Bacteria Disease and Warm Water Concerns
for the Aquaculture Agriculture Industries
Tim Visel, The Sound School
- **The Lovejoy Pure Oyster Case –**
- **Clean Milk for Cities – Climate Cycles and Public Policy**
Have we forgotten our environmental history?
An Account of Tom's Creek, Madison, CT

A Capstone Proposal
ASTE Standard's Bacterial Food Contamination and Spoilage, Animal Science 13 Aquaculture #4 Biofilters

Updated March 2015

Preface –

Pure Oysters and Clean Milk
Farmers and Fishers Fight Bacterial Contamination
in the Great Heat Waves of the 1890s

This report started in March 2014 and was a Capstone proposal for our students looking into HAACP and bacterial contamination for milk and oysters. One of the features it reviewed was the "Hot Term," or what I call, The Great Heat in the 1880 to 1920 period, which saw progressively hot summers and Long Island Sound was the heat sink for moderating winters. It took a series of very hot summers to warm Long Island Sound until its peak in 1898. The impacts of smaller bodies of water were more noticeable; New England had an ice failure in 1899. Lakes and ponds just did not lose the "heat" fast enough for ice to form, even if it was "cold enough." An ice panic ensued and "ice famines" and (NPR has a great segment titled, "The Heat Wave of 1896 and the Rise of Roosevelt", August 11, 2010) prices soared.

When ice speculation (market manipulation to obtain the highest prices) withheld ice supplies in the New York area, Theodore Roosevelt just went in and took it. Ice was the war material he needed to fight death and control bacteria in food. He made certain that New York cities' poorest residents got a fair share of ice; an act they did not forget, nor should we. It was a battle against bacteria as well as temperature; the two are very much a combined concern.

The Great Heat and the Rise of Bacteria

Although this Capstone/SAE proposal does specifically look at fish and shellfish it does examine a common foe; one that is increasingly gaining importance in habitat quality – bacteria and how climate patterns can impact habitats and habitat capacity for seafood we "value." While many programs have targeted nitrogen removal or reducing contaminants, the study of marine bacteria has languished in high heat however, bacteria becomes very important as most fish and shellfish species need shallow areas for their early life stages. This is where bacteria have such an important, often unseen, role in habitat quality.

The past three years a tremendous amount of habitat change has occurred in New England. After many years of heat, warm winters and few storms, the cold (or at least colder) climate has returned. At the same time, nature with these storms has turned natures compost pile marine Sapropel and revealed the extent of these bacterial populations. Much of the habitat exchange can now be attributed to sulfur reducing and ammonia reducing bacteria, during hot and cold periods bacteria change in response to heat or cold.

The examination of "hot" and cold periods offer a unique opportunity to glimpse into these bacteria populations and how they can impact us and the seafood (foods) we consume.

A Close Look at the Sulfur Cycle and Sulfur-Reducing Bacteria is Needed

The current environmental policy supporting non-bottom disturbance is exactly the conditions sulfur-reducing bacteria require to thrive. Sapropel deposits that have waxy paraffin residues (much from decomposing oak leaf residues) seals off oxygen from surface waters allowing sulfur-reducing bacteria to multiply with all their negative impacts in this marine compost. Most terrestrial gardeners know the benefits of "turning" over a compost pile to add oxygen to aid the "good" bacteria, especially in hot weather. The bacteria that reduce organic matter into a useable soil/nourishing constituent, but that knowledge did not transcend into the marine environment. Although shellfishers for centuries have noted the positive benefits of marine soil cultivation/ "working the bottom" that runs counter to most of the coastal policy today, which seeks to minimize disturbance in any way. A rich, heavy layer of organic matter provides a culture media for sulfur bacteria that slowly consumes organic matter in the presence of sulfate, releasing hydrogen sulfide into the water. The same situation can occur in terrestrial composts termed smelly as ammonia/sulfide smells emanate from them. The same process occurs in the marine environment. In this case, good composting bacteria lose out to the sulfur bacteria; with all their deadly and disease causing impacts. Warm (hot) seawater with little bottom disturbance is what enables sulfur bacteria to become so deadly to laval forms and even fish and shellfish eggs; they in fact rob the seafood cradle.

As these bacteria crave quiet, stable conditions, nature can upset them by natural turning of marine composts by storms. The currents and the waves are nature's compost shovels and like chemical processes on land, there is an oxygen tension imbalance (deficits) immediately after such overturn followed by an acidic "wash," low pH condition which is very devastating in warm weather.

In areas of high organic deposition and no disturbance, nature helps sulfur win – and when that happens, we lose the good bacteria and the seafood upon which we value.

I respond to all emails at tim.visel@new-haven.k12.ct.us.

Introduction

New England has had many periods of great cold and heat, one of the first indicators of warm climate cycles was the cycle of Malaria outbreaks associated with warm weather and mosquito populations. It is now suspected that Malaria was brought to our region by the first European settlers' trappers or fishers. There has been periodic outbreaks of mosquito disease all occurring in "hot terms" the latest being West Nile virus. The changes in New England weather influenced at times by immense cold air masses moving south or the presence of the gulf stream –a river of very warm water that brushes our coast over time have influence over the length of terrestrial "growing seasons" and the prevalence of near coastal fin and shellfish species for thousands of years.

Long term hot and cold periods do influence public policies but it is the hot periods that experience the most change as they often bring disease. The last century has also lead to "trust" legal cases about weather and climate – mostly about pollution but also floods with National Flood and Erosion Control legislation in the 1950s. Rain water and flood waters once were termed under broad category of the "common enemy" doctrine are today termed natural. The last century focused upon "point sources" of pollution discharge outfalls, drainage pipes and effluent treated at municipal facilities. While toxic chemicals would provide the foundation for toxicology and the change legal opinions from "reasonable" waste waters to those "unreasonable" which needed to meet certain discharge "limits." Coastal waters continue to be influenced from terrestrial flows both natural and "unnatural." Add to this the impact of cold and heat upon fin and shellfish populations – and a new type of common enemy came into being – ourselves, pollution.

