Automated Ullage Sensors for Hopper Dredge Material Measurement

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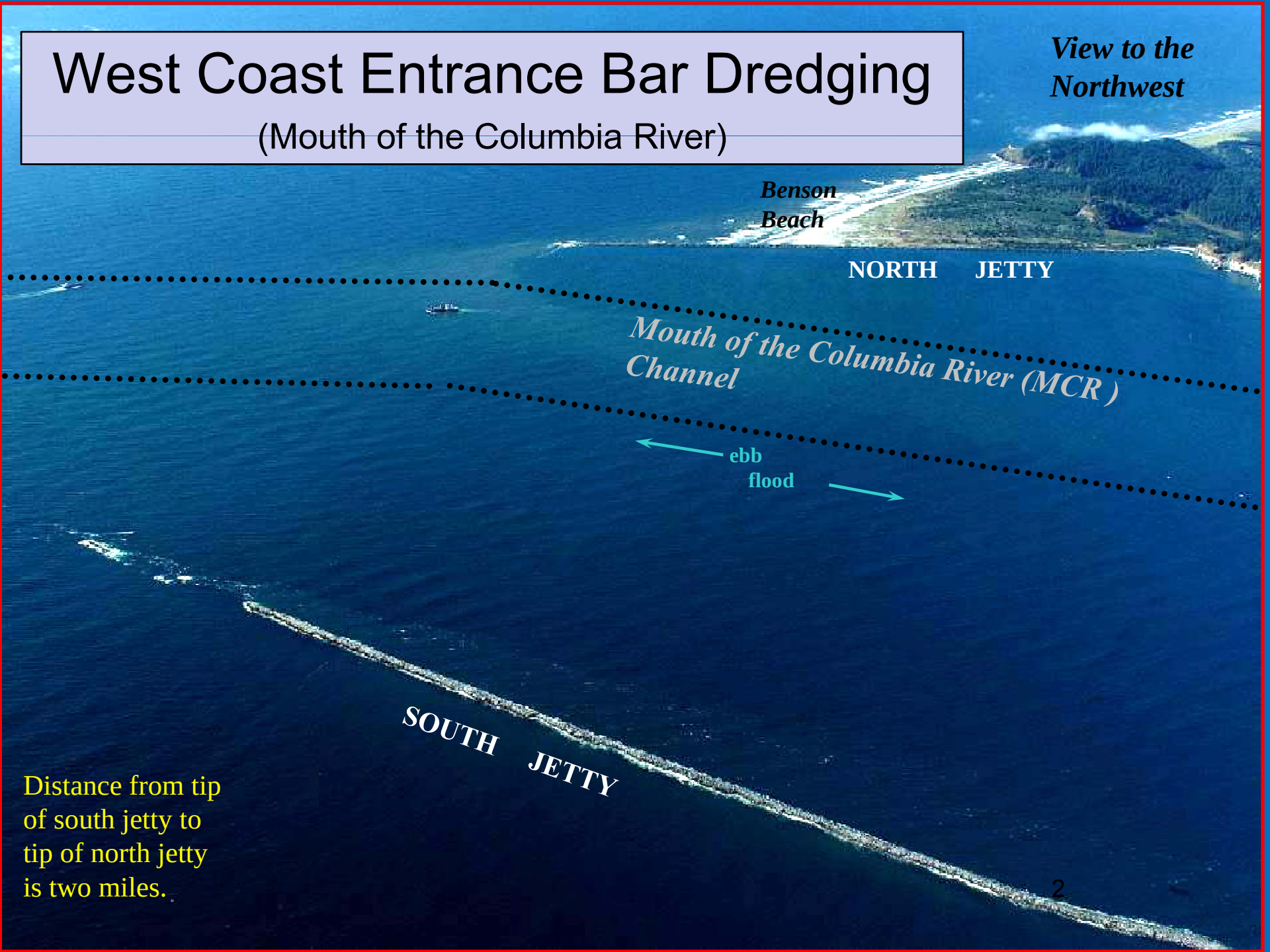
West Coast Entrance Bar Dredging

(Mouth of the Columbia River)



Distance from tip of south jetty to tip of north jetty is two miles.

COASTAL ENTRANCE BAR DREDGING

- 4-6 million cubic yards dredged annually at the Mouth of the Columbia River (MCR) ; several other west coast bars are dredged annually

- Material is typically sand which is placed in ocean disposal sites

- Contract earnings can top $100,000 per day ($2.50 to $3.50 per CY)

- Rough sea conditions on most coastal bars necessitate a compressed dredging season, typically July – Oct

- At MCR, two hopper dredges typically work simultaneously in the same four mile stretch

Hydrosurveys

- Pre-dredge hydrosurveys are used to identify and prioritize work areas at the Mouth Columbia River and other coastal bars

- Hydrosurveys cannot be used to determine the volume removed for payment on coastal bars

