WATER QUALITY IMPACTS AND BUCKET DREDGING OPERATIONS

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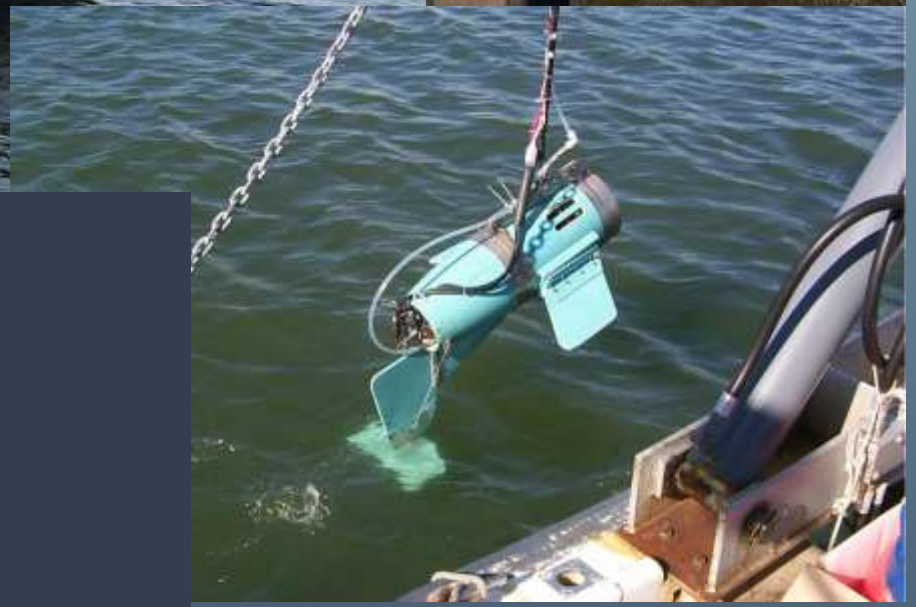
Bucket Types

- Cable Arm Navigation Bucket
- Great Lakes Enclosed Bucket
- Conventional Clamshell Bucket

Near-field Data Collection

- Front of dredge barge
- Turbidity/TSS at 4 depths
- ~ 10 m from bucket
- Video recordings of dredging operation

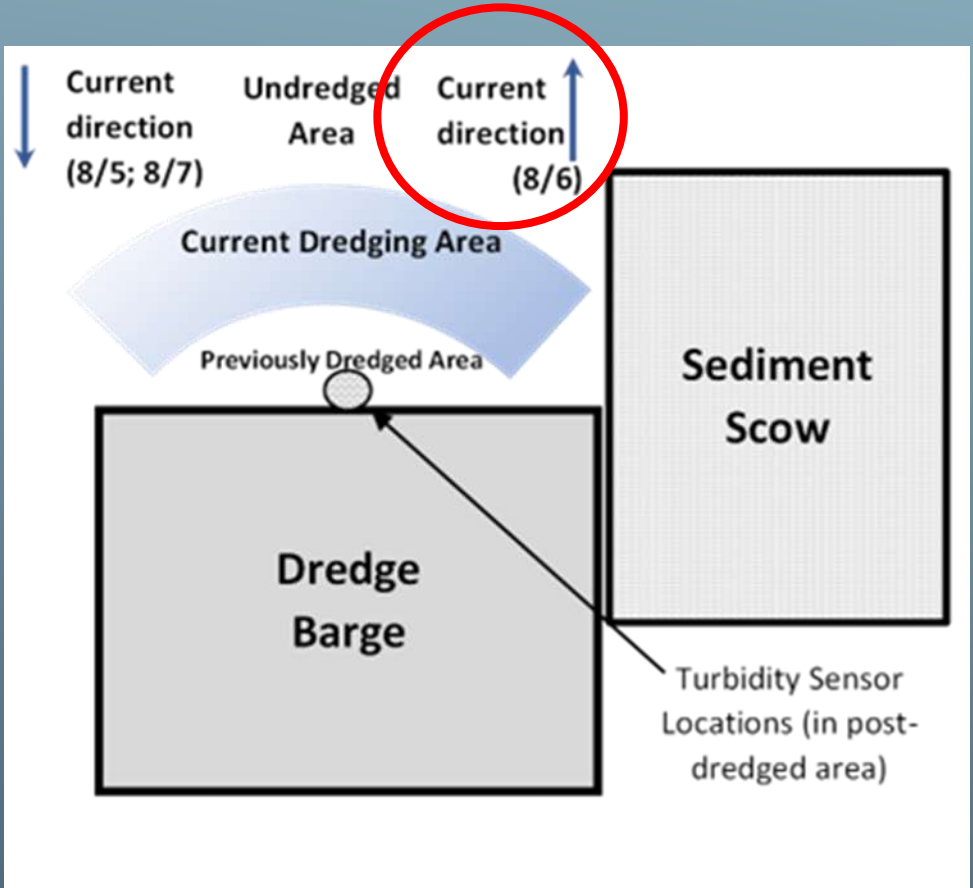


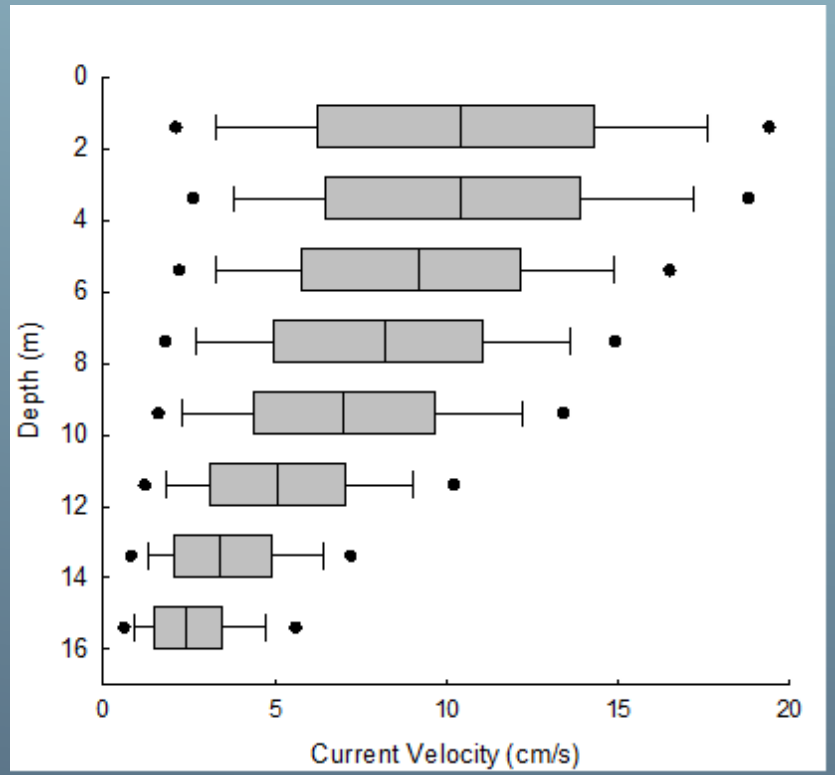
Far-field data collection

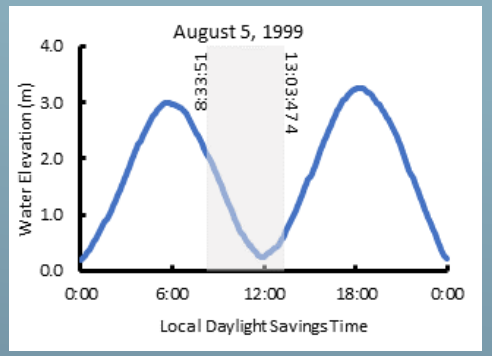
- ADCP (currents, turbidity)
- BOSS sampling (TSS, turbidity, etc.)
- Upstream and downstream
- Data not available

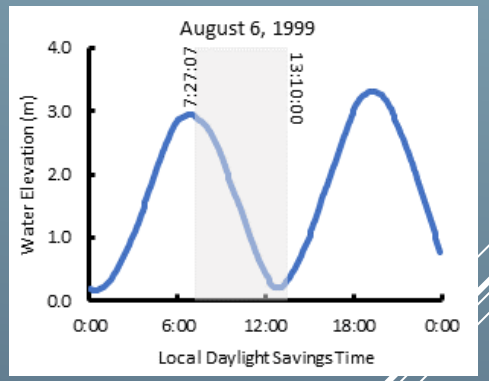
- Conducted in 1999
- Sponsored by USACE – NED & ERDC (Tim Welp)
- TSS data analyzed and published in 2000.

