List of Early HF Radar Papers Important Papers are Indicated by *

The First Papers Showed that HF Radio Waves are Scattered From the Sea Surface

*Crombie, D. D. (1955). Doppler spectrum of sea echo at 13.56 Mc/s. *Nature* **175**(4449): 681-682.

First observations of HF radio signals scattered from the sea.

- Sofaer, E. (1958). Phase-coherent back-scatter of radio waves at the surface of the sea. *Institution of Electrical Engineers* **Paper 2591**: 383-394.
- Ranzi, I. (1961). Experiments on backscatter of HF radiowaves from open and coastal sea, Centro Radioelettrico Sperimentale G. Marconi: 8.
- Ranzi, I. (1961). Backscatter of HP radio waves from coastal and continental ground reliefs, Centro Radioelettrico Sperimentale G. Marconi: 6.
- Ranzi, I. (1961). Doppler frequency shift of HF-to-SHF radio waves returned from the sea, Centro Radioelettrico Sperimentale G. Marconi: 4.
- Wait, J. R. (1966). Theory of HF ground wave backscatter from sea waves. *J. Geophys. Research* **71**(20): 4839-4842.

Papers From the Collaboration of

Scripps Institution of Oceanography and Stanford Center for Radar Astronomy Showed HF Radar Could Observe Waves, Currents, and Wind

- Munk, W. H. and W. A. Nierenberg (1969). High frequency radar sea return and Phillips saturation constant. *Nature* **224**(5226): 1285.
- Peterson, A. M., C. C. Teague and G. L. Tyler (1970). Bistatic-radar observation of long-period, directional ocean-wave spectra with Loran A. *Science* **170**: 158-161.
- Teague, C. C. (1971). Bistatic-radar techniques for observing long wavelength directional ocean wave spectra. *IEEE Trans. Geoscience Elect.* **GE-9** (4): 211-215.
- Stewart, R. H. (1971). *Higher order scattering of radio waves from the sea*. IEEE/GAP International Symposium Digest, Los Angeles 190–193.
- *Tyler, G. L., W. E. Faulkerson, A. M. Peterson and C. C. Teague (1972). Second-order scattering from the sea: ten meter radar observations of the Doppler continuum. *Science* **177**: 349-351.

Showed the limitations of the first-order theory of radar scatter from the sea.

- *Stewart, R. H. and J. W. Joy (1973). *HF radio measurements of ocean currents*. IEEE International Conference on Engineering in the Ocean Environment, Seattle, Washington: 64–67.
- Teague, C.C., G. L. Tyler, J.W. Joy, R.H. Stewart. (1973) Synthetic aperture observations of directional height spectra for 7-second ocean waves. U.S. National Committee — International Union of Radio Science Meeting, Boulder CO. 87.
- Teague, C.C., W.E. Faulkerson, A.M. Peterson, G.L. Tyler, R.H. Stewart, J.W. Joy. (Apr 1973) Directional spectra measurements of 7-second ocean waves using synthetic aperture antenna. *EOS* 54(4): 315.
- Teague, C. C., G. L. Tyler, J. W. Joy and R. H. Stewart (1973). Synthetic aperture observation of directional height spectra for 7s ocean waves. *Nature Physical Science* **244**(137): 98-100.
- Stewart, R.H., C.C. Teague, G.L. Tyler, and J.W. Joy. (1973) HF measurements of ocean-wave direc-

Stewart

tional spectra, in *Propagation Effects on Frequency Sharing*, edited by I. Rangi. London: North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development Publication AGARD-CP-127: 18-1–18-7.

- *Tyler, G.L., C.C. Teague, R.H. Stewart, A.M. Peterson, W.H. Munk, J.W. Joy. (1974) Wave directional spectra from synthetic aperture observations of radio scatter. *Deep-Sea Research*, **21**: 989–1016. First very high resolution (2°–3°) measurements of the directional distribution of wind-generated waves at sea.
- *Stewart, R. H. and J. W. Joy (1974). HF radio measurements of surface currents. *Deep-Sea Res.* **21**: 1039-1049.

First measurements of surface currents using HF radar, and theory for relating currents to HF Doppler spectrum.

*Stewart, R.H. J.R. Barnum. (1975) Radio measurements of oceanic winds at long ranges: an evaluation. *Radio Science*, **10**: 853–857.

First estimates of the accuracy of measurement of wind velocity at distances of more than a thousand kilometers using an over-the-horizon HF radar.

