THE PHYSICS OF DREDGED MATERIAL PLACEMENT WITHIN NEARSHORE WATERS: AS OBSERVED BY CRAB

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Regional Sediment Management

Clatsop Community College

PROJECT: Dredged sand is being placed within a nearshore location adjacent to the Mouth of the Columbia River (MCR), USA to address a chronic coastal sediment deficit while minimizing impacts to the site's benthic ecology.

MOTIVATION FOR PLACEMENT OF DREDGED MATERIAL IN NEARSHORE ZONE: The nearshore morphology along the south side of the MCR inlet has been receding for many decades compromising the stability of the MCR inlet, jetties, and navigation channel. Progressive loss of shoreface morphology (sand) at the MCR also degrades the benthic substrate for nearshore ecology. **Solution:** Implement **R**egional **S**ediment **M**anagement.

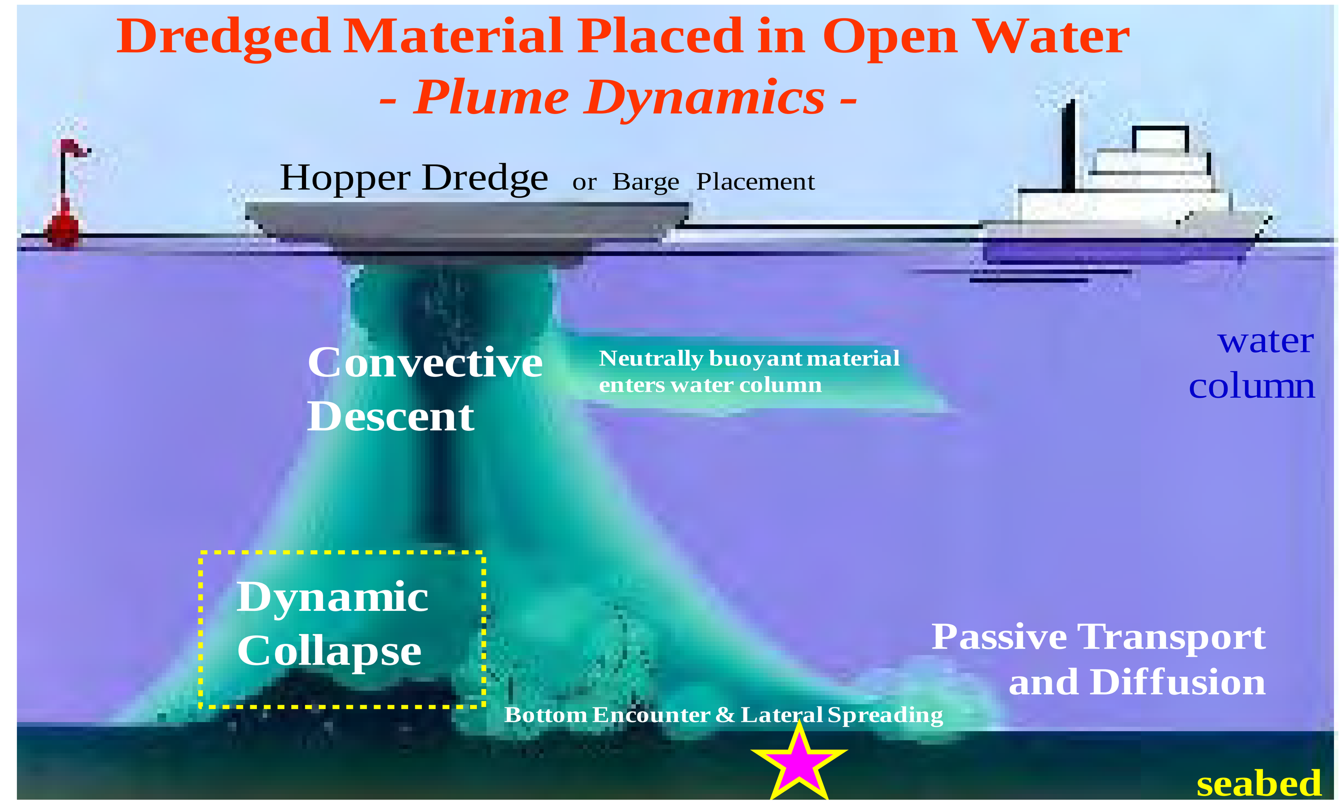
Regional Sediment Management (RSM) sustains water resource projects, that interact with natural sediment processes, by implementing balanced approaches for managing affected sediment. An objective of RSM is to emulate the natural system of sediment transport pathways that may be affected by a project: To Work with Nature, Not Against.

