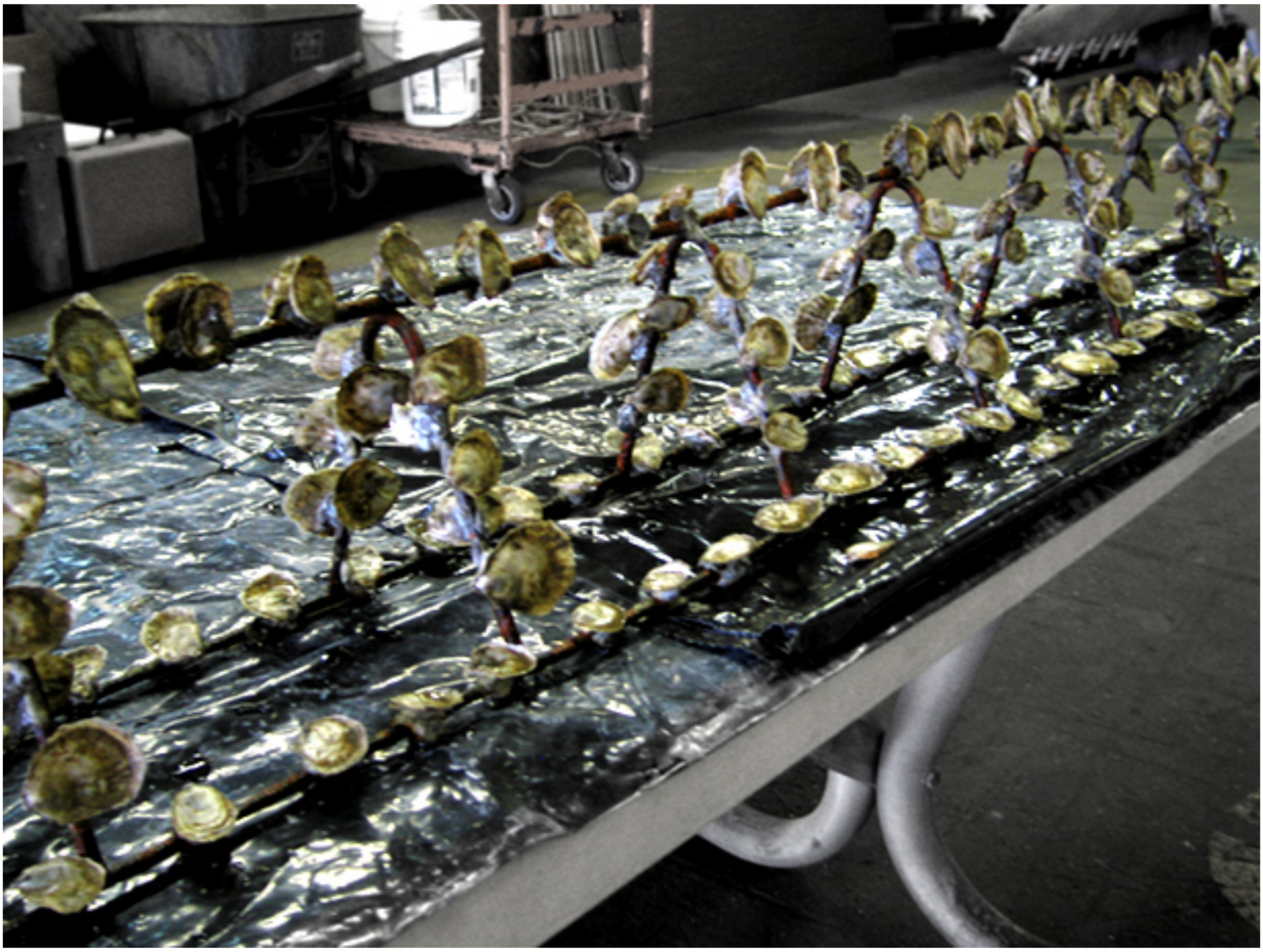
Oyster Growth Study using Biorock® Accretion Technology



By Nikola Berger

Undergraduate Thesis, The City University of New York

Baccalaureate For Unique And Interdisciplinary Studies, The Graduate Center

Submitted to: Prof. Haydee Salmun, Environmental Studies Department, Hunter College

Supported by: Mara Haseltine, J. T. Boehm, Thomas J. Goreau PhD

January 2009

ABSTRACT

Since Europeans settled in the Hudson Bay area in the 17th century, oysters filled the estuary until the 20th century when the last oyster beds collapsed from over harvesting, siltation, diseases and pollution. Oyster reefs historically were very important to the NY/NJ bay area—economically and ecologically. A group of non-profit organizations in the NY/NJ Bay area have been trying to bring the American oyster *Crassostrea virginica*, back for various reasons—among them, habitat improvement, storm surge and coastal erosion protection, spawning grounds for other marine life and the oyster's water "filtering" capacity. Different projects have been in the works to create oyster reefs with mixed results. The Oyster Growth study that I have been involved with and is described in this paper is examining one possible way to help jump-start a reef by growing larger oysters in a shorter amount of time. The method we examined, known as Biorock™ Technology, has shown to increase coral growth during coral reef restoration projects. The technology works by using electrostatically mediated calcium carbonate deposition on submerged metal structures. The accreted minerals may be more bio-available to the oyster on the metal structure and therefore, possibly promote oyster shell growth. One goal of this study was to see if this method can be used to aid in oyster reef restoration.

The Oyster Growth Study was conducted in the summer/fall seasons of 2007 and 2008 at the facilities of The River Project, a non-profit environmental organization I had been volunteering at for a few years. Our hypotheses tested 1) if oysters provided with an electric current (experiment) grew larger than oysters not provided a current (control), and 2) if mortality rates differed between the different conditions. The results of the oyster growth study showed that oysters in the experimental tank adhered to metal structures, e.g. "reefs", which were under a 6 – 9 volt current, grew significantly larger and faster than the oysters in the control tanks that were not connected to an electric current. In addition, we found statistically significant differences between the total mortality, with fewer deaths in the experimental than control tank. The results were the same for both years.

Aiding reef formation could have large-scale regional benefits. The commercial, as well as recreational fishery could benefit from the reintroduction of the keystone species of the past, as major reefs can increase the species abundance by about tenfold[8]. Increased water clarity also promotes more bioactivity. Oyster reefs and salt marshes are the low cost armor for our regions vulnerable coasts. And with an assumed increase sea level rise and hurricanes due to global climate change, this becomes even more important.

INTRODUCTION – HISTORY OF THE EASTERN OYSTER IN NY/NJ HARBOR

The Eastern oyster (or also called American oyster), *Crassostrea virginica*, can be found from the east coast of Canada to Argentina[8] and since the early 20th century also on the west coast (where they have been exported to as the waters here started to deteriote[7]). In the Hudson-Raritan Estuary (HRE) archeological findings suggest that the Eastern oyster has made this region her home since the end of the last ice age[2] and the oldest shell midden was found by Dobbs Ferry and dated 6500 years old[7]. Before the 20th century, the oyster reefs covered approximately 350 miles of the HRE, from Sandy Hook, NJ, north as far as Ossining, NY and especially in the Raritan Bay, the Navesink and Shrewsbury Rivers, the Arthur Kill, Jamaica and Newark Bay[3]. The natural beds covered the shoreline and all major islands and shoals[2]. But by 1812 many of those beds were depleted, and a commercial oyster industry took over, creating large artificial oyster beds and importing seed oysters from Chesapeake Bay and the Long Island Sound. Oysters were the economic foundation of many coastal towns including Keyport, Perth Amboy, Red Bank and the south shore of Staten Island.

