U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Offshore Wind Turbine Radar Interference Mitigation (WTRIM) Webinar Series
Oceanographic High Frequency (HF) Radar

Patrick Gilman, DOE Wind Energy Technologies Office

July 27th, 2020

OSW Turbine Radar Interference Mitigation Webinar Series

Objective

- Building relationships between key industry stakeholders and federal agencies
- Sharing perspectives on potential impacts of wind turbine induced radar interference on critical radar missions and offshore wind development
- Identifying research and development (R&D) needs to address these impacts

Webinar attendees will

- Achieve a better understanding of agency perspectives on potential impacts of offshore wind on radar missions and industry perspectives on offshore wind development
- Hear about government and industry-led wind-radar interference research, including potential impacts of offshore wind on radar missions and technical mitigation options
- Share perspectives on the strengths and weaknesses of the current state of knowledge of potential technical impacts and mitigations
- Help identify research needs for offshore wind-radar mitigation and assist in identifying a pathway forward for future government-industry collaboration
- Network with professionals representing domestic and European offshore wind developers, OEMs, radar vendors, the WTRIM Working Group, and technical radar experts.

Tentative Future Webinar Agenda & Information

Oceanographic HF Radar R&D Follow-on Meeting

- **1 hour long meeting to discuss R&D needs, and potential collaborations for HF radar**
- **Please reach out if this meeting would be of interest**

TBD- August 24th 2020

Air Traffic Control/Air Surveillance Radars: *State of Understanding of U.S. Offshore WTRIM Issues from an Federal Aviation Administration (FAA) Perspective*

- *Terminal and Long-Range Radars*
- *Technical and operational issues regarding each system in an OSW environment and potential mitigations*

TBD, Fall, 2020 (TBD)

Forward Looking Research & Collaboration and Government/Industry Virtual Roundtable

All Webinar Information Can Be Found on the DOE Website

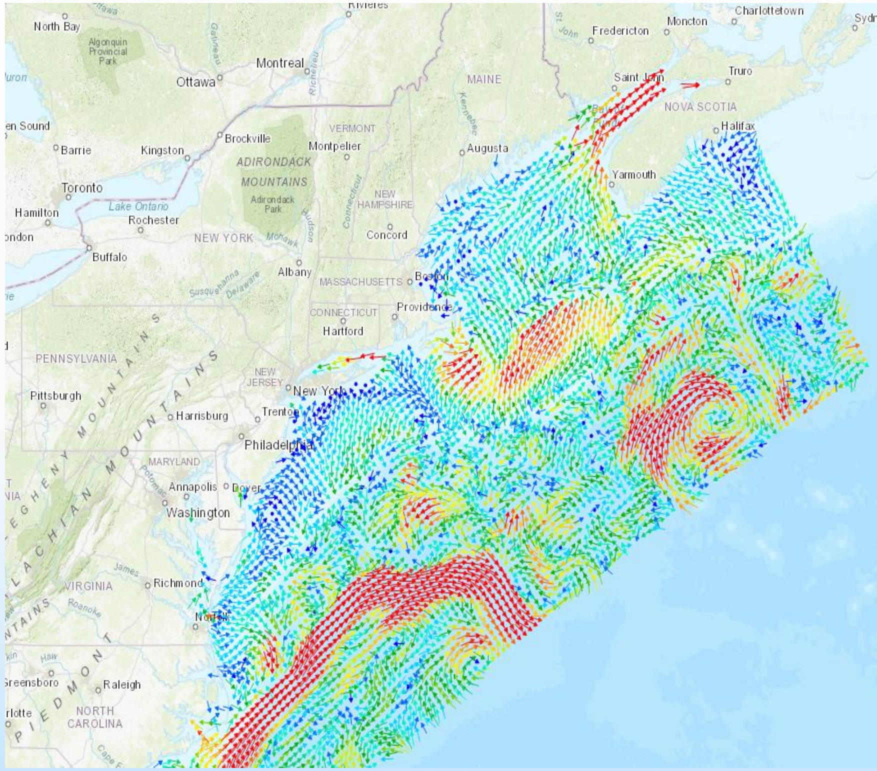
https://www.energy.gov/eere/wind/articles/offshore-wind-turbine-radar-interference-mitigation-webinar-series

Agenda

Monday, July 27, 2020	
11:00 a.m.	Welcome, Meeting Objectives *Speaker: Patrick Gilman | U.S. Department of Energy's Wind Energy Technologies Office (WETO)*
11:05 a.m.	The United States National High-frequency (HF) Radar Network *Brian Zelenke | National Oceanic & Atmospheric Administration (NOAA)*
11:15 a.m.	Background Information and Previous Mitigation Efforts *Hugh Roarty | Rutgers University*
11:30 a.m.	Wind Turbine Interference (WTI) Mitigation Efforts *Chad Whelan and Dale Trockel | CODAR Ocean Sensors, Ltd.*
11:45 a.m.	Assessing the Effectiveness of WTI Mitigation and Impacts to Observations *Anthony Kirincich | Woods Hole Oceanographic Institution (WHOI)* *Brian Emery | University of California, Santa Barbara (UCSB)*
12:00 p.m.	Importance of Reliable and Accurate Environmental Data in the U.S. Coast Guard's Search and Rescue Optimal Planning System (SAROPS) *Cristina Forbes | U.S. Coast Guard (USCG)*
12:15 p.m.	Turbine Siting and Opportunities for Impact Mitigation *Angel McCoy | Bureau of Ocean Energy Management (BOEM)*
12:30 p.m.	Audience Questions & Answers *Moderator: Patrick Gilman | WETO*
1:00 p.m.	Conclude

Oceanographic High-frequency Radar (HFR)—Wind Turbine Radar Interference Mitigation (WTRIM)

The United States’ National HFR Network



Presented by:
Brian Zelenke (brian.zelenke@noaa.gov)
Surface Currents Program Manager
National Oceanic & Atmospheric Administration (NOAA)
U.S. Department of Commerce

National Ocean Service

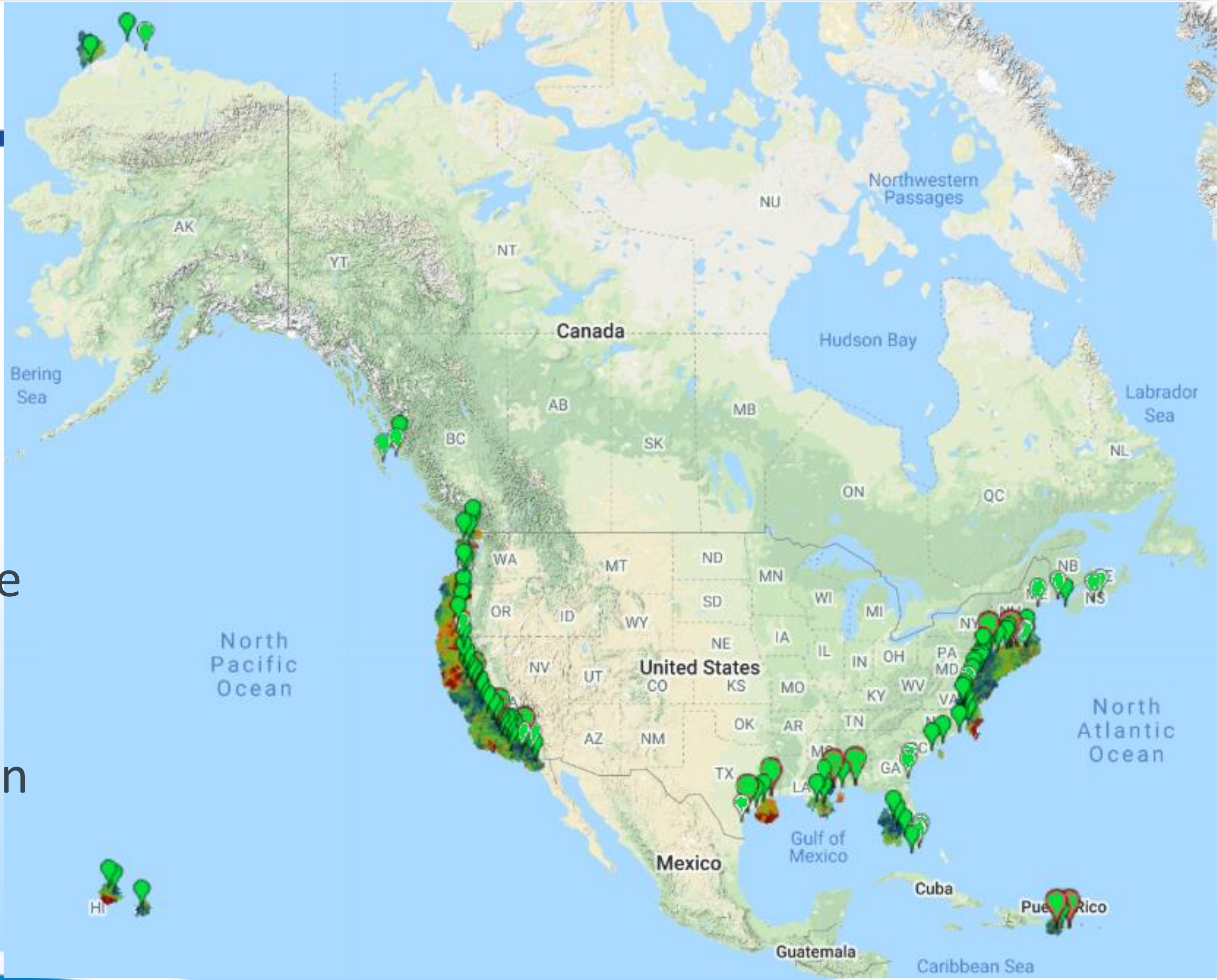
7/27/2020

Agenda

- HFR Network Overview
- What HFR Does
- WTRIM for HFR

HFR Network Overview

- ~160 HFRs operating at any given time.
- Covers thousands of square kilometers.
- ~150+ km offshore.
- HFR-derived ocean surface current maps update hourly.
- 0.2–6 km spatial resolution (bandwidth dependent).



Agenda

- HFR Network Overview
- What HFR Does
- WTRIM for HFR

What HFR Does

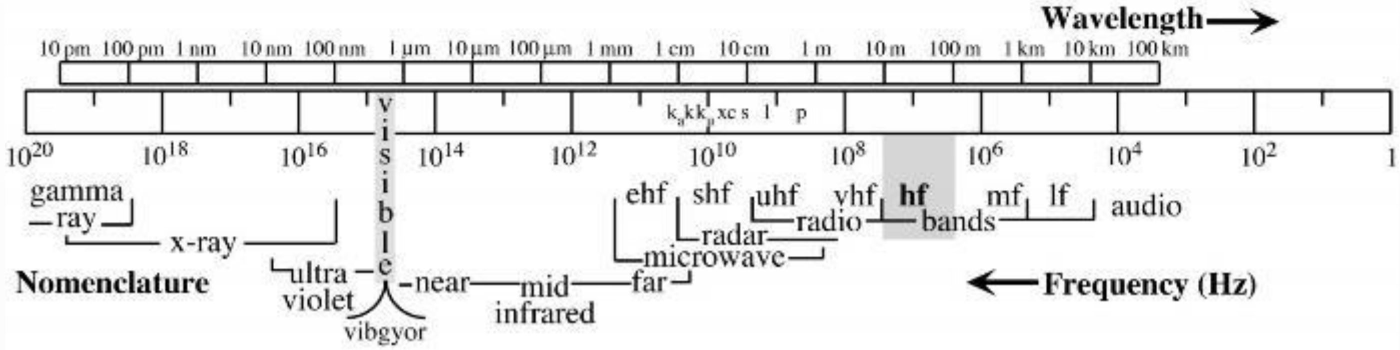
- Operational:
  - Search & Rescue
  - Oil Spill Response
  - Oil Spill Risk Analysis
  - Marine Navigation
  - Advanced Weather Interactive Processing System
  - Coastal Monitoring
- Development:
  - Tsunami Detection
  - Significant Wave Height
  - Hydrodynamic Modeling

NOAA Integrated Ocean Observing System (IOOS)

Agenda

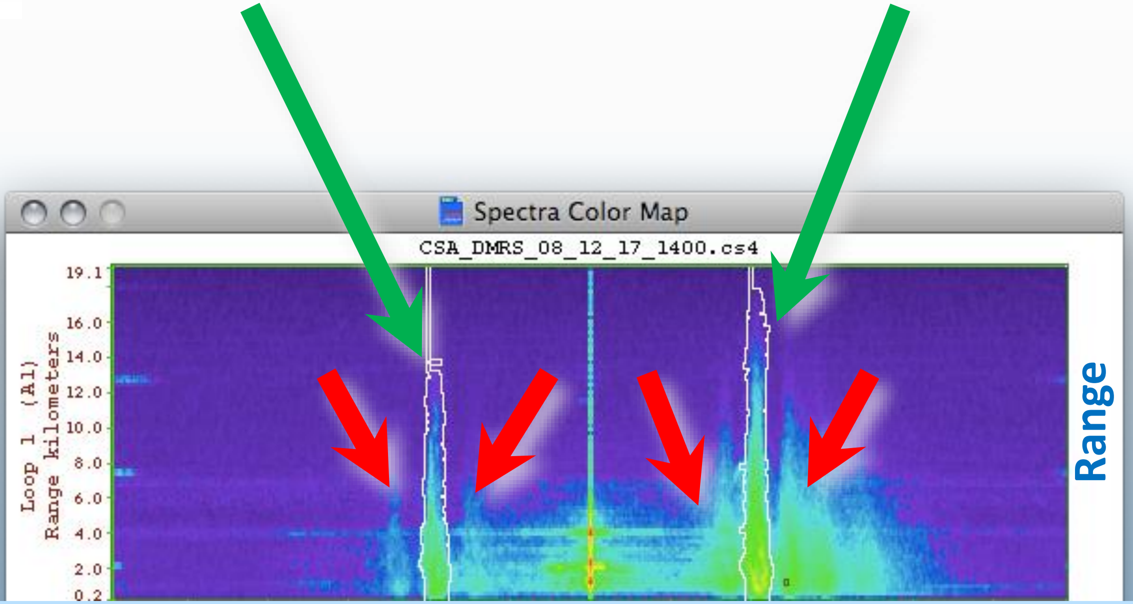
- HFR Network Overview
- What HFR Does
- <u>WTRIM for HFR</u>

WTRIM for HFR



- Oceanographic HFR (e.g., ~5 MHz, ~12 MHz, ~25 MHz) is, technically speaking, not radar.
- In bays and estuarine areas the higher frequencies oceanographic HFR uses (e.g. ~42 MHz) are really VHF.

- -Current information derived from 1st-order peaks in Doppler spectra (**green arrows**).
- Wave info. derived from 2nd-order echo peaks (**red arrows**).

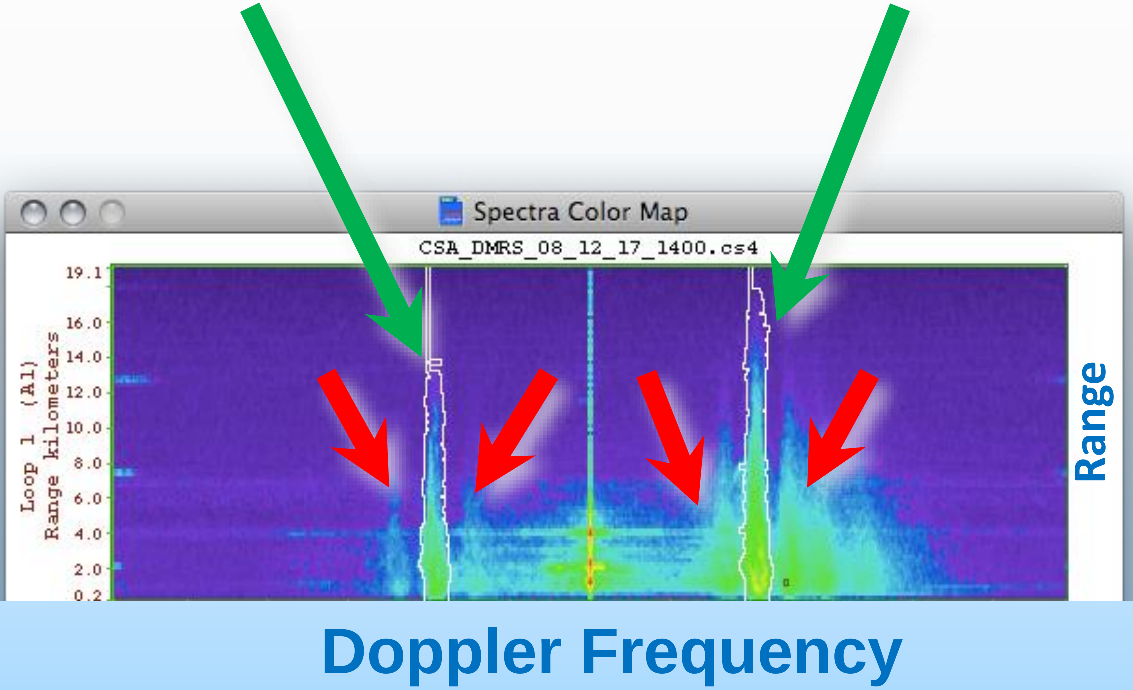


Doppler Frequency

WTRIM for HFR

- Wind farms may be able to help address the voids wind turbines will cause in the HFR network's measurement field by taking measures such as instrumenting their wind farms with oceanographic sensors (e.g., current and wave meters) that telemeter their real-time data stream to NOAA's Integrated Ocean Observing System (IOOS).
- HFR manufacturer-specific mitigations to wind turbine interference may additionally be possible, but depend on early forewarning of intended wind farm layouts and may require real-time feeds of each turbine's rotor speed and nacelle position.

- -Current information derived from 1st-order peaks in Doppler spectra (**green arrows**).
- Wave info. derived from 2nd-order echo peaks (**red arrows**).

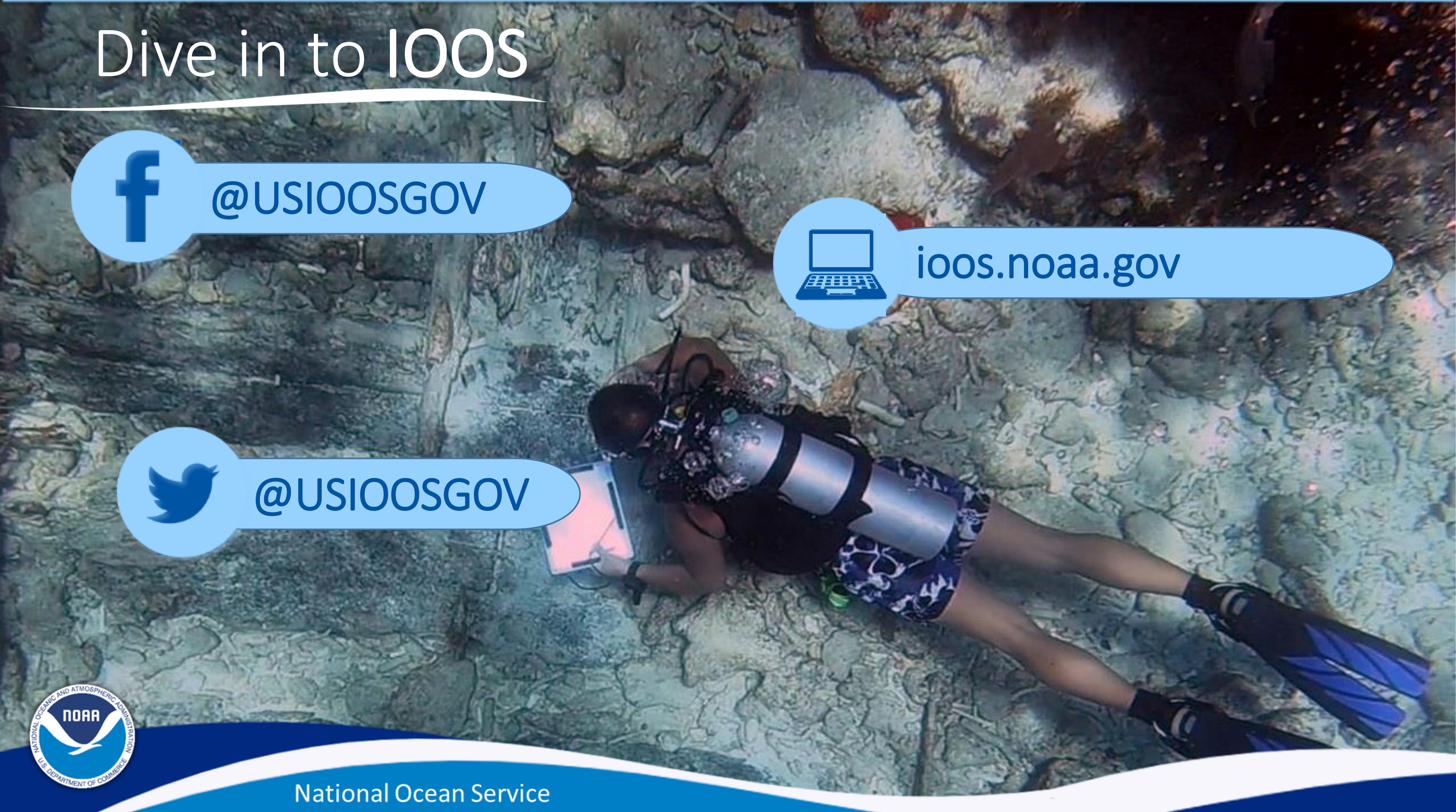


Dive in to IOOS

@USIOOSGOV

ioos.noaa.gov

@USIOOSGOV

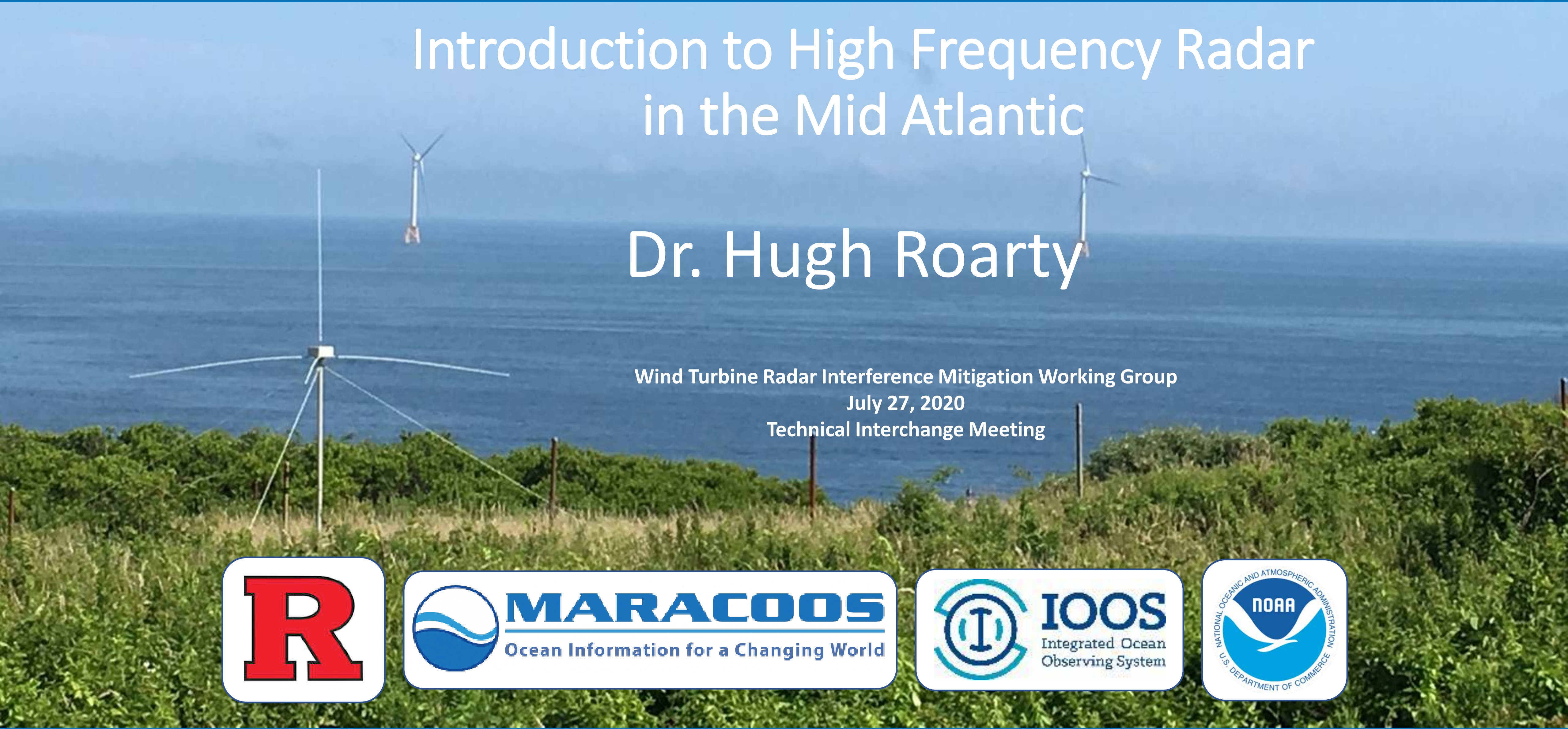



National Oceanic & Atmospheric Administration
Integrated Ocean Observing System
brian.zelenke@noaa.gov
National Ocean Service

