Northeast Fisheries Science Center Reference Document 02-01

Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern United States October 23-25, 2001 Boston, Massachusetts

by

Northeast Region
Essential Fish Habitat
Steering Committee

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
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Northeast Fisheries Science Center Reference Documents

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The EFH Steering Committee would like the thank the workshop panel (listed in Appendix A) for their hard work and dedication to having a successful workshop. Thanks to Kathie Ciarametaro for her assistance with workshop logistics. Thanks to Jeff Citrin of Resolve, Inc. for providing workshop facilitation services.

The workshop was sponsored by NOAA / National Marine Fisheries Service, New England Fishery Management Council and Mid-Atlantic Fishery Management Council.

The views expressed herein are those of the workshop panel and do not necessarily reflect the views of the EFH Steering Committee members, the agencies they represent, or the sponsors.

INTRODUCTION

The 1996 Amendment to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) tasked the National Marine Fisheries Service (NMFS) and federal fishery management councils with identifying and describing essential fish habitat (EFH) for all species that are managed under a federal fishery management plan (FMP). Additionally, each FMP is required to identify and assess the impacts of all fishing gears on EFH, and where practicable, minimize any adverse effects caused by fishing.

Assessing gear impacts and implementing management measures that will minimize the effects of fishing requires scientific information documenting the following: the effects of different fishing gears and practices used in the region; the distribution of fishing effort; the distribution of habitats within the region; the recovery rates of the effected habitats; and any reduction of an essential fish habitat's capacity to support exploited marine resources as a result of fishing. Studies have been conducted in the Northeast region and in other geographic areas around the world which address some of these questions, but to date there has been little attempt to evaluate all of the available information in order to identify adverse impacts to the specific habitat types of the Northeast region. For the purposes of the workshop, the Northeast region encompasses the area from Maine through North Carolina. The uncertainty regarding the identification of adverse impacts on the various habitat types found within the Northeast has resulted in reluctance to implement risk-averse habitat protection measures.

The workshop convened a panel of experts in the fields of benthic ecology, fishery ecology, geology, fishing gear technology, and fisheries gear operations (List of Participants in Appendix A). The purpose of the panel was to assist the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC) and NMFS with: 1) evaluating the existing scientific research on the effects of fishing gear on benthic habitats; 2) determining the degree of impact from various gear types on benthic habitats in the Northeast; 3) specifying the type of evidence that is available to support the conclusions made about the degree of impact; 4) ranking the relative importance of gear impacts on various habitat types; and 5) providing recommendations on measures to minimize those adverse impacts. The workshop was held from October 23 - 25, 2001, in Boston, Massachusetts (Workshop Agenda in Appendix B).

Although the workshop was entitled "The Effects of Fishing Gear on Marine Habitats of The Northeastern United States," the workshop focused on benthic habitats. The goal of the workshop was to evaluate the impacts of fishing gear used in federally regulated fisheries on habitats of the Northeast shelf ecosystem, and to recommend management measures that will reduce those impacts (Appendix C). Only impacts to habitat were considered; effects of fishing on exploited species populations were not considered. Definitions of terms, such as "adverse effect", that were used to focus the discussions are provided in Appendix D.

There will be two final products as a result of this workshop. The first is this workshop report which summarizes panel discussions and conclusions relating to the effects of fishing gears on benthic habitats in the Northeast region. The second product will be a peer reviewed document produced by NMFS staff which describes gear types used in federal and state waters in the

Northeast region, the spatial distribution of fishing trips made by each gear type in federal waters, oceanographic regimes and habitat types in the region, and the results of scientific studies of the effects of fishing gear on benthic habitats in the Northeast U.S. and elsewhere. Preliminary Draft copies of this document (White Paper) were distributed to panel members in advance of the meeting to assist them in achieving workshop objectives. These documents will be available for use by the NEFMC and MAFMC to fulfill their MSFCMA requirements to include an assessment of fishing gear impacts on EFH in all of their FMPs.

WORKSHOP FORMAT

Although there are many fishing gear types utilized in the Northeast region, the workshop focused on gear types that are federally managed under the MSFCMA. An exception to this was made for lobster pots due to their widespread use in both state and federal waters. The following gear categories were evaluated:

Bottom-tending Static Fishing Gear
- Pots and Traps
- Sink Gill Nets, Bottom Long Lines

Bottom-tending Mobile Fishing Gear
- Clam Dredges (hydraulic and non-hydraulic)
- Otter Trawls
- Sea Scallop Dredges
- Beam Trawls

Pelagic Fishing Gears (Static and Mobile)

The panel was provided a set of 15 questions, in advance, to guide the workshop discussions (Appendix E). These questions were divided into four categories: gear descriptions, gear effects on habitat, strength of evidence supporting the effects, and management actions. Individual panelists led the discussion for each gear type, guided by the questions. Some discussion leaders provided short presentations on their assigned gears which were then followed by group discussions. During the first two evenings, the discussion leaders held individual sessions with selected experts and workshop staff to further evaluate the available information and to prioritize the effects of each gear type in different habitats. On the third and final day the panel reviewed the results of these sessions.

A gear impact matrix was completed for each gear type which summarized the degree of impact for three substrate types, mud, sand, and gravel (Appendix D for definitions). The panel evaluated the types of impact caused by the gear for each substrate type, the degree of each impact, the duration of the impact, and the type of evidence available to support these conclusions. Four types of impacts were considered for each gear type and habitat: 1) removal of physical features; 2) impacts to biological structure; 3) impacts to physical structure and; 4) changes to benthic prey (Appendix D for definitions). After the matrices for each gear type were completed, the panel ranked the relative significance of each gear and impact type for all three substrate types. Once the types of impacts and habitats of greatest concern were identified, the panel recommended management actions that could be considered by the Councils to reduce the adverse effects of fishing gear on benthic habitats in the Northeast region.

This report clearly identifies when panel consensus was reached, and when points are attributed to individual panelists. The workshop began with introductory remarks by representatives of NMFS, MAFMC and NEFMC. The following sections summarize the introductions, discussions, conclusions and recommendations of the panel.

INTRODUCTORY PRESENTATIONS

NMFS Welcoming Address

Peter D. Colosi, Jr., Assistant Regional Administrator for Habitat Conservation

I am excited to welcome you to this workshop on the effects of fishing gear on fish habitat with such a panel of knowledgeable scientists, gear technologists, and fishermen.

As most of you are aware, with the 1996 Amendment to the Magnuson-Stevens Fishery Conservation and Management Act, the National Marine Fisheries Service and fishery management councils have had the task of identifying and describing essential fish habitat for all federally managed species. Additionally, we have had to identify and assess the relative impacts of all fishing gears on essential fish habitat for all of our fishery management plans, and where practicable, minimize any adverse effects from fishing.

Assessing gear impacts and implementing management measures to minimize impacts has been a very daunting task when faced with limited scientific information related to gear impacts on specific habitats, recovery rates, and the applicability of research conducted in other locations to the Northeast. Additionally, we are currently unable to quantify the intensity of gear interaction on specific habitat types in the Northeast. This has lead to much uncertainty regarding the identification of adverse impacts to the various habitat types found within the Northeast as well as apprehension to implement risk-averse habitat protection measures.

This panel has been convened to assist in interpreting the existing scientific research, determining the applicability of existing studies to the Northeast and evaluating the strength of that evidence. Your deliberations over the next three days, will provide valuable information to the New England and Mid-Atlantic Fishery Management Councils for use in fulfilling the habitat requirements of the Magnuson-Stevens Act.

I would also like to take this time to thank the Northeast Region EFH Steering Committee, which is comprised of staff from the National Marine Fisheries Service's Regional Office and Northeast Fisheries Science Center, the Mid-Atlantic and New England Fishery Management Councils and the Atlantic States Marine Fisheries Commission, for their hard work in organizing this workshop.

Good Luck over the next several days and I look forward to your results.

<u>Mid-Atlantic Fishery Management Council Welcoming Address</u>

Gary Caputi, Vice-Chairman, Ecosystem Planning Committee

On behalf of the Mid-Atlantic Fishery Management Council, its members and staff, I'd like to welcome this distinguished group of scientists, fishery managers and fishermen to this important workshop. It is our hope that the documents and the recommendations for future research produced by this gathering of specialists will help us move forward with the responsibilities placed on our shoulders by the Sustainable Fisheries Act.

With the passage of the Act in 1996, Congress and the Administration charged the eight regional management councils with identifying essential fish habitat and addressing threats to the health and viability of that habitat. One perceived threat was specifically identified in the language of the Act and was, therefore, required to receive a heightened level of investigation and action in FMP amendments. That is the impact of fishing gear on EFH or its subset, habitat areas of particular concern (HAPCs).

In trying to meet this mandate, the Mid-Atlantic Council has run into a problem caused by the lack of targeted scientific data addressing specific gear types used in the wide ranging fisheries we are responsible for managing. This poses a dilemma for managers because we have found ourselves unable to identify whether specific gears pose a threat or have no impact on the wide range of marine habitats exposed to their use. The problem is a double-edged sword. Our inability to justify positions on gear impacts has generated disapprovals of portions of recent plan amendments in which we identified no discernable impacts as well as those in which we identified possible impacts. Without adequate scientific documentation, the decisions we make are unsupported and, therefore, cannot be approved by the Agency and the Secretary. That is why this workshop was developed and why we have asked for this distinguished panel to convene. We desperately need scientific documentation to support the management objectives we assume under the Sustainable Fisheries Act so we can we do our jobs better.

In the past, a lot of scientific investigation was performed and scholarly papers were published on a wide variety of subjects. Many did little to provide fishery managers with the bedrock work they need to make better management decisions. This is not to say that such work was not important, or that it did not serve a purpose in furthering our understanding of the marine environment and its workings. But when it comes to the work the Councils are charged with performing, scientific research and documentation is required that specifically addresses our needs. It is in the management process that the scientific rubber meets the road and that is why the steering committee has worked so diligently to make it clear what we as managers need from you as scientists to make our efforts to rebuild and maintain sustainable fisheries and protect the marine environment more successful.

In the past two years, the Mid-Atlantic Council has seen the "Gear Impacts" sections of four major FMPs disapproved. They include *Summer Flounder, Scup and Black Sea Bass*; *Surfclams and Ocean Quahogs*; *Squid, Mackerel and Butterfish* and the *Bluefish FMP*. The amount of work involved in writing these plan amendments, incorporating entirely new sections detailing EFH and then trying to divine whether there are or are not threats to the identified important habitat from fishing gear, with little or no scientific data to fall back upon, was a frustrating exercise. One that we do not want to see repeated. Our inability to adequately identify gear impacts has lead to the Council and the Agency being criticized by constituencies on all sides of this rather volatile issue.

Not only have we experienced amendment disapprovals in major plans, but we have also been unable to justify the incorporation of "gear restricted areas" in the *Tilefish FMP*. Tilefish represent possibly the most habitat dependent of all the species of finfish the Mid-Atlantic Council is responsible for managing. It is a sedentary species that is believed to spend a major portion of its life cycle in relationship to burrows in the clay bottom located near the major canyon heads and along the edge of the continental shelf. After a great deal of examination of the existing data, it was "divined" that the doors of bottom tending mobile gear presented a potential negative impact to tilefish burrows. Therefore boundaries were developed to identify areas known to have concentrations of burrows and the Council proposed a restriction on the use of bottom tending mobile gear in those areas. Did the Council go too far? By proposing this action, based on impressions gleaned from the limited scientific study available, did the Council overstep its bounds? Apparently so because the gear restricted area concept was found to be unjustifiable after lengthy public hearings.

Without concise documentation, fishery managers are damned if they do and damned if they don't act. Is it possible that there is sufficient published literature to justify some actions or inactions, but it simply has not been compiled into documents that will stand up under Agency and possible judicial review? That is for you to determine.

It is our desire to see this workshop produce a comprehensive compendium of the work already done on identifying gear impacts to marine habitat and also identify areas where additional work is necessary that directly addresses the needs of managers so that we may accomplish our mandates in a more accurate and timely manner. With that, we wish you Godspeed and good luck in your endeavor.

New England Fishery Management Council Welcoming Address

Doug Hopkins, Chairman, Habitat Committee

Good morning and thank you for the invitation to speak to you as you begin these important deliberations on the effects of fishing gear on fish habitat.

My name is Doug Hopkins. I am wearing four hats, those of New England Council member, Chair of the Council's Habitat Committee, Environmental Defense staff member, and lawyer. So the lens through which I view these issues may be a little different from yours.

Yes, you will identify many, many unanswered scientific questions related to the effects of fishing gear on marine habitat and will conclude that much additional research is needed. Nevertheless, you can play a critical role in helping the regional councils, the National Marine Fisheries Service and the scientific community to avoid paralysis, and I urge you to do so.

Let's look closely at the Magnuson-Stevens Act mandate. The law, as amended by the Sustainable Fisheries Act (SFA), allows – actually it requires -- action by the councils and NMFS to protect habitat from harmful fishing impacts even in the absence of thorough scientific understanding.

Yours is not a forensic undertaking whose aim is to present evidence for a jury to conclude beyond a reasonable doubt what gear should be convicted of assault and battery on Essential Fish Habitat (EFH). Congress has already reached the conclusion that many of today's fishing gears and practices adversely affect EFH.

It is now the managers' job to implement all practicable measures to minimize harm by fishing gear to EFH. This is what the SFA requires. So what do we, as managers, need from you, the scientific experts, so that we can do our jobs effectively? We need a diverse menu of measures that singly or together will reduce the adverse effects of fishing on habitat. We also need good explanations that let us, fishermen and the general public understand how these measures will provide benefits to fish habitat. In addition, and very importantly, we need as much help as possible prioritizing these proposed measures by characterizing the relative expected benefits of each.

Finally, and crucially, since the Magnuson-Stevens Act requires that any fishery management plan must "minimize to the extent practicable adverse effects on . . . [essential fish] habitat caused by fishing," the regional councils and NMFS need your help to systematically evaluate the practicability of each of the measures you propose. To do this you may have to include in your deliberations fishery economists and other experts who are not present today for this workshop.

Addressing a few other points, first I believe the New England Council would welcome suggestions for creating incentives for fishermen to develop and adopt new fishing practices and gear that would reduce harmful habitat impacts, so long as they would in fact benefit habitat. In other words we seek your help identifying ways to harness the enormous, proven ability of fishermen to solve problems and increase their efficiency through innovations in gear and fishing methods.

Next, I wish to highlight an example of a proposed measure that needs additional scientific input to adequately evaluate its potential. The New England Scallop Oversight Committee and the full Council are considering a measure for possible inclusion in Amendment 10 to the Scallop FMP that would bar future scallop fishing from the historically least productive scallop grounds. The pertinent scientific question then is whether data exist to determine whether the historically least productive scallop grounds can be distinguished from the historically most productive? The initial designation of the least productive grounds would not have to be perfect, only scientifically supported and practicable. If subsequent surveys disclosed that a rare but significant set of scallops had occurred in an area initially closed as within the historically least productive grounds, a subsequent framework adjustment to the FMP could always reopen the area.

Touching on research needs, I want to emphasize that the regional councils and NMFS clearly need significant input from the scientific community to identify and prioritize additional research that would help to answer important questions related to minimizing the adverse effects of fishing on EFH. That said, identifying research needs should not become an excuse for management inaction. You can help the Councils and NMFS determine how best to encourage valuable research. For example, we need to know: How can the New England Council and NMFS best utilize the Research Steering Committee? Should we be considering creating Habitat Research Areas where fishing activity would be barred except as specifically allowed for research? If so where should these be sited and how large should they be? How important would it be to have baseline benthic surveys done and how should the survey areas be prioritized, recognizing that funding won't allow them to be completed all at once?

When it comes to research, engendering accurate expectations of the benefits of specific research projects will be critical. The Councils, the fishing communities and the general public need accurate information as to how long any particular research activity will likely take to yield results relevant to management decisions. Is it two years, five years or 20 years? Unrealistic expectations can damage scientific credibility among non-scientists and erode public confidence in fishery management.

In conclusion, Congress has determined that fishing gear and practices can and must evolve to reflect the scientific understanding we have of the high and unnecessary cost of fishing on the marine environment. Fishing yields food for people to eat and money and livelihoods for fishermen and their communities. You can help the fishery managers and fishermen to figure out better ways to provide these yields more sustainably than current fishing practices allow. The technology and practices used to catch fish in New England have not changed significantly for decades, while scientific understanding of the stresses on marine ecosystems caused by fishing has grown dramatically during this time. This imbalance is simply wrong. Your scientific advice will be crucial to helping managers and fishermen change fishing gear and practices to dramatically decrease their ecological and economic costs.

Thank you, and good luck in your deliberations over the next three days.

HABITAT CHARACTERIZATION

Dr. Page Valentine (U.S. Geological Survey) summarized major marine habitat characteristics applicable to the Gulf of Maine, Georges Bank, southern New England and mid-Atlantic Bight and their variability in terms of topography, sediment texture and hardness, substrate roughness and surface area, substrate dynamics, water column characteristics, habitat usage, and fishing impacts (Table 1). This is information that could be considered when evaluating the setting, function, and vulnerability of various habitats. Additional information was presented for eleven different geographical habitat types on Georges Bank and in the Gulf of Maine using these generalized habitat characters (Appendix F). No detailed information was presented for habitat types in southern New England and the mid-Atlantic Bight.

Panel members concluded that this was very useful information and recommended that: 1) detailed habitat types between Cape Cod and Cape Hatteras also be described, and 2) several new characters be added to the habitat type descriptions. It was noted that information is available for certain habitats (e.g., soft corals) south of Cape Hatteras. Additional habitat characters that were suggested by panel members were the principal types of fishing activity, estimates of the area covered by each habitat type, and depth range. Dr. Valentine pointed out that there is some information on the areal extent of some of the offshore habitats he described in the Gulf of Maine – Georges Bank region, particularly for Georges Bank itself, but thorough maps are not available.

