OIL BOOM FAILURE DUE TO WIND-DRIVEN CURRENT

The death knell for conventional oil booms?

Interspill London 2012
Spill Industry Seminar

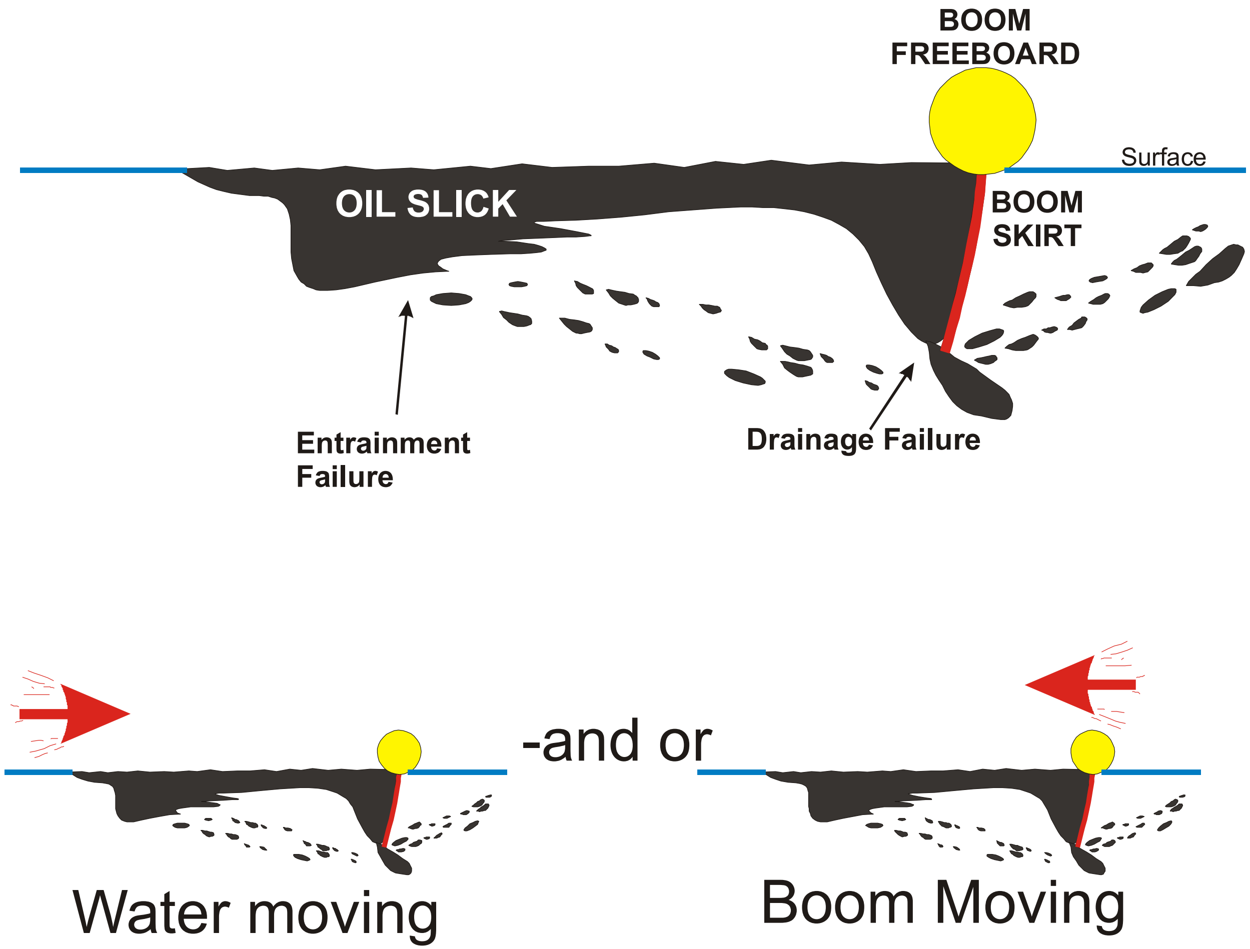
Dag Nilsen
R&D Manager

TOPICS:

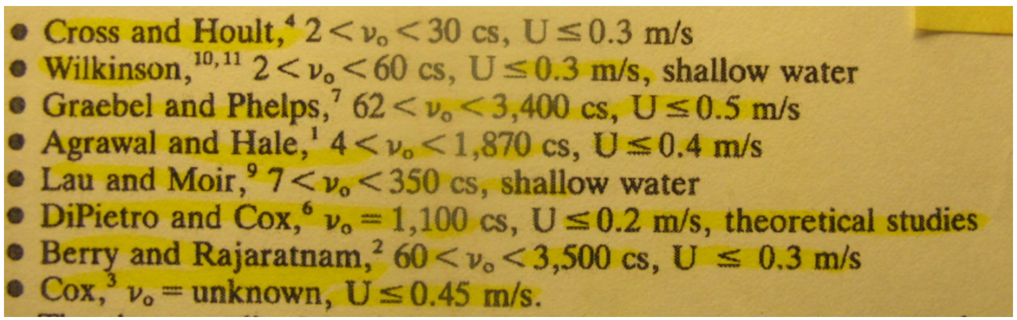
- Main failure mechanisms relative to conventional oil booms
- What are the current challenges faced by spill responders?
- Contribution from wind driven current
- Conclusion


THE QUESTION:
Why does the oil go straight through
an offshore conventional oilboom
- on a calm day inshore?

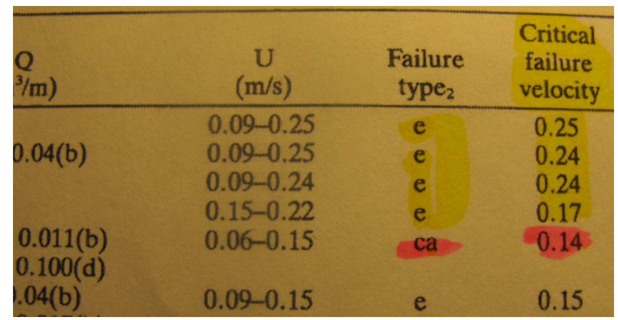
Drainage failure and entrainment



Critical speed towards water for entrainment and drainage failure



- Cross and Hoult,[4] $2 < \nu_o < 30$ cs, $U \leq 0.3$ m/s
- Wilkinson,[10,11] $2 < \nu_o < 60$ cs, $U \leq 0.3$ m/s, shallow water
- Graebel and Phelps,[7] $62 < \nu_o < 3{,}400$ cs, $U \leq 0.5$ m/s
- Agrawal and Hale,[1] $4 < \nu_o < 1{,}870$ cs, $U \leq 0.4$ m/s
- Lau and Moir,[9] $7 < \nu_o < 350$ cs, shallow water
- DiPietro and Cox,[6] $\nu_o = 1{,}100$ cs, $U \leq 0.2$ m/s, theoretical studies
- Berry and Rajaratnam,[2] $60 < \nu_o < 3{,}500$ cs, $U \leq 0.3$ m/s
- Cox,[3] ν_o = unknown, $U \leq 0.45$ m/s.