The oyster reefs of the past provided a large and exceptional habitat for a diverse group of marine life forms. Oysters were a keystone species in the larger Hudson Bay area, playing a central role in the estuary’s web of life and linking the benthic and pelagic food webs. The oyster not only sustained a whole industry in its own name for centuries but also the fishing industry by providing fish habitat and clear water in the estuary. Over 30 fish species are found to be connected to the oyster reefs in the Mid-Atlantic Bight, including juvenile striped bass, tautog, black sea bass, adult black drum and even the American eel, which has been in trouble for decades[4]. Another study states that about 75% of all commercial fish and shellfish depend on estuaries at some point in their lives[8]. The reefs provide refuge from predators, especially for young fish that hatch in the estuary as well as a good source of food. One adult oyster can filter up to 50 gallons of water per day[1], thereby improving water purity and clarity as they remove suspended sediments and micro-algae[6]. Increased water clarity encourages more biological activity at greater depths and results in higher dissolved oxygen levels[5]. The whole population of oysters in the HRE in the past centuries was counted in billions, filtering the entire estuary in a few days8. Oysters do not cleanse the water in the sense that they remove harmful pollution permanently but they trap impurities and expel them in larger particles that sink to the bottom rather than make the water turbid[1].

In recent years, a few environmental organizations are working to bring oysters back to the New York, New Jersey bay area in order to regain many of the lost benefits to the ecosystem that once were. The NY/NJ Baykeeper wants “to restore this key species to most of its historical range as an integral part of a healthy Estuary ecosystem” as they explain in their mission statement. River Project, The Harbor School, along with other groups and the NY/NJ Baykeeper now work together on fulfilling this goal. In 1999 Baykeeper began by creating a new "artificial" oyster reefs. Another goal of restoring the oysters is what their reefs can do over time. Jamaica Bay is a proposed reef location since it has been polluted by sewer plant discharges with excess nitrogen, degrading the natural spartina grass that normally protects the Bay’s shore and the islands against storm and wave action. Enter sea-levels rise from natural as well as anthropogenic causes, the shore and island marshes that protect the coast are eroding away faster even. The proposed huge-scale Jamaica bay oyster reefs could work against this trend by creating new benthic habitat on the windward side of the bay’s salt marshes. Incoming waves would break on the hard-shelled reefs instead of the marshes, thereby stopping land erosion and increasing sediment deposition. The Shoreline’s depth would also be decreased and the slopes would be less steep, all aiding the preservation of the marshes and therefore coastline. Large-scale artificial reefs covering hundreds of acres would have to be created consisting of a special material developed by the Gia Institute and used by Baykeeper, a kind of calciferous concrete structure on which a natural reef could form.

The other option that we are exploring with our study would be to use different kinds of metal structures, that we would be connected to a low voltage current (powered by a floating solar panel) to aid mineral accretion (Biorock® technology).

The Biorock™ technology may also counteract threats to oysters due to increased ocean acidification[5]. This and other threats that are probably due to increased CO_2 partial pressure in the atmosphere are explained in detail in Kaitlin Baird's master thesis.

THE STUDY - Background

I have spent the last two summer/fall seasons working on this study looking at possible methods to support sustainable reef formation in oysters. I started to head up the oyster growth study in the summer of 2007 after having been an oyster gardener for over a year with the same organization that hosted this study—The River Project. J.T. Boehm, the resident marine biologist and other volunteers helped me design and set up this study that is similar to a study previously conducted by Kaitlin Baird-then a master's student at Columbia University-in the intertidal zone in the East River at College Point, New York. At the River Project, we were interested in repeating the study in a more controlled environment since Baird's results were compromised by the large amount of oysters she lost due to crab predation and other disturbances.

Naturally, oysters are called bioengineers since they create three-dimensional structures (reefs) as they grow on the backs of older oysters[5]. Oysters cannot naturally sustain themselves without having old shell (cultch) to attach to, which is one of the reasons oysters became depleted; harvested oyster shell was not returned to the water for new oysters to attach to but used as gravel and fertilizer.

Oysters, which can grow intertidally, rid themselves of many predators by being able to survive out of the water for long periods of time, whilst other organisms can't. This characteristic was a great advantage to us in our study since we could lift the metal reef structures out of the tanks to glue oysters onto them initially and subsequently measure them conveniently while the reef is on a table. The previous study done in the intertidal areas of the Hudson were more difficult because measuring the samples was dependent on the tides and other environmental factors.

We tested if oyster reef formation can be supported through the use of Biorock™ technology, which possibly promotes faster growth, creating larger and stronger shell as well as reduced mortality in oysters. It was found that shell size is positively correlated with reduced mortality due to the ability to avoid predation (Galstoff 1964, Arnold *et al.* 1996). We were able to reduce predation by conducting the study in large tanks on Pier 40 in Manhattan that use a flow through system of Hudson river water with screens that stop any organisms larger than a quarter of an inch to get into our tanks. Crab larvae did make it into the tanks and grew larger in the tanks while feeding on the oysters but were removed when found. Both tanks, the control and experimental tanks had several large crabs in them over the course of the study. It's hard to know if our data is biased due to one tank suffering from more predators than the other but we found a similar number of large crab in both tanks and there is no technical reason why one tank would receive more crab larvae than the other as they are connected in the same way to the source. It is therefore possible that the reduced mortality in the experimental tanks is due to their statistically significantly greater size relative to the control tank.

METHODS AND MATERIALS

The experiment examined the use of 'Biorock™' to:

1) Examine if providing low voltage current accelerates oyster growth rates,

2) See if total mortality is reduced in the experimental vs. the control tanks

3) And if Biorock™ technology helps to aid in calcium accretion in an estuarine environment

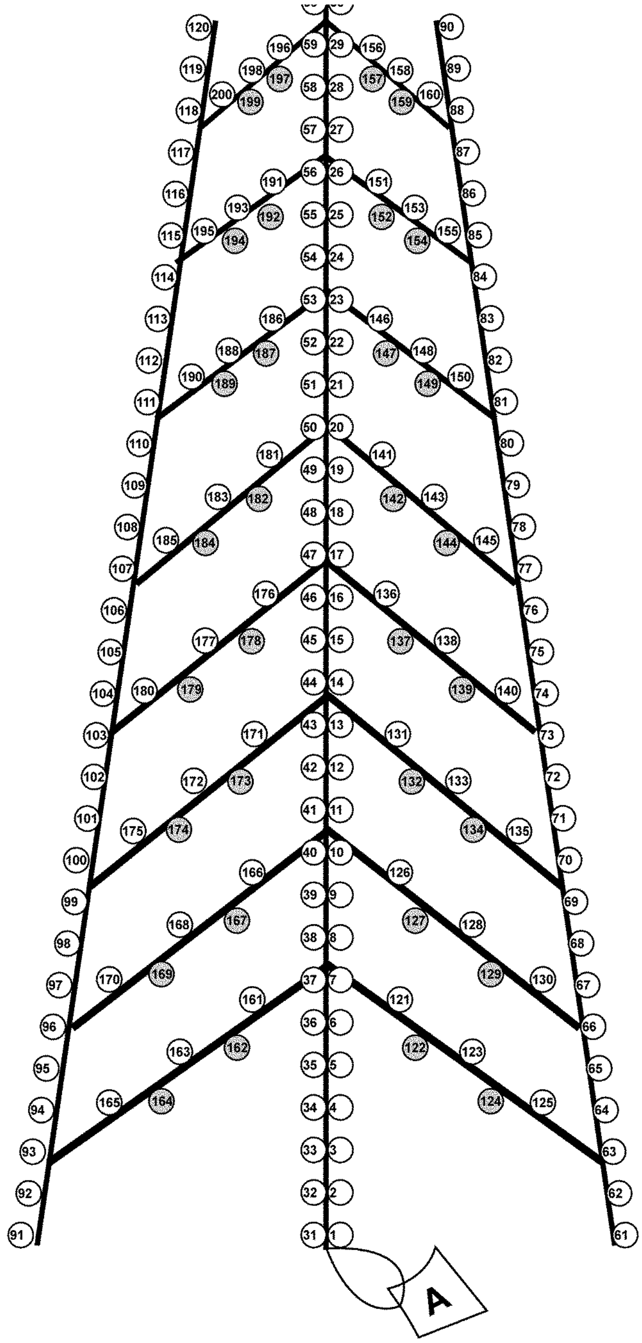


Figure 1: Oyster reef layout and oyster numbering system

The Biorock™ Technology the study utilized was developed by the late German architect Wolf Hilbertz in 1976 and was subsequently patented in 1996 by him in conjunction with Dr. Thomas Goreau (biogeochemist and marine biologist). The mechanism of the Biorock™ technology, also called Mineral Accretion method, Seament or Seacrete, is based on creating a difference in pH across the metal reef structure. The cathode is connected to the reef structure, reducing it and thereby attracting positively charged ions like Calcium and Magnesium. The resulting deposition of $CaCO_3$ through this application of an electric potential may make the mineral more bioavailable to the oysters due to close proximity[7 9]. Since one of the limiting factors to oyster reef formation is the metabolic energy that oysters need to grow shell according to Goreau and Hilbertz, making Calcium carbonate more abundant with the application of Biorock™ is thought to increase the efficiency of metabolic processes[10].