Table 1. Habitat Characteristics and Variability

HABITAT CHARACTER	VARIABILITY
TOPOGRAPHY	FEATURELESS --- FEATURES
SEDIMENT TEXTURE [and HARDNESS]	FINE --- COARSE ---------------------------- [SOFT] --- [HARD] ---------------------------- MUD ----------------------- SAND ------------ GRAVEL; SHELLS; BEDROCK
SUBSTRATE ROUGHNESS [and SURFACE AREA] · PHYSICAL · BIOLOGICAL	SMOOTH -- ROUGH [LOW] -- [HIGH] MUD ------------------------ SAND ----------------- SHELLS; GRAVEL; BEDROCK | --BURROWS-- | | ---------- BEDFORMS ------ | | --STRUCTURES (TUBES and ATTACHED EPIFAUNA) -------------------
SUBSTRATE DYNAMICS · PHYSICAL mud, sand, shells · BIOLOGICAL -------------------------------------- · PHYSICAL hard bottom · BIOLOGICAL	WEAK CURRENTS --- STRONG CURRENTS --------------------------------- TIDAL; STORM; OTHER --------------------------------- STABLE SUBSTRATE ----------------------------------- UNSTABLE SUBSTRATE MUD ----------------- | SAND ---------------------- | ------------------ SAND and SHELL MOVEMENT ---- ADAPTED TO STABLE ----------- and/or ------MOVING SEDIMENT-------------- STABLE SUBSTRATE --- GRAVEL MOUNDS, BEDROCK, GRAVEL PAVEMENT --------------------------- ADAPTED TO NON-MOVING SUBSTRATE
WATER COLUMN PRODUCTIVITY WATER DEPTH	STRATIFIED --- MIXED LOW --- HIGH DEEP -- SHALLOW
HABITAT USAGE · by FAUNA · by FISHERS	 SPAWNING, JUVENILE SURVIVAL, ADULT POPULATION ROUNDFISH, FLATFISH, BIVALVES (EPIFAUNAL, INFAUNAL) TARGET SPECIES and/or HABITATS using MOBILE GEAR, STATIONARY GEAR
FISHING IMPACTS · PHYSICAL · BIOLOGICAL	 TOPOGRAPHIC FEATURES, TEXTURE, ROUGHNESS and SURFACE AREA, SUBSTRATE DYNAMICS ROUGHNESS and SURFACE AREA (TUBES and ATTACHED EPIFAUNA), BIODIVERSITY

EFFECTS OF FISHING GEAR

CLAM DREDGES

Gear Description

Mr. Dave Wallace (Wallace and Associates) presented a thorough description of the evolution and current use of the hydraulic clam dredge for the surfclam and ocean quahog fisheries. A brief discussion of "dry dredges" used in the Maine "mahogany" ocean quahog fishery was led by Mr. Wallace with contributions from the workshop panelists. This section of the report summarizes his presentation and the panel discussion.

Hydraulic clam dredges have been used in the surfclam fishery for over five decades and in the ocean quahog fishery since its inception in the early 1970s. These dredges are highly sophisticated and are designed to: 1) be extremely efficient (80 to 95% capture rate); 2) produce a very low bycatch of other species; and 3) retain very few undersized clams.

The typical dredge is 12 feet wide and about 22 feet long and uses pressurized water jets to wash clams out of the seafloor. Towing speed at the start of the tow is 2.5 knots and declines as the dredge accumulates clams. The dredge is retrieved once the vessel speed drops below 1.5 knots, which can be only a few minutes in very dense beds. However, a typical tow lasts about 15 minutes. The water jets penetrate the sediment in front of the dredge to a depth of about 8 - 10 inches, depending on the type of sediment and the water pressure. The water pressure that is required to fluidize the sediment varies from 50 pounds per square inch (psi) in coarse sand to 110 psi in finer sediments. The objective is to use as little water as possible since too much pressure will blow sediment into the clams and reduce product quality. The "knife" (or "cutting bar") on the leading bottom edge of the dredge opening is 5.5 inches deep for surfclams and 3.5 inches for ocean quahogs. The knife "picks up" clams that have been separated from the sediment and guides them into the body of the dredge ("the cage"). If the knife size is not appropriate, clams can be cut and broken, resulting in significant mortality of clams left on the bottom. The downward pressure created by the runners on the dredge is about 1 psi.

It was pointed out by a panel member that the high water pressure associated with the hydraulic dredge can cause damage to the flora and fauna associated with bottom habitats. However, water pressure greater than that required for harvesting will reduce the quality of the clams by loading them with sand and increase the rate of clam breakage. Therefore, water pressure is usually self regulated.

There are currently two types of hydraulic dredges used in the fishery, stern rig dredges and side rig dredges. The chain bag on a side rig dredge drags behind the dredge and helps smooth out the trench created by the dredge. The chain bag results in significantly more damage to small clams and other bycatch than occurs with the stern rig dredge. With the stern rig dredge, which is basically a giant sieve, small clams and bycatch fall through the bottom of the cage into the trench and damage or injury is minimal. Improvements in gear efficiency have reduced bottom time and helped to limit the harvest of surfclams to a relatively small area in the mid-Atlantic Bight.

Prior to 1990, the resource was managed by controlling the number of hours a vessel could fish. Consequently, towing speeds were maximized to catch as many clams as possible regardless of the damage done to the clams or the habitat. Cutting and breakage of discarded clams were estimated to be as high as 90% in some locations and under some conditions decomposition of dead clams caused reduced oxygen concentrations in sediments to the point that clams were killed. Incidental mortality is currently estimated to be well under 10% because quota management has removed the need for vessels to catch as many clams as possible as quickly as possible.

Concurrent with the change in harvesting practices that occurred after 1990, there has also been a significant reduction in fishing effort and a shift to stern rig dredges. About 60 side-rig vessels pulling 80 dredges were taken out of the fishery after 1990. The number of surfclam vessels decreased from 128 in 1990 to 31 in 2000, while the number of vessels that landed ocean quahogs (excluding the Maine fishery) dropped from 56 in 1990 to 29 in 2000. Currently there are only 4 side rig vessels pulling five dredges left in the fleet.

Surfclams live mostly in sand which is disturbed and re-suspended by storms and, in some locations, by strong bottom currents. Ocean quahogs live at greater depths, mostly in finer sand and silt/clay substrates which are less affected by natural physical disturbances. Surfclams and ocean quahogs are not found in commercial quantities in gravel or mud habitats or in depths greater than 300 feet.

Hydraulic clam dredges can be operated in areas of large grain sand, fine sand, sand and small grain gravel, sand and small amounts of mud, and sand and very small amounts of clay. Most tows are made in large grain sand. Dredges are not fished in clay, mud, pebbles, rocks, coral, large gravel greater than one half inch, or seagrass beds. Boat captains will not dredge in areas with very soft or hard substrate where they run the risk of losing or damaging the gear. The fishery is also limited to sandy sediment because the processors do not want mud blown into the clam bodies by the dredge.

The spatial scale of fishing effort varies depending on which species is the target: surfclams are harvested primarily in a small area off the New Jersey coast whereas ocean quahogs are harvested over a larger area that includes offshore waters. Areas with denser concentrations of clams would presumably be dredged more intensively, i.e., a higher percentage of the bottom would be affected. Because surfclams are concentrated in a very defined area off the New Jersey coast where the bottom is so homogeneous, a high proportion of the bottom over this large contiguous area is affected by dredging. Surfclams grow much more rapidly than ocean quahogs and surfclam beds are dredged every few years. Areas dredged for ocean quahogs are left untouched for many years. Ocean quahogs are much more likely to be dredged from a number of more or less discrete patches that are surrounded by undisturbed areas. It was noted, as a general rule, that once 50% of the harvestable clams are removed from an area, the catch rates drop to a point where it is no longer economically feasible for fishing to continue there.

In federal waters, the amount of bottom area directly impacted by the hydraulic clam dredge fleet in 2000 was about 110 square miles (Table 2). An additional 15 square miles were dredged in State waters of New Jersey, New York, and Massachusetts. The predominant substrate on the southern New England/Mid-Atlantic Bight shelf is sand. Thus, during any given year, this fishery is conducted in a very small proportion of a habitat type that characterizes most of the 40,000 square miles of continental shelf between the Virginia/North Carolina border and Nantucket Island (69˚ W longitude). The Georges Bank region has been closed to clam harvesting since 1990 because of the potential of paralytic shellfish poisoning.

Table 2. Estimated area in federal waters towed by hydraulic clam dredges in 2000 (Source: Dave Wallace).

	Quahogs	Surfclams
Hours at sea per year	28,440[a]	19,907[a]
Setting & hauling gear (25%)	7,110	4,977
Hours fished per year	21,330	14,930
Average speed/tow (nmi/hr)	2	2
Total distance towed (nmi)	42,660	29,860
Ft per nmi	6076	6076
Total distance towed (ft)	2.385×10^9	1.814×10^9
Average dredge width (ft)	9.2	9.2
Area towed per year (ft^2)	2.385×10^{10}	1.669×10^{10}
Square ft per n mile	3.69×10^7	3.69×10^7
Area towed per year (nmi^2)	64.6	45.2
a = From clam vessel logbook data, excludes Maine quahog fishery		

The dry dredge used in the Maine fishery is a cage with wide skis and a series of teeth about 6 inches long in the front. These dredges are used on smaller boats (about 30 to 40 feet long) and are pulled through the seabed using the boat's engine. The cutter bar is limited to a width of 36 inches by State law. This fishery takes place in small areas of sand and sandy mud found among bedrock outcroppings in depths of 30 to > 250 ft in state and federal coastal waters north of 43˚ 20' N latitude. The dredges scoop up clams and sediment, and the vessel's propeller wash is used to clean out the sand and mud.

Effects and Evidence

Dr. James Weinberg (Northeast Fisheries Science Center - NEFSC) led the discussion of the direct physical and biological effects of hydraulic clam dredging, and Dr. Roger Mann (Virginia Institute of Marine Science - VIMS) led the discussion on the available evidence. Most of the evidence for dredging impacts that was considered by the panel was from the Northeast U.S., but there are studies from other areas that show the same effects. It was noted that early studies done in the Northeast region were conducted during development of the fishery, when clam dredging was more damaging to the habitat than it is now.

According to these studies, the direct physical effects of hydraulic clam dredging are basically two-fold. First, a trench about 8 inches deep is left behind the dredge and windrows of sediment and organisms are formed on either side of the trench. The second direct physical effect is the resuspension of sediment. If a dredge goes through silt or loose sediment, it produces a sediment cloud. In the panel's judgement, fine sediment may take as long as 24 hours to resettle and would end up outside the trench, while heavier particles would settle much more rapidly, primarily back into the trench. The evidence for physical effects (trench, windrows, and sediment re-suspension) is strong because these effects are so obvious.

Physical impacts to bottom habitat last longer (months) in low energy environments than in high energy environments (hours). In sand, the sides of the trench start to erode as soon as it is cut; this happens more rapidly when bottom currents are strong. The rate at which it fills in depends on the grain size of the sediment, water depth, and the strength and frequency of storms and bottom currents. It was noted that there are permanent, longshelf, sand ridges with low elevation off the New Jersey coast, but there is no evidence to indicate that clam dredges remove them, even though they may be towed through them.

The direct biological effects of hydraulic dredges vary, depending on whether organisms are hard-bodied like clams or soft-bodied like amphipods or polychaetes. What happens when a clam dredge goes through an area is not fully known and more study is needed. It was noted that structure-forming epifauna such as anemones and sponges would clearly be removed. Emergent epifauna growing on shell beds in the mid-Atlantic Bight is known to provide cover for juvenile fish species like black sea bass. Removal of these organisms, or their burial by re-suspended sediments, could therefore cause the loss of habitat for some species of juvenile fish.

It is not clear what happens to soft-bodied organisms that are moved by the dredge or pass through the trench and are deposited back on the seafloor. Often, after an area is dredged, scavengers move in rapidly and eat broken clams and soft-bodied organisms that are removed from the substrate. However, the panel considered that evidence for effects on infaunal prey organisms was weak because there aren't many studies that link changes in benthic community structure in dredged areas to the food supply for fish, and those that do exist do not show definitive results. The panel concluded that infaunal communities would be likely to recover more quickly than emergent epifauna, and therefore removal of structure-forming organisms was judged to be more of a concern. However, one panelist noted that the potential loss of secondary production of benthic invertebrates which are prey for bottom-feeding fish is the effect that is least understood, and that any reduction in prey abundance – if it occurs – would not necessarily be limited to the dredge tracks themselves, but would affect the entire dredged area. Moreover, the effects of fluidizing the sediment on benthic infauna are unknown and may be important.

The panel noted that there may be cumulative physical and biological effects in areas that are dredged several times annually. As previously stated, surfclams grow much more rapidly than ocean quahogs and surfclam beds are dredged every few years, whereas areas dredged for ocean quahogs are left untouched for many years. It was also noted that benthic organisms that occupy muddy bottom in deep water are less adapted to physical disturbance and therefore would presumably take longer to recover from dredging than organisms in sandy bottom areas in shallower water.

Conclusion

The panel concluded that the habitat effects of hydraulic dredging were limited to sandy substrates, since the gear is not used in gravel and mud habitats (Table 3). Two effects -changes in physical and biological structure – were determined to occur at high levels. The evidence cited for these two effects was a combination of peer-reviewed scientific literature, gray literature, and professional judgement. There are no effects of hydraulic dredges on major physical features in sandy habitat because, in the panel's view, there are no such features on sandy bottom. Panel members evaluated changes to benthic prey as unknown.

The temporal scale of the effects varies depending on the background energy of the environment. Recovery of physical structure can range from days in high energy environments to months in low energy environments, whereas biological structure can take months to years to recover from dredging, depending on what species are affected.

Table 3. Impacts of Clam Dredges on Benthic Habitat

TYPE OF IMPACT	DEGREE OF IMPACT	DURATION	TYPE OF EVIDENCE	COMMENTS
MUD				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	N/A			
Impacts to Physical Structure	N/A			
Changes in Benthic Prey	N/A			
SAND				
Removal of Major Physical Features	Unknown			
Impacts to Biological Structure	XXX	Months - Years1	PR, GL, PJ	1 Dependent upon species composition (eg. Amphipod tubes < 1 yr recovery)
Impacts to Physical Structure	XXX2	Days - Months	PR, GL, PJ	2 Represents major alteration to regime for soft bodied organisms
Changes in benthic prey	Unknown			
GRAVEL				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	N/A			
Impacts to Physical Structure	N/A			
Changes in benthic prey	N/A			

KEY: X = Effect can be present, but is rarely large; XX = Effect is present and moderate; XXX = Effect is often present and can be large; N/A = Effect is not present or not applicable; Unknown = effects are not currently known; (H) = High energy environment; (L) = Low energy environment; PR = Peer reviewed literature; GL = Grey literature; PJ = Professional judgement. For definitions of Substrate Type and Type of Impact see Appendix D.
NOTE: Ongoing Canadian studies for clam dredges are near completion and will contribute substantially to this discussion.

The panel agreed that hydraulic dredges have important habitat effects, but even in a worse case scenario, where there were known to be severe biological impacts, only a small area is affected and therefore this gear type is less important than other gear types like bottom trawls and scallop dredges which affect much larger areas. It was also pointed out, however, that even though the effects of dredging (at least for surfclams) are limited to a relatively small area, localized effects of dredging on EFH could be very significant if the dredged area is a productive habitat for one or more managed fish resource. The same would be true if dredging in a particular area coincided with a strong settlement of larval fish. A major question for this gear is "what are its long-term biological impacts" *i.e.*, how, and to what extent, are benthic communities altered in heavily dredged areas, particularly the prey organisms, and how long does it take for them to recover once dredging ceases?

Management

Dr. William DuPaul (VIMS) led the discussion on the types of management actions that could be taken to minimize adverse impacts of hydraulic dredging to benthic habitat.

The effectiveness of the Individual Transferable Quota (ITQ) management program since 1990 and the opinion that the two resources are underfished, led the panel to conclude that reductions in effort are probably not practicable. Nor is it likely that gear substitutions or modifications are practical since the current gear is highly efficient at harvesting clams. Therefore spatial area management seems to be the only practicable approach to minimizing gear impacts, if necessary.

It was emphasized that hydraulic dredges are designed to operate in sandy substrate. This gear could be very destructive if fished in the wrong sediment type or in structured environments like gravel beds or tilefish pueblo villages. The panel emphasized the gear should not be used in sediment types where it would cause more damage. Areas of known structure-forming biota should be mapped and set aside as a priority. It was emphasized that since we really do not know what the effect of this gear is to soft-bodied benthic organisms, a possible precautionary measure would be to restrict the fishery to areas of high clam productivity. Seasonal closures were mentioned if times and areas of high recruitment could be detected.

SCALLOP DREDGES

Gear Description

Dr. DuPaul led the discussion on scallop dredges. The New Bedford scallop dredge was described during a general review of scallop dredges and their use. This dredge is the primary gear used in the Georges Bank and mid-Atlantic sea scallop (*Placopecten magellanicus*) fishery. The scallop dredge used in coastal waters of the Gulf of Maine was also described briefly. The European scallop dredge was briefly discussed.

The forward edge of the dredge includes the cutting bar, which rides above the surface of the substrate, creating turbulence that stirs up the substrate and kicks objects up from the surface of the substrate (including scallops) into the bag. Shoes on the cutting bar are in contact with and ride along the substrate surface. The bag is made up of metal rings with chafing gear on the bottom and twine mesh on the top, and drags on the substrate when fished. New Bedford dredges are typically 14 feet wide; two of them are towed by a single vessel at speeds of 4 to 5 knots. Dredges used along the Maine coast are smaller (5.5 to 8.5 ft). Towing times are highly variable, depending on how many marketable sized scallops are on the bottom and the location. Scallops are shucked at sea, but small amounts (< 50 baskets) are returned to shore whole for specialty markets.

In the Northeast region, scallop dredges are used in high and low energy sand environments, and high energy gravel environments. Although gravel exists in low energy environments of deepwater banks and ridges in the Gulf of Maine, the fishery is not prosecuted there.

