The Sound School Regional Vocational Aquaculture Center
The Search for Megalops Special Report #1
"You do not need to be a scientist to Report"
Important Notice for Blue Crabbers – Estuarine Researchers
Timothy C. Visel
February 1, 2016

Last year's many blue crabbers experienced the harmful impacts of Desulflovibrio bacteria – commonly known as sulfate reducing bacteria or SRB. Sulfur – sulfate reducing bacteria need organic matter to live but exist in low or no oxygen environments. At high tide waters have a fresh change of oxygen and blue crabs can forage over Sapropel deposits – deep blue – black organic deposits that forms a marine compost. This caution is for those crabbers who crab in these areas and may be exposed to these often dangerous bacterial strains.

Several southern states are reporting blue crabbers with serious skin and wound infections – as a result of puncture or cuts while crabbing. Preliminary research indicates that this was first noticed in southern states in the 1980s (JW Davis et al 1982 Galveston Bay Texas) and as the heat continued to build north into the middle Atlantic and then by 2012 into New England as illness attributed to gram negative sulfur reducing bacteria increased. The agent for these cautions were Vibrio vulnificus and V. parahaemolyticus also identified as being found in Blue Crabs. These are members of a larger and dangerous bacterial group know as the Desulflovibrio series. The most infamous perhaps of this Desuflovibrio group of the last century is desuflovibrio cholerae – shorted to cholera. A Maryland Paper Rodgers et al appeared in Society of Applied Microbiology Oct 2014, which comments on these bacteria.

Florida appears to be the hardest hit and issued a caution on them in May 2015 and again in June 2015. The vector or host culture media (food) for these sulfate reducing bacteria is Sapropel – large organic deposits found in hot shallow and often poorly flushed areas – ideal blue crabbing habitats at high tide but in heat and low tide with reduced oxygen conditions the breeding ground for these gram negative bacteria.

The Vibrio first caution was issued in 2012 as some of the seafood diseases – the necrotic flesh wasting strains necrotizing fasciitis (winter flounder fin rot) and shell dissolving bacteria (lobster shell disease strains chinoclastic Vibrio) were showing up in larger amounts in this warm marine compost – Sapropel.

The caution now is for crabbers and researchers working in estuarine waters – sulfate reducing bacteria are being found in these warm water deposits and now suspected in dangerous bacterial infections. Crabbers will recognize Sapropel by its blue black color, sticky jelly or greasy consistency and the smell of sulfur. It is also being associated with the blood fluke in our area termed clammers itch schistosomes and now potential links to the MSX oyster disease. (An early MSX outbreak here in the 1980s occurred in the lower Hammonasett River near deep Sapropel deposits).

When oxygen is low and the temperature goes up Sapropel (mostly leaf compost) provides the sugars or glucose (primarily terrestrial leaf material collecting in bays) to grow these sulfate reducing bacteria. Extreme bacterial action is now suspected of creating sulfide Blue Crab Jubilees in historical events to our south during low energy (poor mixing or flushing) hot weather and storm free periods.

Gloves and aprons are suggested when working with Sapropel – treat any puncture or cuts with serious and rapid anti bacterial agents. The problem with these gram negative bacteria is that they are often antibiotic resistant – as discovered in 1976 (Joel O'Connor, NOAA) in all of the New York dumpsites that obtained animal fats and grease.

I have attached a quick reference guide for Sapropel – it is a very destructive habitat type that needs more review – my view.

Notes on Sapropel – (Black Mayonnaise)
Timothy C. Visel, The Sound School Regional Vocational Aquaculture Center
February 2016 - Tim Visel

- Sapropel is called many names but most New England fishers may recognize the term Black Mayonnaise. It collects in poorly flushed coves and bays or behind tidal culverts, road and railroad crossing that restrict energy or tidal flows. It collects in low energy, shallow waters frequently Harbor bottoms and starting under eelgrass meadows. (See appendix LIS Seminar, May 10, 1985).

- Sapropel is an organic marine compost (once harvested for an organic fertilizer and soil nourishment here a century ago) and is the food or culture medium for sulfate reducing bacteria (SRB). These bacterial thrive in heat and low oxygen conditions as they use sulfate as an oxygen source which is not limiting in coastal estuaries. In high heat and low dissolved oxygen condition they can dominate the bottom bacterial spectrum.

- A rebuilt forest canopy – once below 30% coverage in the 1880s has rebuilt to 78% coverage today (Connecticut). This has caused a tremendous increase in leaf material entering our coves and bays (New England) oak leaves are especially problematic they are acidic – contain a natural tannin flocculant and dissolve slowly – into a brown "oak leaf tea" after heavy rains. Research in Norway and Europe have indicated that such organic deposits may contain a tannin signature that can be used to fractionate terrestrial organic source material.

- Oak leaves are both acidic and high in wax esters a substance that protects the oak leaf in times of heat and drought. On hot dry August days oak leaves will glimmer or shine from this wax. It is the wax or leaf parrafins that gives Sapropel its greasy sticky consistency. When the wax seals off oxygen to the organic layers below Sapropel builds and becomes sulfide rich (hydrogen sulfide or rotten eggs smell).

