#8

New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

July 23, 2008

Dr. John T. Everett, President
Ocean Associates
4007 N. Abington Street
Arlington, VA 22207

Dear Dr. Everett,

Thank for providing the Council with a revised copy of your paper, *Report on Mobile Fishing Gear Effects and Citation Validity in NEFMC Documents Affecting the Atlantic Sea Scallop Fishery.* The Council's Scientific and Statistical Committee (SSC) is scheduled to review the paper when it also reviews the Habitat Plan Development Team evaluations of fishing gear impacts on habitat. The SSC provides scientific advice to the Council on a variety of issues and the Council will consider the SSC's recommendations in developing actions to Essential Fish Habitat. The anticipated date for that meeting is October 6, 2008 and a meeting agenda will be posted on the Council's website, www.nefmc.org, before the meeting.

Please feel free to contact me if you have any questions.

Sincerely,

Paul J. Howard
Executive Director

cc: Council members

New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
John Pappalardo, *Chairman* | Paul J. Howard, *Executive Director*

April 8, 2008

Dr. John T. Everett, President
Ocean Associates, Inc.
4007 N. Abingdon Street
Arlington, VA 22207

Dear Dr. Everett,

Thank you for providing us with an advanced copy of your work. The Council continues to applaud the efforts of researchers who approach questions with direct applicability to the management of our marine fishery resources. As you noted in your letter, such direct applicability is not often present in the published literature.

The Council typically relies on published literature for use in supporting management decision analysis, but we have created avenues for pre-publication and grey literature review through the Research Steering Committee, the various Plan Development Teams, and the Scientific and Statistical Committee. I agree that the research you are presenting may be applicable to ongoing initiatives, most directly to the Omnibus Habitat Amendment. Over the next few weeks I will be working with the Council and staff to determine the most appropriate mechanism for review of this work.

Once we have determined our approach to the review, I will let you know to what extent we are able to take you up on your kind offer to assist in presenting your work.

Again, we appreciate your willingness to tackle research issues with direct management applications and to share your work with us.

Sincerely,

Paul J. Howard
Executive Director

Ocean Associates, Inc.

Ocean Associates, Inc.
4007 N. Abingdon Street
Arlington, Virginia USA 22207
http://www.OceanAssoc.com

Phone: 703-534-4032
Fax: 815-346-2574
Email: OceanAssociates@OceanAssoc.com

April 2, 2008

Paul J. Howard, Executive Director
New England Fisheries Management Council

Ref: Report On Mobile Fishing Gear Effects And Citation Validity In NEFMC Documents Affecting The Atlantic Sea Scallop Fishery

Dear Mr. Howard,

Transmitted herewith is a report with far reaching implications as to how mobile gear fisheries are managed. There were three report objectives. The first was to evaluate the accuracy of scientific citations in recent FMP/EIS/EFH documents prepared by the NEFMC relative to the actual scientific papers. Dr. Emory Anderson led this analysis. The problems we found are minor. Council staff did a credible job in assembling the documents.

The second objective was to ascertain the validity of studies about dredging impacts, particularly those included in Council documents. There are major problems with several studies that purport to measure productivity, but only assess what can be caught in sampling dredges or coring tools, missing all the fish and what the fish have eaten. The authors did not return sufficiently, nor did they compare against suitable controls. Several references and their implications should be replaced. This is not a problem with the Council staff, but rather with the available literature.

The third objective was to determine if the literature supports the hypothesis that dredging can cause increased productivity. When I left fishing to join NMFS, my father charged me with learning why dredging caused a bloom of quahog production in Fairhaven, MA. I found the answer several years ago and shared it with my NMFS colleagues and family, planning to write a paper some day. A cousin raised it with me a year ago, but with respect to sea scallops. I then proposed a study of my hypothesis to the Fisheries Survival Fund. The findings are integrated with the other elements of this report. In brief, dredging disturbs the sea floor removing the film of fine silt, algae, and detritus that suffocates and clogs the gills of setting bivalve, polychaetes, flounder, and other larvae, and can suffocate herring egg masses. This is the primary effect, but there are several others that can contribute to increasing productivity.

Sincerely,

John T. Everett

John T. Everett
President

Ocean Associates, Inc.

Ocean Associates, Inc.
4007 N. Abingdon Street
Arlington, Virginia USA 22207
http://www.OceanAssoc.com

Phone: 703-534-4032
Fax: 815-346-2574
Email: OceanAssociates@OceanAssoc.com

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

April 2, 2008

John T. Everett and Emory D. Anderson

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.

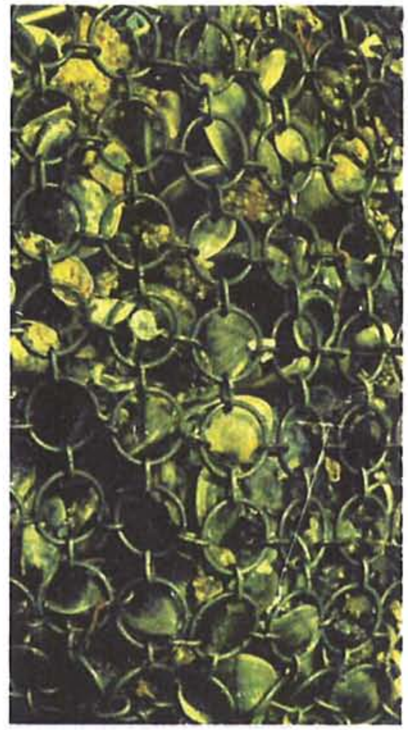

Figure 1. Full chain bag of littlenecks. Rings: 2" diameter

---

* 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.

References (In the order they appear in the text; repeated in full as they are used in order to facilitate verification and use)

.

[1] Kaiser, M. J., K. R. Clarke, H. Hinz, M. C. V. Austen, P. J. Somerfield. 2006. Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series 311, 1–14.

[2] Johnson, K. A. (2002). A review of national and international literature on the effects of fishing on benthic habitats. *NOAA Technical Memorandum*, NMFS-F/SPO(57). NOAA: Silver Spring, MD (USA). 72 pp.

[3] Gray, J. S., P. Dayton, S. Thrush and M. J. Kaiser, On effects of trawling, benthos and sampling design, Marine Pollution BulletinVolume 52, Issue 8, , August 2006, Pages 840-843. (http://www.sciencedirect.com/science/article/B6V6N-4KSDF48-3/2/d9e75486126c2a51ede6a70fe2cab522)

[4] Løkkeborg, S., 2005. Impacts of trawling and scallop dredging on benthic communities. FAO Fisheries Technical Paper No. 472

[5] Gray, J. S., P. Dayton, S. Thrush and M. J. Kaiser, Fishing for facts on the environmental effects of trawling and dredge fisheries: Reply to Løkkeborg, Marine Pollution Bulletin Volume 54, Issue 4, , April 2007, Pages 497-500. Available: (http://www.sciencedirect.com/science/article/B6V6N-4NC5T98-3/2/1ac1575ef2a4fa9e86462a2c477ee1ac)

[6] Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J., 2006. Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series 311, 1–14.

[7] ICES, 2002. Report of the ICES Advisory Committee on Ecosystems, 2002. ICES Cooperative Research Report No. 254.

[8] Løkkeborg, S., 2005. Impacts of trawling and scallop dredging on benthic communities. FAO Fisheries Technical Paper No. 472.

[9] Lindholm, J. B., P. J. Auster, and P. C. Valentine. A comparison of habitat structure in fished and unfished, mobile and immobile sand habitats on Georges Bank (Northwest Atlantic) [abs.]: Symposium on Effects of Fishing Activities on Benthic Habitats; Linking Geology, Biology, Socioeconomics, and Management, Tampa, FL, November 12-14, 2002

[10] 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.

[11] Eleftheriou, A.; M. R. Robertson (1992). The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. Neth. J. Sea Res. 30: 289-299.

[12] Sullivan, M. C., R. K. Cowen, K.W. Able, and M. P. Fahay. 2003. Effects of anthropogenic and natural disturbance on a recently settled continental shelf flatfish. Mar. Ecol. Prog. Ser. 260: 237-25. Available: http://www.rsmas.miami.edu/groups/larval-fish/Cowen%20Papers%20in%20pdf/Cowen%202002%20PROOF.pdf

[13] Currie, D. R. and G. D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. *Marine Ecology Progress Series,* 134: 131–150.

[14] Guijarro, G. E., S. A. Ragnarsson, and H. Eirıksson. 2006. Effects of scallop dredging on macrobenthic communities in west Iceland. ICES Journal of Marine Science, 63: 434e443.

[15] Eleftheriou, A. and M. R. Robertson. 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. Neth. J. Sea Res. 30: 289-299.

[16] Thrush, S. F., J. E. Hewitt, V. J. Cummings, P. K. Dayton, M. Cryer, S. J. Turner, G. A. Funnel, R. G. Budd, R. G. Milburn and M. R. Wilkinson. 1998. Disturbance of the marine benthic habitat by commercial fishing: Impacts at the scale of the fishery. *Ecological Applications,* 8: 866–879.

[17] Kenchington, E. L. R., K. D. Gilkinson, K. G. MacIsaac, C. Bourbonnais-Boyce, T. J. Kenchington, S. J. Smith and D. C. Gordon, Jr., Effects of experimental otter trawling on benthic assemblages on Western Bank, northwest Atlantic Ocean, Journal of Sea ResearchVolume 56, Issue 3, October 2006, Pages 249-270. Available: (http://www.sciencedirect.com/science/article/B6VHH-4JY413T-1/2/1a03ac9dbbed72354cf8037ec21d944e)

[18] Currie, D. R. and G. D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. *Marine Ecology Progress Series,* 134: 131–150.

[19] Gilkinson, K. D., D. C. Gordon, Jr., K. G. MacIsaac, D. L. McKeown, E. L. R.Kenchington,, C. Bourbonnais, and W. P. Vass. 2005. Immediate impacts and recovery trajectories of macrofaunal communities following hydraulic clam dredging on Banquereau, eastern Canada.ICES J. Mar. Sci. 62: 925-947. Available: http://icesjms.oxfordjournals.org/cgi/content/full/62/5/925

[20] Currie, D. R. and G. D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. *Marine Ecology Progress Series,* 134: 131–150.

[21] Sullivan, M. C., R. K. Cowen, K.W. Able, and M. P. Fahay. 2003. Effects of anthropogenic and natural disturbance on a recently settled continental shelf flatfish. Mar. Ecol. Prog. Ser. 260: 237-25. Available: http://www.rsmas.miami.edu/groups/larval-fish/Cowen%20Papers%20in%20pdf/Cowen%202002%20PROOF.pdf

[22] Jennings, S., T. A. Dinmore, D. D. Duplisea, K. J. Warr, and J. E. Lancaster. 2001. Trawling disturbance can modify benthic production processes. J Anim Ecol 70:459–475.

[23] Dayton, P. K., and R. R. Hessler. 1972. Role of biological disturbance in the deep sea. Deep-Sea Res 19:199–208.

[24] Lampadariou, N., E. Hatziyanni and A. Tselepides, Meiofaunal community structure in Thermaikos Gulf: Response to intense trawling pressure, Continental Shelf ResearchVolume 25, Issues 19-20, , Impact of Natural and Trawling Events on Resuspension, dispersion and fate of POLlutants (INTERPOL), December 2005, Pages 2554-2569. Available: (http://www.sciencedirect.com/science/article/B6VBJ-4H98T8K-1/2/fcb204f6cc7eaa24404ce32462bfeca7).

