TECHNICAL SUMMARY

Study Title: Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species

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Contract Number: M09PC00014

Sponsoring OCS Region: Pacific

Applicable Planning Areas: Alaska (*North Slope, Frontier Areas, Aleutian Islands)*, Atlantic (North, Mid, South), Gulf of Mexico (*Eastern, Central, Western*), Pacific (*Washington/Oregon; Northern, Central, Southern California*)

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Project Manager: Ann Pembroke

Affiliation (Project Manager): Normandeau Associates, Inc.

Address: 25 Nashua Rd., Bedford, New Hampshire 03110

Principal Investigators: Eric Nestler, William Bailey PhD., Timothy Tricas PhD., Andrew Gill PhD.

Key Words: electromagnetic fields, EMF, direct current, magnetic fields, electric fields, electrosensitivity, magnetosensitivity, offshore renewable energy, impacts from offshore wind power, impacts from undersea (or subsea) power cables, power lines, transmission lines, undersea (or subsea) cables, submarine power lines, elasmobranch, shark, marine mammals, whales, sea turtles

Background: Growing demand for clean domestic power sources has stimulated interest in offshore renewable energy technologies. Commercial development of these technologies is new to US waters, and the Energy Policy Act of 2005 authorized the Department of the Interior to grant leases, easements, or rights-of-way for various energy-related activities on the US Outer Continental Shelf (OCS). This authority was delegated to the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), which has established an Alternative Energy and Alternate Use Program for approval and management of these new activities on the OCS. BOEMRE's responsibilities cover activities that "(1) produce or support production, transportation, or transmission of energy from sources other than oil and gas, or (2) use, for energy-related or other authorized marine-related purposes, facilities currently or previously used for activities under the OCS Lands Act" (BOEMRE 2009). Although FERC (Federal Energy Regulatory Commission) has the responsibility for the licensing of wave and ocean current projects and BOEMRE is responsible for issuing leases for offshore wind projects, all components of these projects (energy generating arrays and transmission cables) require leases from BOEMRE. As a result, BOEMRE is responsible for understanding the potential impacts associated with power transmission from any of these projects before a lease can be granted.

BOEMRE has funded research projects to increase understanding of various issues associated with the development of renewable energy projects on the OCS. One issue, common to all

offshore renewable energy technologies, is the effect of electromagnetic field emission from inter-array and export cabling on marine organisms. Information on the magnitude and environmental effects of EMFs is widely scattered throughout the peer-reviewed and "gray" literature. In this era when many marine species have been found to be under increased stresses, the need for adding hundreds, if not thousands, of miles of submarine transmission lines makes it imperative that the regulators and developers have a comprehensive understanding of issues related to EMFs.

Objectives: This document provides a compilation of relevant literature (through 2010) that was assembled to meet two primary study objectives:

- Characterization and quantification of electromagnetic (EM) fields produced or predicted to be produced by underwater transmission cables associated with offshore wind projects;
- An understanding of the marine species occurring in the study area that may be sensitive to electric or magnetic fields, the physiological basis for those sensitivities, life history and behavioral characteristics that may affect potential for exposure, and potential effects of exposure to the field strengths identified in the first objective. The results of these investigations were assembled into a literature database for use in the NEPA analysis of proposed offshore renewable energy projects.

Description: A comprehensive literature survey was conducted on existing and proposed undersea power cables and on research related to the sensitivity of marine species to electric or magnetic fields. Literature was compiled into a database containing 441 documents to support the synthesis of this information and to provide a source of information to evaluate this topic during the NEPA analysis of individual projects or other BOEMRE actions related to the development of offshore renewable energy projects. Using the information available for 19 alternating current (AC) and direct current (DC) cables, direct magnetic fields and induced electric fields were modeled in order to quantify the intensity of these fields. Modeled field strengths as a function of distance above or lateral to the cable were developed so that the area of detectable field could be determined for individual species with known sensitivity thresholds. Much of the information on electro- or magneto-sensitivity came from research unrelated to offshore renewable energy and, as such, has limitations in its applicability to this subject. Based on this information, it is possible to conclude that at least certain species of marine organisms are capable of detecting the fields surrounding undersea power cables. Very few studies are available that test the response of organisms to these fields and there are fewer authors who extrapolate their results into impact assessments.

