Creation of a “Data Trust” to Include Fisherman’s Knowledge in Offshore Wind Energy Decision Making

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Creation of a "Data Trust" to Include Fishermen's Knowledge in Offshore Wind Energy Decision Making

Final Report

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Abstract

Changes in climate have created significant new challenges in the regulation of marine environments by altering both the structure of, and demand for, their resources. In order to ensure informed and equitable marine resource management (MRM), regulators and researchers need more timely and granular access to environmental and operational data collected by members of the fishery. These Fishery Dependent Data (FDD) are essential to addressing urgent questions in MRM such as conflicts between renewable energy development and existing fisheries as well as structural changes to the resource itself.

Conducting timely and trusted research using FDD can be challenging for researchers. These data include highly confidential trade secrets and are often disaggregated across hundreds of different private sector sources. Government agencies, the primary aggregator of FDD, are limited by confidentiality restrictions making access to granular data in a timely manner extremely difficult, if not impossible. This study examines the development of an independent, knowledge sharing system called the Fishery Knowledge Trust that provides researchers with trusted access to aggregated and standardized confidential information collected by the fishing industry.

Two pilot projects were completed to test the viability of the system. The pilots, which worked with participants of two large fisheries, aggregated historical movement and landings data from over 45 vessels and conducted cooperative research with the participants to evaluate the minimum estimated impact of proposed wind lease areas (WLAs) and wind planning areas (WPAs) in the mid-Atlantic and New England. The results of the study demonstrate that an independent, knowledge sharing system for FDD is both viable and urgently in demand. The technical and organizational structure of the system is described in detail, findings and lessons learned from the pilot studies are discussed, and a Go-Forward plan outlining a growth strategy for the Fisheries Knowledge Trust is presented.

Keywords

Offshore wind energy development, Atlantic herring, Atlantic mackerel, Atlantic surf clam, ocean quahog, Fisheries Knowledge Trust, wind energy area, traditional ecological knowledge

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Acronyms and Abbreviations

ACL	Annual Catch Limit
AIS	Automatic Identification System
ARP	Advisory and Review Panel
ASMFC	Atlantic States Marine Fisheries Commission
BLE	Bureau of Law Enforcement
BOEM	Bureau of Ocean Energy Management
Clam Participants	Members of the surfclam and ocean quahog fishery participating in pilot project
CLOG	Clam logbook data
CLOG-DLR	Clam-Specific Dealer Reported Data
CLOG-VTR	Clam-Specific Vessel Reported Data
DLR	Dealer Trip Reports
ETL	Extract, Transform, and Load
FDD	Fishery Dependent Data
FID	Fishery Independent Data
GARFO	Greater Atlantic Regional Fisheries Office
GW	Gigawatt

Herring Participants	Members of the Atlantic herring and mackerel fishery participating in pilot project
MAFMC	Mid-Atlantic Fishery Management Council
MBTG	Mobile bottom tending gear
MOU	Memorandum of Understanding
MRM	Marine Resource Management
MT	Metric Ton
MW	Megawatt
MWT	Mid-water Trawl
NDA	Nondisclosure agreement
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NYSERDA	New York State Energy Research Authority
OBS	Observer Data
OWED	Offshore Wind Energy Development
PAC	Project Advisory Committee
QA	Quality Assurance
QC	Quality Control
RODA	Responsible Offshore Development Alliance
TEK	Traditional Ecological Knowledge
The Platform	Distributed Database
Trust	Fisheries Knowledge Trust
VPS	Vessel Permit System
VTR	Vessel Trip Report
WLA	Wind Lease Area
WPA	Wind Planning Area
WPLA	Wind Planning and Lease Area
WLA	Wind Lease Area
WSS	Within-cluster Sums of Squares

Summary

The Fisheries Knowledge Trust's ("the Trust") objective is to help regulators make informed and equitable decisions about Marine Resource Management (MRM) by providing researchers with trusted access to confidential information collected by the fishing industry. By streamlining the way members of the fishery manage their data and maintain explicit control over its use, the Trust makes it possible for researchers, policy makers, and fishing industry leaders to access crowdsourced data sets and qualitative insights they need to answer some of the hardest and most impactful questions about our changing oceans.

Founded in 2020, the Trust was developed to help regulators navigate a rapidly changing marine ecosystem. Changes to marine habitats, as well as increasing demand for access to emerging resources, such as wind energy, are creating urgent management challenges that require granular data to which only the fishery has access. This information, which includes both fishing as well as environmental data collected during operations, is tightly held by fishermen. Decades of conflict between the fishery, regulators, and research communities has created a culture of mistrust that not only makes fishermen reluctant to share their information, but regulators and researchers skeptical of the use of non-traditional data sets and the analyses produced from them.

The Trust offers members of the fishery, researchers, and public agencies a trusted, cost-effective way to develop fishery information using science-based knowledge. The Trust manages the governance processes required to securely share proprietary information, provides the technical infrastructure, and processes (shared database, standard schemas, data request protocols) required to aggregate this information for analysis, and produces the needed evidence to demonstrate the provenance of both the data and analysis needed to build trust with regulators.

In 2019, the New York State Energy Research Authority (NYSERDA) awarded a founding team, which included experts in marine science, fishery management, and data systems technology, with a grant to develop the Trust and conduct two proof-of-concept pilots focused on the impact of wind development in the New York Bight on fisheries. Challenges related to COVID-19 pandemic, which began in March 2020, extended the initial project timeline, but the team was able to successfully build the technical and organizational infrastructure necessary to complete two successful pilot projects in 2022.

The following report contains three main assets, which collectively meet the deliverables of the grant. They provide the operational detail needed to run the trust, the case studies needed to recruit new projects, and a Go-Forward plan required to grow the organization sustainably. Even more importantly, these assets were developed to ensure that the Trust was positioned for long-term success.

S.1 Trust Design and Structure

The first section of the report provides an overview on the Trust design and structure of operation. The operating manual describes the standards and conventions for common fishery data, the technical platform and governance policies through which the data is managed, and a step-by-step guide to enabling researchers to access confidential fisheries data for research within the Trust. The policies and procedures were developed, in conjunction with input from the Project Advisory Committee (PAC), from insights in conducting the two pilot projects.

Conceptually, the Trust operates similarly to a financial Trust. Individuals or groups place an asset (e.g., data) in Trust, the Trustees of which manage the way the asset is used on their behalf. The Trustees have a degree of autonomy in the way in which the asset is used, but inevitably rely on the consent of the owners. The way in which the data can be used is defined in a detailed governance policy to which the Trustees and the owners agree and are in turn, subject.

In practice, the Trust provides three types of products and services. First, the Trust designs and promotes standards for structuring common types of fishery information such as Vessel Monitoring System (VMS), Federal Observer (OBS), or Vessel Trip Reports (VTR). These standards, which determine the way in which data is stored and formatted, are essential to effective crowdsourcing of fishery information. Second, the Trust manages and governs fishery information on behalf of members of the fishery. Data is stored in a distributed database and governed by a strict governance process that enables the fishermen to maintain control over the data while research is being conducted. Lastly, a set of project rules govern the way in which researchers can access information and define a set of internal review procedures to ensure the provenance of the data and quality of the analysis.

S.2 Pilot Products

In the second section, the pilot products are described in detail. The goals of the pilot projects were to validate and inform the design of the Trust as well as offer valuable insights for regulators of wind energy in New York State. Two pilot projects were conducted: one with members of the herring and mackerel fleet operating in the New England and Mid-Atlantic regions and another with members of the surfclam and ocean quahog fleet also operating in the New England and Mid-Atlantic regions. The pilot projects sought to use fishery information to improve understanding of the impact of existing and future wind energy development on their fishery.

Together, these pilot projects successfully aggregated, stored, and analyzed over a decade of highly confidential movement and landings data for over 45 vessels across 10 fishing operations. After prolonged challenges in acquiring the necessary fishery information from the respective government agencies, a streamlined process was developed and executed that dramatically reduced the request time and ensured data was returned in a standard format. Extensive interviews and surveys were also conducted with members of the fishery. By integrating granular movement and landings data, foundational analyses were developed that provide a minimum potential view into the overlap of 29 wind lease areas (WLAs) and 10 wind planning areas (WPAs) on the participants in both fleets. The analyses provide a starting point for evaluating impact with additional economic and social analyses needed to capture the full impact of offshore wind energy development (OWED) on the fisheries.

The pilot projects were successful in that they demonstrated the viability of the technical and governance infrastructure of the Trust to develop crowdsourced analyses using fishery information. Members of both fisheries were willing to share and aggregate over a decade of highly confidential movement and landings data for research purposes if these data were properly governed and actively used. A technical architecture and governance system was developed, using a simple cost-effective solution, to meet the needs of the fishermen while crafted to also deliver the type of transparent, repeatable analyses required to recruit researchers and build trust with regulators. With proper future investment from the fishery and research communities, regulators now have an additional path to developing objective, granular analysis that can help ensure responsible offshore wind energy investment does not displace the fisheries that support coastal communities across the U.S.

However, the pilot projects also faced substantial challenges, which present critical lessons learned for future development. First, the process of requesting fishermen data from the respective government agencies was extremely time-intensive and inconsistent. The streamlined process developed in the pilots should solve many of these problems, but the speed at which these agencies can deliver data remains a major barrier to responsive research using fishery information. Close cooperation with the agencies is essential to the success of the Trust. Second, trust is built by people but sustained by communication. Inadequate communication of major changes in the timeline to the fishery participants jeopardized the relationships. Maintaining trust with owners requires consistent and transparent communication. Lastly, data collection must occur in the context of an ongoing project. Onboarding and processing the data required substantial investment from the owners, which was only possible because there was a clearly defined outcome.

S.3 Go-Forward Plan

The final product for the Trust was the Go-Forward Plan. To ensure long term success, a Go-Forward Plan was developed to define the mission, products, and services offered; overview of existing landscape, and factors driving demand for the Trust; key audiences and differentiation; an operating and revenue model; and growth plan for 2023 are included.

The Trust is setup as a not-for-profit model that funds its activities through pay-per-service fees for projects and grants to fund broader development. To use the Trust, researchers pay a fee that accounts for labor costs related to the project, incremental technology expenses, and an overhead fee that covers non-project related costs. These revenues pay for ongoing expenses related to the Trust. The Trust uses grant funding to support larger “research and development” investments such as the development of new data standards, updates to the system infrastructure, such as the development of new data standards, and updates to the technical infrastructure.

Over the next year, the Trust plans a two-pronged approach to recruiting new projects. In the first few months of 2023, the Trust will launch publicly and initiate a broad awareness campaign targeted at researchers interested in using fishery information for offshore wind and fishery issues and fishery management. In parallel, the Trust will initiate a second outreach initiative focused on direct recruitment of wind planning and mitigation projects by targeting specific fleets throughout the country.

The Trust is already working on new projects. In spring 2022, the Trust was awarded a grant, in conjunction with the University of Maine and the Maine Lobstermen's Association, to demonstrate the viability of crowdsourcing plotter data in the Maine lobster fleet. The fishery has long been "data poor," and aggregating movement and activity data will provide essential information for future issues both between wind and the fishery, but also within the fishery itself. This project plans to ramp up soon after this initial project is complete.

Conversations with regulators, researchers, and members of the fishery routinely affirm demand for the Trust and its services. The experience over the last few years has validated critical assumptions underlying the Trust's model. With a working infrastructure and two successful proof-of-concept pilot projects completed, the Trust is now well-positioned to scale. The key challenge will be to generate enough revenue in the coming months, through projects and grant funding, to fund the full-time staff required to educate and recruit the more conservative members of the research and fishery communities. Doing so will require not only time and investment from staff, but more practical examples of projects that have used the Trust successfully.

1 Introduction

1.1 Introduction to Marine Resource Management

Marine environments offer an array of resources essential to human civilization. These include living marine resources such as fish and plants used for food; wind, oil, and gas extracted for energy; and minerals such as sand and other marine materials used in construction and technology manufacturing. As common goods, these resources require public management to ensure their sustainability and to mitigate conflicts between interested parties. However, changes in climate have created significant new challenges in the regulation of marine resources by altering both the structure of marine ecosystems and the demand for their resources.

Seafood is the largest and most well-regulated of these resources. In the U.S., the commercial seafood industry supports over 1.2 million jobs, which range from on-water activities like fishing to seaside occupations like processing and retail (NMFS 2022, 8). Commercial and recreational fishing is regulated in the United States. by the National Marine Fisheries Service (NMFS), which works with a network of regional fishery management councils (Councils) that determine at-sea operations for federally managed fisheries. Councils rely on analysis conducted by their plan development or fishery management action teams, which include NMFS staff, state agency staff, and academic researchers to manage tradeoffs between the interests of the fishing industry and other non-commercial interests such as environmental organizations.

Warming waters caused by climate change pose a significant challenge to the fishery management process. The Gulf of Maine, for instance, has experienced an increase in water temperatures at a faster rate than other oceans throughout the world (Greene 2016, 14; Pershing et al. 2015, 809). This warming is associated with shifts in species distributions (Atlantic cod, northern shrimp), declines in species abundance such as *Calanus finmarchicus,* and suspected related declines of other species such as Atlantic herring (Pershing et al. 2021, 1). The New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), NOAA Fisheries, and Atlantic States Marine Fisheries Commission (ASMFC) are working together to actively examine the implications of climate-induced shifts in distribution, abundance, and productivity on fisheries management (MAFMC 2022b). Through their East Coast Climate Change Scenario Planning effort, they will identify, with stakeholder involvement, the drivers of change to develop scenarios, which will then be used to draft fisheries management strategies.

Climate is affecting MRM in other ways as well. Policies aimed at accelerating the development of renewable energy infrastructure have led to investment in other offshore resources, the largest of which is wind energy. Estimates suggest that the current offshore wind development pipeline represents a generating capacity of over 40,000 megawatts (MW) (U.S. DOE 2022); the State of New York has a current procurement goal of 9,000 MW. Meanwhile, investment in offshore mining has also increased as demand for cobalt and other metals essential in batteries used to store electricity have grown substantially. Access to both resources is managed by the Bureau of Ocean Energy Management (BOEM), which controls access to wind, oil, and mineral deposits by generating and granting lease areas in which private firms can build and operate wind turbines, offshore drilling rigs or mining operations. The leasing and permitting of OWED is a multi-year process, which includes intensive research and collaboration across various constituencies. Table 1 summarizes the various groups involved in the management of different marine resources.

Table 1. Roles and Groups Involved in the Regulation of Key Marine Resources

Type	Wildlife (Fish, Aquaculture, etc.)	Energy (Wind, Drilling)	Minerals (Sand, Gravel Shell)
Industry	Fishermen Dealers Processors	Wind developers Energy companies	Mining
Regulator (e.g., State, Federal, Independent)	NMFS Regional Councils	Bureau of Ocean Energy Management (BOEM) Arbitration	Bureau of Ocean Energy Management (BOEM)
Researcher	National Marine Fisheries Service State Research agencies Universities Independent Researchers	Bureau of Ocean Energy Management (BOEM) State Research agencies Universities Independent Researchers Non-Governmental	Bureau of Ocean Energy Management (BOEM) State Research agencies Universities Independent
Advocates	Environmental Groups (The Nature Conservancy, Conservation Law Foundation) Industry groups	Non-Governmental Organizations Advocacy Groups	Non-Governmental Organizations Advocacy Groups

These investments do not occur in a vacuum: the development of offshore energy and mineral operations can conflict significantly with the footprint of existing fisheries. OWED often overlaps with fishing grounds increasing gasoline fuel costs by forcing fishermen to find new paths or eliminating access to critical fishing grounds altogether if they cannot access the wind energy area (WEA) safely. BOEM has analyzed the impacts of OWED on the fishing industry and has found these impacts to be moderate to major (BOEM 2022a). BOEM has also published, and recently ended a public comment period on, its Draft Fisheries Mitigation Guidance providing recommended guidance to OWED developers (BOEM 2022b).

Both climate-related factors—increasing changes in fish stocks and competition from new resources such as wind—pose an existential threat to fishing operations and the communities they support. Many fishing organizations operate on already small margins and substantial disruptions to operations caused by fishery management decisions or safety considerations could lead to forced departure from the fishery. The collapse of these fisheries not only affect the outlook for private firms and individuals actively involved in the industry but could lead to social and economic impacts for the coastal communities which they support. Accurate and timely MRM, therefore, is essential to the equitable and sustainable deployment of renewable energy.

1.2 Opportunities and Challenges for Fishery Dependent Data in Marine Resource Management

Informed and equitable MRM requires representative, trusted, and timely data about both the structure of, and the communities that access, marine resources. As climate causes changes in both the resource (e.g., fish stocks) as well as the way in which humans use those resources (e.g., wind), regulators need more timely access to existing and novel forms of information about the marine environment to ensure they properly manage tradeoffs between the social, economic, and environmental interests involve in MRM.

Fishermen spend their lives on the water, and in doing so, collect essential information about the fishery and the marine habitats in which they operate. These data, referred to as Fishery Dependent Data (FDD), include a range of information that are collected as part of government-mandated reporting requirements, cooperative research programs (NMFS Study Fleet, eMolt, Commercial Fisheries Research Foundation) and internal operations. FDD might include information on vessel activity (Vessel Monitoring System (VMS), Automatic Identification System (AIS), logbook systems), catch estimates (dealer landing reports), vessel landing reports, federal observer programs, cooperative research programs such as

study fleets), or environmental data such as seafloor mapping (proprietary software). The amount of FDD collected varies substantially by fleet. Certain fisheries have detailed reporting requirements and widespread participation in cooperative research programs (e.g., Study Fleet) while other fisheries such American lobster have had no reporting requirement and limited coverage (measures are under consideration to require reporting in the lobster fishery (87 FR 41084). Table 2 provides an overview of commonly collected FDD.

Table 2. Common Fishery-Dependent Data Types

Data Type	Why It's Collected	How It's Collected
VMS	Regulatory Requirement. VMS is used to support law enforcement initiatives and to prevent violations of laws and regulations.	The vessel monitoring system (VMS) is a satellite surveillance system primarily used to monitor the location and movement of commercial fishing vessels within U.S. jurisdiction and treaty areas. The transceiver units send position reports that include vessel identification, time, date, and location, and are mapped and displayed on the end user's computer screen.[a]
Dealer Reports (DLR)	Regulatory Requirement. Any person or company purchasing or receiving federally managed species must have a dealer permit and submit reports for most species purchased.	Dealers submit weekly trip-level reports for most species purchased via electronic system approved by Greater Atlantic Regional Fisheries Office (GARFO).
Vessel Trip Report (VTR)	Regulatory Requirement. VTRs must be submitted for each fishing trip made for federally permitted vessels. Data collected used for quota monitoring, impacts analyses, and in support of stock assessments and fishery management.	Vessels must submit one VTR per trip unless they change statistical area, gear type, mesh, or ring size on the trip.
Observer (OBS) / At Sea Monitor	Regulatory Requirement. Collected to support stock assessments and fishery management, reduce bycatch, FishWatch, scientific and research community support, explore new fisheries, document species, and special collections.	Trained observers are deployed on fishing trips to collect information (weight and length collected on sub-sample) on catch (landings and discards) and interactions with marine mammals, sea birds, and sea turtles.
Study Fleet	Not a Regulatory Requirement. Provides high-resolution data on fishing effort, catch, and environmental conditions to estimate fishery footprints, develop catch-per-unit-effort indices for stock assessments, understanding potential impacts of offshore wind, and informing models (e.g., thermal niche, regional oceanographic).	Partnership between fishing industry and NOAA Fisheries. Captains and crew are trained to collect detailed information.
Seafloor Mapping / Acoustics	Not a Regulatory Requirement. Fishing vessels often use software to map the seafloor bed. These data are valuable for a range of environmental research.	On-board technology solutions automatically collect these data as fishermen move throughout the ocean.

Table 2 continued

Data Type	Why It's Collected	How It's Collected
Plotter Data	Not a Regulatory Requirement. Private information generated by vessels for their own records that allows them to track tows made and associated catch.	Logbooks or electronic systems that allow for mapping of tows.
Electronic Monitoring	Regulatory Requirement for some fisheries. Used in similar ways as observer data; however, is not a source of socioeconomic data.	Cameras are used to monitor fishing operations at sea. Processing of video occurs on land after trip is completed.
Dockside Monitoring	Regulatory Requirement for some fisheries. Used in similar ways as observer data.	Trained monitors document retained and landed catch on the dock.
Traditional Ecological Knowledge	Not a regulatory requirement. Knowledge learned from time spent on water and from other captains.	Can be collected through independent research surveys.
AIS	Partial regulatory requirement. Vessels larger than 65 feet are required to have AIS turned on within 12 miles of shore.	VHF signal collected by system (can handle over 4,500 reports per minute) and stored in a publicly accessible database.

[a] NOAA Website: https://www.noaa.gov/

FDD are an essential source of fisheries data for quota monitoring, stock assessments, ecosystem-based science, and fishery action analysis. FDD are also currently used for protected species interaction monitoring. In the U.S., FDD, in conjunction with fishery independent data (FID), are frequently used together in stock assessments that inform fisheries management decisions. FDD have been used to analyze impacts of proposed wind development projects to describe fishing footprints and revenues generated from Wind Energy Areas (WEAs) (for an example see South Fork Wind Farm DEIS).

Confidentiality concerns, however, limit the speed and breadth in which FDD can be used. All FDD submitted to regulatory entities (e.g., federal and state agencies) are confidential by law, unless the submitter authorizes the sharing of such information. Researchers can access certain forms of aggregate data through public portals (AIS, ocean data portals). Typically, FDD are grouped to ensure that a minimum of three vessels, dealers, or harvesters are included in the data sets made available for public use to maintain confidentiality. This results in the loss of some spatial or temporal resolution in order to maintain confidentiality. These aggregate data can be valuable in assessing broad-scale spatial trends, but lack the resolution needed to conduct more precise analyses. For instance, anonymized VMS data are displayed on the ocean data portals (e.g., Northeast Ocean Data Portal) but data are aggregated across years to meet confidentiality requirements making annual trends difficult to detect.

Time is another factor limiting in the use of FDD in MRM today. Researchers, both inside and outside of government, can request access to granular federally reported FDD but requests are highly sensitive and can take months to process. As described in Section 3: Pilot Projects, the process of requesting federally reported data can take up 3–6 months even for the fishing organizations themselves. For regulators, researchers, and industry advocates, the delay can limit their ability to develop research needed to accurately respond to time-sensitive management issues—a challenge that is particularly acute in OWED where the speed of investment is a top priority.

These limitations are compounded by a culture of mistrust within the fisheries ecosystem between fishermen, scientists, managers, and environmental non-governmental organizations (NGOs). In research conducted for this project, fishermen shared that, in addition to broader competitive concerns associated with sharing information, one of the main factors limiting their willingness to share operational data was the belief that they would lose control over the information, and it could be used incorrectly against their own interests. These beliefs stem in part from past experiences with fisheries management but also from structural realities of federal reporting data, which is used for both science and enforcement. Additionally, potential users of these data, such as regulators and researchers, expressed some skepticism over the provenance and quality of FDD used, particularly when it is collected by an organization outside of the government.

In summary, three factors limit the ability for FDD to play a larger role in the regulatory process. First, the data collected by members of the fishery for operational purposes is disaggregated and unstandardized making it extremely difficult for researchers, regulators, and industry advocates to aggregate quickly. Second, the government is the primary holder of FDD and thus controls the dissemination of these data to the MRM community. While government programs serve an extremely important role in research, governance requirements surrounding confidentiality limit their ability to share and make accessible granular FDD to the broader community in a timely manner. Third, members of the MRM community lack trust in the process by which FDD is analyzed, which limits both the willingness of members of the fishery to share data as well as the confidence regulators and researchers have in analyses built on FDD.

1.3 Development of the Fisheries Knowledge Trust

Investigations into the development of a secure, data sharing system for FDD began in 2018. Two all-day workshops were held with fishermen, researchers and regulators in Cape May, NJ and Port Judith, RI. Participants were briefed on various data sharing models used in other industries and requirements and challenges for the development of a data sharing system in the fishing industry were discussed. Additional

interviews were conducted during the first year of this project with members of the fishery, marine researchers, regulators, and data sharing experts. A set of initial requirements were developed. These requirements were then translated into five founding principles that informed the design and development of the Trust outlined below.

1.3.1 Founding Principles of the Trust:

1. **Persistent Ownership**: Owners must retain control over their information, including the way it's stored, accessed, and analyzed. Without access to FDD, the Trust does not exist.
2. **Scientific Objectivity**: Any analysis conducted on information stored in the Trust must seek to improve the best available science surrounding marine fisheries. Without objectivity, the products developed will have no impact on regulatory decision-making.
3. **Common Standards**: All data must fit into a previously defined schema for its specific data type. Data cannot be crowdsourced at any meaningful scale unless it follows specific, common standards.
4. **Transparent Reproducibility**: Analyses and data products must document methodology used so that others can reproduce their findings. Trust is built through transparency and reproducibility.
5. **Trusted Collaboration**: All projects must work closely with the owners of the data to ensure that correct data are interpreted correctly. Successful interpretation of data requires intimate collaboration with the very subjects being measured.

1.3.2 Introduction to the Fisheries Knowledge Trust

In 2020, the Fisheries Knowledge Trust was formally launched, a knowledge sharing organization that manages sensitive, scientifically valuable information on behalf of members of the fishing industry. By streamlining the way members of the fishery manage their data and maintaining explicit control over its use, the Trust makes it possible for researchers, policy makers and fishing industry leaders to access the crowdsourced data sets and qualitative insights they need to answer some of the hardest and most impactful questions about our changing oceans.

1.3.3 Solution Overview

The Trust delivers solutions that help the fishing industry, researchers, and regulators aggregate and analyze confidential fishery information needed for equitable MRM. These products and services, which were developed based on the "founding principles" outlined above, focus on the three solution areas: standards setting, data aggregation and management, and science development. Table 3 describes the problem each solution area seeks to solve as well as the products and services the Trust provides to solve the problem.