[25] Lampadariou, N., E. Hatziyanni and A. Tselepides, Meiofaunal community structure in Thermaikos Gulf: Response to intense trawling pressure, Continental Shelf ResearchVolume 25, Issues 19-20, , Impact of Natural and Trawling Events on Resuspension, dispersion and fate of POLlutants (INTERPOL), December 2005, Pages 2554-2569. Available: (http://www.sciencedirect.com/science/article/B6VBJ-4H98T8K-1/2/fcb204f6cc7eaa24404ce32462bfeca7).

[26] Lampadariou, N., E. Hatziyanni and A. Tselepides, Meiofaunal community structure in Thermaikos Gulf: Response to intense trawling pressure, Continental Shelf ResearchVolume 25, Issues 19-20, , Impact of Natural and Trawling Events on Resuspension, dispersion and fate of POLlutants (INTERPOL), December 2005, Pages 2554-2569. Available:

(http://www.sciencedirect.com/science/article/B6VBJ-4H98T8K-1/2/fcb204f6cc7eaa24404ce32462bfeca7).

[27] Levin, L.A. 1984. Life history and dispersal patterns in a dense infaunal polychaete assemblage: community structure and response to disturbance. Ecology 65(4):1185-1200

[28] Collie, J. S., G. A. Escanero and P. C. Valentine. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES Journal of Marne Science 57:987-1001.

[29] Currie, D. R. and G. D. Parry. 1996. Effects of scallop dredging on a soft sediment community: a large-scale experimental study. *Marine Ecology Progress Series,* 134: 131–150.

[30] Garcia, G. E., S. A. Ragnarsson., and H. Eirıksson. 2006. Effects of scallop dredging on macrobenthic communities in west Iceland. ICES Journal of Marine Science, 63: 434e443

[31] Packer, D. B., L. M. Cargnelli, S. J. Griesbach, and S. E. Shumway. 1999. Essential fish habitat source document: Sea Scallop, *Placopecten magellanicus*, life history and habitat characteristics. NOAA.

[32] Helm, M. M.; N. Bourne, A. Lovatelli (comp./ed.) Hatchery culture of bivalves. A practical manual. *FAO Fisheries Technical Paper*. No. 471. Rome, FAO. 2004. 177p Available: http://www.fao.org/docrep/007/y5720e/y5720e0a.htm

[33] Rijnsdorp, A. D., A. M. Buys, F. Storbeck, and E. G. Visser. 1998. Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms. ICES Journal of Marine Science 55:403-419.

[34] Rijnsdorp, A. D. & F. A. van Beek, 1991. Changes in growth of plaice *Pleuronectes platessa* L. and sole *Solea solea* L. in the North Sea. *Netherlands Journal of Sea Research,* 27: 433–439.

[35] Rijnsdorp, A. D. and P. I. van Leeuwen. 1996. Changes in growth of North Sea plaice since 1950 in relation to density, eutrophication, beam trawl effort, and temperature. ICES Journal of Marine Science 53:1199-1213

[36] Rijnsdorp, A. D. and B. Vingerhoed, Feeding of plaice Pleuronectes platessa L. and sole Solea solea (L.) in relation to the effects of bottom trawling, Journal of Sea ResearchVolume 45, Issues 3-4, , June 2001, Pages 219-229. Available: http://www.sciencedirect.com/science/article/B6VHH-43KJNT2-4/2/8c18faa1521e75846a4f730eba54fafb

[37] Lecchini, D.; S. Planes, and R. Galzin. E.xperimental assessment of sensory modalities of coral-reef fish larvae in the recognition of their settlement habitat. Behavioral ecology and sociobiology . 2005, vol. 58, n°1, pp. 18-26 [9 page(s) (article)] (51 ref.)

[38] Helm, M. M.; N. Bourne, A. Lovatelli (comp./ed.) Hatchery culture of bivalves. A practical manual. *FAO Fisheries Technical Paper*. No. 471. Rome, FAO. 2004. 177p Available: http://www.fao.org/docrep/007/y5720e/y5720e0a.htm

[39] Helm, M. M.; N. Bourne, A. Lovatelli (comp./ed.) Hatchery culture of bivalves. A practical manual. *FAO Fisheries Technical Paper*. No. 471. Rome, FAO. 2004. 177p Available: http://www.fao.org/docrep/007/y5720e/y5720e0a.htm.

[40] Su, Z., H. Liangmin, Y. Yan and L. Hengxiang. The effect of different substrates on pearl oyster Pinctada martensii (Dunker) larvae settlement, AquacultureVolume 271, Issues 1-4, 3 October 2007, Pages 377-383. Available:

http://www.sciencedirect.com/science/article/B6T4D-4N5TN4N-1/2/9bc59b13a91e549b64c4a7de71e838f4

[41] Helm, M. M.; N. Bourne, A. Lovatelli (comp./ed.) Hatchery culture of bivalves. A practical manual. *FAO Fisheries Technical Paper*. No. 471. Rome, FAO. 2004. 177p Available: http://www.fao.org/docrep/007/y5720e/y5720e0a.htm.

[42] Mayer, L.M., D.F. Schick, R.H. Findlay and D.L. Rice. 1991. Effects of commercial dragging on sedimentary organic matter. Marine Environmental Research 31:249-261.

[43] Les Watling, Robert H. Findlay, Lawrence M. Mayer and Daniel F. Schick, Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community, Journal of Sea ResearchVolume 46, Issues 3-4, , December 2001, Pages 309-324. (http://www.sciencedirect.com/science/article/B6VHH-44MX8W2-K/2/de81a64c9773b4d0288492eb0a56b349)

[44] NOAA Technical Memorandum NMFS-NE-134. 1999. *Essential Fish Habitat Source Document:* Sea Scallop, *Placopecten magellanicus*, Life History and Habitat Characteristics. Available: http://www.nefsc.noaa.gov/nefsc/publications/tm/tm134/tm134.pdf

[45] 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.

[46] de la Roche, J. P., A. Louro and G. Román. Settlement and Growth of Spat of the Black Scallop *Chlamys varia* in Hatchery Culture. 14th International Pectinid Workshop. St. Petersburg, Florida, 2003.

[47] Su, Z., H. Liangmin, Y. Yan and L. Hengxiang. The effect of different substrates on pearl oyster Pinctada martensii (Dunker) larvae settlement, AquacultureVolume 271, Issues 1-4, 3 October 2007, Pages 377-383. Available: http://www.sciencedirect.com/science/article/B6T4D-4N5TN4N-1/2/9bc59b13a91e549b64c4a7de71e838f4

[48] Su, Z., H. Liangmin, Y. Yan and L. Hengxiang. The effect of different substrates on pearl oyster Pinctada martensii (Dunker) larvae settlement, AquacultureVolume 271, Issues 1-4, 3 October 2007, Pages 377-383. Available: http://www.sciencedirect.com/science/article/B6T4D-4N5TN4N-1/2/9bc59b13a91e549b64c4a7de71e838f4

[49] Lampadariou, N., E. Hatziyanni and A. Tselepides, Meiofaunal community structure in Thermaikos Gulf: Response to intense trawling pressure, Continental Shelf Research Volume 25, Issues 19-20, , Impact of Natural and Trawling Events on Resuspension, dispersion and fate of Pollutants (INTERPOL), December 2005, Pages 2554-2569. Available: (http://www.sciencedirect.com/science/article/B6VBJ-4H98T8K-1/2/fcb204f6cc7eaa24404ce32462bfeca7

[50] Rosenberg, R. H., C. Nilsson, A. Gremare and J. M. Amouroux, Effects of demersal trawling on marine sedimentary habitats analysed by sediment profile imagery, Journal of Experimental Marine Biology and Ecology Volumes 285-286, , 12 February 2003, Pages 465-477.

[51] NEFMC. 2006. Final Amendment 1 to the Atlantic Herring Fishery Management Plan including a Final Supplemental Environmental Impact Statement (FSEIS) and Initial Regulatory Flexibility Analysis (IRFA) (Section 7). Available: http://www.nefmc.org/herring/planamen/final_a1/ha1_fseis_may06_sec04.pdf

[52] NEFMC. 2006. Final Amendment 1 to the Atlantic Herring Fishery Management Plan including a Final Supplemental Environmental Impact Statement (FSEIS) and Initial Regulatory Flexibility Analysis (IRFA) (Section 7). Available: http://www.nefmc.org/herring/planamen/final_a1/ha1_fseis_may06_sec04.pdf

[53] Lassuy, D. R. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)—Pacific herring. U.S. Fish and Wildl. Serv. Biol. Rep. 82 (11.126).U.S. Army Corps of Engrs., TR-EL-82-4. 18 pp.

[54] de Veen, J. F. 1976. On changes in some biological parameters in North Sea sole (*Solea solea* L.). Rapports et Proce`s- Verbaux des Re´union du Conseil International pour l'Exploration de la Mer, 172: 124–136.

[55] Sullivan, M. C., R. K. Cowen, K.W. Able, and M. P. Fahay. 2003. Effects of anthropogenic and natural disturbance on a recently settled continental shelf flatfish. Mar. Ecol. Prog. Ser. 260: 237-25. Available: http://www.rsmas.miami.edu/groups/larval-fish/Cowen%20Papers%20in%20pdf/Cowen%202002%20PROOF.pdf

[56] Sheppard, C., Trawling the sea bed, Marine Pollution Bulletin Volume 52, Issue 8, , August 2006, Pages 831-835. Available: (http://www.sciencedirect.com/science/article/B6V6N-4KSDF48-2/2/2847e2ff6ee90f3eb41f89683329c81f)

[57] 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.

[58] Rauck, G. 1985. Wie scha¨dlich ist die Seezungenbaumkure für Bodentiere? Information Fischereiwissenschaft, 32:165–168.

[59] Rijnsdorp, A. D., A. M. Buys, F. Storbeck, and E. G. Visser. 1998. Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms. – ICES Journal of Marine Science, 55: 403–419.

[60] Stokesbury K. D. E., B. P. Harris, Ii M. C. Marino, J. I. Nogueira. 2004. Estimation of sea scallop abundance using a video survey in off-shore USA waters. J Shellfish Res 23:33–44

[61] Stokesbury K. D. E., B. P. Harris, Ii M. C. Marino, J. I. Nogueira. 2007. Sea scallop mass mortality in a Marine Protected Area. *Mar. Ecol. Progr. Ser.*, 349: 151-158.

[62] Rauck, G. 1985. Wie scha¨dlich ist die Seezungenbaumkure für Bodentiere? Information Fischereiwissenschaft, 32:165–168.

[63] Rijnsdorp, A. D., Buys, A. M., Storbeck, F., and Visser, E. G. 1998. Micro-scale distribution of beam trawl effort in the southern North Sea between 1993 and 1996 in relation to the trawling frequency of the sea bed and the impact on benthic organisms. – ICES Journal of Marine Science, 55: 403–419.

[64] de Veen, J. F. 1976. On changes in some biological parameters in North Sea sole (*Solea solea* L.). Rapports et Proce`s- Verbaux des Re´union du Conseil International pour l'Exploration de la Mer, 172: 124–136.

[65] Collie, J. S., G. A. Escanero and P. C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. Marine Ecology Progress Series 155:159-172.

[66] Hermsen, J. M., J. S. Collie, and P. C. Valentine. 2003, Mobile fishing gear reduces benthic megafaunal production on Georges Bank: Marine Ecology Progress Series, v. 260, p. 97-108.

