BOEM
Bureau of Ocean Energy Management

Information Transfer Meeting

America's First Offshore Wind Farm and the Influence of Oil & Gas Experience

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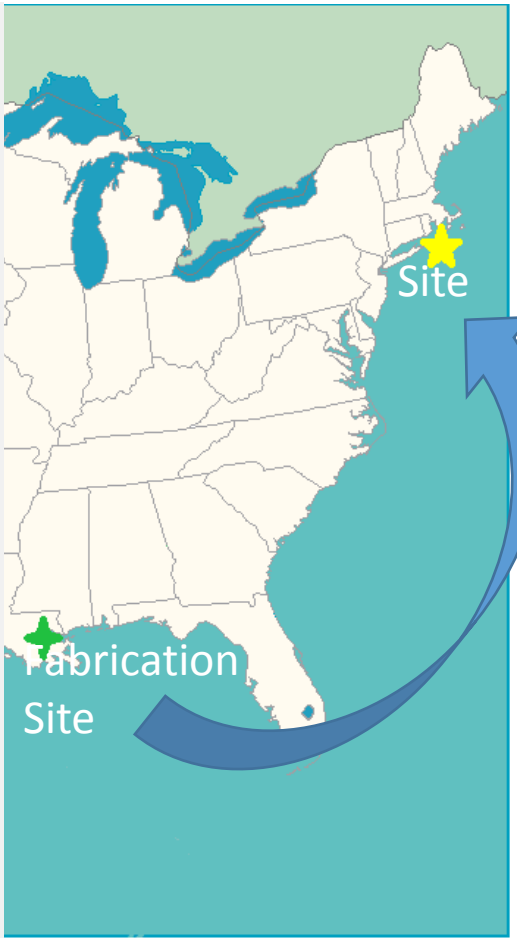
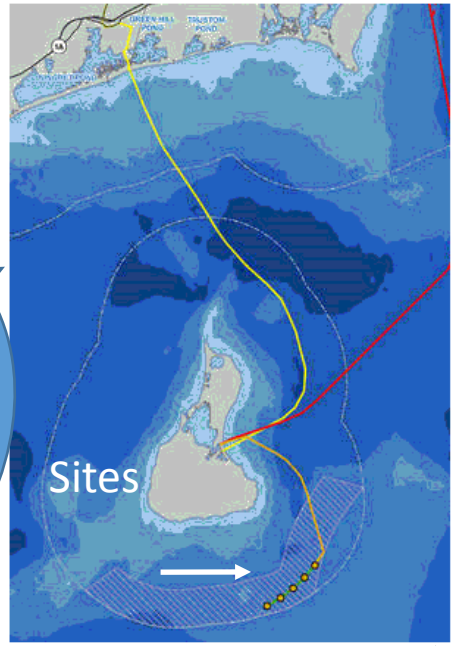
PROJECT PARTICULARS

- Deepwater Wind – Block Island Wind Farm:
  - CAPEX 290,000,000 USD
  - 30MW – 17,000 homes
  - 5 GE Haliade 150 6 MW Wind Turbine Generators
  - 3 Miles from Block Island, 15 Miles from Mainland
  - 28m Water Depth
- First Offshore Wind Power Generation Plant Operating in US:
  - 40% Energy Savings for Block Island
  - 300 Constructions Jobs
  - 40,000 tonnes of Carbon Dioxide Offset

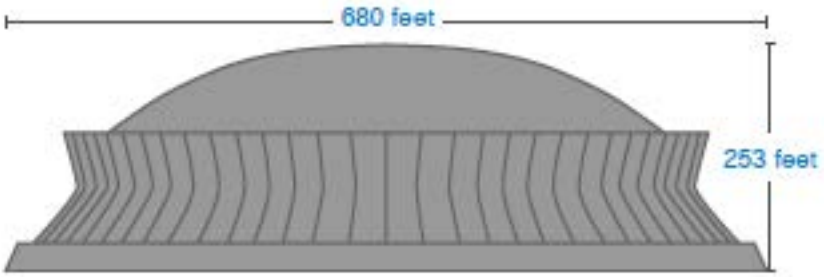




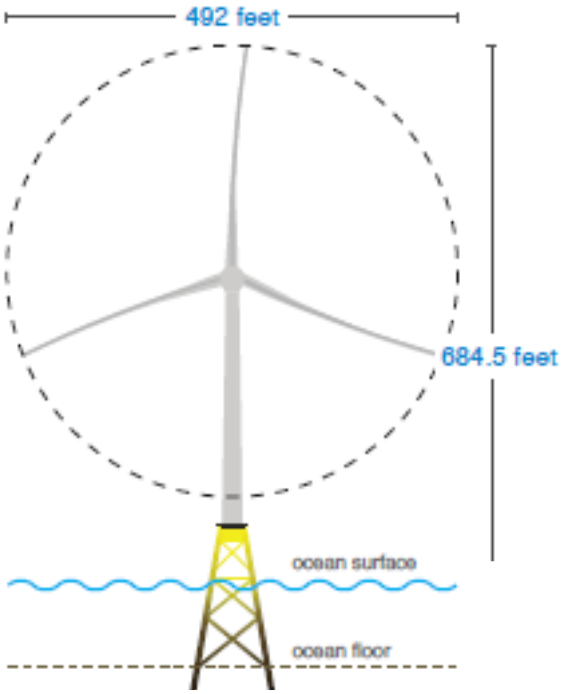
BLOCK ISLAND WIND FARM
America's First Offshore Wind Farm

UNDERSTANDING THE SCALE OF WIND

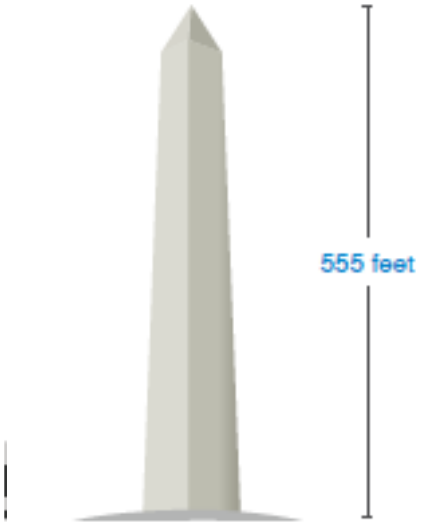
HOW DOES WIND MEASURE UP?



