Case Studies in Submerged Oil Spill

Submerged Oil Workshop

Coastal Response Research Center

December 12, 2006

Steve Lehmann, NOAA

With thanks to:

Jacqui Michel, Ed Levine, Chris Pfeifer
and others for the contribution of many slides.

Notable submerged oil spill in the North America

Terms

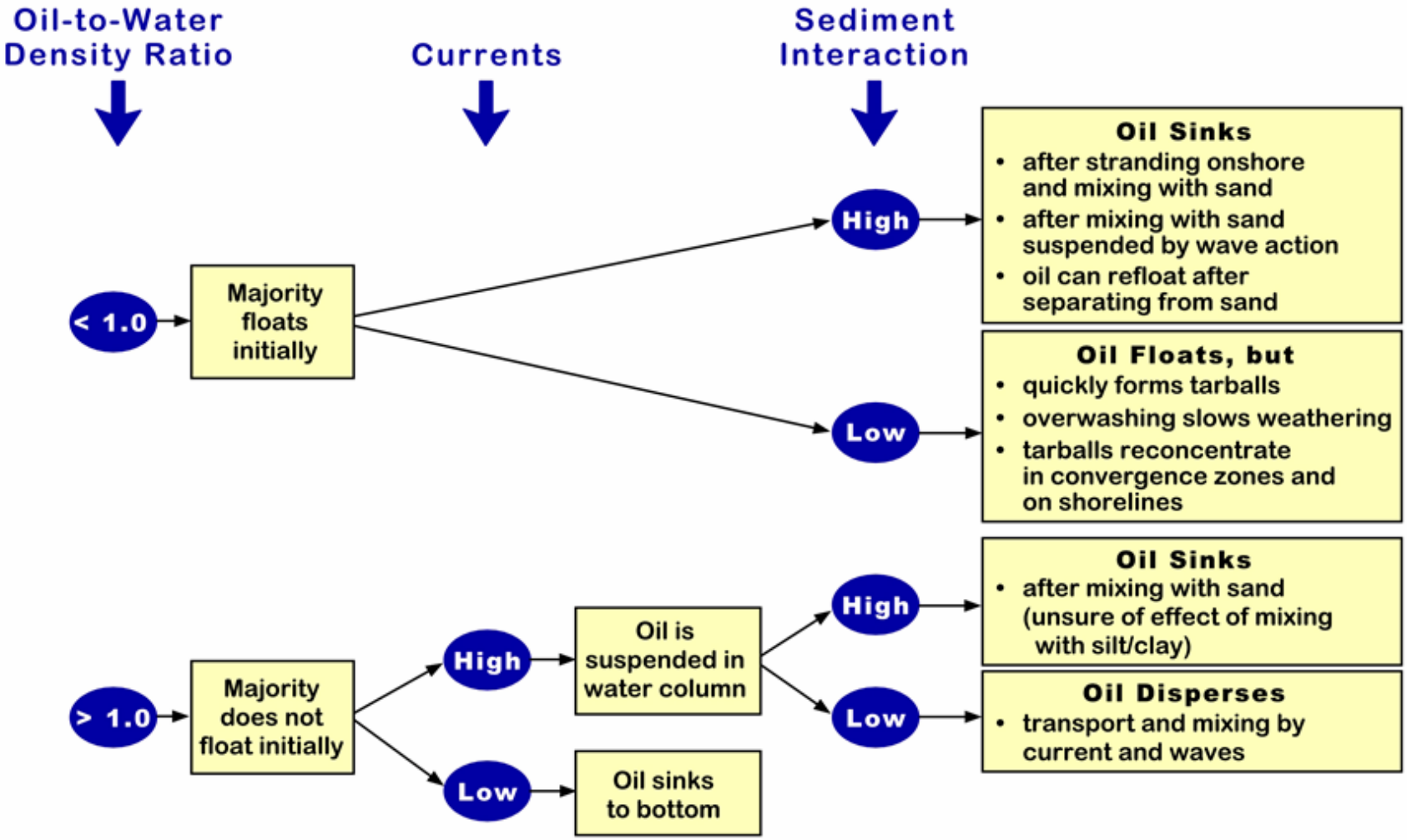
- Submerged Oil
  - *Sinking, sunken, non-floating, low API oils (LAPIO), type 5 oils, buoyancy-challenged*

  1. Where oil submerges as a function of it inherent mass relative to that of the receiving water
  2. Where oil submerges as function of its inherent mass plus sediment

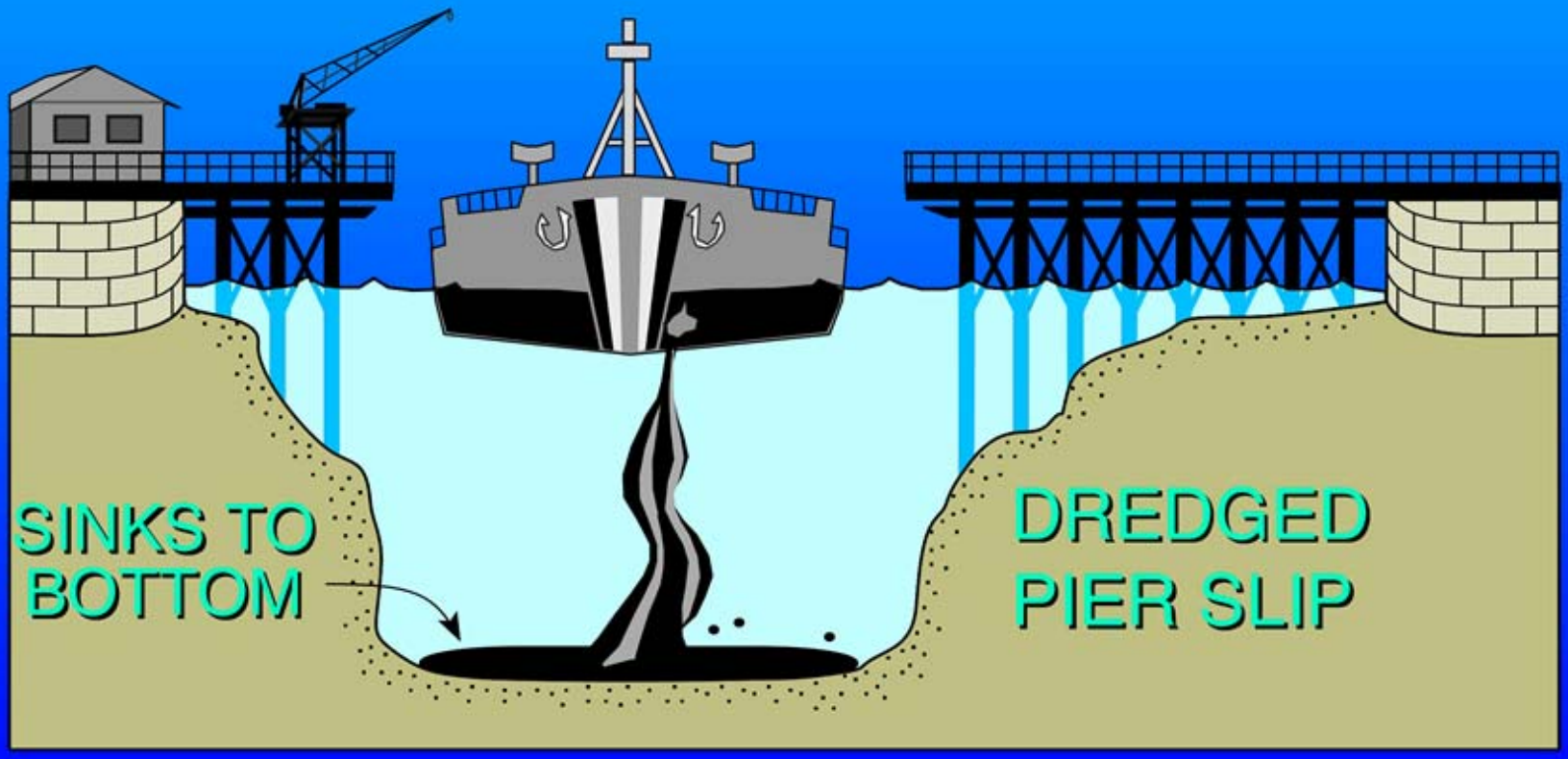
- Oil Contaminated Sediments

  1. Where oil coats or stains the surface of sediments such that the sediment accounts for most of the mass

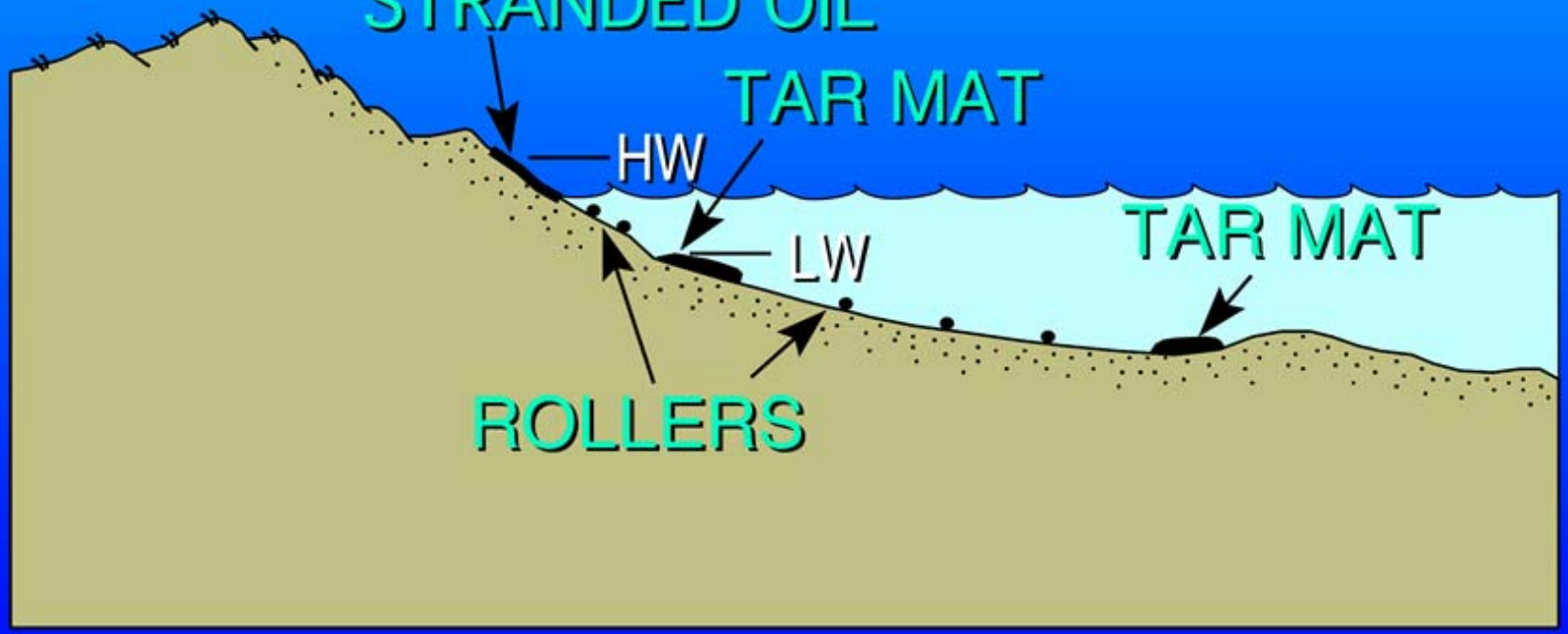
BEHAVIOR OF SPILLS OF HEAVY OILS



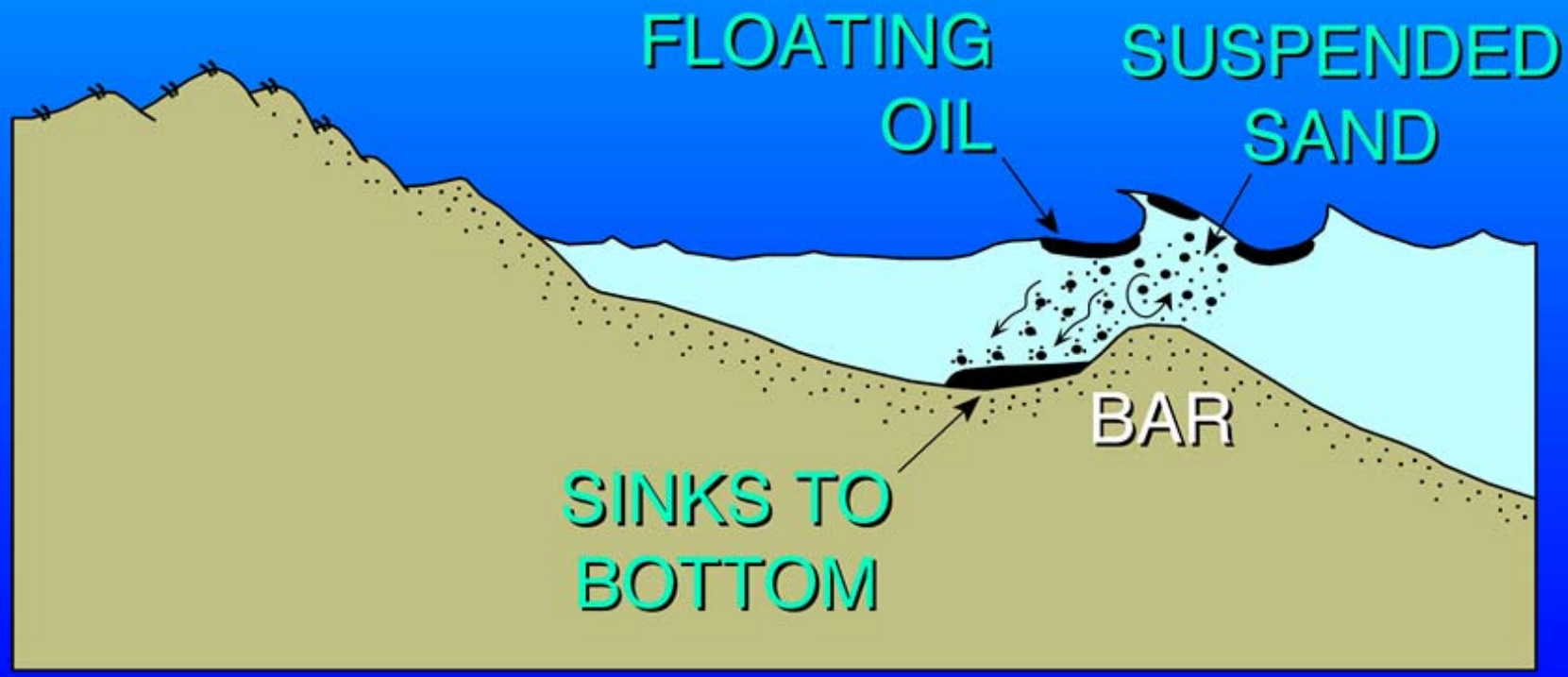
MODEL 2. - MAJORITY DOES NOT FLOAT
- CURRENTS < 0.1 KNOTS