The study took place in a flow-through system with two identical round fiberglass tanks, of approximately 300 gallons each (18" height x 82" diameter). Tanks 1 and 2 each contained three replicate metal "reefs," housing an equal number of oysters (200 per reef, 600 per tank). The metal grid substrates (reefs) in tanks 1 and 2 are identical, and we treated all 3 reefs in each tank as if it was one reef (why this might not entirely accurate is explained in the section titled "Accretion"). The first tank used the Biorock™ technology; a low voltage current added to the reefs to promote mineral accretion (Experiment). The second tank acted as replicate control, with simply river water flowing through. A random subset of 30 oysters per reef were chosen using a random number generator and marked with nail polish for the duration of the study. 90 oysters per tank were measured twice per month for growth for approximately 3 months in two consecutive years. Mineral accretion and water chemistry (salinity, temperature, and pH) were also recorded to ensure they are in a normal range and equal to the estuarine chemistry and identical in both tank environments.

In 2007, we used oysters of different ages (sizes). In 2008 we decided to use oysters that were all from the same source and the same age to reduce variability in our data. All oysters came from Flowers and Sons, Oyster Bay, Long Island and were approximately the same size (one year olds) and under the same conditions before and during the experiment. Their size (height) was normally distributed in both tanks and showed no statistically significant difference in size. We attached them to the reefs with two-part epoxy adhesive in 2007. The epoxy was not specifically for marine environments and oysters did fall off the reef regularly and we re-attached them when possible. Our sample size of 90 oysters per tank did decrease slightly over time due to lost oysters.

In the 2008 study we used a combination of two-part marine-grade epoxy adhesive and quikrete cement. We found the marine-grade epoxy to hold up better than the other adhesives. The quikrete cement dissolved some of the shells initially or made them very brittle, this may have been due to an unknown additive. We also experimented with Instant Krazy Glue with inconsistent results. The three reefs in the experimental tank were attached to an electric current of 6 – 9 volts continuously throughout the study (day and night, unlike the solar powered study at College Point that only supplied the reefs with a current in the day only). Approximately every two weeks the randomly selected sample of 90 oysters per tank was measured. We recorded oyster height (from the hinge to the furthest tip of the shell as defined by Cardoso et al.[11]) and their width, which is perpendicular to height.

Since the oysters are shaped non-uniformly, width is very hard to measure consistently. The easiest to measure and therefore the most reliable data came from the oyster height, because it is simply the longest part of the shell starting from the hinge. In 2007 we used simple plastic calipers to measure the shell and in 2008 we used digital calipers, which sped up the measuring process. There was also some variability in the two studies in terms of timing: the 2007 study was done from August 15th until November 15th and the 2008 study started on June 20th until September 15th.

The Data:

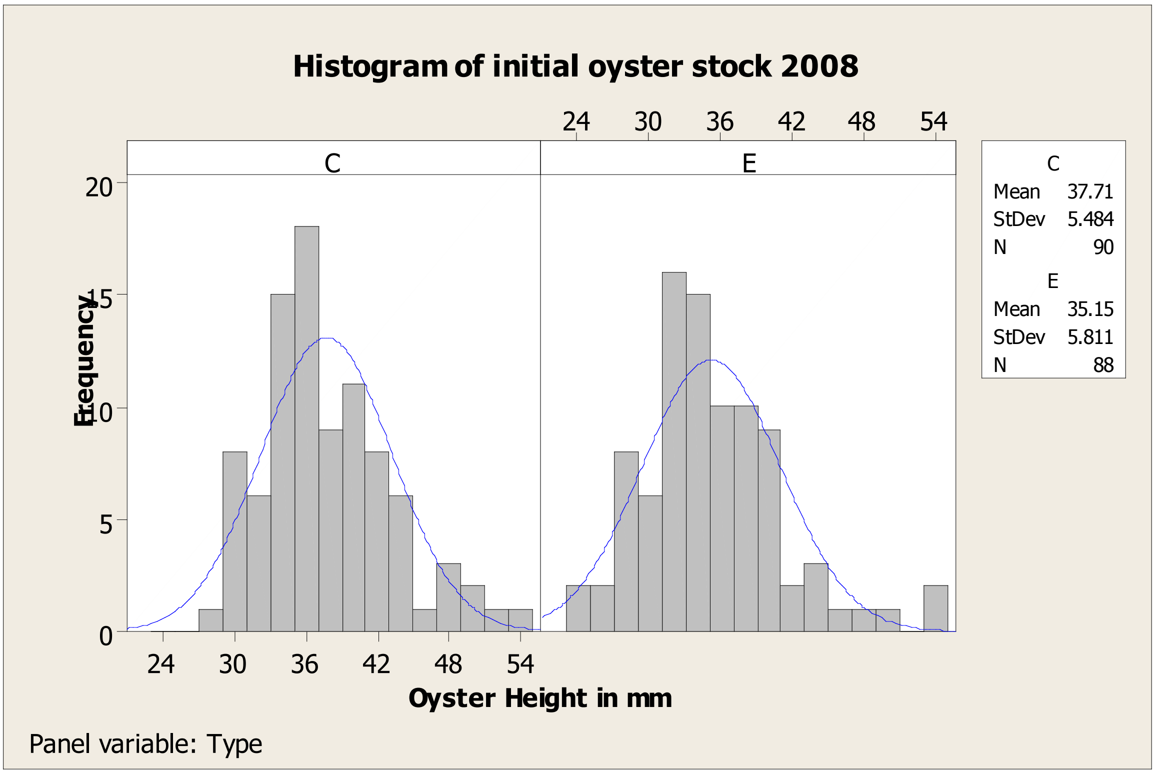
Comparing the initial size of the Oysters in the experimental and control tanks

Before the overall growth and rate of the growth were examined, the initial stock of oysters were checked for a normal size distribution. In order to compare the growth of oysters in the two tanks for both years it was important to make sure that the initial stock was similar in its distribution (size) as to have a meaningful comparison during and at the end of the study.

Oysters grow in different directions depending on where they are in reference to environmental factors like space, light and nutrient access; some may grow more in height, some more in width and some grow more evenly in both directions. Since the width measurements did not produce reliable data I only compared the height.

