Draft Metocean Plan for the New York Wind Energy Area

Draft Report

November 2016

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Draft Metocean Plan for the New York Wind Energy Area

Draft report

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Abstract and Intent of this Draft MetOcean Plan

The objective of the Metocean Plan (MOP) is to define the requirements of a floating LiDAR deployment to gather wind resource data at the site identified by the Bureau of Ocean Energy Management (BOEM) as the New York Wind Energy Area (NY WEA). The intent is to define what will be required to collect data at a quality level sufficient for developers and financiers to use when developing a wind farm in the area. If the New York State Energy Research and Development Authority (NYSERDA) is not successful in securing the BOEM lease for this site, this MOP will be adapted to assess potential sites for the location of additional WEA off New York's Coast. This MOP will be executed by contractors selected through a competitive solicitation issued and forms the basis of a Request for Information (RFI) being managed by NYSERDA. Feedback on this draft version of the MOP is sought through RFI 3396 to engage the offshore wind industry in its proposed site assessment activities for the New York Wind Energy Area. The RFI will run until December 15 2016 5:00pm Eastern Time and further details on how to respond can be found in RFI 3396.

This MOP will be executed by contractors selected through a competitive solicitation issued by NYSERDA and forms the basis of a Request for Information (RFI) being managed by NYSERDA. Feedback on this draft version of the MOP is sought through RFI 3396 to engage the offshore wind industry in its proposed site assessment activities for the New York Wind Energy Area. The RFI will run until December 15 2016 5:00pm Eastern Time and further details on how to respond can be found in RFI 3396.

After feedback provided through the RFI has been received, this document will be updated to account for any comments. The MOP will then be finalized and used within a RFP for floating LiDAR system suppliers and data analysis contractors regarding the wind resource assessment within the New York Wind Energy Area.

While NYSERDA welcomes feedback of any nature relating to topics covered in the draft MOP under this RFI 3396, a list of key questions and criteria are set out below in order to gather targeted comments and seek consistency of feedback.

Feedback Questions

1. **To prospective offshore wind developers:** NYSERDA's aim is that this deployment meets the needs of the end user. Are there any areas set out in this Metocean Plan that could be improved to better meet your requirements?
2. **To prospective system suppliers:** NYSERDA is interested in having a fair and open supplier engagement – please make any suggestions as to how your technology might have a better advantage in this Metocean Plan?

3. Would you have any major concerns if a quasi-static type buoy was deployed without a pre-deployment verification of the floating LiDAR system (but, with a pre-deployment verification of the LiDAR)?
4. What do you consider your key areas of risk in relation to this Metocean Plan and do you have any suggestions as to how these can be mitigated?
5. What other opportunities for simultaneous data collection or collaboration do you see?
6. Do you have any comments regarding the proposed locations of the floating LiDAR systems?
7. Are all datasets that you would expect to collect from such a campaign covered within this Metocean Plan?

Table of Contents

List of Figures

Acronyms and Abbreviations

AEP	Annual Energy Production
AIS	Automatic Identification System
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
Carbon Trust Roadmap	Carbon Trust Offshore Wind Accelerator roadmap for the commercial acceptance of floating LiDAR technology
DOE	Department of Energy
DOI	Department of Interior
GW	Gigawatt
HSE	Health, Safety and Environment
IEA RP	IEA Wind Annex 32 Recommended Practices for Floating Lidar Systems Issue 1.0, Feb 2016
IEC	International Electrotechnical Commission
KPI	Key Performance Indicator
LiDAR	Light Detection and Ranging
Measnet	Measuring Network of Wind Energy Institutes
MOP	Metocean Plan
NEPA	National Environmental Policy Act
NREL	National Renewable Energy Laboratory
NOAA	National Oceanic and Atmospheric Administration
NWP	Nationwide Permit
NYSERDA	New York State Energy Research and Development Authority
NY WEA	New York Wind Energy Area
OSHA	Occupational Safety and Health Standards
OWA RP	Offshore Wind Accelerator Recommended Practice for Floating LiDAR Systems
ROI	Return on Investment
RP	Recommended Practice
SAP	Site Assessment Plan
SD	Standard Deviation
USACE	United States Army Corps of Engineers
UXO	Unexploded Ordnance

Executive Summary

This document is NYSERDA's Metocean Plan (MOP) for the New York Wind Energy Area (NY WEA). The MOP is part of NYSERDA's overarching Master Plan for Offshore Wind in New York State, which includes bidding in the Bureau of Ocean Energy Management's (BOEM) auction for the lease of the New York Wind Energy Area in December 2016.

The objective of the MOP is to define the requirements of a floating LiDAR deployment to gather wind resource data at the site. Other metocean data will also be collected simultaneously and NYSERDA encourages the collection of additional data such as wildlife and vessel movement data.

Floating LiDAR data collection will be sufficient and the construction of a met mast is not required. The key reason is that the confidence in floating LiDAR technology has greatly increased in recent years. However, deployment of floating LiDAR requires a robust set of requirements to ensure bankable data is obtained and that developers and financiers are content to use the data when further developing the wind farm.

Floating LiDAR devices will be required to follow the Carbon Trust Roadmap for commercial acceptance and meet all the requirements of Stage 2 to be considered for deployment. The devices will also be required to carry out a pre-deployment verification alongside a trusted reference source, which has been expanded to include onshore LiDAR and platform mounted LiDAR due to the lack of fixed offshore met masts in U.S. waters. The pre-deployment verification should take place in waters representative of the sea states expected within the New York Wind Energy Area (NY WEA) to minimize uncertainties from the data.

Two floating LiDAR systems will be deployed in the NY WEA, centrally located within the zone, avoiding key areas of benthic habitat, shipping lanes, and subsea cables. With a 10km radius buffer around both systems, as advised by Measnet's best practice for wind resource assessments, 92 percent of the buildable area within the zone will be covered.

The deployments will run for a minimum of 12 months, although these may extend to 18 or 24 months dependent on the permits available and the information obtained regarding the atmospheric conditions in the region to minimize the uncertainty of the data collected.

Floating LiDAR system suppliers will support NYSERDA in obtaining and complying with any permits required to deploy the systems. It is noted that BOEM is currently undertaking a review of the permitting system for floating LiDAR buoys under their Site Assessment Plan process. Therefore, this will be considered as the time approaches to deploy the systems.

The floating LiDAR system supplier will be responsible for the maintenance of the devices during the deployment and the devices must be able to fully function for a full six months without an offshore maintenance visit. The devices must be monitored on an on-going basis during the deployments.

The floating LiDAR system will collect measured quantities of wind speed and direction, turbulence intensity, and air temperature, pressure, and humidity along with height and datum used. This data will be collected across five heights which are representative of the rotor swept area of a typical wind turbine that might be installed in the area. The system will also measure metocean quantities such as significant maximum wave height and mean wave period.

A separate data management and analysis contractor will be employed who is completely independent of the floating LiDAR system supplier. This contractor will be responsible for collecting, transferring and storing the raw data as well as analyzing the data in relation to KPIs set out in Carbon Trust's Recommended Practices for Floating LiDAR document. Written reports will be provided to NYSERDA for wider dissemination, and all data will be made publically available for access and download. Upon completion of the deployments, both devices will be fully decommissioned to minimize any residual impacts once removed.

1 Background

1.1 Introduction

NYSERDA seeks to bolster the development of both distributed and large-scale renewable energy resources, like offshore wind, to meet the State's Clean Energy Standard. This ambitious policy mandates 50 percent of all electricity consumed in NYS by 2030 comes from renewable energy sources. Offshore wind will work together with land-based wind farms along with other renewable energy technologies like solar, to create a cleaner energy system across the State.

In NYS, wind turbines are currently only on land while offshore wind turbines have been operating continuously in Europe since 1991. Seeking to create a 21st century energy system, Governor Andrew M. Cuomo called for the development of an offshore wind strategy in the 2016 State of the State address. Known as the Master Plan, the State's strategy will provide a comprehensive roadmap to advance offshore wind in a manner that is sensitive to environmental, maritime and social issues while addressing market barriers and lowering costs.

The Master Plan envisions NYSERDA conducting pre-development assessments, studies and surveys, and in-depth analysis of field data with the goal of reducing and mitigating risks of offshore wind development. Reduced uncertainty leads to lower development and energy costs. By NYSERDA conducting pre-development assessments in collaboration with State stakeholders, local environmental and economic interests will be better protected.

This document comprises the Metocean Plan (MOP) for the NY WEA. Its goal is to set out the parameters for the wind resource assessment that NYSERDA intends to carry out. The aim of the MOP is to define the scope of a wind resource assessment that would provide bankable and reliable wind resource data for the NY WEA in an effort to reduce uncertainty and risk while increasing attractiveness to developers and investors. NYSERDA aims to carry out a high quality, cost-effective campaign that meets the standards and expectations of offshore wind farm developers and prospective future lessees of the NY WEA.

1.2 Document Structure

The document covers all the variables that feed into the planning and execution of a successful wind resource assessment. This includes the project management and organizational structure of a campaign followed by technical details of floating LiDAR validation and selection of location and duration of the deployment. As permits are a requirement when deploying the systems, the current permitting process is described in this document. Finally, the maintenance and logistical issues regarding a deployment, and data collection and analysis are described in order to ensure the smooth operation of the campaign and successful dissemination of results.

At each stage, the requirements of a floating LiDAR system supplier are clearly set out, along with any recommendations that should be considered when suppliers submit their proposals to NYSERDA for the contract to supply the systems. The requirements of a data management contractor, who will remain independent, are also set out to define the line between the two and maintain the integrity of any data collected.

1.3 Site Background

1.3.1 History

The NY WEA is a renewable energy lease zone off the coasts of New Jersey and NYS undergoing a leasing round in Q4 2016 as part of BOEM's wind energy lease process – see Figure 1.1 Map of NY WEA.

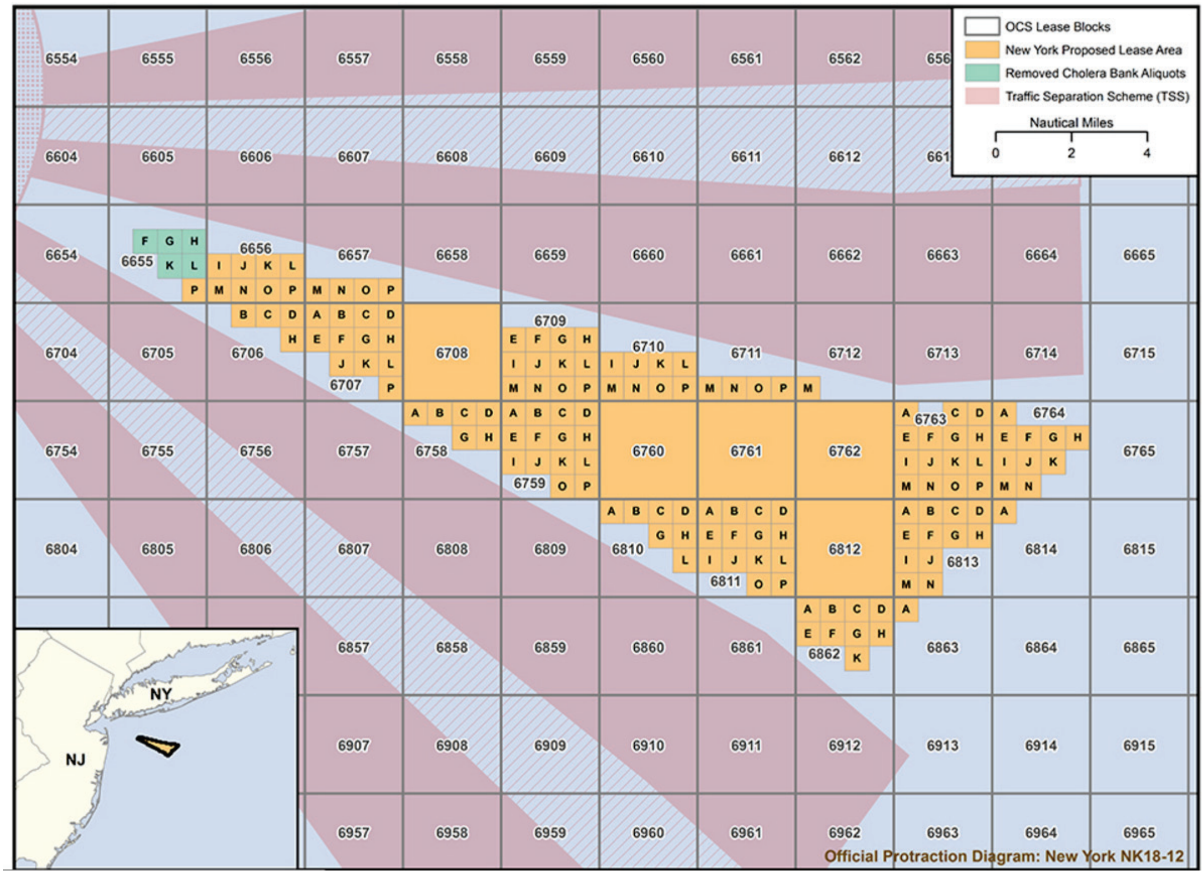
The site has been selected due to its proximity to shore (20km south of Long Beach), the predominantly shallow water depths (20-42 m), and minimal potential for impacts on key activities such as fishing and shipping.

The NY WEA was formally identified in 2016 as a renewable energy lease zone. Prior to this, NYSERDA sought to evaluate environmental and physical properties around the area, including undertaking pre-development assessments of the metocean characteristics of a potential site (1).

The NY WEA is a key part of the wider U.S. offshore wind strategy document (2). The strategy document aims to define the vision of the offshore wind energy policy and its ambition to deploy 86 GW of offshore wind capacity in U.S. waters by 2050. This includes areas of particular focus where it is acknowledged that there is work required to increase the knowledge and skill base of the U.S., but also to apply lessons learned from Europe. One of the focuses is in wind resource assessments, and ensuring the U.S. adopts the latest technological advances to minimize the cost and maximize the data quality of its developments. The aim of this is to increase the attractiveness of the U.S. as a country to build and invest in offshore wind.