Table 3. Solutions Provided by the Trust for a Range of Potential Problems

Solution Area	Problem	Solution Description	Products and Services
Standards Setting	Fishery data is fragmented and inconsistent making building crowdsourced analyses extremely time intensive.	The Trust maintains a "standard" data model for key fishery data sets that allows members of the fishing industry to import their information once, and then easily reuse and combine with others in the future.	• Common standards for FDD. • Processing and validation scripts based on common standards. • Standards management and governance.
Data Aggregation and Management	Members of the fishery lack the time, technical, and governance infrastructure to securely aggregate and manage confidential information.	The Trust manages FDD on behalf of members of the fishery so they can easily and securely participate in research.	• Secure, permissioned data management infrastructure. • Request protocols and forms for federally reported data. • Governance and management of FDD. • Aggregation and Onboarding of FDD.
Scientific Research	If researchers cannot trust the provenance of the data or quality of the analysis, regulators will not use the data effectively.	The Trust provides researchers and regulators with detailed documentation that describes each step taken to integrate and interpret the information.	• Documentation for all data in the Trust including reproducible scripts. • Advisory and Review Panels (ARP) Certifications. • Data provenance reviews and audits.

1.3.4 Operating Model

The Trust is currently operated by the Responsible Offshore Development Alliance (RODA). Today, RODA staff and independent contractors are responsible for management of the Trust and the execution of its policies. As described in Section 4: Go-Forward Plan, the goal over the next 1–2 years is to build a small, full-time staff that can operate and grow the Trust. The project team is still exploring whether the Trust should remain a part of RODA or form an independent organization. More information about staffing and growth plans can be found in Section 4: Go-Forward Plan.

The Trust makes its FDD-related products and services available to stakeholders in the MRM community through discrete time-bound projects with specific researchers. These projects might involve the development of new standards and schemas, aggregation of new or updated data, or access to existing data for the development of new scientific products. All projects are tightly managed by the Trust. Detailed information on how projects are accepted, onboarded, and managed, and debriefed can be found in Section 2.4: Scientific Research.

Importantly, in most cases, the Trust does not provide research-related analytical services. Instead, the Trust works with researchers recruited by the individual projects to make its products and services available to the broadest possible community.

The Trust is funded through a combination of grant funding and fee-for-services revenues from projects. To conduct a project on the Trust, researchers pay a project fee, which is based on the expected labor associated with the project, any incremental technology costs required, as well as an overhead fee (a share of the labor and incremental technology costs) to cover the ongoing expenses of the Trust. The goal of the model is to have project fees cover operating expenses and grants to fund further research and development. A more detailed discussion of pricing can be found in Section 2.4.3: Determining Cost for a Project.

2 Trust Manual

This section provides a comprehensive overview of the technical and governance procedures that ensure secure, trusted, and scalable analysis within the Trust. The section is divided into three subsections aligned with the key solution areas of the Trust described above: standards and schemas, data aggregation and management, and scientific research. The following sections provide more detailed information on each area, including governance and other operating procedures required by the Trust.

2.1 Standards and Schemas

Standardizing the way a fishery stores, names, and structures their information is essential to conducting repeatable, cost-effective research using FDD. The Trust has developed a set of schemas and standards for common FDD that are open to the public. Even if members of the fishery do not store their information within the Trust, using these standards will dramatically accelerate future regional research efforts.

To support these standards, the Trust has developed a set of documented R scripts that execute basic cleaning and error checking functions. These scripts will be published and are free for the community to use. Additionally, the Trust has defined specific procedures for updating or modifying these standards, which are described in detail below.

2.1.1 Common Standards for Fishery Dependent Data

The Trust currently supports a range of federally reported FDD, including vessel monitoring system (VMS), vessel trip report (VTR) and dealer data (DLR), and observer data (OBS). A comprehensive list of commonly used FDD can be found in Table 2. The sections below enumerate the fields collected, describe the conventions for naming and field type, provide an overview of the field itself and provide links to publicly available data definitions offered by the provider.

2.1.1.1 Vessel Monitoring System

VMS data contains geospatial information about a vessel's location along with other data such as bearing, declaration code and time which can be helpful in analysis.

The standard convention for VMS data collected in the Trust is outlined below (Table 4). All VMS data entered in to the Trust should match this schema. The data dictionary for VMS is not made public by the Bureau of Law Enforcement (BLE); therefore, links to data dictionaries are not available.

Table 4. Trust Data Standards and Dictionary for Vessel Monitoring System Data

Trust Field Name	Import Field Name	Data Type	Description
course	Course	Double	Course from GPS
declaration_code	Declaration Code	Character	Code declaring type of trip taken
docnum	Docnum	Character	Document number
lat	Lat	Character	Latitude (Degrees, Min, Sec)
lat_1	lat_1	Character	Latitude (Digital degrees)
lon	Lon	Character	Longitude (Degrees, Min, Sec)
lon_1	lon_1	Character	Longitude (Digital degrees)
name	Name	Character	Vessel Name
permit	PERMIT	Character	Vessel permit number assigned by the Northeast Regional Offices Vessel Permit System (VPS). 000000=no permit or no vessel, check hull number; 190998=Unknown under tonnage vessel; 390998=Unknown tonnage vessel.
Speed	Speed	Double	Speed from GPS
utc_time	utc_time	Datetime	Universal time from GPS

2.1.1.2 Vessel Trip Reports

Landings data is reported both by vessels via VTRs and dealers via DLRs. Additionally, there are species specific reporting formats for certain fisheries such as surfclam and ocean quahogs. Operators of most federally permitted commercial, for-hire, and private recreational tilefish vessels must submit a VTR for each fishing trip. VTR data contains vessel-reported information on activity and catch for commercial fishing vessels by trip (Table 5).

Table 5. Trust Data Standards and Dictionary for Vessel Trip Report Data

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
area	AREA	Character	3-digit statistical area fished. Includes inshore areas. Link to VTR.AREA. NEMAREA.	Images	https://www.fisheries.noaa.gov/inport/item/17033
date_landed	DATE_LAND	Datetime	Primary date and time vessel docked.	Document	https://www.fisheries.noaa.gov/inport/item/17032
date_sailed	DATE_SAIL	Datetime	Date and time vessel left the dock.	Document	https://www.fisheries.noaa.gov/inport/item/17032
date_sold	DATE_SOLD	Datetime	Date catch was sold.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
dealer	DEALER_NUM	NUMBER	Federally issued dealer catch was sold to. Link to PERMIT. DEALER table.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
gearcode	GEARCODE	Character	3-letter gear code. Link to VTR.VLGEAR.	Images	https://www.fisheries.noaa.gov/inport/item/17033
permit	VESSEL_PERMIT_NUM	NUMBER	Federally issued 6-digit vessel permit number.	Document	https://www.fisheries.noaa.gov/inport/item/17032
port	PORT_LANDED	Character	Port(city) where catch was landed.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
pounds_discarded	DISCARDED	NUMBER	Amount discarded. Commercial = pounds; Party/Charter = count.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
pounds_kept	KEPT	NUMBER	Amount kept. Commercial = pounds; Party/Charter = count.	Catch	https://www.fisheries.noaa.gov/inport/item/17031

Table 5 continued

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
serial_no	SERIAL_NUM	Character	FVTR serial number. 7- to 8-digit for paper FVTRs; 14-digit for eVTR.	Images	https://www.fisheries.noaa.gov/inport/item/17033
species	SPECIES_ID	Character	Species name abbreviation. Link to VLSPPSYN table.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
state_landed	STATE_LANDED	Character	State where catch was landed.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
status	Fished	Character	Status of catch	Catch	https://www.fisheries.noaa.gov/inport/item/17031

2.1.1.3 Dealer Trip Reports

DLRs are required for any person or company purchasing or receiving fish from a federally permitted vessel. DLRs provide information on landings and associated revenues. DLR data contains dealer-reported information on activity and catch for commercial fishing vessels by trip (Table 6).

Table 6. Trust Data Standards and Dictionary for Dealer Data

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
date_sold	DATE_SOLD	Datetime	Date (Local time)	Catch	https://www.fisheries.noaa.gov/inport/item/17031
dealer	DEALNUM	Character	The dealer permit number assigned by the Northeast Regional Office Permit System (PERMIT). 00000=Unknown. Not available for 1994 in CFDBS data.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
dealer_name	DEALER_NAME	Character	Dealer Name	No link	No link
dealer_rpt_id	DEALER_RPT_ID	Character	Confirmation number that identifies the record and is given to the dealer.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
grade_desc	GRADE_DESC	Character	Description of a grade based on SAFIS Grade Code Descriptions.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
permit	PERMIT	Character	Vessel permit number assigned by the Northeast Regional Offices Vessel Permit System (VPS). 000000=no permit or no vessel, check hull number; 190998=Unknown undertonnage vessel; 390998=Unknown tonnage vessel.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
port	PORT_LANDED	Character	Port(city) where catch was landed.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
spp_common_name	SPP_COMMON_NAME	Character	Common name for a species based on the nespp3 code.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
spplivlb	SPPLIVLB	Double	The live weight of species landed.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
spplndlb	SPPLNDLB	Double	The pounds landed for a given species.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
sppvalue	SPPVALUE	Double	The value of landed catch to the nearest dollar (U.S.), paid to fisherman by dealer, for a given species. 0 = unknown.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
st	STATE_LANDED	Character	State where catch was landed.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
vessel_name	VESSEL_NAME	Character	Vessel Name	No link	No link

Table 6 continued

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
vtrserno	VTRSERNO	Character	The serial number of the first page of the trip report, printed in the upper right corner of the vessel trip report (vtr) form.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
year	YEAR	Double	The year in which the landings or negative report occurred.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366

2.1.1.4 Clam Logbook Dealer Reports of Landings

Beginning in 1978, participation in the surfclam fishery became conditional upon a set of requirements including detailed logbook reporting. In the early 1980's ocean quahog vessels became subject to the same detailed logbook reporting requirements. The clam logbook dealer report (CLOG-DLR) tables contain information unique to the surfclam and quahog fishery, including fields such as bushel (Table 7). The CLOG-DLR files can be considered the clam-specific alternative to the DLR data.

Table 7. Trust Data Standards and Dictionary for Clam Logbook Dealer Report Data

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
anum	ANUM		Allocation number.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
bush	BUSH	Double	Number of bushels landed (32 cages = 1 bushel).	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
carea	CAREA	Character	Calculated statistical area fished based on Lat/Lon coordinates or Loran bearings entered on the VTR by the operator.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
catch_date	CD	Datetime	Catch Date	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
clatsec	CLATSEC	Character	Calculated latitude seconds from Loran bearings.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924

Table 7 continued

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
clatsec	CLATSEC	Character	Calculated latitude seconds from Loran bearings	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
clonsec	CLONSEC	Character	Calculated longitude seconds from Loran bearings	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
cy	CY	Character	2 digit county code. Link to VTR.PORT.COUNTYCD.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
dealer	DNUM	Character	Dealer permit number.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
discard_%	DISP	Double	Percent of catch discarded by the vessel.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
pc	PC	Character	2 digit port code. Link to VTR.PORT.PORT2.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
permit	PERMIT	Character	Vessel permit number assigned by the Northeast Regional Offices Vessel Permit System (VPS). 000000=no permit or no vessel, check hull number; 190998=Unknown undertonnage vessel; 390998=Unknown tonnage vessel.	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
pr	PR	Double	Price per bushel in dollars.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
species	SPECIES	Character	Species name abbreviation. Link to VLSPPSYN table.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
tas	TAS	Double	Time at sea (tenths of hours).	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
tf	TF	Double	Time fished (tenths of hours).	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
trip_num	TRIP_NUM		Trip number. Set automatically by application. User may override but not set directly.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924

2.1.1.5 Clam Logbook Vessel Trip Report

The clam logbook vessel trip report (CLOG-VTR) files can be considered the clam-specific alternative to the VTR data (Table 8).

Table 8. Trust Data Standards and Dictionary for Clam Logbook Vessel Trip Report Data

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
bushels	BUSH	Double	Number of bushels landed (32 cages = 1 bushel).	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
cy	CY	Character	2 digit county code. Link to VTR.PORT.COUNTYCD.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
dealer	DNUM	Character	Dealer permit number.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
num	NUM	Character	Vessel permit number.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
pc	PC	Character	2 digit port code. Link to VTR.PORT.PORT2.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
permit	PERMIT	Character	Vessel permit number assigned by the Northeast Regional Offices (now GARFO).	CFDERS_ALL_YEARS	https://www.fisheries.noaa.gov/inport/item/17366
pr_rec_id	PR_REC_ID	Character	Foreign key. Link to SFOQPR.	SFOQPR	https://www.fisheries.noaa.gov/inport/item/11923
price	PR	Double	Price per bushel in dollars.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924
purchase_date	PD	Datetime	Purchase date.	SFOQPR	https://www.fisheries.noaa.gov/inport/item/11923
species	SPECIES	Character	Species name abbreviation. Link to VLSPPSYN table.	Catch	https://www.fisheries.noaa.gov/inport/item/17031
st	ST	Character	2 digit State code. Link to VTR.PORT.STATECD.	SFOQVR	https://www.fisheries.noaa.gov/inport/item/11924

2.1.1.6 Observer Data

Trained observers are deployed on fishing vessels, or dockside, to collect catch information. There are two categories of observers: at-sea observers and at-sea monitors. All at-sea observers are trained in the identification of fish, seabird, and protected species and biological sampling. Observer coverage is determined by the Northeast Fisheries Science Center using the Standardized Bycatch Reporting Methodology. Coverage can vary annually, based on discard estimates and variability from observer data of the previous year. At-sea monitors are essential for the higher observer coverage required by fisheries management regulations for the NE Multispecies fishery. At-sea monitors collect "scientific, management, regulatory compliance, and economic data" (NEFSC 2022).

Data from both categories of observers are high resolution, often providing tow-level landings data, as well as discards data, and location data. Observer coverage is not set at 100% for most fisheries (although some electronic monitoring programs may call for 100% coverage) resulting in the majority of FDD coming from sources with lower resolution. OBS are used to inform stock assessments and fisheries management actions, to reduce bycatch, to support scientific research, and to document species.

No public data dictionary was available for OBS data (Table 9).

Table 9. Trust Data Standards and Dictionary for Fishery Observer Data

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
TRIPID	TRIPID	Character	Trip identifier	N/A	N/A
HAULNUM	HAULNUM	Character	Ordinal number of haul within the trip.	N/A	N/A
OBSRFLAG	OBSRFLAG	Character	indicator of whether haul was observed for discards.	N/A	N/A
HULLNUM1	HULLNUM1	Character	Number on the hull of the vessel on which observer is deployed.	N/A	N/A
HULLNUM2	HULLNUM2	Character	Number on the hull of the pair trawl vessel, when used.	N/A	N/A
PERMIT1	PERMIT1	Character	Permit number	N/A	N/A
PERMIT2	PERMIT2	Character	Permit number for pair trawl vessel.	N/A	N/A
YEAR	YEAR	Character	Year landed	N/A	N/A

Table 9 continued

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
MONTH	MONTH	Character	Month landed	N/A	N/A
DATESAIL	DATESAIL	Date	Date vessel left dock to go fishing (“%d-%b-%y”),	N/A	N/A
HAULDUR	HAULDUR	Double	Length of haul	N/A	N/A
AREA	AREA	Double	Statistical area(s) in which trip occurred: position taken at beginning of haul for fixed gear and end of haul for mobile gear.	N/A	N/A
DEPTH	DEPTH	Double	Towing depth	N/A	N/A
NEGEAR	NEGEAR	Double	Code for gear type used on trip.	N/A	N/A
GEARNM	GEARNM	Character	Common name for netgear code.	N/A	N/A
DATEHBEG	DATEHBEG	Date	Date of beginning of haul format = “%d-%b-%y”	N/A	N/A
TIMEHBEG =	TIMEHBEG =	Date	Time at beginning of haul.	N/A	N/A
GIS_LATHBEG = col_double(),	GIS_LATHBEG = col_double(),	Double	Latitude beginning of haul.	N/A	N/A
GIS_LONHBEG = col_double(),	GIS_LONHBEG = col_double()	Double	Longitude beginning of haul.	N/A	N/A
GIS_LATHEND	GIS_LATHEND	Double	Latitude at the end of haul.	N/A	N/A
GIS_LONHEND	GIS_LONHEND	Double	Longitude at end of haul.	N/A	N/A
SPECIES_ITIS	SPECIES_ITIS	Character	Integrated Taxonomic Information System serial number for a species.	N/A	N/A
COMNAME	COMNAME	Character	Common name for species.	N/A	N/A
HAILWT	HAILWT	Double	Estimate of weight of each species caught.	N/A	N/A
FISHDISP	FISHDISP	Character	Codes for disposition of fish caught (bycatch, landed, other).	N/A	N/A

Table 9 continued

Trust Field Name	Import Field Name	Data Type	Description	NOAA Table	Link to Data Dictionary
FISHDISPDESC	FISHDISPDESC	Character	Description of fish disposition code.	N/A	N/A
WGTTYPE	WGTTYPE	Character	One digit code denoting type of weight of species (e.g., 1=actual; 2=estimated).	N/A	N/A
WGTTYPEDESC	WGTTYPEDESC	Character	Measurement type description.	N/A	N/A
DRFLAG	DRFLAG	Double	Code for round or dressed.	N/A	N/A
DRFLAGDESC	DRFLAGDESC	Character	Description for round or dressed.	N/A	N/A
ESTMETH	ESTMETH	Character	Method used to estimate catch weight of each species.	N/A	N/A
ESTMETHDESC	ESTMETHDESC	Character	Description of estimation method.	N/A	N/A

2.2 Metadata Conventions for All Data Sets

Proper metadata—defined as information about each data set—is critical to the long-term success of the Trust. Access to clear, simple, and consistent metadata allows researchers to easily validate the provenance of the data and identify supporting documents that are critical to its interpretation.

In order to comply with the Trust standard, the first 15 lines of each data table must include a header with a set of pre-defined metadata fields. When data is being onboarded into the Trust (see Section 2.4.4: Onboarding a New Project) these metadata are added as part of the initial "cleaning" process (Table 10).

Table 10. Conventions for Fishery Dependent Data Metadata

Field	Type	Description
Source data link	Character	URL link to the raw data sets.
Processed On	Datetime	Date and time in which the data processing was completed.
Metadata restrictions	Character	Restrictions on the metadata.
Fishery	Character	The fishery about which the data describes.
Type and range	Character	Short description of the data including type and timeframe.

2.2.1 Processing and Validation Scripts for Supported Data Types

Scripts were developed in R to process and conduct basic error checking for the supported data types described above. These scripts prepare data for processing by ensuring the data includes the correct fields, follows proper naming and formatting conventions, includes proper metadata, and does not have any outliers (e.g., latitude-longitude pairs located outside of a reasonable area).

2.2.2 Standards Management and Governance

2.2.2.1 Introducing New Data Standards

The Trust plans to support a wide range of data types in the future including both governmental reporting as well as proprietary formats such as plotter data. The data types listed in Table 2 offer a good roadmap for the data types the Trust will support. Before onboarding new data, Trustees must ensure that a standard has been documented by the Trust. This is discussed in more detail in Section 2.3.2.5: Aggregation and Onboarding of FDD.

The Trustees are responsible for creating new data standards. New data types will be added on a project-by-project basis, which will allow the Trust to subsidize new data type development within the context of a paying project. These might include other types of government-controlled data (e.g., study fleet) or proprietary data collected directly by fishermen for business operations (e.g., plotter, acoustics, personal charts).

New standards will aim for the following best practices:

1. **Align the standard with the way in which it is exported from the source.** As much as possible, the Trust standard should reflect as closely as possible the existing data source. If a data type has multiple schemas (e.g., plotter data from multiple manufacturers), the one with the largest installed base or usage by data providers should take precedence.
2. **Naming conventions should follow existing data standards.** If possible, replicate conventions in existing standards. For instance, if existing standards use specific formatting types (e.g., all lowercase), new standards should use those standards.
3. **Collect and document all available fields in data source.** Even if the project does not need certain fields, standards should be inclusive of all data fields.

2.2.2.2 Updating Existing Data Standards

Existing data standards might need to be updated occasionally. New fields might need to be added or naming conventions might need to be changed. The Trustees are responsible for decisions related to updating data standards.

Updating existing data standards should follow these best practices:

1. **All Existing Data Sets Must Be Updated.** In order to update a data standard, existing data must be reconciled with the new data model. All data *must* follow the same conventions to ensure data integrity and compatibility.
2. **Limit Updates as Much as Possible.** Updates to data standards should be done as infrequently as possible but also as necessary as possible to ensure data in the Trust can be properly utilized. Updates should only be done if existing standards are creating distinct challenges for specific active projects.

2.3 Data Aggregation and Management

In addition to defining standards, the Trust facilitates fishery-based research by managing data on behalf of members of a fishery. The Trust operates a secure, permissioned data management infrastructure ("The Platform") in which members of the fishery store their information. The Platform, and the data which it stores, is managed by a set of governance and management policies that ensure these data are protected, vetted, and standardized. Additionally, the Trust has developed a streamlined process for requesting standardized data from federal agencies for supported data types.

2.3.1 Secure, Permissioned Data Management Infrastructure

2.3.1.1 Platform Overview

The Platform is composed of a distributed database built on Dropbox Enterprise in which sensitive FDD is managed on behalf of owners. Data is stored in individual files following a tightly governed file structure and governance conventions that allow researchers to easily aggregate data from multiple owners without sacrificing the ability for them to easily see and manage the individuals that have access to their data.

The Platform is organized around three primary repositories: datastore, projects, and administration. The datastore houses the confidential information, and supporting documentation, provided by the fishery; the project repository consists of folders which hold scripts, data, outputs, and other supporting documentation related to specific products created on the Trust; the administration repository contains information related to the management of the Trust including overviews of the Trust, governance policies, and technical documentation.

2.3.1.2 Platform File Structure and Conventions

High-level descriptions of the file structure are described below. More descriptions of the role, permissions, and conventions of different parts of the hierarchy are described in detail in appendix A.

- **Datastore:** The Datastore is the heart of the Trust where raw owner data is stored.
    - Fishery Dependent Data (FDD): Data about fishing activity provided by owners. This includes government reporting data such as VMS, landings, and OBS.
        - **Reference Data:** Includes all non-proprietary reference data that helps researchers navigate the owner data. Examples include operator lookup tables.
        - **Owner Data:** Upon joining the Trust, the Trustees provision each owner with an owner folder. The folder is labeled using the owners randomly generated 4-digit identifier. All raw data is stored in this folder.
            - **Agreements:** Executed documents made between owner and Trust. This will include onboarding documents to the Trust (e.g., memorandum of understanding (MOU) and nondisclosure agreement (NDA)) as well as any data request forms used to request data.
            - **R Project File:** R project file used to ensure that projects are reproducible by ensuring that the exact versions of external R software packages are recorded and used by all researchers opening the project. The ability for all users to have a consistent analytical development environment is a key component for project reproducibility.

        - **Projects:** Outputs from projects in which owner has participated. Examples include charts, tables, reports, and other summary data created during a project.
        - **Raw:** Raw, unaltered data provided to the Trust. Broken down in folders by data type and batch delivered. This data will never be edited.
        - **Processed:** Data after initial Trust processing including ensuring standard format, field type, and more. For more details on this process see Section Data Aggregation and Management. This data is broken down in folders by data type and batch delivered.
        - **Scripts:** Documented scripts used to process the data.
        - **Survey:** Results from any quantitative research (e.g., survey).
        - **Supporting Documents:** Owner-specific supporting docs including reference tables or documents that assist in the analysis of these data.
    - **Fishery Independent Data:** Data about the ecosystem more generally. This primarily consists of survey data, e.g., Northeast Fisheries Science Center's (NEFSC) Northeast Bottom Trawl Survey.

- **Projects:** All code and aggregate data used in specific analyses. These folders are only available to the researchers working on the specific project. Each pilot project and future project will follow the same high-level directory structure:

    - **R:** contains scripts to process and transform fishery dependent (e.g., landings, VMS, and observer (when applicable) and independent data (e.g., wind planning and lease area spatial shape files) and code to conduct analysis and data summaries.
        - **Archive:** previous versions of scripts and one-off scripts that are not part of the final project.
    - **Data:** stores data from the Trust participants used in the fleet and Trust specific analyses, with each data file named as `fleet` or with specific Trust owner identifiers.
        - **archive:** during project development, previous versions of intermediate and final data sets were stored here for reference.
    - **Output:** stores results of analyses.
        - **tables:** table data are generally stored as a csv, png, and pdf files that may be stored in descriptively named subdirectories and files are labeled as `fleet` or with specific Trust owner identifiers.
        - **plots:** plots are saved as .pdf. Files are labeled as `fleet` or with specific Trust owner identifiers.
    - **Renv:** file that stores configuration settings that permit project-local R package dependency management to help ensure that the R workflows work across different machines as well as over time.
    - **Project Configuration:** stores project specific configurations for `renv.`

- **Administration:** These include administrative documents for the Trust. These files are only available to the Trustees and select researchers. The data structure is not fixed for this folder, but could include:
    - Overviews of the Trust
    - Agreement Templates
    - Data Request Forms

2.3.2 Governance and Management of Fishery Dependent Data

2.3.2.1 Governance Agreements and Requirements

All participants in the Trust, including Trustees, researchers, and owners must sign two types of documents before gaining access to the Trust infrastructure. These include an NDA, which protects the confidentiality of the data while stored in the Trust, as well as a MOU that defines governance and administrative policies. As part of the MOU, researchers and owners must agree to the following set of rights and obligations that dictate their behavior while working with the Trust.

Rights and Obligations for Trust Participants

Owners

- Rights
    - Remove Information at any time without the consent of the Trustee.
    - Determine the individuals or organizations that have access to their Confidential Information.
    - Determine the projects for which their Information will be included in analysis.
    - See Trustees and researchers that have access to their Confidential Information.
    - Receive timely updates about the ways in which files are used and accessed.
    - Access any cleaned version of their Information (e.g., cleaned) so long as it does not infringe on another Owner's rights.
    - Access products developed using their data.
    - Consult with researchers on the interpretation of their Information for products.
    - The Trust will ensure that "Confidential Information" will not be shared with anyone without the expressed permission of the data owner.
- Obligations
    - Share information with the Trust that reflects their best available understanding of the ecosystem.
    - Ensure that collaboration with the Trust or its participants will be conducted in a good faith effort to improve the best available science of the ecosystem.
    - Not manipulate information provided to the Trust at anytime.

