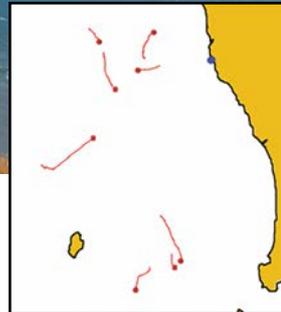


## Augmenting SeaSonde Networks With Ship Detection



Doppler processing allows multiple vessels to be tracked simultaneously even when in close proximity.

From their inception, SeaSondes have bucked the trend of traditional microwave radar systems. Whereas the latter treat sea echo as clutter and vessel echoes as signal, SeaSonde software for environmental monitoring was designed with the exact opposite in mind. Now, with SeaSonde real-time vessel detection software, users can have both. Information provided includes real-time vessel position, speed, estimated HF radar cross section and a unique identifier for tracing through time. Detections and position updates are output at user-specified intervals, typically every one to four minutes.

In a network utilizing SHARE™ - enabled frequency sharing, each receiving site running the vessel detection software can provide independent monostatic, bistatic or multistatic detections using transmissions originating from itself and/or other nearby SHARE-enabled SeaSonde Remote Units or bistatic transmitters. With multiple “looks” from different bearings and radial Doppler speeds, multistatic network detections allow for increased vessel position and motion accuracy, larger areas of continuous detections and increased probability of detection during commingling of vessel and sea echoes or changes in vessel speed and aspect. Due to the HF Doppler processing, multiple vessels can be tracked simultaneously, even when in close proximity to one another.

This software package is designed to run in parallel with all other SeaSonde software on the SeaSonde Remote Unit computer and does not affect traditional current or wave measurement processing. Vessel detection software can be used at any SeaSonde operating frequency and performance is subject to local RF noise conditions. Please contact a CODAR representative for more information.

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# From the Desk of Don Barrick

## *Company President reflects on how CODAR technology evolved from conventional HF radar*

In the late 1960s, the Defense Department became intrigued by coastal HF radar, eager to exploit the conducting sea surface which allowed coverage well beyond the visible horizon. During this period I was technical director for several DARPA programs aimed at seeing ships, aircraft, missiles, and wakes.

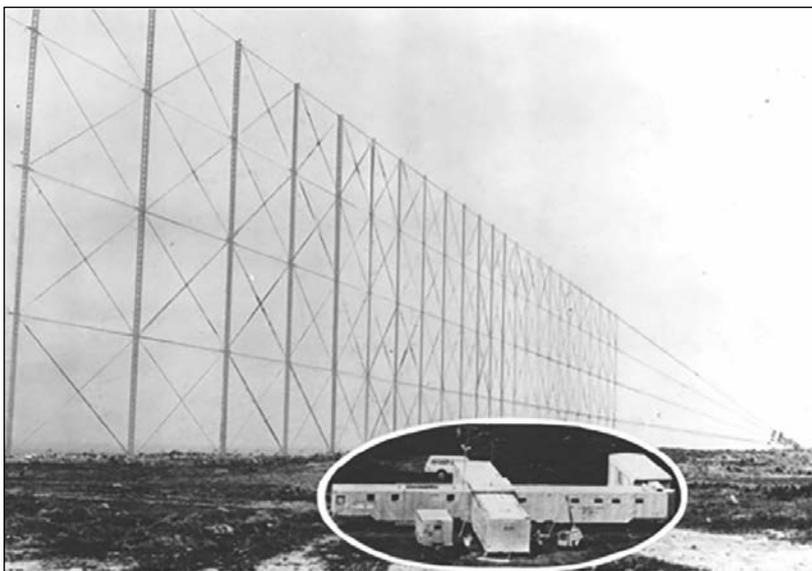
Several large companies (like Raytheon) built massive phased-array antennas to demonstrate military beyond-the-horizon surveillance capability. Indeed, they all saw hard targets. But based on the size and cost, the militaries at that time decided they were not cost-effective for operational use. You see, conventional target bearing determination says that you need an antenna tens of wavelengths across to form and scan a narrow beam. A flashlight is one example. A scanning 1-m dish is the microwave radar equivalent, where wavelength is 3 cm. Scaling down to HF where wavelength might be 30 m leads to an antenna aperture that is 1000 m long (yes, that's 1 km), far too big to rotate mechanically. But with this approach, building an array and carefully phasing its signals electronically does allow one to form and scan a narrow beam.

In the meantime, I noticed in the signal spectrum data a consistent presence of two strong peaks on either side of the zero Doppler. I derived mathematically, and then field-validated in 1972 using the radar on California's San Clemente Island, that these two strong signals far above background noise floor were the backscatter off ocean waves half the radar transmit wavelength: one exhibiting positive Doppler from waves approaching shore and other negative Doppler from those waves traveling away from shore. These echoes were considerably stronger than noise floor due to fact they were adding coherently as they made their way back to the receiver at shore and which I dubbed as "Bragg echoes". This commemorated Sir Bragg who 100 years earlier discovered the nature of crystals by probing with x-rays by the same diffraction-grating method. Given the fact these Bragg echoes were virtually omnipresent I was inspired to explore how HF radar could be used for environmental (currents, waves) rather than military (hard target) ocean applications.

NOAA hired me to develop this environmental measurement capability as the agency was being formed in 1972. The first strong nudge I got from higher up was: "Don, we want to use this widely, but with antennas like that, we're dead in the water. If you want funding to develop this, it must be practical, small size, low cost." So I came up with the artist sketch of a compact antenna concept and asked "How about something like this"? And so we headed off in that direction. From this point, we called it CODAR, initially for Coastal Ocean Dynamics Applications Radar (and today CODAR acronym more widely denotes Compact Radar, and also our company name).

My team inside NOAA grew to about 25, with a dozen or more tests to validate its capability and utility, and earning the Department of Commerce's distinguished Gold Medal of Excellence award. At the urging of NOAA, it became time to leave government with my key people for transitioning into a commercialized version, and hence in 1986 CODAR Ocean Sensors, Ltd. was born. Our first product was the SeaSonde®, with the compact single-mast antenna that did not differ conceptually from what I proposed in 1972.

Today NOAA is an important user of SeaSonde which constitutes approx. 90% of their Integrated Ocean Observing System (U.S. IOOS) National HF Radar Network. This compact radar has also been adopted in approximately 30 other countries and is the technology of choice for large-scale national observing networks.