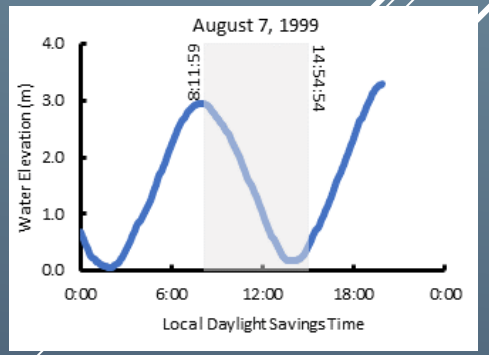
Hayes, D., Borrowman, T., and Welp, T. (2000). "Near-field turbidity observations during Boston Harbor bucket comparison study," Proceedings of the Western Dredging Association Twentieth Technical Conference and Thirty-Second Annual Texas ARM Dredging Seminar, Warwick, RI, June 25-28, 2000.



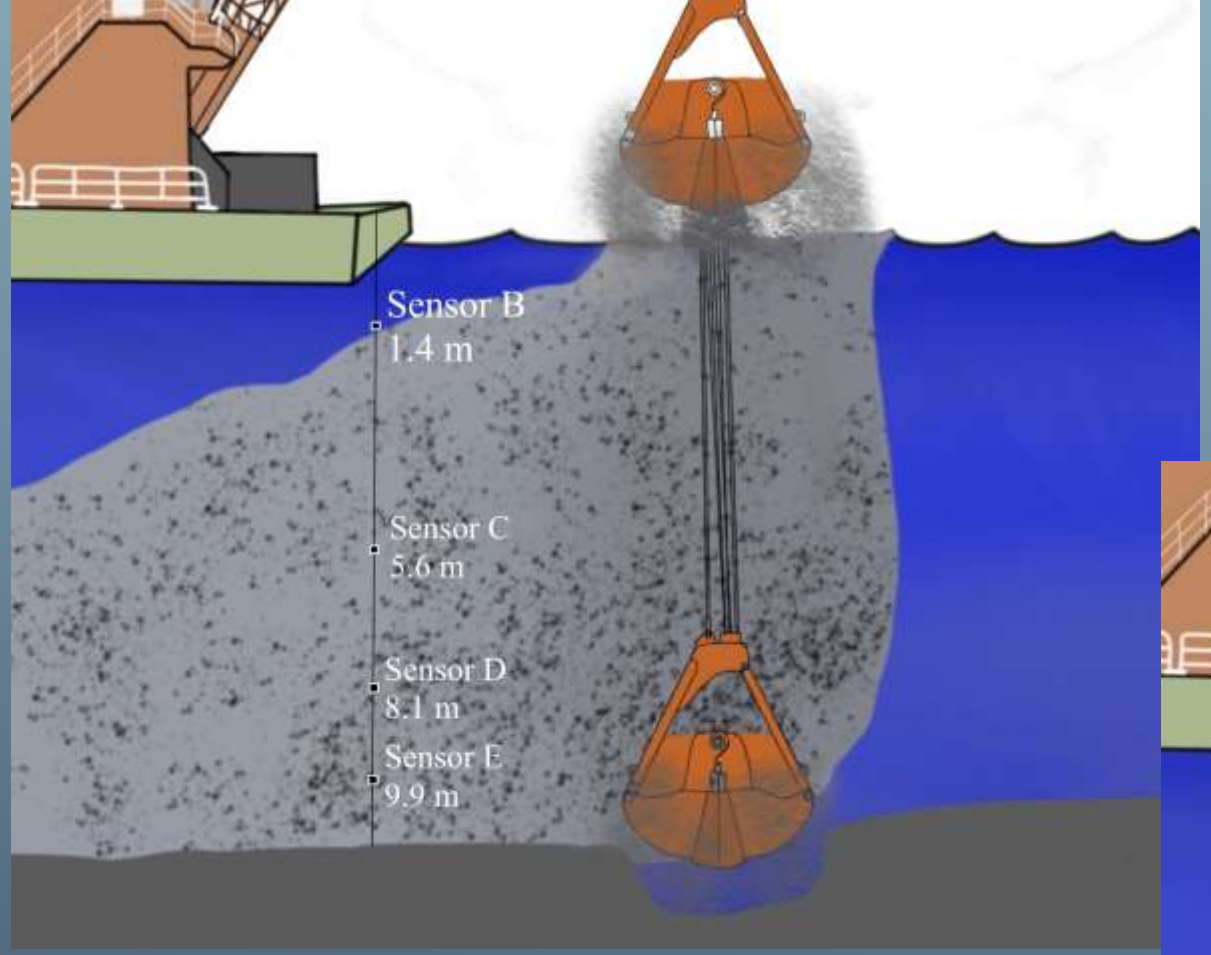




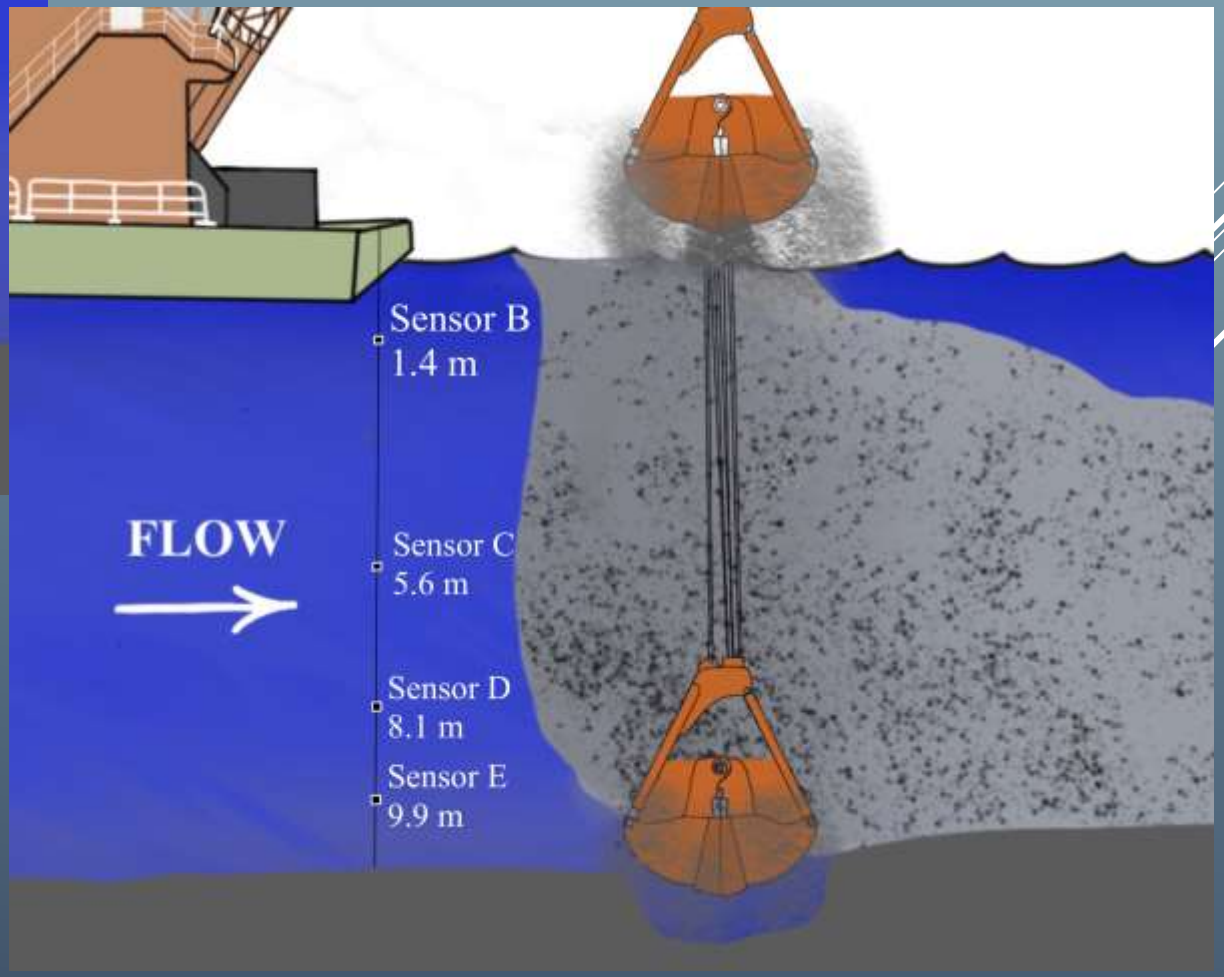


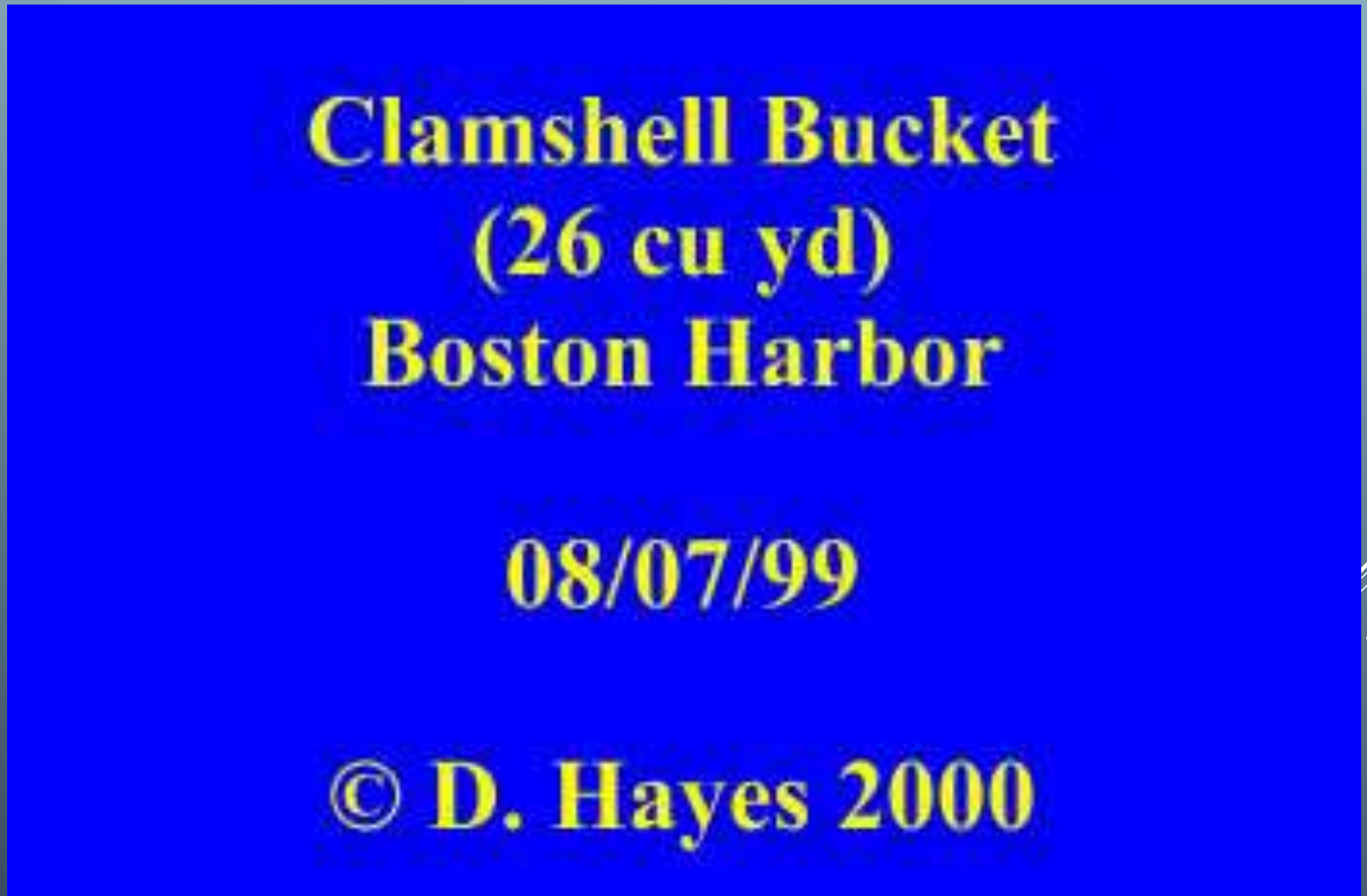


EBB TIDE MONITORING



SENSOR & SAMPLE LOCATIONS




Clamshell Bucket
(26 cu yd)
Boston Harbor
08/07/99
© D. Hayes 2000

GLDD Enclosed Bucket (39 cu yd) Boston Harbor