- Stewart, R.H. (1975) Application of HF scatter to oceanography. XVI General Assembly of the International Union of Geodesy and Geophysics, 25 August to 6 September 1975, Grenoble. IAPSO Scientific Program, 142.
- Teague, C.C., G.L. Tyler, R.H. Stewart. (1975) The radar cross section of the sea at 1.95 MHz: Comparison of in-situ and radar determinations. *Radio Science*, **10**: 847–852.
- Stewart, R.H. Sea state. (1975) 1976 McGraw-Hill Yearbook of Science and Technology, 357–359.
- Teague, C. C. (1975). In-situ decametric radar observations of ocean-wave directional spectra during the 1974 NORPAX Pole experiment: Final Report, Radioscience laboratory, Stanford University Tech. Report No. 3615-2: 1-34.
- Teague, C.C., G.L. Tyler, R.H. Stewart. (1977) Studies of the sea using HF radio scatter. *IEEE Trans. Antennas and Propag,* **AP-25**: 12–19.
- *Teague, C. C. and R. H. Stewart (1978). Joint HF radar/wave buoy experiments. Jasin Cruise Report R/V Atlantis II.

As far as I know Cal Teague was the first to use a personal computer at sea for a scientific project.

*Ha, E. C. (1979). Remote sensing of ocean surface current and current shear by HF backscatter radar, Ph.D. Thesis, Stanford Electronics Laboratory Report D415-1.

First demonstration of use of HF radar to measure current shear at the sea surface.

- Teague, C. C. (1979). Synthetic aperture HF radar wave measurement experiment. *Proceedings of the Conference on Ocean Wave Climate*: 203-219.
- *Stewart, R.H., C. Teague. (1980) Dekameter radar observations of ocean wave growth and decay. J. *Phys. Oceanography*, **10** (1): 128–143.

First direct measurements of the decay of waves propagating against the wind.

*Teague, C. C. (1986). Multifrequency HF radar observations of currents and current shears. *IEEE Jour*nal of Oceanic Engineering **OE-11**(2): 258--269.

First complete report on the use of HF radar to measure current shear at the sea surface and its relation to wind stress.

Barrick's Papers

Barrick, D. E. and W. H. Peak (1968). A review of scattering from surfaces with different roughness

scales. Radio Science 3(8): 865-868.

- Barrick, D. E. (1971). Theory of HF and VHF propagation across the rough sea. I. The effective surface impedance for a slightly rough highly conducting medium at grazing incidence. *Radio Science* **6**(5): 517-526.
- Barrick, D. E. (1971). Theory of HF and VHF propagation across the rough sea. II Application to HF and VHF propagation above the sea. *Radio Science* **6**(5): 527-533.
- Barrick, D. E. (1972). First-order theory and analysis of MF/HF/VHF scatter from the sea. *IEEE Trans. Antennas and Propag.* **AP-20**: 1-10.
- *Barrick, D. E. (1972). Chapter 12: Remote sensing of sea state by radar. *Remote Sensing of the Troposphere*: 12-11 through 12-46.

Theory for the radar cross-section of the sea, and doppler spectrum of radio waves reflected from the sea.

- Barrick, D. E., J. M. Headrick, R. W. Bogle and D. D. Crombie (1974). Sea backscatter at HF: Interpretation and utilization of the echo. *Proc. IEEE* **62**(6): 673-680.
- Barrick, D. E. and J. B. Snider (1977). The statistics of HF sea-echo Doppler spectra. *IEEE Trans. Antennas and Propag.* **AP-25**: 19-28.
- Barrick, D. E. and B. L. Weber (1977). On the nonlinear theory for gravity waves on the ocean's surface. Part II: Interpretation and applications. *J. Phys. Oceanog.* **7**(1): 11-21.
- *Barrick, D. E., M. W. Evans and B. L. Weber (1977). Ocean surface currents mapped by radar. *Science* **198**: 138-143.

First implementation of an HF radar to map surface currents near shore.

*Lipa, B. (1977). Derivation of directional ocean-wave spectra by integral inversion of second-order radar echoes. *Radio Science* **12**(3): 425-434.

Showed the sidebands of the Doppler spectrum of HF radio waves scattered from the sea are also directly related to the directional spectrum of ocean waves in the scattering area. See also Hasselmann (1971).

- Lipa, B. (1978). Inversion of second-order radar from the sea. J. Geophys. Research 83(C2): 959-962.
- Weber, B. (1978). Gravity wave propagation in the presence of a current with an arbitrary vertical profile. A report, NOAA/ERL Wave Propagation Lab, Boulder Colorado.
- Barrick, D. E. and B. J. Lipa (1979). Ocean surface features observed by HF coastal ground-wave radars: A progress review. *Proceedings of the Conference on Ocean Wave Climate*: 129–152.
- Barrick, D. E. and B. J. Lipa (1979). A compact transportable HF radar system for directional coastal wave field measurements. *Proceedings of the Conference on Ocean Wave Climate*: 153–201.
- Lipa, B. and D. Barrick (1980). Methods for the extraction of long-period ocean wave parameters from narrow beam HF radar sea echo. *Radio Science* **15**(4): 843-854.

