An Economic Analysis of Mobile Gear Fishing Within the Proposed Wind Energy Generation Facility Site on Horseshoe Shoal in Nantucket Sound

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Introduction

This report outlines, and empirically tests a method to value the economic loss of displaced mobile gear fishing effort on Horseshoe Shoal, the proposed wind energy generation facility site, under two scenarios: 1) a wind farm developed on Horseshoe Shoal and closed to mobile gear fishing, 2) a wind farm developed on Horseshoe Shoal and open to mobile gear fishing. Economic loss is defined by a compensating surplus measure of welfare.

This report also is intended to supplement the Draft Environmental Impact Statement (DEIS), recently released for public comment by the Minerals Management Service (MMS), with information regarding the level of mobile gear fishing use in the proposed wind energy generation facility site on Horseshoe Shoal in Nantucket Sound. This report examines mobile gear fishing activity in a regional context as well as within the proposed area of the wind farm. Specifically, this report will show:

- An exclusive group of fishermen permitted by the State of Massachusetts to use mobile fishing gear within the proposed development site
- Shortcomings of Cape Wind's DEIS/R, FEIR, and the MMS DEIS
- Temporal patterns of fishing activity and the importance of species fished
- The Best Management Guidelines to mitigate wind farming v. commercial fishing
- The economic method of valuation
- The total economic value of the Horseshoe Shoal area as a mobile gear fishing grounds
- The spatial distribution of Horseshoe Shoal landings
- The economic impact (or multiplier effect) of a loss in ex-vessel landings from medium sized trawlers to Cape Cod fishing regions
- Written comments by Horseshoe Shoal mobile gear users about the impact of this development to their normal fishing activities

Cape Wind's Final Environmental Impact Report (FEIR) and the subsequent MMS DEIS concludes that a wind farm developed on Horseshoe Shoal is not expected to have any net economic consequences to the commercial fishing industry in Nantucket Sound. However, these analyses did not thoroughly evaluate all of the potential environmental impacts of this large and precedent-setting project to commercial fishermen in general, and specifically to mobile gear fishermen. This report will show significant economic losses to mobile gear fishermen in Nantucket Sound regardless of whether or not the wind project area is closed to trawling.

The level of analysis in Cape Wind's FEIR and the MMS DEIS concerning the commercial fishing industry is minimal when compared with similar efforts undertaken by other existing and proposed offshore wind farm developers and governments around the world. European offshore wind farm development is subjected to best management guidelines to deal with the concerns of the commercial fishing industry. The guidelines help to mitigate the nuisances to commercial fishing from the development of a wind farm on traditional fishing grounds.

The Best Management Guidelines do not recommend trawling or mobile fishing due to serious safety concerns. Offshore wind farms in other parts of the world have been closed to trawling, sometimes permanently. In some cases, compensation has been negotiated with affected parties. In one case, legal action was taken by a group of displaced mobile gear fishermen against the wind farm developer to argue for compensation even though the wind farm remained open to trawling.

The rest of this report is organized into five sections.

Section 1 characterizes the existing environment, in which a competing mobile gear user group is identified, available data sources are reviewed, shortcomings of the environmental impact reports are noted, and lessons learned about conflicts with commercial fishing from other offshore wind farms around the world are reviewed.

Section 2 presents the theory behind the economic analysis and the methods of collecting new data for this study. This section will also show the types of data collected, the approach used to design the data collection tool and to identify Horseshoe Shoal users, and the validity/critiques of this approach.

Section 3 shows the results of the data, which will include the presentation of findings, estimates of the economic value of Horseshoe Shoal to the distinct group of mobile gear users, significant determinants of the economic value and the consistency of the findings with economic theory and past research.

Section 4 demonstrates how the results of an economic model developed in the previous section may be used with the Northeast Regional Input-Output Model (NERIOM), developed by researchers at NOAA Fisheries, to estimate regional and sub-regional economic impacts to certain fishing regions from a reduction in ex-vessel landings from specific gear types.

Section 5 concludes the report and discusses the significance of the findings considering the cumulative impacts of other federal management regulations. Recommendations are made to help mitigate the impacts of this development to the commercial fishing user group.

1. Existing Environment

According to the National Environmental Policy Act (NEPA), Cape Wind is responsible for characterizing the impact of their development to the communities and stakeholder groups that could be adversely affected. But, minimal effort was made to directly communicate with the mobile gear fishermen that use the Horseshoe Shoal area about the impacts of this development to traditional operations, or to examine and use the lessons learned from other offshore wind farms regarding appropriate communication channels and correct mitigation measures.

Although the Horseshoe Shoal area is technically located within federal waters, it may be fished by mobile gear fishermen who hold a state of Massachusetts Coastal Access Permit (CAP) without having to declare a federal day at sea (DAS) because it is located within Nantucket Sound. In general, Massachusetts has no jurisdiction beyond three miles off of the coast. However, the Magnuson-Stevens Act specifically cedes authority to the Commonwealth to manage the fisheries and related habitat in the federal waters of Nantucket Sound. The Division of Marine Fisheries (MA DMF) is the State agency charged with managing the marine fisheries resources of the Commonwealth.

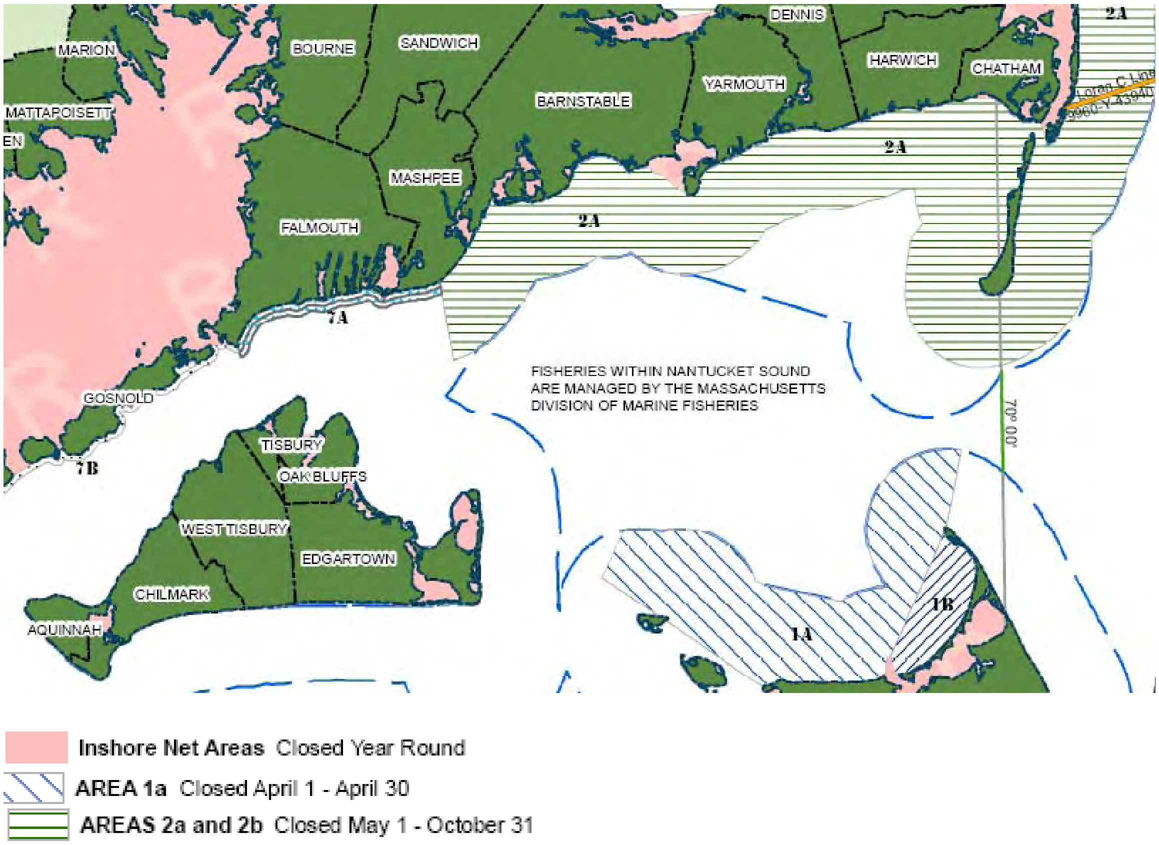
This fishing access is very important now due to a dramatic reduction of federal days-at-sea for some ground fishing areas, which will be enacted for the 2008-fishing season. New regulations now count every federal day-at-sea as two days, effectively cutting in half the amount of time fishermen may groundfish in some of the most valuable federal waters. However, a fisherman who holds a Massachusetts Coastal Access Permit may fish in the federal waters of Nantucket Sound during specified open seasons without having to declare a federal day-at-sea, which is now a significant economic advantage.

1.1-Mobile Gear User Group

Massachusetts state endorsements applicable to trawlers include inshore net, coastal access, small mesh fishing for whiting, and small mesh fishing for squid. Also, some species-specific endorsements, like summer flounder (fluke), are also required to trawl inshore state waters. For example, a *CAP-* (*squid*) is a type of endorsement that allows mobile gear fishermen to tow small mesh (4.5”) for squid during the spring trawl season in waters south of Cape Cod and the Islands, which includes the Horseshoe Shoal area of Nantucket Sound. By DMF regulations, no vessel larger than 72 ft may hold a CAP-endorsement. This allows smaller, in state vessels that don’t necessarily hold a federal permit to fish closer to home and still make a living without having to compete with the larger trawlers.

The squid trawl fishery in Nantucket Sound opens on April 23. Traditionally, draggers who hold a CAP-squid endorsement are allowed to use small mesh to fish for squid inside the three-mile line, from Succonesset Shoal in Mashpee to Point Gammon in Yarmouth for one week. On May 1st, a longstanding three-mile closure for mobile gear fishing goes into effect and extends from Mashpee east to Chatham (see map).

Figure 1. Mobile Gear Regulated Areas



Source: MA DMFa (2007)

This means that after May 1st, vessels that can no longer fish within the three mile area near shore may still fish (and do fish) for squid outside this three mile area in other parts of Cape Cod and the Islands, including Horseshoe Shoal until June 9th. There is a 2500 lb. trip limit for *Loligo* squid before May 1st, because 80% of the federal quota is usually caught by the time the April opening occurs.

But after May 1st, vessels are unrestricted by a daily catch limit because it is the beginning of a new quota period, and there is no trip limit until 80% of the quota is reached again. This is a significant economic advantage for the small mesh squid season trawlers.

In July of 1993, the Massachusetts state legislature requested a study of the *Loligo* squid fishery in Nantucket and Vineyard Sounds, which was conducted by the Massachusetts Division of Marine Fisheries (McKiernan and Pierce 1995). It characterizes both the abundance and location of the inshore squid fishery in Massachusetts. According to this study, nearly all squid landed in Massachusetts state waters are taken from Nantucket and Vineyard Sounds. Trawlers were found to dominate the fishery, accounting for 78 percent of the total squid landings from 1978 to 1993. Specifically:

> Trawling (in Nantucket Sound) is concentrated in two locations. The first area is along the Falmouth shore from Nobska Point in Woods Hole to Succonnesset Point in Mashpee – the only area along the southern Cape Cod shore open to trawling during the squid season. Smaller vessels are confined to near shore areas around Falmouth during days of strong winds and rough seas. (McKiernan and Pierce 1995).
>
> The second most trawled area is a large portion of the center of Nantucket Sound near Horseshoe Shoal. This area is frequented by larger vessels in the fleet (greater than 50 gross registered tons-GRT). During 1989-1993, DMF observers noted that by mid May most vessels abandoned Vineyard Sound near Falmouth and followed the "run" of squid east towards Horseshoe Shoal (McKiernan and Pierce 1995).

Figure 2. Trawlers Fishing on Horseshoe Shoal

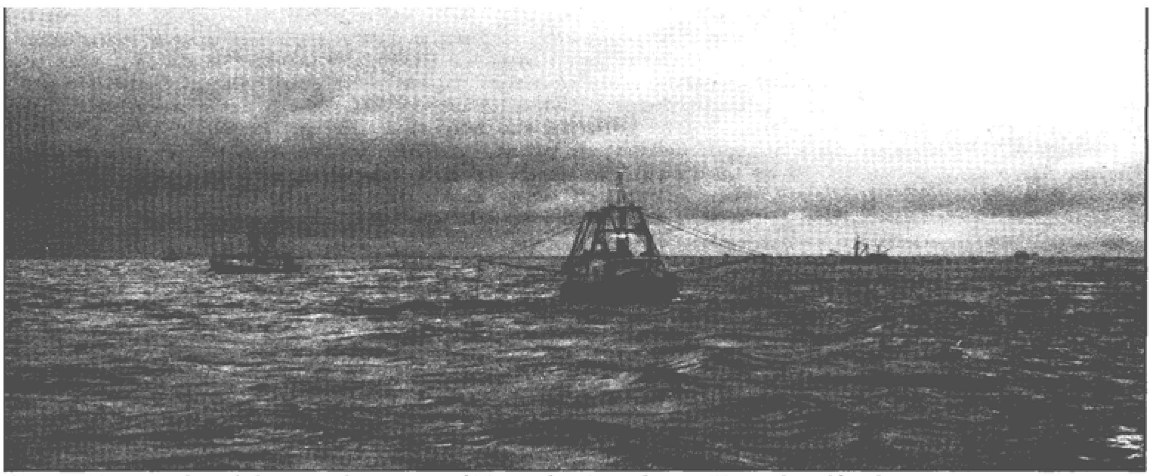


Figure 10. *Trawlers fishing in the center of Nantucket Sound near Horseshoe Shoal.*
(Source: McKiernan and Pierce 1995).

This photograph (Figure 2) of trawlers derby fishing for squid on Horseshoe Shoal was taken over ten years ago, but the only significant change in the fishery since then is the exclusion of vessels greater than 72 ft from this area. As will be shown later in the report, this has changed the mobile gear fleet dynamic in Nantucket Sound to a much more homogenous group of vessels with an average boat size of about fifty feet.

Each spring *Loligo* squid still migrate into Nantucket Sound where they are eventually tracked and caught (still derby style) by the fleet of mobile gear fishermen permitted to trawl through Horseshoe Shoal. The springtime seasonal surge in squid abundance is attributable to the warm shallow water temperatures in Nantucket Sound (McKiernan and Pierce 1995).

1.2-DEIS/R Errors-

The Draft EIS/R reported that mobile gear fishermen who hold a squid endorsement may fish anywhere in Massachusetts and do not necessarily fish in Nantucket Sound or the proposed wind project area. This is inaccurate. Not every fisherman who holds a CAP-squid endorsement uses their endorsement to fish for squid. However, those who do fish Massachusetts waters for squid most definitely fish in Nantucket Sound and Vineyard Sound, and most likely fish within and around the proposed project development site on Horseshoe Shoal after May 1st.

The Draft EIS/R reports that both the squid and fluke fisheries were the most popular fisheries for otter trawling, which is correct. However, the citation below misrepresents both the number of boats that have squid and fluke endorsements as well as the area that these boats fish.

> For both squid and fluke fisheries, mobile gear render the most success, and the otter trawl is the most popular method. In 2001, 34 boats were permitted to fish for squid in Massachusetts, 31 used mobile gear. Similarly, of the 58 boats permitted to fish fluke in Massachusetts, 40 used mobile gear. It is important to note that these boats could fish anywhere in Massachusetts, and do not necessarily fish in Nantucket Sound or the proposed project area (Draft EIS/EIR/DRI Section 5.4).

According to the Massachusetts Division of Marine Fisheries (MA DMF. 2007b), 146 mobile gear fishermen held a CAP-squid permit in 2007. Also, every vessel that held a CAP-squid permit also held a fluke endorsement. Unlike squid, fluke are abundant almost everywhere in Massachusetts state waters and don't require significant gear changes to catch.

Therefore, it is likely cost effective for a vessel already fishing in Nantucket Sound for squid to switch gear before the summer fluke season begins. The total number of fluke endorsements for all types of fishing issued by the State of Massachusetts in 2004 was 1130. At least 146 of these permits were for trawlers, not 58. Fifty-eight, is likely the number of trawlers who used their fluke endorsement in 2001. But, every fisherman who holds an endorsement has the potential to use it. The summer fluke season in Nantucket Sound is generally characterized as July and August. Regulators close the summer fluke fishing season once the total allowable catch is met, so depending on the season, this fishery may last between four to eight weeks.

The information used in the Draft EIS/R to report the number of permitted squid and fluke fishermen in Massachusetts was most likely adapted from a presentation given by MDMF biologist, Vincent Malkoski, at a public meeting about the proposed development. RAAB Associates[1] hosted this meeting in 2001. The title of the presentation was "Fishing Activity, Resources, Habitat in Nantucket Sound and Related Questions". According to the presentation, 34 trawlers landed 637,522 pounds of squid in Nantucket Sound in 2000. Fifty-eight trawlers landed 508,785 pounds of fluke in Nantucket Sound in 2000.

Of the 58 trawlers who landed fluke in Nantucket Sound, it is likely that many of these trawlers caught their fish in and around Horseshoe Shoal. This is because Horseshoe Shoal is outside the three-mile mobile gear closed area. And according to fishermen

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[1] Raab Associates is the consulting firm hired to produce the Draft EIS/EIR/DIR for Cape Wind Inc.

interviewed for this study, roughly 75% of Nantucket Sound is not tow-able. The closed areas limit much of the dragging, and other parts of the sound do not have the right type of bottom to effectively use mobile gear. Fishermen interviewed for this study cited that the area in and around Horseshoe Shoal is historically productive fishing grounds for summer flounder (fluke).

