Monitoring the Socioeconomic Impacts of New Jersey's Offshore Wind Development on Recreational Fisheries Economy

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Motivation/Objective (Proposal Description)

Consistency with the goals and objectives of the Research and Monitoring Initiative (RMI)

This proposed project is well suited to the Research and Monitoring Initiative’s (RMI) goal of conducting rigorous scientific research that upholds the State’s mandate to protect and responsibly manage New Jersey’s coastal and marine resources while supporting its Offshore Wind Development plans. Furthermore, it will help achieve the RMI goal of balancing New Jersey’s environmental goals and furthering our scientific understanding by producing credible, scientifically rigorous data, analysis, and reporting. It will do so by creating an approach that will adapt to new scientific information and circumstances that emerge as offshore wind projects are developed and reflect evolving research and monitoring needs of the state. Moreover, this project reflects New Jersey’s highest research priorities of consulting, partnering with, and maintaining effective communication with existing regional offshore wind and wildlife/fisheries groups and other stakeholders. Below, we describe in detail how the project addresses RMI’s goals.

Balancing New Jersey’s environmental goals: This project will help the effort to balance New Jersey’s environmental goals of protecting the State’s natural resources while also meeting the Board of Public Utilities’ statutory mandates and priorities. It will do so by recognizing there is an increasing variety of activities that are or will be taking place in the State’s coastal waters, including renewable energy production, laying of pipelines and cables, shipping, coastal and maritime tourism, and recreational and commercial fishing. How the sectors interact with each other can create complexities, which may affect the distribution of benefits and costs associated with the use of marine resources (Micheli et al. 2013, Halpern et al. 2015, Goodale and Milman 2019).

This interrelationship is seen through offshore wind (OSW) energy production, which has implications for other natural resources, such as occupying ocean space that is no longer available to other users (Lacroix and Pioch 2011, Kyriazi et al. 2015, Pérez-Collazo et al. 2015, Piasecki et al. 2016). Understanding how these different uses of marine space and resources interact with each other can also help build synergies among sectors, for instance, by sharing costs, personnel, logistics, and infrastructure and by implementing a common licensing procedure (ICES 2018).

Thus, understanding access and spatial constraints, including use of natural resources therein, is critical since these waters host cultural and natural capital along with providing various services in oceanographic monitoring and research. As the type and volume of these activities is likely to grow, the timeliness of this study is appropriate given the likelihood of further intensifying potential conflicts between these sectors and the resulting impact on the environment.

This study will also help support management actions whose net benefit of combined uses will be greater than the sum of their individual effects, and lead to a diversification of sectors that can provide additional socio-economic benefits to coastal communities and the state overall [Schultz-Zehden et al 2018, ICES 2018]. This is especially important in the context of future scenarios, as such information will be useful in terms of building the socio-economic and environmental systems' resilience and adaptation [European MSP Platform workshop report 2018].

Furthering our scientific understanding: This project will advance our scientific understanding by producing credible, scientifically rigorous data, analysis, and reporting, and address an important research gap. Research gaps include a lack of an assessment of the best methods for collecting data appropriate for scaling local recreational fishing effects to regional levels or socio-economic regional assessments of research and monitoring (Gill et al. 2021). The multi-use nature of ocean space brings together previously separate industries and technologies. Whereas the individual effect of those activities has been studied to a degree, their performance/impact when they occur at the same time in a given space is not as well known (Bocci et al 2019, Goodale and Milman 2019).

Advancing scientific understanding of offshore windfarms (OWFs) on recreational fisheries: As artificial reefs and fisheries exclusion zones grow, OWF areas become greater contributors to locally increased attraction, concentration, and food provision for some fish species, with possible consequential effects to fish stocks (Mavraki, 2020). The complexity and the spatiotemporal variability of coral reef interactions and impact on recreational fisheries have not been studied, and significant knowledge gaps remain (Gill et al. 2021).

Recent monitoring requirements are now shifting from a species-centric approach toward an ecosystem-based focus (e.g., the Marine Strategy Framework Directive in Europe). Furthermore, integrated assessments can be framed in societally meaningful terms, such as articulating whether recreational fishing within the area of an OWF could be ecologically and economically sustainable over time (Wilding et al 2017, Gill et al 2021). Fisheries ecosystem services operate at varying scales, which are not the same as fisheries scientific assessment and management scales currently practiced. Hence, understanding effects at the right scales (such as at the sub-state level) underpins determination of impacts resulting from the interactions between OWFs and fisheries, and therefore is essential for sustainable coexistence.

While the science highlights the need to consider ecosystem and transboundary scales, policies and consenting requirements in various national jurisdictions result in an uneven ability to effectively monitor and conduct fundamental research to understand fisheries and OWF interactions at the appropriate scales. When assessing fishery-effort changes that may be attributable to OWFs, it is important to interpret those changes in the context of the existing long-term trends and spatial boundaries (e.g., Addison et al 2015). This type of research is especially important given that offshore wind is considered a “hard-use” type of ocean usage, which involves long-term installation of major infrastructures, as opposed to "soft-use" type, which is mobile and fleeting, and often requires less investment (EU Blue Economy Report 2018). Moreover, soft-use types of use can afford minimal investigation and monitoring, whereas hard-use types of use require close monitoring and follow up (Van den Burg et al. 2016, Schultz-Zehden et al 2018).

Although the concept of multi-use is gaining in popularity, limited knowledge is available on cross-sectoral and cumulative effects on the marine environment (Varona et al 2017, Franzén et al.2017). Even though competing claims for space can be a source of conflict, they may also lead to mutual benefits for different users when sustainable combinations are sought. Understanding these competing interests and monitoring their interaction and evolution over time is an important element in marine planning and developing solutions to competing uses (Arbo and Thủy 2016, Harris et al 2019). Our research plan addresses the issue of spatial efficiency of supporting more sustainable use of marine space and fosters a multidisciplinary approach on key cross-cutting maritime challenge. Thus, we believe this study is relevant and timely for the state.

Being adaptive: The approach we use in this project is adaptable. The joint use of marine resources in close geographic proximity itself represents a shift from the concept of exclusive resource rights to the inclusive sharing of resources by one or more users (Zaucha et al 2017). However, not all waters can foster inclusivity given multi-use concepts (Bocci et al 2019). Physical conditions, availability of space, and ecological richness are important factors influencing the viability of specific multi-use combinations. For example, areas that can foster multi-use activities involving aquaculture, fisheries, and environmental protection do not necessarily foster multi-uses that involve offshore wind and aquaculture, or even multi-uses that involve recreation or fishing (Halpern et al 2015, Goodale and Milman 2019). Thus, it is important to carefully consider local conditions when deciding whether single or multi-use should be favored in each location and what the social, economic, and environmental impacts of various combinations would be. Such a systematic assessment as proposed here is inherently adaptive. Such information can also be expanded through future studies that can identify which specific multi-use combinations can have the greatest opportunity instead of reacting to the developments that are already taking place and determining the ways to make them work together.

