Advancing American Offshore Wind Research

September 20, 2016

Hyatt Regency Washington on Capitol Hill
Washington, DC

Tufts

Presentations by Key Agencies

Tufts

Presentations by Key Agencies

Tufts

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE's Offshore Wind Program

Jose Zayas, Director
Wind Energy Technologies Office
September 20, 2016

Wind Energy Program
Overview

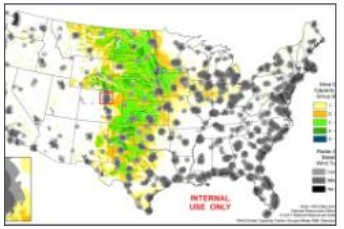
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Wind Energy Major Programmatic Goals and Endpoint Targets

The Wind Energy Program aims to accelerate widespread U.S. deployment of clean, affordable, reliable, and domestic wind power to promote national security, economic growth, and environmental quality. Program RDD&D activities are applicable to **utility-scale land** and **offshore wind** markets, as well as **distributed** turbines—typically interconnected on the distribution grid at or near the point of end-use. Achieving LCOE goals will support deployment of wind at high penetration levels, sufficient to meet up to 20% of projected U.S. electricity demand in 2030, and up to 35% in 2050, compared to **4.8% of demand in 2015**.

Wind Energy Programmatic Impact

- **Optimize wind plant cost of energy reduction** through complex aerodynamics R&D, advanced component development, wind plant reliability improvement and resource characterization
- **Establish a competitive U.S. offshore wind industry** through offshore system development and demonstration
- **Optimize grid integration and transmission** for wind systems through integration studies and operational forecasting tool development
- **Eliminate and reduce market barriers** through accelerated siting and deployment strategies



Wind Energy 2017 Targets Towards Programmatic Goals

- Reduce the unsubsidized market LCOE for **utility-scale land wind** energy systems from a reference wind cost of $.074/kWh in 2012 to $.057/kWh by 2020 and $.042/kWh by 2030*
- Reduce the unsubsidized market LCOE for **offshore fixed-bottom wind** energy systems from a reference of $.20/kWh in 2010 to $.167/kWh by 2020 and $.136/kWh by 2030*

** For Programmatic purposes, all costs are reported at a 7% discount rate.*

Historic Investments in Offshore Wind
DOE Funding since 2009

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Three Major Focus Areas

Technology Development

World-Class Test Facilities

FOA 112 (FY09)

Clemson 15 MW Dynamometer

Massachusetts Large Blade Test Facility (to 90m)

$70M

Next Generation Drivetrain R&D

FOA 439 (FY11)

Aggressively Targets Key Cost Components

$7.5M

Developing Innovative Technology

FOA 415 (FY11)

Computational Tools

Turbine Design

Marine Systems Engineering

$26.5M

Market Barrier Removal

Removing Market Barriers

FOA 414 (FY11)

Siting and Permitting

Infrastructure Studies

Resource Planning

$16.5M

Advanced Technology Demonstration

Demo Projects

FOA 410 (FY12-18)

Advanced Technology Deployed on Demonstration Scale

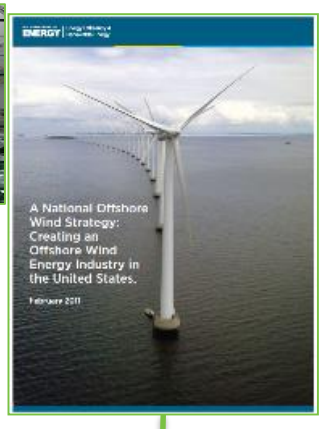
Partnerships with 50% Cost Share

$168M

Historic Investments in Offshore Wind
Key Milestones

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

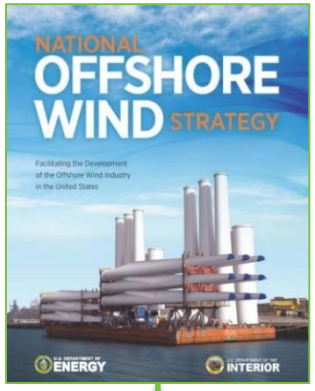
DeepCWind Consortium



National OSW Strategy (2011)

Demonstration Projects Initiated

DOE Lidar Buoys



National Offshore Wind Strategy (2016)

ARRA Funding of Test Facilities

Technology and Market Barrier Funding Opportunities

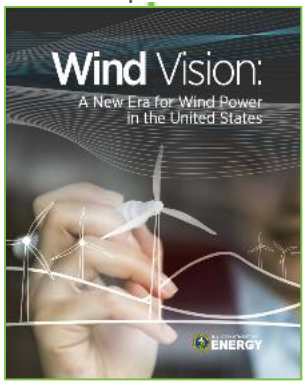
Deployment of UMaine VolturnUS

2009

2015

Tomorrow

Wind Vision Report

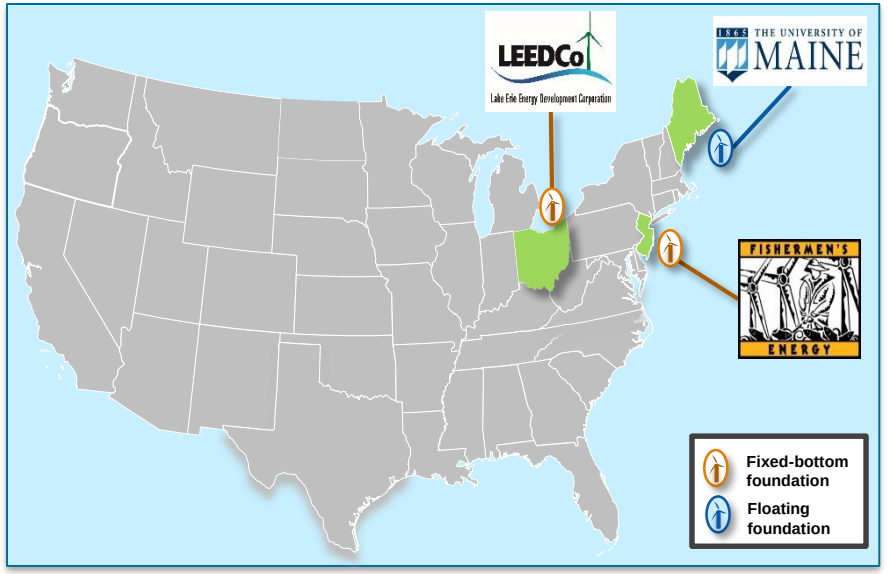


Current Activities
Offshore Wind Demonstration Projects

DOE seeks to demonstrate offshore wind innovations at multi-megawatt scale to reduce the cost of energy and address regional challenges and opportunities, expediting development of the US offshore wind industry ($168M)

The three selected projects, are all demonstrating unique innovations aimed at lowering the cost of energy.

- Fishermen's Energy (New Jersey)
  - **Twisted jacket foundation**
  - Demonstration of **wake effects and steering**
- University of Maine
  - **Floating concrete semisubmersible**
- LEEDCo
  - **Monobucket** (monopile with suction bucket) to **resist surface ice conditions** of the Great Lakes



Potential for Collaboration/Data Sharing

- Highly instrumented platforms
- Project cost data

Offshore Wind Energy
FY 2017 Priorities

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Offshore Wind R&D Consortium

- FOA to jump start the U.S. offshore wind industry by means of a joint industry project (JIP) with industry, academia, and national laboratories to accelerate fundamental R&D targeted at U.S.-specific offshore wind technology barriers, including:
  - **Advanced substructure technology** to address unique U.S. site conditions, e.g. deep water, and operating and extreme conditions
  - Technology to enable reduction of **installation** cost and risks, e.g. 'flip-up' turbines and sound mitigation
  - Technology that enables less on-site **O&M** intervention, e.g. prognostic health monitoring
  - **Design standards development** for the extreme marine conditions unique to U.S. waters
  - Technologies to address turbine-turbine **wake interaction**

Offshore Wind Demonstration Projects

- Continue sixth year of FY 2012 Offshore Wind Advanced Technology Demonstration Project FOA, to support the establishment of a competitive U.S. offshore wind industry through the development and demonstration of **innovative offshore wind technologies with the potential to lower the cost** of offshore wind energy in the U.S.

Offshore Wind Plant Optimization – Atmosphere to electrons (A2e)

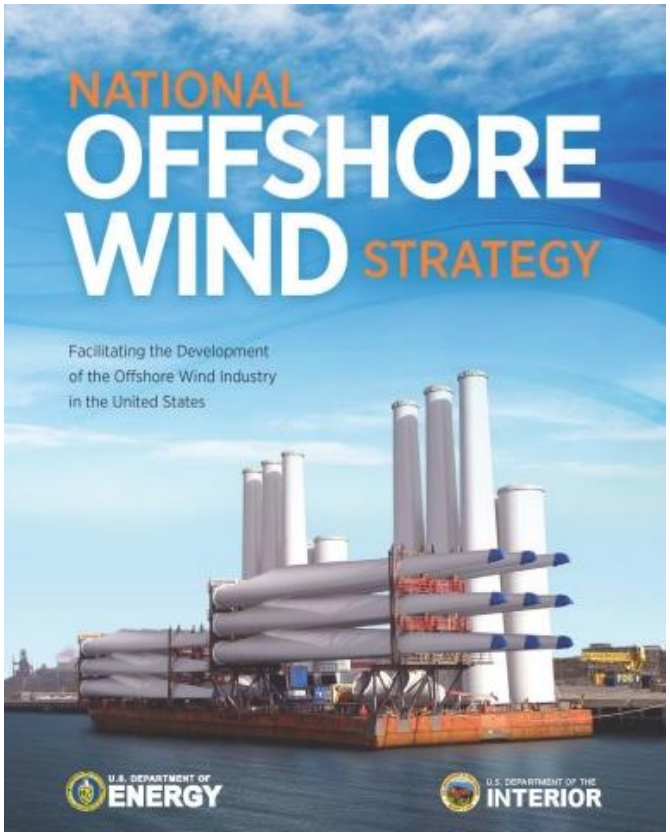
- Improve the performance and reliability of **next-generation "smart wind" plants** by investigating systems-level interactions influenced by atmospheric conditions and turbine-turbine wake interactions.

Offshore Wind Market Acceleration and Deployment

- Development of technologies for **monitoring wind-wildlife interactions** in the offshore wind space and **information aggregation and dissemination** through the Tethys database and international WREN initiative.

National Offshore Wind Strategy
DOE-DOI Collaboration

- Five year **dual-agency update** of the 2011 Strategy published in September 2016
- Reflecting on the implementation and outcomes of the 2011 Strategy
- Building upon the ***Wind Vision*** **roadmap** and stated benefits of offshore wind
- Utilize and reflect on industry feedback through DOE Request for Information (July '15), DOI Request for Feedback (January '16), and DOE-DOI Workshop (Dec '15)
- Showcase the value of offshore wind utilizing **new analysis from NREL**
- Guide federal investment and regulation implementation over the coming five years

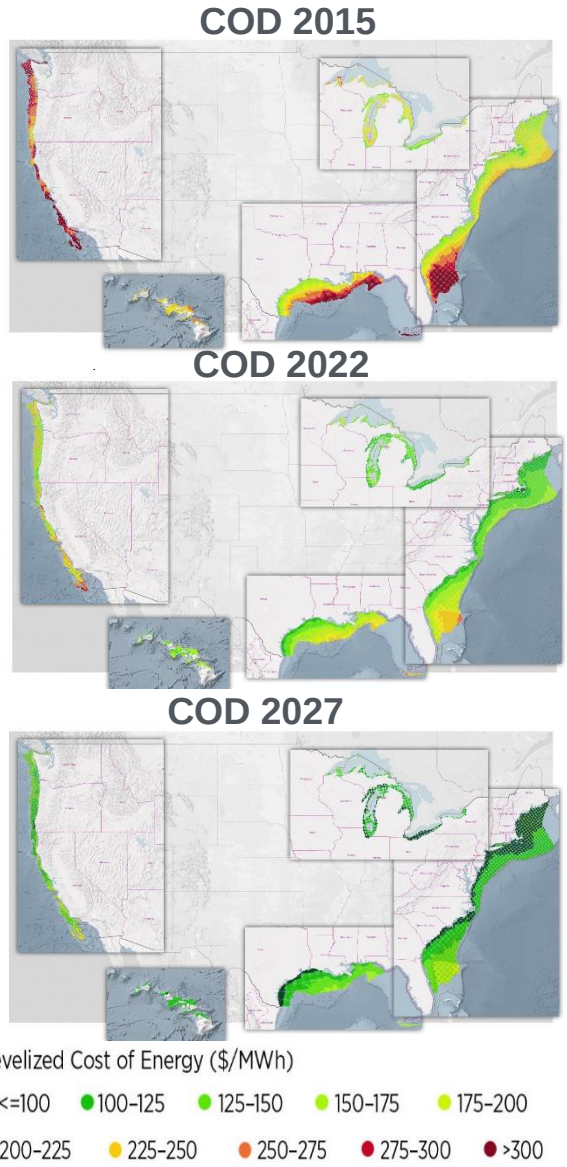


National Offshore Wind Strategy: *Facilitating the Development of the Offshore Wind Industry in the United States.* Released September 9, 2016

National Offshore Wind Strategy
Key Takeaways

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- **Offshore Wind Represents a Significant Opportunity for the Nation**
  - Technically accessible resource with ample space available for lease **(2,058 GW)**
  - Electricity demand growth and power plant retirements create a significant market opportunity for new generation
  - Potential to achieve competitive cost
- **Key Challenges Remain**
  - Reducing technology costs and risks
  - Ensuring efficient, effective regulatory construct
  - Supporting effective stewardship of the environment and public space
  - Improving understanding of offshore wind's benefits
- **Robust and Credible Plan for Federal Action**
  - **Over 30 DOE and DOI initiatives** to address 7 action areas and three strategic themes



National Offshore Wind Strategy
The Benefits

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Offshore Wind Benefits

GHG (Cumulative)	Air Pollution (2050)	Water (2050)
1.8% reduction in cumulative GHG emissions (1,600 million tonnes CO_2-equivalents), saving $50 billion in avoided global damages	$2 Billion in avoided mortality, morbidity, and economic damages from cumulatie reductions in emissions of SO_2, NO_x and fine PM	5% less water consumption and 3% less water withdrawals for the electric power sector

Energy Diversity	Jobs	Local Revenues
Increased offshore wind power adds fuel diversity in key regions of the country, including populous coastal metropolitan areas, ultimately reducing sensitivity to changes in fossil fuel costs. Similarly, by reducing demand for fossil fuels offshore wind can support fuel cost savings for consumers based on lower prices outside of the electric sector.	Offshore wind investments could support approximately 160,000 gross jobs in coastal regions and around the nation	By 2050, $440 million annual lease payments and approximately $680 million in annual property tax payments

Thank you.

National Science Foundation

Directorate for Engineering

Offshore Wind Workshop
Washington, DC

Barry W. Johnson
Acting Deputy Assistant Director

September 20, 2016

NSF Mission and Vision

Mission

- **"to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."**

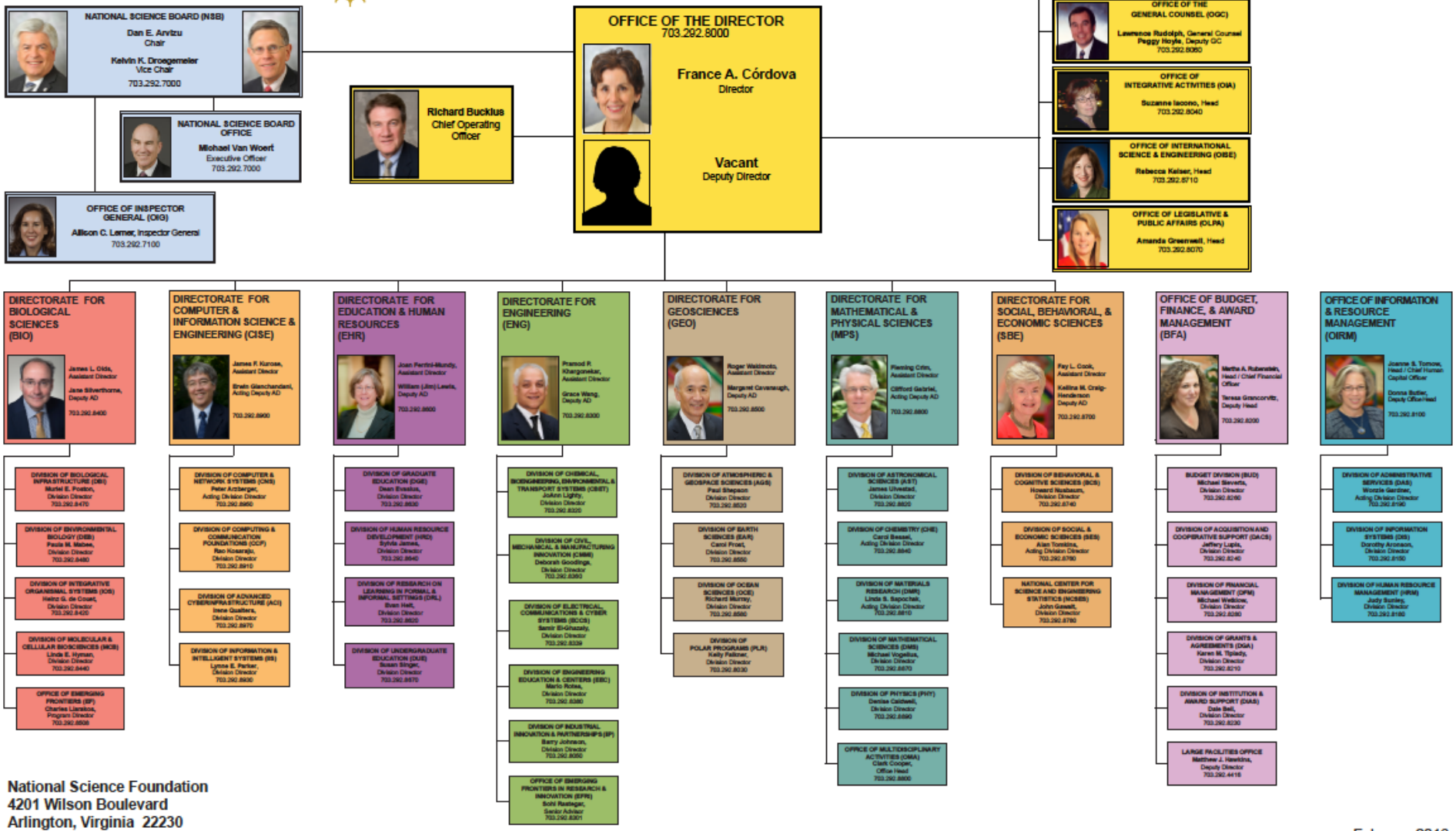
Vision

- **"A Nation that creates and exploits new concepts in science and engineering and provides global leadership in research and education."**

NSF Strategic Goals

- **Strategic Goal 1: Transform the frontiers of science and engineering.**
- **Strategic Goal 2: Stimulate innovation and address societal needs through research and education.**
- **Strategic Goal 3: Excel as a federal science agency.**

NATIONAL SCIENCE FOUNDATION

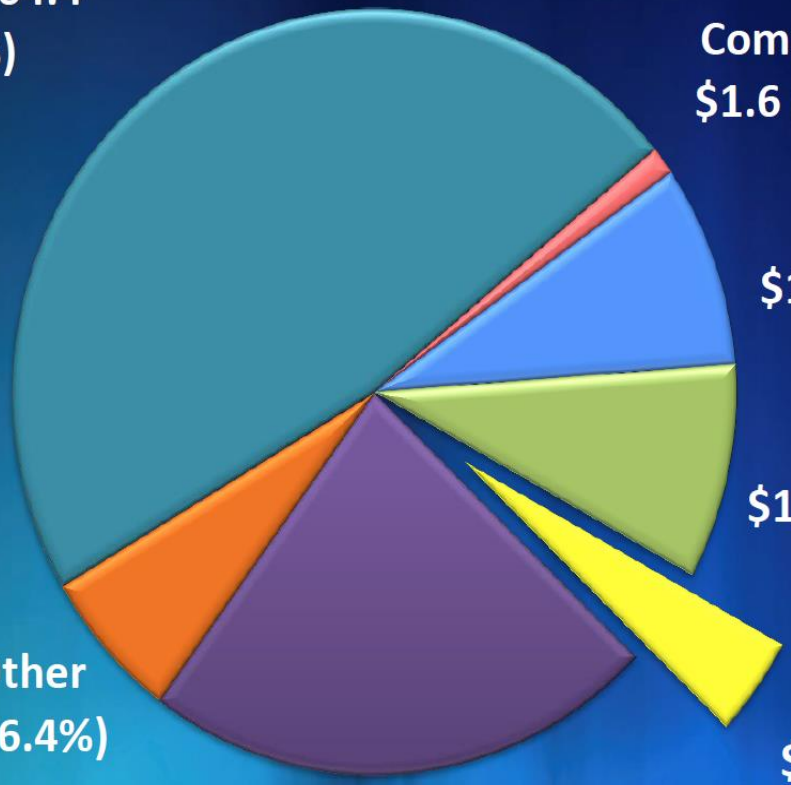


National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230
TEL: 703.292.5111 | FIRS: 800.877.8339 | TDD: 800.281.8749

February 2016

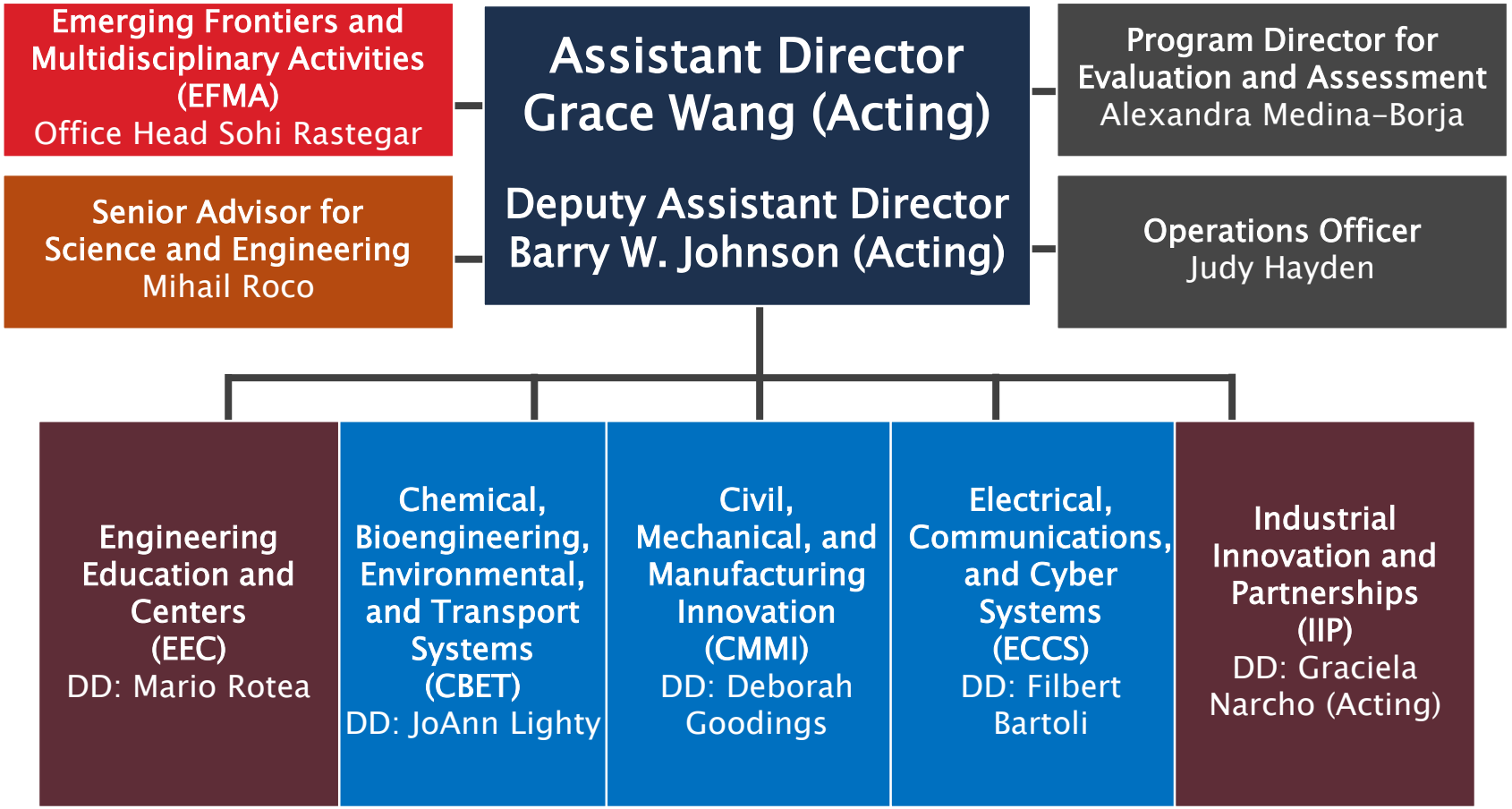
NSF in Perspective

2015 Total Federal R&D Budget for the United States ($135.4 billion)



*Dollar Amounts in billions

Directorate for Engineering



NSF and ENG Initiatives and Priorities

- Innovations at the Nexus of Food, Energy, and Water Systems
- Risk and Resilience
- Clean Energy Technology
- Cyber-Enabled Materials, Manufacturing, and Smart Systems
  - Advanced Manufacturing
- Smart and Connected Communities
- National Nanotechnology Initiative
- Understanding the Brain
  - BRAIN Initiative
- Broadening Participation
  - NSF INCLUDES: Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science
- National Strategic Computing Initiative
- Innovation Corps (I-Corps)

Clean Energy Funding

Program	FY 2014 Actual	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
Clean Energy R&D	$351.07	$356.02	$371.45	$512.22

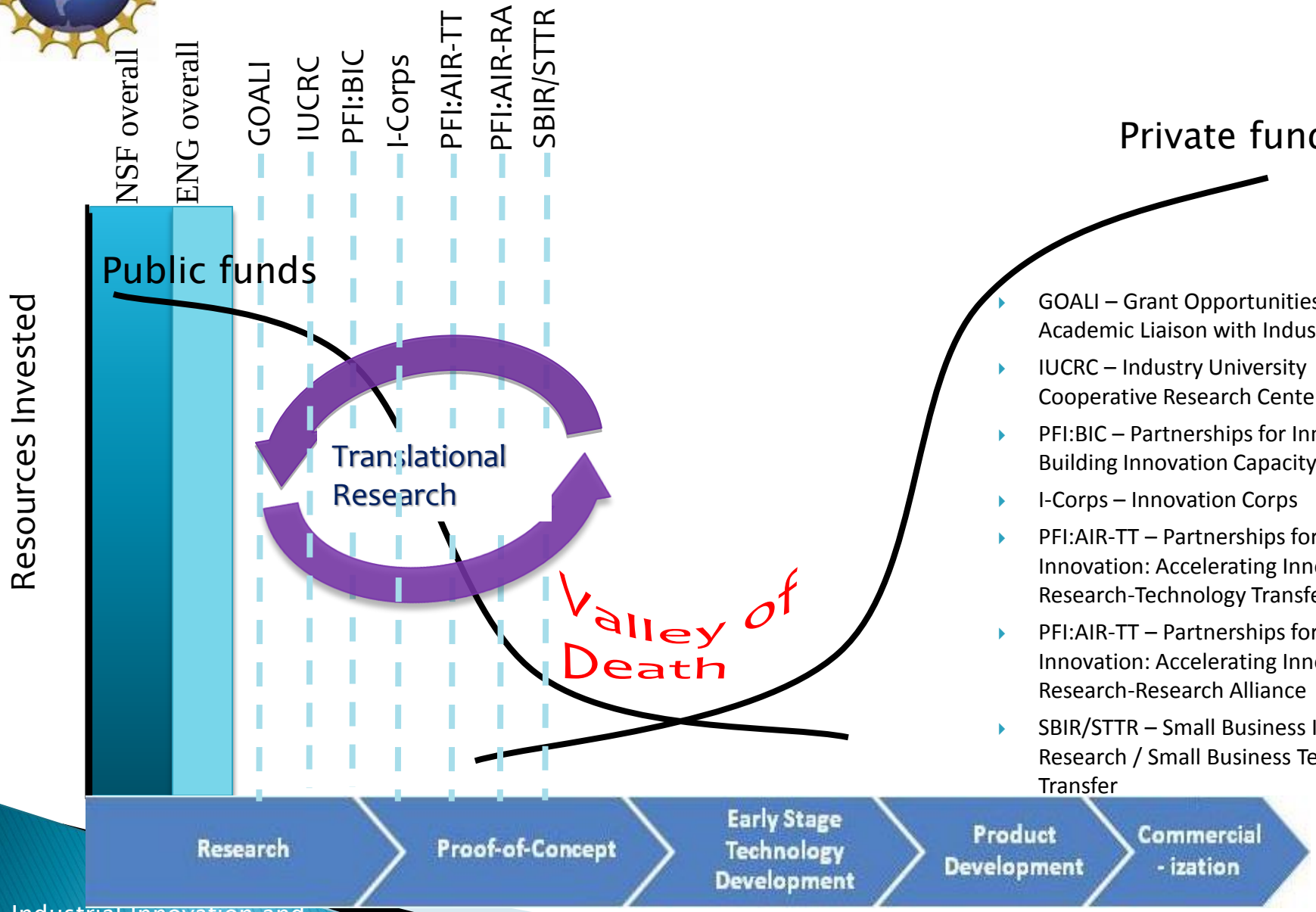
Note: Dollars in Millions

- NSF's clean energy portfolio supports research and education in innovative renewable and alternative energy sources for electricity (solar, wind, wave, geothermal) and fuels (chemical and biofuels).