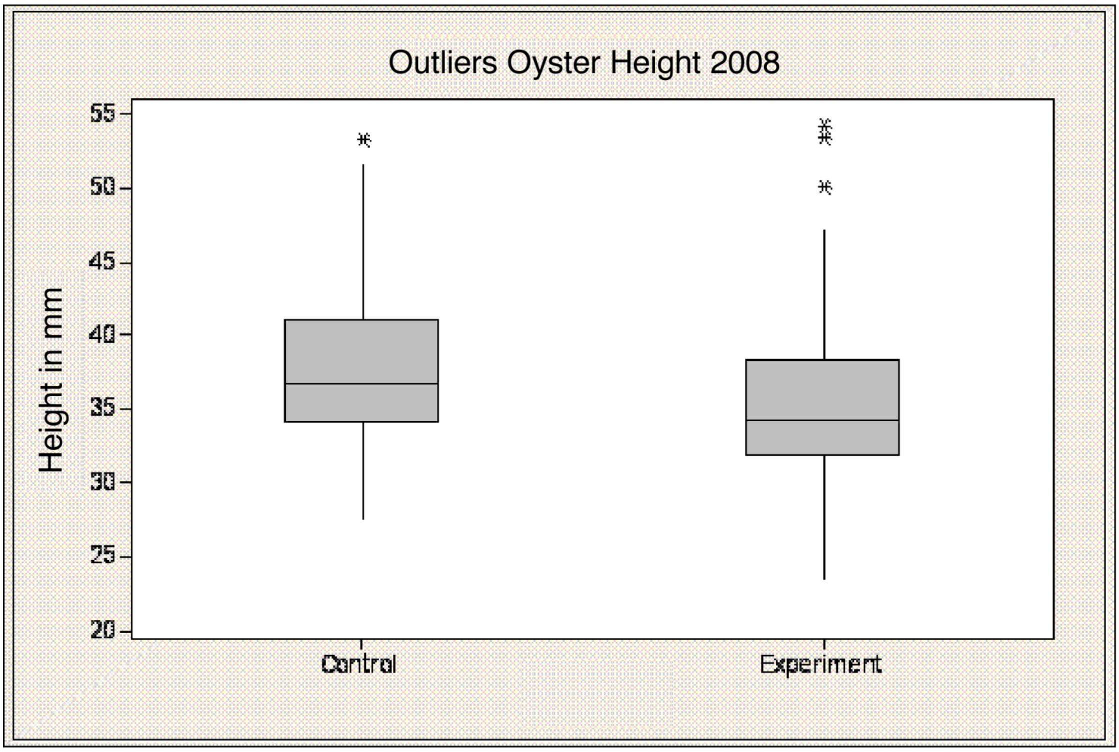
On the next pages I have posted graphs and statistical information on the initial oyster stock.

2008 Initial oyster stock: comparison of Height; tank 1 (Experiment) and Tank 2 (Control)



The first histogram on the left shows the control tank (C) sample distribution in terms of their height in mm, the histogram on the right represents the experimental tank (E) sample. The distribution for both the experiment and control followed a normal distribution of the initial heights.

Outliers were examined using boxplots for both tanks. Outliers can cause data to be skewed in one direction and make the data on the whole less reliable.



In the above box plots we can see a total of 4 outliers in our sample oyster populations. One outlier in the control group and three outliers in the experimental group. Since all of the outliers are at the upper end of the height, the data is skewed to the right in both sets, somewhat more in the experimental group but both exhibit a skewness less than 1 and therefore are still acceptable as normally distributed sample population.

Descriptive statistics of the height of the initial oyster stock 2008:

Type	N	Mean	StDev	Variance	CoefVar	Skewness	Minimum	Maximum	Range
Control	90	37.707	5.484	30.077	14.54	0.67	27.450	53.260	25.810
Experiment	88	35.146	5.811	33.771	16.53	0.89	23.380	54.170	30.790

Hypothesis testing, Independent Samples; Two-tailed t-test:

H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

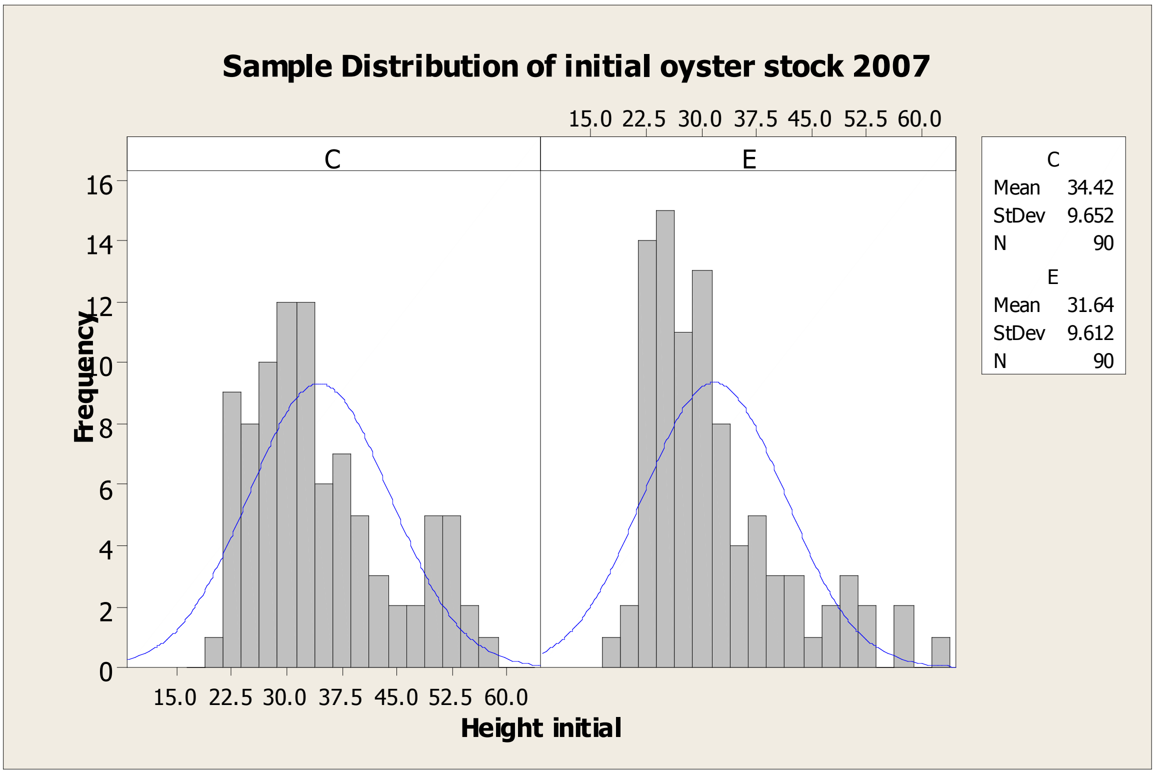
H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 3.02; at 95% confidence. P-Value: 0.0026; $H_0 \neq H_A$

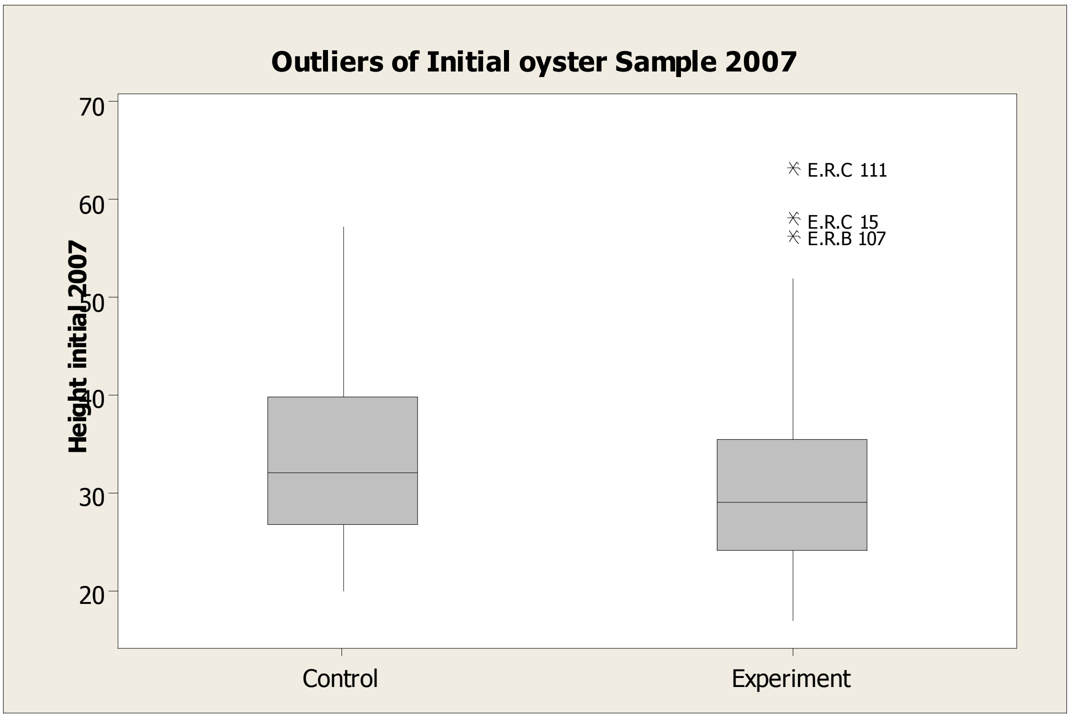
P < 0.05, reject Null hypothesis, the samples are statistically significantly different.