At engineered coastal inlets where navigation channels are maintained through dredging, RSM coordinates dredged material placement activities to:

-> Sustain processes affecting the natural sediment budget and morphology,
-> Stabilize Infrastructure dependent upon ephemeral coastal morphology,
-> Improve efficiency of dredging maintenance for navigation projects, and
-> *Protect Ecology affected by natural sediment processes or dredged material placement*.

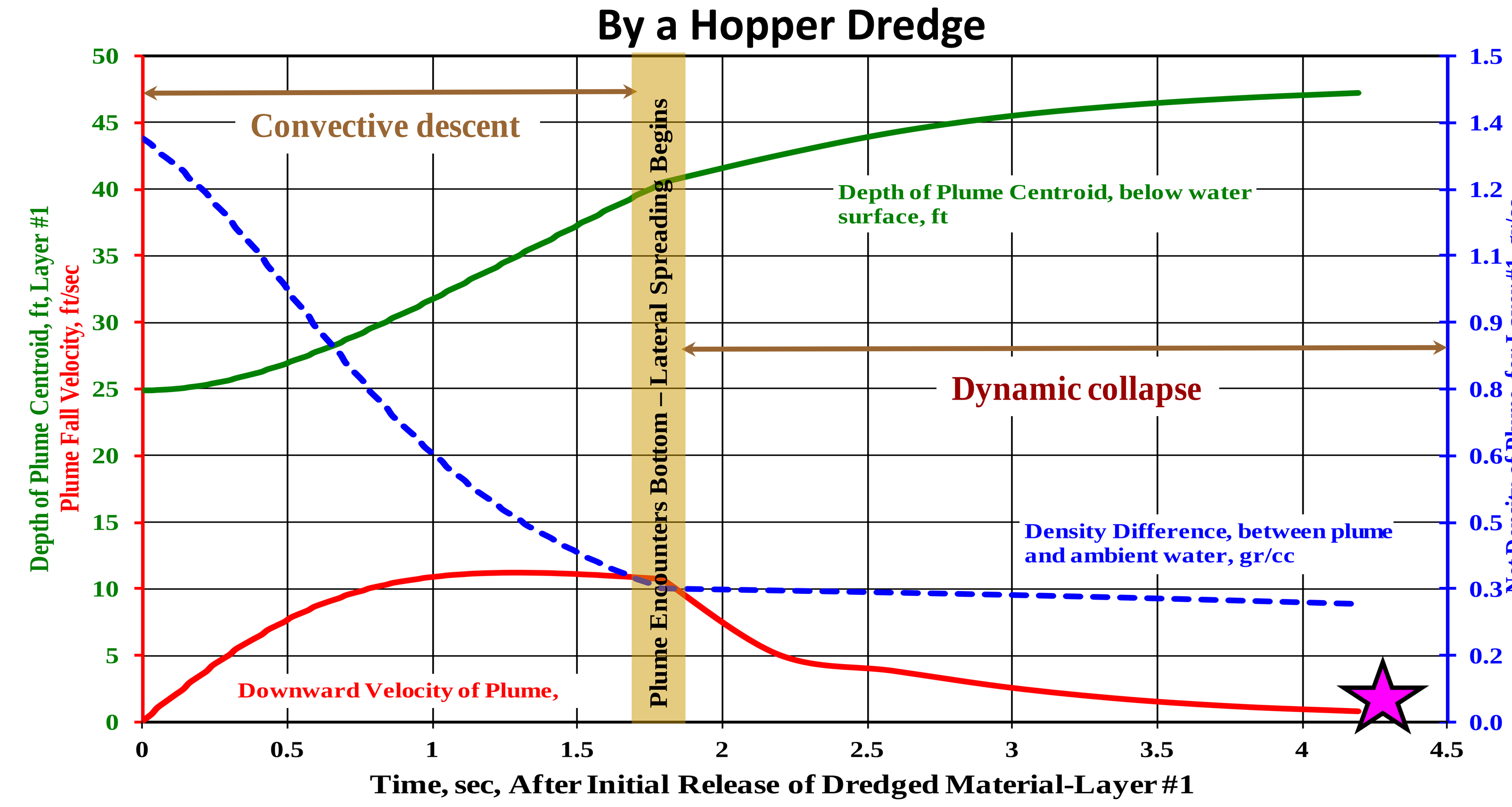
THIS POSTER: Summarizes In-situ observations of dredged material deposition on the seabed, when placed in nearshore waters of the PAC-NW, USA. Predictions for the physics affecting bottom deposition (of placed dredged material) are consistent with observations. Initial observations indicate that bottom dwellers like Dungeness crab (Metacarcinus magister) may not be adversely affected by dredged material placement.

