USGS Pacific Coastal and Marine Science Center

Coastal Dynamics
Coastal Change
Ecosystems

Geologic Hazards
Earthquakes
Tsunamis

Marine Resources
Marine Structure
Minerals

Administration

Environmental Labs

Communications

Field Operations and Equipment Development

Information Technology

Nearshore Disposal of Fine-grained Sediment in a High-Energy Environment

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U.S. Geological Survey,
Pacific Coastal and Marine Science Center
Santa Cruz, CA

versus

QUESTION: *Does fine-grained dredge material impact the coast, and if so, how does it compare to natural processes???*

An outline for today…..

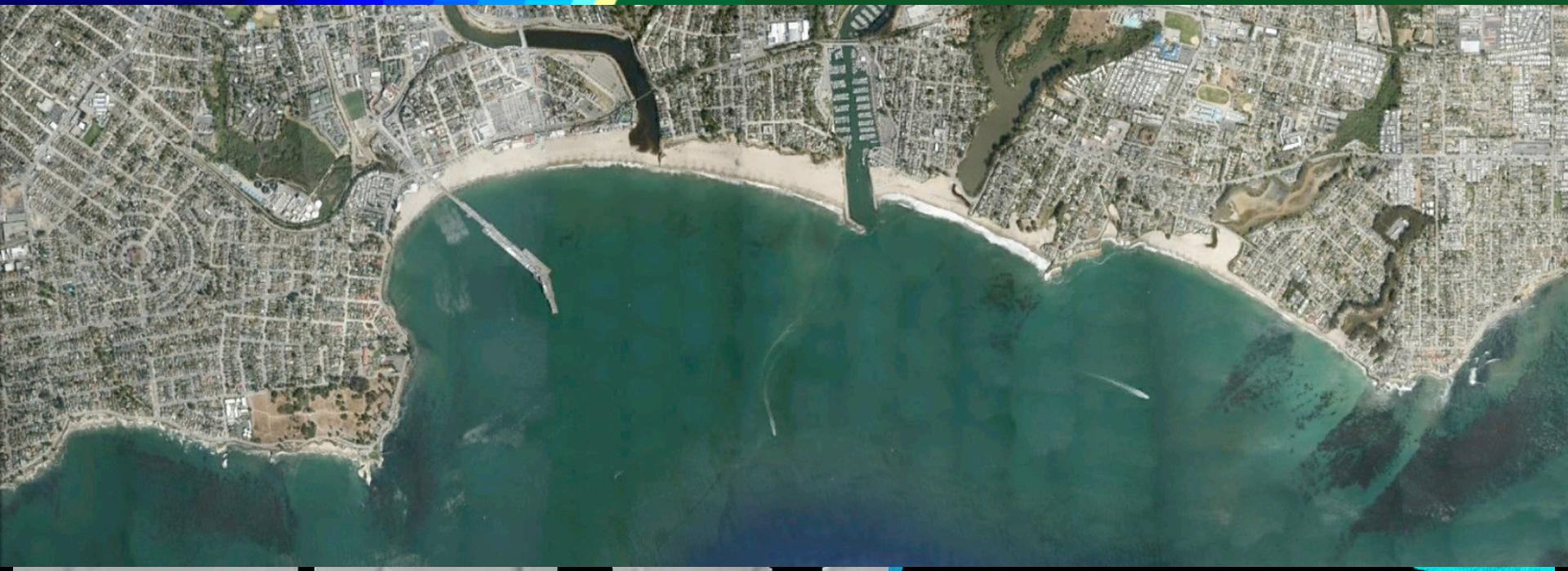
1) "The issue"

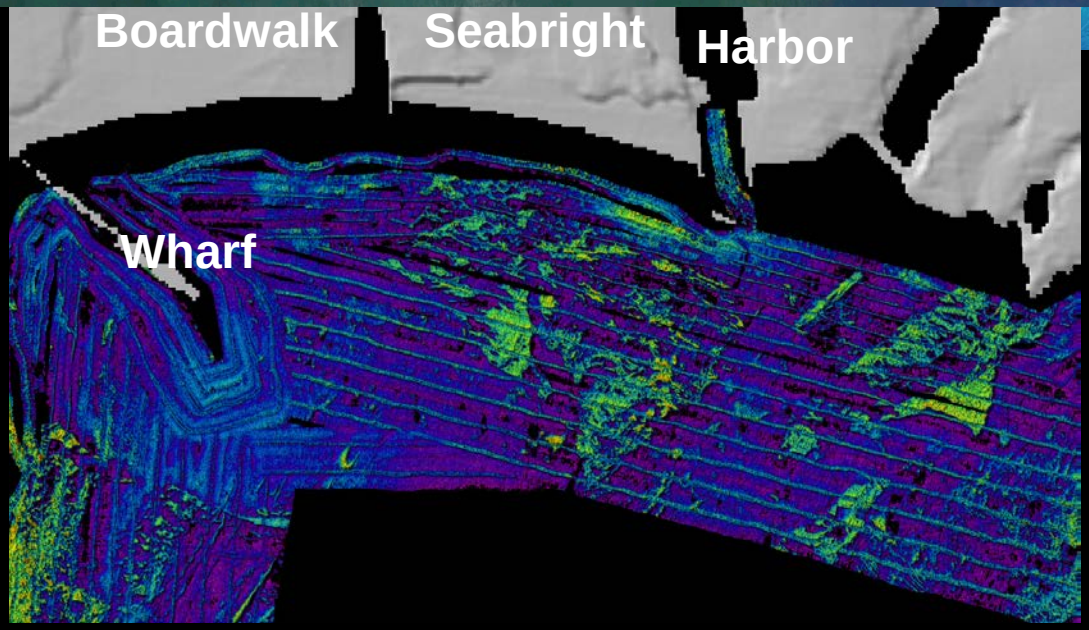
2) Some history…

3) The experiment

4) The results

5) Implications of results to the disposal of fine-grained dredge material in the nearshore





Substrate
Rock
Sand

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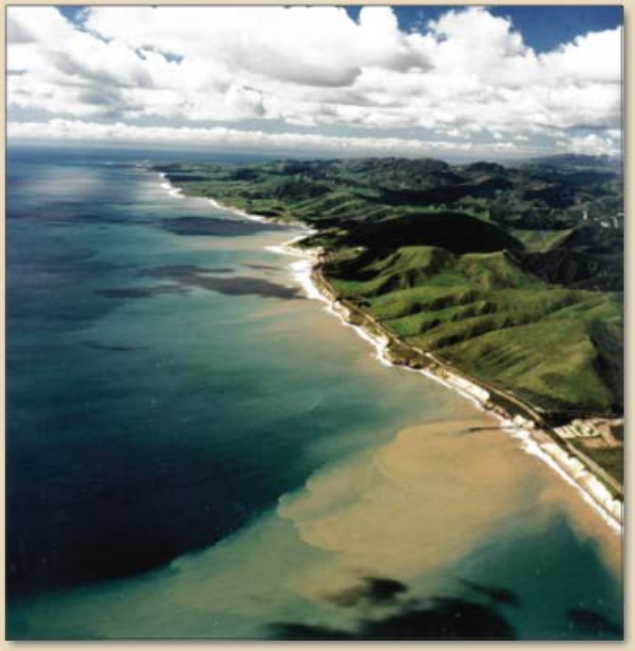
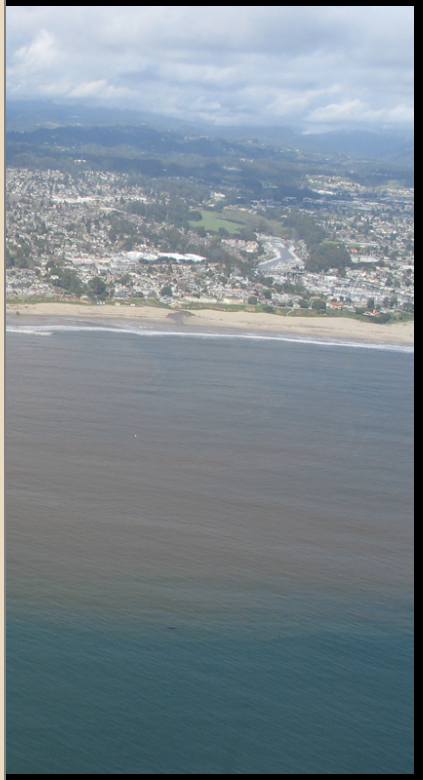
Sources, Dispersal, and Fate of Fine Sediment Supplied to Coastal California



Scientific Investigations Report 2007–5254

U.S. Department of the Interior
U.S. Geological Survey



"The issue"

Erosion happens…

The "80:20" Rule

The Monterey Bay National Marine Sanctuary ***REALLY*** does not like dumping on its protected natural resources

UNITED STATES CODE OF FEDERAL REGULATIONS, TITLE 15, PART 922.40 "PROHIBITED ACTIVITIES"

Some history….