- NSF funding also addresses the collection, conversion, storage, and distribution of energy from diverse power sources, including smart grids; the science and engineering of energy materials; and energy use and efficiency, including for computing systems.

- Clean energy research addresses our advancement toward reliable and sustainable energy resources and systems that preserve essential ecosystems and environmental services, promote positive social and economic outcomes, and prepare society to responsibly adopt them.

Example Relevant Translational Programs



- GOALI – Grant Opportunities for Academic Liaison with Industry
- IUCRC – Industry University Cooperative Research Centers
- PFI:BIC – Partnerships for Innovation: Building Innovation Capacity
- I-Corps – Innovation Corps
- PFI:AIR-TT – Partnerships for Innovation: Accelerating Innovation Research-Technology Transfer
- PFI:AIR-TT – Partnerships for Innovation: Accelerating Innovation Research-Research Alliance
- SBIR/STTR – Small Business Innovation Research / Small Business Technology Transfer

One Example

Universities

- University of Massachusetts at Lowell
- University of Texas at Dallas

Research Topics

- Composites and blade manufacturing
- Foundations and towers
- Structural health monitoring, non-destructive inspection, and testing
- Wind farm modeling and measurement campaign
- Control systems for turbines and farms
- Energy storage and grid integration

Questions and Contact

Barry W. Johnson, Ph.D.
Acting Deputy Assistant Director
Directorate for Engineering
National Science Foundation
Email: bwjohnso@nsf.gov

Science-Informed Decisions from Use-Inspired Research

BOEM's Environmental Studies Program

Dr. Rodney E. Cluck

Chief, Environmental Studies Program

BOEM | Office of Environmental Programs

September 20, 2016 | *www.boem.gov*

BOEM MISSION

Manage ocean energy and mineral resources on the Outer Continental Shelf in a safe and environmentally sound manner.

PROGRAM AREAS

Oil & Gas

5-year leasing plan

Regional lease sales

Renewable Energy

Site identification through stakeholder input and state task forces

Marine Minerals

Through negotiated agreement with state and local entities

ENVIRONMENTAL PROGRAMS MISSION

To study and prevent environmental harm from energy development and minerals extraction on the Outer Continental Shelf

ENVIRONMENTAL STUDIES PROGRAM PRINCIPLES

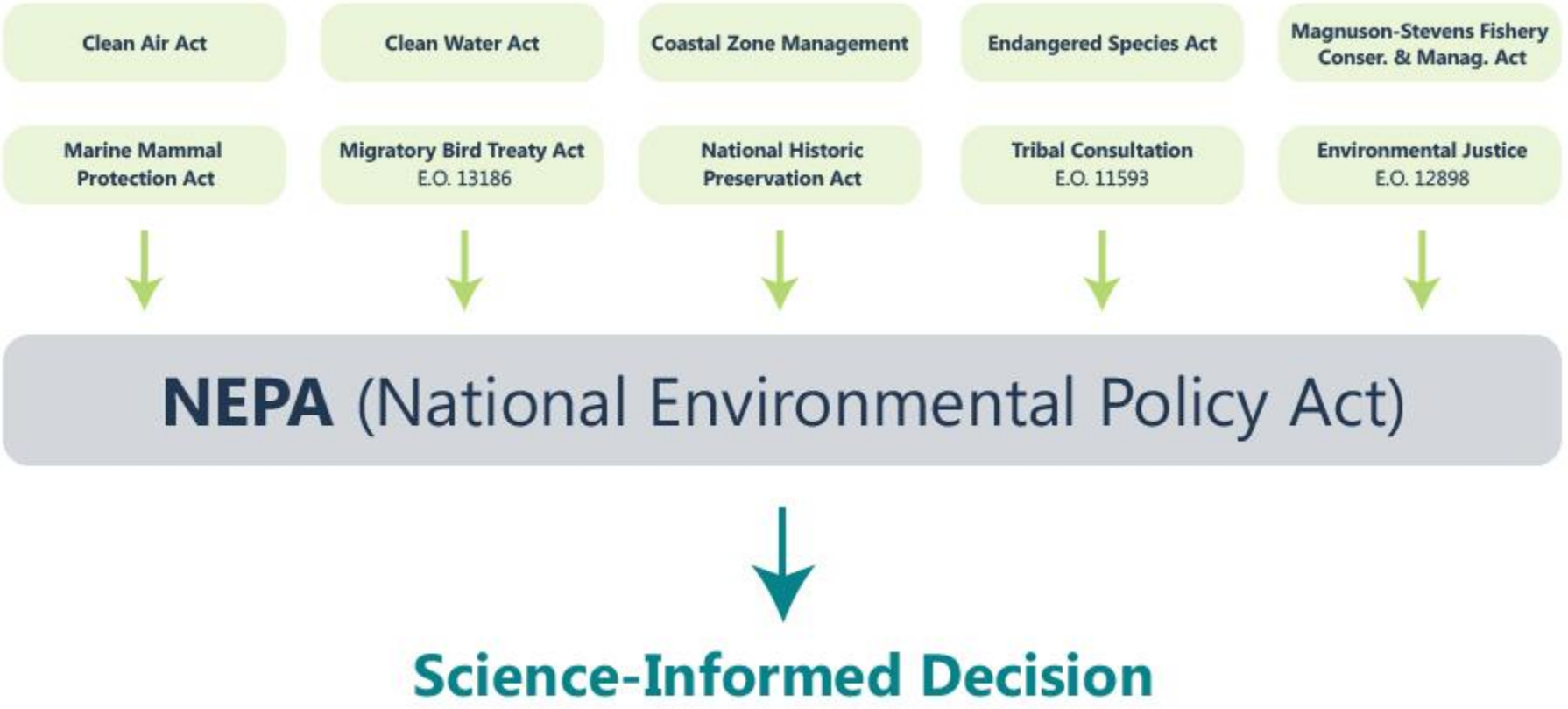
Remain **use-inspired** to apply results towards management decisions

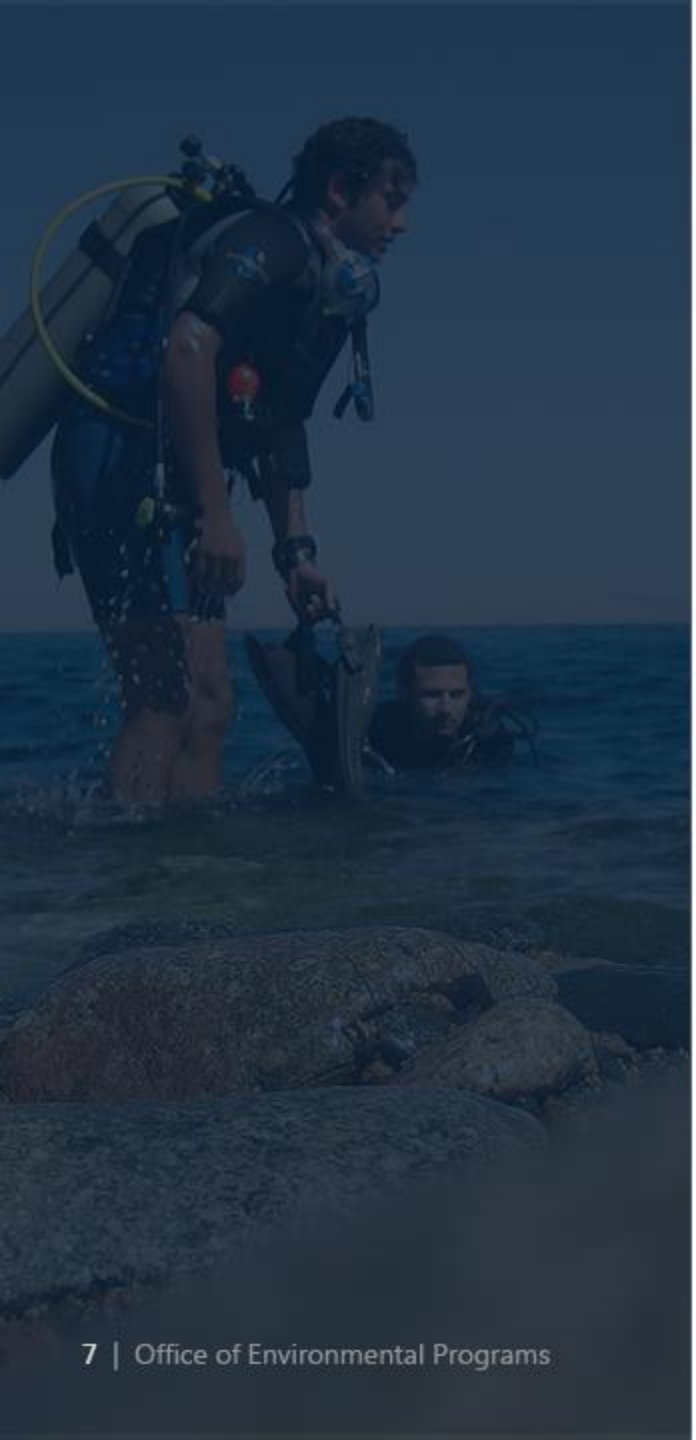
Adhere to the utmost levels of **scientific integrity** and credibility

Seek partnerships to leverage funds and maximize utility of results

Engage regularly with stakeholders and public educational outreach for quality assurance, peer-review planning, and data dissemination

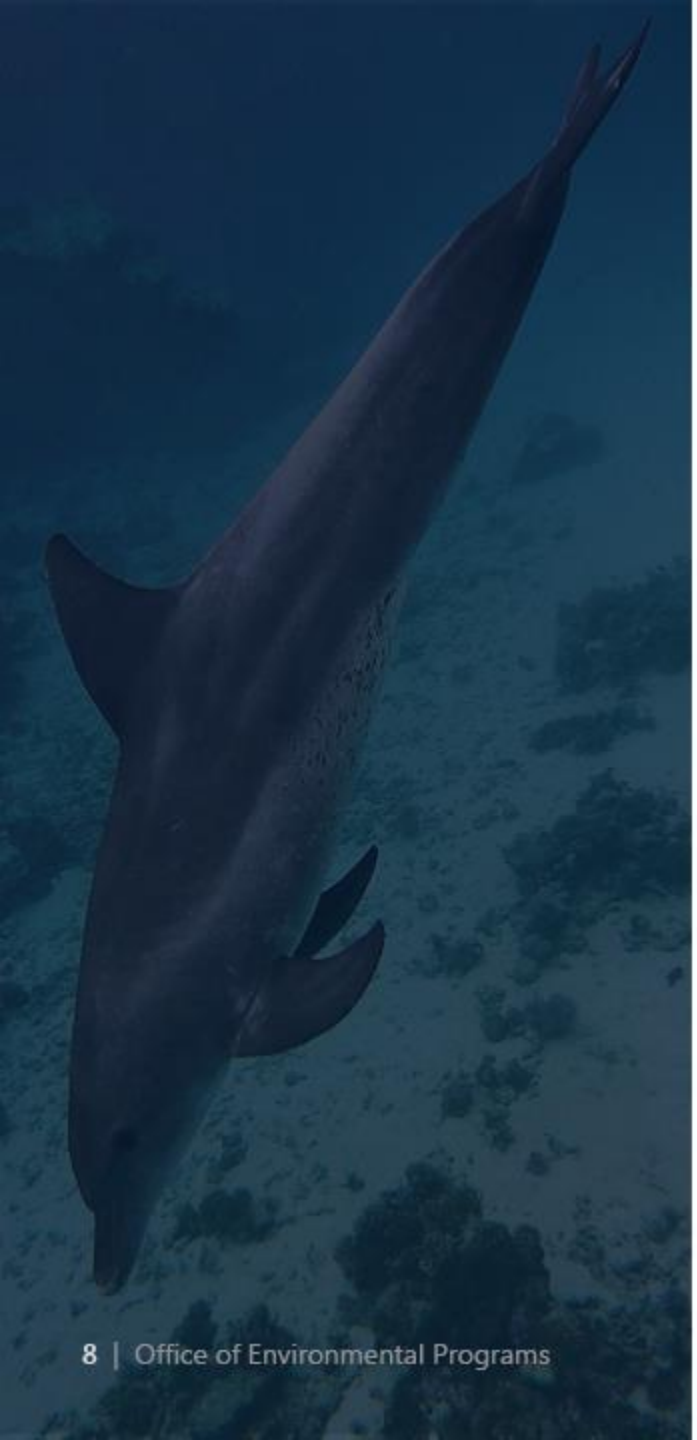
SCIENCE/ASSESSMENT INFLUENCE





STUDY DEVELOPMENT PLAN

Allows **ideas to flow**
with a look toward the future



ESP RESEARCH AREAS

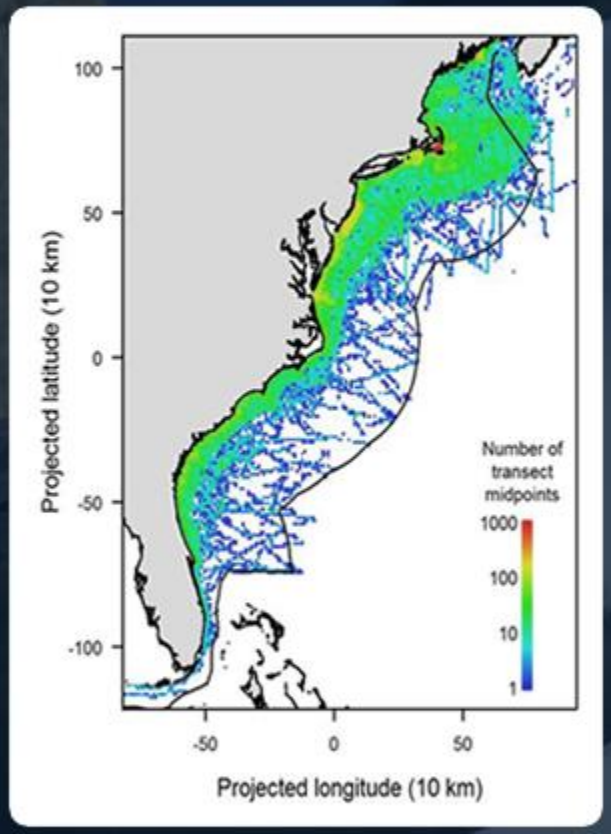
avian biology
marine mammals
sea turtles
fish
invertebrates
corals
benthic ecology
chemical and physical oceanography
marine and coastal ecology
marine acoustics
marine archaeology
data management
meteorology, air quality
economics
sociology and anthropology

ARCHAEOLOGY

Inventory and analysis of **archaeological site occurrence** on the Atlantic Outer Continental Shelf

Surveys off Massachusetts, North and South Carolina, Virginia, Rhode Island, and Maryland

Compendium of Avian Occurrence Information for the Continental Shelf Waters along the Atlantic Coast



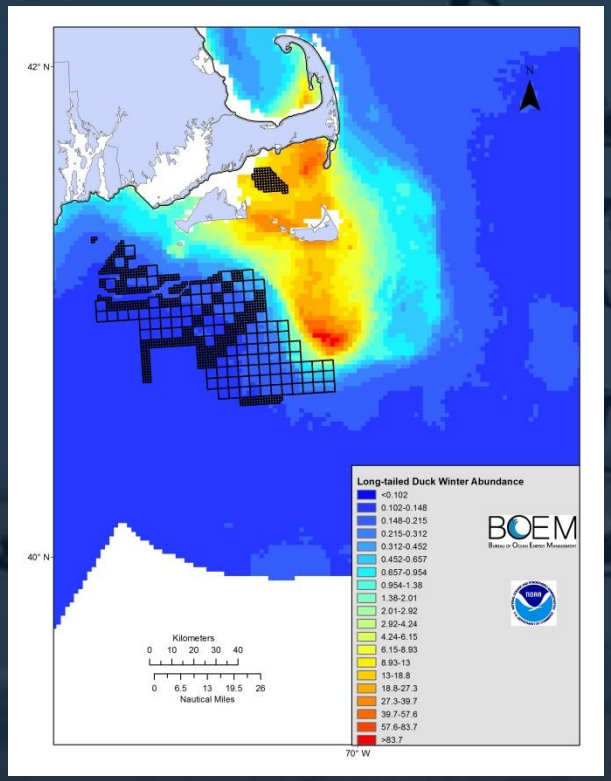
Partnership with **USGS, USFWS** and **NOAA** to compile existing survey data

80 datasets from federal and state sources and developers. Continually updated

Data standardized into common format for regional analyses

Informs siting decisions and consultations

Integrative Statistical Modeling and Predictive Mapping of Seabird Distribution & Abundance on the Atlantic OCS



- Partnership with **NOAA**
- Over **70 data sources**
- Seasonal maps of **46 species**
- Informs siting decisions and consultations
- Maps available on *MarineCadastre.gov* and Northeast Regional Ocean Council's website

TELEMETRY – Tagging & Tracking

Understanding migratory patterns of birds, turtles, and marine mammals

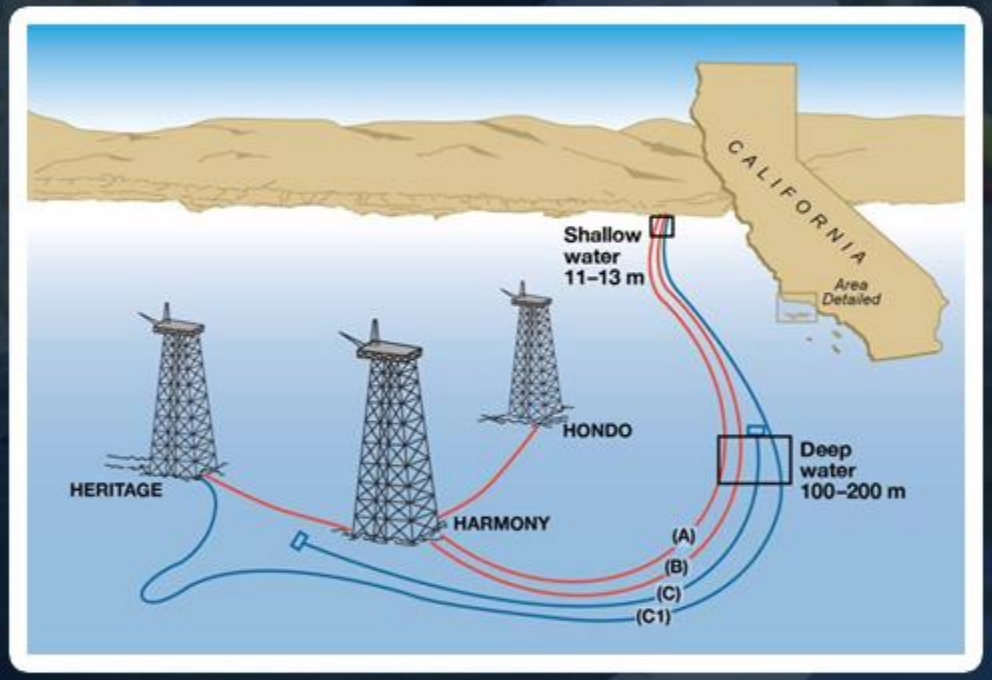
BOEM, ONR, MMC, and NOAA/IOOS initiated the evolving Animal Telemetry Network (ATN) — long-term monitoring — ecosystem-based management

Dr. Peter Paton, Dept. of Natural Resources Science, Univ. of Rhode Island

ATLANTIC MARINE ASSESSMENT PROGRAM for Protected Species

Partnership with **NOAA** and **USFWS** to collect data on distribution and abundance of marine mammals, sea turtles, and seabirds

Renewable Energy in situ Power Cable Observation



Determine attraction or repulsion of **fish and macroinvertebrates** to EMF

Measured EMF along both energized and unenergized power cables from offshore oil platforms

No response from fish or macroinvertebrates to EMF

Real-time Opportunity for Development Environmental Observations (RODEO)

Collecting sound measurements, Block Island Wind Farm, *September 2015*

Collect real-time measurements of the construction and operation activities **from the first facilities to be built** to allow for more accurate assessments of the **actual environmental effects** and inform development of appropriate mitigation measures.

Real-time Opportunity for Development Environmental Observations (RODEO)

5-year contract with HDR Engineering

Initial project at **Block Island Wind Farm** off Rhode Island

Potential projects could be Virginia, New Jersey, or Massachusetts, depending when steel is in the water

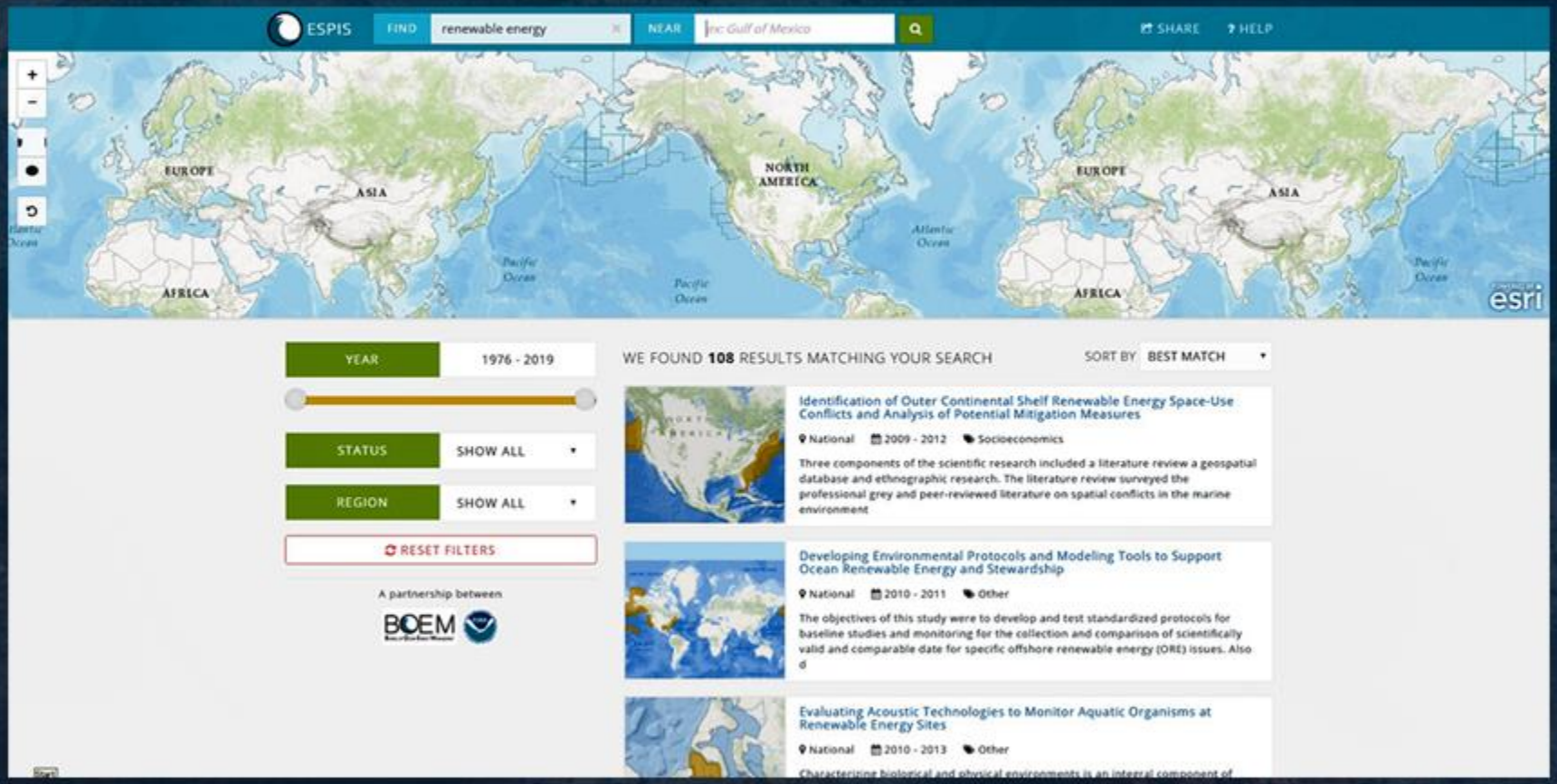
Topic areas addressed:

Air Quality | Sound | Seafloor Disturbance | Visual
Testing of Monitoring Equipment | Evaluating Mitigation Equipment

BENTHIC HABITAT

Fishery Physical Habitat and Epibenthic Invertebrate Baseline Data Collection

Environmental Studies Program Information System (ESPIS)



www.boem.gov/Studies

"Science for Informed Decisions"