Effects and Evidence

Dr. Valentine led the discussion on the effects of scallop dredging and Dr. Weinberg led the discussion on the available evidence. The panel noted that much of the scientific literature is based on the European dredge, which differs in structure and use from the New Bedford dredge. The leading edge of the European dredge contains teeth which dig into the substrate. This type of gear is used by smaller vessels that are not able to tow a non-toothed dredge fast enough (4-5 knots is necessary) to fish effectively. The panel noted that because of these differences, research using the European dredge was not completely relevant to North American scallop fisheries or the habitats in which they are found, and should only be applied in a limited fashion.

An analysis of vessel monitoring system (VMS) data for vessels in the scallop fishery provided to panel members at this workshop revealed that the scallop fishery is highly concentrated. Total fishing activity (dredges and trawls) in year 2000 was dispersed throughout 12,800 one square nautical mile sub-areas, but 81% of the total catch was harvested in only 2,946 of these sub-areas. A full description if this information that includes plots of fishing activity in 1998 and 1999 is in Appendix G. One panelist noted that based on his analysis of logbook data from the mid 1980s to the mid 1990s, the distribution of fishing effort for scallop dredges in the Northeast U.S. was patchy, with areas that were fished intensively and other areas that were fished very lightly, and generally did not overlap with areas that were fished heavily with bottom trawls.

The findings of the studies summarized in the white paper which took place in the Northeast region were discussed and considered to be applicable to other areas of similar habitat type within the region. These findings included:

- disruption of amphipod tube mats and decline in dominant megafaunal species in gravelly sand in the Gulf of Maine from fishing (Langton and Robinson 1990);
- increased epifauna (hydroids, bryozoans, sponges, serpulid worms and sea cucumbers) on a cobble/shell bottom in an area on the Maine coast closed to dredging and trawling in 1983 (Auster et al. 1996);
- disturbance of storm-created coarse sand ripples (10-20 cm high) by scallop dredges on Stellwagen Bank, in the southwestern Gulf of Maine (Auster et al. 1996);
- increased abundance of emergent sponges inside a sandy area closed to dredging and trawling for 4.5 years (Almeida et al. 2000);
- redistributed gravel, pebbles, and boulders, flattened sand and mud bedforms, and resuspended fine sediments caused by mussel and scallop dredging in lower Narragansett Bay, Rhode Island (DeAlteris et al. 1999);

- reduced epifaunal community, smoother bottom, and disturbed and overturned boulders in gravel areas on Georges Bank affected by dredges and trawls compared to unfished areas (Valentine and Lough 1991);
- reduced densities, biomass, and species diversity of megabenthic organisms in disturbed gravel habitat on Georges Bank (Collie et al. 1997);
- higher percent cover of emergent colonial epifauna in undisturbed gravel habitat sites on Georges Bank (Collie et al. 2000).

A number of international studies were also discussed. Although the gear differed in some of these studies as described above, findings in these studies were considered to be relevant. The findings were as follows:

- long-term shifts in benthic community composition in the Wadden and Irish Seas following the introduction of scallop dredging (Reise and Schubert 1987, Hill et al. 1999);
- increased abundance of some epifaunal species (sea urchins and some crustaceans) in gravel areas closed to dredging in the Irish Sea (Bradshaw et al. 2000);
- mortality of large epifauna and sand lance (*Ammodytes*) in the path of the trawl in high energy sand in Scotland, with no significant effects on abundance of mollusc or crustacean infauna (Eleftheriou and Robertson 1992);
- loss of emergent tubes and sediment ripples and decreased density of common macrofauna from dredging in sub-tidal sand flats in New Zealand, with complete faunal recovery within a few months (Thrush et al. 1995);
- reduced abundance of 6 of the 10 most common benthic infaunal species from dredging, with recovery within 6 months for most, but greater than 14 months for a few, in mud and sand habitat in Australia (Currie and Parry 1996).

The panelists agreed that effects and their significance vary by habitat type, and that research results could not be applied widely across habitat type. The panelists also agreed that the first pass of a dredge over an undisturbed area is expected to have more significant effects than subsequent passes and that the return of cut shell-stock to the environment could enhance sea floor structure and provide substrate for settling scallop larvae. There was some discussion about the discarding of viscera from shucked scallops and its value to EFH, but no consensus was reached.

Several studies conducted on Georges Bank were discussed in detail. Valentine and Lough (1991) compared trawled and dredged gravel areas with undisturbed gravel areas and noted that the epifaunal community was more diverse with abundant attached organisms at the undisturbed sites. Subsequent research by Collie et al. (2000) in gravel pavement habitat showed that *Filograna implexa*, a colonial, rock-encrusting polychaete, and bushy colonial epifauna such as bryozoans and hydroids, were more abundant in the undisturbed areas. The study by Almeida et al. (2000) showed an increased abundance of emergent sponges (*Suberites ficus* and *Polymastia* sp.) on sandy bottom at stations inside Groundfish Closed Area II four and a half years after it was closed, compared to stations just outside the area that have remained open to bottom fishing.

The panel clarified that the results of the studies done on gravel bottom on Georges Bank could be applied to dredged areas in the Gulf of Maine where the same taxa are present in hard bottom habitats, but not to sandy scallop fishing grounds in southern New England and the mid-Atlantic Bight where different emergent epifaunal species are present and where there are fewer epifaunal organisms growing on the bottom. Panel members agreed that structure-forming biota that are present in sandy habitats are just as vulnerable to scallop dredging as in gravel habitats, but that the biological impacts of dredging on emergent epifauna are less significant in high energy sand environments because the organisms are better adapted to sediment disturbances caused by storms and strong bottom currents and therefore recover more quickly from dredging. It was noted that hard bottom benthic habitats in the Gulf of Maine and in deeper water on Georges Bank are more vulnerable to bottom mobile gear than sand bottom habitats south of Cape Cod because they support more diverse and prolific epifaunal communities and because recovery times are slower. It was also noted that long-term effects are more significant than short-term effects and are harder to differentiate from effects caused by environmental changes.

There was some discussion about the indirect biogeochemical effects of sediment resuspension caused by dredging and trawling. It was noted that the re-suspension of fine sediments (clay, silt and fine-grained sand) could have important effects on habitat quality by releasing nutrients, metals and contaminants that are "trapped" in anaerobic bottom sediments. These effects would be negligible in shallow water, coarse sand habitats. The release of nutrients could be beneficial, but the release of metals and other contaminants could have adverse effects on pelagic and benthic habitats. Most of the research that has been done on this subject is in inshore coastal and estuarine waters, not in deeper, offshore waters.

There was also some discussion about the effects of scallop dredging on the functional value of benthic habitats for exploited marine resource populations. Two habitat functions mentioned were: 1) cover from predators provided for juvenile fish and prey species by emergent epifauna; and 2) the bio-energetic benefits of sand ripples and waves for bottom fish (e.g., flounders) that seek refuge from bottom currents. The panel noted that some studies have been conducted in these two subject areas and others are in progress.

Conclusion

The panel determined that the effects of scallop dredging were of greatest concern in the following three habitat types: high and low energy sand and high energy gravel. Scallop fishing does not generally occur in deep water, low energy gravel habitats. The basis for all the panel's conclusions regarding the degree of impact and recovery time estimates were a combination of peer reviewed literature, gray literature, and the panelists' professional judgement.

Low energy sand habitat occurs in deeper water, where the bottom is unaffected by tidal currents and where the only natural disturbance is caused by occasional storm currents. In this habitat type, the primary physical bottom features are shallow depressions created by scallops and other benthic organisms. Reduction of biological structure and changes in physical structure were both considered to occur at a high level as a result of scallop dredging (Table 4). Recovery of physical structure was expected to vary from days to months depending on how long it takes different species of animals to create new depressions in the seafloor. The degree of impact to biological structure in low energy sand habitats was judged to be high because emergent epifauna is more abundant in this more stable environment. Recovery from reduction in structural biota was expected to take from months to years.

Table 4. Impacts of Scallop Dredges on Benthic Habitat

TYPE OF IMPACT	DEGREE OF IMPACT	DURATION	TYPE OF EVIDENCE	COMMENTS
MUD				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	N/A			
Impacts to Physical Structure	N/A			
Changes in Benthic Prey	N/A			
SAND				
Removal of Major Physical Features	Unknown			
Impacts to Biological Structure	XXX (L) X (H)	Months - Yrs	PR, GL, PJ	
Impacts to Physical Structure	XXX (H, L)	Days - Months	PR, GL, PJ	Cut (shucked) shell provides additional structure.
Changes in Benthic Prey	Unknown			Disposal of shucked scallop viscera may alter local food sources - impacts unknown.
GRAVEL				
Removal of Major Physical Features	Unknown			
Impacts to Biological Structure	XXX (H) N/A (L)	Several Years (H)	PR, GL, PJ	(L)=deepwater banks, gravel ridges in GOM; fishery is not prosecuted here
Impacts to Physical Structure	XXX (H) N/A (L)	Months - Years (H)	PR, GL, PJ	(L)=deepwater banks, gravel ridges in GOM; fishery is not prosecuted here. Cut shell provides additional structure.
Changes in Benthic Prey	XXX (H) N/A (L)	Months - Years (H)	PR, GL, PJ	(L)=deepwater banks, gravel ridges in GOM; fishery is not prosecuted here

KEY: X = Effect can be present, but is rarely large; XX = Effect is present and moderate; XXX = Effect is often present and can be large; N/A = Effect is not present or not applicable; Unknown = effects are not currently known; (H) = High energy environment; (L) = Low energy environment; PR = Peer reviewed literature; GL = Grey literature; PJ = Professional judgement. For definitions of Substrate Type and Type of Impact see Appendix D.
NOTE: Ongoing Canadian experiments will be able to provide additional information in the near future.

In high energy sand habitats, effects on biological structure were considered to be low, since organisms in this environment would be adapted to a high degree of natural disturbance. Changes to physical structure such as smoothing out of sand ripples, sand waves, and sand ridges were rated as high. The range of recovery times for physical structure in high energy sand habitat was based on the rapid recovery time for sand ripples that are produced by bottom currents (days) and a longer time (months) for storm-created sand waves and ridges. Similar to low energy sand, recovery time for biological structure was expected to range from months to years. The range in recovery time was based on how long it would take for amphipod tubes to re-form compared to the growth rates of sponges and other longer-lived species. The panel did not have enough information to evaluate the effects of scallop dredging on benthic prey in sandy bottom and therefore concluded that the degree of this effect was unknown in both low and high energy habitats**.**

In high energy gravel habitat, the panel concluded that the degree to which biological structure was reduced by scallop dredging was high, as were changes in physical structure, and changes in benthic prey. Dredging disturbs gravel and pebbles, breaches gravel "pavement," and redistributes cobbles and small boulders. Recovery of physical structure in this habitat type was estimated to take anywhere from months to a year. Once gravel pavement is breached, it re-forms fairly quickly as the underlying exposed sand is removed by bottom currents leaving gravel behind as the predominant substrate. Attached epifauna known to be removed by scallop dredges in high energy gravel habitats include sponges, bryozoans, hydrozoans, and colonial polychaetes. Recovery times for biological structure were estimated as years (but fewer than ten years).

Since many of the structure-forming organisms that are removed from high energy gravel habitat by scallop dredges are either preyed upon by bottom-feeding fish or provide cover for invertebrates and small fish that are consumed by bottom-feeding fish, habitat impacts caused by changes in prey species composition and abundance were rated as high in this habitat type, with recovery times of months to several years, depending on which taxa are affected. Panel members noted that it was difficult to evaluate impacts to benthic prey in the absence of information linking known alterations in the species composition and abundance of benthic organisms to changes in the food supply for fish.

The panel acknowledged that impacts of scallop dredging to sand and gravel habitats represent two extremes in a continuum of effects (gravel being more vulnerable) and that what happens to mixed sediment habitat types that fall in between these two extremes is harder to evaluate. It was also pointed out that the more important question may not be what happens in the dredge path itself and how quickly the seafloor and the benthic community in the dredge path recovers, but instead what is the net impact of dredging on the affected environment and its value to marine resources?

Management

Dr. Michael Fogarty (NEFSC) led the discussion on the management of scallop dredge impacts. Three main approaches to minimizing habitat impacts were discussed: effort reduction, gear modification, and area management. Panelists noted that maintaining a high biomass of scallops would reduce harvesting time and therefore reduce the amount of bottom time devoted to dredging. Panelists also noted, however, that the high initial impact of the gear on habitat (from the first tow) could confound attempts to minimize impacts by reducing effort.

Suggestions for gear modifications included innovations to "float" the ring bag so it does not drag along the bottom. Use of a "hard dredge" which only has two skids in contact with the bottom was also discussed; however, panelists did not agree that this would be feasible since rigid frame dredges are reportedly difficult to use and cause a higher non-harvest mortality of scallops. Other gear modifications discussed included development of a foil that uses a vacuum to harvest scallops.

Many panelists spoke favorably about the use of area based management. Based on the distribution of scallop dredge fishing trips (Appendix G), the panel noted that there are many locations where scallop dredging does not occur. The panel discussed focusing fishing effort in productive areas and areas without sensitive habitats. Since scallop recruitment is episodic, some panelists felt that it was important that all areas be available for fishing. In a rotational area management system, the panel discussed keeping sensitive areas closed for a longer period of time. Panelists also noted that a comprehensive approach to area management that included consideration of the habitat impacts of gears used in other fisheries (e.g., bottom trawls) should be considered.

OTTER TRAWLS

Gear Description

Mr. Frank Mirarchi (Boat Kathleen A. Mirarchi, Inc.) and Mr. James Lovgren (F/V Sea Dragon) identified the types of otter trawl gear used in the northeast. They stressed the diversity of otter trawl types used in this region, explaining that the diversity of gear types was a result of the diversity of fisheries prosecuted and bottom types in the region. The specific gear design used is often a result of the target species (whether they are found on or off the bottom) and the composition of the bottom (smooth versus rough and soft versus hard). The presenters described the various components of otter trawls, including the sweeps, the net body, bycatch reduction devices, bridles or ground cables, and the doors. The sweeps can be chain-wrapped wire, rubber cookies, rockhoppers, rollers, street-sweepers, or tickler chains. The net body depends upon the head rope height, the amount of overhang, and the mesh sizes of the various net panels. Bycatch reduction devices include the Nordmore grate and mesh panels. Types of bridles include chain, bare wire, covered wire, or seine rope. Trawl doors can be polyvalent, flat, or vee type.

Small mesh nets are used to target whiting and squid, and these configurations usually employ a light chain sweep. Flatfish are primarily targeted with a mid-range mesh flat net that has more ground rigging and is designed to get the fish up off the bottom. A high rise or fly net is also used with larger mesh. There are three components of the otter trawl that come in contact with the bottom: the doors; the ground rigging behind the doors; and the sweep.

The panel members discussed these descriptions, noting that otter trawls are actually very complex systems designed to target specific types of fish rather than simple sieves used to collect everything in their path. Fish herding is an important aspect of trawl design and depends upon the hydrodynamic forces of the doors and the sediment clouds generated by the ground rigging and sweep. Panel members reported that roller gear is obsolete in the Northeast, having been replaced by rockhopper gear. Rockhopper gear is no longer used only on hard bottom habitats, but is actually quite versatile for use on a variety of habitat types.

The panel considered the weight in water of the different otter trawl configurations, relative to their weight on land. Contrary to some assumptions, rockhopper gear is not the heaviest type of otter trawl in use in this region as it loses 80% of its weight in water (i.e., a rockhopper rig that weighs 1000 pounds on land may only weigh 200 pounds in water). Streetsweeper gear is much heavier due to the use of steel cores in the brush components. Cookie gear can be heavier as it retains 80-85% of its weight in water. Plastic-based gear has the smallest weight in water to weight on land ratio, at approximately 5%. The panel agreed that the weight of the gear in water is a very important consideration in understanding the relative effects of different otter trawl configurations.

Effects and Evidence

The discussion leaders for the effects of otter trawling were Dr. Robert Van Dolah (South Carolina Department of Natural Resources) and Dr. Ellen Kenchington (Department of Fisheries and Oceans, Canada). At the outset of the discussion, the panel agreed to two general points: first, otter trawls are one of the most studied fishing gear types; and second, otter trawls are one of the most widely used fishing gears. The effects of otter trawls are believed to vary by the specific configuration used, by the intensity of the trawling activity, and by the type of habitat in which the gear is used. Some of the panel members were of the opinion that benthic habitats are dynamic systems, and the changes that result from otter trawling may not necessarily be detrimental.

The panel members discussed a variety of direct effects of the gear operating on the bottom. These effects included: 1) the scraping or plowing of the doors on the bottom, sometimes creating furrows along their path; 2) sediment resuspension resulting from the turbulence caused by the doors and the ground gear on the bottom; 3) the removal or damage to non-target species such as benthic or demersal predators; and 4) the removal or damage to structure-forming biota. The relative significance and/or duration of these effects often depends upon whether the gear is used on low versus high energy environments (these environments could also be thought of as stable versus unstable). It was mentioned during discussion that with the exception of the doors, the trawl gear has to be relatively light on the bottom to maintain its shape and effectiveness. If it rides too heavily on the bottom the gear would collapse in on itself.

Some panel members stated that even relatively light trawl gear will still have an impact on structure forming taxa. Discussion included the opinion that static weight of the gear alone is not the only factor to consider, but that the horizontal and vertical forces on the gear (i.e., the speed of the vessel) are also important considerations. It was agreed that more research is needed to better understand the relationships of gear weight and the forces on the bottom and the differences between gear types.

The panel members also discussed some potential indirect effects of the gear operating on the bottom. The indirect effects included: 1) altered trophic function of benthic communities, primarily caused by a reduction or change in large biota, a reduction or change in predators, or a reduction or change in epiphytes; and 2) altered demersal communities, primarily caused by a loss of structure-forming biota and an alteration of physical features.

