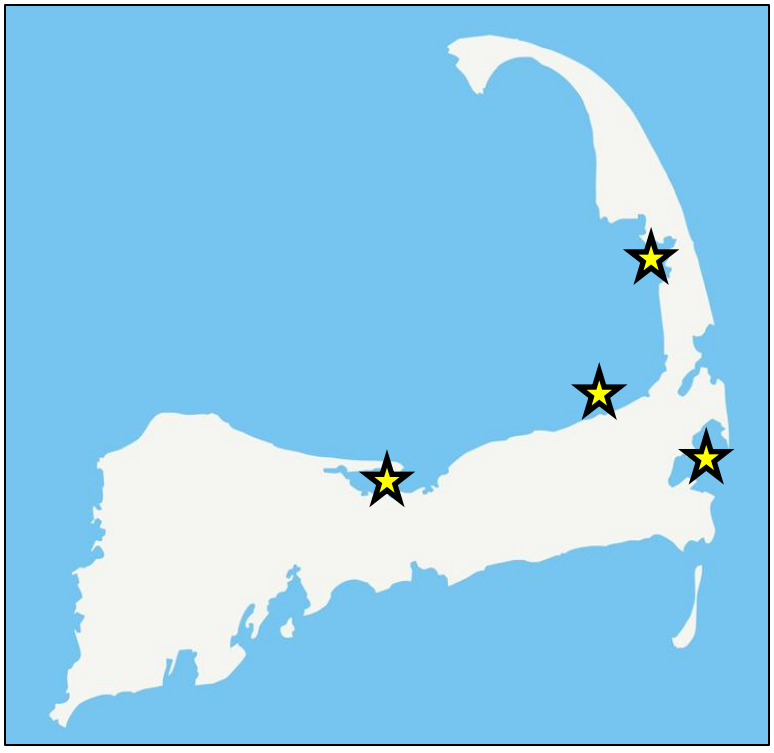
Shellfish Habitat Assessment Results

2003-2017

Barnstable Harbor, Brewster Cape Cod Bay, Orleans Pleasant Bay, Wellfleet Cape Cod Bay



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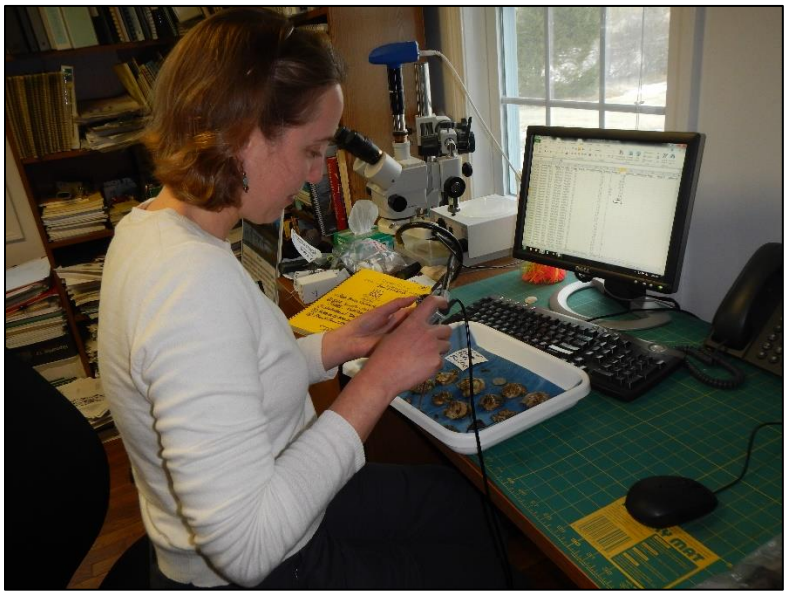
Since 2003 Cape Cod Cooperative Extension Marine Program staff, with funding from Woods Hole Sea Grant and the Southeastern Massachusetts Aquaculture Center, have conducted a shellfish habitat assessment study in four embayments on Cape Cod: Pleasant Bay, Cape Cod Bay, Barnstable Harbor, and Wellfleet Harbor. The goal of this long-term monitoring is to provide growers and researchers with standardized data on site-specific shellfish survival and growth.

Seed quahogs and seed oysters are purchased from the same source, from the same batch, and are treated exactly the same. For oysters, we place three vinyl-coated trays (0.5" x 0.25" mesh) at each site, propped up on 2" PVC pipe with the intent to keep them above the sediment. Each tray is stocked with 25 seed oysters. Due to their small size, these oysters are initially enclosed in 3 mm mesh bags within the cages. After one month, the oysters are removed from the original bags and placed in ones with a larger mesh to allow greater flow of seawater.

For quaho gs, at each site we place six plastic plant pots (10" diameter and 10" deep, or 0.55 ft^2) in the substrate (flush with the bottom) and fill each with the removed sediment, including any infaunal organisms residing in the sediment. Each pot is stocked with 50 seed quahaugs. To test the effects of predators, half of these pots are protected from predation by securing predator-exclusion netting over the top of the pot with a rubber band.

The study period ideally runs from July 1-September 1 although variability in seed delivery dates and weather often delays deployment. Over the past 15 years oysters are in the field anytime between 56-76 days. Deployment dates have ranged from 6/23-7/13 and retrieval date ranges from 8/27 to 9/17.

After retrieval, surviving oysters are counted in each bag and any signs of predation are noted. Similarly, surviving quahaugs are retrieved by sieving the contents of each pot over 3 mm mesh screen. Survivors from each pot and any natural set of shellfish are counted and any signs of predation are noted. All shellfish are then taken back to the lab where length is measured and average growth rate in millimeters per day is calculated.



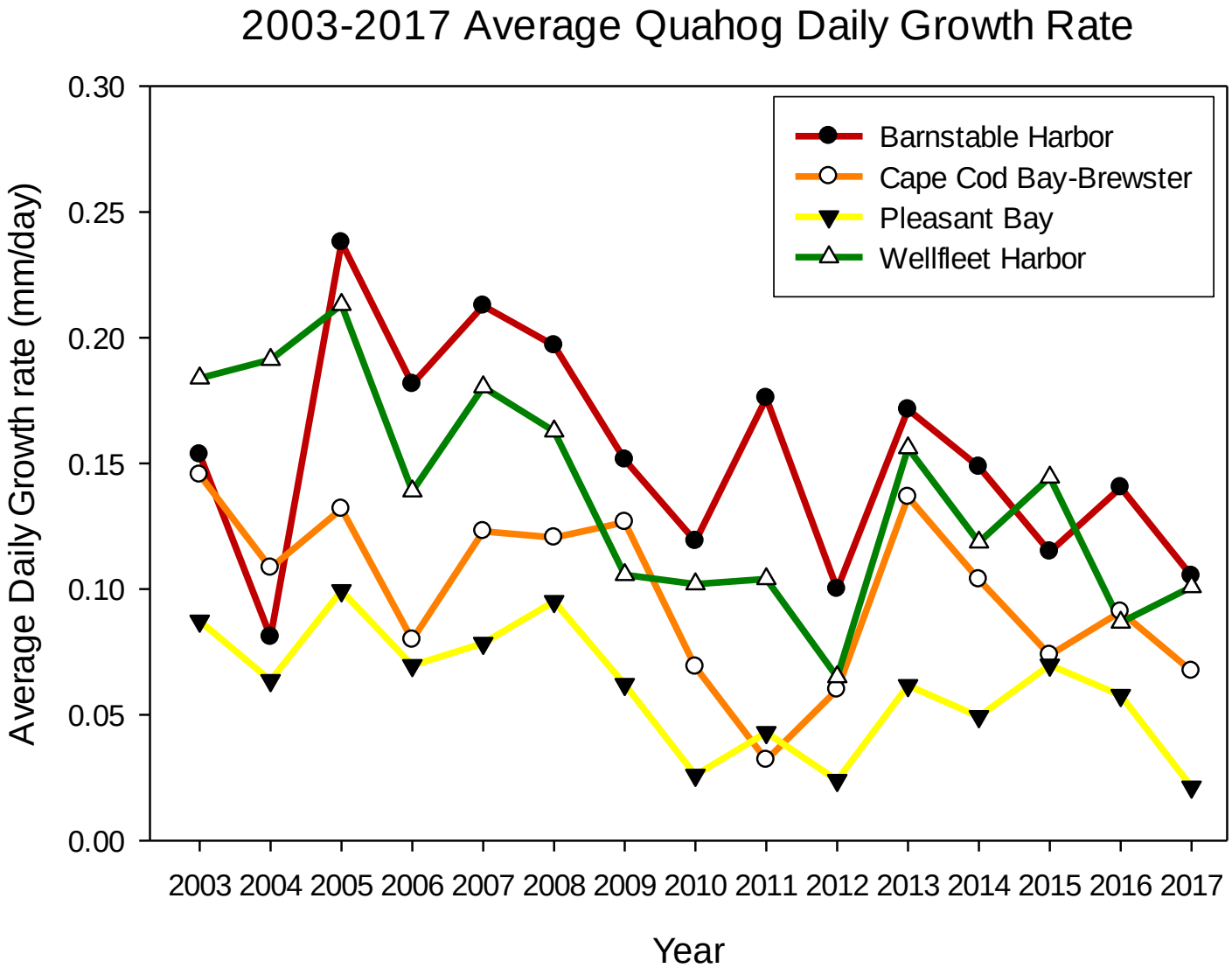


Figure 1. Summary data for all 4 sites. Average daily growth rate of quahogs in the four Shellfish Habitat Assessment sites from 2003-2017.

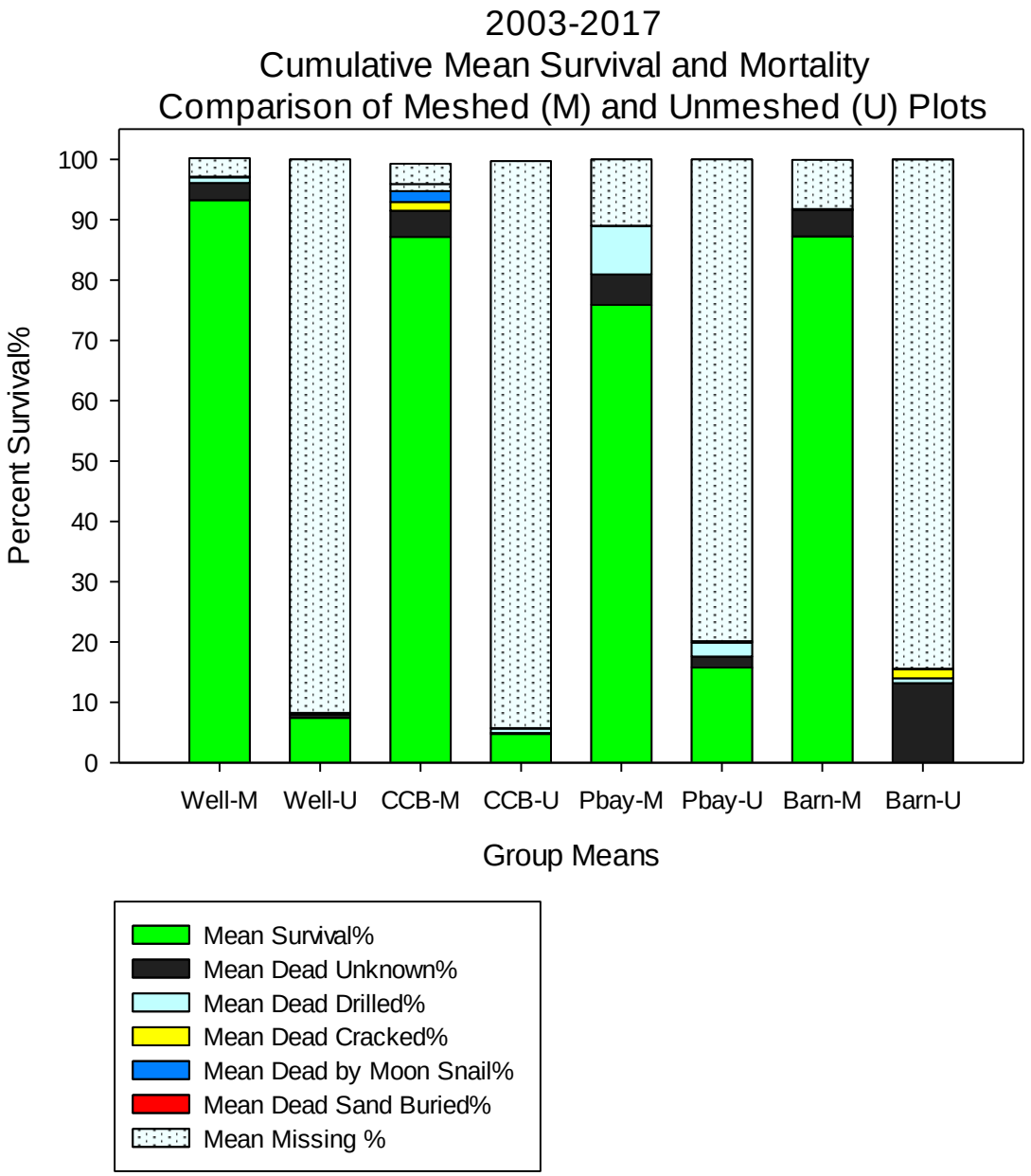


Figure 2. Summary data for all 4 sites. Average percent survival of quahogs in the four Shellfish Habitat Assessment sites from 2003-2017.