Dr. Rodney Cluck
Chief, Environmental Studies Program
BOEM | Office of Environmental Programs

rodney.cluck@boem.gov

BOEM
Bureau of Ocean Energy Management

Welcome

WIND . ASSURING CONFIDENCE THROUGH COMPETENCE

Andreas Reuter

Fraunhofer IWES

Short profile of Fraunhofer IWES North-West

Managing Director	Prof. Dr.-Ing. Andreas Reuter
Research spectrum	Wind energy from material development to grid connection
Operational budget 2015	€ 15 million
Staff	150 employees
Located in	Bremerhaven, Oldenburg, Bremen, Hanover
Investments to date in the establishment of infrastructure	€ 60 million

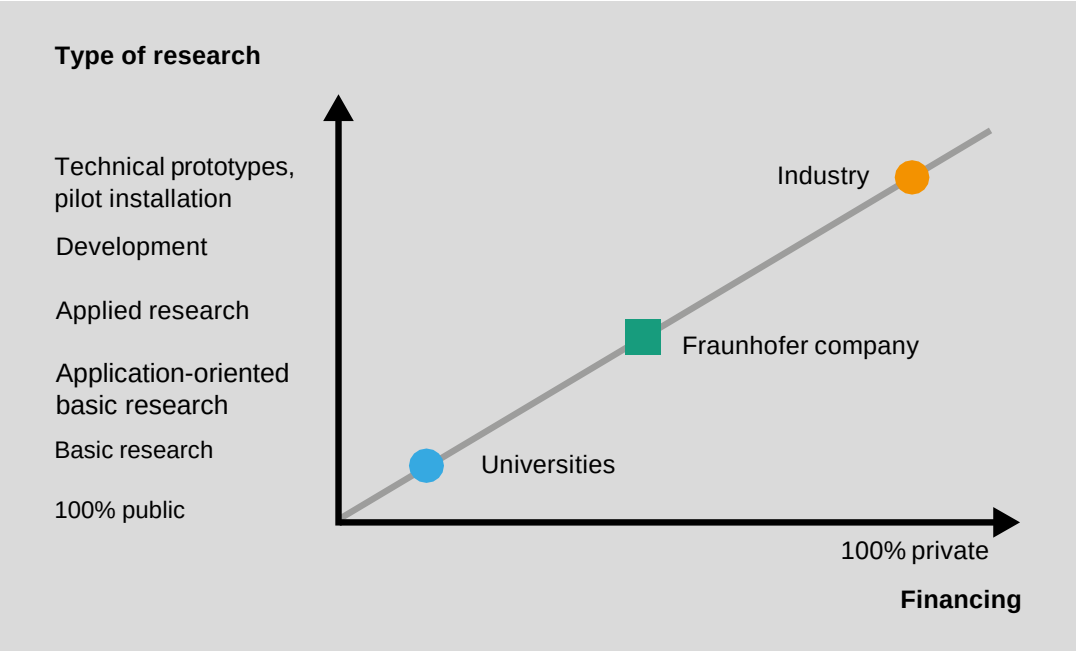
Research Alliance Wind Energy

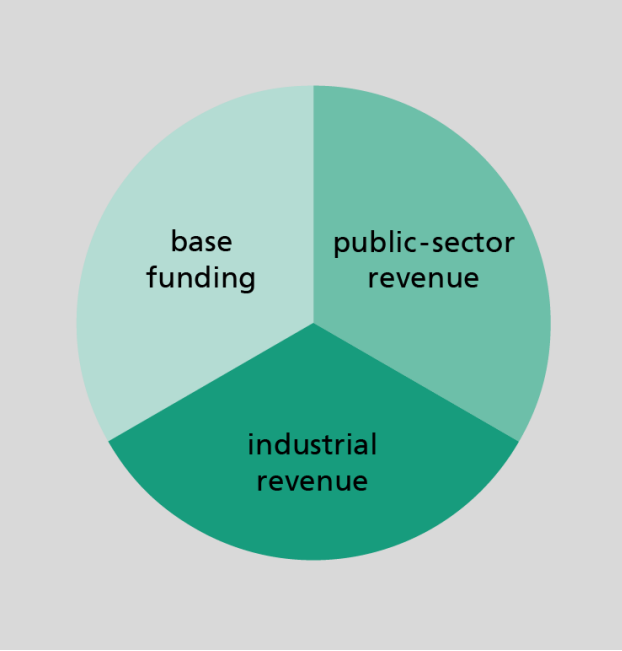
Strategic Alliance with ForWind and the German Aerospace Center (DLR)

Fraunhofer IWES

Fraunhofer's business model: Focus on industry as a factor for success

- 67 Fraunhofer institutes in Germany
- More than 24,000 employees, mainly with an academic background in natural or engineering sciences
- € 2.1 billion annual research budget





Fraunhofer IWES


Accelerated time to market through realistic testing

Rotor blade test hall up to 90 meters

- Testing of design prototypes prior to series production
- Max. static bending moment 115,000 kNm; max. dynamic bending moment: +/- 30,000 kNm

DyNaLab with 10 MW drive performance / peak 15 MW

- Nominal torque: > 8.6 MNm
- Rotor load application unit for dynamic bending moments, thrust and radial forces
- Artificial grid: 44 MVA installed inverter power

Support structure test center

- Testing of fatigue behavior of foundations and support structures
- Scale 1:10 to 1:3.5

Fraunhofer IWES

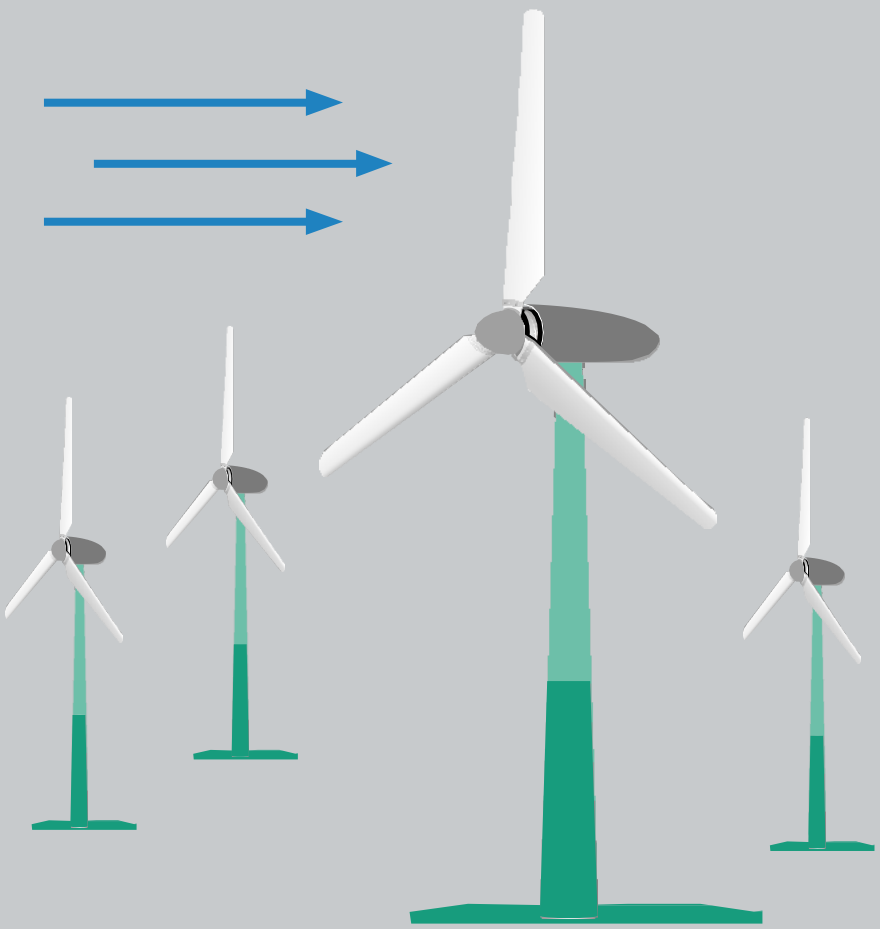
Research with added value

Field measurements, computational fluid dynamics and wind farm simulation

Rotor

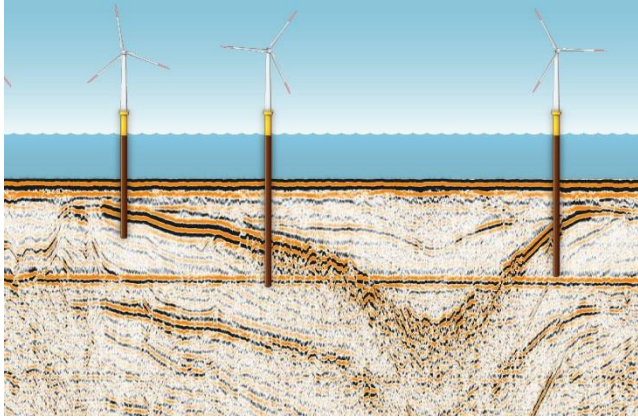
Drive train and grid connection

Support structures, foundations and assessment of soil conditions



Fraunhofer IWES





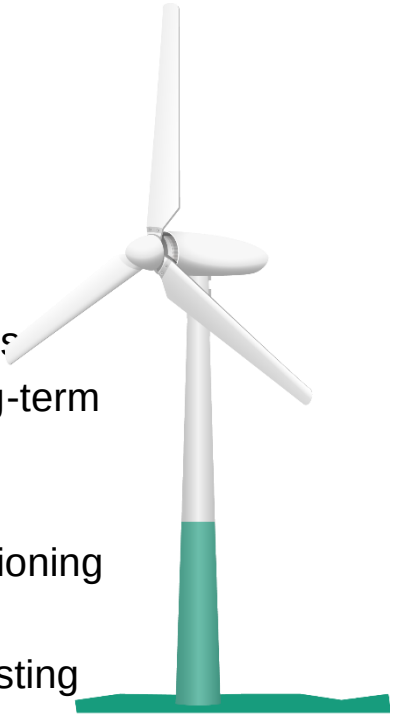
Support structures, foundations and assessment of soil conditions

Support structures & foundations

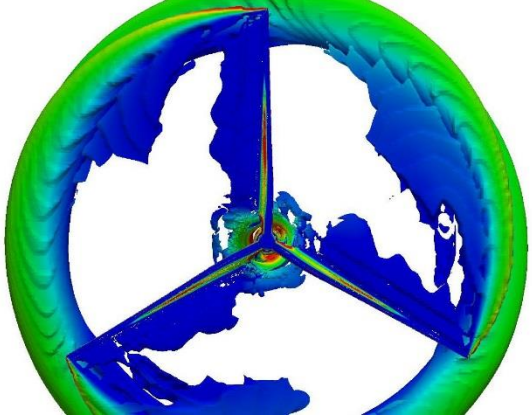
- Experimental model testing on foundation elements and substructures
- Numerical calculation and simulations
- Development and testing of environmentally friendly construction methods
- Simulation of the structure's dynamic and fatigue behavior under the long-term cyclic influence in "time lapse"

Geotechnical measurement and consulting service

- Evaluation of the subsoil with multi-channel seismic for improved dimensioning of support structures
- Drilling campaigns, in-situ soil exploration and geotechnical laboratory testing of seabed samples



Fraunhofer IWES



Rotor

Aerodynamic modeling

- Optimization of aerodynamic characteristics, e.g., adjustable flaps, trailing edge
- Numerical simulation of flow effects with OpenFOAM
- Wind field generator based on the continuous time random walk model

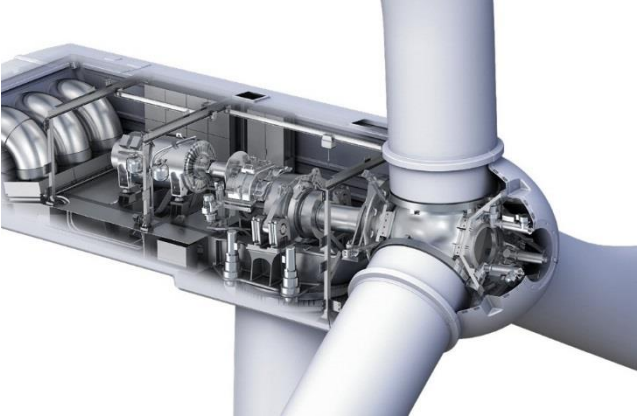
Qualification of composite materials and components

- 70- and 90-meter testing facility certification approval
- Accredited testing of specimens and components

Industrialized manufacturing

- Experimental tests in the “BladeMaker“ demonstration center
- Validation testing of manufacturing processes and materials
- CNC-controlled production cell with 2 cooperating 6-axis gantries

Fraunhofer IWES



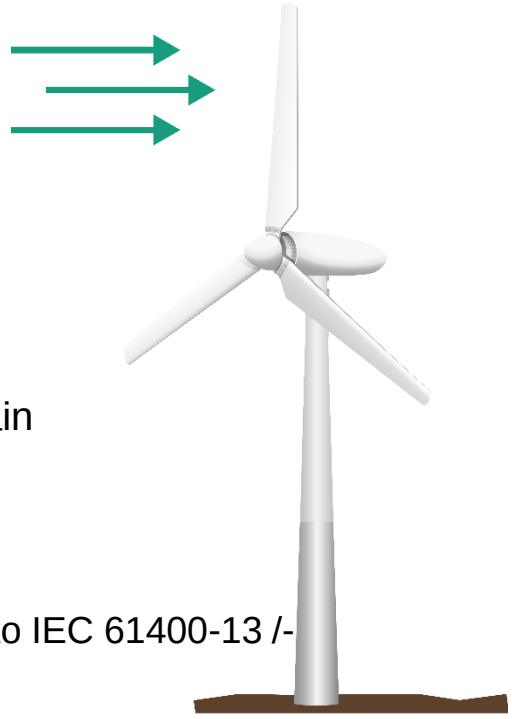
Drive trains and grid connection

- Technical reliability of mechatronical systems
- Identification and certification of the electrical characteristics of wind turbines as generating units in the laboratory and high resolution, electrical measurements of generator converter interfaces
- Pitch bearings and drives for “continuous individual pitch control”
- Planning and implementation of system tests, accelerated lifetime tests
- Model validation

Fraunhofer IWES



Site assessment, CFD simulation and field measurements



Site assessment onshore and offshore

- wind speed measurements with LiDAR devices up to 200 meters
- high-resolution, spatial geophysical analysis of planning areas

CFD simulation and wind farm modeling

- Numerical simulations (CFD) for site assessment in complex terrain
- Optimization of entire wind farms with flapFoam

Accredited measurements of operating turbines

- Measurement of mechanical loads and power performance according to IEC 61400-13 /-12
- Analysis of component dynamics, loads and operating behavior

Fraunhofer IWES

RAVE – Research at alpha ventus

- North Sea, EEZ
- 45 km north of Borkum
- Water depth: 30 m
- 12 turbines 5 MW class AREVA Wind M5000 REpower 5M
- CAPEX: 250 M€

Fraunhofer IWES

RAVE – Research at alpha ventus

Fraunhofer IWES

RAVE – Research at alpha ventus

- Funded by the Federal Ministry for Economic Affairs and Energy (BMWi)
- Accompanying research at the alpha ventus test site
- +30 R&D projects
- +50 mill. € support
- +50 project partners

RAVE – Steering Committee :

Projektträger Jülich Forschungszentrum Jülich · Fraunhofer IWES · Adwen An AREVA Gamesa Company · SENVION wind energy solutions · KIT Karlsruhe Institute of Technology · ForWind Zentrum für Windenergieforschung · FH Flensburg · Hochschule Bremerhaven · BSH Bundesamt für Seeschifffahrt und Hydrographie

Bundesministerium für Wirtschaft und Energie · alpha ventus · BAM · DEWI · Leibniz Universität Hannover · Universität Stuttgart Germany · Carl von Ossietzky Universität Oldenburg

Fraunhofer IWES

RAVE – Research at alpha ventus

~ 1,200 sensors

- strain gauges
- acceleration
- acoustic sensors
- hydrographic sensors
- met data (sonic, lidar)
- sonars
- water pressure sensors
- SCADA
- corrosion
- video cam, radar

Fraunhofer IWES

RAVE – Research at alpha ventus

Fraunhofer IWES

Acknowledgements
Fraunhofer IWES is funded by the:

Federal Republic of Germany

Federal Ministry for Economic Affairs and Energy

Federal Ministry of Education and Research

European Regional Development Fund (ERDF):

Federal State of Bremen

- Senator of Civil Engineering, Environment and Transportation
- Senator of Economy, Labor and Ports
- Senator of Science, Health and Consumer Protection
- Bremerhavener Gesellschaft für Investitions-Förderung und Stadtentwicklung GmbH

Federal State of Lower Saxony

Thank You For Your Attention

Fraunhofer IWES

Explorations of Research and Innovation Frameworks

Tufts

ATMOSPHERE TO ELECTRONS

U.S. DEPARTMENT OF ENERGY

Atmosphere to Electrons (A2e)

Research Consortia

Michael Derby, Program Manager RDD&T
Wind Energy Technologies Office
September 20, 2016

Atmosphere to Electrons (A2e)

A technology initiative to enable design and deployment of
low-cost Smart Wind Power Plants

- Transform today's wind plant operating environment through advanced physics-based modeling, analysis and simulation
- Revolutionize advanced systems-level control capabilities that adopt flow monitoring and active wake control to mitigate energy and performance losses;
- Enable innovative wind plant technologies through an enhanced understanding of wind plant physics

DOE Wind Program

- Federal Engagement & Oversight
- Integrated Program & Project Management
- Budgetary Control

National Labs & Universities

- Subject Matter Expertise
- Project Planning
- R&D Execution

Atmosphere to Electrons (A2e)

- ✓ DOE lead partnership with National Laboratories, Universities, Industry, and International Stakeholders
- ✓ Integrated strategic research planning coordinated through lead National Labs & DOE
- ✓ Research conducted by appropriate stakeholders
- ✓ 7 year anticipated duration

Other Fed Agencies

- Leverage Strategic Programs
- Access to HPC Core Competencies
- Subject Matter Expertise

Private Industry

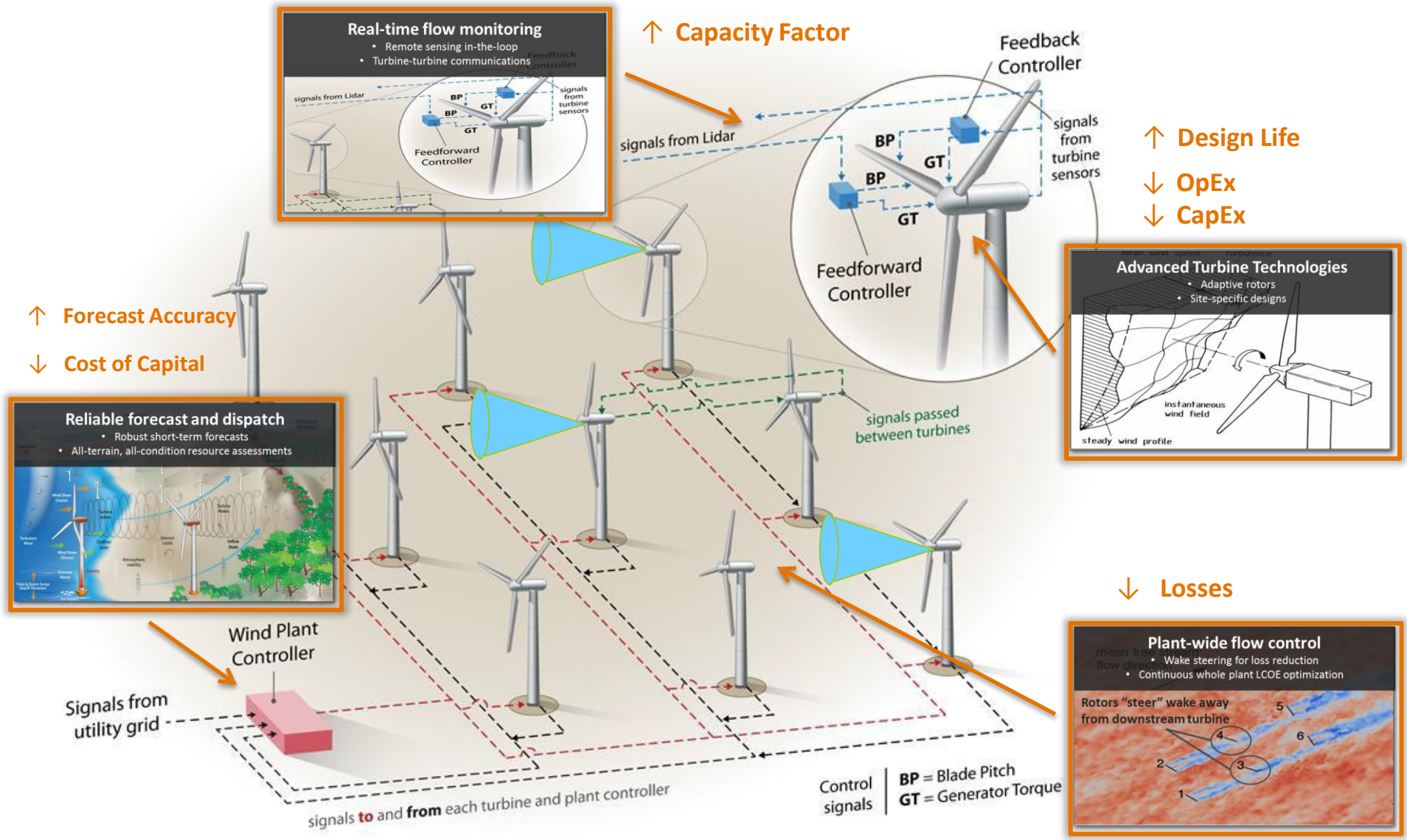
- R&D Execution
- Operational Expertise
- End User Requirements
- Access to Operating Plants

Int'l Collaboration

- Coordinated & Collaborative Research Campaigns

ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e Wind Plant of Tomorrow

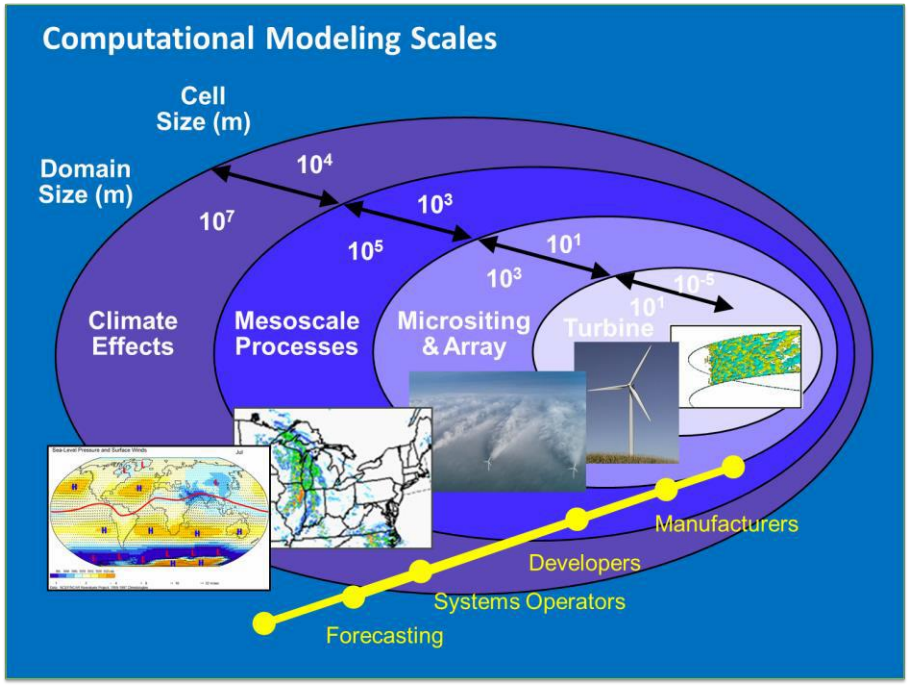


ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e Science Challenges:

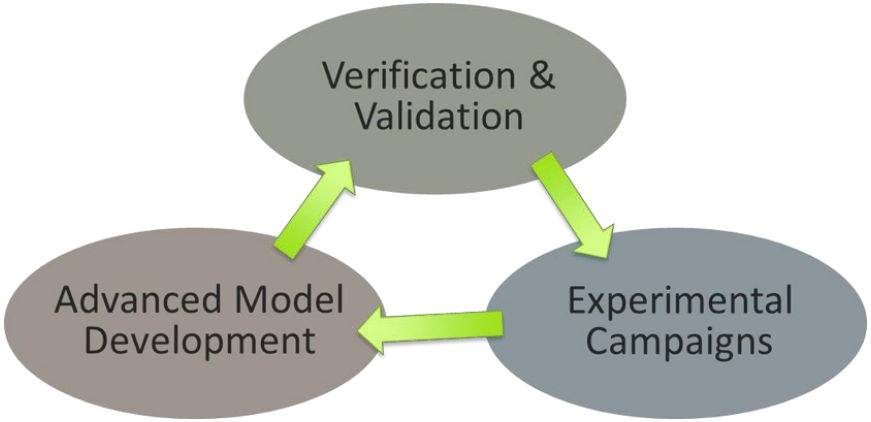
Energy Capture & Performance Driven by Multiple Scale Physical Processes

- Wind resource determined by weather driven phenomena at Mesoscale;
- Planetary Boundary Layer (PBL) is the wind plant energy resource;
- Turbine scale (e.g. rotor, blade) inflow characteristics directly impact production and turbine loading
- Blade scale sets the dynamic wake flow (meandering) & aeroacoustic characteristics
- Multiple turbine arrays and complex flow modify and alter the inflow, create energy loss, add turbulence and adversely impact turbine & plant performance



Wind Plant Physics Challenge:

- Multiple physics at multiple scales drive wind plant performance
- Physics resolved through loosely or uncoupled modeling and simulation approaches
- Quantifying uncertainty is the critical factor to industry in order to quantify risk.
- HPC capability to assess the temporally and spatially complex PBL/wind plant interaction driving wind plant performance



ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e management construct

Executive Management Committee (EMC)

Director: *Michael Derby*
Chief Scientist*: Mike Robinson (NREL)*
DOE Reps*: Joel Cline, Nick Johnson*
National Labs*: Laird (NREL), Shaw (PNNL), Womble (SNL)*

- Provides vision & direction and coordinates integrated program planning activities
- Develops and "owns" A2e integrated, multi-year strategic plan
- Conducts formal quarterly reviews of all R&D planning and project performance
- EMC members assigned to each A2e focus area

External Merit Review Board

- External assessment of A2e performance and impact on industry
- Constituency includes senior representatives from industry, national laboratories, academia, government agencies, and international stakeholders
- Members meet with A2e leadership on an annual basis to provide an outside perspective on strategic priorities

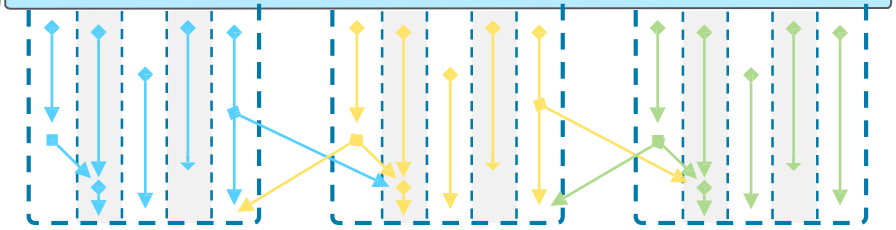
R&D Implementation Organizations

- EMC plans and coordinates R&D, does not execute
- R&D organized around Strategic Focus Areas
- Research will be conducted by the best entity for the job and will include a diverse group of industry stakeholders and research organizations