Collectively, the results will provide critical insights that will help monitor OSW impacts on the fisheries economies and the ensuing impact on communities. This information will contribute towards long-range improvement and sustainability of OSW development and will be relevant to policy makers, scientists, and land managers at local, state, regional, and national levels. Results can be used directly to monitor socioeconomic impacts on recreational fisheries economies, their management and control, co-existence with OSW farms, and scaled up to improve ecosystem benefits.

Engaging stakeholders, maintaining communication and coordination: We will integrate results from desktop analysis with inputs from stakeholders in the applicable sectors. We will do this by engaging local and regional (state level) stakeholders such as developers, recreational fishing groups, and community leaders through literature review and interviews in consultation with the NJDEP project support team.

Stakeholder driven evaluation of multi-use potential, both in terms of drivers and barriers, as well as the overall expected effect, both in terms of added values and impacts, will be useful in measuring expected positive and negative impacts of multi-use implementations (Franzen et al 2017, Bocci et al 2019). By identifying relevant technical, economic, environmental, and societal dimensions of the drivers, barriers, expected value additions and the possible negative impacts of multi-use options, we will be able to generate detailed insights and recommendations.

Through regular monitoring of spending and other measures of demand, we will be able to characterize the recreational fishers as well as people who engage in activities allied with recreational fishing in the state. By measuring their preferences and spending decisions, we can also estimate the likely economic impacts. Thus, by integrating inputs from stakeholders belonging to the OSW sectors, we will be able to develop a structured data and be able to determine priorities as well as concerns and opportunities.

Effective management of the marine environment requires appropriately scaled and focused data collection to ensure that meaningful changes are attributable to OWFs and acceptable to society (Wilding et al 2017). The present-day debate between fisheries and OWFs highlights the need for directing knowledge advancement (both monitoring and research) toward addressing societal concerns, which fundamentally relate to fisheries (e.g., through effects on stock size, structure, and/or distribution, recreational fishing economies). Current monitoring and research programs primarily target observing the aggregate effects of fisheries rather than determining the underlying cause-effect pathways that will be more applicable in case of OWF and recreational fishing economies (Gill et al 2021). The conflict between societal concerns and OWFs can be addressed by an iterative four-way interaction (i.e., society, including fishing communities; OWF industry; policy; and science). The goal is to translate societal concerns into a selection of tangible scientific questions.

Proposed Research

Study Area

NJBPU announced that Ørsted's Ocean Wind Project was awarded a solicitation for a 1,100 MW offshore wind project off the coast of Atlantic City, followed by 2,658MW of combined offshore wind capacity for Atlantic Shores Offshore Wind and Ørsted. Other areas along the NJ Coast (e.g., Boardwalk Wind, and NY Bight) are being developed/considered for OWF development. The areas approved in the first two solicitations along the coastline are ideal areas for a study of this kind. In this project will focus on the waters where the solicitations have been awarded (wind farm projects awarded to Ørsted and Atlantic Shores)[1]. We will

[1] The research will have flexibility and additional utility beyond the study area (e.g., NY Bight); however, this will not be the focus of the study.

identify recreational fisheries and associated tourism economies at these two sites to develop recreational fisheries economy baseline, to monitor and study how OWFs can potentially impact their landscape.

Objective

The objective of this study is to develop a recreational fisheries and tourism baseline for Offshore Wind Farm (OWF) development and monitor its change over the years, including the nature and size of OWFs' potential effects on recreational fishing.

Baseline data is critical in monitoring and evaluating changes resulting from specific additions to a given system. It is either impossible or at least challenging to measure change, positive or negative, without baseline data. Such data is essential in measure not only whether a change has occurred but also in measuring its size. Collecting pre-operation data on various variables of interest is useful in measuring the impacts on those same variables and to attributing those changes to the given set of causes being investigated.

Recreational fisheries-based baseline data is necessary, as the existing databases are not specific to the waters of interest or to OWFs. The existing data, including the APAIS, focuses more on the length, weight, and species of fish caught, along with limited information about the fishing trip (NOAA 2021). The For-Hire Survey collects information but elicits the data from for-hire operators to estimate fishing effort only from the for-hire sector. Though this makes their data indicative of actual fishing activity in respect to experience and implications for fisheries, their relevance to estimating reactions new developments such as the OWF is limited. Furthermore, these surveys lack questions to monitor the changes occurring due to OWF developments; we will measure recreational fisheries and associated tourism values in the applicable waters before the various proposed plans for OWFs come online for later comparison. In other words, we will develop a baseline that can provide the historical point of reference that can be used to OWFs and their associated impacts in future. This is an ideal time to do such a baseline analysis, as construction and operation of OWF are on the horizon, but there are no completed projects.

Specifically, we will elicit and keep for comparison data such as the amount of money recreational fishers spend per trip, the number of trips they make in a year, what they spend those monies on, the average per trip size of their party, impacted species, gears used, what other fishing and water sporting waters they visit, other recreational habits they participate in, and what attitudes they hold. We will also assess other potential factors that could affect those variables of interest, including changes in fishing quota, that need to be accounted for in measuring the effect of each OWF site that comes online. This will help not only improve the accuracy of our analyses, but also build confidence regarding the results and the recommendations that follow. The data collection and analysis will provide the information needed to be able to help us answer questions that are important for understanding the current economic value of recreational fishing in NJ and how that might change because of offshore wind, as follows:

Spatial and temporal variability in catch, harvest, and effort

- How does angling trend across space and time?

- What is the economic value of costal recreational fisheries harvest?
- What is the economic value of catch-and-release fishing?

Angler details

- How far into the ocean do anglers travel for fishing purposes?
- Which anglers comprise a given species-specific fishery?
- How do angler preferences vary across approved solicitation sites? Fisheries (recreational/commercial)? Landscapes (seasonal/private/public access)?
- How do other forms of recreation impact fishing activities (e.g., displacement of anglers by water sports, recreational floaters, boaters, displacement of anglers; resident vs. non-resident)?
- How do urban and rural fisheries compare on different metrics of value (e.g., money vs. participation vs. angler recruitment/reaction to the introduction of offshore wind farms in the waters)?
- Who accounts for the most effort, catch, harvest? Are there areas with subsistence vs. sport fishing?
- How do more frequent anglers differ in motivation from more casual anglers? What is the exact measure of variance?

