Using Oysters and Ribbed Mussels for Remediation and Bioextraction in Chilmark Ponds

Request for funding from the Town of Chilmark

Martha's Vineyard Shellfish Group, Inc

February 2014

Summary

We propose an investigatory study in the Chilmark Ponds system, to explore the potential of using shellfish (oysters and ribbed marsh mussels) to improve water quality. We propose to investigate methods for increasing the numbers of shellfish in the pond system to take greater advantage of their unique ecosystem services to improve the marine environment.

Background and Introduction

Eutrophication, the over enrichment of water bodies with the nutrients nitrogen and phosphorus, is a worldwide problem fueled by a growing human population. Martha's Vineyard is no exception. Nearly all of the Island's water bodies so far studied under the Massachusetts Estuaries Project are impaired to some degree by high nitrogen. Over enrichment by nitrogen is the greatest threat to our coastal water bodies resulting in noxious algal blooms (both micro- and macroalgal), hypoxia, loss of shellfish habitat and overall damage to the integrity of their marine ecosystems. Restricted flushing in coastal salt ponds like the Chilmark Ponds make them particularly vulnerable. High levels of nutrients fuel excessive growth of primary producers such as microalgae and macro algae. The nighttime respiration of such vegetation can lead to hypoxic conditions as well as extreme anoxic events as when large quantities of biomass die and degrade on the bottom sediments. Continued anoxia can lead to 'dead zones', where there is no oxygen in the sediment or bottom waters to support plants or animals.

Filter-feeding bivalve shellfish naturally clear and cleanse water as they feed. Their filter feeding can help remove nitrogen by incorporating it in their tissues and by transferring it to bottom sediments where it is removed through bacterial processes. Microalgae in the water use dissolved nitrogen (in the forms of nitrate and ammonia) to grow and reproduce, which in an over-enriched environment can lead to noxious blooms. Shellfish filter and ingest nutritious particles like microalgae to fuel their growth and reproduction. Nitrogen from the microalgae is transformed into proteins in the shellfish. When we harvest shellfish, we remove nitrogen – bound in delicious, nutritious, oysters, clams, steamers and mussels – out of the pond. While filter feeding, shellfish also remove particles that they do not digest. These particles are remove from the water column, deposited in pond sediments as *pseudofeces*. By removing particles from the water column and depositing them as feces and pseudofeces on the sediment shellfish perform a process sometimes referred to as *benthic-pelagic coupling.* This process provides food for bottom dwelling organisms including denitrifying bacteria that remove further nitrogen from the ponds by releasing it as a harmless gas into the atmosphere.

What?

We propose an investigatory study in the Chilmark Ponds system, to explore the viability of using shellfish (oysters and ribbed marsh mussels) to improve water quality. We propose to investigate methods for increasing the numbers of shellfish in the pond system to take greater advantage of their unique ecosystem services to improve the marine environment. Foremost benefits expected from increasing shellfish numbers in the pond, will be increased water clarity through filtration and reductions in nitrogen. Increased shellfish filtering will prune plankton biomass and remove other suspended solids (i.e. fine sediment, detritus, protists and some bacteria) resulting in overall increased water clarity. Nitrogen reductions are expected to be realized through enhanced denitrifying bacterial action in sediments and through the removal of nitrogen sequestered in shellfish tissues when shellfish are harvested from the system.

We propose to use both oysters and ribbed mussels because they are both excellent filter feeders yet have different characteristics that make them appealing for the use of this project. Oysters are a commercially important shellfish, making them valuable in economic and ecological sense. An

adult oyster can filter 30 – 50 gallons of water a day and contain 0.4-0.5g of nitrogen when it is harvested. However, the taking of shellfish is prohibited in Chilmark Pond due to high levels of coliform bacteria, which makes growing them in these waters not simple. The Massachusetts Division of Marine Fisheries (DMF) requires that edible shellfish species grown in closed waters be removed from the system before they reach marketable size. As they approach market size they must be moved to water approved for shellfish harvest and allowed to purge for a period of time before they may be harvested. The need to relay the oysters will require us to keep the oysters in bags and cages so they can be moved efficiently. This will require an initial investment of gear, but will save on time and ensure that all the oysters are moved, per state DMF requirements.