That is the foundation of the climate change issues of today – climate change is not new to Connecticut – our geography describes glaciers and our State is home to a dinosaur park in Rocky Hill. Climate change is real – evidence is now being examined from several sources and "indicators" are sought to measure long term changes. Two of the most significant for the coast is perhaps organic matter undergoing sulfate reduction to the increase of bacterial contamination of coastal waters, and the related issue of nitrogen pollution both with temperature a potential public policy "gate keeper."

Nitrogen pollution has the ability to alter habitat quality but that factor is also greatly influenced by temperature and coastal energy pathways (storms). These events have long been an interest of the aquaculture industry as these events mirror terrestrial factors of floods, forest fires and droughts. We may find that the most useful indicators comes from long term observations of the most susceptible habitats for climate changes – those closest to land. A modest environmental fisheries history could be established and help some of the current pollution questions along our coast. Agriculture has a long history of recording climate/growing seasons, aquaculture in the future may have just as a significant role.

Organic matter influences nitrogen levels which are connected to climate and energy pathways including bacteria. A need exists for environmental history review of the current nitrogen TMDL to include bacterial processes. The role of second source nitrogen or the impacts of reduced organic material in sediments is under review in Florida, the Chesapeake Bay region and Great Bay New Hampshire but other estuary programs are also looking at organic matter and Sapropel formation. The cost of removing excess nitrogen is estimated in the hundreds of billions but how did nature cope with excess nitrogen overtime and what were the impacts of it to coastal shellfish populations? Recent information now indicates waste water treatment plants need bacteria for "filters" – so does nature. Warm water bacteria and excess nitrogen leading to low oxygen has long been a concern to the shellfish industry, bacterial contamination of milk can have disastrous consequences. We recognize the "good" bacteria- those that help break down nitrogen compounds and those termed "bad" – the bacteria that brings diseases.

Bacterial Diseases and Heat

As waters warmed in the 1970s bacteria levels increased much as they did in the 1890s impacting shellfish harvests. Basically the same thing occurred in dairy production a century ago – warm temperatures (1890s) caused bacterial levels to contaminate milk. As milk was consumed raw and also oysters and clams each were linked as disease vectors a century ago. At this time well publicized disease outbreaks were associated with raw oysters leading to a national conference on shellfish growing water sanitation in 1925. In 1918 some states required milk distributors to pasteurize in accordance with the Pure Food Act, by 1935 most states required it. (Milk that entered interstate commerce.)

When the bacterial closures for shellfish harvesting areas first went up in the late 1960s along central coastal Connecticut fishers questioned the reason as their customers gave them few complaints (who cooked them) and reported that no one had ever gotten sick. The water quality regulations had been written for the raw half shell trade (the milk raw food aspect is very similar) for people who consumed them raw on the half shell – most in restaurants. Nate Walston of Guilford, a shellfisherman, told me the shellfish closures notices went up and they were told to stop oystering – that wasn't always observed at first and the shellfish waste that followed later would fill volumes. Mr. Walston would provide comments to the Shoreline Times, a local Guilford newspaper about this shellfish waste in the 1970s. Closures in the shallow areas are where small boat tongers could harvest oysters for local customers, restaurants or seafood markets.

I was involved in oystering while still in high school at first a recreational activity – our house was near a creek filled with oysters soon word got around and having spending money meant we soon had a few oyster customers ourselves who liked shucked oysters. As fishers in our area recycled glass mayonnaise jars to hold oysters which we also soon put to good use. Nate Walston of Guilford (now deceased) an oyster tonger gave me the most detailed oyster shucking account from the Guilford CT East and West Rivers. Each town had a few oyster tongers who each fall went for oysters. Contrary to what is commonly thought most of the oyster sales were then shucked oysters being sold in those recycled glass jars. Oysters would be placed and jars retuned for reuse. (This clearly would not meet HACCP standards today). Nearly all the oysters sold were then cooked in stews scalloped, or holiday stuffing and the incidence of disease virtually unknown. This was far different than the larger oyster companies who served restaurants and the half shell trade which brought a higher retail price "per piece" count. Here a century ago Connecticut oyster farmers would sue cities over sewage pollution that ended in a famous water quality lawsuit known today as the LoveJoy case. LoveJoy an oyster farmer in Norwalk and New Haven was one of the first to claim "injury" as a result of sewage. His oysters were not "pure" but contaminated with bacteria. This lawsuit connected diminished oyster production and sales in markets to an increase in pollution in a carefully detailed history. (The write up of the decision is in the appendix).

I think that is the reason those earning a living and producing seafood held different views on coastal resource abundance was the sudden closure – from bacteria. They experienced the pollution changes (bacteria) – something you could not see, and this was especially true for shellfishing and it was for the most part local and habitat specific. In the early 1970s I was also to experience environmental history in a much smaller personal way – Tom's Creek, Madison. Every fall I would put on a pair of hip waders and with my brother Raymond together descend into Tom's Creek looking for native oysters. It was fun and the oyster stews were of course delicious. We harvested wild oysters, long and bent some then growing up from muddy bottoms. Our oysters were the result primarily natural growth and did not have the best half shell shape – in fact the larger "dog" oysters were preferred – less sucking to the quart – opposite the half shell trade. We didn't think much about the "mud" then; there was plenty of oysters and always some for our uncle Edward Visel who also had an appreciation for fresh shucked oysters. Each fall around Thanksgiving we would bring two recycled glass mayonnaise jars full of oysters to our uncle in Hamden Connecticut. A bushel of Tom's Creek oysters then would yield an average five quarts of shucked meats (they were large oysters).

When Tom's Creek was closed to shellfishing (high bacteria counts), our oyster trips stopped. It also started to get "warm." By 1973 Tom's Creek was permanently closed to direct shellfishing. In the spring of 1974 while attending a Jensen Beach Florida Oceanography Technology Program (then part of Florida Institute of Technology) I was exposed to an oyster depuration facility at a small Fort Pierce Marine lab that was to become Harbor Branch Foundation. Here in a plastic covered pipe Quonset building was a pilot 20 bushel oyster depuration module. In small tanks oysters were allowed to filter water treated with ultraviolet light in a process that would "pasteurize" the oysters of bacteria making them suitable for food. I was amazed at this project and the potential to again use of Tom's creek oysters back home. That set off a series of letters back to Connecticut and then Connecticut Aquaculture Division Chief Mr. John Baker who suggested relaying them to clean waters instead. Relaying then was a natural "depuration process" of bacteria elimination (under strict licensing) and involved moving oysters to clean water. We pursued that option in mesh bags working closely with the FDA (1974-1978). Once oysters were in clean water bacteria counts dropped quickly.