2000: The McLaren STA report…*and associated legal maneuvers*

2001: The Moss Landing Marine Lab report

March: ~2300 m^3 at 40:60

2005: The Sea Engineering, Inc. reports

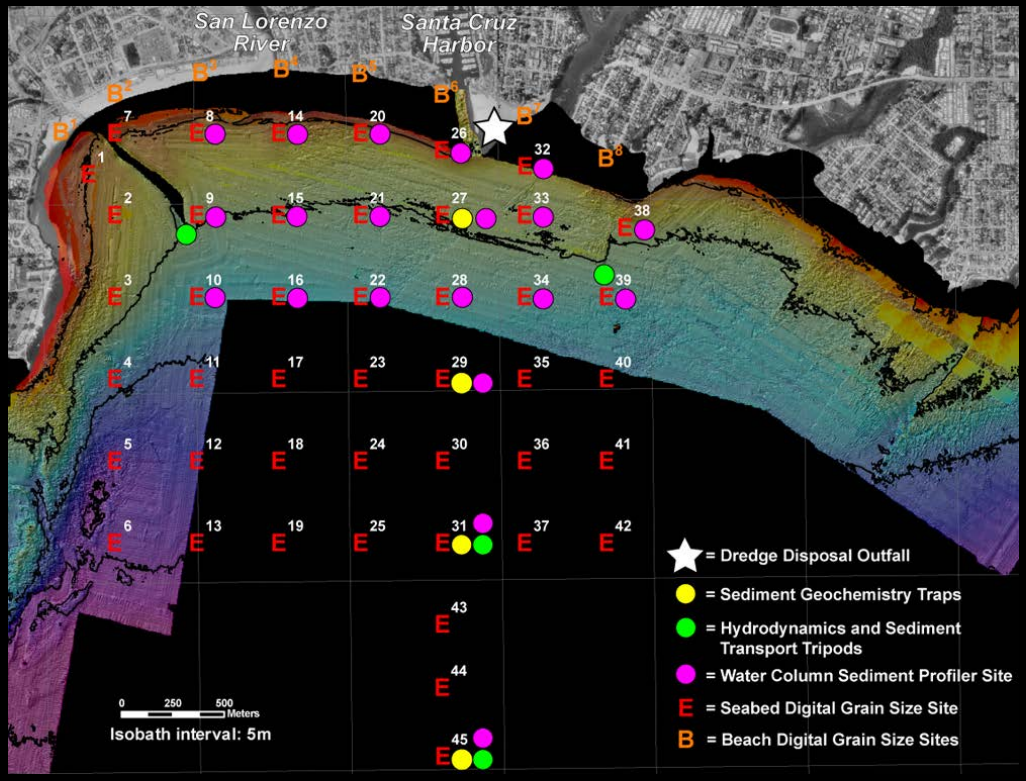
Feb-Apr: ~5400 m^3 at 80:20 and Oct: ~5000 m^3 at 30:70

2009: The U.S. Geological Survey's turn….

Oct-Nov: ~7600 m^3 at 30:70

The 2009 USGS experiment's goals

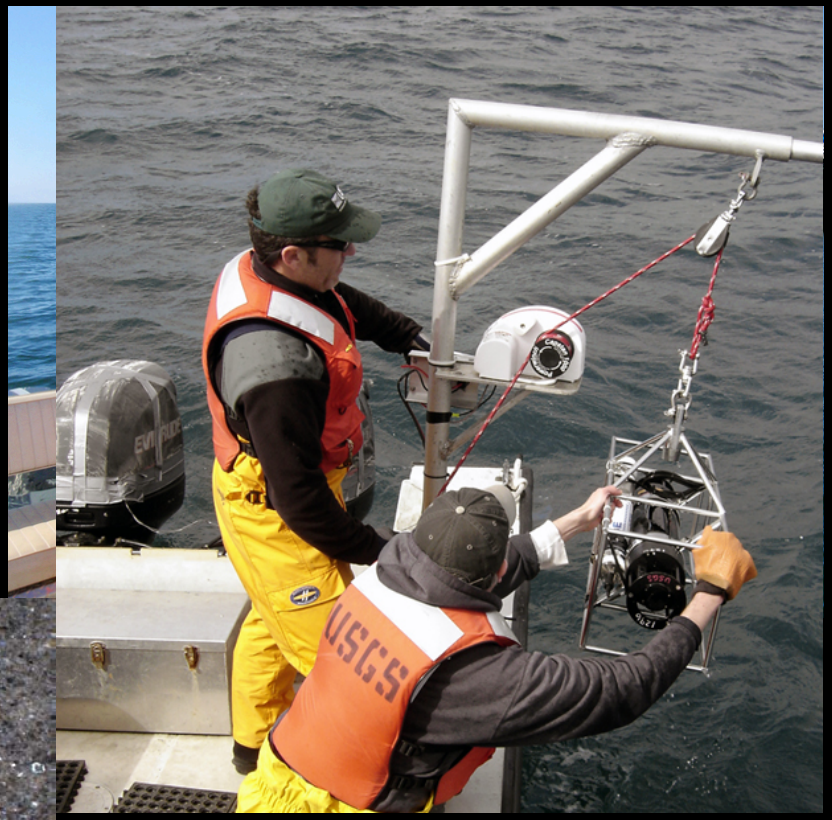
1) Determine if fine-grained dredge material ***is stable*** on the beach and inner shelf, and if not, ***why***?



2) If the fine-grained dredge sediment is not stable, ***where*** does it go?

Determine if fine-grained dredge material is stable on the beach and inner shelf

Measure water column, beach, and seabed response (change in turbidity or grain size) to determine if change, and thus ***impact***, occurs



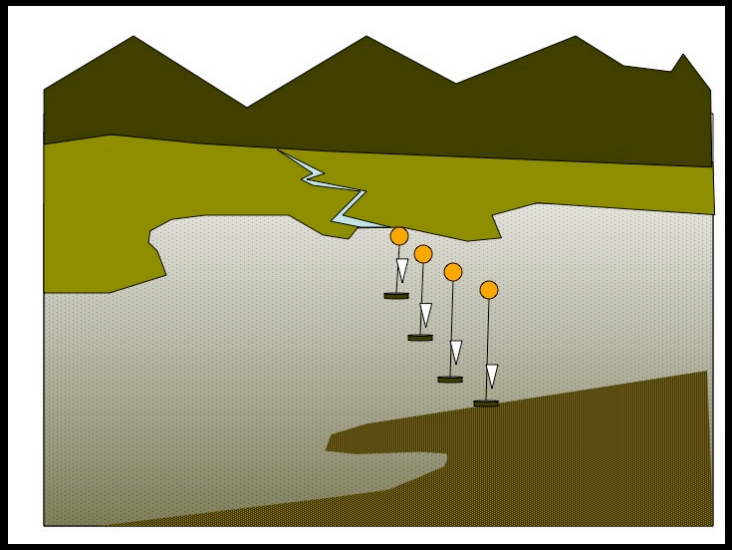
If fine-grained dredge material is (or is not) stable on the beach and inner shelf, why?

Measure ***forcing*** (tides, waves, and currents) using instruments and determine if hydrodynamics are sufficient to ***allow*** or ***inhibit deposition*** of fine-grained material on the beach and inner shelf

Deployment of hydrodynamic and sediment transport tripods from the *R/V Shana Rae*

Where does the fine-grained dredge material go if it is not stable on the beach and inner shelf?