1.3-Fisheries Data in Nantucket Sound -

The Final Environmental Impact Report (FEIR) EOEA #12643 reviews the fisheries data available for the Cape Wind Energy Project. A Fisheries Data Report was developed and submitted along with the FEIR to be used by the MMS DEIS to characterize the commercial and recreational fishing activities in Nantucket Sound over the past eleven years (FEIR Appendix 3.8-B). Information on L*oligo* squid and fluke landings was obtained via NOAA Fisheries Vessel Trip Report (VTR) data.

Loligo squid accounts for about fifty percent of federally reportable finfish and squid landings in Nantucket Sound over the eleven-year period and fluke accounts for approximately twelve percent of the federally reportable finfish and squid landings in Nantucket Sound over this time frame. The majority of squid and fluke landings are harvested by otter trawl. Only fishermen who hold a Massachusetts coastal access permit endorsed with squid and fluke may harvest these species by otter trawl in Nantucket Sound and the proposed project development site.

If a fisherman holds both a federal permit and a Massachusetts CAP-(squid, fluke), they are required to file a federal VTR for their landings from Nantucket Sound. However, roughly one-third of the 146 CAP- (squid, fluke) holders do not hold federal permits[2]. Those fishermen that do not hold federal permits file a state catch report instead. So, VTR landings data alone underestimate the actual landings from Nantucket Sound.

Because squid and fluke account for the majority of mobile gear landings in Nantucket Sound, it is important to know the number of fishermen that hold the right to fish for these species. The Fisheries Data Report in the FEIR provides information about the number of Massachusetts licenses issued for the gill net, fish pot, and fish weir fisheries. However, the report does not identify the mobile gear fishermen who hold a CAP-(squid, fluke), nor does it show specific Horseshoe Shoal mobile gear landings.

This is a critical oversight. These vessels account for the majority of landings in Nantucket Sound over the course of the spring and summer. Also, given the nature of mobile gear fishing, these fishermen will be the most directly affected if a wind farm is developed on their traditional fishing grounds.

[2] The list of fishermen holding coastal access permits endorsed with squid and fluke was obtained via the Massachusetts Division of Marine Fisheries records of 2007 permit and endorsement holders online. It was cross-referenced against the 2007 National Marine Fisheries Service Federal Permit Holders list. Approximately two-thirds of the CAP-(squid, fluke) holders also held a federal permit.

Since roughly two-thirds of the CAP- (squid, fluke) holders also hold a federal permit; VTR data can provide a general idea of the mobile gear landings for these two species in Nantucket Sound. The following table shows VTR landings data by month in Nantucket Sound for *Loligo* squid and summer flounder in 2004. This is the last year of VTR data reported in the Fisheries Data Report used in the FEIR.

Table 1. 2004 Federally-reportable commercial landings (pounds) for L*oligo* Squid and Summer Flounder in Nantucket Sound
(Source: NMFS Vessel Trip Report Data for Area 075)

	April	**May**	**June**	**July**	**August**	**September**
Loligo Squid	**14,770**	**636,082**	**31,075**	0	0	0
Summer Flounder	0	5,121	21,488	**40,888**	**59,181**	16,322

For the Loligo squid fishery, all of the reported landings are from the springtime small mesh squid season, April 23rd to June 9th. Only mobile gear vessels endorsed with a CAP-squid may participate in this fishery. Recall that after May 1st no trip limit exists for this fishery, making it a very lucrative, albeit short fishing season. And, according to McKiernan and Pierce (1995), the second most trawled area during this springtime small mesh squid season is the area in and around Horseshoe Shoal.

Similarly, July and August characterize the CAP-fluke season for inshore mobile gear fishermen. As the landings data show, the majority of fluke landed are taken during the months of July and August, which coincide with the mobile gear coastal access permit fluke season. A fisherman who holds a coastal access permit endorsed with both squid and fluke is likely to switch gear after the springtime small mesh squid season closes in June, and begin trawling for fluke once the fluke season opens in July. This is consistent with the evidence that all CAP-squid holders have also endorsed their coastal access permit with fluke.

1.4-Scientific Data of Finfish Abundance

The DEIS/R notes that relatively few scientific studies of finfish abundance in Nantucket Sound have been published.

> The primary sources of information used to characterize finfish resources within Nantucket Sound are from studies published by the NMFS and the MDMF. NMFS collects “fishery independent” data through a bi-annual bottom research trawl survey program. However, discussion with the NMFS suggested that the bi-annual research trawl data is not available for Nantucket Sound and that these bi-annual trawl surveys occur farther offshore from Nantucket Sound (Draft EIS/EIR/DRI Section 5.4).

The DEIS/R relied primarily on the Massachusetts Division of Marine Fisheries (MDMF) seasonal trawl surveys in early May and September. These surveys were used to account for the abundance and distribution of finfish in the proposed wind project area. It was noted that the timing of the surveys does not adequately account for the abundance and distribution of finfish over the entire year.

> The MDMF research trawl data is the only dataset available to characterize finfish resources in the project area. There are, however, limitations to these data. The long-term research trawl program is not designed to statistically test for similarities/differences in finfish resources between specific sites. Any results from abundance/distribution analyses using this data must be interpreted cautiously. Also, the timing of the surveys (May and September) does not allow the surveys to adequately represent the abundance and distribution of finfish over the entire year. (Draft EIS/EIR/DRI Section 5.4)

The timing of the surveys is particularly problematic because fish and fishing effort are not evenly distributed across this temporal horizon. The arrival of squid in Nantucket Sound is variable from year to year, and when they do arrive, they are not evenly abundant everywhere.

Fishermen are adept at figuring out the seasonal movement of the squid school, and when the school is found, it is fished very intensely. For many of these boats, the rest of the summer in Nantucket Sound is spent fishing fluke. The commercial fluke fishery generally opens around the first week of July, and lasts from four to eight weeks. The season is usually characterized as July and August. Therefore, the MDMF trawl surveys on Horseshoe Shoal miss the fluke season and most likely miss the squid season because squid don't tend to migrate to the middle of Nantucket Sound until mid to late May (McKiernan and Pierce 1995).

1.5 MDMF Review of Cape Wind's DEIS/R

The Massachusetts Division of Marine Fisheries (MA DMF) reviewed the Cape Wind Energy Project Draft Environmental Impact Study/Report and Cape Cod Commission Development of Regional Impact NAE 2004-338-1 & EOEA #12643. Based on this review, Director of the MA DMF, Paul Diodotti, expressed concern in written public comment that this project may have substantial, even significant impacts to fisheries resources, habitat, and harvest activities in Nantucket Sound. Concern was also expressed that the use of incomplete data is highly likely to result in an underestimation of potential impacts to these resources and the resource-based economy of the region. "We strongly recommend the preparation of a Supplemental DEIS/R for this project" (MA DMFa 2005).

State and federal resource agencies have both acknowledged that all existing data sets are limited in their scope and resolution. These agencies recommend directed studies of commercial fishing activity in the preferred and alternative project areas to evaluate potential impacts resulting from the construction and operation of this facility (MA DMFa 2005).

Even though the MDMF expressed concern that supplemental analyses be done to more carefully characterize the impact of this development to commercial and recreational fisheries in the proposed project development area, these efforts were not incorporated into the Final Environmental Impact Report (FEIR). This is an unfortunate oversight because the MMS DEIS characterizes fishing within the proposed wind project development site based on the analysis of the Cape Wind Project FEIR.

1.6 Mitigation Measures and Lessons Learned From Other Offshore Wind Farms

Section 5.3.2.7 of the Minerals Management Service's DEIS suggests that mitigation measures have been made to avoid conflicts with mobile gear fishing vessels. The analysis concludes that no net economic impacts to commercial and recreational fishing are expected as a result of this development.

Mitigation measures taken by Cape Wind include: relocating some of the wind turbines from an area of deeper water to an area of shallow water, spacing the wind turbines one-third to one-half mile apart, and burying the electrical cables six feet under the sand. Although, the DEIS cites that these measures were done explicitly to appease commercial and recreational fishing, other reasons could also exist for these actions. Specifically; relocating some of the wind turbines may also have been done to place the wind farm entirely in Federal waters, the spacing of the wind turbines is also the result of engineering needs to optimize the utilization of wind through the park, and burying the electrical cables in the sand is a necessary requirement of construction.

Based on the experience and efforts of other offshore wind farms around the world, these mitigation measures are minimal. European developers have over ten years of experience building offshore wind farms, and cooperating with the competing needs of commercial fishing is of critical concern. Lessons learned from European wind developments can provide insight into proper mitigation efforts, which have helped to minimize impacts to stakeholder groups and perpetuate future developments. However, even with elevated mitigation measures, some conflicts between commercial fishing (especially trawlers) and wind developers still persist.

1.61-Best Management Practices

The British Wind Energy Association working in close cooperation with various fisheries groups such as NFFO (National Federation of Fishermen's Organisations), SFF (Scottish Fishermen's Federation), SFI (Sea Fisheries Inspectorate) and other relevant marine organizations have developed 'Best Management Practices' (BMPs) intended as guidelines for developers of offshore wind farms and the fishing community. They are based on best practice developed through the experience of the UK's fishing community, and the offshore oil and gas and cable industries (BWEA 2004b).

The purpose of the BMPs is to provide guidelines for any company involved in offshore wind development when dealing with fishing and fisheries. These guidelines therefore hold much valuable information and represent an invaluable reference. They have been compiled in a spirit of cooperation and with the intention of forming a long-term partnership between the offshore wind industry and the UK's fisheries community (BWEA 2004b). .

Fisheries Liaison Officer

Every wind developer is required to have a full time fisheries liaison officer (FLO). The FLO is a full time company employee nominated as the developer's fishing/fisheries contact. They are the point of contact for the fishing industry in those situations where direct communication with the developer is sought. The FLO is the principal liaison between the developer and the fishing community. The FLO will at the earliest possible stage and preferably prior to a bidding round and/or to announcing the position of the wind farm or of the associated cable routes, make contact with and establish a working relationship with the fishing industry. They are the focal point for all nationwide fishing and fisheries matters pertaining to the offshore wind industry. The FLO also serve:

- To discuss issues arising from the interaction of fishing and offshore wind farm activities;
- To share best practice;
- To agree to standards under which compensation may be considered for any direct disruption to work and loss of income.

The purpose of the FLO is to:

- liaise effectively on generic national issues with the fishing industry including with inshore fisheries managers;
- represent the industry on national issues to the government;
- develop a common set of standards in accordance with which offshore wind developers will work with the fishing industry;
- share best practice with the European and American wind industries;
- distribute information to the fishing industry;
- produce industry-wide proposals for fisheries liaison;
- produce and maintain a fisheries guidebook.

(BWEA 2004a).

Fisheries Liaison Representative

It is enormously helpful for the wind industry when they are able to also have a single contact point within the fishing community who can be trusted to represent the fishing industry view to the developer. That person, termed a Fishing Liaison Representative (FLR), should be able and willing to disseminate information from the Developer to the fishing community, on a timely and all-inclusive basis. The FLRs should be nominated by elected members of the fishing industry and should therefore be representative of those bodies. Problems have been created in the past where the FLR has been unacceptable to the affected fishermen because there is little local knowledge of or trust in that person (BWEA 2004a).

Principal roles

The principal roles of the FLR should include:

- Form the principal link between the fishing community and the wind farm operator;

- Provide the operator with guidance on fishing activity in the area and draw attention to particular fishing sensitivities;

- Liaise with fishing skippers with the objective of relaying accurately their concerns back to the FLO;

- Disseminate updated project information to fishermen and communicate any changes that occur;

- Promote methods of work that minimize disturbance to fishing;

- Monitor fishing activities in the wind farm area;

- Advise fishing vessels of works activities;

- Liaise with fishermen to identify any particularly sensitive issues that the fishing community requires to see included in environmental statements as well as any other particular EIA requirements that they may consider to be appropriate;

- Fishing is a 24-hour operation; therefore the FLR will be expected to be on call 24 hours a day.

Guard Vessels

Guard vessels may be required during the construction phase as well as during major tower/turbine maintenance and cable repair and at any other time. Where possible and where the vessels proposed are suitable and are available at competitive rates, local fishing vessels should be employed to carry out any guard vessel duties. This is one way to mitigate some of the adverse economic impacts from the developments (BWEA 2004a).

Safety Concerns-*“Avoid Trawling”*

The MMS DEIS claims that burying the cables six feet in the sand is a mitigation effort. European wind farms bury their cables six to nine feet in the sand. This is not considered a mitigation effort, but rather a necessity of development and a serious safety concern for mobile gear fishing. The Best Management Guidelines cite that anchoring or trawling in the vicinity of submarine cables should be avoided. Seabed mobility may leave cables spanning sub-sea sandbanks and this, in turn, may cause fishing gear to be snagged and may put the fishing vessel in severe danger.

Fishermen need to exercise extreme caution when fishing in areas where wind turbine installations and associated submarine power cables is located. Furthermore, fishermen are cautioned of the real snagging risk if trawling in close proximity to a submarine power cable and/or wind farm installation. For these reasons, certain developers have included exclusion/safety zones around their developments, and where these are in effect fishermen should observe the limits of those zones. Also, such zones may be introduced automatically as part of the new legislative requirements introduced by the government’s Energy Bill (BWEA 2004a).

It is important to note that burying the cables in the sand or maximizing the space between wind turbines is not sufficient to ensure Best Management Practice. Rather, both of these measures are still treated as a serious safety concern. At the very least, Cape Wind should have hired a Fisheries Liaison Officer and worked with a Fisheries Liaison Representative to make sure that the environmental impacts included in any type of environmental impact statement were consistent with viewpoints and concerns of the affected commercial fishermen.

<u>1.62 Other Offshore Wind Farms</u>

For the most part, European wind farms are located in areas of very low commercial fishing use. This is a mitigation effort. Even so, potential conflicts with the commercial fishing industry are treated very seriously. The Environmental Impact Assessments (EIA’s) from other European offshore wind farms all detail the potential conflicts between commercial fishing and wind farm developers more precisely and in-depth than Cape Wind’s FEIR or the MMS DEIS. Some examples are given below.

<u>North Hoyle Offshore Wind Farm</u> Environmental Statement (2002, Chapter 5)

The North Hoyle environmental statement cites that construction of the wind farm is bound to lead to a loss of access to the site for fishing vessels. A discretionary safety zone of 200m from all construction plants will be required during the construction phase; in addition, there will be an increase in traffic across the site. Vessels intending to fish on the site will need to work elsewhere, and other vessels intending to navigate across it will be forced to divert around it (NHES 2002, *5.4.4.2.1).*

Also, the laying and burial of the cable will prevent both static gear and trawl vessels from fishing the site during these operations. The cable route crosses directly over grounds that are fished by inshore trawlers. Laying and burying operations will not prevent vessels from fishing, but may force them to change the routes that they tow. In addition, the disturbance caused by these operations could temporarily displace fish from the area, reducing catch rates to vessels that remain in the vicinity (NHES 2002, *5.4.4.2.2).*

Burbo Bank Offshore Wind Farm Main Report on Commercial Fishing (MRCF) 2002.

The Main Report on Commercial Fishing prepared by Poseidon Aquatic Resource Management Ltd cites that fishermen, especially trawlers have raised their concerns over operating within the area of the wind farm. Given the strength of tidal flows in the area, potential sea conditions in bad weather, and the likelihood the vessels would at times be drifting while hauling nets, conducting emergency repairs or idling for other reasons, serious questions were raised about the possibility of collision with wind turbines. Many trawlers said that even if there were no exclusion zone around the area, they would probably choose to avoid it.

The assumption that vessels can simply alter course to avoid wind turbines, is deemed by fishermen to be impractical. Trawls tend to follow a specific tow pattern, and extensive deviation could well cause damage to the trawl. Skippers are likely to have to haul their gear if they perceive that their tow will take them into potentially dangerous territory within the wind farm (MRCF 2002, 2.1.2.3).

Impact on trawl operations could result from obstructions such as exposed cables, or items discarded by vessels belonging to the wind farm operators working in the area. Such items not only generate serious safety concerns but also raise the possibility of possible gear damage and associated financial loss (MRCF 2002, 2.1.2.3).

Trawlers working in the Horseshoe Shoal area have cited similar safety and operational concerns about continuing their normal fishing within the vicinity of a wind park. However, the specific Horseshoe Shoal trawlers were not identified and their concerns were not specifically mentioned in Cape Wind's FEIR or the MMS DEIS.

Middelgrunden Offshore Wind Farm

Extensive netting takes place in the area of this wind farm, primarily for eel, cod and flatfish. Compensation was settled with the local fishermen, as fishing was prohibited during construction. Now fishing can resume as before, but no tool scraping the bottom may be used, which restricts trawlers, and it is prohibited to anchor within 200 meters from the sea cable (World Wind Energy Association 1995).

Barrow Offshore Wind

Fishermen from Fleetwood and Barrow have engaged legal advisors to assist them in seeking compensation for the loss of fishing grounds in the Barrow area as a result of this wind farm development, which is not closed to trawling. According to the witness statement of Dr. Steven Atkins, the Chief Executive of the North Western and North Wales Fisheries Committee (NWNWSFC), the inshore mobile gear fleet is in serious trouble. On top of high operating costs, they have lost a good quarter of their regular fishing grounds to the Barrow wind farm. Wind farms are concentrating fishing effort into smaller areas. This should be a matter of serious concern for the future of the fishery with the prospect of further large areas being lost to wind farm development in the near future (Atkins 2007).