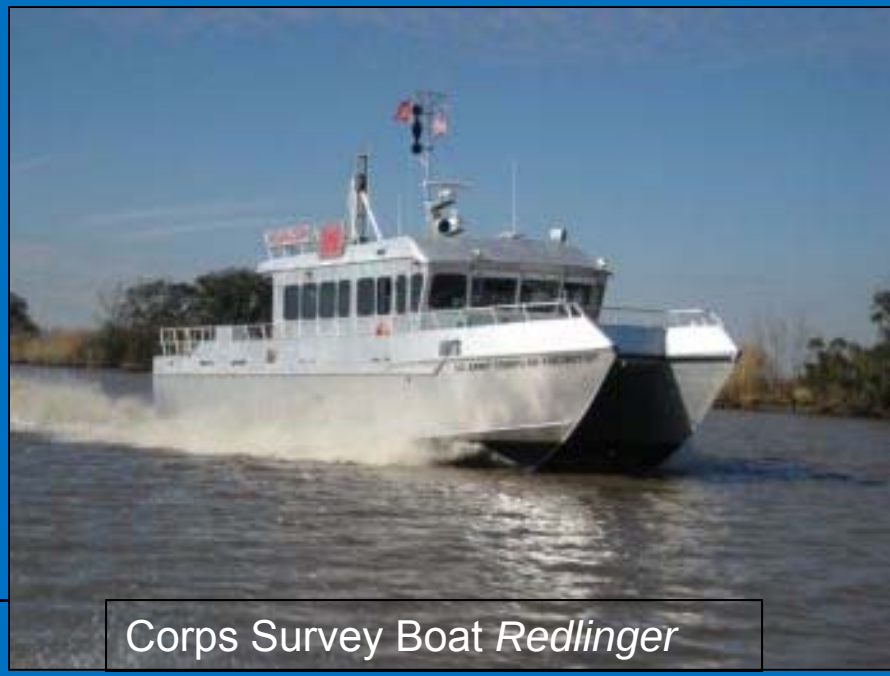
    - Sea conditions often keep survey vessels off the bar (payment surveys must be timely)

    - Wave conditions, strong currents, and tides often prohibit accurate surveys

    - Two dredges working in close proximity (MCR) complicate hydrosurveys and accurate accounting of material

Thus, dredged material is measured for payment by hand soundings taken in the hopper by dredge inspectors

Columbia River Bar Pilot Boat *Chinook*



Corps Survey Boat *Redlinger*

MEASUREMENT OF DREDGED MATERIAL
(Hand Sounding Method)

- Sand is measured in the hopper of contract dredges by Government inspectors 24/7
- Ten measuring stations are located around the hopper
- Soundings are taken by measuring the sand surface with a hand sounding line (boat anchor and chain) from pre-set reference points.
- Soundings are averaged and total hopper volume is determined from the dredge ullage table
- Government dredges use a similar method for material measurement for material accounting and production tracking

Hopper Material Measurement
(current method)

DREDGE Mc FARLAND
HOPPER ULLAGE TABLE
TOTAL HOPPER

ULLAGE	CU. YDS	ULLAGE	CU. YDS	ULLAGE	CU. YDS
6'-0"	3138	13'-0"	2269	20'-0"	1395
-3"	3107	-3"	2238	-3"	1363
-6"	3076	-6"	2207	-6"	1331
-9"	3045	-9"	2176	-9"	
7'-0"	3014	14'-0"	2146	21'-0"	
-3"	2983	-3"	2114	-3"	
-6"	2952	-6"	2083	-6"	
-9"	2921	-9"	2052	-9"	
8'-0"	2890	15'-0"	2021	22'-0"	
-3"	2859	-3"	1990	-3"	
-6"	2829	-6"	1959	-6"	
-9"	2798	-9"	1928	-9"	
9'-0"	2767	16'-0"	1897	23'-0"	
-3"	2736	-3"	1865	-3"	
-6"	2706	-6"	1834	-6"	
-9"	2674	-9"	1803	-9"	
10'-0"	2643	17'-0"	1772	24'-0"	
-3"	2612	-3"	1741	-3"	
-6"	2580	-6"	1710	-6"	
-9"	2549	-9"	1679	-9"	
11'-0"	2517	18'-0"	1648	25'-0"	
-3"	2486	-3"	1616	-3"	
-6"	2455	-6"	1584	-6"	
-9"				-9"	
12'-0"				26'-0"	
-3"				-3"	
-6"	2331	-6"	1458	-6"	
-9"	2300	-9"	1426	-9"	