- Acknowledge that products developed through the Trust are evaluated exclusively on the basis of contributions to best available science. Accept that a Trust product might not align with personal or organizational interest.

Researchers

- Rights
  - Documentation demonstrating the provenance of the data.
  - Documentation demonstrating the cleaning completed on the data.
  - Confidence that data in "raw" or "processed" format has not been edited in any way without clear documentation.
- Obligations
  - Conduct analyses in accordance with the guidelines and processes established by Trust.
  - Conduct analyses in a "good faith" effort to improve the "best available science" for the problem on which they are working.
  - Never disseminate data, products, code, or other confidential information accessed through the Trust to individuals or organizations not specified as part of the project team without the express written consent of the project team and the Trust.
- Disclose all ties, both informal and formal, to external individuals, organizations, and interests relevant to the project before actively working with a project team.

Roles and Access

In the Platform, users take one of three roles codified as members of groups (Table 11). Roles are managed by the Trustee. Members of these groups receive certain permissions within the platform. Users can be removed from these groups; and group permissions can be set.

Table 11. Breakdown of Roles and Permission for Each User Group

Group	Role	Permissions
Trustees	Trustees manage the ongoing operations of the Platform.	Trustees have global access to the Platform. They can: Grant/revoke permissions to specific folders Create and delete groups Assign roles within groups Monitor activity of users.
Owners	Owners provide knowledge to the Trust. Knowledge can be in the form of structure data, semi-structured qualitative data (e.g., surveys) or unstructured tacit information (e.g., collaboration).	Owners have access to their own FKT Folder, but no other folders. They can: Write data into the folder if it follows the conventions prescribed by the Trust Read any files in their folders View who has access to their folder at any time Remove Trust access to the folder at any time without permission.
Researchers	Researchers produce scientifically rigorous products using knowledge from the Trust.	Researchers have access to their specific project folder and the owner folders for those who have explicitly agreed to participate. In the project folders, they can: Read, write, and edit any files in the folder In the owners folder, they can, Read files in the folder Write files to the output folder

2.3.2.2 Termination of Access

Trustee Terminating Researcher Access

The Trustee has the right to terminate the researcher's access if one of the following conditions is met: (1) the researcher breaks a governance policy established in the MOU or NDA, (2) the owner chooses to remove access for any reason.

If the Trustee chooses to terminate a researcher's access, the Trustee will alert the researcher that their access to the Trust will be terminated. Forty-eight hours after the notice is sent the Trustee will remove the researcher from the permissioned group and initiate a process within the Platform to remove any files stored in the directory on their local machine. The Trustee will then send documentation to the researcher with a request to delete any confidential information within seven days per the NDA. All enforcement actions are subject to other agreements signed between the Trust and the researcher.

Trustee Terminating Owner Access

Trustees can terminate participation of owners in the Trust if governance rules are broken. If the Trustee choses to terminate the participation of an owner, the owner will retain all of their own data contributed to the Trust as well as any products delivered by researchers based on their data—ensuring the protection of other owner's confidentiality. RODA will be responsible for determining confidentiality conflicts. All enforcement actions are subject to other agreements signed between the Trust and the owner.

Owner Terminating Trustee Access

Owners can terminate the Trust's access to their data at will. Owners simply remove the Trust's permission to access their Datastore folder. While this presents challenges for researchers working with the Trust, interviews with the industry suggest that the ability to remove access at any point is a key requirement for participation. This also should encourage researchers to work closely with the industry throughout the project, which should strength the quality of the end product.

2.3.2.3 Quality Assurance and Quality Control Procedures for Data

Confidence in the data held in the Trust is critical to long-term success of the organization. To ensure researchers and regulators are confident in the data, the Trust has developed a strategy built to create trust in the provenance of the data and ensure the data meets basic quality standards. The strategy is built on three key pillars: attestation, transparency, reproducibility.

- Establishing Provenance of Data
  There's a saying in data science: "garbage in, garbage out." To develop products that improve the best available science, it's critical that regulators have access to the best available data. While there is no silver bullet for ensuring the provenance of the data is legitimate, the following procedures help ensure data entering the Trust represents the best available information from the owners.
  - Raw from the Source
    The Trust only accepts data in its most raw form. Owners must submit data as it was received from the system by which it's produced. Owners must not alter any part of the file including name and metadata.
    For federally regulated reporting data (e.g., VMS, VTR, DLR, OBS), owners can grant the Trust "Proxy" status so that the Trust can request the data directly from the responsible agency. Additionally, the Trust has documentation of the schema used by the government database, which it can use to verify the regulatory data provided by an owner directly.

- Attestation from the owners
  As part of the onboarding process, each owner signs a MOU, a non-binding document that outlines the rights and obligations they have as owners within the Trust. The owners must attest that the knowledge they provide to the Trust represents their best available data and was not manipulated from the source data.
- Transparency in Metadata
  All processed data files contain references to the raw data, descriptions of the data type, and the name of the individual who processed the data. This transparency provides researchers with the resources needed to understand the source of the data set.

- Standardizing Data Types
  To aggregate data from multiple sources, all data sets must adhere to a common standard. Without standardization, the process of cleaning and merging the data will devolve to ad hoc manipulation that is not only time intensive but error prone and difficult to document. Data fields and types are standardized using a common script. If data does not fit the standard schema, the processing researcher will make document adjustments within the "processing" script for the specific owner.
- Identifying Common Errors and Outliers
  All data can contain accidental errors. For example, a fisherman enters an extra 0 while reporting catch or a GPS-device malfunctions and reports the wrong latitude-longitude. These data errors can cause headaches for researchers down the line and can lead to findings that are not accurate.
  As part of the data onboarding process described in Section 2.3.2.5 Aggregation and Onboarding of FDD, data sets are scanned for common errors using parameters established as part of a common standard for a data type. For instance, for VMS data, any latitude-longitude pair that does fall within a reasonable geographic region is excluded.
- Documenting Reproducible Scripts
  Reproducibility is a key pillar of open science efforts.[1] By enabling stakeholders to reproduce transformations of data within the Trust, the Trust can increase trust in the data and reduce unnecessary duplication of effort.
  The scripts used to process an owner's data are kept in the Owner Datastore. These files are read-only to researchers but allow researchers to easily see the transformations made on the raw data at the code level. Links to the processing scripts and the raw data processed are included in the metadata field of each data set.

[1] See FAIR Data principles for more information.

2.3.2.4 Request Protocols and Forms for Federally Reported Data

As part of the pilots conducted for this project, a streamlined process for requesting federally reported data was developed for supported data types. The process substantially reduced request times and ensured that data was returned in the standardized format necessary to properly aggregate the information later.

Standard request forms for each data type were developed to support the request process in conjunction with the respective agency described in Table 12. The forms can be signed physically or digitally based on the preference of the owner. Each form includes information on the name of the owner and permit numbers, fields requested, and the structure in which it should be returned. Additionally, forms were also developed for VMS and VTR/DLR data to declare an individual or group an authorized proxy for the data.

Table 12. Standardized Forms for Requesting Federally Reported Fishery Dependent Data

Form	Managing Agency
VMS Request Form	Bureau of Law Enforcement (BLE)
VMS Authorization Form	BLE
Vessel Landings Request Form (General)	Greater Atlantic Fisheries Office (GARFO)
Vessel Landings Request Forms (Surfclam and Quahog)	GARFO
Vessel Landings Authorization Form	GARFO
Observer Request Form	GARFO

2.3.2.5 Aggregation and Onboarding of Fishery Dependent Data

New data added to the Trust must follow the following process (Table 13). A member of the Trust will lead the onboarding process, typically as part of a broader project. The steps should be followed sequentially.

Table 13. Checklist for Onboarding Fishery Dependent Data into Trust

Step	Action	Relevant Sections
Ensure Data Standard Exists	Trustee ensures that data aligns with existing standard already documents in the Trust.	Currently Support Data Standards Introducing New Data Standards Updating Data Standards
Sign Governance Documents with Owner	NDA and MOU are signed between Owner and Trustee.	Governance Agreements Rights and Obligations for Participants Onboarding a New Project
Create Necessary Folders Within Trust	Trustee creates new folders for data within the Trust following conventions described in Platform Overview.	File Structure and Conventions
Aggregate Data	Owner or Trustee places data in “Raw” data folder.	File Structure and Conventions
Visual Review of Data	Trustee visually reviews data types to evaluate to ensure they were directly exported from source (e.g., examine naming conventions).	N/A
Manually Update to Meet File Conventions	Trustee renames, if needed, files to meet Trust conventions and place in correct structure.	File Structure and Conventions
Process Data Using Scripts	Use Data Processing Scripts for data type to automatically ensure that data meets standards, identify, and correct common errors, add metadata and transfer to the “Processed” folder.	Onboarding Scripts

2.4 Scientific Research

The Trust is only as valuable as the scientific analyses researchers produce using its data and insights. To improve the best available science, these products must be trusted by a range of stakeholders, from fishermen and regional councils to regulators and researchers.

The Trust *does not* conduct analysis; rather, it provides the infrastructure to allow researchers and other stakeholders to create analytical products using fishery knowledge and insights made available through the Trust.

2.4.1 Principles of Successful Trust Project

- **Impactful Scope.** Does the project focus on a problem that can materially improve the best available understanding of the Fishery? The research problem and project objectives are clearly defined.
- **Rigorous Methodology.** In order to be trusted, all analysis must meet the standards for best available science. The methods need to be scientifically rigorous, transparent, and repeatable.
- **Collaboratively Developed.** In order for products to be impactful, they must consider the expertise of the stakeholders which they impact as part of the development process.
- **Cost Effective.** The Trust cannot succeed unless the cost for labor and overhead is adequately supported by those who use the platform.

2.4.2 Establishing a Trust Project

- Submitting a proposal
  Any group or individual who would like to run a project using the Trust must submit a project proposal. The proposal will help the Trustees determine whether the project meets the principles outlined above. The Trust will also use the information provided to develop an initial price quote. Criteria include:
  - Definition of research question.
  - Proposed methodology used to answer the research question.
  - Audience for analysis.
  - Types of data required to complete analysis (e.g., VMS, landings, plotter).
  - Number of permit owners involved.
- Evaluating a proposal
  Trustees are responsible for evaluating the proposal to determine whether the following questions have been addressed. Questions include:
  - Is this a cooperative research project?
  - Are the research problem and project objectives clearly defined?
  - Does the proposed researcher add to the body of research on the topic, or feed into a specific action under development?
  - Does the solution fit the problem?
  - Is the scientific solution rigorous, transparent, and repeatable?
  - Is the solution doable with the resources available and within the timelines identified?
  - Are end products concise and clearly articulated for the intended audience?
- Consent of Data Owners
  Before the project can continue, the Trust will work with existing owners who might be in scope to determine whether they would like to participate. Any owner that declines will not be included in the analysis.
- Agreement on Statement of Work
  The Trustees and proposers will develop a statement of work that will define the scope, goal, and services rendered by the Trust. This agreement will also serve to define expectations for the project.

2.4.3 Determining Cost for a Project

The Trust operates as a not-for-profit, but it's critical that the Trust can generate enough funding to support the services it provides to the community. The Trust charges researchers a project fee for using the Trust. This fee includes three main parts: fees for services rendered (e.g., Trust administration, data integration and management, community management), incremental technology costs (e.g., additional licenses for Dropbox Enterprise), and an overhead charge (30% of labor and technology costs) that funds a portion of the administrative costs of the Trust (Table 14).

Table 14. Pricing Elements for Trust

Price Elements	Description
Labor	Cost of the labor associated with managing projects, including project management, data cleaning, and orientation.
Incremental Technology Cost	These include additional technology costs that are not already covered by the Trust—namely, license to Dropbox for researchers.
Overhead	All projects are charged a 30% overhead fee that contributes to the maintenance of the infrastructure and supports research and development, legal, and other organizational costs.

Project pricing will vary substantially based on number of participants, complexity of data requirements and length of project. Estimates for a relatively simple hypothetical project are described below.

The Trust offers three "packages" based on the requirements of the project. These depend on whether the projects are working with existing data in the Trust, aggregating new data for an existing data type or aggregating new data for a net-new data type. Table 15 outlines each offering.

Table 15. Packages Offered for Projects

Type	Description	Services Provided
Existing Data Within the Trust	Projects want to work with existing data within the Trust. E.g., VMS and Landings data for Clam Participants.	Onboard project team Sign governance documents Provide Trust access Recruit Advisory and Review Panel (ARP) Determine data requirement Facilitate meeting with owners to review initial assumptions Facilitate kick-off of ARP Facilitate interim ARP Review meeting Facilitate certification process Facilitate interaction/questions for fisheries Removal of access to data Reincorporation of data and analytics into Trust
New Data Based on Existing Standard	Projects want to aggregate new data for a standard the Trust already supports. E.g., VMS data for new fleet in Rhode Island.	Services described above plus Request data from source (e.g., government) "Process" data using common scripts Co-develop knowledge survey Coordinate survey with owners Integrate survey into common format
New Data for New Data Type(s)	Projects want to aggregate data for a standard that the Trust does not support. E.g., Plotter data for Lobster fleet.	Services described above plus. Create standard Trust scheme for data Update data management and governance policies Design data retrieval model Develop ETL scripts

Several factors affect the price of each package including, number of participants, receptibility of owners to the project, number of researchers, difficulty of data retrieval, documentation of new data type and more. Pricing will be done on a per project basis. However, a mean pricing has been estimated for each package and estimated low and high values based on a 20% deviation from the mean (Table 16). These prices are based on itemized estimates on labor for a relatively straight forward project that assumes two researchers on each project. Pricing for projects could be lower or substantially higher based on the specific requirements.

Table 16. Estimated Pricing for Common Packages

Offering	Low	Median	High
Existing Data, Existing Data Type	$5,632	$7,040	$10,559
New Data, Existing Type	$8,814	$11,018	$16,526
New Data, New Type (1)	$17,404	$21,756	$32,633

2.4.4 Onboarding a New Project

Once the Statement of Work is signed, onboarding begins. The goal of onboarding is to ensure that everyone involved with that project (a) understands the governance principles and processes of the Trust, (b) signs the necessary documents and (c) has access to Trust Datastore where necessary.

- Identify Key Points of Contact
  - **Project Lead.** The project team will assign a project lead who will be the key point of contact for the Trust. They will help coordinate any activity between the project team and the Trust.
  - **Trustee.** The Trust will assign a trustee who will serve as the key point of contact for the project team at the Trust.
  - **Researchers.** The project lead will disclose all researchers or other project team members who will interact with the data within the Trust. Credentials and background will be included for each researcher.
- Brief Project Team on Trust Policies
  The Trust will hold a webinar with project team members to walk through the onboarding process and address open questions about the Trust.
- Sign Governance Documents
  All researchers on the project team will sign governance documents that enumerate the principles of the Trust and serve to protect owner information.
  - **MOU:** Non-binding agreement that establishes the rights and obligations of researchers in the Trust pursuant to the principles of the Trust.
  - **NDA:** Ensures that all confidential data is secured.
- Provide Trust Access
  Managing access to Trust data is one of the central responsibilities of the trustees.
  - **Project Folder:** Once all documents are established, a new project will be provisioned within the Trust.
  - **Datastore:** Researchers will be provisioned with access to the relevant owner's data sets.

2.4.5 Preparing Trust Infrastructure

The Trust will work with the project team to aggregate the data and insights required for the project.

- Determine data requirements
  The project team works with the Trustee to establish the requirements for the data and insights needed to support the project. The project team will also identify the data types needed and the owners of these data.
- Create standard trust scheme for data
  All data types supported by the Trust must have a defined and documented standard schema.
- Update data management and governance policies
  Trustees need to determine how the data is stored within the Trust and how that specific data is managed.
- Design data retrieval model
  Data retrieval can be time complex and require Trustee time to work with regulators, vendors, and other data holders.
- Develop extract, transform, and load (ETL) scripts
  Scripts must be developed to extract the data, transform it into the common form, and load it correctly into the Trust.

2.4.6 Aggregating Data into Trust

- Collecting Quantitative Data
  - **Request data from source (e.g., federal agency).** Project team will work with the trustee to request the data from the source ensuring that data is delivered in standardized format.
  - **"Process" data using common scripts.** Trustee will process data using standard scripts described in section 2.3.2.3 Quality Assurance (QA) and Quality Control (QC) Procedures for Data.
- Collecting Qualitative Data from Owners
  Collecting and structuring insights from owners and other stakeholders is a critical part of knowledge development within the Trust. The project team will work with the trustee to conduct a survey of owners to capture tacit knowledge about key behaviors, e.g., fishing activity.
  - Develop Knowledge Survey
    If a survey has not already been conducted, the project team will work with the trustee to develop a survey evaluating the key behaviors to be analyzed during the project. For instance, if a project seeks to analyze historical fishing activity, a survey would query fishermen involved about fishing behavior and other assumptions needed to conduct analysis (e.g., average trip length, perceived shifts in fishing habits). Please see appendix B for an example survey from the pilot.
  - Conduct Survey with Owners
    The project team will conduct the survey with owners. The survey can be conducted either via an online form or verbally. If the survey is conducted verbally, the project team is responsible for transcribing responses.

- Integrate Survey into Common Format
  All survey responses must fit the standard format for the data type. Responses will be loaded as a csv file into the correct part of the Trust. The goal is for researchers to be able to query questions within a console as they conduct analysis. More information is provided in Section Platform File Structure and Conventions.

- Reviewing Assumptions with Owners
  After completing an initial draft of the products, the project team will review key assumptions used in the analysis with the owners. This is a critical step to ensure the assumptions underlying the analysis are correct.

2.4.7 Creating an Advisory and Review Panel

Each project using the trust to develop scientific products are required to form an Advisory and Review Panel (ARP) early in the project cycle. The objective of the ARP is to provide expert guidance and peer review of the development of science products through the projects to ensure that products are high in quality, likely to be impactful, and thus worthy of certification by the Trust.

- Minimum Requirements for Acceptable ARP Members:
  - 3–4 members.
  - No conflict of interest with project goals. Reviewers cannot be members of the project team.
  - Demonstrated expertise in either: fishery science(s), policy, and fishery(s) relevant to the project scope.
  - One member of each review/advisory panels must be an individual actively working in the fishing industry with expertise in relevant fishery(s).
  - The remaining members must be experts in science or policy related to project scopes.
- Typical responsibilities for ARP members:
  - 2-3 meetings with project team (kickoff, interim, final)
  - Review and comment on:
    - FKT project frameworks.
    - Tools used to develop solutions as requested.
    - Rough draft and final project end products.
    - Provide advice as requested when possible.
- Steps for forming ARPs:
- Project Leads will be responsible for the recruitment of the ARP candidates early in the project and be identified during project scoping.
- For each candidate, project leads will submit the ARP questionnaire to the trustees who will accept/deny ARP members based on whether they meet the requirements established.
- ARP will meet with the project team at least once before products are created.

2.4.8 Reviewing and Certifying Products with the Advisory and Review Panel

All Certified Fisheries Knowledge Trust Products must complete a review by an independent Advisory and Review Panel described above. Table 17 summarizes criteria for ARP certification.

- **Hold Initial ARP Meeting:** The project team will work with the Trustee to hold an initial meeting with the ARP at the beginning of the project. During the meeting, the project team will present an overview of the project, including research question, hypotheses and methodology. The trustee will also provide details to the ARP about their expected role and timeline for the project.
- **Draft ARP Review:** The project team will review draft products with the ARP. The ARP will evaluate the products and make comments on methodology.
- **Certification:** The ARP will determine whether to certify a product based on whether the project meets the following criteria.

Table 17. Criteria for Advisory and Review Panel Certification

Question	Criteria
Is this a cooperative research project?	The project team has collaborated with the fishing industry in developing the project and conducting the analysis.
Are the research questions and project objectives clearly defined?	The project team has clearly defined the research questions and objectives for the project.
Does it add to the body of research on the topic, or feed into a specific action under development?	The research question addresses a material and timely need for the marine ecosystem and influences clearly defined actions and decisions currently under development.
Is the scientific solution rigorous, transparent, and repeatable?	The solution is scientifically rigorous, and the methods used by the team are documented well-enough as to allow for future reproduction.
Does the solution fit the problem?	The solution addresses the main requirements established in the research questions.
Are end products coherent and clearly articulated for the intended audience?	The end products are articulated in a manner that can be digested by the intended audience and more broadly to the general public. There is a clear plan for outreach and communication of project results.

2.4.9 Final Review with Owners

In addition to certification from the ARP, researchers must review all final products with the owners of the data used in the analysis. Owners have a right to remove their data from the analysis at any time. They do not need to provide justification for removing their information. If owners chose not to participate in the project, researchers must remove these data from any analyses referenced in the products. Additionally, the trustee will initiate processes described in the Termination of Access section to remove researchers' access to the owners' data.

While owners have the right to decline to participate in research, both before and during the research process, they do not have the right to define the structure of the analysis or presentation of products. All products developed in the Trust must meet the standards of best available science, as described in section 2.3.2 Governance and Management of FDD.

2.4.10 Closing a Project

- Removal of Access to Data
  Trustee must remove access to the researchers from the Trust. Trustee should follow procedures outlined in the Termination of Access section.
- Reincorporation of Data and Analytics into Trust
  The Trust is built so that data and code can be reused between projects, if the project team agrees. If agreed at the beginning of a project, project team must publish relevant code within the Trust code base and document any data sources.

2.4.11 Checklist for a Trust Project: Activities and Deliverables

Below, a summary of the steps above is provided broken out by activities and deliverables for each stage (Table 18).

Table 18. Checklist of Activities Supported by Trust Team in Common Project

Step	Activities (Trust + Project Team)	Deliverables (Trust + Project Team)
Onboarding a New Project	• Onboard project team • Sign governance documents • Provide Trust access • Recruit ARP	• Webinar with participants • 1-on-1 meetings with participants • Signed MOU and NDA documents • Signed project scope • Launch meeting of ARP
Preparing the Trust Infrastructure	• Determine data requirements • Create standard Trust scheme for data • Update data management and governance policies • Design data retrieval model • Develop ETL scripts	• List of data sources for project • Updates to Trust file structure/ schema • Standards documented for new data types • ETL scripts
Aggregating Data into Trust	• Request data from source (e.g., government) • "Process" data using common scripts	• Standardized data loaded and processed in the Trust
Collecting Qualitative Data from Owners	• Develop knowledge survey • Conduct survey with owners • Integrate survey into common format	• Survey questions • Survey responses in standard format
Reviewing Assumptions with Owners	• Facilitate meeting with owners to review initial assumptions	• Provide guidance on development Interim report
Certifying Products	• Facilitate kick-off of ARP • Facilitate interim ARP review meeting • Facilitate certification process • Facilitate interaction/questions for fisheries	• Certification justification for project
Closing a Project	• Removal of access to data • Reincorporation of data and analytics into Trust	• Documented code and data • Updated permissions

3 Pilot Projects

3.1 Overview

3.1.1 Goals and Purpose of Pilot Projects

Two pilot projects were conducted with active fishing fleets in the Mid-Atlantic in order to evaluate the feasibility of the Trust in addressing conflicts between OWED and fisheries. Both pilots involved the recruitment of members of the fishery, aggregation, standardization and storage of their data, and preliminary analysis of their information to address key challenges relating to OWED. Insights from the pilot projects were used to refine the governance, organizational, and technical structures of the Trust described in the previous section. As pilots, the primary goal was to determine the efficacy of the existing Trust design and develop solutions based on lessons learned. The success or failure of these pilots should be measured against three primary criteria for feasibility of the Trust: (a) do stakeholders have the motivation to participate, (b) does the Trust have the capability to aggregate and operationalize crowdsourced information, and (c) can a research team develop potentially impactful products with these data. These criteria (Table 19) were used to evaluate the success and lessons learned in the pilots.

Table 19. Key Success Criteria for Trust Pilot Projects

Assumption	Criteria
Motivation	On-water stakeholders are willing to share confidential federally reported data with the Trust.
Motivation	On-water stakeholders are willing to share qualitative data (e.g., surveys) with the Trust.
Motivation	On-water stakeholders are willing to work with researchers to inform proper interpretation of the data.
Capability	The data necessary to complete the analysis existed in a structured format.
Capability	The data could be accessed and collected in a scalable way from the source.
Capability	The data could be standardized and aggregated into a standard format.
Capability	The data could be analyzed in a way that met the confidentiality requirements of the on-water stakeholders.
Capability	The data could be analyzed in a way that provided the necessary documentation to easily reproduce the findings.
Impact	Stakeholders in the wind energy industry trust the credibility of methods used and data collected in the analysis.
Impact	Stakeholders in the on-water community view the products as valuable.

3.1.2 Development of Research Area

The pace of OWED in U.S. waters is increasing in order to address climate change. Identification of wind planning areas (WPAs) and wind lease areas (WLAs) is complicated by overlaps with previous ocean uses (e.g., commercial and recreational fishing and shipping). This is especially a challenge for the fishing industry who rely on open space to operate their mobile bottom tending gear (MBTG) within the strict parameters of fisheries management regulations.

Given the potential scale of overlap between OWED and fisheries operations, it is imperative to identify the fishing footprint of each fishery as accurately as possible. Individuals in the fishing industry have in-depth empirical knowledge of the ecology and human social dimensions of the ecosystems in which they operate. However, fishery information required to establish the footprint is confidential, which can serve as a barrier to analysis. FDD can also have limitations such as VTR only collecting one geographic location per trip. OWED regulators have considered using publicly available AIS data to describe fishing patterns; however, AIS is not required to do so on vessels less than 65 feet in length, which excludes many vessels resulting in an inaccurate depiction of any one fishery.

The other goal of the Trust was to show that independent businesses could cooperatively establish a standardized, accessible database of their FDD. Such databases are a major resource for any fishery because the data can be used to answer a range of questions, including those arising from fishery management. Spatial management measures are frequently used in fishery management, but the fishing industry rarely has the opportunity to analyze fleet-level data itself as these measures are developed.

Both pilots sought to address whether the Trust could fill this “data” gap. Each pilot used the Trust infrastructure to aggregate and standardize data from a subset of vessels in each fleet and develop foundational analyses that evaluate the historical intersection between these vessels and the WLAs and WPAs defined by BOEM, as of June 2022. These analyses do not provide the breadth or depth required to estimate the full financial impact of OWED on the fisheries, but rather demonstrate the potential for future, more in-depth analyses using the Trust.

