New York State Great Lakes Wind Energy Feasibility Study: Relative Risks, Minimization/Mitigation, and Benefits

Final Report | Report Number 22-12i | December 2022

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New York State Great Lakes Wind Energy Feasibility Study: Relative Risks, Minimization/Mitigation, and Benefits

Final Report

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New York State Energy Research and Development Authority

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Reading, PA

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Abstract

The Great Lakes Wind Energy Feasibility Study investigates the feasibility of adding wind generated renewable energy projects to the New York State waters of Lake Erie and Lake Ontario. The study examines myriad issues, including environmental, maritime, economic, and social implications of wind energy areas in these bodies of freshwater and the potential contributions of these projects to the State's renewable energy portfolio and decarbonization goals under the New York State Climate Act.

The study, which was prepared in response to the New York Public Service Commission Order Case 15-E-0302, presents research conducted over an 18-month period. Twelve technical reports were produced in describing the key investigations while the overall feasibility study presents a summary and synthesis of all twelve relevant topics. This technical report offers the data modeling and scientific research collected to support and ascertain Great Lakes Wind feasibility to New York State.

To further inform the study in 2021, NYSERDA conducted four public webinars and a dedicated public feedback session via webinar, to collect verbal and written comments. Continuous communication with stakeholders was available through greatlakeswind@nyserda.ny.gov NYSERDA's dedicated study email address. Additionally, NYSERDA and circulated print advertisements in the counties adjacent to both Lake Erie and Lake Ontario as to collect and incorporate stakeholder input to the various topics covered by the feasibility study.

Keywords

Great Lakes Wind Energy, Lake Erie, Lake Ontario, environmental impacts, mitigation

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Acronyms and Abbreviations

ABC	American Bird Conservancy
AIS	Automatic Identification System
AOC	Areas of Concern
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BTS	Bureau of Transportation Statistics
BUIs	Beneficial Use Impairments
°C	Celsius
Caltrans	California Department of Transportation
CEA	Critical Environmental Area
CEC	California Energy Commission
CEHA	Coastal Erosion Hazard Area
CLCPA	Climate Leadership and Community Protection Act
CO	Carbon Monoxide
CO_2	Carbon Dioxide
cSEL	Cumulative Sound Exposure Level
dB	Decibel
DoD	Department of Defense
EIA	Energy Information Administration
EMF	Electro-magnetic Fields
EPA	Environmental Protection Agency
ESA	Endangered Species Act
°F	Fahrenheit
FAA	Federal Aviation Administration
FCF	Fisheries Contingency Fund
FCO	Fish Community Objectives
FL	Flight Level
ft	Feet
GHG	Greenhouse Gas
GIS	Geographic Information System
GLAHF	Great Lakes Aquatic Habitat Framework
GLANSIS	Great Lakes Aquatic Nonindigenous Species Information System
GLCWC	Great Lakes Coastal Wetland Consortium
GLFC	Great Lakes Fishery Commission
GLSE	Great Lakes Shoreline Ecosystem
GWh	Gigawatt Hour
HETF	Haudenosuanee Environmental Task Force

HMS	Her Majesty's Ship
HRG	High Resolution Geophysical
IBA	Important Bird Area
IEA	International Energy Agency
IMO	International Maritime Organization
kg	Kilogram
km	Kilometers
kWh	Kilowatt Hour
LAMPs	Lakewide Action and Management Plans
lbs	pounds
LEC	Lake Erie Committee
LEEDCo	Lake Erie Energy Development Corporation
LOC	Lake Ontario Committee
m	Meters
mi	Miles
MMP	Mitigation and Monitoring Practices
MTR	Military Training Route
MW	Megawatts
MWh	Megawatts Hour
NABCI	North American Bird Conservation Initiative
NHPA	National Historic Preservation Act
NIMBY	Not in My Backyard
NMFS	National Marine Fisheries Service
nmi	Nautical Mile
NO_2	Nitrogen Dioxide
NO_X	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NREL	National Renewable Energy Laboratory
NY PAD	New York Protected Areas Database
NYS	New York State
NYS ESA	New York State Endangered Species Act
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSERDA	New York State Energy Research and Development Authority
NYSHPA	New York State Historic Preservation Act
OCS	Outer Continental Shelf
OSAMP	Ocean Special Area Management Plan
PM	Particulate Matter

$PM_{2.5}$	Fine Particulate Matter
POI	Points of Interconnection
PTS	Permanent Threshold Shifts
R&D	Research & Development
RSZ	Rotor Swept Zone
SAP	Site Characterization Plan
SCFWH	Significant Coastal Fish & Wildlife Habitats
SCUBA	Self-contained Underwater Breathing Apparatus
SMS	Safety Management System
SO_2	Sulfur Dioxide
SO_X	Sulphur Oxides
St	Saint
TEC	Tidal Energy Conversion
TTS	Temporary Threshold Shifts
μPa	microPascal
U.S.	United States
US PAD	United States Protected Areas Database
USACE	United States Army Corps of Engineers
USDOC	United States Department of Commerce
USDOT	United States Department of Transportation
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VHF	Very High Frequency
W	Watts
WEC	Wave Energy Conversion
WTG	Walleye Task Group
WTG	Wind Turbine Generation
YPTG	Yellow Perch Task Group

Summary

As part of the New York State Energy Research and Development Authority's (NYSERDA) the Great Lakes Wind Energy Feasibility Study, the Relative Risk Analysis, Minimization/Mitigation, and Benefits study describes the following in relation to Great Lakes Wind Energy: (1) distribution and habitat use of wildlife, human use conflicts, and potential risks of environmental and resource impacts (2) mitigation measures currently available in offshore wind that could be applied to minimize potential adverse impacts, and (3) potential benefits of Great Lakes Wind Energy. The study area is New York State waters of Lakes Ontario and Erie and coastal areas up to 2 kilometers (km; 1.3 miles [mi]) inland. Because no Great Lakes Wind Energy project has been developed to date, the environmental interactions and potential impacts described within this document draw on an interpretation of current species and lake-user distribution information, experience with comparable wind energy projects, and relevant local information.

The purpose of this document is to provide NYSERDA and the public with an assessment, based on the best information available, of the relative risks associated with the environmental and use conflicts as well as describe some benefits of New York State Great Lakes Wind Energy— the State decide to pursue such developments. Risk is the potential for harm to environmental resources or conflict with other uses (e.g., fishing, recreation). This study captures the main risks associated with Great Lakes Wind Energy development and assesses these risks at a high level with the best available science in New York State waters of Lakes Ontario and Erie. A risk may be greater in one area than another, so a relative risk assessment has been developed that captures spatial differential risk in cases in which there were sufficient differential data to allow for such comparisons. These findings provide critical information on the key potential environmental and biological impacts, user conflicts, benefits, and knowledge gaps to inform decisions about Great Lakes Wind Energy development. The challenges and opportunities described herein will be considered by the State of New York in determining the feasibility of developing Great Lakes Wind Energy in New York State waters.

The study was developed with a desktop literature review, synthesis of available data, webinars soliciting public input, and phone interviews with experts and State and federal agency representatives. For the purposes of this study, "receptors" are resources (e.g., wildlife, habitats, and human activities, such as fishing and recreation) that may be affected by Great Lakes Wind Energy; "stressors" are aspects of Great Lakes Wind Energy (e.g., pile driving, long-term structures) that can affect receptors; "impacts"

are adverse or beneficial effects of influencing factors on receptors; and "mitigation" concerns the choices or actions (e.g., application of sound dampening technology, seasonal limits for installation) that can avoid, minimize, offset, restore, or compensate for adverse impacts on receptors.

S.1 Wildlife and Habitats

The study considered birds, bats, invertebrates, and fish as major types of wildlife with the potential to be affected by Great Lakes Wind Energy. A variety of sensitive and specially designated habitats were also considered.

The Great Lakes are within the Mississippi and Atlantic flyways, major bird migration routes with millions of birds (of over 395 species according to BirdLife International) passing through the Atlantic flyway each year. Of these migratory birds, 34 species are federal or NYS listed as endangered, threatened or species of concern. Bird distribution and habitat use are described in the study in the context of bird clades: waterbirds, shorebirds, land birds, raptors, and gulls and terns. These distribution patterns are generalizations for purposes of assessing risk of likely spatial and temporal overlap with Great Lakes Wind Energy stressors, but bird movements and use patterns are variable by species and conditions.

Generally, waterbirds spend most of their time on water, and some forage in areas up to 16 km (10 mi) from shore. Shorebirds rarely travel more than 100 meters (m; 328 feet [ft]) from the water's edge. Land birds include upland game birds, songbirds, and others that may migrate in the region but do not forage on or spend significant time on or over the lakes or shorelines. Raptors are large, predatory species with wide home ranges that may forage over nearshore areas. Gulls and terns typically forage nearshore but can forage over open water. Within these groups, there are also birds that nest along the Great Lakes shoreline areas, some in colonial nesting habitats where large numbers of birds could be disturbed concurrently during activities like cabling to shore, port development, or substation and terrestrial infrastructure construction. Migratory birds tend to migrate mainly around the lakes rather than over open water, but it is uncertain how many birds travel over open water, under what conditions, at what heights and flight behaviors, and how weather and day/night cycles affect movements over the water. Migrating birds tend to use islands and peninsulas to move across lake areas, so areas close to western Lakes Erie and Ontario and eastern Lake Ontario in the study area have potentially more migratory activity than other parts of the lakes. There are specially recognized habitats, mainly in nearshore areas, that have been identified as nesting, stopover, and roosting areas, which were considered in evaluating relative risk to birds from Great Lakes Wind Energy development in different parts of the study area.

Less is known about bat than bird distribution and habitat use, but it is thought that bats also use islands and peninsulas to move across lake areas and roost in areas also used for nesting and roosting by birds (though threatened and endangered bats are not known to make long migrations), so important habitats for birds likely also constitute important habitats for bats. It is likely that similar to birds, landscape features such as forest cover, wetlands, and river margins are likely important habitat areas for bats.

Invertebrates in the study area are distributed in zones associated with depth and bottom substrates, for which different species have preferences, but there is not enough information to differentiate densities or species of invertebrates in the study area beyond those preferences. Invasive Zebra Mussels prefer hard substrates, so turbine structures may create connectivity for spread of this species, though benthic surveys of both lakes in 2018 and 2019 showed no presence of Zebra Mussels. Quagga Mussels are the dominant benthic organism in the lakes.

Fish are also generally distributed according to habitat preferences for nearshore, offshore benthic, and offshore pelagic habitats and move widely within these zones, but little is known about more refined distribution and use patterns in the study area. Data associated with movement and habitat use are available for some species, particularly those with commercial and recreational importance. Temperature preferences are used in fishing to locate some species, suggesting temperature may be predictive of dynamic fish distribution in some cases. Most fish spawn in nearshore areas, making those areas potentially more vulnerable to disturbance of fish. There are some migratory species that have different distributions by season, such as Walleye. As with benthic organisms, invasive fish species cause problems for native fish and habitats, and potential to affect those species with Great Lakes Wind Energy is important to consider in project development.

Specially designated habitats, such as critical habitat under the Endangered Species Act (ESA), NYS Areas of Concern (AOC), NYS Critical Environment Areas (CEA), Significant Coastal Fish and Wildlife Habitats, and Coastal Erosion Hazard Areas (CEHA) were all considered in relative risk analysis. Potential to impact terrestrial species is mainly related to potential to affect terrestrial habitats with activities like cable landing and port development. Wetlands and dunes were identified as terrestrial habitats that would have potential to be affected by Great Lakes Wind Energy. Further, habitats identified by stakeholders, such as Important Bird Areas (IBAs) and Critically IBAs, were also considered and are shown in maps included in the relative risk analysis.

S.2 Human Use Conflicts

For this study fisheries, water use, shipping, Department of Defense (DoD) activities, recreation, tribal uses, and historic/cultural areas were considered. There are a variety of terrestrial areas within the study area that have historical or cultural sites, and the Cattaraugus Reservation is within part of the study area on the shoreline of Lake Erie. There are major shipping lanes that traverse the northwestern part of the study area in Lake Ontario, and the Department of Defense and the Federal Aviation Administration have specially designated sites on Lake Ontario as well. A National Marine Sanctuary has been proposed to protect wrecks in Lake Ontario, and there are larger concentrations of known and possible wrecks in the eastern half of Lake Ontario than the rest of the study area. There are few data available on refined patterns of use by fisheries, recreational users, or communities and tribes within the study area, so relative risk associated with these factors is difficult to assess. Fishing activity also can vary with markets, conditions, fuel costs, and environmental factors that make fishing effort distribution difficult to predict.

S.3 Relative Risk Analysis

The relative risk analysis provided information related to relative risk associated with potential biological, environmental, regulatory, cultural, and social conflicts associated with Great Lakes Wind Energy across the study area. A phased approach to relative risk analysis was used to select Great Lakes Wind Energy stressors, identify receptor groups, assess the quality and quantity of data regarding receptor groups' distribution, and prepare relative risk maps. Although there are a variety of data that inform species distribution in the Great Lakes, there are limited data at the level of detail and resolution needed to show differential risk of species and/or user groups across the study area. The relative risk maps include potential points of interconnection (POIs) for cables to shore. This study focuses analysis on POIs that are within the study area as the cable-to-shore locations are more readily assessed as they are likely to be proximal to the POI; however, all POIs in the general assessment are also considered in evaluating potential cable-to-shore risks along the shoreline for inland POIs where there may be multiple options for bringing the cable to shore. Receptor groups were identified based upon their vulnerability and likelihood of interaction with Great Lakes Wind Energy and available data regarding locations, distribution, and seasonal use within the study area. The maps developed to inform relative risk were synthesized to describe relative risk across the area.

For purposes of this analysis, the area where turbines would most likely be installed was considered to be at least 16 km (10 mi) from shore in Lake Ontario and at least 8 km (5 mi) from shore in Lake Erie. The 16 km (10 mi) minimum distance from shore was chosen in Lake Ontario as a means to assess potential turbine stressors in Lake Ontario, where substantial lake area for possible development exists at that distance. In the narrow, east end of Lake Erie, the same 16 km (10 mi) minimum distance would eliminate most of the lake area in New York State waters. Therefore, a closer minimum distance for turbine placement was necessary for feasible construction in State. For the purposes of this analysis, a distance of 8 km (5 mi) from shore in Lake Erie was used. These distances (16 km and 8 km, respectively) were used as references to illustrate possible impacts but do not represent any decision by New York State regarding placement of wind turbines should Great Lakes Wind Energy development move forward in the future. These reference distances are shown in Figure S-1 and detailed further in section 4.1. This approach was used to identify a “turbine zone” offshore and a “cabling zone” from the turbine zone to shore to consider in terms of most likely potential impacts in those areas. The current study does not consider physical factors, like ice presence or geology, and is focused on relative risk to wildlife and human uses based on the best available information about how these receptors use the study area.

Figure S-1. Study Area with 16 km (10 mi) Line in Lake Ontario and 8 km (5 mi) Line in Lake Erie Indicating the Offshore Turbine Zones and Inshore Cabling Zones for Each Lake

In reviewing the data, data gaps were identified, and ongoing and potential future research was described. Spatial data for birds and bats flying over the lakes in the study area are not readily available, including data on flight paths, flight height, magnitude of birds/bats flying over the lakes, and changes in flight patterns over the lakes relative to weather and light conditions. Likewise, habitat use patterns and movements of most fish are not well studied within the study area. Distribution and use patterns of fisheries, including subsistence and cultural fisheries, are at lower resolution than ideal for assessing relative risk. Marine fish with swim bladders have more potential to be injured by sound and particle motion than fish without swim bladders, but little is known about the potential for freshwater fish with swim bladders to be impacted by sound or the potential behavioral reactions of Great Lakes fish to sound, electromagnetic fields, and other disturbance. Some data are available on distances from shore where benthic organisms are most likely to be found, but high-resolution species distribution data are not available. There is also a lack of resolution in data regarding human use patterns, such as recreational activities, tourism, and cultural uses.

S.3.1 Stressors

Table S-1 describes the Great Lakes Wind Energy stressors identified in the relative risk analysis.

Table S-1. Great Lakes Wind Energy Potential Stressors and Impacts

Pre-Construction	
Potential Stressors (Short-Term)	**Potential Impacts**
Sound/particle motion	Behavioral disturbance, interference with human uses.
Bottom Disturbance	Behavioral disturbance, turbidity, contaminant release, injury/mortality of some benthic organisms.
Increased Vessel Traffic	Behavioral disturbance, emissions
Short-Term Structures	Short-term habitat changes, attraction, displacement, connectivity for invasive species, navigational/fisheries hazard.
Construction	
Potential Stressors (Short-Term)	**Potential Impacts**
Sound/Particle Motion	Behavioral disturbance, injury/mortality, interference with human uses.
Sound/Particle Motion with Pile-Driving	Behavioral disturbance, injury/mortality, interference with human uses.
Increased Vessel Traffic	Behavioral disturbance, emissions
Bottom Disturbance	Behavioral disturbance, turbidity, contaminant release, injury/mortality of some benthic organisms.
Habitat Alteration	Behavioral disturbance, displacement, navigational/fisheries hazard, injury/mortality for benthic organisms.
Post-Construction	
Potential Stressors (Long-Term)	**Potential Impacts**
Sound/Particle Motion	Behavioral disturbance, displacement
Scour	Behavioral disturbance, displacement
Electromagnetic Fields, Vibration, Heat	Behavioral disturbance, displacement, barrier
Long-Term Structures	Lighting attraction, other attraction, displacement, collision, barrier, navigational/fisheries hazard, connectivity for invasive or native species, reef effects, habitat creation/modification/fragmentation, radar interference, aircraft hazard.
Increased Vessel Traffic	Behavioral disturbance, emissions, interference with other human uses.

S.3.2 Lake Ontario Relative Risk

Based on the best available data at this time, the turbine placement and cable route that would likely have the least impact on the resources considered in this study (assuming a turbine area at least 16 km [10 mi] from shore), would be turbines placed in the area of Lake Ontario south of the southernmost shipping lane to the east of the known and possible wrecks and with cables to shore that land at the westernmost POI in the study area. POI choice is driven mainly by ability to receive power, so if that POI were infeasible for projects, additional mitigation for sensitive habitats and CEHA permitting could be applied to bring power to shore in other identified POI locations, with risk increasing for cabling moving eastward. Alternatively, POIs outside the study area, further inland, may be used with cables extending larger distances on land to reach those POIs. See section 4.7.1 for more details.

S.3.2 Lake Erie Relative Risk

In summary, based on the best available data at this time, when considering turbine placement and cable laying, turbines placed more than 8 km (5 mi) from shore in the Central West part of the Lake with cables to shore at the POI near Central West Lake Erie would likely have the least impact related to the receptors considered here, followed by turbine placement in the southwest area with cables to shore at the POI near Central West. As noted above, POI choice is driven mainly by ability to receive power, so if that POI were infeasible for projects, additional mitigation for sensitive habitats and CEHA permitting could be applied to bring power to shore in other identified POI locations, with risk increasing for cabling to POIs moving eastward, as is the case with Lake Ontario. Alternatively, POIs outside the study area, further inland, may be used with cables extending larger distances on land to reach those POIs. See section 4.7.2 for more details.

S.3.3 Relative Risk across the Study Area

In the study area, both Lake Erie and Lake Ontario have lower risk associated with turbine placement away from areas that have peninsulas, islands, short connection between land areas that can be migratory areas for birds and bats, and Walleye fishing habitat (in Lake Erie), reducing the suitability of the eastern and western areas of Lake Ontario and the eastern area of Lake Erie (the western area does not border land but rather extends into Pennsylvania waters). There is also some heightened risk in the western part of the study area in Lake Erie because of proximity of the Long Point peninsula extending out from shore in Canada. Lake Ontario has substantively more known and possible wrecks that could affect turbine placement, configuration and cables among turbines as well as to shore for interconnection. Both lakes have a substantive portion of the coastline that is designated as CEHA, making it likely that permits and mitigation associated with erosion areas will be needed to bring cables to shore, though cables may be routed through areas without CEHA and continue on land to substations and POIs. This land-based approach could increase risk in the lakes and onshore because of additional cabling disturbance. CEHA itself is not necessarily a risk relative to cable crossings to shore, as engineering choices can minimize potential effects to coastal erosion and generally crossings are achieved through horizontal directional drilling under the ground, but the legal designation of CEHA could affect how cable-crossings are routed because permitting may be more difficult in CEHA.

Few or low-resolution data are available to assess bird flight patterns, heights, and behavior; benthic organism and fish distribution; and distribution of human uses, such as fisheries, cultural uses, or recreation. Lake Ontario has more area in New York State in which wind projects could be distributed, but the potential sanctuary designation, wrecks and military activities, and vessel corridors within Lake Ontario may be considered to increase risk in this lake relative to Lake Erie; however, Lake Erie has an abutting reservation and would have challenges for siting large-scale projects as far from shore as is possible in Lake Ontario because of the relatively limited size of NYS submerged land area in Lake Erie.

Overall, based on environmental and human use conflict risk assessment, it is feasible to develop wind in either lake, but different constraints apply to each, and filling data gaps (see section 4.5.1) and/or developing predictive models could help to reduce risk associated with receptors for which there are few or low-resolution data.

S.3.4 Assessment of Mitigation

The assessment of mitigation includes tables of stressors, potential impacts, and mitigation measures that can be used to avoid, minimize, offset, restore, and/or compensate for potential adverse impacts. Mitigation options are mainly based on those developed for marine offshore wind. Mitigation measures were organized in four categories: benthic organisms, birds and bats, fish, and fisheries, as these receptors had the most available information for potential mitigation measures.

Not every impact can practicably be mitigated, so priorities related to the likelihood and severity of impacts and the vulnerability of receptors to population level consequences or long-term impairments (such as reduced fisheries access) need to be considered in choosing mitigation measures for Great Lakes Wind Energy if it moves forward. The study area has existing impairments, including water quality issues, invasive species, coastal erosion, and habitat loss that could potentially be considered in the context of offset mitigation measures. It is common for impacts to species like birds and bats to be addressed with offsets in terrestrial windfarms, along with directed mitigation measures, such as smart curtailments or lighting that reduces attraction and also meets Federal Aviation Administration and other regulatory requirements. In addition, mitigation measures associated with the following are common mitigation measures in offshore wind plans and authorizations to date:

- Seasonal construction activities.
- Trenching and burying cables.
- Horizontal directional drilling and trenchless crossings for cable from water to land.
- Sound abatement measures (like bubble curtains) for pile driving.
- Distances from shore meant to limit visibility of turbines from shore.
- Notices to mariners.
- Configuration determinations in collaboration with Coast Guard and Department of Defense.
- Fisheries compensation.

Pre-construction and post-construction monitoring are often also included in planning and authorization requirements. Each project's unique location and equipment would help determine project-specific mitigation that would address the issues raised by a given project.

S.3.5 Assessment of Benefits

Great Lakes Wind Energy would reduce greenhouse gasses (GHGs) and air pollution by replacing fossil fuel generated electricity. Reducing reliance on fossil-derived electricity and decarbonizing the electrical sector could reduce climate change related public health issues. Reductions in air pollution would contribute to better public health. Great Lakes Wind Energy would not require water to generate electricity and could be an alternative that reduces industrial water use by displacing thermoelectric forms of power production.

Great Lakes Wind Energy is supported by the federal government's Executive Order on Tackling the Climate Crisis at Home and Abroad and NYS's Climate Leadership and Community Protection Act, both of which commit to decarbonizing the energy sector and increasing offshore wind energy. The U.S government and NYS are committed to reaching zero emissions by 2050. Great Lakes Wind Energy could contribute to these commitments. NYS is committed to environmental justice, and NYS has made strong commitments to ensure that disadvantaged communities can benefit from offshore wind energy, with 40% of the overall benefits from clean energy programs going to disadvantaged communities for job creation, workforce development, low-income energy assistance, housing, and other benefits. If Great Lakes Wind Energy moves forward, it could provide opportunities to address inequalities in local and regional communities; for example, by offering job training; employing local residents during construction and operations; and investing in the communities. In addition, eliminating harmful air pollutants that can disproportionately affect disadvantaged communities will ensure better public health in these communities.

1 Introduction

This study supports New York State Energy Research and Development Authority's (NYSERDA) Great Lakes Wind Energy Feasibility Study. First, the study describes the distribution and habitat use of wildlife, human use conflicts, and potential risks of environmental and resource impacts to Great Lakes Wind Energy. Second, the study describes the mitigation measures currently available in offshore wind that could be applied to minimize potential adverse impacts of Great Lakes Wind Energy. Third, the study describes the potential benefits of Great Lakes Wind Energy. The study areas are New York State waters of Lakes Ontario and Erie and coastal areas up to 1.3 miles (mi; 2 kilometers [km]) inland. Because no Great Lakes Wind Energy project has been developed to date, the environmental interactions and potential impacts described within this document draw on interpretation of current species and lake-user distribution, experience with comparable wind energy projects, and relevant local information.

The purpose of this document is to provide NYSERDA and the public with an assessment, based on the best information available, of the relative risks associated with environmental and use conflicts as well as describe some benefits of New York Great Lakes Wind Energy, should NYS decide to pursue such developments. As possible, based on available data, relative risk is described across the study area. These findings provide information on the key potential environmental and biological impacts, user conflicts, benefits, and knowledge gaps to inform assessment of feasibility of Great Lakes Wind Energy development in the study area.

2 Methodology

This study was developed with a desktop literature review, synthesis of available data, and phone interviews with experts and NYS and federal agency representatives. For a further description of methodology for each part of the study see sections 3.1, 4.1, 4.6.1, 5, and 6.1.

2.1 Study Area

The study area is the New York State waters of Lakes Ontario and Erie including coastal areas up to 1.3 miles (mi; 2 kilometers [km]) inland along each lake's NYS edges (Figure 1).

Lake Ontario is the smallest of the Laurentian Great Lakes, (O'Gorman 2017, Stewart, Todd and LaPan 2017) and the eighth largest body of fresh water in North America (Junior 2018). More than half of the lake's surface area (52%) is within the Province of Ontario Canada, and the remainder is in New York State (Stewart, Todd and LaPan 2017). Its deepest depths are reached in the western portion of the lake (Figure 2). It has a mean depth of 86 meters (m; 282 feet [ft]) and a maximum depth of 243.8 m (799.9 ft) (USEPA 2020b).

Lake Erie was formed from glacial activity around 3,500–12,000 years ago (Francis, et al. 2020). Lake Erie is the shallowest of the Laurentian Great Lakes, the eleventh largest freshwater lake in the world (Ludsin, et al. 2001), and the sixth-largest body of fresh water in North America (Junior 2018). It has three basins: Western, Central, and Eastern. Each basin differs with depth, hydrology, bathymetry, and biological productivity. The deepest depths are reached in the northwest portion of the eastern basin, with shallower depths toward the south southeast (Figure 2).

The average depth in the Eastern Basin is 24 m (79 ft), and maximum depth is 64 m (210 ft). The Western Basin is the shallowest basin with average depth of 7.3 m (24 ft) and maximum depth of 18.9 m (62 ft). The Central Basin is the most uniform in terms of depth, with average depth of 18.3 m (60 ft) and maximum depth of 25 m (82 ft) (USEPA 2020a). The New York State waters of Lake Erie are within the Eastern Basin of the lake (Burns 1985), which holds 32% of Lake Erie's volume (Bolsenga and Herdendorf 1993). Because NYS waters/lands are only within the Eastern Basin, the study area does not include areas of the Central or Western Basin.

Figure 1. New York State Great Lakes Wind Energy Feasibility Study Area (outlined in red).

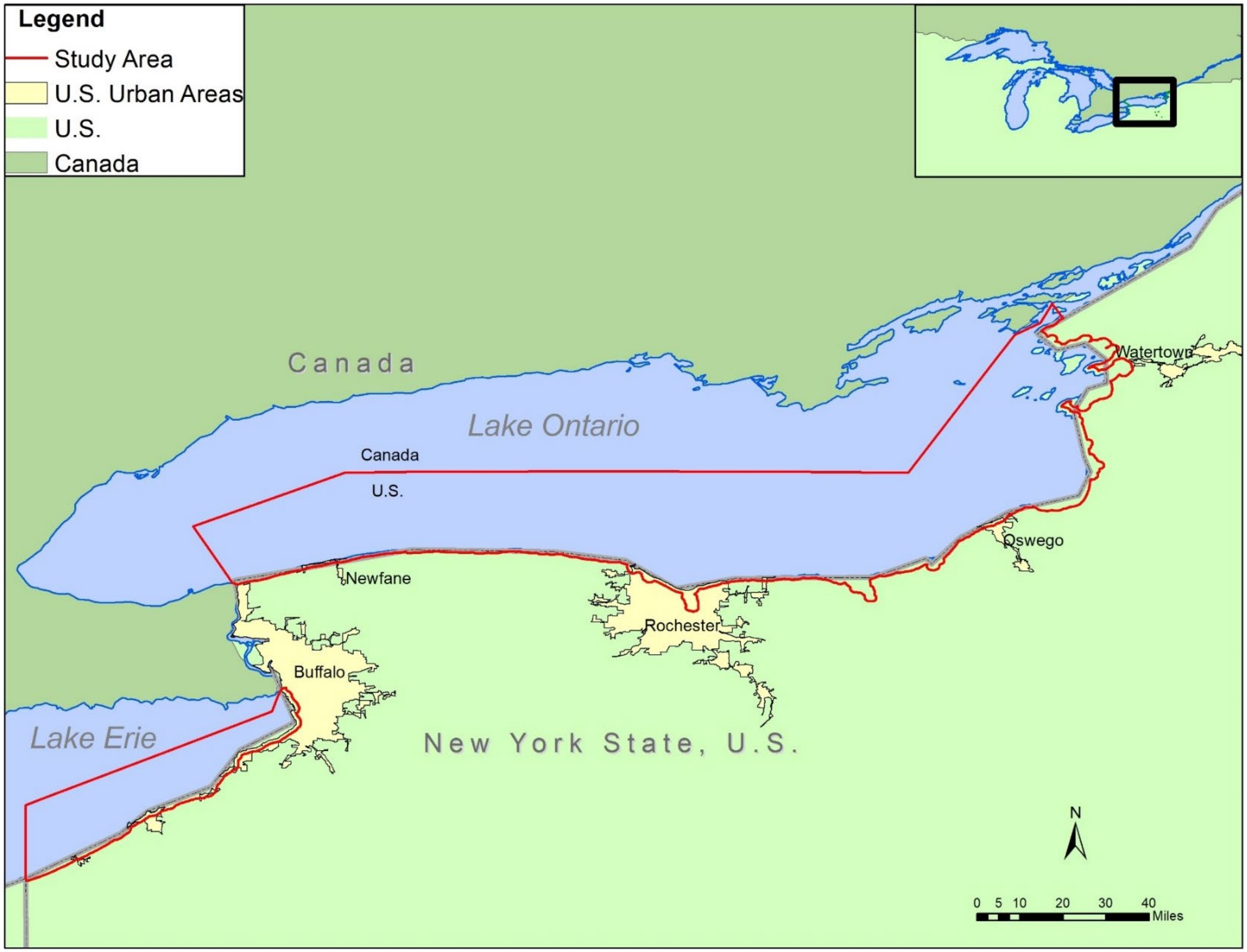
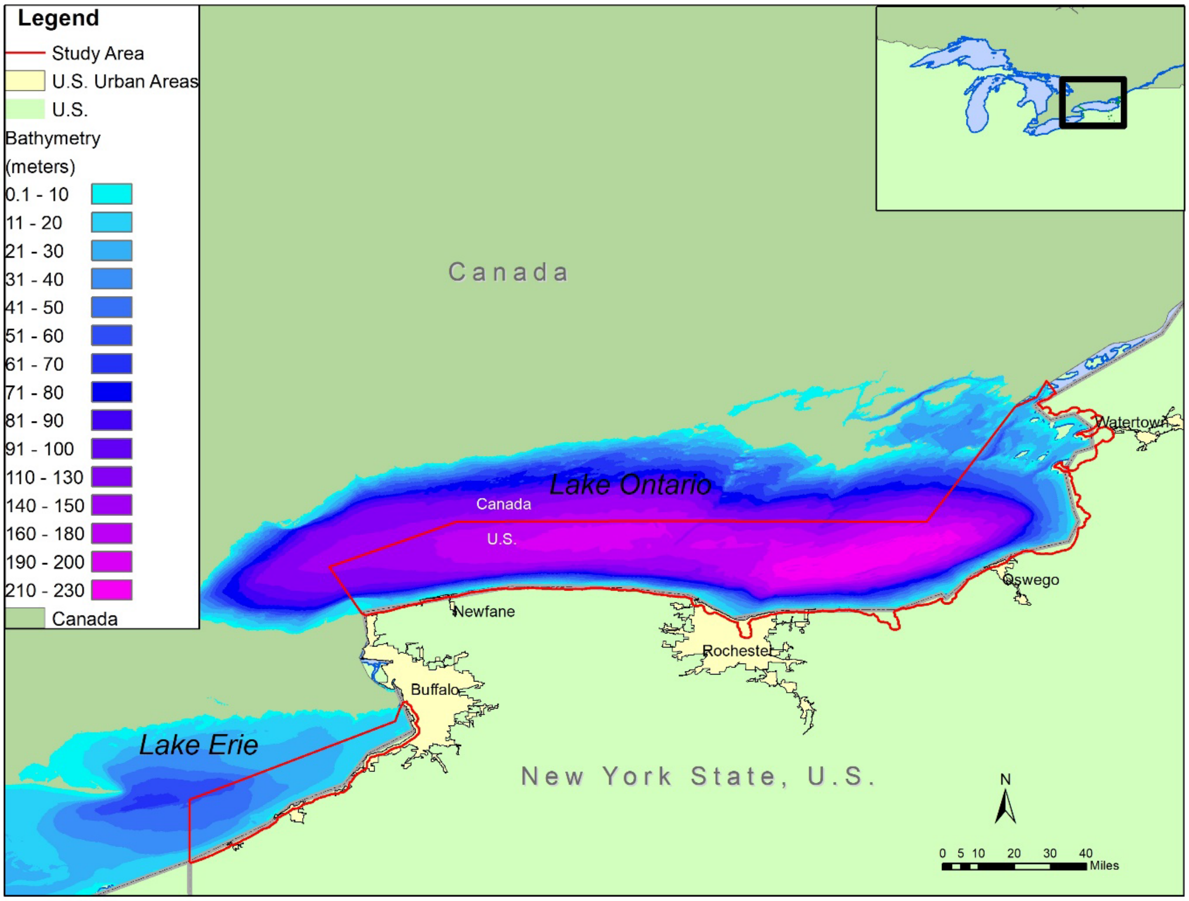


Figure 2. Bathymetry of Lakes Ontario and Erie

Source: (NCEI 2021a, NCEI 2021b)



3 Receptors and Their Habitat Use and Distribution

This section describes what is generally understood about the distribution and habitat of wildlife and human uses in the study area. Available data, scientific literature, agency reports, and publicly available assessments, and other projects were used to prepare this section. Lake Erie Energy Development Corporation's (LEEDCo.) Great Lakes Wind Energy proposed project in Ohio waters of Lake Erie (or Icebreaker project), which included local wildlife distribution information and discussion of potential environmental, biological, and socioeconomic impacts of Great Lakes Wind Energy (LEEDCo. 2018) was used in this study. Lakes Ontario and Erie are inhabited by many species and have a wide variety of aquatic and terrestrial habitats, spawning and nursery areas, and other biologically productive areas. Humans rely on these lakes for water, recreation, power, and trade and commerce. For the purposes of this study, "receptors" are resources (e.g., wildlife, habitats, and human activities, such as fishing and recreation) that may be affected by Great Lakes Wind Energy; "stressors" are aspects of Great Lake Wind Energy (e.g., pile driving, long-term structures) that can affect receptors; "impacts" are adverse or beneficial effects of influencing factors on receptors; and "mitigation" is choices or actions (e.g., application of sound dampening technology, seasonal limits for installation) that can avoid, minimize, offset, restore, or compensate for adverse impacts on receptors.

3.1 Methodology

The literature search began with review of several foundational information sources, including the 2010 NYSERDA Great Lakes wind energy feasibility study (Ecology and Environment Engineering 2017) and documentation associated with the Icebreaker project. Additional scientific and technical reports were used to assess available information and research on wildlife and human uses and their patterns for Lakes Erie and Ontario and their potential vulnerability to Great Lakes Wind Energy interactions.

Further, relevant organizations and agency authorities were contacted, and interviews were conducted to validate findings from the desktop study and address information gaps. Several of the interviewees made themselves available for additional follow-up calls and emails to confirm details. Literature available on Great Lakes collaboration between the U.S. federal government and NYS government with Canadian government agencies, as well as case studies on offshore wind projects with relevant potential challenges, were also considered in the study.

3.2 Birds

The Great Lakes are located within the paths of both the Mississippi and Atlantic flyways (Figure 3), major corridors of bird migration. The study area is largely within the Atlantic Flyway through which, according to BirdLife International, millions of birds from over 395 species transit each year (BirdLife International Accessed 2021), which are protected by the Migratory Bird Treaty Act. Of the species that pass over, 34 are federally or NYS-listed as endangered, threatened, or species of concern (NYSDEC 2015, U.S. Fish and Wildlife Service 2021).

Figure 3. Major Continental Bird Migratory Flyways

Source: (USFWS Accessed 2021)

Some species that are not federally or NYS-listed are considered priority species for conservation action by advocacy groups like the Audubon Society (Audubon NY 2017).

3.2.1 Clades of Birds

Birds can be grouped into different clades based on their breeding, nesting, foraging and other habitat use. This allows us to generalize across these larger groups when considering potential impacts the birds may face from offshore wind development activities.

Waterbirds spend most of their time on water, and while most species spend the majority of their time foraging and resting in the nearshore environment, (typically within 5 km [3.2 mi] of shore), some (e.g., loons and diving ducks) may forage in deeper water, up to 10 m (32.8 ft) deep and 16 km (10 mi) from shore (Lott, Seymour and Russell 2011). Nesting typically takes place in the nearshore environment, either in coastal wetlands, on floating mats of vegetation, or onshore within sight of a body of water. Shorebirds, in contrast, spend the majority of their time at the interface between the land and the water in the nearshore environment. They forage on intertidal mudflats, freshwater and brackish wetlands, and beaches (Norazlimi and Ramli 2015). The shorebird group includes small species like Sandpipers (Scolopacidae), which prefer more open habitat along the water's edge and species like Rails (Rallidae) and Bitterns (Botaurinae), which are larger and more secretive and are primarily restricted to dense vegetation around wetlands (Johnsgard 2009).

Landbirds represent a diverse group of upland game birds, songbirds, and others. This group makes use of a wide variety of habitats, but most of their activities are restricted to areas onshore. While some species in this group may make use of wetland habitat (for example, Red-Winged Blackbirds [*Agelaius phoeniceus*] and Marsh Wrens [*Cistothorus stellaris*]), they are not nearshore obligate species like the shorebirds (Ozesmi and Mitsch 1997).

Raptors are typically larger, predatory species with wide home ranges. They occupy diverse habitats but are typically found in areas that are more open, along forest margins or in sparsely forested areas. Many species frequent cliff edges near water for nesting activities or to ride the air currents. Their activities are primarily restricted to the onshore environment, though some species such as osprey and bald eagles will hunt or scavenge in the nearshore environment on land and over open water nearshore (Watson, Garrett and Anthony 1991).

Gulls and terns include species like the Ring Billed Gull (*Larus delawarensis*) and the Common Tern (*Sterna hirundo*). These species are primarily restricted to the nearshore environment. Typically forming large colonial nests on rocky shores, islands, and sand spits. They typically forage in the nearshore environment on small fish, insects, and crustaceans, though can also be found in land, usually within sight of water. Gulls and terns may also forage in the offshore environment following fishing boats or seeking out fish near offshore reefs and islands (Hudson and Furness 1989). The studies of gulls and terns cited here generally focus on marine environments, but similar patterns may occur in the Great Lakes.

Table 1 lists some of the common birds in each of these clades of birds found in the study area.

Table 1. Example Species of Clades of Birds in the Study Area

Waterbirds	Shorebirds	Landbirds		Raptors	Gulls and Terns
- coots	- avocet	- blackbirds	- nuthatches	- eagles	- gulls*
- cormorants*	- bitterns	- buntings	- pewees	- falcons	- terns*
- ducks	- cranes	- creepers	- phoebes	- harriers	
- geese	- dowitcher	- crows	- pipits	- hawks	
- grebes	- egret*	- cuckoos	- ravens	- kestrels	
- loons	- godwits	- doves	- shrikes	- merlins	
- mergansers	- heron*	- flycatchers	-sparrows	- osprey	
- pelicans	- ibis	- gnatcatchers	- starlings	- owls	
- scoters	- knots	- grosbeaks	- swallows		
- swans	- phalaropes	- grouse	- swifts		
	- plovers*	- hummingbirds	- tanagers		
	- rails	- jays	- thrushes		
	- sandpipers	- killdeers	- titmice		
	- soras	- kingbirds	- turkeys		
	- stilts	- kinglets	- vireos		
	- yellowlegs	- larks	- vultures		
		- martins	- warblers		
		- nighthawks	- waxwings		
		- woodpeckers	- wrens		

* Many of the species within these clades form large colonial nesting sites.

The study area is within the lower Great Lakes/Saint (St.) Lawrence Plain, which the U.S North American Bird Conservation Initiative (NABCI) has identified as a Bird Conservation Region and which provides important shoreline and wetland habitats that attract large concentrations of migrating birds (NABCI, North American Bird Conservation Initiative 2020). Agriculture has converted much of the deciduous and mixed-wood forests in the area, but remnants of these communities remain important stopover and nesting habitats for terrestrial birds (NABCI, North American Bird Conservation Initiative 2020). Twenty-seven bird species (shorebirds and waterbirds, but also some landbirds) have been identified as priority species for conservation action within this Bird Conservation Region. The Audubon Society recognizes four priority bird species (those that have significant conservation needs) for the Atlantic flyway: Common Tern, Canada Warbler (*Cardellina canadensis*), Sanderling (*Calidris alba*), and Bobolink (*Dolichonyx oryzivorus*); and two priority bird species for the Great Lakes: American Bittern (*Botaurus lentiginosus*) and Black Tern (*Chilidonias niger*) (Audubon Society 2021). Because of its importance to birds, Ducks Unlimited identifies the Great Lakes system as a major conservation priority area (Ducks Unlimited 2021). The Lake Ontario and Lake Erie region has over

30 Important Bird Areas (IBAs; 28 in Canada and 5 that span the Canada/U.S. border) (Audubon 2021, IBA Canada 2021, U.S. Fish and Wildlife Service 2021). The Audubon Society has identified five priority colonial waterbird nesting areas for conservation (Audubon 2021) and mapped 84,708 hectares of coastal wetlands for priority conservation around all of Lake Erie and Lake Ontario (beyond the study area) (J. Grand, et al. 2020). The many clades of birds that use the study area commonly forage, nest, and breed in specific areas of the lakes (Table 2). Figure 4 displays the common forage distributions of waterbirds, landbirds, shorebirds, raptors, and gulls and terns. Waterbirds, gulls, and terns forage both nearshore and in areas of open water.

Table 2. Bird Clades Common Use Areas within the Study Area

Source: (Lott, Seymour and Russell 2011, Cornell Lab of Ornithology 2021, Johnsgard 2009, Ozesmi and Mitsch 1997, Norazlimi and Ramli 2015, Hudson and Furness 1989, Watson, Garrett and Anthony 1991)

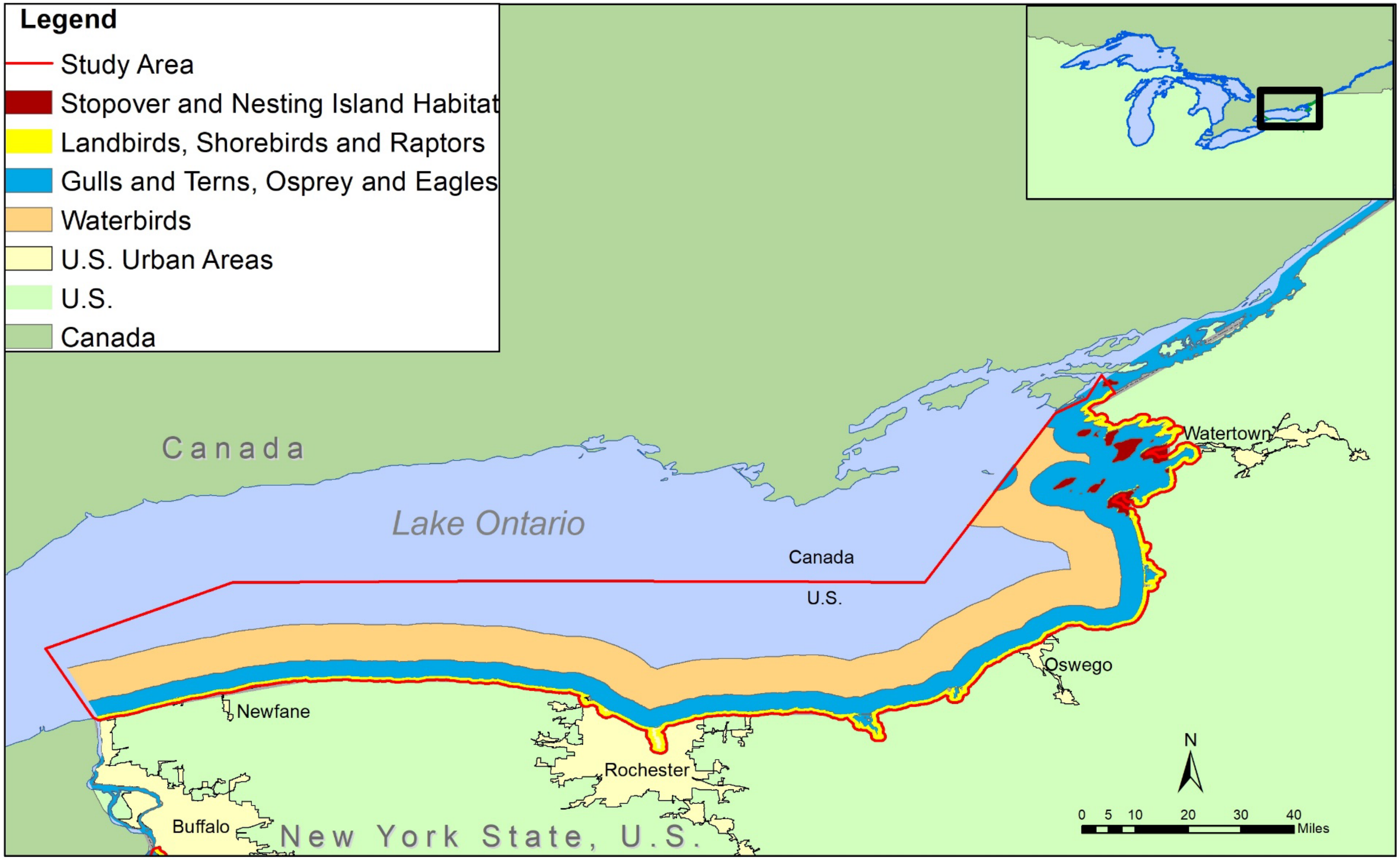
	Onshore	Nearshore	Offshore
Waterbirds	Nest (some species nest in tree cavities or in grassy fields near water) Forage (some species may forage in open fields Some species may overwinter in these areas.	Breed (majority of breeding occurs on or near water for most species) Nest (some species make nests on floating mats of vegetation) Forage (typically within 5 km [3 mi] of shore). Some species may overwinter in these areas.	Forage (majority of foraging takes place within 5 km [3 mi] of shore, but some species may forage to depths of 10 m [32 ft] or up to 16 km [10 mi] from shore). Some species may overwinter in areas free of ice.
Landbirds	Breed (wide variety of habitat types- forests, grasslands, wetlands, and bare soil. Breeding primarily occurs in the spring for most species). Nest (wide variety of habitat types, from forests, to grasslands, to bare soil. Mostly in the spring). Forage (wide variety of habitats, including open fields, forests, wetlands, and agricultural fields). Some species may overwinter in these areas.	Forage (some species may use areas around coastal wetlands and marshes; the majority of foraging takes place on land).	
Shorebirds	Breed (typically within 30m [98 ft] from shore within wetland margins, and riparian habitat) Nest (within wetland margins, and riparian habitat) Forage (typically within 30m [98 ft] of water within wetland margins, and riparian habitat).	Breed (within coastal wetlands and shore edges) Nest (within coastal wetlands and shore edges) Forage (majority of foraging occurs within coastal wetlands, shore edges and river deltas).	

Table 2 continued

	Onshore	Nearshore	Offshore
Raptors	Breed (typically in natural habitats) Nest (primarily at the top of large trees, in tree cavities and on cliff sides) Forage (majority or foraging takes place in open fields, forests, and forest edges). Some species may overwinter in these areas.	Forage (some species such as osprey and eagles may hunt in the nearshore area over open water, while others may hunt within coastal wetlands).	
Gulls and Terns	Breed (typically close to waterbodies) Nest (typically within 106 m [350 ft] of the water) Forage (Most foraging occurs on water. Some foraging will occur on land, typically within sight of water though). Some species may overwinter in these areas.	Breed (majority of breeding occurs on or near water for most species). Nest (nesting typically occurs in large colonies on rocky islands and shores). Forage (majority of foraging takes place within 5 km [3 mi] of shore, but foraging can occur at any place within the lake system). Some species may overwinter in these areas.	Forage (majority of foraging takes place within 5 km [3 mi] of shore, but foraging can occur at any place within the lake system). Some species may overwinter in areas free of ice.

Figure 4. General Forage Distribution for Waterbirds, Gulls and Terns, Landbirds, Raptors, and Shorebirds

Source: (NOAA 1999, NOAA 1999)



All of the clades shown in Figure 4 also forage inland. The distribution map emphasizes the different distances over open water for gulls and terns, raptors, and waterbirds that forage in the study area. The islands in the northeast are heavily used stopover and nesting habitat (ABC 2020, Lott, Seymour and Russell 2011, Cornell Lab of Ornithology 2021).

In addition to rare species or species that agencies or stakeholders consider important targets for conservation, the Great Lakes hosts large numbers (tens of thousands) of waterbirds (Youngman, et al. 2017). For example, Canvasback (*Aythya valisineria*), scaups (*A. affins* and *A. marila*), Redhead (*A. americana*), Mallard (*Anas platyrhynchos*), Tundra Swan (*Cygnus columbianus*), Ruddy Duck (*Oxyura jamaicensis*), Red-Breasted Mergansers (*Mergus serrator*), and Canada Geese (*Branta canadensis*), among many other waterbirds, have been observed during aerial surveys on the Great Lakes (Goodale, Stenhouse and Williams 2014). Notably, common diving ducks (waterbirds) comprised over 70% of the observations from aerial surveys of lakes Erie, Huron, and Michigan in the winter and spring of 2012–2013 (Goodale, Stenhouse and Williams 2014).

Audubon has designated the Central Basin in Lake Erie (just west of the study area) as a key migratory corridor due to large concentrations of certain species (Audubon 2021). An example of this is the Red-Breasted Merganser, for which counts show a quarter of a million individuals in this basin, with a continental population of half a million, meaning a large portion of the global population passes through this basin during the migration season (Audubon 2021, Craik, Pearce and Titman 2015, Ewert, et al. 2006). Spring and fall nearshore surveys conducted from 1968–2011 of Lake Ontario by the Government of Canada (Government of Canada 2021) found large concentrations of scaups (Lesser Scaup [total >60,000] and Greater Scaup [total >750,000]), Greater Snow Geese (total > 45,000), Canvasback (total over 2 million), and Redhead (total over 1.3 million). Concentrations of over 10,000 Red-Necked Grebe (*Podiceps grisegena*) individuals (roughly a quarter of their total continental population) have also been observed on Lake Ontario (Wood, et al. 2021). Many of the IBAs represent areas of concentration of birds, from raptors, gulls, and shorebirds to colonial nesting waterbirds.

Globally, IBAs for 2020 were identified by the American Bird Conservancy (ABC), US Fish and Wildlife Service (USFWS), and Bureau of Land Management (BLM). These areas were defined as areas where 500,000 or more migratory birds congregate at some point during the year; key habitat areas for threatened species that may be vulnerable to wind development; critical habitat for species listed under the Federal Endangered Species Act (ESA); high importance “bottleneck areas” used by migrants; and key migration routes (ABC 2020, IBA Canada 2021). For example, the Niagara River Corridor IBA contains hundreds of thousands of wintering gulls such as Ring Billed Gulls (*Larus delawarensis*) and Herring Gulls *(L. argentatus)* (Audubon 2021, IBA Canada 2021). Taken together, the study area contains key habitats used by multiple bird species.

3.2.2 Endangered Species

Table 3 shows federal and NYS ESA-listed birds that can be found in the study area, and Table 4 shows bird species of conservation concern identified by USFWS. NYS also lists species of special concern, which are species for which a welfare or risk of endangerment has been documented in NYS (NYSDEC 2015).

Table 3. Federal Endangered Species Act and New York State Endangered Species Act listed Birds within the Study Area

Source: (NYSDEC 2021, USFWS 2015)

Common Name	*Scientific Name*	Federal Status	State Status	Occur In
Bald Eagle	*Haliaeetus leucocephalus*	Not listed	Threatened	Onshore
Black Tern	*Chlidonias niger*	Not listed	Endangered	Nearshore/offshore
Common Tern	*Sterna hirundo*	Not listed	Threatened	Nearshore/offshore
Henslow's Sparrow	*Ammodramus henslowii*	Not listed	Threatened	Onshore
Least Bittern	*Ixobrychus exilis*	Not listed	Threatened	Nearshore
Least Tern	*Sternula antillarum*	Not listed	Threatened	Nearshore/offshore
Loggerhead Shrike	*Lanius ludovicianus*	Not listed	Endangered	Onshore
Northern Harrier	*Circus cyaneus*	Not listed	Threatened	Onshore
Peregrine Falcon	*Falco peregrinus*	Not listed	Endangered	Onshore
Pied-billed Grebe	*Podilymbus podiceps*	Not listed	Threatened	Nearshore
Red-Headed Woodpecker	*Melanerpes erythrocephalus*	Not listed	Special Concern	Onshore
Sedge Wren	*Cistothorus platensis*	Not listed	Threatened	Onshore/nearshore
Short-eared Owl	*Asio flammeus*	Not listed	Endangered	Onshore
Upland Sandpiper	*Bartramia longicauda*	Not listed	Threatened	Onshore
Piping Plover	*Charadrius melodus*	Endangered	Endangered	Nearshore
Red Knot	*Calidris canutus rufa*	Threatened	Threatened	Nearshore

Table 4. List of Additional Birds of Conservation Concern within the Study Area

Source: (USFWS 2021)

Common Name	*Scientific Name*	Habitat Use
Black-Billed Cuckoo	*Coccyzus erythropthalmus*	Breeding
Eastern Whip-poor-will	*Antrostomus vociferus*	Breeding
Chimney Swift	*Chaetura pelagica*	Breeding
American Golden-Plover	*Pluvialis dominica*	Non-Breeding
Upland Sandpiper	*Bartramia longicauda*	Breeding
Ruddy Turnstone (Atlantic)	*Arenaria interpres morinella*	Non-Breeding
Dunlin (Hudson Bay)	*Calidris alpina hudsonia*	Non-Breeding
Buff-Breasted Sandpiper	*Calidris subruficollis*	Non-Breeding
Pectoral Sandpiper	*Calidris melanotos*	Non-Breeding
Semipalmated Sandpiper (Eastern/Central)	*Calidris pusilla (Eastern/Central)*	Non-Breeding
Short-Billed Dowitcher	*Limnodromus griseus*	Non-Breeding
Lesser Yellowlegs	*Tringa flavipes*	Non-Breeding
Long-Eared Owl	*Asio otus*	Breeding
Short-Eared Owl	*Asio flammeus*	Non-Breeding
Belted Kingfisher	*Megaceryle alcyon*	Breeding
Red-Headed Woodpecker	*Melanerpes erythrocephalus*	Breeding
Wood Thrush	*Hylocichla mustelina*	Breeding
Evening Grosbeak	*Coccothraustes vespertinus*	Breeding
Bobolink	*Dolichonyx oryzivorus*	Breeding
Eastern Meadowlark	*Sturnella magna*	Breeding
Golden-winged Warbler	*Vermivora chrysoptera*	Breeding
Blue-winged Warbler	*Vermivora cyanoptera*	Breeding
Cerulean Warbler	*Setophaga cerulea*	Breeding
Prairie Warbler	*Setophaga discolor*	Breeding
Canada Warbler	*Cardellina canadensis*	Breeding
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*	Breeding

Birds nest, forage, shelter (thermal and security), roost, stage, migrate, and stopover in parts of the study area. At a very coarse level, seasonal habitat-use and distribution of birds in the study area can be generalized, consisting in part, of spring and fall migration corridors, stopover/staging habitat, summer nesting habitat, nearshore and pelagic foraging habitat, and overwintering habitat. The following sections describe these use patterns in more detail.

