Willapa Bay Marine Ecology Research: 2003 Summary

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2003 was full of scientific excitement and discovery for us – and, as you may have noticed, a "tent city" that periodically sprang up around our house at 27707 Sandridge. At last count, 25 undergraduates, 10 graduate students, 5 research assistants, 5 faculty, 3 state scientists, 2 federal scientists, 1 international professor and 2 volunteers stayed with us over the past year. As usual, most of what we 'discovered' about the ecology of Willapa Bay was already well-known by local shellfish growers. Nevertheless, this (2^{nd}) annual report gives a brief summary of our research in 2003. We genuinely appreciate your patience, as well as your willingness to share and collaborate. We couldn't have done it without you!

Please continue to stop by, give us feedback, bring us a bucket of oyster drills, tell us about curious things you've seen, or check out the chickens anytime that 'the doctors are in.'

The following pages update five research questions that are similar to those in last year's annual report. First, we continued to examine the spatial pattern of Pacific oyster growth in Willapa Bay. Interest in this question goes back a century, and indeed the general answer has been known at least that long: rich oceanic waters prompt people to move oysters closer to the mouth of the bay where they grow and fatten faster. A paper we published last year (Estuaries 26:1079-1093) reports on this striking large-scale difference in oyster growth across the estuary. We found that Pacific oysters grow best near the ocean and in river-influenced areas almost to South Bend (these are your fattening beds, no surprise). In 2003 we added a study to understand the underlying causes of this variation. Lots of laboratory evidence (by others over many decades) points to three main factors that influence oyster growth: temperature, food, and seston (the fancy word for all the small particles in the water). Temperature has an optimum; that is, Pacific oysters feed best at 18.9°C (66°F). More food generally has a positive effect on growth (surprise!). Seston can interfere with feeding when the particles reach high densities, because they clog oyster gills. The surprising result from 2003 is that oysters grew well in the south part of the bay even though we measured very low levels of chlorophyll (food) there.

Second, we continued to put out weekly shellstrings from May to August to measure the recruitment of native and Pacific oysters. In this effort, we're continuing to add to the WDFW time series of recruitment starting in the 1930s. For many decades, scientists developed these records, as well as weather and water temperature reports, to try to develop effective forecasting methods to predict spatfall. These efforts were often overwhelmed by idiosyncracies of particular conditions from year to year. Many of you have told us, however, that Pacifics are spawning at lower temperatures each decade, and that spatfall is more reliable

now than it has been in the past. Our analysis so far supports your beliefs; setting dates have moved earlier, on average, by four days each decade since 1936, and the frequency of commercial sets is more common. If this trend continues, setting should occur by July 25 this year (as opposed to

August 25 in 1936.) However, "bay-wide" spawning and setting of Pacific oysters in really high numbers (>350 per shell) has not occurred since 1966. On another note, native oysters have already spawned and are beginning to set (starting May 25 or so) in reasonable numbers (2-3/shellface), similar to what we have found for the last few years – but a little sooner, probably from the warm bay water conditions.

Third, we are collecting information on native oysters from the perspective of trying to understand why they remain far below population densities that supported commercial exploitation in the 1800s. In 2003, we completed two experiments to test grow-out strategies. We found out that, when native oysters are settled on Pacific cultch, they move considerably in winter storms, so this year we'll be testing alternative cultching materials. We also measured growth and survival of native oysters at multiple tidal elevations, with and without competitors. Natives are extremely sensitive to tidal elevation, with poor survival above mean lower low water. Fouling organisms also reduce both the growth and survival of native oysters. It appears that a major challenge for restoring native oysters is to develop ways to prevent fouling, but still keep the oysters underwater almost all the time.

Fourth, we have completed two years of studies on introduced oyster drills to understand how fast their populations change and how they might be more effectively controlled. The Japanese drill has a "live fast, die young" lifestyle, producing many offspring but experiencing high mortality. Our calculations indicate that it is more valuable to remove or destroy as many Japanese drill egg capsules as possible to achieve rapid reductions in population sizes than to just kill/remove adults; 70% of the adults die anyway each year. In contrast, the Eastern drill takes a slow and steady approach, with each individual living for many years. Removing/killing Eastern drill adults should have a large impact on population size.