In 1978-79, I was able to work closely with Malcolm Shute of the CT Health Dept., to revise protocols on oyster meat testing. Some of the mud from the outside shells were falling into bacteria plates and impacting bacteria counts. Once steps were taken to cleanse shells before shellfish meats were extracted surface bacterial contamination ceased. The mesh bag relay system (August 7, 1978) was written up and printed as a UCONN Sea Grant Marine Advisory Program fact sheet CT-SG-8902 in March 1989. It is on the Sound School website under publications – "Bay Shellfish Relaying Systems in Connecticut" (T.C. Visel et al- Adult Education Reissue December 2007.

I did see an interesting clip on the television a few weeks ago – a short documentary an oystering "How it is Made" (2011) and focused upon the oyster operations. The segment an oyster culture is finished off with a video of the shellfish depuration plant a 48-hour period of UV light treatment (similar to milk pasteurization). Overseas this seems to be an accepted practice even utilizing those waters for growth that do not meet bacteria water quality standards. A few years ago I wrote a report for members of the Long Island Sound Assembly and detailed the shellfish loss worth hundreds of millions of dollars for want of a depuration process here in Connecticut. I could never get past the fact that shellfish were still alive in the posted areas (most of Europe now depurates; England since 1914, The State of Massachusetts since 1928) a common misperception – shellfish populations exist subject to natural conditions. One of these conditions is a natural reef process in which oysters suffocate other oysters in an attempt to overcome burial by terrestrial organics and subject to increased bacterial populations that reduce (consume) it. That is the situation that Nate Walston described in Guilford's East and West Rivers in the late 1970s.

Heat Brings Increased Bacteria Problems to the Shore

The habitat loss of environment services in these shallow habitat areas is also very significant, denied the "harvest energy" they quickly became eutrophic natural not so much cultural with leaves logs and organic debris. These shelly previously worked areas held fish and Nate Walston and other oyster tongers all mentioned these areas had winter flounder, black fish and stripers in or over them. An active "worked" and harvested area held fish in fact often while tonging they would set baited hooks from frames (the old rectangular wood spools) for them. The best fishing was just as the tide turned as black fish and stripers seemed to follow the mud debris – a chumming effect right to them (I noticed this once while clamming off Wickford, RI). In time these areas no longer produced shellfish but under growing Sapropel deposits those now buried fish habitats were lost as well.

Most of inshore shellfish areas could support these beds again but they would need to be worked – kept free of trees and leaves but would not meet bacteria levels, thus in some instances requiring a depuration plant. Some of these beds have Sapropel deposits so the bottom disturbance factor comes in as well, the concept of new energy in near shore areas and high shellfish productivity overtime are largely unsustainable. Assurances of long term production from shellfish reserves or sanctuaries are not realistic at best – worse a misrepresentation of marine habitat succession. Some oyster areas would be naturally covered by terrestrial organics. In heat these organic deposits house some of the most dangerous bacteria – known as the Vibrio series. This is the same family of bacteria associated with cholera outbreaks a century ago. The Vibrio series (family) thrives in warm waters and soft organic bottoms and continual heat is a huge concern to the shellfish industry. So is the black organic deposits that often sustains them, some of the most pathogen causing species are of the Vibrio family.

In habitat conditions linked to heat in 1975, we approached the Madison Shellfish Commission about relaying oysters from Tom's Creek (to clean waters) which was delayed until a shellfish resource and sanitary assessment could be done. Tom's Creek indeed was now showing very high bacteria counts. When we revisited Tom's Creek to check the population most of the oysters were dead. In just a few years a black jelly like material had suffocated the oysters. Any living oysters were under dead and decaying leaves – a black jelly like substance had covered and killed most of the other shellfish in the creek. A few more Madison Shellfish Committee meetings resulted in taking an empty mayonnaise jar grabbing up some of the material and showing at the shellfish meeting in the Town Hall. The contents of which were black.

Charles "Bud" Schroeder, who was Shellfish Committee Chairman at the time, remarked "It's just mud." I countered, "It looks like mud, but feels like mayonnaise," and had a noticeable sulfur odor. By 1978 Black Mayonnaise was a frequent topic at Madison Shellfish Committee meetings as the Neck River and Hammonasset Rivers now showed the same material growing and killing shellfish, some oyster beds were under two to three feet of this black jelly. The year 1962 was the year of the first East River bacteria closure then permanent in 1971. Habitats were changing and I could see the long term changes in Tom's Creek. The warming temperatures I did not believe were responsible for this habitat reversal because I then lacked knowledge of a fisheries history linked to climate. But you could see the changes in the bottom habitat, there was no mistaking that. As this organic compost rotted in summers sulfate reducing bacteria released stored nitrogen compounds locked in leaves or today what is termed "hard" nitrogen. This now available nitrogen in the form of compost bathed waters in ammonia compounds quickly followed by algae filled "brown waters" – frequently termed brown tides.

After Hurricane Gloria in 1985 Tom's Creek oyster sets failed as huge amounts of organic matter now rotted and was followed by growths of spaghetti weed (Enteromorpha) then and surviving oysters were killed by MSX.

Few oysters survived this MSX outbreak and dead oysters now lined the bottom of the creek. Planted seed oysters had died in 1986-1987, no seed oysters were observed.

