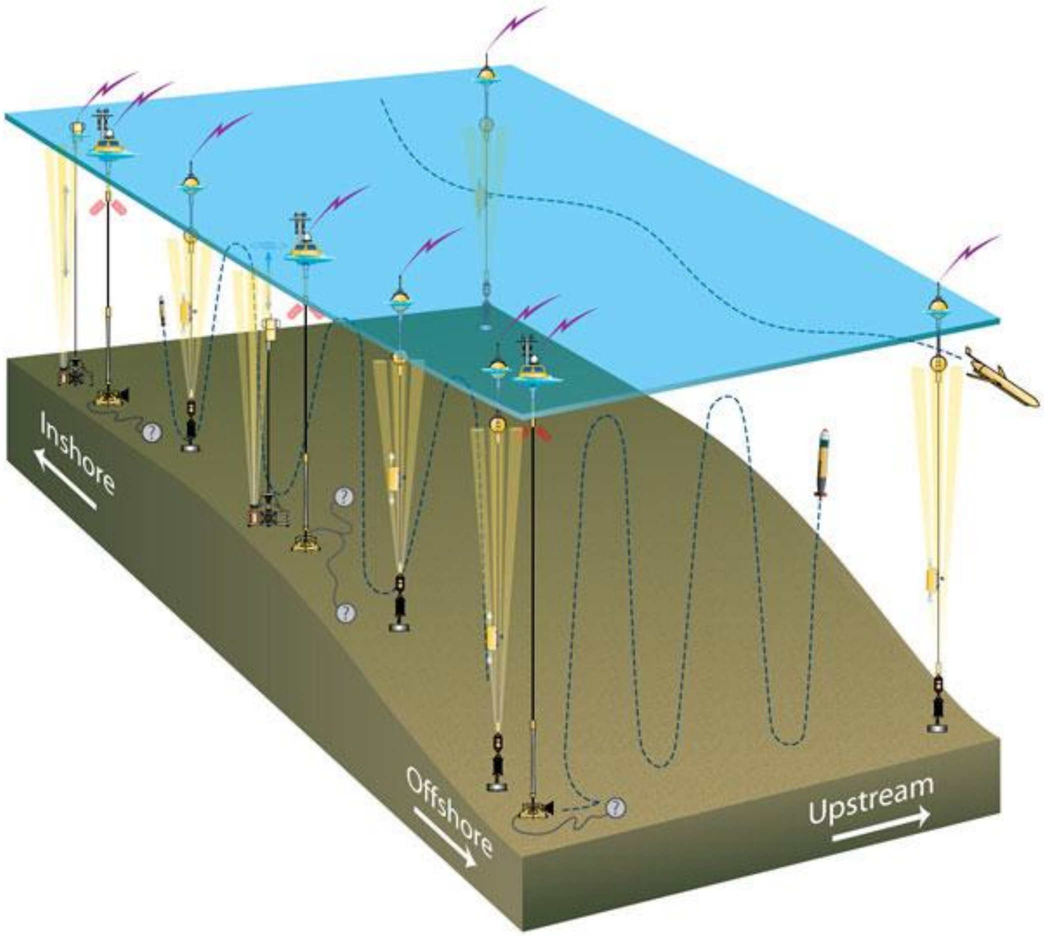
Socioeconomic Impact Analysis Report for the Proposed Pioneer Array of the Ocean Observatories Initiative



Prepared by:

GENTNER CONSULTING GROUP

Silver Spring, MD

January 2011

Acronyms and Abbreviations

ABC	allowable biological catch
AUV	autonomous underwater vehicle
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CGSN	Coastal/Global-Scale Nodes
COOS	Coastal Ocean Observing System
CSN	Coastal-scale Nodes
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
ESA	Endangered Species Act
EO	Executive Order
fm	fathom
FMC	Fisheries Management Council
FMP	Fisheries Management Plan
FONSI	Finding of No Significant Impact
HMS	Highly Migratory Species
IOOS	Integrated Ocean Observing System
Lat/long	latitude/longitude
min	minute
MRFSS	Marine Recreational Fisheries Statistical Survey
MSA	Magnuson-Stevens Act
NEPA	National Environmental Policy Act
nm/nm^2	nautical mile/square nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTMAR	Notice to Mariners
NPV	net present value
NSF	National Science Foundation
O&M	Operations and Maintenance
OFL	overfishing level
OOI	Ocean Observatories Initiative
PATON	Private Aid to Navigation
PEA	Programmatic Environmental Assessment
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
ROI	Region of Influence
SAR	Seach and Rescue
SIAR	Socioeconomic Impact Analysis Report
SSEA	Site-Specific Environmental Assessment
TAC	total allowable catch
U.S.	United States
U.S.ACE	U.S. Army Corps of Engineers
U.S.C	United States Code
VTR	Vessel Trip Report

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report estimates the benefits and costs of the proposed installation and operation of the National Science Foundation (NSF) funded Ocean Observatories Initiative (OOI) Pioneer Array. The Pioneer Array is a series of 10 relocatable moorings in 7 mooring locations approximately 68 nm south of Martha's Vineyard, Massachusetts. The moorings consist of 2 lines running north-south across the continental shelf. The western (downstream) line would consist of 5 surface moorings with small surface expression, and the eastern (upstream) line would consist of 2 moorings with small surface expression. Gliders and AUVs would run missions in the vicinity of the moored array, but are assumed to not have an impact on fisheries. The economic analysis contained herein focuses on the Pioneer Array moorings only and specifically on the proposed 0.5 nautical mile (nm) radius buffer zone around each mooring.

As stated in the 2008 Final Programmatic Environmental Assessment (PEA) (NSF 2008) regarding the need for additional detailed assessment of the proposed OOI at the site-specific stage, to support a previous qualitative analysis, and in response to public comments on the Draft Site-specific EA (SSEA), this Socioeconomic Impact Analysis Report (SIAR) has been prepared to provide a quantitative site-specific analysis of potential impacts to socioeconomics (fisheries) from the installation and operation and maintenance (O&M) of the proposed Pioneer Array. Even under the most conservative assumptions across the most conservative additional operating cost scenario, installation and operation of the Pioneer Array does not constitute a significant impact on harvesters or shoreside businesses supported by their fishing activity in the area of the proposed buffer zones.

The report begins with the benefits of ocean observing systems in general and then focuses on the benefits that accrue to commercial and recreational fishing; very important industries in the Mid-Atlantic and New England regions. Commercial fishermen land $1.4 billion annually in seafood in both regions supporting $18.3 billion in total sales, $7.6 billion in income, and 271,441 jobs through the entire product chain from harvesters to consumers. On average, recreational anglers take 36.4 million trips each year spending $9.0 billion and generating $9.6 billion in total sales, $3.2 billion in income, and supporting 75,118 jobs. Combined both industries represent a significant economic engine in the Mid-Atlantic and New England regions. However, due to increasing regulations and reductions in the allowed harvest, commercial catches and recreational effort have been declining. The proposed installation and operation of the Pioneer Array would benefit both fisheries sectors and other industrial sectors in these regions. The Pioneer Array would also increase commercial fishing costs, but at a much lower level than benefits are increased.

An exhaustive literature search was conducted and benefits estimates from the literature are presented. This examination demonstrates that the proposed installation of the Pioneer Array could produce significant benefits for fisheries and other industries. Annual commercial fisheries benefits are projected to be $61.6 million across Mid-Atlantic and New England communities. Recreational fisheries benefits were estimated to be $96.4 million annually across the same regions. When other benefits to tourism, agriculture, shipping, search and rescue, and other industries are included, benefits of the OOI are likely to be in excess of $201 million per year.

This report compiles, at the 10-minute (min) (latitude/longitude) square level, revenue generated and economic impacts supported by commercial fishing, for-hire recreational fishing, and private recreational fishing in the study area. Due to confidentiality restrictions, 13.0% of all commercial and for-hire trips could not be reported at the 10-min square level. These remaining trips were allocated to 10-min squares based on the proportion of area not containing non-confidential estimates. Private recreational effort in the study area was estimated using the National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistical Survey data. Since on-water fishing location is not collected in that survey, effort was projected onto the ocean surface using vessel characteristics and algorithms that project maximum possible travel distances.

Only 666 commercial fishing trips were taken in the average year across all three 10-min squares encompassing the area of the proposed Pioneer Array. Of those trips, 78.4% were fished by bottom trawl gear, pots and traps make up 9.5%, with gillnets and longlines following at 8.9% and 2.3% of the effort, respectively. All of the other gear types make up less than 1% of the effort and are likely an artifact of the apportionment of the confidential data rather than an actual representation of effort by that gear type. Across the entire study area, the effort in these three 10-min squares represents less than 0.5% of all effort in the Vessel Trip Report (VTR) database for NMFS statistical areas 526, 533, 534, 537, and 541 and less than 1% of the trips reporting landed value. The commercial effort in the three 10-min squares containing the Pioneer Array generates $25,386 in revenue which supports $142,068 of annual income, including all sectors from the harvester to the shoreside dealers, processors, wholesalers and retailers, within the proposed buffer zones around the Pioneer Array moorings (Table ES-1).

The NMFS guidelines for economic analysis indicate that changes in operating costs are the appropriate metric to assess the significance of the impact on harvesters and shoreside businesses. Under Executive Order (EO) 12866, the $162 lower bound and $40,676 upper bound estimates of the increase in operating costs do not rise to the $100 million bar set by EO 12866 and therefore this action does not constitute a significant impact. Denominating these costs by the number of trips in each scenario, Scenario 1 estimates a cost per vessel trip of $10.80 in additional costs. Doing the same for the Scenario 2 costs, avoidance costs per vessel trip would be $61.08 in additional costs per trip. If instead, revenues at risk are used, the revenue at risk in the mooring buffer zones is only $25,386, still well below the threshold. It is completely unreasonable to think that all revenues in those three 10-min squares are at risk. Because this analysis did not have access to individual vessel level data, it is impossible to assess disproportionality. It would be necessary to bin all vessels fishing in the study area into large and small entities and then assess the impacts of this action on their costs and profitability. Because the actual change in operating cost per vessel per trip is very small and because this change likely impacts a very small proportion of the fishing fleet (not a substantial number), it is likely that under the profitability Regulatory Flexibility Act (RFA) standard, the installation and O&M of the proposed Pioneer will not generate a negative impact on the profitability of a substantial number of small businesses.

No private recreational fishing effort was found to exist in the study area. Relaxing some of the assumptions made to conduct the private recreational analysis could potentially estimate some private recreational effort in the study area. However, because no activity was found around the mooring locations for the for-hire fleet, often a proxy for private recreational activity, and because there aren't any significant benthic features that typify recreational hotspots, it is likely that the analysis correctly indicates that there is no recreational activity occurring in the proposed buffer zones.

In conclusion, the Pioneer Array would produce very modest costs and likely no costs in the future as fishermen adapt to the location of the moorings and buffer zones. While net present value (NPV) is calculated in the summary section, the result contains many uncertainties. Over the proposed 5-year life of the Pioneer Array in this proposed location, benefits to society would have to exceed $11.3 million per year after the first year to produce a slightly positive NPV over the 5-year life of the array in this location. It is likely that benefits will exceed this value, but it may take several years for them to begin to accrue. Either way, the vast majority of the project costs are in design, installation and operation and the actual avoidance costs represent a very small portion, less than 0.01% at the upper bound level of avoidance cost, of the $47.9 million cost of the Pioneer Array over 5 years.

Table ES-1. Summary of Potential Economic Impacts of the Proposed Pioneer Array

Sector		Potential Impact: Value	Potential Impact: Per Vessel Per Trip
Commercial Fishing	Revenue at risk - According to the NMFS economic analysis guidelines, revenue at risk is often used when operating cost calculations cannot be made. Therefore, this estimate is an extreme upper bound	$25,386	$1,692
	Lower bound avoidance cost – This scenario assumes that only the 15 trips estimated to occur directly in the buffer zones incur any additional avoidance costs and that those additional costs involve relocating their gear set by 1 nm to avoid the buffer zone.	$162	$11
	Upper bound avoidance cost – This scenario assumes that all 666 trips in all three 10-min squares containing buffer zones will avoid the entire 10-min square containing the buffer zone and includes the cost of moving the set of their gear by the width of the 10-min square where the effort occurred.	$40,676	$61
For-Hire Recreational	No trips will be impacted by the operation and installation of the Pioneer Array.	$0	$0
Private Recreational	No trips will be impacted by the operation and installation of the Pioneer Array.	$0	$0
Conclusion – No Significant Impact	Even under the most conservative assumptions across the most conservative additional operating cost scenario, installation and operation of the Pioneer Array does not constitute a significant impact on harvesters or shoreside businesses supported by their fishing activity in the area of the buffer zones.		

1.0 INTRODUCTION

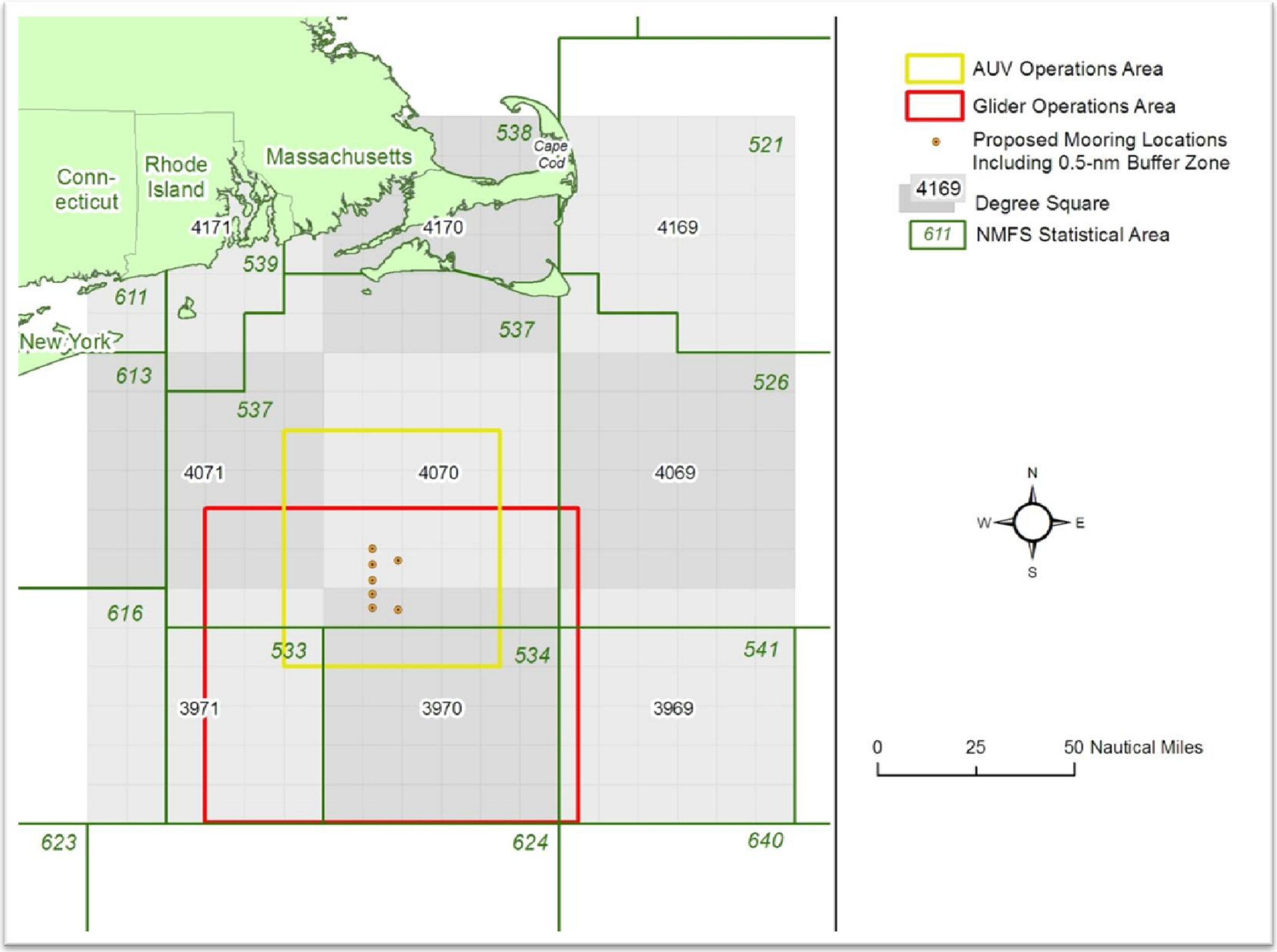
This Socioeconomic Impact Analysis Report (SIAR) was prepared in support of the National Science Foundation (NSF) funded Ocean Observatories Initiative (OOI) Pioneer Array, one of the Coastal Scale Nodes of the OOI. The Pioneer Array is a proposed offshore sensor array comprised of 10 moorings in 7 locations that is proposed for deployment approximately 68 nautical miles (nm) south of Martha's Vineyard, Massachusetts. Installation of the moorings is proposed to begin during the 3rd quarter of 2013, with data flow and commissioning occurring in the 4th quarter of 2013. The Pioneer Array project area includes the mooring array, an autonomous underwater vehicle (AUV) operations area, and a glider operation area (Figure 1). The moorings consist of 2 lines running approximately north-south across the continental shelf. The western (downstream) line would consist of surface moorings, wire-following profiler moorings with a small surface expression, and surface-piercing profiler moorings with intermittent surface expressions. The eastern (upstream) line would consist of wire-following profiler moorings with small surface expression.

In an effort to reduce the potential for gear entanglement and mooring damage, each mooring location would have a proposed 0.5-nautical mile (nm) radius buffer zone or voluntary avoidance area around each of the 7 proposed mooring locations. The 7 proposed mooring locations (Figure 1) were evaluated in order to estimate cost of the potential loss of commercial and recreational fishing access within the proposed area of the Pioneer moorings. In addition, a glider operations area and an AUV operations area are proposed for the operation of 6 gliders and 3 AUVs within a larger area surrounding the moorings (Figure 1). Unlike the proposed moorings, the AUV and glider mission boxes would not have any associated proposed fishing avoidance areas or buffer zones. The economic analysis contained herein focuses on the Pioneer Array moorings only.

The Pioneer Array operation area (i.e., moorings, AUV operations area, and glider operations area) falls within National Marine Fisheries Service (NMFS) statistical areas 526, 533, 534, 537 and 541 (Figure 1). This SIAR will supplement ongoing analysis being conducted by NSF regarding the proposed installation and operation & maintenance (O&M) of the Pioneer Array, and supports the SSEA being prepared by NSF under the National Environmental Policy Act (NEPA). The proposed location of this array has potential fishery economic impacts for both the Mid-Atlantic and New England fishery management regions.

