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REPORT ON MOBILE FISHING GEAR EFFECTS AND CITATION VALIDITY IN NEFMC DOCUMENTS AFFECTING THE ATLANTIC SEA SCALLOP FISHERY*

April 2, 2008

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Preface

The senior author of this report (Dr. John Everett) returned to the family fishing business in Fairhaven, MA, in February 1970. The outer harbor of Fairhaven-New Bedford had been opened to shellfishing a few years before, after decades of closure due to sewage pollution. Using hydraulic dredges, three boats worked the small area (about 1.5 miles by 0.5 miles) on the Fairhaven side of the channel. The first two years, it took all day to catch the 30 bushel limit of bay quahogs (*Mercenaria mercenaria*), with only a dozen littlenecks among the bulls. During the 3rd year, much of the catch was littlenecks, and by the 4th year the limit could be caught in less than two hours, and only the more valuable littlenecks (2 to 2.5”) were kept. The photo at right[1], taken during the 5th year shows this incredible production, as a full chain bag of mostly littlenecks (about 3 bushels) comes out of the water after a 15 to 20 min. tow, despite the visible gap between rings. Over decades of literature review and inquiry, Dr. Everett developed an explanation of how fishing could cause the explosive growth of the population. More recently, similar questions have been raised about gains observed in scallop populations after dredging. The Fisheries Survival Fund commissioned this present report, in part, to determine if there was scientific support for the hypothesis of Dr. Everett linking productivity to dredging, to delineate all its aspects, and determine its applicability to sea scallops and other fisheries.

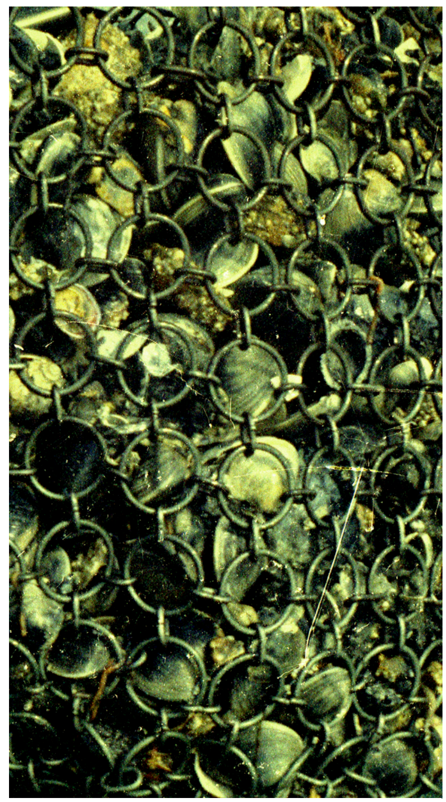

Figure 1. Full chain bag of littlenecks. Rings: 2” diameter

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* Pending formal publication, this paper may be cited as: Everett, John T. and Emory D. Anderson. 2008. Report on Mobile Fishing Gear Effects and Citation Validity in NEFMC Documents Affecting the Atlantic Sea Scallop Fishery. Ocean Associates, Inc. Arlington, VA. Available: http://www.OceanAssoc.com/scallopdredgeeffects.pdf

1 Several photos from this fishing day are available, with setting, dredge, crew, catch, and area: http://www.oceansart.us/dredgesphotos/quahogdredgephotos.html

Report Objectives
(1) Evaluate the accuracy of scientific citations in recent FMP/EIS/EFH documents prepared by the New England Fishery Management Council relative to the actual scientific papers, (2) Ascertain the scientific validity of studies about dredging impacts, particularly those included in Council documents, and (3) Determine if there is scientific support for the hypothesis of Dr. Everett explaining the observed bloom of productivity caused by dredging, to delineate all its aspects and any relationships to the productivity of non-target species.

Executive Summary
The first step in this review centered on the validity of citations, rather than the documents themselves. However, after we read and re-read the pertinent parts of thousands of pages, a broad deficiency emerged. The purported damage to the fisheries habitat is treated in somewhat general terms, inferring that, because some sea bottom is being moved around, all impacts must be negative. To counteract this bias, there are some citations of studies taking broader views of ecosystem impacts that could be added, and we suggest that some citations be removed because the studies they reference are flawed. From a technical citation perspective, the science is generally cited correctly, but there is some limited carelessness as to source. The full section on citations is an attachment, following the references to the main body of this report.

The second step was to evaluate the current research on scallop gear impacts and compare it to the NEFMC documents. We show that studies that use the Naturalists' dredge to estimate production have used an inappropriate tool that misses fish and should not be cited. The NEFMC documents capture the essence of the majority of the research on mobile gear impacts fairly, but the bulk of the research is not particularly relevant to fisheries management. For example, there are no economic impact analyses. Much is directed at seeking and documenting gear-induced changes to substrate and fauna and the amount of time to recover to the preexisting conditions. However, most places being dredged have been subjected to the effects of bottom-tending gear over a long period of time. The issue, therefore, is not so much maintaining virgin ground, but maintaining the productivity of existing fishing grounds. The fisheries management approach should be similar to the manner in which we think about New England cornfields. Productivity research should be done holistically, determining not only the impact of gear passage on the benthos but also impacts on fisheries productivity over the near and long term. Research should nominate areas requiring protection and should provide benefit/cost information for doing so.

The lack of productivity data is problematic. Assumptions must be avoided as those about habitat values, that seem precautionary, can lead to closing traditional fishing grounds, shifting fishing to new areas. This can have unintended consequences, as documented in this report. On the other hand, closing areas that are historically under-fished, has less risk associated with the action and indeed could be considered precautionary.

The few studies that have taken a macro view of fishing impacts show increased production (landings) at the fisheries level, consistent with the mechanisms believed to be enhancing quahog production in dredged areas. Mechanisms that enable this can be gleaned from some of the existing work and are presented, along with information from aquaculture research and elsewhere, supporting the proposition that dredging is, in fact, like tilling the field and improves productivity in significant areas, if not most. Lastly, the major issue in all the research is not so

much quality of science, but rather philosophy about resource management. Are we stewards of a food resource AND of wildlife, or are we solely focused on wildlife protection. Most extant research is of use to the latter mission and not the former. We show how alternative findings can be derived from the extant literature and propose research that is more relevant to a mission focused on wise use of our nation's resources. We find significant evidence to indicate there are physical and biological mechanisms initiated by dredging that increase benthos productivity, particularly of bivalves such as scallops and clams, and also of opportunistic species that are food for many fish species, leading to increased fisheries production. Former fishing areas now lying fallow due to lack of fish and shellfish might be brought back into production through a research program designed to test the impact of mobile gear on larval settlement.

Specific findings (summary - citations are in the supporting text):

1. Studies that exclusively use the Naturalists' dredge or coring tools to determine production are flawed. Other studies show that the dredge's catch rate is too variable to be used quantitatively. Most importantly, the dredges cannot sample fish, missing the most important measure of production. Further, studies that compare fished vs. unfished areas, or fished vs. a control site and do not come back over months and years to assess both fish production and growout of bivalves and crustaceans cannot determine fisheries productivity. These studies should not be cited in the NEFMC documents to demonstrate loss of production. They include Collie et al. 1997 and Hermsen et al. 2003 that use data from the 1994 Collie cruise and later similar sampling and Jennings et al. 2001 (and probably others of Jennings). There may be other studies as well.

2. Even in the most heavily fished areas, there are de facto mini sanctuaries. These areas remain lightly or non-disturbed because of boulders, ledges, mud, shipping lanes, or shipwrecks.

3. Most studies have failed to monitor study sites long enough to observe the increased larval influx and growout, particularly of fish and the long-lived bivalves (e.g., scallops, clams, quahogs). These studies should be removed from NEFMC documents wherever they are used to demonstrate loss of production. They include Collie et al. 1997 and Hermsen et al. 2003.

4. Only several Dutch authors have taken a systematic view that includes: documenting benthos changes, the density of the fishing effort, fish diet, fish growth rates, and harvest production levels over suitably long periods. Their studies show increases in fisheries production in the shorter term and over decades. Jennings (above) used flawed methodology to discredit these studies. These studies should be integrated into the NEFMC documents, and highlighted, as they are the only ones to take the macro view needed for resource management.

5. The vulnerability to scallop dredging for the EFH for the life stages of some species (e.g., juvenile Atlantic cod) is rated as high. To the extent this rating is caused by the reduction in epifauna and other hiding places, this may not be correct, as it is likely more than offset by increasing prey and making prey more visible to cod in the fished areas. Predation rates on young of the year cod may be higher in complex habitat, when compared to vast stretches of sand and fine gravel, due to the higher levels and diversity of predators including older cod.

6. In Council documents, the movement of sand, shells, rocks, surficial sediment and algae by mobile gear is inferred to be bad. However, as explained in this report, it may be key to the continued productivity of the fishing grounds for many of our largest fisheries. For example, most of our most productive fishing grounds are high energy environments where bottom fishing activity has been shown to have no significant impacts.

