



HF Radar Ocean Current Mapping: IOOS Perspective

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NOAA IOOS Program



HF Radar Outline

- **What It Does**
 - **Some Examples**
- **What It Looks Like**
- **How It Works**
- **How Much It Costs**
- **What NOAA Is Doing With It**



What It Does

- **Provides Maps of Ocean Surface Currents**
- **Speed and Direction**
- **Covering Thousands of Square Kilometers**
- **Near-real-time**
- **Hourly**
- **0.2 km to 6 km Spatial Resolution**



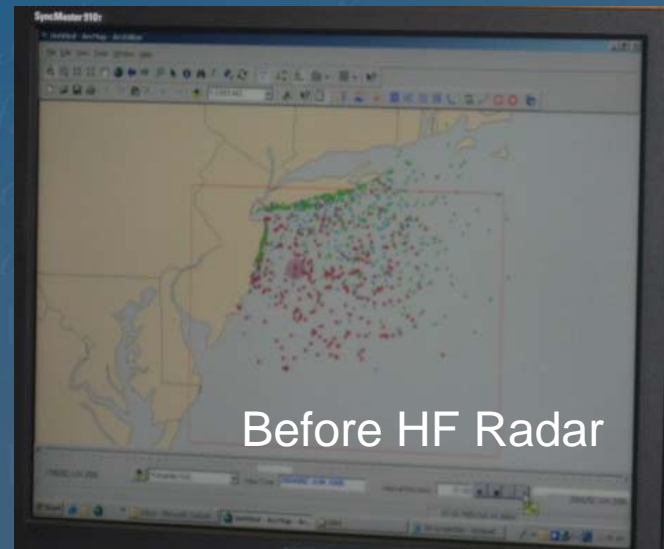
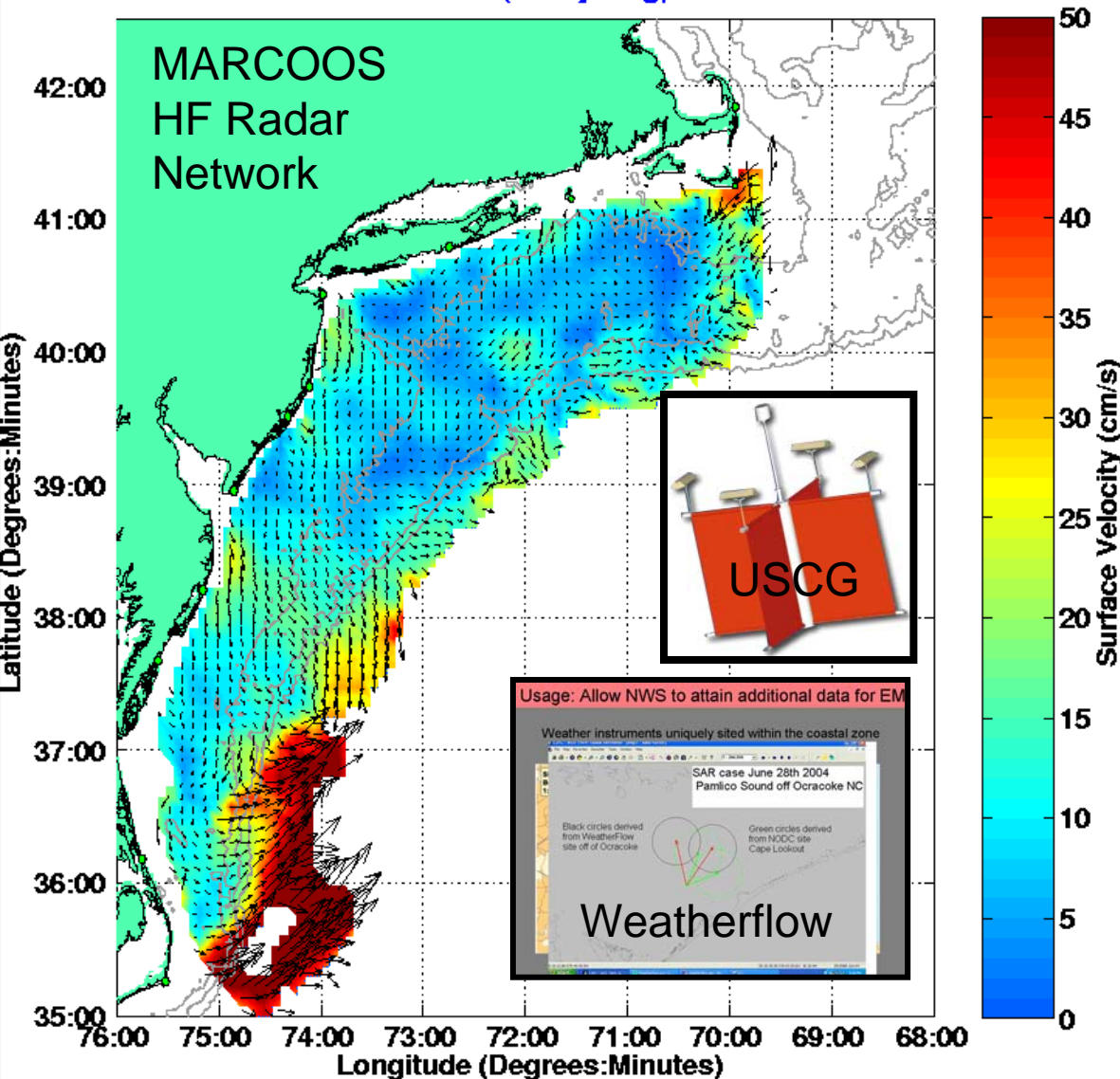
Existing Applications

- **Federal, State, Local Agencies**
 - **USCG Search & Rescue**
 - **Water quality monitoring**
 - **Rip current prediction**
 - **Marine navigation**
 - **Fisheries and ecosystem management**
 - **Oil Spill response, both NOAA and state**