According to Dr. Atkins, trawling is very unlikely to take place because the risk of hitting a turbine in bad weather or in case of engine failure is too great. The area used by trawlers and other fishing sectors is much more restricted than generally assumed. Fishermen only fish where they know it is safe from seabed hazards and dangerous water currents. They give hazards a very wide margin of error. Therefore, they tend to use the same carefully defined tows repeatedly and are understandably reluctant to risk losing gear by experimenting with unknown areas of seabed. On safety grounds, it is not possible or practicable for fishing to continue within or in the immediate vicinity of the wind farm. This will result in the loss of the fishing ground known as 'Between the roughs' to the fishermen, which will be a significant financial blow (Atkins 2007).

Every other offshore wind farm in the world has been closed to fishing, at least temporarily, and trawling is given the utmost attention and concern. Both Developer and fisherman realize the trawling in the area of a wind farm is not safe and should be avoided. Cape Wind's FEIR has said that they do not plan to limit or exclude fishing in the vicinity or in the area of the wind farm. This is considered a mitigation effort. Based on the evidence of other offshore wind farms around the world, this does not seem feasible or safe. The Best Management Practices recommend that trawling be avoided completely through the construction, operational, and decommissioning phases of a wind farm project. Perhaps the reason for the Cape Wind's decision to not exclude mobile fishing is because they had not identified a competing mobile gear user group.

The intent of this study is to supplement the MMS DEIS with information regarding the level of mobile gear fishing within the proposed project development site on Horseshoe Shoal, and to provide an analysis of changes in the economic well being of mobile gear fishermen due to this development. Because all existing data sets are limited, the total value of the Horseshoe Shoal area as a mobile gear fishing grounds will be estimated through economic techniques by directly contacting and interviewing a sample of the population of Massachusetts fishermen who hold coastal access permits endorsed with both squid and fluke.

It will be shown that the common property nature of the marine environment presents a situation where both the wind farm developer and the mobile gear fisherman would like to claim rights to the Horseshoe Shoal area. Ideally, neither party would like to acknowledge the impact of their operations to the other party's business operations. In an economic sense, these external costs are considered externalities. Externalities are a market failure, and their presence signals that some type of re-allocation of resource use could make both parties better off. The government sometimes corrects for externalities through taxes on pollution, for example. But in the case where the externality is localized to two parties and there is a possibility of negotiation, it is more efficient for the affected parties to reach a mutually beneficial agreement on their own.

2. Theory and Methods

2.1- Common Property Resources

Without clearly defined property rights, natural resource use is inefficient. Ocean resources, like fish, are classically considered common property. Since no one owns the resource, no one has an incentive to save the resource for next years harvest. All of the profits from a fishery are eventually dissipated, and the resource is exhausted to an unsustainable level (Gordon 1954). This is the “tragedy of the commons”.

However, most fisheries are not truly open access anymore. In fact, many operate under some type of regulated open access or limited access framework. In these fisheries, regulators restrict fishing area, total allowable catch, gear and/or season length or number of boats to meet some management objective. The Massachusetts Cap-squid and fluke fisheries are examples of limited entry regulated open access fisheries, or restricted regulated open access fishery (Homans and Wilen 1997). There is a limit to the number and size of boats that may participate in these fisheries, and regulators control total allowable catch by restricting gear and season length. In restricted access fisheries, profits may exist if the number of boats is limited sufficiently (Clark 1980).

As evidence that the Massachusetts spring squid and summer fluke fisheries in Nantucket Sound could generate positive profits, fishermen choose to purchase or hold special endorsements (Cap-squid, fluke endorsements) that allow them access to these fisheries for the duration of their season lengths. Coastal access permits (CAPs) may be bought and sold on the open market (www.athearnmarine.org) and may sell for between $10,000 and $50,000, depending on the size of the vessel to be endorsed.

Generally, fishermen have had only to compete with one another when using certain endorsements or permits. However, private businesses now realize that the ocean floor itself may be a valuable resource. And like fish, the ocean floor is still considered common property. Theoretically, it may be used by anyone. Down east Liquefied Natural Gas (LNG) Inc. just built a natural gas well and pipeline off the coast of Massachusetts. Other oil and gas companies have proposed to drill for crude oil reserves under George’s Bank. And Cape Wind has proposed to develop a twenty-five square mile area of Nantucket Sound.

Commercial fishermen do not own territorial rights to any particular area of the ocean even though they may own the right to fish for various species throughout different fishing seasons. But, as shown in the previous section, for certain times of the year some species like squid and fluke are very area specific. Endorsements allow fishermen to access these areas and fish for these species during the specified open periods. Because there is a market for these endorsements, and because they offer a degree of exclusivity to the holder, these endorsements in a sense act like a property right. Mobile gear fishermen know that a limited amount of CAP-(squid, fluke) endorsements exist, and that only fishermen who hold these endorsements may fish in the same area they do during the same time of year.

2.11 Externalities

Due to the nature of mobile gear fishing, disruption of the normal seabed with buried power cables and permanent obstacles such as wind turbines could disrupt or displace traditional fishing. The costs to fish Horseshoe Shoal are thought to increase with a reduction in the state of the environment on Horseshoe Shoal. These increased costs are due to increased steam time from negotiating new navigational obstacles, an increased risk of collision with permanent obstacles or power cables, the loss of access to traditional tow patterns, a reduction in the total number of tows, a reduction in the total number of days fished, concessions to avoid temporary or permanent closed areas, and increased transactions costs associated with increased communication and cooperation with development plans. These are all social costs imposed on mobile gear fishing by the development of a wind farm. These additional costs are thought to increase the costs of fishing on Horseshoe Shoal.

Based on the experiences of developed and developing wind power plants around the world, constructing and maintaining an offshore wind farm could not proceed without some type of capitulation by commercial fishermen to reduce their effort and increase their cooperation with development plans, at least temporarily. If the wind power company is granted the development rights to Horseshoe Shoal, then too much fishing effort will also lead to social costs imposed by commercial fishing on the wind power company. These social costs are assumed to marginally increase with an increase in fishing effort and a decrease in cooperation with development plans.

For example, high fishing effort in the area of a proposed wind farm is assumed to increase the social costs to a wind power company from a higher probability of collisions between fishing vessels and wind turbines, a higher probability of towing and damaging a ground power cable, a higher probability of delaying construction or repair work, new costs associated with mitigation (like the hiring of a full time fisheries liaison officer and fisheries liaison representative), new costs associated with enforcing area closures and hiring guard vessels, higher insurance costs (due to increased risks of collision), possible legal costs, and other transactions costs associated with organizing and coordinating cooperation and outreach with commercial fishermen.

In an economic sense, these social costs constitute negative externalities. Externalities are a type of market failure that exists because incomplete property rights lead to less than perfectly competitive markets. In this case, neither the wind power company nor the mobile gear fishermen internally recognize their external cost to one another. One way to correct for externalities is to assign rights to one party or the other, and allow the two parties to negotiate to an appropriate level of externality. In certain cases, two parties may be small enough so that transactions costs are very low. If the externality is localized to only these two parties, then a court could assign initial rights over the externality to one party or the other. An economically efficient outcome could be reached through negotiation or bargaining.

2.2 "The Problem of Social Costs"

Ronald Coase's seminal essay, "The Problem of Social Cost" (1960) is one of the most cited articles in the economics and legal literatures. Much of this is owed to a proposition that has come to be known as the Coase Theorem. Coase argued that from an economic perspective, the goal of the legal system should be to establish a pattern of rights such that economic efficiency is attained. It asserts that under perfect competition, private and social costs will be equal. If one assumes rationality, no transactions costs, and no legal impediments to bargaining, all misallocation of resources would be fully cured in the market by bargains (Calebresi 1968). When parties can bargain together and settle their disagreements by cooperation, their behavior will be efficient regardless of the underlying rule of law (Cooter and Ulen 2004).

For example, suppose development rights to the Horseshoe Shoal area was granted to the wind power company, but a court ruled that the exclusive group of Horseshoe Shoal mobile gear fishermen had the right to impose an externality on the wind power company. If development were to take place, the wind power company would need to compensate mobile gear fishermen. According to the Coase Theorem, there exists some transfer payment where mobile gear fishermen would voluntarily reduce their level of externality to an equilibrium point that is beneficial and pareto efficient for both parties.

Suppose the wind power company and the commercial fishing user group was to sit down together and discuss development plans prior to the release of any type of environmental impact statement. What is the minimum amount that commercial fishermen would be willing to accept to voluntarily reduce their fishing effort and increase their level of cooperation? Theoretically, fishermen would accept a compensation offer if it is at least equal to the value of lost production from using less of the externality creating input.

2.21 Horseshoe Shoal Effort

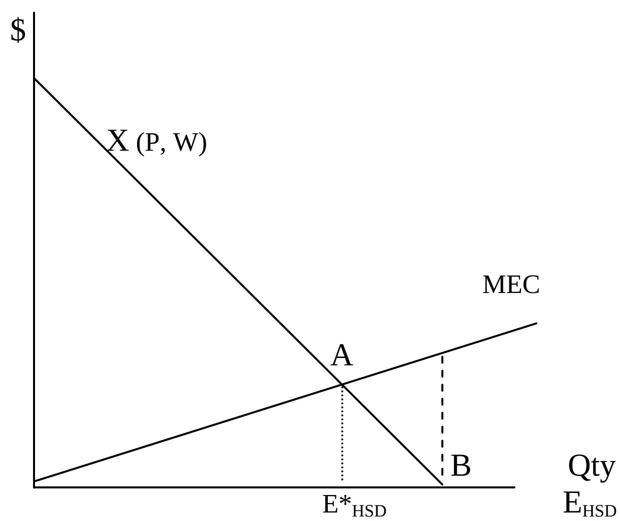
The externality creating input may be viewed as the level of effort used to fish on Horseshoe Shoal. It is common in fisheries economics and management to view the concept of fishing effort as an aggregate index of the individual factors of production such as capital, labor, and fuel. These separate components of effort can be consistently aggregated into a composite index under a fairly restrictive condition on the production technology, homothetic separability (Squires 1986).

Following Squires (1986), Horseshoe Shoal effort may be defined as $E_{HSS} = f(x_1, x_{2 \ldots} \; x_n)$ and f is a consistent aggregator function. The optimal amount of effort is determined by solving the optimization problem $E_{HSS} = f\,(X')$. Weak separability of the technology in all inputs is necessary and sufficient for the existence of the aggregate E_{HSS}. Homotheticity is a necessary and sufficient condition for the validity of sequential optimization.

The multi-product firm's profit function gives the maximum economic profit as a function of product and factor prices. The profit function ∏ is derived from the firm's maximization problem. Assume that the firm takes product prices $P = (P_1,\ldots P_m) > 0$ and input prices $W = (W_1,\ldots W_n) > 0$ as given, and attempts to adjust outputs and inputs so as to solve $\max_{(Y, X)}\{PY - WX\}$. If {Y*, X*} solves this problem, then the firms profit function is $\prod(P, W) = PY^* - WX^*$. For competitive firms, the technology conditions imply that the profit function is smooth, convex in prices, twice differentiable, and bounded (Squires 1986).

The firm's profit maximizing product supply and factor demand equations can be obtained directly from the profit function by Hotelling's Lemma: $D_P\prod(P, W) = Y^*(P, W)$ and $D_W\prod(P, W) = -X^*(P, W)$, where D is a vector differential operator. So, a downward sloping input demand curve exists for Horseshoe Shoal Effort. If increasing fishing effort also increases the marginal external cost to a wind power company, the following presents a graphical depiction of this scenario.

Graph 1. Optimal Horseshoe Shoal Fishing Effort



The quantity of Horseshoe Shoal fishing effort is represented by E_{HSD} on the horizontal axis. It is the aggregate amount of effort that commercial fishermen choose for fishing Horseshoe Shoal during the Cap- (squid, fluke) fishing seasons. The price vector P and W are vectors of both input and output prices, respectively. The industry input demand X (P, W), is assumed to be downward sloping. This means that the marginal value of an additional unit of effort is decreasing.

High fishing effort in the area of a proposed wind farm is assumed to increase the social costs to a wind power company. This is represented by the increasing marginal external cost (MEC) curve. Point B represents maximum Horseshoe Shoal fishing effort. This is the level of use that would occur with no wind farm. Suppose this level of effort could continue throughout the development and maintenance of a wind farm.

Hypothetically, if commercial fishermen did not reduce any effort, they would not change tow patterns, they would not make an effort to avoid wind turbines, they would fish through temporary work zones, they would not adhere to temporary closed areas for laying cables, and they would not cooperatively communicate with developers. A wind farm could not easily be built under this scenario, and at point B, the marginal external cost to the wind company is highest.

However, given the nature of the externality also imposed on commercial fishing from the development and maintenance of a wind farm, safety concerns of mobile gear fishermen could force them to accept a reduced level of effort to point A, non-voluntarily. A wind farm could be developed under the assumption that fishermen would necessarily reduce their effort for safety concerns. A developer would not recognize the full level of unimpeded effort of mobile gear fishing at point B. If the two parties did not negotiate with one another ahead of time, fishermen would be forced to bear the full costs of a reduction of effort and an increase in transactions costs.

Point A could be determined ahead of time though through education and negotiation by both parties with one another about the necessary requirements of developing a wind farm, and about the traditional effort used to fish on Horseshoe Shoal. If proper communication and negotiation between these two groups did not occur *a priori*, then a role exists for the courts or policy makers to define the dynamics of the externality between these two parties.

If policy makers assigned the rights to create an externality to mobile gear fishing based on the full level of fishing effort, the marginal benefit of an additional unit of effort on Horseshoe Shoal past point A is less than the marginal external cost to the wind power company. It would then be in the wind company's best interest to offer commercial fishermen "co-operation" money or equivalent compensation to reduce their effort. It can be shown that any reallocation of fishing effort from point B towards point A will make both parties better off. At point A, no re-allocation of effort or co-operation monies would make either party better off.

Now, suppose the US Coast Guard recommended a mobile gear exclusion zone around the wind farm. This would effectively require a reduction in the level of fishing effort, or the total number of days fished on Horseshoe Shoal, to zero. Could bargaining take place under this scenario? Theoretically, yes if we assume that commercial fishermen still have the right to create an externality to the wind power company.

If development were to occur, the wind power company would need to compensate commercial fishermen for their loss of effort. If we assume no loss aversion (loss aversion will be discussed briefly), the Coase theorem says that the minimum amount of money fishermen would be willing to accept to voluntarily reduce their level of fishing effort on Horseshoe Shoal to zero would be at least equal to the total loss in profits from this total reduction.

2.22 Environmental Quality as a Factor Input

Suppose Q is the undeveloped, pristine state of the environment on Horseshoe Shoal. The development of wind turbines on Horseshoe Shoal then decreases the quality of the initial state of the environment to Q'. The state of environmental quality will continue to decrease with cumulative additions of wind turbines. The total reduction in environmental or resource quality, Q'', is equal to zero when Horseshoe Shoal is fully developed and closed to mobile gear fishing. The task is to estimate in monetary terms the changes in an individual's welfare associated with changes in Q. Broadly speaking, Q can affect an individual's welfare or utility in three ways.

1. Q can produce utility indirectly as a factor input in the production of a marketed good or service.

2. Q can be an input in the household production of utility-yielding commodities; or

3. Q can produce utility directly by being an argument in an individual's utility function (Freeman 2003).

When Q is a factor of production, changes in Q lead to changes in production costs, which in turn affect the price and quantity of output or the returns to other factor inputs, or both. Effectively, Q becomes an argument in the profit function, ∏(P,W,Q) and the input demand function, X (P,W,Q). Because $d\prod(P,W,Q)/dQ > 0$, a decrease in the level of Q will decrease profits. As Q decreases in quality, it is more expensive to use the aggregate effort input, X (P,W,Q). Assuming a fishing firm is operating as a profit-maximizing firm, an increase in the cost of using an input will reduce profits. Also, profits from the use of X(P,W,Q) are zero when Q''=0 (when Q''=0, Horseshoe Shoal is developed and closed to mobile gear fishing).

If Q is reduced from its original state, it is likely to also directly affect the utility function of the commercial fishing users, U(C, Q). In this sense, Q may have a non-use value or passive use value. The last term was coined by the D.C. Court of appeals in its ruling in Ohio v. U.S. Department of Interior (880 F.2d 432 [1989]) which legitimized the inclusion of these values in natural resource damage cases brought by the federal government. Non-use value may be defined within a utility theoretic framework and it has the characteristics of a public good. Because non-use value contributes to the economic well being of individuals, it is relevant to economic efficiency (Kopp 1992).

If Horseshoe Shoal were eventually closed to fishing, and fishermen were forced to fish elsewhere or fish different gear and different species, analysis of the welfare effects could also include a "psychological cost" to leaving this traditional fishery. Freeman (1993, 2002) shows that there can be a meaningful distinction between the loss of non-use values of resource that continues to exist and the loss associated with the destruction of a resource, the latter being a pure existence value.

Following Freeman (1993, 2002), a resource is said to cease to exist if Q fell below some level Q^{min}, at which the input demand, X(P,W,Q) fell to zero even at zero price. Freeman defines use, existence and non-use value in a consistent manner such that total value satisfies an adding up condition. Where there is a threshold value for Q, the total value of a decrease in Q that crosses that threshold is the sum of three components:

1. a loss of use value because crossing the threshold makes use no longer possible
2. the loss of user's nonuse value associated with degradation of Q down to the threshold
3. the loss of pure existence associated with falling below the threshold of existence

The fish household production model may be used to show how a change in the quality or changes in the state of the environment on Horseshoe Shoal has an affect on the fish household's utility function as well as the fish household's production function. The next section presents a model of the fish household in which both the producer and consumer behavior of the household are defined.