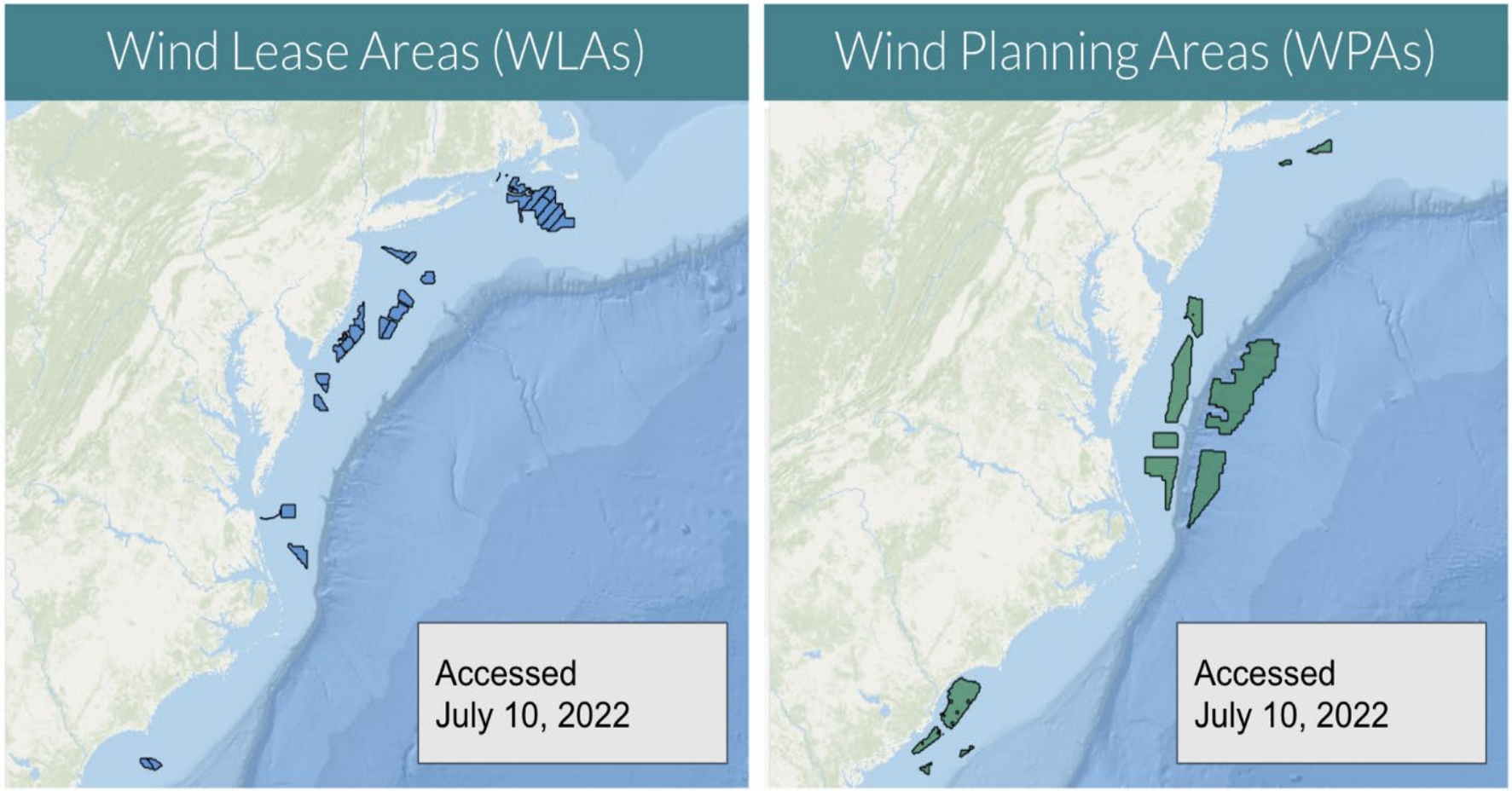
3.1.3 Selection of Fisheries

Four fisheries were targeted based on the potential impact of OWED as well as the number of the participants. The first pilot (Herring Pilot) was conducted with the six permit owners (10 permits) in the herring and mackerel fisheries (herring participants) operating primarily out of New Jersey and New York. The herring participants represented 74% of the overall herring landings in 2020. The second pilot (Clam Pilot) was conducted with four permit owners (71 permits) in the ocean quahog and surfclam fisheries (clam participants) based primarily out of New Jersey which accounted for 84% of clam and quahog landings in 2020.

3.1.4 Offshore Wind Energy Development Areas Analyzed in Pilots

The analyses considered two types of OWED areas defined by the Bureau of Ocean Energy Management (BOEM) as of July 10, 2022. These include 27 WLAs that span from the New York Bight to the Carolinas (Figure 1). These regions have already been leased to wind energy companies for development. The second group includes approximately 10 WPAs with six located in the Mid-Atlantic region. Importantly, the WPAs in the Gulf of Maine, Gulf of Mexico and Oregon were not included in this analysis. Together, the WLA and WPA will be referred to as wind lease and planning areas (WLPAs) in the report.

Figure 1. Wind Lease and Planning Areas Included in Analysis



3.1.5 Limitations for Pilots

These pilots provide foundational analyses intended to demonstrate the validity of the Trust, the results of which provide a minimal view of the economic impact of OWED. These analyses do not include the entire represented fleets and are not adjusted accordingly. In addition, these findings do not include the necessary economic analyses to evaluate the total impact of OWED on a given fishery (e.g., multipliers that estimate the total economic output associated with a dollar of fish sold). Analysis in these pilots should be viewed in the contexts of the goal of the project: to demonstrate the viability of the Trust, not to provide conclusive evidence about the impacts of OWED. It is hoped that other researchers will use the Trust to build the necessary economic and social analyses required to fully account for the impact of OWED on the fisheries included in the analysis.

3.2 Herring Pilot

3.2.1 Fishery Overview

Proposed OWED occurs in the context of the already complex dynamics of fisheries that are simultaneously driven by the dynamics of species habitat and population ecologies as well as economic, regulatory, and other human social dimensions. Mackerel and herring are both high-volume, low-price fisheries that require large landings for trips to be profitable.

Mackerel are fast swimming pelagic schooling fish in all life history stages, while herring are pelagic and schooling in all but the egg stage. Habitats for both species are defined primarily by highly dynamic water column properties and processes that affect their bioenergetics, growth, movements, and survival. These species couple their life cycles through extensive migrations that are flexible and adaptive (NEFMC 2006, 1-1660; Reid et al. 1999, 1-48; Studholme et al. 1999, 1-25; MAFMC 2022a, 1-8). Fishermen hunt for moving shoals of marketable quantities of valuable adult herring and mackerel. Fishing grounds for these species are only loosely tied to place and the fisheries; like the fish, they are dynamic in space and time. Herring and Mackerel are both cold temperate pelagic species whose movements, distributions, and productivity have been changing in response to changes in ocean-atmospheric processes associated with global warming (Allan et al. 2022, 401; dos Santos Schmidt et al. 2020, 102257; Moyano et al. 2020, 106146). Therefore, the location and timing of fishing has and will continue to change to the degree permitted by management regulations and other logistical constraints.

Fisheries management regulations including spatial management regulations impacting the herring and mackerel fisheries are exceptionally complex. While the two species are strongly associated, the species are managed by three different governance bodies and management plans (The Mid-Atlantic Fishery Management Council manages the Atlantic Mackerel fishery. The New England Fishery Management Council and Atlantic States Marine Fisheries Commission (ASMFC) manage the Atlantic herring fishery). The first federal Fishery Management Plan for Atlantic herring was implemented in 1999. The total catch limit was reduced to under 100,000 metric tons (mt) beginning in 2010, with the annual catch limit (ACL) undergoing continued reductions reaching a low of 12,225 mt in 2020 (NEFMC 2022, 1–154). These quota reductions are the result of poor recruitment of young fish into the fishery, possibly due to a warming ocean and a potential shift of the zooplankton the stock depends upon to the north and east.

The herring fishery has strict spatial regulations in four management sub-areas: Inshore Gulf of Maine (Area 1A), Offshore Gulf of Maine (Area 1B), Georges Bank (Area 3) and Southern New England and Mid Atlantic Bight (Area 2) that are subject to closure for various reasons including sub-annual Catch limits (ACL) for herring that can limit the mackerel fishery. Once sub-ACLs are met, the incidental catch limit of herring is 2000 pounds. These limits can exert strong constraints on the spatial dynamics of the mackerel fishery, as well as the herring fishery, particularly for large trawlers that can land several 100,000 pounds of fish per tow. Fisheries management actions by these entities can drive a fisheries' footprint. For example, both fisheries, until 2022, had been impacted by a ban on midwater trawl gear inshore of the 12-nautical mile territorial sea boundary from Canada to Connecticut and inshore of 20 nautical miles off the east coast of Cape Cod. However, this rule was overturned on March 29, 2022, following a lawsuit filed by the fishing industry (Sustainable Fisheries Coalition v. Raimondo 2022). In addition, quota limits and spatial closures in the herring fishery frequently impact the mackerel fishery because of specie co-occurrence and are frequently caught in the same tows. Incidental catch limits of mackerel have also affected the herring fishery.

In addition, both fisheries are limited by groundfish closures in the Gulf of Maine and Georges Bank, and from spatial and temporal limits for American shad, blueback herring, alewife, and haddock.

Seasonal closures impacting the two fisheries from 2008 through 2019 are summarized in the Framework Adjustment 8 impact analysis for the herring fishery (NEFMC 2021, 1–168). The complexity of these existing and ever evolving fisheries regulations place time varying spatial constraints on fishing activities in the herring and mackerel fisheries. It is the industry's view that the establishment of the proposed OWED areas with restrictions on fishing activity will only increase the spatial constraints on the two closely associated fisheries.

3.2.2 Research Questions

The purpose of the pilots was to demonstrate the viability of the Trust by producing a foundational analysis using the Trust infrastructure. Moreover, two key research questions informed the Herring Pilot:

Can the Trust successfully aggregate, validate, and integrate proprietary fleet-level data and knowledge and create basic, transparent analytical products?

What is the scale of the likely financial and harvest impacts that the proposed and existing wind planning and lease areas (WPLAs) would have on historical fishing activity?

3.2.3 Participant Recruitment

Permit owners were recruited to participate in the pilot project between January and April 2020 with two additional members joining in February 2021. Introductory conversations with project participants were conducted via web conference. Project participants joined two webinars and participated in several one-on-one conversations to learn about the goals and expectations of the project and about the Trust itself. Once project participants agreed to participate an NDA and MOU were signed between the Trust and the individual who controlled the necessary permits, or owner.

Overall, six different fishing organizations agreed to participate accounting for 10 permits in the herring and mackerel fishery between 2008–2020. These permits include mostly large capacity commercial vessels. Six of the vessels fished in three pair trawling operations.[2] Between 2015–2020,

[2] A pair trawler is one of two vessels towing one single trawl net. https://www.fao.org/fishery/en/vesseltype/940/en

permits belonging to the Herring Participants accounted for 59% of total herring landings and 73% of the total catch of mackerel in U.S. waters. Total landings decreased substantially between 2015 and 2020 due in large part to management actions that decreased Annual Catch Limits in response to stock assessments indicating decreasing biomass and recruitment.

Table 20. Vessels Considered in This Report Compared with Total Commercial Landings of the Species in U.S. Waters from 2015 to 2020

All values are in metric tons. (Total Landings data from NOAA Fisheries and MAFMC).

	Herring Landings			Mackerel Landings		
	Herring			Mackerel		
	Participants	Total	%	Participants	Total	%
	50,027	81,204	61.61	3,821	5,616	68.04
	43,512	62,597	69.51	4,874	5,687	85.70
	30,910	48,796	63.35	7,046	6,975	101.02
2018	29,697	45,527	65.23	7,400	8,717	84.89
2019	10,677	12,782	83.53	5,148	5,379	95.71
2020	6,938	9,368	74.06	6,984	8,019	87.09

3.2.4 Materials and Methods

The main sources of quantitative data for our analysis (Table 21) included standardized VMS, VTR, DLR, and OBS maintained by the U.S. Department of Congress/National Oceanic and Atmospheric Administration/National Marine Fisheries Service (USDOC/NOAA/NMFS). All these data collections are mandated by the U.S. government for fisheries monitoring and are vetted by NMFS.

Table 21. Data Used in Herring Pilot Project

Data type	Source	Use	Date last accessed
VMS	NOAA/GARFO	Vessel geolocations in time on fishing trips.	2/10/2021
OBS	NOAA/ NEFSC	Verify tow and catch estimates.	4/2/2021
DLR	NOAA/GARFO	Fishing Trip landings.	12/10/20–2/22/21
VTR	NOAA/GARFO	Fishing Trip sail and landing dates and times.	12/10/20–2/22/21
Answers to Fishery Questionnaire	RODA Trust	Qualitative information about factors influencing fishing practices.	3/1/2021–6/1/2021
OWED shape files	BOEM	Shapefiles describing WPAs and WLAs used in evaluating impact.	07-22-22
Fishery regulation shapefiles	NOAA	Show spatial regulation.	12/4/2020

3.2.4.1 Aggregating Federal Reporting Data

The process of requesting federally reported data from the respective government agencies took over 18 months due to situational and structural challenges. Requesting data from these agencies is a time-consuming process that can typically take from 1–4 months. The emergence of COVID-19 during the beginning of the pilot projects dramatically disrupted the operations of the government agencies responsible for managing data requests resulting in substantially extended timelines. While the fishery remained operational, many government agencies shifted to remote operations which limited their capabilities.

Data requests were initially made by project participants in March 2020. When the data were returned from the respective agencies during the Summer 2020, the data were inconsistently formatted between owners. Standardized data is essential to proper aggregation. Over the next few months, work was completed to identify and remedy the problem. The inconsistencies in the data were due in part to a misunderstanding about the goals of the project. Database managers often adjust headers and include additional data to make the data more digestible for the requestors.

During fall 2020, a new, streamlined process was developed with both the fishery and government agencies, which dramatically cut down on request times. First, an e-sign process was implemented for all necessary forms, which dramatically reduced completion time. Second, through close cooperation with the government agencies, a common structure was defined and followed in fulfilling the requests. A standardized request form was developed for each data type, which specified in detail the required structure of the data. Additionally, the agencies provided the Trust with the Structured Query Language (SQL) code used to query the database to ensure standardized delivery in the future. Third, some project participants chose to grant the Trust "proxy" status, which allows the Trust to request—and, critically, update—data on their behalf. Together, the new processes substantially reduced request time and error rates in data delivery.

3.2.4.2 Quantitative Data Integration and Cleaning

Basic data quality checks were then conducted. For each data type, processing scripts, which were developed by the team, were run to standardize field names and data types and checked for basic quality control issues such as numerical outliers (e.g., latitude-longitude pairs outside of the operational areas of the participating vessels). Additionally, VMS data, which were originally delivered in files for each year, were consolidated into a single file for each permit number. Once the data were processed, finalized files were delivered to the "processed" folder, per the Trust file structure. These data, along with the raw files, will remain in the Trust along with the relevant processing scripts until the owner removes access.

3.2.4.3 Qualitative Information Sources

Semi-structured interviews were performed with the captains of fishing vessels participating in the project to develop an understanding of the socio-ecological dimensions of the fishery that shape the context within which OWED fishery impacts are likely to occur. A structured questionnaire was developed that covered basic information about the fishermen, their experience in the fishery and technical aspects of fishing (appendix B). In addition, detailed questions were asked about the impacts on the fishery of fish ecology, management regulations, and economics. Finally, fishermen were asked questions to gather views about perceived potential impacts of OWED on the fisheries. Vessel captains and owners were provided with the questions before scheduled interviews. Interviews were conducted over the telephone. Questionnaire answers were stored in standardized form with quantitative data and reviewed during the analysis and the development of this document.

3.2.5 Analysis

3.2.5.1 Categorizing Vessel Monitoring System Data into Trips

VMS transponders report data approximately every 30 minutes regardless of the vessel's activity. VMS records include information about location, speed, heading and the fishery for which a given vessel sought to fish, but do not include unique identifiers that can identify "active" trips where vessels are catching and landing fish. The data are valuable in attributing a given trip to a specific fishery, but do not contain information needed to link the VMS records to a specific landing record. Vessels with Atlantic herring permits must declare their intention to take a trip prior to leaving the dock.

Therefore, an analytical method was developed to classify VMS observations that reflected a vessel during a fishing excursion versus simply a vessel at port or transiting. VTR data were used to create a unique time-bracket for each trip. Captains are required to report the date and time in which they depart for a given trip (*date_sailed)* and the data and time in which they sold a given catch (*date_sold)*. These data were used as filters for VMS records: all VMS records with dates and times within the *date_sailed* and *date_sold* were attributed to a specific landings record.

Summary statistics for estimated trips are shown in Table 22. The number of trips for the herring participants decreased substantially between 2015 and 2020 reflecting decreases in overall catch and quotas described in 3.2.1 Fishery Overview. In 2020, project participants took 103 trips with a mean time at sea of 2.9 days traveling 355.7 nautical miles. These data were reviewed with herring participants during the interim review meeting. Herring participants agreed that the summary statistics reflected their best available understanding.

Table 22. Summary Statistics for Estimated Trips Taken by Herring Participants per Year

Year	Number of Trips	Mean Time at Sea (Days)	Mean Annual Distance Traveled (Nautical Miles)
2008	184	2.0	185.1
2009	287	2.3	251.2
2010	235	2.7	316.2
2011	256	2.2	268.4
2012	237	2.5	300.3
2013	286	2.8	321.6
2014	274	2.5	281.9
2015	317	2.5	303.3
2016	259	2.3	258.3
2017	241	2.2	255.3
2018	187	2.1	250.7
2019	104	2.4	300.3
2020	103	2.9	355.7

3.2.5.2 Classify Vessel Movements by Behavioral States

Time spent during a fishing trip is not equally valuable. Identifying "behavioral states" provides important context to the analysis of the historical impact of OWED on the fishery. Working with the fishery, four key states were identified: processing/laying up, fishing, searching, or steaming (Table 23). Initial findings were reviewed with project participants.

Table 23. Definitions of Behavioral State

State	Definition
Processing/Laying up	Activities associated with preparing landings for storage as well as sleeping or waiting out bad weather.
Fishing	Gear in the water actively catching fish.
Searching	Time spent at sea actively looking for fish.
Steaming	Transiting between two locations, e.g., port and fishing grounds.

The “elbow method” was used to determine the optimal number of clusters to use for the K-means clustering approach. This works by minimizing the within-cluster sums of squares (WSS). As you increase the number of clusters, the improvement in the fit does not change and that allows you to select the optimal number of clusters. It is subjective, but an often-used approach. For the Herring Pilot project, four clusters optimized the WSS, which were related to known behaviors based on interviews with the Herring Pilot participants.

Summary statistics for trip classifications are described in Table 24. Speeds ranging from approximately 3–5 knots indicated fishing activity, greater than 5 knots, but less than10 knots was likely searching activity, highest speeds were steaming to and from port, and speeds under 3 knots were assigned to processing (handling the catch). Steaming values above 12 knots are extremely rare and likely reflect errors in VMS data collection.

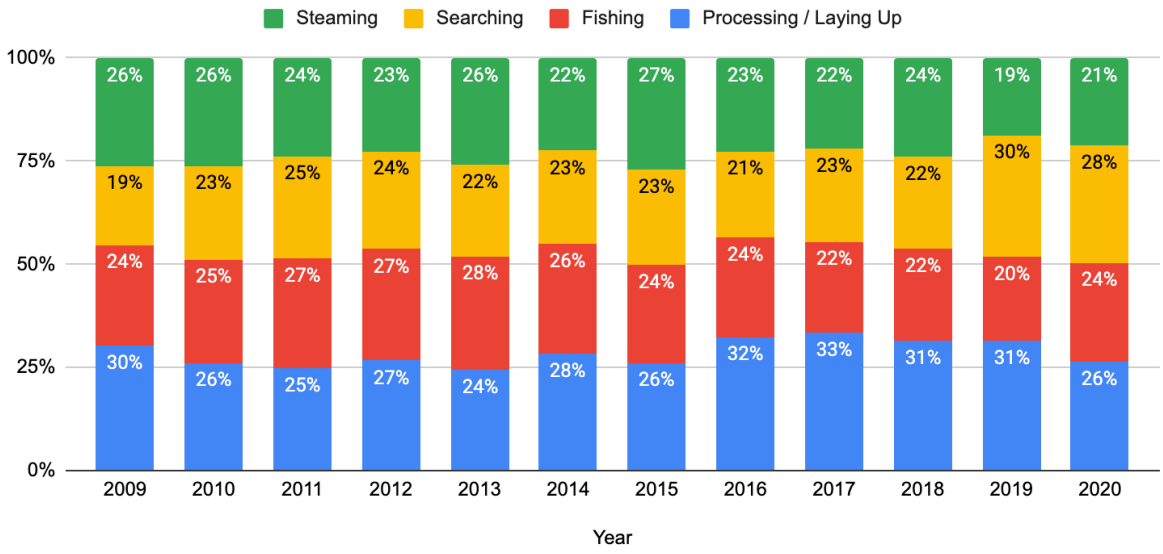
Table 24. Mean/Range Speed by Vessel State by Year for Project Participants

	Processing Speed (Kts)		Fishing Speed (Kts)		Searching Speed (Kts)		Steaming Speed (Kts)	
year	Mean	Range	Mean	Range	Mean	Range	Mean	Range
2008	0.7	0-1.8	3.3	1.8-4.9	6.5	5-7.8	9	7.9-13.6
2009	0.8	0-1.8	3.3	1.8-4.9	6.3	5-7.8	9.3	7.8-16.9
2010	0.8	0-1.8	3.4	1.8-5.2	6.7	5.2-8.1	9.4	8.2-12
2011	0.8	0-1.8	3.3	1.8-5.1	7	5.2-8	9.1	8-13.5
2012	0.8	0-1.7	3.3	1.7-5	6.9	5.1-7.9	9	7.9-17.2
2013	0.8	0-1.6	3.1	1.6-4.9	6.6	4.9-7.6	8.7	7.6-14.6
2014	0.6	0-1.7	3.4	1.7-5.1	6.8	5.1-7.8	8.9	7.8-15.3
2015	0.6	0-1.4	2.7	1.4-4.4	6	4.5-7.3	8.6	7.3-14
2016	0.5	0-1.5	2.9	1.5-4.7	6.7	4.8-7.8	8.9	7.8-17.5
2017	0.5	0-1.5	2.9	1.5-4.8	6.8	4.9-7.9	9.1	7.9-17.5
2018	0.6	0-1.5	3	1.5-4.8	6.7	4.9-7.9	8.9	7.9-16.5
2019	0.5	0-1.7	3.3	1.8-5.5	7.5	5.5-8.6	9.7	8.6-16.1
2020	0.5	0-1.5	3.0	1.5-4.7	6.5	4.8-7.7	8.9	7.7-15.4

Vessels owned by the herring participants spent roughly one quarter of their time at sea between 2010 and 2020 actively fishing, according to the analysis (Figure 2). Total time at sea includes time values for VMS segments, which were deemed as being part of a trip. These segments often include time spent transiting to and from port as well as actively processing/laying up, fishing, searching, and steaming. Initial versions of these data were reviewed with the project participants in June 2022. The herring participants suggested that the processing category might include observations in which a vessel was laying up, sleeping, or waiting out bad weather. The final behavioral states reflect this change.

Importantly, these behavioral states were not included in the final analysis of historical impact. Searching and processing/laying up behaviors are essential to fishing operations; however, quantifying their impact relative to fishing or steaming proved difficult given the constraints of the project. Further analysis should consider behavioral states in evaluating impact of WPLAs on historical fishing activity.

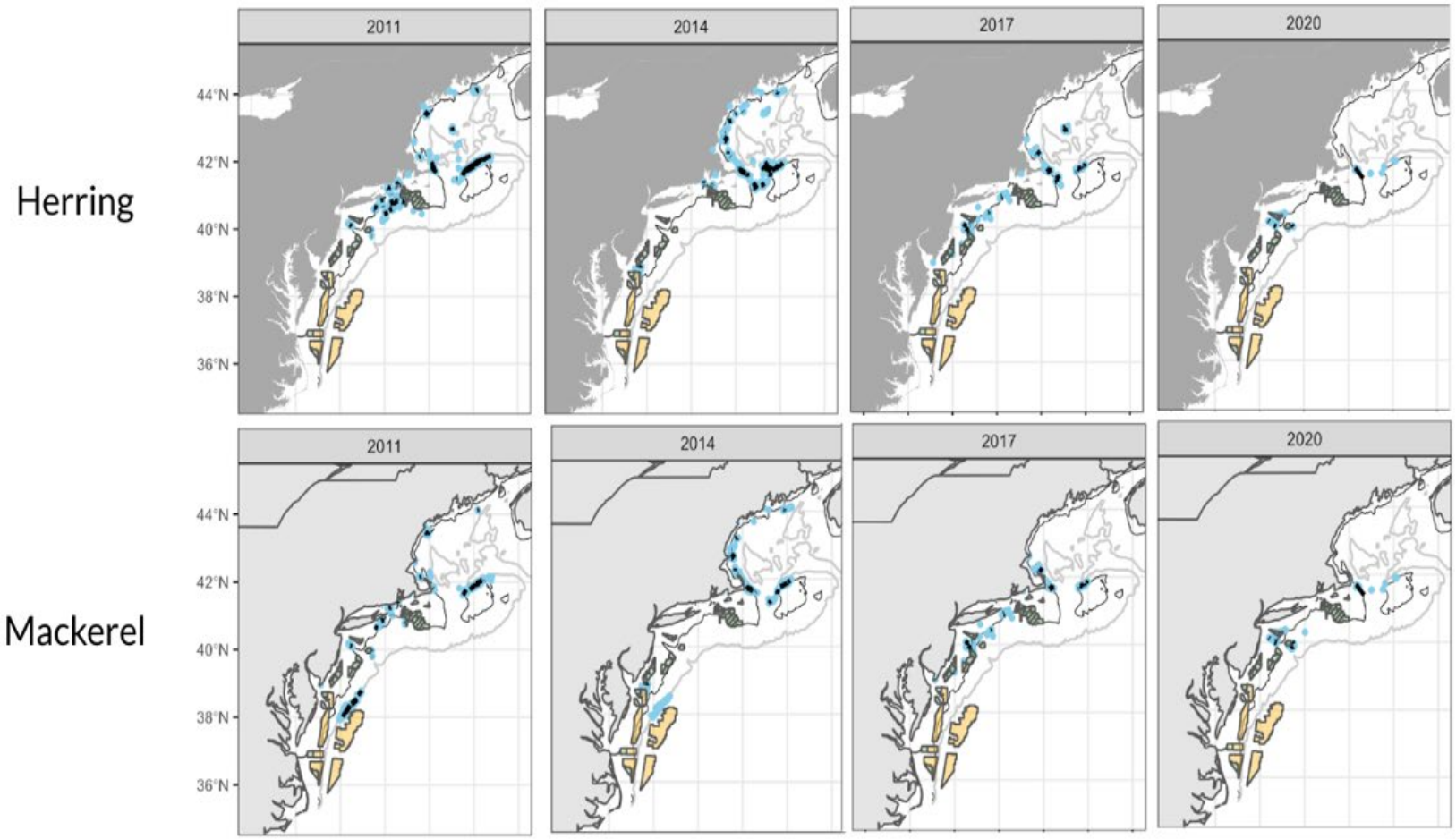
Figure 2. Share of Time at Sea by State for Herring Project Participants



OBS data were used to evaluate the accuracy of statistical classification of fishing behavior (Figure 3). These data include times and locations of fishing gear deployments and counts and weights of representative samples of fish caught on deployments. Of the 3,750 trips identified in the VMS data, 14.5% of those trips carried observers. Figure 3 plots fishing activity observed in the OBS data (black) overlaid over estimated fishing activity using the approach described above (blue).