Ribbed mussels, *Geukensia demissa,* are not commercially valuable, and for that reason may be seeded and grown freely in waters closed to harvest such as Chilmark Pond. Ribbed mussels are an excellent candidate for this experiment as they have an exceptional ability to filter smaller particles than oysters, or any of the other bivalves common to our region. Laboratory studies have shown that ribbed mussels can filter bacteria (0.2um in size) and even use bacteria as an effective food source.

Methods

Oyster culture for nitrogen bioextraction through sequestration and relay

Naturally ripe oyster broodstock from the Edgartown Great Pond will be spawned at the MVSG solar hatchery in Vineyard Haven. There, the larvae will be reared for 2-3 weeks until reaching 'eyed' stage, at which point they are ready to metamorphose. After metamorphosis the oyster larvae will lose its ability to swim and will be permanently attached to a hard substrate to be provided to them. Approximately 250,000 eyed larvae will be set on shell (scallop, oyster, clam) at the Hughes Hatchery in Oak Bluffs (a procedure referred to as *remote set*, which gives a product of *spat on shell*), where they will be maintained for approximately 2 weeks in flowing seawater. MVSG encourages the use of remote set over the production of single, "cultch-less" oysters because:

- It is more cost effective because oysters are moved out of the hatchery sooner reducing
    - Algal feed costs
    - Labor costs
    - Utility costs
- Spat on shell are protected from predators until they over grow the shell edge they are on

An estimated 50,000 oyster spat will be moved from the Hughes Hatchery to OysterGro cages in 3 designated locations in the Chilmark Pond system. Sites will be chosen for their accessibility, protection in the case of a storm and bottom type.

Bags of shell will also be hung in Chilmark Pond in early July, to serve as natural spat collectors for any larvae produced by wild oyster population in the Pond. The collectors with natural oyster set will then hang in the pond for 2-4 weeks, after which time they will be grown adjacent to seed spawned in the MVSG hatchery.

Random samples of spat from both wild and hatchery cohorts will be counted and measured at deployment to the pond and four more times before the end of the second summer. At that time, when the oysters are just under legal harvestable size, they will be moved to state Approved waters (see summary of Mass Division of Marine Fisheries Relay Guidlelines) for

public harvest. Samples will be collected at the time of relay for nitrogen and carbon content. Overall growth and survival of the hatchery-reared vs. wild-set oysters will be evaluated as well.

Geukensia enhancement for filtration services
Adult ribbed mussels will be collected and placed into floating cages, referred to as *spawning cages* in efforts to enhance natural spawning and improve the chances of collecting natural seed.

MVSG promotes the use of spawning cages for several utilitarian reasons, as they:

- are low in labor and investment
- hold adult shellfish near the surface of the water where the best plankton food is available
- reduce response time of cohorts to the first spawning shellfish
- increase fertilization efficiency of eggs by sperm via increased proximity
- serve as a platform for spat collectors and attract larvae to conspecifics

From the spawning cages, we will hang various types of spat collectors. Spat collection is a common practice in oyster, scallop and blue mussel culture, but there have been very few – if any – successes collecting ribbed mussel spat. Ribbed mussels are different from the above mentioned species because they do not cement themselves to a substrate, nor do they have strong byssal thread to cling to a substrate like scallops or blue mussels. Therefore we will experiment with different types of spat collectors ranging from familiar such as shell bags, fuzzy rope and stuffed spat bags, to novel such as flower pots of sediment and dead marsh grass.

Colleagues in Connecticut who have worked with Geukensia advise that while gonads look ripe in June and July, gametes are not viable until later in August and September. Understanding the reproductive cycle of our local ribbed mussel populations will help us manipulate them to spawn in the hatchery, in the future. Monitoring gamete production will also help us know when to expect new recruits to our spat collectors in the field
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Mussel spat that we collect will be reared in mesh bags - or a similar adaptation to common shellfish husbandry practices – until October when they will be placed in suitable habitat, and marked for future monitoring. In 2015, these juveniles will be measured and counted on the same dates the oyster seed is also counted and measured.