This SIAR first examines the benefits of ocean observing systems in general and then focuses on the benefits that accrue to commercial and recreational fishing; very important industries in the Mid-Atlantic and New England regions. This report then compiles, at the finest spatial resolution possible at this time, revenue generated and economic impacts supported by commercial fishing, for-hire recreational fishing, and private recreational fishing in the study area. The inclusion of the for-hire and private recreational fishing in this report is an improvement over the economic impact assessments conducted for other recent offshore development projects in the Northeast. Furthermore, this report includes an analysis of potential impacts on shoreside businesses, since previous studies of other offshore projects have received criticism from the NMFS for not assessing shoreside impacts.

Figure 1. Pioneer Array Location Showing NMFS Statistical Areas, Pioneer Array Location and AUV and Glider Mission Boxes



For a number of reasons, including lack of spatial data and data confidentiality issues, it was not possible to identify the exact number and potential economic impacts at the individual mooring site level. This report analyzes the potential economic gains and losses associated with the proposed installation and O&M of the Pioneer Array and the subsequent loss of access to fishing grounds and the potential of gear loss within the buffer zones surrounding the mooring locations. Revenue estimates were compiled for each sector using the smallest geographic polygon possible. Custom fisheries economic impact models were used to assess the economic impacts, both gains and losses, due to the proposed installation and O&M of the Pioneer Array. These custom economic impact models produce a proxy estimate of potential economic value gains and losses.

Using this methodology to estimate activity and impacts in the buffer zones required assuming that the potential economic impacts found within each polygon are equally distributed across the polygon. In this case the polygons used for the for-hire recreational and commercial fishing sectors are 10-minute (min) squares which are fairly small relative to other studies of this type. If the polygons developed are not sufficiently small in scale, caution is warranted when making this assumption as it is likely that fishing effort within a polygon is concentrated in a small portion of the polygon, particularly for bottom trawling. For example, each mooring buffer zone with a diameter of 1 nm covers 0.79 square nm (nm^2) and a 10-min square includes 76.29 nm^2[(1)]. Across private recreational fishing the analysis presented here represents the best available data and it is unlikely that the spatial precision of these estimates can be improved without NMFS implementing a specially designed data collection. While it is possible to improve the for-hire recreational and commercial fishing estimates with confidential, individual vessel and trip level data, it is unlikely that NMFS would ever release such data.

This study used 2005-2009 Vessel Trip Report (VTR) and dealer report data for the commercial and for-hire sectors and 2005-2009 Marine Recreational Fisheries Statistical Survey (MRFSS) data for both the for-hire and private recreational fisheries sectors. The report begins with an overview of the methods used in this analysis and is followed by a summary of the benefits of offshore observation systems across all industries with specific focus on fisheries industries. This benefit section includes the current economic footprint of recreational and commercial fisheries in the region. Next, 5-year average activity, defined by industry income generated, is detailed at the 10-min square level and the potential industry costs are detailed for each sector: commercial, for-hire, and private recreational fisheries. Finally, the analysis concludes with net present value (NPV) calculations for the life of the Pioneer Array.

2.0 METHODS

The NMFS Guidelines for the Economic Analysis of Fishery Management Actions identify a series of criteria for determining if a management action produces significant economic impact (NMFS 2000). Executive Order (EO) 12866, *Regulatory Planning and Review*, requires that a management action "have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local or tribal governments or communities," among other criteria not germane to this project, for an action to be judged as having a significant economic impact. The effect is measured in terms of changes in revenue or changes in operating costs. In the absence of the ability to measure changes in operating costs, revenue at risk is often used (NMFS 2000).

Additionally, the Regulatory Flexibility Act (RFA) (5 U.S. Code 601-612), while requiring similar analyses, focuses on the impacts on small business entities. Appendix 1 lists the business size standards. The RFA contains two standards: disproportionality and profitability. Under RFA, a management action

[1] Due to the curvature of the earth, minutes of longitude are closer together closer to the poles. As a result, each 10-minute square in the study area contains a slightly different area. The area value referenced here represents the area of the 10-minute square containing the northernmost four mooring locations.

generates significant economic impacts if the regulation falls disproportionately on a substantial number of small entities or reduces the profitability of a substantial number of small entities.[2] While this study does not constitute a complete Regulatory Impact Review (RIR)/RFA analysis under the guidelines established by NMFS, the criteria established by NMFS (NMFS 2000) will be used to assess the significance of the potential economic impact of the installation and operation of the Pioneer Array.

This section details the data and basic methods that will be used to estimate both the potential benefits and costs of the proposed Pioneer Array. The section begins with a description of the spatial grid numbering scheme used by NMFS and the data that will be used to populate those cells. Second, the basics of economic impact models, used to estimate both benefits and costs, will be discussed. Next the general methods used to estimate benefits will be detailed. Finally, the cost estimation procedure will be discussed.

2.1 Data

All proposed Pioneer Array activities would occur in NMFS statistical areas 526, 533, 534, 537 and 541 (Figure 1). All mooring locations are located in statistical area 537 while the glider operations area also includes statistical areas 533 and 534 to the south and statistical areas 526 and 541 to the east, and the AUV operations area falls mostly in statistical area 537 with a small portion occurring in statistical areas 533 and 534. While NMFS publishes estimates of aggregate commercial and for-hire recreational fishing activity, Gentner Consulting Group requested the volume and value of commercial landings and for-hire recreational effort at a finer spatial scale. NMFS agreed to provide VTR data by 10-min by 10-min squares (hereafter 10-min square). The layout of these squares is provided in Figure 2 for the study area.

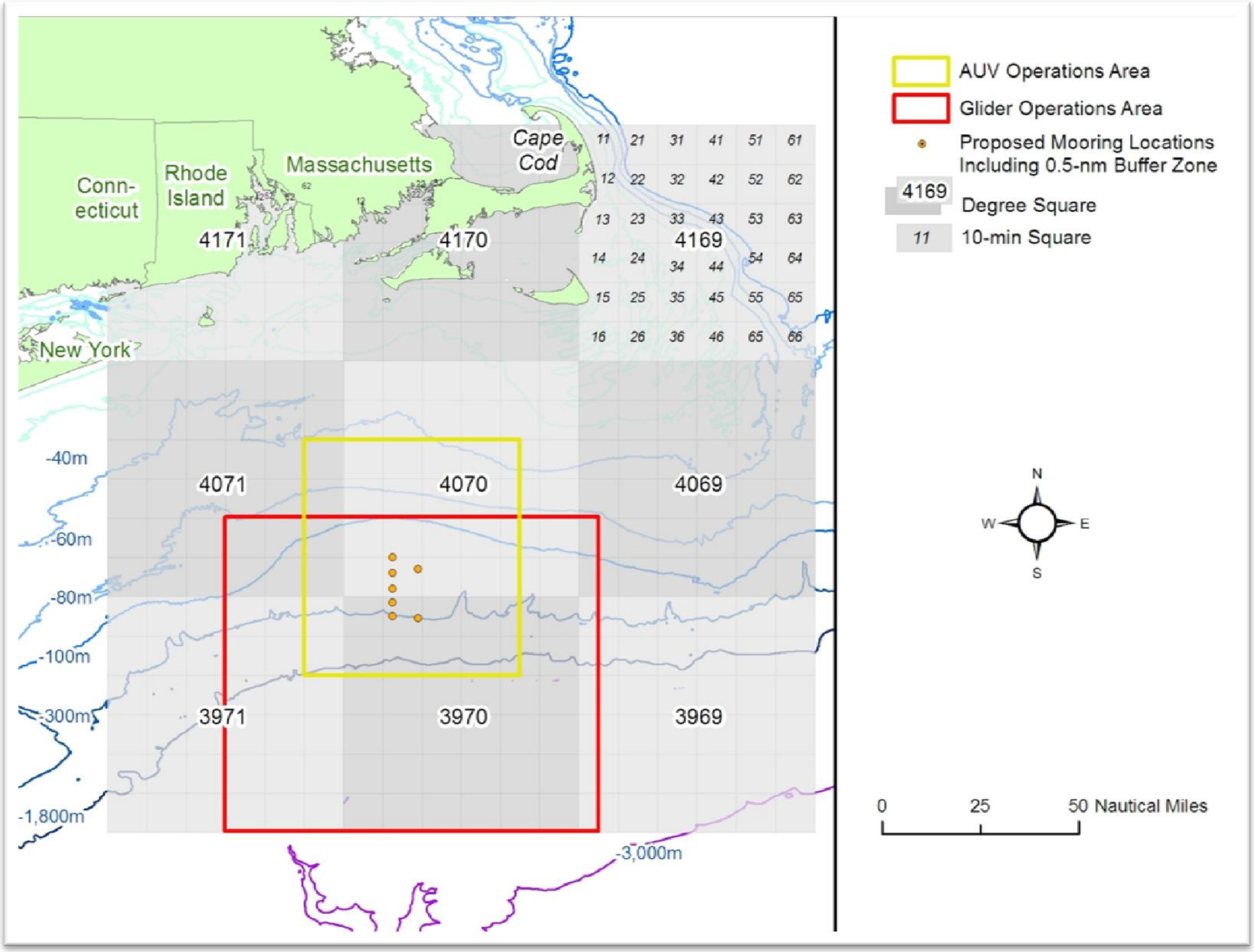
Commercial fishermen that fish in federal waters are required to complete a VTR for every fishing trip that includes fishing location and weight of their catch by species. This data set contains estimates of fishing effort and catch. This system requires the vessel captain to record fishing location based on Loran or latitude/longitude (lat/long) coordinates but also collects that information using global positioning satellites for some vessels. As a result, sometimes there is disagreement between reported and recorded location. Additionally, in the case of trawling or longlining, the location of a beginning of a set is recorded as is the location of the end of a set. NMFS uses an algorithm to attribute the official effort and harvest locations to the specific 10-min square. While this spatial resolution can be deemed too fine at shorter temporal scales, such as a month or as long as a year, averaging this data across a 5-year span was deemed to be a good balance between high spatial resolution and accuracy.[3]

NMFS labels each degree square using the degrees of longitude concatenated with the degrees of latitude describing that degree square. Each degree square is also broken into quarter degree squares. For example, in Figure 2, degree square 4169 describes the degree square at longitude 41 north and latitude 69 west. Continuing to use degree square 4169 as an example, NMFS numbers each 10-min square beginning in the upper left (northwest) corner with the number 11 and moving south to 10-min square 16. Each quarter degree square is composed of nine 10-min squares in each four quarters of the degree square. The numbering restarts with the next square east of 11 with 10-min square 21 and proceeds to the lower right (southeast) of the degree square with 10-min square 66 for a total of 36, 10-min squares per each degree square. This same naming convention is used in every degree square, but the actual 10-min square numbers have been omitted from all other maps presented here to avoid clutter. The Pioneer Array is located in 10-min square 25 and 26 in degree square 4070 and 10-min square 21 in degree square 3970.

[2] Substantial is not defined quantitatively in the statute.

[3] Personal communication from Dr. John Witzig, NMFS, Director, Fisheries Statistics Office, Northeast Regional Office, Gloucester, MA.

Figure 2. Numbering Scheme for All 10-min Square Blocks



NMFS requires data confidentiality to access this data. The reporting of revenue and landing information cannot occur if any one individual can be identified by the estimate. NMFS has determined that the rule of three must be followed; meaning that at the finest spatial resolution allowed, there cannot be less than three trips within that block. Only 13.0% of trips and 13.1% of the landed weight violated this rule of three at some spatial resolution (Table 1).

Table 1 details the number of trips that could be attributed to each stratum across all NMFS statistical areas in the northeast. If a trip could not be attributed to even the NMFS statistical area, the count of that trip is included in the gear type stratum. Table 2 details the data in Table 1 in percentage form. Overall, the vast majority of trips could be attributed to a 10-min square. Across all 5 years examined here, 87.0% of all trips could be attributed to a 10-min square. Table 3 details the numbers of fish reported being caught that could be attributed to a 10-min square in percentages of the total number of fish reported. Again, the vast majority, or 86.9% on average, of harvested fish could be attributed to a 10-min square.

Table 1. Counts of VTR Effort Records by Stratum, 2004-2009

	Year				
Stratum	2005	2006	2007	2008	2009
10-min square	124,426	126,429	120,640	113,023	108,942
Quarter degree square	2,883	2,687	2,592	2,290	2,387
Degree square	1,317	1,148	1,096	1,057	1,077
Statistical area	5,001	5,749	5,645	5,385	7,279
Gear type	16,689	15,857	15,259	15,071	15,601
Grand Total	150,316	151,870	145,232	136,826	135,286

Table 2. Percent of VTR Effort Records by Stratum, 2004-2009

	Year				
Stratum	2005	2006	2007	2008	2009
10-min square	87.7%	88.0%	87.3%	87.0%	84.9%
Quarter degree square	1.0%	0.9%	0.9%	0.9%	1.0%
Degree square	0.3%	0.3%	0.3%	0.3%	0.3%
Statistical area	2.4%	2.9%	3.1%	3.1%	4.5%
Gear type	8.5%	7.9%	8.4%	8.7%	9.3%
Grand Total	100%	100%	100%	100%	100%

Table 3. Percent of VTR Catch (Number of Fish) Records by Stratum, 2004-2009

	Year				
Stratum	2005	2006	2007	2008	2009
10-min square	89.1%	88.0%	85.8%	86.6%	84.7%
Quarter degree square	4.4%	5.7%	6.0%	6.5%	4.6%
Degree square	3.0%	1.3%	1.5%	1.3%	2.2%
Statistical area	1.9%	3.0%	4.4%	3.0%	6.2%
Gear type	1.6%	2.0%	2.3%	2.6%	2.2%
Grand Total	100%	100%	100%	100%	100%

The effort and landings that could not be attributed to the 10-min square due to confidentiality were attributed to the empty 10-min squares proportional to the area covered by the empty cell. For instance if 100 pounds of landings could not be attributed to two out of nine 10-min squares within a quarter degree square due to confidentiality, those pounds would be reported at the quarter degree square level. To apportion those pounds back to the 10-min square, 50 pounds would be attributed to one empty 10-min square and 50 pounds would be attributed equally to the other empty 10-min square. If a 10-min square was delivered not empty, the value in that 10-min square represents the totality of landings for that 10-min square. However, an empty 10-min square is only truly empty if there are no remainder landings at the quarter degree square level.

Using this technique to apportion confidential landings is naïve, but the only technique available as providing any additional information about the location of these trips would violate confidentiality. This technique does not take into account current activity in apportioning landings. As a result many cells that contained apportioned values may not actually contain any activity. Additionally, it may obscure activity in a particular cell. If a vessel had a particularly large haul of fish during one trip, those pounds would be confidential and could potentially be spread across nine 10-min squares equally under this allocation strategy while in reality the catch originated from only one discrete location. In both the commercial and for-hire sector analyses below where the VTR data is utilized, the non-confidential data is displayed first and then a second map is generated showing how the confidential landings were apportioned to 10-min squares.

The commercial sector analysis also requires the landed value of fish reported in the VTR data. Dealers that purchase fish from the harvesters were required to also complete a dealer report that includes the total value of the catch for each trip. This study required harvester revenue by location, and, as a result, the dealer reports had to be linked to the VTR data. This process was not fool-proof and resulted in trip records from the commercial fishermen that cannot be matched to dealer report records. Therefore, these records did not contain the value information necessary to directly estimate total revenues by block (NMFS 2010). Instead, prices were imputed from the trips that could be matched and applied to the landings that could not be matched to a dealer record.

There are some gaps in this data for commercial fishing, but they are assumed to be minor, and the best available data have been used. The VTR is only required for federally permitted vessels. As such, state-permitted vessels not fishing for federally managed species could be fishing in the proposed Pioneer Array area, but their landings are not included here. This gap is not likely to include very many trips due to the distance the Pioneer Array is located from shore.[4] Additionally, federal reporting requirements are not applicable to vessels that only land lobster, nor are dealers required to report lobster landings if all they buy are lobsters. However, if a lobster fisherman has any federal permits they are required to participate in the VTR program. While they are not required to report on lobster-only trips, if they want to land any federally permitted species during that trip, lobster landings must also be reported on the VTR. It is expected that the lobster gap is small as most of the Pioneer Array is in relatively deep water and many lobster boats will hold other permits so they can land incidental catch. The best available landings data, detailed below, contain lobster and groundfish harvest indicating that at least some lobster fishermen are being included in this analysis.

The northernmost mooring location falls half in degree square 4070 and 10-min square 25 and half in degree square 4070 and 10-min square 26 along with three other moorings. The southernmost three mooring locations occur in degree square 3970 and 10 minute square 21. The AUV operation area encompasses portions of 4071, 4070, 3971, and 3970 degree squares and the glider operations area encompasses portions of 4071, 4070, 4069, 3971, 3970, and 3969 degree squares. For the remainder of this analysis reference to the NMFS statistical area will be dropped in favor of the degree square plus 10-min square nomenclature as shown in Figure 2. Confidentiality limitations for both the for-hire and

[4] There are only a few species in this region that are not under federal management including striped bass, weakfish, tautog and others. These are species caught near shore and it is unlikely that much effort is being missed this far offshore for state permitted vessels fishing for these species. Additionally, most vessels that travel this far offshore carry federal permits to increase the number of species that they can land.

commercial data was the primary limiting factor controlling the spatial scale at which revenue estimates can be developed. All GIS analyses were done using Environmental Systems Research Institute (ESRI) ArcGIS 9.2 and all maps were created using the UTM Zone 18N projection.

Of the three sectors, analysis of private recreational fishing presents the most challenges. While NMFS collects private recreational fishing catch and effort data annually, they collect spatial information at a scale that is not very useful for this analysis. As a result, data from a special economic add-on survey conducted in 2006 plus secondary data on vessel characteristics was used to estimate potential travel radii in order to distribute angler expenditures across the study area (Gentner et al. 2008). This information was also used to post-stratify NMFS official effort estimates to the county and estimated ocean zone allowing the estimation of total expenditures and economic impacts.

NMFS uses the MRFSS to collect the data it needs to manage recreational fishing. The MRFSS consists of two independent but complementary surveys conducted in six 2-month waves every year in the Mid-Atlantic region and is designed to estimate recreational angler catch, effort, and participation. The first part consists of an intercept survey conducted at fishing access sites and is designed as a random sample of recreational trips. The intercept sample is stratified by year, sub-region, state, 2-month wave, mode (shore, private/rental boat, charter, and party), and fishing area (inshore, offshore but inside state waters, offshore greater than three miles). The main function of the intercept survey is to estimate catch per unit effort and the unit of effort is a single day trip. The second part of the survey involves a random digit dial survey of all coastal counties. The telephone survey in combination with the intercept survey is used to estimate total effort (number of trips) and total participation (number of people).

The MRFSS survey does not collect information, as does the VTR data, on the on-water fishing location(s) visited during a fishing trip. The only spatial information the MRFSS survey collects is fishing area broadly defined as inshore (coastal rivers, bays, and estuaries), offshore less than 3 nm, and offshore greater than 3 nm. Additionally, effort estimates provided by the MRFSS are only stratified at the state level. Detailed information on the estimation routine used to allocate trips and expenditures to the study area will be detailed in the private recreational section below.

