St. Mary’s River 2019 Recruitment Study

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Prepared for St. Mary’s College of Maryland

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Abstract

The goal of this oyster larval recruitment study in the St. Mary's River is to use both cost effective and accurate methods to determine where the best spatfall occurs - in order to inform decision-makers (government, industry, public, etc.) in determining where substrate plantings should be located so as to maximize investment and future harvest. An additional goal should be to inform an expanding body of science regarding restoration efforts that seek to answer questions such as: Are sanctuaries playing a significant role in restoration of non-sanctuary waters? How important is it to have areas of high density of oysters (>100/m^2) within the overall goal of restoration? Are sanctuaries playing a role in the genetic development of disease resistance? How does the placement and size of sanctuaries play into the overall goals of the sanctuaries as stated in the 2010 executive order expanding Maryland's sanctuaries?

In the St. Mary's River, we studied spatfall (recruitment) at thirteen sites in the river both inside and outside the sanctuary and spread throughout the lower six miles of the tidal river (Figure 1 & 2). Data collected at each of the thirteen sites included number of spat recruited during the study timeline June through September 2019, monthly water quality readings (turbidity, salinity, temperature, and dissolved oxygen), and site characteristics (depth, bottom type, existing oyster density).

Study sites located within the sanctuary (4), with the exception of the site farthest upriver, Bryan, generally had the highest spatfall. Bottom surveys at each site showed that existing oyster density was related to recruitment success; those sites in the sanctuary that had high densities of existing oysters also had high spatfall. The three study sites located farthest downstream exhibited very limited spatfall. Bottom surveys at these three sites indicated that no living oysters were nearby.

Background

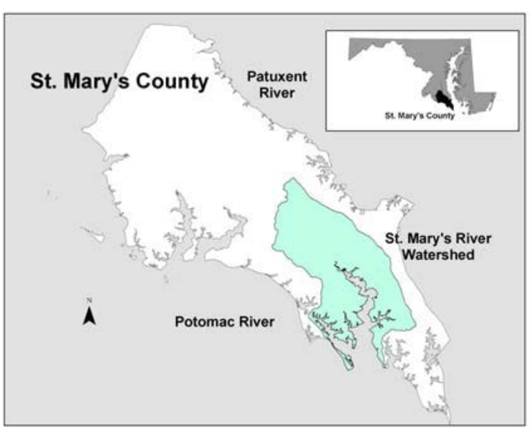
The loss of the Eastern Oyster (*Crassostrea virginica*) can be directly linked to over harvesting. In addition, diseases such as Dermo and MSX have furthered the decline and have pushed the Eastern Oyster, a once prevalent organism in the Chesapeake Bay, to the brink of extinction (O'Beirn et al. 2000). The depletion of the Eastern Oyster has had far reaching impacts and has led many to work to re-establish the organism's prominence.

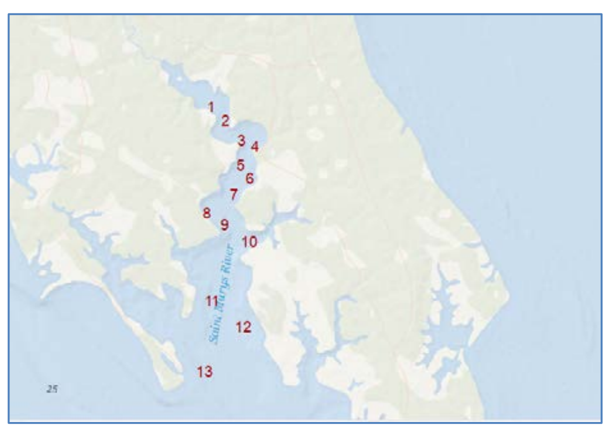
The St. Mary's River qualifies as a Tier 1 tributary and has most of the characteristics supporting oyster restoration (Maryland Department of Natural Resources, 2018). There are fifty-one documented oyster sanctuaries in Maryland's portion of the Chesapeake Bay. The sanctuaries are of varying size and condition but represent the State's commitment to restore the Eastern Oyster population. The St. Mary's River shellfish sanctuary was first established on October 1, 2010 (Code of Maryland Regulations 08.02.04. 2016). The prohibition on harvest within the sanctuary has led to: 1) the establishment of thriving oyster bars with multi-age-classes, which today exhibit better survival rates than the 20-year average, and 2) substantial oyster population growth—both in overall area and animal density. Within the sanctuary, a 5-acre three dimensional reef area currently undergoing restoration is immensely successful with water clarity and quality noticeably enhanced compared to seven years earlier. Ongoing scientific monitoring by St. Mary's College of Maryland confirms this success.

St. Mary's College of Maryland (College) and the St. Mary's River Watershed Association (Association) implement outreach programs such as the Marylanders Grow Oyster (MGO) program and the Living Reef Action Campaign, as well as other direct restoration related efforts within the St. Mary's River Shellfish Sanctuary. Additionally, they engage in or support research by a variety of different entities including local high school and college students, graduate students from regional institutions, and marine scientists. The five-acre reef project in many ways serves as a living classroom.

Methodology

Fifty-two "traps" (wire cages measuring 12" x 18" x 8") were each filled with 120 wild-grown, aged oyster shells selected for equivalent size and surface area. Shells were then power washed while the traps were rolled over several times. Four of these survey traps were placed on the river bottom in a square pattern and spaced three meters apart at each of the thirteen study sites. Sites were selected by Maryland Department of Natural Resources staff (Department) and included five sites that the Association had studied in 2018 (Figures 1 & 2). The Department's detailed explanation for site selection is included in appendix A.





