Project Number:	672
Category:	Design/Construction of Fixed Bottom Turbines
Date:	February 2014
Subject:	*Development of an Integrated Extreme Wind, Wave, Current, and Water Level Climatology to Support Standards-Based Design of Offshore Wind Projects*
Performing Activity:	Virginia Tech Advanced Research Institute
Principal Investigator:	G. Hagerman
Contracting Agency:	Bureau of Safety and Environmental Enforcement
Summary:	The researchers developed and applied methodologies to create a storm event climatology that characterizes standards-based design parameters for extreme winds, waves, currents, and water levels. These methodologies were applied at event return periods appropriate to the acceptable risk for the safe operation and survival of the various components of offshore wind projects, including the turbine, rotor-nacelle-assembly, the turbine support tower, turbine and tower foundation structures, and accessory platforms. The purpose of the study was to assist regulators and CVAs in their review of the design basis for upcoming offshore wind farm projects. The study consisted of the following phases: • Reviewing IEC 61400-3 and ABS guidelines with respect to metocean parameters specified for load cases involving extreme conditions. • Deriving fundamental metocean parameters for hurricanes and nor'easters. • Deriving specific wind and wave design parameters from the fundamental parameters. Measured data were used to validate multipliers from standards, or revised multipliers were recommended. • Develop methods for estimating extreme water levels, surface current speeds, and current profiles.
Key Findings:	• IEC 61400-3 specifies an extreme event return period of 50 years and ABS specifies 100 years; however, both specify the same design load cases (DLC) for parked conditions, with or without power for yaw control, using similar multipliers for combined DLCs of wind and wave. • Extreme wave loads or breaking waves may occur during hurricanes at wind speeds below cutoff speed, possibly resulting in a significant fatigue design load case. • Hurricanes may cause breaking or plunging waves in deeper water

	than normal.
Recommendations:	• Fundamental wind and wave metocean parameters are recommended for both hurricanes and nor'easters at 50- and 100-year return periods for 26 grid points within the designated Atlantic Wind Energy Areas. • For turbines subject to both hurricane and nor'easter conditions, the metocean basis of design should use a mixed, rather than commingled, analysis of peak wind speeds and significant wave height. • Shear wind profiles to determine design wind speed at hub height should be based on measured values from hurricanes, rather than the values specified in IEC 61400-3 and ABS. • New multipliers are recommended for combined DLCs for extreme wind and wave conditions. For reduced wave heights, the multiplier should be increased from 1.3 to 1.7. For extreme wave heights, the multiplier should be increased from 1.86 to 2.2.
Subsequent Studies/Activities:	• The U.S. Army Corps of Engineers (USACE) and the National Centers for Environmental Prediction (NCEP) are working on expanding metocean parameters within wind energy areas. • An incorporation of results into IEC 61400 is a possibility.
Report Link:	AA: IEC 61400-3 Table 1 Design Load Cases (DLCs)
	AB: Extratropical Storm Winds, Waves, and Water Levels
	AC: Extratropical 50- and 100-Year Winds and Waves
	AD: Offshore Synthetic Hurricane Track Model Development
	AE: Fundamental Wind and Wave Parameters for Offshore Wind Design
	AF: Additional Atlantic Offshore Wind Grid Points for New 30-Year Re-Analyses by USACE Wave Information Studies and by NCEP Wavewatch III
	AG: Final Report