- R&D activity and implementation planning
- Coordinate research across technical areas
- Ensure research is conducted by the best entity for the job

Atmospheric Science | **Wind Plant Aerodynamics** | **Technology Development**

- Foundational R&D – Modeling & Validation
- Smart Wind Plant Technology Innovations



ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e - Identify Wind Plant Performance Challenges & Initiate Solutions

A2e Focus Area Development

1. **Financial Risk, Uncertainty, and Portfolio Analysis**
   - John Meissner (DOE Contractor)
2. **High Fidelity Modeling**
   - Dr. David Womble (SNL), Dr. Steve Hammond (NREL)
3. **Experimental Measurement Campaigns**
   - Dr. Scott Schreck (NREL), Dr. Jon White (SNL)
   - Dr. Jim Wilczak (NOAA)
4. **Data Archive and Portal**
   - Chitra Sivaraman (PNNL)
5. **Integrated Wind Plant Control**
   - Dr. Kathryn Johnson (Colorado School of Mines/NREL)
   - Dr. Dave Wilson (SNL)
6. **Wind Plant Reliability**
   - Dr. Carsten Westergaard (SNL Contractor)
   - Dr. Jonathan Keller (NREL)
7. **Aeroacoustics and Propagation**
   - Dr. Pat Moriarty (NREL)
8. **Integrated Wind Plant Design and Analysis**
   - Sandy Butterfield, (PNNL Contractor))

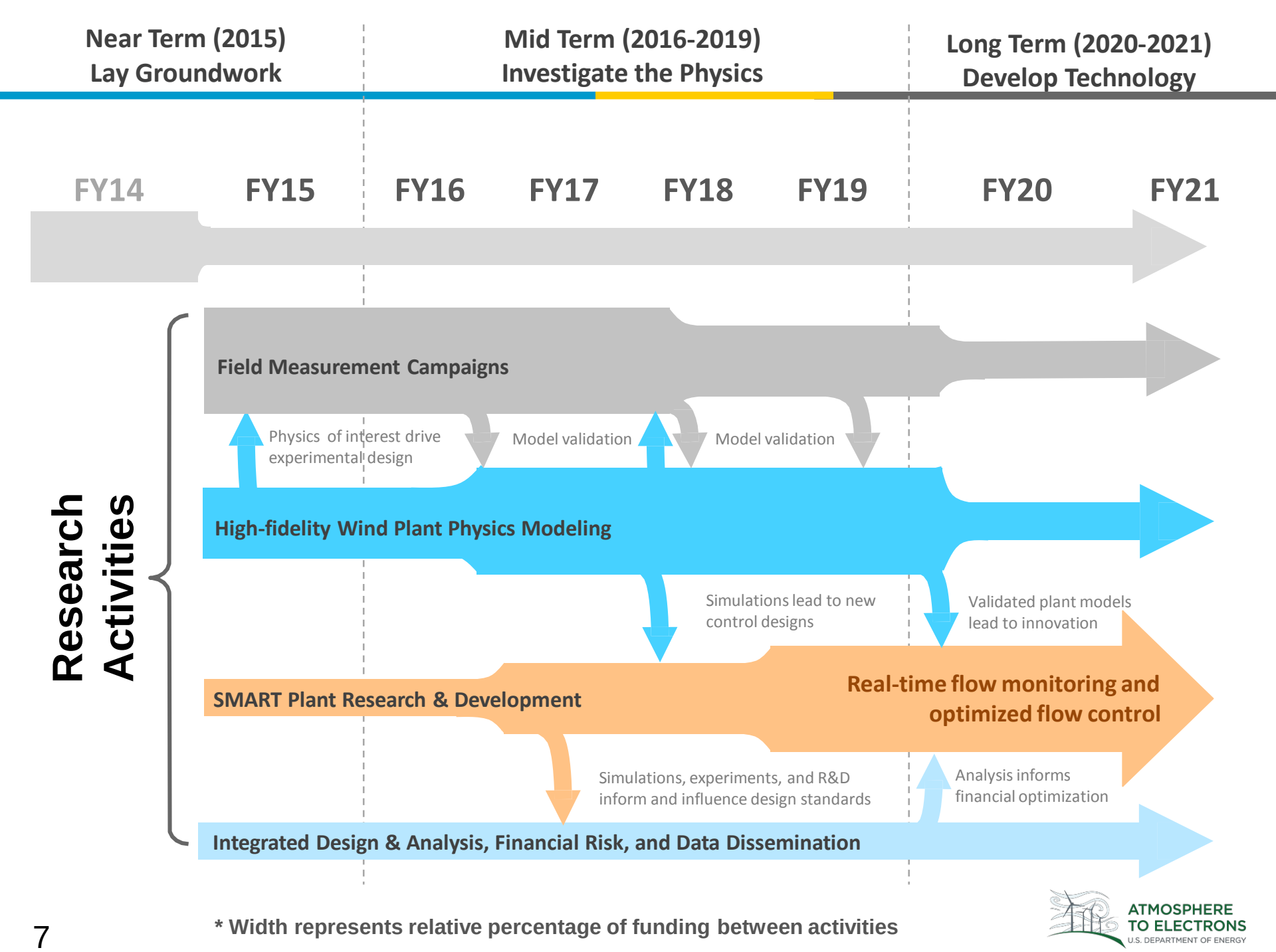
Focus Area Community Engagement

- Utilized an "Office of Science" external stakeholder workshop approach;
- Eight Strategic Workshops w/ published findings
- In excess of 350 scientists and engineers participated – domestic & international

Major Outcomes

- Identified major science challenges to wind plant optimization
- Proposed and implemented key R&D initiatives and **collaborative** programs
- Developed an A2e Strategic Plan, Multiyear Program Plan, A2e Program Fact Sheet, A2e.gov website
- Formal merit review of proposed initiatives by the Merit Review Panel
- ***Consensus for higher fidelity modeling and underlying physics determination***
  - ***High Fidelity Modeling required to resolve underlying physics***
  - ***Formal coupling of V&V, experimental validation and model development***
  - ***Experimental Data a Critical Need to Advance the State of the Art***

ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY



* Width represents relative percentage of funding between activities

ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

Established National Collaborative Projects

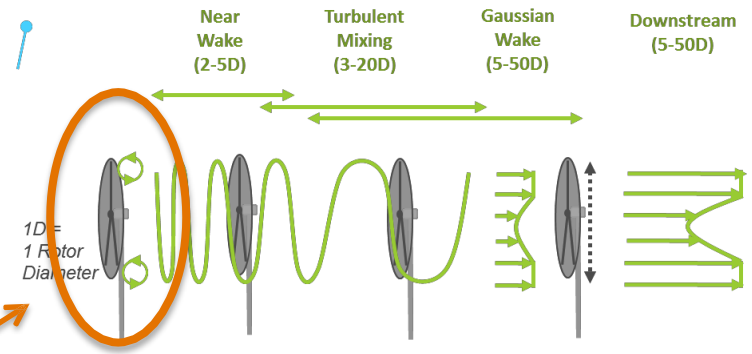
Example:

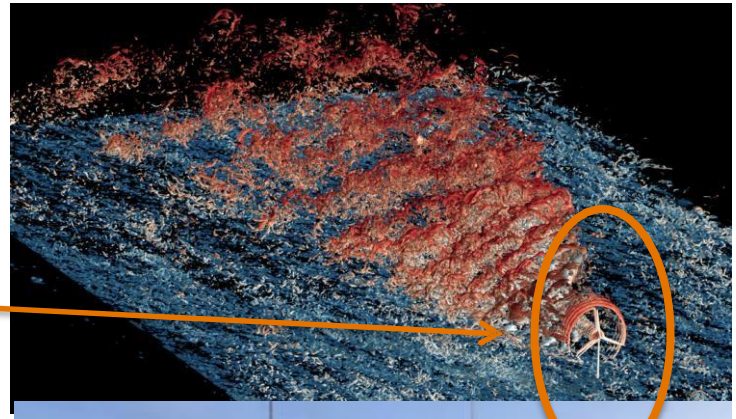
Wake Dynamics Initiative Starting with the Near Wake Development Collaborative

- Model development support (NREL & SNL)
- University modeling participation (no funds)
- Wind tunnel campaign (EU joint program?)
- SWiFT facility & wake instrumentation development

Approach:

- Workshop to identify key science challenges
- Identify required program activities
  - Simulation & Modeling
  - Wind Tunnel Testing
  - SWiFT facility validation
- Identify Collaborative Leadership Assignments (Lab/University/Industry)
  - Program PI & Activity PIs
- Develop a PIRT Requirements Document utilizing formalized V&V processes
- Finalize integrated project plans
- Implementation under a joint AOP





ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e FY16 Research

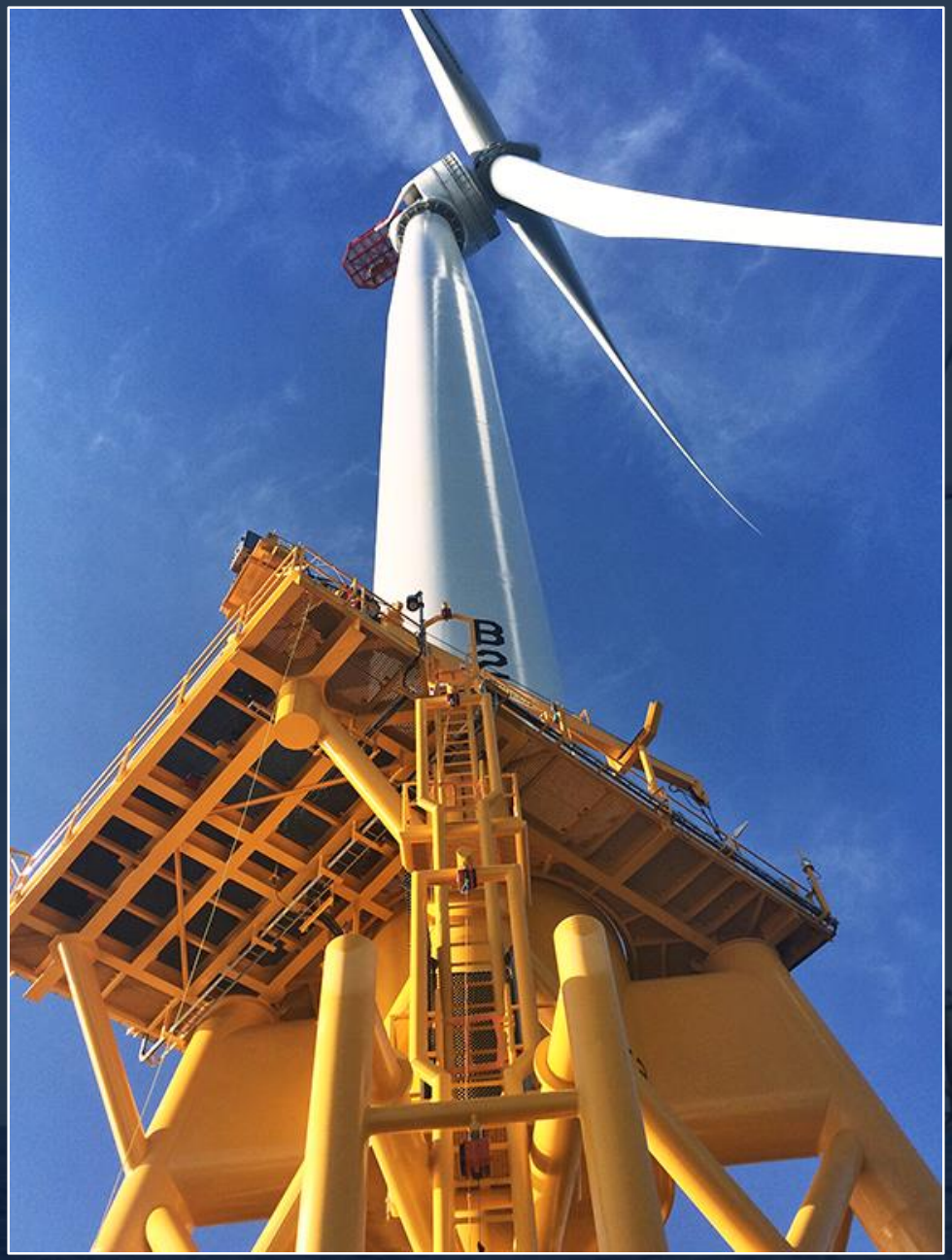
Research Area	Project	Consortia
Field Measurement Campaigns	***Wind Forecasting Improvement Project II (FOA)*** • Field measurement campaign to improve turbulence parameterizations within weather forecasting models such as WRF and improve the short-term forecasting models. • The awardee, Vaisala, Inc., is working with a larger, integrated team from NOAA and 4 DOE Laboratories to conduct a field study in the Columbia Gorge region of Washington and Oregon	Vaisala, PNNL, LLNL, NREL, ANL, NOAA
High-fidelity Wind Plant Physics Modeling	***Mesoscale-microscale Coupling*** • Bridge the modeling gap between mesoscale (≈ 1km) scale to wind plant scale (≈ 1m) – necessary to understand the exact inflow into a wind plant based on global weather patterns. • Enable simulation of critical microscale flow characteristics impacting turbine and wind plant uncertainties and performance, thus allowing substantive improvements in wind plant design, operation, and performance projections	PNNL, LLNL, NREL, LANL, ANL, NCAR
SMART Plant Research & Development	***Wind Plant Wake Dynamics and Control*** • Demonstrate wind turbine wake flow control strategies at the SWiFT facility and quantify the potential of these strategies for performance enhancement and load mitigation objectives. • Obtain high-quality datasets with uncertainty quantification closely coordinated with model development to improve industry design capability.	SNL, NREL
Supporting Crosscut Activities	***Performance, Risk, and Uncertainty in Finance (PRUF)*** • Improve understanding of financial and performance risks and uncertainties to drive lower LCOE; specifically, in initial priority, improve wind plant energy production and operational estimation process to drive reduced wind plant costs, including improved financial lending rates and increase availability of capital for investment.	NREL, LBNL, SNL, ANL

Summary

- Addressing Future R&D Wind Plant Cost & Performance Challenges
  - Expanding collaboratives with multiple laboratories, universities & industry stakeholders
  - Establishing collaborative development environments for High Performance Computing & formalized V&V
  - Collaborative field campaigns with industry to develop HFM wind plant system modeling & integrated control capability

ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

energy.gov/eere/wind/atmosphere-electrons



BOEM
Bureau of Ocean Energy Management

Offshore Renewable Energy Program

Technical Research Efforts

Daniel P. O'Connell, PE, GE

September 20, 2016

Advancing Offshore Wind Infrastructure
Washington, DC

TECHNICAL RESEARCH EFFORTS: OREP ETRB

- Technology Assessment Program
- Studies funded from other sources
- BOEM-sponsored workshops
- Interagency efforts
- Joint Industry Projects (JIPs)

TECHNOLOGY ASSESSMENT PROGRAM

- Managed by BSEE with BOEM funding
- **27 Renewable Energy Studies** completed since 2005
- Focus on structural and geotechnical aspects of foundations and support structures, and site characterization
- Assist BOEM in developing guidelines and standards
- Budget constraints limit project scope

RECENT TAP PROJECTS

- Model testing to Evaluate Degradation of Lateral and Axial Pile Capacity from Cyclic Loading
- Fatigue Design of Mooring Systems-Floating Turbines
- Cables and Offshore Substation Design Standards
- Development of Regional Metocean Conditions and Hazard Curves for Individual WEAs
- Feasibility of Suction Bucket Foundations
- Fully vs. Partially Coupled Dynamic Modeling
- Structural Health Monitoring Guidelines
- Breaking Wave Analyses

STUDIES FUNDED FROM OTHER SOURCES

- Geophysical and Geotechnical Investigation Methodology Assessment for Atlantic OCS
- UXO Survey Methodology Investigation
- Metocean Characterization Guidelines -- *pending*
- Project scope dependent on fund availability

WORKSHOPS

Georgia Tech, *May 2014*, Research Priorities

BOEM, *June 2014*, Metocean Standards

BOEM, *April 2016*, Structural Modeling

Research Priorities for Offshore Wind Foundations

- Design methods used successfully so far in EU may not be sufficient for U.S. subsurface and metocean conditions (hurricanes)
- Open questions on foundation design with respect to geometry, serviceability loading conditions, extreme loading conditions, and site characterization.
- Need R&D to focus on reducing costs through standardization of production and deployment, and establishing risk-based performance standards

Standards and Guidelines for Metocean Aspects of Offshore Wind Development

- High quality methods for metocean modeling exist but need verification for US conditions
- Improvements needed on designing for sudden wind changes and yaw control, freshwater ice, and breaking waves.
- Standards need to be updated to set levels of acceptable risk, possibly using hazard curve approach

BOEM Bureau of Ocean Energy Management NREL National Renewable Energy Laboratory April 2016 Workshop

State of Practice for Design of Offshore Wind Turbines in the U.S.

- Overview of current design practices and models for structural, geotechnical, and wind farm design
- Identification of gaps in standards and methods for U.S. offshore conditions
- **State of Practice Report** published proposing next steps to fill gaps and promote U.S. offshore wind industry development, including updating of AWEA OCRP 2012 focusing on metocean, geotechnical, and structural modeling issues, plus new OCRP for floating OWTs

INTERAGENCY EFFORTS

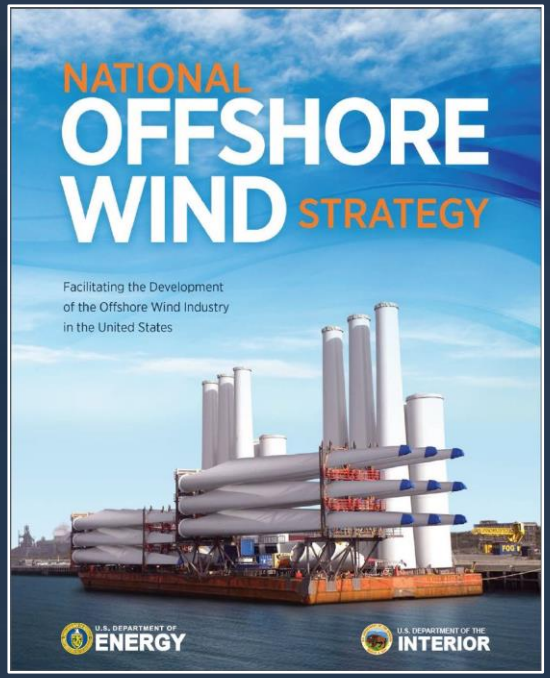
- Interagency Agreements with NREL

- DOE-DOI National Offshore Wind Strategy

- Coordination with State Agencies

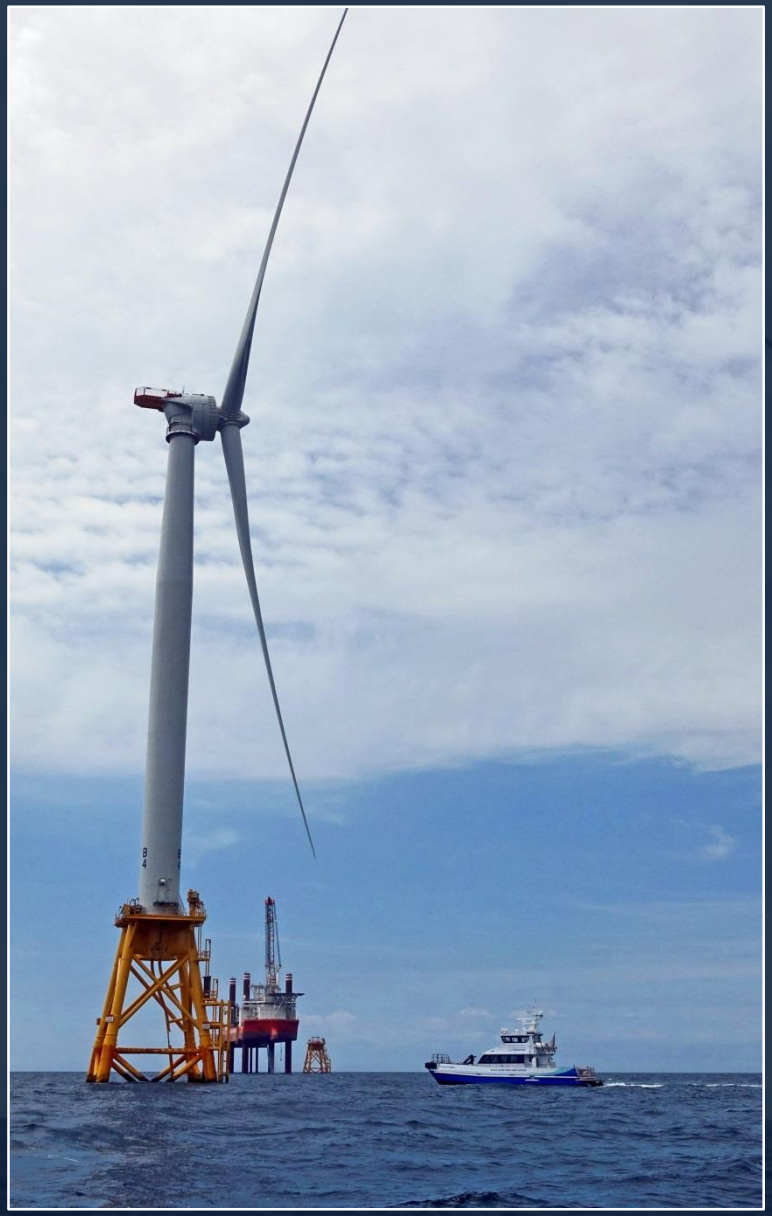
DOE-DOI NATIONAL OFFSHORE WIND STRATEGY

- 5-year update just released
- DOE focus on technological advancement
- DOI (BOEM) to enhance regulatory process to promote transparency and certainty
- Standards development and site characterization data collection and methods important issues



JOINT INDUSTRY PROJECTS (JIPS)

- Common in oil & gas
- Much larger budgets (full scale testing, site characterization studies, etc.)
- Need U.S.-based company interest



KEY PRIORITIES

Development and incorporation of U.S. standards in CFR

Structural model validation

Early site characterization data (buoys, G&G surveys)

QUESTIONS?

Thank you!

Daniel P. O'Connell, PE, GE
daniel.o'connell@boem.gov
703-787-1672

For more information visit **www.boem.gov**
Click on Renewable Energy Programs

NCCOS Biogeographic Assessments

- A Framework to Support Offshore Wind Development

September 20th, 2016

Mary Erickson & Tim Battista
NOAA's Ocean Service
National Centers for Coastal Ocean Science
Silver Spring, MD

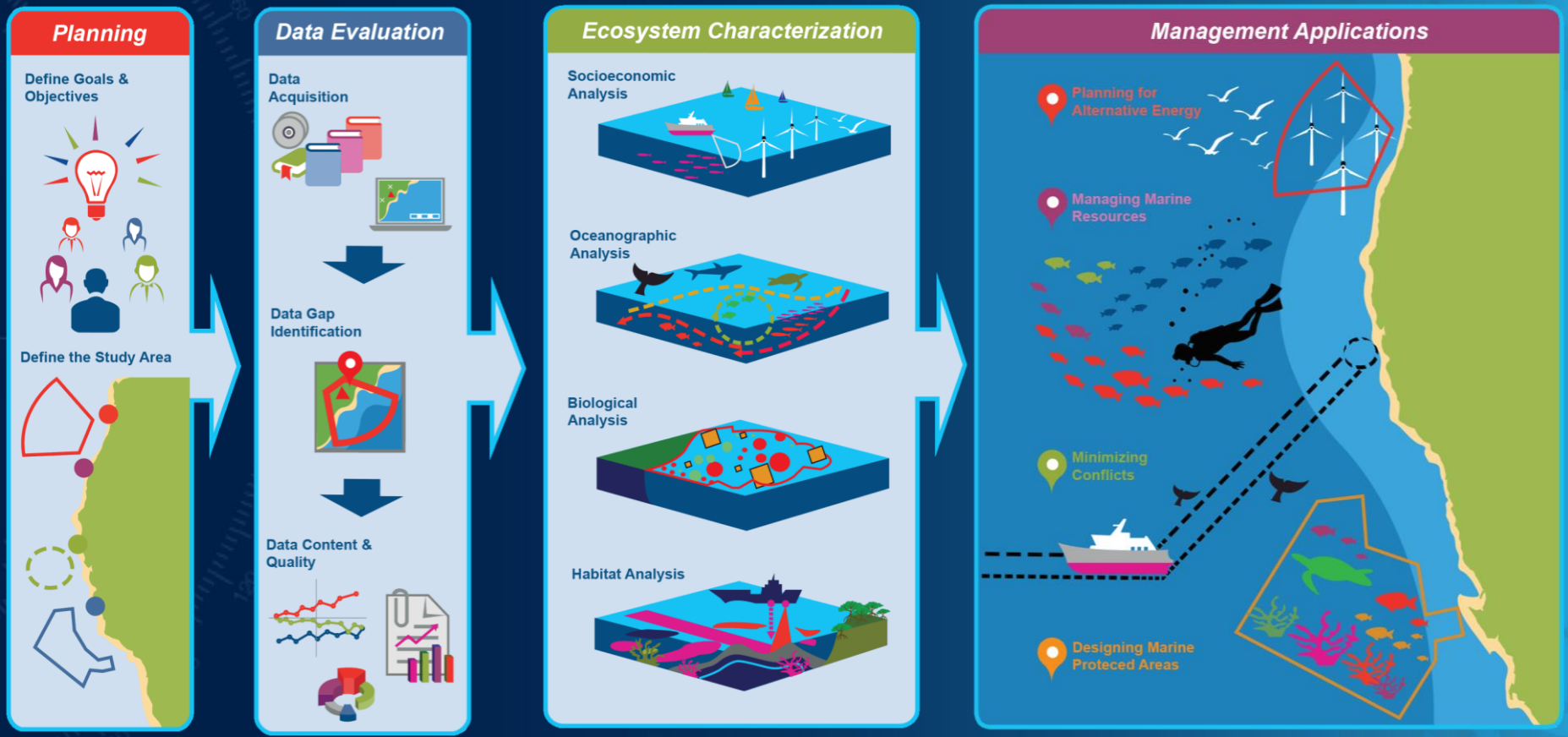
Marine Spatial Ecology

Planning for Offshore Wind Energy

- How are animals distributed spatially and temporally, and what environmental conditions may be influencing their distributions?
- Which areas are most frequently utilized by living marine resources?
- What significant gaps exist in our knowledge about the biogeography of an area?

Biogeographic Framework to Support CMSP

Caldow, C. et al. 2015. Biogeographic Assessments: A framework for information synthesis in marine spatial planning. *Marine Policy.* 51: 423-432.



