4.0 FISHING-RELATED IMPACTS AND MANAGEMENT MEASURES

4.1 BACKGROUND

The Council is required to identify and assess fishing activities that may adversely affect EFH. The Magnuson-Stevens Act defines fishing as "any activity, other than scientific research conducted by a scientific research vessel, that involves (1) the catching, taking, or harvesting of fish; (2) the attempted catching, taking, or harvesting of fish; (3) any other activity that can reasonably be expected to result in the catching, taking, or harvesting of fish; or (4) any operations at sea in support of, or in preparation for, any activity described in paragraphs (1), (2), or (3) of this definition" (50 CFR 600.10). 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.

The effects of fishing, such as the direct effects of gear on seafloor habitats (e.g., direct removal of epifauna, smoothed bedforms) and the indirect effects of fishing (e.g., producing shifts in the benthic community because of initial removals of fauna), and other habitat related fishing activities that can be controlled by the Council are considered in this assessment. NMFS recommends that the assessment include, if known: a description of the mechanisms or processes of fishing gear causing adverse effects on habitat; the particular portion of EFH that is affected; a description of known or potential habitat functions disturbed or disrupted by these effects and the extent of such disturbance or disruption; options the Council will consider to minimize adverse effects from fishing practices; and mitigation measures to conserve and enhance EFH adversely affected by fishing activities, if appropriate. According to NMFS, a gear assessment should consider the relative impact of the gear and rate gear types according to their relative impact on different types of EFH, and the Council should consider the severity of the effect, the amount of EFH affected, and the duration/lasting impact of the adverse effect. NMFS suggests the Council also take into account the sensitivity, rarity, resistance, and resilience of different habitat types.

4.2 GEAR IMPACTS ISSUES

The disturbance and alteration of natural seafloor and pelagic communities, even at small scales, is inevitable when fishing with any gear type. There is always a noticeable effect, since simply removing an organism has an effect at some level. This alteration is a necessary component of fishing, and in some cases the effect is relatively short-lived and minor (Jones 1992; Brylinsky *et al.* 1994). Considerations of anthropogenic impacts to habitat must include a comparison to chronic natural disturbances (e.g., currents, waves, etc.) as well as acute natural disturbances (e.g., storms). Wave-induced physical disturbances are rare, however, at depths greater than 30 meters, in large part because of the near-exponential decrease in wave-induced water velocity as a function of depth (Witman 1998; Valentine, pers.comm. 1998). Some types of fishing activities, especially in certain habitat types, may cause long-term changes in the habitat and the structure of the marine community (Auster *et al.* 1996; Kaiser and Spencer 1996). Auster and

Langton (MS1998 and in press) produced a review and synthesis of the fishing gear impact literature for use by the Regional Fishery Management Councils. Ninety studies, virtually all focused on the seafloor, were reviewed. The studies all reported the effects of fishing on habitat (i.e., structural habitat components, community structure and ecosystem processes) for a diversity of habitats and fishing gear types. Immediate effects on species composition and diversity and a reduction in habitat complexity were documented in all the reviewed studies. Studies of acute effects were found to be a good predictor of chronic effects. Recovery after fishing was variable, depending on habitat type, life history strategy of component species, and the level of natural disturbance.

The spatial and temporal scales of fishing gear impact research do not generally correspond to the spatial and temporal patterns of fishing activities and ecosystem functions. The challenge is to apply the results of relatively small-scale gear and habitat specific studies as well as the results of long-term chronic impact studies (which show the cumulative results of multiple gears and unknown patterns of effort over time). It must also be recognized that disturbances from fishing are likely to be patchy within and between different habitats. The degree of patchiness as well as the frequency and intensity of the disturbance can greatly influence the effects of fishing in particular habitats. However, Auster and Langton (MS1998 and in press) have shown that the patterns and direction of impacts from small scale studies, and patterns seen in long-term studies of chronic impacts, are consistent with the results of those fewer research projects which determined the effects of fishing at the scale of fishing grounds. For example, Thrush *et al.* (in press) sampled multiple fishing grounds which were impacted by various degrees of fishing effort. The grounds subject to the most (highest) fishing effort had decreases in large epifauna and long-lived surface dwellers and an increase in deposit feeders and small opportunistic species, and reduced species diversity when compared to grounds with less fishing effort and areas closed to fishing. While the types and direction of impacts are known, rates of impacts based on particular levels of effort, produced by specific gear types, are not well understood. In order to clearly understand the effects of fishing on different types of habitat, areas currently closed and in an advanced stage of recovery would need to be used to experimentally determine effort-specific rates of impacts. Dorsey and Pederson (1998) suggest that research on the impacts of fishing gear in New England has been limited by the lack of unfished areas to compare with the fished areas, as well as by the high cost of conducting research on the sea floor.

Auster and Langton (MS1998 and in press) report that one of the most difficult issues regarding estimating the extent of fishing-related impacts on habitat is the lack of high resolution data on the distribution of fishing effort. Although data and information exists in a variety of formats and from a variety of sources (logbooks, interviews, observers), it is not consistent and represents only a portion of total fishing effort. This lack of information on the extent and frequency of the areas fished with particular gear types makes an assessment of the impacts of fishing activities on EFH difficult at best.

Auster and Langton (MS1998 and in press) demonstrate that one of the primary effects of bottom-tending mobile fishing gears is to reduce the complexity of the habitat. As fishing effort or intensity increases, the complexity of the habitat is reduced by removal of emergent epibenthic species (e.g., sponges, bryozoans, hydroids), smoothing of sedimentary bedforms (e.g., sand waves and ripples), and removal of species which produce structures (e.g., crabs and fish which produce depressions and burrows). Maintaining habitat complexity is an important consideration, as many demersal species, especially juveniles, are associated with structural components in all habitats types. As the complexity of the habitat is reduced, these individuals are more likely to suffer higher levels of predation and fewer fish survive to recruit to the fishery. Habitat structure is more than just sediment type (e.g., mud, sand, gravel, boulder). While each sediment type varies in grain size (such that boulders provide deep crevices and sand can be used for burial), each also varies in types of bedforms and structures (e.g., mud burrows, sand waves) and the types of epifauna (e.g., burrowing anemones in mud; hydroids and amphipod tubes in sand; sponges and corals on gravel).

Based on the existing scientific literature, Auster and Langton (MS1998 and in press) present a model which integrates the range of effects observed in various studies. The model shows that the entire range of habitats from mud to boulders (except for pebble-cobble with no epifauna) can have a loss of complexity in the most impacted state. Sand wave fields can be smoothed, epifauna removed from sand and mud, epifauna removed from cobbles, and boulders moved to reduce the total amount of crevice space for boulder reef dwelling fishes (such as juvenile redfish). However, based on a method to score each habitat according to the level of complexity it provides, pebble-cobble with epifauna, piled boulders, and dispersed boulders-cobble are three categories of habitat showing the greatest reductions in habitat complexity from increasing fishing effort.

The issue of defining pelagic habitats and determining effects of fishing is difficult because these habitats are poorly described at the scales that allow for measurements of change based on gear use. While pelagic habitat can be defined based on temperature, light intensity, turbidity, oxygen concentration, currents, frontal boundaries, and a host of other oceanographic parameters and patterns, there are few published data that attempt to measure change in any of these types of parameters or conditions concurrent with fishing activity and associations of fishes. Kroger and Guthrie (1972) showed that menhaden (*Brevortia patronus* and *B. tyrannus*) were subjected to greater predation pressure, at least from visual predators, in clear versus turbid water, suggesting that turbid habitats were a greater refuge from predation. This same type of pattern was found for menhaden in both naturally turbid waters and in the turbid plumes generated by oyster shell dredging activities (Harper and Hopkins 1976). However, no work has been published that addresses the effects of variation in time and space of the plumes or the effects using turbid water refugia on feeding and growth.

There are also examples of small scale aggregations of fishes with biologic structures in the water column and at the surface. Aggregations of fishes may have two effects on predation patterns by: (1) reducing the probability of predation on individuals within the aggregation, and (2) providing a focal point for the activities of predators (a cue that fishermen use to set gear). For example, small fishes aggregate under mats of *Sargassum* (e.g., Moser *et al.* 1998) where high density vessel traffic may dis-aggregate mats. Also, fishes have been observed to co-occur with aggregations of gelatinous zooplankton and pelagic crustaceans (Auster *et al.* 1992, Brodeur in press). Gelatinous zooplankton are greatly impacted as they pass through the mesh of either mobile or stationary gear (unpublished observations), which may reduce the size and number of aggregations and disperse associated fishes. These changes could reduce the value of aggregating, resulting in increased mortality or reduced feeding efficiency.

4.3 PROCESS

To complete an assessment of the current and potential adverse impacts to essential fish habitat associated with the various fishing-related activities occurring in the New England region, the Council used the following process:

1. *Identify all gears used in the New England fisheries*. This was completed by analyzing summary information from the NMFS commercial and recreational landings databases to identify any gear used to land a managed species during the fifteen-year time period, 1982 - 1996. Any gear type for which a minimum of 100 pounds was recorded during this time period is included. The list of gear types and this assessment includes the available information on recreational landings, correlated to the recreational fishing "mode" (shore, party/charter, or private/rental). [See Table 6.]
2. *Develop a list of all gears used, based on % of landings*. Landings for all gear types with recorded landings from 1982 - 1996 were totaled and the landings represented as a percentage of the total landings for that time period. Any gear identified as responsible for at least 1% of the landings is considered a primary gear type. [See Table 7.]
3. *Characterize the gears used in the New England region*. Information on the function, size, use and variations of the gears was developed.
4. *Identify the habitat impacts of the primary gears*. The Council is focusing the discussion of habitat impacts on the primary gears, using best available information as a reference, and correlating these impacts to generalized habitat types. Specific impacts, where known, of a particular gear type on a particular habitat type are identified.
5. *Focus consideration of mitigation measures on these areas*. Management action will most likely be limited to management measures available through the framework adjustment process, although the Council is considering several measures which will mitigate some of the adverse effects of fishing activity on EFH.
6. *Other issues*. The Council is also assessing the habitat impacts from aquaculture, "ghost" fishing gear and marine debris, and off-shore fish processing. These are activities / issues that have been identified as potential fishing-related impacts to essential fish habitat. All other activities that have the potential to adversely impact habitat are considered to be non-fishing related activities and are addressed in the non-fishing impacts section.

The Council's assessment of fishing-related activities includes the following:

- identification and characterization of fishing gears used in New England -- this section identifies the various gear types used to harvest the species managed by the Council and describes the form and function of the gear types.
- assessment of the effects on habitat from fishing-related marine debris and "ghost" gear.
- assessment of the effects on habitat from aquaculture.
- assessment of the effects on habitat that are likely to occur from at-sea fish processing.
- assessment of existing and new management measures implemented by the Council that either directly or indirectly protect and conserve EFH from the effects of fishing-related activities.
- description of measures to protect the area designated as a habitat area of particular concern for juvenile Atlantic cod.
- description of the Council's process for developing and implementing framework adjustment measures for EFH.
- "The Effects of Fishing on Habitat," a synthesis of the effects of fishing on fish habitat produced to aid the fishery management councils in assessing the impacts of fishing activities, prepared by Peter J. Auster of the National Undersea Research Center, and Richard W. Langton of the Maine Department of Marine Resources (included as Appendix E).

4.4 GEAR IMPACTS ASSESSMENT

Auster and Langton (1998 and in press) showed there is very little information on impacts to habitat associated with several gear types used in the New England region, principally gillnets, longlines, haul seines, hand lines, mid-water trawls, purse seines, and stop seines. Gear types designed to work in mid-water do not impact the seafloor but may effect mid-water aggregations of gelatinous zooplankton which has been demonstrated to serve as habitat for some species. Other gear types which fish in a static fashion on the seafloor such as traps, gillnets and longlines are thought to minimally impact the seabed. However, the cumulative effects of static gear remain unknown. It is important to remember, however, that the impacts of fishing gear depend not only on the type of gear used, but also the frequency and intensity of use, the type of bottom and the composition of the benthic community. Taking these considerations into account, the bottom-tending mobile gears (otter trawls, scallop dredges, beam trawls, and hydraulic clam dredges) are most likely to be associated with adverse impacts to habitat. Jones (1992) suggests that beam trawls, otter trawls, and dredges are all essentially similar in impact, and the severity of the impact can be correlated to the weight of the gear that is in contact with the bottom. The heavier the gear in contact with the bottom, the greater the impact. This may be an oversimplification, but it illustrates an important point -- the lighter the gear, the less impact it is likely to have.

Most research on gear impacts has been done on beam trawls, otter trawls, and scallop dredges, which contribute to the majority of landings in the New England fisheries. The impacts that can presently be deduced to affect fish populations occur on the relatively more complex habitat types, such as cobble, shell, or rock (Auster and Langton MS1998 and in press). These impacts are especially acute in the presence of emergent epifauna or other biogenic structure (Auster and Langton MS1998 and in press). It is clear that current scientific knowledge can predict the types and direction of impacts from high levels of fishing effort with mobile gear types which would allow managers to take precautionary approaches.

4.5 FISHING GEARS USED IN THE NEW ENGLAND AREA

Based on a review of the National Marine Fisheries Service commercial fisheries landings data for the species managed by the New England Fishery Management Council, forty-three categories of fishing gear were identified as having been associated with landings during the fifteen-year period between 1982 and 1996. Table 6 displays the forty-three gear types and indicates the species landed. These gear types were identified as having been used to land a minimum of one hundred pounds of at least one species, either as a target catch or bycatch. Any gears with less than one hundred pounds of landings are not considered here. The categories of fishing gears are taken from the NMFS commercial and recreational landings databases. An "X" indicates that the gear type is associated with at least one hundred pounds of landings of the species at some time during the fifteen year assessment period (1982 - 1996).

Gears of primary concern in an analysis of the impacts of fishing activity on essential fish habitat are those identified as having been used to land at least one percent of all landings of at least one species during the same fifteen year time frame. Table 7 provides the percentage landings associated with each gear type for each species landed. Eighteen gear types are considered primary gears, and these will be examined in more detail, including an assessment of the likely impact the gears have on essential fish habitat. This assessment is based on a review of the current literature on fishing impacts to the sea floor.

Table 7 summarizes the percent of total landings of each managed species associated with each gear type used in the fishery. For example, the sea scallop dredge (listed as "dredge scallop, sea") accounted for 32% of the monkfish landings from 1982 - 1996, 6% of the yellowtail flounder landings, 3% of the windowpane flounder landings, 2% of the winter flounder landings, 1% each of the landings of American plaice and witch flounder, and 95% of the landings of sea scallops. The three gear types that accounted for the top percentages of landings for each species were the otter trawl, scallop dredge, and purse seine. However, the otter trawl accounted for the majority of catch for all species except sea scallops and Atlantic herring.

Many gears only accounted for a trace amount of landings (less than 0.5%) and these are indicated by a "+". Several gear types (dip nets, diving outfits, crab dredges, sea urchin dredges, bay scallop dredges, fykes and hoop nets, pound nets, mackerel purse seines, spears, trammel nets, stop nets, and jigging machines) accounted for only trace amounts of landings for fewer than five species and were not included in the table.

Recreational fishing is also a consideration when examining the effects of fishing on the habitat. The available information on recreational landings were examined and incorporated into this assessment. Tables 6 and 7 include recreational fishing, identified by fishing mode -- shore, party/charter, or private/rental. Additional information would be required to complete a more comprehensive assessment of the effects of recreational fishing on essential fish habitat.