These baseline data are needed to project angler use after the introduction of offshore wind farms in the waters, including:

- Will the introduction of offshore wind farms in the waters drive ecological change and how does that affect angling?
- Is the variability in catch, harvest, effort a function of the introduction of offshore wind farms in the waters; non-resident vs. resident anglers)?
- How does the introduction of offshore wind farms in the waters/climate change and other stressors impact angler satisfaction over time? Where are the changes the most felt or impacting satisfaction the most?
- Where are potential new areas of increased harvest after the introduction of offshore wind farms in the waters/under different climate conditions?
- Do temporal trends in harvest vary across waters near/far from the offshore wind farms?
- Which aspects of a fishery attract anglers to travel long distances?

- What type of fishery is most attractive to new or young anglers?

Species composition

- Which species are targeted: where and by whom?
- Tracked change in the fishing opportunities for structure-associating species (e.g., black sea bass) as compared to (e.g., migratory pelagic such as tunas) after the introduction of offshore wind farms?
- Do consumptive anglers shift harvest to compensate for species abundance changes?
- Will anglers respond adaptively to shifting species assemblages as more offshore farms are introduced in the local waters?
- Which species are more likely to be harvested vs. released? Is there spatial or temporal variation in these trends?
- What are impacts of changing angler trends to fish management?

Subtask: Estimate and track over the years the nature and size of OWFs' potential effects on recreational fishing

Evidence suggests that turbines will create recreational fishing opportunities, however it is possible that some displacement of recreational fishing during construction and operation will occur. To ensure fishing boats' safety as well as the safety of the cables involved, it is possible some fishing grounds will not be accessible to recreational fishing during construction or operation. If this change of fishing waters and opportunities is considerable and if it leads to a sizeable enough change in fishing in the affected areas, it will have implications for recreational fisher and recreation fisher-based tourism-related businesses around those waters during construction. Recreation spending, jobs, and tax revenues will be impacted, and the overall impact can be even greater. Thus, we will estimate the impact on recreational fisheries due to OWF developments in waters in which they fish.

To determine the nature and size of the economic impact that could result from OWF development, it is also important to understand how reactional fishers could respond to such developments. For example, while some could fish elsewhere, others could fish less, leading to a migration of tourism monies out of local areas and to a net reduction in the size of the tourism economy, respectively. Others yet could simply change their method of fishing or the types of gears the will use. These various ways of adapting to the change each have their respective implications and require their own types of policy responses. Gauging how OWFs interact with recreational fishing and how recreational fishers respond to them will help us estimate the likely economic impacts and tradeoffs for local recreational fishing.

Surveys will be conducted for the purpose of estimating expenditures related to marine recreational fishing trips. Recreational fishers will be asked questions about their most recent fishing trip and their expenses. The data will be used to determine average trip expenditures and be reported for each segment of the fishing population (rural/urban, instate/ out of state, mode of fishing such as for-hire, private boat, and shore, among others).

Methodology

Systematic document review

We will collect, collate, and systematically review a range of documents related to recreational fisheries, and OFW impacts. These documents will provide the insight needed to formulate questions for our interviews and surveys and will also provide improved understanding of the recreational tourism impact. These will consist of reports, past surveys, journal articles, news reports, and other documents. This will help us summarize, collate and/or synthesize existing works that better tailor the survey to understand New Jersey's context.

Recreational fisheries survey design

As recreational fisheries represent a diverse sector, it's important to study what differences exist and how they affect the sector in practical terms. Since secondary data is not detailed and specific enough, surveys must be used to generate the data required for this assessment. Accordingly, we will employ a structured survey approach to assess recreational fishers' perceptions, spending decisions, reactions to OWFs, and corresponding risk minimizing measures.

We will have two surveys, namely: i) Saltwater registry database survey and ii) a Qualtrics based survey. Both these surveys will be conducted each year. The saltwater registry survey needs a supplemental Qualtrics based survey for reasons such as: i) Saltwater registry does not have email of all registrants as providing emails is not a requirement for registry; ii) vessel owners/operators need to register but not the individuals who engage in recreational fishing in the marine and fresh tidal waters of the state of NJ or engage in recreational fishing in the marine waters outside the state but land their catch in NJ don't need to register; and iii) he Saltwater registry exempts individual saltwater angler who solely fish on for-hire (party and charter) vessels that are registered with the NJ Saltwater Registry.

The approach of using zip codes for measuring the rough distance of the respondents from the wind farms will be applied to winnow it down to the study area of approved OWF. Our prior experience suggests that same on the NJ Saltwater Registry have zip code information while others might not. For completeness and to verify that they still reside in their location, in case some have moved, we will ask respondents their current zip code. In order to tie the model back to the study area, we will ask the NJ Saltwater registrants where they go to fish, how far it is from their residence, the frequency of their trip, among others, to gauge the expected probability of their visit to the study area. Multivariate regression will be used to develop a statistical model that allows us to profile/determine each angler's fishing and spending decisions/patterns with respect to the study area.

We will run pre and post estimation tests to validate the model and produce the relevant statistics like the F, t, R^2, and p values to gauge the model's overall reliability. This will ensure confidence in the soundness of the conclusions and the recommendations that follow from these analyses. In the proposed study, we will send the survey to all NJ Saltwater registry registrants. We will analyze the data after a careful data cleaning effort that removed missing and incomplete responses.

Distance from zip codes will be used in Qualtrics survey as well, as a measure of how far the potential respondents' location is from the OSW farms. This is important because, given cost considerations, distance can play a role in which attractions tourists/anglers go to visit/fish. Respondents who are geographically closer to the offshore wind sites are the ones more likely to be affected by the introduction of offshore farms, for instance, then their responses should be weighted higher. Qualtrics, which is the company we will use to administer this survey, has resources for accommodating this distance-based weighting criteria.

Our surveys will include both open-ended and close-ended questions. Open-ended questions allow respondents to articulate their opinion and provide feedback, which can be analyzed qualitatively. Close-ended questions allow respondents to respond to a question within given constraints, which can be analyzed quantitatively. The survey focusing on the recreational fishers, who are affected more directly and possibly to a greater extent, will assess how OWF affects their fishing decisions. The results will elicit what new practices/equipment they plan to use, how long they plan to keep using those new practices, if they plan to visit other waters instead, and where exactly they intend to go so that the broader economic impacts of their decisions can be tracked.