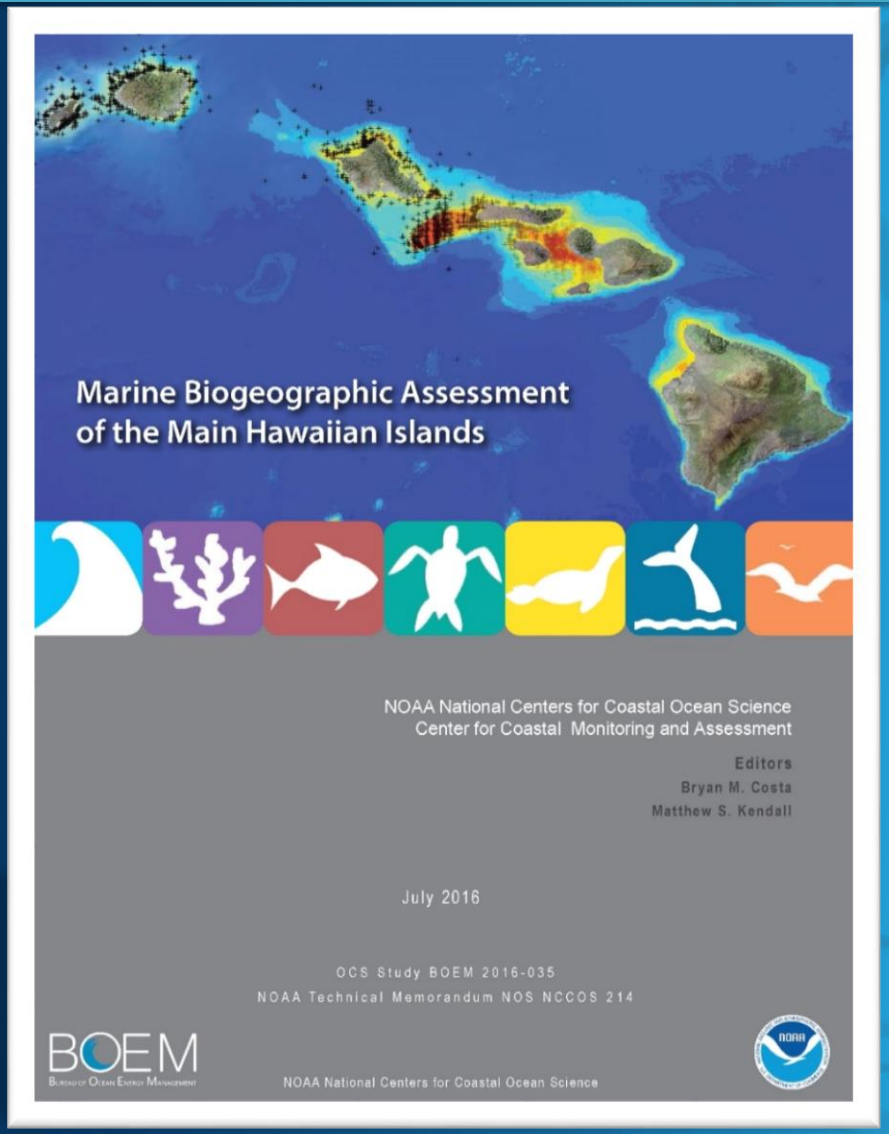
Regional Biogeographic Assessment (BOEM)

Chapter 1 – Background
Chapter 2 – Environmental Setting
Chapter 3 – Benthics
Chapter 4 – Fishes
Chapter 5 – Sea Turtles
Chapter 6 – Marine Mammals
Chapter 7 – Seabirds

Appendix A – Ch. 2 maps
Appendix B – Ch. 6 & 7 Methods
Glossary – Definition of key technical terms in report

Total = ~ 375 pages

https://coastalscience.noaa.gov/projects/detail?key=163



Ch. 2: Environmental Setting

Authors: Bryan Costa, Matthew Poti, Arliss J. Winship, Peter I. Miller, Jamison Gove

Purpose: Provide regional context & inputs for species distribution models.

111 Spatial Layers (Public):

Topographic & Geographic

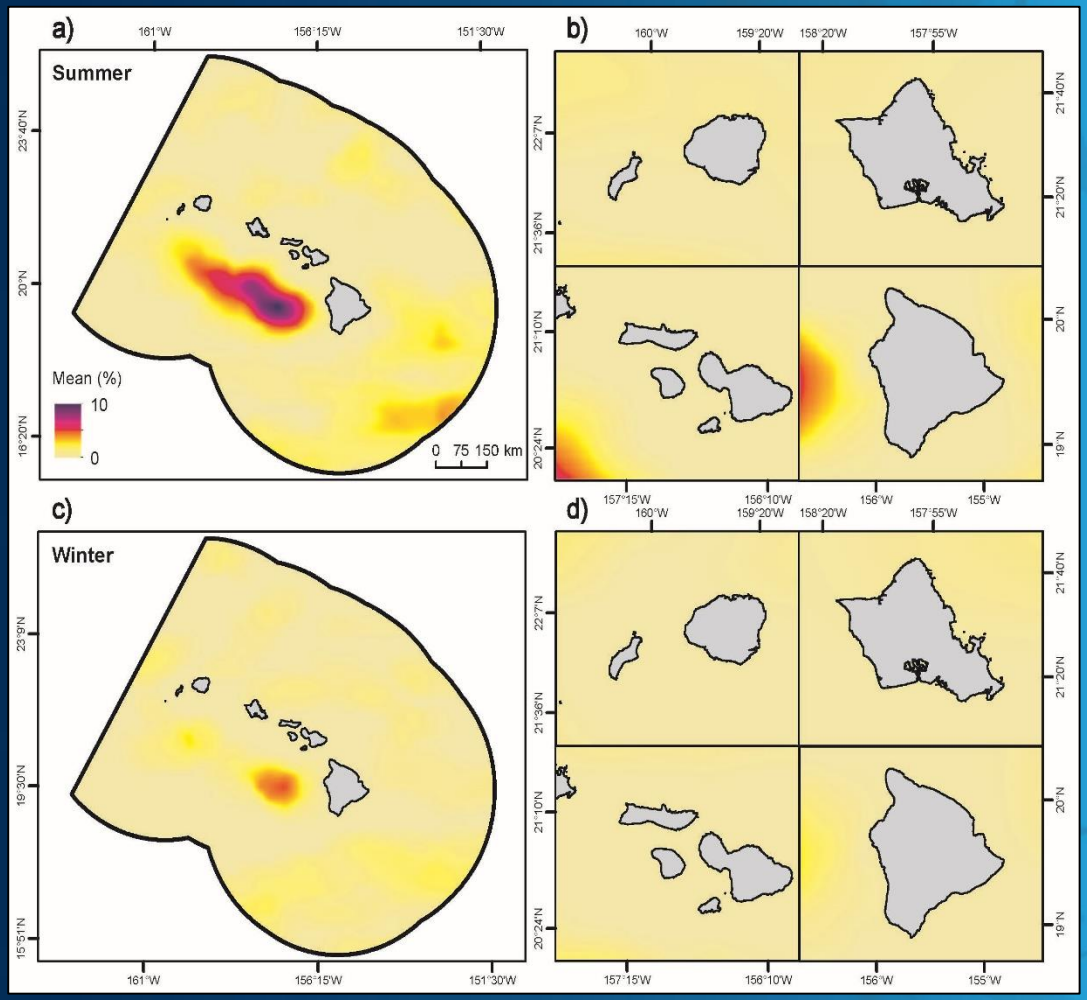
- Depth (17)
- Distance (8)

Atmospheric & Oceanographic

- Wind (12)
- Chlorophyll-*a* (12)
- Water clarity (6)
- Water height (4)
- Water movement (29) (e.g., currents, upwelling)
- Water temperature (15)
- Waves (8)

Summer & Winter

Fig 1. Probability of Cyclonic Eddies around the MHI.



Ch. 3: Benthics

Authors: Laurie Bauer, Matthew Poti, Bryan Costa, Daniel Wagner, Frank Parrish, Mary Donovan, Brian Kinlan

Purpose: Differentiate among seafloor habitats. Inform anchor & cable placement.

171 Spatial Layers (Public):

Shallow-water (0-50 m)

- Maps of benthic habitats (2)
- Maps of *in-situ* benthic cover & coral species richness (4)

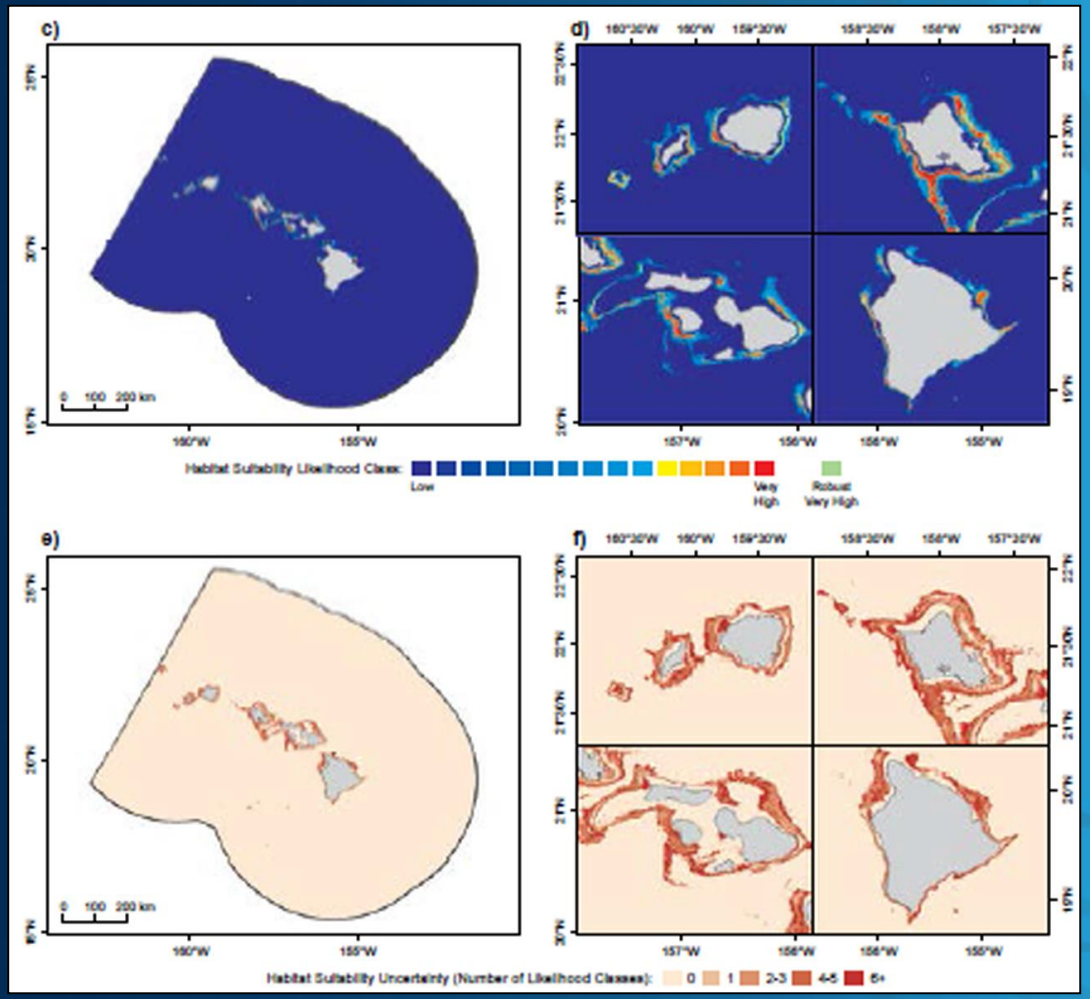
Mesophotic (50-150 m)

- Spatial predictions, uncertainty + inputs for 3 coral genera (44)

Deep-water (>150 m)

- Spatial predictions + inputs (18 taxonomic groups) (121)

Fig 1. Predicted likelihood of Kulamanamana sp. (gold corals) habitat suitability in the Main Hawaiian Islands.



Ch. 5: Sea Turtles

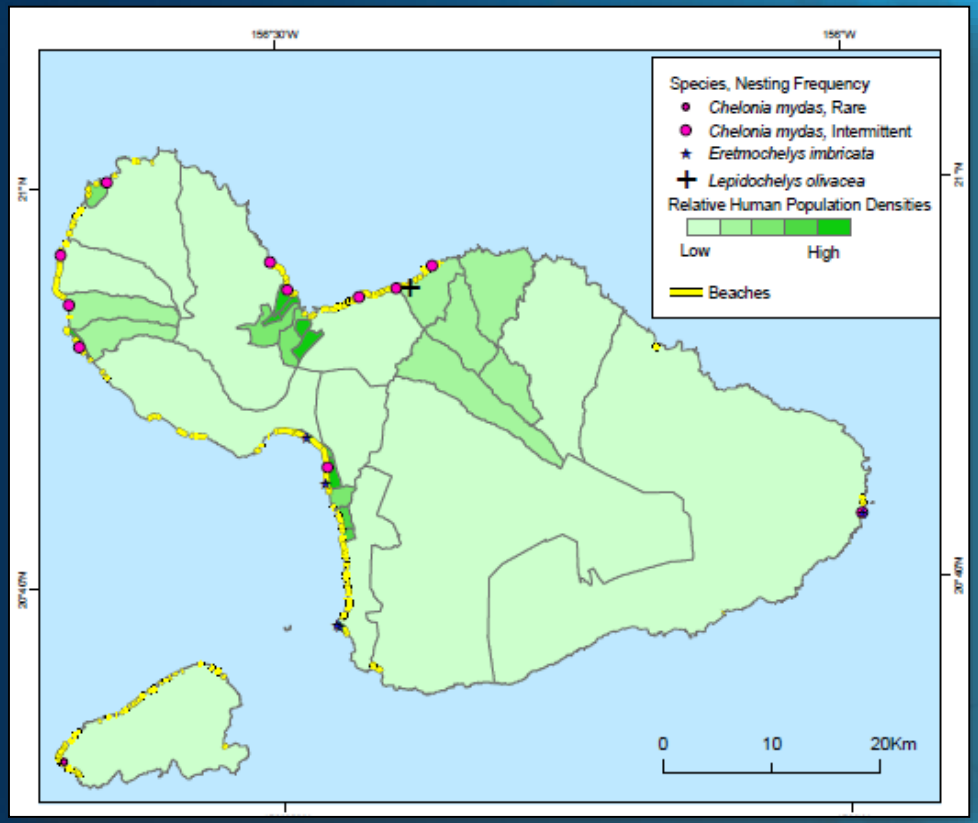
Authors: Kimberly Roberson, Matthew Kendall, Denise Parker, Shawn Murakawa and George Balazs

Purpose: Identify locations of turtle terrestrial activity. Inform cable routing onshore.

7 Spatial Layers (Public):

- Nesting locations for 4 species (1)
- Stranding locations for 4 species (1)
- Basking locations for 1 species (1)
- Beaches & Cliffs (3)
- Human Population Density (1)

Fig 1. Sea turtle nesting locations on Maui and Kaho'olawe.



Ch. 6: Marine Mammals (Cetaceans)

Simon J. Pittman, Arliss J. Winship, Matthew Poti, Brian P. Kinlan, Jeffery Leirness, Robin W. Baird, Jay Barlow, Elizabeth A. Becker, Karin A. Forney, Marie C. Hill, Peter I. Miller, Joseph Mobley & Erin M. Oleson

Purpose: Identify at-sea locations for cetaceans. Inform leasing process.

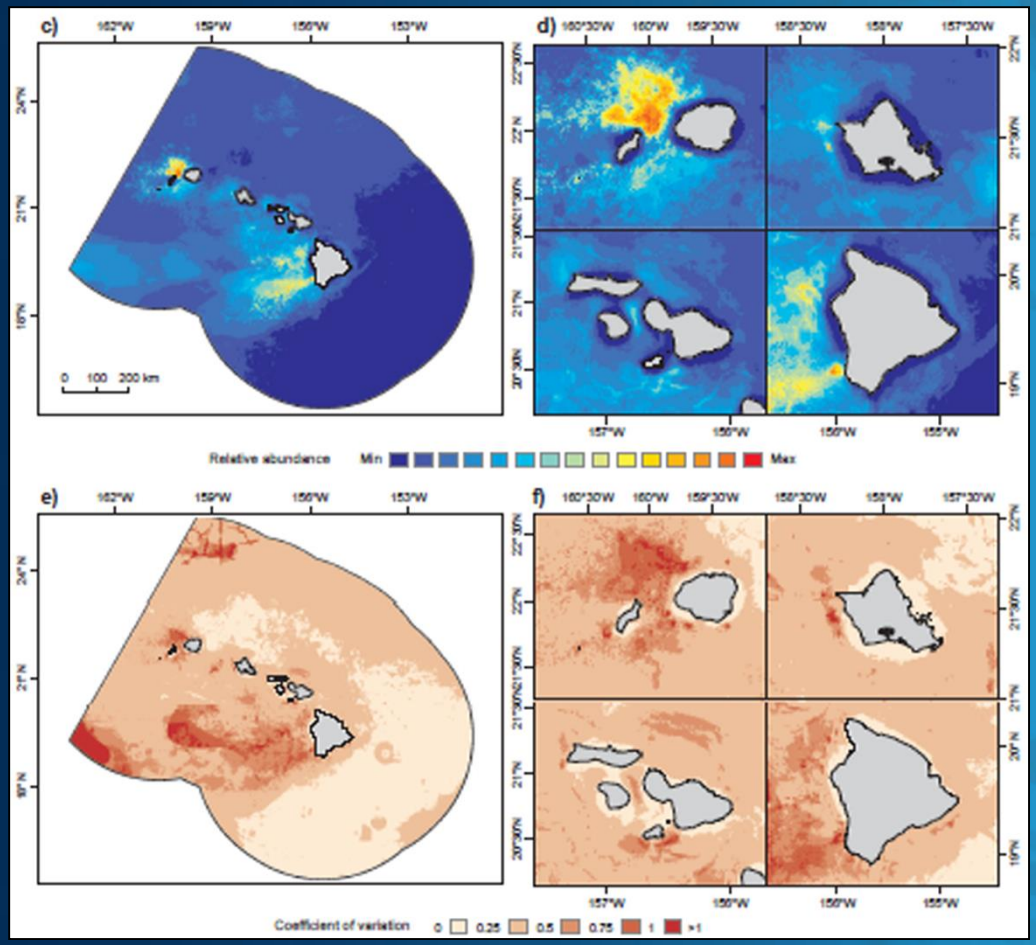
2 Spatial Layers (BOEM-only):

- Compiled at-sea sightings data & key (2)

66 Spatial Layers (Public):

- At-sea summer/winter presences for 24 species (42)
- Summer/winter spatial predictions & uncertainty for 7 species (24)

*Fig 1. Predicted relative abundance of Rough-toothed dolphins (*Steno bredanensis*) in the summer.*



Ch. 7: Seabirds

Arliss Winship, Brian Kinlan, Lisa Ballance, Trevor Joyce, Jeffery Leirness Bryan Costa, Matthew Poti, Peter Miller

Purpose: Identify at-sea locations for seabirds, major colonies & foraging areas. Inform leasing process & cable routing onshore.

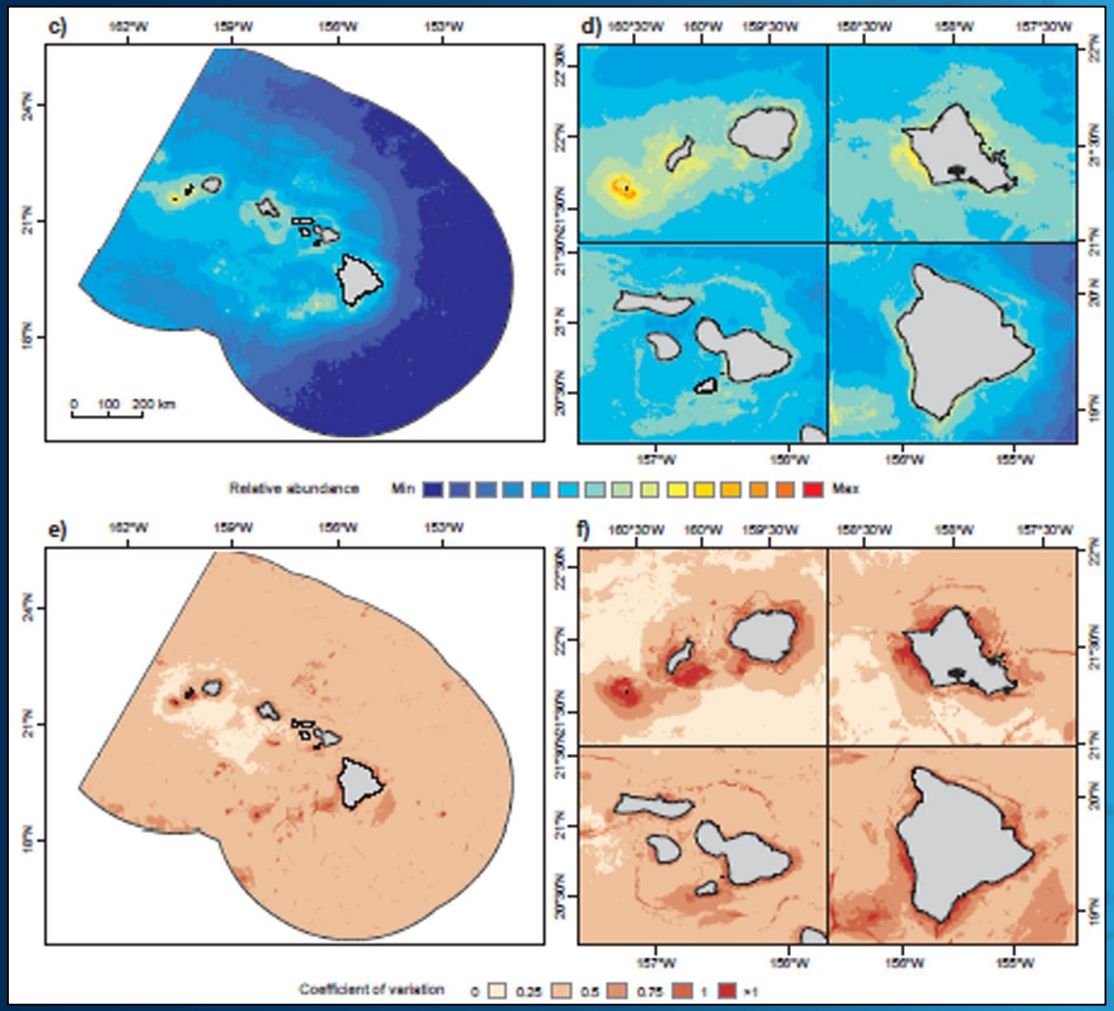
12 Spatial Layers(BOEM-only):

- Compiled at-sea sightings data & key (2)
- Terrestrial site locations (1)
- Distance to nearest terrestrial site for 9 spp (9)

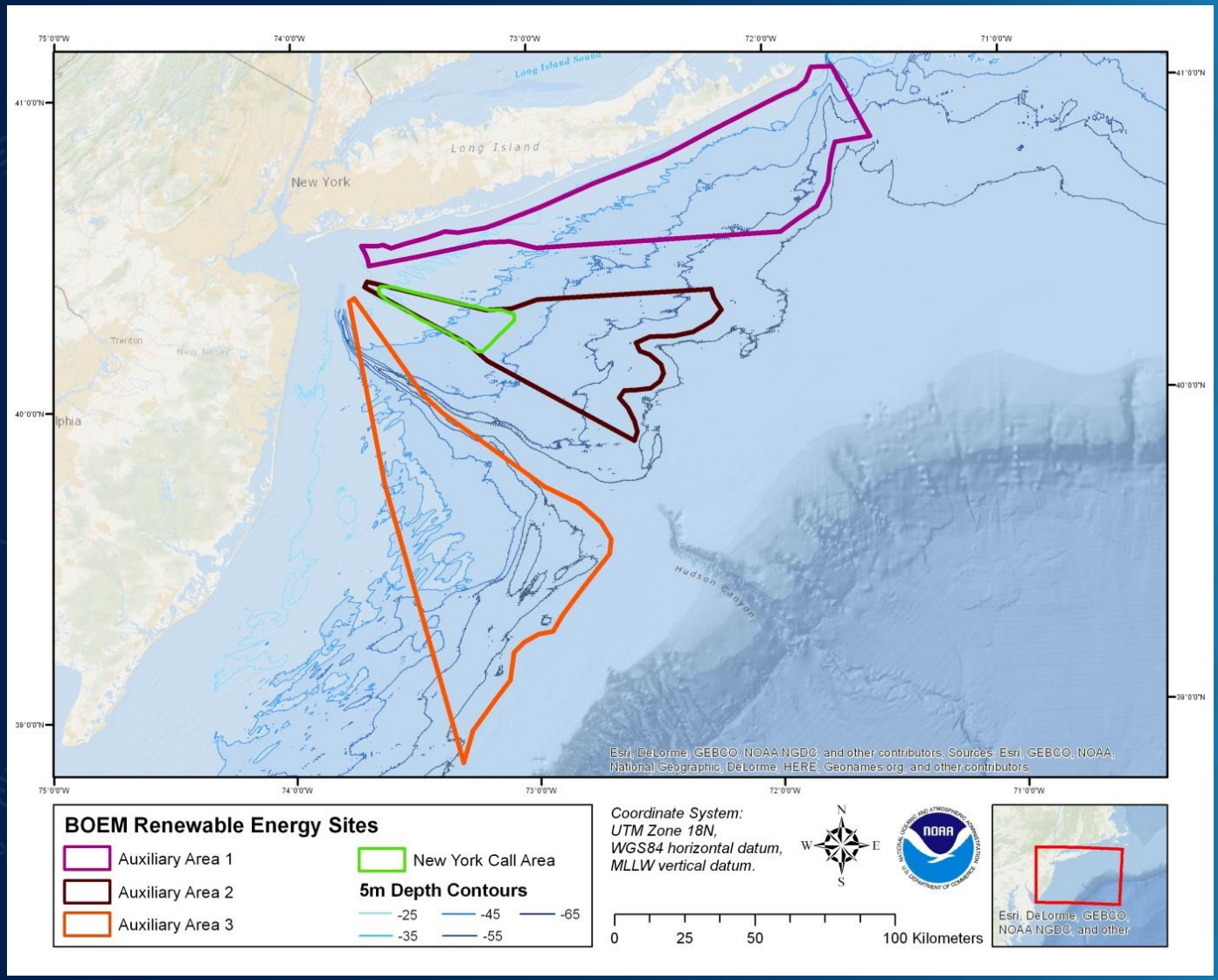
66 Spatial Layers (Public):

- At-sea presences 24 spp(42)
- Foraging ranges for 8 spp (8)
- Spatial predictions & uncertainty for 14 spp (29)

*Fig 1. Predicted relative abundance of Wedge-tailed Shearwater (*Puffinus pacificus*) in the summer.*

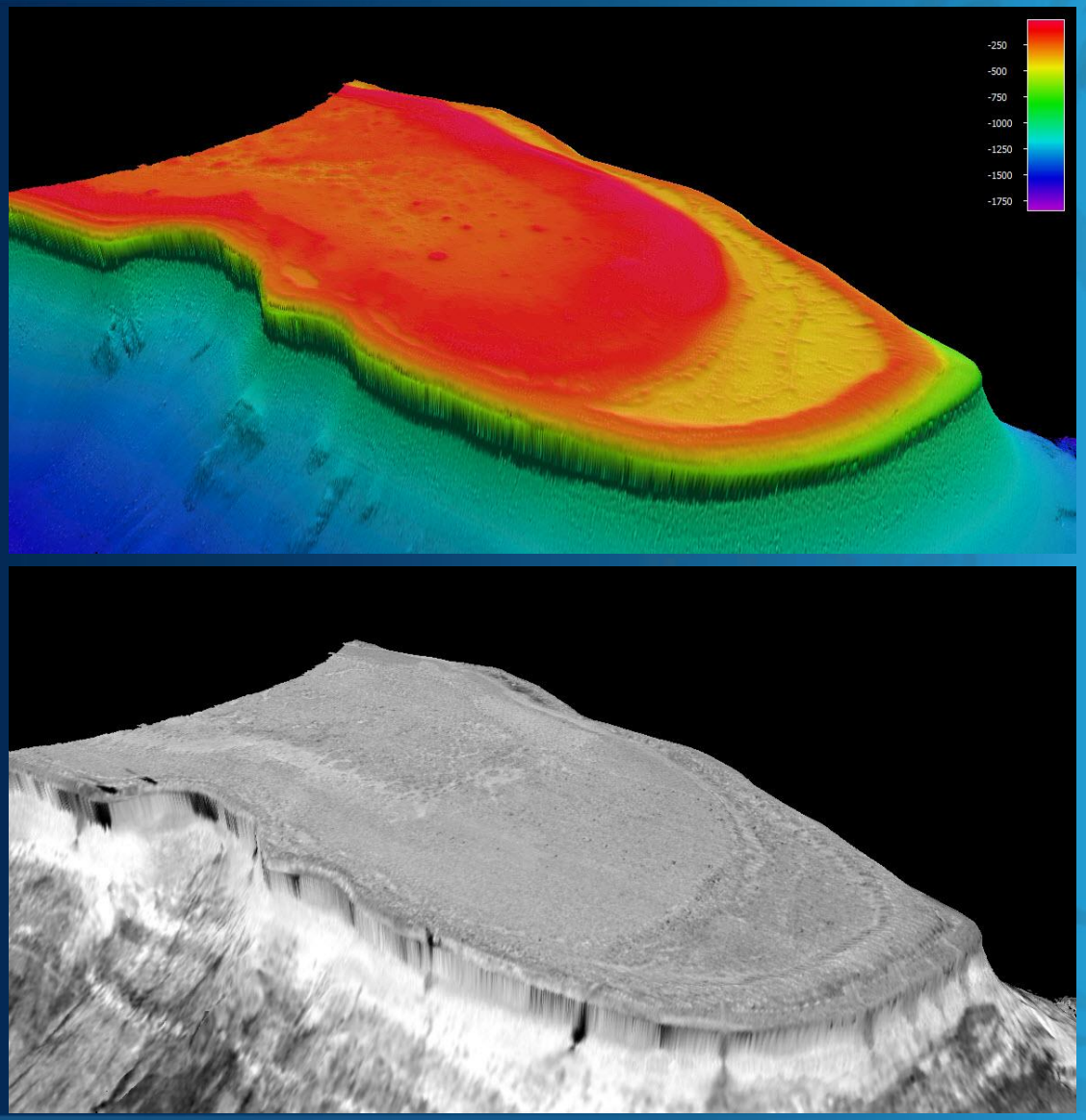


Targeted Assessment (New York Call Area – BOEM)



Task 2-2.1 Seafloor Sonar Analysis

- Deliver fully corrected/normalized processed bathymetry and backscatter mosaics to NOS Hydrographic Specifications.
- Deliver raw data and metadata, and archive to NOAA NCEI.