[67] Jennings, S., T. A. Dinmore, D. D. Duplisea, K. J. Warr, and J. E. Lancaster. 2001. Trawling disturbance can modify benthic production processes. J Anim Ecol 70:459–475

[68] Watling, L., R. H. Findlay, L. M. Mayer and D. F. Schick, Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community, Journal of Sea ResearchVolume 46, Issues 3-4, , December 2001, Pages 309-324. (http://www.sciencedirect.com/science/article/B6VHH-44MX8W2-K/2/de81a64c9773b4d0288492eb0a56b349)

[69] Jennings, S., T. A. Dinmore, D. D. Duplisea, K. J. Warr, and J. E. Lancaster. 2001. Trawling disturbance can modify benthic production processes. J Anim Ecol 70:459–475

[70] Watling, L., R. H. Findlay, L. M. Mayer and D. F. Schick, Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community, Journal of Sea ResearchVolume 46, Issues 3-4, , December 2001, Pages 309-324. (http://www.sciencedirect.com/science/article/B6VHH-44MX8W2-K/2/de81a64c9773b4d0288492eb0a56b349)

[71] Elliott, J. M., and 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.

[72] NEFMC. 2003. From Northeast Multispecies Amendment 13 SEIS December 18, 2003, P. I-459. There are a few studies that compare benthic communities or physical habitat features in areas exposed historically to different levels of fishing effort. One of them (Frid et al. 1999) compared periods of low, medium, and high otter trawling activity at two sites in the North Sea over a 27-year period. At the heavily-fished, mud-bottom, site, benthic organisms that were predicted to increase as fishing effort did increase in abundance, but organisms that were expected to decrease in abundance did not. At the lightly fished, sand-bottom site, there was a correlation with primary production, but no correlation with fishing effort. In a similar study, Kaiser et al. (2000b) compared benthic communities exposed to high, medium, and low fishing intensity by otter trawls, beam trawls, toothed scallop dredges, and lobster pots in the English Channel (sand substrate) and found no significant effects of increased effort on the numbers of benthic organisms or species, but did find reductions in the abundance of larger, less mobile, emergent epifauna and increased abundance of more mobile invertebrate species, fewer larger organisms, and more smaller organisms in high effort areas.

[73] Langton, R. W. and W. E. Robinson. 1990. Faunal associations on scallop grounds in the western Gulf of Maine. Journal of Experimental Marine Biology and Ecology 144:157-171.

[74] Collie, J. S., G. A. Escanero and P. C. Valentine. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES Journal of Marne Science 57:987-1001.

[75] Levin, L. A. 1984. Life History and Dispersal Patterns in a Dense Infaunal Polychaete Assemblage: Community Structure and Response to Disturbance. Ecology: Vol. 65, No. 4 pp. 1185–1200.

[76] Watling, L., R. H. Findlay, L. M. Mayer and D. F. Schick, Impact of a scallop drag on the sediment chemistry, microbiota, and faunal assemblages of a shallow subtidal marine benthic community, Journal of Sea ResearchVolume 46, Issues 3-4, , December 2001, Pages 309-324. (http://www.sciencedirect.com/science/article/B6VHH-44MX8W2-K/2/de81a64c9773b4d0288492eb0a56b349)

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

---

[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.

Primary NEFMC Documents Reviewer: Dr. Emory D. Anderson
Secondary Reviewer: Dr. John T. Everett
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

Ocean Associates, Incorporated
Oceans and Fisheries Consulting

July 9, 2008

David Preble, Chair
Habitat/MPA/Ecosystems Oversight Committee
New England Fisheries Management Council
50 Water Street, Mill 2
Newburyport, MA 0195

Ref: Report On Mobile Fishing Gear Effects And Citation Validity In NEFMC Documents Affecting The Atlantic Sea Scallop Fishery

Dear Chairman Preble and Committee Members,

Since providing the Council with my hypothesis to explain how mobile gear can facilitate the settling of bottom seeking larvae, I am aware of some criticisms of the explanation. To facilitate evaluation, I am addressing the points I have encountered and also have appended an earlier Sea Grant document just brought to my attention that has similar observations as those that led to my hypothesis. The 39th Stock Assessment Workshop, of May 2004, also investigated, to inconclusive results, a very similar theory[1]. My hypothesis was developed independently of these two prior endeavors.

Specifically, the SAW report on Atlantic sea scallops stated: "It has been suggested that scallop dredging may increase settlement success by clearing the bottom of benthic fauna" (NEFSC 2004). That suggested mechanism is different than mine – that is, I posit that the beneficial effects of dredging derive from multiple effects. Principal among these are the clearing of silt, organic matter, and other materials that suffocate (too deep) and clog gills (too much and too fine) of ¼ mm larvae, and the provisioning of requisite clean surfaces (e.g., turned over shells and stones) to which scallop larvae can attach. All bivalve larvae must attach at least once during metamorphosis (sea scallops twice). However, the point is that similar notions have been advanced, and thus far there has not been a solid basis for proving or disproving the theory.

Furthermore, while clean substrate is undoubtedly a necessary condition for scallop recruitment success, as is demonstrated in bivalve aquaculture, it alone is not a sufficient condition. According to the various recent SAWs that have assessed the scallop stock, egg production has been more than sufficient to sustain the scallop population since at least 1995 in both Georges Bank and the Mid-Atlantic regions. Recruitment, though, has been episodic (although it has been high in the Mid-Atlantic since 1996, with only a couple of exceptions, even though areas have generally only been closed when large settlements of juvenile scallops have been discovered). Recruitment success requires the confluence of good environmental conditions,

[1] Northeast Fisheries Science Center. 2004. 39th Northeast Regional Stock Assessment Workshop (39th SAW) assessment summary report. U.S. Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 04-10a; 16 p. Available: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0410/crd0410.pdf

abundant egg production, suitable habitat, favorable currents, and too few predators to overwhelm recruitment. When those conditions align, we have seen tremendous bursts of recruitment, such as on Georges Bank in 2001.

Fishing activity is not the only factor influencing the substrate. Massive storms can turn over bottom and expose rocks and gravel. Many of these areas, particularly the Great South Channel, are highly dynamic with strong currents and tidal activity. The bottom line is that recruitment success for any species is dependent on a highly complex set of factors. My position is merely that what is known about the impacts of dredging can influence these factors in a positive direction, and there is more than a little evidence to support this point-of-view, as detailed in my report.

Regarding closed area recruitment being high

Scallops were present before there was ever fishing. My hypothesis is not meant to explain every successful or unsuccessful settlement season. It explains how gear prepares the bottom for settlement and initial growout. As mentioned, storms, currents, gyres, and animal excavators such as monkfish and horseshoe crabs can do the same. However, only gear can do it reliably over a large scale in non-dynamic areas. And the effect can be tested.

If a closed area had a good recruitment event within 4 years of closure, the hypothesis may well be still in play. The quahog fishing that led to my inquiry was a winter/early spring fishery and larvae were not present until several months later. This plus the literature cited in my report leads me to believe the bottom stays suitable for settlement and initial growout for 6 months.

Moreover, the SAW reports over the past few years do not show any large scale recruitment events on Georges Bank, except for the 1998 and 2001 year classes. The interesting fact is that while egg production on Georges Bank has increased significantly since 1995, recruitment on Georges Bank has been below average every year from 1999 to 2004, with the one exception noted. As the 45^{th} SAW reported, "A plot of recruitment vs. egg production … gives no indication that the recent increase in egg production has led to an increase in recruitment."[2] At the very least, the objective evidence does not tend to disprove my theory.

Even as regards the 2001 Georges Bank recruitment event, it may be relevant that the each of the three closed areas had been accessed, either for surveying or fishing, between 1998 and 2000, inclusive. This event is paradigmatic of the confluence of factors discussed above, and absent a finer scale look at exactly where the settlement occurred, it is impossible to know whether this fishing activity had a hand in creating more favorable recruitment conditions. The area of attachment is more important than the location of observed juvenile scallops, as Atlantic sea scallops are quite mobile. Indeed, SMAST researchers are investigating the possibility that some Nantucket Lightship Area recruitment may be the result of scallops that moved into the area from the Great South Channel (http://www.smast.umassd.edu/Fisheries/Scallops/lifehistory.htm).

---

[2] 45th Northeast Regional Stock Assessment Workshop (45th SAW). 2007. 45th SAW assessment summary report. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 07-11; 37 p. Available: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0711/index.htm.

Regarding damage to the bottom

A colleague sent me a picture of clean gravel before dredging and the "after" picture that showed just sand and some shells – nether element being present in the other picture. Beyond being suspicious that these were in fact true before and after pictures (where did the gravel really go?), it occurred to me that there were no fouling organisms on the gravel. If the gravel were not in a dynamic area, getting moved around nearly daily, there should have been at least barnacles on the stones. The requirement for a clean surface applies to barnacles, just as to bivalves, so it is likely this gravel had a thin veneer of algae or another substance that inhibits attachment. The newly excavated shells would not.

As a former lobsterman, back in the days of wooden pots, a pot that had been in the water since March would never get barnacles, beyond an occasional straggler. The nearly invisible layer of "slime" seemed to protect it. If a patch were made during summer with a new lath, that lath would turn white in about 3 days with barnacle spat . Teredo worms (shipworms-a bivalve mollusk) would dissolve softwood in a couple weeks and oak in a couple months, whereas the rest of the pot would make it through to the winter, albeit very damaged. Further, the teredos rarely settled on the top surface of a dirty pot, but rather on the underside of the laths. Testing was done by opening the door and scraping the undersurface deeply to reveal teredo burrows. Before dismissing the hypothesis, there must be an explanation for the barnacle-free seemingly clean gravel observed throughout non-dynamic areas. I think something like silt or algae is on it and on the bottom in general, blocking attachment and growth.

Regarding productivity

The observed explosion of quahog recruitment was real. Imagine nearly 3,000 pounds of littlenecks in less than 2 hours with a small boat and a dredge made for catching larger sizes, 6 days per week. Up to 2 years prior, less than a dozen would be caught in the 8 hours required to catch 3,000 lbs of large quahogs. I have found no alternative mechanism and the hypothesis is supported by the science. The Sea Grant paper by Timothy C. Visel, "The Hydraulic Cultivation of Marine Soil to Enhance Clam Production" is appended below, because it documents similar observations by others. I was not aware of this material nor its observations until a few weeks ago. While not primary literature, several of the documented instances and suggested explanations have similar elements of my broader hypothesis. Again, the hypothesis should not be discarded without an equally valid alternative hypothesis for observed production increases.

Regarding the efficacy of closed areas and interaction with this hypothesis

Dr. Serge Garcia, recently retired FAO Director for Fisheries Resources, reacted to my paper as below. He is trying to get substantiation from Moroccan scientists for the fisherman's observation.

> *"On 4/27/08 4:57 AM, "Serge Garcia" <garcia.sergemichel@gmail.com> wrote:*
>
> *Oggetto: Report On Mobile Fishing Gear Effects And Citation Validity In NEFMC Documents*

John,
I finally found time to have a look at this message opening the attachments. Advocating positive secondary effects of dredging on overall is courageous but after all makes sense intuitively even if it may be shocking for conservation. After all, tilling is now questioned because of its effects on the in-fauna and successful experiments are reporting of agriculture without tilling which I cannot completely figure out.

I just wanted to tell you that, during a recent symposium in Casablanca on shared pelagic stocks management, I met a very old fisherman (90 or so). He said that along the Atlantic coast of Morocco, there are large areas that have been profitably trawled for decades and then have been put under protection and trawling was banned. He said that since then algae have grown all over the area, covering the bottom with a thick fur and that all fish had gone. According to him, trawling used to "clean" the area regularly turning it into a productive ground and protection had wasted that ground. He complained that no-one listens to them, the fishers.