The most significant potential effects of otter trawls identified by the panel included long-term changes in bottom structure and long-term changes in benthic trophic function or ecosystem function. The panel suggested that these changes may result either from a reduction of organisms or the replacement of organisms. The potential replacement of some organisms with other organisms is significant because this may prevent the ecosystem from being able to return to its original state, even in the complete absence of fishing activity.

The panel discussed a proposed model for determining the degree of effect on various habitats. The model ranked habitat types along a continuum from mud/sand with no major epifauna or structure-forming biota in a high energy environment to gravel/hard bottom with abundant epifauna and/or structure-forming biota, and suggested that the degree and duration of the effects on these habitat types ranged from lowest for the mud/sand with no major epifauna or structure-forming biota in a high energy environment to highest for the gravel/hard bottom with abundant epifauna and/or structure-forming biota. This model utilized a variation of the major categories of effects previously described: 1) removal of physical features, 2) reduction of structural biota (impacts to biological structure), and 3) reduction of habitat complexity and sea floor structure (impacts to physical structure). Generally, there was a low level of concern for the effects of trawling in mud and sand habitats without major epifauna or structure-forming biota, but a high level of concern for gravel and hard bottom habitats with epifauna and/or structure-forming biota. There was some discussion among the panel members as to whether mud deserved its own category, based on the deep-water basins in the Gulf of Maine that contain long-lived epifauna, but there was no consensus on this issue. The degree and duration of a fourth category of effect, changes in benthic prey, was suggested as being case specific. This conceptual model is discussed in more detail in a subsequent section.

The panel discussion identified several indirect effects of otter trawls on different habitat types, including the attraction/movement of scavengers into the area behind the trawl and changes in diatoms and other primary producers. It was suggested that although scavengers are attracted to areas recently trawled, they do not move in from great distances. Rather, the scavengers that are already in the general vicinity do well, but there are not significant increases in the numbers of these scavengers. It was also suggested that there may be important cascading effects of the changes in diatoms and other primary producers.

The panel discussed the changes in habitat complexity resulting from the tracks made by the doors in further detail. The door tracks themselves create an increase in complexity at the scale for small organisms, but there is a net loss in complexity due to the reduction of biogenic structure. The panel also discussed the duration of effects and agreed to define "long-term" as whenever the recovery period is longer than the natural period of disturbance. The panel agreed that the duration of effect would be greater in habitats toward the gravel/hard bottom with epifauna and/or structure-forming biota end of the continuum identified above.

Following the discussion on the types and relative importance of the different effects of otter trawling on benthic habitats, the panel discussed the strength of the scientific evidence for these effects. This discussion was led by Dr. James Lindholm (Stellwagen Bank National Marine Sanctuary). The panel agreed that there is a great deal of literature to apply to otter trawl fishing activities in the northeast. Most of the available information can be applied to otter trawls in general and deals with chronic effects rather than acute effects. The most difficult issue remains establishing the link between the alteration of the habitat and the effects on biological communities.

It was suggested that ultimately, to make real progress on these issues, we need to be able to look at the differential effects of fishing gear on different types of habitats, and be able to do this by the type of otter trawl rather than only considering otter trawls in general. The current situation is limited to the generalized effects of otter trawls, without the ability to tease out the good and bad elements of these fishing activities. This situation also creates a problem for conservation engineering because there are no specific objectives or problems to solve, only generalities.

In spite of this problem, there was agreement that the general principles and results of the worldwide body of literature on the effects of otter trawling on benthic habitats were applicable to the northeast, even though the gear used might be slightly different. Of all the gears the panel has been charged with considering, otter trawls represent the type where the results of studies from other areas are the most applicable. The panel generally agreed that there was strong evidence in the scientific literature for each of the four primary types of effects as identified earlier.

Conclusion

The panel concluded that the greatest impacts from otter trawls occur in low and high energy gravel habitats and in hard clay outcroppings (Table 5). In gravel, the greatest effects were determined to be on major physical features, and physical and biological structure of the habitat. The panel found it was unable to reach consensus on the degree of impact for sand and low energy mud habitats, but a majority of panel members agreed upon the final conclusions in Table 5.

In gravel and other hard bottom habitats, the degree of impact of otter trawls on major physical features, physical structure, and biological structure were all considered to be high in both low and high energy environments. Major physical features in this habitat type are boulder mounds, which can be knocked down by trawls. Once this happens, the mounds can never be re-formed, and the resulting changes are permanent. Trawls also cause alterations to physical structure by redistributing cobbles and boulders and breaching gravel pavement. Impacts to biological structure in gravel were of greater concern to the panel than impacts to biological structure in other habitats because structural biota is more abundant on gravel bottom. Effects to physical and biological structure of these habitats were judged to last from months to years. The basis for all the panel's conclusions were professional judgement, peer-reviewed literature, and gray literature. Changes to benthic prey caused by trawling were considered to be unknown. In mud habitats, the panel distinguished between hard clay outcroppings that occur in deep water on the outer continental shelf and soft mud (silt and clay) sediments found in deep water basins in the Gulf of Maine and many shallower locations on the shelf. Bottom trawling takes place in both of these habitat types.

Clay outcroppings are found on the slopes of submarine canyons that intersect the shelf on the southern edge of Georges Bank and the New York Bight. These outcroppings provide important habitat for tilefish (*Lopholatilus chamaelonticeps*) and other benthic organisms which burrow into the clay. Based on the panel's professional judgement, removal of this material by trawls was considered to be a permanent change to a major physical feature, and was rated as a high degree of impact. The panel determined that trawls could also cause a high degree of impact to the physical structure of hard clay habitat that could last from months to years. This determination was based on peer reviewed and gray literature, and the panel's professional judgement. Due to a lack of information, the panel was not able to rate impacts to biological structure or benthic prey in this habitat type.

The panel did not reach consensus on the degree to which otter trawls affect physical and biological structure in soft mud habitats. However, most panelists agreed that impacts to biological structure (including worm tubes and burrows) and physical structure were moderate. Panelists agreed that these impacts would be expected to last from months to years. Peer reviewed and gray literature and professional judgement were relied on to make determinations about impacts to physical structure, while professional judgement was the only basis for determination of impacts to biological structure. A lack of information prevented the panel from drawing conclusions about impacts to benthic prey. Panelists determined that removal of major physical features was not a concern in this relatively featureless habitat.

Determining the impacts from trawling on sand habitat was particularly difficult for the panel. There was no consensus on the degree of impact to biological or physical structure, or to benthic prey, in high and low energy environments. However, with one exception, the panelists agreed that these impacts were moderate. Trawl induced changes to physical structure in high energy sand were rated as low. Recovery times for biological structure and prey were considered to range from months to years, and for physical structure from days to months. The basis for all determinations was peer reviewed and gray literature, and professional judgement. The panel determined that removal of major physical features was not an impact that applied in what is a relatively featureless environment.

There was a general consensus that the acute impacts of bottom trawls (i.e., impacts caused by a single tow) on physical and biological structure are less severe than for a scallop dredge, but the chronic impacts resulting from repeated tows are more severe for trawls because a greater bottom area is affected by trawling than is affected by scallop dredging. Additionally, otter trawls are towed repeatedly in the same locations, much more so than scallop dredges and clam dredges. One panel member pointed out that the only part of a trawl that disturbs the bottom in the same manner as a scallop dredge is the door - the rest of the trawl behaves very differently. Another panel member reiterated that there are a large variety of trawls in use in the Northeast U.S. Some (squid nets, high rises) are very light trawls that barely contact the bottom at all, whereas others (flatfish nets) "hit hard" which makes it difficult to generalize the impacts associated with this gear. It is important to recognize that the greatest challenge the panel faced in drawing their conclusions is the fact that there is such a wide variety of otter trawl gear in use over a very wide range of habitat types and known impacts from trawl gear is aggregated and not typically attributed to a specific gear configuration.

Table 5. Impacts of Otter Trawls on Benthic Habitat

TYPE OF IMPACT	DEGREE OF IMPACT	DURATION	TYPE OF EVIDENCE	COMMENTS
MUD				
Removal of Major Physical Features	XXX (H) N/A (L)	Permanent	PJ	(H) in Mud referrs to clay (i.e., tilefish burrows) in all cases
Impacts to Biological Structure	Unknown (H) XX* (L)	Months - Yrs	PJ	(L) opinions ranged from X-XXX
Impacts to Physical Structure	XXX* (H) XX* (L)	Months - Yrs	PR, GL, PJ	(L) opinions ranged from XX-XXX and unknown
Changes in Benthic Prey	Unknown			
SAND				
Removal of Major Physical Features	N/A	N/A	N/A	
Impacts to Biological Structure	XX* (H, L)	Months - Years	PR, GL, PJ	(H) opinion ranged from X-XXX (L) opinion ranged from XX-XXX
Impacts to Physical Structure	X* (H) XX* (L)	Days - Months	PR, GL, PJ	(H, L) opinion ranged from X-XXX
Changes in Benthic Prey	XX* (H, L)	Months - Years	PR, PJ, GL	(H) opinions were XX or unknown (L) ranged from X-XXX and unknown
GRAVEL				
Removal of Major Physical Features	XXX (H, L)	Permanent	PR, GL,PJ	
Impacts to Biological Structure	XXX (H, L)	Months - Years	PR, GL, PJ	
Impacts to Physical Structure	XXX (H, L)	Months - Years	PR, GL, PJ	Rocks altered or relocated
Changes in Benthic Prey	Unknown			

KEY: X = Effect can be present, but is rarely large; XX = Effect is present and moderate; XXX = Effect is often present and can be large; N/A = Effect is not present or not applicable; Unknown = effects are not currently known; (H) = High energy environment; (L) = Low energy environment; PR = Peer reviewed literature; GL = Grey literature; PJ = Professional judgement. For definitions of Substrate Type and Type of Impact see Appendix D.

NOTE: Ongoing Canadian experiments will be able to provide additional information in the near future.

* This does not represent a consensus among the panel

Management

Dr. Joseph DeAlteris, (University of Rhode Island) was the discussion leader for the management section and offered a framework of management approaches that could be considered for reducing the impacts associated with otter trawls on benthic habitats. The approaches included effort reductions, area restrictions, and gear improvements. He acknowledged that fishing effort by bottom-tending mobile gear has been reduced approximately 50% in the Northeast over the last ten years. He also acknowledged that the existing year-round closed areas (Georges Bank Closed Areas I and II, the Nantucket Lightship Closed Area, and the Western Gulf of Maine Closed Area) have been effective at reducing fishing-related impacts within the areas. He suggested that there are ways to make fishing gear more “habitat-friendly” by lowering the associated turbulence and making the gear lighter on the bottom, but stressed that these efforts would require cooperative work with the fishing industry and specific goals and objectives. Overall, the panel agreed with the discussion leader on these points as general principles.

The panel discussed these management approaches. Panel members suggested that reductions in effort do not necessarily translate into similar reductions in impacts, while area closures guarantee protection to the areas closed that effort reductions cannot. Panel members also suggested that what is really needed is an adjustment to fishing capacity, and that over-capacity in the fleet is forcing people to fish in ways and in areas that they otherwise would not. Excess fishing power results in people fishing very inefficiently at lower catch-per-unit-effort (CPUE) than would otherwise occur and this results in increased fishing time. The panel members suggested that conservation engineering is a key management factor to develop fishing gears that have less impact on benthic habitats. It was also suggested that the concept of closed areas should be revisited to target specific habitats and bycatch concerns, and that the areas closed could be more discrete.

The panel also identified the link between effort reduction and specific closed areas as an important consideration in evaluating the effectiveness of management measures. By itself, effort reduction may not accomplish the objective of reducing impacts to habitat. Ideally, the three components identified by the discussion leader (effort reduction, closed areas, gear improvement) would be used together to manage fishing activities. The panel was cautioned that the concept of effort reduction is not necessarily as simple as it sounds. Managers must be able to deal with latent effort and changes in fishing behavior, the differences between nominal effort and effective effort, and issues related to effort displacement. For example, in response to a reduction in the allowable fishing effort, vessels may move inshore, but this could increase the impacts to inshore habitats.

The panel agreed that another management challenge will be the need to consider how to protect habitat from adverse impacts from otter trawls and other fishing gears in the context of a rebuilt fishery when fishing effort would likely increase.

POTS AND TRAPS

Gear Description

Pots and traps were described by Mr. Arnold Carr (Massachusetts Division of Marine Fisheries). Mr. Carr's descriptions focused on lobster, seabass, scup, red crab and hagfish pots. Even though the intent of the workshop was to focus only on gears used in federally-managed fisheries, lobster pots were included because they are by far the most commonly used gear in this category and because they could potentially affect habitats that support federally-managed resources.

<u>Lobster Pots</u>: Mr. Carr pointed out that these are fished as either 1) a single pot per buoy (although two pots per buoy are used in Cape Cod Bay, and three pots per buoy in Maine waters), or 2) a "trawl" or line with up to 100 pots. It was also pointed out that habitat impacts

are probably due mostly to the pots and the mainline between pots, not the buoy line. Other important features of lobster pots and their use were the following:

- About 95% of lobster pots are made of plastic-coated wire.
- Floating mainlines may be up to 25 feet off bottom.
- Sinklines are sometimes used where marine mammals are a concern - neutrally buoyant lines may soon be required in Cape Cod Bay.
- Soak time depends on season and location - usually 1-3 days in inshore waters in warm weather, to weeks in colder waters.
- Offshore pots are larger (more than 4 ft long) and heavier (~ 100 lb.), with an average of ~ 40 pots/trawl and 44 trawls/vessel; they usually have a one-week soak and a floating mainline.
- There has been a three-fold increase in lobster pots fished since the 1960s, with more than four million pots now in use.

Other Pots: Seabass/scup and red crab pots are similar in design to lobster pots. Seabass/scup pots are usually fished singly or in trawls of up to 25 pots, in shallower waters than the offshore lobster pots and red crab pots. Pots may be set and retrieved 3-4 times/day when fishing for scup. The red crab fishery uses 400-600 pots/vessel, hauled on a daily basis, and operates on the continental slope and canyons. Hagfish pots (40 plastic gallon barrels) are fished in deep waters, on mud bottoms.

Effects and Evidence

Mr. Carr led the discussion on the habitat effects that can be attributed to pots. Most of the discussion focused on lobster pots. The primary direct impacts of any kind of pot are the scouring of the bottom and injury or death to benthic organisms that occur directly under the pot or in its path when it is retrieved. The total impact is thus the aggregate effect of the pot's "footprint," the area through which it is dragged when it is hauled (which may be 2-3 times larger than its footprint), any damage caused by the mainline in a trawl of pots, the number of pots that are in use in any period of time, and the number of times each pot is hauled. Although panel members agreed that the habitat impacts caused by individual lobster pots were minimal, they believed that the cumulative effects of so many pots could be significant, especially in sensitive habitat areas of high structural complexity. Panel members also mentioned that lobster pots normally remain on the same place on the bottom for days at a time and that they are set repeatedly in certain heavily-fished areas; both of these factors further magnify their site-specific impacts on benthic habitats.

Lobsters concentrate in coastal, hard substrate areas, offshore canyons, and in mud substrate with a high clay content where they produce burrows. The types of habitat that the panel considered most vulnerable to alteration by pot fishing were complex hard bottom habitats with abundant structural biota. The panel did not consider high-energy sand habitats to be vulnerable, and pointed out that lobster pots are usually not fished there except during times of the year when lobsters move across open areas of bottom.

Other observations made by panel members included the following:

- Sinking mainlines can turn over rocks and shear off epifauna when pots are hauled.
- Lobstermen tend to avoid using sinklines in rocks.
- Attached epifauna in low energy mud and sand habitats are susceptible to damage from sinklines, which are used in relatively flat, featureless bottoms.
- Baits used in pots enrich benthic ecosystems and may increase the abundance of infaunal benthic organisms in heavily-fished locations.
- Pots may also act as reef habitat, though this effect is reduced by their frequent retrieval.
- At certain times of year, pots indirectly provide some habitat protection by making areas inaccessible to mobile gear.

Dr. Doug Rader (Environmental Defense) led the discussion of the evidence and pointed out that there is some published evidence from Florida and the Caribbean of damage to hard substrates, benthic epifauna, and submerged aquatic vegetation. He also mentioned an evaluation of the habitat impacts of fish pots in the Gulf of Mexico as ranging from "an impact" to "a significant impact" (as opposed to "no impact" or an "extreme impact). The panel agreed that there is a paucity of information for the Northeast U.S., but studies from other regions are applicable if they address impacts to analogous species of emergent epifauna or types of biogenic structure.

Conclusion

The panel concluded (Table 6) that the degree of impact caused by pots and traps to biological and physical structure and to benthic prey in mud, sand and gravel habitats was low. In both mud and sand, the duration of impacts to biological structure could last for months to years, whereas physical structure and benthic prey should recover in days to months. Professional judgement was used to make the evaluations for benthic prey, while the panel relied on grey literature for the other types of impacts. In gravel, reduction of structural biota and changes in seafloor structure and benthic prey could all persist for months to years. Again, the panel relied on professional judgement to assess changes to benthic prey, while grey literature was also considered for the other impacts. In all three habitats, changes in benthic prey could be negative, due to damage by the gear, and may be positive or negative due to nutrient enrichment or food availability from bait.

Table 6. Impacts of Pots and Traps on Benthic Habitat

TYPE OF IMPACT	DEGREE OF IMPACT	DURATION	TYPE OF EVIDENCE	COMMENTS
MUD				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	X	Months - Years	GL, PJ	
Impacts to Physical Structure	X	Days - Months	GL, PJ	
Changes in Benthic Prey	X	Days - Months	PJ	Enrichment mediated effects, damage mediated effects due to baited gear
SAND				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	X	Months - Years	GL, PJ	
Impacts to Physical Structure	X	Days - Months	GL, JP	
Changes in Benthic Prey	X	Days - Months	PJ	Enrichment mediated effects, damage mediated effects due to baited gear
GRAVEL				
Removal of major physical features	N/A			
Impacts to Biological Structure	X	Months - Years	GL, PJ	
Impacts to Physical Structure	X	Months - Years	GL, PJ	
Changes in benthic prey	X	Months - Years	PJ	Enrichment mediated effects, damage mediated effects due to baited gear

KEY: X = Effect can be present, but is rarely large; XX = Effect is present and moderate; XXX = Effect is often present and can be large; N/A = Effect is not present or not applicable; Unknown = effects are not currently known; (H) = High energy environment; (L) = Low energy environment; PR = Peer reviewed literature; GL = Grey literature; PJ = Professional judgement. For definitions of Substrate Type and Type of Impact see Appendix D.