Even though the average height is significantly greater in the control group than the experimental group, the two tanks were treated as comparable in their initial stock, since 1) a comparison of growth rate and final minus initial height is independent of the overall size and 2) we are testing to see if the experimental oysters grow larger than the control, so the experimental group has no initial advantage (rather a slight disadvantage from our perspective).

2007 Initial oyster stock: comparison of Height; tank 1 (Experiment) and Tank 2 (Control)



The histogram on the left shows the control tank (C) sample distribution in terms of their height in mm and the histogram on the right represents the experimental tank (E) sample. Again, the distribution for both the experiment and control tanks meet a normal distribution.



In the above box plots the experimental tank has 3 outliers. As in 2008, the average height is greater in the Control tank but statistically not significantly different so we can treat them as two equal samples at the start of the study. We can therefore have a meaningful comparison at the end of the study.

Descriptive statistics of the height of the initial oyster stock 2007:

Type	N	Mean	StDev	Variance	CoefVar	Skewness	Minimum	Maximum	Range
Control	90	34.42	9.65	93.15	28.04	0.67	20.00	57.30	37.30
Experiment	90	31.64	9.61	92.39	30.38	0.89	17.00	63.40	46.40

Hypothesis testing, Independent Samples; Two-tailed t-test:

H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

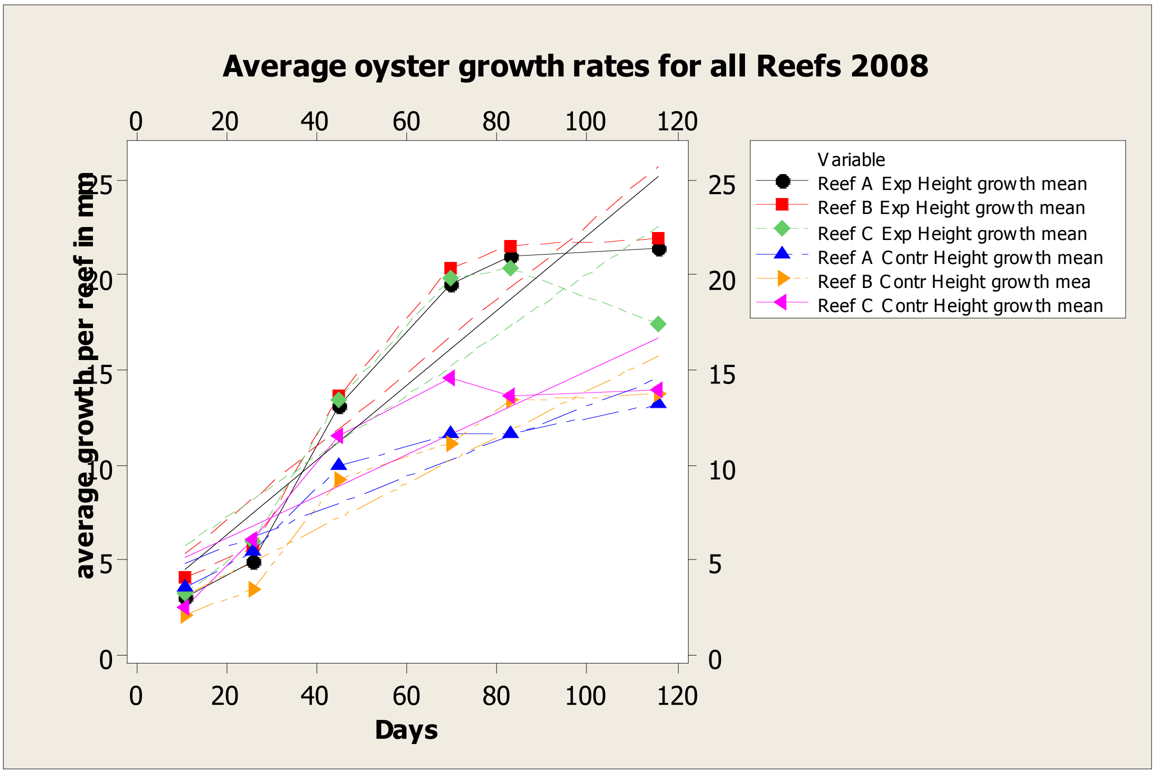
H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 1.94; at 95% confidence. P-Value: 0.054; $H_0 = H_A$

P > 0.05, cannot reject Null hypothesis, the samples are not statistically significantly different.

