Fish Habitat: A Focus on New England Fishermen's Perspectives

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Importance of Benthic Habitat Complexity for Demersal Fish Assemblages

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Abstract.—Major amendments in 1996 to the Magnuson-Stevens Fishery Conservation and Management Act require fisheries managers to define "essential" fish habitat and address the impact of fishing gear in their management plans. However, before considering what might qualify as essential fish habitat, it is necessary to first understand the association between fish and their habitat. Some studies have already revealed subtle relationships between fishes and sediment type; however, this approach does not quantify habitat complexity. We undertook a large-scale survey of demersal fish populations and benthic communities in the southern North Sea and eastern English Channel. As in other studies, water depth was closely linked to the main dichotomy in assemblage composition. Flatfishes occurred in shallow water, whereas roundfishes and small shark species were found in deeper habitats. Within each of these two sample station groupings, the assemblages dichotomised further on the basis of habitat type and benthic faunal associations. Three further groupings were identified within the deepwater habitat. These groupings were characterized by the presence of rocks, broken shells, or a large biomass of sessile epibenthos. Small shark species were almost exclusive to habitats with shelly substrata. In contrast, the shallow-water habitats were topographically less complex with sessile epibenthos of a smaller biomass. Flatfishes that were visual predators were most closely associated with habitats with some sessile epibenthos, whereas sole Solea solea, which largely locate their prey using chemosensory cues, were more closely associated with the least complex habitat. Although these flatfish habitats are intensively fished by bottom trawls, the characteristic sessile epifauna are relatively fast growing and are probably able to withstand such disturbance. In contrast, the deepwater sessile communities had sessile epifauna of a greater biomass with some slow-growing species that would be more vulnerable to fishing disturbance. However, these habitats are seldom fished using invasive techniques.

Recent studies have demonstrated that fishing gears that are towed across the seabed lead to the perturbation of benthic fauna and habitats (for reviews see de Groot 1984; Messieh et al. 1991; Jones 1992; Dayton et al. 1995; Jennings and Kaiser 1998; Auster and Langton 1999, this volume). Towed bottom fishing gears are used to catch species that live in, on, or in association with the seabed. Typically, these gears are designed or rigged to remain in close contact with or dig into the seabed such that the catch rate of the target species is maximized. At the same time, benthic fauna are removed directly from the seabed or are killed, damaged, and exposed on the seabed, whereupon they are consumed by predators and scavengers (Kaiser and Spencer 1994; Ramsay et al. 1996, 1997). In the short term (days to months), fishing can result in a decrease in the abundance and diversity of benthic organisms and reduction in habitat complexity (Thrush et al. 1995; Currie and Parry 1996; Kaiser and Spencer 1996; Collie et al. 1997; Tuck et al. 1998). These effects are manifested most clearly in stable habitats in which large emergent species such as sponges, corals, and bryozoans tend to predominate (Sainsbury 1987; Auster et al. 1996; Collie et al. 1997). These organisms increase the structural complexity of habitats and provide important refuges and feeding sites for juveniles and adults of some commercial species (Walters and Juanes 1993). Conversely, fishing activities cause relatively few changes to the structure of less-complex habitats. These habitats are typically found in shallow inshore waters and tend to have a sandy substratum with few large sessile epifauna. Although it is possible to detect short-term community changes in such habitats (Currie and Parry 1996; Kaiser and Spencer 1996), they recover relatively quickly from the effects of fishing disturbance (Kaiser et al. 1998). There is now evidence to show that the magnitude of the effects of fishing in different habitats varies relative to the background of natural disturbances encountered within each habitat (Sainsbury 1987; Auster et al. 1996; Kaiser and Spencer 1996;
fected water temperature (staying warmer), causing a lag in fishing seasons. Temperature is thought to be the cause of a smaller size-class of groundfish being caught. (Cape Cod Bay is now 68–72°F in July, August, and September.)

The October storm of 1990 coated the bottom (out to 20 fathoms) with marsh hay, and the rain storm in October 1996 halved salinity; both of these incidents caused problems for fish and shellfish.

Storm debris can be a problem in the Gulf of Mexico.