Tom's Creek had literally "died", but under it seems natural events? Tom's Creek was neither near a city nor a sewage treatment plant; rather it was surrounded by "healthy" salt marshes, a few homes and a state park of low development. At the time I looked at the leaves and no cultivation, not people for blame; I could see the leaves and observe the formation of Sapropel. Although high bacteria levels in warm water had closed the creek to direct shellfishing, it was the buildup of leaves that had killed the shellfish. Moving the leaves and keeping the shell base clean seemed paramount. In the late 1970s early 1980s I again explored depuration (something that Massachusetts had done since 1928) but was unsuccessful. The FDA did offer that if Connecticut shellfish was cooked overseas that it could be imported back similar to the canned clams from Asia. Connecticut would not allow this. Depuration technology could have helped prevent this huge shellfish waste – food production and economic loss which is now in the billions. In 1971, J. Richards Nelson of Long Island Oyster Farms (LIOF) once estimated that 500 million had been lost in the closed Connecticut shellfish areas --by 2007 it would be billions. (See 1971 Report on The Water Quality of Long Island Sound EPA pg vi, item 3).

"Many commercial shellfish areas in New York and Connecticut are closed to the harvesting of shellfish for direct human consumption or market purposes as a result of high bacteria levels or proximity to sources pollution. It is estimated that losses to the shellfish industry over the past 50 years have exceeded $500 million as a result of these closures." (EPA 1971).

I think today this is the chief reason that so often there is a disconnect between environmental policy and people who live and fish along the coast in that, they experience the changes in fish and shellfish populations. They can observe over time changing habitat conditions. When I accepted employment on Cape Cod in 1981 black mayonnaise seemed to follow me to Massachusetts. Shellfishers there were beginning to see the same thing happened to them (often followed quickly when areas were closed to shellfishing, no harvest energy to remove organic matter – mostly dead eelgrass). Coastal residents in New England were to experience the impacts of now warming waters and the largest habitat reversal in a century. Frequently connected to bottom changes termed organic deposits are today still is called black mayonnaise. The scientific community knows it as Sapropel - putrefying organic matter in high heat low oxygen conditions. The presence of black mayonnaise is still controversial but the habitat impacts are not. They are very real and substantial and can be determined in long term environmental habitat histories. Tom's Creek was a personal experience as to what was to then impact almost every cove and bay in southern New England. As the climate moderated then became "hot," habitat failures followed. It was an experience that would be shared by many other fishers – high heat habitat failures that would decimate Southern New England's winter flounder and lobster populations, but bring an increase of blue crabs not seen here for a century.

Fisheries and Habitats Change Over Time

The concept of fisheries habitat history is the reflection of long term climate pattern impacts upon marine habitat succession. Marine habitats "succeed" or change as much as those as land but only take much longer, buffered from the world's largest temperature heat sink, the sea. Long term habitat histories are available however and some of the best habitat and fisheries histories come from the New England oyster industry. Here oyster growers kept records of beds, noted the increase or decrease of known oyster predators and bottom conditions. They cultivated and worked the bottom; they in fact "raked the leaves." It was also known that cold and storms were damaging to cultivated oyster crops and just as high heat and excess organics would suffocate oysters turning the water black as dead oyster meats fueled low oxygen fish kills. Many such high heat low energy dead zones were written up in the historical literature by shellfish biologists decades ago. They were called black water deaths – today termed sulfide waters.

Climate History and Fisheries History – What the past can tell us

Cycles or climate patterns would cause both the rapid rise of the New England oyster industry (1880-1920) during a period of Great Heat and few serious storms and then largely end it as the climate pattern later "reversed" turning colder with much more frequent and violent storms of the New England Oscillation 1932 to 1972. The 1940s and 1950s coastal storms were devastating to New England oyster farmers then and by the 1960s most of the oyster farms of the last century were largely gone or just a fraction of previous harvest levels. Habitats often in the same area had reversed-again. However in 1958, during a period of cold the U.S. shad harvest would hit record levels, New England bay scallop catches increased and the quahog (hard shell) clam vanquished in the Great Heat (1880-1920) would be the foundation fishery of a new generation of Rhode Island "bullrakers" in the 1960s as New England quahog clam production improved. It had now gotten "cooler" with frequent storms. However most Long Island Sound water quality documents fail to review long term climate patterns and impacts to fisheries instead they tend to focus on short term human causes of falling fish and shellfish catches or declines of living marine resources. How much is "us" and how much is natural? That question still remains.

That is the Capstone question which corresponds to the three case studies: Florida, Indian River Lagoon; Conowingo Dam, Maryland or Great Bay, New Hampshire, and did the Long Island Sound Study 1994 CCMP include long term natural conditions for the priority decision and policy making processes? Some related potential Capstone Projects may include:

A) Does long term natural fluctuations of energy and temperature upon nitrogen TMDL and fisheries habitats have a historical foundation?

B) Can we identify a public policy bias that reflects a resource management bias for decreases in finfish and shellfish that largely excludes non human causes?

C) The New England Shellfish Industry had bacteria and warm water outbreaks of Vp bacteria in 2011-2012 and 2013. Is this a factor with global warming?

D) Compare contrast – purification of milk and other foods – is cholera a link to food disease outbreaks of the last century. Why did it take so long for the United States to accept pasteurization of milk?

The Call for Pasteurization 1888-1917
<u>The Germ Theory and Clean Milk</u>

Nothing would divide the agricultural community than the pasteurization of milk in the 1890s. Producers feared extra costs – many could not afford the equipment while others feared the consolidation of markets and losing local customers all of which did occur. While the farm community focused attention upon the sanitation of cities (and to some extent supported the miasma theory) years before Louis Pasteur created the basis of the germ theory following his work in the middle 1850s around fermentation and the souring of wine (a constant battle to prevent the formation of vinegar). The hot summers of the latter 1880s to 1890s brought new concerns about bacteria in raw foods – especially oysters and milk and although Europe the rapid heating of milk to eliminate certain bacteria happened in the 1880s (called pasteurization) it would be nearly three decades before the United

States supported the process. Following some milk related outbreaks of tuberculosis, scarlet fever (often called milk fever) and diphtheria it was Chicago that first required pasteurization in 1908. Within a decade the rest of the US would adopt some form of pasteurization of milk. By 1918 only oyster companies shipped raw foods that came in contact with water borne bacteria across state lines. Although Wales experimented with shellfish depuration in 1914 (using sterilized seawater) a series of shellfish related outbreaks – thyroid, cholera among others were linked to the practice of floating or "drinking" oysters in less saline waters to have them gain weight just before sale. Some of the more devastating disease shellfish outbreaks 1914-1918 were traced to New Haven oysters floated in brackish waters which also at times received sewage. By 1925 National Shellfish Sanitation Program had eliminated this industry practice.