Mercedes-Benz Superdome



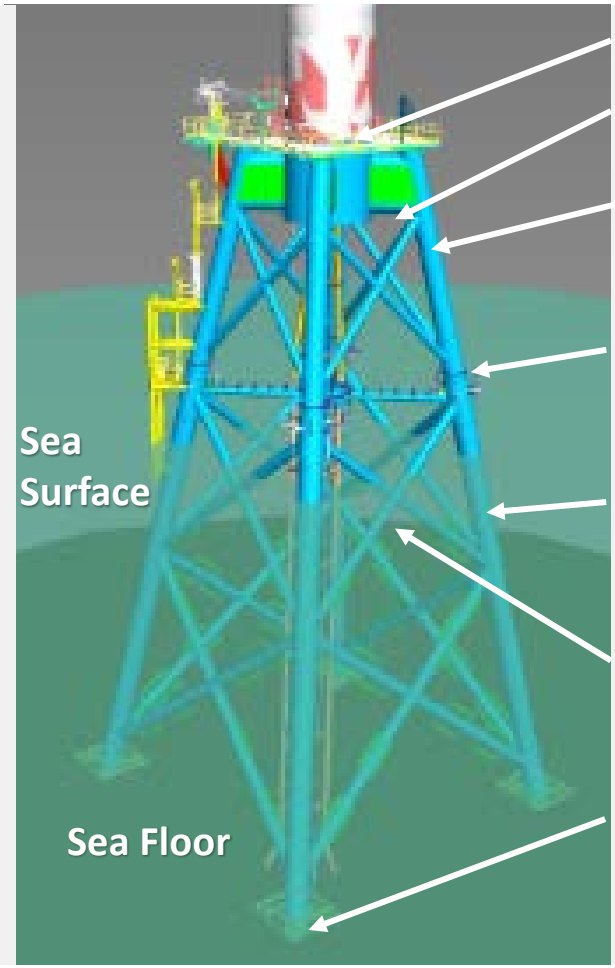
Block Island Site 1
Wind Turbine & Support Structure



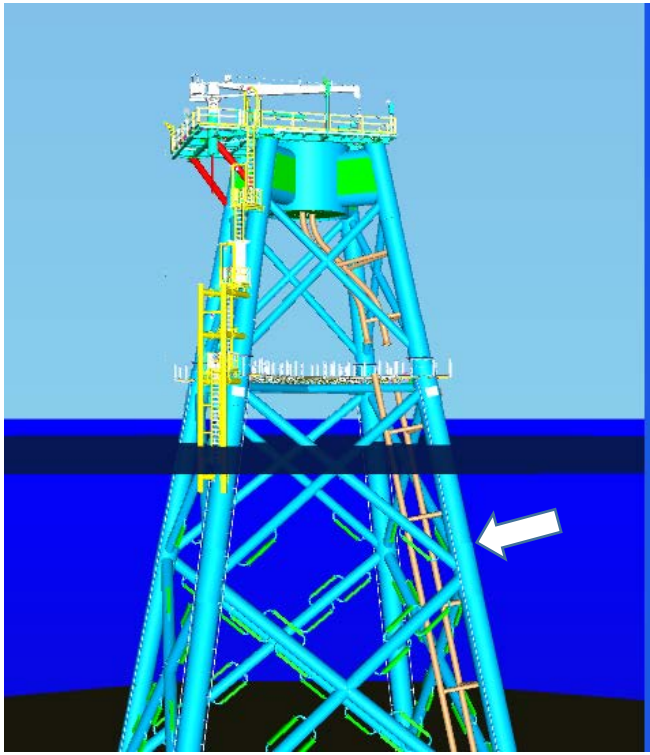
Washington Monument

CONFIGURATION SIMILAR O&G 4 PILE JACKET

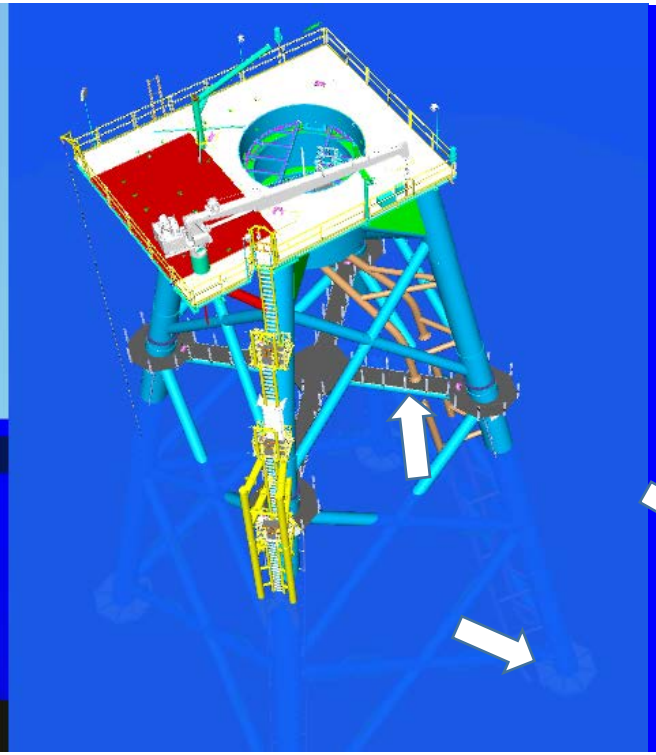
- SELECTION CRITERIA
  - Maximize Use of the US Offshore Supply Chain
  - Maximize Existing US Experience Fabricating O&G Platforms
  - Utilize US Flagged Jones Act Compliant Marine Vessels
  - Minimize Offshore Lift Weights
- THE SUB-STRUCTURE SOLUTION
  - Separate Jacket and Transition Section Deck Installed Offshore
  - Post-piled Through Jacket Legs
  - TKY Standard Weld Profiles and Qualifications