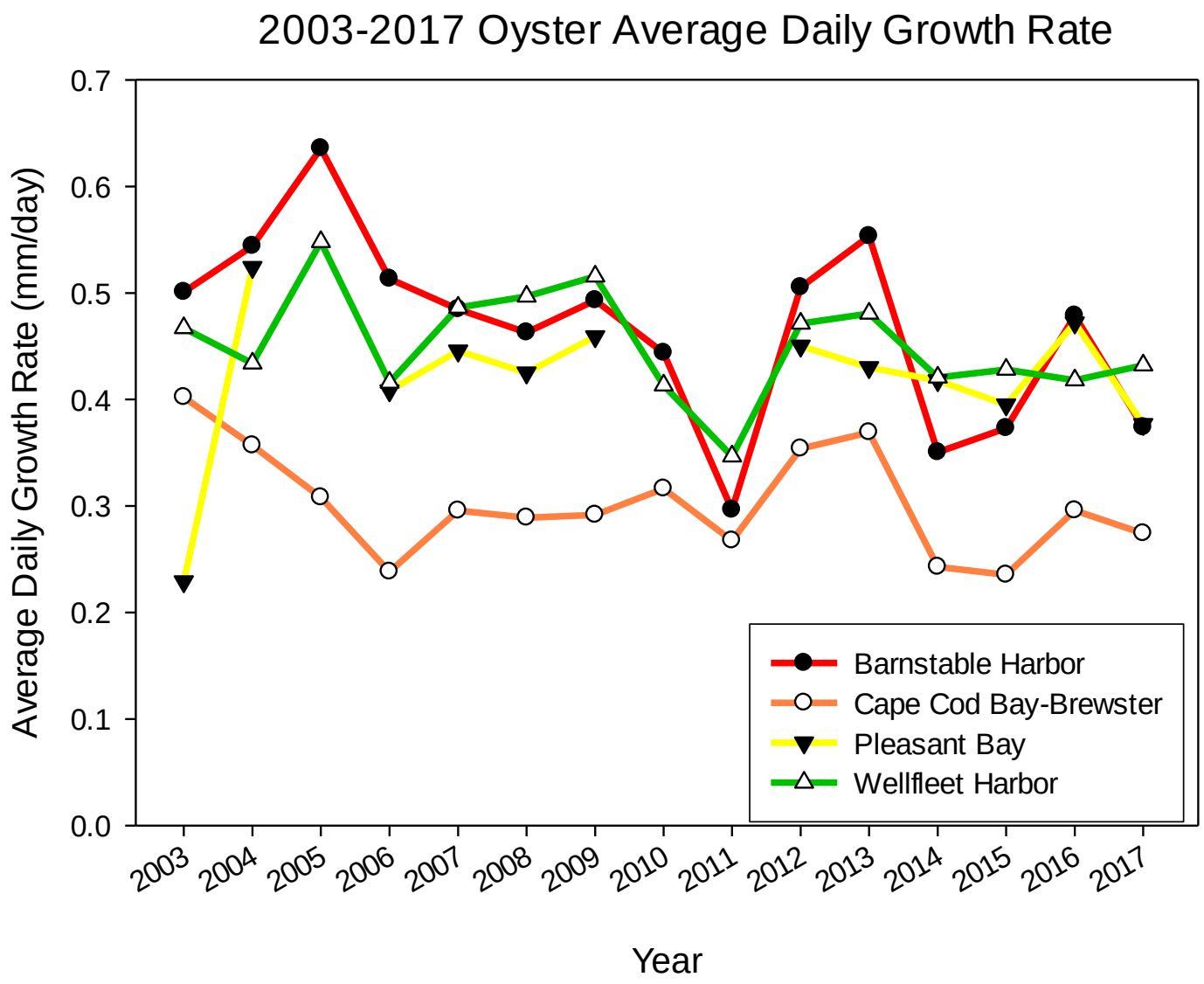


Figure 3. Summary data for all 4 sites. Average daily growth rate of oysters in the four Shellfish Habitat Assessment sites from 2003-2017.

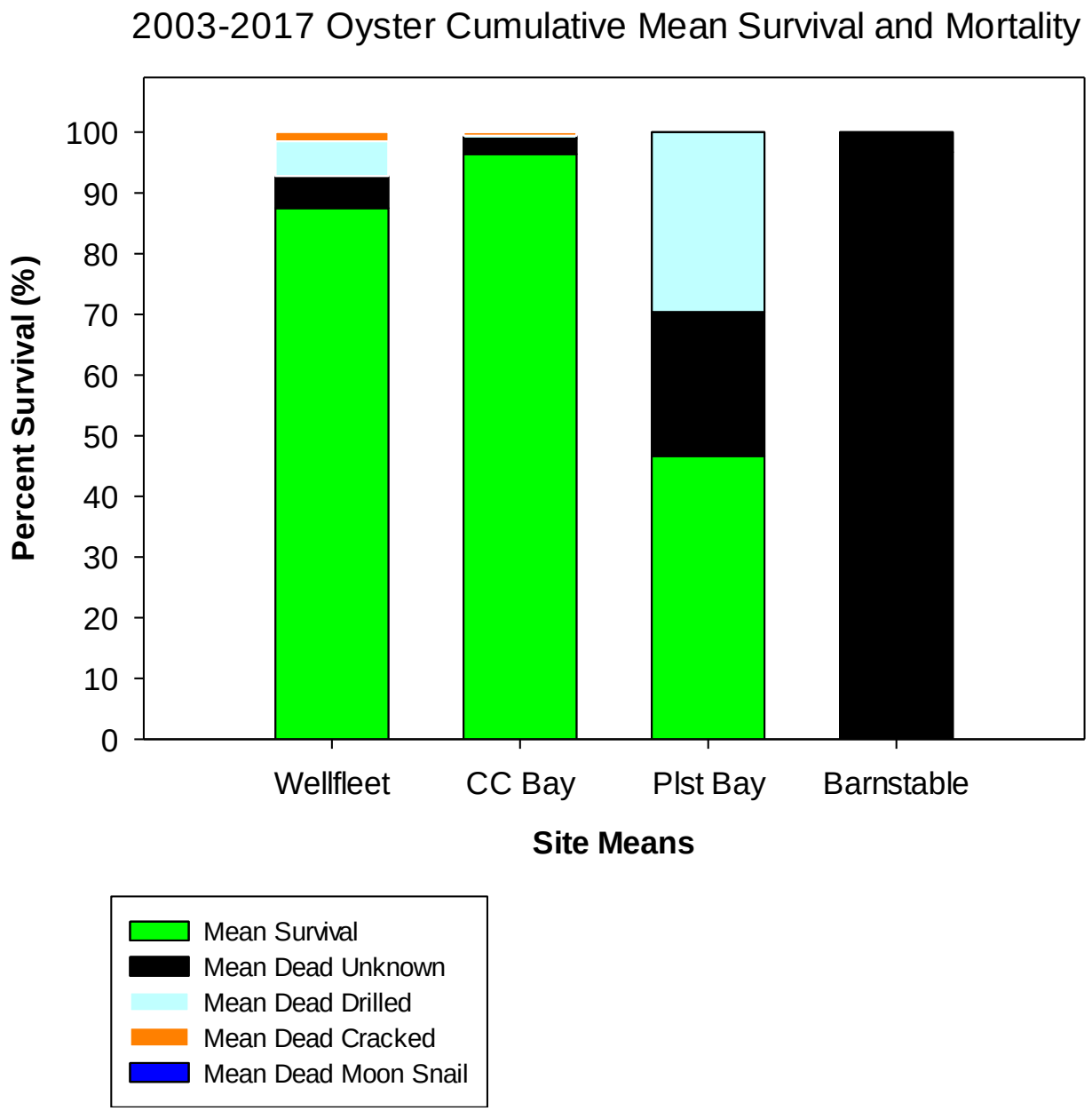


Figure 4. Summary data for all 4 sites. Average percent survival of oysters in the four Shellfish Habitat Assessment sites from 2003-2017.

Shellfish Habitat Assessment

2003-2017

Barnstable Harbor

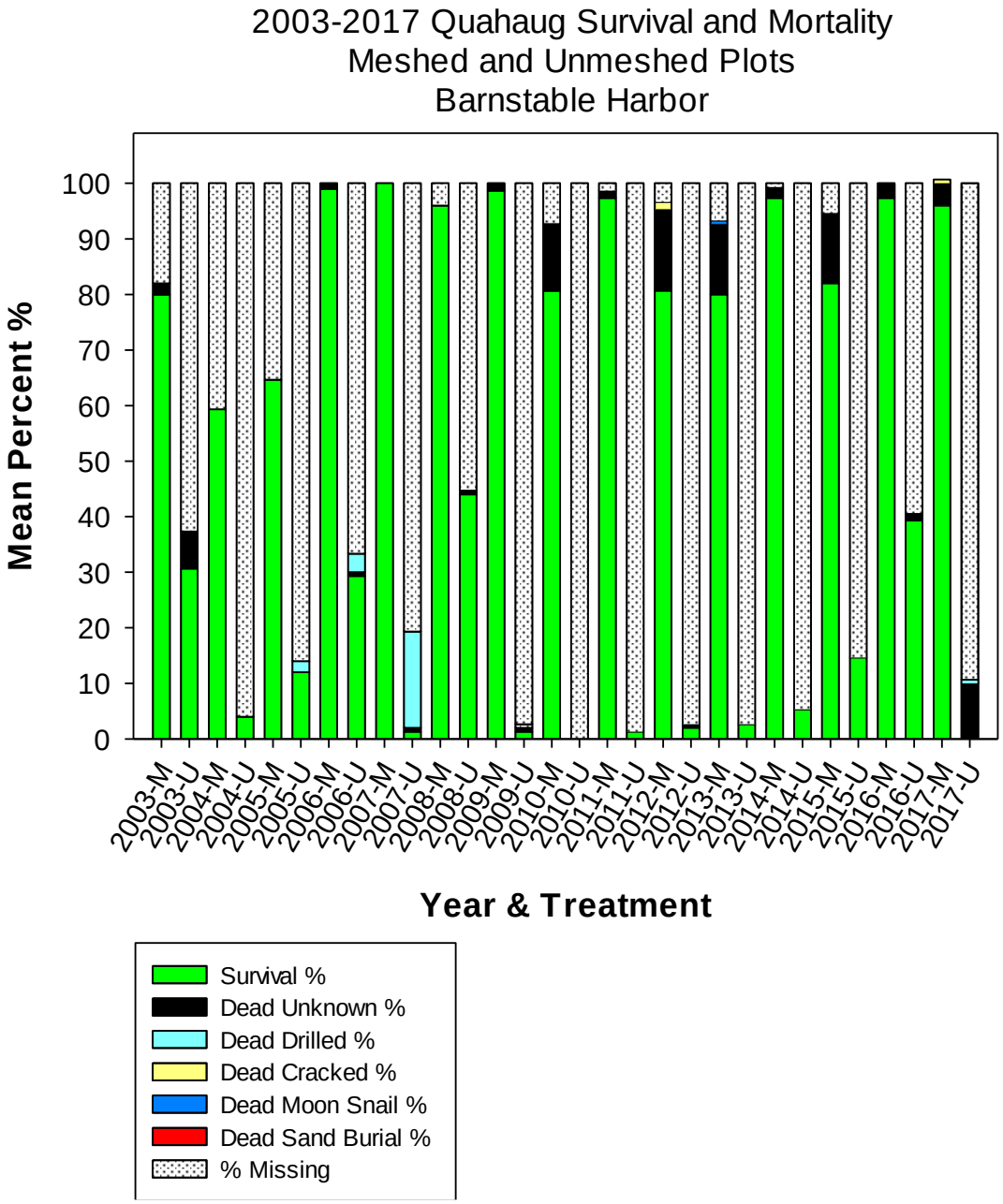


Figure 5. Mean percent survival of quahaugs in pots with mesh and without mesh from 2003-2017 in the Barnstable Harbor Shellfish Habitat Assessment site. M=pots with mesh installed across the top. U=Pots without mesh installed across the top.