2.2 Benefits of Offshore Observing Systems

Natural oceanic systems interact with economic systems. In general, ocean observing systems improve what we know about the natural systems that interact with the industries that drive our nation’s economy. Improved data on these systems benefits commercial fishing, shipping and marine transportation, outdoor recreation, search and rescue, damage avoidance, public health, construction, crop agriculture, and energy exploration, development and distribution. Additionally, ocean observing systems contribute to basic research and basic research drives economic growth (Adams et al. 2000).

From an economic standpoint, economic value is the measure used to describe the benefits and costs of a particular action. For both consumers and businesses, total value is the sum of consumer and producer surplus. Producer surplus is measured by examining the supply curves for commercial producers. In the case of commercial fishing this includes the surplus that accrues to harvester, processors, wholesalers, distributors and retailers, as well as the supply curves for for-hire recreational service providers. Essentially, producer surplus is the difference between the cost of producing the good and the dollar value generated by the sale of the good and is similar to the concept of business profit. While the concept of producer surplus as profit is intuitive and easily understood, consumer surplus is less intuitive. Sometimes it helps to think of consumer surplus as a consumer’s profit. Consumer surplus is measured by examining the demand for goods at the consumer level including the demand for fish at markets and restaurants and the demand for recreational fishing trips. Consumer surplus is the difference between the amount actually paid and that consumer would have been willing to pay for the good in question. It is important to point out, that willingness to pay is less than the market price for a good as there are always costs in the production of any good. In the case of recreational fishing, or any other environmental good, that is not traded in a market, special techniques are needed to estimate consumer surplus or willingness to pay.

Weather and climate sensitive industries account for about one third of the nation's gross domestic product (GDP), or approximately $4 trillion 2002 dollars (Dutton 2002). Industries directly impacted by weather such as agriculture, construction, outdoor recreation and others contribute as much as 10% of U.S. GDP (National Oceanic and Atmospheric Administration [NOAA] 2002). Damages from drought, fires, floods and other related events cost the U.S. hundreds of billions of dollars annually (NOAA 2008). Harmful algal blooms cause $97 million in losses each year from direct health, commercial fishing, recreational fishing, tourism and other impacts (Hoagland 2006). Travel and tourism in the U.S. generates $700 billion annually with beaches the leading destination (Leeworthy 2000). Approximately 89 million people vacation and recreate on U.S. coasts each year. As a result, 85% of that $700 billion is earned by coastal states. Maritime shipping supports 8.4 million jobs in the U.S. and contributes $2 trillion to the U.S. economy (NOAA 2008).

Benefits from ocean observing flow to industry through two basic pathways: improving efficiency and reducing risk. Better data on natural systems improve nowcasts[5] and forecasts of environmental conditions. Better nowcasts and forecasts allow business owners and consumers to make better decisions reducing costs or improving revenues. Cost reductions can take the form of a container ship avoiding a coastal storm or homeowners preparing better for that same storm. Tourists can reduce costs by avoiding contaminated beaches and coastal resource managers can use data to avoid beach contamination in the first place. Better nowcasts and forecasts reduce the number of search and rescue missions (SARs) because at-sea risks are reduced; both for the ocean going vessel and the rescuer. For example, a recreational boater decides to stay at home because of an accurate small craft advisory. This reduces costs for the recreator as she did not waste the time and fuel to drive to her boat only to cancel the trip and return home, and it reduces costs to society because she did not take the trip and risk becoming the focus of a SAR mission. Overall, NOAA (2008) estimates that the Coastal Ocean Observing System (COOS) in the U.S. generates between $500 million and $1 billion in benefits to the U.S. economy each year. The Pioneer Array is the only observing array on the east coast that is part of the proposed NSF-funded OOI; however, there are NOAA-funded COOS within the Northeast and Mid-Atlantic regions.

Unfortunately, it is very difficult to estimate the direct benefits of ocean observing systems for a number of reasons. First, the basic data needed to estimate producer surplus, consumer surplus and therefore total surplus is lacking for most industries or consumer goods. Second, there is very little data on how improved observing information is used and therefore how it interacts with production and consumption to generate value. These relationships are extremely complex and difficult to measure. The benefit estimation section will detail the limited research performed to date pertaining to the estimation of the benefits of COOS and estimate potential benefits of COOS.

2.3 Economic Impacts as a Proxy for Economic Value

Previous economic studies for recent offshore projects in the Northeast have focused only on revenue changes in the commercial harvesting sectors (Jin and Hoagland 2005; Hoagland 2007). This narrow focus has been consistently criticized by NMFS and fishery participants. As a result, this study will broaden that focus to include revenue change in the for-hire and private boat recreational sectors. Additionally, custom economic impact models tailored specifically for use in Mid-Atlantic fisheries will be used to estimate the potential direct, indirect, and induced economic impacts to shoreside businesses

[5] Nowcast is a term used in the ocean observing literature used to describe real time condition reporting on weather or other environmental conditions that are pertinent to industry such as current wind direction and speed, wave heights, etc. (Kite-Powell et al. 2005).

within the Northeast and Mid-Atlantic fisheries regions with installation and O&M of the proposed Pioneer Array.

Economic impact models compile national business and consumer transaction data and translate changes in sector spending into direct, indirect, and induced effects within a user defined regional economy. Direct effects are the changes accruing to the industries directly impacted by the change in economic activity. Indirect effects are the effects accruing to industries that support the directly affected industry by supplying capital, material, and labor inputs to the directly affected industries production process. Finally, induced effects are those effects generated by the labor sector spending income they earn from the directly and indirectly affected industries in the local region (Minnesota IMPLAN Group, Inc. 1997).

This analysis will include the sum of the direct, indirect, and induced effects in addition to the revenue changes for both costs and benefits. The sum of these effects can be expressed in terms of total sales, income, and employment impacts. Total sales are a measure of the total economic activity generated by commercial harvesters, seafood processors, seafood wholesalers, for-hire recreational providers, and all the businesses that support commercial or recreational fishing. Employment impacts detail the total number of jobs supported by economic activity in the region. Income impacts represent the wages, salaries, bonuses and business profits generated by the same economic activity.

Often, income impacts are used as a proxy for direct estimates of net value or profits (Edwards 1990; Kirkley et al. 2000). Edwards (1990) however, showed that income estimates from economic impact models always overstate profits. It is appropriate within this analysis context to use the most conservative assumptions possible and, by using income as a measure of profit, estimates of net value or profits are pushed in a conservative direction. Using a properly constructed economic impact model allows income estimates to vary by sector and region, which produces a more accurate picture of potential value, or profits, in each polygon. As a result, Gentner Consulting Group feels that, in the absence of data on actual sector costs and profits, using income as a proxy for profits was more appropriate than simply applying a fixed ratio as other assessments have used (e.g., Jin and Hoagland. 2005; Hoagland 2007).

The economic impact models used for this analysis are based on IMPLAN data augmented with additional data for fisheries sectors (Minnesota IMPLAN Group, Inc. 1997). Fisheries sectors, particularly the commercial and for-hire recreational fishing sectors, are poorly represented in the base IMPLAN data sets and therefore were modified to better represent these sectors. The commercial economic impact model was based on the Kirkley et al. (2004) model that was developed for the NMFS while the for-hire and private recreational model was based on a custom recreational economic impact model developed for NMFS (Gentner and Steinback 2008).

2.4 Buffer Zone Avoidance Cost

This report will first detail seafood and recreational fishing industry income in the area immediately surrounding the proposed 0.5 nm radius mooring buffer zones and within the AUV and glider operation areas. It will also estimate industry income within each proposed mooring buffer zone using the average value per square nautical in the 10-min square where the mooring is located. While these estimates are indicators of the level of activity occurring in the proposed Pioneer Array area, they do not represent the actual increased costs these buffer zones may produce for the fishing industry.

At best, these estimates of value at the 10-min square and buffer zone level represent an extreme upper bound on the actual cost of the small buffer zones because anglers, for-hire captains and commercial captains will adapt and switch fishing locations. As a result, the actual cost of these buffer zones is the cost of avoiding entry to the buffer zone. If the value of landings in the area surrounding mooring locations is low relative to other areas, it indicates that the mooring locations are low quality fishing locations and may result in very low avoidance costs. If the mooring locations are located in very productive waters, the cost of avoidance of these buffer zones is the sum of the additional steam time it takes to search for a new fishing ground, the steam time it takes to get to this alternate fishing ground and perhaps the additional fishing time it takes to make up for the potentially better harvest rates that may be experienced within the proposed buffer zones associated with the 7 moorings. The search cost will be short lived as fishers learn new spots and may not come into play at all if substitute sites are already known.

The most accurate method to estimate theses costs is to estimate a model of angler, for-hire and commercial fishing behavior that estimates the cost of changing fishing locations in response to the proposed buffer zones such as a site choice random utility model. These types of models require massive amounts of time and massive amounts of data, including confidential individual vessel, individual trip level data, to estimate. NMFS will not release confidential data for the commercial and for-hire fishing sectors and on-water location choice data is not available for private recreational anglers.

Instead, this report will simulate a range of costs using trip cost models developed for this fleet in the Mid-Atlantic and New England (Jin 2008). Jin (2008) developed models using individual vessel, individual trip data to estimate cost for all gears combined, otter trawl, paired otter trawls (also known as mid-water trawls), gillnets, dredges and longline gear types. These models were developed for NMFS for use in policy analysis and are currently being used for policy analysis at the Northeast Fisheries Science Center. The VTR data used here also included pots and traps and “other” gear types. These two gear types’ costs will be modeled using the “all gears” model from Jin (2008). The parameter estimates for these models are detailed in Appendix 2. Gentner et al. (2010) improved the otter trawl cost model using 2 additional years of data and that model will be used for the otter trawl estimates. Appendix 2 details the parameters developed by Jin (2008) and Gentner et al. (2010) for these trip cost models. Because individual vessel level data was not available for this analysis, mean values from the Jin (2008) study were used to estimate the trip cost changes.

To simulate increased cost, two scenarios will be examined. First, it will be assumed that fishing effort that would have taken place in the buffer zones will move immediately outside the buffer zone. For some gear types (e.g., anchored gillnets, trawls, pots and traps, dredges) it is assumed that the buffer zones would require simply moving the initial set of the gear by at most 1.0 nm. This assumes that the fishers would steam past the mooring to start fishing, regardless of where they encountered the mooring relative to where they wanted to set their gear. For gear types with gear that drifts on the open ocean (e.g., drift gillnets and long lines), it is assumed that they will need to move the distance of their average length of set in order to completely avoid interacting with the buffer zones. Under both of these scenarios it is assumed that fishing effort found in the 10-min square is distributed equally across the square and that effort and landings can be attributed to the buffer zone proportional to the area the buffer zone occupies. This may overstate impacts if no fishing effort actually occurs in the buffer zone and it may understate impacts if the buffer zones are actually located in hotspots of activity. As such, this scenario is viewed to be a lower bound on actual costs.

Because it is unknown where the exact fishing effort occurs inside a 10-min square and because commercial fishermen may choose to be more risk averse and give the buffer zones a wide berth, the second scenario assumes that all effort in the 10-min squares occurs in the buffer zones and in response all fishing vessels would avoid the entire 10-min square. This assumption involves traveling an additional distance equivalent to the length of one of the sides of the 10-mins square or approximately 8.75 nm for the non-drift gear. That is, the vessel simply transits around each square. This assumption is an attempt to account for the potential cumulative impact of locating multiple buffer zones in close proximity to one another. For drift gears, this is particularly important as it is likely that long drift gillnet sets and longline sets may need to avoid the entire area depending on wind and currents.[6] For instance, the inshore, central-inshore and central moorings are roughly 4 nm apart and the distance apart shrinks to 3.5 nm between central, central-offshore and offshore moorings (Figure 3). The two upstream moorings are 5 nm from the north/south line created by the 5 downstream moorings. As such, it would be difficult for a longline vessel with more than 20 nm of gear to make a set eastward and upstream of the entire mooring without potentially fouling their gear. For gears where the gear is attached to the vessel and towed, this scenario assumes that the risk of entanglement is too great to set gear in the area, which, while possible, is likely too limiting an assumption. As a result, this scenario is felt to be an upper bound on actual costs, particularly for the trawl gears (dredges, otter trawl, midwater trawl) and fixed gears (anchored gillnets and pots and traps) as those gears should be able to operate right up to the buffer zone boundaries.

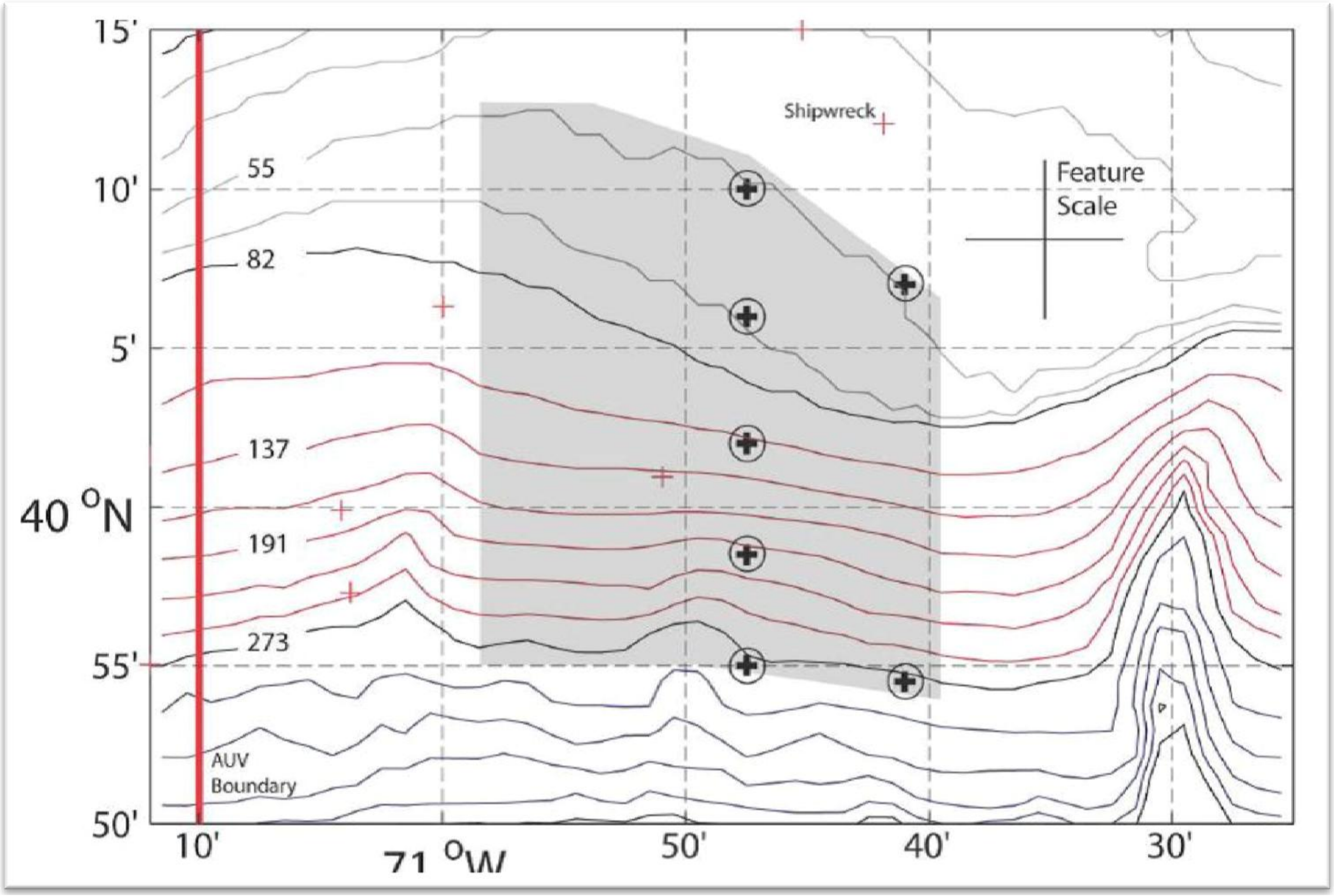
It is further assumed that "other gear" and pots and trap gear types have a cost structure that can be represented by the average cost structure of all the gears included in Jin's (2008) analysis. Looking at the cost models in Appendix 2, there are many variables, like vessel characteristics and crew size, which cannot be used for this analysis because NMFS could only release aggregated data and not individual vessel, individual trip level data. However, all trip cost models contain either trip duration in hours (atripdur), steam time (steamtime) or both. Trip duration describes the entire trip length from port to port while steam time describes only the time spent steaming and not fishing. Therefore all cost increases will be modeled through increased travel time to avoid the site. It is assumed that these proposed buffer zones would not increase time spent fishing; instead it is assumed that effort would simply be re-located. It is further assumed that these buffer zones would not increase search time beyond the time it takes to adjust course and fishing location as defined under the first and second cost scenarios. It is also assumed that all vessels steam at 8 knots and the additional trip duration and/or steam time will increase by the distance divided by this vessel speed.[7]

It is further assumed that if commercial and recreational vessels honor these buffer zones, there would be no gear entanglement and no subsequent gear loss. The only potential costs from the installation and O&M of the Pioneer Array are the costs of avoiding the proposed buffer zones around the mooring locations. It is assumed that there will be no cost to recreational or commercial fishermen from the operation of the AUVs and gliders. The AUVs and gliders would operate 24 hours per day, 7 days per week and would only be retrieved to replace batteries or repair the devices. They are designed to run continuously in this manner for up to 6 months. The lat/long of the mission boxes for the AUVs and gliders would be published in the Notice to Mariners (NM) and Local Notice to Mariners (LNM), and published on NOAA nautical charts. There is no need to exclude any type of fishing vessel from or request that fishermen avoid the mission boxes as the AUVs and gliders pose absolutely no risk to vessels and essentially no risk of gear entanglement. Anecdotal evidence from 20 plus years of using AUVs and gliders on both coasts shows that they have not generated additional costs to fishing vessels or damaged or otherwise entangled their associated gear (Collier 2010; Plueddemann 2010). All AUVs and gliders would be marked with the owning organizations' telephone numbers and contact information in case one is brought up in a net/trawl or found on the surface. In the very few instances where an AUV or glider was brought up in a net, the fisherman called the university and was told to simply put it back in the water. The AUV or glider then continued on its way without harm to the gear or the craft.

[6] Gillnets in the area are limited to no more than 6,600 feet of gillnet in a set. Longline vessels have no limit to set length, but it is common for longline sets to be between 20 and 40 nm in length.

[7] Determined through key informant discussions and industry experience.

Figure 3. Detail of Moorings and Their Relationship to Each Other.