Q ³/m)	U (m/s)	Failure type₂	Critical failure velocity
	0.09–0.25	e	0.25
0.04(b)	0.09–0.25	e	0.24
	0.09–0.24	e	0.24
	0.15–0.22	e	0.17
0.011(b)	0.06–0.15	ca	0.14
0.100(d)			
.04(b)	0.09–0.15	e	0.15

SOURCE: Barrier Failure by Critical Accumulation, Gerard A. L. Delvigne

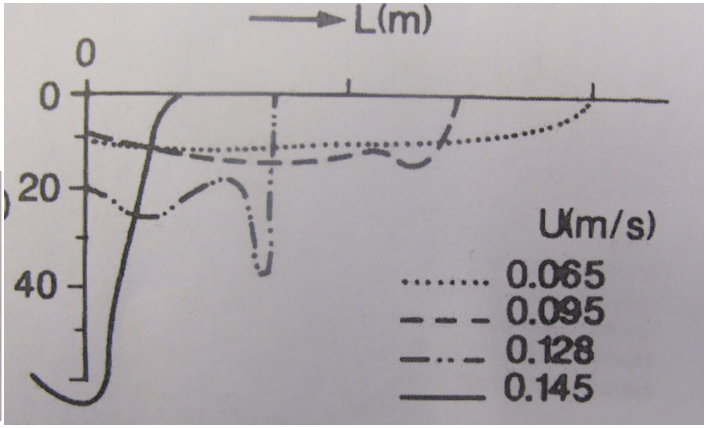
There are many different studies and practices concerning the maximum speed through water before oil loss occurs.

A reasonable figure to use for an «average» conventional oil boom is a oil loss speed of **0,6 knots** (0,3 m/s).

Failure due to Critical Accumulation

The reduction to an infinitely small slick length causes all the oil to pass under the barrier independent of the barrier draft.

Experiments on barrier failure were performed in two laboratory flumes using a wide range of oil types and oil viscosities. Critical accumulation always occurred with oil viscosities $\nu_o \gtrsim 3{,}000$ cs. The critical relative velocity was $U_{ca} \simeq 0.15$ m/s for oil with $3{,}000 \text{ cs} < \nu_o < 20{,}000$ cs, with a slight increase in U_{ca} for higher viscosities. U_{ca} is independent of other oil and hydrodynamic parameters.



SOURCE: Barrier Failure by Critical Accumulation, Gerard A. L. Delvigne

- For oil with a viscosity of between 3000-22000 cSt the oil loss speed is 0,3 knots!

- The phenomenon of Critical Accumulation is not widely known in the spill recovery industry

- Weathering and evaporation of lighter fractions causes (for example) crude oil, to rapidly reach the critical limit of 3000 cSt.

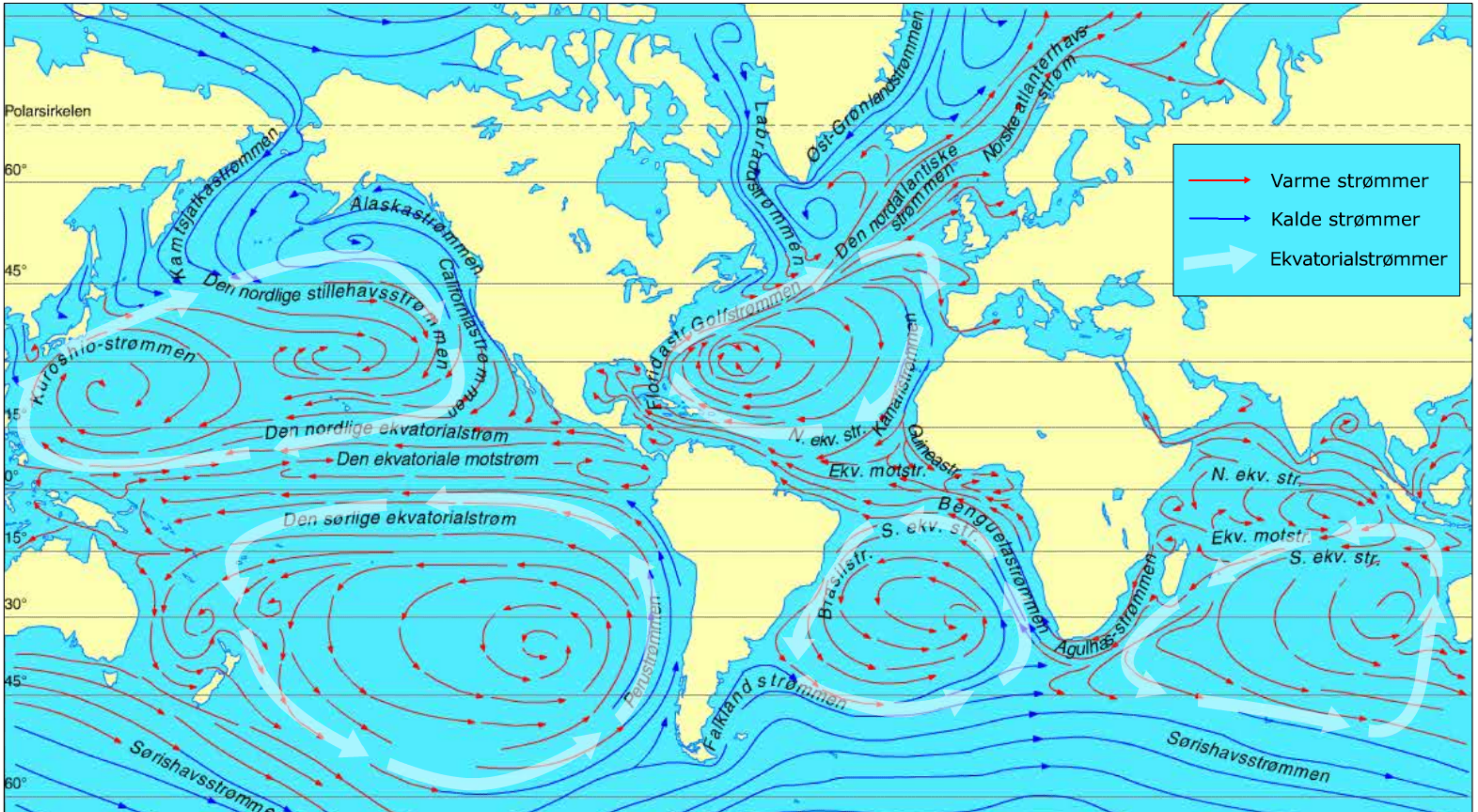
Maximum towing speed for an oil boom

- When towing an oil boom, there will be a need for a buffer or margin against failure. Depending on the type of speed measuring devices employed (GPS is of no use at all), current variations etc., this buffer should be an absolute minimum of 0,3 knots.