08/06/99

Date	Dredge Bucket Used	Monitoring		Dredge Cut (m)	Before Dredging		Initial Tide* (m)	After Dredging Depth* (m)	Dredge Movement
		Start	End		Starting Depth* (m)	Sediment Elev. (m MLLW)			
8/5	CableArm (26 cy)	8:33:51	13:03:47	0.7	12.7	-10.7	2.0	13.4	Upstream
8/6	Enclosed (39 cy)	8:00:36	13:10:00	1.5	13.1	-10.4	2.7	14.6	Downstream
8/7	Convent. (26 cy)	8:27:34	10:29:59	0.5	15.3	-12.5	2.8	15.8	Upstream
		10:30:00	14:35:28	1.0	10.7	-8.7	2.0	11.7	

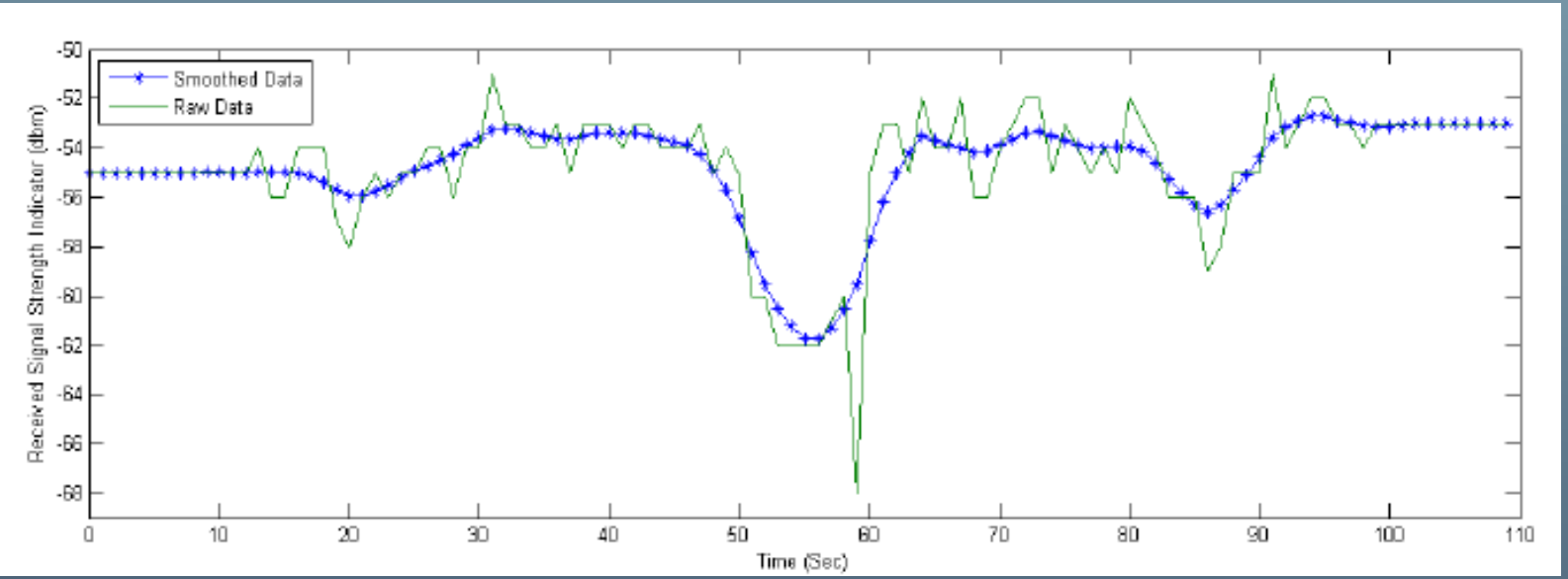
***These values varied with time due to tides; values shown reflect NOAA station 8443970 tide level at the beginning of the monitoring period.**