7. Several scientists have tried to grapple with the increases in production they found in fished areas. They propose such rationales as:

   - Smaller animals with high intrinsic rates of increase may benefit from the reduction in competition from larger animals;
   - Opportunistic species are favored in a disturbed environment;
   - Turnover of the sediment oxygenates the deeper layers and releases nutrients, increasing primary production and subsequently increasing biomass, which serves as the food for most demersal fish;
   - Fishing may be beneficial for fish if their increased mortality is balanced by an increasing food supply from damaged or discarded animals;
   - If the timing of disturbance coincides with periods of peak larval availability, there can be successful colonization by opportunistic species;
   - Opportunistic species are "resistant to disturbance and their abundance is enhanced by decreased competition for space with the more fragile epifauna";
   - There is increased predation of organisms uncovered by dredging and it may be long term;
   - If larvae descend to an area of only a millimeter (mm) or two of barely visible fine silt and detritus, they can suffocate. Larvae may not have suitable adaptation ability to move the material, or to escape from it;
   - Fine suspended detritus and sediments (that accumulate over time) reduce the availability of food and inhibit filter feeding of larval and young stages;
   - The rise in flatfish production is due to their increase in growth rate as a "result of increased productivity of suitable benthic food in heavily (beam) trawled areas".

Information from such studies helps explain why heavily fished areas remain productive over the course of decades and longer; in addition, these processes and effects may be characteristic of certain dynamic and productive environments such as the Great South Channel. We propose that information taken from research on other marine species, on harbor dredging, and particularly from aquaculture research on many of these species of concern is applicable to further explain increased production from dredged areas. Again, the citations are in the main text that follows this summary. These other possible explanations for the increased production are:

- Fish larvae use visual, chemical and mechanical cues for habitat selection, and can discriminate where their own species live, or have lived, or where there is prey to finance their growth;
- As bivalve larvae (0.25 mm) descend and crawl on the substrate searching for a suitable place to settle, they are more likely to find it in the fished area with recently overturned, clean shells and stones and sand, than in one covered with the slightest amount of surficial detritus and silt and loose algae;
- Damaged scallops, surf clams, polychaetes, barnacles, ocean quahogs and other mollusks provide a chemical scent that attracts larvae of their own kind;

- Shells of the animals that recently have lived in the area are uncovered and brought to the sea floor's surface, whereby their chemical scent can serve as an attractant and the shells serve as an attachment point for conspecific larvae;
- The thin veneer of mud, algae, and detritus that rapidly accumulates in all but the fastest moving environments is swept away allowing the settlement of larvae of all types in areas where they do not suffocate in detritic and sedimentary ooze and where the ooze does not clog their gills;
- The availability of suitable surfaces on which to settle is a primary requirement for successful scallop reproduction;
- Invertebrate larvae, including scallops, are known to be attracted to dark settlement areas, such as that created by passage of a scallop dredge;
- For many species of fish, eggs laid directly on the bottom begin to die when the fine layer reaches 0.5 mm (reducing the exchange of gases and metabolic waste) and hatching success is greatest on clean gravel or sand substrates;
- Those fish species with adhesive egg masses, such as Atlantic herring, require a stable and clean substrate, such as recently overturned scallop shells, gravel and sand.

Stokesbury et al. (2004) show that recruitment has fallen in areas set aside as a conservation measure. They suggest it is caused in some way by the presence of large quantities of mature scallops, which had set prior to closure. We believe it is far more likely that reduced recruitment is due to the closure itself, allowing the fishing grounds to be covered with a fine film that is inimical to all settling larvae, whether scallops, flounder, polychaetes, or other bottom dwellers. Under the hypothesis presented in this paper, and supported by the literature, fisheries production should rise immediately following dredging due to scavenging and predation on exposed prey. If dredging occurs when there are larvae (of all types) in the water column ready to set, the production will continue without interruption. If dredging occurs in the winter, the bottom will remain suitable for setting for the spring and perhaps summer larvae. Bivalve recruitment to market size should begin to rise in the third year after fishing begins in opened areas. On the other hand, in newly closed areas, small sizes (sub market) of bivalves should be less prevalent beginning about two years after fishing ceases, although established animals will continue to increase in biomass until they begin to atrophy or die of old age, or natural predators move in, eventually succumbing to mass mortality as documented by Stokesbury (2007). The cyclical nature of scallop recruitment is likely not just due to the size of the breeding stock and environmental conditions, but also whether there is too much predation on eggs and larvae such as by jellyfish and filter feeding fish, and whether there is suitable habitat for larvae settlement.

Evaluation of Published Research on Scallop Gear Impacts

The Process

This evaluation was done by first reviewing Council documents and evaluating their supporting citations against the underlying references. We then reviewed most of the extant literature (about 50 papers) on mobile gear including several meta analyses of studies. Studies concerning non-scallop mobile gear were included, particularly if they were cited often, or if the gear, as does scallop gear, also alters the sea floor in ways consistent with the premise explaining quahog productivity growth. We then extended the review to include larval settlement papers, much of it from aquaculture research and practice. Following this review, the important NEFMC documents were again reviewed to verify the report that follows is complete.

General critique of the habitat analysis in Council documents

As for the citations themselves that are included in NEFMC documents, very few were used in ways that, in our judgment, warranted examination of the original papers for authenticity of any comments or summaries. There is very little information in the NEFMC documents pertaining to the effects of scallop dredging, and most is not accompanied by literature citations. Parts that did have citations were not contentious or open to question; they were mainly simple statements that, for example, dredging has an impact on the biological and physical state of the ocean bottom, particularly when repeated over long periods of time. Further, several principal documents are familiar to the reviewers and are known to contain the materials referenced. The three Collie et al. papers (1996; 1997; and 2000) were examined more closely because their research focus on the impacts of bottom-tending fishing gear on Georges Bank on benthic fauna and the statements about that research in several of the Council documents was deemed sufficiently important to warrant cross-checking. Statements in the Council documents were found to be relatively accurate. The only problem detected was the incorrect assignment of the various Collie *et al.* papers to the appropriate descriptions of findings. This appears simply to reflect some sloppiness on the part of those drafting these sections. However, as explained below, the Collie studies that are based on cruises that used the Naturalists' dredge as its primary data source, used an inappropriate tool, by itself, for making the generalizations reported in these papers placing most, if not all, of Collie's conclusions into question. The detailed report of this review is in the Appendix.

Nature of the Literature and the Backdrop

There have been over 100 treatments in over 50 papers dealing with the impact of mobile gear on the sea floor (Kaiser et al. 2006).[1] Johnson (2002) reviewed 11 papers that have tried to assess what conclusions could be drawn.[2] Since that assessment there have been several others, one of the most notable being that of UN Food and Agriculture Organization (FAO). It is notable both for what it said and the rancor with which it was attacked by those attempting to discredit it (e.g., Gray 2006).[3] Since FAO has a stellar record in accomplishing major advances in global fisheries stewardship, it is important to understand the FAO report. The essence of their evaluation is that long-term effects of beam trawling and scallop dredging have not been investigated, there are significant methodological issues among the studies of mobile gear impacts, and that decisions need to be circumspect in terms of what needs to be accomplished, at what cost, and in light of the mission to ensure wise use of the fisheries resources (Løkkeborg, 2005).[4] In attacking the FAO report, Gray et al. (2007) assert: "Most people now accept that fishing has effects on the seabed (however variable) – therefore the question is how bad is it?"[5] It is clear what these authors are seeking in their research as they are the investigators on several of the gear impact studies. Ameliorative or beneficial effects escape their field of view.

There is no denial that any fishing gear on the bottom leaves a mark behind that can be detected for a few hours in dynamic habitats to many years in an area with corals and other fragile epifauna. Just as our nation plans for terrestrial wildlife preserves and farms, there is similar opportunity in the oceans. Fragile marine wildlife can be protected while also keeping productive fishing areas as a vital food resource. There is a balance that needs to be struck to ensure wise use of resources, and in the balancing, there needs to be recognition of the costs, benefits, and efficiencies that are ours to decide. There is a growing body of science providing evidence that the most benefit can be gained by protecting those areas with the least fishing effort.

We, as does FAO, point out that within the extant literature, the findings, methods, assumptions, use of controls or not, time of year, type of bottom, type of assessment gear, and similar differences make comparisons difficult. There are sufficient findings to enable any advocacy group to make a case to support any position. Some of these studies can be used to show that the use of all mobile gear spells the end of life forms we need to protect. Some of these same studies, or other studies, support the assertions that there are no negative effects or none lasting for more than a few months, from scallop dredges or any other device. Several studies show that dredging or beam trawling (a gear that slices through the bottom to get under flounders) has positive impacts that last for decades. In the words of Kaiser et al., (2006) "Reviews of the available literature are open to interpretation and distortion by different user groups (fishers, scientists, conservationists) and hence their utility to marine environmental policy makers is limited at present."[6]

The popular press, and some concerned scientists, write about how society is engaged in a fight with industry to protect an environment that should be kept in a pristine state for the benefit of all plants and animals (sometimes ostensibly to support fisheries). To many, such a theoretical pristine state equates with productivity. However, fishing grounds are ***not*** in pristine condition; thus, one question that must be considered is how to keep these grounds productive. Human needs must also be considered.