- For oil with a viscosity of less than 3000 cSt, the maximum towing speed is consequently 0,6 knots – 0,3 knots = 0,3 knots

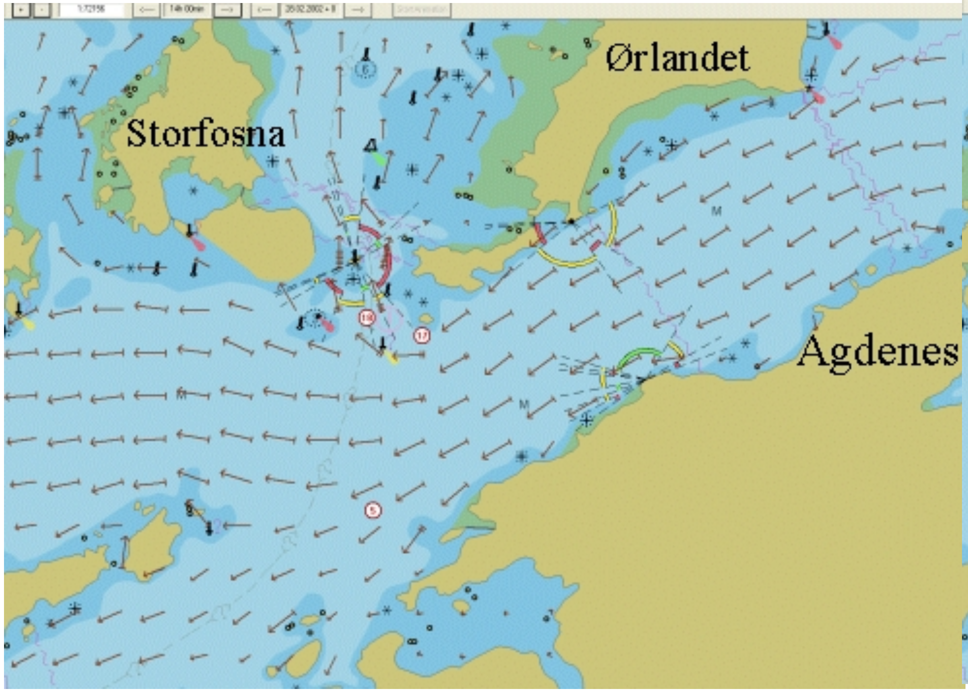
- For oil between 3000 and 22000 cSt and where Critical Accumulation may be a failure issue, the maximum planned speed should be 0,3 knots – 0,3 knots = 0,0 knots - i.e. no movement at all!