Task 2-2.2 Seafloor Morphometric Analysis

1. DERIVE METRICS

TRI

Curvature

(Plan)

(Profile)

Depth

(Mean)

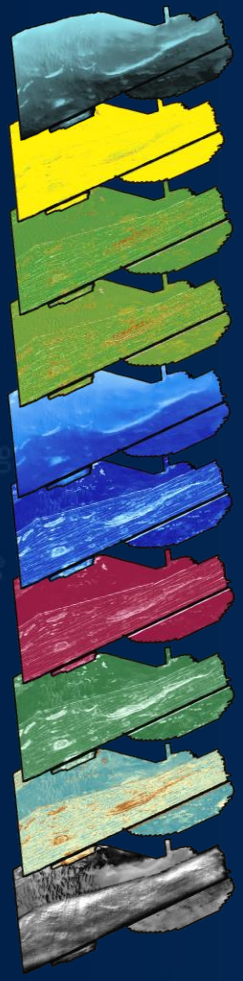
(Stdev)

Rugosity

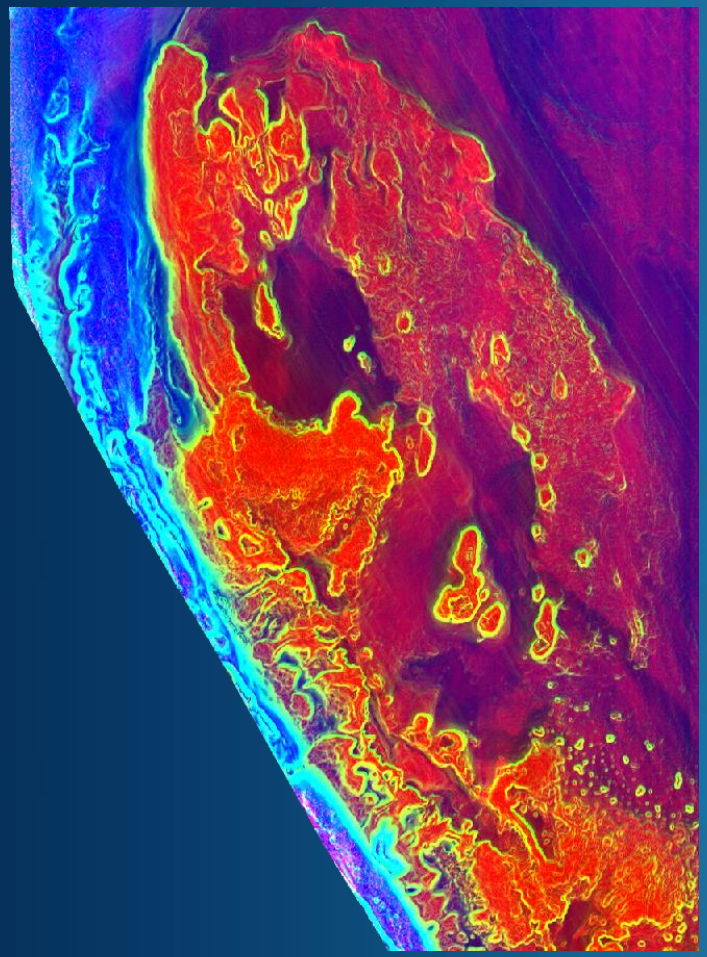
Slope

Slope of Slope

BPI



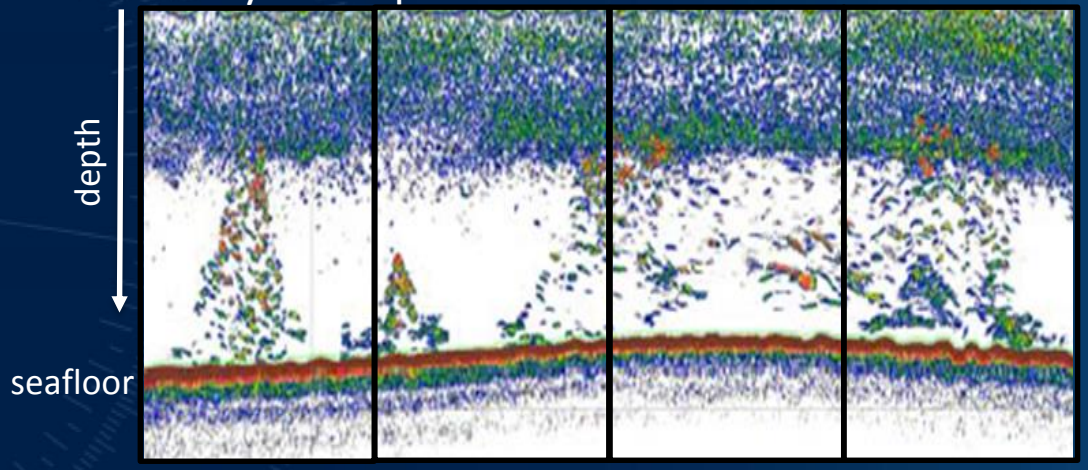
2. PRODUCE PCA



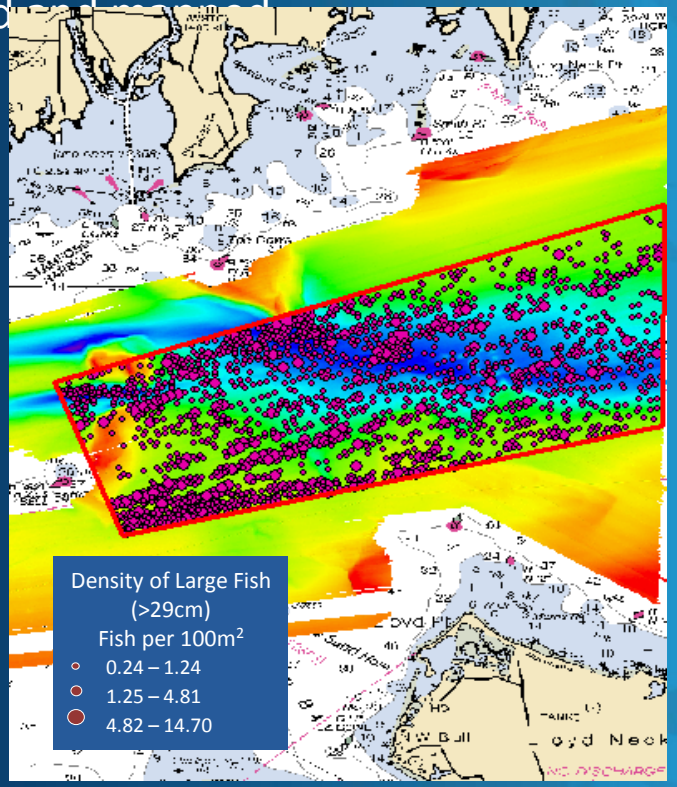
- Deliver all metrics as GeoTIFFs with ISO metadata.

Task 2-2.7 Fishery Acoustic Analysis

- Fish acoustics processing: bottom detection, noise removal, and fish tracking algorithms.
- Fish counts, fish size, and fish density are summarized and mapped.
- Delivery as shapefiles with ISO metadata.



Echogram depicting fish schools and scattering layer in upper water column
Channel Islands NMS May 2016



Final product: maps of fish density by size class
Long Island Sound Oct 2015

Task 2-2.3 Regional Hardbottom Prediction Modeling

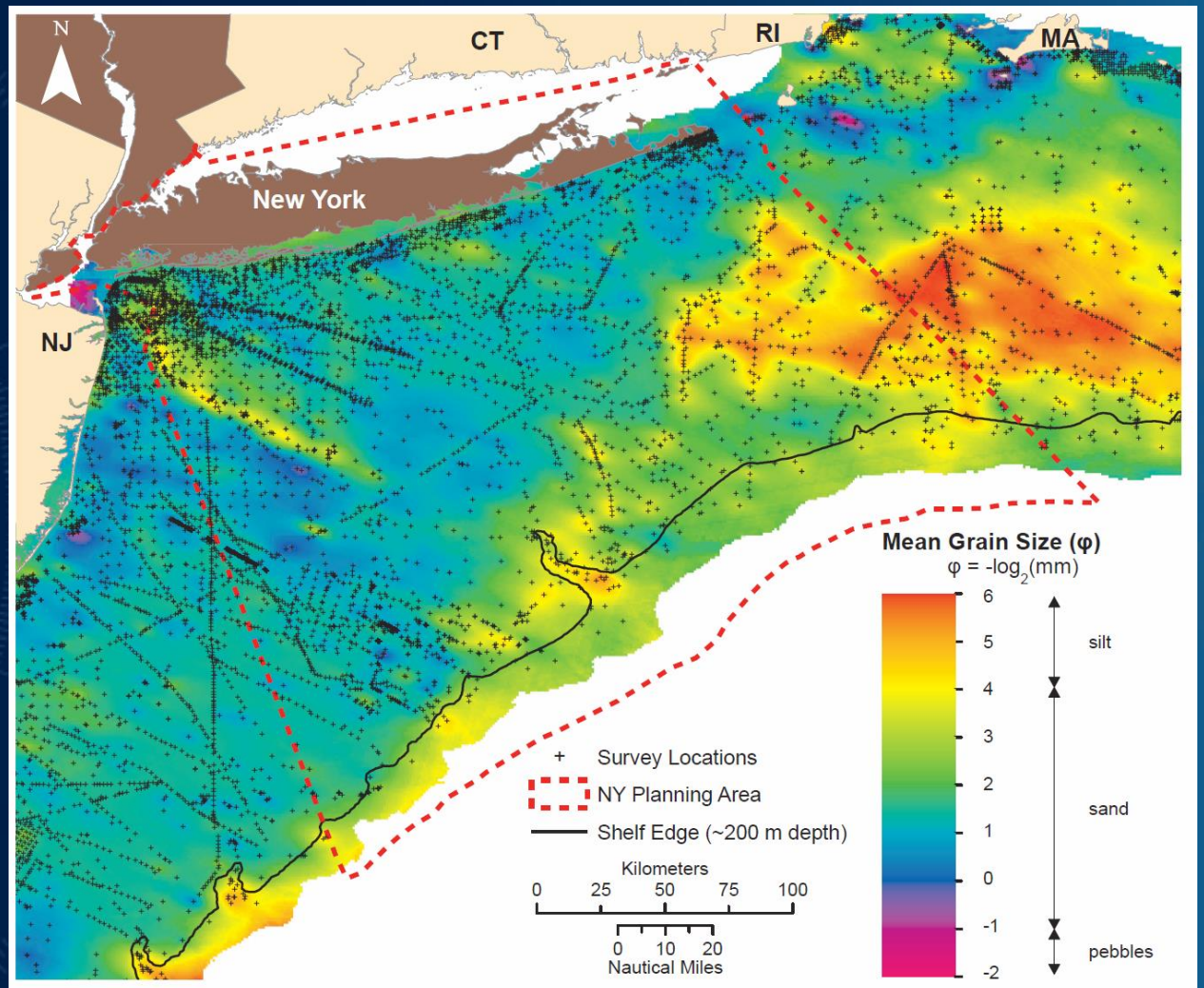
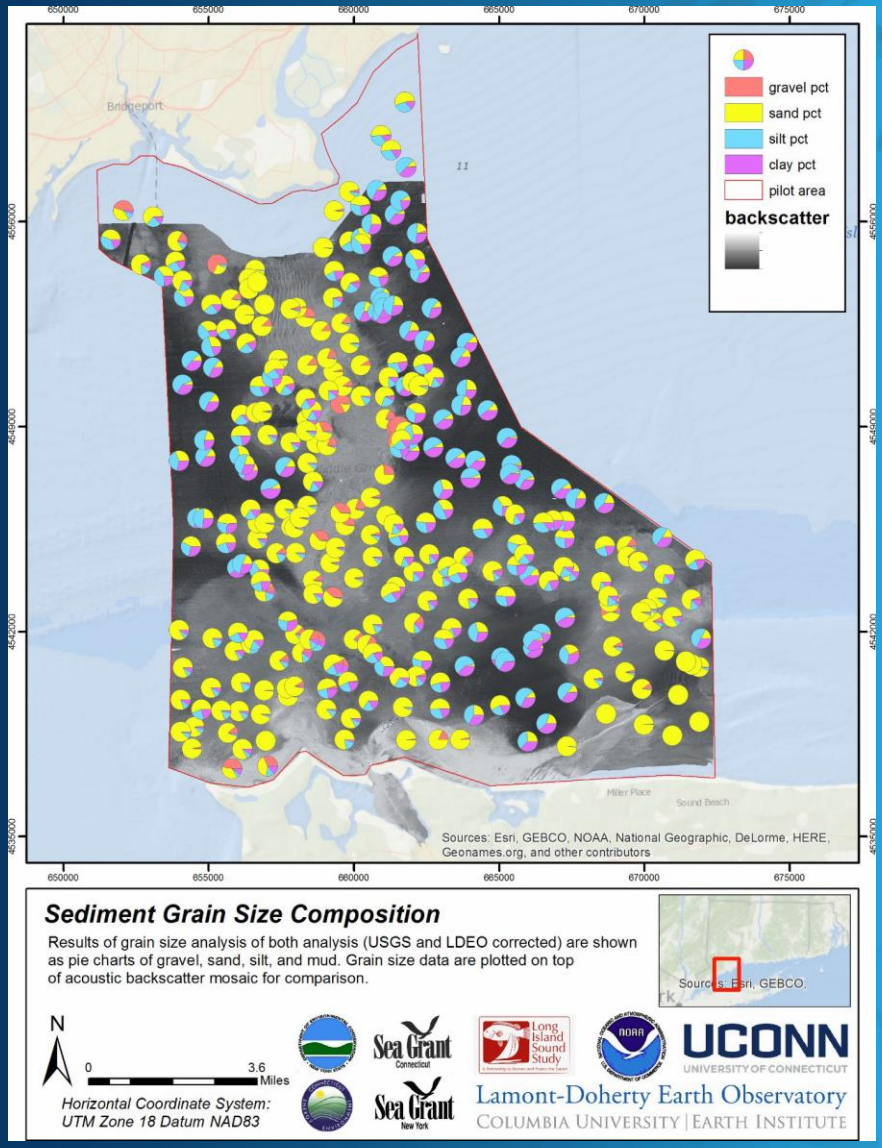


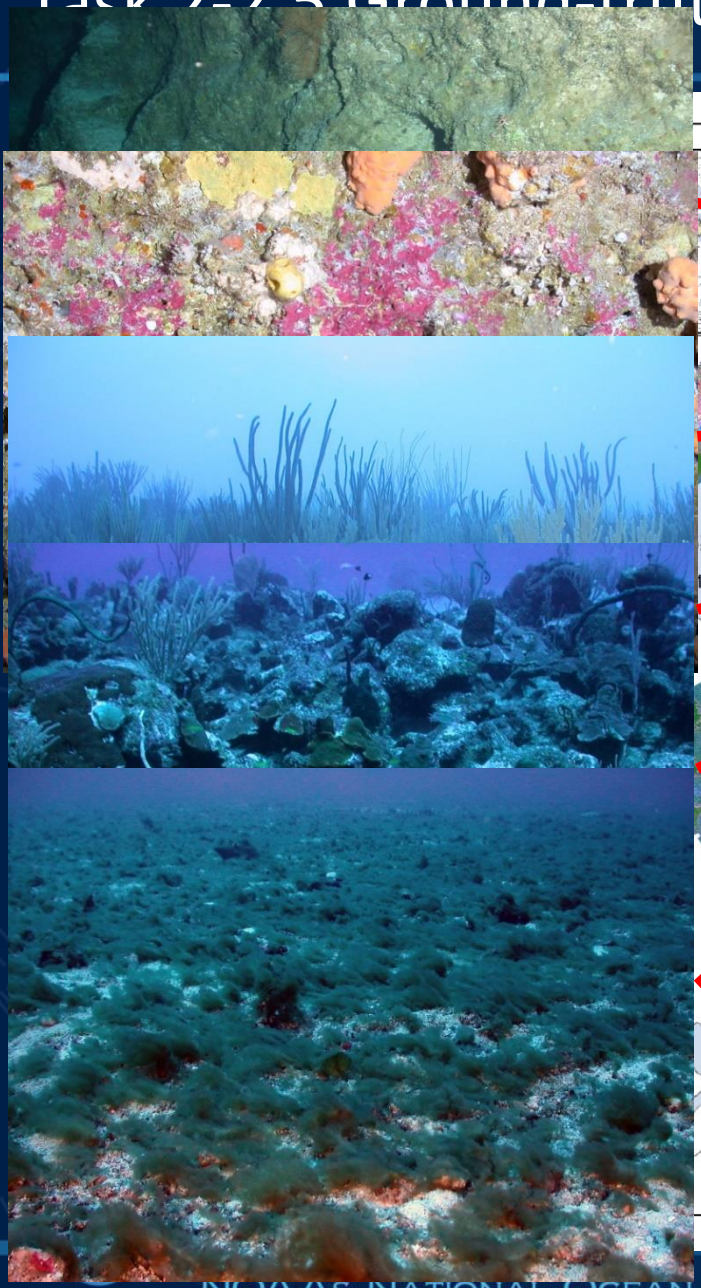
Figure 3.1. Predicted mean grain size of surficial sediments from kriging interpolation of mean grain size data in the Mid-Atlantic Bight. Mean grain size is in φ units, where φ = -log$_2$(mean grain diameter in mm). Data courtesy of J. Goff (University of Texas at Austin), derived from USGS usSEABED database (Reid et al., 2005).

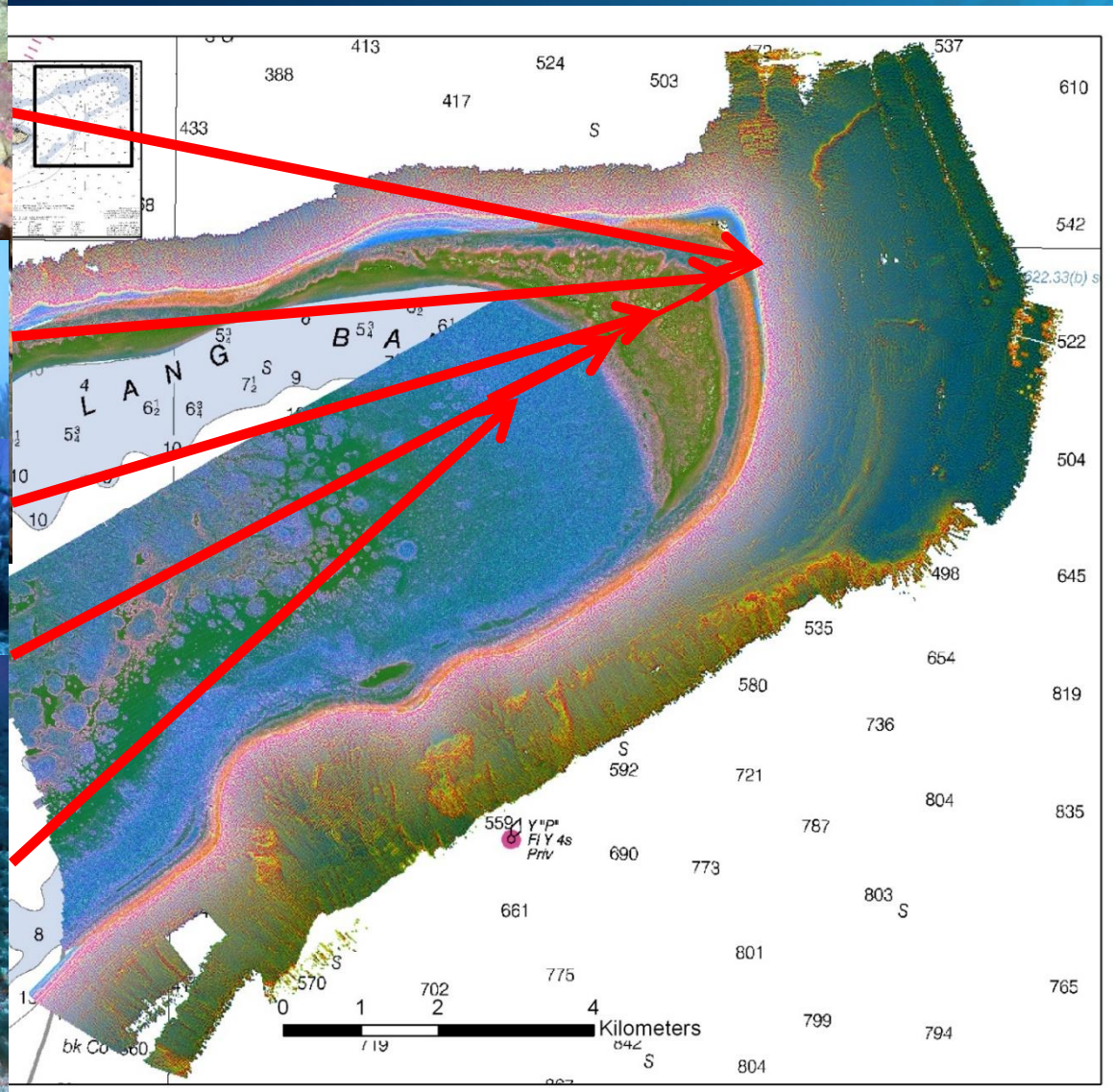
Task 2-2.6 Sediment Grab Analysis

- Percent grain size analysis (gravel, sand, silt, and clay) per sample using hydrometer (< 75 microns) and sieving techniques
- Results to be uploaded into ArcGIS shapefile including initial sampling observations.
- Delivery with ISO metadata.

