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DO WE HAVE THE CORRECT SCALLOP GRASS? A HABITAT HISTORY FOR EELGRASS ZOSTERA MARINA IN NEW ENGLAND COASTAL WATERS. **Timothy C. Visel**, The Sound School Regional Vocational Aquaculture Center, New Haven Public Schools, 17 Sea Street, New Haven, CT 06519. **tim.visel@new-haven.k12.ct.us**

This paper reports upon a historical review of eelgrass meadows as they relate to much discussed positive shellfish habitat associations. The previous association between eelgrass and healthy shellfish habitats needs to be entirely reviewed. Central to this reevaluation is the indexing of coastal habitats for temperature and energy input – storms, waves, tidal circulation, flushing capacity/exchange and development on barrier inlets. These factors are largely absent from current habitat studies but should be included. Since 1870, we have four habitat "reversals" each connected to climate and energy changes – bay scallops Argopecten irradians, oysters Crassostrea virginica, soft shell clams Mya arenaria, hard shell clams (quahogs) Mercenaria mercenaria have all been negatively impacted by dense growths of eelgrass. The sources for these negative impacts come from several governmental out-of-print publications – both state and federal. They often contain a different eelgrass viewpoint from fishermen and shellfish managers at the time. This viewpoint is largely absent from current bay scallop habitat discussions.

DO WE HAVE THE CORRECT SCALLOP GRASS? A Habitat History for Eelgrass Zostera Marina in New England Coastal Waters

The Historic Negative Impacts of Eelgrass Zostera marina Upon Shellfish Habitats in New England

Centuries-Long Climate and Energy Pathways Linked to Habitat Quality

Timothy C. Visel

Abstract

This paper reports upon a historical review of eelgrass meadows as they relate to much discussed positive shellfish habitat associations. The previous association between eelgrass and healthy shellfish habitats needs to be entirely reviewed. Central to this reevaluation is the indexing of coastal habitats for temperature and energy input – storms, waves, tidal circulation, flushing capacity/exchange and development on barrier inlets. These factors are largely absent from current habitat studies but should be included. Since 1870, we have four habitat "reversals" each connected to climate and energy changes – bay scallops Argopecten irradians, oysters Crassostrea virginica, soft shell clams Mya arenaria, hard shell clams (quahogs) Mercenaria mercenaria have all been negatively impacted by dense growths of eelgrass. The sources for these negative impacts come from several governmental out-of-print publications – both state and federal. They often contain a different eelgrass viewpoint from fishermen and shellfish managers at the time. This viewpoint is largely absent from current bay scallop habitat discussions.

Do We Have the Correct Scallop Grass?

For some people, this will be a difficult paper to read. The information presented here is a collection of accounts and references as well as published and unpublished works. To provide clarity, a large reference section is included; also descriptions of accounts attempt to describe the thoughts and views of numerous conversations and meetings that took place from 1974 to the present.
Many thanks go to Alex Disla, Susan Weber and Taylor Samuels for their assistance compiling, organizing and editing this text. I am not the writer in the family so without their help, it would not have been possible.

To those who have spent hours and funds trying to restore eelgrass, this work may help explain why some projects have worked and why some have failed. I obtained no grant funds for this research, and my participation on the Long Island Sound Study, an EPA Connecticut Department of Energy and Environmental Protection (DEEP) partnership represents the Sound School, one of the Connecticut's nineteen Agriculture Science and Technology Centers. As such, this paper is designed to support the understanding and educational awareness of the rich, living marine resources of Long Island Sound. The Sound School, a public high school founded as New Haven's first school of choice (1982), has for its mission the Sound and near shore areas as an extension of "its classrooms." Marine study and aquatic research has been a part of its educational experience since the first days.

The Sound School opened and operated its first scallop hatchery in 1988 with Jeff Alpert, help from Dave Cohen, an aquaculture researcher in Hawaii and Edwin Rhodes from the Milford NOAA NMFS facility. Jeff Alpert continues his science teaching at the Sound School to this day. We also continue to operate a small scallop hatchery, with continued assistance from the Milford NOAA NMFS laboratory that is currently headed by John Roy, Senior Aquaculture Teacher with Angel Santiago and Stuart Mattison as our Fish Production Laboratory technical staff. The Sound School campus has grown tremendously since it started in 1982 with 20 students. We now enroll 340 students from 23 sending communities continuing the program components of vocational agriculture education developed in the last century. "Learning by Doing" still best describes our teaching and learning styles today and the practical application of scientific knowledge.

The vocational agriculture curriculum long contained a senior culminating special project. The special project was something that the advisor teacher would organize with a student. Topic choice was a consensus between staff and the student and a greater monitoring role was sought in 2007 with a National Fish and Wildlife Federation grant to the Sound School. Project Shellfish/Finfish was started in 2008 to provide students a list of potential "Special Topic" research areas. With a new State of Connecticut Department of Education culminating graduation requirement, the Special Topics have been renamed a Senior Capstone Project, but the elements remain basically the same.

Nearshore fish shellfish and plant species are being incorporated into Capstone Projects for Sound School students. One of the Capstone Projects was an old question from my University of Rhode Island and Massachusetts Cooperative Extension employment. Do we have the correct vegetation habitat association to scallops? The more I looked into the question, the more questions were uncovered including its eelgrass "habitat history."

The topic "Do We Have the Correct Scallop Grass?" builds up on research conducted in Niantic Bay by Nelson Marshall. Here, the habitat histories of eelgrass Zostera marina and the bay scallop Argopecten irradians would cross in a much broader study of population dynamics for the last 150 years. The Niantic Bay scallop fishery flourished in the complete absence of eelgrass, and Dr. Marshall's work defined many of the habitat questions presented here. The views expressed in this paper are my own, developed in the educational context of assisting the next generation to better understand the habitat dynamics and ecological relationship of inshore shellfish and finfish resources.

In this regard, many thanks go to these individuals who took the time to assist me; they include hundreds of inshore fisherman who attended my University of Connecticut Extension workshops from 1978 to 1990, and in particular, Mr. George McNeil of Clinton, Connecticut, Mr. John Hammond of Chatham, Massachusetts and Mr. Luther Blount of Warren, Rhode Island. Each of these gentlemen (all former oyster growers) helped me understand and learn from their oystering experiences; my thanks will never be sufficient.

The Beginnings

Few people today can remember the period of New England's history called "The Great Heat" (on the Vineyard and Nantucket it was called "The Hot Term"), a period roughly extending from 1880 to 1920. During this time, summers grew progressively hotter, then brutally hot with the record breaking heat extending well into Canada by 1914. It also was a period in which New England had remarkable few hurricanes, the Blizzard of 1888, the Portland Gale of 1892 and the Summer Gales of 1903 and 1905 being the exceptions. Overall, it was a period of stable habitats and low energy inputs. The Great Heat is largely credited for the huge increase in water fowl, especially Brant that fed on rich, thick eelgrass meadows that spread out to 75 foot depths off Woods Hole (Nichols 1920). What was good for oysters and eelgrass however was deadly to the bay scallop and southern New England lobster stocks. The increasingly hot summers were devastating to the kelp/cobblestone habitat needed for lobsters. The cold, deep water Rhode Island bay scallop habitats failed in response to very hot temperatures and increasing amounts of submerged vegetation. Shallow habitats are acutely more sensitive than offshore waters and noticeable by fishermen and resource managers. By 1910, all the New England coastal states, except New Hampshire, were operating large lobster hatcheries in a desperate attempt to replace stage 4 lobsters. The lobster fishery collapsed in the face of a shallow water habitat failure so critical to successful recruitment into the lobster fishery.

One of the largest fish kills recorded in modern times occurred in August in 1914 in Hempstead Harbor. Here small winter flounder died by the millions. In 1905, beaches in Wickford, Rhode Island recorded barracuda catches. Human populations also suffered and during prolonged heat waves, many horribly. Disease outbreaks became common and polio, typhoid and malaria rocked cities like medieval plaques. New York and Boston recorded hundreds of deaths and thousands perished in the Heat Wave of 1896. Summer coastal communities quickly grew as desperate city dwellers sought relief from the extreme heat and rushed to cooler shore areas to seek seasonal relief. In the haste, many summer colonies first started as tented campsites.

The hot, relatively storm-free period helped eelgrass also re-establish itself after the much cooler and stormier era a half-century before. In the 1890s, a young chemist named Samuel Cabot apparently was perplexed by the enormous reproductive capacity of Zostera. He later would develop a batt insulation product which would propel the fledgling paint and stain (Cabot Company) business for more than 50 years. While the summers were warm, winters were still cold and eelgrass insulation would have seasonal use in ice barns to prevent ice blocks from melting in the extreme summer heat. But what was good for eelgrass and ice sales would devastate bay scallop fisheries. They prefer energy from storms to maintain habitat quality – firm relatively clear, slightly alkaline bay bottoms. The heat helped another industry, the oyster industry which was poised for incredible expansion. The warming temperatures made oyster sets heavy on cleaned or planted oyster shell. In 1899, Connecticut set was the set of the century, but bay scallop production fell quickly. Soft shell sets also increased, but hard shell clam catches, aside from a huge bed discovered in 1910 off Nantucket, became minimal.

What was born during the Great Heat would perish in the New England Oscillation (1951-1965), a period of sharply cooler temperatures and a tremendous surge in powerful hurricanes. The amount of energy applied to these coastal habitats at this time is legendary, but this energy would have its consequences, beginning in 1931, 1935 and 1938 with the start of the end of the oystering industry. The 1950s hurricane season including Dog and Easy hurricanes, were to deal a devastating blow to the Massachusetts, Rhode Island and Connecticut oyster fisheries, a blow from which they would never recover. The cooler temperatures would rejuvenate the bay scallops, hard shell clams and lobsters. The hard clam sets after these hurricanes were tremendous, especially in Narragansett Bay. Eelgrass was destroyed and huge windrows of torn-free eelgrass now covered New England beaches, estuarine soils, recultivated and freed of organic, acidic mucks supported an alkaline red coralline algae Agardhiella subulata. Bay scallop production recovered and then soared. The remaining oyster companies switched to hard shell clams while soft shell clams retreated into deeper, more protected bays and coves as shallow areas would freeze often killing soft shell clam sets. Storms, once rare events, now raked the coast each winter, pulling sands off glacial deposits offshore cobblestones, freeing them for the kelp hold fasts. Lobster recruitment improved and most of the state and federal lobster hatcheries closed in the 1950s (except for the one on Martha's Vineyard which remains open to this day).

Then like a switch the energy stopped, thousands of acres of bay bottoms got heavy sets of clams, Mya scallops productivity soared and once again Connecticut had its bay scallops recover, east of Clinton Harbor, although scallop populations were again in Clinton, Old Saybrook, Groton and Stonington, the largest fishery was in Niantic Bay by 1954 saw Niantic Bay producing nearly a half million pounds of meats (Smith et al 1984).

Eelgrass was absent from many of these regions and then as the shellfishery developed, it returned and slowly at first and choked out shellfish habitats. This was not a new occurrence but like a long vanquished foe, a competitor for habitat space was back with a vengeance it seemed. It was discouraging for shellfishermen to see as explained to me after an East Lyme workshop in the 1980s. Early shellfish researchers had seen and reported this before. Meade, Belding, Collins, Ingersoll, Kellogg, Galtsoff, Loosanoff all reported negative eelgrass habitat associations, over ran clam habitats, trapped organics, raising elevations, smothered clam beds, suffocated oysters and while noting the scallops did set an eelgrass (clean and green) thick growths impacted meat weights and could starve scallops living in it. (Detailed accounts in reference sections and can be found in the appendix). These habitat changes were hard to miss especially when your livelihood depended upon it. Shellfishermen were quite ready to battle this renewed Zostera population. Efforts of control included drags, fence and chain link cultivators. The old Cabot quilter cutters and mowing machines were put back in use, and in the case in the State of Massachusetts, Westport River study possible herbicides 2, 4-D and in Canada 245-T or its granulated salt ester commonly known as Agent Orange. Mr. Hammond described to me that hard shell clam fishermen made a determined last stand against eelgrass in Pleasant Bay on Cape Cod 1970-71. That effort included powerful chemical plant killers, suspected to be Agent Orange. In the last attempt to control Zostera was in 1974 at Niantic Bay, Connecticut.

The Bay Scallop Fishery which had soared to unbelievable production levels had fallen to none. Shellfishermen blamed eelgrass which had grown so thickly it reportedly "stopped the tides." Here a NOAA NMFS Niantic Bay project placed dynamite charges in an effort to clear a channel. This use of explosives was also unsuccessful. The eelgrass got thicker until a few months after Hurricane Gloria which dislodged tremendous amounts of oatmeal died off (according to conversations during local workshops, the plants "rotted off") as roots got weak and broke and huge mats of the plant drifted out with the tide.

In 1986, a scallop set occurred in Niantic Bay and 1987 saw a modest return of scallops and they also reproduced with a sizable set. The 1988 scallops from Niantic Bay for the Sound School hatchery came from this population. This is because Jeff Alpert and I transported 50 scallops to the Sound School. The previous week, the bay bottom on the west was a different matter, here the eelgrass was slimy – covered with black spots and weak. It trapped enormous quantities of leaves and the shell fisherman with me, Bob Porter carried a length of pipe probing the bottom determining the depth of the organic debris. In some places measuring over three feet deep over once Mya-soft shell clams beds. It was in those areas winter flounder fishermen once fished "hard bottom" for flounder. It was as the entire bottom was covered in partially rotted leaves, some eel plants were nearly completely buried its leaves also, completely black blades with the leaves, a fast raking yielded all black blades those few still green had a brown slime covering them. The entire bottom was now largely a marine compost pile- sulfurous mud with likely low pH could be found in some of the deepest sections of the Niantic River (Bob Porter personal communications 1980s). A pipe survey of sections of Keeney Cove and Golden Spur, yielded thick black acidic accumulations. In front of then Camp O'Neil, a shallower organic deposit was found over about one meter of loose organic ooze, containing weak discolored and dying eelgrass plants. The plants were easily dislodged and the health root systems typical of sandy salt pond bottom of Rhode Island or on Cape Cod, were quite different, shorter and brown; it appeared as thought they were also rotting. (See survey descriptions in Appendix.) It is now thought that this acidic sulfide rich deposit was damaging the roots, and now explains perhaps the initial weakening of the bottom pH and chemistry now was impacting the eelgrass root health.

Although Bob Porter was concerned about the shellfishery loss (scallops and clams and the large amounts of leaves and organic debris had ruined a hard shell clam experiment) several local winter flounder fishermen described soft shell beds and productive winter flounder areas now completely covered in organic debris. Reports included the eelgrass buried by several inches to sometimes feet started to turn black, brown and decompose. Eelgrass was a concern but the changing bottom conditions soon triggered a couple of East Lyme/Waterford Shellfish Commission workshops in the area. Shellfishermen and flounder fishermen were quite upset and partially blamed a Millstone Power plant sampling program for the absence of winter flounder. The truth of the matter was it was hot and the organic matter in high heat "cooked" the eelgrass roots as Bob Porter termed it and weakened the eelgrass and it just drifted along. The roots had trapped vast quantity of leaves, sticks and organic debris, smothering any shellfish and making low pH conditions even worse. Although eelgrass was mentioned as the reason for the scallop decline in 1989 and 1990 eelgrass contained little life and plants appeared sick, and slime covered. The eelgrass was dying off, again.

That seems to be its habitat history in Niantic Bay. In the 1930s, an October Blizzard (most likely a hurricane) delivered a storm runoff that most likely swept organic matter into the bay. That followed a very hot June in 1931 along the entire eastern seaboard and the same cycle would begin again.

In 1931 would mark the height of the winter flounder fishery and beginning of the end of eelgrass by 1944, it was largely gone from the bay and plugs were planted by the state in an effort to restore it. The eelgrass link to bay scallops was casual, it was more in response to basic food for waterfowl, and especially Brant who saw its primary food resource practically disappear. US Fish & Wildlife Services and the US Department of Agriculture once sent out monthly "Brant/eelgrass advisories in the 1930s. As the winters grew colder in the 1930s and 1940s bay scalloping improved in the absence of eelgrass. By the 1950s bay scallop production would soar in the complete absence of eelgrass to the surprise of Nelson Marshall who conducted bay scallop research for local shellfish commission often with Richard Cooper, a United States Fish & Wildlife Service researcher, then working out of Woods Hole with the Bureau of Commercial Fisheries. This research will haunt Dr. Marshall who for decades struggled with this dichotomy producing a paper about it and mentioned in his 1994 back the Scallop Estuary – reviewing early Niantic Bay fisheries. The 1950s in which bay scallops soared in the absence of eelgrass would historically always ask this question: Do we have the correct scallop grass? In the end, Dr. Nelson surmised it was the uncanny ability of scallops to select red weed Agardhiella subulata in which to set in the absence of eelgrass. But what if it was the other way around? In the absence of red weed bay scallops were able to choose a less favorably substrate upon which to set, a clean and green eelgrass in sandy current swept areas. Shellfishermen in Niantic were delighted to see eelgrass go (see paper #25 Niantic Bay Transplants 1916 to 1935 on The Sound School website). It was leaving many of New England's bays and coves in the 1940s and 1950s. Bay scallops returned during this period of energy and cold thrived extending into the Buzzards Bay district, Cape Cod and the Islands New England Bay scallops fisheries all greatly improved that is shown in state and federal catch reports.

Not only did the scallopers notice this absence of eelgrass, but the remaining oyster growers noticed also. Although bay scallops returned, oyster sets grew infrequent, and natural growth seed oyster products dropped across Connecticut. Then the energy stopped and then it gradually started to warm.

George McNeil, Luther Blount and John Hammond, all three oyster growers would watch as habitat conditions for them failed again and thick growths of vegetation covered thousands of acres of bay bottoms cleaned by the storms of the 1930s, 1940s and 1950s. Eelgrass, once the crop of the depression (Cabot Quilters) was back and growing into cleaned, storm-cultivated soils, the same estuarine soils that had abundant clam sets. All three would watch as bay and cove bottoms once covered with estuarine shell became leaf-filled, covered by organic debris and what was frequently called "oatmeal" by Cape Cod shellfishers in the 1980s.

User group accounts (shellfishers) often describe during the very warm/low energy periods bottoms containing detrimental remains called oatmeal that would ruin local shellfish habitats. However, Harshberger (1916) talks about the same tidal trash consisting of dead stems, leaves of eelgrass and salt marsh grass but also loose floating *Ulva* and *Enteromorpha*. They even caused marsh diebacks then essentially flat, barren spots and depressions as anaerobic decay rots the marsh peat below in high heat. Nichols, in his book *The Vegetation of Connecticut*, (1920) on page 545, tells of areas where vegetation became matted "smothering out the existing plant cover. A rapid decay sets in affecting not only the aerial plant organs but the underground parts as well, and eventually a depression of some depth may thus arise." This and other accounts of the same period for the causation of flat, barren spots which if more organic material prevents oxygen from contacting plant tissue, continues this composting process. This could result in the formation of sulfur –rich pools or pans. Such pools or pans have a frequent grey to white film produced by sulfur-reducing bacteria. Sulfur-reducing bacteria would come to play a larger role in the absence of both cooler temperatures and energy.

In the account for Clinton Harbor/Lower Hammonasset River, George McNeil details how, at the end of his oyster business, leaves and sticks were a constant problem. He described a run-off after heavy rains of 1 to 3 feet of "chaf," partially rotted stems, leaves, sticks, bark and dead grasses. He would explain that this material needed to be raked off the oyster beds beginning March 15 or the oysters would die. They would suffocate and the meats would decompose in their shells. It was easy to tell when this had occurred; black running meats oozed out when the oysters were dredged and a horrible stench was present as well. Such paired shells signify winter death or winter kill but really was not from cold temperatures as most people thought but from suffocation from decaying leaves which still looked like leaves but were black and had started to decompose. Such winter kill in Connecticut was referred to as stools (the connection to the smell is somewhat obvious). Thousands of bushels of oysters would needlessly be wasted in the early 1970s as oyster sets returned to the Connecticut shores. Cultivation scheduling did not occur in many of the closed areas and seed oysters just suffocated. The stools would obtain heavy sets also and grow until another cold winter with heavy runoff containing detritus would kill the oyster bed. This process would continue as the oyster bed now elevates "Into a reef" (Galtsoff 1964).

What was described by George McNeil was that in stormy and cooler periods, this "chaf" is what fed eelgrass meadows off-shore. The "clean and green" eelgrass connotation actually came from Mr. McNeil. To him, the eelgrass looked "healthy" in the off-shore eelgrass meadows that lined both sides of the river channel. It was clean and green, not the furry, slimy, weak blades where in 1978 with Edwin Rhodes, Lance Steward, John Baker and my friend, Brian Sullivan planted our first 10,000 seed scallops. Mr. McNeil described a habitat history for the eelgrass and bay scallops connected to a local barrier beach called the Dardanelles. It would be many years before I would come back to Mr. McNeil for some information about the Dardanelles. After my conversations with John Hammond when he encouraged me to pursue a temperature and habitat history for eelgrass in Clinton waters* I started to closely observe eelgrass populations in Clinton. "The Habitat History of Clinton Harbor – Madison Bay" is found on the Sound School website as paper #46.

The "Bay Scallops Genetics and Transplant Programs To Niantic Bay, 1916 to 1935", is also available on the Sound School website as paper #25. It is an early recollection of the beginning of a productive bay scallop fishery initiated by an influx of bay scallops seed from northern areas such as Westport, Massachusetts.

As habitats became unfavorable for oyster culture, off-bottom culture would be tried in Chatham, Massachusetts with researchers from the Bureau of Commercial Fisheries, US Fish and Wildlife Service and Luther Blount. Mr. Hammond had battled eelgrass and now a new plant, *Codium fragile*, on his oyster grant in the Oyster Pond River in Chatham.

*By the 1790 State Statute that separated Guilford from Old Saybrook and further separated Madison, Guilford did not relinquish its rights to the Hammonasset shellfisheries but instead transferred them to Madison even though some of the land territory would reside in the eventual township of Clinton.

At the end, he also felt that bottom culture was ending and that environments and culture conditions had turned sharply against them, the oyster growers. Mr. Hammond was quite interested in the 1981 Luther Blount study in which oysters were termed excellent nitrogen removers. Although excess nitrogen was problematic, Mr. Hammond continued to believe his temperature and energy connection. In the 1950s, nitrogen did not hang around because it was quickly washed from the coves. George McNeil, at the end of his oystering career in the lower Hammonasset River in Clinton, Connecticut, was fighting huge accumulations of leaves from a greatly rebuilt forest canopy. By March 15, he would start to rake off the thick blanket of leaves that covered the Cedar Island oyster beds. If he did not get the leaves off the oysters, they would all be suffocated often referred to terminal winter kill. That really had no connection to the nitrogen issue. What Mr. Hammond, Mr. Blount and Mr. McNeil noticed was noticed by others as well. They were not alone in observing these changing habitat conditions. As eelgrass spread from Long Island Sound north, fishermen organized to fight it as it was frequently deserved to overtake productive hard shell clam beds. It was particularly aggressive in those estuarine soils; for clammers who used hand equipment in bays and coves, it was especially damaging. They watched as it quickly spread in the 1950s and 1960s into once productive hard shell beds such as Pleasant Bay, Cape Cod, Massachusetts.

Mr. Hammond kept track of its progress north as it extended into southern Rhode Island then in to the Fall River and Buzzards Bay districts of Massachusetts. Fishermen and shellfish managers sought to hold back the advance of eelgrass, first with some drags and chain link cultivators, then with chain cutters once used to harvest the eelgrass for insulation just a few years before (See Appendix for description of Cabot Quilters). Soon, more elaborate machines, described as underwater mowing machines, were used. In the end, as eelgrass meadows extended as they had in the 1880s and 1890s, shellfishermen became desperate. Eelgrass now had changed entire ecosystems, changed circulation patterns, covered and suffocated clam and oyster beds. These control methods now included herbicides 2, 4 – D and salt esters of 2, 4, 5 – T in Canada.