- Sapropel in high heat can purge have levels of ammonia and is now being linked to jumpstarting those harmful algal blooms (HABs) who can utilize warm water ammonia. Research from the Florida Indian River lagoon study indicate that such Black Mayonnaise deposits can account for 50% or more of ambient nitrogen ammonia. In poorly flushed coves ammonia residence time is greatly increased allowing levels to bloom the brown algal species that require it.

- Sulfate reducing gram negative bacteria can include members of the desulfovibrio bacteria group deadly to some fish and shellfish species. Winter flounder fit rot (necrotic lesion or fasciitis and shell blistering) lobster shell bacteria disease agents. The desulfovibrio bacteria can cause human infection and illness.

- Sapropel many at times of habitat sucession may have a vegetation crust, under eelgrass at first until the sulfides build up to high levels it rots the roots away but can then sustain sea lettuce Ulva lactura that feeds on the abundant ammonia from this marine compost. Sapropel deposits at low tide may appear green and support dense sea lettuce moncultures.

- Sapropel by way of its biochemical living bacterial processes complex heavy metals including aluminum and mercury. The older the deposit the greater metal chelation occurs. Sapropel naturally concentrates heavy metals and in Europe it is often used to remove heavy metals from spills (contamination on land). In 1973 the EPA investigated sulfate/sulfide treatments to remove heavy metals from mine drainage. Sulfate is not limiting in coastal waters.

- There appears to be a reluctance for federal agencies to review Sapropel habitats. Instead of the European description and research identity (Saprobien system) we have in the United States a numerous names and conflicting terms that largely exclude the "living compost" description. They include black mumie, black facies, black mayonnaise, fines, unsuitable fines, unconsolidated fines, turbid floc, silt, oatmeal, ooze, sulfide ooze, guytta, marine snow, benthic flux, sulfide flux, acidic sulfate soil (US Army Corps of Engineers uses this term) sediment and "unknown." Sapropel is a marine compost of value in Europe and termed Sapropel. We should adopt this universal term – my view.

- Oceanographers have studied the impacts of bacterial sulfur reduction since the 1930s (see appendix below).

- The EPA in 1973 issued circular 670/2-73-080 September (Removal of Heavy Metals from Mine Drainage by precipitation) Office of Research and Development US EPA – Environmental Protecting Technology Services (see appendix below).

Recent Marine Sediments

A Symposium

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OCCURRENCE AND ACTIVITY OF BACTERIA
IN MARINE SEDIMENTS

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ABSTRACT
Aerobic as well as anaerobic bacteria are found in marine bottom deposits. They are most abundant in the topmost few centimeters of sediment below which both types of bacteria decrease in number with depth. A statistical treatment of the data on their vertical distribution suggests that aerobes are active to a depth of only 5-10

centimeters whereas anaerobes are active to depths of 40-60 centimeters below which they seem to be slowly dying off. However, microbiological processes may continue at considerably greater depths owing to the activity of the bacterial enzymes that accumulate in the sediments. The organic content is the chief factor which influences the number and kinds of bacteria found in sediments.

Bacteria lower the oxidation-reduction (O/R) potential of the sediments. Vertical sections reveal that the reducing *intensity* of the sediments increases with depth but the muds have the greatest reducing *capacity* near the surface. Three different types of oxygen absorption by the reduced muds are described, namely, chemical, enzymatic, and respiratory.

Bacteria that decompose or transform proteins, lipins, cellulose, starch, chitin and other organic complexes occur in marine sediments. These bacteria tend to reduce the organic matter content of the sediments to a state of composition more closely resembling petroleum although methane is the only hydrocarbon known to be produced by the bacteria. The precipitation or solution of calcium carbonate as well as certain other minerals is influenced by microbiological processes that affect the hydrogen-ion concentration. Other bacterial processes influence the sulphur cycle and the state of iron in the sediments. The possible role of bacteria in the genesis of petroleum is discussed.

DECOMPOSITION CAUSED BY BACTERIA

Various physiological or biochemical types of bacteria have been demonstrated in the sediments that are capable of attacking most kinds of organic matter present in the sea. The rate and end-products of decomposition of the organic matter depend upon environmental conditions and the types of bacteria that are present. Waksman and Carey (49) have shown that diatoms, *Fucus,* alginic acid, copepods and other marine materials are utilized by bacteria with the rapid consumption of oxygen and the production of carbon dioxide and ammonia. More resistant fractions of marine plants and animals such as lignins hemicellulose-protein complexes may be only partially decomposed to give rise to marine humus (50).