HF phased array antenna 500 m long I built in 1971 for military surveillance on San Clemente Island, CA. Equipment and phasing cabling were housed in four trailers, weighing about 50 tons. Output power was about 25 kW peak, or 500 W average.



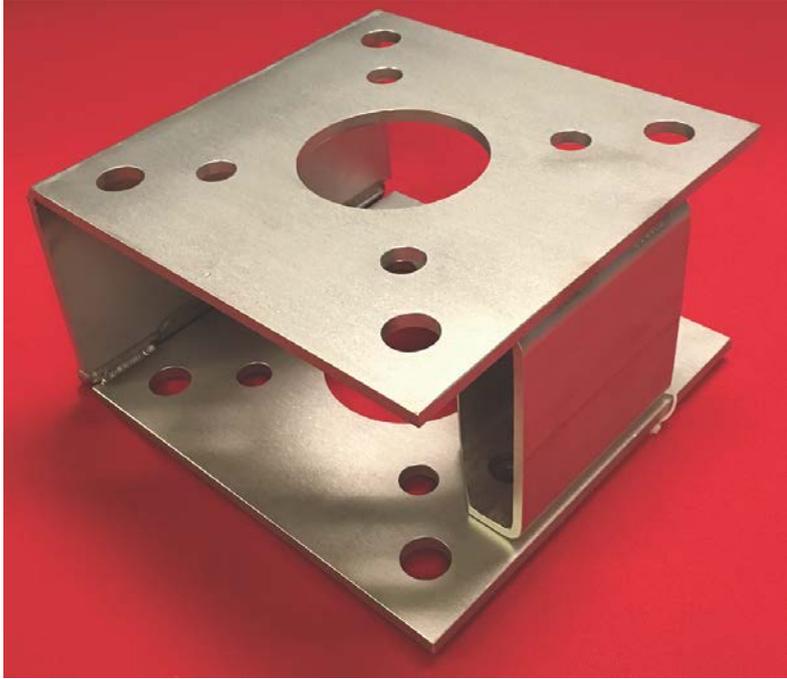
My conceptual drawing of compact CODAR antenna in 1972 at NOAA.

# New SeaSonde Antenna Accessories

*Added convenience for uprighting, lowering, and stabilizing your antennas*

## SeaSonde Antenna Base Hinge Assembly

**C**ODAR designed the SeaSonde Antenna Base Hinge Assembly to ease maintenance and repair work for field technicians. This assembly enables a single operator to more simply lower and upright a SeaSonde antenna.



SeaSonde Antenna Base Hinge Assembly



Parts included in assembly kit (above shown in red). SeaSonde Antenna Base Hinge Assembly at Point Bonita lighthouse, on the coast of northern California.

The SeaSonde Antenna Base Hinge Assembly is compatible with the dome-style antennas (receive-only and combined transmit-receive) and long-range transmit antennas. The assembly is both durable and rugged, fabricated of 316 stainless steel.

The hinge assembly can be fixed to a variety of footings including a concrete pile or a steel base plate (such as shown in example above). Footings are not included.

## Dome Antenna Guy Rope Holder

While the SeaSonde dome antenna mast is designed to be bolted at its base, the new Dome Antenna Guy Rope Holder provides a simple means to secure the dome antenna via alternative method. Installation of this new accessory is as easy as lowering the antenna, unscrewing the dome, and slipping the flange onto the mast.



Dome Antenna Guy Rope Holder mounted to combined transmit-receive dome antenna and stabilized with high-temperature aramid rope.



Four eye hooks fixed to a coated fiberglass flange provide tie-ins for guy ropes. Exposed metal components (washers, nuts, and eyebolt screws) are fabricated of 316 stainless steel.

# A Peek Inside SeaSonde Radial Suite® Release 8

Under development for four years, Radial Suite Release 8 will include improved interfaces and powerful new tools. As a preview, we highlight two applications that process and visualize current and wave data.

Users will experience:

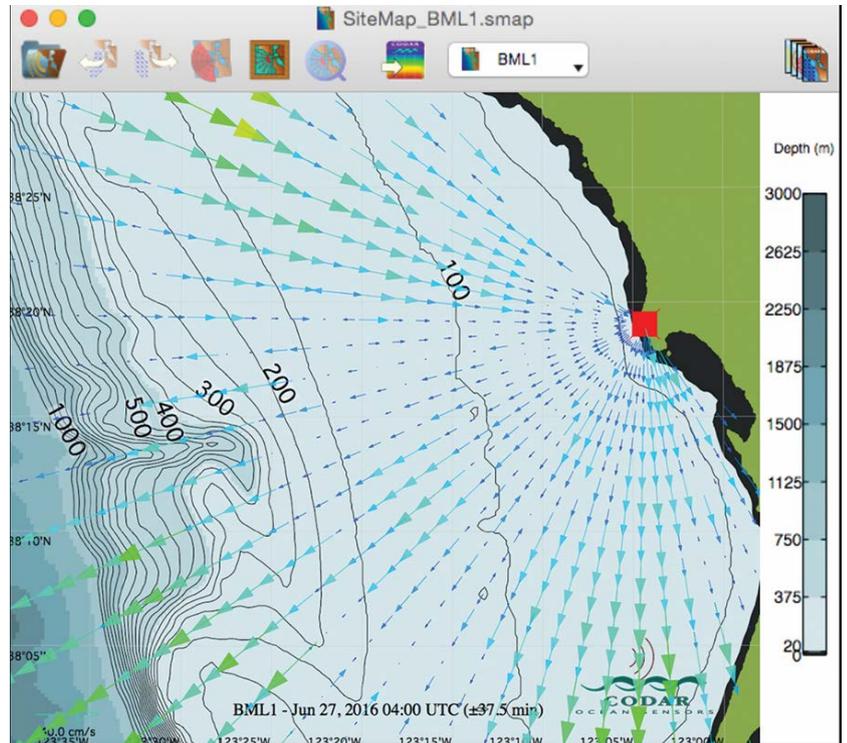
- Ease of use - many of Radial Suite Release 8's tools feature enhanced graphical user interfaces with one-handed keyboard-controlled navigation capabilities, right-click menus, new toolbar functions, and new main menu items.
- Access to print-quality graphics - increased pixelation, font size control, and export-to-pdf means infinite resolution, report-quality figures.
- Increased functionality/New capabilities - Plan your network and make site maps on the fly with SeaDisplay 8. Access filtered wave data and explore flexible viewing options with WaveDisplay 12.