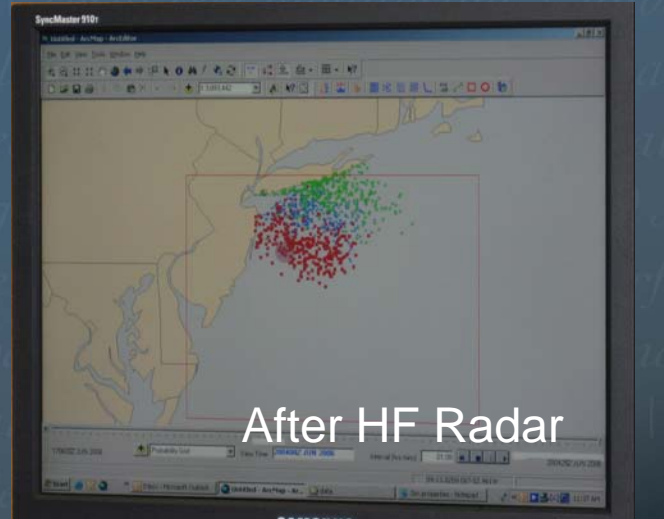


Maritime Safety – Search And Rescue

Mid-Atlantic Raw Velocities (1 Day Avg) 2007/05/01 1000 GMT



Coast Guard SAROPS





The Technology



CODAR Transmit Antenna





CODAR Receive Antenna





Receive and Transmit Antennas





HF Radar Electronics Enclosure



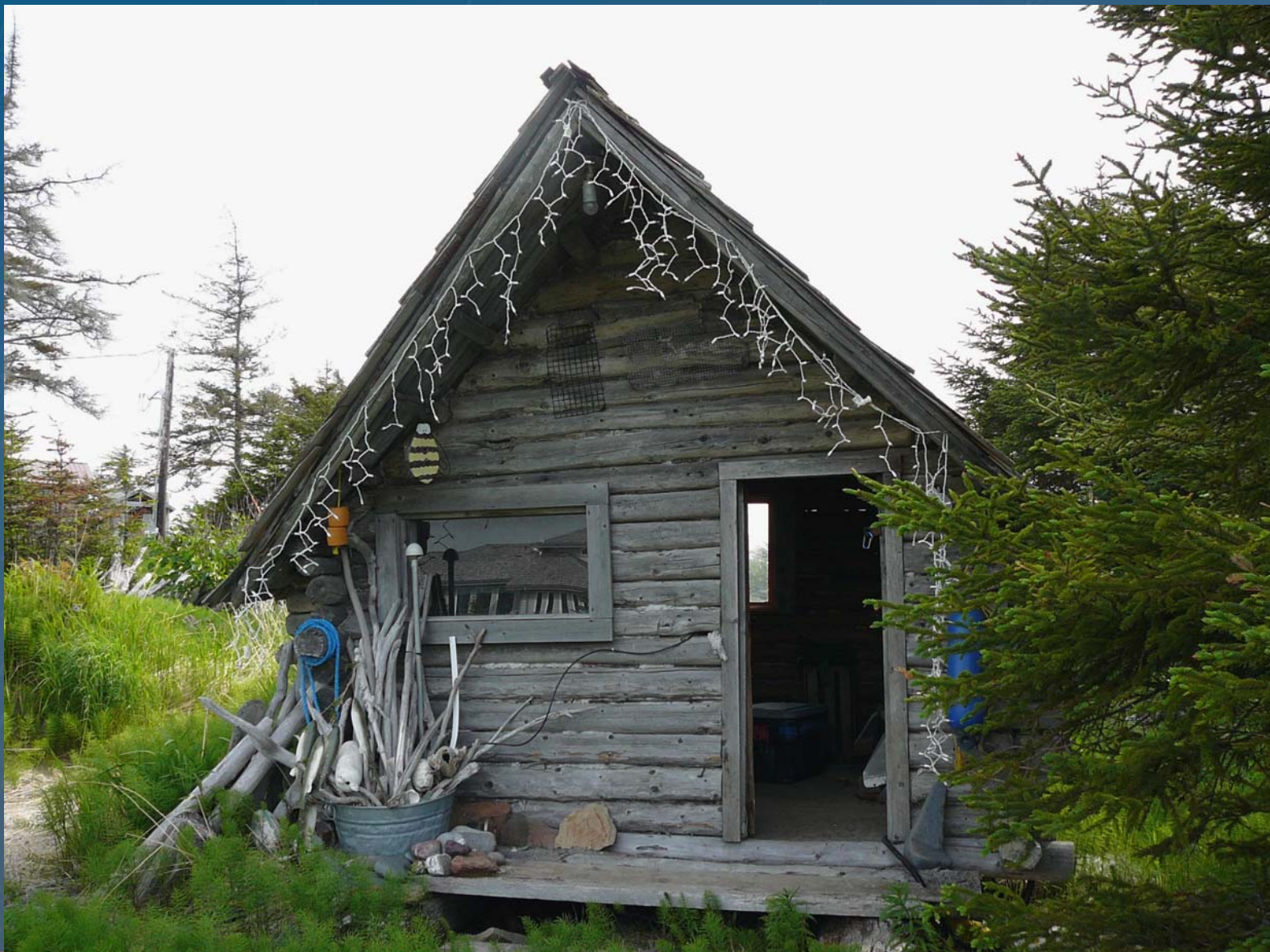


HF Radar Electronics Enclosure



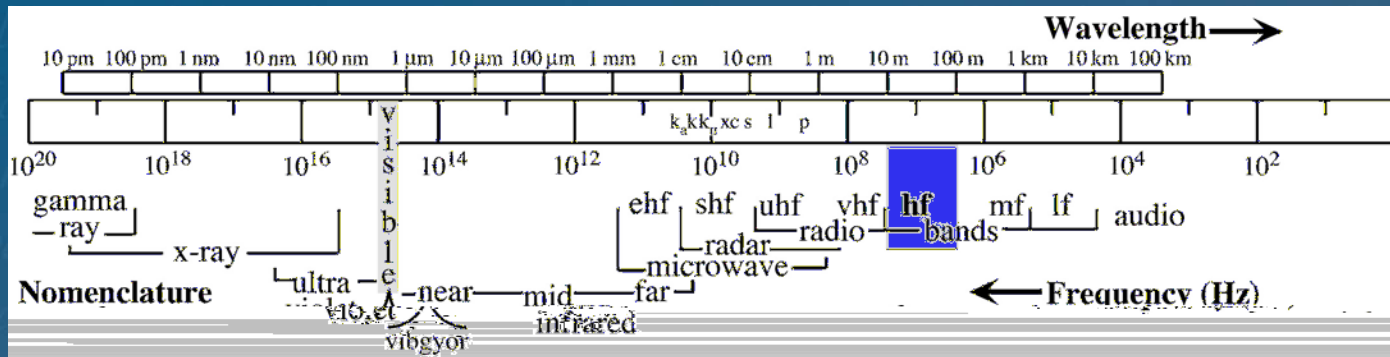


HF Radar Electronics Enclosure





HF Radar: How It Works



The Plus Side

- Longer Wavelengths than Met Radars → Immune to Precip
- Ranges to 250 km
- Radiates Less Energy than Household Lightbulb
- Mature Technology