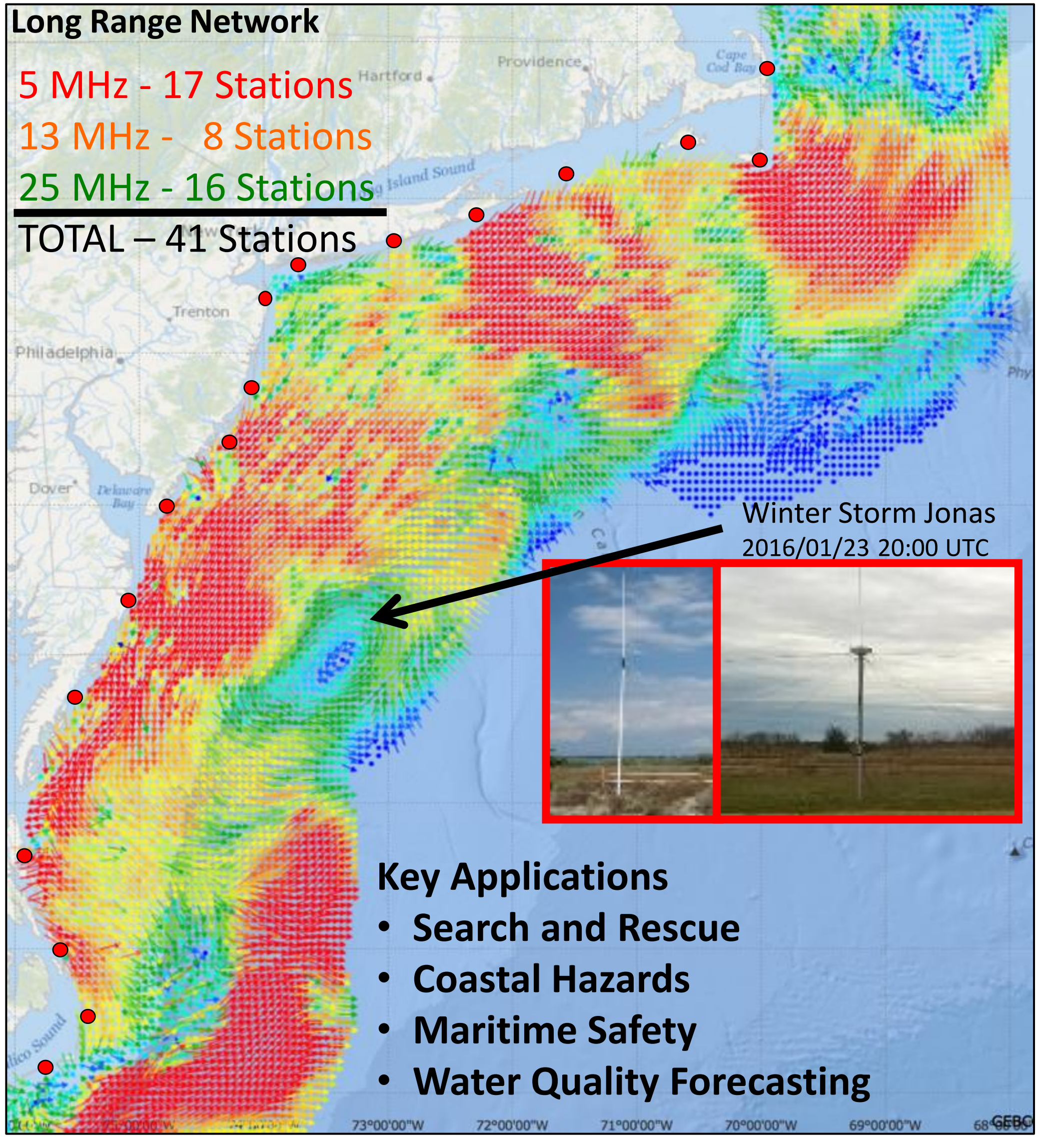
Introduction to High Frequency Radar in the Mid Atlantic

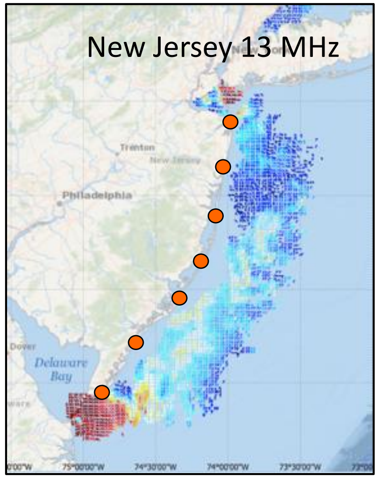
Dr. Hugh Roarty

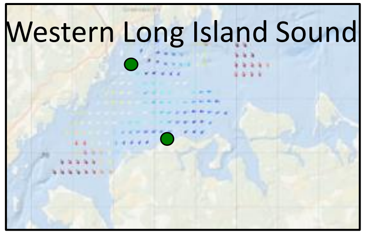
Wind Turbine Radar Interference Mitigation Working Group
July 27, 2020
Technical Interchange Meeting