Articles and studies detailing the damage that mobile gear causes often present one side of the picture. Another side, taken from some of the same papers cited in NEFMC documents, and some that should be included, show another perspective to this debate. In essence, you find what you seek, whether it is in a research project at sea, or in reviewing someone else's publication to find support for your own methods and findings. With a small community of qualified scientists, everyone must be wary of "groupthink" that obscures the information we all need. The ICES Advisory Committee on Ecosystems concludes that "It is evident that the scientific information presently available is inadequate to evaluate the impact of current fishing practices on sensitive habitats, thus precluding the provision of advice on appropriate mitigation strategies" (ICES 2002).[7]

The Other Side of the Story

Scallops don't grow everywhere, and they can't be fished in many areas they do grow. Scallopers avoid the few scallops in areas of coral, or rocky bottom, or mud, which cause delays in fishing operations and damage to gear. The FAO report on impacts notes that higher densities of scallops in disturbed areas (vs. undisturbed) "simply reflects fishers' preference for areas with high densities of the target species, and thus indicates that the sites studied involved different habitat types" (Løkkeborg 2005).[8]

Many studies show that in dynamic areas where tides and storms move even boulders around, the sediment plume is gone in minutes and dredge marks are gone within a day or so. Scallop dredging has been shown to have no negative impact in dynamic environments (Lindholm 2002;[9] Stokesbury and Harris 2006;[10] and Eleftheriou and Robinson 1992[11]) and no or only short term negative impact in intermediate environments such as the New York bight (Sullivan et al. 2003)[12], and no negative impact greater than normal variation in soft sediments (Currie and Parry 1996).[13] As a further check to discern impacts, data from an Iceland study "do not show evidence of any major impact of scallop dredging on the distribution and abundance of bycatch taxa" leading the authors to state that the study area, which had been fished for many years, demonstrated an "apparently small effect of fishing effort on the benthic community (Guijarro et al. 2006).[14] Studies of bottom topography and water chemistry changes from scallop dredging showed that effects "were not translated into changes in the disposition of the sediments, their grade distribution and the organic carbon and chlorophyll content, all of which showed no effects" (Eleftheriou and Robinson 1992) [15]. The issue is not about pulling scallop gear through sensitive habitats of ages old corals and other epifauna. It is about continuing the use of fishing grounds that have been developed and fished for over 100 years.

Just as many fishermen (and some scientists) have noticed, dense scallops and improved fisheries tend to appear a few years after an area with just a few scallops is fished, long after the scavengers and opportunistic predators (e.g., flounders, cod, haddock) have come and gone, having consumed the enhanced food made available immediately through the dredging (Thrush et al 1998[16]; Kenchington et al. 1996[17]; and Currie and Parry 1996[18]) and then after feeding on the increased (70-300% more) opportunistic brittlestars, polychaetes and amphipods for 8 months to more than two years following dredging (Gilkinson et al.[19]; Currie and Parry 1996[20]) perhaps having then been consumed themselves or caught and carried off to be someone's dinner. A finding by Sullivan (2003) of "inordinately large recruitment of yellowtail flounder in dredged areas of the NY Bight"[21] garners no attention by American researchers and impact assessors. One can only wonder why.

We believe the higher energy areas are the most productive because of their naturally cleaned substrate and that areas of less energy may be made more productive by regular fishing that similarly provides a cleaner substrate. This can be verified with a carefully controlled research program.

When analyzed at the fisheries level, as appropriate for a fisheries stewardship mission, beam trawling, which digs up to several centimeters (cm) into the sea floor, has been shown to increase fisheries yields over decadal periods. No similar evaluation of dredged, or trawled, areas has been conducted in the NW Atlantic, but the species are identical or similar. Many studies note the shift after dredging or trawling to a more opportunistic ecology and most deplore this fact, but from a fisheries perspective, the effect can be positive. The rapidly setting and growing species, such as brittle stars, polychaetes and amphipods, quickly settle out on the clean substrate following gear passage and serve as important food for flounders of all ages, for young cod, for haddock and for many other species. On the clean substrate, these rapidly colonizing animals have fewer places to hide and can nourish the fish this Council stewards. Not only do these items at the base of the food chain find a place to flourish, so do all larval forms requiring a clean surface for attachment or deposition, free of suffocating algae, detritus, and fine silt. This includes scallops, ocean quahogs, surf clams and even flounders. The reported large recruitment of yellowtail flounder in dredged areas supports the Dutch studies that also documented the increased food supply from opportunistic items and faster flounder growth rates in fished areas. The change to a more opportunistic ecology, including smaller, faster growing species, benefits some of the inhabitants and is not bad just because it is different. Species such as flounders, haddock, and young cod that feed on certain polychaetes, brittlestars, amphipods and other organisms that quickly colonize the disturbed area benefit the most.

We believe that future research will show that, just as for quahog dredging, the shift is not just to opportunistic species. This is an artifact of the sampling gear and protocols being used. Rather the benefit extends to all species whose larval forms require a clean substrate for settling out. This includes the observed opportunistic species that quickly appear before the typical study ends, and it also includes those that are not observable for many months or that are difficult to observe in research gear and protocols designed to detect damage. These include all the bivalves, such as scallops, surf clams, and ocean quahogs as well as the flounders and other bottom dwelling fish. The bivalves are slow to grow and periodic sampling is needed to assess their presence, while the fish need special gear beyond dredges to detect their recruitment.

Mechanisms in the literature that have been proposed to account for the increased production noted in fished areas include:

- Smaller-bodied animals with high intrinsic rates of increase may benefit from the reduction in biomass of larger-bodied benthic fauna through a reduction in competition (Jennings et al. 2001).[22]
- Opportunistic species would most likely be favored in a moderately disturbed environment(Dayton and Hessler 1972).[23]
- Turnover of the sediment surface, causing the oxygenation of the deeper layers and release of buried organic matter and nutrients, leading to a general increase in primary production and subsequently to increases in benthic biomass and densities (Lampadariou 2005).[24]
- Benthic production is known to be the food and energy resource for most demersal fish.[25]
- Fishing may also be beneficial for fish if their increased mortality is balanced by an increasing food supply from damaged or discarded animals (Lampadariou 2005).[26]

- If the timing of disturbance coincides with periods of peak larval availability there can be successful colonization by opportunistic species (Levin 1984).[27]
- Opportunistic taxa are "resistant to disturbance and that their abundance is enhanced at disturbed sites by decreased competition for space with the more fragile epifauna" (Collie et al. 2000).[28]
- There is increased predation of infaunal organisms uncovered by dredging (Currie and Parry 1996)[29] and it may be of long term nature (Garcia et al. 2006).[30]
- If larvae descend to an area of only one or two mm of barely visible fine silt and detritus (that accumulate over time), they can suffocate, but even as they grow, fine suspended particles reduce the availability of phytoplankton and inhibit filter feeding, and require frequent expulsion of sediments by clapping, in the case of scallops (Packer et al. 1999)[31]. Other larvae may not have suitable adaptation ability to move the material, or to escape from it. Most bivalves, for example, can re-new their swimming ability after reaching bottom, to find a better place, but some, such as oysters, cannot Helm et al, 2004).[32]
- The rise in flatfish production (sole and plaice) in the North Sea (Rijnsdorp 1998)[33] is due to the increase in growth rate as a "result of increased productivity of suitable benthic food in heavily (beam) trawled areas" (Rijnsdorp and van Beek 1991)[34]; also Rijnsdorp and VanLeeuwen (1996)[35] and Rijnsdorp and Vingerhoed (2001)[36] have similar statements.

Such studies help explain why heavily fished areas remain productive over the course of decades and longer; in addition, these processes and effects may be characteristic of certain dynamic and productive environments such as the Great South Channel. In addition to the mechanisms cited above, we propose that information taken from research on other marine species, on harbor dredging, and particularly from aquaculture research on many of these species of concern is applicable to further explain increased production from dredged areas.