By measuring the length of the trip and breakdown of spending on various spending categories, we will obtain a profile of the most recent marine recreational fishing trip. The estimated average expenditures can be used in future iterations of this monitoring effort to estimate total angler expenditures and the economic contributions of marine recreational fishing to regional and state economies as well as gauge how they are changing over time. Primary data will be collected to establish baseline and subsequent economic analyses, as shown in Table 2.

Table 2. Information to be collected from survey data.

Trip/spending decisions

- Number of trips completed in a year
- Amount of spending per trip per person
- Breakdown of spending in terms of transportation, lodging, groceries, restaurants, bait, ice, parking, boat rental/chartering fees, etc.
- Number of people traveling together
- Distance traveled to offshore fishing site
- Number of trips to sited leased for offshore wind development
- Tendency and length of average overnight stays
- Typical place of accommodation
- Preferred sites of fishing (offshore, onshore, inland)
- Number of hours fished on the last fishing trip

Opinions/perspectives

- Opinions about offshore wind energy production in terms of creating new jobs, producing clean energy, scenic beauty, electricity costs, energy security and independence, property values, local tourism and economy, marine environment
- Perspective on the effect of view shading
- Motivations for fishing at their preferred site
- How choice of preferred site or number of trips to the site changes in response to the introduction of offshore wind farms nearby
- Likelihood of visiting a beach at least once to see an offshore wind farm or take a boat tour

Affiliated activities

- Type of other outdoor recreational activity preferred
- Borrow or own sports/fishing equipment
- Timing of preferred water activity relative to the fishing season

Demographic information

- Gender
- Region of residence (state, rural/urban)
- Age

• Level of education • Income • Size of household • Ethnicity

Sample size

The first Saltwater Registry survey will be administered to all registrants on the list with emails. The first survey specifically targeting recreational fishers will be done using the NJ saltwater recreational registry database[2] at the NJDEP. Rather than selecting a sample of respondents from a target population to conduct a survey, we will send the survey to all the individuals on the NJDEP's registry by email.

While a large sample size provides more reliable results, it can be costly and unnecessary. A carefully designed survey that targets the appropriate sample size can deliver the kind of data that can provide statistically significant results. To determine a representative sample size from the target population of the anglers for Qualtrics based survey, we will use Cochran's formula. Cochran (1977) developed a formula to calculate a representative sample as

$$n_0 = \frac{z^2 pq}{e^2}$$

Where $n_0$is the sample size, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population $q = 1 - p$ and $e$is the desired level of precision. In our case, we want to calculate a sample size of a large population whose degree of variability is unknown. Taking 99% confidence level with ±5% precision, the calculation for required sample size will be 666 respondents. The number of individuals we would have to survey increases as we increase the confidence level we are trying to achieve. For instance, if we want to be 99.9% certain that the result from that survey can truly represent the whole fishing community, then we would have to survey 1072 individuals. A confidence level between 99% and 99.9% is usually used for sampling and that is why we picked the sample size of approximately 800 respondents (higher than 99% confidence interval requiring 666 respondents and lower than 99.9% requiring 1072 respondents) for this study.

Institution Review Board approval

As our research will involve human participants, we will obtain Institutional Review Board approval for our survey. The IRB is charged to review, approve initiation of, and conduct periodic reviews of research projects that involve human participants. As mandated by federal law and consistent with the university policy, each investigator must have prior dated and written approval from the IRB before beginning a research project that uses human participants. We will undertake this approval once the survey design is finalized.

[2] https://www.nj.gov/dep/saltwaterregistry/

Survey pre-test

We will develop the surveys and pre-test them through soft launch and use the results to assess whether changes need to be made to the survey. Our survey pre-test will focus on the following:

- Comprehension: Ensure that respondents understand the aim of the survey and the wording of the introduction and questions.
- Logic and flow: Ensure that choice experiment questionnaire follows a logical order and questions do not seem out of place or confusing.
- Length and adherence: Validate that most respondents can complete responses without losing interest and focus.
- Technical pre-test: Ensure that survey platform operated smoothly in the pre-test and there are no glitches.

The pre-test of the surveys will allow us to recruit a small sample of the target population and generate data on the kind of responses that will be collected so that we can recalibrate the survey or the overall approach as needed. The recreational fisheries survey pre-test will be undertaken in consultation with NJDEP support team. We can pre-test by sharing the survey with an expert group or a small sample of the DEP saltwater registry database. An expert group within DEP (and/or outside) will be preferred, as we will need to exclude the pretest respondents from the actual launch. We can also expand this survey following a mixed method approach, if desired and based on resource budget, through an in-person survey.

We will analyze pre-test results to ensure that results are meeting the goal of the analysis. We will, thus, use the knowledge survey testing has provided to improve the research process and survey instruments.

Survey administration

The first survey specifically targeting anglers and recreational fishers will be done using the NJ saltwater recreational registry database[3] at the NJDEP. We will adapt Total Design Method (TDM) as offered by Dillman (1978) whereby we will send, introductory mail, followed by our survey. Non-responders will be followed up one week after the initial mail-out with a reminder mail, and two and three weeks after the initial mail-out with replacement surveys. The TDM is based on sound research principles and confirms that when attention is paid to administrative detail, high response rates can be achieved from difficult subjects. We will undertake this survey after a careful data cleaning effort that will remove missing and inaccurate email registrants. Our approach will also handle missing and incomplete responses as they will reach out to enough potential survey takers in the area to generate completed responses.

Our second survey will target 800 respondents, targeting in-state and bordering state residents who have visited the New Jersey shore recreationally in the last year. Surveys will

[3] https://www.nj.gov/dep/saltwaterregistry/

be administered using the third-party survey agency, Qualtrics. Using such an approach will help us get representative samples and ensure completed responses. While the average response rate for Qualtrics is around 30%, the completion rate is really important (800 completed responses).

As elaborated earlier, we will use zip codes and respective distances from OWF of interest to filter the applicable sets of respondents. This will help us more effectively target the respondents who are more likely to visit the recreational fishing sites in proximity of OWF given that distance is a major factor in deciding which waters fishers go to.