3.0 ESTIMATING THE BENEFITS OF COOS

In 2000, NOAA convened an expert panel to assess the benefits of investment in a national COOS including benefits that accrue to agricultural, construction, shipping, SAR, fisheries, tourism and other industries (Adams et al. 2000). The aim of this document was to establish if there were enough potential benefits of a COOS to justify the investments in COOS that were being proposed. A formal cost/benefit analysis was beyond the scope of their work. Overall, the expert panel developed some important concepts that have been used by all subsequent work in this area. The first is the concept of network externalities. With network externalities, the value of the network of ocean observing systems will be greater than the sum of all the components. That is, each component provides its own value, but additional value can be produced when all components are networked together in an integrated, sustained and comprehensive way. Their work detailed that data are necessary on expected value of new information with and without investment and this type of data are not currently available. In general, the report found that benefits will greatly exceed the costs.

Kite-Powell and Colgan (2001) expand on Adams et al. (2000) work focusing on 5 sectors in the Gulf of Maine; maritime commerce, commercial fishing, recreational fishing, SAR and pollution management. Overall, COOS would generate $33 million per year in benefits in the Gulf of Maine region. They estimate that maritime commerce will realize a 5% reduction in costs for a total benefit of $500,000. Commercial fishing will benefit mainly through improved management. Better environmental data will produce better stock assessments with less uncertainty. With less uncertainty, total allowable catches (TACs) can be increased, producing benefits. For their analysis, they assume that better data will allow the New England groundfish and shellfish fisheries to increase fishing by one additional day in each fishery.[8] Summed across all participating states, an additional day of fishing in each sector would produce $4.1 million per year in benefits, based on the 2001 value of a day at sea.[9] Because of the increase in fuel costs since 2001, this value may be different today. A 1 day increase represents slightly more than a 1% increase in benefits in the groundfish fishery and slightly less than a 1% increase in the shellfish fishery.[10]

Achieving these benefits means that the data must be utilized correctly in the management process. This assumes that: the data can be utilized in the current stock assessment process; the additional data will actually reduce uncertainty; and the reduction in uncertainty will translate into increased harvest during the often political fishery management council process. Additionally, commercial fisheries would enjoy reduced costs from better weather forecasts and aquaculture producers would see reduced costs through better ocean current and pollution transport forecasts. However, the value of these cost reductions was not estimated.

For recreational fishing, Kite-Powell and Colgan (2001) used the willingness to pay for recreational fishing access estimates from the literature and assumed that recreational anglers would take 1% more trips in the face of improved harvests, reduced risks and reduced costs. This technique generates a benefit estimate of $4.2 million for the region (Hicks et al. 1999). Their report did not estimate any benefits that might accrue to beach goers, boaters or other coastal recreators.

---

[8] Both the groundfish fishery and the scallop fishery are managed under days at sea restrictions. The groundfish fishery in 2001 was limited to 60 days and the scallop fishery was limited to 120 days (Kite-Powell and Colgan 2001).

[9] The value of a day a sea in each fishery was determined using the value added of all fisheries activities in each state as estimated by NMFS in the 1999 Fisheries of the U.S..

[10] This concept of the 1% increase as a proxy for actual, estimated benefit increases was developed by Nordhaus (1986) and is the central technique used in the absence of better sector data and probabilistic estimation techniques. Adams et al. (2000) mention it and Kite-Powell and Colgan (2001), Kite-Powell et al. (2005), and Lynch et al. (2003) rely on this principle as their primary estimation technique.

For SAR, Kite-Powell and Colgan (2001) estimated the benefit of increasing the number of lives saved by 1%. Annually, there are 6,000 SAR missions in the Gulf of Maine resulting in 500 lives saved. This represents about 15% of all U.S. Coast Guard SAR activity. Time to respond is a critical factor in survivability and it is thought that better nowcasts and forecasts will improve response time, saving lives. Currently, 28 lives are lost each year. A 1% increase in lives saved (from 90% to 91% lives at risk saved) will generate $24 million in benefits based on a $4 million dollar value of a human life (Viscusi 1993).

Finally, Kite-Powell and Colgan (2001) estimate the value of improved pollution management. Their main focus was on the reduction of oil spills. The Gulf of Maine sees 2,000 barge and tanker transits a year moving 960 million barrels of oil in 1998. Portland, Maine is the third largest oil port in the U.S. and the largest oil refinery in Canada is located in the Gulf of Maine. Using British Petroleum estimates of the cost of recovery per barrel, a 1% decrease in recovery costs would generate benefits from $1.8 to $42.5 million each year. While COOS would be helpful in predicting sewage outfalls and harmful algal blooms with public health and tourism benefits, no estimates were provided for this type of pollution control.

Lynch et al. (2003) examination of the benefit of COOS to the Gulf of Mexico region expanded the list of benefits to include national security, although they don't estimate those benefits. They also develop the idea further that climate forecasts generate economic value. Producers and consumers use forecasts to improve the outcomes of their decisions. This improves efficiency, reduces costs and provides value. In addition to network externalities that will generate benefits beyond the sum of each sector's benefits, Lynch et al. (2003) also state that coastal populations are increasing and therefore the benefits of COOS will also increase over time. While their benefit estimates will not be detailed here because they focused on the Gulf of Mexico, their study again used this idea that benefits will be at least 1% of the current economic footprint of each sector. They are also the only study examined for this effort that estimated the economic impacts of the increase in benefits from COOS implementation, a technique that will be used for this study.

Kite-Powell et al (2005) extend their previous Gulf of Maine work. While this work did estimate benefits at a national level, it also developed the conceptual side of benefit estimation considerably. The estimation of benefits from COOS is challenging. Systems are partially deployed currently and technology is rapidly evolving. Inputs to the system, the sensors themselves, are rapidly evolving as are the products that COOS can offer. Additionally institutions are just beginning to utilize the new products. Because of this rapid evolution and propagation of network externalities, it is very difficult to forecast benefits into the future.

Kite-Powell et al. (2005) catalog how benefits enter society from COOS. Better raw data becomes new parameters in all sorts of forecasting models improving accuracy, improving resolution, providing a finer spatial scale and providing a finer geographic scale to model outputs. Better products, such as nowcasts and forecasts, reduce risk and allow longer forecast horizons which benefits businesses and consumers. Their report examines benefits accruing to recreational activities, transportation, health and safety, energy and commercial fishing. They estimate benefits by cataloging the current economic footprint of the industry and assuming that COOS will result in a 1% increase in current benefit levels across the 5 sectors described above. In most cases, true surplus, or WTP, estimates were not available, so benefits were forecast as 1% of total sector revenue or cost depending on context. No modeling or primary data collections were conducted nor were probabilistic techniques utilized. Table 4 contains their estimate for the Mid-Atlantic and New England.[11]

[11] The Mid-Atlantic includes the states from Virginia north to New York and New England includes the states north from Connecticut to the Canadian border.

Table 4. Estimates of Potential Annual COOS Benefits in the Mid-Atlantic and Gulf of Maine

Sector	Sub-Sector	Mid-Atlantic	Gulf of Maine
Recreation	Fishing	$30.0	$11.0
	Boating	$2.0	$1.0
	Beach	*	*
Transportation	Freight	$2.0	$1.0
	Passenger	*	
Health and Safety	Search and Rescue	$16.0	$24.0
	Oil Spills	*	*
	Tropical Storm Prediction	*	*
	Residential Property	*	*
	Beach Restoration	*	*
Energy	Oil and Gas Development	*	*
	Electric Load Planning	*	*
Commercial Fishing		$3.0	$4.0
	Grand Total	$53.0	$41.0

Source: Kite-Powell et al. 2005.

Overall, for both the Mid-Atlantic and Gulf of Maine, COOS will generate $94.0 million annually in benefits to society with the $53.0 million arising from the Mid-Atlantic and $41.0 million arising from Gulf of Maine. These estimates were derived using other studies of sector value. Recreational activities constitute a significant portion of these benefits and they would be significantly higher if the benefits accruing to beach goers could be estimated. Across other regions, beach visitor benefits are as high as $100 million. Interestingly, Kite-Powell and Colgan (2001) estimate the benefits of reduced oil spill recovery costs as high as $42.5 million in the Gulf of Maine, but they did not include those estimates here. These two additional estimates alone would more than triple the Gulf of Maine estimates presented in the table below.

Perhaps this is why Kite-Powell et al (2005) also develop what they call “order of magnitude” estimates as they are best used to suggest an order of magnitude for potential benefits of ocean observing systems (Kite-Powell et al. 2005:33). In this section of the report, they posit that benefit estimates could be as high as hundreds of millions of dollars in each sector and each region. While these estimates aren’t suitable for benefit/cost analysis, they point out that benefit will likely exceed costs and that network externalities will likely produce benefits on the high side of these estimates. Their estimates assume full COOS deployment and cost effective and efficient dissemination of the data and products. They further assume that users are aware of the enhanced data and products and incorporate those products in their decision making. For commercial fishing this means that data and products will reduce uncertainty in stock assessments such that commercial harvests can be increased.

Finally, Wellman and Hartley (2008) extended the work presented here to examine the benefits that would accrue to commercial fisheries in Alaska from implementation of COOS. Instead of using the 1% rule, they used expert interviews and a quantitative discussion of plausible scenarios to estimate commercial fishery benefits. They posit that benefits to Bering Sea and Gulf of Alaska groundfish and Kodiak king crab will arise through improve harvest rates and avoidance of overfishing. They also state that benefit estimates should include benefits through the first wholesale value of processed product. They also include estimates of payments to labor, also known as income impacts, as a proxy for total producer surplus.

Wellman and Hartley (2008) develop exactly how COOS outputs can be used to improve fisheries management. COOS outputs have the potential to reduce uncertainty in estimates of stock exploitation rates, improve predictions of recruitment failure or success, and reduce stock assessment errors stemming from not including environmental parameters in stock assessment models. In Alaska, as in many regions, the environmental parameters that impact stock assessment accuracy include salinity, upwellings, temperature, currents, chlorophyll concentrations, and weather front strength. These factors impact maturation, migration, spawning and catchability and each is more or less important depending on the fishery.

By including this data, or in some cases providing better spatial or temporal resolution in this data, reduces stock assessment uncertainty and enhances predictions of growth, productivity and migration. The Alaska Fisheries Management Council and the Alaska Department of Fish and Game set harvest levels very conservatively. Wellman and Hartley used 25 interviews with biologists, oceanographers, fishery managers and fishers to determine what extent harvests could be increased if better environmental condition data was available. In the case of Alaskan groundfish, reduced uncertainty in stock assessments would result in 34% higher harvests of groundfish, or $504 million in wholesale value each year.

Fishery management councils across the U.S. use a similar management strategy. In most fisheries, TAC is set by the fishery management council. Stocks are periodically assessed and NMFS scientists determine how much can be harvested without falling below the maximum sustainable threshold called the overfishing level (OFL). The scientist then set the allowable biological catch (ABC) below the OFL using a buffer such that there is a low probability of exceeding the OFL. This probability is determined by the uncertainty in the data and therefore the stock assessment. The ABC is sent forward to the Scientific and Statistical Committee (SSC) for their approval. The council's advisory panel takes the recommendations of the SSC and sets the TAC, again buffering the TAC lower than the ABC.

The setting of the TAC is tempered by business and political factors. It is also reduced from the ABCs based on uncertainty of the estimates and the precautionary approach to management. Overall the process manages single species at maximum sustained yield as mitigated by formal precautionary safeguards and mitigating social goals. Overall, OFL > ABC > TAC. From a percentage standpoint the difference between the ABC and the OFL is small but can represent large dollar values. Similarly the difference between the ABC and the TAC can represent significant dollar values.

Wellman and Hartley (2008) found that better COOS products could reduce uncertainty in stock assessments and close the gaps between the TAC and the OFL in the Alaskan groundfish fishery producing significant additional value. Over the first 5 years, the gains would be over $1 billion per year and would stabilize around $400 million per year after the initial 5-year period. Their estimates are upper bound increases as they do not consider potential price effects of such large product volume increases.

The story is slightly different for Kodiak king crab. The stock collapses experienced in that fishery are attributable to spawning failures. These spawning failures occurred because crab recruitment was overestimated. Because of the stock collapse, the fishery was closed. With better data on environmental factors, recruitment prediction would be better and collapse could have been avoided. In 2002, additional crab catches would have generated $62.7 million annually, a 47.5% increase in benefits. However, Wellman and Hartley (2008) felt that this estimate was relatively speculative.

Wellman and Hartley (2008) base their conclusions on the following assumptions: the system will actually provide better data, the better data will be incorporated into stock assessments, and the incorporation will improve stock assessment reliability. Very importantly, they assume that the improved reliability will be accepted and utilized by managers and the industry. Using an expected value model across these assumptions yields a 9% chance that the $504 million in benefits to the fishing industry will be realized. Without using the expected value model the NPV of building the array is $17.5 million. Under the expected value model with a 9% chance of benefits, the NPV may very well become negative.

They also conclude that it is very difficult to estimate benefits quantitatively. Because the technology and products are so new, scientists do not know how beneficial this additional and improved data could be. Also it is very difficult to model biological relationships. Many parameters in biological models interact in non-linear ways. Additionally, there is a broad array of influential parameters, and, due to a lack of information, the jump from decisions to open or close a fishery and the associated economic outcomes is significant. Finally, as models become more and more complex, uncertainty may not fall.

From this discussion, benefits in the New England and Mid-Atlantic region from COOS implementation could exceed $100 million dollars across all sectors and by $7.0 million across commercial fishing and $41.0 million across recreational fishing. It is likely that the total benefits will be larger than the sum of the benefits in each individual sector due to network externalities. Wellman and Hartley also show that the 1% rule, as applied to the fisheries sector, may very well underestimate the benefits that could be possible across the commercial fisheries sector.

While not discussed in Wellman and Hartley (2008), recent changes in fishery management laws enhance these formal safe guards, further reducing TACs, now called annual catch limits (ACLs) based on a formal recognition of uncertainty in stock assessments and the data underlying these assessments. In addition, this new approach in multi-species fisheries, such as New England groundfish, may mean reducing harvests of species in relatively good biological shape because of stock assessment uncertainty across other species in the multispecies complex. For example, suppose there are three species (x, y, and z) in a multispecies fishery. The technology used to harvest these fish catches all species at the same time and the harvester has very little control over the mix of species in each set of the gear, much like trawling. Species x and y are in good shape with little uncertainty in the stock assessment, but species z’s stock assessment is very uncertain. ACLs would be set for each species, but the season may be closed for species x and y when the harvest of z is reached or, in anticipation, the ACLs of species x and y may be reduced to avoid overfishing z. This has been termed ‘managing to the weakest stock’ and better ocean observing data may reduce restrictions of this nature.

3.1 Economic Footprint of the Fisheries Industry in New England and the Mid-Atlantic

While there are certainly other sectors that benefit from the implementation of COOS, the focus of the rest of this benefits section will be on commercial and recreational fisheries sectors. This is in response to public comments stating that negative fishery impacts have been ignored in the OOI planning process, in particular the NEPA process and the preparation of the SSEA. No other sectors came forward disputing either the benefits or costs of the proposed Pioneer Array. As a result the focus here is on fisheries.

Commercial fisheries in the Mid-Atlantic and New England regions are extremely valuable and support significant economic activity. Table 5 details the 5-year average landed value and economic impact of commercial fisheries by state. Overall, the Mid-Atlantic generates $527.2 million in landed value which supports $7.0 billion in total sales, $2.9 billion in income and 103,745 jobs across the entire seafood industry from the harvester to the consumer (NMFS 2010a). Similarly, using the custom seafood industry economic impact model referenced in section 2.3, New England commercial fisheries land $852.1 million in seafood supporting $11.3 billion in total sales, $4.7 billion in income and 167,696 across the entire seafood industry. Across both regions, commercial fisherman land $1.4 billion supporting $18.2 billion in total sales, $7.6 billion in income and 271,441 jobs.

Due to declining stocks and declining real prices, the seafood industry in both regions has been on the decline (Kirkley 2006). Figure 4 displays the trend in both landed pounds and landed value. It is exactly these declines that the COOS is designed to counteract through the pathways detailed in the benefits section above. Figure 4 also demonstrates that using a 5 year average to estimate benefits and costs will overestimate both over using the most recent year of data.

Table 5. Average Landed Value 2005-2009 and Economic Impacts of the Seafood Industry in the Mid-Atlantic and New England

Region	State	Average Landed Value*	Total sales*	Income*	Employment
Mid-Atlantic	Connecticut	$31.0	$145.8	$73.4	2,931
	Delaware	$6.4	$41.4	$21.1	912
	Maryland	$64.7	$450.4	$227.7	2,718
	New Jersey	$152.3	$607.8	$305.8	11,159
	New York	$56.1	$275.6	$127.9	6,282
	North Carolina	$76.2	$449.6	$242.0	10,984
	Virginia	$140.4	$821.4	$450.9	19,227
	Total	$527.2	$6,984.4	$2,915.3	103,745
New England	Maine	$337.8	$1,113.5	$580.5	23,200
	Massachusetts	$416.9	$1,899.7	$984.4	35,609
	New Hampshire	$18.6	$126.8	$68.5	2,707
	Rhode Island	$78.8	$318.2	$163.0	6,801
	Total	$852.1	$11,289.7	$4,712.3	167,696
	Grand Total	$1,379.3	$18,274.0	$7,627.5	271,441

*Millions of 2009 U.S. dollars
Source: NMFS 2010a

Recreational fishing is also a major economic engine in both the Northeast and Mid-Atlantic the regions. Table 6 details recreational effort (number of trips), expenditures and economic activity supported by both private recreational anglers and the for-hire fishing sectors combined averaged over the last 5 years. In the Mid-Atlantic, recreational anglers took 28.9 million trips spending $7.5 billion to take those trips (NMFS 2010b). This level of spending generated $8.4 billion in total sales, $2.7 billion in income and supported 64,414 jobs in 2008. In New England, recreational anglers took 7.4 million trips spending $1.8 billion (Gentner and Steinback 2008). Their spending generated $1.3 billion in total sales, $433.7 million in income and supported 10,704 jobs. Across both regions, recreational angling generated $9.6 billion in total sales, $3.2 billion in income and support 75,118 jobs. Figure 5 displays the trends in recreational fishing effort over the last 5 years. Figure 5 shows a downward trend suggesting that there is room for quality improvements from the installation of a COOS and the subsequent improvements in catch that could result.