I am not sure what this is worth but it sounds like your quahog story. I know that when you turn over land and let it stand, pioneering species invade it at the beginning. These are usually very few species (one or two) and the habitat is rather inhospitable. It takes time to get the proper succession of vegetation and turn the area into a more natural and productive ecosystem. This could be what could happen under the ocean when you close an area to trawling, at least on certain types of ground (soft sandy mud) with high organic content (from cities and strong upwellings).

Best regards
NB: may I distribute your report inside FAO?

Serge Michel GARCIA
Via Perdasdefogu, 14,
00050 Aranova (Roma)

If there is any way I can help explain my hypothesis further, please let me know.

Sincerely,
John T. Everett

Dr. John T. Everett, President
Ocean Associates, Incorporated
4007 N. Abingdon Street
Arlington, Virginia USA 22207
JohnEverett@OceanAssoc.com
On the web at http://www.OceanAssoc.com

Ocean Associates, Incorporated
Oceans and Fisheries Consulting

The Hydraulic Cultivation of Marine Soil to Enhance Clam Production

Compiled by Timothy C. Visel
Sea Grant/Marine Advisory Program
University of Connecticut Avery Campus Groton, CT 06340

Oral Histories: Dolan Shellfish Company Experiences with the Hydraulic Hard clam dredges, George McNeil soft shell production from New Haven Harbor

Testimony and Supporting Appendices

(1) The Hydraulic Harvesting of the hard shell clam, Madison Presentation, September 20, 1990.
(2) Environmental concerns raised by shoreline residents – Madison – The Hard Shell Clam Fishery – newspaper and press reports.
(3) Resource Allocation issues and shellfish resource waste as raised by commercial shell fishermen in Madison waters – a review of comments and written records.

Key words: hard shell clam, soft shell clam, increased shellfish productivity, marine soil cultivation practices, hydraulic and mechanical clam dredges, renewable natural resources, water quality issues, industry practices, shellfish management concepts.

Abstract:

In the late 1950's and early 1960's hydraulic "wet dredge" hard clam harvesting equipment was introduced into Connecticut. This was a period of reduced oyster harvest and several large oyster companies, reequipped starfish map vessels and some production vessels for hydraulic harvesting of the hard shell clam (Quahog) *mercenaria/mercenaria* on leased and granted shellfish grounds. Shellfish operators soon noticed the differences in clam growth and clam setting when combined with light plantings of oyster shell cultch.. This paper is the result of a presentation made in support of hydraulic clam harvesting when environmental concerns were raised about its continued use. Resource allocation/use questions were discussed as part of the presentation.

This paper reviews observations that hydraulic or mechanical manipulation of the soil changes chemical, circulation and grain/pore sizes. Increases in pH seems to indicate increase growth and cultivation of suitable bottom types (soil) indicates increased hard clam sets. A review of the available literature highlighting these industry observations are found in Appendix #1 which was updated in 2005.

Reprinted by The Sound School December 2005

The Hydraulic Cultivation of Marine Soils to Enhance Clam Production
September 20, 1990 Special Meeting
Madison Town Hall, Madison CT

Timothy C. Visel, SGMAP
Environmental Fisheries History - Frank Dolan of Dolan Brothers Company 1971-1986 (Slide show)

Also Presented To The Madison Shellfish Commission Public Hearing Madison Surf Club, Madison Waters and Work Conducted on Cape Cod

Mr. Frank Dolan who co-owned a shellfish company with his brother, Joseph out of Guilford, Connecticut. On several occasions, I was able to accompany Mr. Frank Dolan oystering on the "Teal" "Laura and Ellen J." three oyster boats owned by Frank and Joseph Dolan. Shellfish experiences included cultch planting, bottom cultivation, hydraulic clamming, relaying and oystering.

This article concerns the hydraulic harvesting of hard shell clams and is being submitted in support of written and oral testimony about the effects of hydraulic clam dredging. Madison has a rich shellfishing history that includes clamming for hard shells or round clams from its 6,000 acres of shellfish area. Recent experiments also have been conducted for determining the extent of subtidal soft shell clams in town waters.

Hydraulic Dredging – Fisheries History
Soft Shell Clam Harvesting

From what I have been able to learn, the clam dredge was preceded by the oyster dredge and early beam trawls. Beam trawls were mentioned in 1372 as England was recording complaints by its oystermen over oysters being taken by such means. Often beam trawls were weighted by chain to scrape the bottom to catch clams. One practice that was utilized in Bridgeport and New Haven was to plow tidal populations of soft shell clams with a horse/oxen team and then at high tide drag a beam trawl over the clam beds. They caught tremendous amounts of soft shell clams, but the breakage was high, thus the term "soft shell." The modern day version of this modified bream trawl/shellfish drag still can be found in commercial offshore scallop dredges and oyster dredges which use a combination of medieval chain mail and mesh netting. Previous to this point, most "steamers" were called

The Sea Grant/Cooperative Extension Service
University of Connecticut at Avery Point September 1990
Reprinted by The Sound School Regional Vocational Aquaculture Center September 2006

"long clams" in Connecticut. We also know that clam plows were being used to cultivate tidal flats in Massachusetts and Connecticut for aquacultural purposes. In the 1870's, one direct reference (pg. 590 History and Methods of the Fisheries Vol. II GPO 1887, The Fisheries and Fishery Industries of the United States, George Brown Goode, editor) describes this early practice.

"After many trials of all sorts of plows and cultivators, surface and subsoil and providing them unadapted to the turning of the dense, wet, heavy mixture of sand and mud, Mr. Wheeler Hawley (of Bridgeport, CT) succeeded in inventing a light plow, having a thin, narrow, steel mold-board, which did the work satisfactory after seeding the comments regarded the clams being shoulder to shoulder and growing slowly." At one point, the US Fish Commission considered locating its first shellfish station in Clinton, Connecticut because of the tremendous softshell clam population in Clinton Harbor. Milford, Connecticut was selected instead.

According to George McNeil, an oyster grower from New Haven, the plowing of clam bar flats and light clam dredging continued until about 1910.

He attributed the decline from a lessening demand for salted softshell clams to be used as bait in the long line industry. This early clam dredge (from early terms drege meaning "oyster net" and dredge "to draw") is the antecedent of the oyster dredge. Clam cultivation by use of plows was to continue for another 25 years here in CT and on the Cape but proved to be uneconomical as the vast percentage of softshell of clams were used for bait and pig fodder and not for food. However, Mr. McNeil estimated that catches of soft shell clams in New Haven was once in the tens of thousands of bushels each year. A similar method of catching clams with nets has continued until modern times in the Carolinas. It is called "clam kicking." In 1986 and 1987, the Madison Shellfish Commission used a Bourne/Yarmouth wand a hydraulic, single stream 5hp pump sampling device. Substantial/subtidal soft clam populations were found at Circle Beach, the flats off Fence Creek and the end of Hotchkiss Lane at Webster Point.

Hard Shell Quahog Dredges Fisheries History
Hard Clam Cultivation Practices

The concept would return in a different way a century later to harvest the hard shell or round clam. Earlier methods included hard tine weighted pole rakes made by the Quinnipiac Indians and other tribes. Long poles enabled them to rake deep water hard shell clams from salt ponds and coves such as the Niantic River between East Lyme and Waterford. Thus the first references to early clam dredges call them "drag rakes" and not dredges. The first clam dredges were attributed to Dutch oyster farmers of New York City who noticed quahogs or hard shell clams living under oyster shells that were harvested for the production of lime and street surfaces. Laws soon were enacted to end this practice as it was deemed to be harmful to the lucrative oyster business (page 518, George Brown

Goode). The demand for seafood in a growing New York City soon caused clam dredging as a direct off-shoot of oyster shell dredging and, by 1870, emerges as a distinct "fishery." An early account describes the clam dredge as being thrown overboard and when it has sunk into the sand it is "drawn" along the bottom, and taken up about once a minute, when the clams are extracted from the sand, washed and thrown into the vessel. This is, the account continues, exceedingly laborious work and four to five hours of it in one day is sufficient to use up the "stoutest scrapper" (US Fish Commission Report, 1887).

Modern Clam Dredges

The literature review I was able to undertake, including the clam fisheries prior to World War II attribute the dry dredge to have originated in New Bedford, Massachusetts. Apparently, some of the first powered fishing vessels experimented with a heavy dredge called the New Bedford rocking chair dredge. The concept was that vessels lacked sufficient power to cut through the bottom, so the boat was put into a fast forward, slow forward motion as to rock the dredge, causing it to chop into the bottom one bite at a time. It was slow and hard work-the cutting blade that cut into the bottom would often hit a boulder causing the boat to lurch, and the great weight of the dredge was necessary to keep it from jumping off the sea floor (which I am told it often did). After World War II, the shortage of fish greatly expanded the clam markets. More powerful engines were being installed resulting in less rocking and more direct sea bottom contact in a steady cutting motion. This new method caught more clams but greatly increased breakage – up to 40% of the clams were now being broken or crushed. This was caused by the fact that the cutting bar now was acting like a knife and striking the clam in the middle tended to cut the clam in half according to Mr. Dolan. Frank said that few Connecticut oyster growers would clam this way. It was punishing to the wood frame oyster boats, and George McNeil thought they would "rattle the boats apart." George also stated that the oyster business was far more valuable than clams and that Rhode Island had pretty much taken over the clam market by the 1940's. That would change dramatically in 1958.

The First "Wet Dredges" for Hard Shell Clams

The hydraulic effects of pumped water into soil was well known in the mining industry. First applications were used to wash over burdens off silver and gold deposits and flume the flows for densities – the heavy constituents being the metals. In 1954, two researchers looked at reducing the clam mortalities with clam harvesting both soft and hard clams and taking the land-based hydraulics application pumped water to fluidize the bottom in front of the clam dredge. The first experiment was conducted in Massachusetts with a hydraulic manifold followed by traditional rakes for the collection of subtidal soft shell clams. This method allowed harvesting of never exposed subtidal population not that unsimilar to the horse and oxen plowing and beam trawls almost a century before. The early experiments with this manifold of water jets was quickly communicated to other

New England states, and by 1956, manifolds were being welded to the dry rocking chair dredges with immediate implications; catches improved, the horse power required to tow the dredges decreased, and mortalities dropped to under 8% and many times between 2% or less. According to Mr. Dolan, news soon spread to Connecticut with Massachusetts and Rhode Island fishermen quickly converting their dry to wet dredges. By 1958, oyster growers started to experiment with the so called hydraulic dredges. Mr. Dolan commented it couldn't have come at a better time. More people were coming to the shore as tourists, and they were able to market clams they just could not catch easily before. Most of the hard clams were in 15 to 25 feet of water. Waves and tides in the Sound made tonging and bullraking both difficult and economically unfeasible. The oyster industry was having a decade of poor oyster sets, and many oyster growers were "just hanging on." It also came during a period when hard shell clams "were everywhere" after the 1940's, and now in the 1950's, clam beds had matured such as the one off Madison. (Mr. Dolan states that the hard clam bed extended from Guilford Harbor to Tuxis Island and out to Madison Reef – some 600 to 800 acres. This was confirmed by surveys in the mid 1980's). He was disappointed in the response from Madison to attempts to harvest these deep water clam beds, and by the 1960's, most of the clams had died. He said he thought the clam bed off Madison was one of the largest in the country, and it was a shame to waste that much seafood. It also was frustrating because the waters off Madison were clean and certified for shellfishing. What I have been able to determine is that it was just not only Madison's beds that had dense concentration of hard shell clams but many areas in Connecticut had clam sets. It is just that Madison's beds were by far the largest. Repeated attempts by fishermen in Guilford who knew the extent of the beds were rejected by the Town of Madison. (Most of the clam beds were in Town of Madison waters.) Mr. Dolan said most of the clamming then was in the Thames River and Norwalk and Milford Harbors. He said the Thames River held more clams than any other river in New England. According to Mr. Dolan, by 1975, these offshore beds had "died out" but he could show me "how to bring them back."

