

# IOOS HF Radar Data and Its Use by the U.S. Coast Guard for Search and Rescue

## Background on HF Radar Network

The United States HF radar network consists of 130 coastal radars under the auspices of the US Integrated Ocean Observing System (US IOOS<sup>®</sup>). More than 90% of the radars are SeaSondes manufactured by CODAR Ocean Sensors, Ltd. The other radars include WERA radars and University of Hawaii radar systems. The current geographical configuration is depicted in Figure 1.

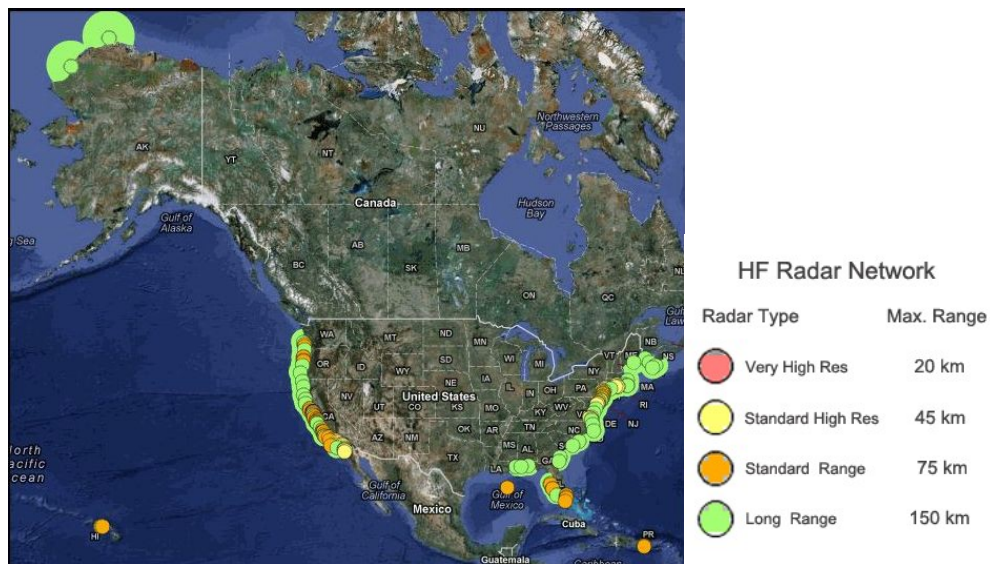


Figure 1. Location of HF Radars – 2012<sup>1</sup>

## Background on U.S. Coast Guard Search and Rescue System

Search and Rescue (SAR) is one of the eleven missions of the U.S. Coast Guard (USCG). The ultimate goal of the USCG SAR program is to prevent loss of life in every situation where USCG actions and performance could possibly be brought to bear.

**Search and Rescue Optimal Planning System (SAROPS)** is the software used by the USCG for Maritime Search Planning. SAROPS is deployed to every USCG unit that has SAR responsibilities, encompassing 51 USCG Sector and District Operation Centers.

SAROPS has the ability to handle multiple scenarios and search object types, model pre-distress motion and hazards, and account for the effects of previous searches. An Environmental Data Server (EDS) provides real-time gridded environmental products to SAROPS.

<sup>1</sup> Some nested and seasonal radars are not shown.

## **Background on HF Radar Use in SAROPS**

Beginning in 2000, the USCG Research and Development Center began a multi-year investigation into the utility of real-time HF radar surface-current measurements for SAR. This assessment showed a better comparison of CODAR-derived currents when compared against available NOAA tidal current predictions. Additionally a key element using the HF radar currents was the development of the Short Term Predictive System (STPS), a forecasting model that uses statistical information for surface current prediction. Following these evaluation studies, available in situ data were used to evaluate and define appropriate parameters for inclusions on the USCG search and planning tool. In May 2009, the current velocities from the Mid-Atlantic long-range CODAR network and the STPS forecasts were included in the USCG SAROPS.

The USCG is responsible for SAROPS and determines the schedule for providing new data types, such as HF radar data, to additional areas. It is expected that in fall 2012 all of the necessary documentation and training will be completed so that the remainder of the coastal United States will have access to the HF radar-derived current velocities and the STPS-derived forecasts.