3.2.3 Migration Corridors and Stopover Habitat

Bird migration is the typical seasonal movement, often along a flyway, between wintering and breeding grounds. In spring and fall, migrating birds travel through the study area, largely in a northeast direction in the spring and a southwest direction in the fall (Diehl, Larkins and Black 2003, Horton, et al. 2016, Rathbun, et al. 2016). Some studies have suggested that fewer birds fly across offshore, open-water environments compared to overland or coastal locations. For example, Gesicki et al. (2016) found that 62% of migrating sparrows and warblers deviated their direction toward the coast when encountering Lake Erie, even when winds were favorable for a crossing. Similarly, migrating American Woodcock (*Scolopax minor*) have been shown to fly around the Great Lakes during their migration, with very few individuals making direct crossings (Fish, Blomberg and Roth 2019). For at least some species, the Great Lakes might pose a barrier to migration (Gesicki, Jamali and Bingman 2016). For this reason, it has been suggested that windfarms be placed in areas where birds are more likely to avoid overwater crossings, such as areas far from shore away from land features which concentrate migrants (Gesicki, Cech and Bingman 2019).

Information about how migratory birds travel across the Great Lakes and the routes they take is incomplete. To date, most studies employ radar and tagging surveys and recently, acoustic recordings of nocturnal flight calls, to assess birds in the Great Lakes. However, there are limitations these methods. Accurate counts of birds may not be possible during inclement weather which interferes with radar's ability to accurately collect migration data, and in some instances, correction factors are required to estimate the density of birds at varying heights (Diehl, Larkins and Black 2003). Acoustic sampling has limited range and poses challenges over open water. Recent advances in telemetry are improving knowledge of bird migration, particularly with the increased use of the Motus wildlife tracking system (Motus), a telemetry array that coordinates and automates detections of tagged animals (Motus Wildlife Tracking System 2021).

It is thought that birds concentrate in areas where distances over open water are reduced, or where rest areas lie within their flight path, along island chains and peninsulas (Buler and Dawson 2014, Sanders and Mennill 2014), which likely reduce overwater crossing distances. Other studies have observed similar behaviors with large concentrations of birds making crossings via peninsulas and islands (Diehl, Larkins and Black 2003). Moreover, migrants have been observed to reorient themselves toward land when flying over open water at dawn; this has the effect of shortening the time that they spend over open water (Diehl, Larkins and Black 2003, Rathbun, et al. 2016). These features and behaviors may promote use of stopover habitat to rest and forage, making the shoreline itself important habitat before birds make a long flight across open water. Bonter et al. (2009) found that high-migrant activity was concentrated within 9.7 km (6 mi) of the shores of the Great Lakes. Moreover, they found that most migrant activity was positively associated with water (e.g., wetlands and rivers) and forest cover and was negatively associated with agricultural lands. Buler and Dawson (2014) found similar characteristics associated with stopover habitat; migrants were positively associated with largely deciduous forest and the shores of major waterbodies within agricultural landscapes. Bird stopover sites and habitats are further detailed in section 4.4.1

3.2.4 Nearshore and Pelagic Habitat Use

Bird use of aquatic environments in the Great Lakes increases in spring and fall as migrants pass through the area and is year-round for some species (Diehl, Larkin and Black 2003, Horton, et al. 2016, Rathbun, et al. 2016). Large concentrations of mergansers and dabbling ducks (particularly Mallards) are found in ice-free areas during winter throughout the study area (Prince, Padding and Knapton 1992). Major waterbird coastal breeding habitats are found on the Canadian side of Lake Erie at Long Point and in northeast Lake Ontario (e.g., around Presqui'ile Provincial Park) and Southcentral Lake Ontario (e.g., Braddock Bay, Sodus Bay, and East Bay) (Prince, Padding and Knapton 1992).

Generally, dabbling ducks, swans, and geese remain close to shore in shallow (15 m [50 ft] depth) water with clay substrates, whereas loons typically remain in deeper waters (up to 30 m [98.4 ft]) with high productivity (Williams, et al. 2015). Islands, reefs, and shoals offer important habitat for other waterbirds (grebes and cormorants), gulls and terns, and other colonial nesting birds (Stapanian and Bur 2002, Stapanian and Waite 2003). Terns are often exclusively found near coastal marshes, sand spits, and islands, and Long-Tailed Ducks (*Clangula hyemalis*) inhabit cold waters with sandy bottoms, often in the deepest portions of the lakes (Williams, et al. 2015). Gulls are found across the lakes, often following commercial fishing ships (Lagen, et al. 2005, Lott, Seymour and Russell 2011).

Birds use the offshore, nearshore, and onshore space (Lagen, et al. 2005, Lott, Seymour and Russell 2011, Norris and Lott 2011), with offshore presence and distribution likely, though aerial surveys of areas offshore in Lakes Michigan and Huron outside of the study area indicated presence of birds but not relative hotspots of use offshore (Great Lakes Commission 2017). This study also found that, in Eastern Lake Erie, mergansers, scaups, and gulls were the most common species, with large aggregations of waterbirds near the mouth of the Buffalo River and most birds observed in nearshore areas. The exception was loons observed offshore during migration (Great Lakes Commission 2017).

Pelagic foraging is commonly engaged in by waterbirds and gulls and terns. These two clades would have the most likelihood of vulnerability to Great Lakes Wind Energy during foraging due to their distribution. However, waterbird surveys in the Great Lakes found most birds inhabit waters close to shore and it is suggested that open water environments more than 5 km (3.2 mi) from shore and more than 10 m (32.8 ft) deep have low densities of birds (Stapanian and Waite 2003). Pelagic bird surveys in the Great Lakes have found that bird abundance declines with increasing distance from shore, particularly at distances greater than 8.1 to 11.3 km (5 to 7 mi). Generally, most birds occur within 4 km (2.5 mi) of shore (Lott, Seymour and Russell 2011, Norris and Lott 2011, Schummer, Petrie and Bailey 2008, Stapanian, Bur and Tyson, et al. 2002). Often, bird density is highest near the mouths of rivers, islands, and reefs (Lott, Seymour and Russell 2011). Despite the fact that most birds appear to inhabit areas close to shore, gulls are noted to occur throughout open water areas (Lott, Seymour and Russell 2011).

Higher densities of birds correspond to where food abundance is higher; likely related to wave action and currents close to shore (Schummer, Petrie and Bailey 2008) or other productive areas such as upwellings (Lagen, et al. 2005). It has been speculated that diverse substrates and bathymetry in nearshore environments and creeks and their outflows may contribute to upwelling leading to productive areas for foraging (Norris and Lott 2011, Wood, et al. 2021). The ability to access food resources may help determine bird abundance and richness. Many species present over winter concentrate near harbors and river mouths where ice is absent (Kerlinger 2020). Overwintering ducks have been shown to accumulate in near shore areas with depths of 4.9 to 14.9 m (16 to 49 ft) where invertebrate abundance is highest (Schummer, Petrie and Bailey 2008). Similarly, most cormorants in Lake Erie forage for fish in waters shallower than 10.1 m (33 ft) (Stapanian, Bur and Tyson, et al. 2002), and dabbling ducks require shallow waters (15 m [49 ft] depth) conducive to their foraging.

Other waterbirds are limited by the depth that they can dive to reach food. For example, common birds of the Great Lakes, such as waterbirds like the Greater and Lesser Scaup generally dive to depths of less than 2 to 3 m (6.5 to 10 ft), respectively, but can reach depths up to 5 to 7 m (16 to 23 ft) (Anteau, et al. 2020, Kessel, Rocque and Barclay 2020). Canvasbacks (generally 0 to 2 m [6.5 ft] but reach up to 5 m [16 ft]), Redheads (generally 2 m [6.5 ft] but reach up to 4 m [13 ft]), and Red-Breasted Mergansers (generally 0 to 2 m [6.5 ft] but reach up to 9 m [29.5 ft]) dive to similar depths (Mowbray 2020, Woodin and Michot 2020, Craik, Pearce and Titman 2020). Long-tailed Ducks, the deepest diving duck in the Great Lakes, generally dive to about 15 m (49.2 ft) but can reach as deep as 66 m (216.5 ft) (Robertson and Savard 2020). These independent studies serve to highlight that while many species can, and do, make use of offshore areas, because of food availability, the nearshore areas are the most commonly used areas of the Great Lakes for foraging.

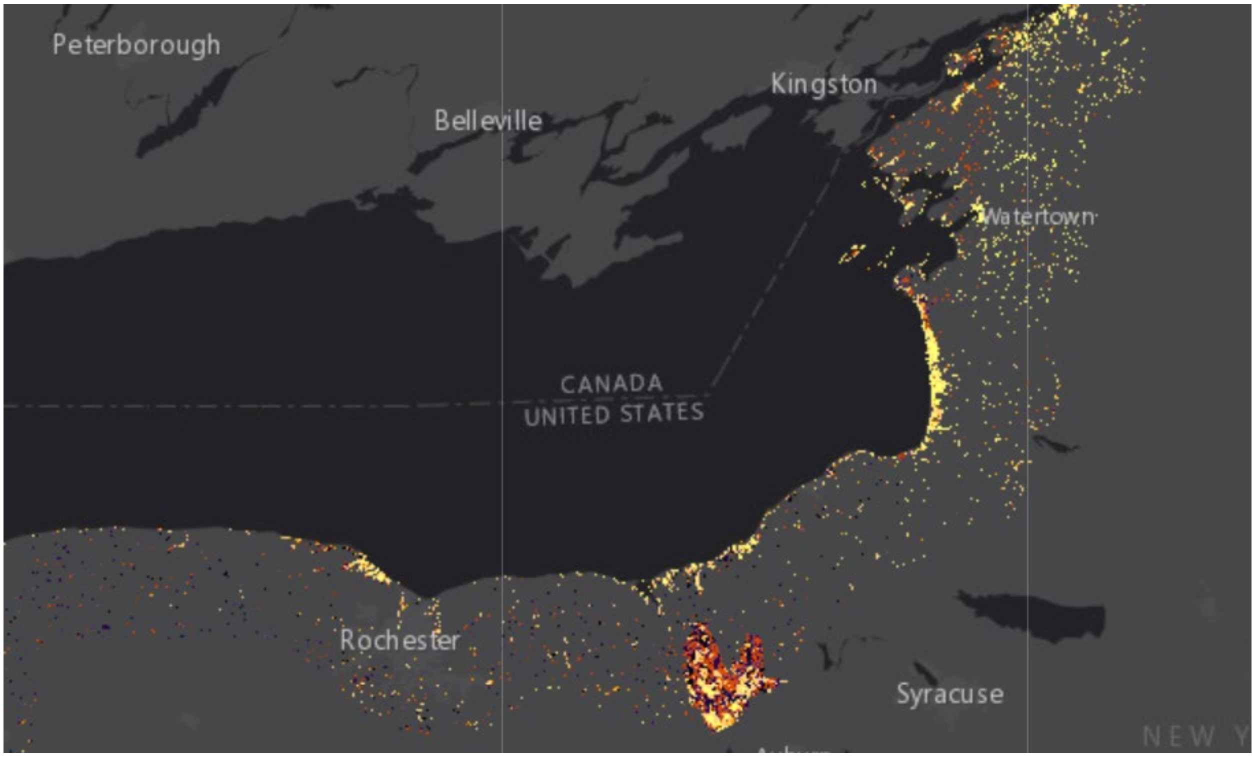
3.2.5 Summer Nesting Habitat

Given the diversity of birds inhabiting the study area during the main breeding seasons in the spring and fall (with ~249 species breeding the Great Lakes region), most terrestrial environments, whether disturbed or undisturbed will provide some form of nesting habitat for some species (New York State Ornithological Association 2021). While undisturbed forests may offer obvious nesting habitat, secondary forest, disturbed environments, bare soils, and anthropogenic infrastructure also provide nesting habitat for many species of birds (Drapeau, et al. 2000). The areas at the interface of the aquatic and terrestrial environments of the Great Lakes provide important nesting habitat, particularly for the federal and NYS ESA-listed Piping Plover (*Charadrius melodus*), colonial birds (e.g., gulls, terns, herons, and cormorants), as well as other waterbirds and shorebirds. Many species congregate and nest on the islands in northeast Lake Ontario (Figure 5). The Institute of Great Lakes Research has assessed ideal marsh and coastal wetland nesting habitat (Institute for Great Lakes Research 2020, J. Grand, et al. 2020).

Many of the identified IBAs discussed above are used to indicate vulnerable bird areas discussed in section 4.4.1, including areas that contribute to important nesting habitat for federal and NYS ESA-listed species and colonial waterbirds (Audubon 2021, IBA Canada 2021, Prince, Padding and Knapton 1992, Blokpoel and Tessier 1993, Government of Canada 2021, Scharf, et al. 1979).

Figure 5. Marsh and Coastal Wetland Nesting Bird Areas in Eastern Lake Ontario

Source: (Institute for Great Lakes Research 2020, J. Grand, et al. 2020)



3.3 Bats

Compared to birds, much less is known about how bats use and move through the Great Lakes region. Nine species of bats occur within the study area and may move through the region as part of a seasonal migration or while traveling between their summer grounds and overwintering hibernacula, traveling mainly over land (Norquay, et al. 2013, NYSDEC 2020). Of the species that occur in the study area, two are federal ESA and NYS ESA-listed species (Indiana Bat [Myotis sodalist: Endangered] and Northern Long-Eared Bat [*Myotis septentrionalis*: Threatened]) (USFWS 2015, NYSDEC 2021, National Park Service 2020).

Similar to birds, bats use the study area for a variety of functions including migrating and stopover, foraging, breeding, and roosting (both during overwintering and at other times). Using a high-level generalization of bat habitats that might be affected by Great Lakes Wind Energy, the following were considered: spring and fall migration corridors; stopover/staging habitat; summer breeding, roosting, and foraging habitat; and overwintering habitat.

Very little information exists on how or if bats cross the Great Lakes, (Thorne 2015). Long-distance migrant tree-roosting bats (e.g., Hoary Bat [*Lasiurus cinereus*], Eastern Red Bat [*L. borealis*], and Silver-Haired Bat [*Lasonycteris noctivagas*]) are known to cross the Great Lakes as they move from their overwintering habitat in the southern U.S. to their breeding areas in the north and around the Great Lakes (G. A. Smith 2015). Conversely, short-distance migratory bats that overwinter in caves in the region (e.g.,, Big Brown Bat [*Eptesicus fuscus*], Eastern Pipistrelle Bat [*Perimyotis subflavus*], Northern Long-Eared Bat, Indiana Bat, Small-Footed [*Myotis leibii*], and Little Brown Bats [*M. lucifugus*]) move shorter distances in the summer between their winter hibernacula and their breeding areas (Norquay, et al. 2013, NYSDEC 2020).

Similar to birds, it is likely that bats attempt to minimize energy expenditures when crossing during these periods. For example, Dzal et al. (2009) found that Long Point, Ontario in Lake Erie, a peninsula that serves as a migratory bird stopover site and is in a concentrated bird migratory corridor, likely functions similarly for long-distance bat migrants like Hoary and Silver-haired Bats. Dzal et al. (2009) similarly suggested that short distance migrants such as Little Brown Bats also use the site and may fly over the Great Lakes (Dzal, et al. 2009). Similarly, Thorne (2015) found that three species of bats appeared to make use of islands and peninsulas in Lake Erie to shorten their time spent migrating over open water. Threatened and endangered bats are not known to make long migrations. Long-distance migrants such as Hoary and Silver-haired Bats are also tree-roosting bats, and bats are well known to forage near wetlands and riparian environments (Grindal, Morissette and Brigham 1999). As such, it is likely that similar to the avian stopover habitats described above, landscape features such as forest cover, wetlands, and river margins are likely important habitat areas for bats.

3.4 Invertebrates

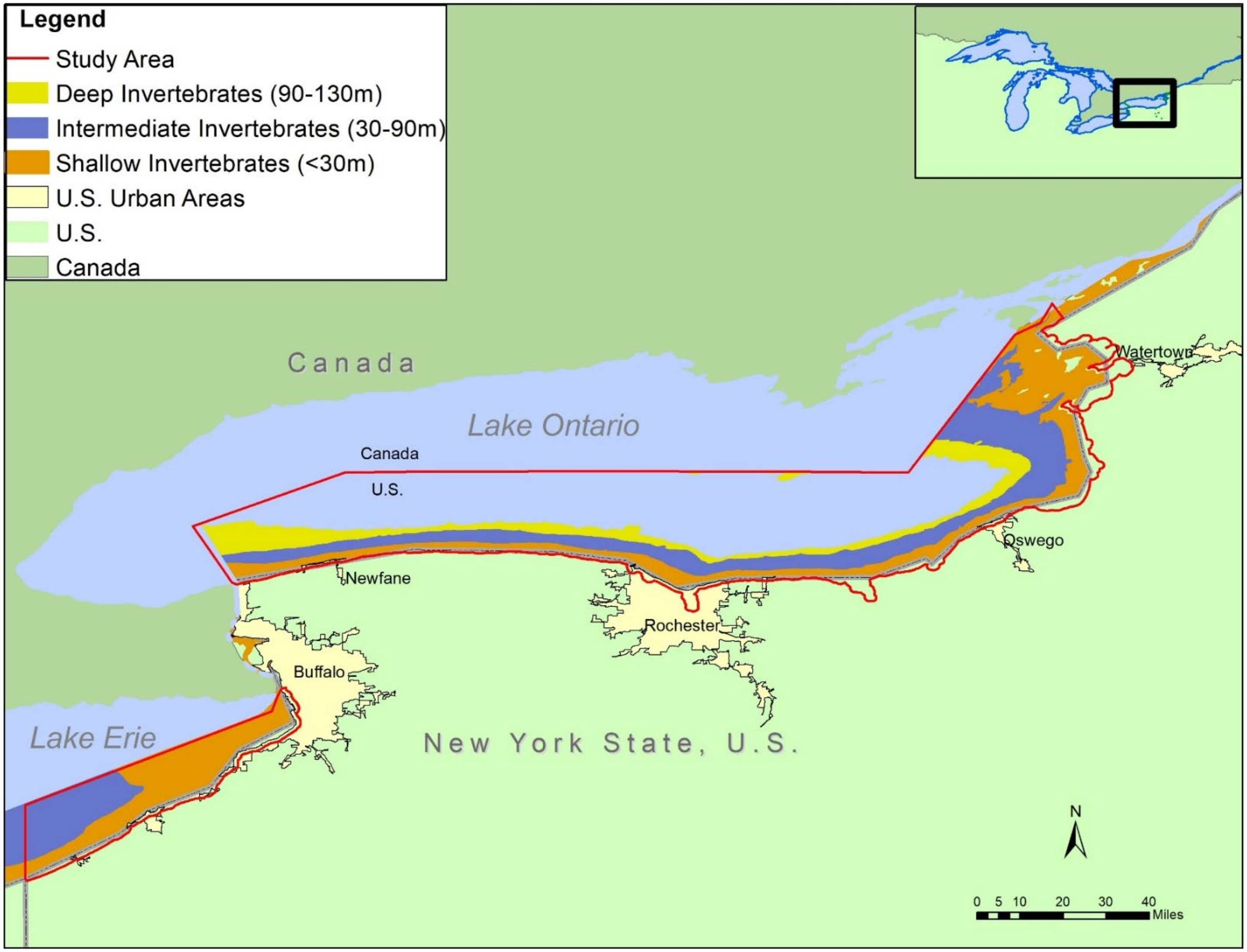
3.4.1 Benthic Communities

The Great Lakes benthic invertebrate communities are primarily made up of a mix of native and non-native mollusks, gastropods, worms, crustaceans, and insects. Limited recent or historical distributional data are available for most invertebrate species within the New York State waters of Lake Erie and Lake Ontario. Distribution data have historically been collected opportunistically, with few dedicated monitoring programs (Burlakova, Karatayev and Hrycik, et al. 2021).

In Lake Ontario, the most dominant taxon is *Dreissena* (mussels), particularly Quagga Mussels (*D. bugensis*). A benthic study in 2008/2009 measured *Dreissena, Diporeia* (amphipods), *Oligochaeta* (worms), Chironomidae (aquatic insects), and Sphaeriidae (b) (Birkett, Lozano and Rudstam 2015). They found that *Diporeia* densities at depths of >90 m (295.2 ft) declined by an order of magnitude from 2003 to 2009. Oligochaetes were the second most abundant taxonomic group lake-wide after Quagga Mussels. Quagga Mussels accounted for 70% of organisms sampled and 98% of biomass. In Lake Erie the dominant taxa are *Dreissena* (mussels), *Pisidium spp.* (clams), Chironomidae (aquatic insects), Oligochaeta (worms), and *Asellus* (crustacean) (Burlakova, Karatayev and Pennuto, et al. 2014). Over the past 30 years, both Lake Erie and Lake Ontario have undergone significant shifts in their benthic invertebrate communities with the introduction of two invasive species of *Dreissena*—the Zebra Mussel (*D. polymorpha*) and Quagga Mussel (Burlakova, Karatayev and Pennuto, et al. 2014). These species comprise the majority of benthic invertebrate biomass today and are likely responsible for the decline of the *Diporeia sp*. (amphipods) that dominated the benthos prior to non-native mussel invasion (Burlakova, Karatayev and Pennuto, et al. 2014). Most mollusks inhabit shallow, soft sediment-type habitats (Birkett, Lozano and Rudstam 2015), with a few species (Zebra Mussels and the Buffalo Pebblesnail) preferring rocky substrate (Higgins and Vander Zanden 2010, Kipp, et al. 2013).

Benthic invertebrates can generally be broken into three depth zones: shallow <30 m (98.4 ft), intermediate 30–90 m (98.4-295.2 ft), and deep 90–130 m (294.2–426.5 ft). Some common taxa found in greatest numbers in the shallowest zone (<30 m [98.4 ft]) include Amphipoda, Gastropoda, and Hirudinea. The intermediate zones (30–90 m [98.4–295.2 ft]) include highest numbers of Oligochaeta and Turbellaria, although Oligoghaeta are numerous at all depth zones. Common taxa found in highest numbers in the deepest zones (>90 m [295.2ft]) include Sphaeriidae and Mysidae. Quagga mussels are found in high numbers at all depth zones, with slightly greater abundance in the deepest zones (Burlakova, Karatayev and Hrycik, et al. 2021). The distribution and potential depth areas available for colonization are shown in Figure 6 below. Species' sediment preference and the competition with Quagga Mussels determines the distribution and biomass of invertebrates within the study area.

Figure 6. General Distribution Depths for Invertebrates within the Study Area



Generally, benthic invertebrate density and biomass is greatest in nearshore shallow water sediment habitats (<30 m [98.4 ft]) (Burlakova, Karatayev and Pennuto, et al. 2014). Species-specific distribution and abundance data are limited. Lake-wide surveys were conducted through the Environmental Protection Agency (EPA) Cooperative Science and Monitoring Initiative for Lake Erie in 2019 and for Lake Ontario in 2018 (United States Environmental Protection Agency 2021). Current and historical invertebrate distributional data has primarily focused on the two invasive mussel species (Zebra and Quagga Mussels) that colonized the Great Lakes in the 1980s (Benson, et al. 2021).

3.4.2 Endangered Species

Due to the limited abundance and distribution data available for federal and NYS ESA-listed species, most information on these species in the study area (Table 5) are based on historical data, often collected during single survey events. The two species of valvata, or valve snail, (*Valvata lewisi* and *V. sincera*) typically occur in soft sediment habitat down to considerable depths and in association with submerged aquatic vegetation (A. H. Clarke 1981). The endangered species tend to occur in rivers and would not be expected to occur beyond coastal areas of the Lakes. In addition to listing species under the NYS ESA, New York State has developed a list of Species of Greatest Conservation Need.[1] This list is part of NYS' Comprehensive Wildlife Conservation Strategy.

Table 5. Federal Endangered Species Act and New York State Endangered Species Act Invertebrates within the Study Area

Source: (NYSDEC 2021, U.S. Fish and Wildlife Service 2021)

Common Name	Scientific Name	Federal Status	State Status
Fringed Valvata	*Valvata lewisi*	Not Listed	Special Concern
Mossy Valvata	*Valvata sincera*	Not Listed	Special Concern
Clubshell	*Pleurobema clava*	Endangered	Endangered
Northern Riffleshell	*Epioblasma torulosa rangiana*	Endangered	Endangered
Rayed Bean	*Villosa fabalis*	Endangered	Endangered
Longsolid	*Fusconaia subrotunda*	Proposed Threatened	

1 List of Species of Greatest Conservation Need is available at https://www.dec.ny.gov/docs/wildlife_pdf/sgnc2015list.pdf

3.4.3 Invasive Species

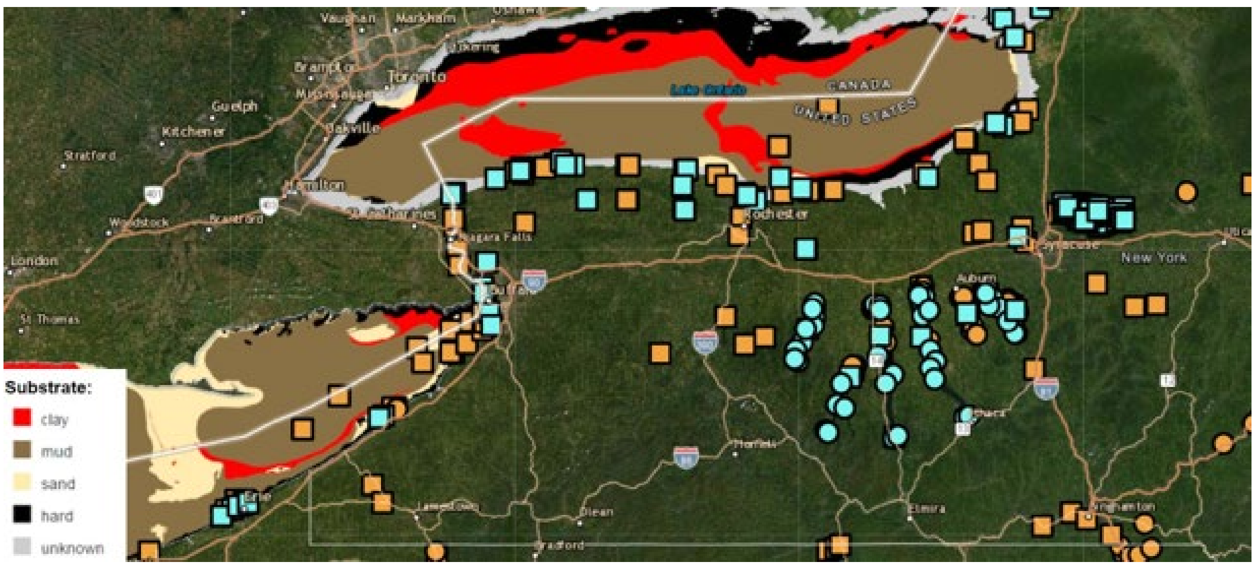
Zebra and Quagga Mussels were introduced to the Great Lakes in the late 1980s and have since become the most dominant benthic invertebrates (Burlakova, Karatayev and Hrycik, et al. 2021). Zebra Mussels were the dominant species in 1989, but since the early 2000s Quagga Mussels have comprised the greatest biomass of the two species, as is common when the two mussel species co-exist for greater than nine years (Karatayev, Burlakova and Padilla 2015, Birkett, Lozano and Rudstam 2015). Quagga Mussel dominance has been driven by their tolerance of higher temperatures and ability to inhabit soft sediments, as compared to Zebra Mussels which require hard substrate habitats (Driedger-Marschall, et al. 2009). Quagga Mussels can survive to depths of 130 m (426.5 ft), and during recent surveys in Lake Ontario have been shown to dominate benthic habitats from 0 to >90 m (295.2 ft) (Burlakova, Karatayev and Hrycik, et al. 2021). In contrast, Zebra Mussels prefer hard substrate and are more prevalent in shallow waters <30 m (98.4 ft) (Burlakova, Karatayev and Hrycik, et al. 2021). Benthic surveys of Lake Erie in 2019 and Lake Ontario in 2018 showed no Zebra Mussels, indicating they may have been outcompeted by Quagga Mussels (Burlakova, Karatayev and Pennuto, et al. 2014, Burlakova, Karatayev and Hrycik, et al. 2021). In both lakes Quagga Mussel biomass represents approximately 98% of total lake-wide biomass (Birkett, Lozano and Rudstam 2015, Burlakova, Karatayev and Pennuto, et al. 2014, Burlakova, Karatayev and Hrycik, et al. 2021).

Zebra and Quagga Mussels are among the most well-studied invertebrate species in the Great Lakes due to their significant impact on the ecosystem dynamics. As suspension feeders, they have altered the composition of pelagic systems in the Great Lakes with their ability to filter large volumes of water, reducing the availability of plankton (Higgins and Vander Zanden 2010, Karatayev, Burlakova and Padilla 2015). This can have a negative impact on other species that are not able to readily utilize benthic system resources (e.g., planktivorous fishes) (Higgins and Vander Zanden 2010). In shallow waters, Zebra Mussels can negatively impact manmade infrastructure, notably around marinas and high-flow areas, where they form mats or 'druses' of mussels on boats and other hard substrates. However, in shallow benthic habitats (<30 m [98.4 ft]) druses of mussels positively impact the diversity of native invertebrates by increasing habitat complexity (Higgins and Vander Zanden 2010). Figure 7 includes all reports of Zebra and Quagga Mussels from 1989 to 2020. It should be noted that Quagga Mussels have displaced Zebra Mussels in most areas of the lakes, particularly in the deeper zones, and these species only regularly coexist in shallow areas of the Great Lakes (GLANSIS 2021).

Benthic macroinvertebrates, including non-native Zebra and Quagga Mussels, are highly sensitive to water quality, which makes them key indicators of environmental change (LEEDCo. 2018). Both Zebra and Quagga Mussels play a significant role in water filtration; they negatively contribute to the availability of lower trophic food sources for other species, while simultaneously promoting vegetative growth in deeper waters (Higgins and Vander Zanden 2010, Nalepa and Schloesser 2013). Quagga Mussels are a key link to higher trophic levels as they are an important food species for the invasive Round Goby (*Neogobius melanostomus*) fish (Birkett, Lozano and Rudstam 2015). These invasive species' impacts on water quality are discussed in section 3.9

Figure 7. Zebra and Quagga Mussel Distribution and Substrate in Lake Ontario and Lake Erie

Source: (GLANSIS 2019, GLANSIS 2021)



Notes:

Orange = Zebra Mussel

Blue = Quagga Mussel

☐ Square shapes indicate the species is established at that location

○ Circles indicate the species was stocked, cultivated, collected, or of unknown status

3.5 Fish

Lakes Ontario and Erie are home to fish species that move and use the study area in diverse ways. The lakes support a mix of native and non-native fish species. Native species are considered to be those that established self-sustaining populations prior to the area being colonized by Europeans. Species that were intentionally introduced after the colonization or were unintentionally introduced are considered non-native species (Stewart, Todd and LaPan 2017). Non-native species that thrive are considered "invasive" species that can negatively affect native species. Factors that led to destabilization of the historical fish communities in Lakes Ontario and Erie were invasive species, overfishing, changes in environmental conditions, and habitat degradation or loss (Stewart, Todd and LaPan 2017, Francis, et al. 2020). All non-native species that exhibit natural reproduction in the wild are considered "naturalized" (Stewart, Todd and LaPan 2017, Markham and Knight 2017). Invasive species are described separately and in detail in section 3.5.8.

3.5.1 Fish Habitat Zones

Lake Ontario fish communities are distributed across nearshore and offshore pelagic and benthic environments. The nearshore includes the shallower (≤15 m [49.2 ft] depth) exposed coastal habitats and sheltered embayments (an indentation of a shoreline that creates a bay or recess in a coastline), and it is these areas that serve as spawning grounds and nursery areas for a vast majority of fish species (O'Gorman 2017, Stewart, Todd and LaPan 2017). The offshore pelagic zone (≥15 m [49.2 ft] deep) contains the majority of the lake's water and biomass. During summer the offshore pelagic zone is organized into a warm upper layer and a cool deeper layer. Many prey fish and introduced non-natives use these areas. The lake bottom is the coldest area and contains a variety of native and non-native species and is referred to as the offshore deep benthic zone (O'Gorman 2017). This means that at certain times of the year there are three offshore fish habitats (starting at the 15 m [49.2 ft] depth limit for the study area): offshore pelagic warm upper, offshore pelagic cool deeper, and offshore deep benthic.

The eastern basin of Lake Erie supports fish species that inhabit a range of nearshore, offshore, and deep environments. Thermal stratification, circulation patterns, bottom structures, and dissolved oxygen levels influence the offshore fish communities (Francis, et al. 2020). Nearshore areas in Lake Erie typically do not thermally stratify in summer. Offshore cold-water species are supported by oligotrophic areas that contain high oxygen levels and low plant nutrients. Offshore regions with thermal stratification occur mainly in the central and western basins (Francis, et al. 2020). Offshore pelagic and benthic fish communities move throughout the lake during the year based on wind, current, and weather patterns.

3.5.2 Nearshore Fish Community

The nearshore zone is defined as 15 m (49.2 ft) of depth or shallower coastal areas (Stewart, Todd and LaPan 2017). Almost all fish species in Lakes Ontario and Erie use this zone for spawning and/or to support early life stages. The diverse fish community in the nearshore zone consists of warm- and cool-water species. This area includes complex habitats of wetlands, open coastal areas, embayments, rivers, and estuaries (Markham and Knight 2017, O'Gorman 2017).

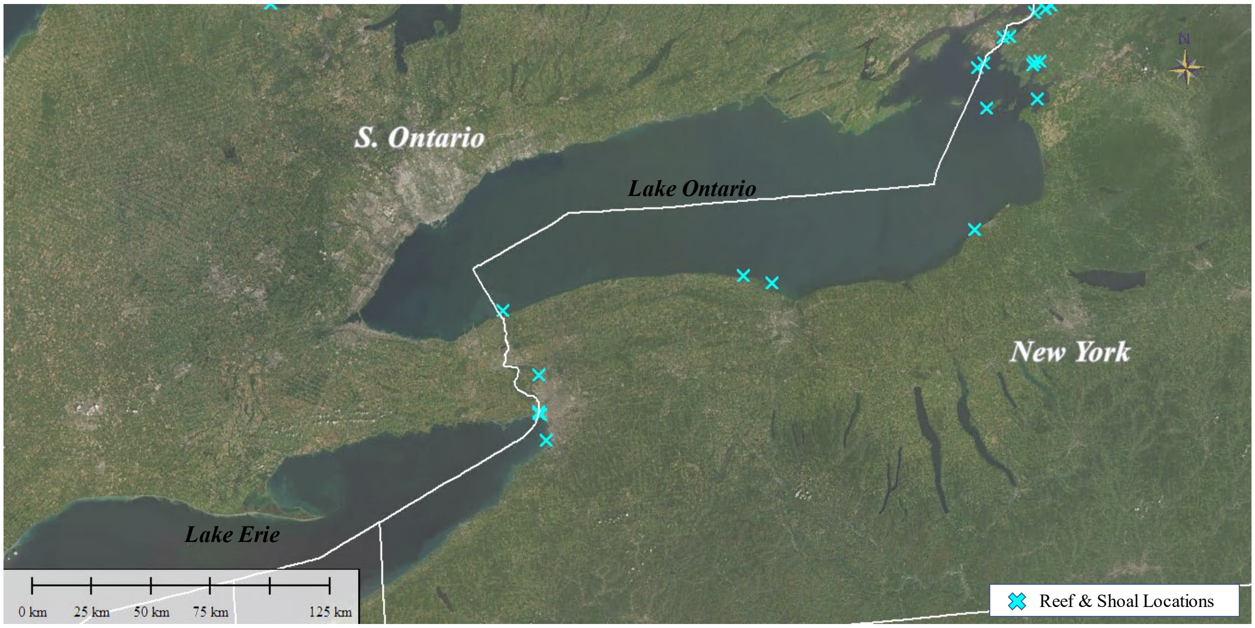
The nearshore environment in Lake Ontario includes a diversity of habitat types and fish species, including many prey species and native species. Changes to environmental variables such as nutrient inputs, climate, and invasive species have led to challenges for fisheries managers with respect to maintaining biodiversity. Native species populations have declined (O'Gorman 2017). During 2017 and 2019, water levels in Lake Ontario were the highest ever recorded, measuring at more than 80 centimeters (31 inches) higher than the seasonal average for the previous five decades (Smith, et al. 2021). Coastal wetland vegetation was impacted by high water levels, and some nearshore fish habitat was altered.

The eastern basin of Lake Erie is a unique area, as the environmental conditions are more stable than in all other areas of the lake. Because conditions are generally stable, when environmental changes do occur, the nearshore areas tend to experience alterations of food webs and cool-water fish community structure (Markham and Knight 2017). Nearshore spawning and nursery habitats, which include wetlands, play particularly vital roles to support stable fish communities and fish stocks.

Shoals and reefs are important habitat and fish spawning locations. There are several locations of shoals and reefs within the NYS waters of Lake Ontario and a few in the northeast of Lake Erie. All of the identified shoals and reefs are in the nearshore habitat and are important to the nearshore fish community discussed above. The Great Lakes Aquatic Habitat Framework (GLAHF) compiled a listing of known reef and shoal locations from various data sources Erie (Figure 8). Additional sites may be present and not formally documented in the GLAHF data set and some sites are located across the international border in Canadian waters.

Figure 8. Locations of Reef and Shoal Sites within Study Area

Source: (GLAHF 2020)



3.5.3 Offshore Pelagic Fish Community

The separation between nearshore and offshore is at the ≥15m (49.2 ft) contour depth. The offshore area contains two zones, the pelagic and benthic. The offshore pelagic zone contains the majority of the water and living components of the lakes (O'Gorman 2017, Markham and Knight 2017). From June through October the offshore pelagic zone of the lakes is thermally stratified into an upper warmer layer (epilimnion) and a lower cool layer (metalimnion). The offshore fish communities in both lakes typically display a stable balance of predator and prey species (O'Gorman 2017, Markham and Knight 2017).

3.5.4 Offshore Deep Benthic Fish Community

The offshore benthic zone is the area in the water column below the thermocline to the lake bottom of Lake Ontario (244 m [800.5 ft]) and Lake Erie (64 m [210 ft]). These are the deepest and coldest areas of Lakes Ontario and Erie, known as the hypolimnion (O'Gorman 2017). Within the deep benthic zone, the fish community composition of both lakes has shifted dramatically, as non-native and invasive species have become prevalent. In Lake Erie, the eastern basin is the deepest area of the lake and supports cold-water predator and prey species (Markham and Knight 2017). Although most fish in both lakes Ontario and Erie spawn in shallow, nearshore waters, some members of the deep benthic fish communities likely remain in deep water to spawn, as they are not known to move great distances. Deepwater Ciscoes (Coregonus spp.) have been documented spawning in shallow and deep waters of Lake Michigan (Kao, et al. 2020). The Deepwater Sculpin (*Myoxocephalus thompsonii*) appears to have very limited movements, and this behavior along with catch data locations suggest that they remain in deep water to spawn (NY Department of Environmental Conservation 2013).

3.5.5 Migratory versus Non-Migratory Fish

Non-migratory fish species remain in the same general location year-round and consequently rely on resources in one area, and migratory species move seasonally as needed for feeding or spawning, making use of more areas of the lakes. In Lake Ontario, nearly all fish species use the nearshore zone for spawning, so migration to these areas is common for fish not already residing there. The Round Goby (an invasive species) has been observed residing in nearshore waters during the summer and migrating to offshore benthic habitats in the winter. This migratory behavior has led to complications discerning the impacts of this invasive species as predator and prey (O'Gorman 2017).

In Lake Erie, many migratory species cross the central basin during spring or fall while moving to their spawning or feeding grounds (Markham and Knight 2017). There is a seasonal migration of Walleye (*Sander vitreus*) that spawn in the western basin and migrate to the eastern basin in the summer (Matley, et al. 2020, Raby, et al. 2018). The scale of this migration varies annually, seasonally, and as a function of the size of the western Walleye population (Markham and Knight 2017). This annual Walleye migration is important in driving the eastern basin Walleye fisheries (Einhouse and MacDougall 2010). Eastern basin Walleye stocks usually stay in the area year-round and are smaller than western basin stocks; this makes them more susceptible to relatively large takes during spring harvest and when stock migration from the west is reduced (Dippold, Adams and Ludsin 2020, Zhao, Einhouse and MacDougall 2011).

3.5.6 Prey Fish

Prey fish (also known as forage fish) are defined as those that are consumed by larger predatory fish. In Lakes Ontario and Erie, healthy prey fish populations not only provide food for fish species that are part of the commercial and recreational fisheries but also help to maintain balanced lake ecosystem and food web functions by providing food for non-target fish species. Prey fish in both lakes include native (e.g., Yellow Perch [*Perca flavescens*]) and non-native (e.g., Alewife) species (Francis, et al. 2020, Stewart, Todd and LaPan 2017).

In Lake Ontario, prey fish diversity in the offshore pelagic zone has shown a general decline in recent decades primarily due to increasing Alewife populations and decreasing populations of all other species surveyed (O'Gorman 2017). In deeper pelagic and offshore benthic waters of Lake Ontario several prey fish species such as Deepwater Cisco, Deepwater Sculpin, Bloater (*Coregonus hoyi*), and Slimy Sculpin (*Cottus cognatus*) were abundant in the early 1900s but declined thereafter as non-native species like the Round Goby were introduced and other shifts in fish community structure occurred (O'Malley, Goretzke and Holden 2020).

In the eastern basin of Lake Erie, the once prevalent but now extirpated Cisco has been replaced by other species such as Rainbow Smelt, Emerald Shiner (*Notropis athernoides*), Gizzard Shad (*Dorosoma cepedianum*), Round Goby and various pelagic prey fish species. It is possible that a remnant Cisco population survives today, as occasionally, individuals of this species are caught in commercial fisheries. Data from trawl surveys conducted in 2020 indicated that total prey fish abundance increased in the eastern basin waters of New York State compared to 2019 but was still below the average across the 1990s and 2000s (Forage Task Group 2021).

3.5.7 Endangered Fish Species

There are eight NYS endangered or threatened fish species that are known to occur in the study area (Table 6) (NYSDEC 2021) and there are no federal ESA-listed fish species within the study area. According to the NYSDEC, Silver Chub (*Macrhybopsis storeriana*), once prevalent in Lake Erie, has been extirpated from NYS.

Table 6. New York State Endangered Species Act Fish Species within the Study Area

Source: (NYSDEC 2021)

Common Name	*Scientific Name*	Status	Lake Zone
Black Redhorse	*Moxostoma duquesnei*	Special Concern	Nearshore
Deepwater Sculpin	*Myoxocephalus thompsoni*	Endangered	Offshore Deep Benthic
Eastern Sand Darter	*Ammocrypta pellucida*	Threatened	Nearshore
Lake Chubsucker	*Macrhybops isstoreriana*	Threatened	Nearshore
Lake Sturgeon	*Acipenser fulvescens*	Threatened	Nearshore
Mooneye	*Hiodon tergisus*	Threatened	Nearshore
Northern Sunfish	*Lepomis peltastes*	Threatened	Nearshore
Pugnose Shiner	*Notropis anogenus*	Endangered	Nearshore
Redfin Shiner	*Lythrurus umbratilis*	Special Concern	Nearshore
Round Whitefish	*Prosopium cylindraceum*	Endangered	Offshore Deep Benthic

Deepwater Sculpin and Round Whitefish (*Prosopium cylindraceum*) live in the offshore deep benthic zone (discussed in section 3.5.4); the other eight fish species from Table 6 live in the nearshore zone (discussed in section 3.5.2). The nearshore zone has major challenges for biodiversity conservation due to ever-changing nutrient input, invasive species, ecological drivers, and climate change (O'Gorman 2017). Both the Lake Ontario Committee (LOC) and Lake Erie Committee (LEC) maintain programs to restore native and protected species (Stewart, Todd and LaPan 2017).

3.5.8 Invasive Fish Species

Invasive species are not native to an ecosystem and can cause harm. Invasive species can have significant impacts on environments by disrupting local ecosystems and communities, and often cause rapid and unpredictable changes. These species can be very difficult to control or eradicate. In Lakes Ontario and Erie, the occurrence of invasive fish species has contributed to uncertainty in the understanding of food webs (Francis, et al. 2020); (Stewart, Todd and LaPan 2017). Not all non-native species cause clear adverse impacts; in Lake Ontario for example, the Round Goby has become a dominant prey species for nearshore fish predators and has recently expanded offshore (Stewart, Todd and LaPan 2017). Conversely, the Sea Lamprey has caused clear and considerable harm to fish populations as a piscivore in both Lakes Ontario and Erie (Markham and Knight 2017, O'Gorman 2017).

In Lake Erie, Round Goby became prevalent in the late 1990s, and was controlled by the Burbot (*Lota lota)* population in offshore waters of the eastern portion of the lake (Madenjian, et al. 2011); however, Burbot underwent a decline from 2002 to 2007 with decreased recruitment (Stapanian, Witzel and Cook 2010). Grass Carp (*Ctenopharyngodon idella*), which originated in Asia and one of four species known collectively as Asian Carps, have been present in Lake Erie since the 1970s (Cudmore and Mandrak 2004, United States Geological Survey 2020). In 2008 Jerde et al. (2013) found Asian Carp eDNA in Lake Erie, though no viable population has been established. The Lake Erie eastern basin is especially susceptible to invasion by Asian Carps, and this would pose serious ecological threats to the overall ecosystem by competing with other plankton consuming fishes (Francis, et al. 2020, Zhang, et al. 2015).

Invasive fish species for both lakes are listed in Table 7 below (Markham and Knight 2017, Stewart, Todd and LaPan 2017).

Table 7. Invasive Fish Species in Lakes Ontario and Erie

Source: (Markham and Knight 2017, Stewart, Todd and LaPan 2017)

Invasive Fish Species in Lake Ontario	Invasive Fish Species in Lake Erie
Alewife	Alewife
Rainbow Smelt	White Perch
White Perch	Round Goby
Common Carp	Tubenose Goby
Round Goby	Sea Lamprey
Tubenose Goby	-
Sea Lamprey	-

3.5.9 Sea Lamprey Control

Multiple methods are used to control invasive Sea Lamprey populations in the Great Lakes region, and the Great Lakes Fishery Commission (GLFC) has made it a priority to continuously control Sea Lamprey populations in efforts to decrease wounding and mortality rates of native species, such as Lake Trout (*Salvelinus namaycush*) (Stewart, Todd and LaPan 2017). For adult Sea Lampreys, preventing upstream movements by creating barriers limits their reproductive output, as adults require access to tributaries with spawning gravel. Traps are used to capture adults as they move into tributaries, although traps alone do not remove enough adults to reduce reproductive rates substantially. For Sea Lamprey larvae, the main mechanism to reduce populations is treating tributaries with a lampricide, chemicals known to kill young Sea Lampreys before they are able to harm other fish (Marsden and Siefkes 2019). A lampricide is a toxin applied to an aquatic area that results in Sea Lamprey larvae mortality (McDonald and Kolar 2007). Lampricides have been used since the 1950's, and this method has been effective at substantially reducing the abundance of Sea Lamprey in the Great Lakes region (Francis, et al. 2020).

Although barriers and lampricides are effective at controlling Sea Lamprey populations, there is concern that these methods may harm other, non-target fish species or the integrity of the ecosystems where they are used (Marsden and Siefkes 2019). Solicitations for research on additional control methods have been made by GLFC, led by the Sea Lamprey Research Board. Lamprey genetic research has included mapping the Sea Lamprey genome and transcriptome analysis, which may provide insight into the development of more species-specific lampricides that will not harm native fishes and information about the Sea Lamprey's unique immune system and how to use this as a control mechanism (McCauley, et al. 2015). New research on larval and adult pheromones shows promise as a possible control tool in the form of Sea Lamprey repellants; Sea Lamprey use sense of smell during reproduction, so a disruption to this process may prove to limit reproductive outputs (Buchinger, et al. 2015). Assessments of the effectiveness of current control methods and the implementation of new methods will likely be necessary to continue to effectively control this invasive species in the Great Lakes region (Markham and Knight 2017).

3.6 Terrestrial Species and Habitats

The New York State shores of Lakes Ontario and Erie consist of a mosaic of wetlands, sand dunes, and beaches, as well highly anthropogenically impacted areas such as farmland and harbors. The large diversity of birds inhabiting the lakeshores comprise a large portion of terrestrial species of concern and are covered in section 3.2, while the remaining sensitive and rare terrestrial species and their habitats are the focus in this section. Many habitats are protected at the local or State level to conserve the sensitive species within them, such as the rare plants that occupy freshwater dune ecosystems. Though these sensitive habitats often fall within wildlife management areas, restrictions within these areas range from a complete ban on human admittance on one end to allowing anthropogenic activities such as hunting, fishing, and development on the other. Because of this variation, the feasibility of development within protected or managed areas must be assessed on a case-by-case basis.

Six NYS ESA-listed terrestrial animal species are known to currently, or historically, occupy the study area; four reptiles and two insects (Table 8). Of these, the Bog Turtle (*Glyptemys muhlenbergii*), is the only federal ESA-listed species known to currently occupy the terrestrial habitat of Lakes Erie and Ontario (Rosenbaum and Nelson 2010).

Table 8. Federal Endangered Species Act and New York State Endangered Species Act Terrestrial Species within the Study Area

Source: (NYSDEC 2015, USFWS 2015)

Common Name	Scientific Name	Federal Status	State Status
American Burying Beetle	*Nicrophorus americanus*	Not Listed	Endangered
Blanding's Turtle	*Emydoidea blandingii*	Not Listed	Threatened
Bog Buckmouth	*Hemileuca sp.*	Not Listed	Endangered
Bog Turtle	*Glyptemys muhlenbergii*	Endangered	Endangered
Eastern Spiny Softshell	*Apalone spinifera*	Not Listed	Special Concern
Queen Snake	*Regina septemvittata*	Not Listed	Endangered

The NYS Protected Native Plants Program protects 27 native plants that are known to currently or historically occupy the study area (Table 9). All are NYS ESA-listed endangered, threatened, or rare. There are no federal ESA-listed plant species known to occur in the study area.

Table 9. Protected Native Plant Species within the Study Area

Source: (NYSDEC 2015, USFWS 2015)

Common Name	Scientific Name	State Status
American Knotweed	*Polygonum buxiforme*	Endangered
Big Shellbark Hickory	*Carya laciniosa*	Threatened
Bushy Cinquefoil	*Potentilla supina* ssp. *paradoxa*	Endangered
Cream-Colored Avens	*Geum virginianum*	Threatened
Creeping Sedge	*Carex chordorrhiza*	Threatened
Dragon's Mouth Orchid	*Arethusa bulbosa*	Threatened
Forest Blue Grass	*Poa sylvestris*	Endangered
Frank's Sedge	*Carex frankii*	Threatened
Goldie's Starwort	*Stellaria longipes* ssp. *longipes*	Threatened
Great Lakes Sand Cherry	*Prunus pumila* var. *pumila*	Endangered
Houghton's Sedge	*Carex houghtoniana*	Threatened
Leonard's Skullcap	*Scutellaria parvula* var. *missouriensis*	Endangered
Lily-Leaved Twayblade	*Liparis liliifolia*	Endangered
Livid Sedge	*Carex livida*	Threatened
Marsh Horsetail	*Equisetum palustre*	Threatened
Northern Bog Aster	*Symphyotrichum boreale*	Threatened
Pawpaw	*Asimina triloba*	Threatened
Pod Grass	*Scheuchzeria palustris*	Rare
Puttyroot	*Aplectrum hyemale*	Endangered
Ram's Head Lady's Slipper	*Cypripedium arietinum*	Threatened
Rock Elm	*Ulmus thomasii*	Threatened
Sand Dune Willow	*Salix cordata*	Threatened
Schweinitz's Flat Sedge	*Cyperus schweinitzii*	Rare
Slender Bulrush	*Schoenoplectus heterochaetus*	Endangered
Sparse-Flowered Sedge	*Carex tenuiflora*	Endangered
Texas Wild Flax	*Linum medium* var. *texanum*	Threatened
Wafer Ash	*Ptelea trifoliata* var. *trifoliata*	Threatened

3.6.1 Wetlands

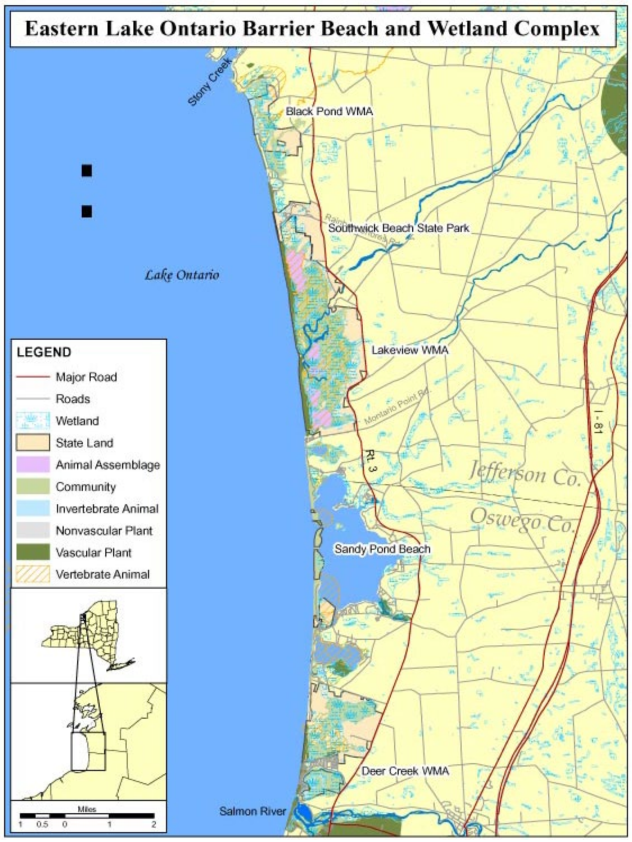
Wetlands (also known as swamps, marshes, bogs, and similar areas) are areas saturated by ground or surface water sufficient to support vegetation adapted for life in saturated soil conditions (NYSERDA, Wetlands Accessed 2021). Wetlands make up 20 of the 90 areas designated as Significant Coastal Fish and Wildlife Habitat within the study area by the New York Department of State (NYSDOS 2021). Of these, the majority are contained within Jefferson County followed by Oswego County along the eastern edge of Lake Ontario. Over 80% of wetland area in Lake Ontario and the upper St. Lawrence River occurs in the eastern half of the Lake Ontario basin and Thousand Islands region (International Lake Ontario - St. Lawrence River Study 2006).