Figure 3. Observed Fishing Trips Plotted against Classified Fishing Activity

Blue shading indicates observer data; black dots represent the state of fishing as identified by analysis; yellow areas represent wind planning areas; green areas represent wind lease areas.



3.2.5.3 Mapping Vessel Monitoring System Activity Over Wind Planning and Lease Area Footprint

OWED can impact a fishery either directly or indirectly. A WPLA can directly impact a fishery by overlapping with historical fishing, processing, searching, or steaming grounds. Indirect impacts on fishery activity can also occur outside of the designated areas: OWED may lead to increased competition for dock space or increase costs (shipping, fuel, ice) making some fisheries locally cost-prohibitive. The lack of dedicated transit lanes in WEAs can lead to extended transit times to the fishing grounds because of safety concerns over turbine structures in the lease areas. Due to the limited scope of the current study, only direct impacts were assessed. Moreover, "impact" was defined as instances in which VMS records occurred within the geo-spatial boundary of a WPLA.

All VMS segments (temporally sequential VMS records) were queried against the WPLA shapefiles. The operation could result in one of four outcomes. A segment could (a) not intersect at all with a WPLA, (b) be fully contained a WPLA, (c) partially intersect with a single WPLA, or (d) intersect with multiple WPLAs. Of the segments that intersect with any WPLA (b-d) between 2010–2020, 35% were fully contained (b), 55% partially intersected with a single WPLA (c), and 10% intersected with multiple WPLAs (Table 25).

Table 25. Categorization of Spatial Queries

Year	Total Segments Impacted	Fully Contained by WPLA		Partially Contained by WPLA		Intersects Multiple WPLAs	
		Number	%	Number	%	Number	%
2010	971	305	31%	539	56%	127	13%
2011	352	103	29%	207	59%	42	12%
2012	384	108	28%	233	61%	43	11%
2013	980	371	38%	524	53%	85	9%
2014	573	285	50%	251	44%	37	6%
2015	968	378	39%	483	50%	107	11%
2016	1,173	509	43%	523	45%	141	12%
2017	572	254	44%	262	46%	56	10%
2018	411	115	28%	275	67%	21	5%
2019	461	119	26%	294	64%	48	10%
2020	409	129	32%	238	58%	42	10%

Due to the scope of the pilot, a decision was made to limit the complexity of the analysis by characterizing any segment that intersected with at least one WPLA (b-d) as "impacted." It is important to note that including partially intersecting segments (c-d) technically overcounts impact. If a segment began outside but ended inside a WPLA, the entire time passed in that segment would be characterized as impacted. An WPLA boundary reflects an "imagined" boundary for fishermen: while it is a fixed boundary for wind developers. In practice, fishermen might choose to fish closer, or much farther away, from the WPLA boundary depending on turbine layout, weather, or risk tolerance of captains. Consequently, it is assumed that including partially intersecting segments affects the accuracy of the analysis and at worst reflects the most inclusive use of data that could have been used.

Figure 4. Plot of Historical Fishing Activity by Year over Wind Planning and Lease Areas

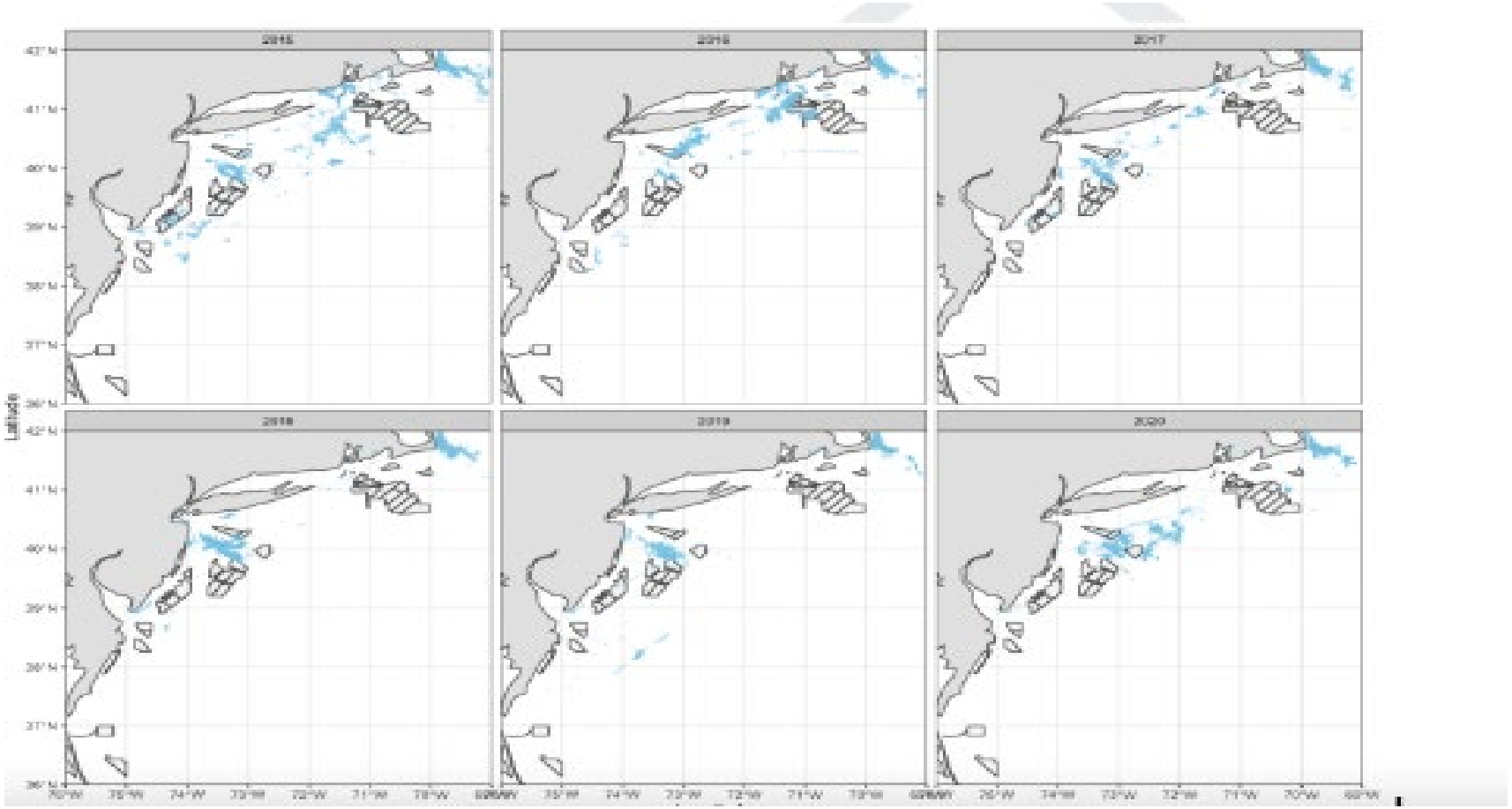
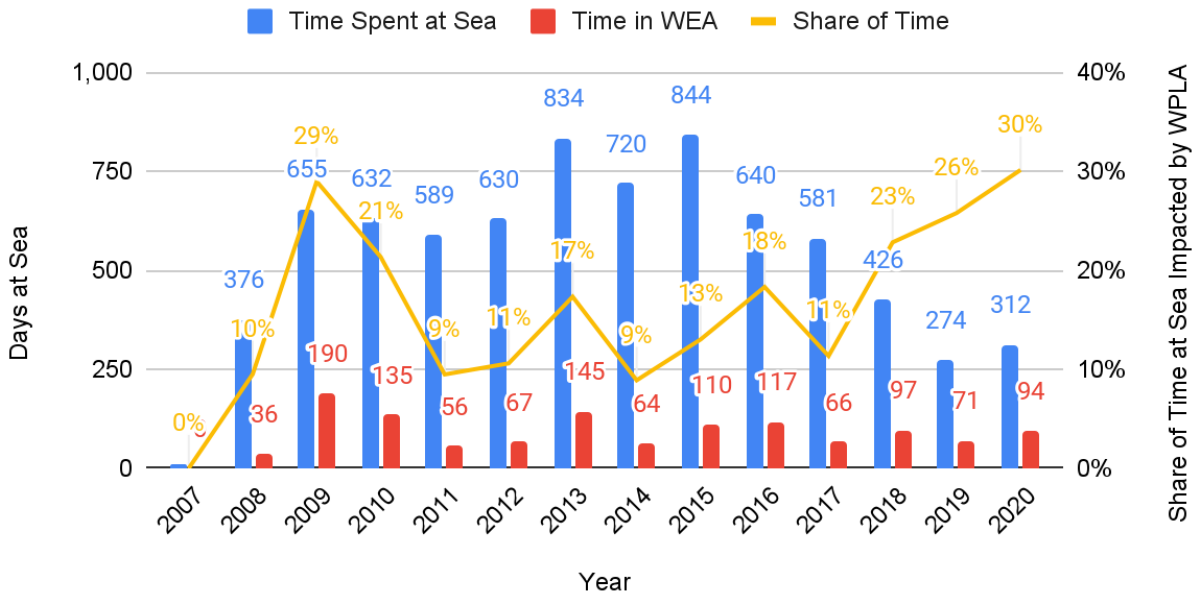


Figure 4 shows historical fishing activity by year over WPLAs. As the plot shows, the geospatial footprint of the Herring Participants varies substantially by year. Between 2010-2020, 17% of trips were impacted (e.g., intersected in any way) by a WPLA (Figure 5). Share of trips impacted increased from 9% in 2014 to 30% in 2020.

Figure 5. Share of Trips Impacted by Wind Planning and Lease Areas



Time spent in WPLAs was also calculated. Between 2010–2020, vessels owned by the project participants spent 2.5% of their time at sea in a WPLA. Share of Time at Sea in a WPLA increased from a low in 2011 (1.23%) to a high in 2016 (4.53%) (Table 26). These statistics were calculated at the WPLA level, so impact by each WLA and WPA was also determined. The overwhelming majority of time spent in WPLAs occurred in the WLAs due to the footprint of the herring participants; and between 2015–2020, six WLAs represented over half of the time spent in all WLAs.

Table 26. Time Spent by Herring Participants in Wind Energy Areas as Share of Total

Year	Time Spent at Sea (Days)	Time in WPLA (Days)	Share of Time (%)
2010	626	23	3.63
2011	572	7	1.23
2012	601	8	1.28
2013	799	19	2.42
2014	683	11	1.62
2015	795	18	2.24
2016	597	27	4.53
2017	536	11	2.03
2018	395	10	2.43
2019	251	9	3.72
2020	296	8	2.74

3.2.5.4 Estimating Historical Impact of Wind Planning and Lease Areas on Fishery

Measuring the impact of OWED on a given fishery is a complex and multifaceted process. Many factors beyond a fishery's historical overlap with an OWED area must be considered in order to fully understand the economic impact. Given the scope of the pilot, the current analysis only examines the overlap of OWED on fishery activity and landings for a portion of the total fleet. This represents the "Minimum Estimated Impact" for the vessels included in the analysis.

Four methods were considered and two were used to calculate minimum estimated impact. Table 27 shows a two-by-two quadrant describing four potential methods governed by (a) whether state is considered and (b) whether calculations are based on share of trips impacted or share of time impacted. Within each quadrant, the formula for the calculator is shown.

Behavioral state was not considered in the impact analysis for this study. The trip-based method attributes all herring and mackerel caught on a given trip as impacted if the vessel intersected at any point with a WPLA. The time-based method attributes herring and mackerel landings for a given trip based on the share of time at sea spent in a WPLA. For instance, if a vessel caught $10,000 in herring or mackerel on a given trip in which 1 of the 10 days at sea were spent in a WPLA, $1,000 would be classified as "impacted" by a WPLA.

Importantly, these methods only account for the minimum estimated impact on the fishery. They represent the direct impacts of a given spatial restriction on the historical catch of the vessels that participated in the project. As discussed above, these analyses should be viewed as foundational, and should not be used to measure the economic and social impact of OWED on the fishery.

Table 27. Methods for Measuring Minimum Estimated Impact of Wind Planning and Lease Areas on Fishery

Green: Methods Used White: Method Considered, Not Used.	Trip-based: If any part of trip is affected, all landings are attributed.	Time-based: share of time spent in WPLA is used to attribute impact.
All activity: Considers all " at sea" activity (fishing and seaming).	A: landings * (if any VMS segment in trip intersects = 1, if not = 0) = total impact.	B: landings * (Time spent for all activity in WPLA/Time spent for all activity at sea) = total impact.
Fishing: Considers only fishing activity.	C: landings * (if any VMS segment classified as fishing in trip intersects = 1, if not = 0).	D: landings * (Time spent for fishing activity in WPLA/Time spent fishing at sea) = total impact.

Trip-based estimates for historical impact of all WPLAs on the project participants range from $1.5 to $4 million annually (Table 28). In 2020, declines in overall landings were offset by increased share of trips impacted leading to $2.2 million in historical impact on the Herring Participants.

Table 28. Minimum Estimated Impact of Wind Planning and Lease Areas on Herring Participants (Trip-Based Method)

Year	Total Landings ($)	Minimum Share of Trips Impacted (%)	Minimum Impacted Landings ($)
2010	$9,402,035	25.00%	$2,350,509
2011	$10,156,159	16.00%	$1,624,985
2012	$11,084,594	15.00%	$1,662,689
2013	$13,010,559	23.00%	$2,992,429
2014	$13,442,501	11.00%	$1,478,675
2015	$15,154,006	18.00%	$2,727,721
2016	$16,908,430	22.00%	$3,719,855
2017	$17,224,421	9.00%	$1,550,198
2018	$11,711,648	22.00%	$2,576,563
2019	$7,790,029	36.00%	$2,804,410
2020	$6,216,711	35.00%	$2,175,849

The time-based method is a substantially more conservative approach. Estimated historical impacts range from $100,000–$700,000 between 2010–2020. In 2020, WPLAs impacted an estimated $186,501 in landings (Table 29).

Table 29. Minimum Estimated Impact of Wind Planning and Lease Areas on Herring Participants (Time-Based Method)

Year	Total Landings ($)	Minimum Share Impacted	Minimum Impacted Landings ($)
2010	$9,402,035	4.00%	$376,081
2011	$10,156,159	1.00%	$101,562
2012	$11,084,594	1.00%	$110,846
2013	$13,010,559	3.00%	$390,317
2014	$13,442,501	1.00%	$134,425
2015	$15,154,006	1.00%	$151,540
2016	$16,908,430	4.00%	$676,337
2017	$17,224,421	1.00%	$172,244
2018	$11,711,648	3.00%	$351,349
2019	$7,790,029	4.00%	$311,601
2020	$6,216,711	3.00%	$186,501

WLAs accounted for 78% of estimated impact using the time-based method. Table 30 shows the estimated impact using the time-based method for all WLAs between 2010–2020. Of the WLAs, the top 20% of the areas account for 44% of overall impact in the timeframe.

Table 30. Minimum Estimated Impact on Herring Participants by Wind Lease Areas using Time-Based Method (2010–2020)

WLA	Minimum Impacted Landings ($)	Share of Total WLA Impact
0486	$513,514.87	11.5%
0544	$464,528.26	10.4%
0512	$417,230.83	9.3%
0538	$300,676.47	6.7%
0500	$285,473.73	6.4%
0487	$277,027.76	6.2%
0537	$217,905.98	4.9%
0499	$211,149.21	4.7%
0532	$201,014.05	4.5%
0542	$195,946.47	4.4%
0539	$182,432.92	4.1%
0549	$172,297.75	3.9%
0506	$163,851.79	3.7%
0498	$157,095.01	3.5%
0541	$131,757.11	2.9%
0520	$121,621.94	2.7%
0534	$109,797.59	2.5%
0521	$106,419.20	2.4%
0501	$79,392.10	1.8%
0522	$48,986.62	1.1%
0517	$43,919.04	1.0%
0482	$20,270.32	0.5%
0508	$16,891.94	0.4%
0483	$15,202.74	0.3%
0490	$8,445.97	0.2%
0519	$5,067.58	0.1%
0497	$1,689.19	0.0%

3.2.6 Discussion

Through this pilot, the team was able to successfully establish a herring fleet database stored in the Trust and accessible by researchers. The herring fishery represented an ideal pilot fleet given its small size; however, challenges were experienced. The structure of the existing data request process, compounded by slow-downs related to COVID-19, posed substantial challenges for the pilot. However, working with the fishery and federal agencies, a new streamlined process for conducting large-scale, standardized data requests was developed. The efficacy of these new processes in enabling time-sensitive and consistent data requests is essential to the long-term success of the Trust.

Additionally, as delays were navigated, the herring participants were not sufficiently updated on developments, which left the project participants without a strong sense of control over its information. In serving as the Trustee for fisherman data, the Trust must ensure it continues to provide clear, consistent updates to owners on the status of their information and projects.

As discussed, the results offer a foundation for future analysis, but do not reflect the extent of the impacts on the fishery. The analysis shows that the WLAs have a material impact on the fishery. Between 2010–2020, 17% of trips intersected with at least on WPLA. However, further analysis is needed to fully determine the economic impact of the proposed OWED on the fishery. It's important to note that these figures represent the minimum estimated impact and do not consider indirect impacts such as economic multipliers or costs related to the rerouting of steaming paths. Further discussion of lessons learned and future research can be found in the conclusion.

3.3 Clam Pilot

3.3.1 Fishery Overview

The surfclam fishery may be highly impacted by OWED because of the overlap of their fishing footprint and the WPLAs (Kirkpatrick et al. 2017, 1–154). This makes it imperative to document and understand the surfclam fishery in terms of how it operates, its strengths and vulnerabilities, and its contribution to the broader culture and economy. The U.S. portion of the surfclam fishery generally concentrates on the populations off the coasts of New Jersey, southern New England, Georges Bank, and most recently off the southern portion of the Delmarva Peninsula. Other areas are closed due to environmental degradation or to toxins that cause paralytic shellfish poisoning.

Atlantic surfclams (Spisula solidissima) are distributed along the coast between the southern Gulf of St. Lawrence and Cape Hatteras, NC. The Mid-Atlantic Fishery Management Council manages surfclam in federal waters, greater than three miles from shore, but the species is also found in state waters less than three miles from shore. Surfclams are suspension feeders extending their siphon above the seabed to pump in water containing plankton. Surfclam distribution is sensitive to temperature changes in the Northwest Atlantic, with surfclam moving northward and into deeper waters (MAFMC 2022c) as ocean temperatures rise. The primary port of landings is also shifting north, with more surfclams landed north in New Bedford, MA and ports such as Chincoteague, VA no longer in use.

The commercial fishery is operated via an individual transferable quota program, which allocates the annual catch limit among individual fishermen or vessels. Vessels are not restricted by trip limits. The number of vessels participating in the surfclam fishery has been relatively stable for the last decade with a total of 43 vessels in 2020 (MAFMC 2022d).

The principal gear used in the fishery is the hydraulic clam dredge, which uses jets of pressurized water to dislodge ocean quahogs and surfclams from sediments. Dredge and hand harvest are authorized in the commercial fishery, with hydraulic clam dredges used as the primary gear type. There are no specific gear requirements for this fishery. However, all federally permitted fishing vessels use standard cages (dimensions of a clam cage are 5 ft. x 4 ft. x 3 ft.—cages are used to transport surfclams or ocean quahogs to the processor) and must tag cages before offloading with a tag issued by NMFS. Clam dredge gear is vulnerable to hanging up on cables, including those used in the transmission of offshore wind energy. Vessels also have severe maneuverability constraints during operations, which are major safety risks.

Processing of surfclams is highly specialized, which restricts the ability of vessels to find new or additional processors as fisheries shift from environmental and anthropogenic stressors. Additionally, clam processing is vertically integrated making it difficult for vessels to move operations to new ports. In 2021, there were eight processors who reported purchasing surfclams outside of Maine (MAFMC 2022d) with a majority processed in New York State, New Jersey, and Massachusetts. The 2021 average ex-vessel price of surfclams as reported by processors was $14.90 per bushel (1 bushel is approximately 17 pounds) resulting in a total ex-vessel value of $24 million (MAFMC 2022d).

Fuel costs and the availability of haulers are also affecting where landings can occur. Fuel costs further prohibit the ability to land further away from processing plants and then truck the product to the plant (MAFMC 2022c). If safety risk excludes clam dredge vessels from WPLAs, the reduced landings would also negatively impact those processors who specialize in surfclams. This could increase costs for both the processors and harvesters and drive both to switch to other species (Kirkpatrick et al. 2017).

3.3.2 Research Question

Similar to the Herring Pilot project, the purpose of the Clam Pilot project was to demonstrate the viability of the Trust by producing a foundational analysis using the Trust infrastructure. Moreover, two key research questions informed the Clam Pilot:

- Can the Trust successfully aggregate, validate, and integrate proprietary fleet-level data and knowledge and create basic, transparent analytical products?
- What is the scale of the likely financial and harvest impacts that the proposed and existing wind planning and lease areas (WPLAs) would have on historical fishing activity?

3.3.3 Participant Recruitment

Permit owners were recruited to participate in the pilot project between January and June 2020. Introductory conversations with members of the fleet were conducted via web conference. Clam participants participated in one webinar as well as several one-on-one conversations to learn about the goals and expectations of the pilot project and learn about the Trust. Once members of the clam participants agreed to participate, a NDA and MOU were signed between the Trust and the individual who controlled the necessary permits. The clam participants that chose to participate then selected a point of contact (POC) who served as the primary intermediary between the Trust and the clam participants for the remainder of the project.

Overall, four fishing organizations agreed to participate accounting for 71 permits in the Surfclam and Quahog fisheries between 2010–2020. Together, the permits belonging to the Clam Participants accounted for 84% of all permits issued for surfclam and ocean quahog between 2015–2020 (Table 31). Between 2015–2020, the clam participants accounted for 81% of surfclam landings and 89% of ocean quahog landings (Table 32).

Table 31. Clam Participants Share of Total Surfclam and Ocean Quahog Permits (2015–2020)

Source: NMFS clam vessel logbooks (MAFMC 2022c).

	Number of Surfclam or Quahog Permits		
Year	Total	Clam Participants	%
2012	42	31	74%
2013	40	32	80%
2014	38	32	84%
2015	37	33	89%
2016	38	34	89%
2017	40	32	80%
2018	39	34	87%
2019	43	34	79%
2020	43	34	79%

Table 32. Clam Participants Share of Total Surfclam and Ocean Quahog Landings (2015–2020)

	Surfclam Landings[a]			Quahog Landings		
Year	Total (bushels)	Participants (bushels)	%	Total (bushels)	Participants (bushels)	%
2015	2,354,000	1,931,744	82.1	3,022,000	2,542,752	84.1
2016	2,353,590	1,841,616	78.2	3,027,900	2,811,520	92.9
2017	2,192,000	1,710,736	78.0	3,172,000	2,766,080	87.2
2018	2,110,000	1,771,211	83.9	3,216,000	2,840,032	88.3
2019	1,943,000	1,609,064	82.8	2,460,000	2,279,712	92.7
2020	1,560,000	1,324,704	84.9	2,006,000	1,772,960	88.4

[a] 1 surfclam bushel is approximately 17 pounds.

3.3.4 Materials and Methods

The main sources of quantitative data for the analysis (Table 33) were federally reported data including standardized VMS, clam logbook vessel trip report (CLOG-VTR), dealer reports of landings (CLOG-DLR) maintained by the USDOC/NOAA/NMFS. Federal Observer data is not available for the surfclam and ocean quahog fishery. These data are all mandated by the U.S. government for fisheries monitoring and are vetted by NMFS.

Table 33. Quantitative Data Sources Used in Clam Pilot Project

Data type	Source	Use	Date Last Accessed
VMS	NOAA/GARFO	Vessel geopositions in time on fishing trips	2/10/2021
Clam Logbook dealer reports of landings (CLOG-DLR)	NOAA/GARFO	Fishing trip landings	12/10/20–2/22/21
Clam Logbook vessel trip report (CLOG-VTR)	NOAA/GARFO	Fishing trip purchase dates and times	12/10/20–2/22/21
OWED shape files	BOEM (https://www.boem.gov/renewable-energy/mapping-and-data/renewable-energy-gis-data)	Shapefiles describing wind planning areas (WPAs) and wind lease areas (WLAs) used in evaluating impact	07/03/22
Fishery regulation shapefiles	https://www.fisheries.noaa.gov/resources/maps	Show spatial regulation	12/4/2020

3.3.4.1 Wind Planning and Lease Areas Analyzed

The analysis considered two types of OWED areas as described in Section 3.1: Overview.