## **Data and Forecasts Used by SAROPS**

### *Real-time current velocities*

Thirty institutions operate HF Radars within the US IOOS network; however, all of the data are provided in a consistent format to allow for a national product suite. US IOOS provides HF Radar data in gridded resolutions of 1 km, 2 km and 6 km.<sup>2</sup> For the initial rollout of HF radar data to the USCG EDS, only 6 km resolution data are being acquired by the USCG's SAROPS. Expansion to the finer resolution (1 km, 2 km) HF radar data for SAROPS is under development by USCG for a gradual rollout over the next twelve months into CY2013.

The near real time currents are posted every hour on the National Data Buoy Center, <http://hfradar.ndbc.noaa.gov/> and at Scripps Institution of Oceanography (SIO) Coastal Observing Research and Development Center, <http://cordc.ucsd.edu/projects/mapping/>. Data can be downloaded in the NetCDF format.

In addition to the standard gridded surface current velocity data, an optimally interpolated real-time vector (OI RTV) gridded product is also being made available in FY2012. This product provides a more gap-filled data field which has benefit to the NOAA oil spill modeling efforts and to USCG for some instances. OI fields are very computationally-intensive so a new computer server is being put into place at SIO to handle that load.

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<sup>2</sup> Additionally, within San Francisco Bay only, there are 500m-resolution gridded data based on the VHF radars located there.

### ***Description of STPS***

The University of Connecticut developed the STPS and now operates the model. STPS runs automatically but has human technical support and troubleshooting on-call. Every hour, it creates a 24 hour forecast of current field evolution that is consistent with the most recent data and the statistics of the observed current variability.

The STPS forecast is created by exploiting the periodicity of the tides and the fact that weather systems move slowly. The tidal part of the current can be predicted using traditional methods and then the less-regular, weather-forced part can be isolated and extrapolated. Adding these parts together then results in a complete forecast of the currents.

The approach is applicable to any coastal area regardless of coastal geometry and bathymetry, and it does not make any assumptions about the underlying circulation dynamics. The primary advantage of this approach is that the algorithm can be readily applied with limited effort and expense in any area with an operational surface current data set.

See Appendix A for maps of the areas where STPS forecasts are currently made.

## **How the Data Flows from the IOOS Community to USCG SAROPS**

### ***The National HF Radar Data Management Configuration***

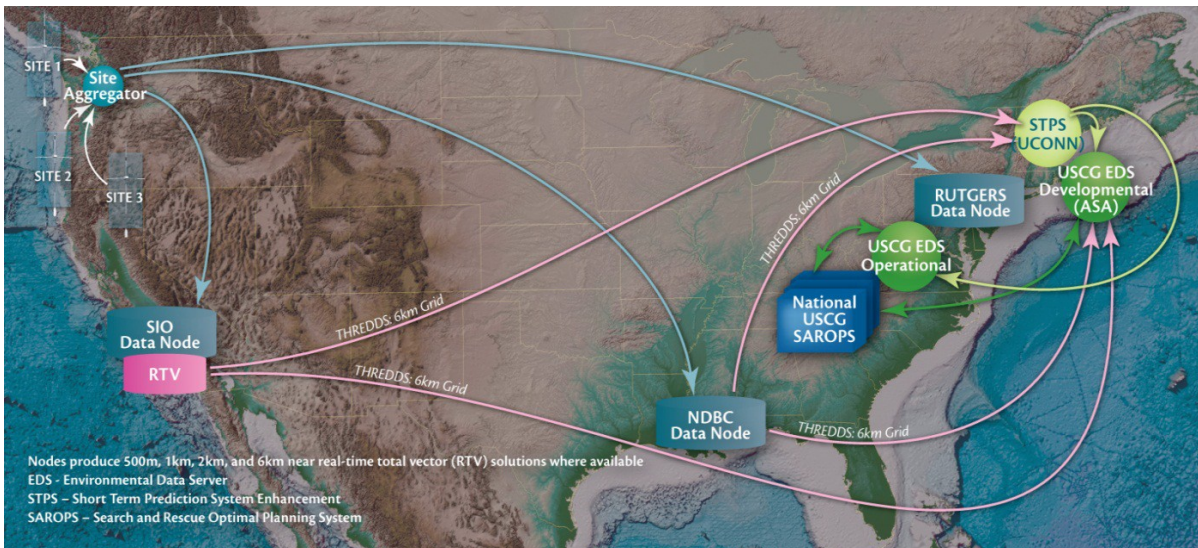
The network is characterized by a tiered structure that extends from (a) the individual field installations or “sites” of HF radar equipment, (b) a regional operations center or “aggregator” server which maintains multiple radar sites, and (c) centralized locations or “nodes” which combine data from multiple regional aggregators (Figure 2). Nodes are also known as the “national servers.” There are currently 130 radar sites, 10 aggregators and 3 nodes in the network. Scripps (SIO) and Rutgers have both a node and an aggregator. Robust aggregator to node communications along with centralized data repositories are key goals of the network maintenance and operations.