Wetlands within the Great Lakes can be categorized into three broad types: riverine, barrier-protected, and lacustrine wetlands. Riverine wetlands make up the greatest percentage of wetland area along Lake Ontario and Lake Erie and occur where a river mouth meets the lake or at tributaries along rivers (EPA 2021). Barrier-protected wetlands are the second most common wetland type and form long stretches of coastline where structures such as dunes have created physical barriers between the lakes and wetlands that protect the wetlands from wind and wave action. Lacustrine wetlands are the least common type, usually occurring in more protected areas such as large bays where the waters of the lake can directly support the wetland.

Within the study area, both riverine and barrier-protected wetlands are distributed across the eastern and southern shores of Lake Ontario, while only riverine wetlands occur in Lake Erie. The highest concentrations of barrier-protected wetlands fall along eastern Lake Ontario (Figure 9), which coincides with where dunes occur. Small patches of lacustrine wetlands occur along the southeastern shore of Lake Ontario but are not a common wetland type within NYS (EPA 2021). In 2019, the Niagara River, associated with the Niagara River watershed, was designated as a Wetland of International Importance under the Ramsar Convention (Our Niagara River Accessed 2022). Lakes Ontario and Erie have seen a reduction in wetland and other nearshore habitats due to factors such as water level regulation and habitat degradation (Markham and Knight 2017, O'Gorman 2017). The majority of wetlands in Lake Erie occur in the western basin, although some do occur in the eastern basin (Great Lakes Coastal Wetland Consortium 2019).

Figure 9. Barrier-Protected Wetland Habitat Along Lake Ontario's Eastern Shore

Source: (NYSDEC 2021)



Differences in soil composition and water levels across the lakeshore region result in wetland sub-types harboring unique and rare species assemblages, especially plant species. For example, the Deer Creek Marsh Wildlife Management Area in Oswego County is home to the Livid Sedge (*Carex livida*) and Low Sand-Cherry (*Prunus pumila*), two NYS-listed endangered species (NYSDEC 2020). Further, this management area also contains six significant ecological communities, with two of these classified as "rarest" by the New York Natural Heritage Program (NY Bureau of Wildlife 2018).

Two species of NYS ESA-listed turtles occupy Great Lakes wetlands: Bog Turtle and Blanding's Turtle (*Emydoidea blandingii*). The Bog Turtle is a small turtle found in scattered colonies in the eastern U.S. from Lake Ontario to northwest Georgia (NYSDEC 2021). This species can reach 30 years of age and is threatened by habitat loss, which has resulted in listing as endangered within NYS and federally as threatened under the ESA. Bog Turtles prefer habitat with good sunlight for basking and cool, shallow, slow-moving water, such as wet meadows or open peat-accumulating wetlands. Additionally, their known habitat often contains various species of wetland sedges and mosses (NYNHP 2021). Bog Turtles occur in wetlands associated with Lake Ontario's eastern shore where recent surveys have identified small populations each containing less than 100 individuals (Rosenbaum and Nelson 2010). Extant populations are also known in Oswego and Wayne Counties; however, exact locations of known habitat are not made publicly available in order to protect the turtles from illegal poaching.

Blanding's Turtles are listed as threatened within NYS and are under review for listing federally. They only occur in eastern North America in the area surrounding the Great Lakes (USFWS 2013). They inhabit a variety of wetland habitats and rely upon sandy areas covered in grasses or shrubs for nesting, not reaching maturity until at least 18 years of age (NYSDEC 2021b). Habitat destruction is the major threat to these turtles, in addition to illegal capture by poachers for the pet trade.

3.6.2 Dunes

The Great Lakes are home to the largest system of freshwater dunes in the world (New York Natural Heritage Program 2021). The species that occupy these dunes must be able to withstand extreme temperature changes throughout the seasons as well as extreme weather events. Their greatest threats are development, invasive species, and habitat overuse and alteration. The majority of dune habitat within NYS is restricted to approximately 27.4 km (17 mi) of Lake Ontario's eastern shore within Oswego, Monroe, and Jefferson Counties, though some dune habitat occurs near Lake Erie (White 2011). About 50 percent of the vegetation coverage on a typical dune can be classified as herbs, such as beach grass, while trees taller than 5 m, such as Hemlock-Hardwood and Red Oak (Quercus rubra), make up another 25 percent (New York Natural Heritage Program 2021). The Federal and NYS ESA-listed Piping Plover is known to occupy Lake Ontario's dune habitats, as is Champlain Beachgrass (*Ammophila champlainensis*), which is a NYS-listed endangered species (The Nature Conservancy 2021).

3.6.3 Invasive Species

Invasive species are a threat to the terrestrial ecosystems of Lakes Ontario and Erie, particularly invasive plants within wetland habitats. These plants out-compete native species through prolific seed production and the formation of large, dense, homogenous stands that prevent regeneration of native plants and reduce habitat for native animal species, for example, basking and breeding habitat for the Bog turtle (Cao, Larson and Sturtevant 2019, Midwestern Invasive Plant Network 2021).

One highly invasive species is Purple Loosestrife (*Lythrun salicaria*), a perennial herb that was introduced to the lakes in ship ballast water and by European settlers in the early 1800's as an ornamental plant. It has since spread throughout much of the northeastern U.S. and southeastern Canada and is found in many of the wetland habitats around Lake Ontario (Cao, Larson and Sturtevant 2019). Purple Loosestrife can propagate either through seeds or through stem or root fragments and has low-nutrient requirements, allowing it to withstand sites that native plants may find inhospitable or to have an advantage on disturbed sites. Its seeds are mostly dispersed by water but can also travel by adhering to animals, people, vehicles, and within ship ballast water. Biological controls, such as the Leaf Beetle (*Galerucella calmariensis*) and the Root-Mining Weevil (*Hylobius transversovittatus*), have proven to be most effective at reducing Purple Loosestrife populations. Physical controls, such as mechanical extraction and flooding, have proven ineffective (Cao, Larson and Sturtevant 2019).

Common Buckthorn (*Rhamnus cathartica*) is a tall shrub that has reportedly invaded all counties surrounding Lakes Ontario and Erie (Midwestern Invasive Plant Network 2021). It was introduced as an ornamental shrub in the early 1800's but is now broadly recognized as an invasive species and sales are prohibited in most states surrounding the Great Lakes (Midwestern Invasive Plant Network 2021). It is tolerant of many soil types, from well-drained sand to clay, allowing it to invade dune habitat along Lake Ontario's eastern shore where its long branches crowd out and shade native shrubs and herbaceous species (NY State Invasive Species Information 2019). Common Buckthorn management options include manual, chemical, and mechanical removal (Western New York PRISM Accessed 2022).

3.7 Sensitive Habitats

Sensitive habitats refer to natural environments where the biotic and abiotic components can be particularly vulnerable to human impact or are very important to particular species or ecosystem function. The label sensitive habitat might refer to the presence (year around or seasonal) of an endangered species, the presence of features that are necessary for the survival of a species, or the presence of a diverse community or ecosystem that needs specific protection from potential anthropogenic disruptors. Sensitive habitats may not all be recognized by the federal or NYS legal framework, but below, categories of recognized sensitive habitats are described. Regulatorily recognized sensitive habitats in the study area include critical habitats, Critical Environmental Areas (CEAs), Areas of Concern (AOCs), and Significant Coastal Fish & Wildlife Habitats (SCFWHs).

3.7.1 ESA Critical Habitat

Under the ESA, a critical habitat is officially designated for listed species. Critical habitat is a zone within the geographical range (current or historic) of a threatened or endangered species that is considered crucial to its conservation. The area usually includes biological or physical features that are essential to this species. Such features may include resources (e.g., water, food); vegetation; or habitat providing shelter, cover, or areas for breeding/rearing offspring that are key aspects of the life history of the species of interest. Generally, pre-existing human-made structures are excluded from the critical habitat designation and its provisions. Activities and development can be authorized in a designated area of critical habitat. However, activities on federal lands, requiring federal authorizations, or using federal funds are required to avoid or minimize any destruction or adverse modification to critical habitat.

Within the study area, one ESA-listed species, the Piping Plover, has a designated critical habitat. As part of the 35 units forming the critical habitat for the Great Lakes breeding population designated on May 7, 2001 (Federal Register 66 FR 22938 2001), the NYS region encompasses a 27.4-km (17 mi) stretch of Piping Plover critical habitat on the northeast edge of Lake Ontario between Salmon River and Stony Point in Oswego and Jefferson counties. This critical habitat particularly focuses on the Great Lakes sandy substrates associated with wide, unforested systems of dunes and inter-dune wetlands (USFWS 2009). Generally, the Great Lakes breeding sites have been found to be largely restricted to the shoreline region (USFWS 2009). Currently, shoreline development is listed as the main cause of habitat destruction and degradation for this region, and the main conservation efforts focus on habitat improvement and protection through acquisition.

3.7.2 Areas of Concern

The U.S.-Canada Great Lakes Water Quality Agreement (Annex 1 of the 2012 Protocol) defines AOCs as "geographic areas designated by the Parties where significant impairment of beneficial uses has occurred as a result of human activities at the local level." Beneficial Use Impairments (BUIs) are described as “a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause significant environmental degradation” (EPA 2021). Under the Great Lakes Water Quality Agreement, the Great Lakes region has implemented international Lake-wide Action and Management Plans (LAMPs) aimed at restoring and protecting the Great Lakes ecosystems and maintaining the physical, biological, and chemical integrity of the lakes' water. Both Lake Ontario and Lake Erie have LAMPs (Environment and Climate Change Canada and the U.S. Environmental Protection Agency 2021, Environment and Climate Change Canada and the U.S. Environmental Protection Agency 2018).

For each AOC defined through the LAMPs, BUIs have been identified and can be removed (i.e., delisted) once environmental improvements have reached restoration targets. These regions continue to be monitored until all BUIs have been removed. For the AOCs listed below, ongoing remediation and restoration efforts continue to be made to address the current BUIs. Efforts include but are not limited to habitat restoration, species monitoring, sediment remediation, and cleanups. Table 10 shows the New York State specific-AOCs for each lake along with their currently active BUIs.

Table 10. New York Areas of Concern and Beneficial Use Impairments

Source: (EPA Accessed 2022)

AOC Name	Location	Beneficial Use Impairment (BUI)
Eighteenmile Creek AOC	Lake Ontario	Degradation of fish and wildlife populations. Bird or animal deformities or reproductive problems. Degradation of benthos. Restriction on fish and wildlife consumption.
Rochester Embayment AOC	Lake Ontario	This AOC has been successful at habitat restoration and the majority of BUI have been removed. The following BUIs remain active for this area: • Bird and animal deformities or reproductive problems. • Loss of fish and wildlife habitat. • Degradation of aesthetics.
Buffalo River AOC	Lake Erie	Restriction on fish and wildlife consumption. Degradation of fish and wildlife populations. Fish tumors or other deformities. Bird or animal deformities or reproduction problems. Degradation of benthos. Restrictions on dredging activities. Loss of fish and wildlife habitat.
Niagara River AOC	Lake Erie/ Lake Ontario	Restrictions on Fish and Wildlife Consumption. Degradation of Benthos. Restrictions on Dredging Activities. Loss of Fish and Wildlife Habitat. Degradation of Fish and Wildlife Populations. Bird or Animal Deformities or Reproduction Problems.

3.7.3 New York State Critical Environmental Areas

New York State recognizes environmentally relevant areas referred to as CEAs. CEAs are areas which have been designated to recognize a specific geographical area that has:

- An exceptional or unique natural setting.
- An inherent ecological, geological, or hydrological sensitivity to change that maybe adversely affected by any physical disturbance (NYSDEC 2020).

Other features such as archaeological and historical importance can also trigger the CEA designation in NYS. During the permitting process, potential impacts on a CEA characteristic may warrant consideration in determining the significance of actions that may affect that CEA during the State Environmental Quality Review process. Table 11 and Table 12 summarize the CEAs identified within the study area.

Table 11. Lake Ontario Critical Environmental Areas, Designating Agency, and Reason for Designation within the Study Area

Source: (NYSDEC 2020)

CEA Name	Designating Agency and Reason for Designation
Hotel Creek	Town of Riga Trout habitat and may be spawning ground.
Land within 30 m (100 ft) of Genesee River Barge Canal, Lake Ontario, or River Gorge except in manufacturing industrial zone.	City of Rochester Environmentally Sensitive
Slopes and Crests of the following glacial formations: Cobbs Hill Pinnacle Hill Lesser hills between Conrail ROW and I-590	City of Rochester Environmentally Sensitive
Freshwater Wetlands	City of Rochester Environmentally Sensitive.
Sandy Ponds	Town of Sandy Creek Protect barrier dunes, wetlands, resources.

Table 12. Lake Erie Critical Environmental Areass, Designating Agency, and Reason for Designation within the Study Area

Source: (NYSDEC 2020)

CEA Name	Designating Agency and Reason for Designation
Freshwater wetlands within town	Town of Cheektowaga Significant and Sensitive Recharge Area
Reinstein Woods–109-hectare (269-acre) Nature Preserve with 122 m (400 ft) wide peripheral buffer	Town of Cheektowaga Preserve Wildlife and Green Area
John Stiglmeier Park	Town of Cheektowaga Preserve Wildlife and Green Area
Cayuga Creek to 100-year floodplain	Town of Cheektowaga Preserve Wildlife and Green Area
Eighteen Mile Creek	Town of Hamburg Exceptional or unique character

3.7.4 Significant Coastal Fish and Wildlife Habitats

Designated SCFWHs provide feeding and living areas for animals and are economically important. These coastal habitats include wetlands, beaches, marshes, mud and sandflats, riparian corridors, rocky shores, submerged aquatic vegetation, harbor bottoms, dunes, grasslands, and woodlands. They are designated based on their ecosystem rarity or the presence of a species of interest (NYSDOS 2021). There are 70 habitats in the study area listed as Significant Coastal Fish and Wildlife Habitats, and many areas overlap with the other sensitive habitats detailed throughout this section.

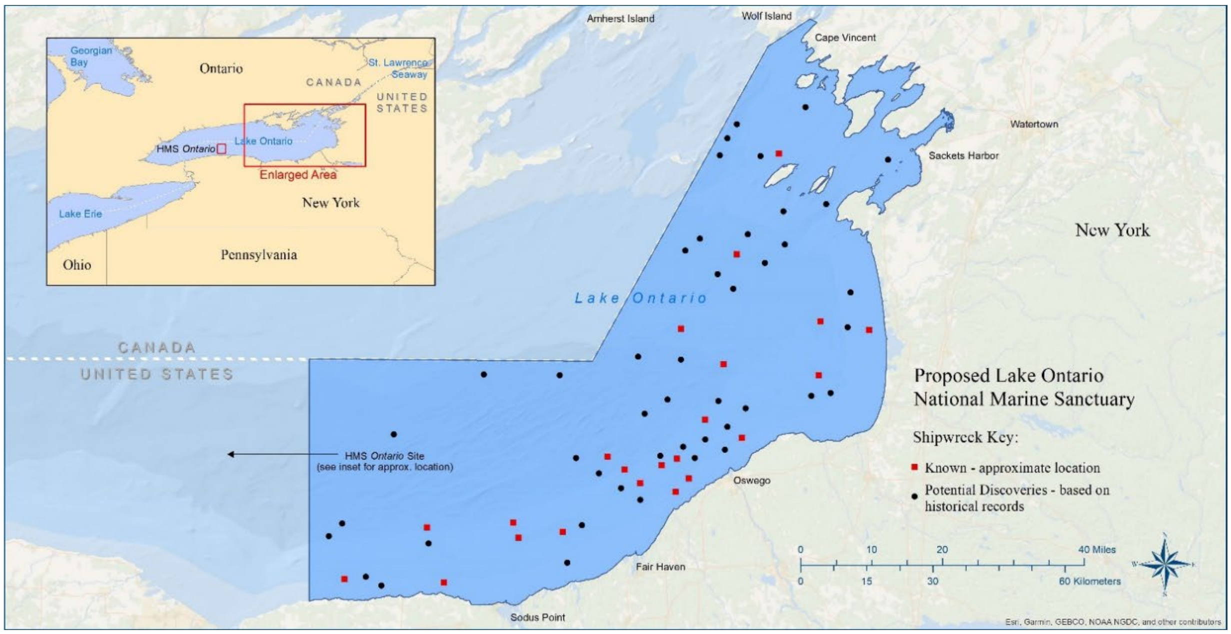
3.7.5 Proposed National Marine Sanctuary Designation

The National Oceanic and Atmospheric Administration's (NOAA's) National Marine Sanctuaries are federally designated ocean and Great Lakes waters protected under the National Marine Sanctuaries Act. Resources such as historical sites and biodiversity are protected under this designation. The Sanctuary designation process begins with a nomination. A community-driven nomination was submitted to NOAA in 2017 for Lake Ontario. In April 2019, NOAA proposed to designate roughly 2,774 square km (1071 square mi) of Lake Ontario's waters and bottomlands as a National Marine Sanctuary (encompassing Jefferson, Wayne, Oswego, and Cayuga counties Figure 10). This area contains at least 21 known shipwrecks and one military aircraft encompassing over 200 years of American history. An additional 47 shipwrecks are also believed to be within the designated zone (Office of National Marine Sanctuaries 2021) and are discussed in section 3.14. The potential National

Marine Sanctuary boundary is under consideration. Alternatives have been proposed that include the Thousand Islands. If approved, this sanctuary designation would enable NOAA to manage, research, interpret, and improve public access to a nationally significant collection of maritime heritage resources, including historic wrecks.

Figure 10. Proposed Lake Ontario National Marine Sanctuary Indicating Known and Potential Wrecks

Source: (NOAA National Marine Sanctuaries Accessed 2022)



Under the National Marine Sanctuaries Act, certain activities could become either "prohibited or otherwise regulated." However, sanctuaries can be compatible with commercial activities, so designation of a sanctuary in Lake Ontario does not necessarily exclude wind development. The HMS Ontario, a Revolution War-era British warship, is thought to be in southwestern waters of Lake Ontario, as seen in the inset in Figure 10. Her Majesty's Ship (HMS) Ontario represents a significant Great Lakes shipwreck. If the proposed sanctuary is designated, NOAA would conduct research and attempt to locate the HMS Ontario with a goal of adding it to the sanctuary (Office of National Marine Sanctuaries 2021).

3.8 Fisheries

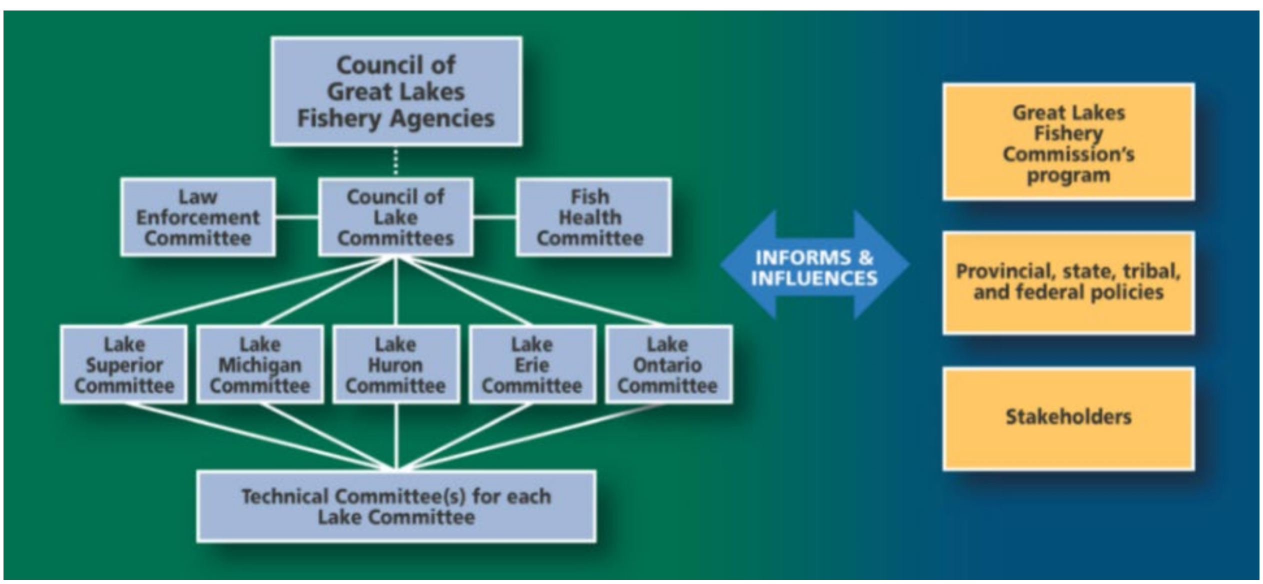
Fisheries in the Great Lakes are supported by the Canadian and U.S. Federal governments and are managed by State, provincial, and tribal agencies. Great Lakes fisheries management occurs cooperatively to support commercial, recreational, and subsistence fisheries and to achieve a productive and well-balanced fish community. In 1981, fishery management agencies agreed to cooperate in the Joint Strategic Plan for Management of Great Lakes Fisheries, a non-binding agreement to ensure the actions of one fishery management agency would not jeopardize interests of another agency (Gaden, et al. 2008, GLFC 2007). The GLFC facilitates this process.

3.8.1 Great Lakes Fishery Commission

The GLFC operates through the 1954 Convention on Great Lakes Fisheries, a permanent mechanism for bilateral cooperation across the U.S. and Canada (Gaben, Brant and Lambe 2020). GLFC has two main responsibilities: (1) design and coordinate Great Lakes research programs and recommend measures to permit the maximum sustained productivity of fish stocks of concern based on research findings and (2) create and implement a Sea Lamprey eradication program in the Great Lakes (GLFC 2007). Each lake within the Great Lakes has a committee, which acts as the primary body to implement the Joint Strategic Plan. The LOC and LEC members comprise U.S. state, Canadian provincial, and intertribal fishery agency officials (U.S. and Canada). Each lake committee's members develop fish community objectives (FCOs), design and implement management plans, determine harvest targets and stocking levels, and establish law enforcement priorities. FCOs are updated periodically in accordance with the Join Strategic Plan (Great Lakes Fishery Commission 2021). Figure 11 below displays the committee structure and cooperation of agencies to manage fisheries in the Great Lakes (Great Lakes Fishery Commission 2021).

Figure 11. Great Lakes Fisheries Commission Committee Structure

Source: (Great Lakes Fishery Commission 2021)



3.8.2 Lake Ontario Fisheries

Lake Ontario fisheries management is shared between the Ontario Ministry of Natural Resources and Forestry and the NYSDEC. Together they develop Lake Ontario FCOs to guide the LOC within the GLFC. Commercial fisheries in the New York State waters of Lake Ontario are within the embayments and nearshore open waters of the eastern basin (NYSDEC 2020a). Commercial fishing usually targets Yellow Perch and uses trap nets, fyke nets, and gill nets (NYSDEC 2021b). Table 13 shows the recorded catches (kilograms [kg] and pounds [lbs]) for Lake Ontario fisheries between 2016-–2020.

Table 13. Lake Ontario Top Commercial Fisheries Catches Between 2016–2020

Source: (NYSDEC 2017a, NYSDEC 2018a, NYSDEC 2019a, NYSDEC 2020a, NYSDEC 2021b)

Common Name	2016 Catch (kg & lbs)	2017 Catch (lbs)	2018 Catch (lbs)	2019 Catch (lbs)	2020 Catch (lbs)
Yellow Perch	30,574 kg 67,405 lbs	30,588 kg 67,435 lbs	17,684 kg 38,987 lbs	24,745 kg 54,553 lbs	26,394 kg 58,188 lbs
Brown Bullhead	-	-	14 kg 30 lbs	-	54 kg 120 lbs
White Perch	224 kg 494 lbs	-	68 kg 150 lbs	222 kg 490 lbs	230 kg 508 lbs
Whitefish	95 kg 210 lbs	-	-	-	-
Cisco	819 kg 1,806 lbs	231 kg 509 lbs	91 kg 201 lbs	2 kg 5 lbs	-

Trout and salmon are popular recreational fisheries in Lake Ontario. Each year NYSDEC surveys boats fishing in New York State waters of Lake Ontario to provide data for salmon and trout fisheries management. Records date back to 1985 but do not include fishing from shore (NYSDEC 2020a). Recreational boating in Lake Ontario mostly occurs through channels that are associated with embayments and tributaries. Table 14 summarizes the number of fish caught by anglers surveyed between April 15 and September 30 of 2016–2019 (NYSDEC 2017, NYSDEC 2018, NYSDEC 2019, NYSDEC 2020). “Caught” is defined in these surveys as individual fish that were either kept or released by anglers. The NYSDEC fishing boat survey was not conducted in 2020 because of the COVID pandemic.

Table 14. Lake Ontario Top Recreational Fishing Survey Records Between 2016–2019

Source: (NYSDEC 2017, NYSDEC 2018, NYSDEC 2019, NYSDEC 2020)

Common Name	2016 Number Caught	2017 Number Caught	2018 Number Caught	2019 Number Caught
Chinook Salmon	60,435	96,226	173,691	114,861
Brown Trout	20,871	17,092	39,763	17,624
Rainbow Trout	16,639	22,556	18,047	15,861
Lake Trout	36,336	15,444	12,205	16,354
Yellow Perch	18,176	19,459	11,782	3,045
Coho Salmon	3,219	10,630	8,232	3,852
Smallmouth Bass	26,719	12,079	26,875	10,524
Atlantic Salmon	704	394	994	1,426
Round Goby	12,982	5,817	5,383	2,889
Walleye	671	208	0	919

Fishing for many species, especially in Lake Ontario, can involve focusing on preferred temperatures. Handheld or lowered temperature probes are readily available to the public to accurately read water temperatures in the water column down to greater than 30 m (98.4 ft). Thermoclines can also be displayed on depth finder equipment on boats. Table 15 shows the preferred and optimum temperatures for valuable recreational fisheries in Lake Ontario (NYSDEC Accessed 2021).

Table 15. Preferred and Optimum Temperatures for Lake Ontario Salmon and Trout

Source: (NYSDEC Accessed 2021)

Common Name	Preferred Temperature (°C & °F)	Optimum Temperature (°C & °F)
Atlantic Salmon	13-18 °C 55-65 °F	16 °C 60 °F
Brown Trout	12-17 °C 54-63	14 °C 58 °F
Rainbow Trout/Steelhead	13-18 °C 55-65 °F	16 °C 60 °F
Lake Trout	6-11 °C 42-52 °F	9 °C 48 °F
Coho Salmon	11-14 °C 52-58 °F	12 °C 53 °F
Chinook Salmon	11-14 °C 52-58 °F	12 °C 53 °F

Chinook Salmon (*Oncorhynchus tshawytscha*), Atlantic Salmon (*Salmo salar*), Coho Salmon (*Oncorhynchus kisutch*), Rainbow Trout (*Oncorhynchus mykiss*), and Brown Trout (*Salmo trutta*) are stocked in Lake Ontario to reestablish predator-prey interactions and to provide a recreational fishery (Stewart, Todd and LaPan 2017). GLFC has been stocking Lake Trout from 1970 to present. In 1970, stocking of Lake Trout increased and the GLFC began to execute control measures for Sea Lamprey. Now, more restoration initiatives are in place to increase Lake Sturgeon (*Acipenser fulvescens*) and American Eel (*Anguilla rostrata*) populations. New York State is stocking Atlantic Salmon to support their put-grow-take recreational fishery (Stewart, Todd and LaPan 2017). The term “Put-grow-take” fishery is a recreational fishery where the target species is stocked into the lake to grow and be caught by recreational anglers. For the last 25 years, Lake Ontario’s mix of native and non-native fish species have remained resilient. The LOC will continue stocking Salmon and Trout, initiatives to restore native species, science-based assessment monitoring, and implementation of regulations to sustain diverse fisheries to ensure long-term benefits (Stewart, Todd and LaPan 2017).

3.8.3 Lake Erie Fisheries

Lake Erie fisheries management is shared between Ontario Ministry of Natural Resources and Forestry (Canada), NYSDEC, Pennsylvania Department of Natural Resources, Ohio Department of Natural Resources, and Michigan Department of Natural Resources. Together the agencies develop Lake Erie FCOs to guide the LEC within the GLFC. Lake Erie produces more human-consumed fish than the four other Great Lakes combined (NYSERDA 2010). The New York State fishery mainly targets Yellow Perch and Walleye. Since the 1985 legislation regulating nets (ENV § 11-1503), all gill nets are prohibited in New York State waters of Lake Erie (NYSDEC 2021b). Anglers in commercial fisheries are required to submit monthly reports to NYSDEC that summarize their daily catches and fishing effort. Not all non-target species discarded during fishing are recorded. NYSDEC reports these data to the Yellow Perch Task Group (YPTG) within the LEC. The YPTG uses these data and data from other agencies to produce a Yellow Perch status summary for Lake Erie’s eastern basin (NYSDEC 2020, YPTG 2021). Table 16 shows the recorded commercial fisheries catches (kg and pounds) from March to December between 2016–2021 that NYSDEC reported to the YPTG.

Table 16. Lake Erie Top Commercial Fisheries Catches Between 2016–2021

Source: (NYSDEC 2017, NYSDEC 2018, NYSDEC 2019, NYSDEC 2020, NYSDEC 2021b, NYSDEC 2022a)

Common Name	2016 Catch (kg & lbs)	2017 Catch (kg & lbs)	2018 Catch (kg & lbs)	2019 Catch (kg & lbs)	2020 Catch (kg & lbs)	2021 Catch (kg & lbs)
Yellow Perch	5202 kg 11,468 lbs	5609 kg 12,366 lbs	4834 kg 10,657 lbs	8505 kg 18,750 lbs	6730 kg 14,837 lbs	5150 kg 11,354 lbs
Burbot	432 kg 952 lbs	517 kg 1,140 lbs	590 kg 1300 lbs	715 kg 1,577 lbs	342 kg 754 lbs	456 kg 1,005 lbs
White Perch	139 kg 306 lbs	129 kg 284 lbs	45 kg 100 lbs	37 kg 81 lbs	15 kg 32 lbs	81 kg 179 lbs
Suckers	38 kg 84 lbs	35 kg 78 lbs	9 kg 19 lbs	-	6 kg 13 lbs	-
White Bass	-	-	-	-	0.9 kg 2 lbs	-
Catfish (Channel cat)	69 kg 152 lbs	81 kg 178 lbs	20 kg 43 lbs	86 kg 190 lbs	-	-
Freshwater Drum	-	-	-	25 kg 55 lbs	-	11 kg 25 lbs

Since 1988, annual recreational open lake sport fishing surveys have been conducted for angler activity in the New York State waters of Lake Erie. Walleye and Yellow Perch dominate the recreational fishery. These annual reports are submitted to both the LEC Walleye Task Group (WTG) and YPTG to be incorporated into their Lake Erie management quota, assessment, and progress reports (WTG 2021, YPTG 2021). The State does not have assigned quotas for Walleye (WTG 2021). Table 17 summarizes the NYSDEC recreational fishing records for Lake Erie from April to October between 2016 and 2021.

Table 17. Lake Erie Recreational Fishing Survey Records Between 2016–2021

Source: (NYSDEC 2017, NYSDEC 2018, NYSDEC 2019, NYSDEC 2020, NYSDEC 2021b, NYSDEC 2022a)

Common Name	2016 Number Caught	2017 Number Caught	2018 Number Caught	2019 Number Caught	2020 Number Caught	2021 Number Caught
Walleye	60,223	119,944	188,701	216,507	103,850	57,964
Yellow Perch	33,532	57,895	40,462	70,730	38,877	67,900
Smallmouth Bass	73,342	56,477	93,465	56,685	39,694	50,325
Lake Trout	1,072	-	-	2,232	1,556	1,015
Steelhead (stocked)	696	978	1,623	-	-	278
White Bass	30,100	21,485	17,015	11,477	8,194	-
Pumpkinseed	-	-	-	307	-	-
Freshwater Drum	-	-	34,143	-	-	-
Sheepshead	-	29,466	-	-	-	-
Other species	52,961	25,103	12,358	64,533	54,982	-

Stocking continues in Lake Erie for Steelhead, Lake Trout, and Lake Sturgeon. The GLFC has been administering Sea Lamprey management control since the 1950s (Francis, et al. 2020). Anthropogenic impacts and climatic events affect fishery performances and fish community dynamics. Invasive species and native fish losses continue to alter the fish food-web structure (Francis, et al. 2020). Timely management of Lake Erie is impacted by the differing government processes and structures of the five jurisdictions and two nations within the LEC. Lake Erie fishery managers focus on managing fish stocking and fishing mortality to achieve fish community structure goals (Francis, et al. 2020).

3.9 Water Use

Water use includes human consumption, industrial and commercial use, and current conditions. NYS has more than 7,600 freshwater lakes, ponds, and reservoirs, as well as portions of two of the five Great Lakes (Lake Erie and Lake Ontario) and over 112,654 km (70,000 mi) of rivers and streams (NYSDEC 2021). These waterbodies provide drinking water supplies, provide flood control to protect life and property, and support recreation, tourism, agriculture, fishing, power generation, and manufacturing and provide habitat for aquatic plant and animal life. Lakes and rivers are managed through programs that protect and restore water quality, including action agendas, partnerships, commissions, local actions, plans, reports, and projects (NYSDEC 2021).

3.9.1 Water Quantity

New York State's Great Lakes lands and waters, including Lake Erie, Niagara River, Lake Ontario, and the St. Lawrence River, are a part of the Great Lakes ecosystem in the U.S. and Canada which holds 21% of the world's freshwater resources and contains 250 different species of fish (NYSDEC 2021). Almost one-third of the land area in NYS drains into Lake Ontario, the most downstream of the Great Lakes. The total watershed area of Lake Ontario is approximately 64,025 square km (24,720 square mi). The New York State portion of the Lake Ontario Basin comprises 35,230 square km (13,602 square mi), with the remaining 45% of the watershed in Canada (NYSDEC Accessed 2021, Stewart, Todd and LaPan 2017). Approximately 2.8 million people reside in the New York State portion of the Lake Ontario Basin (FLLOWPA 2000, NOAA 2021). In 2010, the Niagara River/Lake Erie Watershed had a total population of roughly 1,193,327 people (Erie County, NY 2019).

Water resources have the following usages for the 2.8 million residents in the Lake Ontario Basin and the nearly 1.2 million people in the Niagara River/Lake Erie Watershed (GLC 2016):

- Public Water Supply
- Commercial Water Use
- Domestic Water Use
- Industrial Water Use
- Thermoelectric Power
- Mining
- Livestock
- Irrigation
- Wastewater Treatment
- Transportation

The three jurisdictions that share the Lake Ontario watershed withdrew 10,377 million gallons per day of water in 2020, excluding hydroelectric use which accounted for an additional 139,394 gallons per day; the six jurisdictions that share the Lake Erie watershed withdrew 5,877 million gallons per day in 2020, with an additional 56,623 million gallons per day for hydroelectric use (Great Lakes Commission for the Great Lakes, St. Lawrence River Water Resources Regional Body and the Great Lakes, St. Lawrence River Basin Water Resources Council 2020a).

3.9.2 Water Quality

The 2019 State of the Great Lakes Technical Report documents an overview of the status and trends in various components of the Great Lakes ecosystem. In a joint collaboration between the U.S. and Canadian government focusing on Great Lakes water quality, more than 180 researchers on both sides of the border contributed to this report. While many of the Great Lakes indicators have shown improvements in the last several years, invasive species continue to be one of the most challenging issues facing the region (ECCC and U.S. EPA 2021).

With more than 185 aquatic invaders already identified in the Great Lakes basin and the ever-present threat of new species being introduced, the water quality indicator associated with invasive species has been assessed as "poor" and is on a deteriorating trend. Though the rate of introductions has slowed significantly, the impacts of established invaders persist, where many have negative effects on the ecosystem as well as on human communities. At least 30% of the aquatic non-native species found in the Great Lakes have significant negative environmental or socioeconomic impacts (Lower and Sturtevant 2021). For example, as a result of more frequent algal blooms, including nuisance and harmful algal species, due to the introduction of Zebra and Quagga Mussels and their propensity for altering plankton communities, natural turbidity is decreased (Sturtevant 2021). The impacts of these invasive species continue to accumulate as the species each spread from their point of introduction to new watersheds within the basin (Sturtevant 2021).

Contaminated sediment is also a concern in the Great Lakes region. Contaminants released into the lakes initially remain suspended, and those that are not taken up by a biotic source settle out into the sediments. Surface sediments in the Great Lakes are dominated by two Perfluoroalkyl Compounds, perfluoro-n-butanoic acid and perfluoro-n-hexanoic acid, and concentrations reported indicate that these chemicals may enter the food chain. When sediments are disturbed by a natural or anthropogenic source, contaminants are resuspended for uptake by organisms on the bottom and in the water column; contaminants like Perfluoroalkyl Compounds can bioaccumulate, leading to trophic transfer of contaminants, including fish that humans consume (ECCC and U.S. EPA 2021). NOAA, EPA, and other agencies have been working together since 2010 through the Great Lakes Restoration initiative to fund projects to clean up AOCs, prevent and control invasive species, reduce runoff, and restore habitat (NOAA 2022).

3.10 Shipping

In the Great Lakes, the territorial waters of NYS include an Eastern Lake Erie and all waters of Lake Ontario within the U.S. border. These NYS Great Lakes waters are home to a vibrant commercial shipping industry that carries about 40 million metric tons of cargo annually and generates billions of dollars of economic activity for both the U.S. and Canada (Volpe National Transportation System Center 2017). This shipping activity consists primarily of vessels transiting the St. Lawrence Seaway, which connects the waters of the Atlantic to the Great Lakes. The seaway consists of dredged channels in the St. Lawrence River, a series of locks and canals that connect the St. Lawrence River with Lake Ontario, and the Welland Canal, which connects Lake Ontario with Lake Erie.

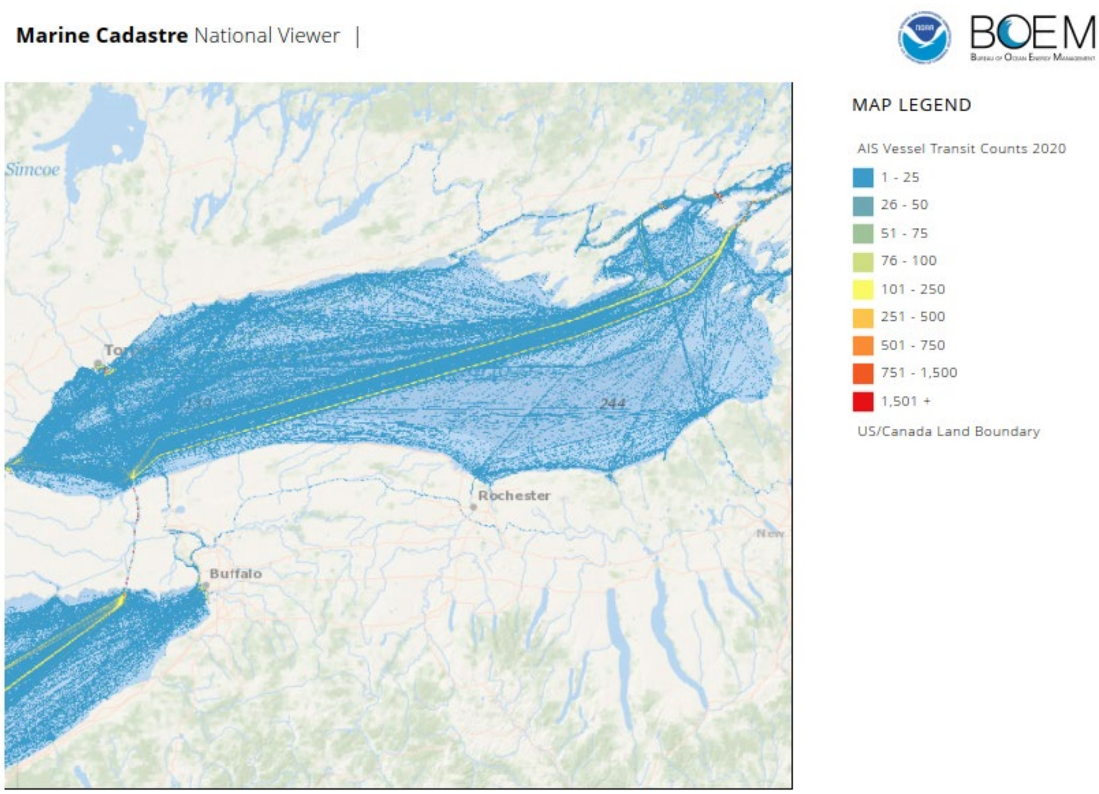
Figure 12 shows 2020 Automatic Identification System (AIS) vessel transit counts within New York State Great Lakes waters. The yellow transit tracks represent the most heavily transited routes with 101 to 205 trips annually (BOEM and NOAA 2021a). These heavily traveled lanes are the routes traveled by vessels transiting Lake Ontario and Lake Erie via the St. Lawrence Seaway. Vessels take the straightest line possible to transit the lakes, causing these transit lanes to cross the international border in several places (i.e., some of the traffic is in Canadian waters, some in U.S. waters). The portions of these lanes within New York State waters are in the southwest part of Lake Ontario (northwest part of NYS waters). The portion of these lanes within Lake Erie is entirely within Canadian waters, with the transit lanes starting at Port Colborne (in Canadian waters northwest of Buffalo) and moving southwest through the lake. Similar to auto traffic, ships traveling in opposite directions pass with the oncoming traffic to the left. Therefore, the southern lake transit lane is traveling to the east, and the northern lane is traveling to the west.

The locks and canals that connect the St. Lawrence River, Lake Ontario, and Lake Erie limit the size of vessels traveling within the lakes. Vessels up to 300 m (984.2 ft) in length can travel west of the Welland Canal on Lake Erie and the other upper Great Lakes but cannot transit east into Lake Ontario. Lock dimensions allow for a maximum vessel size of 226 m (741.4 ft) in length and 24 m (79 ft) in beam (width). In short, vessels within Lake Ontario waters can be up to 226 m (741.4 ft) in length and vessels within Lake Erie can be up to 300 m (984.2 ft) in length (Volpe National Transportation System Center 2017).

There are several ports along the shores of Lake Ontario including Rochester and Oswego on the U.S. side and Toronto and Hamilton on the Canadian side. Vessels typically travel in straight lines along primary routes across Lake Ontario when connecting to these ports. Secondary diagonal transit lanes see far less traffic than the two primary vessel lanes used for transiting the lake in an east/west direction. There is also recreational boating traffic within these waters, including sailing vessels, fishing vessels, and other pleasure craft. While these recreational vessels may also travel in relatively straight lines between ports, they tend to deviate from straight routes more so than commercial vessels because efficiency and cost saving is not their primary goal, and, in the case of sailing vessels, their routes are influenced by wind conditions (BOEM and NOAA 2021a).

Figure 12. 2020 Automated Identification System Vessel Transit Counts within the Study Area

Source: (BOEM and NOAA 2022)



3.11 Department of Defense Activities

Several military bases are found around Lake Ontario and Lake Erie but there is currently no permanent surface or waterway restricted zones within the study area. Training exercises using boats and aircrafts (sometimes in collaboration with Canadian military forces) occur regularly, but no specific area is dedicated to these exercises. The Air National Guard has four areas in Lake Ontario regulated as Special Use Airspace. R-5203 (Restricted-5203) in Oswego in NYS is designated as Special Use Airspace from the surface to Flight Level (FL) 500 and is designated as restricted by Notices to Airman 24 hours prior to the beginning of an exercise (Figure 13).

Similarly, Misty 1, Misty 2 and Misty 3 are also restricted airspaces (Military Operations Areas, a type of Special Use Airspace) used by the Air National Guard during weekdays from 0800–2200 and on weekends from 0800–1600. These airspaces can also be restricted outside of these hours with 24-hour Notice to Airman. In terms of altitude Misty 1–3 highest allowable altitude is up to but not including 4,586 m (18,000 ft), the lowest allowable altitude is 91.4 m (300 ft) above ground level for Misty 2; 1,219 m (4,000 ft) above mean sea level for Misty 1; and 3,353 m (11,000 ft) above mean sea level for Misty 3. R-5203 covers the airspace from the surface up to FL 500 (approximately 15,240 m [50,000 ft]). (These Special Use Airspaces are published in Federal Aviation Administration (FAA) Order JO 7400.10C. FAA reviews all Special Use Airspace designations annually and makes occasional updates to these designations, their geographic extents, altitudes, and times of designation. The information above is from the February 16, 2022, version of the FAA order.

Figure 13. Misty 1, 2, 3, and R-5203 Restricted Air Space within the Study Area

Source: (Secretary of Defense 2012)

The U.S. Coast Guard conducts vessel training operations within the waterways as well as helicopter search and rescue and other training activities. A Military Training Route (MTR) is used by the military for conducting high-speed, low-altitude flight training. There is an MTR, identified as IR801, in the northeast section of the study area in Lake Ontario. Only a segment of the flight would be conducted at altitudes above 457 m (1,500 ft) above ground level and lower altitude flights could occur on a regular basis for training purposes.

3.12 Recreation and Other Uses

Recreational areas and activities are abundant within the Great Lakes region, with numerous activities concentrated along the coasts and in the waters of Lakes Ontario and Erie. The natural beauty of the area combined with a variety of land uses and a hot summer climate make the Great Lakes region a popular local and international tourist destination (AWS Truewind 2010). The study area encompasses 980 km (610 mi) of coastline along Lakes Ontario and Erie.

In 2018, the counties of Western New York (including Cattaraugus, Chautauqua, Erie, and Niagara), Finger Lakes (Monroe, Orleans, and Wayne), and Central New York (Cayuga and Oswego) accounted for approximately 12% of NYS's total traveler spending (Tourism Economics 2018). Excluding major markets in New York City and Long Island, traveler spending in Upstate New York was 3% (of total spending) in Chautauqua, 14% in Niagara, 17% in the Finger Lakes region, and 13% in the Central region. Tourism is described as an integral part of every New York region's economy, generating from 6% to 19% of employment (Tourism Economics 2018). Similar numbers are reported for 2019 (Tourism Economics 2019). There are parks, trails, beaches, hiking areas, campgrounds, and RV Parks. Recreational boating and sport fishing are well supported by small boat harbors, marinas, piers and boating/yacht clubs, and there are charter and sport fishing companies to serve non-boat-owning visitors.

Golf courses and country clubs dot the coastline, along with event venues. There are amusement parks within the study area as well as a resort at Henderson Bay. The study area also hosts museums, scenic spots, landmarks, and historical sites, such as Fort Ontario, the Lakeview Marsh and Barrier Beach National Natural Landmark, and Sackets Harbor Battlefield. Agrotourism options are plentiful, including fruit stands, destination farms, vineyards, and cideries. Closer to the cities, towns, and hamlets, and concentrated in downtown areas, there is a wide variety of dining establishments, accommodations, casinos, and other entertainment options. The City of Buffalo's downtown core is situated on the shores of Lake Erie within the study area.

Table 18 details examples of potential recreation and activities in addition to those identified above. Local organizations may have an interest in Great Lakes Wind Energy based on land ownership, economics, cultural, environmental, or advocacy work, and/or logistics.

Table 18. State Parks, Nature Preserves and Sanctuaries, Wildlife Management Areas, Farms, Vineyards, and Non-government Organizations within the Study Area

Source: (New York State Parks 2021, Eco-USA 2021, Lake Erie Wine Country 2021)

State Parks	Nature Preserves and Sanctuaries	Wildlife Management Areas	Farms	Vineyards	NGO's
Lake Erie	Bournes Creek Falls	Braddock Bay	Kappus Farms, Inc	White Caps Winery (Farm and Vineyard)	Onandaga Audubon
Sunset Bay State Marine Park	Canadaway Creek Nature Sanctuary	Lake Shore Marshes	Baehrs Farm	Walter Vineyards	Friends of Mexico Point Park
Cattaraugus Creek Harbor	Tifft Nature Preserve (City of Buffalo)	Deer Creek Marsh	Breslawski Farms Inc	Vinewood Acres	Save Ontario Shores Inc.
Evangola	Times Beach Nature Preserve	Lakeview	Bear Creek Bend Farm	Baideme Farm	Citizens Campaign for the Environment
Woodlawn Beach	Manitou Beach Preserve	Black Pond	DeMarree	Willow Creek Winery	Great Lakes Coalition
Buffalo Harbor	Whistlewood Park Nature Preserve	Point Peninsula	Smith Brothers Farms Inc.	Black Widow Winery	National Wildlife Federation
Fort Niagara	Sterling Nature Center	-	Willow Tree Farm	Schulze Vineyards and Winery	Friends of Times Beach Nature Preserve
Four Mile Creek	Lakeview Marsh and Barrier Beach National Natural Landmark	-	Chestnut Creek Farm	The Winery at Marjim Manor	Graycliff Conservancy
Wilson Tuscarora	Eldorado Beach	-	Peaceful Acres Farm	BlackBird Cider Works	Genesee Land Trust

Table 18 continued

State Parks	Nature Preserves and Sanctuaries	Wildlife Management Areas	Farms	Vineyards	NGO's
Golden Hill	Ray Bay Beach	-	Minckler Farms	Boom Point Winery	The Nature Conservancy
State Parks	Nature Preserves and Sanctuaries	Wildlife Management Areas	Farms	Vineyards	NGO's
Lakeside Beach	Henderson Shores	-	Agbotic Inc (Greenhouses)	Thorpe Vineyard	Friends of Fort Ontario
Hamlin Beach	Braddock Bay Bird Observatory	-	BS Recreational Farm	Colloca Estate Winery	-
Irondequoit Bay Marine Park	Richard A Noyes Bird Sanctuary	-	Erdle Farm	-	-
Beechwood	Derby Hill Bird Observatory	-	Voigt Family Farm	-	-
Chimney Bluffs	-	-	Kludt Brothers Inc.	-	-
Fair Haven Beach	-	-	-	-	-
Fort Ontario Park	-	-	-	-	-
Selkirk Shores	-	-	-	-	-
Sandy Island Beach	-	-	-	-	-
Southwick Beach	-	-	-	-	-
Robert Wehle	-	-	-	-	-
Westcott Beach	-	-	-	-	-
Sackets Harbor	-	-	-	-	-
Long Point	-	-	-	-	-

3.13 Indigenous Nations

With respect to Indigenous Nations, the Cattaraugus Reservation is within the Great Lakes region and borders Lake Erie. This Indian reservation is home to the federally recognized Seneca Nation of Indians (Seneca Nation of Indians 2021).

3.13.1 The Haudenosuanee Confederacy

The Haudenosuanee ("people of Longhouse") Confederacy is comprised of nations (also known as the Six Nations) in northern New York State and southern Canada. In the late 1990s, the Haudenosuanee Confederacy formed the Haudenosuanee Environmental Task Force (HETF) (Wallenfeldt Accessed 2021, Haudenosaunee, Birch and Hart 2018). The purpose of the HETF is to discuss environmental degradation and restoration. The HETF has discussed its concerns about Great Lakes Wind Energy with NYSERDA and has emphasized the major role Lake Ontario plays in their founding history and stories. Almost every tributary along the shore has culturally significant areas and archeological sites of significance for indigenous fishing villages. Potential environmental impacts from Great Lakes Wind Energy are a concern to the HETF, especially any impacts that could adversely affect fishing resources, water quality, lead to potential algal blooms, and/or negatively change the overall health of the Lakes.

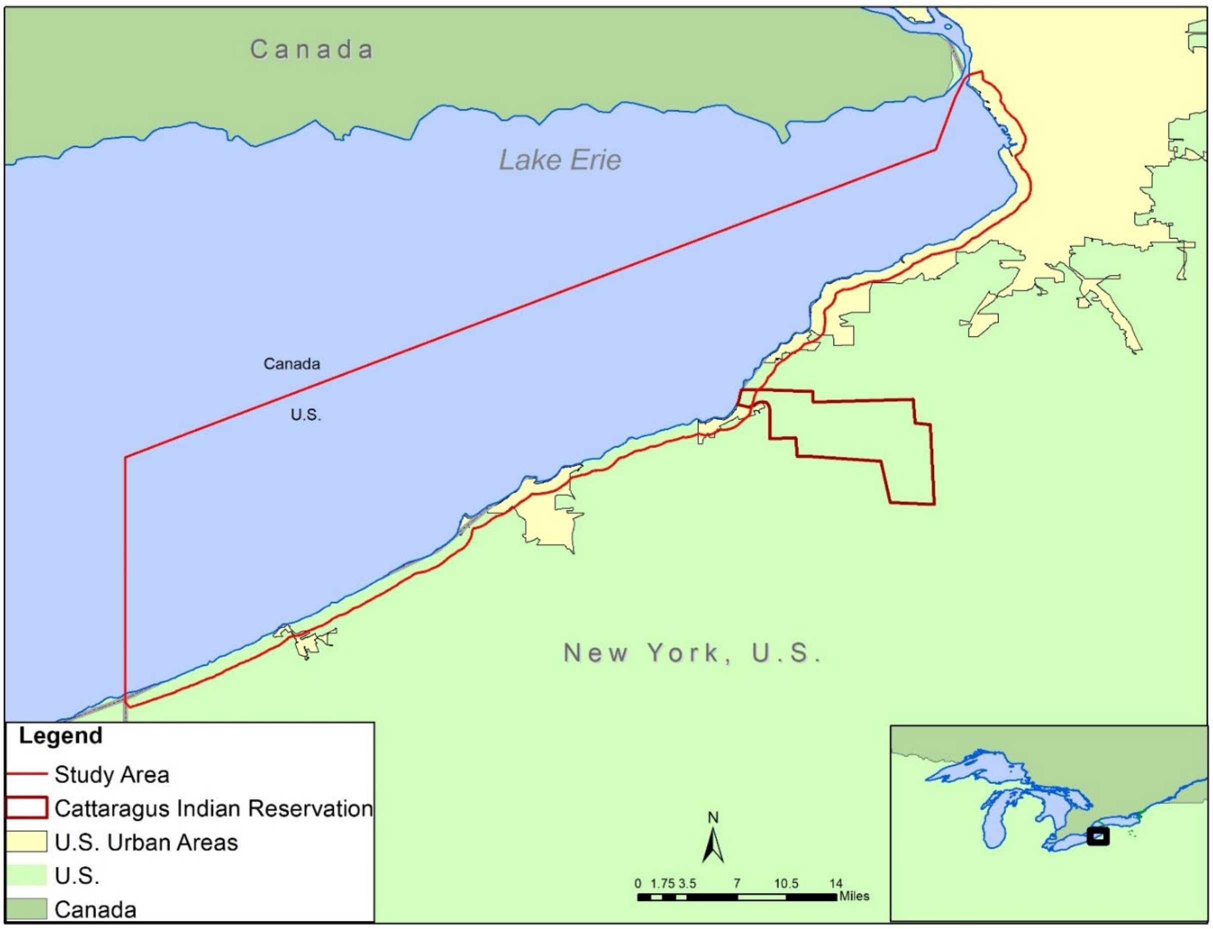
3.13.1.1 The Seneca Nation

The Seneca Nation has over 8,000 members, including 175 fluent speakers of the Seneca language. Unlike other nations whose territories are held in trust by the U.S. government, the Seneca own their territories, including the Cattaraugus Reservation and the nearby Allegany and Oil Springs Reservations (Szczepaniec 2018). The Seneca people—also known as "Keepers of the Western Door" or Onödowa'ga:' ("People of the Great Hill")—historically occupied territories south of Lake Ontario, throughout the Finger Lakes region in what is now known as Central New York and the Genesee Valley in Western New York State (Seneca Nation of Indians 2021). They relied heavily on agriculture for food and engaged in subsistence hunting and fishing (Seneca Nation of Indians 2021, National Museum of the American Indian 2009). Following the seasonal rounds, they fished in the spring, and, in autumn, small hunting parties left the villages for the annual hunt, returning in mid-winter. Seneca women were responsible for the cultivation of corn (maize) and other vegetables (Perrotto 2015). The Seneca people are perhaps best known for their important role in early democracy as one of the founding nations of the Iroquois Confederacy (Seneca Nation of Indians 2021).