3.3.4.2 Aggregating Federal Reporting Data

Initially, the project planned to use VMS and landings data recently collected by the clam participants as part of a previous research project. However, based on further exploration, these data lacked the standardization and chain of provenance necessary to deliver on the governance policies defined in the section titled, Trust Manual. Project participants were contacted through the POC and all agreed to request updated VMS and landings data using the Trust's process.

A modified version of the streamlined process described in the Herring Pilot was used to request the data (see "Herring Pilot" for more details). Clam participants used the same standardized form and e-sign process used in the Herring Pilot, but authorized the POC, not the Trust, to serve as the Authorized Proxy. The Trust however still orchestrated the completion and delivery of the necessary forms to the government agencies.

Data requests were formally made in December 2020 and the last request was filled in July 2021. Delays were primarily caused by productivity declines at the Greater Atlantic Regional Fisheries Office (GARFO) related to COVID-19. However, delays in the Clam Pilot were also caused by legal complexities related to access to historical data. Permits are often sold, so database managers at GARFO and BLE needed to go through each permit to determine eligible dates for data collection for each current holder, in some cases receipts had to be reviewed or new vessel receipts issued that included historical data. Access to a single, responsive POC was particularly important during this phase.

The data were sent first to the POC who served as "authorized proxy" for the individual permit holders through a secure file transfer service operated by the government. The POC downloaded the files from the service and uploaded each file to the respective permit holder's datastore within the Trust. A preliminary visual analysis of the data was conducted by the Trust to ensure data provenance. The files were then manually reorganized and renamed to fit the conventions outlined in the Trust Manual.

3.3.4.3 Quantitative Data Integration and Cleaning

Basic quality checks were conducted on the data using the standard process described in Section 3.2: Herring Pilot. Additional scripts were developed and used for the clam logbook data (CLOG) data, which is unique to the surfclam and quahog fisheries.

3.3.4.4 Qualitative Information

Unstructured interviews were also conducted with both the POC and a captain from the project participants. These interviews were essential in collecting qualitative information relevant to the analysis pertaining to details about the fleet as well as fishing activity. For example, through interviews with the POC, a simple methodology was identified for differentiating between steaming and fishing activity: for vessels operating outside of the line of demarcation, vessels traveling under 4 knots would be fishing and over four knots would be steaming. The POC also explained nuances in the data by providing critical operational context, particularly around reporting behavior.

3.3.5 Analysis

3.3.5.1 Categorizing Vessel Monitoring System Data into Trips

Similar to vessels in the Herring Pilot project, vessels with surfclam and ocean quahog permits must declare their intention to take a trip prior to leaving the dock. These declaration codes, described in more detail in the Herring Pilot project are valuable in attributing a given trip to a specific fishery, but do not contain information needed to link the VMS records to a specific landing record.

Therefore, an analytical method was developed to identify VMS observations that reflected a vessel during a fishing trip versus one at port or transiting. Associating landings information with VMS records is particularly challenging in the surfclam and quahog fishery due to the unique way in which vessels report landings. Unlike other fisheries, the surfclam and quahog fisheries report landings through a fishery-specific program. The CLOG include information unique to the fishery such as bushels caught, which differ from the general VTR and DLR reporting requirements.

Importantly for this analysis, the CLOG data do not include the date or time information for date sailed and date sold available in the general landings' data set. Instead, the CLOG data only include a "date purchased" in day/month/year format. Consequently, the method used in the Herring Pilot project, which used the dates sailed and sold as time brackets, could not be used to define trips in the Clam Pilot project. Using only the purchase date information available in the CLOG data as the brackets for trips yielded substantial errors in trip identification since these periods included times in which the vessel was not actively at sea.

To address these issues, an alternative methodology was developed. CLOG-DLR data was used to define trip windows, primarily because it was more straightforward to join CLOG-DLR data to the DLR data that was used to provide a bridge to linking landings to dock using vessel, dealer, port, and state information. The purchase dates of successive surfclam and quahog trips were used to set the maximum interval between trips for each vessel. Thus, the time window for any clam trip would be bound by the previous purchase date and the purchase date in the current record. For the first trip record in the CLOG-DLR for a vessel (i.e., one with no previous trip data), the previous purchase date was set to one week before the recorded purchase date. Individual CLOG-DLR records are identified by the

"pr_rec_id" field. In lieu of a direct approach to assigning CLOG-DLR "pr_rec_id" trip record identifier to VMS data, the following logic was applied to link CLOG-DLR trips to VMS data. For each vessel trip in CLOG-DLR CLD data the corresponding VMS data that fell between 00:00 on the previous purchase date and 04:00 on the day after the purchase date as landings that occurred overnight could be recorded as a purchase on the previous day.

Vessel paths were identified from VMS position and timestamp data by identifying the first time a vessel crossed from "inside" the demarcation line—three miles off the U.S. coast—into federal waters and then the final return across the demarcation between sequential purchase dates in CLD data. This process was conducted for all VMS records from January 1, 2008 to December 31, 2020.

Error rates for the methodology were on average below 10%. Successful trips were those in which the corresponding VMS records began and ended at the line of demarcation. However, three types of errors occurred: (1) a trip could begin at the line of demarcation and never return, (2) begin outside of the line of demarcation and return, or (3) begin outside of the line of demarcation and end outside the line of demarcation. Table 34 shows the error rates by year.

Table 34. Error Rates in Trip Identification

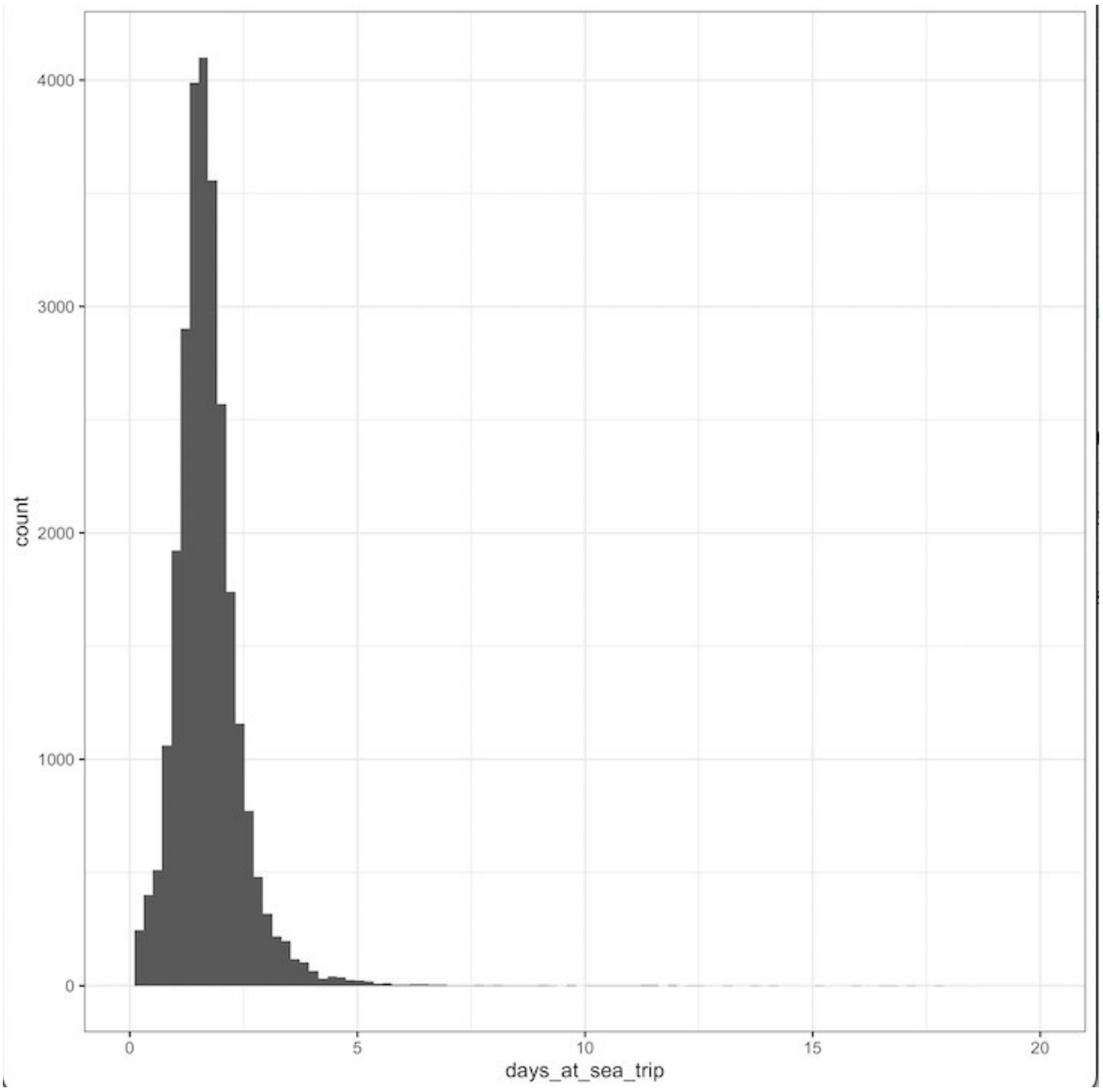
Year	Total Trips	Successfully Identified (%)	Error: No Return (%)	Error: No Departure (%)	Error: Other (%)
2010	239,360	73.98	0.45	2.47	23.09
2011	244,544	89.64	0.00	0.00	10.36
2012	199,808	91.11	0.48	0.83	7.57
2013	204,352	94.55	0.00	0.00	5.45
2014	199,264	92.55	1.20	0.00	6.24
2015	245,312	94.63	1.98	0.13	3.27
2016	294,624	96.24	0.00	0.00	3.76
2017	307,904	95.54	0.33	0.00	4.13
2018	218,304	92.44	0.47	0.00	7.09
2019	235,776	91.00	0.08	0.37	8.55
2020	162,016	85.58	1.26	0.00	13.15

Table 35 shows summary statistics for trip identification for the clam participants. Between 2010–2020, the clam participants took an average of 2,066 trips per year with a mean duration of 1.7 days that covered a mean distance of 160 nautical miles. Figure 6 shows that trips are mostly normally distributed. Interviews were conducted with the POC to ensure these findings reflected best understanding of historical activity from the project participants.

Table 35. Summary Statistics for all Trips Taken by Clam Participants per Year

Year	Number of Trips	Mean Annual Time at Sea (Days)	Mean Annual Distance Traveled (NM)
2008	1,607	1.4	117.2
2009	2,013	1.5	130.6
2010	2,013	1.6	145.2
2011	1,969	1.7	147.9
2012	2,149	1.6	158.4
2013	2,227	1.6	157.9
2014	2,208	1.6	163.3
2015	2,271	1.6	165.3
2016	2,294	1.8	178.5
2017	2,181	2.0	189.3
2018	2,258	1.8	169.2
2019	2,018	1.8	168.1
2020	1,653	1.9	186.4

Figure 6. Histogram of Trip Lengths (Days)



3.3.5.2 Classify Vessel Movements by Behavioral State

Identifying the behavioral state of a VMS segment was therefore critical to the analysis. Unlike other forms of fishing, clams are a mostly stationary species. Subsequently, clam fishermen often return to the same fishing ground for months if not years and thus operate in one of two states: fishing or steaming. Fishing activity therefore is both uniquely valuable, and easily identifiable, in the surfclam and ocean quahog fishery. Through interviews with the clam participants, it was determined that line segments with a total speed less than 4 knots were classified as “fishing” and those with speed over 4 knots were classified as “steaming.”

Table 36 shows estimated time spent fishing and time spent steaming for the clam participants by year. In 2020, for instance, clam participants spent an estimated 69% of its time fishing beyond the line of demarcation representing 36% of distance traveled.

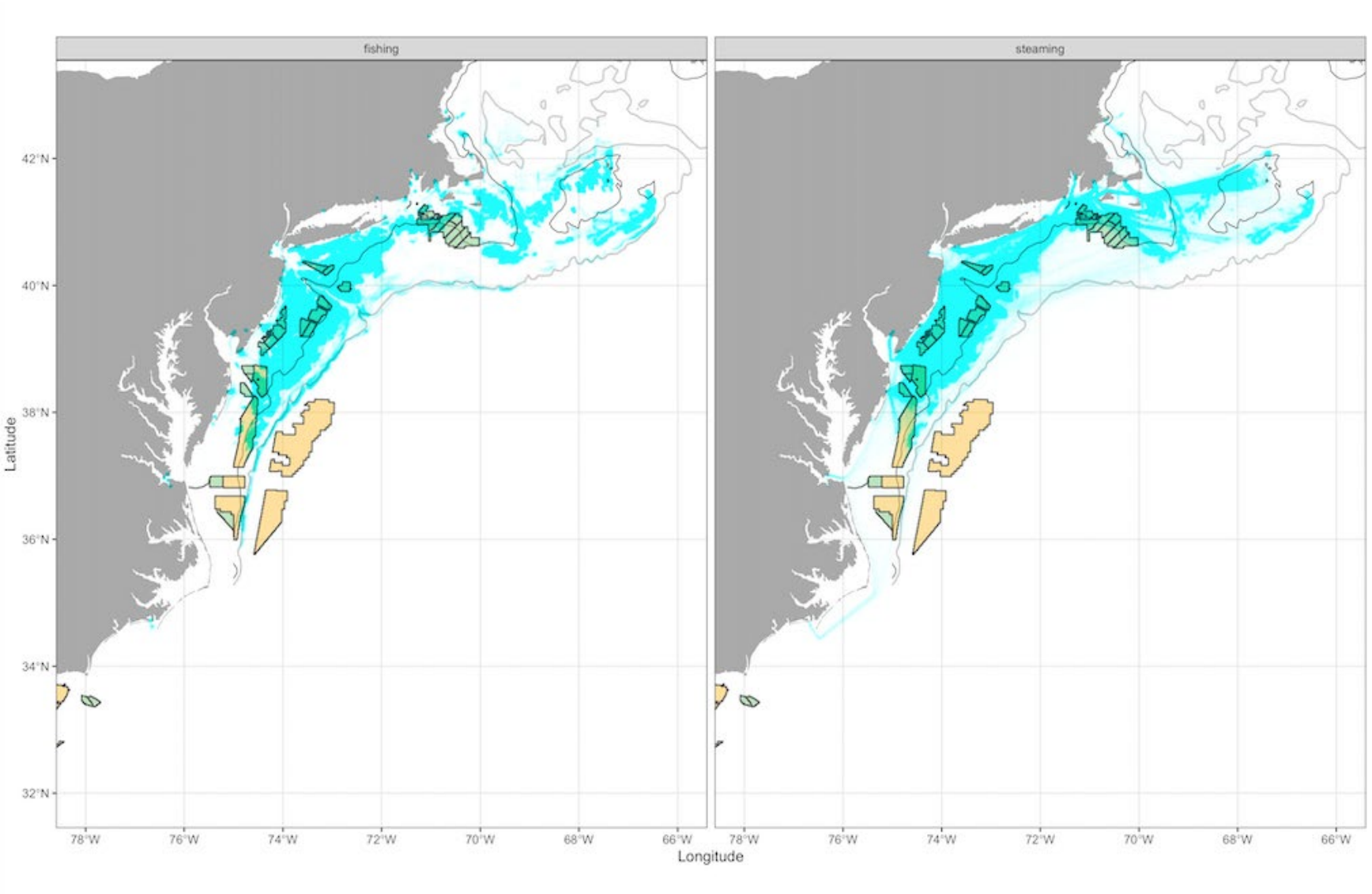
Table 36. Time Spent Fishing versus Steaming for Clam Participants by Year

	Time Spent Outside Demarcation Line		Distance Traveled Outside Demarcation Line	
Year	Steaming (%)	Fishing (%)	Steaming (%)	Fishing (%)
2009	27%	73%	70%	30%
2010	26%	74%	66%	34%
2011	29%	71%	69%	32%
2012	35%	65%	74%	27%
2013	36%	64%	75%	25%
2014	38%	62%	77%	23%
2015	37%	64%	75%	25%
2016	34%	66%	74%	26%
2017	32%	68%	67%	33%
2018	33%	67%	67%	33%
2019	33%	67%	59%	41%
2020	31%	69%	65%	36%

3.3.5.3 Mapping Vessel Monitoring System Activity Over Wind Planning and Lease Area Footprint

All VMS segments (temporally sequentially VMS records) were queried against the WPLA shapefiles. With over a decade of data for many vessels (nearly 10 million records), completing the operation posed a significantly greater computational challenge than with the Herring Pilot. To reduce computational load, VMS segments were first queried against an aggregate shapefile of the WPLA regions; then, only if the location was within the aggregate region were the VMS segments queried against the 29 WLAs and 10 WPAs. This method can and should be used in analyzing spatial overlaps in any fishery with large amounts of data. Figure 7 shows a heatmap of fishing and steaming activity for clam participants between 2010–2020 overlaid over the WPLAs. Both figures demonstrate visually that there is substantial overlap between historical activity of clam participants and WPLAs.

Figure 7. Plot of Historical Vessel Activity by State for Clam Participants



As with the Herring Pilot project, the operation could result in one of four outcomes. A segment could (a) not intersect at all with a WPLA, (b) be fully contained by a WPLA, (c) partially intersect with a single WPLA, or d) intersect with multiple WPLAs. Of the segments that intersect with any WPLA (b-d) between 2010–2020, 52% were fully contained (b), 41% partially intersected with a single WPLA (c), and 7% intersected with multiple WPLAs (Table 37). A decision was also made in the Clam Pilot project to limit the complexity of the analysis by characterizing any segment that intersected with at least one WPLA (b-d) as "impacted."

Table 37. Categorization of Spatial Queries

Year	Total Segments Impacted	Fully Contained by WPLA		Partially Contained by WPLA			
		Number	%	Number	%	Number	
2010	43,610	23,997	55%	16,372	38%	3,241	
2011	33,316	16,517	50%	14,411	43%	2,388	
2012	34,198	18,484	54%	13,890	41%	1,824	
2013	31,956	16,601	52%	13,329	42%	2,026	
2014	32,261	16,408	51%	13,721	43%	2,132	
2015	29,254	13,884	47%	13,443	46%	1,927	
2016	40,437	22,441	55%	15,666	39%	2,330	
2017	49,000	26,616	54%	19,228	39%	3,156	
2018	44,397	23,153	52%	17,565	40%	3,679	8%
2019	39,518	18,357	46%	17,161	43%	4,000	10%
2020	42,961	24,178	56%	15,845	37%	2,938	7%

Based on the analysis described above, time spent and distance traveled through WPLAs were calculated. Between 2015–2021, clam participants spent an estimated 15.4% of their total time fishing and 18.9% of their total time steaming within a WPLA. Both measures increased between 2015 and 2020 with the share of time fishing and steaming in a WPLA rising from 11% and 17.5% respectively in 2015 to over 19% and 21% respectively in 2020 (Table 38).

Table 38. Time Spent by Clam Participants Fishing and Steaming in Wind Planning and Lease Areas as Share of Total

Year	Fishing			Steaming		
	Time at Sea (Days)	Time in WPLAs (Days)	Share of Time at Sea	Time at Sea (Days)	Time in WPLAs (Days)	Share of Time at Sea
2010	2,810.00	450.9	16.05%	1,007.3	155.0	15.39%
2011	2,422.63	317.5	13.11%	1,008.2	192.8	19.13%
2012	2,299.53	331.5	14.41%	1,243.1	225.6	18.15%
2013	2,442.32	369.8	15.14%	1,400.2	254.3	18.16%
2014	2,406.98	345.7	14.36%	1,476.1	251.6	17.04%
2015	2,483.84	273.4	11.01%	1,426.3	249.0	17.46%
2016	2,829.40	421.9	14.91%	1,429.9	250.6	17.52%
2017	2,941.67	517.0	17.57%	1,366.6	259.0	18.96%
2018	2,857.11	422.7	14.80%	1,392.5	259.9	18.66%
2019	2,445.05	371.5	15.19%	1,225.9	244.3	19.92%
2020	2,323.36	442.3	19.04%	1,051.0	222.2	21.14%

3.3.5.4 Minimum Estimated Impact of Wind Planning and Lease Areas on Fishery

A method similar to the Herring Pilot project was used to estimate the historical impact of proposed OWED on the clam participants. Given the scope of the pilot, the current analyses only consider the overlap of OWED on historical fishery activity and landings for a portion of the fleet. As discussed in Section 3.2: Herring Pilot, these estimates only represent the "minimum estimated impact" on the clam participants.

Six methods were considered in the analysis. Table 39 shows a two-by-three quadrant describing six potential methods governed by (a) whether state is considered and (b) whether calculations are based on share of trips impacted, share of time impacted, or share of distance impacted. Within each quadrant, the formula for the calculations is shown.

Based on discussions with the POC, different methods were selected for minimal estimated impact on the herring pilot. First, state was considered in the analysis. As discussed earlier, estimating state is simpler with vessels in surfclam and quahog than in the herring and mackerel fisheries. Moreover, only fishing activity (under 4 knots) was considered. (See Section 3.3.5.2: Classify Vessel Movements by Behavioral

State for more information on methodology). Second, the trip-based method was not used in this analysis. Third, distance, not time, was used. Both measures correlate substantially, but POC felt that distance represented a more accurate representation of effort given for the fishery. In order to remain transparent, results from both distance and time-based methods were included below.

Table 39. Methods for Measuring Minimum Estimated Impact of Wind Planning and Lease Areas on Fishery

Green: Methods Used White: Method Considered, Not Used	**Trip-based: If any part of trip is affected, all landings are attributed**	**Time-based: Share of time spent in WPLA is used to attribute impact**	**Distance-based: Share of distance traveled in WPLA is used to attribute impact**
All activity: Considers all "at sea" activity (fishing and seaming)	A: landings * (if any VMS segment in trip intersects = 1, if not = 0) = total impact.	B: landings * (Time spent for all activity in WPLA / Time spent for all activity outside line of demarcation) = total impact.	B: landings * (Distance traveled for all activity in WPLA / Distance traveled for all activity outside line of demarcation) = total impact.
Fishing: Considers only fishing activity	E: landings * (if any VMS segment classified as fishing in trip intersects = 1, if not = 0).	F: landings * (Time spent for fishing activity in WPLA / Time spent fishing outside line of demarcation) = total impact.	F: landings * (Distance traveled for fishing activity in WPLA / Distance traveled for fishing outside line of demarcation) = total impact.

Both methods demonstrated substantial annual impact on the fishery. Between 2010–2020, the WPLAs impacted between $77 million (time-based method) and $89 million (distance-based method) in landings (Figure 8). Annual impacts for both methods range from $6–$10 million in impact annually. The overwhelming majority of impacts (>98%) come from the WLAs with little impact from the WPAs (Table 40).