Finally, last year we began a study of the growth and reproduction of eelgrass, with particular interest in whether oysters or bed practices enhance conditions for eelgrass in ways that might mitigate the disturbance that occurs during shellfish harvest. Eelgrass grows extremely rapidly in Willapa Bay, up to 6 cm (>2 inches) per day in July! This year we've also been surprised by the number of new plants growing from seeds, a mode of reproduction that is not commonly observed in this species – usually old plants give rise to new ones through branching, not through seeds. So far, we have not measured any consistent differences in growth of eelgrass between aquaculture and non-aquaculture areas, nor are there consistent differences in sediment type or nutrients. The results from 2003 are presented later in this report, but we have already collected samples in a new, better-designed study in 2004, which should provide a more rigorous answer to the question of how eelgrass responds to aquaculture.

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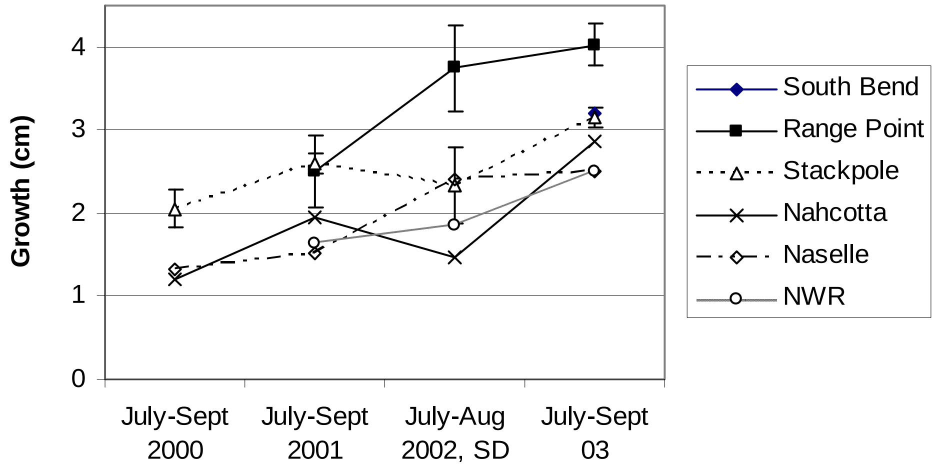
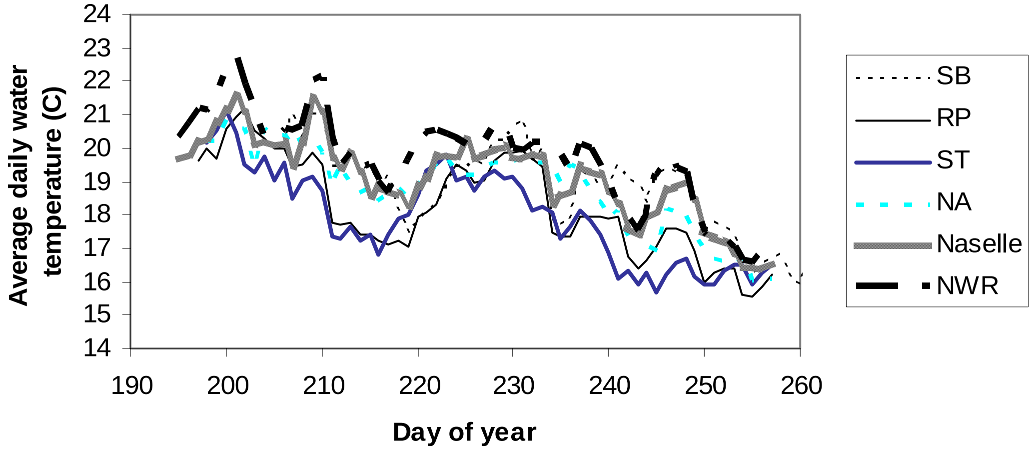
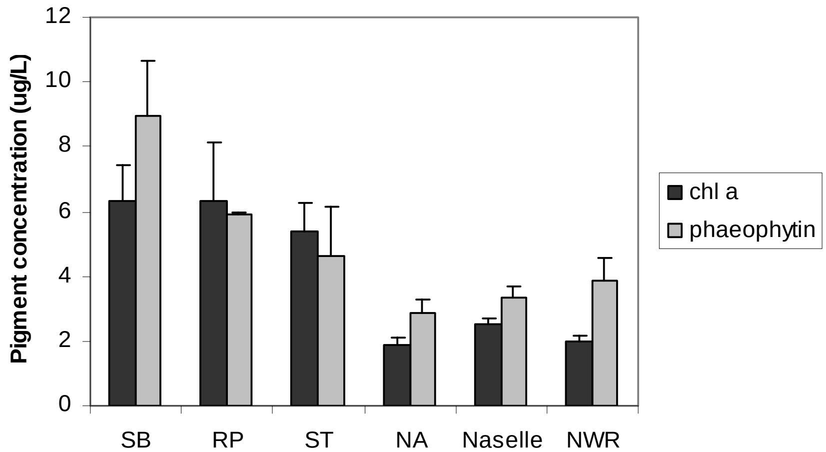
Question 1: Where do oysters grow best, and why?