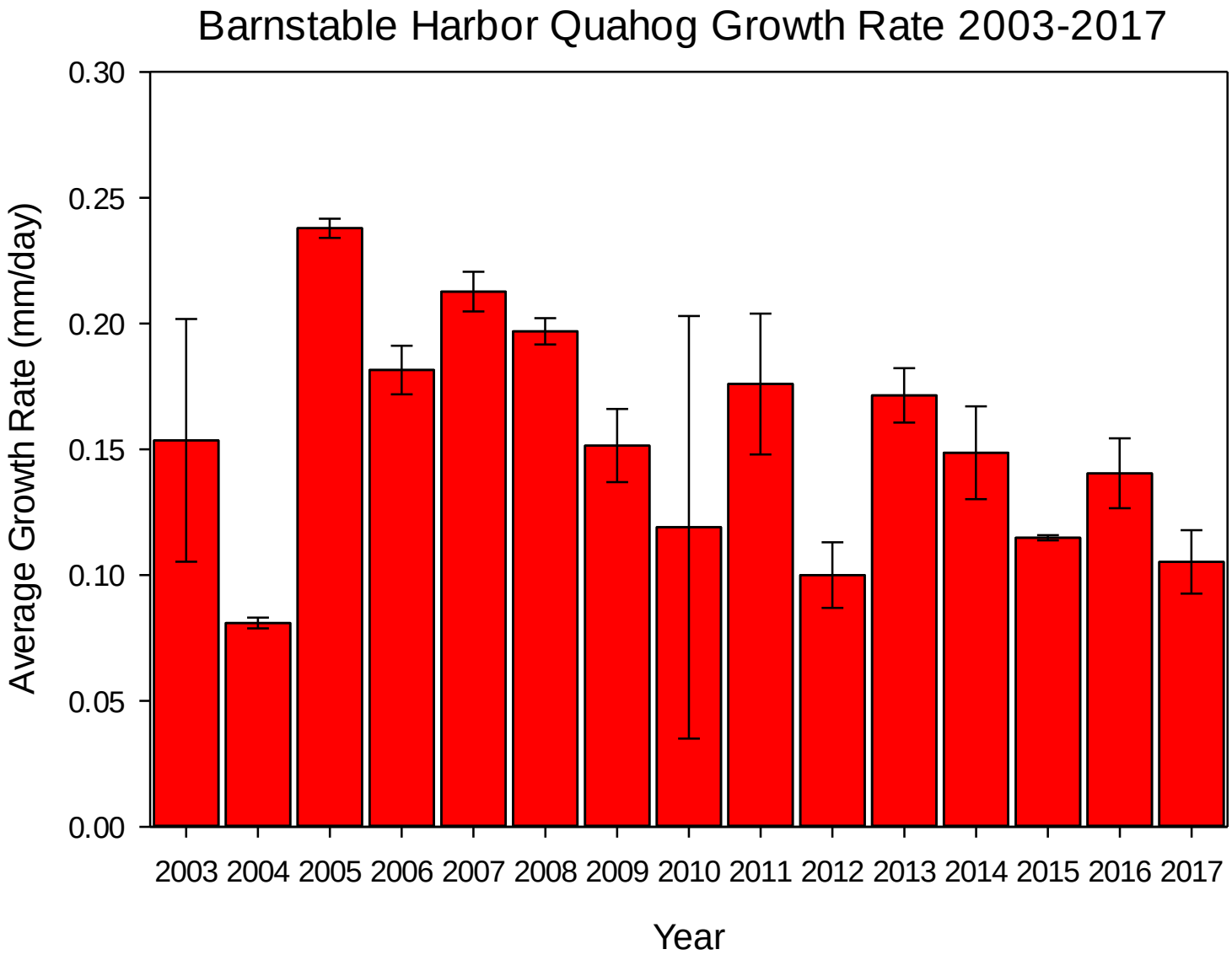


Figure 6. Average daily growth rate of quahaugs in pots with mesh at the Barnstable site from 2003-2017.

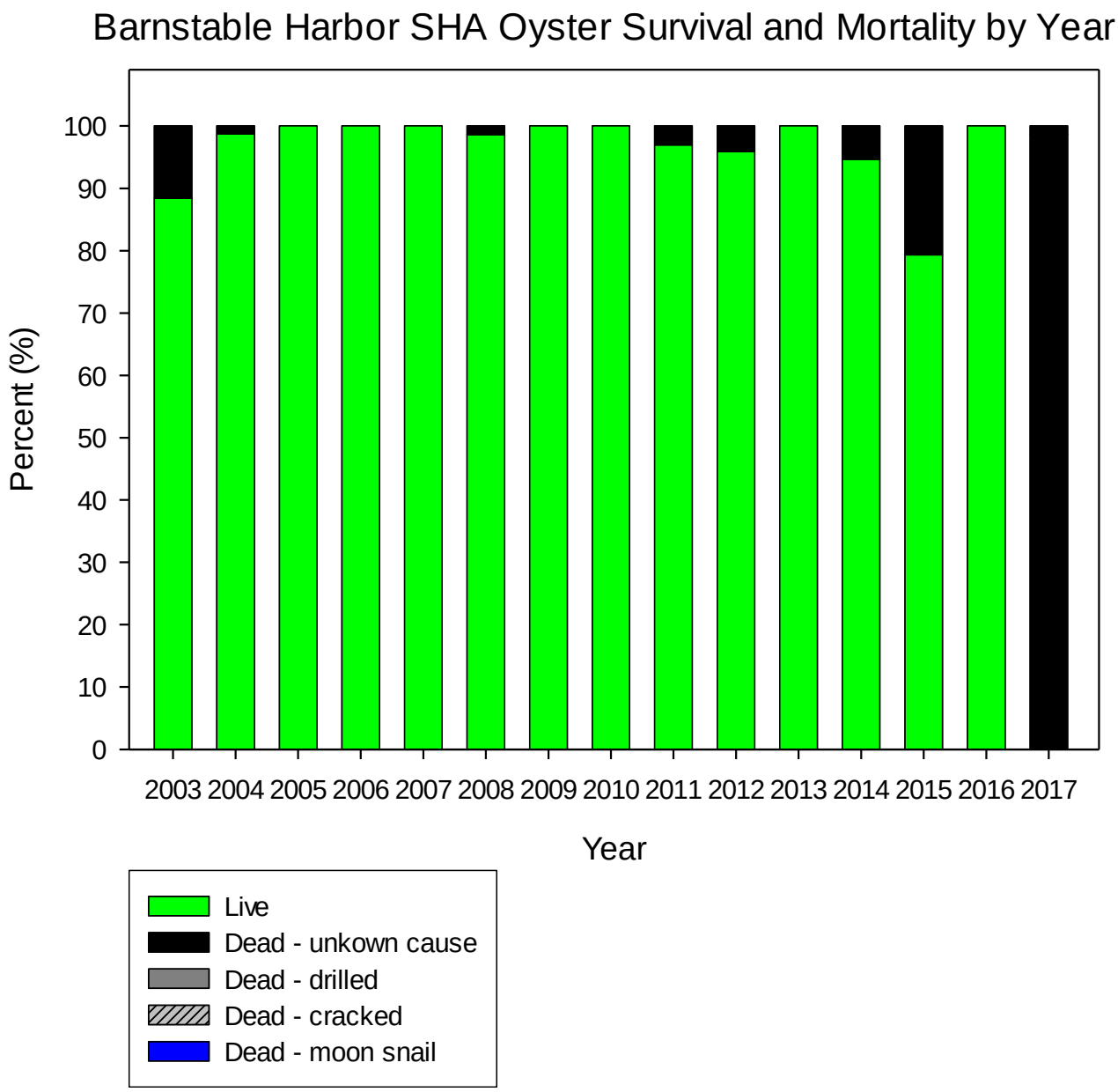


Figure 7. Mean percent survival of oysters in the Barnstable Harbor Shellfish Habitat Assessment site in 2003-2017. No predator control measures were taken.

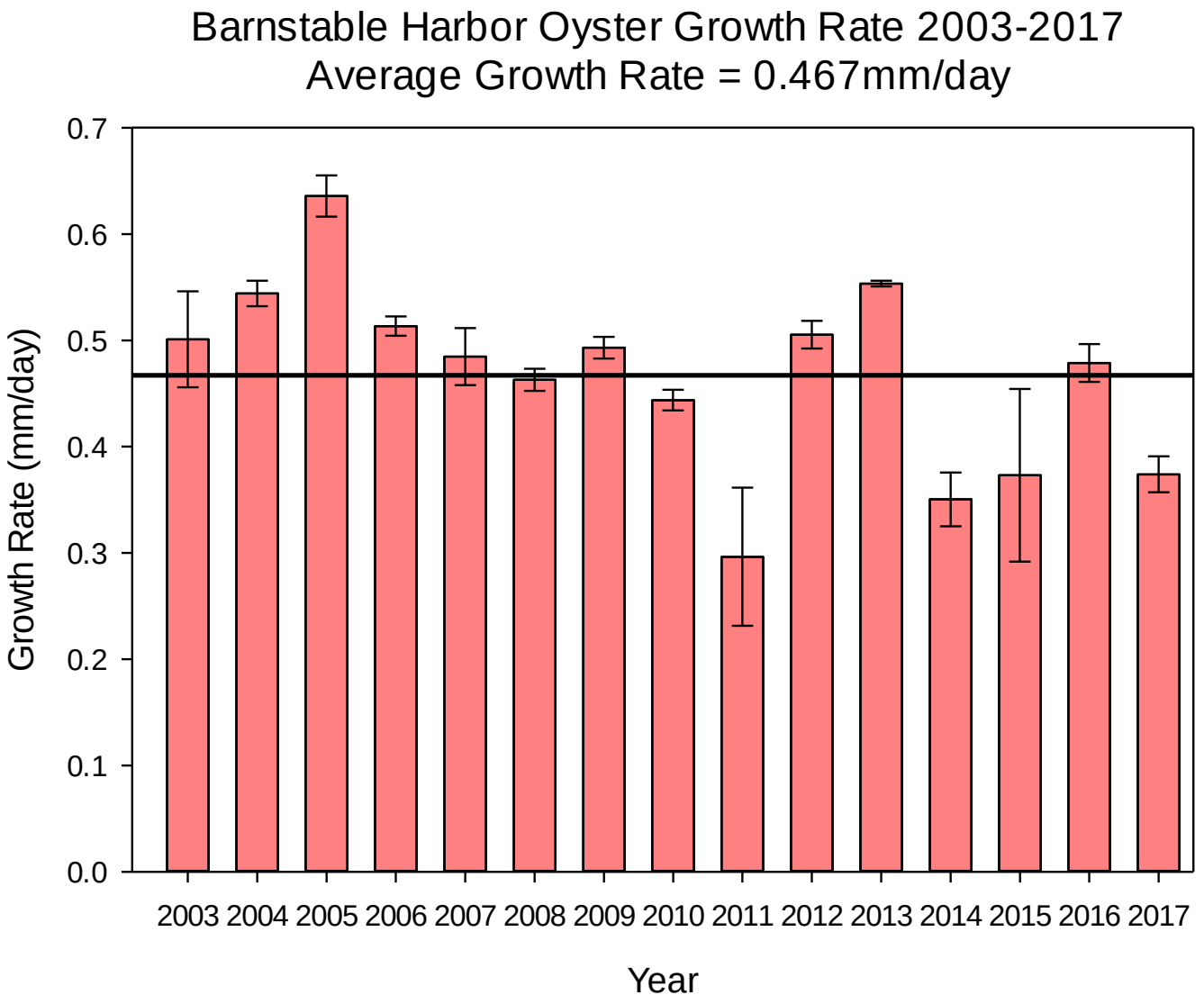


Figure 8. Average daily growth rate of oysters at the Barnstable Shellfish Habitat Assessment site from 2003-2017. The black bar shows the average growth rate in mm/day over the past 15 years. This converts to 0.018 in/day.