- Fish larvae are known to use visual, chemical and mechanical cues for effective habitat selection at settlement, and have the ability to discriminate species-specific sensory cues, to select areas where their own species live, or have lived, or where there is prey to finance their growth (Lecchini et al. 2005).[37]
- As bivalve larvae drop out of the water column and crawl around on the substrate using their foot and search the surface for a suitable place to settle, they are more likely to find it in the fished area with clean shells and stones and sand (Helm et al. 2004)[38] than in one covered with a fine surface of silt. If the surface is unsuitable, they will move off or swim away, if they can, and seek a more suitable location.
- Damaged scallops, surf clams, polychaetes, barnacles, ocean quahogs and other mollusks provide a chemical scent that is akin to that in hatcheries wherein settlement areas are "painted" with the fluids of crushed animals to create a biofilm in order to attract larvae (Helm et al. 2004)[39], a broad range of which have demonstrated strong capabilities to seek conspecific adults (Su et al., 2007).[40]
- Shells of the animals that recently have lived in the area are brought to the bottom's surface, whereby their scent can serve as an attractant for conspecific larvae (Helm et al. 2004).[41]

- The thin veneer of algae, mud, and detritus that rapidly accumulates in all but the fastest moving environments is swept away (Mayer et al. 1991[42]; Watling et al. 2001[43], allowing the settlement of larvae of all types in areas where they do not suffocate in 1-3 mm or more of detritic and sedimentary ooze and where the ooze does not clog their gills. Upon descent to the bottom, scallop larvae are only 0.25 mm. If there is more detritus or silt than this, they may not be able to settle successfully. "The availability of suitable surfaces on which to settle seems to be a primary requirement for successful scallop reproduction" (NOAA 1999).[44] The findings of Stokesbury and Harris (2006) that periodic scallop fishing causes less impact than environmental conditions in dynamic areas such as the Great South Channel [45] are consistent. Both currents and dredging maintain the sea floor in a state necessary for successful larvae settlement and apparently have equivalent impacts in these areas on other seabed components.
- Bivalve larvae, including scallops, are known to be attracted to dark settlement areas (De la Roche 2003[46]; Su et al. 2007[47]) and "this phenomenon may be explained by the preference of spat for darker substratum." (Su et al. 2007) [48] At least in less turbulent areas, the passage of a scallop dredge leaves a relatively dark path by, as characterized by Lampadariou (2005), disturbing the sediment surface and exposing buried organic materials to oxygenation,[49] similar to that noticed by clam diggers along the shore. The darkening resulting from chemically-reduced black sediment being brought to the surface and exchanged with oxidized yellowish top sediment is so pronounced and persistent, that it can be used with photographic analysis to detect whether an area has been fished (Rosenberg et al.).[50] This darkening can persist, at least for areas subject to tidal and sub-tidal area clamming for several weeks. Just as has been found through aquaculture research and practices cited above, many invertebrate (at least) larvae will be attracted to the fished areas for settlement. It may be that species have developed this affinity to dark sites for settlement due to successful settlement and growout in areas disturbed by "plowing" animals such as certain rays and horseshoe crabs.
- For many species of fish, eggs laid directly on the bottom begin to die when the fine layer reaches 0.5 mm (reducing the exchange of gases and metabolic waste) and reaches total mortality at 2.0 mm. Hatching success is greatest on clean gravel or sand substrates (NMFS 2006).[51]
- Atlantic herring have adhesive egg masses requiring a stable substrate (NMFS 2006).[52] They are better able to attach to clean substrate such as recently overturned scallop shells, gravel and sand. Rigidity, smooth texture, and the absence of sediment are important components of suitable substrates (Lassuy 1989).[53]

Broad Scale Impacts

In the NEFMC documents, there is innuendo, but no hard data, on the impacts, whether positive or negative, that are being caused by mobile gear in the NW Atlantic. There is no analysis of whether the ocean bottom has become more productive or less, after over 100 years of bottom gear working on most of the accessible bottom on the shelf. Similarly, there is no broad impact analysis documenting what mobile gear does to fisheries productivity. Many authors have tried to document damage, and do so when writing about changes at the biological level immediately before and after gear disturbs an area (and sometimes for suitably long periods), or in comparing fished and non-fished sites. Nevertheless, the required evaluation at the fisheries level has not been done. Only several Dutch authors (e.g., Rijnsdorp, de Veen, Vingerhoed and several others) are known to have addressed this rigorously, showing that after decades of beam trawling in the North Sea, flounder production has not been harmed and has actually improved. For example, "significant correlations were only found with fishing effort and with indices of the disturbance of bottom layers by active gears. Additional evidence points to the possibility that the amount of beam-trawling with chains has a positive effect on the growth rate and on other biological parameters of the sole"(de Veen 1996).[54] Such a macro analysis of the NW Atlantic, or of any of its areas, has not been done. Without it, the micro studies are merely interesting and, as FAO fears, subject to misinterpretation and misuse by special interest groups. In light of the Dutch findings, determination of fisheries level effects should be of paramount importance.

Council documents omit or ignore important broad scale impacts

The NEFMC documents, and virtually all the citations that underpin them, focus on changes to habitat, implying that change is, perforce, bad. The studies cited in the documents, as well as some more recent ones, usually note how the disturbances lead to fewer large plants and animals and that it takes some amount of time for recovery to an unfished state to occur, depending on various factors. When positive effects are mentioned, such as inordinately large recruitment of yellowtail flounder in dredged areas of the NY Bight (Sullivan et al. 2003)[55], they are not further investigated, leaving the impression that the sea floor is damaged and for long periods of time. Just as a New England cornfield that was perhaps first developed by Native Americans is different than the virgin forest it replaced, it is important to consider whether continued tilling of that field remains productive for society. Very few studies have considered this concept, other than to attack the notion (e.g., Sheppard 2006)[56], and none are included in Council documents. Clearly, there may be a greater diversity of species in a complex unfished habitat bordering a fishing ground, but the fishing ground is more productive in meeting societal needs for food.

The fact that mobile gear may change the structure and performance of the low energy bottom is not bad, in itself, even though the bottom is different. Of course, in areas of strong natural disturbances, there is little change, and most literature supports this view as (e.g., Stokesbury and Harris, 2006)[57] and other examples above. The change to a more opportunistic ecology, through natural processes or fishing, including smaller, faster growing species, benefits some of the inhabitants and injures others. Most importantly, the research is clear that the beneficiaries are those under the primary responsibility of this Council, such as flounders, haddock, and young cod, that either feed directly on the opportunistic organisms that quickly colonize the disturbed area, or eat the fish that do. If longer term research were to be done, it would likely be found that spat of bivalves requiring initial attachment points (e.g., clams, quahogs, and scallops) have also settled and found clean gravel and shell surfaces for their required initial attachment. Further research would also likely show a greater abundance of herring eggs (and other bottom-setting eggs) on recently fished bottom because they also had been placed on clean substrate to which they could adhere and that would help oxygenate the eggs and remove wastes.

The vulnerability to scallop dredging for EFH for the life stages of some species (e.g., juvenile Atlantic cod) is rated as high. To the extent this rating is caused by the reduction in epifauna and other hiding places, this may not be correct, as it is likely more than offset by increasing prey and making it more visible to cod in the fished areas.

Need to consider effects of dredging on productivity

Of particular importance is the need to step back and consider whether areas that have been fished heavily by trawls and dredges are still productive after decades of heavy fishing. This will provide insight as to whether the frequently cited benthos impact studies are valid or not as information sources for managing fisheries at their optimum yield. The Dutch studies (Rijnsdorp and several others) cited above studied the beam trawl fishery in the North Sea. The gear is towed at 6 knots, two per vessel, and each measures 12 meters wide. This gear, meant to catch flounders and other bottom fish, digs so deep that it leaves scars in the shells of ocean quahogs (*Artica islandica*) and counts of these scars were used as a measure of trawling frequency in a given area. These authors see no negative impact on productivity: "*The data collected so far do suggest that the claim by Rauck (1985)*[58] *that beam trawling has a detrimental effect on the benthos is untenable. The areas of intensive beam trawling shown in the present study, have already been trawled intensively for several years and still provide profitable fishing grounds. Without ample benthic food for plaice and sole, these fishing grounds would have lost their profitability for fishing*"(Rijnsdorp et al. 1998).[59] Later studies (cited above) showed there was an increase in production and postulated the mechanisms.

Stokesbury et al. (2004)[60] show that recruitment has fallen in areas set aside as a conservation measure. They suggest it is caused in some way by the presence of large quantities of mature scallops, which had set prior to closure. We believe it is far more likely that reduced recruitment is due to the closure itself, allowing the fishing grounds to be covered with a fine film that is inimical to all settling larvae, whether scallops, flounder, polychaetes, or other bottom dwellers. Under the hypothesis presented in this paper, and supported by the literature, fisheries production should rise immediately following dredging due to scavenging and predation on exposed prey. If dredging occurs when there are larvae (of all types) in the water column ready to set, the production will continue without interruption. If dredging occurs in the winter, the bottom will remain suitable for setting for the spring and perhaps summer larvae. Bivalve recruitment to market size should begin to rise in the third year after fishing begins in opened areas. On the other hand, in newly closed areas, small sizes (sub market) of bivalves should be less prevalent beginning about two years after fishing ceases, although established animals will continue to increase in biomass until they begin to atrophy or die of old age, or natural predators move in, eventually leading to mass mortality as documented by Stokesbury (2007).[61] The cyclical nature of scallop recruitment noted by Stokesbury is likely not just due to the size of the breeding stock and environmental conditions, but also whether there is too much predation on eggs and larvae such as by jellyfish and filter feeding fish, and whether there is suitable habitat for larvae settlement.