Analysis

Given the distance of the offshore wind farms from the coast and that not all anglers travel that far for fishing purposes, we can assess the more relevant segment of the fishing population by filtering using the question: 'how far into the ocean do you go for fishing purposes?' This will help us put the estimated effect in context. By gauging if and how those who travel shorter distance respond to the introduction of OWFs, we can put in greater context what the fishing/fish population effects will be. Using our stated preference-based public preference, and recreational angler baseline surveys, we will assess angler perceptions and preferences, recreational tradeoffs associated with OWFs, and its associated economic value. We will assess recreational anglers' participation and per capita-per trip spending decisions along with, through stakeholder engagement, local business establishments' plans for responding to the possible economic changes, which will likely reflect both in the duration and frequency of patronage from such anglers.

To understand which segments of the recreational fishers will change their behavior in given ways, we will estimate regression model in a framework where

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \dots \dots . + \beta_k X_k + \mathcal{E}$$

Where Y is the variable of importance, whether/specific type of change in fishing gear considered and $X_{1\text{-}k}$ are the explanatory factors such as familiarity with various fishing gears and equipment.

To model the choices respondents' make among the various options available to them, we will use such options as a latent-class finite-mixture logit model of the type

$$\Pr\,(Choice = i|x_i x_j) = \sum_q \Pr\,(Choice = i|x_i x_j, \beta_q)\pi_q$$

where π_q are the class probabilities where within a class.

$$\Pr\big(Choice = i\big|x_i x_j, \beta_q\big)\,\pi_q = \frac{e^{v(x_i, \beta_q)}}{\sum_j e^{v(x_i, \beta_q)}}$$

Such an approach is ideal as it assumes that attributes of the alternatives have heterogeneous effects on choices across a finite number of groups or classes of respondents (Mariel et al. 2021). It has the added benefits of describing heterogeneity by segments and being a parsimonious estimator with a unique solution. It also requires smaller samples than the other alternatives.

For each regression model we conduct, we will test the model's fit by assessing its Likelihood Ratio, the overall F-test statistic, and the Root Mean Square Error (RMSE) value. These measures are based on Sum of Squares Total (SST) and Sum of Squares Error (SSE), and are combined in different ways to provide different insights into the model's predictive value. These tests will help us develop regression models that produce predicted values that are close to the observed values.

For the specific variables within the regression model, we will use their respective p-value, or probability value, ranging between 0 and 1, to determine how likely it is that the predicted effect will occur by random chance. The smaller the p-value is, the stronger the evidence is for rejecting the null hypothesis. We will thus use a p-value threshold of 0.1 in this project in deciding whether to accept or reject the hypothesis being tested.

Estimating sector specific and regional level multipliers and regional impact

We will use sector specific and regional level multipliers to determine the rate of re-circulation of a tourist's dollar spending within the region. These flows can be predicted by assessing what each industry must buy from every other industry to produce a dollar's worth of output (Wickramasinghe et al 2021). Any added spending resulting from the introduction of OWFs will have a broad snowball effect on various aspects of the recreational fishing economy. The multiplier values we use will capture the proportional amount of that increased economic activity.

By using each industry's production function, we can also determine the proportions of sales that go to wage and salary income, proprietor's income, and taxes. Ratio type income multipliers for instance can be computed as:

$$Income\ multiplier = \frac{\text{Direct income} + \text{Indirect income}}{Direct\ income}$$

$$Income\ multiplier = \frac{\text{Total direct, indirect, and induced income}}{Direct\ income}$$

We will also estimate sales and employment ratio type multipliers by replacing income with measures of sales or employment in the above equations. Such multipliers will help us determine how much income or jobs are impacted per dollar of sales.

To ensure greater accuracy we will deduct the producer prices of imported goods that tourists buy before applying the multiplier to tourist spending. We will also apply local margins such as local retail margins and possibly wholesale and transportation margins if these firms in the chain of affected businesses lie within the region. This will be done by determining the capture rate, which shows the proportion of the local final demand with respect to the total tourism spending in local areas. We will apply this rate to ensure that only the margins on goods purchased at retail stores are counted as local final demand. We will do this because failing to account for such capture rate could result in an inflated estimate of total sales effects and an inflated overall estimate of a sector's impacts.

Schedule of activities

This proposal covers two years from the start of the project. Table 3 shows the order in which tasks will be completed over the two years of the study.

Conceptual timeline following the preconstruction project phase. Our monitoring and analyses approach can adapt to the different phases of the OSW project beyond the pre-construction phase[4]. Similar project-phase specific projects have been developed elsewhere. The MERMAID project for instance was an innovative multi-purpose offshore platform spanning the planning, design, and operation phases (Zanuttigh et al. 2015, Van den Burg et al. 2016, Stuiver et al. 2016, van den Burg et al. 2019). Such a project has been useful in evaluating in detail the technical and economic implication of feasibility of OSW related multi-use activities. Aquaculture installations within areas of offshore wind energy production, for instance, can be implemented though the direct attachment of installations such as cages or long lines to OSW turbine foundations (Bocci et al. 2019). Such integration, however, requires engineering adjustments to be made in the planning phase to accommodate the extra load safely. Thus, consideration of multi-use opportunities is important even at the planning phase of OSW projects and the studies that explore the impacts of these opportunities can evolve with the different project phases.

While we cannot speculate what the effects of its decommissioning will be given that the OSW platforms are not operational yet, the processes we have in place will be adaptable enough to accommodate that phase and be able to determine its impacts on the allied sectors as well as recommend ways to minimize adverse impact on recreational fisheries economies. Thus, by adapting our approach to the different project phases, we will be able to track these concerns and opportunities.

Table 3. Specific tasks and order of activities.

Tasks & Activities	**Q 1**	**Q2**	**Q 3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
Develop recreational fishing and tourism baseline for OWF development								
Collection & Analyses of Secondary Data	X	X			X	X		
Survey Design & Institution Review Board approval	X	X			X	X		
Survey Pre-Test	X	X			X			
Survey Administration	X	X			X	X		
Data Analysis & Recreational Angler Baseline Development		X	X	X	X	X	X	X
Assess Anglers' Preferences Regarding Fisheries and OSW Tourism			X	X		X	X	
Estimate Sector Specific and Regional Level Multipliers				X	X	X	X	
Assess Anglers' Activities Change due to OWF and Recreational Tourism			X	X	X	X	X	

[4] This project covers preconstruction baseline phase for two years. The construction and post-construction research and monitoring will encompass another three years.