**Cyclical Change**

“Changes reflect 32–33-year cycles. Two I have observed are the same: sea turtles and dolphins died 1957–1958, also died 1987–1989. Fisheries were the same [in each] cycle.”

The effects of solar cycles, the 18.6-year tide, and the Russell cycle that is 15 to 20 years in the North Atlantic are all important.

“The only thing one can count on is a constant state of flux. We have seen abundance, and lean years time and again.”

“I have seen dramatic changes in habitat over a few (2–3) years. For example, there are certain areas where sponges comprised 90% of the bottom for years, then I no longer saw the sponges, they were replaced by sand dollars. Then, a year or two later, the sponges returned.”

**Chlorine and Other Chemical Pollutants**

Despite conservation efforts, blackback flounder are diminishing due to habitat degradation. Haddock are no longer found nearshore in the Gulf of Maine. Flounders (blackbacks, and dabs) with cancerous lesions have been found. Dioxins and chemicals that mimic sex hormones are thought to be affecting spawning in the nearshore Gulf of Maine. Cumulative impacts rather than individual pollutants are thought to be causing problems.

Estrogen and similar chemicals, chlorine, and dioxins are problems.

**River Flows**

Salinity, and temperature of estuaries are affected by water discharge of the Mississippi, and Atchafalaya Rivers, and a hypoxic zone there is related to the nutrients of the river water.

**Water-Quality Problems**

Respondents cited as problematic water quality, particularly in estuaries; oil spills; waste spills from treatment plants; hog farm runoff; groundwater contamination; and inefficient sewage treatment from municipalities.

Upper Cape Fear River has an odor, and shad and menhaden have declined there.

Increases and decreases of viable oyster reefs are a function of water quality.

**Air Pollution**

Film on water after two or three calm days was thought to be air pollution that could be affecting larval stages.

Atmospheric deposition of nitrogen is a problem.

**Coastal Marsh Loss**

Coastal marsh and wetland loss (particularly important for shrimp and crabs) occurs due to saltwater intrusion, ship channels, and wind and wave erosion.

**Invasive Species**

Before the early 1970s there were no signs of *desmarestia vividus* in Narragansett Bay, but now close to 15% of the bay is covered. Pebbley bottom, a prime winter flounder spawning area, is now devoid of fish. This weed’s roots can hold fast to these pebbles. Trawlers cannot tow over one minute in these areas without slowing down to a halt from the filling of their nets with this weed. There are not any fish in these areas, which were once some of the most productive.

**Algae Blooms**

Blooms have been increasingly common in the past 10 to 12 years.

There have been increased algae, and fish kills due to overfertilization.

Decline in menhaden during *Pfiesteria*-related fish kills has caused a change in food and prey abundance.

**Debris**

Plastic garbage and other debris (especially during high tides of full or new moon) are present.

Oil field-related debris caught off Louisiana in nets. Garbage and plastics wash ashore.


Appendix: Responses to Open-Ended Questions and Focus-Group Discussion Topics

Not every respondent chose to elaborate on the questions, but those who did commented on fishing impacts to habitat, nonfishing impacts, and some positive changes in fisheries over time. Some of their responses repeat what has been recorded, and presented elsewhere in this chapter, but classifying the responses in the following manner reiterates major perceptions, and reveals additional insights. Furthermore, this section includes some of the lengthier observations recorded during the focus groups.

Habitat

Defining

Important, perhaps essential, habitat is anything that has some variability in it, and in its structure. "It's living stuff, it breathes..." Mussels, lemons, and kelp are included in the respondents' concept of habitat.

Resident Fish

There are residential fish, and there are fish that travel through. Once the residential fish are gone, they are never coming back; "that's why that spot won't produce much anymore."

"This isn't the nursery anymore because the draggers destroyed it, now it's just a little lump. You can catch a few if no one's been poking at it for a week or so, which tells you they still swim through there, and they would settle if there was anything to hold them, but they don't. There must be nothing to eat."

Fishing Impacts (Overfishing)

Overfishing has led to decreases in stock abundance, and size of individual fish. Selective fishing is breeding a slower-growing fish of smaller size.