SITE CHARACTERISTICS

SEDIMENT CHARACTERISTICS

	8/5/99		8/6/99		8/7/99		Average
	A	B	A	B	A	B	
Water Content (%)	178.2	130.5	121.1	142.6	151.7	132.2	142.7
Specific Gravity, Gs	2.74	2.64	2.7	2.7	2.7	2.67	2.69
> 140 sieve (%) (medium and coarse)	0	0	0	31	2	1	5.7
Fine Sand (%)	19	23	23	9	29	21	20.7
Silt (%)	63	47	44	33	51	41	46.5
Clay (%)	18	30	33	27	18	37	27.2
Classification	Sandy Silt (ML), Dark Gray					Sandy Clay (CH)	

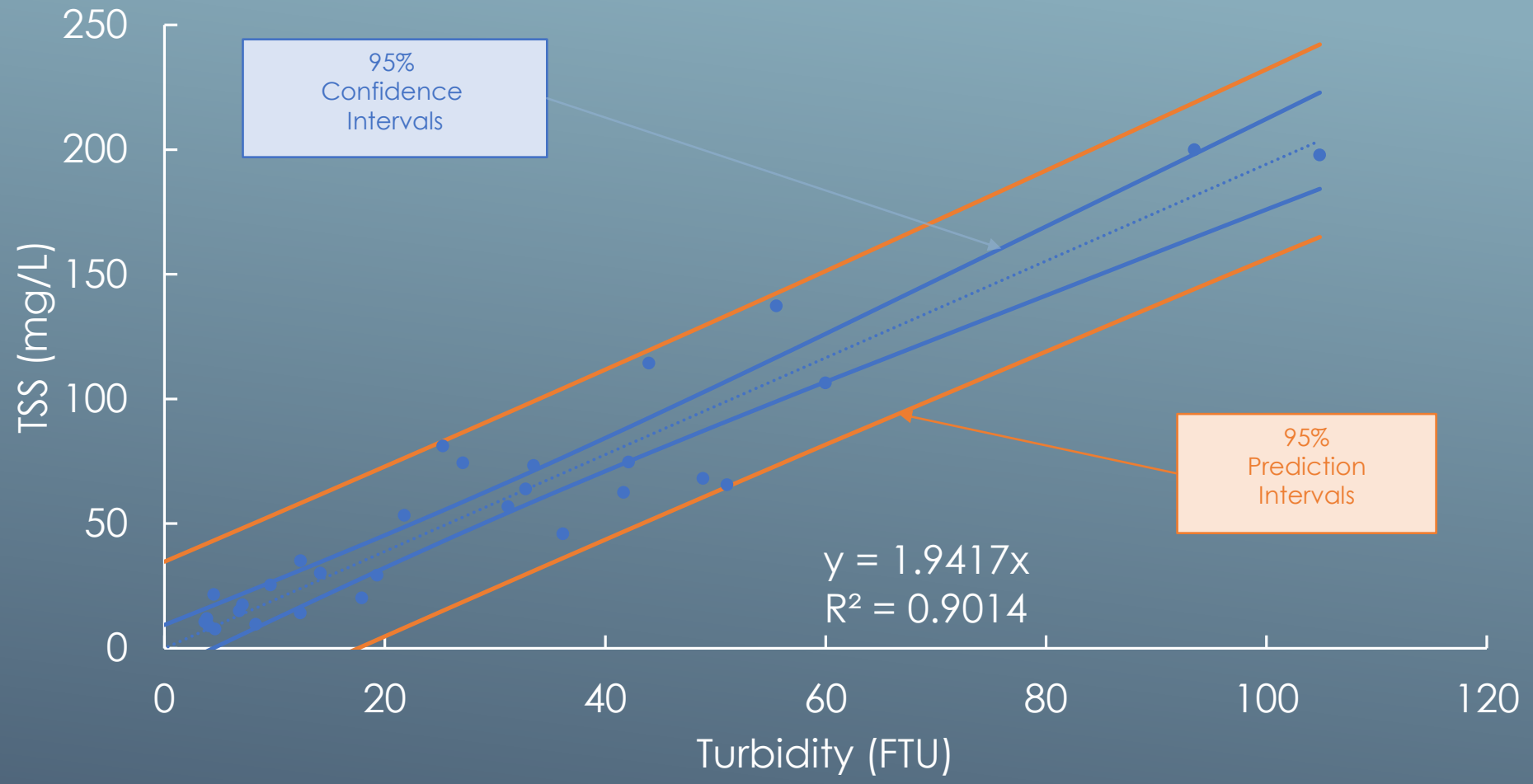
- ~200,000 turbidity readings
- Significant noise and some outliers
  - Kalman Filter used to remove noise
  - Hampel outlier detection