## SeaDisplay 8



SeaDisplay 8 introduces dynamic SeaSonde site coverage plotting. If you're considering expanding your coverage with additional SeaSondes or wish to view the impacts of changing the location or settings of an existing antenna, your analysis tool

is here. Explore the impact of antenna siting and attributes such as stability angles, resolution, expected range, and expected angular view on radial and combined site coverage. For further optimization, the elliptical feature illustrates the impact of operating one or more antennas in bistatic mode. SeaDisplay 8 provides one-step site map creation and dynamic editing: now you can modify the map viewport and SeaSonde site locations, names, and attributes without site map re-creation. An upgraded world database extraction tool provides smooth and expedient zoom navigation. Integrated bathymetry and contour mapping are available at the click of a button. International language support means map titles can be created in any language.



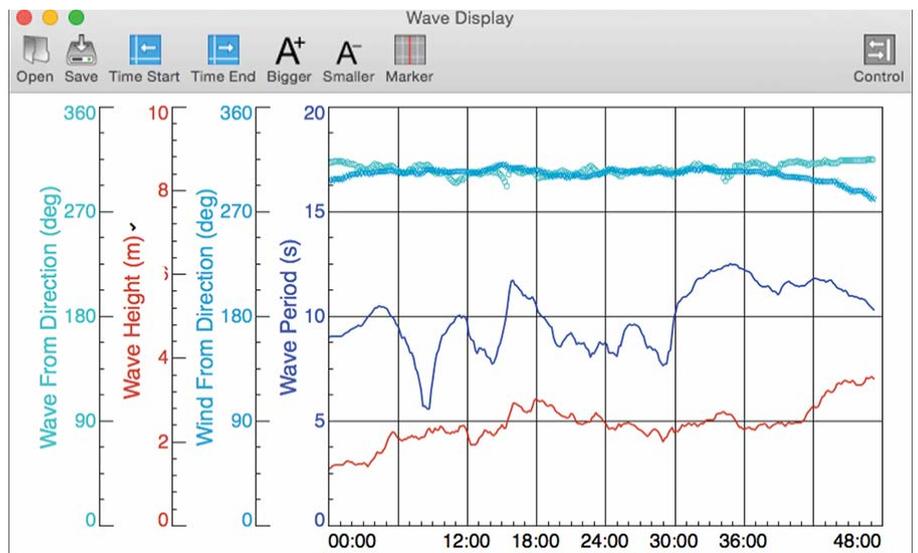
SeaDisplay's shaded, 50-ft contoured bathymetry and jet black color coding for 20-meter deep, user-defined shallow water. Radial data is from UC Davis Bodega Marine Laboratory site in Bodega Bay, California.

## WaveDisplay 12



WaveDisplay 12 plots computationally enhanced data generated by a new outlier removal tool. The tool applies filtering and temporal/spatial averaging for smoothed wave

output across the coverage area. Classic, ranged wave output for individual range cells is available, too. To support these two modes, new view options are featured. In a single frame, users can plot several wave parameters. Alternately, a single wave attribute like wave height can be displayed for up to four range cells. In addition, users can open and orchestrate multiple windows for expansive data inspection. First-generation features such as visualization of multi-range data, export-to-png, and the control panel have been retained for long-time users who prefer the familiar.



WaveDisplay's new, four parameter main window.

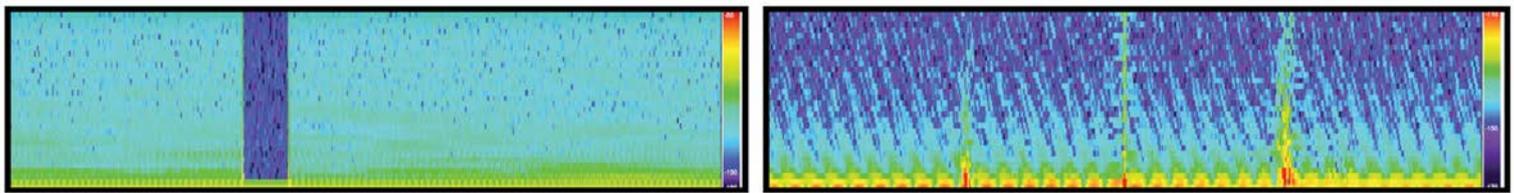
# Call-Sign Capability for SeaSondes



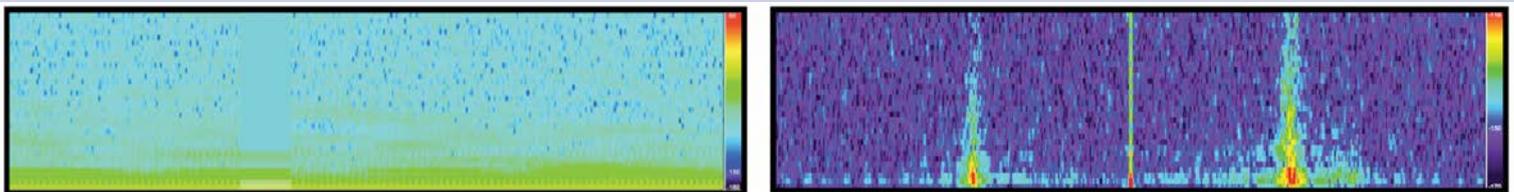
**C**ODAR's unique, proprietary call-sign algorithm — CallSign™ — is designed to fulfill the International Telecommunications Union (ITU) requirement that each oceanographic HF radar routinely issue a unique Morse code identifier signal within its transmissions.

Traditionally, call signs for radio broadcasts are sent out during periods when normal transmission is halted. This practice of suspending normal transmissions for issuing a call sign is not an option for HF radar users who rely on a continuous data stream for supporting emergency response activities like search and rescue, oil spill tracking, or tsunami detection, as the result would be recurring instances of large data gaps. CODAR's patent-pending call-sign routine sends the Morse code signal ingeniously without adversely affecting normal SeaSonde ocean monitoring processes.

CallSign allows each radar to maintain continuous Doppler signal processing. When a region in a time series is zeroed out to make way for a call-sign transmission, the impulsive nature of on/off blanking around the gap causes digital sideline noise throughout the Doppler spectrum. To mitigate this digital interference, an interpolation scheme in CallSign replaces the gap signal for each range cell with a time-series average that eliminates the gap. With this solution, the call sign can be placed anywhere in the time series, and, unlike the less elegant approach of stalling computations, signal processing remains continuous.