3.13.1.2 Cattaraugus Reservation

The Cattaraugus Reservation is located on the eastern shore of Lake Erie, occupying areas in Cattaraugus County, Chautauqua County, and Erie County. The reservation stretches from Lake Erie inward along Cattaraugus Creek, along either side of NYS Route 438, and is shown in Figure 14 (Native Heritage Project 2012).

Figure 14. The Cattaraugus Indian Reservation on Lake Erie



The Cattaraugus Reservation is 8774 hectares (21,680 acres) in size and home to approximately 3,000 people, primarily members of the Seneca Nation of Indians. (Iroquois Indian Museum Accessed 2021). Historically, the Seneca were the largest nation of the Iroquois (Haudenosaunee) Confederacy, also called the Six Nations (Seneca Nation of Indians 2021).

The Canandaigua Treaty of 1794 affirmed Haudenosaunee land rights and restored to the Six Nations lands in western NYS that had been ceded by previous agreements. (Friends of Ganondagan Accessed 2021). The Treaty of Big Tree, signed three years later, sold all but a small portion of the property to the Holland Land Company (Iroquois Indian Museum Accessed 2021). The four largest pieces of unsold land became Allegany, Tonawanda, Buffalo Creek, and Cattaraugus Reservations. Cattaraugus Reservation is mostly rural, with single-family homes along Route 438 interspersed with businesses. There are artist studios, a bingo hall, library, daycare center, health center, and senior housing. Cattaraugus Creek provides a place to swim, fish, and picnic. Parts of Cattaragus Reservation are within 2 km (1.3 mi) of the shore of Lake Erie (Iroquois Indian Museum Accessed 2021) and thus within the study area.

3.14 Historic/Cultural Areas

The Great Lakes region in NYS encompasses a variety of historic and cultural areas. The historic and cultural areas of NYS described below are protected under the National Historic Preservation Act (NHPA) and the New York State Historic Preservation Act (NYSHPA). Some are owned and administered by the National Park Service, a branch of the Department of the Interior under the U.S. National Historic Landmarks Program, and others are managed by local organizations. The NYSHPA created the National Register of Historic Places, an official list of properties significant in the architecture, history, culture, and archeology of the U.S. Some are major heritage attractions with a full range of visitor services. Visits to New York State's state parks, historic sites, campgrounds, and trails increased by 33%, with 77.1 million visits statewide from 2011–2019 (New York State 2020).

There are 24 State Parks within the study area, including recreational day use areas, campgrounds, State beaches, and marine parks (Table 18). This includes Fort Ontario State Historic Site, a large military heritage attraction in Oswego County located on the shore of Lake Ontario (NYSDEC Accessed 2021). The proposed National Marine Sanctuary, discussed in section 3.7, contains at least 21 known shipwrecks and one military aircraft encompassing over 200 years of American history, with an additional 47 potential shipwrecks contained within the area (Office of National Marine Sanctuaries 2021). Wrecks may possibly fall under section 233 of the state Museum Education Law under which objects of historic interest owned by the state are under the custody of the State Museum.

Cultural sites exist on the shores of both lakes. Along Lake Ontario there are two historic lighthouses and the Sackets Harbor Battlefield State Historic Park. Along the eastern shore of Lake Erie there are the Erie Maritime Museum and the Historic Erie Lighthouse. All of these sites are designated and protected under the NHPA and NYSHPA.

4 Relative Risk Analysis

This section describes the relative risk analysis that was prepared on behalf of NYSERDA to support the Great Lakes Wind Energy Feasibility Study. This study captures the main risks associated with Great Lakes Wind Energy development and assesses these risks at a high level with the best available science in NYS waters of Lakes Ontario and Erie. A risk may be greater in one area than another, so a relative risk assessment was developed that captures spatial differential risk in cases in which there were sufficient differential data to allow for such comparisons.

This analysis provides relative risk related to potential biological, environmental, cultural, and social conflicts associated with Great Lakes Wind Energy in the New York State waters of Lakes Ontario and Erie and up to 2 km (1.3 mi) inland. Subject matter experts identified stressors (i.e., activities, structures, vessels, etc. that could cause impacts) associated with wind development and considered receptor groups (i.e., groups that could be impacted by stressors such as different taxa, habitats, and user groups) based upon their vulnerability and likelihood of interaction with Great Lakes Wind Energy stressors and available data to assess receptor locations, distribution, and seasonality within the study area. Available data layers and information from peer-reviewed scientific and agency studies were used to assess potential occurrence and distribution of receptor groups throughout the study area. Relative risk maps were assembled in a Geographic Information System (GIS) to support interpretation of data and identification of locations of lesser and greater risk for Great Lakes Wind Energy development.

4.1 Methodology

The study applied a phased approach, which included an assessment of data availability, quality, and gaps; engagement with data holders and agencies; qualitative assessment of risk for receptor groups with few data; and a final report that provides a relative risk analysis for wildlife and human conflicts with Great Lakes Wind Energy in the study area. Although there are a variety of data that inform species distribution in the Great Lakes, there are limited data at the level of detail and resolution needed to show differential risk of species and/or user groups across the study area with respect to wind development stressors.

Minimum distances from shore for wind turbine locations were assumed to be 16 km (10 mi) for Lake Ontario and 8 km (5 mi) for Lake Erie and are termed the “turbine zone.” The 16 km (10 mi) minimum distance from shore in Lake Ontario was chosen as a means to assess potential turbine stressors in Lake Ontario, where substantial lake area for possible development exists at that distance. In the narrow, east end of Lake Erie, the same 16 km (10 mi) minimum distance would eliminate most of the lake area in NYS waters. Therefore, a closer minimum distance for turbine placement was necessary for feasible construction in NYS. These distances (16 km [10 mi] and 8 km [5 mi], respectively) were used as references to illustrate possible impacts but do not represent any decision by NYS regarding placement of wind turbines should Great Lakes Wind Energy development move forward in the future. The area within 2 km (1.3 mi) inland from shore and up to 16 km (10 mi) and 8 km (5 mi) from shore into Lake Ontario and Lake Erie, respectively is termed the “cabling zone.” This area is where cables may come to shore or onshore infrastructure, such as port development or substation construction, would be most likely to occur. Because cable and transmission infrastructure are not likely to extend into rivers and tributaries, details about rivers and tributaries are not included in this study. Fixed-bottom and floating turbine stressors were identified and used in this analysis because of the potential to use either turbine approach in Great Lakes.

Figure 15. Study Area with 16 km (10 mi) Line in Lake Ontario and 8 km (5 mi) Line in Lake Erie Indicating the Offshore Turbine Zones and Inshore Cabling Zones for Each Lake

4.2 Assumptions and Limitations

Many of the receptor groups identified in this analysis do not have sufficient data available to see variation in distribution or use across the study area or understand variation in vulnerability and thus identify areas of lesser or greater risk of impacts from Great Lakes Wind Energy, but qualitative assessment of risk is considered where data are lacking. Layers in the relative risk maps in section 4.6 indicate where vulnerable receptor groups could be within the study area. Some spatial data were limited in indicating where receptor groups were distributed within the 3-dimensional space of the study area, for example, bird flight height. Each of the relative risk maps provides information about potential points of interconnection (POIs) in the study area that could be where Great Lakes Wind Energy power cables come to shore and connect to the grid.

4.3 Stressors

This section details the potential stressors involved in Great Lakes Wind Energy development in the study area. Pre-construction activities, construction, operations and maintenance, and decommissioning of both fixed-bottom and floating turbines and associated stressors were considered to assess relative risk of impacts to receptor groups. Stressors can differ between fixed and floating structures; for example, pile-driving fixed structures can result in more noise than installation of moorings for floating structures.

A literature synthesis of both offshore wind in the marine space and other applicable projects was conducted to identify Great Lakes Wind Energy stressors that are anticipated to potentially impact receptors within the study area. Both scientific studies and agency reports were reviewed to predict how specific species and/or multiple species groups could respond to Great Lakes Wind Energy stressors. Great Lakes Wind Energy stressors were grouped into three categories: pre-construction, construction, and post-construction stressors. These development phases have been used by other studies to address risk using similar categories (European Commission 2016, MMO, Marine Management Organization 2013, Ecology and Environment Engineering, New York State Offshore Wind Master Environmental Sensitivity Analysis 2017). Great Lakes Wind Energy stressors and impacts considered in this relative risk analysis are detailed in Table 19. The study area includes the shoreline, and terrestrial species and habitats are considered generally in the context of cabling zone stressors, such as port development and cable connections to POIs. In addition to the relevant literature, stakeholder feedback and information received at various webinars hosted by NYSERDA were considered.

Table 19. Great Lakes Wind Energy Potential Stressors and Impacts

Pre-Construction	
Potential Stressors (Short-Term)	Potential Impacts
Sound/particle motion	Behavioral disturbance, interference with human uses.
Bottom Disturbance	Behavioral disturbance, turbidity, contaminant release, injury/mortality of some benthic organisms.
Increased Vessel Traffic	Behavioral disturbance, emissions, navigational/fisheries hazard, interference with human uses.
Short-Term Structures	Short-term habitat changes, attraction, displacement, connectivity for invasive species, navigational/fisheries hazard.
Construction	
Potential Stressors (Short-Term)	Potential Impacts
Sound/Particle Motion	Behavioral disturbance, injury/mortality, interference with human uses.
Increased Vessel Traffic	Behavioral disturbance, emissions, navigational/fisheries hazard, interference with human uses.
Bottom Disturbance	Behavioral disturbance, turbidity, contaminant release, injury/mortality of some benthic organisms.
Habitat Alteration	Behavioral disturbance, displacement, injury/mortality for benthic organisms.
Post-Construction (Long-Term)	
Sound/Particle Motion	Behavioral disturbance, displacement
Scour	Behavioral disturbance, displacement
Electromagnetic Fields, Vibration, Heat	Behavioral disturbance, displacement, barrier.
Long-Term Structures	Lighting attraction, other attraction, displacement, collision, barrier, navigational/fisheries hazard, connectivity for invasive or native species, reef effects, habitat creation/modification/fragmentation, radar interference, aircraft hazard.
Increased Vessel Traffic	Behavioral disturbance, emissions, interference with other human uses, navigational/fisheries hazard.

4.3.1 Pre-Construction Stressors

Pre-construction is the time before construction begins in an area. Surveys are conducted to understand and locate development sites. Geophysical surveys use sound producing equipment, and geotechnical surveys involve taking cores and samples of bottom substrate. These surveys can include geochemical sampling to assess contaminants. To collect metocean and wind data, buoys, meteorological towers, gliders, and other types of equipment are deployed on potential wind development sites, causing temporary bottom disturbance and structures in the water. In addition, dedicated wildlife surveys may be undertaken to increase understanding of presence, seasonality, and variation in habitat use by wildlife. Wildlife surveys can include platforms for acoustic monitors, radars, and other equipment. Vessels are used to deploy, maintain, and remove equipment. Safety buffers for vessels may be needed around equipment and structures. Sound and bottom disturbance are generally considered the main stressors of concern during pre-construction activities.

4.3.1.1 Sound/Particle Motion

High-resolution geophysical (HRG) surveys are used to assess geohazards, habitats, and geology of potential wind energy areas to provide information about sensitive habitats, archaeological/culture resources, and engineering needs and constraints. Side-scan sonar and multi-beam sonar are the main technologies used to assess bottom features and depth. These two technologies use sound waves to determine bottom depth and bottom features in an image.

In general, sonar surveys generate frequency ranges undetectable to fishes and invertebrates (Popper and Halvorsen 2007, Halvorsen, et al. 2012), which suggest these technologies have limited impacts. Considering the narrow hearing range overlap of fish and invertebrates and the sound generated from HRG surveys, minimal behavioral impacts for individuals are likely (BOEM OREP 2013, BOEM OREP 2016, NYSERDA 2015). Bottom-disturbing geotechnical surveys, such as vibracoring (discussed in section 4.3.1.2 below), introduce underwater sound. Dynamic positioning thrusters may be used to keep the vessel in place during coring or other bottom sampling, generating some sound. These sound energy levels are typically lower than HRG surveys described above and have little likelihood of disturbing organisms beyond areas very near to the vessel. In offshore wind and marine infrastructure projects, generally, potential disturbance to fishing from HRG and geotechnical surveys are addressed through seasonal restrictions and/or Notices to Mariners.

Sound is also generated during installation of meteorological towers or moored structures, such as buoys, for data collection during pre-construction periods. Vessels associated with deploying, maintaining, and removing equipment and conducting surveys of wildlife generate sound, but these sound levels are unlikely to rise to meaningful levels above ambient sounds. Minor, temporary displacement of organisms could occur as a result of vessels or equipment deployment.

4.3.1.2 Bottom-Disturbance

Bottom-disturbing geotechnical surveys are required to determine sediment type, bathymetric contours, and overall suitability. Vibracoring and sediment profile imaging are the two main technologies to characterize sediments; other less common methods include box coring, rotary core boring, and piston coring (NYSERDA 2017). These sediment characterizing surveys can increase local turbidity and temporarily displace benthic organisms through sediment coring. Local benthic organisms could be impacted by resuspended sediment contaminants (Hiscock, Tyler-Walters and Jones 2002, New Jersey Department of Environmental Protection 2010).

The impacts from this stressor are similar to the impacts from construction bottom-disturbance but on a smaller scale and are temporary and local. These surveys are conducted in specific areas within the wind project area and over a limited period of time. Benthic communities have been found to recover to similar biodiversity and density levels as nearby areas void of bottom-disturbing surveys (Daan, Mulder and Bergman 2009, Hiscock, Tyler-Walters and Jones 2002). Deployment of meteorological towers or moored buoys or other data collection equipment may cause temporary, localized, bottom disturbance.

4.3.1.3 Increased Vessel Traffic

Any activity that requires vessels, such as surveys or buoy deployment, increases vessel traffic. Local Notices to Mariners and other outreach would likely be used to coordinate with existing vessel traffic. The number of vessels needed for this type of pre-construction activity relative to existing vessel traffic in the study area would be minimal. Vessels also generate emissions and have the potential to experience fuel spills or result in other pollution.

4.3.1.4 Structures

The presence of meteorological towers, buoys, or equipment to collect environmental and wildlife data, such as stations for bird/bat radar or acoustic detection, are likely to be used prior to construction of a windfarm. Structures of this nature have small footprints so are unlikely to create significant barriers, hazards, or substrate for wildlife or fisheries or constitute substantive interruptions to viewsheds.

4.3.2 Construction Stressors

The construction phase of a windfarm involves the period of wind development when installation of wind turbines, cables, and additional supporting activities occur. Construction stressors include sound/particle motion, increased vessel traffic, bottom disturbance, and habitat alteration, which can result in behavior changes, injury, collision, attraction, and/or displacement of organisms' or human activities. Potential impacts associated with pile-driving are a priority concern for some fish species that may be affected by the sound produced by pile driving. Various analyses and workshops have focused on pile-driving as a stressor (BOEM 2017, Ecology and Environment Engineering 2017, MMO, Marine Management Organization 2013).

4.3.2.1 Sound/Particle Motion

There are a variety of fish and invertebrates that can detect sound, mainly in low frequencies (A. N. Popper, A. D. Hawkins and R. R. Fay, et al. 2014). In addition to detecting sound (vibration), some species can detect particle motion. Particle motion is the oscillating motion of particles that move due to a vibrating source (Nedelec, et al. 2016). Much of the sound and particle motion produced from construction activities would be localized and temporary (limited to the construction period). Construction could result in temporary displacement of mobile aquatic and terrestrial species as they move away from the localized construction disturbance (European Commission 2016). Sound and particle motion could propagate in the aquatic environment; this could overlap with the hearing range of some fish species which could cause them to avoid the area during construction (Hildebrand 2009, Scholik and Yan 2001), which can also interrupt fisheries.

Pile-driving produces sound and particle motion in the water column and substrate that propagates outward from the pile (Popper and Hawkins 2018). Pile-driving is a common practice when installing fixed-turbine monopiles or jackets; however, pile-driving may be used in both fixed-bottom and floating turbine technology installation. Sound and particle motion created from pile-driving during construction could overlap with the hearing ranges of fish, potentially resulting in behavioral and physical impacts, ear injuries, stress, and possibly mortality (BOEM 2017). Above normal sound-intensity can cause Temporary Threshold Shifts (TTS) and Permanent Threshold Shifts (PTS), recoverable and non-recoverable reduction in hearing sensitivity, respectively (NYSERDA 2017). One study that measured pile-driving sound pressure on the bottom and at different water depths determined sound pressure measured at the bottom was roughly twice that measured at the next deepest water depth (Dahl and Dall'Osto 2017). Pile-driving has been identified as an activity of primary concern, especially for fish, due to the high-intensity sound generated and distances reached (European Commission 2016, MMO, Marine Management Organization 2013, BOEM 2017).

In addition to pile driving, dredging, vessels, trenching, drilling, installing moorings, building substations, and other activities could generate sound and particle motion that disturbs aquatic and terrestrial species (Ecology and Environment Engineering 2017, MMO, Marine Management Organization 2013).

4.3.2.2 Increased Vessel Traffic

Increased vessel traffic would occur during construction as vessels are needed for turbine, substation, and cable installation. Increased vessel traffic due to construction activities could impact commercial and recreational fishing effort temporarily within the construction area. Vessel traffic could also pose a risk to sturgeon, which are known to be susceptible to vessel strike injury and mortality (e.g., Brown and Murphy 2011). Vessels also generate emissions and have the potential to experience fuel spills or result in other pollution.

4.3.2.3 Bottom Disturbance

Bottom disturbance occurs during the installation of cables, turbines, and substations. Cables are typically placed in a trench and substrate is backfilled over and above them. Horizontal directional drilling may be used for cable landfall and installation. Potential impacts of this activity would need to be assessed for individual projects. In the case the substrate is too hard for burial, cables may be laid directly on the substrate and held in place with rocks or rock mattresses. For cable laying, bentonite is used in drilling fluids to cool drilling tools and could release into the environment and/or disturb the lakebed sediments during installation (LEEDCo 2014).

Turbine installation and/or mooring also disturbs substrate. Pile-driving or dropping fixed foundations will disturb sediment and locally increase turbidity. For floating wind, there are a variety of mooring options, such as tension leg platforms, which go straight down to the bottom, or catenary moorings, which arc outward from the platform, which may be installed in different ways, affecting the levels and relative locations of bottom disturbance.

Bottom disturbance from installation can vary and depends on the cable/turbine size, burial depth, local substrate, and the installation technology. Both cable and turbine installation cause temporary turbidity as the bottom substrate is disturbed, resulting in suspended sediments which can impact benthic habitats and species (Hiscock, Tyler-Walters and Jones 2002, New Jersey Department of Environmental Protection 2010). Suspended sediments, if thick enough, can smother organisms resulting in mortality (BOEM 2021a). Bottom disturbance can disturb species that inhabit the benthic environment such as sessile invertebrates and juvenile fish. Impacts would be temporary and local, and benthic communities are expected to recover depending on habitat type and local biodiversity (Hiscock, Tyler-Walters and Jones 2002). Additional sheathing is used when cables are installed in hard substrate areas which could affect benthic community structure (Hiscock, Tyler-Walters and Jones 2002, Heery, et al. 2017).

Bottom disturbance could potentially release chemical contaminants into the lake environment. The Environmental Protection Agency assesses AOCs with sampling in the Great Lakes and implements sediment remediation. Assessments tend to be in rivers and estuaries where runoff is greatest (EPA 2020). Further identification of areas with chemical contamination and higher resolution of contamination distribution mapping would be helpful to assess impacts of proposed projects should Great Lakes Wind Energy move forward.

4.3.2.4 Habitat Alteration

Temporary habitat alteration can occur when installing fixed-bottom or floating turbine foundations on the bottom and when dredging and laying cable among turbines and from turbines to shore. Sessile species present on the bottom would be unable to avoid habitat alteration impacts and could experience similar impacts as those detailed in section 4.3.2.3 above. The area of the bottom that would be impacted is relatively small compared to the overall project area of a windfarm.

Construction-related habitat alteration, along with other stressors may result in temporary displacement of species. Fish may be displaced during construction, though fish use large areas of Lakes Ontario and Erie and a potential windfarm area and day-to-day construction activity zone is relatively small in comparison. Birds could be attracted to construction areas in order to use structures as perches or roosts (English, et al. 2017, Palmquist and Gard 2017). Birds may use unfinished turbines to expand their foraging range or as outposts (Dierschke, Furness and Garthe 2016a). Migrating seabirds are attracted to flares and lights associated with offshore wind construction (Ronconi, Allard and Taylor 2014). In shoreline environments, construction includes crossing cables onto shore to POIs and potentially developing ports or other infrastructure. Construction activities may disrupt spawning, nesting, or other essential activities of fish birds, bats, and other nearshore and terrestrial species.

4.3.3 Post-Construction Stressors

Post-construction is the operational phase of a windfarm after cable, substation, and turbine installation are completed. Post-construction stressors include sound/particle motion (operational); scour (i.e., the build-up and erosion of sediment around structures); electro-magnetic fields (EMF), vibration and heat, long-term structures, and increased vessel traffic. Although decommissioning is not described in detail below, post-construction includes the decommissioning phase, which has similar stressors to the construction phase.

4.3.3.1 Sound/Particle Motion

Operating wind turbines produce underwater sound, particle motion, and seismic surface waves from the rotating blades, the electricity generator, and the gear box, which move downward and transmit into the bottom substrate and water column from the bottom support structure (Hawkins, et al. 2021). Wind turbine effects on bottom substrate are well documented, but very few measurements have focused on substrate particle motion and seismic surface waves from operating wind turbines (Hawkins, et al. 2021). Operating wind turbine sound underwater maintains low frequencies (< 1 kiloHertz) (Madsen, et al. 2006). Measurements indicate that particle motion close to foundations is similar to levels at which behavioral reactions by fish have been observed in studies; however, particle motion decreased, and in some cases was below sensory thresholds at a distance of 10 m (32.8 ft) in one study (Sigray and Andersson 2011). These findings suggest that most particle motion impacts may be limited and are relatively close to a wind turbine (Hawkins, et al. 2021). Sound and particle motion levels and distance traveled may differ with foundation technology types (Tougaard, Hermannsen and Madsen 2020). Studies have determined that operational sound generated from fixed-bottom turbines does not have destructive impacts on fish hearing, even when fish were relatively close to turbines (Wahlberg and Westerberg 2005).

4.3.3.2 Scour

Scour can occur when an installed turbine foundation disrupts the flow of water, causing erosion around turbine bases, resulting in a sea floor hole formed at the base of a turbine (MMO, Marine Management Organization 2013, Prendergast, Gavin and Doherty 2015). The change in water flow can result in local sediment deposition and erosion on different sides of a turbine foundation (Hiscock, Tyler-Walters and Jones 2002). Water flow around and through a windfarm could be altered if multiple turbine foundations were placed close to each other (Hiscock, Tyler-Walters and Jones 2002, New Jersey Department of Environmental Protection 2010, Heery, et al. 2017). Wave energy could also be changed around and within a windfarm which could result in local reductions in wave height and energy, altering sediment dynamics (Hiscock, Tyler-Walters and Jones 2002, MMO, Marine Management Organization 2013, New Jersey Department of Environmental Protection 2010). Water flow and disturbance could impact sediments differently, as smaller grain sizes more easily resuspend and move, which could impact the local benthic community (Heery, et al. 2017). Foundation design could affect the scale of scour and water flow impacts. Scour protection is a common mitigation.

4.3.3.3 Electromagnetic Fields, Vibration, Heat

Windfarms generate electricity, which is transported from turbines to shore to connect into the grid through transmission cables. Electricity moving through transmission cables generates EMF, which may impact fish species' ability to orient, migrate, avoid predators, and forage (Normandeau 2011a); (New Jersey Department of Environmental Protection 2010). EMF differ depending on transmission choices and cable composition, sheathing, and burial depths. High-voltage alternating current varies rapidly in direction, while high-voltage direct current is static, resulting in different EMF. In addition to fish, crustaceans may also be electro-sensitive (Gill, et al. 2009) (Normandeau 2011a).

Studies on the potential EMF from buried cables to affect fish mitigations have not indicated that buried cables create a barrier to migration for electrosensitive fishes (Kavet, et al. 2016). BOEM has conducted multiple studies to determine potential adverse impacts of EMF to fish and fisheries. Operational wind energy projects in offshore marine environments are expected to have negligible impacts on fishes, bottom-dwelling species, or pelagic species (BOEM 2019). There have been less studies focusing on EMF in freshwater environments. These studies show that submarine cable generated magnetic fields decrease exponentially with distance and are similar to background fields (Bevelhimer, et al. 2013, Cada and Bevelhimer 2011, Cada, Bevelhimer and Fortner, et al. 2012).

Certain life stages, such as embryos and juveniles could be sensitive to EMF. Delays in hatching were observed in fish embryos that were exposed to EMF in a controlled lab (Krylov, et al. 2014). A study focusing on Lake Sturgeon, an electrosensitive species that inhabits both deep and shallow environments in Lakes Erie and Ontario, found that no behavioral response to EMF was observed 10–20 centimeters (4–8 inches) from an EMF source in a lab setting (Bevelhimer, et al. 2013). Burial and sheathing are used for mitigating EMF from cables.

Vibration and heat can both be emitted from subsea cables. There is limited research available on mechanical vibrations effects of on fish, though vibratory effects would be expected to be extremely localized (Andersson 2011, Nedwell, Langworthy and Howell 2003). High-voltage cables produce heat which is heavily dependent on substrate type, cable type, burial depth, and ambient temperatures (Emeana, et al. 2016, Meissner, et al. 2006). Meissner et al. (2006) studied a benthic invertebrate's preference to buried cable heat and concluded that bottom-dwelling fish and benthic species may avoid areas of higher heat emissions.

4.3.3.4 Long-Term Structures

Long-term structures in the water and air could overlap with important habitat for feeding and migrating birds, bats, and fish and potentially interfere with human uses (i.e., fishing, cultural practices, boating, and other recreational uses) where turbines are present. Habitat alteration occurs when a habitat, for example soft substrate, is changed to hard substrate with the installation of a fixed-bottom turbine. Habitat alteration can change the structure and community of a local area as different species may thrive in the new habitat, compared to other species that relied on the previous habitat. Benthic species could lose habitat where turbines and substations are placed on substrate, though the amount of area would be relatively small compared to the overall size of available habitat. Long-term structures also include cables, which will require continued monitoring and maintenance throughout the post-construction phase, potentially resulting in periodic bottom disturbance. Studies of offshore wind in Europe indicated long-term structures impacted local hydrodynamics, oceanic parameters, and vertical stratification, which could impact fishes. These studies also concluded that hydrodynamic impacts from offshore wind on fishes was comparable to natural variability (van Berkel, et al. 2020).

New hard substrate in an area with very little hard substrate could provide new habitat for benthic fish and invertebrates, particularly encrusting organisms, potentially benefiting species richness (European Commission 2016, MMO, Marine Management Organization 2013, Palmquist and Gard 2017), but also potentially providing substrate for invasive Zebra Mussels, though recent benthic surveys of Lake Erie and Lake Ontario showed no presence of Zebra Mussels (Burlakova, Karatayev and Pennuto, et al. 2014, Burlakova, Karatayev and Hrycik, et al. 2021). Long-term structures on the bottom will have less substrate for colonization with floating turbine moorings than fixed-bottom turbines.

Changes in biodiversity can be linked to changes in ecosystem function (Causon and Gill 2018). New habitat could increase biodiversity as local fish are attracted to the new accumulation of prey species; this phenomenon is known as the "reef effect" (Dauterive 2000, Degraer, et al. 2020) (van Hal, Griffioen and van Keeken 2017). The reef effect could establish secondary habitat. An example of this is mussel beds colonizing new hard substrate leading to increased complexity as mobile species use the new habitat for shelter and feeding opportunities (Wilhelmsson and Malm 2008, Krone, et al. 2012, Chapman, People and Blockley 2005, People 2006, Witman 1985). Artificial substrate in the water column and on the seafloor have been shown to increase fish density compared to nearby soft bottom substrates with no added structures in the marine environment (Reubens, et al. 2013). Reef effects can benefit fisheries by providing fertile fishing areas near turbines. Depending on vessel size and potential gear in use, fisheries vessels are able to operate within windfarms. The increase in biodiversity can also attract foraging birds close to turbines, increasing their chance of collision and/or mortality (Palmquist and Gard 2017).

The potential overlap of long-term structures and areas used by birds and bats for feeding, mating, and migration can put birds and bats at an increased risk of collision with turbine towers, blades, and rotors. Terrestrial windfarms have demonstrated that some types of lighting can attract bats (generally as a result of bat prey attraction) and birds if birds and bats are present in areas with turbines (Drewitt and Langston 2008, Gaultier, et al. 2020). Post-construction collision/attraction/displacement can impact species that are drawn to and/or try to avoid turbines. Collision is a priority concern for birds and bats, potentially resulting in lethal injuries. Studies of offshore wind show the majority of birds are able to successfully avoid turbine collision by dodging rotor blades or circumventing windfarms (Cook, et al. 2014) (Desholm and Kahlert 2005). Collision risk is dependent on the rotor swept zone, flight path, flight altitude, season, time of day, and weather conditions (European Commission 2016). Large-bodied, soaring birds that are less maneuverable and fly at heights near rotor swept zones tend to be more at risk for collision in offshore windfarms (Drewitt and Langston 2008, Fox and Petersen 2019). Bird and bat species that avoid a windfarm area could in turn avoid a preferred forage area, which could result in habitat loss (Cook, et al. 2014, European Commission 2016, Drewitt and Langston 2006). Displacement to avoid a windfarm could result in longer flight paths, resulting in a reduction in energy reserves which could impact overall fitness (Cook, et al. 2014, European Commission 2016, Drewitt and Langston 2006, Desholm and Kahlert 2005).

It is unclear what bird and bat flight altitudes are over the lakes, though some clade and species fight heights were inferred from Atlantic coast flight height studies by Kerlinger (2020). Clade flight altitudes over the Atlantic coast could be similar to altitudes used for cross-lake flights, but it is difficult to extrapolate these findings without further investigation into lake prevailing air currents and clade preferred weather patterns. Birds and bats flying at night may be at an increased risk of collision, although one study conducted in waters off of Denmark indicated that waterbirds fly further from turbines at night and avoid harm (Desholm and Kahlert 2005). Bird and bat migratory patterns at night can be difficult to determine, as many methods involve direct human observations that cannot take place in the dark. Several studies on birds and bats migrating in the Great Lakes area use acoustic or radar observations. Results from these studies indicate that large numbers of birds, and possibly bats, continue to fly over some parts of the lakes near islands and peninsulas or along the shorelines at night, so these species may be at risk of collision with wind turbines depending on turbine placement (Diehl, Larkins and Black 2003, Sanders and Mennill 2014, Heist, et al. 2018). Heist et al. (2018) was unable to distinguish birds and bats, so it is difficult to determine if only birds or some birds and bats were detected in their radar study. A study of Silver-Haired Bats at Long Point, Ontario in Lake Erie indicated that about half of the 30 bats tracked in the study departed the site moving across Lake Erie, while the other half departed along the shore, suggesting some bat migratory activity may occur offshore (McGuire, et al. 2012)

Long-term structures can also pose safety risks to marine traffic and fishing vessels and require assessment and mitigation for navigational hazards and potential radar and air traffic interference. Long-term structures can have viewshed and visual impacts.

4.3.3.5 Increased Vessel Traffic

Increased vessel traffic would occur for operations and maintenance of windfarms, as vessels are needed for turbine, substation, and cable monitoring and maintenance, and likely, long-term environmental monitoring will also require use of vessels. Increased vessel traffic due to post-construction activities could impact commercial and recreational fishing effort periodically within the maintenance area. Increased vessel traffic could increase the probability of bottom disturbance from anchoring. Vessels also generate emissions and have the potential to experience fuel spills or result in other pollution.

4.4 Receptor Groups

This section describes the identification of receptor groups that are anticipated to interact with and/or be vulnerable to Great Lakes Wind Energy. Receptor groups were defined based on their likelihood of vulnerability and exposure to stressors and the potential severity of impacts associated with stressors (see Table 19 for potential stressors and impacts). Vulnerability and exposure are potentially affected by population status (e.g., endangered, declining), distribution and use spatially and temporally within the study area, importance of the receptor to the ecosystem function of the area, likelihood of interaction with Great Lakes Wind Energy, and type of impact (e.g., collision may be more severe than temporary behavioral disturbance). Certain receptors groups have seasonal distributions and vulnerability (e.g., migratory birds), whereas other receptor groups are present year-round (e.g., shipping). Stressors can impact a particular receptor group in the turbine and/or cabling zone. As previously noted, for purposes of this study, the turbine zone is defined as the area within the study area ≥16 km (10 mi) from shore for Lake Ontario and ≥8 km (5 mi) from shore for Lake Erie (Figure S-1). Justification for the distances chosen is detailed in section 4.1. The cabling zone is defined as the area within the study area 2 km (1.3 mi) inland from shore and up to 16 km and 8 km from shore into Lake Ontario and Lake Erie, respectively. Receptor groups with sufficient data to indicate differential presence in the study area were included in the relative risk maps in Figure 20 through Figure 24. Table 20 shows the data layer names that indicate presence of specific receptor groups selected for the relative risk maps in section 4.6. Each receptor group is discussed below. Many layers, especially in the cabling zone, overlap and indicate presence of multiple receptor groups. Table 21 shows information about the data layers used, their sources, and further details.

Table 20. Data Layers Used to Indicate Presence of Receptor Groups

Data Layer Name	Receptor Group
Important Bird Areas Highly Important Bird Areas Critically Important Bird Areas NY Environmental Conservation Areas Coastal Wetlands	Shorebirds Waterbirds Landbirds Gulls and Terns Bats Wetlands
USFWS Critical Habitat (Piping Plover)	Shorebirds Dunes
Spring Walleye (2.4-3.7 m [7.8-12 ft]) Summer Walley (18.3-24.4 m [60-80 ft]) Spring, Summer, Fall Walleye (6.1-15.2 m [20-50 ft])	Walleye Fishing Areas
Commercial Shipping Lanes	Commercial Shipping Lanes
AOCs CEAs Protected Areas Significant Coastal Fish & Wildlife Habitats	Landbirds Waterbirds Shorebirds Bats Wetlands
Known and Potential Wrecks	Wrecks
U.S. Indian Reservations	Cattaraugus Reservation

Table 21. Information about Data Layers Used to Indicate Presence of Receptor Groups

Data Layer Name	Collection and Identification
Important Bird Areas	Data for the NYS Great Lakes Region is compiled from ebird citizen science and local Audubon Society chapter counts that are ongoing and updated frequently; at some IBAs (e.g., Niagara River Corridor) there are monitoring programs in place that provide additional bird count data. IBAs were mapped by the Great Lakes Commission.
Highly Important Bird Areas	Location data collected in 2015 and updated in 2020 by USFWS and Bureau of Land Management (BLM) and mapped by ABC. These areas were identified due to their important breeding and wintering habitats for birds. These identified areas fit at least one of the following criteria: • Key migration corridors where bird risk will differ from season to season and may also differ from year to year among specific locations within the corridor. • Widespread eagle species where the species may not be present year-round.

Table21 continued

Data Layer Name	Collection and Identification
Critically Important Bird Areas	Location data collected in 2015 and updated in 2020 by USFWS and BLM and mapped by ABC. These areas were identified due to their important breeding and wintering habitats for birds. These identified areas fit at least one of the following criteria: • Congregations of 500,000 or more migratory birds at one time during the year • Are likely to be vulnerable to wind-related habitat impacts critical habitat designated for species listed under Federal ESA; • Important habitat for Federal ESA species and/or included “bottleneck areas” migrant birds.
Data Layer Name	Collection and Identification
NY Environmental Conservation Areas	NY Environmental Conservation areas represent lands protected, designated, or functioning as conservation lands by NYS and are available in the New York Protected Areas Database (NYPAD) and obtained from the GLAHF.
Significant Coastal Fish and Wildlife Habitats	The data set for Significant Coastal Fish & Wildlife Habitats as identified by NYS Department of State and the Office of Planning and Development from 2021. Downloaded from the New York State of Opportunity Geographic Information
Coastal Wetlands	Identified and mapped by the Great Lakes Commission and the Great Lakes Coastal Wetland Consortium (GLCWC) in the mid-2000s and combined into a data layer by the GLAHF (Minc 2004).
USFWS Critical Habitat (Piping Plover)	The 27 km (16.7 mi) stretch of shore along northeast Lake Ontario designated Critical Habitat for the Piping Plover is available from the USFWS.
Walleye Depth Contours	A literature synthesis revealed specific depth contours of 6.1-12.2 m (20-40 ft) and 18.3-24.4 m (60-80 ft) in the summer, 6.1-12.2 m (20-40 ft) in the fall, and 2.4-3.7 m (7.8-12 ft), 6.1-9.1 m (20-30 ft), and 6.1-15.2 m (20-50 ft) in the spring were indicators of Walleye target fishing areas (Clark-Kolaks 2008, NYSDEC Accessed 2021). Bathymetry of Lake Erie was obtained from NOAA and the GLAHF and used with the above Walley depth contour preferences to indicate where Walleye fishing most likely occurs in Lake Erie (NOAA, National Geophysical Data Center 1999).
Commercial Shipping Lanes/Vessels	NOAA navigational charts, and AIS 2019 vessel transit data from Marine Cadastre were used to represent the most heavily traveled shipping routes within Lake Ontario and Lake Erie.
AOCs	AOC locations were designated and identified by the EPA and updated in 2021.
CEAs	New York CEAs are designated by the State of New York. GIS Data files were obtained from the NYSDEC.
Protected Areas	Protected Areas were collected from the United States Geological Survey (USGS) Protected Areas Database of the U.S. (PAD-US) and include all public open space and private protected areas.
Known and Potential Wrecks	Data from automated wrecks and obstructions information systems and survey navigational charts were used to identify the locations of known and potential shipwrecks. Data were downloaded from NOAA and Marine Cadastre.
U.S. Indian Reservations	Data from the Department of Homeland Security and downloaded from the GLAHF.

4.4.1 Birds

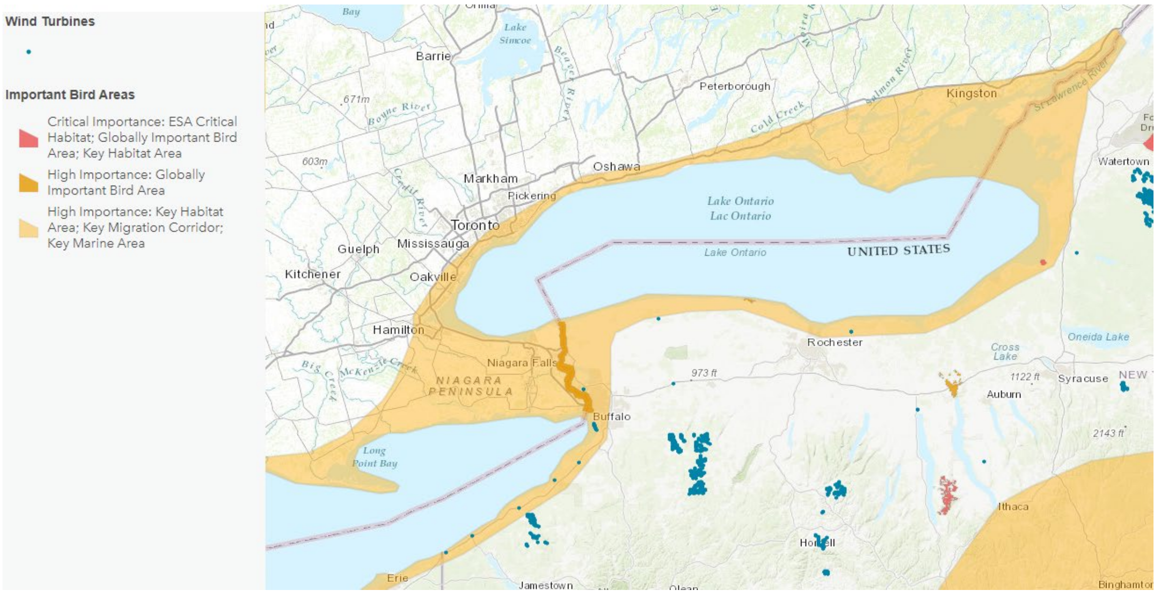
4.4.1.1 Relative Risk Mapping

The Great Lakes region represents both important habitat for nesting, migrating, and overwintering birds and a major barrier to migrants seeking to move further north (Diehl, Larkins and Black 2003). For the purposes of this study, landbirds, shorebirds, gulls and terns, raptors, and waterbirds are defined in section 3.2. Resident landbirds, shorebirds, and waterbirds use areas along the shoreline as stopover, feeding, and nesting habitat (Buler and Dawson 2014, Diehl, Larkins and Black, Radar observations of bird migration over the Great Lakes 2003, Bonter, Gauthreaux and Donovan 2009). Resident waterbirds and gulls and terns use the areas of open water for foraging and do not leave the area in winter (Chapman and Parker 1985, Dierschke, Furness and Garthe 2016). Migrating landbirds, shorebirds and waterbirds may fly through major migration corridors along peninsulas and islands to minimize the amount of time they spend traveling over open water. (Buler and Dawson 2014).

A major island chain exists along the northeastern edge of Lake Ontario, where increased migrant bird activity occurs (ABC 2020, Lott, Seymour and Russell 2011, Cornell Lab of Ornithology 2021). The choice of crossing the lakes directly versus going around may differ by species, population, and individual and may be dependent on time of year, weather conditions at the time, or body condition (Richardson 1978, Sorte, et al. 2014, Duijns, et al. 2017). While the extent of these major migratory routes is still poorly understood, some of the main paths were identified via the ABC wind risk assessment map, the Nature Conservancy's Great Lakes stopover map, and radar data from migratory studies in the Great Lakes regions (Diehl, Larkins and Black 2003, UMGLJV 2020, ABC 2020). These migratory routes, seen in Figure 16 below, span the entire edge of Lakes Ontario and Erie.

Figure 16. Migratory Routes, Including Critically and Highly Important Bird Areas, within the Study Area

Source: (ABC 2020)



Major migratory routes exist across the edges of Lakes Ontario and Erie and extend more than 16 km (10 mi) from shore in some areas (e.g., Long Point Ontario in Lake Erie and the islands between Henderson, NY and Prince Edward, Ontario in eastern Lake Ontario). Due to the potential for attraction and collision, Critically and Highly IBAs have been designated and published as maps by ABC, USFWS, and the BLM (Table 20). These areas were used to indicate higher risk to birds in the relative risk maps in Figure 21, Figure 22, Figure 23 and Figure 24. There are no spatial data regarding migrating birds much beyond shoreline areas, so relative risk across open water is uncertain, but studies of birds over Lake Erie (Diehl, Larkins and Black 2003, Norris and Lott 2011, Gosse, et al. 2018, Tetra Tech 2012, WGLBBO 2018) are discussed as part of the analysis below.

During migration, species may seek out habitat along the shores of the Great Lakes, either as stopover or staging habitat as they prepare to cross the lake, or as nesting, breeding, or foraging habitat (UMGLJV 2020). Important stopover and staging habitat has been identified as part of conservation efforts and includes IBAs, major conservation areas, and State and local parks, which have been designated by a variety of conservation organizations (Moore and Couturier 2011, ABC Birds 2019, Audubon 2021). These areas provide important natural habitat, serve as migratory stopovers or bottlenecks, or support species of concern or a large proportion of species' populations (Moore and Couturier 2011). During the winter, these same areas may sustain populations of overwintering waterbirds, which use the area for foraging and roosting (Prince, Padding and Knapton 1992). Other important areas for birds include wetlands, where protected areas of open water, varied habitats, and an abundance of insects and other food resources provide optimal habitat for many species and lead to higher concentrations of individuals (Crewe and Timmermans 2005).

Similarly, the nearshore environment provides foraging sites for waterbirds, gulls and terns, and shorebirds, where the shallow waters, currents, and upwellings serve to concentrate food resources. These areas are also important in the wintertime, as overwintering waterbirds use areas of nearby open water for foraging. Coastal wetland boundaries were obtained from the GLAHF and were used in the relative risk maps to indicate potentially important areas that shorebirds, waterbirds, and landbirds use (Crewe and Timmermans 2005). Although most birds forage in the nearshore area, some waterbirds, such as Long-tailed Ducks, tend to forage far from shore in areas of open water during the winter (Mallory, et al. 2006), and gulls follow fishing boats offshore on occasion (Chapman and Parker 1985). However, few data are available on offshore foraging activities.

Other important areas for birds relative to Great Lakes Wind Energy potential impacts include known locations of nesting colonies for colonial waterbirds and shorebirds. These areas are reused by birds each year, resulting in high concentrations of specific species. These nesting colonies are especially vulnerable to disturbance, as there may not be suitable alternative habitat in the area, and they contain a large number of juveniles and fledglings (U.S. Fish and Wildlife Service Midwest Region 2020). As a result, these areas would be at risk from cabling zone construction stressors, such as terrestrial substation construction or cable landings to shore.

Landbirds, shorebirds, and raptors are more restricted to the nearshore environment as they do not have the capacity to land on open water. As a result, most of their activities are expected to be limited to 1.6–4.8 km (1–3 mi) from shore (Bonter, Gauthreaux and Donovan 2009, Buler and Dawson 2014, Heist, et al. 2018, Norris and Lott 2011). Landbirds and raptors also do not require access to areas of open water for overwintering in contrast to waterbirds (Mallory, et al. 2006). Raptors rarely fly more than 16 km (10 mi) from shore and would therefore not be likely to interact with Great Lakes Wind Energy turbine structures in the area defined in this study as the Lake Ontario turbine zone (Gordon and Erickson 2016). Waterbirds, shorebirds, and gulls and terns also maintain colonial nesting sites, unlike landbirds, and they typically travel larger distances to forage (Chen 1996, Johnson, Schmidt and Taylor 2014, Norris and Lott 2011, Stapanian and Bur, Overlap in offshore habitat use by double-crested cormorants and boaters in western Lake Erie. 2002, Stapanian and Waite 2003). Despite these differences, there is a large overlap in the areas which are important to landbirds, shorebirds, raptors, gulls and terns, and waterbirds. This is because many of the habitat needs are the same and the important migratory corridors and stopover sites are frequently important areas for both groups. These migratory corridors and stopover sites are shown in section 4.6. Coastal wetlands provide important food sources and nesting habitat for a wide variety of species (Crewe and Timmermans 2005, Grindal, Morissette and Brigham 1999, Bonter, Gauthreaux and Donovan 2009). To indicate presence of waterbirds, landbirds, shorebirds, gulls and terns, and raptors in the relative risk maps, the following data layers were used (Table 20):

- IBAs
- Highly IBAs
- Critically IBAs
- NY Environmental Conservation Areas
- Coastal Wetlands

While the areas described above are known to be important to birds for migration, stopover, breeding, foraging, nesting, and overwintering, they are not exhaustive. For example, very little is known about the specific routes that migrants may take across the Great Lakes and how these crossings may be impacted by weather conditions (Diehl, Larkins and Black 2003). Many migratory birds avoid crossing the lakes at night and prefer to fly over land, but those that do cross the lakes at night tend to fly with increased migratory heights at dawn (known as “dawn ascent”) (Diehl, Larkin and Black 2003). One study conducted in the Great Lakes region revealed a median dawn migration height of over 250 m (920 ft) higher than the median height measured during peak migration times (approximately 475 m [1,558.4 ft) (Archibald, et al. 2016). “Dawn ascent” could move migrating birds almost 600 m (1,968.5 ft) in altitude (Gosse, et al. 2018, Diehl, Larkins and Black 2003), potentially above turbine heights.

Flight altitudes can predict if a bird’s lake migration path overlaps with the Rotor Swept Zone (RSZ) of a Great Lakes Wind Energy turbine. The RSZ for Great Lakes Wind Energy would likely be between 30–194 m (98–636 ft) above water level. Bird flights over open water are very different than over land. Kerlinger (2020) analyzed how birds fly over open water using radar and inferred information from long-distance flight studies in the western Atlantic and coastal Canadian waters. The analysis showed waterbirds, specifically Red-Throated Loons and Common Loons, typically fly at high altitudes (900 m [2,952 ft]) over land and descend significantly to 3–30 m (10–98 ft) over water (Kerlinger 2020). Cormorants migrate parallel to the Atlantic Coast at less than 100 m (328ft) over water in flocks of 50–100. Kerlinger (2020) found that large gulls generally fly between 30–100 m (98-328 ft) over water. Studies of Common and Roseate Terns off the Atlantic coast indicate high flight altitude migration over land and low flight altitude (15–250 m [50–820 ft] over water) (Loring, et al. 2019). Alerstam (1985) found that some terns fly at high altitudes (nearly 1.7 km [1 mi]) directly after takeoff during fall ocean migrations in Europe. Black Terns have been documented flying high, long-distances, and at night (Kerlinger 2020).

These studies of flight heights over water indicate clades of birds may have a wide range of flight altitudes over the lakes. Red-Throated and Common Loons could fly under the RSZ. Cormorants, large gulls, and some terns could overlap with the RSZ. While Black Terns could fly far above the RSZ in the turbine zone. Kerlinger (2020) extrapolated many of these findings from past studies off the Atlantic coast, so it is difficult to state for certain which clades or species may fly in the RSZ without data detailing flight heights over the lakes. Loons, terns, gulls, and ducks are expected to treat ocean waters similar to open lake waters. The height of the prevailing air currents could differ between the Atlantic coast and Lakes Ontario and Erie, influencing flight altitudes of long-distance migrants over the lakes.

While there is some information available on the use of the offshore habitat by certain species (e.g., waterfowl—dabbling ducks, primarily mallards (*Anas platyrhynchos*) and American black ducks (*A. rubripes*), and mergansers (*Mergus spp*.) (Prince, Padding and Knapton 1992), detailed surveys like those conducted to inform the Icebreaker project in central Lake Erie (Diehl, Larkins and Black 2003, Norris and Lott 2011, Tetra Tech 2012, WEST 2017, Gosse, et al. 2018, WGLBBO 2018) have not been conducted within the current study area and are not directly transferable; however, useful information can be gleaned from these studies, such as seasonal changes in migration activity by birds and bats and lake avoidance (Diehl, Larkins and Black 2003, Tetra Tech 2012), as well as the possibility of bathymetry and sediment type influencing bird density or absence (WEST 2017).

Gosse et al. (2018) observed migratory activity over the Ohio waters of Lake Erie from late August until early November and found a shift in patterns that included less regular but more intense migration events. Studies included in Icebreaker's assessment found higher densities of landbirds and waterbirds in western Ohio waters than eastern and suggest this finding could be due to the unique shallow depths and diverse sediment bottom types (Norris and Lott 2011). Waterbirds along the western shores of Lake Michigan are counted each spring and fall by the Western Great Lakes Bird and Bat Observatory. In 2017, over 175,000 migrants were counted in the spring and over 200,000 in the fall (WGLBBO 2018). One study showed avian radar median flight height was 8–9.6 m (26–31.5 ft) in spring and 116–257 m (380.5–842 ft) in fall for the Ohio Icebreaker project site (Tetra Tech 2012). This study was not species-specific. However, because the Icebreaker study area does not overlap the current study area it cannot be determined whether these same patterns would hold over Lake Ontario and Eastern Lake Erie. There are not enough data available to inform risk mapping associated with flight patterns above the study area beyond the coastal patterns.

4.4.1.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 22shows the potential stressors and impacts for the bird receptor groups.

Table 22. Bird Receptor Groups, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Landbirds	Cabling Zone Construction: sound, habitat alteration. Cabling Zone Post-Construction: long-term structures.	Behavioral disturbance, displacement Lighting attraction, other attraction, displacement, collision.
Waterbirds	Cabling/Turbine Zone Pre-Construction: sound, short-term structures. Cabling/Turbine Zone Construction: sound/particle motion, habitat alteration. Cabling Zone Post-Construction: long-term structures. Turbine Zone Post-Construction:	Behavioral disturbance, short-term habitat changes, attraction, displacement. Behavioral disturbance Behavioral disturbance, collision, attraction, displacement/barrier. Reef effects, habitat creation/modification/fragmentation.
Shorebirds	Cabling Zone Construction: sound, habitat alteration. Cabling Zone Post-Construction: long-term structures.	Behavioral disturbance, displacement Lighting attraction, other attraction, displacement, collision.
Raptors	Cabling Zone Construction: sound, habitat alteration. Cabling Zone Post-Construction: long-term structures.	Behavioral disturbance, displacement Lighting attraction, other attraction, displacement, collision.

Table 22 continued

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Gulls and terns	Cabling/Turbine Zone Pre-Construction: sound, short-term structures. Cabling/Turbine Zone Construction: sound/particle motion, habitat alteration. Cabling Zone Post-Construction: long-term structures. Turbine Zone Post-Construction:	Behavioral disturbance, short-term habitat changes, attraction, displacement. Behavioral disturbance Behavioral disturbance, collision, attraction, displacement/barrier. Reef effects, habitat creation/modification/fragmentation.

Waterbirds, gulls, and terns that feed in the turbine zone could interact with Great Lakes Wind Energy turbine structures. The migratory species among the receptor groups could be vulnerable to turbine zone stressors, such as collision or displacement, during spring and fall migration seasons in the event they travel over open water (Diehl, Larkins and Black 2003, Horton, et al. 2016, Rathbun, et al. 2016). Landbirds, shorebirds, gulls and terns, waterbirds, and raptors could interact with Great Lakes Wind Energy in the cabling zone.

Habitat loss from terrestrial wind turbine developments has potentially decreased bird numbers in some areas, as land-based structures may have reduced nesting areas; the amount of nesting habitat impacted is not considered to be likely to lead to population level impacts (Zimmerling, et al. 2013). Wind turbine lighting has the potential to attract some species which could lead to collisions, although different lighting systems may lead to different levels of collisions. For example, FAA communication towers in Michigan changing to flashing lights only (as opposed to flashing and fixed lights) had lower collision rates and reduced fatalities by approximately 50–71% (Gehring, Kerlinger and Manville II 2009).

Wind turbines may create new habitat or serve as an attractant to fish in a manner analogous to that of an artificial reef, as described in section 4.3.3.4 (Langhamer 2012). This increased diversity/density of fish or other food resources may in turn serve as an attractant to waterbirds and gulls and terns, which may result in collision risk (Dierschke, Furness and Garthe 2016). Studies in Europe indicate that monitoring barrier and displacement impacts has been difficult, with challenges associated with identification of root causes of impacts and determination if population level impacts are likely. European offshore windfarms surveyed experienced low levels of long lived, large-bodied bird collisions but were inadequate for addressing impacts to small-bodied birds (Fox and Petersen 2019).