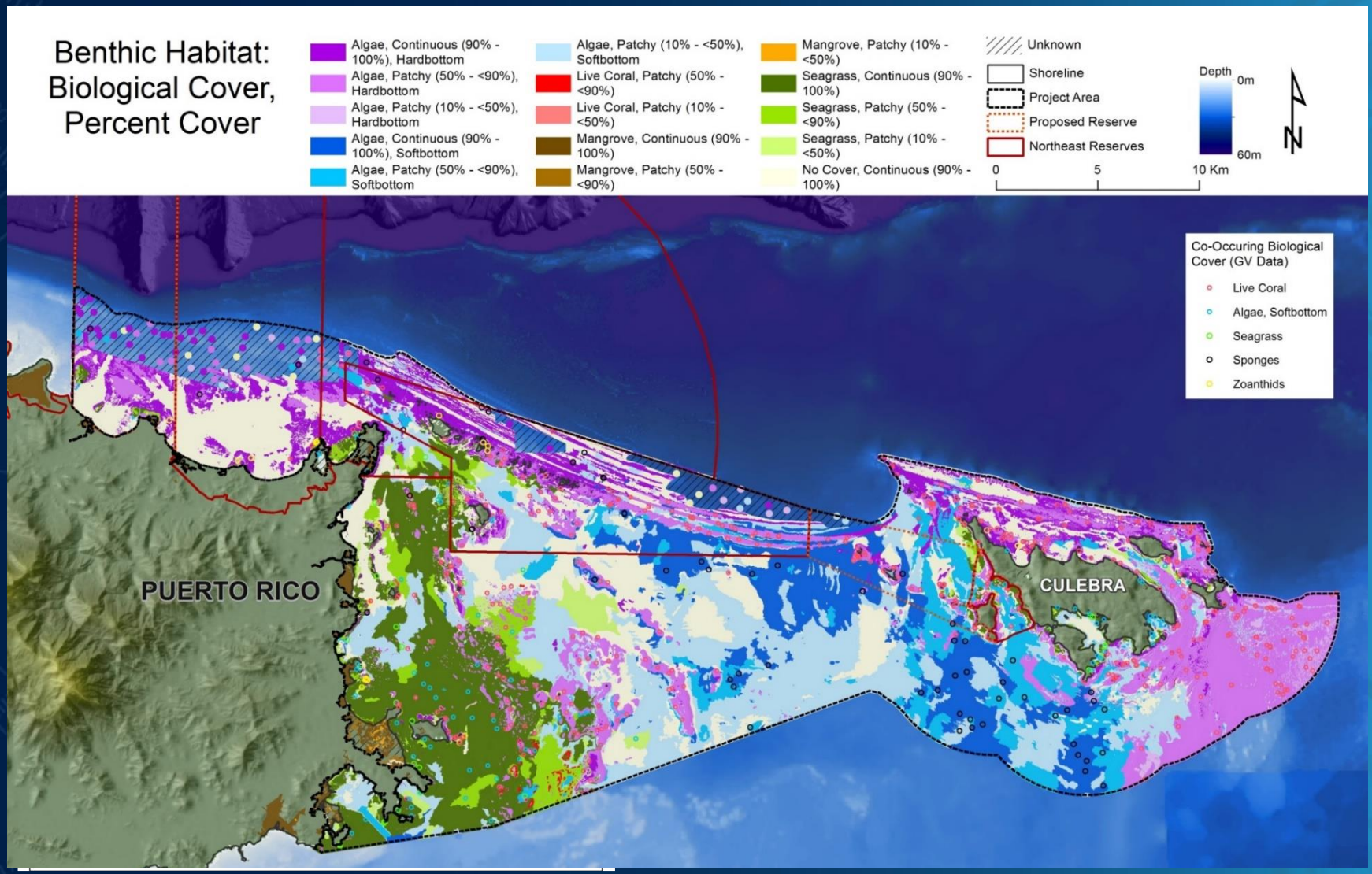


Task 2-2.5 Ground-truthing Analysis





Task 2-2.4 Sediment Texture & Habitat Maps

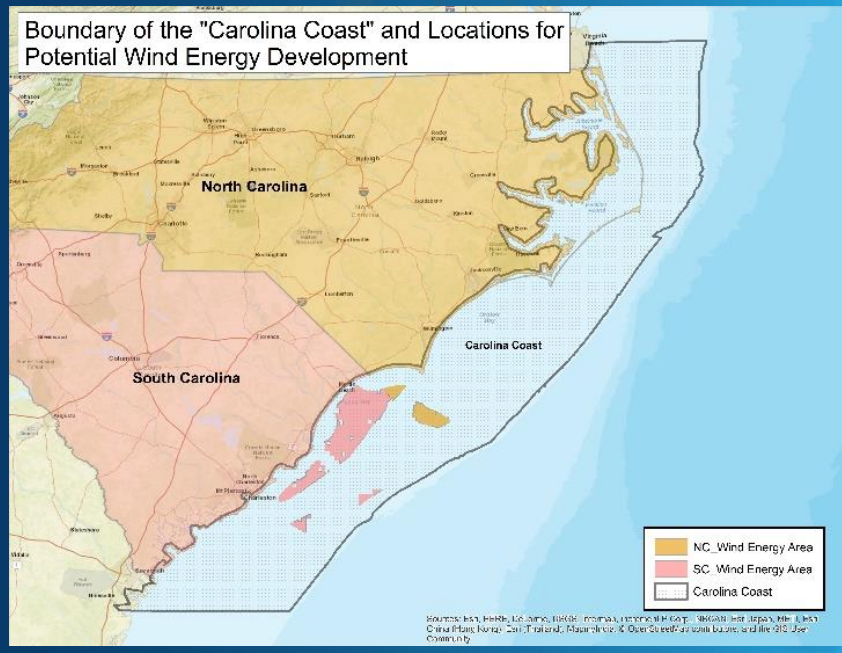


Assessment of Spatially-Explicit Social Values Relative to Wind Energy Areas: Outer Continental Shelf Offshore North Carolina

Project Goals:

- Document the social and environmental values held by residents relative to marine and coastal geographies, energy production options, and offshore wind energy development

- Model the relationship between spatially-relevant value orientations and local support/opposition and social action for offshore wind



Thank You!

Mary Erickson
Mary.Erickson@noaa.gov
240-533-0193
&
Tim Battista
Tim.Battista@noaa.gov
240-533-0379

National Centers for Coastal Ocean Science

Delivering ecosystem science solutions

- *for stewardship of the nation's ocean and coastal resources*
- *in direct support of NOAA, State & Federal priorities*
- *to sustain thriving coastal communities and economies*

CATAPULT
Offshore Renewable Energy

Offshore Wind Innovation

Dr Stephen Wyatt

Strategy Director, ORE Catapult

September 2016

Agenda

About the ORE Catapult

The UK Market (size and costs)

Case studies:

1) Blyth demonstrator
2) Smarter testing
3) Academic research hubs
4) Collaboration in O&M
5) Innovation Challenges

Final Thoughts

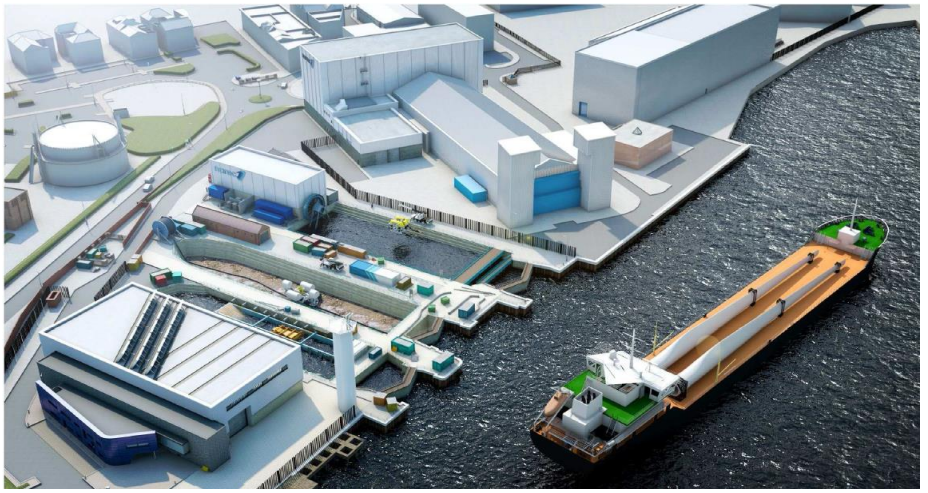
The Catapult Network

A long-term vision for innovation & growth

CATAPULT Offshore Renewable Energy

11 Catapults

- £1.4bn IUK programme, funded by BEIS
- To transform the UK's capability for innovation
- Driving growth in key strategic sectors for the UK



ORE Catapult

"Affordable energy from Wind, Wave and tidal".

Funding ~£25m/pa

- Funding other public sector sources (e.g. EU)
- Funding from industry
- Core funding Innovate UK

People ~140

Strong collective experience

Drawn from industry, Public sector and Academia
~80 dedicated research staff and engineers
8 technical project managers
Analysts and financial /risk modeling

Our Knowledge areas	Wind & Ocean Conditions
Blades	Foundations & Substructures
Drive Trains	Operations & Maintenance
Electrical Infrastructure	Wave and Tidal

Research

Delivering applied research projects

Testing

Managing and operating testing and R&D infrastructure

Programmes

Convening our stakeholders to create knowledge and know-how

Thought Leadership

Relevant actionable advice and insight on key industry issues

Catapult Levenmouth Research Turbine

- Catapult own a 7MW offshore turbine
- Become the world's only large scale, offshore, open access research turbine
- Significant scope for applied research
  - Performance and efficiency
  - Lifetime operations and costing
  - Skills and training
  - Access of a "real" turbine for early stage high growth companies
  - Currently focusing on non invasive research while we learn how to operate it!

Agenda

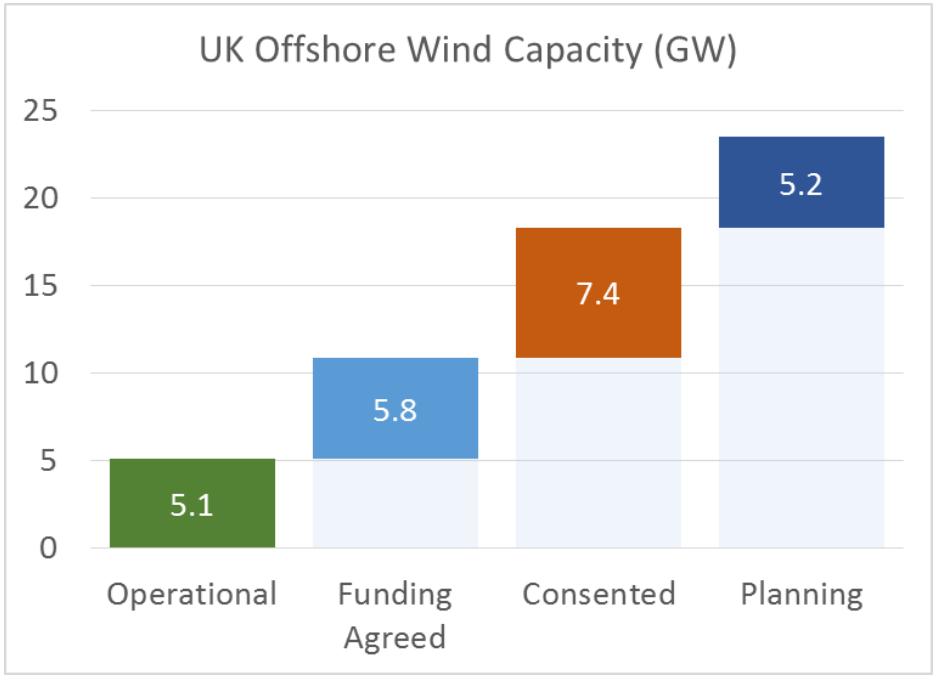
About the ORE Catapult

The UK Market (size and costs)

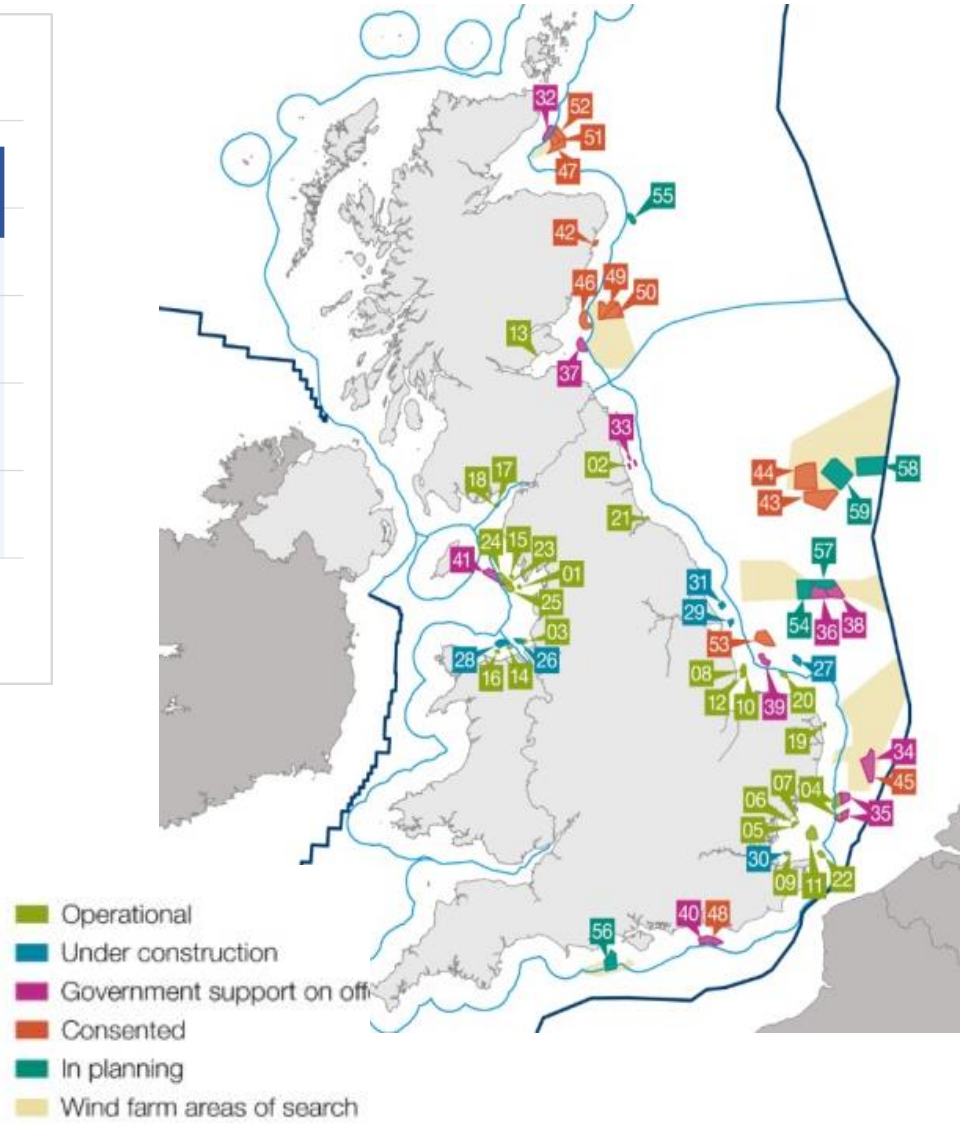
Case studies:
1) Blyth demonstrator,
2) Testing,
3) Academic research hubs
4) Collaboration in O&M,
5) Innovation Challenges

Final Thoughts

UK's offshore renewable energy opportunity

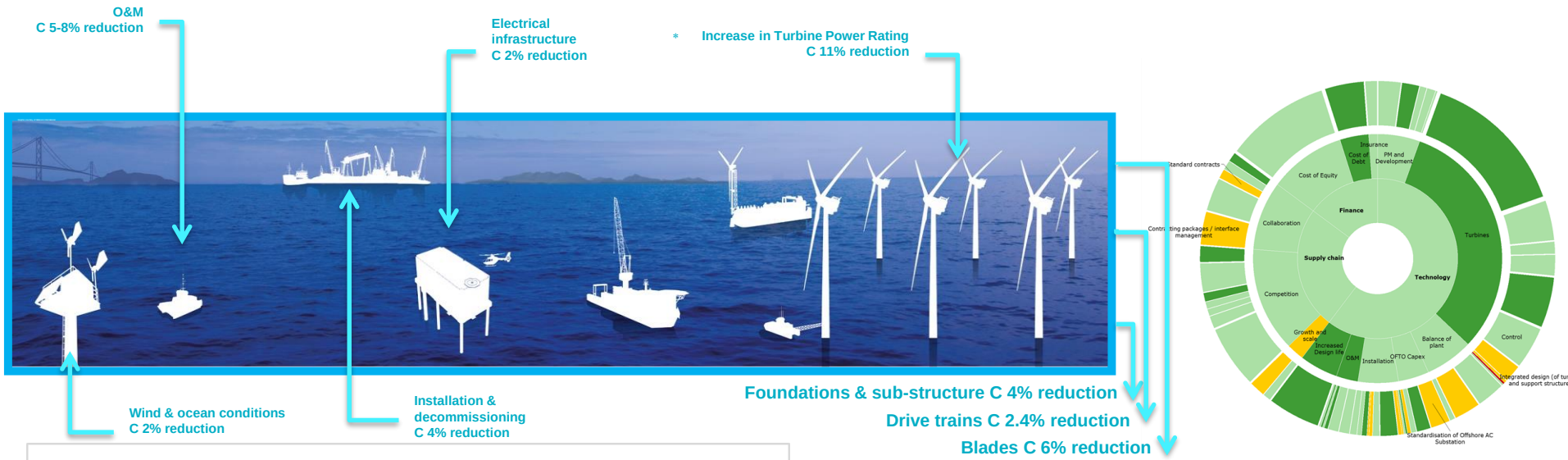


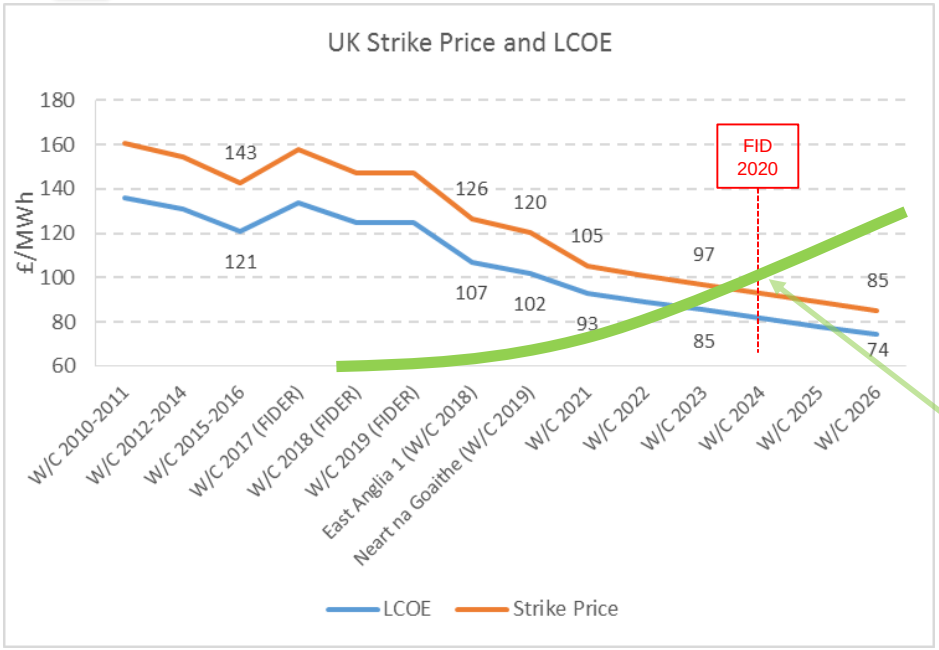
- **1,465 offshore turbines**
- **5.1GW operational (around 10% of UK demand)**
- **10GW installed by 2020**
- **Latest CFDs £105-120/MWh indicate LCOE £102-107/MWh**



Credit: UK Government: dept. UK Trade and investment

Our Cost Reduction Monitoring Framework: Creating confidence & informing priorities





- Each year ORE Catapult tracks cost reduction on behalf of the industry though financial “audit” and interviews with the supply chain.
- The resultant “CRMF” is the dash board which is used to inform where we focus efforts

UK Supply chain and growth

Agenda

About the ORE Catapult

The UK Market (size and costs)

Case studies:
1) Blyth demonstrator,
2) Testing,
3) Collaboration in O&M,
4) Innovation Challenges

Final Thoughts

Case study 1: Blyth Offshore Demonstrator

- 3 arrays for testing of up to 15 turbines including deep water foundations
  - EDF Renewables progressing 1st array
- Plus Catapult platform providing broad spectrum of opportunities for:
  - LiDAR and floating LiDAR validation
  - Evaluating environmental conditions
  - Collecting wildlife data
  - Observing marine conditions
  - Geotech research
  - Foundations with detailed data capture

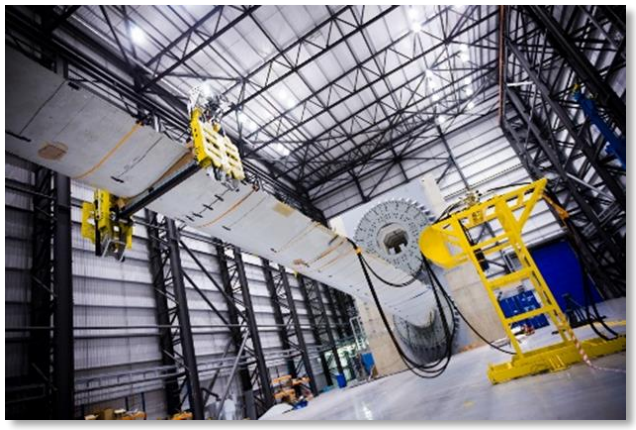
Case study 2: Supporting the development of next generation turbines

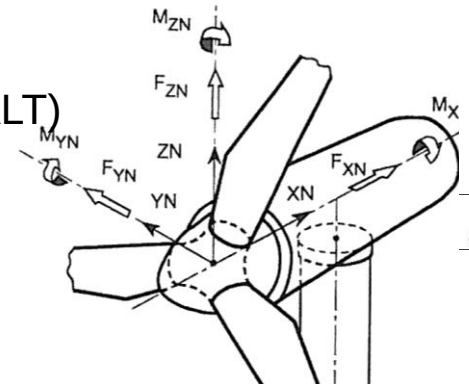
Blades to 100m:

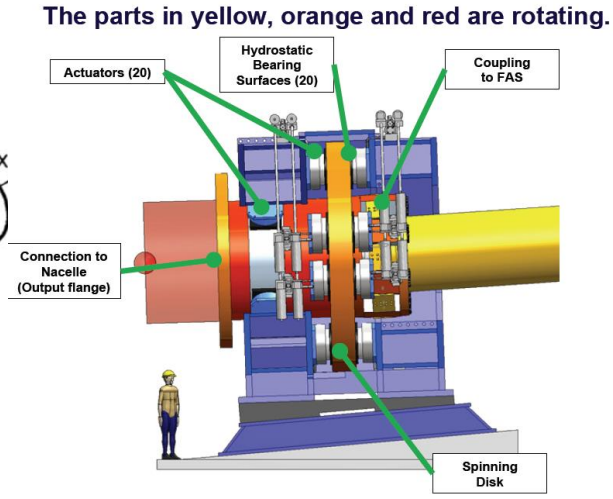
- Blade Certification testing
- Static, Proof Loading & Fatigue testing

Drive Trains 15 MW:

- Certification testing
- Entire nacelle prototype test capability
- Major component testing
- Highly Accelerated Lifetime Testing (HALT)
- Research and development



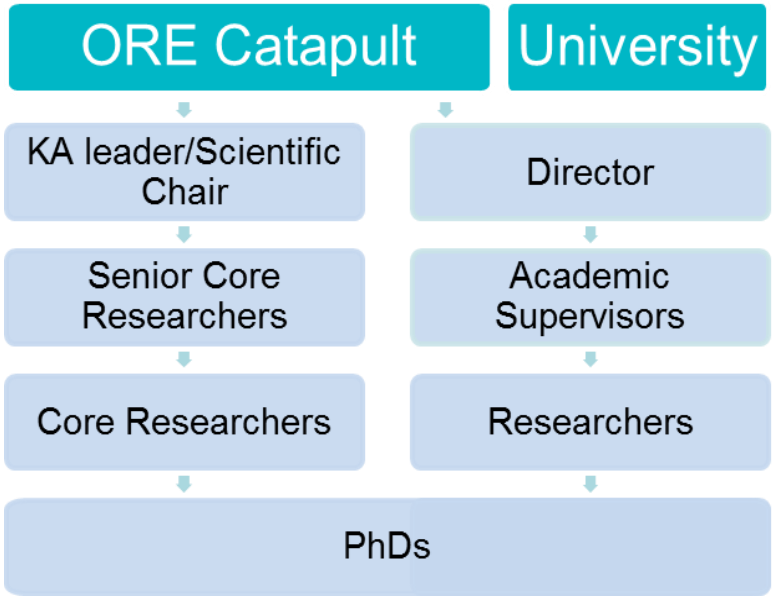




Academic Engagement: ORE Catapult Research Hub model

ORE Catapult Research Hubs:

- Formed between ORE Catapult and a partner University to extend technical reach and ensure industry relevance
- ORE Catapult establishes the overall direction and monitoring processes
- Jointly defined R&D agenda between ORE Catapult and the partner University
- PhD, Research Associates, postdoc sponsorships, etc
- Can incorporate industry sponsors



Our first call for a Research Hub for Blades open now

Case study 3: O&M Forum

- Discussion forum with UK offshore wind farm owner/operators
- Attended by offshore wind farm asset managers and other key staff
- Valuable insight to help promote best practice and shape ORE Catapult activities
- Joint Industry Project on scheduled maintenance excellence being developed with forum members

Case study 3: BLEEP

BLEEP

Bade Leading Edge Erosion Programme

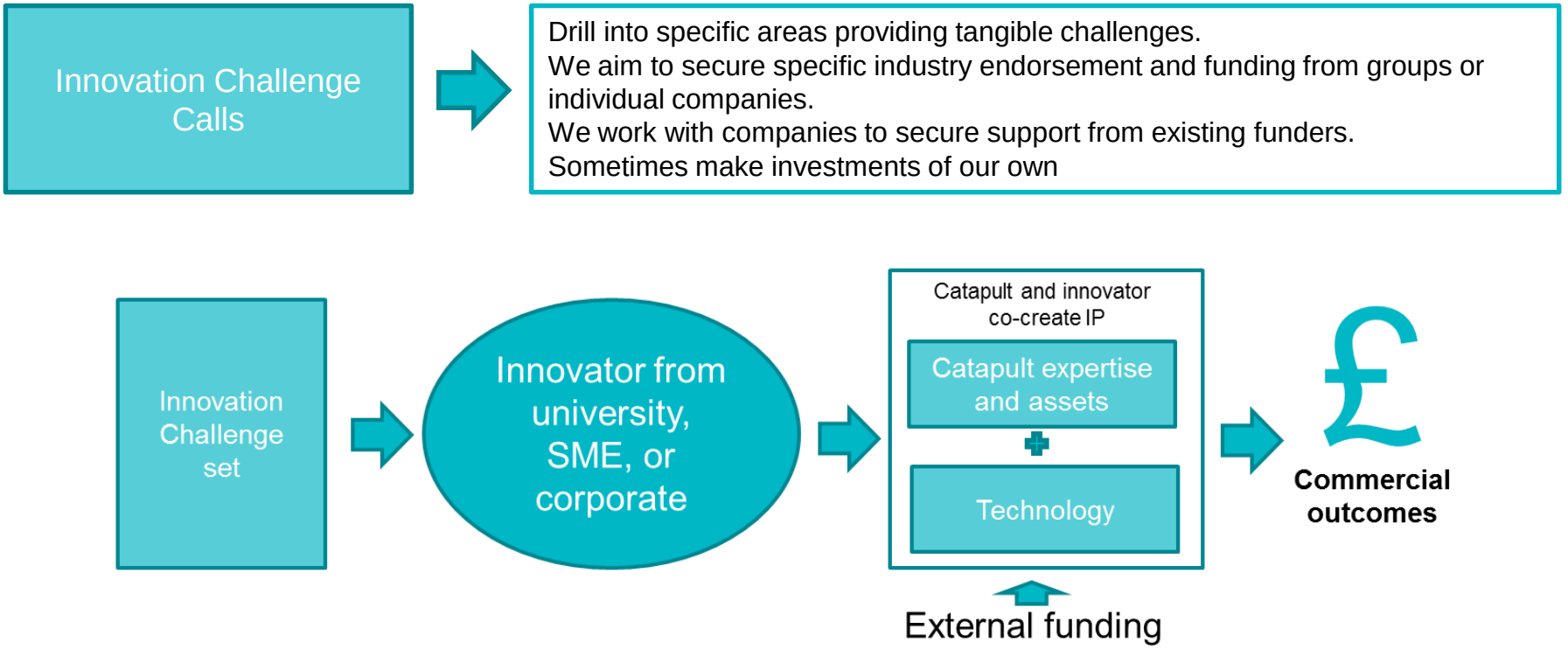
Collectively investing £505k

Leading edge erosion is one of the biggest issues facing 3-5yr old turbines.
LEE affects yield and structural integrity

Yield Impact AEP decrease	Back to back trials	Impact of environment	Finding solutions
Lyne and inner dowsing	Working with Centrica	Working with Centrica	Retrospective repair
Sheringham Shoal	Analysis for detailed scada data		OEM improvements
Rhyl flats			

Case study 4: Innovation Challenges

- Innovation Challenges provide market pull and drive our SME engagement - they are focused on key current challenges, and demonstrate real market appetite for successful solutions.
- ORE Catapult seeks to co-develop technology with SME (and others), provide access to assets, and may ultimately derive revenue from services and product sales.