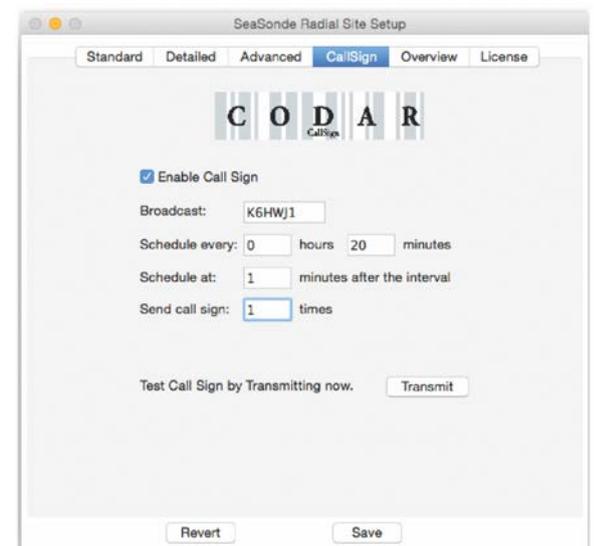
Time series with indigo vertical band blanked for call sign transmission, range (y-axis) vs. time (x-axis) vs. intensity (color bar) (above left). Resulting Doppler spectrum with sideband noise manifesting as slanted streaks, range (y-axis) vs. frequency (x-axis) vs. intensity (color bar) (above right).



Time series augmented with averaged data (above left), and resulting, uncorrupted Doppler spectrum (above right).

Because of ITU requirements, numerous SeaSondes operating in proximity to each other as part of a network typically use the same frequency. CODAR has tested its call-sign broadcast to ensure that the call sign's presence is not seen by these nearby SeaSonde radars in the network, meaning it falls below their noise floors and does not impact their performance. However, the call sign signal intensity and bandwidth are designed to match SeaSonde intensity and bandwidth so that any adversely impacted radio receivers will hear the identifier signal.

CallSign's operating parameters are easily set inside its graphical user interface. Setting up call-sign transmission function is as simple as entering its designation and desired scheduling parameters, typically set to transmit every 20 minutes and not precisely on the hour. User can also select whether signal is to be sent more than one time in sequence thereby providing listeners with multiple opportunities to capture it. Different call signs for neighboring sites that share frequency band can be scheduled one or two minutes apart from each other to avoid issuing overlapping, undecipherable call -sign signals.



Graphical User Interface for CallSign setup

Look for CODAR's CallSign in upcoming Radial Suite Release 8.

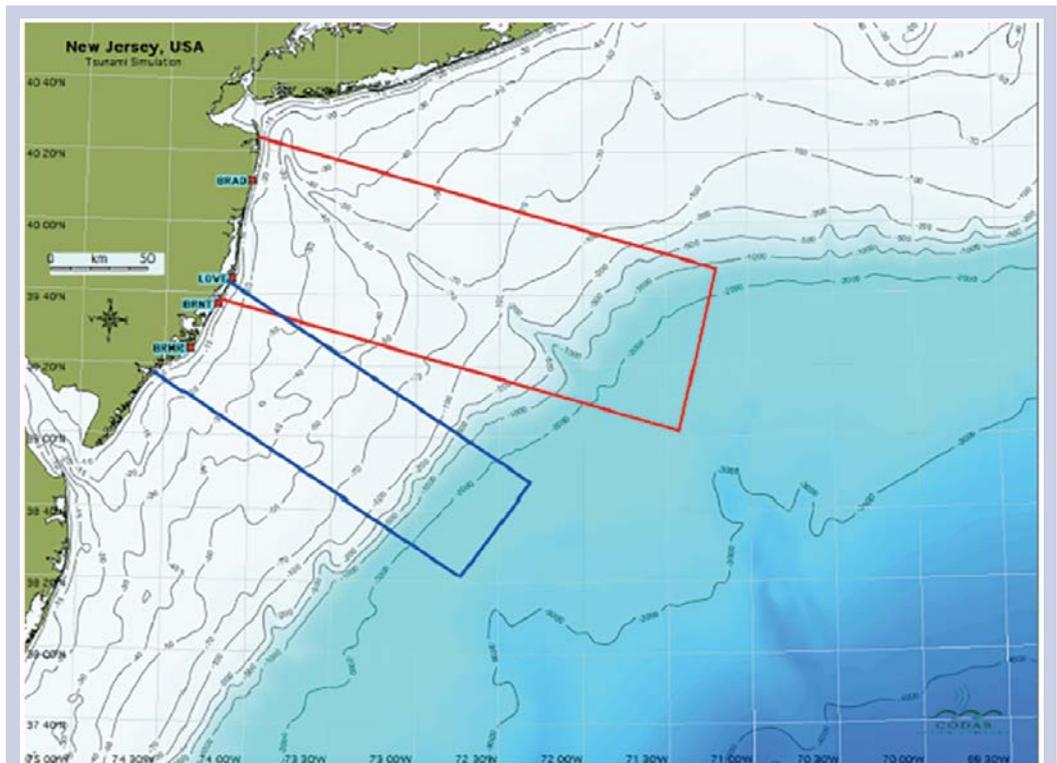
# Launch of Joint CODAR/NOAA Program for HF Tsunami Warning

Starting July 2016 CODAR Ocean Sensors, Ltd. is under contracted partnership to refine SeaSonde HF radar outputs that will provide useful warnings of approaching tsunamis off U.S. coasts. Directed out of the Tsunami Warning Center (TWC) in Palmer, Alaska, and co-sponsored by U.S. NOAA/National Weather Service (NWS) Tsunami Program Office's Tsunami Research Advisory Council (TRAC) and NOAA/NOS U.S. IOOS, the specific aim is to optimize detection while reducing false alarms.

CODAR has in past years created and published details on a "q-factor" tsunami pattern recognition algorithm that successfully detected offline over 26 times confirmed events of both seismic and atmospheric origin (the latter known as 'meteo-tsunamis'). Under this new program CODAR's q-factor detection algorithm will be installed and run in real-time on four SeaSondes operating in New Jersey, correlating false alarms with external influencers such as background currents, radio interference and noise.

Program will geographically focus on measurement sites in New Jersey for the following reasons: (a) Recent metro-tsunamis were observed there (e.g., 2013), and the shallow shelf has allowed long SeaSonde warning times (43 minutes). (b) Group can take advantage of a long-standing partnership between CODAR and Rutgers, who oversees the maintenance of MARACOOS' SeaSondes (43 of them).