Gear Impacts

Bottom Features

Smoothing out of humps, and pinnacles, and loss of bottom features have been attributed to repeated towing of heavy gear, notably scallop dredging, and otter trawling (particularly street-sweeper gear, and rollers). This smoothing, and loss have meant that some previously productive areas are no longer productive, and spawning areas are thought to have been reduced. Some hard-bottom areas are showing signs of soft bottom (e.g., slime eels are showing up).
come supplement to the less-than-optimal number of government assessment cruises that can be undertaken given the costs of such cruises.

Again, it is the follow-up to this project that will prove its value. Fisheries scientists, especially those serving the needs of managers, need to think seriously about what information would help improve predictive models and what kind of training fishermen would need to provide that missing information. In addition, a mechanism for handling data and incorporating data from fishermen into the science and management processes would be needed.

**Outreach**

In order for the techniques highlighted above to be applicable beyond the small segment of the fishing industry from which we were able to elicit information, it will be necessary to better publicize the new significance of habitat to management. In addition, fishermen must be assured that their data will be used in aggregate form to minimize revelations that would help competitors. Fishermen also must be convinced that their knowledge is considered valuable.

**Fishermen’s Reluctance to Get Involved**

Both fishermen and those who work with fishermen have been very concerned about the Magnuson-Stevens Act’s mandate for Councils to amend their fishery management plans to include EFH considerations by October 1998. Many have feared that the short amount of time allotted to identifying EFH and amending FMPs would result in haphazard regulation based on incomplete information that would address neither the needs of the fish stocks nor the fishing industry.

Nevertheless, many fishermen have been reluctant to volunteer information about bottom habitat because this knowledge is considered proprietary information upon which their success in fishing depends. As in any business, fishing industry members are competitive with each other and reluctant to divulge specialized knowledge that could provide their competitors with an advantage. In addition, some fishermen fear that habitat issues will be used to further restrict their fishing effort, making it impossible to survive financially. Therefore, they have little incentive to provide information that could be used against them.

For example, not far from Stellwagen Bank, inshore waters off Plymouth, Massachusetts are characterized by a complex mix of “good bottom” and boulders. The best fishermen among the small draggers of the Plymouth-based fleet weave in and out of the boulders, managing to avoid hanging up and still finding fish while recording their tows and movements on plotter charts. These charts become a kind of “currency” that is traded among friends and family (St. Martin, personal communication). The charts might also be said to function as a limited-entry mechanism, because without the detailed information about where to find the fish and how to avoid ripping nets, few newcomers can make a living.

Another problem with incorporating fishermen’s knowledge is that not all fishermen are in accord with each other. For example, hook and line fishermen that were part of this study pointed out that they have often testified about the negative impacts on rocky habitat of mobile gear, but they feel that the New England Fishery Management Council is composed of too many representatives of mobile-gear fisheries and therefore will never restrict such gear.

A strong, coordinated, educational outreach effort for fishermen is needed. At the best of times, gathering fishermen is difficult and time-consuming, although there are many people around the country who, given time and financial support, would be able and willing to do so. We have found during other fieldwork projects that rapid assessment techniques work best in situations where there groundwork is already laid. The EFH issue is so new and its impacts (both positive and negative) are so poorly understood that the immediate reaction by fishermen to the EFH policy is antipathy, negativ, and suspicion. With time and effort, that reaction could be changed and valuable information could be obtained.

**Conclusions and Recommendations**

Based on our questionnaire responses and focus-group meetings, currently available information can be used to assist with the identification of essential fish habitat. If a framework for using and managing data were established, fishermen’s local knowledge could be valuable to the management process of identifying habitat and could contribute to achieving sustainable fisheries. Fisheries managers, with the assistance of advisory groups, should identify the types of information needed. Without such a framework, data collected
The survey did not ask fishermen to identify prey items, but anecdotal information offered during one of the focus-group meetings suggested that prey data could be gathered from fishermen. Fishermen who gut their fish and observe the contents of their catches' stomachs could preserve samples and record what they observe. Similarly, asking fishermen to identify invertebrate species caught by fishing gear is another potentially valuable source of information. There are several user-friendly identification books that fishermen can use as guides. Using a field guide, figs and lemons (fishermen's terms) can be identified to phyletic group as anemones and ascidians, if not to genus and species. Similarly, encrusting organisms on rocks and algae can be more accurately identified by fishermen using guides. Some fishermen could be trained to collect data quantitatively and record observations, for example, collecting otoliths or measuring, counting, and tallying nonfish bycatch.