Papers by Other Groups

- Bass, F. G., I. M. Fuks, A. I. Kalmykon, I. E. Ostrovsky and A. D. Rosenberg (1968). Very high frequency radiowave scattering by disturbed sea surface. *IEEE Trans. Antennas and Propagation* **AP-16**(5): 554-568.
- Crombie, D. D. and J. M. Watts (1968). Observations of coherent backscatter of 2-10 MHz radio surface waves from the sea. *Deep Sea Research* **15**: 81-87.
- King, R. J. (1968). An introduction to electromagnetic surface wave propagation. *IEEE Trans. on Education*: 59-61.
- King, R. J. (1969). Electromagnetic wave propagation over a constant plane. *Radio Science* **4**(3): 255-268.

Stewart

- Ward, J. F. (1969). Power spectra from ocean movements measured remotely by ionospheric radio backscatter. *Nature* **223**: 1325-1330.
- Watts, J. M. (1970). Instrumentation for observing HF sea scatter, ESSA Research Lab. Tech. Memo. ERLTM-ITS 223.
- Crombie, D. D. (1971). *Backscatter of HF Radio Waves from the Sea*. Electromagnetic Probing in Geophysics, pp. 131-162, Golem Press.
- *Hasselmann, K. (1971). Determination of ocean wave spectra from doppler radio return from the sea surface. *Nature (Physical Science)* **229**: 16-17.

First to show that the sidebands of the first-order Bragg scatter from the sea is directly related to the ocean-wave spectra in the scattering area.

- Barnum, J. R. (1973). Skywave polarization rotation in swept-frequency sea backscatter. *Radio Science* **8**(5): 411-423.
- Long, A. and D. B. Trizna (1973). Mapping the North Atlantic winds by HF radar sea backscatter interpretation. *IEEE Trans. Antennas and Propag.* **AP-21**: 680-685.
- Rozenberg, A. D., I. Y. Ostrovskiy, V. I. Zel'Dis, I. A. Leykin and V. G. Ruskevich (1973). Determination of the energy-containing part of the ocean-wave spectrum from the phase characteristics of a radio signal scattered by the ocean. *Atmos. and Oceanic Phys.* **9**(12): 1323-1326.
- Fuks, I. M. (1974). Determination of the parameters of ocean waves from amplitude and phase fluctuations of reflected radio waves. *Izvestia Atmospheric and Oceanic Physics* **11**(10): 1038-1046.
- Headrick, J. M. and M. I. Skolnik (1974). Over-the-horizon radar in the HF band. *Proc. IEEE* 62(6): 664-687.
- Rhodes, R. S. and R. B. Chadwick (1974). Economic appraisal of real-time synoptic sea-state measurements by over the horizon radar, Department of Commerce, NOAA Tech. Report NOAA TR ERL 299-WPL 32.
- Wait, J. R. (1974). Recent analytical investigations of electromagnetic ground wave propagation over inhomogeneous earth models. *Proc. IEEE* **62**(8): 1061-1072.
- Maresca, J. W. and J. R. Barnum (1975). Measurement of sea scatter and buoy tracks at long ranges by high-resolution OTH-B radar. Stanford Research Institute Final Report Contract N00014-74-C-0138 (NR 083-320).
- Ward, J. F. and P. E. Dexter (1976). A long range ocean radar for ocean surface studies using backscatter via the ionosphere. *Australian Journal of Physics* **29**: 183-194.
- Barnum, J. R., J. W. Maresca and S. M. Serebreny (1977). High-resolution mapping of oceanic wind fields with skywave radar. *IEEE Trans. Antennas and Propag.* **AP-25**: 128-132.
- Mareska, J. W. and J. R. Barnum (1977). Measurement of oceanic wind speed from HF sea scatter by skywave radar. *IEEE Trans. Antennas and Propag.* **AP-25**: 132-135.
- Crombie, D. D., K. Hasselmann and W. Sell (1978). High-frequency radar observations of sea waves travelling in opposition to the wind. *Boundary-Layer Meteorol.* **13**: 45-54.
- Maresca, J. W. and T. M. Georges (1980). Measuring rms wave height and the scalar ocean wave spectrum with HF skywave radar. *J. Geophys. Res.* **85**(C5): 2759-2771.