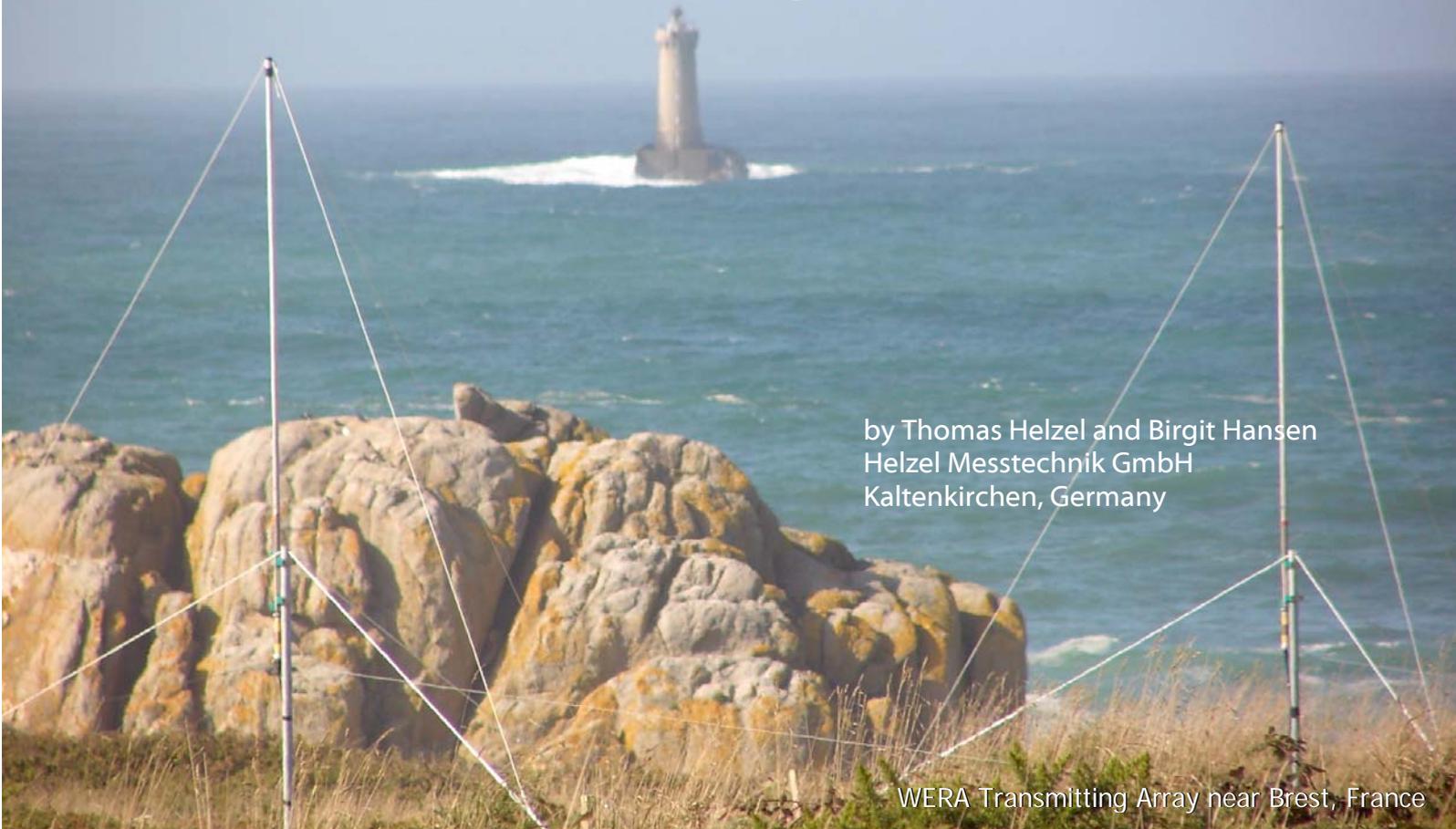


How monitoring by Coastal Radar becomes more and more important as tool for hazard management and environmental protection