**Physical and Chemical Data**

To the extent that meteorological and physical data are useful to fish habitat management, fishermen can add significantly to the database. Correlating physical oceanographic data with fishing success is complicated because of seasonal changes and annual variability. Fishermen participating in this study either did not observe any physical and chemical changes or noted changes and related them to seasonal, annual, or longer-term variability. One fisherman related changes in fish abundance to solar cycles, and a few related changes in fish abundance to El Niño. Several fishermen, particularly from the Gulf of Mexico and southeast United States, related changes in shrimp and fish abundance to meteorological events (e.g., rainfall and river flow) and land-based human activities (development and destruction of marshes). A project recently funded by a federal Saltonstall-Kennedy grant will address the feasibility of using fishing vessels as scientific platforms with a variety of equipment that will passively collect meteorological and physical oceanographic data (C. Goudey, Massachusetts Institute of Technology Sea Grant College Program, personal communication). Correlation of such data with productivity will require a long-term commitment to both passive data collection and active tallying of catch and other parameters dictated by working hypotheses.

**Pollution and Productivity Data**

Fishermen from the Louisiana Intercoastal City noted the relationship between runoff and fishing success. Fisheries biologists have also correlated runoff, salinity, currents, and fronts to biological productivity, but the majority of survey respondents did not make the same observations. The problem may be one of scale, both in time and space. Fishermen are apt to notice changes in parameters that are part of the fishing process and notable in their fishing cycle.

If scientists wished to test hypotheses examining on local, short-term scales the effects of physical parameters on fish productivity, fishermen could easily assist with data collection. Hypotheses that attempted to correlate environmental changes with productivity of fish that live 5–10 years and cover thousands of miles in range, however, would need a much longer time commitment on the part of both scientists and fishermen.

Whatever the premise, fishermen can record temperature, salinity, currents, and other meteorological conditions related to productivity with great precision today given the availability of sophisticated equipment. However, data collection is only useful if it is needed to answer questions and test hypotheses. Fisheries managers, the NMFS, and Councils must identify what data are needed.

Fishermen often tout pollution effects, especially plastics and gear debris, as a significant cause of declining fish populations. Oil, chemicals, and sewage are identified by fishermen as problems to a lesser extent. However, with the exception of catastrophic events such as major oil spills, observations of fishermen are difficult to use in correlating (either quantitatively or qualitatively) declining fish abundance with pollution.

The mandatory keeping of logbooks in current federal management regimes indicates an awareness of the potential value of fishermen's observations for management decisions related to pollution and fish productivity. The state of Maine has already begun to base management decisions in part on fishermen's local knowledge. The timing of the 1999 closures due to spawning and juvenile cod distribution, for example, is based, in part, on information gathered by Ted Ames (1997) during his efforts to collect Maine fishermen's oral histories.

Testing of fishermen's observations has been endorsed by several Maine scientists. Daniel Shick with the Maine Department of Marine Resources noted that shrimp fishermen's claims about the ab-
Fishing Gear Effects

The last two questions of section two (numbers 14 and 15 in Figure 1) focused on observed habitat changes and asked fishermen to identify how their gear affects the seafloor, including bottom features. Of the 35 fishermen who responded to this question, 10 stated that their fishing gear affected the bottom, although minimally, and 25 stated their gear did not. Long-liners reported that they retrieved several types of bottom features including mussels, lemons (stalked sea squirts), pumpkins (sea squirts), figs (sea squirts) and rocks with barnacles and calcareous tubeworms, weeds, and other life. One fisherman noted that these features were retrieved to nearly the same area from which they were retrieved. Two groundfish fishermen noted that they picked up prey items including starfish, worms, clams, small fish (herring and mackerel), squid, and small bottom-dwelling invertebrates. All seven long-liners from New England noted that biota are less abundant than in the past and that rocks are nearly devoid of life in current hauls.