Timeline and Goals

Oysters will be spawned at the MVSG solar hatchery in Vineyard Haven when broodstock are naturally ripe, typically early to mid-July. Spat-on-shell will be moved to Chilmark Pond in floating cages around mid-August 2014. Cages will be sunk to the bottom for the winter to avoid ice and wind damage to the gear. Cages will be brought to the surface the following spring where they will grow until the end of the summer of 2015, when they will be tested for oyster diseases, carbon and nitrogen content and moved to Approved water for depuration. These oysters will be harvestable size the following winter of 2016. Oysters will be monitored for growth and survival on four accounts after leaving the MVSG hatchery; likely November 2014, April, June and August 2015, with relay occurring in October 2015. At the end

of Year 2 we will determine which site enabled the fastest growth rate of the oysters, as well as the nitrogen content of a 1 year old oyster relayed out of Chilmark Pond.

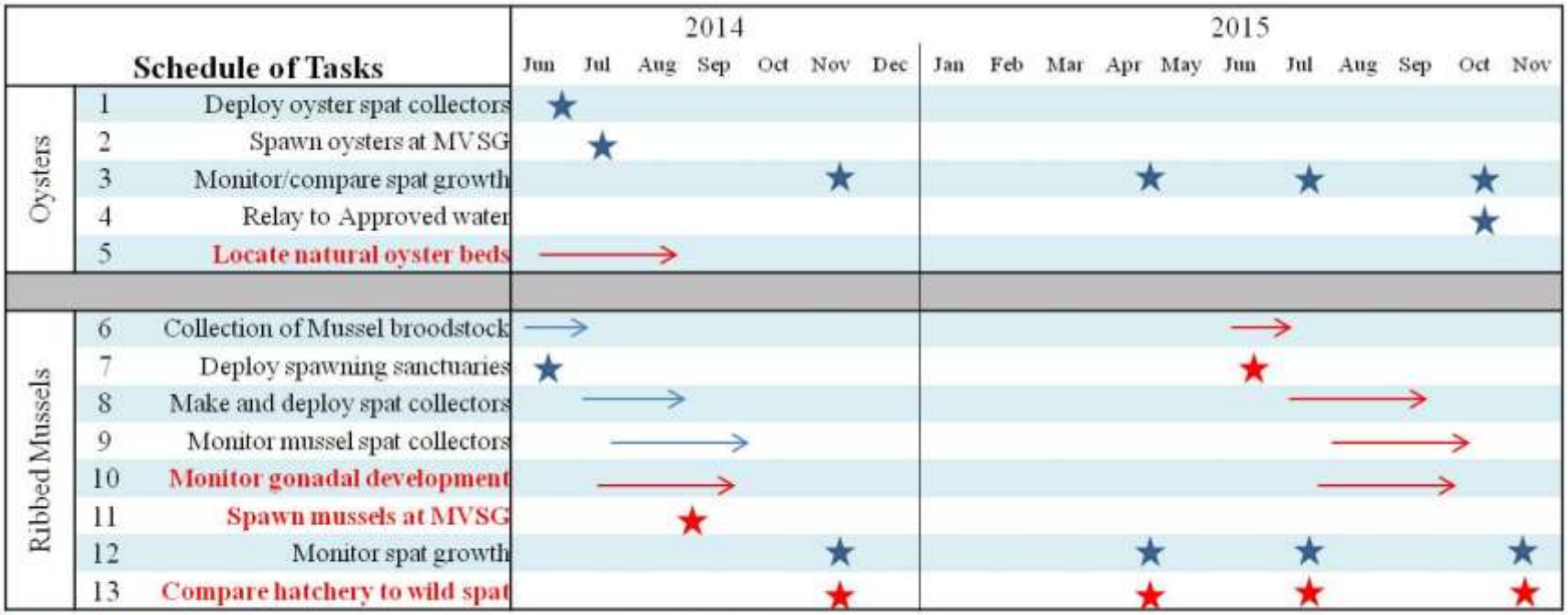
Mussel broodstock may be held in temporary bags or cages until spawning cages are constructed and ready for deployment. Spawning cages will be deployed by June 1 and spat collectors by July 15. After spat collectors are placed they will be checked every 2 weeks for new mussel recruits until the end of September, or when recruits taper off, whichever comes first. At the end of Year 1 we will determine spawning and setting time of mussels in Chilmark Pond, as well as the most favorable spat collectors.