4.4.2 Bats

4.4.2.1 Relative Risk Mapping

Bats are subject to many of the same natural stressors as landbirds and raptors. For example, they face potential migratory barriers in the Great Lakes and are possibly restricted to limited migratory bottlenecks, which they may use to avoid crossing large areas of open water (Diehl, Larkin and Black 2003, Thorne 2015), though it is possible that some bats do fly over open water of the Great Lakes.

Landbirds and bats have many of the same habitat requirements and forage in many of the same areas (Veverka 2011). For example, riparian areas and coastal wetlands represent important habitat to both birds and insectivorous bats (Grindal, Morissette and Brigham 1999). As such, it is thought that bats are concentrated in the same areas as many landbirds: bird migratory corridors, major bird migratory stopover areas, large natural habitat areas, and coastal wetlands (Dzal, et al. 2009). These areas are identified in relative risk maps in section 4.6. Coastal wetlands have been identified as important foraging and roosting sites for resident bats (ABC 2020, Thorne 2015, Grindal, Morissette and Brigham 1999). To indicate presence of bats in the relative risk maps, the following data layers were used (Table 20):

- IBAs
- Highly IBAs
- Critically IBA
- NY Environmental Conservation Areas
- Coastal Wetlands
- AOCs
- CEAs
- Protected Areas

4.4.2.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 23 shows the potential stressors that could impact bats.

Table 23. Bat Receptor Group, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Bats	Cabling Zone Construction: sound, habitat alteration.	Displacement, behavioral disturbance
	Cabling Zone Post-Construction: long-term structure.	Collision, lighting attraction, other attraction, displacement, barrier.
	Cabling Zone Post-Construction: long-term structures.	Behavioral disturbance, collision, attraction, displacement/barrier.

Bats are relatively unlikely to be in turbine areas offshore in most cases. Potential impacts to bats are similar to potential impacts to birds.

4.4.3 Invertebrates

4.4.3.1 Relative Risk Mapping

Lakes Ontario and Erie invertebrate communities, once a diverse collection of benthic species, have been dominated by two invasive species of mussels for over 30 years: Zebra and Quagga Mussels (Burlakova, Karatayev and Pennuto, et al. 2014). There is a lack of publicly available high-resolution data on invertebrate distribution in the study area, but benthic invertebrate distribution can be inferred based on habitat characteristics. Benthic invertebrates can colonize shallow <30 m (98.4 ft), intermediate 30–90 m (98.4–295 ft), and deep 90–130 m (295–426.5 ft) depths (Figure 6) (Burlakova, Karatayev and Hrycik, et al. 2021). Shallow (<30 m depth) species' sediment preference and competition with Quagga Mussels will determine the exact distribution and biomass of invertebrates within the study area. Benthic invertebrate densities have been shown to be greatest in soft-bottom habitats for most species (Burlakova, Karatayev and Hrycik, et al. 2021). Figure 7 includes all reports of Zebra and Quagga Mussels from 1989 to 2020. Quagga Mussels have displaced Zebra Mussels in the study area. Distributional data for Federal ESA and NYS ESA mollusks is limited due to much of the data either being one single historical sighting (>15 years old) (NYSDEC 2021), or restricted to scientific reports or studies without publicly available data to enable mapping (Burlakova, Karatayev and Hrycik, et al. 2021).

4.4.3.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 24 shows the potential stressors that could impact benthic invertebrates.

Table 24. Invertebrate Receptor Group, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Benthic Invertebrates	Cabling/Turbine Zone Pre-Construction: bottom disturbance.	Turbidity, contaminant release, injury/mortality of some benthic organisms.
	Cabling/Turbine Zone Construction: bottom disturbance, habitat alteration.	Turbidity, contaminant release, injury/mortality of some benthic organisms, displacement.
	Cabling/Turbine Zone Post-Construction: scour, long-term structures.	Displacement, connectivity for invasive or native species, creation/modification/fragmentation.

Habitat alteration during construction will potentially impact sessile benthic invertebrates as there will be some permanent loss of habitat and injury/mortality of individuals. Habitat alteration could result in the introduction of hard substrate that may enable colonization by the invasive Zebra Mussels, which currently have limited deep water (90–130 m depth [295–426.5 ft]) distribution due to the dominance of Quagga Mussels (Burlakova, Karatayev and Hrycik, et al. 2021). Zebra Mussel introduction in deeper benthic habitats would likely have a limited negative impact, specifically associated with being a nuisance for the maintenance of structures and the Zebra Mussels' ability to filter large volumes of water, which negatively impacts plankton availability for other species, as described in section 3.4., could create new habitat and reef-effects. Scour may also impact benthic invertebrates. Scour, or the loss of sediment from around long-term structures, would negatively impact infaunal species' habitat availability. However, further assessment of neighboring habitat similarity would be needed in order to determine the relative impact of this stressor on this receptor group within the study area.

With respect to EMF, studies of invertebrates suggest no significant differences in survival or reproductive health between specimens exposed to EMF and those that were not (Bocher and Zettler 2004). During the construction phase, bottom disturbance occurring during cable and turbine installation has the potential to affect dominant sessile filter feeding mollusks (non-moving species that feed by filtering water) (LEEDCo. 2018). As sessile filter feeders, the ability of mollusks to filter food would be negatively impacted due to an increase in sediment suspended in the water column during cable installation. This impact would be temporary as turbidity and sediment suspension would return to pre-disturbance levels after the completion of the construction phase. A study by Kraus and Carter (2018) suggests that the physical presence of underwater cables and the temporary disturbance caused by the burial process do not have clear impacts on benthic invertebrates.

4.4.4 Fish

4.4.4.1 Relative Risk Mapping

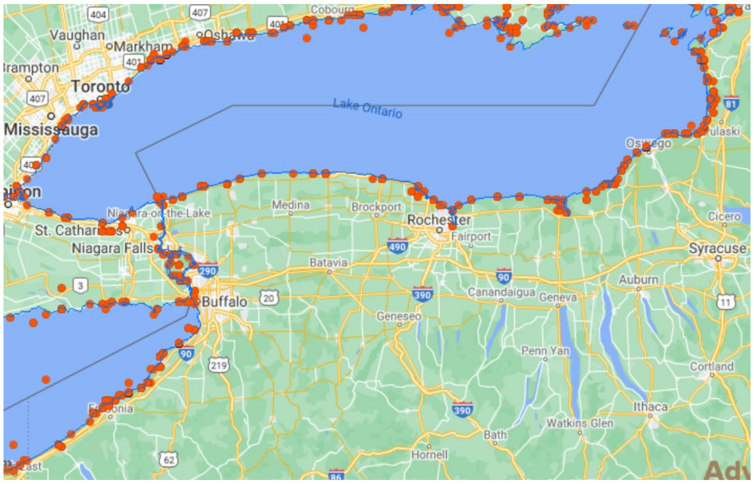
Lakes Ontario and Erie have a diverse range of fish species that move and interact within the aquatic habitat in multiple ways. Many of the same fish species are distributed in the nearshore, offshore pelagic, and offshore pelagic deep benthic habitats across the study area and there are not data to differentiate their distribution well within the lakes.

To consider relative risk in potential development areas across the lakes, subgroups of fish were identified as receptor groups with greater vulnerability to stressors than other groups. Because most fish spawn in nearshore habitats, and data were available to identify spawning areas, spawning and nursery habitat has been included as a fish receptor group for the sensitivity study. The fish receptor groups that would be expected to be most vulnerable to Great Lakes Wind Energy stressors are fish with swim bladders (impacts from pile-driving and other sound), spawning and nursery habitat (stressors from cables to shore and pre-construction surveys), and pelagic deep benthic fish (stressors from pre-construction and construction and long-term structures presence). Fish with swim bladders are located throughout the study area and are not known to have differential distribution across the study area.

Almost all fish species migrate to nearshore embayments, rivers, or tributaries for spawning and many use these areas as nursery habitats (Francis, et al. 2020, Markham and Knight 2017, O'Gorman 2017, Stewart, Todd and LaPan 2017). Spawning locations for multiple fish species were obtained from the Great Lakes Aquatic Framework (Great Lakes Aquatic Habitat Framework Accessed 2021). Spawning occurs in almost every nearshore shallow area, as indicated in Figure 17. These areas are along the entire shore edges of Lakes Ontario and Erie and would potentially experience construction and post-construction stressors involved in bringing power to shore from Great Lakes Wind Energy. Due to the large habitat area available for spawning and nursery areas, areas where cables come to shore should not affect more than a small percentage of this habitat. Siting Great Lakes Wind Energy away from large tributaries and river mouths would aid in decreasing potential impacts to spawning and nursery areas.

Figure 17. Spawning Locations within the Study Area

Source: (USFWS 1982)



Stressors could potentially pose a threat to the fish community that uses the benthic environment for habitat and/or food. The spatial data to understand distribution of deep benthic fish species are limited. Due to the limited knowledge of benthic fish community differential distribution this fish receptor group cannot be addressed in the context of relative risk across the study area.

4.4.4.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 25 shows the potential stressors that could impact fish.

Table 25. Fish Receptor Groups, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Fish with Swim Bladders*	Cabling/Turbine Zone Pre-Construction: sound/particle motion.	Behavioral disturbance
	Cabling/Turbine Zone Construction: sound/particle motion with and without pile-driving, habitat alteration.	Behavioral disturbance, displacement, injury/mortality .
Spawning and Nursery Habitat	Cabling Zone Pre-construction: sound/particle motion, bottom disturbance.	Behavioral disturbance, turbidity, contaminant release.
	Cabling Zone Construction: habitat alteration, bottom disturbance, sound/particle motion.	Behavioral disturbance, injury/mortality, turbidity, contaminant release, displacement.
	Cabling Zone Post-Construction: EMF.	Behavioral disturbance, displacement, barrier.
Pelagic Deep Benthic Fish	Cabling/Turbine Zone Pre-Construction: sound/particle motion, bottom disturbance.	Behavioral disturbance, turbidity, contaminant release.
	Cabling/Turbine Zone Construction: habitat alteration, bottom disturbance, sound/particle motion with and without pile-driving.	Behavioral disturbance, injury/mortality, turbidity, contaminant release, injury/mortality of some benthic organisms.
	Cabling Zone Post-Construction: scour, long-term structures.	Behavioral disturbance, displacement, connectivity for invasive or native species, habitat creation/modification.
	Turbine Zone Post-Construction: scour, long-term structures.	Behavioral disturbance, displacement, connectivity for invasive or native species, reef effects, habitat creation/modification/fragmentation.

* Fish with swim bladders also have the potential to experience other stressors, but the ones listed here are stressors expected to have more impact on fish with swim bladders than fish without swim bladders (A. N. Popper, A. D. Hawkins and R. R. Fay, et al. 2014).

Fish with swim bladders are more likely than other fish to experience sound and particle motion-related impacts (A. N. Popper, A. D. Hawkins and R. R. Fay, et al. 2014). In general, sound can cause TTS in fish hearing from being exposed to above normal sound-intensity. TTS is a recoverable reduction in hearing sensitivity. PTS in fish can cause permanent damage and is a non-recoverable reduction in hearing. Inner ear damage can result from continuous high-intensity sound (M. Hastings, et al. 1998, McCauley, Fewtell and Popper 2003, NYSERDA, New York State Offshore Wind Master Plan Environmental Sensitivity Analysis 2017). The Fisheries Hydroacoustic Working Group has established sound injury thresholds which have been adopted by NOAA. Peak sound pressure level greater than

206 decibels (dB) re 1 microPascal (μPa) or a cumulative sound exposure level (cSEL) occurring within a single day greater than 187 dB re 1 μPa2 • seconds for fishes 2 grams (0.07 ounces) or larger, or 183 dB for smaller fishes are the dual criteria for injury to fish (NYSERDA, New York State Offshore Wind Master Plan Environmental Sensitivity Analysis 2017, Stadler and Woodbury 2009). Behavioral effects are expected at 150 dB re 1 μPa root mean square (GARFO 2020). Fish can exhibit behavioral effects from sound and avoid construction areas, though construction disturbance would be temporary. Studies have shown that pile-driving peak sound levels can range between 165 and 195 dB within 9.8 m (32 ft) of the source (Illingworth and Rodkin 2007).

Particle motion is the oscillating motion of particles that move due to a vibrating source, for example, a pile-driving hammer (Nedelec, et al. 2016). Fish with swim bladders can detect particle motion and pressure, whereas fish without swim bladders cannot (Andersson 2011, Wahlberg and Westerberg 2005). Fish with swim bladders could be vulnerable to Great Lakes Wind Energy construction sound and particle motion, especially if pile-driving were used. Fish with swim bladders could also be sensitive to pressure changes, as the air within their swim bladder rapidly expands and contracts (Hastings and Popper 2005). Sound pressure can cause lethal injuries with fish with swim bladders at 207–210 dB cSEL and can cause recoverable injury at 203 dB cSEL (Popper and Hawkins 2019). Sound from operating turbines is limited to short distances from the foundation (Bergstrom, et al. 2014). There is very little known of how sound/particle motion physically and behaviorally impact fish in freshwater.

As stated in section 4.3.3.3, there have been multiple studies conducted by BOEM to determine potential adverse impacts of EMF to fish and fisheries. Operational wind energy projects in the marine offshore space are expected to have negligible impacts on fishes, bottom-dwelling species, or pelagic species (BOEM 2019). A study in Lake Ontario revealed no notable trends in fish density relative to cable locations (Dunlop, Reid and Murrant 2015), suggesting limited or no attraction or repulsion.

Vessel traffic could also pose a risk to sturgeon, which are known to be susceptible to vessel strike injury and mortality e.g., (Brown and Murphy 2011).

4.4.5 Terrestrial Species and Habitats

4.4.5.1 Relative Risk Mapping

The shoreline of Lakes Ontario and Erie are made up of a mixture of natural and anthropogenic environments such as beaches, cities, farms, and wetlands. Habitats within the study area that have historically undergone significant urban development likely contain species adapted to live within them and thus will not contain receptor groups likely to be sensitive to Great Lakes Wind Energy. To consider relative risk of potential development in terrestrial habitats (e.g., cables to shore, substations, port development), subgroups of terrestrial habitat were identified as receptor groups with greater vulnerability to stressors than other groups. The terrestrial receptor groups that would be most vulnerable to Great Lakes Wind Energy are wetlands and dunes.

Wetlands and dune habitats contain rare and sensitive animal and plant species, such as the federal ESA-listed bog turtle and the low sand-cherry, as described in section 3.6. The Bog Turtle is highly sought after by poachers for the pet trade, and thus occurrence data are not made publicly available. Should Great Lakes Wind Energy move forward, bog turtle occurrence data would likely need to be considered. However, because wetlands are key habitat for the bog turtle, a general understanding of the extent of bog turtle occurrence can be understood by examining coastal wetland locations.

Dune habitat is contained within barrier-protected wetland habitat. The USFWS critical habitat for the Piping Plover includes a 27.4 km (17 mi) stretch of northeast Lake Ontario shoreline of unforested dunes and inter-dunes wetlands. Thus, these habitats can serve as proxies to vulnerable locations for several terrestrial NYS and federal ESA-listed species. Coastal wetlands are included in the relative risk maps in section 4.6, and dunes and wetlands are also inferred by proxy by the Piping Plover critical habitat.

4.4.5.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 26 shows the potential stressors that could impact terrestrial receptor groups.

Table 26. Terrestrial Receptor Groups, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Wetlands	Cabling Zone Construction: habitat alteration, bottom disturbance.	Behavioral disturbance, displacement, or injury/mortality of organisms in wetlands habitat, turbidity, contamination release.
	Cabling Zone Post-Construction: long-term structures.	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in wetlands habitat.
Dunes	Cabling Zone Construction: habitat alteration, bottom disturbance.	Behavioral disturbance, displacement, or injury/mortality of organisms in dunes habitat.
	Cabling Zone Post-Construction: long-term structures.	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in dunes habitat.

Dune and wetland habitats, and thus the sensitive species they contain, could be impacted by cabling construction stressors, such as habitat alteration or bottom disturbance from trenching. Moving sediment to land cables within these sites would likely result in their localized destruction, removing the habitat that these species depend on. Research into the permitting requirements for cable landing revealed that industrial development is significantly restricted within wetland habitats (NYSDEC 2021). If Great Lakes Wind Energy is deemed feasible, future siting will need to incorporate in-water and shoreline resilience projects that could pose challenges to potential landfall locations.

4.4.6 Sensitive Habitats

4.4.6.1 Relative Risk Mapping

Generally, sensitive habitats are associated with ecosystems and species susceptible to some of the cabling zone stressors associated with bringing power to shore. To consider relative risk in potential development in sensitive habitats (beyond those already addressed in sections 4.4.4 and 4.4.5), subgroups of sensitive habitats were identified as receptor groups with potentially greater vulnerability to stressors than other groups. The sensitive habitat receptor groups that would potentially be most vulnerable to Great Lakes Wind Energy are ESA critical habitat, AOC, the proposed National Marine Sanctuary, CEAs, and SCFWHs.

In the case of the Piping Plover, the NYS breeding critical habitat encompasses a 27.4-kilometer (17 mi) stretch of shoreline unforested dunes and inter-dunes wetland on the northeast shores of Lake Ontario. This habitat was designated because it supports breeding and nesting piping plovers. Areas that have the potential to revert or to be rehabilitated to suitable habitats are also considered in the critical habitat designation.

In April 2019, NOAA proposed to designate approximately 4,403 square km (1,700 square mi) of Lake Ontario's waters and bottomlands as a national marine sanctuary encompassing Jefferson, Wayne, Oswego, and Cayuga counties (Office of National Marine Sanctuaries 2021). The purpose of the Sanctuary is to preserve the wrecks found in the proposed area. While it is unclear how the designation of the Sanctuary could directly impact the development of wind energy in this specific area, turbines and cables could be sited to avoid wrecks within the Sanctuary area once a more comprehensive assessment of the wrecks' locations is conducted. Because this Sanctuary is under consideration, it is included in the receptor group for historical/cultural areas and is discussed further in section 4.4.13.

Generally, CEAs encompass a wide range of features (historical, archaeological, or biological). For the CEAs around Lake Ontario and Lake Erie, the majority of these include nearshore habitat that could be impacted by Great Lakes Wind Energy cabling activities. CEAs are designated by the NYS, as detailed in section 3.7. There are 70 SCFWHs in the study area. These coastal habitats include wetlands, beaches, marshes, mud and sandflats, riparian corridors, rocky shores, submerged aquatic vegetation, harbor bottoms, dunes, grasslands, and woodlands, as detailed in section 3.7.40. Many of these areas overlap with habitats detailed throughout section 4.4.

To indicate presence of Critical Habitat, AOCs, CEAs, and SCFWHs in the relative risk maps in section 4.6 the following data layers were used (Table 20):

- Critical Habitat (Piping Plover)
- AOCs
- CEAs
- Protected Areas
- SCFWHs

4.4.6.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 27 shows the potential stressors that could impact sensitive habitat receptor groups.

Table 27. Sensitive Habitats Receptor Groups, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
ESA Critical Habitat (Resource with designated Critical Habitat is piping plover)	Cabling Zone Construction: sound/ particle motion, bottom disturbance, habitat alteration.	Behavioral disturbance, displacement, or injury/mortality of organisms in Critical Habitat.
	Cabling Zone Post-Construction: sound/particle motion, long-term structures.	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in Critical Habitat; behavioral disturbance.
Areas of Concern (AOCs)	Cabling Zone Construction: sound/particle motion, bottom disturbance, habitat alteration.	Behavioral disturbance, displacement, or injury/mortality of organisms in AOCs.
	Cabling Zone Post-Construction: sound, long-term structures .	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in AOCs; behavioral disturbance.
Proposed National Marine Sanctuary (Sanctuary Resource of Concern is Wrecks)	Cabling/Turbine Zone Pre-Construction: bottom disturbance.	Turbidity, contaminant release, interference with human uses (potential to damage undetected wrecks).
	Cabling/Turbine Zone Construction: bottom disturbance, habitat alteration.	Turbidity, contaminant release, interference with human uses (potential to damage undetected wrecks).
	Cabling/Turbine Zone Post-Construction: long-term structures.	Displacement
New York State Critical Environmental Area (CEAs)	Cabling Zone Construction: sound/particle motion, bottom disturbance, habitat alteration.	Turbidity, contaminant release; behavioral disturbance, displacement, or injury/mortality of organisms in CEAs
	Cabling Zone Post-Construction: sound/particle motion, long-term structures.	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in CEAs, behavioral disturbance.
Significant Coastal Fish and Wildlife Habitats	Cabling Zone Construction: sound/ particle motion, bottom disturbance, habitat alteration.	Behavioral disturbance, displacement, or injury/mortality of organisms in habitat.
	Cabling Zone Post-Construction: sound/particle motion, long-term structures.	Habitat creation/modification/ fragmentation; displacement, barriers for organisms in Critical Habitat; behavioral disturbance.

Generally, sensitive habitats are nearshore and onshore, and most potential for impact is associated with cabling to shore and construction of shore-based infrastructure. For Piping Plover critical habitat, shoreline development is currently listed as the main cause of habitat destruction and degradation, and Great Lakes Wind Energy could contribute to shoreline development. Stressors in sensitive habitats could impact the wildlife and plants that live in them.

4.4.7 Fisheries

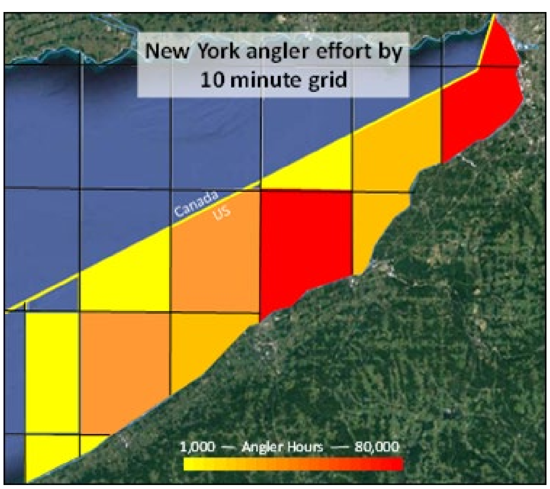
4.4.7.1 Relative Risk Mapping

Lakes Erie and Ontario offer some of the best freshwater recreational fishing in the U.S. Fisheries receptor groups potentially vulnerable to Great Lakes Wind Energy activities occur in both the cabling and turbine zones (Francis, et al. 2020, Markham and Knight 2017, O'Gorman 2017, Stewart, Todd and LaPan 2017). There are few data regarding the relative distribution of commercial, recreational, and tribal fisheries use patterns at high-resolution in the lakes, but data products were available to consider Walleye Fishing Areas as a receptor group in the relative risk study.

Offshore fishing areas vary widely across the two lakes and depend on many variables, such as depth and thermal stratification. Great Lakes Wind Energy projects are likely to be sited within Lakes Ontario and Erie at depths where commercially and ecologically important fish species are known to operate (Nienhuis and Dunlop 2011). Lake Erie New York Angler (recreational) effort was collected in 2017 by NYSDEC and is presented in Figure 18. The areas of highest fishing effort occur in the cabling zone in the northeast and center, and in the turbine zone in the center of the lake.

Figure 18. Lake Erie New York Angler Fishing Effort

Source: (Robinson 2021)



Walleye is the main recreational fishery in Lake Erie (NYSDEC 2020). A literature synthesis revealed specific depth contours in the spring, summer, and fall that indicate Walleye target fishing areas (Clark-Kolaks 2008, NYSDEC Accessed 2021). Depth bathymetry of Lake Erie was obtained from NOAA and the GLAHF and used with the above Walleye depth contour preferences to indicate where Walleye fishing most likely occurs in both the cabling and turbine zones (NOAA, National Geophysical Data Center 1999). To indicate presence of Walleye fishing areas in the relative risk maps in section 4.6 the following data layers were used (Table 20):

- Spring Walleye (2.4-3.7 m [7.8-12 ft])
- Summer Walley (18.3-24.4 m [60-80 ft])
- Spring, Summer, Fall Walleye (6.1-15.2 m [20-50 ft])

4.4.7.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 28 shows the potential stressors that could impact Walleye Fishing Areas, which would be applicable to other fisheries.

Table 28. Fisheries Receptor Group, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Walleye Fishing Areas	Cabling/Turbine Zone Pre-Construction: sound/particle motion, increased vessel traffic short-term structures.	Interference with human uses (walleye fishery), navigational/fisheries hazard.
	Cabling/Turbine Zone Construction: sound/particle motion with or without with pile-driving, increased vessel traffic, habitat alteration.	Interference with human uses (walleye fishing), navigational/fisheries hazard.
	Cabling/Turbine Zone Post-Construction: sound/particle motion, scour, EMF, long-term structures, increased vessel traffic.	Interference with human uses (walleye fishing), navigational/fisheries hazard.

Creating new habitat in what used to be the pelagic open aquatic environment can have positive and negative impacts. It has been well documented that new long-term structures in marine offshore wind create new habitats and areas for settlement by a range of species in the marine environment (Dauterive 2000, Degraer, et al. 2020, van Hal, Griffioen and van Keeken 2017). This increase and change in aquatic structure can impact ecosystem function (Degraer, et al. 2020). The reef effect can enhance prey availability and attract commercial and recreational target species, which can influence a new biodiverse fishing area (Hooper, Ashley and Austen 2018). However, structures can also create connectivity for spreading invasive species, such as Zebra Mussels, which prefer hard substrates. Having long-term structures in the turbine zone could cause fishing vessels to avoid the area due to safety and gear damage concerns. This effort displacement could cause resource enhancement or redistribution and lead to consequences to fisheries elsewhere (Gill, et al. 2020). Safety buffers around turbine structures could also displace or otherwise affect some fishing effort. There are no officially designated fishing grounds in Lakes Ontario and Erie. As such, there are not prohibitions that would restrict fishing in an alternative area for anyone displaced. Design of marine offshore windfarms on the east coast of the U.S. includes configurations of turbines meant to allow for fishing within windfarms, which is an approach that could be applied in the Great Lakes. Construction sound/particle motion, especially with pile-driving, may cause people to avoid fishing in areas during construction activities.

4.4.8 Water Use

4.4.8.1 Relative Risk Mapping

The New York State waters of Lake Ontario and Lake Erie are managed through programs to protect and restore water quality, including action agendas, partnerships, commissions, local actions and plans, reports, and projects. Water quality and the methodologies by which these water sources are utilized are enforced via local, State, and federal laws. Given this, water usage does not appear to be wholly categorized as a true "receptor group."

4.4.8.2 Potential Impacts

Great Lakes Wind Energy impacts to water usage would be monitored and reviewed via existing law, and it is unlikely to have significant impacts to existing water use (limited vulnerability). Modeling data indicate that a Great Lakes Wind Energy windfarm sited in the southern waters of Lake Erie's central basin would potentially impact the central basin by reducing mixing, decreasing current speeds, and increasing surface water temperature. The model indicated that there would be no significant impacts on the waters of the eastern or western basins (Afsharian, Taylor and Momayez 2020).

4.4.9 Shipping

4.4.9.1 Relative Risk Mapping

Shipping and marine traffic use much of the aquatic environment of the study area. There are vessel transit lanes present in both lakes, as well as recreational vessel traffic, described in section 3.10. The receptor group that would be most vulnerable to Great Lakes Wind Energy is vessel traffic that is not within the primary vessel transit lanes, because a windfarm could be constructed in an area that disrupts these routes, requiring vessels to maneuver around wind turbines.

Beyond the two primary lake transiting shipping routes, there are other routinely used navigation routes in Lake Ontario and Lake Erie (these are visible in AIS transit count data and on NOAA Navigational Chart 14800). For example, there is shipping that transits the lake in a north/south direction from major ports in Canada to U.S. ports (e.g., Gosport to Oswego); however, the traffic along these routes is not nearly as heavy as the two primary transit routes. Further, these secondary routes are not regulatory routes established by the Coast Guard, they are the shortest distance between two common destinations and are therefore shown on NOAA navigational charts as a navigational aid. For purposes of this study, it was assumed that, if necessary, these secondary routes would be altered by the Coast Guard and NOAA to maneuver around Great Lakes Wind Energy installations; therefore, they do not represent areas that would exclude windfarm development. Because windfarm development would likely be prohibited within the primary vessel transit lanes, vessel activities within these lanes would likely not be vulnerable receptors, except to the extent that a nearby windfarm could reroute additional vessel traffic across these lanes. These lanes and AIS data are included in the relative risk maps in section 4.6.

The U.S. Coast Guard provides Marine Planning Guidelines for offshore renewable energy installations and safe vessel navigation in the Navigation and Vessel Inspection Circular NVIC-2019-01, and this includes a recommendation that renewable energy installations be set back at least 2 nautical miles (nmi) from the outer edges of Traffic Separation Schemes, which are regulatory navigation routing measures that the Coast Guard establishes at the entrances to major ports and harbors (USCG 2019). While the vessel transit lanes transiting Lake Ontario and Lake Erie are not technically Traffic Separation Schemes, this setback distance was used as a basis for establishing 2 nmi buffers around the transit lanes in which Great Lakes Wind Energy would be unlikely to be sited (Figure 19). The vessel transit lanes are those that transit Lake Ontario connecting the St. Lawrence River to the Welland Canal and exiting the Welland canal to the west to transit Lake Erie. In Lake Erie, these two shipping routes do not cross into New York State waters and are therefore not within the study area. These routes are shown on NOAA navigational charts, and 2019 vessel transit data confirms that these are by far the most heavily traveled shipping routes within Lake Ontario and Lake Erie (BOEM and NOAA 2021a). The portion of these shipping traffic lanes within New York State waters are in the southwestern corner of Lake Ontario (northwestern corner of State waters).

4.4.9.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 29 shows the potential stressors that could impact vessel traffic.

Table 29. Shipping Receptor Group, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Vessel Traffic	Cabling/Turbine Zone Pre-Construction: increased vessel traffic, short-term structures.	Interference with human uses, navigational hazard.
	Cabling/Turbine Zone Construction: increased vessel traffic.	Interference with human uses, navigational hazard.
	Turbine Zone Post-Construction: long-term structures, increased vessel traffic.	Interference with human uses, navigational hazard.

During construction of Great Lakes Wind Energy, construction vessels such as pile drivers, heavy lift vessels, and barges will navigate from nearby ports to the windfarm construction site, contributing to an increase in local vessel traffic, which will minimally increase navigational risk, although this risk is small in comparison to the risk posed by stationary obstructions in the water.

In post-construction, wind turbines create physical obstructions to vessel navigation. Wind turbines create a risk of allision (contact between a moving vessel and a stationary object), especially in emergency circumstances such as loss of vessel power or steering. An unpowered vessel will tend to drift with the winds and currents and is therefore at risk of allision if an in-water wind turbine is nearby (BOEM 2019). Structures could interfere with radar communications adding to potential risk.

Wind turbines can also pose a risk when vessels are forced to maneuver to avoid them. Commercial vessels tend to travel in the straightest line possible between their point of origin and destination in order to minimize fuel use and time and to reduce the risk of collision with other vessels. When wind turbines lay in the path of these preferred "straight line" routes, vessels must maneuver to avoid them, which can lead to navigational safety risks in several ways (BOEM 2019):

- Any additional vessel maneuvering can increase human error, increasing risk (i.e., it is more difficult to maneuver around an obstacle than to travel in a straight line).
- Obstructions can funnel vessels into an area with less "sea room," decreasing the spacing between vessels and increasing chances of interaction between them.
- Obstructions can cause disparate vessel types to mix. For example, faster, more maneuverable deep draft vessels, which are typically separated from slower, less maneuverable tug and tow vessels can be mixed into the same area, leading to a greater frequency of the faster vessels overtaking the slower vessels.
- Wind turbines can reduce visibility of other vessels. For example, smaller fishing vessels traveling through windfarms and emerging to enter traffic lanes with larger vessels can be difficult to spot by the larger vessels, leaving them less time to react and maneuver if necessary.
- Wind turbines can create interference for ship-based radar, meaning that smaller vessels traveling near or within windfarms can be masked by the large radar returns of the wind turbines, contributing to reduced ability to prepare and react if small vessels exit windfarms and merge into traffic lanes.

The Great Lakes Wind Energy proposed project, Icebreaker by LEEDCo., identified the increased risk of impacts due to commercial shipping lanes and sited the windfarm away from commercial vessel lanes (EDR 2017).

4.4.10 Department of Defense Activities

4.4.10.1 Relative Risk Mapping

The Misty 1, 2, and 3 military operating areas along with R-5203 are designated special use airspace under FAA regulations. As such, restrictions in the areas are limited to aircraft during certain hours and altitudes within these air spaces, as discussed in section 3.11, but the restrictions do not apply to structures, buildings, or vessels. The FAA obstruction evaluation regulatory process addresses how structures or buildings could impact a special use airspace. The relative risk analysis cannot accurately predict the outcome of negotiations and the scope of modifications an FAA review would involve.

4.4.10.2 Potential Impacts

Potential wind turbines heights are expected to be at least 194 m (639 ft), including blade tip, which will likely extend into the Special Use Airspace of Misty 2 and R-5203 and would be evaluated through the FAA obstruction evaluation process. During the obstruction evaluation process, FAA would discuss the use of Misty 2 and R-5203 with users of this airspace to characterize the risk posed to Department of Defense activities by proposed wind turbine obstructions. The outcomes of this discussion could include requested changes to the height or position of the wind turbines, modification of the Special Use Airspace, or both. While FAA is responsible for designating Special Use Airspace annually through FAA Order JO 7400.10C, FAA is very likely to carry out and designate any Special Use Airspace requested by Department of Defense.

4.4.11 Recreation and Other Uses

4.4.11.1 Relative Risk Mapping

Recreation opportunities in the Great Lakes area include use of state parks, privately owned farms, and nature reserves and sanctuaries. Recreation occurs within private and government-owned land. Fisheries are described above in section 4.4.7 as a separate receptor group, so are not included in the analysis of recreation. Recreational use is also accounted for in section 4.4.9. There are not sufficient data to differentially distribute recreational uses across the study area.

4.4.11.2 Potential Impacts

Recreational fisheries are considered in section 4.4.7. A variety for tourist activities and shoreline destinations and industrial activities are noted in section 3.12. The impacts to recreational boating and activities on the water can include temporary and permanent displacement for some types of activities. On land, disruptions from cable installation and construction of terrestrial infrastructure could affect other uses, and permanent structures, such as substations, may affect activities in localized areas.

4.4.12 Indigenous Nations

4.4.12.1 Relative Risk Mapping

The Cattaraugus Reservation is located on the eastern shore of Lake Erie. It is one of three reservations of the Seneca Nation. There is not much information available on tribal use patterns in the study area aside from the location of the Cattaraugus Reservation. Given its proximity to and inclusion in the study area, the Cattaraugus Reservation as designated tribal lands may be affected by Great Lakes Wind Energy. The

Cattaraugus Reservation is owned by the Seneca Nation of Indians, and therefore the State of New York does not have jurisdiction to site any terrestrial components of Great Lakes Wind Energy on those lands. Seneca Nation tribe members historically subsistence fished steelhead in the lake and in Cattaraugus Creek and presently they do so primarily as a tradition (Kappen, Allison and Verhaaren 2012). The Cattaraugus Reservation is included in the Relative Risk Assessment maps in section 4.6.

4.4.12.2 Potential Impacts

As the reservation land extends to the shoreline into the eastern basin of Lake Erie and encompasses a large portion of the Cattaraugus Creek, Great Lakes Wind Energy could impact the reservation if any cables came to shore nearby, and members of the Seneca Nation may use areas of the Lakes for fisheries,

subsistence, and cultural activities that could be affected by Great Lakes Wind Energy. A table of potential stressors and impacts is not provided for the Cattaraugus Reservation, as data are not available to fully describe the potential for impacts associated with cultural and subsistence practices.

4.4.13 Historic/Cultural Areas

4.4.13.1 Relative Risk Mapping

Historic/Cultural Areas within the study area exist along the shorelines of the lakes and in the water, though not all culturally important areas are documented. Historic/Cultural Areas in this study are defined as those designated by NHPA or NYSHPA. Several cultural sites exist on the shores of both lakes. Along Lake Ontario these include the Fort Ontario State Historic site, two historic lighthouses, and the Sackets Harbor Battlefield State Historic Park. Along the eastern shore of Lake Erie there are the Erie Maritime Museum and the Historic Erie Lighthouse. All of these sites are discussed in section 3.14 and are designated historic sites owned by a government entity and are protected under the NHPA and NYSHPA run by the State of New York. section 106 of the NHPA requires federal agencies to consider the impact of their actions on historic properties and provide the Advisory Council on Historic Preservation with an opportunity to comment on projects before implementation. As early in the planning process as may be practicable, any project undertaken by a State agency, or prior to the funding of any project by a State agency shall consult with the commissioner concerning the impact of the project if it appears that any aspect of the project may or will cause any change, beneficial or adverse, in the quality of any historic, architectural, archeological, or cultural property that is listed on the national register of historic places or property listed on the State register or is determined to be eligible for listing on the State register by the commissioner (Parks, Recreation and Historic Preservation Chapter 36-B, Title C, Article 14, §14.09).

In addition, wrecks may be culturally and historically significant and were identified as a receptor group with vulnerability to stressors, particularly as they may be undiscovered and accidentally damaged. Wrecks are also sometimes kept out of public documents to avoid encouraging diving and other activities near particularly vulnerable or valuable wrecks, but some sites are publicly available through the Automated Wrecks and Obstruction Information System and other resources. In April 2019, NOAA proposed to designate approximately 4,403 square km (1,700 square mi) of Lake Ontario's waters and bottomlands as a National Marine Sanctuary. The purpose of the sanctuary is to preserve the wrecks found in the proposed area (Office of National Marine Sanctuaries 2021). Some wreck locations are noted in maps for this nomination, although they may not be specific, but the general locations are available as public information and are included in relative risk maps in section 4.6. To indicate presence of the wrecks in the relative risk maps the following data layer was used (Table 20):

- Known and Potential Wrecks

4.4.13.2 Potential Impacts

Stressors and general impacts associated with pre-construction, construction, and post-construction are described in section 4.3. In addition, Table 30 shows the potential stressors that could impact wrecks.

Table 30. Historic/Cultural Areas Receptor Group, Potential Stressors, and Potential Impacts

Receptor Group	Potential Stressor(s)	Potential Impact(s)
Wrecks	Cabling/Turbine Zone Pre-Construction: bottom disturbance.	Turbidity, contaminant release, interference with human uses (potential to damage undetected wrecks).
	Cabling/Turbine Zone Construction: bottom disturbance, habitat alteration.	Turbidity, contaminant release, interference with human uses (potential to damage undetected wrecks)

4.5 Data Availability, Quality, and Gaps Table

This section identifies the data that were collected, the quality, and the gaps identified during the literature and data synthesis. Data quality is based upon high-, moderately high-, and low-data precision/resolution. The data collected and sources are shown in Table 31. Not all data layers are shown in maps in this study; some data layers did not show differentiation across the study area at a resolution that would allow for assessment of differential risk, so they were not included in the syntheses of data in study figures.

Table 31. Data Availability and Quality

Data Layer	Description		Data Quality Citation
Airports	Points for airport locations in US	High	Great Lakes Commission 2019. Airport locations in the Great Lakes region. retrieved March 24, 2021 from https://www.arcgis.com/home/item.html?id=1460c7cdb520461ca01640429ac0f44a
Airports	Polygons of airport extents in Ontario	High	Land Information Ontario. 2012. Nav Canada Official Airports. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/datasets/lio::official-airports/about
Anchorage Areas	Areas Where Ships are Anchored Off Port	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. Anchorage Areas. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021. Anchorage Areas. https://www.fisheries.noaa.gov/inport/item/48849
Aquatic Habitat	Sturgeon Spawning Locations (Michigan Dept Natural Resources)	High	GLAHF. Sturgeon spawning locations. Michigan Department of Natural Resources. Retrieved March 24, 2021 from https://www.glahf.org/data/
Aquatic Habitat	Fish Access Tributaries	High	GLAHF. Fish access tributaries. Retrieved March 24, 2021 from https://www.glahf.org/data/
Aquatic Habitat	Fishing Access Locations on Lake Ontario	High	Land Information Ontario. 2021. Fishing Access Point. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/datasets/fishing-access-point/explore?location=49.369199%2C-84.745000%2C4.88
Aquatic Habitat	Annual Ice duration information from 1973 to 2014 (in days)	High	GLAHF 2021. Annual ice duration. retrieved March 24, 2021 from https://www.glahf.org/data/
Aquatic Habitat	Locations of known reefs in Great Lakes	High	GLAHF. Locations of known reefs in the Great Lakes. Retrieved March 24, 2021 from https://www.glahf.org/data/
Area of Concern/ Sediment	Area of Concern 18 Mile Creek	High	EPA (U.S. Environmental Protection Agency). 2021. Eighteenmile Creek AOC Boundary Map. Retrieved July 20, 2021 from https://www.epa.gov/great-lakes-aocs/eighteenmile-creek-aoc-boundary-map
Area of Concern/ Sediment	AOC buffalo river	High	EPA (U.S. Environmental Protection Agency). 2021. Buffalo River AOC Boundary Map. Retrieved July 20, 2021 from https://www.epa.gov/great-lakes-aocs/buffalo-river-aoc-boundary-map
Area of Concern/ Sediment	AOC Niagara River	High	EPA (U.S. Environmental Protection Agency). 2021. Niagara Creek AOC Boundary Map. Retrieved July 20, 2021 from https://www.epa.gov/great-lakes-aocs/niagara-river-aoc-boundary-map
Bathymetry	NOAA bathymetry of Lake Erie	High	GLAHF. Bathymetry of Lake Erie. https://www.glahf.org/data/. Retrieved March 24, 2021. Primary data source: NOAA National Geophysical Data Center. 1999. Bathymetry of Lake Erie and Lake St. Clair. NOAA National Centers for Environmental Information. https://doi.org/10.7289/V5KS6PHK

Table 31continued

Data Layer	Description		Data Quality Citation
Bathymetry	NOAA bathymetry of Lake Ontario	High	NOAA National Geophysical Data Center. 1999: Bathymetry of Lake Ontario. First. NOAA National Centers for Environmental Information. Retrieved March 24, 2021 from https://doi.org/10.7289/V56H4FBH
Bathymetry	Bathymetry Contours Lake Erie	High	Great Lakes Commission 2017. Bathymetry of Lake Erie. Retrieved March 25, 2021 from https://www.arcgis.com/home/item.html?id=f9aa394692544f1dab4b32d300e6b225
Birds	Important Bird Areas in Great Lakes	High	Great Lakes Commission. 2017. Audubon Important Bird Areas. Retrieved March 24, 2021 from https://www.arcgis.com/home/item.html?id=325d48c5cadb415481afc8bbf3b85e6e
Birds	Important Areas for Migratory Bird Stops West Erie	High	Great Lakes Commission 2019. Migratory bird stopover sites for Western Lake Erie. Retrieved March 24, 2021 from https://www.arcgis.com/home/item.html?id=c23d618c0d4e41b8a985ad30193fccc7
Birds	Highly Important Bird Area	Moderate - High	American Bird Conservancy. 2021. American Bird Conservancy Wind Risk Assessment Map, Highly Important Bird Areas. Retrieved July 20, 2021 from https://abcbirds.org/program/wind-energy-and-birds/wind-risk-assessment-map/. Primary sources: American Bird Conservancy. 2011. The American Bird Conservancy Guide to the 500 Most Important Bird Areas in the U.S.: Key Sites for Birds and Birding in All 50 States. Random House. 560 pp. ISBN 9780307481382
Birds	Critically Important Bird Areas	Moderate-High	American Bird Conservancy. 2021. American Bird Conservancy Wind Risk Assessment Map, Critically Important Areas. Retrieved July 20, 2021 from https://abcbirds.org/program/wind-energy-and-birds/wind-risk-assessment-map/. Primary source: USFWS Threatened & Endangered Species Active Critical Habitat Report at https://ecos.fws.gov/ecp/report/critical-habitat
Coast Survey Submarine cables	Coast Survey Submarine cables	High	NOAA (National Oceanic and Atmospheric Administration), MarineCadastre.gov. Office of Coast Survey's Electronic Navigational Charts. retrieved April 28, 2021 from https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html
Coastal Erosion Hazard Area	Coastal Erosion Hazard Area	Low	NYSDEC Coastal Erosion Management Program. 2021. New York State Coastal Erosion Hazard Areas. Provided by NYSDEC via email on May 14, 2021
Coastal Wetlands	Wetlands around Great Lakes coastal areas	High	GLAHF. Coastal wetlands. Retrieved March 24, 2021 from https://www.glahf.org/data/. Primary sources: Great Lakes Coastal Wetland Consortium at https://www.glc.org/library/2002-coastal-wetlands-consortium. Michigan Tech Research Institute at https://geodjango.mtri.org/coastal-wetlands/
Coastal Zone Management Areas	NOAA Coastal Zone Management Areas	High	NOAA, DOC. 2020. *Coastal Zone Management Act* Boundary. retrieved March 25, 2021 from https://data.noaa.gov/dataset/dataset/coastal-zone-management-act-boundary1

Table 31 continued

Data Layer	Description		Data Quality Citation
Commercial Waterway	Commercial Shipping Lanes in Lakes	High	Great Lakes Commission 2021. Commercial waterways. redrived March 24, 2021 from https://www.arcgis.com/home/item.html?id=a4940deebec84fb9b6afa65afcbf891d
Conservation Areas	Conservation Areas in Ontario	High	GLAHF. Conservation Areas in Ontario. Retrieved March 24, 2021 from https://www.glahf.org/data/
Critical Environmental Area	Critical Environmental Area	High	NYSDEC (New York State Department of Environmental Conservation) Division of Environmental Permits. 2020. Critical Environmental Areas in New York State. Retrieved July 20, 2021 from http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1330
Critical Habitat	Critical Habitat - Threatened and Endangered Habitat in Canada	High	Government of Canada. Critical Habitat of Species at Risk. Retrieved March 24, 2021 from https://open.canada.ca/data/en/dataset/db177a8c-5d7d-49eb-8290-31e6a45d786c
Critical Habitat	US Fish & Wildlife Critical Habitat	High	USFWS. 2013. USFWS Critical Habitat Portal. Retrieved March 24, 2021 from arcgis.com/home/item.html?id=2c2453ee613f47cdae9dbd0ed7939409. Primary source: USFWS Threatened & Endangered Species Active Critical Habitat Report at https://ecos.fws.gov/ecp/report/critical-habitat
Danger Areas/Restricted Zones	Restricted or Dangerous Areas for Shipping	High	NOAA (National Oceanic and Atmospheric Administration), MarineCadastre.gov. 2021. Office of Coast Survey's Automated Wrecks and Obstruction Information System, Danger Areas/Restricted Zones. Retrieved April 28, 2021 from https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html
Ecosites	Lake Erie Primary Ecosites - Eco Survey of Lake Erie Shoreline	High	Land Information Ontario. 2019. Great Lakes Shoreline Ecosystem Inventory V 1.0 - Lake Erie, Primary Ecosites. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/documents/fb6cb57e75ba4040ae74d1e0fd9a724a/about
Ecosites	Secondary ecosites on Lake Erie	High	Land Information Ontario. 2019. Great Lakes Shoreline Ecosystem Inventory V 1.0 - Lake Erie, Secondary Ecosites. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/documents/fb6cb57e75ba4040ae74d1e0fd9a724a/about
Environmental Conservation Areas	NY State Dept of Enviro Conservation	High	GLAHF. New York Environmental Conservation Areas. New York State Department of Environmental Conservation. Administrative Boundaries dataset, NYSDEC_lands data layer. Retrieved March 24, 2021 from https://www.glahf.org/data/. Primary Source: The New York Protected Areas Database (NYPAD). New York Environmental Conservation Lands. Available at http://nypad.org/
Federal Lands	Federally Owned Land in Ontario	High	GLAHF. Federally owned land in Ontario. Retrieved March 24, 2021 from https://www.glahf.org/data/
First Nations	Michigan Indian Treaty Areas	High	GLAHF. Michigan Indian treaty areas. Retrieved March 24, 2021 from https://www.glahf.org/data/.

Table 31 continued

Data Layer	Description		Data Quality Citation
First Nations	U.S. Indian Reserves	High	GLAHF. US Indian reserves. Retrieved March 24, 2021 from https://www.glahf.org/data/. Primary Source: Department of Homeland Security. Indian Reservations. Available at https://catalog.data.gov/dataset/indian-reservations
First Nations	First Nations Reserves in Canada	High	GLAHF. First Nations reserves in Canada. Retrieved March 24, 2021 from https://www.glahf.org/data/
Fish and Aquatic species	Occurrences of Fish and Aquatic Species in Lakes/Rivers	High	Land Information Ontario. 2015. Aquatic resource area polygon segment. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/datasets/aquatic-resource-area-polygon-segment-/explore?location=43.665065%2C-78.919710%2C9.76
Fish spawning	Goodyear Spawning Atlas	High	GLAHF. Goodyear Spawning Atlas. Retrieved March 24, 2021 from https://www.glahf.org/data/. Primary Source: USFWS. 1982. Atlas of the spawning and nursery areas of Great Lake fishes. Prepared by U.S. Fish & Wildlife Service. Final Repot FWS/OBS.
Fish spawning	Fish spawning areas	High	GLAHF. Fish spawning areas. Retrieved March 24, 2021 from https://www.glahf.org/data/
Fish spawning	Fish Spawning Locations in Great Lakes	High	GLAHF. Fish spawning locations in the Great Lakes. Retrieved March 24, 2021 from https://www.glahf.org/data/
Fishery Management Zones	Fishery Management Zones in Canada	High	GLAHF. Fishery management zones (Canada). Retrieved March 24, 2021 from https://www.glahf.org/data/
Geology	Bedrock Geology for Great Lakes Basin	High	GLAHF. Bedrock geology for Great Lakes Basin. Retrieved March 24, 2021 from https://www.glahf.org/data/
Invasive Species	Locations of surveyed invasive species in Great Lakes	High	Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS). GLANSIS Map Explorer. Retrieved March 24, 2021 from https://www.glerl.noaa.gov/glansis/mapExplorer.php
Lake Erie Field Photos	Locations of field photos on Lake Erie	High	Land Information Ontario. 2019. Great Lakes Shoreline Ecosystem Inventory V 1.0 - Lake Erie, Field Photos. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/documents/fb6cb57e75ba4040ae74d1e0fd9a724a/about
Lake Erie GLSE Field Datacards	Locations of field Datacard Entries on Lake Erie	High	Land Information Ontario. 2019. Great Lakes Shoreline Ecosystem Inventory V 1.0 - Lake Erie, Great Lakes Shoreline Ecosystem Field Datacards. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/documents/fb6cb57e75ba4040ae74d1e0fd9a724a/about
Location of wrecks	Location of Wrecks	High	NOAA (National Oceanic and Atmospheric Administration), MarineCadastre.gov. Office of Coast Survey's Automated Wrecks and Obstruction Information System. Retrieved April 28, 2021 from https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html

Table 31 continued

Data Layer	Description		Data Quality Citation
Location of wrecks	Location of Wrecks	High	NOAA (National Oceanic and Atmospheric Administration), MarineCadastre.gov. Office of Coast Survey's Electronic Navigational Charts. Retrieved April 28, 2021 from https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html
Municipal Parks	Municipal Parks in Ontario	High	GLAHF. Municipal parks in Ontario. Retrieved March 24, 2021 from https://www.glahf.org/data/
Obstruction Information	Undersea obstructions	High	NOAA (National Oceanic and Atmospheric Administration), MarineCadastre.gov. Office of Coast Survey's Automated Wrecks and Obstruction Information System. Obstructions. Retrieved April 28, 2021 from https://nauticalcharts.noaa.gov/data/wrecks-and-obstructions.html
Ohio Dept of Natural Resources - Lands	Ohio Dept of Natural Resources - Lands	High	GLAHF. Protected Areas. Ohio Department of Natural Resources. Retrieved March 24, 2021 from https://www.glahf.org/data/
Port Facilities	US Department of Transportation	High	USDOT (U.S. Department of Transportation)/BTS (Bureau of Transportation Statistics). 2019. Major Ports. National Transportation Atlas Database. Retrieved March 24, 2021 from https://hub.arcgis.com/datasets/usdot:ports/about
Protected Areas	Great Lakes Marine Protected Areas	High	GLAHF. Great Lakes marine protected areas. Primary source: USGS Protected Areas Database at https://www.usgs.gov/media/images/pad-us-20-viewer-showing-key-navigation-using-map-interface. Retrieved March 24, 2021 from https://www.glahf.org/data/
Protected Areas	Protected Areas in US	High	GLAHF. Protected Areas in the U.S. Administrative Boundaries dataset, USGS_PADUS data layer. Retrieved March 24, 2021 from https://www.glahf.org/data/
Provincial Parks	Provincial Parks in Ontario	High	GLAHF. Provincial parks in Ontario. Retrieved March 24, 2021 from https://www.glahf.org/data/
Resources Ownership	Michigan Dept Natural Resources ownership layer	High	GLAHF. Michigan Department of Natural Resources ownership. Retrieved March 24, 2021 from https://www.glahf.org/data/
Shipping Tracks	AIS shipping tracks for 2019	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. Vessel Transit Counts: All Vessels. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021: 2017 Vessel Transit Counts. https://www.fisheries.noaa.gov/inport/item/55365
Soils	Soils classified by drainage	High	GLAHF. Soils classified by drainage class. Retrieved March 24, 2021 from https://www.glahf.org/data/
Soils	Soils classified by slope	High	GLAHF. Soils classified by slope. Retrieved March 24, 2021 from https://www.glahf.org/data/
Soils	Soils classified by rooting depth	High	GLAHF. Soils classified by rooting depth. Retrieved March 24, 2021 from https://www.glahf.org/data/
SCFWH		High	New York State Department of State, Office of Planning & Development. Significant Coastal Fish & Wildlife Habitats. Retrieved April 5, 2022 from http://opdgig.dos.ny.gov/#/map

Table 31 continued

Data Layer	Description		Data Quality Citation
Substrate	Great Lakes substrate data	High	GLAHF. Substrate on bottom of Great Lakes. Retrieved March 24, 2021 from https://www.glahf.org/data/
Temperature	Mean Monthly Vertical Temperature	High	GLAHF. Mean monthly vertical water temperature for years 2006-2012. Retrieved June 25, 2021 from https://www.glahf.org/data/
Temperature	Mean Monthly Vertical Temperature	High	GLAHF. Mean monthly vertical water temperature for years 2006-2012, spring only. Retrieved June 25, 2021 from https://www.glahf.org/data/
Temperature	Mean Monthly Vertical Temperature	High	GLAHF. Mean monthly vertical water temperature for years 2006-2012, summer only. Retrieved June 25, 2021 from https://www.glahf.org/data/
Temperature	Vertical Temp Cumulative Degree Days over year	High	GLAHF. Cumulative Degree Days - Vertical Temperature and Surface Water Temperature. Retrieved March 24, 2021 from https://www.glahf.org/data/
Urban Areas	Urban Areas within U.S.	High	GLAHF. U.S. Urban Areas. Retrieved March 24, 2021 from https://www.glahf.org/data/. Primary source: U.S. Census Bureau Urban Areas. https://www.usgs.gov/products/data-and-tools/gis-data
Vegetation	Lake Erie Tree Prism Sweeps - Tree surveys on Lake Erie	High	Land Information Ontario. 2019. Great Lakes Shoreline Ecosystem Inventory V 1.0 - Lake Erie, Tree Prism Sweeps. Retrieved March 24, 2021 from https://geohub.lio.gov.on.ca/documents/fb6cb57e75ba4040ae74d1e0fd9a724a/about
Vessel Tracks	All vessel tracklines	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. AIS Vessel Tracks 2019. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021. AIS Vessel Tracks 2019. https://www.fisheries.noaa.gov/inport/item/59927
Vessel Transit	All vessel transit	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. 2015, 2016, 2017 Vessel Transit Counts: All Vessels. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021. 2015 AIS Vessel Transit Counts. https://www.fisheries.noaa.gov/inport/item/54958. Office for Coastal Management. 2021. 2016 AIS Vessel Transit Counts. https://www.fisheries.noaa.gov/inport/item/54957. Office for Coastal Management. 2021. 2017 Vessel Transit Counts. https://www.fisheries.noaa.gov/inport/item/55365
Vessel Transit	Cargo vessel transits density across GL in 2017	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. 2017 Vessel Transit Counts by Type. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021. 2017 Vessel Transit Counts by Type. https://www.fisheries.noaa.gov/inport/item/55363

Table 31 continued

Data Layer	Description		Data Quality Citation
Vessel Transit	Fishing vessel transit density across GL in 2013, 2017	High	USDOC (U.S. Department of Commerce), NOAA (National Oceanic and Atmospheric Administration), NOS (National Ocean Service), MarineCadastre.gov. 2016 and 2017 Vessel Transit Counts: Fishing. Retrieved April 28, 2021 from https://marinecadastre.gov/nationalviewer/. Primary source: Office for Coastal Management. 2021. 2016 Vessel Transit Counts by Type. https://www.fisheries.noaa.gov/inport/item/55362. Office for Coastal Management, 2021. 2017 Vessel Transit Counts by Type, https://www.fisheries.noaa.gov/inport/item/55363
Walleye Management Units	Lake Erie Walleye Management Units	High	GLAHF. Lake Erie walleye management units. Retrieved March 24, 2021 from https://www.glahf.org/data/
Water	Upwelling is the occurrence of cooler bottom water rising to the surface as warm water is pushed offshore during high winds.	High	GLAHF. Annual upwelling index for the years 1995-2013. Retrieved June 25, 2021 from https://www.glahf.org/data/
Water Chemistry	Water chemistry collection sites - Sites of water collection locations in lakes, plus tables of water results	High	GLAHF. Water chemistry collection sites. Retrieved May 19, 2021 from https://www.glahf.org/data/
Wildlife Habitat	Coastal Habitat areas in NY State	High	GLAHF. Administrative Boundaries dataset, data layer LOB_coastalhab_NYS. Retrieved March 24, 2021 from https://www.glahf.org/data/
Wind	Wind travel distance and direction for Great Lakes	High	GLAHF. Great Lakes fetch. Retrieved March 24, 2021 from https://www.glahf.org/data/
Windfarms	Windfarm locations in U.S.	High	Hoen, B.D., Diffendorfer, J.E., Rand, J.T., Kramer, L.A., Garrity, C.P., and Hunt, H.E. 2018. U.S. Wind Turbine Database (ver. 3.3, January 14, 2021): U.S. Geological Survey, American Clean Power Association, and Lawrence Berkeley National Laboratory data release. https://doi.org/10.5066/F7TX3DN0. Retrieved April 8, 2021 from https://eerscmap.usgs.gov/uswtdb/
Yellow Perch Management Units	Lake Erie Yellow Perch Management Units	High	GLAHF. Lake Erie yellow perch management units. Retrieved March 24, 2021 from https://www.glahf.org/data/

4.5.1 Data Gaps

Spatial data for birds and bats flying over the lakes in the study area are not readily available, including data on flight paths, flight height, magnitude of birds/bats flying over the lakes, and changes in flight patterns over the lakes relative to weather and light conditions. Likewise, habitat use patterns and movements of fish are not well understood at high resolutions within the study area. Distribution and use patterns of fisheries, including subsistence and cultural fisheries, are also not as refined as would be preferable for assessing risk from wind development. Fish with swim bladders have more potential to be injured by sound and particle motion, but little is known about that potential for freshwater fish with swim bladders to be impacted by sound, and potential behavioral reactions of Great Lakes fish to sound, EMF, and other disturbance is unclear. Potential for wind turbines to affect currents and wind patterns in a manner that affects fish is not well understood. Some data are available on distances from shore where benthic organisms are most likely to be found, but direct species distribution data are not refined in the study area. There is also a lack of understanding of distribution and variability in human use patterns, such as recreational activities, tourism, and cultural uses. There may be additional data and data products, such as creel surveys, available from agencies in the future. Wind developers should seek to access data from agencies.