Clam Research in Town Waters

In the late 1970's, I approached Mr. Dolan about surveying a section of Madison Town Waters as part of a shellfish management plan. He agreed only after the previous clam bed he purchased in 1961 would be finally approved by the Madison Shellfish Commission. This was done on July 5, 1983. I was able to accompany him on several occasions from 1975 to 1983 for shellfish surveys. I had clams (only living ones) aged at the University of Connecticut. I also kept records on age distribution and bottom conditions. The first survey yielded only a very few living clams, all big "chowders." In 1978, they were aged by slicing the shells and examining deposits (similar to counting tree bark rings). They were old – 30 to 40 years with some 50 or more. Mr. Dolan would work the dredges in circles and sometimes drop a marker buoy. Most of the first day yielded dead clam shells, some still paired but all dead. Frank asked that he be brought a pail of salt water and asked for some dredged shells to be brought to him. Taking two shells, he rubbed them vigorously together and placed them in the pail of water. A white cloud occurred and Mr. Dolan than said "what I thought; the bottoms gone sour." I had heard this comment about bottoms before with inshore trawl fishermen in New York. He then repeated the "test" several times with the same results, a white cloud. The second survey was done in 1981, in the same location with mostly the same results – but we washed two boat loads of dead clam shells back on the beds. Tens of thousands of bushels had died according to Mr. Dolan. We dredged all day and found less than 30 live clams.

Mr. Dolan said that he believed the 1938 hurricane was responsible for the great widespread clam sets in 1939-41. He felt many of the clam predators were killed, and that areas that had muck accumulations had gone back to clean and sandy bottoms. He also felt the waves loosened the bottom that could get as hard as "pavement," allowing the clams to "set in" better. The better bottoms had no such cloud from the shell test. He would need to bring in a light coating of shell several times to sweeten the bottom. The shape of the clam also told him a lot. According to Mr. Dolan, the "points" and "blunts" tasted different which he attributed to sweet or sour bottoms. Points were faster growing clams that had hard shells. Sweet meaning those bottoms which were slightly alkaline and sour for bottoms that had no shell cover. Blunts were often found in muddy or muck covered bottoms. I stated it seems you are controlling the pH of the bottom with shells just as a farmer does with agricultural lime. "Yes we are and one more thing think about the soil." It was the first time I had heard the bottom referred to as soil. Then he steamed out beyond Charles off Madison, set the dredge, engaged the pump and then stopped it mid-dredge. By turning the water off, he took a chunk off the bottom in the dredge and hold hauled it up. It contained a piece of orange brown bottom – Clay; Frank explained, no good for clams. You could turn (meaning "cultivate") this over and over again with no clams – you cultivate the bottom we do, that is if the bottom is good – close to the beach is mud/sand we can work that, out deep is clay/sticky bottom and that rarely works. We learned that we could take good bottom and cultivate it using the dredge then shell it slightly and get a set of clams.

Mr. Dolan recounted how it was by accident that this was discovered. They had years of experience of catching hard clams under shell cover from oyster operations in New Haven Harbor. They initially thought the shells protected the clams from predation. Only later did the concept of controlling pH and examining soil structure for suitability develop for hard clam "aquaculture." They were farmers and rotated cultivated prepared "fields." It was just the same to him.

When the first hydraulic dredges can into existence, Connecticut clam production soared but consisted of almost entirely of market "chowders." In the first 5 or 8 years, everyone caught clams and, at times, there was a glut. Eventually all these chowders were caught and production declined. (He stated it was in the mid- 1960's.) From time to time, boats would rig up for clams, especially if the market price improved. On one of these trips, they returned to a bed in the Thames River to relay clams to clean water and, much to their surprise, they found small clams, thousands of small "necks" and seed. This was the same bed several years that before had only chowders. They believed that the hydraulic clam "cultivation" aspect had done some good. They then started to return to some of the other areas and found much the same thing. The shell cover aspect seemed to work on grounds with no shell cover and, if, the bottom was sticky (high clay) or had shells pitted and soft (the white cloud in the pail of water), the bottom was acid. They once had a shipment of river clams rejected because they tasted "bitter" and took them and planted them in Guilford for 3 months. The bottom had shells on it and other clams, and when resold, they were told they "tasted great." He never had the time to pursue this except if on acid bottoms they would often taste bitter, on shelly bottoms "sweeter." It wasn't proved. However if the bottom started to "sour," they would dredge up some buried oyster shells and scatter them on the clam bottoms. In one interesting conversation, he recalled a situation when they did this with oyster shell, and they didn't realize it had an oyster set on it. When they checked on the bed several months later, they discovered a good crop of seed oysters and moved it to the Hammonassett River so it wouldn't be killed by starfish. It didn't take long for other clammers to realize that they could manipulate beds for setting. It worked most of the time but in some instances, it didn't, so they would need to "check it" every so often. Key to the production is that beds were rotated, cultivated, lightly shelled and then wait. Mr. Dolan said it was usually 5 to 7 years, again, depending upon the bottom conditions. They didn't publicized this feature. (It took a while to get Mr. Dolan even to confide in me. After all they had learned it the "hard way" and it was a competitive business.) Only recently have other researchers and industry people acknowledged this aquacultural practice. Recently, articles have appeared about the same practices on the east and west coasts and in Canada.

Mr. Dolan stated that during harvesting oysters, if they ran off the line (area of planted oysters), they would hit the clams under a thin layer of shells. The problem was they weren't worth that much (pre-1945). Everyone (oyster growers) knew hard shell clams set under the shells. It was a common occurrence in New Haven Harbor Mr.Dolan's beds were listed as Stone House in New Haven after a restaurant they owned.

He felt hard shell clams preferred a sandy soil closer to shore, and he rarely fished in waters over 30 feet deep. He could tell by squeezing a clump of mud; if it held a ball, he would say too much clay and not worth cultivating. They looked for old beds that still had clams believing if some were still alive the bed could support additional clams. Some of the densest clam beds he ever worked were in the Thames River in old oyster beds. If then contained clams, if they could be cultivated. Mud and sand, 80% sand, 20% mud over 50% mud, clams would grow slow – acid would dissolve the new shell. Mr. Dolan felt good sets followed storms, washed mud from the soil and also loosened the beds allowing dredges to catch better. He did note that the clams responded to dredging by burrowing deeper. He would move off the area and fish another when he returned all the clams were "at the surface again." The hydraulic action was a mini storm and that larger storms like hurricanes prepared bottoms for big wide spread sets even out to the deeper water. He felt it key to production that beds be "rotated" Mr. Dolan compared it to Christmas tree growing. Problems happened when the beds were harvested early. Newer people had this happen. It's hard to wait but not waiting wasted a lot of small clams; they were dislodged to be eaten by predators. Sometimes he would cultivate, and it could take 3 years to get a set. They knew it worked because if they got off the area, the bottom would be hard and contain dead clams just like the previous conditions.

Problems with Hydraulic Dredges

One concern Mr. Dolan mentioned was regulations/control of the beds. He had seen clam beds ruined by continuous harvesting and not letting the crop mature. He stated that continual harvesting jets out seed clams for predators. In a very short time the person is in the business of raising "clam predators instead of clams." Once the area is cultivated, it needs to mature. Early harvesting can give the illusion of a good return, but he estimated that for every clam harvested, 100 small clams would be killed by predators. He gave an interesting example of a school yard and quarters. If you took a 12 quarters and threw them onto a grass-covered school yard, chances are they would all be lost and none recovered. Imagine if you took 10 thousand quarters and did the same thing – he guaranteed that people would become highly interested and attracted to this activity. He recounted that was the same thing that happens in the marine environment; early harvesting brings in predators, in some cases thousands of them (He thought the worst were blackfish and spider crabs) It can build up the predator population to a point that all the vulnerable clams, especially the small ones, can be killed. In one case, he remembered the spider crabs got so thick over the bed they couldn't dredge. When he returned weeks later, nearly all the small clams had been eaten. If the beds were cherrystones or larger, this "chum effect" is reduced. One of the suggestions was the area be divided into "lots" and testing made to determine when to open. It would maximum economic harvests and increase the percentage of clams to the Town of Madison. (Madison had asked that a percentage of the clam catch be relayed to shallow waters for recreational harvesters).

1) Blackfish were confirmed off Charles Island in Milford 1986 - the sound of the pumps brought them under the boat before water was actually delivered to the dredge.
2) First attracted to the beds were large adult flounder who he felt were getting sand worms and not clams as a result of the dredging. Sometimes people would fish by the boat for flounder and he could see them catching them.

Environmental Conditions for Clams Notes and Observations

Mr. Dolan was willing to share his observations about hard clams from almost 50 years in the fishing business. He felt that hard clam offshore beds set well only two or three times in his lifetime, in the 1930's, 1950's and 1970's. He believed that they occurred after a hurricane or very bad winter (Northeasters). He also felt that the conditions were better in the rivers for sets, 2nd best was under oyster shells and lastly, in the offshore waters. When he cultivated (although he had caught both razor clams and surf clams in Connecticut), the only other commercial quantities of other clams he saw were soft shells off Ledyard and in New Haven. That was associated with hard clams; the soft shells were so thick they jammed the clam dredge making hard shell clamming impossible. If he hit the soft shells he had to stop. He would occasionally hit razor and surf clams off Guilford but not in any large quantities. He felt the dredge for hard clams was just too small to catch the others.

River and Bank Edges

Mr. Dolan fished the Thames River from Montville to Green Harbor, New London. He felt sets occurred often but the bottoms turned mucky in the 1950's. He believed that over 50% muck could slow growth or kill clams. He also saw sea lettuce in Montville get so thick as to suffocate clams off the edge (away from the channel). He also observed clams with soft sticky bottoms, their shells were often pitted and were soft, very much unlike the clam shells from cleaner sandy mud. He felt that the clams off Montville and Ledyard were the most concentrated. The soft shell clam bed off Ledyard was over a 100 acres in size. The Connecticut River had too much fresh water for clams he felt.

He also found that heavy rains would wash leaves and sticks over the beds in rivers. One day little "trash" after a heavy rain a lot of debris etc. Rivers were good he thought because predators also were fewer. He felt the currents would clean off new edges preparing them for sets. That would occur after heavy rains.

Near Oyster Leases

He (and the oyster growers) had seen multiple sets of hard shell clam occur under seed oysters for decades. Oyster set had been planted, and when harvesting the oysters with oyster dredges, they would always get some clams. In fact, they knew the oysters were getting "thin" when greater amounts of hard shell clams would come up. This is when the practice of cultivating and laying down shell started. If it was done on the edge of oyster ground, clams sets were nearly assured. Sometimes they just planted a thin layer of shell over an area with no cultivation. They often would get a set that way.