These will operate in a "simulator mode", first collecting false alarm data. Then simulated "test tsunami" signals obtained from CODAR's tsunami model (based on the local bathymetry) will be injected into the data stream, to optimize detection probability. Near-real-time ASCII files of q-factor spikes from the four New Jersey radars will be sent to the TWC in Palmer, AK, as well as to Rutgers and CODAR. This will allow feedback from TWC to improve CODAR algorithm and NOAA decision thresholding. It will also permit site-specific performance assessment, based on local background, bathymetry, and tsunami intensity.



Bay New Jersey coast region selected for tsunami optimization/simulation study. Four MARACOOS radar sites running q-factor pattern-recognition are (from North) BRAD, LOVE, BRNT, and BRMR. The two domains marked by the rectangles are where incoming tsunamis will be modeled. Like the 2013 meteo-tsunami, the wave will initially start inward from the box edge at the far East, in deep water (>2000 m). Model outputs are based on initial tsunami velocity (and height) intensities. These will be set to study detectability and false alarm rate sensitivity, based on bathymetry and background masking.

# CODAR Patent Pending “Coastal HF Radar System for Tsunami Warning”

In April 2016 CODAR Ocean Sensors, Ltd. submitted Application No. 15/140,325 with the U.S. Patent & Trademark Office and also filed officially for patents in Germany, China, Japan, and U.K.

CODAR's invention describes the series of steps unique to HF radars that are needed to maximize the robustness and utility of candidate warning messages sent to tsunami warning centers. The first steps in this are filtering, to remove false alarms based on correlation with other information. The second involve QA (quality assurance), namely attaching a flag to potential detections with a confidence level.



This invention describes how the q-factor spikes -- denoting a possible approaching tsunami -- are related to other information that may be used to filter and QA them to reduce false alarms. For example, applications are available online that give the location of any subsea earthquake worldwide; from this, a time window will be set up at the site, within which a tsunami would be expected. Correlations with detection spikes from adjacent coastal sites (e.g., within 50 km) will be used as a filter and QA flag. Finally, real-time correlation with background currents (e.g., from storms) and external noise/ interference will guide credibility determination for a potential alert spike candidate. This is a dynamic process, with alert credibility changing as background seen by the radar varies with time.

## April 2016 Ocean Radar Conference for Asia-Pacific



### *Thriving HF Radar Presence in Asia Reflected at ORCA Conference*

With over 150 SeaSonde HF radars operating in Asia, CODAR Ocean Sensors and SeaSonde users across Asia were well-represented at the 3rd Ocean Radar Conference for Asia-Pacific (ORCA).

The event, hosted by China's Wuhan University, attracted approximately 100 oceanographic scientists and engineers from China, Japan, Korea, Taiwan, and the United States. The boost in attendance from 62 participants at ORCA's 2012 inaugural meeting is a sign of the cohesion and strength of Asia's HF radar community.

Chad Whelan, CODAR's Chief Technical Officer, spoke on site suitability for tsunami detection. Warning time and estimate of intensity upon arrival are key metrics of radar site utility, and bathymetry and coastline geometry are the drivers.

Tsunami detection proved to be a popular topic as Yu Toguchi and Satoshi Fujii of the University of Ryukyus used SeaSondes to compare the natural oscillations of Ise bay with those generated by the Tohoku tsunami. Research at Hokkaido University conducted by Wei Zhang, graduate student of Naoto Ebuchi, is the first of its kind in Japan to detect sea ice off Hokkaido's coast and quantify its drift speed using SeaSondes.

The Taiwan Ocean Research Institute and Kenting National Park Headquarters collaborated on an assessment of the trajectories and settlement of coral larvae during spawning in Nanwan Bay, Taiwan. Taiwan Ocean Radar Observation System surface current data and wind data drove their projections, and results compared well with the coral reef distribution in Nanwan Bay. These findings suggest future opportunities for SeaSonde output to meaningfully inform coral conservation and restoration planning.

At the conclusion of the 2016 conference, ORCA's quest to promote communication across international lines and foster development and growth of the Asia-Pacific HF radar network was reflected in the formalization of its multinational steering committee. The next ORCA installment is expected to take place in Japan in 2018.

# Kingdom of Morocco Implements its First HF Radar System

Contributed by *Direction de la Météorologie Nationale, Kingdom of Morocco*



ROYAUME DU MAROC



Ministère de l'Énergie, des Mines, de l'Eau et de l'Environnement

**M**orocco, known for its rich cultural heritage and breathtaking natural landscapes, is also recognized as a reference in science and technology in Africa.

Confirming this idea, the Direction de la Météorologie Nationale (DMN) (<http://www.marocmeteo.ma>), a public agency within the Ministry of Energy, Mines, Water & Environment of the Kingdom of Morocco and also a permanent member of the World Meteorological Organization, has made in April 2016 a relevant step towards compliance with its mandate of providing accurate and continuous marine weather and climate information. More specifically, it has made great improvements in 2D surface currents maps and wave data by starting the kingdom's first operational coastal HF radar ocean observing system which monitors the marine conditions up to 200 km from the coast (figure 2).



Figure 1: HF Radar antenna in Casablanca (in the background, the Grande Mosquée Hassan II).

The network has been installed by the Moroccan firm Qualitas (<http://www.qualitasenv.com>). The first HF radar station has been implemented in Casablanca Port (figure 1), on top of the Met Office building having a spectacular view of the sea and of the Grande Mosquée Hassan II which is the tallest and the second largest Mosque in the world. The second station is set on the premises of the Civil Protection in Temara (close to Rabat) taking advantage of the uniquely compact design of the chosen SeaSonde HF radar technology. The new observing platform illuminates an area of large interest to the Moroccan society and also to the international community for the unique oceanographic conditions and for the significant maritime traffic in the area (figure 3). The project shall be very beneficial to the Kingdom of Morocco, primarily to all activities related to:

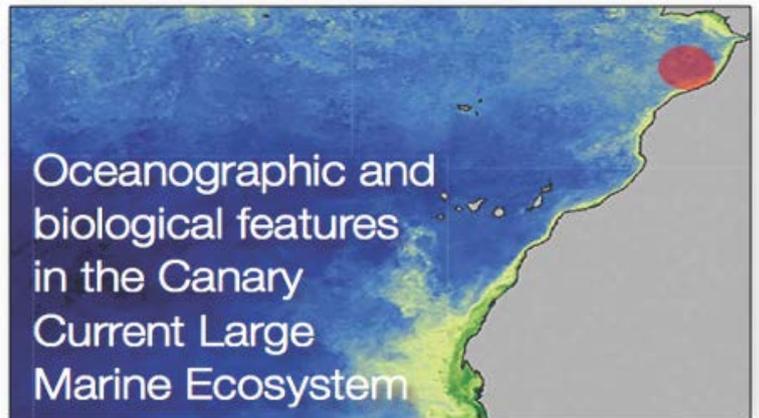


Figure 2: Canary Current and monitoring area of the HF Radar System in Casablanca and Temara.

