Marine Extension Bulletin

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Woods Hole Sea Grant Program
Cape Cod Cooperative Extension

A Comparison of Bottom and Floating Gear for Growing American Oysters (*Crassostrea virginica*) in Southeastern Massachusetts

Introduction

The oyster aquaculture industry in southeastern Massachusetts primarily grows product using "bottom gear" which includes cages, hanging baskets, rack & bags, and stacking trays made of wire or plastic affixed to the bottom or just above. Bottom gear can be purchased or fabricated in many different sizes and configurations, is relatively easy to access by foot or vehicle and work with at low tide, and conforms to local regulations regarding gear height. Intertidal shellfish grant locations are not always available, so in recent years several versions of floating gear have been developed to utilize subtidal locations. Potential benefits of growing oysters higher in the water column are greater access to plankton, greater distance from benthic predators, warmer water temperatures, and ease of access in deep water growing areas. In addition, surface gear can be periodically overturned, exposing oysters and gear to help reduce fouling. Some floating gear types can also be submerged to the bottom in anticipation of storm events or winter ice. For these reasons oyster growers in the region became interested in this type of gear, and a comparison of bottom and floating gear was initiated through the Research Farm Network (RFN).

The RFN program conducts applied research on shellfish culture methodology in the waterbodies of southeastern Massachusetts with the help and support of licensed shellfish farmers. Begun in 2005, it is supported with funds from the Southeastern Massachusetts Aquaculture Center, Cape Cod Cooperative Extension, and Woods Hole Sea Grant. The goals of the RFN are to 1) provide high quality relevant data to local shellfish farmers, 2) provide multiple "platforms" for demonstration and outreach in different communities, and 3) increase communication among shellfish farmers around the County.

In the 2011-2012 growing season five oyster growers from the towns of Yarmouth (Lewis Bay), Wareham (Bourne Cove), Onset (Buzzards Bay), Orleans (Little Pleasant Bay), and Chatham (Oyster Pond) participated in a Research Farm Network study comparing bottom and floating gear for growing oysters.

The main research questions were:

- Do oysters grown in floating cages have a higher average percent survival, daily growth rate or condition index than oysters grown in bottom cages?
- Within floating cages, is there a difference between oysters grown in the upper shelves vs. lower shelves in terms of average percent survival, daily growth rate, or condition index?
- Within bottom cages, is there a difference between oysters grown in the upper shelves vs. lower shelves in terms of average percent survival, daily growth rate, or condition index?

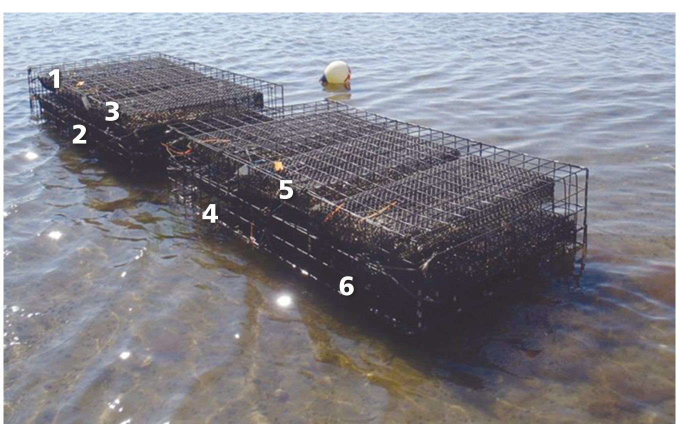

Figure 1. View of bottom gear (left) and floating gear (right) with numeral shelf labels.

Figure 2. Marine Program Specialist Josh Reitsma removes oysters from bottom gear for counting and measuring.