Figure 8. Estimated Historical Impact of Wind Planning and Lease Areas by Method (2010–2020)

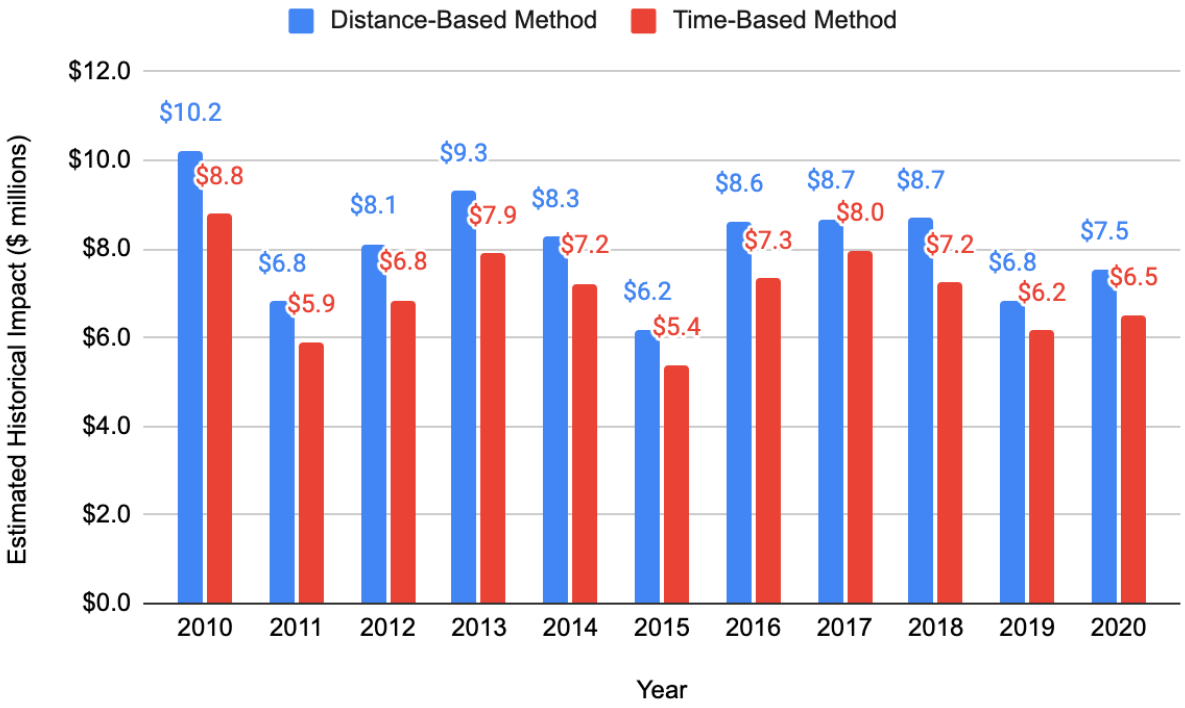


Table 40. Minimum Estimated Impact of Wind Planning and Lease Areas on Clam Participants by Year (Time-Based Method)

	Wind Lease Areas			Wind Planning Areas		
Year	Total Landings ($)	Share Impacted	Impacted Landings ($)	Total Landings ($)	Share Impacted	Impacted Landings ($)
2010	$49,675,533	17.7%	$8,782,634	$49,675,533	0.0%	$0
2011	$47,057,534	12.5%	$5,896,309	$47,057,534	0.0%	$4,706
2012	$49,527,392	13.8%	$6,844,686	$49,527,392	0.0%	$4,953
2013	$50,432,153	15.6%	$7,877,502	$50,432,153	0.1%	$25,216
2014	$48,440,396	14.9%	$7,212,775	$48,440,396	0.0%	$14,532
2015	$48,210,785	11.1%	$5,365,860	$48,210,785	0.0%	$4,821
2016	$48,983,195	15.0%	$7,327,886	$48,983,195	0.0%	$0
2017	$46,706,136	17.1%	$7,963,396	$46,706,136	0.0%	$4,671
2018	$48,171,339	15.0%	$7,220,884	$48,171,339	0.0%	$9,634
2019	$41,418,904	14.8%	$6,121,714	$41,418,904	0.1%	$41,419
2020	$33,288,990	19.5%	$6,504,669	$33,288,990	0.0%	$0

Table 41. Minimum Estimated Impact of Wind Planning and Lease Areas on Clam Participants by Year (Distance-Based Method)

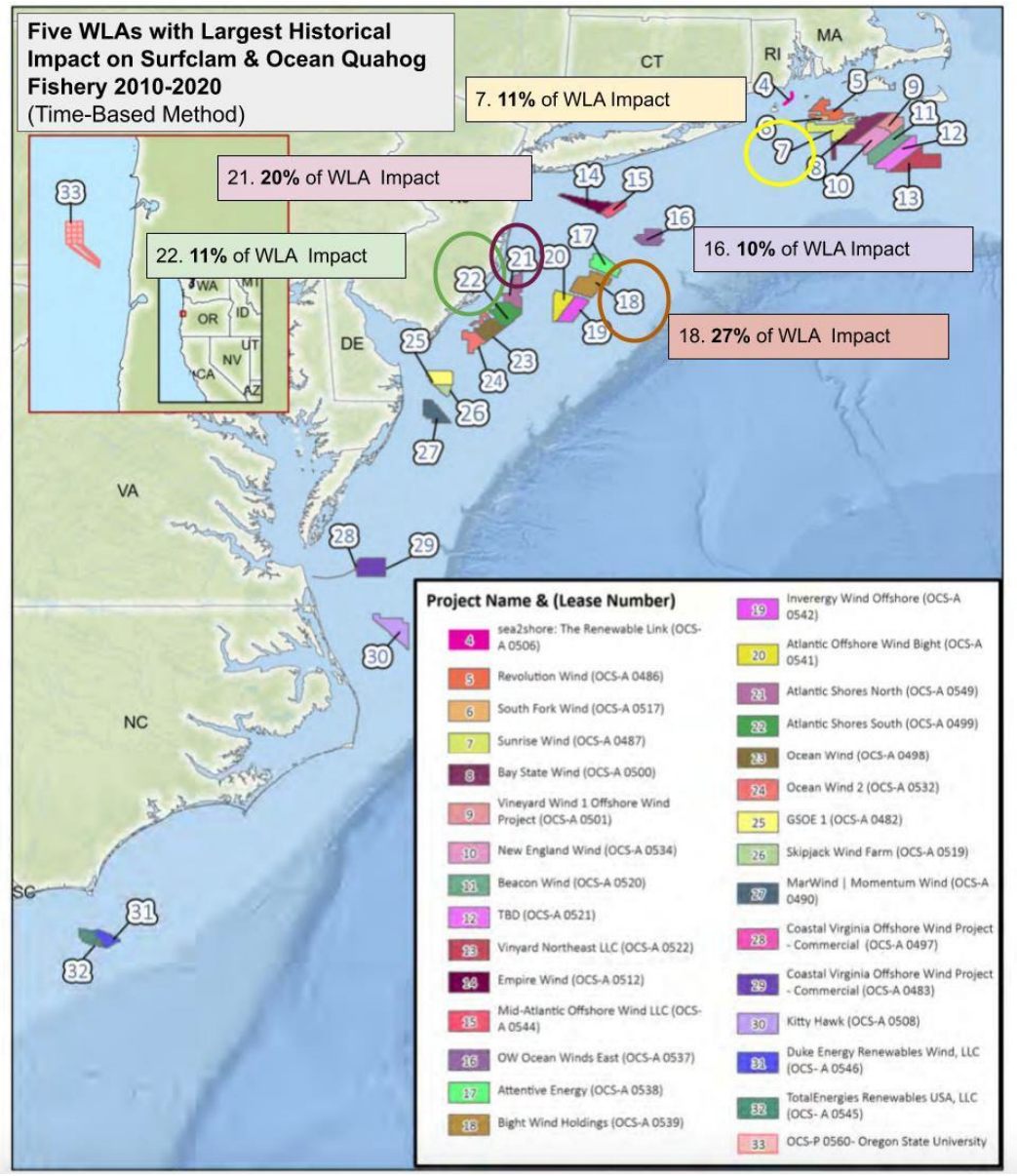
	Wind Lease Areas			Wind Planning Areas		
Year	Total Landings ($)	Share Impacted	Impacted Landings ($)	Total Landings ($)	Share Impacted	Impacted Landings ($)
2010	$49,675,533	20.6%	$10,223,225	$49,675,533	0.0%	$0
2011	$47,057,534	14.5%	$6,813,931	$47,057,534	0.0%	$9,412
2012	$49,527,392	16.4%	$8,112,587	$49,527,392	0.0%	$4,953
2013	$50,432,153	18.4%	$9,259,343	$50,432,153	0.1%	$45,389
2014	$48,440,396	17.0%	$8,249,399	$48,440,396	0.1%	$29,064
2015	$48,210,785	12.8%	$6,170,980	$48,210,785	0.0%	$4,821
2016	$48,983,195	17.6%	$8,621,042	$48,983,195	0.0%	$0
2017	$46,706,136	18.6%	$8,678,000	$46,706,136	0.0%	$4,671
2018	$48,171,339	18.0%	$8,690,110	$48,171,339	0.0%	$9,634
2019	$41,418,904	16.4%	$6,776,133	$41,418,904	0.2%	$62,128
2020	$33,288,990	22.7%	$7,546,614	$33,288,990	0.0%	$0

The fishery is primarily impacted by a handful of WLAs (Table 42). The WLAs with the largest impact between 2010–2020 account for 78% of the total impact for all WLAs. As depicted in Figure 1, these include Community Offshore Wind (OCS-A 0539), Atlantic Shores North (OCS-A 0549), Atlantic Shores South (OCS-A 0499), Sunrise Wind (OCS-A 0487), and OW Ocean Winds East (OCS-A 0537).

Table 42. Estimated Landings Impacted by Wind Lease Area

Historical Impact 2010–2020				
	Time-Based Method		Distance-Based Method	
WLA	Share of Total WLA Impact	Impacted Landings ($)	Share of Total WLA Impact	Impacted Landings ($)
0539	27%	$21,295,554	30%	$26,568,251
0549	20%	$15,203,797	21%	$18,633,610
0499	11%	$8,446,554	11%	$9,828,717
0487	11%	$8,190,598	8%	$7,473,920
0537	10%	$7,422,729	10%	$9,214,422
0541	5%	$3,532,195	4%	$3,941,725
0542	4%	$3,122,665	4%	$3,583,386
0498	3%	$2,508,371	3%	$2,508,371
0486	3%	$2,354,797	2%	$1,842,884
0500	3%	$2,201,223	3%	$2,354,797
0532	1%	$1,126,207	1%	$1,330,972
0538	1%	$819,060	1%	$972,633
0512	1%	$563,104	1%	$511,912
0501	0%	$307,147	0%	$409,530
0544	0%	$307,147	0%	$307,147
0490	0%	$102,382	0%	$102,382
0506	0%	$102,382	0%	$153,574
0517	0%	$102,382	0%	$102,382
0534	0%	$102,382	0%	$102,382
0519	0%	$51,191	0%	$51,191
0482	0	$0	0%	$0
0483	0	$0	0%	
0497	0	$0	0%	$0
0508	0	$0	0%	
0520	0	$0	0%	$0
0521	0	$0	0%	$0
0522	0	$0	0%	$0

Figure 9. Five Lease Areas with Largest Historical Impact 2010–2020 Using Time-Based Method



3.3.6 Discussion

The Clam Pilot project was designed as a "stress test" for the Trust due to both the size of the fleet and availability of data. The number of permits included in the analysis was substantially larger than in the Herring Pilot. The Clam Pilot included 71 vessels representing over 80% of both the overall permits issued for the fishery and overall landings during the past decade. With 12 years of historical

VMS and landings data, the pilot analyzed over 10 million observations. Additionally, the analysis was substantially more challenging due to the unique fishery reporting requirements. Since the surfclam and ocean quahog fisheries only report the date of purchase, existing methods to identify trips and associating landings to VMS data also proved challenging.

The success of the pilot demonstrated the feasibility of the Trust in working with a larger fleet, but also highlighted several technical and organization limitations of the Trust. From a governance perspective, the Trust was able to convince a large, highly organized, and competitive fishery to share trade secrets into a common infrastructure. Additionally, the Trust's emphasis on industry collaboration proved essential for the researchers in developing solutions to the challenges described above. And technically, the Trust was able to clean, standardize, and operationalize a substantial data set for use by analysts.

However, the choice of infrastructure presented challenges for the analysis. The Trust infrastructure was designed to optimize control for owners, which comes at the cost of analytical efficiency. Researchers were able to conduct the analysis using the file structure architecture, but it did present several challenges for large-scale processing. Conducting the spatial queries on VMS segments was particularly computationally intensive: processing the entire fleet took well over 4 days of computational time even after time-saving adjustments were made.

The results of the study reinforce existing findings: the surfclam and ocean quahog participants are materially impacted by the WLAs. Two methods were used to estimate impact: (1) a time-based method, which estimated impact by multiplying landings per each trip by the share of time spent fishing in WPLAs by overall time spent fishing on a given trip, and (2) a distance-based method, which estimated impact by multiplying landings per each trip by the share of distances traveled while fishing in WPLAs by overall distance traveled while towing gear fishing on a given trip Between 2010–2020, the WLAs the estimated impact over $75 million in total landings. These estimated impacts were primarily concentrated in five lease areas, which accounted for 78% of estimated historical impact during this period: Community Offshore Wind (OCS-A 0539), Atlantic Shores North (OCS-A 0549), Atlantic Shores South (OCS-A 0499), Sunrise Wind (OCS-A 0487), and OW Ocean Winds East (OCS-A 0537).

3.4 Conclusion

3.4.1 Lessons Learned

The purpose of the pilot projects was to demonstrate the viability of, and help shape, the design of the Trust. As described earlier, the success of these projects was measured by the ability to validate three sets of assumptions critical to the long-term success of the Trust: motivation of key communities to participate, ability for those communities to participate, and the ability to positively impact the management process.

Overall, researchers looking to crowdsource fishery data should consider four main takeaways from the projects:

1. **Communicate Consistently:** Establishing confidence is built by people, but it's sustained through communication. Maintaining that confidence requires consistent and transparent communication. The biggest mistake was not communicating project delays to the project participants.
2. **Collaborate on Methodology:** Collaborating on methodology with key stakeholders not only improves the quality of analysis, but it generates buy-in to the results of that analysis from the stakeholders that matter in the decision-making process.
3. **Aggregate Insights, Not Data:** Data is a resource, not a commodity. It needs to be tended to maintain its value. Without the proper context, researchers will not believe the data enough to use it. Consequently, it is critical that data is collected in the context of a specific project that solves an urgent, material problem for those involved. Otherwise, participants will not make the "soft investments" (e.g., answering questions from researchers, providing critical context) needed for successful analysis.
4. **Commitment to Robust Analysis:** Regulatory decisions are often made under significant time pressure. Meeting these deadlines requires researchers, regulators, and fishery participants to navigate tradeoffs between robustness and the timeframe of an analysis. Researchers must ensure that they can develop minimal viable analysis that both meet the standards of best available science, while also meeting the time sensitivity of many regulatory decisions.

Key lessons learned from conducting the pilots are described in Table 43.

Table 43. Lessons Learned from Pilot Projects

Assumption	Criteria	Lessons Learned
Motivation	On-water stakeholders are willing to share confidential federally reported data with the Trust.	Utility, not necessarily security, was the top barrier to fishermen sharing data. Many fishermen have participated in past projects, but never saw the value. The ability to “remove access” at any time was a valuable capability for the Trust. Consistent communication is absolutely essential. Fishermen will not think about the project for months. However, if they feel like they do not know what is happening with their data, the project will be at risk.
Motivation	On-water stakeholders are willing to share qualitative data (e.g., surveys) with the Trust.	Fleets showed a varying willingness to share qualitative data through surveys. Some fleets are reticent to use captains time for research purposes.
Motivation	On-water stakeholders are willing to work with researchers to inform proper interpretation of the data.	Involve fleets in the analysis. Both fleets were willing to support Researcher questions. Involvement not only improved the products but built trust with the fishery as well in the outcome.
Capability	The data necessary to complete the analysis existed in a structured format.	The federal government does not have a primary key that links VMS and Landings data. Many researchers inside the government use the methods described in this paper to conduct similar research. When fulfilling data requests, database managers will often adjust data structure to make the data more human readable. This created substantial issues for the project team and raw data is preferred to reduce such issues.
Capability	The data could be accessed and collected in a scalable way from the source.	Requesting federal fishery data is a time-consuming, non-standardized process. Find and build a relationship with the database manager responsible for executing the requests. Agencies responsible for data are not used to receiving requests that require standardization. Ensure data is transferred exactly as it exists in the system. Pre-fill all forms with the necessary information. Add in the permit numbers, names of individuals etc. Use an e-sign workflow where possible to get signatures from fishermen. If requested, federal agencies will accept e-sign documents. Fishermen do not live at their computers. This can substantially delay the data request process. Where possible, request data “proxy” status.
Capability	The data could be standardized and aggregated into a standard format.	Standardization is absolutely essential. Before onboarding a new data type, make sure a clear schema has been developed and vetted with experts in the source format. Ensure all fields match existing formats so that combining new data with existing data is seamless.

Table 43 continued

Assumption	Criteria	Lessons Learned
Capability	The data could be analyzed in a way that met the confidentiality requirements of the on-water stakeholders.	Interpersonal trust is king. Although governance processes matter, fishermen trusted the researchers with the data because they trusted the members involved with the project. Ensure that a trusted member of the fishery is working closely with the project.
Capability	The data could be analyzed in a way that provided the necessary documentation to enable transparency and reproducibility.	Metadata is essential to reuse. Make sure to include metadata in each file with information about who did the analysis as well as the scripts which produced the data file. The existing infrastructure prioritized control for the owners over efficiency. An online (spatial) database as a service would provide a more robust platform/interface for managing data, standardizing queries, and producing analyses and reports.
Value	Ind energy developers trust the credibility of methods used and data collected in the analysis.	For government data, “provenance” was not as big of an issue as expected. The bigger issue was providing access to documented code that underlaid the analysis.
Value	Stakeholders in the on-water community view the products as valuable.	Seeing is believing for many fishermen. It’s critical to show actual interim products in order to solicit feedback.

3.4.2 Future Research

The analysis conducted in both pilots represents a foundational analysis to evaluate the historical impacts of WPLAs on the respective participants. The aggregation and processing of movement and landings data paired with the foundational analysis conducted provide a valuable foundation on which further analysis of fishery impact can be conducted. The high-spatial resolution of the data used in the pilot project will continue to be valuable in understanding the impact of OWED on a fishery. This project underscores the importance of using FDD, straight from fishermen, to improve understanding and quality of analysis.

First, the existing analysis does not provide a comprehensive view of the economic impact of OWED on these fisheries. Given the scope of the pilots, the existing analysis does not consider a range of factors including temporal trends in fishery activity, economic multipliers of fishery impact across coastal communities, and costs related to transit route disruption. Researchers could address these questions with limited additional data collection from the fishery.

Second, these analyses can be relatively easily replicated for other fisheries and OWED regions. Using the Trust governance model and scripts developed in the pilots, regulators and researchers can relatively rapidly assess the historical impact of OWED on specific fisheries. Once the data is requested by the project participants and returned to the Trust, the Trust can replicate these analyses with a small, incremental effort in a fraction of the time.

Third, these data provide an important foundation for understanding the impact of *any* spatial intervention in a fishery, such as a protected habitat regulation. Using these data and the analysis scripts developed, impacts of other spatial regulations can be assessed with incremental investment.

4 Go-Forward Plan

The Trust has already seen substantive interest from researchers working on projects related to FDD. In spring 2022, the Trust was awarded a funding grant from SeaGrant, in conjunction with the University of Maine and the Maine Lobstermen's Association (MLA), to demonstrate the viability of crowdsourcing plotter data in the Maine lobster fleet. The fishery has long been "data poor," and aggregating movement and activity data will provide essential information for future conflicts resolution between OWED projects and the fishery, as well as within the fishery itself. Additionally, discussions have occurred with several other fishing groups interested in developing analyses to better understand how OWED impacts their fishery.

The overarching imperative for the Trust over the next 12–24 months will be to recruit new projects while ensuring its model is both operationally and economically feasible. Key strategic goals include the successful execution of new projects, winning funding opportunities to develop a next generation infrastructure, and building a core team of full and part-time employees. To achieve these goals, the Trust needs to ensure it has an efficient and effective education and outreach strategy, a clear and responsible hiring plan, and sustainable economic model to underpin these efforts.

4.1 Education and Outreach Strategy

The Trust's mission is to help regulators make informed and equitable decisions about MRM by providing researchers with secure access to confidential information collected by the fishing industry. However, given limited resources, it's imperative for the Trust to define a select set of specific ways in which the Trust would be used ("Use Cases.") Additionally, before developing an outreach plan, it's essential that the Trust identify the stakeholders involved in these use cases and define the value the Trust could bring to their work.

4.1.1 Target Use Cases

Conflict between OWED and fisheries is a pressing and widespread problem facing the MRM community. Regulators urgently need access to FDD to ensure impact on existing fisheries is minimized and members of fisheries across the country recognize the value in participating. Additionally, FDD will play a critical role in helping to inform mitigation compensation discussions between wind

developers and members of the fishery. In the longer term, the Trust is also well-positioned to influence the fisheries management process as well. Interviews with researchers, fishermen, and regulators all suggest that substantial demand exists for Trust services to help inform regulatory decisions including stock assessments, benchmarks, protected species restrictions, and more.

Over the next 12–24 months, the Trust will focus on developing and delivering solutions to address both wind-fishery and fishery management conflicts. Table 44 describes several types of use cases for the Trust within each area and outlines a set of questions the Trust could help answer with FDD. Conflicts related to minerals are not included but the Trust will actively monitor for future opportunities.

Table 44. Target Use Cases for Fisheries Knowledge Trust

Type	Use Case	Description of Process	Potential Questions
Wind-Fishery Conflict	Wind Lease Design and Planning	BOEM is responsible for designing and managing wind lease areas, which have potential impact on fishing operations.	Where is a fishery primarily executed? How is a fishery using their fishing grounds?
	Mitigation Compensation	Federal and state guidance (under development) recommends that wind energy developers provide compensation to members of the fishery impacted by deployments; developers may also negotiate this privately.	Socioeconomic footprint of fishing communities built around each fishery and how OWED changes communities over time.
Fishery Management	Stock Assessment Updates	NMFS conducts stock assessments for fish species that have substantial impact on regulatory decisions made by regional councils.	Sensitivity of stock assessments to changes in FDD and survey data inputs.
	Stock Benchmarks	Assessments are updated with new data each year.	Same as stock assessment updates.
	Protected Resources	Regional Fishery Management Councils and NMFS develop fishery management measures to minimize impacts on protected resources for some fishery management plans;. NMFS also issues an allowed take of marine mammals for each OSW project, which undergoes a public comment period.	How much are protected resources seasonal distributions overlapping with WPLAs? Does this distribution change because of any phase of an OWED project?

4.1.2 Key Audiences

Wind-Fishery and fishery management conflicts involve a similar, but somewhat divergent, set of stakeholders. The key audiences include the seafood industry, which provides the data, researchers who build scientific products informed by data, and regulators who make decisions based on the research. Additional audiences also include non-governmental organizations (NGOs) involved in environmental and other forms of advocacy as well as energy companies (e.g., wind developers) involved in extracting marine resources.

Table 45. Target Audiences for Trust over the Next 12–24 Months

Audience	Description	Examples	Role
Seafood Industry Members	Fishermen, processors, and other members of the commercial fishing industry provide the data and insights for which the Trust was designed to collect.	Commercial fishing organizations/businesses /seafood processors, independent fishermen/crew, vessel owners, owner/operators, vertically integrated businesses.	Provide access to data and insights.
Marine Regulators	Federal and state regulators must have faith in the products produced from data and insights within the Trust or data collection and analysis will not be trusted. These regulators, the process which they follow, vary substantially by the type of resource (e.g., fish, wind) and geography.	Regional fishery councils, BOEM, NOAA.	Make decisions about marine resource management.
Researchers	Scientific analysis is essential to the regulatory process of any marine resource. Federal agencies (e.g., NOAA, BOEM), academic institutions (e.g., University of Massachusetts Dartmouth School for Marine Science and Technology, University of Rhode Island, University of Maine), private interest groups fund and conduct research that plays an important role in management decisions by Marine Regulators.	NMFS, Regional Fishery Management Councils, ASMFC.	Use data and insights to answer questions relevant to marine resource management.
Non-Governmental Organization	Independent organizations aligned around a common interest or mission (e.g., environmental protection, industry trade groups). Often serve as Interest Groups but also fund and conduct research.	The Nature Conservancy, Oceana, Conservation Law Foundation.	Effectively collaborate with local fisheries to develop regulations.
Wind Developers	Energy companies developing OWED.	Orsted North America, Equinor ASA.	Conduct research for impact analyses.

4.1.3 Value Proposition

In order to develop an effective messaging and outreach plan, it's important for the Trust to clearly define its value proposition to key stakeholders. Table 46 describes the value and differentiation of the Trust to the primary audiences (seafood industry, researchers, regulators) as well as the features within the Trust that support those statements.

Table 46. Value Proposition by Audience Type

	Seafood Industry	Researchers	Regulators
Primary Value	Providing confidential fishery information to the Trust.	Build scientifically rigorous products using fisheries information.	Using products developed in the Trust to inform decisions.
Key Differentiation	Never lose control over your data. Get your voice heard at a fraction of the cost.	Dramatically accelerate the data collection process for fishery research. Don't deal with complexities of collecting and managing confidential data.	Trust in the source of the data and analysis in products Ensure decisions are made with a full view of impact.
Supporting Features	Built on Dropbox Enterprise, you can remove access whenever you want. Always see who has access to your information Trust governance policies ensure data is interpreted correctly.	Federally reported data for over 70 vessels already structured and cleaned. Standardized request, cleaning of data, and aggregation scripts for common federal reporting types. Well-developed governance policies to enable owners to share information.	All code used to integrate data and develop products is documented and reproducible. Advisory and Review panels ensure analysis conducted meets "best available science" standard. Provenance of data is reviewed by Trust to ensure no tampering from source.

4.1.4 Education and Outreach

Successful onboarding of new projects is paramount to the success of the organization. To recruit projects, the Trust will take a two-pronged strategy. First, the Trust will invest in dramatically increasing awareness of the organization among the research community through a broad public launch and communications campaign. Second, the Trust will target specific communities (namely, fishing fleets facing wind energy conflicts) with direct outreach educating them about the potential of working with the Trust like both the clam and herring pilots. While under the current contract, the project will consult with NYSERDA before engaging in any of the outreach tactics described in Table 47.

Table 47. Strategies and Tactics for Trust in 2023

Strategy	Tactics	Elements
Increase awareness of the Trust within Research Community	Joint "Public Launch" of Trust in conjunction with NYSERDA Marketing efforts.	Update website, social media channels with new messaging.
		Speak at industry conferences and other public events.
		Write guest Op-Eds for relevant media sites.
		Apply for "innovation" and other awards.
	Engage researchers at key institutions (e.g., BOEM, NOAA, Universities) about Trust.	Conduct "lunch and learn" webinars explaining the Trust.
		Create materials around best practices for developing science using fishery information.
		Share tools (e.g., request forms, data models) with research community.
Co-Develop Wind Projects with Fleets	Increase awareness of pilots within fishing community.	Speak at industry conferences and other public events.
		Conduct webinar with "pilots" fleets to describe experience working with Trust.
	Direct outreach to target fleets.	Target fisheries with highest potential wind impacts.
		Develop "packaged" research offering with select researchers.

4.2 Growth Plan and Key Performance Indicators

Three distinct growth phases for the Trust have been identified. In Stage 1, the key focus will be on maintaining the infrastructure and projects with a minimal team; in Stage 2, focus will shift to generating incremental traction through the existing team and independent contractors; and in Stage 3, investments will be made to substantially grow both the staff and output of the organization.

Table 48 describes the goals, timeframe, key performance indicators (KPIs), and staffing levels for each stage. The goal is to shift from Stage 1 to Stage 2 by the end of Year 1 and shift from Stage 2 to 3 during Year 2.

Table 48. Growth Stages for Trust

Stage	Goals	Time Frame	KPI	Staffing
Stage 1	Maintain existing infrastructure. Generate handful of new projects.	6-8 months	3 new projects recruited. 1 grant application submitted.	Part-time work from existing team. In kind contributions from RODA.
Stage 2	Maintain existing infrastructure Close enough projects/grants to justify full-time leader.	Estimate time frame 3-5 Months	2 new projects recruited. 1-2 grant application won.	Part-time work from existing team. In kind contributions from RODA. 2 independent contractors.
Stage 3	Maintain existing infrastructure. Substantially expand the reach of the Trust. Invest in next-generation technological and governance infrastructure.	12+ months	5 new projects recruited. 1-2 grant application won.	Full-time executive director. Full-time Trust administrator.

4.3 Hiring Plan

One of the main goals of the Trust over the next 12–24 months is to build a small full-time staff that can rapidly grow and effectively operate the Trust infrastructure. Four key roles were identified, most of which can be filled by a single individual as the Trust grows, but eventually should be full or part-time positions. The staffing model for the Trust was developed to minimize non-project related expenses. In Table 49, core responsibilities for each role are outlined and broken out by general administrative and project-based needs.