Table 6: Types of Fishing Gears Used in New England Fisheries *

	beam trawls	dip nets	diving outfits	dredge clam	dredge crab	dredge scallop, bay	dredge scallop, sea	dredge urchin, sea	floating traps, shallow	fyke and hoop nets	gillnets, drift, other	gillnets, sink/anchor, other	gillnets, stake	haul seines, beach	haul seines, long	lines hand, other	lines jigging machine	lines long set with hooks	lines troll, other	otter trawl bottom, crab	otter trawl bottom, fish	otter trawl bottom, lobster	otter trawl bottom, other	otter trawl bottom, scallop	otter trawl bottom, shrimp	otter trawl mid-water	pots and traps	pound nets, fish	pound nets, other	purse seines, herring	purse seines, mackerel	purse seines, other	recreational, shore	recreational, party/charter	recreational, private/rental	scottish seine	spears	stop nets	stop seines	trammel nets	trawl bottom, paired	trawl mid-water, paired	weirs
American plaice	X						X				X	X	X		X	X		X			X		X		X		X					X				X					X		
Atlantic halibut												X				X		X			X			X	X											X					X		
Atlantic cod	X			X		X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X				X	X	X	
flounder, windowpane	X			X			X		X		X	X		X	X	X		X	X	X	X	X		X	X		X	X								X		X			X	X	
flounder, winter	X	X		X	X		X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X				X	X	X	X	X	X	X			X	X	
flounder, witch	X						X		X		X	X		X	X	X		X	X	X	X	X		X	X		X									X					X	X	
flounder, yellowtail	X						X				X	X			X	X		X			X			X	X		X	X				X				X					X	X	
haddock	X						X				X	X	X		X	X	X	X		X	X	X		X	X		X					X		X		X					X		
hake, red				X			X		X		X	X	X	X	X	X		X	X		X	X		X	X		X		X				X	X	X	X					X	X	
hake, white	X						X		X		X	X	X		X	X	X	X	X	X	X	X		X	X		X	X				X		X		X					X	X	
Atlantic herring									X	X	X	X	X	X		X		X			X		X		X	X	X	X	X	X	X	X	X	X	X				X		X	X	X
monkfish	X			X		X	X		X		X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X				X				X		X		X	X	X	
ocean pout							X					X			X	X		X			X				X		X									X					X		
pollock	X						X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X					X	X	
redfish							X				X	X		X	X	X		X		X	X	X		X	X	X	X							X		X					X		
sea scallop	X		X	X		X	X	X	X			X				X				X	X	X	X	X	X		X					X				X							
whiting	X		X	X			X		X	X	X	X	X	X	X	X		X		X	X		X	X	X	X	X	X		X						X		X			X	X	

* Based on the categories used in the NMFS Commercial and Recreational Landings Database, from 1982 - 1996.

Table 7: Percentage of Landings for Each Fishing Gear Type Used in the New England Fisheries, 1982 - 1996 * (1000's of pounds total landings from 1982 - 1996 in parentheses)

	American plaice (73,379)	Atlantic halibut (398)	Atlantic cod (1,119,265)	flounder, windowpane (67,946)	flounder, winter (277,686)	flounder, witch (119,167)	flounder, yellowtail (85,641)	haddock (162,358)	hake, red (60,954)	hake, white (192,007)	Atlantic herring (1,366,278)	monkfish (382,121)	ocean pout (27,845)	pollock (393,243)	redfish (76,997)	sea scallop (359,761)	whiting (573,412)
beam trawls	+	-	+	+	+	+	+	+	-	+	-	+	-	+	-	+	+
dredge clam	-	-	+	+	+	-	-	-	+	-	-	+	-	-	-	+	+
dredge scallop, sea	1	-	+	3	2	1	6	+	+	+	-	32	+	+	+	95	+
floating traps, shallow	-	-	+	+	+	+	-	-	+	+	+	+	-	+	-	+	+
gillnets, drift, other	+	-	+	+	+	+	+	+	+	+	+	1	-	+	+	-	+
gillnets, sink/anchor, other	2	4	17	+	2	1	3	4	1	25	+	11	+	36	2	+	+
gillnets, stake	+	-	+	-	+	-	-	+	+	+	+	-	-	+	-	-	+
haul seines, beach	-	-	+	+	+	+	-	-	+	-	+	+	-	+	+	-	+
haul seines, long	1	-	+	+	+	1	+	+	+	+	-	+	+	+	+	-	+
lines hand, other	+	+	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+
lines long set with hooks	+	32	5	+	+	+	+	1	+	7	+	+	1	+	+	-	+
lines troll, other	-	-	+	+	+	+	-	-	+	+	-	+	-	+	-	-	-
otter trawl bottom, crab	-	-	+	+	+	+	-	+	-	+	-	+	-	+	+	+	+
otter trawl bottom, fish	95	62	72	97	93	96	89	94	90	67	4	54	98	62	97	1	97
otter trawl bottom, lobster	-	-	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-
otter trawl bottom, other	+	-	+	-	+	-	-	-	-	-	+	+	-	+	-	+	+
otter trawl bottom, scallop	-	+	+	+	+	+	+	+	+	+	-	+	-	+	+	5	+
otter trawl bottom, shrimp	+	+	1	+	1	1	+	+	3	+	+	+	+	+	1	+	1
otter trawl mid-water	-	-	+	-	-	-	-	-	-	-	13	+	-	+	+	-	+
pots and traps	+	-	+	+	+	+	+	+	3	+	+	+	+	+	+	+	+
pound nets, fish	-	-	+	+	+	-	+	-	-	+	+	+	-	+	-	-	+
purse seines, herring	-	-	+	-	-	-	-	-	-	-	79	-	-	+	-	-	+
purse seines, other	+	-	+	-	+	-	+	+	-	+	+	+	-	+	-	+	-
recreational, party/charter	-	-	2	-	+	-	-	-	+	-	+	-	-	+	-	-	-
recreational, private/rental	-	-	1	-	1	-	-	-	+	-	+	-	-	+	-	-	-
scottish seine	+	+	+	+	+	1	+	+	+	+	-	+	+	+	+	+	+
stop seines	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
trawl bottom, paired	+	+	1	+	+	+	+	1	+	+	+	+	+	+	+	-	+
trawl mid-water, paired	-	-	+	+	+	+	+	-	+	+	1	+	-	+	-	-	+
weirs	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-

"+" Indicates that there were trace (< 0.5 %) landings associated with this gear type for this species.
"-" Indicates that there were no landings recorded for this gear type for this species.

Much of the following information is taken from either *Commercial Fishing Methods: An introduction to vessels and gears*, (3rd Ed.) by John C. Sainsbury or was provided by Dr. Joseph DeAlteris, University of Rhode Island.

Beam Trawls

The beam trawl is essentially a trawl net much like an otter trawl, only the net is spread horizontally by a wooden or steel beam that runs the horizontal width of the trawl rather than with otter boards. The trawl net is spread vertically by heavy steel trawl heads that generally have skid-type devices with a heavy shoe attached. The otter boards and quarter ropes of the more common otter trawl are not needed. The net's headrope is fastened directly to the beam and the groundrope is connected loosely between the bases of the shoes. Modern beam trawls range in size from 4 to 12 meters beam width and the beam is held about 1 meter above the bottom. Depending on the ground being fished, beam trawl nets may be fitted with a number of tickler chains or a heavy chain mat. The tickler chains are usually rigged between the ends of the shoes to dig out fish lying on or buried in sand and mud and the number of chains that will be used depends on the species being targeted. A chain mat is generally used in place of the tickler chains on hard and rocky grounds.

Towing speeds of at least five knots are generally considered most effective for the capture of flatfish with a beam trawl. The advantages claimed for beam trawls over otter trawls in catching demersal species, especially flatfish include:

- The warp length has less influence on performance;
- The size of the net opening remains constant during turns;
- The effectiveness of the gear is less affected by soft muddy bottoms;
- The gear has less drag (reducing the power required); and,

Smaller vessels with restricted warp capacity can fish deeper since less scope is needed. Modern beam trawlers often use double beam trawls, in which two beam trawls are towed from heavy booms rigged from a large A-frame mounted to the deck of the vessel. Additional recent modifications to this gear type include:

- Replacing the chain mat with an electrode array fed by an on-board generator;
- Replacing the trawl head shoes with wheels; and,
- The development of a high-lift net design where the headline is not attached to the beam but rather allowed to billow upwards.

(Sainsbury, J.C. 1996. from *Commercial Fishing Methods: An introduction to vessels and gears*, 3rd Ed. Fishing News Books, Oxford, England.)

Dip Nets

Dip nets are relatively small, handled nets used to scoop fish from the water.

Diving Outfits

By either free diving or using SCUBA, divers collect crustaceans, mollusks and some reef fish in shallow water. Most often a support vessel is used to transport the diver(s) to the fishing site and carry the landings to port. In deeper waters, helmet diving systems are used and the diver is tethered to the vessel with air pumped from the surface. This method is most often used by sea urchin divers and some lobster divers. Divers normally use small rakes or hoes to scrape creatures off rocks or dig them out of the seabed. Generally, the catch is placed in bags which are either towed to the surface by the boat or floated to the surface using an air source and a lift bag. Divers rarely work deeper than about 50 meters. (Sainsbury 1996)

Clam Dredge

To dig up clams from out of the sediment, hydraulic dredging is often used. In hydraulic dredging, high pressure water jets ahead of the rake teeth or blade are used to scour out the shells which are then dug up by the blades and passed back into the bag. High pressure water is supplied to the jets through a hose from the operating vessel by a diesel pump and the bag is generally carried on a heavy sled. This gear is generally fished in relatively shallow inshore and estuarine areas. (Sainsbury 1996)

In the ocean surf clam fishery, large vessels (>30 m), tow dredges up to 4.5 m in width slowly across the seabed. The vessels are equipped with large pumps, connected to the dredges via flexible hoses, that use water and inject it into the sediment through a manifold with multiple nozzles, ahead of the blade of the dredge. The dredge must be towed slowly so as to not exceed the liquification rate. These dredges, operated correctly, are highly efficient, taking as much as 90% of clams in their path. In the estuarine soft-clam fishery, the dredge head (manifold and blade) is attached to an escalator that continuously carries the materials retained on the blade to the working deck of the vessel to be selected by the fishermen. These vessels are restricted to water depths less than one-half the length of the escalator. However, the soft clam is a shallow water clam, so the technology is most appropriate and is typically operated from 15 m vessels in water depths of 2-6 m. (DeAlteris, J. 1998. Training Manual: Fisheries Science and Technology, prepared for the NOAA Corps Officer Program.)

Crab Dredge

Crabs are harvested during the winter months with dredges similar to oyster dredges. The oyster dredge consists of a steel frame 0.5-2.0 m in width, with an eye and “nose” or “tongue,” and a blade with teeth. Attached to the frame is the tow chain or wire, and a bag to collect the catch. The bag is constructed of rings and chain-links on the bottom to reduce the abrasive effects of the seabed, and twine or webbing on top. The dredge is towed slowly (<1 m/sec) in circles, from vessels 7 to 30 m in length. Stern-rig dredge boats (≈ 15 m in length) tow two dredges in tandem from a single chain warp. The dredges are equipped with long teeth (10 cm) that rake the crabs out of the bottom. (DeAlteris 1998)

Bay Scallop Dredge

Since scallops usually lie on the bottom, on clear bottoms no raking teeth are needed, and the dredge is actually quite a simple gear. The bay scallop dredge may be 1 to 1 1/2 meters wide and about twice as long. The simplest bay scallop dredge can be just a mesh bag attached to metal frame that is pulled along the bottom. For bay scallops that are located on sand and pebble ground, a small set of raking teeth are set on a steel frame, and skids are used to align the teeth and the bag. (Sainsbury 1996)

Sea Scallop Dredge

In the open ocean, a larger dredge is used to harvest sea scallops. Scallops inhabit sandy, gravelly, and cobble bottom, and live on the surface of the sea bed as epifauna. Scallops are mobile animals and can evade a dredge approaching too slowly. Therefore, scallop dredges have to be towed at speeds up to 2.5 m/sec. The scallop dredge includes a steel frame with a tongue with an eye, a blade with no teeth, and a bag. Scallop dredges are usually defined by the width of the dredge frame, the width or mouth opening of which ranges from 1 - 4.5 meters, with the weight of the dredge varying from 20 to 1000 kg. The New Bedford style dredge is usually between 4 and 4.5 meters wide. The front of the steel frame of the dredge, called the bale, usually rides up off the bottom. The bottom of the frame is called the cutting bar and it tends to ride up off the bottom about four inches on flat, smooth bottoms. On rougher bottoms, the cutting bar will come in contact with the higher areas of the sea floor.

There is a chain sweep that attaches to the ends of the frame at the shoes, reinforced bottom pads. The bag of the dredge is known as a "ring bag" and is made of rings and chain-links on the bottom and webbing on top. Using a scallop dredge on hard bottom usually requires the addition of "rock chains" that run front to back, along with the side-to-side tickler chains used on all types of scallop dredges. The rougher the bottom, the more rock chains are used, to prevent rocks and boulders from getting into the ring bag. Selectivity of the dredge is controlled by the size of the rings in the ring bag. The smallest dredges are towed by 6 m vessels and hauled by hand. The largest scallop vessels, about 30 m in length, tow two 4.5 meter dredges, one from each side of the vessel, and use winches and navigational electronics to maintain high efficiency. (DeAlteris 1998 and Smolowitz 1998)

Sea Urchin Dredge

Similar to a simple bay scallop dredge, the sea urchin dredge is designed to avoid damaging the catch. It consists of an up-turned sled-like shape at the front that includes several leaf springs tied together with a steel bar. A tow bail is welded to one of the springs and a chain mat is rigged behind the mouth box frame. The frame is fitted with skids or wheels. The springs act as runners, enabling the sled to move over rocks without hanging up. The chain mat scrapes up the urchins. The bag is fitted with a codend for ease of emptying. This gear is generally only used in waters up to 100 meters deep. (Sainsbury 1996)

Shallow Floating Traps

In New England, because of the rocky shoreline and shallow subtidal environment, stakes can not be driven into the bottom, so the webbing is supported by floats at the sea surface, and held in place with large anchors. These traps are locally referred to as "floating traps." The catch, design elements and scale of these floating traps is similar to pound nets. (DeAlteris 1998)

The floating trap is designed to fish from top to bottom, and is built especially to suit its location. The trap is held in position by a series of anchors and buoys. The net is usually somewhat "T-shaped," with the long portion of the net (the leader net) designed to funnel fish into a box of net at the top of the T. The leader net is often made fast to a ring bolt ashore. (Sainsbury 1996)

Fyke and Hoop Nets

Constructed of wood or metal hoops covered with netting, hoop nets are long (2.5 - 5 meter) nets, "Y-shaped" with wings at the entrance and one or more internal funnels to direct fish inside, where they become trapped. Occasionally, a long leader is used to direct fish to the entrance. Fish are removed by lifting the rear end out of the water and loosening a rope securing the closed end. These nets are generally fished to about 50 meters deep. (Sainsbury 1996)

On a smaller scale, a fyke trap is a small, unbaited cylindrical pot that includes the addition of a leader and heart to direct migrating fish into the funnel of the pot. This gear is set in shallow ponds and estuarine embayments for animals migrating in this habitat. The leader, constructed of webbing supported by stakes is only 10-30 m in length and 1-2 m in height. The trap is cylindrical, constructed of hoops 1-2 m in diameter, surrounded by webbing with 1-2 funnels, non-return devices, leading into the conical holding area. (DeAlteris 1998)

Drift Gill Nets, Other

Gillnets operate principally by wedging and gilling fish, and secondarily by entangling. The nets are a single wall of webbing, with float and lead lines. The nets are designed and rigged to operate as either sink or floating nets, and are anchored or drifting. The webbing is usually monofilament nylon due to its transparency; but multifilament, synthetic or natural fibers, are also used. Drift gillnets are designed so as to float from the sea surface and extend downward into the water column and are used to catch pelagic fish. In this case the buoyancy of the floatline exceeds the weight of the leadline. Floating gillnets are anchored at one end or set-out to drift usually with the fishing vessel attached at one end. (DeAlteris 1998)

Sink/Anchor Gill Nets, Other

Anchored sink gillnets are used to harvest demersal fish along all coasts of the U.S. The nets are rigged so that the weight of the leadline exceeds the buoyancy of the floatline, thus the net tends the seabed, and fishes into the near bottom water column. Anchors are used at either ends of the net to hold the gear in a fixed location. The nets vary in length from 100 to 200 m, and in depth from 2-10 m. Multiple nets are attached together to form a string of nets, up to 2000 m in length. In shallow water, sink gillnets may fish from bottom to surface, if the webbing is of sufficient depth. (DeAlteris 1998)

Stake Gill Nets

Generally a small boat, inshore method in which a gill net is set across a tidal flow and is lifted at slack tide to remove fish. Wooden or metal stakes run from the surface of the water into the sediment and are placed every few meters along the net to hold it in place. When the net is lifted, the stakes remain in place. These nets are generally fished from the surface to about 50 meters deep. (Sainsbury 1996)