The State's strategy is also for 50 percent renewable energy by 2030 (3); a key part of this will be offshore wind. Not only is the goal linked to a capacity target, but NYS also aims to deploy this at least cost. To do this, NYSERDA intends to bid in the BOEM lease auction, minimize site risk, and gather bankable data. If successful in securing the lease for this site, the State will then combine environmental, site assessment, and site characterization work (such as this metocean plan), with a power purchase mechanism and select a project developer through a competitive process. This strategy minimizes project risks and provides developers certainty to secure financing, maximizing competition to participate in development and ultimately lowering project costs for New Yorkers

Figure 1-1. Map of NY WEA (4)



1.3.2 Site Description

1.3.2.1 Physical Conditions

The NY WEA is located in the Atlantic Ocean in the New York/New Jersey bight. The site is bordered by shipping lanes to the north and south, which explains its convergent shape. The NY WEA lies predominantly between the contiguous zone (24 nm) and the exclusive economic zone (200 nm) and therefore is under the jurisdiction of BOEM who manages the development of the U.S. Outer Continental Shelf energy and mineral resources under the U.S. Department of the Interior. Key parameters of the site are found in Table 1-1 below.

Table 1-1. NY WEA Site Characteristics

Total area	65,000 acres (263 km2)
Water depths	20 - 42 m (66 to 138 ft)
Distance from shore (nearest point)	11.5 nm
Prevailing wind direction	SSW
Prevailing wave direction	SE

1.3.2.2 Summary of Existing Information

To date, there is limited metocean information and data available specific to the NY WEA. NYSERDA's pre-development metocean assessment (1) provides the most comprehensive summary of the conditions in the local area. The assessment uses data from a previous anemometer located near to the NY WEA on a light house, that has since been decommissioned, as well as buoy data and regional estimates to model predicted average wind speeds for the NY WEA.

The key results of this study show good wind resource potential in the area, with mean wind speeds predicted to be approximately 8.8m/s (±0.3) for the NY WEA. Capacity factors of up to 43.4 percent are calculated based on these figures and annual energy production of up to 2625GWh from a 700 MW project. Significant wave heights are also considered comparable to sites in the UK and northern Europe, therefore providing suitable conditions to operate and maintain an offshore wind farm.

The resource potential in the area is sufficient such that the study recommends further actions for meteorological evaluation to include measurements using a fixed platform such as meteorological mast or LiDAR. It is considered that floating LiDAR has now moved on sufficiently since 2010 when the assessment was published for it to be a suitable alternative to the suggested methods.

The study also recommends deployment of two metocean buoys and two acoustic Doppler current profilers (ADCPs) to provide further information on the wave and current environment. It is considered that much of the required metocean data could be obtained from a floating LiDAR buoy and that ADCPs could be deployed in conjunction with them to fulfil this objective – see section 2 for further information.

1.4 Goals of the MOP

The core goals of the MOP are:

1. Accelerate the deployment of offshore wind energy development in the NY WEA.
2. Reduce the cost of offshore wind and maximize the benefit for rate payers in NYS.
3. Obtain and publically disseminate high quality, bankable metocean data sufficient to conduct a robust wind resource assessment for yield prediction purposes.

The MOP will serve as the basis for a metocean campaign that NYSERDA plans to execute in in 2017. NYSERDA will use the MOP to ensure the services and materials specified in the procurement are appropriate for collecting high quality, bankable data.

2 Collaboration and Coordination

2.1 Requirements and Recommendations

2.1.1 Floating LiDAR System Supplier

2.1.1.1 Requirements

- The floating LiDAR supplier will be required to report directly to NYSERDA.
- The floating LiDAR supplier and the Data Analysis and Management Contractor must be independent entities with no commercial ties or conflicts of interest.

2.1.1.2 Recommendations

- Any proposal to deploy a floating LiDAR system may also incorporate additional data collection such as wildlife and/or AIS data.
- The floating LiDAR system supplier should endeavor to seek efficiencies during installation, operation, and decommissioning to minimize cost and maximize data collection.

2.1.2 Data Management and Analysis Contractor

2.1.2.1 Requirements

- The Data Management and Analysis Contractor will report directly to NYSERDA.
- The Data Management and Analysis Contractor must be completely independent of the floating LiDAR system supplier.

2.1.2.2 Recommendations

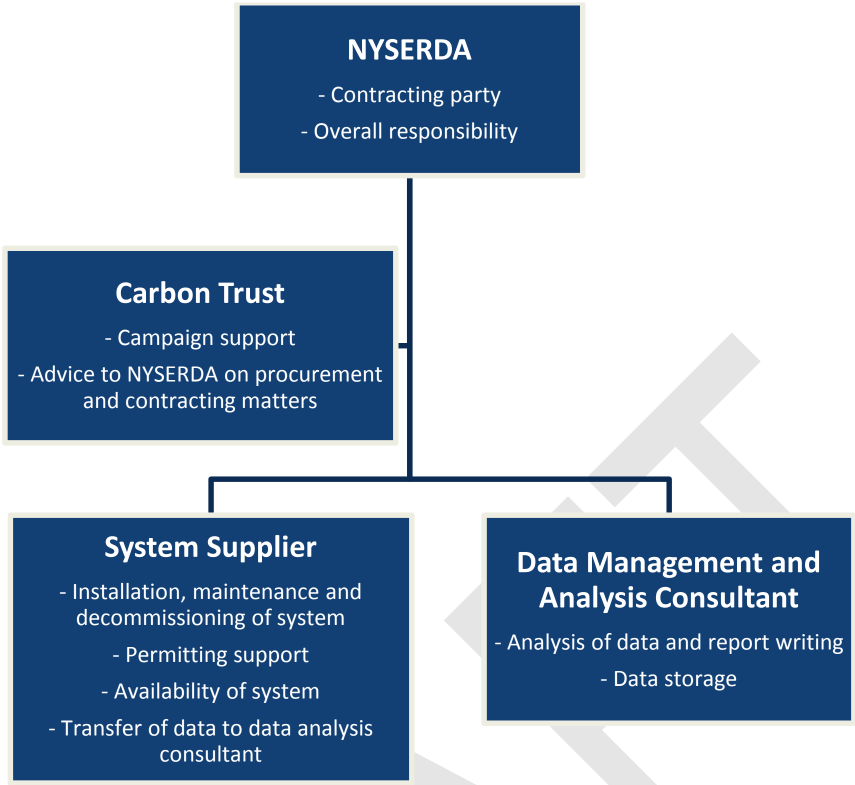
- The Data Management and Analysis Contractor may also be required to provide services to store or process any additional data (such as wildlife and/or AIS data).

2.2 Coordination

2.2.1 Project Organization

The structure of the parties involved in the metocean campaign is set out in Figure 2.1 - Organizational Structure of the Metocean Campaign. As the contracting party, NYSERDA will retain overall coordination and management of the campaign with support from Carbon Trust as necessary. Responsibilities between these two parties may vary dependent on the level of management of the campaign required. The system supplier(s) (buoy, LiDAR, mooring etc.) will work independently of the Data Analysis and Management Contractor in order to retain the objectivity of the data. The anticipated division of responsibilities are provided within Figure 2.1

Figure 2-1. Organizational Structure of the metocean campaign



2.3 Areas for Collaboration

2.3.1 Within the Wind Energy Area

2.3.1.1 Wildlife Data

While deploying a floating LiDAR system there will be the opportunity to simultaneously collect other data in addition to the required metocean data (section 8.2). NYSERDA has an overarching research program plan of which marine wind and wildlife is research area 4 (5). NYSERDA sees the deployment of a floating LiDAR system as an opportunity to further explore research into this area and will continue to openly pursue opportunities to meet this goal.

While high quality wildlife surveys are designed to provide a more complete understanding, leveraging a metocean buoy deployment with a wildlife survey can bring additional value. For example, the next generation of floating LiDAR devices are being designed to incorporate additional environmental sensors such as marine mammal hydrophones and bird and bat acoustic detectors. Alternatively, a hydrophone could be deployed separately, but using the same vessel located near the floating LiDAR system to maximize efficiencies relating to vessel charter and personnel cost.

This data could be useful in providing initial indications of the timing and density of aerial vertebrates or marine mammals in the area as well as in providing baseline projections of ambient noise to feed into any future environmental impact assessment that studies the impacts of operations such as piling on receptors.

Prospective floating LiDAR suppliers should consider how their systems may be able to accommodate such additional sensors when submitting their proposals.

2.3.1.2 Automatic Identification System (AIS) Data

In addition to wildlife data, AIS data could also be collected using the floating LiDAR system. AIS sensors are used on ships to identify and locate vessels for safety reasons. The range of a typical AIS system is up to 20 miles, meaning any AIS sensor fitted to a buoy centrally within the zone would gather data for the whole NY WEA. Collecting AIS data would provide a valuable source of data for a prospective environmental assessment and would negate the future need to actively deploy these sensors, potentially removing the need to carry out significant marine traffic surveys.

AIS data is also used in identifying marine traffic relating to commercial fishing in the area and could provide valuable input into assessing the potential impact of a wind farm on commercial fishing.

2.3.2 Beyond the Wind Energy Area

2.3.2.1 Further Modeling

Collaboration on the NY WEA could also extend beyond the primary uses within the wind energy area. Due to the site specificity required by financiers, the data collected onsite within the NY WEA would not be applicable as a primary source of wind resource assessment data elsewhere. However, the data collected will be a valuable resource for the wider NYSERDA strategy regarding offshore wind farms in the New York Bight. As stated in the Blueprint for the New York State Offshore Wind Master Plan (6), the deployment of floating LiDAR devices would assist in the identification of key areas within the New York Offshore study area. For example, the data collected from the floating LiDAR systems could be combined with historic wind data from the area to create a more refined mesoscale model for the whole study area. This model could then be used for:

- Gaining a far better understanding on how onshore wind conditions (there is much data) corresponds to offshore conditions (there is little data) in this general offshore area;
- Targeting future lease areas that offer the best return on investment (ROI);
- Optimizing future wind farm design;

- Modeling the cumulative wake effects of several wind farms in the New York Offshore study area; and
- Refining the estimates of potential resources in the area previously calculated by NREL (6).

2.3.2.2 Further Deployments

Dependent on the contract terms with the floating LiDAR system supplier, cost savings could be achieved if the systems were deployed in another area immediately after the original campaign. There would be limited savings in installation and decommissioning costs, although there may be some efficiencies in vessel charter. The main saving would be the ability to procure a longer-term contract with the system supplier.

The practical lessons learned from the deployment is of particular value, both from a general perspective and in relation to local factors. For example, practical lessons from deploying floating LiDAR devices from a particular port may be applicable to future campaigns. These learnings are often invaluable to the organization running the campaign, as well as across the industry.

3 Floating LiDAR Selection and Validation

3.1 Requirements and Recommendations

3.1.1 Requirements

- The LiDAR used for the system selected for the NY WEA must be verified through onshore tests in accordance with the guidelines set out in IEC 61400-12-1, Annex L (9).
- The floating LiDAR system (type) must have reached Stage 2 of the Carbon Trust Roadmap using one of the following offshore references:
  - Fixed offshore met mast.
  - LiDAR mounted on a fixed offshore platform.
  - Onshore met mast sufficiently close to shore with minimal flow disturbance.
  - LiDAR located onshore or on a pier with minimal flow disturbance.
- The floating LiDAR system (unit) must undertake a pre-deployment verification before deployment, following RP89 and 91 of the OWA RP (7), unless it is of a quasi-static/spar buoy type where NYSERDA will consider the requirement for this on a case-by-case basis dependent on a scientific case for this being made in any proposal.
- During the deployment, data will be reviewed by the Data Management and Analysis Contractor on an on-going basis to check for any obvious errors or technical issues.
- Upon conclusion of the campaign, the data collected will be analyzed by the Data Management and Analysis Contractor to check for any systematic errors. If evidence of errors are found, the Data Management and Analysis Contractor may recommend, and NYSERDA may require a two week onshore verification must be carried out to identify and investigate these errors.

3.1.2 Recommendations

- LiDAR models that demonstrate they have previously met the KPIs set out in the Carbon Trust Roadmap (8) on at least two different offshore trials and on more than one buoy design will be preferred.
- Any pre-deployment verification and validation should take place in sea states as representative of NY WEA as feasible. Proposals that consider this along with a strategy to accommodate this and evidence of minimizing the uncertainty within measurements will be favored.
- Floating LiDAR system suppliers should consider whether their system can mount more than one LiDAR and describe how this could impact the uncertainty of their measurements.

3.2 Selection of Floating LiDAR

3.2.1 Overview

When developing an offshore wind site, detailed data must be collected regarding wind speed, direction, and other metocean conditions. This is to inform optimal site layout, design and operation, and perhaps more importantly to understand the predicted wind resource at the site for a given design of wind farm.

There are two stages in this assessment: the first is to collect data at the site upfront, and the second is to analyze the raw data in conjunction with the proposed wind farm design to translate this into an expected annual energy production (AEP) estimate. This information is relied upon by funders and advisers when assessing the risk of project developments. Therefore, it is essential that the wind resource data and measurements are seen as reliable, accurate, and bankable for the purposes of AEP calculations regardless of project funding structure.

This data can be collected in a number of ways, including met masts, fixed and floating and even scanning LiDARs. When deciding which option is most appropriate for a given campaign, one of the main considerations is finding the best balance between upfront cost and uncertainty reduction. This uncertainty evolves with the project as data gathering exercises generally become increasingly costly.

A desktop study has already been produced for the NY WEA using data modeling to provide an indicative view of the expected resources at the site (1) – the results of this study, commissioned by NYSERDA are discussed in section 1.3. The modeling data from this study has implied that the NY WEA is a favorable site, therefore the next stage is to gather onsite data. When collecting such data, there are a range of options available. These include meteorological masts and various forms of LiDAR measurement systems, including floating LiDAR, scanning LiDAR and fixed vertical profiling LiDAR among others. Different options will be appropriate for different sites, and so there is no one-size-fits-all approach as each deployment must be assessed on a case-by-case basis. As there is no guarantee that the wind farm will be developed, the upfront investment of a full met mast may not be the best approach and you could reach similar conclusions with lower cost methods such as floating LiDAR deployments. This also leaves the option open, if the data collected is favorable yet marginal, to collect further data through a met mast deployment, or in a more likely scenario, further floating LiDAR deployments.