Deployable "deposition meter", designed for simplified deployment and retrieval similar to crab pots. A video camera, was attached to the deposition meter mount, and recorded in-situ deposition and bottom-encounter physics resulting from dredged material placement. A staff gauge was attached to the center support element of the deposition meter. Three deposition meters were fabricated and deployed; each 13 inch high and 40 inch base dia. Photo, concept, and fabrication by CURTIS ROEGNER-NOAA.

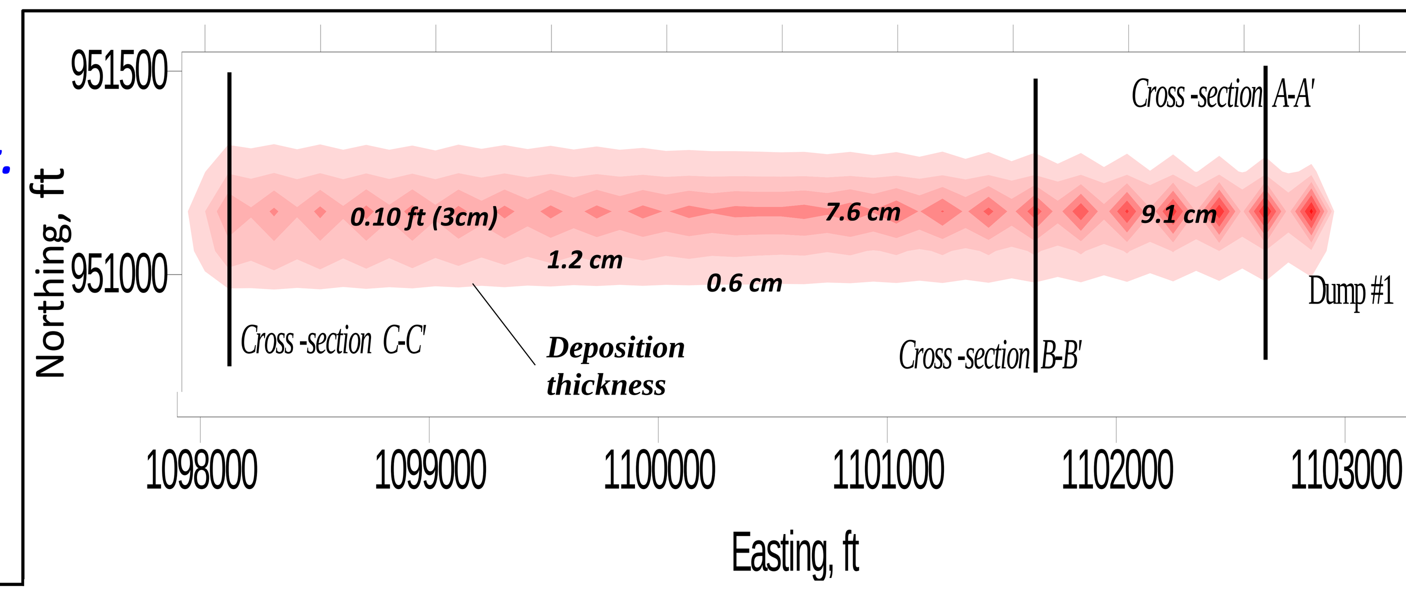


When dredged material is released in open water by a disposal vessel, the material falls through the water column, mixes with ambient water, and forms a plume. This process is called convective descent. **When the dredged material plume encounters the bottom (river bottom or seabed), the downward moving plume slows its descent and spreads radially along the seabed. This process is called dynamic collapse and is the focus of this poster.** After the plume has expended all of its momentum along the seabed, the dredged material slowly settles under the influences of gravity and the ambient current environment. This process is called passive transport and diffusion. The STAR indicates approximate event timing for video frames shown below . Computer models MDFATE (Moritz and Randall 1995) and STFATE (Johnson and Fong 1995) can be used to evaluate plume dynamics and deposition aspects of dredged material placed in open water. Example results are shown to the right and below.

