Tech Talk: To Pit or Not to Pit?

The threat of ice damage has forced intertidal oyster farmers to devise strategies to reduce potential losses. Here in southeastern Massachusetts, some oyster farmers move their oysters from the farm location to a storage area, or 'seed pit', that is typically cold (30-40º F) and damp (over 90% relative humidity) for approximately three months. Local farmers have reported typical survival rates of over 90% using this method for first year seed– but it's a lot of work and time.

What other options are there? Here farmers either leave the oysters on the intertidal farm site or move them to deeper water, below any ice that might form. This past year we did an experiment to see how these methods stacked up. Specifically, we asked:

What are the typical physical characteristics and average survival of oysters kept in seed pits? We put temperature/humidity sensors in 9 pits around the region and found that oysters were typically stored in cold (38° F), humid (100.1% relative humidity) conditions, for periods ranging from 45 to 124 days (with an average of 90 days). Survival was over 80% in all the pits and only pit duration seemed to affect survival, with survival decreasing as the number of days stored in the pit went up.

Does storage time in a pit affect survival or average revival time of oysters? After the third week of pitting and every two weeks thereafter, we removed batches of oysters from a seed pit, placed them in aerated seawater and checked to see how many showed signs of life over 28 days. In the 15th week, batches started to show a significant decrease in survival. Also, the oysters in the first batch (3rd week) revived faster than any of the batches after that.

How do the three methods (pitting, sinking or leaving on the flats) compare in terms of oyster mortality and growth – and do any effects have a carry-over effect through the following growing season? Not surprisingly, winter mortality was significantly highest among the oysters on the flats (which were crushed under ice), compared to the other two methods. Over the rest of year (from March to December), the oysters from each of the overwintering methods survived equally well.

Also, not surprisingly, the oysters sunk in deep water showed an increase shell length over the winter (although small) while the other two methods did not grow. Surprisingly though, the oysters overwintered sunken in deep water ended the year with the smallest increase in shell length!

To summarize, overwintering oysters in a seed pit avoids the risk of ice damage, which can inflict significant mortality. To our surprise, pitted oysters did not lose any growth in the following year. In fact, unexpectedly, the oysters kept in the water over the winter had the smallest growth. This was perhaps due to the metabolic costs of remaining active through the food-poor winter.

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Additionally, the first-year oyster seed survived well under a variety of pit conditions, suggesting they are relatively resilient. Importantly, survival tended to decrease with storage time and oyster farmers report a sharp increase in overwintering mortality with increasing age of stored oysters.

In addition to the presented data, oyster farmers reported that placing oysters in seed pits reduced fouling both through direct mortality of any fouling organisms stored with the oysters (e.g., blue mussels) and the avoidance of any late winter/early spring sets of fouling organisms.

Therefore, of the tested methods, pitting oysters seems to provide the best combination of survival and growth. Despite the perceived risks and the considerable labor involved in seed pitting, this method is recommended as an excellent method of overwintering oyster seed.

To Pit or Not to Pit?
A Comparison of Oyster Overwintering Methods

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INTRODUCTION

The threat of ice damage has forced intertidal oyster (*Crassostrea virginica*) farmers to devise strategies to reduce potential losses. In New England, some oyster farmers move their oysters from the farm location to storage area, or 'seed pit', that is typically cold (0-4º C) and damp (over 90% relative humidity) for approximately three months. Qualitatively, local farmers have reported typical survival rates of over 90% using this method. Preliminary work suggested that survival decreased with age of the stored oysters and the duration of storage. Alternatives to pitting include leaving the oysters on the intertidal farm site or moving them to deeper water, below any ice that might form. Local oyster farmers requested a quantitative comparison of the various methods to help them select an optimal overwintering strategy.

Fig. 1. An oyster farmer packs up his oysters for overwintering in a seed pit (photograph by Chris Linder)

Fig. 2. The oysters are stacked in a cold, humid storage building (photograph by Chris Linder)

In this study, we address three questions.