It was in 1918 producers of milk were required to pasteurize if it was shipped across state lines. This authority was reaffirmed in the case CT vs. Stoddard Supreme Court of Errors (Connecticut) May 1, 1940, 126 Conn 623 as appeal of CT General Statutes 797C 107a (1935) "provides for the appointment of a milk administrator with extensive powers detailed in 800c to regulate the milk industry of the state."

The Typhoid Outbreak of 1924-25
National Shellfish Sanitation Guidelines Approved

The oyster industry resisted many attempts at national legislation concerning shellfish "sanitation" believing that local and state health depts. had the authority and means to keep shellfish pure (also reacting to similar deep industry divisions with the pasteurization of milk) until a 1924 outbreak of typhoid linked to oysters occurred.

Three cities, Chicago, New York and Washington were hit hard with typhoid outbreaks and after years of raw shellfish associations to smaller disease outbreaks articles highlighted this disease vector. The winter 1924-25 typhoid outbreak was sudden and almost immediately linked to raw oysters by the print media. News reports had labeled the disease vectors as "typhoid oysters" a term that stuck for months and largely stopped oysters sales for weeks. Many oyster growers faced financial ruin when the contaminated oysters where linked to New York.

The oyster industry did recognize the dangers of growing food in sewage containing waters and sought legal measures to eliminate the pollution (mostly sewage) as demonstrated in a famous court case commonly referred to as the Lovejoy case a Connecticut oyster grower who sued cities for sewage pollution. Lovejoy last this court battle largely set aside by the Clean Water Act decades later.

The event however galvanized public opinion against the oyster growers and with wide market disruption which could have eliminated raw shellfish sales.

A national conference was convened in Washington, D.C. called by the US Surgeon General on Feb 19, 1925, just a few days after New York announced it was the source of the oysters linked to the Typhoid outbreak. This conference led to the formation of National Shellfish Sanitation Program (NSSP) with a letter issued by the Surgeon General in August 1925 containing guidelines for the shellfish industry. (FDA Section IX, History of the National Shellfish Sanitation Program).

The Ice Failure of 1899 – The Great Heat Ice Famines

The 1890s would bring a series of heat waves or "heated terms" that warmed coastal waters – Connecticut for example now showed commercial blue crab landings. The trouble with ice supplies grew worse as winters became mild, ice production conditions became uncertain and failed in 1899. Waters just did not cold enough to "make" ice.

So critical was t he supply of ice in preserving food a severe ice shortages were termed "famines" a word used today to describe the devastating impacts of food shortages. The "ice famines" could cause speculation in the price of ice causing some suppliers to withhold it from the market in hopes of driving ice prices even higher (not unlike some of the grain speculation that occurred after World War One with French fields the bread basket of Europe that lay ruined by bombing and the remain of unexploded artillery shells. A special commission still exists to clear ordinance and explosives from this war a century ago). This is the situation that Theodore Roosevelt found as hundreds of New York residents perished from the great Wave of 1896 when it (ice) was not offered for sale (except perhaps at very high prices) he just reportedly took it. This action was something that soon elevated his respect with the poor and helped form the political future of our 26th President. NPR radio has a great feature broadcast just about this time period "The Great Heat Wave of 1896 and the Rise of Theodore Roosevelt." It aired on August 11, 2011 and it is, great reference for this study.

For more information about the extreme heat waves that hit the Northeast cities at this time, which ended in a huge upswing in great white shark attracts along the New Jersey Coast in 1916 – see "Hot Time in the Old Town! The Great Heat Wave of 1896 and the Making of Theodore Roosevelt" by Edward Kohn.

One of the features of ice famines was an increase in milk contamination and brought about the first commercial ammonia process ice plants to alleviate chronic ice shortages for nearly two decades.

Drought/Heat as a Pollution Indicator Hammonasset River, Clinton and Madison (1962)

Thermal pollution had been recognized as a serious impairment/barrier to fish passage and having long term fish habitat impacts. Heat could help sustain warm water fish species at the expense of brook trout. Here is an excerpt from a Connecticut report that mentions these habitat concerns over 50 years ago. It is interesting to note that this report was written during a cooler period of 1931-71. The impacts of thermal pollution would be greatly enhanced during a much warmer 1972-2011 period.

"The Hammonasset River, rising in the town of Durham, is obstructed by a large dam creating the Hammonasset Reservoir at Route 80 in the towns of Madison and Killingworth. This reservoir is owned by the New Haven Water Company. Below the dam, the Hammonasset River has a history of populations of shad, alewives, white perch, striped bass, tomcod, and sea-run brown trout. There is one small barrier below the Hammonasset Reservoir; the abandoned dam at the old Paper Mill Pond site had practically disappeared, and no longer impounds water.

Fairly intensive study of this stream system in connection with the sea-run brown trout investigation had indicated that the new Hammonasset Reservoir has contributed to the deterioration of water quality through warming and irregular flows. These factors, plus the establishment of a warm water fish population in the reservoir which, in turn, has encroached upon stream habitat, have eliminated evidence of natural populations of trout. The only recommendations that can be made regarding this system would be to assure for constant flows out of the reservoir and to eliminate the remnants of the abandoned dam at the old Paper Mill site. Some blasting could improve conditions for fish passage at this abandoned dam site and thus upon up an additional five miles of stream for brown trout and shad."

