Near real-time passive acoustic monitoring off New Jersey to mitigate the effects of offshore wind development on baleen whales

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Objective

Monitoring of protected species' occurrence and distribution during construction activities and along shipping routes servicing wind farms will be essential to minimizing disturbance to these species by offshore wind development activities. Although current monitoring efforts are focused primarily on measuring changes in occurrence before and after construction, little effort has been spent on understanding how monitoring efforts can or should be used to inform mitigation efforts, such as construction shutdowns or ship speed restrictions when protected species are present. In the case of acoustic monitoring of large whales, very different kinds of monitoring techniques are needed for these two important tasks; archival recording of whale sounds can be used for cost-effective long-term monitoring of pre- and post-construction activities, whereas detection and reporting of whale sounds in real time must be used to implement immediate mitigation measures to protect whales that are in or near areas where acoustic disturbance or vessel strikes are likely. Both of these monitoring efforts are vital to understanding the effects of construction activities as well as actively managing risks to protected species.

Real-time acoustic detection of whales for mitigation has received the attention of regulatory agencies in the U.S. only recently with the development of the NOAA Slow Zones for Right Whales program, which establishes areas in which ships are asked to voluntarily slow to 10 knots or less because of the acoustic or visual detection of right whales nearby. Last winter, 46 Slow Zones were established from Maryland to Massachusetts because of acoustic detections of right whales from Slocum gliders and moored buoys equipped with the digital acoustic monitoring (DMON) whale-detection technology developed by the Woods Hole Oceanographic Institution (Figures 1 & 2). We propose here to continue the operation of the whale-detection buoy currently located off the coast of Atlantic City, New Jersey adjacent to one of Orsted's wind energy development lease areas to (1) continue to educate all stakeholders about the capabilities of near real-time acoustic monitoring technology, (2) support the NOAA Slow Zones for Right Whales program in New Jersey waters, (3) assess how quickly detection data can be generated and delivered to stakeholders, and (4) foster dialogue about the appropriate use of the technology for mitigating risks associated with construction noise and vessel strikes during wind energy development activities.

The proposed work is strongly aligned with RMI Research and Monitoring needs #10 and #11. Need #10 reads *"Estimate habitat use, distribution, and abundance by season for the right whale, other whales and dolphins through supporting PAM efforts in the NY Bight; identify environmental variables driving these patterns."* The 8 DMON buoys operating on the U.S. east coast (Figure 1) provide right whale occurrence information over long periods (deployments last 1 year), and are contributing to a greater and immediate awareness of the distribution of right whales, particularly when right whale distribution is shifting because of climate change. The Atlantic City buoy is a critical node in this network of monitoring buoys. Need #11 reads *"Evaluate relative threat of mortality/injury to the right whale, other whales and dolphins from vessel strikes (including increased vessel interactions due to creation of traffic corridors) associated with OSW and non-OSW activities."* Real-time acoustic monitoring is already being used to attempt to mitigate vessel strikes through the NOAA Slow Zones for Right Whales program (and likely in the future through mandatory dynamic speed zones included in NOAA's currently proposed rule), but its effectiveness is unclear, as is how the program will apply to managing vessel strike risk from ships associated with the offshore wind energy development sector. As federal and state agencies grapple with regulations to protect whales from vessel strikes, it is critical to continue to demonstrate and evaluate how near real-time monitoring can help to support vessel-strike mitigation efforts. Finally, the proposed work also addresses one of the RMI Objectives: *"Identify and inform actions for adaptive management to avoid, minimize, and/or mitigate impacts, including cumulative impacts, from offshore wind on coastal and marine resources, including habitat, biota, and recreational and commercial fisheries."* Real-time monitoring is central to adaptive management because immediate conservation action cannot be implemented without an understanding of where animals and industrial activities are currently overlapping.