The Minus Side

- Interference from Distant Sources, Crowded Radio Spectrum
- Need “Deep” Water = > 1/2 the radio wavelength

The Dark Side

- Interference Hard to Mitigate
- Water Wave Nonlinearities



HF Radar: How It Works

Direction Finding Radar

- Where Am I?
- Broad Beam
- Compact Antenna
- Wave Info Limited
- 95% of US HFRs



Beam Forming Radar

- How Fast Am I Going?
- Narrow Beam
- Large Antenna
- Wave Info Easier





Radar Site Issues

- **The Plus Side**
 - Unattended and Low Maintenance
- **The Minus Side**
 - Locating Sites and Access
 - Power and Communications
- **The Dark Side**
 - Local Siting Permits
 - Vandalism, Rodents, Lightning, Erosion



Radar Specs

- **Velocity Resolution:** 2 to 4 cm/s *
- **Range Resolution:** 0.2 to 6 km **
- **Temporal Resolution:** 10 to 60 min
- **Range Extent:** 1 to 200+ km *
- **Velocity Accuracy:** 5 to 10 cm/s

*Depends on Transmit Frequency, Signal Processing

** Depends on RF bandwidth



What Else Can HF Radar Measure?

Easiest

- **Surface Wind Direction**
- **Surface Current Speed**
- **Significant Wave Height**
- **Dominant Wave Period**
- **Dominant Wave Direction**
- **Surface Wind Speed**
- **Non-Directional Wave Spectrum**
- **Directional Wave Spectrum**

Hardest



Now, The Big Picture



National Network of Regional Associations



- 11 RA s serve the entire US Coastline, including Great Lakes, the Caribbean and the Pacific Territories
- RAs are the legal entities that seek out user needs, design and implement the Regional Coastal Ocean Observing Systems (RCOOS)





US HF Radar Prior to 2004

- No central data repository or standards
- Funding from grants, Congressionally-directed funds
- ~50-60 HFRs in use by research institutions
- Using “experimental” radio licenses
- Self-Organized
- User base not well-defined
- **NOT OPERATIONAL**



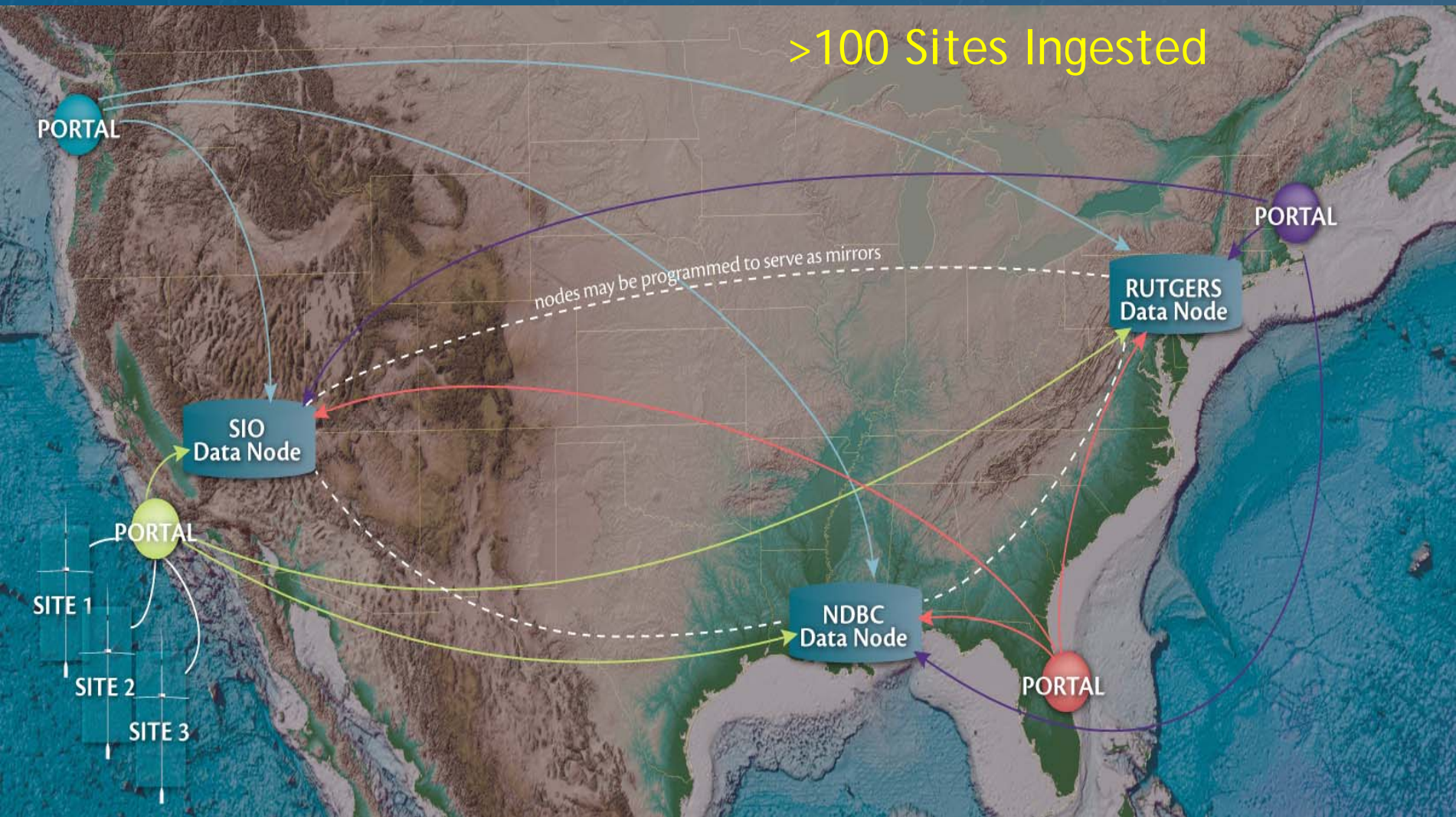
National HF Radar Network

- **Research toward Operations: HF Radar Current Measurement Capability:**
 - Create national HFR data servers to provide
 - Near-real-time and retrospective data
 - Create real-time quality control algorithms
 - Adopt, adapt or create data/metadata standards
 - Obtain standard radar frequency licenses
 - Acquire, deploy, and operate a national HFR surface current monitoring system