Barnstabe Average Oyster Growth Rate 2003-2017																		
Question: Is the average growth rate in Barnstable each year statistically different from the other years?																		
Hypothesis Test - Pairwise Comparisons - Tukey's Honestly Significant Difference Test																		
Blue Shading = Statistically Same White Shading= Statistically Different p-value ≤ 0.05																		
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	Tally of Same	% Same
2003		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	7	50.00
2004	2003		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	4	28.57
2005	2003	2004		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	0	0.00
2006	2003	2004	2005		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	7	50.00
2007	2003	2004	2005	2006		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	8	57.14
2008	2003	2004	2005	2006	2007		2009	2010	2011	2012	2013	2014	2015	2016	2017	8	57.14
2009	2003	2004	2005	2006	2007	2008		2010	2011	2012	2013	2014	2015	2016	2017	9	64.29
2010	2003	2004	2005	2006	2007	2008	2009		2011	2012	2013	2014	2015	2016	2017	6	42.86
2011	2003	2004	2005	2006	2007	2008	2009	2010		2012	2013	2014	2015	2016	2017	1	7.14
2012	2003	2004	2005	2006	2007	2008	2009	2010	2011		2013	2014	2015	2016	2017	8	57.14
2013	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012		2014	2015	2016	2017	2	14.29
2014	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013		2015	2016	2017	3	21.43
2015	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		2016	2017	4	28.57
2016	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		2017	7	50.00
2017	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016		3	21.43
Tally of Different	7	10	14	7	6	6	6	8	13	6	12	11	9	6	10		
% Different	50.00	71.43	100.00	50.00	42.86	42.86	42.86	57.14	92.86	42.86	85.71	78.57	64.29	42.86	71.43		
The year with the highest % difference: 2005																	
The year with the highest % sameness: 2009																	

Table 1. Results of a pairwise comparison of average oyster growth rates in Barnstable from 2003-2017. Even though the bar chart in Figure 8 shows that averages were different from year to year – that does not automatically mean that the averages are truly, statistically different from each other. The pairwise takes into account how many oysters survived to be measured in a particular year, and how much variation there was in a particular sample. This table shows which years were statistically different from each other (white boxes) and which years are statistically the same (blue boxes).

Summary: 2005 was a statistically significant 'good' year for growth rate - none of the other 15 years had as high a growth rate. 2013 was also a high growth rate year –similar only to 2004 and 2012. 2011 was a statistically significant low growth rate year–the only other year it was similarly low was 2014. Growth rate in 2017 was statistically the same as growth rates in 2014, 2015, 2016.

Shellfish Habitat Assessment

2003-2017

Cape Cod Bay, Brewster

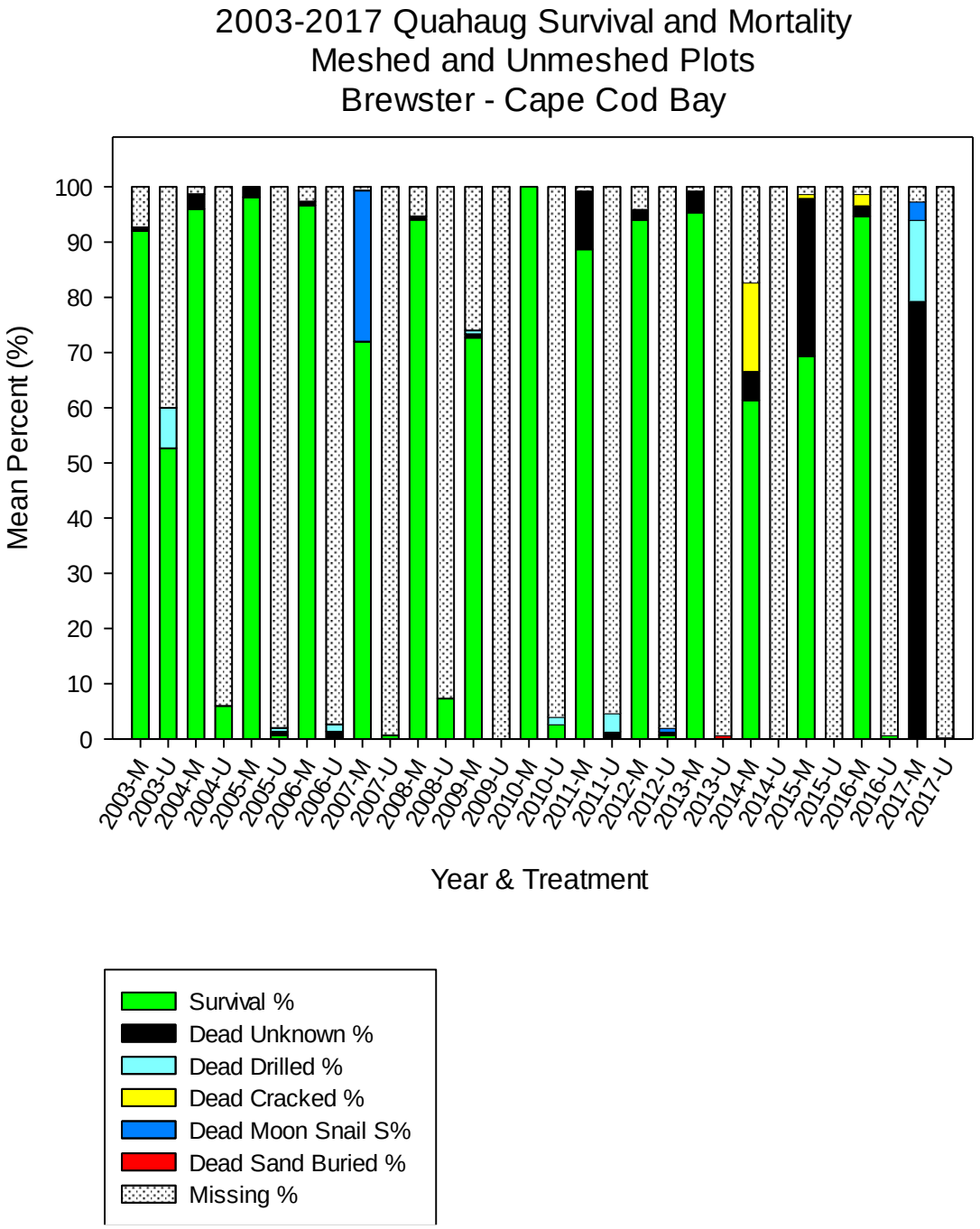


Figure 9. Mean percent survival of quahaugs in pots with mesh and without mesh from 2003-2017 in Cape Cod Bay, Brewster Shellfish Habitat Assessment site. M=pots with mesh installed across the top. U=Pots without mesh installed across the top.

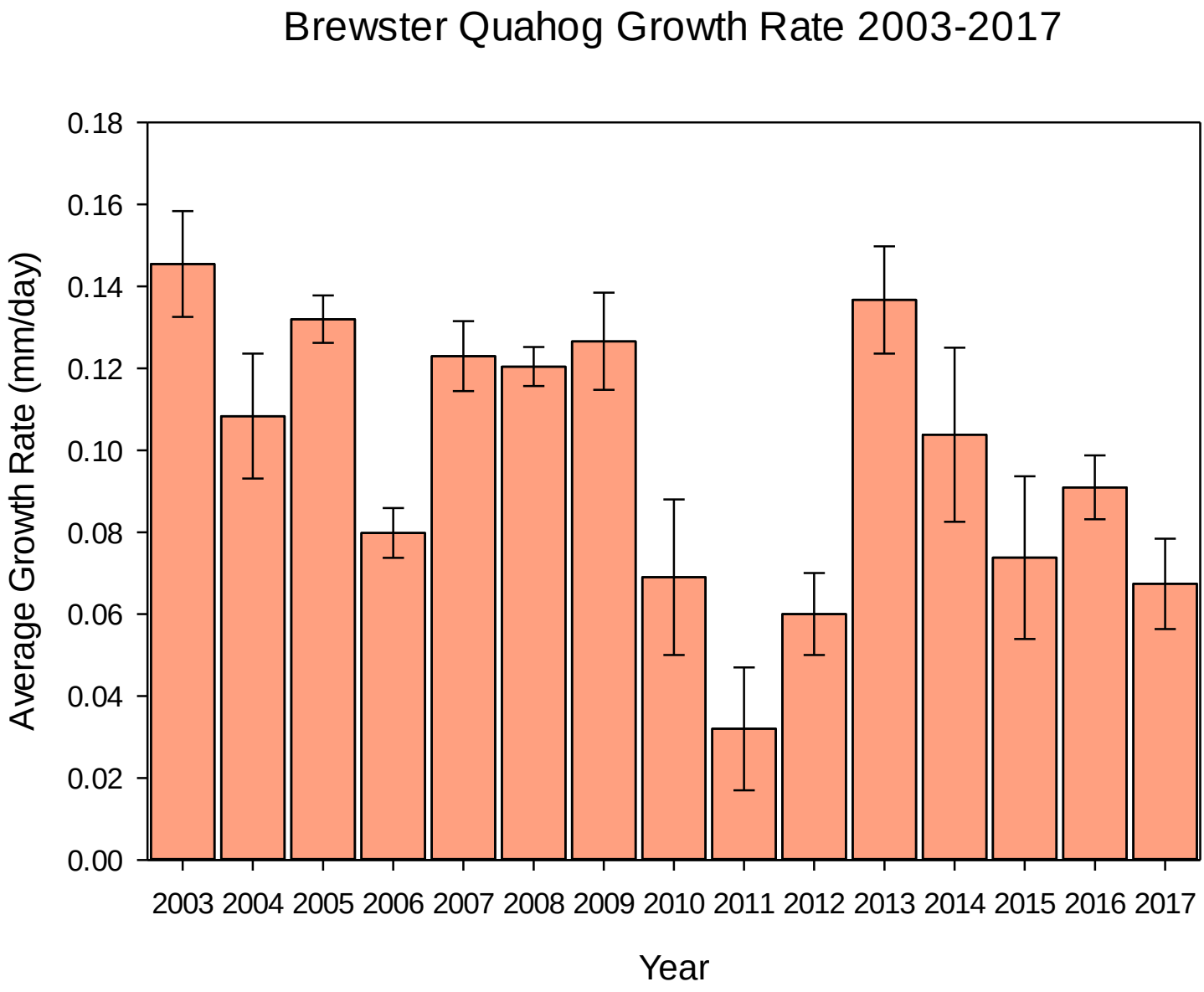


Figure 10. Average daily growth rate of quahaugs in pots with mesh at the Brewster site from 2003-2017.