- Protection of the marine and coastal environment.
- Increased safety of navigation and efficiency in maritime rescues and various sea-related operations such as oil spill response preparedness.
- Meteorological assistance for the better planning and conduct of port operations and in support of a more acknowledged coastal management.
- Better understanding of the marine physical environment supporting the management of fisheries resources and coastal engineering in general
- The further improvement of the existing currents and waves nowcast and forecast.

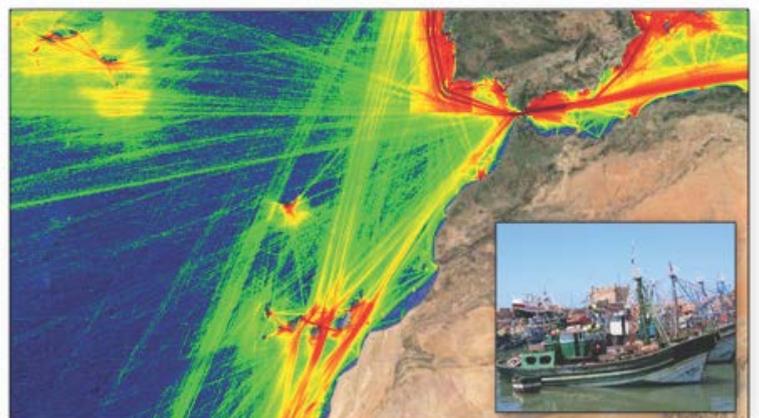


Figure 3: Maritime traffic along the Moroccan coast, a country with a strong industrial and traditional fishery sector.

Special consideration has been paid by Maritime Department of the Met Office when choosing and implementing the new technology to all activities that influence the long-term sustainability and short-term utility of such a project. So for instance:

- The highest quality, easiness of use and reliability of the chosen technology.
- The implementation of the most advanced global QA/QC methods and system operation software tools (figure 4) implemented into a versatile redundant IT platform (figure 5) with an advanced architecture (2x1TB HD software [mirroring] and 3x1TB HD data [RAID5]).
- The in-depth training and education (figure 6) of the department staff to fully assimilate all capabilities that are needed to integrate the new observational component with the other technologies and resources that are at present in application at the the Met Office.

Relevant system specifications:

- HF radar sensor: SeaSonde 4.438 to 4.488 MHz
- Data management platform: Combine Suite®
- + PORTUS by Qualitas
- Range of 2D currents mapping: > 200 km
- Range of significant wave height: 1.5 to 20

For further information to the project contact:

Mr. Hassan BOUKSIM

Chef du Service de Météorologie Maritime

Direction de la Météorologie Nationale

BP 8106, Casa Oasis, Casablanca, Maroc

Tél: (00 212) 522 65 49 20

Fax: (00 212) 522 91 36 98

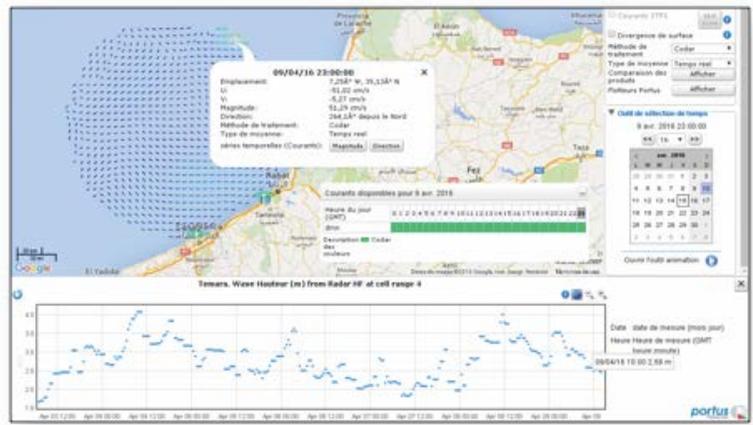


Figure 4: 2D currents and wave data obtained by the HF Radar system in Morocco, between Casablanca and Temara.

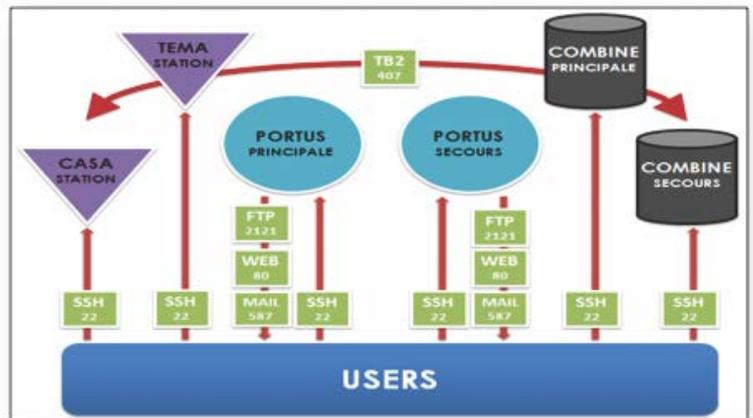


Figure 5: Morocco IT system scheme (HF Radar stations, central platform and software utilities).



Figure 6: HF Radar training held in Casablanca during March 2016. There were five (5) training courses oriented to management, administration, operation, maintenance and R&D.