TURBIDITY DATA, SMOOTHING, AND OUTLIERS

DREDGING PERIODS

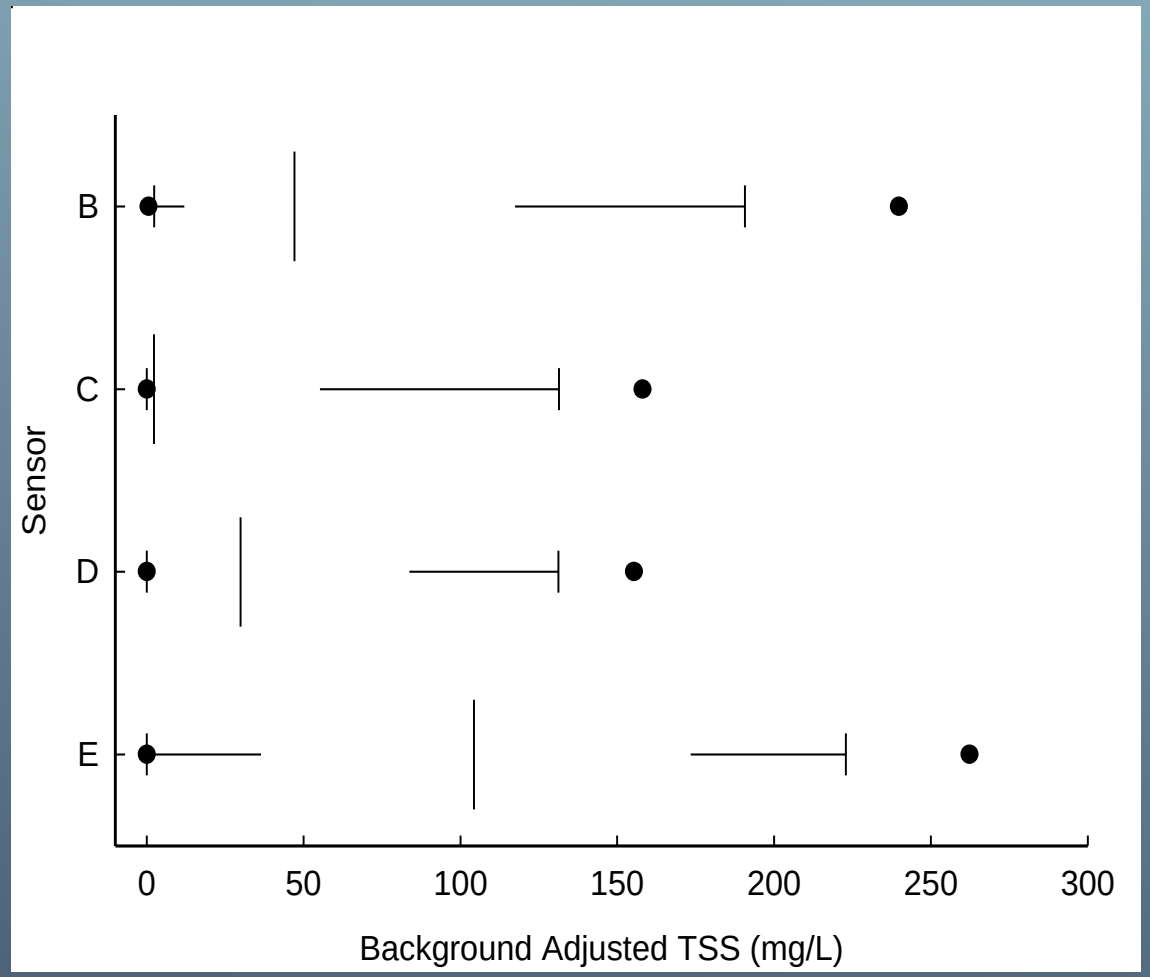
Dredging Period	Start Time	Duration (m:s)	Bucket Cycles		Dredging Period	Start Time	Duration (m:s)	Bucket Cycles
D-5-A	8:33:51	2:30			D-6-I	9:28:19	16:33	17
D-5-B	8:36:22	17:16	17		D-6-J	9:46:36	2:47	
D-5-C	8:56:01	6:51			D-6-K	9:49:24	15:35	18
D-5-D	9:02:53	13:11	11		D-6-L	10:05:00	9:59	
D-5-E	9:16:05	4:15			D-6-M	11:23:32	22:11	
D-5-F	9:37:24	4:55			D-6-N	11:46:49	19:01	
D-5-G	9:42:20	12:47	12		D-6-O	12:08:29	45:42	
D-5-H	9:56:51	3:07			D-6-P	12:55:18	14:42	
D-5-I	9:59:59	9:46	10		D-7-A	8:37:24	54:23	18
D-5-J	10:09:46	3:59			D-7-B	8:59:30	24:57	28
D-5-K	10:13:46	2:04	2		D-7-C	9:24:28	04:45	
D-5-L	10:18:48	2:43			D-7-D	9:29:14	3:46	5
D-5-M	10:21:32	7:08	7		D-7-E	9:33:01	4:11	
D-5-N	12:04:53	44:33			D-7-F	9:41:25	11:39	14
D-5-O	12:50:07	13:40			D-7-G	10:18:05	11:17	13
D-6-A	8:00:36	8:35			D-7-H	10:44:25	5:37	
D-6-B	8:09:12	9:49	8		D-7-I	10:56:26	11:33	
D-6-C	8:22:40	20:18	21		D-7-J	11:09:25	28:01	
D-6-D	8:43:57	3:06			D-7-K	12:31:43	28:16	
D-6-E	8:47:04	19:19	21		D-7-L	13:01:33	28:10	
D-6-F	9:07:13	11:59			D-7-M	13:33:55	20:31	
D-6-G	9:19:13	4:55	6		D-7-N	13:57:38	29:21	
D-6-H	9:25:31	2:47			D-7-O	14:27:55	07:33	



TSS -TSS RELATIONSHIP

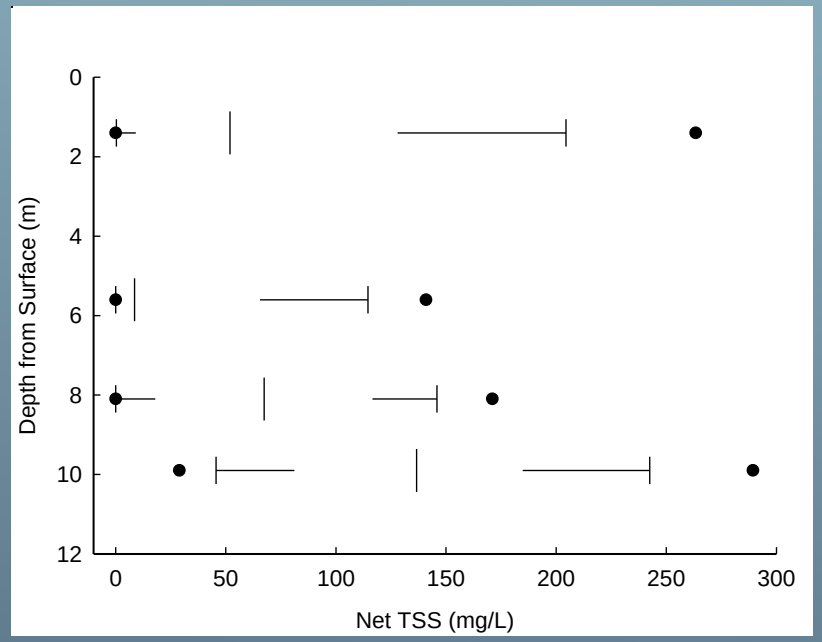
BACKGROUND TSS/TURBIDITY

- Battelle study data not available
- Background TSS/Turbidity estimated from "non-dredging" time periods, e.g. downtime, repositioning, scow exchange
- Challenges
  - ND period durations
  - Influence of external factors
  - Temporal changes, especially sensor proximity to bottom

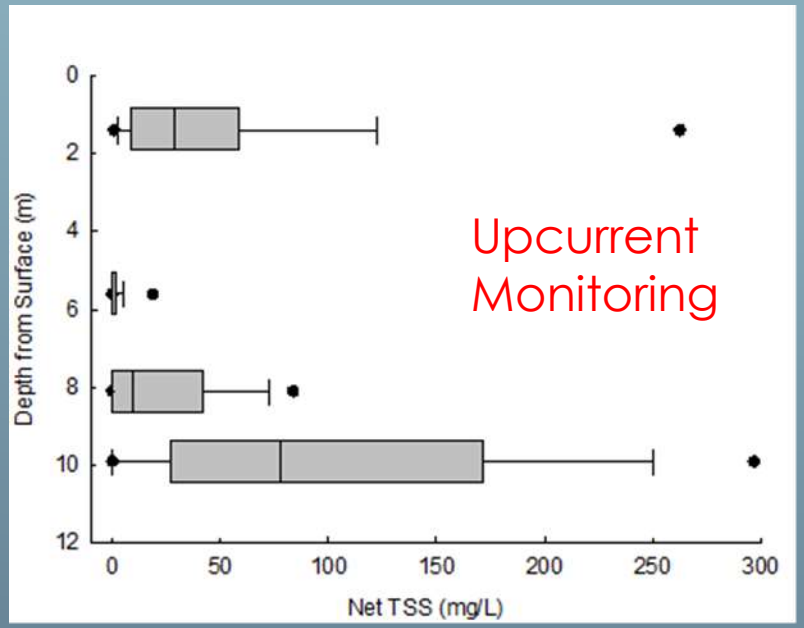


Sensor	B	C	D	E
Count	36,706	36,706	36,706	36,706
Max	2401	281	438	448
Min	0	0	0	0
Median	**47.1**	**2.3**	**29.9**	**104.6**
Mean	81.3	35.7	49.6	111.6
Std Dev	116.7	55	55.1	87.1
25%	12	0	1.6	36.7
75%	117.4	55.2	83.7	173.5
Skewness	5.6	1.5	1.2	0.5
Kurtosis	58.5	1.2	1.2	-0.3