Methods

In June 2011 each study participant was supplied with five six-slot floating cages, two six-slot wire bottom cages, and (42) 4 mm mesh APDI bags. They also each received ~21,000 R6 oyster seed from the local shellfish hatchery, Aquacultural Research Corporation in Dennis, MA. It was intended that the 21,000 oyster seed would be distributed evenly between bags in bottom and floating gear at 500 oysters/bag. Due to a discrepancy in that actual amount of seed received, it was necessary to modify the original experimental design. Each grower had enough seed to stock six bags in one floating cage and three bags in each of their two bottom cages, so that six experimental bags were monitored in floating gear and six bags in the bottom cages for the duration of the study. In the spring of 2012 the stocking density was reduced to 150-200 oysters per bag. Each slot (shelf) in the cage was assigned a numeral so that differences between the upper and lower shelves could be tested for (Figure 1).

Cape Cod Cooperative Extension staff visited the sites and sampled the oysters in the two gear types a total of five times—in September and November of 2011 and then May, August and November of 2012. The sampled oysters were counted, weighed, and measured to determine percent survival, daily growth rate (mm/day) and condition index.

Percent survival was calculated in May 2012 at between 310-322 days using a subsample of about 200 oysters or half of each bag, and in November 2012 at between 504-509 days post deployment counting the entirety of each bag (~150-200 oysters). In Chatham the second sampling for survival took place in August instead of November as the oysters had largely reached market size. Final growth rate was calculated by dividing the change in length from the initial 6 mm size by the number of total growing days which ranged from 504-509.

Condition Index (CI) is a measure of the meat quality and an indicator of the nutritional status of oysters, and was determined using the method described by Lawrence and Scott (1982). A higher CI value indicates a greater quantity of meat and a higher quality oyster. The CI was calculated using the samples from November 2012.

Two sample student t-tests were used to test for differences in mean proportion survived between the bottom gear and floating gear in May and in November for individual sites, and with data pooled from all five sites. Differences were also tested for in mean proportion survived in the upper and lower shelves of the floating gear, and the upper and lower shelves of the bottom gear. A one way analysis of variance (ANOVA) was used to test for significant differences in mean values for condition index and for daily growth rate in floating vs. bottom cages, floating gear upper vs. lower shelves and bottom gear upper vs. lower shelves, at each site, and with pooled data from all five sites. Ninety five percent confidence intervals were calculated and are shown on figures 3 and 4. A p value of ≤ 0.05 was considered significant for all tests.

Results

Survival

Pooling the data together from all five sites, mean percent survival was significantly lower in the bottom cages than in the floating cages in both May and November (Table 1). No differences were found between the upper and lower shelves of the floating gear or the bottom gear in either of the two months.

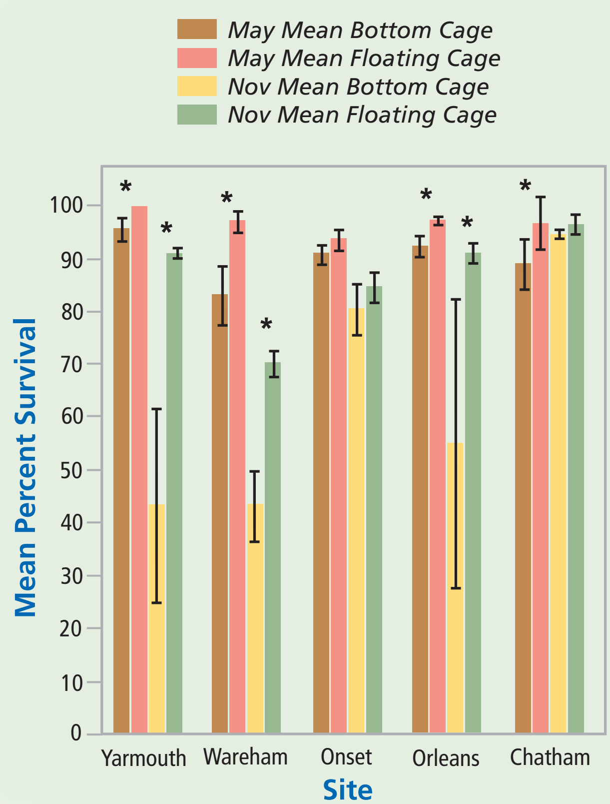

Figure 3. Comparisons of mean percent survival in the bottom and floating cages at each of the sites in May and November of 2012. Bars indicate 95% confidence intervals. Asterisks indicate significant differences at $p < 0.05$.