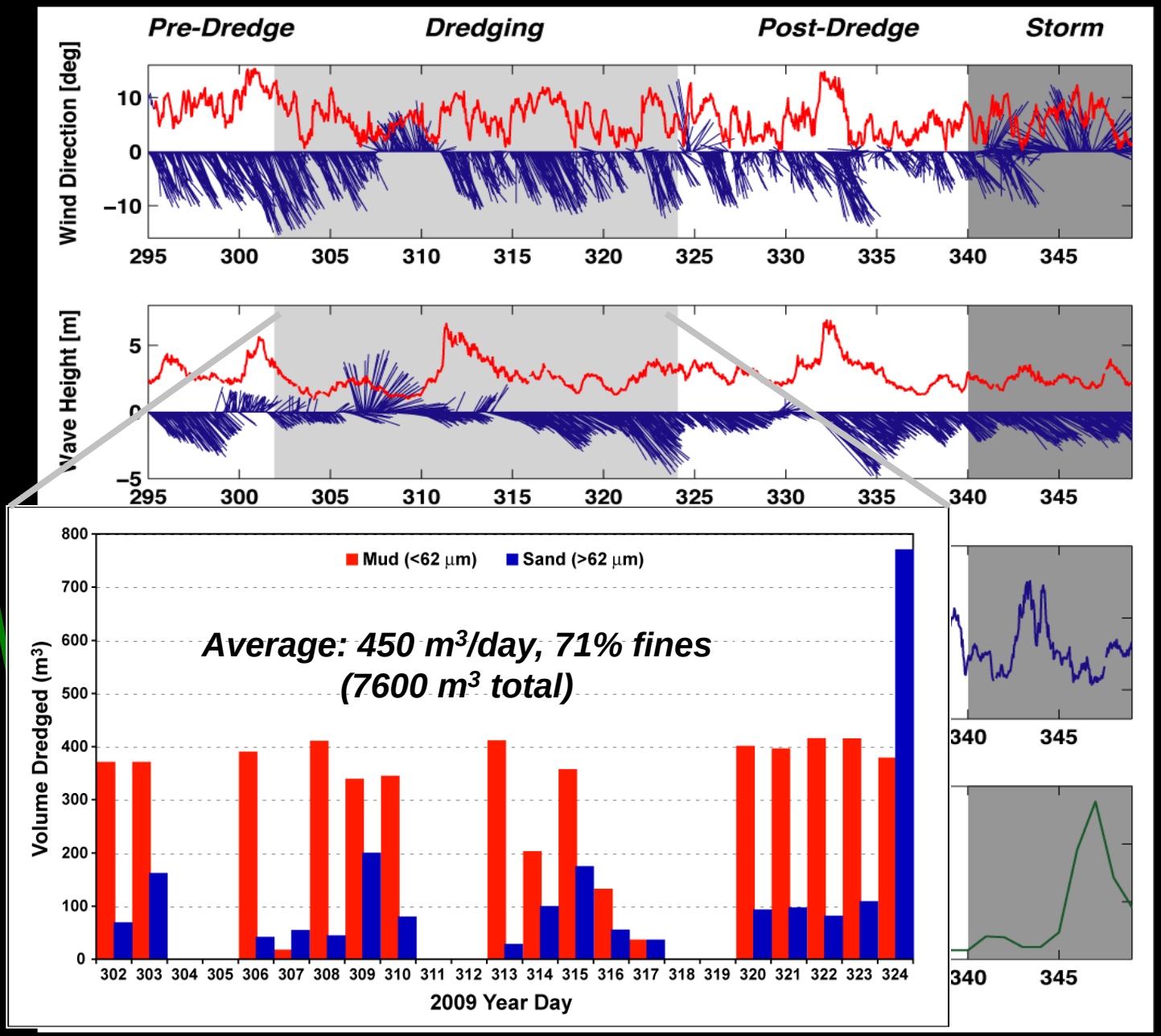
1) Measure ***sediment flux*** using tripods *(What are sediment concentrations, where are they going, and how fast?)* and sediment traps *(Is sediment relict, fluvial, or dredge material?)*



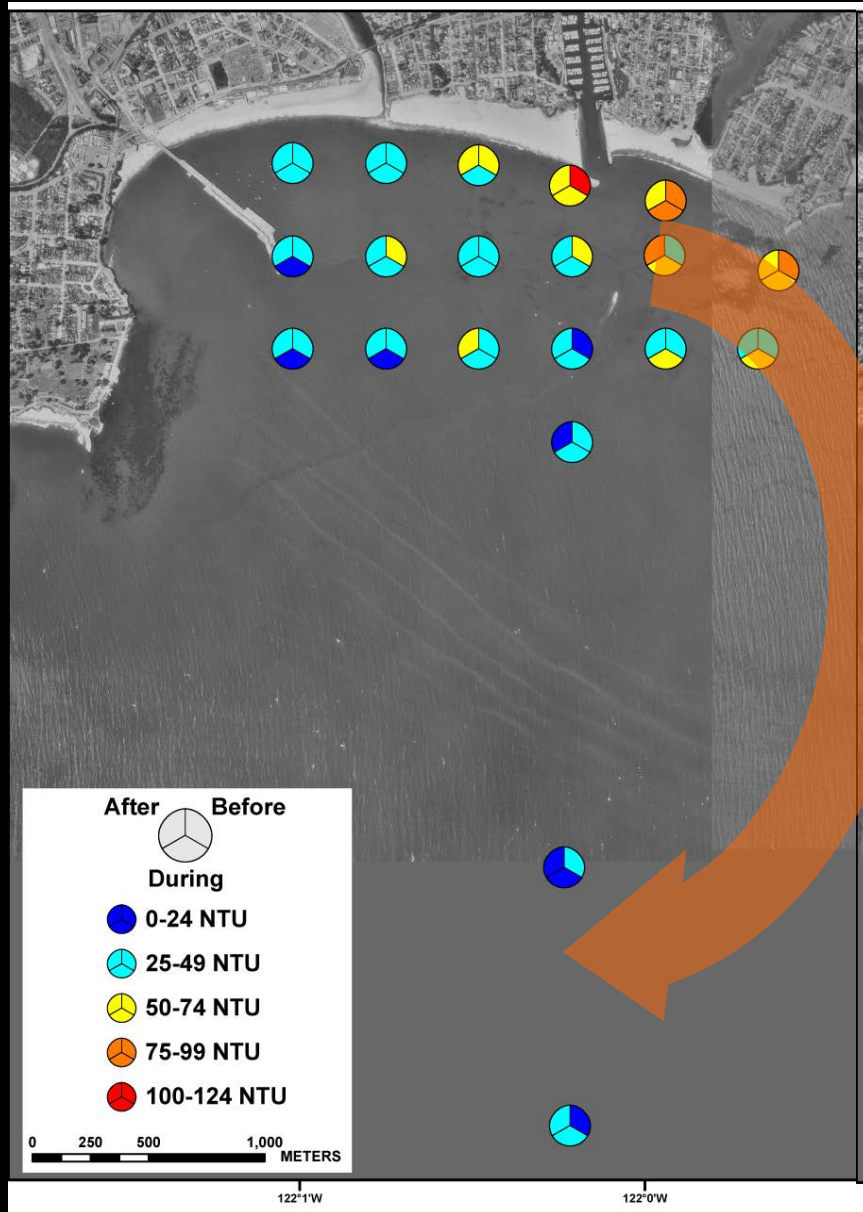
2) ***Model*** dredging using Delft3D

Using geochemistry to determine sediment origin

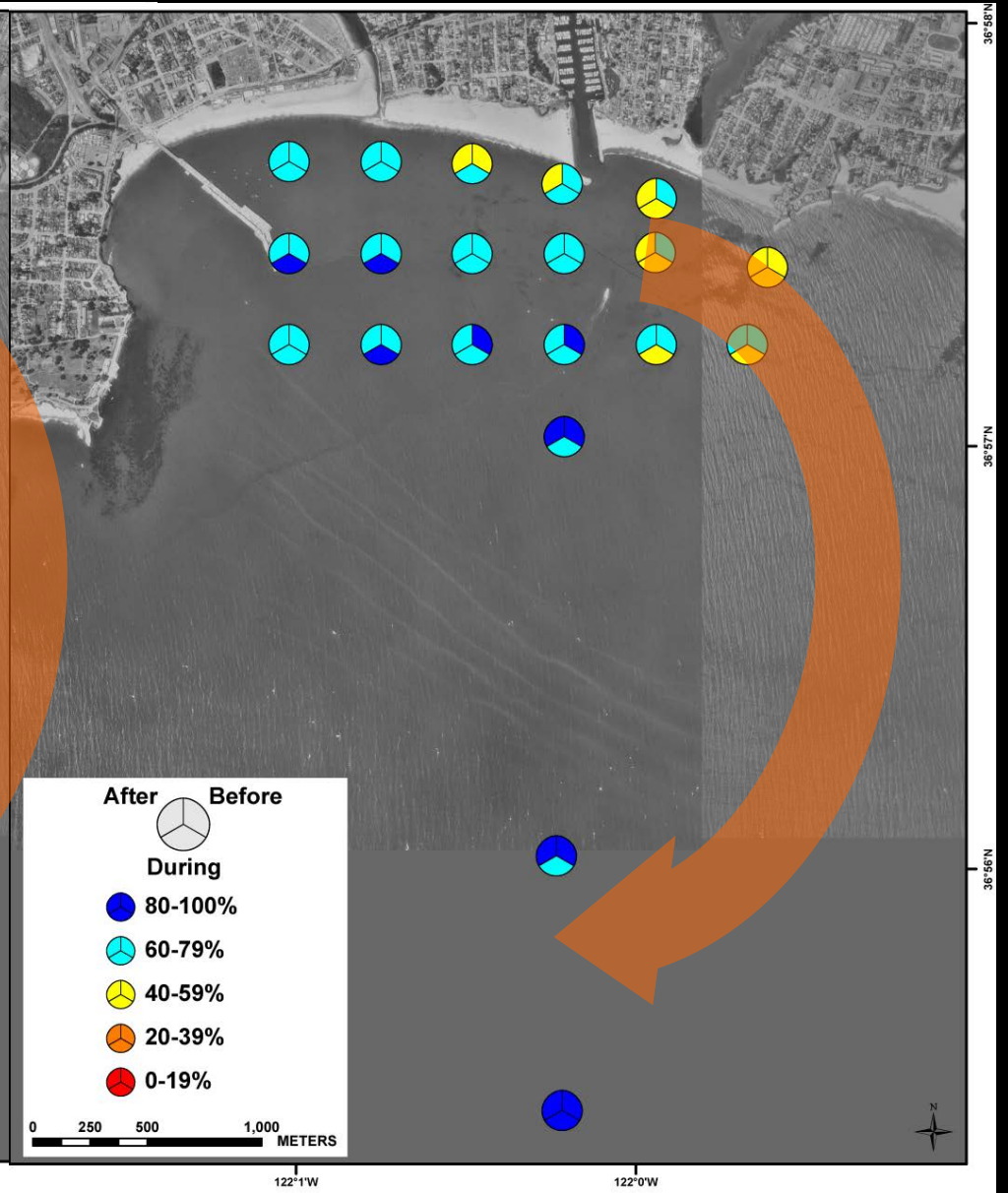
Dredge sediment:	High Cu, low ^{7}Be
Relict shelf sediment:	Low Cu, low $^{7}Be/^{210}Pb_{xs}$, low ^{7}Be
New fluvial sediment:	Low Cu, high $^{7}Be/^{210}Pb_{xs}$, high ^{7}Be