Connecticut State Board of Fisheries and Game

June 1962

A Capstone Project Proposal
Bacteria and Warm Waters
Milk for Cities, Its Production and Care 1886
By Professor WH Brewer of New Haven Sheffield Institute[*]
Evening Session of the 1885 Meeting of the Connecticut Board of Agriculture pg 209
The Farmers Convention of Dec 15, 16, 17, 1885

As the 1870s turned to the 1880s Connecticut experienced warmer temperatures and food related disease outbreaks. The problems of bacterial contamination of milk was described then as spontaneous decomposition – Professor Brewer proceeds his talk with this simple statement "In the free air it (milk) soon goes into spontaneous decomposition, this decomposition being due to the growth of microscopic organisms, or "germs" as the public has come to call them bacteria and microbes are other popular names." He continues later in his presentation and issues a call for regulation of the milk industry an evident supporter of food safety issues until his death in 1910. [Professor Brewer graduated from the first class of Sheffield (1852) Scientific School (Yale University) eventually becoming chair of the Agriculture Dept there in 1864. Professor Brewer well known for his west coast geography studies and support of agriculture education but was the first to apply bacterial study (germ theory) to the food safety issues surrounding milk.]

"These microbes are killed by heat, and this is why boiling milk retards its souring and why scalding is so effective in the cleansing of milk utensils. Here let me digress to say that the cholera infantum among the poor of our larger cities is intimately related to the milk. In New Haven we have on several occasions had an investigation made of the surroundings and conditions of each death by cholera infantum (and all forms of infantile diarrhea which are so destructive to infant life in our cities in hot weather) in certain summer months and whenever so investigated, we have found that nearly all the fatal cases of children using entirely or mostly of cow's milk. As much as seven-eighths of the fatal cases are of this class, if my memory saves me right certainly as much as five – sixths! How much of this is due to unwholesome milk, originally and how much to the surroundings and conditions which would tend to pollute the milk or sour it quickly, cannot be well determined, as several factors in the problem have each one their influence.

All this points to the necessity of official inspection some sort of which is already extensively practiced in some places, but not all in others … In the city of my home (New Haven) our city government have repeatedly and deliberately refused to provide for any inspection, whatever and from analyses I know that watered milk is sold, and, as I have said much skim milk is wholesaled there which in all probability is retailed as pure milk. That some is I have some strong evidence."
Although Professor's dramatic account of milk contamination was printed in 1886 the concept of milk purification would divide the agricultural community for a half a century and continues to present times.

{Note – It is now thought that the water used to adulterate milk was in fact subject to high heat bacterial contamination in addition Tim Visel}.

In 1947 the support of pasteurization led to the FDA to prohibit the interstate sale of raw milk. Because transportation had improved (especially specialized refrigerated rail cars) interstate sale of milk was significant. Slowly state regulations matched those of the FDA and by 1950 most dairy shippers pasteurized nearly a century after Louis Pasture applied to patent the process.

- Capstone suggestions –

Why did it take so long for milk purification to occur, and how does current efforts to allow raw milk sales influence public policy?

Oyster Grower Loses to Pollution Case
A Capstone Proposal

The Day, New London, Connecticut, Friday, February 15, 1929

Needs of Cities for Sewage Superior in
Importance to Oyster Growing, Says Judge

Introduction

Commencing in the 1890s, oyster growers in New England became the subject of health department scrutiny. Several regional disease outbreaks and one of the first that gained national attention is when members of the Wesleyan crew team became ill from consuming raw oysters that were linked to New Haven grown oysters (1894). As waters warmed, disease outbreaks linked to the oyster trade increased and the wastewaters flowed out of exposed sewers into the tidal waters. Human sewage at times flowed over production oyster beds, closing them to any harvest operations. In an ironic sequence of events, the very communities that once fostered natural oyster harvests and later oyster culture would now pollute them or degrade their habitats making them unsuitable for public oyster harvest or oyster culture. Oyster growers now turned to the courts for compensation (called damages) and the signature case for this period was the Lovejoy case.

Fredrick F. Lovejoy was a Connecticut oyster grower who had oyster beds in Bridgeport and New Haven, but centered in Norwalk. Sewage, at times, completely covered oyster beds (several feet deep), which in warm waters, became black ooze that had strange sulfide smells. We would most likely call that organic deposit, Sapropel. Mr. Lovejoy sought "relief" from this pollution. Direct financial losses (an unsaid public confidence in oysters as food) but other oyster growers were unsuccessful taking legal efforts all the way to the United States Supreme Court (see Darling vs. the City of Newport News, 1918).

Apparently Judge Arthur Ellis felt the need to explain his decision and this is an article that appeared on Friday, February 15, 1929 in The Day newspaper relating to this case:

"Rather an interesting document is the memorandum of decisions by Judge Arthur F. Ellis of the superior court in which he strikes a deadly blow at oyster-growing in Connecticut waters – at least to such part of it as may come in conflict with the needs of some city for disposing of its sewage by inexpensive dumping into tidal waters. The decision is given in the case of Fredrick F. Lovejoy of Norwalk, who sought $100,000 damages from the city of Norwalk because its sewage disposal had put his oyster beds out of business. The case is to go to the supreme court of errors, though a factor in the situation is the effort the city of Norwalk is now making to get authority to spend $1,000,000 for a modern sewage disposal plant.

Judge Ellis' decision in full is as follows: "The decision of the supreme court of the United States in the case of Darling vs. the city of Newport News rendered in 1918 is of controlling importance. Mr. Justice Holmes lays down the principle that a tidal harbor is open to the discharge of sewage from cities upon its shores and that the ownership of oyster beds is subject to such municipal use. He distinguishes the species of ownership, the franchise, which persons may have in land under tide water from the absolute ownership which exists with regard to fresh water streams. Applying this reasoning and that of the well-considered Virginia case upon which the Darling case is based, to the facts in the present case, I have come to the conclusion that the plaintiff cannot recover from the city for such pollution of the waters of Norwalk harbor as has been occasioned by the municipal sewage.

"Counsel for the plaintiff admit that the Newport News case established the law at the time, but claim (a) that it become obsolete because of the advance of science (b) because the ownership in the Virginia case differed from that in this case. The evidence does not disclose that there has been any vital change in the scientific situation since 1916, the date of the Darling case. The plaintiff experts all testified that entirely adequate and available systems for tidal water cities have been in use for 80 years. As to the second claim it appears that the difference in the kind of title does not change the principle.

Tide Water Distinction Drawn.