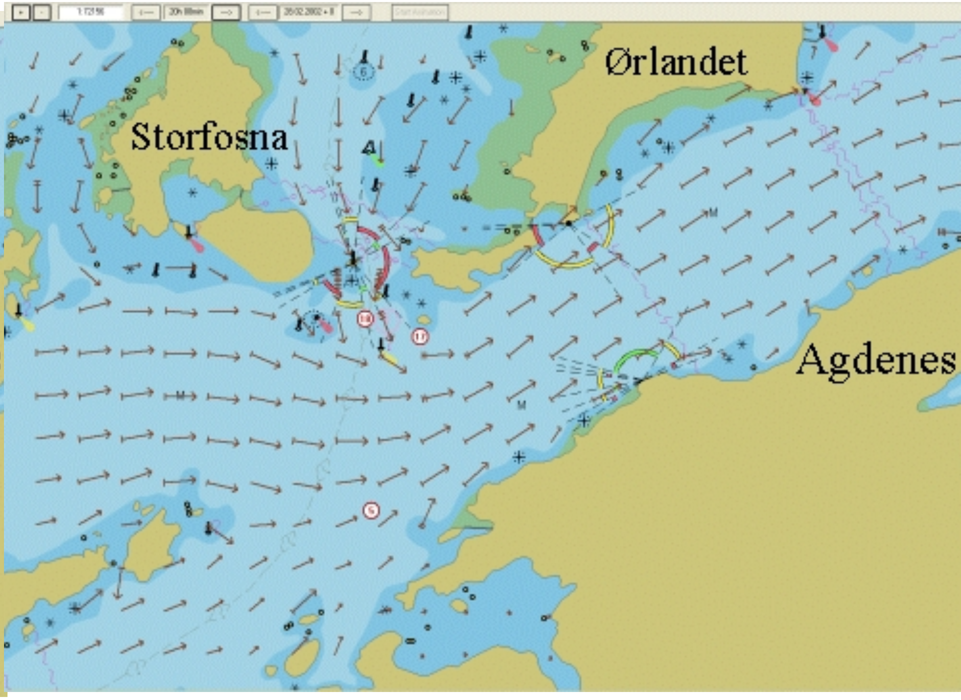
Coastal currents



Tidal currents

- Turn approximately every 6 hours
- Can be strong, up to several knots

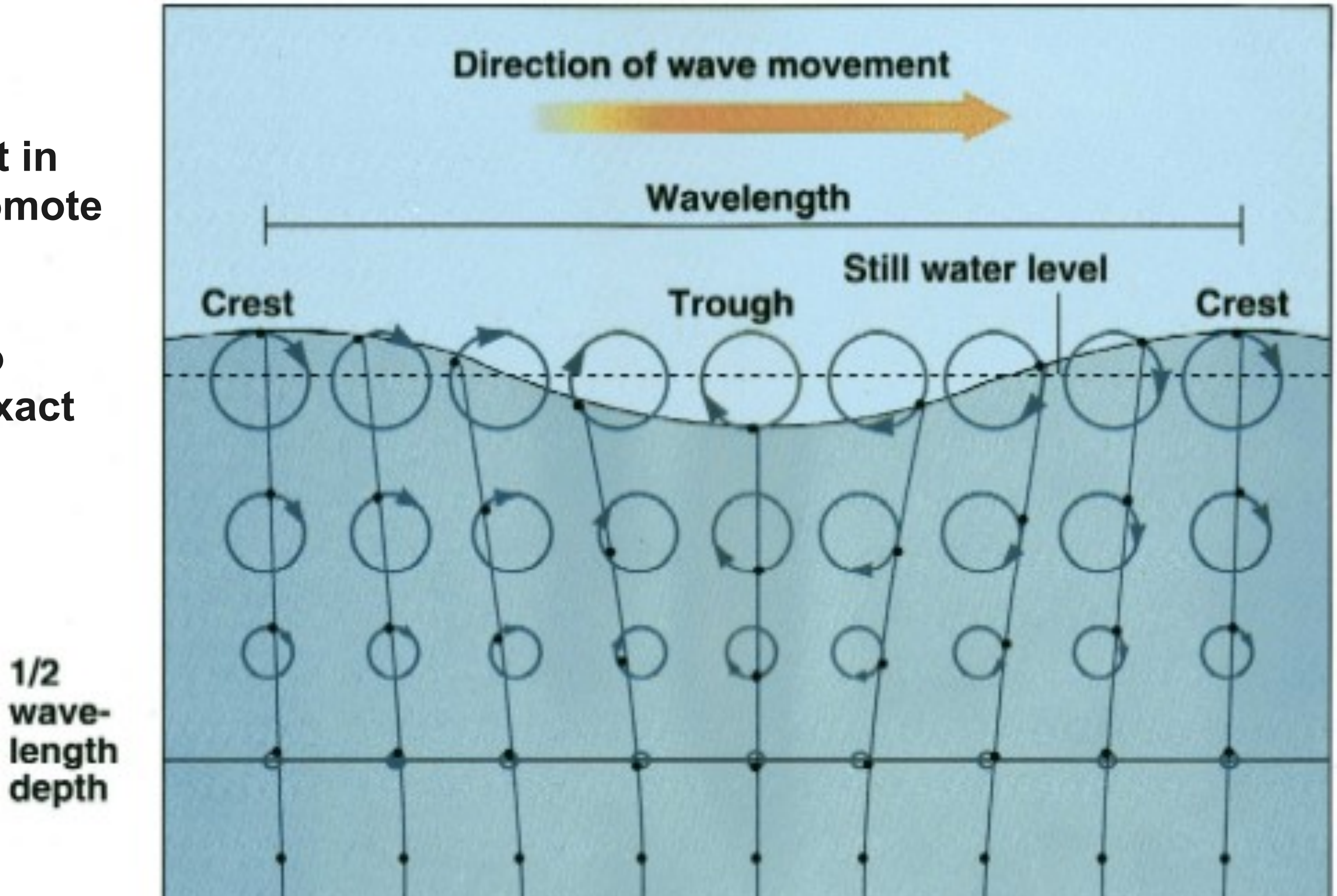




Orbital current in swell (non-breaking waves)

Orbital current in waves will promote drainage loss!

It is difficult to quantify the exact extent of loss.



Front current in breaking waves

In the case of wind-driven breaking waves, the front of the breaking wave will create a powerful local current in towards the oil boom. There has been no evidence that conventional oil booms have functioned effectively in wind-driven breaking waves, beyond smaller waves in harbours and similar areas.