A final effort to restore tidal flushing in Niantic Bay even would resort to using explosives (dynamite) to improve the circulation patterns. Accounts from Niantic Bay at the time described thick eelgrass so dense that it stopped tidal flows. This effort failed too, and the local shellfish commission hired two former shellfishermen to cut swaths of a "clear area" in which the tide could flow (Bob Porter, personal communications 1963 and Mackenzie 1988). It was particularly discouraging to the Niantic Bay scallopers to see eelgrass return. It had died off during the last stages of the Great Heat but with a modest seed scallop transplant from northern areas bay scallops, it took off after the 1931 hot summer, the same year the last eelgrass disappeared.

By the late 1930s, colder weather had made Niantic bay bottoms firmer and several storms had cleaned them also. In the midst of the coldest, energy-filled period of 1951-1965, bay scallop production would soar in New England, in the absence of eelgrass. To see eelgrass return again, shellfishermen wondered why they knew it would harm habitats as it had done before. It appeared to be like waves, first appearing too thick and then completely disappearing. What had changed to bring it back now, to the utter dismay of shellfishermen and fishermen? The answer was temperature.

During the last century, shellfish researchers (Belding, Meade and Kellogg to name a few) noted the negative impact of eelgrass during the Great Heat. This condition would be absent in the 1950s as it grew colder, with winters sometimes even completely covering Long Island Sound with ice.

Mr. Blount's former oyster business would be hard hit by the numerous hurricanes beginning in the 1930s. The last half of the century had large portions of Narragansett Bay bottoms hardened for oyster culture. At first, millions of bushels of oyster shell was used to "harden bottoms," but that was what was needed for oyster culture to be successful. Gravel, crushed rock, cinders and brick waste was used, anything to firm up soft bottoms was used. During the Great Heat, the Upper Bay became famous for the grow-out of Connecticut's seed oysters. The 1950s would end that as powerful waves recultivated once firm bottoms into soft ones. Excess organics from rivers and millions of cubic yards of leaf rot were swept along by surging flood waters and deposited on planted oyster beds. In some cases, it was several feet deep. Many times, eelgrass returned to these shellfish habitats following the habitat change.

George McNeil once described this clearing action of flood waters, squeezed by the hydraulic pressure of decades of accumulated leaf rot as pressing up on a open toothpaste tube. In the case though, the paste was leaf rot and the quote Mr.

McNeil, all of "it ended up on us." After the hot and relatively quiet period, organics built-up in salt ponds, inlets tended to close and "heal" and insufficient energy (tidal flushing) allowed soft deposits to become quite deep in rivers, coves and bays. Eelgrass declines were noted during this same period. The cooler and more energy-filled 1950s would change that; inlets tended to open during this period, barrier beach cuts occurred or re-opened and tidal flushing increased. Cooler water meant a renewed vigor in sediment, as more oxygen-sufficient respiration occurred. Organic deposits built up over decades and melted as it was reduced or consumed by organisms. Into these now cultivated and "cleaned" estuarine soils, eelgrass now grew quickly, filling in areas that also had primarily hard clam beds.

In the 1950s, nitrogen was frequently termed limiting in Long Island Sound and any excess quickly flushed from bays and coves in New England.

When I met John Hammond in 1981, he was putting the habitat pieces together by watching Monomoy and the changing patterns of temperature and energy. Mr. Blount, who I spoke with only a few times was concerned about energy, a powerful memory of the hurricanes and would eventually pioneer oyster nitrogen removal experiments in the 1980s with an off-bottom oyster hatchery on Providence Island, well protected, I might add, from coastal storms. Mr. Hammond was studying eelgrass and its association with green crabs as a temperature link to the plant's reoccurrence. George McNeil urged me to look at the impacts of tidal flushing and organic leaf litter in periods of what he called "stagnation." Each had experienced the wide habitat fluctuations in response to heat and cold, quiet and then energy. All had seen the changes because they lived through them. But what about before, the 1870s?

Mr. Philo S. Beers of Cheshire, Connecticut never would see The Great Heat. He died shortly after writing and submitting his report for the Connecticut Board of Agriculture 1874 Bulletin. A fruit specialist, Mr. Beers details (on page 326) the impacts of the extremely cold temperatures upon his apple and fruit orchards shortly before his death,

> *The winter of 1872-73 was the coldest on record and the mercury sank to a lower point, according to the records kept in New Haven, than for the last one hundred years. The mercury at my house (Cheshire, CT) indicated, on the coldest morning 22 degrees below zero. One-half mile north, and fifty feet lower in the hollow, the same morning and the same hour the mercury indicated 30 degrees below 0. There I had another orchard of apple trees, and many limbs were killed entirely, both on grafted and natural trees; they have not, and never will recover from the effects of that cold morning.*

He continues in his report to include that apple trees planted on hills did much better: cold air sinks and those fruit trees planted in valleys fared the worst during this bitter cold. From the 1870s onward, apple orchards would be planted on hilltops; many still can be found today. That was one of Mr. Beers's suggestions. The agricultural community placed much effort on learning about and predicting climate and storm activities learning from them and adjusting agricultural practices. They had a vital need for this as they were so dependent upon climate and energy pathways. Apple and fruit trees were a long-term investment, and to nurture and care for orchards only to have them killed by habitat choice or climate was of interest to all fruit growers.

In the estuarine and coastal environments, habitat changes also were attention getting. Bay scallop production suddenly surged between 1865-1875. The colder and storm-filled winters certainly reset the habitat clocks for bay scallops, and bay scallop populations suddenly "appeared" from Cape Cod to Long Island New York.[1]

Bay scallops like clean and re-cultivated bay bottoms; they like energy and cold. They seek these areas for the habitats they contain, clear and alkaline marine soils and red coralline macro algae. This energy connection is found in the fishery records, not as detailed or personal as the agricultural community but on (page 570) can be found this reference. "The scallopers will tell you everywhere that the more they raked, the more abundant they became. I heard this from many dredgers myself, and the reports of others contain the same assertion."[2]

This clear and clean bottom, firm or hard habitat preference also can be found in numerous historical references. By 1910, the warm and relatively storm-free period saw the ruin of bay scallop fisheries. The habitat had failed, replaced by summers of extreme heat; bay bottoms became soft, and dense meadows of eelgrass spread from Connecticut to Cape Cod. Summer storms were particularly destructive, the 1898 Portland Gale and the September Gale of 1903 being most notable. A new and different fishery came into being an eelgrass fishery. Eelgrass, the scourge of bay fishermen (except eel fishermen), had spread into the shallow and higher salinity, deeper waters, and every summer storm dislodged huge windrows of eelgrass. The industry consisted of drying eelgrass and selling it to Cabot Corporation in Massachusetts for use in home insulation. (See Cabot's

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[1] The bay scallop fishery from US Fishery Reports, Park XX Pg 505: the oyster, scallop, clam, mussel and abalone industries by Ernest Ingersoll. The section on the Scallop Fishery, section is found on pages 565-580.)

[2] The scallop section Ernest Ingersoll has no less than 22 references to sudden appearance or disappearance of bay scallops which continues into modern accounts.

Quilting in the Appendix.) It could have been harvested in Maine as some reports also mentioned it.

Scallop production surged between 1865-1875 following a series of bitter cold winters and some powerful storms especially in the Buzzard's Bay region. Reports tell of scallop fisheries on the Cape and Islands and a substantial Hyannis fishery (Lewis Bay) in 1877. Although local legend on Cape Cod claims that scallops were consumed as a first food source after the Blizzard of 1888, the Buzzard's Bay fisheries such as Acushnet River and Fairhaven, Massachusetts were substantial two decades earlier and reported by Ingersoll. In fact, the best bay scallop habitats appear to be from Narragansett Bay to Bourne, Massachusetts, the Buzzard's Bay district. River mouths and salt ponds were frequently mentioned as the best locations and Buzzard's Bay contains some of the most favorable areas that could contain bay scallop habitats. It is this area that contains the most interesting habitat history for eelgrass, and it is centered in the Westport River area of Buzzards Bay. Here, determined efforts were tried in an attempt to stop the advance of eelgrass harming oyster, clam and bay scallop fisheries; that reference material can be found in the appendix.

The bay scallop fishery is highly sensitive to warm and low energy habitats and this is currently a period of warmth and low energy. During this prolonged period of warmth after the cooler New England Oscillation (1951-1965) has altered what appear to be natural habitats. Without that long-term habitat perspective, do we have the correct scallop grass? By the time the United States Fish Commission reports were printed in 1887, they recorded the information that occurred during a much colder period, the 1850s to 1870s. The winters then were brutally cold and active with storms which came to be called "Northeasters" or "Nor'easters" today. Our habitat perspectives have been altered over the last century; this can be observed in the scientific literature. We need to acknowledge that what is reported today has been so in the past and historical reviews are very much needed to correctly analyze long-term habitat shifts. The organisms we value today and their assign habitat types change as the habitat that sustains them change.

For long lived species, habitat changes would take years or even decades to notice except for short-lived species such as bay scallops. With unusually short life spans (rare beyond 30 months for scallops), they react quickly to improved habitat conditions and make them a great indicator species for temperature and energy conditions. Therefore, in the historical literature, bay scallops have wide fluctuations in abundance. In the 1870s, during a cold period Bridgeport, Norwalk and Greenwich, Connecticut all supported a large bay scallop fishery (page 577, Section 5, Volume 2, US Fish Commission 1887). But nature had provided this shellfish a particular advantage. It could choose its habitat in which to live, grow and spawn; it could swim. Reports of bay scallops schooling are present in historical records, especially before storms (Ibid. page 568) and also living in deeper sandy shoals (Ibid. page 579). Within its short life span, the scallop needs three distinct habitats; shallow vegetation containing areas, a 4 to 8 foot deep clean to sandy bottoms habitat as one year olds and deep clear areas 8 to 30 feet which supported the large vessel adult dredge fisheries (Ibid. page 579). The larger the scallop, the deeper the water and typically the larger the scallop fishery. Connecticut and Long Island Sound were at the southern limit of this cold water species, but during periods of great cold, the bay scallop fishery even extended into southern New Jersey. It is this fishery that responded to the extreme cold in 1876-77, and it reached its abundance height in Greenwich, Connecticut. It was very cold but by the beginning of The Great Heat, bay scallops declined (Ibid. page 580). The gradual decline occurred as temperature warmed in all New England states; the northern and cooler areas held up the best. By 1911-12, with extreme heat, bay scallop production had plummeted, most notably on Long Island.

The Great Heat (1880-1920), roughly a four decade period in our environmental fisheries history, saw bay scallops decline as warm water and few energy events allowed cove and bay bottom habitats to transition; they were becoming softer and more sediment filled. Scallops quickly declined during this period and many reports concluded it must have been overfishing. However, scallop fishers had very different accounts; the habitat quality had declined. Eelgrass, noticed to be helpful to the younger scallops, was not the preferred adult fishery habitat; deeper clear areas were the best areas and supported a bull rake fishery called a push/pull which had links to earlier Native American capture types. The warmer temperature was changing shallow habitats quickly and in the intense summer "heats" they often stagnated in poorly flushed areas. In the Poquonock River in Groton, Connecticut, dairy farming practices linked excess nutrients to the thick growths of eelgrass to the point of stagnation and black accumulations of soft muck. It was declared a public health hazard and is mentioned in the US Fish Commission Report written by J. W. Collins. Warm periods often see massive habitat changes and especially warm periods with little energy. Shallow areas transition first; they suffer oxygen loss, and tend to go acidic and then anaerobic, producing the rotten egg odor. Organic material tends then to collect as tidal exchange is reduced; inlets and cuts made wider during stormy periods tend to close and fill in. The natural "flushing" tidal change capacity is lessened.

By the time the US Fish Commission Reports were on their way to the GPO (1888), the scallop fisheries were already in steep decline in Connecticut. Greenwich, Connecticut was no longer the bay scallop capital of New England. That privilege had moved north to a new Greenwich - Greenwich by Narragansett Bay, Rhode Island. By the 1900s, only Stonington, Connecticut supported deep water beds, and bay scallops held out the longest in the cooler waters to the north with most of the fishery now on the Cape and Islands by 1915. The Rhode Island Fisheries collapsed under the habitat collapse from the Great Heat in 1905 Connecticut's collapsed much earlier in 1895.

An interesting account can be found in Niantic (East Lyme and Waterford) shores during this period. At the turn of the century, eelgrass became thick in Niantic Bay and the brutal hot summers gave rise to an entire industry – ice production to preserve food in storage required specially built barns with very thick walls- some were packed with saw dust, but over time it would lose its insulating characteristics, and would rot. Eelgrass was found to be an excellent insulating material and during the 1900s, eelgrass became an industry in the Niantic area. At times, according to Olive Chendoli, East Lyme, Connecticut historian, every fence and picket had eelgrass drying on it, abundantly supplied by dense monocultures during The Great Heat. There were no bay scallops. At times, Niantic Bay would stink in the hot August evenings. Eventually the insulating benefits of chopped eelgrass would find its way between paper batts as the first house rolled insulation. Although the rolled batt is still with us, it now has fibers rather than eelgrass blades.[3] It was created to keep ice during a period of intense heat in which eelgrass thrived. Summers grew increasingly hot after 1896, and the supply of eelgrass needed was easy to obtain.

In the 1920s, that would change again. The climate here turned cooler and more energy changed bay bottoms from warm and acidic to cooler, sandy and more alkaline. A "new" algae type now dominated now. Red algae became the true scallop grass, as fishermen tried to tell Nelson Marshall (one of my URI faculty advisors for my Masters program), a noted bay scallop researcher of the 1950s and 1960s. In times of warmth, bay scallops moved north; it just became too warm here. Vegetation grows thick in transitioning acidic sediments. Darker bottoms tend to absorb more heat while vegetation collects silt and leaves from land changes, transitioning habitats all related to climate and energy. Dr. Marshall missed that because he only looked at habitat conditions prevalent during his study. If he had looked earlier, he would have seen the explosion in Connecticut bay scallop productivity in the colder 1860s and 1870s. We had indications of the extent bay scallop habitat range left as shell middens by Native Americans. Scallop shells can be found in all of them over a wide geographic area. In colder periods, bay scallops do well; in times of heat, they do not. We cannot change that. As New England's climate changed, so did its fisheries. The 1920s and 1930s were a transition period.

It grew colder, and storms became stronger and more frequent. Bay scallop habitats changed slowly at first; good quantities of bay scallops now were regular on the Cape and Islands first, then Buzzards Bay and returning next to Rhode

[3] See a brief description of "Cabot's Quilters" in the Appendix.

Island. It had not yet been cold enough for Connecticut's turn. A change in the law (prohibition) would cross its path with that of the bay scallop and Niantic Bay. As the scallop fisheries returned to the north and storms increased, so did the waste of scallops especially seed, which were storm driven up on shores. Hundreds of thousands of seed scallops were wasted but that was natural during this transition process. The silt-covered bottoms now were changing, becoming firmer and "cleaned" of excess organics. Niantic Bay fishermen needed a bay scallop fishery and with trucks bringing a new product north and then south, seed scallops often returned on empty trucks to the East Lyme area. The hope was, like agriculture, seed was needed, and shellfishermen long accustomed to the oyster industry started on unofficial seeding program. For its time, it was significant. Trades were made, and soon up to 100 burlap bags of seed scallops found their way each year into Niantic Bay[4]. It seemed to work and continued to about 1935 when nature seemed to do its share. With colder winters, the decline of eelgrass (long seen to be a detriment to scalloping) Niantic Bay fishermen attributed the return of scallops to eelgrass harvesting and the return of red weed, a highly branched red algae species. (Conversations with Niantic Bay scallopers, 1980s) This is the real scallop grass Niantic Bay fishermen kept mentioning to Nelson Marshall.

An advantage is we now can look before Nelson Marshall's 1950s and 1960s work during the New England Oscillation (1951-1965) to a cold and storm-filled time through now a four-decade long warm period. So from the middle 1850s then into the cold period 1870s, into the four-decade hot period (1880-1920), then again into a cooler 1950s and now a half century of warmer temperatures today, trends can be identified. The simple response is "yes." Bay scallop populations increase in the cooler periods and decline during the warmer in all New England states. Nitrogen has little overall impact; in fact, some local habitats transitioned (failed) faster with thick growths of eelgrass despised by shellfishermen in Connecticut waters. In the colder storm filled 1950s, nitrogen was often "limiting" as it was quickly flushed out of bays and coves. Eelgrass benefits from habitat transitioning to warm and for a period towards cooler temperatures (See Chart #1). At the

[4] At 100 bags/season I estimate that each burlap bag from the oral report I noted about 1,000 seed scallops or 100,000 each year for several years, most likely millions of seed scallop. It ended in 1935 with tougher laws about transporting undersized seed scallopers were afraid they would lose licenses, etc. By 1935-36 however, the scallop fisheries returned, it had gotten cold enough and most likely the seed transplants were no longer needed. As cold returned, storms increased eelgrass declined and Niantic Bay Scallops populations would soon skyrocket. Since Westport, Mass was mentioned as a bay scallop seed source in the 1920s, several years ago I did a short habitat history of the bay scallop population in that community. Apparently large numbers of seed scallops died naturally and continue to get periodically blown ashore there and efforts included raking them doing a beach front, (1990s communications with Karin Tammi of The Water Works). In the 1950s and 1960s, local efforts continued to move bay scallops from shallow water to deeper, apparently to minimize storm losses. This effort was often in the thousands of bushels. A Massachusetts Report titled, A survey of the Marine Resources of the Westport River details transplant activity.

highest heat period, it too succumbs to disease, as noted here a century ago, and in Europe. At the coldest and more severe energy periods, it retreats into areas of lower salinity like protected creeks, coves and bays. During warm and calmer periods, it extends into high salinity areas offshore into dense monocultures offshore such as "meadows." Storms can and do alter those meadows. Eelgrass was seen as a habitat destroyer which it was, but more correctly, termed habitat modifier and something that now had choked Niantic Bay. By 1974, the growth of eelgrass with warmer summers and few storms grew to such an extent that it collapsed the tides in Niantic Bay, Connecticut. The same year, a NOAA – NMFS project would set charges of dynamite to create a channel clear of eelgrass to assist bay wide circulation. [5]

That is only part of the problem; another by product of high heat respiration is acidity in the marine soil itself, which does not smell unless disturbed also but is released as sulfuric acid. H_2S0_3 containing reduced bottoms tend to become acidic over time. Another is a toxic form of the nitrogen cycle is ammonia NH_3, poisonous to fish but a great nutrient to sustain plankton blooms. Higher temperatures tend to produce quickly a huge nutrient supply for plankton "blooms" but not vascular plants. In fact, the continued presence of higher temperature - tolerant bacteria seems to accelerate plankton blooms especially in poorly flushed areas. This acidic bottom condition also made habitats unsuitable (acidic) for other species including winter flounder and bivalves. Eelgrass thrived and became dense on these bottoms, often killing shellfish below.

Fishermen in Niantic Bay and on the Cape were correct to link this eelgrass abundance and leaf compost to winter flounder fin rot disease many years ago (Appendix 1986). As oak leaves, already acidic (tannic acid), accumulated on cove and bay bottoms and rotted in eelgrass meadows this process became even worse.

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[5] In summer stagnant conditions produced huge clouds of sulfuric gas and at night the infamous rotten egg smells of hydrogen sulfide. It had become common knowledge not to park cars under Niantic street lamps in the late 1960s. On foggy nights, the hydrogen sulfide gas would condense on warm street lights producing a concentrated "acid rain drip" that pitted automobile finishes parked below. Similar events were recorded next to the Rhode Island Narrow River salt ponds (Pattaquamscutt Lake shores) during the same period. Most of the nutrients however by this time were runoff from streets, and oak leaves thanks to a new restored/replanted forest canopy.

Nitrogen Cycle: Although few people today raise chickens, the association of the pungent marsh gases to rotten eggs does date back to the turn of the century. Fishermen knew that such prolonged oxygen deficient times were bad for fisheries and they were correct during the time of "The Great Heat." When oxygen levels drop in shallow waters inverse solubility principles kick in. Bacteria in the marine environment reduce organic matter releasing composting products dependent upon bacteria species. Two groups of bacteria compete for dominance – oxygen reducers and sulfur reducers. With sufficient oxygen, aerobic bacteria -- nitro somonas and nitrobacters break down organic matter, releasing eventually nitrate a plant nutrient. Excess nitrogen is "banked" in accumulated organic compost layers we call muck. When oxygen is in short supply, decomposition continues without oxygen and sulfur reducing bacteria take over. They utilize H2S04 hydrogen sulfate gaining the oxygen molecules needed but releasing H2S hydrogen sulfide as a byproduct gas; the infamous warm summer night smell or "stink." At this same time, they release ammonium, a plant nutrient that favors plankton, not macro algae and can lower ambient pH. This ready nutrient supply would plague fishermen as the brown tide blooms ruined eastern Long Island shellfisheries in the 1990s.

Eelgrass traps leaves and organic litter and presents them from flowing out with tide action. Its roots and blades act as a comb trapping leaves and providing it a perfect nutrient base. Runoff of organic leaf litter from road paving has lead to salt ponds and coves filling in with many feet of oak and tree leaves. In times of heat, it has overwhelmed the nitrogen cycle capacity linked to the nitrogen accumulation in reduced mucks. Muck backs up and coves become shallow. Although coastal domestic homeowners have been linked as the "chief cause of habitat degradation," that is simply not the case. This nitrogen is in a soluble form and is quickly dispersed by tides. The increase of trees and pavement (runoff surfaces) together has provided organic debris, leaves, stems "oatmeal" detrital remains that gets caught in the eelgrass labyrinth root system. The thicker the monoculture (meadow) the more it can trap decaying organic matter in its roots, and the faster it can destroy shellfish habitats. This is the nutrient source that generates the most habitat change, not people. Shellfishermen would watch this happen over years and explains the historic negative association of eelgrass to shellfish habitat health. In high heat, poorly flushed areas would reek of hydrogen sulfide smells. "Oatmeal" in coves and bay bottoms sometimes reached extreme levels, and two to three feet deep in Lewis Bay, Hyannis, Massachusetts, was common. (T. Visel personal observation, 1982). This was the same Lewis Bay that a century earlier has supported a large bay scallop fishery.

Shortly after my June 1981 talk for the Rhode Island Aquaculture Association, Bruce Rogers called me about a report regarding seed oysters in the Narrow River also known as the Pattaquamscutt Lakes. They are really two salt ponds restricted by tidal obstructions, some natural and some not such as the road causeway. A Narrow River area homeowner had attended the meeting and called Bruce about moving seed oysters before they all died. It was my belief that most of the productive Rhode Island seed oyster producing areas had been silted over in the 1920s. Curious and having made the crossing hundreds of times, I never imagined a seed oyster capacity. I was wrong; the neighbor described heavy sets of oysters that never matured. In fact, they died at one or two years old, fouled the water and produced terrible hydrogen sulfide smells. I contacted the homeowner and we walked the shores at low tide. We found a tremendous amount of finger-sized seed oysters, but according to the neighbor, since never got that large they usually died in August during hot spells (low oxygen). I raked up huge collections of dead oyster shells set on soft bottoms and on shoreline rocks, short and thin and stunted.

According to this resident, the hydrogen sulfide smells were so intense, it sometimes stained the paint on the sides of area houses. From the depth of the shells, it must have been an annual occurrence for a long time. In hot weather, the upper lakes could go anoxic; that was natural for such a water body. The news did not go over that well, having believed that an aggressive oyster harvest could solve the problem of anoxia (smells), but I could not support that view. The area could support a large seed oyster harvest but I doubted that would end the anoxia. The oysters made it worse; perhaps all these dead oyster meats were decaying but the area was just poorly flushed, something that would also impact Clinton Harbor and Niantic Bay during as discovered reviews of their "habitat histories." In terms of high heat and minimal tidal exchange, you could easily imagine low oxygen conditions and yes, the sulfide smells also. The revelation that it was natural and not easily fixable was disappointing to the homeowner, but no quick easy solution to this problem was evident. I did however make a call to Art Ganz at Rhode Island Department of Environmental Management. A later shellfish survey done of the area did identify large areas of seed oysters.