Failure to account for the narrow bands of fished areas relative to total area

The Council documents and scientific studies also offer little recognition that even in the most heavily fished areas, there are de facto mini-sanctuaries. These areas remain lightly or non disturbed because of boulders, ledges, mud, shipping lanes, or shipwrecks. Further, if one looks at log books and aggregates that data to determine how often a zone (ICES 30x30 mile grid) was fished, the result (as computed by Rauck (1985) [62]) can be interpreted to show that the zone was fished 5 to 7 times per year – leading to an immediate call for action. However, a more detailed analysis (e.g., based on automated position logs as is now possible with GPS or VMS) can find that an individual plot of bottom in that same zone may have a small chance of being fished in a year. "*We also estimated the trawling frequency for the eight most heavily fished ICES rectangles where fishing was not restricted by closed areas. This analysis showed that 47–71% (mean=62%) of the surface area was trawled 1–5 times per year; 9–44% (mean=29%) was trawled less than once every year, and 0–4% (mean=1%) was trawled between 10–50 times a year*." Because of unfishable areas, "*within the most heavily trawled ICES rectangles, on average 15% of the surface area is trawled less than once a year, and 4% is estimated to be trawled less than once in every 5 years*", making it possible for representatives of the most sensitive organisms to remain in any area (Rijnsdorp et al. 1998).[63] This study shows that detailed approaches to establishing fishing coverage is required and that coverage is less homogeneous than often thought. This leaves mini-sanctuaries throughout even heavily fished areas.

Trawled areas can remain productive over the long-run

Even in the heavily fished areas, the most detailed studies of the impacts of gear with a heavy "footprint" show no negative long-term effects on key measures of productivity. The de Veen (1976) paper states "*Biological parameters such as length and weight-at-age, fecundity and length at first maturation, derived from market sampling in Dutch ports, showed significant changes in the period under observation 1957–1973. An attempt was made to correlate these changes with environmental factors such as the density of the sole stock, temperature in the growth-season, eutrophication, and fishing effort. Of these factors significant correlations were only found with fishing effort and with indices of the disturbance of bottom layers by active gears. Additional evidence points to the possibility that the amount of beam-trawling with chains has a positive effect on the growth rate and on other biological parameters of the sole.*"[64]

Inappropriate tools and methods are often used to measure productivity

Virtually all the studies make a mistake in measuring productivity. The studies generally find that the disturbed area has far fewer species and abundances than other areas, but they only look at part of the seabed community. Many compare what comes up in the sampling dredge or coring device from fished and unfished areas and then make generalizations (e.g. Collie et al. 1997[65]; Hermsen et al. 2003[66]; Jennings et al. 2001[67]; and Watling et al. 2001.)[68] Since the disturbed areas lead to higher colonization by opportunistic species, and there is much less shelter for them, they are likely eaten by a variety of animals such as flounders, haddock, and young cod. They will not appear in a sampling dredge. Newly settling larvae of bivalves and flounders also will not be detected (less than 1 mm) until growth makes them visible to sampling or fishing equipment, several months or years later. If a study does not consider these aspects when documenting productivity, it is missing the true impact. For example, the Jennings et al., 2001[69] study found that productivity was lower in fished areas because they only used a Naturalists' dredge, and thus missed the productivity that was captured by the flounders in the same areas of the North Sea that was documented by Rijnsdorp and other Dutch authors cited above. Not knowing the cause of the fisheries level production increase, they suggested it was due to climate change, but they had actually used an inappropriate sampling tool. These studies should be removed from NEFMC documents wherever they are used to show changes in productivity. They include Collie et al. (1997) and Hermsen et al. (2003) that use data from the 1994 Collie cruise (and similar later cruises) and Jennings et al. (2001) (and probably others of Jennings). The study by Watling et al. (2001) used a coring tool rather than a sampling dredge, but they too did not come back after the initial year and did not sample the fish (Watling et al. 2001) [70]. There may be other studies like these.

Further, none of the studies compare the productivity of the area over time quantitatively, from the moment of disturbance with its influx of scavengers and predators, to the increased clean substrate ready for the deposition of larvae of all benthos creatures, to their contribution to the diet of fishes, crabs, and lobsters, and then to the conversion to an undisturbed state. It is a very rare study that comes back more than a few months later to determine what is happening, and rarer still that shellfish and fish abundance and stomach contents in the area are analyzed over suitable time periods (years). Those studies that do look at stomach content have not quantified the fish present, or taken from, the fished area. If the study area is disturbed some time before or while larvae of all types are settling, these new inhabitants are less likely to find themselves in one mm or much more of fine silt or detritus that can clog their gills or smother them. None of the papers studied have taken this into account, yet it may be a key factor affecting the variability in recruitment noted in many papers, by other scientists, and by fishermen.

Some studies use sampling dredges to derive quantitative estimates of abundances in the different locations (e.g., Collie et al. series). However, the one detailed study of sampling dredges found that catching variability was so high among the 4 tested dredge types and even with the same type of dredge (including the Naturalists' dredge), that quantification was inappropriate and inferences should be limited to qualitative observations (Elliot and Drake 1981).[71] When authors using these dredges go on to show that productivity in unfished areas is higher, they have extended their projection beyond the capability of their sampling method. The sampling gear, such as the Naturalists' dredge used by Collie et al., sample the top few inches of the bottom and the epifauna. This type of dredge does not capture cod, or even flounder, unless accidentally, and if it doesn't come back to the same area for the next 3 seasons, it will not capture the settlement (and growout) of large bivalves in the clean substrate. Further, since there are few places to hide in the frequently dredged areas, the number of species and their amounts is usually (not always) lower. This is viewed as a bad thing. In fact, it is far more likely that there are fewer observed organisms in fished areas because it is more difficult to hide in the open. The many larval forms that are attracted to the dredged areas feed on each other, as well as the plant forms responding to the release of buried nutrients, eventually being consumed by flounders and other fish and …..humans. Thus the many organisms that are produced are converted into the body mass of a lower number of large fish and shellfish. It is likely fished areas are more productive because they are being fished steadily, as was found by Rijnsdorp et al.

These concepts are rare in the literature outside of the Dutch scientists (Rijnsdorp et al.) studying flounders and beam trawls. It requires a broader perspective so we can check credibility by seeing the forest before us, rather than the individual trees. We suggest that the Council discuss these matters and certainly add the Dutch papers. Jennings (above) used flawed methodology (the Naturalists' dredge without fish assessment) to discredit these studies. These studies should be integrated into the NEFMC documents, and highlighted, as they are the only ones to take the macro view needed for resource management.

The closest Amendment 13 SEIS gets to this concept is to include the text we copied to an endnote, noting the change to a more opportunistic structure, but implying this is a negative impact (NEFMC 2003)[72]. Only a detailed study that looks at area-wide production can ascertain whether the observed changes to a more opportunistic structure, combined with an area more suited for larval settlement of all types, leads to more fisheries production or less. Much is made of the observations that there are more numerous and diverse species in unfished areas and then this is interpreted as meaning these areas are more productive. The opposite is likely true, as it is also usually noted that such areas provide hiding places that protect these diverse creatures. When everything can hide and fewer are available for food, it is true that these animals will be more numerous and grow larger. Because these species are not eaten, they are not contributing to the productivity of the area as much as those fully experiencing the great cycle of life in the more open areas, as do wildebeest in the Serengeti. The fact that the fished areas have fewer and less diverse species may well be because all are finding food more easily and themselves are then eaten (or caught). Because the scavengers and predators (many of which form the basis of our fisheries) roam widely over fished and unfished areas, only broad-scale studies at the basin level can get at the true impacts. When an argument is made that a juvenile cod can hide from predators in an area of high relief, we must consider that the converse is also true. Juvenile cod have low energy reserves and must be able to find food consistently. There is also the need to consider the higher levels of a diverse group of young of the year cod predators on complex bottom.

Research Suggestions

It is difficult to get research funded in any field when the findings may not be newsworthy or of direct application to the funder. We believe resource managers need information from the following work as soon as possible to enable an ecosystem approach to scallop management in the NW Atlantic. This work is also important for demersal fish management. We suggest the work be funded as soon as worthwhile proposals are received.

1. Development of a research protocol for studies of mobile gear impact on the benthos. The protocol should provide that studies: (1) sample infauna to about 25 cm (10 in.) to capture deep burrowers such as surf clams and ocean quahogs; (2) sample infauna and above bottom species such as fish at the same time and place (e.g., a Naturalists' dredge on one side rig (outrigger) and a sufficiently large otter or beam trawl on the other, and (3) repeat coverage for appropriate intervals up to 3 years, to measure changes including larvae settlement/spatfall in the dredged areas and subsequent growout to detectable or market sizes (e.g., quahogs, clams, flounders, and scallops).