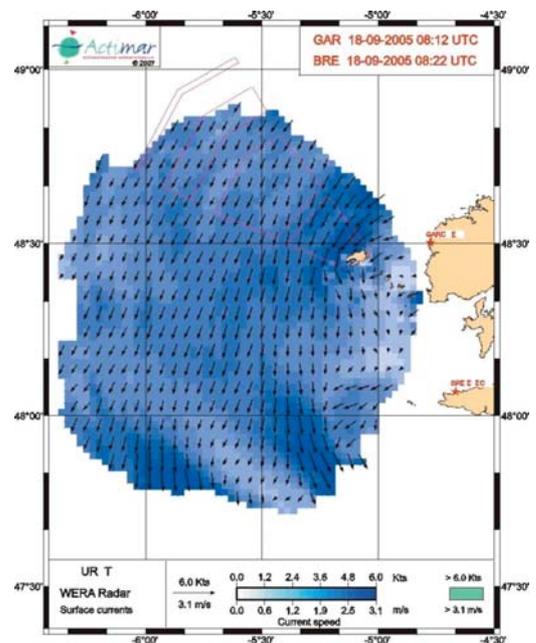


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WERA Transmitting Array near Brest, France

During the past few years, Remote Ocean Sensing by HF radar has become more and more valuable to modern Coastal Management. It offers insights into the dynamics of the coastal seas for a variety of applications without ever leaving dry land.

Search and Rescue operations for example can narrow down the search radius for overboard persons, port authorities can use the data to improve vessel traffic services, environmental protection benefits from this information in case of oil spills or lost containers. Even the marine renewable energy sector has discovered the advantages of using this reliable technology. Diverse studies prove the benefits of using HF radar for hazards management and more and more countries rely on this method by integrating it into their ocean observing networks. One of the leaders in the field of HF radar is the German company Helzel Messtechnik GmbH providing the shore based Remote Ocean Sensing System WERA (Wave Radar) which contributes to coastal management by monitoring surface currents, wind direction and wave parameters with the highest spatial and temporal resolution.



Surface current map with averaging time of 12 min and 1.5 km range cell size at the French coast near Brest. Data kindly provided by www.actimar.fr

Ocean Radar

The WERA long range, high resolution monitoring system is based on short radio wave radar technology. The vertically polarised electromagnetic wave is coupled to the conductive ocean surface and follows the curvature of the earth. This over the horizon oceanographic radar can pick up back-scattered signals from the rough ocean surface (Bragg effect) from ranges of more than 200 km. The concept of the WERA system has been developed at the University of Hamburg by Gurgel et al in 1995 and the hardware development was completed in 2000 at Helzel Messtechnik GmbH. Results from more than 50 installations worldwide demonstrate the features and flexibility of the system: High resolution monitoring with a range cell size of 300 m for short ranges or for long range applications with 3 km range cell size, all generated with the typical high temporal resolution of 10 minutes. As it is a very flexible system, it can be adopted to the user's needs and requirements, as well as optimized to site-specific conditions.

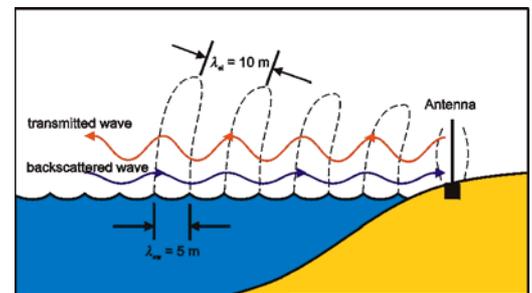
Accuracy and Reliability

A pair of WERA ocean radar stations have been operational since 2006 delivering data from an extremely dynamic ocean area off the French coast near Brest. The range of these systems is about 120 km with a spatial resolution of 1.5 km and a temporal resolution of 6 measurements per hour. These two shore based stations cover an ocean area of about 10,000 km². The normal purpose of these systems is to provide real-time maps of ocean surface currents and significant wave height for the Vessel Traffic Services and for Oceanographic research.