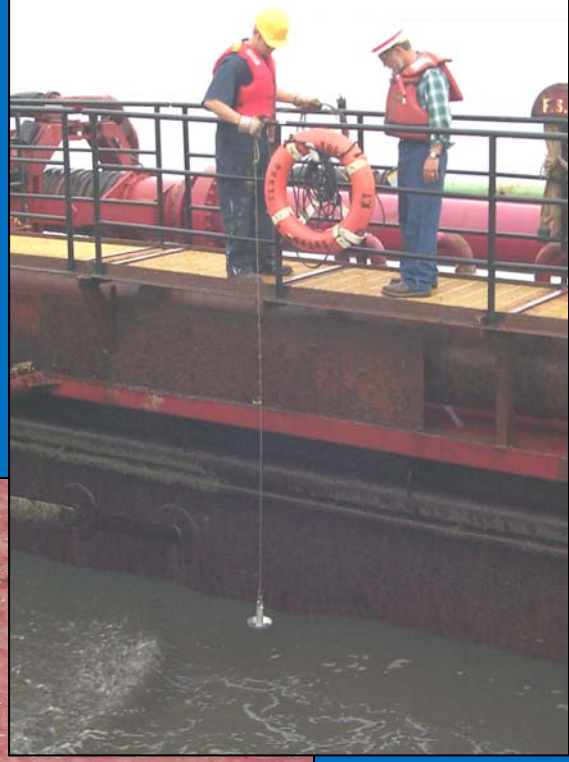
	ULLAGE
TOTAL HOPPER FULL	5'-11"
TOTAL HOPPER EMPTY	39'-8 5/8"

28 Appendix

Ullage Table

Boat Anchor & Chain

Sounding Hopper for Sand



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CHALLENGES
(Current Measurement Method)

• Hopper dredge inspection 24/7 is expensive ($15,000 to $20,000 per week plus “hidden costs” for recruiting, training and managing inspectors).

• Hopper dredge inspectors and contractors work in very difficult conditions; safety of personnel is a constant concern

• Significant management effort is expended in recruiting, training, scheduling and managing 24/7 inspection.

The Goal

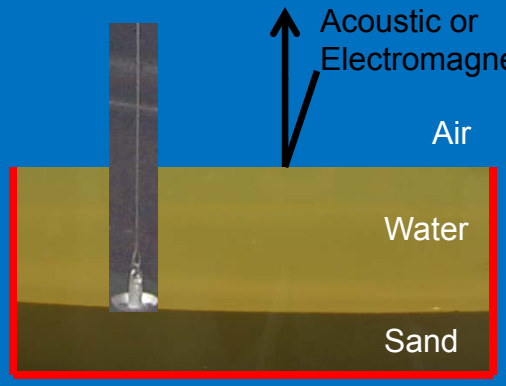
- An accurate automated mechanical measurement system for determing (sand) volumes that replicates volumes determined by hand soundings

- Reduced hopper dredge inspection for cost savings and safety; possibly single shift inspection

- A measurement system that contractors can use as a basis for bidding

- A measurement system that is reliable and accurate

All Measurement Has Error



Sources of Error

Instrumental Errors: Imperfection in construction, adjustment, etc., of instruments

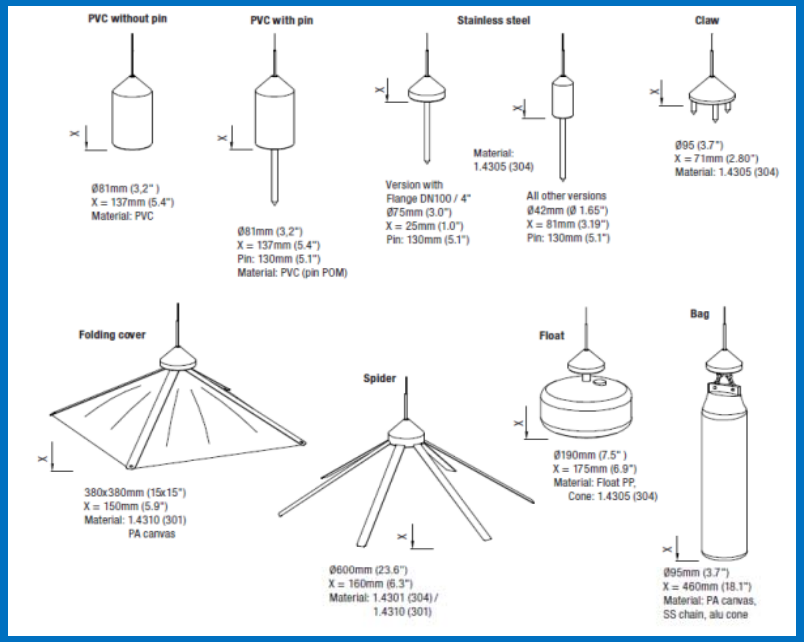
Personal Error: Limitations of the human senses of sight, touch, and hearing

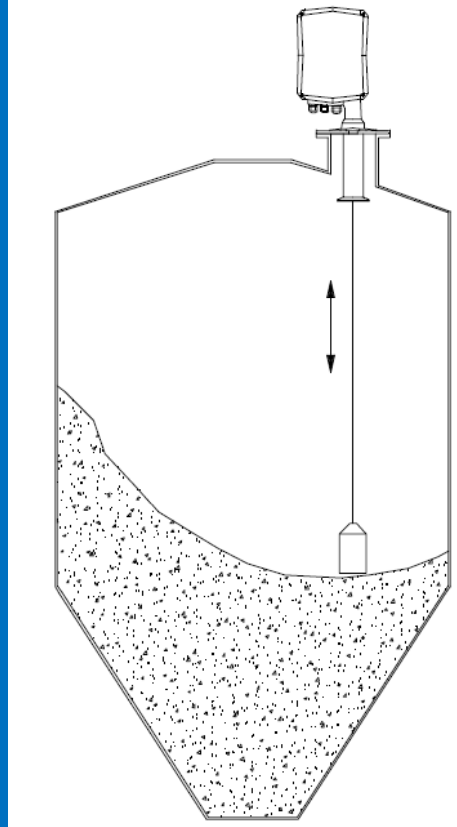
Natural Errors: Variation of temperature, wave conditions, etc.