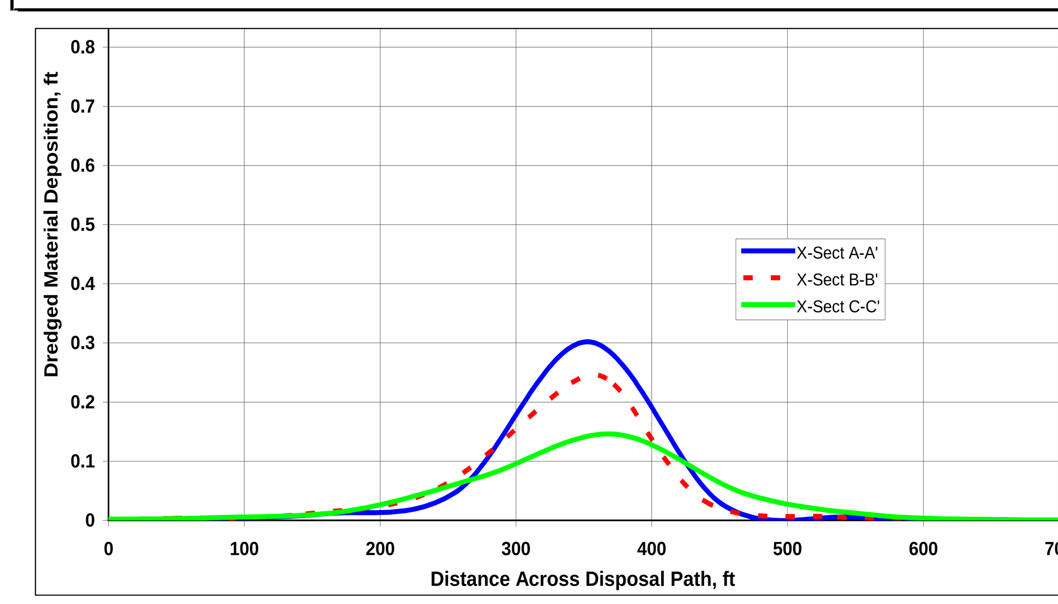
Dynamics of Dredged Material During Placement in Open Water By a Hopper Dredge



Summary metrics for a simulated dredged material plume, formed when 3,000 cubic yards (2300 cm) of dredged sand is placed in open water (total depth of 50 ft) by a hopper dredge. Three (3) time-varying metrics are shown at the **START** of a dredged material placement run: Downward velocity of the plume, Net density of the plume, and depth of plume centroid. The initial release point is at the bottom of the hopper dredge hull, 20 ft below the water surface. The computations of dredge material behavior begin with the centroid of the sand plume is 5 ft below the hull. At this point, the dredged material falling out of the hopper dredge has a bulk density of 2.34 g/cc. The plume density is rapidly reduced due to mixing with ambient water during convective descent. When the leading edge of the plume encounters the seabed, **dynamic collapse** begins. At this point, the plume centroid is located 10 ft above the seabed moving with downward velocity of 11 ft/sec (plume bulk density has been reduced to 1.3 gr/cc) . As the plume continues to encounter the seabed, its downward velocity is decelerates and the plume spreads radially outward along the seabed. Toward the END of the dredged material placement activity, the plume dynamics are most active within 5-10 ft of the seabed. The **STAR** indicates approximate event timing for video frames shown below .