Figure 4. Trends in Landed Volume and Value for the Mid-Atlantic and New England Combined (NMFS 2010a)

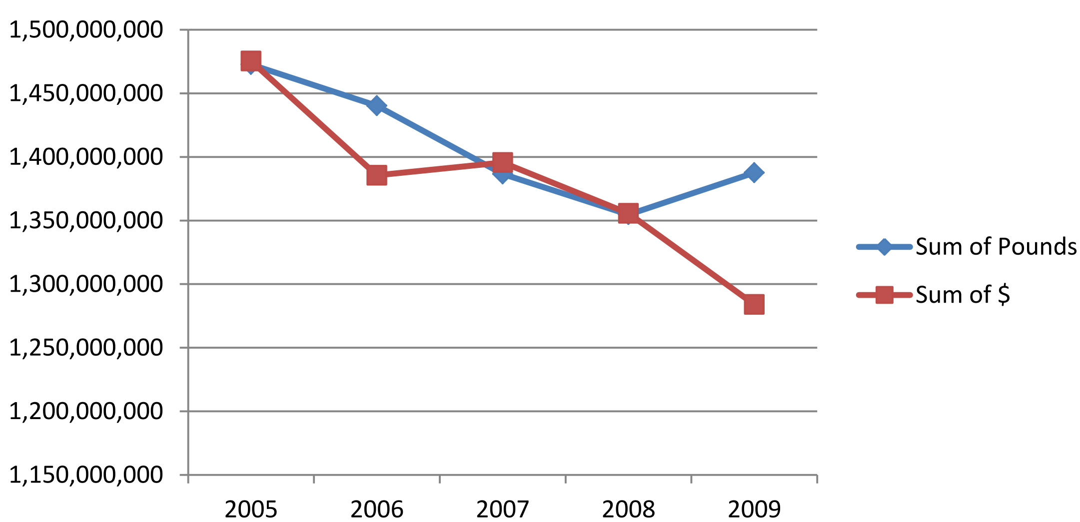
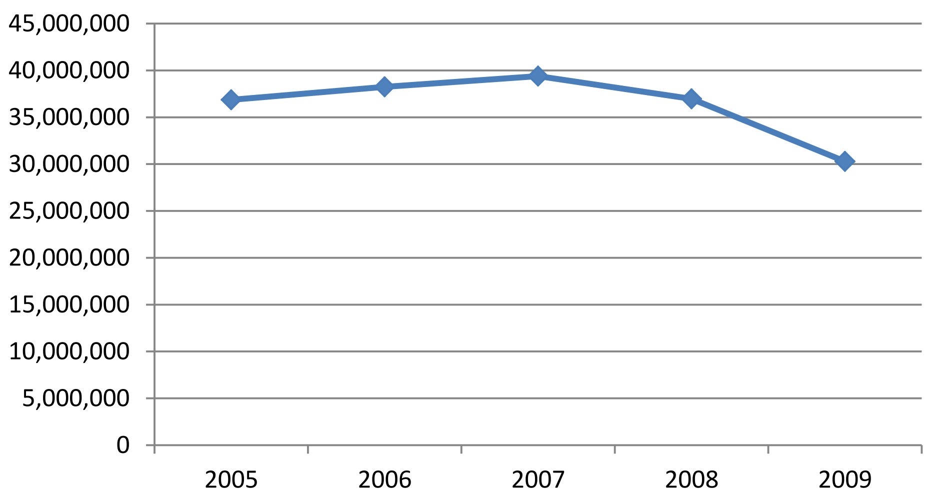


Table 6. Average Recreational Fishing Effort, Expenditures and Economic Impacts in the Mid-Atlantic and New England (2005-2009)

Region	State	Average Effort	Expenditures*	Total sales*	Income*	Jobs
Mid-Atlantic	Connecticut	1,620,290	$704.8	$704.3	$269.2	4,614
	Delaware	1,107,053	$312.4	$280.9	$77.5	1,782
	Maryland	3,403,619	$1,396.6	$1,332.5	$442.4	9,471
	New Jersey	6,716,023	$1,475.2	$1,705.2	$554.7	10,403
	New York	5,712,041	$817.2	$861.0	$292.6	5,686
	North Carolina	6,777,998	$2,153.2	$2,666.4	$827.7	25,209
	Virginia	3,574,733	$891.3	$820.8	$276.3	7,249
	Total	28,911,757	$7,750.8	$8,371.2	$2,740.3	64,414
New England	Maine	1,072,517	$204.9	$185.2	$60.7	2,167
	Massachusetts	4,388,693	$817.6	$850.5	$296.7	6,446
	New Hampshire	473,599	$65.6	$59.7	$20.8	527
	Rhode Island	1,504,588	$193.6	$176.9	$55.6	1,565
	Total	7,439,398	$1,281.8	$1,272.3	$433.7	10,704
	Grand Total	36,351,154	$9,032.6	$9,643.5	$3,174.1	75,118

*Millions of 2009 U.S. dollars; Source: NMFS 2010b and Gentner and Steinback 2008

Figure 5. Trends in Recreational Fishing Effort for the Mid-Atlantic and New England Combined (NMFS 2010b)



3.2 Potential Economic Benefits Accruing to the Commercial and Recreational Fisheries Sectors

From the literature review above, better data, nowcasts and forecasts will reduce costs of fishing and also allow for faster fishery recovery and ultimately higher harvests in the future. This increases benefits to both the recreational and commercial fishing sectors. While estimates exist in the individual fishery management plans for stock recovery trajectories, it is impossible to estimate how much faster those species might recover with better ocean observing data and it is impossible to know if the better data will be utilized in the fishery management process such that it will result in higher harvests. Instead, the 1% increase rule described in the literature, as presented previously in Section 3.0, will be used here.

Table 7 details the potential benefits of the COOS system in the Mid-Atlantic and New England. A 1% increase in landings would be $5.3 million and generate $29.2 million in income seafood industry wide. A similar increase for New England would generate $8.5 million in additional landings and support $47.1

million in income. Across both regions, the potential benefits include $19.1 million in additional landings and $61.6 million income. As a reminder, income is serving as a proxy for total surplus (Edwards 1990).

Recreational angling could also reap benefits from COOS implementation. Recreational anglers have been shown to be willing to pay for more and bigger fish to harvest (Hicks et al. 1999). Additionally seasons for many important species, such as summer flounder and black sea bass, are short and anglers would be willing to pay for increased season length. Again, estimating willingness to pay for these improvements is beyond the scope of this project. Instead, 1% increases in 5-year average expenditures were estimated. Table 8 details those increases. For the Mid-Atlantic, COOS would increase spending by $77.5 million and $83.7 million in value. For New England, COOS would increase spending by $12.8 million and income by $12.7 million. Across both regions spending could rise by $90.3 million and income could rise by $96.4 million.

Table 7. Potential Commercial Fishery Benefits: 1% Increases in Landings and Income

Region	State	1% Increase in Landings*	1% Increase in Total Seafood Industry Income*
Mid-Atlantic	Connecticut	$0.31	$0.73
	Delaware	$0.06	$0.21
	Maryland	$0.65	$2.28
	New Jersey	$1.52	$3.06
	New York	$0.56	$1.28
	North Carolina	$0.76	$2.42
	Virginia	$1.40	$4.51
	Total	$5.27	$29.15
New England	Maine	$3.38	$5.80
	Massachusetts	$4.17	$9.84
	New Hampshire	$0.19	$0.69
	Rhode Island	$0.79	$1.63
	Total	$8.52	$47.12
	Grand Total	$19.06	$61.60

*Millions of 2009 U.S. Dollars

Table 8. Potential Recreational Fishery Benefits: 1% Increases in Expenditures and Income

Region	State	1% Increase in Expenditures	1% Increase in Income
Mid-Atlantic	Connecticut	$7.05	$7.04
	Delaware	$3.12	$2.81
	Maryland	$13.97	$13.33
	New Jersey	$14.75	$17.05
	New York	$8.17	$8.61
	North Carolina	$21.53	$26.66
	Virginia	$8.91	$8.21
	Total	$77.51	$83.71
New England	Maine	$2.05	$1.85
	Massachusetts	$8.18	$8.50
	New Hampshire	$0.66	$0.60
	Rhode Island	$1.94	$1.77
	Total	$12.82	$12.72
	Grand Total	$90.33	$96.44

*Millions of 2009 U.S. Dollars

Across the recreational and commercial sectors COOS implementation could generate $109 million in increased landed value and increased recreational expenditures per year. This translates into a $158 million increase in income, our proxy for total value, per year. Only the benefits accruing to fishing, both commercial and recreational, have been estimated in this section. Including other benefits from Table 4 increases these benefit estimates by $20 million and $26 million for the Mid-Atlantic and New England respectively, bringing the total potential annual benefits to $204 million per year. Wellman and Hartley (2008), in a groundfish fishery with very similar stock assessment and stock condition issues as the New England groundfish fishery, estimate that commercial fishing landings may increase by almost 34%. Additionally, because of the nature of multi-species fisheries, the biggest benefit may lie in avoiding closures due to managing for the weakest (or most uncertain) species in the multi-species complex. If any of the species in the multi-species fisheries in these regions are limited by the status of a single stock, increased and improved data could quickly reduce or eliminate costly closures from managing to the weakest species.

4.0 COMMERCIAL FISHING SECTOR

The VTR data merged with the dealer value data required some manipulation before it could be used. First, all value data was converted to 2009 dollars using the consumer price index. In this data set there were three reasons for empty cells at the 10-min square spatial resolution; missing harvest data, inability to merge value data, or data confidentiality. First, all trips lacking harvest data were dropped. In discussion with NMFS, these trips represent trips where all fish brought up in the gear were discarded or disposed of before reaching the dealer for any number of reasons.[12] In addition to discards, this could include fish used as bait or taken home for personal consumption.

Second, due to data limitations, some trips could not be matched to dealer data. In these cases, average prices and conversion factors were created using the data that could be matched and applied to the catch that could not be matched to dealer data. If a matching price could not be found the price and conversion factor for the nearest substitute was used. If the inability to match dealer data is random and not systematic, this will produce unbiased value estimates. If, however, the inability to match trips to dealer data is due to one particular dealer or vessel for benign or strategic reasons, it may introduce a bias into the value estimates.

Finally, as with the for-hire data, confidential trips were reported at the next level of spatial resolution that would allow non-confidential reporting. From Table 3, only 13% of all harvested fish could not be reported at the 10-min square level due to confidentiality. The value represented by these confidential trips was distributed to 10-min squares based on the proportion of empty cells in the spatial schema immediately below it in the schema. This rather naïve apportioning technique assumes that all confidential effort is spread equally over a larger area when in actuality, it is likely that the confidential effort occurred in a single 10-min square. As such, the imputed confidential estimates underestimate actual activity at the 10-min square level and, as a result, the map below will show small amounts of value in areas that likely produced no value. Fortunately, across the statistical areas in this analysis, imputed data represents less than 8% of the total value reported. As will be demonstrated below, the imputed data changes the estimates of impact in the actual buffer zones very little.

As mentioned previously, these estimates from the VTR data may miss landings from lobster vessels and state permitted vessels. Within the three 10-min squares that contain the moorings, the pot and trap gear type landed lobster, red crab, rock crab and Jonah crab indicating at least some of the lobster landings are being captured in the VTR data. It is likely that lobster boats fishing this far off shore hold federal permits and that this gap is likely small. The VTR data also included landings of inshore and other non-federally

[12] Personal communication from Dr. John Witzig, NMFS, Director, Fisheries Statistics Office, Northeast Regional Office, Gloucester, MA.

managed species. While it is impossible to know if state permitted only vessels are landing fish in these areas, it is unlikely that they would without also holding a federal permit.

4.1 Commercial Fisheries Economic Footprint in the Study Area

Figure 6 displays the annual average income from the harvester, processor, wholesale and retail seafood sectors. Approximately 92.4% of all value in the study area from the VTR data is accounted for in this figure and represents the best indicator of actual fishing activity in and around the Pioneer Array. On average, degree square 4070 10-min square 25 generates \$2.6 million income, degree square 4070 10-min square 26 generates \$1.7 million in income. Distributed proportionately to area, there is \$74,860 in income activity for the inshore, central-inshore, central and upstream inshore moorings. Degree square 3970 10-min square 21 generates \$2.0 million in income for a total income in the central-offshore, offshore and upstream offshore mooring buffer zones for \$60,377. Summing all activity in the AUV mission box includes \$56.0 million in income and similarly the glider mission box supports \$60.0 million in income. Summing the two mission boxes without overlap contains \$77.5 million in income.

After imputation, only 666 trips were taken in the average year across all three 10-min squares that include moorings. Of those trips, 78.4% were fished by the bottom trawl gear, pots and traps make up 9.5%, gillnets 8.9%, and longlines 2.3% of the effort. All of the other gear types make up less than 1% of the effort and are likely an artifact of the apportionment of the confidential data rather than an actual representation of effort in that gear type. Across the entire study area, the effort in these three 10-min squares represents less than 0.5% of all effort in the VTR database for NMFS statistical areas 526, 533, 534, 537 and 541 and less than 1% of the trips reporting landed value.

After imputation, the three 10-min squares in the study area generate \$1.2 million on average each year in harvester revenue which supports \$6.6 million in shoreside income and 235 jobs in the harvesting, processing, wholesaling and retailing sectors. Allocating this revenue and shoreside economic impacts proportionally by area to the 7 buffer zones yields harvesting revenue of \$25,386. Including the economic impact on shoreside businesses, this level of revenue generates \$142,068 in income and supports 5 jobs. Figure 7 displays the estimated income in each 10-min square after the imputation of confidential data. Degree square 4070 and 10-min square 25 generates \$488,041 in revenue supporting \$2.7 million in shoreside business income while 10-min square 26 generates \$330,841 in revenue supporting \$1.9 million in shoreside income. Across the moorings in these two 10-min squares, commercial fishing generates \$14,388 in revenue supporting \$80,606 in shoreside business income; an increase of \$5,746 in income after imputation. For degree square 3970 and 10-min square 21, commercial fishing generates \$356,103 in harvester revenue which support \$2.0 million in shoreside business income. Across the mooring locations in this 10-min square, commercial fishing generates \$10,998 in revenue supporting \$61,462 in shoreside business income; an increase of a little over a \$1,000 for a total across all buffer zones of \$142,068 in income. Commercial fishing in the AUV mission box supports \$59.7 million and in the glider mission box \$64.6 million in income. Summing across both mission boxes represents \$83.6 million in income.

Figure 6. Average Annual Commercial Harvester, Processor, Wholesaler and Retail Income by 10-min Square, Reported Trips Only

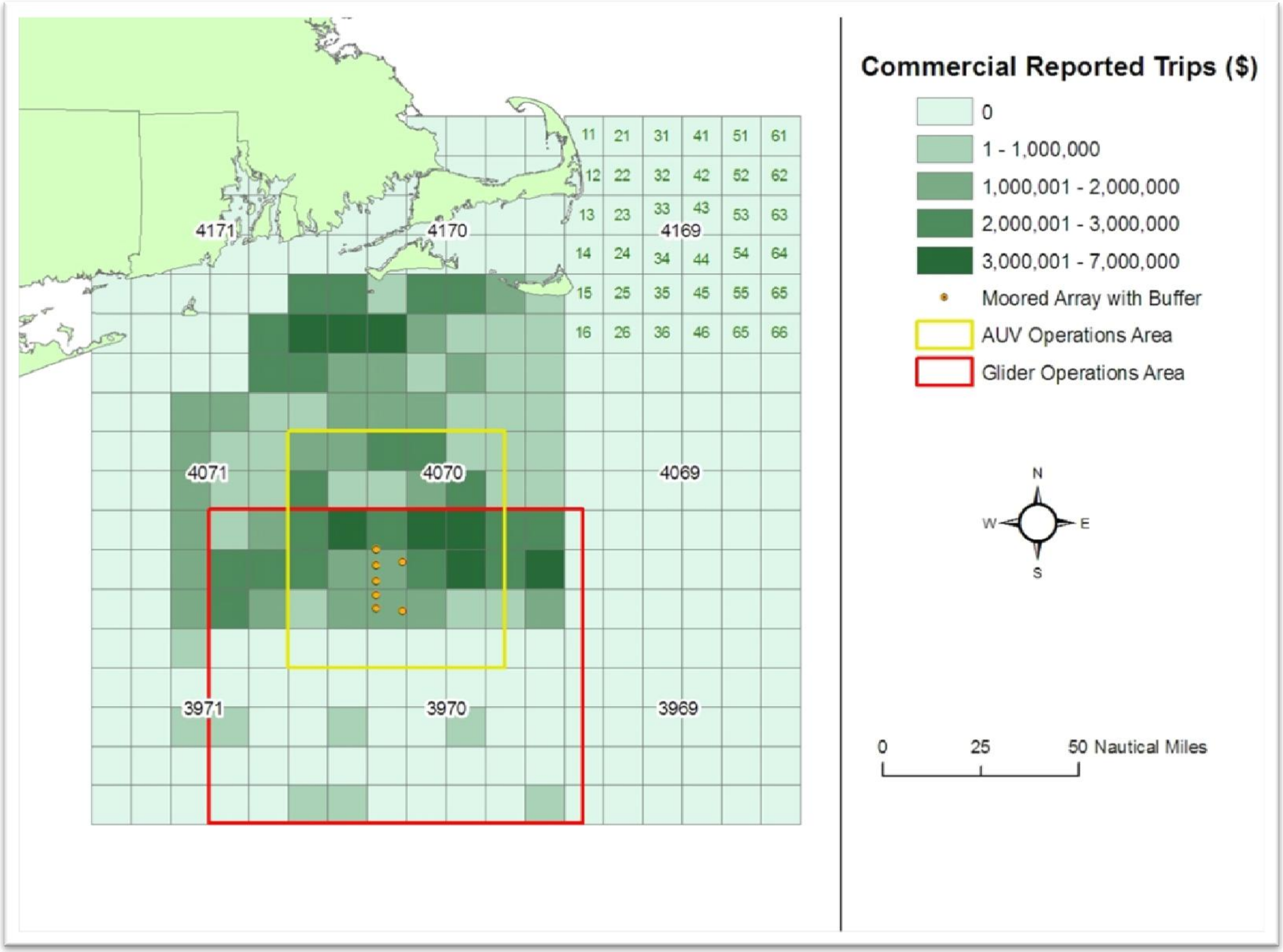
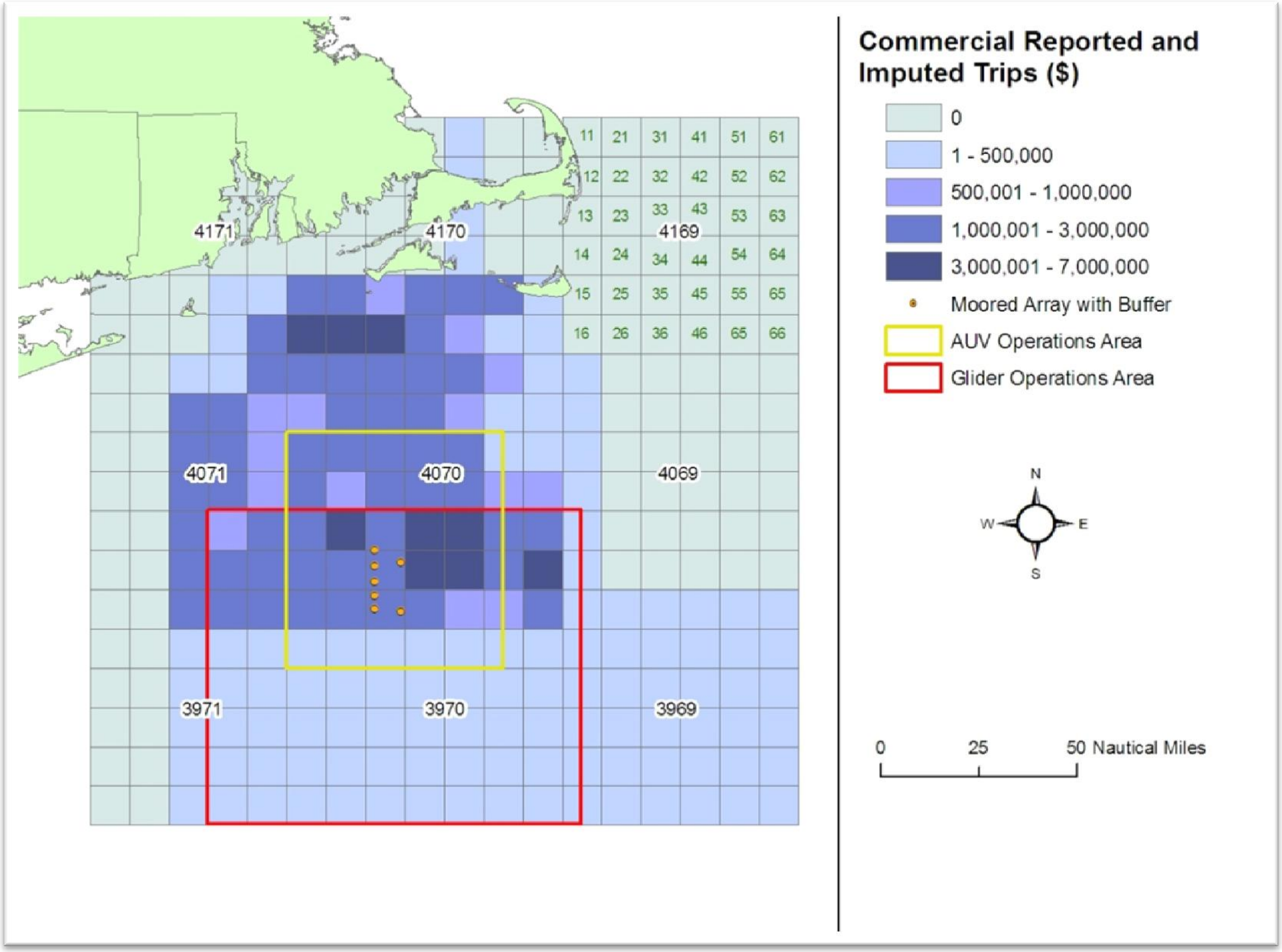