An Eelgrass Habitat History

Eelgrass by its very biology transitions habitats; it has flowers fruiting bodies which can be spread by water currents and tides. In rough weather, these potential shoots break off and are transplanted by tides and currents to potential new sites. Once a suitable habitat is found, it also quickly gains control. Rhizome spreading its roots are thick and begin to slow currents and trap organic matter. Eelgrass likes acidic bottoms; most bottom fish do not. Fishermen started to notice fish rot and flesh lesions in winter flounder in Niantic Bay as hard bottoms become "soft" and acidic; they linked it to softer, muck-filled bottoms. They again were correct with this assumption. That is why they felt eelgrass "invaded" healthy shellfish bottoms making it eventually unsuitable for shell fishing. It did.

Eelgrass is known to have "overrun" hard shell clam beds in the Pleasant Bay, Orleans/Chatham area in the late 1960s. It quickly replaced other Rhode Island salt pond vegetative types (Virginia Lee 1980) and shares many characteristics of the dreaded invasive plant called Phragmites australis.[6]

Phragmites australis is not a strain from Australia, but is most likely a Mongolian strain imported by the US Dept of Agriculture in 1911 as a potential hemp substitute. Its aggressive habitat changing characteristics of newly disturbed soils, especially on steep grade banks, soon caught the attention of another federal agency, the Soil Stabilization Service in 1920. By 1924, it was planted on the steep railroad rail beds and new highway grades. First experiments with it were in the marshes in the Meadowlands of New Jersey; it would be planted along Interstate 95 in the 1950s in Connecticut. I know this is not going to win me many friends in the

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[6] Phragmites has the ability also to spread by flowers and roots, that's what makes it so successful in also colonizing new and disturbed soils and on salt marshes. If the roots trap organic matter/forming its own micro habitat and quickly displaces adjacent or "native" vegetation types by this process. It forms incredible dense meadows, such as eelgrass.
In many respects, eelgrass is the Phragmites of the shallow composting environments, for until it becomes so dense and so acidic, it too succumbs to disease, mostly molds and "wastes" away, which is natural with such thick monocultures which nature tends to prevent overtime.

eelgrass crowd, but it is not a key indicator species of estuarine health; it is a byproduct of one. In fact, its appearance signals habitat change and so does its decline.

When it is cold, and stormy bays are hard bottom and shelly, red algae predominates and is the true scallop grass as it contains natural setting and spawning agents (chemicals). [7] Scallops seek them out; many papers about this are quickly accessible in the Internet. Eelgrass does not contain the same qualities. While specific habitat services have been associated with eelgrass, especially scallop sets, young scallops prefer coralline red algae and alkaline bottoms, not eelgrass with acidic bottoms. When eelgrass first invades areas, its higher salinity deepwater habitat does provide structure such as the "clean and green eelgrass" (reef surface) but shallow thick, warm areas are poor settlement sites. The truth of the matter is bay scallops prefer submerged Christmas trees as discovered by accident during a fall shellfish survey of the Centerville River in Osterville, Massachusetts in 1981. Here Christmas trees discarded a year earlier were covered with bay scallop set. The highly branched structure, similar to coralline reds tends to keep scallops off the bottom and away from predators. Biologists long ago watched crab species crawl up the eelgrass blades and attack set scallops and consume newly attached bay scallops by the thousands. A follow-up experiment in 1982, again in Osterville, was a string of cedar trees and had tremendous bay scallop sets; in fact "Christmas tree tape" has now been patented as a spat collector and now is available commercially.

In the absence of eelgrass, bay scallop young will set on anything but seem to prefer loose manila rope. That always perplexed Nelson Marshall. How could the Niantic Bay scallop fishery become so large with 450,000 pounds of meat in 1954 without any eelgrass at all? Mr. Marshall was unaware of the energy systems impacts of energy (hurricanes) and colder temperatures impacts upon bay scallop habitat. Red weed, the true scallop grass, came back during this brief period and so did the scallops. Nitrogen runoff also was huge during this period, especially due to many severe flood events. The energy quickly dispersed it offshore and cold water had more oxygen for bacterial respiration; habitats were not composting but were "clean," shelly and free of organic debris. Several Long Island Sound studies conducted in the 1950s describe nitrogen levels in Long Island Sound as minimal or impoverished. When eelgrass reappeared, scallop fishermen dreaded it; they knew that habitats were turning against them. The bay scallop and history from the earlier period still was present among shellfishermen. Some had harvested eelgrass for home insulation decades before. At least one in Niantic Bay area was believed to be a Cabot Quilter®. That is why some retired shellfishermen on the Cape hated it also; it was a sign and not a good one for them. Shellfishermen who caught soft

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[7] A worldwide association between reds, the coralline species that produce mearl, a thick grayish alkaline substance and scallops now exists.

shell clams watched eelgrass kill soft shell clams completely cover quahog bed and suffocate oysters. The accounts from Buzzard's Bay in the 1960s bring these accounts forward in great detail. By the late 1960s, New England fishermen had largely lost the eelgrass battle.

A 1974 paper describes an effort by NOAA NMFS to blast a channel through thick eelgrass to restore tidal circulation flushing in Niantic Bay. A later study (NOAA Technical Report #127 page. 108[8]) mentions this relationship between dense eelgrass meadows and the absence of bay scallops. "Annual bay scallop production in the Niantic River has fluctuated with changes in eelgrass abundance. The River is about 900m (3,000 feet) wide and is mostly 2-2.5m (6-8 feet) deep. When eelgrass was abundant in this confined area, it grew too thickly for scallops and usually inhibited them from attaining commercial densities. After the eelgrass died in the 1930s, scallops were frequently abundant. After it reappeared in the late 1940s, scallops were less often abundant. In recent years, the two towns managing the River have tried to improve the scallop habitat by cutting paths through dense eelgrass meadows." (NOAA Technical Report NMFS 127).

According to Clint Hammond, an oyster grower in Oyster Pond River, Chatham would reverse its policy of view boxes and dip nets for harvesting scallops because the eelgrass meadows became so thick that they stagnated and blades turned black. Chatham selectmen voted to return to hand hauled seed oyster dredges as fishermen realized the "green cutting" benefits to shellfish habitats. (Personal communication, T. Visel 1980s).

Probably the most detailed account of the negative aspects of eelgrass meadows upon shellfish habitats can be found in a State of Massachusetts Report for the Westport River. Here efforts to control eelgrass included cutting, underwater mowing and herbicides.

Before refrigeration and during The Great Heat, (1880-1920), smoking and curing food by salt was a few of the options for preserving food. Eels were smoked and for many, were a special seafood treat. Eels had developed some unique biological traits; the eel absorbed oxygen through its skin. In times of extreme low oxygen levels, eels could seal their gills and utilize specialized skill cells for oxygen exchange into the blood stream. They also had a defense mechanism for acidic low pH conditions found in eelgrass, irritating and lesion-causing in other species. It produces tremendous amounts of mucus to protect itself. It overwintered in a habitat type that few others could endure and when spear fishing fishermen sought

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[8] NOAA Technical Report #127, September 1997; the History, Present Condition and Future of the Molluscan Fisheries of North and Central America and Europe. Volume 1, Atlantic and Gulf Coasts.

out this habitat for eels to smoke, they called that habitat eelgrass for the eels that could live in it.

Many have referred to eelgrass as an important indicator pollution species, the canary in the coal mine, so to speak. During the last century, miners often carried such birds to notify them if mine oxygen levels were low. A dead canary below was sure to set off a panic, but eventually people would go below again and test the mine for life support with new canaries. A dead canary was just that—a dead canary, but what if it was sick or starved or just died of natural causes? We need to reflect upon the role of eelgrass over the long term and not short-term events. A long-term view of eelgrass has a very different environmental (climate and energy) perspective and to shellfishermen decades ago a very disturbing one. It is a signal of massive habitat change largely defined by temperature and energy (storms).

Lack of Harvest Energy

Shellfish closures from bacterial contamination are seen to be more environmentally destructive; it closed the beds and removed critical harvest energy – the raking and scratching from shellfish equipment. The concept of working the bed or cultivating the soil is well known by shellfishermen. When estuarine areas actually needed energy inputs, to remove composting organics, mostly dead vegetation and leaves, it obtained less. Shellfishermen provided critical harvest energy and without it, the valued resources (habitats) collapsed even faster.

H. Karl Rask of the Cape Cod Extension Service summed it up best in a December 1986 paper titled: "The Effect of Hydraulic Harvesting on Sediment Characteristics Related to Shellfish Abundance." Hydraulic shellfishing opened a new door to habitat restoration impacts, similar to coastal storms in a limited way. [9] (H. K. Rask, Regional Marine Resource Specialist Cooperative Extension, Barnstable – December 1986). Here Mr. Rask describes the cascading impacts of shellfish closures and the speed-up of harvesting from no loss declining habitat clocks. Once shellfish areas were closed, the energy shellfish quickly transitioned shellfish producing areas into composting, acidic environments. This described situation was to me on the Cape by a retired oyster grower John C. Hammond. On page 1 of the Mr. Rask's report, 1988, is found this paragraph:

> *In cases of chronic pollution, where there are permanent closures, shellfish are lost unless they are relayed to clean waters for depuration. However, this is not always done, and the closures have made it possible to observe*

[9] Reprinted. In "Aquaculture Today" fall, 1988, Pg 4-8, Getting More From Your Sediment Bottoms – The Effects of Hydraulic Harvesting. H. Karl Rask.

the effects of not harvesting. When the beds are not worked, many areas suffer from increased sedimentation, followed by poor setting and recruitment. Within a few years, only larger shellfish can be found. This absence of seed is a sign of a deteriorating bed, which will eventually die out. A closer look at the sediment often reveals larger populations of worms and other invertebrates, instead of clams or quahogs. Many of these are predators of the newly set seed. In addition, sediments can become anaerobic, sulfurous, or otherwise chemically altered.

The article also describes the positive impacts of marine soil cultivation long witnessed by the shellfishermen in the Bourne area who at one time conducted public demonstrations of the benefits of hydraulic soft shell clam harvesting during the 1980s (T. Visel attended). Shellfishermen knew the "energy" benefits of soil cultivation; they had for the first time a way to turn back the habitat clock and to deliver controlled energy sources into estuarine soils thus reversing acidification. The "new sand or clean sand" comments found in early shellfish research literature always described better shellfish sets, faster growth and improved survival (Belding). Mr. Rask describes this common observation in the article on page 4.

Even before this study was started, some benefits from this type of harvesting were recorded. 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.

Shellfishermen for decades have commented on the positive impacts of working the bottom, removing excess organics, reversing acidic soil conditions, cleaning and increasing soil porosity and removing fines. Many of these principles are part of terrestrial soil cultivation practices. Shellfishermen in the Bourne area had written survey reports of experiments in Buttermilk Bay that started in 1979. Comments pertaining to these experiments can be found in the Appendix. (See Bourne Sandwich 1981 Shellfishing Report in Appendix). This feature would help explain why worked shellfish beds started to pick up eelgrass shoots that over time became thick meadows. These meadows could then trap fines and soils washed from land.

The ability for eelgrass to alter sediment constituents has been known for decades (1988 Fishery Bulletin, Vol. 81 #2 Fonseca et al, NOAA-NMFS-Beauford, North Carolina). In this study, replicated sediment cores in a hard shell clam distribution catch analysis revealed that in the sea grass bed (80% Zostera marina) sediment size “shifted substantially towards finer size classes” (page 430). Marine soils high in fines tended to have reduced poor water circulation and created a thinner oxidized layer and therefore making them more susceptible to heat including anaerobic respiration. One of the consequences therefore could be a natural lowering of sediment pH beneath eelgrass meadows that combines with higher organic loadings by the blades of eelgrass plants themselves.

In an ironic twist, the very nature of eelgrass to raise elevations by trapping silt particles and organic leaf litter may create conditions that accelerate its decline. Eelgrass meadows often bury previous swept and clean sandy soils transitioning them into soft organic rich areas. In shellfish surveys of Niantic Bay and Clinton Harbor in Connecticut and Pleasant Bay in Massachusetts, I found dead clams (shells still paired) under eelgrass. In Pleasant Bay, it was dead quahog Mercenaria clams, but in Clinton Harbor and Niantic Bay, it was buried Mya (soft shell clam) beds. Shell under eelgrass exhibits extreme shell softening by low pH conditions. Eelgrass slow currents and reduce the flushing capacity retaining nitrate and ammonia in poorly flushed areas. It is this sulfide rich, low pH condition that eventually renders the soil unfit for eelgrass roots; periodic energy inputs such as barrier beach breaks allow energy to re-cultivate marine soils. Rinsing them of organic acids and the cycle commences once more. Systems that contain barrier beaches, such as Pleasant Bay, Niantic River and Clinton Harbor contain a habitat history of barrier breaches and energy cycles. This is quite evident on Long Island also, and some bayman interviews made available by the US Army Corps of Engineers – Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York makes the point directly.

> *Bayman Interview: One baymen stated, “No flushing makes a dead sea. Quantuk Bay, between Moriches and Shinnecock Bays, is always brown. The flushing is not good in Quantuk Bay, and in the summer the brown tide percolates and turns the water brown. There is seasonal shellfishing in the winter months, but you can’t make a day’s pay, and the clams don’t look healthy. There is not enough oxygen for the clams on the bottom. Clams need to have a frequent flushing over them, and a soft and clean bottom without silt build-up. Dredging occurred in the 1970s in Quantuk Bay. Suffolk County had two dredges back then, but one has been sold. After dredging, productivity was high for at least 10 years. The year after the breach, in the spring, there was an abundance of clams. After the breach was closed, the clams were gone. Houses are being built on drained salt marshes where clams used to grow. This bayman’s major concerns were the loss of habitat for both fish and shellfish, which use the estuary as a nursery, and an increase in pollution, which further damages the remaining habitat.*

He believes additional flushing in the bay would stabilize conditions enough so that marine organisms would flourish."

Summary

In cold periods, deep water eelgrass does provide habitat services to many fin and shellfish species. However, the "clean and green" eelgrasses in oxygen sufficient cooler waters are relatively rare today. Instead, we often have mucky or silt covered flats with eelgrass that continues to transition habitats by trapping silt and increasing the relative elevation. It buries and suffocates previous shellfish habitats. Cape Cod shellfishermen noticed this transition and despised eelgrass for this habitat degradation. Sandy areas tend to reflect solar energy, but eelgrass beds absorb it, creating shallow hot spots which lower oxygen levels impacting marine soil pH and sediment respiration. Winter flounder flee these areas in high heat (personal observation T. Visel, Niantic Bay). Areas to the north of Connecticut had scallop fisheries persist into the 1970s and 1980s before organic accumulations on bay bottoms also overwhelmed sediment respiration. In coves of low organic debris influx and good flushing, shellfish habitats persisted but those with huge runoff and high organic loadings soon had soil sulfide levels soar.

In times of warmth and few storms, a reduced habitat energy pathway tends to favor reduced flushing; inlets tend to close; warm water has less erosion impacts than cold dense water. This can be seen along most New England sandy beaches. In the summer, sand bars move closer to shore, creating these hazardous rip currents for swimmers. As waters turn colder, denser water erodes the sand back to its winter "profile." We can see and measure this impact because it occurs over a few months. Habitat changes that take decades of observation and are recorded over time by a relatively few other than the fin and shellfishermen who fished them.

While much attention has been placed upon eelgrass, I urge great caution. Eelgrass by its very nature changes swept/non-composting habitats into composting ones. It can alter energy; it reduces wave energy and tidal flows and thereby accelerates habitat changes. Although similar to other submerged aquatic vegetation such as kelp forests, its life history mirrors invasive plants. This dual reproductive pathway and responses to nutrients swept into cove and bays from land runoff and is very much connected to our current long term climate and energy impacts. During colder periods and much storm energy, any habitat benefits from eelgrass are very different than during prolonged warm periods with few energy events as the one we are in now. References to this impact has been recorded in the literature numerous times (Belding, Kellogg, Collins, Meade).

Early shellfish biologists often made mention of eelgrass as they also encountered it. While clams could exist in eelgrass, especially at its margins, it is a transitory existence. Eventually, it also will succumb to habitat transitions. In a 1905 US Commission of Fish and Fisheries (George M. Bowers, Commissioner for the year ending June 30, 1905. Part XXIX; James Kellogg, Professor of Zoology, Williams College in a report of the Conditions Concerning Existence and Growth of the Soft Clam Mya arancia this statement is on page 198.

> *In the eelgrass (arenaria), which grows between the tide lines as well as below, clams may also sometimes be found, but they are not numerous; like the thatch, the eelgrass prevents the erosion of the bottom, but also probably makes it impossible for the clams to obtain a large amount of food, and, moreover, such areas contain a large amount of decaying vegetable matter.*

In regards to eelgrass and bay scallops, a much frequented habitat association apparently may be incorrect, a false assumption based upon an incomplete understanding of marine habitat succession or "clocks." A world-wide association apparently exists for scallop species and biochemical elements found in coralline red algae. Investigations are underway for maerl and most particular by the red algae containing attractors/setting agents for several species of scallops. Red algae prefer swifter tidal currents, deeper and more alkaline bottoms like those often found in more energy prone areas and cooler temperatures. In times of habitat transition, these habitat clocks cross one another (see Chart #1), and give the appearance of a habitat relationship, while in fact, there could be none. I believe red weed is the correct scallop grass (Agardhiella subulata).

Could this be the "red weed" that scallop fishermen kept telling Nelson Marshall during his report in 1960 "Studies of the Niantic River, Connecticut with Special Reference to the Bay Scallop, Aequipecten irradians? I suspect it was, and my personal conversations with Nelson Marshall at the URI School of Oceanography in the early 1980s confirmed this aside. It also perplexed him. When eelgrass left Niantic Bay, scallop productivity increased, tremendously. During his study, the Niantic Bay vegetative favored a red species thought to be Agardhiella subulata and on page 93 of the previous 1960 study confirms a much different habitat profile.

"However small branching red algae made up the bulk of the vegetation and were abundant almost everywhere except on bottoms swept clean by scouring currents." Conversations (T. Visel) with local scallop fishermen tell of "money dung," a grayish sticky deposit that sometimes would come in push pull rakes while scalloping. This sticky grayish mass, I believe it to be maerl, the byproduct of red algae coralline species and today only found offshore.

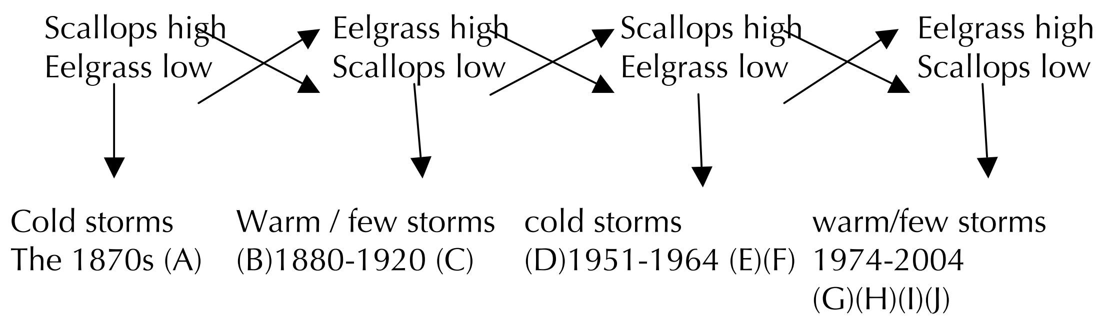
For years, Nelson Marshall studied these red algae and its ability to catch a set of seed scallops is noted in his 1960 report on page 100. "It was evident that the small branching algae observed to be very abundant throughout the river, were heavily laden with attached scallops. In this connection it is noteworthy that fishermen of the Niantic River refer to such algae as scallop grass."

In the late 1960s, eelgrass grew thick again in the Niantic Bay as it once had during the warm period (1880-1920) typified by the Great Heat Wave of 1896. By 1972, only twelve years after Nelson Marshall's paper, eelgrass had become so thick that it had stopped tidal circulation in large areas of the Niantic Bay. It had become warmer and eelgrass quickly spread into marine soils cleaned during the 1950s. The bay scallop fishery was not alone in missing the connection between energy and warmer temperatures during The Great Heat.

The connection between summer energy events and oyster sets would go unnoticed for over a century. The Portland Gale (1898) cleaned and moved tremendous amounts of estuarine oyster shell. The Connecticut oyster set in 1899 was heavy and delighted the oyster industry. It was to be the set of the century! The connection between the storm and oyster set was missed by researchers but not oystermen. The 1900/1901 oyster sets were a failure and the oyster industry grew nervous by 1902 (Kellogg, 1905). In 1903, Connecticut saw the September Gale of 1903 and the 1904 oyster set was very heavy. These gales washed out shell, cleaning vast oyster setting areas, and they also cultivated near shore areas for soft shell clam sets. The soft shell clam sets following these gales are legendary. The sets in the North River (Massachusetts) and Clinton Harbor (Connecticut) were huge in 1902-1904. Blue crab populations during the Great Heat surged, and the rapid increase of blue crabs was mentioned in Rhode Island reports. Connecticut's best blue crab year this past century was 1912; it would hold for almost a century. In 2010, Connecticut experienced an unprecedented blue crab year. These summer storms, however did nothing for bay scallops, or lobsters for that matter. They were rapidly declining in response to this region-wide habitat change.

The year 1905 had Southern New England lobster stocks in a free fall, and Rhode Island has the distinction of being the only New England state to close its lobster fishery then. The Great Heat and the period following would see several habitat reversals kelp cobblestone would increase and eelgrass would decrease (much evidence that the denser growth of eelgrass during the Great Heat lead to diseases both part of a natural cycle of abundance tied to energy and temperature). Although much has been written about eelgrass and its habitat services, the environmental community would be well advised to reassess habitat roles of eelgrass indexed with energy and temperature as quickly as possible. While nothing of the scale of fusion in a bottle or the alleged biography of Howard Hughes, in times of heat and ample nutrients mostly from leaf litter and few storms, eelgrass degrades habitats that support shellfish resources that the public values and connects to eelgrass returning. For environmental policy, it is a real Jekyll and Hyde depending upon climate temperature and energy.

Chart #1 – Habitat Responses of Climate and Energy Pathways
Four Recorded Habitat Reversals 1870-2004
For Bay Scallops and Eelgrass



(A) Habitat conditions as noted in US Fish Commission Reports – Tremendous Bay Scallop production in New York (Long Island and along Connecticut Shoreline). Leading scallop producers, Norwalk, Bridgeport, Greenwich.

(B) David Belding's Work on Cape Cod – Acidic soil conditions – the Great Heat, Ingersoll reports on choking eelgrass growth in the Poquonock River, Groton, CT – US Fish Commission Report.

(C) James Kellogg – notes on eelgrass (1903) Rhode Island sees Scallops Return after two bitterly cold winters and storms (1923). Eelgrass now harvested for home insulation 1896.

(D) Nelson Marshall childhood recollections – Niantic Bay Scallops return to Niantic River (1935) – Bay scallop transplants by fishermen begin in the 1920s, heavy sets occur in 1924.

(E) Nelson Marshall notes habitat shifts as bay scallop production soars in the absence of eelgrass (1955) but numerous hurricanes. Niantic Bay bay scallop production records highest population in 1955. (Cold period and the number of storms record setting.)

(F) The Town of Westport, Mass. Applies herbicide 2-4-D in an effort to eradicate eelgrass and applies tons of lime to battle low pH conditions killing clams in 1965. (See appendix)

(G) Fred Short documents wasting disease in Niantic Bay (1986) NOAA NMFS earlier uses dynamite to help clear choking eelgrass beds in Niantic Bay (1974).
(H) Phil Swind, noted Cape Cod author and shellfishermen comments on the negative aspect of eelgrass upon clam habitats (1981). Also, first reports of eelgrass overrunning hard clam beds – Army Corp of Engineers Reports in Pleasant Bay, Cape Cod, 1965.