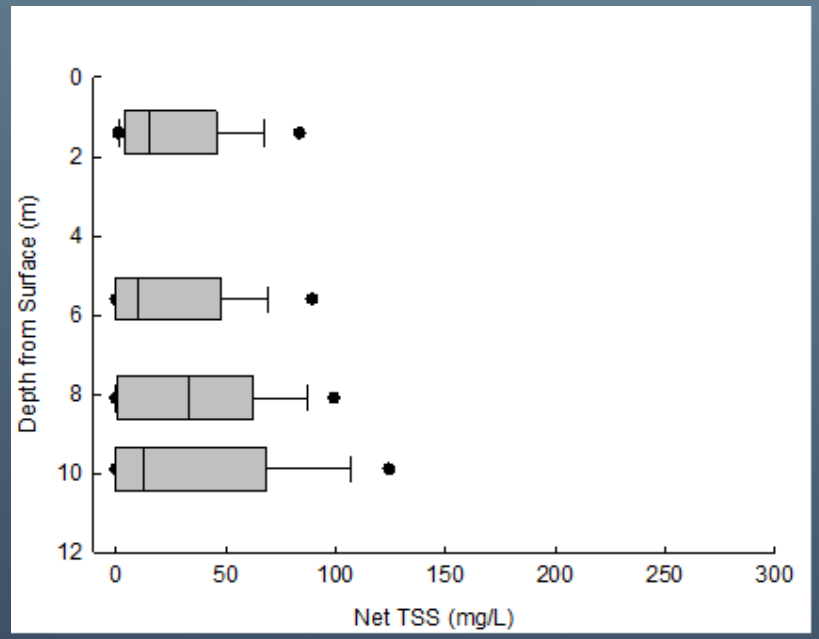
COMBINED DATA ANALYSIS



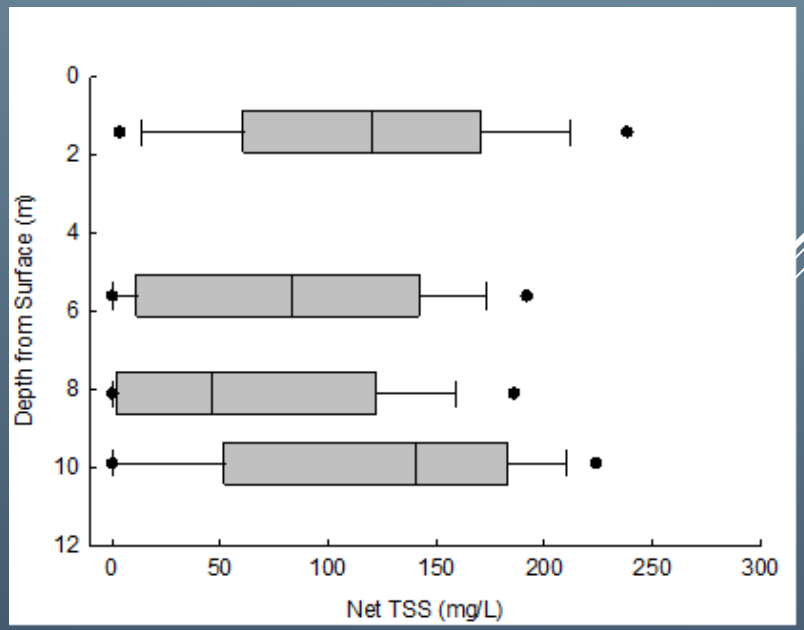
Cable Arm Navigation Bucket



39-cy enclosed bucket



26-cy conventional bucket (Thin Cut)

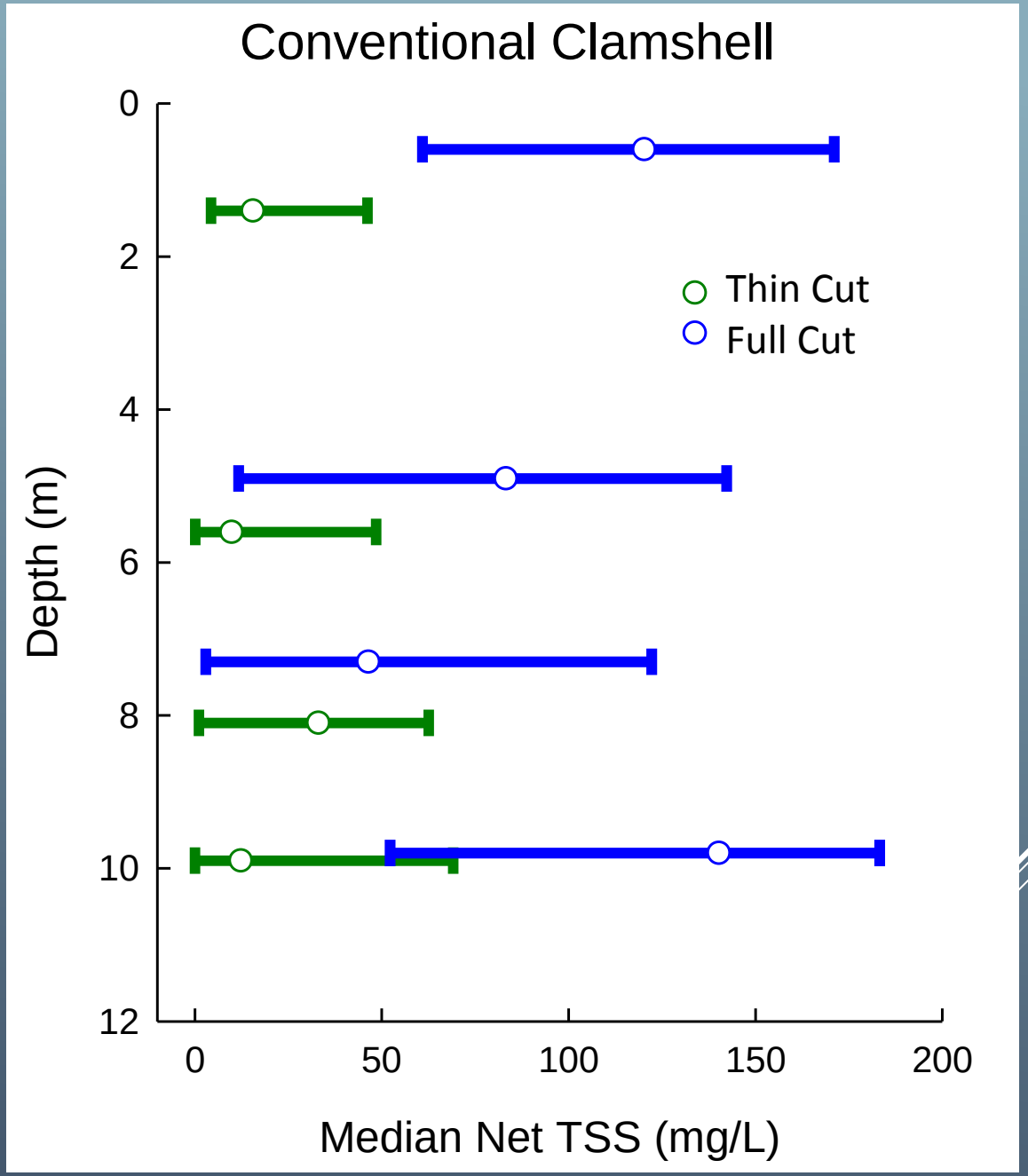


26-cy conventional bucket (Regular Cut)

THIN (1 FT)

VS FULL (4 FT)