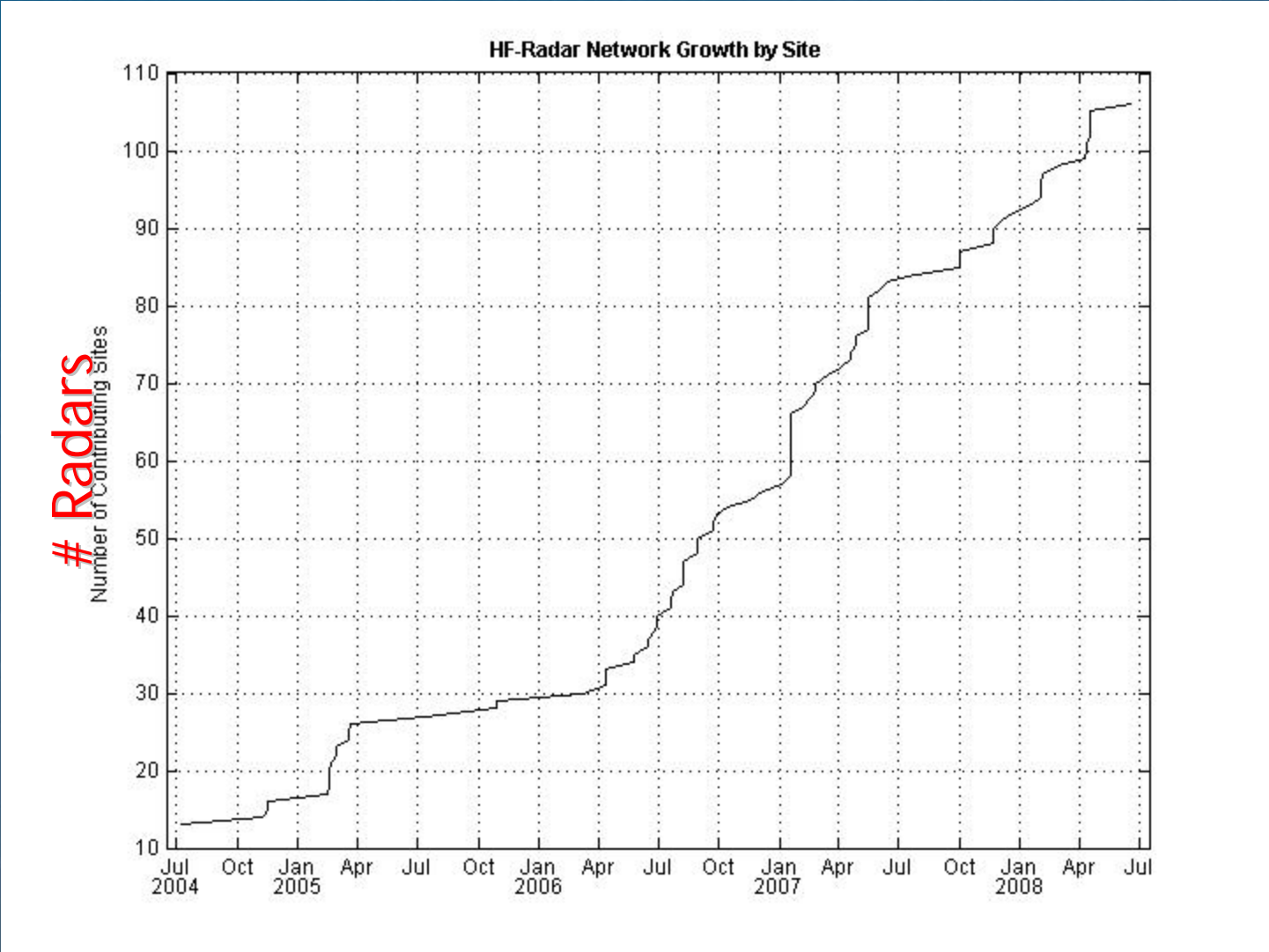
Network Data Infrastructure

>100 Sites Ingested



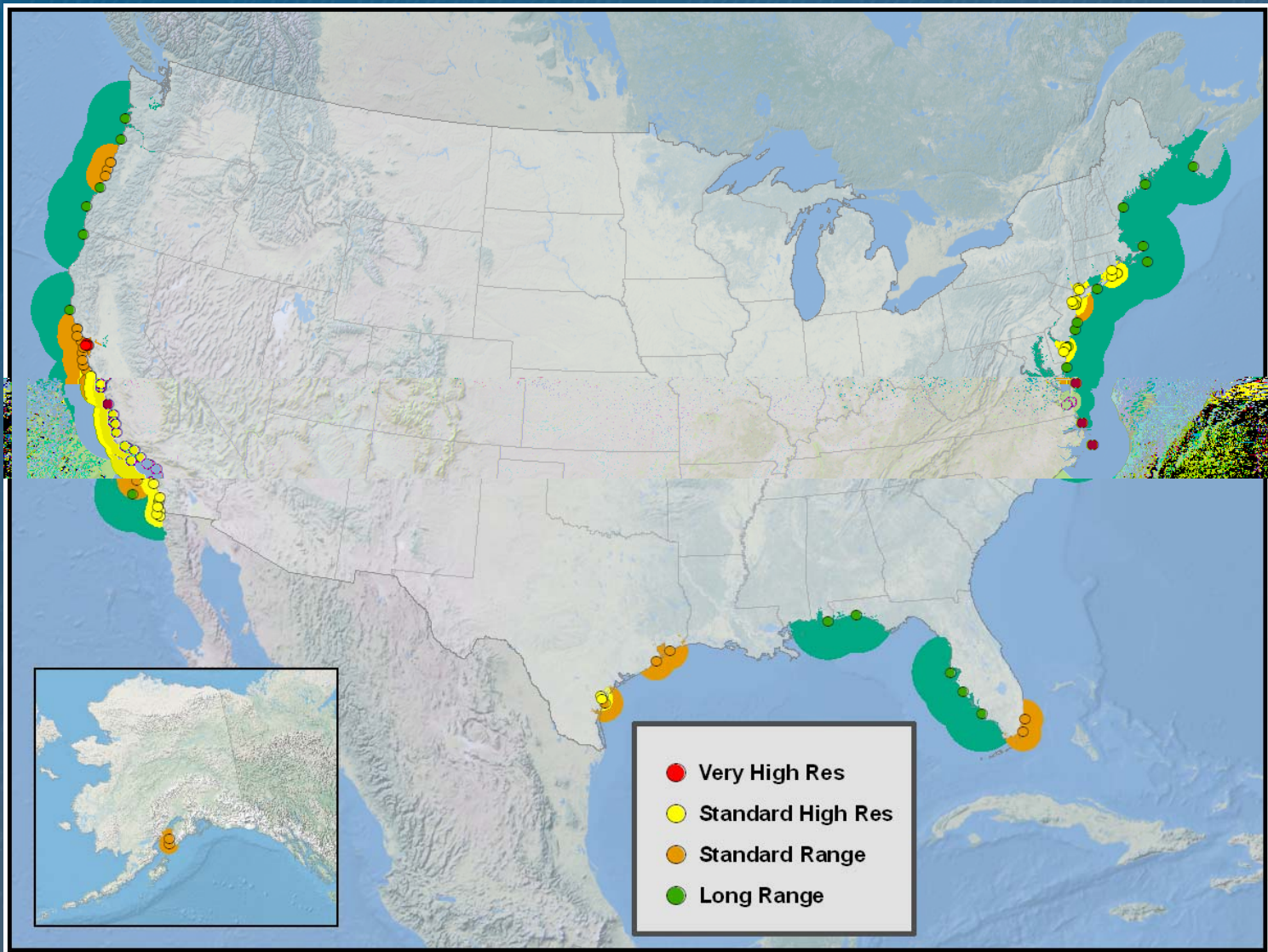


HFR Network Growth: Jul '04-Jun '08



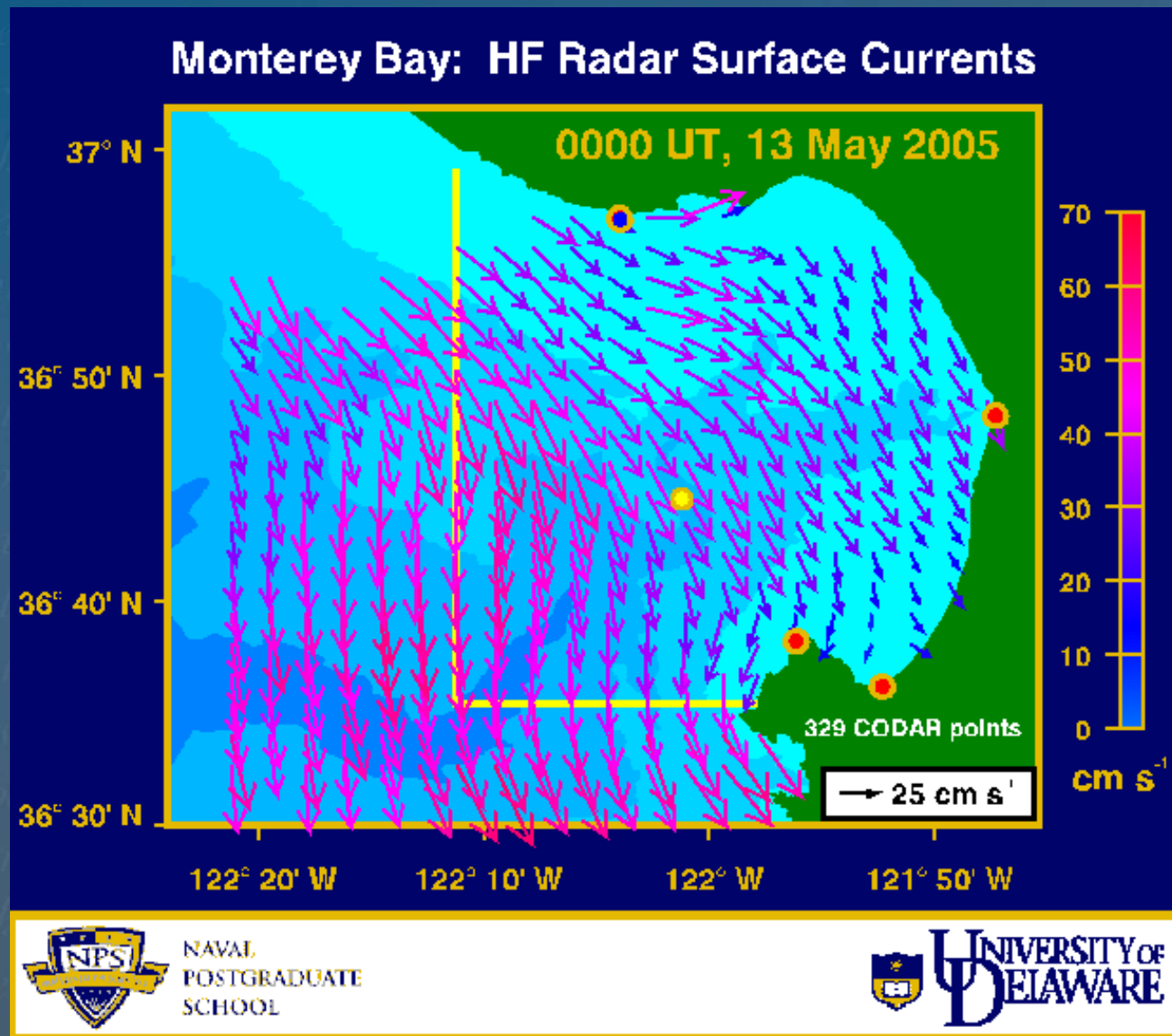


20,000 HFR Velocities/Hour





What HF Radar Provides





What HF Radar Provides

Scripps National HF Radar Data Server



Applications

- **Federal, State, Local Agencies**
 - **USCG Search & Rescue**
 - **Water quality monitoring**
 - **Rip current prediction**
 - **Marine navigation**
 - **Harmful Algal Bloom Forecasts**
 - **Fisheries and ecosystem management**
 - **Oil Spill response, both NOAA and state**
 - **Hydrodynamic Modeling**



Example Applications/Products

- Long Beach Harbor Product
- NOS/CO-OPS Tidal Velocity
- NOS/OR&R HAZMAT Spill Response Trajectories
- SoCal Hyperion Wastewater Outfall
- NoCal Ocean Beach Wastewater Outfall
- S FL US Army Corps of Engineers Dredging



Example Application



Ports & Harbors - Los Angeles / Long Beach



San Pedro Wave Buoy

Height 0.79 meters (2.59 feet)
 Period 5.56 seconds
 Direction 289°
 Temperature 18.1°C (64.6°F)
 Time 2008-06-18 17:59:00 UTC

Nearby Surface Currents

Location 33.5943, -118.3042
 Resolution 6km
 Time 24-hour average
 Magnitude 8.03 cm/s (0.16 knots)
 Direction 146.00° from North

LEGEND

Currents

- Surface Currents (6Km)