Brinker and Wolf 1977

Nivobob Continuous Measuring System

NB 3300
Rope version





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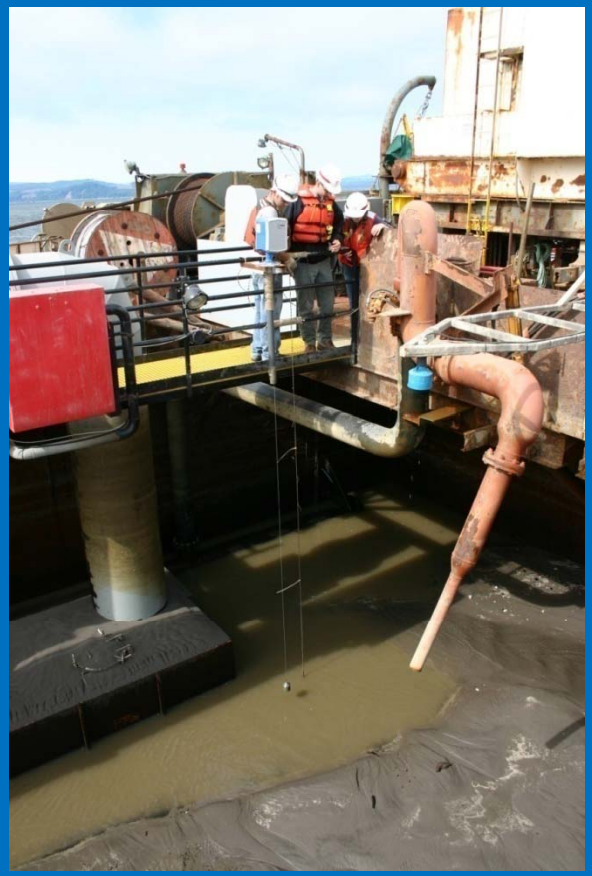
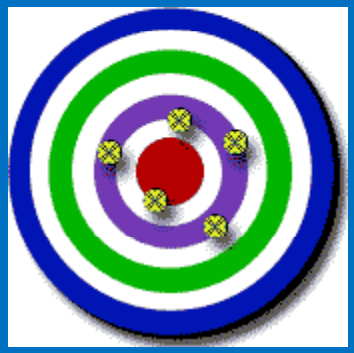
Nivobob In Action

Study Objective: Evaluate Nivobob accuracy, precision, and reliability.



Comparison between manual and instrument soundings.



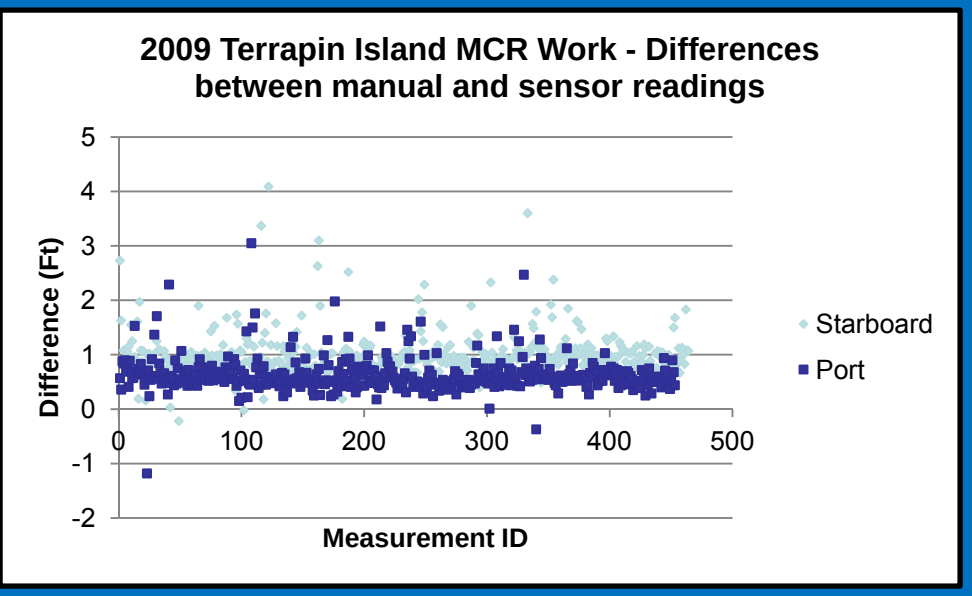
Investigate instrument survivability.