MODEL 3. - OIL INITIALLY FLOATS
- STRANDS ON BEACH
- OIL/SEDIMENT MIXTURE SINKS



MODEL 3. - OIL INITIALLY FLOATS
- MIXES WITH SAND, THEN SINKS



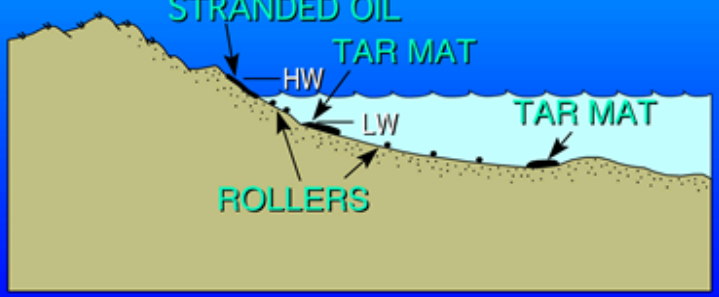
T/B *Morris J. Berman*
San Juan, Puerto Rico

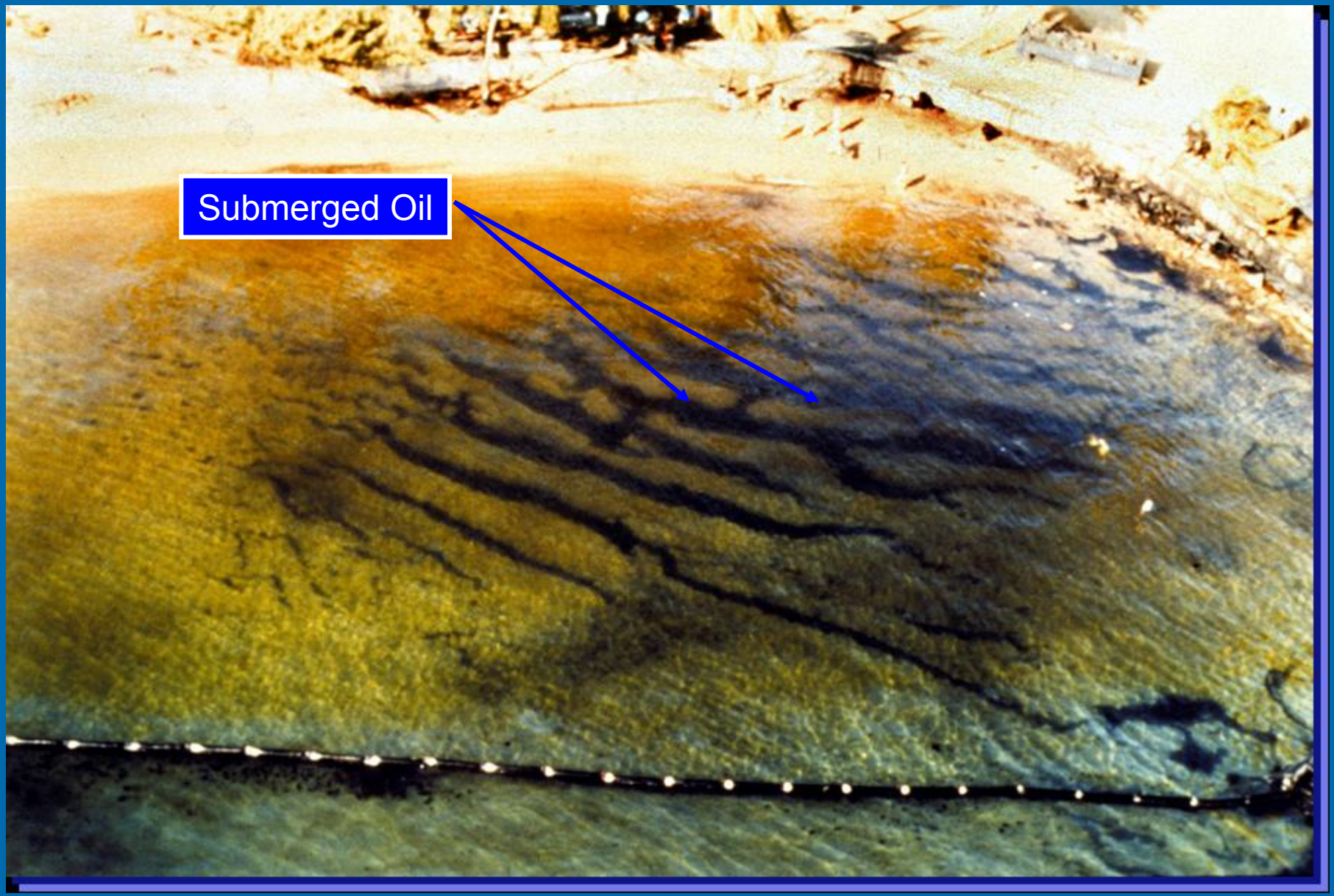
- January 07, 1994
- 800,000 gallons (19,000 barrels)
- Density
  - API = 9.5
  - Spec. Grav. = 1.005

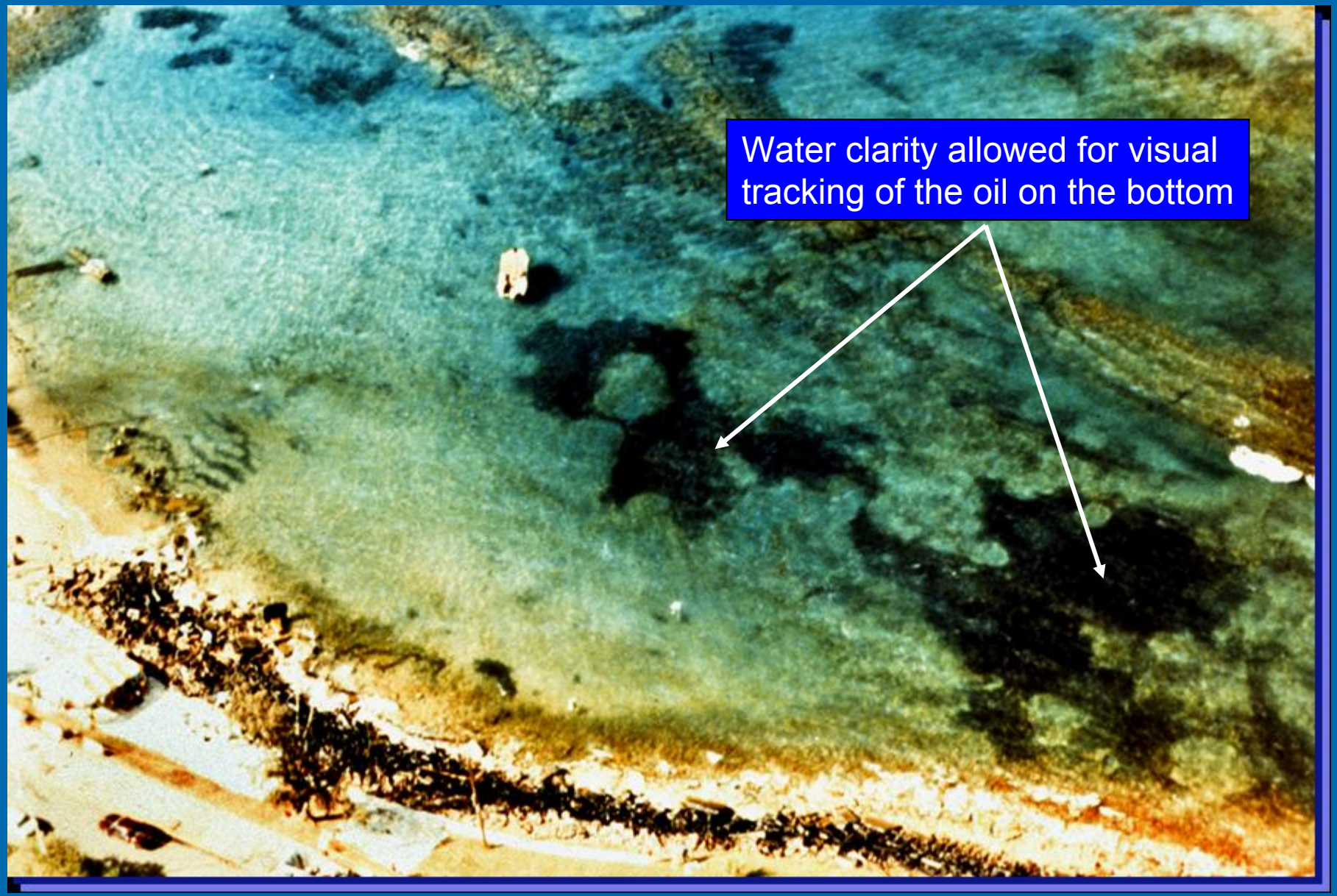

15CM

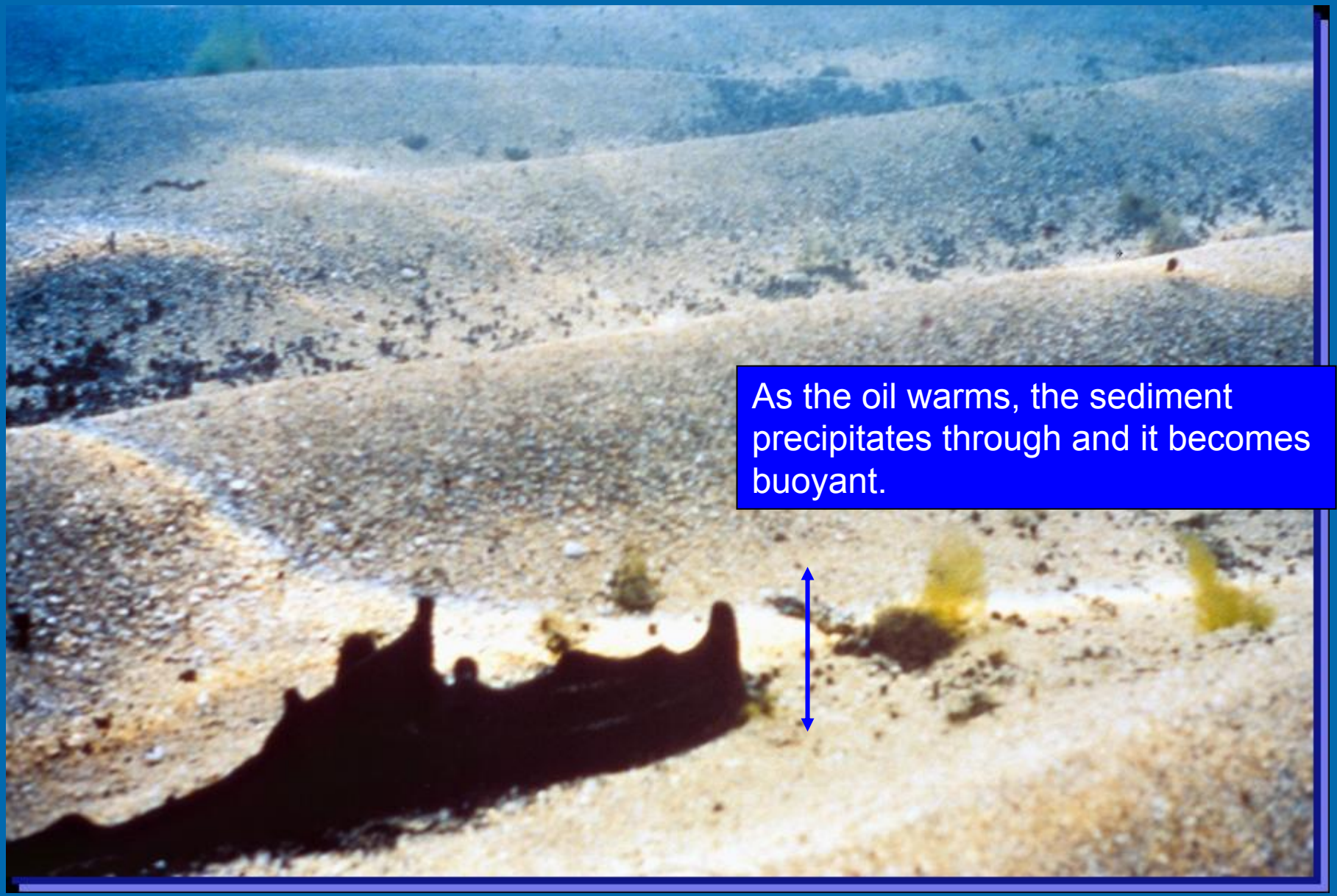

Decanting and Storage Tank
(aka: hotel swimming pool)