One trawler stated that he rarely picks up bottom features and identified plastics and debris as the material causing habitat problems. Louisiana fishermen observed oil debris and vegetation from storms in their trawls. Shrimp fishermen from Louisiana noted that their gear caused an increase in turbidity. Because tables and graphs do not adequately capture such perspectives and insights of fishermen, gear-related responses to the open-ended survey questions and questions at focus-group meetings are summarized in the Appendix.

Documentation of Observations

Not all fishermen answered questions 16 and 17 (Figure 1). Thirteen fishermen did not respond, and several fishermen responded to question 17 but did not indicate what if any documentation they had. Twenty-two fishermen noted that they had coordinate headings for habitat locations. Twenty-three fishermen indicated that they maintained logbooks. Eleven and ten fishermen, respectively, kept charts and tow plots, and nine had videos of habitat. Four fishermen that marked “others” in question 16 indicated that they had photographs, samples of algae, and invertebrate specimens. Of the respondents, 24 stated that they would share information with scientists and others, 11 did not answer, two stated that they would not share information, and four stated that they might share information.

Discussion

Collective Knowledge

Fishermen’s nearly daily forays onto fishing grounds over the course of many years lead the more observant among them to notice changes over time, especially in their target species. Sometimes the passing on of logbooks from one generation to the next extends the time line of observations. Even fishermen who are not themselves observant are usually interested enough in their business to learn from fellow fishermen what they have noticed.

The collective knowledge of active fishermen generally includes observations about the extremes in their own and others’ catch (e.g., largest examples of the species, physical or coloration oddities, sores or lesions). Changes in average sizes of their target species, size of their catch, migration patterns, and sites of successful harvests are also noted. Fishermen know when spawning occurs and often where they are found. They know bottom features from their benthic records. They know what features they retrieve with gear and know how some of these bottom features have changed in time and space. For every noted change, fishermen have an explanation based on their observations, impressions, and perceptions of the change, which are colored by their values or culture and may or may not be scientifically defensible. The challenge is to develop a reporting mechanism that is consistent among fishermen and useful to fisheries managers.

This project has revealed that many fishermen have documented their observations about habitat and changes to habitat caused by fishing gear or other effects. The question still to be answered is to what extent can fishermen’s data be used in the identification of EFH for fishery management plans (FMPs) as required under the Magnuson-Stevens Act. Specifically, we would like to know what data are needed and whether fishermen can provide these data.

Fishery management plans rely on quantitative data. Many of the fishermen’s observations are qualitative. Examination of the questionnaire responses regarding biological components of the ecosystem, physical and climatological changes, and human-induced activities suggests that some observations lend themselves more than others to quantification and inclusion in FMPs. The following sections identify types of information currently available from fishermen that can be used to help identify EFH and stress the need to "train" a cadre of fishermen to record data in a standardized format for use by fisheries managers.
in abundance varied with environmental conditions. New England fishermen observed that fish size has decreased over time such that large breeders are rarely caught these days. Longline fishermen in Massachusetts claimed that gillnetters were occupying areas that long-liners traditionally fished, thus restricting the access of long-liners to prime fishing areas and thereby limiting their catch.

Species identified as increasing were small flounder (graysole), monkfish, cod (attributed to conservation efforts), pollock, and haddock. Respondents that identified decreasing fish abundance did not always identify their target species, but rockfish were observed to decrease off California, with salmon and albacore tuna showing no change. Increases in lobsters on smooth bottoms were attributed to decreased cod and flatfish, and some of the decrease in cod and flatfish was attributed to increased striped bass that prey on juvenile groundfish. Several respondents referred to overfishing, habitat degradation (especially of spawning areas), improved technology, and predation by seals and birds as additional causes for observed decreases in target species. In addition, incidences of sores and lesions on fish were increasing, according to some respondents.

The next series of questions (questions 10–13 in Figure 1) asked fishermen to focus on biological changes, environmental trends, signs of pollution, and causes of changes to the habitats of species they fish. The responses are presented in the following four sections (Figure 7). Respondents were fairly consistent in their responses regarding observed changes and their perceptions of causation.