Measurement Environment

Data Collection

- Dredges
  - *Terrapin Island* 2009
  - *Yaquina* and *Dodge Island* 2010
  - *Yaquina* and *Terrapin Island* 2011
- Collection Locations
  - Mouth of the Columbia River
  - In-river along the Columbia River
  - Shallow water ports on the Oregon Coast

3.1.2.3 Ullage Sensor Description for Sand Measurement
a. The Government intends to test an ullage sensor technology during the operation of the Contract to evaluate its accuracy for hopper sand measurements and its reliability under hopper dredge operating conditions.
b. The Contractor is required to purchase and install two ullage sensors (with power) at locations specified by the Government. The intent is to mount the ullage sensors next to hand sounding stations so that data (at each respective sounding station) can be collected at the time hand soundings are done. Measurements will be recorded by the GQAR from a local read-out on the sensor. There is no requirement to automate the measuring system with the Contractor's electronic dredge data. However, if the Contractor elects to automate the readings, these shall be included as a parameter in the daily electronic dredge data provided to the Government.
c. The ullage sensors shall be installed as required by the manufacturer and shall be mounted so the read-outs are displayed in a manner that they can be easily read by the GQAR. The sensor mount design will be submitted and approved by both the manufacturer and the Government prior to the sensor installations. A copy of the manufactures specifications and manual shall be submitted with the PSMP and one copy kept on the dredge in a location that is readily accessible to Government personnel.
d. During the first five days of operation, the Contractor shall have a representative of the sensor manufacturer present to inspect and approve sensor mounts and operation. All necessary calibrations shall be performed in the presence of the sensor manufacturer and a government representative in accordance with manufacturer's recommendations. The reference point of the ullage sensors shall be the same as the reference points of the hand sounding stations.
e. The sensors shall respectively be located in a minimum of two different locations during the life of the Contract. The locations will be next to hand sounding stations and the Government will specify the exact locations. After a sufficient amount of data is collected at the initial locations, the Government will require the Contractor to relocate the sensors to their final locations. If the Contractor agrees to provide additional locations, and the Government determines that this is beneficial to the data collection and analysis, additional locations may be utilized upon approval of the Government. The Contractor is encouraged to provide power at all locations, or to provide power from a power cord to allow the ullage sensors to be moved to multiple locations throughout the Contract for collection of data at all sounding stations. However, only two locations for each ullage sensor are required as stated above. If the Contractor elects to purchase and install more than two ullage sensors, they shall meet all criteria specified herein and all data shall be readily accessible to the Government.
f. The Contractor shall maintain the ullage sensors as necessary to insure they are fully operable at all times during dredging operations. In the event that an ullage sensor malfunctions, it shall be repaired or replaced within seven calendar days. Should the sensor be inoperable more than 10 total days, it shall be replaced and at that time, a spare shall be provided on board to prevent future interruptions in data collection.
3.1.2.4 Ullage Sensor Specifications
The ullage sensor shall be of the electromechanical plumb bob style:
a. The unit shall be of the weight and cable style.
(1) The unit shall consist of a single pass pulley system with only one counting pulley and one mechanical driven wind pulley.
(2) The cable shall be braided stainless steel with a corrosion resistant protective coating and have an expected life time (measurement cycles) of approximately 100,000.
(3) The weight shall consist of a corrosion resistant polymer casing into which separate stainless steel or plastic weighted discs may be placed.

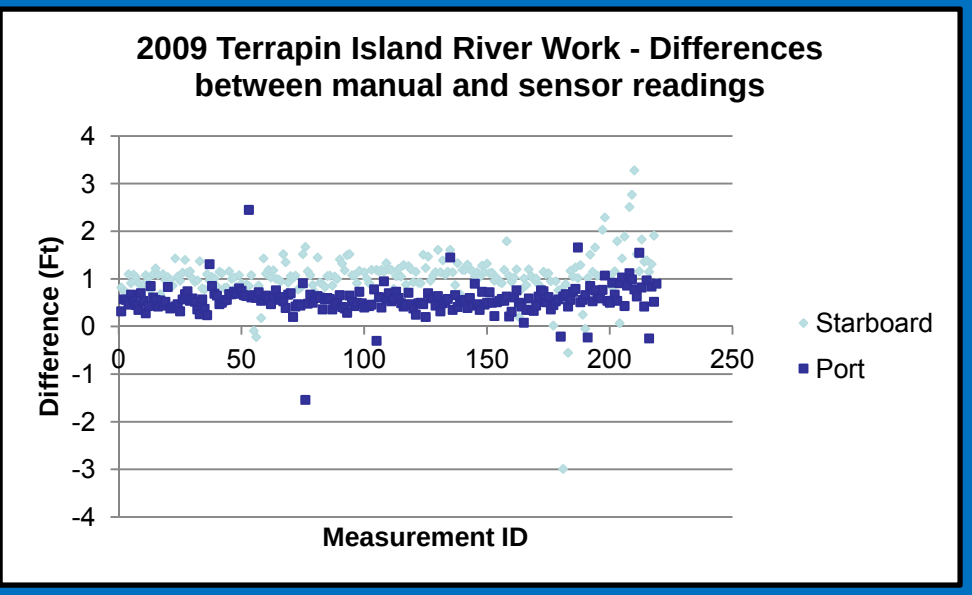


	LL Sta 6	Port Ullage	Difference
Mean	14.12	13.50	0.62
Std Dev	1.25	1.17	0.09
Median	13.8	13.21	0.59