Management

The strongest recommendation made by the panel to minimize adverse effects of pots and traps was a reduction of effort, although it was recognized that reducing the total number of pots in use is not a complete solution since the remaining pots could be set more often or left for longer set times. Other suggestions made by panel members were:

- "Zoning" habitats (i.e., identifying zones within each habitat type for various uses, including habitat protection) and protecting sensitive areas (e.g., clay pipes).
- If pots can be made lighter without lifting off the bottom, impacts could be reduced.
- Minimizing the amount of line on the bottom would also be helpful.
- Fewer pots per string would reduce impacts of dragging the gear across the bottom.

These observations focused on lobster pots, but some apply to other types of pots as well. Pot fisheries for black sea bass and conch in certain locations are also characterized by a high density of pots which maximizes the likelihood of site-specific habitat impacts.

SINK GILL NETS AND BOTTOM LONGLINES

Gear Description

These two gears were described by Mr. Carr. Other types of bottom static gear (e.g., stake gill nets, handlines, electric or hydraulic reels) were not covered because they are not used extensively in federal waters.

Sink/Anchor Gill Nets: Individual gill nets are typically 300 feet long, and are usually fished as a series of 5-15 nets attached end-to-end. Gill nets have three components: leadline, webline and floatline. Fishermen are now experimenting with two leadlines. Leadlines used in New England are ~65 lb/net; in the Middle Atlantic leadlines may be heavier. Weblines are monofilament, with the mesh size depending on the target species. Nets are anchored at each end, using materials such as pieces of railroad track, sash weights, or Danforth anchors, depending on currents. Anchors and leadlines have the most contact with the bottom. Some nets may be tended several times/day, e.g., when fishing for bluefish in the Middle Atlantic; for New England groundfish, frequency of tending ranges from daily to biweekly.

Bottom Longlines: Mr. Carr was most familiar with longlines fished off Chatham, MA, where about six vessels use them. Up to six individual longlines are strung together, for a total length of about 1500 ft, and are deployed with 20-24 lb anchors. The mainline is parachute cord or sometimes stainless steel wire. Gangions (lines from mainline to hooks) are 15 inches long and 3-6 ft apart. The mainline, hooks, and gangions all come in contact with the bottom. Circle hooks are potentially less damaging to habitat features than other hook shapes. These longlines are usually set for only a few hours at a time. Other panelists noted that: 1) the soak time is regulated, such that the longlines cannot remain in the water for very extended periods; 2) longlines for tilefish in deep water may be up to 25 miles long, are stainless steel or galvanized wire, and are deployed in a zig-zag fashion; and 3) in the Southeast, longlines are prohibited in waters less than 300 ft deep (except for sharks), and are also prohibited in the wreckfish fishery (which is generally prosecuted in depths from about 1200-2000 ft). The prohibition is due to evidence of damage to corals, lost gear, and conflicts with other gears.

Effects and Evidence

Discussions of effects and strength of evidence were led by Dr. Robert Diaz (VIMS) and Dr. DeAlteris. It was noted that both gears are dragged over the bottom when they are retrieved. In addition, gill nets move around to some extent while they are on the bottom and longlines can be moved back and forth across the bottom if there is enough current or when hooked fish pull on the mainline. Dr. Diaz noted that direct effects could include alteration of physical structure and injury or death of emergent epifauna, while indirect effects could include alterations of benthic assemblages toward species that provide less cover or prey for demersal fish. He also pointed out that the amount of damage will depend on the frequency and duration of sets, and the amount and type of structure present. Mr. Carr, who has done research on lost or abandoned gill nets in New England, observed damage to bottom habitats caused by trapped schools of dogfish dragging the nets across the bottom.

Dr. DeAlteris noted that observations in an area off Alaska indicated that the effects of bottom longlines could be of the same type and magnitude as those caused by mobile gear, if longlines are used intensively in areas with abundant biological structure. However, these gears cause relatively little harm when used in non-sensitive habitats that have little or no vertical physical or biological structure. Vulnerable areas are those with 1-3 ft tall structure. Dr. DeAlteris also noted that in order to fully evaluate the significance of the habitat impacts of these two gear types in the Northeast region, the types of gear used and how they are used need to be matched up with the types of habitat where they are used. Two other factors to consider are the amount of gear used and the total area affected.

Except for observations of “ghost” gill nets, there are no studies of the habitat impacts of either of these gear types in the Northeast region. However, in the opinion of Dr. DeAlteris, studies from other areas could be applied to the Northeast, as long as the gear was used in the same type of habitat.

Several panel members noted that tilefish are unusually important in structuring the bottom in offshore canyon head areas. These areas then become important habitat for lobsters, crabs and other species, and that removal of these fish (with longlines) should perhaps be considered a habitat effect, as it may lead to reduced burrow-forming and maintenance. It was noted that part of the continental shelf break habitat for golden tilefish in the Southeast U.S. is now protected, and research is being done on the value of this habitat.

Conclusion

The panel concluded that sink gill nets and longlines cause some low degree impacts in mud, sand and gravel habitats (Table 7). In mud the impacts to biological structure could last for months to years. Duration of impacts to physical structure could be days to months on soft muds, and permanent if impacts were on hard bottom clay structures found in deep water on the continental slope. Impacts to physical structure in mud would be caused by lead lines and anchors used with sink gill nets, not by longlines. In the panel’s judgement, impacts in sand would be limited to biological structure and would last days to months. The panel’s evaluations of impacts in mud and sand habitats were based on professional judgement alone. Impacts in gravel would also be to biological structure, and the duration could be months to permanent (the latter if the damage involved corals), as indicated by peer review and gray literature, as well as professional judgement.

Table 7. Impacts of Sink Gill Nets and Bottom Longlines

TYPE OF IMPACT	DEGREE OF IMPACT	DURATION	TYPE OF EVIDENCE	COMMENTS
MUD				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	X	Months - Years	PJ	
Impacts to Physical Structure	X	Permanent[1] Days - Months[2]	PJ	[1] Refers to clays [2] Soft bottom muds
Changes in Benthic Prey	N/A			
SAND				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	X	Days - Months	PJ	
Impacts to Physical Structure	N/A			
Changes in Benthic Prey	N/A			
GRAVEL				
Removal of Major Physical Features	N/A			
Impacts to Biological Structure	X	Months - Permanent[1]	PR, GL, PJ	[1] corals
Impacts to Physical Structure	N/A			
Changes in Benthic Prey	N/A			

KEY: X = Effect can be present, but is rarely large; XX = Effect is present and moderate; XXX = Effect is often present and can be large; N/A = Effect is not present or not applicable; Unknown = effects are not currently known; (H) = High energy environment; (L) = Low energy environment; PR = Peer reviewed literature; GL = Grey literature; PJ = Professional judgement. For definitions of Sediment Type and Type of Impact see Appendix D.

Management

The panel agreed that better information is needed on the distribution of habitats that are sensitive to alteration from sink gill nets or bottom longlines, and recommended that sensitive habitats be protected through closures. It was also pointed out that there are areas where emergent epifauna would naturally grow, but has been removed by mobile bottom gear. The panel also suggested that gill net and longline vessels should have observers to record bycatch of benthic structural material.

BEAM TRAWLS

Description

Dr. Chris Glass (Manomet Center for Conservation Sciences) and Mr. Mirarchi led the panel discussion on beam trawls. The panel was unaware of any beam trawls being used in the Northeast U.S. at this time. A few beam trawls were used in the 1970s to catch monkfish, but the fishery was unsuccessful. In the mid 1990s, a number of boats off New Bedford used what were referred to as beam trawls, but the gear more closely resembled a scallop dredge rather than the traditional, European beam trawls. There are a few boats that are currently coded as beam trawls in the fishery landings database, but the panel felt that these were most likely miscoded and were otter trawls being deployed from the side of the vessels.

The panel also felt that it is unlikely that fishermen would begin using beam trawls in the Northeast U.S. Beam trawls are prevalent in the North Sea where the water is dark and murky and the fisheries target flatfishes, which sit slightly under the sediments. In these fisheries, the beam trawl acts to sieve the fish up off the seafloor. The lack of conventional herding effect and small mouth opening of the beam trawl would not be effective for harvesting U.S. target species. Furthermore, most vessels being used in the Northeastern U.S. do not have the size or power required to handle a beam trawl.

Effects and Evidence

There has been long standing concern (dating back to the 14th century) about the adverse effects resulting from the use of beam trawls. Therefore, there exists a large body of good information on the effects of this gear on different habitats.

Management

No management measures are necessary at this time. This issue should be revisited if beam trawls start being used in the Northeast in the future.

PELAGIC GEAR

Description

Dr. DeAlteris discussed a number of pelagic gear types used in the Northeast, including pelagic trawls, drift gill nets, purse seines and longlines. The discussion focused on the fact that, if operated correctly, pelagic fishing gear should only incidentally come into contact with the seafloor. Pelagic trawls, for example, are not designed to touch the seafloor and would be damaged by such contact. Furthermore, the trawl doors would be unstable and would not fish correctly. Purse seines are fished primarily in offshore areas to target tunas. Only a small number of vessels (5 or 6) use purse seines to fish for tunas in coastal waters. Drift (i.e., floating) gill nets and longlines (which are fished in deep waters) only inadvertnetly contact the seafloor. Paired midwater trawls have been banned except for herring, and drift gill nets, once employed for swordfish, are no longer in use.

Effects and Evidence

Dr. DeAlteris and Dr. Fogarty led the discussions on effects and evidence. It was stated that if pelagic gear were to incidentally contact the seafloor, the trawl doors, footropes, leadlines of stationary or floating nets, the nets themselves, or components of longlines could drag across benthic habitats or become entangled on benthic structures. Occasionally boats fishing with purse seines follow fish into shallow water depths where the height of the net (the only one the boat is equipped with) could cause dragging along the seafloor. In the Northeast, purse seines were permitted into Groundfish Closed Area II in 2000 and 2001 with observers. No benthic materials came up in the nets during those observed trips. A few boats observed in 1996 captured benthic materials in the net when it was fished in the shallow waters of Massachusetts Bay. This contact with the bottom is accidental and normally is avoided to prevent damage to the nets.

The opinion of the panel was that pelagic gear has a lower priority than gear that is intentionally dragged across the seafloor. There would be more concern over the potential effects of pelagic fishing gears if seafloor contact was other than incidental, or if there was evidence that contact occurred frequently. Therefore, the panel concluded that we need a better understanding of how often contact occurs. For example, West Coast fisheries that use purse seines such that they frequently contact bottom habitats are monitored with 100% observer coverage.

The panel also discussed ecosystem implications of pelagic gear due to removal of pelagic prey items. It was determined, however, that this issue would be more appropriately addressed through the population management provisions of the Magnuson-Stevens Act, rather than the EFH provisions of the Act.

Management

No management measures are necessary at this time, however, Councils and NMFS should consider increasing observer coverage to track, to the extent possible, the frequency that pelagic gear comes into contact with the seafloor.

CONCEPTUAL HABITAT IMPACT MODEL

Dr Fogarty and Dr. DeAlteris presented a conceptual habitat impact model which was partially described in the previous Otter Trawl section. Although this model has not been extensively reviewed and discussed by the panel, the panel agreed that the model did relate habitat impacts, structural complexity of habitats and recovery time rather well. Based upon the panel's agreement as to the merits of this conceptual model it is presented here in greater detail.

Habitat Classification and Assessment

The potential impacts of fishing gear on a habitat type are a function of the structural complexity of the habitat, the expected recovery time following a disturbance, and characteristics of the gear itself. Habitats characterized by high structural complexity (including emergent biological structures (EBS) such as attached macroalgae, epibenthic organisms etc.) are expected to exhibit higher levels of vulnerability to disturbance. The expected recovery time for a habitat is a function of its physical and biological characteristics and geological structure. For habitats with high complexity attributable to biological structure, the life history and generation times of the emergent or attached organisms will critically determine recovery times. Disturbance to geological structures such as cobble/boulder mounds may effectively be permanent. The expected recovery times for certain organisms that contribute to structural complexity of the environment (e.g. hard and soft corals) may be measured on decadal time scales. Conversely, disturbance to sand/mud substrates without emergent biological structure is expected principally to involve short term impacts and rapid recovery times.

Although a number of habitat classification schemes are possible (e.g. Auster 1998), most involve consideration of grain size characteristics and the presence or absence of biogenic structure. For the purposes of assessing priority for protection, we propose a simple classification scheme with the following categories:

mud/sand without emergent biological structure
mud/sand with emergent biological structure
small gravel (< 2cm) without emergent/attached biological structure
small gravel (< 2cm) with emergent/attached biological structure
shell aggregations and/or reefs without emergent/attached biological structure
shell aggregations and/or reefs with emergent/attached biological structure
cobble/boulder without emergent/attached biological structure
cobble/boulder with emergent/attached biological structure

We expect a general relationship between the structural complexity of these habitat types and recovery time from a disturbance. The specific geological and biogenic structures impacted by particular fishing gears will of course determine if recovery is possible and, if so, the expected time scales. Highest vulnerability to fishing gear occurs in habitat types with high structural complexity and long recovery times. Although the specific biological and geological characteristics of particular habitats must be assessed to determine vulnerability to fishing gear, we propose a general conceptual model for the purpose of defining areas of potential high vulnerability (Figure 1).

Consideration of the physical oceanographic characteristics in the habitats will also be critical. In high energy environments, we anticipate coarser grain size and biological communities adapted to disturbance. The expected impact of additional anthropogenic disturbance due to fishing activities must be assessed with respect to rates and magnitude of natural disturbance. In low energy environments, we anticipate biological communities that are not adapted to natural disturbance regimes and these communities may be particularly vulnerable to fishing gear impacts.

Consideration of priorities for protection must also consider the relative availability of particular habitat types. Rarer habitat types should be accorded high priority for protection with the highest priority assigned to those habitats with low availability and high expected recovery times (Figure 2). In the Northeast region, habitat with low structural complexity and short recovery times are relatively abundant. Conversely, habitats with high structural complexity and long recovery times are comparatively less abundant. These characteristics lead to the shape of the curve depicted in Figure 2. Types of protection can range from constraints on particular gear types in specific habitats to the establishment of marine protected areas in which all extractive activities are prohibited.

Figure 1. Conceptual model of the relationship between vulnerability to fishing gear (structural complexity and recovery time) and habitat availability for the Northeast region.

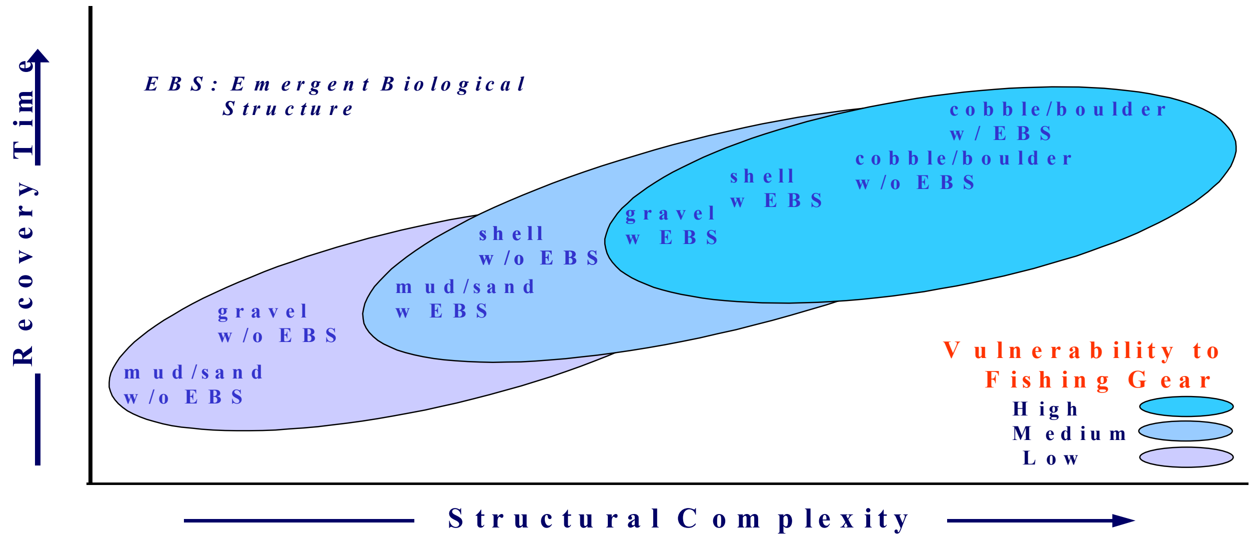
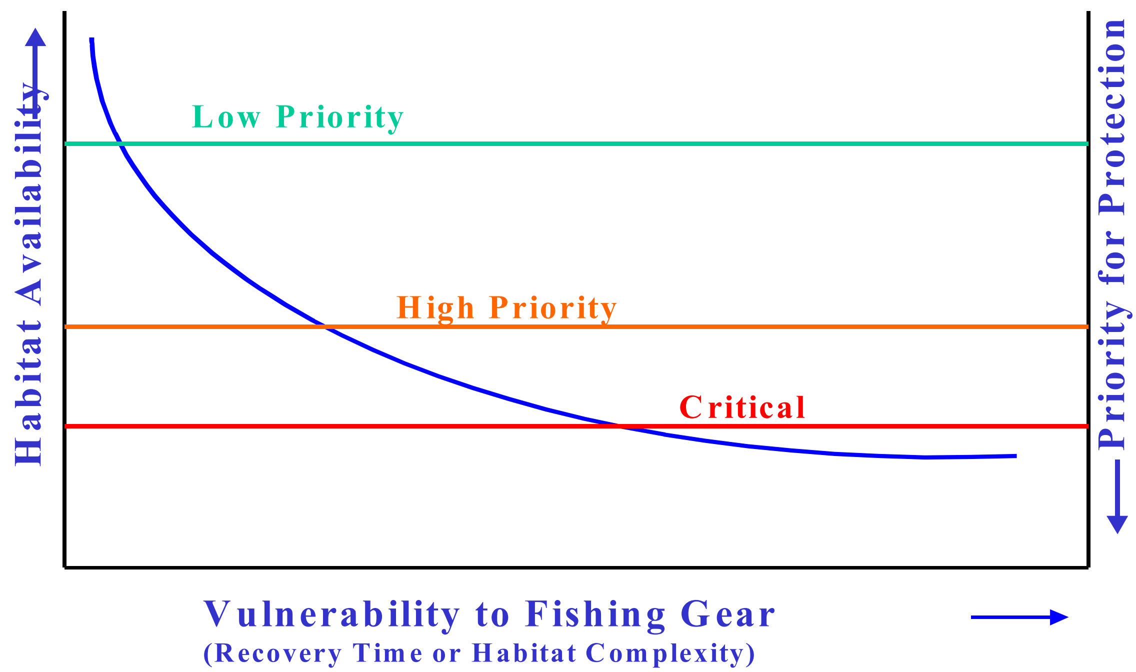


Figure 2. Conceptual model of the relationship between vulnerability to fishing gear (structural complexity and recovery time), habitat availability, and priority for protection.