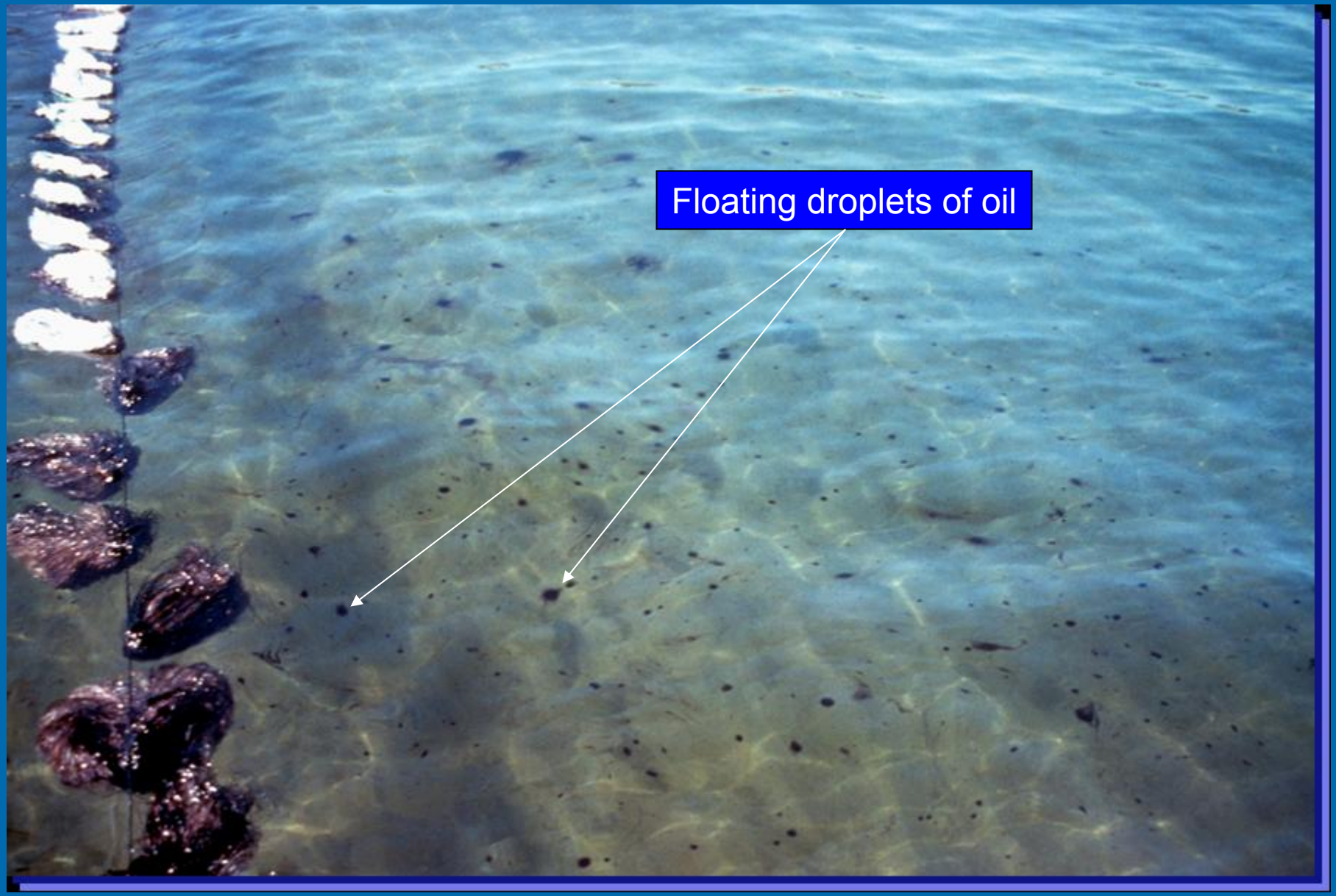
MODEL 3. - OIL INITIALLY FLOATS
- STRANDS ON BEACH
- OIL/SEDIMENT MIXTURE SINKS

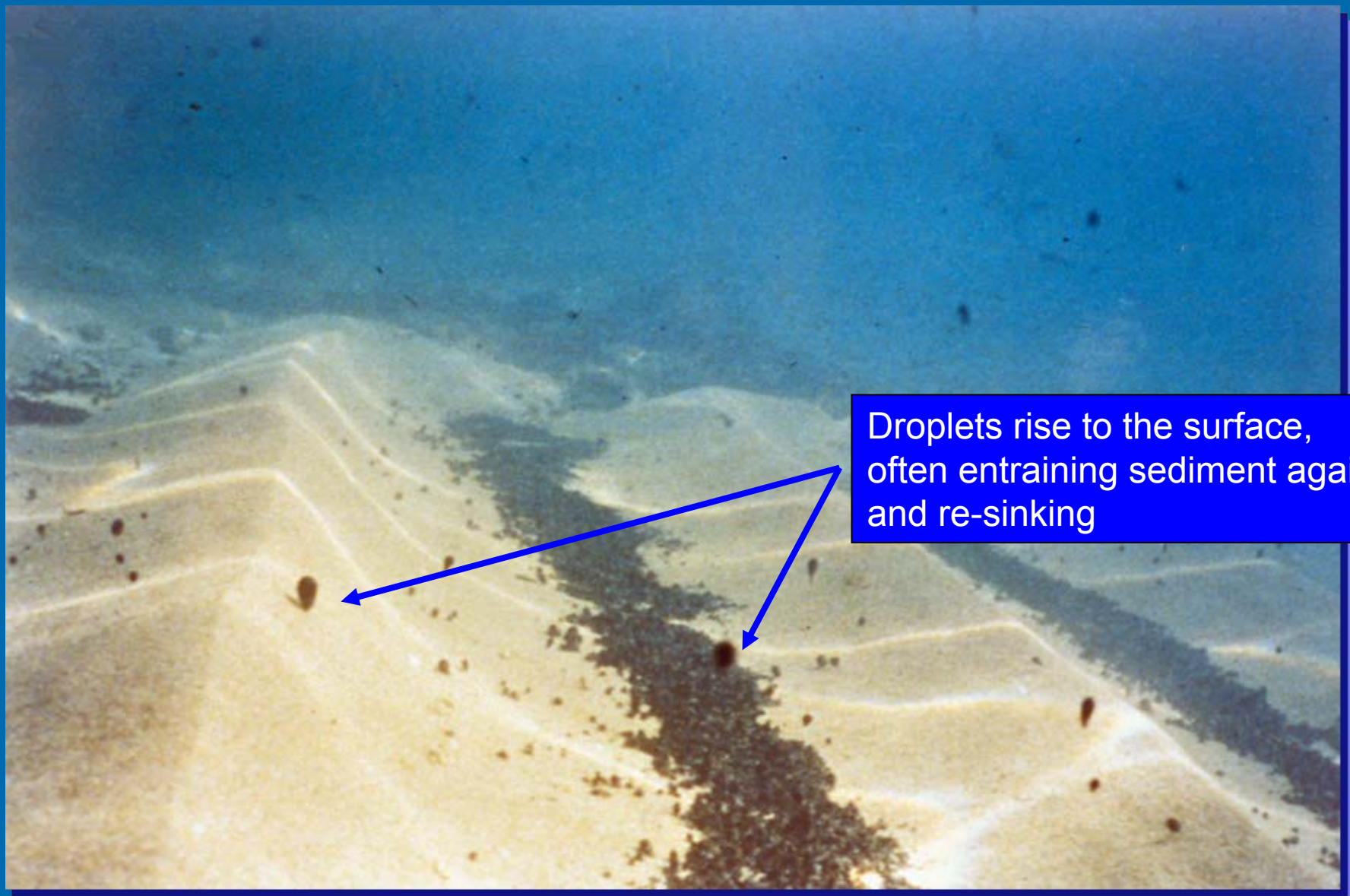



Submerged Oil


Water clarity allowed for visual tracking of the oil on the bottom


As the oil warms, the sediment precipitates through and it becomes buoyant.


Floating droplets of oil


Droplets rise to the surface, often entraining sediment again and re-sinking

Barge DBL-152

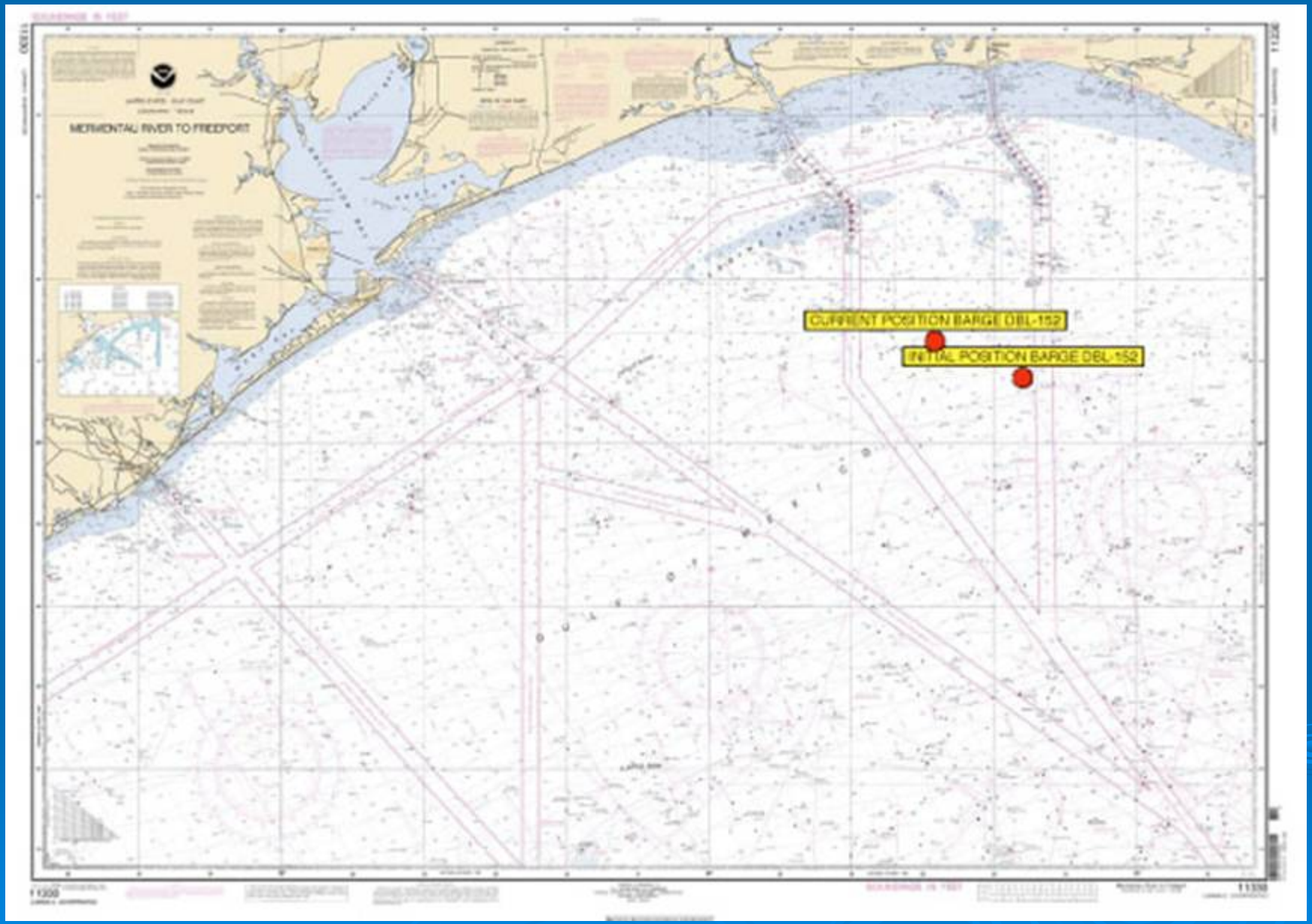
November 11, 2005

- Allision with oil rig sunk by Hurricane Rita
- ≈ 30 miles (≈ 50 kilometers) offshore of Port Arthur, TX
- 3 million gallons (71,400 barrels)
- Slurry Oil
  - Denser than seawater
  - Viscosity of a medium crude oil
- Depth: approx. 50 ft (15 meters)

DBL-152 Cargo

API	barrels
9.7	10,300
3.8	50,700
-2.3	15,500
3.9	41,950
24.6	1,870

Receiving water ≈ API 9.7


MERMENTAU RIVER TO FREEPORT
CURRENT POSITION BARGE DBL-152
INITIAL POSITION BARGE DBL-152

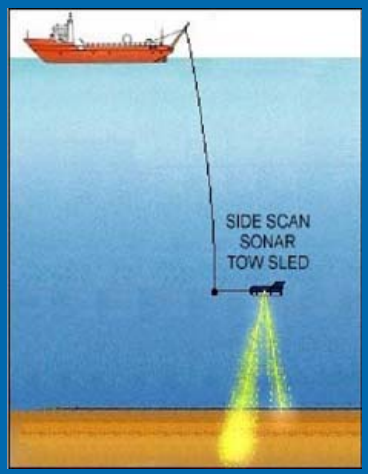
Day One

Day Three

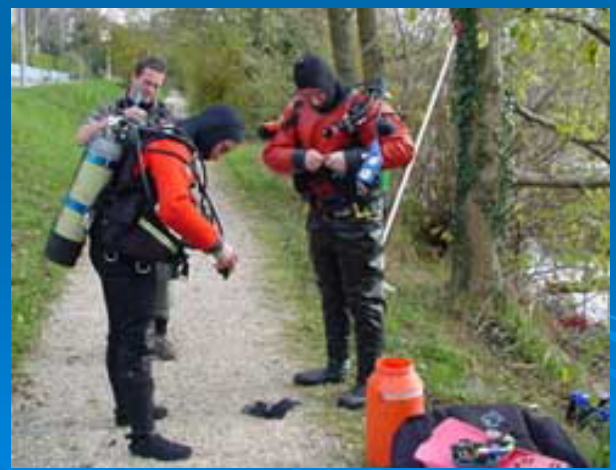
Day Five

NOAA ORR Emergency Response Division
Submerged Oil Workshop

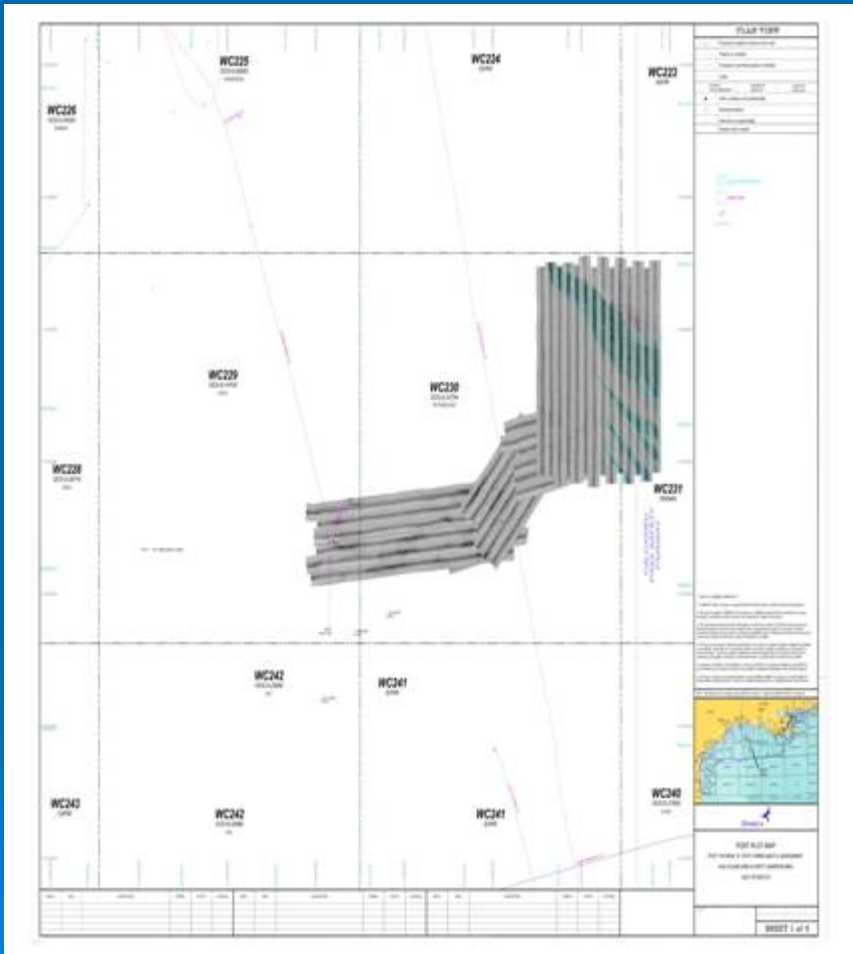
Detection Techniques



- Side Scan Sonar
- ROV
- Snare
- Divers



Side Scan Sonar



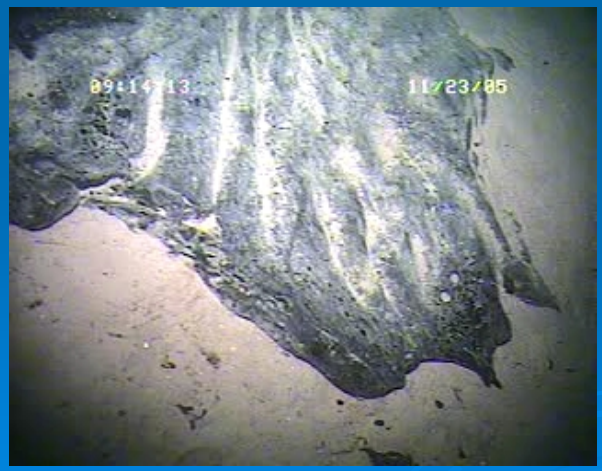
- Issues
  - Post Processing Time
    - (days, not hours)
  - Weather delays
  - Ground Truthing
    - Many false positives
    - Verification with dive team necessary
  - Less reliable as concentrations decreased

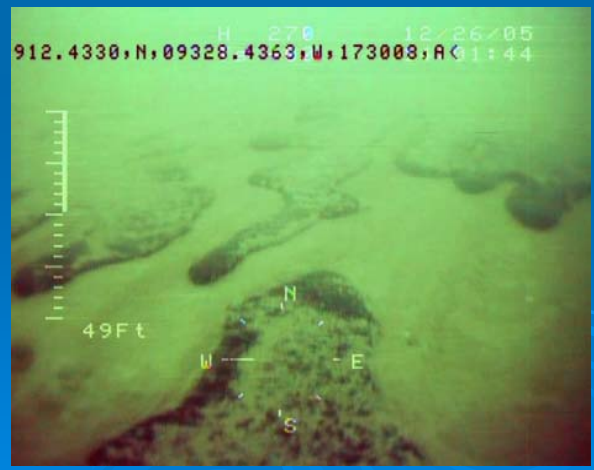
Remotely Operated Vehicles

- Issues
  - Weather delays
  - Visibility
    - When visibilty was good, the ROV was very useful
  - Tether
    - A towed ROV would have allowed for transects

What it looks like.