Beach Haul Seines

The beach seine resembles of wall of netting of sufficient depth to fish from the sea surface to the sea bed, with mesh small enough that the fish do not become gilled. A floatline runs along the top to provide floatation and a leadline with a large number of weights attached ensures that the net maintains good contact with the bottom. Tow lines are fitted to both ends. The use of a beach seine generally starts with the net on the beach. One end is pulled away from the beach, usually with a small skiff or dory, and is taken out and around and finally back in to shore. Each end of the net is then pulled in towards the beach, concentrating the fish in the middle of the net. This is eventually brought onshore as well and the fish removed. This gear is generally used in relatively shallow inshore areas. (Sainsbury 1996)

Long Haul Seines

The long-haul seine is set and hauled in shallow water estuaries from a boat (about 15 m). The net is a single wall of small mesh webbing (< 5 cm), and is usually greater than 400 m in length and about 3 m in depth. The end of the net is attached to a pole driven into the bottom, and the net is set in a circle so as to surround fish feeding on the tidal flat. After closing the circle, the net is hauled into the boat, reducing the size of the circle, and concentrating the fish. Finally, the live fish are brailed or dip-netted out of the net. (DeAlteris 1998)

Hand Lines, Other

The simplest form of hook and line fishing is the hand line. It consists of a line, sinker, leader and at least one hook. The line is usually stored on a small spool and rack and can vary in length from $1\text{-}10^2$ m. The line varies in material from a natural fiber to synthetic nylon. The sinkers vary from stones to cast lead. The hooks are single to multiple arrangements in umbrella rigs. An attraction device must be incorporated into the hook, usually a natural bait and artificial lure. There are both recreational and commercial hand line fisheries in the U.S. In fact, although this is a technologically sophisticated fishery with fish finding and navigation electronics, it is still conducted by individual or pairs of fishermen in small boats (< 10m), so it may be considered an artisinal fishery. Operationally, hand lines offered a high degree of efficiency, so that the fisherman is able to feel the fish bite the bait, and then set the hook. Hand lines can be used as a fixed or static gear or towed as a mobile gear. Hand lines are usually a passive gear because the fisherman attracts the target, and the fish then voluntarily takes the hook. However, in certain cases, if the hand line is equipped with a treble or ripper hook, then the hand line becomes an active device, as the hook snags the prey. (DeAlteris 1998)

Jigging Machine Lines

Mechanized line hauling systems have been developed to allow more lines to be worked by smaller crews. Electric or hydraulic reel systems, termed bandits, are mounted on the vessel bulwarks. The reels have a spool around which the mainline is wound. Each line may have a number of branches and baited hooks, and the line is taken from the spool over a block at the end of a flexible arm. The vessel's movement combined with the flexible arm provides a fishing action to the line and the hooks. This gear is used to target several species of groundfish, especially cod and pollock and it has the advantage of being effective in areas where other gears cannot be used. Jigging machine lines are generally fished in waters up to 600 meters deep. (Sainsbury 1996)

Long Lines Set with Hooks

Bottom Longline Gear: With the guiding philosophy that if one hook is good, many hooks are better, commercial fishermen developed bottom longline gear. The principle element of this gear is the mainline or groundline that can extend up to 50 km in length. Branching off the mainline at regular intervals are leaders or snoods, and hooks. Anchors hold each end of the mainline in place, and surface buoys attached via float lines to the anchors mark the location of the gear. The mainline was initially constructed of natural fiber lines, that was replaced by a hard-lay, twisted, tarred nylon, and now monofilament and wire cables are typically used. Leaders were initially tied to the mainline, and now they typically snap on to the mainline allowing separate storage of the hooks and leaders and the mainline. All bottom-set, longline gear is considered fixed and passive because once deployed the gear does not move, and the fish voluntarily takes the hook.

In the early 1900s, fishermen on the northwest Atlantic banks, set longlines from dories deployed from sailing schooners. The longlines were stored in tubs or baskets neatly coiled with hooks placed around the outside perimeter of the tub (hence, the term "tub trawling"). Nearly 100 years later this form of fishing continues aboard intermediate-sized coastal vessels fishing for cod and other species. Today, longliners typically use a groundline of approximately 1800 feet per tub of gear. A single set typically consists of connecting from two to four tubs of gear. The groundline is heavy parachute cord with gangions (leaders) spaced at roughly six foot intervals. Usually, the hooks are baited on shore.

Some boats have replaced the tubs with large, hydraulically powered reels as the storage device for the mainline, and leaders with their hooks are snapped onto or off the mainline as the gear is set or hauled respectively. The tilefish fishery on the U.S. east coast uses this type of gear, and a typical 25 m vessel sets and hauls 50 km of mainline with thousands of hooks set and hauled daily, while operating in the canyons on the edge of the continental shelf. More mechanized bottom longline systems have been developed in Norway by Mustad for operation by large vessels (> 25 m). These auto-line systems include baiting machines, variable hook spacing, etc., and enable these vessels to fish up to 10,000 hooks per day. (DeAlteris 1998)

Pelagic Longline Gear: An evolution from bottom longline gear was the development of pelagic longline fishing methods. The mainline is suspended at depth from buoys and dropper lines, with the minimum depth (about 20 m), being that required to avoid entanglement by coastal maritime traffic. The length of the mainline varies from 300 to 100 km depending on the size of the vessel. The mainline material began as 3-strand twisted, hard-lay, tarred nylon, but has been entirely replaced by monofilament. The line is stored on a reel equipped with a level-winder to prevent tangles on the reels. Hooks, leaders and dropper lines are stored on small reels end to end. If the mainline is set level at a fixed depth, then the leader length varies from 2-40 m, so as to ensure the hooks are distributed over a range of depths. If a line-shooter is used to set the mainline in a catenary shape with regard to depth, then the leaders are usually a single minimal length, but are still distributed by depth. (DeAlteris 1998)

Troll Lines, Other

Essentially, trolling involves the use of a baited hook or lure maintained at a desired speed and depth in the water. Usually, two to four or more lines are spread to varying widths by the use of outrigger poles connected to the deck by hinged plates. Line retrieval is often accomplished by means of a mechanized spool. Each line is weighted to accomplish the desired depth and may have any number of leaders attached, each with a hook and bait or appropriate lure. This gear is generally fished from the surface to about 20 meters. (Sainsbury 1996)

Bottom Otter Trawl (fish)

Otter trawls developed as fishermen sought to further increase the horizontal opening of the trawl mouth, but without the cumbersome rigid beam. In the late 1880s, Musgrave invented the otter board, a water-plane device that when used in pairs, each towed from a separate wire, served to open the net mouth horizontally and hold the net on the bottom. Initially, all otter boards were connected to the wing ends of the trawl, as they are today in the shrimp trawl fishery. In the 1930s, the Dan Leno gear was developed by Frenchmen, Vigarnon and Dahl, that allowed the otter boards (doors) to be separated from the trawl wing ends using cables or “ground gear.” This technology increased the effective area swept by trawl from the distance between the net wings to the distance between the doors. The ground gear can be as long as 200 m, thus increasing the area swept by the trawl by as much as three fold. It is the spreading action of the doors resulting from the angle at which they are mounted that creates the hydrodynamic forces needed to push them apart. These forces also push them down towards the sea floor. On fine-grained sediments, the doors also function to create a silt cloud that aids in herding fish into the mouth of the trawl net (Carr and Milliken 1998).

The bottom trawl net is a funnel-shaped net composed of upper and lower sections joined at seams referred to as “gores”. Some bottom trawls also have side panels to increase the vertical opening, and therefore have four seams. The mouth of the trawl net consists of jib and wing sections in both the upper and lower panels. A “square” section forms a roof over the net mouth. The body of the trawl net includes belly sections, leading to the cod-end where the catch is collected. The webbing is attached to a rope frame consisting of a headrope, along the upper panel leading edge, and a footrope, along the lower panel leading edge. The sweep which tends bottom as the net is towed, is attached to the footrope. The headrope is equipped with floats that provide buoyancy to open the net mouth vertically. The headrope and footrope/sweep are attached to bridles (also referred to as legs) at the wing ends, that lead to the ground wires and the trawl doors. The sweep also comes in contact with the bottom as it acts to collect fish that lie or congregate before it. The configuration of the sweep can vary considerably and is dependent upon both the bottom type and species of fish targeted (Carr and Milliken 1998).

On smooth bottoms, the footrope may be weighted with chain or leadline, or may be rope wrapped with wire. This is the simplest and lightest sweep, known as a chain sweep. On soft or slightly irregular bottoms, rubber discs (known as "cookies") stamped from automobile tires can be strung along the sweep (Carr and Milliken 1998). On rougher bottoms, rubber rollers or steel bobbins are rigged to the footrope to assist the trawl's passage over the bottom. Both the rollers and the bobbins use small steel or rubber spacers between the much larger roller and bobbins. In New England, the rollers have been largely replaced with "rockhopper" gear, that uses larger rollers that are actually fixed in place, spaced with the smaller rubber discs (Carr and Milliken 1998). This setup enables the trawl to pass over, yet still effectively fish, areas with large rocks and boulders.

A newly developed gear known as "street-sweeper" trawl gear, is constructed of a series of rubber disc spacers and bristle brushes, as found in actual street sweepers. The distinguishing component of this sweep is the brushes made of stiff bristles mounted on a cylinder core. The brush cylinders are up to 31 inches in diameter and have smaller diameter rubber disc(s) placed between them. The discs are strung on a cable or chain and aligned in series forming the sweep of the trawl net. This innovation probably allows the trawl to be fished on rougher bottom than any other design and it is lighter than the rockhopper (Carr and Milliken 1998).

The raised-footrope trawl was designed especially for fishing for whiting, red hake, and dogfish. It was designed to provide vessels with a means of continuing to fish for small mesh species without catching groundfish. The configuration consists of a 42 inch long chain connecting the sweep to the footrope, which results in the trawl fishing about 18 - 24 inches above the bottom (Carr and Milliken 1998). The raised footrope keeps the net slightly above the bottom, allowing complete flatfish escapement, and theoretically it is supposed to travel over codfish and other roundfish (whiting and red hake tend to swim slightly above the other groundfish). Carr and Milliken (1998) report that studies have confirmed that the raised footrope sweep has much less contact with the sea floor that does the traditional cookie sweep that it replaces.

Bottom trawl vessels are classified as to the location of the pilothouse, and manner in which the net is set and hauled. Eastern rig vessels handle the trawl gear from the side of the vessel and the pilothouse is located aft of the working deck. Western rig vessels handle the trawl gear over the stern of the vessel and the pilothouse is forward of the working deck. Most western rig or stern trawlers stow the trawl net on a reel located at the stern of the vessel.

Bottom trawl fisheries are prosecuted for demersal species on all coasts of the U.S. In the northeast, vessels from 15 to 50 m fish in waters ranging from 10 to 400 m in depth. Small mesh nets are used to capture northern shrimp, whiting, butterfish and squid. Large mesh trawls are used to harvest cod, haddock, flounder and other large species. These trawls are typically rigged with long ground wires that create sand clouds on the seabed, herding the fish into the trawl mouth. The largest trawlers, from 50-100 m in length, catch, process and freeze their products onboard, and are referred to as factory, catcher, processor trawlers. (DeAlteris 1998)

<u>Bottom Otter Trawl (crab)</u> See the description above for Otter Trawls.

<u>Bottom Otter Trawl (lobster)</u> See the description above for Otter Trawls.

<u>Bottom Otter Trawl (other)</u> See the description above for Otter Trawls.

<u>Bottom Otter Trawl (scallop)</u> See the description above for Otter Trawls.

<u>Bottom Otter Trawl (shrimp)</u>

In the southeast and Gulf coast areas, small mesh trawls are used to harvest shrimp. Because shrimp can not be herded, shrimp trawl nets are usually connected directly to the trawl doors. Southern shrimp trawl vessels tow 2-4 trawls from large booms extended from each side of the vessel. (DeAlteris 1998)

<u>Midwater Otter Trawl</u>

Pelagic fishes are harvested using off-bottom or midwater trawl nets. The nets must be aimed or directed at specific concentrations of fish. Therefore, the fishermen must be able to identify the location of fish both laterally and vertically, and to direct the pelagic trawl to that position. Hydroacoustic instruments are used to locate both fish and the fishing gear. Sonar, a forward searching acoustic device is initially used to locate the fish ahead of the vessel. As the fisherman directs the vessel over the fish, the echosounder is used to verify the exact size and depth of the school. As the fisherman is approaching fish, he is also using the net sounder, an acoustic device on the pelagic trawl mouth, to determine the depth and vertical opening of the trawl. By adjusting the length of the tow warp and speed of the tow vessel, the fishing depth of the trawl mouth is adjusted to match the depth of the fish. In general, pelagic fish have a high visual acuity and are fast swimmers, so pelagic trawls are very large and must be towed fast. Thus, pelagic trawl vessels, must be equipped with relatively more horsepower than similarly sized demersal trawlers.

The pelagic trawl mouth is opened horizontally by high aspect otter boards, that act as foils or wings oriented vertically in the water column. The net initially is opened vertically, by the floats along the headrope and weights along the footrope. After stabilizing position in the water column, water flow acting on the tapered panels of the funnel shaped net opens the net. The net is always constructed of four panels, with a gentle taper, so as to appear as an endless tunnel to the fish. Generally, the net employs webbing of multiple mesh sizes, the largest in the jibs and forward bellies, reducing to smaller mesh sizes in aft bellies, and the smallest mesh size in the cod-end, suitable for retaining the target species. (DeAlteris 1998)

Pots and Traps

The essential element of any pot or trap fishing gear is a non-return device, that allows the animal to voluntarily enter the gear, but makes escape difficult, if not impossible. The terminology used to identify pots and traps is also confusing, as both terms have been applied to the small portable, 3-dimensional gear. In this document, a pot is defined as a small, portable, 3-dimensional device, whereas a trap is identified as large, permanent, 2-dimensional gear.

Pots: The principle of operation of pot gear is that animals enter the device seeking food, shelter, or both. The non-return device, while allowing the animal to enter the gear, restricts escape. The holding area retains the catch until the gear is retrieved. Bait is placed in a bag or cage within the pot. Culling rings or escape vents are added to the exterior wall of the pot to allow for the release of undersize sub-legal animals. Finfish, shellfish and crustaceans are all harvested with pots in the estuarine, coastal and offshore waters of the U.S.

Clawed lobsters are harvested with pots in the waters of the northwest Atlantic. The pots were previously constructed of wood lath over steam bent frames, but because wood boring bivalves destroy wood, in many cases vinyl coated wire pots have replaced them. Cost is another factor leading to the switch to vinyl coated wire pots. The pots are typically divided into two sections. Lobsters enter the pot into the "kitchen area," via either of two funnels in response to the bait, then move into the "parlor" area via a second funnel. Escape vents, sized to minimize the retention of sub-legal lobsters are occasionally installed in both areas of the pot. The pots are fished individually or in "trawls" attached to a mainline in shallow water, and only in trawls of 20-50 pots in deep water. Buoys and lines mark both the single pots, and the ends of the trawls of pots. Fishermen haul pots either by hand in shallow water, or use an hydraulically powered pot hauler in both shallow and deep water. The pot hauler was a significant mechanization introduced into the pot fishery, that allowed for the development of deep water fisheries.

The crab fisheries conducted in the inshore waters of the mid and south Atlantic regions also use a wire mesh pot. The design of the pot incorporates two sections, an "upstairs" and "downstairs." Crabs attracted by bait, enter the "downstairs" via one of two-four entrance funnels. Once in the pot, the escape reaction is to swim upward, so a partition with two funnels separates the two sections. The "upstairs" section serves to hold the catch for harvest. Escape vents or cull rings may be installed in the pot to reduce juvenile by-catch. Crab pots are always fished as singles and are hauled by hand from small boats, or with a pot hauler in larger vessels. Crab pots are generally fished after an overnight soak, except early and late in the season. (DeAlteris 1998)

Trap Gear: Traps are generally a large scale, 2-dimensional device that use the seabed and sea surface as boundaries for the vertical dimension. The gear is fixed, that is installed at a location for a season, and is passive, as the animals voluntarily enter the gear. Traps consist of a leader or fence, that interrupts the coast parallel migratory pattern of the target prey, a heart or parlor that leads fish via a funnel into the bay section, and a bay or trap section that serves to hold the catch for harvest by the fishermen. The non-return device is the funnel linking the heart and bay sections. The bay, if constructed of webbing, is harvested by concentrating the catch in one corner, a process referred to as "bagging" or "hardening" the net." The catch is removed by "brailing," with a dip net. The advantages of traps are that the catch is alive when harvested, resulting in high quality, that the gear is very fuel efficient, and that there is the potential for very large catches. The disadvantages are that the initial cost of the gear is high, that there is competition for space by other users of the estuarine and coastal ecosystem, and finally that the fish must pass by the gear to be captured, so any alterations in migratory routes will radically affect catch.