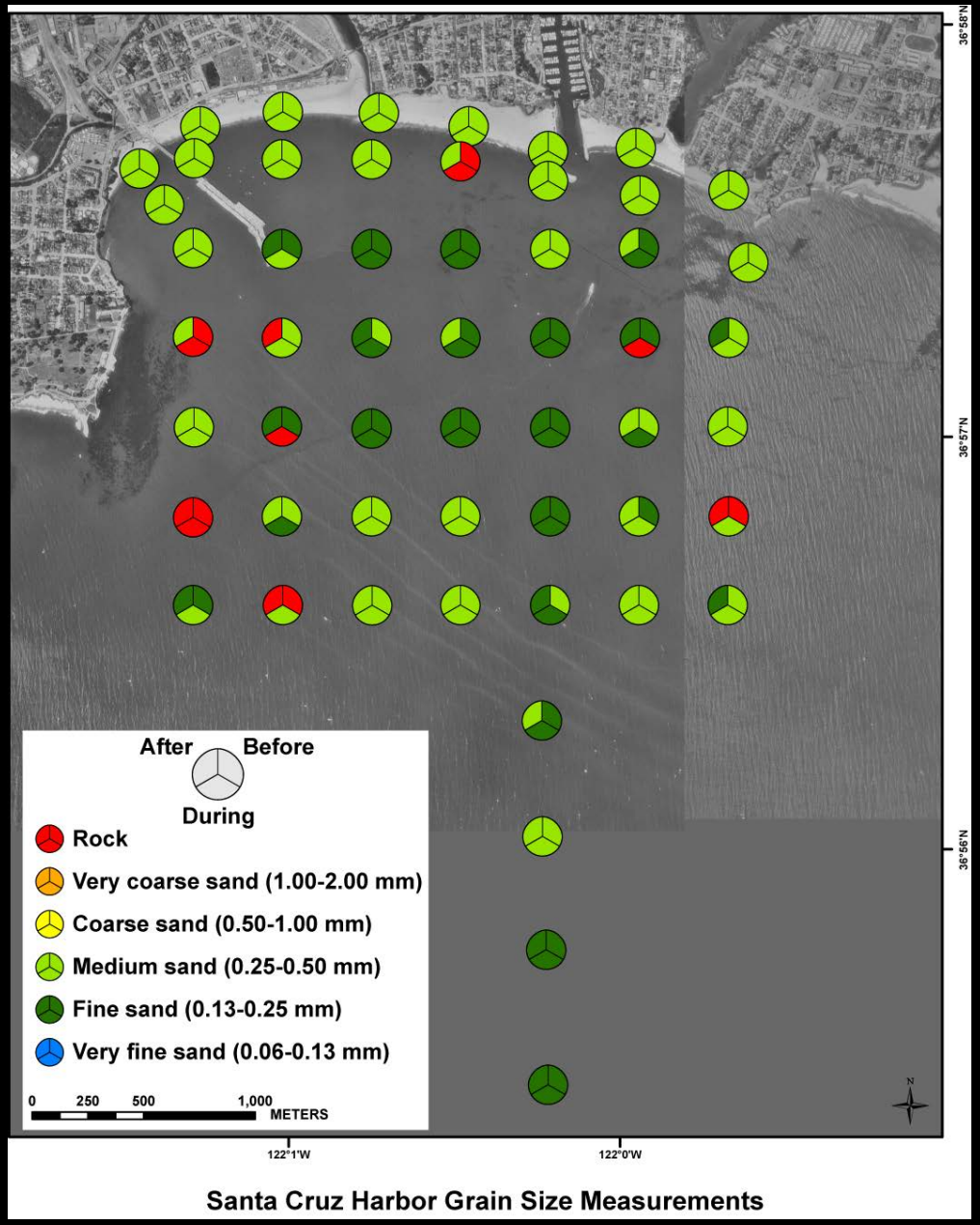
remnants of Super Typhoon Melor ~48 m³/m



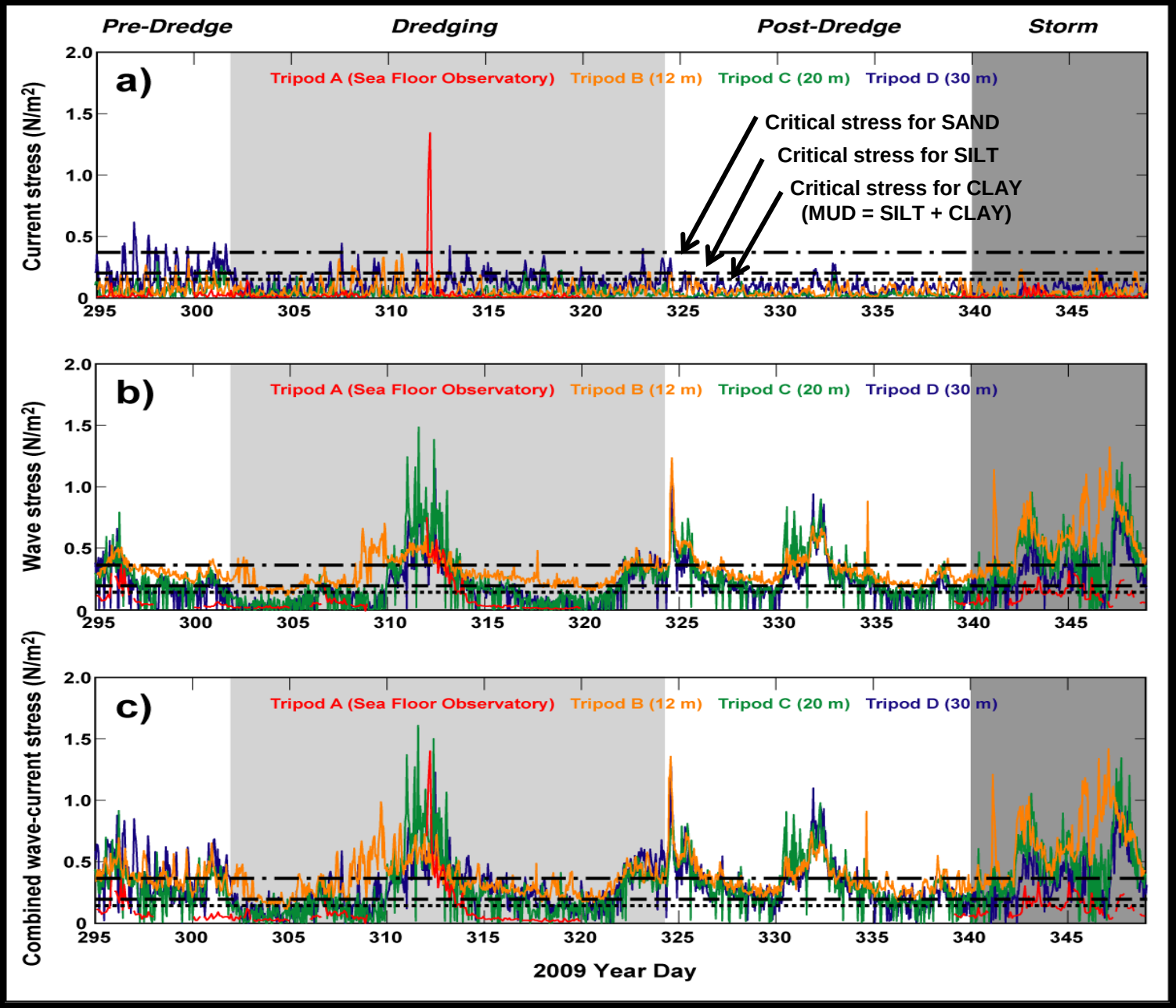
Santa Cruz Harbor Turbidity Measurements