3.2.2 Approach for NY WEA

NYSERDA will use floating LiDAR to collect data so the construction of a met mast is not required. The key reasons are that the confidence in floating LiDAR technology has greatly increased in recent years as significant advances have been made in the technology. There are a range of devices available on the market with numerous validation campaigns and trials conducted globally. This collective understanding and experience in the technology, as well as the track record of delivering accurate and reliable data, has underpinned floating LiDAR's role. Indeed, a number of projects are now choosing to install fewer met masts or do away with them altogether, and replace with floating LiDAR systems. This move greatly reduces the cost of developing a zone in many cases, offering greater confidence and flexibly to developers and advisers alike.

It should be noted that the information in this section is based primarily on a number of key documents, including the OWA Floating LiDAR Recommended Practice (OWA RP), the IEA Floating LiDAR Recommended Practice (IEA RP), the Carbon Trust Offshore Wind Accelerator Roadmap for the commercial acceptance of floating LiDAR technology (Carbon Trust Roadmap) and the IEC61400-12-1 CDV/Annex L (7), (8), (9). Although these documents were primarily drafted for the European market, this section follows the recommendations and requirements cited. In a number of key areas the recommended approach goes over and above what is stated in the various standards and recommended practices in order to reflect that these recommendations are being made for a U.S. project.

3.2.3 Turbulence measurements

Turbulence measurements will not be required upfront. Once the wind resource is assessed in more detail alongside available turbulence calculations, a review can be made as to whether onsite turbulence measurements are required for the project.

Although not strictly within scope of this MOP, it is worth noting the differences in approaches when evaluating turbulence measurements. Assessing turbulence isn't required for a wind resource assessment, but it is necessary for structure design and turbine selection. To date, the use of LiDAR (both fixed and floating) for turbulence assessments remains a research topic (10), and met masts are currently the only way to gain this information through onsite measurements.

However, turbulence and extreme wind data could be determined by other means. If an onshore met station indicates low turbulence, then this could be assessed to conservatively apply to the offshore site, which may allow a lower-turbulence turbine class and a relatively cheap support structure design. On the other hand, if high turbulence is indicated then it would be required to prove that less severe conditions apply offshore (as is usually the case) through modeling, which is inevitably more uncertain than measurements.

If onsite measurements are required, a quasi-static spar buoy or platform instrumented in the same way as a met mast could be used instead of a fixed structure. However, this approach has not yet been seen in the market and would need further study and consideration before deployment.

3.2.4 Site specific considerations

As the NY WEA sits relatively far offshore and there are no appropriate offshore platforms in or around the zone, this immediately rules out scanning LiDAR or Doppler radar as options. In any case, these would not be advised as they are not yet commonly used for AEP assessments, although this may change in future.

The two technologies currently used for wind resource assessment are primarily met masts and floating LiDAR. Although met masts have historically been favored, recent developments and validation of floating LiDAR systems have greatly increased the confidence and understanding of this technology. For example, a recent paper by DONG Energy (11) has stated that it is "difficult to see met masts in DONG Energy's future." The same paper provides a very cogent description of how wind resource measurements add value to an offshore wind farm development. Floating LiDAR offers a number of advantages over met masts including:

- Significantly reduced upfront capex. Floating LiDAR systems cost $2-3 million compared to a met mast at around $15 million depending on the site.
- Increased flexibility. Floating LiDAR devices can be moved around a site if required and offer greater flexibility of deployment locations.
- Accelerated deployment. The timescales required to deploy floating LiDAR systems are generally significantly less than required for a met mast due to reduced technical challenges.
- Measurement ability. LiDAR systems are typically able to measure to higher altitudes than a conventional met mast thus increasing the flexibility of measurement requirements and are more suitable for contemporary offshore turbines.

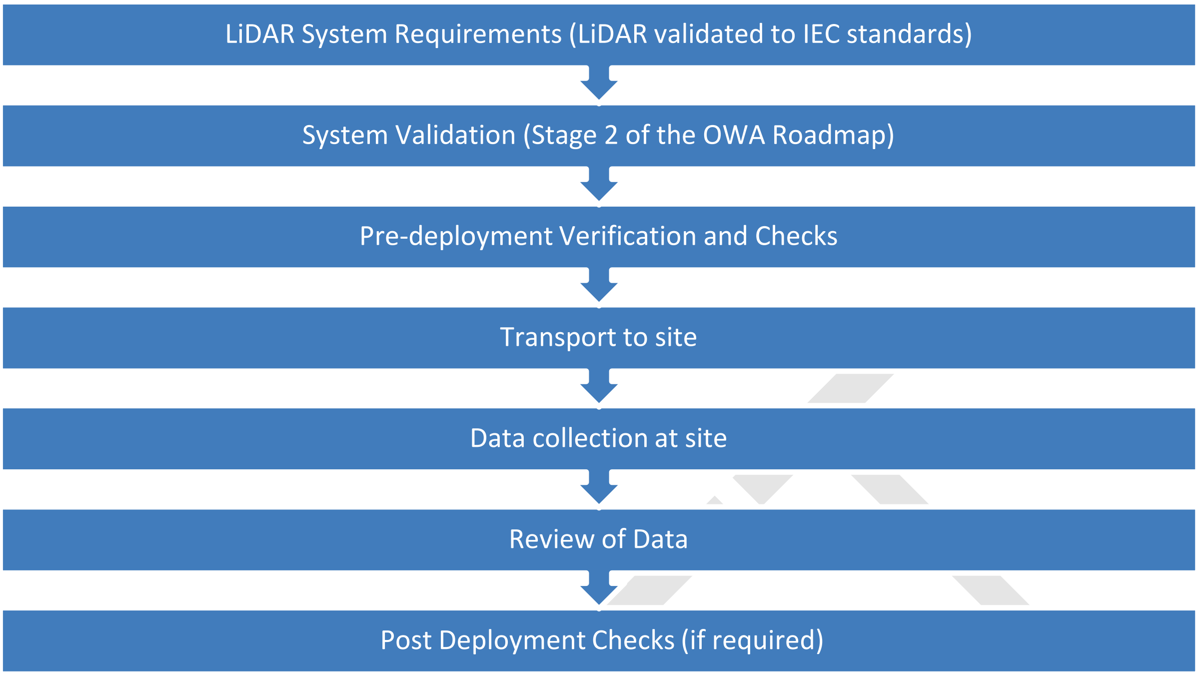
The key advantage of met masts over floating LiDAR systems is that they have a greater track record of providing wind resource assessment data for both offshore and onshore wind projects.

3.3 LiDAR System Validation and Verification Requirements

Floating LiDAR system validation and verification is key to the bankability and confidence in the data from any offshore campaign. Although many guides and recommended practices set out the requirements for such validation, there is no set approach and many options are open to LiDAR suppliers when validating their system.

There are several stages in the validation process, including a separate validation of the LiDAR itself as well as the performance of the buoy in an offshore environment. Figure 3.1 Overview of Validation and Verification Process sets out the main steps required throughout the process, with each stage covered in detail below.

Figure 3-1. Overview of Validation and Verification Process



3.3.1 LiDAR system requirements

The LiDAR system selected for the NY WEA must be verified through onshore tests in accordance with the guidelines set out in IEC 61400-12-1, Annex L (9). The LiDAR should be well accepted within the industry and have been used in numerous onshore or offshore trials with success demonstrating high levels of accuracy and reliability, and meet the best practice criteria set out in the Carbon Trust Roadmap (8). In addition, the guidelines on verification, industry acceptance and motion compensation as set out in the OWA RP document (7), including RP57 – 60 inclusive must be followed.

To maximize the confidence in the data, preference will be given to exact floating LiDAR models (but not necessarily the system itself) that can demonstrate that they meet the KPIs set out in the Carbon Trust Roadmap (8) on at least two different offshore trials. Additional preference will be given to LiDARs that have been validated on more than one buoy design.

There is the possibility of mounting more than one LiDAR on the buoy, depending on the buoy design. This has the advantage of increasing the likelihood that one of the systems will be operational. However, given other safeguards this will not be a requirement for the deployment, but proposals including this will be favored dependent on cost.

3.3.2 System validation

The most widely accepted guidance document for floating LiDAR system validations is the Carbon Trust Roadmap (8). However, this document relies on an offshore IEC compliant met mast to validate the floating system. Although there are several in the pipeline, there are currently no operational met masts located in offshore U.S. waters, therefore the guidelines set out in the Carbon Trust Roadmap (8) must be adapted to allow for other validation approaches. The aim of this particular trial is to minimize uncertainty to ensure bankability of data, therefore a more conservative approach has been recommended than may be required for other campaigns. In the absence of appropriately detailed guidelines, NYSERDA requires the following principles apply.

The floating LiDAR system must be demonstrated to have reached Stage 2 as set out in the Carbon Trust Roadmap (8), with the allowance that this may not be required to be tested against an IEC compliant offshore met mast as required in the roadmap, but can instead be validated against another appropriate offshore reference.

It is important to make the distinction between a floating LiDAR system type and the unit itself. The system validation applies to the type, therefore if a floating LiDAR system type has previously been validated and met the criteria of Stage 2 in the Carbon Trust Roadmap (8), then system validation may not be required. However, the floating LiDAR supplier must demonstrate that the use condition and sea state of the validation trial do not bring in too much additional uncertainty similar to the sea states expected in the NY WEA.

If the buoy is non-static (i.e., the buoy moves with the waves) then the trusted reference source should be among the following:

- **Fixed offshore met mast.** Although this is the standard approach, the process of transporting the floating LiDAR system any significant distance will raise the uncertainty of the performance of such a system. The preference is for the validation to take place within easy transportation distance of the measurement site itself. There are several plans for fixed offshore met masts to be installed in offshore U.S. waters and therefore if these can be used in the requisite time frames this would be acceptable. Alternatively, a technical case or track record of transporting the system may be considered in any proposal provided a sufficiently robust and scientific case is made.
- **LiDAR mounted on a fixed offshore platform**. This platform could be any stable structure, such as an oil and gas platform or offshore wind turbine. It is likely that the platform may contribute to flow distortion around the test buoy, therefore wind directions in the sector surrounding any structure should be excluded from the validation. The reference LiDAR should comply with the validation requirements set out in the LiDAR System Requirements section. As stated, the LiDAR on a fixed offshore platform must be within easy transportation distance of the measurement site itself, otherwise a scientific case must be made for an exclusion.

- **Onshore met mast sufficiently close to shore with minimal flow disturbance**. There is no set requirement for how close or far the met mast must be from shore, but the distance from the shore to the floating LiDAR system should be maximized, and the distance between the met mast and the floating LiDAR minimized where possible. RP 78 in the OWA RP (7) recommends that the separation between the system and reference should be no more than 500m, however in this instance the distance is likely to be greater. The effect on distance and flow distortion should be assessed in detail by a trusted independent technical adviser.
- **LiDAR located onshore or on a pier with minimal flow disturbance**. As with the met mast reference above, the distance from the shore to the floating LiDAR system should be maximized, and the distance between the reference LiDAR and the floating LiDAR minimized where possible although it is recognized that this is likely to be greater than the recommended 500m maximum distance. Again, the effect on distance and flow distortion should be assessed in detail by a trusted independent technical adviser.

In any of the above cases, the independent assessment of the validation trial should cover the suitability of the reference system. RP77 in the OWA RP (8) must be followed in full.

If the buoy can be classed as a quasi-static structure, for example some spar or TLP type platforms, then it could be justified that a LiDAR validation is required and the offshore validation is not necessary. Should a supplier wish to adopt this approach, it would need to be clearly justified by the floating LiDAR system owner with clear evidence on the static or near-static behavior of the system. This should be included in any formal proposal submitted to NYSERDA and will be considered on a case-by-case basis.

Overall, whichever approach is adopted or proposed by a floating LiDAR system supplier, their proposal must detail which validation method is proposed and a technical analysis of the methodology provided showing that it is:

- Clearly justified;
- Mapped back to existing standards, roadmaps and recommended practices;
- Following best industry practice; and
- Verified by a trusted independent adviser, similar to the requirement for the data analysis from the validation itself.

3.3.3 Pre-deployment verification and checks

Due to the lack of offshore structures within the NY WEA, the above system validation will not be able to take place within the zone and may have taken place sometime prior to the NY WEA campaign is planned to commence. In this case, for a non-static buoy a pre-deployment verification will be required, in accordance with RP 89 and 91 in the OWA RP (7). A floating LiDAR supplier may make a case for a quasi-static buoy to follow RP90 (7) and just the LiDAR to be verified rather than the entire system, however a robust and scientific case must be made for this in any proposal.

The structure of the pre-deployment verification falls under the same requirements as the system validation, but would not be required to have as long duration – four to eight weeks depending on wind conditions.

It is recommended that the pre-deployment verification is carried out in representative sea states and floating LiDAR system suppliers who provide either a strategy to accommodate this or evidence showing that this is a consideration will be favored.

3.3.4 Review of data

Throughout the deployment duration, the data collected will be reviewed on a regular basis to check for any gaps indicating faults in the system and also to review for any errors in the data. This will be carried out by the Data Analysis and Management Contractor to retain the independence and integrity of the checks. This will allow for a swift remedy of any errors that arise. RP88 in the OWA RP must be followed.

3.3.5 Post-deployment checks

At the conclusion of the campaign the data collected should be analyzed by the Data Management and Analysis Contractor to check for errors. If questions are raised, a two week onshore verification of the LiDAR itself against either another LiDAR or met mast will be carried out to investigate these anomalies.

4 Location

4.1 Requirements and Recommendations

4.1.1 Requirements

- The floating LiDAR buoys will be located as shown in Figure 4.1 Proposed Deployment Scenario.
- The floating LiDAR supplier will accommodate flexibility for any micro-siting requirements.

4.1.2 Recommendations

- There are no recommendations for this section.