We use oysters settled on tiles to measure growth rates, based on change in shell length. These oysters are about 2 months old.

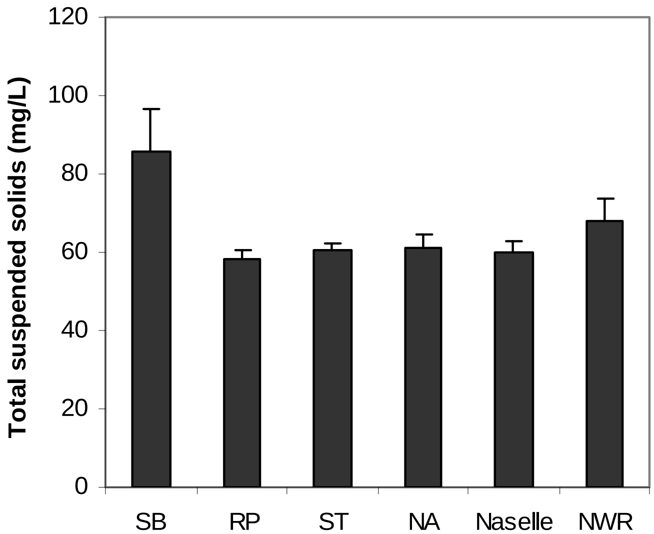


The graph above shows how fast oysters have grown in each of the past 4 years over a 6-8 week period in late summer (1 inch = 2.54 cm, so oysters grew more than an inch at highly productive sites). The techniques and starting sizes have been a little different each year, but we are still convinced that there has been a continued shift to better growing conditions (besides, you've told us so!). The graphs below show that chlorophyll (found in phytoplankton) is high in the north part of the bay; the water contains more particulate matter towards the rivers; temperatures range from cool at the mouth to warm within the bay, and they fluctuate with weather patterns. SB = South Bend, RP = Range Point, ST = Stackpole, NA = Nahcotta, Naselle = north end of Long Island Slough, NWR = National Wildlife Refuge headquarters





This graph presents a huge puzzle. The food levels (measured by phytoplankton pigments) were lower in the south part of the bay, but oysters grew just fine there, according to our outplants.