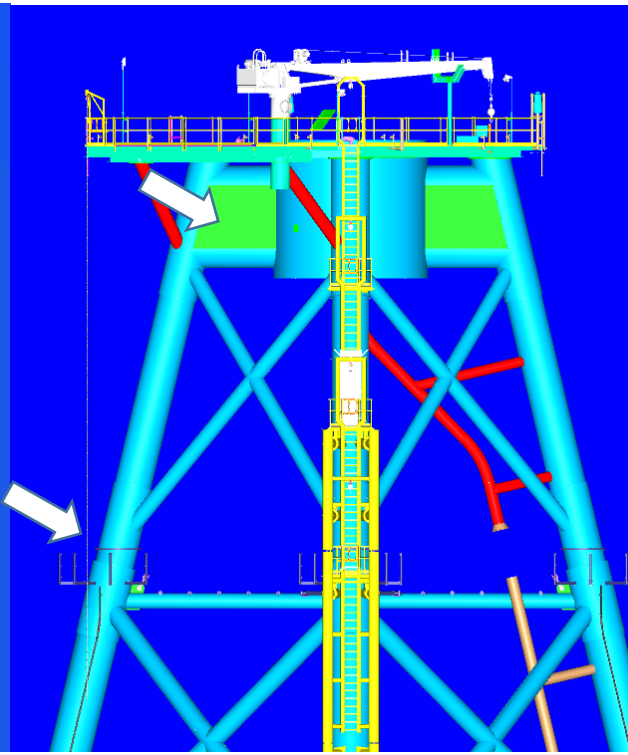
A UNIQUE WIND TURBINE FOUNDATION



- Jacket Legs Grouted to Piles to reduce Jacket Weight and improve Connection Strength



- Jacket supported by Mudmats during Pile Driving with
- Temporary Access Walkways for Leveling by Pile Cut-off



- Separate Deck Transition with Elongated Brace Cross-Sections
- Connecting Legs to the Transition (Field Welded Offshore to Piles)

ANALYSIS METHOD UNIQUE TIME DOMAIN

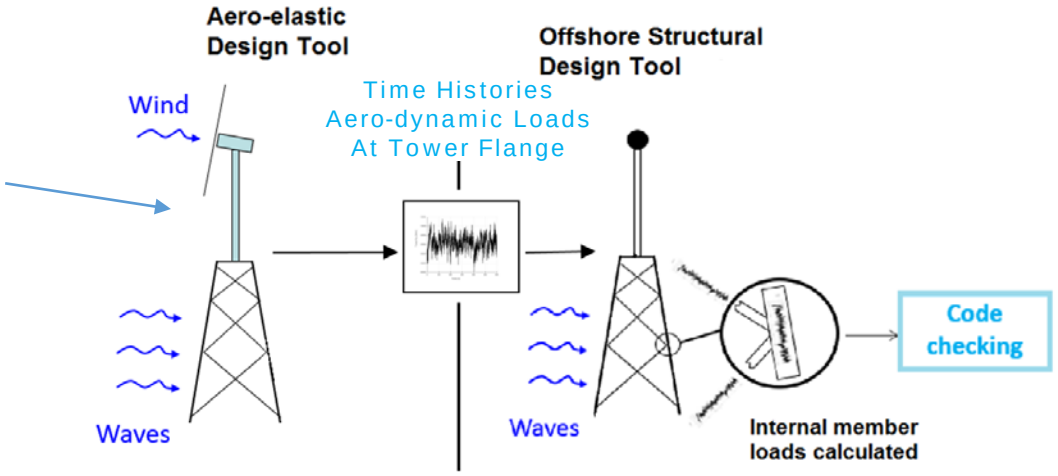
SEMI-COUPLED LOADS APPROACH

2500 Design Load Cases (DLC's)

(Typical 6 Seeds for Each10 min Load Simulation)

5000 Hours of Simulation Per Design Loop

Each Loop Taking Engineers Months to Complete



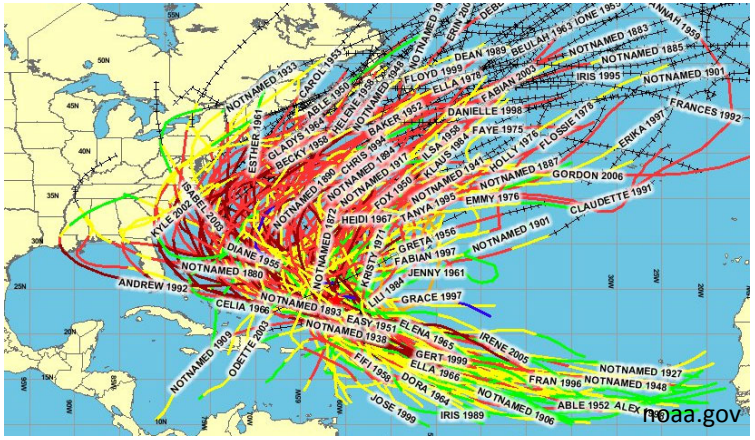
Bladed (DNV-GL)

SACS (Bentley)