<u>Fish Pound Nets</u>

Pound nets are constructed of netting staked into the sea bed by driven piles. Pound nets have three sections: the leader, the heart, and the pound. The leader (there may be more than one) may be as long as 400 meters and is used to direct fish into the heart(s). One or more hearts are used to further funnel fish into the pound and prevent escapement. The pound may be 15 meters square and is the hold for the fish until the net is emptied. These nets are generally fished in waters less than 50 meters deep. (Sainsbury 1996)

<u>Pound Nets, Other</u> See the description above for Fish Pound Nets.

<u>Purse Seines, Other</u>

The purse seine is an evolution of the ring net. The ring net is a single wall of webbing that is also used to surround concentrations of pelagic fish. A discontinuous line, the hauling rope, attached to the center bunt section of the net, is used to close the bottom of the net after a school of fish has been circled. The ring net is usually a relatively small net (about 200 m in length) and is typically used in fresh water fisheries. The discontinuous hauling line has been replaced by a continuous purse line. Functionally, purse seines are used to surround a concentration of fish, then the purse seine is hauled in so as to close the bottom of the net. Critical aspects of the design and operation of a purse seine include:

- sufficient weight on the leadline to achieve a rapid submersion of the net.
- adequate floatation to support the webbing and leadline.
- the net must be of correct length to allow for the complete enclosure of the school of fish.
- the mesh size must neither be too big so as to allow escape or gilling of fish, and not so small as to create excess bulk and drag.

The puretic power block developed in the early 1950s, was a significant mechanization of the purse seine fishery. The V-shaped sheave, attached to a beam end, and powered by a hydraulic motor, has replaced 10-20 men that used to haul in the long wings of the small seines (300 m) used to harvest menhaden in Chesapeake Bay. The largest purse seines now used on tuna fish in the open ocean are more than 2000 m in length and 200 m in depth. Without the power block, these fisheries would not have developed. (DeAlteris 1998)

Herring Purse Seines See the description above for Purse Seines.

Mackerel Purse Seines See the description above for Purse Seines.

Scottish Seine

Danish seining or anchor dragging was developed in the 1850s prior to the advent of otter trawling. The Danish seine is a bag net with long wings, that includes long warps set out on the seabed enclosing a defined area. As the warps are retrieved, the enclosed area (a triangle) reduces in size. The warps dragging along the bottom herd the fish into a smaller area, and eventually into the net mouth. The gear is deployed by setting out one warp, the net, then the other warp. On retrieval of the gear, the vessel is anchored. This technique of fishing is aimed at specific schools of fish located on smooth bottom. In contrast to Danish seining, if the vessel tows ahead while retrieving the gear, then this is referred to as Scottish Seining or fly-dragging. This method of fishing is considered more appropriate for working small areas of smooth bottom, surrounded by rough bottom. Scottish and Danish seines have been used experimentally in U.S. demersal fisheries. Space conflicts with other mobile and fixed gears, have precluded the further development of this gear in the U.S., as compared to Northern Europe. (DeAlteris 1998)

Spears

A pole or shaft with a point on it can be used as a spear and a fisherman operating from shore, floating raft, and boat would be able to capture an animal previously out-of-reach. However, the single prong spear required an accurate aim, and fish easily escaped. With the addition of a barb, fish retention was improved; and spears with multi-prong heads increased the likelihood of hitting the target. Spears were initially hand-held, then thrown, then placed in launching devices including cross-bows, spear guns for divers, etc. Spears with long shafts (gig) are used by fishermen in small boats at night in the Carolina sounds for flounder, through the ice for eels in New England bays, and by divers for fish in coastal waters. (DeAlteris 1998)

<u>Stop Seines</u>

Seines that are used in coastal embayments to "shut off" schools of fish such as herring, once they enter the embayment.

<u>Trammel Nets</u>

A trammel net consists of three layers of netting all attached to the same framing ropes, consisting of a float line and a lead line. The net is formed by placing a very loose small mesh sheet of netting between two large mesh sheets. Upon striking the net, fish push a pocket of small mesh through a large mesh and are trapped. Trammel nets may be used as drift nets or set nets at virtually any depth. (Sainsbury 1996)

<u>Paired Bottom Trawl</u>

Pair trawling is undertaken by two vessels towing a single net either on the bottom or midwater. The separation of the towing vessels is used to open the net mouth horizontally. Pair bottom trawls have been used to harvest groundfish in New England waters, and these trawls are generally no larger than the net towed by the vessel singly. The advantage of pair bottom trawling is that considerably more ground gear may be used so as to increase the area swept, due to the reduction in drag resulting from the absence of trawl doors. (DeAlteris 1998)

<u>Paired Midwater Trawl</u>

Large pelagic species are also harvested with a huge pelagic pair trawl towed at high speed near the surface. The nets have meshes exceeding 10 m in length in the jibs and first belly sections, and reduce to cod-end mesh sizes of 20 cm. (DeAlteris 1998)

<u>Weirs</u>

In Maine, Nova Scotia, and Alaska, large traps constructed of stakes set so close to each other, that they form a fence are referred to as weirs. The target species are migrating small pelagic fishers including herring and sardines. Sometimes the design is asymmetric so as to only capture fish migrating in one direction. (DeAlteris 1998)

4.6 IMPACTS OF FISHING-RELATED MARINE DEBRIS AND LOST GEAR ON HABITAT

When considering the potential adverse impacts of fishing activities on habitat, the attentions of most researchers and policy-makers are focused on active fishing, i.e., what are the effects on the seabed from mobile gear. Habitat, however, may be adversely affected by other fishing-related activities. Fishing gear has the potential to cause adverse impacts to habitat not only when being actively fished, but also if the gear becomes lost or broken accidentally or intentionally disposed of at sea. Storm activity is unavoidable and a leading cause of lost or broken gear, but fishermen may also contribute to the adverse impacts to habitat by disposing of non-biodegradable waste products at sea (cups, bags, casings, packaging materials, bait boxes, gloves, light sticks, etc.) (Cottingham 1988; EPA 1994).

Marine debris is usually defined as any man-made solid object that is introduced into the marine environment and is not actively utilized (Hoagland and Kite-Powell 1997). Debris can be found on the surface, in the water column, and on the seafloor, as well as along the coastline (Hoagland and Kite-Powell 1997). Marine debris can come from a variety of sources, including:

- municipal treatment systems
- beach users
- oil and gas operations
- recreational boating
- commercial fishing
- cargo vessels

In fact, studies done in New England report that the principal sources of marine debris in the region are from household trash, lobster pots, and monofilament gillnets (Anon. 1988). As much as eighty-five percent of the debris collected during beach cleanups in New England over the past ten years is attributed to shore-based sources (Hoagland and Kite-Powell 1997). In the Gulf of Maine, commercial fishermen are thought to account for approximately half of the remainder (Hoagland and Kite-Powell 1997). Data from the Center for Marine Conservation (various years) attribute approximately five percent of the marine debris in Massachusetts and five to ten percent of the marine debris in New Hampshire and Maine to commercial fishing vessels. These data may not accurately reflect the amount of debris from fishing related sources. The volunteers who conduct the beach clean-ups are not necessarily trained to identify all fishing-related marine debris and may mis-identify fishing-related debris as non-fishing-related debris. The true percentage of marine debris in New England that comes from fishing-related sources may be higher than previously reported (Howe, p.c.1998; Barr, p.c. 1998). Only in the northern northwest Pacific is commercial fishing identified as the primary source of marine debris (Anon. 1988). Along the northwest Atlantic coast, the most serious effects of marine debris are aesthetic and economic in nature (Heneman 1990). As debris mounts, beaches and harbors become defiled and the tourism industry risks losing its base of support.

The issue of marine debris and lost, or “ghost,” gear has recently gained more attention for its impacts on marine mammals, birds, and fish populations. New developments in uses for plastic materials have increased the amount and variety of plastics that find their way into the ocean. In fact, plastics now account for more than half of all marine debris in the Gulf of Maine, the rest being approximately equal proportions of metal, glass, and paper (Hoagland and Kite-Powell 1997). Marine mammals, birds, sea turtles, and fish are all known to become entangled in plastic debris and, in many cases, die as a result. Commercial fishermen also know these materials to be a nuisance, especially when they lose time and money making repairs when their propellers and propeller shafts become entangled. Fishermen also lose time and money replacing gear lost or broken as a result of storms or gear conflicts with other fishermen.

Fishermen are also known to bring in much of the gear that they accidentally tow up or observe floating in the ocean (Howe, pers. comm. 1998). These fishermen return the lost gear to shore and dispose of it; however, more and more fishermen are having problems properly disposing the gear, as landfills are filling up and traditional disposal sites are refusing to accept this debris (Howe, p.c.1998; Barr, p.c. 1998).

"Ghost" fishing has been defined as "the ability of fishing gear to continue fishing after all control of that gear is lost by the fisherman" (Smolowitz 1978). Lost gear includes ghost gear as well as gear that is lost to the fisherman but does not continue to fish. For the purposes of addressing the habitat impacts of gear that is lost to the fisherman, we will not differentiate between ghost gear and lost gear. Rather, we will use the term lost gear as more inclusive. One potential problem associated with lost fishing gear and habitat impacts involves the increasing proportion of gears constructed of non-degradable materials (Breen 1990). Unlike gear made from natural materials that deteriorate quickly, gear made from stainless steel, injection-molded plastic, fiberglass, vinyl-coated wire, polypropylene twine, or monofilament line persist in the environment for long periods of time (Breen 1990).

As concentrations of commercial fish species become harder to find, fishermen are seeking out new areas, fishing where the risk of gear hang-ups, tears, or loss is increased. Much of the lost gear is concentrated on the most productive fishing grounds (Carr and Harris 1997). Most assessments of the effects of fishing-related marine debris, including lost gear, focus on aesthetic and economic losses and the direct effects to the lives and health of fish, mammals, sea turtles, and birds (see Laist 1997 for review). No studies have been completed which address the effects of these materials on the habitat and very few data are available on marine debris on the seafloor (Hoagland and Kite-Powell 1997). An examination of the known effects on wildlife and fish, however, can provide some indication of the habitat impacts caused by marine debris.

Several studies were examined to determine if there are any known adverse impacts resulting from lost fishing gear on the seafloor (Breen 1990; Carr 1988; Carr and Harris 1997; Carr *et al.* 1992; Cooper *et al.* 1988; Laist 1997). All studies focused on the effects of the lost gear on fish populations due to the ability of certain gear types (primarily traps and gillnets) to continue fishing after becoming lost to the fishery (Breen 1990; Carr 1988; Carr and Harris 1997; Carr *et al.* 1992; Cooper *et al.* 1988; Laist 1997). The only times this lost gear was mentioned in reference to habitat or ecosystem-level processes was to suggest that the lost gear provided additional habitat for many species. According to Carr and Harris (1997), lost trawl nets have a low ghost-fishing potential, and the lost trawl net material may form additional habitat for certain demersal species, such as ocean pout, wolffish, and cod. Carr and Harris (1997) also suggest that the net material may serve as a substrate for sessile invertebrates, such as hydrozoans and sea anemones.

Cooper *et al.* (1988) used a submersible ROV to assess ghost fishing effects, and they observed three general types of associations between the animals and the gear: (1) entanglement in the gear; (2) taking shelter within the interstices of the net; and, (3) attaching to the net. Several species of fish were documented using the net as shelter, including the sea raven, sculpin, and wolffish (Cooper *et al.* 1988). Stalked ascidians and sponges were observed attached to and growing on the net float lines (Cooper *et al.* 1988). Carr *et al.* (1992) also found sessile invertebrates using lost gillnets as substrate. They observed colonial bryozoans established on the monofilament webbing of an experimental gillnet only 72 days after the gear was set (Carr *et al.* 1992). The rapid colonization by sessile invertebrates on derelict fishing gear, transforming the gear into an inadvertent artificial reef, could be considered a beneficial effect of a situation that is otherwise considered problematic. Cod, in particular, appear to utilize lost gear as shelter. Carr (1988) observed cod, pollock, sculpin, redfish, and wolffish all in association with a derelict gillnet under study. Cod were the most abundant fish, observed each day of the survey and always within ten feet of the net, but never entangled in the net (Carr 1988). Carr (1988) states that "cod reacted to the net as if is was part of the bottom."

There is some debate on the issue of lobster and crab pots and traps. Pecci *et al.* (1978) reported significant ghost fishing of American lobster, *Homarus americanus*, and high levels of attendant mortality associated with field studies near Boothbay Harbor, Maine, and Woods Hole, Massachusetts. More recently, Parrish and Kazama (1992) report no evidence that lost traps result in increased mortality for Hawaiian spiny lobster, *Panulirus marginatus*, and slipper lobster, *Scyllarides squammosus*. It is difficult to make a direct comparison between these two studies, however, as they not only sampled different species, but also used very different trap designs and materials. It is significant to note that, using a more modern trap design, Parrish and Kazama (1992) were able to conclude that "such traps, when unbaited and intact, may best be considered short-term artificial shelters that lobsters enter and exit occasionally, more or less at will." The design of the lobster pot now used in the New England region includes a ghost panel as required by 50 CFR part 649.21(d), and may in fact operate as temporary artificial habitat allowing lobsters and fish free entrance and egress and reducing the potential impact of ghost gear on both the resource and the habitat.

Based on the limited literature focused on the interactions between lost gear and fish habitat, from the research that has been done, it appears that lost fishing gear does not pose a significant threat to essential fish habitat in New England. Marine debris is an issue that bears continued attention due to the limited information and studies focused on the habitat-related impacts of lost gear, as well as the potential impacts to marine life and the aesthetics and economics of shore-based communities. Technological advances and changes to gear design and materials should be monitored for potential impacts to habitat should the gear become broken or lost. For instance, as a result of measures to protect right whales in the Gulf of Maine, lobstermen are now required to switch from floating line (which rises to the surface if it becomes disassociated from the lobster pots) to lead line (which will remain on the seafloor and be harder to retrieve).

There are many good programs assessing the larger issue of marine debris as well as developing mitigation measures. The Center for Marine Conservation has the most comprehensive program, supporting its annual beach cleanup activities with research, conferences, and educational programs. For a review of the habitat-related impacts resulting from non-fishing activities, please refer to Section 5.0 of this amendment. For a complete review the sources of and problems associated with marine debris in the Gulf of Maine, as well as a discussion of mitigation techniques, please see *Characterization and Mitigation of Marine Debris in the Gulf of Maine*, by Porter Hoagland and Hauke L. Kite-Powell (1997) for the Gulf of Maine Council on the Marine Environment.

4.7 IMPACTS OF AQUACULTURE IN NEW ENGLAND ON HABITAT

The farming of aquatic and marine finfish, shellfish, and plants has been practiced for thousands of years to provide a variety of resources (NRC 1992). Aquaculture is defined as any activity that manipulates reproduction, spawning, feeding, settlement, growth, and development of marine or freshwater organisms (e.g. the controlled cultivation and harvest of aquatic animals and plants) (USDA National Aquaculture Development Plan 1983; deFur and Rader 1995). The culture industry (i.e. aquaculture) is rapidly expanding because of increased understanding of the life requirements of reared species and the depletion of natural stocks. Research on the development and requirements of aquatic organisms has led to efficient farming practices that yield a substantial amount of resources. The decreasing catches of the commercial fishing industry has triggered increased attention on other methodologies to obtain marketable finfish, shellfish, and seaweed. Both the demand for fish and its price relative to other protein sources has led to an increasingly thorough investigation of culturing finfish and shellfish (Rosenthal 1994). The National Aquaculture Act of 1980 encourages the development of aquaculture in the United States. Effective management and strategic planning may increase productivity of the culture fishery industry and potentially reduce the pressure of the capture fishery on wild populations and habitats.

World aquaculture production has doubled since 1984 and represented 18.5% of the total world seafood supply, according to 1995 data (FAO 1997). China and India are the world leaders of aquaculture production (FAO 1997). China, Japan, Thailand, Philippines, Chile, and Norway have made aquaculture a national priority (USDA 1998). The declining populations of wild fish stocks, increasing demand for seafood, and government promotion of aquaculture is leading to the growth of aquaculture in the U.S. However, aquaculture development in the U.S. has occurred slower than in other countries (Fridley 1995). U.S. aquaculture has expanded steadily since the 1980's and is poised to be a major growth industry in the 21st century (USDA 1998).