# of measurements: 453

	LL Sta 1	Stb Ullage	Difference
Mean	13.73	12.75	0.98
Std Dev	1.24	1.09	0.15
Median	13.5	12.54	0.96

# of measurements: 464

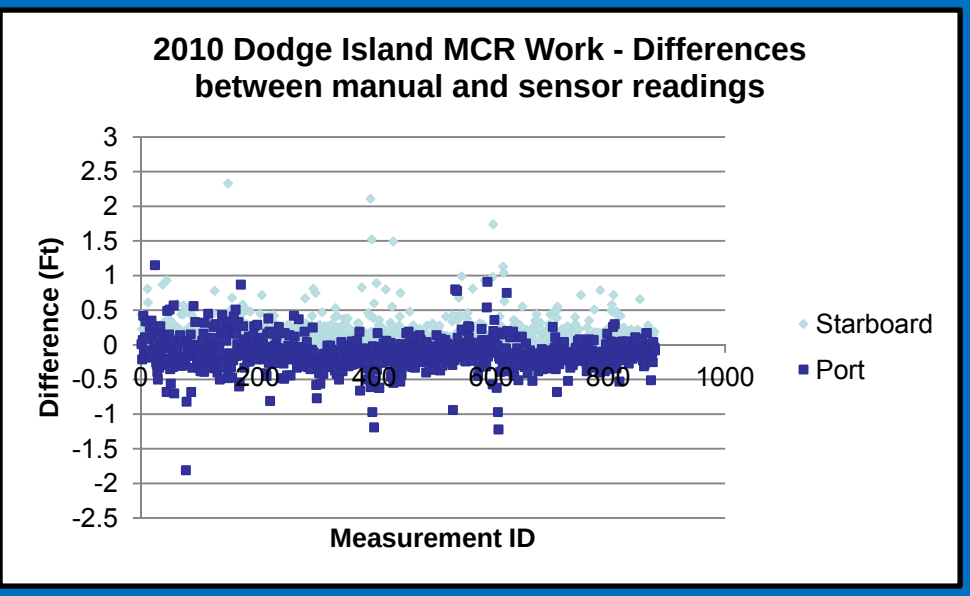


	LL Sta 6	Port Ullage	Difference
Mean	14.03	13.47	0.57
Std Dev	1.04	1.03	0.01
Median	13.8	13.22	0.58

# of measurements: 219

	LL Sta 1	Stb Ullage	Difference
Mean	13.25	12.19	1.06
Std Dev	1.41	1.46	-0.05
Median	13	11.92	1.08

# of measurements: 219

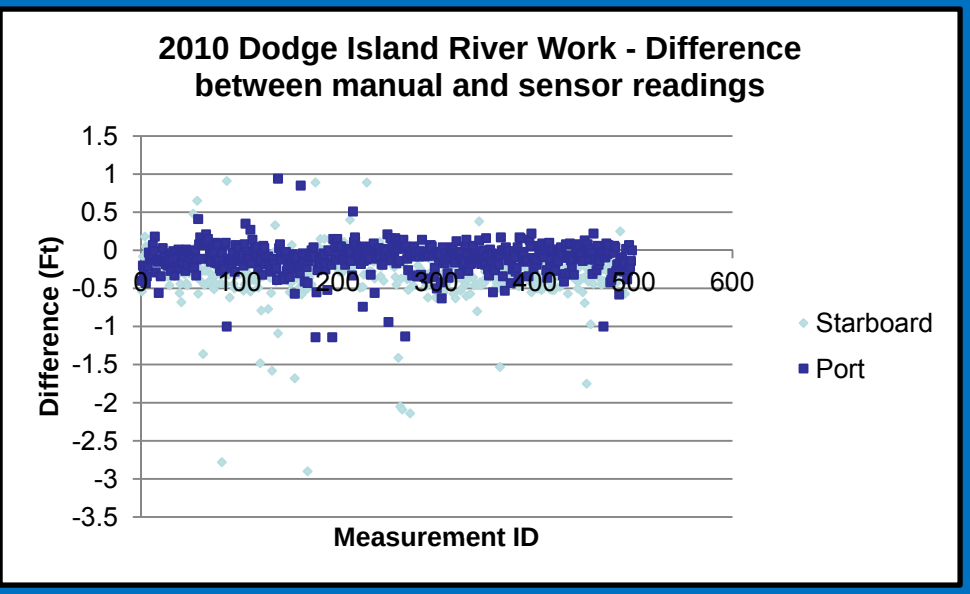


	LL Sta 10	Port Ullage	Difference
Mean	9.15	9.28	-0.13
Std Dev	1.44	1.43	0.01
Median	9.2	9.32	-0.12