2. Determine fisheries impact over the long term for various fished areas in the manner of Rijnsdorp et al., while accounting for past overfishing and regulatory measures.

3. Determine areas best set aside as sanctuaries, to protect sensitive areas, based on specific evidence of biological and physical characteristics, and with benefit/cost information for doing so.

4. Langton and Robinson (1990), using a submersible, noted that piles of rock and scallop shells were apparently deposited after catches in dredges were sorted.[73] Also, some studies (including two of Collie) note, as if it were fact, that fishermen remove boulders from the fishing grounds, as do farmers from their fields (e.g., Collie et al. 1997, 2000)[74]. Where do these rocks get dumped? What is the norm for scallopers when sorting their catch? Do they return debris as it is culled or do they wait until the end of sorting before dumping? What happens to dumped material? Does it form mini reefs?. What is their ecological significance? Are there guidelines that might be helpful for improving fishing efficiencies or habitat productivity?

5. What is the best timing for scallop dredging relative to larval settlement of desirable species? Often, conventional wisdom is to not fish during reproductive seasons, but if the sea floor is to be made ready for the seed, it should happen just before or during settlement. For example, in a multi-year study of polychaete (several species) recolonization after clam digging and other disturbances, Levin found that "the timing of disturbance must coincide with periods of peak larval availability for successful colonization by these species. In general, the annual life cycles and flexible small-scale mobilities of most species enable persistence in the face of frequent fine-grained disturbance" (Levin 1984).[75] The experience of quahog dredging in Fairhaven indicates that the bottom is maintained ready for seed for weeks or even months after fishing takes place. A study by Watling et al. (2001) found that fine surficial sediments took several months to return after dredging in an area without much mixing.[76]

6. There is considerable concern expressed in the NEFMC documents over both bycatch and young scallops being killed by prolonged time on deck, particularly during times of good fishing and hot days. Are there reasonable ways for vessel crews to reduce the catch's exposure to heat and rain? What are present practices? Perhaps there could be development of guidelines for using ameliorative measures, such as hosing down the catch and suspending a tarp over the deck, protecting both crew and catch from the sun and rain, which reduces salt in fish/shellfish gills and stops respiration. It may be that this has been discussed *ad nauseum*, but it is not evident.

Note: the detailed section on the review of citation accuracy is an attachment. It follows the references.

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Attachment

Report on accuracy of scientific citations in recent FMP/EIS/EFH documents

This section deals only with the accuracy with which cited materials reflect the referenced documents. There are significant problems in some of the cited works. These are addressed in the main body of this report and in the letter of Mr. Ron Smolowitz, referenced and provided below.

Documents examined:

1. Atlantic Sea Scallop Fishery Management Plan (SSFMP) Final Amendment 10 with a Supplemental Environmental Impact Statement, Regulatory Impact Review, and Regulatory Flexibility Analysis, December 2003;
2. SSFMP Final Amendment 11 including a Final Supplemental Environmental Impact Statement FSEIS) and Initial Regulatory Flexibility Analysis (IRFA), September 2007;
3. SSFMP Amendment 13 and Public Hearing Document including an Initial Regulatory Flexibility Analysis, July, 2007;
4. SSFMP Framework Adjustment 16 and Framework Adjustment 39 to the Northeast Multispecies FMP with an Environmental Assessment, Regulatory Impact Review, and Regulatory Flexibility Analysis, July 2004; and
5. SSFMP Framework 19 including an Environmental Assessment, an Initial Regulatory Flexibility Analysis and Stock Assessment and Fishery Evaluation (SAFE) Report, November 2007 (not completely finalized).
6. SSFMP Framework 20 including an Initial Regulatory Flexibility Analysis, July 2007;
7. Essential Fish Habitat Omnibus Amendment 2, Draft Supplemental Environmental Impact Statement (DSEIS), March 2007;
8. 2005 Stock Assessment and Fishery Evaluation (SAFE) Report and Framework Adjustment 18;
9. Final Amendment 13 to the Northeast Multispecies Fishery Management Plan Including a Final Supplemental Environmental Impact Statement and an Initial Regulatory Flexibility Analysis, December 2003;

In addition, a letter from Mr. Ron Smolowitz to Mr. Louis Chiarella, NMFS Northeast Regional Office, dated March 2, 2001, and a report entitled "The Seabed Impacts of Scalloping: the Scientific Evidence" prepared by Trevor Kenchington for the Fisheries Survival Fund in May 2000 were also examined. Documents were examined by inspection/reading and, separately, by searching for the words "effect" and "impact" to ensure nothing was missed in the hundreds of pages of text.

Results:

1. **Final Amendment 10 to the Atlantic Sea Scallop FMP**
   http://www.nefmc.org/scallops/planamen/a10/final_amend_10.htm

The primary intent of Amendment 10 is to introduce spatial management of adult scallops, to identify and describe adverse effects of fishing on EFH, and to minimize to the extent practicable these adverse effects. Much, if not all, of the text pertaining to the impact of scallop dredging on the EFH of various species is identical to that included in Final Amendment 13 to the Northeast Multispecies FMP. Consequently, many of the comments (below) for that document are applicable here.

2. Final Amendment 11 to Atlantic Sea Scallop FMP
http://www.nefmc.org/scallops/planamen/a11/final_amendment11.htm

Very little is said in this document about the impacts of dredging. Section 4.2.2, Essential Fish Habitat / Biological Environment (pp. 90-112), which describes the physical and biological environment of the area, is one of the few parts of the document containing "scientific" results with literature citations. Nothing in this part pertains to dredging impacts. Section 4.3, Protected Resources (pp. 112-116), contains information about the potential of turtle bycatch in scallop dredges, but mainly reports on observed catches (with several literature citations) with no interpretive comments warranting examination of the scientific papers cited. Section 5.1.1.2.6, Measures to reduce incentive for limited entry qualifiers to fish for scallops with trawl gear (pp. 185-190), within Section 5, Environmental Impacts, contains some text on scallop bycatch, but this is quite straightforward and, in our opinion, not controversial or subject to alternate interpretation. There are literally no other sections of the document that contain literature citations in support of any statements.

3. Amendment 13 to the Atlantic Sea Scallop FMP and Public Hearing Document
Including an Initial Regulatory Flexibility Analysis
http://www.nefmc.org/scallops/planamen/a13/A13_Submission_070307.pdf

This amendment deals mainly with observer coverage. There are no citations of interest to this review.

4. Framework Adjustment 16 to the Atlantic Sea Scallop FMP
http://www.nefmc.org/scallops/frame/frame_16.html

Framework Adjustment 16 was developed as an addition to Amendment 10 to address and implement scallop area management in parts of the groundfish closed areas. Virtually the only section of the document with cited literature references was that on habitat. The review of the effect of fishing on habitat is the same as in Final Amendment 10, with the same conclusions: much, if not all, of the text pertaining to the impact of scallop dredging on the EFH of various species is identical to that included in Final Amendment 13 to the Northeast Multispecies FMP. Consequently, many of the comments (below) for that document are applicable here and there were no further references requiring checking for validity.

5. Framework 19 to the Atlantic Sea Scallop FMP
http://www.nefmc.org/scallops/cte_mtg_docs/oversight/3_Oct_FW19_draft_octCmte.pdf

This framework adjustment addresses fishery specifications for FY2008 and 2009 and area rotation adjustments (if necessary), but is still in the development process. Consequently, many sections are incomplete. There are no literature citations in the present document.

6. Framework 20 to the Atlantic Sea Scallop FMP
http://www.nefmc.org/scallops/frame/fw20/FW20_Final_submission.pdf

This is a relatively short document (17 pp.) and nothing was found warranting further examination. There was basically no scientific section and no literature citations are given in the document.

7. EFH Omnibus Amendment 2, Draft SEIS
http://www.nefmc.org/habitat/planamen/draft_DEIS_final.html

In Section 4, Management Alternatives Under Consideration (pp. 61-849), there are extensive sets of descriptions of the habitat for eggs, larvae, juveniles, adults, and spawning adults for various alternatives, as well as associated charts. No literature citations were presented with any of this information. In Section 6.1.2, Biological Environment (pp. 1005-1064), there is an extensive description of the biological environment, much of which is a duplication of the text contained in Final Amendment 11. Most of the references cited in Final Amendment 11 are included, as well as many more. However, there is virtually nothing on sea scallops or scallop dredging. In Section 7.2.1, Impacts on Biological and Physical Environment, within Section 7.2, Alternatives to Designate Habitat Areas of Particular Concern, there are only general statements about the impact of towed bottom-tending gear, including scallop dredges, none of which are viewed as disputable. The scientific statements and associated literature citations in the section on Georges Bank cod HAPC (contained in various places within pp. 1228-1351) are the same as those commented on by Ron Smolowitz in his 2001 letter, which are still relevant. His comments raise specific problems with citations of several source documents, showing that important parts were misinterpreted and also that there were significant problems within some source documents. Because of its importance, a copy has been placed at
http://www.oceanassoc.com/OAIhome_files/OAI_data/EFH_Comment_letter_Smolowitz.doc

8. 2005 Stock Assessment and Fishery Evaluation (SAFE) Report and Framework Adjustment 18
http://www.nefmc.org/scallops/frame/frame_18.html

There are no literature citations in support of any statements that require review of the source.

