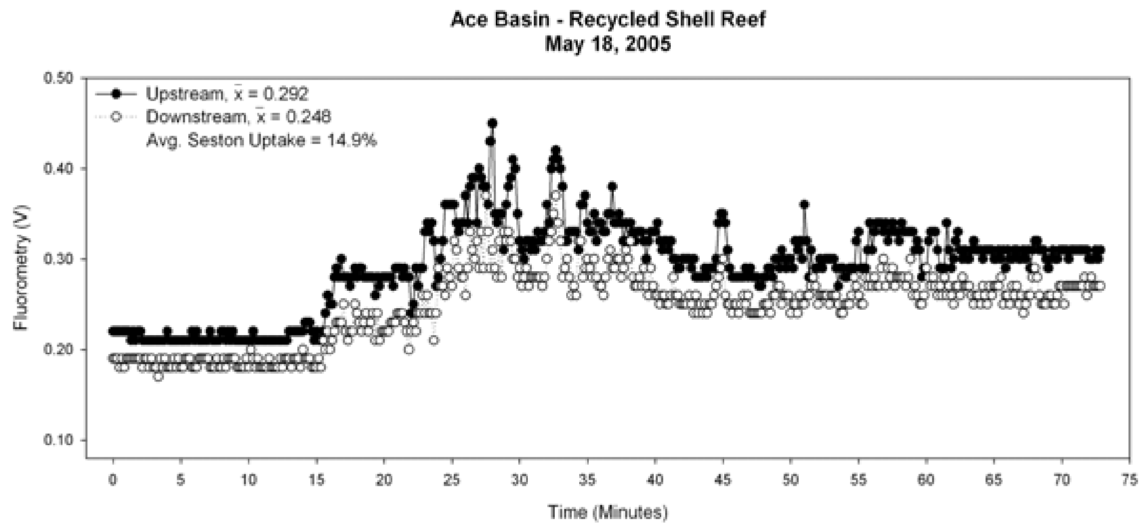


Nearly Constant Seston Removal Rate



Examples of Constructed/Restored Reefs





Conclusion: Seston removal depends on oyster size and density

How do feeding rates based on *in situ* fluorometry compare to laboratory-measured rates?

Typically cited oyster clearance rate: <u>5 L/hr/g DW</u>

(76 mm shell height ~ 1 g DW)

Powell et al. (1992) generic 76 mm bivalve: <u>2 – 8 L/hr</u>

37 mm bivalve: <u>0.7 – 3 L/hr</u>

Average of all SC *in situ* fluorometry-based clearance rates:

mean shell size: 37 mm

mean clearance: <u>0.5 L/hr</u>

Recent (2005-06) Studies on SC Reefs

Major Conclusions

1. **Laboratory Chl *a* measurements compare well with *in situ* fluorometry (sometimes), but many factors cause variability**

2. **The water quality impacts of constructed /restored *and* natural reefs are largely a function of bivalve size and density relative to water column characteristics**

Next Steps for *in situ* Fluorometry

1. **Laboratory pigment analyses compared to *in situ* fluorometry**

2. **Additional fluorometers (and other sensors) needed for increased resolution (NSF proposal)**

3. **Datasondes with multiple probes (NSF proposal)**

4. **Development of predictive models and other management tools (NSF proposal)**

Should assessments of water quality impacts be included in oyster restoration projects?

TABLE 1. Ecosystem services measures used at various ongoing shellfish restoration sites. Target species include: bay scallop *Argopecten irradians* (*Ai*), eastern oyster *Crassostrea virginica* (*Cv*), hard clam *Mercenaria mercenaria* (*Mm*), blue mussel *Mytilus edulis* (*Me*), and Olympia oyster *Ostrea conchaphila* (*Oc*).

STATE	WATER BODY	TARGET SPECIES	POPULATION PARAMETERS	SHORELINE PROTECTION	WATER QUALITY	HABITAT/ BIODIV.
FL	Indian R. Lagoon	*Cv, Mm*	•	•		•
LA	Grand Isle	*Cv*	•	•		•
MS	Biloxi Bay, Grand Bay	*Cv*	•	•		•
NH	Great Bay	*Cv, Me*	•		•	•
NY	Peconic Bay, Great South Bay	*Ai, Mm, Cv*	•			•
NC	Pamlico Sound	*Cv*	•	•		•
OR	Netarts Bay	*Oc*	•			•
SC	ACE Basin	*Cv*	•	•	•	•
TX	Copano Bay, GICW	*Cv*	•	•	•	•
VA	Ches. Bay, East. Shore Lagoons	*Cv*	•	•		•
WA	Puget Sound	*Oc*	•			•

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CICEET The Cooperative Institute for Coastal and Estuarine Environmental Technology