Waves

Observations

- Wave Buoys

Models

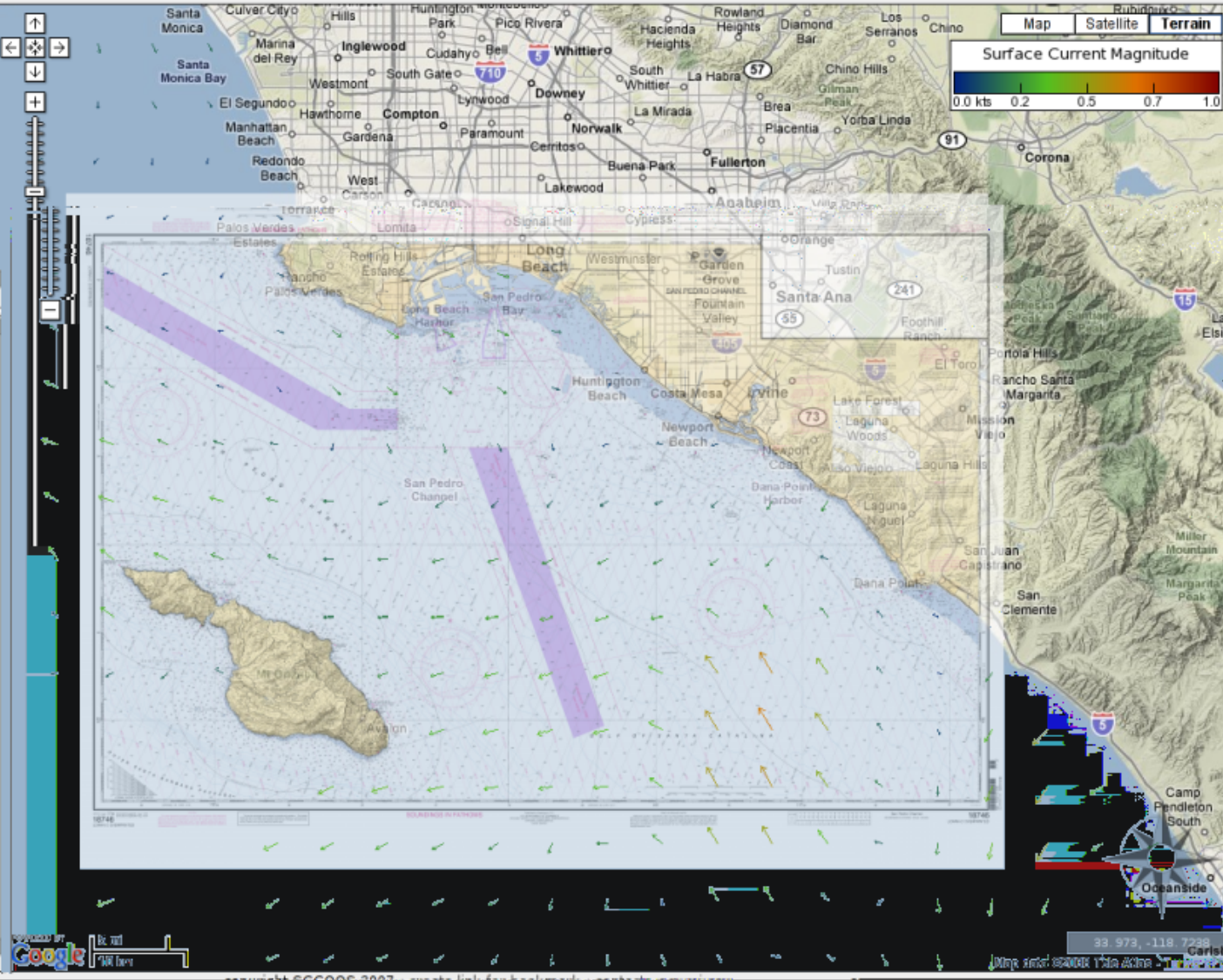
- Model Prediction Points
- Wave Height
- Peak Wave Period
- Average Wave Period
- Wave Direction
- Hide Models

Routes

- Shipping Lanes
- Catalina Ferry Path

NOAA Nautical Charts

- San Pedro Channel (18746_1)
- San Pedro Bay (18749_1)
- Anaheim Bay (18749_2)
- LA/LB Harbors (18751)
- Hide NOAA Nautical Charts

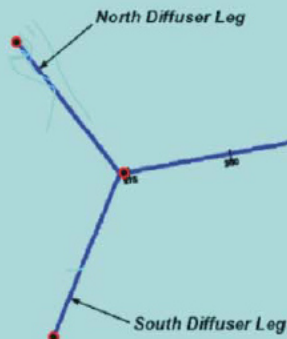




Hyperion Outfall Diversion November 28-30, 2006

5-Mile Outfall Field Inspection

1. Multi-Beam Precision Scanning Sonar (entire length including diffusers, except in the shallow nearshore area)
2. ROV Inspection at Key Points (along entire length of outfall)
3. Internal Dive Inspection of First 2,500ft. of Outfall (entry from shore structure)
4. Pipe Coring at Indicated Locations
5. Internal Sonar Scanning of Part of Diffusers
6. Piezometric Testing at Indicated Locations
7. Geophysical Seismic Reflection Survey (Phase II, if needed along entire length of outfall, except nearshore area)