Freshwater culture, dominated by large catfish and trout farms, is more advanced than marine culture (i.e. mariculture) in the U.S. Marine mollusk rearing constitutes 95% of the U.S. marine culture production, and 80% of the production is oyster culture (Fridley 1995). Oyster culture appears to be declining due to pollution, disease, overharvesting, habitat loss, reduced production, and lack of seedlings in coastal waters (Volk 1998), but the culture of other mollusks (i.e. clams, scallops, and mussels) appear to be expanding (Fridley 1995). Salmon is virtually the only finfish commercially reared in marine waters of the U.S. However, there are several water-based demonstration projects for flounders and other salmonids. Important farmed species in the U.S. include catfish, oysters, crawfish, trout, salmon, clams, baitfish, tilapia, hybrid striped bass, shrimp, mussels, and sturgeon (FAO 1997). Emerging aquaculture projects in the U.S. have the opportunity to address the environmental, institutional, and economic constraints associated with aquaculture to assist with minimizing the problems of production and environmental impacts and the set of new options in siting and culturing (Fridley 1995).

The majority of New England aquaculture occurs along the coast and in state waters. There are many successful salmon farms within Maine state waters (i.e. 500 net-pens) (Panchang *et al.* 1997). Currently, culture locations are being investigated throughout New England state and federal waters. The development of New England aquaculture into a sustainable industry has great promise given appropriate technical planning and development, including the insight of environmental issues, proper siting, and efficient monitoring (see Spatz *et al.* 1995 for review of New England aquaculture). The array of factors influencing the market for fresh seafood such as decreasing wild fishery stocks and increasing demand for seafood may stimulate large-scale aquaculture development. Tasks dealing with possible clean-up costs after the facility closes and by-product threats that may add to larger environmental problems (e.g. eutrophication and groundwater contamination) (deFur and Rader 1995) may inhibit the development of New England aquaculture. Despite the potential problems, the culture fishery in New England federal waters appears to be developing with several current and potential farm sites (Table 8).

Table 8: Current and proposed aquaculture sites and descriptions in the New England federal waters.

NAME	LOCATION	TYPE	REARED ORGANISMS
Current			
Seastead Site (Westport)	south of Martha's Vineyard	bottom	sea scallops
Sea Scallop Cage Growout Project	off of Gloucester, Cape Ann, MA, Stellwagen and Jeffreys Ledge	bottom cage	sea scallops
Proposed			
American-Norwegian. Fish Farms, Inc	Gulf of Maine	net-pens	finfish
Univ. of New Hampshire demonstration project	Isle of Shoals (*state waters*)	net-pens	summer flounder
WHOI Blue Mussel Project	Rhode Island Sound	submerged longline	blue mussels

4.7.1 Aquaculture Types and Characteristics

Aquaculture systems can be separated into two categories; (1) land-based and (2) water-based. Land-based aquaculture systems include ponds, tanks, raceways, flow-through, and recirculating systems and are used throughout New England for the cultivation of a variety of marine and aquatic organisms. Land-based aquaculture is used for pilot studies, commercial production, and stocking programs. Water-based aquaculture methods include ocean ranching, cages / net-pens, longline culture, and bottom culture (infauna and epifauna) (reviewed in Goldburg and Triplett 1997). Water-based aquaculture is used to grow a variety of marine and anadromous finfish, shellfish, and seaweed to develop effective culture techniques and for commercial harvest.

Land-Based Aquaculture

(1) Ponds are the most widely used system in the U.S. (majority are found in the southeast) used to raise both finfish and shellfish in fresh or brackish water. They are constructed outdoors and vary in size. Impoundments (diked wetlands and marshes or excavated coastal environments) can be considered a form of pond system. Ponds account for approximately 75% of world production of finfish by aquaculture and almost all shellfish production (dominated by shrimp) (Royce 1996). Catfish, carp, baitfish, tilapia, and shrimp are a few of the major organisms cultured in ponds.

(2) Tanks are similar to ponds but are constructed of concrete, fiberglass, or treated wood (MCZM 1995). They are used to rear both marine and freshwater finfish and shellfish species. They vary greatly in size (e.g. pilot studies to commercial production), are usually circular or oval, and are constructed indoors and outdoors. They can operate as a flow-through or recirculating system. Tanks are used as hatchery and grow-out culture and brood stock management.

a) Flow-through filtration systems are used for land-based facilities. They are characterized as open systems that do not re-use water. They are used as hatcheries and grow-out facilities and containment of brood stock of a variety of organisms. Clean water is pumped in and out of the holding containers to maintain good water quality.

b) Recirculating filtration systems are used for land-based facilities. They are characterized as closed systems that the water is treated and re-used (50-90%) within the system. They are used as hatcheries and grow-out facilities for a variety of finfish and shellfish. Very few large-scale recirculating systems are operating in the U.S. Mollusks may be purified in recirculating systems. Hybrid striped bass, tilapia, trout, and others are cultured in recirculating systems.

(3) Raceways (generally freshwater) are usually a series of long, narrow, rectangular tanks with continuously flowing water. They are also constructed in other shapes and sizes. Raceways are located either inside or outside and are used primarily for salmonid culture. They operate primarily as a flow-through system but can also run as a recirculating system. Catfish, tilapia, and yellow perch are also raised in raceways.

Water-Based Aquaculture

(1) Ocean ranching is a culture process that involves hatching fish from eggs and rearing to juvenile stages in freshwater captivity (land-based) then releasing fish into native feeding grounds in the sea. Fish develop and sexually mature in the natural environment and return to their home stream (the land-based hatcheries) to spawn and are harvested along their migratory route (Royce 1996). This aquaculture procedure has been used with salmon.

(2) Cages, net-pens, rafts, and trays are either floating, anchored to the bottom, or a combination of both within a natural body of water. Cages / net-pens are currently found close to shore and are used to rear finfish (e.g. salmon) and mollusks (e.g. sea scallops). Finfish culture usually involves anchored pens floating in open water. Cages or trays anchored to the seafloor adjacent to suitable environmental conditions are used for mollusk grow-out. Rafts or floats may also be used to culture seaweeds.

(3) Longline culture (or hanging culture) is used for shellfish (i.e. mollusk) growout. Shellfish are grown in bags attached to a line either suspended in the water column or on the water surface. Longlines have been used vertically and horizontally. Lines must be placed in regions with proper water quality. The longlines are usually easily moved to find suitable environmental conditions for fastest growth. Mussels are potential organisms reared with this method. Seaweed can also be cultivated using longlines.

(4) Bottom culture is used for mollusks. Infaunal bottom culture occurs within the benthos. Hard clams are seeded and reared this way. Epifaunal bottom culture involves rearing techniques on the surface of the seafloor. Bottom culture depends on a sufficient food supply and water quality provided by tidal circulation and currents. This method applies to any seeding project (i.e. presettled or juvenile organisms transplanted to growing enclosures or proper substrate).

4.7.2 Environmental Considerations

The progress of the culture fishery may be inhibited by potential aquaculture-induced threats impacting habitat. The intensity and magnitude of impacts to habitat differ between the types of aquaculture systems and organisms cultivated (Table 9). Land-based facilities appear to be less intrusive and have fewer potential direct impacts to aquatic and marine habitats than water-based systems. Land-based aquaculture facilities require discharge permits [i.e. National Pollution Discharge Elimination Systems (NPDES)] (see Ewart *et al.* 1995); however, land-based culture is still a potential source of contaminants and physical disturbances that could contribute to the degradation of coastal environments. Systems constructed and maintained directly within marine and aquatic environments (water-based facilities) may pose serious threats to the health and natural productivity of habitat. The potential environmental problems of land- and water-based facilities have separate impacts to habitat, yet all aquaculture types have potential impacts on habitat and concern has been voiced on the particular characteristics of these impacts.

Numerous differences exist between cultivation of shellfish and rearing finfish in the wild. Several studies have illustrated the possible problems with finfish farms (Bedzinger 1994; Findlay *et al.* 1995) and potential problems associated with shellfish cultivation (Grant *et al.* 1995; Herke 1995; Thompson 1995; MCZM 1995). A major discrepancy between finfish and shellfish (mostly mollusk culture in New England) culture is the foraging behavior of the different taxa. Finfish require a large amount of feed, which has several environmental implications. Mollusks are filter feeders and generally require no feed additives. Shellfish bottom culture also appears to be less intrusive than fish pens by simply manipulating natural conditions, making the environment more suitable for faster growth and higher survivorship of the cultivated organism. Noting that large-scale aquaculture in the wild may increase the productivity of a few selected species, but the overall ecosystem productivity and health may be diminished (Herke 1995).

The environment can also be used with relatively minor impacts for the rearing of finfish by properly locating and carefully operating and monitoring fish pens to reduce possible habitat problems. The impacts (e.g. waste, direct benthic disturbance, etc.) of properly sited net-pens appear to be limited to the area directly beneath the pens in habitats with slower currents and softer sediments. Habitats associated with stronger currents and coarse sediments appear to have more widely distributed but less intense impacts due to spreading and diluting the contaminants over a large area (see review Conkling and Hayden 1997). Suspended shellfish culture may have similar impacts as net-pens (Conkling and Hayden 1997), and the impacts may be diminished using the same siting criteria. However, stating several options that may reduce the potential impacts of aquaculture on habitat and the generic differences between types of aquaculture and species cultivated, discharge (e.g. effluent and metabolic waste) may contaminate water quality and benthos, natural ecosystems may be altered, and direct loss of habitat may occur with the development of aquaculture.

Discharge

Aquaculture discharge into the water column, either land- or water-based, may include metabolic wastes (e.g. feces and pseudofeces), nutrients, ammonia, particulate matter, pesticides, and drugs (*discussed under feed additives*). The variety of threats within aquaculture effluent or waste presents potential impacts to the water column, benthos, and associated biological associations. Water quality can be adversely impacted by these threats (Hopkins *et al.* 1995) and degrade overall habitat conditions. Discharges may also include excess food and shell debris in addition to the previously mentioned threats, and may also specifically contribute to degradation of benthic habitat surrounding the aquaculture site (Findlay *et al.* 1995; Panchang *et al.* 1997). Discharge and waste may disrupt and change benthic structure and biological associations (Rosenthal 1994; Findlay *et al.* 1995; Grant *et al.* 1995;).

Discharge may contribute to nutrient over-enrichment, leading to organic loading and eutrophic conditions in the water column and benthos. Eutrophication has been associated with serious harmful algal blooms (HABs), finfish and shellfish kills, and habitat degradation. The benthos may accumulate wastes discharged from aquaculture facilities and contribute to anoxic conditions in the bottom sediments and overlaying water (deFur and Rader 1995) characterized by bacterial mats growing on the bottom sediments below aquaculture sites (Rosenthal 1994). Areas adjacent to aquaculture facilities may also exhibit increased sedimentation rates (Grant *et al.* 1995). Nutrient enrichment and sedimentation can also contribute to the degradation of submerged aquatic vegetation that provides important habitat for a variety of marine and aquatic organisms (Goldsborough 1997). The additional nutrients and metabolic wastes from aquaculture facilities may disrupt nutrient cycling between the benthos and water column

(Kelly 1992) and potentially promote hypernutrification and oxygen depletion (Rosenthal 1994). Poor benthic habitat conditions may change, disrupt, or destroy benthic communities and may present a future source of contamination if disturbed (i.e. channel dredging). Additional nutrients and wastes entering the environment or alterations to existing nutrient cycles potentially have long-term impacts on both chemical, biological, and physical characteristics of habitat (Kelly 1992).

Although not used by all aquaculture facilities, pesticides are frequently used to control a variety of nuisance organisms within aquaculture sites and can be present in effluents. Algicides, herbicides, and fungicides are pesticides that can be used to control aquaculture water quality and organism health. Pesticides may hinder growth or directly destroy aquatic vegetation and phytoplankton and lower dissolved oxygen levels (Stickney 1994). Alteration of aquatic vegetation potentially limits the availability of important habitat (Goldsborough 1997), and the removal of phytoplankton may have cascade effects on wild resources. Antibiotics can also be added to the water to control diseases in cultured organisms (*discussed under feed additives*). Public concerns about human food safety, human health, and environmental impacts have resulted in strict interpretation and enforcement of U.S. Food and Drug Administration (FDA) on the use of chemicals to treat water in aquaculture facilities (MCZM 1995).

Feed Additives: Antibiotics and Hormones

Feed additives are part of the maintenance of reared organisms in many water- and land-based aquaculture operations. The occurrence of diseases in aquaculture facilities is frequently due in part to the high densities of organisms (see USFWS 1995). Antibiotics and hormones are added to feed in order to supplement and enhance the diet of the reared species to control disease, induce spawning, produce strains of organisms resistant to disease, produce high quantities of meat, grow faster, and alter a variety of phenotypic characteristics. Feed supplements may be toxic to nontarget organisms, accumulate in wild stocks, inhibit microbial decomposition, and lead to antibiotic-resistant pathogens (Conkling and Hayden 1997).

The high densities of organisms within an aquaculture system may lead to high levels of feed additives in the water and benthos. Antibiotics and hormones added to the environment for aquaculture uses can potentially disrupt habitat. Antibiotics may produce drug-resistant strains of pathogens that can spread disease among marine and anadromous organisms (Landesman 1994). New strains of pathogens can have sublethal or lethal impacts on fish and invertebrates and possibly degrade overall habitat conditions. The accumulation of antibiotics within the benthos may inhibit microbial decomposition (NRC 1992). Accumulation of antibiotics and hormones in both wild and cultivated organisms is a potential health risk for human consumers. Feed supplemented with hormones potentially changes natural growth and spawning behaviors of finfish and shellfish populations. Changes in natural behavior, development, and growth patterns (Goldburg and Triplett 1997) can lead to niche competition and overlap (Lura and Seagrov 1991; Jonsson *et al.* 1991).

These potential impacts of feed additives may contribute to habitat degradation, yet only four drugs are approved for the use on reared organisms in the U.S. The U.S. appeared to take cautious approach with the addition of diet supplements to reared organisms that potentially risk human health until recently. The Animal Medicinal Drug Use Act of 1994 and implementing regulations promulgated by the Food and Drug Administration has led the U.S. to become considerably less cautious with the use of drugs in aquaculture operations (Goldburg pers. com.).

<u>Exotic and Reared Species</u>

Introduction of non-native organisms have altered biological and physical composition of several freshwater and marine habitats (Rosecchi *et al.* 1993; Witman 1996). The issue of the introduction of exotic or reared species, including finfish, shellfish, plants, and parasites, in the wild is a major concern and possibly the largest problem for aquaculturists, ecologists, and managers (deFur and Rader 1995). Reared and exotic organisms have been released from aquaculture facilities accidentally (e.g. escapees) and intentionally (e.g. stocking programs) (Bedzinger 1994). The natural community structure may be changed through increased competition, niche overlap, predation on indigenous organisms, decreased genetic integrity, and transmission of disease. The impacts of released or escaped organisms are the focus of much attention. Several methods, including producing sterile organisms and escape-proof facilities, are being developed to lessen the ecological threats associated with exotic and reared organisms (Conkling and Hayden 1997; MCZM 1995).

The United States Fish and Wildlife Service (USFWS) has determined that salmon aquaculture poses a notable threat to the wild stocks of Atlantic salmon (*Salmo salar*) (Conkling and Hayden 1997). Farmed salmon have been documented to spawn successfully and later in season than wild Atlantic salmon (Lura and Seagrov 1991; Jonsson *et al.* 1991) often taking over the breeding sites of the wild salmon (Bedzinger 1994) and limiting the success of the natural spawning process. Genetic problems may also occur with the release of reared organisms, either from escapees or stock enhancement projects, due to limited genetic drift in small broodstocks and interbreeding potential with wild stocks.

The selection of fish in a hatchery, illustrating their captive characteristics (appearance, size, and fast growth) and not their selective characteristics, are expected to become less fit for survival in the wild (USFWS 1995; Bedzinger 1994). The genetic diversity and phenotypic plasticity of natural populations may be diluted with the release or escape of cultured finfish (Fleming *et al.* 1994; Tave 1994). For example, there has been a growing concern that Atlantic salmon, , that escape from farms may interact with wild stocks and pose a serious threat to the native populations, leading to changes in genetic composition, introducing diseases and parasites, and other possible negative impacts to habitat (USFWS 1995; Windsor 1997). Interactions between native and reared striped bass (*Morone saxatilis*) have also been noted (NRC 1992). The consequences of exotic and reared organisms is not limited to salmon aquaculture. Trophic structures, stock health and fitness declines, and overall habitat degradation may result from the release or escapement of any organism from aquaculture facilities.