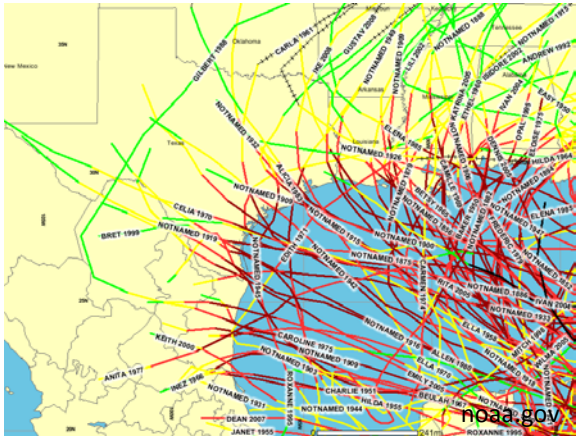
FIRST FOUNDATION DESIGN FOR HURRICANES

NREL Photo

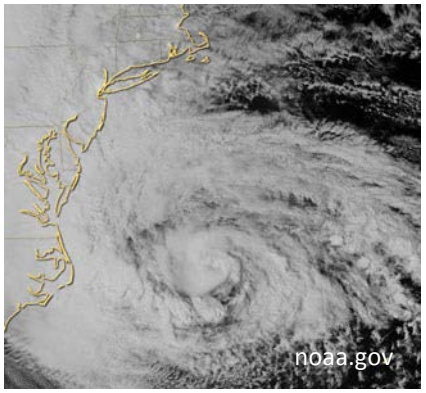
DESIGNING FOR HURRICANES



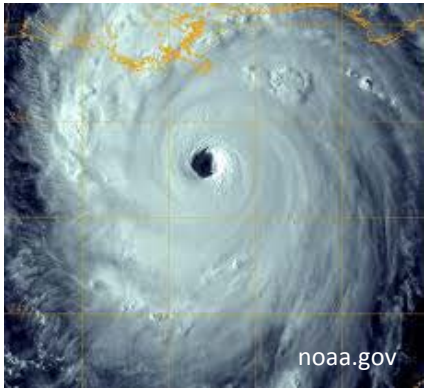
History – Tropical Cyclones Atlantic Coast