Data aggregators are currently deployed at ten institutions:

Scripps Institution of Oceanography (SIO)  
Rutgers University  
University of Southern Mississippi  
Monterey Bay Aquarium Research Institute  
University of Miami  
University of Maine  
Oregon State University  
University of California, Santa Barbara  
San Francisco State University  
California Polytechnic State University.

The five aggregators in California were acquired and installed as part of the State of California’s Coastal Ocean Current Monitoring Program.

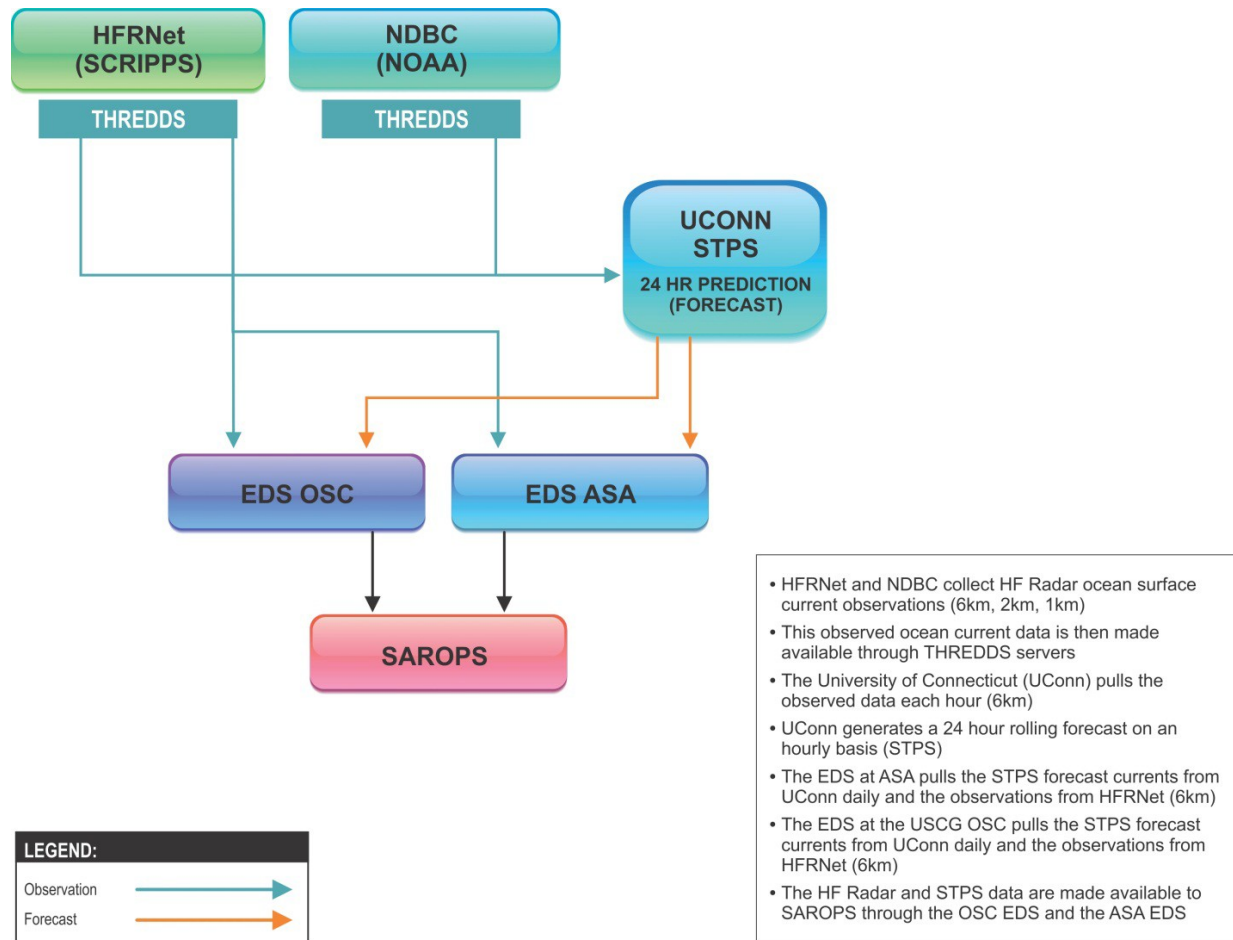
Figure 2 depicts the flow of HF radar data within the national network and to USCG SAROPS. Applied Science Associates (ASA) is the primary contractor for USCG SAROPS development. For clarity, not all the radar sites or aggregators are shown.