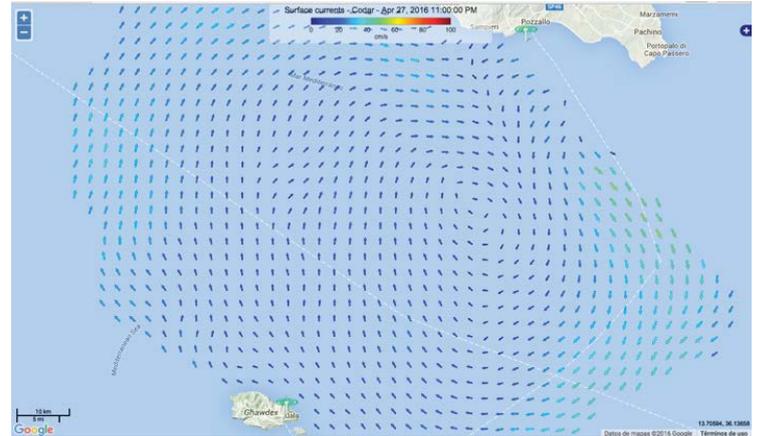


# Malta-Sicily CALYPSO Observing Network Enhanced

## *Additional SeaSonde unit installed in Sicily for coverage expansion*

As part of the project and to increase network coverage, a new SeaSonde station has been commissioned in Marina di Ragusa, Italy during December 2015 by Qualitas Remos company ([www.qualitasremos.com](http://www.qualitasremos.com)) under the coordination of the Sicilian focal point of the project, University of Palermo. This new station has been integrated into the existing Malta-Sicily CALYPSO network, now consisting of 4 SeaSonde stations (2 in Sicily and 2 in Malta) providing 2D surface currents maps with higher spatial coverage.

The risk of oil spills beaching on shores, impacting important economic resources and causing irreversible environmental damage is a very realistic threat in the stretch of sea between Malta and Sicily as this region is situated along the main shipping lanes of the Mediterranean Sea. Risks can be highly minimized by using the best tools for surveillance, operational monitoring against pollution threats as well as improving capacity to respond with informed decisions in case of emergency.



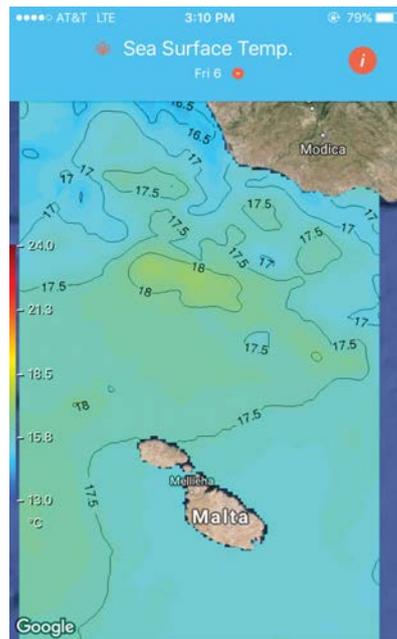
Surface currents map showing 'CALYPSO' gyre

With the main target of improving joint preparedness and response capabilities against major oil spills in this area, a state of the art SeaSonde HF radar network was constructed in 2013 as part of the international CALYPSO Project to monitor sea surface currents in real-time within the Malta-Sicily Channel. The CALYPSO Follow-On (FO) intensive 6- month project is a continuation of CALYPSO resulting from its success. The CALYPSO FO partnership comprises one Maltese partner, the Physical Oceanography Research Group from the University of Malta (as project leader), and four Sicilian partners: University of Palermo, Istituto Ambiente Marino Costiero – CNR IAMC, University of Catania (CUTGAN) and ARPA SICILIA – Agenzia Regionale per la Protezione dell’Ambiente. Both projects were partially supported through ERDF funds under the Italia-Malta Cohesion Policy for 2007-2013.

Coastguards, civil protection organizations, harbor authorities and local environmental protection agencies in both Malta and Sicily stand to benefit from this enhanced HF radar network. The CALYPSO data is shedding new light on the dynamics of the sea in this part of the Mediterranean, leading to research efforts also related to improved forecasting of the marine environment, protection from oil spills, search and rescue, safer maritime transportation and fisheries. As an example, a new and previously unknown persistent gyre that moves and stretches in time in the Malta-Sicily Channel has been discovered thanks to the HF radar measurements; project partners have informally named this structure the “CALYPSO Gyre”.



Tap first point of transect



Observed by satellite

The Physical Oceanography Research Group of the University of Malta has also developed a web service and mobile application called “Kaptan” as part of CALYPSO FO (available for iPhone at iTunes app store and for Android on Google Play app store). Kaptan uses HF radar operational data, satellite data and numerical models to provide useful information on the present and predicted sea conditions in the Malta-Sicily Channel as an aid to mariners for safer navigation.



“Kaptan” mobile application screen shots of SeaSonde ocean surface currents (left) and satellite-derived sea surface temperature (right).

# Recommended Reading

## SeaSondes & Hurricane Intensity Prediction

While the science of predicting hurricane tracks is well established, the understanding and forecasting of the mechanisms driving storm intensity near landfall have lagged. With the aid of data from the Mid-Atlantic Regional Association Coastal Ocean Observing System, including a largescale CODAR SeaSonde network, a key oceanic influence on tropical storm intensity in the coastal ocean has now been identified.

Researchers have described their findings in the *Nature Communications* journal, March 2016 edition. They found that a stratification-driven cooling mechanism on the shallow continental shelf inhibited development of all 11 studied Mid-Atlantic Bight summer storms, including Hurricane Irene of August 2011. Further, this same driver was found in data of other storm events in the Yellow and East China Seas.



Satellite view of Hurricane Irene, 27 August 2011.  
Image Credit: NASA/NOAA GOES Project

According to study co-author Dr. Hugh Roarty, "The mid-Atlantic's extensive network of surface current mapping radars indicated that the strong winds on the leading edge of the storm set up the circulation pattern that cooled the ocean surface." (Rutgers Today, March 8, 2016). [Though not mentioned in this paper, it is worth noting research findings also indicated that autumn storms like 2012's Hurricane Sandy may experience rapid intensification near landfall under non-stratified warmer water conditions.]

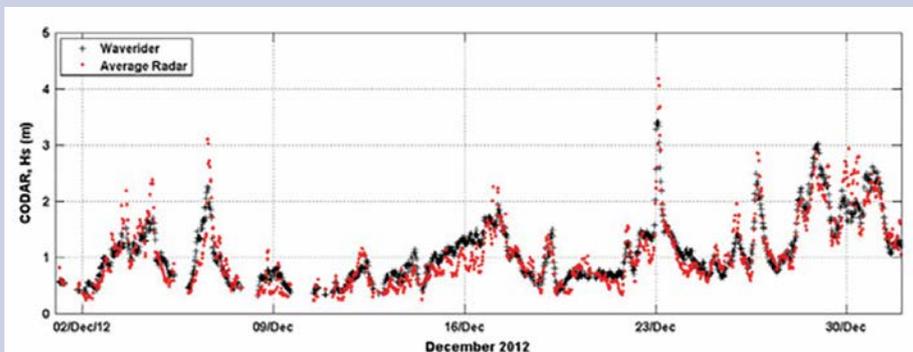
As tropical cyclone intensities continue to increase, better forecasting of storm intensity will be key in making informed, emergency planning decisions for coastal communities. Maintaining long-term coastal ocean observation systems that include SeaSondes will play an important role.