PRIORITIZATION OF IMPACTS

The workshop participants were asked to participate in an exercise to rank the relative importance of various gear impacts on habitat. The panelists considered the three general habitat types of mud, sand and gravel, and within those habitat types four impacts 1) Removal of major physical features, 2) Impacts to biological structure, 3) Impacts to physical structure, and 4) Changes in benthic prey.

All of these impacts and habitat types were tabulated on a large chart. The panelists were allowed seven votes each. They voted by placing stickers on the chart next to the combinations of impacts and habitats that they felt were the most critical. They could allocate their votes as they saw fit based on any criteria they chose. Some panelists did not specify the type of impact and simply voted by gear type and habitat type. The results from this exercise are found in Tables 8 and 9.

Table 8. Prioritization of Habitat Impacts: Votes Cast by Panel

HABITAT	TYPE OF IMPACT	PANEL RANKING (number of votes, N = 84)					
		Scallop Dredge	Otter Trawl	Nets & Lines	Pots & Traps	Clam Dredges	Total
MUD	Any Impacts	.	5	.	1	.	6
	Removal of major physical features	.	3	.	.	.	3
	Impacts to biological structure	.	1	.	.	.	1
	Impacts to physical structure	.	2	.	.	.	2
	Changes in benthic prey	.	.	.	.	.	.
SAND	Any Impacts	.	.	.	.	1	1
	Removal of major physical features	.	.	.	.	.	.
	Impacts to biological structure	7	4	.	.	2	13
	Impacts to physical structure	2	1	.	.	4	7
	Changes in benthic prey	.	.	.	.	.	.
GRAVEL	Any Impacts	8	11	.	.	.	19
	Removal of major physical features	.	1	.	.	.	1
	Impacts to biological structure	9	10	5	.	.	24
	Impacts to physical structure	4	3	.	.	.	7
	Changes in benthic prey	.	.	.	.	.	.
TOTAL		30	41	5	1	7	84

Table 9. Priority Ranking of the Level of Concern Over Potential Adverse Impacts to Benthic Habitats

Concern by Sediment Type

Rank	Sediment Type	Percentage	Votes
1	Gravel	61%	51/84
2	Sand	25%	21/84
3	Mud	14%	12/84

Concern by Type of Effect

Rank	Type of Effect	Percentage	Votes
1	Impacts to biological structure	65%	38/58
2	Impacts to physical structure	28%	16/58
3	Reduction of physical features	7%	4/58

Concern by Type of Gear

Rank	Type of Gear	Percentage	Votes
1	Otter trawls	49%	41/84
2	Scallop dredges	36%	30/84
3	Clam dredges	8%	7/84
4	Nets and Lines	6%	5/84
5	Pots and Traps	1%	1/84

Concern by Sediment Type and Effect Combination

Rank	Sediment Type - Effect	Percentage	Votes
1	Gravel - Impacts to biological structure	41%	24/58
2	Sand - Impacts to biological structure	22%	13/58
3	Sand - Impacts to physical structure	12%	7/58
3	Gravel - Impacts to physical structure	12%	7/58
5	Mud - Reduction of physical features	5%	3/58
6	Mud - Impacts to physical structure	3%	2/58
7	Mud - Impacts to biological structure	2%	1/58
7	Gravel - Reduction of physical features	2%	1/58

Concern by Sediment Type and Gear Type Combination

Rank	Sediment Type - Gear Type	Percentage	Votes
1	Gravel - Otter trawls	30%	25/84
2	Gravel - Scallop dredges	25%	21/84
3	Mud - Otter trawls	13%	11/84
4	Sand - Scallop dredges	11%	9/84
5	Sand - Clam dredges	8%	7/84
6	Sand - Otter trawls	6%	5/84
6	Gravel - Nets and Lines	6%	5/84
8	Mud - Pots and Traps	1%	1/84

Several conclusions can be drawn from this evaluation. First of all, gravel habitat was clearly considered to be most at risk, followed by sand and mud (Figure 3). Secondly, impacts to biological structure were of greatest concern, particularly in gravel habitat, followed by any impacts to gravel habitat (Figure 4). Impacts to physical structure ranked third and removal of major physical features ranked fourth. Thirdly, otter trawls and scallop dredges were of much greater concern than clam dredges, gill nets and longlines, and pots and traps (Figures 5). Otter trawls and scallop dredges were judged to have the greatest impacts on gravel habitat (Figure 6). Additionally, otter trawl effects were of concern in all three habitat types, whereas scallop dredge effects are limited to gravel and sand, and clam dredging impacts are limited to sandy bottom. Sink gill nets and bottom longlines were only of concern in gravel. Changes in benthic prey received no votes at all and only one vote was cast for pots and traps. Overall, the panelists stated that this was a valuable exercise and that the results were consistent with their discussions throughout the workshop.

Figure 3. Priorities by Habitat Type

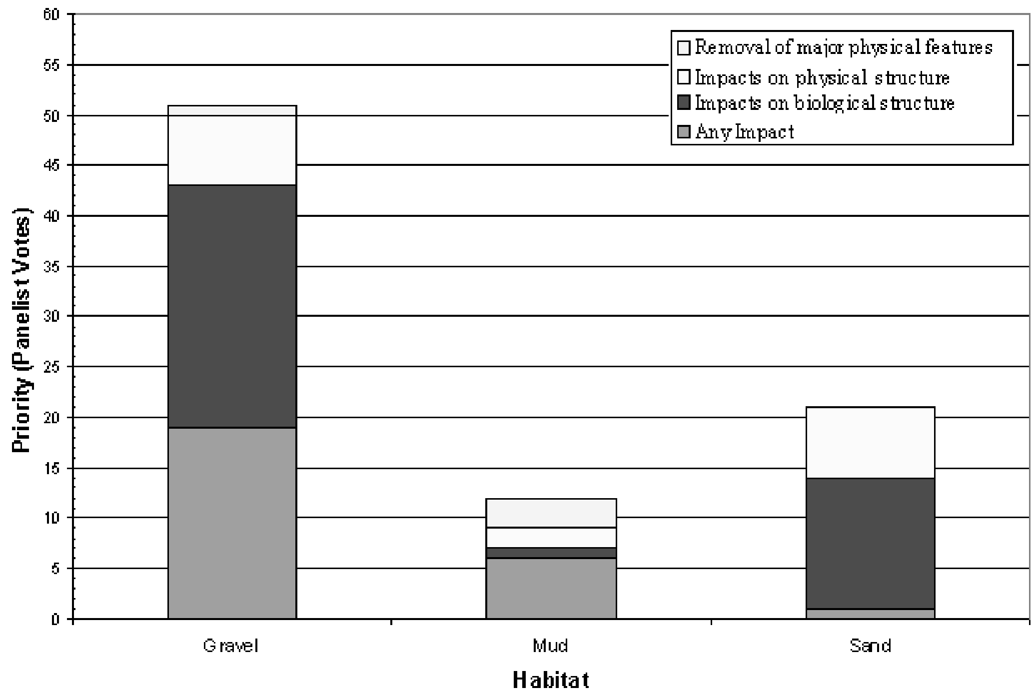


Figure 4. Priorities by Impact Type

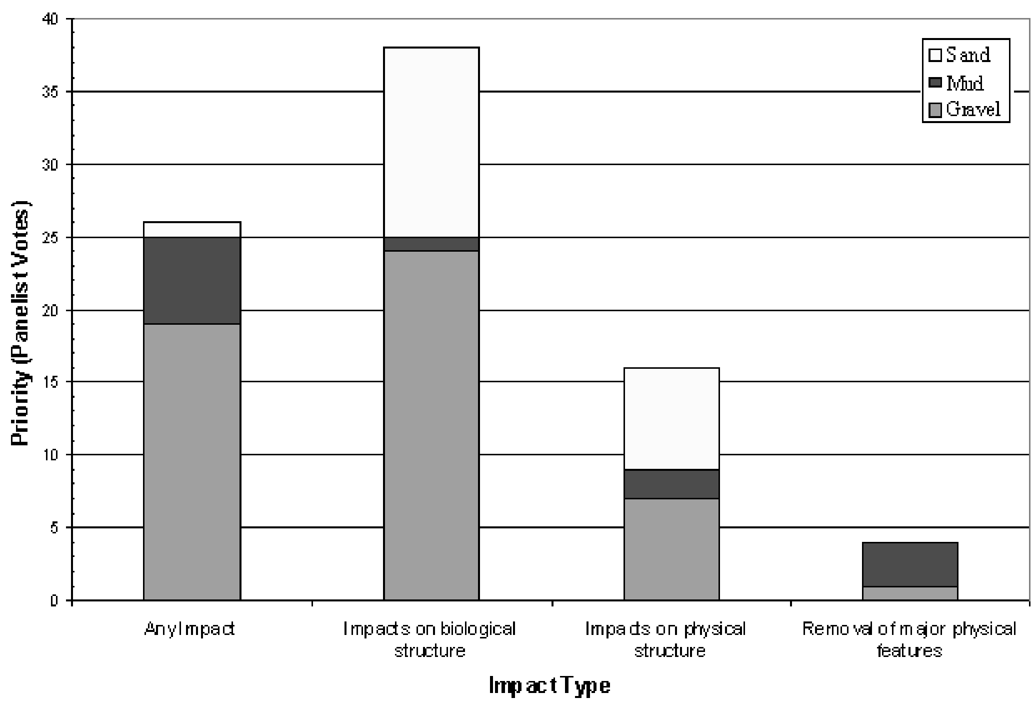


Figure 5. Priorities by Gear

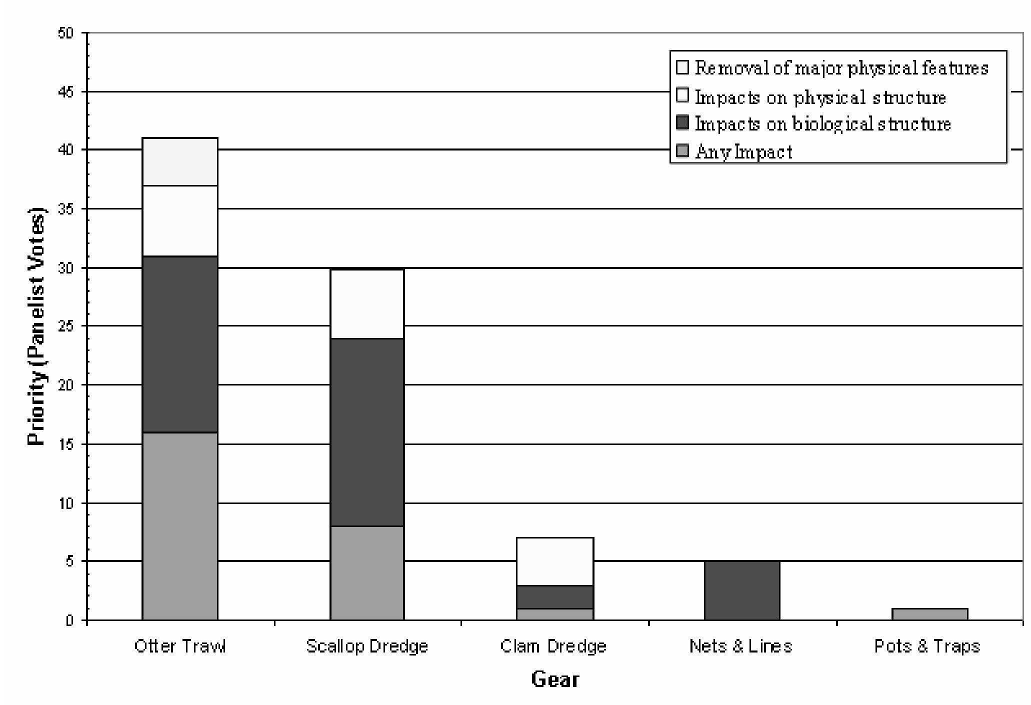
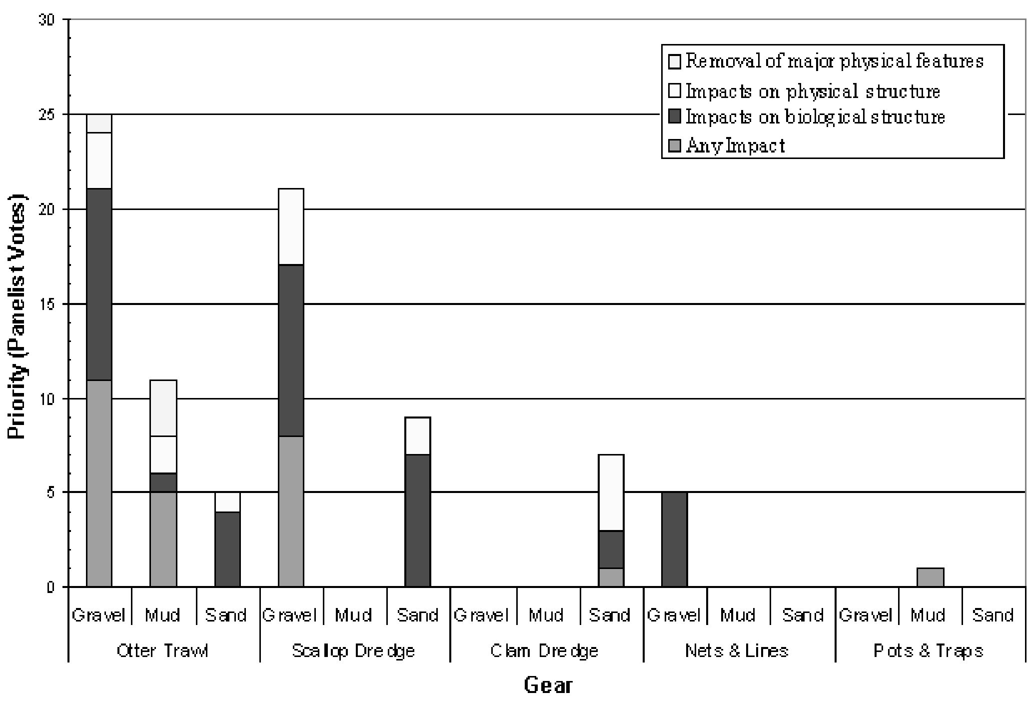


Figure 6. Priorities by Gear and Habitat



RECOMMENDATIONS FOR ACTION

Overall the panel stressed a theme throughout the workshop that in order to protect habitat from gear impacts three management measures deserve consideration: 1) effort reduction, 2) spatial closures, and 3) gear modification. During this specific session of the workshop these themes were raised again and the panel also made several other and more specific suggestions related to gear impacts and habitat. The panel members were free to suggest anything they thought appropriate but were asked to consider both research and management recommendations. For the most part the panel reached consensus on each of these recommendations. When they did not reach consensus, it is noted and the reasons for differing opinions are explained. Many of the recommendations focused in three areas, spatial closures, increased mapping, and effort data. The discussions supporting these three types of recommendations along with the other recommendations offered by the panel are included below. The panel recommended:

Spatial Closures: To protect critical and/or vulnerable habitat areas as an important tool to minimize gear impacts on habitat. The panel indicated that some closed areas need to be closed to all gear types in order to protect critical habitat while other areas only need to be closed to gear types that significantly impact the bottom. Some panel members argued that long term and even permanent closed areas were needed for habitat protection as well as for research. Other panel members thought that short term or more temporary closed areas, which adapted to changing conditions in the habitat or fishery, were sufficient. While all panel members agreed that areas should be closed to protect critical or vulnerable habitat , some panel members emphasized the need to protect portions of representative habitat types in the Northeast region; such closures would include habitats that may not be as vulnerable to alteration from fishing. All panel members agreed that the selection of closed areas should be based on scientific information. Some panel members felt it was important to extend the duration of the current closed areas on Georges Bank and the western Gulf of Maine in order to continue habitat protection which is already in place and to allow established research programs to continue. Other panel members indicated that these areas were chosen for fishery resource management rather than habitat protection purposes and therefore new areas should be considered.

Mapping: The habitats in the Northeast region should be mapped. This mapping effort should begin with the most critical habitats but then should eventually encompass the entire region.

Effort Data: Effort data for the various fishing fleets, especially otter trawls and clam dredges, should be gathered and mapped as has been done in the scallop fishery. While systems such as VMS are currently installed on some vessels for enforcement purposes, the panel agreed that collection of real time trip data was not necessary; instead, any mechanism to gather information that could be mapped at a later date would be sufficient.