Agenda

About the ORE Catapult

The UK Market (size and costs)

Case studies:

1) Blyth demonstrator,
2) Testing,
3) Academic research hubs
4) Collaboration in O&M,
5) Innovation Challenges

Final Thoughts

Three fundamentals to reduce risk and costs from our UK experience

- **Create policy consistency and industry confidence**
  - Clear line of sight to invest in R&D
  - Greater confidence for project investors
- **Greater collaboration across industry and public sector**
  - Sharing best practice, learning, risk
  - Co-ordination of public sector funding support for technology development
- **Technology innovation**
  - Learning by doing
  - Volume of activity
  - Technology breakthroughs

UK has good experience in:

- Spatial planning
- Site development
- Offshore operations
- Cumulative impact

ORE Catapult board just signed off our international direction:
United States and China

Opportunities for collaboration:

- A US version of the CRMF to track cost reduction priorities
- Joint innovation challenges to tackle key opportunities / issues
- Exchange of personal into key organisations
- Simply use ORE Catapult as your front door to UK experience

Thank you for listening

Stephen.wyatt@ore.catapult.org.uk
ore.catapult.org.uk

Discussions of Research Grand Challenges

- Site Characterization and Environmental Assessment
- Technology Advancement
- National Framework of Innovation

Tufts

MASSACHUSETTS CLEAN ENERGY CENTER

Massachusetts Landscape for Offshore Wind Research

Massachusetts Research Partnership

DC Workshop

September 20, 2016

Massachusetts OSW Initiatives

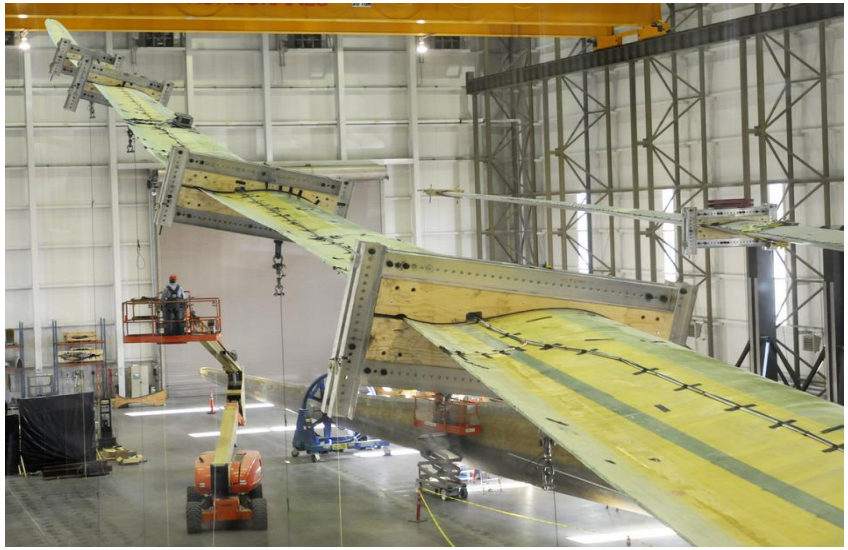
- **Legislation**
- Stakeholder and Regional Engagement
- **Infrastructure**
- MassCEC Offshore Energy Program
  - Site Characterization
  - Analysis and Information
  - Sector Development
  - **Research, Monitoring and Evaluation**

Massachusetts Energy Legislation

In August, Governor Baker signed legislation to launch offshore wind:

- Utilities to solicit 1,600 MW of OSW, largest state commitment
- First solicitation issued by June 2017
- All 1,600 MW shall be contracted by June 2027
- Each solicitation not less than 400 MW
- Costs must decrease over time

Infrastructure



Wind Technology Testing Center

Among the largest indoor wind blade test facilities in the world. Enabling the industry to advance blade technology and drive down costs.

New Bedford Marine Commerce Terminal

Multi-purpose facility designed to support the staging and deployment of offshore wind projects, as well as handle bulk, break-bulk, containers, and other marine cargo

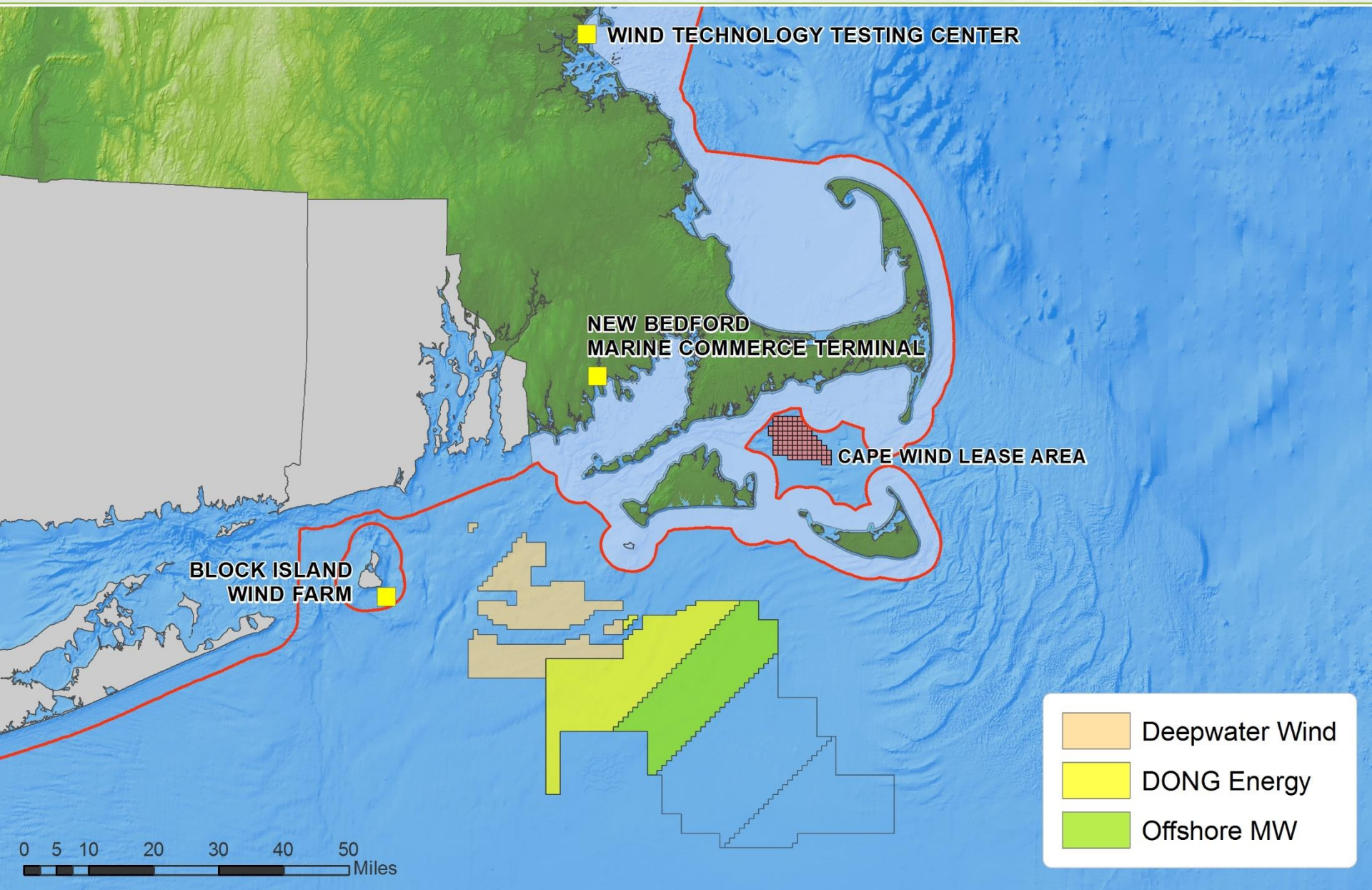
MassCEC Support for Research

- Program areas
  - Academic Collaboration Program http://www.masscec.com/innovate-clean-energy/academic-collaboration
  - Offshore Energy and Commonwealth Wind programs

- MassCEC funding role
  - Matching grants
  - Primary sponsor
  - Capacity-building grants

- 2016 offshore wind solicitation
  - 25 applications
  - Initial awards announced August 2016
  - Possible additional awards ~October 2016

MASSACHUSETTS: *Offshore Wind Hub*



Massachusetts Research Partners

UMass Amherst

UMass | Dartmouth

UMASS LOWELL

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Northeastern University College of Engineering

Tufts UNIVERSITY | School of Engineering

Project: Consider the Design of a Offshore Wind Energy Research Framework and Network

Project Motivation: A data-driven multi-disciplinary system-level framework and network is needed to create a highly resilient, low-risk, productive, and world-leading offshore wind infrastructure and portfolio of wind farms.

Project Approach: Review literature, host nat./intl. workshops, engage with agencies and labs, learn from other initiatives

Today's Session on Grand Challenges

- Site Characterization and Environmental Assessment (WHOI & UMass-Dartmouth)
- Technology Advancement (UMass-Amherst and Northeastern University)
- National Framework for Innovation (led by UMass-Lowell and Tufts University)

NATIONAL OFFSHORE WIND STRATEGY

Facilitating the Development
of the Offshore Wind Industry
in the United States


Fraunhofer
IWES

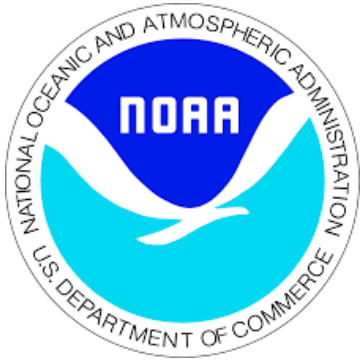

CATAPULT
Offshore Renewable Energy


U.S. DEPARTMENT OF
ENERGY


U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849


BOEM
Bureau of Ocean Energy Management


NATIONAL SCIENCE FOUNDATION


NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE


U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY


NASA


DARPA


NIST
National Institute of
Standards and Technology
U.S. Department of Commerce


DEPARTMENT OF THE NAVY
USN
ONR
Science & Technology


BSEE
Bureau of Safety and
Environmental Enforcement

US National Labs

Office of Science Laboratories

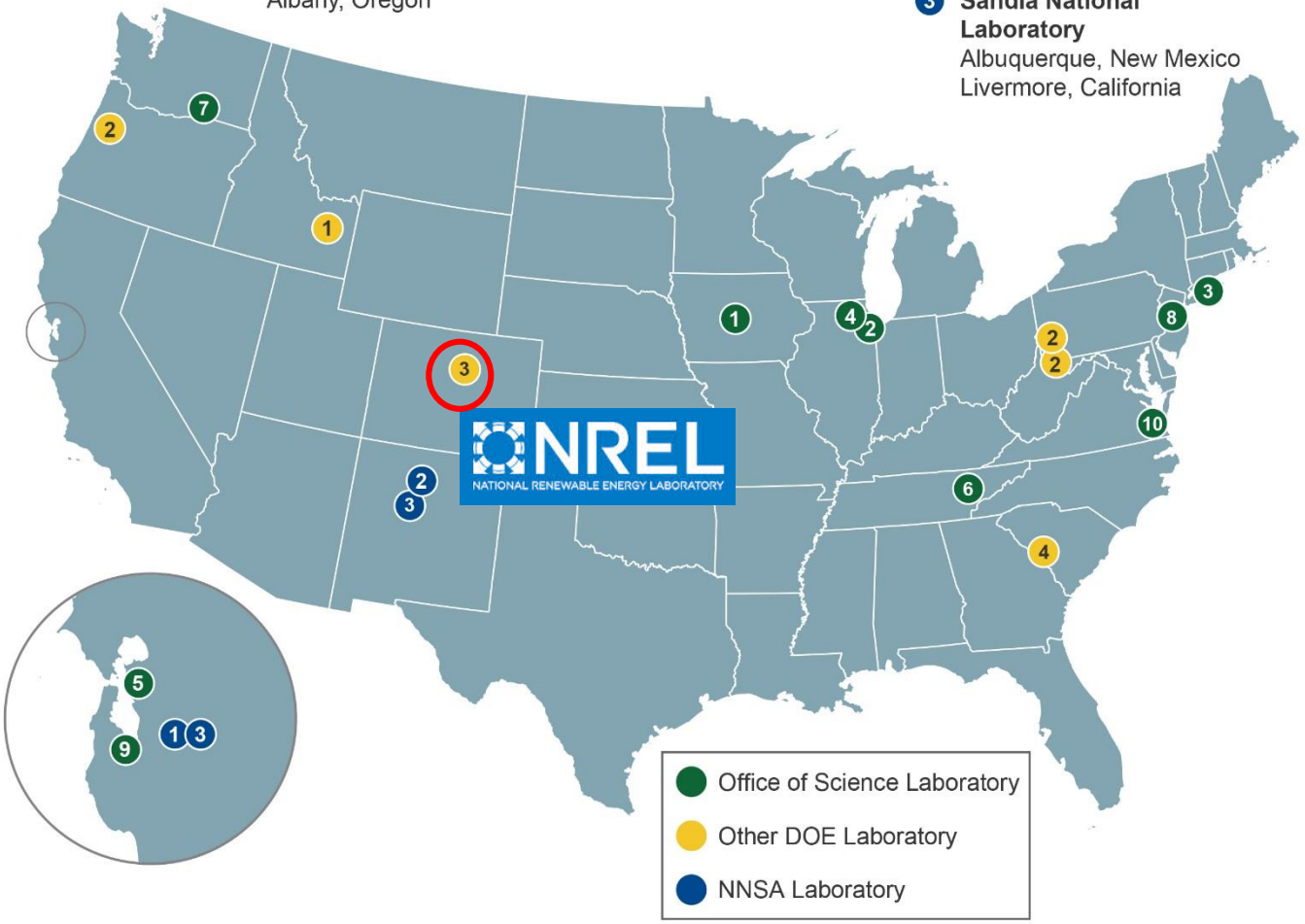
1. **Ames Laboratory**
   Ames, Iowa
2. **Argonne National Laboratory**
   Argonne, Illinois
3. **Brookhaven National Laboratory**
   Upton, New York
4. **Fermi National Accelerator Laboratory**
   Batavia, Illinois
5. **Lawrence Berkeley National Laboratory**
   Berkeley, California
6. **Oak Ridge National Laboratory**
   Oak Ridge, Tennessee
7. **Pacific Northwest National Laboratory**
   Richland, Washington
8. **Princeton Plasma Physics Laboratory**
   Princeton, New Jersey
9. **SLAC National Accelerator Laboratory**
   Menlo Park, California
10. **Thomas Jefferson National Accelerator Facility**
    Newport News, Virginia

Other DOE Laboratories

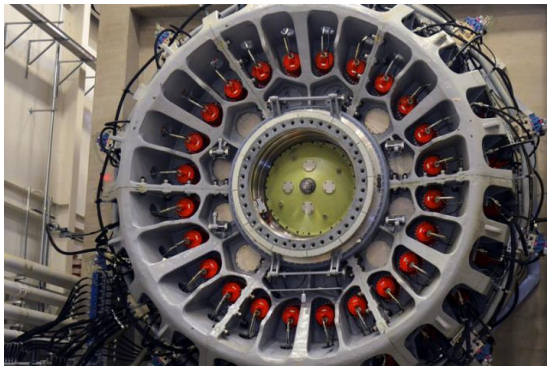
1. **Idaho National Laboratory**
   Idaho Falls, Idaho
2. **National Energy Technology Laboratory**
   Morgantown, West Virginia
   Pittsburgh, Pennsylvania
   Albany, Oregon
3. **National Renewable Energy Laboratory**
   Golden, Colorado
4. **Savannah River National Laboratory**
   Aiken, South Carolina

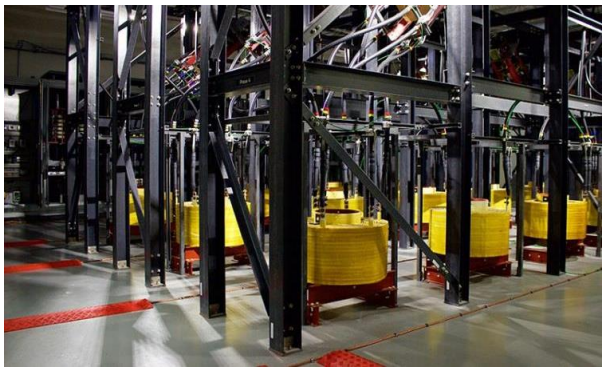
NNSA Laboratories

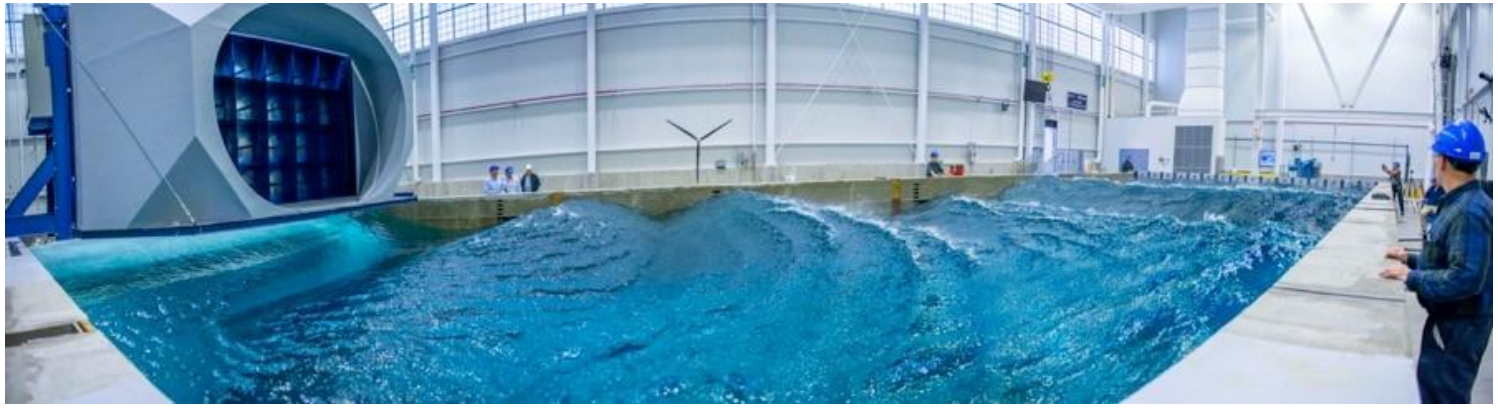
1. **Lawrence Livermore National Laboratory**
   Livermore, California
2. **Los Alamos National Laboratory**
   Los Alamos, New Mexico
3. **Sandia National Laboratory**
   Albuquerque, New Mexico
   Livermore, California



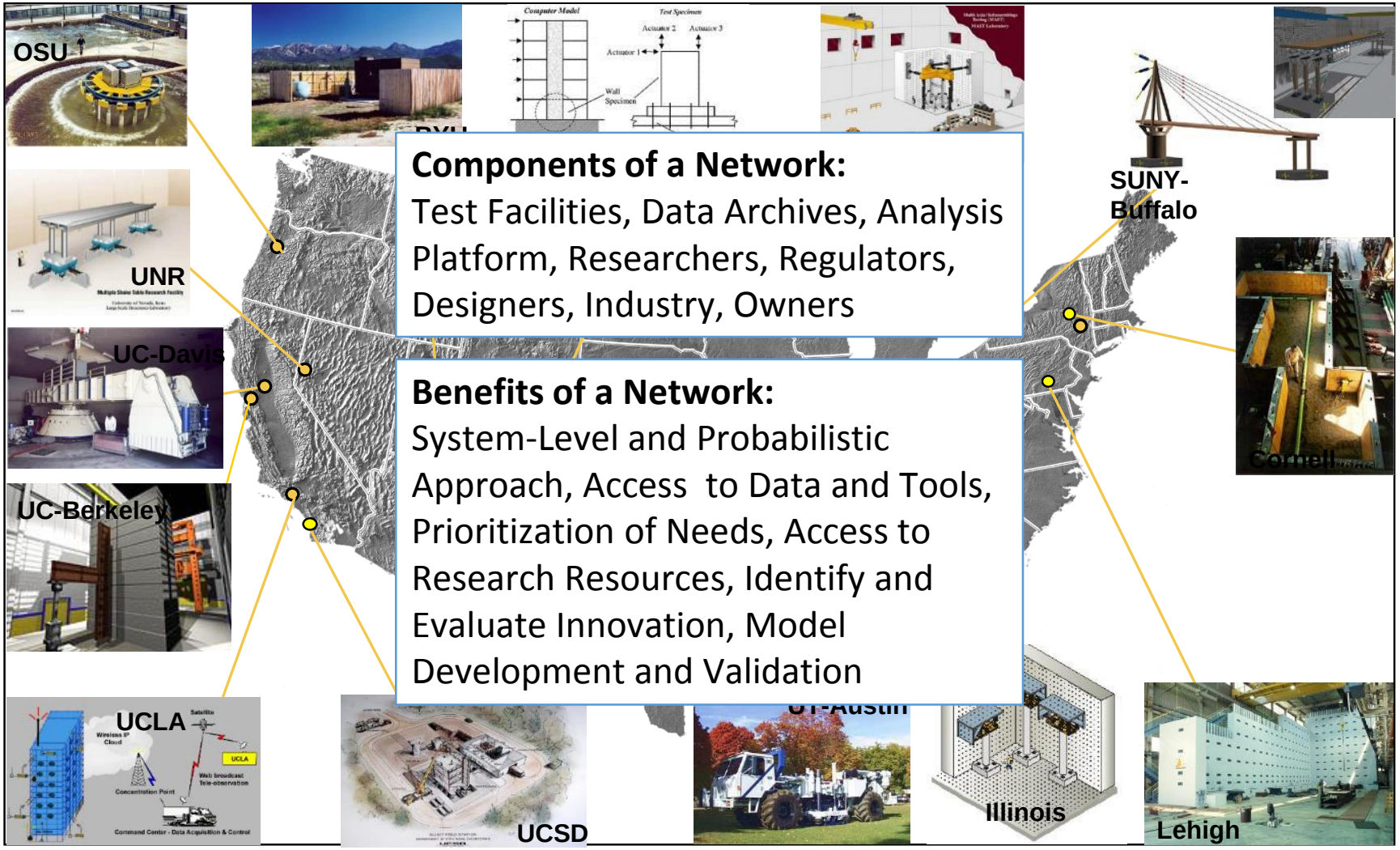
US Academic and Other Testing Facilities and Equipment

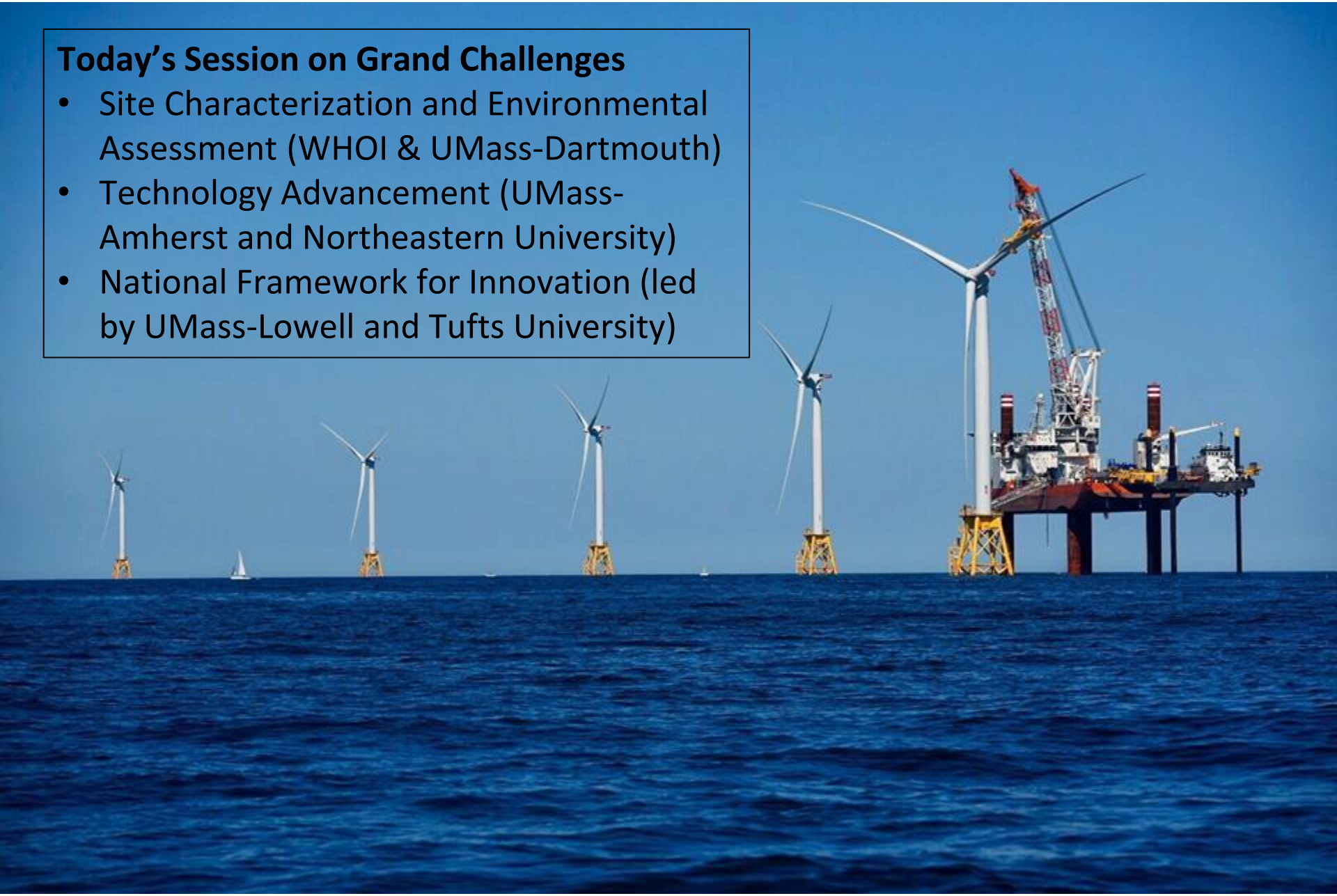






Components and Benefits of a Research Network (e.g. NSF Network for Earthquake Engineering)





Today's Session on Grand Challenges

- Site Characterization and Environmental Assessment (WHOI & UMass-Dartmouth)
- Technology Advancement (UMass-Amherst and Northeastern University)
- National Framework for Innovation (led by UMass-Lowell and Tufts University)

Closing

Tufts