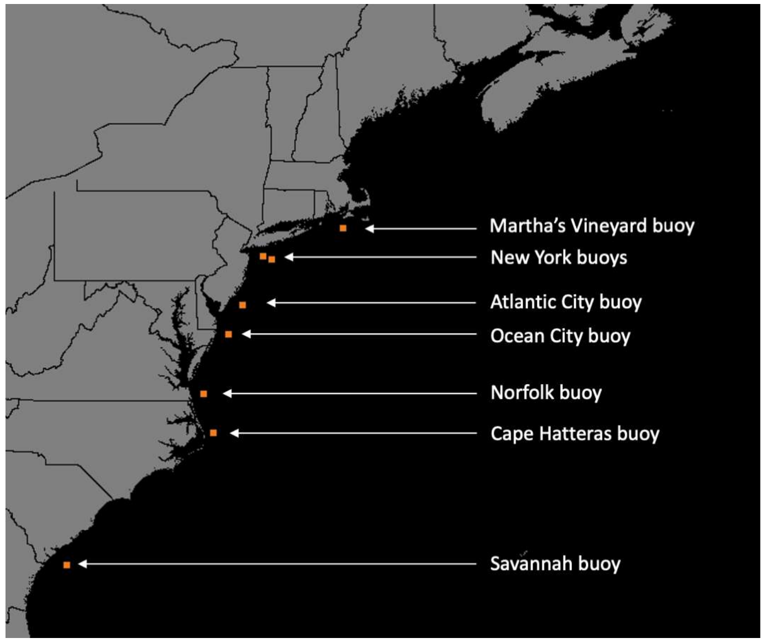

Figure 1. Current location of 8 DMON whale-detection buoys operated by WHOI along the U.S. east coast.

Wind energy developers are currently funding much of the regional near real-time acoustic monitoring in and around their lease sites. There is no obligation for them to do so, and they can end this monitoring at any time. Case in point, Orsted is ending their funding for the Atlantic City DMON buoy, so without RMI funding, we will lose this node in the east-coast monitoring network and with it, an important tool to understand and highlight the rather frequent presence of right whales in New Jersey waters from late fall to early spring (and perhaps infrequent presence at other times of the year; see Baumgartner and Mate 2005). One can argue about whose responsibility it is to conduct such monitoring (is it the developers', is it the federal government's, or is it the state's?), but without it, we won't know when right whales are present and we won't learn more about how to apply this technology to the challenging task of mitigating the impacts of wind energy development on right whales.

The focus of mitigation efforts are North Atlantic right whales, as they are a highly endangered species that lives along the U.S. and Canadian east coasts. Right whales are impacted by a number of industrial activities in the ocean, including trap/pot fishing, shipping, recreational boating and offshore wind energy development. A relatively small but vitally important segment of the right whale population comprised mostly of pregnant females migrates to the southeastern U.S. during early winter to calve. These animals return to their feeding grounds off the northeastern U.S. during late winter and early spring. However, right whales can be found all along the U.S. east coast from late fall to early spring (Davis et al. 2017); it is not just pregnant females that use the mid-Atlantic area of the U.S. east coast (i.e., from New York to the Carolinas) during this time of year. By mid-spring, right whales converge on the Gulf of Maine to feed, and by summer, they are distributed on the feeding grounds throughout the Gulf of Maine, Scotian Shelf and the Gulf of Saint Lawrence in Canada and remain in these areas until early fall.