Oil on the seafloor.





Divers

- Disadvantages:
  - Hard-hat diving only
  - Visibility
  - Time on bottom
  - Diver safety
  - Expensive
  - Slow
- Advantages
  - Real-time human observations
  - Targeted & specfic
  - Adaptable & flexible
  - Credible observer

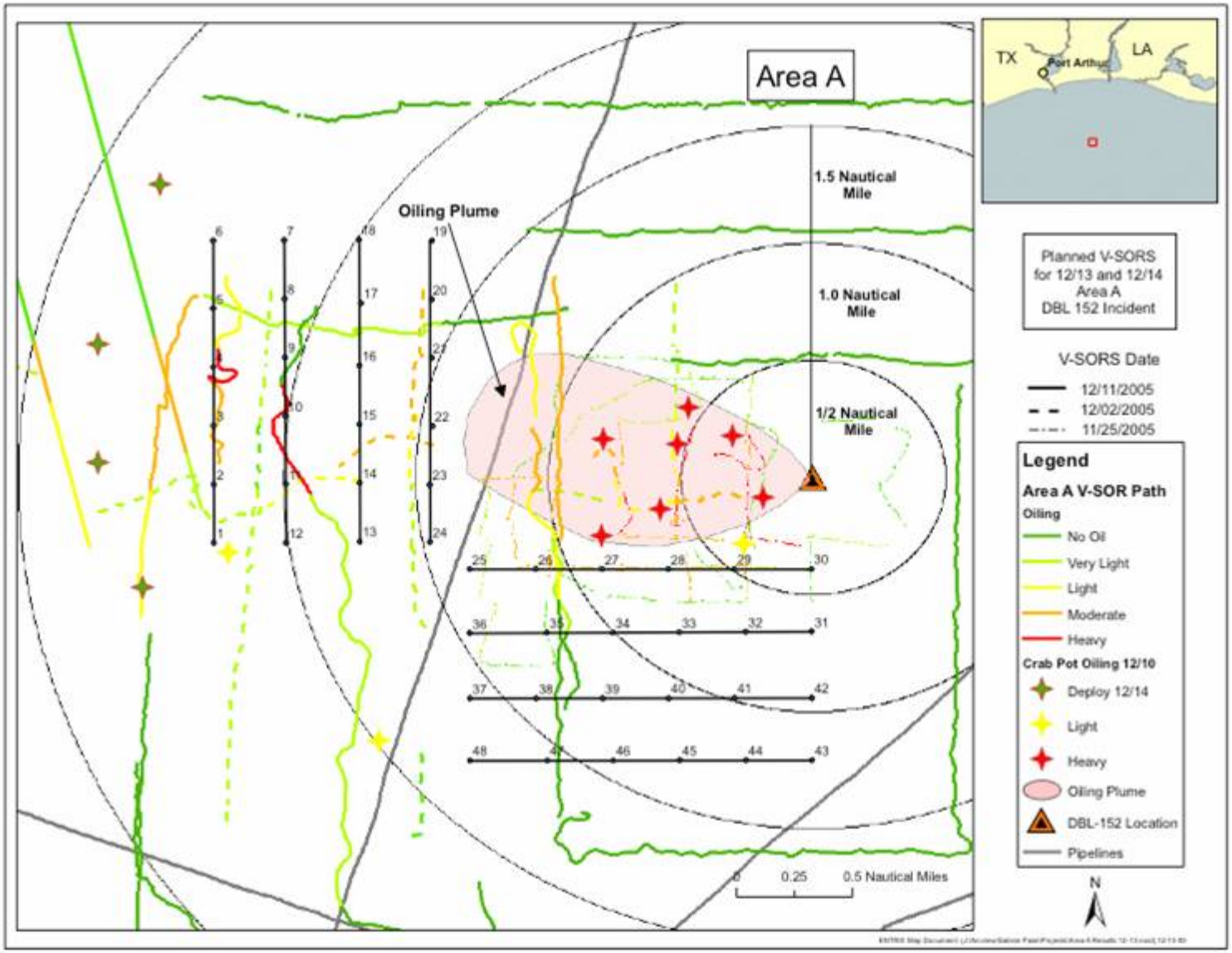
Vessel Submerged Oil Recovery System (VSORS)

V-SORS
"light"

aka: Chain Drag

Snare Sentinels

aka: snare-baited traps


Area A
Oiling Plume
1.5 Nautical Mile
1.0 Nautical Mile
1/2 Nautical Mile
TX
LA
Port Arthur
Planned V-SORS for 12/13 and 12/14 Area A DBL 152 Incident
V-SORS Date
12/11/2005
12/02/2005
11/25/2005
Legend
Area A V-SOR Path
Oiling
No Oil
Very Light
Light
Moderate
Heavy
Crab Pot Oiling 12/10
Deploy 12/14
Light
Heavy
Oiling Plume
DBL-152 Location
Pipelines
0 0.25 0.5 Nautical Miles
N

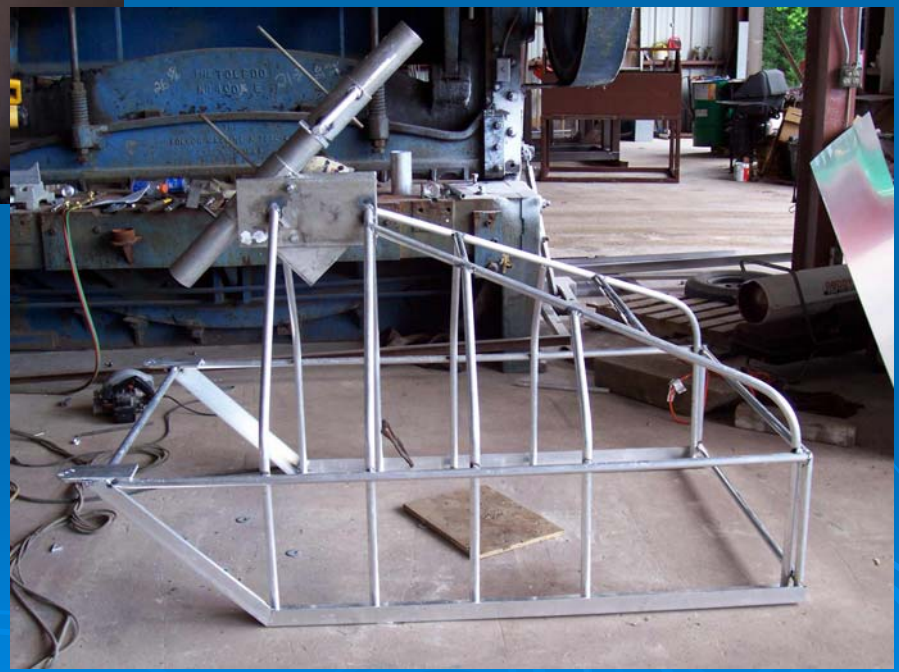
Snare

- Issues
  - Calibration
    - How to quantify the results
  - Snagging pipelines
  - Feedback is immediate
  - Inexpensive (relatively)

Oil “Fence”