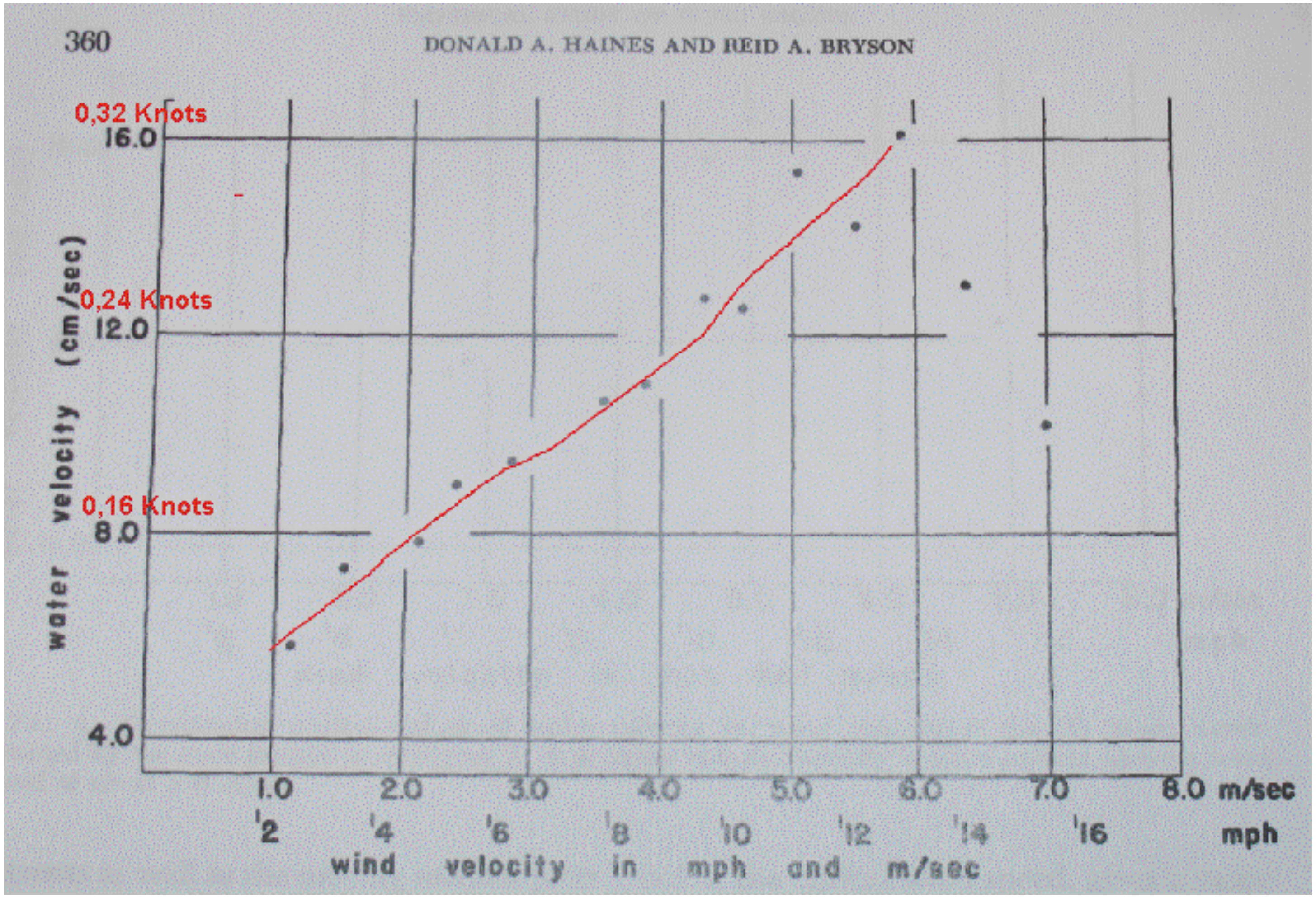
Other currents to be considered

- Local currents from estuaries (three-phase medium; salt water, fresh water and oil)
- Local vortex currents
- Rip currents
- Backwash from waves hitting the shoreline
- Propeller wash from vessels
- Towing

Wind-driven surface currents

Wind-driven current is readily acknowledged in oil drift models; however, it is only to a limited degree that this is reflected in actual field spill cleanup operations using conventional oil booms.

Wind driven surface currents



AN EMPIRICAL STUDY OF WIND FACTORS IN LAKE MENDOTA
D. A. Haines and R. A. Bryson

Wind-driven surface currents

For oil with a viscosity of between 3000 -22000 cSt, where the failure speed is 0,3 knots, even a moderate wind of 6 m/s (13 mph), causing a surface current of 0,3 knots, may cause a conventional oilboom to fail, independently of all other possible oil boom failure factors.

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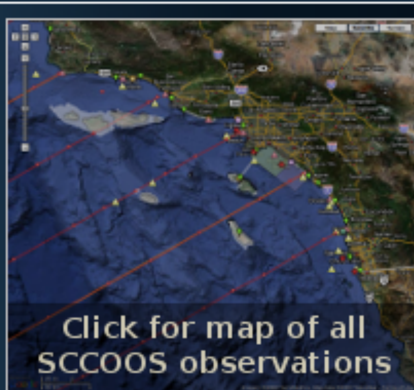


Available Products

- Automated Shore Stations
- Bathymetry
- CA ASBS System
- Gliders
- Harbors
- Harmful Algae & Red Tides
- Manual Shore Stations
- Meteorological Observations
- Moorings
- Plume Tracking
- ROMS Model Output
- Satellite Imagery
- Ship Tracking (AIS)
- Ship Casts
- Surface Current Mapping
  - Overview
  - Optimally Interpolated
  - Surface Currents
  - Morro Bay
  - Santa Barbara
  - Ventura
  - Los Angeles
  - Orange County
  - North San Diego
  - San Diego & Mexico
  - South Channel Islands

UTC Time: 2012-03-05 20:35:10
Local Time: 2012-03-05 21:35:10

Surface Current Mapping

Interface to HFRADAR Derived Surface Currents

click for **View Full Page**

« -1 Day | -1 Hour | 2012-03-05 20:00:00 | -12:00 from UTC | +1 Hour | +1 Day »

UTC Time: 2012-03-05 20:35:10
Local Time: 2012-03-05 21:35:10

Resolutions

	Hourly	25hr Avg
500m	☐	☐
1km	☑	☐
2km	☑	☐
6km	☑	☐

* Vector size is not visually consistent between resolutions.

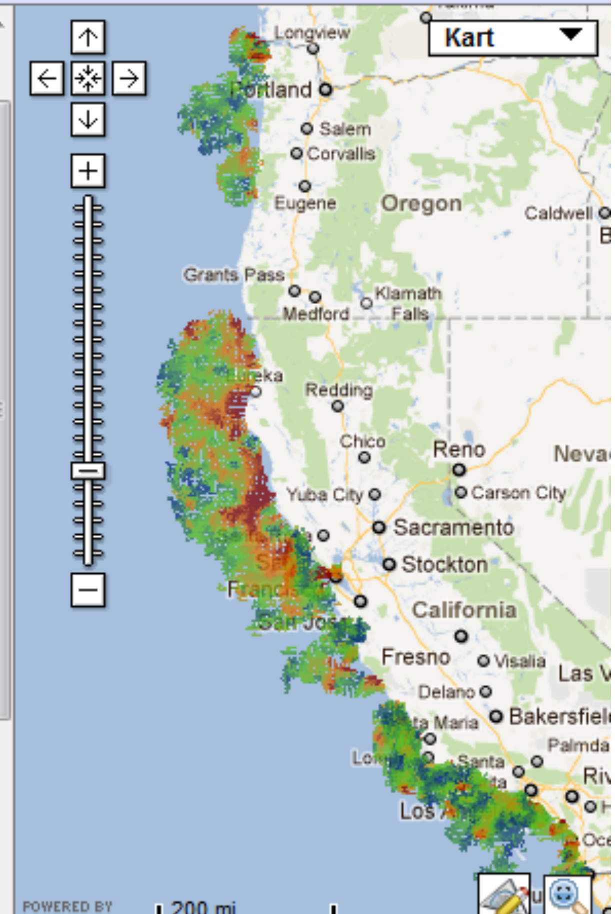
Overlays

- ☐ Station Placemarks
- ☐ So-Cal Oil Platforms

Colorbar

Current Strength (kts)

0.0 0.2 0.4 0.6 0.8 1.0



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Control Panel

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UTC Time: 2012-03-05 19:40:43
Local Time: 2012-03-05 20:40:43

Resolutions

	Hourly	25hr Avg
500m	☑	☐
1km	☑	☐
2km	☑	☐
6km	☑	☐

* Vector size is not visually consistent between resolutions.