Open Areas - Offshore

These are the areas that obtained widespread sets but only very rarely. This was the type of clam bed off Madison. For them, he would just cultivate and leave them alone for a few years. Later he would cultivate and add shell if there was few shells. Usually they were enough dead shell on the bed so that. This didn't happen. However, if the shells were so old that they crumbled in his hand, he would add new shell (if he could get it). This was the most risky of the three habitats; sometimes he would get a set, yet some times it was a complete "blank," and he never knew why.

Impacts of the Sea Bottom

Mr. Dolan felt that hydraulic dredging was less harmful than dry dredges. **Almost no clams were broken and the bottoms were cleaner after clamming. He likened it to raking the leaves off your lawn so the grass could grow.** In Connecticut, he had noticed the tendency of the bottoms to go "sour" with muck. Green Harbor in New London where he said he found the densest and concentration of clams ever, went progressively to a muck sticky bottom. Once the clams were harvested, no small ones appeared and they tasted bad (see previous reference). What started off as sandy mud became sticky muck, some times so bad that the dredge get stuck in it. After a while, they started setting the dredge with full pump pressure to avoid this from happening. If the bottom was very sticky, they didn't even bother. The last time he sampled in Eastern Connecticut for the town of Groton, he stopped in at Green Harbor. The place he used to fish was full of leaves and sticks; he called it a "dead bottom." He tried for an hour to catch any clams but didn't even get one dead shell. He thought the bottom had changed so much, he could not get down to the bottom he clammed 30 years ago. It was now extremely "soft." He said the bottom was like jelly. One time he hit a patch in Green Harbor and harvested over 500 bushels of necks and cherries from an area about a third of an acre.

Summary

One of the things that bothered Mr. Dolan is that he could never see "his farm," a problem I encountered with similar size operations. He often wondered what the area looked like before and after he dredged. He wondered about fish, (he used to catch flounders and blackfish in the dredges once in a while) and if they watched the dredge or came in right after it. He wondered if the bottom had sand worms in it – he thought it did. I was able to provide Mr. Dolan with a copy of a video oystering in the East River, but I don't think he ever got to look at the "soil" he worked on his entire life.

Introduction for Appendix 1-3

The Cultivation of Marine Soils
The Hydraulic Harvesting of the Hard Shell Clam

Mercenaria mercenaria

Timothy C. Visel

In 1990, a concern was raised that hydraulic clam harvesting off the coast of Madison was environmentally dangerous to the water and sediments. The group which called itself Save our Shores claimed detrimental impacts ranging from increased heavy metals to the source of bacteria on bathing beaches. The research community weighed in and dismissed these claims. Pet waste it appeared was more of a threat to Madison beaches in the form of storm water runoff than hydraulic clamming.

The conflict in the end was more about noise than anything else and it was handled the way most noise issues were – regulations and municipal ordinances. It was also suggested that shellfish resource issues were a long standing problem in Madison. According to local shellfishermen policies that had existed for more than half a century were also to blame," if I can't harvest them nobody else should" and references to his belief were found in the Town of Madison Shellfish records (see appendix #3). The town once founded by farmers and fishermen had become an affluent shoreline community and had a history of marine resource conflicts in recent years (Charlette Evarts, Town Historian). In 1972 and 1973 oysters began to set strongly in town waters. Natural growth harvestors (seed oystermen) asked to harvest seed oysters in major rivers and creeks – but were continuously opposed. Only after oysters grew to depths of 6 to 8 feet deep impacting navigation in Neck River did the town allow commercial harvests, but by then approximately 80 to 90 thousand bushels of seed oysters had died from overgrowth (1978). In 1971 most of Madison waters were closed to shellfish from bacterial contamination (runoff). This accelerated the waste of oyster resources as no relaying or transplanting programs were then underway. The waste of oysters in the East and Hammonasset rivers was enormous.

In March 1990 when the first concerns were raised I was employed by the University of Connecticut Sea Grant Marine Advisory Service and a life long resident in Madison. According to newspaper reports the conflict was very divisive one pitting wealthy shore front owners against people who liked to eat and harvest shellfish. The Madison Shellfish Commission had for 15 years under cooperative management efforts had a part of the commercial catches set aside for shallow recreational relays) which greatly had increased recreational permit sales – and the satisfaction of shellfishing a traditional fall activity for many Madison residents. It is in this context that the information is contained and with a slide show presented to the combined groups to demonstrate the techniques and impacts of hydraulic clam cultivation. The aquacultural aspects are included in appendix #1. The environmental aspects are detailed in appendix #2. The resource allocation issues are reviewed in appendix #3

As it relates to the resuspension of bottom sediments clam fishermen claimed that storms and hurricanes resuspended more sediments that could possibly be accomplished by hydraulic dredging. The group opposing hydraulic clamming claimed serious long lastly negative environmental impacts. Several agencies provided testimony in support of hydraulic clam fishing.

Yet to this day, the association of increased resource enhancement and cultivation of marine soils refuses to go away. Rather than avoiding the issue we need to objectively look at it and involve industry resource managers and regulatory agencies in these discussions. In that way, aquacultural cultivation practices can be discussed in a non emotional way with industry and resource managers. The practice of marine soil cultivation is continuously mentioned in research and industry accounts. I have listed some references as a way to demonstrate that Connecticut's example is not unique but forms part of a international research effort. They were included after my slide lecture presentation at the Town Hall on the equipment and different types of hydraulic dredges. I have summarized sections of these handouts below.

On a final note – one prediction.

One prediction that Mr. Frank Dolan a local shellfishermen made did come true but he did not live long enough to witness it. The State waters did pick up strong sets of mercenaria in 1987, following Hurricane Gloria and another following Hurricane Bob in 1992. The harvest of hard clams soared in 1994 and continued to the year 2000 following these widespread sets, and as he predicted this event would be followed by a decline just as the previous three cycles he had described. He told the group that storms changed the bottom and moved more sediment than the hydraulic clam dredge could ever accomplish. "On rough night from a southwest wind moves more silt than we could in a year."

<u>Reference for the Cultivation of Marine Soils</u> – Prepared for the Madison Shellfish Commission

Appendix #1 Aquaculture Aspects Associated with hydraulic clamming.

Note: Most of the shell fishermen that I have had the benefit of meeting and engaging in conversation all told me the benefits of "working the bottom" and negative associations of plants (Marine grasses) and decaying plant matter. They seemed to be both indicators, clean, relatively mud free habitat was good and thick grass or heavy accumulations of seaweed, sticks or leaves were poor or low productive habitats. There was consensus that clean good bottom can be ruined by excess plants, both terrestrial and marine. This was more prevalent in the regions that suffer from nutrient enhancement. The working the bottom aspect can be found in many clam fisheries, raking, tonging and dredging, only with hydraulic clamming did I find reference to the activity as a farming or cultivating activity aside from harvesting. In this way, the area was prepared for a set or harvest." Much as terrestrial farmers cultivated and prepared "soil". I have listed some references for the process - We absolutely, need more research in this area. Most of the research today has been done by shellfish constables, shellfish commissions and the shellfishermen themselves. Although it is continuously mentioned by shellfish managers and the shellfish industry, it remains an area that is still poorly understood by the general public. As the concept of marine soil manipulation is often contrary to accepted norms and may infringe upon long standing environmental and regulatory provisions, it needs to have a historical context of shellfish utilization by early setters and of course native Americans. Much of the practice of hydraulic cultivation was utilized as a way to minimize the negative impacts of eutrophication and siltation.

1) Biological Effects on Hard Clams of Hand Raking and Power Dredging
October 1953 - By John B. Glude and Warren S. Landers
Fisheries #110 United States Dept of the Interior Fish and Wildlife Service

"Narragansett Bay, Rhode Island, has supported an intensive commercial fishery for the hard-shell clam, Venus Mercenaria, known locally as the quahaug or quahog, for many years. Hand diggers, using tongs or bullrakes, are allowed to fish in any unpolluted waters in the State. Power dredgers have been restricted to the southern half of the Sakonnet River except for a short time during World War II when additional areas were opened to increase food production. Locations of fishing areas are shown in Figure 1.

Controversies continually arise between fishermen using power methods and those who harvest the clams by hand. Rakers and tongers claim that they are using the only method which do not harm the bottom or destroy young clams. They claim the dredges tear up the bottom, breaking many of the clams which are caught as well as those which go through the bag of the dredge and are left to die. They also believe the dredges bury the small clams so deeply that they are smothered, and that the bottom is sometimes plowed to such an extent that current action causes scouring which prevents a new "set" from surviving.

Dredges claim that they are merely cultivating the bottom and preventing it from becoming too compact for the clams to live. Dredging, they state, really improves the bottom, inducing new sets and increasing the growth rate of those clams which are left.

Bottom samples confirmed the indications of the underwater photographs that surface appearance of the three areas was similar. Mixing of the sandy-mud layer and the underlying clay was more pronounced in both fished areas than in the control. Fished areas were also softer and had less odor of decomposition than the control. No differences in the above physical characteristics was observed between dredged and bullraked sections.

This experiment shows no biological basis for restricting either method of fishing."

2) Fisheries Research Board of Canada 1962 -

"The Martha's Vineyard hydraulic clam rake (Mya) is the proto type from which the present machine was developed. We believe the hydraulic rake, which operates on flats while they are submerged is a better harvesting tool. It causes so little damage to clam stocks that it must be ranked high as a saving gear. We wish to thank Dr. Matthiessen who in 1959 acquainted us with Martha's Vineyard fishermen who were using hydraulic rakes."

3) Yankee Magazine October 1974 -

"Rev. Richard Burton, founder of Project Dominion, demonstrates his homemade cultivator, seawater pumped through the device agitates the surface of an ecologically stagnant clam flat and adds oxygen and nutrients – resulting in a healthy set of clams." {Mya}

4) Hydraulic Harvesting of Soft Shell Clams – Results of Soil Cultivation Experiments – MacPhail Model of the Hydraulic Rake – Page 9

Bourne – Sandwich Shellfish Assn. September 8, 1980, March 20, 1981

"When the manifold was rolled across the bottom, gases formed from the decaying matter were observed bubbling to the surface. The substrate was devoid of the usual animal life, such as sea worms and the winkles. After pumping these areas, and removing the harvestable clams, the conditions improved remarkably. The surviving seed was able to return to the newly turned over bottom, while the dead shells and decaying matter remained on the surface. The mortality rate of the remaining seed dropped drastically, and an increased growth rate was noted.

We have also encountered certain spots where this dying process is complete, and only the many clam shells remain beneath the substrate. Though the area has since repopulated with sea worms, and other marine life, as yet, no clams have re-set there. One explanation could possibly be taken from the 1930 Belding Report, which states: "Clams are usually absent from soils containing an abundance of organic material. Organic acids corrode their shells, and interfere with the shell- forming function of the mantle. Such a soil indicates a lack of water circulation within the soil itself, as indicated by the foul odor of the lower layers, the presence of hydrogen sulfide, decaying matter, dead eelgrass, shells and worms. If such a soil could be opened up by deep plowing, or resurfaced with fresh soil to a sufficient depth, it would probably favor the growth of clams."[1]

[1] Belding, David L. MD; The Soft-shell Clam Industry of Massachusetts, November, 1930.

5) University of Maine Orono August 1984 – Development of a Harvester for seed clams

"There had initially been some concern regarding damage to the fragile young clams, and disturbance of the flats themselves by the action of this hydraulic harvester. Both these aspects were studied. Samples of clams harvested by the machine were taken to Orono and placed in the shellfish laboratory running sea wakes system. After three days a count of dead clams was made and the percentage mortality calculated. For no sample was this figure over 5% a level considered acceptable by all concerned. Shell damage from the shore of the jetting {water} action is simply not a problem."