9. Final Amendment 13 to the Northeast Multispecies FMP
http://www.nefmc.org/nemulti/planamen/amend13_dec03.htm

VOLUME I – MANAGEMENT ALTERNATIVES AND IMPACTS

Table 15 on page 93 of Section 3.7 contains the following statement describing an area on the Northern Edge of Georges Bank: "*This area is primarily sand and gravelly sand. About half of this relatively small access area is deep undisturbed bottom with a high cover of emergent epifauna (Collie et al., 2000).* The statement is correct, but the citation should be Collie *et al.*, 1996).

The following italicized paragraphs, found on pp. 94-95 and on pp. 452-453, are "boilerplate" text used repeatedly when describing impacts of trawling and/or dredging on bottom habitat or justifying habitat closed areas; they are also found in various other NEFMC Multispecies and Essential Fish Habitat documents.

"Several sources document the importance of gravel/cobble substrate to the survival of newly settled juvenile cod (Lough et al. 1989; Valentine and Lough 1991; Gotceitas and Brown 1993; Tupper and Boutilier 1995; Valentine and Schmuck 1995). A substrate of gravel or cobble allows sufficient space for newly settled juvenile cod to find shelter and avoid predation (Lough et al. 1989; Valentine and Lough 1991; Gotceitas and Brown 1993; Tupper and Boutilier 1995; Valentine and Schmuck 1995). Particular life history stages or transitions are sometimes considered "ecological bottlenecks" if there are extremely high levels of mortality associated with the life history stage or transition. Extremely high mortality rates attendant to post-settlement juvenile cod are attributed to high levels of predation (Tupper and Boutilier 1995). Increasing the availability of suitable habitat for post-settlement juvenile cod could ease the bottleneck, increasing juvenile survivorship and recruitment into the fishery. For these reasons, areas with a gravel/cobble substrate meet the first criterion for habitat areas of particular concern.

Specific areas on the northern edge of Georges Bank have been extensively studied and identified as important areas for the survival of juvenile cod (Lough et al. 1989; Valentine and Lough 1991; Valentine and Schmuck 1995). These studies provide reliable information on the location of the areas most important to juvenile cod and the type of substrate found in those areas. These areas have also been studied to determine the effects of bottom fishing on the benthic megafauna (Collie et al. 1996; Collie et al. 1997). Gravel/cobble substrates not subject to fishing pressure support thick colonies of emergent epifauna, but bottom fishing, especially scallop dredging, reduces habitat complexity and removes much of the emergent epifauna (Collie et al. 1996; Collie et al. 1997). Acknowledging that a single tow of a dredge across pristine habitat will have few long-term effects, Collie et al. (1997) focus on the cumulative effects and intensity of trawling and dredging as responsible for potential long-term changes in benthic communities. For these reasons, the identified area on the northern edge of Georges Bank meets the second criterion, as well as the cumulative effects consideration, for designation as a habitat area of particular concern. Collie et al. (1997) also describe the relative abundance of several other species such as shrimps, polychaetes, brittle stars, and mussels in the undisturbed sites. These species are found in association with the emergent epifauna (bryozoans, *hydroids, worm tubes) prevalent in the undisturbed areas. Several studies of the food habits of juvenile cod identify these associated species as important prey items (Hacunda 1981; Lilly and Parsons 1991; Witman and Sebens 1992; Casas and Paz 1994; NEFSC 1998). These areas provide two important ecological functions for post-settlement juvenile cod relative to other areas: increased survivability and readily available prey. These areas are also particularly vulnerable to adverse impacts from mobile fishing gear."*

Ronald Smolowitz, in his letter to Mr. Louis Chiarella, NMFS Northeast Regional Office, dated March 2, 2001, raises questions on statements attributed to some of the literature citations given (e.g., Lough et al, 1989; Valentine and Lough, 1991; Gotceitas and Brown, 1993; Tupper and Boutilier, 1995; Valentine and Schmuck, 1995). These references are used in other papers to also show that cod are associated with the gravel substrate. As this document shows, cod may be in these areas to feed on opportunistic species associated with the passage of mobile gear or with a dynamic environment that leaves a clean substrate, devoid of the veneer of fine detritus and silt that can clog breathing apparati or smother settling larvae. The comments remain valid.

Our analysis did, however, examine the two papers by Collie *et al.* (1996 and 1997) pertaining to the impacts of scallop dredging and bottom trawling on benthic organisms on Georges Bank. After cross checking the above text with the two papers, it is concluded that the text accurately reflects what is reported in the two papers.

However, we think it is inappropriate use the term "bottleneck" with respect to cod habitat. The true "bottleneck" for cod production is not the amount of habitat available to young (or older) cod. In prior decades scallop dredging and bottom trawling were both very high, and so were cod stocks. The true bottleneck is in the mortality at the egg and pre-settlement stages, with cod egg mortality alone averaging 22%/day[2]. By the time the young cod settle on the bottom, their cohort abundance has decreased some 4-5 orders of magnitude with a mortality rate of 6-8%/day[3]. Post settlement mortality is much lower than this.

Section 5.3.4.5.3, US/Canada Resource Sharing Understanding (Selected), contains the following paragraph on page 453 which cites Collie *et al.* (2000):

"*Collie et al. (2000), in a follow-up publication, analyzed video images and still photographs recorded at five of the six study sites surveyed in the two 1994 research cruises to George Bank. In the videotapes, the U sites at both depths had slightly coarser sediments (higher frequency of pebble -gravel than sandgravel); in the still photos, there was a higher frequency of sand and cobble in U sites and a lower frequency of pebbles. Bottom photos showed a high percent cover of colonial hydroids and bryozoans at one of the deep U sites and of the rock-encrusting polychaete, Filograna implexa, at both deep U sites. In contrast, at the D sites the gravel was free of epifaunal cover and few animals were visible. Statistical analysis confirmed that the U sites had a significantly higher percent cover of Filograna implexa. However, cover provided by this species was also significantly greater in deeper water than in shallow water. Emergent hydroids and bryozoans were significantly more abundant in the deep U sites, but less abundant*

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[2] N. Daan, *Rapp. P.-v. Reun. Cons. Int. Explor. Mer* **178**, 242 (1981).
[3] R. G. Lough, in *The Propagation of Cod Gadus morhua L.,* E. Dahl, D. S. Danielssen, E. Moksness, P. Solemdal, Eds. *Flodevigen rapportser* **1**, 395-434 (1984).

at the shallow U site. Significant differences between the disturbed and undisturbed sites were noted. However, overall, the percent cover of all emergent epifauna was significantly higher at the deep sites, but there was no significant disturbance effect. It was clear from this study that depth appeared to be just as important as disturbance."

Upon examination of both the above text and the Collie *et al.* (2000) paper, it is clear that Collie *et al.* 1966 is that paper that should be cited. Collie *et al.* (2000) is a paper that provides a quantitative analysis of fishing impacts on bottom benthic organisms based on 57 different observations of the effects of fishing disturbance on benthic fauna and communities extracted from 39 separate publications. It does not provide the information on Georges Bank that is summarized in the above paragraph.

Section 5.3.6.1.2, Year-round Closed Areas, contains the following paragraph on page 462 which cites Collie *et al.* (1997):

"Collie et al. (1997) sampled two shallow (42-47 m) and four deep (80-90 m) gravel sites in U.S. and Canadian waters on eastern Georges Bank during two cruises in 1994 that were classified as disturbed (D) or undisturbed (U) by bottom-tending mobile gear based on the number of dredge and trawl tracks in side-scan sonar images, the presence or absence of large boulders and epifauna in bottom photographs, and 1993 records of scallop dredging effort in ten minute squares of latitude and longitude in U.S. waters on the bank. There were three U sites and one D site in deep water and one U and one D site in shallow water. Bottom substrates were predominantly pebble/cobble with or without encrusting organisms, with some overlying sand. Quantitative samples of epibenthic organisms (>10 mm) were collected with a 1 m wide Naturalists' dredge fitted with a 6.4 mm square mesh liner. Organisms such as colonial sponges, bryozoans, hydroids, and the tube-dwelling polychaete Filograna implexa that were not quantitatively sampled by the dredge were excluded from analysis."

Examination of the above text and the Collie *et al.* (1997) paper indicates that the more appropriate citation for the text should be Collie *et al.* (1996). The 1997 paper provides further analysis of the original sampling initially described in the 1996 paper. While the statements made in the above paragraph are supported in the references, the citation of the incorrect paper implies some degree of sloppiness on the part of those preparing this text. This infers the drafters may not have reviewed the original literature and instead borrowed text from other authors, writing for other purposes. The same applies to the incorrect citation, mentioned earlier, of Collie *et al.* (2000).