4.2 Buoy Location

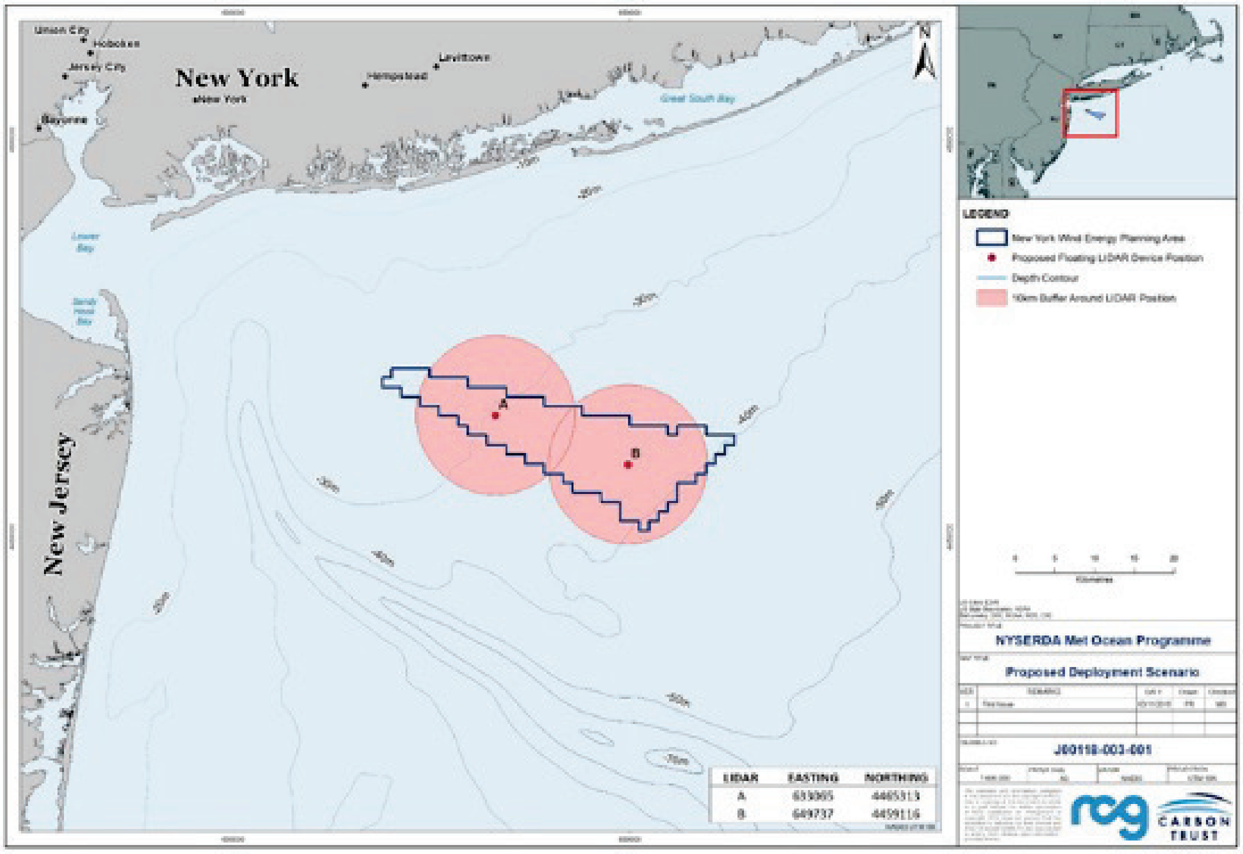
Utilizing the information gathered on the constraints affecting the location of the two floating LiDAR systems, it is proposed that two floating LiDAR buoys are situated in the center of the NY WEA, optimized to maximize the overlap between the 10km buffer recommended by Measnet (12) and the zone itself. At the same time this is balanced with achieving separation to understand the wind resource gradients across the site as well as any micro-siting applied at deployment or after survey. Furthermore, there are environmental concerns regarding the western corner of the site with blocks having already been removed to protect sensitive benthic habitats. This is perceived as a higher risk area for both turbine and floating LiDAR location, and therefore, priority has been given to the central and eastern sides of the NY WEA.

The locations of the two floating LiDAR buoys are shown in Figure 4.1. In this deployment scenario, 92 percent of the NY WEA would be covered by the 10km buffers.

4.3 Constraints

There are a number of considerations determining the location of the floating LiDAR system(s). The following section summarizes the results of a constraints mapping exercise undertaken to determine the optimal location for deploying up to two devices in the NY WEA.

Figure 4-1. Locations of the two floating LiDAR buoys covering 92 percent of the NY WEA by the 10km buffers.



4.3.1 Bankability

The main consideration for the location of the floating LiDAR systems is bankability. The principal objective of the wind resource assessment is to collect data on wind speeds that provides sufficient confidence for investors in the annual energy production estimates. This is a crucial step in the pre-development work affecting the overall value of the lease site and the project, once it is operational.

In terms of location, Measnet provide site assessment guidance (13) that is considered industry standard for assessments of this type. The guidelines recommend a maximum distance of 10km from the measurement location and all wind turbines. Given the expectation that turbines could be located across the zone, it is anticipated that two measurement locations would be required to cover the majority of the NY WEA with a 10km buffer. It is also considered that, provided other constraints allow, the floating LiDAR systems are located centrally within the zone to further maximize this coverage.

Other location factors that influence bankability would be the presence of any other structures affecting the free stream measurements of the floating LiDAR system, or terrain impacts that may disturb the flow and affect turbulence and shear in the area. An initial assessment from the data available suggests that the zone is in a clear space and far enough offshore for these points to be considered negligible.

4.3.2 Environmental Constraints

A key consideration of the regulators when deploying a floating LiDAR system is to minimize the environmental impact it will have. This is required by legislation such as the National Environmental Policy Act (NEPA) (14). Environmental issues pertaining to the deployment of a floating LiDAR system are considered in detail in the environmental assessment report for the NY WEA (15). This report outlines the likely deployment scenarios, including provision for up to two meteorological buoys in the NY WEA. In doing so, it considers the likely environmental impacts of a deployment and considers that, following best practice methodologies, the magnitude would be minor.

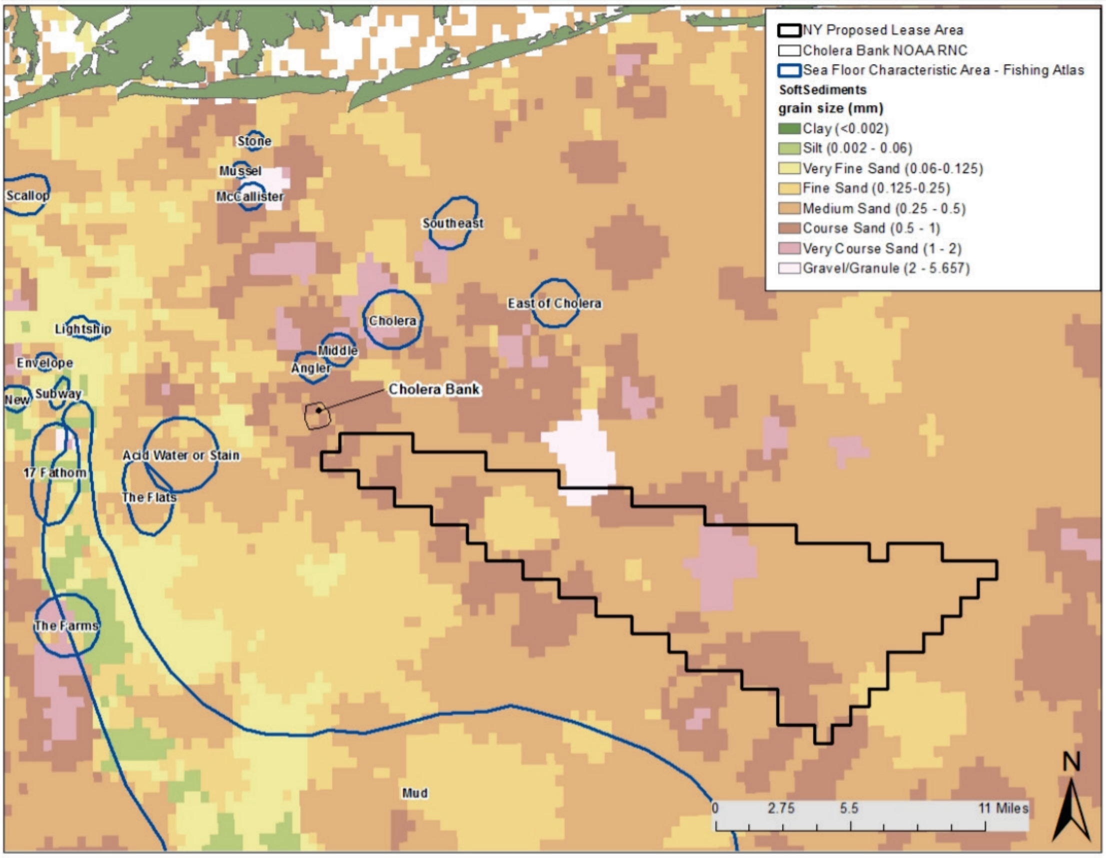
4.3.2.1 Benthic Habitats

In terms of location, the biggest spatial variation in impact will come from the effect of the anchor(s) on the benthic communities such as crushing or smothering organisms or through suspended sediments when deploying and recovering anchor(s) (15). For the purposes of this evaluation, a high level review of the sea floor characteristics has been undertaken, sourced largely from the environmental assessment undertaken by BOEM (15), and also from data readily available from sources. BOEM's report shows modeling of the sediment/habitat type across the zone as displayed in Figure 4.2 Sediment Type and Other Seafloor Characteristics. This shows an increasing likelihood of more sensitive habitats northwest of the NY WEA. Therefore, BOEM stated that any pre-deployment surveys would have to consider the habitats in these areas and for any deployments to minimize their impacts on these areas in particular, if they are found to contain sensitive species.

In BOEM's final sale notice (16), it announced that five OCS sub-blocks have been removed from the original NY WEA proposed lease due to environmental concerns regarding the presence of Cholera Bank Aliquots in these areas. This shows that this area may be a high-risk area for developers and for the siting of wind turbines with respect to impacts on benthic habitats. This is further highlighted in Figure 4.2.

Taking all of this into account, it is proposed that any floating LiDAR systems are deployed away from the western corner of the NY WEA to reduce the risk of discovering and disturbing sensitive species minimizing the environmental impacts of any deployment.

Figure 4-2. Sediment Type and Other Seafloor Characteristics (17)



4.3.2.2 Marine Protected Areas and Other Ecological Management Schemes

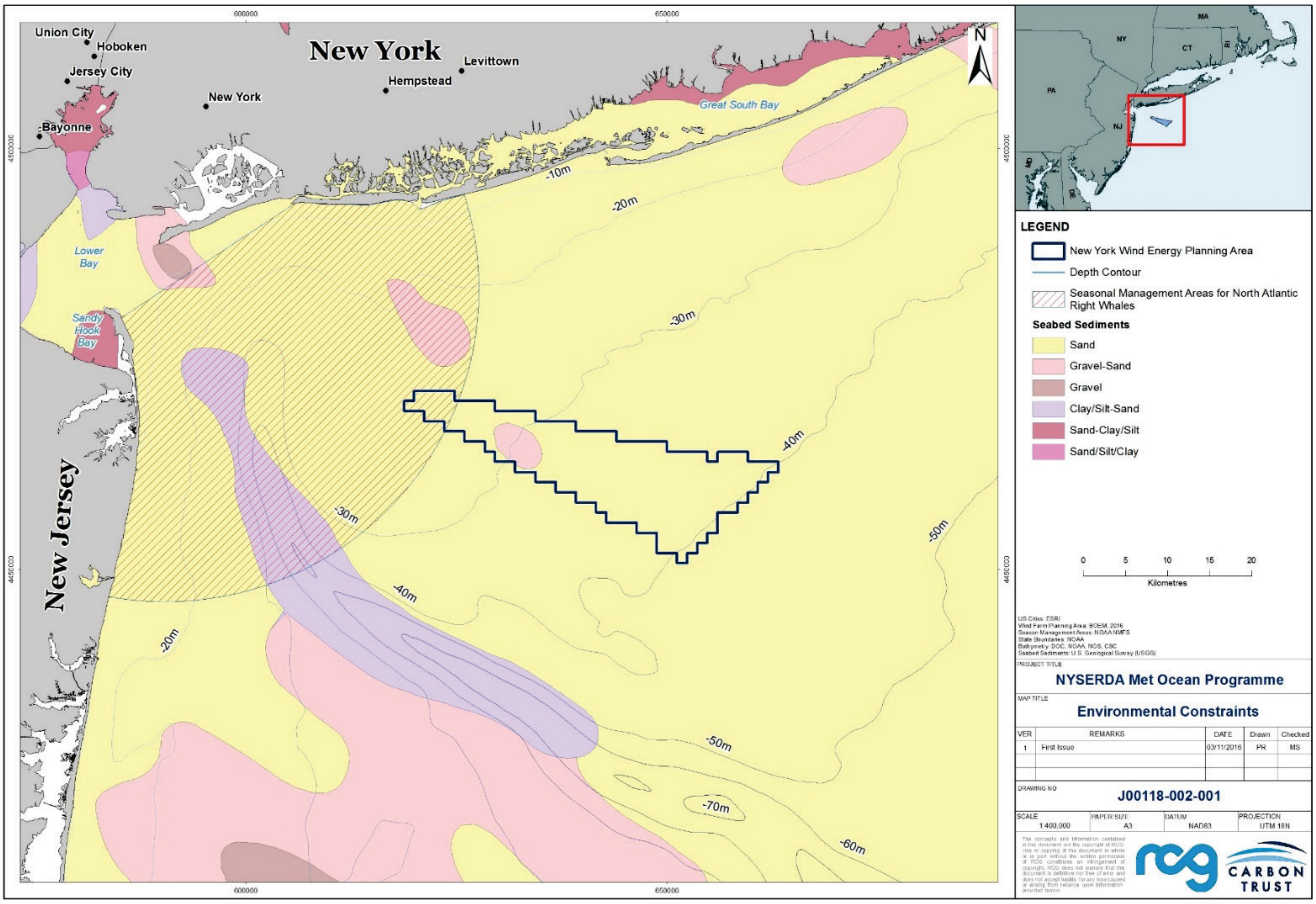
All Marine Protected Areas (MPAs) in the vicinity of the NY WEA relate to seasonal restrictions on fishing vessel activities and are therefore not deemed relevant for consideration within this MOP.

As shown in Figure 4.3, there is a seasonal management area for the North Atlantic right whale that overlaps the western edge of the NY WEA. This management area restricts vessel speed to 10 knots or less for vessels 65 feet or longer. While this does not have an immediate impact on the location of floating LiDAR it shows that the western side maybe less favored by developers due to the possible presence of the right whale.