Table 1. Comparisons of mean percent survival in May and November 2012, daily growth rate, and condition index ± standard deviation based on combned data from all 5 sites.

	Bottom Cage	Floating Cage	Significant Difference?
% Survival May	90.12 ± 4.56	96.83 ± 2.29	YES $t(8) = -2.94$, $p = 0.01$
% Survival Nov	63.19 ± 23.16	86.44 ± 10.09	YES $t(8) = 2.06$, $p = 0.04$
Daily Growth Rate	0.12 ± 0.02	0.14 ± 0.02	YES $F(1,892) = 141.25$, $p = 0.00$
Condition Index	8.32 ± 3.83	9.93 ± 2.39	YES $F(1,357) = 23.96$, $p = 0.00$

On a site by site basis there were significant differences in mean percent survival between the bottom and floating gear – but the results should be interpreted with caution because the sample sizes are small. Mean percent survival was lower in the bottom cages than the floating cages in both May and November at the sites in Yarmouth, Wareham, and Chatham (Figure 3). At the site in Chatham a significant difference was found only in May (Figure 3). No differences were found in Onset (Figure 3).

No significant differences were found in the floating gear between the upper and lower shelves at any of the sites. For bottom gear in May the oysters in the lower shelves had a lower mean percent survival than in the upper shelves in Yarmouth and Onset. In Chatham in August and Orleans in November, the mean percent survival in the lower shelves was significantly lower than that in the upper shelves.

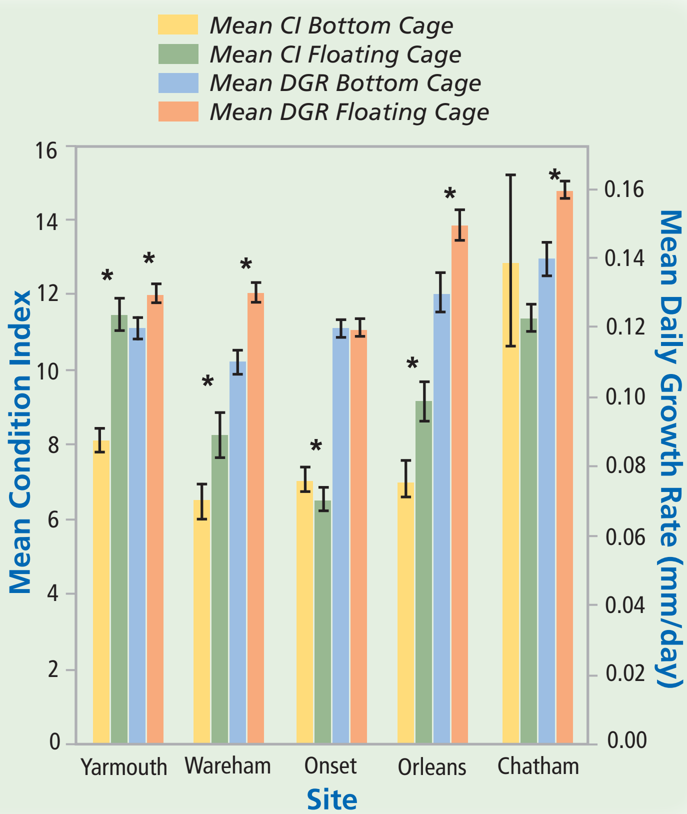

Figure 4. Comparison of condition index and average daily growth rates (DGR) of oysters grown in floating and bottom cages from June 2011 to November 2012. Bars indicate 95% confidence intervals. Asterisks indicate significant differences at $p < 0.05$.