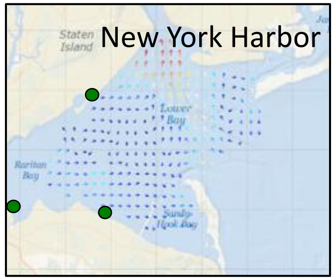


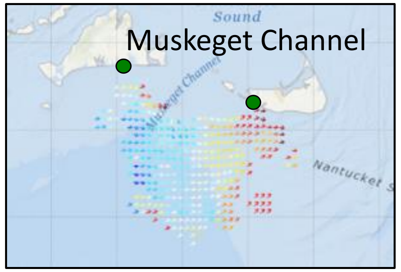
MARACOOS High Frequency Radar Network

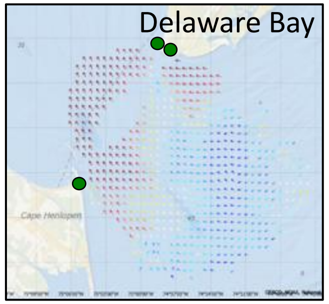


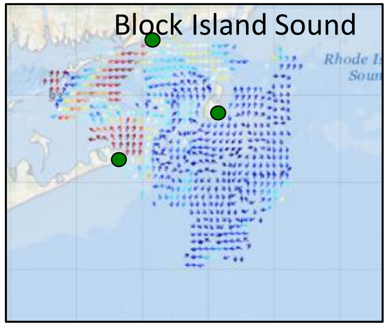


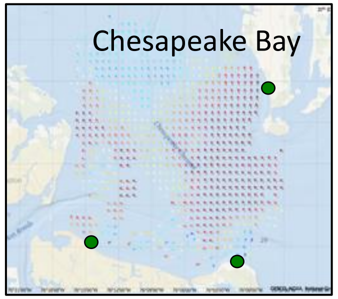




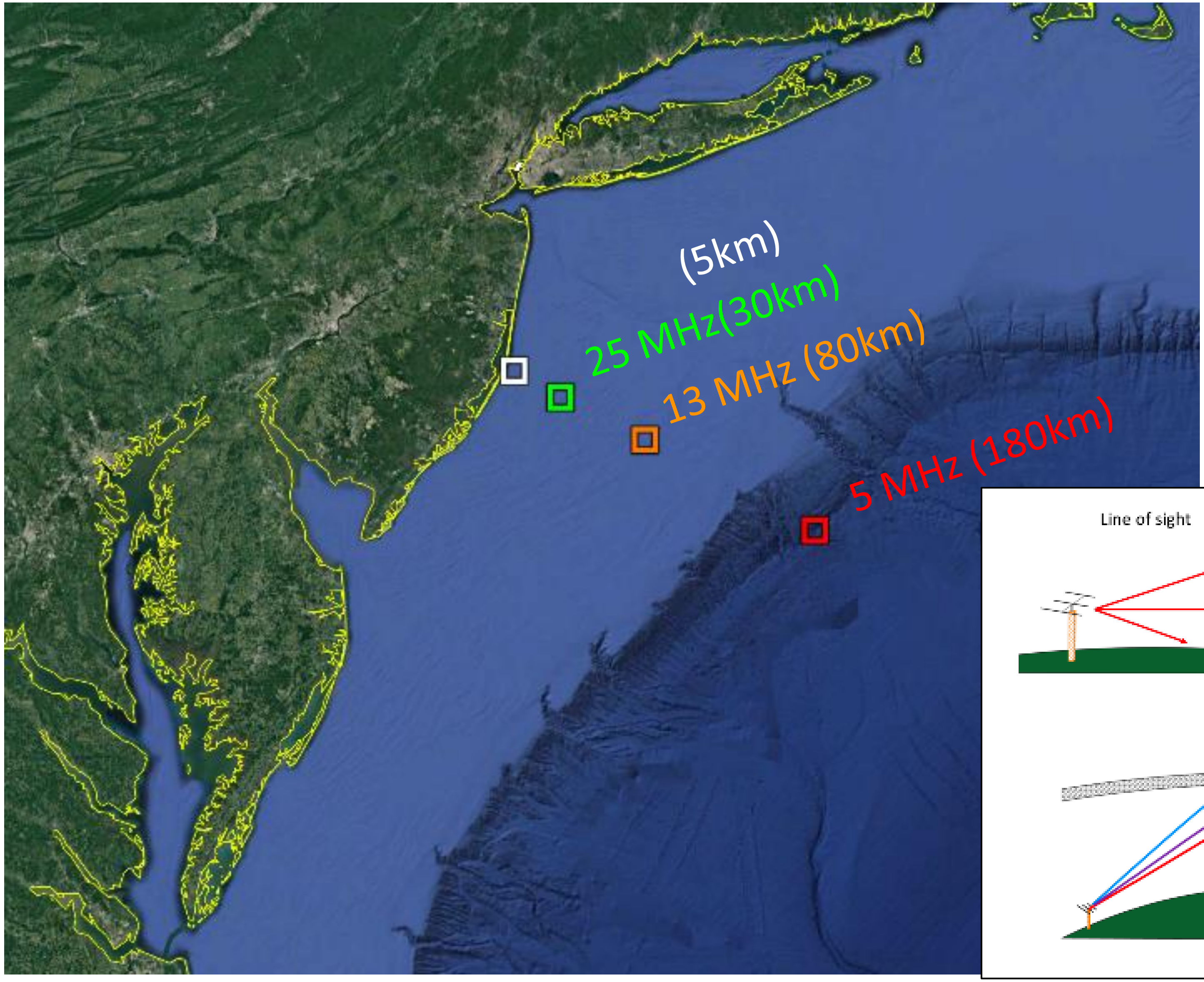


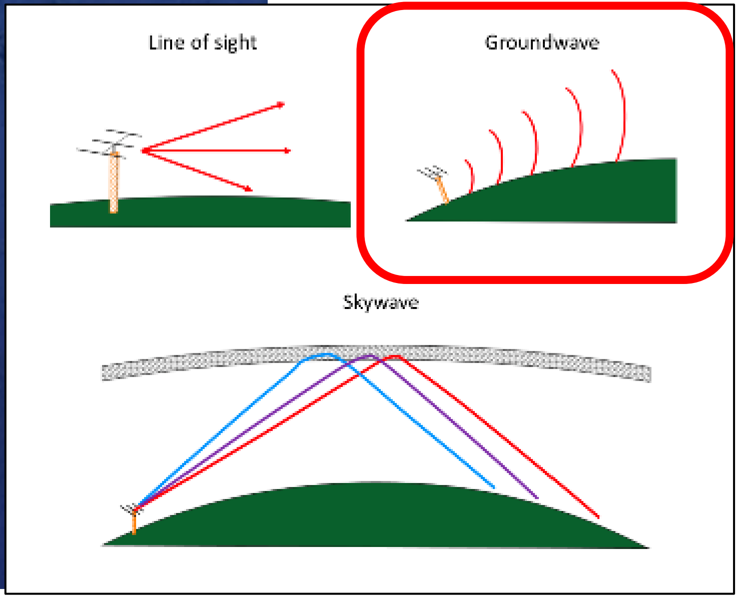




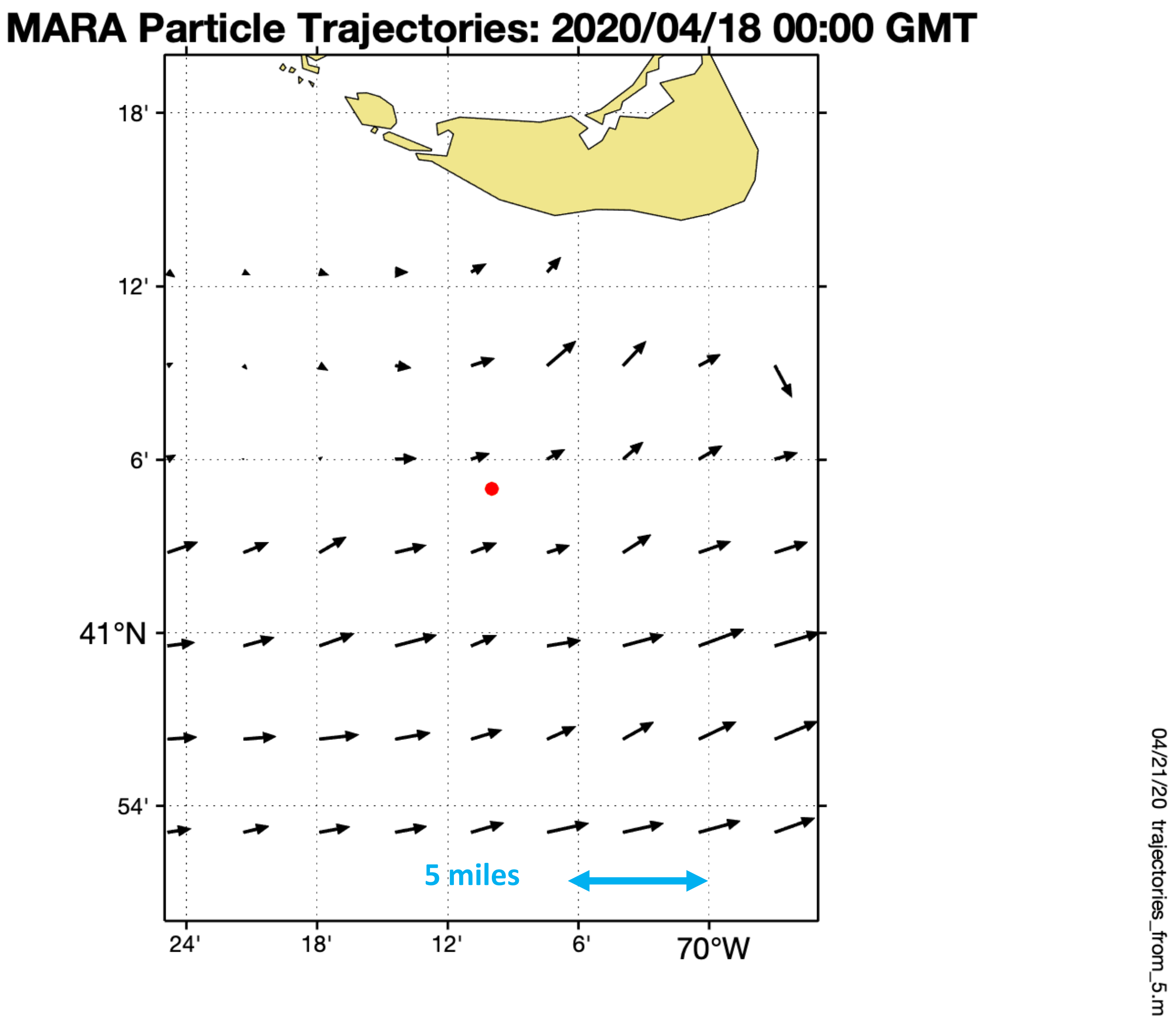


Benefit of High Frequency Radar





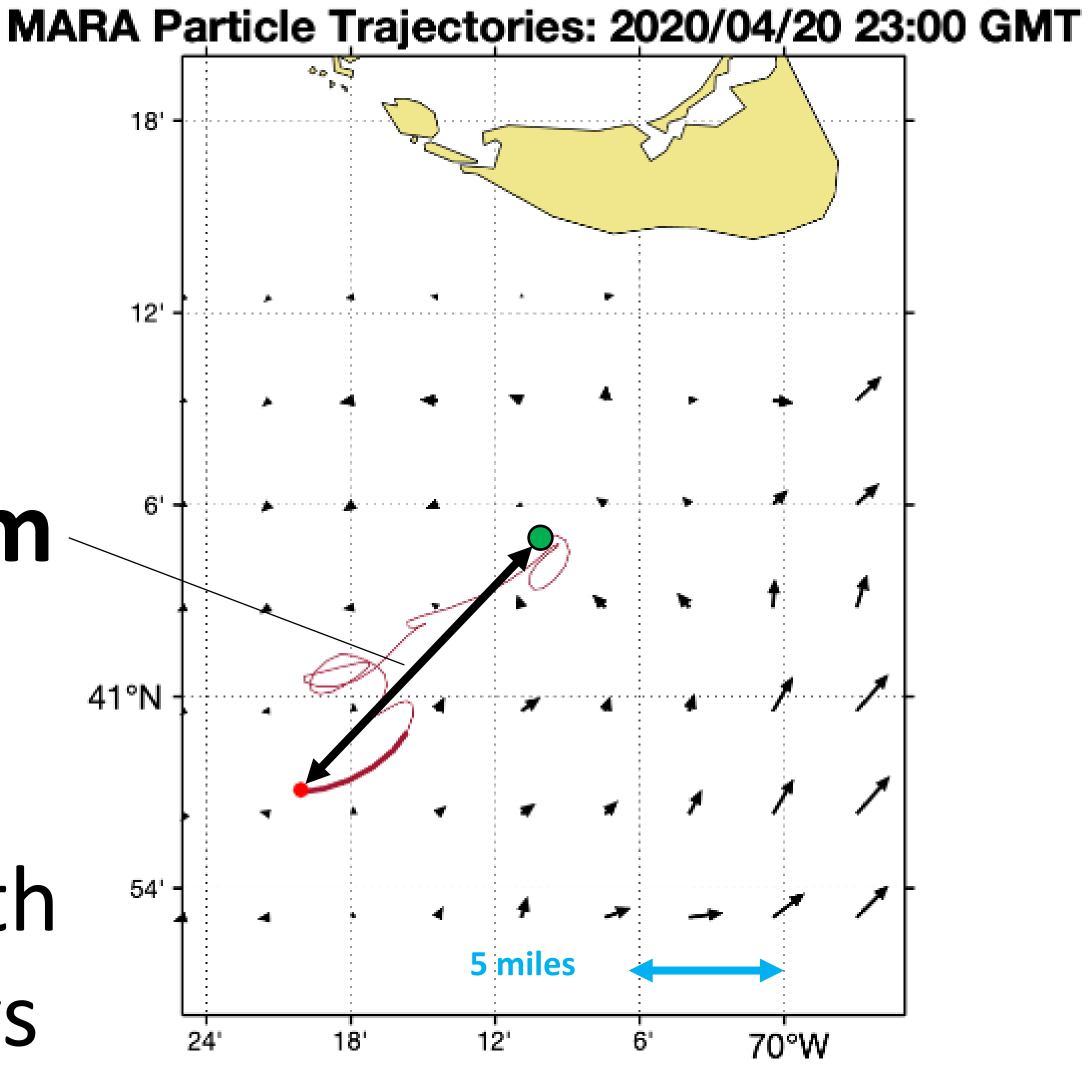
Surface Currents from HF Radar



Surface Currents from HF Radar

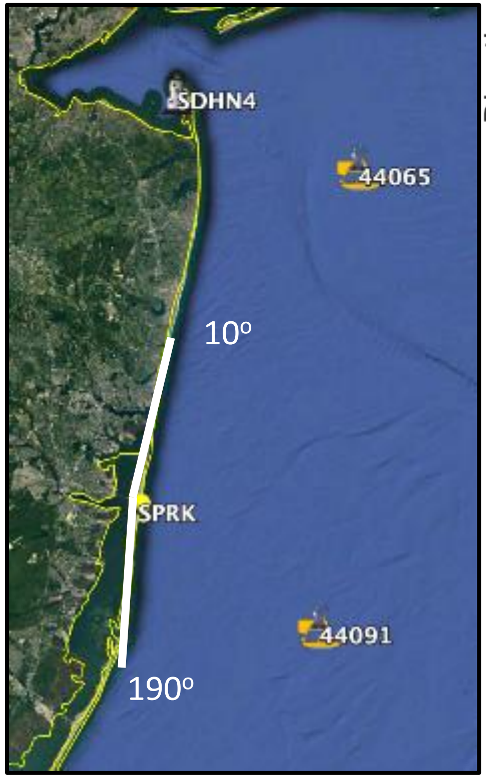
24 km

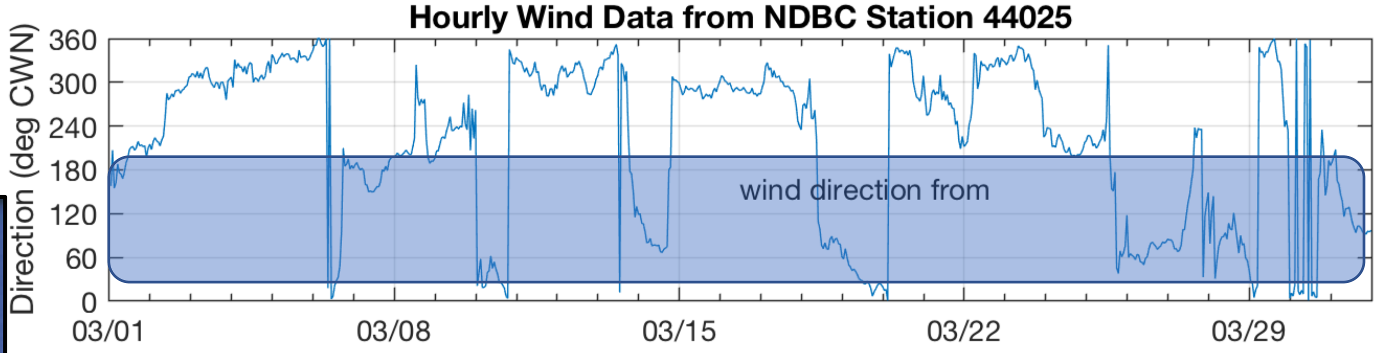
70 km
total path
in 3 days

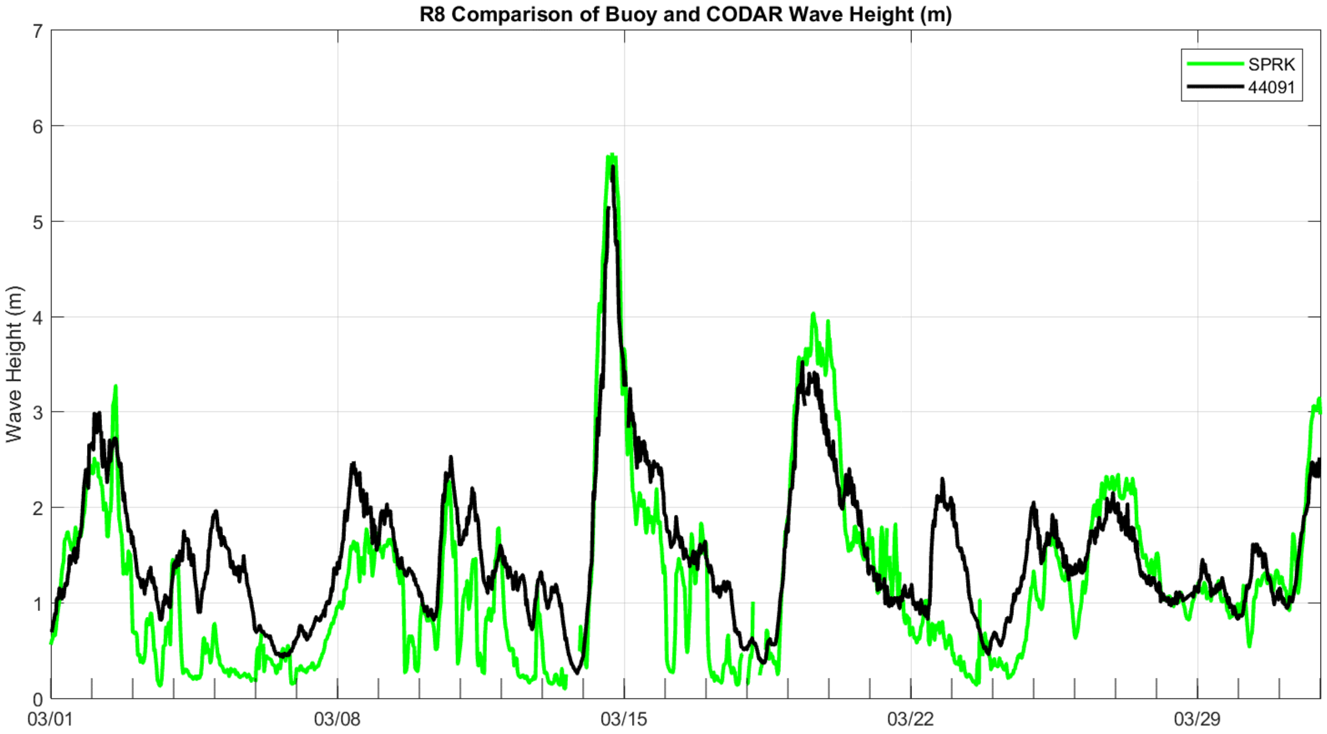


04/21/20 trajectories_from_5.m

Wave Measurements from HF Radar Stations

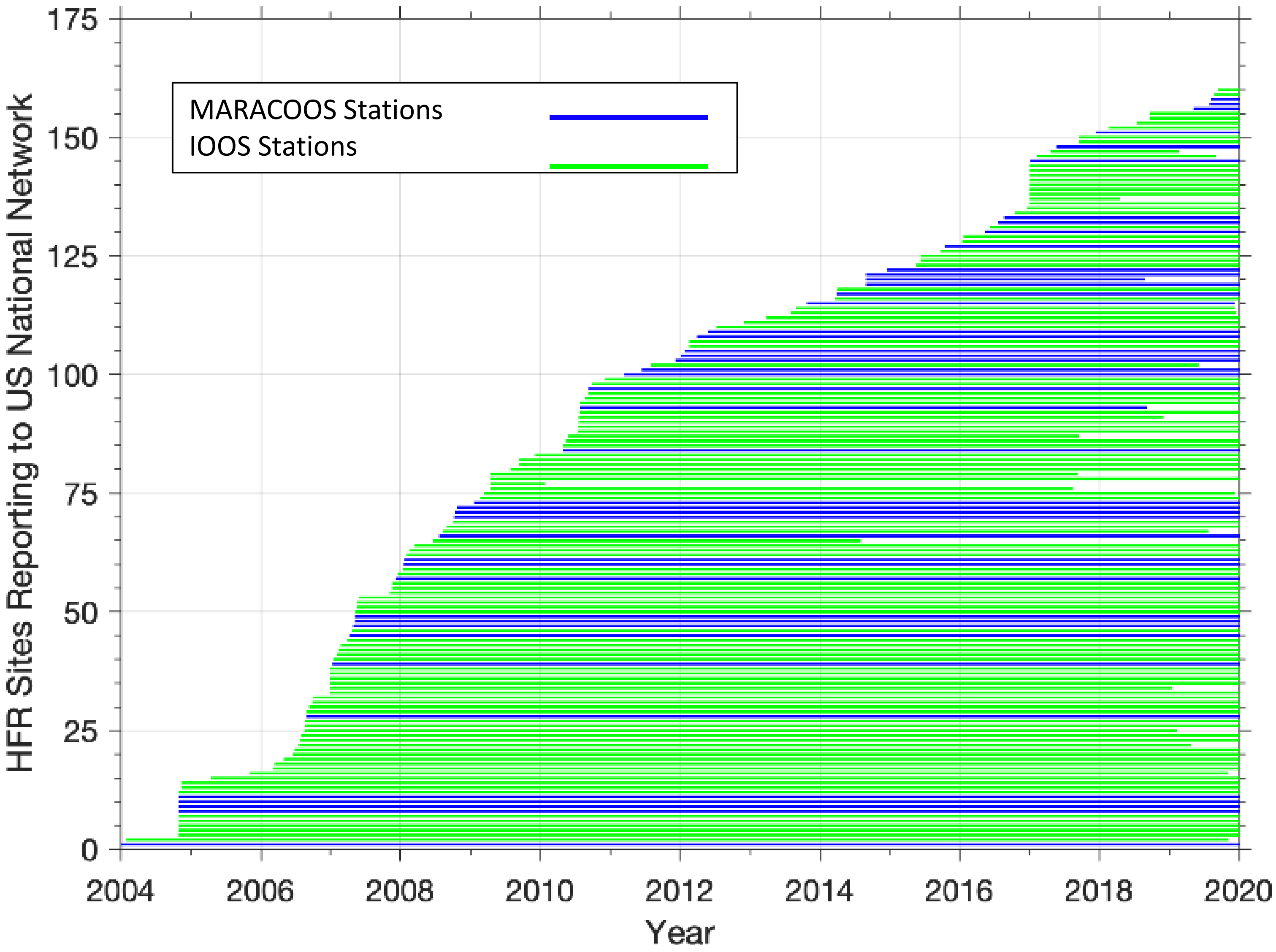






March 2017

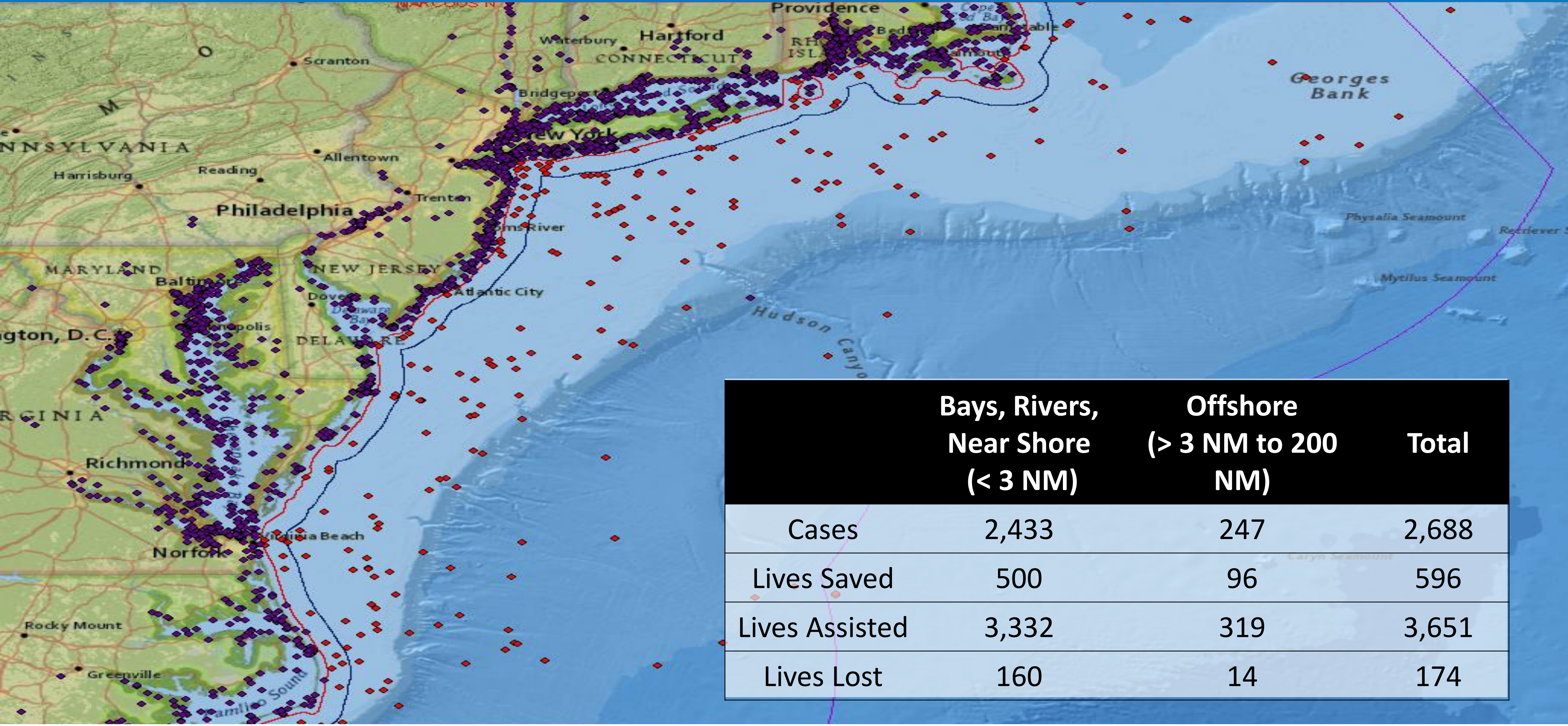
Growth of HF Radar in the US



Application:

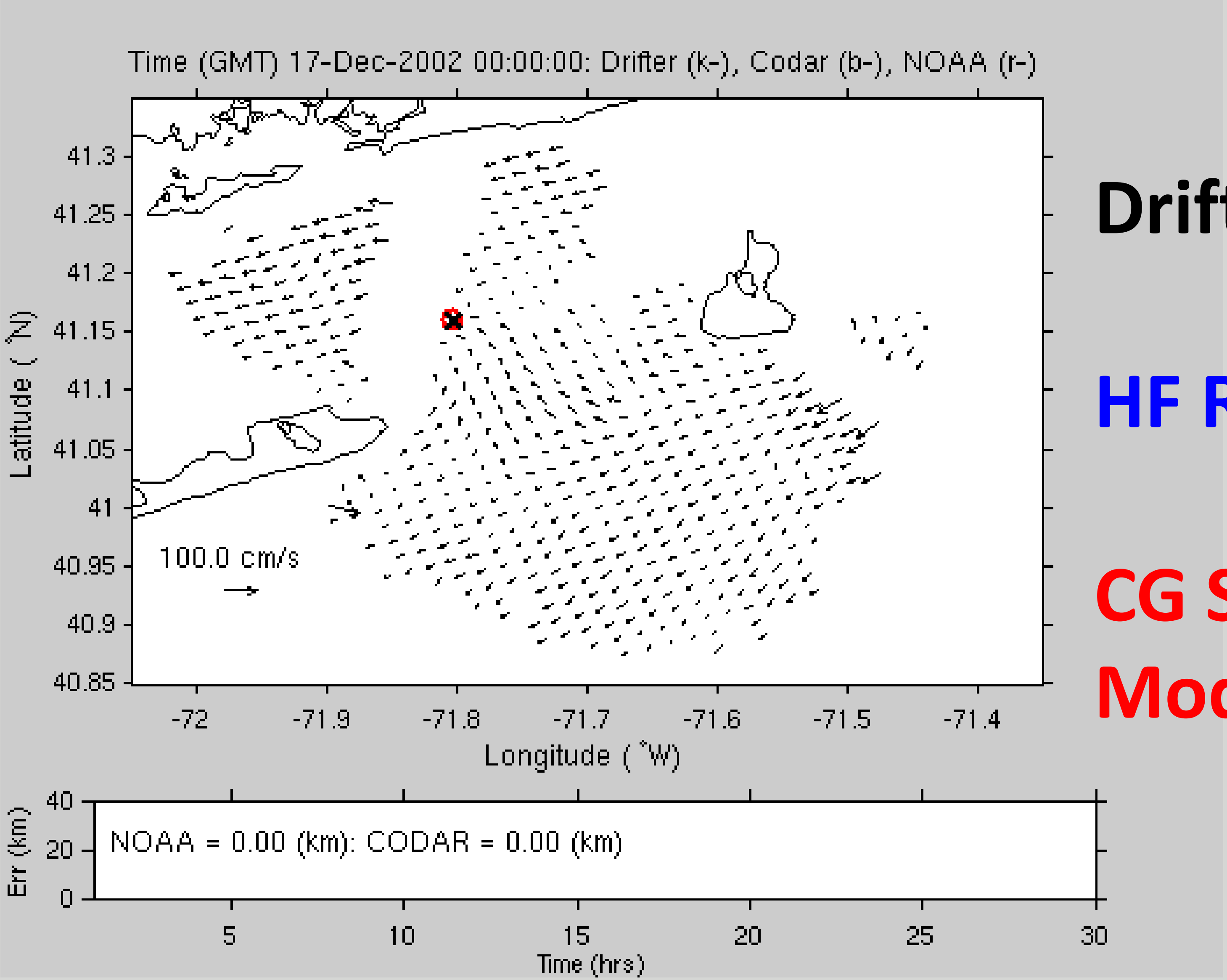
Coast Guard Search and Rescue

Search and Rescue Cases in the MARACOOS Region FY 2014

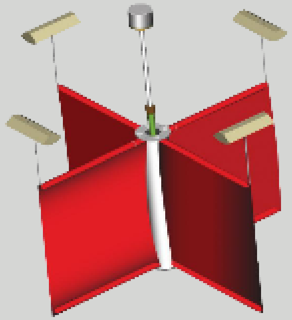


	Bays, Rivers, Near Shore (< 3 NM)	Offshore (> 3 NM to 200 NM)	Total
Cases	2,433	247	2,688
Lives Saved	500	96	596
Lives Assisted	3,332	319	3,651
Lives Lost	160	14	174