MDFATE simulation of seabed deposition resulting from open water placement of dredged material by the *Essayons*. The amount of dredged material released along a 5,000 ft placement transect was 5,500 cy. Seabed elevation varied from -40 to – 53 ft MLLW along the path of the hopper dredge during disposal run (proceeding from east/right to west/left). Maximum thickness of deposited dredged material, via model simulation, varied from 0.1 to 0.30 ft (3 to 9 cm) along the disposal transect. Three (3) cross-sections: A-A', B-B', and C-C' are shown in the figure to the right. Deposition asymmetry is due to cross-current and *Essayons* draft reduction during dredged material placement. The dredged material originates from the MCR federal navigation channel and is classified as fine-medium sand (average D50 = 0.2 mm), having less than 3% fines content.



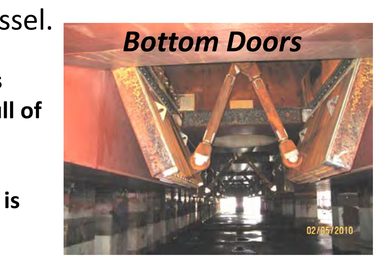
Bottom deposition of dredged material placed in open water , shown in terms of cross-sections: A-A', B-B', and C-C'. Section A-A' is located near the beginning of the disposal run (simulated for the *Essayons*). C-C' is located near the end of the disposal run. The width of the deposition along the disposal transect varies from 350 ft to 500 ft.

The *Essayons*

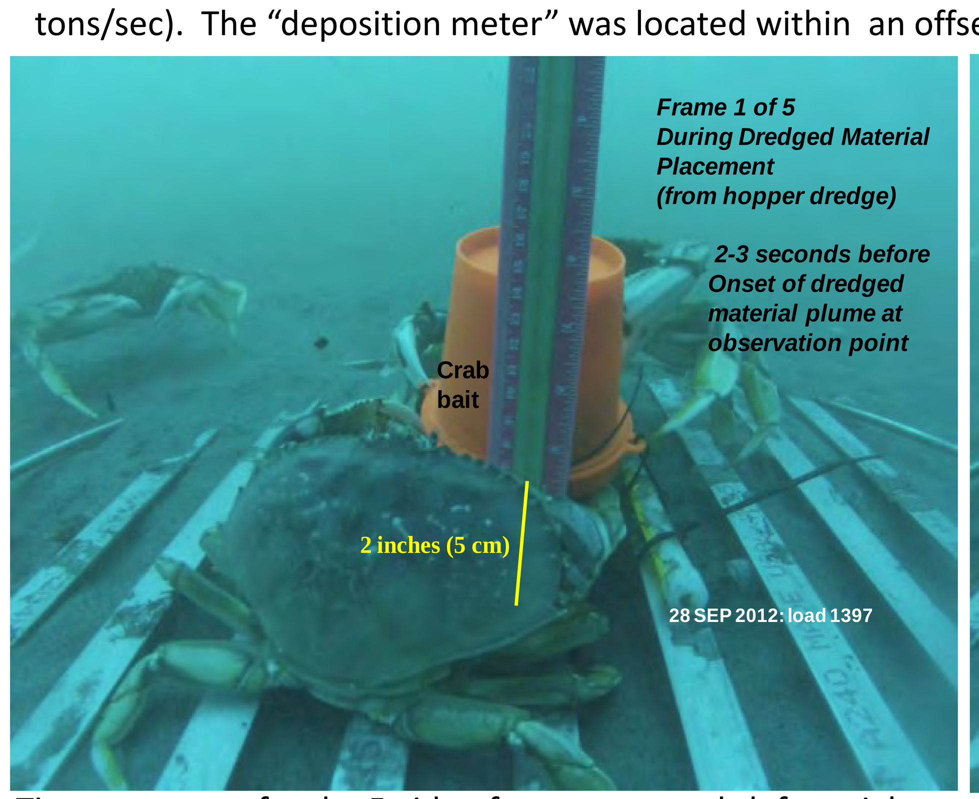
The hopper dredge *Essayons* utilizes a series of 12 doors located on the hull bottom to sequentially release each load of dredged material. resulting in a gradual release of dredged material from the vessel.