4.6 Relative Risk Maps

This section describes the relative risk maps generated for the Lake Ontario Turbine Zone (Figure 19. Lake Ontario Potential Risks for Great Lakes Wind Energy in the Turbine Zone between the 16 km (10 mi) Line and the U.S.-Canada International BorderFigure 19), the Lake Ontario Cabling Zone (Figure 20, Figure 21, Figure 22, Figure 23, and Figure 24), the Lake Erie Turbine Zone (Figure 25), and the Lake Erie Cabling Zone (Figure 26, Figure 27, Figure 28, Figure 29, and Figure 30). These relative risk maps use the data that were collected and available, identified in Table 20 to indicate the presence of receptor groups detailed in section 4.4. and to identify potential areas of least and greatest risk from Great Lakes Wind Energy.

4.6.1 Methodology

GIS data were gathered from numerous sources (Table 20) and uploaded onto a web-GIS viewer. This allowed subject matter experts to view and interact with the data layers and make assessments and decisions on the suitability of those layers for inclusion in the final relative risk mapping, as well as develop the risk maps themselves. The mapping was created by using GIS ArcGIS v10.7 software (ESRI, Environmental Systems Research Institute 2018). In addition to the layers displayed in Table 20, port facilities, submarine cables, CEHAs, and POIs within the study area were added to the maps. Areas of least and greatest risk were identified based on the presence of fewer or more receptor groups and the vulnerability of those groups to stressors. It would be expected that cables to shore would need to avoid obstructions (like wrecks) and ideally come to shore nearby to POIs. POIs near sensitive habitats, such as CEHAs and bird nesting sites, would have higher cabling risk associated with them because cables would either traverse more sensitive or regulated habitat or need to be longer to circumvent such habitat.

4.6.2 Assumptions and Limitations

To determine if a receptor group could be vulnerable to or interact with Great Lakes Wind Energy, understanding how that receptor group is dispersed within the area is needed. Some taxa, such as birds and bats, are data poor regarding understanding where and how species use areas over Lakes Ontario and Erie. The spatial data collected for such receptor groups was insufficient to determine refined relative risk for Great Lakes Wind Energy. This study does not evaluate the technical feasibility of nearshore routing related to avoiding sensitive habitats in cabling.

The study assumes that Great Lakes Wind Energy turbines will be placed beyond 16 km (10 mi) from shore in Lake Ontario and beyond 8 km (5 mi) from shore in Lake Erie (see section 3.1 for a full explanation of how distances were chosen). This does not represent any decisions made by NYSERDA about turbine placement if Great Lakes Wind Energy moves forward. The end boundary of New York State and Canadian waters was given a 2 nmi buffer.

In addition, this study does not consider physical parameters such as ice, geology, sediment type, etc. with respect to feasibility of turbine or cable placement. The relative risk analysis focuses on biological risks involving flora, fauna, and habitats and human use conflicts, such as fisheries, recreation, and tribal uses. Locations of POIs and ports are included for relative risk associated with cabling to shore and port development.

As described in sections 4.4 and 4.5, there are not sufficient data to understand relative risk for all receptors (i.e., there may be few data, or the available data do not provide sufficient resolution to differentiate risk across the study area). For example, benthic organisms demonstrate some habitat preferences, but the available data do not provide sufficient differential distribution in coastal areas where cables would come to shore and potentially disturb these organisms to assess differential risk.

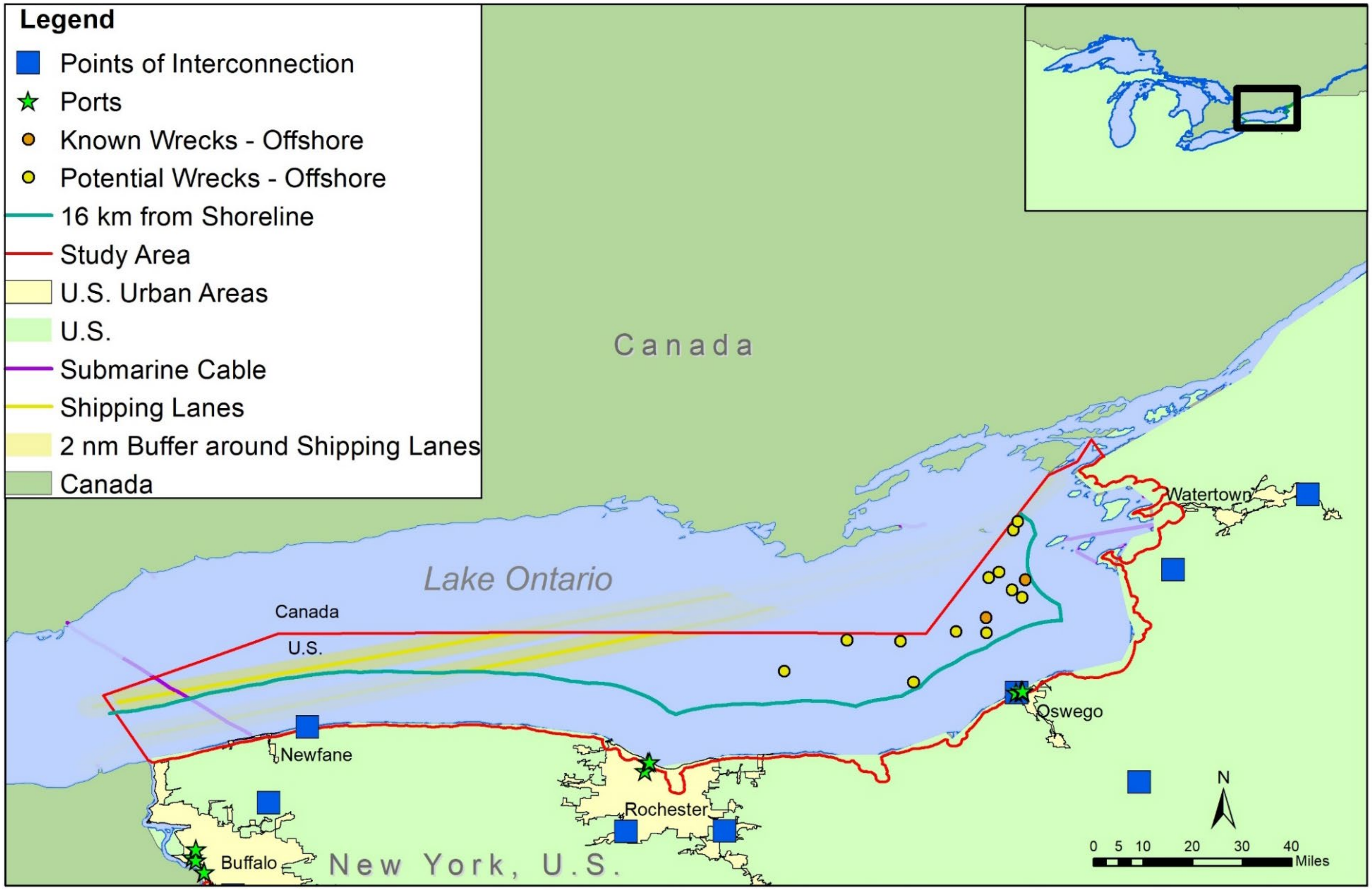
4.6.3 Results and Risk Assessment

This section presents and interprets the results of the relative risk analysis based on the phased approach of identifying Great Lakes Wind Energy stressors, receptor groups that could be vulnerable, and collecting data and information to indicate where receptor groups are likely to be present and affected by Great Lakes Wind Energy.

4.6.3.1 Lake Ontario Turbine Zone

The Lake Ontario Turbine Zone Map (Figure 19) focuses on the area that would most likely be used for turbines (≥16 km [10 mi] from shore). There are two vessel transit lanes that enter NYS waters on the western half of Lake Ontario. Great Lakes Wind Energy would likely be excluded from the primary vessel transit lanes that are a part of the St. Lawrence Seaway along with at least a 2 nmi buffer around the two vessel transit lanes. There is one POI close to shore in the Southwest area of Lake Ontario that could be accessible for turbines in the western half of the lake. There is an area potentially available for Great Lakes Wind Energy development in a northwest triangle to the north of the vessel transit lanes (Figure 19; yellow line). There is also an area potentially available for Great Lakes Wind Energy development in the region between the two vessel transit lanes (53 square nmi outside the 2 nmi buffer around the two vessel transit lanes). This area is closest to the same POI as the area north of the vessel transit lanes. Risks associated with the region above and between the two vessel transit lanes are not substantively different in terms of obstructions, POIs, or ports, but only one vessel transit lane would need to be crossed to access the area between the transit lanes. However, the navigational risk of having a windfarm within two vessel transit lanes may be higher than above or below the vessel transit lanes and configuration of the windfarm may be awkward in an elongated space on an angle. There are fewer wrecks on the western half of Lake Ontario, reducing risk, but ports and POIs are generally further from this area than in central and eastern parts of the study area, increasing risk (Figure 19). The proposed National Marine Sanctuary is a potential risk in the eastern half of NYS waters in Lake Ontario, though a sanctuary would not necessarily exclude wind development. In general, the eastern and central parts of Lake Ontario in areas with lower densities of wrecks, may be less risky for turbine or cable installation, though more wrecks and the HMS Ontario may be present, making the lowest risk area the central lake, southeast of the vessel transit lanes (Figure 19).

Figure 19. Lake Ontario Potential Risks for Great Lakes Wind Energy in the Turbine Zone between the 16 km (10 mi) Line and the U.S.-Canada International Border



4.6.3.2 Lake Ontario Cabling Zone

The Lake Ontario Cabling Zone Map (Figure 20) focuses on the area that would most likely include cables in water to shore and shoreline development, such as port development or substations. For clarity, the Lake Ontario Cabling Zone is divided into four sections, Southwest, Central, Southeas,t and Northeast and these sections are shown individually in Figure 21,Figure 22, Figure 23 and Figure 24.

Figure 21 shows Southwest Lake Ontario with a focus on areas where cables may pass through and come to shore and shoreline infrastructure may be built. An AOC is on the western most edge on the lake. The POI in that area is the one that is located farthest from critically IBAs, IBAs, protected areas, and major migration routes relative to other POIs. While much of the Lake Ontario coastline is designated as CEHA, there is an area not designated as CEHA to the east of this POI, which means that if an export cable landfall could be placed there, it could avoid impacting an area with high-coastal erosion and avoid an additional permitting burden as CEHA permits are required for construction in CEHA designated areas. There is one submarine cable that lands west of this POI. A Freedom of Information Act request of the NYS review of the Crosslake Fiber USA project crossing in Lake Ontario can be further assessed in the future and would need to be submitted to New York State Department of State (NYSDOS) referencing NYSDOS file #F-2018-0332.

Figure 22 shows Central Lake Ontario, which has no POI within the study area (2 km [1.3 mi] from the shoreline); however, there are POIs inland from the study area that could be used, though would require cabling through this region on land (Figure 20). There is an area not designated CEHA in the eastern portion of this region (see top left panel in Figure 22); however there is a large wetland area with an IBA onshore at the area without CEHA. There is also an offshore reef area associated with this location, which likely makes this area a risk for cabling. There is another area not designated as CEHA on the western side of this region (see bottom left panel in Figure 22) that is also clear of any other protected areas and may be at less risk for cabling. There is a known wreck just offshore of this location that would need to be avoided. Cabling activities in other areas of Central Lake Ontario could disrupt nesting or overwintering bird colonies. There are several areas of CEA, protected areas and SCFWHs, increasing risk to cable landing. More wrecks are present in Central Lake Ontario than Southwest Lake Ontario, making cable laying riskier in the central part of the lake.

Figure 23 shows Southeast Lake Ontario, which has one POI within the study area (middle left panel) with an additional POI well inland from the study area (Figure 20). The nearshore POI is surrounded by CEHA, a protected area, SCFWHs, known potential wrecks, and a port. There is an area without designated CEHA to the east and west of the POI. These areas also have multiple known and potential wrecks nearby in coastal waters which could pose a challenge with landing cables in these areas. The western side of this section of Lake Ontario has considerable areas of wetlands, protected areas, and SCFWHs that create risk for cabling to shore (top left panel in Figure 23). The remainder of the shoreline in this section has sparser wetland and protected areas but with higher densities of known and potential wrecks offshore (middle and bottom panel in Figure 23).

Figure 24 shows the Northeast part of Lake Ontario. This area has no POI within the study area, but there are two inland POIs south and east of Watertown (Figure 20). The southern-most portion of this section of Lake Ontario is dense with wetlands, protected areas, CEAs, SCFWHs, piping plover critical habitat, and an IBA, with relatively dense known and potential wrecks offshore, making this area a high risk for cabling to shore. The central portion of Northeast Lake Ontario also has extensive protected areas and wetlands with the additional complication of undersea cables present. There are some areas with limited protected areas and wetlands and no CEHA where cabling to shore may be lower risk, although the existing submarine cables would need to be avoided or mitigated. The northern-most portion Northeast Lake Ontario has substantial protected areas, SCFWH, wetlands, offshore reefs, and conservation lands that would likely complicate cabling, although this area does not have CEHA.

Figure 20. Lake Ontario Potential Risks for Great Lakes Wind Energy in the Cabling Zone

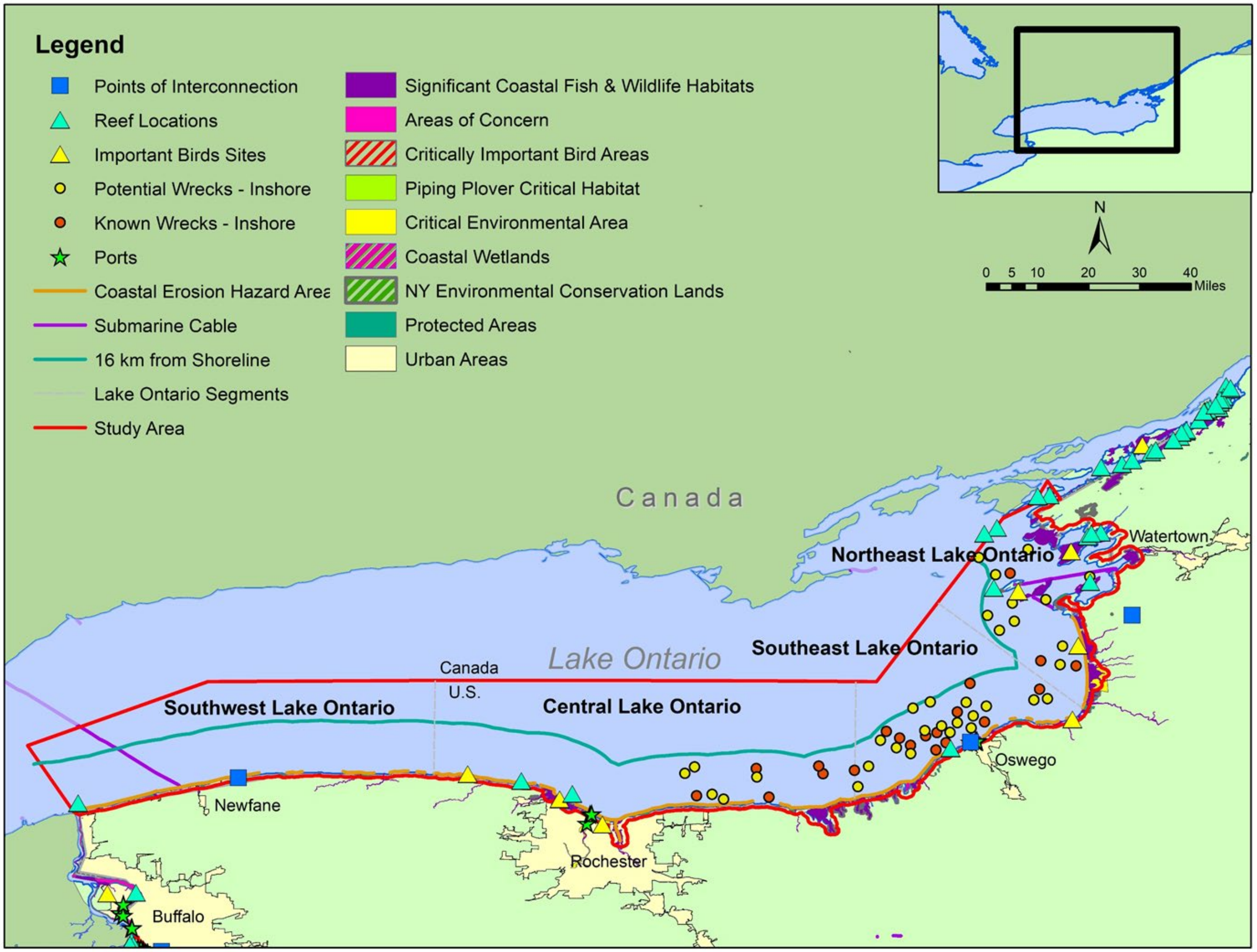


Figure 21. Potential Risks for the Southwest Region of Lake Ontario for Great Lakes Wind Energy in the Cabling Zone

Bottom right shows full Central Region, panels on left show enlargements of the Central Region coastline.

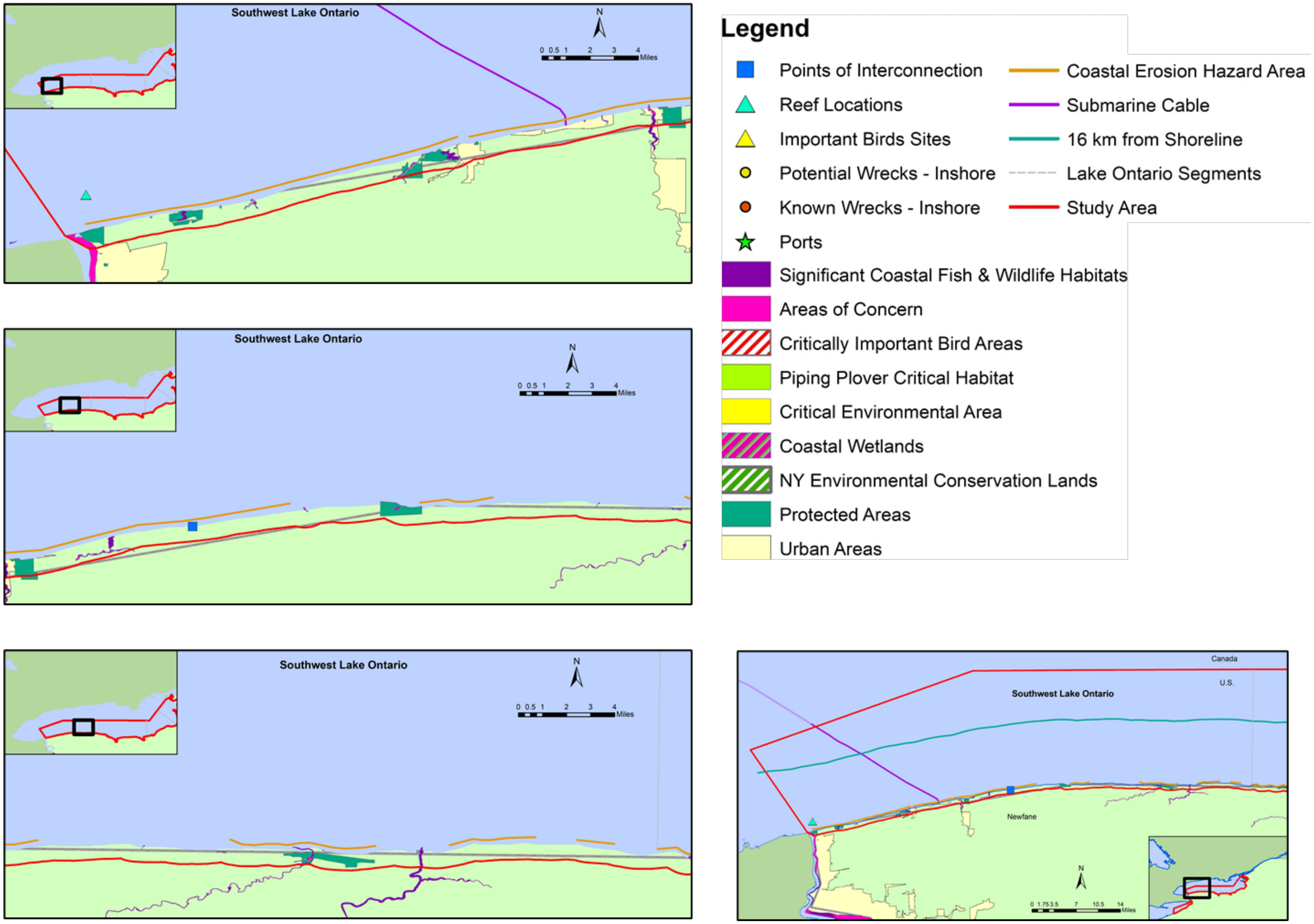


Figure 22. Potential Risks for the Central Region of Lake Ontario for Great Lakes Wind Energy in the Cabling Zone

Bottom right shows full Central Region, bottom right shows full Central Region, panels on left show enlargements of the Central Region coastline.

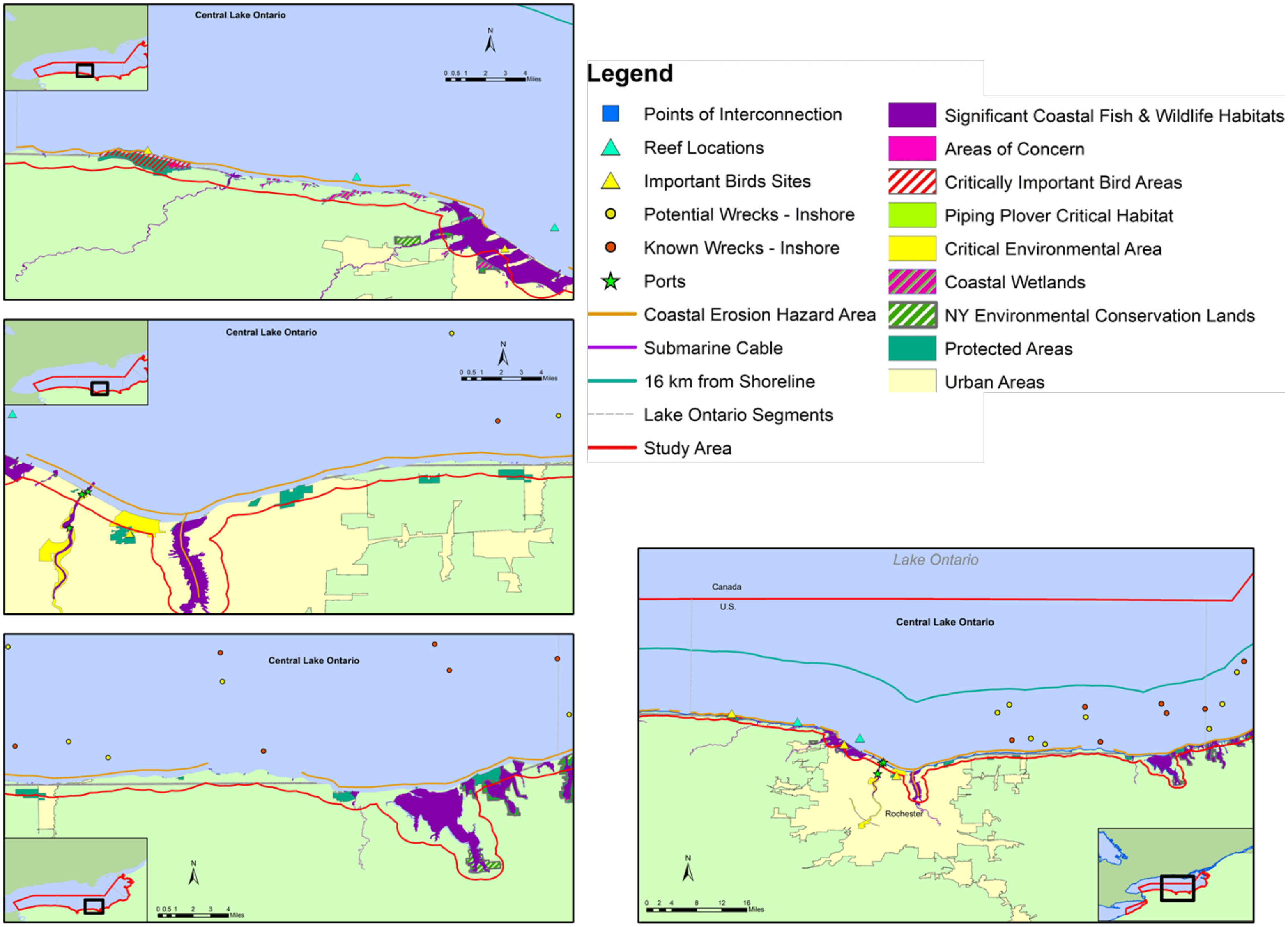


Figure 23. Potential Risks for the Southeast Region of Lake Ontario for Great Lakes Wind Energy in the Cabling Zone

Bottom right shows full Southeast Region, panels on left show enlargements of the Central Region coastline.

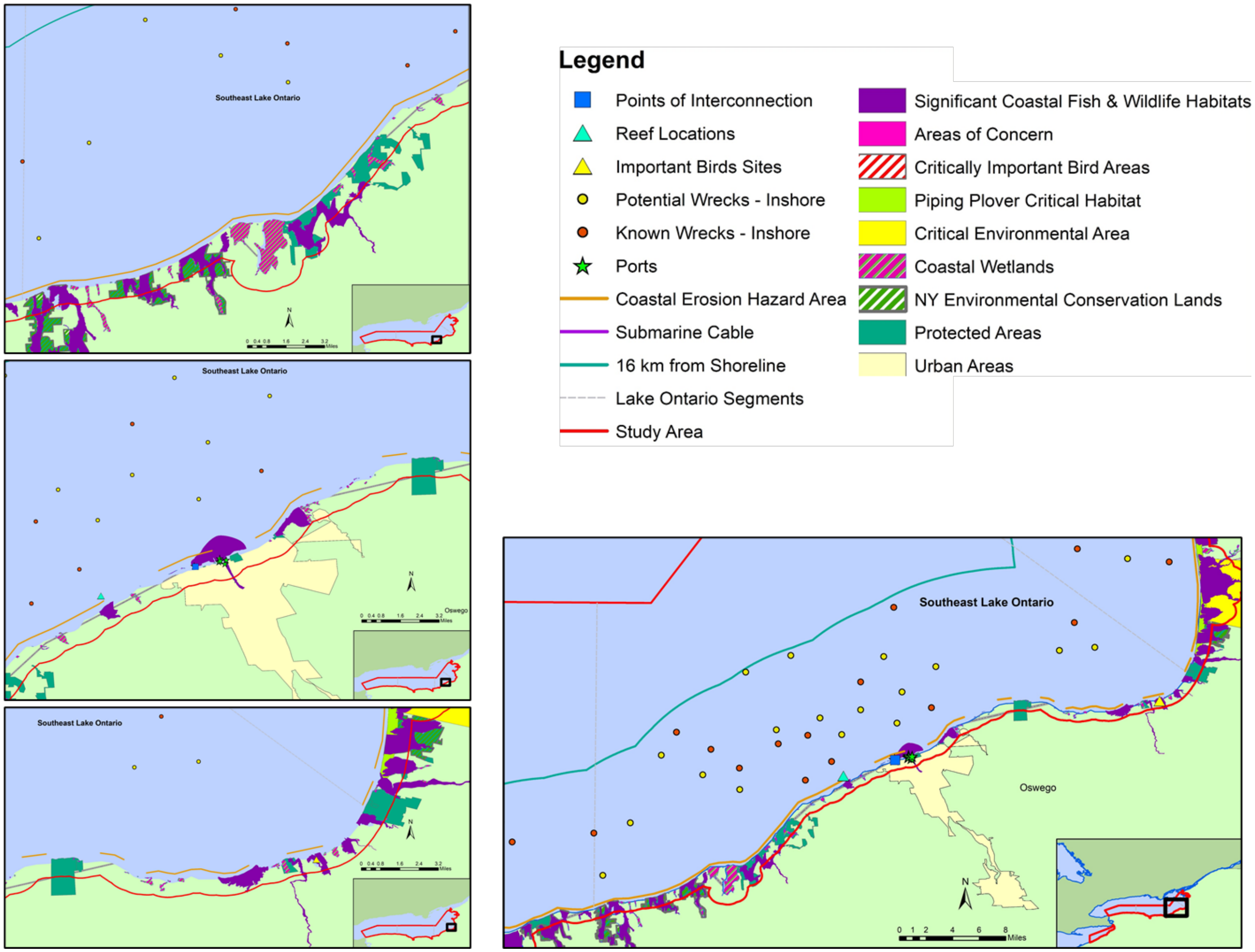
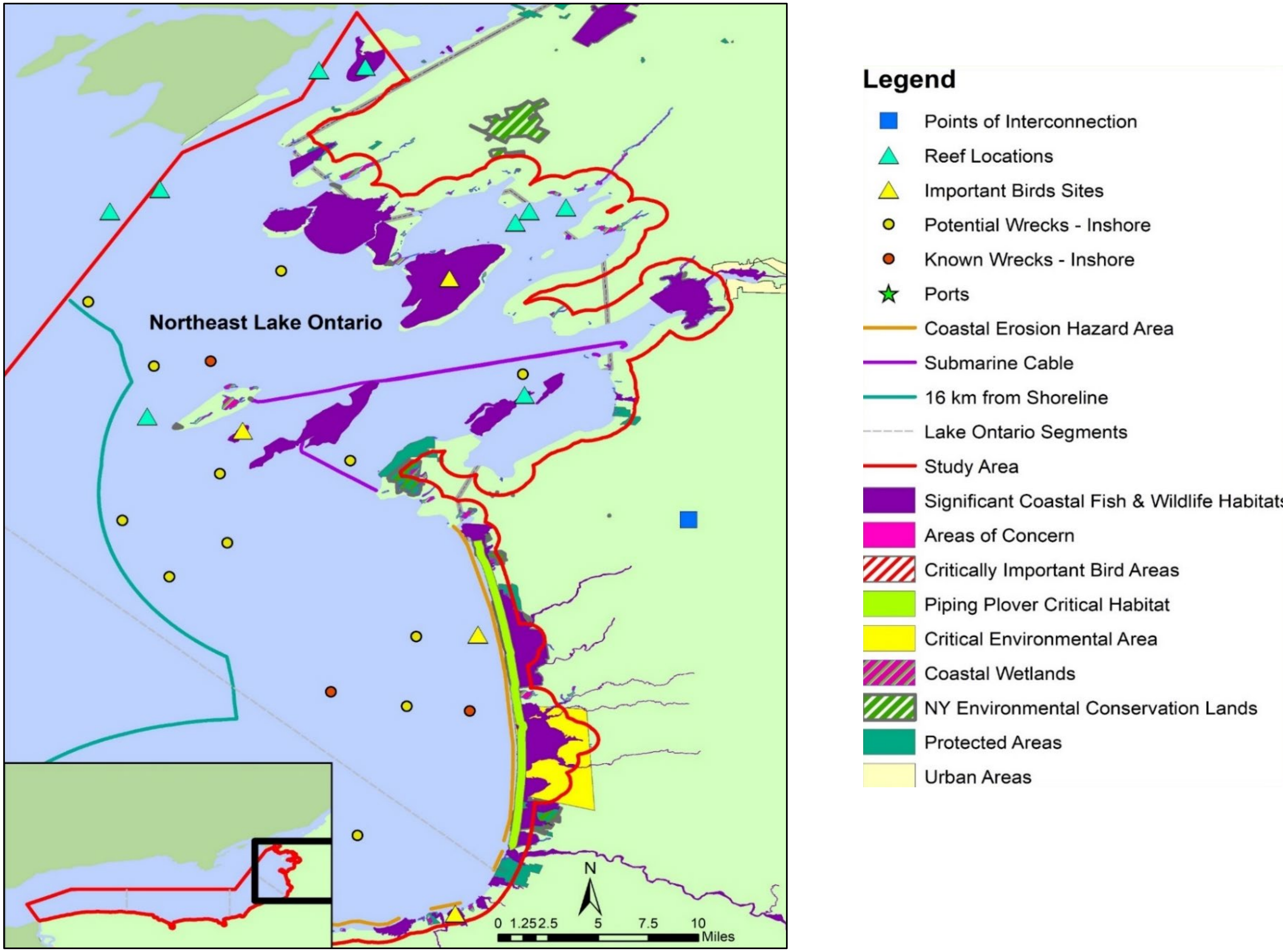


Figure 24. Potential Risks for the Northeast Region of Lake Ontario for Great Lakes Wind Energy in the Cabling Zone

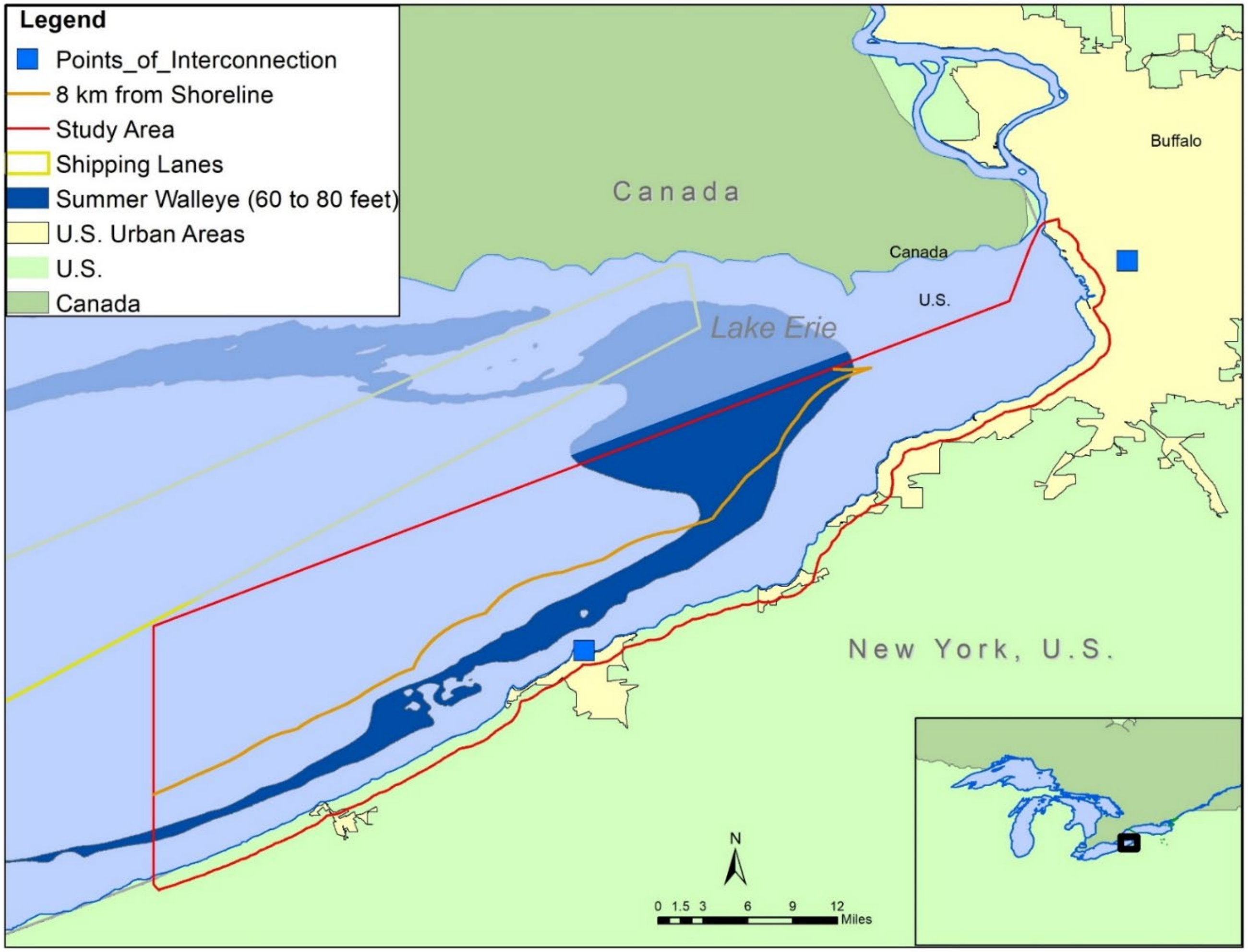


4.6.3.3 Lake Erie Turbine Zone

The Lake Erie Turbine Zone Map (Figure 25) focuses on the area that would most likely be used for turbines (≥8 km [5 mi] from shore).

There are no known wrecks in Lake Erie's turbine zone. No major AOCs were identified for birds or bats in this region of Lake Erie, but there is some increased bird and bat risk associated with the westernmost area near Long Point, northwest of the NYS waters. While there are no migratory data available over the lake for this location, the area forms a peninsula, and as such it may funnel bird and/or bat migrants through a migratory bottleneck, particularly during the fall migration when birds will be moving from north to south (Diehl, Larkins and Black 2003, Thorne 2015). There is some potential for summer Walleye fisheries to be more active in the eastern area of the turbine zone. Given the data available, the areas in the eastern and western Lake Erie turbine zone represent the greatest risk for Great Lakes Wind Energy development, with the central area having less risk. The area in the center of the turbine zone could avoid potential summer Walleye fishing areas to the east and bird and bat migratory areas extending from Long Point in Canada in the west. The center area also has a POI within the study area. With the data available, this area represents the least risk for Great Lakes Wind Energy development in the turbine zone for Lake Erie.

Figure 25. Lake Erie Potential Risks for Great Lakes Wind Energy in the Turbine Zone



4.6.3.4 Lake Erie Cabling Zone

The Lake Erie Cabling Zone Map (Figure 26) focuses on the area that would potentially include cables to shore and shoreline development, such as port development or substations. Figure 26 shows an overview of the Lake Erie cabling zone, and this zone is divided into four sections to enable the discussion. These four sections are depicted in Figure 27, Figure 28, Figure 29, and Figure 30.

Figure 27 shows the Southwest section of the Lake Erie study area. There are no nearshore POIs in this area. The entire shoreline in this section is designated as CEHA, which may require additional permitting for any cabling to shore. There are also known and unknown nearshore wrecks in this area that would need to be avoided. Spring, summer, and fall Walleye fishing could occur in coastal waters along the shoreline, though there are not available data to indicate differentiation of other fishing resources and vessels in the cabling zone.

Figure 28 shows the Central West section of the Lake Erie study area and includes one nearshore POI located west of a SCFWH and near an IBA. The IBA is situated on an embayment, which may be used by nesting or overwintering waterbirds. There is no designated CEHA within this SCFWH and IBA. There is one known potential wreck which is over 4.8 km (3 mi) to the west of the POI. There is a small, protected area west of the POI. Spring, summer, and fall Walleye fishing could occur in the coastal waters along the shoreline, though there are not available data to indicate differentiation of other fishing resources and vessels in the cabling zone.

Figure 29 shows the Central East section of the Lake Erie study area. There are no nearshore or inshore POIs. The Cattaraugus Reservation, which is a large, protected area and belongs to the Seneca Nation, is located in this area along with SCFWHs just south and offshore of where the Cattaraugus Reservation meets the lake. Spring, summer, and fall Walleye fishing could occur in the coastal waters along the shoreline, though there are not available data to indicate differentiation of other fishing resources and vessels in the cabling zone. The entire coastline of this area is designated as CEHA. The nearest area without CEHA is to the southwest in Dunkirk-Fredonia.

Figure 30 shows the Northeast section of the Lake Erie study area. There are no POIs within this study area; however, there are two inshore POIs that that could be reached with overland cabling (Figure 26), The Northeast area has a large cluster of port facilities within 2 km (1.3 mi) inland. Spring, summer, and fall Walleye fishing could occur in the bulk of the waters in this area. There are not available data to indicate differentiation of fishing effort or catch along the area. The northern half of the shoreline is covered by protected areas, SCFWHs, wrecks, AOCs, and includes a major port. There is no designated CEHA for the majority of the northern half of the shoreline. The entire southern half of the shoreline of this section is designated CEHA. There is one CEA in the southwestern end of the section.

Figure 26. Lake Erie Potential Risks for Great Lakes Wind Energy in the Cabling Zone

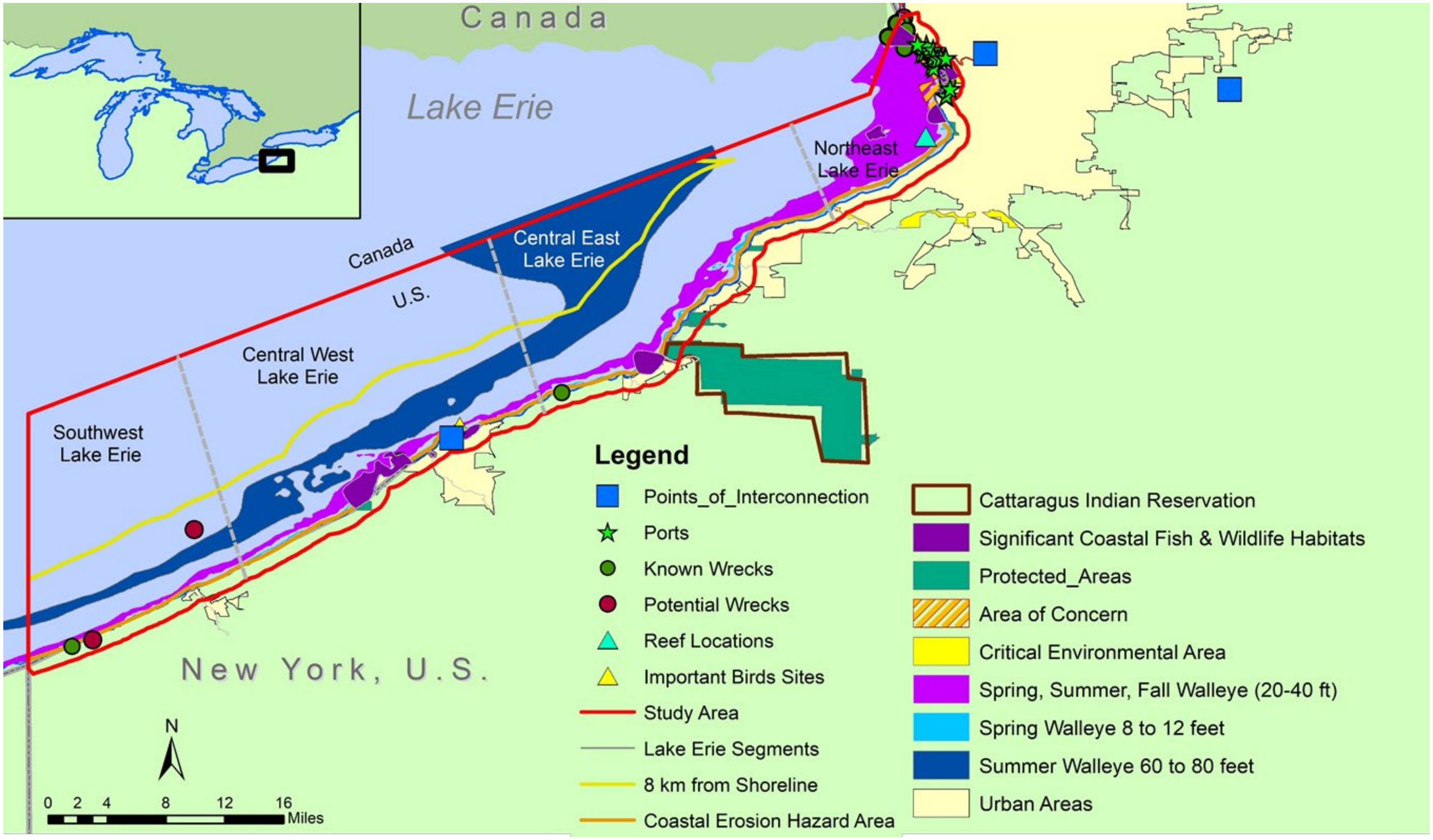


Figure 27. Southwest Section of the Lake Erie Cabling Zone

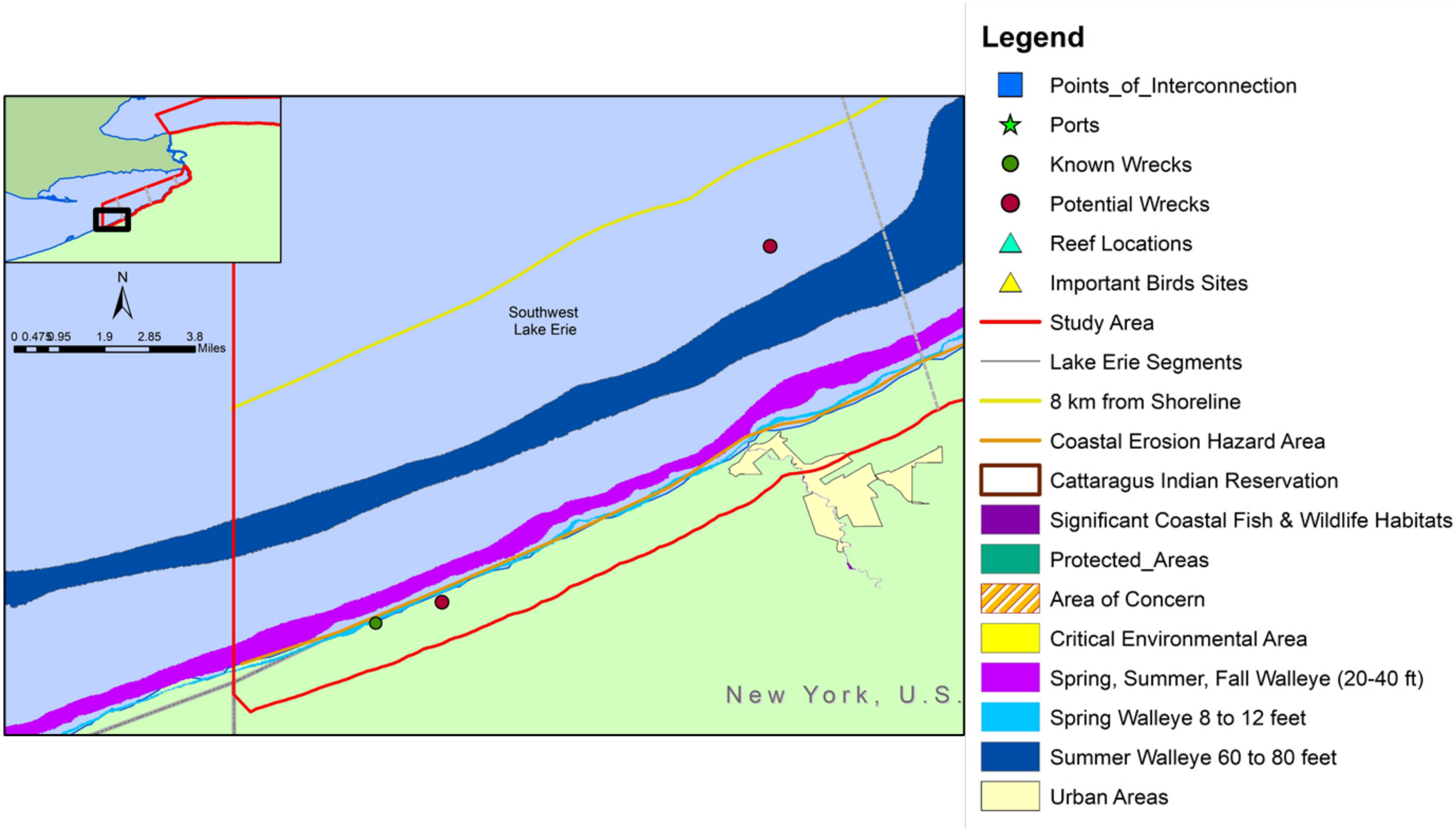


Figure 28. Central West Section of the Lake Erie Cabling Zone

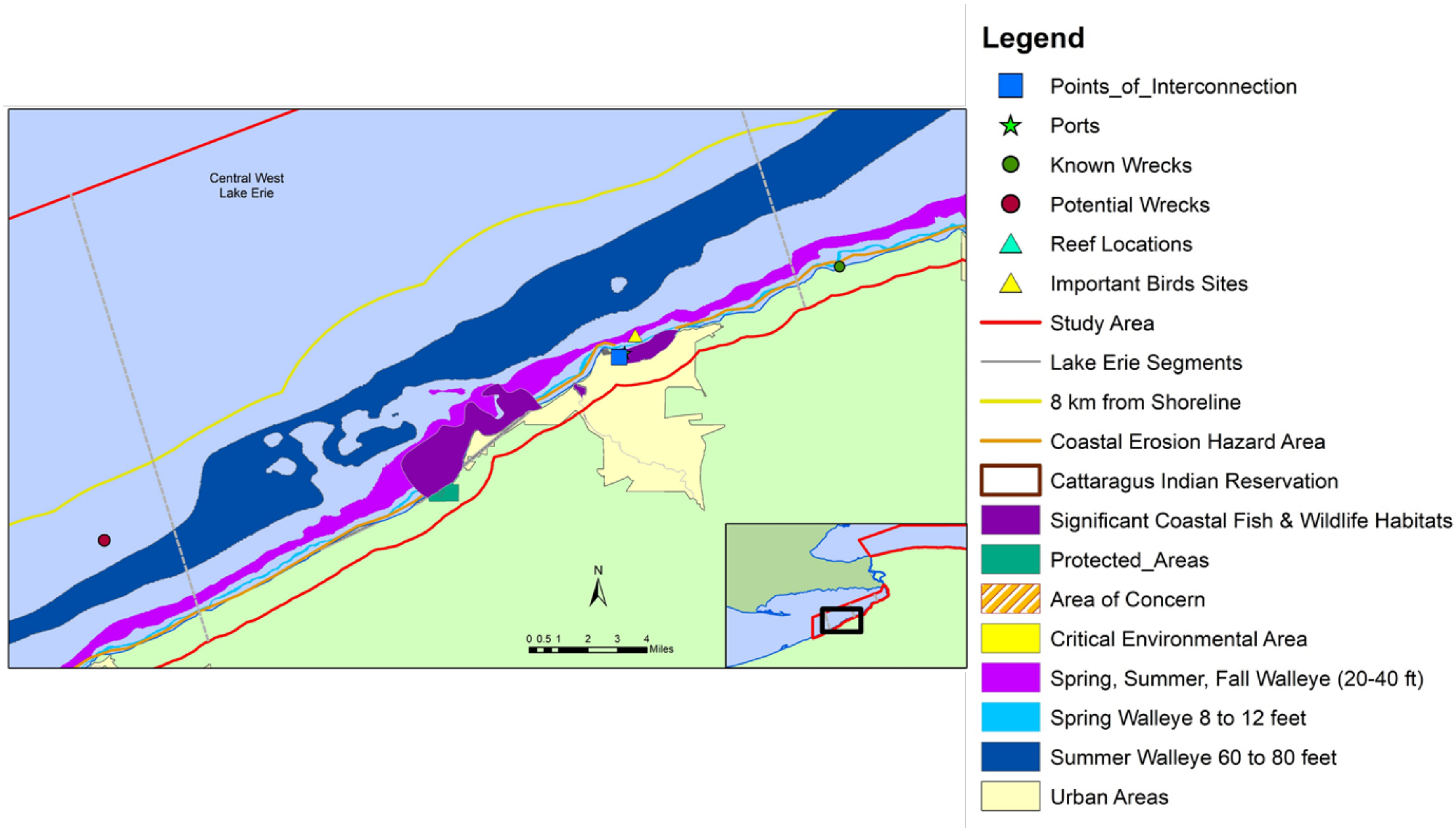


Figure 29. Central East Section of the Lake Erie Cabling Zone

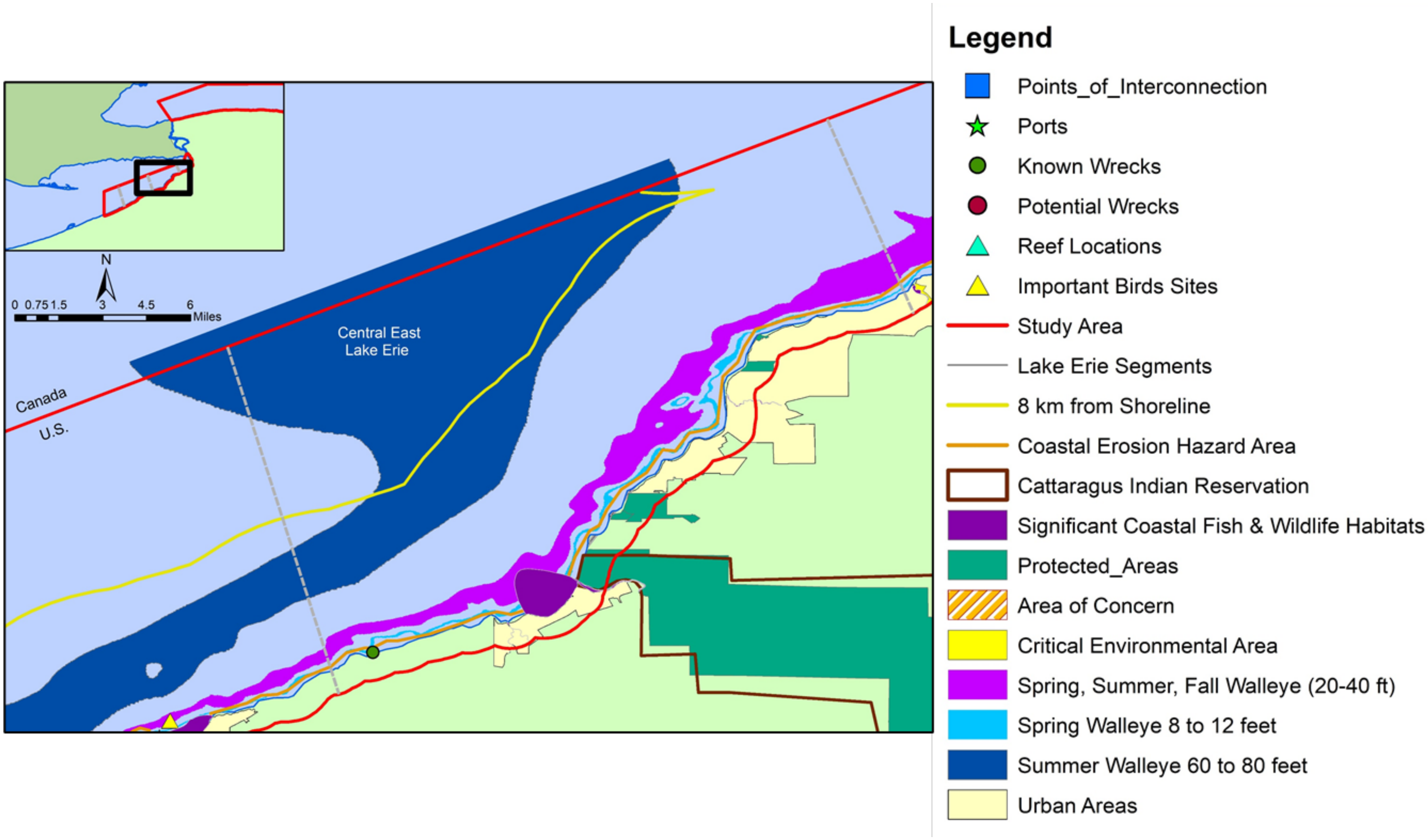
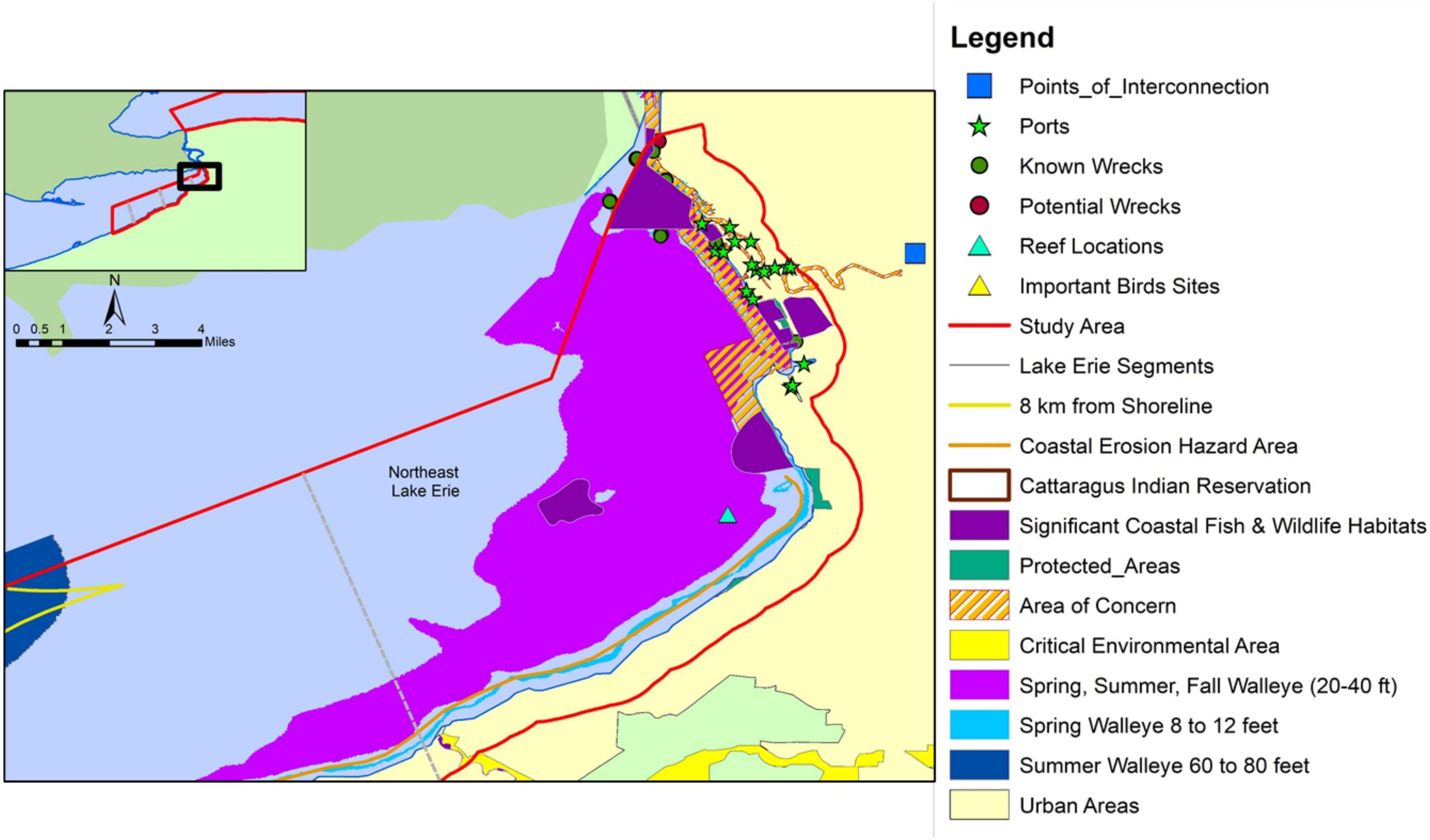


