DEP/EPA Long Island Sound Study
Habitat Restoration Committee
The Importance of Recycling
Estuarine Molluscan Shell for Shellfish Sets
Replacing Shell May Speed Habitat Recovery During
Climate and Energy Transitions
Marine Soil pH of Near Shore Habitats, East River Guilford,
Oyster River Old Saybrook Case Studies Reviewed

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Agenda Item for Discussion
Estuarine Shell as a Distinct Habitat Type

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(Please do not cite without acknowledgement)

Abstract:

The Long Island Sound Study and other New England resource marine management agencies have expended much effort – research and spatial planning spending towards other specific habitat types, those including kelp forests, northern corals, sea grasses (SAV) kelp/cobblestone, eelgrass, ledge/structure, but little mapping/study of estuarine shell.

Estuarine shell has multiple structure – habitat services to vegetation especially alkaline seeking coralline reds, encrusting algae (Maerl), provides habitat cover for crustaceans and in our area, particularly young of the year (YOY) winter flounder. Encrusting organisms such as barnacles and similar species also deserve additional study.

Estuarine shell naturally seems to facilitate bivalve sets recruitment of the hard and soft clams and more recently Mya is suspected of providing key over wintering habitat areas for blue crab megalops and early blue crab life cycle stages, the critical star to visible sizes as well as other juvenile crabs including the invasive green crab.

Problem: Estuarine shell enhancement/replacement of historical sub tidal habitats shell has been somewhat controversial. Occasionally it is referred to as fill or unnatural bottom habitats even during a period of suspected region wide ocean acidification. Much of the estuarine shell containing habitats especially those of Mya, the soft shell clam is very susceptible to natural low acidic sediment conditions, their shells are thin, and dissolve quickly in oak leaf compost (Sapropel) deposits. Connecticut's forest cover has recovered from the early 1900s and the oak canopy has greatly increased. This compounds the problem of bottom acidification in many bays and coves. Some coves contain several feet of partially rotted leaves.

Many natural oyster beds Crassostrea virginica have been dredged for navigation improvements providing a detailed habitat history for these areas. Thousands of acres of estuarine shell containing areas have been impacted by breakwater and railroad tidal restrictions. Losses of estuarine shell containing subtidal areas can be well documented such as those in Long Wharf New Haven Harbor (for an account of the impacts upon shell by the construction of breakwaters, see New Haven's Lost Natural Oyster Beds, available from the Sound School Adult Education and Outreach Program). Offshore mussel Mytilus and hard clam Mercenaria are very dependent upon natural energy (storms) and climate (temperature) cycles. Offshore shell containing areas (natural oyster beds) however, have been linked in the past to providing important ecological services to other species including lobsters, winter flounder, and tautog (blackfish).

A huge habitat loss occurred for the Bay scallop Irradians an important western Connecticut fishery in the late 1890s. A malaria outbreak from 1901 through 1905 resulted in a state and local health department orders to fill all coastal salt ponds within a mile of the coastline between Greenwich to Stamford. The order in response to eradicating the vector for the malaria outbreak (mosquitoes) eliminated many salt ponds ending an important habitat for Bay scallops. It is these same small ponds that once contained shells found to be important to winter flounder. Thousands of acres of soft shell clam beds have been lost to filling and bulk heading of coastal areas, many from wharfing out to deeper water during Colonial times. Almost every coastal town has filled areas of this description.

Between breakwater construction, eastern tidal restrictions (particularly from railroad construction) bulkheading for wharfs and 20th century dredging of river natural oyster beds for navigation improvements thousands of sub tidal acres that once contained estuarine shell have been lost, impacted, modified and no longer are capable of providing previous habitat functions/services. Pollution has also reduced habitat quality, Perry Mill Pond in Fairfield, CT, for example has been identified as one of the most significant blue crab larval concentration areas and linked to areas of extensive sub tidal Mya soft sell clam beds, but is now contaminated with lead. Warnings as to lead contaminated seafood have been posted for this area.

Watershed changes have in addition had implications for the habitat quality as shown redirection of much of the fresh water input for Alewife Cove between New London and Waterford. The result has reduced ebb channel formation and by doing so decreased ebb hydraulic flows. Without strong ebb channel flows, sand waves enter and advance up into the salt pond restricting tidal exchange, changing salinity profiles making the habitat no longer suitable for shell producing bivalves. Estuarine shell bottoms are also important to numerous and forage fishes, which support both commercial and recreational fisheries.