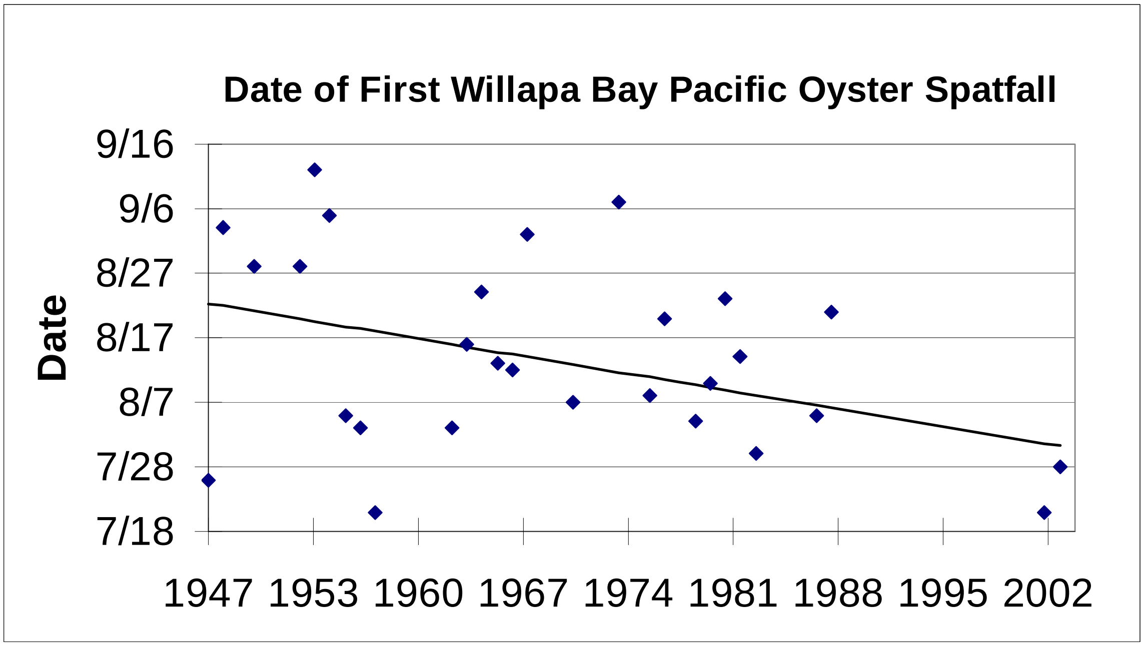


Seston begins to interfere with oyster feeding at about 50 µg/L, and feeding shuts down at 200 µg/L. Most sites except for South Bend have low seston.

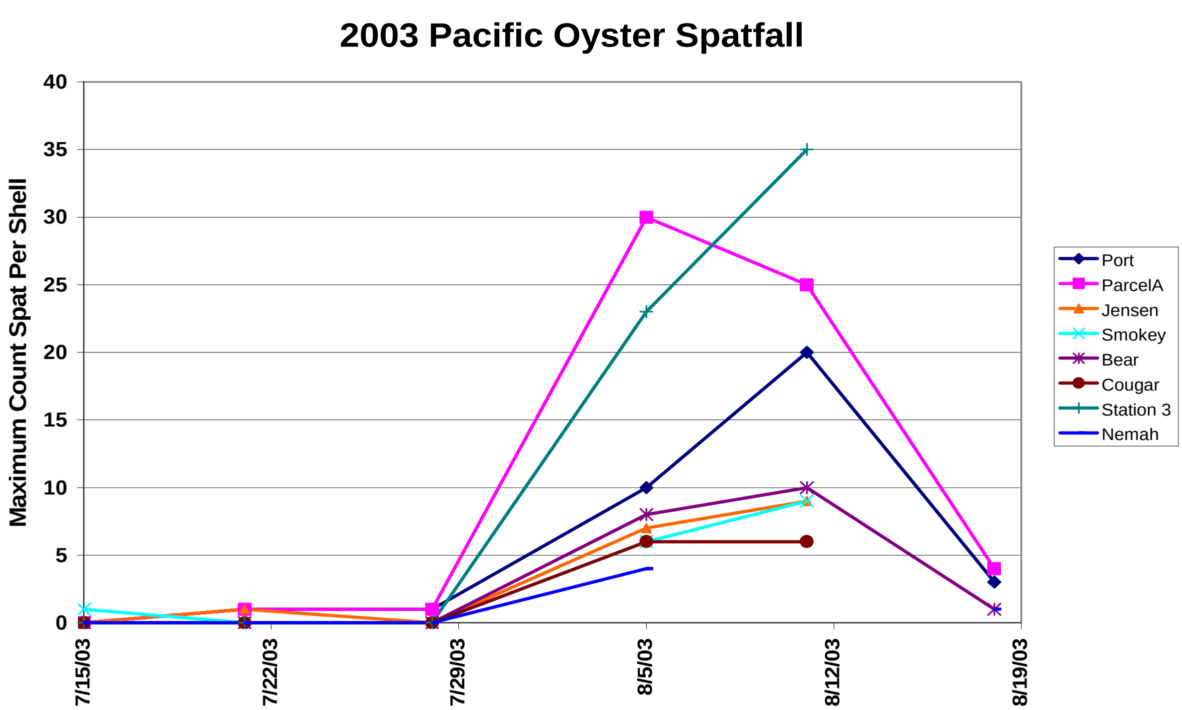
WE WOULD LIKE TO KNOW FROM YOU… Have you noticed changes in the growth or fattening of oysters over the past few years? What allows oysters to fatten – is it just getting a lot of food, or are there other considerations? Did oysters grow faster and/or fatten on Middle Sands in 2003?

Question 2: How did oyster recruitment in 2003 compare with other years?

Pacifics set in late July and early August, as you well know. The timing of spat fall was earlier than most other years on record.