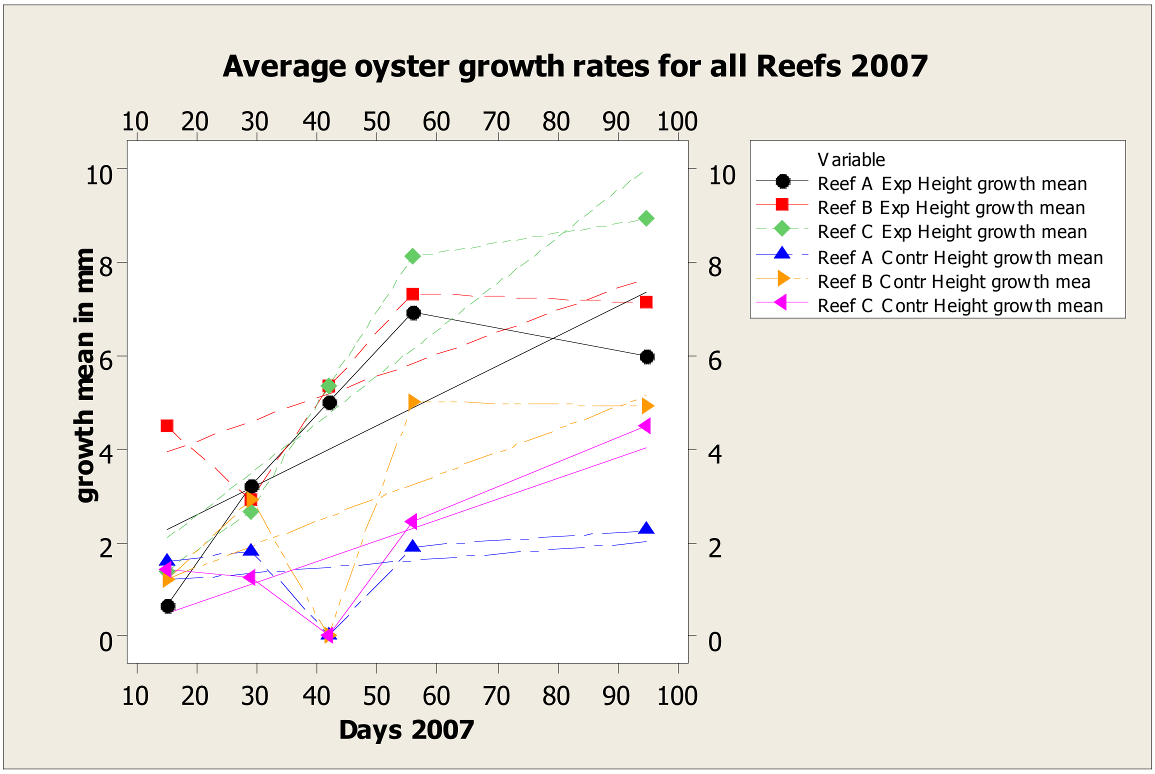
Rate of Growth

2008 oyster growth rate by reef



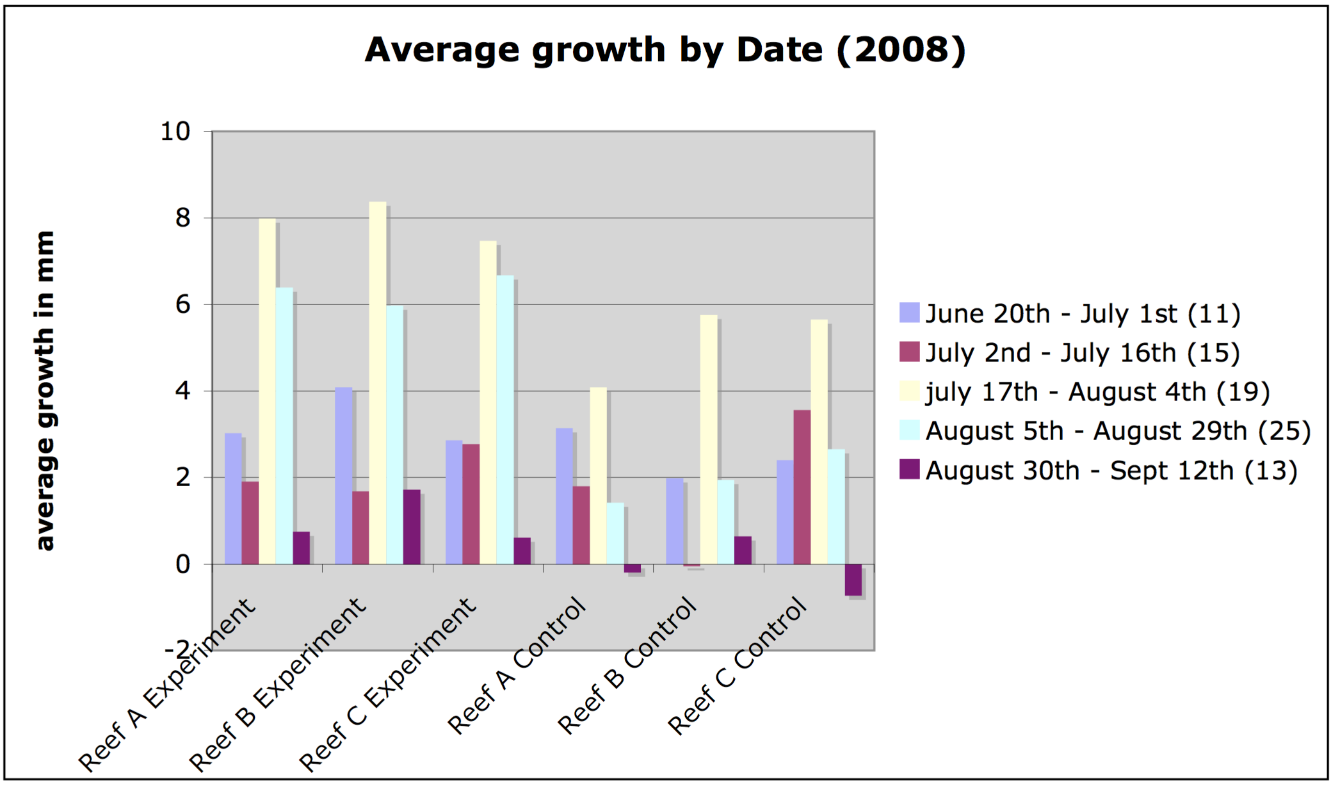
The top three lines (black, red and green) are following the growth of the experiment tank oysters, the bottom three lines (Blue, yellow and pink) represent the reefs in the control tank. On first glance we can see that all reefs in the experimental tank grew at a faster rate than the reefs in the control tank and were larger at the end of the study. This result rejects the null hypothesis that there is no significant difference between the experimental and control tanks shown in the t-test below in the FINAL GROWTH COMPARISON section.

2007 oyster growth rate by reef



The 2007 growth rate results are similar to the 2008 results. The top three lines (black, red and green) are following the growth of the experiment tank oysters, the bottom three lines (Blue, yellow and pink) represent the reefs in the control tank. Again, we can see that all reefs in the experimental tank grew at a faster rate than the reefs in the control tank and were larger at the end of the study. The dip around day 42 of the reefs in the control tank is due to lack of data from that week.

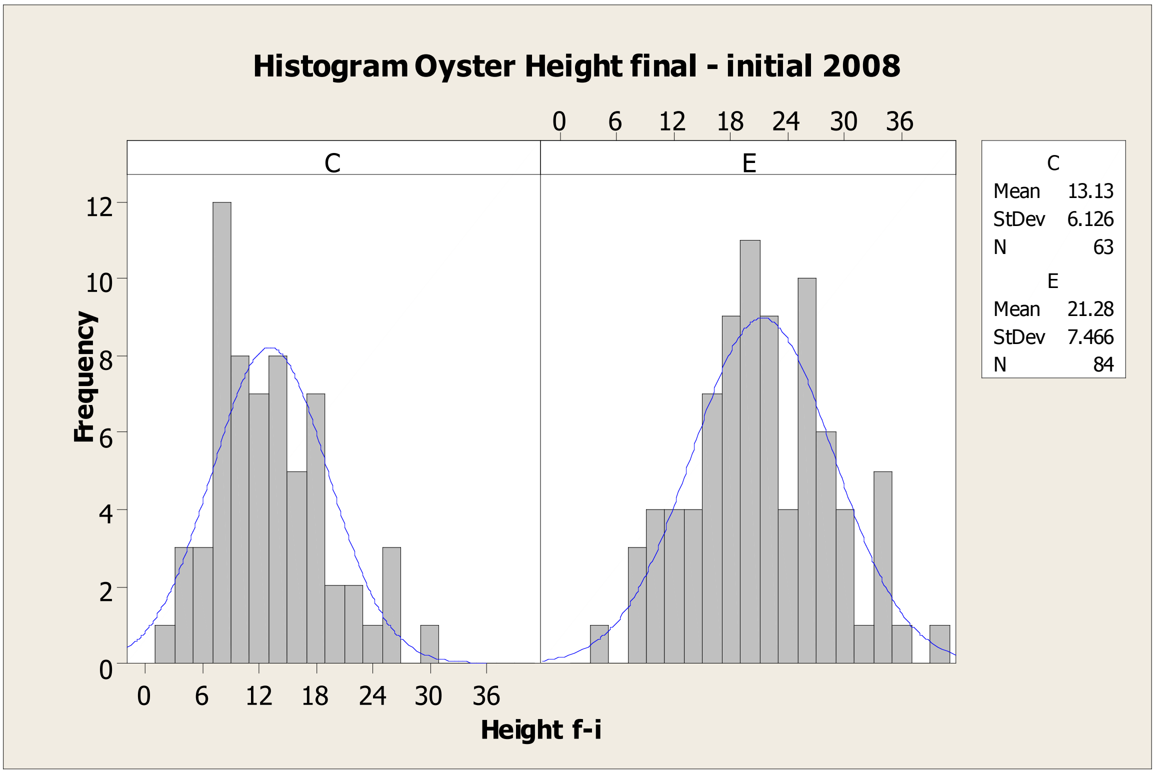
Growth Rate By Dates



The above figure depicts the average rate of growth vs. date. July 17th until August 4th was the time interval that showed the most growth for all reefs. Note that the time intervals are not equal (see amount of days of interval in brackets behind dates), so the figure should be interpreted with care.

Since the 2007 study was done later in the season we had much less overall growth and the data breakdown by date was not very conclusive. It seemed that the first 2 weeks after the put in date of August 15th showed the most growth.

FINAL GROWTH COMPARISON



The above Histogram shows how much the oysters grew in each tank from June 20th until September 15th 2008. On the left is the control tank (C) oyster's final height minus the initial height, and on the right panel the experimental (E) oyster's final height minus initial height. On average, the control group grew by 13.13 mm in 3 months time and the experimental group grew by 21.28mm. The Two-tailed t-test I conducted shows that there is a significant difference in the two sample's growth, therefore the Null hypothesis can be rejected with 95% confidence.