Some of the studies performed in Cape Cod area salt ponds found greater organism diversity and richness when habitats in total area had balance, estuarine shell, vegetation, sandy/mud and cobble/structure. When one of these habitat types predominated over 50% of a given area or region biological diversity declined. (Art Gaines, 1982, personal conversation). More recently studies can be found; Habitat Enhancement As A Means To Increase The Abundance Of The Northern Quahog (Kassner) Juvenile Winter Flounder Distribution By Habitat Type (Howell and Harris) and Dissolution Mortality of Juvenile Bivalves in Coastal Marine Deposits (Green et al). We might be able to learn a great deal from looking at estuarine shell, its role in our coastal waters and ecological services supporting organism richness.

Habitat History Examples -

East River Guilford – Case History Mitigation of Navigational Dredging Impacts

Frank Dolan of Guilford, CT at the end of his oystering career didn't feel bad about the navigational dredging of rivers, he felt bad about losing the shell associated with the dredging of rivers. For oyster growers taking the shell was like chopping down an apple tree, the resource loss was immediate but all the future crops were lost as well. Mr. Dolan had seen the mouths of tidal rivers reef up with natural oyster beds over time and pulled off many a boater stuck on the oysters in the West River in Guilford. When the oysters reefed high up 6 feet in the Neck River and natural growth oystermen were cheered as depths increased from seed oyster harvesting (Jackson Wommack letter July 1988). Mr. Dolan saw periods of too much shell and then not enough. It had happened before in 1949 in the East River. He had seen the great sets and then few or none. No matter the strength of the oyster spat fall the set would in the final analysis depend upon the availability of clean shell, the setting surfaces.

Mr. Dolan during his oystering business operated traditional wooden oyster dredge boats and many will remember the Guilford Harbor sluice dock with at one time when three such boats were berthed. Built at the turn of the century when oyster fisheries seemed without limits most had been converted to mechanical boom dredges during World War II. A shortage of labor prompted the change and when the oyster fisheries collapsed those who could soon converted to hydraulic hard shell clamming. While still good production vessels offshore in close to shore within limited river spaces they were less effective. As the post war boating and shore communities grew additional channels and mooring areas were dredged. Often the mouths of river were dredged to create protected mooring areas such as the lower portion of the East River. In these out of the high energy areas and protected from a saltwater predators, natural oysters beds were frequently located. The larger dredge boats could not operate here and many natural oyster beds overgrew such as the ones in the Guilford/Madison area (Shoreline Times 1949). North Cove in Old Saybrook is an example of these federally dredged – as a Harbor of Refuge was created during the 1950s boating post war boom.

Oyster beds in Connecticut were frequently navigationally dredged in the 1950s and 1960s. At first oysterman opposed the dredging for the loss of oysters and shell base but after each dredging they noticed the remaining oysters grew faster and remaining habitats were "cleaner". What they didn't miss was the leaves, sticks and logs that once covered the bottoms. Later when these areas became closed to direct harvesting, thousands of bushels of oysters would perish from lack of harvest and leaf litter, logs and sticks filled channels in several tidal rivers. This is frequently mentioned in the historical literature – long thin razor blade oysters in such soft bottom crowded conditions. These long tapered shells tend to trap organic debris. Logs could sometimes ruin many oyster areas and oystermen had blacksmiths make tree spikes to remove them (a form of harpoon). Once cleaned of organic material oyster and finfish populations which included winter flounder would often reappear (Specialists Warns of Black Mayonnaise Threat - New London Day, June 12, 1985).

George McNeil who oystered in Clinton for decades commenting on a dredge project in the Hammonasset River once remarked "they can take all the black muck they want, just leave the shells." Although, Mr. Dolan had removed 30,000 bushels of dead overgrown oysters in 1974 from the East River during much controversy because he used a mechanical and not a hand hauled oyster dredge – he remarked that at least he returned the shells later for spatfalls – the Army Corps Dredging Projects (Army Corps of Engineers) didn't do that. That was the end of the discussion. He had made his "point." His project was approved (Guilford Shellfish Commission Minutes available as directory paper #27). He would mention that Shellfish Commission meeting to me frequently, his hope that someday the boaters and shell fishermen could work together and maintain together the ecology of these channels. His plan was to speed up habitat recovery by planting shell. He was willing to try a test and became the subject of a research project in the mid 1980s while I was still employed at NOAA Sea Grant (University of Connecticut). He wanted to see if active oystering could maintain certain depths –providing both shellfish commercially and saving the boating community a lot of money. His plan was that by removing slight accumulations of silt, leaves and sticks yearly and maintaining a healthy oyster bed depth the need to dredge would be lessened or perhaps eliminated.