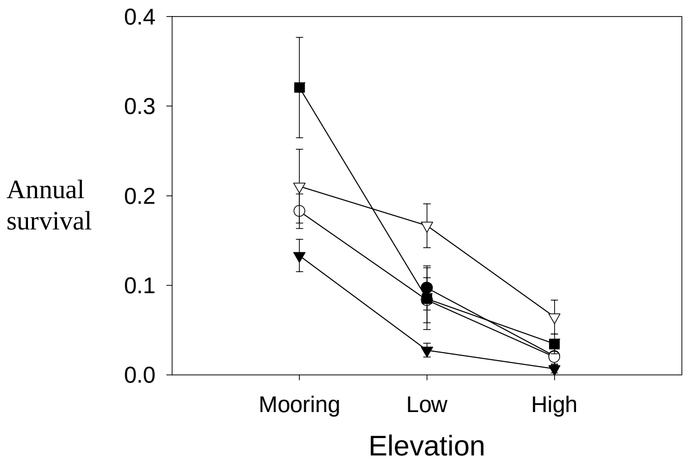


Spatfall was particularly high in Mill Channel and Stanley Channel near Lewis Slough. The south part of the bay – and areas of traditionally high recruitment like Cougar Bend – recorded lower recruitment.



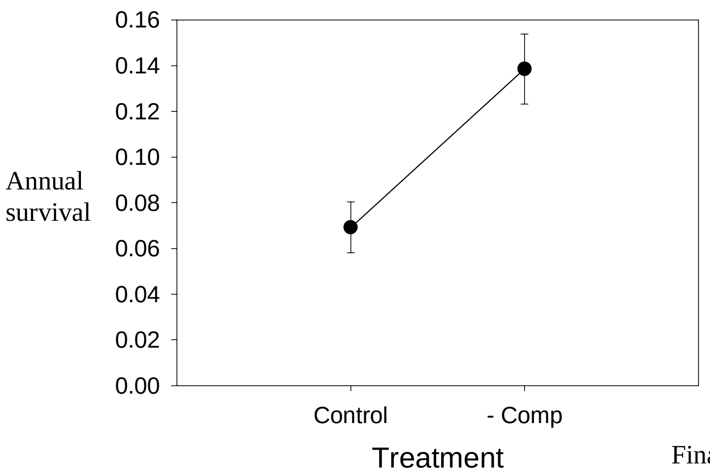
Question 3: What factors influence the growth and survival of native oysters?

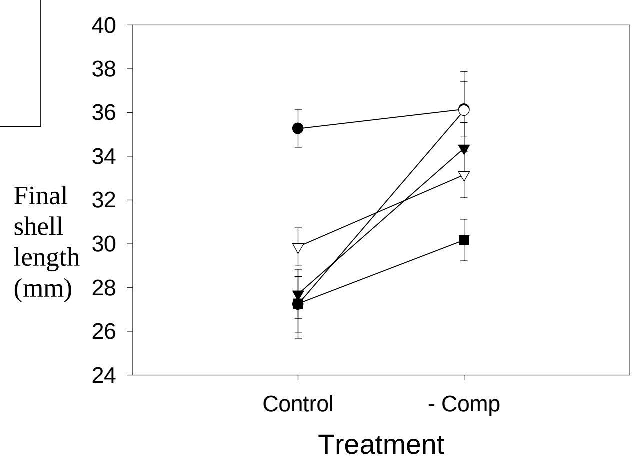
In 2002, native oysters from Willapa Bay broodstock were settled on tiles in a hatchery. We outplanted these tiles to 5 locations and three tidal elevations (-1', +1', and continually submerged on a mooring), and we regularly removed fouling organisms from half of the plates.



Tidal elevation had a large impact on survival. Above 0 MLLW, native oysters were 2-6 times more likely to die. The five separate lines in this graph indicate that the effect of tidal elevation on survival varied across sites. Worst survival (filled triangles) occurred in front of the WDFW lab.

Fouling organisms, such as barnacles, ascidians, and hydroids, also had a large impact. When competitors were removed (-comp), native oysters doubled their chance of survival (14%) and their growth rate.





In a related study with WDFW, we used Pacific oyster shell as cultch for native oysters. This cultch suffered two problems: A lot of it disappeared altogether from our small experimental plots during the winter. But, if cultch were anchored in place (within a mesh bag or on stakes) then heavy fouling from sponges, ascidians, hydroids and barnacles tended to stunt the growth of oysters and reduce survival.