Overlays

☑ Station Placemarks
☐ So-Cal Oil Platforms

Colorbar

Current Strength (kts)

0.0 0.2 0.4 0.6 0.8 1.0

0.00 kts 0.97

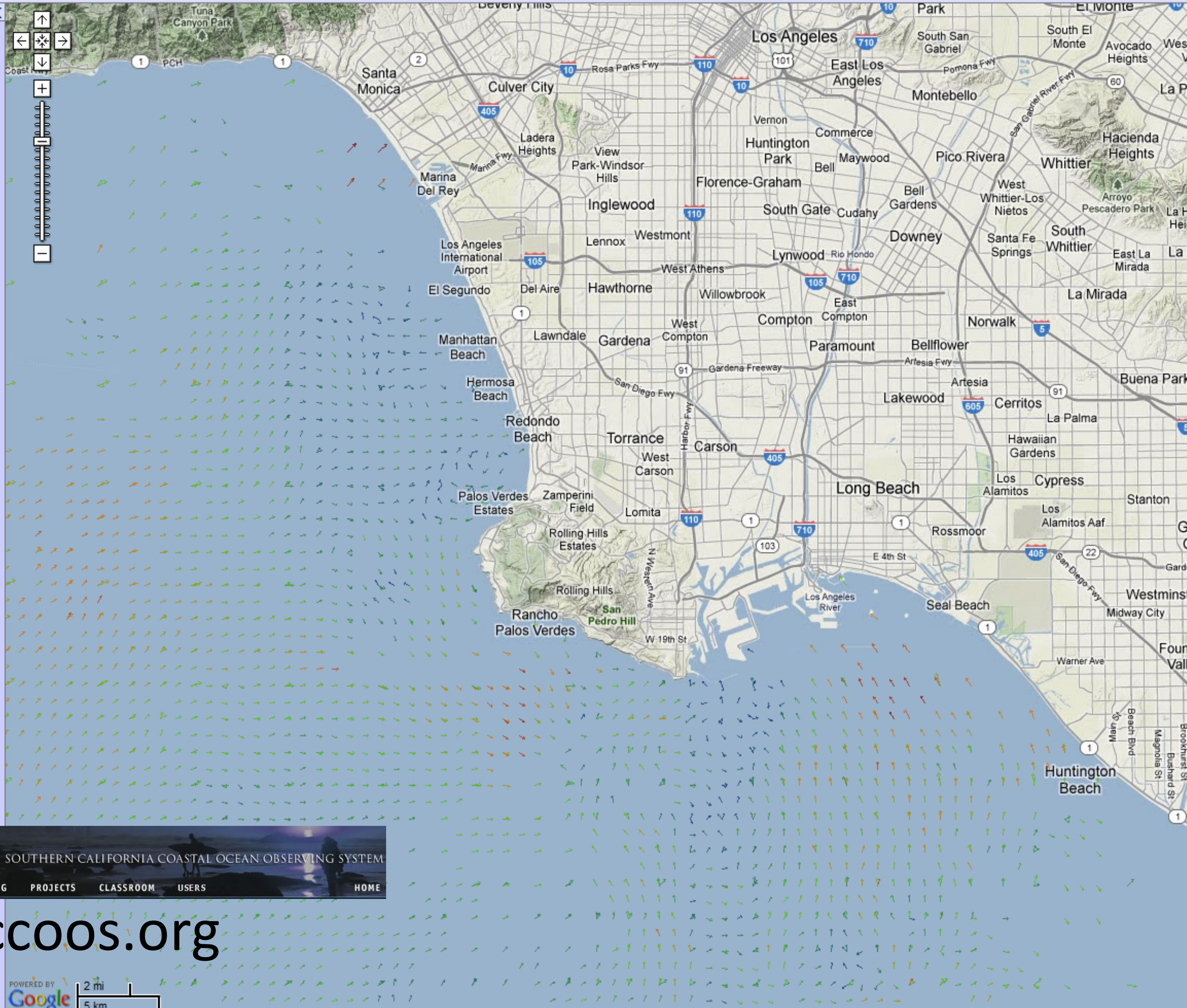
Default

Coordinate Locator

Lat:

Lon:

Locate



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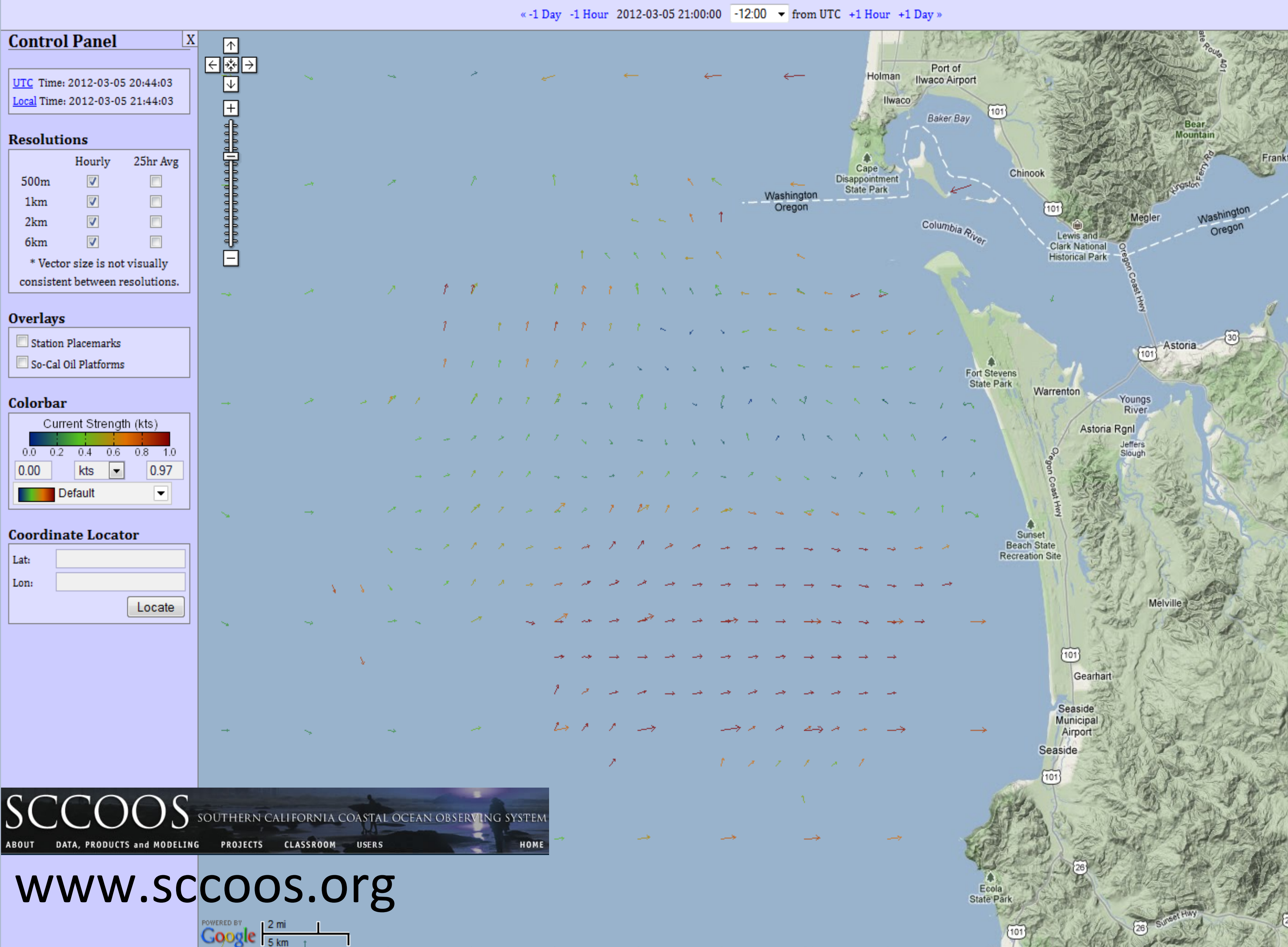