First Use of HF Radar for SAR - 2003



Drifter

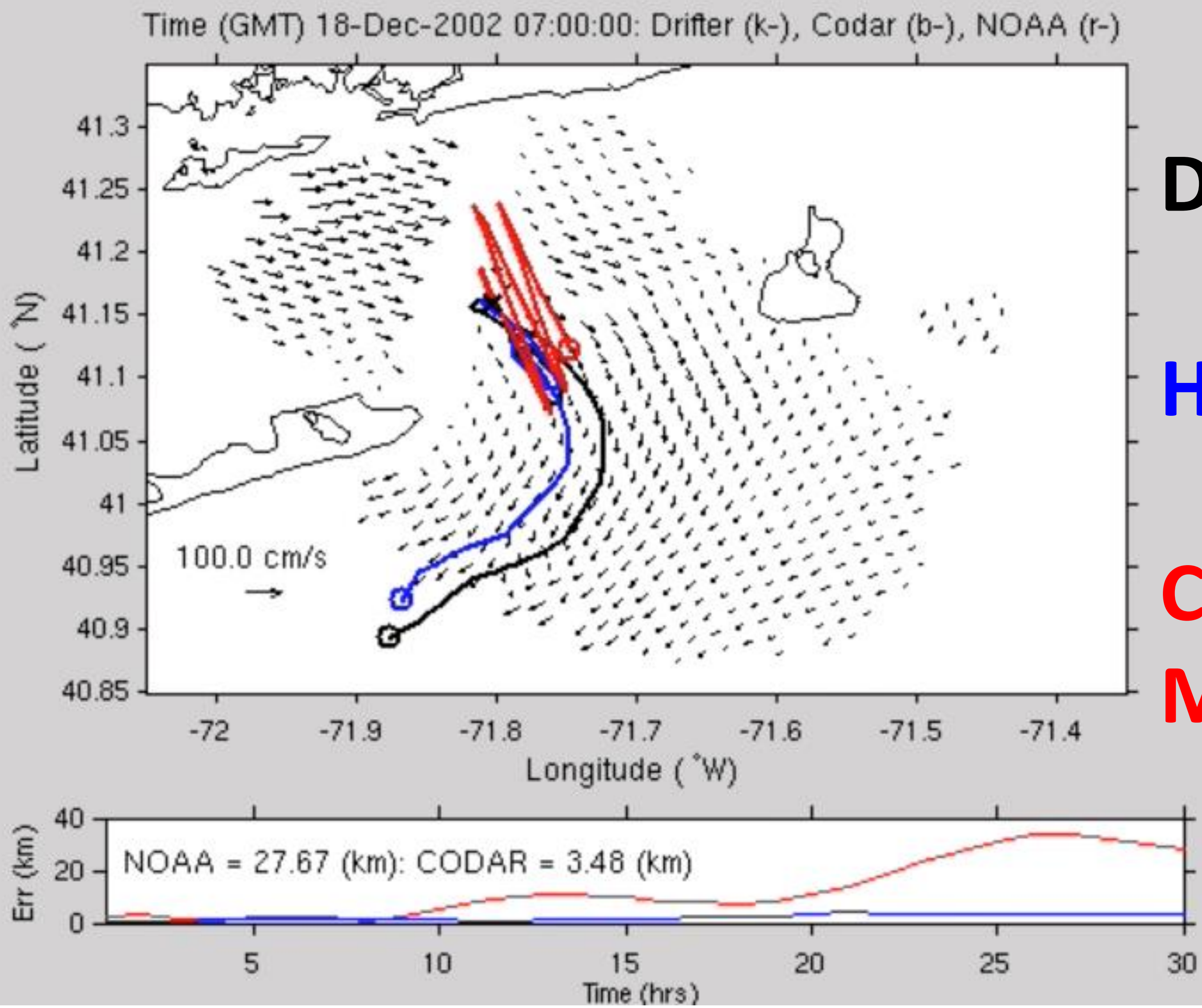


HF Radar

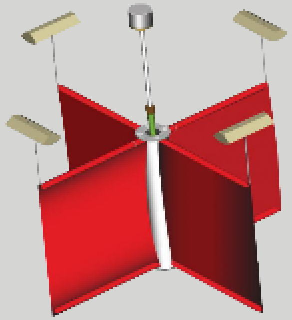
CG SAR Model 2003

25 MHz

First Use of HF Radar for SAR - 2003



Drifter



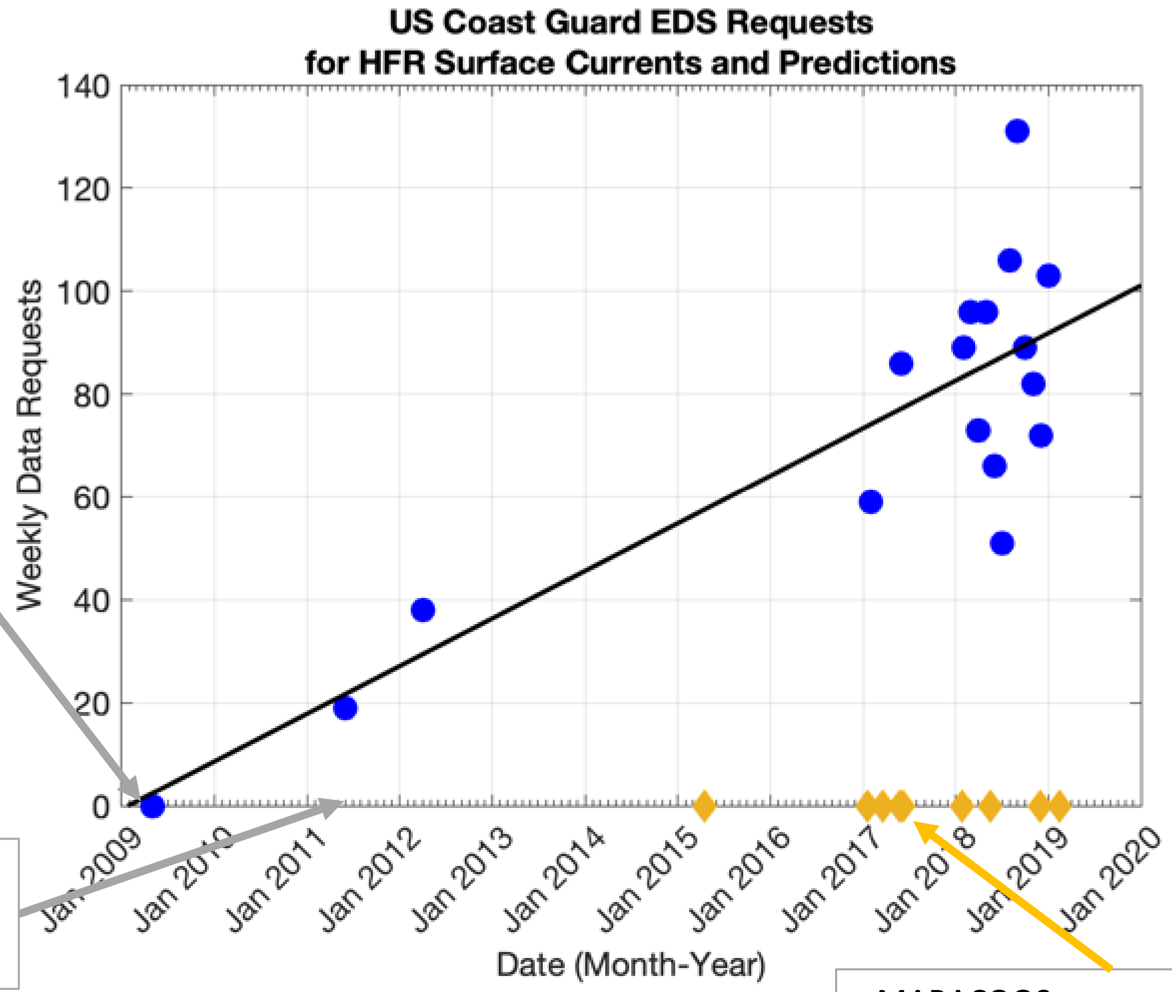
HF Radar

CG SAR Model 2003

25 MHz

National Use of HFR Data and Predictions

MARACOOS surface currents operational with USCG May 4, 2009

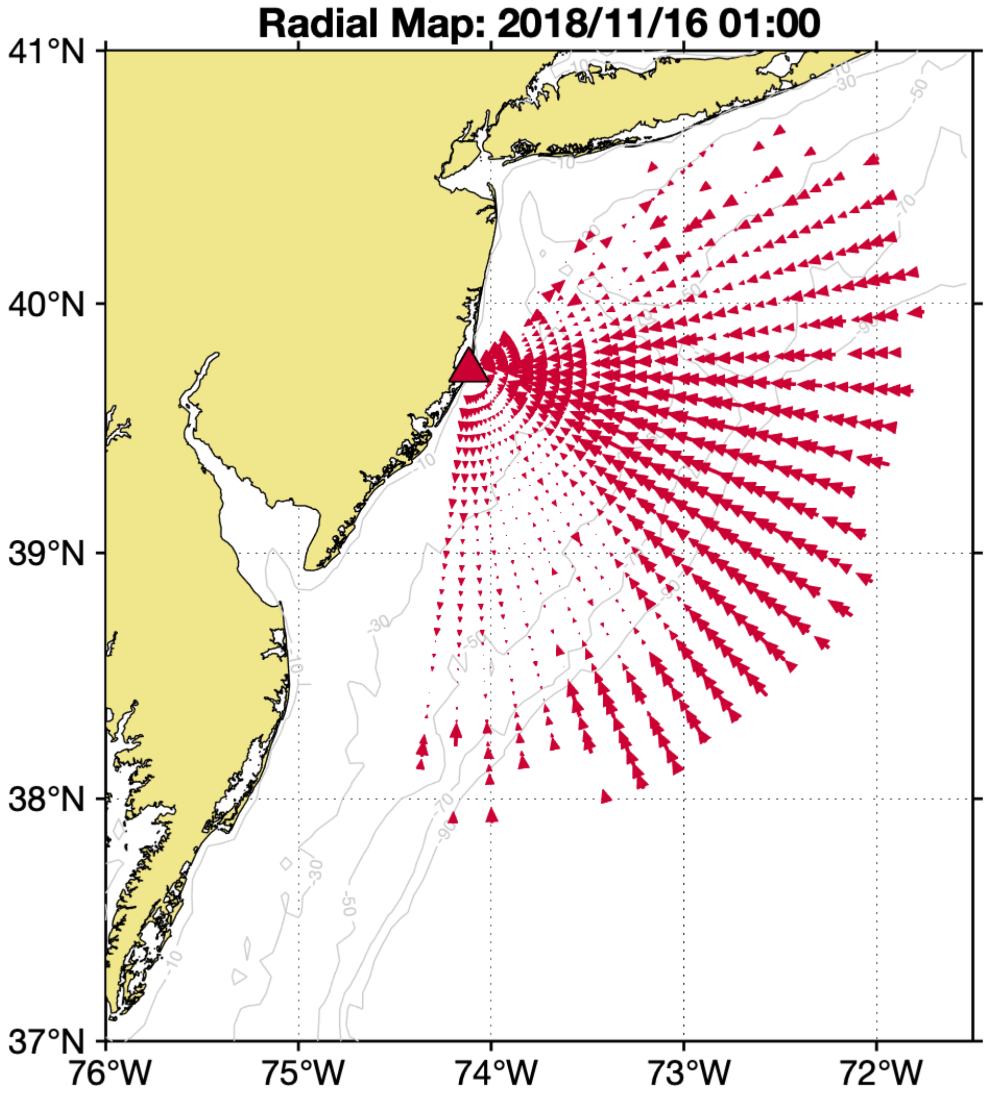


US IOOS surface currents operational with USCG March 2011

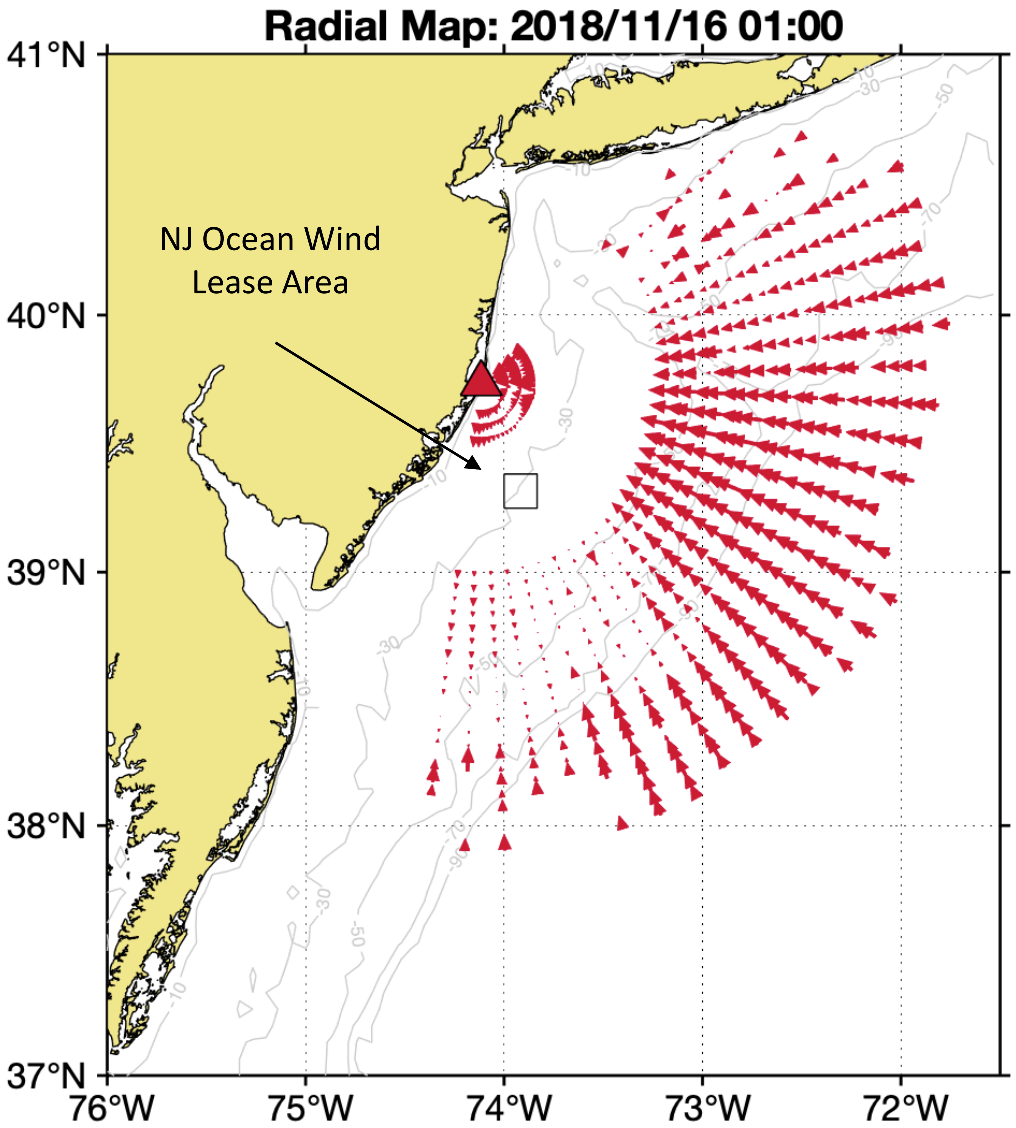
MARACOOS engagement events with USCG

Interference and Mitigation

Normal Radial Surface Current Vector Map

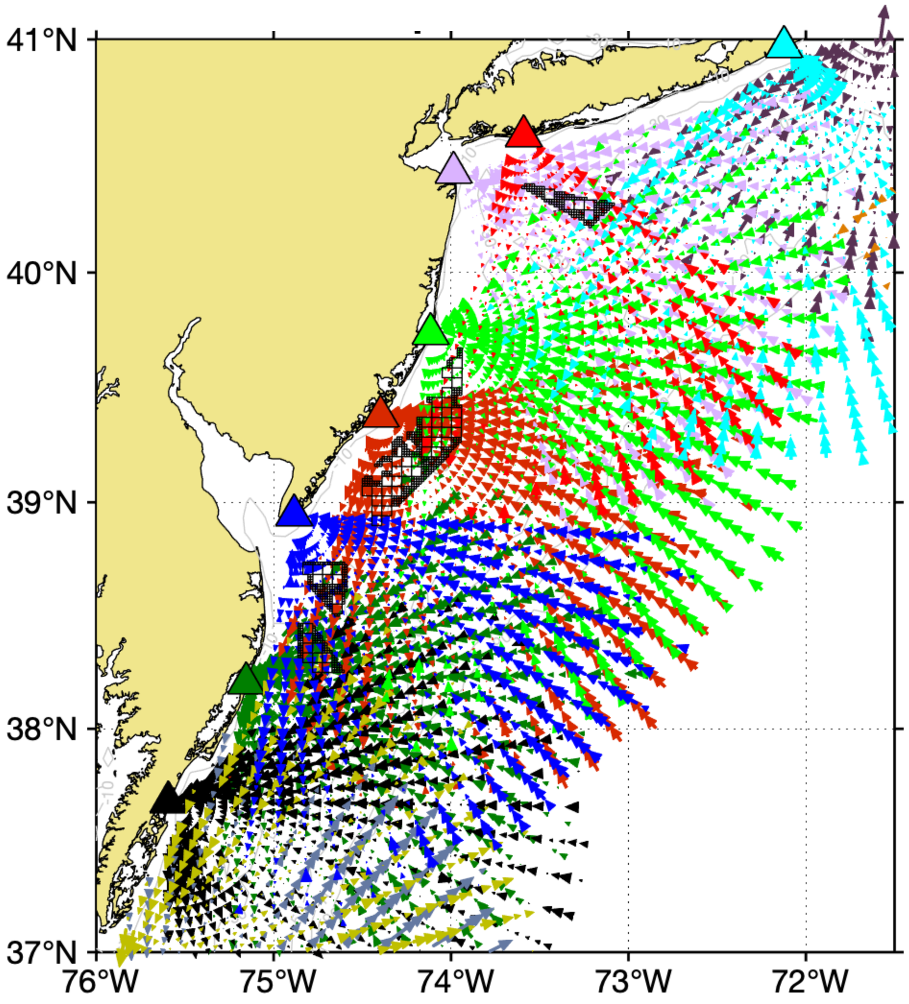


Loss of 9 Range Cells in Vicinity of Wind Farm

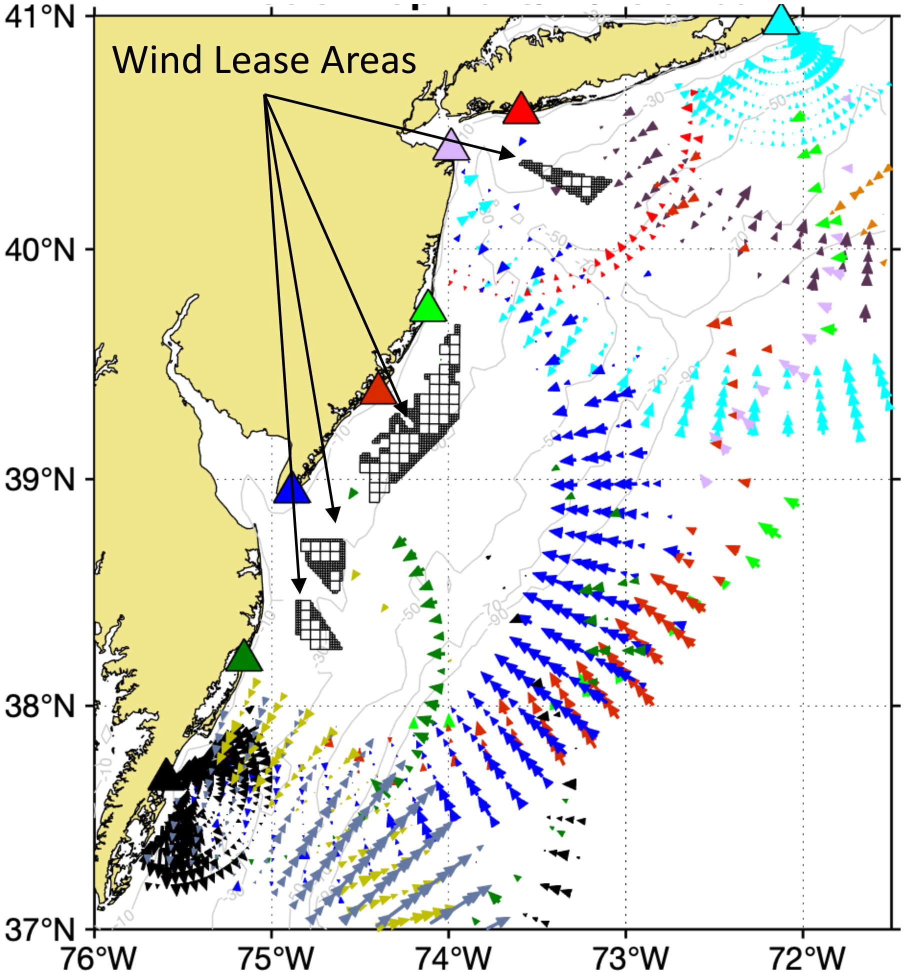


Interference from Multiple Wind Farms

No Interference

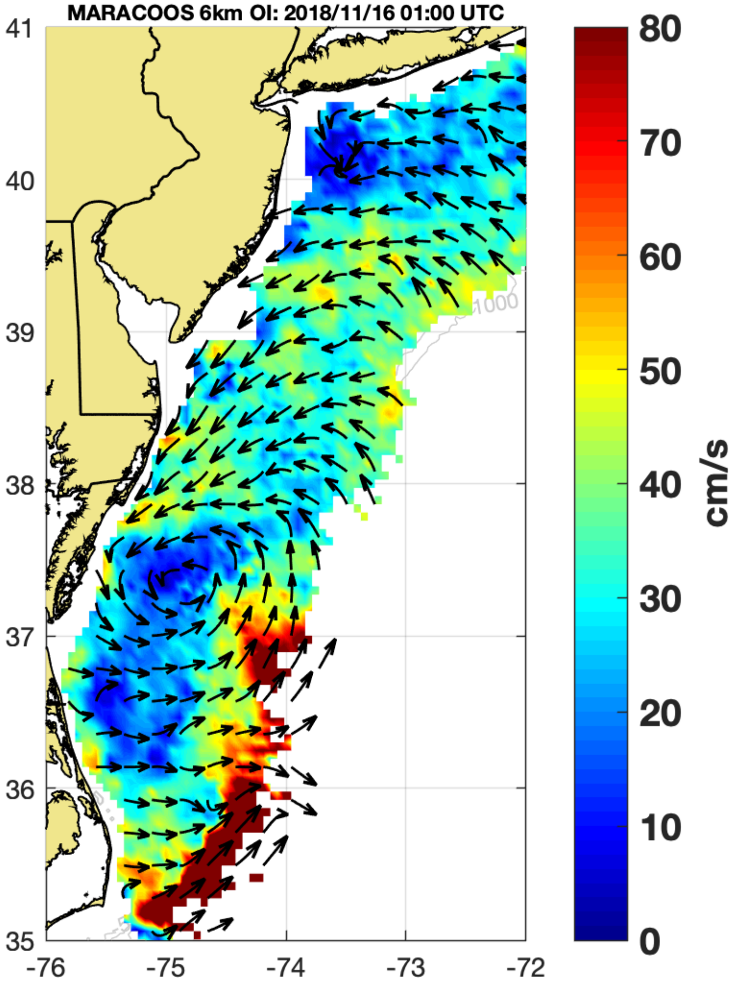


With Interference

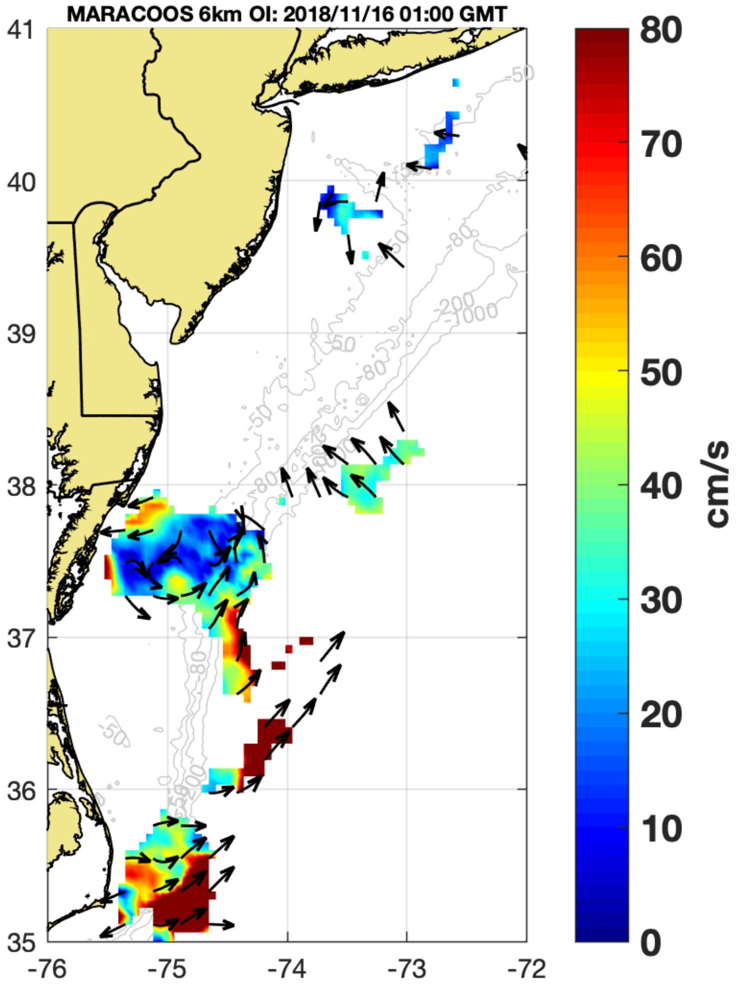


Corresponding Total Vector Map

Total Map **With No** Interference



Total Map **With** Interference



Both maps filtered by 0.6 normalized uncertainty

Introduction to High Frequency Radar in the Mid Atlantic

THANK YOU

Wind Turbine Radar Interference Mitigation Working Group
July 27, 2020
Technical Interchange Meeting