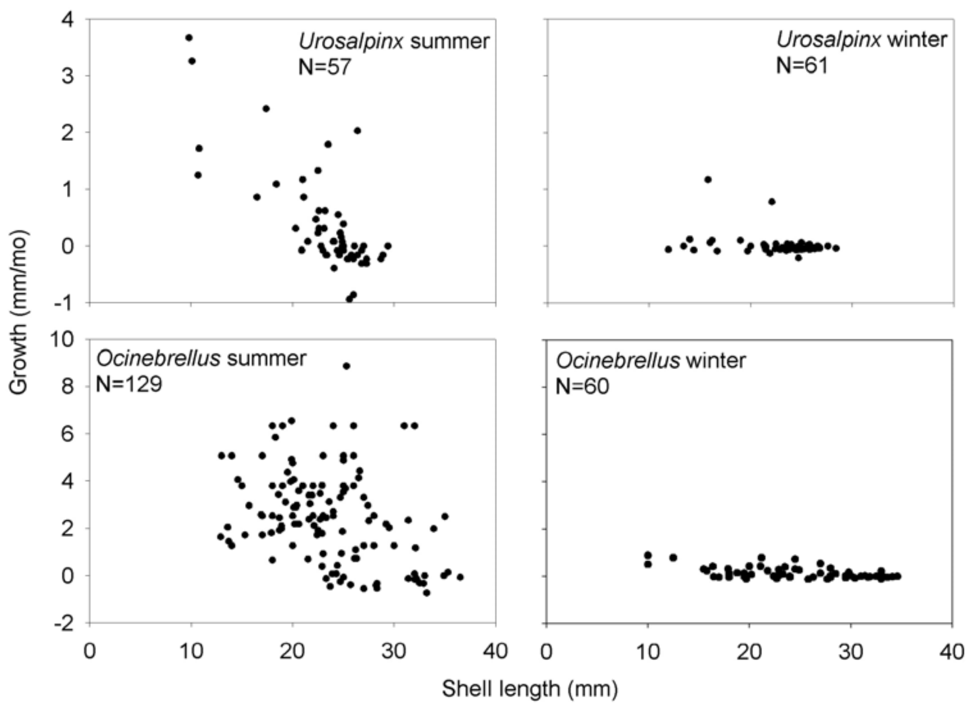
Question 4: What are the population dynamics of two species of introduced oyster drills? Why are oyster drills so difficult to control?

Urosalpinx cinerea: introduced accidentally from eastern North America before 1920

”Slow and steady” life history: Eastern drill shells are difficult to crack. Adults have high natural survival (>30% annually), and low reproductive rates. Small individuals are rare.

Ocinebrellus inornatus: introduced accidentally from Japan or Puget Sound about 1960

“Live fast, die young” life history: Japanese drills are easy to crack, so they have low survival (<10% annually), probably due to crabs. They produce many egg capsules with lots of offspring.



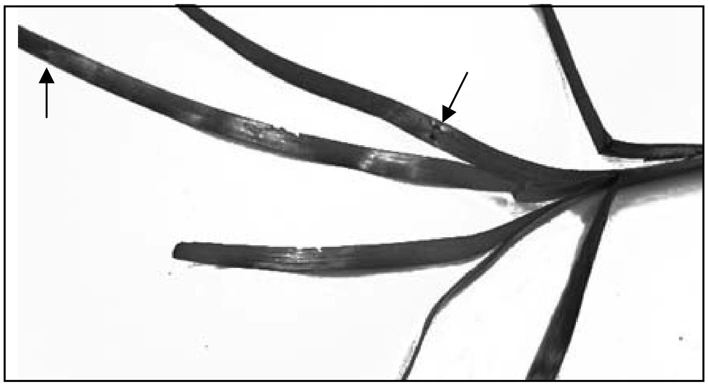
Both species grow rapidly when young, up to ¾ inch over the summer (and hardly at all when they are inactive during the winter). They can reproduce after 1-2 years.

We found out this information about drills by individually tagging more than 5000 from hummocks in the Nemah region and near Peterson Station. We measured growth when we recaptured them (and death when we didn’t). These tagging studies also allowed us to determine total population size. Even with diligent searching in hummocks, we were only able to find about 20% of the drills in each survey. The total number of drills in moderately-sized hummocks (a little bigger than a person sprawled out on the ground) ranged from 150 to 800!

Drills are difficult to control for two reasons: It’s impossible to pick them up all at once (we find only 20%, and the small ones are particularly cryptic). And many of the adults would die anyway, even if they weren’t picked up. It should definitely help to remove egg cases (with a screwdriver, for instance) at the same time.