Figure 30. Northeast Section of the Lake Erie Cabling Zone



4.7 Relative Risks Conclusions

This section interprets the conclusions of the relative risk analysis based on the phased approach of identifying Great Lakes Wind Energy stressors, receptor groups that could be vulnerable, and collecting data and information to indicate where receptor groups are likely to be present and affected by Great Lakes Wind Energy.

4.7.1 Lake Ontario Relative Risks

Based on the available data regarding the receptors considered in this study, the area of least risk for turbine placement in Lake Ontario would likely be the central area of the lake southeast of the primary transit lanes (Figure 19). Although additional surveys may reveal more wrecks across Lake Ontario, at this time, the bulk of known and possible wrecks are identified in the eastern half of the lake. Although there are more wrecks in the central lake area than the western part of the lake, the western part of the lake includes vessel corridors that increase risk, as siting between vessel corridors may pose navigational hazards and siting northwest of the vessel corridors requires crossing the vessel corridors for construction and maintenance of turbines and for installation of cabling to potential POIs that have been identified in the study area. Although data were insufficient to map bird and bat distribution over Lake Ontario, it could be inferred from studies that the central lake area may also have less bird and bat interaction risk for turbines when considering preference for flying over areas with peninsulas and islands rather than open water.

Location of turbines will require consideration of other factors such as ice heights, geology, and substrates for foundations and/or moorings. Placing turbines within or north of the vessel corridors is the greatest risk because of those corridors. Otherwise, risk also increases for turbines moving eastward, with more wrecks and increased potential for bird and bat corridors nearer to islands and peninsulas. If turbines were placed between shore and the 16 km (10 mi) line, the risk profile would be similar, with least risk in the center, greater risk in the west, and greatest risk in the east, relative to the receptors considered here. Human use data, such as fisheries and tourism, have low resolution, as do data for benthic organism and fish distributions. Little is documented about bird and bat patterns over the lake. These factors cannot be well differentiated in terms of relative risk in Lake Ontario at this time.

With respect to cables to shore, the area of least risk for Lake Ontario would likely be the Southwest portion of the lake (Figure 20 and Figure 21). There are areas of coastal wetlands and SCFWH through the bulk of the eastern half of the lakeshore and additional wetlands concentrated in a portion of the

Central Lake area (Figure 22 and Figure 23). CEHA is very prevalent along the lakeshore, but there are breaks in this habitat outside of wetlands areas and dunes areas (represented by Piping Plover critical habitat), that reduce risk for cabling to shore at the westernmost POI (Figure 21). Other POIs have combinations of habitats that could be vulnerable to development (Figure 23 and Figure 24). POI choices will be related to the ultimate ability of the POI to receive the amount of power that will be produced, so although the westernmost POI area has less risk, other POIs can be reached by cable and developed, but more permitting or mitigation may be required at those sites. Islands and peninsulas on the eastern side of the lake create barriers and include important bird stopover areas with sensitive and important habitats for avian and terrestrial species, making this area the greatest risk for cabling to shore and shoreline infrastructure development. Although more wrecks may be discovered with additional surveys, the known and possible wrecks are concentrated in the eastern half of the lake, making cable laying likely to be more challenging on that side. Areas of submarine cable in the eastern and western parts of the lake create a potential barrier to burying cables that would cross pre-existing cables (Figure 21 and Figure 24).

In summary, based on the best available data at this time, when considering turbine placement (restricted to more than 16 km [10 mi] from shore) and cable laying in combination, turbines placed in the area of Lake Ontario south of the southernmost shipping lane to the east of the known and possible wrecks that have cables run to shore to connect at the westernmost POI in the study area would likely have the least impact to the resources considered here,. POI choice is driven mainly by ability to receive power, so were that POI to be infeasible for projects, additional mitigation for sensitive habitats and CEHA permitting could be applied to bring power to shore in other identified POI locations, with risk increasing for POIs moving eastward. Alternatively, POIs outside the study area, further inland, may be used with cables extending larger distances on land to reach those POIs.

4.7.2 Lake Erie Relative Risks

Based on the available data regarding the receptors considered in this study, the Central West area has the least risk overall, likely followed by the Southwest area, which has some increased risk over the Central West area due to the proximity to Long Point peninsula in Canadian waters where birds and bats may be more likely to cross the lake (Figure 25). The Central East area is higher risk because of the amount of area included in summer Walleye fishing. The Northeast area is less suitable because of spring, summer, and fall Walleye fisheries, SCFWHs, and a potential migratory bottleneck for birds and bats on the eastern side of the lake (Figure 30).

With respect to cables to shore, the area of least risk for Lake Erie would likely be within Central West Erie (Figure 28), which is relatively close to a potential POI and port in that area. If a POI were closer to the Southwest area, there is least conflict in that area. The Central West Erie area has a break in CEHA, which is not present in Southwest Lake Erie (Figure 27 and Figure 28). However, Central West Lake Erie has an Important Bird Area near the POI and a SCFWH directly east, but the POI is much closer to shore in that area than other Lake Erie POI, potentially reducing the land-based disturbance that would occur with cable landing and interconnection, and landing would not need to occur on the embayment where the Important Bird Area is located. CEHA is prevalent in Lake Erie, so most areas would require permits to pass a cable through such areas onto land. Areas of preferred fishing habitat for spring, summer, and fall Walleye are similar across the lake, with some expanded areas of fishing in the Central East area (Figure 26). There are few known wrecks to obstruct cables to shore. The Central East Lake Erie area includes the Cattaraugus Reservation, which increases the risk of development that could be in conflict with tribal uses, though there are no available to maps of specific patterns of human uses, aside from Walleye fishing areas. Cabling from a turbine site south of the Central East area could avoid overlap with summer Walleye fishing, but there are no nearby POIs in that area.

In summary, based on the best available data at this time, when considering turbine placement and cable laying, turbines placed more than 8 km (5 mi) from shore in the Central West part of the Lake with cables to shore at the POI near Central West Lake Erie would likely have the least impact related to the receptors considered here, followed by turbine placement in the Southwest part with cables to shore at the POI near Central West. POI choice is driven mainly by ability to receive power, so were that POI to be infeasible for projects, additional mitigation for sensitive habitats and CEHA permitting could be applied to bring power to shore in other identified POI locations, with risk increasing for POIs moving eastward. Alternatively, POIs outside the study area, further inland, may be used with cables extending larger distances on land to reach those POIs.

4.7.3 Comparison of Risk for Lakes Erie and Ontario

In the study area, both Lake Erie and Lake Ontario have lower risk associated with turbine placement away from areas that have peninsulas, islands, and short connections between land areas that can be migratory areas for birds and bats, and away from Walleye fishing habitat (in Lake Erie), reducing the suitability of the eastern and western areas of Lake Ontario and the eastern area of Lake Erie (the western area of Lake Erie does not border land but rather extends into Pennsylvania waters). There is also some heightened risk in the western part of the study area in Lake Erie because of proximity of the Long Point peninsula extending out from shore in Canada. Lake Ontario has substantively more known and possible wrecks that could affect turbine placement and configuration and cables among turbines and to shore for interconnection. Both lakes have a substantive portion of the coastline that is designated as CEHA, making it likely that permits and mitigation associated with erosion areas will be needed to bring cables to shore, though cables may be routed through areas without CEHA and continue on land to substations and POIs. This land-based approach could increase risk in the lakes and onshore because of additional cabling disturbance. CEHA itself is not necessarily a risk relative to cable crossings to shore, as engineering choices can minimize potential effects to coastal erosion and generally crossings are achieved through horizontal directional drilling under the ground, but the legal designation of CEHA could affect how cable-crossings are routed because permitting will likely be more difficult in CEHA. Few or low-resolution data are available to assess bird flight patterns, heights, and behavior; benthic organism and fish distribution; and distribution of human uses, such as fisheries, cultural uses, or recreation. Lake Ontario has more area in New York State in which wind projects could be distributed, but the potential sanctuary designation, wrecks and military activities, and vessel corridors within Lake Ontario may be considered to increase risk in this lake relative to Lake Erie; however, Lake Erie has an abutting reservation and would have challenges for siting large-scale projects as far from shore as is possible in Lake Ontario because of the relatively limited size of State submerged land area in Lake Erie.

Overall, based on environmental and human use conflict risk assessment, it is feasible to develop wind in either lake, but different constraints apply to each, and filling data gaps (section 4.5.1) and/or developing predictive models could help to reduce risk associated with receptors for which there are few or low-resolution data. This comparison does not consider physical factors that could affect feasibility, such as ice, depth, substrates, and geology.

4.7.3.1 Future and Ongoing Research

There are projects currently underway in the study area that should address some of the data gaps identified in section 4.5.1. The Great Lakes Acoustic Telemetry Observation System is currently being used to conduct multiple studies that could help inform fish species distribution, preferred habitat, and spawning locations. Another project is collecting data to determine the spatial (horizontal and vertical) home ranges for Salmonids in Lake Ontario (Larocque, et al. Accessed 2021). Another is determining the movement of stocked juvenile Lake Trout and the spawning behavior of Cisco in Lake Ontario

(Gorsky and Furgal Accessed 2021). A pilot project is being conducted to better understand the movements of data-poor fishes, such as Channel Catfish, Steelhead, and Brown Trout, in eastern Lake Erie to provide managers with more accurate fisheries knowledge (Robinson and Markham Accessed 2021). Both of these latter projects have completed data collection and are awaiting synthesis. These planned and ongoing projects will improve the spatial knowledge of home ranges for species', preferred habitat, and spawning locations.

Recent advances in the analysis of archived weather data using U.S. and Canadian weather satellites may provide a better understanding of broadscale migratory pathways for birds and bats around and across the Great Lakes (Lin, et al. 2019). These analyses use a new approach that relies on using convolutional neural networks and machine learning to disentangle bird and bat migration (as measured via historical weather radar data) from precipitation data, thereby allowing researchers to plot out historical seasonal migrations (Lin, et al. 2019). These data may also be useful in generating more accurate maps of stopover habitat in the Great Lakes region both during spring and fall migrations (Northeast Conservation Planning Atlas 2018).

U.S. Geological Survey and Pacific Northwest National Laboratory are also examining approaches to study bird flight behavior over the Great Lakes with intent to conduct studies that could inform Great Lakes Wind Energy development in general (beyond New York State). Data collected from existing offshore marine windfarms, such as Block Island, and pending windfarms could help inform risks to birds, fish, and other species, though care must be taken in drawing conclusions for Great Lakes based on marine environments.

4.8 Recommended Research

This section recommends various research studies to attempt to close the gaps detailed in section 4.5.1 to better understand how Great Lakes Wind Energy may affect receptors and how those effects may be mitigated.

4.8.1 Birds and Bats

Additional data from radar stations, acoustic detectors, thermal imaging, or radiotracking of birds and bats could provide a more complete picture of how species are migrating and foraging over the lakes. Understanding the altitude that species are migrating and foraging under different conditions in these areas would also be helpful for Great Lakes Wind Energy siting, were it to occur, as this may determine the risk that individuals face of entering the RSZ. This type of data could be used to develop more effective mitigation measures to limit collision mortality during specific weather events. Further analysis of prevailing air currents and preferred environmental and weather patterns for long-distance flights could help identify clade flight altitudes over lakes Ontario and Erie. Improved understanding of how migrations are affected by weather conditions, interannual variation, and time of year would also be beneficial. Radio-tracking studies of species which frequent open waters for large parts of the year (e.g., Long-tailed Ducks, Herring Gulls, Ring Billed Gulls, Common Terns, Least Terns [*Sternula antillarum*], Common Loons [*Gavia immer*], Double-crested Cormorants [Phalacrocorax auratus]) could be useful to provide improved understanding of where species are spending their time and understanding how they may interact with Great Lakes Wind Energy projects (Chapman and Parker 1985, Mallory, et al. 2006). Studies on the potential of turbine platforms to generate a reef effect and attract fish and other species may also be important for understanding their potential to impact waterbirds and gulls and terns (Langhamer 2012). Improved maps of the available stopover habitat based on land type and the location of major cliff ecosystems, which are important sites for raptors (Brambilla, et al. 2010, UMGLJV 2020), may improve the opportunity for fine-scale siting of cabling to shore.

Compared to birds, little is known about bats and how they use the Great Lakes area. Additional information on their movement patterns from radio-tracking studies and locations of their overwintering hibernacula would provide valuable information on their habitat use (Norquay, et al. 2013). Additionally, studies on how bats may interact with wind developments in the turbine zone may be warranted as bats have previously exhibited behaviors that put them at an increased risk of collision with wind projects (Cryana, et al. 2014). Bat prey may be attracted to turbines, which would potentially attract bats. Studies being conducted to assess bat activity in marine environments in association with offshore wind (Peterson 2020) could be useful for developing methodologies to study bats in the Great Lakes.

4.8.2 Invertebrates

In order to refine species distribution and identify an accurate likelihood of interaction for federal ESA and NYS ESA-listed mollusks, further shallow subtidal sediment sampling surveys could be conducted, and details on distribution could be made available in public domains. Bottom disturbance is a temporary stressor, and pending further assessment of benthic habitats, disturbed habitats may be able to be recolonized by surrounding species assemblages reasonably quickly if similar neighboring habitats exist. Invasive mussels are better studied in the Great Lakes than other benthos, but studies that address the question of how potential connectivity provided by new hard substrate and benthic disturbances could affect distribution and proliferation of invasive mussels would be useful to assessing offshore wind risks related to improving conditions for spread of these species.

4.8.3 Fish and Fisheries

Further research is recommended to identify how local species with swim bladders could be impacted by Great Lakes construction sound and particle motion in the freshwater environment. Increased spatial data on deep benthic habitats could aid in identifying the preferred habitat and the amount of benthic habitat that is needed to sustain the deep benthic fish communities and reduce wind siting risks. Potential for reef effects and which species may be attracted to new structures could also be useful, as would identification of species that may react to EMF, heat, or vibration from cables and studies to assess if typical sheathing and burial mitigation sufficiently address potential impacts from these stressors.

Studies would be helpful to develop more refined understanding of the distribution, effort, and fishery productivity of turbine zone fishing locations in both lakes. Identification and study of commercially, recreationally, and culturally important species would be informative.

4.8.4 Recreation, Indigenous Nations, and Historic/Cultural Areas

In addition to fisheries, other human uses also could benefit from more study, including distribution of cultural activities, recreational uses, and tourism. Socioeconomic studies and spatial planning actions can help inform differential distribution of these types of activities in the lakes to improve siting and mitigation measures.

5 Potential Mitigation Measures

This section provides tables of mitigation measures that could potentially be applicable or adapted to the potential Great Lakes Wind Energy projects. Mitigation tables were generated for each of four receptor groups: benthic organisms, birds and bats, fish, and fisheries. The diversity of these receptor groups ensures wide coverage of the mitigation measures potentially applicable to Great Lakes Wind Energy.

Not every impact can practicably be mitigated, so priorities related to the likelihood and severity of impacts and the vulnerability of receptors to population level consequences or long-term impairments (such as reduced fisheries access) need to be considered in choosing mitigation measures for Great Lakes Wind Energy if it moves forward. The study area has existing impairments, including water quality issues, invasive species, coastal erosion, and habitat loss that could potentially be considered in the context of offset mitigation measures. It is common for impacts to species like birds and bats to be addressed with offsets in terrestrial windfarms, along with directed mitigation measures, such as smart curtailments or lighting that reduces attraction and also meets FAA and other regulatory requirements. In addition, mitigation measures associated with the following are common mitigation measures in offshore wind plans and authorizations to date:

- Seasonal construction activities.
- Trenching and burying cables.
- Horizontal directional drilling and trenchless crossings for cable from water to land.
- Sound abatement measures (like bubble curtains) for pile driving.
- Distances from shore meant to limit visibility of turbines from shore.
- Notices to mariners.
- Configuration determinations in collaboration with Coast Guard and Department of Defense.
- Fisheries compensation.

Pre-construction and post-construction monitoring are often also included in planning and authorization requirements. Each project's unique location and equipment will help determine project-specific mitigation that will address the issues raised by the given project.

To develop the tables, a list of potential mitigation measures was generated using the Mitigation and Monitoring Practices (MMP) Tool developed by NYSERDA for offshore wind (NYSERDA 2020) and from input from NYS agencies. The MMP tool provides access to a searchable database containing

MMPs extracted from sources such as agency reports, environmental assessments, scientific literature, and technical guidance documents. To narrow the full MMP database to applicable MMPs for Great Lakes Wind Energy, filter categories were used within the MMP tool to retrieve mitigation measures specifically related to the stressors and receptor groups pertinent to the current study. A summary of filter criteria is shown in Table 32. The database was then queried to produce a list of mitigation measures that were each paired with applicable stressors and receptor groups. References for the source of each mitigation measure in Table 32 are included in section 8. Each mitigation measure was then analyzed for its applicability to the stressors specific to Great Lakes Wind Energy and to ensure data quality.

The MMP Tool primarily contains mitigation measures associated with environmental and fisheries resources but does not address user groups, such as the maritime industry or coastal habitats resources. The MMP tool is independent of this study, and stressors and potential impacts may differ for Great Lakes Wind Energy than for offshore wind. The terms and mitigations in the tables can be unique to individual offshore wind projects. This is a collection of mitigation measures used and proposed; this is not a recommendation as to which measures would be appropriate if Great Lakes Wind Energy moves forward. These measures are adapted from offshore wind measures, so additional measures specific to Great Lakes Wind Energy may be appropriate if such projects were developed (e.g., measures to address potential impacts to water supplies).

Table 32. Mitigation and Monitoring Practices Tool Mitigations Search Criteria

Filter Category	Search Terms
Generalized MMPs	Barriers, Compensation, Deterrence/Attraction Reduction, Engagement/Communication, Fisheries Safety, Lighting Alternatives, Limit an Activity, Shutdown/Low Power, Siting/Seasonality, Structure Configuration, Turbine Operation Parameters, Vessel Operation Parameters, Water Quality Management
Resources	Benthos, Birds & Bats, Fish, Fisheries
Stressors	Bottom Disturbance, Changes in Vessel Traffic, Effects to Fishery Target Species, EMF, Heat, Impaired Safe Fishery Access, Inadequate Infrastructure, Insufficient Communication, Light, Long-term Structures, Loss of Fishing Grounds, Scouring, Sound, Vibration, Water Quality Changes
Potential Effects	Attraction, Behavioral Disturbance, Change in Fishing Effort, Community Alteration/Invasive Species, Displacement, Habitat Fragmentation/Modification, Injury/Mortality, Loss of Revenue

Table 5 continued

Filter Category	Search Terms
Developmental Phases	Pre-Construction, Construction, Operation and Maintenance, Decommissioning
Industries	Offshore Wind
Sub-groups	All Bats, All Benthos, All Birds, All Fish, All Fisheries
Implementation Status	Field Tested, Implemented, Implemented and Evidence of Effectiveness, Not Implemented, Unknown
Mitigation/Monitoring	Mitigation
Mitigation Hierarchy	Avoidance, Minimization, Offset, Restoration

Because many of the environmental considerations and receptor groups are similar between marine and freshwater environments, these mitigations may be tailored to meet the needs of Great Lakes Wind Energy. This is a general review and does not suggest any particular mitigation measure is appropriate for a specific project nor is the intent to recommend that all measures be applied at once or in the same manner across projects. Any changes to language from the original MMP Tool output to focus on Great Lakes rather than marine environments are noted in brackets. Table 33 describes mitigation for potential impacts to benthic organisms; Table 34 describes mitigation for potential impacts to birds and bats, Table 35 describes mitigation for potential impacts to fish, and Table 36 describes mitigation for potential impacts to fisheries.

Table 33. Mitigation for Potential Impacts of Great Lakes Wind Energy on Benthic Organisms

Stressors	Potential Impacts	Mitigation	Citations
Water quality Changes	Behavioral Disturbance	Use of dynamic-positioning vessels and jet plow embedment to minimize sediment disturbance and alteration during cable-laying processes.	Deepwater Wind 2012; Rhode Island Coastal Resources Management Council 2010
EMF, Vibration, Heat, Bottom Disturbance	Behavioral Disturbance, Displacement, Attraction, Habitat Fragmentation/Modification	Burial of cables and cable sheaths/armor.	BOEM 2011; BOEM 2016a; BOEM 2016c; Deepwater Wind 2012; Taormina et al. 2018
Long-Term Structures	Displacement, Attraction, Habitat Fragmentation/Modification, Community Alteration/Invasive Species	Creation of new habitat on and near structures to offset habitat fragmentation/modification (e.g., artificial reefs).	Anderson et al. 2009; BOEM 2016a; BOEM 2016c; Guernsey Renewable Energy Team 2011; Langhamer 2012; Wilhelmsson et al. 2010
Sound	Behavioral Disturbance, Injury/Mortality	Incorporate the use of sound-reduction technologies in construction, such as soft-start methods during pile driving.	BOEM 2016a; BOEM 2016c; Caltrans 2015; Deepwater Wind 2012; Gartman et al. 2016; USACE 2014; Weilgart 2018; Wilhelmsson et al. 2010

Table 33 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures	Habitat Fragmentation/Modification, Injury/Mortality	Expansion of "no take zone" within/around windfarms to further enhance the positive benefits for fish and invertebrate stocks and habitat.	Ashley et al. 2014; Langhamer 2012; Wilhelmsson et al. 2010
Sound	Behavioral Disturbance, Injury/Mortality	Avoid the use of explosives during construction.	BOEM 2016a; BOEM 2016c
Scouring, Long-Term Structures	Displacement, Attraction, Habitat Fragmentation/Modification, Community Alteration/Invasive Species	Scouring protection and periodic routine inspections to ensure structural integrity. Scouring protection examples include boulders, gravel, and scour mats.	BOEM 2016a; BOEM 2016c; Hansen et al. 2007; MMS 2007; USACE 2014; Whitehouse et al. 2011; Wilhelmsson et al. 2010
Water quality Changes	Behavioral Disturbance, Injury/Mortality, Community Alteration/Invasive Species	Plans for potential spills, contaminated sediments, and other project- or site-specific emergency protocols.	BOEM 2016b; Deepwater Wind 2019; MMS 2007; Rhode Island Coastal Resources Management Council 2010
EMF, Vibration, Heat, Bottom Disturbance	Behavioral Disturbance, Displacement, Attraction, Habitat Fragmentation/Modification	Choices in current flow, cable configuration and orientation, and distances between cables.	BOEM 2011; BOEM 2015; BOEM 2016a; BOEM 2016c; Öhman et al. 2007
Bottom Disturbance	Injury/Mortality	Avoid anchoring on sensitive seafloor habitats.	BOEM 2016a; BOEM 2016c
Scouring, Long-Term Structures, Bottom Disturbance	Displacement, Habitat Fragmentation/Modification, Injury/Mortality	Scour protection devices should use midline buoys on anchor sweeps to minimize negative benthic impacts from anchor line sweeps.	BOEM 2015
Bottom Disturbance	Injury/Mortality, Habitat Fragmentation/Modification	Use of drilling muds during deep geotechnical borings. Use of biodegradable drilling muds and use of on-board drilling mud containment systems.	NYSDOS
Bottom Disturbance	Injury/Mortality, Habitat Fragmentation/Modification	Use mid-line floats on moored met buoys to minimize anchor sweep on the benthos ecosystems.	NYSDOS
Sound, Water quality Changes, Bottom Disturbance	Behavioral Disturbance, Injury/Mortality	Construction activity windows based on species-specific spawning, migration behaviors, and other key life stages on a project-specific basis.	BOEM 2015; BOEM 2016a; BOEM 2016c; Gartman et al. 2016; Guernsey Renewable Energy Team 2011; Taormina et al. 2018; Weilgart 2018; Wilhelmsson et al. 2010
EMF, Vibration, Heat	Behavioral Disturbance, Displacement, Habitat Fragmentation/Modification	Utilize two or more parallel cables in each cable route with electric currents running in opposite directions to minimize electromagnetic field (EMF).	BOEM 2015; Öhman et al. 2007; SeaPlan 2015

Table 33 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Scouring, EMF, Vibration, Heat, Bottom Disturbance	Displacement, Attraction, Habitat Fragmentation/Modification, Community Alteration/Invasive Species	Site and assess development areas prior to activity to reduce potential impacts on known sensitive seafloor habitats and species (including mobile species) and those of ecological interest.	Deepwater Wind 2012; Deepwater Wind 2019; Guernsey Renewable Energy Team 2011; Rhode Island Coastal Resources Management Council 2010; Southeast Florida Coral Reef Initiative 2008; Taormina et al. 2018
Long-Term Structures	Habitat Fragmentation/Modification, Injury/Mortality	Strategically locate windfarms to protect certain marine resources (via fisheries exclusion zones), as long as the disturbance effects of construction and operation do not outweigh/neutralize the advantages of limited/exclusion of commercial fishing.	BOEM 2016a; BOEM 2016c; Guernsey Renewable Energy Team 2011; Wilhelmsson et al. 2010

Table 34. Mitigation for Potential Impacts of Great Lakes Wind Energy on Birds and Bats

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures	Injury/Mortality	Use post-construction monitoring data to inform repowering plans, e.g., revise windfarm layout, decommission problematic turbines or areas, etc.	Marques et al. 2014
Long-Term Structures	Injury/Mortality	Implement curtailment based on interpolated model of temporal patterns of bird use in the area (observations per day). By understanding daily/seasonal patterns in bird presence and counts, one can identify days with the highest risk of collision and curtail operations during those periods.	Singh et al. 2015
Long-Term Structures	Attraction, Injury/Mortality	Create artificial nesting, roosting, or feeding platforms outside the windfarm to attract birds and bats away from turbines.	Gartman et al. 2016a; Langston 2013; Marques et al. 2014; May et al. 2017
Long-Term Structures, Changes in Vessel Traffic	Displacement	Construction should be implemented in phases, with phase 2 commencing only once the licensing authority was satisfied there was no significant impact to marine birds.	BOEM 2017
Long-Term Structures, Scouring, Changes in Vessel Traffic, Bottom Disturbance	Habitat Fragmentation/Modification, Community Alteration/ Invasive Species	Close industrial fisheries to offset windfarm impacts to marine birds and their prey/habitat	Gartman et al. 2016a
Long-Term Structures	Injury/Mortality	Curtailment or temporary turbine shutdown to avoid collision events.	May et al. 2017
Long-Term Structures	Injury/Mortality	Raising rotors (e.g., having blades higher above sea level) may be effective as most birds are flying near the water's surface under most circumstances.	Cook et al. 2011

Table 34 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures	Attraction, Injury/Mortality	Reduce perching through the installation of structural deterrents (i.e. perch guards, wires, spikes, and electrical tracks) particularly on horizontal structures within the rotor-swept area.	Clarke 2004; Cook et al. 2011; Curry and Kerlinger 1998
Long-Term Structures, Scouring, Changes in Vessel Traffic, Bottom Disturbance, Sound, Light	Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species	Eradicate invasive species/predators to offset windfarm impacts on marine birds and their prey/habitat.	Gartman et al. 2016a
Long-Term Structures	Injury/Mortality, Community Alteration/Invasive Species, Displacement, Habitat Fragmentation/Modification, Behavioral Disturbance	Compensation via in-kind habitat conservation, also known as biodiversity offsets; involves habitat expansion, creation or, restoration including breeding, roosting, and wintering sites.	Arnett and May 2016; CEC 1992; Lüdeke 2017; Peste et al. 2015
Sound, Changes in Vessel Traffic	Behavioral Disturbance, Displacement	Construction window should avoid predicted periods of high abundance of birds and bats on the site.	BOEM 2017; USDA 2012a; Vaissière et al. 2014
Sound, Water quality Changes, Changes in Vessel Traffic, Bottom Disturbance	Displacement	Cause temporary habitat loss of no more than 1% of a population's habitat area.	Lüdeke 2017
Long-Term Structures	Injury/Mortality	Use repowering to constrain growth or reduce the number of wind turbines per unit area, especially in core use areas for birds.	Grunkorn et al. 2016
Long-Term Structures	Behavioral Disturbance, Displacement, Attraction, Habitat Fragmentation/Modification, Injury/Mortality, Community Alteration/ Invasive Species	Implement mitigation measures according to the prioritized steps of the mitigation hierarchy (avoid during siting/planning, minimize during project design, reduce impacts as much as possible during construction/operations, compensate for unavoidable impacts, and restore area as much as possible during decommissioning).	May et al. 2017
Sound, Light, Changes in Vessel Traffic, Bottom Disturbance	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality	Time construction and routine maintenance activities to avoid sensitive avian life history periods (breeding, migration).	Cook et al. 2011; Eshleman and Elmore 2013; Langston 2013
Light	Behavioral Disturbance, Attraction, Injury/Mortality	Area and work lighting should be limited to the amount and intensity necessary to maintain worker safety.	BOEM 2013

Table 34 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Light, Changes in Vessel Traffic, Sound	Injury/Mortality, Habitat Fragmentation/Modification, Community Alteration/Invasive Species, Displacement, Behavioral Disturbance	Compensation through out-of-kind solutions to enhance populations by acting on biological parameters that influence population levels including (1) habitat expansion, (2) prey fostering, (3) predator control, (4) exotic/invasive species removal, (5) species reintroductions/resettlement, and (6) supplementary feedings.	Arnett and May 2016; Lüdeke 2017; Marques et al. 2014
Long-Term Structures	Injury/Mortality	Auditory deterrents: Acoustic whistle cue in the best hearing range for birds (2-4 kHz) to help birds hear the turbine blades to avoid collision.	Dooling 2002
Long-Term Structures	Attraction, Injury/Mortality	Use of feeding stations to attract birds away from dangerous areas.	Cook et al. 2011
Long-Term Structures	Displacement	Take into account prevailing wind and bird flight paths to minimize barrier effects when designing layout of turbines.	Vaissière et al. 2014
Long-Term Structures	Injury/Mortality	Use a framework for balancing costs and benefits of curtailment for reducing bird mortality that would allow curtailment strategies to be assessed for current or proposed windfarms.	Singh et al. 2015
Light	Behavioral Disturbance, Attraction, Injury/Mortality	Use flashing lights instead of steadily burning lights or strobe lights, whenever possible.	Cook et al. 2011; Evans et al. 2007; Gartman et al. 2016a; Gehring et al. 2009; Kerlinger et al. 2010
Light	Behavioral Disturbance, Attraction, Injury/Mortality	Increase visibility/decrease attraction through use of different color lights.	Cook et al. 2011
Sound, Light, Changes in Vessel Traffic, Bottom Disturbance	Behavioral Disturbance, Displacement	Preclusion of construction activity near breeding territories and/or during the breeding season.	May et al. 2015
Long-Term Structures	Attraction, Injury/Mortality	Efforts to reduce insect abundance around towers could help reduce risk of collision for bats. Methods could include painting turbine blades.	Ahlen et al. 2007; Arnett and May 2016
Long-Term Structures	Injury/Mortality	Use collision risk modeling to determine periods of high risk when turbine shutdown should occur.	Marques et al. 2014
Long-Term Structures	Displacement, Habitat Fragmentation/Modification, Injury/Mortality	Arrange turbines in clusters or rows (clusters recommended to promote avoidance by waterfowl at offshore facilities).	Arnett and May 2016; Drewitt and Langston 2008; Eshleman and Elmore 2013; Gartman et al. 2016b; Masden et al. 2012

Table 34 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Light	Injury/Mortality	Implement a collision-avoidance program that includes (1) continuously monitoring migration intensity and direction by radar and measuring fog, drizzle, precipitation, cloud cover, visibility, and wind; and (2) installing an audio system in order to have an instantaneous automatic collision risk indicator, which in turn can be used for mitigation such as temporary shutdown.	Hüppop and Hilgerloh 2012
Long-Term Structures	Injury/Mortality	Temporary shutdown during peak migration, which could include shutdown only of turbines directly in migration path.	Cook et al. 2011
Light	Behavioral Disturbance, Attraction, Injury/Mortality	Minimize use of artificial lighting on structures and vessels to the extent allowable based on aviation and maritime safety limitations.	BOEM 2013; Cook et al. 2011; Drewitt and Langston 2008; Gartman et al. 2016a; Langston 2013; Lüdeke 2017; Miles et al. 2010; Schuster et al. 2015; USFWS 2015
Long-Term Structures	Injury/Mortality	Curtailment during high-risk periods for species determined based on season, weather conditions, temperature, wind speed, or other timing/environmental variables. Offshore high-risk conditions include during mass migration, poor weather, at night, during periods with high flight activity (for windfarms near breeding colonies), during certain seasons/wind directions, and in relation to species-specific activity patterns.	Arnett et al. 2008; Gartman et al. 2016a; Horn et al. 2008; Hüppop et al. 2006; Langston 2013; Marques et al. 2014; Martin et al. 2013
Long-Term Structures	Injury/Mortality	Place few or no additional turbines within crucial core areas for breeding and staging birds.	Grunkorn et al. 2016
Long-Term Structures	Displacement, Habitat Fragmentation/Modification, Injury/Mortality	Reduce adverse effects by avoiding siting turbines in areas of high bird usage or known feeding, staging, or loafing locations, as well as other sites where birds are known to concentrate, or particular high-risk topographical features.	Henderson et al. 1996; Langston 2013; Larsen and Guillemette 2007
Long-Term Structures	Displacement, Behavioral Disturbance, Injury/Mortality	Design turbine layout to include gaps in turbines to act as corridors for bird movement. These corridors need to be several km wide in order to be effective.	Arnett and May 2016; Drewitt and Langston 2006; Gartman et al. 2016b; Tulp et al. 1999
Sound, Changes in Vessel Traffic, Bottom Disturbance	Behavioral Disturbance, Displacement	Sequence piling and turbine erection in a direction to minimize effect on nearby [bird] colonies during the breeding season.	BOEM 2017
Long-Term Structures	Injury/Mortality	Design windfarm to include decoys (towers, conspecifics) at the end of turbine lines to deter perching activities on turbines. This could include the use of substations.	Cook et al. 2011; Marques et al. 2014; May et al. 2015

Table 34 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures	Behavioral Disturbance, Displacement, Injury/Mortality	Configure turbines to avoid alignment perpendicular and favoring parallel alignment to main flight paths of birds.	Arnett and May 2016; Drewitt and Langston 2006; Gartman et al. 2016b; Tulp et al. 1999
Long-Term Structures	Injury/Mortality	Mitigation approaches should be adapted for each project. Factors contributing to collision risk include species characteristics (morphology, sensorial perception, phenology, behavior, and abundance), site (landscape, flight paths, food availability, and weather), and windfarm features (turbine type and configuration, and lighting).	Marques et al. 2014
Long-Term Structures	Injury/Mortality	Cause no more than 1% additional annual mortality in migratory birds.	Lüdeke 2017

Table 35. Mitigation for Potential Impacts of Great Lakes Wind Energy on Fish

Stressors	Potential Impacts	Mitigation	Citations
Sound	Behavioral Disturbance, Displacement, Injury/Mortality	Use of sound-reducing techniques during construction such as soft start methods, and other sound-reducing materials.	BOEM 2015b; BOEM 2016b; Caltrans 2015; Deepwater Wind 2012; Gartman et al. 2016; Guernsey Renewable Energy Team 2011; Lucke et al. 2014; SeaPlan 2015; USACE 2014; Wilhelmsson et al. 2010
Changes in Vessel Traffic	Behavioral Disturbance, Displacement, Injury/Mortality	Gather information from [fisheries managers regarding] existing aerial surveys, necropsies, research vessel observations, and existing vessel traffic to minimize potential impacts on marine life due to vessel traffic increases.	BOEM 2018; Deepwater Wind 2019
Sound	Injury/Mortality, Behavioral Disturbance, Displacement	Noise modeling to assess pile-driving sound levels produced over an area to assess likelihood of exposing protected species to impacts.	Andersson et al. 2017; BOEM 2018
Sound	Injury/Mortality, Behavioral Disturbance, Displacement	Conduct a cost-benefit analysis for pile-driving activities. The analysis should consider the lifetime of turbine foundation needs when frequent stoppages cause equipment fatigue due to fish and wildlife presence.	BOEM 2018
Bottom Disturbance	Habitat Fragmentation/ Modification	Where possible, habitat that is disrupted should be restored to preconstruction conditions.	BOEM 2016d; Lüdeke 2015

Table 35 continued

Stressors	Potential Impacts	Mitigation	Citations
Sound, Water quality Changes, Long-Term Structures, Scouring, EMF, Vibration, Heat, Light, Changes in Vessel Traffic, Bottom Disturbance	Behavioral Disturbance, Displacement, Attraction, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/Invasive Species, Change in Fishing Effort, Loss of Revenue	Development and implementation of communication and outreach plans.	BOEM 2014b; BOEM 2015a; BOEM 2016b; BOEM 2016d; Lipsky et al. 2016; Rhode Island Coastal Resources Management Council 2010
Long-Term Structures, Water quality Changes	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification	Design turbine layouts to minimize contiguous barriers that could restrict normal waterbody flow, larvae, eggs, or other planktonic resources and/or interrupt migration routes.	BOEM 2015b
Bottom Disturbance	Habitat Fragmentation/ Modification	Provide construction and maintenance work vessel operators with detailed maps that identify sensitive habitat areas to minimize anchoring.	BOEM 2015b; BOEM 2016c
Water quality Changes	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality	Plans for potential spills, contaminated sediments, and other project- or site-specific emergency protocols.	BOEM 2014b; BOEM 2015b; BOEM 2016b; Deepwater Wind 2019; MMS 2007; Rhode Island Coastal Resources Management Council 2010; USACE 2014
Sound	Behavioral Disturbance, Displacement, Injury/Mortality	Avoid the use of explosives during construction.	BOEM 2016a; BOEM 2016c
Sound, Long-Term Structures, Water quality Changes, Scouring, Bottom Disturbance	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality	Construction activity windows based on species-specific spawning and migration behaviors on a project-specific basis.	BOEM 2014a; BOEM 2015b; BOEM 2016a; BOEM 2016c; BOEM 2016d; BOEM 2018; Gartman et al. 2016; SeaPlan 2015; Taormina et al. 2018; Wilhelmsson et al. 2010
Long-Term Structures	Displacement, Attraction, Habitat Fragmentation/ Modification, Community Alteration/ Invasive Species	Enhance shellfish and finfish stocks via transfer of hatchery or wild juveniles or mature animals to windfarm areas.	Buck et al. 2008; SeaPlan 2015

Table 35 continued

Stressors	Potential Impacts	Mitigation	Citations
Bottom Disturbance, Long-Term Structures	Habitat Fragmentation/ Modification	Developers are recommended to design improvements to fishery habitat such as creation and/or encouragement of artificial reefs or reef patches to enhance fishery production.	Anderson et al. 2009; BOEM 2016d; Guernsey Renewable Energy Team 2011; Langhamer 2012; SeaPlan 2015; Wilhelmsson et al. 2010
Bottom Disturbance	Behavioral Disturbance, Displacement, Injury/Mortality	Seismic survey mitigation and monitoring strategies should be reviewed for consideration of creating alternative monitoring plan minimum requirements.	BOEM 2018; Carroll et al. 2017
EMF, Vibration, Heat	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification	Proper cable burial at a depth sufficient to create a physical barrier between cables and electromagnetic field (EMF)-sensitive species to minimize impact.	BOEM 2014b; BOEM 2015b; Deepwater Wind 2012; SeaPlan 2015; Taormina et al. 2018
Long-Term Structures, Scouring	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality	Site and assess development areas prior to activity to reduce potential impacts on known sensitive seafloor habitats and species.	BOEM 2015b; BOEM 2016a; Deepwater Wind 2012; Deepwater Wind 2019; Gartman et al. 2016; Rhode Island Coastal Resources Management Council 2010; Taormina et al. 2018; USACE 2014
EMF, Vibration, Heat	Behavioral Disturbance, Displacement, Habitat Fragmentation /Modification	Use of proper electrical shielding on cables to minimize electromagnetic fields (EMF), vibrations, and heat.	BOEM 2011; BOEM 2016a; BOEM 2016c; CMACS 2003; Taormina et al. 2018
Long-Term Structures, EMF, Vibration, Heat, Changes in Vessel Traffic	Behavioral Disturbance, Displacement, Attraction, Community Alteration/ Invasive Species, Habitat Fragmentation/ Modification	Data transparency and sharing.	BOEM 2015b; BOEM 2016b; BOEM 2016d; BOEM 2018; Lipsky et al. 2016; MAFMC 2014; Rhode Island Coastal Resources Management Council 2010
Water quality Changes, Bottom Disturbance	Behavioral Disturbance, Displacement	Use of dynamic-positioning vessels and jet plow embedment to minimize sediment disturbance and alteration during cable-laying processes.	BOEM 2015b; Deepwater Wind 2012; Rhode Island Coastal Resources Management Council 2010

Table 35 continued

Stressors	Potential Impacts	Mitigation	Citations
Scouring	Behavioral Disturbance, Displacement	Evaluate scour and sedimentation potential through pre-activity modeling.	Black 2008; BOEM 2014a
Scouring	Behavioral Disturbance, Displacement	Use of scour protection such as rock mattresses, boulders, grout bags, and grass mattresses.	BOEM 2015b; BOEM 2016a; BOEM 2016c; Hansen et al. 2007; MMS 2007; USACE 2014; Whitehouse et al. 2011; Wilhelmsson et al. 2010

Table 36: Mitigation for Potential Impacts of Great Lakes Wind Energy on Fisheries

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Scouring, Effects to Fishery Target Species	Habitat Fragmentation/ Modification, Community Alteration/ Invasive Species	Platform Design Considerations. It is recommended that the developer use materials and turbine platform designs that are conducive to minimizing negative impacts.	BOEM 2015b; NYSERDA 2017
Impaired Safe Fishery Access, Changes in Vessel Traffic	Change in Fishing Effort	In general, development of [Great Lakes] energy structures or windfarms should not prejudice the safe use of Traffic Separation Schemes, Inshore Traffic Zones, and recognized sea lanes, or safe access to anchorages, harbors, and places of refuge. Buffer zones could be placed around existing uses. If an offshore wind energy facility is sited in an area of high commercial and recreational use, it may be feasible to permit access to vessels of a suitable size, draft, and use. For example, at the Nysted Windfarm located offshore of Denmark, regulations permit sailing through the windfarm. Anchoring, however, is not permitted due to the presence of transmission cables on the seabed. Similarly, docking at the turbines or transformer platform is not permitted due to safety concerns.	BOEM 2012; IFC 2012; MMS 2007
Long-Term Structures	Change in Fishing Effort, Habitat Fragmentation/ Modification	Enhancement of fishing in the offshore wind facility area and/or other nearby locations through measures such as the establishment of public mooring buoys and turbine foundations designed to enhance fishery production.	BOEM 2014a
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	Lessees shall conduct all necessary studies of potential interference of proposed wind turbine generators with commercial air traffic control radar systems, national defense radar systems, and weather radar systems, including identification of possible solutions.	MMS 2007

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Changes in Vessel Traffic, Insufficient Communication	Loss of Revenue, Change in Fishing Effort	It is recommended that the developer create a communication protocol or a point of contact for communicating real-time hazards or emergencies to fishing vessels (centralized entity, channel for disseminating information – Vessel Monitoring System, text, smart phone apps, etc.). The protocol should designate the emergency response organization and identify the roles and responsibilities of individuals and agencies tasked with implementing the plan.	BOEM 2014a; BOEM 2016a; NYSERDA 2017
Impaired Safe Fishery Access, Insufficient Communication	Change in Fishing Effort	Use of a vessel monitoring system, such as Boatracs in the northeast Atlantic Ocean that can send and receive emails to notify people fishing of important issues.	BOEM
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	All vessels shall comply with the International Maritime Organization standards for the marine environment.	IMO
Impaired Safe Fishery Access	Loss of Revenue	It is recommended that the developer design the offshore windfarm(s) to augment current safety and emergency practices, e.g., provide helipad, provide safety ladders painted in contrast color of tower, add cell tower and VHF (very high frequency) functions to turbines, etc. It is recommended that the developer provide tie-offs to the tower or at least nearby mooring buoys (most emergencies are mechanical).	BOEM 2014a; BOEM 2016a; BOEM 2021; MAFMC 2014; NYSERDA 2017
Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Coordinate with [fisheries representatives] and engage the appropriate [managers] regarding fishing effort reduction measures such as permit banking and vessel and permit buyback programs. The idea of a buy-out program is most commonly used to reduce fishing effort in specific fisheries such as the Alaskan crab fishery and the groundfishery in Morro Bay. Buy-outs have also been used to compensate fisheries displaced by the establishment of Marine Protected Areas in Australia. This concept may have applications in terms of compensating fisheries displaced by offshore renewable energy projects. Some noted that the amount of money needed to truly compensate for the losses felt in the short-term as well as the long-term would be higher than what they believe they would actually be paid. They also noted that fairness will be difficult to achieve in a direct buy-out situation.	BOEM 2012; BOEM 2014a; Squires 2010

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Impaired Safe Fishery Access, Water quality Changes	Displacement, Injury/Mortality, Loss of Revenue	Emergency Planning. It is recommended that the developer develop and conduct training and emergency readiness drills to prepare for emergency situations. Standards and procedures for generator shutdown and other operational requirements should be developed to deal with search and rescue, counter pollution, or salvage operations in or around an installation.	BOEM 2012; BOEM 2014a; BOEM 2016a; BOEM 2021; MAFMC 2014; NYSERDA 2017
Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	It is recommended that developers promote a knowledge exchange within the fishing industry and between the fishing industry and developers to support existing fishing opportunities and development of new opportunities.	Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Bottom Disturbance, Sound, Insufficient Communication	Displacement, Injury/Mortality, Change in Fishing Effort, Loss of Revenue	Early communication between the lessee and fishing community before development of preconstruction survey/site monitoring plans to avoid, minimize, or mitigate impacts during site characterization and assessment activities. This includes minimization of the area disturbed by preconstruction site monitoring and testing activities.	BOEM 2015a; Lipsky et al. 2016; MMS 2007
Changes in Vessel Traffic, Inadequate Infrastructure	Change in Fishing Effort, Loss of Revenue	It is recommended that developers install biodiesel-production units at ports to reduce the use of conventional diesel; this would facilitate the development of sustainable fishing industry practices. The developer could use fish waste by-products for raw material, which, in-turn, could result in reduced fuel costs for both the fishing industry and developers.	Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access, Insufficient Communication	Change in Fishing Effort	Radio Navigational Warnings and Notices to Mariners can be issued before and during offshore windfarm construction.	BOEM 2012; BOEM; Deepwater Wind 2019
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	All vessels shall comply with the International Maritime Organization maritime safety standards for radio communication and search and rescue.	IMO
Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	Avoiding the siting of offshore renewable energy facilities in high-use fishing grounds.	BOEM 2012; BOEM; Smythe et al. 2016
Long-Term Structures, Impaired Safe Fishery Access, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	During the earliest planning stages of offshore wind facility development, the lessee will meet with the local fisheries groups most likely to be affected by the project for input on the following: wind facility configuration, including size, spacing, and access route planning; minimization of scour and sedimentation; minimization of turbidity; cable route planning, installation, and removal techniques; and dockside facility coordination.	BOEM 2014b; BOEM 2016a; Lipsky et al. 2016; MAFMC 2014; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	Establish guidelines that specify when, where, and how exclusion zones can be established.	BOEM 2016a; NYSERDA 2017
Impaired Safe Fishery Access, Insufficient Communication	Change in Fishing Effort	Use of a dedicated VHF channel for the transmission of any warnings related to local renewable energy projects.	BOEM; Deepwater Wind 2018
Impaired Safe Fishery Access, Insufficient Communication	Change in Fishing Effort	Outreach to the fishing community to inform mariners of ways to identify and avoid hazards when traveling in the vicinity of offshore wind energy projects.	BOEM 2012; BOEM
Impaired Safe Fishery Access, Loss of Fishing Grounds, Changes in Vessel Traffic	Change in Fishing Effort, Loss of Revenue	Lessees and grantees shall review planned activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts. Lessees and grantees shall minimize conflict with fishing activity and gear by notifying state and [local] fishery management organizations and local fishing groups of the location and timeframe of the project construction activities well in advance of the mobilization and with updates throughout the construction period.	BOEM 2014b; BOEM 2016a; Gray et al. 2016; MMS 2007; Moura et al. 2015; NYSERDA 2017
Sound, Water quality Changes, EMF, Vibration, Heat, Bottom Disturbance, Effects to Fishery Target Species, Loss of Fishing Grounds, Long-Term Structures, Impaired Safe Fishery Access	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Change in Fishing Effort, Loss of Revenue	Highly valued grounds should be disrupted as little as possible at those times of year that provide the best fishing opportunities and during vulnerable times for the species (i.e., during spawning and foraging).	BOEM 2012; BOEM 2014b; BOEM 2016a; BOEM 2021; NYSERDA 2017
Impaired Safe Fishery Access, Inadequate Infrastructure	Loss of Revenue, Change in Fishing Effort	Provide updated vessel and personal safety equipment to fisheries. It is recommended that developers provide vessel and personal safety equipment for those operating in or near a windfarm site. This may include radar, global positioning systems, life rafts, and emergency position-indicating radio beacon and floatation suits, or possibly the developer may provide the necessary funds for updating equipment that may be procured from developers through low-interest loans or grants. This measure could address some of the safety concerns about operating around offshore wind facilities.	BOEM 2012; BOEM 2014a; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species	Change in Fishing Effort, Loss of Revenue, Habitat Fragmentation/ Modification, Community Alteration/ Invasive Species	To the extent it addresses issues that are outside the current scope of [existing] research agendas, financial or other support for research activities might be warranted as an indirect mitigation strategy. Examples in the fisheries context include developing a better understanding of how to prevent parasites in aquaculture efforts, identifying causes of decline in certain target species not affected by offshore renewable energy projects, and understanding the impacts of certain harvesting technologies with an eye toward reducing those impacts through technological innovations. Results from such research opportunities could enhance fishing in sectors that absorb any displaced fishing effort that might result from the construction of offshore renewable energy facilities. In addition to producing useful science, research activities may also present opportunities to engage displaced people who possess skills useful in ocean-based research (e.g., familiarity with fishing gear, ability to safely navigate a vessel, etc.).	BOEM 2012
Impaired Safe Fishery Access, Inadequate Infrastructure	Change in Fishing Effort, Loss of Revenue	Maintaining vessels for safe and efficient use can be costly to vessel owners and is required for all active fishing boats. Using mitigation funds to support the maintenance of these vessels might not only reduce expenses of boat owners, but also increase boats' capacities to safely maneuver in the vicinity of the offshore renewable energy projects. Maintenance support will also benefit the industries responsible for maintaining the fleets.	BOEM 2012
Long-Term Structures, Impaired Safe Fishery Access, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	BOEM regulations require a Safety Management System (SMS) that includes clear communication protocols and describes roles and responsibilities. The SMS must include procedures for emergency events such as collision of a vessel with a turbine structure, gear entanglement, or damage to cabling by fishing activity, catastrophic failure of a turbine, or other events. The SMS will include clear communication protocols including the fishing community and points of contact should an emergency arise.	BOEM 2014a; BOEM 2016a; BOEM 2021; DOI MMS 2009; Dominion 2013; Moura et al. 2015
Long-Term Structures	Habitat Fragmentation/ Modification	It is recommended that developers reach an agreement with the fishing industry on what offshore windfarm infrastructures and materials are to be removed following decommissioning and how they are to be removed.	Gray et al. 2016; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	A strategy to improve the marketability of fisheries is the idea of enlisting assistance to address some of the foreign trade arrangements (e.g., 25 percent shrimp tariff in Europe and Whiting Treaty in Canada) to make fisheries more profitable.	BOEM 2012
Impaired Safe Fishery Access, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	It is recommended that developers provide funding for marketing campaigns to enhance the visibility and market of the tourism and recreation markets. Promotion should focus on opportunities for fisheries to supplement income through guided sight-seeing tours, recreational fishing, diving, and other activities.	Moura et al. 2015; NYSERDA 2017
Scouring, Long-Term Structures, Water quality Changes, Bottom Disturbance, Effects to Fishery Target Species	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Loss of Revenue, Change in Fishing Effort	It is recommended that developers design improvements to fishery habitat to enhance fishery production. Where possible, habitat that is disrupted should be restored to preconstruction conditions. Additional construction of new structures outside the offshore windfarm planning areas should be explored to provide alternatives to areas experiencing seasonal or spatial closures.	BOEM 2016a; NYSERDA 2017
Long-Term Structures, Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Role of a Fisheries Representative. It is recommended that a position or function be established, often funded by but not employed by the developer, to "speak for" the fishing community's interests and to conduct outreach/communication. Developers should develop clear guidelines for the selection and responsibilities of the fisheries representative, which can be outlined in the Fisheries Communication and Outreach Plan.	FLOWW 2014; Lipsky et al. 2016; MAFMC 2014; Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access, Long-Term Structures	Change in Fishing Effort	Use of a collision risk assessment to determine navigational safety risks that includes consideration of controls that could be put in place to reduce those risks. The assessment might conclude that siting is too high risk, or that risk is acceptable with controls. The U.S. Coast Guard takes a risk management approach to wind turbine generator (WTG), wave energy converter (WEC), and tidal energy converter (TEC) installations. This approach does not dictate specific suggestions for buffer zones or marking, but the review may result in the imposition of measures to reduce risks. The U.S. Coast Guard has primary authority to implement this mitigation strategy.	BOEM 2012; Deepwater Wind 2012
Water quality Changes	Displacement, Injury/Mortality	It is recommended that developers remove all waste material.	Gray et al. 2016; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	The increasing consumer interest in sustainable fisheries presents an opportunity for fisheries to seek a sustainability certification such as that offered by the Marine Stewardship Council (http://www.msc.org). Mitigation funds could be used to help people in the fisheries organize for the sake of applying for certification.	BOEM 2012
Impaired Safe Fishery Access	Change in Fishing Effort	Employ Guard Vessels. It is recommended that the developer employ guard vessels during construction and any major maintenance efforts.	BOEM 2016a
Impaired Safe Fishery Access, Loss of Fishing Grounds, Long-Term Structures, Inadequate Infrastructure	Change in Fishing Effort, Loss of Revenue	Internationally, there are examples of funding mechanisms that have been established to compensate for gear lost or damaged as a result of wind energy projects and for related purposes. Within the U.S. offshore oil and gas industry, the federal Fishermen's Contingency Fund (FCF) has been established. The FCF, which was established in 1978 by an amendment to the *Outer Continental Shelf Lands Act*, is a revolving fund paid for by assessments on oil and gas interests. It compensates for property and economic loss caused by obstructions related to oil and gas development on the OCS. Within the offshore subsea communication cable business, there are examples of agreements between undersea fiber-optic cable companies and fishing associations that release those participating in fisheries from any possible civil liability for "ordinary negligence to a fiber optic cable company" and provide compensation for gear that becomes snagged on a cable. The lessee will consider various forms of direct compensatory mitigation support for gear loss or modification in order to develop or purchase "wind facility safe" fishing gear to enable safe fishing operations to continue within an offshore wind facility with minimal interactions. Examples include shortening pot strings or using smaller towed nets. Gear modifications/development should occur in close coordination with people who fish, who may have reservations about using some gear types in close proximity to offshore renewable energy projects. Because fishing gear can be a significant capital cost, financial support will enable continued fishing within the offshore wind facility after modifying gear to meet the requirements of a particular fishery. The level of financial support would require detailed discussions between the impacted fishing community and the lessee.	BOEM 2012; BOEM 2014a; BOEM; Deepwater Wind 2018; Sharp and Sumaila 2009.