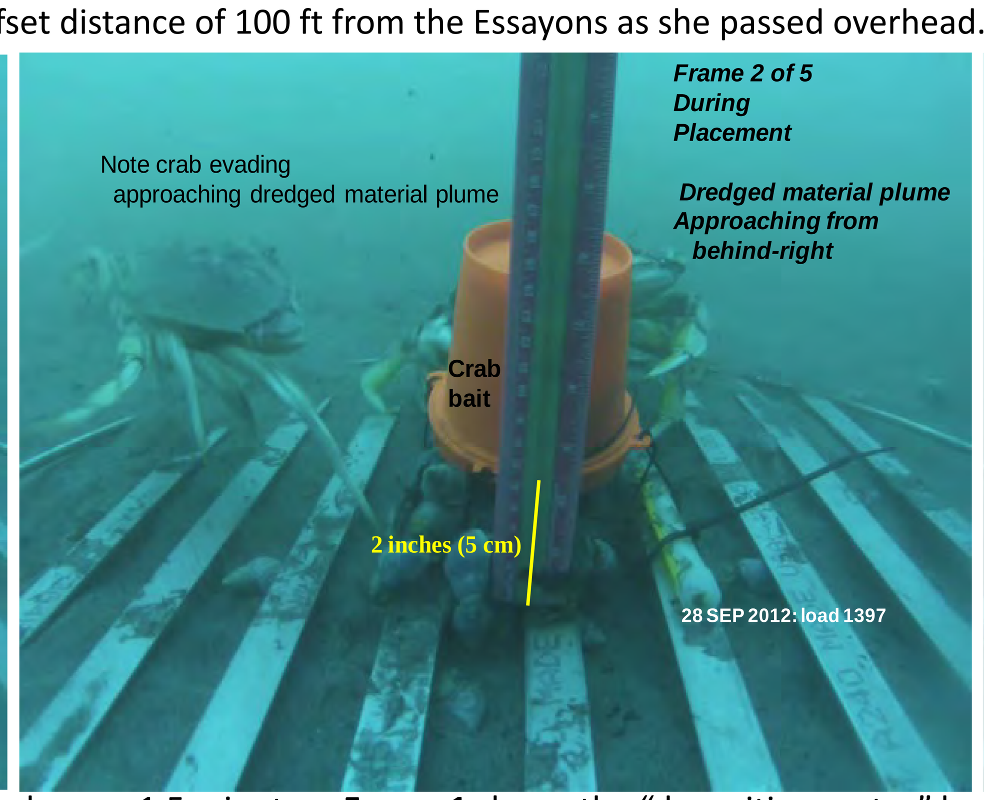
Bottom doors on bottom hull of *Essayons*.

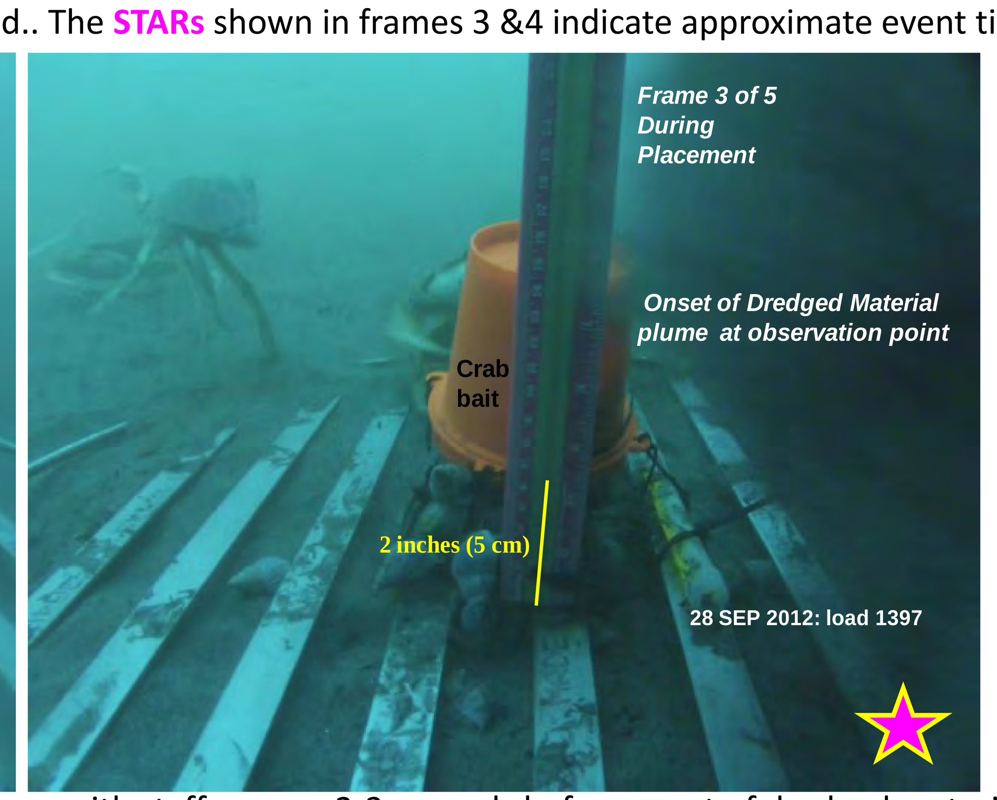
Each opening is 8ft x 8ft.