6) Producing Clams for the US Market by Jim Conrad
Aquaculture Magazine, May 1984 – Pg 38

"First of all, we own the bottom of the bay we work on," he says. "We own six acres and lease 1.5 acres from the State. Second, we till and groom the beds-clear off the overburden of mussel shells, take away predators, and keep digging up the substrate all the time. The reason we keep digging up the beds with hand diggers is that if you let the substrate sit, silt drifts over the beach, plugging up the pores so that water won't circulate through it. Then the clams, three or four inches down, or even a foot down, no longer can survive because they can't get enough water filtering down to feed on. Then they start migrating upwards to a fairly thin layer at the surface of the beach. You can't get as many clams per acre if there are all in a thin layer at the beach's surface as you can if they area scattered through several inches of the substrate. We try to make the beach substrate 'fluffy,' like the soil of a well tilled agricultural field."

7) Quahog Management
Aquaculture Magazine, November/December 1988

"By using excellent management techniques, David A. Roach, Jr. of Westport, MA has increased this community's quahog production from 50,000 to 1,000,000 in five years, making Westport the fourth largest quahog producer in Massachusetts.

Roach has also implemented another new management program for the Westport River; he and his staff use a hydraulic dredge to turn over the river's bottom in areas that are either unproductive or have gone from good to poor production. This procedure changes the chemistry of the largest particle size, breaks up thick mud accumulation and releases sequestered nutrients."

8) Getting more from your sediment bottoms
The effects of hydraulic harvesting - Aquaculture Today, 1988, pg 4 to 8

H.K. Rask Regional Marine Resource Specialist Cooperative Extension Service
University of Massachusetts

"Pollution closures and the future shellfish resources are receiving increasing attention. In addition to closure restrictions, declining harvests can also be traced to poor setting and, especially, to the deterioration of bottom quality. The result is considerable acreages of nonproductive bottom sediments.

Cultivation a solution

One obvious solution is to cultivate the beds to improve sediment quality. This was well known over 100 years ago, but is almost totally neglected today.

In the past, horses or oxen often were used to cultivate the flats. Today this can be done hydraulically, and tremendous yields have been found in areas that have been hydraulically harvested or naturally disturbed. Recent work with hydraulic seed harvesters and other hydraulic gear also shows that cultivating the bottom enhances setting; good sets can also be found when storms, currents or dredging activities wash the sediments free of organic material and detritus.

There is a link here to the excellent sets of shellfish found in new sand deposited by storms or currents. Clams (Mya), for example, are a colonizer species and can quickly populate an empty area. New sand is not only free of decaying organic detritus, but is also free from predators. Hydraulic action can easily be seen to imitate some of these natural phenomena."

9) A Marine Resources Management Plan for the State of Connecticut - July 1984

Department of Environmental Protection
Division of Conservation & Preservation
Bureau of Fisheries
Marine Fisheries Program

"The condition of hard clam stocks on private commercial beds is enhanced by the seeding and predator control activities of the shellfish companies that own them. The hard clam is a productive species for aquacultural efforts and Connecticut waters are capable of sustaining much larger populations than they currently do. A major drawback to increased production of marketable clams is the limited amount of productive ground located in unpolluted water. The hard clam is probably the most abundant species available for recreational shellfishing in Connecticut at the present time."

10) Connecticut Aquaculture Findings and Recommendations Aquaculture Commission - January, 1986

Compiled by John H. Volk, Chairman
Aquaculture Commission

"In some locations in Connecticut, clams (Mercenaria) and oysters (Crassostrea virginica) are cultivated and harvested from the same leases. Commercial shellfish grounds in New Haven Harbor are an example of this. Annually, in the late fall or springtime, juvenile oysters are transplanted off the setting bedsIn anticipation of oyster setting on these same grounds, large quantities of cultch (approximately 2,000 bushel per acre) are planted. This cultch cover, which provides a substrate for oyster larvae to settle upon and attach, also seems to provide some protection from predators for the Mercenaria populations in the sediments below. Thus, a shellfish farmer may reap the benefits of two crops from his one lease."

The following items have been added after the 1990 Slide Presentation. They are added only to illustrate continued references to hydraulic cultivation.

New to File – Updated References Clam Culture and Enhancement

11) Department of Health and Human Services Public Health Service Food and Drug Administration

September 22, 1992

Dear Mr. Stoecker:

You requested the Food and Drug Administration's position concerning the mechanical dredging of shellfish.

The Food and Drug Administration has no problem with the use of mechanical or hydraulic dredges for the harvesting of shellfish. In fact, the use of dredges to harvest clams and oysters from moderately polluted (restricted) waters for relaying (transplanting) into approved waters is a most efficient method as compared to hand raking, tonging, etc.

Most significant is that a renewable food resource is being removed efficiently and effectively from polluted waters so as not to be harvested illegally and placed onto the market where it can cause illness. The shellfish are then naturally purified in approved waters so they may be harvested for food use. Thus, a renewable resource is used, jobs are created, and there is a public health benefit as well.

Keep up the good work.

Sincerely,

Jerrold H. Mulnick
Senior Regional Shellfish Specialist

Copies: John Volk, CT AD
James Citak, CT AD

12) Proceedings of the Third Rhode Island Shellfisheries Conference - August 18, 1994

Narragansett, Rhode Island
Published by Rhode Island Sea Grant
Habitat Enhancement as a Means to Increase the Abundance of the North Quahog, Mercenaria mercenaria

Shell Planting as a Habitat Enhancement Option

"Based on the distribution of quahog abundance and the environmental biology of quahogs, substrate modification – through the addition of shells to low-quahog-abundance sediments lacking shell—would appear to be an effective approach to habitat enhancement. Several anecdotal reports provide support for this approach. In Long Island Sound, for example, shell (cultch), distributed on the bottom to provide substrate for oysters to set upon, was also associated with increased quahog abundance (Volk, 1986). In the Broadkill River, Del., quahogs were found in an area that had been recently covered with surf clam shells to create oyster habitat (Maurer and Watling, 1973).

There have been three reported pilot-scale projects that added ("planted") shell to bottom sediments in order to increase quahog abundance. In North Carolina, in the early 1970's, Parker (1975) planted scallop shells at a density of .081 cubic meters (m3) of shell/m2 of bottom, and found that the average initial recruitment was 10 times greater in the planted shell than in an unshelled control. In 1989 in the Great South Bay, N.Y., 100 m3 of surf clam shells were planted in two 0.4-hectare (ha) plots located in muddy, low-quahog-abundance areas that lacked shells (Kassner et al, 1991). The planting, however did not result in increased quahog abundance, because the shell sank in to the bottom and the project's scale was deemed to be too small to give meaningful results (Kassner, unpublished). In 1990, 120 tons of clam shell was planted in Barneget Bay, N.J., in six plots, each measuring 20m by 70 m (Cronin, 1990). Three of the plots were covered with "light" shell, while three unshelled plots served as controls. Three years later, the shelled plots had slightly more than five times more recruits than the unshelled control. (Clyde MacKenzie, National Marine Fisheries Service, Sandy Hook, N.J., (personal communication)

Jeffrey Kassner
Town of Brookhaven
Division of Environmental Protection
3233 Route 112
Medford, New York 11763

13)) Atlantic Fish Farming July 21, 1997
"Sea Bottom Treatment Helps Clams"

"If cultivating agricultural field before planting a new crop of potatoes or corn is essential to the commercial success of an agricultural farm, wouldn't the same apply to clam seeding activities for an aquacultural farm? The benefits of cultivating and enriching the soils for agricultural activities are well known and special treatment for specific crops are readily available. This knowledge and various applications have evolved from many decades of research, development and trials.

Aquaculture, however, is relatively new and although culture techniques have develop rapidly over the past decade, sea bottom treatment methods for shellfish aquaculture is still relatively unknown. Liquefying the sediment with the hydraulic rake mainly affects the upper 15 cm of the sea bottom. The affected areas area looser and this is evaluated by determining the bulk density and velocity of sediment samples or cores using an x-ray like piece of equipment called the Multi Track Sensor.

Within a two week period, most of the changes in the physical properties of the upper sediments have returned to their original state. It is believed that the rapid recovery is being driven by biological activity which may be influenced by the chemical characteristics of manipulated sediment."

The chemical and biological aspects of this research is only in its infancy and will be looked at in more detail this summer in a project funded by the Canada NB Alternate Species Program. It has been documented, however, that sediment modification with the hydraulic rake does not kill newly settled clams and, in fact, may enhance their chance of survival when performed a short time before they settle. This suggests that sediment modification or cultivation of the sea bottom could, in fact, be beneficial to the development of clam culture. Providing a better environment for clams to achieve higher production has to include a better understanding of the sediment.

Ocean Associates, Incorporated
Oceans and Fisheries Consulting

Appendix #2
Environmental Aspects Concerns Raised by Save our Shores a citizen group organized to fight hydraulic clam dredging

1. Clam Dredging increases odor and debris

Clam Dredging may increase odor and debris if the operation is working in sea grass or other vegetation. This occurrence in our waters is rare, and would likely limit harvesting hard clams harvesters have told me that they avoid vegetation because it blocks the dredge grills and muds up the dredge. In fact, they avoid areas with eelgrass and sea lettuce as they believe these can kill clams by increasing sedimentation and choking the clams, (silt is trapped in the blades of eelgrass). Several clam fishermen believe that sea lettuce is toxic to clams and avoid these areas at all costs. They do not seek vegetation areas as they are considered poor hard clam habitats.

2. Removal of clams will result in increased turbidity because clams eat silt.

Clams do not eat silt; they eat small microscopic plant life algae. Madison has had several summers of huge brown algae blooms, but that is not associated with clams or clam operations, but nitrogen enhancement and eutrophication processes. It is the brown algae that make the water look turbid –it's quite noticeable at several town beaches. It can be seen from the air adjacent to much of the Connecticut shoreline.

3. Hydraulic clam dredging increases pollutants such as lead

Not so, especially if the area has been tested for heavy metals. Madison Shellfish was tested by the Dept of Health for metals in the 1980's. Madison metal counts except for zinc in the Hammonasset River were very low. Sung Feng of the University of Connecticut, has found metals in shellfish to be decreasing not increasing, and Madison tests confirmed low levels. Higher levels of lead can be found surround almost every home built before 1960 from paint, than sediments off Madison's shores.

4. Hydraulic clam dredging will cause bacteria and close our beaches

Hydraulic clamming does not cause bacteria nor would it lead to closing of beaches. Rain water runoff and ground water contamination from poorly designed domestic septic systems are more likely sources. Because of the concerns expressed about bacteria tests (counts) at Madison beaches, the town has committed to a long term bacterial extension study of runoff – storm sewer discharges surrounding each public beach. The study is in conjunction with the National Shellfish Sanitation Program and will be conducted by the Madison Shellfish Commission. Initial reviews realized that pet waste was responsible for high bacteria counts at East Wharf Beach, Madison. A few years previously a sanitary survey of the East Wharf Shellfish Depuration area has indicated pet waste contamination from a storm water/street basin pipe. After a heavy rain the pipe effluent had extremely high counts. It was then determined that the area was a popular pet walking area and subject to contamination in that way. Discussions centered around moving the storm water discharge pipe or creating its own leaching field under the east wharf parking lot (personal communication John Bowers, 1986). In fact, shell fisherman as a group, are probably the most environmentally concerned about water quality as their livelihood depends on it. One interesting fact is the first series of environmental lawsuits are brought by oyster companies in New Haven in the 1920's. There, oyster beds were polluted by sewage from the city causing them enormous financial losses. One landmark case, Lovejoy versus the City of New Haven went all the way to the Supreme Court. Mr. Lovejoy lost to the City of New Haven and the oyster business there lost its former prominence. But the final chapter is yet to be written. Lovejoy was finally overturned in 1967 by the Clean Water Act. So, if you research the clean water initiative, you will find arguments from the Lovejoy oyster case. And, most of the history of the Clean Water Act was based upon waters suitable for sustaining shellfish and referenced decisions from numerous shellfish industry/clean water complaints.