The site of the study was the lower East River, Guilford Federal Anchorage area. After the channel had stabilized post dredging the shell base was replaced and monitored for seed oysters. The University of Connecticut Dive Team made photographic and written logs of observations (See appendix #1 Dive Report Bob DeGoursey). Not only did seed oyster setting capacity quickly return to the area, but winter flounder as well. The results of habitat renewal were positive a slide lecture presentation was made to the Army Corps of Engineers at the time. The research was published in the Journal of Shellfish Research in 1988. (Mitigation of Dredging Impacts to Oyster Populations 1988 JSR 7-2 Pg 267-270).

Old Saybrook, CT Oyster River Case History
Observations from Shellfishers – Habitat Services

Inshore fishermen have long recognized the need of shell for oystering but also its value to other shellfish and fish species as well. This was clearly evident after oyster harvesting and reshellling occurred in The Oyster River 1981-84. Shellfishermen especially noticed the association between shellfish and finfish populations including winter flounder, tautog and lobsters when small immature stages were associated with deep water oyster beds. This was the case with the Oyster River Project in Old Saybrook 1979 – 1982. (See fact sheet titled Oyster River Management Plan as comments to Judy Preston, The Nature Conservancy May 2002). In this case, a 1981 shellfish management plan in cooperation with local shellfishermen and town officials to clean the oyster beds of fouling leaves sticks and logs. Oyster river neighborhood residents noticed that winter flounder returned to the river immediately after cleaning the oyster beds (Anthony Ronzo, communication 1983). The research is highlighted in the 1992 book, Introduction to Aquaculture, written by Matthew Landau on pg 46. He highlights the Old Saybrook project as a local shellfish commission shellfish management success.

Shellfish harvesting and shell covered bottoms had other positive habitat benefits and had long been an industry claim, that a healthy bottom was a shellfish bottom and that shell was important to many other fish and shellfish species. Shellfishermen both recreational and commercial have long insisted that a worked (harvested) bottom with shell cover was good for clam sets. The planting of oyster shell had in many industry accounts also facilitated the hard clam – Mercenaria clam sets. They in fact were buffering the acidity of marine soils by using calcium containing shell – just as agricultural terrestrial soil "lime". This had been discovered ancillary to the oyster industry under layers of shell were always populations of the hard shell clam – commonly referred to as the qhahog or hard shell clam (George McNeil, personal communications).

Other Areas – Habitat Associations to Other Species

Many oyster tongers in Central Connecticut would often hand line for fish while oystering, no doubt attracted to the bottom cultivation and chumming effect. According to Robert Ketchale of the Guilford Shellfish Commission - Striped Bass, Tautog and Flounder were frequently caught in such a manner in tidal shellfish beds in rivers in the 1930s and 1940s. See, A Review of Fisheries Histories for Natural Oyster Populations in Tidal Rivers (2007) Sound School publication #33.

Some of those habitat comments are found in a report titled "The Niantic Bay Flounder Fishery" once famous there in areas of productive subtidal soft shell clam beds. The recreational fishermen fishing for flounders in more open areas of Long Island Sound frequently sought out commercial oyster beds upon which to fish and often used clam necks as bait (personal communication John Curtis 2009).

<u>Bivalve Shell Contains Environmental Services</u>

It is not surprising that Connecticut shellfishermen and finfishermen had long recognized the habitat benefits from estuarine shell. It functions much like an artificial reef and it buffered soil acidity raising the soil pH as well. The oyster industry especially had experienced the habitat enhancement aspects as deeper portions of Long Island Sound were planted with seed oysters. The structure and food web benefits were hard to miss, they kept reappearing. Commercial oystering in modern terms was perhaps some of the first marine ground truthing surveys. While hundreds of thousands of dredge hauls each year sought out oysters or oyster predators other creatures would also be present. It would be hard to miss all the organisms in those dredge hauls year after year. The association of a healthy oyster bottom offshore was also good for other species, namely tautog and lobster. Inshore oyster growers were aware of the impact of shells to clam sets as well as fish including winter flounder. This knowledge would influence many of the first 1979 Coastal Management Act habitat conversations here in Connecticut.