4.3.2.3 Other Considerations

While the benthic communities are the most sensitive to floating LiDAR system deployments, other environmental receptors should be considered as a matter of best practice. The BOEM Environmental Assessment (15) has considered all of the remaining issues and has deemed the deployment of up to two meteorological buoys to be acceptable. Therefore, there are no further specific locational issues to consider in the siting of two floating LiDAR systems.

Figure 4-3. Environmental Constraints



4.3.3 Human Constraints

As well as environmental factors, human constraints also play a part in determining the location of floating LiDAR systems. Of particular importance are:

- Shipping activity;
- Leisure activity;
- Commercial fisheries; and
- Subsea infrastructure such as telecoms cables and gas pipelines.

Other factors such as visual impact, radar signature, and diving may also have an impact on the wind farm location. However, an initial review suggests that there are no major issues to be considered that might preclude the installation of floating LiDAR systems or wind turbines at any particular locations in the zones.

4.3.3.1 Shipping Activity

The NY WEA is specifically designed to avoid two main shipping lanes (and Traffic Separate Schemes) to the north and south (as shown on Figure 4.4 Human Constraints). These explain the triangular shape of the NY WEA and ensures that the majority of activity does not pass through the zone. BOEM has stated its intention to implement a restriction on any lessee of no placement of a structure with surface occupancy within a 1nm buffer of the traffic separation schemes. This is noted as the 'preferred action' by BOEM in its environmental assessment (15) and is shown in Figure 4.4. This buffer would prevent the placement of floating LiDAR systems within these buffers and therefore should be taken into account when considering the proposed location.

4.3.3.2 Subsea Infrastructure

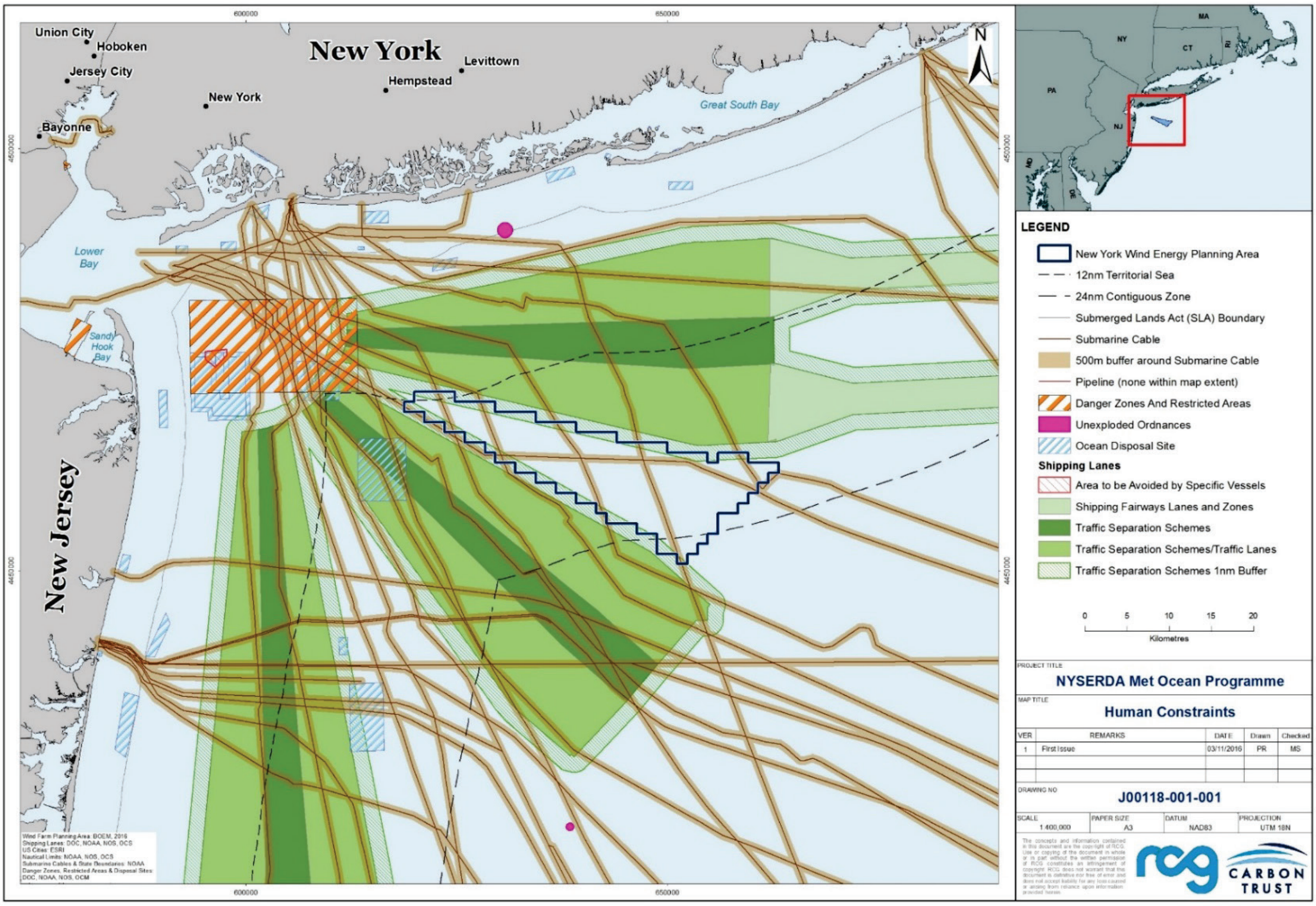
Floating LiDAR systems should also be sited away from subsea infrastructure – in particular oil and gas pipelines or telecoms cables. Operators typically request a buffer around their assets to minimize the risk of anchors puncturing pipelines or severing cables. Although there are no pipelines in the vicinity of the NY WEA, there are a number of telecoms cables that intersect the zone and should be avoided. Typically, operators request a buffer of 500m from their assets for devices such as floating LiDAR systems. This data is shown in Figure 4.4, including the buffers that have been avoided.

Shipwrecks and unexploded ordnance (UXO) would also be of consideration, however due to the size and nature of these it is anticipated that they would be detected in any pre-deployment geophysical surveys (which will be carried out by the floating LiDAR system supplier if these surveys have not already been carried out) and micro-siting undertaken to mitigate impacts. An initial review of the shipwrecks currently recorded (16) suggest that there are few enough to not affect the general location of the floating LiDAR systems. A UXO is picked up on Figure 4.4, but it is outside of the NY WEA and not of concern for locating floating LiDAR systems.

4.3.3.3 Leisure Activity

Leisure activity, particularly sailing, can also affect the location of a floating LiDAR system. LiDAR systems should avoid areas of high density so as to limit the impact a buoy might have on their activities and reduce the risk of collision. Upon initial analysis of the 2013 density data for leisure and pleasure craft on the Marine Cadastre (16), there is negligible leisure sailing within the NY WEA and will not impact the siting of the floating LiDAR systems.

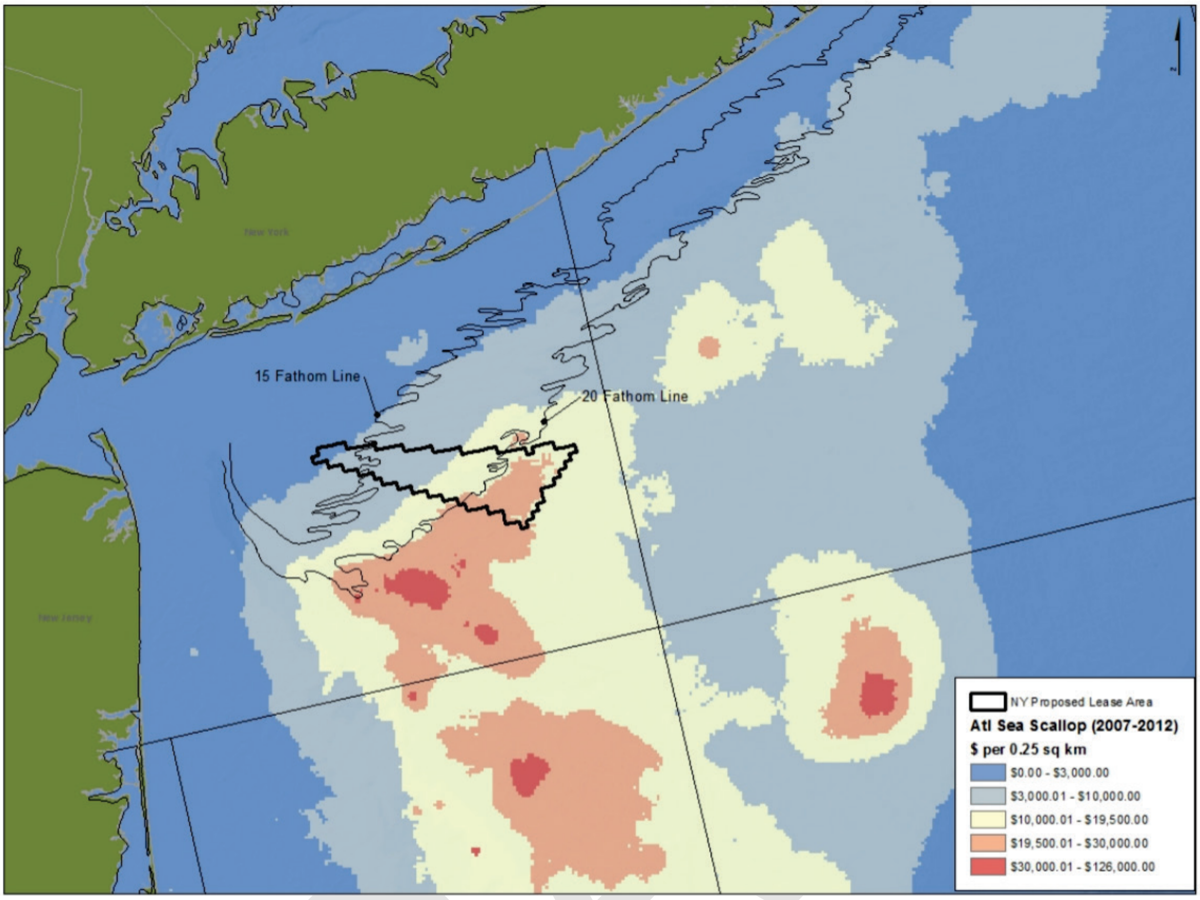
Figure 4-4. Human Constraints



4.3.3.4 Commercial Fisheries

Commercial fishing is present within and around the NY WEA. The main risks associated with the deployment of floating LiDAR systems in the vicinity of fishing operations is the risk of nets tangling with the mooring lines, anchor drags damaging the system and/or moorings, and vessel strike with the buoy. Therefore, it is favorable to locate the floating LiDAR systems outside of areas of higher density. The BOEM Environmental Assessment (15) shows coarse figures relating to commercial and recreational fishing in the vicinity of the zone. Of most significance is the spatial variation associated with the commercial dredging effort and scallop landings across the zone. Greater densities of both activities are further offshore in the eastern and southeastern parts of the NY WEA as shown in Figure 4.5 - Scallop Landings within the Vicinity of the NY WEA. While there is a notable increase in these locations, it is not considered statistically significant enough to affect the siting of a floating LiDAR system as activities in these areas are still relatively moderate and the main fishing grounds are outside the NY WEA.

Figure 4-5. Scallop Landings in the Vicinity of the NY WEA (17)



4.3.4 Physical Constraints

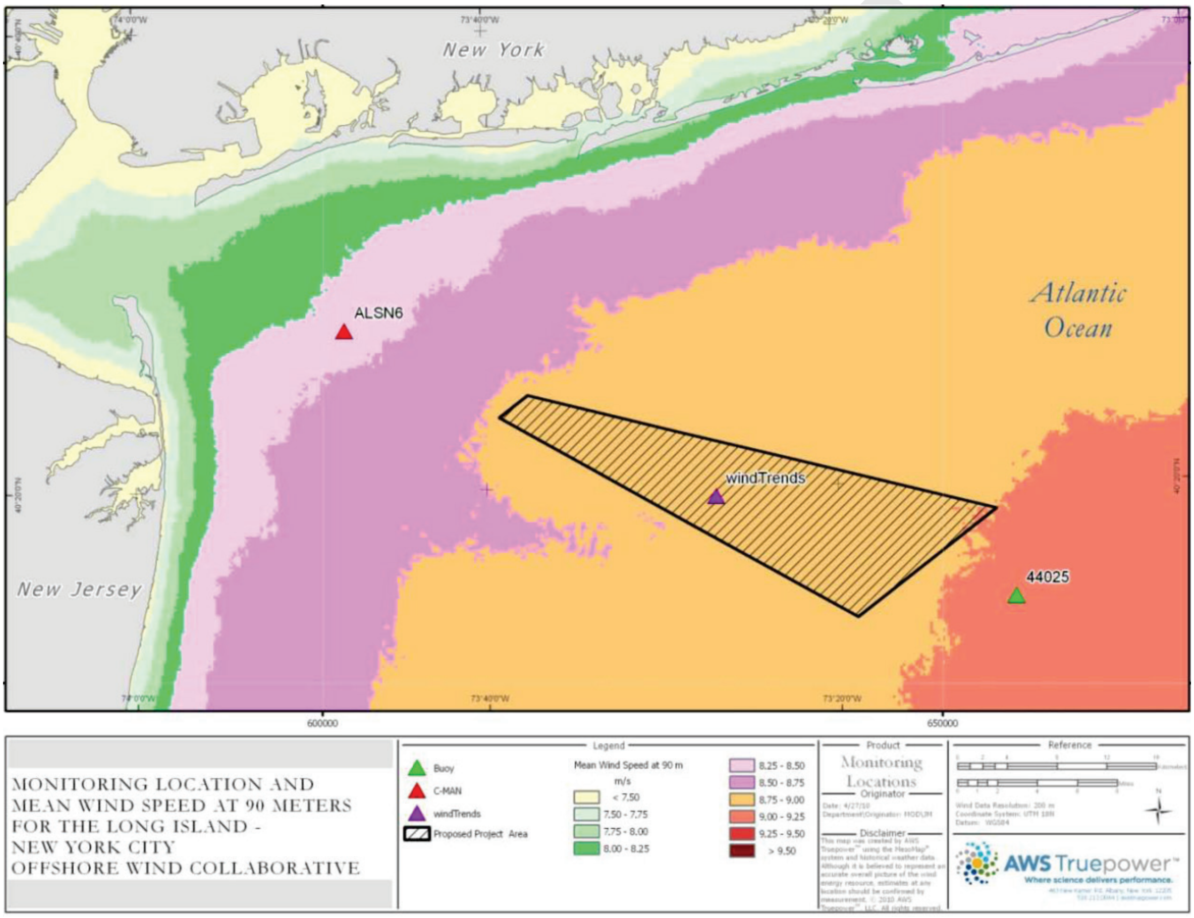
4.3.4.1 Wind Resource

The most important physical constraint relating to the location of floating LiDAR systems is the potential wind resource and the spatial variation across the zone. It is also important that wind speed is measured in a free stream and that there are no obstructions causing turbulence or atmospheric instability affecting the validity of results.