Legend

- 10 Pipe Cores
- 8 Piezometric Testing Locations

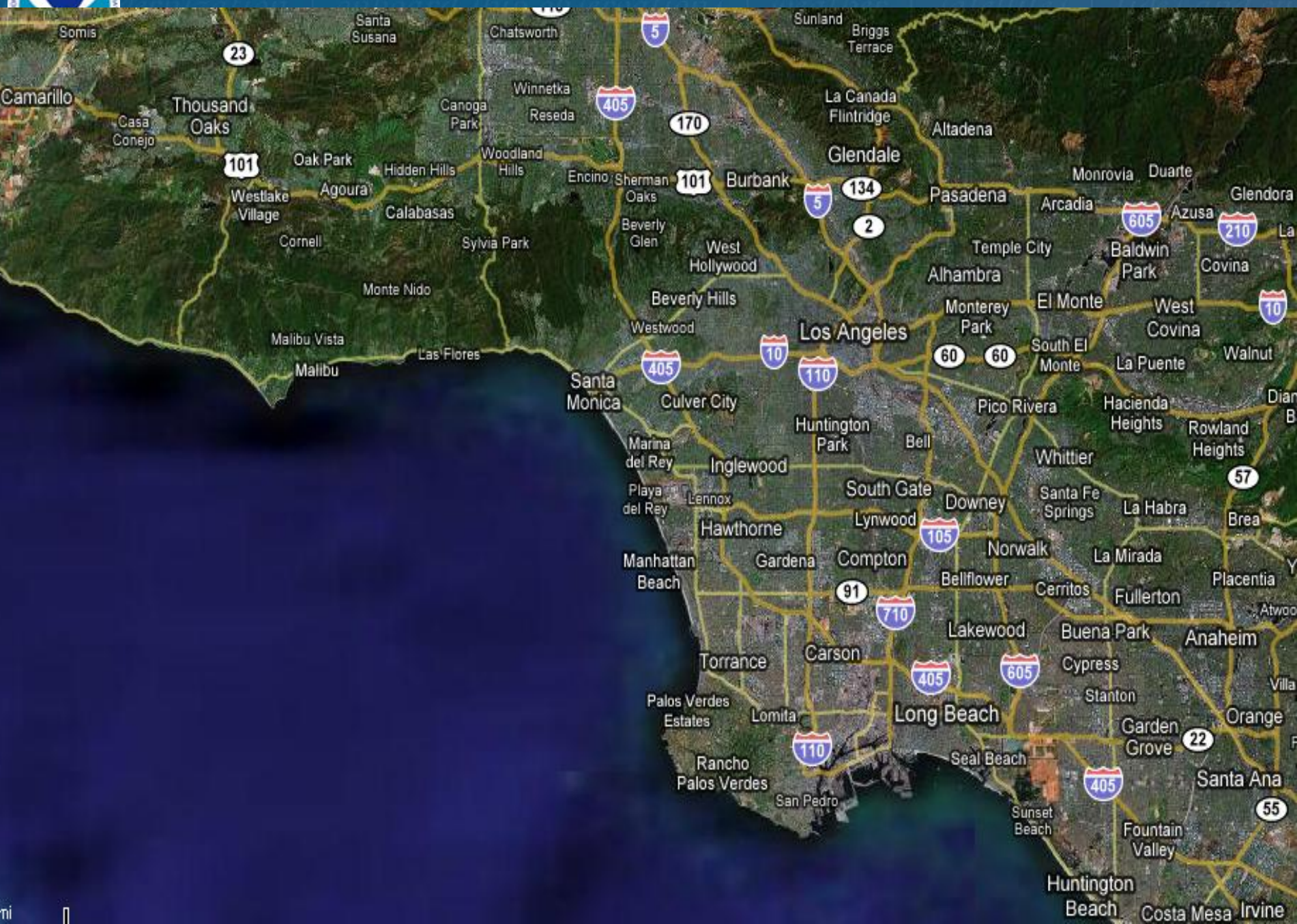
1-Mile Outfall Field Inspection

1. Multi-Beam Precision Scanning Sonar (entire length including diffusers, except in the shallow nearshore area)
2. Dive Inspection, 1,550ft. Encased Section
3. Dive Inspection of Undercut Section
4. Internal ROV Inspection 2,000ft. Offshore (entry from existing 18"x72" diffusers)
5. Internal ROV Inspection 2,000ft. Onshore (entry at shore structure)
6. Pipe Coring as Indicated to be Determined after ROV Inspection
7. Geophysical Seismic Reflection Survey (Phase II, if needed along entire length of outfall, except nearshore area)

- Inspection of Hyperion Outfall Pipe (never internally inspected for 50 years). Serves City of Los Angeles. One of the world's largest coastal populations.
- Close to a billion gallons of sewage to be diverted to an in-shore/shallow outfall.
- Concern of extent of impact and public health risk in the Santa Monica Bay



SANTA MONICA BAY





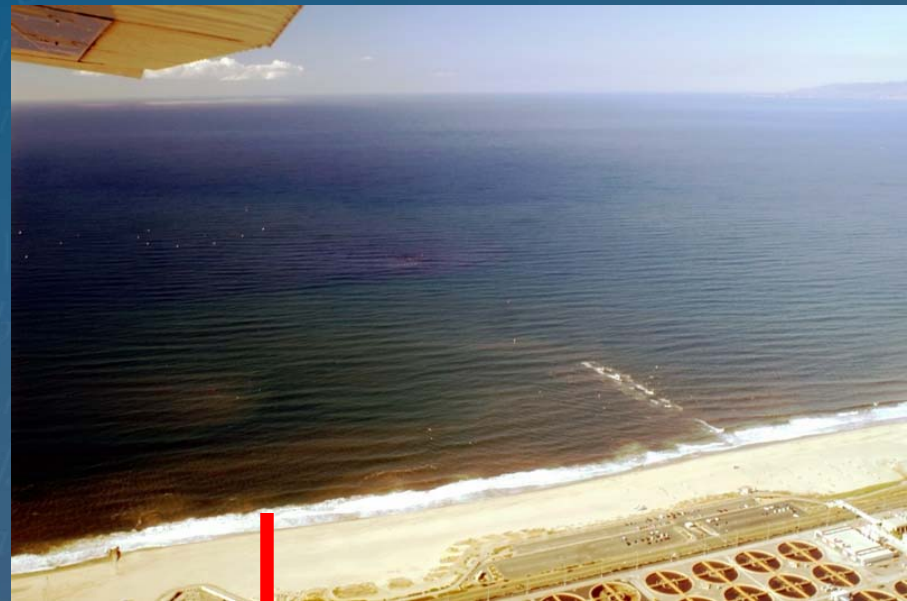
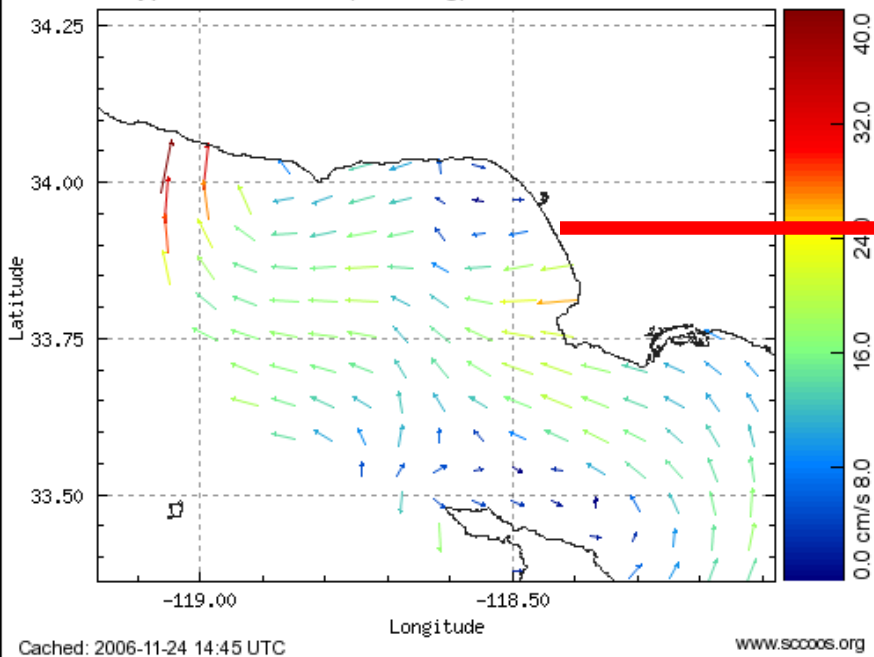
Hyperion Outfall