In some of the initial Coastal Area Management discussions here in CT included the first State Aquaculture Division, Chief of the Dept of Agriculture, Mr. John Baker. Mr. Baker pleaded with state agencies (multiple times) to do finfish and shellfish habitat studies associated with the placement of estuarine shell and bottom cultivation during the period 1976-78. The perspective was that industrial cultivation of shellfish beds benefited other important species as well. Connecticut Coastal Area Management Notes for Adam Whelchel, The Nature Conservancy 2008).

The association between oyster growers and flounders and flounder habitat is not new. In one of the first recorded fishing gear conflicts between early beam trawlers for Plaice in England and oyster growers can be found in the early 1370's.

It is thought that oyster growers even in the middle ages also noticed the affinity between oyster beds and Plaice – a flounder species similar to our winter flounder when they would come up in primitive oyster dredges as they do today. Eventually the oyster dredges or drag as it was more aptly described was modified to catch flounder and not oysters with the addition of a beam. The conflict was often a complaint that the flounder drags were also disturbing the oyster beds, a gear conflict not impossible to imagine – today except the year was 1376. A complete write up of this conflict is found in an account of the Fishing Gear of England and Wales written by F. M. Davis (1925).

Recreational fishermen in CT would often seek out oyster beds on which to fish for winter flounder. Pounding or scratching the bottom in or near shellfish beds was a known practice in the winter flounder spear fishery a century ago (Niantic Bay) and was utilized in near shore areas (Tom Creek report series).

The association of juvenile lobsters for example with oxygen sufficient off shore areas and oysters could have supplemented or replaced the usual inshore kelp/cobblestone habitats. Few could argue that the shell habitat could provide both protection and nourishment services for the critical stage 4 juvenile lobsters. It's also possible that the structure and habitat reef services could also assist blackfish or tautog. Cultivating oyster beds no doubt dislodges small crustaceans which could be quickly consumed by opportunistic bottom feeders. For example, an experimental hard clam dredge trial off Charles Island Milford in the middle 1980s drew dozens of mature tautog after pumps started even before hard clamming commenced. To the UCONN drive team watching the operation below the sudden appearance of the tautog resembled a food bell. No doubt the hard clam hydraulic dredge dislodged food and attracted the attention of nearby fish over time. Tautog have been observed to develop similar feeding behaviors in tank systems over time (T. Visel, personal communications with John Roy, Sound School Senior Aquaculture Science Teacher).

The oyster industry was able to modify and sustain habitats by the application of energy (work). Key to this was the industrial practice of planting and cultivating shell. The loss of shell became a constant concern of oyster growers but at the same time shelled areas seemed to contain more "life" than those not shelled. Despite requests by the shellfish industry during the period 1976-78 these habitat studies were not completed although frequent and similar claims were made by inshore baymen, especially from Cape Cod, Narragansett Bay, Great South Bay, New York and Connecticut. The Association of Rhode Island Great Quahog Clam Sets following hurricanes on shell covered bottoms for over a century is well known. Almost every Rhode Island Shellfish Commission bulletin from the last century has a section in it on the benefits of working the bottom or the application of energy to estuarine bay bottoms (laying down shell for example).

Soil Chemistry is Important to both Fish and Shellfish

Dr. David Beldings research a century ago would first recognize the transition of alkaline marine soils to acidic ones and the impacts upon clam growth and recruitment (Beldings research is available from the University of Massachusetts Cape Cod Extension Service Deeds and Probate Building Barnstable Mass). Not only providing structure or reef habitat services molluscan shell was a chemical modifier of marine soil pH. Although not new to terrestrial agriculture the soil pH tendency to become acidic from organic matter overtime was evident in the marine near shore environment as well. This ability attributed to oyster culture and the practice of shelling acted to buffer the acidification of marine soils enhancing hard clam sets. (The Rhode Island Great Clam Sets of 1939-1940, 1951-1952 report is available from The Sound School Adult Education Program).