Daily Growth Rate

Pooling the data together from all five sites, the mean daily growth rate (DGR) of oysters grown in floating gear is approximately 15 percent higher than the mean DGR of oysters grown in bottom gear (Table 1). Within the floating cages no significant difference was found in mean DGR between the upper and lower shelves. Within the bottom cages, the oysters in the upper level had an 8 percent higher mean DGR than oysters in the lower level.

Examining the individual sites, the mean DGR of the oysters is significantly greater in the floating gear at all sites than the bottom gear, except at the site in Onset (Figure 4). Within the floating cages, the means of the upper and lower shelves did not significantly differ, except at the Chatham site where the mean DGR in the upper shelf was significantly higher. Within the bottom cages there was a trend for slightly higher growth in the upper shelves over the bottom as mentioned above, though within individual sites this was significant only at the Chatham site.

Condition Index

Pooling the data from all five sites the mean condition index (CI) of oysters grown in floating gear was significantly greater than those grown in bottom gear (Table 1). No significant difference in mean CI was found between oysters grown in upper vs. lower shelves of floating gear, or in oysters grown in the upper and lower levels of bottom gear.

At three of the individual sites the mean CI of oysters grown in the floating gear was significantly greater than those grown in the bottom gear at all sites (Figure 4). In Onset the trend was reversed but only marginally significant (Figure 4). Within the floating cages the upper and lower shelves did not significantly differ except at the Onset site where the upper CI was higher. Within the bottom cages no differences were present between the upper and lower levels, except at the Orleans site where the oysters grown in the upper level had a higher CI.

Discussion

Based on the pooled data from all five sites floating cages had a higher mean percent survival, mean daily growth rate, and mean condition index than the bottom gear. These general results were found at most, but not all of the individual sites. Though performance overall seems to improve with floating gear this may not be true at all sites and growers are advised to try out new gear on a small scale to determine localized site effects as performance did vary in this study. A similar study in Canada found suspended oysters reached market size in three to four years in comparison to the five to eight years typical of bottom oysters (Comeau 2013).

Figure 5. Grower checking on a string of floating cages.

No dramatic differences were observed within the two gear types between upper and lower levels. In the floating cages oysters grown in the upper and lower shelves were basically the same in terms of survival, condition index and growth rate. The small differences seen in daily growth rate in Chatham and condition index in Onset again highlight that site conditions are not uniform. Within the bottom cages oysters grown within the upper and lower shelves were also basically the same in terms of survival and condition index, but the lower shelf oysters did grow at a rate eight percent slower than those in the upper shelf when comparing overall means.

Anecdotally, oyster growers experimenting with floating cages did find advantages in keeping oysters and gear clean because floating cages could be flipped to expose the oysters to the air and allow for drying of fouling organisms. While data is lacking on the extent of biofouling reduction in floating cages through periodic flipping and air drying, this was recognized as an advantage of floating cages. The large six bag floating cages were somewhat cumbersome to flip with just one person so another consideration for interested growers is the size of cage to be used and the method of flipping.

Growers in southeastern Massachusetts wishing to experiment with floating gear are advised to keep several other factors in mind. Per the Army Corps of Engineers Programmatic General Permit for the state, floating equipment can only cover 10 percent of a project area, or 20,000 square feet, whichever is greater. In addition, floating gear may be prohibited or limited in areas where there is risk from marine animal entanglement, such as Cape Cod Bay. Difficulties have been experienced with birds perching on the floating gear, but there are some modifications being proposed to address this (Comeau et al, 2009). The floating cage design has a higher profile than floating bags but both are visible at high tide which may require discussion with nearby upland landowners to prevent conflict. Additionally, it should be noted that elevating oysters up and out of the water for extended periods of time may require different handling protocols during the Massachussett's Vibrio Control period.

If additional detailed information is desired, a more complete report is available through the Cape Cod Cooperative Extension or Woods Hole Sea Grant.

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