# of measurements: 881

	LL Sta 5	Stb Ullage	Difference
Mean	10.37	10.48	-0.11
Std Dev	1.10	1.13	-0.02
Median	10.1	10.24	-0.14

# of measurements: 879



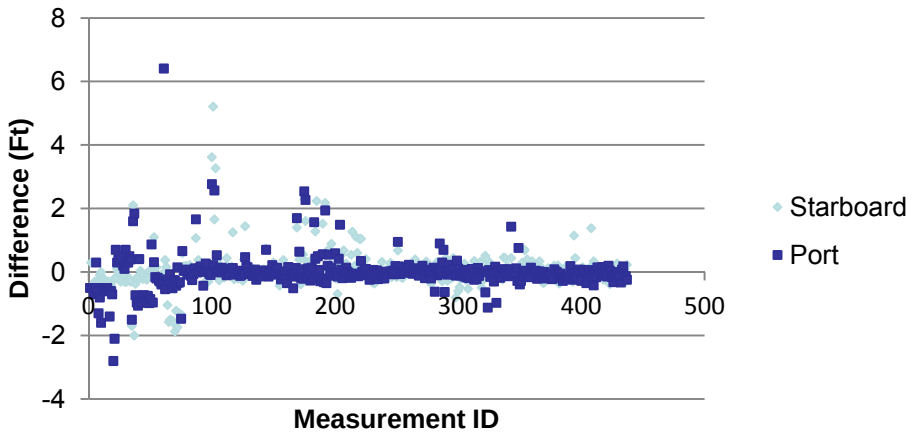
	LL Sta 10	Port Ullage	Difference
Mean	7.18	7.28	-0.11
Std Dev	2.17	2.14	0.03
Median	7.2	7.265	-0.065

# of measurements: 453

	LL Sta 5	Stb Ullage	Difference
Mean	12.26	12.56	-0.30
Std Dev	2.53	2.62	-0.09
Median	11.9	12.255	-0.355

# of measurements: 464

2011 Terrapin Island MCR Work - Differences between manual and sensor readings



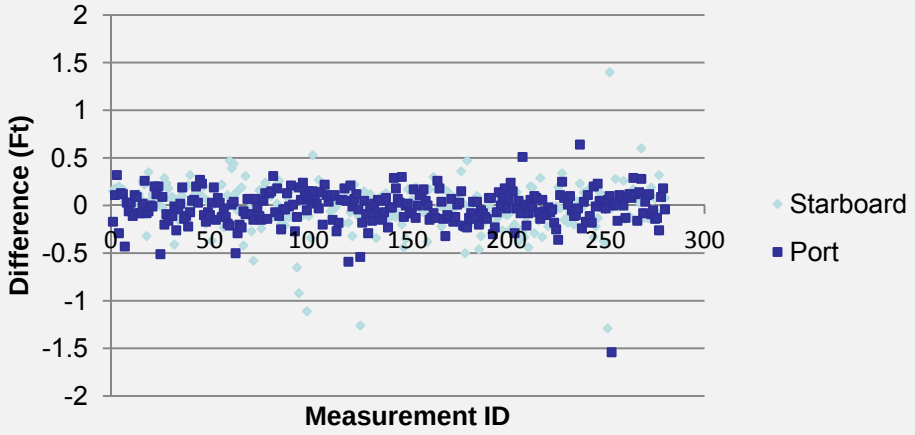
	LL Sta 6	Port Ullage	Difference
Mean	13.427	13.445	- 0.018
Std Dev	1.409	1.212	0.197
Median	13.100	13.230	-0.130

# of measurements: 436

	LL Sta 1	Stb Ullage	Difference
Mean	13.406	13.371	0.035
Std Dev	1.524	1.309	0.215
Median	13.100	13.160	-0.060

# of measurements: 436

2011Terrapin Island River Work - Difference between manual and sensor readings



	LL Sta 6	Port Ullage	Difference
Mean	13.605	13.624	-0.019
Std Dev	1.119	1.116	0.003
Median	13.500	13.555	-0.055

# of measurements: 280

	LL Sta 1	Stb Ullage	Difference
Mean	11.278	11.293	-0.015
Std Dev	0.879	0.855	0.024
Median	11.300	11.350	-0.050

# of measurements: 280

COMPARISON BETWEEN MANUAL AND MECHNICAL SOUNDINGS
2011 NORTH COAST HOPPER MAINTENANCE DREDGING

Condition	Number of Soundings	Average of Manual Soundings (ft)	Average of Mechanical Soundings (ft)	Difference Between Averages (ft)
Bar Work Port Fwd. Sounding Station	436	13.427	13.445	- 0.018
Bar Work Stb. Aft Sounding Station	436	13.406	13.371	0.035
River Work Port Fwd. Sounding Station	280	13.605	13.624	- 0.019
River Work Stb. Aft Sounding Station	280	11.278	11.293	- 0.015
Bar & River Work Port Fwd Sounding Station	716	13.499	13.517	- 0.018
Bar & River Work Stb. Aft Sounding Station	716	12.574	12.543	0.031