**Biological Changes**

The top three biological changes identified by fishermen were habitat productivity, bycatch, and fish health followed by bottom organisms, target species, and “other” changes (Figure 7b). Written comments on the questionnaires elaborated on these responses. (See Appendix for comments excerpted from the open-ended questions on the survey.) Changes in fish health reported by respondents were based on observed increases in numbers of tumors,
fished. These data reflect when and where fish aggregate or when they are available throughout the year (Figure 6). Some fisheries (e.g., squid) were noted as both site and season specific, reflecting spring spawning aggregations over sandy bottoms. Other target species, such as “groundfish,” were generally fished over a variety of habitat types throughout the year (Figure 6c). Tuna and swordfish, groundfish, and lobsters and crabs (Figures 6b, 6c, and 6d) were the most popular fisheries among respondents, particularly in the northwest Atlantic Ocean. Shrimp (6a) was a popular fishery among respondents representing the Gulf of Mexico and northwest Atlantic Ocean, with a wide diversity of habitats fished. Because only one questionnaire was submitted to account for the 75 shrimp fishermen of the Louisiana Intercoastal City, the number of shrimp fishermen represented is larger than indicated in Figure 6a.

The questionnaire indicated that fewer scallop fishermen are active today (Figure 5c), which reflects, in part, closures on Georges Bank of scallop fishing grounds and lowered catch over the past several years (USDOC 1996). Groundfish catch has also decreased over the past decade in New England, and although biomass appears to be recovering on Georges Bank, this recovery has not occurred throughout the Gulf of Maine (NEFSC 1998). Although dogfish are often cited as having replaced depleted groundfish stocks in terms of biomass, few fishermen responding to our survey targeted dogfish or other sharks. Whiting and hake, halibut, herring and mackerel, and squid were fished by some but not all respondents. A number of “other” fish species, such as rockfish, sablefish, and monkfish, were mentioned by only one of the respondents. As noted earlier, the responses are heavily weighted toward New England fisheries.

Questionnaire results indicated a stronger correlation between season and specific targeted species than fishing gear and specific targeted species. Although for several species there were few responses to draw definitive conclusions. Squid are most heavily fished in the spring and summer, and tuna and swordfish (Figure 6b) are heavily fished in the summer and fall. Fishermen also indicated that they fish some habitats for specific species, for example, fine-grained sediments for shrimp (Figure 6a), squid, and whiting. Most other species appear to be evenly distributed through all habitat categories, according to questionnaire results. Several lob-

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1 See also http://www.st.nmfs.gov/commercial/landings/qc_runc.html, an online database maintained by the National Marine Fisheries Service, Northeast Fisheries Science Center.
TABLE 1.—Distribution of fishermen as owners and captains and boat sizes. A blank space means no answer was provided in the questionnaire. (California and Oregon are not included.)

<table>
<thead>
<tr>
<th>Geographic region</th>
<th>Owners</th>
<th>Captains</th>
<th>Range of boat size (ft)</th>
<th>Horsepower</th>
<th>Hold capacity (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gulf of Mexico ²</td>
<td>1 of 9</td>
<td>1 of 9</td>
<td>18-180</td>
<td>200</td>
<td>350 cubic ft ³</td>
</tr>
<tr>
<td>Southeast Atlantic</td>
<td>20 of 28</td>
<td>23 of 28</td>
<td>19-23 23-185</td>
<td>90-900</td>
<td>1.500-250,000</td>
</tr>
</tbody>
</table>

* Three responses represented three different gear types with between 7 and 15 fishermen fishing each gear type.
* Boats ranged from 18 to 20 ft for crab fishermen, 60 to 75 ft for shrimp fishermen, and 180 ft for menhaden fishermen.
* Response of shrimp fisherman from Texas.
* States of Massachusetts, New Hampshire, Maine, Rhode Island, and New Jersey are represented.

response was ambiguous. Fifteen of the twenty-seven New England respondents used hook and line, and fourteen of those respondents were long-liners who used tub trawls or jigged. One of the respondents indicated using a scallop dredge, and three other respondents indicated having done so in the past.

The following discussion about gear types, seasons, and bottom types fished reflects previous experience (of retired fishermen), as well as the responses of active fishermen (Figure 5). Fishermen currently using various gear types are distinguished by shading from those who fished the gear in the past. The bar graphs in Figure 5 include responses from the Louisiana Intercoastal City, and these responses are treated as one response for each gear type. Other gear considered in Figure 5 includes gear used by recreational fishermen (several from the southwest Atlantic region) and unique gear (primarily recreational gear).