Other Techniques Tried

Video Sled



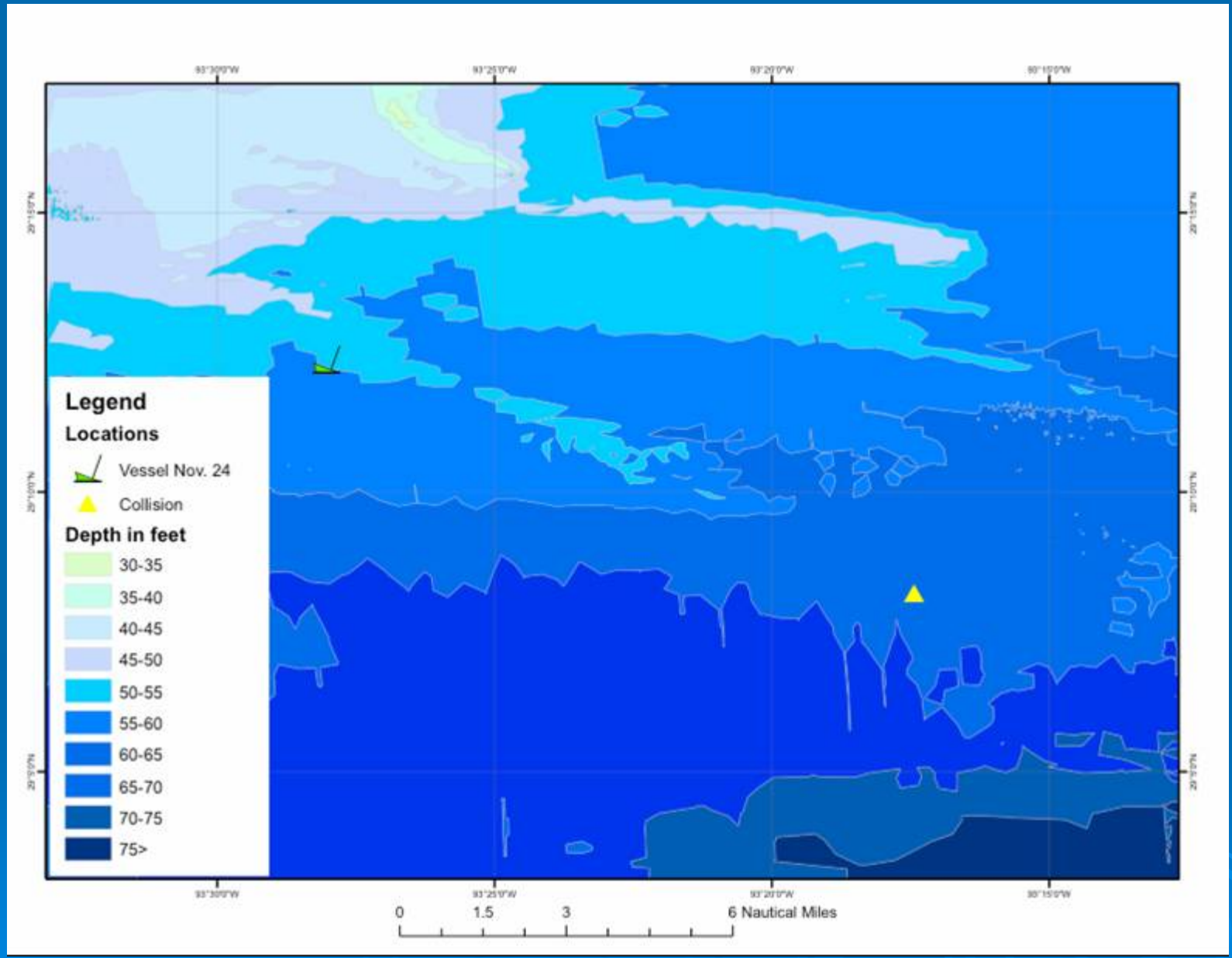
Understanding Oil Movement

Texas

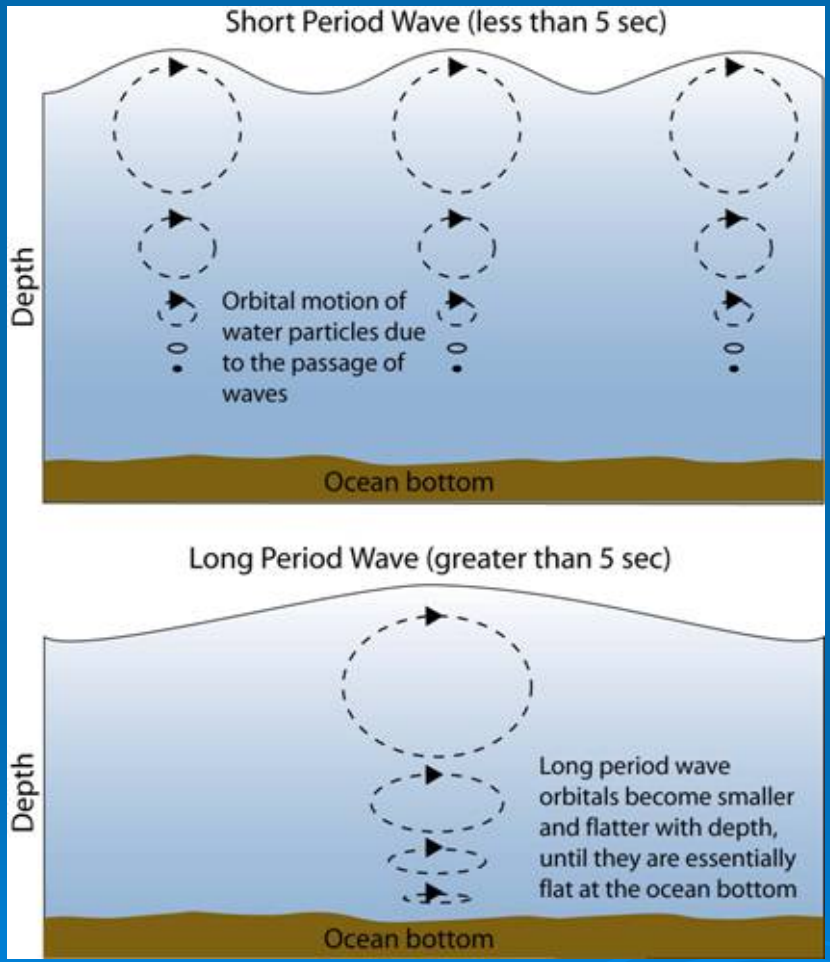
Automated

Buoy

System

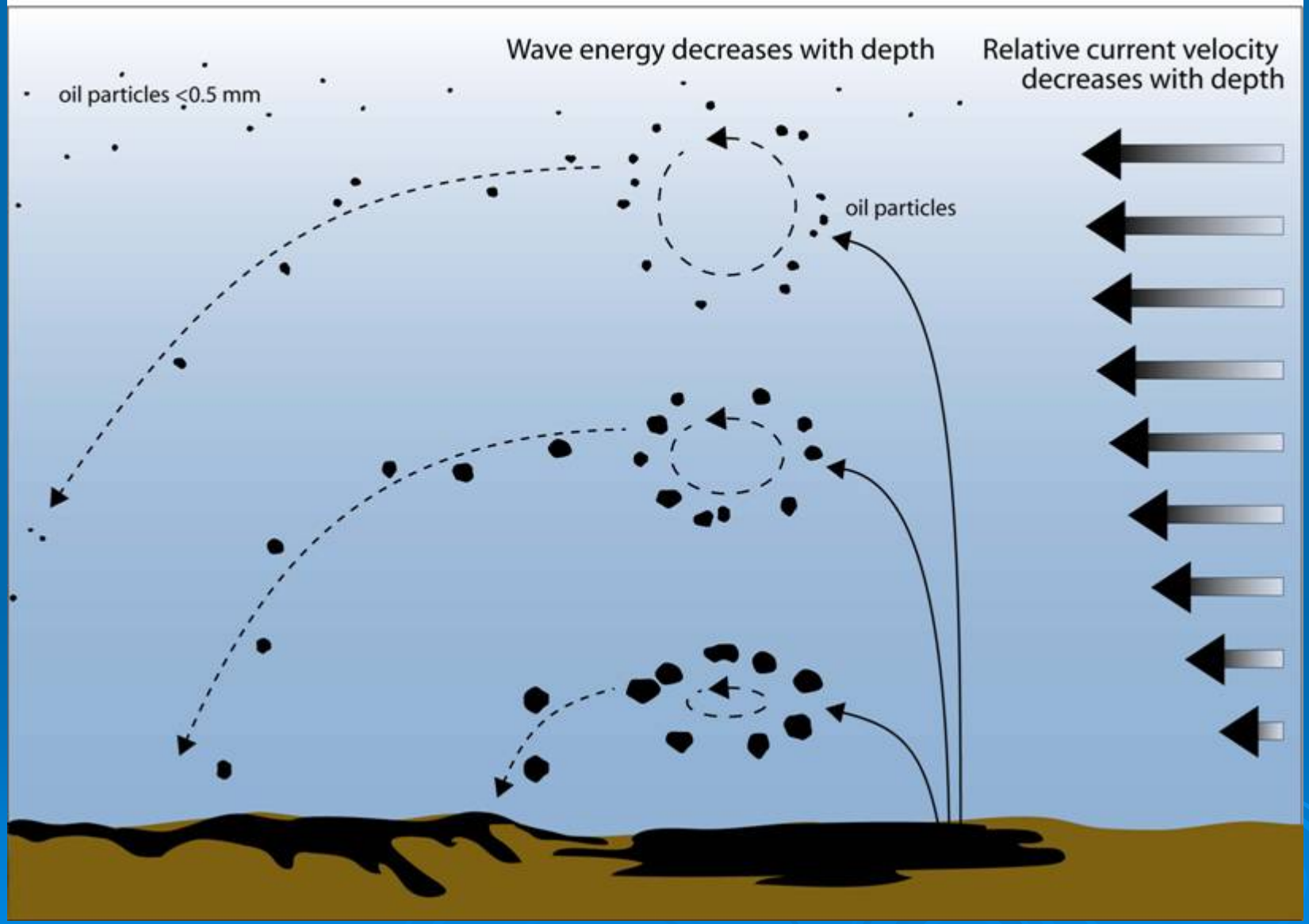

Legend
Locations
Vessel Nov. 24
Collision
Depth in feet
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75>
0
1.5
3
6 Nautical Miles

Effects of Wave Energy

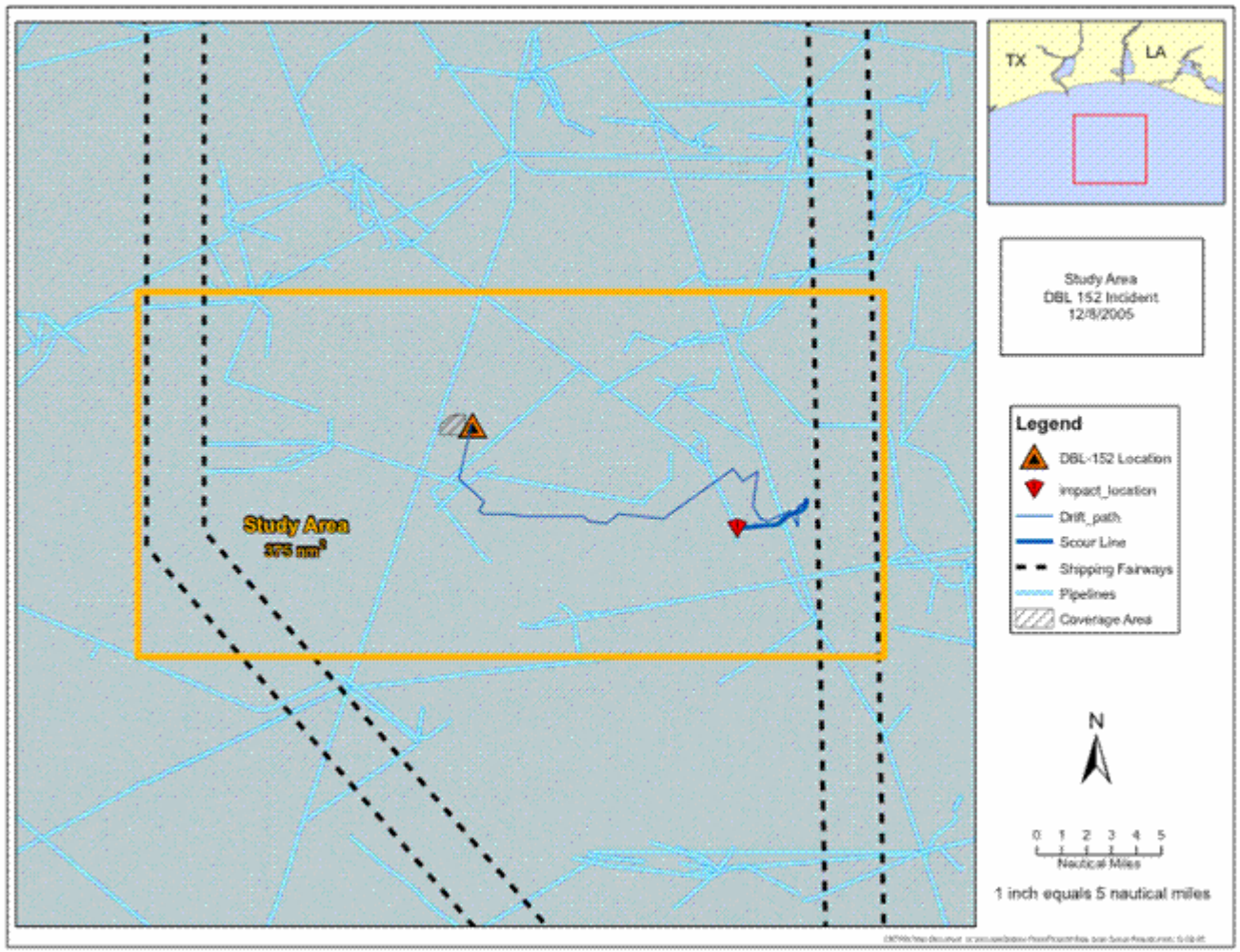


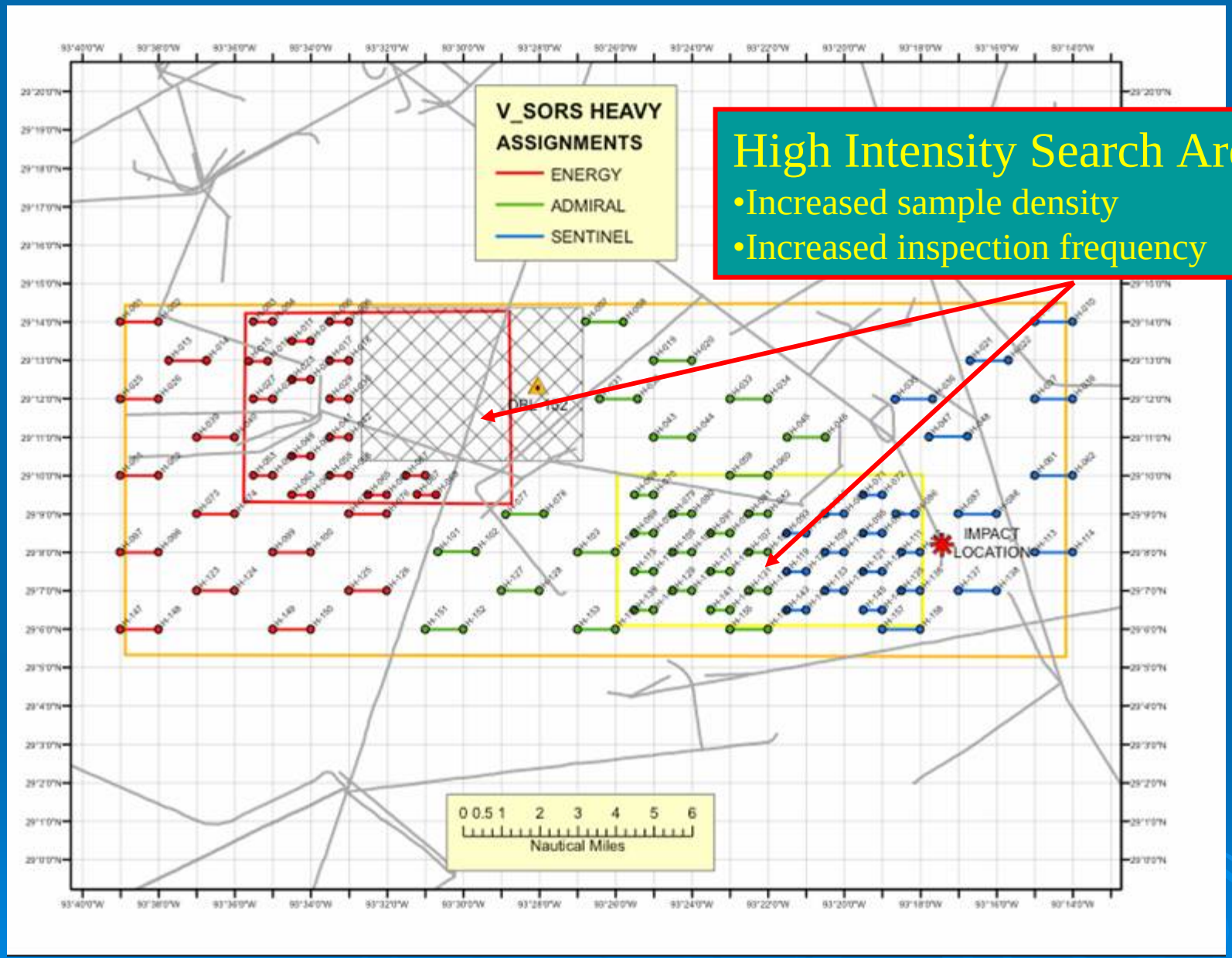
- Energy at bottom increases with wave period
- Energy increases with wave height
- Energy decreases with depth and bottom friction
- Orbit oblates (flattens) closer to ocean floor
- Horizontal transport is primarily a function of currents, not wave energy
- Enough wave energy can re-suspend the oil
- Smaller particles will travel further than larger particles because they fall slower
- Very small particles (grains of sand) may stay suspended

Re-suspension and Transport of T/B /DBL-152/ Oil

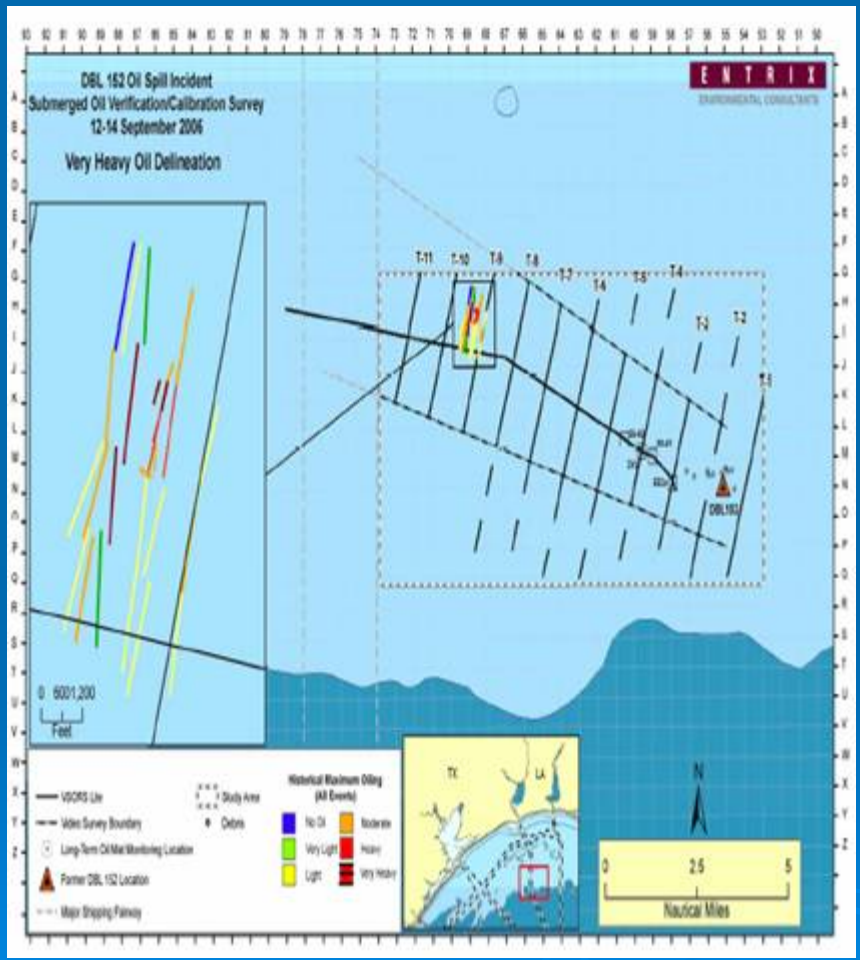


We could not look everywhere …
A systematic sampling approach quantifying oil distribution.