(I) Dense vegetation kills oysters in Clinton Harbor, 1985, winter flounder show high prevalence of fin rot disease, New Haven Harbor, 1982. Oyster Pond River, Chatham Mass. Huge accumulation of eelgrass, 1982-83 suspected to be causing winter flounder fin rot disease.

(J) Anoxic conditions persist in Niantic Bay winter flounder fishery collapses 1988; bay scallops end after a brief return to Niantic Bay following Hurricane Gloria, 1989. Connecticut winter flounder fishery collapses – coast wide 1992.
Note since 2004, our Connecticut winters have turned slightly colder, a continuing trend would favor "red weed" and the possible return of bay scallops.

In the transition periods scallops and eelgrass both occur, with overlapping habitat clocks. This gives the appearance (however wrongly) that they need each other. (Chart #1) Following the Great Heat, Niantic Bay scallops returned to incredible densities (1954-1955) during a period of no eelgrass and unbelievable storms. This perplexed Nelson Marshall. Rhode Island officials expressed shock at the rapid increase of bay scallops as winters turned bitter in the 1920s, believing wrongly that such cold and violent winters should yield poor results but the exact opposite was happening. They were amazed at the huge scallop crops after bitter cold storm filled winters. The 1924 Rhode Island bay scallop crop was in excess of 300,000 bushels.

How did shellfishermen in four states almost identically describe habitat conditions for shellfisheries? The fact was to fully explain these habitat shifts a long term look is needed at environmental habitat history. What did described is their fisheries experience and some oral histories (accounts) that spanned two generations or more?

Two consistent accounts persisted, the recent increase in softer/vegetative bottoms, the decline over time of swept, hard bottom or clear areas free of vegetation.
John Hammond of Chatham MA and George McNeil of Clinton, CT mentioned both temperature and energy, some mentioned temperatures, while others mentioned storms or energy.

This study attempts to describe historical climate and storm cycles to habitat quality and therefore fisheries abundance for bay scallops. But, it has more questions than answers. A detailed appendix follows.

Eelgrass as several published accounts that illustrate is not always a positive shellfish habitat indicator for bay scallop oysters and clams; in fact it is often a negative one and the views expressed by small boat baymen in four states three decades ago were almost entirely correct, in current vernacular, "they nailed it". A review of the historical literature research fisheries and the environment is urgently needed. I hope this paper will further those discussions. Comments always welcome, email tim.visel@new-haven.k12.ct.us

Addendum

Mr. John "Clint" Hammond made me take the plans off his oyster scow in January of 1983. Mr. Hammond had cultivated oysters on his Chatham, Massachusetts grant for decades and he had just recently retired. He borrowed a skiff and took me across The Oyster Pond River in Chatham to view where he and other growers would skid these oysters scows in and out of the salt marsh across from his oyster shops. Mr. Hammond's favorite scow was beached in the marsh, and after a long July morning (several cups of coffee) I had offered to sketch one his oyster scows. It was now January. I'm the last one, I recall him saying and although well into his eighties, he was nimble in the skiff, he picked a stone to step on but I picked a tree rail – a primitive railway made of wood slipped and took a spill into the river – watch it he said, wood is slippery here. So cold and wet I took the plans, why, because he wanted me to "print them up" so a new generation would "know how to do it."

The scow was among 3 or 4 others and in the best of shape – the others were badly rotted - I soon realized was among the equivalent of old tractor field, the ones farmers have abandoned, that no longer work, but won't let go – an old friend of a time with so many memories that are now gone – sketch it, he called out "its getting cold" (it was!) so I did the sketch. It is available at the end of the presentation. He like many others of his shellfishing generation was anxious to pass on his knowledge and his shellfishing experiences to others who were interested.

He felt that my generation had no sense of history, his research was the history of the barrier beach that formed Chatham's easterly edge to the Atlantic Ocean, Monomoy. No one else it seemed to him was interested in the shellfish ecology. Mr. Hammond had spend decades studying Monomoy and the temperature and energy impacts its to near shore habitats. To him he had a front seat to the largest war on earth a habitat war, the struggle between land and sea and the fruit of which he and others had cultivated shellfish. Much of this paper is about his unpublished research into the impacts of temperature and energy pathways upon shellfishing habitats. I credit Mr. Hammond with the concept of a habitat history and his concerns about Zostera marina, eelgrass.

Problem Statement – Fisheries History The Forgotten Discipline

It is difficult to ascertain why this view history has been almost entirely overlooked, ignored, or forgotten. Part of the explanation has been the practice of completely missing the impacts of tidal energy and temperature upon these shallow waters environments in general, however they both are long considered oceanographic study essentials? Other factors may include the public policy environmental concerns as they relate to climate change storm "damage" or the decline in resource productivity (fisheries) both of which are subject to short term value judgments. Both of these responses however are insufficient, we keep land records of temperatures and storm history. We have related clocks of 50,100 and 500 year storms and flood events. We had mapped flood plains and wetlands. It would seen logical therefore that habitat histories of the sea, should be as important as land. What we have here is the equivalent of completely missing the dust bowl three times over 150 years, many books have been written about that disaster. It would seen logical therefore that habitat histories of the shore and marine soils, should be as important as land. The shallow habitats which are keys to several recreational and commercial fisheries have undergone tremendous habitat changes and we missed it. We don't know our fisheries habitat history and without it errors have been made, some large others minor.

The truth of the matter is we have made public policy mistakes regarding several species such as bay scallops, lobsters and winter flounder and that has been worsened by multi decade environmental policies. This is especially true for the habitat history for eelgrass. These policies govern (regulate) bottom disturbance only as negative impacts and often portray current environmental, conditions such as diminished resource abundance attributed only to negative human involvement, namely nitrogen pollution and frequently overfishing. That eclipsed much of the information that history could have provided us. The principal cause of harm to Long Island Sounds living marine resources this last half century is not water pollution, it is temperature governed by climate linked to energy pathways (storms). During the past century we have seen dramatic changes in species abundance that were largely out of our purview. We may find by objective analysis that many of our inputs although sometimes negative will appear minor in regards to climate and energy. When the New Haven Harbor breakwaters were built it had lasting environmental changes – loss of natural oyster bed sets unforeseen by the builders. When the bar that splits Niantic Bay from the river was stabilized that also would change the ecology there that we are just now beginning to understand. I also realize that I ask much to put aside many of the environmental norms of the past half century and most of the coastal habitat studies of the past three decades. I can only hope that this will open up the discussion of climate and energy roles in fisheries habitat quality for both inshore and offshore ecosystems. It's just not always about "us."

As an educator, I believe we owe it to the next generation of students to provide them as much information as possible. To completely ignore the historical negative habitat consequences of eelgrass during warm climatic periods is to compromise the realm of scientific study itself and may eventually lead to the alienation of the benefactors of public resources spent for the public good – which includes seafood consumers and seafood producers.

While the environmental community often champions the value of eelgrass it is a natural habitat modifier and often changes what seafood producers and consumers "value" into something that they do not. The shellfishermen of the last century often blamed eelgrass for the loss in shellfish productivity around it but eelgrass was doing what it does best, invade and dominant previous "habitats." We need to completely understand this natural succession habitat parameter. We have today so mingled resource values and "regulatory science" to a point that often excludes non human causes and effects for any under desired environmental (resource) outcomes. Into this mix enters the environmental values of the last century – protection and conservation and today's quest for sustainability. It seems in the quest to protect the environment we have greatly diminished our capacity to understand it. That is how we got to this point and it is not a great place to be.

The Environment and Us

An environmental consensus of the past few decades has focused much attention upon us, as the chief modifiers and destroyers of coastal areas. For example, many reports claim that fisheries have declined because we overfished them or habitat quality has lessened because we polluted them. The fact is some fisheries declined and we had nothing to do with it, although decreasing pollution isn't in itself a negative management goal but to link it with a decline in resource abundance is often self serving from a regulatory perspective. Some fisheries have increased and some have collapsed, but all have had habitat impacts both positive and negative that we cannot control.

Most coastal ecologists if pressed will admit to the role of energy (storms) in habitat creation and succession, two long recognized key biological knowns. But not many will describe the positive impacts of coastal energy into near shore environments, (unpopular) nor discuss long term habitat sustainability of man made energy pathways – such as periodic dredging (unnatural) because they do not fits today's mainstream environmental values and beliefs. Sustainability is only possible when work (energy) is applied to marine environments. Energy is largely governed by temperature or climate. In other words the greatest modifiers of shellfish habitats is largely outside of our regulatory governance. While we continue to regulate the smallest energy or disturbance factors that policy is in itself not natural. Our coastal environments are recipients of coastal energy hurricanes/storms as terrestrial environments have forest fires or floods and also their habitat byproducts such as the Nile River Delta effect. After certain energy events some habitats are improved while others are destroyed. That is natural, it is unnatural not to have energy. When you block or alter energy pathways such as the many eastern Connecticut railroad causeways you have severe habitat consequences. Those causeways dramatically altered the habitat clocks for winter flounder in those areas.

Much public concern was aroused by anoxic conditions of Long Island Sound in the late 1980s, but in times of heat and few storms anoxic periods is a natural occurrence. With rivers carrying nutrients from land during periods of few storms and high sea water temperatures it would be unnatural not to have anoxic conditions occur. This type of information is only available from a long term view of environmental conditions indexed with climate and energy (storms). This long term environmental history is not only missing from today's environmental discussions, it does not exist at all.

When bottom disturbance only became negative and protection of coastal habitats entered a regulatory phase we looked for examples or indicators of past regulatory misuse. Eelgrass was a known identity largely because of the work of Nelson Marshall in Connecticut (Niantic Bay) and it seemed to be perfect analytical measure upon which we could draw habitat connections. Eelgrass was mapable, accessible, been the subject of forage studies for bird life (Brant) a century ago and seen as a bay scallop essential habitat. Very quickly it became a hero to people trying to restore fish and shellfish populations and that desire evolved into an effort to fulfill a regulatory mandate. Instead we selected a species which transitions habitats – often at the expense of much publicized beneficial attributes. Quite simply we picked up the aggressor in this habitat war not the vanquished in need of assistance (restoration). This is a harse reality but the urge to produce a victim after the Coastal Zone Management Act soon became too irresistible, and by doing so we ignored most of the terrestrial features of habitat change widely accepted as scientific research. What we need to do now is to take a step back and review basic habitat ecology – it's not always just about us. When regulatory and research initiatives mingled with the belief and value discussions of pollution, and protection public policies needed anchors (justification) for regulatory change and one of those anchors become eelgrass. In the rush to fulfill environmental regulatory agendas we lost sight of the disciplines of biology, climatology, but most importantly history. If we had looked at history some of the issues surrounding eelgrass would have come to light. In the early 1900s when it was hot, eelgrass formed dense offshore meadows. When it turned colder and stormier, 1951 to 1965 eelgrass declined as storms destroyed offshore meadows. Instead we focused upon us – it had to be our fault, it must have been something we did, when the simple reason was it got cold and energy levels increased, eelgrass soon followed. When it got warmer soils "failed" and eelgrass declined.

This is how this eelgrass debacle occurred. We lost our sense of history.

We need to review all three biology, climatology and history. For too long we have ignored the first bay watchers – our fishers that could provide a view into this habitat conflict even from records of the last century, but we just ignored them. When the early shellfish researchers themselves had questions or concerns about eelgrass we failed to cite their research. Although we built facilities to replace lobsters a century ago, we threw out their records. When winter flounder fishermen caught flounder – with necrotic lesions, catch restrictions were enacted not habitat studies about what was happening to winter flounder habitats at the time. Some fisheries collapsed because their habitats collapsed when we narrowed our view we lost sight of this big picture. This is something we must do, we need to take a broad look upon a plant species such as eelgrass that attempts overtime to create dense monocultures. We need a long term environmental fisheries history for other Long Island Sound organisms and we need it quickly.

Tremendous public expenditures for Long Island Sound and other Sounds are at stake – to be in the best public interest, all views should be represented even if they are sometimes unpopular or seem to be inconsistent with current environmental regulatory beliefs and values. We also need balance in the public policy regulatory sphere.

In 2010, Connecticut had the best blue crab year in almost a century – at times unbelievable catch rates were made along our coves and bays but that event went unreported. To my knowledge not one article appeared from any Connecticut organization about this. Our lobster fishery is at lowest level not seen also since the last century that has had tremendous coverage and in the press media. We need to bring both messages and its not just about us, we have soon good news and not so good news.

The general public – the ones we ask to help keep Long Island Sound a viable and productive ecosystem need to know all we can provide them. They need hope that what we do as a vested interests will benefit our society that it makes, economic/employment sense and actually helps the environment. They need to trust the scientific community, that trust unfortunately in my estimation needs strengthening.

A Sense of History

New England Shellfishermen in the 1950s and 1960s along with resource managers then would do battle with eelgrass. The future as it turned warmer and less energy, however contained even more powerful foes (1970s) saw sea lettuce, Ulva and spaghetti weed (1980s) a Gracilera species choked many harbors. In 1987, enteromorpha grew so thickly in Clinton Harbor it became a hazard to Boaters at night, hydrogen sulfide smells were strong. According to Gary Wikfors of the NOAA (National Marine Fisheries Service (1987) an outbreak of bloom of green seaweed in Clinton Harbor was linked to temperature he describes the impact of thick growth of enteromorpha, a filamentous green algae, when an unknown combination of water temperature and light produces a thick spawning and growth. But, area fishermen offered a different explanation, one that has been part of the Clinton Harbor Habitat history for centuries that may have enhanced the event. In a July 30 1987 Hartford Courant article, titled, "Thick Green Seaweed has Clinton Harbor in its Grip," George McNeil, formerly of New Haven and a retired oysterman, and Jack Andrews, a local lobsterman and member of a long time Clinton fishing family, mentions habitat changes after a barrier spit inlet was closed in the Cedar Island area:

> George T. McNeil, an oysterman in Connecticut for more than 61 years, said he has seen nothing like it before.
> "I started to notice it a couple of weeks ago," McNeil said, "and now it's all over the place."
> McNeil, who cultivates the last oyster bed in the inner harbor, said he was afraid the growth could hurt the bed.
> He explained that when oysters spawn, the spat or juvenile oysters must settle on clean shell to survive.
> McNeil said he has noticed the growth covering the oyster shells in the bed and could think of no way to remove the growth without disrupting the oyster bed.
> Jack P. Andrews, owner of J&J Lobster on Commerce Street, said lobstermen and recreational boaters have had boat motors clogged by the slimy green growth.
> Andrews said he grew up by Clinton Harbor and had never seen or heard of anything like this.
> He said a possible reason for these types of abnormal plant blooms in the harbor could be the closing in the 1930s of a harbor inlet called the Straits of Dardanelle.
> Fishermen and residents say that when the inlet was closed, the flushing action of the tides was disrupted between the harbor and Long Island Sound, allowing decaying organic materials to build up in the harbor.

Finally in the middle of the warmest period (1990s) Connecticut fishermen learned excess plant nutrients now almost constantly released by sulfide reducing bacteria fueled explosive plant blooms of the low carbohydrate containing algae – the browns. In the 1980s, you could see a brown band along Connecticut central and western coastlines. It was worse in New York bays here shellfish simply starved to death. The more nutritious algal feeds important to bivalves was displaced and shellfish died by the millions. For some Long Island New York baymen it was 1914 all over again. That was during a period often referred to as The Great Heat following the 1896 Great Heat wave which devastated New York City. It would have devastating impacts to bay scallops, winter flounder and lobsters also.

- For in depth study of the damage these two species could do please review comments by fishermen from Chatham MASS and Clinton, CT in the Appendix.

This period is not that widely discussed today, it happened over a century ago and we just forgot. But, The Great Heat would define coastal settlement, pollution control policies and fisheries management for the next century. The Great Heat would collapse the Southern New England Lobster Fishery and the bay scallops but would stimulate the oyster industry and softshell clam fisheries. In the colder and storm filled 1950s and 1960s lobsters and bay scallops recovered, soft clams retreated into deeper coves and bays. The oyster industries were devastated by colder temperatures and numerous strong storms.

In 1981, I assisted Edward Wong of the EPA with a shellfish survey of Mumford Cove, Groton, CT. Thick lush growths of sea lettuce died and rotted, releasing the hydrogen gas at night which made coastal residents anxious. Something was happening and many blamed a sewage outfall for nitrogen contamination and shellfish closures. The flats also contained enormous quantities of Mya, the soft shell clam and economic justification could be made for relocating the outfall (which was done in 1987) if the shellfisheries were reopened. Part of the study included cores, some five to eight feet deep. These were examined later. In 1982 I also arranged from Edward Wong to tour a shellfish project in Old Saybrook (Oyster River) then part of my master thesis at the University of Rhode Island. Mr. Wong greatly assisted my research while attending the University of Rhode Island. When we toured The Oyster River I mentioned the Mumford Cove survey, he said that any chance of reopening the clam beds was now stalled, they found viable red tide cysts under several feet of organic muck and sandy/shell layers (I believe the sand shell mix occurs during storms). It was somewhat of a concern – that bringing red tide cysts to the surface was harmful (chance of blooms) but that wasn't all, they had found remnants of a different diatom mix and that Niantic and Clinton cores has also shown red tide cysts or something very similar. When I questioned him about the finding, he said they tell me that this (layers) represents periods of Connecticut's past when it was extremely hot in these coves – it got colder and the cysts left a record of past hot periods.

That information, the evidence of previous hot and cold periods were combined with historic events from the oyster industry, also included storm energy related events. Definite patterns were emerging but I was unable to pursue this issue for many years – until now. Much of the research here was presented to me by Mr. Hammond during those Cape Cod visits. It would take decades for me to believe and finally comprehend what he was saying.

To anchor this climate to energy habitat research, I also needed an indicator and that became bay scallops long recognized to be both a cold water short life span species, but what about the habitat history for other inshore fisheries. That defined the habitat proposal to the Coastal Coves and Embayment Board in 1986. We needed historical reviews for finfish and shellfish populations for a century or more – a long term effort to examine in details the effects of temperature and energy upon coastal habitats – a habitat history indexed to temperature, catch and storm energy reports. We needed to know what had happened in these shallow bays and coves and how that impacted near shore shallow habitats. That is what Mr. Hammond also felt that needed to be done, similar to his Monomoy research was just a glimpse of a much bigger ecosystem "story." The largest example of a habitat history to him was eelgrass – the changes after a colder and storm filled era was observable. He had watched and talked to fishermen in Connecticut about eelgrass. He followed how it spread in the southern waters first spreading into the Rhode Island and then into the Buzzards Bay district, finally to Cape Cod in the late 1960s.

To accomplish this research, I have reviewed dozens of state and government publications, much of it from them 1880-1920 period known as The Great Heat (from the heat wave of 1896) and a cooler, storm filled period often called The New England Oscillation roughly 1951 to 1965. Here the Icelandic low was particularly "robust" and created stormier and colder – New England weather. Many longitudinal sea water temperature mention this unusual "cooling" during this period.

The 1950-1960s are particularly of interest as it contained shellfishermen who once used to harvest eelgrass as a crop when it was extremely abundant during the pre depression decades (Cabot's Quilters). Eelgrass is a fascinating plant worthy of our study but highly habitat aggressive in transitioning marine soils. It is those some alkaline and bivalve shell containing soils that obtained huge clam sets after storm activity. This is why I have urged caution until we know more about root soil chemistry interactions and linking eelgrass to enhanced shellfish populations, even for bay scallops. There is even a chance promoted by Mr. Hammond that eelgrass will prove to be invasive carried to our shores as packing fresher for live crabs and shellfish (see appendix). In fact, several people have agreed with trips and vessels back and forth for so many years it would not be a surprise at all for this to be true. Mr. Hammond's conversations centered around as eelgrass spread northward as storms abated vast acreages of sandy acid free soils were now suitable habitat. Shellfishermen watched they did not like to see these extensive meadows because some had harvested eelgrass during the Depression, others were bullrakers (quahog clammers) while still others scallopers.

Dense eelgrass meadows often made shellfishing impossible a frequent complaint in the Niantic Bay area in Connecticut. Eelgrass returned to the southern areas first, being warmer so eelgrass flourished in the Niantic and Mystic Rivers spreading in the Pawcatuck and Southern Rhode Island salt ponds by the late 1940s, and with it spread green crabs. Noticeable in the southern areas at the turn of the century its presence was seen as a serious soft shell clam predator later also for the hard shell clam. As eelgrass spread into the Buzzards Bay and northern areas so did the green crab all the way to the Canadian Maritimes. To John Hammond, the spreading eelgrass gave it cover during the day sheltering it from fish and bird predators, to him they were connected. Although green crabs had been spread to the Cape with the first Chesapeake Bay oyster bedding stock, he felt populations were localized and small. To him what had happened was more like an invasion – green crabs moving north in large numbers wiping out soft shell clam beds along the way. When I showed him to the letter to the Madison Shellfish Committee dated February 5, 1953 from Victor Loosanoff, he became very excited by it. His letter mentioned the movement north of green crabs in the Massachusetts and coastal Maine regions, and Mr. Hammond felt the eelgrass and green crabs were more that a happen stance; it was a relationship that had gone on for centuries, perhaps even longer further and one that benefited the green crab as it expanded its range into New England. In the Oyster River in Chatham, Massachusetts he had watched green crabs and the eelgrass. In areas with cobbles and vegetation it was natural cover but rocks, ledges and crevices were also good. Eelgrass provided large extensive habitat "bridges," it allowed green crabs to live in areas that just a few years before, were clean swept sandy areas, modern day "habitat corridor" so to speak. Every wave of eelgrass came with it more green crabs. But this wave was different (1970s); it followed an unusually storm filled period – numerous hurricanes and strong gales that "cleaned out" many coves and rivers of built up muck. It was colder so bottoms were "sweet" alkaline and not "sour" acidic.

Eelgrass soon spread into shellfish habitats and with it, a new pest, green crabs came by the thousands. If eelgrass was the "tanks" than green crabs were the infantry to Mr. Hammond. His comments about habitats turning against the shellfishermen – more weed, warmer temperatures and softer bottoms would mirror those winter flounder fishermen found in the eastern sections of Connecticut during the late 1970s and 1980s. Here fishermen felt, local fishing spots once firm and shell covered also had changed. Niantic Bay and eastern Connecticut coves were becoming sediment filled and covered with rotting leaves. Fishermen felt that after the 1950s, the bottoms had changed. So many fishermen in eastern Connecticut came forward with similar stories of former hard and shelly bottoms that were now soft and mucky. It is becoming apparent that a wide-spread habitat failure for winter flounder occurred in southern New England after the New England Oscillation 1951-1965. Winter flounder need clean, alkaline and shelly bottoms for optimum juvenile growth and survival. Acidic, oxygen depleted environments are poor for winter flounder. In 1982, a winter flounder study for Schooner Inc., of

New Haven found incidence of fin rot – necrotic flesh wasting disease in areas were as high as 42% some of sampled in New Haven Harbor winter flounder. A decade later, winter flounder populations fell to historic lows.

Some of my own University experiences guide this research I have done some shellfish surveys in Clinton Harbor, Connecticut in which eelgrass smothered soft shell clam beds as described by George McNeil and also found dead hard shell clam beds under dense eelgrass meadows in Pleasant Bay on Cape Cod as mentioned by John Hammond. Winter flounder fishermen fishing in habitats covered by eelgrass linked it to fin rot disease (eelgrass stagnation) decades ago in Niantic Bay. Shellfishermen often had a much different view about Zostera. We need to know more about its apparent habitat transitioning capacity, therefore my review and concerns.

This work would have not been possible without the help of several shellfishermen, now largely gone. They were kind enough to take to explain to me their experiences and beliefs about shellfishing. I will always be grateful to them. At the time, I did not always fully appreciate the wisdom and experience that was provided and my apologies. In fact some of the oral histories I did not fully appreciate until recently when John "Clint" Hammond a retired oyster grower on Cape Cod told me they used herbicides on eelgrass in Pleasant Bay, I did not believe him. When a Rhode Island fishermen from showed me his fathers deep water bay scallop dredge, I thought at the time such a fishery was impossible. When George McNeil informed me in 1978 that placing bay scallop seed in shallow water eelgrass was probably the worst place to plant such seed, I doubted him. Sorry to all, I was wrong.