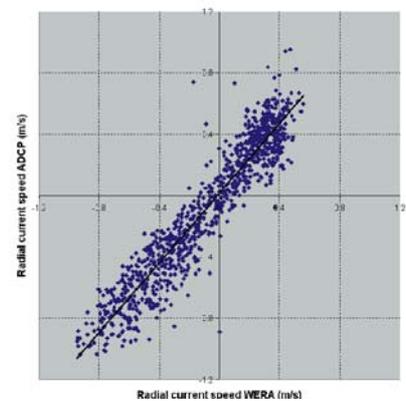
Over a period of 3 months a study was carried out to validate the quality of the provided data by means of a comparison with buoy data. Furthermore the reliability was quantified by comparing the users' demands for data availability with the resulting data. The accuracy and reliability was studied by SHOM (Service Hydrographique et Océanographique de la Marine) using an ADCP and a Wave Rider buoy for ground truthing. Both instruments were located about 30 km off the coast. The corresponding correlation between the ADCP and WERA data shows a correlation coefficient of 0.947. This excellent agreement proves the accuracy of the WERA system to measure ocean surface currents.

Search and Rescue

To test this technique for SAR applications, surface drifters were launched and tracked. The drift prediction for this simulated "man-over-board" situation were carried out by means of a 2D tidal model typically used for the SAR operations and by a drift prediction based on the ocean currents measured by the WERA systems. Presently, search and rescue tools are based on hydro-dynamic and atmospheric models to provide hindcast and forecast situations. Even if these oceanic numerical models are efficient in the production of instantaneous maps of currents, the accuracy of derived Lagrangian trajectories has limitations for search and rescue purposes. Results of the SAR-DRIFT project show the significant improvement of the drift simulation, when using real-time current data provided by radar systems instead of using results from numerical models. This improved quality of the drift prediction can be very useful for Search and Rescue applications.

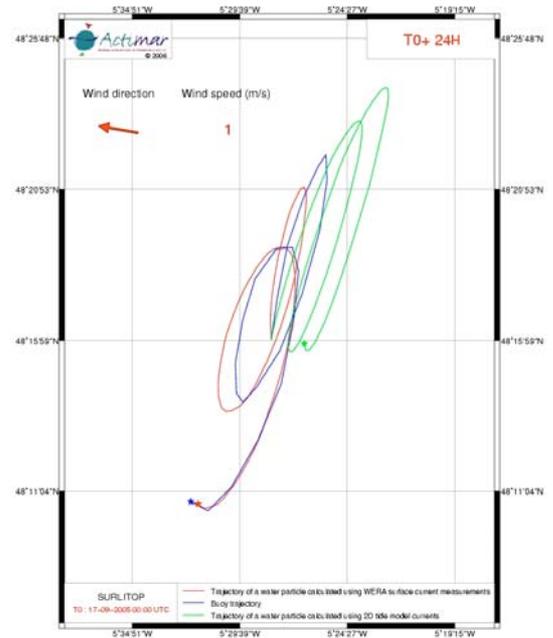


Radar Principle of ocean backscatter due to Bragg-effect



Comparison of radial current velocity measured with WERA and ADCP: $r = 0.947$

In addition, this drift prediction can be used for the forecast of drifting oil spill or containers in case of an accident to make the management of the pollution more effective. Furthermore this tool can be used in case of oil pollution for backtracking any detected pollution to identify the origin and time of this pollution. In connection with the SAR-Drift project [Røang, 2009], two in-situ experiments were carried out in Norway and France with drifting objects. With the help of the Navy in both cases, models of containers and a real container were left to drift in the area of coverage of HF radars. The current-induced drifts of the objects were first predicted using forecast models, and then re-computed using currents from the radar measurements. All the results show a very good agreement between the observed trajectories and the radar-computed ones, while the predicted drifts without radar data rapidly diverge from the real trajectories.