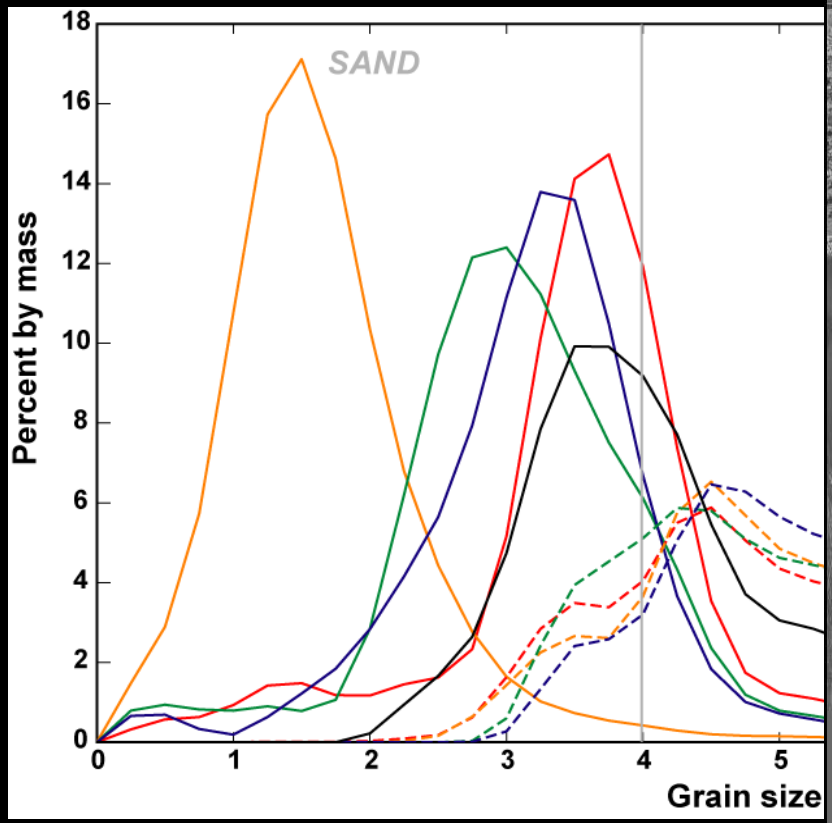


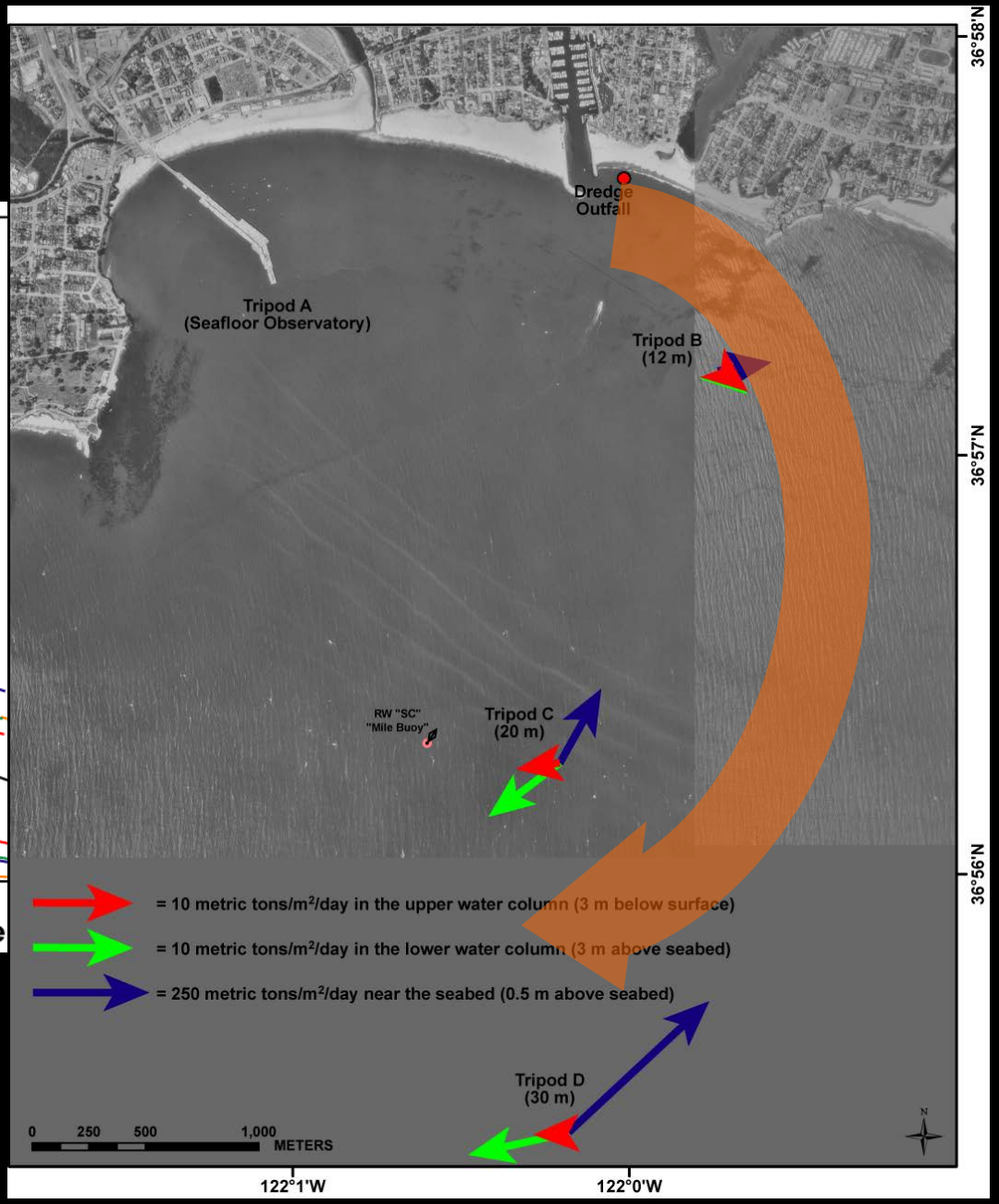
Santa Cruz Harbor Light Transmission Measurements