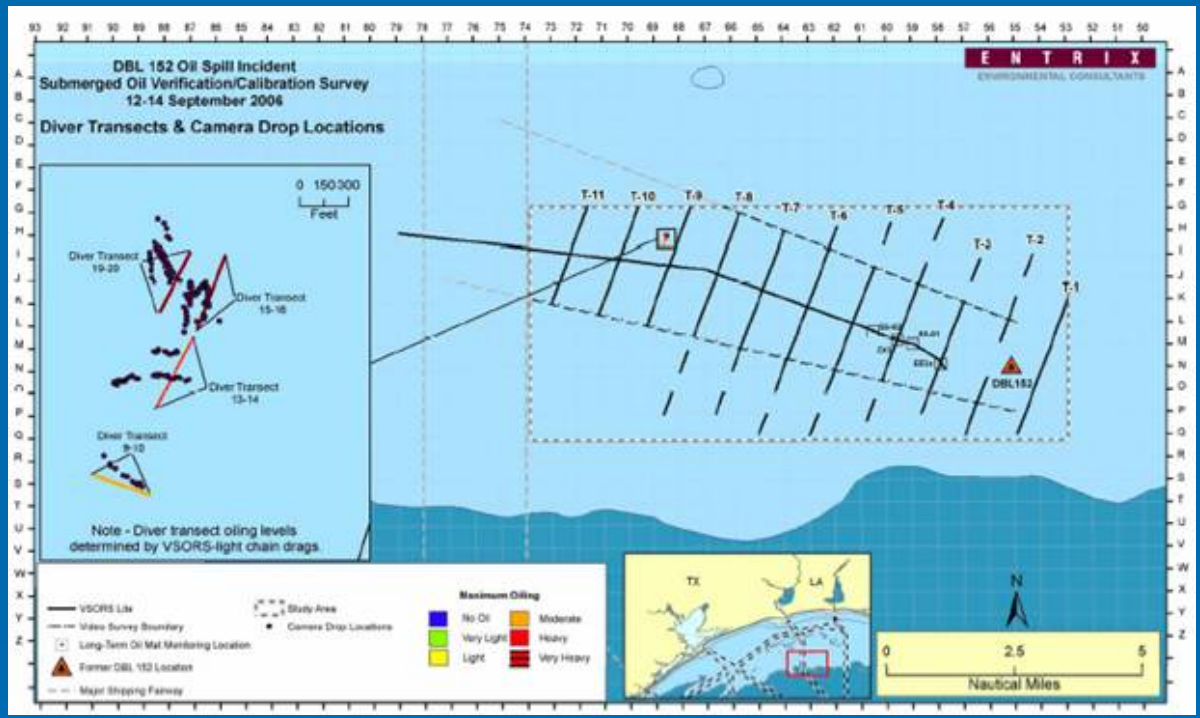

V_SORS HEAVY
ASSIGNMENTS
ENERGY
ADMIRAL
SENTINEL
High Intensity Search Areas
•Increased sample density
•Increased inspection frequency
IMPACT
LOCATION
0 0.5 1 2 3 4 5 6
Nautical Miles

Longterm Monitoring & the “Bolus”



- Discovered concentration of oil, the “*bolus*”
- Fingerprints to DBL-152 oil (API 9.7)
- Only part of cargo NOT line blended (therefore poorly mixed)
- Viscosity assumed to be higher (not confirmed)

Bolus Monitoring & Tracking

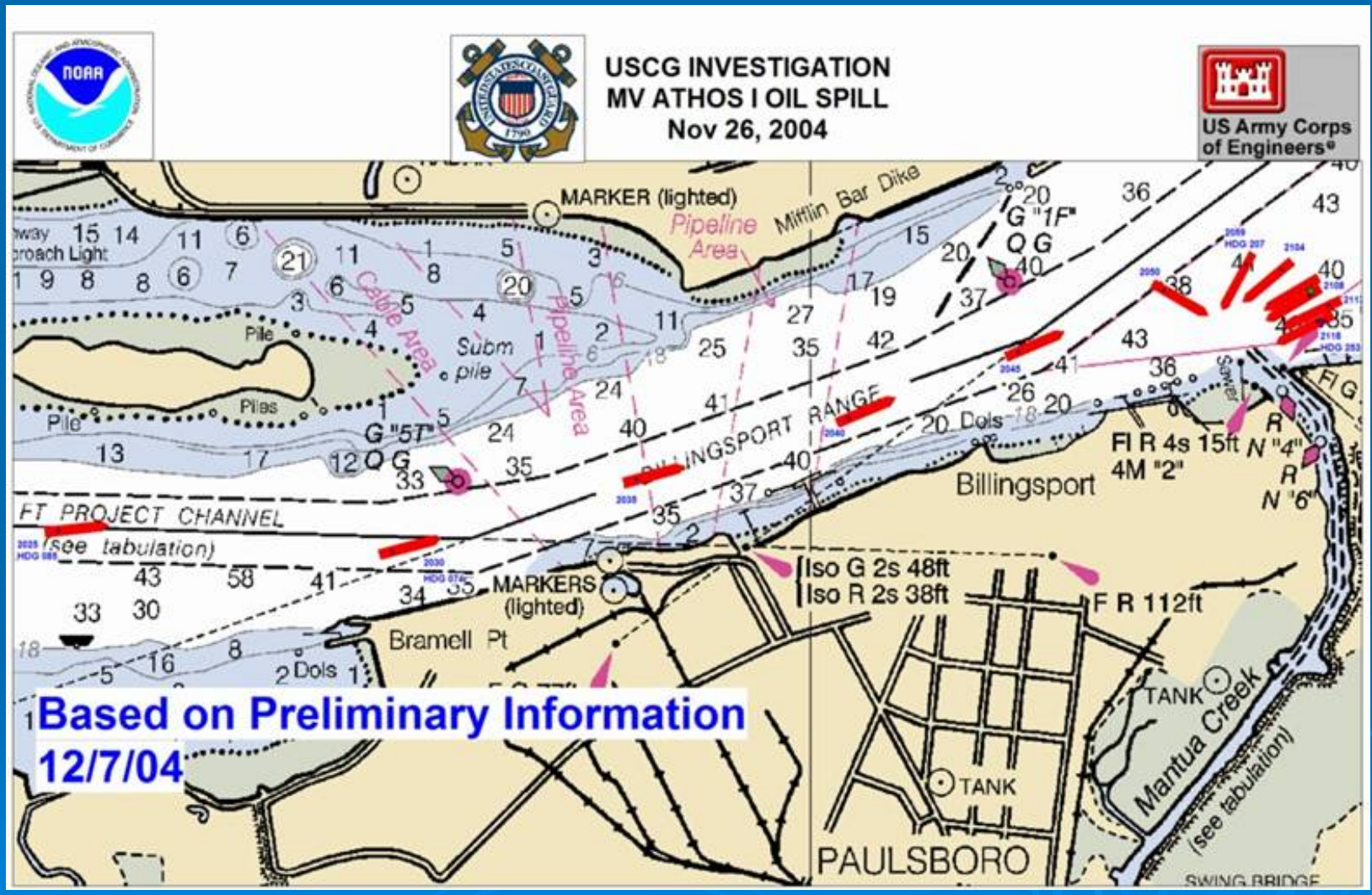


- VOSRS-light drags
- Dropped Camera
- Divers

M/V ATHOS I

Submerged Oil Response

Tanker Information



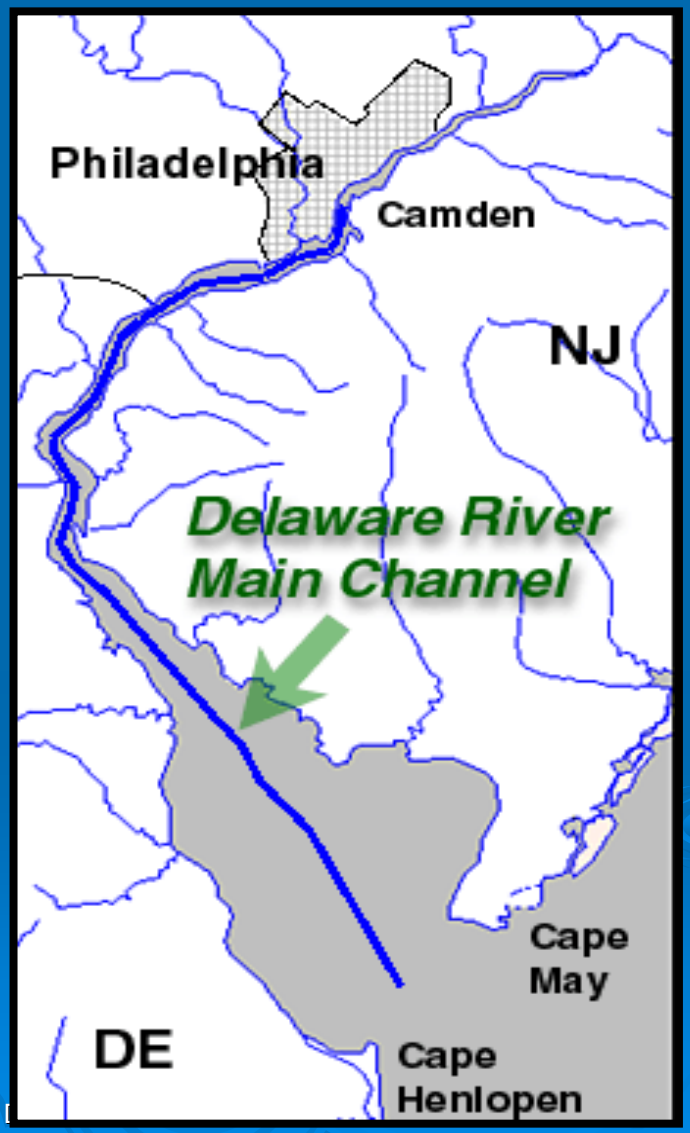
Area Information

COTP Philadelphia Statistics

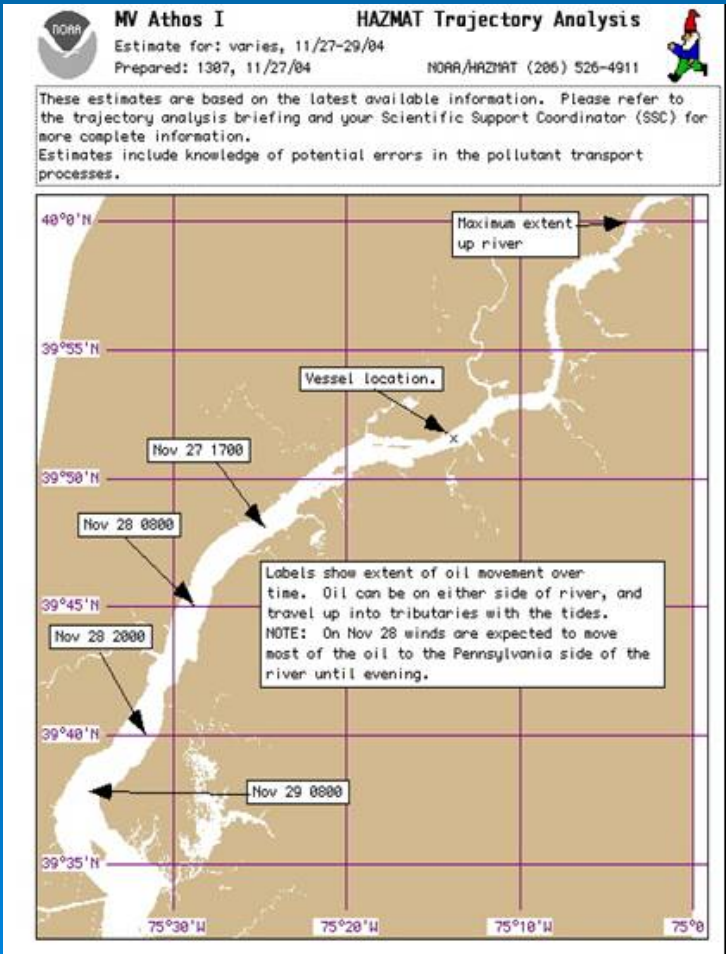
- 2nd largest petro-chemical port in the nation (largest for crude oil imports)
- Largest VLCC receiving port in nation
  - 1 million barrels of crude oil imported daily

Home to:

- Five of the largest east coast refineries
- Six nuclear power plants
- Three states and two federal regions



Initial Timeline



- **26 Nov 2130 hrs** M/V ATHOS I reports an 8 degree list to port
- **27 Nov** Initial weather flat calm- oil observed on Delaware River
- **28 Nov** high easterly winds drives oil against PA shore
- **29 Nov** overflight indicates significant oil has been released
- **30 Nov** high level of response effort including shoreline assessment
- **1 Dec** high westerly winds drives oil against NJ shore

Oil Properties

- Slightly buoyant
  - 0.987 specific grav.
- Very viscous
- High pour point
- Very sticky
- High asphaltive content
- Weathers slowly
- Forms tarballs