The introduction of infectious diseases, particularly nonindigenous parasites, transmitted to wild resources is a major issue facing aquaculture proponents. The impacts of pathogens on wild stocks are generally misunderstood or seriously underestimated (MCZM 1995). The transmission of disease from aquaculture facilities through effluent, stocking programs, or escapement is a potential issue that may impact the health of the stocks and environment. For example, salmonid populations have been infected with whirling disease (*Myxobolus*) from releasing disease-infected organisms in a stock enhancement project. This particular disease has had serious impacts of salmonid populations in Colorado, Utah, New York, and Connecticut (MCZM 1995).

Habitat Removal or Alteration

The development of aquaculture facilities, either land- or water-based, may directly remove or change the physical and biological properties of habitat (Rosenthal 1994; deFur and Rader 1995; Thompson 1995). Construction of facilities on the shoreline may directly remove important watershed habitat. Water withdrawal for land-based aquaculture may present entrainment and impingement problems (Hopkins *et al.* 1995). Large facilities require an abundant supply of water, and may disrupt habitat conditions in the area surrounding the intake and effluent pipes. Conflicting water-use issues may be an additional problem facing aquaculture development (*discussed below*).

Improperly placed water-based facilities may attract unnatural species assemblages or change existing biological communities (Thompson 1995). Specifically, bottom culture of shellfish directly alters the benthos in order to improve habitat conditions for survival, growth, seeding, and harvesting (Ito 1988; Anonymous 1990; Thompson 1995; Conkling and Hayden 1997). Other organisms dependent on these habitats may suffer because of the loss or manipulation of habitat to construct aquaculture systems (Landesman 1994; Rosenthal 1994). The loss and change of habitat and natural community structure is a potential adverse effect of land- and water-based aquaculture on habitat.

High densities of shellfish or finfish within water-based operations may remove a large quantity of indigenous organisms (Ulanowicz and Tuttle 1992) and essential nutrients from the environment (Kelly 1992). Large assemblages of filter feeders (e.g. mollusks) and larval fish in cages or pens may feed on unusually high amounts of plankton. The removal of plankton from an ecosystem may have cascade effects on the trophic structure. Increasing mollusk concentrations may decrease phytoplankton productivity as well as pelagic populations of microbes, ctenophores, medusae, and particulate organic carbon (Ulanowicz and Tuttle 1992). Filtering unusual amounts of nutrients from the water column and benthos may alter the nutrient cycle. Long-term implications to the environment may result with large-scale aquaculture projects.

Other Considerations

- Predator control devices and techniques around aquaculture facilities may *eliminate organisms* from the wild, presenting trophic implications (Rosenthal 1994). Birds potentially disrupt aquaculture facilities by foraging on reared organisms. Killing the predator may have cascade effects on trophic dynamics. Concern has been voiced over the authorization to kill predators at aquaculture facilities (Goldburg and Triplett 1997). Also, marine mammal, birds, and reptiles can be trapped in aquaculture nets (MCZM 1995), although entanglement is rare (Conkling and Hayden 1997).

- *Capturing wild species* for the purpose of stocking aquaculture facilities is a potential problem contributing to declining stock size and habitat degradation (Landesman 1994). All facilities need organisms to begin and maintain production. Brood stock are often collected from the wild to provide a source of organisms for the facility. Extensive collections may add to the current problem of overfishing and may degrade habitat.

- *User conflicts* may evolve with the development of land- and water-based aquaculture. User groups may compete for existing habitat for their specific interests, potentially contributing to habitat removal or degradation. Particularly, water-based aquaculture practices may inhibit other activities (e.g. commercial fishing and navigation). Land-based facilities also face potential water-use conflicts, especially with terrestrial agriculture. Therefore, the siting of aquaculture facilities may be an issue of controversy for a variety of interest groups.

4.7.3 Environmental Benefits

Rosenthal (1994), referring to salmon aquaculture in Europe, stated that the negative effects of aquaculture on the environment have not been as severe as the scientists anticipated, the media reported, or the public perceived. Some cases have actually demonstrated the importance of aquaculture in maintaining productive habitats and possibly contributing to a healthier environment. These examples of aquaculture development appear to positively influence habitat. Proper siting and monitoring measures can lessen the potential threats that aquaculture pose to habitat. Water-based cultivation (e.g. net-pens) and land-based facilities (e.g. ponds) can be constructed that abate potential impacts to habitat.

The health and success of organisms in the wild and aquaculture facilities depend on good water quality. Studies have illustrated the importance of aquaculture contributing to good water quality (Ulanowicz and Tuttle 1992) and the importance of water quality on aquaculture (Volk 1998). The filtering capacity of mollusks may eliminate unwanted nutrients and contaminants from the water column (Ulanowicz and Tuttle 1992). Culture facilities that depend entirely on natural trophic dynamics and receive important nutrients from agricultural run-off may assist in reducing the threats of land-based pollutants (Rosenthal 1994). Culturing mollusks at an appropriate density in coastal areas may contribute to improving water quality, lessening eutrophication, and enriching habitat conditions for natural stocks.

Shell debris from mollusk cultivation may provide a suitable substrate for benthic communities. Shells may provide some level of protection and refuge for fish and invertebrates under and within cultivation areas, improving habitat conditions.

Productive culture facilities may reduce pressure on natural fish and shellfish stocks, but should not be viewed as a method to sustain fish stocks. The culture industry may effectively provide a source of finfish and shellfish to consumers world-wide. A source of seafood besides the traditional commercial fishery (capture fishery) may lessen the amount of fishing effort on natural finfish and shellfish populations. Reduced effort on natural populations may indirectly provide habitat and fish stock protection.

Table 9: Aquaculture type and impact to habitat.

AQUACULTURE TYPE	POTENTIAL IMPACTS TO HABITAT
Land-Based	
Ponds	• run-off and discharge may add metabolic wastes, nutrients, particulate matter, antibiotics, and hormones to water column and benthos • seepage of contaminated water into groundwater • potential source of reared organisms entering the environment • direct destruction of habitat and biological properties for construction - construction of impoundments in coastal waters alters important habitat for estuarine-dependent organisms
Flow-Through Tank and Raceway Systems	• discharge may contribute levels of metabolic wastes, nutrients, particulate matter, antibiotics, and hormones to water column and benthos • water use may present withdrawal issues (e.g. entrainment and impingement)
Recirculating Tank and Raceway Systems	• limited discharge may contribute minor levels of metabolic wastes, nutrients, particulate matter, antibiotics, and hormones to water column and benthos • water withdrawal for operation may present impacts associated with entrainment and impingement
Water-Based	
Ocean Ranching	• interbreeding with wild stocks may cause genetic problems and natural behavior changes (e.g. unnatural foraging behavior) • disease transmission from hatchery and grow-out facility into environment
Cages / Pens	• by-products – including metabolic wastes, nutrients, particulate matter, excess food, and shell debris – may contaminate water quality and benthos • feed additives – antibiotics and hormones – may contribute to diseases and community structure changes • introduction of exotics or reared organisms via escapement can lead to trophic structure changes, genetic and disease problems • removal of indigenous organisms may hinder natural processes • bottom cages may attract unnatural species assemblages and remove substrate • “ghost” gear (e.g. broken pens, lost nets, or damage due to violent storms) may present habitat problems due to settling and rolling on the seafloor
Longline	• poor water quality and accumulation of wastes in benthos from by-products – metabolic wastes, nutrients, particulate matter, excess food, and shell debris • feed additives – antibiotics and hormones – may contribute to diseases and community structure changes • removal of indigenous organisms (i.e. plankton) may hinder natural processes • lines may attract unnatural species assemblages
Bottom Culture - infauna / epifauna	• poor water quality and accumulation of wastes in benthos from by-products – metabolic wastes, nutrients, particulate matter, excess food, and shell debris • feed additives – antibiotics and hormones – may contribute to diseases and community structure changes • introduction of reared organisms may increase competition and predation on naturally occurring species • direct loss of habitat / loss of natural biological components of habitat • attract unnatural species assemblages

4.7.4 Legal Authority

The Magnuson-Stevens Act's broad definition of "fishing" encompasses the catching or taking of fish, the harvesting of fish and any other activity or at-sea operations in support of such activity which may result in the catching, taking or harvesting of fish. As harvesting implies the gathering of a crop and as aquaculture facilities engage in the "harvest" of fish from the EEZ, any aquaculture facility located in the EEZ is thus within the purview of the Act and is subject to management plans developed by the Council. That aquaculture is considered to be equivalent to fishing is further supported by the Vessel Documentation Act, 46 U.S.C. 12101(a)(1) which defines "fisheries" as including "planting, cultivating, catching, taking, or harvesting fish . . . in the EEZ."

Any vessel, including a barge, used to support aquaculture activities and facilities is considered a fishing vessel under Magnuson and is subject to regulation beyond documentation and endorsement at the discretion of the Council, subject to the approval of the Secretary of Commerce. In this context, it would appear that structures used to support and anchor net pens for finfish aquaculture would also be considered fishing vessels under the Magnuson-Stevens Act's broad definition which includes "other craft which is used for . . . aiding or assisting . . . any activity relating to fishing, including . . . storage . . . " 16 U.S.C. 1802(11).

4.7.5 Federal Involvement with EEZ-Based Aquaculture

No single federal agency has been delegated or statutorily charged with lead or overall responsibility to administer aquaculture, but rather, through authorities derived from various statutes, a number of agencies are involved. This situation is somewhat confused from the perspective of project developers who must complete an array of permit applications and meet a variety of requirement, some duplicative, in order to undertake an EEZ-based aquaculture operation. This section identifies those institutions and the basis of their derivative authority. This section also identifies other jurisdictions concerned with aquaculture that operate within or adjacent to the New England EEZ that may be applicable to the Council's activity.

<u>U.S. Army Corps of Engineers</u>

The ACOE authority stems from Section 10 of the River and Harbors Act of 1899, 33 U.S.C. 403. The Corps' traditional and primary role relates to the potential impact of activities upon the navigable waters of the U.S. and, with regard to aquaculture, is it particularly concerned with structures and the mooring systems used to anchor these structures within the navigable water. Its authority also extends to a full range of other considerations including those related to the environment and its permit certifies that the project will not impede navigation or negatively affect environmental quality.

<u>U.S. Environmental Protection Agency</u>

Section 402 of the Federal Water Pollution Control Act established the National Pollutant Discharge Elimination System (NPDES) to ensure that point source discharges would not impair the nation's water quality. The EPA, which has statutory authority to administer NPDES permits, has determined that floating fish pens constitute "concentrated aquatic animal production facilities" under the Act and are thus subject to permit requirements. The agency has also determined that the Ocean Disposal Criteria of section 403(c) of the Act applies, thus mandating an environmental effects review of aquaculture projects proposed for offshore waters. Currently, the EPA requires an NPDES permit for fish pen operations only; shellfish or other "low impact" aquaculture operations are administratively exempt, however, a broad interpretation of the Act's "concentrated aquatic animal production facilities" language could be construed to apply to these operations as well.

<u>National Oceanic and Atmospheric Administration (NOAA)</u>

NOAA, through the National Oceans Service, administers the Coastal Zone Management Act (CZMA), 16 U.S.C. 1451 *et seq.*, which requires a consistency determination with approved state coastal zone management programs for federally permitted activities that affect land, water, or natural resources of the coastal zone. Federal consistency reviews are conducted by the state coastal zone management programs, consistent with the CZMA. The Marine Protection, Research, and Sanctuaries Act which prohibits certain activities within areas designated as National Marine Sanctuaries and requires a permit (in the Stellwagen Bank National Marine Sanctuary) and consultation with NOAA's National Ocean Service in some instances.

<u>National Marine Fisheries Service</u>

The National Marine Fisheries Service has regulatory authority to enforce measures adopted pursuant to Council or Secretarial FMPs. The harvest of Atlantic salmon in the EEZ, for example, is currently prohibited under provisions of a Council FMP and the taking of other species is restricted in a variety of ways including minimum size restrictions and vessel permit requirements which are enforced and administered by NMFS. As aquaculture facilities are subject to the Magnuson-Stevens Act, NMFS does have direct regulatory control over aquaculture, albeit incidental to management plans for other fisheries at this time. In the absence of an aquaculture focused FMP, NMFS' principal role in aquaculture is with respect to its statutory authority to administer the Marine Mammal Protection Act, 16 U.S.C. 1361 *et seq.*, its statutorily shared responsibility with the U.S. Fish and Wildlife Service to administer the Endangered Species Act, 16 U.S.C. 1531 *et seq.* and its prerogatives as a review agency under the Fish and Wildlife Coordination Act, the National Environmental Policy Act, and the Magnuson-Stevens Act.

<u>U.S. Coast Guard</u>

U.S. vessels, including barges, that support aquaculture facilities and that measure five net tons or larger must obtain Coast Guard documentation.

Other Federal Agency Involvement

Beyond the agencies and activities outlined above, there are several other federal agencies that may have involvement with EEZ-based aquaculture depending on the nature of the venture. These agencies include the U.S. Fish and Wildlife Service as a review agency addressing issues somewhat related to those that would be of concern to NMFS and the U.S. Food and Drug Administration if the use of medicated feeds is contemplated. It is also possible that the U.S. Department of State as well as the Minerals Management Service may have an interest in certain aspects of EEZ-based aquaculture activities. In addition, there is a growing list of federal agencies involved in aquaculture research and development activities which are beyond the scope of this review.

4.8 IMPACTS OF AT-SEA FISH PROCESSING ON HABITAT

Fish processing is an important component of fishing operations and economies of many New England fishing communities. Processing includes, but is not limited to, cleaning, cooking, canning, smoking, salting, drying, or freezing. Fish processing plants can be permanent, land-based or mobile, water-based operations. Commercial fisheries and aquaculture facilities require processing operations to produce high-quality, marketable seafood. There are several environmental considerations associated with all types of fish processing plants. Treatment of fish processing effluent to reduce environmental impacts has become a matter of interest to many countries and fisheries (Parin *et al.* 1983).

The type and severity of waste effluent from fish processing depends upon the type and characteristics of the processing operation. For example, processing limited to freezing whole fish may have less of an environmental impact than processing methods that requires fish cooking (Battistoni and Fava 1994). The type of organism processed may also determine the severity of the potential threats. Battistoni *et al.* (1992) reviewed studies reporting higher concentrations of nutrients in effluents from salmon and herring processing operations than effluents from clam and oyster processing plants. Generic classification of fish processing approaches include;

- *Traditional Approach* which includes the establishment of permanent, shore-based, centralized facilities (Kneller *et al.* 1993); and
- *Mobile fish processing plants* which have developed with technological advancements in vessel capacity and size. This approach provides an at-sea, mobile infrastructure to support the capture fisheries and aquaculture facilities (Kneller *et al.* 1993) for quicker processing to yield higher quality products.

In New England, fish processing plants are primarily shore-based located within fishing ports and harbors. There are currently no at-sea fish processors operating in federal waters off New England, but several mobile processors operate in state waters. At-sea processing in state waters currently occurs in internal the waters of a state landward of the baseline used to delineate the inner boundary of the territorial sea (e.g. bays). Federal waters can potentially be used for at-sea fish processing by joint venture operations. Joint ventures include any operation by a foreign vessel assisting fishing by U.S. fishing vessels, including processing. Joint venture generally entails a foreign vessel processing fish received from U.S. vessels. In New England, the federal size restrictions placed on vessels possibly limits the financial benefits of processing at sea.

The herring, menhaden, and mackerel fisheries present potential opportunities to use at-sea processors in New England waters. The development of water-based aquaculture (e.g. net pens, bottom culture, etc.) may also present greater financial opportunities for the advancement of at-sea processing operations for reared organisms (Kneller *et al.* 1993). Permanently located culture sites may develop at-sea processors to quickly supply high-quality, fresh seafood to consumers.