CODAR's WTI Mitigation Efforts for Oceanographic HF Radar

Authors: Dale Trockel, Chad Whelan

Acknowledgements

- Initial Mitigation efforts: Contracts M16PC00017, 140M0120C0002

BOEM
Bureau of Ocean Energy Management

- Data and Site Maintenance

MARACOOS
Ocean Information for a Changing World

- Funding For Radar Operations

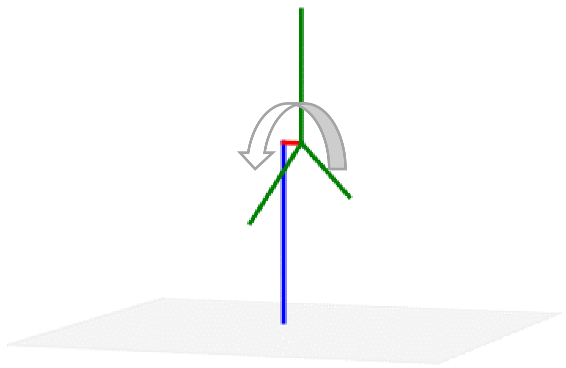
IOOS
Integrated Ocean Observing System

Background

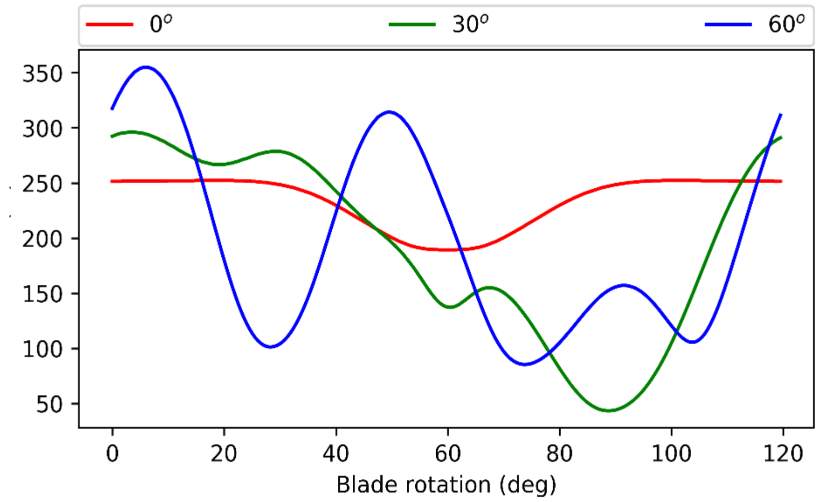
- Wyatt, L. R., A. M. Robinson, and M. J. Howarth. "Wind farm impacts on HF radar current and wave measurements in Liverpool Bay." *OCEANS.* IEEE-Spain, 2011. 1-3.
- Teague, Calvin c., and Donald E. Barrick. "Estimation of wind turbine radar signature at 13.5 MHz." *Oceans.* IEEE, 2012. 1-4.
- Ling, Hao, et al. “Final Report DE-EE0005380: Assessment of Offshore Wind Farm Effects on Sea Surface, Subsurface and Airborne Electronic Systems.” United States: N. p., 2013. Web. doi:10.2172/1096175.
- Trockel, D., et al. "Impact Assessment and Mitigation of Offshore Wind Turbines on High Frequency Coastal Oceanographic Radar." *Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM* 53 (2018): 49.
- Kirincich, Anthony R., Cahl, Douglas, Emery, Brian, Kosro, Mike, Roarty, Hugh, Trockel, Dale, Washburn, Libe, Whelan, Chad, "High Frequency Radar Wind Turbine Interference Community Working Group Report", 2019-06, DOI:10.1575/1912/25127, https://hdl.handle.net/1912/25127

Cause of WTI In Ocean HF Doppler Radars

A Wind Turbines Radar Cross Section (RCS) is Periodic

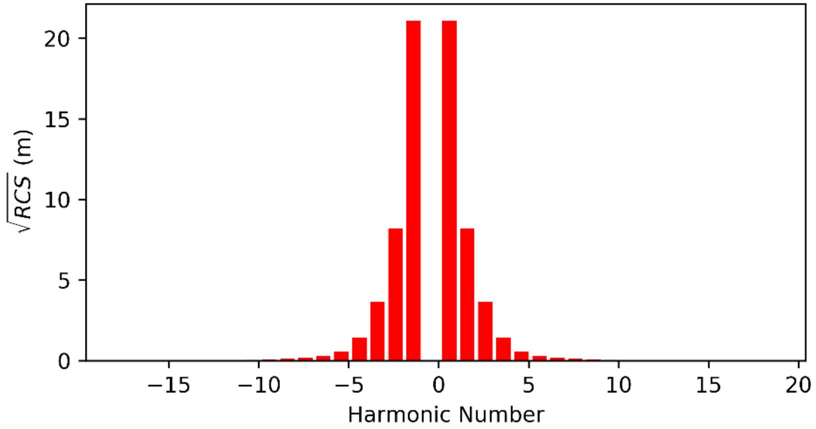


RCS As Turbine Rotates 120˚ (5 MHz)



The amplitude modulation caused by the periodic RCS introduces interference at its harmonic components.

Harmonic Decomposition of RCS



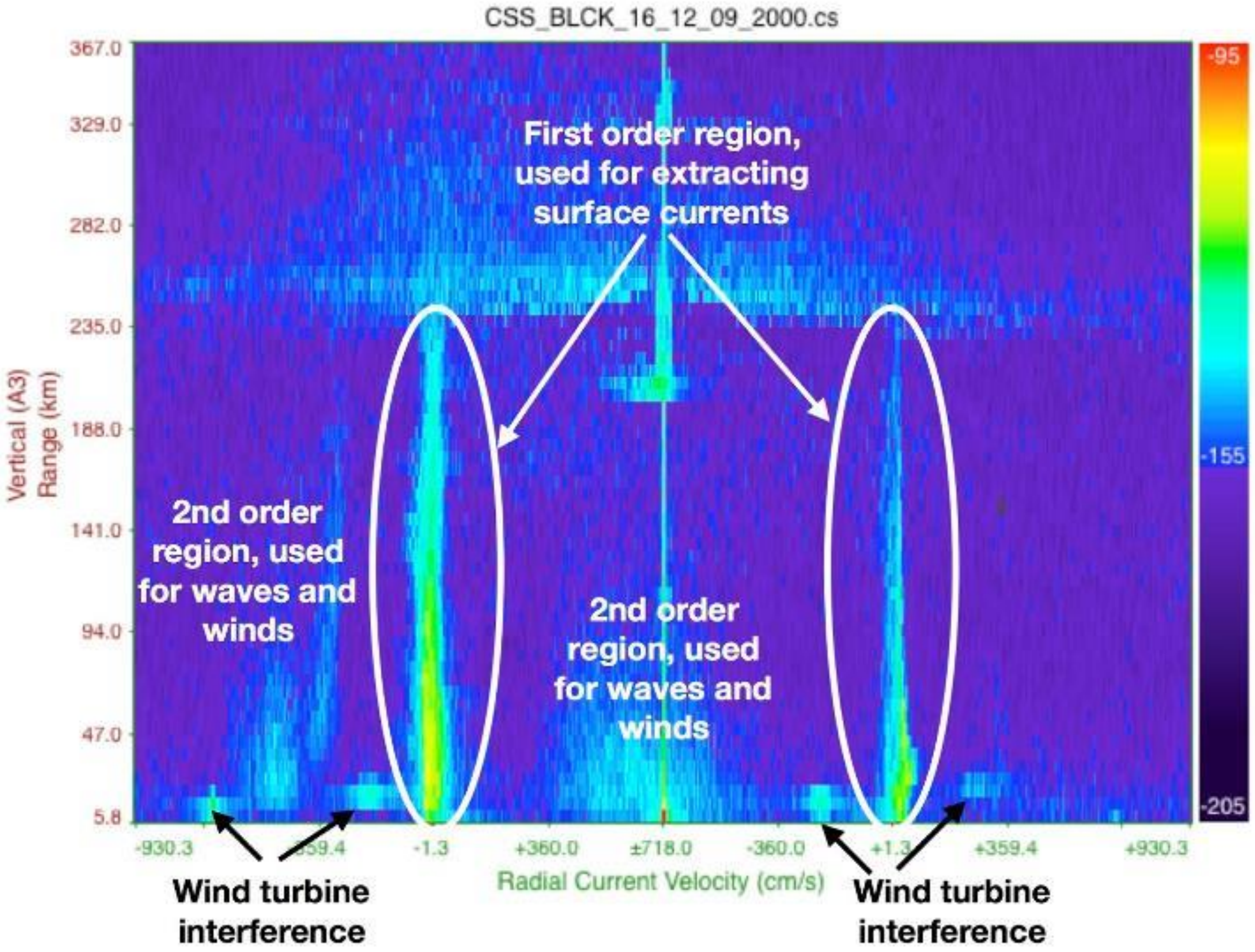
Range-Doppler location of Turbine Interference is well defined

$$R_m = R_t + \frac{c}{2B}\left(\frac{\frac{3m(r)}{60} + \frac{1}{2T}}{\frac{1}{T}}\right)$$

$$f_d = \left[\left(\frac{3m(r)}{60} + \frac{1}{2T}\right) \bmod \frac{1}{T}\right] - \frac{1}{2T}$$

m := harmonic number
r := rotation rate (rpm)
R_m := range bin with interference
R_t := range of the turbine
f_d := interference doppler cell
B := bandwidth
T := sweep rate

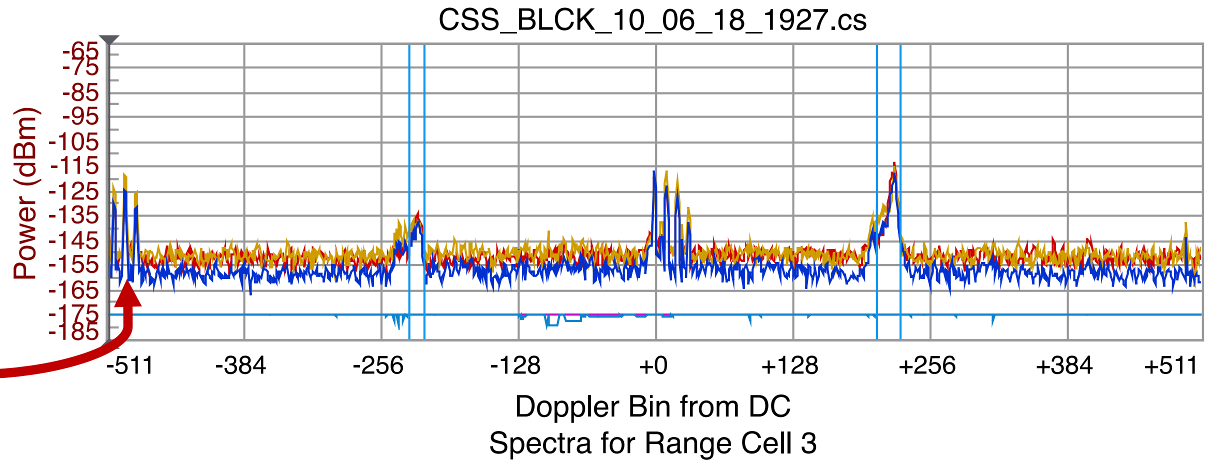
Turbine interference in Cross Spectra at 4.538 MHz

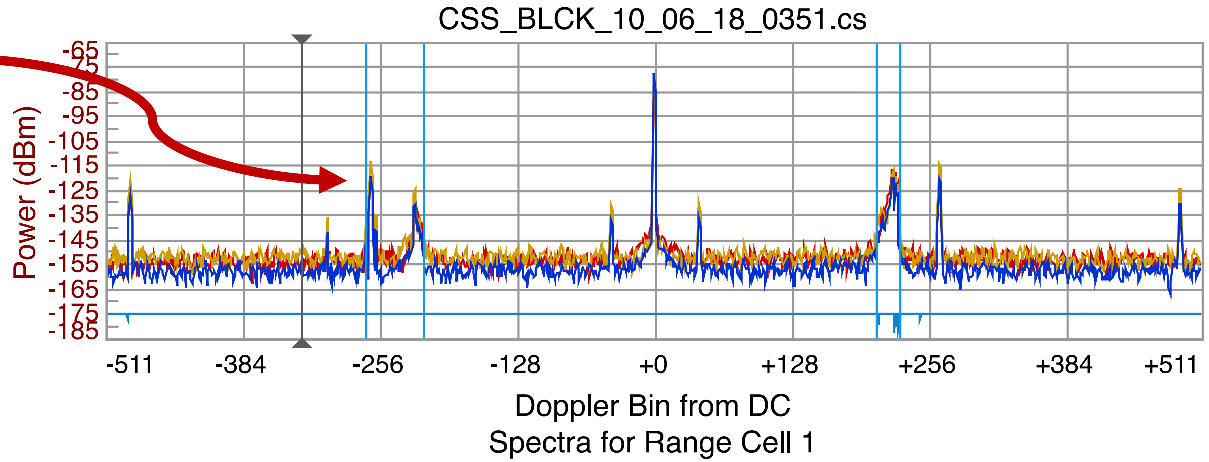


Impact of WTI on Doppler Processing

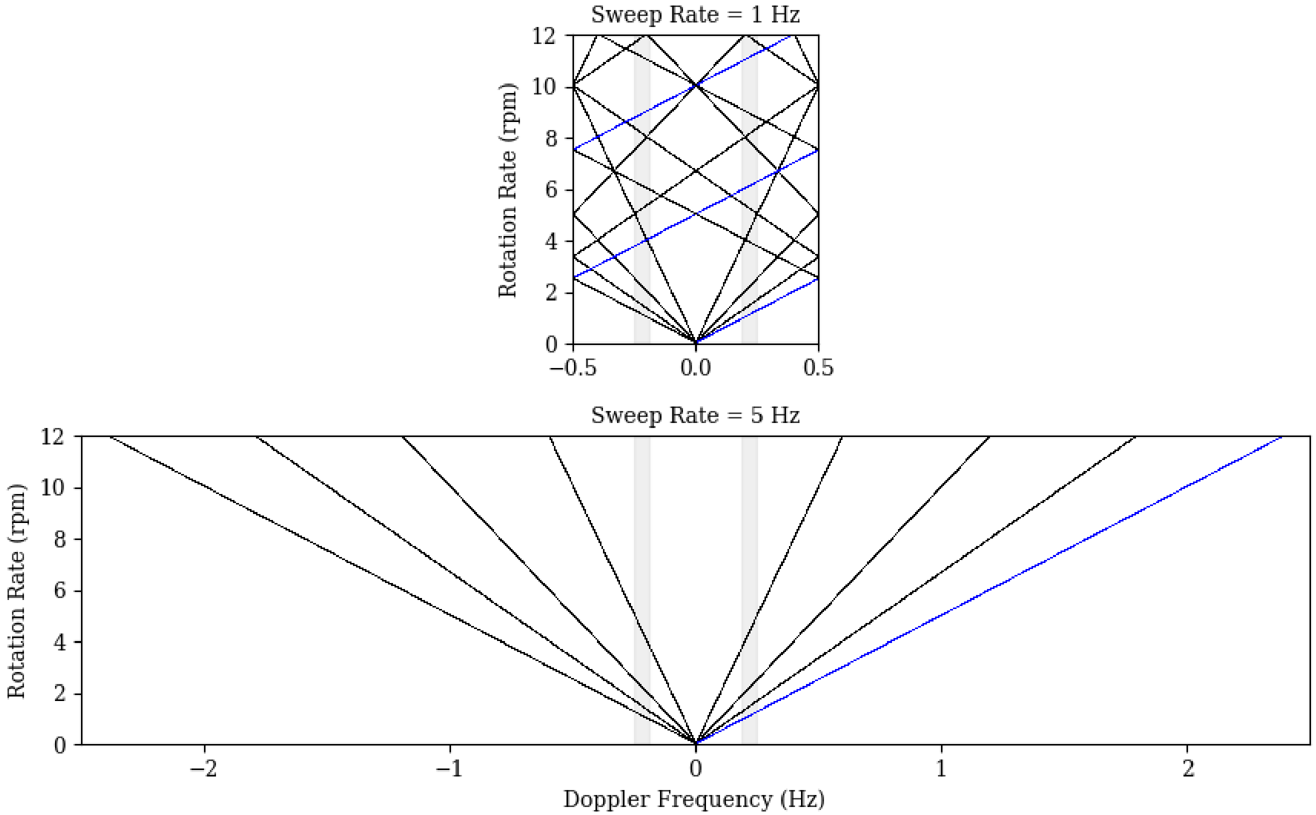
1. **Interference in the Bragg**
   Change the bearing determination or radial current measurements.

2. First order lines (FOL) shift
   1. **Bragg region shrinks**
      Interference near the edge of the spectra
   2. **Bragg region grows**
      Interference near the FOL





Mitigation: Higher sweep rates “unwrap” aliases



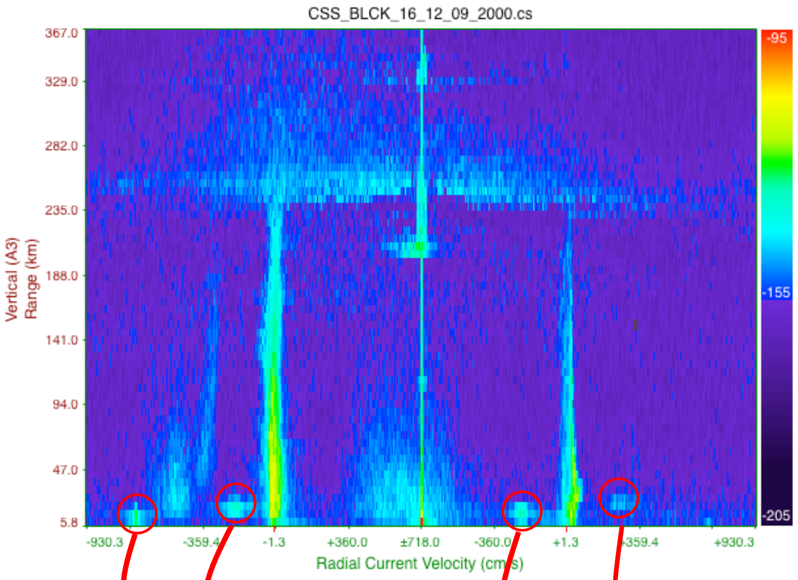
<u>Standard sweep rate</u>

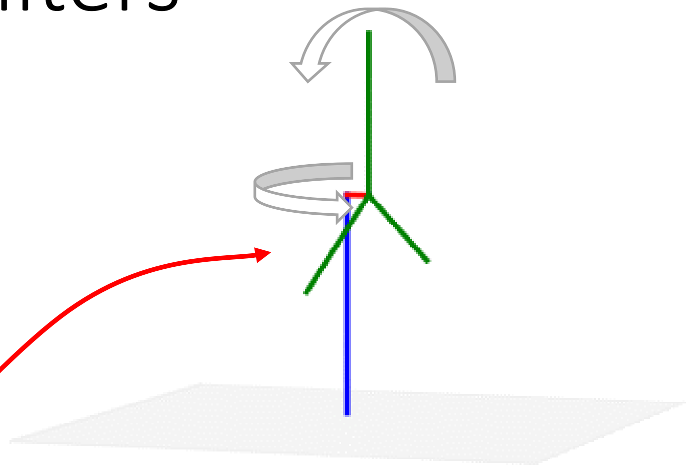
harmonics aliased back over sea echo

<u>Higher sweep rates</u>

harmonics spread to higher Doppler frequencies than sea echo

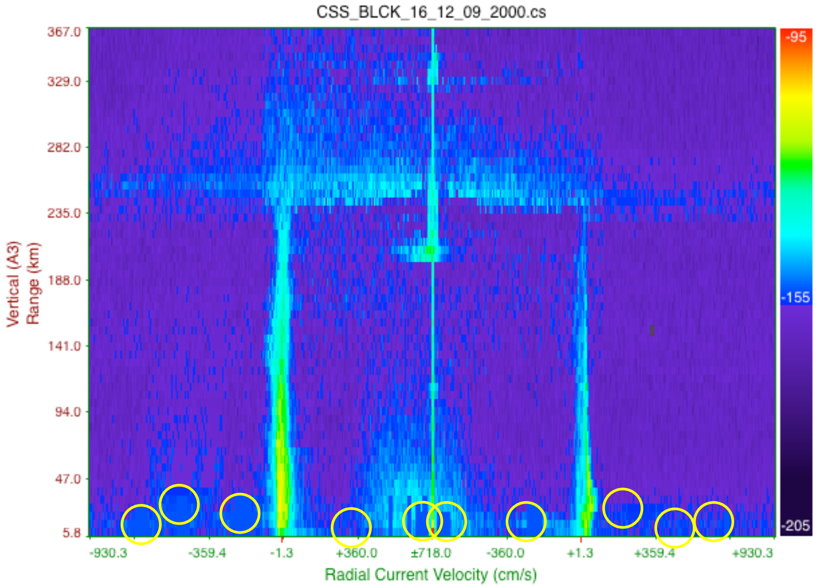
Mitigation: Filters





Estimate rotation rates and nacelle angles from turbine harmonics

Filter Impacted Range Doppler bins from observed & modelled turbine peaks

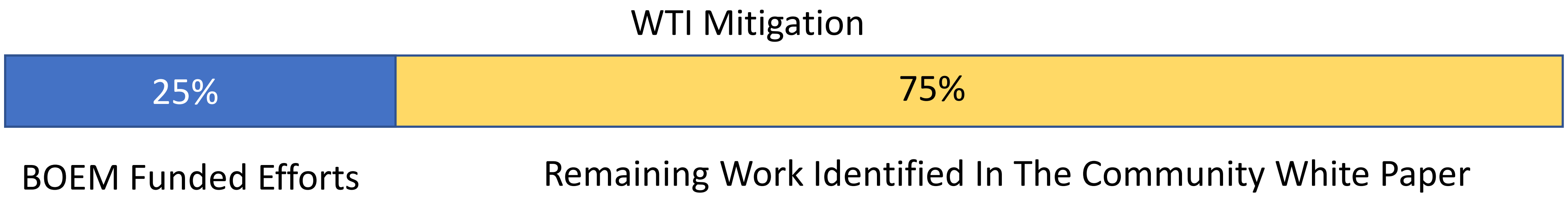


Status of WTI Mitigation Efforts

Status	Simulations	Mitigation
Complete	Simulate small wind farm WTI	Design of basic mitigation methods
Under Development	Simulations for large complex wind farms	Development of real time of mitigation software
Needed	Additional calibration and validation efforts	Testing, calibration, and expansion of WTI mitigation methods

Key Points

- Wind turbines interfere differently with coastal HF radars than with other radars.
- CODAR characterized WTI in coastal HF radars and identified methods of mitigation.
- BOEM has funded the initial WTI characterization and mitigation efforts.