Figure 7. Average Annual Commercial Harvester, Processor, Wholesaler and Retail Income by 10-min Square, Reported and Imputed Trips



4.2 Commercial Fisheries Cost Models

In the methods section above, two cost scenarios were developed. Scenario one assumes that only the trips imputed to occur within the proposed buffer zones relocated their effort to just outside the buffer zones. The cost models discussed above were then used to model the cost of moving 1 nm for the non-drift gears (otter trawl, midwater trawl, dredges, other gears and pots and traps) and the length of the average set for the drift gears (gillnet and longline). From Kerstetter (2008) the average length of longline deployed per set averaged 22 nm as taken from observer data. Therefore it is assumed that longline vessels would move 22 nm before redeploying their gear. From a custom query run by the NMFS Observer Program, gillnetters set 16 panels 300 feet long on average out of 1,586 sets in NMFS Statistical Area 537.[13] That equates to a gillnet set length of 0.79 nm. Since 92.2% of observed gillnet trips are anchored gillnet trips (Warden and Orphanides 2008), the majority of gillnet effort in the region is fixed gear and gillnet effort was included in the fixed gear category. Scenario two assumes that all effort in the three degree squares will simply avoid those squares entirely. This is viewed as likely an extreme upper bound as most non drift gears should have no problem setting their gear in an among the buffer zones.

Table 9 contains the estimates of the cost of avoiding the buffer zones for both scenarios. Under Scenario 1, costs would increase by $162 for all vessels annually, a very small cost increase. Because trips could only be reported at the 10-min square, it is impossible to know if any trips have been taken in the last 5 years in the actual buffer zones. Assigning the trips to a buffer zone using the proportion of area in the proposed buffer zone (roughly 0.79 nm^2) is naïve, but all that is possible. It could be that no trips were taken in the buffer zone at all or it could be that all of the gear was set within the buffer zone (unlikely at best). Scenario two examines this worst case scenario by assuming that all effort falls in the buffer zone.

Table 9. Potential Increased Cost of Avoiding Proposed Buffer Zones

	Scenario 1		Scenario 2	
Gear	Trips Impacted	Increased Cost	Trips Impacted	Increased Cost
Bottom Trawl	12.86	$113.16	521.79	$31,068.17
Dredge	0.08	$0.58	2.87	$175.62
Midwater Trawl	0.01	$0.26	1.16	$181.33
Longline	0.11	$34.95	14.99	$1,846.07
Gillnet	0.18	$2.36	58.86	$3,694.07
All Gears*	1.67	$10.76	65.78	$3,710.82
Total	14.92	$162.08	665.45	$40,676.08

*Includes pots, traps, and other gears.

From Figure 7, the mooring locations do not fall in areas that could be considered commercial fishing hotspots relative to other areas. The three 10-min squares are definitely not hotspots for dredge, midwater trawl, longline gear or other gears with only a handful of trips supported in these three squares. Additionally, 10-min squares to the northeast and northwest produce more income suggesting search time for new fishing locations will be minimized. Under Scenario 2, costs would increase by $40,676 annually for all vessels fishing in the three 10-min squares in the study area. Even at the high end of this broad spectrum, this is a very minor increase spread across many vessels.[14]

5.0 FOR-HIRE RECREATIONAL FISHING SECTOR

For-hire recreational fishing vessels can be grouped in to two categories; charter boats and party boats. Charter boats are typically smaller boats licensed to carry 6 or fewer passengers. The entire vessel is hired

[13] D. Duarte. Personal Communication. NMFS Observer Program.

[14] The total number of individual vessels fishing in this area is unknown, however more than three vessels had to report effort in any cell reported in Figure 4.

and may take a single individual or a small group. Charter costs can range from $300/day for small inshore boats to $2,000/day for long range offshore trips. Party boats, on the other hand, are usually much larger vessels with extensive passenger capacities. Party boat operators sell individual places on the vessel for a cost usually less than $100 for a single day trip.

Data on actual fishing locations for this sector came from the same NMFS vessel trip report database described above. All federally permitted boats are required to complete log books for their fishing activities, including for-hire recreational vessels. In general, the area surrounding the mooring locations is a relatively low activity area for this sector. Traveling 60 miles or more offshore is a long haul for a charter boat or a party boat on a single day trip. For NMFS Statistical Area 537, the statistical area containing all the mooring locations, only 411 charter trips hosting 2,088 anglers were taken, on average, each year and the majority of those trips took place closer to shore.

The VTR data on for-hire fishing does not contain information on vessel revenues for each trip. Instead, angler expenditure data was used to estimate charter and party boat revenue as well as any shoreside spending by the anglers taking a for-hire trip. The angler expenditure data comes from the MRFSS 2006 economic add-on as discussed in section 3.1. Mean expenditures per person per trip were estimated using the methods of Gentner and Steinback (2008) across the Mid-Atlantic and New England states. For the charter mode, each angler spent $149.35 and each party boat patron spent $89.89 on average, per trip in 2009 dollars.[15] This includes the charter or party fee plus any fuel surcharge or additional expenditure on food and incidentals. Total expenditures in each 10-min square were estimated by taking the average per angler expenditure and multiplying it with the number of anglers estimated in each 10-min square from the VTR data.

To estimate total surplus using income impacts as a proxy, total expenditures by block were applied to the economic impact model developed in Gentner and Steinback (2008). Figure 8 displays the income generated in each 10-min square across the study area. The northernmost four mooring locations all occur in degree square 4070 and 10-min square 26. The southernmost three mooring locations occur in degree square 3970 and 10-min square 21. Before the allocation of confidential data, there has been no for-hire fishing activity recorded in either of these 10-min squares over the previous 5 years. Before imputation the AUV mission box contained $33,961 of for-hire fishing income while the glider mission box contained $49,757 in income. Together, both mission boxes contain $60,227 in income. Looking at the VTR data without imputation, the area around the moorings are not hotspots of for-hire recreational fishing activity.

Figure 9 details the reported and imputed average annual income generated in the study area. Only degree square 3970 10-min square 21 contains any activity at $61 worth of income annually. Distributing this across the mooring sites suggests that less than a dollar’s worth of income is generated in each mooring location. This result is likely an artifact of the imputation strategy rather than any indication of any actual activity. The AUV mission box contains only $34,747 worth of income and the glider box only contains $54,452 in income activity. Combine both mission boxes contain $64,922 in income activity. Clearly the area around the mooring locations or the mission boxes are not a high activity zones for the for-hire fleet and there is likely to be no costs to this sector associated with the installation and O&M of the proposed Pioneer Array.

[15] Spending inflated to 2009 dollars using the consumer price index.

Figure 8. Average Income Generated by For-Hire Recreational Fishing in the Study Area Reported Trips Only, 2005-2009

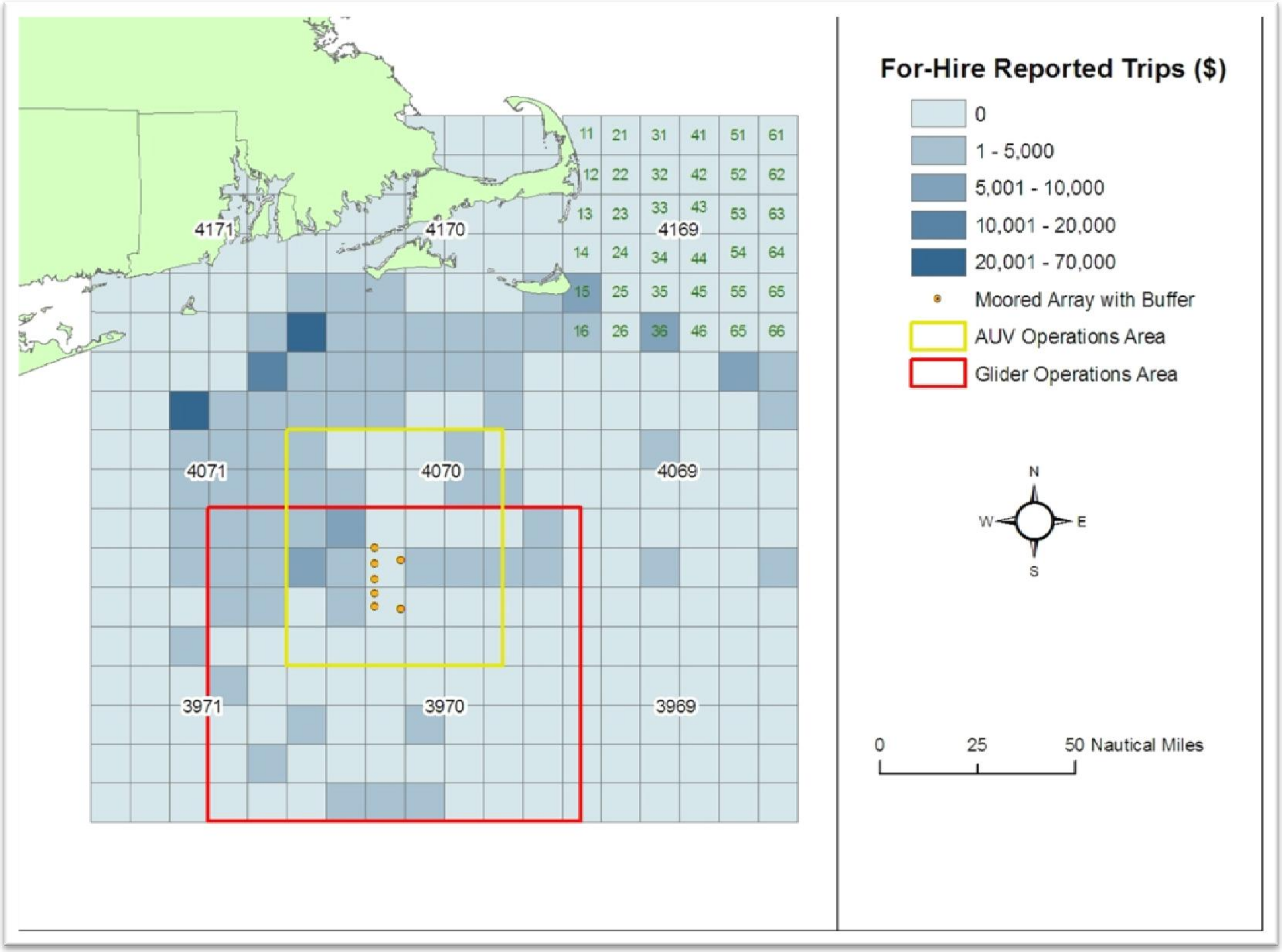
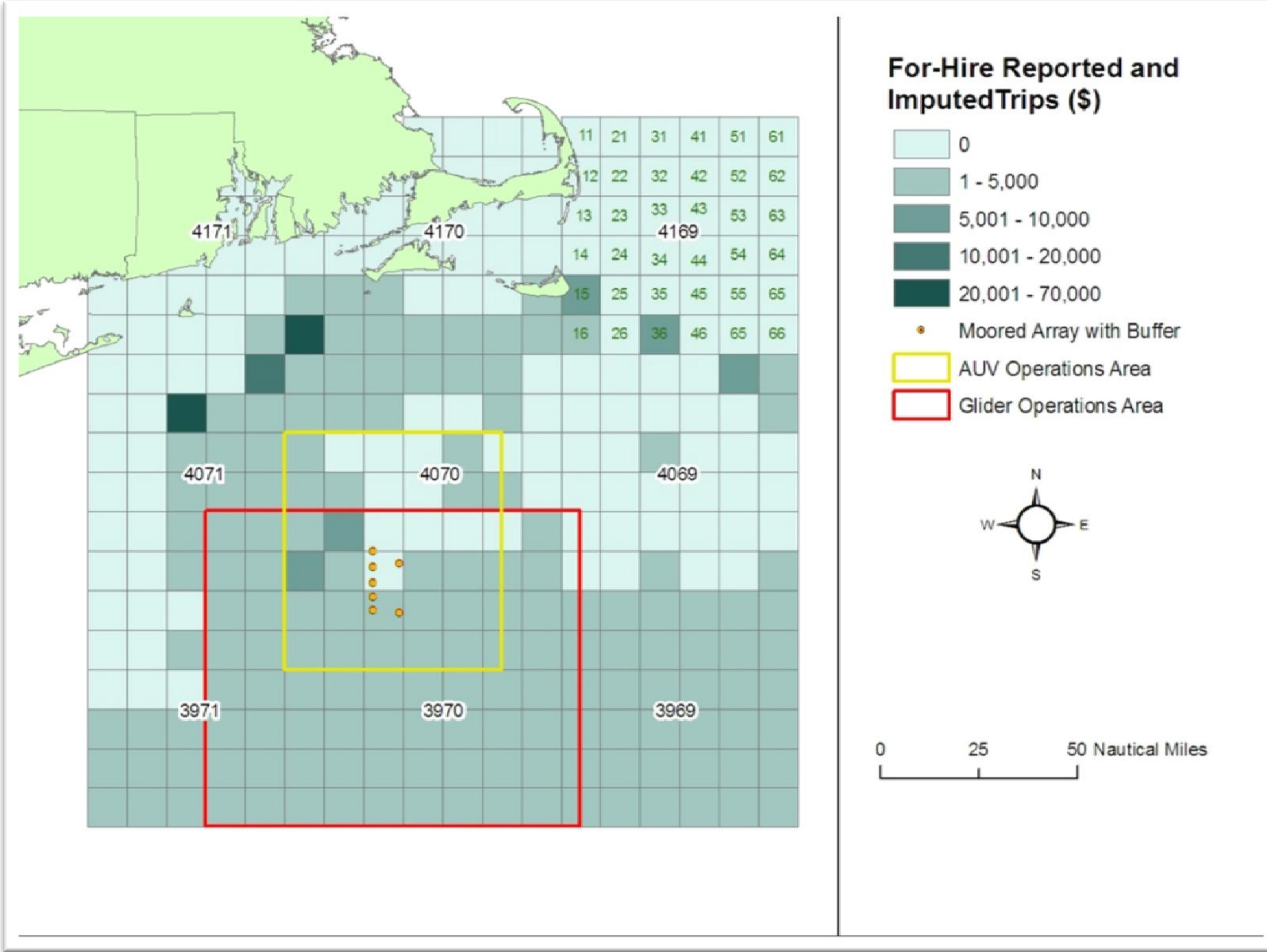


Figure 9. Average Income Generated by For-Hire Recreational Fishing in the Study Area, Reported and Imputed Trips, 2005-2009



6.0 PRIVATE RECREATIONAL FISHING SECTOR

The base MRFSS only collects area-fished using three categories; inshore, offshore less than three miles and offshore greater than three miles. As a result, it is necessary to use MRFSS economic add-on surveys to estimate probable offshore fishing locations used by the private fleet. The first step in this analysis was to post-stratify MRFSS effort estimates.

The most ideal strategy from an analysis standpoint would be to post-stratify effort at the individual MRFSS intercept site level. However, with more than 600 intercept sites in the study area, sample size concerns required aggregation of intercept sites to a larger spatial area. The aggregation strategy used for this analysis follows the standard NMFS aggregation strategy used in numerous studies (e.g., Gautam and Steinback 1998; Haab and Hicks 1999; Hicks et al. 1999; Gentner 2007). Essentially, MRFSS intercept sites were aggregated to the county level. If the county has a barrier island, the county was divided in to a sound-side site and an ocean-side site. The ocean-side portion of each county was defined as a zone for the purposes of this report and used the post-stratification of effort. Effort estimates were post-stratified based on the proportion of MRFSS intercept interviews in each strata; state, area, and zone. Effort estimates at the state level were downloaded from the NMFS online data queries. Table 10 contains the 5 year average post-stratified private recreational boat effort estimates, before the additional stratification of additional offshore zones to be developed below. The estimates in Table 10 were generated by GCG using effort data from the MRFSS online data queries (NMFS 2010b)

Table 10 shows that proportionately, very little recreational effort occurs offshore. The majority of the effort in each zone occurs either in the inland or less than 3 nm offshore zones. For Connecticut, there are no effort estimates in the MRFSS except for the inland portion of Long Island Sound. Also in Rhode Island, the MRFSS data shows no offshore activity greater than 3 nm offshore for any county/zone except Washington County, Rhode Island.