Effort Reduction: The panel noted that for many overexploited species, resource management measures which require reductions in fishing effort to maximize yield will have the added benefit of protecting habitat.

Gear Modification: Continued gear research and modification. Throughout the workshop, gear modification was mentioned as a possible way to reduce the impact of certain gears on critical or vulnerable habitats.

Enforcement: Law enforcement for current and any future closed areas should be improved.

Reduce damage to habitat in low yield areas: Identifying areas of low yield of bottom dwelling resources and prohibiting fishing with bottom-tending gear in those areas. This would reduce habitat damage while at the same time minimizing socioeconomic impacts to fishing communities. Some panel members disagreed with this recommendation, indicating that if an area is not productive for fishery resources than it is most likely not productive habitat.

Research: Funding should be provided to support additional research that would address information deficiencies identified in this workshop. Some panel members recommended that greater use be made of observers to collect detailed information on bycatch and the distribution of fishing effort. Additionally it was noted that deep water corals, the continental shelf break, and the heads of submarine canyons are also very important habitats that require more research to understand their importance and provide appropriate protection measures.

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APPENDICES

APPENDIX A

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APPENDIX B.

FINAL AGENDA
Effects of Fishing Gear on Fish Habitat in the Northeastern U.S.
October 23 -25, 2001
Boston, MA
Hilton Boston Logan Airport (617) 568 -6700

Tuesday 10/23

9:30-10:00	*COFFEE*
10:00 - 10:30	Welcome and Introductions (Colosi, Hopkins, Caputi)
10:30 - 11:15	Overview of Meeting Format and Products (Chiarella, Citrin)
11:15 - 11:45	Habitat Description and Overview (Valentine Lead)
11:45 - 12:45	Effects of Fishing Gear: Bottom Static, Pots and Traps (Panel)
12:45 - 2:00	LUNCH
2:00 - 4:15	Effects of Fishing Gear: Clam Dredges (Panel)
3:30 - 3:45	*Coffee Break*
4:15 - 5:15	Effects of Fishing Gear: Pelagic Gear (Panel)

Wednesday 10/24

8:00 - 9:00	Effects of Fishing Gear: Bottom Static, Nets and Hook Gear (Panel)
9:00 - 12:15	Effects of Fishing Gear: Scallop Dredges (Panel)
10:20 - 10:35	*Coffee Break*
12:15 - 1:30	LUNCH
1:30 - 4:45	Effects of Fishing Gear: Otter Trawls (Panel)
2:50 - 3:05	*Coffee Break*
4:45 - 5:45	Effects of Fishing Gear: Beam Trawls (Panel)

Thursday 10/25

8:00 - 8:45	Peer Review of White Paper (Panel and Staff)
8:45 - 11:30	Conclusions of Last Two Days (Panel and Staff)
9:45 - 10:00	*Coffee Break*
11:45 - 1:00	Relative Importance of Impacts (Panel)
1:00 - 2:00	LUNCH
2:00 - 3:30	Recommendations for Action (Panel)
3:30 - 4:00	Wrap-Up, Adjourn

APPENDIX C.

Workshop Goals and Objectives

Goal: Evaluate the impact of fishing gear used in federally regulated fisheries on habitats of the Northeast shelf ecosystem, and ways to reduce impacts.

Objective 1: Peer review background document prepared by the Workshop Steering Committee.

Objective 2: Evaluate the applicability of national and international fishing gear effects research to the Northeast.

Objective 3: Evaluate the strength of evidence regarding the effects of different types of gear and fishing practices on marine habitats in the Northeast.

Objective 4: Identify and evaluate types of management measures that could reduce the impacts of fishing gear on marine habitats in the Northeast.

Objective 5: Provide advice and recommendations to the New England and Mid-Atlantic Fishery Management Councils for minimizing adverse effects of fishing gear on marine habitats in the Northeast.

APPENDIX D.

DEFINITIONS

Essential Fish Habitat *(Magnuson-Stevens Act , MSA)*
"EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

Adverse Effect *(EFH Interim Final Rule, IFR)*
"Adverse effect means any impact which reduces quality and/or quantity of EFH. Adverse effects may include direct (e.g. contamination or physical disruption), indirect, (e.g. loss of prey, or reduction of species' fecundity), site-specific or habitat-wide impacts including individual, cumulative, or synergistic consequences of actions."

"Adverse effects from fishing may include physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem."

"**Identifiable" Adverse Effect** *(IFR)*
1. "Impacts from fishing practices that justify the implementation of management measures should be identifiable"
2. "Identifiable means both more than minimal and not temporary in nature…"
3. "Intent is to regulate fishing gears that reduce an essential habitat's capacity to support marine resources, not practices that produce inconsequential changes in the habitat."

Substrate Types
1. Mud - For purposes of the workshop this category consisting of clays and silts. Particle sizes range from 0.001 - 0.004 mm for clay and 0.004 mm - 0.062 mm for silt. *(USGS 2001)*

2. Sand - Sediment particles ranging from 0.062 mm - 2.00 mm *(USGS 2001)*

3. Gravel - For purposes of the workshop this category includes pebbles, cobbles, boulders, as well as hard bottom (ledge) and hard corals. Pebbles are the smallest particles in this category and range from 2.0 mm - 64.0 mm. Cobbles range from 64.0 mm - 256.0 mm. Boulders are > 256.0 mm *(USGS 2001)*

Type of Impact Used in Gear Impact Tables *(Modified from ICES, 2001):*

1. Removal of Major Physical Features - Fishing gear may cause the loss or dispersal of physical features in the environment such as peat banks or boulder reefs. These changes are always permanent, and lead to an overall reduction in habitat diversity. This, in turn, can lead to the local loss of species and species assemblages dependant upon such features, for example, attached bryozoan/hydroid turf and important fish habitat. Even when substantial quantities of the habitat feature remain, if the habitat has become highly fragmented, this may compromise the viability of populations dependent upon it. *(ICES 2001)*

2. Impacts to Biological Structure - Fishing gear can cause the loss of structure-forming organisms such as colonial bryozoans, *Sabellaria,* hydroids, seapens, sponges, mussel beds, and oyster beds. These changes may be permanent, and can lead to an overall loss of habitat diversity. This in turn, can lead to the local loss of species and species assemblages dependent upon such biogenic structure, for example, important fish habitat for juvenile gadoids. The viability of populations dependent on biogenic features may be compromised even if the feature remains but has become highly fragmented. *(ICES, 2001)*

3. Impacts to Physical Structure - Fishing gear can cause a reshaping of seabed features such as sand ripples, and damage to burrows and associated structures (e.g. mounds and casts, microhabitats, and shell windrows). These features provide important habitats for smaller animals (meiofauna) and can be used by fish to reduce their energy requirements. These changes are not likely to be permanent. Fishing gear can cause the redistribution and mixing of surface sediments which can lead to a decrease in the physical patchiness of the sea floor (i.e., decreased heterogeneity) within the fishing grounds. These changes are not likely to be permanent. *(ICES 2001)*

4. Changes in Benthic Prey - Fishing gear can cause reductions in the abundance and/or species composition of benthic invertebrate populations that are consumed by bottom feeding fish. These changes have the potential to affect habitat suitability for growth, survival, and reproductive capacity of predatory fish.

APPENDIX E.

Questions for the Workshop Panel:

I. Introductory Questions. (Habitat Overview)

1. What types of habitat are found in the Northeast region?
2. What are the characteristics of the habitats in the Northeast region and how do these differ in the Gulf of Maine, Georges Bank, Southern New England shelf, and Mid-Atlantic Bight?

II. Questions on Fishing Gear Types.

The categories of fishing gears used for the workshop include the following:

Bottom-Tending Static Fishing Gears -- Pots and Traps

Bottom-Tending Mobile Fishing Gears -- Clam Dredges (hydraulic and non-hydraulic)

Bottom-Tending Static Fishing Gears – Gill Nets, Long Lines, Hooks

Bottom-Tending Mobile Fishing Gears -- Sea Scallop Dredges

Bottom-Tending Mobile Fishing Gears -- Otter Trawls

Bottom-Tending Mobile Fishing Gears -- Beam Trawls

Pelagic Fishing Gears (Static and Mobile)

The Workshop Panel is asked to answer specific questions about the effects of different fishing gears and the applicability of available information to the Northeast Region. The following set of questions apply to each of the above categories of fishing gear used in the Northeast Region.

1. What fishing gears in this category are used in the Northeast?
2. How are fishing gears in this category used in the Northeast?
3. What, if any, components or elements of fishing gears in this category come in contact or interact with the sea floor?
4. What are the direct effects of fishing gears in this category on different habitats?
5. What are the principal indirect biological effects of gear induced habitat alterations on exploited resource populations?
6. What effects of fishing gears in this category are most significant?
7. Which habitats are most or least vulnerable to effects of fishing with fishing gears in this category?
8. How do we judge the temporal scale of the effects of fishing gears in this category on different habitats?
9. What studies or elements of studies of the effects of fishing gears in this category are applicable to the Northeast? Why?
10. What studies or elements of studies of the effects of fishing gears in this category are <u>not</u> applicable to the Northeast? Why not?
11. How strong is the evidence for the potential effects of fishing gears in this category on different habitats in the Northeast?

12. What are the most important overall potential effects of fishing gears in this category in the Northeast?

13. What types of management actions would be most effective to mitigate the potential adverse effects of fishing gears in this category in the Northeast?

14. Would any changes to fishing practices with fishing gears in this category reduce their interaction with or contact with the bottom, or in some other way reduce the impacts to habitat associated with fishing gears in this category?

15. Are there any design modifications that could be made to fishing gears in this category that would reduce their interaction with or contact with the bottom, or in some other way reduce the impacts to habitat associated with fishing gears in this category?

In addition, the following questions apply to the pelagic categories of fishing gear:

16. Relative to impacts from other gear types on sea floor habitats, how important are potential impacts from pelagic gears to the water column?

17. Would there be more or less concern over the potential effects of pelagic fishing gears if they were used in contact with the bottom, either intentionally or accidentally?

APPENDIX F.

Descriptions of some representative habitats as presented by Dr. Page Valentine, USGS.
Note: This is not a complete listing of habitats of the Northeastern United States

A. GEORGES BANK – Northeastern Edge

HABITAT CHARACTER	DESCRIPTION
A. Topography	**Featureless gravel except for few large sand ridges**
B. Sediment texture and hardness	**Gravel pavement (hard bottom); small areas of gravel with sand veneer; sand**
C. Substrate roughness and surface area (undisturbed)	
• **Physical**	**Gravel pavement: pebbles, scattered cobbles and boulders; little rippled sand** **Sand ridges with ripples**
• **Biological**	**Gravel pavement: calcareous worm tubes, bryozoa/hydrozoa, sponges, and anemones attached to gravel** **Sand:**
D. Substrate dynamics	**Strong tidal and storm currents winnow sand from gravel pavement, move shells, and move surfaces of sand deposits;**
E. Water column	**Generally mixed; high productivity; shallow**
F. Possible fishing impacts	**Disturb gravel pavement, reduce hard bottom and expose sand for movement; move cobbles and boulders; disturb epifauna; alter biodiversity**

B. GEORGES BANK – Central Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	**Sand bedforms ranging from small ripples to very large sand ridges**
B. Sediment texture and hardness	**Sand; shell beds; small areas of gravel between sand ridges**
C. Substrate roughness and surface area (undisturbed)	
• **Physical**	**Sand bedforms of varying sizes; associated shell beds** **Gravel: pebbles, cobbles, boulders**
• **Biological**	**Sand bedforms: amphipod tubes, sand dollar concentrations and burrowing anemones** **Gravel: minimal epifauna due to sand movement**
D. Substrate dynamics	**Strong tidal and storm currents build bedforms and shell beds; daily sand transport; large stable sand ridges are oriented parallel to direction of current flow; bi-directional sand movement**
E. Water column	**Mixed; high productivity; shallow**
F. Possible fishing impacts	**Disturb sand bedforms and shell beds; disturb amphipod tubes and burrowing anemones and expose sand for movement**

C. GEORGES BANK – Southern Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	Featureless sand except for patches of ripples from intermittent storms
B. Sediment texture and hardness	Sand
C. Substrate roughness and surface area (undisturbed)	
• Physical	Depressions in sand formed by benthic fauna; scattered shells
• Biological	Erect yellow sponges attached to shell fragments; amphipod tubes
D. Substrate dynamics	Weak tidal currents do not move sediment; intermittent strong storm currents form sand ripples
E. Water column	Mixed or seasonally stratified; high productivity; shallow
F. Possible fishing impacts	Disturb sand depressions, erect sponges, and amphipod tubesl break shells

D: GEORGES BANK – Large Submarine Canyons on Southern Margin

HABITAT CHARACTER	DESCRIPTION
A. Topography	Deep incision into continental shelf edge; gentle to steeply sloping canyon walls; sand bedforms in canyon axis
B. Sediment texture and hardness	Sand and gravel on canyon rims and in axis; gravel pavement common on eastern rims; clay layer and rock outcrops on canyon walls
C. Substrate roughness (undisturbed)	
• Physical	On canyon rims: depressions in sand formed by benthic fauna; scattered shells; sand bedforms; gravel pavement of pebbles and scattered cobbles and boulders In canyon: sand bedforms; scattered pebbles, cobbles, and boulders; clay burrows (formed by crustaceans, fish, worms …); irregular rock outcrops
• Biological	Sponges, bryozoa/hydrozoa, soft corals attached to gravel and rock outcrops; burrowing anemones; …
D. Substrate dynamics	Moderate currents move sand from shelf onto canyon walls; strong tidal currents form sand bedforms in canyon axis
E. Water column	Stratified; low productivity; shallow to deep
F. Possible fishing impacts	Disturb gravel pavement, reduce hard bottom and expose sand for movement; move cobbles and boulders; disturb hardbottom epifauna; disturb clay burrows; disturb burrowing anemones

E. GULF OF MAINE – Central Deep Water Banks

HABITAT CHARACTER	DESCRIPTION
A. Topography	**Banks, ridges, hills, mounds**
B. Sediment texture and hardness	**Gravel and bedrock with intermittent thin veneer of mud; patches of mud; hard and soft bottom**
C. Substrate roughness and surface area (undisturbed)	
• **Physical**	**Gravel: pebbles, cobbles, boulders, and bedrock outcrops; scour depressions around cobbles and boulders** **Mud: mud burrows (crustaceans, fish, worms, …)**
• **Biological**	**Gravel: sponges, brachiopods, and anemones attached to gravel Mud: burrowing anemones, sea pens**
D. Substrate dynamics	**Very weak currents; little or no sediment transport**
E. Water column	**Stratified; low productivity; deep**
F. Possible fishing impacts	**Flatten small gravel mounds; move cobbles and boulders; re-suspend fine sediment and increase turbidity; disturb epifauna; disturb mud burrows; disturb burrowing anemones and sea pens**

F. GULF OF MAINE – Central Deep Water Basins

HABITAT CHARACTER	DESCRIPTION
A. Topography	**Featureless mud except for small mounds**
B. Sediment texture and hardness	**Mud; soft bottom**
C. Substrate roughness and surface area (undisturbed)	
• **Physical**	**Mud: mud burrows (crustaceans, fish, worms, …)**
•	
• **Biological**	**Mud: burrowing anemones; sea pens, “amphipod” tubes**
D. Substrate dynamics	**Very weak currents; little or no sediment transport**
E. Water column	**Stratified; low productivity; deep**
F. Possible fishing impacts	**Disturb burrows; re-suspend fine sediment and increase turbidity; disturb burrowing anemones and sea pens**

G: GREAT SOUTH CHANNEL REGION – Central Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	Featureless gravel; gravel mounds; bedforms ranging from small ripples to very large sand ridges
B. Sediment texture and hardness	Gravel pavement; gravel between large sand ridges; gravel with thin veneer of sand; sand
C. Substrate roughness and surface area (undisturbed)	
• Physical	Gravel pavement and mounds: pebbles, scattered cobbles and boulders; shell beds Sand bedforms of varying sizes
• Biological	Gravel: bryozoa/hydrozoa, sponges, attached anemones Sand:
D. Substrate dynamics	Strong tidal and storm currents; daily sand transport; sand ridges relatively stable and oriented normal to direction of current flow; bi-directional sand movement
E. Water column	Mixed; high productivity; shallow
F. Possible fishing impacts	Disturb gravel pavement, expose sand for movement; flatten small gravel mounds; move cobbles and boulders; disturb gravel epifauna; disturb small bedforms and shell beds

H. GREAT SOUTH CHANNEL REGION – Northern Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	Featureless gravel with veneer of rippled sand
B. Sediment texture and hardness	Gravel with mobile patchy sand veneer
C. Substrate roughness and surface area (undisturbed)	
• Physical	Gravel: Pebbles, cobbles, and boulders; current scours around boulders Sand: rippled sand patches; rippled sand deposits streaming downcurrent from boulders
• Biological	Gravel: little attached epifauna due to sand movment Sand:
D. Substrate dynamics	Strong tidal and storm currents; sand moving through gravel
E. Water column	Generally mixed; high productivity; shallow
F. Possible fishing impacts	Move cobbles and boulders; disturb attached epifauna; disturb sand ripples

I. GREAT SOUTH CHANNEL REGION – Northeastern Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	Featureless except for storm sand ripples
B. Sediment texture and hardness	Coarse sand and gravel
C. Substrate roughness and surface area (undisturbed)	
• Physical	Sand: storm-generated ripples Gravel: pebble gravel pavement in ripple troughs; scattered cobbles and boulders
• Biological	Gravel: sponges and bryozoa/hydrozoa attached to gravel Sand:
D. Substrate dynamics	Moderate tidal currents; strong storm currents transport sand and form ripples
E. Water column	Mixed or seasonally stratified; high productivity; shallow
F. Fishing impacts possible	Disturb sand ripples and gravel pavement; move cobbles and boulders; disturb gravel epifauna

J. GREAT SOUTH CHANNEL REGION – Southwestern Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	Featureless gravelly sand except for widely spaced very large sand ridges
B. Sediment texture and hardness	Gravelly coarse sand between sand ridges; sand on ridges
C. Substrate roughness and surface area (undisturbed)	
• Physical	Gravelly coarse sand: depressions in sand formed by benthic fauna; scattered shells Sand ridges with ripples
• Biological	Gravelly coarse sand: erect yellow sponges, attached anemones, amphipod tubes Sand:
D. Substrate dynamics	Moderate tidal currents; strong storm currents transport surfaces of relatively stable sand ridges; bi-directional sand movement
E. Water column	Generally mixed; high productivity; shallow
F. Fishing impacts possible	Disturb depressions in gravelly coarse sand, erect sponges, attached anemones, and amphipod tubes

K. GREAT SOUTH CHANNEL REGION – Western Part

HABITAT CHARACTER	DESCRIPTION
A. Topography	**Featureless**
B. Sediment texture and hardness	**Mussel bed; hard bottom**
C. Substrate roughness and surface area (undisturbed)	
• **Physical**	**Mussel shells**
• **Biological**	**Mussel bed with attached epifauna**
D. Substrate dynamics	**Strong tidal and storm currents**
E. Water column	**Mixed; high productivity; shallow**
F. Possible fishing impacts	**Disturb living mussels, shells, and attached epifauna; expose underlying sediment to strong currents**

APPENDIX G.