Figures 1 & 2. Regional map and map depicting location of Study Sites

The traps were placed on the river bottom equidistant from each other three meters apart and fastened together with a sinking rope of exactly three meters in length (Figure 3). Attached to one of the traps at each site was a buoy suspended in the water column to approximately three feet below MLW. In addition to the underwater buoy a second surface-floating buoy was attached to an anchor and was placed next to one of the nearshore traps at each of the thirteen sites. Should a passerby disturb the floating buoy, it would not disturb the experiment. Each of the thirteen floating buoys were labeled:

DO NOT DISTURB
DNR Study
SCP 1978
301-904-2387

The labeling indicated desire that the area not be disturbed, the contractor for the study (the Department), our scientific collections permit number, and a cell phone number where we could be reached to address any concerns or questions.

Traps were deployed on June 5^{th}, 6^{th}, 23^{rd}, and 24^{th}, and GPS coordinates were recorded for the central location of each deployment at the thirteen sites. (Figure 4) The contract with St. Mary's College was not fully executed by June 5; therefore the Association decided to deploy traps on a limited number of sites (6) so as to capture early spawn. Once the contract was fully executed, traps were deployed at the remaining seven sites as required in the scope of work. [Appendix A]

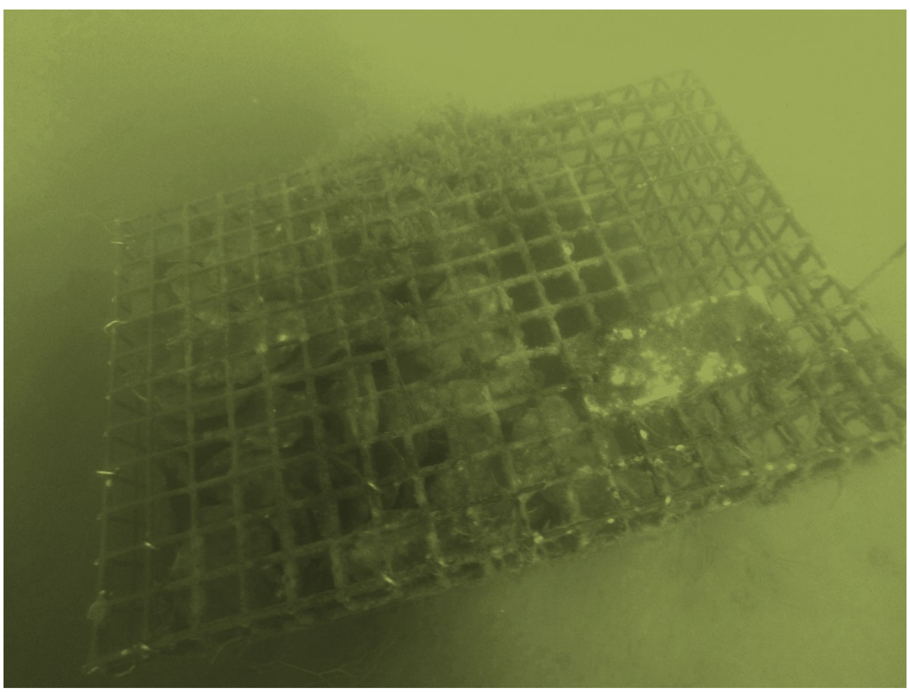


Figure 3. Photo of trap deployed on bottom (August 2019)

STUDY SITES			
Site Number	Location	Latitude	Longitude
1	Bryan	38.20361°	-76.45626°
2	Horseshoe	38.19901°	-76.44684°
3	Pagan	38.19192°	-76.44279°
4	Seminary	38.18845°	-76.43736°
5	West St. Mary's	38.18477°	-76.44388°
6	Gravelly Run	38.18309°	-76.43397°
7	Green Pond	38.17402°	-76.44097°
8	Cooper Creek	38.16768°	-76.45879°
9	Coppage	38.16265°	-76.45182°
10	Kennedy	38.15889°	-76.43498°
11	Edmund	38.13651°	-76.45775°
12	Fort	38.12918°	-76.43597°
13	Mouth of Creek	38.11414°	-76.46421°

Figure 4. Exact coordinates for study sites

Traps were checked monthly and water quality readings taken on June 24, July 9, August 8, September 10, and September 29. A Secchi disk and a YSI PRO2030 were used to collect water quality readings. The YSI was factory calibrated for use on June 24. Subsequently, trained interns (Lisabeth Stewart and Toby Beauregard) calibrated dissolved oxygen immediately prior to sampling the thirteen sites. Standard log sheets were used to record the data and in every case a second set of eyes verified the datum entered for each parameter. Divers looked at the traps on July 12, August 10, and September 10 for fouling and carried hard bristled brushes in order to clean fouled traps. In no case did any of the fifty-two traps become fouled sufficiently (greater than 5% obstruction) to merit cleaning. (Figure 3) Still, we did brush off the top and sides of all the cages in situ on July 12 and again on August 10.

Also recorded during the latter half of July were depth (MLW), bottom firmness and type, wild oyster density by size, and presence of SAV. (Figure 6) To complete this divers using scuba gear swam around and between the deployed traps at each site looking for SAV and oysters. Samples from the bottom were determined by one trained diver (Jack O'Brien) to be one or more of the types: gravel, sand, firm mud, soft mud, shells, or oyster bar.