The State of Massachusetts did use herbicides to fight eelgrass, Rhode Island did have a huge 1870s deep water bay scallop fishery and shallow water silt/soft dense eelgrass meadows are not good for bay scallops.

Before people start looking for clubs I did not come to my findings quickly or without some investigation. Just the opposite is true, the last three decades I have spent thousands of hours researching and reading historical manuscripts reports and books. Unfortunately, this is a ride for which there is no safety seat – only bumps, it is long and hard. No one is completely responsible for any particular blame for this – I do not do this research for that, there is no blame, we went down a road it was a dead end – that was all. Time to turn around and try again. Our environmental future depends on it. But to understand the future, we must know our past. We need to research and distribute our environmental fishery history to the public and I can add something of a personal note, the public has to be able to read it. So much of the material today is difficult to understand, compared to that of the century before. I look for the Land and Sea Grant Universities to fulfill this objective.

Finally, we need less fear, fear of losing funding is a chief cause for this neglect of history. No one it seems is willing to pay for it, no less even store the materials. Funding today has an outcome link and that outcome is detailed in the grant proposal "guidelines" often with a specific goal or purpose. Nelson Marshall whose 1947 study of Niantic Bay started this eelgrass/bay scallop association mentioned this in his last book. Much of what gets funded today is not research as Nelson Marshall generation described it but contractual/consulting arrangements. In Dr. Marshall last book, In The Wake of a Great Yankee Oceanographer, of which I suggest reading he comments to this situation as no longer "publish or perish," but a far more dangerous grants or gone. Teaching and basic research at public Universities has been relegated to the sidelines when instead that was once its primary public mission. We have lost sight of that and society does pay a price for this competitive grant process. On page 144, Nelson Marshall wrote about his concern for the lack of research funding.

> "As brought out in these discussions, the principal investigators in research institutions and graduate programs in the United States need to seek funds from government or other outside sources to cover a substantial share of their operating expenses. The quest is for grants, or for contracts which serve essentially as grants, and, in some cases, consulting arrangements relating to the investigator's research interests. Commonly, the support to be obtained must cover the salaries of any technical personnel working on the investigators' projects, the assistantships and related expenses of any graduate students they may be sponsoring, a wide variety of operating and equipment expenses, and, in many cases, at least some percentage of the principal investigator salaries. Since the money available from funding sources falls far short of the need these days, this search is a very frustrating exercise. Of necessity, very good proposals are often turned down and the only resource is to apply to numerous support groups and to revamp proposals, trying over and over again. Thus, to keep their programs alive, very capable scholars are spending countless hours and energy preparing proposals at the expense of time that might far better be devoted to their ongoing work. And other aspects of the funding limitations may come into play. For instance, the disproportionately large numbers of those involved in biological studies means more competition for their share of the remaining amount available.
>
> On day, after grim news about cuts to federal agencies supporting research, I overhead a younger scientists say: "I expect next year will be a 'twelve-proposal year'." And to make things even more difficult, there is increasing pressure to provide assurance that any research proposed will lead to practical results. This new emphasis on the applied reminds me of a faculty

> member who, discouraged with present day demands, said in desperation: "Where can one go to get support for just plain curiosity-driven research?"

In three decades I have never seen funded research products contradict the funding source, never. My URI statistics teacher would collapse if he heard that because that's just not possible. We need to look at that, especially when public funds are involved. Science should not be a customer client relationship connected to a public policy outcome. If that happens science as we know it is compromised.

NOAA Fisheries Milford Aquaculture Seminar

Do We Have The Correct Scallop Grass? A Habitat History for Eelgrass Zostera Marina in New England Coastal Waters

Reference Section for The Milford Paper – February 2012

Comments about Eelgrass and Shellfish during The Great Heat 1880-1920

Niantic Bay, Connecticut

To supply an industry that purchased eelgrass Niantic residents cut and harvested immense quantities for the eelgrass insulation batt – dried and chopped eelgrass (1920's) was collected and dried and almost every Niantic fence and yard – trucks would bundle eelgrass for a plant in Massachusetts or used for soil fertilizer locally. But Scallops soon appeared in cleared areas (Olive Chendoli, Retired Niantic Bay Scallopers, Personal communications 1984-1987). A series of chain drags cut free eelgrass and scallops returned to these harvested areas. Encouraged by this appearance of a few adults in the cleaned areas seed transplants from Massachusetts were implemented. By 1935 eelgrass was gone and scallops returned in large numbers.

Cape Cod, Massachusetts

Eelgrass – growing conditions for the hard clam David L. Belding – 1910 – A report upon the Qhahaug and Oyster Fisheries of Massachusetts.
"Natural conditions – eelgrass – the soil exerts an indirect influence on growth by the abundance or scarcity of eelgrass, which if thick prevents the free circulation of water over the bed – the presence of eelgrass is not necessarily an indication of slow growth, as it only becomes a detriment when thick enough to interfere with circulation."

Cape Cod and Buzzards Bay, Massachusetts

Eelgrass growing conditions for the Bay Scallop – The Scallop Fishery of Massachusetts David L. Belding 1910.

"In observing the catch {landed by scallopers} it is noteworthy that the larger scallops always came from the deep water or channel, while the smaller were taken in the eelgrass or shallow water. The shallow water scallops are much smaller, usually proportionally thicker and have not the large eye, and fine appearance of the channel scallops. The difference in growth is not due to the mere change in the depth of water but to current. The channel scallops on clear bottom received better circulation of water than in the eelgrass which cuts off nearly all flow of water."

All Waters South of Cape Cod

A Report Upon The Soft Shell Clam Fishery of Massachusetts By David L. Belding (Date)

"Eelgrass as we have seen is fatal to a good clam bed. Many productive beds would be quickly spoiled by eelgrass if it were not for constant digging. The grass raises the surface of the bed above the normal level by bringing in silt, which smothers the clams. The reclamations of such flats can be accomplished by destroying the grass and allowing the water to carry away the accumulated muddy deposits. At Newburyport {Mass} an eelgrass flat with a surface layer of soft mud was converted in a productive hard flat by digging."

Poquonock River, Groton, Connecticut

Notes on the Oyster Fishery of Connecticut by J. W. Collins, U.S. Fish Commission Bulletin Vol 1X 1889 22- Notes on the Oyster Fishery of Connecticut pg 477-26 the Poquonock method. "The Poquonock oyster on driven brush caught and grew oysters but eelgrass caught among the brush spot collectors stopped the tides and the river "fouled." There are several reasons why it has not proved entirely successful among which may be the collection of large quantities of eelgrass about the flats at the mouth of the stream, causing stagnation of the water and producing such conditions that Board of Health of the town has caused the bushes (spat collectors) to be pulled up and destroyed."

Connecticut Injury to Oysters – Known causes – J. W. Collins

39 – Stagnant Water - "Injury to oysters by Stagnant water is comparatively rare. The only place where Mr. Steven son found this had occurred was on the Poquonock River in the Town of Groton. There the current is checked by eelgrass and during hot weather, it sometimes becomes peculiarly offensive and causes the death of the oysters within the limits of the Stagnant Water." Pg 483.

In the time of The Great Heat Bay Scallops in the Poquonock River did not exist but oyster sets were tremendous as waters cooled and energy increased the Poquonock River would become Connecticut's second largest producer of bay scallops – in the 1940s – 1950s thousands of bushels of bay scallops would be harvested here and oyster sets become rare or non existant and witnessed a familiar exchange between colder and warmer tolerant species.

New England Waters - The Shellfish Industry by James C. Kellogg 1910

The Soft Clam – Page 302

Masses of dead eelgrass, which were barely floated at high tides, also remained on the beds {soft shell} for days at a time during the summer.

Setting – edges of currents. "Two such areas, for example, lying under parallel and sharply defined currents that were separated by a dense matt of eelgrass, were nearly two hundred yards wide – figure 61."

Great South Bay (New York) – James C. Kellogg 1910

The Hard Shell Clam was also impacted by mats of seaweed but could be easily raked off (page 326). A greater concern was apparent system wide set failures – during The Great Heat organics and lack of storm related cultivation of marine soils most likely created acidic low pH conditions unfavorably for any large hard clam sets. But Kellogg never made the link and blamed like many others researchers during the period on over fishing, on pg 323 can be found this paragraph.

"The Hard {Shell} clam, like Mya, has suffered a marked decrease in numbers during the last few years. In 1898 a single company that had been marketing ten thousand cans of hard clams daily for years, was compelled to abandon the Great South Bay of Long Island for the Carolina sounds, because of an almost complete failure in the supply. Most other bottoms where hard shell clams were formerly abundant have failed because of excessive digging."

What we know today is that it got so hot in these bays that soil pH dropped to extremely low levels at night killing vulnerable hard clam veligers. Great South Bay as others bays during this hot spell experience clam set failures – 1890-1896. The growth of oysters however greatly improved. The next four decades would see remarkable changes for Great South Bay (New York) with cooler ocean temperatures and increased storm activity (highlighted by the Hurricane of 1938) these soils and habitat transitioned back and the hard clam fishery rebounded. In the 1950s tidal exchange increased, inlets widened and the built up organics of The Great Heat period were dissipated – hard clam production soared often mixed with relic remaining oyster shells from the oyster era which proceeded. With greater salinities oyster predators also greatly increased namely the channelled whelk and starfish.

Comments about the New England Oscillation – the Advance of Eelgrass 1951-1965

After some devastating eelgrass monocultures of the early 1900s eelgrass fell victim to mold and fungal inventions which is a common occurrence with species that tend to create terrestrial like monocultures. It appears from European accounts to be a natural cycle – climate and energy dependent, heat stress and declining soil chemistry. Storms (such as our Hurricanes) would rip up offshore meadows only to return when temperatures rose and energy levels lessened.

The 1950's would see coastal New England experience numerous gales, Northeasters and hurricanes – the 1950 to 1960 period amount of energy applied into New England shallow waters is legendary – then it stopped and the cleaned, cultivated soils lay exposed to the enormous eelgrass reproductive capacity – but oral history existed within the shellfish community remembering extremely well the "trouble with eelgrass" from decades before. Shellfishermen and shellfish managers at the time planned and implemented a spirited but unsuccessful defense of shellfish habitats, which included under water mowing machines, use of cutting bars, cutters with chains, herbicides 2-4-D and even explosives in Niantic Bay, Connecticut. These efforts to battle the eelgrass were all unsuccessful and perhaps nowhere was this "lost cause" so well documented than in the Buzzards Bay Area of Massachusetts. Almost every shell fishing area from the Rhode Island border to Buttermilk Bay on the Cape had eelgrass return in great meadows (monocultures) and then impact the local shellfish populations. It was devastating even in the more northern Cape areas of Pleasant Bay – Chatham/Orleans, Massachusetts. Here eelgrass overran like a conquering army entire hard shell clam beds. John Hammond spoke of the last stand before the eelgrass advance at Pleasant Bay Cape Cod - -1970-71 in which chemicals used in Vietnam were possibly deployed in a failed final effort.

No community had more to lose than the shellfishers of the Westport River Massachusetts. Here a state financed report titled "A Study of the Marine Resources of the Westport River" Department of Natural Resources Division of Marine Fisheries documents in great detail the attitude towards eelgrass overrunning clam beds and impacting scallop populations. Sections of the report are reproduced here so that readers of this account may have a better understanding of what eelgrass meant to this shellfish community in May of 1968.

* Need confirmation from State of Massachusetts.

THE COMMONWEALTH OF MASSACHUSETTS

Department of Natural Resources

BOARD OF NATURAL RESOURCES

Thomas a. Fulham, Chairman

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DIVISION OF MARINE FISHERIES

A Study of the Marine Resources of the Westport River is the seventh in a series of monographs initiated by the Division of Marine Fisheries in 1963. These reports relate the extent and value of the marine resources of the major bays and estuaries in Massachusetts. (page 32).

The major factor limiting quahog abundance seems to be lack of favorable bottom. During the past decade eelgrass has been rapidly spreading on bottom areas which were formerly productive in quahogs. Quahogs sampled in eelgrass areas have reflected poor growth suggesting that the dense eelgrass interferes with circulation and food supply to the quahog. Soft bottom and dense eelgrass is especially obvious in the west branch of the river. The tendency toward less forceful ebb and flow of the tide in the west branch may be associated with hydrographic changes which have occurred with the gradual filling in of the lower harbor. Future dredging projects may bring about hydrographic changes which will favor the ecology of the quahog. (page 31).

It has generally been acknowledged that current, or circulation is of major importance to the growth of the scallop, although certain studies in recent years

(Cooper and Marshall, 1963) have suggested that current may not necessarily be the main factor accounting for the condition of the scallop. While no extensive sampling was conducted in the Westport River to compare the size of the scallops from areas of good and poor circulation, the shellfish officer and fishermen have reported that scallops growing on the flats among dense growths of eelgrass are considerable smaller in size than those growing on the adjacent relatively clean channel bottoms. On September 23, 1966 biologists made a survey of scallops occurring on an extensive shallow eelgrass flat in the west branch of the river. This sampling occurred about one week before the opening of the scallop fishing season. The average size (dorso-ventral height) of 60 scallops gathered in the area was 54.8mm, or about 2 3/16 inches. The "eyes" were notably small and not of commercial quality. Because of the small size of the scallops and the density of eelgrass in the area which hampers dredging, fishing during the scallop season was confined to the deeper areas further downstream in the estuary. (page 31)
Eelgrass.

Below mean low water, eelgrass (Zostera marina) is the most prevalent vascular plant growing in the Westport River. In recent years eelgrass has been rapidly spreading in the Westport River just as it has in other protected bays and estuaries of Southern Massachusetts. In moderate density, eelgrass is beneficial to many forms of marine animals. For instance, bait fishes and the juvenile forms of large species find shelter amidst the eelgrass clumps. Young bay scallops, upon reaching the setting stage, anchor themselves to the grass blades. Decomposing eelgrass forms detritus which is fed upon by many mollusks and crustaceans. (page 43).

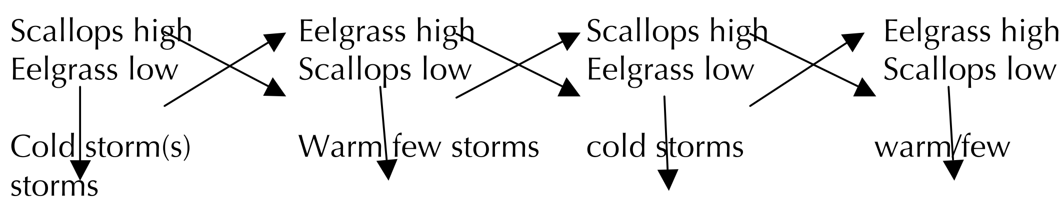
Detriment to shellfisheries also occurs when dead eelgrass accumulates in dense mats and smothers beds of shellfish. (page 44).

Because of the increasing growth of eelgrass on shellfish beds, considerable research is presently being conducted to find an effective method of control. To date, no attempted methods have proven themselves completely practical. One town on the south shore of Massachusetts has attempted to cut eelgrass with an underwater mower designed for cutting submerged vegetation. At best, this method is only temporary since the plan stalk is cut off above the substrate surface leaving the stems and roots to produce new growth. Experimentation by various agencies with herbicides is presently being conducted. While certain chemicals such as 2, 4-D have effectively destroyed eelgrass, the toxicity of the chemicals to associated fauna is not clearly known. Similarly, it is still not known to what degree herbicide residues may accumulate in the live bodies of shellfish within and adjacent to the treatment are. Further investigation and analysis may pave the way for future practical and safe us of herbicides in the estuarine environment. Until such time, no herbicides should be introduced indiscriminately into our coastal bays and rivers. (page 44).

An experimental attempt was made in 1961 to improve bottom conditions in areas void of shellfish by applying lime. Fifty-two tons of lime were spread over 12 acres of the river.   During that same year fishermen were hired to dredge and remove starfish from the river. Similarly, dredges were used tin 1962 to thin out blue mussels which had become a problem by encroachment in mats upon valuable quahog producing bottom. (page 30).

The blue claw crab is a species which were formerly abundant n the south shore of Massachusetts but has been declining in numbers for a t least the last decade. Such decline has also been observed in waters south of Massachusetts. Jeffries (1966) noted that the blue crab began to decline in Rhode Island in the mid-1930's and that by 1938 they had diminished to the point that it was no longer profitable to fish for them commercially. The cause of the decline of this crab in our waters is unknown. Many fishermen along the shore have expressed the belief that the loss of blue claw crabs- also fiddler crabs (Uca spp.) is due to the careless use of pesticides in coastal areas. While it is certainly possible that pesticides have had a detrimental effect upon crab populations no conclusive evidence has been documented in this regards. (page 39).

Chart #1 – Habitat Responses of Climate and Energy Pathways
Four Recorded Habitat Reversals 1870-2004
For Bay Scallops and Eelgrass



The 1870s (A)   (B)1880-1920 (C)   (D)1951-1964 (E)(F) 1974-2004 (G)(H)(I)(J)

(A) Habitat conditions as noted in US Fish Commission Reports – Tremendous Bay Scallop production in New York (Long Island and along Connecticut Shoreline). Leading scallop producers, Norwalk, Bridgeport, Greenwich.
(B) David Belding's Work on Cape Cod – Acidic soil conditions – the Great Heat, Ingersoll reports on choking eelgrass growth in the Poquonock River, Groton, CT – US Fish Commission Report.
(C) James Kellogg – notes on eelgrass (1903) Rhode Island sees Scallops Return after two bitterly cold winters and storms (1923). Eelgrass now harvested for home insulation 1896.
(D) Nelson Marshall childhood recollections – Niantic Bay Scallops return to Niantic River (1935) – Bay scallop transplants by fishermen begin in the 1920s, heavy sets occur in 1924.

(E) Nelson Marshall notes habitat shifts as bay scallop production soars in the absence of eelgrass (1955) but numerous hurricanes. Niantic Bay, bay scallop production records highest population in 1955. (Cold period)
(F) The Town of Westport, Mass. Applies herbicide 2-4-D in an effort to eradicate eelgrass and applies tons of lime to battle low pH conditions killing clams in 1965. (See appendix)
(G) Fred Short documents wasting disease in Niantic Bay (1986) NOAA NMFS earlier uses dynamite to help clear choking eelgrass beds in Niantic Bay (1974).
(H) Phil Swind, noted Cape Cod author and shellfishermen comments on the negative aspect of eelgrass upon clam habitats (1981). Also, first reports of eelgrass overrunning hard clam beds – Army Corp of Engineers Reports in Pleasant Bay, Cape Cod, 1965.
(I) Dense vegetation kills oysters in Clinton Harbor, 1985, winter flounder show high prevalence of fin rot disease, New Haven Harbor, 1982. Oyster Pond River, Chatham Mass. Huge accumulation of eelgrass, 1982-83 suspected to be causing winter flounder fin rot disease.
(J) Anoxic conditions persist in Niantic Bay winter flounder fishery collapses 1988; bay scallops end after a brief return to Niantic Bay following Hurricane Gloria, 1989. Connecticut winter flounder fishery collapses – coast wide 1992.
Note since 2004, our Connecticut winters have turned slightly colder, a continuing trend would favor "red weed" and the possible return of bay scallops.

The Story of Cabot's Quilt – 1893 Eelgrass Stitched Kraft Paper Batt

Extracted from the Samuel Cabot Company® History

During the Great Heat (1880-1820) eelgrass would support two industries, acting first as an insulating material for barns and ice houses, long a place for sawdust packing (keeping cold in). In the extreme heat, sawdust would get wet and occasionally smolder, similar to pouring a bucket of water on hay bales. Worse, the sawdust in these thick ice barn walls would begin to rot. Secondly providing income for hundreds of people cutting, collecting and drying eelgrass for resale for home insulation (keeping warmth in).

The story takes a turn, either Samuel Cabot, a graduate of Massachusetts Institute of Technology (MIT) learned of eelgrass insulating value in homes or ice barns and set out to make a commercial product or saw piles of it washed up on beaches and thought of a practical use.

According to company history: "No one in Massachusetts shore could think of a use for eelgrass, which got in the way of boats and swimmers, resulting in huge ugly piles of the stuff on the beach."

Some reports indicated Cabot's fascination with the high silicon content of the leaf which would not oxidize when wet (a huge advantage over saw dust) and would not alone support combustion. Others comment and that the long strands could be stitched so as not to allow them to settle in the bays of framed houses (previous materials would often fall to the bottom leaving a good portion of the bay with no insulation). With heavy Kraft® paper layered between dried eelgrass held in place by stitching and "Cabot's Quilt" was born. That was the summer of 1893, three years before the record breaking heat wave of 1896. That year the product found a huge and "eager market" and became one of Cabot's primary products until 1945.

Fiberglas® and polyester resin fibers invented in 1938 would become cheap after the war economy and a new company Owen/Corning® captured the insulation market, with the same heavy Kraft® paper backing. Reports linked the last Cabot Quilt production to the spring of 1946.

Times had changed for eelgrass, however, a slim mold and devastating hurricanes had greatly diminished the Buzzard's Bay supply, at the end Cabot was paying $35 dollars a ton for dried eelgrass. The cheaper product, "Fiberglas®" pushed eelgrass quilts out of the market and the eelgrass fishery came to end.

Two decades later eelgrass meadows would come back in force to plague shellfishermen. They were ready; some of the fishermen in the 1960s were the "quilters" of the 1920s. They already knew about eelgrass and made preparations to fight it. It was quite a fight.

Appendix

Pleasant Bay Survey Report

Department of the Army

New England Division Corps of Engineers
Waltham, Massachusetts
November 1968

From: Floyd B. Taylor
Region l Program Chief
Water Supply and Sea Resources Program

RE: New Inlet for Nauset Beach, Cape Cod
Appendix F-16

To: John Wm. Leslie, Chief
Engineering Division
New England Division, Corps of Engineers
424 Trapalo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie,
This will refer to your letter of 30 August 1968. There is attached a report on the subject by Mr. George Meyer, our Assistant Regional Shellfish Consultant. Our principal concern is with shellfish harvesting for Pleasant Bay. This Bay is almost entirely open for this and has an outstanding shellfish resource.

With respect to the questions you asked, we find:

1. The proposed changes which would decrease the water depth, thereby increasing bottom area affected by solar radiation, could result in additional eelgrass growth. However, increased circulation of the bay water could diminish the growth of eelgrass. Spreading eelgrass has been noted in Pleasant Bay to be taking over quahog setting and growing bottoms. Also, too much eelgrass is deemed a detriment to scallop fishing, while too little is also harmful. We conclude that the net effect will be little change.

Page 6 February 10, 1983 VILLAGE ADVERTISER

EDITORIAL

TOO MUCH EELGRASS? **"Working Bay Bottoms"**

I was pleased to read Mr. Nawoichik's letter in the February 3rd edition of the Village Advertiser commenting on Mr Dow's January 20th article about shellfishing. One thing was mentioned in both the articles regarding how beneficial eelgrass is in our bays. I wonder how many studies have been done on eelgrass, codium and other grasses when they become over abundant?

In the Hyannis bays, the over abundance is more than obvious by the huge windrows piled high on the beaches, the nuisance caused by blocked marsh ditches as well as the considerable expense to the town to remove it each year.

If great amounts of eelgrass are the criteria for good crops of shellfish, then certainly this area should produce extremely well each year. Just the opposite is the case and it appears that other towns up Cape from Barnstable are experiencing the same effects. In some of the bays, the eelgrass and codium are slime and silt covered, greatly reducing the flow of nutrients to the shellfish. This silt laden mess is certainly not preferred as a setting place for shellfish as they leave the veliger stage. When the roots finally get so thick that they crowd one another out, the losers decay; and with no oxygen in the soil create gases that shellfish cannot live in.