A review of the area shows that there are no concerns regarding the ability to achieve a free stream velocity in any direction including the predominant wind direction (south-southeast). Therefore, this is not considered further.

The spatial variation of the wind speed across the zone has been modeled using mesoscale modeling carried out by AWS Truepower on behalf of NYSERDA (1). The modeling utilizes data from metocean buoys currently deployed, and historical cup anemometer deployed on an offshore lighthouse that has since been decommissioned. The results of the modeling are replicated in Figure 4.6 Mesoscale modeling of mean wind speed at 90m. This shows that there is very little variation of the mean wind speed at 90m across the zone expected. The general trend is for higher wind speeds to be expected further offshore, and therefore the southeastern side of the zone will be the favored side. However, given the size of the NY WEA and the wind speeds across the zone showing good speeds for development, it is anticipated that turbines would be located across the zone. Therefore, there are no constraints pertaining to wind speed that should affect the siting of a floating LiDAR system.

Figure 4-6. Mesoscale modeling of mean wind speed at 90m (1)



4.3.4.2 Water Depths

The physical profile of the NY WEA may also affect the siting of the floating LiDAR systems. In the first instance, it is favorable to deploy buoys in shallower water to minimize costs and risks associated with longer mooring lines. Floating LiDAR systems should also be deployed in areas closest to the prospective wind farm. Given the size of the zone and the relative shallow waters throughout the NY WEA, it is not anticipated that a developer would favor or rule out any one area within the zone at this stage. Therefore, it is assumed that the floating LiDAR systems should maximize data coverage across the zone. This factor influences the siting of the floating LiDAR systems more than the cost savings previously referenced.

4.3.4.3 Currents

Currents have the potential to affect the placement of floating LiDAR systems if they are particularly strong at any one time especially with relation to access and maintenance of the systems. Upon review of the modeling and data from the NYSERDA pre-development metocean assessment (1) there is not a significant spatial variation of the ocean current velocities across the NY WEA. Therefore, this should not be considered further in relation to the siting of the floating LiDAR devices.

4.3.4.4 Waves

The wave environment may also affect the placement of floating LiDAR systems. Systems should be sited away from areas frequently experiencing severe wave heights both to minimize potential damage to the device and to ensure the device can be accessed regularly as required. Upon review of the data available from metocean buoys currently deployed and the NYSERDA pre-development metocean assessment (1) the wave conditions within the NY WEA are consistent with surrounding area and there are no specific areas that should be avoided.

5 Duration

5.1 Requirements and Recommendations

5.1.1 Requirements

- Data collection will take place for a minimum of 12 months.
- LiDAR system suppliers will be required to provide quotations for optional 18 and 24 month campaigns should permits allow it.

5.1.2 Recommendations

- LiDAR system suppliers should assist in providing input to assessments of inter-annual variability and thermal stability to inform whether 18 and 24 month campaigns may be required.

5.2 Selection of Deployment Duration

Based on the analysis carried out, the campaign will run for a full 12 months, however, go/no-go decisions will be built in to any contract with the floating LiDAR supplier to extend the campaign to 18 or 24 months. This is also dependent on requisite permits being obtained from BOEM for a deployment longer than 12 months. These decision points will be informed by studies carried out regarding factors presenting uncertainty into any assessment such as inter-annual variability and thermal stability. As more information is gathered on the atmospheric conditions and wind characteristics off the east coast of the U.S., a more informed decision can be made as to the need for carrying out a full 24-month campaign.

5.2.1 Bankability

The principal reason for collecting wind resource data is to provide estimates of AEP to feed into financing decisions for the developers and investors in offshore wind farms. While there are other key benefits such as understanding wind resource distribution over the area for layout optimization and reducing wake losses, the underlying guiding principle of this campaign is to achieve reliable and bankable data.

One of the main ways of achieving this is ensuring the campaign duration is appropriate. There is limited public guidance on achieving bankable data, however the industry accepted minimum is 12 months, but this is often dependent on a number of factors including existing data at or near the site. In addition, duration considerations can be affected by the number and type of data collection methods used.

Duration is also affected by the current knowledge of the atmospheric conditions and inter-annual variability of the region. At present, this is not very well documented for the east coast of the U.S. and there is an additional uncertainty that will require further data.

Banks and investors will associate a risk with different durations and penalize capital depending on the perceived risk. As floating LiDAR systems are perceived as a higher risk than traditional fixed bottom met masts or indeed platform mounted LiDAR, this campaign will address that risk through proposing a campaign with options to extend it longer than might ordinarily be carried out with a met mast.

5.2.2 Review of Previous Campaigns

The initial review undertaken by NYSERDA in 2010 (1) states that the recommended next step is to acquire site-specific meteorological and wave data for a minimum period of one year.

Appendix B lists the publically available information on floating LiDAR campaigns carried out to date. Most of the floating LiDAR campaigns to date have been validation trials and provide little data to support a decision on a wind resource assessment. Of the wind resource assessments that have been carried out the minimum duration is 13 months, at Walney Extension. Burbo Bank Extension also ran a campaign for 16 months. Both of these sites are extensions to existing wind farms, and the understanding of the wind resource in the area is already much better than the NY WEA. Therefore, it can be reasonably expected that any campaign for the NY WEA should aim to be longer than both of these campaigns.

The Lake Michigan wind resource assessment took 28 months over a number of locations and is not a true representation of a wind resource assessment. A more similar study is the wind resource assessment at Virginia Beach, near Dominion's Lease Area, which is undertaking a campaign for 19 months.

6 Permitting

6.1 Requirements and Recommendations

6.1.1 Requirements

- Floating LiDAR system suppliers will provide information to support any permit applications.

6.1.2 Recommendations

- Suppliers with a working knowledge of the U.S. permit system and a track record of compliance with them will be preferred.

6.2 Permits Required

A key part of the buoy deployment will be obtaining the necessary permits in order to proceed with the campaign. The following section outlines the current permits required, the permitting authority and the typical timeframes in order to obtain the permits. It should be noted that this section focuses on the current legislation, however BOEM may alter this process as a result of the ongoing implementation of the DOE and DOI's National Offshore Wind Strategy (18). Action 2.1.1 of the strategy document states that feedback has been received stating that the SAP process for meteorological buoys is overly onerous. Therefore the SAP process will be reviewed and potentially eliminated for this purpose. In the event that this is the case, revised guidance will be provided by BOEM, which will be reviewed by NYSERDA to ensure this MOP remains up to date.

6.2.1 Site Assessment Plan (SAP)

The main permit currently required is through the Site Assessment Plan (SAP). This is enforced through legislation made by BOEM through the lease agreement at 30 C.F.R. 585.600 (17). The SAP will be the ownership and responsibility of NYSERDA as the lessee of the NY WEA. However, it is anticipated that key input will be provided by the floating LiDAR system supplier.

The SAP will describe the activities to be carried out in order to characterize the lease, particularly the installation of the floating LiDAR systems. Key information on such parameters including size, mooring detail, maintenance activities, health and safety features, and pollution prevention measures will need to be included. Much of this will come from the floating LiDAR system supplier.

The SAP is managed by NYSERDA and will be submitted to BOEM within one year of the lease agreement being signed under the requirements. BOEM will facilitate the review of the SAP and coordinate the approval of the necessary permits, with the exception of the USACE Nationwide Permit 5.

6.2.2 Nationwide Permit 5

The United States Army Corps of Engineers (USACE) administers the Nationwide Permits for activities in federal waters. Nationwide Permit 5 (NWP 5) pertains to the deployment of scientific measurement devices. A floating LiDAR system qualifies under the regulations as a scientific measurement device and will be required to adhere to the general conditions set out as part of the Nationwide Permit 5.

In the event that NYSERDA is successful in securing the lease to the NY WEA, NYSERDA would retain overall responsibility for obtaining this permit. However, the floating LiDAR system supplier will provide much of the information to apply for this permit.

It is important to note that the permit's requirements pertain largely to floating LiDAR system supplier carrying out most, if not all, of the offshore activities. Therefore, it will be of vehement importance that the floating LiDAR system supplier is familiar with these requirements. These include such requirements to maintain navigational safety lighting, maintaining any device, and following the correct protocol in the event of discovering historic artefacts at sea. Floating LiDAR system suppliers that can show familiarity in complying with such requirements will be favored in any tender process.

7 Logistics and Maintenance

7.1 Requirements and Recommendations

7.1.1 Requirements

- A fully detailed mooring design will be required in any proposal from the floating LiDAR supplier and the supplier should have, or have sub-contractors with, experience in the local waters (or waters similar to those off the coast of NYS) to ensure the design is robust.
- The floating LiDAR system will be fully decommissioned with minimal impact on the sea bed and surrounding habitat.
- The floating LiDAR system will be able to fully function for six months without a maintenance visit.
- The floating LiDAR system supplier will have plans in place to replace the entire system in no longer than three weeks from the point that the fault is known.
- The floating LiDAR system supplier will be responsible for maintenance activities.
- The LiDAR supplier shall observe and comply with all relevant and current statutory requirements, approved codes of practice, and industry guidance on HSE matters.
- The floating LiDAR system supplier will continually monitor data availability, power, data quality, and location throughout the deployment and assure that data flows to the Data Analysis and Management Contractor.

7.1.2 Recommendations

- To be most cost-effective and to mobilize quickly in the event of an emergency, it is recommended that one of the ports listed within section 7.2 is used as the base port for operations due to their proximity to site, but also ability to handle and store a floating LiDAR system.
- Power systems should consider safety, redundancy of any generation technology, battery storage life, and optimization for maintenance.
- Installation and commissioning processes in-line with the OWA RP (7) is encouraged.

7.2 Transport

With respect to transport, the main focus will be on the base port or harbor where the device is both commissioned and maintained in the event any major repairs are required.

BOEM has already identified a number of staging ports that would meet the requirements of the installation, commissioning and maintenance activities foreseeable for a floating LiDAR system (15). The criteria used to screen the available ports included deep water vessel access (>15ft), landing and unloading facilities in close proximity to fabrication yards, and located within 40 miles from the NY WEA boundary. The list of potential ports is as follows:

- Staten Island, NY
- Erie Basin, NY

- Brooklyn, NY
- Bayonne, NJ
- Newark, NJ
- Elizabeth, NJ
- Perth Amboy, NJ

Given the number of options, there are no concerns regarding the ability of the local ports to meet the needs of a floating LiDAR system and no major risks regarding availability should there be any necessary major maintenance activities.

7.3 Power Systems

As different systems have different power capacities, it is not appropriate to be prescriptive of the power requirements for the system. However, listed below are NYSERDA's key points that must be considered when a floating LiDAR system supplier puts forward a proposal:

- **Safety considerations** - The power will prioritize safety mechanisms such as mooring lights over data capture when power becomes critical. All batteries and fuel cells will be stored and housed with safety as a primary concern. RP6 and RP7 (7) must be followed.
- **Redundancy of generation technology** - Due to the location and timing of the deployments, it is expected that both solar and wind generation will be effective at re-charging batteries; the former in summer months, the latter during winter. Other back up generation such as fuel cells should also be considered. As a guide, the system should be able to operate fully for six months with one generation system offline. This would allow sufficient time for repair or replacement.
- **Battery storage life** - A reasonable balance needs to be made between cost and weight efficiency, and redundancy and reliability of the system. Given the distance from shore, it is expected that the battery life is a minimum of four weeks at full operation, however this could be more or less depending on the set up and redundancy of the generation technologies on board.
- **Maintenance** - As the system will be expected to operate without requiring maintenance for at least six months, the entire power systems will be maintained, including inspection, cleaning and/or replacement of the components when the routine maintenance visits are carried out.

7.4 Installation and Commissioning

The floating LiDAR system supplier is encouraged to follow the relevant recommended practices within the OWA RP (7) when carrying out installation and commissioning, which includes the following key points:

- Commissioning be carried out at the quayside (7);
- All verification checks have been carried out to confirm the LiDAR's performance; and
- Installation and commissioning be carried out by a suitably qualified contractor, ideally with experience deploying and installation floating LiDAR systems previously.

7.5 Mooring

One area where conditions are notably different in the northeast U.S. coastal waters to that in Europe is the increased prevalence of extreme weather conditions including hurricanes. Therefore, European developed recommended practices and standards may not be sufficient when deploying in U.S. waters.

The mooring of a floating LiDAR system primarily affects the safety of the sea users, but also the data availability for the purposes of a wind resource assessment campaign. Therefore, this item is viewed as critical for the floating LiDAR supplier to provide a robust and proven solution when submitting their proposal.

The floating LiDAR supplier will be required to demonstrate that they have (or have sub-contracted) competence and experience in deploying buoys in local waters (or waters similar to those off the coast of NYS). In addition to this, they will also be required to provide an independent report justifying their proposed mooring solution when submitting their proposal. This will ensure that adequate engineering and protection of the mooring occurs.

7.6 Maintenance Requirements

The system supplier will coordinate the maintenance activities, with the oversight of NYSERDA and/or the project manager of the campaign.

More rigorous maintenance requirements may be stipulated in the final contract with the floating LiDAR system supplier. However for the purposes of this MOP, maintenance is refined to the minimum expected to uphold the integrity of the data.

Due to the distance from shore, the buoy will be maintained every six months at most. In reality, unscheduled maintenance trips may be required. In this case, the supplier should be prepared to undertake additional checks and maintenance (e.g., on the power systems, data loggers, communication systems, buoy structure) while accessing the buoy in order to mitigate the need for additional scheduled maintenance trips.