Glenn, S.M., T.N. Miles, G.N. Seroka, Y. Xu, R.K. Forney, F. Yu, H. Roarty, O. Schofield, and J. Kohut. "Stratified Coastal Ocean Interactions with Tropical Cyclones." *Nature Communications*, 1-10 (2016).

## SeaSonde Wave Data Used in Galway Bay Wave Harvesting Assessment

Global estimates of deep water wave power show that Ireland's west coast is a prime candidate for harnessing wave energy. A suite of wave data sources, including CODAR's SeaSonde HF Radar, is examined to quantify the potential of the Galway Bay 1/4-scale wave energy test site. A recent *Ocean Engineering* article details this research, performed at the Centre for Marine and Renewable Energy and the Ryan Institute for Environmental, Marine and Energy Research at the National University of Ireland, Galway.

An approach developed by the authors establishes relationships between wave parameters (such as waveheight thresholds) with wind characteristics (such as strength and direction) to determine wave harvesting viability and annual and seasonal variation at a given location. SeaSonde coastal wave measurements can serve as a valuable planning tool for the exploration of this alternative energy resource.

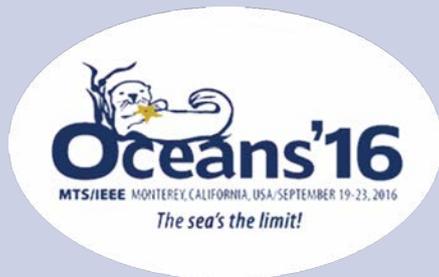


Atan, R., J. Goggins, M. Harnett, P. Agostinho, and S. Nash. "Assessment of Wave Characteristics and Resource Variability at a 1/4-Scale Wave Energy Test Site in Galway Bay Using Waverider and High Frequency Radar (CODAR) Data." *Ocean Engineering*, Vol. 117, 272-291 (2016).

Above Figure: Time series of significant waveheight (Hs) during December 2012 generated by a 25 MHz CODAR SeaSonde (red points) against waverider buoy Hs (black points). From Atan, R., J. Goggins, M. Harnett, P. Agostinho, and S. Nash. "Assessment of Wave Characteristics and Resource Variability at a 1/4-Scale Wave Energy Test Site in Galway Bay Using Waverider and High Frequency Radar (CODAR) Data." *Ocean Engineering*, Vol. 117, 272-291 (2016).

# CODAR's Recommended List of Presentations

Many excellent presentations are expected at both the upcoming MTS/IEEE Oceans'16 conference in Monterey, California and the American Geophysical Union (AGU) 49th Annual Fall Meeting held in San Francisco this Fall. Here is a select list of those having some connection to HF radar (especially SeaSonde) that are considered "must attend" by CODAR staff. We hope to see you in the audience!



## MTS/IEEE Oceans '16

**Session: Real time Quality Control of Oceanographic Data 1 / 22 Sept. / 8:30-10AM at Portola Cotton Wood 2 Room**

- Hugh Roarty: Automated quality control of high frequency radar data II.

**Session: Coastal Radars and E-M Propagation 1 / 22 Sept. / 8:30-10AM at Marriott, Los Angeles Room**

- Luz Zarate: High frequency radar oceanic current monitoring system on the Texas coast.

**Session: Coastal Radars and E-M Propagation 2 / 22 Sept. / 10:30AM- 12PM at Marriott, Los Angeles Room**

- Chloe Baskin: Effectiveness of a bistatic system on high frequency radar resiliency.
- Donald Barrick: Simulator to evaluate tsunami warning performance for coastal HF radars.
- Donald Barrick: Call sign specifically optimized for FMCW HF oceanographic radars.

**Session: 146 Next Generation of Ocean Observing Systems: Polar Region Observing Systems / 22 Sept. / 1:30AM-3PM at Marriott, Los Angeles Room**

- Josh Kohut: Project CONVERGE: Impacts of local oceanographic processes on Adélie penguin foraging ecology.



## AGU Fall Meeting

**Session OS030: Toward an International Coastal Ocean Radar Network: Technology Development, Research, Demonstration and Operational Applications. Session ID# 13034.**

- Donald Barrick: Improved model for wave extraction from compact HF coastal radars (164935).
- Elizabeth A Livermont: Extracting a 2D wave field from a shore-based direction-finding HF radar through characteristic matching with a numerical wave model (165050).
- Mike Muglia: Hourly Gulf stream position, width and orientation estimates with HF radar

off Cape Hatteras, North Carolina, U.S.A. (174436).

- Giuseppe Ciralo: CALYPSO: A new HF radar network to monitor sea surface currents in the Malta-Sicily channel (Mediterranean sea) (179434).
- Hugh Roarty: Observations of the surface circulation over the Mid Atlantic Bight continental shelf (184847).
- Jack Harlan: US Integrated Ocean Observing System HF radar network: National applications and international implementation (188169).
- John Wilkin: Comparing coastal radar wavenumber spectra for surface currents and sea level from observations by HF radar (CODAR) and CryoSat-2 Satellite Altimetry (188936).
- Arne R Diercks: HF radar signal propagation as a function of salinity-A case study in the Mississippi Sound (191944).
- Peter Rogowski: An Assessment of Seasonal Circulation Patterns in the Gulf of Tonkin, Vietnam, Utilizing a Numerical Model, HF Radar and In Situ Observations (193137).
- Lisa Hazard: National high frequency radar network (HFRNET) and Pacific research efforts (197441).
- John Largier: Tracking the surface circulation in coastal upwelling off central and northern California over long times and large areas (198967).
- John D Farrara: Assimilating high-frequency (HF) radar surface currents into a real-time California coastal ocean nowcast/forecast system (134947).
- Libe Washburn: Antenna pattern measurements for oceanographic radars using small aerial drones (152327).
- Anna Rubio: HF radar insight into coastal mesoscale eddies and associated cross shelf transports in the south eastern Bay of Biscay (NE Atlantic) (158247).