During 1980-81, Frank Dolan would allow me to spend several days hydraulic hard shell clamming within and he would frequently assess bottom pH by scraping to shells together to determine how soft the outer shell was. Hard clam shells in low pH bottoms would quickly "pumice" when rubbed together producing a white cloud when submerged in a pail of water. "That was Mr. Dolan's pH test." That process is described in a report titled The Cultivation of Marine Soils now the most popular report on The Sound School Adult Education publications directory http://www.soundschool.com/directory.html please choose paper #26. The account describes the value of estuarine shell not only for oyster culture but for clam culture as well. Oysters growers who converted to hard shell clamming planted a thin layer of shells over recently cultivated bottoms containing a few clams to gain higher clam sets. The practice is an old one done noticed a century before for oyster setting which was continued into this century and mentioned in the first CT Aquaculture Commission Report compiled by John H. Volk then Connecticut Aquaculture Division Chief in 1986.

New England clammers would also come to recognize the importance of shell and bottom cultivation for the productivity of clam sets. Nearly every clam fishery at some point mentions cultivation or the presence of shell as beneficial. Hard shell clammers in the 1960s and 1970s soon realized the soil conditions necessary for habitat enhancement – cultivation and pH frequently terming low pH bottoms as "sour" (conversations with Great South Bay clammers and correspondence to Arnold Carr in 1983) and lightly cultivated shelly bottoms as "sweet". The research community followed Belding's research and more recent studies regarding the association between shell and good sets or higher densities of hard shell clams are hard to dismiss. (Kassner 1994 Habitat Enhancement as a Means to Increase the

Abundance of the Northern Quahog, Mercenaria mercenaria). In a related detailed study of the soft shell clam Dr. Mark Green of St. Josephs College in Maine found that marine soils mixed with seawater and free of organic acids with shell cover enhanced the setting of Mya the soft shell clam on previously barren flats. Belding (1910) reports that some of the densest sets of soft shells occurred upon dredge spoils (now termed material) placed on flats rinsed of organic acids on Cape Cod. A Rhode Island report in 1905 mentions that soft shell clammers always remarked as to the positive enhancement effect of cultivating clam flats (The Soft Shell Clam Industry pg 8 of the State of Rhode Island 36 Annual Report of the Commission of Inland Fisheries 1905).

Estuarine Shell as a Distinct Habitat Type

It is now thought that the blue crab megalops stage migrating into Connecticut or spawning here seeks out estuarine shell particularly Mya before metaphorsis. A Connecticut DEP Study Howell and Harris Estuaries Vol 22, #4 P - 1090-1095 Dec. 1999) found that young flounder preferred a bivalve shell matrix (litter) habitat when compared to other habitat types. Therefore when calculating the habitat conditions associated with estuarine molluscan shell, several factors, structural biological and chemical need to be considered for future study. The loss of estuarine shell has habitat consequences far beyond that of live shellfish, even dead shellfish beds or buried shells are important to our current habitat studies. The impacts of pH can be subtle for example in one often cited study, Oyster Culture in Long Island Sound 1966 – Commercial Fisheries Review No 859, January 1970) black shells in acid bottoms were able to catch a set of seed oysters when raised to the surface.

Dr. Mackenzie (NOAA NMFS Biologist) found as the shellfish industry had, that buried shells dislodged from muddy bottoms were biologically clean from the acidic conditions of them and therefore able to catch a set of seed oysters. (Page #30 CFR #859 1/1970) Absent from the discussion is what impacts the acidic bottoms were having upon the supply of shell. In fact, the so called CT oyster wars in the 1920s occurred in part to declining shell reserves available for seed oyster planting. (See The New Haven Lost Natural Oyster Beds available from The Sound School Adult Education Program).

Some of the losses could be attributed to low pH bottoms dissolving shell as well as over harvesting. Acidification of coastal waters occurs during periods of heat and less oxygen. As such organic decomposition as burial in warm temperatures speeds acidic conditions as much as ten times that cooler oxygen rich waters (George McNeil, personal communication). Acidification was extreme – 1890 to 1920 here in New England during The Great Heat and could have partly created the shell supply crisis in the industry during this period. This period is marked by intense heat which lowered oxygen levels in shallow waters and recorded significant fish kills. The lower oxygen and nutrient enhanced respiration most likely dissolved shell faster making supply (cultch) problems even worse. During this period obtaining ample of supplies of cultch for seed oyster planting surpassed the importance of predator control.