Estimate the OWFs' Potential Effects on Recreational Fishing in the State of New Jersey			X	X	X		X	X
Estimate the Nature and Size of OWFs' Potential Effects on Recreational Fishing			X	X	X		X	X
Quarterly Progress Meeting/Briefing	X	X	X	X	X	X	X	X
Interim Technical Report Development and Documenting the Model and Results			X	X	X	X	X	X
Incorporating Feedback From NJDEP			X	X	X	X	X	X
Final Technical Report							X	X
Journal Manuscript Development & Submission					X	X	X	X

Expected Outcomes

Our study results will provide important insights regarding how the OWFs could impact recreational fisheries and recreational tourism, as well what the broader effects of these impacts could be. Such information is critical in developing the most suitable policy responses to benefit the stakeholders involved and minimize potential harmful effects. Finally, by identifying various opportunities and challenges, we will have highlighted existing areas of good practice and helped determine more innovative means of integrating the two sectors. The results will be able to provide insights regarding recreational angler preference for offshore wind and assist the decision and policy makers in incorporating a more holistic analysis. It will also help alleviate stakeholder concerns by showcasing the potential for more economic and employment opportunities.

This information is essential to policy and decision makers who establish management strategies and formulate extension and policy initiatives. Furthermore, this will fill the research void as the existing monitoring studies are not so rigorous because none have incorporated how and why fishers might change or respond to OWF, and how these changes may impact the economic viability of recreational fishing economies.

The research will involve a peer reviewed publication, stakeholder engagement as well as improving communication between stakeholders, to avoid errors in understanding the specific steps as well as the main goals. Regular participation of the NJDEP project support team comprising of Chief Bureau of Marine Fisheries, Chief Economist, and Administrator Marine Fisheries Administration will help achieve successfully expectations set in the project. Furthermore, periodic updates to the NJDEP project managers will ensure that project activities are on the right track.

Research findings will be widely disseminated through publications, presentations, and collaborative discussion, which can contribute towards enhanced public awareness of the interlinkages between OSW and recreational fishing and increase stakeholders' engagement with scientific research and management. The study benefits the understanding of the scientific community and a broad audience of managers, government officials, and private sector managers by demonstrating the integrated socio-economic and ecosystem management needs, and how this information can be transferred to inform the real-world decisions that they make.

Deliverables

The deliverables for the proposed work will include:

1. Develop recreational fishing and associated tourism baseline for OWF development through literature review, industry stakeholder, and general public surveys.
2. Estimate the nature and size of OWFs' potential effects on recreational fishing in the state of New Jersey through predictive regression models.
3. Monitor changes over time for i) recreational fishing and tourism; and ii) nature and size of OWFs' potential effects on recreational fishing.
4. Interim technical report.
5. Final technical report developed by incorporating the feedback received from the NJDEP.
6. At least one manuscript to be submitted to peer reviewed journal.

The CESAC team will develop an interim technical report documenting the recreational fisheries baseline, key assumptions, and analyses listed. This interim technical report could help inform/refine the research outlined here. Based on the feedback from NJDEP on the interim results, the final technical report will be developed and submitted to NJDEP. The technical report to DEP and the manuscript for peer reviewed journals will help share the research results with the broader scientific community.

Budget

The CESAC team will perform the work at an estimated cost of $440,983 over the performance period of two years beginning approximately April 1, 2022.

Cost-effectiveness: This project optimizes value and maximizes the use of limited resources because it relies on study objectives, and it builds upon existing capabilities and existing initiatives. The combined amount of project time allocated by the project investigators and supporting research students will allow all project objectives to be achieved in a timely and cost-effective manner. CESAC and University Support Services, are well versed in interfacing with the NJDEP and NJBPU through ongoing contracts, and can help quickly launch the project if selected.

Expertise

The Clean Energy and Sustainability Analytics Center (CESAC) engage and work with partners in government (e.g., New Jersey Board of Public Utilities, New Jersey Department of Environmental Protection, NJ Economic Development Authority) towards meeting clean energy goals of the state, research with industry partners (e.g., Ørsted, PSEG), clean energy workforce development, research with national labs (Argonne National Lab, Idaho National Lab), partnered with other universities in NJ and beyond and disseminated information and engaged with the nonprofit community in NJ towards furthering energy access and equity.

Key Projects in CESAC

- University Research Initiative on Offshore Wind
- Clean Energy and Sustainability Research Related to Offshore Wind
- Evaluation of New Jersey's Flounder Summer Education Program,
- Rapid Economic Analysis of Summer Flounders Harvest Restrictions
- Office of the Economist: Research and Technical Assistance-Utility Bill Deferments in New Jersey
- Assistance to New Jersey Fuel Cell Task Force Report Development
- Renewable Greenhouse Gas Initiative Related Economic and Energy Dispatch Modeling.
- Economy-wide modeling of energy and environmental policies.
- Exploring geographic opportunities for clean energy sustainability.
- Socioeconomic impacts of bioenergy development.
- Exploring place-based opportunities for bioenergy sustainability.
- Achieving green growth through terrestrial natural capital restoration in Rwanda.
- Sustainability regulatory integration and reform for Superfund sediment remediation projects.
- Ecosystem service tradeoffs, incentives, and optimal policy design to promote sustainable ecosystems.

CESAC projects are partially funded by:

- The New Jersey Board of Public Utilities (BPU)
- The New Jersey Economic development Authority (EDA)
- Ørsted
- iCheck Energy
- The National Science Foundation (NSF)
- Commission on Science, Innovation, and Technology (CSIT)
- The German Society for International Cooperation (GIZ)
- The Sediment Management Working Group (SMWG)
- The New Jersey Department of Environmental Protection (DEP)
- The United States Department of Agriculture (USDA)
- PSEG Foundation

Our experienced research team uses cutting-edge research to provide actionable, science-based insights to our clients. We help to identify the factors that may influence economic and environmental implications of a clean energy project, including policy and sustainability relevance, market dynamics and stakeholder impacts. We undertake applied analysis to advise our clients and recommend ideal implementation strategies. We excel in applying analytic techniques and adapting models for novel purposes and developing new ones to satisfy project requirements. We use a variety of techniques, including qualitative analyses, data analytics, geospatial models, behavioral models, resilience analysis, financial models, surveys, and economy-wide models, at different stages of the project life cycle to provide timely and accurate analyses for our clients. We aim to stay up to date on the most current research across industry and academia to gain an unmatched perspective on energy and sustainability concerns. We specialize in making learning accessible for students, stakeholders, and clients, via a variety of media, including presentations, webinars and publications. We strive to impart best practices within clean energy disciplines, and tailor our expertise to ensure effective skill development.

The CESAC team has considerable experience in baseline development monitoring evaluation stemming from a wide range of projects. We are capable of targeted evaluations to assist specific projects, programs and policies, which aim to improve efficiency and effectiveness, and inform clients and other stakeholders on sustainability initiatives. Using tools – systematic review, interviews, surveys, meetings, and qualitative and quantitative analysis – we tailor our approach to individual projects to maximize impact.