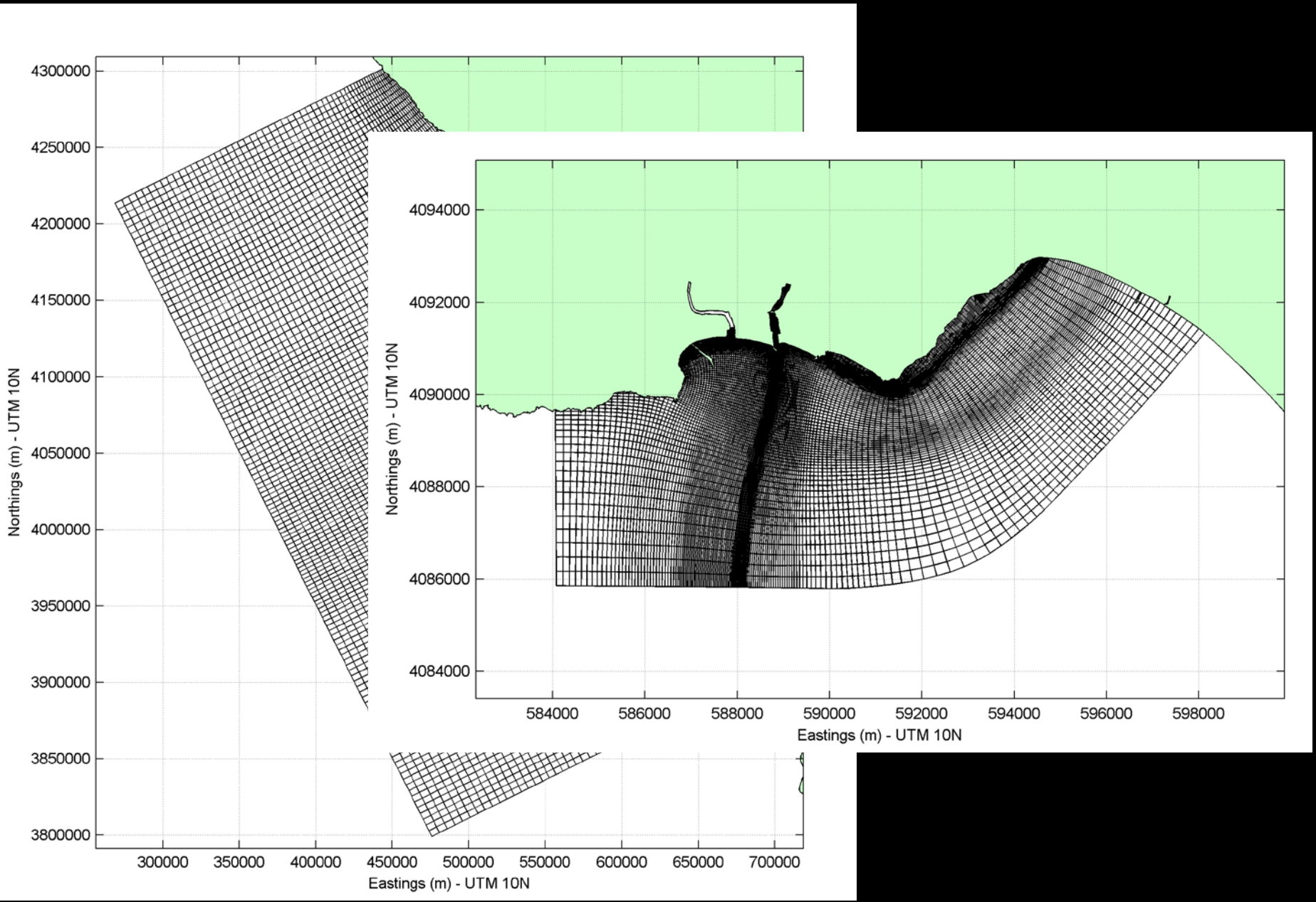


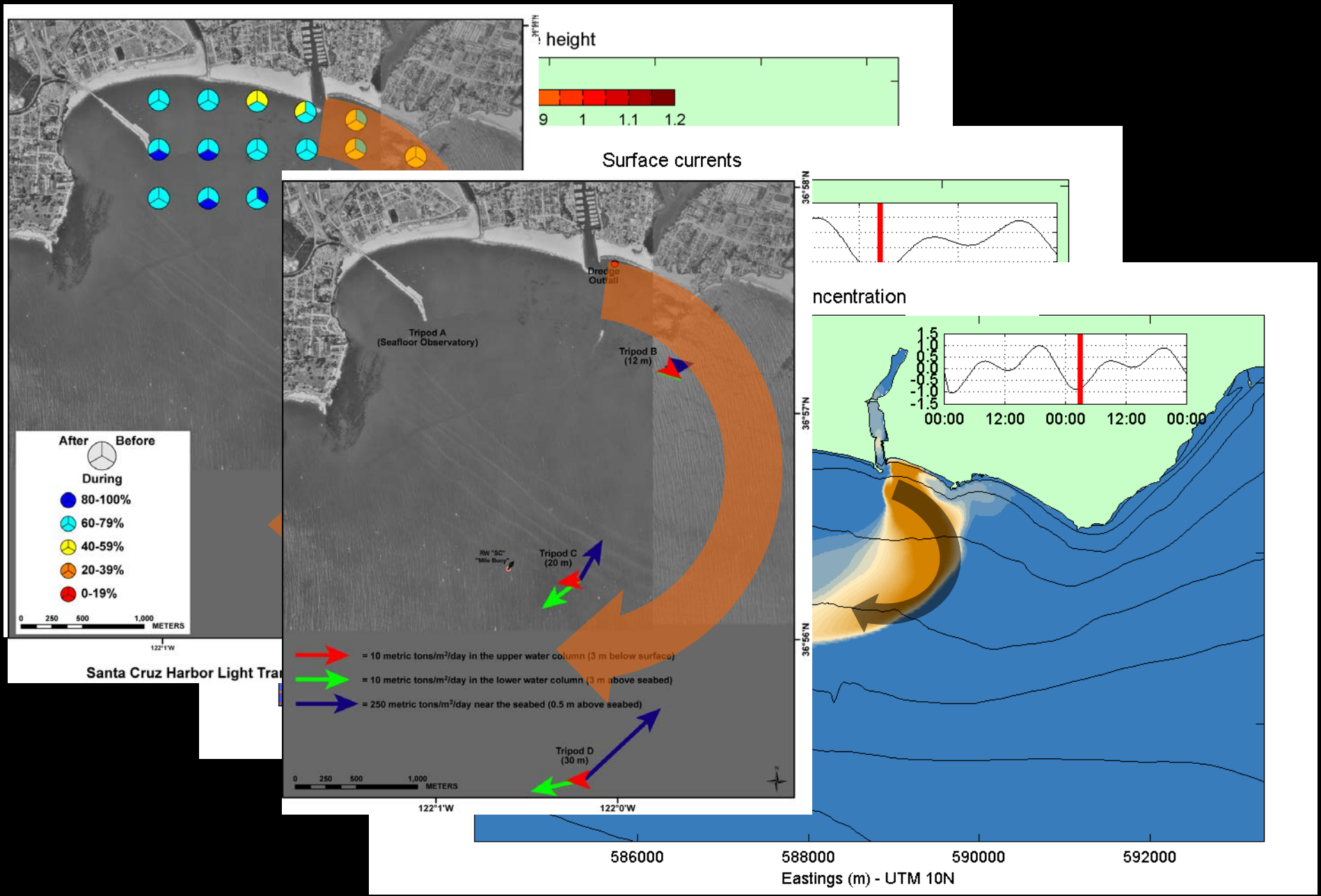
Santa Cruz Harbor Grain Size Measurements


Pre-Dredge
Dredging
Post-Dredge
Storm
a)
b)
c)
Tripod A (Sea Floor Observatory)
Tripod B (12 m)
Tripod C (20 m)
Tripod D (30 m)
Critical stress for SAND
Critical stress for SILT
Critical stress for CLAY
(MUD = SILT + CLAY)
Current stress (N/m²)
Wave stress (N/m²)
Combined wave-current stress (N/m²)
2009 Year Day


SAND
Percent by mass
Grain size
0
2
4
6
8
10
12
14
16
18
0
1
2
3
4
5


Dredge Outfall
Tripod A
(Seafloor Observatory)
Tripod B
(12 m)
RW "SC"
"Mile Buoy"
Tripod C
(20 m)
= 10 metric tons/m²/day in the upper water column (3 m below surface)
= 10 metric tons/m²/day in the lower water column (3 m above seabed)
= 250 metric tons/m²/day near the seabed (0.5 m above seabed)
Tripod D
(30 m)
0
250
500
1,000
METERS
N
36°58'N
36°57'N
36°56'N
122°1'W
122°0'W


4300000
4250000
4200000
4150000
4100000
4050000
4000000
3950000
3900000
3850000
3800000
Northings (m) - UTM 10N
300000
350000
400000
450000
500000
550000
600000
650000
700000
Eastings (m) - UTM 10N
4094000
4092000
4090000
4088000
4086000
4084000
Northings (m) - UTM 10N
584000
586000
588000
590000
592000
594000
596000
598000
Eastings (m) - UTM 10N

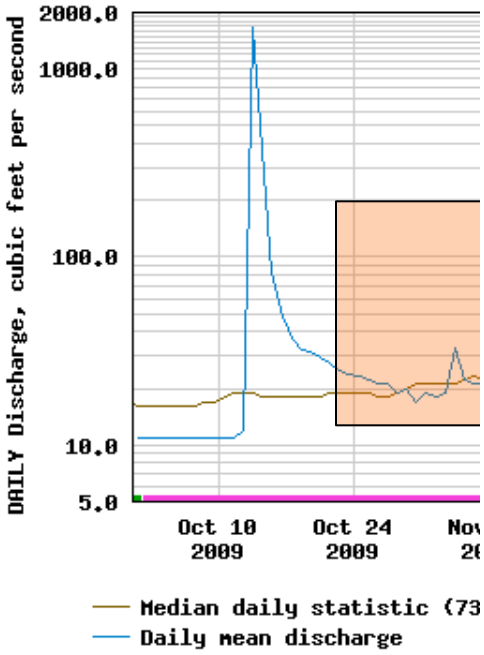

height
9
1
1.1
1.2
Surface currents
ncentration
Tripod A
(Seafloor Observatory)
Tripod B
(12 m)
Tripod C
(20 m)
Tripod D
(30 m)
Dredge
Outfall
After
Before
During
80-100%
60-79%
40-59%
20-39%
0-19%
0
250
500
1,000
METERS
= 10 metric tons/m²/day in the upper water column (3 m below surface)
= 10 metric tons/m²/day in the lower water column (3 m above seabed)
= 250 metric tons/m²/day near the seabed (0.5 m above seabed)
122°1'W
122°0'W
36°58'N
36°57'N
36°56'N
00:00
12:00
00:00
12:00
00:00
586000
588000
590000
592000
Eastings (m) - UTM 10N