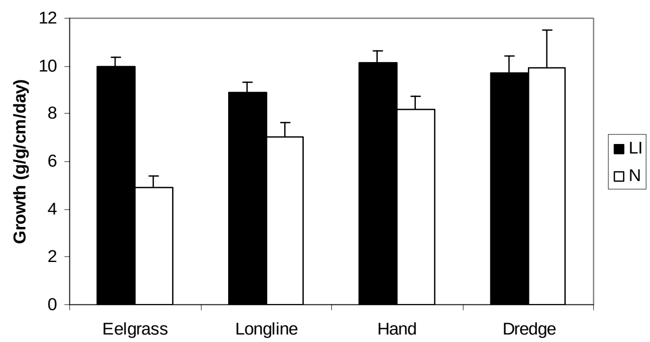
Question 5: What are the effects of oysters on eelgrass?

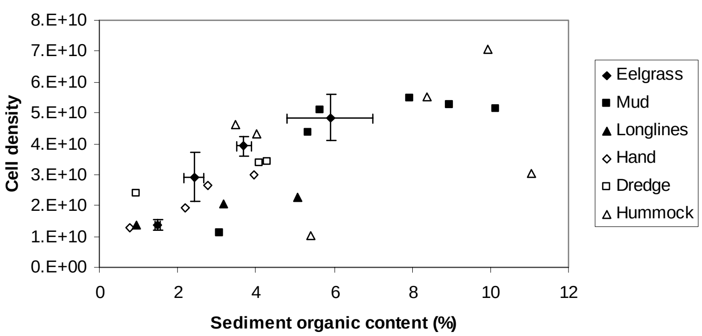
This is not a simple question. It is challenging to separate the effects of different aquaculture practices from the effects of oysters themselves - and eelgrass may respond in terms of density, growth rate, branching rate, plant size, or recruitment. In 2003, we focused on whether oysters (in a variety of aquaculture types) alter sediment properties such as grain size, organic content, nutrients, and microbial communities, and we also measured eelgrass growth. The data here are from Long Island (LI), Nemah (N), Middle Sands (MS) and Oysterville (Oys).

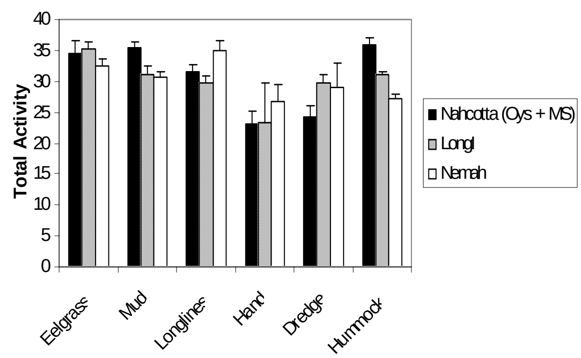


Eelgrass grows from the base of the plant, with new leaves emerging at the center. Four days before this picture was taken, this plant was marked near the base with double holes. If you look carefully, you can see that the holes have traveled up the growing leaves. The small center leaf has no holes at all – it was produced within the last four days. We use this technique to measure the growth rate of eelgrass. We always standardize growth for plant size, because large plants grow faster than smaller ones.

This graph shows that eelgrass grew similarly wherever we measured growth, except in one eelgrass bed at Nemah. Why would growth be lower here? Possibly the bed was so dense with eelgrass that light was limited for growth. There is no evidence that aquaculture practices reduce eelgrass productivity on a per-plant basis. However, total production is obviously lower where disturbance has thinned the eelgrass.







Bacteria in the sediment can be measured in two ways: 1) Cell density indicates how many bacteria are present, including those that live in aerobic and anaerobic conditions. The graph on the left above shows that bacterial cell density is highly correlated with organic content in the sediment. However, aquaculture practices show no consistent relationship with sediment organic content or bacterial cell density. The organic-rich samples were collected from sites close to river mouths. 2) Total activity indicates how fast aerobic bacteria use carbon sources as fuel. Beds with on-bottom culture show slightly lower rates of breakdown of organic materials. Do these differences matter for ecosystem functioning? On the whole, we were surprised at how much variability in estuarine sediments occurs naturally and is not related to aquaculture practices.

WE WOULD LIKE TO KNOW… what sediment characteristics, for instance grain size, oxygen content, or pH , you attempt to achieve for best oyster growth.