2008 Descriptive statistics of the height $_{final}$ – height $_{initial}$:

Type	N	Mean	StDev	Variance	CoefVar	Skewness	Minimum	Maximum	Range
Control	63	13.129	6.126	37.532	46.66	0.71	2.08	30.75	28.67
Experiment	84	21.278	7.466	55.737	35.09	0.16	4.88	40.69	35.81

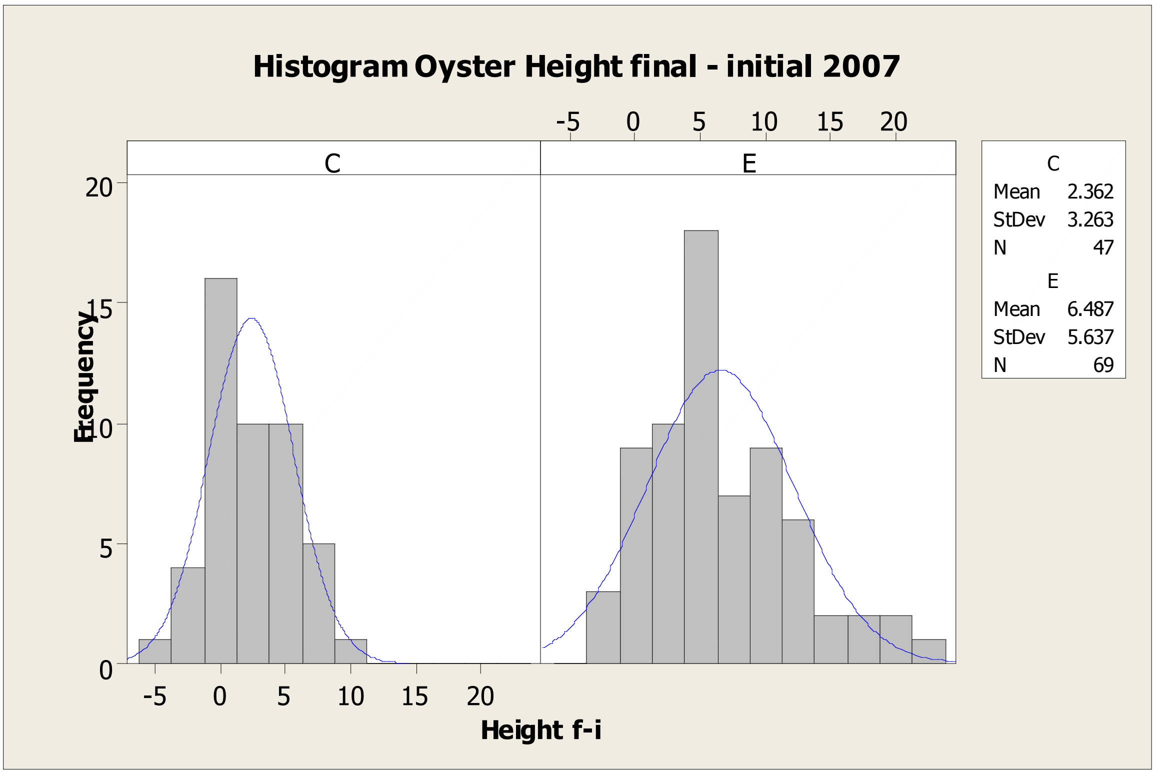
Hypothesis testing, Independent Samples; Two-tailed t-test:

H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 7.26; at 95% confidence. P-Value: 0.000; $H_0 \neq H_A$

P < 0.05, reject Null hypothesis, the samples are statistically significantly different.



The above Histogram shows how much the oysters grew in each tank from August 15h until November 15th 2007. On the left is the control tank (C) oyster's final height minus the initial height, and on the right panel the experimental (E) oyster's final height minus initial height. On average, the control group grew by 2.36 mm in 3 months time and the experimental group grew by 6.49mm. The Two-tailed t-test I conducted shows that there is a significant difference in the two sample's growth, therefore the Null hypothesis can be rejected with 95% confidence.

2007 Descriptive statistics of the height $_{final}$ – height $_{initial}$:

Type	N	Mean	StDev	Variance	CoefVar	Skewness	Minimum	Maximum	Range
Control	47	2.36	3.26	10.65	138.18	0.37	-4.00	10.5	14.5
Experiment	69	6.49	5.64	31.77	86.89	0.74	-2.70	21.50	24.2

Hypothesis testing, Independent Samples; Two-tailed t-test:

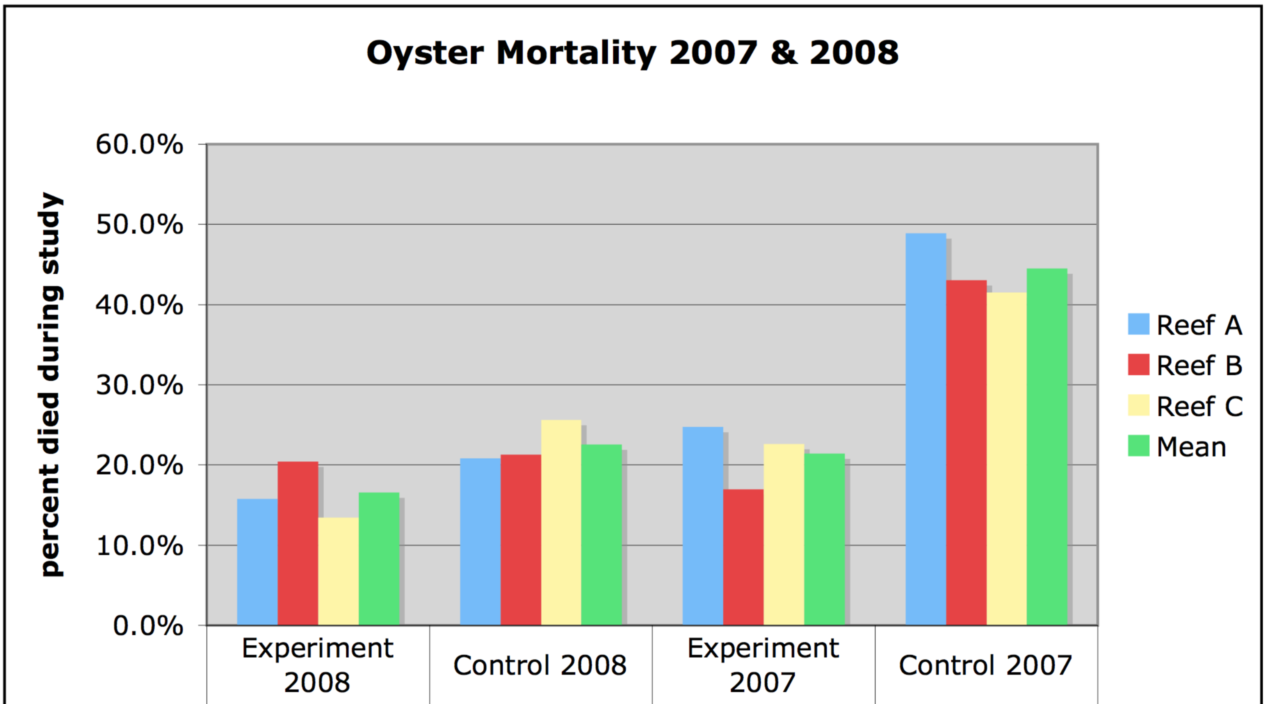
H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 4.98; at 95% confidence. P-Value: 0.000; $H_0 \neq H_A$