2.3 Theory-Fish Household Production Model (WTA)

This section defines a theoretical measure of compensation necessary to make an individual indifferent to a change in the quality of an environmental service from the status quo. This compensation is a "compensating surplus" measure of total value or total welfare and is defined by WTA^s. It is the amount an individual would be "willing to accept" to voluntarily accept the new state of the environment.

The first part of the fish household is the loss in fish household profit from a non-marginal change in the quality of the environment. Depending on the level of change, the amount of fixed inputs required to compensate for this quality change will vary. The adjustments in fixed inputs could include: changing fishing areas, fishing gear, or adjusting other inputs of production. The use of these inputs requires additional expenses, and hence profits loss. The value of adjusting these inputs may be thought of as the shadow price of using the Horseshoe Shoal effort as an input for fish household production.

Two types of household models discussed in the literature are recursive and non-recursive. Recursive models can be solved sequentially when all the goods that are included in both the utility function and production function are traded on the competitive market (Singh et al 1986). Non-recursive models cannot be solved sequentially because demand and supply decisions interfere with one another. In this case, the household subjective equilibrium gives some goods a value that is different than their market price (Nakijima 1969). This corresponds to a situation where the fisherman values his enjoyment and exclusive access to fish a pristine Horseshoe Shoal. Any reduction in the quality of Horseshoe Shoal not only reduces profits, but also reduces the enjoyment or utility from fishing.

2.31 The Basic Model

The behavior of the fish household is characterized by the maximization of its utility subject to a budget constraint. In the initial absence of any wind farm and subsequent restrictions, the budget constraint is characterized by restricted profit generated by the on boat activities:

$$\begin{aligned}&\mathit{Max} \quad U(C, Q)\\ &\qquad \text{s.t.}\\ &\qquad C \leq \prod\nolimits^{R} (P, X, Q)\\ &\qquad Q \geq 0 \end{aligned} \qquad (1)$$

The parameters of the utility function are the household private consumption C, expressed in monetary terms and Q, the environmental quality (or state of the environment) of Horseshoe Shoal. Since Q enters the utility function, this implies that the fish household derives a passive or non-use value for the original, undeveloped state of Horseshoe Shoal. This initial state of the environment, Q, is assumed to decrease with cumulative additions of wind turbines, and cumulative additions of fishing restrictions, all of which reduce utility as well as profits. Suppose Q equals zero if the entire Horseshoe Shoal area is developed and closed to mobile gear fishing. Also suppose that U(C, Q) is increasing, concave, and differentiable in C and Q.

The restricted profit function $\prod^{R}$ (P, X, Q) represents the fishing technology using the dual approach, and is assumed to be convex. The vector X represents the short term fixed production characteristics of the boat, which includes aggregate Horseshoe Shoal effort. The P vector includes the prices of factors and products freely allocated. The solution to the first model are denoted C_0 Q_0, $U_0 = (C_0, Q_0)$.

2.32 Definition of the Household Willingness to Accept by Surplus Variation

To define the fish household willingness to accept, assume that the state of the environment on Horseshoe Shoal is reduced by a non-marginal change from it's initial state Q_0 to Q_1, such that: $\Delta Q = Q_1 - Q_0 < 0$. The willingness to accept is classically formalized by the surplus variation WTA^s. This willingness to accept is derived from model (2), which defines the restricted expenditure function $e^R(P, Z, Q, U_0)$:

$$e^R(P, X, Q, U_0) = \min \left[C - \prod\nolimits^{R} (P, X, Q);\ U(C, Q) > U_0\right] \qquad (2)$$

$$WTA^s = e^R(P, X, Q_1, U_0) - e^R(P, X, Q_0, U_0) \qquad (3)$$

Equation (3) describes the minimum payment the household accepts to maintain its initial utility level U_0, while the state of the environment is reduced from Q_0 to Q_1. The next equation proceeds to separate the consumer and producer behavior of the household as described by Dupraz (2001).

2.33 Consumer and Producer behavior of the Household

With $C^*(P, X, Q, U_0)$ the solution to model (2), expression (3) becomes:

$$WTA^s = [\ \prod^R (P, X, Q_0) - \prod^R (P, X, Q_1)\ ] - [C^*(P, X, Q_0, U_0) -- C^*(P, X, Q_1, U_0)] \qquad (4)$$

The first term with brackets in equation (4) is the fish household profit loss. The second term in brackets in equation (4) is the value of utility loss due to a decrease in the state of the environment Q, from Q_0 to $Q_{1.}$ The first term in equation (4) is smaller than the second term since monetary consumption would need to increase to maintain initial utility if the state of the environment of Horseshoe Shoal decreased to $Q_{1.}$ If the loss in utility that the own household receives from a decrease in the environmental quality of Horseshoe Shoal is neglected, the WTA^s underestimates the amount of compensation necessary to keep an individual on their initial utility level. In other words, if profit loss alone were used as a measure of compensation, the total loss of a reduction in the quality of Horseshoe Shoal is underestimated and economic efficiency would not be attained.

2.4-Methods-The Contingent Valuation Method

A measure of total value or WTA^s may be obtained through direct stated preference (SP) valuation techniques. One such technique is the contingent valuation method, or CV method. The most commonly used CV questions simply ask people what value they place on a specified change in an environmental amenity or the maximum amount they would be willing to pay to have it occur or not occur. These may be open-ended in that ultimately the individual has to state a number that corresponds to their value consistent with their budget constraint.

Some pioneering works on CV include: Randall, Ives and Eastman (1974), Cummings et al (1986), Mitchell and Carson (1989), and Carson et al (1992). These are still the primary references for the CV method, especially for design and implementation. Also, the so-called NOAA Blue Ribbon Panel (U.S. National Oceanographic and Atmospheric Administration 1993) reviewed CV in the context of assessing damages to natural resources in support of litigation and provided guidelines for best practice.

2.41 Empirically Testing Coase Through the “Bidding Game” CV Method

An open-ended willingness to accept (WTA^s) technique based on a variation of the bidding game was developed to elicit a measure of compensating surplus. In the bidding game, individuals are first asked if they would be willing to accept $X for a change in the state or quality of the environment. If the individual answers, yes this offer amount is reduced and the question is iteratively repeated in this manner until a final value is elicited. If the individual initially answers no, the offer is raised iteratively until a final value is agreed upon. The final value that a respondent agrees upon is considered their direct value for the particular good or service.

A direct valuation question produces a set of welfare measures W_i (i=1,…i,…n) for the n respondents in the sample. An estimate of the total value of the welfare change for the population from which the sample is drawn can be obtained by calculating the sample mean W^* and multiplying by the total population. Alternatively, the responses can be regressed on income or monetary consumption (C) and other economic determinants of profit (P) to obtain a bid function for a given change in Q.

$$Bi^* = B^*(C, Pi) \quad (5)$$

Pi is a vector of socio-economic and economic determinants of profit, which are thought to affect individual's valuation. An alternative approach is to include variation in the size of the change in Q across the sample as part of the survey design. Then the bid function

$$Bi^* = B^*(C, Pi, \Delta Q) \quad (6)$$

is used to calculate values for alternative scenarios of environmental or resource change. In our survey, the first quality change reduces the initial, pristine quality of Horseshoe Shoal Q to a state Q' where the wind farm is fully developed, but the area remains open to mobile gear fishing. The second level of quality change reduces the initial, pristine quality of Horseshoe Shoal Q to a state Q'' where the wind farm is fully developed and the area is closed to mobile gear fishing. In the second case, Q falls below the threshold of existence, which is thought to impose additional non-use costs to the fish household.

2.5 Gathering New Data

This section is organized into three parts. The first part describes the methods for identifying the competing mobile gear user group. The second part describes the steps taken to develop the contingent valuation survey, outlines the hypothetical valuation scenario, and details design steps for mitigation against potential bias. The third part shows how the survey was administered.

2.51Competing Mobile Gear User Group

The target population was the annual Horseshoe Shoal mobile gear fishermen. It was important that respondents to the survey be historical users of this area. As shown in the last section, only CAP-(squid, fluke) endorsement holders are allowed to mobile gear fish within the proposed project development site during the small mesh squid and summer fluke fishing seasons. Therefore, all of the annual Horseshoe Shoal mobile gear users are encompassed by the universe of CAP-(squid, fluke) endorsement holders.

The Massachusetts Division of Marine Fisheries (MA DMFb) keeps records of all commercial fishing endorsements and permits issued to commercial fishermen on there website. Based on these records, a database of all commercial fishermen who held both a CAP-squid and fluke endorsement was developed. This database encompassed 146 commercial fishermen.

However, only the names of the boat owners and their fishing vessels are maintained online at the MDMF. For purposes of this analysis, it was necessary to have both the phone numbers and addresses. So, this database was cross-referenced against the federal multi-species permit holder's list, which contains both phone numbers and addresses. Ninety of the 146 CAP-(squid, fluke) endorsement holders were found to also hold a federal multi-species permit, which provided their personal contact information and characteristics of their vessel. An additional twenty-six phone numbers and addresses of non-federal permit holders was obtained via online directories.

After incomplete or duplicate addresses were eliminated (some fishermen jointly register their boats under one name or one address), a final database of 106 commercial fishermen who hold a Massachusetts CAP-(squid, fluke) endorsement was developed. This database included their name, their vessel name, their phone number, and address. So, to gather new data for this study, a mail and telephone survey was developed and administered to these fishermen. The goal was to obtain enough responses from this sample population so that a target user group of Horseshoe Shoal fishermen could be identified and surveyed.

2.52 The Contingent Valuation Survey

After the user group was identified, the contingent valuation survey was developed through consultation with leaders in the fishing community. Due to the anticipated small sample size, a pre-test survey was impractical. To gauge the acceptability and validity of the survey, two small focus groups were held. One took place at the Massachusetts Fishermen's Partnership and the other took place in Plymouth, MA at the home of Capt. Ron Borjenson, a Horseshoe Shoal user.

The focus groups resulted in two survey re-designs due to heavy objections, dismissals or disbeliefs concerning the initial designs. The final design employs a willing to accept (WTA) measure of compensating surplus to value the welfare loss to the population of mobile gear users from a non-marginal reduction in the state of the environment on Horseshoe Shoal.

2.53 WTA v WTP

Two types of contingent valuation studies appear in the literature: willingness to accept (WTA) and willingness to pay (WTP). In a willingness to accept scenario, a respondent is asked what the minimum amount they would be willing to accept to give up some type of good or service. For example, a mobile gear fisherman may be asked to state the minimum amount he would be willing to accept (WTA) to give up fishing on Horseshoe Shoal. Conversely, the same fisherman may be asked to state the maximum amount he would be willing to pay (WTP) to gain the unimpeded use rights to fish on Horseshoe Shoal. Standard interpretation of economic theory predicts that with small income effects, WTP and WTA should be equivalent, or at least within a tight bound (Randall and Stoll 1980).

However, empirical evidence has shown a large discrepancy between these two measures of welfare. In general, people place a higher value on goods that they own than goods that they don't own. Hence, WTA values have been found to be higher than WTP values for the same good. Various explanations have been provided for these observed discrepancies. Hanemann (1991) attributes the discrepancy to the income and substitution effects while Thaler (1980) attributes the gap to an endowment effect. Horowitz and McConnell (2002) found, by reviewing several studies, that the less the good is like an ordinary market good; the higher is the ratio of WTA/WTP.

A willingness to accept (WTA) measure of value was used for this analysis for two reasons. The first reason is that many of the arguments against willingness to accept do not necessarily apply to this scenario. Secondly, fishermen in the focus groups thought that the notion of paying to access an area that they already feel that they own could produce unreliable results and a large number of protest bids.

2.54 Income, Substitution, and Endowment effects

When an individual chooses how much they would be willing to pay to preserve or protect some state of the environment, they are constrained by their income. Even in a hypothetical scenario, it is more likely that an individual will consider their budget before responding to a WTP question than to a WTA question. If a respondent does not consider their household budget before responding to a direct valuation question, responses are likely to be inflated. In order to mitigate income effects from biasing the analysis, the survey should be designed so that respondents are reminded of their income in a meaningful manner prior to answering any direct valuation question (Carson et al 1992).

Our survey had respondents explicitly separate their income into four different sources. They were first asked to state their total annual income. Next, they were asked to state the percentage of their total annual income derived from Nantucket Sound. They were then asked to state the percentage of their total income from Nantucket Sound derived specifically from Horseshoe Shoal. Finally, they were asked to report any other sources of income external to commercial fishing. The final analysis shows that the distribution of responses to the WTA valuation question varied consistently with the distribution of self-reported income. This is a measure of construct validity, which is one way to test the validity of the contingent valuation survey.

Many environmental, or non-market goods or services have no close substitutes or direct use value. Also, because environmental goods are not bought and sold in the market, it is likely an individual could have a hard time placing value on certain non-market goods or services. If an environmental good or service has no close substitutes, WTA measures of welfare have been shown to reflect this lack of substitutability through disproportionately high compensation needs for a reduction of initial environmental quality. This is the so-called substitution effect.

But, for the case of Horseshoe Shoal, respondents are very familiar with the annual value of this area as a fishing ground. They are also thought to have a downward sloping marginal benefit curve for the use of Horseshoe Shoal as an input in their production process, which means they are necessarily aware of substitutes. Therefore, it is not anticipated that the substitution effect should significantly bias the results of this analysis.

Kaneman, Knetsch and Thaler (1990) suggested that loss aversion due to an endowment effect is likely to occur in studies that use a WTA measure of compensating surplus to empirically test the Coase Theorem. This means that an individual experiences a greater loss from losing a good then the gain from acquiring the same good. For this analysis, it was necessary to control for loss aversion in the design of the survey.

It was hypothesized that if fishermen were asked to state the minimum amount they would be willing to accept to permanently give up their lifetime access to Horseshoe Shoal, significant loss aversion would be observed. This is attributed to two things. First, fishermen feel a sense of ownership to this area. As owners, it is likely that a sense of loss is would inflate the self reported values to this area. Secondly, it is likely that fishermen have lexicographic preferences (Edwards 1986) for fishing. This means that if fishermen were offered fair compensation to quit fishing, and they still had a choice to accept this offer or continue to fish, they would choose fishing.

Therefore, the hypothetical valuation scenario was designed to control for loss aversion and lexicographic preferences. Instead of allowing fishermen to choose between a lifetime of fishing on Horseshoe Shoal and an equivalent amount of compensation, fishermen are instead presented with a hypothetical scenario where they choose between one more year of fishing on Horseshoe Shoal or an equivalent amount of compensation.

Survey respondents were presented one of two versions of a hypothetical scenario. Under the first version, the development rights to Horseshoe Shoal are granted to Cape Wind, and the area remains open to mobile gear fishing. Under the second scenario, development rights are granted to Cape Wind and the area is closed to mobile gear fishing. Based on these scenarios, fishermen then choose whether or not to participate in a law suit against Cape Wind for possible compensation, given that the law suit would at least delay development of Horseshoe Shoal for one more fishing season. The first hypothetical scenario is presented below:

> If Cape Wind is granted the development rights to the Horseshoe Shoal area of Nantucket Sound, the Massachusetts Fishermen's Partnership and the Commonwealth of Massachusetts may file a lawsuit against Cape Wind to compensate the mobile gear fishermen who could be affected by this development.
>
> Suppose it would not cost anything to participate in this law suit, you would only need to provide proof of historical use (e.g. Vessel Trip Reports, State Catch Reports, or Personal Log Book Data) and reasonable legal arguments why and how a wind farm would disrupt historical use, keeping in mind that this area will not be closed to mobile fishing.

Q1: Suppose that the lawsuit would delay development of the wind farm for at least one more fishing season (one more year), and may also provide a chance of compensation for obstruction of historical use at that point, based on this scenario is it likely that you would take part in this law suit?

The second version of the hypothetical scenario specifies that the Horseshoe Shoal area will be closed to mobile gear fishing. This version was administered to roughly half of the survey respondents, and is shown below:

If Cape Wind is granted the development rights to the Horseshoe Shoal area of Nantucket Sound, and this area was closed to mobile gear fishing, the Massachusetts Fishermen's Partnership and the Commonwealth of Massachusetts may file a lawsuit against Cape Wind to compensate the mobile gear fishermen who could be affected.

Suppose it would not cost anything to participate in this law suit, you would only need to provide proof of historical use (e.g. Vessel Trip Reports, State Catch Reports, or Personal Log Book Data) and reasonable legal arguments why and how a wind farm would disrupt historical use.

Q1: Suppose that the lawsuit could delay development of the wind farm for at least one more fishing season (one more year), and would also provide a chance of compensation if this area were then closed to mobile gear fishing. Based on this scenario, is it likely that you would take part in this lawsuit?

If fishermen agreed to participate in the lawsuit under either scenario, they were then presented a scale from zero to one hundred percent, and were asked to subjectively state the odds of winning such a lawsuit. Next, a bidding type format was used to elicit the minimum compensation they would be willing to accept today to forego the extra year of fishing on Horseshoe Shoal and the possibility of compensation next year.

Fishermen were initially presented with a settlement amount of $20,000. This initial amount was chosen through focus group meetings to proxy approximate yearly incomes from Horseshoe Shoal. Respondents could either accept this settlement amount or continue with the lawsuit. If the settlement amount were accepted, respondents were asked if they would accept one half of this amount, or $10,000. Regardless of their answer to this second settlement amount, the next question finally asks, what is the minimum amount they would be willing to accept to settle the lawsuit.