**Figure 2.** National HF radar data flow. All 3 data nodes (national servers) are shown. For clarity, only 3 radar sites & 1 aggregator are shown.

***Data flow between STPS and SAROPS and the Short Term Prediction System***

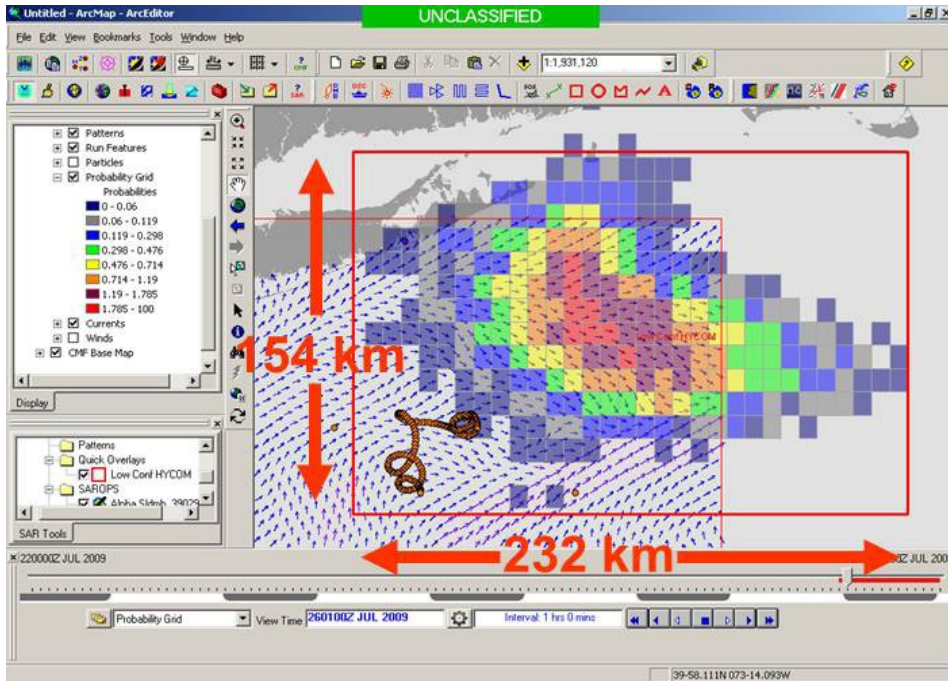
The STPS expansion to all coastal areas has been implemented by IOOS partners with USCG oversight. Data flow among the IOOS national HF radar data nodes (servers), the USCG developmental Environmental Data Server (EDS) located in Rhode Island at the Applied Science Associates facilities and the operational EDS located in West Virginia at the USCG Operations Systems Center (OSC) is shown in Figure 3. Their relationships to the forecasts created by STPS are also illustrated. Note that presently, UConn receives data from NDBC for all regions and from the Rutgers server for just the Mid- Atlantic region, although UConn has the flexibility to receive data from the Scripps THREDDS as illustrated in Figure 3.