Figure 5. Underwater photo of oyster bar at Seminary taken August 23, 2016

STUDY SITES				
Site Number	Location	Depth MLW (feet)	SAV*	Bottom Type**
1	Bryan	6-8	No	Sparse Oyster Bar over Soft Sand with Shell Fragments
2	Horseshoe	6-7	Sparse	Oyster Bar over Hard Sand/Shell Mix with Sharp Dropoff
3	Pagan	7-9	No	Sparse Oyster Bar over Hard Mud/Sand/Shell Fragments with Sharp Dropoff
4	Seminary	7-8	No	Dense Oyster Bar over Sand/Shell Mix
5	West St. Mary's	6-7	Sparse	Sparse Oyster Bar over Sand/Shell Mix
6	Gravelly Run	6.5-7	No	Sparse Oyster Bar over Hard Sand/Shell Mix
7	Green Pond	7	No	Shells 7 to 10 Inches Deep over Hard Mud and Sand Closer to Shore
8	Cooper Creek	8.5	No; Dense Inshore	Hard Mud/Shell Fragments Mix
9	Coppage	6.5	No; Dense Inshore	Sparse Oyster Bar over Hard Mud/Sand Mix
10	Kennedy	6.5-7	Dense Patches Over 60% Bottom	Mud with Dense SAV (few shell fragments)
11	Edmund	6.5	Sparse; Patchy Inshore	Hard Sand (few shell fragments)
12	Fort	7.5-9	Sparse; Patchy Inshore	Soft Sand (very few shell fragments)
13	Mouth of Creek	7.5	No	Hard Sand (very few shell fragments)

*SAV found was Horned Pondweed only

**Survey data determined by one trained diver, Jack O'Brien

Figure 6. Bottom survey, SAV presence, and depth of study sites

Existing oyster density was determined using a quadrat with interior area exactly 0.25 square meters, which was randomly placed once on the bottom in between the four traps and placed three more times within 5 meters of one of the traps. Four samples were taken at each site by trained scuba divers. All material within the quadrat was taken onto the work vessel and both live oysters and dead oysters ("boxes") were counted and recorded by size groupings: under 1 inch, 1 inch to under 3 inches, and equal to 3 inches and over. (Figure 7)

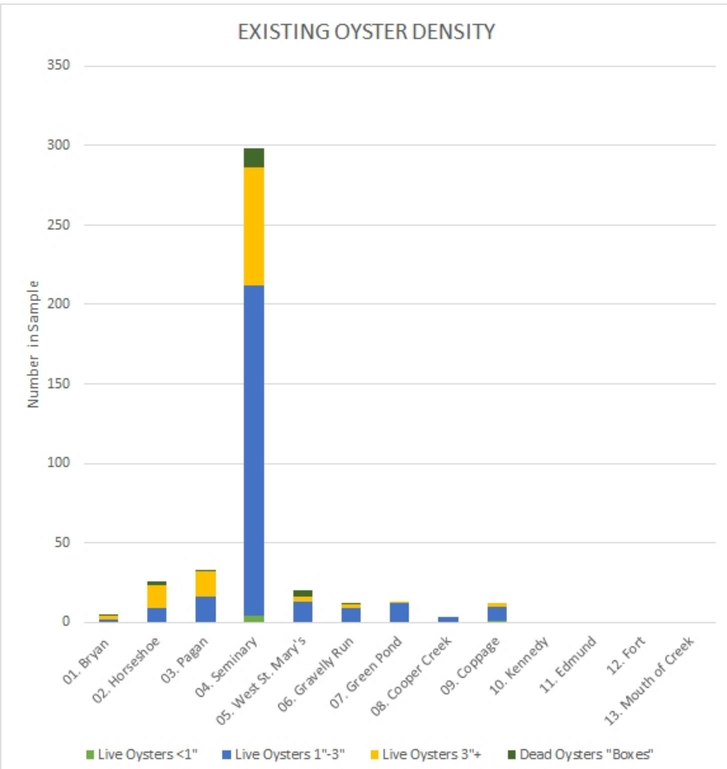


Figure 7. Existing oyster density at each study sites

Traps were retrieved on September 29th and 30th and taken to a holding area at the St. Mary's College of Maryland waterfront where they were placed in shallow water on hardwood pallets. Each shell within the traps was inspected for spatfall and a standard log sheet was used to record the presence of live and dead spat (referred to as "boxes") in three size groupings: equal to and under 10mm, 11mm to 25mm, and over 25mm. Counters included two DNR Shellfish Division staff (Jodi Baxter and Laurinda Serafin) who recorded the actual size of each spat found. This encouraged other counters to duplicate this detail and resulted in the recording of exact measure of all spat in fifty-one of the fifty-two traps. [Our analysis and graphs depict the size groupings, not the actual measurements.] Counting of spat occurred on September 29th and 30th and concluded on October 6th. Due to the brief time that traps were in the holding area, no spatfall from the holding area (from the college waterfront area) was counted. Any spatfall during this eight-day holding period would be too small to see and identify with the naked eye (black specks the size of fine-ground pepper). Note that total spatfall counts include both live and boxes (dead).

In the analysis, in order to maximize accuracy, for each study site total spatfall by size grouping and live/dead animals was used. Counters were trained and all animals (and mortality) found were double-checked for accuracy and consistency by a second trained person.

The dataset will be shared with decision makers—DNR Shellfish Division, Maryland legislators, county oyster committee, scientists at St. Mary's College of Maryland—and made publicly available through the website http://www.SMRWA.org

Our permit required us to remove the cages prior to October 1, which is opening day for public harvest with hand tongs. The study areas are not usually harvested in October with hand tongs, but are harvested by dredge beginning November 1. Note that in some years the breeding season does linger well into October and we suspect this may have been the case in 2019 (James from Piney Point Hatchery reported heavy spawn in September).