"It is the law of the state of Connecticut that the mere grant to the city of legislative authority to discharge sewers into a fresh water stream does not necessarily make such use of the sewers a governmental act which exempts the city from all liability to lower riparian proprietors who are injured by such sewage; that such use may be justifiable upon the ground of public necessity but only upon the payment of compensation for the property thus taken. That the right to maintain such a nuisance cannot be acquired by prescription. The question as to tidal waters has never been decided in this state. The plaintiff maintains there is no distinction whatever between two situations. Mr. Justice Holmes says there is.

Clearly the Platt brothers case and it is the prevailing law in America is based on the common law right of the riparian owner.

Sewage Disposal Primary

“At the time of the original grants and all subsequent transfers it was clearly the right of the state to permit the discharge of municipal sewage into Norwalk harbor. This harbor was open to the discharge of sewage cities on its shore. The oyster man could use the land to cultivate oysters. The legislature in granting him the privilege did not create a right superior to the primary and vital right of the state to employ tidal waters for sewage discharge. Sewage systems for thickly populated towns are an imperative necessity, a public right, which is superior to and overrides the limited purposes for which the land was granted to the individual. When he buys thus species of property to be used for the cultivation of oysters under tidal waters surrounded by cities and towns, he takes the risk of pollution of the water by sewage. His title gives him no right in derogation of the right of the municipality to drain sewage into such water, with the resulting damage to his franchise.

“The sea is the natural outlet and so long as such use does not constitute a public nuisance, the supremely vital interests of the public health demand that this use shall not be obstructed except in public interest. There is another aspect to be considered – one which is rather difficult to clearly express. When the plaintiff acquired his franchise the city was sewering into the harbor by direct authorization of the legislature. The city under the law as the law existed in 1918, clearly was not liable to the oyster growers. Just when in the past ten years did the law change and the city become liable?

Law Unchanged

“There is no visible sign of change in the law. The Supreme Court case remains unreversed. Just when did the pollution in Norwalk harbor increase so as to make the city liable? It clearly was not liable prior to the action of the state board of health in 1927. The tests as to whether the current and tide carried contamination to these particular beds and how much contamination was carried, the method of determining whether or not there was contamination were very delicate, and the scientific knowledge apparently changed during the two years while the tests were being carried on. There is no evidence in this case that the water flowing over the oyster beds had undergone any change that to become contaminated to a greater degree than ten years ago. The only evidence is that a new scientific standard was set up by the state board of health in 1927 and that water that is tested for the first time failed in some places to meet this new standard. Did the city suddenly become liable where no liability existed before? Pollution became a highly relative word.

“An imaginary line was drawn across the harbor and it was arbitrarily said that water on one side of this line was polluted; on the other side not. The sewage here is infinitesimal quantities hardly discernible and deleterious only for oysters. When recovery is had in the fresh water cases it is always for gross and ugly polluted [areas].

"It further appears in this case that since the city was confronted with this changed condition. It immediately took steps to remedy the situation and caused exhaustive plans to be prepared for modern disposal plants, and is asking the present legislature to construct one. It would seem the city has acted according to good law and morals.

"A clear statement of the law is this. A municipal corporation sitting on the arm of the sea adjacent to tidal waters has the right to use such waters for the purpose of carrying off its refuse and sewage to the sea so long as such use does not create a public nuisance and injury occasioned thereby to private oyster beds is not a monetary injury.

"Naturally I have sympathy for the plaintiff. He has been damaged (although not to anything like the extent claimed). He cannot recover from the city in my opinion. The state board of health has done a very careful and praiseworthy piece of work and has acted in accordance with the most advanced scientific knowledge. It was a precautionary measure, possibly taken in an excess of caution, but the public health requires that no chances be taken. All this has resulted in some damage but because of the kind of ownership which he had and the overpowering necessity of such government function, it is not right that the public should have to pay the bill. When the legislature made the original grant for the very limited and carefully specified purpose and practicality without any consideration paid by the grantee, the city did not and probably could not grant such property to an individual practically without compensation to the exclusion of the great governmental necessity of sewage disposal. All subsequent grantees took subject to the right and if they paid too much for their grants that is not the public's fault. Judgment is for the defendant."

Capstone question: How did the Lovejoy case enter into the Clean Water Act of 1972? If Mr. Lovejoy brought his case into court today, would he win?

Students that select HACCP or bacteria Capstone projects should contact their ASTE FFA Advisor.
SAE Projects – See Tim Visel in the Aquaculture Office, Sound School.

Gravity Fed Self Regulating Bio-Suspended Solids Pillow Filter for Crab and Lobster Tanks

By Timothy C. Visel - Finfish/Shellfish Specialist Sea Grant Marine University of Connecticut Sea Grant/Extension Service Advisory Program - Groton, CT 06340
1988
Center
Aquaculture Science and Natural Resources Class October 2004
(Exercise #11)

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Abstract-

In the late 1960 and early 1970's, it became uneconomical to "car up lobsters," so to clear intestinal residues or hold for market. Lobsters were arriving with full gut cavities and small- refrigerated retail systems were showing increased losses to ammonia toxicity. In finfish aquaculture, an emphasis on water reuse looked at living or bio filters to grow nitrogen-reducing bacteria as part of the culture operation. Suspended solids also needed to be lessened to keep protein fractions from bubbling/foaming. The lobster retail market needed clear water to provide customer appeal. A small bio/pillow - sand, gravel and broken clean oyster shell was seen to buffer pH, maintain bacteria to reduce ammonia smell and toxicity and at the same time, trap fecal matter (bio solids) in a shell/sand/gravel matrix.

Introduction -

The lobster and new Red Crab Fishery in Rhode Island retail recirculating systems desired to reduce holding losses.
Water often appeared cloudy and frequently had an ammonia odor. Often these large systems were at floor level for customer viewing and needed remote treatment. A by-pass system loop was seen as a way to redirect 50% of the flow to a special two-tier filter system. Gravity would return treated water to the retail tank. Filter systems (bacterial media) would be out of retail/customer view. Smaller systems could use a combined pillow and one treatment filter tank.

Description -

The solid/bacterial filter system consisted to two rectangular tanks slightly off-center. A bypass system re-circulating pump delivers 50% of the flow to the pretreatment filter - sand and gravel pillow for solids, and an oyster shell pillow, which holds the nitrogen reducing bacteria. Solids can smother bacteria, so heavy solid loading (after a shipment of red crabs it was not unusual to lose 50%), can overwhelm the bacteria. It is necessary to remove solids before water proceeds to the bio-filter. The gravel/sand filter may require frequent rinsing during heavy loading.