1. What are the typical physical characteristics and average survival of oysters kept in seed pits (Cape Cod, MA, USA)?
2. Does storage time in a pit affect survival or average revival time of oysters?
3. Comparing the three commonly employed methods of overwintering oysters (pitting, leaving on the flats, or moving to deeper water in a nearby harbor), is there a difference in mortality or growth? Moreover, do any such effects have a carry-over effect through the following growing season?

Fig. 3. A view of the farm site and three common oyster overwintering methods: from left to right, storing in a pit, leaving on the flats, and moving to deep water.

METHODS

Typical Seed Pit Conditions and Oyster Survival

To quantitatively describe the physical conditions and oyster survival in representative seed pits of Cape Cod (MA, USA) oyster farmers, we provided Hobo Pro Series data loggers to 9 volunteers in December 2003. These recorded temperature and humidity every 15 min. Growers were provided 3 bags of 60 oyster seed each to provide a standard measure of survival.

Effect of Storage Duration on Oysters

To determine the effects of different storage times on the survival and average revival time of oysters (i.e., the average number of days before proof of life was observed), replicate batches of 60 oysters were removed from an intertidal sand flats farm site in Dennis, MA and stored in a cold cellar seed pit on December 17, 2004 (with temperature and humidity recorded every 15 min). After 3 weeks (January 6, 2005, three bags were removed, and the oysters were immersed in aerated sea water (22-25‰, ~10-15º C). Oyster condition was assessed on days 1, 5, 7, 14, 21 and 28. Oysters observed pumping or defecating were scored alive, sprung oysters were scored dead, and remaining oysters were scored to be determined.

This process was repeated every two weeks, with the eighth and final set removed from the pit on April 14th, 2005. Here we present the cumulative number of live, dead and to be determined by the 28th day of observation. Furthermore, the average number of days required for an oyster to be considered revived was calculated.

Comparison of Three Common Overwintering Methods

Finally, to compare survival and growth among three common methods of overwintering farmed oysters, 5 replicate batches of 60 oysters were stored in a pit, kept on the flats, or moved to the deep water of a nearby harbor. In each batch, 20 individuals were marked with a uniquely numbered bee tag, allowing us to track individual changes in length and weight. The treatments began on December 17, 2004. Oysters were returned from the pit or the harbor to the flats on March 3, 2005.

Oyster shell length was measured to 0.1 mm and dry weight (including shell) was measured to the nearest 0.01 g. Though oysters were assessed monthly through December 2005, here we present data for the duration of the winter (survival assessed in April 2005, growth assessed in March 2005), and the duration of the growing season (through December 2005).

Fig. 4. A typical seed pit is a root cellar, insulated at least in part by earth, with a cement floor and wooden railings, and bags of seed covered under a tarp.

RESULTS

Typical Seed Pit Conditions and Oyster Survival

Of the 9 pits sampled, oysters were typically stored in cold (3.44° C), humid (100.1% relative humidity) conditions, for periods ranging from 45 to 124 days (with an average of 86.9 days). There was no significant relationship between any of these factors and seed survival, though there was a strong tendency for survival to decline with increasing number of days stored in the pit ($p = 0.058$). Notably, survival was over 80% in all the pits.

Within a typical pit, temperature dropped in late January and began to climb in mid-March. Relative humidity rose rapidly in the pit and remained relatively high until April.

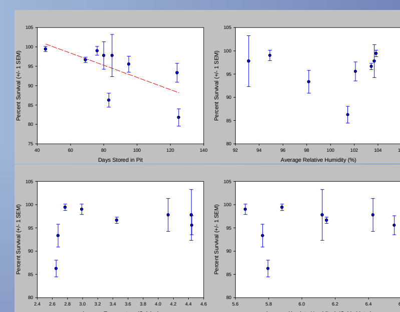

Fig. 5. Lack of relationship between oyster seed survival and days stored in pits, temperature and humidity.