Should the system fail entirely, for example if the LiDAR fails or buoy is irrevocably damaged, the manufacturer must have plans in place to replace the entire system in no longer than three weeks from the point that the fault is known, weather permitting. This will require a standby system that can be shipped in at short notice, or any other solution the supplier prefers.

Prospective suppliers must outline in detail the track record of maintenance requirements relating to their proposed system and set up, ideally including the same components and equipment (communications, data loggers, fuel cells, solar panels, turbines) as will be on the proposed buoy set up. The suppliers will be able to show evidence of previous trials in similarly demanding metocean conditions where the system has not required maintenance and reliably collected data for six months or more. Where this is not available, the supplier will set out why the evidence and track record of the system shows confidence in the system performing well for six months or more.

Maintenance visits must be planned wherever possible to minimize outages and maximize the data collection period. This should include factoring in preventative maintenance to suitable weather windows or seasons in advance.

The floating LiDAR supplier must also follow RP 88 of the OWA RP (7) that stipulates ongoing monitoring of data availability, on-board power system function, LiDAR data quality criteria and location of the floating LiDAR system is carried out. This will be conducted daily for the first two weeks of deployment and subsequently on a weekly basis as a minimum. Finally, this monitoring will also include alerts to trigger reactive interventions.

7.7 Decommissioning Requirements

Full decommissioning of the floating LiDAR systems is required upon completion of the wind resource assessment. Decommissioning should minimize the environmental impact and maintain the integrity of the components on the device in the case of future deployments of the same device.

Given that decommissioning will occur following the completion of the trial, there are no further issues that might pertain to data quality aside from ensuring that any hard back up data storage is suitably retrieved.

7.8 Health and Safety

The LiDAR supplier shall observe and comply with all relevant and current statutory requirements, approved codes of practice and industry guidance on HSE matters, such as Occupational Safety and Health Standards (OSHA) or regulations of The Bureau of Safety and Environmental Enforcement (BSEE).

The LiDAR supplier shall take all necessary steps to ensure all personnel engaged by them and their supply-chain are appropriately trained and competent, comply with all relevant HSE legislation and guidance, and that they are:

- Fully conversant with the conditions, the hazards and risks associated with the deployment and operation of the floating LiDAR device and the necessary standards relating to the environment including the handling of waste and hazardous materials;
- Fully aware that they are expected to bring to the immediate notice of their supervisor all health, safety and environmental risks which they believe not to be under adequate control so that action may be taken to prevent potential injuries or other losses; and
- Fully conversant with all health, safety, environmental, and all other working instructions and guidance.

8 Data Handling

8.1 Requirements and Recommendations

8.1.1 Floating LiDAR System Supplier

8.1.1.1 Requirements

- The floating LiDAR system will collect measured quantities of wind speed and direction, turbulence intensity, and air temperature, pressure, and humidity along with height and datum used.
- Wind data will be recorded at five heights that cover lowest rotor tip height, hub height, and highest rotor tip height of the anticipated turbine model and two points equidistant in between these three (approximately 40m, 80m, 120m, 160m and 200m).
- The floating LiDAR system will also record measured quantities of significant maximum wave height, peak, and mean wave period; wave direction; spectra and salinity; current speed; water temperature; and tidal range and water depth.
- Two separate means of communication on the floating LiDAR system will be required.

8.1.1.2 Recommendations

- Motion compensation algorithms applied to the system should be outlined in the proposal in detail including whether the same algorithms have been applied on previous validation trials.
- Wildlife data and additional data collection will also be judged favorably in proposals to supply the floating LiDAR system.
- Proven transmission systems and ability to use quicker and more secure methods of transmitting data will be preferred.

8.1.2 Data Management and Analysis Contractor

8.1.2.1 Requirements

- The Data Management and Analysis Contractor will have no commercial ties or conflicts of interest with the floating LiDAR supplier.
- The Data Management and Analysis Contractor will be suitably qualified and experienced.
- Data will be analyzed in relation to KPIs as set out in the OWA RP (7).
- Wind speed and associated data will be made available for public access and download.
- Written reports of the data analysis will be provided to NYSERDA.
- All raw and processed data must be securely stored by the Data Management and Analysis Contractor and made available to NYSERDA whenever required.

8.1.2.2 Recommendations

- Suggestions of how best to manage the data and provide efficient public access will be viewed favorably.

8.2 Data Collection

8.2.1 Wind Data

The following measured quantities must be collected by the floating LiDAR system, as per the OWA RP (7):

- Wind speed (10-minute average, min, max, and SD).
- Wind direction (10-minute average, min, max, and SD).
- Turbulence intensity.
- Air temperature, pressure, and humidity.

All quantities will record the height and datum used, as relevant. Data on the floating LiDAR systems' inclination and translational and rotational accelerations must also be recorded for reference in case of anomalies. Humidity, cloud cover, and precipitation must also be recorded in line with the wind speed and wind direction data to assist with correlation.

Wind data will be recorded at a range of heights that cover the lowest rotor tip height, hub height, and highest rotor tip height of the anticipated turbine model and two points equidistant in between these three. For example, a typical MHI Vestas V164 8.0MW turbine might require measurements at approximately 40m, 80m, 120m, 160m and 200m. Some additional tolerance may be required to accommodate increases in turbine size, although this will be dependent on the capabilities of the LiDAR installed on the floating buoy.

8.2.2 Motion compensation

Some systems, although not many, adopt motion compensation mechanisms to mount on the LiDAR. Where such a system is proposed, previous validation trials must be conducted with the system in place to demonstrate accuracy of the measurements including the motion compensation.

Motion compensation algorithms applied to the system should be outlined in the proposal in detail including whether the same algorithms have been applied on previous validation trials. It is preferable that previous validations be carried out with similar software or post-processing applied to verify the performance of the system as a whole.

8.2.3 Other metocean data

As part of the campaign, it will be important to maximize the deployment of the floating LiDAR buoy and measure other metocean data. This will include as a minimum:

- Significant maximum wave height (30-minute average);
- Peak and mean wave period (30-minute average);
- Wave direction, spectra, and salinity (at or near the surface);
- Current speed (at or near the surface);
- Water temperature (at or near the surface); and
- Tidal range and water depth.

Dependent on the floating LiDAR device selected, additional wildlife data may also be available as noted in Section 2.3.1.

8.2.4 Data Transmission

Data will be transmitted from the buoy at regular intervals. Two separate means of communication will be required and the type of communication should switch automatically (7). Satellite communication would be preferred due to the size of the data being transferred and the inherent coverage issues with cellular networks offshore, however, costs may constrain this. Data retrieval should primarily be done remotely, either from shore or a nearby workboat to minimize the need for crew to transfer onto the buoy for collection.

At a minimum, the communications system will allow real-time, or near real-time monitoring of the status of the buoy and any critical systems including power and LiDAR data retrieval. Ideally, it will also allow real-time transfer of all metocean measurement taken on the buoy also, although this is not critical.

Due to issues regarding outages and potential loss of networks, the floating LiDAR system will have redundancy measures on board to store data for later transmittal. As per RP 64 of the Recommended Practices for Floating LiDAR systems (7), there should be sufficient data storage on-board to ensure that all data measured for the duration of the campaign is stored and recoverable after the trial in the event communication fails.

Once recovered or transmitted, data will be stored by the data analysis contractor. Data should be stored securely with remote access available to NYSERDA, should it be required.

8.3 Data Management and Analysis

A completely independent Data Management and Analysis Contractor will be contracted to handle and analyze the raw data from the wind resource assessment. The key duties and requirements of this consultant are outlined.

8.4 Data Management

The Data Management and Analysis Contractor will securely store all data from the floating LiDAR supplier and facilitate the transfer of this dataset to their servers.

The raw and processed data will be available to NYSERDA at all times upon request and once the analysis has concluded, the Data Management and Analysis Contractor will provide NYSERDA with all the data on hard drive disks or electronic transfer. The Data Management and Analysis Contractor may also provide suggestions as to further means of ongoing management of the data.

8.4.1 Data Analysis

The Data Management and Analysis Contractor will undertake an initial analysis at 12 months to determine whether an 18-month campaign will provide sufficient data or whether a 24-month campaign is required.

The Data Management and Analysis Contractor will be suitably qualified, experienced, and completely independent of the floating LiDAR supplier in order to maintain integrity of the results.

Data will be analyzed in relation to KPIs as set out in the OWA RP (7) unless otherwise advised. This will include KPIs for availability which should be monitored to ensure that availability criteria can be met at the end of the campaign.

Only data deemed 'good' by the floating LiDAR system supplier will be analyzed, following the agreement of a suitable filter proposed by the supplier. The Data Management and Analysis Contractor will employ best practice quality control measures to ensure this filter has been correctly applied.

The Data Management and Analysis Contractor will provide NYSERDA with written reports analyzing the data with key conclusions. The raw data should also be made available for further analysis such as annual energy production estimates and further mesoscale modeling. These reports will include an assessment of uncertainty as prescribed in section 8.6 of the OWA RP (8).

8.5 Data Distribution

Data collected from the campaign will be the property of NYSERDA, however, the selected Data Management and Analysis Contractor will be required to make the final wind speed and associated data publically available for download.

References

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8. **Carbon Trust.** Recommended Practices for Floating LiDAR Systems. s.l. : Carbon Trust, 2016.

9. **Carbon Trust.** Carbon Trust Offshore Wind Accelerator Roadmap for the Commerical Acceptance of Floating LiDAR Technology. [Online] 2013. https://www.carbontrust.com/media/422195/ctc819-owa-roadmap-commercial-acceptance-floating-lidar-technologies.pdf.

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15. **U.S. Environmental Protection Agency.** National Environmental Policy Act. U.S. Environmental Protection Agency. [Online] October 20, 2016. https://www.epa.gov/nepa.

16. **BOEM.** Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York - Environmental Assessment. 2016.

17. **BOEM**. New York Final Sale Notice. BOEM. [Online] October 31, 2016. [Cited: November 3, 2016.] https://www.boem.gov/NY-FSN/.

18. **BOEM**. Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York - Revised Environmental Assessment. 2016.

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20. **Department of Energy and Department of Interior.** National Offshore Wind Strategy. 2016.

21. **U.S. Government Publishing Office.** Electronic Code of Federal Regulations. U.S. Government Publishing Office. [Online] October 27, 2016. http://www.ecfr.gov/cgi-bin/text-idx?SID=8d94ab584c6867c64f6e9ffe754585f7&mc=true&tpl=/ecfrbrowse/Title30/30cfrv2_02.tpl#500.

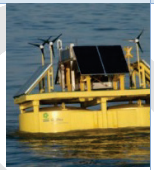
Appendix A – Bibliography of Metocean Information

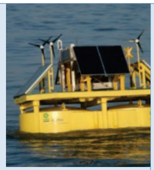
The below table provides a complete bibliography of relevant metocean information relevant to the Metocean Plan.

Source	Description	Link
Pre-Development Assessment of Meteorological and Oceanographic Conditions for the Propose Long Island – New York City Offshore Wind Project Area, NYSERDA, 2010	Published in October 2010, this NYSERDA document provides a specific overview of the NY WEA and the metocean characteristics. The report uses a range of sources including buoys and lighthouses with sensors to report on the meteorological climatology and environment. The report also utilize mesoscale modeling to provide an overview of the wind resource in the locality of the NY WEA.	https://www.nyserda.ny.gov/-/media/Files/EIBD/Research/LI-NYC-offshore-wind-climatology.pdf
Assessment of Offshore Wind Energy Resources for the United States, NREL, 2010	Published in June 2010, this NREL report provides an overarching assessment of the national offshore wind resource. Analysis specific to the NY WEA is not present, however estimates of wind speeds by state (including New York) are provided and grouped by water depth. The report also expands on the mean wind speed data at 90m/s to provide estimates of offshore wind potential resource in GW.	http://www.nrel.gov/docs/fy10osti/45889.pdf
2016 Offshore Wind Energy Resource Assessment for the United States, NREL, 2016	This report published in 2016 by NREL provides an update to the 2010 report highlighted previously. Similar outputs are provided at a regional scale with no direct analysis of the resource for the NY WEA.	http://www.nrel.gov/docs/fy16osti/66599.pdf
National Data Buoy Center, NOAA, 2016	Access to any of the buoys within the New York Bight is provided through NOAA's National Data Buoy Center – this website hosts the information and data from the buoys currently deployed but also historically deployed. Buoys are typically collecting data on waves, temperature and wind speeds (at low levels, typically 3-5m).	http://www.ndbc.noaa.gov/maps/New_York.shtml

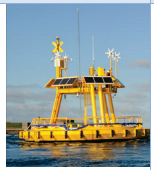
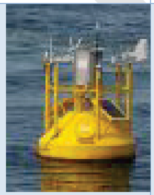
Appendix B – Previous floating LiDAR campaigns

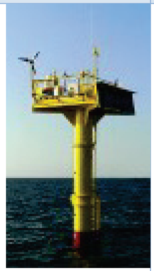
The following table provides publically available information on previous floating LiDAR campaigns – it does not represent a complete, comprehensive list of all floating LiDAR trials to date. Therefore, some trials may not be recorded here.