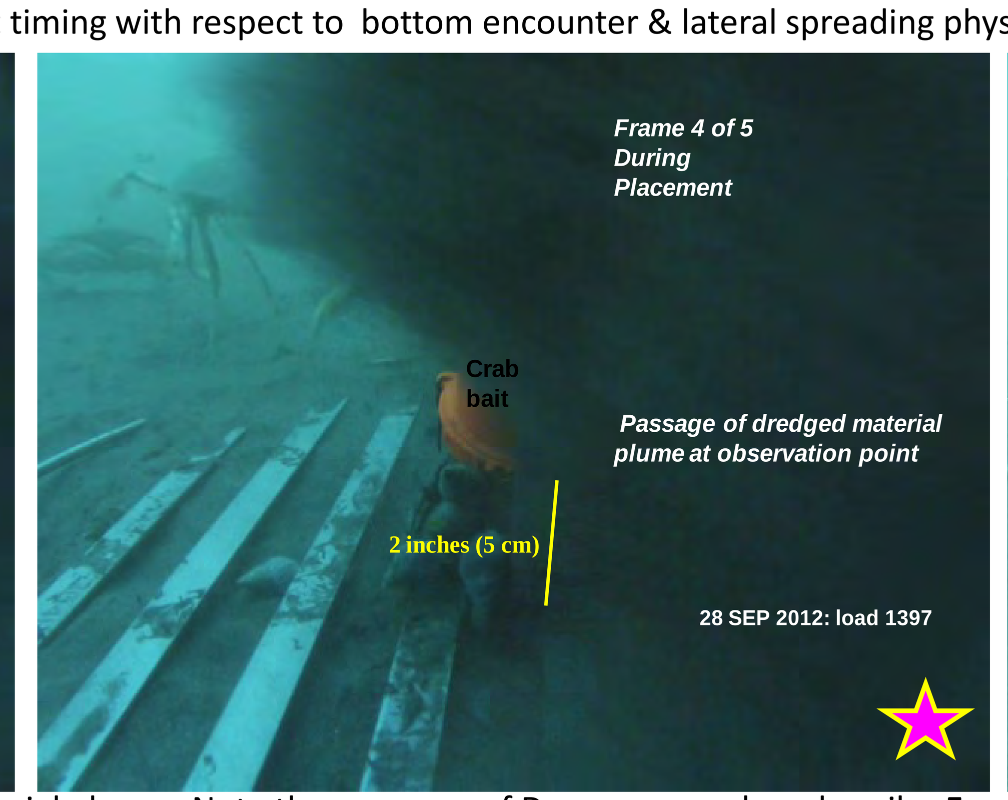


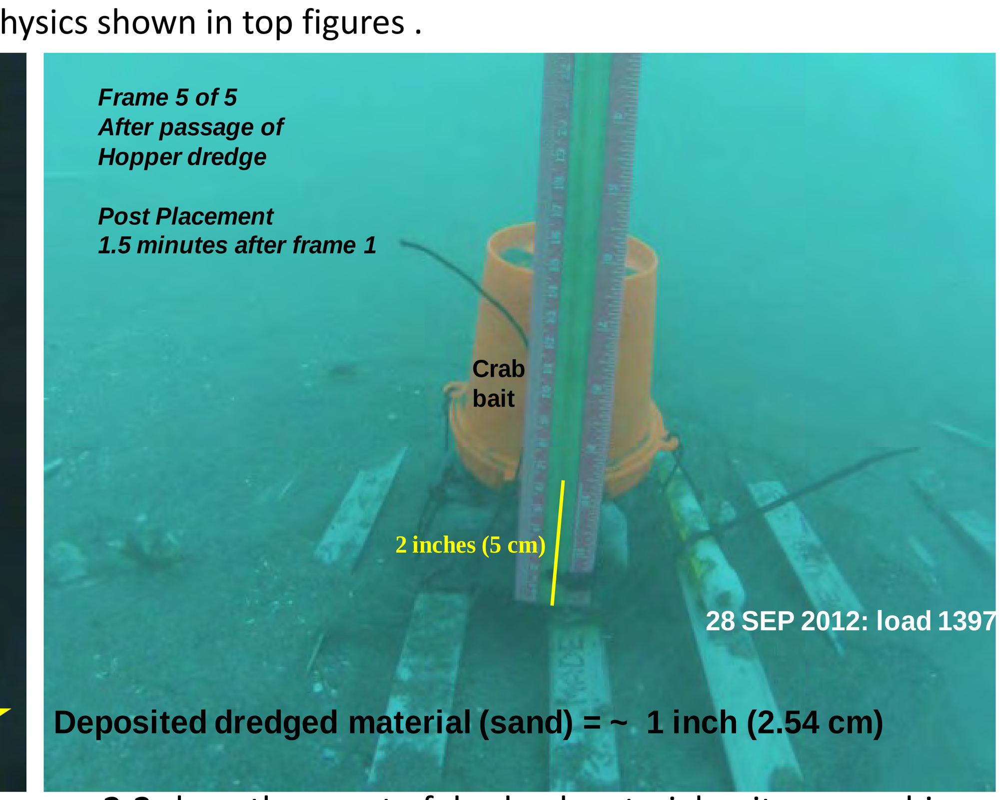
The below video images were obtained from NOAAs "deposition meter" positioned below a hopper dredged during placement of dredged material (fine-medium sand) on 28 SEP 2012. The "deposition" meter was deployed on the seabed in water depth of 50 ft, 1 mile south of the Mouth of the Columbia River. The hopper dredge *Essayons* transited over the "deposition meter" as it placed 5,500 cubic yards (4200 cubic meters) of sand in 50 ft water depth for load 1397. Dredged material was released uniformly from the hopper dredge along the 5,100 ft long placement transect, as verified by integrated KDGPS vessel tracking and vessel displacement measurements. The amount of dredged material released into the water column (per unit length along the 5,100-ft placement transect) was 1.1 cubic yard/ft (or 1.3 tons/ft). The rate of dredged material release during the 17-minute placement event was 5.4 cubic yards/sec (or 6.8 tons/sec). The "deposition meter" was located within an offset distance of 100 ft from the Essayons as she passed overhead.. The **STARs** shown in frames 3 &4 indicate approximate event timing with respect to bottom encounter & lateral spreading physics shown in top figures .