Table 49. Roles and Responsibilities for Trust Team Members

Role	General Responsibilities	Requirements
Executive Director	Admin Responsibilities: 70% of the time promote confidence among key constituencies. Recruit and prioritize projects. Raise funding through grants. Manage staff and finances. Project Responsibilities: 30% of the time negotiate funding for projects.	Experience with and Trust in fishery management community. Strong leadership and management skills. Clear vision for future of the Trust.
Community Manager	Admin Responsibilities: 20% of the time Engage researchers interested in the Trust. Engage regulators interested in the Trust. Project Responsibilities: 80% of the time Educate researchers and other project participants on Trust structure and rules. Manage questions/concerns from data owners.	Deep relationships in the fishery management community. Clear understanding and ability to communicate Trust vision and value proposition.
Trust Manager	Admin Responsibilities: 40% of the time. Manage existing Trust infrastructure. Monitor data usage. Manage governance process including depreciation and access requests outside project. Develop and manage product and services roadmap. Project Responsibilities: 60% of the time Onboard new projects and data owners into Trust. Enable, monitor, and remove access to Trust data during projects. Develop new technical capabilities (e.g., data standards, changes to file structure) necessary for project.	Proficient in R and other coding languages Experience at data management Interest in Data Trust and other shared data models
Project Manager	Admin Responsibilities: 0% of the time Project Responsibilities: 100% of the time Develop and manage project plans to ensure services are delivered successfully. Ensure projects meet and follow governance requirements of Trust.	Technical project management experience. Experience in fisheries researcher.

The speed at which staff is brought on the team will depend on new projects and funding secured by the Trust. The goal over the next year is to generate enough funding to support a full-time executive director and technical trust administrator. Table 49 outlines staff and the roles they will play for each of the growth stages defined above. Each stage is determined by a gate that depends on the team's success in achieving the previous goal (new projects and funding sources).

Table 50. Staffing Plan Next 12–18 Months

Phase / Gate	Title	Type	Roles
Phase 1 Gate: NYSERDA funded project completed	*Acting* Director Steven Jacobs, SquareThread	Founding Team	Executive Director Trust Manager
	Community Lead Fiona Hogan, RODA	Founding Team	Community Manager Project Manager
Phase 2 Gate: At least 2 projects committed.	*Acting* Director Steven Jacobs, SquareThread	Founding Team	Executive Director
	Community Lead Fiona Hogan, RODA	Founding Team	Community Manager Project Manager
	Technical Contractor TBD	Part Time	Trust Manager
Phase 3 Gate: 3+ projects committed and grant funding secured.	Executive Director TBD	Full Time	Executive Director Community Manager
	Trust Administrator TBD	Full Time	Trust Manager Project Manager

4.4 Funding and Financial Model

4.4.1 Revenue Streams

The Trust has two main sources of funding: fee-for-service charges to projects using the Trust and funding opportunities for specific investments. By design, individuals or groups who share data with the Trust are not charged for storage needs related to storage of their information. Incremental storage costs are limited with the current infrastructure and "free storage" removes any additional barriers to adoption by fishermen and other members of the industry. See: "How to Price a Project in Operating Manual" for a more detailed discussion about the way in which project fees are calculated.

- **Project Fees:** Each project pays a one-time fee to use the Trust. The fee is determined using a simple pricing model that includes three factors: labor related to execution of projects, incremental technology costs (e.g., Dropbox licenses), and an overhead fee, which is 30% of the total costs of the project.
- **Funding Opportunities:** The Trust will apply for funds to support both projects using the Trust (as co-PI) as well as specific investments in the Trust itself (e.g., building new data models or updating technology).

4.4.2 Operating Costs

The Trust has two types of costs (billable and nonbillable) across two categories (technology and labor). Billable costs are paid by project fees for specific projects. Non-Billable costs include general and administrative labor and technology infrastructure costs (e.g., base plans for Dropbox, Github). Today, back-office costs such as insurance, legal, and Human Resources are covered by RODA. These costs would shift to the Trust if a decision was made to make the Trust an independent organization. Technology costs are mostly subscription-based (e.g., Dropbox) and can be scaled up and down on a monthly basis based on the number of individuals who need access. Labor costs include both project-based contractors and eventually full-time employees.

Table 51. Types of Costs for the Trust

		Types of Expense	
		Billable	Non-Billable
Category of Cost	Labor	Community management. Trust administration. Project management. Incremental updates to Trust related to project.	Infrastructure management. Marketing and communications. Community (data owner). Management.
	Technology	Incremental seats for Dropbox. Enterprise required on projects. Other technology costs.	Core Dropbox Enterprise subscription.

4.4.3 Financial Model by Growth Stage

As the Trust acquires new projects and hires staff, revenues and expenses will fluctuate substantially. Moreover, it's critical the Trust ensures that the growth and hiring plan described in previous sections is economically viable. To evaluate this, a Pro Forma financial model was developed to estimate non-billable costs and revenues over the next 24 months. The model is developed around the three growth phases described in Table 48 and includes assumptions about the number of new projects acquired and staff hired. Table 52 describes estimated revenue and costs for year 1 and 2 as well as key assumptions (e.g., grants won, timing of stages) that inform the model.

Table 52. Pro Forma Financial Plan for Trust

Element	Year 1	Year 2
Total Revenue	$25,350	$113,232
Project Overhead Revenue	$12,850	$33,232
Project Recruited	5	9
Avg. Trust Fee	$15,392	$15,392
Overhead Share	30%	30%
Avg. Length of Project	10	10
Grant Overhead Revenue	$12,500	$80,000
Grants Won	1	2
Avg. Size of Grant	$150,000	$150,000
Overhead Share	40%	40%
Avg. Length of Grant	24	24
Overhead Costs	$24,065	$110,185
Stage 1	0 – 9 Months	--
Stage 2	9-12 Months	--
Stage 3	--	13-24 Months
Net Income	$1,285	$3,047

4.5 Conclusion

Conversations with the MRM community throughout this project clearly demonstrate the need for the Trust and its services to address a range of pressing issues. Members of the fishing community have already expressed interest in both conducting impact assessments, like the pilots, in other fisheries across the United States as well as using the existing data to understand the impact of other proposed spatial fisheries management decisions. Given the urgency with which the federal government is pursuing the development of renewable infrastructure, navigating wind-fishery conflicts is posed to be a top issue for both members of the fisheries and regulators over the next several years. In particular, the use of the Trust to improve understanding on “data poor” fisheries by aggregating proprietary data, such as ongoing Maine Lobster project, present a substantial opportunity to dramatically improve the regulatory process around OWED.

The success or failure of the Trust will depend first and foremost on the ability to secure participation by fishermen. Without the participation and trust of fishermen, the organization cannot succeed. The Trust must be able to build awareness around the Trust in the fishing community and spend the necessary time to educate fishermen on the organization's goals and policies. Additionally, the Trust must also work to educate users of the infrastructure such as researchers about these same policies and ensure that products developed on the Trust are trusted by MRM regulators. To achieve these goals, the Trust must secure the financial resources needed to build a committed and skilled team of contractors and employees. Building this team will require not only additional grant funding but the commitment of the MRM community to not only use but pay for Trust products and services.

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Appendix A. Detailed File Structure for Knowledge Trust

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
fisheries knowledge trust	Fixed	Folder				
datastore	Fixed	Folder	fisheries knowledge trust	datastore	Securely store data needed for fishery research	- All files should use snake_case - All data files should be kept in comma separated values (csv) where possible
fdd	Fixed	Folder	datastore	datastore/ fdd	Data generated from the fishery including government reporting data (VMS, landings, observer, study feet) as well as other data provided by industry	n/a
reference	Fixed	Folder	fdd	datastore/fdd/reference	Reference tables documenting key metadata about the fishery (including owners, vessels etc)	n/a
operator.csv [example reference table]	Variable	File	"reference"	datastore/fdd/reference/operator.csv	Reference table	- Follow general conventions - Name should only include simple name (ex: operators.csv) – no year, author etc. - Only tables (.csv) should be in this folder
[FKT1234*]	Variable	Folder	fdd	datastore/fdd/FKT1234*	Individual data stores for members of the fishery, which include core operational and reporting data	- FKT[Anonymous ID] - Ex: FKT1234
agreements	Fixed	Folder	[FKT1234*]	datastore/fdd/ fkt1234*/agreements	Executed onboarding documents made between owner and Trust (NDA & MOU)	n/a
data_requests	Fixed	Folder	agreements	datastore/fdd/ fkt1234*/agreements/data_requests	All signed requests forms including both authorization and request forms	-

Appendix A continued

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
landings_offspring_p12314_nov2020_auth_request	Variable	File	data_requests		Data request and authorization forms	- [data type]_[vessel name]_[permit number]_[date]_[request type] - ex: landings_offspring_p12314_nov2020
mou_1234.pdf	Variable	File	agreements	datastore/fdd/fkt1234/agreements/mou_fkt1234.pdf	Executed memorandum of understanding between Trust and Owner	- mou_[fkt#].pdf - ex: mou_1234.pdf
nda_1234.pdf	Variable	File	agreements	datastore/fdd/fkt1234/agreements/mou_fkt1234.pdf	Executed non-disclosure agreement between Trust and Owner	- nda_[fkt#].pdf - ex: nda_1234.pdf
onboarding		Folder	agreements	datastore/fdd/fkt1234*/agreements/onboarding	all onboarding agreements including NDA and MOU	- nda_[fkt#].pdf
FKT1234.rproj	Variable	File	[FKT1234*]	datastore/fdd/fkt1234*/fkt1234.rproj	R project file for owner folder	- [fkt#].rproj - ex:fkt1234.rproj
processed	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/processed	Fully processed fishery dependent data files provided by owner. "Processed" files have all been standardized in file name, data structure, and formatting. For more information, see here	N/A
vms	Fixed	Folder	processed	datastore/fdd/fkt1234*/processed/vms	Processed vessel monitoring system (vms) data for directory owner	n/a
vms_1234_pr.csv	Variable	File	vms	datastore/fdd/fkt1234*/processed/vms/vms_1234_pr.csv	File contains all "processed" vms data for all years / all permits owned by the owner	- vms_[fkt#]_pr.csv - ex: vms_1234_pr.csv
landings	Fixed	Folder	processed	datastore/fdd/fkt1234*/processed/landings	1 or 2 files of landings data for all boats / all years for the owner.	n/a

Table A continued

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
landings_vtr_1234_pr.csv	Variable	File	landings	datastore/fdd/fkt1234*/processed/landings/landings_vtr_1234_pr.csv	Fishermen reported landings for all years / all vessels	- landings_vtr_[fkt#]_pr.csv - Ex: landings_vtr_1234_pr.csv
landings_dlr_1234_pr.csv	Variable	File	landings	datastore/fdd/fkt1234*/processed/landings/landings_dlr_1234_pr.csv	Dealer reported landings for all years / all vessels	- landings_dlr_[fkt#]_pr.csv - Ex: landings_dlr_1234_pr.csv
observer	Fixed	Folder	processed	datastore/fdd/fkt1234*/processed/observer	Single data file for all observer data for all permits / all years for owner	n/a
observer_1234_pr.csv	Variable	File	observer	datastore/fdd/fkt1234*/processed/observer/observer_1234_pr.csv	Single data file for all observer data for all permits / all years for owner	- observer_[fkt#]_pr.csv - Ex: observer_1234_pr.csv
studyfleet	Fixed	Folder	processed	datastore/fdd/fkt1234*/processed/studyfleet	Single data file for all studyflet data for all permits / all years for owner	n/a
studyfleet_1234_pr.csv	Fixed	File	"studyfleet"	datastore/fdd/fkt1234*/processed/studyfleet/studyfleet_1234_pr.csv	Single data file for all studyflet data for all permits / all years for owner	- studyfleet_[fkt#]_pr.csv - Ex:studyfleet_1234_pr.csv
readme.md	Fixed	File	processed	datastore/fdd/fkt1234*/processed/readme.md	Documentations and instructions for data included in processed folder. Includes: Name of owner, Contact information, Researcher who processed data, Processing script, Restrictions, Date each data was downloaded, Links to original files in raw directory, See full list here: https://bit.ly/2JmFdqR	Always: readme.md
products	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/products	All appropriate outputs from analysis conducted within the Trust	

Appendix A continued

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
raw	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/raw_organized	Includes core fishery dependent data (VMS, landings etc) in "raw" state directly from the owner without any manipulation from the Trust.	n/a
vms	Fixed	Folder	raw	datastore/ fdd/ fkt1234*/ raw_organized/vms	"Unprocessed" vms data files with updated conventions	n/a
[permit#]	Variable	Folder	vms	datastore/fdd/fkt1234*/raw_organized/vms/[permit#]	"Unprocessed" vms data files with updated conventions for specific permits	- [permit number] - Ex: 592187
vms_fkt1234_4320_2020.csv	Variable	File	[permit#]	datastore/ fdd/ fkt1234*/ raw_organized/vms /[permit#]/[[year]/vms file	"Unprocessed" vms data files with updated conventions for specific permits by year.	- vms_[fkt#]_[permi#]_[year].csv - Ex: vms_1234_402321_2020.csv
landings	Fixed	Folder	raw	datastore/fdd/fkt1234*/raw_organized/landings	"Unprocessed" landings data files with updated conventions	n/a
landings_dlr_1234.csv	Variable	File	landings	datastore/fdd/fkt1234*/raw_organized/landings/landings_dlr_1234_pr.csv	"Unprocessed" reported landings for all years / all vessels	- landings_dlr_[fkt#].csv - Ex: landings_dlr_1234.csv
landings_vtr_1234.csv	Variable	File	landings	datastore/fdd/fkt1234*/raw_organized/landings/landings_vtr_1234_pr.csv	"Unprocessed" reported landings for all years / all vessels	- landings_vtr_[fkt#]_pr.csv - Ex: landings_vtr_1234_pr.csv
observer	Fixed	Folder	raw	datastore/fdd/fkt1234*/raw_organized/observer	"Unprocessed" observer data files with updated conventions	n/a
observer_1234_402321_2020.csv	Variable	File	observer	datastore/fdd/fkt1234*/raw_organized/observer/observer_1234_402321_2020.csv	All observer data... likely a single file	- observer_[fkt#].csv - Ex: observer_1234.csv
studyfleet	Fixed	Folder	raw	datastore/ fdd/ fkt1234*/ raw_organized/studyfleet	"Unprocessed" study fleet files with updated conventions	n/a

Appendix A Continued

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
observer_1234_402321_2020.csv	Variable	File	studyfleet	datastore/fdd/fkt1234*/raw_organized/studyfleet/stuydyfleet_1234_402321_2020.csv	All study fleet data... likely a single file	- studyfleet_[fkt#].csv - Ex: studyfleet_1234.csv
readme.md	Fixed	File	raw	datastore/fdd/fkt1234*/raw_organized/readme.md	Documentation and instructions for data included in raw_organized folder. Includes: - Conventions around different data types See full list here: https://bit.ly/2JmFdqR	- Always: readme.md
scripts	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/scripts	Contains "processing" scripts for all data processed	n/a
prscript_vms_1234.r	Variable	File	scripts	datastore/fdd/fkt1234*/scripts/prscript_vms_1234.r	R script used for processing vms data in the folder	- prscript_vms_[fkt#].csv
prscript_landings_1234.r	Variable	File	scripts	datastore/fdd/fkt1234*/scripts/prscript_landings_1234.r	R script used for processing landings data in the folder	- prscript_vms_[fkt#].csv
prscript_observer_1234.r	Variable	File	scripts	datastore/fdd/fkt1234*/scripts/prscript_observer_1234.r	R script used for processing observer data in the folder	- prscript_observer_[fkt#].csv
prscript_studyfleet_1234.r	Variable	File	scripts	datastore/fdd/fkt1234*/scripts/prscript_studyfleet_1234.r	R script used for processing studyfleet data in the folder	- prscript_studyfleet_[fkt#].csv
supporting_docs	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/supporting_files	All files that provide context on the core data files. Examples include: - Permit history - Overviews provided by data source	n/a
permit_history_1234.csv	Variable	File	supporting_docs	datastore/fdd/processed/supporting_files/permit_history_1234.csv	Permit history file (example)	- [data_name]_[fkt#].[type] - ex: permit_history_1234.csv
survey	Fixed	Folder	[FKT1234*]	datastore/fdd/fkt1234*/survey	Contains all files with completed survey responses from captains	n/a

Appendix A continued

Folder	Category	Type	Parents	filepath	What's Included	Naming Conventions
survey_pequod_ahab_1234.csv	Variable	File	survey	datastore/ fdd/ fkt1234*/survey/survey_pequod_ahab_1234.csv	Complete survey for specified captain	- Survey_[vesselname]_[captain name]_[fkt#].csv - ex: survey_pequod_ahab_1234.csv
fid	Fixed	Folder	datastore	datastore/fid	All data not generated by the fishery (e.g shapefiles, studies)	n/a
[data category]	Variable	Folder	fid	datastore/fid/wind_energy_areas	Categories of fishery independent data (e.g., wind planning and lease areas (WPLAs))	- All snake case - Name of data category - Under 20 characters
fid_data_file.xyz	Variable	File	[data category]	datastore/fid/wind_energy_areas/fid_data_file.xyz	Fishery independent data file	[filename].[type] ex: wind_energy_shapefile.shp

Appendix B. Example Knowledge Survey from Herring/Mackerel Pilot

Below is the text of a survey used in the herring/mackerel pilot.

1 Basic information on survey participant

1.1 Date: _____

1.2 Fishermen's Name:_____

1.3 Permit Number: _____

1.4 Vessel ID: _____

FKT Project: __Herring/Mackerel wind energy_____

The purpose of this written survey is to collect your detailed observations of your fishing practices, how they have changed over time and the ways they are shaped by the ecology of fish, the economics of fishing, fishery policy and regulations, and the use of the ecosystem by others. Your insights into your practices and the ecosystem are essential for understanding and communicating the complex issues you face on the water, in the ports and in regulatory spheres and for accurately interpreting the data you have stored within the Fishery Knowledge Trust.

You're answers to these questions will remain confidential. If you are engaged in a Fisheries Knowledge Trust project in which your answers are to be synthesized with others to develop a consensus view of one or more of the fisheries you participate in, you will be asked for permission first. You will be also be provided with a draft of any synthesis in which your information is integrated for comment. Your comments will be integrated into the final synthesis.

Specific project objective (if applicable):

This project will use historical fishing activity in the herring/mackerel fishery and the costs and benefits in time and money of that activity to estimate impacts on access to fish and revenue if the proposed wind planning and lease areas had been developed during the period of analysis. Our goal is to explicitly account for important changes in fish ecology, fishery regulations and economics, because we know they have provided important constraints on your fishing practices in the past and will continue to do so in the fure.

2 Questions designed to determine your experience in the fishery

2.1 How old are you?

2.2 How many years have you been a commercial fishery?

2.3 Which of those years were you a Cap?

2.4 In what fisheries do you partici?

2.5 What types and sizes of vessel have you fished?

2.6 How many days do you fish per year?

2.6.1 Has the number of days you fished per year changed?

2.6.2 If your days at sea have changed when and why did it change?

2.7 Have other members of your family participated in fisheries? Which fisheries and when?

2.8 How many years have you fished commercially for Atlantic herring and Atlantic mackerel? What years?

2.9 Do you mostly fish single day trips, or multi-day trips?

2.10 What years have you fished in:

2.10.1 The Northern Gulf of Maine for

2.10.1.1 Mackerel, Herring, Both?

2.10.1.2 What years for each species?

2.10.1.3 What seasons for each species?

2.10.2 Southern Gulf of Maine for

2.10.2.1 Mackerel, Herring, Both?

2.10.2.2 What years for each species?

2.10.2.3 What seasons for each species?

2.10.3 Georges Bank

2.10.3.1 Mackerel, Herring, Both?

2.10.3.2 What years for each species?

2.10.3.3 What seasons for each species?

2.10.4 East side of Cape Cod

2.10.4.1 Mackerel, Herring, Both?

2.10.4.2 What years for each species?

2.10.4.3 What seasons for each species?

2.10.5 South of Nantucket and Martha's Vineyard to Hudson Canyon

2.10.5.1 Mackerel, Herring, Both?

2.10.5.2 What years for each species?

2.10.5.3 What seasons for each species?

2.10.6 Rhode Island Sound

2.10.6.1 Mackerel, Herring, Both?

2.10.6.2 What years for each species?

2.10.6.3 What seasons for each species?

2.10.7 Hudson Canyon to Cape Hatteras

2.10.7.1 Mackerel, Herring, Both?

2.10.7.2 What years for each species?

2.10.7.3 What seasons for each species?

2.11 What types of gear have you used to fish for herring or mackerel? Please specify

2.11.1 What is the minimum, maximum and average number of sets you make in a day for each type of gear?

2.11.2 Have you changed gears in the past?

2.11.3 When did you change gears?

2.11.4 Why did you change gears?

2.11.5 Do you use different gears in different seasons? If s======

2.11.6 Specific gear questions

2.11.6.1 Pair trawlers

2.11.6.1.1 What vessels are in the pair?

2.11.6.1.2 Have the vessels changed over time?

2.11.6.1.3 Have you ever worked in pair trawling operations with more than 2 boats?

2.11.6.1.4 How often are you midwater fishing compared to fishing with a highrise on the bottom?

2.11.6.1.5 How should total landings per trip be calculated for pair trawl operations?

2.11.6.2 Purse seiners

2.11.6.2.1 Have you used a carry boat?

2.11.6.2.2 How should total landings per trip be calculated for purse seine operations?

2.11.6.3 Single boat trawlers

2.11.6.3.1 How often are you midwater fishing compared to fishing with a highrise on the bottom?

2.11.6.4 Jig boats

2.11.6.4.1 How many hours are you fishing per day?

2.12 Searching

2.12.1 What proportion of the time do you spend searching? Describe how you search?

2.12.2 Have you ever used an airplane or drone to search for fish? If so when?

2.13 What is your home port?

2.13.1 Has this always been your home port?

2.13.2 What port(s) do you land fish in?

2.13.2.1 Has your landing port changed?

2.13.2.2 Why has it changed?

2.13.2.3 Do you change ports between seasons? (please explain)

2.13.2.4 Do you change ports within fishing seasons? (please explain)

2.14 Time and position are recorded by vessel monitoring systems about once every hour. Do you think that your differences in your boats movements during fishing, searching, transiting between fishing grounds and from grounds to ports can be identified sampling at that rate?

3 Questions about regulatory, economics and other human dimensions affecting fishing practices and observations

3.1 How have changes in regulations affected your fishing practices for (please describe details including the timing of the changes)

3.1.1 Herring

3.1.1.1 Effects of herring quota

3.1.1.2 Quotas for “Incidental species” including mackerel, “river herring”, protected species, nuisance species (e.g., dogfish)

3.1.1.3 Space- and time-based management measures

3.1.2 Mackerel

3.1.2.1 Effects of mackerel quota

3.1.2.2 Quotas for “incidental species” including herring, “river herring”, protected species, nuisance species (e.g., dogfish)

3.1.2.3 Space- and time-based management measures

3.2 How have the costs of fishing/processing and prices of fish affected your fishing activities?

3.2.1 The species you targeted?

3.2.2 Locations and times where & when you fish

3.2.3 Landing port

3.2.4 When did the most important changes in costs and revenue that affected your fishing activity occur?

3.2.4.1 What factors determined these changes in costs, value and targeting? Were they

3.2.4.1.1 Biological (Changes in relative abundance stocks and alternatives)

3.2.4.1.2 Market driven (Changes in relative prices in domestic/international markets, boycotts)

3.2.4.1.3 Driven by changes in fishing regulations

3.2.4.1.4 Have other fisheries or ocean uses affected the economics of your fishing practices? If yes, please describe their nature and timing.

4 Questions about ecological changes you have observed in your fishery including species impacting your fishery

4.1 Have you noticed changes in the distribution of the species over time (NorthEast←–>SouthWest; inshore←–>offshore; deeper ←–>shallower) for:

4.1.1 Atlantic herring

4.1.2 Atlantic Mackerel

4.1.3 Incidental catch affecting the fishery including

4.1.4 Regulated species (e.g., river herring/protected species)

4.1.5 Nuisance species (e.g., dogfish)

4.2 If species distributions changed, when did they change?

4.2.1 Atlantic Herring

4.2.2 Atlantic Mackerel

4.2.3 Incidental catch species regulated and/or nuisance

4.2.4 Did these changes occur gradually over time, or abruptly?

4.2.5 Have the distributions changed back?

4.3 Why do you think distributions of the species changed over time?

4.4 Have you noticed changes in the timing of migration (Fall, Spring, Spawning etc.) including the time of year that you see your target species in specific locations?

4.4.1 If so when did the change in migration occur

4.4.2 Why do you think the change occurred?

4.5 Do you think your perception of changes in species distributions and migration could be influenced by changes in your fishing practices due to regulations, economics or other factors? If yes, please explain?

4.6 What features of the water column (temperature, current rips and shears, green or blue water) and/or the seabed (edges, gullies, banks, sediment types etc…) do you look for when searching for and targeting?

4.6.1 Atlantic Herring

4.6.2 Atlantic Mackerel

4.6.3 Or avoiding incidental/nuisance species

4.7 Are there events (storms, tide states, times of day, wind directions) that you believe affect the availability of the species? Please explain.

4.8 Do you find all sizes (~ages) of the fish you pursue in the same water column (temperature, current rips and shears, green or blue water) and/or seabed (edges, gullies, banks, sediment types etc…) features for:

4.8.1 Herring

4.8.2 Mackerel

4.8.3 Incidental Catch /Nuisance species

4.8.4 If different sizes of herring, mackerel or incidental species use different habitats please explain the differences

4.9 Have you noticed any other ecosystem features or changes in them that you think are important in determining the distribution the fish you target and your access to them (examples:. changes in the environment, including abundance of prey or predators, or other factors including those associated with humans including fixed gear, offshore development etc.)?

4.10 Is there something we have not asked that you think is important for understanding your fishery and the fish you pursue? If yes please explain?

5 Project specific questions

5.1 What do you think will be the impact of proposed wind energy development on your specific fishing activities such as:

5.1.1 Searching

5.1.2 Transiting between fishing grounds

5.1.3 Transiting between fishing grounds and port

5.1.4 Seasonal changes in use of different landing ports

5.2 Are there other factors that you think will or will not intensify the impacts/conflicts of wind? (E.g. Fishery regulations, conflicts with other fisheries and ocean users, Incidental catch and other species)

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