Results

Results demonstrate spatfall in all sections of the St. Mary's River, although spatfall was minimal at the site farthest upriver (likely due to environmental conditions specific to this year and/or this site) (Figure 8). Results were strongest in the sanctuary with the exception of Bryan, the site farthest upriver. Green Pond and Coopers Creek had the highest spatfall for sites outside the sanctuary, and were closely followed by West St. Mary's, Coppage, and Kennedy. With the exception of Bryan, all sites had the highest spatfall early in the study season (the season ran June 24 to September 19) as indicated by the number of quite large spat (up to 60mm). Mid- to late-season spatfall, as indicated by spat size 10mm and under, was significant only at Fort if compared to Fort's total season's spatfall.

At all sites, mortality of spat was minimal with the exception of Mouth of Creek where mortality represented 21% of the total (3 of 14). Since the total recruitment count at Mouth of Creek was so low, the study site's mortality may not be a realistic indicator of overall mortality for this area.

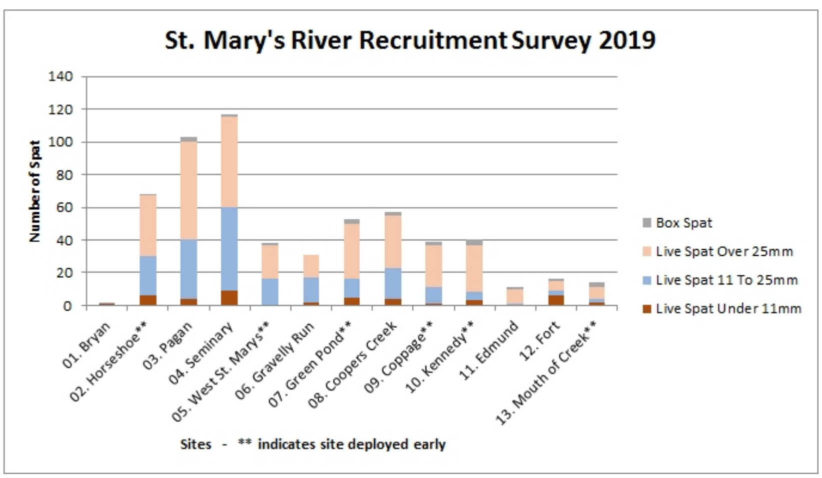


Figure 8. Spatfall at the Thirteen Study Sites

Trap deployment on six sites—Horseshoe, West St. Mary's, Green Pond, Coppage, Kennedy, and Mouth of Creek—occurred twenty days prior to the other seven sites. Comparison between nearby sites suggests this may not be a major factor in the study results. The very low salinity in 2018 lingering into the first half of 2019 might suggest that mature oysters did not spawn or minimally spawned in the month of June—a typical month for oysters to spawn. Instead the oysters may have waited, building up metabolic resources that had been depleted due to the low salinity and poor environmental conditions throughout the previous 20 months (Brian Hite and the county oyster committee – September 2019 phone call).

Low dissolved oxygen levels at the river bottom were recorded at five sites on July 9, 2019—Bryan, Horseshoe, Pagan, Seminary, and Fort. (Figure 9.)

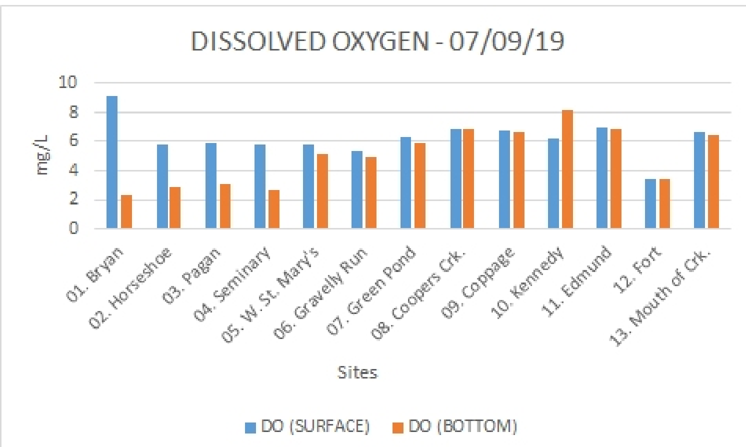


Figure 9. Dissolved oxygen at low levels on July 9 at five study sites

Other relationships between spatfall and water quality data were not apparent. The one relationship that stands out is the suggested correlation between oyster density and spatfall (Figure 10). Seminary exhibits both high spatfall *and* high density of existing oysters.

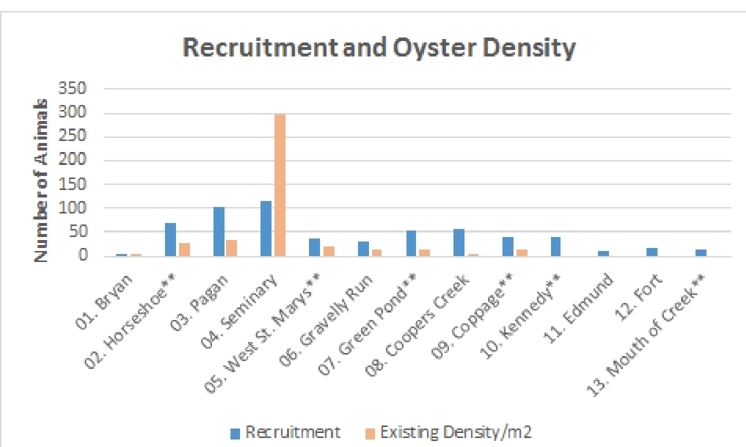
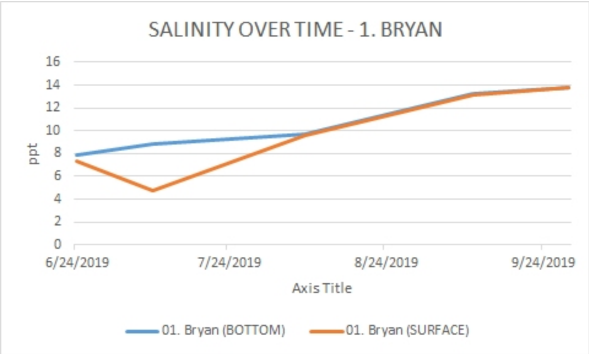