Table 10. Average Boat Effort Estimates by Coastal Zone and Distance from Shore

County, State and Area	Effort	% Effort
Barnstable, MA	825,613	
Inland	354,941	42.99%
Ocean (≤ 3 nm)	327,534	39.67%
Ocean (> 3 nm)	143,138	17.34%
Bristol, MA	214,663	
Inland	144,661	67.39%
Ocean (≤ 3 nm)	34,595	16.12%
Ocean (> 3 nm)	35,408	16.49%
Bristol, RI	29,823	
Inland	29,823	100.00%
Dukes, MA	52,917	
Inland	41,758	78.91%
Ocean (≤ 3 nm)	11,160	21.09%
Kent, RI	117,505	
Inland	114,706	97.62%
Ocean (≤ 3 nm)	2,800	2.38%
Middlesex, CT	330,732	
Inland	330,732	100.00%
Nantucket, MA	27,215	
Inland	17,896	65.76%
Ocean (≤ 3 nm)	7,812	28.70%
Ocean (> 3 nm)	1,507	5.54%
New London, CT	617,132	
Inland	613,878	99.47%
Newport, RI	76,017	
Inland	71,118	93.55%
Ocean (≤ 3 nm)	4,900	6.45%
Providence, RI	66,529	
Inland	66,529	100.00%
Suffolk Oceanside, NY	1,545,669	
Inland	497,147	32.16%
Ocean (≤ 3 nm)	983,276	63.61%
Ocean (> 3 nm)	65,246	4.22%
Washington, RI	362,313	
Inland	79,147	21.84%
Ocean (≤ 3 nm)	250,585	69.16%
Ocean (> 3 nm)	32,581	8.99%

Expenditure and economic impact estimates developed for this analysis did not include any of the inland fishing or offshore less than three miles effort as it did not impact the study sites. For the purpose of this study it was important to estimate where recreational anglers might go when they take trips beyond the three mile limit. While no additional data on fishing location was collected other than area fished, the base MRFSS survey collects total hours fished and total hours spent on the boat. Additionally, the mail survey collected information on boat horsepower and boat length, if the respondent owned a boat. Carter et al. (2007) used total hours fished and total hours spent on the boat to estimate maximum travel range in southern Florida. Maximum one-way travel range in their study was defined as:

$$Range = \frac{r_m\left(h_j - f_j\right)}{2}$$

Where r_m is the maximum vessel speed, h_j is hours spent on the boat, and f_j is the hours spent fishing. To calculate maximum vessel speed, Carter et al. (2007) used Crouch's formula as taken from Gerr (2001:15-17). Crouch's formula is:

$$r_m = \frac{k}{\sqrt{\frac{d_m + l_m}{p_m}}}$$

Where k is a constant estimated by Crouch to be 150 for small planing hulls of the type used for recreational fishing, d_m is the vessel displacement, l_m is the vessel load, and p_m is the vessel brake horsepower, which was calculated of 85% of reported horsepower. While Carter et al. (2007) used average values for displacement, load, and horsepower; this study estimates those parameters directly using the mail survey data. Vessel displacement was calculated using an equation developed by Vasconcellos and Latorre (1999) that related vessel length to displacement across all pleasure boats manufactured in the U.S. from 18 to 70 feet in length. Their model covered 593 different boat designs and can be expressed as:

$$displacement = 599(e^{0.0796 Length})$$

Load was calculated by taking the number in each boat party times 175 pounds per person plus the weight of fuel onboard the vessel. Vasconcellos and Latorre (1999) found the average fuel capacity of the vessels in their study to be 227 gallons. Fuel weight was calculated by multiplying this average times the weight of gasoline (6.2 pounds per gallon). This assumes that each vessel had a full tank of gas, which may or may not be accurate. If the actual fuel capacity of a vessel were less or the vessel was not carrying a full tank of gas, the load would be lighter, the maximum speed greater, and the maximum range greater. Additionally, it was assumed that all vessels were gasoline. The majority of vessels in the Vasconcellos and Latorre study were gasoline; however, they did not estimate the percentage of gasoline versus diesel vessels. Additionally, the NMFS mail survey did not collect fuel type. Because diesel weighs more than gasoline (7.3 pounds per gallon), the assumption that that all boats were gasoline increases the maximum speed and therefore the maximum range.

Mean travel distance was calculated for every observed trip outside of the 3 mile federal limit. Due to relatively few observations on horsepower and length in the mail survey data, missing values in the intercept data were replaced with the mean value for boat length and horsepower across the study area. The mean boat length in the data was 20.0 feet and the mean horsepower was 165.4 horsepower. Two additional offshore areas were created by taking the 75th and 100th percentile of the mean maximum travel distance. The mean maximum travel radius within these two new offshore fishing area stratum were used to post-stratify the offshore (greater than 3 nm) effort in Table 10. Economic impacts were also calculated using the custom recreational economic impact model developed in Gentner and Steinback (2008). All dollar values were converted to 2009 dollars to match the commercial estimates using the consumer price index.

In Figure 10, the estimates of income were mapped over the study area based on the estimated maximum travel radii. Using the coastline of each county, bands were drawn using the three different distances for each zone and the economic impacts for that maximum travel radius were applied to the polygon created by mapping the radius. After the three bands were drawn around each zone, a union was performed that overlaid all of the bands. The value of each polygon created by this overlay was determined by adding all of the overlapping bands together for that location. Each polygon in Figure 10 shows the total value of the intersecting bands. From Figure 10, there does not appear to be any private recreational fishing activity anywhere in the study area.

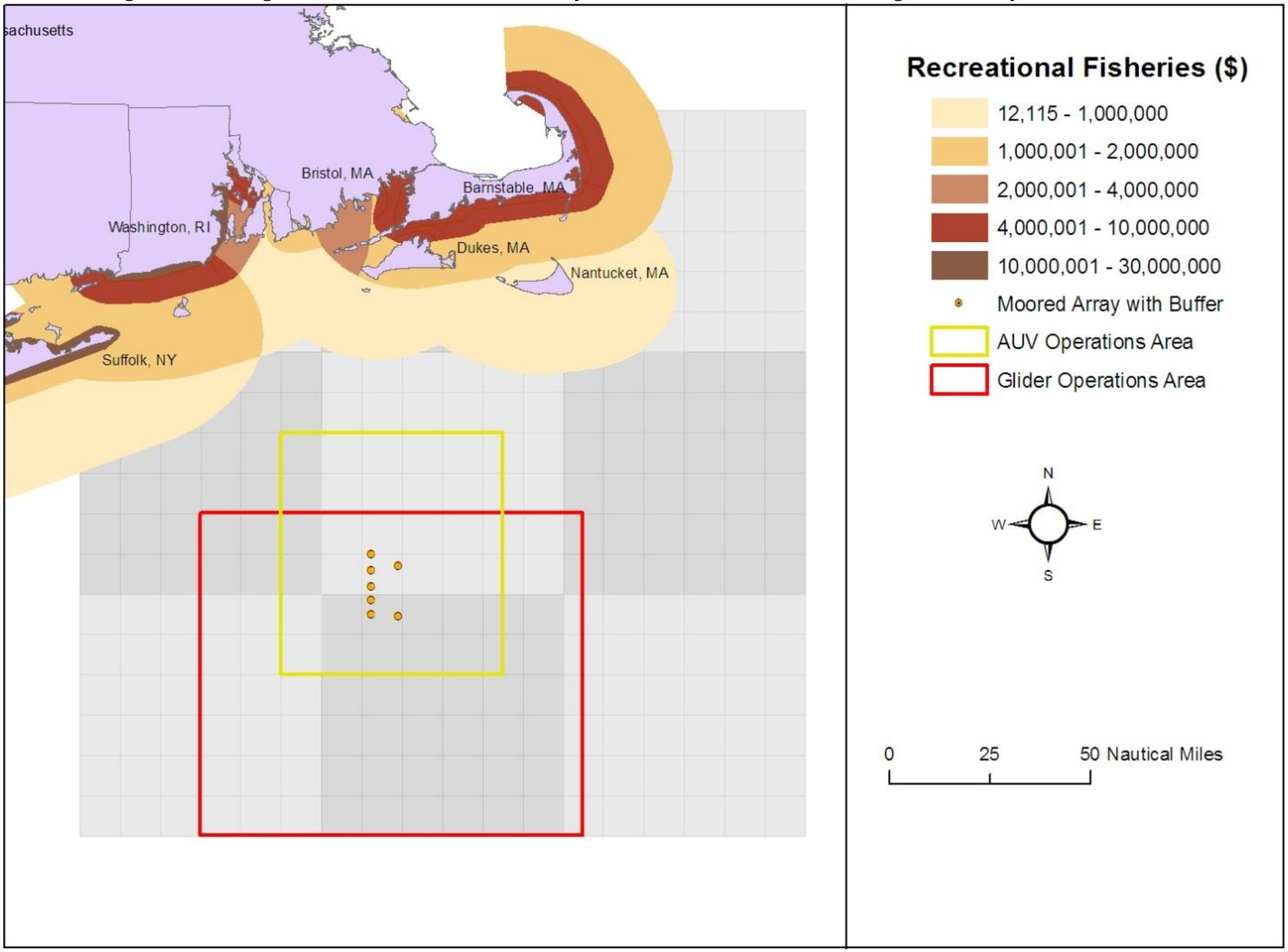
The vessel load calculations discussed above play an important role in maximum speeds and therefore estimated maximum travel distances. The average maximum vessel speed across the sample was 25.51 miles per hour, which was a plausible average maximum speed for a recreational vessel. Two assumptions impact this estimate. The biggest factor in this calculation was the assumption that all vessels are carrying a full tank of gas and that the average fuel capacity of the recreational fleet in the study area was in line with 227 gallon average taken from Vasconcellos and Latorre (1999).

The intercept add-on trip expenditure survey asked respondents for their boat fuel expenditure for the trip. Dividing the amount of fuel purchased by the fuel price for the date of the trip in the state of the trip yields a much lower fuel capacity number. Using the amount of fuel purchased as an estimate of fuel capacity assumes that the tank was emptied on the trip and refilled to capacity. This was highly unlikely and therefore the fuel load estimate created using fuel purchased would represent a lower bound on actual fuel load. Average fuel capacity using fuel purchased was 4.6 gallons across the sample and 8.8 gallons for those vessels traveling greater than 3 nm offshore. If this estimate was used to estimate fuel load and therefore maximum distance, maximum travel distances increase 15.5%. Even at this increase, none of the travel radii intersect the study area.

The second biggest factor in the maximum speed equation was the replacement of missing values for boat length and boat horsepower using the mean value for these two variables. If missing values weren't replaced with the mean values, maximum speeds and maximum distances actually fall slightly; 1.5% across the entire sample and 19% across the anglers traveling greater than 3 nm offshore. The next major caveat involves the use of the distance radii. Estimated maximum travel radii were not calculated for those stating a trip distance inside 3 nm. The current method assumes that the response to the base MRFSS question regarding area fished was more accurate than a calculated distance. Counter to this assumption, anglers may not know exactly how far offshore they traveled.

Third, this analysis assumes that the maximum travel radii were best represented by the mean estimated maximum distance across two new strata created by taking all trips below the 75th percentile and all trips above the 75th percentile using the estimated maximum distance. While using the maximum values for distance across these categories could be justified, it was felt that the mean would be more representative. The mean maximum travel distance across the entire sample that traveled more than three miles offshore was 11.68 miles for the 75th percentile group and 39.46 miles for the greater than 75th percentile group. If the maximum values were used instead, the 75th percentile group's maximum distance would increase to 25.46 miles and the greater than 75th percentile group would increase to 146.41 miles. This travel distance is unrealistic and likely an outlier in the recreational data.

Figure 10. Average Estimated Income Generated by Recreational Private Boat Fishing in the Study Area, 2005-2009



Fourth, after searching the literature, a relationship between fuel consumption and vessel length and horsepower could not be found. Searches were also conducted for a database of vessel length, horsepower, and fuel consumption across boating industry and Coast Guard sources in hopes of estimating a fuel consumption relationship directly. This data was not available. Had it been available, maximum travel radii could have been calculated using fuel expenditure information, assuming fuel purchased was equal to fuel consumed.

Finally, this analysis assumed that anglers traveled the maximum estimated travel distance in a straight line from the shore access point, fished, and then returned to port. It was far more likely that each vessel spent some of their travel time searching for fish in a direction different from a straight line representation used in the mapping exercise.

Changing the assumptions used in this mapping exercise is a double edged sword. If assumptions are changed to increase maximum travel distance, more ocean area will be included in the area that generates recreational economic impacts. If radii are extended to the maximum calculated travel distances as opposed to the mean travel distance, this will decrease the unit impacts, but might generate travel radii that would intersect with the Pioneer Array mooring locations. Often, studies of this nature will use charter boat effort as a proxy for recreational effort. In this case, the Pioneer Array is planned near the maximum extent of the for-hire fleet and no for-hire trips occurred near the mooring locations. As a result, it is safe to conclude that this analysis shows no private recreational value loss.

7.0 SUMMARY

Commercial and recreational fishing in the Mid-Atlantic and New England is big business. Commercial fishermen land $1.4 billion in seafood in both regions supporting $18.3 billion in totals sales, $7.6 billion in income and 271,441 jobs through the entire product chain from harvesters to consumers. On average, recreational anglers take 36.4 million trips each year spending $9.0 billion and generating $9.6 billion in total sales, $3.2 billion in income and supporting 75,118 jobs. Combining both industries represents a serious economic engine in the Mid-Atlantic and New England region. However, due to increasing regulations and reductions in the allowed harvest, commercial catches and recreational effort have been declining. The installation and O&M of the proposed Pioneer Array will benefit both fisheries sectors and other industrial sector in these regions. The Pioneer Array could also increase commercial fishing costs, but at a much lower level than benefits are increased.

This analysis demonstrates that there is relatively little activity in the Pioneer Array location and what activity exists is dominated by commercial fishing. No private recreational or for-hire recreational activity was found in two of the 10-min squares and only a very small amount, $61, was imputed for the third 10-min square in the study area. Table 11 summarizes the potential costs of the installation and operation of the Pioneer Array. On the commercial side annually and across all vessels, harvesting activity generates $25,386 in revenue supporting $142,068 of income and 5 jobs across all shoreside businesses, on average within the buffer zones. Using the trip cost models develop by Jin (2008) and Gentner et al. (2010), the costs of shifting effort to avoid the buffer zones ranges from $162 per year for all vessels under Scenario 1 to $40,676 per year for all vessels under Scenario 2. Scenario 1 represents the cost of moving around the buffer zone for only those vessels estimated to be fishing in the buffer zone. Scenario two assumes that all effort estimated to occur, on average, in the three 10-min squares avoids fishing in the entire 10-min square and their additional cost is the cost of steaming across the 10-min square to set their gear in an adjacent 10-min square. Therefore this is an upper bound estimate on the cost of avoidance.

This analysis also demonstrates that the installation of the Pioneer Array could produce significant benefits for fisheries and other industries. Commercial fisheries benefits are projected to be $61.6 million across Mid-Atlantic and New England communities. Recreational fisheries benefits were estimated to be

$96.4 million across the same region. When other benefits to tourism, agriculture and other industries are included, benefits are likely to be in excess of $201.0 million each year.

Table 11. Summary of Potential Costs and Benefits of the Pioneer Array

Sector		Potential Impact Value	Potential Impact Per Vessel Per Trip
Commercial Fishing	Revenue at risk - According to the NMFS economic analysis guidelines, revenue at risk is often used when operating cost calculations cannot be made. Therefore, this estimate is an extreme upper bound	$25,386	$1,692
	Lower bound avoidance cost – This scenario assumes that only the 15 trips estimated to occur directly in the buffer zones incur any additional avoidance costs and that those additional costs involve relocating their gear set by 1nm to avoid the buffer zone.	$162	$11
	Upper bound avoidance cost – This scenario assumes that all 666 trips in all three 10-min squares containing buffer zones will avoid the entire 10-min square containing the buffer zone and includes the cost of moving the set of their gear by the width of the 10-min square where the effort occurred.	$40,676	$61
For-Hire Recreational	No trips will be impacted by the operation and installation of the Pioneer Array.	$0	$0
Private Recreational	No trips will be impacted by the operation and installation of the Pioneer Array.	$0	$0
Conclusion – No Significant Impact	Even under the most conservation assumptions across the most conservative additional operating cost scenario, installation and operation of the Pioneer Array does not constitute a significant impact on harvesters or shoreside businesses supported by their fishing activity in the area of the buffer zones.		

The NMFS guidelines for economic analysis indicate that changes in operating costs are the appropriate metric to assess the significance of the impact on harvesters and shoreside businesses. Under EO 12866, the $162 lower bound and $40,676 upper bound estimates of the increase in operating costs do not rise to the $100 million bar set by EO 12866 and therefore this action does not constitute a significant impact. Denominating these costs by the number of trips in each scenario, Scenario 1 estimates a cost per vessel per trip of $10.80 in additional costs. Doing the same for the Scenario 2 costs, avoidance costs per vessel trip would be $61.08 in additional costs per vessel per trip. If instead, revenues at risk are used, the revenue at risk in the mooring buffer zones is only $25,386 still well below the threshold. It is completely unreasonable to think that all revenues in those three 10-min squares are at risk. Because this analysis did not have access to individual vessel level data, it is impossible to assess disproportionality. It would be necessary to bin all vessels fishing in the study area into large and small entities and then assess the impacts of this action on their costs and profitability. Because the actual change in operating cost per vessel per trip is very small and because this change likely impacts a very small proportion of the fishing fleet (not a substantial number), it is likely that under the profitability RFA standard, the installation and O&M of the proposed Pioneer Array will not generate a negative impact on the profitability of a substantial number of small businesses.

Public projects typically evaluate the present value of the stream of benefits net of costs arising from the project to judge the value of the investment. Calculating NPV for this project presents many challenges.

First the Pioneer Array will have a relatively short stay in this proposed location. It is slated to be moved after 5 years and may stay in the general region or move to another region entirely. It will continue moving every 5 years across the expected 25 year life of the OOI. Therefore it is impossible to know where it will continue to provide benefits; the Mid-Atlantic, New England or somewhere else entirely. Additionally, there is a possibility that the array will not produce useful data. If the data is useful and high quality there is the chance that it will not be adopted by scientists and forecasters and there is a chance that the users will not use better nowcasts and forecasts to their full advantage. Overall, the adoption process takes time and therefore benefits lag the installation and operation of these arrays, sometimes for many years. Wellman and Hartley (2008) hypothesized that commercial fishing harvest increases would take 15 years to be realized because it takes time to build new models and get potential harvest changes through the council process. Additionally, costs are uncertain. While it is possible that the avoidance costs estimated here could persist for the life of the array, it is more likely that those avoidance costs would only persist for the short term.

Ideally, a full NPV analysis would involve estimating probabilistic models of each source uncertainty in the information adoption and diffusion process and the current fishery participant's behavior. This type of analysis is currently not possible due to lack of data on the myriad of industries that would be necessary for an analysis of this magnitude. Instead, NPV will be calculated across two scenarios using the Office of Management and Budget recommended discount rate of 7%.[16] In all scenarios, design and installation costs are $17.9 million and annual operation costs are $6.0 million for the 5 year life of the array. In the first scenario we assume that all benefits, $201.0 million each year, accrue to their fullest extent one year after installation and continue until the array is relocated. Under this scenario, the NPV of the array is $600.5 million under the high commercial cost estimate and $600.7 million under the low commercial cost estimate.