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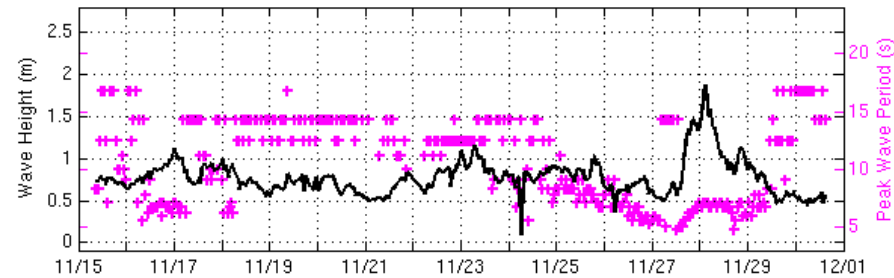
Hyperion Diversion (25hr avg) - 2006-11-24 01:00 UTC



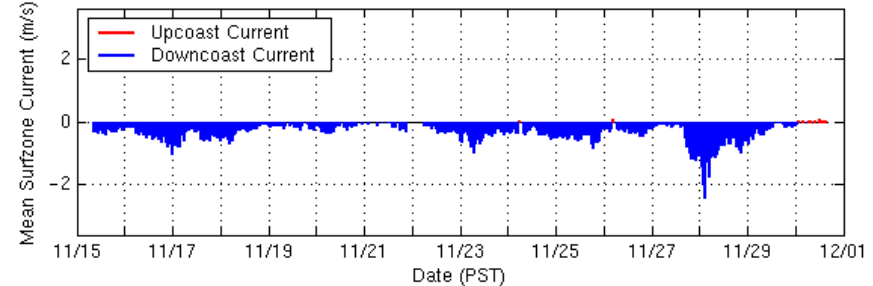
HF radar derived surface current map.

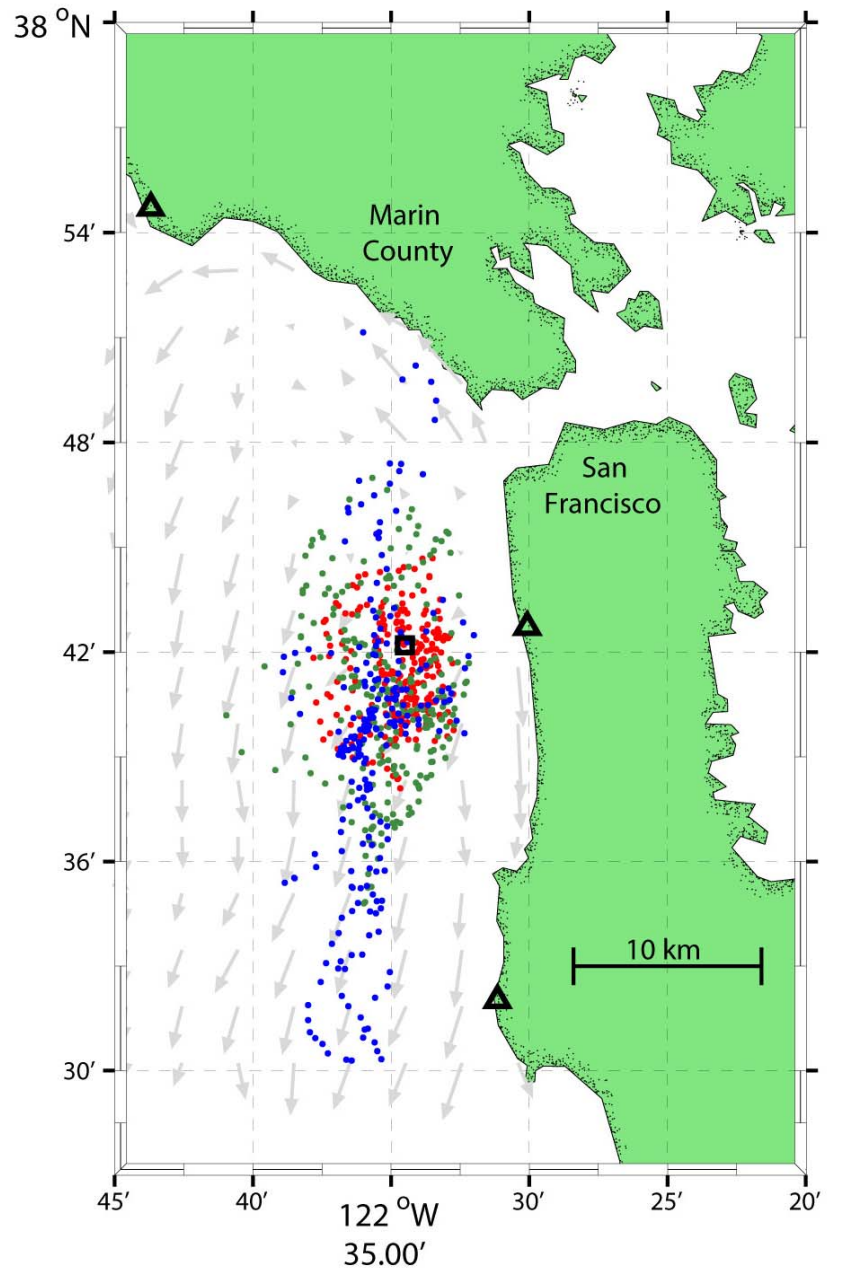
Both offshore and surfzone circulation required observation.

Wave Height and Peak Period



Average Alongshore Surfzone Current





Ocean Beach Outfall Support





Present IOOS Efforts

- **International/national transmit licenses**
 - January 2011 World Radiocommunications Conference
- **Standards for Data, Files, Metadata, Quality Control**
- **National Plan w/Federal & Regional Input**
 - Comprehensive from Gap Analysis to Detailed O&M Procedures
- **Shell-NOAA Gulf of Mexico Project**



Near Future

**New Compact
CODAR
Antenna**

**One Pole =
Receive &
Transmit**

No Side Whips





Summary

- **Mature Technology for Measuring Ocean Current Velocities over Large Coastal Areas**
- **Numerous Mission-Critical Applications**
- **Hourly, Near-real-time**
- **Spatial Resolution ~1 to 5 km**
- **Relatively Low Maintenance**
- **NOAA IOOS is Developing a Data Management and Distribution System for the Nation**