WTI Mitigation Efforts: Assessing the Effectiveness, and Impacts to Observations

Anthony Kirincich, Woods Hole Oceanographic Institution

Brian Emery, University of California at Santa Barbara

High Frequency Radar Wind Turbine Interference Community Working Group Report

June, 2019

A-Executive Summary

Land-based High Frequency (HF) Radars provide critically important observations of the coastal ocean that will be adversely affected by the spinning blades of utility-scale wind turbines. Pathways to mitigate the interference of turbines on HF radar observations exist for small number of turbines; however, a greatly increased pace of research is required to understand how to minimize the complex interference patterns that will be caused by the large arrays of turbines planned for the U.S. outer continental shelf. To support the U.S.'s operational and scientific needs, *HF radars must be able to collect high-quality measurements of the ocean's surface in and around areas with significant numbers of wind turbines*. This is a solvable problem, but given the rapid pace of wind energy development, immediate action is needed to ensure that HF radar wind turbine interference mitigation efforts keep pace with the planned build out of turbines.

A comprehensive mitigation strategy, with specific research objectives, is required to ensure that HF radars will be able to provide continuous observations in service of our national environmental intelligence needs:

DOI:10.1575/1912/25127

High Frequency Radar Wind Turbine Interference Community Working Group Report

June, 2019

Key Findings:

- To support the U.S.'s operational and scientific needs, HF radars must be able to collect high-quality measurements of the ocean's surface in and around areas with significant numbers of wind turbines

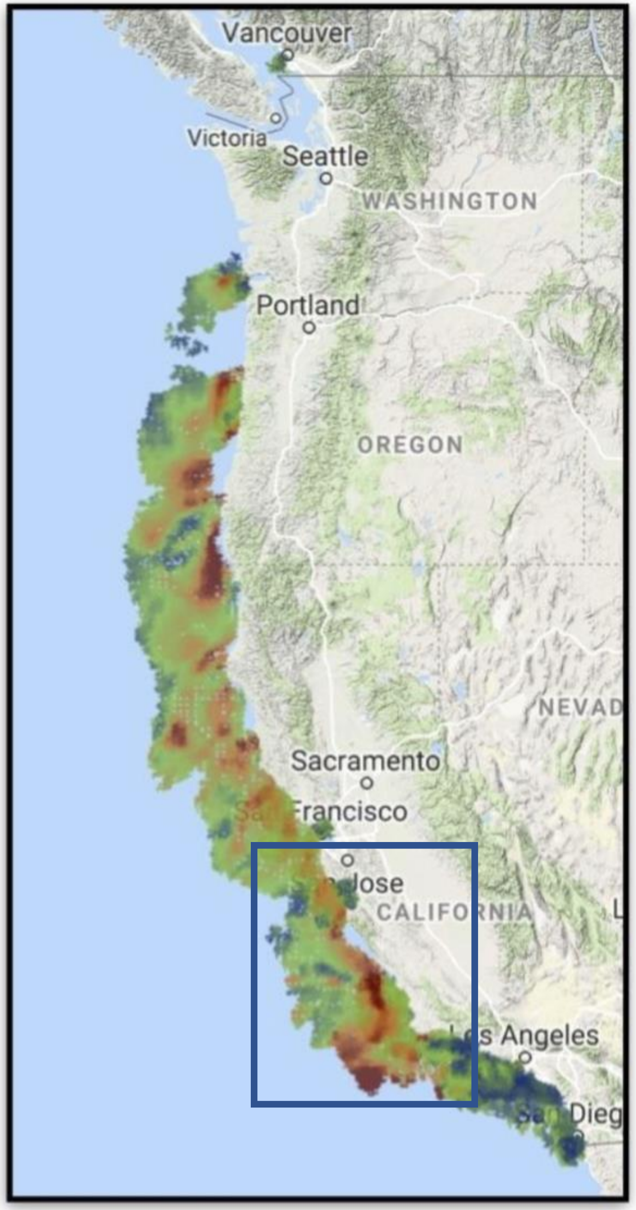
- Immediate action is needed to ensure that mitigation efforts keep pace with the planned build out of turbines

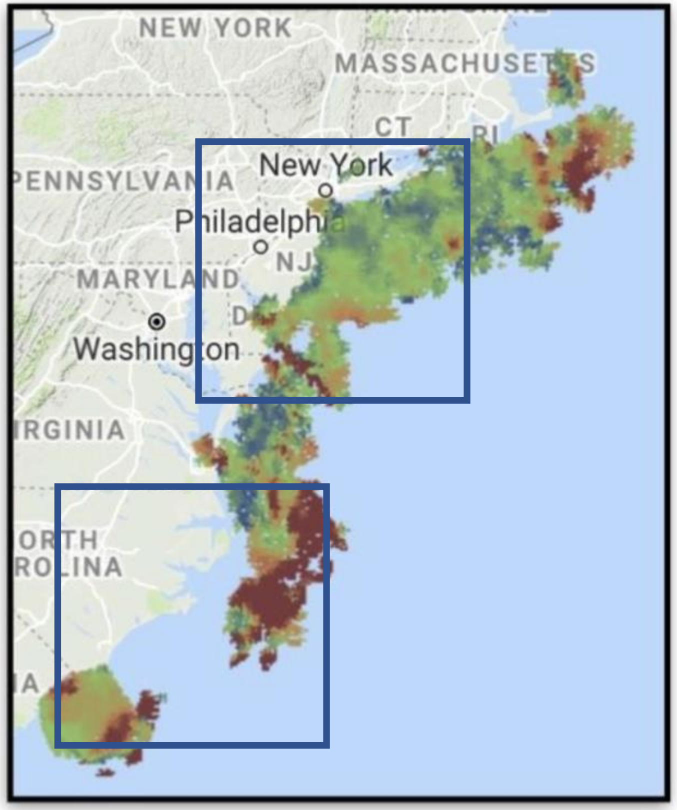
DOI:10.1575/1912/25127

High Frequency Radar Wind Turbine Interference Community Working Group Report:

National coverage via operators coordinated by NOAA IOOS.

Sponsored by: NOAA, NSF, States, Universities, etc.

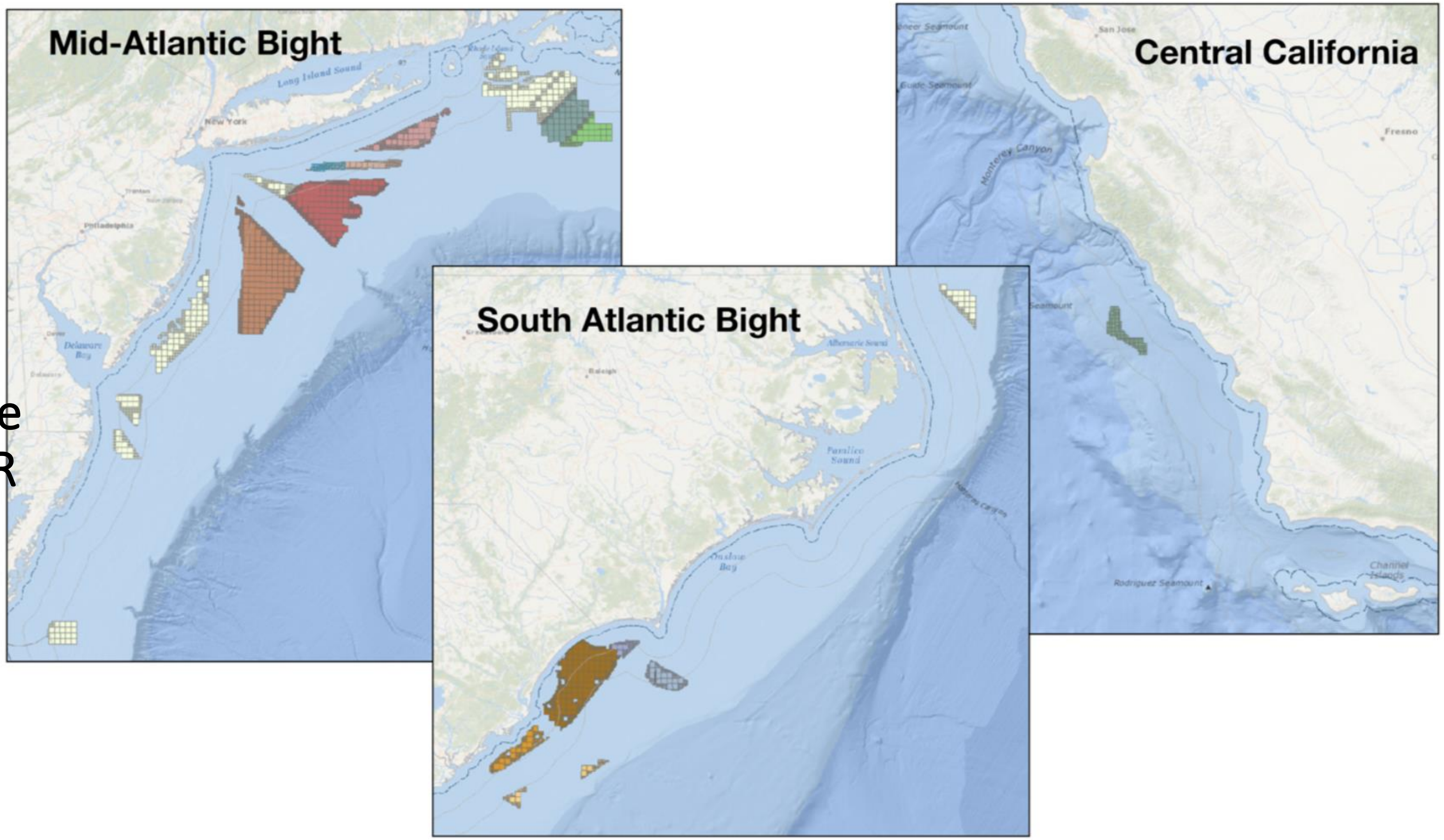




Snapshot of real-time surface current coverage for U.S.-based long range HFRs

High Frequency Radar Wind Turbine Interference Community Working Group Report:

Wind energy areas will have significant overlap with HFR surface current coverage.

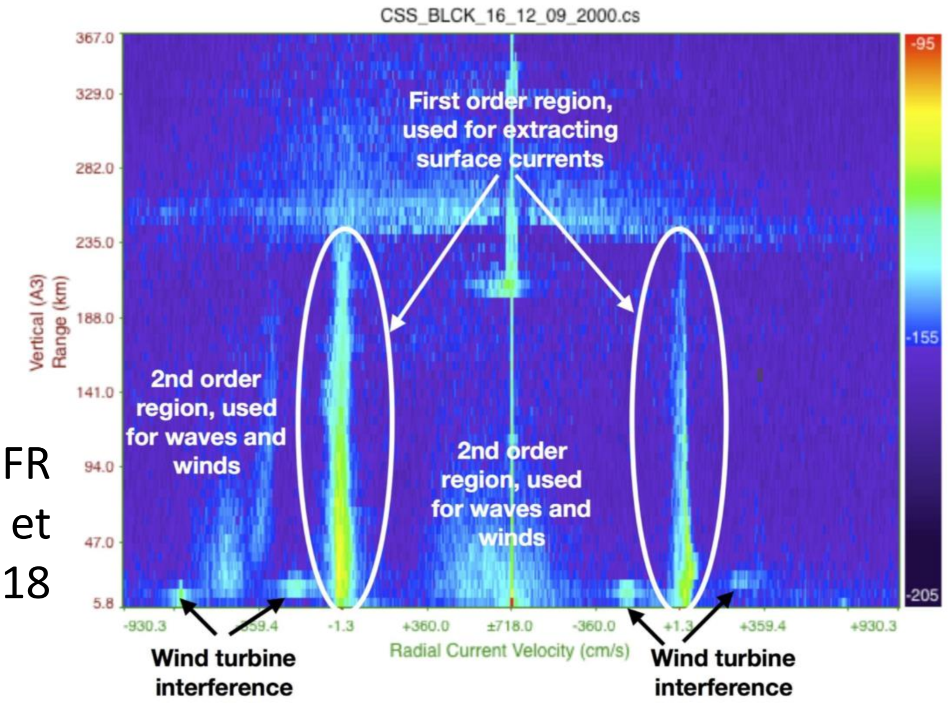


Federal offshore wind energy lease/planning areas (from https://www.marinecadastre.gov)

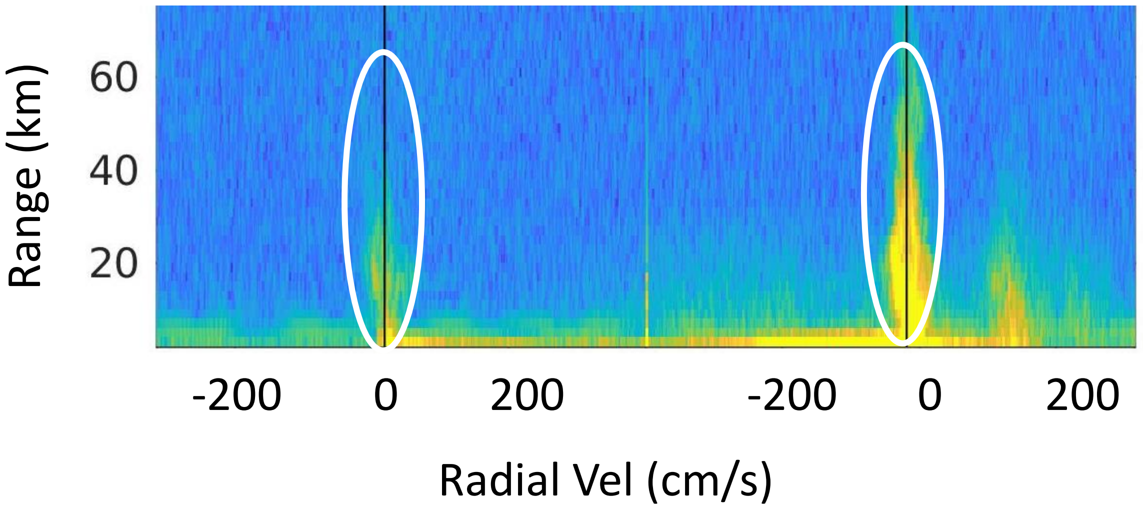
High Frequency Radar Wind Turbine Interference Community Working Group Report:

Radar backscatter from HFRs near existing offshore wind turbines in U.S.

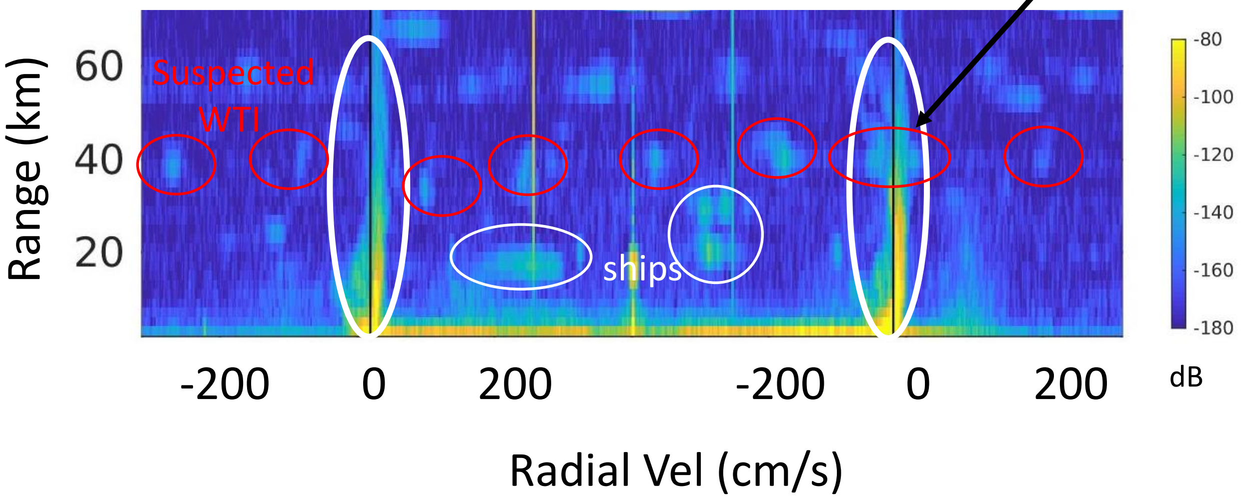
Long-range HFR from Trockel et al. 2018



Mid-range HFR with no view of BI turbines



Mid-range HFR with view of BI turbines



High Frequency Radar Wind Turbine Interference Community Working Group Report:

<u>**Suggested Timeline for Mitigation Research Activities:**</u>

Near-Term (0-1 year):

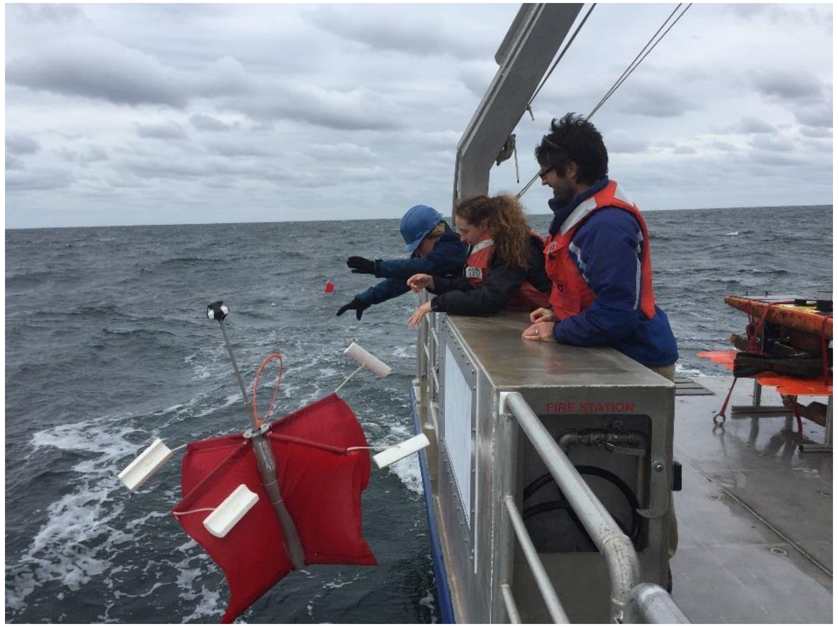
Data collection at HF radar systems in view of the Block Island Wind Farm

Test changes to HF radar operational parameters to minimize WTI effects.

Develop modelling capabilities toward arbitrary radar and wind farm configurations.

UH HFR receive antenna installed on Nantucket Island, MA.

High Frequency Radar Wind Turbine Interference Community Working Group Report:



USCG Academy Cadets deploy surface drifter for measuring currents.

<u>**Suggested Timeline for Mitigation Research Activities:**</u>

Mid-Term (1 to 3 years):

Conduct model calibration studies to improve simulations

Develop a focused research dataset and conduct **field studies** - high quality radar coverage, in situ sensor deployments, real and simulated WTI

Build and **test initial mitigation solutions using the research dataset and simulation tools**, moving concept testing from TRLs of 4 or 5 to 7.

High Frequency Radar Wind Turbine Interference Community Working Group Report:

CODAR SeaSonde on Martha's Vineyard, MA.

Suggested Timeline for Mitigation Research Activities:

Long Term (3-6 years):

Test and document the efficacy of proposed mitigation approaches with validation datasets.

Conduct secondary **field validation effort at alternative locations that encompass different parameter regimes for turbine, radar, and ocean conditions**.

Move mitigation solutions to a TRL of 9.

Conduct mitigation development and testing for advanced data products available from oceanographic HF radars (waves, winds, etc.)

High Frequency Radar Wind Turbine Interference Community Working Group Report:

CODAR SeaSonde on Martha's Vineyard, MA.

Report Summary

The community report provides a road map for mitigation

The emphasis*:*

- WTI for HFR appears to be a critical, but solvable problem
- Instruments in the water are needed to assess mitigation techniques and impacts to ocean current accuracies.

High Frequency Radar Wind Turbine Interference:

Mitigation Status

CODAR SeaSonde on Martha's Vineyard, MA.

Mitigation Research Activities:

Short Term (0-1 year): present day

BOEM funded project (with CODAR) to build on simulation tools and examine mitigation approaches.

Mid-Term (1-4 year)

NOAA-IOOS Ocean Technology Transition funding (starts Fall 2020). This will:

Expand data collection, WTI simulation, and testing,

Conduct field validations,

Iteratively build and test mitigation approaches.

Long-Term (4-6 year)

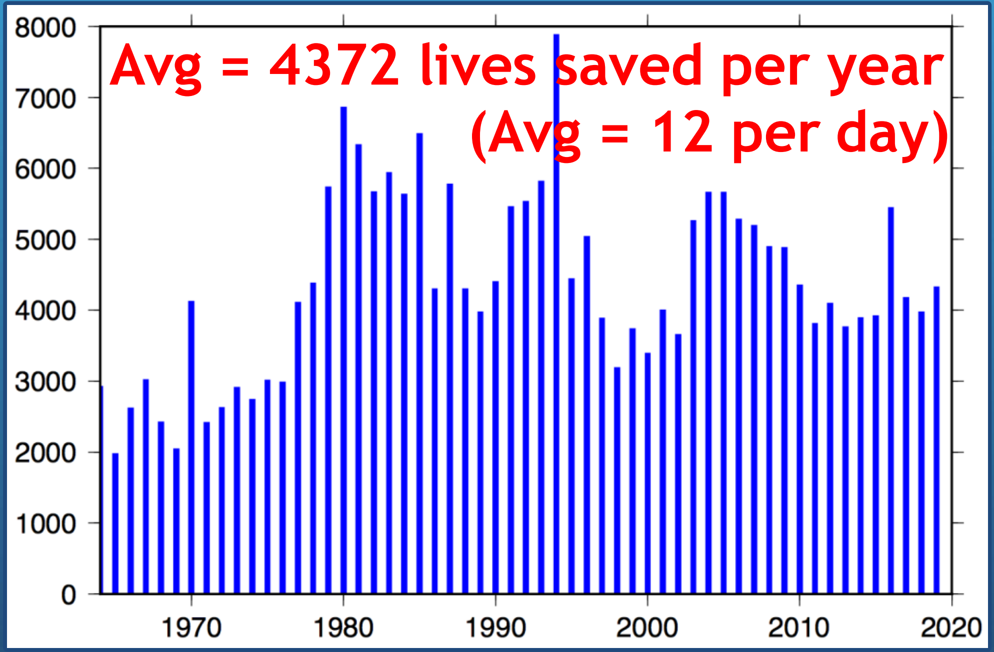
Not known

Importance of Reliable and Accurate Environmental Data in the U.S. Coast Guard's Search and Rescue Optimal Planning System (SAROPS)

Cristina Forbes
U.S. Coast Guard
Office of Search and Rescue

USCG Search and Rescue (SAR)

- USCG responsible for more than 21.3 million sq. NM of ocean
- Since 1964 until 2019 there have been more than 2,198,259 cases and more than 244,809 lives saved



Search and Rescue (SAR) Drift Modeling

- Maritime SAR involves estimating a search area by quantifying a number of unknowns:
  - the last known position and time of distress,
  - the person or object type/ size and
  - environmental conditions the wind, sea state, and currents affecting the person or object,
- Compute the evolution of the search area with time
- Rapidly deploy SAR units (SRUs) to the search area.