I have glassed the bays on the south side of the Barnstable for a third of a century and when I started, there was very little eelgrass, no codium, and small amounts of floating grasses. We had a good crop of scallops each year, were allowed a bushel of oysters per week on our family permit as well as a peck of clams and quahogs. As the grasses closed in, silting became much more noticeable. The oysters had no place to set except on the stones, shells or grass at the shore's edge and this area is periodically blasted by severe winter weather and most oysters are frozen and lost. Finding very few areas to set, scallops have greatly diminished in numbers and are found in small places where the bay floor is grass free. I would assume that the grasses will again get a blight as they did in the nineties and twenties and a more balanced shellfish situation will return.

During the late 1920's and all through the 30's, there were unbelievable amounts of shellfish and finfish in our bays. This was a period of practically non-existent eelgrass. I realized that weather conditions during that period were the reasons for such unusual shell fishing because the predators were greatly reduced but also the bay floors were clean, creating a fine environment for shellfish and finfish to live on and in.

It is time to talk facts about our bays, their potentials and the wise use of them. There can be a very good shellfish resource there and with cooperation from the shellfishermen, users of the waterway, and the shore owners, this could be accomplished. The shellfishermen, by continually working the bay bottoms, prepare the soil for future crops by realizing predators' eggs and destroying predators living there. With some help from mother nature in the eventual reduction of grasses and some work by the shellfish department when the time presents itself,
all could enjoy much better fishing.

John B. Farrington
50 Fire Station Road, Osterville.

D.E.P. Public Hearing Comments by Tim Visel
July 9, 1986

{Re-keyed on October 2006}

PROPOSAL:
The regulations of Connecticut State Agencies are amended by adding Section 26-159a-8 as follows:
(NEW) Section 26-159a-8. Winter flounder.
The taking of winter flounder by any method from the waters of the Niantic River upstream from the highway bridge on Route 156 during the period December 1 through March 31 is prohibited.

COMMENTS:
A staff member of the University of Connecticut Marine Cooperative Extension Service observed that he was also very concerned about the winter flounder populations in the Niantic River.
"I have been working with the East Lyme and Waterford shellfish Commissions for two years. There has been a major die-off of (eelgrass) algae near Camp O'Neill. We have examined it, and it would seem the cause is a brown algae of a filamentous type that is blocking sunlight so it cannot reach other plants. I agree there has been a significant change in the vegetation. I believe it is related to a more serious problem, and that is the accelerating eutrophication of our estuaries, and I would like to direct the DEP to two 'side studies,' not yet completed. One, we are finding that the buildup of organic matter on the bottom is very acidic and can produce fin rot in flounder. Secondly, there seems to be a greater abundance of algae and higher oxygen debts due to the increased buildup of organic matter on the bottom. I feel that we should look at dissolved oxygen content and eutrophication of the sediments. I don't believe this has anything to due with the (Millstone) sampling program."

The staff member of the Sea Grant Program further noted that, over the last few years other states have experienced environmental degradation of their salt ponds and coastal rivers, and have totally lost their flounder resources. Also, three salt ponds on Cape Cod have gone completely anaerobic, two on Martha's Vineyard, and several large salt ponds in Connecticut have been lost; Holly Pond is one of the largest ones.

"I think we should initiate a habitat restoration program. You can turn some of these areas around. There has been some work done by Clyde MacKenzie down in

New Jersey, where he found a strong correlation between pH, shellfish beds, organic matter, and flounder. I think we have lost a lot of our shellfish beds in this state and we have lost a lot of flounder habitat, too."

J. C. HAMMOND
PLANTER AND WHOLESALE DEALER IN

CHATHAM OYSTERS

CHATHAM, MASS 02633
"Home of the Pedigreed Oysters"
106 Main Street December 31, 1978

Mr. Robert Wallace
Wellfleet Shellfish Warden
Wellfleet, Mass.

Dear Mr. Wallace:

Thank you for your time in talking with Mr. John Richards and myself last Friday. I had wanted to meet you and also to inquire about a report by Mr. Richard Nelson of the Cotuit Oyster Co. that Wellfleet was having a high mortality in its oyster crop.
After talking with you and also with Mr. Howard Snow relative to the oyster mortality I have come to the following conclusions:

Because of an extremely heavy growth of the Green Algae, Ulva lactuca, (Sea Lettuce), oysters at Wellfleet were smothered and particularly those of large size, which because of their larger size may have come in more direct contact with the weed which laid heavily upon them. All shellfish such as clams, oysters, scallops and mussels, require a considerable amount of oxygen to sustain life and when dissolved oxygen is absent in the water shellfish soon die.

The next question is – Why is Wellfleet experiencing such a luxuriant growth of this weed? Ulva and similar algae are stimulated by the presence of additional nitrogen compounds. Nitrogen is scarce in sea water. For this reason, Ulva and its relatives are often found in particular abundance at locations of moderate pollution. Mr. Snow informed me that pollution is entering your harbor from Duck Creek. Are there any other sources? Leakage from storm sewers, cesspool seepage, and agricultural runoff would favor the growth of Ulva.

One of the best known cases of this kind occurred on Long Island some years ago when nutrients from various duck farmers entered Great South Bay causing excessive vegetative growth that put the oyster industry out of business there.
It appears that it would be well for you to make a thorough investigation of any sources of pollution into Wellfleet harbor.

If you can get pollution stopped by yourself, I urge you to do it. Otherwise the whole Wellfleet Harbor may be quarantined by the State Environmental Health Department. Yours for less Ulva and more Ostrea virginica.

Annoted Reference Section

Nelson Marshall – The Scallop Estuary, The Anchorage Publisher St. Michaels Maryland (1994)

Page 42 "Perhaps the scallops prospered in the Niantic River in spite of, rather than as the result of the loss of Zostera. It is well known that the very young scallops need a surface such as the blades of eelgrass to attach to when they first settle out of the water columns. It is not as widely appreciated that they can settle on a variety of alternatives about as well we found them attaching to the filamentous red algae – Agardhiella, that grew in abundance where the eelgrass had disappeared. In other words, nature provided a substitute attachment surface."

Phil Schwind – Making a Living Along Shore International Marine Publishing Company Camden, Maine 1976.

The original bar or box scallop drag. This is probably the first scallop drag – it is now outlawed in Chatham, MASS for no known reason. Page 74 (1976). Note: According to John Clint Hammond – this was not a bay scallop conservation measure but a protection measure for eelgrass (Personal communication T. Visel).

Chatham reverses ban eelgrass got to thick, killed scallops – not enough storms to flush it out – John Hammond - Chatham.

In a Sounds Conservancy Inc. September 1989 publication "Planning for Sea Level Rise In Southern New England" John Matthiessen mentions this habitat war – on pg 13, chapter 2 "Stabilization versus retreat." "Many areas where it has been decided to attempt to stabilize the coast rather than retreat have become battle grounds between man and sea. Man may be able to fight the sea to a draw, but the cost of control of the coast is excessive; a Pyrrhic victory. To paraphrase a sardonic epigram during the Vietnam War, it may be necessary to destroy the shoreline to save it."

Page 347 – The Scallop, The Shellfish Industries by James Kellogg
{insert entire page}
Take section as quote describes life cycle impacts upon bay scallops from during cold periods, T. Visel.

Pleasant Bay – Survey Report

Chatham, Orleans, Harwich, Massachusetts – Department of the Army – New England Division, Corps of Engineers, Chatham, Massachusetts

November 1968 – 57 pages, 19 plates, 5 appendices, 132 pages in total – fisheries section included. This study reviews the proposal to create a 1,000 foot wide stabilized inlet through Nauset Beach. Testimony of area fishermen predicted a Nauset Beach break north of Ministers Point* and comments about reduced tides (tidal height pg A-2 – A-3). A proposed stabilized inlet was sited just north of Ministers Point – as the likely location of the next breach plan C-2 Plate E-1 July 1968, however final plan favors stabilized inlet south of Chatham Fish Pier, Plate #1, see comments A-12 – A-13.

Reference historic break before John C. Hammond, Climate conditions – 1850s to 1880s was a cold and storm filled era – hazards to navigation numerous and created public policy development support for federal supports – see Army Corps Rivers and Harbor Act.

Plans C-C1 – C2 would have increased tidal exchange but would allow colder ocean water to reduce the water temperature within Pleasant Bay (E-4).

This is an invaluable report as it describes historic conditions of Pleasant Bay and contains so many accounts of fishermen including some environmental histories. John Hammond (see page A-2) includes weather and storm sections – gales 1870-1940 - 160 gales, 50% Northeastern (C-15). This is the study that John Hammond gave me in 1981 – It is a very detailed document with historic finfish shellfish sections (1966 6,000 bushels bay scallops). No study of Pleasant Bay should be compiled without reviewing this very detailed report. It was thought that a new inlet and closing off the South Chatham light entrance would add hydraulic channel maintenance.

Eelgrass comments –
See letter in Army Corps report.

Eelgrass overrunning hard shell clam beds – take section describing negative eelgrass impacts -

Great South Bay letter – Fishermen comment best fishing after new breaks – don't build on barrier inlets 1983.

Energy comments – Nauset Beach resembles to some extent smaller barrier beach descriptions of Clinton Harbor and Niantic Bay (bar) at times the barrier beach breaks and slowly heals over time leaving a characteristic "lobe." These lobes are clearly evident on Niantic Bay Bar early maps (showing at least three active breaches and Clinton's Cedar Island spit show similar lobes.

ENVIRONMENTAL ASSESSMENT OF THE USE OF EXPLOSIVES FOR SELECTIVE REMOVAL OF EELGRASS (ZOSTERA MARINA)

Michael Ludwig
Environmental Assessment Division
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Milford, Connecticut 06460

ABSTRACT

Data were obtained regarding the biological and physical impacts associated with using explosives as a herbicide for eelgrass (Zostera marina). Removal of the rooted marine vegetation from an area approximately 122 meter wide and 550 meters long within Niantic Estuary at Waterford, Connecticut has been proposed in an attempt to improve water quality and containment of egg and larval stages of the Bay Scallop (Argopectens irradians). Creation of a channel through dense stands of eelgrass should reestablish a persistent tidal eddy in the inner estuary which would improve dissolved oxygen levels and allow more complete habitation of the embayment. Relying on a physical model and in situa-generated information from both the private and public sectors it has been concluded that such an attempt, with proper constraints should be allowed.

Marshall's 1960 discussion of this situation describes the scallops as setting on red algae in the absence of eelgrass within the estuary. Apparently the algae served as a suitable substitute for the destroyed eelgrass. As eelgrass reestablished itself along the coastline it also re-vegetated the estuary and had, by the early 1960s, extensively reduced the tidally-generated gyre's persistence and mixing capabilities. During this same period bay scallop production suffered a serious decline. Compounding the reduction in numbers of juveniles the area experienced a series of concurrently occurring harsh winters which had caused the almost complete exclusion of bay scallops from the area.

The Rhode Island Deep Water Scallop Beds 1875-1895 - Part I
A Fisherman's Account - Wickford Rhode Island URI Fisheries School
Timothy C. Visel, The Sound School January 2012

Also see US Fish Commission Report – Part 2
The Bay Scallop Fisheries of Rhode Island (1887)
(Work in progress)

It was Richard Wing my former URI fisheries engineering professor who took an interest in my interest – fisheries history. After my teaching was finished (I had just been hired for a international program at the fisheries Dept (ICMRD) to teach fisheries gear technology to 32 students from Guineau Bissau Africa) I worked on a series of historic model trawl nets – some dating back to the turn of the century. They were needed for evening fisherman workshops for both the Rhode Island and Connecticut Sea Grant programs. (Note this research work (1980) has been recently put on line by GEAR NET – The History of New England Trawl Net Design.) It was the Cruz Cotton Trawl introduced from Portugal in the 1930s and a popular design in New Bedford. I had researched and found about 50 old net plans of trawl dating back to the first Boston eastern rig side trawlers.

Dick was intrigued and offered a retired fisherman from Jamestown who always enjoyed talking about the past fisheries – I welcomed it. I had been mentored by such "retirees" since high school in Madison, Connecticut they included Frank Dolan, George McNeil, Charles Beebe and many others. So the chance to talk fisheries history – my favorite topic was to good not to accept. A few weeks later, Dick came into the Wickford fisheries laboratory twine lab with an elderly gentleman and Dick carried his old shellfish dredge. I recall, at first I was a little disappointed, I had towed a similar hand dredge in Connecticut in 1974 – a hand hauled seed oyster dredge on the Hammonasset River in Clinton/Madison before a navigational dredging project. (Move the oysters or loose them, etc) So the seed oyster dredge wasn't that historic or different until I came closer. It was wrought iron made in a Blacksmith shop not the rebar welding dredges that my friend Lucian Simone of Clinton built for me, similar but not the same. That's old I said, he responded something like "you bet it is."

At first, we generally spoke about oysters – my topic of interest in the early 1980s but eventually we turned the dredge I commented – it's a seed oyster dredge – no this man replied, it looks like one but its not, it's a Rhode Island deep water bay scallop dredge. I never heard of such a thing – and he said something to the effect and you never will again – the account – as much I can recall is a follows,

The Rhode Island Deep Water Scallop Dredge 1875-1895, it wasn't his dredge, I had suspected it was but it was his fathers and was about a hundred years old, towed from a cat boat (and it looked it). The round stock sections had flat hammer marks the tow eye not a perfect circle – but a bend around another round object and then hit hard to close the eye. The rings were rusted thin and remains the chain bag wasn't linked by smaller links but elongated rings he called chain mail – each has been lapped and hammered shut – a open link but tapered so it has to longer than the rings. The scallop dredges I used in Stonington and Niantic didn't look like this – it was a very different type of chain bag we used.

First of all it had no chain sweep, instead a curved flat tapered iron bar, 3" inch wide the curve was very noticeable – apparently this helped the dredge "seat" and resembles an old sickle blade curved and attached to the triangle from the dredge frame was tapered flat and two iron pins held the blade to the frame these were hammered flat like a rivet. About two inches below the blade was as second rivet which held a smooth 3/8" diameter smooth ring stock that held the chain mail links for the chain (ring) bag. A second round stock located about a foot above also about 12" called the "mesher" and held the manila twine for the bag top that was consistent but he recalled the mesh was gone when he was a young boy – that makes sense manila twine even in a barn will suffer bacterial damage. But surprisingly a barn in the Hamburg Cove section of Old Lyme, Connecticut was found largely intact the Daniels family fyke nets (about 15 total and dozens of hickory poles were found 2006) with the manila twine still pliable from the 1920s. Hamburg Cove used to be deeper (its got 8 to 12 feet of leaves in it today) and had a winter flounder fishery during the cold period before the 1880s. The Connecticut River in Essex, Connecticut has saved some of wood hoop fykes and made a video about them.

Here on this scallop the dredge mesher rod was split and wrapped around the frame stock – hammered one under one over. I looked at it and shook it hard and the joint was still tight. But all of the 1/2 iron stock made the dredge heavy. This is when it gets interesting – it had to because they were bay scallops in deep water on the western side of the bay – I want to say off Quonset but I just can't be certain – 35 to 50 feet deep – his father fished out of Greenwich.

It was definitely this side – Wickford side of the bay – his father worked on a sail sloop, setting and hauling these dredges up to four dredges per boat – depending on the wind – he kept mentioning how cold it was then as stories told by his father, he had never used the dredge but kept it as a reminder of his father and of the bay scallop fishery back then. His comments about the scallop fisheries today were small in comparison ' "just scraps" of what it was once. And the scallops were different also they were bigger in the deep water, what was caught today his father called "seed" even the fishery in Point Judith Pond. He called them "Greenwich scallops" but kept mentioning that the scallop today were about half the size of this deep water fishery which was a winter time event – when this father was young (perhaps born 1870?).

What happened, it's evident that the bay didn't support those deep water fisheries today (with the price of bay scallops even then that would be hard to ignore), the response was the grasses came in and ruined it. Now that was a surprise (and he didn't say eelgrass but "grasses" so I don't' know if it was eelgrass or another grass) and he explained that to sail on scallops certain tows were good, and his father mentioned "tows between the dung." This I believe is the monkey dung sometimes associated in the trawl fisheries, a grayish sticky mass usually full of shell pieces which is now attributed to coralline red algae. I had some experience with monkey dung in trawl nets but never fully understood what it was (someone called it whale vomit, but growing up along Long Island Sound, I didn't see many whales, so I doubted that explanation) until now. It was an offshore fishery and supported many boats not just the one his father fished on (not certain if this man's father was a boat owner or crew). It was a cold, harsh and brutal fishery, his father recalled, having to survive this fishery with "all of his fingers". But he did say that scallops even then brought "a price," and his father never complained about the fishery just the conditions in which it was pursued.

When the grasses came in it covered the dung and the scallops left. They had tried to keep the beds clean but storms just kept bringing more grass in and the scalloping dropped off. After a while the fishery ended, his father blamed the "grasses" for ending it. At the end of his father's life (1950s and 1960s), he became upset with scallop fishing in the "ponds' even in Point Judith Pond because according to his father it was these ponds that provided the scallop seeds for the deep water beds, the ones he used to fish as a young man. His feelings were that scallops spawned twice not once (*) and if left alone, the following year, they (scallops) would be in the deep waters as he had known as a boy. The dredges used today were "grass dredges" designed to slip over vegetation not the hard bottom blade dredges before. I really do not remember much more, but I asked if I could keep the dredge, take some pictures, etc. He was reluctant – he had promised it to a Rhode Island Historical Society but I persisted and he left it. I used it for several years at Sea Grant Workshops in Connecticut. I took it to Riverhead, New York for a Cornell Extension Fishermen's Forum; fishermen there had never seen anything like it. And unfortunately lost track of it and never returned it to him.

In 1990, I left Sea Grant University of Connecticut and they took down the building in which I used to work. I'm contacting the Sea Grant staff there to see if it is still around, but I suspect it's not the only one, in fact dozens of them may still survive. I did not think much about this account. I have talked to dozens of fishermen in four states over the past four decades so I know how oral accounts can drift over time. The concept of three-year-old giant bay scallops in 50 feet of water seemed impossible at the time. That was until 1998.

My wife Pamela surprised me with a nine volume US Fish Commission George Goode series about historic fish census fishing reports that year. During the past decade. I have read and re-read them, they are a fascinating series if you like fisheries history, which I do. When I read the scallop section, I chilled as it described the deep water bay scallop fishery in Narragansett Bay in the 1870. It is all there, what my visitor described, the one Dick Wing introduced to me. This was a substantial fishery and it was a dredge fishery, in deep water using hundreds of dredges (estimated US Fish Commission 500 dredges). So the chances are very good that one or more of these antique deep water "blade" dredges still exists. For example, in many of Connecticut Antiques Store along the coast you can still purchase antique blacksmith eel and flounder spear heads. The problems with these dredges is that they were heavy, and perhaps had the blade not been there, they could have been converted or reused in the ponds as scallop dredges. (The newer dredges have chain and net, a bar and were according to this man, pond or "grass" dredges, not hard bottom dredges). Perhaps some of them survive in barns, like the wood hoop fyke nets of Hamburg Cove mentioned earlier. I feel bad that I never returned the dredge but good about one thing, he wanted people to know how his father caught scallops a century ago. (*) He was not alone, in the 1950s (Niantic Bay, Connecticut) according to Paul Kumpich, a deepwater bay scallop fishery from Niantic existed and about a third of the scallops had a second growth ring but only the scallops in the deep waters had this. The local lore about double growth rings continues in the Niantic area to this day. It might signify a second spawning event – not certain.

So I am writing this account up and sending in it to Rhode Island to see if another dredge or similar account exists. To be honest, I did not pay that much attention to the account at the time, it was so different than my own scalloping experience. I am kept thinking that hauling up a scallop dredge in the bitter cold from 35 to 50 feet of water was almost impossible. I hauled hand seed oyster dredges in 8 to 12 feet of water with my brother Ray and that was hard enough. That was before I turned my attention to habitat histories and the impact of energy pathways and climate temperature upon shellfish and finfish habitat quality. Now what I realize is that this man was describing to me-- exactly the habitat conditions of The Great Heat 1880-1920 a period of brutally hot summers, more vegetation, record fish kills and the collapse of several cold water species including lobsters, and bay scallops.

This account of the cold water, deepwater bay scallop fisheries makes perfect sense now and confirmed by the US Fish Commission Reports. I'm certain to one of more of these iron hard bottom deep water scallop dredge still exists, perhaps confused with a seed oyster dredge or pond scallop dredge, it is the bar (without teeth) that makes the difference. It is also possible that the bars were removed and re-equipped with chain.

If anyone has ever seen or knows of the existence of this type of scallop dredge please email me at tim.visel@new-haven.k12.ct.us. As for which historical society he intended the dredge to go not, I am certain so I plan to reconstruct this account and combine it with the George Goode accounts of the Narragansett Bay fishery and send it to all of them.

That is my long overdue thanks for his time that day.

(*) See similar accounts in the salt pond and bay small trawl net flounder fishery, keeping the bottoms clear of vegetation improves fishing).

Conversations with John Hammond Oyster Grower

Bay Scallop Habitats – Eelgrass Questions
Tim Visel – January 2012

There was a time I felt the eelgrass/bay scallop connection was significant, and my first bay scallop transplant (1978) with Ed Rhodes of NOAA NMFS and Lance Stewart of NOAA Sea Grant, I sought out the eelgrass beds behind Cedar Island in Clinton Harbor to place seed scallops, I would not do that today. In fact, my conservations with John "Clint" Hammond, a retired oyster grower on Cape Cod, points to an entire new direction, a climate /energy relationship and serious questions about the plant eelgrass in general.

When I arrived on Cape Cod in 1981, I had already been exposed to the great debate about the scallop/eelgrass relationship by old timers who fished PT Judith Pond for bay scallops; they had much different views than my age group. At the Point Judith docks, "strong discussions" would often break out between older fishermen who towed directly over the eelgrass flats and those like myself who avoided it, believing at the time it was good for bay scallops. The older fishermen were trying to remove it; then in fact, there was too much and that angered the much younger crowd. I no longer feel that way; instead I believe red coralline algae to be the real scallop grass, not eelgrass.

I am writing up John "Clint" Hammond's account of his research regarding shellfish habitats including eelgrass which is summarized below:

1) That energy (storms) and climate (temperature) largely govern shellfish habitat quantity and quality and that such conditions can be defined as a "habitat history." He had made a lengthy study of the Monomoy System in Chatham after storms.

2) Fishermen strongly resisted eelgrass returning from the die off I believe was created by extremely warm temperatures and low energy period (1880-1920). It was not an isolated incident (as a NOAA NMFS dynamite experiment in Niantic Bay illustrates) but a determined state/town effort as eelgrass spread from Connecticut to Rhode Island north into Buzzards Bay Massachusetts. It included machinery, Cabot cutters and herbicides and on the Cape, even Agent Orange (I am seeking clarification from Massachusetts.)

3) Mr. Hammond worked with several BCF researchers, namely Paul Galtsoff and William Shaw. Some BCF papers are on the Internet today and thank Mr. Hammond for this help. He was an expert farmer, headed some civic agricultural organizations on the Cape and was highly educated in terrestrial soil sciences. He was at the end of his oystering career fighting Codium fragile, an invasive plant on his oyster grant in the Oyster Pond River in Chatham. He had battled what he believed to be another invasive plant, he believed also to be “foreign” eelgrass. Its presence here was odd, he claimed, against the prevailing winds and currents and its impact to small coves and bays. He was convinced it hitched a ride with green crabs on the first ships here from England several hundreds of years ago. His theory was that eelgrass came over in the packing seaweed to keep shellfish fresh during the large voyage here. Once here, the seaweed was just dumped overboard. It was colder then so the eelgrass did not spread that much at first; later warmer temperatures helped it to grow. At this time, no evidence linking our Zostera to Zostera in England exists, but it does seem plausible; green crabs, he claimed, came over the same way (green crabs is an edible fishery in England.)

At the time, I did not fully understand what Mr. Hammond was talking about, but he kept referring to barrier beach cuts and the impacts that followed – smaller “Monomoys.” He asked if they existed in Connecticut, and I replied Niantic Bay and Clinton Harbor were two. This is why, when I returned to Connecticut, I started shellfish surveys in Niantic and Clinton and found much of what Mr. Hammond described- a barrier beach habitat history in both estuaries.