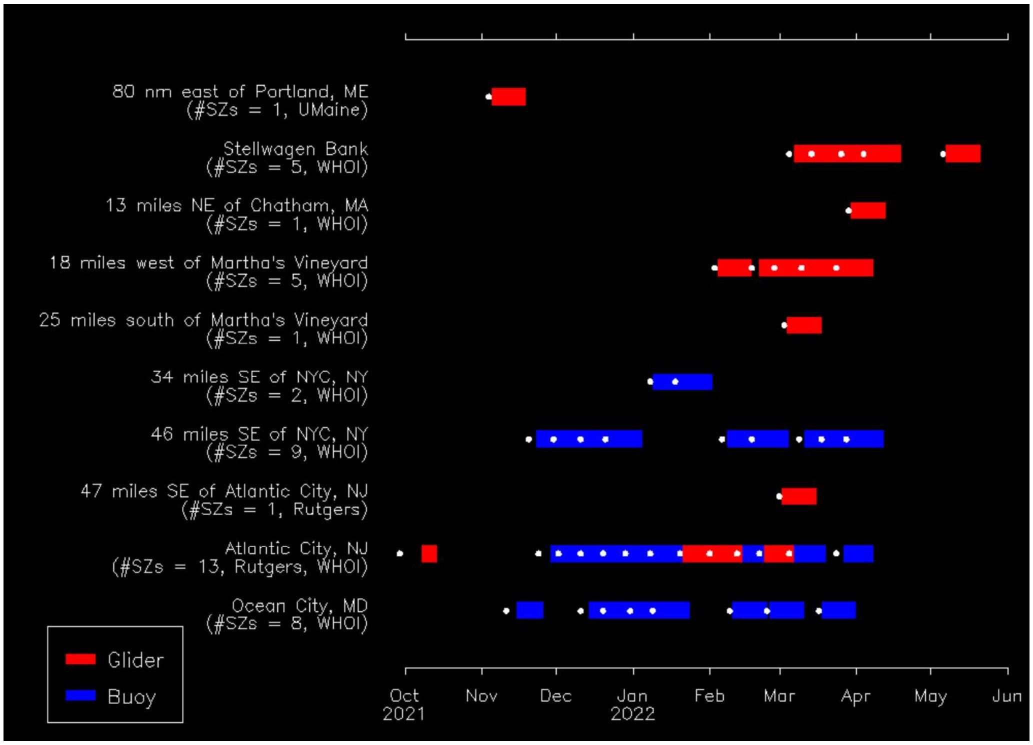

Figure 2. The spatial/temporal distribution of 46 Slow Zones triggered by DMON-equipped Slocum gliders and buoys along the U.S. east coast between October 2021 and June 2022. Locations are arranged from north (top of plot) to south (bottom of plot), and time periods when a Slow Zone was in effect are shown in blue (if triggered by a buoy carrying a digital acoustic monitoring instrument, or DMON) or red (if triggered by DMON-equipped Slocum glider). The date of the right whale acoustic detection that triggered each Slow Zone is indicated as a filled white circle. Beneath each location name is the number of Slow Zones triggered and the institution(s) operating the DMON-equipped platforms in that location. Slow Zones were not implemented south of Ocean City, Maryland. Note that Slow Zones were in effect off Atlantic City, New Jersey nearly continuously between late fall and early spring.

Proposed Research

Plan

For the proposed project, WHOI will assemble, test, deploy and recover a near real-time passive acoustic monitoring buoy near Atlantic City, New Jersey at the same location where an identical buoy has operated for the past 2 years with financial support from Orsted. The buoy hardware has been purchased and fabricated previously with Orsted funds, and WHOI owns this hardware; RMI funds will only be used for expendable portions of the mooring system (e.g., stretch hoses), not to purchase any additional permanent mooring equipment. This proposal is to maintain and operate the same mooring system as has been used at the Atlantic City site during the past two years, not to build a new mooring system. WHOI will operate the buoy for 2 years at sea, including the deployment of a moored buoy, operation of that buoy for 1 year, recovery and immediate deployment of a replacement buoy (downtime of the system during this replacement is only a few hours), operation of the replacement buoy for 1 year, and final recovery. During operation, WHOI will receive data from the buoy via the Iridium satellite system every 2 hours, and an experienced analyst will review these data twice daily using an established and documented protocol (see robots4whales.whoi.edu/#protocol). WHOI will display all DMON buoy data on the publicly accessible website robots4whales.whoi.edu, enable the analyst results to be displayed by numerous web- and smartphone/tablet-based apps (e.g., Whale Alert), and automatically disseminate near real-time occurrence estimates of large whales by text and email messages to stakeholders and other interested parties (e.g., NOAA's Slow Zones for Right Whales program).

Our current protocol involves reviewing data only twice daily because there is no conservation/mitigation action that currently requires any faster response. Slow Zones typically take a day or more to establish, so bearing the cost of having an analyst on standby to review the detection data each and every 2 hours is not needed. However, future mitigation applications will very likely require a faster response time to provide maximum protection for right whales. We have implemented the capability to remotely select a data offload schedule of either 2 hours or 10 minutes. We propose to conduct a week-long experiment whereby an analyst immediately reviews detection data transmitted from the buoy to shore every 10 minutes, and we will compare detection latency (i.e., the time between a whale making a call and the analyst detecting that call) between the typical twice daily data review and the new 10-minute review protocol. It is clear that the latency between the two review protocols will be different, but we are interested in understanding how "real time" the system will be with the 10-minute offload schedule. We chose 10 minutes as the fastest we would want to make connections (i.e., calls) to shore using the Iridium satellite system. Ideally, we would maintain an open connection to shore and send detections in truly real time (i.e., immediately when the calls were received and detected by the DMON), but this is prohibitively expensive with the Iridium system. Iridium charges a per-call fee and a per-minute fee; calling every, say, 1 minute reduces the per-minute fee, but the per-call fee adds up quickly when doing this continuously for long periods. The 10-minute interval balances the per-call and per-minute fees while still allowing us to send data to shore at a reasonably short interval. We could increase that interval, but we get less and less "real time"; conversely, we could decrease the interval, but the satellite communication costs increase. The 10-minute interval is a reasonable compromise.