History – Tropical Cyclones Gulf of Mexico

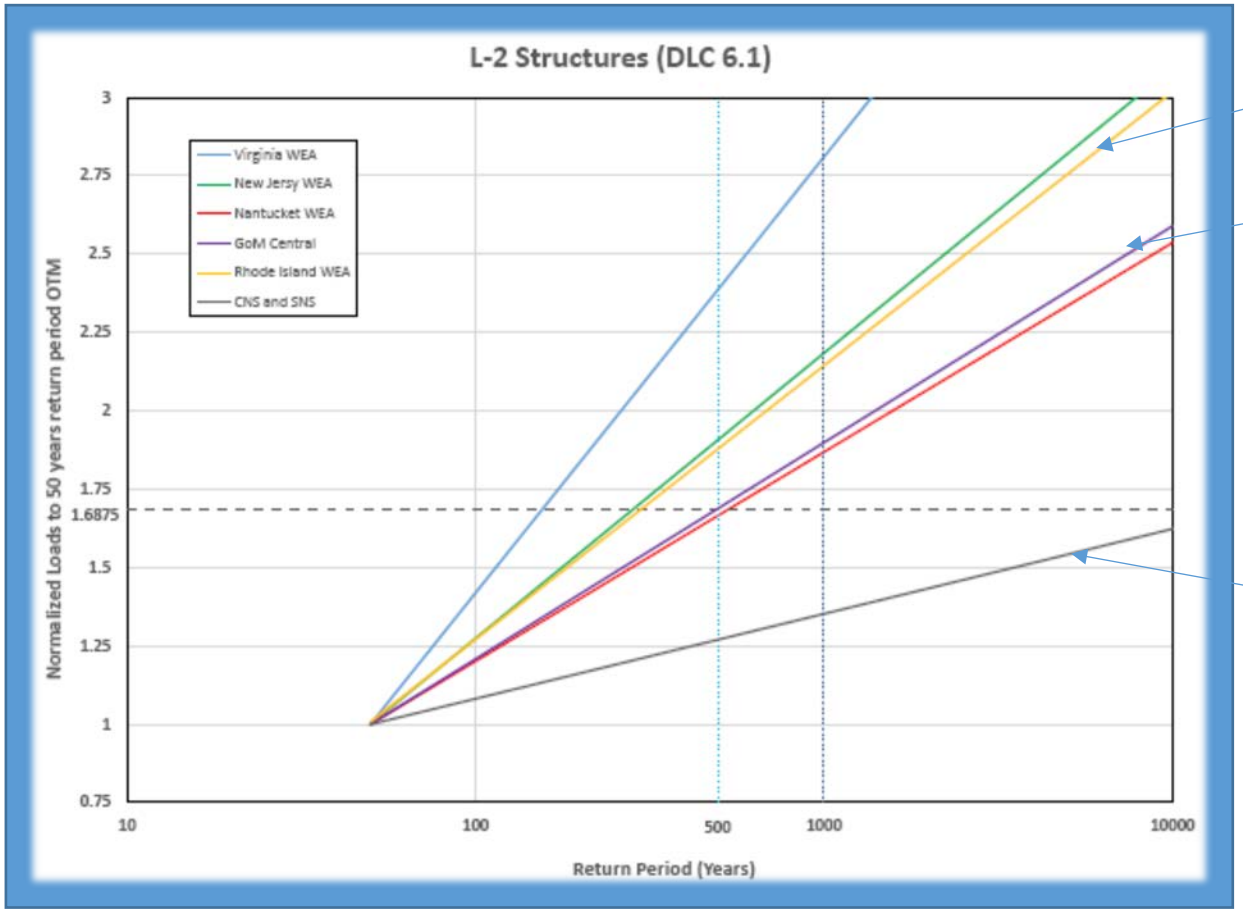


Hurricane Sandy 2012 New Jersey Coast
50 Year<Sandy<100 Year Return Conditions



Hurricane Katrina 2005 Central Gulf of Mexico
400 Year Return Conditions

Hazard Curves Atlantic WEAs L-2 Design

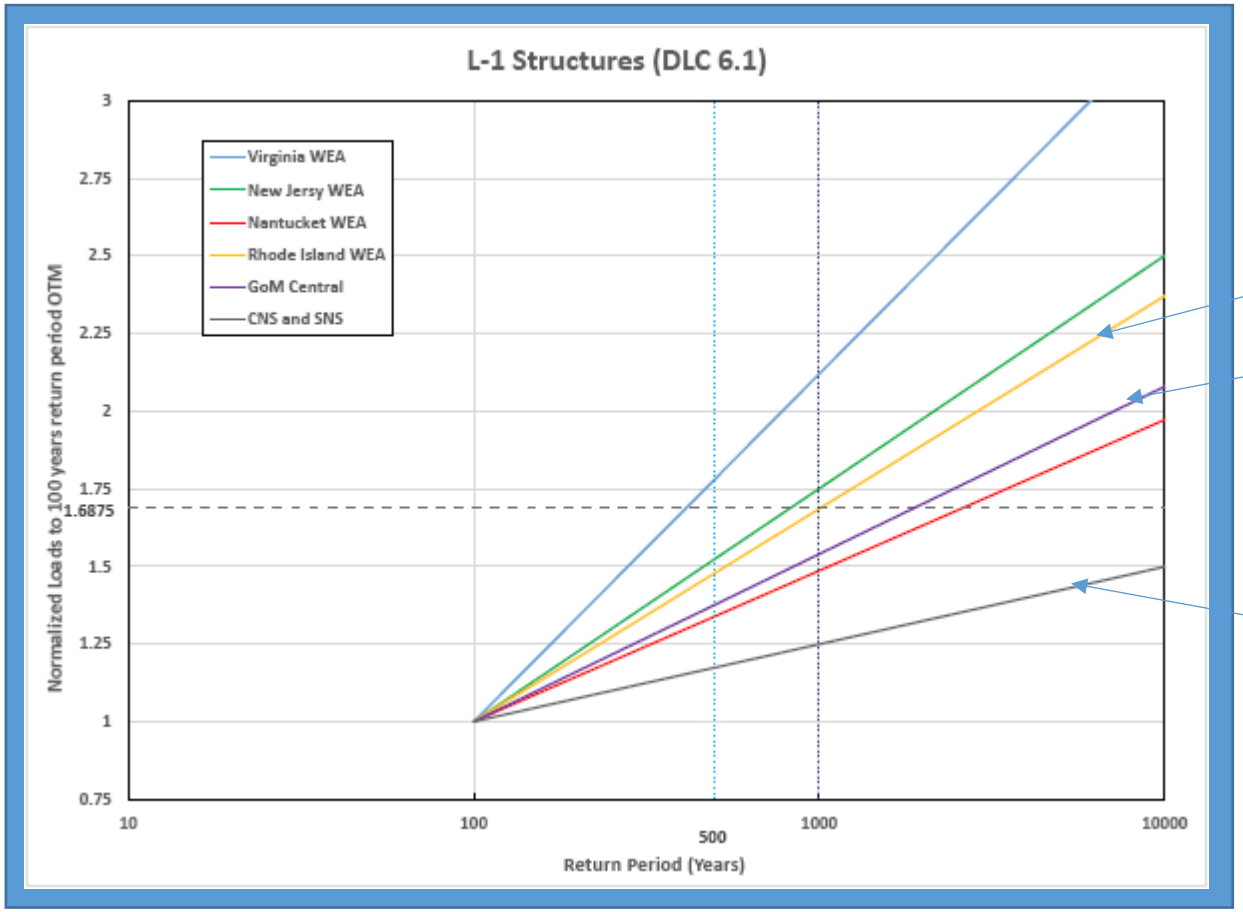


Rhode Island

Central GoM

Southern North Sea (Extra Tropical)

Hazard Curves Atlantic WEAs L-1 Design



Rhode Island

Central GoM

Southern North Sea (Extra Tropical)

IEC 61400-3 EXTREME CONDITIONS

API RP 2A 22nd and API 2MET		AWEA OCRP 2012	Percent Probability of Exceeding n $_{year}$ Return Period Event During Service Life (Years)									
Return Period (Years)	Exposure Category	Default Exposure Category	10	15	20	25	30	35	40	45	50	55
25	L3		33.52%	45.79%	55.80%	63.96%	70.61%	76.04%	80.46%	84.07%	87.01%	89.41%
50	L2	L2 (OWT Support Structure)	18.29%	26.14%	33.24%	39.65%	45.45%	50.69%	55.43%	59.71%	63.58%	67.08%
100	L1	L1 (Electric Serve Platform)	9.56%	13.9[illegible]%	18.21%	22.22%	26.03%	29.66%	33.10%	36.38%	39.50%	42.46%
200			4.89%	7.24%	9.54%	11.78%	13.96%	16.09%	18.17%	20.19%	22.17%	24.10%
500			1.98%	2.96%	3.92%	4.88%	5.83%	6.77%	7.70%	8.62%	9.53%	10.43%
1000			1.00%	1.49%	1.98%	2.47%	2.96%	3.44%	3.92%	4.40%	4.88%	5.35%
5000			0.20%	0.30%	0.40%	0.50%	0.60%	0.70%	0.80%	0.90%	1.00%	1.09%
10000			0.10%	0.15%	0.20%	0.25%	0.30%	0.35%	0.40%	0.45%	0.50%	0.55%

IEC 61400-3 DESIGN CONDITIONS HAVE A SIGNIFICANT POSSIBILITY TO BE EXCEEDED DURING THE SERVICE LIFE.