Because several fishermen used more than one gear type, the total number of fishermen for all gear types in Figure 5 exceeds 43, the number of respondents. Given the limited response to the questionnaire and the bias toward New England fisheries.

![Bathymetry Map](image)

**Figure 4.**—Map showing fisheries characteristics in areas near Provincetown, Massachusetts.
Cod, structural components include nine-fathom hills (near Davis Bank and within Nantucket Shoals), two areas with extensive mussel beds, a clay pipe region, crushed shells, and benthic organisms described as figs (Ascidians), lemons (*Bolithea ovifera*), and pumpkins (Ascidians) (Figure 3). Hook and line fishermen drew the outlines of the cod and haddock areas fished by both themselves and gillnetters. The area around the tip of Cape Cod, near Provincetown (Figure 4), is also used by different types of fishermen. The area is a spawning ground for fluke (also called summer flounder *Paralichthys dentatus*), which is fished by hook and line fishermen within the crook of Provincetown and fished by draggermen on the outer area (as fluke leave the crook). The area around the tip of Cape Cod is also used by lobstermen.

**Results of the Written Survey**

**Fishermen and Vessels**

There were 43 respondents to the questionnaire, of whom 27 were commercial fishermen from New England, except for 1 retiree and 1 recreational fisherman. The distribution of responses from New England were 14 from Massachusetts, 9 from New Hampshire, 3 from Maine, and 1 from Rhode Island. Other responses included 9 from North Carolina; 1 each from Texas, New Jersey, California, and Oregon; and 3 summaries from the Louisiana Intercoastal City representing 7 menhaden fishermen, 75 shrimp fishermen, and 45 crab pot fishermen. These three Intercoastal City responses were treated as single responses and are noted as such where appropriate. Most New England respondents were owners, captains, or owners and captains of their own boats and had fished commercially for 15-20 or more years. Distribution of fishermen, boat size, and hold capacity are summarized in Table 1.

As expected, recreational fishermen’s boats were smaller than commercial fishermen’s boats and had less horsepower. The size of commercial boats for the northeast region ranged from 23 to 185 ft with the majority in the 30-40-ft range. Horsepower ranged from 150 to 850 hp with the majority around 300-400 hp. For mid-sized boats, hold capacity was between 2,000 and 50,000 lbs with larger boats having capacities of up to 250,000 lbs. Based on boat size of respondents, most of the respondents were day fishermen who return to port each night.
9. Indicate which of the following you have observed over time for the target species that you fish:
☐ no change ☐ increase ☐ decrease ☐ replaced by another species ☐ moved to other areas.
Please explain observations:

10. Please indicate what, if any, biological changes you have noticed in the time you have been fishing e.g.
☐ target species ☐ fish health ☐ type of bottom algae and creatures ☐ habitat productivity
☐ bycatch ☐ other changes. Please specify:

11. Please indicate significant changes in the environment that you have noticed, e.g. ☐ salinity ☐ currents
☐ temperature. Please specify:

12. Please identify any signs of pollution that you observed. e.g. ☐ sewage ☐ chemical waste ☐ plastics
☐ gear debris ☐ oil ☐ bottom obstacles ☐ other. Please explain:

13. If you observed a change to the habitats you fish or to specific species, please explain what you think is the cause:
☐ weather ☐ fishing gear ☐ pollution ☐ habitat loss ☐ overfishing
☐ fronts (upwelling/downwelling) ☐ changes in prey or food abundance ☐ other

14. Does your gear ever pick up bottom features? If yes, please describe how, how often (rarely, occasionally, frequently), and general bottom-type where this may occur. Describe changes over time in this location:

15. Does your gear affect the habitat you normally fish? ☐ yes ☐ no If yes, how and how do you know:

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**Documentation of your observations**

16. Do you have any of the following:
☐ Videos of your fishing gear ☐ Logbooks
☐ Fishing ground coordinates ☐ Plots of usual tows from 19___ to 19___
☐ Charts with tows marked ☐ Others
Please explain how your documentation might be used to describe fish habitat.