Response Challenges

Vessel/Crew Safety

Stop Release

Salvage Response

Power Plant Closures

Identify Obstruction

Environmental

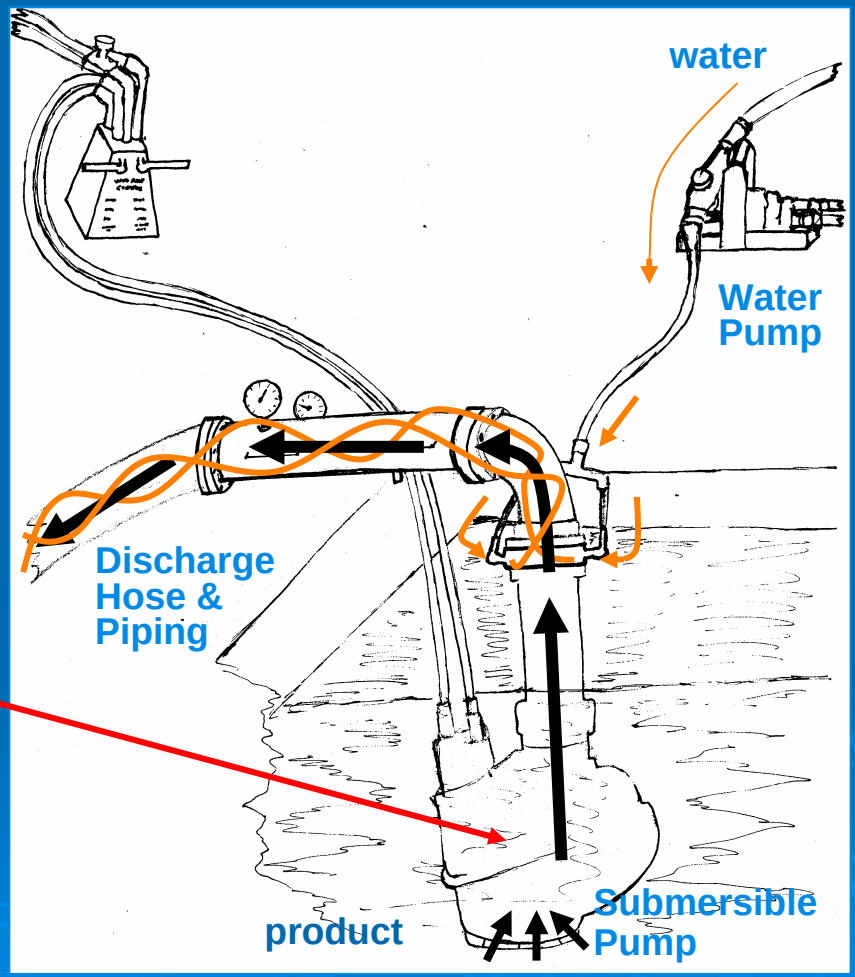
Economic

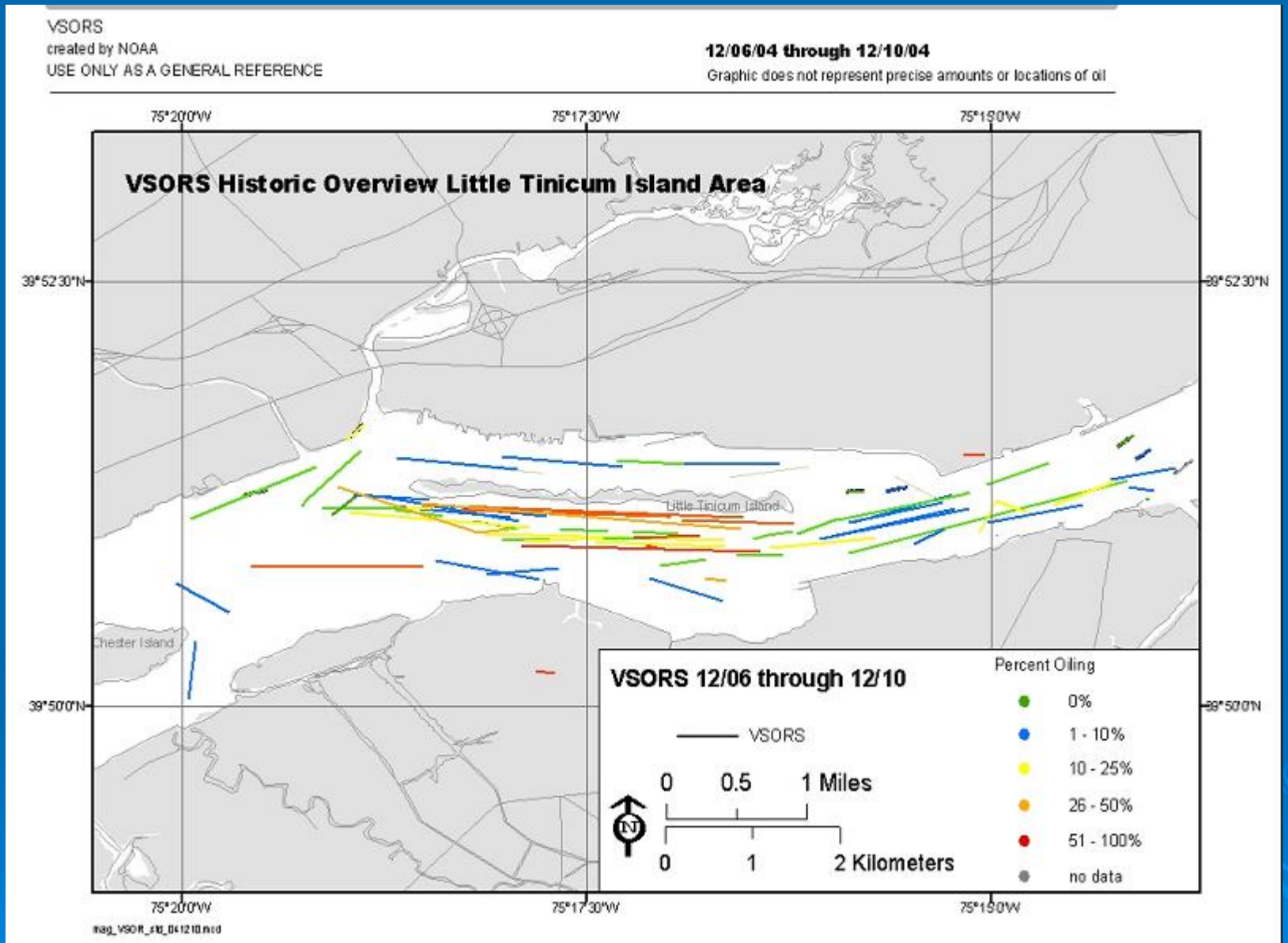
Metrics

- Problem:
  - What is the efficiency of snare?
  - At a given encounter rate, how much oil will it recover?
  - Is it a practical recovery tool?
  - Is it a reliable monitoring tool?

Sunken Oil Recovery

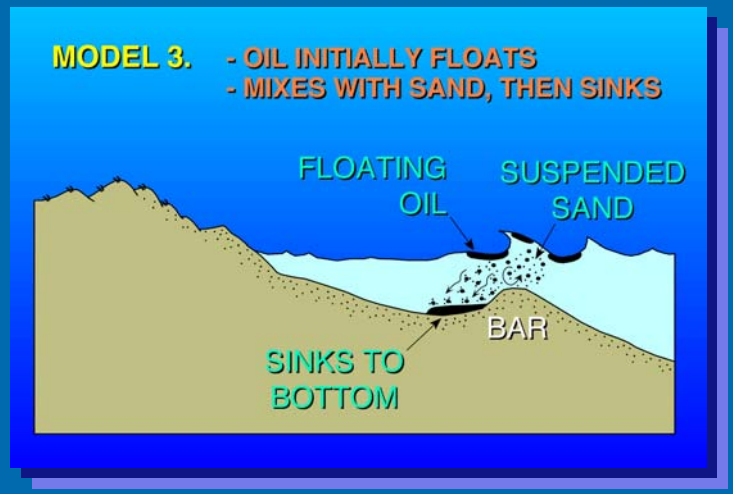
Modification

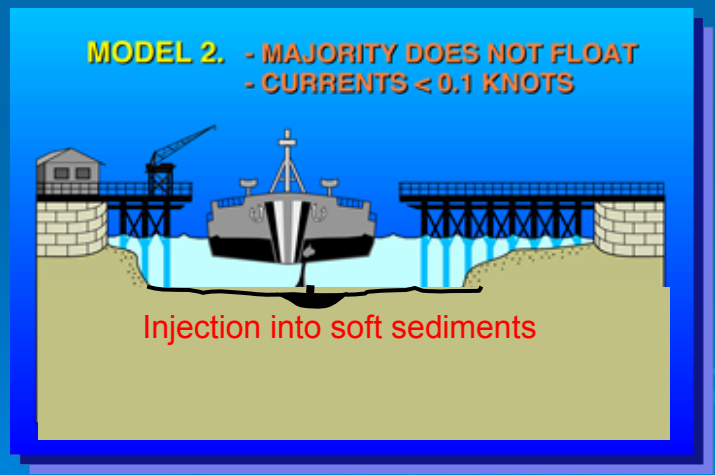



VSORS
created by NOAA
USE ONLY AS A GENERAL REFERENCE
12/06/04 through 12/10/04
Graphic does not represent precise amounts or locations of oil
VSORS Historic Overview Little Tinicum Island Area
75°20'0"W
75°17'30"W
75°15'0"W
39°52'30"N
39°50'0"N
Little Tinicum Island
Chester Island
VSORS 12/06 through 12/10
VSORS
0 0.5 1 Miles
0 1 2 Kilometers
Percent Oiling
0%
1 - 10%
10 - 25%
26 - 50%
51 - 100%
no data

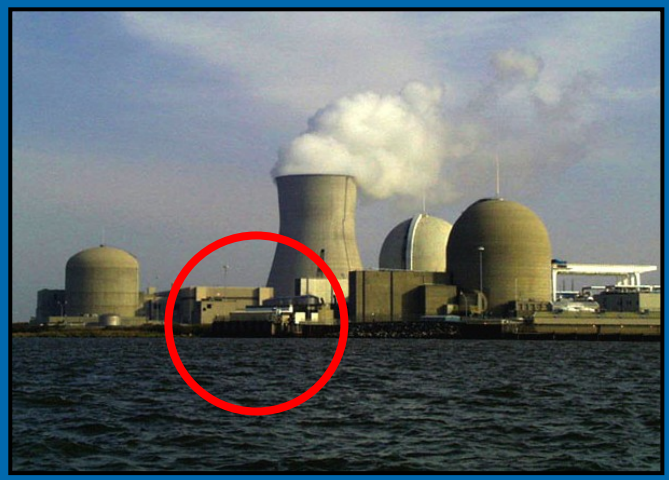
MV ATHOS 1 SPILL

- Mechanisms for subsurface oil
  - Re-mobilization from oiled shoreline
    - Amount unknown
    - Reduced by shore cleanup
  - Initial oil jet in contact with bottom sediment at spill site
    - Approximately 650 gallon
    - Recovered





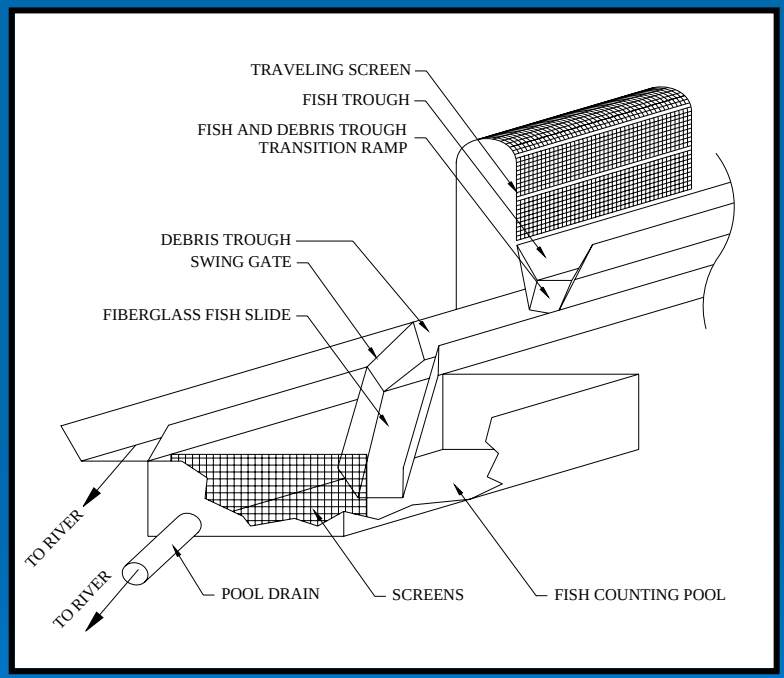
Salem Nuclear Power Plant



- Issue:
  - Cooling water filtration system
  - Confidence to restart

Prototype Protection Screen

Power Plant Cooling System



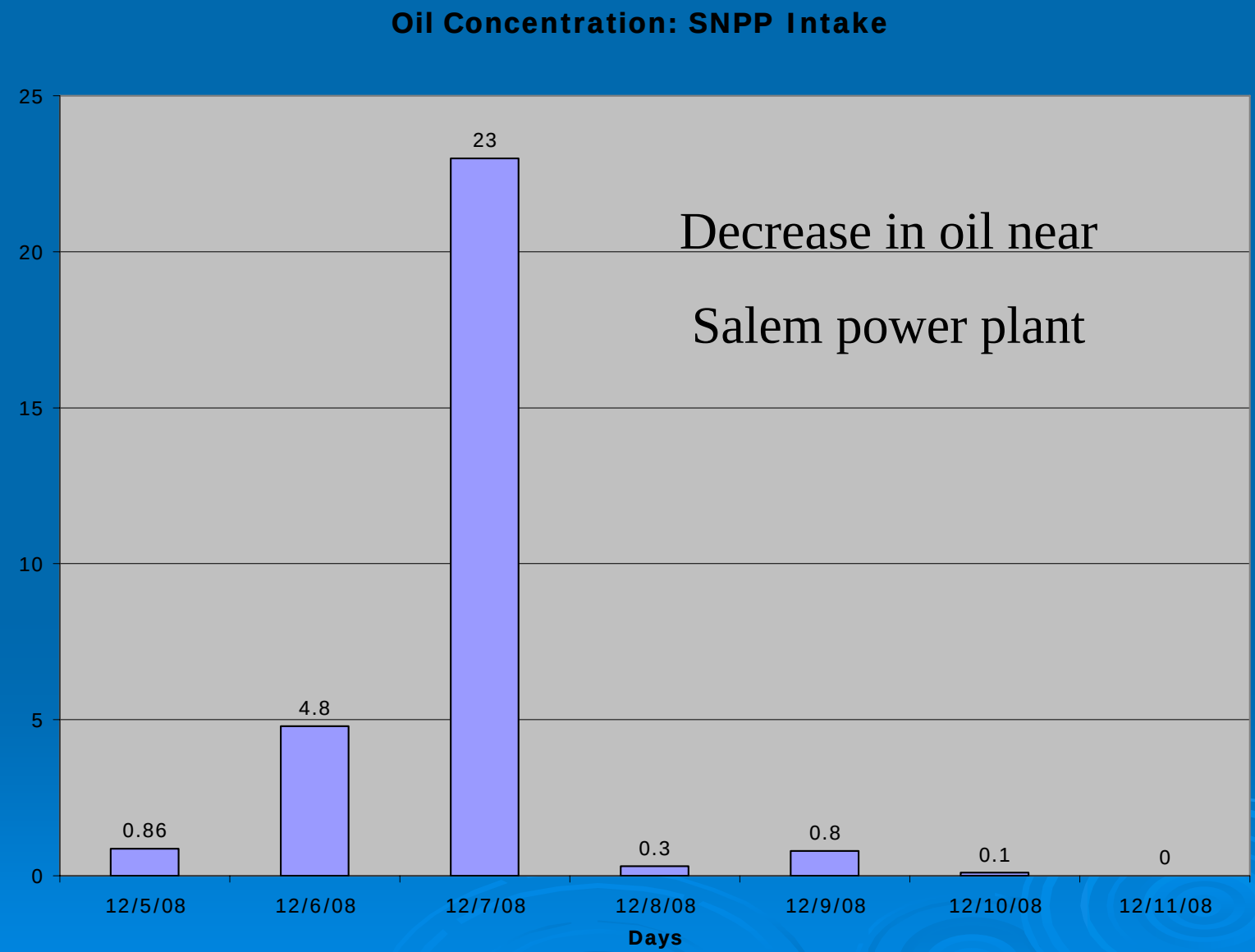
Power Plant Intake Sampling

simple, consistent descriptors

(pea, grape quarter, golf ball, grapefruit)