"ROBUSTNESS" IS AN IMPORTANT DESIGN CONSIDERATION TO ADDRESS THE HURRICANE HAZARD!

THEREFORE, BLOCK ISLAND WAS NOT DESIGNED TO THESE CURRENT IEC 61400-3 DESIGN LOAD CASES (DLCs) FOR EXTREME DESIGN CONDITIONS.
FOR HURRICANE REGIONS ADDITIONAL DLCS MUST BE CONSIDERED TO INSURE THE SUPPORT STRUCTURE IS CAPABLE OF RESISTING LESS FREQUENT AND MUCH GREATER HURRICANE LOADINGS.

WHAT IS *ROBUSTNESS*?

Robustness is Reserve Strength.

Robustness is Measured by the Reserve Strength Ratio (RSR).

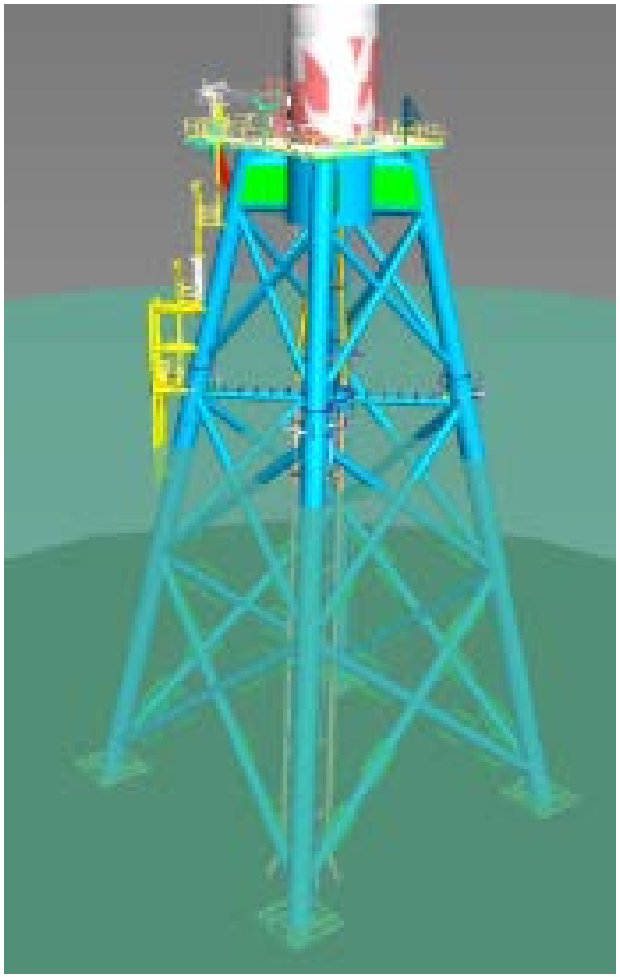
$$RSR = \frac{\text{Ultimate Structure Resistance}}{\text{Design Load}}$$

Greater RSR = Greater Robustness

DESIGNING FOR ROBUSTNESS

- **Utilized American Petroleum Institute's RP 2A Robustness Check Guidelines for Hurricane Regions to design for the Hazard of Exceeding Wind Industry 50 Year Return Design Conditions of IEC 61400-3**

THE BLOCK ISLAND DESIGN



- EXCEEDS CURRENT IEC 61400-3 DESIGN CRITERIA FOR EXTREME CONDITIONS (100 Year Return vs 50 Year Return)
- DESIGNED FOR BOTH HURRICANE AND EXTRA-TROPICAL (NORTHEASTER) EXTREME CONDITIONS
- SATISFIES API RP 2A L-1 STRUCTURES ROBUSTNESS CHECK (1000 Year Return)
- SATISFIES MEDIUM CONSEQUENCE FATIGUE SAFETY FACTORS
- BOTTOM OF TRANSITION ABOVE 1000 Year Return CREST ELEVATION
- THE BLOCK ISLAND SUPPORT STRUCTURE DESIGN IS VERY ROBUST MORE ROBUST THAN A DESIGN PER THE CURRENT IEC 61400-3 AND MORE ROBUST THAN A DESIGN PER THE COMMITTEE DRAFT OF IEC 61400-3-1