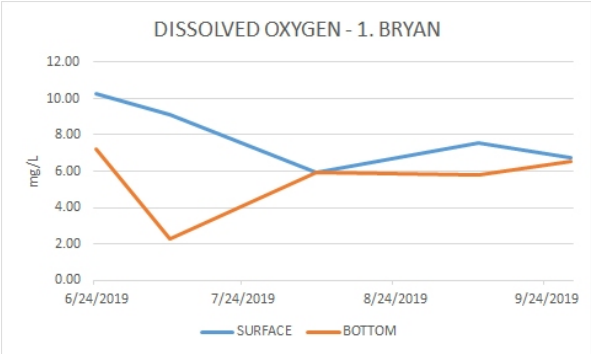
Figure 10. Spatfall Compared to Existing Oyster Density

Review of Results by Site

Site 01. Bryan is located farthest upriver near the western shore and in the middle section of the sanctuary. Traps were placed in water depth of 6 to 8 feet MLW. The bottom was a soft sand with small shell fragments. No SAV was present in the near vicinity. Our bottom sample found 4 oysters; existing bar density in the nearby vicinity was very low. Salinity (on the bottom) at this site was 7.9 ppt on June 24th, well below ideal conditions. Salinity rose to 9.7 ppt by August 8 and to 13.8 on September 29. Dissolved oxygen on July 9th was 2.3 mg/L, an insufficient level to maintain live oysters for very long. (DO was in a healthy range on June 24 and August 8.) This low oxygen likely played a significant role in the survival and success of larvae at this time. Spatfall was the lowest of all the study sites with just two spat; one measuring 18mm and the second 3mm. Likely both spat were recruited after the low oxygen event, the larger one in mid- to late-July and the smaller one about September 1. (Note that spat growth this year is exceptionally strong as some spat grew to over 50mm, a size we had not seen in previous years’ recruitment studies or experiments - 2012, 2013, 2017, 2018.)

Figure 11. Photo of spat from Bryan

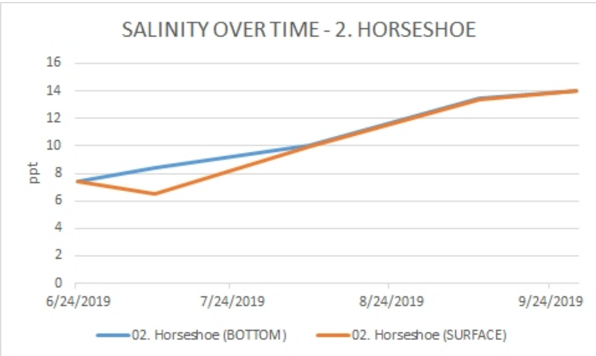


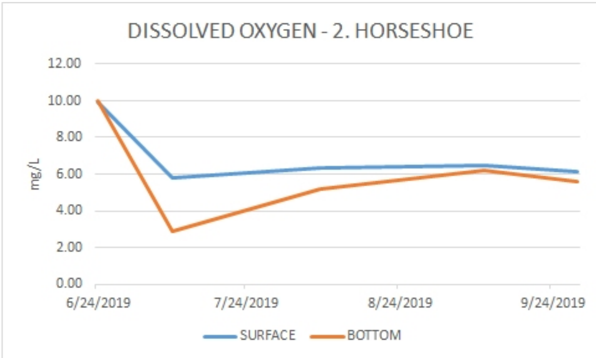


Figures 12 & 13. Salinity and Dissolved Oxygen at Bryan

Site 02. Horseshoe is located along the eastern shore about a half mile upriver of the southern sanctuary boundary. Traps were placed in water depth of 6 to 7 feet MLW. The bottom was an oyster bar with a deep base of sand and shells and existing density of 23 multi-age class oysters in the one square meter sample. No SAV was present in the near vicinity, although SAV was in dense patches closer to the shoreline beginning in waters about 4.5 feet deep MLW. Salinity (bottom) at this site was 7.4 ppt on June 24th, 10.0 ppt on August 8 and 14.0 ppt on September 29. Dissolved oxygen (bottom) was in the healthy range on four of five days we sampled. On July 9 dissolved oxygen was 2.88 mg/L. Spatfall was 68 with about half above 25mm and half below; the largest one measured 40mm.

Figures 14 & 15. Photos of spat from Horseshoe





Figures 16 & 17. Salinity and Dissolved Oxygen at Horseshoe

In the past we have used Horseshoe Bar as a control/study site for a healthy oyster bar bringing underwater photographers to this bar several times over the past eight years. Our dives and reports from divers suggest the bar is quite extensive and includes areas of very high oyster density, possibly as high as 200 per square meter. Oysters, although in diminishing density, were found in up to 16 feet depth. In 2012 we deployed cages of oyster shells from a pier approximately 600 meters north of this study site (Box Oak) with the goal of testing natural recruitment for use in the Marylanders Grow Oysters program. While 2012 is regarded as an exceptional year, it should be noted that our cages recruited an average of 28 spat per shell.

Site 03. Pagan is located along the western shore about 550 meters upriver (northwest) of the southern sanctuary boundary. Traps were placed in water depth of 7 to 9 feet MLW.