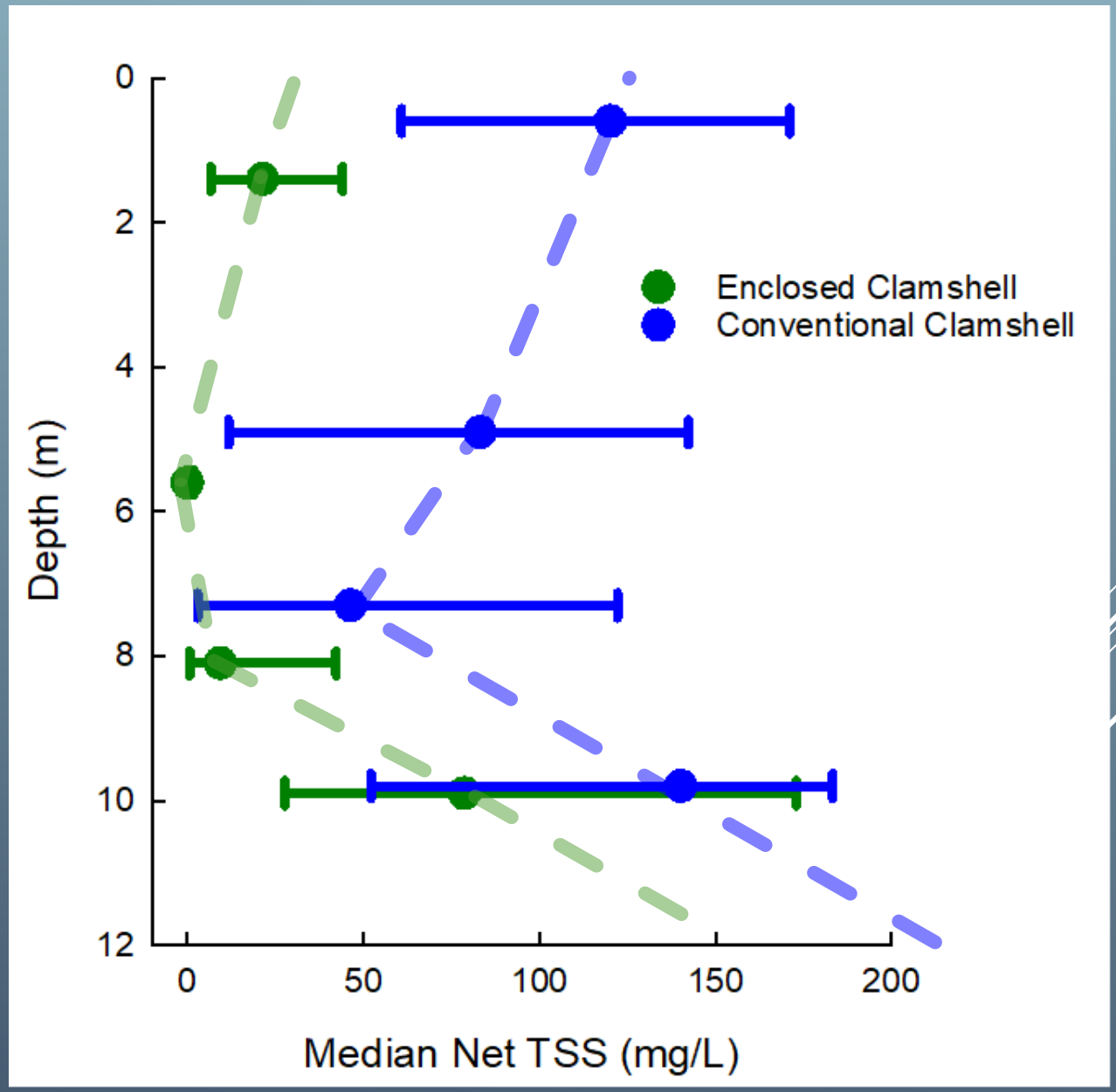
CUTS

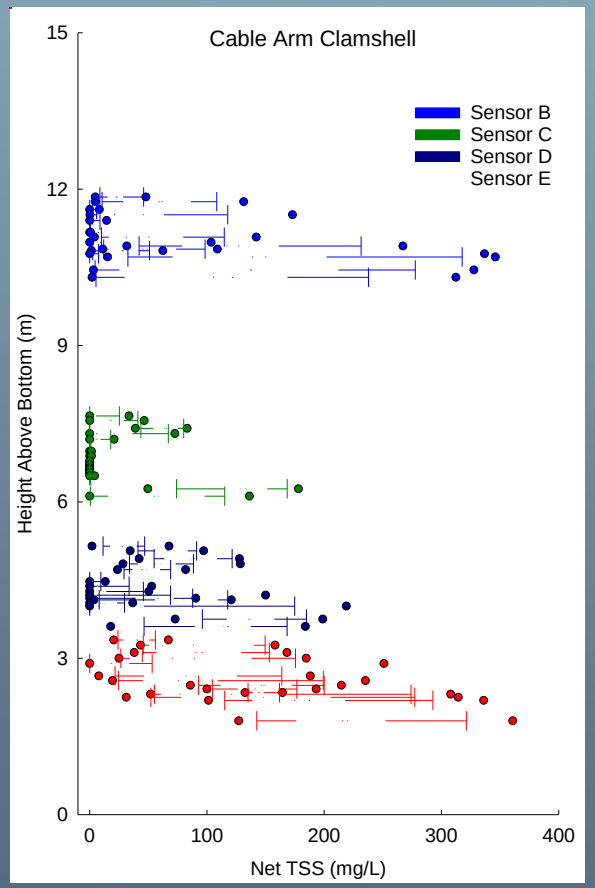


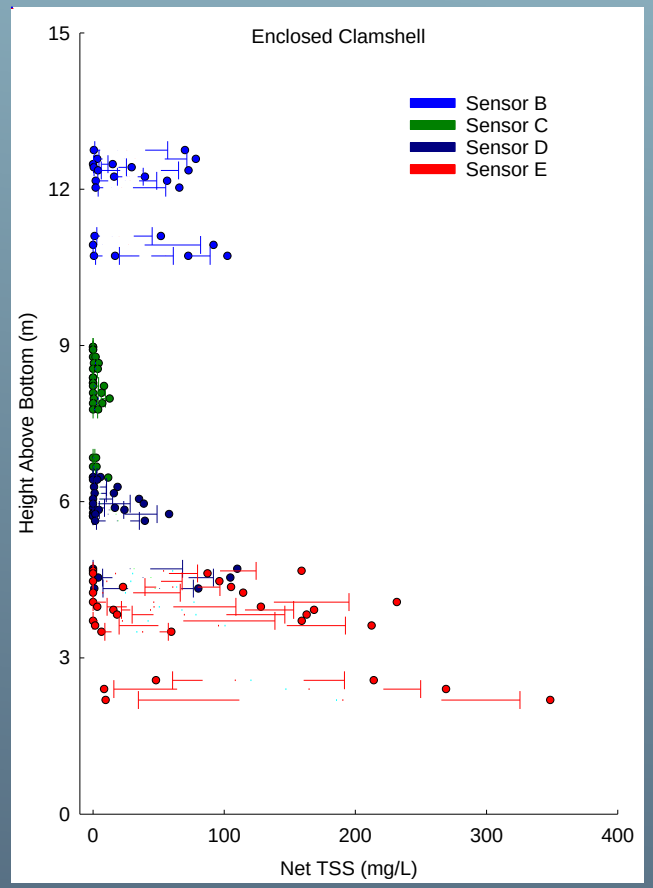
IMPORTANT NOTE

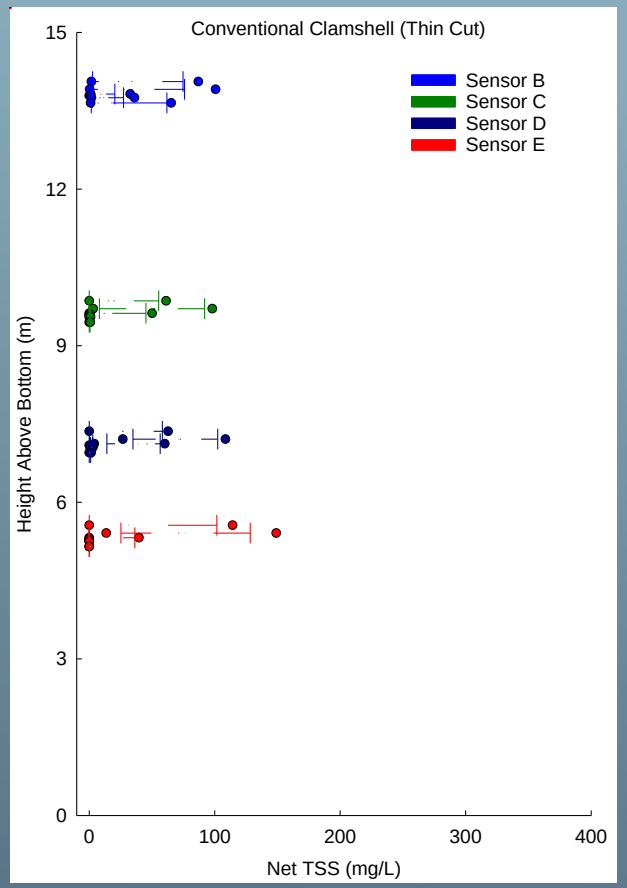
Enclosed clamshell bucket results may be biased low. Monitoring was UPCURRENT compared to being DOWNCURRENT for conventional clamshell bucket.