The Westport River (Massachusetts) studies shed light on the efforts on the second point, so the third question remains. Now that his first and second points are largely confirmed, he might be right on all three. Eelgrass is perhaps an older, invasive plant carried here during numerous crossings, perhaps the first invasive plant to our coast?

It was an industry practice to pack shellfish and crabs/lobsters with seaweed to keep them moist – a practice that continues today. It could be that vessels leaving the Thames River estuary would gather native eelgrass, use and just dump it over here. He had gone to the effort of collecting pressed blades samples and comparing them. That was Mr. Hammond’s last remaining eelgrass question.

Appendix 12

"Do we have the correct scallop grass?"
NOAA Milford Aquaculture Seminar
Pleasant Bay, Chatham, Orleans, Harwich, Massachusetts
Survey Report
Dept. of the Army- New England Division
Corps of Engineers, Waltham, Massachusetts

(Report #527) November 1968 (125 pages numerous charts, graphs Nauset Beach Diagrams over flight photos appendices, climate and storm history barrier beach history)

Comments by Timothy C. Visel, December 2011

If you are conducting research about the impacts of coastal water quality, barrier beach dynamics or fisheries history on Cape Cod and you don't have a copy of this Pleasant Bay 1968 report on your night table or a good photocopy on a desk nearby, your study will most likely be incomplete. Not in three decades have I found such a printed reference that contains so much fisheries data, water quality, shellfish data, climate (storm) records, barrier beach reports and user group accounts in one publication. It is no wonder why John "Clint" Hammond of Chatham, Massachusetts kept two copies; his comments regarding climate and temperature are found on page A-2.

He gave me a copy in 1982 and his conversations have guided this research into energy pathways and shellfish habitat quality. For my research today, the impacts of climate and energy systems primarily storms upon fish and shellfish habitat quality it is one of my best references. Any Pleasant Bay research project without this reference publication I feel is disadvantaged. Dredging, although today it is often described as a habitat degradation activity but for readers please try to keep an open mind about it. Periods of warmth and less energy finds that bay bottoms tend to fill in, organics from land accumulates – this favors salt marsh and meadow formation. However this process suffocates finfish and shellfish habitats. In times of severe cold and strong coastal storms, just the opposite occurs, sediment removal and cultivation. Shellfish and finfish habitats are "restored" by such increases in hydraulic erosion processes. John Hammond a retired oyster grower made a habit of studying the impacts of energy storms and temperature on barrier islands. He called the Monomoy Island complex "My Monomoy" and had kept notes of the habitat conditions after major storm events. He termed hurricanes as "natural dredging events" and leaving a recorded habitat history. A new cut into a bay or cove seemed to stimulate bay scallops; sand over wash from a breach during cold periods found new hard shell clam sets in "new sand". Warmer weather and cleaned sand brought soft shell clams. He knew of places called the Powder Hole where barrier beach sand had layers of alternating soft and hard shell clam sets after storm burials. Any barrier beach system according to Mr. Hammond was likely to have such a habitat history. Dredging to him was a manmade storm. Clams oysters and scallops respond to different habitat conditions, governed by temperature. According to Mr. Hammond, his comments refer to that belief in the Army Corps report[10]. He had spent decades studying the impact of energy and temperature impacts on shellfish. He had on his desk at his home a signed copy of Paul Galtsoff's, "The American Oyster."[11] "*To my friend, John "Clint" Hammond*, *Paul Galtsoff"* -- a hard book copy not like the soft one given to me by Clyde Mackenzie in 1970, in it he had circled a couple of sections Pg. 93, Oyster River, Chatham, Mass.; Figure 92, was a diagram of a Hammonasset seed oyster (Clinton, CT) bedding stock he purchased from George McNeil in 1962 the last year the Clinton McNeil Oyster Company was in business. But that wasn't the only section he circled on page 398 regarding dredging in the back and the section was heavily footnoted.

[10] The Army Corps Report was about creating a second inlet to Pleasant Bay, and fishermen accounts prediction page A-3 of the 1968 dredging report that the Nauset Beach break will happen opposite Ministers Point (site of past breaks). See comments August 27, 1964 Josh Nickerson, Bay Road Chathman, James Kidd, John C. Hammond, Willard McKerson, Linnell Studley comments on lack of energy, stagnation in Pleasant Bay, Paul Henson.

[11] The American Oyster, Crassostrea Virginca, by Paul S. Galtsoff (2) Fishery Bulletin Volume 64, United States Department of the Interior Fish & Wildlife Service, Bureau of Commercial Fisheries US GPO Washington 1964 (later this agency becomes NOAA-NMFS in the 1970s.)

Mr. Hammond's Accounts of Storm & Temperature Impacts – Conversations/Comments to Timothy C. Visel, 1981-83, Chatham, Massachusetts
Shellfish Habitat Studies – December 2011

I would meet with Mr. Hammond many times during my 30 month employment with the University of Massachusetts Cape Cod Extension Service, and after I returned to Connecticut to work full time for the University of Connecticut Sea Grant/Cooperative Extension Program in 1983 and he would often call me. His area of research was Monomoy and Nauset Beaches and the shellfisheries in the area. Productivity and abundance he felt was largely determined not by us, but natural events. He was surrounded by it – the barrier beach systems of Cape Cod. An oyster grower from Chatham, he had worked closely with Woods Hole Bureau of Commercial Fisheries United States Fish & Wildlife Service before it was reorganized into NOAA – NMFS. In fact, several USFWL Reports on the Internet acknowledge and thank Mr. Hammond for his help with several studies, one of which was Paul Galtsoff who wrote <u>The American Oyster</u>. I think the fact that I had obtained one, the Bulletin, while in high school (I grew up just 40 minutes from the Milford Lab and one summer in August helped build oyster spat collectors 1970). I obtained a copy and a lab tour for my work, which to be honest was somewhat boring and hard work! (I soon returned to the New Haven oyster boats trips). Mr. Hammond's study-- "Clint" to his friends-- looked at the habitat renewal aspects of storms. Although he cooperated with researchers he lamented that the research was very site specific and "not long enough". But here on the Cape it was possible to study long term impacts faster because of the barrier beach breaks. He had seen and talked to fishermen before him, that it (shellfish conditions) wasn't always consistent. Things changed. For example, in the 1900s (during The Great Heat), Chatham was (according to Mr. Hammond) a huge producer of soft shell clams on shifting sand bars, which eventually would decline in time. The "soil aged," got mucky and sets stopped. That experiments in the Powder Hole (one of his favorite sites) showed that soils over time "fail" (became acidic until storms rinsed the acids from the soil) in warm weather in which was steamer soft shell clams, in cold temperatures hard shell clams. After breaks in cold weather scallops would do better for awhile until the break healed. He was somewhat frustrated that scientists had seen this impact before, but didn't follow up and needed long term studies. Dredging projects for him (and explains his fascination with the 1968 Pleasant Bay dredging study) were just shellfish energy and temperature experiments; the soil was fine, it just needed to be tilled (he called it rinsed as side casting was a prevalent dredging process in the 1950s). There was nothing wrong with the dredge spoils (and in deference to my Army Corps friends from now on "material") it just needed to be rinsed of organic matter and acid just like farming. Why couldn't people see it, it's all around us he would ask often. Turning to his copy of Galtsoff, page 398, he directed me to the section about dredging. While acknowledging the problems of dredging burial of oyster beds, it could be from both natural and manmade "energy".

The quote is reproduced here as Mr. Hammond spent so much time discussing it as similar to Hurricane impacts and it was discouraging to him, scientists had found or reported the connection but failed to pursue it. (It is important to note that Mr. Hammond was a terrific gardener and once belonged to several agricultural communities on Cape Cod, he used oyster shell and eelgrass as soil nourishment and was well versed in terrestrial soil sciences.)

That's the link- the storms wash and prepare the soil (he also used the term freely while most of the time muck or bottom or sediment (and I use the term marine soil today much to his influence), but they (I suppose the Bureau of Fisheries) didn't see it (1938); several areas on the Cape obtained good sets of Quahogs on the Cape post the 1938 Hurricane. Hurricanes by the waves (energy) they generate re-cultivate and naturally wash estuarine soils, but dredging could do that also, change the "habitat clock" or even reset it, while dredging impacted the oyster beds new sand or material soil rinsed with alkaline sea water promoted clam sets. The process ends one species but may start another. This is the section that Mr. Hammond spoke about several times (Galtsoff, page 398).

> "Many well-documented examples may be cited of the destruction of oyster bottoms by sand mud stirred up by dredging operations in nearby areas. One incidence of this nature occurred in 1935-1938 near the Buzzards Bay entrance to the Cape Cod Canal, Massachusetts, [Note the Bureau of Commercial Fisheries had a laboratory at Woods

> Hole, Paul Galtsoff often worked from it.], where valuable oyster grounds were buried under 8 to 12 inches of material that was disturbed by dredging and then settled on the oyster grounds. Three to four years later the area was repopulated by quahogs and continues to remain highly productive, although the species composition has been completely changed."

He kept repeating that this was important, and the dynamics of barrier beach breaks produced different habitat results dependent upon temperatures. One of his concerns was the increase of grasses and his "oyster thief," an introduced seaweed (Codium fragile). The pictures on pages 429 and 428 area are also from Mr. Hammond's grant. He blamed lack of flushing and warmer temperatures for the increase in nitrogen; people added to it also. Eelgrass was ruining clamming on Pleasant Bay; the bay had become too stagnant and softer bottoms favoring eelgrass which could grow over the hard shell clams killing them. They had used the materials from "Nam" (Vietnam) on it and it still would not die[12]. If a Nauset break opened, colder water would be introduced, and flush out this "compost" bringing in colder waters; the soft shells might go but it could help (he claims) quahogs and scallops. Temperatures (heat) and lack of energy (storms) had turned bottom conditions against shellfish and shellfishermen for that matter.
A cut through Nauset Beach if it was, cold would help Quahogs reverse that condition, if it was warm, soft shell clams would increase. If it turned sharply colder and much more tidal exchange bay scallops would come back.

It is interesting to note that the testimony from Linnell E. Stuckley, East Orleans, Massachusetts (A-2) has this comment in the 1968 Pleasant Bay report.

> "Favors an inlet to Pleasant Bay to prevent stagnation by providing Flow of fresh water from sea with tide changes (comments briefly on the advancing stagnation condition since the last breach in barrier beach. (August 2, 1964)"

After the 1957 – 58 Breach occured, Mr. Hammond recalled, hard shell clam production increased but soft shells production declined (colder temperatures) but by 1963 bay scallops were in decline, and eelgrass

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[12] This is the suspected case of Agent Orange like herbicides (1970-1971?)

was advancing. In the following years the US Fish Commission and US Fish & Wildlife Service fishing reports have yielded key landing statistic information. This information largely confirms the temperature /habitat connection to the reversal of soft shell and hard shell clam production.

At the turn of the century, Chatham was referenced as the most significant soft shell clam producer (1880) in Massachusetts as the detailed in the US Fish Commission reports. The clam fisheries section (Volume 11, 1887 pages 589-590) the fisheries of the winter catch Pleasant Bay, Harwich, 1,125 bushels Chatham 11,500; Orleans 250; Chatham Harbor,15,600 bushels; Total 29,000 bushels of soft shell clams. It’s interesting to note that Quahogs were scarce in the 1880s; Orleans, 15 bushels is only mentioned and a few bushels from Waquoit Bay, Falmouth, (page 604). In the 1960s the catch statistics would change with cooler temperatures showing habitat transitions, the 1965 data is presented here (from the 1968 Army Corps of engineers Report).

Pleasant Bay (Chatham, Orleans, Harwich) pg 17-18
Quahogs 11,200 bushels
Bay scallops 3,000 bushels (about)
Soft shells 200 bushels
Oysters 225 bushels
In other words during The Great Heat, Chatham was a huge producer of soft shell clams, almost 30,000 bushels but that fell to only 200 bushels in 1965. What happened, it was colder then, but Quahog hard shell production has soared.

The changes Mr. Hammond felt were a direct relationship between habitat conditions hot/cold stormy or quiet, the huge difference in Chatham’s Shellfish productivity was not so much the fishermen, but much the environment. The concept of knowing the environmental fishing history was formulated in Mr. Hammond’s kitchen over a cup of coffee. He was aware of the quahog/steamer soft shell clam reversals in Pleasant Bay. Mr. Hammond was curious if Connecticut had similar barrier beach systems he could study – I responded, I know of two -- Clinton Harbor and Cedar Island (where George McNeil would raise his bedding stock – seed oysters) and Niantic Bay, a once productive area for bay scallops in the 1960s. I also had been scalloping on Niantic Bay in 1978. He had heard about the Niantic Bay scallop fishery and I reported on some NOAA-Sea Grant seed scallop transplants there. Where did we plant these seed scallops in eelgrass beds, I replied. Clint was dismayed – worst place most likely and I responded that’s what George McNeil said. He looked up, *you* know George McNeil? Yes, I lobstered and oystered with my brother Raymond in Clinton since ninth grade. Apparently he had purchased bedding stock from Mr. McNeil -- Hammonasset River oysters. I put them back together again after almost two decades. But we finished that day talking about Clinton Harbor and Niantic Bay.

In the past three decades, I have been able to look into both systems for habitat histories. Clinton has a long history of a barrier spit break locally called the Dardanelles. It also has a history of stagnation when this barrier spit closes, at least three times in 150 years Niantic Bay has a similar split, barrier beach and it was last breached in 1815 creating a legendary short west opening and the lore of the "Pug Channel". Early maps of the Niantic "Bar" show the characteristic lobes of previous breaks. In this case, the other breaks were filled and "bar" barrier beach stabilized which had previously a series of rope ferries between them. Niantic Bay also has an extensive habitat history of stagnation, to the point of eelgrass meadows growing so thick it stopped tidal action. This event is mentioned elsewhere in the report. Core studies in these two areas deserve additional study. Niantic Bay and Clinton Harbor should each have what Mr. Hammond described as "habitat histories".

Influence of Temperatures

It was Mr. Hammond who linked nitrogen to increased eelgrass and other seaweed growths but here (other than dumping fertilizer or raw sewage) he urged caution. In cold and stormy periods most of the nitrogen would get lost, flushed away; that was also part of the habitat history. He was more focused upon why the nitrogen was building up the coves as opposed to who put it there. It was long periods of warm very hot temperatures. He is the one basically who introduced me to the concept that all dredging isn't bad, and perhaps a help – again taking into account temperature and energy. If energy is lacking dredging, he felt was one way to replace it. There wasn't much that could be done about very warm temperatures.

In times of cold and energy, we may not have enough nitrogen; when it's hot and few storms, what we have is already too much, but to Mr. Hammond, this may be a part of natural cycle, and organic muck could be the "sand dune" for colder stormier times; when it was needed it was available. He had put this theory to the test, after a severe storm the soils were cleaned and heavy sets occurred if it was warm, soft shells, if it was cold quahogs would set heavy. He felt there was always enough spawn in the water, the question was would the soil have the proper characteristics for the set? The transition was gradual and a good clam Quahog set in a few years would change the composition and amount of spawn (eggs) in the water, hard clam catches would increase. If the habitats failed the catches would drop like a rock because no smaller clams would enter the fishery. Both would need to have basic soils not acidic ones, but temperatures would guide which one became prevalent.

I often think of the times I met with Clint with all the environmental studies underway now I could see him attending every meeting and asking for a copy of every report. He would ask the best questions to be sure.
I'm adding his account to my present eelgrass and bay scallop research, of anything the temperature to energy link is much more important than Mr. Hammond realized, in fact, decades later I believe it to be the most important factor.

Summary

Hard shell clams for example set heavy after storms and increased salinity, like after a break, but cannot take organic matter building up in the soil over time, soft sell clams are more tolerant than quahogs which thrive in full salinity waters. He mentioned breaches in the 1950s which reversed the process. Quahogs then flourished but soft shells (needed warmer water) retreated into the deeper areas of salt ponds. Areas of ample food and high salinity hard shell clams grew well- like at Wellfleet. (This agrees with New York, Rhode Island and Connecticut accounts). Warmer periods – favored soft shells; they like the heat, and some energy also. Their soils need cultivating also but they live in shallow water rather than Quahogs which live in 30 to 40 feet. So the chances of storm cultivation event are much higher, so sets more frequent, but can't take the cold. When Quahogs are high, soft shells are rather low. Watch sets after a summer storm, a couple years after; he often would tell me, it takes time for the soil to settle (balance). Scallops like deep waters, cold and breaks with energy. Good scalloping in the bay until the 1970s --it got hot and eelgrass choked the channels (deep areas). Mr. Hammond despised eelgrass for several reasons, it made harvesting difficult, it was too thick, suffocated shellfish by smothering them (sea lettuce also). The bay turned stagnant, which needs good clean water, colder temps.

At the turn of the century shellfishermen fished in ice, for scallops, very early reports. Before 1900 and eelgrass now covers the beds, killed quahog beds, which grew rapidly as waters warmed up in the late 1960s. (Note not one shellfishermen I met with on the Cape spoke in favor of eelgrass, it's mentioned as overrunning beds in the 1968 Army Corps of Engineers study). Waves could clean out the eelgrass and improve habitats. He predicted that if another wide cut formed, waves would clean out the muck in Pleasant Bay and you could find dead old hard shell clams under the eelgrass. It killed the clams. (Need confirmation North River or Pleasant Bay Survey Report, Massachusetts Division of Marine Fisheries). Some fishermen tried to rake off the eelgrass as he had done on his oyster grant, but it was a difficult process. They just spread shoots / seeds around. I believe he offered me a Pleasant Bay survey but he had only one, and I didn't take it, I am seeking that report now. He claimed the eelgrass situation was in it. He mentioned that it was at this point 1970 or 1971, the State sprayed chemicals on it to stop it from over running the Quahog beds. He worried about the oysters in Oyster Pond River, too much heat and when it's hot, shellfish get diseased, and they're weakened and perish in large numbers. He was at the end of his oystering career battling eelgrass and Codium fragile, the oyster "thief"; he was discouraged by the grass which now covered much of his Grant.

At times Woods Hole researchers came by to study the scallop declines in Chatham and would tell people it was because of eelgrass died. He didn't think that was correct because he had seen redweed covered in scallop set (I had also seen it during State of Massachusetts Division of Fisheries surveys with Sherril Smith). His thoughts were that eelgrass was the proverbial "bad neighbor" to other shellfish species. He even thought that it was carried here with the green crab centuries earlier. He absolutely believed that what was happening now was extreme—eelgrass, dead leaves and sea lettuce completely covered large sections of the bottom and that is something he saw change himself. The bottom turned black and eelgrass rotted off. He had to hire some students to run cultivators at times to keep sea weed from smothering his oysters. He gave me a copy of an outdoors magazine article 1975 by Gordon Smith. The article describes the last days of Mr. Hammond's oyster business and includes this phrase on page 31, which references decades of shellfishing experiences.

> "Clint's grants are in Oyster Pond River, appropriately named. To the untrained eye, there is nothing exciting to see on a grant. The excitement and the work is hidden three feet or more below the river surface. Down there is an oyster book written in

> shellfish Braille, and Clint has the reading skill to decipher volumes."

Mr. Hammond had a theory about coastal energy and storms; first ones to respond to cold were scallops and followed by sets of Quahogs and finally soft shells if it was warm summers. Occasionally he had seen sets of blue mussels so thick they also covered oyster beds. To Mr. Hammond, a strong storm reset habitat conditions. He also felt that temperature and energy combined largely controlled habitat conditions. Shellfish harvesting modified the habitat by mimicking storm cultivation. It could extend a habitat clock but not pause or suspend it. If the energy failed and it got warmer eelgrass would take over, if it got stormy and colder, red weed would predominate. In his words, a tug of war between two great forces, temperature and energy, our involvement was so little to him we were just spectators. Shellfishermen like him watched this situation closely because they made a livelihood from these habitats, to others; it was natures' bounty in times of great abundance if not the fisherman get blamed for overfishing. The actual fact is it's just not that way or easy to explain. Each shellfishery had a cycle and that cycle was habitat dependent, controlled by energy and temperature. To him, the fishermen just harvested what they could. If there was great abundance, catches were high, if not catches fell. People often blamed shell fisheries for the declines but the fact was they did not control the temperature or storms. Like everyone else, the fisheries they depended on were largely out of their control. He had a front seat to this habitat struggle, storms and temperature—that seat was Chatham.

U.S. COMMISSION OF FISH AND FISHERIES.
GEORGE M. BOWERS, Commissioner

PART XXIX.

REPORT

OF

THE COMMISSIONER

FOR

THE YEAR ENDING JUNE 30, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

The growth of soft shell clams – Kellogg page 167 - 1908
(b) Growth of algae. Another very important agency in rendering the surface tenacious, and thus preventing the shifting of its particles, is the growth of algae, which forms a close, thin mat over certain areas, which are sometimes very extensive. The presence of the algae gives a flaky or cake-like appearance to the bottom. It does not extend deep into the sand, but binds the surface grains closely enough to prevent their movement even by strong currents. This firm dark-green crust has been seen on beds in many localities, but the plants composing it have not been identified. Whether the growth occurs only where currents are swift has not been determined, but certain localities have been noticed to have this covering where the tide rushes with much force. This combination of firm bottom, which prevents erosion, and swift current, bearing abundant food, seems to afford the best conditions for clam growth.

(c) The growth of thatch and eelgrass. The growth of thatch plants or eelgrass may convert a waste of sand into a clam bed. Thatch is found on many beaches between the tide lines, and also covers large parts of clam flats. The plants grow close together. Their blades rise to a height of 2 or 3 feet, and their roots form a feltwork beneath the surface. As the conditions of the bottom change from year to year the growth gradually spreads from one place to another. In this mass of vegetation clams are often found in numbers, even when the soil is almost pure sand and the currents are swift. The reason that they are able to establish themselves is that the growth of so many plants prevents any shifting of the bottom, and still does not interfere greatly with the food supply.

DEPARTMENT OF COMMERCE

BUREAU OF FISHERIES

HUGH M. SMITH, Commissioner

THE OYSTER AND THE OYSTER INDUSTRY OF THE ATLANTIC AND GULF COASTS

By E. P. Churchill, Jr.

Assistant, U.S. Bureau of Fisheries

APPENDIX VIII TO THE REPORT OF THE U.S. COMMISSIONER
OF FISHERIES FOR 1919

Bureau of Fisheries Document No. 890

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

The Oyster and The Oyster Industry of The Atlantic and Gulf Coasts E. P. Churchill, Jr. (Assistant, U.S. Bureau of Fisheries) page 24 - 1920
In some cases the depletion or destruction of natural beds is the result of natural causes, such as the cutting off of the inlet to a bay or sound and the reduction of the salinity of the water; the covering of the beds with silt, debris, and fresh water during a freshet; the shifting of sand or mud by storms; or the inroads of living enemies.

The greatest enemy to the oyster, however, is man. Most of the depleted condition of the natural oyster beds is the results of careless overfishing by oystermen. The beds are stripped down so completely that not enough adult oysters are left to furnish sufficient spawn to insure a subsequent crop. Although millions of eggs and spermatozoa are produced, those products are thrown into the water, where many of the eggs fail of fertilization; many eggs and larvae die or are eaten by enemies; and many fall at setting time on soft bottoms and are smothered.

Pg 28 Year 1965

The American or Eastern Oyster by Victor L. Loosanoff, circular 205, Washington, DC., March 1965.

United States Department of the Interior, Steward L. Udall, Secretary, Bureau of Commercial Fisheries. Donald L. Mc Kernan, Director.

Oysters, like many other sedentary bottom invertebrates, are usually found with large numbers of aquatic plants, including Ulva and Zostera. Recently a newly introduced species of algae of the genus Codium appeared on some back in New England; often a thick growth of these plants interferes with circulation of the water, thus depriving oysters of this food. When heavy growth of algae dies, it smothers the oysters and in decomposing, deprives them of necessary oxygen.