Techniques for land-based waste treatment are more advanced than at-sea treatment. Land-based treatment of waste includes physical and physicochemical separation biological treatments (Meo *et al.* 1977). Fish processing wastes can be disposed on land or in the ocean. The wastes present environmental concern, and raise questions on how to reduce the potential threats to habitat. Several methods to reduce or lessen environmental threats of processing effluents are *denitrification* to remove nutrients from effluent, *fermentation* to increase phosphorus removal, *aeration* (oxidation) techniques to increase dissolved oxygen levels in wastewater and lessen anoxic effluent, and *hydrolysis* of wastes to dilute threats (Battistoni and Fava 1995). These techniques potentially lessen impacts to habitat by producing stabilized waste, high quality effluent, and efficient settling velocity of wastes. The techniques rely on plant reliability to efficiently reduce potential habitat impacts (Battistoni and Fava 1995).

4.8.1 Environmental Considerations

Fish processing plants may present several environmental considerations, but the magnitude and severity of potential impacts may depend on the scale of operation. Small-scale processors, either at-sea or shore-based, may present less severe environmental impacts than large processors discharging large quantities of processing byproducts. The particular habitat conditions surrounding a given processing operation may also dictate the severity of impacts to habitat. At-sea or shore-based fish processing operations, in general, may present the following potential environmental threats (reviewed by Battistoni and Fava 1994):

- *Water Exhaustion:* Water is used for defrosting, cleaning, can cooling and can washing, clean up for spills, floors and machine washing. Large quantities of water are needed for processing fresh seafood (Nair 1990). Water use for land-based processing plants may contribute to the depletion of groundwater supply, saltwater encroachment, and land subsidence (Nair 1990) (see *non-fishing threats section*). At-sea processing raises less of concern of water depletion, but no less concern of wastewater discharged.

- *Wastes:* Chemical and biological wastes are produced from, but not limited to, fish evisceration, fish cooking or precooking, and meal production. The large volume of water needed for processing thereby generates large amounts of wastewater effluent and associated habitat threats that potentially deteriorate environmental conditions (Nair 1990) (see *non-fishing threats section*). Wastes found in fish processing effluent include:

- nutrients (nitrogen and phosphorus) – that potentially contribute to eutrophic conditions,
- oil and fats (Parin *et al.* 1983) – that may alter water quality,
- organic matter – large pieces of discarded fish parts (i.e. viscera, bones, etc.) may provide food for birds, marine mammals, and subsurface scavengers (ICES 1991; Gislason 1994) and alter species composition due to competitive trophic interactions (e.g. seabirds) (ICES 1991),
- suspended solids consisting of fine grained fish parts (Nair 1990) – potentially increasing turbidity and attracting unnatural foraging species assemblages,
- fish discards potentially accumulate on the benthos posing a variety of short- and long-term effects on localized habitat (ICES 1991),
- stick water (a fine gel or slime) – can accumulate on surface waters or move onshore to cover intertidal areas (NPFMC 1998),
- mollusk shells – shells are often discarded at-sea and may provide substrate that serve a variety of ecological functions (e.g. settlement habitat for scallops; refuge for juvenile fishes),
- chemicals used during operation – may contaminate water quality (e.g. acidic water) and surrounding benthos,
- warm water plumes – may alter natural temperature regimes, and
- saltwater effluent – often used within processing plant. Salt water can not be discharged to treatment plants because they disrupt the biological cycles used to treat wastes, and can not be discharged directly back to the water because of discharge permit requirements.

4.8.2 Management Authority

Fish processors, either at-sea or shore-based, require National Pollutant Discharge Elimination System (NPDES) permits from the Environmental Protection Agency (EPA). The Ocean Dumping Act also requires any processing operation to obtain a permit from EPA to dispose any wastes. The Ocean Dumping Act gives authority to the EPA to regulate the contents of any disposed material, location, and methodology of disposal of fish wastes, including fish wastes from processing plants. These conditions of processing sites and dumping or discharge of byproducts would be developed by the EPA in consultation with the National Marine Fisheries Service and the fishing industry.

4.8.3 New England Fishery Management Council's Role

The Council has the authority to address and regulate fish processing in federal waters administered under the Magnuson-Stevens Act. The Magnuson-Stevens Act includes at-sea fish processing under its definition of fishing, giving the Council direct authority to regulate all at-sea processing in the Exclusive Economic Zone (EEZ). Currently, the Council does not directly regulate at-sea fish processors in federal waters. At-sea processors may be indirectly regulated by other management measure directly pertinent to fishery regulations (e.g. size restrictions of vessels).

4.9 MITIGATION OF ADVERSE IMPACTS

The Council is required to prevent, mitigate, or minimize any adverse effect from fishing, to the extent practicable, if there is evidence that a fishing practice is having an identifiable adverse effect on EFH. Identifiable impacts are those supported by observable, negative effects on EFH quality or quantity. The previous sections discuss the issues and limitations associated with assessing adverse impacts to habitat from fishing activity, as well as the types of fishing gear and other fishing-related activities that may impact essential fish habitat. The Council also must give special consideration to gear types that will or could affect habitat areas of particular concern. Management measures currently in place protect and conserve essential fish habitat to varying degrees. Certain measures, such as the long-term closures of Closed Areas I and II and the Nantucket Lightship closure directly protect large areas encompassing many types of habitat. Other measures, such as the days-at-sea program, indirectly protect and conserve essential fish habitat by controlling fishing effort. Any reduction of fishing effort will reduce the frequency and intensity with which fishing gear is used.

4.10 IDENTIFICATION OF EXISTING MANAGEMENT MEASURES THAT AFFECT EFH

An understanding of the existing management measures that have the potential to either directly or indirectly protect EFH is important to the assessment of fishing-related threats to essential fish habitat (EFH). In order to determine which current management measures protect EFH, the Council performed an assessment of the habitat effects of all existing management measures.

For the purposes of this assessment, it is assumed that bottom-tending mobile fishing gears, such as dredges and trawls, are likely to have an impact on habitat. This assessment generally assumes some degree of adverse impact from bottom-tending mobile gear on most complex bottom types and is based on the available literature and scientific studies (see Appendix E for review), as well as anecdotal information provided by members of the fishing industry (see Dorsey and Pederson 1998). As more information becomes available on the effects of fishing practices on habitat and the relationships between species productivity and habitat, this assessment may change. Certain fixed gear types, such as lobster pots, gillnets, and longlines, are assumed for the purposes of this exercise to have minimal direct impact on habitat. As more information becomes available on the effects of these gear types, this assessment may change. Other gear types, designed to be used above the sea floor, such as midwater trawls, purse seines, or pelagic longlines, are assumed for the purposes of this assessment to have no direct impact on habitat.

An important issue related to the cumulative effects of several of these measures involves effort displacement. Area closure and other effort restriction measures often simply have the effect of shifting effort from one location to another or from one time of year to another. This effort displacement may not actually result in an overall benefit to habitat. The potential for effort displacement was considered but not incorporated into this assessment in the interest of simplicity, and in order to categorize each specific measure as written. Certainly closing an area containing EFH to the type of fishing activities most detrimental to that habitat type is a benefit and protects the habitat from potential adverse impacts, and the Council does not wish to give the impression that closed areas are not a useful tool to mitigate habitat impacts. It is not clear, however, that this is a straightforward solution. If fishing effort is likely to shift from the closed area to another area of essential fish habitat that is also vulnerable to the fishing activity, then a closed area system may not be the best mitigation technique. It will take time to truly understand the nature of habitat vulnerability and the effects of mitigation. The Council will continue to work to develop a management program that optimizes habitat protection with the needs of the fishing industry and their communities.

The Council reviewed each management measure in place as of August 16, 1998, for the fisheries it manages. The following is a list of the management measures determined potentially to have an impact (either adverse or not) on essential fish habitat. For each measure, we have included a short discussion of the reason it was determined to affect habitat, and whether the impact is generally adverse or not. Each measure, or item within the measure, was considered as to whether there would be a greater or lesser impact on habitat if the measure did not exist. If there is the potential for there to be a greater adverse impact to habitat without the measure, the measure has a positive effect on habitat. If there is the potential that there would be less adverse impact to habitat without the measure, then the measure has a negative effect on habitat. In general, closed areas, certain types of gear restrictions, and effort controls were thought to have a more positive effect on protecting habitat. Changes in mesh size, exemptions for most fixed gear and recreational gear, minimum sizes, possession restrictions, and gear marking requirements were not thought to have any effect on habitat protection.

In the regulations associated with the northeast multispecies fisheries, exemptions are sometimes granted for certain fishing practices or gear types. Some gear exemptions may have an adverse effect on habitat by allowing certain types of fishing activities which disturb the habitat. In general, all exemptions will be evaluated to determine if allowing the exemption has the potential to threaten essential fish habitat. In several of the exemptions, an activity that has the potential to disturb the habitat may be allowed in an area where it otherwise would not occur. All exemptions need to be evaluated to determine whether any potential gear impact resulting from the exemption has a positive or negative habitat effect. According to the regulations (50 CFR 648.2), "Exempted gear, with respect to the northeast multispecies fishery, means gear that is deemed to be not capable of catching northeast multispecies and includes:"

- pelagic hook and line
- rakes
- tongs
- dipnets
- pelagic gillnets
- shrimp trawls
- stop nets
- diving gear
- harpoons
- pelagic longline
- pots and traps
- surf clam / ocean quahog dredges
- spears
- cast nets
- weirs
- pound nets
- purse seines
- midwater trawls

For the purposes of this assessment, it is assumed that surf clam and ocean quahog dredges are the only exempted gears that have any direct adverse habitat impacts. All other gears on this exemption list are assumed to have negligible impact on habitat while being used for normal fishing practices. Certain gear types, however, have the potential to affect habitat if they are lost to the fishery and become ghost gear or marine debris.

648 Subpart A General Provisions for the Fisheries of the Northeastern United States

648.1 Experimental Fishing: The Regional Administrator may grant an exemption for an experimental fishery if he/she determines that the purpose, design, and administration of the exemption is consistent with the management objectives of the respective FMP, the provisions of the Magnuson-Stevens Act, and other applicable law, as long as the exemption will not:

(1) Have a detrimental effect on the respective resources and fishery;
(2) Cause any quota to be exceeded; or
(3) Create significant enforcement problems.

It is unlikely than an experimental fishery could meet this criteria and still have an adverse impact on EFH, so this measure in and of itself does not affect habitat. In some cases, however, it may be deemed necessary to the outcome of the experiment to allow a fishing method or gear which does impact habitat.

648.4 Vessel and individual commercial permits: see below

NE multispecies vessels: see below

Replacement vessels: Limits the horsepower and size of replacement vessels to 120% and 110% percent, respectively, of that of the vessel being replaced. This measure serves to limit the power and size of fishing vessels, and thus limits the amount of potentially detrimental gear these vessels can tow.

Upgraded vessels: Limits the horsepower and size of upgrades to 120% and 110% percent, respectively, of that of the vessel being upgraded. This measure serves to limit the power and size of fishing vessels, and thus limits the amount of potentially detrimental gear these vessels can tow.

Atlantic sea scallop vessels: see below

Replacement vessels: Limits the horsepower and size of replacement vessels to 120% and 110% percent, respectively, of that of the vessel being replaced. This measure serves to limit the power and size of fishing vessels, and thus limits the amount of potentially detrimental gear these vessels can tow.

Upgraded vessels: Limits the horsepower and size of upgrades to 120% and 110% percent, respectively, of that of the vessel being upgraded. This measure serves to limit the power and size of fishing vessels, and thus limits the amount of potentially detrimental gear these vessels can tow.

648 Subpart D **<u>Sea Scallops</u>**

648.51 **Gear and crew restrictions:** Restricting the number of crew allowed on a scallop vessel has an indirect habitat effect by limiting effort, thus the area dredged/trawled.

Small dredge program restrictions: This measure has the potential to increase fishing effort by allowing scallopers of one category (part-time or occasional) to have more days-at-sea if they comply with gear and crew restrictions. It is not clear that these offset each other, but it does seem that they could get significantly more days.

Restrictions on use of trawl nets: By restricting the use of trawl nets, one gear type thought to have an impact on habitat has been limited.

648.53 **Days-At-Sea allocations:** Limits overall fishing time. This indirectly protects habitat by causing an overall reduction of fishing effort using some of the gears and methods likely to impact habitat.

648.54 **State waters exemption:** This measure has the potential to increase fishing effort above what it would be if this measure did not exist.

DAS exemption: A days-at-sea exemption potentially creates increased fishing effort. Since the principal fishing methods used in the scallop fishery have an adverse impact on certain types of habitat, this measure has a adverse impact on EFH.

Gear restriction exemption: The exemption from the previous gear restrictions has the potential to increase the use of fishing methods and gears which may be more destructive to habitat that the fishing methods and gears which would be used if the exemption did not exist.

Gear exemption in state waters: In Maine, New Hampshire and Massachusetts only, the exemption from the previous gear restrictions has the potential to increase the use of fishing methods and gears which may be more destructive to habitat that the fishing methods and gears which would be used if the exemption did not exist.

648.57 **Closed areas:** The Council has temporarily closed two areas of the mid-Atlantic, the *Hudson Canyon South Closed Area* and the *Virginia Beach Closed Area*, to allow juvenile scallops in the areas to grow to a larger size than they would in the face of continued fishing pressure. The Hudson Canyon South closure represents approximately 1800 square nautical miles and the Virginia Beach closure represents approximately 500 square nautical miles of area closed to the use of scallop dredges. Thus the EFH within these areas will be afforded time to recover from the impacts associated with the use of scallop dredges.

648 Subpart F **<u>Groundfish</u>**

648.80 **Regulated mesh areas and restrictions on gear and methods of fishing:** The Council considered each part of this measure item by item.

Gulf of Maine / Georges Bank Regulated Mesh Area: see below

Gear restrictions: This measure allows certain exemptions from the gear restrictions in place in the GOM/GB regulated mesh area. Some of these exemptions may have a negative effect on habitat by allowing certain types of fishing gears and methods which may disturb the habitat. Each exemption will be assessed individually. In general, all exemptions are being evaluated to determine if allowing the exemption has the potential to threaten essential fish habitat.

Scallop Dredge Fishery Exemption within the Gulf of Maine (GOM) Small Mesh Northern Shrimp Fishery Exemption Area: By allowing dredging, an activity that could disturb the habitat has been allowed in an area where it otherwise would not occur.

Nantucket Shoals Mussel and Sea Urchin Dredge Exemption Area: By allowing dredging, an activity that could disturb the habitat has been allowed in an area where it otherwise would not occur.

Southern New England Regulated Mesh Area: see below

SNE Mussel and Sea Urchin Dredge Exemption: By allowing dredging, an activity that could disturb the habitat has been allowed in an area where it otherwise would not occur.

Restrictions on gear and methods of fishing: see below

Pair trawl prohibition: This measure limits the efficiency of trawling vessels by prohibiting the practice of trawling in pairs. This measure has an effect on the efficiency of trawling, but it is not clear that the pair trawl prohibition has any impact on EFH.

648.81 **Closed areas**: For the year-round closed areas, the Council has determined that these areas offer significant conservation benefit to the EFH within the areas by prohibiting all bottom-tending mobile fishing gears, the gear types most often associated with adverse impacts to benthic habitats. It is important to note that on Georges Bank, the location of significant amounts of EFH for most Council-managed species, over 6,500 square nautical miles of area have been closed to bottom-tending mobile fishing gear. This equates to nearly half of the overall area of Georges Bank. For the temporary closures, the Council needs to assess the actual conservation benefits afforded EFH, if any, given that these areas are only closed for a short time each year. This length of time may not be enough time for the habitat within the areas to recover from fishing impacts.

Closed Area I: Restricts all fishing activity that could impact habitat in an approximately 1500 square nautical mile area of Georges Bank.

Closed Area II: Restricts all fishing activity that could impact habitat in an approximately 2650 square nautical mile area of Georges Bank.

Nantucket Lightship Closed Area: Restricts all fishing activity that could impact habitat in an approximately 2400 square nautical mile area of Georges Bank.

Dredge gear exception: By allowing dredging in a closed area, an activity that disturbs the habitat has been allowed in an area where it otherwise would not occur.

NE Closure Area (Aug 15 - Sep 13): Restricts all groundfish fishing activity that could impact habitat in an area of the Gulf of Maine for approximately one month during the spawning season of important groundfish. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

State waters exemption: It is our interpretation that this measure is simply a clarification of the limit of the NEFMC and NMFS jurisdiction in state waters and therefore this measure has no habitat effect.