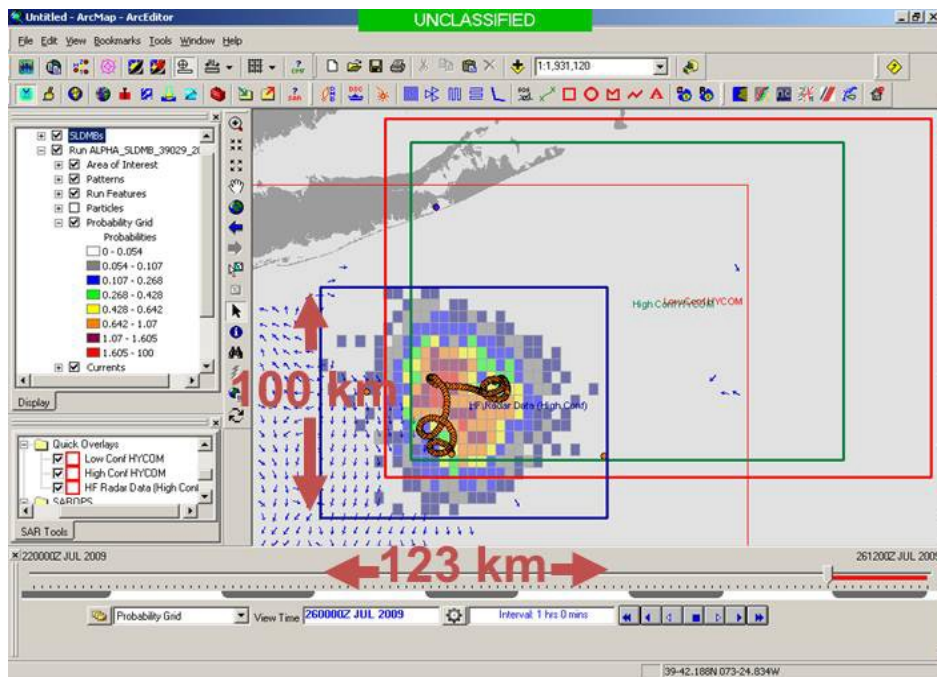
**Figure 3.** Data flow for STPS Forecasts provided to the USCG SAROPS. Acronyms: EDS: Environmental Data Server; OSC: Operational SAROPS Center; ASA: Applied Science Associates, Inc.

### Case Study: Impact of HF Radar on the Efficacy of SAROPS

A test was conducted by comparing the actual path of a Self-Locating Datum Marker Buoy (SLDMB) over 4 days, July 22-26, 2009. The path of the SLDMB was compared with the predicted path of the buoy using four sources (STPS, NCOM, HYCOM and HF radar). The predicted dispersion of the 5,000 simulated drifters using the Hybrid Coordinate Ocean Model (HYCOM) data is shown in Figure 3. The search area using the HYCOM data equates to 36,000km<sup>2</sup>. The predicted dispersion after 4 days of the 5,000 simulated drifters using the HF Radar data source is shown in Figure 4. The search area using the HF Radar data equates to 12,000 km<sup>2</sup>, a 66% decrease in the search area.



**Figure 3.** Screen shot of the SAROPS user interface showing the predicted dispersion of the 5,000 simulated drifters using the HYCOM data source (cloud) and path of the SLDMB (line in the lower left-hand corner of the search area). USCG search area shown as the red box.



**Figure 4.** Screen shot of the SAROPS user interface showing the predicted dispersion of the 5,000 simulated drifters using the HF radar data source (cloud) and path of the SLDMB (line in the center of the cloud). USCG search area is shown as the blue box.

## Appendix A: Areas of STPS Forecast

### Hawaii



- *Longitude:* -157.0 to -147.0 degrees east
- *Latitude:* 20.0 to 40.0 degrees north

### Gulf and Southeast Coasts



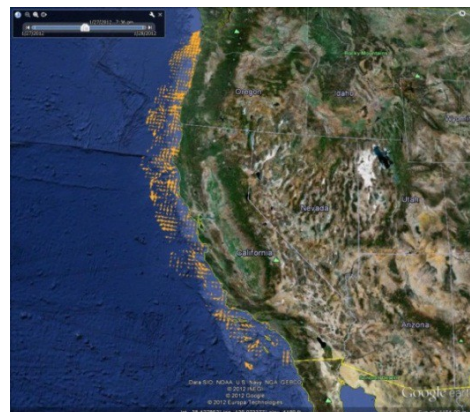
- *Longitude:* -87.0 to -77.94 degrees east
- *Latitude:* 29.0 to 36.65 degrees north

### Mid-Atlantic Bight (MAB)



- *Longitude:* -75.99 to -66.929 degrees east
- *Latitude:* 35.01 to 42.66 degrees north

### West Coast



- *Longitude:* -116.0 to -106.0 degrees east
- *Latitude:* 48.0 to 68.0 degrees north