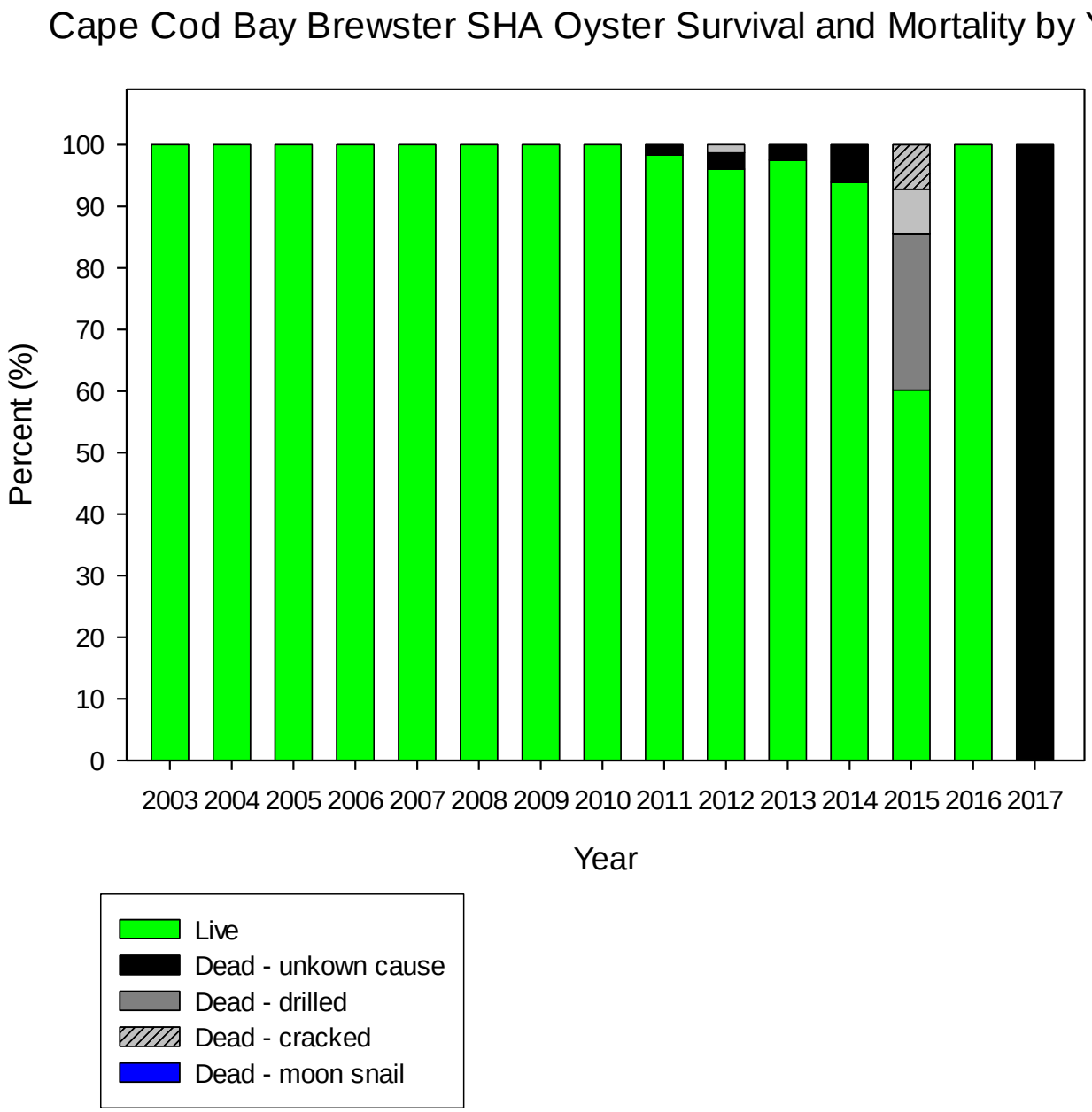


Figure 11. Mean percent survival of oysters in the Cape Cod Bay, Brewster Shellfish Habitat Assessment site in 2003-2017. No predator control measures were taken.

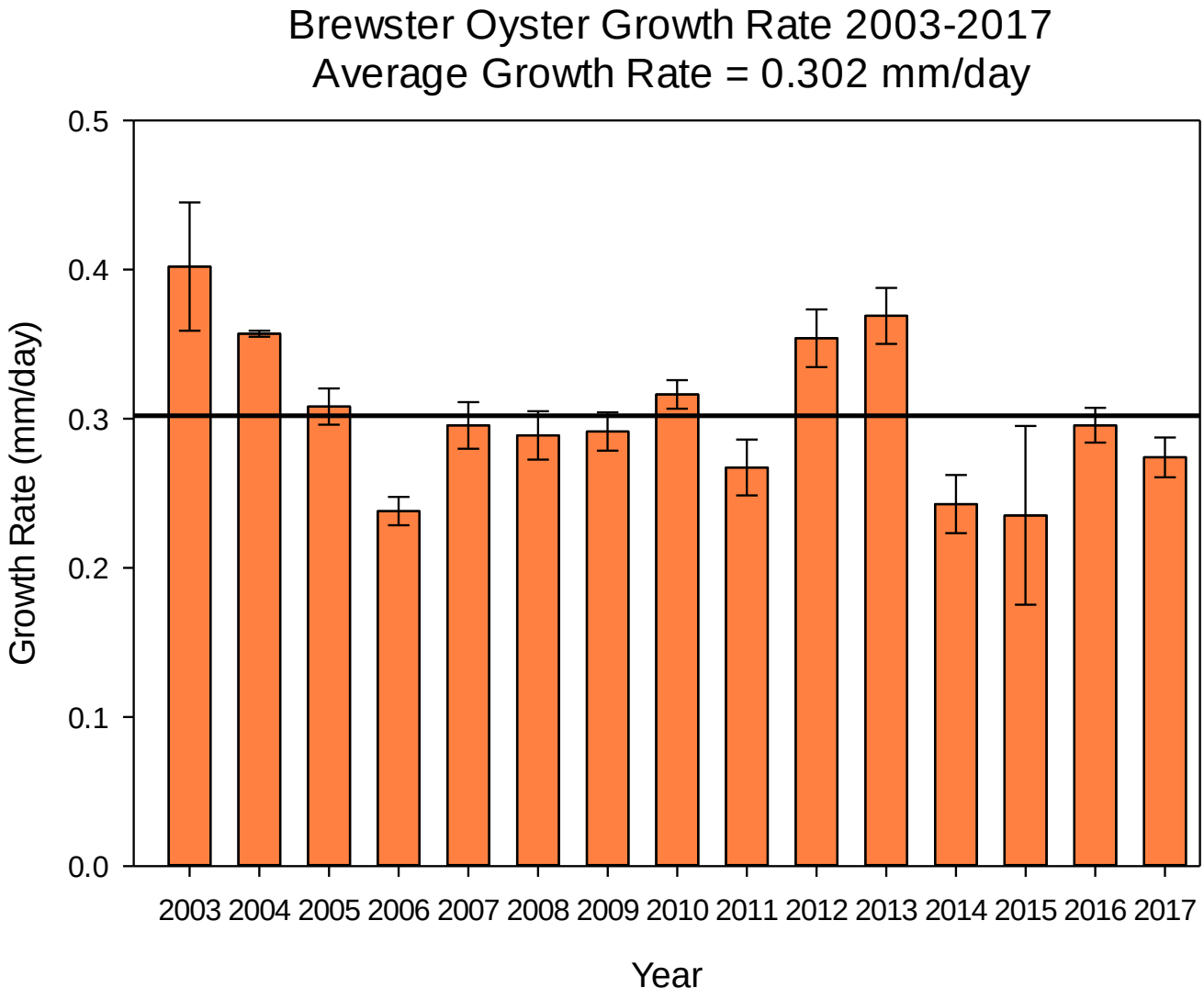


Figure 12. Average daily growth rate of oysters at the Barnstable site from 2003-2017. The average over the 15 years of data is 0.302mm/day or in/day.

Brewster Average Oyster Growth Rate 2003-2017																		
Question: Is the average growth rate in Brewster each year statistically different from the other years?																		
Hypothesis Test - Pairwise Comparisons - Tukey's Honestly Significant Difference Test																		
Blue Shading = Statistically Same White Shading= Statistically Different p-value ≤ 0.05																		
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**		Tally of Same	% Same
2003		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		1	7.14
2004	2003		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		2	14.29
2005	2003	2004		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		7	50.00
2006	2003	2004	2005		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		4	28.57
2007	2003	2004	2005	2006		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		8	57.14
2008	2003	2004	2005	2006	2007		2009	2010	2011	2012	2013	2014	2015	2016	2017		8	57.14
2009	2003	2004	2005	2006	2007	2008		2010	2011	2012	2013	2014	2015	2016	2017		7	50.00
2010	2003	2004	2005	2006	2007	2008	2009		2011	2012	2013	2014	2015	2016	2017		6	42.86
2011	2003	2004	2005	2006	2007	2008	2009	2010		2012	2013	2014	2015	2016	2017		8	57.14
2012	2003	2004	2005	2006	2007	2008	2009	2010	2011		2013	2014	2015	2016	2017		2	14.29
2013	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012		2014	2015	2016	2017		3	21.43
2014	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013		2015	2016	2017		4	28.57
2015	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		2016	2017		10	71.43
2016	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		2017		8	57.14
2017	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016			9	64.29
Tally of Different	13	12	7	10	6	6	6	8	6	12	11	10	5	6	5			
% Different	92.86	85.71	50.00	71.43	42.86	42.86	42.86	57.14	42.86	85.71	78.57	71.43	35.71	42.86	35.71			
The year with the highest % difference: 2011																		
The year with the highest % sameness: 2003,2007, 2012, 2015																		

Table 2. Results of a pairwise comparison of average oyster growth rates in Brewster from 2003-2017. Even though the bar chart in Figure 12 shows that averages were different from year to year – that does not automatically mean that the averages are truly, statistically different from each other. The pairwise takes into account how many oysters survived to be measured in a particular year, and how much variation there was in a particular sample. This table shows which years were statistically different from each other (white boxes) and which years are statistically the same (blue boxes).

Summary: 2003 was a statistically significant 'good' year for growth rate – only the year 2013 had as high a growth rate. 2012 & 2013 were also high growth rate years. Growth rate in 2017 was statistically the same as growth rates in 2005-2009, 2011, and 2014-2016.