Gulf of Maine Inshore Closure Areas: Restricts all groundfish fishing activity that could impact habitat in four areas of the Gulf of Maine over a four-month period during the spawning season of important groundfish. Due to the duration of the closures, it is unclear that this offers any conservation benefit to EFH.

Inshore Closure Area I (March 1 - March 31): see above.
Inshore Closure Area II (April 1 - April 30): see above.
Inshore Closure Area III (May 1 - May 31): see above.
Inshore Closure Area IV (June 1 - June 30): see above.

State waters exemption: It is our interpretation that this measure is simply a clarification of the limit of the NEFMC and NMFS jurisdiction in state waters and therefore this measure has no habitat effect.

Cashes Ledge Closure Area (June 1 - June 30): Restricts all groundfish fishing activity that could impact habitat in an area of the Gulf of Maine for approximately one month during the spawning season of important groundfish. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

State waters exemption: It is our interpretation that this measure is simply a clarification of the limit of the NEFMC and NMFS jurisdiction in state waters and therefore this measure has no habitat effect.

Western Gulf of Maine Closure Area: Restricts all groundfish fishing activity that could impact habitat in an approximately 1200 square nautical mile area of the Gulf of Maine.

Restricted Gear Area I / Mobile gear ban (Oct 1 - Jun 15): Restricts a type of fishing activity that could impact habitat in an area off Georges Bank for 258 days. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

Restricted Gear Area II / Mobile Gear ban (Nov 27 - Jun 15): Restricts a type of fishing activity that could impact habitat in an area off Georges Bank for 201 days. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

Restricted Gear Area III / Mobile Gear ban (Jun 16 - Nov 26): Restricts a type of fishing activity that could impact habitat in an area off Georges Bank for 161 days. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

Restricted Gear Area IV / Mobile Gear ban (Jun 16 - Sep 30): Restricts a type of fishing activity that could impact habitat in an area off Georges Bank for 107 days. Due to the duration of the closure, it is unclear that this offers any conservation benefit to EFH.

648.82 **Effort-control program for limited access vessels:** Limits overall fishing time. This indirectly protects habitat by forcing an overall reduction of fishing effort using some of the gears and methods likely to impact habitat.

Days-at-sea allocations: Limits many groundfish fishermen to only 88 allowable fishing days per year.

648.85 **Flexible Area Action System:** It was determined that this measure does not currently have any habitat effect associated with it as the authority to implement this action is specifically limited to an increase in the discards of juveniles, sublegal sized adults and spawning adults.

648.87 **Gillnet requirements to reduce or prevent marine mammal takes:** No direct habitat impact, but it was noted that a potential by-product of this measure is to open up these areas (during the gillnet closures) to mobile fishing methods which may have a negative impact on the habitat. These mobile fishing methods may not be used in these areas when the closures are not in effect due to the density of fixed gear. If this is not the case, then this measure does not affect habitat.

Mid-coast Closure Area (Mar 25 - Apr 25) and (Sep 15 - Dec 31): Currently determined to have no habitat effect, but we may want to reexamine later based on evidence of any habitat effects of the use of "pingers."

In summary, with the exception of the potential for impacts associated with effort displacement as a result of these measures, there are several existing management measures that directly protect EFH and others that indirectly protect EFH by reducing fishing effort. The system of closed areas on Georges Bank protects approximately 6,500 square nautical miles year-round by completely closing this area to fishing. In the Gulf of Maine, approximately 13,000 square nautical miles of habitat are afforded some degree of protection during temporary closures, with an additional 1,200 square nautical miles closed year-round. In addition, the days-at-sea program has effectively reduced much groundfishing effort to 88 days per year, and much of the scalloping effort to 142 days per year. This reduction of effort, in conjunction with the various restrictions on fishing methods and gear, has lessened the intensity of the impact of fishing on the habitat. Collie (1998) agrees that these recent Council actions to reduce effort and close important areas should reduce the impacts associated with fishing.

4.11 NEW MANAGEMENT MEASURES THAT AFFECT EFH

In the individual Sustainable Fisheries Act amendments, the Council is proposing several new management measures which will have the effect, either directly or indirectly, of mitigating the adverse impacts from fishing activity on EFH. These measures are designed to meet the various requirements of the Sustainable Fisheries Act, such as to conserve fish stocks, reduce overfishing, and reduce bycatch while considering the effects of management on safety at sea and on fishing communities. Considering the impacts of fishing activities on habitat, there are three principal categories of mechanisms that can be used to mitigate the adverse impacts: (1) closing areas to all or certain types of fishing activity; (2) restricting the use of particular gear types; and, (3) reducing the frequency and intensity of the impacts from fishing gear. Immediately prior to the submission of this amendment to the Council's fishery management plans, the Council submitted separate amendments to each of its existing FMPs, as well as new FMPs addressing Atlantic sea herring and monkfish, to address the other provisions and requirements of the Sustainable Fisheries Act. The management measures adopted in these amendments and FMPs, in some cases, provide conservation benefits to the essential fish habitat designated in this amendment. In these cases, additional management measures implemented through this amendment would be redundant and unnecessary. The following is a summary of the significant measures providing conservation benefits to EFH. For a more detailed discussion, please refer to the identified amendment or FMP.

- In Amendment 9 to the Northeast Multispecies FMP, the Council has proposed to ban the use of "streetsweeper" gear. The streetsweeper trawl is a recent gear innovation that covers the footrope with bristles resembling a streetsweeper brush. As reported by the fishermen who use the gear, the effect of this modification is that the footrope is lighter and more flexible than conventional rockhopper and roller gear. Another difference is that the entire trawl sweep (the brushes) is in contact with the bottom, rather than just the rockhoppers that are separated by hard rubber spacers which do not contact the bottom. The Council is concerned that such a net could so greatly improve the efficiency of the trawl so as to undermine the effectiveness of the DAS reduction program. The Council is also concerned that this new type of bottom trawl may have the potential to cause significant adverse effects to essential fish habitat. Since the Council has no way of assessing the impacts of the gear, it is taking the precautionary step of prohibiting it. Under current regulations, interested fishermen may propose limited, controlled experimental fisheries to determine the gear's impacts.

- In Amendment 7 to the Atlantic Sea Scallop FMP, the Council has proposed to reduced the effort in the scallop fishery by over fifteen percent for the fishing year beginning in 1999, with plans to reduce effort by another fifty-eight percent the following year. The principle mechanism to control effort in the scallop fishery is the days-at-sea management program. Prior to Amendment 7, full-time scallop vessels were allowed a maximum of 142 DAS. DAS for 1999 for full-time vessels have been reduced to 120, and will be further reduced to 50 in the year 2000 if the Council fails to act to implement other conservation measures. While there are several mechanisms that could be used to minimize the threat to EFH from scallop dredge gear, any reduction in effort would reduce the frequency and intensity of the use of scallop dredges, thus reducing the effects of fishing on the EFH of many species. The Council is actively considering additional scallop management measures which would have the potential to also provide conservation benefits to EFH, including a system of rotating closed areas. Once an area is closed for the purposes of allowing the sea scallops within the area to reach a larger size, the area will be afforded the opportunity to recover from some of the impacts associated with scallop dredging. The Council has also recommended continuation of the mid-Atlantic closed areas, which also afford the habitat within the areas the opportunity to recover from the impacts associated with scallop dredging.

- In the Atlantic Herring FMP, the Council has not proposed any management measures which would provide any direct conservation benefit to EFH. The vast majority (92%) of herring are harvested using purse seines and midwater trawls and both gear types are believed to cause minimal, if any, adverse impact to any type of EFH. Thus, it is not believed that any measures are needed to conserve EFH from herring fishing-related activities.

- In the Monkfish FMP, the Council has not proposed any management measures which would provide any direct conservation benefit to EFH. Most vessels landing monkfish, however, will also be fishing under either a multispecies or scallop permit, and thus will be subject to those regulations, which include significant areas closed to fishing and reductions in DAS. Thus, the conservation benefits to EFH provided under the Multispecies and Sea Scallop FMPs will also be provided to the EFH likely to be impacted by the monkfish fishery.

- The EFH amendment is the only amendment to the Atlantic Salmon FMP, but since the Council is maintaining a general prohibition on the possession of Atlantic salmon in the EEZ, there can be no adverse impacts to EFH from salmon fishing to minimize. The prohibition on possession of Atlantic salmon also protects the salmon habitat areas of particular concern from any potential adverse impacts associated with the effects of fishing.

The Council may consider additional management measures for the protection and conservation of essential fish habitat from adverse impacts associated with particular fishing gear types, including the use of incentives such as allowing exemptions in closed areas if a particular fishing practice or gear type is shown not to be detrimental to habitat. The Interim Final Rule provides criteria for consideration by the Council regarding the practicability of minimizing an adverse effect from fishing. The Interim Final Rule states that the Council should consider:

- whether and to what extent a fishing activity is adversely impacting EFH;
- the nature and extent of the adverse effect on EFH; and,
- whether proposed management measures are practicable, taking into consideration the long and short-term costs as well as benefits to the fishery and its EFH, along with other appropriate factors consistent with National Standard 7 (minimize costs and avoid unnecessary duplication).

The Council has considered the known adverse impacts to EFH from the fishing-related activities in New England under Council jurisdiction. Any measures implemented by the Council to mitigate habitat impacts would likely be similar to the management measures considered in the other Sustainable Fisheries Act amendments (such as additional days-at-sea reductions or additional closed areas). Many of the measures associated with the existing Council FMPs provide significant conservation benefit to EFH and have minimized many of the potential adverse effects associated with fishing-related activities. Several of the measures associated with the other recently submitted Sustainable Fisheries Act amendments to the Council's FMPs provide conservation benefits to EFH and minimize potential adverse effects of fishing. These measures meet the standards of the Sustainable Fisheries Act for the Council to minimize the effects of fishing on EFH. The Council has developed modifications to the framework adjustment procedures in all of its FMPs to allow for the timely implementation of habitat conservation measures, if and when they are deemed necessary to minimize the effects of fishing on EFH. The Council also has developed a measure specifically to protect the juvenile Atlantic cod habitat area of particular concern from the most significant adverse effects of fishing-related activities.

Any measures implemented by the Council to mitigate habitat impacts would likely be similar to the management measures considered in the other Sustainable Fisheries Act amendments. Before the Council can responsibly develop additional practicable measures specifically for the protection of EFH, if they are determined to be necessary, research and analysis needs to be completed to better understand the net effects of using one particular gear design over another, as well as the effects of effort displacement that may be associated with enacting additional closed areas or reductions to the days-at-sea programs. For instance, reductions to the days-at-sea programs may have the unintended effect of forcing many fishermen to concentrate their efforts in small areas very near shore, rather than spreading their efforts out over large areas. The net effect of this type of measure could be more detrimental to EFH than no measure at all, since many types of inshore habitats are EFH. Also, since almost all areas of New England's fishing grounds are designated EFH for one species or another, a new closed area may have the unintended effect of shifting fishing effort from one area of EFH to another, concentrating effort in this other area. Due to the uncertainty associated with the actual benefits predicted from additional management measures designed to mitigate habitat impacts the Council can not conclude that the additional short and long-term costs to the fishing industry associated with those measures would be justifiable. The Council will work to better understand these issues as it strives to more narrowly refine the designations of EFH.

The Interim Final Rule suggests three options for managing the effects of fishing gear on EFH: (1) fishing equipment restrictions; (2) time / area closures; and (3) harvest limits. The Council will consider these options, among others, if additional management measures are determined to be required to prevent, mitigate, or minimize any adverse effects from fishing activities. Some fishermen, such as Mirarchi (1998) and Pendleton (1998) seem to agree that some areas, especially small areas targeted at particularly critical habitats should be protected from fishing. Additional management measures determined necessary and prudent are most likely to be implemented through the framework adjustment process.

4.11.1 Habitat Area of Particular Concern Management Measure

The following management measure has been approved by the Council. The area on Georges Bank bounded by the following coordinates and displayed on Figure 6 has been designated as a "habitat area of particular concern" for juvenile Atlantic cod. The habitat associated with this area provides critical ecological functions for the survival of post-settlement juvenile cod. The coordinates for this area are as follows:

- 67° 20' W 42° 10' N
- 67° 10' W 42° 10' N (east to the EEZ Boundary)
- 67° 00' W 42° 00' N (south to the EEZ Boundary)
- 67° 10' W 42° 00' N
- 67° 10' W 41° 50' N
- 67° 20' W 41° 50' N
- 67° 20' W 42° 10' N

The area designated as a "habitat area of particular concern" for juvenile Atlantic cod should be afforded a special level of protection. To protect this area from any potential adverse impacts from fishing-related activities, the Council will maintain the current Closed Area II restrictions, pursuant to the provisions of 50 CFR 648.81(b.), for the designated habitat area of particular concern for habitat protection reasons.

Rationale

Protection of this area from any adverse impacts caused by repeated exposure to intense disturbance will ensure suitable settlement habitat for juvenile cod in this area of Georges Bank. The objective of this measure is to improve survival of juvenile cod and increase recruitment to the fishery. This area provides two important ecological functions for post-settlement juvenile cod relative to other areas: increased survivability and readily available prey. The habitat of this area is also particularly vulnerable to adverse impacts from bottom-tending mobile fishing gear.

4.12 FRAMEWORK SPECIFICATIONS

The existing framework adjustment procedures of the Northeast Multispecies, Sea Scallop, Atlantic Herring, Monkfish, and Atlantic Salmon fishery management plans will remain in effect with the following modifications. The Council has developed framework adjustment language for inclusion in these FMPs so that habitat conservation management measures may be approved by the Council in a more timely manner than the plan amendment process. The Council also has developed framework adjustment language for inclusion in these FMPs so that the boundaries of the existing and all future essential fish habitat designations (including the designations of habitat areas of particular concern (HAPC)) may be modified in a more timely manner than the traditional plan amendment process.

The framework adjustment process allows the Council normally to modify specified plan provisions over the span of at least two Council meetings, although there is an exception that provides for more timely Council consideration under certain specific conditions (see 50 CFR 663, App. III. B.). The proposed modification generally will be announced in advance of at least two Council meetings and public comments will be taken at each of those meetings prior to a final Council vote on the issue.

Additionally, a document containing the measure(s) proposed, other alternatives under consideration, and the biological and economic impacts of the measures will be made available at least a week before the meeting at which the final vote is scheduled. If an action is approved, the Council forwards its recommendation to the NMFS Regional Administrator (RA). If the RA concurs with the framework adjustment, it is forwarded to the Secretary of Commerce, who has the discretion to publish it either as proposed or final regulations in the *Federal Register*. Adjustments which are highly controversial or make direct changes in resource allocation are usually considered for the full rulemaking process. The Secretary will publish a proposed rule with an appropriate period for public comment, followed by publication of a final rule. In other cases, the Secretary is expected to waive for good cause the requirement for a proposed rule and opportunity for public comment in the *Federal Register*. The Secretary, in doing so, will publish a "final rule" to remain in effect until amended, assuming that the Council process adequately satisfies the requirement for prior notice and comment.

In the existing framework process, there are other factors which are weighed during consideration of an adjustment. They include:

a) whether the availability of data on which the recommended management measures are based allows for adequate time to publish a proposed rule, and whether regulations have to be in place for an entire harvest/fishing season;
b) whether there has been adequate notice and opportunity for participation by the public and members of the affected industry in the development of the Council's recommended management measures;
c) whether there is an immediate need to protect the resource; and,
d) whether there will be a continuing evaluation of management measures adopted following their implementation as a final rule.

For the protection of essential fish habitat in the EEZ, the Council's recommendations on adjustments or additions to management measures must come from one or more of the following categories:

- changes to the boundaries of the EFH / HAPC designations
- gear restrictions
- changes to days-at-sea programs
- area closures
- the establishment of special management areas or zones
- seasonal closures of one or more management areas
- effort monitoring
- trip limits

- permitting restrictions
- crew limits
- onboard observers
- recreational fishing measures
- any other management measures currently included in the relevant FMP.

It is expected that as more information is made available on the distribution and relative abundance of fishery resources and on the habitat requirements and habitat relationships of the NEFMC-managed species, the Council will choose to modify and refine the boundaries of the essential fish habitat and HAPC designations. The framework adjustment process will be used to make these modifications and refinements without the need to modify all Council FMPs at one time.

The Council intends to use the above-described process to make any necessary adjustments to Council FMPs to facilitate the conservation and protection of essential fish habitat. The intent is to make changes to FMPs in a timely manner.