The area has a significant sloping bottom beginning at about 5.5 feet depth and then drops to over 16 feet depth in just 35 meters distance. The bottom was fragmented oyster bar with a base of hard mud/fine sand and shells and existing density of 32 multi-age class oysters in the one square meter sample. No SAV was present in the near vicinity, although SAV was in sparse patches closer to the shoreline beginning in waters about 5 feet deep MLW. Salinity (bottom) at this site was 8.1 ppt on June 24th, 10.4 ppt on August 8 and 14.2 ppt on September 29. Dissolved oxygen (bottom) was in the healthy range on four of the five days we sampled. (DO was 3.10 mg/L on July 9) Spatfall was 103 of which 60% were over 25mm; the largest one measured 55mm and only two spat were below 10mm.

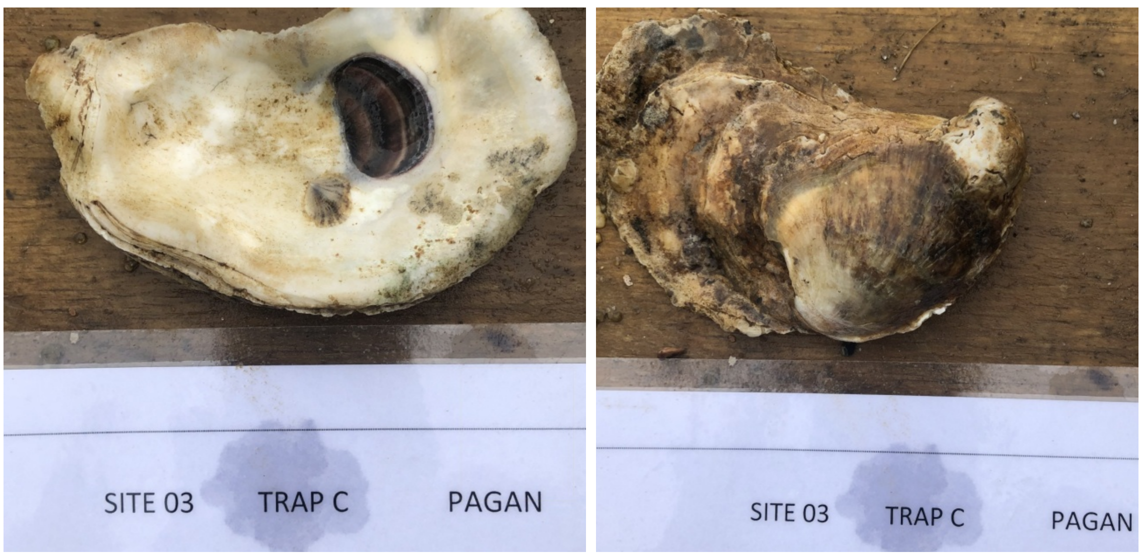
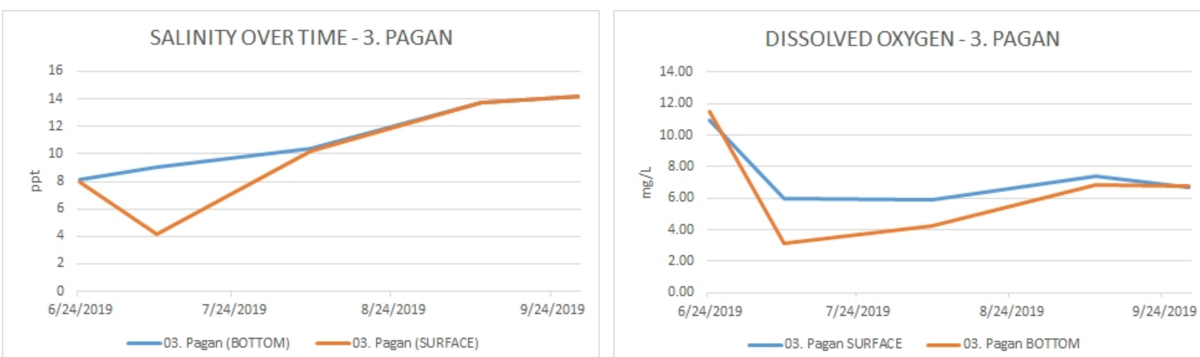


Figure 18 & 19. Photos of spat from Pagan

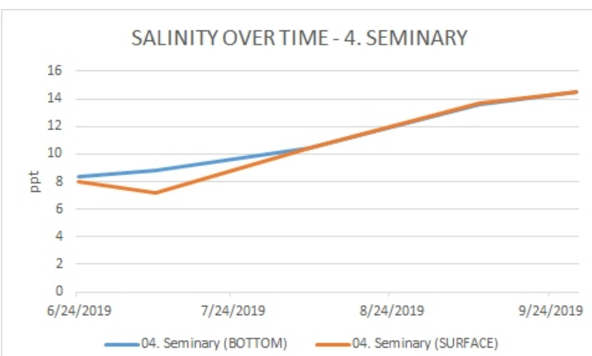


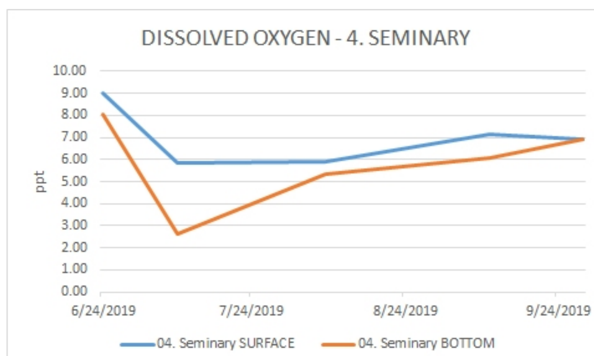
Figures 20 & 21. Salinity and Dissolved Oxygen at Pagan