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Changes in Vessel Traffic, Long-Term Structures, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Cable Communication and Navigational Awareness System. It is recommended that the developer establish a system to ensure mariners have access to information about cable placement and other changes that windfarm development may have had on navigation to ensure safe passage and to avoid gear fouling (e.g., websites, updated navigational charts).	BOEM 2012; BOEM 2016a; BOEM 2021; Deepwater Wind 2012; Moura et al. 2015; NYSERDA 2017
Water quality Changes, Long-Term Structures, Scouring, Bottom Disturbance, Effects to Fishery Target Species	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Loss of Revenue	It is recommended that developers design and implement ecosystem habitat enhancements such as the creation of artificial reefs on windfarm infrastructure for attracting commercially targeted species. Also, enhancing shellfish and finfish stocks via transfer of hatchery or wild juveniles or mature animals to the windfarm area is recommended.	Anderson et al. 2009; Buck et al. 2009; Langhamer 2012; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Scouring, EMF, Vibration, Heat, Changes in Vessel Traffic, Bottom Disturbance, Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species, Change in Fishing Effort, Loss of Revenue	Development of a Fisheries Communication and Outreach Plan. BOEM recommends that lessees develop and implement a project-specific communication plan. This plan should establish the processes for information sharing in an ongoing way that is credible, transparent, and establishes the role of the diverse commercial and recreational fishing communities and other affected stakeholders. The implementation of the plan will be timely and credible and will facilitate two-way communication that leverages existing formal and informal outreach. It is recommended that the plan should: • Establish the roles and responsibilities of Fisheries Liaisons and Fisheries Representatives. • Describe plans for communicating with people fishing at sea. • Describe any activities to educate the public, with an emphasis on educating people in the fishing industry and boaters on construction issues and other pertinent alerts. • Ensure the communication is using the information channels that people who recreationally and commercially fish are used to, including a mix of direct contact through emails, text messages, phone calls to land lines and cell phone numbers, U.S. mail, as well as a project-sponsored 24-hour phone service for project information. • Focus on being adaptive and responsive to best ensure the affected industries are effectively and authentically engaged. • Tailor outreach to specific communities, ports, and impacted fisheries. • Focus on developing trust. BOEM has developed a list of concerns that should be addressed in any Fisheries Communication and Outreach Plan, including the following: exclusion zones/access, regulations, communications, siting process, safety, electric and magnetic fields (EMF), radar interference, maintenance, health, fish, liability, and enforcement.	BOEM 2014a; BOEM 2014b; BOEM 2015a; BOEM 2016a; Lipsky et al. 2016; MAFMC 2014; NYSERDA 2017
Loss of Fishing Grounds	Change in Fishing Effort	Site offshore facilities in areas that are already off-limits to fishing (e.g., in marine conservation zones).	BOEM 2012; BOEM
Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	After initial mapping and characterization based on research of a specific lease area, user communities should have the opportunity to review the aggregated data for ground-truthing and additional observations.	BOEM 2012

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	It is recommended that developers provide funding for marketing campaigns to enhance the visibility and market of fishery products to increase demand for locally produced food and increase fisheries' viability and profitability. This could range from hiring an outside entity to develop and implement marketing strategies, to funding the development of a marketing cooperative where fishing industry members could work together to promote their product as being, for example, unique, sustainable, and/or local.	BOEM 2012; Moura et al. 2015; NYSERDA 2017
Changes in Vessel Traffic, Inadequate Infrastructure	Loss of Revenue, Change in Fishing Effort	It is recommended the developer investigate with the fishing communities and ports any impacts on dock access, fuel access, or other activities that might interfere with fishing operations.	BOEM 2014a; NYSERDA 2017
Long-Term Structures, Insufficient Communication	Loss of Revenue	It is recommended that the developer create protocols for handling gear entanglements, e.g., who to contact, retrieval protocols, and rules regarding compensation.	BOEM 2016a; BOEM; Deepwater Wind 2018; NYSERDA 2017; One Ocean Corp 2013
Long-Term Structures, Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	If fishing is displaced or significantly affected by the development of an offshore renewable energy project (e.g., being required to increase their travel time to fishing grounds in order to avoid a project area), they may benefit from increasing a quota or extending the season to provide a way to financially justify the extra effort needed to fish. These mitigation measures should take into consideration the sustainability implications of additional fishing pressure. Additionally, a change in quotas may create some divisiveness in the affected fisheries, depending on how the quotas are allocated. National Marine Fisheries Service (NMFS) has primary authority to implement this mitigation strategy.	BOEM 2012
Long-Term Structures, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species	Ensure adherence to BOEM's guidelines on acquiring information on fisheries' social and economic conditions. This should be done in a manner that appropriately solicits information on social and economic conditions of both recreational and commercial fishing activities, e.g., fishing seasons and locations and types of fisheries that could be affected by the lessee's proposed activities.	BOEM 2015a; Lipsky et al. 2016; NYSERDA 2017
Changes in Vessel Traffic, Loss of Fishing Grounds, Long-Term Structures	Change in Fishing Effort, Loss of Revenue	A fuel purchase subsidy program could be established if there is displacement and need to travel farther distances to fishing grounds.	BOEM 2012; BOEM 2014a

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Transparency. Developers, agencies, and all stakeholders should facilitate transparency during all phases of the development process.	BOEM 2016a; Lipsky et al. 2016; MAFMC 2014; NYSERDA 2017
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	It is recommended that the developer develop protocols for designating the right-of-way between vessels in the [Great Lakes] windfarms. These protocols may include turbine signs (identifying number, foundation type, scour protections); power air draft markings (indicates gap between water surface and blades); and markings of designated transit zones for vessel traffic.	BOEM 2016a; NYSERDA 2017
Loss of Fishing Grounds, Sound	Change in Fishing Effort, Loss of Revenue, Behavioral Disturbance	It is recommended that the developer schedule noise-generating activities in closed fishery seasons.	BOEM 2015b; Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	While renewable energy projects may displace existing uses of the marine environment, they may also open doors to new opportunities. Some examples include research, repair, construction, enforcement, monitoring, and guarding. Mitigation funds could be used to help those who fish transition into these new positions through the development of training programs and the provision of gear needed to support their new role(s). Other examples of such new industries might include sight-seeing (offshore wind energy projects have been viewed as attractions), charter fishing, and SCUBA (self-contained underwater breathing apparatus) diving excursions. Specific training might include apprenticeships, product-quality training, best practices for the on-board handling of catch, and peer-to-peer networks to facilitate the exchange of information. Expansion into new fisheries could include targeting other wild species as well as becoming involved in aquaculture activities, given the potential opportunities to take advantage of offshore renewable energy infrastructure to establish shellfish and finfish aquaculture operations, or even the culture of algae.	BOEM 2012; Lipsky et al. 2016; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Changes in Vessel Traffic	Change in Fishing Effort	Space turbines at sufficient distances to allow safe passage of boats between the structures and promote safe navigation of fishing vessels within a windfarm.	BOEM; Lipsky et al. 2016; Vineyard Wind 2019
Impaired Safe Fishery Access, Water quality Changes	Loss of Revenue, Injury/Mortality	Lessees and grantees shall use practices and operating procedures that reduce the likelihood of vessel accidents and fuel spills. It is recommended the developer institute measures or a spill control plan to facilitate the prevention of and response to accidents and spills in wind energy areas. This plan should include reduced speed zones and a pollutant and debris removal plan.	BOEM 2014b; BOEM 2015b; BOEM 2016b; MMS 2007; NYSERDA 2017
Changes in Vessel Traffic, Impaired Safe Fishery Access, Loss of Fishing Grounds, Long-Term Structures, Effects to Fishery Target Species, Inadequate Infrastructure	Change in Fishing Effort, Loss of Revenue	Compensation Fund: The developer and fishing industry representatives should develop a compensation fund and the processes for managing the fund. A Compensation Fund Plan should establish the sources and amount of funding, the terms of compensation, the data necessary to measure losses, clear instructions on access to and management of the compensation fund, and a description of the processes. Compensation can account for increased costs (e.g., fuel subsidies), gear or vessel loss or repair, loss of fishing revenue, vessel or gear modifications, assistance with gear modifications, and/or the purchase and installation of new or additional safety equipment or gear modifications. The development of the Compensation Fund and the Compensation Fund Plan should be transparent to facilitate the development of agreements and should include the publication of public meeting minutes. Claims should be evidence based. Claims can include the period of impact, seasonality, number of vessels and intensity, historic use patterns, the importance and proportion of area lost to fishing, any significant deviation or extended transit to fishing grounds, accessibility to other fishing grounds or stocks, and costs for gear relocation or removal.	BOEM 2014a; BOEM 2016a; FLOWW 2014; Gray et al. 2016; Lipsky et al. 2016; Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access	Loss of Revenue	In the event that vessels are allowed to operate in the vicinity of offshore renewable energy developments, there is a chance that their insurance premiums would rise, given the increased risk. Funds could be used to help offset any increased insurance costs.	BOEM 2012; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Effects to Fishery Target Species, Changes in Vessel Traffic	Change in Fishing Effort, Loss of Revenue	Wind Facility Configuration. It is recommended the developer consider many alternative wind facility configurations, including size, spacing, and access route planning. Developers should consider the following in their siting studies: important fishing areas, transit schemes, fishing gear clearance issues, safety, and likelihood for future wind development in the local area. It is recommended the developer, to the greatest extent practicable, consider "micro-siting" options such as modest changes to turbine locations to protect routes, fishing ledges, reefs or other natural features conducive to fish congregation, breeding, rearing, and or juvenile activity.	BOEM 2014a; BOEM 2015b; BOEM 2016a; Moura et al. 2015; NYSERDA 2017
Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	Maximize Fishing Access. It is recommended that the developer maintain fishing access to a windfarm site to the maximum extent practicable during all phases of windfarm development and operation.	BOEM 2016a; Lipsky et al. 2016; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Sound, Water quality Changes, Long-Term Structures, Scouring, EMF, Vibration, Heat, Bottom Disturbance, Effects to Fishery Target Species	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species	Baseline Data Collection. It is recommended that developers use the best available data on fishing activities and fishery resources to establish environmental and economic baselines and to identify candidate wind energy areas with no- to low-conflict with fishing, which should be funded by wind energy developers or wind energy developers and BOEM. Baseline studies should include the following: existing benthic and epibenthic biological communities, high-resolution bathymetry and substrate, harvest species abundance, migratory fish patterns, and spatial and temporal fishing patterns by fishery type. Research priorities should be based on the reproduction, growth, and survival of species that are commercially or ecologically important, have undergone or are in the process of rebuilding, or any species identified for significant impacts or associated with significant uncertainties, or are protected or endangered. An ideal research program would include different gear types for survey work (including otter and beam trawls, pot/traps, fixed nets, and hook and line) and would be accompanied by acoustic telemetry, ichthyoplankton sampling, tissue stomach sampling, visual surveys (habitat cameras), interferometric sonar surveys, and oceanographic observation and modeling (stratification and flow assessments), with data collection occurring during all four seasons. Data management protocols need to ensure that all resultant data are publicly accessible and available for outside analysis and must include appropriate control sites so that impacts can be properly assessed.	BOEM 2015b; BOEM 2016a; Curtice et al. 2016; Gray et al. 2016; MAFMC 2014; Moura et al. 2015; NYSERDA 2017
Impaired Safe Fishery Access, Long-Term Structures, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Communications with fisheries should: • Initiated early in project development, communications should continue often, be ongoing, and be collaborative. • Develop a strong and respected network of stakeholders for consultation. • Work toward an outcome that balances the needs of the fisheries activities and energy development. • Meeting scheduling should be adaptive to times target audiences are available. • Ensure parties are aware of the decision-making process and that all information and data are publicly available and easily accessible. • Ensure consistent and accessible messaging that is in plain language and provides visual representations (e.g., technology design, maps of impacted areas). • Communication should be varied, i.e., through direct mailings, letters and emails, and announcements in fisheries trade publications.	BOEM 2015a; BOEM 2016a; BOEM 2021; Lipsky et al. 2016; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Changes in Vessel Traffic, Inadequate Infrastructure	Loss of Revenue	It is recommended that developers purchase fuel directly from a fuel co-op established and operated by those who fish locally.	Moura et al. 2015; NYSERDA 2017
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	All vessels shall comply with the International Maritime Organization maritime safety standards for navigation.	IMO
Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	There is concern about being crowded into other areas where there may be increased competition for space and fish. Some mentioned that they would be interested in having displaced areas offset by opening previously closed areas. It might be impossible to use mitigation money to study closed areas in the context of re-opening them. New York State has primary authority to implement this mitigation strategy.	BOEM 2012
Long-Term Structures, Impaired Safe Fishery Access, Loss of Fishing Grounds, Inadequate Infrastructure	Loss of Revenue, Change in Fishing Effort	It is recommended that the developer pay into a fund that finances community projects aimed at supporting the fishing industry and shoreside enhancements (e.g., installation of new refrigeration/freezer units, gear or fuel storage facilities, freezers, ice machines, shelters or other equipment, safety training, and certification for windfarm support work) for port or shore-side facilities associated with an offshore wind facility. Well-maintained port or shore-side facilities are important for the efficient and safe operation of every fishing vessel. Shore-side efficiency likely could be improved with modification to facilities. This could reduce the length of the fishing day and provide long-term benefits to local fishing communities. Any monetary support will consider the regional impact of siting an offshore wind facility, as well as the cost and complexity of improvements. Importantly, a key issue for undertaking this MMP is an understanding that only a limited number of people fishing would likely benefit from a particular port improvement project. The level of financial support would require detailed discussions among the impacted fishing community, local governmental bodies, and the lessee.	BOEM 2012; BOEM 2014a; BOEM 2016a; Moura et al. 2015; NYSERDA 2017; Russell 2015

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Long-Term Structures, Scouring, EMF, Vibration, Heat, Changes in Vessel Traffic, Bottom Disturbance, Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species, Change in Fishing Effort, Loss of Revenue	Outreach to State fishery management agencies and regional fishery management organizations during the development of a Fisheries Communications Plan to resolve any issues or disagreements that may arise with these agencies and organizations with respect to the Fisheries Communications Plan.	BOEM 2015a; MMS 2007; Vineyard Wind 2019
Long-Term Structures	Loss of Revenue	It is recommended that the developer create operating protocols to minimize gear entanglements (e.g., inspection and maintenance to ensure cable burial) and collisions.	BOEM 2016a; BOEM; NYSERDA 2017; Vineyard Wind 2019
Impaired Safe Fishery Access, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	It is recommended that developers provide funding for marketing campaigns to enhance the visibility and market of commercial charters or party boat fishing for both sport and tourism fishing in affected areas. This would offset losses to the charter and party boat industry as a result of a closure of the offshore windfarm areas during construction or maintenance.	BOEM 2016a; Lipsky et al. 2016; NYSERDA 2017; Vineyard Wind 2019
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	All vessels shall comply with the International Maritime Organization maritime safety standards for fire protection.	IMO

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	The lessee should develop, prior to construction and in consultation with the fisheries representative and the natural resource management agencies, a detailed, publicly available schedule that reduces conflict with fishing activities. The construction schedule will be included in plans submitted to New York State and will be part of an approved package. The lessee will be required to work with the fisheries representative to determine the best schedule, which will be maintained and updated as changes occur during the construction period. The timing of construction will include consideration of fishing schedules, high-use fishing areas, seasonal species' distributions (e.g., spawning seasons), and current closure periods (e.g., specific days of the week closed to fishing and areas closed to fishing). The schedule will include, as necessary, methods such as alternating construction sites or schedules to minimize impacts on fishing and other OCS (outer continental shelf) uses. It is recognized that different gear types, species, and fishing sectors (recreational and commercial) may have different, and sometimes conflicting, seasonal needs. In such cases, the lessee will work with all impacted fishing sectors to identify a construction schedule that minimizes impacts on all or most users, to the extent possible, and that avoids or minimizes conflict among user groups.	BOEM 2014a; BOEM 2016a; BOEM 2021; MMS 2007; NYSERDA 2017; Vineyard Wind 2019
Impaired Safe Fishery Access, Insufficient Communication	Loss of Revenue	It is recommended that the developer establish a role for people who fish, a role of improving safety practices.	BOEM 2014a; BOEM 2016a; BOEM 2021; MAFMC 2014; NYSERDA 2017
Changes in Vessel Traffic, Impaired Safe Fishery Access	Loss of Revenue, Change in Fishing Effort	All vessels shall comply with the International Maritime Organization (IMO) maritime safety standards for stability and subdivision.	IMO
Bottom Disturbance, Long-Term Structures, Impaired Safe Fishery Access	Loss of Revenue	Once a project is complete, the operator/contractor should remove all obstructions and return the sea floor to its preconstruction depth and topography. In the event that any residue or obstruction remains that, in the opinion of the Aids to Navigation Authority, constitutes a danger to navigation, then the residue or obstruction shall be marked according to the authority's requirements.	BOEM 2012; Deepwater Wind 2012

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Impaired Safe Fishery Access, Long-Term Structures	Change in Fishing Effort	Offshore wind facilities will have both visual markings and automatic identification system (AIS) transponders, which may exceed the requirements of the U.S. Coast Guard and the Federal Aviation Administration. Recommendations include safety lighting on towers at a height visible to smaller vessels and during low visibility (fog) as they approach close to the tower, radar reflection, AIS on fixed stations, radar and beacon, marine navigational lighting, avian obstruction lighting, radar beacons, and reflective tape on turbines for navigational safety.	BOEM 2014a; BOEM 2016a; BOEM 2021; Deepwater Wind 2012; IALA 2008; MMS 2007; Moura et al. 2015; NYSERDA 2017
Loss of Fishing Grounds	Change in Fishing Effort, Loss of Revenue	In the United Kingdom, fisheries management tools exist whereby the public's right to shellfish is removed (known as "Several and Regulating Orders"). These "Orders" give a specific group the right to fish in an area, while prohibiting others (including the public) from fishing at that location. It is believed that such Orders can increase the sustainability of certain fisheries, and as a mitigation tool, it can also limit the number of vessels allowed in the vicinity of a renewable energy project, which would have safety implications as well. Orders could be time-limited to the duration of a renewable energy project (in the United Kingdom, they can be issued for up to 60 years).	BOEM 2012; Whiteley 2016
Long-Term Structures, Impaired Safe Fishery Access, Loss of Fishing Grounds, Effects to Fishery Target Species, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Role of a Fisheries Liaison. It is recommended that a position or function typically employed directly or contractually by the developer provide fisheries community outreach, communication, and coordination services. The third-party fisheries liaison is required (OSAMP [Ocean Special Area Management Plan] sections 560.2.10 and 1160.7.6) to have knowledge and understanding about fisheries, and his or her role is to facilitate direct communication with people who commercially and recreationally fish. Commercial fisheries should have regular contact with and direct access to the fisheries liaison throughout all stages of the project: preconstruction, construction, operations, and decommissioning.	Deepwater Wind 2012; Deepwater Wind 2018; FLOWW 2014; Lipsky et al. 2016; Moura et al. 2015; NYSERDA 2017

Table 36 continued

Stressors	Potential Impacts	Mitigation	Citations
Changes in Vessel Traffic, Impaired Safe Fishery Access, Long-Term Structures	Change in Fishing Effort	The lessee will provide local fisheries groups most likely to be affected by offshore wind facilities with detailed guidelines on safe navigation within and through the project site during construction and operations. The lessee's [Plan] will describe the possible use of exclusion zones, public mooring buoys expected, potential hazards to vessels and gear, and other pertinent information associated with the use of Great Lakes waters for fishing around and within an offshore wind facility.	BOEM 2014a; Deepwater Wind 2019
Effects to Fishery Target Species, Sound, Water quality Changes, Long-Term Structures, Scouring, EMF, Vibration, Heat, Bottom Disturbance	Behavioral Disturbance, Displacement, Habitat Fragmentation/ Modification, Injury/Mortality, Community Alteration/ Invasive Species	Enhancing Fisheries Science and Management. It is recommended that for any data-poor species, monitoring efforts develop specific measures to enhance the state of the science for these species.	BOEM 2016a; Lipsky et al. 2016
Impaired Safe Fishery Access, Loss of Fishing Grounds, Insufficient Communication	Change in Fishing Effort, Loss of Revenue	Government-to-Industry and Industry-to-Industry groups. It is recommended that formal and informal groups (e.g., working groups, advisory bodies, committees) be established with representation from local fishing industry groups, offshore wind developers, and/or government for voicing concerns and facilitating discussions on collaborative problem solving. These groups can be established with the intent to meet regularly, e.g., once a month, to discuss ongoing operations or needs for changes. Example Group: Port Operational Interface Group. A group of developers, fishing associations, and vessel operations contractors that meet regularly to discuss port operations and any need for changes.	BOEM 2016a; Lipsky et al. 2016; Moura et al. 2015
Impaired Safe Fishery Access, Long-Term Structures, Insufficient Communication	Loss of Revenue, Change in Fishing Effort	Create a working group that includes cable owners and people who fish to collaboratively discuss underwater cables (e.g., burial depth) and ways to minimize lost fishing gear and prevent damage to cables. Planned cable corridors should reflect an understanding of local fishing attributes so that high-quality fishing areas are avoided. Cable trenching activities will not expose risks or other material that could negatively impact trawling or other similar activities and cable-burial techniques should adhere to the most current technical methods for minimizing EMF and minimize interactions with mobile fishing gear to the greatest extent practicable.	BOEM 2012; BOEM 2014a; BOEM 2021; Moura et al. 2015; NYSERDA 2017; Vineyard Wind 2019

6 Assessment of Benefits

This section provides a high-level discussion of the potential benefits to communities in the area where the Great Lakes Wind Energy projects were developed. This section focuses on decarbonization, environmental and public health, environmental justice, and potential benefits for disadvantaged communities. In this context, “decarbonization” is defined as reduction of greenhouse gasses (GHGs) from all industrial sectors to mitigate and help reduce climate change.

6.1 Methodology

Potential benefits from Great Lakes Wind Energy have been identified through a desktop synthesis of existing reports and studies, including documented projects in marine offshore wind, information from the Lake Erie LEEDCo Icebreaker Project in Ohio, and information from agencies such as the Energy Information Administration (EIA), NYSERDA, BOEM, and the International Energy Agency (IEA).

6.2 Decarbonization Benefits

The world is transforming its energy system from one dominated by fossil fuel combustion to one with net-zero emissions of carbon dioxide, the primary anthropogenic GHG. This energy transition is critical to both mitigating climate change and protecting human health. “Decarbonization” is the movement to reduce GHGs from all industrial sectors to mitigate and help reduce climate change. Decarbonizing the power sector will likely entail a combination of continued improvements in end-use efficiency; continued substitution of no- or lower-emission power sources; improved grid flexibility and storage; and the use of carbon capture on remaining fossil fuel-based generation (EIA 2021). In the case of wind energy, the industrial sector is power generation and decarbonization entails replacing fossil fuel power with wind power. The EIA has identified seven pillars of decarbonization: energy efficiency, behavioral changes, electrification, renewables, hydrogen and hydrogen-based fuels, bioenergy, and carbon capture and storage (EIA 2021). Great Lake Winds addresses two of these pillars: renewables and electrification.

Context for decarbonization efforts and wind energy includes President Joe Biden’s issuance of an Executive Order *Order 14008) on January 27, 2022, Tackling the Climate Crisis at Home and Abroad. The Executive Order provides a comprehensive plan with a goal to decarbonize the electricity sector by 2035 and achieve economy-wide, net-zero emissions by 2050. The Executive Order aims to increase renewable energy production in water and on land.

NYS is also taking action to invest in clean energy, including wind. NYS has ambitions plans to reduce carbon emissions and support decarbonization in the electrical power sector. New York State's Climate Leadership and Community Protection Act (CLCPA), passed in July 2019, aims to achieve 70% renewable energy by 2030, with 9,000 MW of offshore wind by 2035 and 100% zero-emission electricity by 2040 (New York State Accessed 2021). CLCPA created the Climate Action Council, which developed a Draft Scoping Plan that is the initial framework for how NYS will achieve net-zero emissions, reduce GHG emissions, ensure climate justice, and increase renewable energy usage (New York State 2021a).

In 2020, approximately 4.01 trillion kilowatt hours (kWh) of electricity was generated at utility-scale electricity generation facilities in the U.S. and of this, 60.3% was generated by fossil fuels, 19.8% by renewable energy sources (of which 8.4% was wind), 19.7% by nuclear, and 0.3% by other sources (EIA, Frequently Asked Questions 2021). Electricity generated from fossil fuels contributes substantially to climate change, primarily via carbon dioxide emissions as well as leaked methane. The EIA found that in 2019, power plants that burned coal, natural gas, and petroleum products generated 62% of total U.S. electricity, but accounted for 99% of electricity related carbon dioxide (CO_2) emissions (U.S. EIA 2020). In NYS, electrical energy production in 2018 was approximately 135,585 gigawatt hours (GWh) and wind energy comprised approximately 3.0% of the total 3,985 GWh (ACE NY April 16, 2020, p 5). Wind energy is presently generated by onshore wind turbines, with only two offshore windfarms, one located in Block Island, Rhode Island, generating 30 MW per year and one located off the coast of Virginia generating 12 megawatt (MW) per year. Offshore wind and wind turbines are targeted as renewable energy sources to meet the CLCPA targets and will subsequently support decarbonization of the other sectors, including the electrical sector and transportation.

Energy from Great Lakes Wind Energy could help reduce fossil fuel consumption for electricity and reduce carbon dioxide emissions, thereby mitigating climate change. Although exact data as to how much carbon emissions will be reduced by Great Lakes Wind Energy are not available, other projects indicate that the impact can be substantive. For example, a study in 2009 of a potential 5–20 MW pilot wind energy project in Lake Erie near downtown Cleveland found that generating 45,000 megawatt-hours per year (MWh/yr) could potentially offset 41,175 tons of CO_2 annually during the operational stage (Driedger-Marschall 2009). NYSERDA's 2010 Great Lakes Wind Energy Feasibility Study describes another example in which a single offshore-scale turbine that generated approximately 14,000 MWh/year could displace 9,500 tons of carbon dioxide emissions that would otherwise be produced from coal burning power plants (NYSERDA 2010, p 16). Since the writing of the 2010 feasibility study, turbine technology has improved. New turbines can generate more energy and displace more carbon dioxide emissions. For example, GE Renewable Energy has developed the Haliade-X 12 MW, an 850-foot-tall turbine with three rotors, each spanning more than 720 ft, that can provide electricity to 16,000 homes (Woods 2019). Climate change stress will negatively impact biodiversity and natural habitats (Prakash 2021). Minimizing carbon dioxide emissions benefits natural ecosystems globally,

Wind energy is an important alternative to fossil fuel; however, the extraction and transportation of raw materials for manufacturing, manufacturing itself, and then the transportation of turbines produce harmful emissions (Mohamed R. Gomaa 2019). It is beyond the scope of this study to assess the total carbon displacement of turbine technology that could be used for Great Lake Winds; however, a life cycle assessment may determine more precise decarbonization benefits. In addition, emissions during the construction, operations, and decommissioning phases of wind projects can be estimated, as was done for the Final Environmental Assessment for LEEDCo.'s Icebreaker Project (DOE 2018). These types of assessments can provide a more specific estimate of the decarbonization benefits of Great Lake Wind projects.

6.3 Environmental and Public Health Benefits

Wind is a renewable energy source. Using wind to produce energy is sustainable and has fewer effects on the environment than many other energy sources mainly because

- Wind is abundant.
- Wind turbines do not release emissions that can pollute the air or water (with rare exceptions).
- Use of wind turbines lowers total air pollution and CO_2 emissions.
- Wind turbines do not require water for cooling and do not use water to operate.
- Wind turbines operate at comparatively low costs on land compared to natural gas.

Wind energy can also offset the public health issues that are caused by electricity generated from natural gas and coal burning power plants. This section focuses on air pollution, GHG emissions, and water use by thermoelectric generators.

6.3.1 Air Quality

A major benefit of wind energy is that it displaces fossil fuel generators that release air pollutants that impact human health and wildlife via toxic compounds such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), mercury, and other pollutants (J. Buonocore 2016). In the environment, these pollutants create negative and often devastating environmental impacts as they accumulate in the air, soil, and water, harming ecosystems and wildlife. In addition, emissions from vehicles fueled by gas and diesel contain harmful components, including CO, nitrogen oxides (NO_X), sulfur oxides (SO_X), volatile organic compounds, particulate matter (PM), ammonia and GHGs (Natural Resources Canada 2006). In addition to reducing pollutants from fossil fuel generators, adding wind to the energy mix will reduce reliance on gas and diesel fueled vehicles as electric vehicles enter the market and allow for use of electricity that may be generated by renewables sources rather than oil and gas to contribute to cleaner air.

Regarding ecosystems, research indicates that all ecosystems are vulnerable to air pollution. For example, studies show that lakes are vulnerable to acidification from SO_X and NO_X emissions that affect the diversity and health of freshwater species (Sanderfoot 2017). Bird studies provide another example–SO_x and heavy metal particulates have been found to damage bird's metabolic systems, causing thin-shelled eggs and respiratory problems in some species (Shivni 2017).

Regarding human health, scientific research links exposure to air pollution to adverse human health outcomes. It is widely recognized that exposure to air pollution contributes to chronic and acute health problems, ranging from minor physiological problems to acute respiratory and cardiovascular disease (J. West 2016). Although air quality in the U.S. has markedly improved over the past decades due to policies, laws, and improved technology, air pollution is still a problem from the accumulated effects of fossil fuel combustion, coal burning power plants, and traffic related PM (J. West 2016).

There is a direct correlation between air pollution and deadly diseases, such as asthma, respiratory illness, heart attacks and cancer. A recent study found that more than 8 million people died in 2018 from fossil fuel pollution, indicating that air pollution from burning fossil fuels was responsible for about one in five deaths worldwide (Vohra, et al. 2021). In the same study, the researchers directly attributed approximately 10.2 million premature deaths annually from $PM_{2.5}$ from fossil fuel combustion. Another study found that approximately 17,000 deaths in the U.S. were attributed to air pollution from electricity generation in 2010 (J. Buonocore 2016). A simulated study of a 3,000 MW windfarm in New Jersey predicted that 55 lives would be saved per year by improving air quality (Buonocore, Harvard TH Chan School of Public Health 2016). Buonocore (2018) predicted that 13 lives would be saved per year for every 1,100 MW of wind power built in New Jersey.

Environmental and health benefits vary according to the type of wind turbine; electrical grid infrastructure; technical constraints; electrical market conditions; and the condition of the local and regional power plant fleet, including power plant efficiency, fuel type, emission rates and populations downwind (Buonocore 2018). Although the reduction of CO_2, NO_2, SO_2, $PM_{2.5}$ and other emissions will provide environmental and health benefits, the magnitude of the benefits that can be directly attributed to single projects vary, depending on turbine technology, size of the facilities and their geographic location (Buonocore 2018). Therefore, it is difficult to quantify environmental and health benefits that come with reduced air pollution by Great Lakes Wind Energy at this point in time. If wind projects, such as Great Lakes Wind Energy, can displace fossil fuels to generate electricity, then the negative effects related to air pollution on ecosystems and human health could diminish.

6.3.2 Greenhouse Gas Emissions

Climate change is considered a serious public health threat that impacts communities and individuals' health in many ways, ranging from rising sea levels and subsequent population displacement to wildfires with loss of homes and habitat to volatile weather patterns with increased incidents of flash floods, hurricanes, and tornados in populated areas to air pollution causing health problems (Maibach, et al. 2010). All of these events impact water security, food security, safety, livelihoods, and mental health over at least the short-term, and potentially long-term.

There is an increased interest in the relationship between actions to improve air quality and actions to address climate change. Actions to reduce GHG emissions can reduce other air pollutants from the same sources and provide the co-benefits of GHG reductions with air quality and health improvements (J. West 2016). Aaron Bernstein, Director for the Center of Climate, Health and the Global Environment at the Harvard Chan School stated that "thanks to more rigorous science, we can now see that fossil fuels cause far more harm (to human health) than previously understood. Now more than ever we can see the healthier, more just and sustainable world that climate actions can deliver." Great Lakes Wind Energy can reduce GHG emissions by replacing fossil fuels.

6.3.3 Reduced Industry Water Use

Unlike thermoelectric power plants that heat water and generate electricity from steam turbines (and are fueled by coal, gas, oil, or nuclear power), wind energy does not require water to generate electricity. The EIA states that natural gas, nuclear power, and hydroelectricity together provided more than 90% of NYS's electricity net generation from 2012 to 2019 and renewable resources have provided most of the remaining 10% (U.S. EIA 2020). Five of the State's 10 largest power plants generate electricity from natural gas-fired plants and more than half of New York State's generating capacity is from natural gas-fired power plants (U.S. EIA 2020). Great Lakes Wind Energy can help reduce water used by thermoelectric generators by replacing them or by phasing them out over time.

The Great Lake's ecosystems are vulnerable to water withdrawal under certain low flow conditions (Great Lakes Commission 2011). According to the Great Lakes Commission (2011), over half of the watersheds of the Great Lakes were at moderate to high-risk of degraded ecological health and approximately 36% suffered from degraded water quality (Great Lakes Commission 2011). Wind power that replaces thermoelectric power can save water. It was estimated in 2013 that wind energy (on land) reduced power-sector water consumption by 36.5 billion gallons in the U.S (U.S. Department of Energy 2015). With increased demands for water from all sectors (e.g., water supply for human consumption, thermoelectric generators, manufacturing, agriculture, and other industries), wind power offers the benefit of reducing water use in sum to generate electricity.

6.4 Environmental Justice

Environmental justice is the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA 2021). Environmental justice aims to ensure that minority communities are not subject to disproportionately high and adverse environmental and human health effects, and that they have equal access to decision making mechanisms to ensure that they live and work in healthy environments (EPA 2020). Environmental justice seeks to address historic inequities among races and classes, where low-income, tribal, and minority communities have been disproportionately affected by siting decisions, policies, and permitting of facilities. Specifically, in the wind power context, by displacing sources of pollution, which have disproportionately affected environmental justice communities, a sector-wide shift toward renewable energy serves a central environmental justice objective of reducing industrial pollution.

President William Clinton issued an Executive Order (12898) on addressing environmental justice issues associated with federal actions. President Biden's January 27, 2021 Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad makes a strong commitment to an "equitable, clean energy future" and gives high priority to environmental justice in communities across the U.S. Achieving environmental and economic justice is a central policy in the initiative, which means "investing and building a clean energy economy that creates well-paying union jobs, turning disadvantaged communities—historically marginalized and overburdened—into healthy, thriving communities, and undertaking robust actions to mitigate climate change while preparing for the impacts of climate change across rural, urban, and tribal areas." Executive Order 14008 aims to achieve the following that impacts environmental justice.

- Address climate inequities.
- Reduce air pollution in disadvantaged communities.
- Direct 40% of clean energy benefits to low-income communities and communities of color.
- Support the economic revitalization of communities that have suffered the effects of living and working in areas where power generation activities have contaminated local air and water resources.
- Provide financial assistance programs and training so that residents can gain the skills needed to work in the clean energy economy.

Great Lake's Wind can be responsive to the Presidential Executive Orders noted above and to achieving clean energy plans at the state and federal levels. If Great Lakes Wind Energy moves forward, it could become an important emerging economic and energy sector for New York State. As specified previously, firm commitments at the federal and state levels have been made to address inequities and promote environmental justice. On March 29, 2021, President Biden announced full support of offshore wind energy projects that will "catalyze offshore wind energy, strengthen the domestic supply chain, and create good-paying, union jobs" (White House Brief 2021). The White House has set the goal to generate 30 gigawatts (GW) of offshore wind power by 2030, while at the same time protecting the environment, creating employment, strengthening the domestic supply chain and investing in research and development (R&D) (White House Brief 2021). The CLCPA instructs NYS agencies, authorities, and entities to invest/direct available and relevant programmatic resources in a manner designed to achieve a goal for disadvantaged communities to receive 40% percent of overall benefits of spending on clean energy and energy efficiency programs, projects, or investments. In terms of low-income energy assistance, disadvantaged individuals and communities may benefit from utility bill discounts and other benefits for residents of clean energy project host communities (ACE NY April 16, 2020).

NYSDEC has an Office of Environmental Justice that implements policy through Commissioner Policy 29, which provides guidance for implementing environmental justice through NYSDEC permitting and SEQRA implementation, and Commissioner Policy 42, which provides guidance to NYSDEC on engaging with Indigenous Nations on environmental and cultural issues including environmental justice (NYSDEC 2021a). In addition, New York State regulations at 6 NYRCC Part 487 address the analysis of environmental justice is siting of major energy generating facilities (NYSDEC 2021a). The 2015 New

York State Energy Plan recognizes that disadvantaged communities have been disproportionately impacted by air pollution from fossil fuel power generation facilities and transportation infrastructure that were historically sited in or near these communities (NYS 2021). In addition, low- to moderate-income consumers pay a disproportionate share of their income toward the cost of energy. New York State's CLCPA commits 40% of clean energy investments to benefit low- to moderate-income and disadvantaged communities (Terry 2021).

Environmental and civil rights statutes provide mechanisms to address environmental hazards in minority and low-income communities. Great Lakes Wind Energy projects, were they to occur, would be able to use these mechanisms to identify and mitigate potential negative effects on communities, and in particular, on low-income, minority, and tribal communities. Great Lakes Wind Energy projects would be required to meet NYS's requirements to advance environmental justice, including but not limited to:

- Environmental Justice Analysis to identify and evaluate any significant adverse environmental impacts of a proposed energy facility resulting from its construction and operation.
- Execute a public participation program seeks to engage those from minority and disadvantaged communities to understand their concerns and interests.
- Identify potential environmental and socio-economic impacts of Great Lake Winds in disadvantaged communities.
- Mitigations to reduce possible disproportionate environmental impacts in disadvantaged communities.
- Engagement with individuals from all income, racial, and age groups to ensure social equity.

Recent NYS offshore wind solicitations prioritized disadvantaged communities, which are defined as "communities that bear burdens of negative public health effects, environmental pollution, and impacts of climate change" (Terry 2021). The solicitation's requirements included the following:

- "Forty percent of the overall benefits from clean energy programs must go to disadvantaged communities for workforce development, low-income energy assistance, and housing. Other investments and projects may also qualify.
- Community engagement plans that provide opportunities to build community equity.
- Prioritization of job creation and other benefits for disadvantaged communities" (Terry 2021).

It is also not uncommon for neighbors to oppose renewable energy projects. In this respect, it is important to distinguish between Not in My Backyard ("NIMBY") and environmental justice objections to a project, as the two can overlap, but are nonetheless distinct. NIMBY is a term, which, though often reductive of legitimate grievances, broadly includes any basis for opposition, including concerns such as aesthetics and property values. Environmental justice raises distributive, racial, and socioeconomic factors that

NIMBY responses typically do not. Apart from site objections, electricity from wind energy serves environmental justice goals at the policy level and, in most cases, at the community level as well, offering local environmental justice benefits, not environmental justice harm (Outka 2012). Great Lakes Wind Energy projects could consider NYSDEC's information about potential environmental justice areas that have been identified and mapped out based on the U.S. Census demographic data. This information could be useful to identify environmental justice communities and evaluate potentially significant and adverse environmental impacts that could result from proposed projects.

It is anticipated that local communities and counties will benefit from the influx of capital and economic benefits associated with building and operating windfarms if Great Lakes Wind Energy moved forward, including jobs and spin-off jobs, local hiring and training, procurement opportunities, and corporate taxes. The Icebreaker project proposed in Ohio waters of Lake Erie provides an example of the kind of employment that Great Lakes Wind Energy could generate for onsite construction. Local workers could benefit from construction trades, such as equipment operators, barge drivers, laborers, and electricians and more specialized labor, such as crane operators, turbine assemblers, specialized excavators, and high voltage electrical workers (DOE 2018). Operations and maintenance jobs would create long-term employment opportunities for workers in the area. Local hiring and training for people in disadvantaged communities would be essential to ensure that individuals from those communities could benefit from the work opportunities that Great Lakes Wind Energy would create. Similar to conventional energy projects and best practice, Great Lakes Wind Energy could create community investment programs and benefits agreements for those communities located near the facilities and that are the most impacted

6.5 Conclusions

Great Lakes Wind Energy would reduce GHGs and air pollution by replacing fossil fuel generated electricity. Reducing reliance on fossil-derived electricity and decarbonizing the electrical sector could reduce climate change related public health issues. Reductions in air pollution would contribute to better public health. Great Lakes Wind Energy would not require water to generate electricity and could be an alternative that reduces industrial water use by displacing thermoelectric forms of power production.

Great Lakes Wind Energy is supported by the federal government's Executive Order on Tackling the Climate Crisis at Home and Abroad and NYS's CLPCA, both of which commit to decarbonizing the energy sector and increasing offshore wind energy. The U.S government and NYS are committed to reaching zero emissions by 2050. Great Lakes Wind Energy could contribute to these commitments.

NYS is committed to environmental justice, and NYS has made strong commitments to ensure that disadvantaged communities can benefit from offshore wind energy, with 40% of the overall benefits from clean energy programs going to disadvantaged communities for job creation, workforce development, low-income energy assistance, housing, and other benefits. If Great Lakes Wind Energy moves forward, it could provide opportunities to address inequalities in local and regional communities, for example, by offering job training; employing local residents during construction and operations; and investing in the communities. In addition, eliminating harmful air pollutants that can disproportionately affect disadvantaged communities will ensure better public health in these communities.

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8 Mitigations Matrix Citations

This section (Table 37) contains full citations for the mitigations matrices contained in Table 33, Table 34, Table 35, and Table 36 in section 5.

Table 37. Mitigation for Potential Impacts of Great Lakes Wind on Fisheries

Resource	Short Citation	Full Reference
Benthos	BOEM 2011	Bureau of Ocean Energy Management (BOEM). 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. Final Report. OCS BOEMRE-2011-09. Available at: https://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Pacific-Region/Studies/2011-09-EMF-Effects.aspx. Accessed February 6, 2019.
Benthos	BOEM 2016a	Bureau of Ocean Energy Management (BOEM). 2016a. Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York: Final Environmental Assessment. OCS EIS/EA BOEM 2016-042.
Benthos	BOEM 2016c	Bureau of Ocean Energy Management (BOEM). 2016c. Guidelines for Information Requirements for a Renewable Energy Site Assessment Plan (SAP). Available at: https://www.boem.gov/Final-SAP-Guidelines. Accessed on December 4, 2018.
Benthos	Deepwater Wind 2012	Deepwater Wind. 2012. Block Island Windfarm and Block Island Transmission System Environmental Report / Construction and Operations Plan. Available at: http://dwwind.com/wp-content/uploads/2014/08/Environmental-Report-Exec-Summary.pdf. Accessed on December 4, 2018.
Benthos	Taormina et al. 2018	Taormina, B., J. Bald, A. Want, G. Thouzeau, M. Lejart, N. Desroy, and A. Carlier. 2018. A Review of Potential Impacts of Submarine Power Cables on the Marine Environment: Knowledge Gaps, Recommendations and Future Directions. Renewable and Sustainable Energy Reviews. 96: 380-391.
Benthos	Anderson et al. 2009	Anderson, M.H., M. Berggren, D. Wilhelmsson, and M.C. Öhman. 2009. Epibenthic Colonization of Concrete and Steel Pilings in a Cold-Temperate Embayment: A field Experiment. Helgol Marine Research. 63:249-260.
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Resource	Short Citation	Full Reference
Benthos	Caltrans 2015	California Department of Transportation (Caltrans). 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Division of Environmental Analysis. Report Number CTHWANP-RT-15-306.01.01. Available at: http://www.dot.ca.gov/hq/env/bio/files/bio_tech_guidance_hydroacoustic_effects_110215.pdf. Accessed December 10, 2018.
Benthos	Gartman et al. 2016	Gartman, V., L. Bulling, M. Dahmen, G. Geibler, and J. Koppel. 2016. Mitigation Measures for Wildlife in Wind Energy Development, Consolidating the State of Knowledge – Part 1: Planning and Siting, Construction. Journal of Environmental Assessment Policy and Management. 18:1–45. Available at: https://tethys.pnnl.gov/sites/default/files/publications/Gartman-et-al-Part%201-Mitigation-Measures.pdf. Accessed February 6, 2019.
Benthos	USACE 2014	U.S. Army Corps of Engineers (USACE). 2014. Deepwater Wind Block Island Environmental Assessment and Statement of Findings. Available at: https://www.nae.usace.army.mil/portals/74/docs/topics/deepwaterwind/ea17sep2014.pdf. Accessed February 6, 2019.
Benthos	Weilgart 2018	Weilgart, L. 2018. The Impact of Ocean Sound Pollution on Fish and Invertebrates. Available at: https://www.oceancare.org/wpcontent/uploads/2017/10/OceanSound_FishInvertebrates_May2018.pdf. Accessed on August 8, 2019.
Benthos	Ashley et al. 2014	Ashley, M.C., S.C. Mangi, and L.D. Rodwell. 2014. The Potential of Offshore Windfarms to Act as Marine Protected Areas – A Systematic Review of Current Evidence. Marine Policy. 45:301-309.
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Benthos	Whitehouse et al. 2011	Whitehouse, R.J.S., J.M. Harris, J. Sutherland, and J. Rees. 2011. The Nature of Scour Development and Scour Protection at Offshore Windfarm Foundations. Marine Pollution Bulletin. 62:73-88.
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Resource	Short Citation	Full Reference
Benthos	Öhman et al. 2007	Öhman, M.C., P. Sigray, and H. Westerberg. 2007. Offshore Windmills and the Effects of Electromagnetic Fields on Fish. Ambio 36:630-633.
Benthos	SeaPlan 2015	SeaPlan. 2015. Options for Cooperation between Commercial Fishing and Offshore Wind Energy Industries: A Review of Relevant Tools and Best Practices. Prepared by S. Moura, A. Lipsky, and M. Morse. Available at: https://www.openchannels.org/sites/default/files/literature/Options%20for%20Cooperation%20between%20Commercial%20Fishing%20and%20Offshore%20Wind%20Energy%20Industries%20-%20A%20Review%20of%20Relevant%20Tools%20and%20Best%20Practices.pdf. Accessed January 2, 2019.
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Birds and Bats	Arnett and May 2016	Arnett, E.B. and R.F. May. 2016. Mitigating Wind Energy Impacts on Wildlife: Approaches for Multiple Taxa. Human–Wildlife Interactions. 10:28–41. Available at: https://www.researchgate.net/publication/303788469_Mitigating_wind_energy_impacts_on_wildlife_Approaches_for_multiple_taxa. Accessed February 5, 2019.
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Birds and Bats	Peste et al. 2015	Peste, F., A. Paula, L.P. da Silva, J. Bernardino, P. Pereira, M. Mascarenhas, H. Costa, J. Vieira, C. Bastos, C. Fonseca, and M.J.R. Pereira. 2015. How to Mitigate Impacts of Windfarms on Bats? A Review of Potential Conservation Measures in the European Context. Environmental Impact Assessment Review. 51:10–22.
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Birds and Bats	May et al. 2015	May, R., O. Reitan, K. Bevanger, S.H. Lorentsen, and T. Nygard. 2015. Mitigating Wind-Turbine Induced Avian Mortality: Sensory, Aerodynamic and Cognitive Constraints and Options. Renewable and Sustainable Energy Reviews. 42:170–181.
Birds and Bats	Ahlen et al. 2007	Ahlen, I., L. Bach, H.J. Baagøe, and J. Pettersson. 2007. Bats and Offshore Wind Turbines Studies in Southern Scandinavia. Report 5571. Prepared for Swedish Environmental Protection Agency. Stockholm, Sweden. pp. 1-36. Available at: https://www.naturvardsverket.se/Documents/publikationer/620-5571-2.pdf. Accessed February 5, 2019.
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