If the pump needs to be disconnected, it is important that the bio-filter drains to air contact. The bio-filter (bacteria) can remain alive for several hours in air until the pump or flow can be restarted. Stagnant low oxygen water in hot weather can ruin a bio-filter in an hour (the nitrogen-reducing bacteria are killed). When a bio-filter goes anoxic, it will emit the characteristic hydrogen sulfide (H_2S) (rotten egg) odor.

Description -

System water is redirected to a gravity fed system. Solids are removed in the upper tank before entering the oyster shell bio-filter in the second flower tank. Flow is controlled so system water has 2 minutes in treatment before returning to the primary circulation loop. The by-pass loop is self-regulating; overflow is dumped into the next level. Solids are removed in a sand gravel filter-voids when filled with fines (solids) and need to be periodically changed. The bio-filter (bacteria culture) can last months, but needs at least 10 days to reach full nitrogen reducing potential. It is possible to quick start the salt-water bacteria culture by placing marine mud or sand (obtained below the high tide) into the filter pillow. This will shorten the time needed for growth of the nitrogen reducing bacteria. It is also possible to use some old oyster shell from a previous filter (oyster shell surface has a bacterial "film") and place them in a new dry filter (pillow) to "jumpstart the bacterial filter). One method (not recommended for customer tanks) is to float a dead fish in the system to provide bacteria the food in which bacteria need to grow. Bio-filters can store bacteria and bacterial population adjusts to food, the problem is that the filter can crash quickly, but needs days to respond to heavy loading. If loads lighten it is possible to sustain a filter by placing fish scraps in mesh bags in the filter tanker box. In that way, the filter can still be "nourished" when the lobsters or red crabs arrive, just quickly remove the fish bag.

Experiments/ Trials

The first filters were constructed from 3/8 inch square metal commercial "hardware cloth" available from any hardware store. The filter boxes measured 3 by 8 feet so several "pillows" were placed in the boxes. The solids filter consisted of beach sand and gravel placed into the hardware cloth which was clipped using hog ring lobster trap pliers. The sand fell out of these early pillows so a new attempt was made with fiberglass window screen fabric, also available from hardware stores. The bio-filter (oyster shell) was constructed from hex chicken wire and hog ringed along the edges creating the pillow. The chicken wire pillow held about 3/4 of a bushel of oyster shells. Again because the roll of chicken wire was 36" high, 3 pillows are needed to cover all of the drain holes. Do not use copper clips as to the toxic nature of this material in closed aquaculture systems.

Results -

The results of the bio-filter/solids filter (once bacteria were growing) were immediately seen. The ammonia smell disappeared as this compound was detoxified into nitrite and nitrate. Water clarity improved as the suspended solids were taken out of the recirculation system. It did take longer for the bio-filter nitrogen reducing bacteria to grow (cool water) because the system was refrigerated. Although the chicken wire held up with oyster shells, we used fiberglass door screen material for the next solids pillows with good results. Pillows did have a life period, however, especially the solids filters.

When fine particles closed most of the sand/gravel voids, the filter clogged and water spilled into the overflow pipe to the system tanks, a self- regulating component of this gravity system.

Problems/Concerns -

Sunlight and algae problems seem to be a concern, the ammonia component was reduced lessening toxicity, but then provided algae the available nitrogen on which to grow. One Rhode Island operator was able to clear the tank of nuisance algae overnight by placing 24 oysters on top of the bio-filter. Oysters started feeding if the water temp was in the

55 to 58 degree F range, which it was, and cleared the 1000 gallon system in less than 10 hours. However, questions were raised if these oysters were to be resold as certified.

Shellfish needed to be sold only if harvested from clean "approved waters."It would be difficult to distinguish the "filter oysters" from the "market oysters." Eventually, these oysters were placed in a small hardware cloth bag locked to tank support and a label glued on each oyster bag stating "not for sale."

The second problem was changing the filter pillows especially the solids filter. The sand/gravel matrix worked well. Fines and fecal matter were removed quickly, however, caution must be taken in removing the filter pillow, avoid jerks or twists, solids are loosely held and they will come out if the pillow is pulled or pushed. Careful attention must be paid when changing the filters or the results could easily be negated (collected solids entering the system again).

Reusing the filter pillows-

Filter pillows were recycled by cleaning with a hose and dunk tank. The filter contents were shaken to dislodge the fines and solids. Almost no level of cleaning could completely remove all the fines without loosing most of the contents or ripping the filter pillow. It was concluded that one reuse was all that could be expected. It might be easier to just install a new one. That is up to the owner/operator.

Building and Testing the Bio Bacteria Filter Pillows -

Care should be taken to wash fines from coarse sand and gravel. Oyster shells should be free of mud and sun-dried if possible. Once the filter pillows are built, test the solids filter for a gallon/per minute flow rate. Set up the filter on land and time, a one-gallon and 5 gallon test. This should give up a gallon per minute flow rate. If 50 gallons per minute system flow, the filter (capacity should be able to treat 100 gallons/minute.

Conclusion -

The use of biological bacteria filters and suspended solids filter pillows was an economical way to reduce fouling in lobster and crab re-circulating and holding systems. Filter pillows could last us long as two months and reused although were seen to be less effective with each reuse. Materials could be purchased from hardware or department stores, quickly assembled and integrated into system flows. In one case, which prevented a gravity feed system failure, a by-pass loop was created to treat a portion of the system water in a room apart from the tanks. This by-pass filter "loop" worked well but increased the treatment time as only 50% of the water was subjected to the treatment process as compared to the 100% gravity feed system of all flow to the solid filter which then feed the bio-filter and then entered the system tanks. The gravity feed overflow if filter capacity slowed or prevented flows simply was entered into the system, preventing a dry tank drawdown. In this situation, bacterial reduction is ended and filters must be cleaned/changed.

Reference: Marine Fisheries Review #1349 Volume #10 October 1978
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