JACKET FABRICATION IDENTICAL O&G JACKET

UPENDING X-BRACED JACKET

JACKET FABRICATION IDENTICAL O&G JACKET

UPENDING X-BRACED JACKET

TRANSITION DECK FABRICATION UNIQUE

ASSEMBLING TRANSITION DECKS

TRANSITION DECK FABRICATION UNIQUE

ASSEMBLING TRANSITION DECKS

TRANSITION DECK FABRICATION UNIQUE

'RACE TRACK' BRACE FRAMING

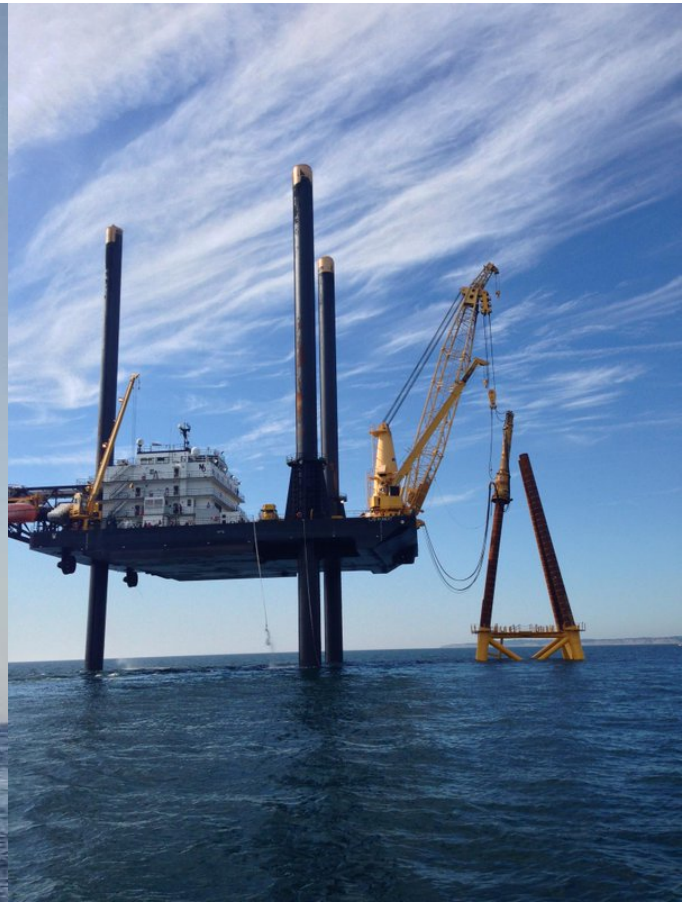
MOVING TRANSITION DECK SIMILAR O&G

LOADOUT ON CARGO BARGE SIMILAR O&G

SEAFASTENING TRANSITION DECKS AND PILES ON US CARGO BARGE

OFFSHORE INSTALLATION SIMILAR O&G

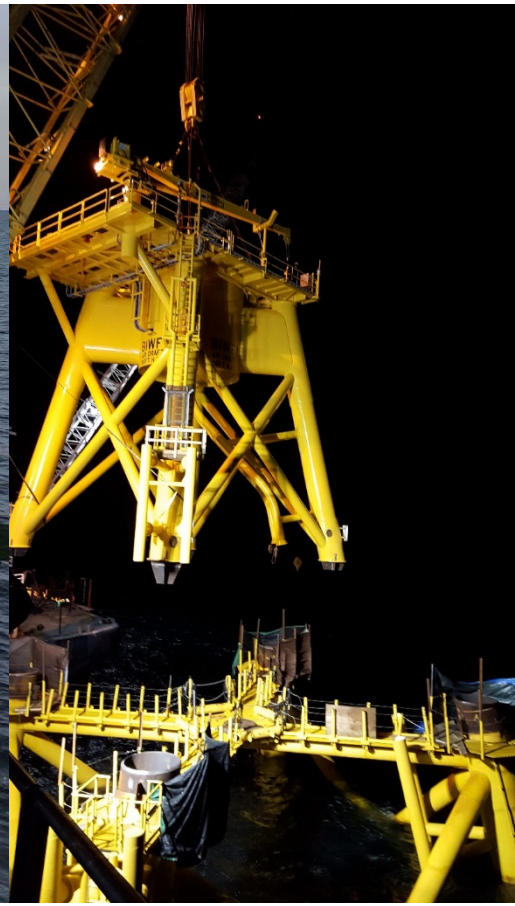
US EAST COAST DERRICK BARGE SETTING JACKET



US GOM LIFTBOAT DRIVING PILES

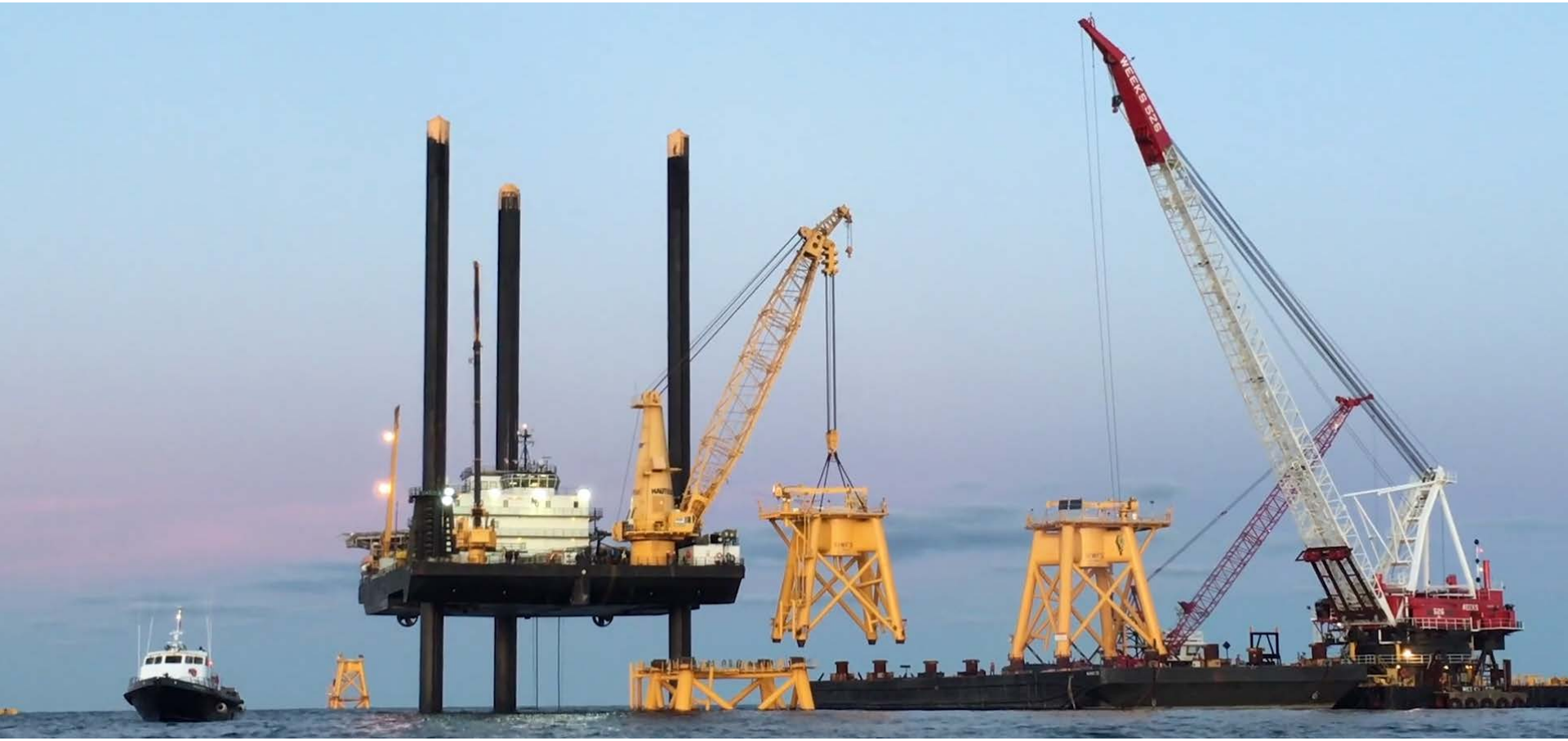
OFFSHORE INSTALLATION SIMILAR O&G

CUTTING PILES OFF LEVEL



LIFTING TRANSITION

OFFSHORE INSTALLATION SIMILAR OIL & GAS



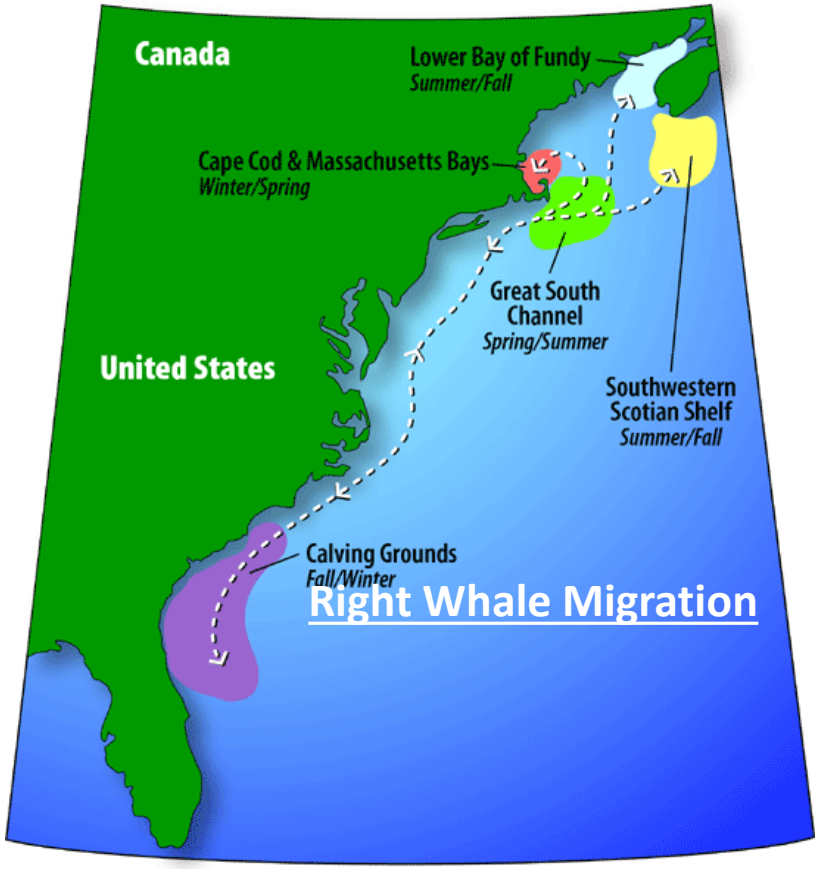
US EAST COAST DERRICK BARGE AND US GOM LIFTBOAT SETTING TRANSITION DECK

LEVELING TOWER FLANGE UNIQUE WIND

- Tower Mounting Flange Must Be Installed Level +/- 0.20 Degrees
- Deck Leg Base Plate As-Built Orientation Relative to Level Flange Determined at Fabrication Site
- After Pile Driving Piles Clips Welded Between Pile and Jacket Legs
- Piles Measured and Cut-off To Match Base Plates

HSE REQUIREMENTS UNIQUE ATLANTIC

- Avoiding Right Whale Migration in Fall and Winter Months Required Scheduling Installation Over Two Summers