Search and Rescue Optimal Planning System

- The U.S.Coast Guard uses Search and Rescue Optimal Planning System (SAROPS) for drift modeling and search planning of persons lost at sea.
- SAROPS is a fast comprehensive framework which:

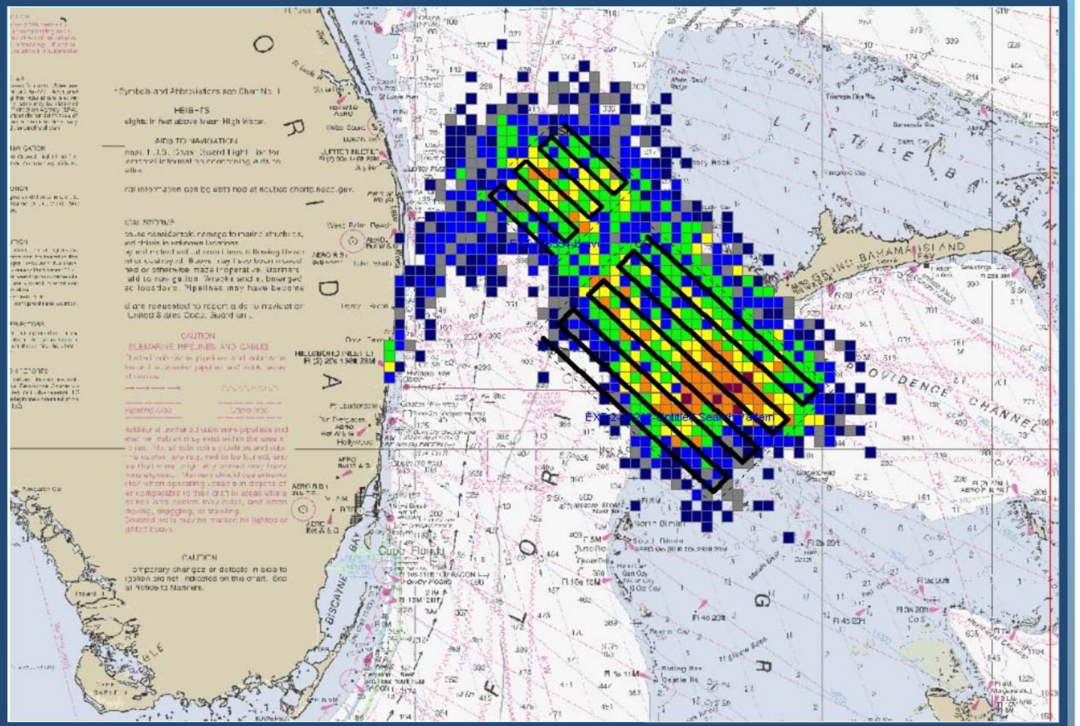
➢Minimizes data entry, reducing the potential for user input error

➢Accesses near real-time global and local environmental data

➢Uses a Monte Carlo method to simulate the drift of thousands of particles for each scenario

➢ Computes probabilistic search areas

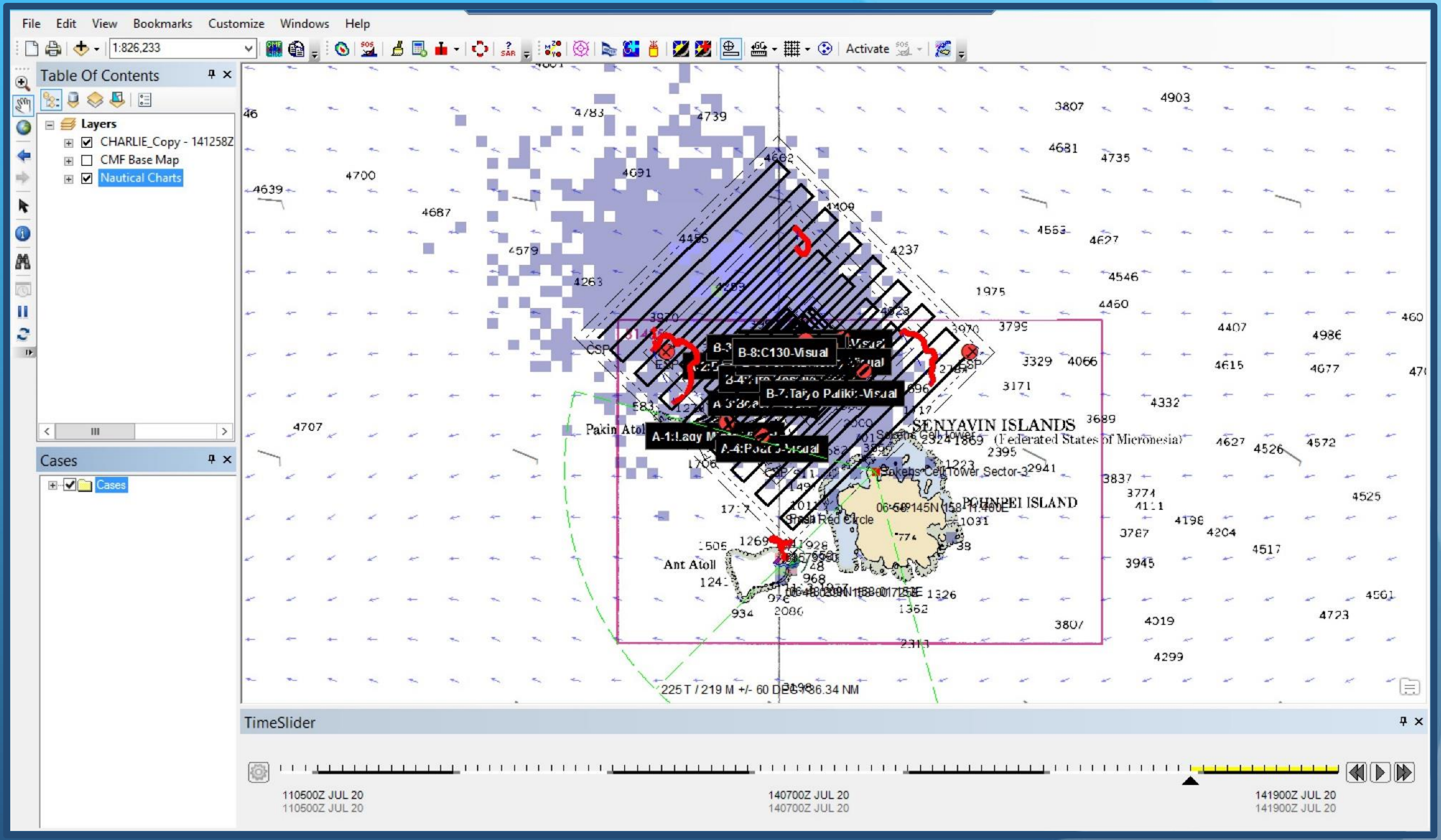
➢Creates action plans (search patterns for available search units: air and maritime platforms) that maximize the probability of success.



SAROPS

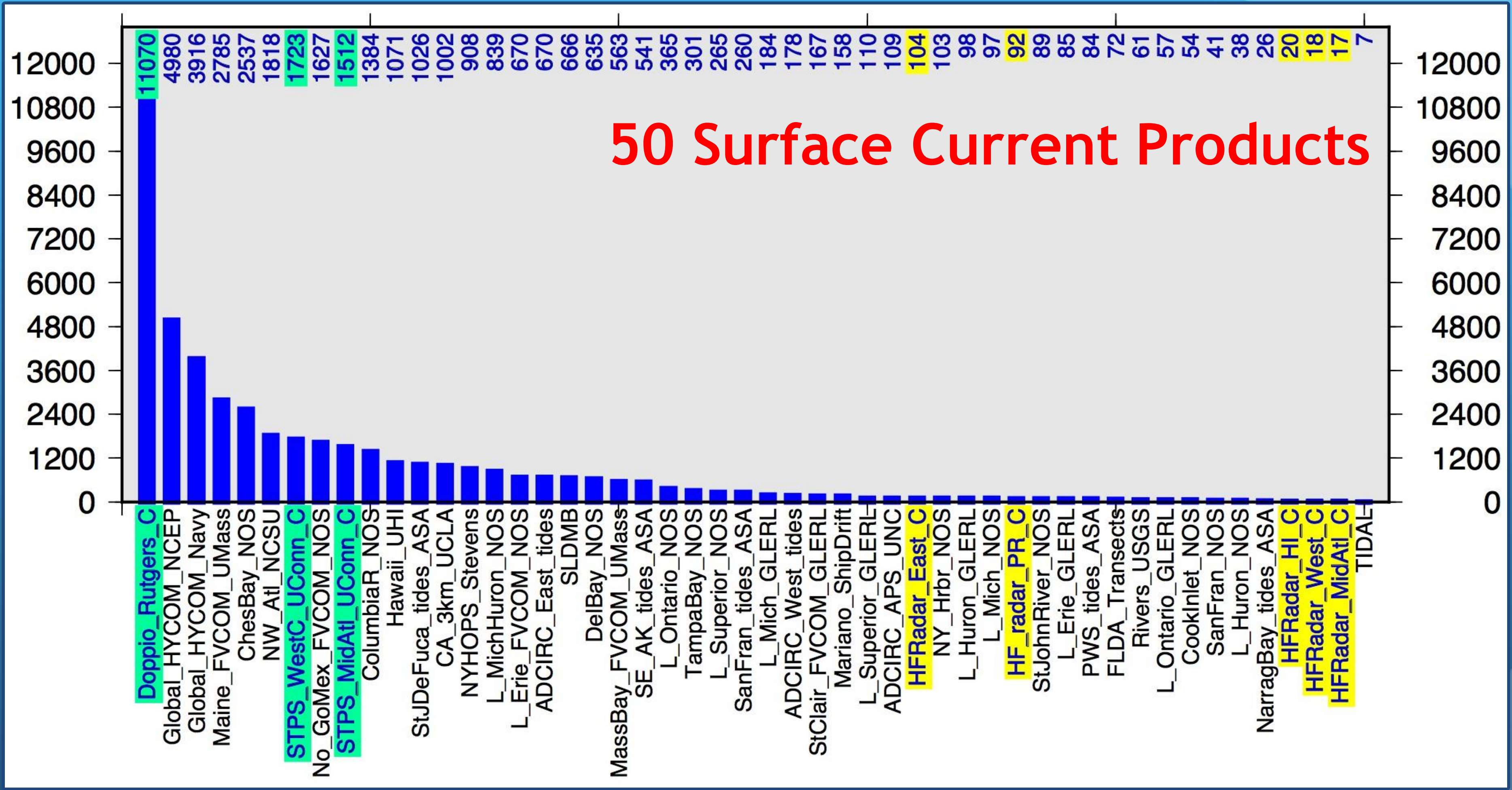
SAROPS has 4 integrated components:

- ➢Graphical User Interface (GUI)
- ➢Environmental data server (EDS)
- ➢ Simulator (SIM)
- ➢ Search Planner



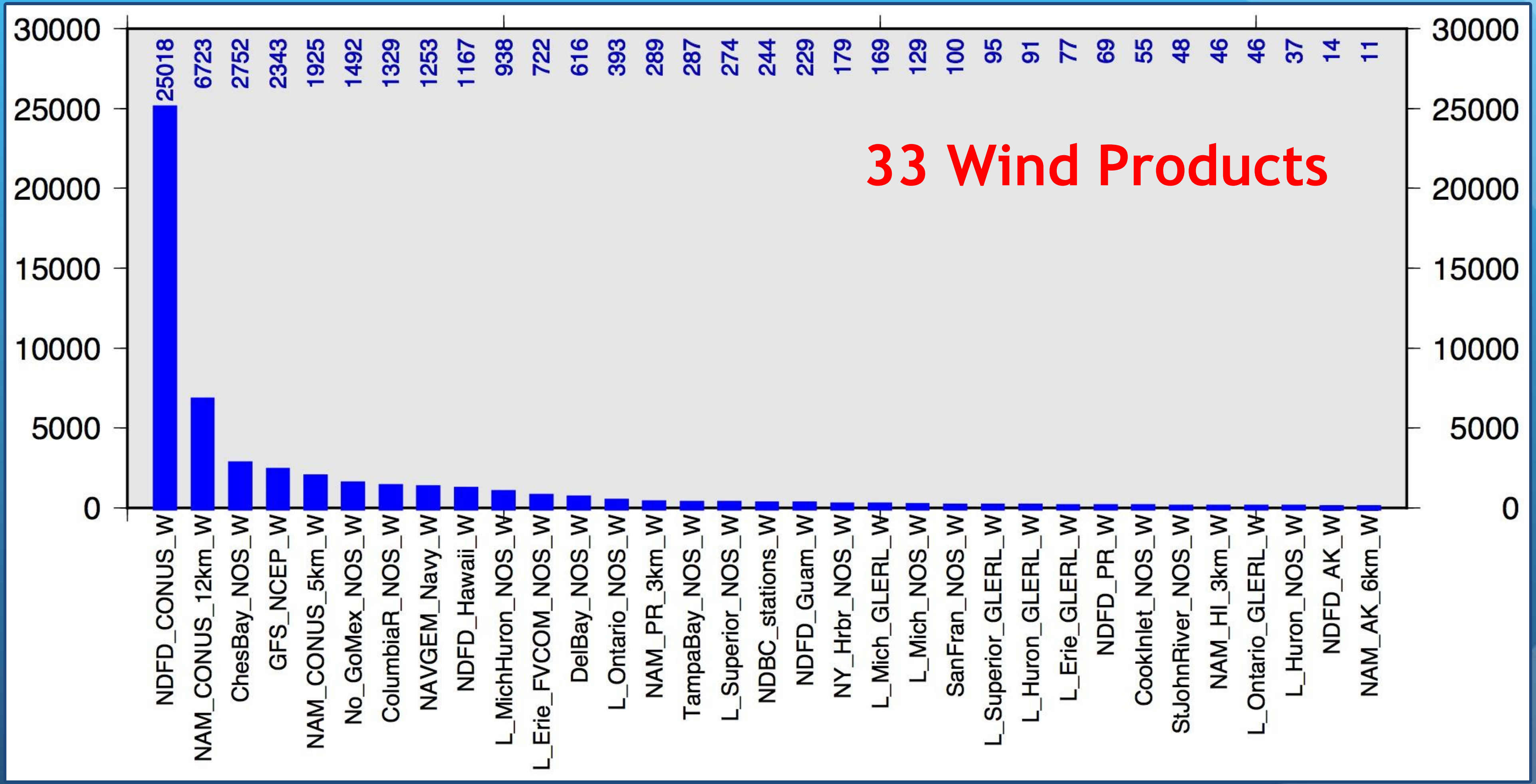
Environmental Data Server

Surface Current Product Usage - July/2019-June/2020



Environmental Data Server

Wind Product Usage - July/2019-June/2020



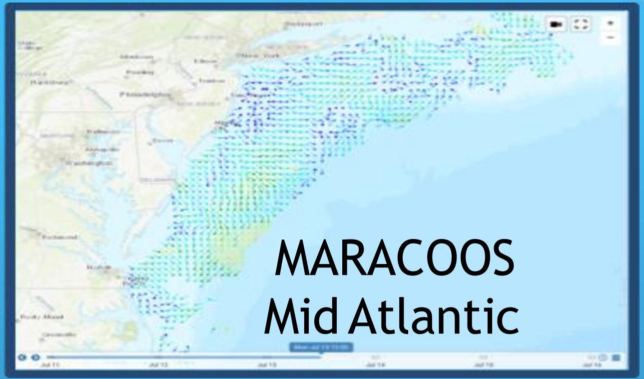
High Frequency (HF) Radar Surface Currents

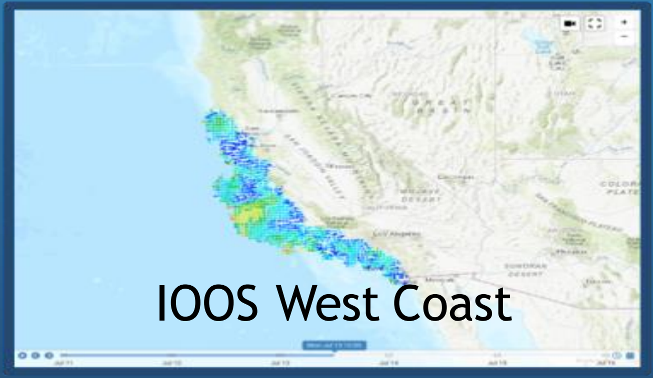
- Utilize high frequency radio waves
- Near real-time measurements of surface current velocities (speed and direction) near the coast (top 1-2 m of water column)
- Higher resolution in space than other sensors (current meters)
- ~160 HF Radar systems presently operating throughout coastal US.
- Real-time surface currents can be used for model validation.

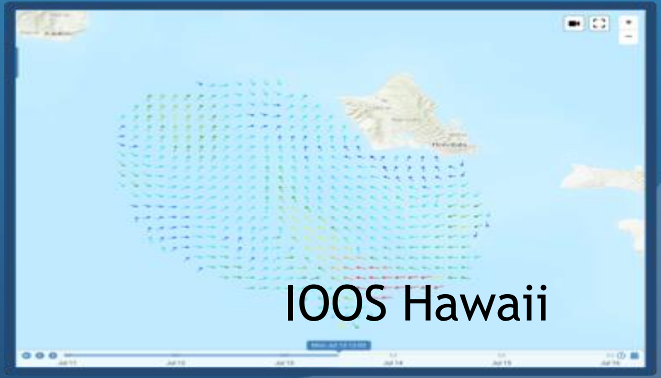
- USCG integrated HFR into SAR in the MA region 2009
- HF Radar data & IOOS-funded Short-term Prediction System (STPS) available in SAROPS via EDS.

HF Radar

- Averaged over 15 min
- As far offshore as 70 km
- Resolution 6 km

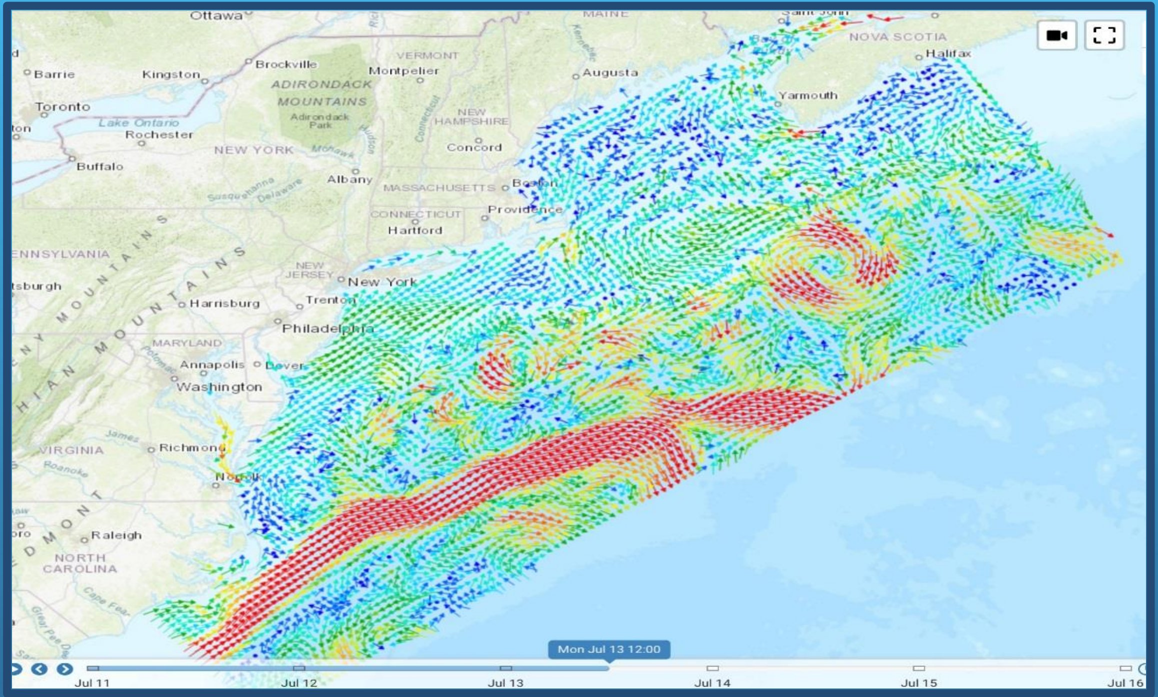






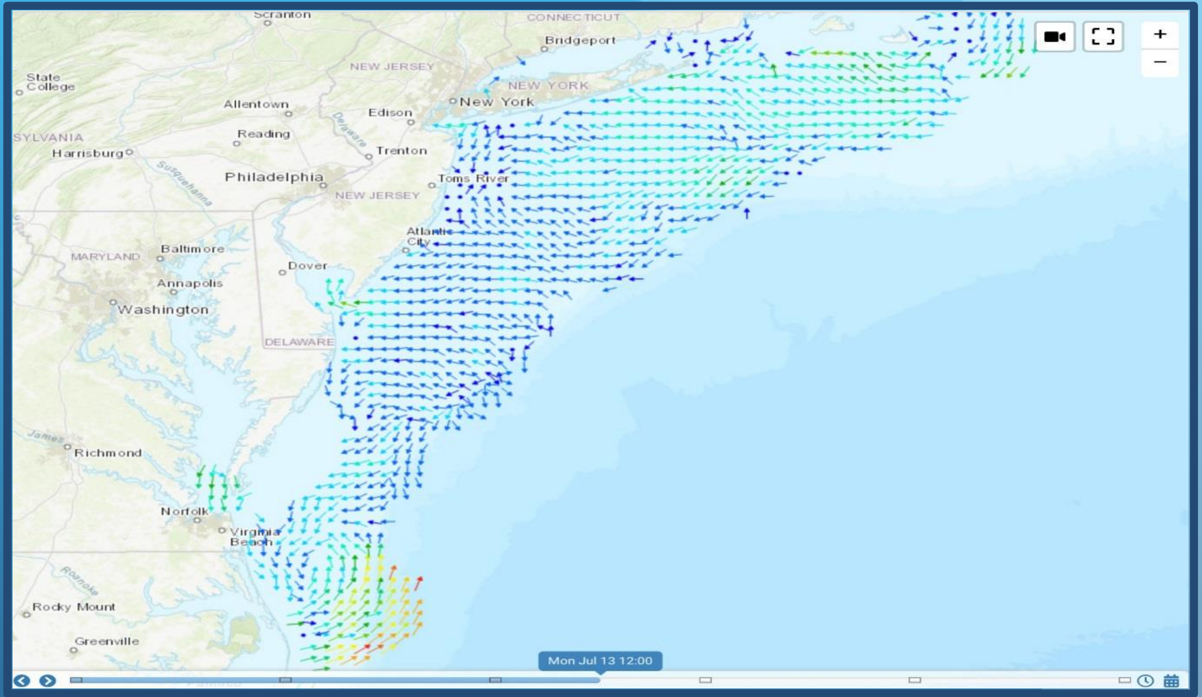
EDS Models using HF Radar Data

Doppio
Rutgers University



- The 4D variational (4D-Var) data assimilation method used for observations of surface currents from HF-radar total vectors