Spatial Distribution of Fishing Effort for Sea Scallops: 1998-2000

Prepared for

Effects of Fishing Gear on Fish Habitat in the Northeastern U.S.
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Introduction

Precise information on the spatial pattern of fishing by commercial vessels is available for few fisheries. Such information is critical for assessment of potential impacts of fishing gear on target and non-target species. The short report summarizes recent information on the spatial distribution of the US sea scallop fishery and estimates the area-specific landings and revenue. Additional information related to this report may be found in Rago et al. (2000).

Methods

Each vessel that participates in the limited access fishery for Atlantic sea scallops is required to use a vessel monitoring device. This device identifies the position of each vessel at intervals of one hour or less. Positions are tracked by a geosynchronous satellite and the information is relayed to ground-based stations. Vessel speed can be computed as the distance between successive position divided by the duration between position reports. The combination of vessel tracking devices, satellite and ground-based monitoring, and associated databases and software define the vessel monitoring system (VMS) for sea scallops. The VMS database was originally designed as an enforcement tool to track time at sea accurately, and to identify possible violations of closed areas. The potential uses of such data for assessment and management, however, are far-reaching. We present a few examples related to development of a synoptic map of fishing activity.

Estimates of area-specific fishing activity by calendar year were derived by overlaying a grid of 1 nm^2 squares over a region extending from Georges Bank to Virginia. Total fishing time in each cell was estimated as the sum of vessel-hours where speed is less than 5 knots (scallop vessel typically fish at 4-5 knots). Speed is estimated as the Euclidian distance between successive position reports divided by the time between observations. This estimate of fishing activity includes haul back time as well as any other time spent processing catch or cessation of fishing during bad weather or mechanical breakdowns. Fishing activity is assigned to the 1 nm^2 cell in which the report is received. In theory however, the fishing activity could have occurred within a five nautical mile radius of the recorded position. In practice, vessels tend to concentrate fishing activity around locations were capture rates are high. The effects of uncertainty in specification of fishing activity time could be examined via various smoothing procedures and through more detailed analysis of individual vessel tracks. For the purposes of this summary, we felt that the overall pattern of vessel activity was sufficiently characterized.

Total fishing activity hours by cell were estimated by quartiles (Table 1) and coded by color (red >75%-ile, 50%-ile<yellow <75%-ile, 25%-ile < green < 50%-ile, blue < 25%-ile. An upper bound on area swept can be obtained as the product of fishing time (hr), an estimated average speed of 4.5 knots while towing, and an industry norm of two 15 ft wide dredges. This product provides a measure of potential bottom contact area, but the actual area covered is determined by the number of times that the bottom is repeatedly towed. The VMS data alone are insufficient to estimate this quantity.

The spatial distribution of landings and revenue was approximated by linking vessel monitoring data with dealer records of landings and total value. Landings associated with each trip were distributed in proportion to time fished over set of 1 nm^2 cells that comprise the area fished. The sum over all trips provides an estimate of the landings per unit area. An equivalent procedure was used to estimate the revenue per unit area. This procedure does not account for the non-uniform distribution of fishing success over the course of a trip. Since most landings are likely to come from the areas fished the most intensively, it is likely that the application of the average success rate (i.e., lbs/hr) to all cells in a trip will overestimate the landings and revenue from marginal areas. Although the VMS reports record all trips, not all VMS trips can be matched with dealer records. The degree of matching exceeded 90% in all years. Unmatched records arise from a variety of sources and can generally be resolved by investigation of individual trips. In some instances it is necessary to combine several “trips” that give rise to a single landing event. Multiple VMS “trips” can arise when a vessel moves back and forth across inshore demarcation lines during a single trip.

Results

The scallop fishery is highly concentrated and the degree of concentration is consistent across years. The spatial distribution of fishing effort in 1998 and 1999 is depicted in Fig. 1. Fishing effort quartiles were estimated for the set of all cells (1 nm^2) in which fishing occurred in 1998 and 1999. Cells below the median hours of fishing activity experienced less than 9 hours of fishing activity per year. The upper quartile of fishing effort was highly concentrated in a zone of about 3000 square miles in all three years (Table 1). Estimated mean fishing activity in these areas was about 110 hr in 1998 and 1999. The fishing activity in cells below the median level is largely incidental and constitutes only about 4% of the total landings per year. It is hypothesized that such fishing activity is exploratory to recheck old fishing sites or to identify overlooked scallop concentrations. The most heavily fished areas produced the 77 to 88% of the total landings. Hence, the VMS data provides a heretofore unknown quantification of the concentration of fishing activity. The implications of this concentration may be important for bycatch and habitat issues (e.g., the environmental “footprint” of fishing effort).

Discussion

Monitoring of fleet behavior during the reopening of area II also revealed the importance localized concentrations of scallops on the distribution and intensity of fishing effort. The observed pattern of effort was consistent with the predicted "limiting distribution of fishing effort" described by Beverton and Holt (1957, p. 162). The concentration of effort on high abundance patches also suggests a reason why predicted yields based on *average* densities may not be realized. The ability to locate and exploit scallop beds will tend to maintain high average catch rates, while at the same time, reduce the true average density faster than would be predicted.

The long term value of the Vessel Monitoring System has been only partially exploited. At a minimum, it provides a common language for fishermen and scientists to gain insights into fishing behavior and resource distribution. Fishermen cannot argue that scientists don't know where the fleet actually fishes and what the catch is. Moreover, scientists cannot dismiss fishermen's observations as anecdotal fragments of the whole. In such circumstance the strengths and weaknesses of each others tenets can be evaluated. Cursory examination of the areal distribution of effort suggests coherence with substrate types. Such coherence may ultimately allow prediction of habitat impacts and bycatch considerations. Managers will find it easier to evaluate the effects of management measures in real time and make short-term corrections when appropriate.

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Appendix

Background on Sea Scallop Biology and Fishery

Sea scallops, *Placopecten magellanicus*, are found in western North Atlantic continental shelf waters from Newfoundland to North Carolina. Principal USA commercial fisheries in the EEZ are conducted primarily on Georges Bank, and in the Mid-Atlantic offshore region at depths between 40 and 100 m where water temperatures are less than 20º C. In terms of total revenue, the sea scallop fishery is the second most valuable fishery in the Northeast USA with annual values in excess of $100 million USD. Average price per kg of adductor muscle (meat) increases with average size with small scallops (~10 g) fetching approximately $8.80/kg and large scallops (>45g) valued at about $15.40/kg.

Scallops grow rapidly during the first several years of life. Between ages 3 and 5, scallops commonly increase 50 to 80% in shell height and quadruple their meat weight. During this time span, the number of meats per kg is reduced from greater than 220 to about 50. Maximum size is about 23 cm shell height, but scallops larger than 17 cm are rare. Sexual maturity commences at age 2, but scallops younger than age 4 probably contribute little to total egg production. Spawning occurs in late summer and early autumn; spring spawning may also occur in the Mid-Atlantic region. Eggs are buoyant, and larvae remain in the water column for four to six weeks before settling to the bottom.

Approximately 250 vessels participate in the year round commercial fishery for scallops. Nearly all landings are taken with dredges (89%) and otter trawls (10%). The USA fishery is managed under the New England Fishery Management Council's Fishery Management Plan for Atlantic Sea Scallops (*Placopecten magellanicus*). Current management measures include a moratorium on permits, days-at-sea limits, and restrictions on gear and crew size. Since the 1998 fishing year, vessels have been restricted to a maximum of 120 days at sea. Days at sea are monitored via a satellite tracking system that logs the position of all full-time scallop vessels on an hourly basis. Scallop dredges must use 3.5 inch (89mm) diameter steel rings to reduce capture of smaller scallops. Crew size is limited to seven individuals. As scallops are shucked by hand at sea, the crew size limitation constrains the daily landings rate during periods of high abundance. The minimum ring size was intended to reduce the catch of undersized scallops to improve yield per recruit, but the efficacy of this measure in the fishery was difficult to isolate in stock assessments (e.g., NEFSC 1997). In addition to these effort reduction measures, closed areas have excluded scallops from traditional harvest areas. Three large areas of Georges Bank were closed to scallop fishing in December 1994 to protect groundfish resources (Murawski et al. 2000). Later, in April 1998, two areas in the Mid-Atlantic were closed to protect undersized scallops present in these areas.

The National Marine Fisheries Service has conducted a stratified random survey of the scallop resource from Virginia to Georges Bank since 1975. In general, the relative biomass indices from scallop survey closely track the landings from the fishery. This is due largely to the intensity of the fishery which rapidly harvests recruiting size classes. The growth potential of sea scallops and the implications of reduced fishing mortality for management have been demonstrated in the closed areas of the Mid-Atlantic and Georges Bank regions (Murawski et al. 2000). Between 1994 and 1998, relative biomass indices from research vessel surveys increased between 5-15 fold in the Georges Bank areas closed to fishing compared to those areas open to fishing. Comparisons of the size structure between 1994 and 1998 for population inside and outside of the closed areas revealed the virtual absence of scallops greater than 110 mm shell height except in the closed area. By 1998 nearly 80% of the total scallop biomass resided in the closed areas. On Georges Bank the closed areas, which historically held about 50% of the total biomass, now had almost 90% of the total. Average densities in August 2000 in Georges Bank closed areas were approximately 4.5 times greater than densities in open areas. Similarly, relative densities of scallops in the Mid-Atlantic were about four times higher than in areas open to fishing (preliminary data from 2000 R/V survey) after only 27 months of closure.

Limited Reopening of Closed Areas in 1999

Partly as a result of information from cooperative studies, standard R/V surveys, and observer sea sampling, the New England Fishery Management Council voted to reopen a portion of Closed Area II south of 41º 30' N to limited scallop fishing. The reopening was subject to strict controls that included a total allowable catch of scallops (4,257 mt), a total allowable bycatch of yellowtail flounder (387 mt), individual vessel trip limits (4.54 mt/trip) , a restriction on the total number of trips per vessel (3 before Oct. 1; 3 after Oct, 1, 1999) , an intermediate decision date for authorization of additional trips (Oct. 1), a requirement for 8 inch (20.3 cm) mesh in the top panel of dredges to reduce yellowtail flounder bycatch, and a requirement that each trip, regardless of its duration, would use 10 of the 120 days-at-sea allotted to the vessel. Moreover, total scallop landings and yellowtail flounder bycatch were to be monitored on a daily basis. Under the plan, the area would be closed whenever the scallop landings or yellowtail flounder bycatch limits were attained. A 10 nm-wide “buffer” area around Area II was closed to improve enforcement of closed areas. The Council also specified a target level of 25% observer coverage for trips to the closed area.

The real-time monitoring requirements for this management action were much greater than normal and would have been impossible to achieve without a vessel monitoring system (VMS). Beginning in May 1998, all full and part-time scallop vessels were required to have a VMS to track of days at sea usage. The VMS also allows the vessel to communicate via e-mail to a central site. Messages received at this site can then be routed to appropriate destinations. The vessel location is embedded in each transmission so it is possible to develop a general map of catch rates by location. Data forms were developed at the central site and distributed to all vessels; hence, the basic components of a real-time monitoring system were already in place. VMS position reports are logged and regularly loaded into a database— generating about 200,000 reports per month.

The limited fishery was closely monitored by observers and via electronic reporting of daily catches. Approximately 2,700 mt (meats) of scallops were landed from this area before closure based on attainment of the yellowtail bycatch limit. Approximately 23% of the vessel-days were covered by at-sea observers.

Table 1. Summary of hours of fishing activity and catches from Vessel Monitoring System data. Quartiles of fishing activity are based on distribution of total number of hours per 1 nm^3 grid for the 1998 and 1999 calendar years.

Year	Quartiles of Fishing Activity (hr) (Range) [mean]	Number of 1-nm sqr sub-areas in which fishing activity occurred	Total Effort—fishing activity (hr)	Total Catch (lb)**	Percent of Total Catch	Value of Catch ** (million $)
1998	(0.1-1.9) [1.0]	2,604	2,521	59,149	1	0.36
	(2-9.2) [4.4]	2,992	13,039	245,087	3	1.65
	(9.3 - 44) [23.9]	3,808	91,181	1,613,070	20	10.04
	(44.1-591) [103.3]	2,796	289,792	6,283,570	77	37.58
	Total	12,200	395,532	8,200,870	100	49.51
1999	(0.1-1.9) [1.0]	3,181	3,127	141,163	1	0.90
	(2-9.2) [4.1]	3,023	12,287	468,550	2	2.83
	(9.3 - 44) [22.5]	2,026	45,677	1,855,170	10	10.43
	(44.1-857.7) [119.4]	2,999	357,934	16,854,300	87	98.63
	Total	11,608	407,787	19,319,200	100	105.48
2000	(0.1-1.9) [0.9]	4,403	3,930	225,839	1	1.14
	(2-9.2) [4.2]	2,953	12,495	760,983	3	3.90
	(9.3 - 44) [23.6]	2,500	59,096	3,883,500	15	20.0
	(44.1-1,543) [104.9]	2,946	309,045	20,620,200	81	102.39
	Total	12,802	384,565	25,490,500	100	127.45

**total catch based on match of VMS data with landings records from commercial dealers. In 1999 the landings were about 91%. In 1998 the match was only 68% in part due to lack of VMS requirement until May 1998

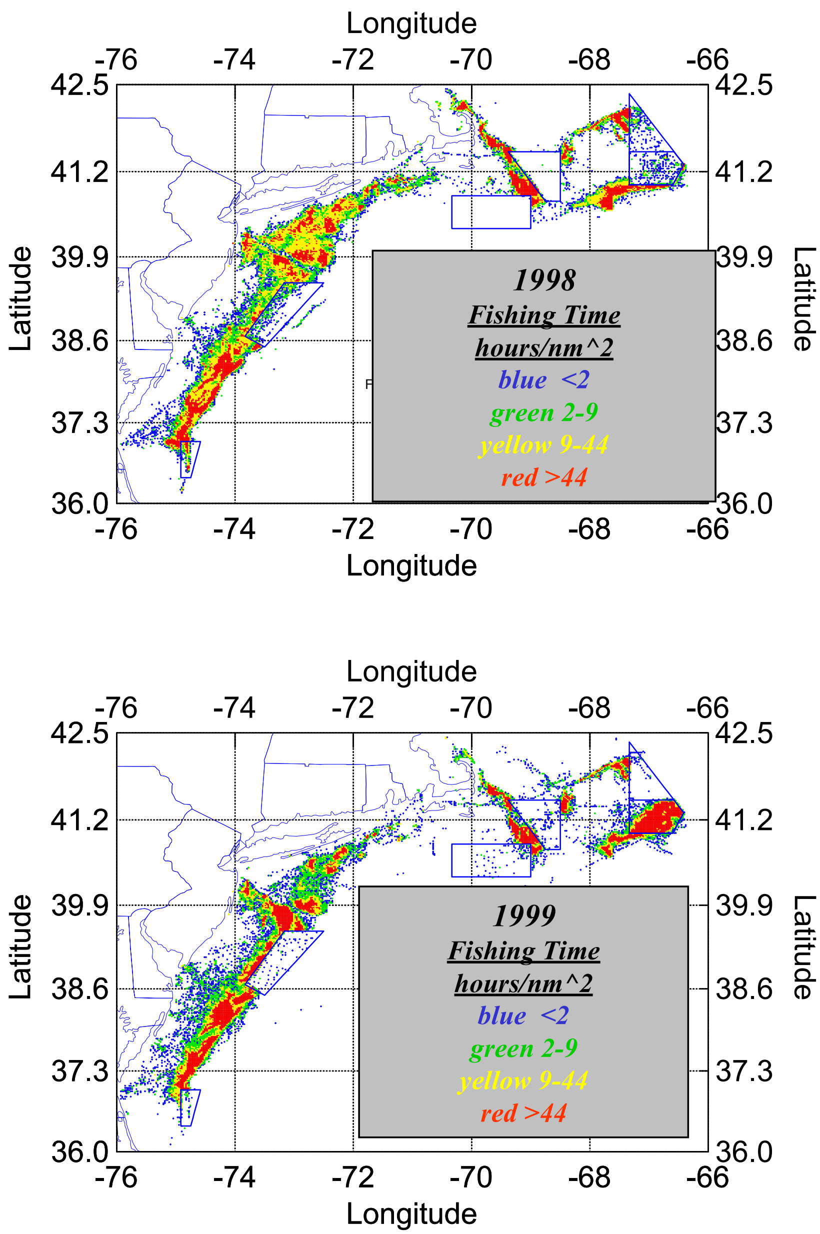

Fig. 1. Spatial distribution of fishing activity by sea scallop fleet in 1998 and 1999. Area II cooperative survey was conducted in 1998; Area I and Nantucket Lightship cooperative surveys were conducted in 1999. Area II was fished commercially in 1999.

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