Finally, we plan to develop a framework for the use of near real-time whale detection data for regional monitoring outside of wind farm construction zones. Some thought is required to develop recommendations about the number and location of near real-time passive acoustic monitoring stations (like the DMON buoys) around wind farms to provide situational awareness of right whale presence for all stakeholders during construction activities as well as along shipping routes used to access the wind farms from shore. Such a monitoring array will be extremely important for monitoring large-scale (i.e., coast-wide) changes in right whale distribution in near real time given rapid changes in the ocean environment due to climate change. Reliance on archival acoustic recorders to monitor for rapid changes in distribution is challenging, because the time between a right whale making a call (i.e., being present in an area) and an analyst detecting that call can be on the order of years due to the time required to recover and analyze the acoustic data. A near real-time array of acoustic monitoring buoys can provide that same data over time scales of tens of hours, allowing for a much more rapid reassessment of mitigation efforts. One example of this would be a regional network of near real-time monitoring buoys indicating that right whales were remaining in an area for longer than expected, prompting a reexamination and possible extension of no-construction periods. As the ocean changes, we expect right whale residency and movement patterns to continue to change as well, and these will be better monitored with near real-time acoustic systems rather than archival acoustic recorders. We will partner with the NOAA Northeast Fisheries Science Center (NEFSC) Passive Acoustics Group (led by Dr. Sofie Van Parijs) to develop recommendations on the utility and design of such a regional network.

Methodology

The whale-detection technology developed at WHOI is designed to detect, classify, and report the sounds of marine mammals in near real time from a variety of autonomous platforms, including Slocum gliders (Baumgartner et al. 2020) and moored buoys (Baumgartner et al. 2019). The moored system consists of three enabling technologies: (1) the digital acoustic monitoring (DMON) instrument (Johnson and Hurst 2007), which is capable of recording and processing audio in real time using custom detection algorithms, (2) the low-frequency detection and classification system (LFDCS; Baumgartner and Mussoline 2011; Baumgartner et al. 2013), software that allows the detection, characterization, classification, and reporting of marine mammal tonal vocalizations, and (3) an acoustically quiet mooring that utilizes stretch hoses (Paul and Bocconcelli 1994) to dampen wave-induced motion and to deliver digital data from the bottom-mounted DMON to the surface buoy (Baumgartner et al. 2019; Figure 3). The buoy relays detection information generated by the DMON to shore via Iridium satellite communications every 2 hours where it is displayed in near real time on a publicly accessible website (robots4whales.whoi.edu) and evaluated by an experienced analyst. The presence of four baleen whale species (right, humpback, sei, and fin whales) is estimated by the analyst and those estimates are also displayed in near real time on the Robots4Whales website, displayed on several web- and smartphone/tablet-based apps, and automatically shared with NOAA's Slow Zones for Right Whales program. The detection range of the system for right whales depends on a number of factors (e.g., oceanographic conditions, background noise, source