Shellfish Habitat Assessment

2003-2017

Pleasant Bay, Orleans

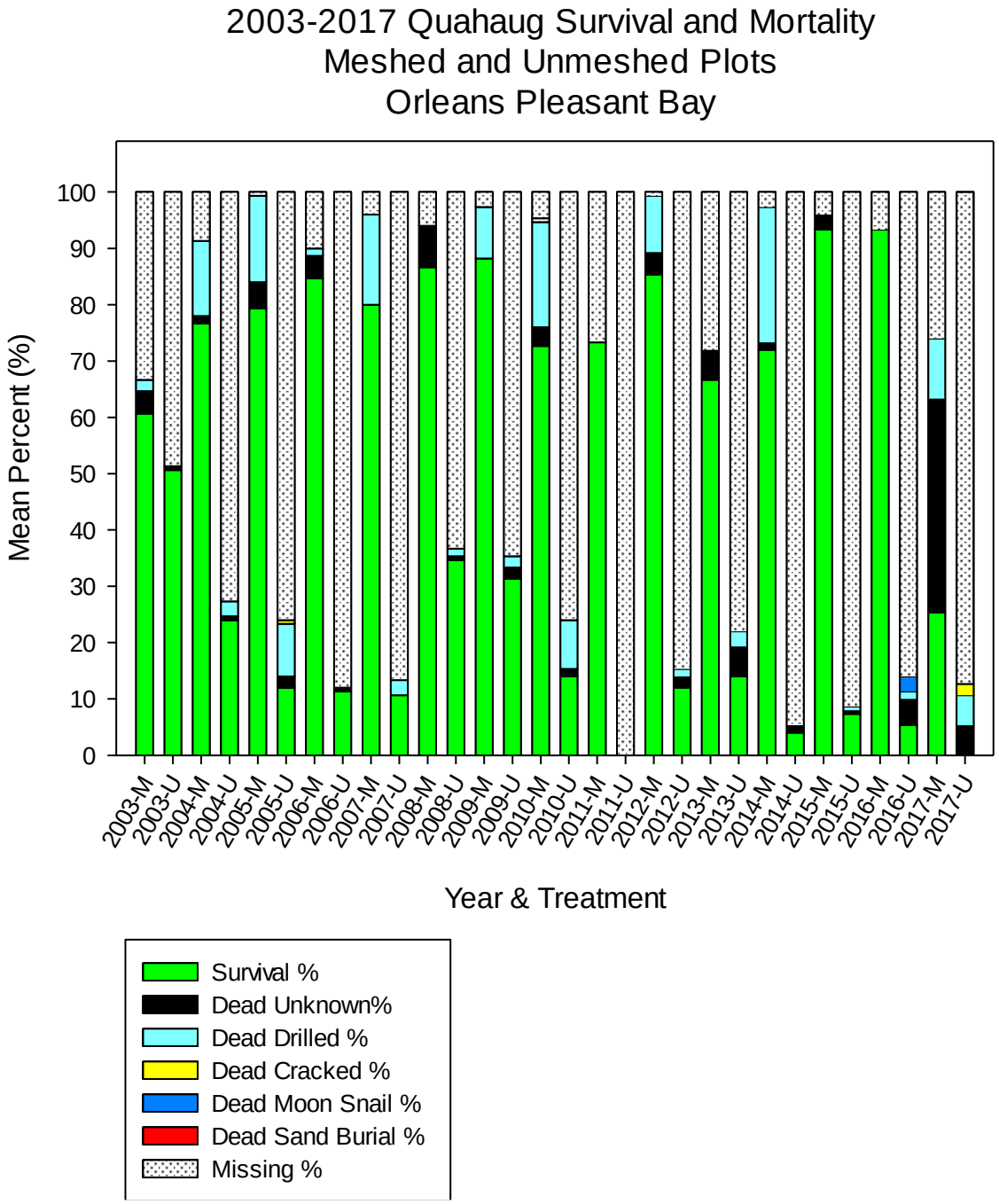


Figure 13. Mean percent survival of quahaugs in pots with mesh and without mesh from 2003-2017 in Pleasant Bay Shellfish Habitat Assessment site. For each year, the bars with hatch marks indicate pots that had mesh over the top, the solid color bars indicate pots that lacked mesh.

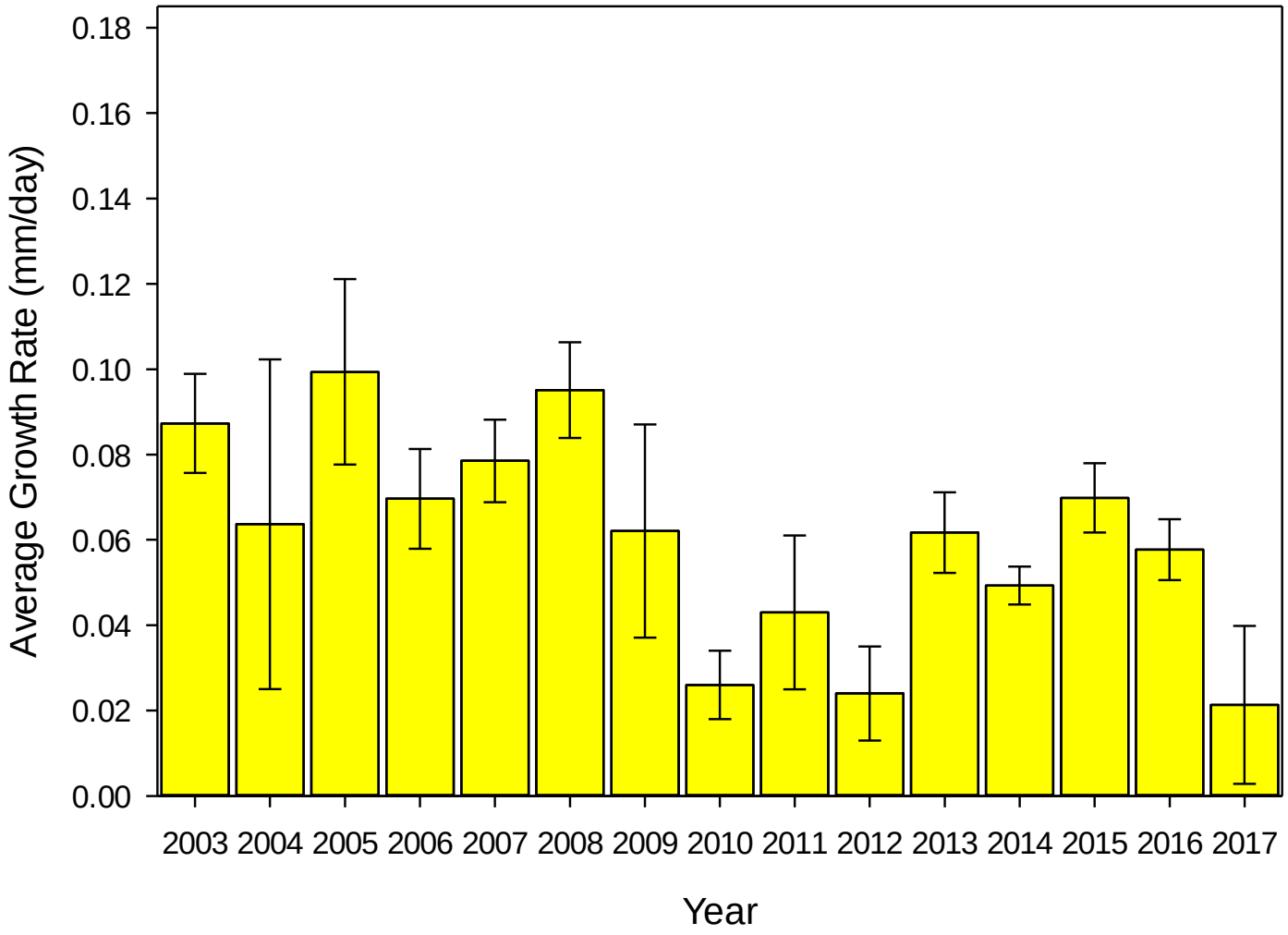


Figure 14. Average daily growth rate of quahaugs in pots with mesh at the Orleans Shellfish Habitat Assessment sites from 2003-2017.

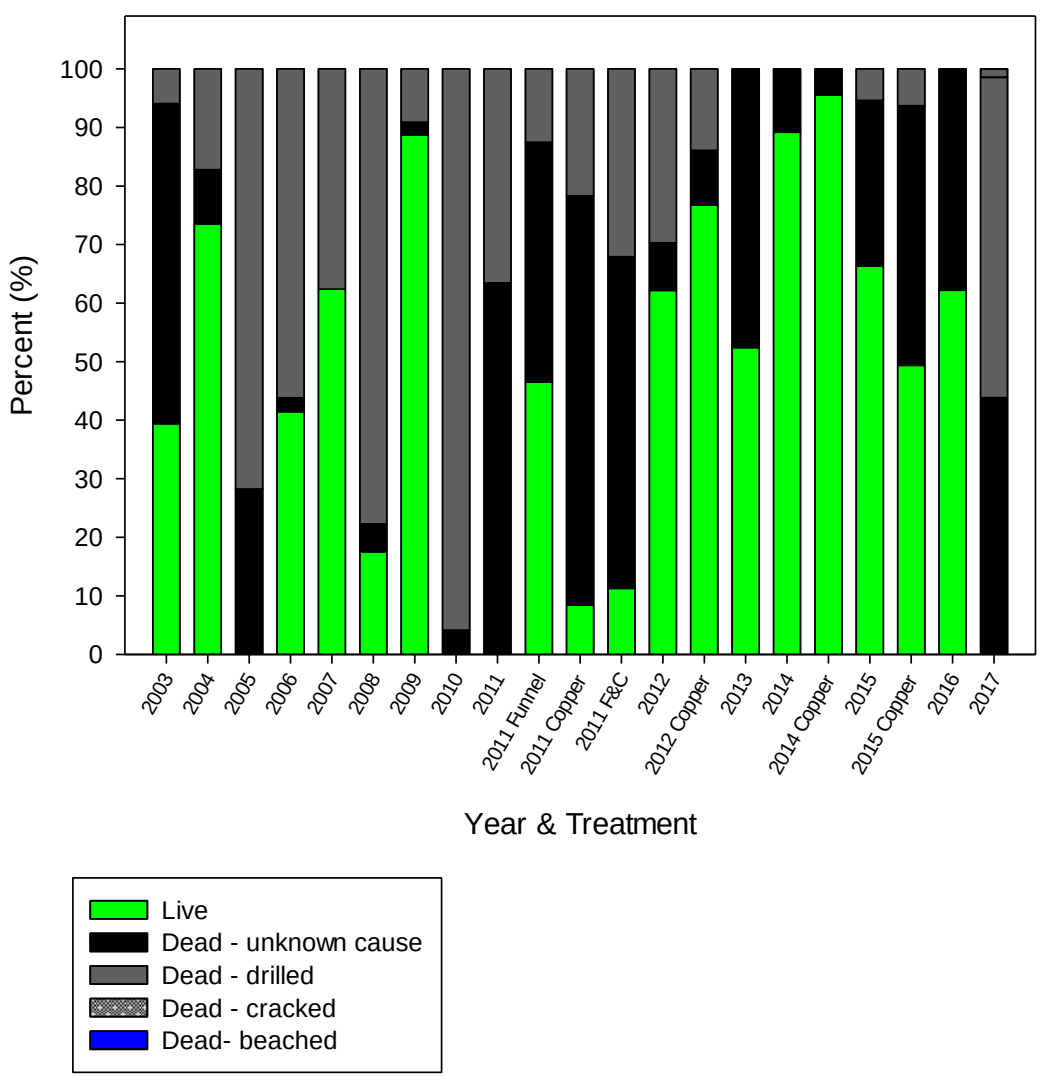


Figure 15. Mean percent survival of oysters in Pleasant Bay Shellfish Habitat Assessment site in 2003-2017. The letter "F" indicated that funnels were attached to the legs of the rack that contained the cage with the bags of oysters. The letter "C" indicates that bands of copper were added to the legs of the rack. These devices were added to try and prevent predatory snails (*Urosalpinx cinerea* & *Eupleura caudata)*, from crawling up the legs of the rack.