Site 04. Seminary is located along the eastern shore and adjacent to the southern sanctuary boundary. Traps were placed in water depth of 7 to 8 feet MLW. The bottom was a dense and healthy oyster bar with a base of sand/shell mix and existing density of 286 multi-age class oysters in the one square meter sample. No SAV was present in the near vicinity, although SAV was in very sparse patches closer to the shoreline beginning in waters about 5 feet deep MLW. Salinity (bottom) at this site was 8.4 ppt on June 24th, 10.4 ppt on August 8 and 14.5 ppt on September 29. Dissolved oxygen (bottom) was in the healthy range on four of the five days we sampled (DO was 2.63 mg/L on July 9). Spatfall was 298 of which nearly half were over 25mm; the largest one measured being 47mm and the smallest two measured 5mm.

Seminary Bar is a Marylanders Grow Oysters planting area. The traps were placed within an area that was planted in 2010 with 135,000 spat and in 2011 with 275,000 spat both plantings from MGO cages. This area was also poached with power dredge in spring 2016. While the dredge damage was plainly obvious in the summer of 2016, our divers this summer were unable to find the paths of the dredge as the oysters have quickly returned.

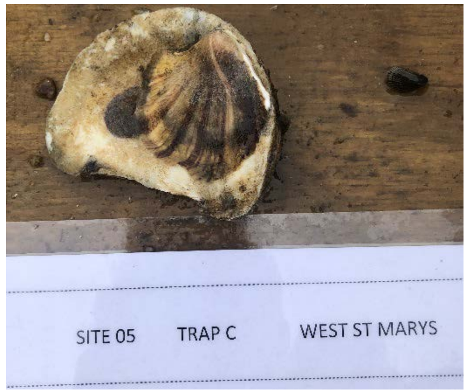
Figures 22, 23, & 24. Photos of spat from Seminary



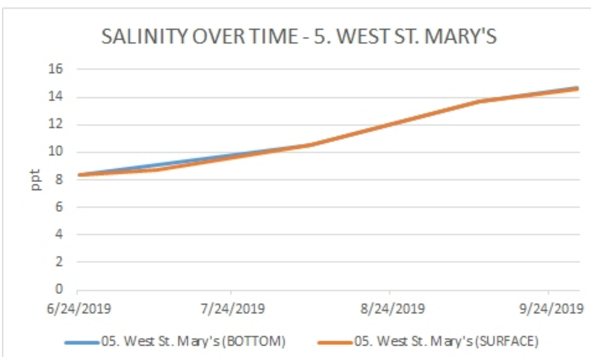


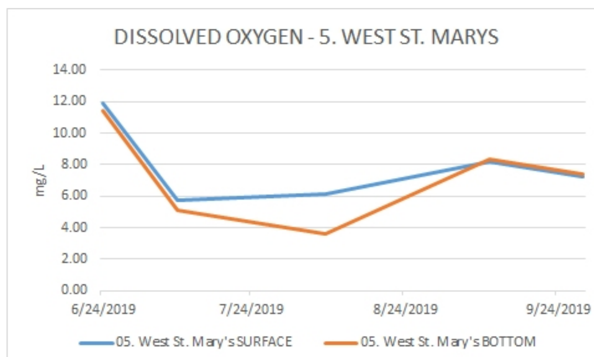
Figures 25 & 26. Salinity and Dissolved Oxygen at Seminary

Site 05. West St. Mary's is located along the western shore 400 meters south of the southern sanctuary boundary. Traps were placed in water depth of 6 to 7 feet MLW. The bottom was a low-density oyster bar in sand/shell mix bottom type. Existing oyster density was 16 oysters in the one square meter sample; all of them more than two years old and only two market-size (3 inches). SAV was somewhat present in the near vicinity, although SAV was in patches closer to the shoreline beginning in waters about 4 feet deep MLW. Salinity (bottom) at this site was 8.4 ppt on June 24th, 10.5 ppt on August 8 and 14.7 ppt on September 29. Dissolved oxygen (bottom) varied reaching the lowest in August and rising in September (DO was 5.09 mg/L on July 9 and 3.62 on August 8). Spatfall was 38 of which 55% were over 25mm; the largest one measured 55mm and the smallest two measured 12mm.



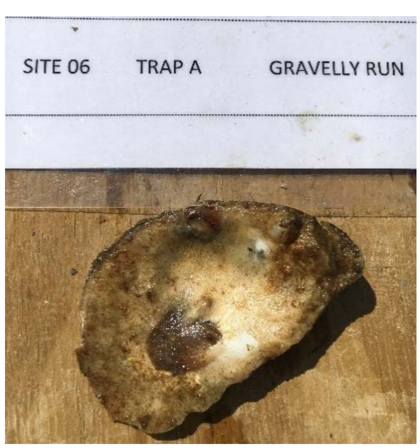
Figures 27 & 28. Photos of spat from West St. Mary's