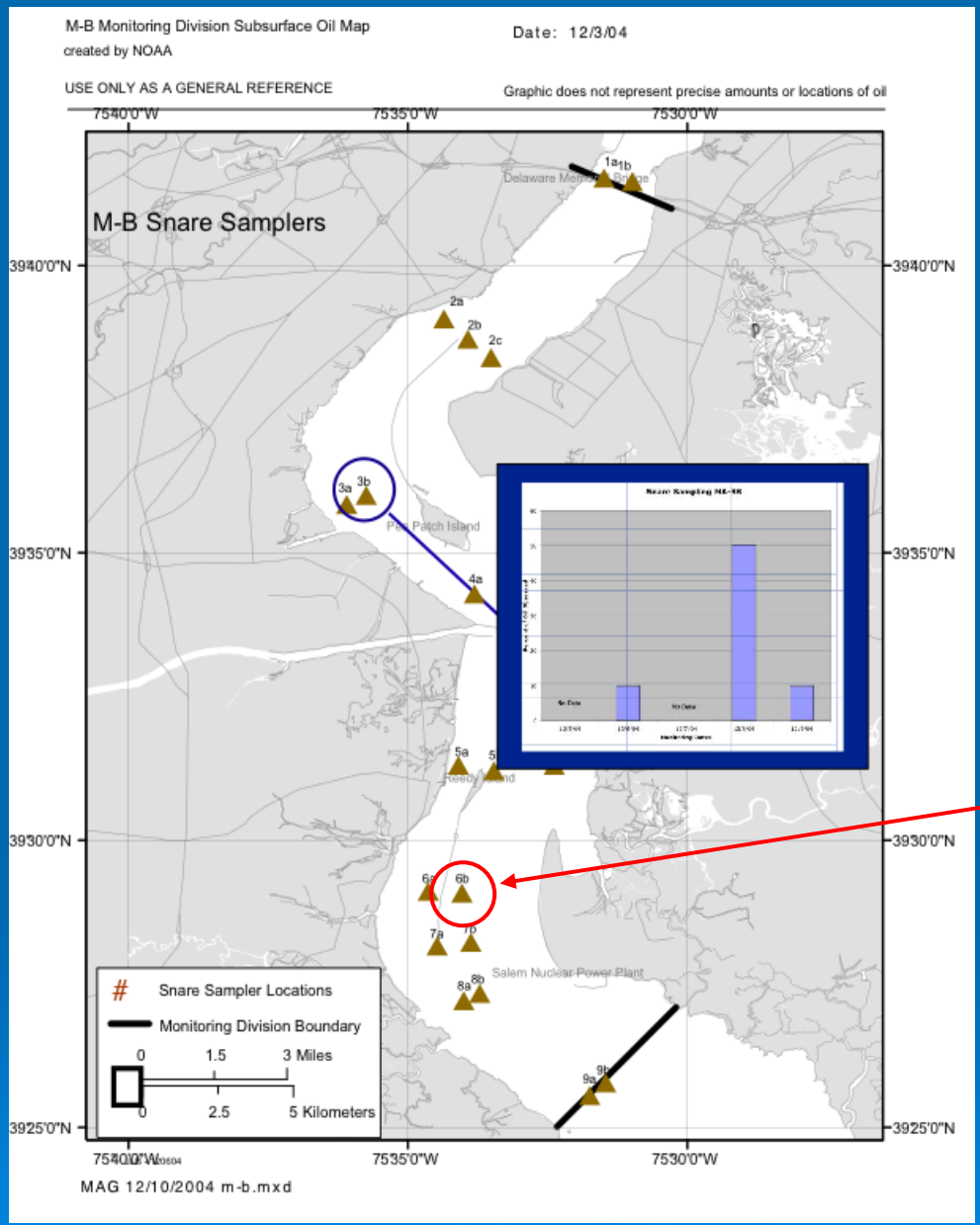
ECSI CW Intake Sampling

Date	Time	Sample Duration	Oil Sheen	Size/Amount Oil Globules
12/5/08	5:25	1 minute	Thin	Numerous pea size
12/5/08	6:30	2 minutes	Medium	10 pea size, 1Õx1Õ area on surface
12/5/08	8:00	2 minutes	Medium	20 raisin size
12/5/08	9:30	2 minutes	Thick	20 grape size, 1Õx1Õ area on surface
12/5/08	11:00	2 minutes	Thick	10-20 pea to quarter size
12/5/08	12:30	1 minute	Thick	75-100 pea size, 2-5 quarter size
12/5/08	14:00	2 minutes	Thin	10 pea size
12/5/08	16:30	1 minute	Light	5 pea to quarter size
12/5/08	18:00	1minute	Light	4-5 pea to quarter size
12/5/08	19:30	2 minutes	Light	4-5 pea to quarter size
12/5/08	21:00	2 minutes	Thick	1 grape size, 8-10 quarter size globules
12/5/08	22:30	2 minutes	Thick	2 grapefruit size and at least 5 quarter size
12/6/08	0:00	2 minutes	Light	2-5 quarter size
12/6/08	1:30	2 minutes	Thick	13 quarter size, Very Strong Ņdiesel oilÓ Odor
12/6/08	5:15	1 minute	Light	4 golf ball size, noticeable odor
12/6/08	6:30	1minute	Light	Noticeable odor
12/6/08	8:00	2 minutes	Light	Noticeable odor
12/6/08	9:30	2 minutes	Moderate	3 golf ball size, noticeable odor


Oil Concentration: SNPP Intake
25
20
15
10
5
0
23
4.8
0.86
0.3
0.8
0.1
0
Decrease in oil near
Salem power plant
12/5/08
12/6/08
12/7/08
12/8/08
12/9/08
12/10/08
12/11/08
Days

Submerged Oil Monitoring Techniques

Early Warning “Sentinels”



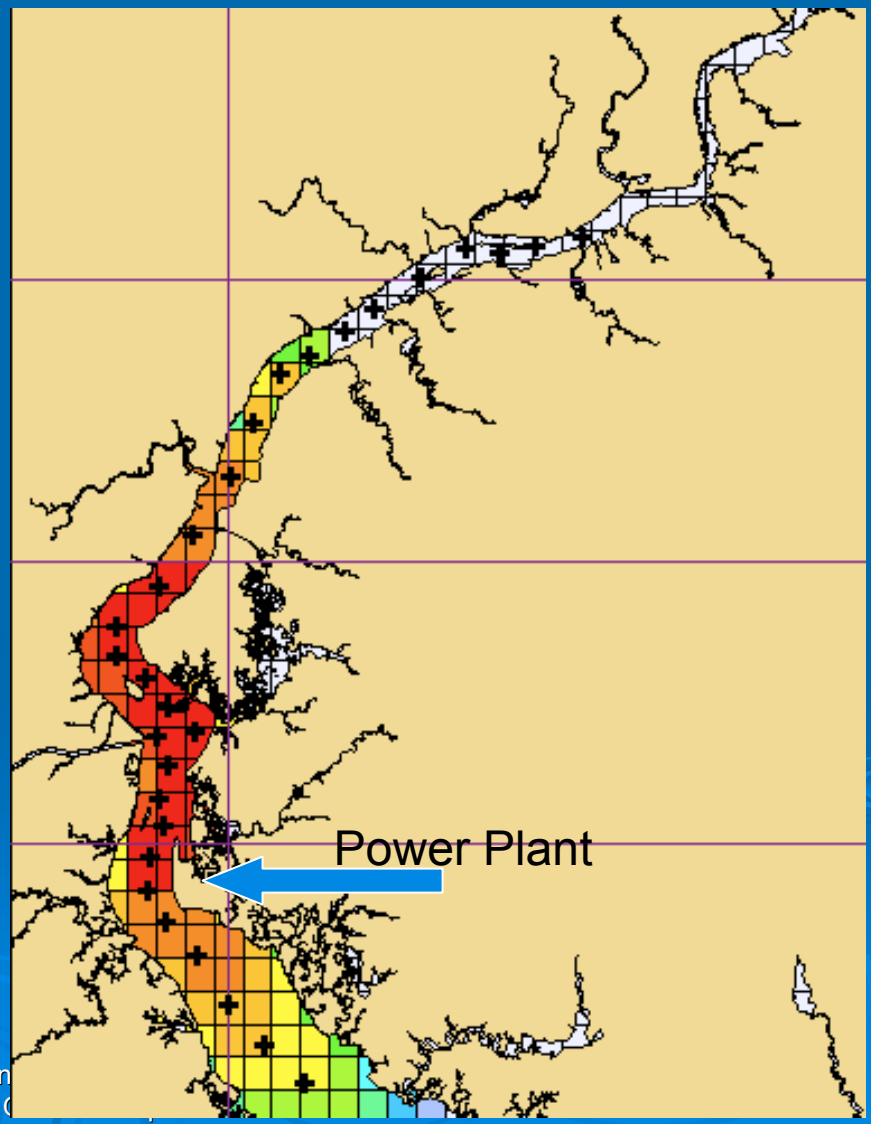
Modeling for Early Warning

Minimum transit time for subsurface oil to power plant intake area

Red <6 hours

Orange < 24 hours

Yellow < 48 hours



Magnolia Marine Transportation

Barge *MM 53*

Ohio River

USCG Sector Ohio Valley

Louisville, Kentucky


MM53
New Albany
Clarks
Sand Island
Sherman Minton Bridge
Louisville and Portland Canal
Google
Pointer 38° 17'04.82"N 85° 48'34.43"W elev 414 ft
Streaming 100%
Eye alt 20705 ft


2006 1 29


Hold: #3 strb
25ft
Hold: #4 strb
center line of the barge
2006 1 29

First Day

Oil was reported to release from the barge in large “pancakes” and would rapidly submerge

Photos courtesy of:
USCG Sector Ohio Valley


Hold: #3 strb
Hold: #4 strb
2006 1 29


2006 1 29

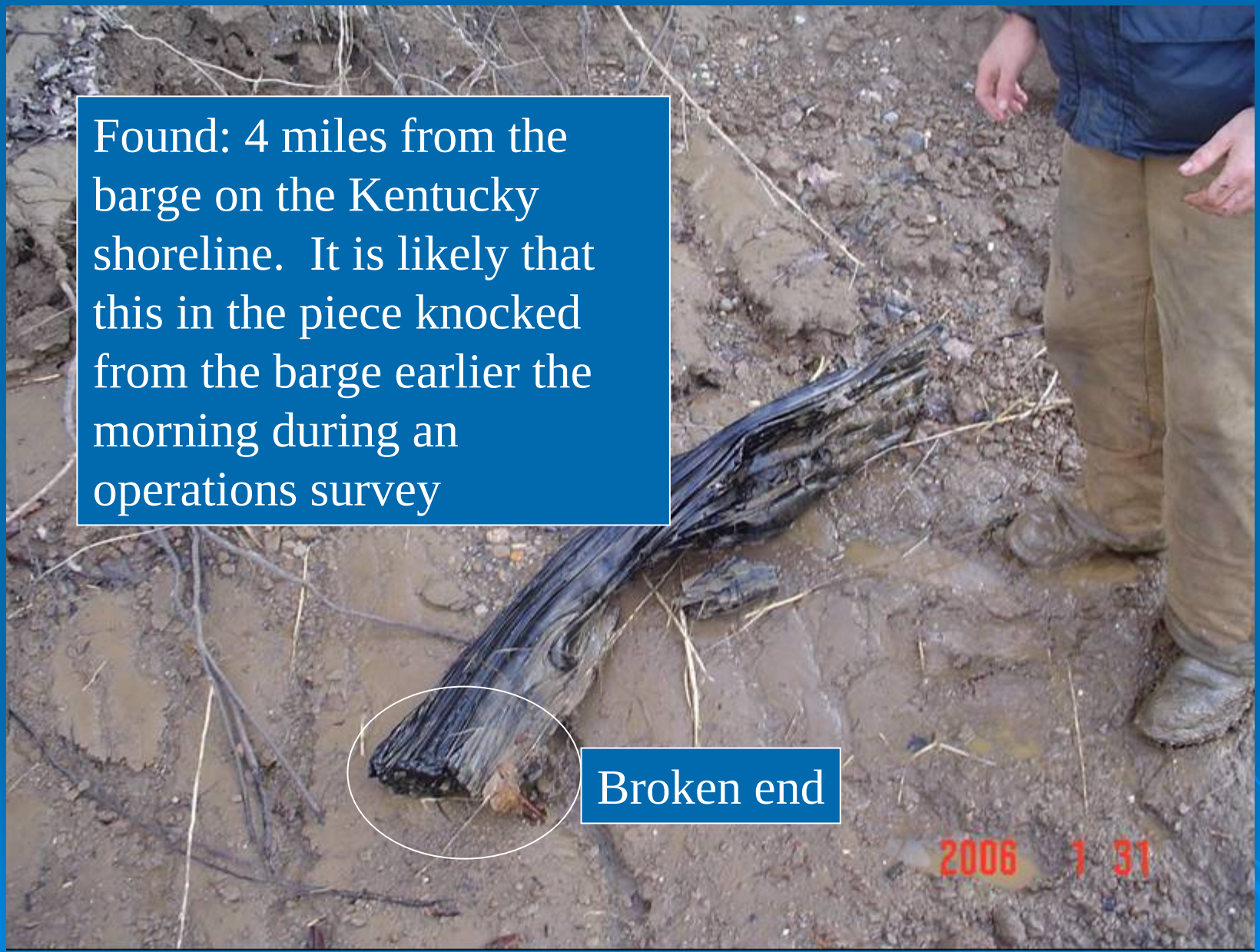
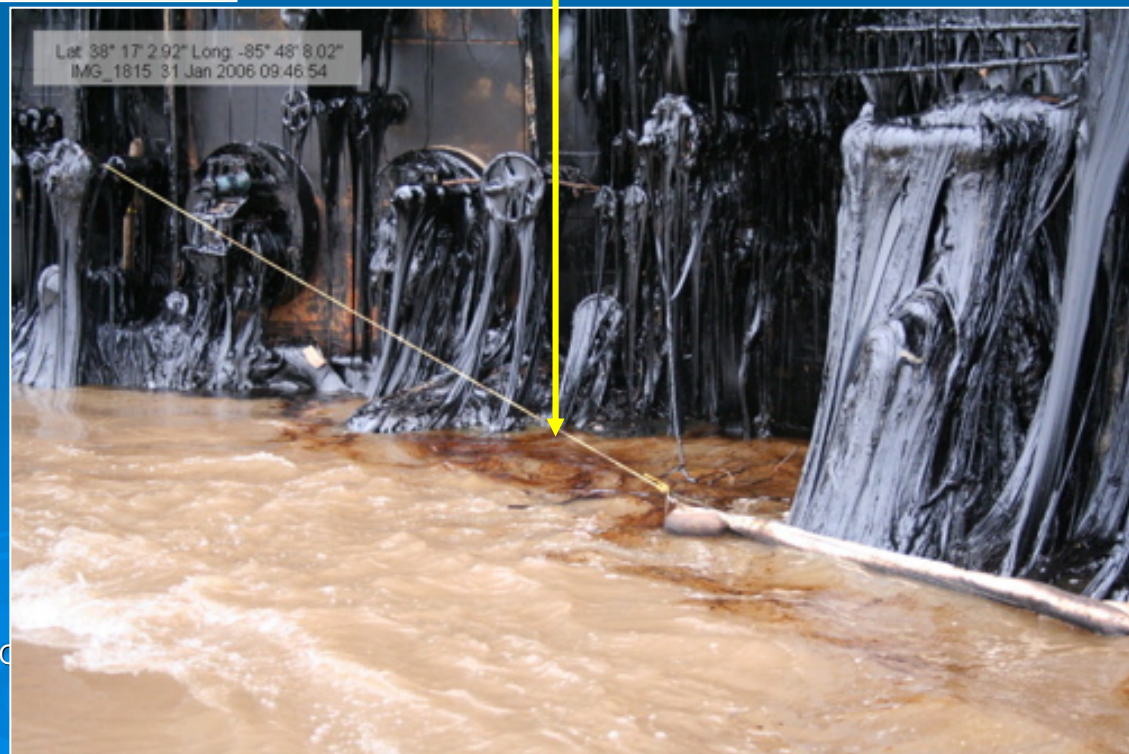


Photo courtesy of Andrew Melanis, WQIS

Pancake-zilla

Found over 1 mile from the barge, 15 ft up the bank of the river. It is assumed that it floated to its location

Thermal oil continues as a slow leak. Sorbent boom remains in place & changed daily



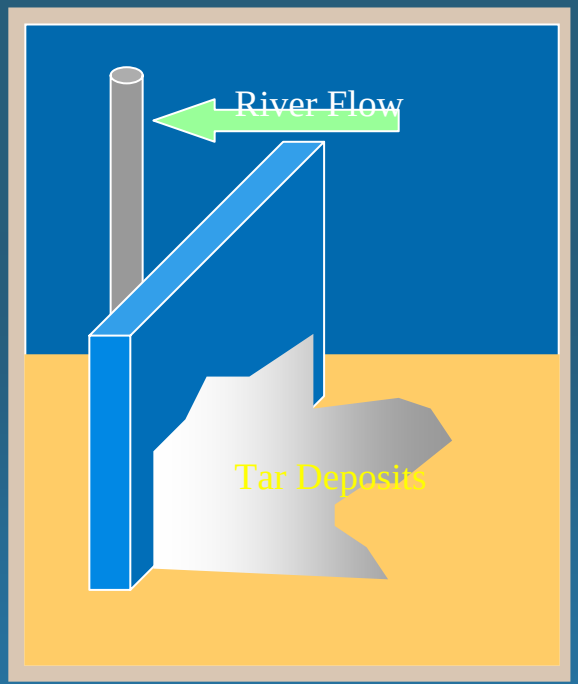
Photos courtesy of Andrew Melanis, WQIS

Side-Scan Sonar

31 January 2006

Asphalt Deposits

Asphalt coating on barge decking up to 1 foot thick



Currents

Barge MM-53

100 feet

eddy

Extent of downriver survey

Asphalt “piles” approx. 6 ft diam. by 5 ft high


31 10:13 AM


Thank You
Questions ?