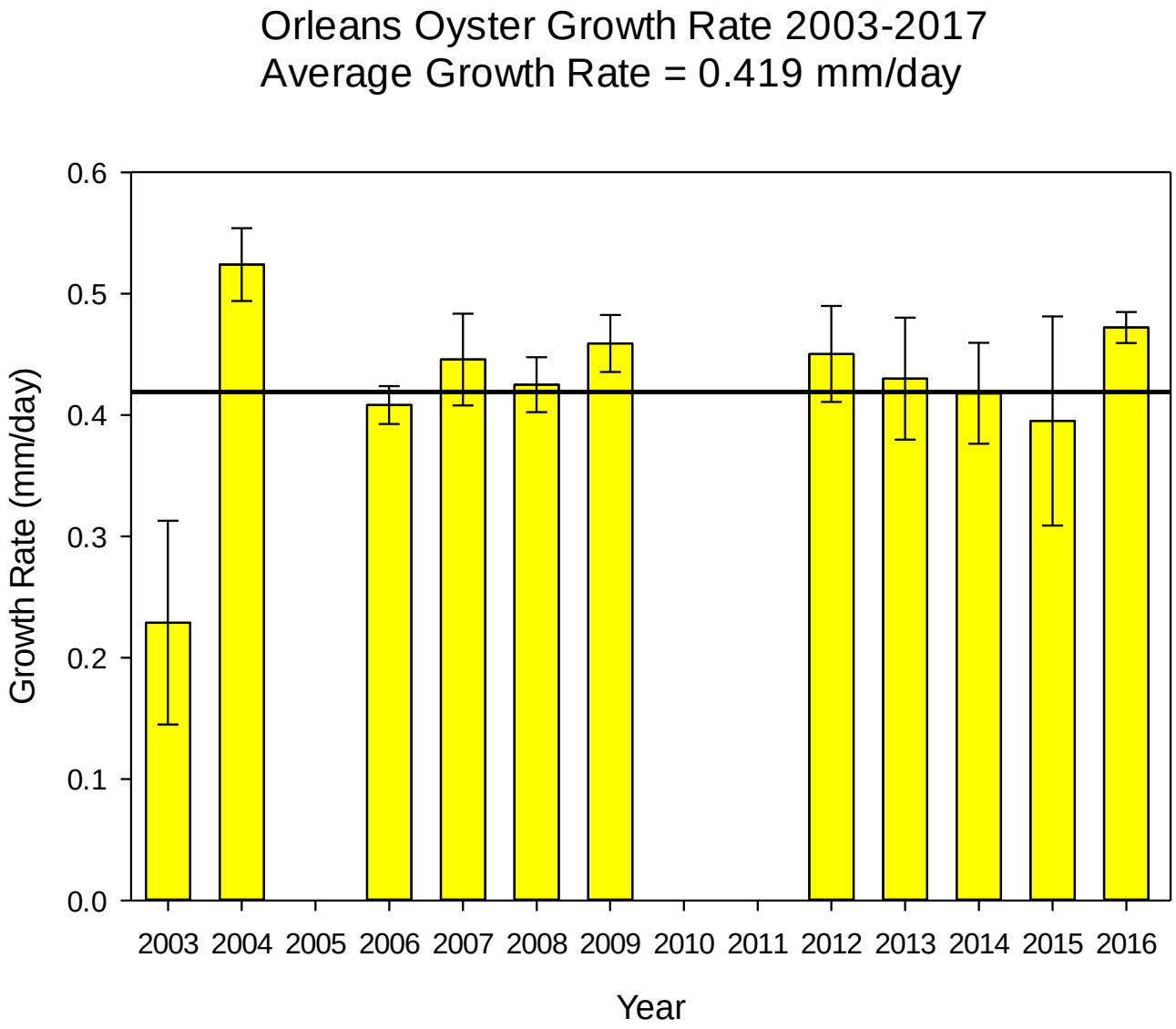


Figure 16. Average daily growth rate of oysters at the Barnstable Shellfish Habitat Assessment site from 2003-2017. In 2005, 2010, and 2011 no oysters survived in the cages without predator control. The black bar shows the average growth rate in mm/day over the past 15 years which is 0.419. This converts to 0.016 in/day.

Orleans Average Oyster Growth Rate 2003-2017														
Question: Is the average growth rate in Orleans each year statistically different from the other years?														
Hypothesis Test - Pairwise Comparisons - Tukey's Honestly Significant Difference Test														
Blue Shading = Statistically Same White Shading= Statistically Different p-value ≤ 0.05														
	2003	**2004**	**2006**	**2007**	**2008**	**2009**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Tally of Same**	**% Same**
2003		2004	2006	2007	2008	2009	2012	2013	2014	2015	2016	2017	0	0.00
2004	2003		2006	2007	2008	2009	2012	2013	2014	2015	2016	2017	9	81.82
2006	2003	2004		2007	2008	2009	2012	2013	2014	2015	2016	2017	10	90.91
2007	2003	2004	2006		2008	2009	2012	2013	2014	2015	2016	2017	10	90.91
2008	2003	2004	2006	2007		2009	2012	2013	2014	2015	2016	2017	10	90.91
2009	2003	2004	2006	2007	2008		2012	2013	2014	2015	2016	2017	9	81.82
2012	2003	2004	2006	2007	2008	2009		2013	2014	2015	2016	2017	9	81.82
2013	2003	2004	2006	2007	2008	2009	2012		2014	2015	2016	2017	10	90.91
2014	2003	2004	2006	2007	2008	2009	2012	2013		2015	2016	2017	10	90.91
2015	2003	2004	2006	2007	2008	2009	2012	2013	2014		2016	2017	6	54.55
2016	2003	2004	2006	2007	2008	2009	2012	2013	2014	2015		2017	9	81.82
2017	2003	2004	2006	2007	2008	2009	2012	2013	2014	2015	2016		10	90.91
Tally of Different	11	2	1	1	1	2	2	1	1	5	2	1		
% Different	100.00	18.18	9.09	9.09	9.09	18.18	18.18	9.09	9.09	45.45	18.18	9.09		
The year with the highest % difference: 2011														
The year with the highest % sameness: 2003,2007, 2012, 2015														

Table 3. Results of a pairwise comparison of average oyster growth rates in Orleans from 2003-2009, and then 2012-2017. In 2005, 2010, and 2011 no oysters survived in the cages without predator control. Although the bar chart in Figure 16 shows that averages were different from year to year – that does not automatically mean that the averages are truly, statistically different from each other. The pairwise takes into account how many oysters survived to be measured in a particular year, and how much variation there was in a particular sample. This table shows which years were statistically different from each other (white boxes) and which years are statistically the same (blue boxes).

Summary: 2003 was a statistically significant low growth rate year for growth rate – none of the other years had as low a growth rate. Growth rates in other years have mostly been statistically the same as each other. Growth rate in 2017 was different only from 2003.

Shellfish Habitat Assessment

2003-2017

Wellfleet Harbor

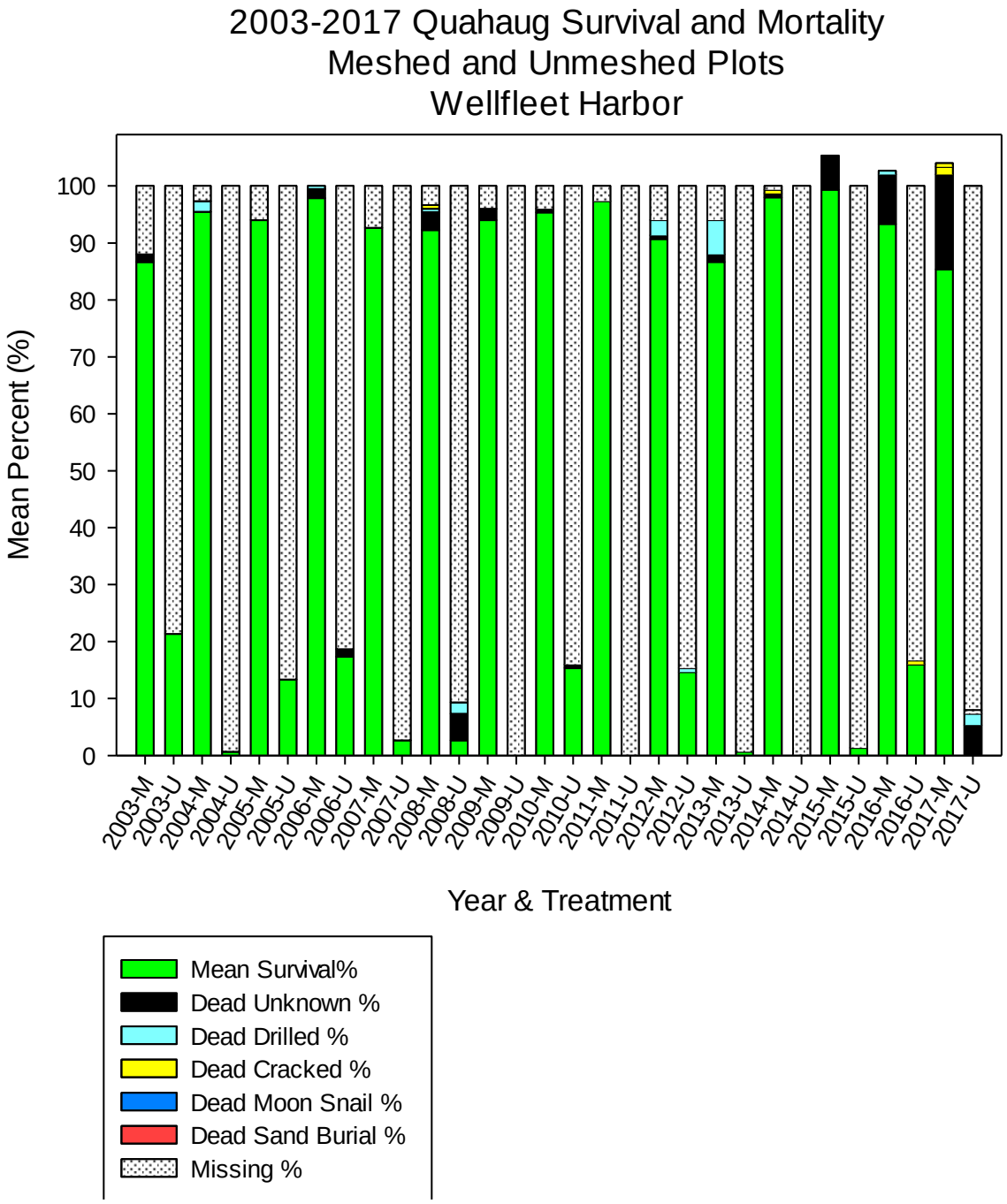


Figure 17. Mean percent survival of quahaugs in pots with mesh and without mesh from 2003-2017 in the Wellfleet Harbor Shellfish Habitat Assessment site. M=pots with mesh installed across the top. U=Pots without mesh installed across the top.

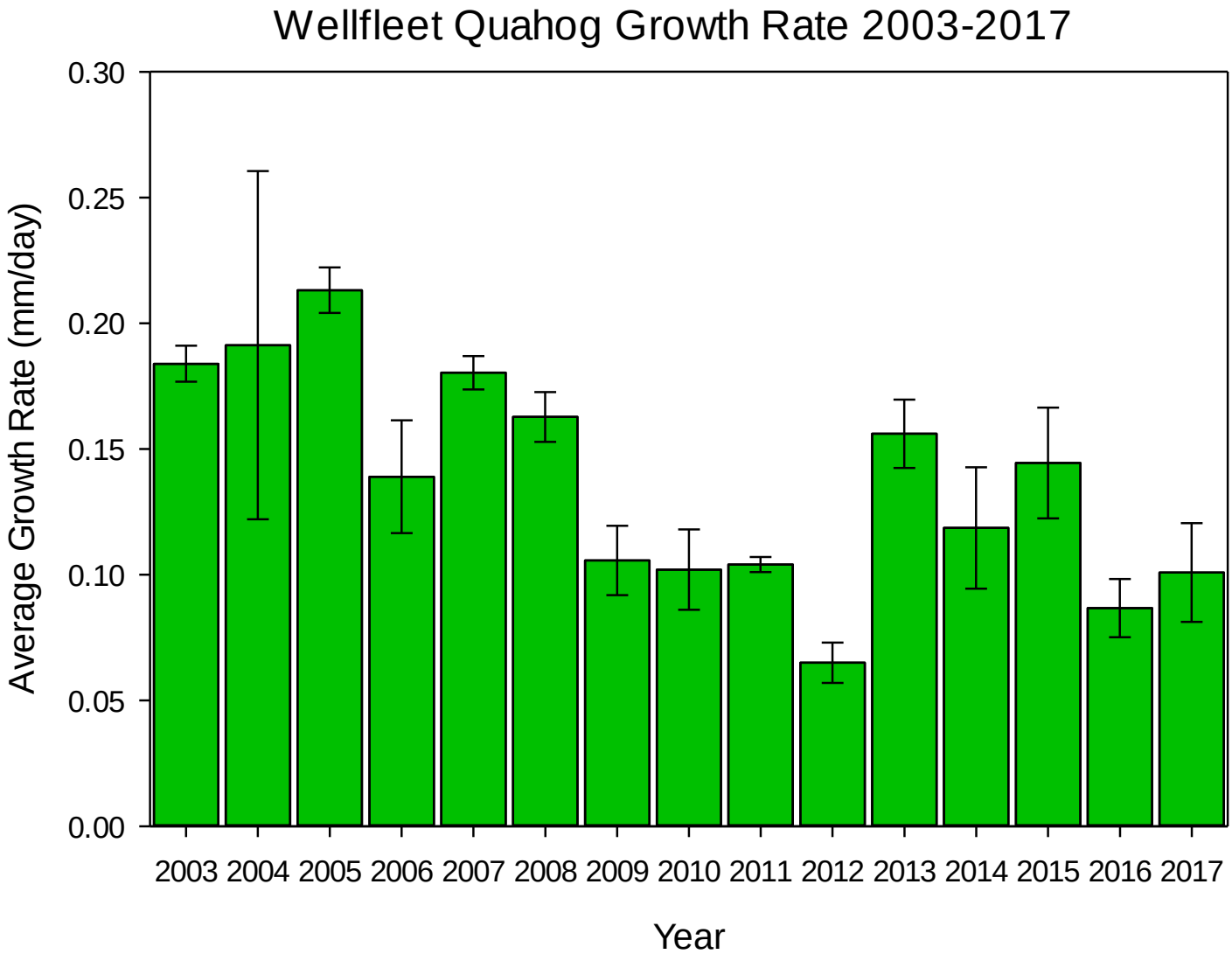


Figure 18. Average daily growth rate of quahaugs in pots with mesh at the Wellfleet Shellfish Habitat Assessment site from 2003-2017.