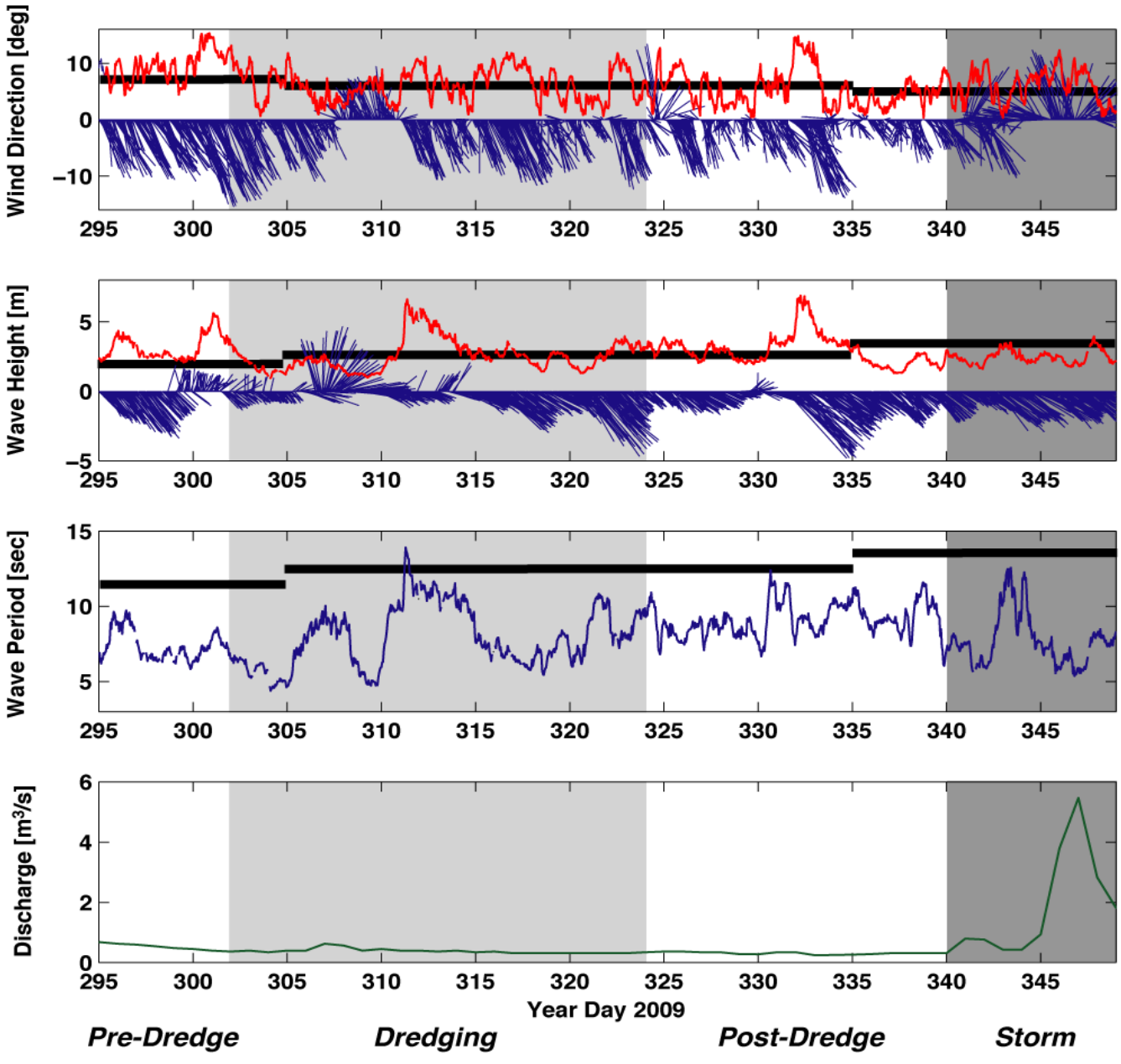
USGS science for a changing world

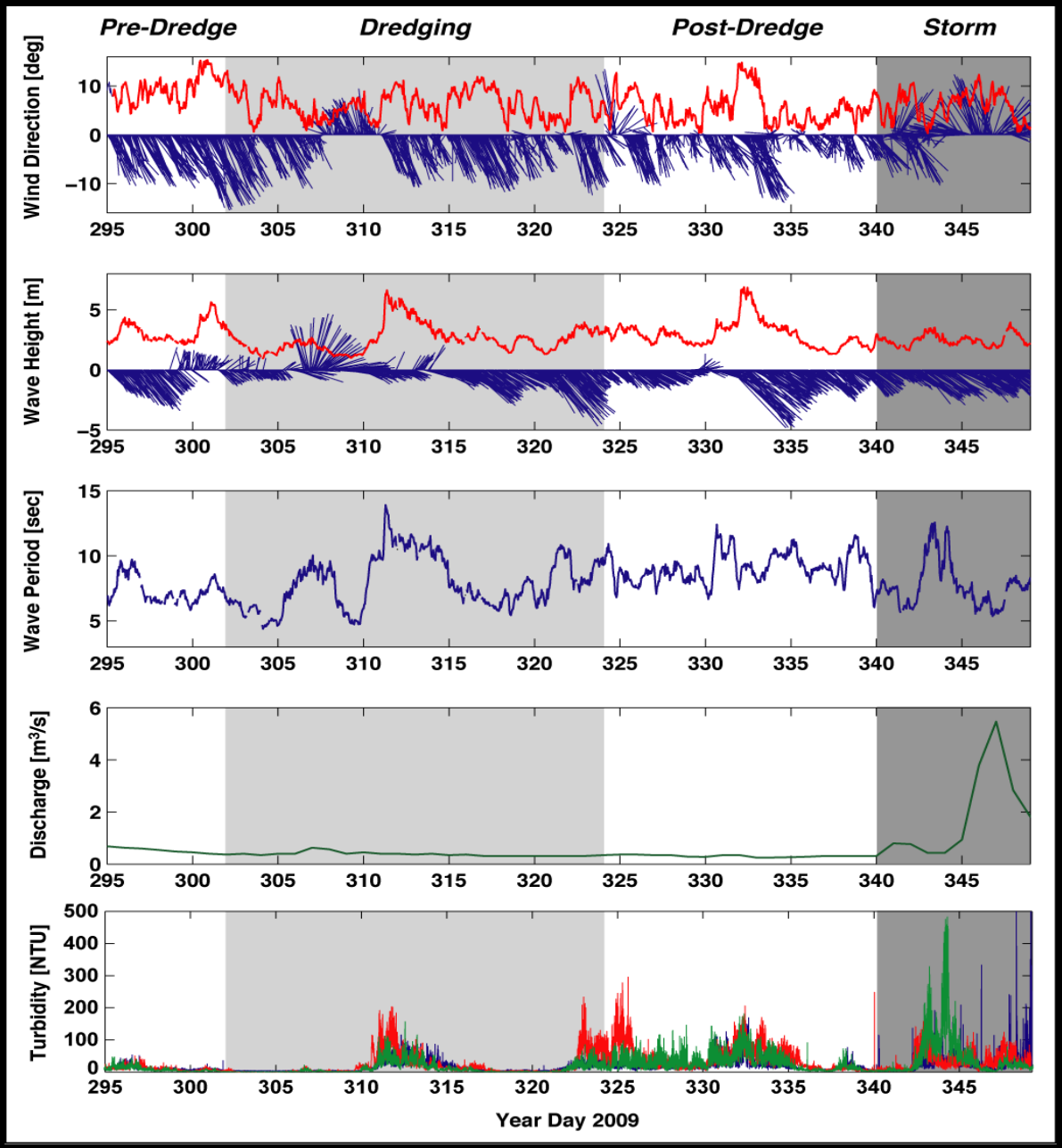
Spatial and Temporal Variations in O
and Meteorologic Forcing Along the
California Coast, 1980–2002

USGS

USGS 11160500 SAN L






Pre-Dredge
Dredging
Post-Dredge
Storm
Wind Direction [deg]
Wave Height [m]
Wave Period [sec]
Discharge [m³/s]
Turbidity [NTU]
Year Day 2009

Conclusions

1) Turbidity was observed during the dredge disposal operations; there was no detectable deposition either on the beach or inner shelf.