Future and Complimentary Activities

Above is a proposal for preliminary investigation into the culture of oysters and ribbed mussels in Chilmark Pond for nitrogen mitigation and water quality improvement. Ribbed mussels, in particular, are sparking the interest of natural resource managers and researchers at an increasing rate, for their superb adaptability and filtration abilities. While a large amount of research has been conducted on the role of ribbed mussels in the marsh ecosystem, very little work has been done on its cultivation. Shellfish researchers and culturists in other states have had minimal success in spat collection and spawning of ribbed mussels, which will be imperative to the wide-spread use of this bivalve. That is why, also attached, is a budget and a Schedule of Tasks outlining a proposed matching project in Chilmark Pond.

A complimentary project, funded by matching funds from the Chilmark Ponds Association would allow continuation of some oyster spat collection, and further development of ribbed mussel culture techniques. Monitoring gonadal development in the ribbed mussel will continue so that we can pinpoint the natural spawning time which is essential for both optimizing wild spat collection, and successful spawning in the hatchery. We will also attempt to spawn naturally ripe mussels at MVSG hatchery, rear the swimming larvae through metamorphosis, and plant mussel seed in the pond.

While no substantial immediate improvements in pond water quality are expected within the small scale of this project, we believe that this preliminary investigation/demonstration of the ecosystem services of shellfish to clarify water and reduce nitrogen can provide much needed insight into the enormous potential for using shellfish as an affordable means of addressing the Island's deteriorating water quality and pave the way for larger, future deployments of shellfish with substantial benefits.



Red text and symbols indicate tasks made possible by Chilmark Ponds Foundation match

Blue symbols indicate tasks funded with Town of Chilmark funding

Town of Chilmark - Budget Summary

Using Oysters and Ribbed Mussels for Remediation and Bioextraction

Martha's Vineyard Shellfish Group, Inc

February 2014

		Quantity	Each	Total Request
Salaries				
	A. Richard Karney, Director	20	$35	$700
	B. Emma Green-Beach	150	$20	$3,000
	C. Summer Assistant	55	$14	$770
Fringe				$1,295
Total salary				**$5,765**
Non-expendable equipment				
	OysterGro cages	3	$250	$750
	Floating spawning cages	3	$10	$30
	Vexar oyster bags	18	$5	$90
	cinder block anchors	6	$5	$30
Materials and supplies				
	anchor lines (3m each)	6	$3	$18
	spat collectors	110	$1	$110
Travel				
	Hatchery - pond rnd trip (22mi)	15	$11	$165
Hatchery Rental				
	spawn and larval rearing	1	$1,000	$1,000
	nursey space and food	1	$700	$700
Laboratory services				
	oyster tissue nitrogen test	3	$11	$33
	official Dermo disease diagnostics	2	$200	$400
Overhead 10%				$909

Total	**$10,000**

Chilmark Ponds Association - Budget Summary

Using Oysters and Ribbed Mussels for Remediation and Bioextraction

Martha's Vineyard Shellfish Group, Inc

February 2014

	Quantity	Each	Total Request
Salaries			
A. Richard Karney, Director	35	$35	$1,225
B. Emma Green-Beach	100	$20	$2,000
C. Summer Assistant	65	$14	$910
Fringe			$1,129
Total salary			**$5,264**
Non-expendable equipment			
Larvae sieves	17	$30	$510
spat collector rafts	5	$10	$50
cinder block anchors	5	$5	$25
Materials and supplies			
anchor lines (3m each)	5	$3	$15
spat collectors	60	$1	$60
Travel			
Hatchery - pond rnd trip (22mi)	15	$11	$165
Hatchery Rental			
spawn and larval rearing	1	$3,000	$3,000
Overhead 10%			$909

Total	**$9,998**