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Control Panel

UTC Time: 2012-03-05 20:19:53
Local Time: 2012-03-05 21:19:53

Resolutions

	Hourly	25hr Avg
500m	☑	☐
1km	☑	☐
2km	☑	☐
6km	☑	☐

* Vector size is not visually consistent between resolutions.

Overlays

☑ Station Placemarks
☐ So-Cal Oil Platforms

Colorbar

Current Strength (kts)

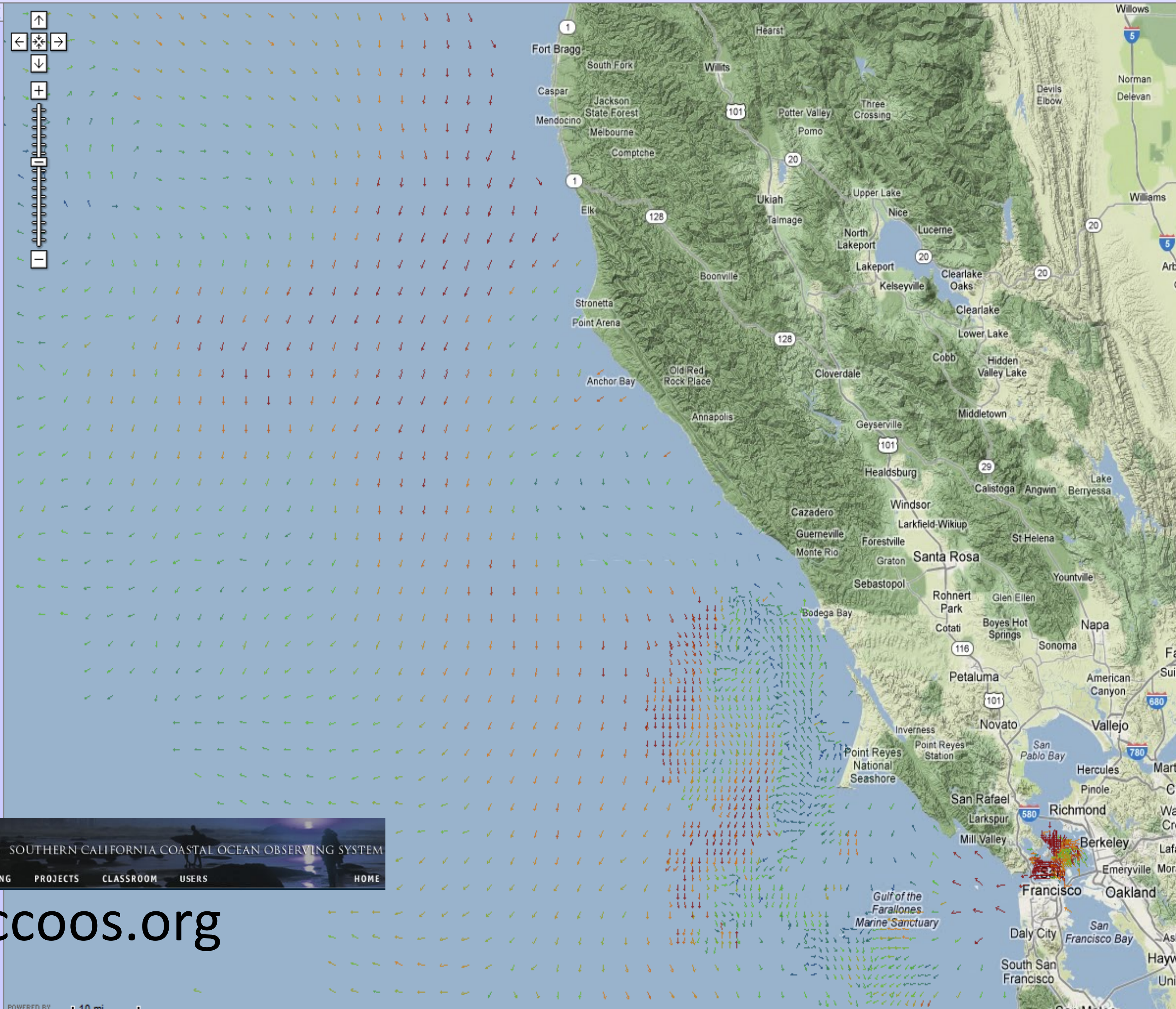
0.0 0.2 0.4 0.6 0.8 1.0

0.00 kts 0.97

Default

Coordinate Locator

Lat:
Lon:
Locate



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« -1 Day -1 Hour 2012-03-05 20:00:00 -12:00 from UTC +1 Hour +1 Day »

Control Panel

UTC Time: 2012-03-05 19:55:22
Local Time: 2012-03-05 20:55:22

Resolutions

	Hourly	25hr Avg
500m	☑	☐
1km	☑	☐
2km	☑	☐
6km	☑	☐

* Vector size is not visually consistent between resolutions.

