HF Radar Ocean Current Mapping: IOOS Perspective

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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

MARCOOS HF Radar Network

Before HF Radar

Coast Guard SAROPS

After HF Radar
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

CODAR
$105-125K

WERA
$150-200K
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?

- **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**

**Easiest**

**Hardest**

- **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**
Now, The Big Picture
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

nodes may be programmed to serve as mirrors
HFR Network Growth: Jul ’04-Jun ‘08

HF-Radar Network Growth by Site

Number of Continuing Sites

# Radars


23
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
• 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.
Both offshore and surfzone circulation required observation.

HF radar derived surface current map.

Surf-zone forecast driven by waves.
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