Approximately one-fourth of the bacteria isolated from marine sediments are actively proteolytic (18,56) as indicated by their ability to attack proteinaceous materials and in so doing liberate ammonia, hydrogen sulphide and carbon dioxide. Presumably the topmost layer of sediment is the zone of greatest proteolytic activity below which there is a gradual, but not very appreciable, decrease in the nitrogen content of the sediments (30). According to Trask (45) amino acids and simple proteins constitute a very minor part of the organic-matter content. Hecht (23) reports that most simple proteins are completely decomposed even under anaerobic conditions and are not converted into adipocere. He records that about 90 percent of the nitrogen content sediments is due to chitin.

Chitinoclastic bacteria are widely distributed (57) throughout the sea but chitin is only slowly attacked by bacteria even in the presence of oxygen and it may be more resistant under anaerobic conditions.

Most simple carbohydrates are readily decomposed (54) by the bacteria that occur in bottom sediments. Under aerobic conditions the end-products of the fermentation of carbohydrates are chiefly carbon dioxide and water. In the absence of oxygen, carbohydrates may be attacked and thus yield organic acids, methane, carbon dioxide, hydrogen and other products. Buswell and Boruff (9) noted the production of acetic, butyric and lactic acids, alcohol, methane, hydrogen, and carbon dioxide from the bacterial fermentation of cellulose under anaerobic conditions. Several types of cellulose-decomposing bacteria (48,49,51) have been isolated from bottom deposits but very little is known concerning their metabolism. The fact (45, 46) that less than 1 percent of the total organic-matter content of recent sediments is carbohydrate,whereas ancient sediments contain none, is indicative of the vulnerability of this class of compounds to bacterial attack. However, much remains to be done to ascertain the end-products of the reactions.

Perhaps bacteria have a greater influence than any other form of life on the hydrogen-ion concentration and O/R potential of sediments; properties that in turn tend to modify both the chemical composition and physical characteristics of the sediments. They may deplete the oxygen as noted above, they may liberate nitrogen from nitrites or nitrates and they may produce carbon dioxide, carbon monoxide and methane in appreciable amounts.

Removal of Heavy Metals from Mine Drainage by Precipitation

Laurence W. Ross

Environmental Protection Agency report number EPA-670/2-73-080, September 1973

Heavy metals in mine drainage waters of the Rocky Mountains can be removed by a two-stage process consisting of (1) neutralization followed by (2) sulfite treatment. The first stage removes ferric and aluminum hydroxides, and the second (sulfide) stage precipitates the heavy metals that are most objectionable as pollutants, and that are of possible interest for economic recovery. The two-stage process has been demonstrated in the laboratory and in a field experiment.

In the field, powdered lime was employed for neutralization, and barium sulfide was employed as sulfide source in a two-stage treatment tank. The ferric and aluminum hydroxides failed to settle when even the slightest winds disturbed the surface of the settling pond, but the sulfides settled within a few feet downstream. The measured pH of treated streams has proven entirely satisfactory for control of chemical additions.

Section II – 1973 EPA Study
Recommendations

Finally, it is recommended that less expensive sources of sulfide than those commercially available be investigated. **This points directly to biological production of hydrogen sulfide insitu from the plentiful sulfate available in drainage waters. The possibility of biological generation of sulfide has been demonstrated by several investigators (including the present investigators), and merits further study (EPA 1973).**

Long Island Sound: Issues, Resources,
Status and Management

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- Preface -

These proceedings are from a seminar on the status and management of living resources in Long Island Sound. The seminar, sponsored jointly by the National Oceanic and Atmospheric Administration's (NOAA) Estuarine Programs Office and the U.S. Environmental Protection Agency's (EPA) Office of Marine and Estuarine Protection, was held in the main auditorium of the U.S. Department of Commerce on May 10, 1985.

The Benthic Ecosystem (Excerpts below pg 47 and pg 52, 56, 148)
D. Rhoads
Department of Geology and Geophysics
Yale University (1985)

"I have a difficult task, as all the speakers do, because we're trying to summarize years of data and experience. In my case, some 20 years, and I hope to do it in 20 minutes or less…

With the build-up of reactive organic matter in the sediment and a lack of pore water oxygen, hydrogen sulfide, ammonia, and methane gas may be generated and enter the overlying water column. These reduced compounds, along with the reactive organic matter, may deplete water in contact with the bottom of its oxygen….

Underlying the dysaerobic and anaerobic water one typically finds organic-rich black (i.e., sulfidic) muds that are termed sapropels. These are rich in iron mono-sulfides. The physical properties of these muds are distinctive and the best description that I have heard of them is that they are like a "black mayonnaise."

Dr. Rhoads: Yes. One reason I mentioned the importance of the sapropels –these black iron monosulfite muds on the bottom—was the direct point that Peter raised. The system is so dynamic that to measure the change from year to year is dissolved oxygen as measured in the water column would take more money than we have. It's not practical at all.

Given that kind of variability, what you need is a low-pass filter and an integrator, and that's the sediment. I suggest that a very sensitive index of the waxing and waning of this condition would be the map of where the sapropels terminate, whatever isobath that might be. Follow the edge of those sapropels. If they're encroaching upwards into shallow water, it's getting worse. If they're receding, it's getting better."