Yaquina Data

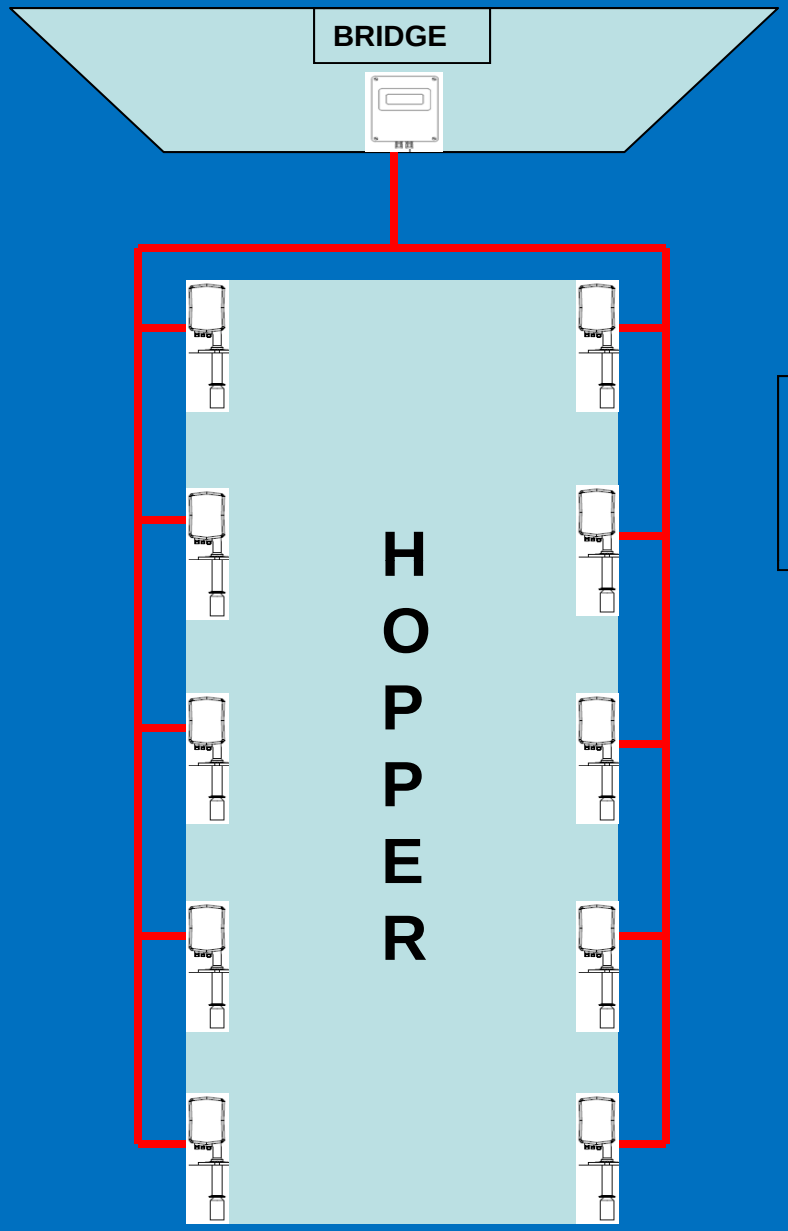
2010	Lead Line	Sensor	Difference
Mean	4.35	4.47	-0.12
Median	3.85	4.00	-0.15
Std dev	1.09	1.10	-0.01

2011	Lead Line	Sensor	Difference
Mean	5.59	5.73	-0.14
Median	4.35	4.40	-0.05
Std dev	2.59	2.71	-0.12

# of measurements 94

Nivobob Evolution to Optimize Measurement Performance

Potential future Nivobob System configuration



Nivobob activation and ullage data logging from bridge

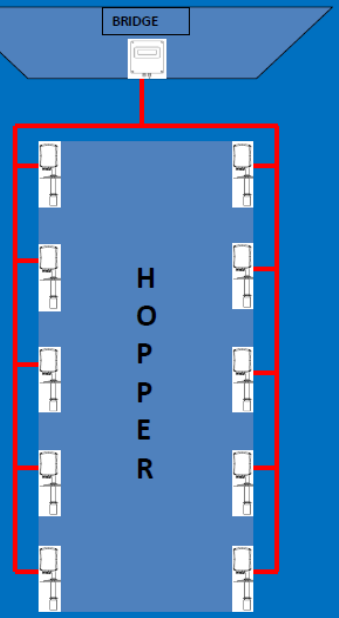
Potential Benefits

- Savings of $10,000 to $15,000 per week in inspection costs

- Improved safety – less time on the deck for inspectors and contractors = reduced safety risk

- More accurate production tracking and cost estimating (Government and contractor hopper dredge operations).

What's Next?



- Possible full scale test as early as summer 2012

- Develop calibration procedure for inclusion into specifications

- Data from 10 ullage sensors would be automated in a stand-alone computer system

- Hand soundings would be collected along side automated ullage sensors to allow data comparisons at the end of the season

- Pending a satisfactory outcome of a full scale test in 2012, ullage sensors could be used for payment in the 2013 hopper contract.

Questions?