Conversely, if respondents decided to continue with the lawsuit, the initial settlement amount of $20,000 was increased by 50% and respondents then choose whether or not to accept this new settlement amount of $30,000. Regardless of their answer to this second settlement amount, the next question finally asks what is the minimum amount they would be willing to accept to settle the lawsuit today. In this way, a final direct valuation was determined for each respondent. See Appendix B for a copy of the survey instrument.

Specifying the hypothetical scenario so that development rights had already been granted to Cape Wind, in essence transferred lifetime ownership of the Horseshoe Shoal area to Cape Wind. Because fishermen could no longer choose a response that prevented this development from occurring, it was thought that bias from loss aversion would be significantly less. Also, since fishermen could now only choose one year of fishing instead of a lifetime of fishing, lexicographic preferences for fishing rather than compensation are thought to be less influential to their decision.

Fishermen in essence choose between two values: a settlement amount today, or the value of one more year fishing on Horseshoe Shoal plus possible compensation a year from now. Mathematically, this can be formalized as:

$$S_0 >= \{e^{R_t}(P, X, Q_1, U_0) - e^{R_t}(P, X, Q_0, U_0) + \Phi C_t\}/(1 + r)^t \qquad (7)$$

Equation (7) says that settlement today S_0 must be greater than or equal to the discounted compensating surplus of a one-year quality change on Horseshoe Shoal plus the value of the probability of compensation next year, ΦC_t. The right hand side of equation (7) is discounted by a factor r, which is assumed to be 10 percent, (where t=1).

Also, from equation (3), $WTA^{S_t} = e^{R_t}(P, X, Q_1, U_0) - e^{R_t}(P, X, Q_0, U_0)$, so equation (7) becomes

$$S_0 = \{WTA^{S_t} + \Phi C_t\}/(1 + r)^t \qquad (8)$$

If the discounted value of ΦC_t is subtracted from today's settlement amount, a measure of WTA^{S_t} may be defined explicitly as:

$$WTA^{S_t} = S_0(1 + r)^t - \Phi C_t \qquad (9)$$

This measure of WTA^{S_t} is a compensating surplus measure of welfare for a reduction in the quality of Horseshoe Shoal for one year. Assuming a lifetime utility function that is additively separable, then the single period utility function is the same for all periods, thus we can write:

$$\text{Total Net Present Value of Compensating Surplus} = \sum_{t=1}^{T} WTA^{S_t}/(1 + r)^t \qquad (10)$$

Equation (9) says that the single period measure of compensating surplus may be discounted for the life of the project, and summed to find a measure of the total net present value of a reduction in the quality of Horseshoe Shoal. The two quality levels are: developed and closed to mobile fishing (Q'') or developed and open to mobile fishing (Q'). It is assumed that Q' > Q'', and that Q'' represents the minimum quality threshold where total use and existence value go to zero.

2.6 Administering the Survey

The final database of 106 commercial fishermen was comprised of Massachusetts coastal access permit holders endorsed with squid and fluke. The database included their name, their vessel name, their phone number, and address. A mail and telephone survey was developed and administered to these fishermen. Respondents were randomly assigned to receive either version A or version B of the survey. As previously mentioned, the surveys were differentiated based on the different hypothetical scenario presented for their consideration.

Initially, an introductory letter was sent out to this population of fishermen telling them that they were chosen to be part of a survey intended to understand the impacts to mobile gear fishermen from the development of a wind farm on Horseshoe Shoal. Next, the survey was sent out via mail, which was quickly followed up (within two to three days) with telephone calls. Hanemann, Loomis and Kanninen (1991) cite this method as the most promising alternative to in-person interviews (which was recommended by the NOAA Blue Ribbon Panel). A mail/telephone combination in which an information package is mailed to respondents who are then interviewed by phone permits an extensive phone interview that seems to provide many of the benefits of an in-person survey at much lower cost.

Thirty-eight fishermen were contacted by phone within two weeks of sending out the initial survey. Of the thirty-eight fishermen contacted, twenty-four said that they annually fish in Horseshoe Shoal and agreed to take the survey over the phone. A second mailing of the survey was sent out two weeks after the first survey. Ten surveys were returned by mail. These surveys were returned and completely filled out by respondents who said they annually fish in Horseshoe Shoal.

In total forty-eight fishermen were contacted from our database of 106 CAP-(squid, fluke) holders. A total of thirty-four Horseshoe Shoal users were identified and completed the survey instrument. It is thought, that these fishermen represent a large majority of the annual Horseshoe Shoal users given the timeliness and importance of this issue. If a fisherman did not annually fish in Horseshoe Shoal, or fished there infrequently, it is less likely they were motivated to return their survey.
The results section will provide further evidence that the majority of the most frequent Horseshoe Shoal users are represented by this sample.

3. Results

The results of the contingent valuation survey will be presented in four sub-sections. The first sub-section will define the commercial fishing user group and present their attitudes and opinions about renewable energy and offshore wind energy. Estimates of the total number of Horseshoe Shoal users and the associated characteristics of the fishing fleet will be presented.

The second sub-section will present fishermen's characteristics and economic data. It will show: sources of fishing income, the economic importance of Horseshoe Shoal as a squid and fluke fishery, and will present an econometric model of Horseshoe Shoal profits based on a linear regression of Horseshoe Shoal income on key economic variables (determinants). It will also show the geographical distribution of landings from Horseshoe Shoal.

The third sub-section will show the extent of averting behavior undertaken by the user group. Averting behaviors are actions that are intended to increase the likelihood that the development of a wind farm does not happen.

The fourth sub-section will present results of the contingent valuation analysis. The distribution of settlement amounts to the lawsuit will be shown, and three different censored Tobit models are estimated based on these responses. A censored Tobit model is an econometric model based on maximum likelihood statistical analysis techniques that impose an upper limit on the dependent variable, in this case, the settlement amount. The models will be used to predict the economic loss from the development of a wind farm on Horseshoe Shoal under two conditions: 1) a wind farm developed on Horseshoe Shoal and closed to mobile gear fishing, 2) a wind farm developed on Horseshoe Shoal and open to mobile gear fishermen.

3.1-Identification of Horseshoe Shoal Users

In total 48 Cap-(squid, fluke) holders were contacted via telephone, mail or both. This represents approximately 32% of the total number of Cap-(squid, fluke) endorsements issued by the State of Massachusetts. Of the 48 fishermen contacted, 34 fishermen said that they annually fish in the Horseshoe Shoal area of Nantucket Sound. A map of Horseshoe Shoal was provided for fishermen to acquaint themselves with this area before they responded to this question (See Appendix B). Only fishermen who identified themselves as Horseshoe Shoal users were asked to complete the rest of the survey.

Some fishermen hold a CAP-(squid,fluke), but fish for these species in areas other than Horseshoe Shoal . Other fishermen have endorsed their coastal access permit with both species but only fish for one or the other. Still other fishermen hold their endorsements instead of using them. They are treated as a hedge against management regulations and fluctuating species prices.

3.11 Attitudes and Opinions

Respondents were asked to gauge the extent to which they agreed or disagreed with five statements regarding the personal importance of renewable energy and the impacts of an offshore wind farm to traditional fishing practices. A statement was presented for respondents' consideration, and based on a five point Likert-scale ranking, they determined how much they agreed or disagreed with each particular statement. Responses ranged from: (1)-strongly agree with the statement, (2)-mostly agree with the statement, (3)-have a neutral attitude about the statement, (4)-mostly disagree with the statement, or (5)-strongly disagree with the statement. The mean results of the Likert-scale analysis are presented below alongside each question.

Table 2. Attitudes and Opinions

Statement (n=34)	**Mean/St. Dev**
1. It is important to me personally, that part of my electricity comes from a renewable source.	2.00 (1.04)
2. An offshore wind farm could be a good idea for renewable energy in Cape Cod if the wind farm were located in a different location.	2.34 (1.53)
3. The development of a wind farm on H.S. Shoal in Nantucket Sound may improve my catch due to the artificial habitat the wind turbines would create.	4.15 (1.32)
4. With turbines spaced 1/3 to ½ mile apart, I could easily tow my gear through the wind farm if it remained open to fishing.	4.56 (0.98)
5. A wind farm developed on Horseshoe Shoal would increase boat congestion, increase my steam time, and increase navigational risks if I were to continue to fish this area.	1.43 (1.07)

Thirty-four respondents answered this section. Most fishermen agreed with the first two statements, as both statements had mean response values in the two's. Overall, respondents thought it was important that part of their electricity come from renewable sources. They also agreed that offshore wind energy could be a good source of renewable energy in Cape Cod if the wind farm were located in a different location other than Horseshoe Shoal. Many fishermen gave suggestions for alternative development sites. This shows that in principle, fishermen are supportive of offshore wind, even in Nantucket Sound.

Fishermen do not believe that wind turbines would improve their catch due to an artificial reef effect. Most trawling in Horseshoe Shoal is directed at squid and fluke. And, as mentioned in the DEIS, these two species are not attracted to monopile devices like wind turbines. Based on the statistical results of this statement, it seems fishermen are aware of this ecological fact.

The highest level of disagreement, and the lowest standard deviation, was measured for the next statement regarding the ease of towing gear through the wind turbines. Horseshoe Shoal mobile gear fishermen do not believe they could continue traditional fishing operations or traditional tow patterns if they were forced to compete for the use of the bottom with wind farming. Further evidence from this report will show that Horseshoe Shoal mobile gear fishermen are also able to estimate the extent of disruption to traditional fishing from the development of a wind farm, even if it remained open to mobile gear fishing.

Perceived disruption of traditional fishing is consistent with evidence of conflicts to fishing by other offshore wind farms around the world, where similar concerns of mobile gear fishermen have been documented. Most offshore wind farms around the world have been developed in areas of low commercial fishing effort, especially low mobile gear use. This is a conscious mitigation effort. However, the Barrows wind farm was developed in an area of higher mobile gear use. Even though the developers were not made to close this area to mobile gear fishing, local mobile gear fishermen have still filed a lawsuit against the developer citing the disruption of normal fishing activities.

Finally, respondents mostly agree to strongly agree that a wind farm on Horseshoe Shoal would increase navigational risks, increase steam time, and increase congestion in the area of the wind farm. All of these could result in a decrease in the amount of aggregate fishing effort by mobile gear fishermen in the Horseshoe Shoal area of Nantucket Sound. It is not likely that a decrease in fishing effort on Horseshoe Shoal could be adequately made up for by fishing elsewhere.

There is a limited amount of tow-able areas in Nantucket Sound, and much of the water that is tow able is closed to mobile gear fishing after May 1. Also, many other areas of Nantucket Sound are littered with fixed gear, which discourages many mobile gear fishermen from towing these areas. Finally, the dramatic reduction of federal days-at-sea would discourage mobile gear fishermen from instead fishing in federal waters because many federal days at sea are now twice as expensive to use.

3.2 The Horseshoe Shoal Fishing Fleet

Thirty-four mobile gear users of Horseshoe Shoal completed this survey. This represents approximately twenty-three percent of the total number of CAP-(squid, fluke) endorsement holders. However, it is likely that the total number of Horseshoe Shoal users is significantly less than the total number of CAP-(squid, fluke) endorsement holders.

Many fishermen do not use their CAP-(squid, fluke), but instead choose to hold their permit as a type of hedge against future fisheries regulations and fluctuating species prices. Twelve out of thirty four fishermen contacted by phone held a CAP-(squid, fluke) but did not use their permit to annually fish in Horseshoe Shoal. Five of the twelve fishermen said that they didn't use their endorsements at all in the past because they could make more money ground fishing in federal waters; but, due to the impending reduction in federal days at sea they all planned to go fish in Nantucket Sound this coming season. The other fishermen said that Horseshoe Shoal is too far away, so instead they fished in other parts of Vineyard and Nantucket Sound. Many of the fishermen contacted have had their endorsement for years and said they may choose to sell it if the market prices increase sufficiently.

Vessels from Rhode Island, Massachusetts, Maine and New Hampshire all hold Massachusetts hold a CAP-(squid, fluke). However, the greater the distance their homeport is from Nantucket Sound, the less likely it is that hey use their permits. This will be statistically shown in sub-section two and four. The largest contingent of out-of-state boats fishing in Nantucket Sound during the inshore squid and fluke seasons are vessels from Rhode Island. These are generally larger vessels that use this area less frequently than local Massachusetts's boats.

Respondents who took this survey via telephone were asked to estimate the total number of Massachusetts vessels that frequently fished the Horseshoe Shoal area of Nantucket Sound. Twenty-four fishermen answered this question. On average, forty Massachusetts vessels (st. dev 10.4) were thought to frequently fish Horseshoe Shoal. Many fishermen who answered this question made a point to say that when the squid and fluke are abundant, there could be as many as fifteen to twenty out-of-state vessels fishing alongside Massachusetts vessels in and around Horseshoe Shoal.

These estimates are consistent with the landings data presented by MDMF biologist, Vincent Makloski, at the public meeting in 2001 about the proposed development hosted by RAAB Associates. According to the presentation, 34 trawlers landed 637,522 pounds of squid in Nantucket Sound in 2000. Fifty-eight trawlers landed 508,785 pounds of fluke in Nantucket Sound in 2000. As previously argued, it is likely that many of these vessels frequented Horseshoe Shoals while fishing in Nantucket Sound. Sub-section two will show that some vessels that fish in Nantucket Sound land their catch outside of Nantucket Sound in New Bedford or Boston. Therefore, these estimates probably do not account for all of the trawlers who caught fish in Nantucket Sound.

Based on this evidence, it is likely that the total number of Massachusetts mobile gear vessels who frequent Horseshoe Shoal is between 40 and 50. If occasional out of state boats are included, the number of boats frequenting Horseshoe Shoal could be as high as 50 to 60. For the rest of this analysis, only the more frequent, Massachusetts users are included in the valuation. Therefore, it is estimated that the number of respondents to this survey (n=34) represent between sixty-eight and eighty-five percent of the most frequent Horseshoe Shoal users.

3.3 Vessel Characteristics

The length of the vessel, the gear tonnage, and the horsepower defines vessel characteristics. Table 2 shows the mean values, standard deviation, and the sample size associated with each vessel characteristic.

Table 3. Vessel Specifications

n=34	Mean Vale	St. Dev
Vessel Length	45.57 ft	(9.08)
Gear Tonnage	29.95 gt	(14.39)
Horsepower	282.20 hp	(90.47)

Because no vessel larger than 72 ft may fish through Horseshoe Shoal, the mean vessel length is quite homogenous. This can be seen by the relatively low standard deviation. The largest vessel in this sample was 72 ft, and the smallest vessel was 35 ft. Most vessels were between forty and fifty feet. Gear tonnage and horsepower were more heterogeneous, as can be seen by their larger standard deviations. This could be because many older fisheries regulations limited vessel sizes, but not capitalization. Therefore, some fishermen have invested more money than others in capital improvements like horsepower and gear tonnage to gain a competitive advantage.

3.4-Fishermen's Characteristics and Economic Information

The following table presents fisherman specific information about age, number of vessels owned, number of employees, and level of education.

Table 4. Fishermen Characteristics

n=34	Mean	St. Dev
Age	54.68	(6.95)
# of Vessels	1.53	(.749)
# of Employees	2	(2.04)

The average age of Horseshoe Shoal fishermen is fifty-five. This is not surprising, as the fishing community in general is aging. Less and less young fishermen are joining the industry due to the uncertain nature of the profession and the very high fixed cost to enter. The youngest fisherman from this sample is thirty-nine years old, and the oldest fisherman is sixty-six.

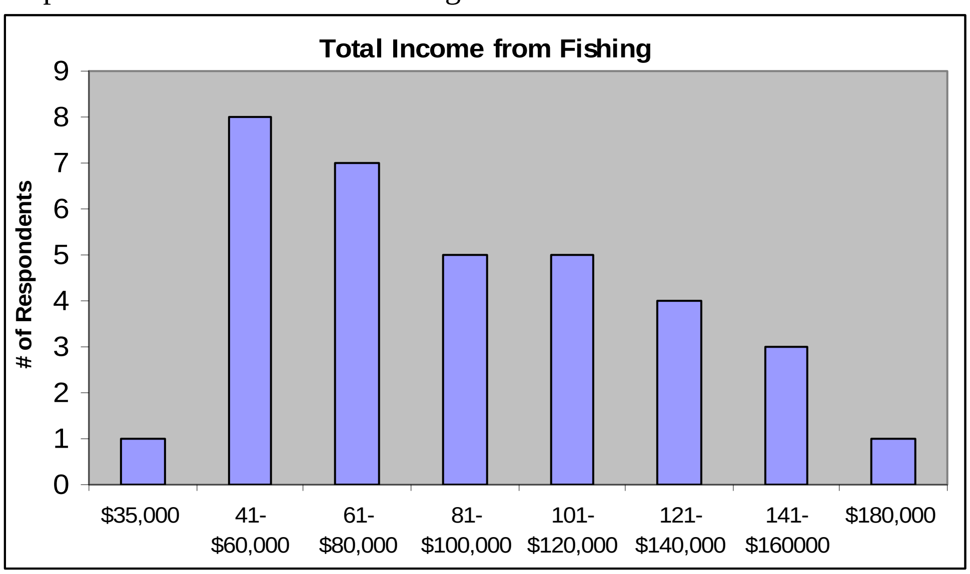
Most fishermen only owned one vessel, but this varied from one to four vessels. The average number of employees is two, but this may be skewed as can be seen by the high standard deviation. The mean is skewed because one fisherman owned four boats and employed twelve employees. The mode or most frequently occurring value is one employee. Forty-six percent of the sample indicated that the highest level of education they had was high school. Twenty-eight percent has some college education, twenty percent held a college degree, and less than one percent of the sample (2 respondents) held a graduate degree.