The natural oyster reefs in river inshore oyster beds and the occurrence of natural offshore beds are primarily dependent upon energy – tides, currents and powerful storms. In river natural oyster beds energy is largely tidal driven with productive areas in faster currents (bends) and in areas of deposition and lower current velocities less dense (See Review of Natural River Oyster Beds, Sound School publication #33). Offshore areas were dependent upon coastal storms to help clear accumulations of silt. Severe gales however could be devastating to adult beds. This is mentioned by E. P. Churchill's 1919 report to the Dept of Commerce, see appendix. To maintain oyster reefs they need periodic energy (cleanings) to prevent shell loss, burial and acid dissolution. On hard bottoms storms can soften them, on offshore soft bottoms storms may scour lose silt and organic debris leaving loose shells or "chips" on firmer bottoms that have been rinsed of organic acids. It is only natural therefore that some organisms would benefit from this energy/cultivation process. These benefits were often observed by shellfish harvesters especially quahog fisheries. That is why they continue to report even to this day the benefits of soil cultivation in the presence of estuarine bivalve shell.

<u>Estuarine Shell May Indicate Species Specific Habitat Types</u>

The three largest factors to shell loss can be acid dissolution, organic burial and overharvesting. In traditional oyster restoration programs, overharvesting is frequently the only area of review, typically ignoring energy (temperature) and deposition (low pH) of acidic organic debris. In areas subject to high detrital leaf inputs, especially from oak trees today, low pH bottoms adds to the problem of shell loss. In a third study area looks at organic burial in which shell is buried under layers of organic debris. This problem is frequently mentioned in US Fish Commission reports 1887-1902, often referred to as The Great Heat.

Three areas of research I believe are needed to determine estuarine shell value to Long Island Sound habitats. First it may be necessary to revisit how energy/temperature and estuarine shell interact to burial. One of the quickest habitat studies may in fact be one of the navigational dredging projects mentioned before. Projects that restore once natural shell bases followed by careful monitoring may provide clues to benefits and ecosystem services of estuarine shell. A project proposal (not funded) included a small pilot study of shelled area, see the Dowd's Creek Restoration Proposal Sound School Adult Education paper #50. Navigational dredging can be termed man made erosion and modify existing energy pathways. Numerous baymen accounts especially from the Great South Bay New York constantly mention inlet size and tidal flow (energy) and the presence of “sweet” shell covered bottoms as significant to local hard clam settings/productivity. In times of inlet size reduction shelly areas tend to become buried and hard clam production declined. (See Great South Bay - New York).

Secondly, what shell reserves we can study will assist in determining such ecological services to macro marine resources. Several oyster riverbeds could show important habitat clues (Project Finfish / Flounder Habitat studies, Guilford, Old Saybrook, Madison – November 2009). Even buried oyster reefs shell shape can be a source of data and Galtsoff’s 1964 bulletin of the American Oyster is a key reference here. Uncovering buried shell bases followed by monitoring can lead to clues as a recent paper titled “Making Dead Oyster Beds Talk” discusses. And finally, the modifications of marine soil pH by shelling long promoted by the oyster industry and associated with productive hard shell clam beds. Here the recycling of shell can duplicate earlier studies conducted in the 1980s on the Cape but in a scientific way measuring marine soil pH parameters (Bourne Shellfishermens Association Report #1,1980).

For a complete description of the type of study involving estuarine shell and tidal creek restoration, see the 1987 Proposal to Restore Dowd’s Creek (Whitlatch Barclay Visel Proposal to The National Sea Grant Office) its available as paper #51 on the Sound School publications website.

Reusing/recycling estuarine shell may be more than a good idea but critical habitat indicators for a wide range of marine species. Although oyster reef restoration is currently targeting oyster population enhancement it may be that future programs will include other species as well. In fact, the modification of an increasing acidic environment may become as common as liming terrestrial fields. With the increase of ocean temperature and acidification of marine sediments only highlights the significance of recycling and restoring estuarine bivalve shell habitats. Shell might be one of the few options we have as habitats change with global warming. Studies on Cape Cod during the 1980s shell bottoms was highly significant to biological richness and organism diversity in the presence of estuarine shell. Similar studies deserve funding for Long Island Sound.

Recent studies have indicated ecosystem services to essential fish habitats and warrants consideration of estuarine bottoms containing shell as a significant distinct habitat type. In fact initial reports as to bethic organisms recovery and responses to energy (dredging) show that species richness is both dynamic and measurable (Response of Macro Benthic Communities to Restoration Efforts in a New England Estuaries Vol. 24, #2, pg 167-183, April 2001). With the increasingly impact of acidification of the worlds oceans the recycling and conservation of estuarine shell for ecosystem services may also become a critical habitat indicator.