Appendix #3 Resource Allocation issues

Towns of Madison Resource Allocation issues and waste of shellfish reserves

After the 1938 hurricane and hurricanes in the 1950's, clam sets occurred in a huge hard shell clam bed that extended from Half Acre Rock, easterly to rocks known as "the bishop," then easterly between Madison Reef to Tuxis Island and in a narrow band inside "outer Reefs" to Webster Point, Madison.

In the 1960's, fishermen approached the town of Madison about a permit to try a new type of clam dredge – the hydraulic dredge. The clams were beginning to perish and this new dredge could work in deeper waters. This is the text of a request (handwritten) by John E. Walston, Jr., a Guilford commercial fishing family, who had trawlers and operated the last of the Guilford whitefish trap nets. (The Madison Town seal has a menhaden on it for it was once Madison's most lucrative industry). This is the letter, as written:

Ocean Associates, Incorporated
Oceans and Fisheries Consulting

Mr. John E. Walston, Jr.
5 Meadow Street
Guilford, CT,

March 7, 1966

Mr. Elmer Sonnichsen
Chairman of the Shellfish Committee
Madison, Conn.

Dear Sir:

I am interested in purchasing round clams in the waters of Long Island Sound under Madison's jurisdiction at a minimum water depth of your determination.

I am prepared to pay sixty cents (60c) per bushel at any interval you so desire: week or month.

I would also agree not to work the grounds during any summer months so as to avoid silting of any beaches and henceforth controversy with any waterfront land owners.

I am prepared to furnish upon request, references pertaining to my honesty and payment from previous dealings. I would also invite your committee to inspect my catches and or record books at any time, whether pre-arranged or otherwise.

If you are interested, I would like very much to take the chairman, committee or any other interested person on a spot survey of the area, so as to determine the amount of clams that might be available. I would also like an audience with your Board of Selectmen, to explain the situation in detail if they so desire.

May I hear from you soon?

Thank you.

Sincerely,
John E. Walston, Jr.

Madison's reply, dated April 19, 1966

April 19, 1966

Mr. John E. Walston, Jr.
5 Meadow Street
Guilford, CT

Dear Mr. Walston:

This is in reply to your letter of March 7th to Mr. Elmer Sonnichsen in which you stated your interest in purchasing the round clams in the waters under the jurisdiction of the Town of Madison.

The Board of Selectmen after discussions have found public reaction unfavorable to your proposal and feel Madison should not commit its resources in this manner.

Sincerely

Robert L. Adams
First Selectman

RLA: vd

Cc/ Elmer Sonnichsen
Robert Schmidt
Charles Schroeder, Jr.

By the time I surveyed these offshore areas with Mr. Frank Dolan – most of these clams were dead. We did find evidence of the clams out to the Red Nun #2, west end of Madison Reef to halfway between C I at the beginning of Madison Reef and Tuxis – running east to Tom's Rocks off Madison's Webster Point.

Oysters – Neck East, Hammonasset and various creeks

In 1971, Charles Beebe was a resident of Madison and owner of Beebe Marine at the East River section of Madison. His property was on the East River just north of the Route 1 Bridge. It was the week of my high school graduation, but he called me up and was very excited – so he brought me to the marina to show me something. It was an old hand oyster seed dredge and it was full of oysters. He was very excited about it, and calculated they were four or five years old. He said he hadn't seen a "set" like this in 20 years. The river he suspected was full of oysters, but had been closed to direct shell fishing since 1966. Mr. Beebe predicted many oysters would be lost if the river wasn't opened to transplanting. He arranged a meeting with the Dolans at the Sluice Creek the next day. The first time I met Frank "Nuke" and Joe Dolan. The Dolans agreed that oysters would start killing "each other." Mr. Dolan gave me an old newspaper to copy (1949) with exactly the same situation – huge overgrowth and many dead oysters. Mr. Joe Dolan said it was 1949 all over again. It's a cycle and now the river is loaded with oysters and starving to death. Attempts were made to open the commercial oyster activity in 1974. Madison would not open the beds until controversy arose when it was detailed that tens of thousands of bushels of oysters had already died. The following article prompted "Nuke" to show me what had happened to the clams in September 1978. That was the first time I went hydraulic clamming off Madison.

Shoreline Times, page 5, August 29, 1978

Title: Clam Diggers, Oystermen Struggle to Battle a Bushel of Problems

According to Charles Schroeder, the chairman of the Madison Shellfish Commission, the round clams or quahogs in the Sound off Madison are thriving because of the ban on commercial fishing. "Those people are after the money – that's all. They're concerned about. As far as leaving seed, if they see one clam down there, they'll go for it. The town has very little to gain from letting commercial fishermen in, and what I consider a great deal to lose."

Ed Lang, an oysterman and aquaculturist responded in the same article: "Lang says the clam beds become overcrowded and produce inferior clams. If they are not cleaned regularly, what good does it do to have these clams just sit and die? He reasoned. When the extent of the resource losses became public, Madison opened its waters to commercial fishing under shellfish management plan, the first municipal plan in Connecticut (December 1978).

The Clinton Recorder – December 1, 1949
"Oyster Problem is Not Simple"

Guilford Has Rare Opportunity for Development

"Reuben D. H. Hill, who has tonged oysters in East River and other Guilford waters for more than sixty years, estimates that there are now in East River 100,000 bushels of oysters, but that for the most part, they are worthless "heels" grown in overcrowded conditions. They might be of value only if broken apart and moved down the river where they might have more room and better feeding conditions.

Dolan Would Invest

Joseph S. Dolan Jr., who carries on probably the most extensive lobstering and fishing operations from Guilford harbor, says that he would like the opportunity to establish beds and raise oysters. He is interested primarily, he says, in grounds outside the river, either on a lease basis or preferably by developing the beds and paying a percentage of the profit to the town. The development of such beds requires a three or four year program; this must be done either by the town or by private enterprise before anyone can profit.

The improvement of oyster grounds, he asserts, has appeared to be everybody's business when times are hard, and nobody's business when people are prosperous. The people who most need the income from oystering in bad times are those who are in no position to maintain the development through thick and thin. He states that practically every town has had to grant some privileges to somebody in order that this difficulty may be solved.

Only when the growth of oysters restricted navigation did the 1949 oyster problem that Mr. Dolan spoke to me about, happened. The Army Corps of Engineers came and dredged the lower East River natural oyster bed."

Shore Lines Times, April 12, 1979

Oyster Contract Goes to J. Dolan

"The towns of Madison and Guilford have awarded a contract for the transplanting of oysters from the East River to Joseph S. Dolan, according to Nathan Walston, chairman of the Oyster Group Advisory Committee.

Of the five parties who bid for the contract, Dolan submitted the lowest bid. He will perform the transplants on a "load for load" basis; that is, Dolan will receive one boat load of oysters for every boat load transplanted for use by the towns.

Currently, the state will not certify the East River as an area where oysters may be raised for consumption due to the high level of pollution there, Walston said. In addition, the oyster population now in the East River is overcrowded and the "oysters are starving each other out." This results in poor quality oysters, he explained. Because of the competition for food, the oysters have not reproduced in years, he added."

And Shoreline Times article, April 8, 1982:

"Some Oyster Areas Are Opened"

In response to many questions that have been asked about this type of permit being granted, the chairman of the Madison Shellfish Commission, J. Milton Jeffrey, explained that the oysters lay in polluted waters and were not available to the local residents for their use. The natural growers harvest the oysters that have become extremely overgrown and sell them to others who have available waters in the Long Island Sound where the oysters can be set out to cleanse themselves, he said. It is the responsibility of the local commission to maintain the shellfish under its jurisdiction in the best possible condition; this requires the cleaning out of old beds, replacing shell and maintaining the best possible harvesting techniques, he explained.

Every fall, the commission transplants a number of bushels of oysters from polluted waters to clean waters off shore for taking by local residents. It is expected that this will be done again in the fall of 1982, Chairman Jeffrey said.

Letter of August 8, 1983:

S. Jackson Wommach,
14 Circle Beach
Madison, Conn.

Dear Sir:
"The 200 feet of Neck River along our property has been surveyed by a member of your commission (shellfish). Oysters 1 to 3" in size were found in abundance. These oysters have accumulated rapidly over several years' to a depth of one to three feet. It was estimated that in excess of 1,000 bushels are in this area. We request these oysters be removed."

And "EDC endorses businesses eyeing restoration of River's Shoreline
See Times, April 26, 1984

Dredging, environmental impact, wetlands, an oyster bed said to be five to six feet deep, the future of the accessability to the West River waterway, and "swift and prudent" action of state, local, and federal agencies are cited by a few of the businesses as problems which need to be addressed and overcome.

They haven't dredged the oysters out of the river in two to three years. We know there's oysters down five or six feet deep. It's been more than once we've sent out work boat our there" to remove a sailboat caught on top of the oyster bed, Mrs. Duhaime said.

That section of the river has been oystered before, she said, but the Board of Health closed it down due to pollution. State statures prohibit mechanical dredging, Mrs. Green said.

"But the type of dredging we're talking about the ousters is scoop dredging – a hand operated mechanism," Mrs. Duhaime said. "Let nature take its course, and encourage the town to dredge those oysters out."

Shoreline Times October 3, 1990

They explained that hydraulic dredging has been going on in Madison since 1982, not since March 1990, when Dr. Morrow first noticed it, nothing however, seemed to satisfy the residents when a live demonstration showed the operations, thanks to a new muffler, to be almost soundless, and when lobstermen and harbor officials said the water was cleaner than before the clamming started. The real issues began to emerge – residents began to say what they really feared was -- the loss of property values, as if the sight of a boat offshore would spoil the priceless view.

Shoreline Times, September 30, 1992. Surf Club, September 24

Morrow, the head of pathology at Yale University and Yale New Haven Hospital, was responsible for presenting the oppositions views on the ordinance at the town meeting. He said that shoreline residents independently grew concerned that toxic amounts of lead were stirred up along with the debris.

Yale Professor Karl Turekian said dredging would disturb the sediment from the bottom of the Sound, in the same way the sediment is disturbed by frequent storms.

Professor Frank Bohlen of the University of Connecticut said the dredges only dug into the ocean floor by a few inches, he said that any sediment stirred up would be very limited and would settle before reaching the beaches.

Madison Surf Club – (Mr. Dolan is a Madison Taxpayer)
Public Meeting, September 24, 1992

Joe Dolan, Frank's brother, of Guilford, speaking at the Special Town Meeting said "Shell fishing is like forestry – you can have old big trees that shut out the younger ones, all little trees – because you cut down the big ones – or some mixture in-between. Closing it now is like putting a fence around the stumps – what you really need is to open it and plant new trees – it's all dead –the clams got old and died. That's no mystery.

We showed you what needed to be done, a lot of clams were wasted – Madison has wasted a lot of shellfish in my time, I can tell you that."