3.5 Economic Information

Information about total income from fishing, total income from Nantucket Sound, and total income from Horseshoe Shoal was collected from respondents. Total income is an estimate of gross income from fishing after all expenses have been paid for the year. After respondents had reported their pre-tax gross income from all commercial fishing in the previous year, they were then told to allocate the percent of their gross income from fishing attributable to Nantucket Sound and Horseshoe Shoal. Thirty-four respondents answered this section.

<u>3.51 Fishing Income</u>

Graph 2. Total Income from Fishing



Six categories of income were presented for their consideration. These categories ranged from (41-$60,000) per year to (141-$160,000) per year. If they made less than $40,000 or over $160,000 per year, they were asked to directly approximate their income. As the graph shows, the income categories captured the majority of responses. One fisherman made less than $40,000 and one fisherman made over $160,000 per year.

The midpoint of each income category was used to calculate the average income for the sample. After they had reported their total annual income, they were presented a scale from 1 to 100% and were asked to estimate the percentage of their total annual income from fishing that came from species landed in Nantucket Sound. Next, they were asked to estimate the percentage of their total annual income from Nantucket Sound that came from species landed in the Horseshoe Shoal area. Table 4 shows the results.

Table 5. Sources of Fishing Income

n=34	Mean	St. Dev	% of Total Income	% of N.S. Income
Total Income	$90,468	($38,882)	—	—
Nantucket Sound Income	$35,015	($26,483)	38%	—
Horseshoe Shoal Income	$14,590	($12,137)	16%	41%

<u>3.52 Squid and Fluke</u>

To gauge the relative importance of Horseshoe Shoal as a squid and fluke fishery, respondents were asked to estimate the loss in profits to both their squid and fluke fishing in Nantucket Sound if the Horseshoe Shoal area was closed to mobile gear fishing. Respondents were shown two scales (one for squid and one for fluke respectively) that ranged from 0 through 10 (see appendix B or C). For example, a response of 0 indicated 0% loss in squid or fluke profit, a response of 5 indicated a 50% loss in squid or fluke profit, and a response of 10 indicated a 100% loss in profit for the respective fishery if the Horseshoe Shoal area were closed to mobile gear fishing. Table 6 shows the results.

Table 6. Squid and Fluke Profits from Horseshoe Shoal

n=34	Mean	St. Dev
Squid	4.98	(3.1)
Fluke	4.67	(2.94)

The results show that on average, about fifty percent of respondent's spring time small mesh squid profits come from Horseshoe Shoal. The high standard deviation means that this percentage is quite variable across the sample. Similarly, about forty-six percent of respondent's summer fluke fishing profits are attributable to the Horseshoe Shoal area. This also had a high variability amongst the sample.

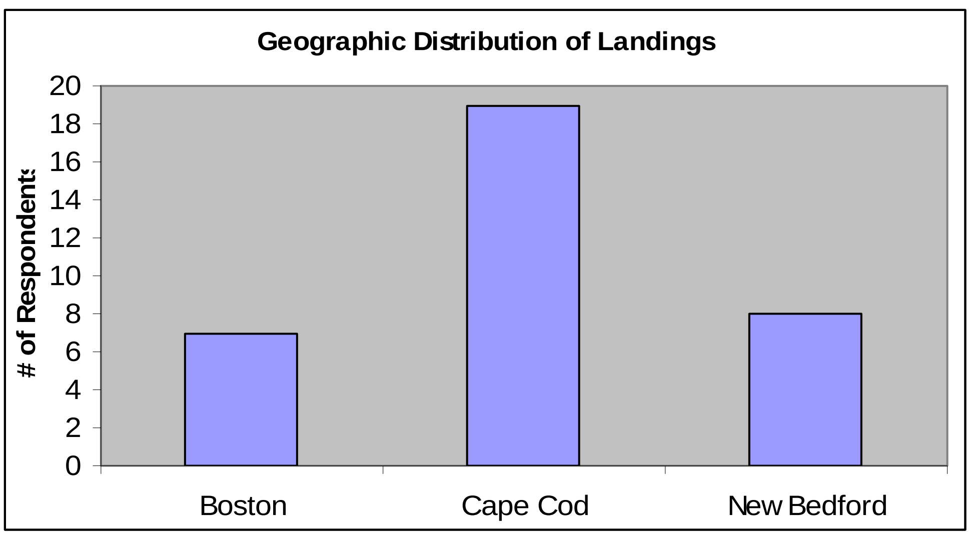
3.53 Distance from Home

The average distance (nautical miles) to the center of Horseshoe Shoal from a fisherman's homeports was 23.4 nautical miles (st dev 15.2). The closest homeport to the center of Horseshoe Shoal was five nautical miles. The furthest homeport to the center of Horseshoe Shoal was eighty nautical miles, which was reported by one fisherman, whose homeport was Rockport, MA.

3.54 Horseshoe Shoal Landings

Respondents were asked where they land the fish that they catch from Horseshoe Shoal. Responses were aggregated into three geographic regions: Cape Cod and the Islands, New Bedford, and Boston. These regions correspond to distinct fishing dependent regions classified by the National Marine Fisheries Service's Northeast Regional Input-Output Model (NERIOM). Figure 3 shows the distribution of landings by geographic region.

Graph 3. Geographic Distribution of Landings



The majority of respondents land their fish from Horseshoe Shoal in Cape Cod and the Islands. Specifically, Cape Cod and the Islands encompass: Hyannis, Nantucket, Woods Hole, Chatham, Fairhaven, and Falmouth. But, almost half the sample lands their fish from Horseshoe Shoal outside of Cape Cod and the Islands in New Bedford or Boston. Section four of this report will show the total value of landings that each of these geographic regions represent. An economic impact model (NERIOM) developed by researchers at the National Marine Fisheries Service will show how the value of landings to these distinct fishing regions impacts or multiplies through their local economies in terms of sales.

3.55 A Model of Horseshoe Shoal Profits

An econometric model was built to determine Horseshoe Shoal income based on key economic determinants. In fishery economics, a fishery's total effort is usually assumed to adjust instantaneously to its profits following Gordon (1954) and Smith (1968, 1969). This suggests that current or expected profits from a specific fishery relative to the employment alternatives available to fishermen are the major determinants of the entry-exit decisions.

Ward and Sutinen (1994) applied this framework to study the dynamics of the Gulf of Mexico shrimp fishery. They found changes in harvesting costs and ex-vessel prices to have equal but opposite effects on the probability of entry and exit of vessels in the fishery. Gautam, Strand, and Kirkley (1996) find that in most fisheries, the two most important variable inputs in the short-run production function are labor and fuel.

The validity of an econometric model is measured by how well it conforms to the theoretical expectations, or *a priori* expectations of the determinants of the model. Based on economic theory, it is expected that profits are a function of input prices, output prices and opportunity costs. Information was gathered through the contingent valuation survey to build an ordinary least squares (OLS) model that proxies these economic determinants of profits. An OLS model takes the following form:

$$Y = X\beta + e \quad e \sim \text{iid } N(0,\sigma^2)$$

$Y=(Y_1, Y_2, \ldots Y_n)'$is the (*n x 1*) random vector of dependent variable outcomes. X is a (*n x k*) nonstochastic matrix of explanatory variables, and *e* is an (*n x 1*) vector of random variables representing the unobservable noise elements of the model. It is assumed that *e* is normally distributed and independent of the explanatory variables, with a mean of zero and a variance of sigma squared. The following describes the economic variables used in this model.

HSSHOAL- represents an individual's annual income from Horseshoe Shoal. It is a proxy for Horseshoe Shoal profits. In this model, HSSHOAL is the dependent variable, and lnHSSHOAL is the log-transformed version of the dependent variable.

NANTUCK- represents an individual's annual income from all of Nantucket Sound. It is a proxy for the opportunity cost of fishing outside of Horseshoe Shoal. For example, a fisherman who earns a high percentage of their total annual income from Nantucket Sound is thought to have less opportunity to make money outside of Nantucket Sound and hence a lower opportunity cost. It is expected that the sign of this variable is positive because a lower opportunity cost outside Nantucket Sound implies a greater reliance or value on the resources within Nantucket Sound. The log-transformed version of this independent variable is lnNANTUCK.

NAUTM-represents the number of nautical miles a fisherman's homeport is from the center of Horseshoe Shoal. This variable is used to proxy the cost of fuel and labor. The greater the distance that a fisherman travels to go fish Horseshoe Shoal, the more fuel and leisure time are spent. This should imply less annual profits from Horseshoe Shoal. Therefore, the expected sign of this independent variable is negative.

FLUKE-represents an individual's annual summer Fluke dependence from Horseshoe Shoal. It is used as a proxy for output prices or sales revenue. It is expected that the sign of this variable is positive.

The variable SQUID was also used to model the profit function, but due to collinearity between the two variables SQUID and FLUKE, only FLUKE was used in the final model. Also, a log-transformed version of the final model is presented due to heteroskedastic errors in the untransformed version of the model. The results of the ordinary least squares (OLS) regression are presented below. The data was analyzed using STATA9™ .

3.56 Profit Function

$$\text{lnHSSHOAL} = \underset{(-0.07)}{-.115} + \underset{(6.18)^{**}}{.9258}\ \text{lnNANTUCK} - \underset{(-2.59)^{**}}{.0180}\ \text{NAUTM} + \underset{(1.82)^{*}}{.0627}\ \text{FLUKE}$$

$R^2 = .7066$ Adj. $R^2 = .672$
F-stat = 22.48 (Prob > F = .0000)
n=32
Figures in brackets are t-values
**the coefficient is significant at the 95% confidence level
*the coefficient is significant at the 90% confidence level

The expected signs of the coefficients are all headed in the right direction and each variable is statistically significant at least at the 90% confidence level. Also, the overall significance of the model is very high, and the R^2 and adjusted R^2 values indicates that this model does a good job explaining the variation in the dependent variable, Horseshoe Shoal income. In fact, these numbers suggest that about seventy percent of the variation in the dependent variable, Horseshoe Shoal profits may be explained by the economic determinants, or independent variables. The expected signs of the independent variables are all headed in the right direction. An estimate of the annual Horseshoe Shoal income for the rest of the population may be made confidently based on this model.

3.6 Averting Behavior

Averting behaviors are actions taken with the intent of averting some type of impending adverse event from occurring. The action is intended to reduce the risk of the adverse event from occurring, see Kahneman and Tversky (1979) for examples of decision making under risk. Commercial fishermen trying to reduce the risk of a wind farm being developed would undertake a costly averting behavior if they felt it had some chance of reducing the probability of a wind farm actually being built.

Averting actions that commercial may take to reduce the probability of a wind farm being built on Horseshoe Shoal are to attend public hearings or meetings about the project, donate money to an organization dedicated to stopping the development of the wind farm, or agree to participate in some type of lawsuit. All of these actions are costly, whether directly through some type of donation or indirectly through the use of one's time and energy.

Nine out thirty-four respondents were registered with a group like the *Alliance to Protect Nantucket Sound*. Ten of thirty-four commercial fishermen have donated an average of one hundred and sixty-five dollars to these organizations. Seven commercial fishermen have attended a public hearing about the proposed development, and thirty-one of thirty-four respondents said they had spent a significant amount of time keeping up with the current news about the proposed development.

3.7 The CVM Scenario-A Quality Reduction on Horseshoe Shoal

Thirty-two of the thirty-four mobile gear users of Horseshoe Shoal agreed to participate in a law suit against Cape Wind if they were granted development rights to Horseshoe Shoal. The scenario specified that participation in this lawsuit would delay development of Horseshoe Shoal for one more fishing year with a chance of compensation at that point. Two versions of the scenario were presented to gauge the importance of different levels of quality reduction on Horseshoe Shoal. The first scenario assumes that Horseshoe Shoal is developed and closed to mobile gear fishing, and the second scenario assumes that Horseshoe Shoal is developed and open to mobile gear fishing.

The two fishermen who chose not to participate in the lawsuit were given the versions of the survey where the wind farm remained open to mobile gear fishermen. Of the remaining 32 respondents, sixteen were given a survey that presented a scenario where the wind farm remained open to commercial fishing, and sixteen were given a survey that presented a scenario where the wind farm was closed to commercial fishing. On average, if the wind farm were developed and closed to commercial fishing, respondents thought there would be a fifty-seven percent change of winning compensation if litigation occurred. And if the wind farm remained open to fishing, on average respondents thought there would be a forty-four percent chance of wining compensation if litigation occurred.

After fishermen had declared to participate in the lawsuit, which would require them to provide proof of historical use (e.g. personal log book, state catch report, or vessel trip reports), a Coase type bidding game was initiated to determine the minimum amount respondents would be willing to accept to settle the lawsuit and forego the extra year of fishing Horseshoe Shoal free from a wind farm.

This measure is comparable to what Gautam, Strand, and Kirkley (1996) refer to as "fishermen satisfaction bonus." They define it as the amount of money that a fisherman would have to be paid to leave the fishery and assume another occupation. The following table shows the distribution of final settlement amounts agreed to by the Horseshoe Shoal commercial fishing user groups. The settlement amounts are differentiated by survey number and are shown along with the level of environmental quality (closed or not closed).

Table 7. Distribution of Settlement Amounts
n=32

Survey#		Settlement		(Closed-1, Open-0)
16		$75,000		1
55		$30,000		1
32		$50,000		1
4		$20,000		1
24		$50,000		1
73		$10,000		1
70		$50,000		1
21		$20,000		1
49		$40,000		1
43		$100,000		1
90		$20,000		1
44		$100,000		1
36		$1,000,000		1
52		$250,000		1
53		$200,000		1
27		$250,000		1
33		$30,000		0
30		$25,000		0
66		$10,000		0
7		$60,000		0
94		$20,000		0
56		$30,000		0
14		$10,000		0
18		$25,000		0
101		$15,000		0
9		$10,000		0
61		$20,000		0
60		$10,000		0
104		$20,000		0
21		$10,000		0
84		$25,000		0
97		$20,000		0

On average, the settlement amounts elicited for the scenario of a wind farm closed to mobile gear fishing were higher than those for the scenario where the wind farm was open to mobile gear fishing. The marginal effect of this quality difference will be tested by econometric methods in the next section. This test can be considered a scope test, which in this case is a split sample scope test. The NOAA panel in its contingent valuation guidelines recommends a scope test. The scope test hypothesizes that sample mean values vary in a consistent fashion with relevant and meaningful variations in the scenario. For example, a decrease in the quality of the good being valued should produce an increase in the magnitude of compensating surplus or $WTA^{s.}$ This is one form of construct validity. Another form of construct validity asks whether responses are related to variables that economic theory suggests should be predictors of WTA^{s}.

As shown before, a settlement amount accepted today, S_0 should be a discounted function of the compensating surplus from a reduction in quality change on Horseshoe Shoal plus the subjective value of the probability of compensation a year from now if settlement were not accepted today. Formally, this was expressed as:

$$S_0 = \{e^{R_t}(P, X, Q_1, U_0) - e^{R_t}(P, X, Q_0, U_0) + \Phi C_t\}/(1 + r)^t \qquad (7)$$

The expression, ΦC_t is the subjective value of the probability of compensation next year. It may also be thought of as the marginal effect of an increase in the subjective probability of compensation next year on the total settlement amount today. This marginal effect may be measured econometrically to equate this effect to a dollar amount.

It is believed that most settlement amounts are reasonable, because most of the reported figures consistently varied with levels of Horseshoe Shoal fishing incomes. Some fishermen, nevertheless, may have given exaggerated figures for strategic reasons. In fact, one fisherman said that he would not accept anything to quit fishing for one year, but when probed said he would accept $1,000,000. Three additional responses were in excess of $200,000.

It may be that these fishermen were thinking about the total net present value extended over the lifetime of the project. However, administering this survey over the phone provided some insight into the thought process of many respondents. For the most part, it seemed they were thinking of how much economic loss they would suffer from relinquishing one more year of fishing on Horseshoe Shoal, rather than the net present value of compensation for the life of the project.

The majority of respondents reported settlement amounts more consistent with their yearly income on Horseshoe Shoal, marginally scaled by their subjective probability of winning compensation and their loss of utility from a reduction in quality. This scaling was on average two to three times respondents mean yearly income from Horseshoe Shoal. Therefore, it is likely all settlement amounts greater than $200,000 were probably protest or strategic bids.

3.71 Censored Tobit Models

Due to the small sample size, it was more feasible to censor these high bids to a level consistent with the rest of the sample than to eliminate these responses from analysis. The censored normal regression model is also known as the tobit model (Greene 1995). Tobit models can be estimated with maximum likelihood estimation, a general method for obtaining parameter estimates and performing statistical inference on the estimates. The tobit model was used to restrict some reported values of the dependent value to be less than or equal to a predetermined level. The tobit model may be described in terms of a latent variable Y* . Suppose

$$Y^* = X\beta + e \quad e \sim \text{iid } N(0,\sigma^2),$$

then the observed variable Y satisfies:

$$Y = Y^* \quad \text{if} \quad Y^* =< \mathbf{a}$$
$$Y = \mathbf{a} \quad \text{if} \quad Y^* >= \mathbf{a},$$

A limit value, **a**, defines the upper limit on the observable settlement amounts. Any settlement amount that exceeds this upper limit will be censored to equal this upper limit. The task of choosing **a** is left to the researcher, and usually a procedure is adopted where a rule of thumb concerning the relationship between the stated bid and the respondent's income. For example, a rule could be to censor all responses greater than X% of reported Horseshoe Shoal average income. Because this rule is arbitrary, it is often that multiple censoring levels are chosen and the model with the best fit is chosen. For this analysis, three different censored tobit models are reported for upper limit values of **a =** ($60,000, $75,000, and $100,000). These limit values are 4 times, 5 times and 8 times the sample's mean income from Horseshoe Shoal.