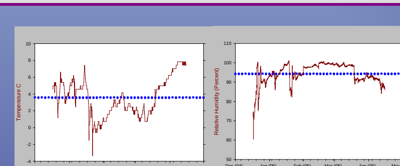

Fig. 6. Detailed changes in temperature and relative humidity in a typical seed pit from December 17, 2004 to April 15, 2005.

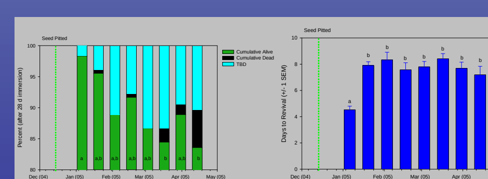

Fig. 7. Effect of storage duration on oyster survival and time to revival.

Effect of Storage Duration on Oysters

With increasing storage time, the cumulative number of live oysters tended to decrease, with the 6th and 8th batches significantly less than the first batch (ANOVA, $P = 0.01$, dF 7,16, Tukey pairwise comparisons $P < 0.02$). Cumulative mortality also began to increase. Average time to revival was significantly shorter for the first batch than any of the other batches, which did not differ.

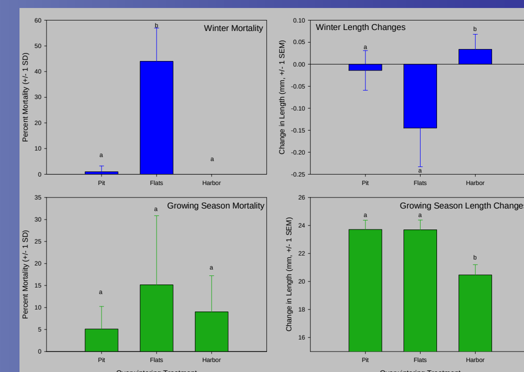

Fig. 8. Effect of overwintering method on mortality (measured in April 2005 and December 2005) and change in individual shell length (measured in March 2005 and December 2005).

Comparison of Three Common Overwintering Methods

Winter mortality was significantly highest among the oysters on the flats (which were crushed under ice), compared to the other two methods (ANOVA, $P < 0.01$, dF 2,12, Tukey pairwise comparison $P < 0.001$). There was no signficant difference among the treatments over the remainder of 2005 among the overwintering treatments (ANOVA, $P = 0.36$, dF 2,12)

Change in shell length over the winter was highest among the oysters in the harbor, and was, in fact, negative in the other two treatments (ANOVA, $P < 0.01$, dF 2,259, Tukey pairwise comparison $P \leq 0.001$). Surprisingly, the oysters overwintered in the harbor ended the year with the smallest increase in shell length (ANOVA, $P < 0.01$, dF 2,230, Tukey pairwise comparison $P \leq 0.01$)

DISCUSSION

Overwintering oysters in a seed pit avoids the risk of ice damage, which can inflict significant mortality. To our surprise, pitted oysters did not lose any growth in the following year. In fact, unexpectedly, the oysters kept in the water over the winter had the smallest growth. This was perhaps due to the metabolic costs of remaining active through the food-poor winter.

Additionally, oyster seed survived well under a variety of pit conditions, suggesting they are relatively resilient. Importantly, survival tended to decrease with storage time and oyster farmers report a sharp increase in overwintering mortality with increasing age of stored oysters.

In addition to the presented data, oyster farmers reported that placing oysters in seed pits reduced fouling both through direct mortality of any fouling organisms stored with the oysters (e.g, blue mussels, *Mytilus edulis*) and the avoidance of any late winter/early spring sets of fouling organisms.

Therefore, of the tested methods, pitting oysters seems to provide the best combination of survival and growth. Despite the perceived risks and the considerable labor involved in seed pitting, this method is recommended as an excellent method of overwintering oyster seed.