Appendix 13

Milford Aquaculture Conference March 12-14 Westbrook, CT and Conversations with John "Clint" Hammond and George McNeil, Oyster Growers

Do We Have The Correct Scallop Grass?
A Habitat History for Eelgrass – Zostera marina
In New England Coastal Waters

The Chatham Massachusetts Experience:
Is our Eelgrass Invasive?
Habitat histories for Clinton Harbor and Niantic Bay, Connecticut
The End of The Great Heat
The Rise of Razor Fish

Mr. John Hammond of Chatham, Cape Cod felt strongly that eelgrass was definitely a bad neighbor to shellfish populations, and that it (this strain) perhaps was invasive, brought over with the first ships to our shores from England.[13] The first settlers came in a very cold period and Zostera at first did not do well, he thought, but it did establish itself in shallow warmer salt ponds and creeks, perhaps competing with or displacing other plant species. In warm periods it would form meadows and in colder, storm filled periods, storms actually helped it spread seed dispersal to other shallows. He felt as his own experiences with it on Cape Cod it was cyclic—changing greatly during warm and cold periods. That is what happened in the Oyster Pond River in Chatham. He was also investigating a possible source of eelgrass introduction as packing material for green crabs or shellfish carried to our shores. Mr. Hammond knew that packing shellfish in a wood barrel was an art for long voyages; shellfish could not be shipped too loosely; they had to be packed tight to prevent chipping and kept moist. The shellfish industry for centuries had used wet seaweed to prevent chipping from waves (during transit) action and to keep the shellfish moist. Another advantage, he noticed, is as a soil fertilizer; it didn't really rot but was consumed over time by "composters" in his gardens. Another possibility and he was focusing upon the fact that in the 1500s and 1600s the green crab *Carcinus maenas* was an edible fishery of England in the Thames River estuary.

It is in some parts of England today that it is known this fishery continues; in fact, green crab recipes are on the Internet and very easy to attain. He believed eelgrass or at least the strain he was dealing with was not natural and had pressed eelgrass blade samples on heavy biological paper (seaweed press) from the Thames River (source unknown). He felt that some live green crabs were taken on as cargo, most likely as food for the crew and eelgrass

[13] "A few widespread eelgrass species limited to marine waters in temperate regions" Walter Conrad Muensuber, 1944, pg 61.

was also used to keep the crabs "fresh" moist. (This practice still is used in the shipment of lobsters and blue crabs). Some had died in transit in high heat, he speculated and perhaps barrels of crabs were dumped overboard here with viable eelgrass plants. During colder weather, crabs could semi hibernate and survived the crossing here. He felt that this exchange occurred often during the first ships here and the hundreds of trips later on. He felt that this is how the green crabs arrived here, perhaps multiple times and he was very suspicious that eelgrass perhaps arrived here in the same way; he was just unable to prove it.

Mr. Hammond was also researching the impacts of temperature and climate upon shellfish abundance. His area of research was in and surrounding Pleasant Bay – Orleans, Chatham. The region mirrors the environmental history from the 1900s, good scallop years were few by the late teens, then almost nonexistent. The cooling and dramatic increases in energy provided conditions more suitable for the Quahog and bay scallops after the 1930s. In 1953 in fact, a scallop war between Chatham and Orleans occurred over the division of Pleasant Bay; a separate reference mentions a line was moved apparently to capture more of new abundant scallop crop (Eldridge, 2000). Today in the midst of the Second Great Heat, Scallops are scarce today in Pleasant Bay. Some good years have been reported but they usually followed colder winters and strong storms.

Even as the very warm 1920s closed, the islands off Cape Cod experienced unprecedented declines in Squeteague (weakfish) and summer flounder (fluke) which once formed huge schools off beaches on summer evenings. The catches from fish traps was tremendous, but these fisheries collapsed and on page 52 off Martha's Vineyard, A Short History and Guide (1953) is found this quote (Joseph Chase Allen)

"Climatic change is largely blamed for the failure of the [island] fisheries – a warming of the water which has driven native fish to colder latitudes. Should this be true, and should it continue, then Vineyard waters may witness the gradual influx of southern fish."

That also occurred on the Cape; here thousands of barrels of soft shell clams were dug in Barnstable Harbor for Boston and New York hotels, the peak years, beginning 1910-1925 Kittredge, (1930). But that came to an end in 1927 and restrictions on the year round soft shell clam open season. It was getting colder. The soft shell clam resource was contracting but at the same time quahog harvests increased. Kittredge, (1930) describes the bull rake fishery, now developed on Cape Cod- "He hauls his rake up and culls out the quahogs from the mixture of sand and eelgrass with which its net-basket is filled (pg 202). The Cape oyster industry was also declining; it was turning stormier and colder. The island of Nantucket was the first to notice the transition, 1918 the island experienced a "freeze up" but nothing like the Winter of 1920 which was still frozen in March 1920, amidst a shortage of heating coal (Nantucket, the Last 100 Years 2001). As the winters turned colder and storm filled, the soft shell fishery would collapse, replaced by a climbing quahog hard clam fishery and now, a renewed bay scallop harvest. By that time, the huge bay scallop fisheries of the 1870s on Cape Cod were nearly forgotten.

Other bay scallop areas in Connecticut also showed the same response; one of these was the Poquonock River in Groton. Here a response of shellfish species to climate and energy pathways namely oysters and soft shell clams and by bay scallops and quahogs is quite evident. Also this system has a history of barrier beach breaks. In 1881, oyster growers were ordered to remove oyster brush spat collectors in the Poquonnock River per recommendations of the Sheffield Scientific School at Yale. Oyster sets were intense, there were no bay scallops, but a dreadful stench in high heat in stagnant eelgrass was felt to be the source of scarlet fever as brush trapped eelgrass causing it to create stagnant waters producing strong smells most likely hydrogen sulfide in hot weather. (Kimball 1984; Collins 1887). There were no bay scallops until the late 1930s.

In 1948, after several hurricanes and increasingly cold winters bay scallops production surged to 25,000 bushels in the Poquonnock that year, and a fifteen bushels per day limit frequently met, but by 1982 not a single scallop was found, but oyster sets were now intense. (Kimball 1984).

At the end of The Great Heat which ended in northern areas in 1918 when the Cape Cod Islands started re-icing (especially Nantucket) Cape Cod, something unusual began in 1908, dramatic increase in razor clam populations (1912). It was called razor fish then (Earle Rich 1973).

Razor clams, *Ensis directis,* like periodic cultivation and warmth, but were very hard to dig. During the hot period in CT 1882, a clam gun was invented in Guilford CT. Here a cylinder (metal) was equipped with a valve. You would position the open end of the cylinder over a clam hole, and push it into the flat, close the valve and the large chunk of flat came up in the cylinder much like a modern core sampler in the sample was a giant soft shell or a razor clam. The clam gun has been reinvented in the West coast for gathering razor clams using PVC plastic pipe, but I think the metal foundry workers of Guilford shell fishermen should get credit for the invention and I leave readers this quote and you can decide for yourself.

> Fifteen years ago quite a number of men made a living by clamming. Clams have been scarce for two years. The tides have not been low enough to get at the big clams. These clams are to some extent dug by using a cylinder of sheet iron about twenty inches in length and five inches in diameter. The top of the cylinder has a metal head in which is an air cock or hold for a vent-plug. Attached to the pipe or cylinder are two irons through which a handle is slipped. The operation of capturing the clam is performed by placing the pipe over the vertical blow-hole made by the clam through the sand to the surface. The air cock is opened or the vent -plug removed, and the pipe is worked down to the depth necessary to reach the clam. The air-cock is then turned or the plug put in, and the column of material in the cylinder is drawn up and the clam taken out. These clams are sold for about three cents each. (Source US Bureau of Labor Statistics 1889-The Oyster Industry, Guilford Pg 136-137).

I can recall one Connecticut enormous razor clam set myself, because I swam into it. While wading off Tom's Creek in the early 1970s (Madison, CT), I felt impacts like sand or pebbles hitting me, at first I thought someone was throwing sand or shell pieces at me, but looking into the water I soon realized that the bumps were inch long small razor clams propelling themselves sideways at the surface. Within a few moments we saw the characteristics splashes of small stripers having a feed, there were billions of them. I think at that point I was running for a fishing rod. We always knew razors were around; their shells often were cast up by a storm, but had never seen razor clams like this!

In the winter time, two or three would get washed up whole, shells intact. They didn't last long with our seagulls on our beaches. In the 1980s I would also see them in hydraulic clam dredges off Guilford and Madison Connecticut shores in 15 to 25 feet of water.

In a very curious case, the end of The Great Heat marked a huge upsurge in razor fish on Cape Cod. The razor clams had entire gangs of fishermen then who used to compete against each other (Earle Rich 1973), but the increase of razor clams was hard to miss and explains why the Guilford clam gun was invented during this very warm period. The hundreds of razor holes in a given area was a sign of great densities. The upturn in razor clams just occurred before it started to get colder 1912-1918 on the Cape. By 1922, the winters were harsh and bay scallops started to return.

It is thought that this species razor clams likes warm (but not extremely hot) and recently cultivated soils after a barrier spit break. It was thought to follow areas first set by the soft shell clam Mya, and the two habitat clocks overlap soft shells and razors together in the same flat, but very cold temperatures seem to push them out to deeper waters and by the 1950s, razor clams grew scarce on the Cape according to Clint Hammond. This was more than offset and increase in bay scallops and hard shell clams at the time.

Mr. Hammond said it was backbreaking work to dig them (razors), and only a few fishermen had mastered it; one being Creighton Nickerson, who used a plank as part of the digging process; what razors clams are around now is nowhere near what it had been decades ago. By the time I met Phil Schwind (who reinforced the negative atmosphere about eelgrass and in his book "Making a Living Along Shore,") he commented that the razor clam fishery was now very low – poor and only a few old timers knew how to dig them, one of them was Mr. Nickerson, who called them a "fish" and not a clam, thinking at the time it was because they could swim, recalling my high school experience of swimming amongst them. Instead I was told by Mr. Hammond, it was how fast they could swim in the sand-down and actually crawl out and move. After watching Mr. Nickerson one day in Chatham dig them (he used a plank in the process), I soon abandoned any hope of capturing them.

Mr. Hammond often talked at great length about the Chatham Monomy barrier island/barrier inlet system. These comments are found elsewhere in the report. However, he pressed me for any Connecticut examples of similar systems in which I could study/research similar responses. I told him I knew of two such systems, close to my home in Madison, CT, one was Niantic Bay, East Lyme, and Waterford, and the other was Clinton Harbor. By the time I met Mr. Hammond, I was well acquainted with both barrier beach inlet systems. However the multiple openings into Niantic Bay which once contained a series of rope ferries were filled all but the most easterly opening. Clinton Harbor had a local opening called the Dardanelles, but that was closed in the late 1940s with the cabling together of abandoned automobiles to make a necklace of scrapped cars (George McNeil personal communications 1980s). When the Dardanelles were closed inner Clinton harbor started to fill in, both according to Mr. Hammond would contain habitat histories of previous barrier split openings and closings.

Niantic Bay is a unique situation because its barrier spit has been substantially hardened and the multiple openings and storm induced breaches was last recorded in 1815. The spit is unable to open because of intense fortifications/hardening did not allow periodic breaks or cleanings. At these times according to Mr. Hammond, strong waves and currents would actually "scrub" the bottoms free of organic matter.

Therefore, its ability to remove excess organics stored or "banked" during The Great Heat was substantially delayed, it would take years of cold and energy to remove accumulated compost, so eelgrass returned first to the outer bay as soon as the energy stopped, then to Niantic River years later, so a habitat overlap occurred; scallops still had suitable habitat while eelgrass habitat wise gained a foothold. Eelgrass meadows during The Great Heat were dense in Niantic Bay but the 1931 October snow storm/hurricane may have stressed eelgrass populations along our coast. Flood waters and storms could have dislodged enormous amounts of leaves, wood debris, sticks and other detritus debris suffocating eelgrass roots weakening the plant allowing it to be overcome by various diseases. In June 1931, it was extremely hot and could have stressed the plants even further. This is the beginning of the wasting disease outbreak. By the 1940s, eelgrass was gone, the victim of molds, but by the late 1960s, it was back. It is in Niantic Bay that NOAA NMFS used dynamite in an effort to restore tidal circulation in 1974-1976 by cleaning a path in dense eelgrass meadows. For those interested in reading more about the Bay Scallop Genetics and Transplant Programs To Niantic Bay, 1916 to 1935: An Historical Account, #25 on our web.
http://www.soundschool.com/directory.html

Clinton Harbor-Hammonasset River- I feel is the best area to study species shifts. Its barrier beach is largely intact (although obvious cut lobes are visible from aerial photography and old maps (Cedar Island has a long history of barrier breach breaks)- clearly shows a barrier inlet called the Dardanelles. In periods of cold and storms, offshore eelgrass meadows flourished in Clinton Harbor, outside of the cut south of Cedar Island. George McNeil and other fishermen felt the break allowed organic debris to nourish the offshore eelgrass meadows and they were absolutely correct. Scallops flourished in the deeper channels adjacent to the eelgrass meadows. When the inlet was closed leaves and sticks accumulated inside the barrier beach, bottoms became softer, filled with muck, the eelgrass that lived here was over a previously hard bottom which at one time was a popular soft shell clamming area. When the inlet was opened, the fisheries improved, it allowed the built up organic matter to disappear. In the 1930s and 1940s, winter flounder were dense on the oyster beds. After the Dardanelles was filled for the last time with abandoned automobiles strung together on wire cables, (there was so much tidal exchange) the scallops disappeared, the eelgrass was starved of its leaves (food) and left. The inside harbor became soft again. After a few years eelgrass meadows grew in areas that once supported both soft shell clams and winter flounder.

Brief habitat Histories for Niantic River – North of Causeway and Clinton Harbor
Dynamic Barrier Spit Openings

In a manuscript titled, "The Nehantic Way" by Herb and Marilyn Davis, 2001, Waterford Historical Society

- One of the few records of the Niantic Bay mentions a possible breach in 1815.

On page 52 of "The Nehantic Way" is found this passage:
"R.B. Wall writes in 1910 that the oldest residents of the region state that the bar appeared to be diminishing previous to the railroad being built upon it in 1852. In the time of the early settlers, the west end of the bar was much wider with many large trees and vegetation covering almost all of its surface. On the 22nd of September, 1815, a great gale occurred in the area with waves 10 to 12 feet over the bar, which resulted in reducing the bar and erecting the channel, north of the bar, previous to the storm, the channel flowed almost north south on the north side of the bar, but following that storm, it assumed the present zigzag flow."
It's difficult to predict if the storm filled 1870s would have breached the west end of the bar, now reinforced as a railroad rail bed, but "west end thinning" is classic for several such barrier spits in New Haven, Clinton and Niantic. In times of breaches, colder water containing more oxygen would be allowed to enter. The nitrogen respiration cycle would shift benthic oxygen reducers would become prevalent. The breach itself would allow a restored energy pathway, surges flow currents and waves to re-suspend and carry away organic accumulations into more active and oxygen rich environments.

As far as the bar in Niantic Bay, the breach or secondary inlet has not been active for nearly 200 years although western and thinning continues over time to be a problem to both the railroad and towns. The bar is currently undergoing additional reinforcement (2011) after northeasters washed away huge amounts of fill at the west end the past two decades. Because of an easterly route above the railroad causeway, organic deposition continues on the "long way out" and the bay acts as both a breakwater and dam to Niantic River bar habitats above. The clearing and cleaning action of periodic breaches of Niantic Bay appear to be over. Maintenance dredging has largely picked up the chore of taking out organic accumulations. Similar dredging projects in Massachusetts report increases in winter flounder populations after cleared channels have stabilized.

The habitat history of Clinton Harbor and the Dardanelles breach is more recent and more active. Cedar Island was breached in the 1898 by the Portland Gale but the town Clinton closed it by 1910. However, a special town meeting in Clinton was held in 1919 to entertain a proposal to reopen the Dardanelles (also a west end opening of the barrier bar) to "let the mud drain off the flats". According to George McNeil of Clinton, local fishermen here asked several times to have the inlet reopened noticing a decline in the fisheries after each closure. Fishermen were correct to link increased flushing tidal exchange to increases in fisheries; valued species then included winter flounder, clams and bay scallops. This could have only come about by significant and observable changes in habitat quality, a February 21, 1989 Clinton Recorder newspaper article, titled "A Bit of Clinton History: What are the Dardanelles?" by Margaret Bushy, staff columnist contains this section, about the history of the Dardanelles barrier beach inlet.

"But Stedman Wilcox, (1989) another Clinton native, remembers hearing his father, the late Sam Wilcox, talk about the Dardanelles. He was a well known local fisherman whose knowledge of the harbor and surrounding waters was deeply respected. He talked about their closing and how they made a mess of it, Wilcox recalls. He said he never heard when they were opened, but a short breakwater was put in across the opening when they were open Wilcox said he favors opening the Dardanelles again."

George McNeil was very helpful to my review of Clinton Harbor for the Cedar Island Improvement Association, available on our school website http://www.soundschool.com/directory.html as # 46 *Environmental Fisheries History Review Clinton Harbor/Hammonasset River* providing two key newspaper articles, both from the local newspaper, the Clinton Recorder, May 26, 1949, discussing building a road to the Dardanelles, then still open; following the 1938 Hurricane and a second article July 6, 1950 in which the title, *Harbor Dredging, Making Progress*- now pumping in the vicinity of the Dardanelles, now filled with Rocks, (Authors unknown but copied from Mr. McNeil's scrapbook). The July 6, 1950 article contains this section as the Dardanelles were being filled with dredge material, "More recently pumping has been going on in the vicinity of the Dardanelles where years ago a channel was cut through to the Sound from the Harbor and this providing an unsuccessful venture as a shortcut exit from the harbor. [This article/author was not evidently aware of the 1919 effort or the natural reopening after multiple closings as part of a barrier beach habitat history detailed in maps from 1790 and mentioned in the US Fish Commission Reports of 1887)] It was stopped up with huge brownstone boulders although this did not prevent the tide from roaring through there at certain stages of the tide and wind." George McNeil recalled that the 1950 effort to fill the Dardanelles was unsuccessful; water still roared in and out at half tides. But the harbor he felt was cleaner from this increased flushing- scallops came back in the outer channel area, winter flounder thrived in the inner harbor, bottoms were cleaner and firmer with more shell and clams. However, the opening did allow easterly swells to enter the harbor and the Dardanelles represented "a hole in the breakwater," similar to what used to occur at the breach in New Haven Harbor. Here a similar barrier breach "bar" from West Haven midpoint in New Haven Harbor would break in New Haven Harbor sending waves and swells against Oyster Point, called City Point today. In Clinton, navigation and boating interests regarded the breach with distain, considered a hole in the breakwater making the harbor rough at times. But the waves helped cultivate and remove organic buildup, as Mr. McNeil would mention to me many times. The 1950 effort was a failure, but a second attempt 1951-1952? was successful here as Mr. McNeil described the cabling together of junk automobiles. He described as necklaces of car with wire rope (cable) so much tide was going out anything placed in the opening just got swept away. At the time, eelgrass beds were in the outer harbor and scallops in the channel edges, some fishermen used a push/pull net to catch them. The flow out on rainy days was filled with leaves which he felt fed the outer eelgrass beds in areas out of the greatest tidal exchange. The automobile cable method was successful and the Dardanelles again filled out almost immediately leaves and organic debris started to collect on the lower river oyster beds. The time and effort now he spent to keep oyster beds soon increased. The channel outside of the Dardanelles filled in and the offshore eelgrass beds had largely disappeared by the 1960s. The scallops were gone and the lower Hammonasset River started to collect leaves and organic matter – bottoms started to get softer and leaf filled – clamming declined especially for soft shells. In the area of Cedar Island, soft black ooze started to accumulate.

All of this seemed amazingly similar to John Hammond's conversations about cuts and changes in the Monomoy system on Cape Cod. As the Hammonasset filled with leaves, the bottom became soft and sediment filled by the Dardanelles, which now supported a dense meadow of eelgrass increase that once held winter flounder and clams. Elevations increased and the once hard bottom deeper areas became filled in, soft that in some cases you couldn't walk across it (I tried in 1978.) This is the area in which, Lance Stewart NOAA Sea Grant, Edwin Rhodes NOAA NMFS, John Baker, Chief Dept. of CT Dept. of

Agriculture Aquaculture; Brian Sullivan, a friend of mine and I placed 10,000 seed scallops in the area that once had been the inner opening of the Dardanelles. As McNeil having known him since high school explained to me later, "…That habitat clock had long since passed." We had planted them in the soft eelgrass meadows, but I was soon to learn that about four feet below this eelgrass was a hard bottom filled with dead Mya soft shell clams and scattered oyster shell. The Area Mr. McNeil claimed was once terrific for winter flounder. Conversations with area fishermen from both Madison and Clinton confirmed this account many times.

The Trouble with Eelgrass

The absence of proper citations of historic shellfish papers and sources to include only beneficial eelgrass attributes is a far larger concern than its invasive characteristics. We have no clear picture of its habitat history. To quote a popular advertisement, "It's like it never happened." Too many of the early shellfish researchers detailed at length the problem with eelgrass for this to be isolated incident; it is not. Some of the same reports cited for beneficial eelgrass benefits also have sections describing how damaging and habitat altering eelgrass can be. Those citations almost never appear in today's studies about eelgrass.

We may be facing an environmental scientific bias on the scale not so long ago that also forced the research community to finally conduct the re-evaluation of health impacts from tobacco smoking. Scientific "research" contracts connected to a public policy is in my opinion a dangerous road upon which to tread. This was quite alarming to some researchers, and Nelson Marshall's last book sets the stage for a new scenario, instead of publishing or perish a new, grants or gone. Instead we see contractual scientific research that often approaches a client/customer relationship as opposed to an open consulting one. Here the grantor is not a business entity per se, but groups and agencies promoting beliefs and values largely based or created in response to public policy concerns. One of these concerns has been the decline of eelgrass and the bay scallop. There are however, other examples.

Although there is much discussion today regarding increasing water temperatures in the scientific literature (which is good) very little can be found concerning the habitat consequences of cold and high energy. Energy or bottom disturbance is only referred to in a negative sense, habitat destruction, property loss and the erosion of the present shoreline. Other than the Nile River Delta impact and construction of Aswan Dam references to the positive impacts of coastal energy (such as dredging projects) are very rare.

In Egypt and the loss of the beneficial nutrient / soil sediment nourishment aspect to agriculture in the Nile River flood delta is one of the few times "good flood erosion" is mentioned. The coastal impacts of energy pathways is even more biased, here the destructive aspect to personal property established the 1960s flood and erosion control acts and a national flood insurance program which lead to armoring the coast as evidenced by breakwater and jetty construction during this storm filled period. In many cases these structures accelerated coastal erosion. For the impacts of temperature more information is found and many species are described as warm or cold water species but very little can be found regarding the long term habitat impacts of cold, just heat. Global warming has eclipsed the habitat studies of cold. While much attention has been placed on high heat habitat degradation cold water species show pronounced changes in abundance over time but these discussions are largely absent in science studies today. The largest current case is most likely the failure of the Southern New England Lobster Fishery.

Blocking or altering energy pathways has profound fishery habitat consequences during both hot and cold periods, but because environmental regulatory policy is currently based upon minimizing energy disturbance (bottom disturbance) even to the point of estimating the impact of a human foot, these impacts remain excluded from view or greatly minimized. The fact of the matter is our coastal fisheries habitats are created and destroyed by energy. The habitat history of Zostera in New England shows strong association to climate and energy. The best case of before and after energy pathways could be perhaps the ancient practice of breaching salt ponds on the …islands (Martha's Vineyard and Nantucket) and Southern Rhode Island. There are consequences to restoring energy and many case studies exist that should be reexamined for species shifts. The energy that shell fishermen frequently mentioned to clear bottoms "clean" and the loss of shellfish habitats when they "grassed up" need a full and impartial review. This is especially true for eelgrass populations in New England.