Drifting „person“, real 24 hour trajectory plotted in blue, prediction based on 2D tidal model in green and prediction based on measured data in red

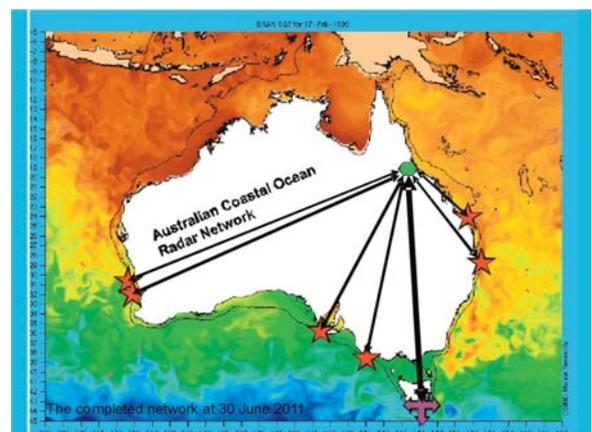
This emphasizes the importance of HF radars for search and rescue operations, especially in dynamic ocean areas. After an accident, an accurate estimation of the location of an object or body can be obtained using HF radar.

HF radar as part of national ocean observing systems

Another trend can be seen in the integration of HF radar into national ocean observing systems as has been done within the German Ocean Monitoring System OMS at the North Sea coast or in larger scale within the Australian Coastal Ocean Radar Network ACORN.

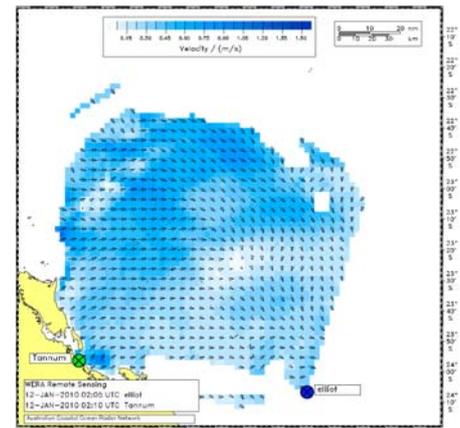
As part of the Integrated Marine Observing System (IMOS), Australia is establishing its first national, and worldwide unique, Coastal Ocean Radar Network. Formally called the Australian Coastal Ocean Radar Network (ACORN), it is a system with exciting implications and widespread potential to help many aspects of coastal ocean research and management, from coral reef restoration and tsunami warning to pollution control and search-and-rescue efforts.

Over the next years, coastal radars will be installed at sites across Australia with over \$5 million in funding allocated through IMOS. In April 2007, the first WERA radar was installed on the beach of Tannum Sands and a second set was installed in September at Lady Elliot Island. After Lady Elliot Island, the next radars were installed in Western Australia from Perth to Jurien Bay followed by set-ups in South Australia.



The Australian Coastal Ocean Radar network. Red stars are HF radar sites (pairs of stations), the green hexagon is the ACORN Laboratory in Townsville, the purple cross is the IMOS headquarters and the location of the staff running the IMOS data archive.

There is potential for application of the data to management of coastal marine resources, and in marine safety areas. Real-time maps of surface currents and the prospect of short-term forecasting have the potential to reduce search areas in coastal waters and to make pollution/spill mitigation more effective. The near real-time provision of surface currents and wave height data in graphic format on a freely accessed web site has the potential to improve the level of awareness of the maritime conditions within the community, e.g. for recreation applications. With the establishment of HF radar monitoring stations like those in ACORN, there is growing opportunity for researchers around the world to access data from well curated archives to carry out basic research on physical oceanography, or applications research without having direct access to the measuring facility.