Time-sequence for the 5 video frames proceeds left to right and spans 1.5 minutes. **Frame 1** shows the "deposition meter" base with staff-gauge, 2-3 seconds before onset of dredged material plume. Note the presence of Dungeness crab and snails. **Frames 2-3** show the onset of dredged material as it approaching from the right-hand side of the image. The dredged material has already encountered the seabed after release from the hopper dredge, and is spreading laterally & radially along the seabed as a plume of sediment as it approaches the "deposition meter". **Frame 4** shows passage of the dredged material plume . The plume's lateral speed along the seabed is estimated to be 8-10 ft/sec as it passes through the field of view. Note the crabs evading the approaching sediment plume in frames 1-4. **Frame 5** shows post-placement sediment deposition for load 1397 after passage of sediment plume. Maximum bottom deposition within field of view (due to dredged material placement) is estimated to be 1 inch (2.5 cm). Two other dredged material placement events were also monitored using the NOAA "deposition meter", during 28 SEP 2012. Maximum deposition observed for all 3 events was estimated to be 3.5 inches (9 cm). Crab sensed and evaded the approaching dredged material plume. Previous laboratory testing indicted that Dungeness crab can withstand bottom surging current of 10-13 ft/sec (and related shear) and rapid burial events of 4 to 6 inches depending upon molting stage (Pearson et al 2006).