2) Measurements and numerical model results suggest that fine-grained dredge sediment was transported offshore to the southwest.

3) The experiment occurred during more benign conditions than typically observed during the time frame based on existing climatologies.

4) Together, these suggest the findings presented here are indicative of the system.

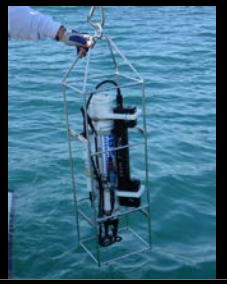
Tijuana Fine Sediment Fate and Transport Demonstration Project

Project:

-Goat Canyon debris basin receives ~30,000 m^3/yr.
-Clean, sorted sediment placed on beach (2008, 2009).
-Sediment is ~40% silt and clay.
-USGS conducted physical science and monitoring

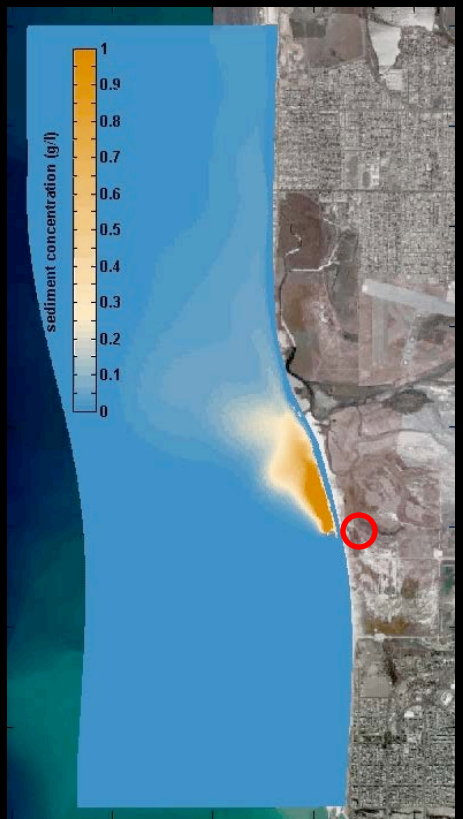
Tijuana Fine Sediment Project
Monitoring and Analyses

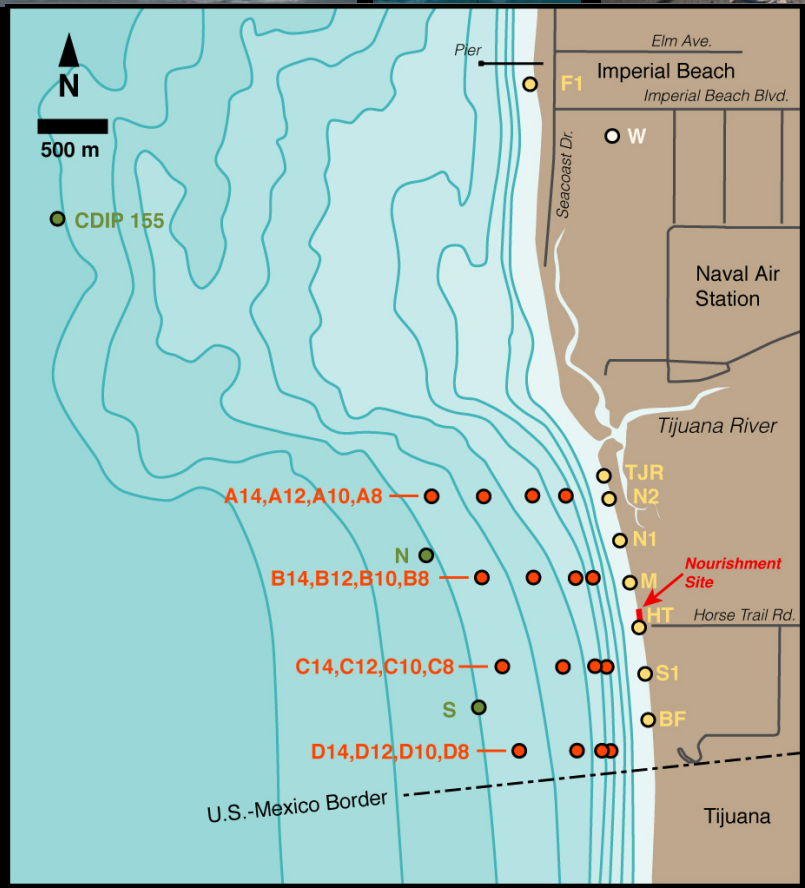
Physical Sampling



Remote Sensing

Modeling





Implications of Finding to Future Fine-Grained Dredge Disposal Projects

1) ***If*** conditions are sufficiently energetic, fine-grained dredge disposal in the nearshore can occur without significant deposition.

2) ***In situ*** measurements, in conjunction with meteorologic and oceanographic climatologies, can provide insight into the suitability of fine-grained dredge disposal for other locations.

Future Research Needs

1) Larger ***"Pilot Projects"*** of beneficial sediment reuse to evaluate fine-grained sediment fate and impacts.

2) Strong engagement with ***stop biological and ecological*** researchers in future projects**.**

3) Engineering solutions to reuse sediment in a manner that ***"mimics" natural sediment supplies"*** from rivers and bluffs**.**

Any questions?

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Fine-Grained Sediment Dispersal Along the California Coast

Fine-grained sediment (silt and clay) enters coastal waters from rivers, eroding coastal bluffs, resuspension of seabed sediment, and human activities such as dredging and beach nourishment. The amount of sediment in coastal waters is an important factor in ocean ecosystem health, but little information exists on both the natural and human-driven magnitudes of fine-grained sediment delivery to the coastal zone, its residence time there, and its transport out of the system—information upon which to base environmental assessments. To help fill these information gaps, the U.S. Geological Survey has partnered with Federal, State, and local agencies to monitor fine-grained sediment dispersal patterns and fate in the coastal regions of California. Results of these studies suggest that the waves and currents of many of the nearshore coastal settings of California are adequately energetic to transport fine-grained sediment quickly through coastal systems. These findings will help with the management and regulation of fine-grained sediment along the U.S. west coast.

Left, a satellite image showing river-sediment plumes off the southern California coast near Los Angeles. Image courtesy of NASA (National Aeronautics and Space Administration). Right, seafloor habitats near Santa Cruz, California. Photo by Curt Storlazzi.

Sources of Fine-Grained Sediment to the Coast

The majority of the fine-grained sediment that enters and circulates through the coastal systems of California is part of the natural processes of erosion and transport associated with the geologic cycle that has been active for millions of years. In California, rivers are the dominant source of fine-grained sediment that enters the ocean, with an average annual discharge of approximately 34 million tons. The erosion of coastal cliffs and bluffs contributes roughly 3 million tons of fine-grained sediment per year. These natural supplies vastly exceed the combined sediment contributions from human activities, which include damming of rivers, emplacement of harbors, hydraulic mining, watershed land-use changes, and movement and management of coastal sediment. The construction of dams on California rivers has had perhaps the greatest impact on fine-grained sediment transport, resulting in a dramatic reduction in sediment supply to the coast—on the order of 25 to 50 percent since the 1960s.

Fine-Grained Sediment and Coastal Ecosystems

Once discharged into the ocean, fine-grained sediment can have significant and important effects on coastal ecosystems, both negative and positive. Turbidity and sedimentation may reduce photosynthesis, decrease visibility for visual feeders, and bury sea-floor habitats. But fine-grained sediment is also an important source of nutrients to estuarine ecosystems, the continental shelf, and the California Current. Additionally, the deposition of fine-grained sediment along coasts may act as a mitigating factor to sea-level rise. These competing concepts of the potential effects of fine-grained sediment on California coastal ecosystems emphasizes the need for a better understanding of the pathways and physical processes of fine-grained sediment delivery, residence times, and dispersal in coastal ecosystems.

Aerial-imagery mosaic showing sediment plumes near the mouth of the Tijuana River, south of Imperial Beach in southern California. Photos were taken during a U.S. Geological Survey-led demonstration project that tracked the dispersal of fine-grained sediment from a beach-nourishment project to its eventual deposition on the seafloor. Imagery collected for the USGS by Ocean Imaging Corp.

U.S. Department of the Interior
U.S. Geological Survey

Fact Sheet 2013–3023
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