Information gathered on potentially affected species was synthesized with the characteristics of the power cables in order to provide the basis for impact analysis. This report summarizes existing literature on characteristics of elasmobranchs, other fishes, marine mammals, sea turtles, and invertebrates to demonstrate the level of certainty regarding the electro- or magnetic sensitivity of these species. Within each group of organisms, species of greatest concern were identified so that NEPA analysis and future research could target those species that may face the greatest risks from EMFs. For each group of species, a case study was presented that documented the level of information available for assessment and the degree of certainty with which impacts could be defined.

Magnetic or electric senses have been reported for a wide range of marine taxa. Among the groups of organisms examined, electrosensitivity is widespread among elasmobranchs and magnetosensitivity is widespread among sea turtles and marine mammals. Sensitivities are highly variable or not well understood among other types of fish and invertebrates. On a qualitative basis, information on sensitivity combined with behavior suggests that elasmobranchs and sea turtles have the highest likelihood of being affected if exposed to power cables. The potential consequences of such exposure at the population or species level are only speculative, however. Behavior of some species (e.g., marine mammals, pelagic fish) tends to minimize the risk of exposure. Mobile benthic invertebrates or demersal fish potentially have a higher risk of exposure yet little is known about the sensitivity of most of these species and generalizations are difficult. Species with electrosensitivity (e.g., elasmobranchs, some teleost fish, and some decapod crustaceans) are likely to be able to detect EMFs from both DC and AC cables, although their sensitivity to DC cables is probably higher. Species with magnetosensitivity (e.g., sea turtles, some marine mammals, some decapod crustaceans) are more likely to be able to detect EMFs from DC cables than AC cables.

Targeted research would increase our understanding of the effects of exposure to EMFs. *In situ* measurements of field strength around operating power cables would serve to validate model results and confirm the magnitude of this potential impact-producing factor. Several suggestions were made for research projects that could improve the ability to assess biological impacts associated with undersea power cables, including mesocosm studies with benthic sharks and sturgeon, laboratory studies with arthropods and sea turtle hatchlings, and statistical analysis of marine mammal stranding data.

A number of engineering approaches to reducing EMF emissions exist and their relative merits are discussed. Cable configuration and voltage have the greatest influence on emissions. Burial depth and additional cover are considered to have moderate effect on emissions because they reduce electric field emission but have a smaller effect on magnetic field emission. On a project-specific basis, however, selection of appropriate engineering features to reduce emissions must account for their potential secondary effects such as greater seafloor disturbance or habitat alteration.

This synthesis of available data and information clearly demonstrates that the nature and magnitude of any potential impacts to marine species from subsea power cable EMFs is not fully understood. Nonetheless, EMF modeling results in this report provide a general reference for understanding the magnitude and characteristics of magnetic and induced electric fields from subsea cables. The listing of priority species for US waters provides a focused list of species for which evidence suggests magneto- or electrosensory capabilities. The analyses of potential direct and cumulative impacts and compilation of data gaps and research priorities provide direction to guide further efforts to address the question of effects from power cable EMFs on marine species.

Study Products: Normandeau Associates Inc., Exponent Inc., T. Tricas, and A. Gill. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Regional Office, Camarillo, CA, MMS OCS Report 2011-09. 159 pp. + appendices

Preliminary results of this study were presented at several conferences:

Pembroke, A.E. and W. Bailey. 2010. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. Poster presented at AWEA Windpower 2010, Dallas TX.
Nestler, E., Pembroke, A.E. and W. Bailey. 2010. Effects of EMFs from Undersea Power Lines on Marine Species. Poster presented at EnergyOcean International Conference 2010, Ft. Lauderdale, FL.
Nestler, E., T. Tricas, A. Pembroke, and W. Bailey. 2010. Will Undersea Power Cables from Offshore Wind Projects Affect Sharks? Poster presented at AWEA Offshore Wind Conference 2010, Atlantic City NJ.