However, there are two issues of greater importance. The first is the final sentence of the above extract, which states that items not quantitatively sampled by the Naturalists' dredge were excluded from analysis. According to the only thorough examination of the catching efficiency of the Naturalists' dredge, the dredge should not be used for quantitative analysis at all because it is unable to accurately sample its intended targets.[4] Secondly, much of the literature points out

[4] J. M. Elliott, C. M. Drake (1981). A comparative study of four dredges used for sampling benthic macroinvertebrates in rivers. Freshwater Biology 11 (3), 245–261. doi:10.1111/j.1365-2427.1981.tb01258.x.

that scallops often dominate their locale and that scallopers fish where the scallops are abundant. The Collie et al. Georges Bank papers likely compared dissimilar habitats in alleging scallop impacts and have been challenged by Stokesbury and Harris (2006): "These studies may have compared different benthic communities, as the sea scallop is strongly associated with sand/granule/pebble substrates, and is the dominant macroinvertebrate in these substrates on Georges Bank but was rare at the control sites in the studies of Collie et al. (1997) and Collie & Escanero (2000), as indicated by the low fishing effort."[5] Thus, it is recommended that these papers be removed from Council documents because they have used inappropriate tools for their analyses and the control areas are likely physically and biologically dissimilar to the dredged areas. They should be replaced by the more robust work of Stokesbury and Harris (2006).

VOLUME II -- DESCRIPTION OF THE RESOURCE AND THE AFFECTED ENVIRONMENT

Section 9.3.1.2.4.1, Overview of Existing Information, within Section 9.3, Habitat Considerations, contains a summary (pp. 1218-1219) of the conclusions reached by a number of authors who reviewed existing scientific literature on the effects of fishing on habitat (Auster *et al.*, 1996; Cappo *et al.*, 1998; Collie, 1998; Jennings and Kaiser, 1998; Rogers *et al.*, 1998; Auster and Langton, 1999; Hall, 1999; Collie *et al.*, 2000; Lindeboom and de Groot, 2000; Barnette, 2001; and National Research Council, 2002. That summary is extracted from a recent NOAA report (Johnson, 2002). This again infers the drafters may not have reviewed the original literature and instead borrowed text from other authors, writing for other purposes, such as to document the harm of dredging rather than to also present the benefits, so that the Council members would be appropriately informed when making decisions.

The statements made in this summary are fairly general, reflect research or observations throughout the world, are descriptive of impacts to substrate and organisms, and do not identify or make recommendations for the closure of any specific areas. Consequently, this review saw no need to investigate each individual reference to ascertain the accuracy or validity with which Council documents reflect the underlying references, with the exception of those noted in the Smolowitz letter. However, several of these references were among the dozens reviewed as part of the overall evaluation of the literature. While there are no significant misrepresentations of these specific references, most of the research is not particularly suited for use in EFH decision making and some is inappropriate, as noted above and in the main part of this report.

In two sub-sections on New Bedford Scallop Dredges – Sand and New Bedford Scallop Dredges – Mixed Substrates, respectively, within Section 9.3.1.2.4.2, Review of Fishing Gear Effects Literature Relevant to the U.S. Northeast Region, pp. 1236-1238, six literature citations are given for studies on scallop dredge impacts on these two substrates (three citations each). These citations are Auster *et al.* (1996), Langton and Robinson (1990), and Watling *et al.* (2001) for impacts on sand, and Caddy (1968), Caddy (1973), and Mayer *et al.* (1991) on mixed substrates. Of the three on sand, the first two pertained to offshore banks in the Gulf of Maine and the last

[5] Stokesbury, K.D.E., and B.P. Harris, 2006 Impact of a limited fishery for sea scallop, *Placopecten magellanicus*, on the epibenthic community of Georges Bank closed areas, Mar. Ecol. Prog. Ser. 307:85-100**.**

was conducted in an estuary on the coast of Maine (not a scallop area). Of the three on mixed substrates, the first two were done in Canadian waters in the Gulf of St. Lawrence 30-40 years ago, and the last was done along the coast of Maine. The physical and biological effects reported for each of these six studies were straightforward and descriptive and reflect the findings in the documents from which they were taken. However, as noted in the main report, movement of sand, shells, rocks, surficial sediment and algae is inferred to be bad. However, it may be key to the continued productivity of fishing grounds for several fisheries.

Note: three of these studies were not even on commercial scallop grounds.

In Section 9.3.1.5, Species-specific Vulnerability Tables, information is presented (Tables 406-447, pp. 1248-1301) on the vulnerability of the EFH of 42 species to bottom-tending fishing gear, including sea scallop dredges, together with a rationale for the determinations. In Table 411 on Atlantic Sea Scallop EFH (p. 1257) the rationale paragraph, with a citation of Packer *et al.* (1999a), concludes that there is little or no vulnerability of the various life stages of sea scallops to fishing gear impacts. The vulnerability to scallop dredging for the EFH for the life stages of some species (e.g., juvenile Atlantic cod) is rated as high. To the extent this rating is caused by the reduction in epifauna and other hiding places, this may not be correct, as it is likely more than offset by making prey more visible to cod in the fished areas.

Scientific documentation of continuing high fisheries productivity from the most active fishing grounds would seem to undermine these conclusions. Such work is not presented. The question should be asked why the areas with some of the highest fishing effort as taken from VMS data coincide with the highest level of juvenile cod in EFH documents.

VOLUME III – APPENDICES

Appendix IV contains the report of a Northeast Fisheries Science Center Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern US held in 2002 by the Northeast Region Essential Fish Habitat Steering Committee. The section on Scallop Dredges (pp. 15-21) summarizes discussion on effects and evidence, contains a conclusion, and suggests three main approaches to minimizing habitat impacts: effort reduction, gear modification, and area management. Various literature citations are given, most of which are the same as those frequently mentioned in the different Council documents. There is no reason to question any of the statements made in this report associated with particular literature references as they are similar or equivalent to those commented upon earlier, are basically general in nature, and represent the state of knowledge contained in the cited papers.

In summary, no major problems were found regarding citation validity in the review of Final Amendment 13 to the Northeast Multispecies FMP. The only point to make is that the authors of the document were sloppy in assigning the correct Collie *et al.* publication to the appropriate statements on the impact of mobile fishing gear on benthic fauna. However, issues regarding underlying documents, approach, or philosophy are discussed in the main section of this report dealing with a review of the research.

Recommendations (Citations Study):

The citations are broadly used in the reviewed documents. They raise the aura of suspicion, but none are cited as the source for alleged negative impacts to the environment or the living resources. No specific damages from dredging are cited in any Council documents we reviewed. We did not expect this. It is not clear whether or not this is a problem, but it is reasonable to expect that if a regulation goes into effect in order to accomplish a goal, and that regulation impinges on someone's welfare, there should be a well-documented basis for that action. This does not seem to be the case. There is a lack of specificity, and actions are justified by inference. The following quote from the EFH Amendment sums up this vagueness nicely:

"Uncertainty increases because the relationship between a fish's habitat and its productivity is only vaguely understood from a qualitative standpoint at this time – not by enough to predict how changing habitat will affect the productivity of target species… Scientific uncertainty about how habitat affects the productivity of fish populations, and data bases that were not designed to capture the spatial heterogeneities of asset attributes and fishermen's behavior constrain a description of the Affected Human Environment and any impact analyses of management alternatives that might be done in phase II."[6]

There seems to be a basis for requiring more specificity before taking actions that would have negative economic impacts. This is particularly true when a well-referenced report in Council documents (Collie et al. 2000) that looked at all available dredging impact studies contains this statement: "In summary, despite some suggestive patterns in the responses of number of individuals and species to fishing disturbance, none of the tests showed statistically significant effects. We suspect this lack of significance is largely due to the low statistical power, but it may also be that negative responses of some taxa are counteracted by positive responses of others".[7] It is interesting that the Council staff have not brought this point forward.

Secondly, we note considerable concern in the documents over both bycatch and young scallops being killed by prolonged time on deck, particularly during times of good fishing and hot days. We did not see in these documents any discussions of the vessel crews taking action to reduce the catch's exposure to heat and rain. This could easily be done by hosing down the catch and suspending a tarp over the deck, protecting both crew and catch from the sun and rain, which reduces salt in fish/shellfish gills and stops respiration. It may be that this has been discussed *ad nauseum*, but it is not evident.

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Résumés are at: http://www.OceanAssoc.com

[6] NEFMC. EFH Omnibus Amendment, Draft Supplemental EIS, March 2007. Available: http://www.nefmc.org/habitat/planamen/efh_amend_2/draft_sec_6b_DSEIS_final.pdf
[7] Collie JS, Hall SJ, Kaiser MJ, Poiner IR (2000) A quantitative analysis of fishing impacts on shelf-sea benthos. J Anim Ecol 69:785–798