17. Are you willing to share this information with scientists or others? ☐ yes ☐ no

Please return this form to: Interim Habitat Study, Massachusetts Institute of Technology Sea Grant College Program, 292 Main Street, E38-300, Cambridge, MA 02139

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Figure 1.—(continued.)
observations, and bycatch, and without other documentation of where, when, and how much fish is caught, managers act on the best information they have available—information that may be incomplete or insufficient. Without appropriate limits or management, target fish production may be limited, nonpreferred species may proliferate, and low-end (both in trophic level and size) fishing is encouraged. A recent analysis of over 60 data sets with complete diet information suggested that global fisheries catches contain an increasing proportion of low-trophic-level animals (Pauly et al. 1998). This study suggested that fishing practices are creating ecological shifts that may be irreversible.

It is certain that "traditional knowledge cannot make a contribution to sustainable development without having a functional link to management" (Bellon 1995:264). By its requirement that the Councils seek information on habitat from local stakeholders as well as other information to augment scientific data, the Magnuson-Stevens Act implicitly recognizes the value of linking management and fishermen's local knowledge.

The Research Effort

As a first step in helping the Councils change their management focus to include habitat and ecosystem considerations, the NMFS supported two habitat studies through a collaborative agreement with the American Fisheries Society, World Wildlife Fund, and National Fish and Wildlife Foundation. One study reviewed scientific, peer-reviewed literature on gear impacts on habitat (Auster and Langton 1999, this volume), and the other study, the focus of this report, reviewed fishermen's knowledge of habitat and gear impacts.

This report summarizes a sample of fishermen's documentation of fish habitat, changes to habitat observed over time, and effects of fishing gear on habitat. Fishermen's knowledge is not neatly written in journals, articles, or technical reports for perusal and distillation. Instead, fishermen must be contacted directly. The results of our contacts with fishermen are presented as a preliminary indication of what documentation is available.

Although the initial purpose of this study was to compile a database of fishermen's documentation of observations about habitat, changes to habitat over space and time, and gear impacts, it became evident early on in the study that the following factors would influence the outcome:

- Methodologies for integrating fishermen's knowledge into fisheries scientific literature and fisheries management are at an embryonic stage.
- For this initial study, resources were limited, and what was to be a "national" survey has a strong New England bias.
- Fishermen are reluctant to get involved for several reasons that will be discussed later in this paper.

A secondary purpose of this study is to evaluate the effectiveness of different approaches to identify fishermen's knowledge and document their observations. For this project, we relied on interviews, focus groups, participation in public hearings, and the use of written questions.

Methodologies and Approach

To collect information from fishermen on their documentation of fishing gear effects and habitat observations, a general solicitation requesting information from a broad audience was sent to newsletters and media targeting fishermen and fishermen's organizations. The primary goal of this initial solicitation was to compile a list of the types of documentation that fishermen maintain about habitat, fishing gear effects, and favored fishing sites, which in turn could be used (to the extent that fishermen were willing to share this information) to support EFH identification and development of federal fishery management plans.

To understand the context of the initial responses about logbooks, videos, or other documentation, a questionnaire was prepared to collect additional information about fishing activities. This survey form was reviewed by fisheries managers, fishermen, and other knowledgeable individuals before distribution and served as the basis for individual discussions with fishermen. It also was used to stimulate focus-group meetings and give structure to the discussions. The survey instrument provided a standardized method for collecting and summarizing information. The questionnaire (Figure 1) requested information in three categories:

1. background information about fishermen, fishing vessel(s), and target species and habitats;
2. fishermen's perspectives on potential causes of change observed in target-fish populations and habitats; and
3. documentation of fishermen's observations.
Sandbanks are marine habitats of conservation importance under the EU Habitats Directive. These habitats are becoming subject to impacts of several human activities including fishing, aggregation extraction, and construction of offshore wind farms that may have detrimental effects on their structure and functioning. We characterised and compared the diversity and biological traits of demersal fish and megafaunal invertebrate assemblages inhabiting three sandbanks, one in the vicinity of a small existing wind farm and two which are proposed sites for future wind farm installations. Samples in t