Dr. Pankaj Lal, Director of CESAC and Professor of Earth and Environmental Studies, has extensive experience conducting research and in assessing impact evaluations of various policies and investment projects. Dr. Lal was awarded Presidential Early Career Award for Scientists and Engineers (PECASE) by President Obama as well as National Science Foundation CAREER award. He also acted as a reviewer for the Fourth National Climate Assessment (NCA4) under the U.S. Global Change Research Program (USGCRP). Dr. Lal leads a team of more than 20 members and has worked on renewable energy program evaluation, adoption and dissemination in New Jersey and beyond. He has managed projects from the New Jersey Board of Public Utility, Department of Energy, National Science Foundation, the Department of Agriculture, New Jersey Department of Environmental Protection, US environmental Protection Agency, Rockefeller Foundation, PSEG Foundation, and other funding agencies equaling a total of more than $20 million. These experiences will be valuable in overall project management, interaction with contract manager, interfacing with NJDEP, BPU, community organizations and other stakeholders, overseeing researchers, and coordination for ensuring successful project completion, including submission of progress reports and other project deliverables. Dr. Lal conducted rapid economic impact analysis of regional summer flounder restrictions, which was successfully used by NJDEP in their request to reconsider Atlantic States Marine Fisheries Commission’s Summer Flounder Management Board's harvest restrictions. He is member of NJDEP Scientific Advisory Board on Biofuels.

Dr. Aditi Ranjan, Professional Staff Researcher and Adjunct Professor at Montclair State University teaches courses in sustainability, energy, environment, and society. She undertakes socio-economic, environmental, geospatial research to improve ecosystems and societal wellbeing. She has worked on several countrywide and regional projects spanning environmental and developmental issues for international clients like Inter-American Development Bank, Ørsted, the German Society for International Cooperation (GIZ), Wildlife Conservation Society, interfaced with governmental and non-governmental organizations and private industries. She has conducted knowledge review, stakeholder and recreational surveys, monitoring and impact assessment of projects, assessed data availability and approaches used for social and environmental assessments, worked on developing framework for collecting additional data/information for valuation exercise, worked on resource surveys design, modeling and analysis conducted ecosystem valuation and delineated their contributions towards national/regional policy goals, and undertaken geospatial mapping and analysis. She has published number of peer-reviewed publications, technical reports and presented her work at international, national and regional conferences and workshops.

Dr. Meghann Smith, is a Research Associate at CESAC. She partakes in a variety of projects ranging from clean energy technology research to sustainable agri-tourism. Dr. Smith is well versed in methods such as discrete choice experiment, best-worst scaling, contingent valuation, and multi criteria decision making. She has worked on statistical analysis and interpretation for the aforementioned methods, in addition to other regression models, analytical hierarchy process, and principal components analysis. Dr. Smith's clean energy research has explored multiple sectors including geothermal heat pumps, offshore and onshore wind farms, and biofuel applying techniques, suitability analysis, and life cycle analyses and life cycle costing analyses. Her further human subjects research has explored perceptions of sustainable agriculture from both producer and consumer perspectives, willingness to pay for sustainably produced goods, and public preferences for niche tourism such as apple cider. She has worked on projects funded by US Department of Agriculture, NJBPU, NSF, GIZ, and the Sediment Management Working Group (SMWG), and the PSEG Foundation.

Jeffrey Brust, is Chief Bureau of Marine Fisheries at NJDEP and is responsible for the administration of marine fisheries management programs. He leads the bureau to protect, conserve and enhance marine fisheries resources and their habitat, and conducting research and inventory projects designed to provide data on fishery resources and on the various user groups to develop and implement sound management plans. Mr. Brust is one of the lead scientists for assessing data poor species and applies methods species like the American eel. He is committed to increasing the stock assessment capabilities of state biologists and has also taught a number of beginner and intermediate stock assessment training courses and helped create a stock assessment mentoring program.

Michael Russel, Chief Economist at NJDEP. He along with his staff conduct environmental economic and regulatory analysis for the agency. Mr. Russel is also doctoral candidate studying comparative education at Lehigh University. Before joining NJDEP, he was an assistant professor of economics at Centenary University and also served as the Director of the Centenary University Center for Sustainability and acted as program director for the Sustainable Practices concentration/minor/certificate. Through Centenary, he was a professor-in-residence at Phillipsburg High School. He is also interested in digital pedagogy, data visualization, and how non-traditional modes of communication can drive social change.

Joseph Cimino as Administrator directs the operations of the Marine Fisheries Administration, which includes both the marine fisheries and shellfisheries bureaus. Mr. Cimino represents the NJDEP and the state of New Jersey at various inter- and intra-state meetings, including the New Jersey Marine Fisheries Council and Shellfisheries Councils, the Atlantic States Marine Fisheries Commission and the Mid-Atlantic Fishery Management Council. Mr. Cimino directs the research and monitoring programs of the Administration to ensure that activities conducted provide the necessary information for the sound management of the marine and shellfish resources. He started his marine fisheries career as a seasonal technician for New York State Department of Environmental Conservation's Hudson River fisheries Unit, he then spent two years with NC DMF in the Elizabeth City office. He spent nearly 14 years with the Virginia Marine Resources Commission in various rolls, ultimately finishing his time there as the Deputy Chief of Fisheries. Joe has degrees from SUNY Cobleskill and Plattsburgh in Fisheries and Wildlife Technology and Environmental Science, respectively.

We have assembled a team of researchers with expertise in economics, human dimensions, survey research, data analytics, clean energy, environmental economics, fisheries research, statistical analyses, regional economic modeling, and recreational research who have extensively worked on qualitative and quantitative research and analyses. The team will be led by CESAC Director Dr. Pankaj Lal will be primary contact for this project and will communicate with the state project manager through email and telephone. In addition to the reporting work explained above, we shall provide quarterly summary progress reports to NJDEP Project Manager comprising of a concise assessment of the status of each objective listed in the above schedule problems encountered, plans for subsequent quarter, and an explanation of any deviation between the schedule and actual progress and any remedial action that might be needed.