- Pile Driving Activity Was Restricted to Slow Start Mode and Driving Could Only Commence in Day Light Two Hours Prior to Sunset
- In Addition During Migration Reduced Vessel Speeds Are Enforced



HSE REQUIREMENTS UNIQUE ATLANTIC

- Protecting Marine Mammals and Sea Turtles Also Required Full Time Whale and Sea Turtle Watchers During All Phases of Construction
- In Addition Underwater Acoustic Monitoring Ensured Noise from Construction Activities Were Maintained Below Limits Harmful to the Behavior of Marine Mammals and Other Aquatic Life

HSE REQUIREMENTS UNIQUE WIND

- Adopted European Wind Industry Boat Fender System
- Operation & Maintenance Personal Access and Egress Bow of O&M Vessel

HSE REQUIREMENTS UNIQUE WIND

- All Ladders Limited to 20 Feet
- Fall Protection Provided on All Ladders
- Tie-off Points Provided on Upper Access Platform

BLOCK ISLAND vs WESTERN GULF OF MEXICO

RECAP WIND vs OIL & GAS

- Hurricane Conditions – Western GoM Wind & Wave Greater
- Hurricane Hazard – BI Hazard Curve Steeper (Robust Check Controls)
- Fabrication – Jacket Identical but BI Tower Transition Unique
- Onshore Construction – Focused on Manufacturing verses One-off
- Loadout – Identical and Repeated
- Installation – Identical Except for Tower Tolerances and Repeated
- Environmental – BI Unique Whale Migration and Noise Mitigation
- O&M – BI Unique Bow Access/Egress Vessels and Boat Fender
- Safety – All Ladders with Fall Protection and Tie-off Points Provided

AMERICA'S FIRST