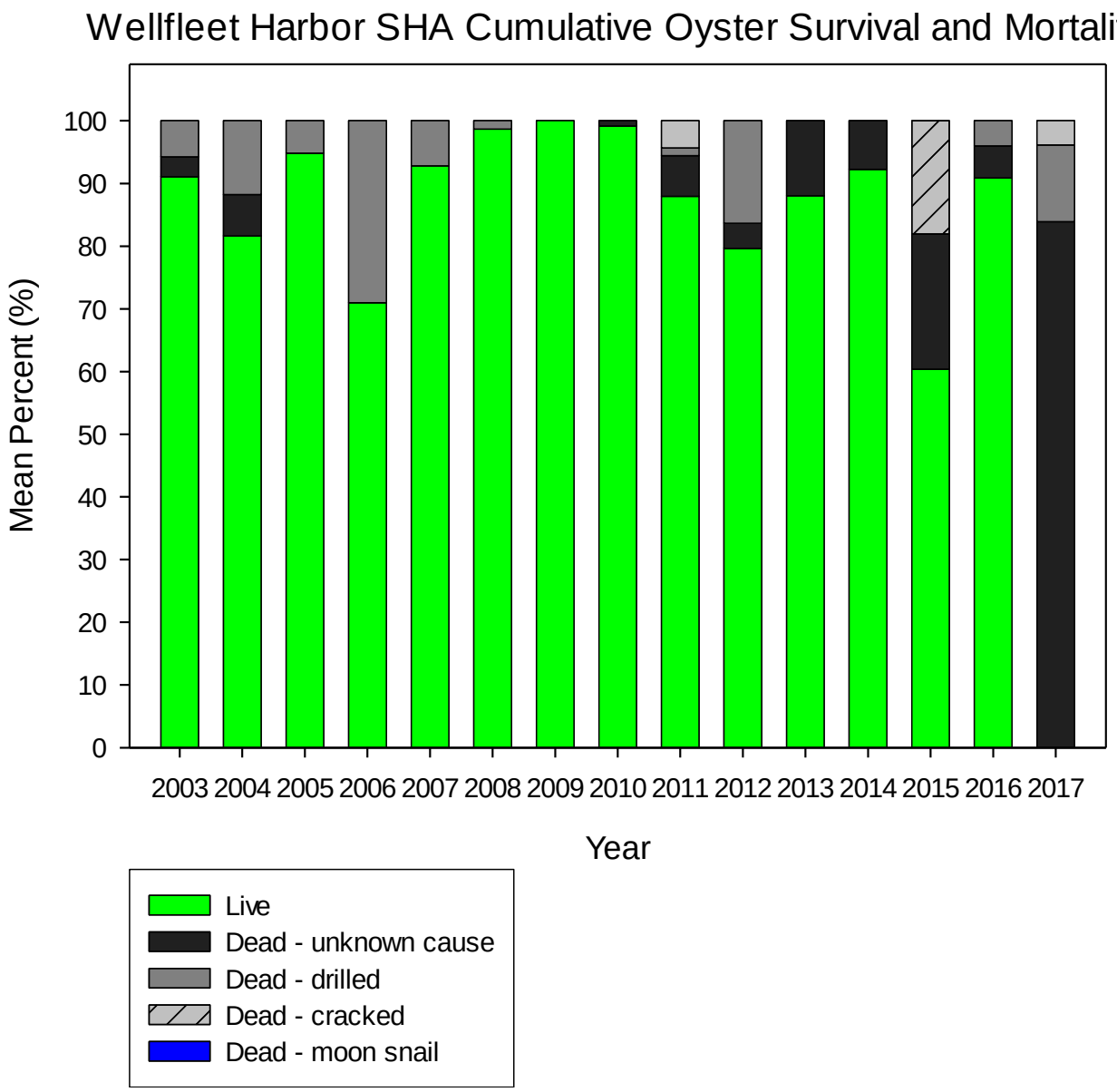


Figure 19. Mean percent survival of oysters in the Wellfleet Harbor Shellfish Habitat Assessment site in 2003-2017. No predator control measures were taken.

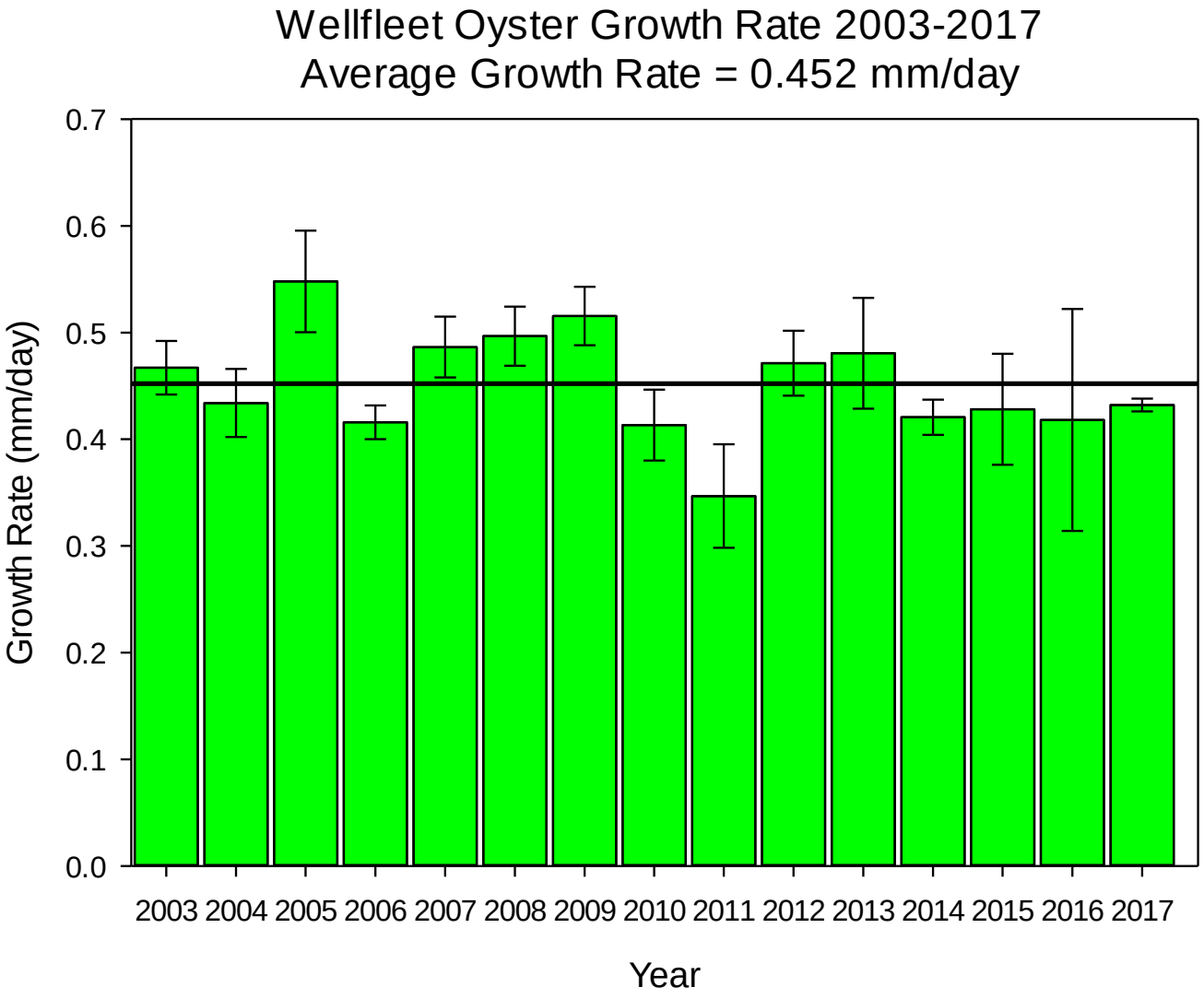


Figure 20. Average daily growth rate of oysters at the Wellfleet Shellfish Habitat Assessment sites from 2003-2017. The black bar shows the average growth rate in mm/day over the past 15 years which is 0.452. This converts to 0.018 in/day.

Wellfleet Average Oyster Growth Rate 2003-2017																		
Question: Is the average growth rate in Wellfleet each year statistically different from the other years?																		
Hypothesis Test - Pairwise Comparisons - Tukey's Honestly Significant Difference Test																		
Blue Shading = Statistically Same White Shading= Statistically Different p-value ≤ 0.05																		
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Tally of Same**	**% Same**
2003		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	11	78.57
2004	2003		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	10	71.43
2005	2003	2004		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	4	28.57
2006	2003	2004	2005		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	7	50.00
2007	2003	2004	2005	2006		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	11	78.57
2008	2003	2004	2005	2006	2007		2009	2010	2011	2012	2013	2014	2015	2016	2017	10	71.43
2009	2003	2004	2005	2006	2007	2008		2010	2011	2012	2013	2014	2015	2016	2017	8	57.14
2010	2003	2004	2005	2006	2007	2008	2009		2011	2012	2013	2014	2015	2016	2017	5	35.71
2011	2003	2004	2005	2006	2007	2008	2009	2010		2012	2013	2014	2015	2016	2017	3	21.43
2012	2003	2004	2005	2006	2007	2008	2009	2010	2011		2013	2014	2015	2016	2017	11	78.57
2013	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012		2014	2015	2016	2017	10	71.43
2014	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013		2015	2016	2017	10	71.43
2015	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		2016	2017	11	78.57
2016	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		2017	7	50.00
2017	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016		10	71.43
Tally of Different	3	4	10	7	3	4	6	9	11	3	4	4	3	7	4		
% Different	21.43	28.57	71.43	50.00	21.43	28.57	42.86	64.29	78.57	21.43	28.57	28.57	21.43	50.00	28.57		
The year with the highest % difference: 2011																	
The year with the highest % sameness: 2003,2007, 2012, 2015																	

Table 4. Results of a pairwise comparison of average oyster growth rates in Wellfleet from 2003-2017. Although the bar chart in Figure 20 shows that averages were different from year to year – that does not automatically mean that the averages are truly, statistically different from each other. The pairwise test takes into account how many oysters survived to be measured in a particular year, and how much variation there was in a particular sample. This table shows which years were statistically different from each other (white boxes) and which years are statistically the same (blue boxes).

Summary: 2005 was a statistically significant 'good' year for growth rate – statistically the same as only 4 other years. 2010 & 2011 were low growth rate years. Growth rate in 2017 was statistically the same as growth rates in 2005,2009, 2011, and 2016.