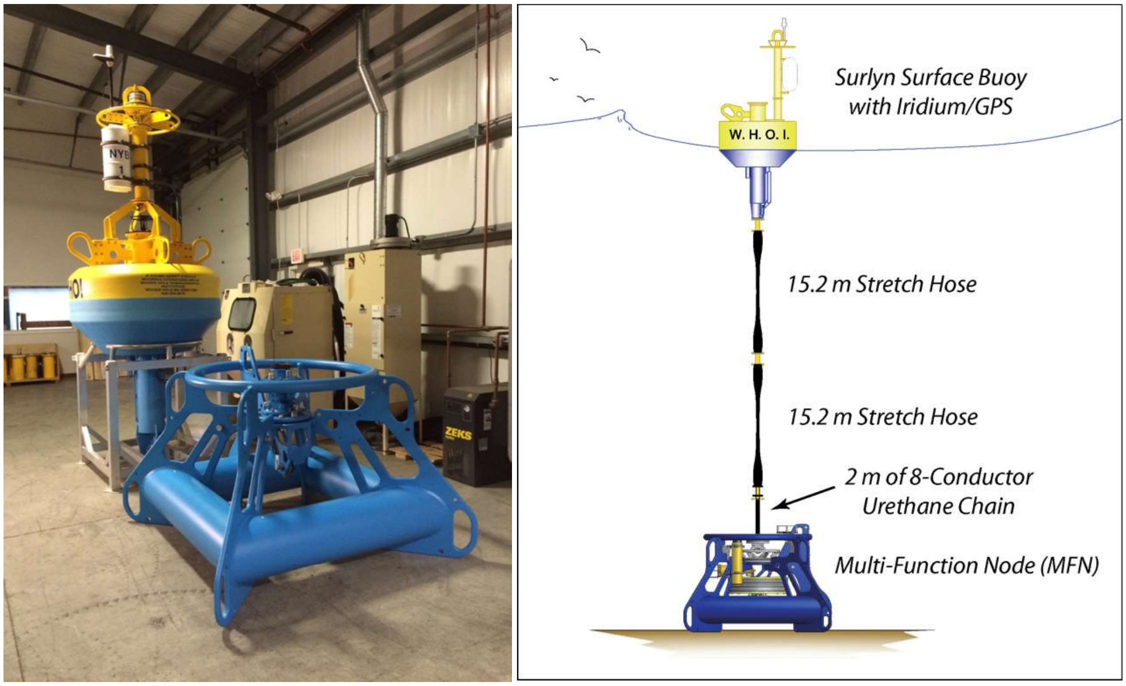

Figure 3: WHOI mooring featuring the bottom-mounted multi-function node (MFN) to which the DMON is attached, stretch hoses, and surface buoy.

level), but Johnson et al. (2022) empirically estimated the detection range of a DMON buoy in relatively shallow water (tens of meters) for a single right whale call was on the order of 10 km.

Post-recovery evaluation of near real-time occurrence estimates from a moored DMON/LFDCS buoy deployed in Massachusetts waters during 2015-2017 by Baumgartner et al. (2019) suggested that the analyst is highly accurate when estimating the presence of large whales: daily false occurrence rates were 0% for right, humpback, and sei whales and 0.1% for fin whales. In other words, when the analyst detects the presence of a large whale from DMON/LFDCS data sent in near real-time, the analyst is correct nearly 100% of the time. The analyst is less accurate when estimating the absence of large whales; daily missed occurrence was 12-42% over daily time scales. However, we have intentionally designed the system to be conservative (i.e., to keep the false occurrence rate very low at the expense of a higher missed occurrence rate) to reduce the chances of implementing mitigation measures (e.g., Slow Zones) when whales are not present.

How conservative the protocol should be is a matter of policy, not science, and it depends entirely on stakeholders' tolerance for both false and missed occurrences. One can imagine a stakeholder (e.g., a developer) who is very interested in keeping the false occurrence rate very low (at the expense of a higher missed occurrence rate) so that potentially expensive mitigation efforts are only implemented when confidence in a right whale detection is very high. The cost of this scenario is a higher chance of right whales being missed and therefore exposed to risk from construction or shipping activities. One can also imagine another stakeholder (e.g., NGO conservation group) who wishes to keep the missed occurrence rate low (at the expense of a higher false occurrence rate) to increase the chances that mitigation efforts are implemented each and every time a right whale comes near a construction site or shipping lane. The cost of this more precautionary scenario is increased financial cost to the industry, since industrial activities may be shut down because of false occurrences. Balancing these stakeholder desires is challenging, and quite frankly, not the job of a scientist. However, our protocol can be easily altered to be less conservative (i.e., more precautionary). When the analyst is presented with evidence of whale presence that is not completely convincing, the protocol instructs them to score that period as “possibly detected” instead of “detected” (see robots4whales.whoi.edu/#protocol). Baumgartner et al. (2019) examined the accuracy of a less conservative protocol that consisted of treating all “possibly detected” determinations as equivalent to “detected” and found that of all the “possibly detected” periods scored for right whales in near real time during their study, 88% had evidence of true right whale presence when the associated recorded audio was examined and 7% had no evidence of right whale presence (Baumgartner et al. 2019, Table 4). This suggests that right whales were actually present during most periods when the analyst was not fully convinced of right whale presence in near real time, and that a less conservative protocol that treats “possibly detected” periods as equivalent to “detected” periods may be warranted for right whales *if* stakeholders can all agree that some false detections are acceptable.