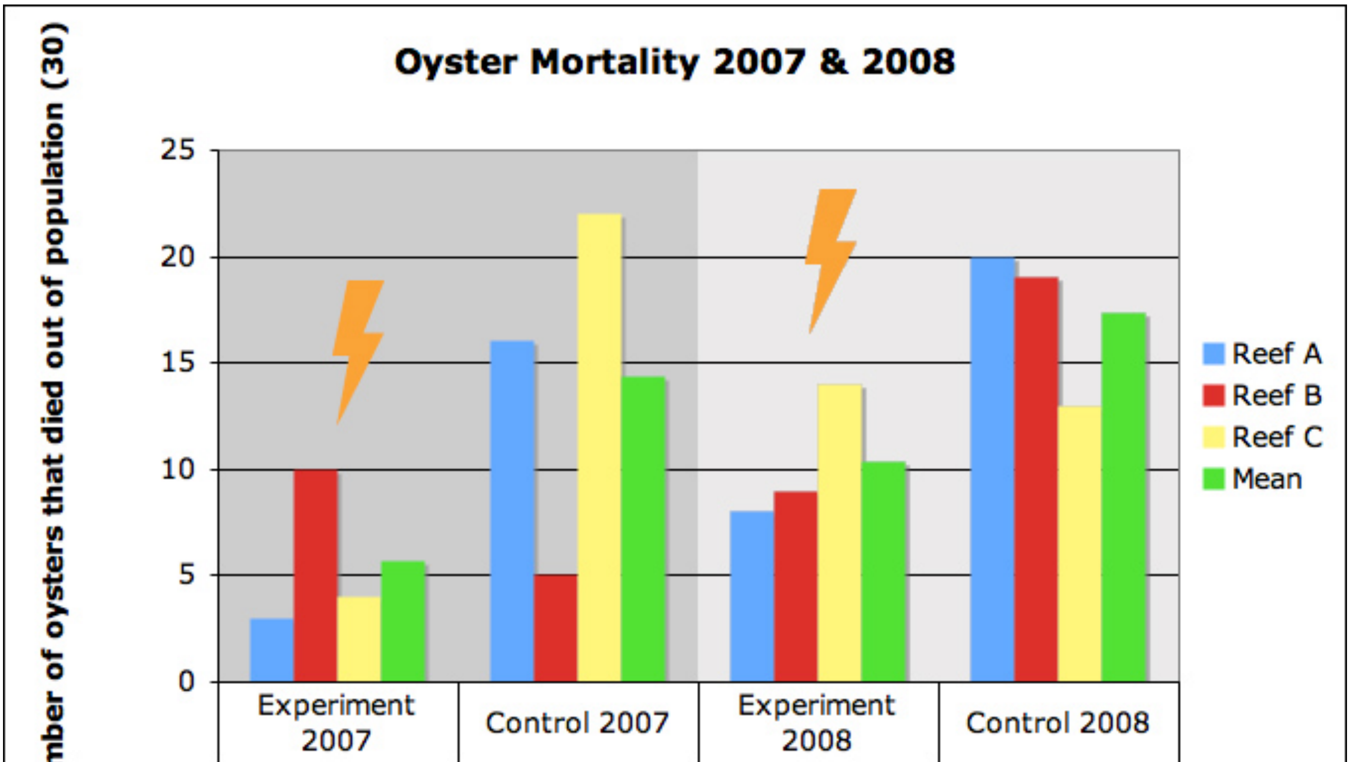
P < 0.05, reject Null hypothesis, the samples are statistically significantly different.

MORTALITY



	Experiment 2008	Control 2008	Experiment 2007	Control 2007
Reef A	15.8%	20.8%	24.7%	48.9%
Reef B	20.5%	21.3%	16.9%	43.0%
Reef C	13.4%	25.6%	22.6%	41.5%
Mean	16.55%	22.57%	21.43%	44.47%

The above figure depicts a comparison of total mortality of both, the 2007 and the 2008 study. Both year's experimental tank have a lower mortality than the control tanks. Looking at a two-tailed t-test to determine if the difference is significant I found that for 2007 there is a significant difference, therefore the Null hypothesis can be rejected with 95% confidence. In 2008, there is no statistically significant difference between the mortality of the control vs. the experimental tank.



	Experiment 2007	Control 2007	Experiment 2008	Control 2008
Reef A	3	16	8	20
Reef B	10	5	9	19
Reef C	4	22	14	13
Mean	5.67	14.33	10.33	17.33

Two-sample T for Control 2008 vs. Experiment 2008

Hypothesis testing, Independent Samples; Two-tailed t-test:

H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 2.35; at 95% confidence. DF = 3; P-Value: 0.101; $H_0 = H_A$

P > 0.05, reject Null hypothesis, the samples are not statistically significantly different.

Two-sample T for Control 2007 vs. Experiment 2007

Hypothesis testing, Independent Samples; Two-tailed t-test:

H_o: $mu_1 = mu_2$; Null hypothesis; both samples are not statistically significantly different

H_a: $mu_1 \neq mu_2$; Alternative hypothesis: the samples are statistically significantly different

RESULTS: T-Value: 7.10; at 95% confidence. DF = 3; P-Value: 0.006; $H_0 \neq H_A$

P < 0.05, reject Null hypothesis, the samples are statistically significantly different.

ACCRETION

The circumference of the metal bars of the reef structure we used in 2007 and reused in 2008 was about 0.8cm. Over the course of the study the metal structure rusted at places but remained about the same size except for the experimental tank's structures. All three reefs in the experimental tank, which were connected to about 9 Volts of an electric current for the entire study time showed significant accretion of minerals. Reef A was the first in line and received more of a current than Reef B, and Reef C a little less than Reef B. For the purpose of this paper I ignored that these three reefs received did not receive an equal amount of an electric current. The difference was visible in terms of the amounts of accretion of minerals and reef A seemed to be covered with the most minerals (in terms of overall mineral coating and thickness), Reef B with a little less and reef C with the least. The accretion was thickest on all reefs close to where they were connected to the wire running the current and showed patches of accretion throughout the structures (See Photo 1 below). The most prominent accretion on Reef A, close to the wire connection measured 1.8cm, more than twice the original circumference. Samples of the minerals were given to Kaitlin Baird for chemical analyses. The final analyses was not available to me to this date but it is expected to be a mixture of aragonite (CaCO3) and Brucite (MG(OH)2). Hilbertz seemed to have found that a lower current (1.5 – 4.5 Volts) promotes the deposition of the harder mineral aragonite, which is the main component of oyster shell[8]. Since we ran a much higher current (~9 Volts) it would be interesting to still look at the chemical analyses of the deposited minerals to see if this finding can be confirmed.

Chemistry involved in Accretion process to Biorock® structure:

In marine environments the pH is determined by reactions between dissolved carbon dioxide (CO_2), carbonite ions ($CO3^{2-}$) and bicarbonate ions (HCO^{3-}), as described by Smith[12]:

(1) CO_2 (g) + H_2O(l) - H_2CO_3 (aq)

(2) H_2CO_3 (aq) - H^+ (aq) + HCO_3^-(aq)

(3) HCO_3^- (aq) - H^+ (aq) + CO_3^{2-} (aq)

The increase in pH at the reef structure is caused by the establishment of an electric potential, which promotes the deposition of CaCO3, as described by Smith[12]:

(4) CO_2 (g) + OH^- (aq) - HCO_3 (aq)

(5) OH^- (aq) + HCO_3 (aq) - H_2O (l) + CO_3^{2-} (aq)

(6) CO_3^{2-} (aq) + Ca^{2+}(aq) - $CaCO_3$ (s)

Photo 1: Close-Up of oysters glued to metal “Reef” Structure. The metal frame exhibits white patches of accretion of minerals (presumably Calcium & Magnesium)

CONCLUSION

The initial oyster samples were close in their average size and distributed normally, a factor important as to have a meaningful comparison of the two sample populations at the end of the study. Over the course of approximately 3 months a subset of 90 oysters in each of the control and the experimental tank both containing 600 oysters were measured from the hinge to the furthest point (height) approximately every two weeks. Oysters in the experimental tank grew statistically significantly more than oysters in the control tank during the course of both studies (2007 & 2008). Mortality was significantly lower for the experimental group only in the 2007, in 2008 there was no significant difference. Accretion of minerals onto the reef structure (aragonite and brucite) was evident and most prominent closest to the attachment point of the wire that ran the electric current. Overall, Biorock™ Technology may be a viable resource to aid oyster reef formation but more data should be collected. Specifically, regarding the actual mechanisms of how Biorock™ Technology works. Mortality reduction was inconclusive in our study, so more research needs to be done looking at the correlation of increased oyster size and mortality. Another open question is the amount and duration of an electric current necessary to get consistent results.

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