“The idea behind ACORN, in a 150 km area, we will have current measurements every 4 km by 4 km along the whole grid,” Prof. Mal Heron of James Cook University says. The data, which are sent back to the ACORN lab every 10 minutes, allow for highly detailed maps of the currents from the shore out to the edge of the radars’ range. With the data, researchers can create maps of sea-surface currents, wave features, and ocean swells generated by the coastal ocean’s intricate dynamics – factors which interact to affect everything from coral bleaching and fish migrations to pollution drift and deep ocean water movements. Describing and understanding these relatively undeciphered yet highly important shifting dynamics will help link the study of deep ocean patterns with near-shore processes. „We have the BLUElink model, and moorings”, Heron says, in reference to a new national ocean forecasting program that recently developed by the Commonwealth Science and Industrial Research Organisation (CSIRO), and other ocean observation tools. „What we haven’t observed so well are the changes: upwellings from the deep ocean, or eddies – small-scale eddies that are difficult to model. We know the large-scale currents around Australia, but we don’t know the interactions and the small-scale details... What we’re doing is putting in a very important basic research layer.”

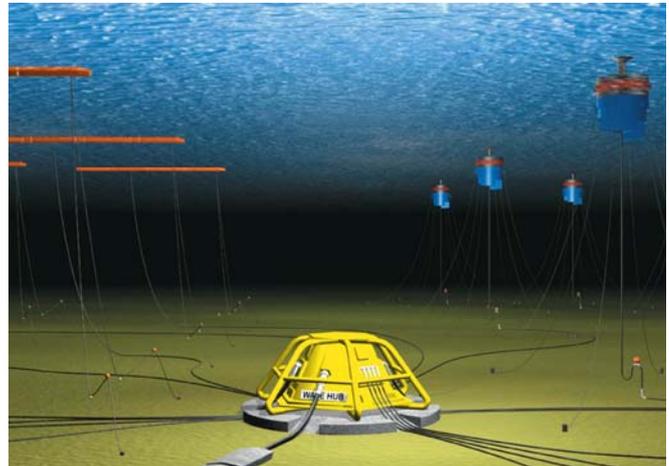
Eventually, there are plans for a public website where surface current images would be freely available. The maps will potentially benefit many sectors of the community, from marine researchers to fishermen to tourist operators and the general public, who may simply want to know what’s happening in local waters. “We want to encourage community use,” Heron says. “We want to be able to demonstrate at the end of IMOS that there is a community following.”

For a more detailed overview, please visit the IMOS website: www.imos.org.au

Benefits of HF radar for marine renewable energies

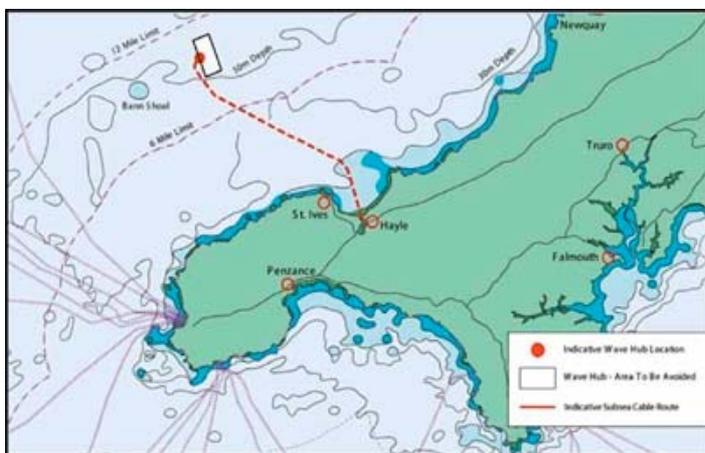
Finally, the renewable energy sector has discovered the usefulness of HF radar for their purpose to measure wave energy resource potential and to judge the influence of the marine renewables on the ocean environment.