Limited empirical work using contingent valuation has been done in the fishing industry to value specific fishing areas. In terrestrial environments, however, a large CV literature exists on the value of open space areas for conservation. In some studies, farmers are asked how much they would be willing to accept to leave areas of their farm pristine for the public good. Bateman (2008), Dupraz et al (2003) and Bonnieux et al (1998) all employ a WTA framework to estimate farmers' willingness accept to protect open space on their own property.

All of these studies found estimated econometric models to be quite robust, and economic determinants of profits were all found to be statistically significant in these analyses. This was attributed in all three papers to the unique familiarity a farmer possesses about the value of their agricultural land. It is thought that fishermen have similar familiarity about the value of their traditional fishing grounds, and the availability of substitutable areas.

One study, Ikiara and Odnik (2000) used a WTA measure of value to determine fishermen's resistance to exiting a certain Kenyan Fishery. They found that economic determinants of profit drove the exit-entry decisions of local Kenyan fishermen. This paper used a simple WTA CVM framework to analyze the factors that drive the exit decision in the Kenyan fisheries of Lake Victoria. The opportunity cost of exiting, fishing experience, and whether the skipper of a fishing unit is its owner or just an employee of the owner, is the significant determinants of unit resistance to exit from these fisheries.

According to Gordon (1954), Smith (1968, 1969), and Ward and Sutinen (1994), current or expected profits from a specific fishery relative to the employment alternatives available to fishermen are the major determinants of the entry-exit decisions. And Gautam, Strand, and Kirkley (1996) find that in most fisheries, the two most important variable inputs in the short-run production function are labor and fuel.

The following list shows the economic variables used in the analysis. These variables are assumed to proxy arguments in the restricted expenditure function, $e^{R_t}(P, X, Q_0, U_0)$ and the probability of compensation ΦC_t.

SETTLE-represents the self-reported settlement amounts to the lawsuit. It is the minimum amount a fisherman would accept to forego an extra year fishing on Horseshoe Shoal and the possibility of compensation in a year. This is the dependent variable.

NANTUCK- represents individual annual income from fishing in Nantucket Sound. It is used to proxy opportunity cost of fishing outside of Horseshoe Shoal. For example, a fisherman who earns a high percentage of their total annual income from Nantucket Sound is thought to have less opportunity to make money outside of Nantucket Sound and hence a lower opportunity cost. It is expected that the sign of this variable is positive because a lower opportunity cost outside Nantucket Sound implies a greater reliance or value on the resources within Nantucket Sound.

NAUTM-represents the number of nautical miles a fisherman's homeport is from the center of Horseshoe Shoal. This variable is used to proxy the cost of fuel and labor. The greater the distance that a fisherman travels to go fish Horseshoe Shoal, the more fuel and leisure time are spent. This should imply less annual profits from Horseshoe Shoal. Therefore, the expected sign of this independent variable is negative.

FLUKE-represents an individual's annual summer Fluke dependence from Horseshoe Shoal. It is used as a proxy for output prices or sales revenue of fluke. It is expected that the sign of this variable is positive.

SQUID-represents an individual's annual summer squid dependence from Horseshoe Shoal. It is used as a proxy for output prices or sales revenue of squid. It is expected that the sign of this variable is positive.

CLOSED-represents the change in quality of Horseshoe Shoal form pristine (Q) to developed and open to fishing (Q'), to developed and closed to fishing (Q''). It is assumed that as the level of environmental quality decreases, the settlement amount increases.

PROB-represents the marginal effect of the probability of compensation (ΦC_t) on self-reported settlement amounts. It is assumed positive, so that the higher the subjective probability of winning compensation from litigation, the higher the self reported settlement amount.

3.72 Model Results

The results of the maximum likelihood estimates are presented below. Analysis of the data was performed with STATA9™ statistical software package. Three models are presented side by side, and the results differ depending on the level of censoring.

Table 8. Censored Regression Analysis

Censor Level	Model 1	**a** = $60,000	Model 2	**a** = $75,000	Model 3	**a** = $100,000
Variable	**Coefficient**	*Marginal Effect dE[y/x] /dx*	**Coefficient**	*Marginal Effect dE[y/x] /dx*	**Coefficient**	*Marginal Effect dE[y/x] /dx*
Constant	1545.78		-3689.2		-14379	
	(0.17)		(-.32)		(-.95)	
NANTUCK	0.2176**	0.194	0.21	0.184	0.147	0.133
	(2.91)		(1.61)		(.90)	
NAUTM	-473.06**	-422.11	-598.16**	-550.15	-704.41**	-640.07
	(-2.84)		(-2.86)		(-2.58)	
FLUKE	2653.64**	2367.889	3837.49**	3529.55	4762.33**	4327.39
	(2.91)		(3.39)		(3.35)	
SQUID	1736.22**	1549.26	1918.4*	1764.45	3014.53*	2739.22
	(2.08)		(1.83)		(2.2)	
CLOSED	12500.74**	11000.59	15390.2**	13950.7	20007.3**	17936.27
	(2.36)		(2.29)		(2.25)	
PROB	17834.59	15914	25782.9*	23713.91	39197.99**	35618.07
	(1.59)		(1.84)		(2.13)	
# of right censored observations	7 obs.		7 obs.		6 obs.	
Pseudo R^2	.0724		.07		0.063	
LR $chi^2(6)$ =	42.68		42.18		40.62	
Prob > chi^2	.0000		.0000		.0000	

The figures in parentheses represent t-values. **indicates the coefficient is significant at the 95% confidence level. *indicates the coefficient is significant at the 90% confidence level. The marginal effect, *dE[y/x] /dx* is the derivative of the conditional expected value of the dependent variable evaluated at the mean of the X's. The dependent variable is conditioned to fall within the specified range of censoring. n=32 observations for all three models.

All three models are significant, indicated by the very low *p-values* of the chi^2 distribution. The model with the best fit is Model 1 as can be seen by the associated pseudo R^2 value and the $LRchi^2$ value, both of which are higher than the other two models. In Model 1, all of the independent variables are significant at a 95% confidence level except PROB, which is significant at an 85% confidence level. In models two and three, the independent variable NANTUCK is not significant anymore at even a 90% confidence level. Conversely, the independent variable PROB becomes more significant the higher the censored limit. All of the signs of the coefficients are headed in the right direction for each model. The high degree of fit for this model may be attributed to the familiarity of the value of the Horseshoe Shoal area to fishermen who use it. Also, the Horseshoe Shoal fleet is quite homogenous, so many of the same revenues and costs exist for this sample. Furthermore, the use of telephone interviews is thought to have contributed to the accuracy of responses.

For purposes of this analysis, Model 1 will be used to estimate a compensating surplus measure of welfare for the two different levels of a change in the state of environment one Horseshoe Shoal. Model 1 will be used for two reasons. The first reason is that compared to the other model, Model 1 is the most statistically significant. Secondly, Model 1 has the lowest censored dependent variable. Using this model could also mitigate against the possibility that loss aversion, income effects, or substitution effects have upward biased the responses to the settlement amounts.

<u>3.73 Total Value of Horseshoe Shoal</u>

The total value of Horseshoe Shoal is calculated based on the results of Model 1 and the use of equations (8) and (9), also assuming a 10 percent discount rate. The following table shows the total net present value for the two levels of quality change on Horseshoe Shoal alongside the mean Horseshoe Shoal income (estimated from the Profit Function) for comparison purposes.

Table 9. Total Economic Loss from Horseshoe Shoal

	WTA^s (Q')-Open	WTA^s (Q'')-Closed	Mean HSS Income
Total Economic Loss per Fisherman (1 year)	$19,370	$31,471	$14,590
NPV Total Economic Loss per Fisherman (25 years)	$182,513	$296,528	$137,469
NPV Total Economic Loss for the Population (25 years, 45 fishermen)	$8,213,118	$13,343,767	$6,186,128

Estimates are presented for a twenty-five year time horizon, which represents the expected life of the wind farm. For this analysis, the population is assumed to be 45 vessels. Along with measures of compensating surplus for the two different quality changes on Horseshoe Shoal, an estimate of the total net present value of a loss in yearly Horseshoe Shoal income based on equation (5) is presented for comparison purposes.

Comparing the compensating surplus measures of a one year reduction in the quality of Horseshoe Shoal to respondent's mean annual income on Horseshoe Shoal provides some insight to the construct validity of the contingent valuation results. Column three of Table 9 shows the net present value of a loss of access to Horseshoe Shoal based on profits loss alone. Column one shows the measure of net present value of an economic loss from a quality reduction on Horseshoe Shoal, where the wind farm is developed and remains open to mobile gear fishing.

These estimates are quite close in value to column three where profits loss alone was used. Also, the same economic determinants of profit were found to be significant in predicting Horseshoe Shoal profits as well as predicting settlement amounts. This is a measure of construct validity of the contingent valuation scenario. It is possible that respondents thought that development of a wind farm on Horseshoe Shoal would necessarily force them to fish elsewhere even though it was specified that the area would remain open to fishing. This is consistent with the self-reported difficulty of fishing through a wind farm (Table 2), and from evidence of other offshore wind farms where fishing effort is displaced even if the wind farm remains open to fishing.

Column 2 shows the net present value of economic loss to Horseshoe Shoal users from a quality reduction below the threshold of existence, where the wind farm is closed to mobile gear fishing. The higher values reported under this scenario might represent the influence of a psychological cost due to a loss of existence value. In both scenarios of quality reduction, the total net present value of an economic loss to Horseshoe Shoal users is greater than if profit loss alone were used to estimate this loss. This is likely because respondents incorporated a non-use value into their compensating surplus measures of welfare loss. Because non-use value contributes to the economic well being of individuals, it is relevant to economic efficiency (Kopp 1992).

These estimates should be considered a starting point for a Coase type negotiation with the mobile gear fishermen who annually fish Horseshoe Shoal for squid and fluke. They represent the minimum amount a fisherman would be willing to accept to voluntarily reduce their level of effort on Horseshoe Shoal to a point where fishermen feel is necessary for the development and operation of a wind farm. If it can be proved through communication, cooperation and negotiation by Cape Wind with commercial fishermen that some level of mobile gear fishing could continue safely, perhaps fishermen would re-evaluate their subjective levels of effort reduction and be willing to accept less money in compensation. If the wind farm is ultimately closed to mobile gear fishing, it has been suggested that one way to mitigate the economic loss is to hire fishing vessels for work duty, or if possible, finance displaced vessels to switch to fixed gear fishing.

4. Economic Impact Analysis

Researchers at the National Marine Fisheries Service (NMFS) just develop a multi-regional, fishery specific input-output model based on IMPLAN Pro structural equations. The NMFS model is known as the Northeast Regional Input-Output Model (NERIOM) (Steinback and Thunberg 2006). Their model is capable of predicting the multiplier effects of proposed fishery management actions in the Northeast. It is constructed at the regional level, but it has been designed so that the multiplier effects can be determined for 24 specific sub-regions within the Northeast.

Steinback and Thunberg (2006) use this model to demonstrate the multiplier effects to the 24 sub regions from a hypothetical reduction in medium bottom trawler ex-vessel revenues. These multiplier estimates were borrowed for this report and applied towards a reduction in ex-vessels landings from medium sized trawler working in Nantucket Sound Table 10 shows the results.

Table 10. Economic Impact Analysis

Total Sales Impacts		*Boston*	*New Bedford*	*Cape & Islands*
Medium Bottom Trawler (loss of sales)		**-$148,841**	**-$122,729**	**-$224,490**
Agriculture		-494	-149	-241
Mining		-178	-23	-18
Transportation, Communications and Public Utilities		-26,660	-2,310	-1,740
	Water Transportation	-6,158	-362	-4,048
	Warehousing and Storage	-1,805	-374	-5
Construction		4,648	-427	-654
Manufacturing		-15,527	-2,016	-541
	Seafood Processing	-296,788	-178,121	-1,161
	Ice	-1,870	-265	-124
	Boat Building	-386	-37	-34
	Paperboard Containers	-333	-108	0
Trade		-18,084	-25,525	-2,879
	Seafood Dealers	-54,069	-35,105	-38,515
	Fish Exchanges/Auctions	-2,529	-8,645	0
	Wholesale Trade	-47,311	-3,057	-1,193
Fianance, Insurance, and Real Estate		-49,779	-1,158	-2,030
Services		-114,056	-6,438	-9,001
Government		-18,453	-1,705	-1,912
TOTAL		**-$798,673**	**-$388,554**	**-$288,586**

Source: Steiniback and Thunberg (2006)

The National Environmental Policy Act (NEPA), Executive Order 12866, and National Standard 8 of the Sustainable Fisheries Act require federal regulators to consider the impacts on businesses that are directly and indirectly affected by proposed management actions. One way to examine direct and indirect effects is to use input-output models of the economy to track how a change in spending trickles through the rest of the economy.

The model of Horseshoe Shoal Profits is used here along with Graph 3 (distribution of landings) to predict the mean distribution of sales over the three geographic areas of Cape Cod and the Islands, New Bedford, and Boston. Table 10 shows how a reduction in ex-vessel landings from medium sized trawlers fishing in Nantucket Sound trickles through the three regional economies. It can be seen that Boston has the largest sales multiplier of 5.36. New Bedford has a sales multiplier of 3.16, and Cape Cod and the Islands have a sales multiplier of 1.28. This means that for every one dollar lost in ex-vessel revenue, a five dollar loss will accrue in Boston, a three dollar loss will accrue in New Bedford, and one dollar and twenty-eight cent loss will accrue in Cape Cod and The Islands.

The reason that Boston has the highest sales multiplier is because they have the most fishing related businesses. This creates a lot of opportunity for re-spending of the same dollar. For both Boston and New Bedford, seafood processing is the largest supporting industry followed by seafood dealers and services. Cape Cod and the Islands are not as diverse in their fishing businesses. However, the employment multiplier is shown to be proportionately highest in Cape Cod and the Islands. This is because the lack of alternative employment increases the importance of commercial fishing as a profession.

This analysis highlights the point that the cumulative impacts of a loss of fishing revenue from displaced Horseshoe Shoal users will not just impact Cape Cod and the Islands, but also the surrounding fishing regions of Boston and New Bedford. A loss in fishing revenue from Boston and New Bedford will significantly impact the fishing related businesses that operate in these areas.

It should also be noted that only Massachusetts vessels are accounted for by this analysis. Although these Massachusetts vessels represent the majority of annual Horseshoe Shoal users, out of state boats still frequent this area, especially Rhode Island trawlers. In 1993, before the mandatory exclusion of vessels greater than 72 ft from trawling in Nantucket Sound, McKiernan and Pierce (1995) report that as much as forty-six percent of the total annual squid catch from Nantucket Sound was landed in Rhode Island processing plants. Because many of the earlier boats from Rhode Island were larger vessels, it is unlikely that some of these boats still frequent Nantucket Sound or Horseshoe Shoal. However, many of the smaller vessels from Rhode Island still do annually fish for squid and fluke in Nantucket Sound. Therefore, estimates from this report of cumulative impacts to the surrounding geographic regions and local fishing related businesses underestimate the total impact.

5. Conclusion

It is clear that Horseshoe Shoal is an important mobile gear fishing grounds for a distinct group of fishermen that hold special access rights to fish there. Based on this analysis, it is likely that between forty and fifty vessels frequently fish this area of Nantucket Sound. These vessels were not explicitly accounted for in Cape Wind's FEIR or the Minerals Management Service's DEIS. The notion that mobile gear fishermen could simply change tow patterns or fish elsewhere if a wind farm is developed is not safe or feasible. If proper communication had been initiated from the start based on the best management practices recommended by European wind developers, much of this information would have been clear to the developer at an earlier stage in the planning process.

This is the first offshore wind farm to be proposed in the United States, it is therefore critically important that it be developed in the best interests of all stakeholder groups involved. This is the point of NEPA. If the interests and input of commercial fishing stakeholder groups are disregarded, conflicts are bound to arise. Mobile gear fishermen may be the most directly affected stakeholder group from such a development due to the nature of mobile gear fishing. The externalities, or nuisances, imposed upon mobile gear fishermen from the development of a wind farm on traditional fishing grounds should not be ignored or dismissed.

The results of this report show a significant economic loss to the Horseshoe Shoal users regardless of whether or not a wind farm is developed and open to mobile gear fishing or developed and closed to mobile gear fishing. It is important that these estimates be treated as an economic loss and not just a number where fishing effort may be bought out. It is clear that if fishermen had their way they would always choose to fish. It is also clear that fishermen value the pristine, undeveloped state of Horseshoe Shoal. Many of the fishermen interviewed for this study have been annually fishing on Horseshoe Shoal for years, and some are second and third generation fishermen.

Given the limited access for mobile gear fishermen to the Horseshoe Shoal area and Nantucket Sound, it is unlikely that a reduction of landings from Horseshoe Shoal could easily be made up elsewhere. Also, next season's reduction in federal days at sea for some of the most valuable federal ground fishing areas will result in a greater dependence on the inshore fishery of Nantucket Sound for these fishermen. Historical users will likely fish more days and more effort in Nantucket Sound, and non-historical users have said that the new federal regulations will force them to now use their permits and mobile gear fish in Nantucket Sound. If the Horseshoe Shoal area is not available to use, the cumulative impacts are likely to be significant. Also, any reduction in ex-vessel landings from Nantucket Sound will produce a multiplier effect to three distinct fishing regions: Cape Cod and the Islands, New Bedford, and Boston.