Location **[Wind farm/met mast, Sea area, Country]**	**Trial name**	**Device** **[LiDAR, Buoy type]**	**Picture**	**Type of campaign**	**Duration**	**Completion date**	**Details**	**Link/Source**
Race Rocks, Strait of Juan de Fuca, Canada	WindSentinel Field Test	AXYS WindSentinel with Vindicator Laser Wind Sensor		Validation trial	1 month	November 2009	Early validation of AXYS WindSentinel system against identical land based sensing equipment. Other sensors included an anemometer, wave sensor, motion sensors, and meteorological sensors.	http://axystechnologies.com/wp-content/uploads/2013/12/Windsentinel-Race-Rocks-trial-report.pdf
North Sea, Belgium		FLiDAR prototype with Leosphere WINDCUBE v2 Offshore LiDAR		Validation trial	1 month	October 2011	Early validation of FLiDAR prototype 15 km of the coast of Belgium. Data validated against fixed WINDCUBE LiDAR device on an offshore communication mast close to the test site.	http://www.3e.eu/flidar-spin-off-launched/ http://www.offshorewind.biz/2011/11/23/flidar-completes-its-trials-in-north-sea-belgium/

Gwynt-y-Môr wind farm zone, Irish Sea, UK	OWA Gwynt-y-Môr validation trial	FLiDAR with Leosphere WINDCUBE v2 Offshore LiDAR		Validation trial	3 months	January 2013	Validation against Gwynt y Môr meteorological mast in the Irish Sea, which includes Measnet-calibrated cup anemometers at 90m and 50m above LAT and a wind vane at 70m. A Waverider buoy was also deployed during the trial.	https://www.carbontrust.com/media/639975/flidar-presentation-ewea-2013.pdf
Lake Michigan, USA	Great Lakes Offshore Wind Resource Assessment Project	AXYS WindSentinel with Vindicator Laser Wind Sensor		Wind resource assessment	28 months	December 2013	A varied measurement campaign to assess the collect and analyses wind data essential to the consideration of future wind industry development on the Great Lakes. The scope of the trial included: - Wind data collection and analysis; - Wind correlation studies; - Offshore wind modeling; - Directional wave monitoring & compass orientation; - Full range of meteorological sensors; - Acoustic sonobat bird and bat detection system; and - Current sensor / acoustic Doppler profiler.	http://axystechnologies.com/wp-content/uploads/2016/10/Great-Lakes-Wind-Resource-Assessment-Project.pdf https://www.michigan.gov/documents/mpsc/Offshore_Wind_Assessment_Overview_3-29-11_348957_7.pdf

Neart na Gaoithe wind farm zone, North Sea, UK	OWA floating LiDAR discretionary project	FLiDAR 4M with a Leosphere LiDAR system		Validation trial / Wind resource assessment	3 months	April 2014	FLiDAR system was validated before and after the trial against the Offshore Renewable Energy Catapult meteorological mast off the coast of Blyth, UK.	https://www.carbontrust.com/about-us/press/2014/09/mainstream-and-dnv-gl-validate-floating-offshore-wind-measurement-device-as-part-of-carbon-trust-owa-programme/ http://www.gl-garradhassan.com/assets/technical/Validation_Report-_FLiDAR.pdf
Burbo Bank Extension wind farm zone, Irish Sea, UK		FLiDAR 4M with a Leosphere LiDAR system		Wind resource assessment	16 months	September 2014	FLiDAR system was validated post trial against an offshore meteorological mast.	http://www.offshorewind.biz/2015/04/24/burbo-bank-extension-first-flidar-calculated-owf-to-be-built/
East Anglia ONE wind farm zone, North Sea, UK	An offshore LiDAR buoy trial against mast reference instrumentatio n	Fugro OCEANOR SEAWATCH Wind LiDAR buoy with ZephIR 300 Lidar		Validation trial	6 months	November 2014	The system was validated against the IJmuiden meteorological mast. The boy was equipped with the following sensors: - Wave height, period, and direction. - 3-axis buoy motion and rotation. - Near surface current profile and water temperature. - Wind speed and direction. - Wind speed and direction profile.	http://www.oceanor.com/related/Datasheets-pdf/eneco_lidar.pdf https://www.windopzee.net/fileadmin/windopzee/user/SDB_20150130_DNVGL_Trial_Campaign_Validation_Report_IJmuiden_GLGH-4257_13_10378_266-R-0003-B_final.pdf

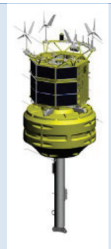
							- Air pressure. - Air humidity and temperature.	
Saint Marcouf Island, France		Nass & Wind Marine Measurements for Meteorological and Environmental Assessment (M^3EA). LiDAR system unspecified.		Validation trial	11 months	December 2014	Device is based on an adapted marine navigation buoy. Validation against onshore fixed LiDAR system. Device LiDAR system unspecified. Other sensors include temperature, pressure, visibility, moisture, location and Acoustic Doppler Current Profiler (ADCP).	http://www.oceanologyinternational.com/__novadocuments/49179?v=635310012225230000 http://nassetwind.com/en/nasswind-smart-services-measure-center/
FINO1 met mast, North Sea, Germany		Fraunhofer IWES Wind LiDAR buoy with ZephIR 300 LiDAR.		Validation trial	Not specified	2014	Validated against FINO1 meteorological mast. Steel hull. Additional sensors: - ADHR and satellite compass record buoy's positions and movements. - Weather station for measurement of barometric pressure, air temperature, horizontal wind speed and direction (at	http://www.zephirlidar.com/fraunhofer-iwes-wind-lidar-buoy-verified-fino1/ http://www.windenergie.iwes.fraunhofer.de/content/dam/windenergie/en/documents/Bojenbrosch%C3%BCre_FINAL.pdf

							low height), relative humidity, precipitation. - AWAC current meter (as autonomous and independent system) for measurement of waves and currents.	
Gwynt-y-Môr wind farm zone, Irish Sea, UK	OWA Gwynt-y-Môr validation trial	Babcock FORECAST with ZephIR 300 LiDAR		Validation trial	16 months	February 2015	Validation against Gwynt y Môr meteorological mast in the Irish Sea. Measnet-calibrated cup anemometers at 90m and 50m above LAT, wind vane at 70m. Waverider buoy. Additional validation against fixed LiDAR (ZephIR 300) on met mast platform.	https://www.carbontrust.com/media/640173/owa-floating-lidar-campaign-babcock-trial-ewea-2015.pdf http://www.zephirlidar.com/babcocks-forecast-floating-zephir-lidar-reaches-stage-2-carbon-trust-owa-roadmap/
Walney Extension wind farm zone, Irish Sea, UK		FLiDAR 6M with single ZephIR 300 type LiDAR.		Wind resource assessment	13 months	June 2015		http://www.norcowe.no/index.cfm?id=422778 [*18 Feb 2015]* http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/
IJMuiden wind farm zone, North Sea, Netherlands	OWA floating LiDAR discretionary project	EOLOS FLS200 with ZephIR 300 continuous wave LiDAR		Validation trial	6 months	October 2015	Validated against IEC-compliant IJmuiden offshore meteorological mast. Additional data collection includes wave (directional) and current information.	http://www.eolossolutions.com/en/blog/press-release-eolos-fls200-successfully-validated-for-offshore-wind-measurements/6

FINO1 met mast, North Sea, Germany	AXYS FLiDAR 6M (WindSentinel), S/N 6NB00160 floating LiDAR device validation at FINO1	AXYS FLiDAR 6M with two ZephIR 300 type LiDARs. **[Note AXYS Technologies Inc. acquired FLiDAR NV in September 2013]**		Validation trial	5 months	November 2015	Validated against the FINO1 Reference Met Mast. Located 310 m to the NW (approx. 340°), west of the wind farm zone.	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf
National Renewable Energy Centre (NAREC), North Sea, UK	Narec-F140	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	1 month	2015	Validation against NAREC Offshore Anemometry Hub, further details unspecified. (Note conflicting reports on whether this trial deployed the device with one or two ZephIR 300 LiDARs)	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf http://axystechnologies.com/axys-deploys-two-dual-lidar-windsentinel-buoys-at-ore-catapults-offshore-met-mast/
National Renewable Energy Centre (NAREC), North Sea, UK	Narec-F150	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	1 month	2015	Validation against NAREC Offshore Anemometry Hub, further details unspecified. (Note conflicting reports on whether this trial deployed the device with one or two ZephIR 300 LiDARs)	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13316-266-R-0001-D_signed.pdf http://axystechnologies.com/axys-deploys-two-dual-lidar-windsentinel-buoys-at-ore-catapults-offshore-met-mast/

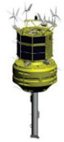
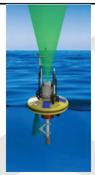
West of Duddon Sands wind farm zone, Irish Sea, UK	West of Duddon Sands AXYS FLiDAR 6M ZephIR F080 pre-deployment validation	FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	6 months	March 2016	Validated against West of Duddon Sands Reference Met Mast, following wind resource campaign for DONG Energy at Walney Extension Wind Farm (described above). Located outside of wind farm to West of met mast on the western edge of the farm zone.	http://axystechnologies.com/wp-content/uploads/2016/08/GLGH-4257-15-13446-267-R-0002-B.pdf
Virginia Beach, Virginia, USA **[next to Dominion's Lease Area for Offshore Wind Energy Development]**	Wind-Profiling Lidar Buoy Deployment Plan	AXYS WindSentinel		Wind resource assessment and additional data collection	19 months	July 2016	52 km (28 nm) offshore from Virginia Beach, VA. This is west of Dominion's lease block. Device also collected data on: - Near-surface air temperature, humidity, and pressure; - Solar radiation; - Waves: Significant and maximum wave height, peak period, directional wave spectrum; - Surface water temperature; - Water velocity profile; and - Water temperature and conductivity profile.	https://ebs.pnnl.gov/uploads/PR-295256-RFP%20Example%20Deployment%20Plan-Virginia_316201535325PM.pdf http://www.offshorewind.biz/2016/07/19/windsentinels-virginia-offshore-wind-data-now-available/

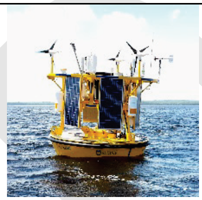
East Anglia wind farm zone, North Sea, UK	OWA floating LiDAR discretionary project	Fugro OCEANOR SEAWATCH Wind LiDAR buoy with ZephIR 300 Lidar		Validation trial	6 months	July 2016	Validated against East Anglia meteorological mast.	http://www.4coffshore.com/windfarms/floating-lidar-deployed-at-east-anglia-one--nid3157.html
Mediterranean, France		BLiDAR LiDAR device not specified in this trial.		Validation trial	6 months	Ongoing	Early validation of the device against a fixed LiDAR located onshore.	http://www.nke-instrumentation.com/news/detail-actualite/article/the-floating-lidar-of-the-blidar-project-begins-a-6-month-validation-campaign-in-the-mediterranean-s.html http://www.blidar.fr/
Mid-Atlantic Wind Energy Area, New Jersey, USA		Axys WindSentinel		Wind resource assessment and additional data collection	Unknown	Unknown	Reports indicate the device was deployed in June 2013 but the duration and validation characteristics of the trial are unknown. Located eleven miles east of Ocean City, NJ, this site is within the Mid-Atlantic Wind Energy Area, in an area Fishermen's Energy ("Fishermen's") proposed to build a 350MW windfarm.	http://www.fishermensenergy.com/press-releases/2013-fe-buoy-fed-waters.pdf http://axystechnologies.com/axys-congratulates-fishermens-energy-on-buoy-deployment/

Demowfloat, Atlantic, Portugal		Axys WindSentinel with Vindicator III simultaneous pulse LiDAR		Wind resource assessment	Unknown	Unknown	Reports indicate device was deployed in September 2014 but the duration and validation characteristics of the deployment are unknown.	http://axystechnologies.com/axys-windsentinel-selected-edp-inovacaos-demowfloat-initiative/
Fécamp wind farm zone, English Channel, France		FLiDAR 4M with a Leosphere LiDAR system		Validation trial	Unknown	Unknown	Reports indicate device was deployed in summer 2015. Validation against the Fécamp meteorological mast.	https://www.youtube.com/watch?v=zwASiRge7es http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/
Calvados wind farm zone, English Channel, France		FLiDAR 4M with a Leosphere LiDAR system		Wind resource assessment	Unknown	Unknown	Unknown	https://www.youtube.com/watch?v=zwASiRge7es http://www.offshorewind.biz/2015/06/24/flidar-reduces-costs-in-combined-operation/

Hsing-Da Harbor, Taiwan		FLiDAR 6M with single ZephIR 300 type LiDAR.		Validation trial	Unknown	Unknown	Validation trial run by National Cheng Kung University of Taiwan. Validation was carried out against fixed onshore WINDCUBE v2 LiDAR.	http://axystechnologies.com/wp-content/uploads/2016/07/NCKU-Testimonial-Letter.pdf http://www.tsoe.org.tw/downloads/thesis/2014H3.pdf
Borssele wind farm zone (BWFZ), North Sea, Netherlands		Two Fugro OCEANOR SEAWATCH Wind LiDAR buoys		Wind resource assessment	Unknown	Ongoing	Fugro OCEANOR has placed two metocean buoys in the BWFZ, which provide meteorological and oceanographic data. The measurement campaign of the buoy positioned in the center of the BWFZ started in June 2015. In November 2015 the second buoy was installed close to the southern border of the BWFZ.	http://www.fugro.com/media-centre/press-releases/fulldetails/2015/06/04/fugro-awarded-contract-to-investigate-wind-farm-sites http://offshorewind.rvo.nl/studiesborssele
Atlantic Ocean, Maine		UMaine DeepCLiDAR with single Leosphere Windcube Offshore LiDAR		Pre-deployment validation	5 months	July 2016	UMaine deployed it DeepCLiDAR off the coast of Maine as part of a pre-deployment validation campaign. The buoy was deployed in February 2016 and recovered in July 2016. The system was validated by AWS Truepower.	https://composites.umaine.edu/2016/10/25/umaine-deepclidar-successfully-completes-pre-deployment-validation-based-carbon-trust-criteria-now-available-commercial-lease-purchase/

Picture references

WindSentinel/AXYS FLiDAR 6M		http://axystechnologies.com/products/flidar-windsentinel/
FLiDAR prototype		http://www.offshorewind.biz/2011/11/23/flidar-completes-its-trials-in-north-sea-belgium/
AXYS FLiDAR 4M		http://axystechnologies.com/products/flidar-windsentinel/
Fugro OCEANOR SEAWATCH		http://www.oceanor.com/related/Datasheets-pdf/eneco_lidar.pdf
Nass & Wind Marine Measurements for Meteorological and Environmental Assessment (M^{3}EA)		http://www.oceanologyinternational.com/__novadocuments/49179?v=635310012225230000

Fraunhofer IWES Wind LiDAR buoy		http://www.zephirlidar.com/fraunhofer-iwes-wind-lidar-buoy-verified-fino1/
Babcock FORECAST		http://www.zephirlidar.com/babcocks-forecast-floating-zephir-lidar-reaches-stage-2-carbon-trust-owa-roadmap/
EOLOS FLS200		http://www.eolossolutions.com/en/product
BLiDAR		http://www.blidar.fr/#
UMaine DeepCLiDAR		https://composites.umaine.edu/research/DeepCLiDAR/

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