The Wave Hub project, for example, is a groundbreaking renewable energy wave power research project to create the UK's first offshore facility to demonstrate the operation of arrays of wave energy generation devices. Many different devices are being developed in the UK and elsewhere to generate electricity from the power of the waves. After the devices have been tested as prototypes elsewhere, the Wave Hub provides an area of sea with grid connection and planning consent where arrays of devices can be operated over several years.



Wave Hub grid-connected socket off the coast of Cornwall

The project will be developed approximately 10 miles off Hayle, on the north coast of Cornwall, UK. The hub is a 'socket' sitting on the seabed for wave energy converters (WEC) to be plugged into.



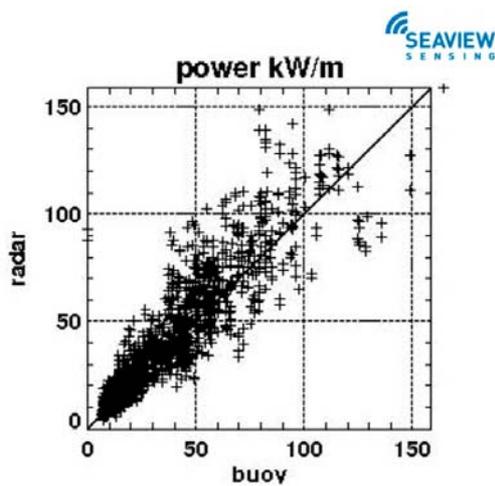
From Hayle, a cable will be taken through a duct beneath the sand dunes and then across the sea bed to an eight square kilometre area within which the devices will be moored. This area will be indicated with navigational markers. A cable from the hub to main land will take electrical power from the devices to the electric grid. Further details on the Wave Hub are available at www.wavehub.co.uk

To monitor the influence of these devices on the ocean environment, the Peninsula Research Institute for Marine Renewable Energy (PRIMaRE / www.primare.org), a joint venture of the University of Plymouth and the University of Exeter will install two WERA systems at the north Cornwall coast to receive current and wave data on the sea area leased to the device developers. The landbased radar systems will be able to deliver valuable real-time data on ocean currents for 110 km and wave data up to 50 km.

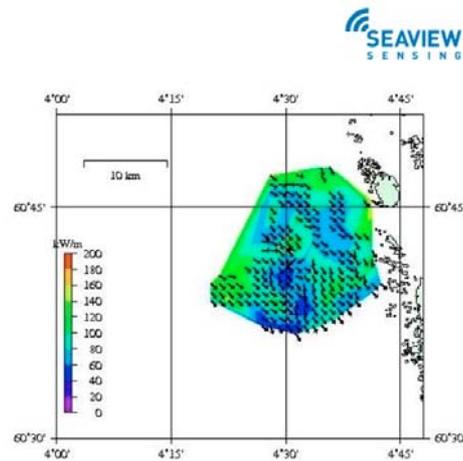
The extraction of energy by the devices will by definition change the physical environment at the Wave Hub site. The radar systems are sought in order to determine the magnitude of this change and to assess the nature and magnitude of far field changes present in the shadow area in the lee of Wave Hub. In addition, they will provide the offshore wave

boundary conditions for numerical simulations of nearshore and shoreline change in the Wave Hub shadow, particularly high-resolution directional wave spectra. It is also expected that Wave Hub, with its large collection of in-situ sensors will provide an optimal site for proving the reliability of high-frequency radar systems for wave measurements.

Thus, HF radar technology proved to have widespread potential to help many aspects of coastal ocean research and management.



Wave power, radar and buoy comparison



Wave power and peak direction measured with WERA at the Norwegian Coast, March 2000.

Additional information on the topics could be found on the following websites: www.helzel.com, www.wavehub.co.uk, www.primare.org, www.imos.org.au, www.seaviewsensing.com, www.actimar.fr

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