Much effort has been directed towards other specific habitat types, corals, submerged sea grasses (SAV) kelp/cobblestone, rock boulders, kelp forests, but little research projects for mapping/studying estuarine shell. Several years ago estuarine shell had a somewhat negative viewpoint as a nuisance or unwanted input into estuaries. We should I believe keep an open mind about its ecological value in the near coastal environment. One of the first Connecticut SCUBA reports on the biological richness of a natural oyster bed was made at Neck River, Madison (Report of Peter Auster to Tim Visel- 1982) which produced a series of 40 underwater slides detailing organism richness living on estuarine oyster shell. They could be made available at the next committee meeting and help address any questions.

In the near future estuarine bivalve shell and ecological benefits to other species besides shellfish may therefore become a critical habitat area for the Long Island Sound Study to review.

Thank you for the opportunity to present this potentional research area.
Tim Visel

The Importance of Recycling Estuarine Molluscan Shell

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34. Roman Zajac and Robert Whitlach, 2001 Responses of Macro Benthic Communities to Restoration Efforts in a New England Estuary Vo. 24, #2, Pg 167-183.

35. A report of the Neck River Oyster Bed by Peter Auster 1988 to Tim Visel – a three page report and 40 Kodak slides.

Appendix I - The Importance of Recycling Estuarine Molluscan Shell

E. P. Churchill – Dept of Commerce – Bureau of Fisheries Document #890 1919 – A Habitat History for Oyster Reefs Pg 18 The Oyster and The Oyster Industry Washington Government Printing Office 1920

"Gales to have an effect on adult oysters in moderately deep water, must be of extra ordinary severity, but they frequently do great damage or exterminate beds in shoal water. The waves sometimes pick up the oysters and throw them on the beach, but more frequently they are destroyed by buried in situ by sand, seaweed, and debris piled up by the sea. Cases are known of where well established beds have been overwhelmed by such deposits and others in which thick strata of sand between layers of old shells indicate a succession of such disasters in the more or less remote history of the beds.

Sometimes the eroding effect of currents and waves will uncover the buried oysters and shells and the beds will again reestablish themselves through the attachment of young; but in other cases the beds are permanently destroyed. The former is the usual result when the reefs rise rather abruptly from the surrounding bottom, and the latter is frequent when they are but little elevated above the general floor of the sea. Planted beds, which usually lie the general level of the bottom, are usually permanently covered. Gales are sometimes agents in the establishments of new beds, carrying oyster and shells to surrounding barren bottoms where they form a nucleus that gradually develops into economic importance."

<u>Characterization of an Area of High and of Low Hard Clam (Mercenaria mercenaria) Abundance in the Eastern Great South Bay, New York</u>

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Analysis of the distribution of hard clam (Mercenaria mercenaria) abundance in the eastern portion of the Great South Bay, New York, as determined by annual population censuses from 1987 to 1989, was used to identify nine distinct and stable regions of high hard clam abundance interspersed within regions of low clam abundance. To define the regional and local environmental parameters associated with hard clam abundance, video photography, and depth profiling were undertaken within abundance areas is polled and compared to the low abundance shallower RPD depth, greater sediment compactness, greater sediment surface roughness, a thinner flocculent layer, and shells and shell fragments in the sediment. **In addition, high abundance areas are generally superimposed on relic oyster reefs.** The transition from low to high abundance generally coincides with increased topographic relief and spatial changes in sediment type parameters.

A detailed characterization was undertaken for one of the high and low clam abundance regions. The high abundance area had muddy-sand sediment that was relatively hard. Sediment surface relief was provided by the sediment, shells and worn tubes. Biogenic reworking was minor. **The low abundance area had sandy-mud sediment which was soft, had a thick flocculent layer, and considerable bioturbation. Surface relief was minor and shells and worm**

tubes were absent. Topographically, the high abundance area was slightly elevated relative to the adjacent area while the low abundance area was slightly depressed.

Population data suggests that differential settlement and/or survival to age 1 and account for the difference in clam abundance between high and low abundance regions. This information, together with the environmental characterization, is being used to evaluate the spectrum of factors that may be contributing to the differential abundance of hard clams.