Table 6. MSU Personnel Involvement in Tasks & Activities

MSU Personnel Involvement in Tasks & Activities *	**PL**	**BW**	**AR**	**MS**	**ST**
Develop recreational fishing and tourism baseline for OWF development					
Collection & Analyses of Secondary Data	X	X	X	X	X
Survey Design & Institution Review Board approval	X	X	X	X	
Survey Pre-Test	X	X	X	X	
Survey Administration	X	X	X	X	
Data Analysis & Recreational Angler Baseline Development	X	X	X	X	X
Assess Anglers' Preferences Regarding Fisheries and OSW Tourism Development	X	X	X	X	

Estimate Sector Specific and Regional Level Multipliers	X	X			
Assess Anglers' Activities Change due to OWF and Recreational Tourism Development	X	X	X	X	
Estimate the OWFs' Potential Effects on Recreational Fishing in the State of New Jersey	X	X	X	X	
Estimate the Nature and Size of OWFs' Potential Effects on Recreational Fishing	X	X	X	X	
Quarterly Progress Meeting/Briefing	X	X		X	
Interim Technical Report Development and Documenting the Model and Results	X	X	X	X	
Incorporating Feedback From NJDEP	X	X	X	X	
Final Technical Report	X	X	X	X	
Journal Manuscript Development & Submission	X	X	X	X	X

Note: PL-Pankaj Lal, AR-Aditi Ranjan, MS-Meghann Smith, ST-Students. The NJDEP support team (Mr. Jeffrey Brust, Mr. Michael Russel, and Mr. Joseph Cimino) will work throughout the project.

Project Roles

Dr. Pankaj Lal will lead the overall project and will be responsible for all project deliverables. He will be primary contact for the state project manager and will supervise and coordinate with NJDEP support team on project tasks and activities. He will lead all aspects of the project, including stakeholder engagement, technical report and final report preparation, presentations, and manuscript development.

Dr. Aditi Ranjan, will work primarily on Qualtrics based angler and recreational fisher surveys, their design, IRB approval, survey implementation, data cleaning and analysis to estimate recreational fishing and associated tourism baseline for OSW farm development at two approved sites. She will also assess anglers' preferences regarding fisheries and OSW tourism, and estimate anglers' activities change due to OSW farms and recreational tourism development. She will also work on technical report preparation, incorporate feedback from DEP, final report preparation and development of research manuscript.

Dr. Meghann Smith will work primarily on saltwater registry-based angler surveys, their design, IRB approval, survey implementation following tailored design method, data cleaning and analysis, estimate OWFs' potential effects on recreational fishing in the state of NJ, and recreational angler baseline development. She will work with Dr. Lal on preparation of quarterly reports, stakeholder engagement. She will also work on technical report preparation, incorporate feedback from DEP, final report preparation and development of research manuscript.

Students working on the project will support data collection, data cleaning, survey implementation and assist in project activities and deliverables, including manuscript preparation.

The NJDEP support team (Mr. Jeffrey Brust, Mr. Michael Russel, and Mr. Joseph Cimino) will work with MSU team throughout the project, especially in saltwater registry-based survey design and stakeholder engagement, survey administration, analysis review, baseline development, and technical report review.

Resources

The Clean Energy and Sustainability Analytics Center (CESAC) at Montclair State University is a public research and technical assistance center that seeks to identify, quantify and interpret the ramifications of clean energy development and to facilitate sustainable planning. The center also provides support for clean energy and sustainability policies, technology and practices through research and education programs, environmental and economic solutions for New Jersey in order to build a sustainable energy economy. The CESAC researchers achieve these goals through (1) encouraging collaborative discussion between energy stakeholders and policymakers, (2) gathering and analyzing data to develop clean energy pathways that can be used for informed decision making, (3) generating Computable General Equilibrium based Integrated Energy Environmental Economic models that can be used for energy and environmental planning in New Jersey, (4) fostering faculty and student research in the area of clean energy and sustainability analytics, and (5) assisting policymakers, businesses and organizations in developing clean energy and transportation initiatives in the state while acting as an information resource hub regarding state regulatory and incentive policies.

Montclair State University possesses the space, research facilities, and institutional support necessary for this program to succeed. Along with CESAC, researchers are affiliated with Earth and Environmental Studies (EAES) Department conduct basic and applied research in the environmental and allied sciences. This research helps make the best use of natural resources while protecting the environment. EAES is housed in the new Center for Environmental and Life Science (CELS) Building, a 100,000 sq. ft. building dedicated to interdisciplinary research, on the northern campus. Most of our laboratories and offices are found in the CELS Building. The CELS Building provides space for student-faculty research, and for group meetings. All CELS Building teaching spaces have movable furniture and are fully mediated to allow for different activities and pedagogical styles. CELS houses a 24-seat GIS and Remote Sensing laboratory. Available software includes ArcGIS, Leica Geosystems' ERDAS Imagine Professional image processing/GIS package, ImageJ, GMS, Matlab by Mathworks, Google Earth, and statistics software packages such as SPSS and JMP. The CELS Building houses a dedicated computational sciences research laboratory equipped with multiple high-performance computers, including five dual six-core linux workstations and five windows workstations with a combined total disk storage capacity of about 100TB. The PI and his students have access to a high-performance computing cluster (HPC). The HPC has 1152 cores operating on 48 computing nodes as well as a head node, large-memory compute node, and storage server, all with Intel Xeon processors. The capacity of the storage server is currently 32 TB; with 24 empty drive bays, storage capacity can easily be tripled if necessary. The HPC is physically located in the secure, on-campus, data center (with redundant HVAC and backup generator) operated by the Office of Information Technology (OIT) of Montclair State University. The College of Science and Mathematics has a full-time network manager to assist faculty. Additionally, all computational equipment within the College is supported by CORE (Computer Operations for Research and Education). University-wide support is provided through OIT.

Researchers have standard laptop/desktops. Public computer facilities are also available. The GIS Lab can be used for both instruction and various research-oriented work. In addition, students have access to the computers in the student labs and 24-seat GIS and Remote Sensing Laboratory. The CELS also includes computational facilities for geospatial, environmental and socioeconomic analysis. Most students working with faculty have dedicated work systems (Lenovo or Macbook). All of the computer work systems that will be used in this study have dedicated up-to- date computers with printing capability. Hardware and software are periodically updated through the University and grant supports for geospatial analysis and statistical modeling. The University has a school-wide computer help service to solve standard computer problems including software, hardware and internet disruptions. The College of Science and Mathematics also has a full-time staff to oversee similar problems.

Adequate office space is available for researcher/s. Researchers typically have a one person, 120 sq. ft. office. The graduate students have assigned workstations, and undergraduate researcher/s will share office space used by the students.

As outlined above, the CESAC at Montclair State University has possession of or access to sufficient resources to successfully complete the proposed work and can launch the project quickly if funded.

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