Schedule of activities

A moored buoy system will be prepared and deployed during winter 2022/2023. This system will replace the identical moored system that is currently deployed off Atlantic City, New Jersey. The moored buoy will operate until early 2024. A replacement buoy will be prepared and tested during fall 2023 and early winter 2023/2024. During a single cruise in early 2024, the extant buoy will be recovered and the replacement buoy will be immediately deployed in the same location. This ensures that the “downtime” of the system is limited to just a few hours as the system is swapped. That buoy will be operated until early 2025, at which time the system will be recovered. The experiment to study detection latency will take place during January or February of 2024, as right whale detections are typically numerous during those months. Analysis of the detection latency experiment will be conducted during the spring/summer of 2024, and the results will be included in the final report. Work on recommendations for a regional monitoring network of near real-time whale-detection buoys will begin in spring 2023 and will continue for the duration of the project. Draft recommendations should be completed by spring 2024 and prepared for publication during summer/fall 2024. This manuscript will be submitted for publication by the end of the project.

Expected outcomes

The moored DMON buoy will provide validated detections of right, humpback, sei and fin whales for 2 years at sea, and these detections will be made available to as many stakeholders via as many data dissemination outlets as possible (e.g., email messages, Whale Alert, Mysticetus, CG1 View). These data will be immediately shared with NOAA NEFSC and NOAA Greater Atlantic Regional Fisheries Office to support the NOAA Slow Zones for Right Whales program. The expected outcome of this is an increasing awareness of the presence of whales, particularly North Atlantic right whales, in New Jersey waters, and the consequences of that presence for offshore wind energy development. The continuously recorded audio collected by the DMON will be archived at WHOI and shared with the NOAA NEFSC for inclusion in their archive and the NOAA Passive Acoustic Cetacean Map (https://apps-nefsc.fisheries.noaa.gov/pacm/). We also intend to experiment to determine how “real time” the buoy system can be by increasing the frequency of data transmission to shore and review by an analyst. The expected outcome of the experiment is a greater understanding of just how fast whales can be detected and actionable information can be delivered to stakeholders. Finally, we intend to develop a publication that offers a framework for regional monitoring using near real-time acoustic whale detection systems for increased situational awareness during wind farm construction and shipping activities associated with offshore wind construction and operation.

Budget

Total Project Budget $602,135

Expertise

The project will be led by Dr. Mark Baumgartner at the Woods Hole Oceanographic Institution. Dr. Baumgartner has studied North Atlantic right whale ecology, distribution and acoustic behavior for the past 24 years, developed the low-frequency detection and classification system used on the DMON, and was a part of the engineering team to redesign the DMON in the late 2010’s. His Robots4Whales program is supported at WHOI by many talented engineers and technicians in the WHOI Acoustic Communications Group as well as the WHOI Mooring Operations and Engineering (MOE) Group. Dr. Baumgartner and his team have fielded DMON-equipped Slocum gliders since 2012 and DMON buoys since 2015, are maintaining 10 DMON buoys at sea (2 on the U.S. west coast, 8 on the east coast) and a fleet of 5 Slocum gliders, and are proving support to several groups that have incorporated DMON instruments into their Slocum glider fleets, including Dalhousie University, University of Alaska Fairbanks, Rutgers University, University of Maine, Stonybrook University, and Skidaway Institute of Oceanography. Dr. Baumgartner will oversee all aspects of the project, including assembly, testing, deployment and recovery of the DMON buoy by the MOE group, data review by a contract acoustician, analysis of the latency experiment data, collaboration with Dr. Sofie Van Parijs on the regional near real-time acoustic monitoring publication, and report writing.

Resources

WHOI has a dedicated facility for coastal and oceanic mooring work called the Coastal Research Laboratory, which includes a high bay, crane, laboratories and office space for the MOE Group. Dr. Baumgartner’s lab has several computers dedicated to receiving data from autonomous platforms at sea (buoys, gliders and profiling floats), processing those data in real time, and hosting the Robots4Whales website. These facilities are sufficient to complete the proposed work.

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