Overlays

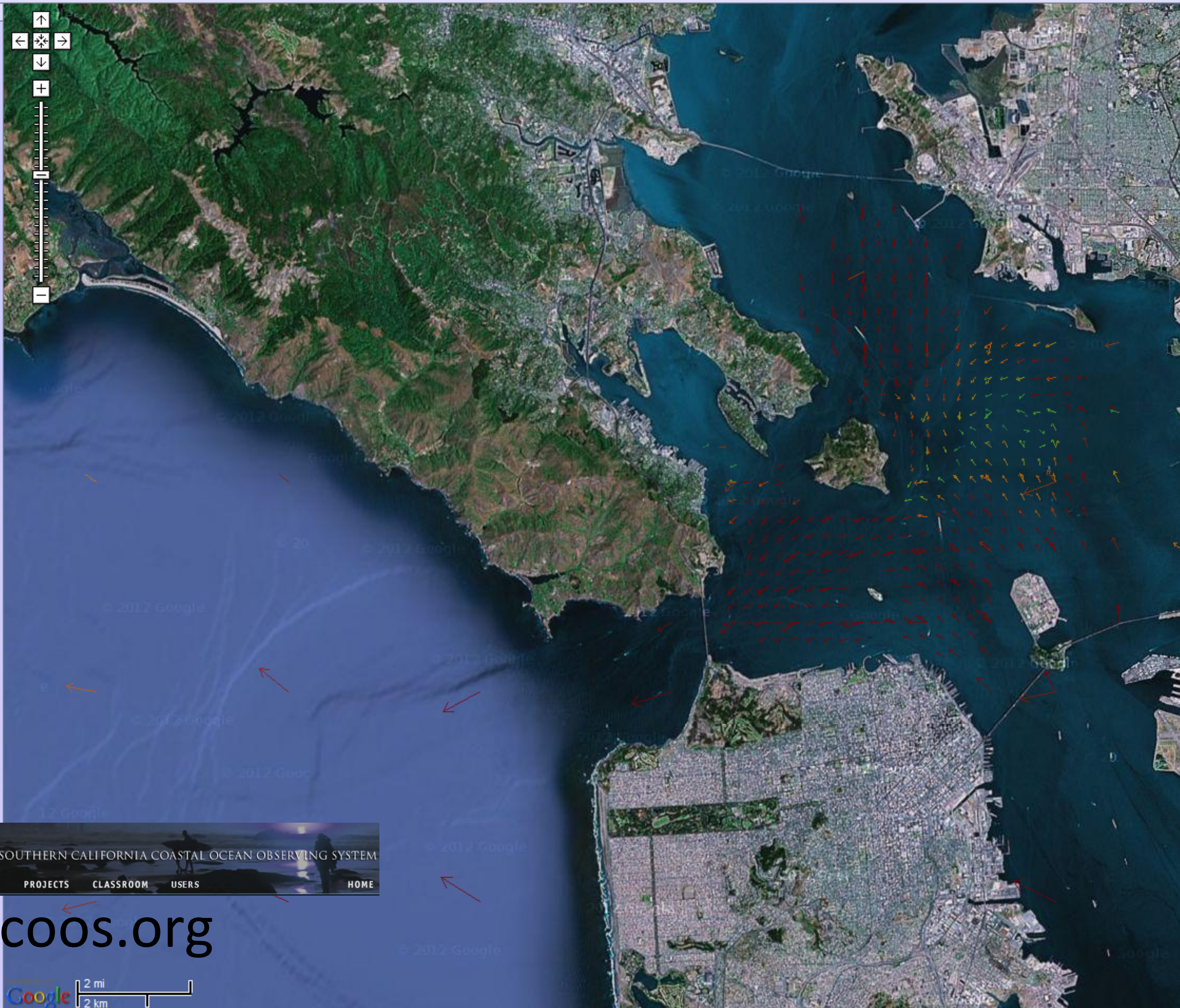
☑ Station Placemarks
☐ So-Cal Oil Platforms

Colorbar

Current Strength (kts)
0.0 0.2 0.4 0.6 0.8 1.0
0.00 kts 0.97
Default

Coordinate Locator

Lat:
Lon:
Locate



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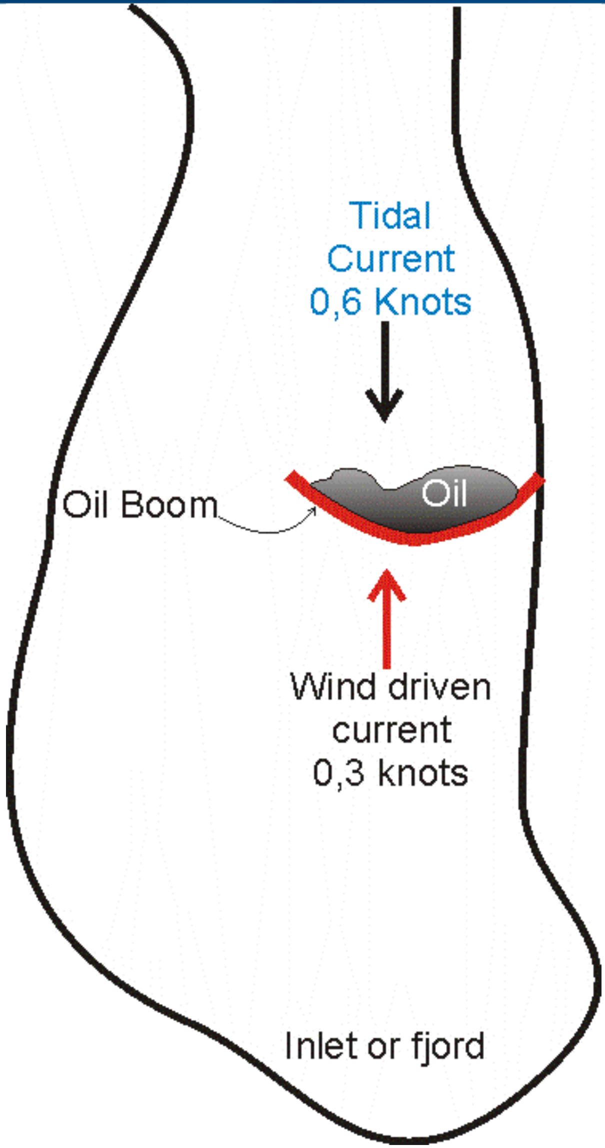

What happens when
the tidal current turns
or the wind changes direction?


ROCKNES SPILL, Bergen, Norway, 2004

Example of Active Oil Boom

NOFI CURRENT BUSTER 4

Despite the fact that several kilometres of conventional oilbooms were in operation during the "Rocknes" oil spill, a 'small' NOFI Current Buster 4, towed by two smaller fishing vessels, collected 90% of the oil collected at sea.

Conclusion:

1. Skilled professional spill responders with a thorough understanding of currents are still faced with an almost impossible task in the field when using conventional oil booms.
   Their primary response tool does not function!

2. A great deal of the risk-reducing contribution planned for by conventional oil booms is probably illusive.

3. Conventional oil booms should be downgraded to a secondary or tertiary response tool, to be used only in the most optimal situations without current or wind.

4. Active mechanical response systems, which can operate effectively up to 5 knots current, should take over the role of primary response tool. Tactics for active oil booms should be developed for most types of response situations.

NOFI

Thank you for your attention!