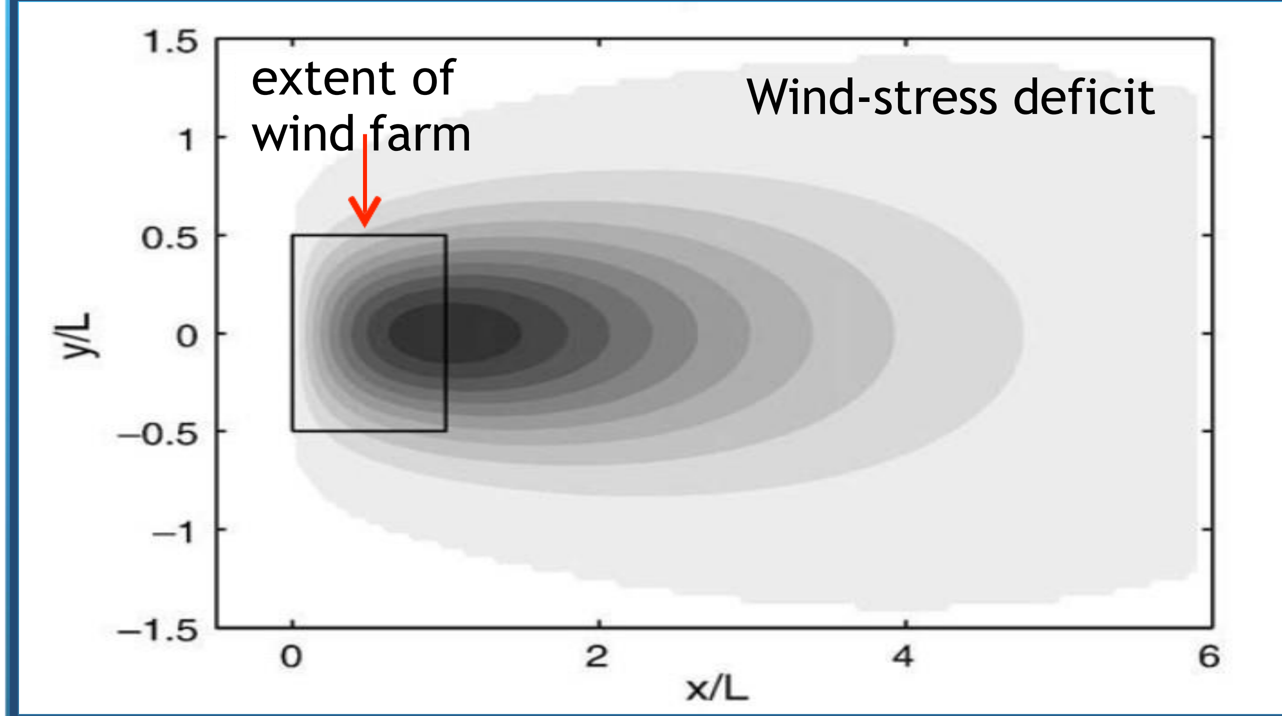
Short-Term Predictive System (STPS)
University of Connecticut (UCONN)

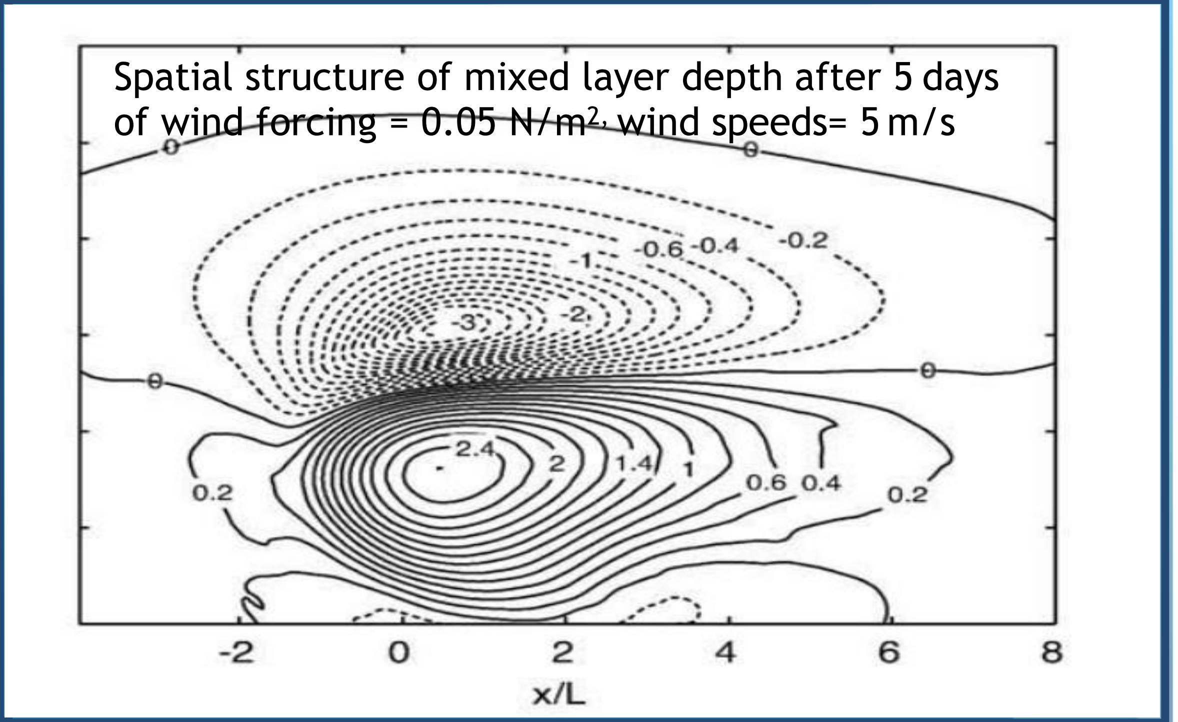


- Uses CODAR data to make surface current predictions into the future (O'Donnell et al., 2005).

Scientific Studies

Göran Broström (2008) “On the influence of large wind farms on the upper ocean circulation”

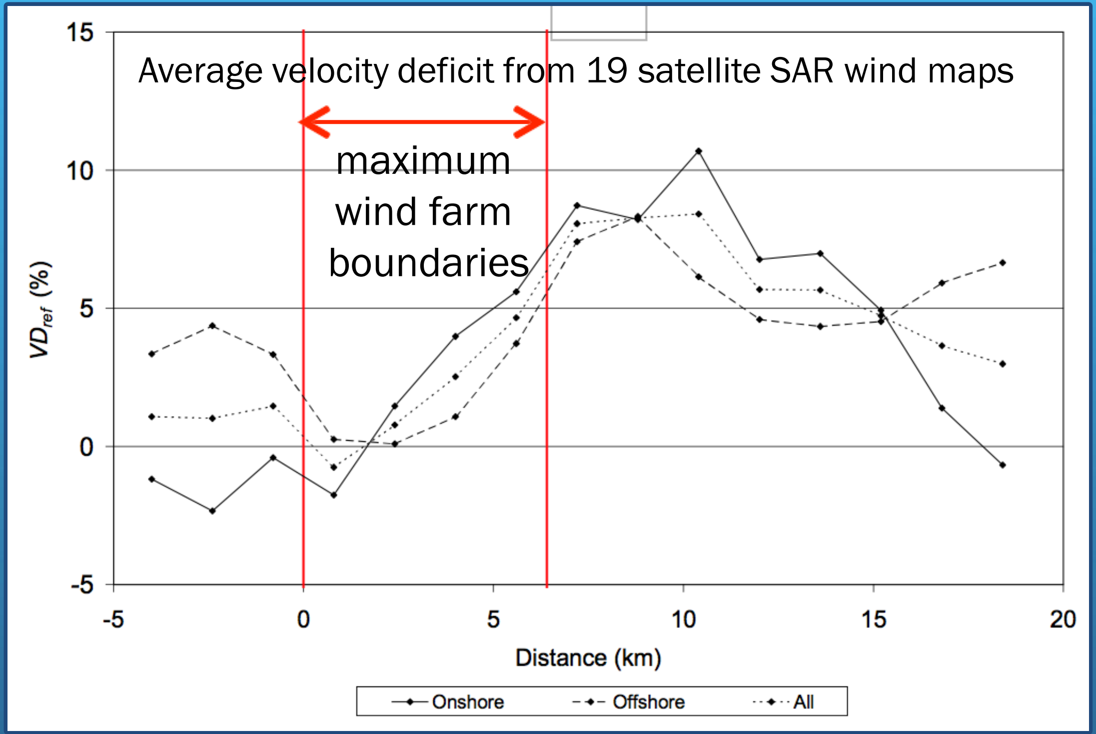




- Wind speeds ~ 5-10 m/s may generate upwelling/downwelling velocities >1 m/day if characteristic width of wind wake is >= internal radius of deformation.
- Implication for USCG: Can modify the surface velocities and drift modeling probabilities, and survival times due to sea surface temperature changes.

Scientific Studies

Christiansen, MB and Hasager C.B (2005) "Wake studies around a large offshore wind farm using satellite and airborne SAR"



$$VD = \frac{U_{freestream} - U_{wake}}{U_{freestream}} 100\%$$

The magnitude and extent of wakes (i.e. regions of reduced wind speed and high turbulence intensity)

VD ~ 10% 0-3 km downstream

VD ~ 4% 10 km downstream

- Wind speed matches free stream velocity over downstream distance of ~ 10 km
- Implications for USCG: wind shadowing over 10 km impact surface circulation and drift modeling.

Wind Turbines and High Frequency (HF) Radar

Impact Assessment and Mitigation of Offshore Wind Turbines on High Frequency Coastal Oceanographic Radar Report (2018)

- Observations indicate that the spinning blades of offshore wind turbines cause interference in HF radars
- Wind turbine interference impacts the ocean current measurements by affecting the sea echo (causing errors in the velocity measurements of up to 48 cm/s)

- Implications for USCG: need accurate HF Radar observations for input to numerical models that drive SAROPS drift modeling and planning

Conclusions

- Availability and access to high-quality and reliable global/regional wind and surface current data (speed and direction) derived from observational networks and from the latest state-of-the-art forecast modeling systems available is essential for:
  - accurate prediction of the drift of persons or objects in the marine environment
  - targeted search and rescue (SAR) operations and planning
  - narrow search areas

- Coupled numerical ocean and atmospheric models need to accurately depict changes in winds and currents due to wind farm structures.
- Observational networks are needed in and around the wind farms
- HF Radar observations need to be accurate so that numerical ocean models that assimilate them (e.g. Doppio) or produce statistical forecast fields (e.g. STPS) will produce accurate currents for use in SAROPS via the EDS.

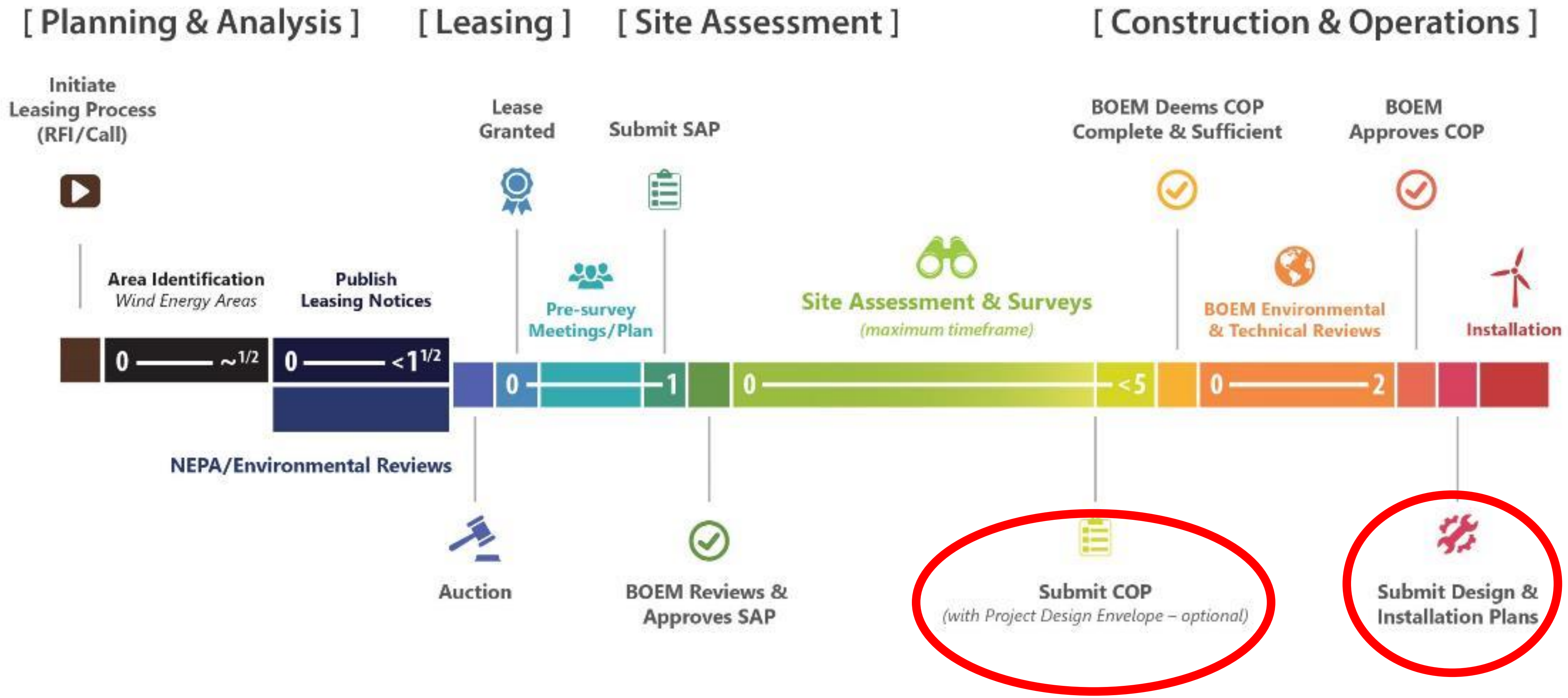
BOEM
Bureau of Ocean Energy Management

WTG Information Availability & Proactive Engagement

Angel McCoy
Office of Renewable Energy Programs

July 27, 2020 | WTRIM Oceanographic HF Radar Webinar

Leasing to Operations Timeline



How to be Proactive as a Community of HF Radar Stakeholders

- Offshore Wind Permitting Subgroup
  - Federal partners
  - Early communication of projects and their paths forward
  - One Federal Decision timelines are established

Executive Order 13807 (April 2017) – One Federal Decision (OFD)

- Sets a government-wide goal of no more than two years from Notice of Intent (NOI) to all Federal authorizations
- Ensures the Federal environmental review and permitting process for infrastructure projects is coordinated, predictable, and transparent
- Requires a single schedule, single EIS, and single record of decision

https://www.whitehouse.gov/presidential-actions/presidential-executive-order-establishing-discipline-accountability-environmental-review-permitting-process-infrastructure/

One Federal Decision MOU

- Agreement between multiple Federal agencies on how to implement E.O. 13807
- Concurrence points
  - Permitting timetable (prior to publication of NOI)
  - Purpose and need (prior to publication of NOI)
  - Alternatives to be carried forward (during preparation of the Draft EIS)
  - Preferred alternative (likely after Draft EIS public comment period)
- Concurrence process
  - Drafts shared and discussed during interagency call(s), 10 business day formal concurrence period, and process for elevation, if necessary

https://www.whitehouse.gov/wp-content/uploads/2018/04/MOU-One-Federal-Decision-m-18-13-Part-2-1.pdf

Department of Interior Clearance Points

COP Submittal

- Completeness and sufficiency review

1 Initial Action Notice

2 Notice of Intent

Public Scoping

- Publish Notice of Intent in *Federal Register*
- 30-day public comment period
- Hold public meetings
- Receive input on issues and alternatives

3 Draft EIS Development

Draft Environmental Impact Statement

- Prepare with cooperating agencies
- Publish Notice of Availability in *Federal Register*
- 45-day public comment period
- Hold public hearings

4 Draft EIS/ Notice of Availability (NOA)

Final Environmental Impact Statement

- Address public comments with cooperating agencies
- Publish Notice of Availability in *Federal Register*

5 Final EIS/NOA

One Federal Decision

- Minimum 30-day wait period prior to Record of Decision (ROD)
- All Federal authorizations within 90 days of ROD

6 Record of Decision/NOA

Opportunities to Contribute

- Cooperating Agency
- Terms and Conditions of Construction and Operations Plan Approval
- Mitigation Measures for inclusion in the NEPA Document/ Environmental Impact Statement

Radar Interference Analysis for Renewable Energy Facilities on the Atlantic OCS

Contractor: Booz Allen Hamilton

Tasks:

- Line of Sight (LOS) and Interference Analysis – computer modeling of radar systems potentially impacted
- Mitigation Techniques – discussion and analysis of potential options for mitigation
- Ducting Analysis – discussion and analysis of ducting events around the planned and hypothetical wind farms

Study Conclusions and Recommendations

1. 36 radar systems affected to some degree by the 9 proposed and hypothetical wind farms evaluated – every wind farm evaluated affected at least 1 radar
2. Unique challenges with SeaSonde HF radar systems, but mitigation may be possible through a software upgrade
3. Effective mitigation will require coordination between radar operators and wind energy developers
4. Expect ducting to occur 10%-30% of the time near wind farms
5. Recommend BOEM consider radar LOS in COP reviews
6. Curtailment agreements should be explored for certain situations (e.g., severe weather)

BOEM

BOEM.gov

Angel McCoy | Angel.McCoy@boem.gov | 703-787-1758

Wind Turbine Radar Interference Mitigation Panel

Patrick Gilman
DOE Wind Energy Technologies Office

Brian Zelenke
National Oceanic & Atmospheric Administration

Hugh Roarty
Rutgers University

Chad Whelan
CODAR Ocean Sensors, Ltd.

Dale Trockel
CODAR Ocean Sensors, Ltd.

Anthony Kirincich
Woods Hole Oceanographic Institution

Brian Emery
University of California Santa Barbara

Dr. Cristina Forbes
U.S. Coast Guard

Angel McCoy
Bureau of Ocean Energy Management
U.S. Department of the Interior

Questions or Comments?

Send additional questions to: Lillie.Ghobrial@ee.doe.gov

Tentative Future Webinar Agenda & Information

Oceanographic HF Radar R&D Follow-on Meeting

- 1 hour long meeting to discuss R&D needs, and potential collaborations for HF radar
- Invite-Only: Please reach out if this meeting would be of interest

TBD- August 24th 2020

Air Traffic Control/Air Surveillance Radars: *State of Understanding of U.S. Offshore WTRIM Issues from an Federal Aviation Administration (FAA) Perspective*

- *Terminal and Long-Range Radars*
- *Technical and operational issues regarding each system in an OSW environment and potential mitigations*

TBD, Fall, 2020 (TBD)

Forward Looking Research & Collaboration and Government/Industry Virtual Roundtable

All OSW Radar Webinar Information (Past & Future) is on the DOE Website:

https://www.energy.gov/eere/wind/articles/offshore-wind-turbine-radar-interference-mitigation-webinar-series

Backup Slides

Offshore Wind Technologies Market Report: Summary

- The U.S. offshore wind energy project development and operational pipeline grew to an estimated potential generating capacity of 25,824 megawatts (MW), with 21,225 MW under exclusive site control
- Four U.S. regions experienced significant development and regulatory activities
- State-level policy commitments accelerated, driving increased market interest
- Increased U.S. market interest spurred strong competition at offshore wind lease auctions
- Several U.S. projects advanced in the development process
- Industry forecasts suggest U.S. offshore wind capacity could grow to 11–16 gigawatts by 2030
- Offshore wind interest accelerated in California
- New national R&D consortium aims to spur innovation
- Global offshore wind annual generating capacity installed in 2018 set a new record of 5,652 MW
- Industry is seeking cost reductions through larger turbines with rated capacities of 10 MW and beyond
- Floating offshore wind pilot projects are advancing
- *2018 Offshore Wind Technologies Market Report*.

LCOE forecasts for offshore wind indicate fixed bottom wind may be near $50/MWh and floating wind may be as low as $60 MWh by 2032 (COD)

Additional Resources

2018 Wind Market Reports

- 2018 Offshore Wind Market Report
- 2018 Wind Technologies Market Report

WINDExchange Wind Turbine Radar Interference

- Wind Turbine Radar Interference Mitigation Fact Sheet
- All public OSW-Radar Summaries
- Federal Interagency Wind Turbine Radar Interference Mitigation Strategy

American Wind Energy Association

Bureau of Ocean Energy Management Renewable Energy Fact Sheet

All Past and Future Offshore Wind Radar Webinar Information