It is recommended that these results be incorporated into the Minerals Management Service's Final Environmental Impact Statement. This analysis helps fulfill the requirements of the National Environmental Policy Act to consider the impacts of a development to affected communities and stakeholder groups.

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Appendix A

Fishermen's Comments

Survey # 35- Why not put the wind farm on No-man's Land. There's always plenty of wind there, and if placed on the island it will not interfere with fishing.

Survey# 4- A wind farm on Horseshoe shoal will have a devastating effect on my spring time trawl fishery, which is a major portion of my business.

Survey# 95-I squid fish around Horseshoe shoal area. My income from squid is a major part of my yearly income. I can think of other spots for a wind farm that wouldn't affect the industry. How about Buzzard's Bay?

Survey# 105-(F/V Josephine) I haven't fished down in Nantucket Sound before, but I plan to go there next year because I still have my CAP-squid, fluke permits. It wasn't cost-effective for me to go down there before, but now that my Federal days at sea (DAS) were cut in half I have no choice if I want to pay the bills. I know guys who drag for squid and fluke through the Horseshoe shoal area. When I go there next year, I plan on fishing where the other boats fish. We all just follow each other around don't you know that?

Survey# 83-The wind farm will not change the fishing impact in this area.

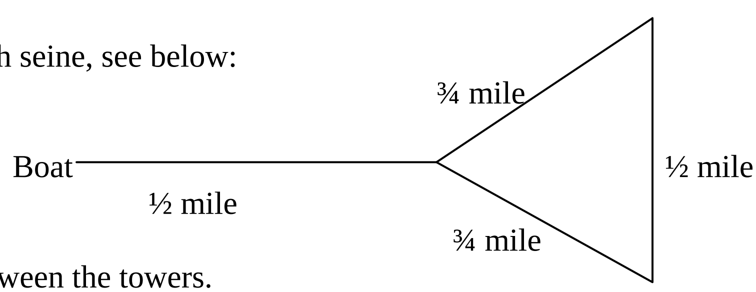
Survey#13-I don't annually fish in this area, but I believe fishermen who do could tow their gear through the wind park. I am in favor of clean energy. If anything, the wind farm is likely to improve fishing because of the artificial reef effect.

Survey# 49- (F/V Alosa) The wind farm would totally hamper my fishing activity in Nantucket Sound. I would never want to see it happen, ever!

Survey# 55- I have not fished in Nantucket Sound for about ten years, but when I did I would fish through the Horseshoe shoal area. This analysis should consider the impact of displaced effort into other areas or fisheries should this project seriously impair access to the Horseshoe shoal area.

Survey# 16- If this area were closed to mobile fishing, I would probably try to fish more conch pots instead. The problem is that only about 25% of Nantucket sound is fishable for mobile gear. Horseshoe shoal is a major part of this area.

Survey# 24- I fish Scottish seine, see below:



My gear would not fit between the towers.

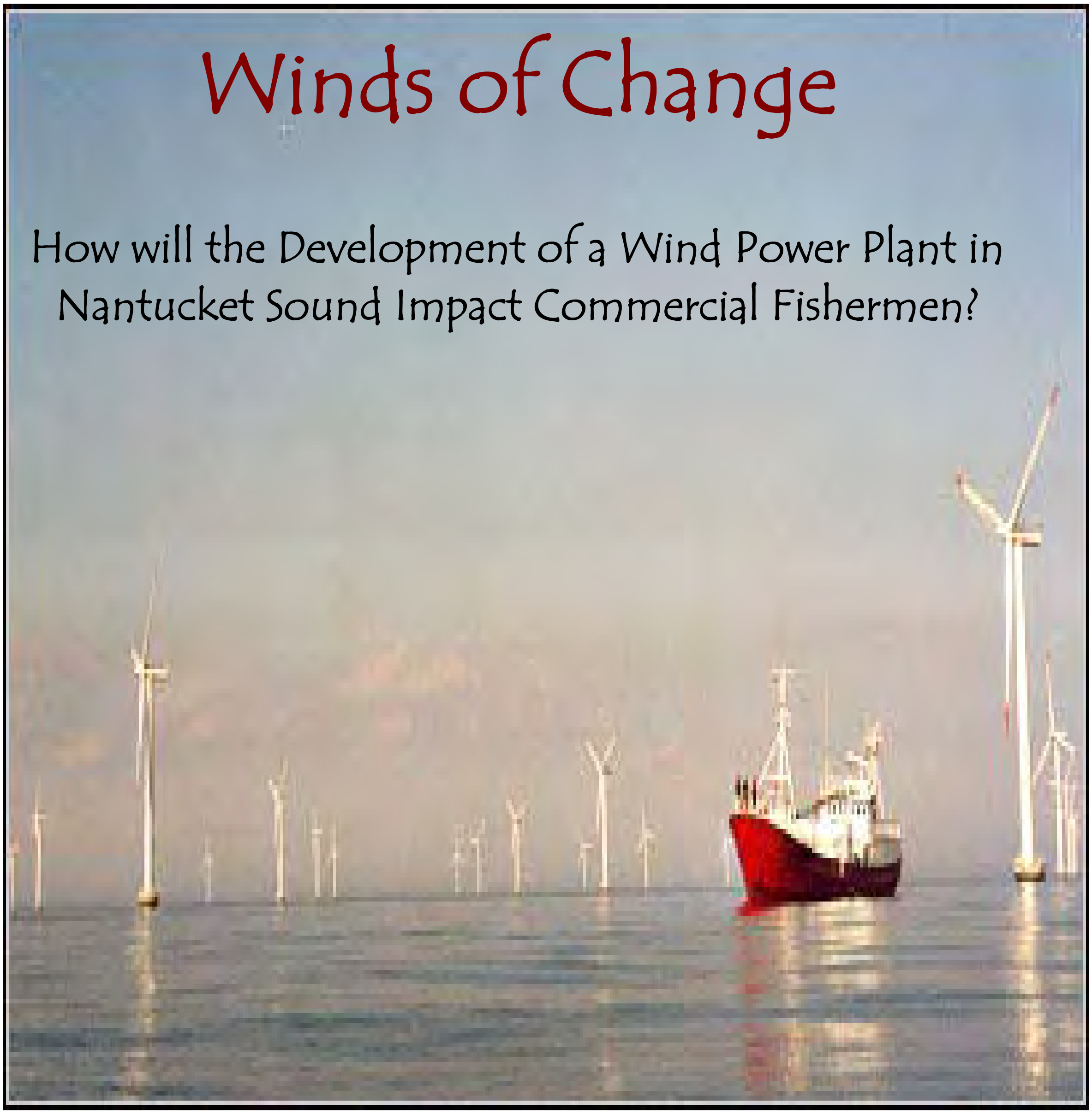
Survey# 53-I don't believe there's any way they would keep this wind farm open to mobile fishing. Just the other day, I almost hit another vessel just south of Horseshoe shoal coming up through Muskeegut Channel. The current was pushing so hard to the north, I couldn't control where I was being pushed. If there were wind turbines in my way, I would have hit them.

Survey# 107- Why don't they put the wind farm in Yarmouth, west of Gayland out in Yarmouth.

Survey# 56-If a wind farm goes in, squid, fluke, scup and sea bass will be harder to catch. And you will not be able to tow around the windmills.

Survey# 71-The fishermen affected by the LNG project were compensated. They got twelve million dollars. A wind farm would be just as destructive to the mobile gear users of Horseshoe shoal and they too should be compensated if this development occurs.

Appendix B



Massachusetts Fishermen's Partnership, Inc.
University of Rhode Island

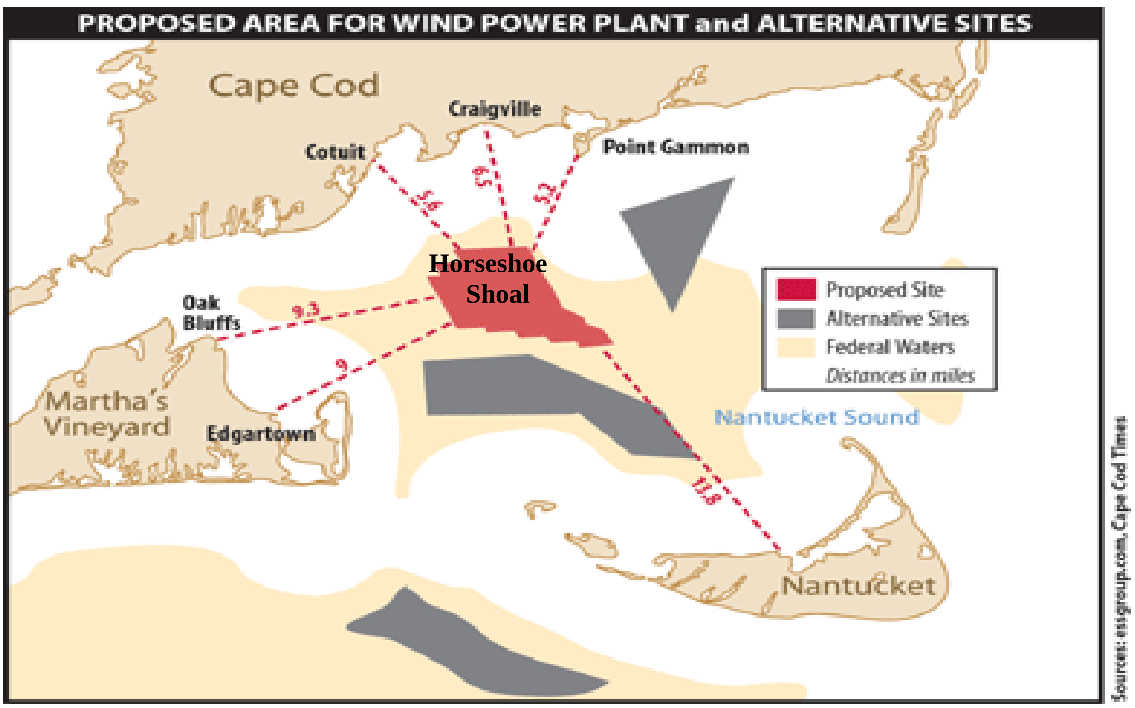
Introduction

The purpose of this study is to evaluate the impact of Cape Wind's proposed development on Horseshoe Shoal to the commercial fishermen who use this area of Nantucket Sound.

The results of this study will be presented during the public comment period of Cape Wind's Draft Environmental Impact Statement, which is rapidly approaching and only lasts forty-five days! It should only take you about 15 minutes to complete, but it is very important for valid statistical results that we have your answers to all questions and that all questions are answered as accurately as possible.

Thank you for your help!

User Group



1. Our research has identified your vessel as a potential user of the Horseshoe Shoal area of Nantucket Sound, is that correct?

Yes__ (Go to **Part 1**) No__ (**Stop!** You are done)

Part 1- Attitudes and Opinions

Please indicate the extent to which you **agree** or **disagree** with the following statement.

1. It is important to me personally that part of my energy comes from a renewable source.

1	2	3	4	5
Strongly Agree		Neutral		Strongly Disagree

2. An offshore wind farm could be a good idea for renewable energy in Cape Cod if it were located in a different location.

1	2	3	4	5
Strongly Agree		Neutral		Strongly Disagree

3. The development of a wind farm on H.S. Shoal in Nantucket Sound may improve my catch due to the artificial habitat the wind turbines would create.

1	2	3	4	5
Strongly Agree		Neutral		Strongly Disagree

4. With wind turbines spaced 1/3 to ½ mile apart, I could easily tow me gear through the wind farm it were open to fishing.

1	2	3	4	5
Strongly Agree		Neutral		Strongly Disagree

5. If a wind farm closed Horseshoe shoal to mobile gear; it would increase boat congestion, increase my steam time, and increase navigational risks if I were to continue to fish this area.

1	2	3	4	5
Strongly Agree		Neutral		Strongly Disagree

6. Now, on a scale of **1-10**, please indicate how much negative economic impact (estimated loss in profit) that this development could have to your fishing income in Nantucket Sound if Horseshoe shoal were closed to commercial fishing.

Squid

0-No Impact

1	2	3	4	**5**	6	7	8	9	**10**
10% Impact				Loss of 50% of my income from Nantucket Sound					Loss of 100% of income Nantucket Sound

Fluke

0-No Impact

1	2	3	4	**5**	6	7	8	9	**10**
10% Impact				Loss of 50% of my income from Nantucket Sound					Loss of 100% of income from Nantucket Sound

Part 2- Important Background Information

1. What year were you born? 19__ __

2. How many vessels do you own?____

3. How many employees?___ Full Time?___ Part Time?___

4. Approx. what was your total income (after all expenses) from *all* fishing activities last year? (please circle one)

Below-$40,000 $41-$60,000 $61-$80,000 $81-$100,000 $101-$120,000
Please Approx._________

$120-$140,000 $141-160,000 Above $150,000 (PleaseApprox.)______________

5. Approx. what percent of your total income from fishing came from species landed in Nantucket Sound (Statistical Reporting area 538)? (please circle one)

1-10% 11-20% 21-30% 31-40% 41-50% 51-60% 61-70% 71-80% 81-90% 91-100%

6. Now, approx. what percent of your total income from species landed in Nantucket Sound (Statistical Reporting area 538) came from fishing in or around the Horseshoe Shoal area? (please circle one)

1-10% 11-20% 21-30% 31-40% 41-50% 51-60% 61-70% 71-80% 81-90% 91-100%

7. Does anything else contribute to your annual income besides commercial fishing?
Yes__ No__

If yes, what percent of your yearly gross income does this other source represent?
_____%

7. What is your highest level of school?

☐ High School ☐ Some College ☐College ☐ Graduate School

8. Approx. how many nautical miles is your home port from the center of Horseshoe Shoal? ___ nm

9. Where do you sell the fish that you land from HS Shoal? _______________, MA

Part 3- Possible Litigation

If Cape Wind is granted the development rights to the Horseshoe Shoal area of Nantucket Sound, and this area was closed to mobile gear fishing, the Massachusetts Fishermen's Partnership and the Commonwealth of Massachusetts may file a class action law suit against Cape Wind to compensate the mobile gear fishermen who could be affected by this.

It would not cost you anything to participate in this law suit, you would only need to provide proof of historical use (e.g. Vessel Trip Reports, State Catch Reports, or Personal Log Book Data) and reasonable legal arguments why and how a wind farm would disrupt historical.

<u>Q1:</u>
Suppose that the lawsuit could delay development of the wind farm for at least one more fishing season (one more year), and would also provide a chance of compensation if this area were then closed to mobile gear fishing. Based on this scenario, is it likely that you would take part in this law suit?

Yes___ (Go to **Q2)** No___ (Go to **Q3)** *(before you answer, you should know that the statistical interpretation of a "no" response here is that a wind farm would cause no economic impact to you or your business)

<u>Q2:</u>
If Yes, in your opinion, what is the probability that Commonwealth of Massachusetts would win this law suit for compensation on behalf of commercial fishermen?
(Please circle one)

1-10% chance 11-20% chance 21-30% chance 31-40% chance

41-50% chance 51-60% chance 61-70% chance 71-80% chance

81-90%chance 91-100% chance → (Go to **Part 4)**

<u>Q3:</u>
If No, why not?
____
____
______________________If you answered No, **Stop here**! Thanks, you are done.

Part 4-A Possible Settlement

If litigation occurs, it may be likely that Cape Wind would want to settle the law suit out of court to avoid the costs and delay of the legal proceedings. Suppose you were offered a one time settlement of $20,000 to discontinue your participation in this lawsuit.

Q1: Please consider your following options:

A. Continuing with the lawsuit

- Chance of compensation next year.
- Delayed development until after the next fishing season.
  (1 more year of fishing Horseshoe shoal)

Go to **Q4** on the next page**:**

B. Accepting the terms of the settlement

- Guaranteed settlement amount today.
- Development of Horseshoe shoal today.
  (closed to mobile gear fishing today)

Go to **Q2** below**:**

Q2:
Now suppose you were offered a one time settlement of $10,000 instead. Is it likely that you would accept this compensation amount today and allow development today, or would you prefer to continue with the lawsuit?

___Accept Settlement ___Continue with lawsuit

Go to **Q3** below**:**

Q3:

What is the absolute minimum amount that you would be willing to accept to discontinue your participation in the lawsuit and accept settlement and development today?

$________.00

Go to **Part 5** on the last page.

Part 4-A Possible Settlement (Continued)

<u>Q4:</u>

Keeping in mind that continuing with litigation will only delay development until after the next fishing season with a chance of compensation at that point, suppose you were offered a one time settlement of $30,000. Is it likely that you would accept this compensation amount today and allow development today, or would you prefer to continue with the lawsuit?

___Accept Settlement ___Continue with lawsuit

Go to **<u>Q5</u>** <u>below</u>**<u>:</u>**

<u>Q5:</u>

Keeping in mind that continuing with litigation ***will not prevent*** the wind farm from being developed (it will only delay development for one more fishing season) what is the absolute minimum amount that you would be willing to accept to discontinue your participation in the lawsuit and accept settlement and development today?

$________.00

Go to **Part 5** on the last page.

Part V-Some Follow up Questions

1. Are you registered as a member of the Alliance to Protect Nantucket Sound or another group dedicated to stopping the development of a wind farm? Yes___ No___

If Yes, have you ever donated any money to one of these groups?
Yes___ No___
If Yes, how much? $ ____.00

2. Have you ever attended a public hearing about Cape Wind's proposed development? Yes___ No___

3. Would you say you've spent a lot of time keeping up with the current news about this proposed development over the years? Yes___ No___

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