This estimate of NPV is unrealistic because all benefits will not accrue immediately and there is some probability of the benefits not being realized at all. For the commercial fisheries benefits, Wellman and Hartley (2008) describe the uncertainty inherent in the chain of events from array installation to benefit realization. Success in clearing each of these uncertain situations can be expressed through probabilities and the multiplicative sum of those probabilities describes the final probability that the benefits will be realized. While the scope of this study did not allow the estimation of each of these probabilities, Wellman and Hartley (2008) suggest some potential probabilities for each of these sources of uncertainty:

- 75% probability that the array will produce better data and it will be used to refine stock assessments.
- 50% probability that improved stock models will support a 1% increase in harvest and a 1% increase in recreational expenditures.
- 50% probability that the councils will act on this information and actually increase harvests.
- 50% probability that the stocks will be in sufficiently good shape in the future to allow for increased harvests.

The multiplicative sum of these probabilities is 9.4%. These probabilities are based on experience in these fisheries and key informant information and err on the side of underestimating benefits rather than overestimating benefits. Wellman and Hartley (2008) also suggest that this chain of events will not be completed for 15 years. For the second scenario, we assume that commercial benefits begin to accrue at year 10 using the expected value framework and persist for 5 years even if the array is moved out of the region.

[16] OMB Circular number A-94. http://www.whitehouse.gov/omb/circulars_a094.

For the $43.0 million in other benefits that accrue to construction, tourism, agriculture, SAR, shipping and other industries, a similar probabilistic adoption process could be envisioned. This process and potential probabilities could be described as follows:

- 75% probability that the array will produce better data and it will be used to improve nowcasts and forecasts.
- 50% that better nowcasts and forecasts will be communicated to the public in a useful and timely manner.
- 50% probability that the users will trust, accept and utilize these better nowcasts and forecasts to reduce their risks and improve economic efficiency.

The multiplicative sum of these probabilities is 18.8%. Because better data for these industries does not need to go through a political process to produce economic benefits, it is assumed that these benefits begin to accrue in the second year. It is further assumed that these benefits will only persist until the array is moved. This second scenario incorporating the expected benefit techniques and probabilities described here generates an NPV under the low avoidance cost scenario of $23.1 million and under the high avoidance cost scenario of $22.8 million.

It is difficult to predict what the NPV of this installation will be. It is likely that benefits will persist for longer than the array is in place, but it is unknown how long. If, after 5 years, the array is moved and stays in either the Mid-Atlantic or New England the benefits will persist longer. The longer the array is kept in Mid-Atlantic or New England area, the likelihood that these benefits will be realized increases. If the array is kept in this area for the entire OOI expected life of 25 years, NPV will be much higher. It is also unknown if 5 years of data will be enough to influence commercial and recreational fishing regulations that may take 10 years or more to come to fruition. If no benefits are realized at all, the NPV of the Pioneer array is -$35.9 million under the high commercial avoidance cost scenario and -$35.7 million under the low commercial avoidance cost scenario across 5 years. One thing is for certain, neither the high nor the low estimate of commercial avoidance costs make any real difference in the final NPV estimate.

It is difficult to measure both the benefits and costs of these operations as there is little data on benefits or costs. For a complete analysis, far more data than is available would be necessary. In this analysis all assumptions made were made to err on the side of estimating more costs rather than less. On the cost side, it is impossible to obtain individual vessel, individual trip level data due to confidentiality rules. As a result, it is only possible to estimate value and costs at the 10-min square level of spatial resolution. Because of this limitation, it is impossible to know if any commercial fishing activity has been occurring immediately within the buffer zones. It is possible to say with certainty that very little longline, dredge, midwater trawl, and other gear activity is occurring in the buffer zones. On the other hand, a moderate amount of bottom trawl, gillnet and pots and traps activity is occurring in the three degree squares surrounding the mooring locations. Additionally, in the NPV calculations, it is assumed that the costs continue every year from the beginning throughout the life of the project. It is much more likely that the costs would persist initially and fade quickly as commercial boats learned to fish without interacting with the buffer zones.

The literature on benefit estimates indicate that the benefit estimates included here are conservative and it is likely that total benefits will exceed the estimates presented here. This study assumed that commercial fisheries revenue would increase by 1% and that recreational expenditures would increase by 1%. Wellman and Hartley (2008), using a case study in a very similar groundfish fishery on the West Coast estimated harvest increase as high as 34% suggesting that commercial benefits could be much higher. Many of the stocks in these regions are recovering from low stock levels and better data could allow these stocks to recover faster, further enhancing benefits. Additionally, because of the nature of multi-species fisheries, the biggest benefit may lie in avoiding closures due to managing for the weakest (or most uncertain) species in the multi-species complex. If any of the species in the multi-species fisheries in these regions are limited by the status of a single stock, increased and improved data could quickly reduce or eliminate costly closures from managing to the weakest species. Tempering this conclusion, however, is the short duration the proposed Pioneer Array would be in place. While fisheries in this region would benefit from better fisheries independent and environmental data, it is unknown if 5 years of data will be sufficient to improve stock assessments and therefore harvests.

While no private recreational or for-hire recreational effort was found in the buffer zones, it may be in the future. The mooring locations will likely become fish aggregating devices (FADs) for pelagic species which will attract commercial and recreational effort. This generates an additional amount of benefits not accounted for in this analysis. Overall, this array would generate very low costs on the commercial industry and no costs on the recreational industry. From a NPV standpoint, the array leads to positive NPVs for two scenarios and negative NPV for the most pessimistic scenario (no benefits). For this project to break-even, from an NPV standpoint, benefits would have to be almost $5.3 million each year for the second through fifth years above the operating cost of $6.0 million and the commercial avoidance costs. Can society expect benefits to exceed roughly $11.3 million annually for 4 years? The literature reviews suggests that it is possible. From the benefits literature, it is widely assumed that the benefits will exceed the modest predictions included here indicating that installation and operation of this array produces net positive benefits. Finally, to put the commercial avoidance costs in perspective, even using the upper bound estimates represents less than 0.01% of the total design, installation and operating costs of the Pioneer Array.

As stated in the PEA regarding the need for additional detailed assessment of the proposed OOI at the site-specific stage, to support a previous qualitative analysis, and in response to public comments on the Draft SSEA, this SIAR has been prepared to provide a quantitative site-specific analysis of potential impacts to socioeconomics (fisheries) from the installation and O&M of the proposed Pioneer Array. Even under the most conservative assumptions across the most conservative additional operating cost scenario, installation and operation of the Pioneer Array does not constitute a significant impact on harvesters or shoreside businesses supported by their fishing activity in the area of the buffer zones.

8.0 REFERENCES

Adams, R., M. Brown, C. Colgan, N. Flemming, H. Kite-Powell, B. McCarl, J. Mjelde, A. Solow, T. Teisberg, and R. Weiher. 2000. The Economics of Sustained Ocean Observations: Benefits and Rationale for Public Funding. A Joint Publication of the National Oceanic and Atmospheric Administration and the Office of Naval Research. August.

Carter, D.W., C. Rivero, S. Aguillar, and K. Kleisner. 2007. South Florida Sportfishing Geodatabase (SFSGEO) Design Document. NOAA Technical Memorandum NMFS-SEFSC-578.

Collier, R. 2010. Personal communication regarding historical AUV/glider entanglement in fishing gear. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Dutton, J. A. 2002. Opportunities and priorities in a new era for weather and climate services. Bulletin of the American Meteorological Society 83:1303-1311.

Edwards, S.F. 1990. An Economics Guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries. NOAA Technical Report NMFS 94. November.

Gautam, A. and S. Steinback. 1998. Valuation of Recreational Fisheries in the North-east United States. Striped Bass: A Case Study. Chapter 23 *in* P. Hickley and H. Tompkins, eds. Recreational Fisheries: Social, Economic and Management Aspects. Fishing News Books, Oxford.

Gentner, B. 2007. Sensitivity of anger benefit estimates from a model of recreational demand to the definition of the substitute sites considered by the angler. Fishery Bulletin 105:161-167.

Gentner, B. and S. Steinback. 2008. The Economic Contribution of Marine Angler Expenditures in the United States, 2006. NOAA Technical Memorandum NMFS F/SPO-94. November.

Gentner, B., J. Kirkley, P.R. Hindsley and S. Steinback. 2010. Summer Flounder Allocation Analysis. NOAA Technical Memorandum NMFS-F/SPO-111.Gerr, D. 2001. Propeller Handbook. McGraw-Hill, New York, NY.

Haab, T. and R. Hicks. 1999. Choice Sets Consideration in Models of Recreation Demand: History and Current State of the Art. Marine Resource Economics 14:255-270.

Hicks, R., A.B. Gautam, S. Steinback, and E. Thunberg. 1999. The Economic Value of New England and Mid-Atlantic Sportfishing in 1994. NOAA Technical Memorandum NMFS-F/SPO-38.

Hoagland, P. 2006. The public policy of harmful algal blooms. Keynote presentation at the 12th International Conference on Harmful Algae, International Society for the Study of Harmful Algae, Copenhagen, 4-8 September.

Hoagland, P. 2007. Report of the Potential Economic Effects on Commercial Fishing from the Safe Harbor Energy Deepwater Port and Pipeline. Draft report prepared for the Atlantic Sea Island Group, LLC. July.

Jin, D. 2008. Development of Commercial Fishing Vessel Cost Models. Project Report prepared for the Cooperative Institute on Climate and Ocean Recsearch, Woods Hole Oceanographic Institution, Woods Hole, MA.

Jin, D. and P. Hoagland. 2005. Report on the Potential Economic Effects on Commercial Fishing From the Northeast Gateway Deepwater Port. Report prepared for Northeast Gateway Energy Bridge, LLC. June.

Kerstetter, D.W. 2008. Measuring the Length of a Pelagic Lonline Set: Applications for Management. North American Journal of Fisheries Management 28:378-385.

Kirkley, J.E. 2006. Potential Economic Ramifications of Reissuing the Rule to Implement the Fish and Seafood Promotion Act of 1986. Reported prepared for NOAA Fisheries, Office of Constituent Services, Silver Spring, MD.

Kirkley, J.E., K.E. McConnell, and W. Ryan. 2000. Economic Aspects of Allocating Striped Bass among Competing User Groups in Virginia. Virginia Sea Grant Technical Report VSG-00-08.

Kirkley, J.E., J. Duberg, and B. Gentner. 2004. The Economic Contributions of the Commercial Fisheries of the United States: A User's Guide to the National Input/Output Model. Final Report, Contract DG133F-02-SE-0908. Prepared for NMFS Office of Science and Technology.

Kite-Powell, H.L. and C.S. Colgan. 2001. The Potential Economic Benefits of Coastal Ocean Observing Systems: The Gulf of Maine. A Joint Publication of the National Oceanic and Atmospheric Administration, Office of Naval Research and Woods Hole Oceanographic Institution. December.

Kite-Powell, H.L., C.S. Colgan, K.F. Wellman, T. Pelsoci, K. Wieand, L. Pendleton, M.J. Kaiser, A.G. Pulsipher, and M. Luger. 2005. Estimating the Economic Benefits of Regional Ocean Observing Systems. Technical Report WHOI-2005-03. Woods Hole Oceanographic Institution, Woods Hole, MA.

Leeworthy, V.R. 2000. Preliminary Estimates from Versions 1-6: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE) 2000. NOAA Oceans and Coasts, Special Projects Office.

Lynch, T., J. Harrington, and and J.J. O'Brien. 2003. Economic Impact Analysis of Coastal Ocean Observing Systems in the Gulf Coast Region. Working Paper. Center for Economic Forecasting and Analysis. Florida State University, Tallahassee, FL.

Minnesota IMPLAN Group, Inc. 1997. IMPLAN Professional: social accounting and impact analysis software. Minneapolis, MN.

NMFS. 2000. Guidelines for Economic Analysis of Fishery Management Actions. Office of Sustainable Fisheries, National Marine Fisheries Service, Silver Spring, MD. Available online at: http://www.nmfs.noaa.gov/sfa/RFA%20Guidelines.PDF . Accessed January 26, 2011.

NMFS. 2010. Personal communication from the Data Management Systems, Northeast Regional Office, Gloucester, MA.

NMFS. 2010a. Commercial landings online data queries. http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html. Accessed December 31, 2010.

NMFS. 2010b. Recreational catch and effort online data queries. http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. Accessed December 31, 2010.

NOAA. 2002. The economic implications of an El Niño. NOAA Magazine Online, March 6. Available at: http://www.magazine.noaa.gov/stories/mag24.htm/. Accessed December 5, 2010.

NOAA. 2008. Economic Statistics for NOAA. Sixth Edition. April. Available at: http://www.ppi.noaa.gov/PPI_Capabilities/Documents/2008_06_04_EconStatsFinal.pdf. Accessed December 5, 2010.

Nordhaus, W.D. 1986. The Value of Information. *In*: R. Krasnow, ed. Policy Aspects of Climate Forecasting. Proceedings of a Seminar held in Washington, DC, March 4, 1986.

NSF. 2008a. Final Programmatic Environmental Assessment for National Science Foundation-Funded Ocean Observatories Initiative (OOI). Prepared by TEC Inc., Annapolis, MD and Bainbridge Island, WA under direction from the Consortium for Ocean Leadership, Washington, DC for the National Science Foundation, Division of Ocean Sciences, Arlington, VA. June.

Plueddemann, A. 2010. Personal communication regarding historical AUV/glider entanglement in fishing gear. Physical Oceanography Department, Woods Hole Oceanographic Institution, Woods Hole, MA.

Vasconcellos, J.M. and R. Latorre. 1999. Development of BOATDSS High Speed Boat Design Database. Ocean Engineering 26:891-904.

Weiher, R. and H. Kite-Powell. 2000. Assessing the Economic Benefits of El Niño and the Benefits of Improved Forecasts. Pages 3-7 *in* R.F. Weiher, ed. Improving El Niño Forecasting: The Potential Economic Benefits. NOAA, Office of Policy and Strategic Planning, Washington, DC.

Wellman, K.R. and M. Hartley. 2008. Potential Benefits of Coastal Ocean Observing Systems to Alaskan Commercial Fishermen. Coastal Management 36:193-207.

Warden, M.L and C.D. Orphanides. 2008. Preparation of the Northeast Fisheries Observer Program Gillnet Data for Use in Bycatch Analyses of Protected Species. Northeast Fisheries Science Center Reference Document 01-17.

APPENDIX 1
REGULATORY FLEXIBILITY ACT SMALL ENTITY SIZE STANDARDS

- Any fish-harvesting or hatchery business is a small business if it is independently owned and operated and not dominant in its field of operation (including its affiliates) and if it has annual receipts not in excess of $3.0 million.
- For related industries involved in canned and cured fish and seafood or prepared fish or frozen fish and seafoods, a small business is one that employs 500 employees or fewer.
- For the wholesale industry, a small business is one that employs 100 or fewer.
- For marinas and charter/party boats, a small business is one with annual receipts not in excess of $5.0 million.
- A small organization is any not-for-profit enterprise that is independently owned and operated and not dominant in its field.
- A small government jurisdiction is any government or district with a population of less than 50,000.

APPENDIX 2
COST MODEL PARAMETERS

Trip Cost Model GMM: Gill Net (Jin 2008)

Observations	858
Adj R^2	0.5942

Parameter	Variable	Estimate	Approx Std Err	t Value	Approx Pr > |t|
a1	Intercept	-260.296	53.3382	-4.88	<.0001
a2	steamtim	57.3782	15.6897	3.66	0.0003
a3	atripdur	13.71389	2.2733	6.03	<.0001
a4	vhp	0.75805	0.2041	3.71	0.0002
a5	vhp2	-0.00049	0.000224	-2.19	0.029

Trip Cost Model GMM: Longline (Jin 2008)

Observations	83
Adj R^2	0.9234

Parameter	Variable	Estimate	Approx Std Err	t Value	Approx Pr > |t|
a1	Intercept	-67.9471	314.4	-0.22	0.8295
a2	steamtim	112.5941	31.6018	3.56	0.0006
a3	vhp	2.488363	0.484	5.14	<.0001
a4	fiberg	-601.123	248.5	-2.42	0.0179
a5	steel	4640.257	515.2	9.01	<.0001

Trip Cost Model GMM: Scallop Dredge(Jin 2008)

Observations	128
Adj R^2	0.7384

Parameter	Variable	Estimate	Approx Std Err	t Value	Approx Pr > |t|
a1	Intercept	-3213.85	850.4	-3.78	0.0002
a2	atripdur	55.91565	6.3826	8.76	<.0001
a3	vhp	7.219974	2.2573	3.2	0.0018

Trip Cost Model GMM: All Vessels(Jin 2008)

Observations	2047
Adj R^2	0.8201

Parameter	Variable	Estimate	Approx Std Err	t Value	Approx Pr > |t|
a1	Intercept	-1119.51	89.5594	-12.5	<.0001
a2	atripdur	51.57708	1.5003	34.38	<.0001
a3	len2	0.451074	0.0489	9.23	<.0001
a4	hpage	0.183001	0.0387	4.73	<.0001
a5	lenage	-1.58867	0.2587	-6.14	<.0001

Trip Cost Model GMM: Paired Otter Trawl

Observations		41			
Adj R^2		0.6526			
			Approx		Approx
Parameter	Variable	Estimate	Std Err	t Value	Pr > |t|
a1	Intercept	-4140.8	2611.6	-1.59	0.1216
a2	atripdur	143.4701	16.3044	8.8	<.0001
a3	crew	1298.847	596	2.18	0.0359
a4	NJ	-5780.97	1910.3	-3.03	0.0046
a5	SNE	-1777.99	1035.8	-1.72	0.0946

Nonlinear GMM Otter Trawl Trip Cost Parameter Estimates (Gentner et al. 2010)

Variable	Estimate	Approximate Std Err	t Value	Approx Pr > |t|
Intercept	-177729	93629.2	-1.9	0.058
ATRIPDUR	52.37899	2.7307	19.18	<.0001
STEEL	-99.6791	88.9099	-1.12	0.2626
STEAMTIM	18.01961	21.579	0.84	0.4039
LEN	-6636.37	3360.5	-1.97	0.0486
LEN2	20.03945	9.7026	2.07	0.0392
LENSQRT	64825.78	33619.9	1.93	0.0542
VHP	2.944961	1.0896	2.7	0.007
VHP2	-0.00029	0.000486	-0.6	0.5516
M1	-375.077	179.1	-2.09	0.0365
M3	-499.643	344.5	-1.45	0.1474
NC	-1817.2	411.1	-4.42	<.0001
MA	498.7661	206.3	2.42	0.0158
R-Square	0.8695			