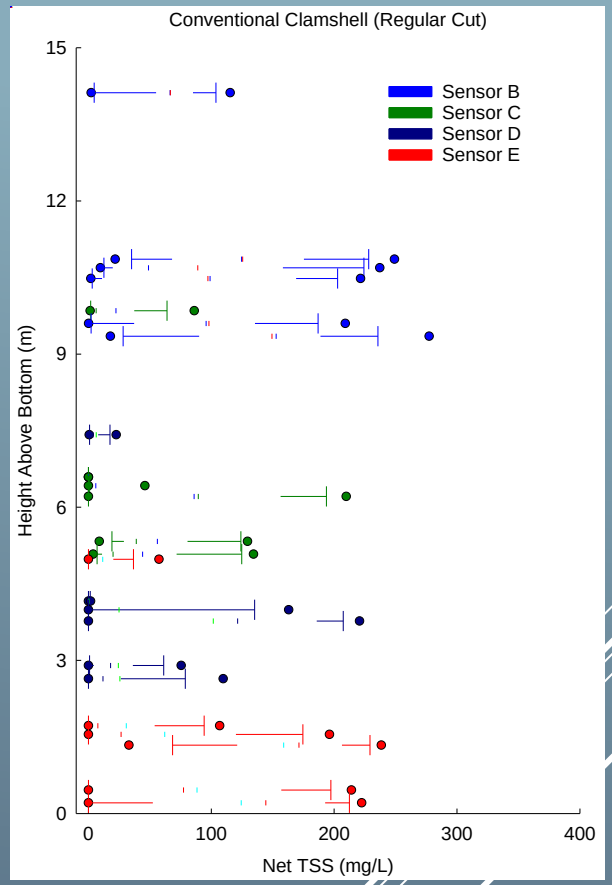
VERTICAL TSS DISTRIBUTION





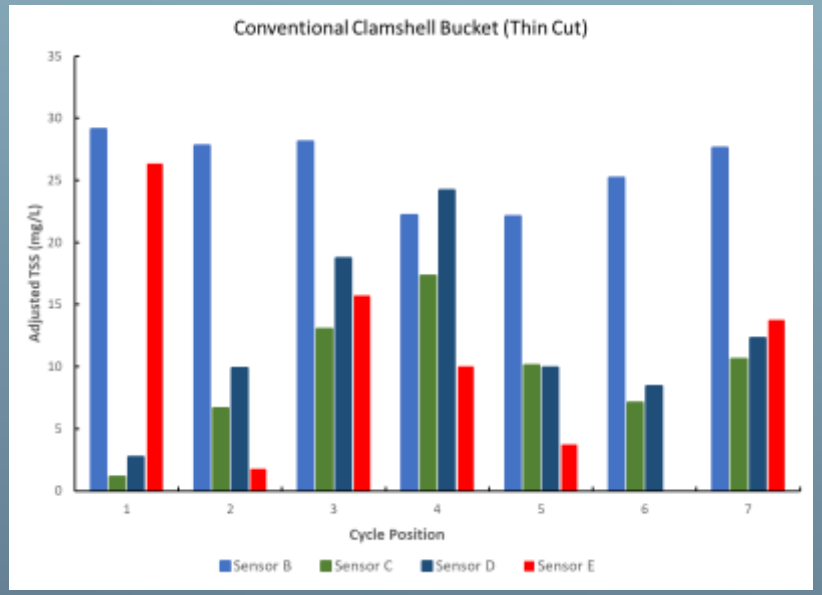


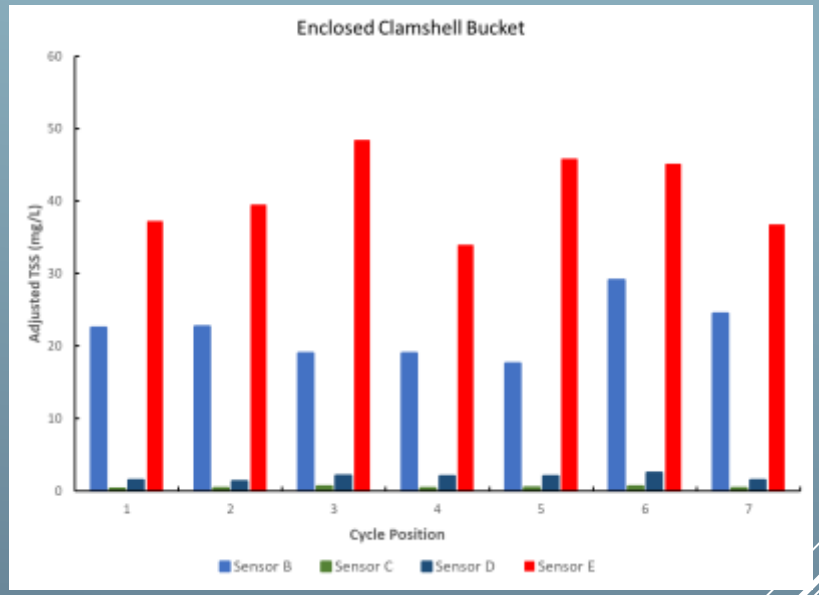




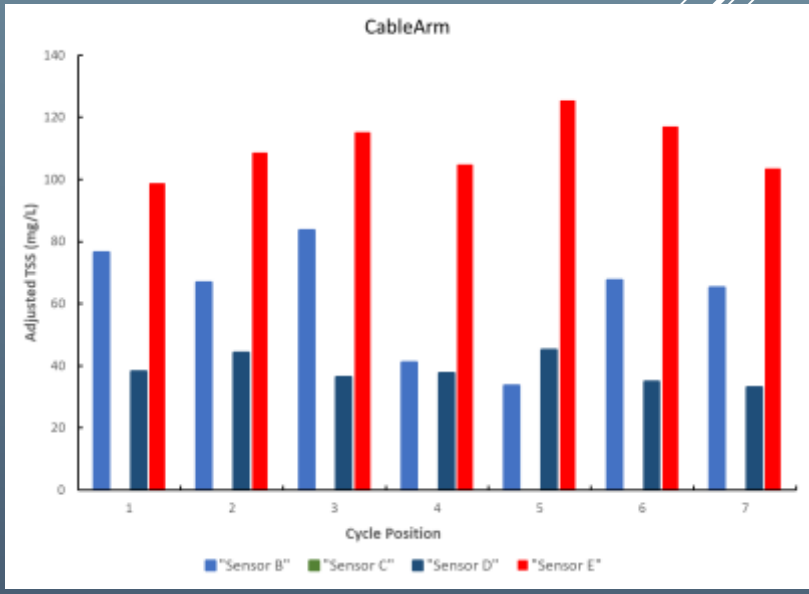
TSS VS DEPTH RELATIONSHIP OR IMPACT OF WATER DEPTH CHANGES DUE TO TIDES

	Action
1	Above water surface, ready to begin cycle
2	Descent through water column
3	Bottom impact and closure
4	Ascent through water column
5	Breaks water surface; slew to barge
6	Bucket over barge and being emptied
7	Slew to next dredging location





VARIATION WITH BUCKET CYCLE POSITION



CONCLUSIONS

- Rich, robust data set; far more analyses possible
- Results seem logical and defensible
- Significant study issues
  - Background TSS
  - Local currents
  - Upcurrent monitoring location – Enclosed Bucket
- Enclosed bucket seems to generate less turbidity/TSS, but see above ⬆
- Bucket flushing an issue

NEXT STEPS

- 2 Journal Papers
  - Paper 1 – More robust paper that leverages the basic information in this paper to provide a broader evaluation of TSS concentrations and operational relationships
  - Paper 2 – Development of TSS mass release estimates
- Improvements:
  - More robust assessment of ambient TSS
  - Near-field TSS modeling to compensate for the upstream dredge monitoring position associated with the enclosed bucket