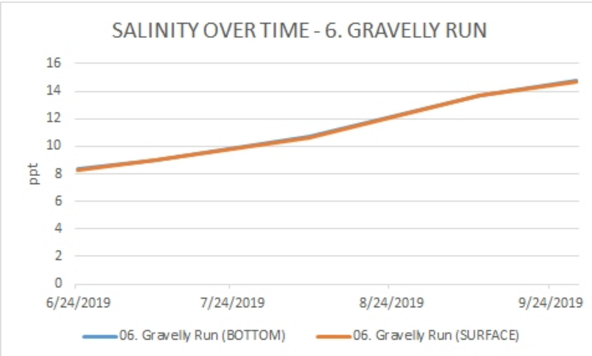


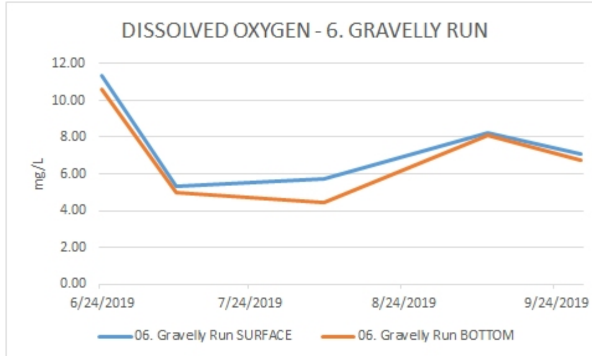
Figures 29 & 30. Salinity and Dissolved Oxygen at West St. Mary's

Site 06. Gravelly Run is located along the eastern shore 675 meters south-southeast of the southern sanctuary boundary. Traps were placed in water depth of 6.5 to 7 feet MLW. The bottom was a low-quality oyster bar in a hard sand/shell mix bottom type. Existing oyster density was 11 oysters in the one square meter sample; all of them more than two years old. No SAV was present in the near vicinity. Salinity (bottom) at this site was 8.4 ppt on June 24th, 10.7 ppt on August 8 and 14.8 ppt on September 29. Dissolved oxygen (bottom) dipped during the summer months although not as much as areas upriver. (DO was 4.97 mg/L on July 9 and 4.46 on August 8) Spatfall was 31 of which 45% were over 25mm; the largest one measured 54mm and the smallest two measured 10mm.



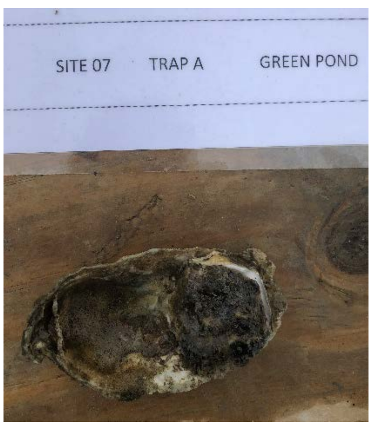
Figures 31 & 32. Photos of spat from Gravelly Run



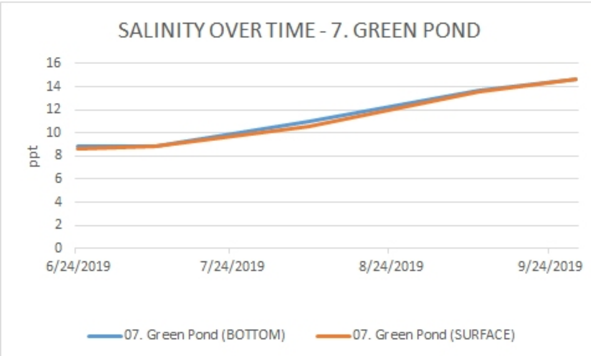


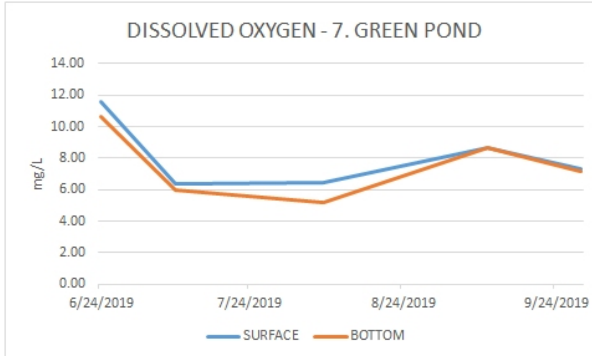
Figures 33 & 34. Salinity and Dissolved Oxygen at Gravelly Run

Site 07. Green Pond is located along the eastern shore 1.6 kilometers south of the southern sanctuary boundary and 625 meters north of Chancellor's Point. Traps were placed in water depth of 7 feet MLW. The bottom was recently shelled (2-3 weeks prior to sampling?) and below it was a firm mud/sand bottom type. Shell depth varied from 7 inches to 10 inches. Existing oyster density was 13 oysters in the one square meter sample; all of them more than two years old. No SAV was present in the near vicinity. Salinity (bottom) at this site was 8.8 ppt on June 24th, 11.0 ppt on August 8 and 14.6 ppt on September 29. Dissolved oxygen (bottom) dipped during the summer months although not as much as areas upriver. (DO was 5.94 mg/L on July 9 and 5.19 on August 8) Spatfall was 53 of which 64% were over 25mm; the largest one measured 51mm and the smallest measured 7mm.



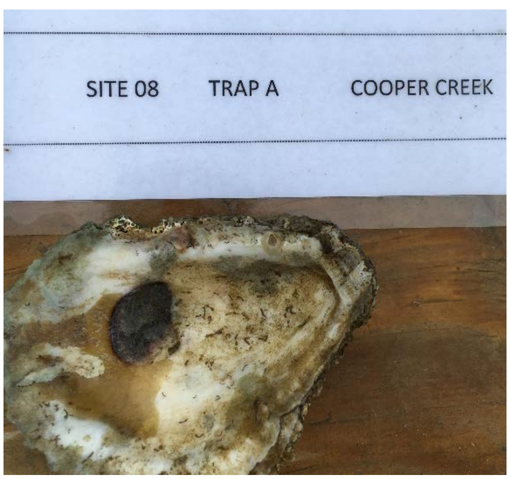
Figures 35, 36, & 37. Photos of spat from Green Pond (Center: Note spat-on-spat-on-shell)



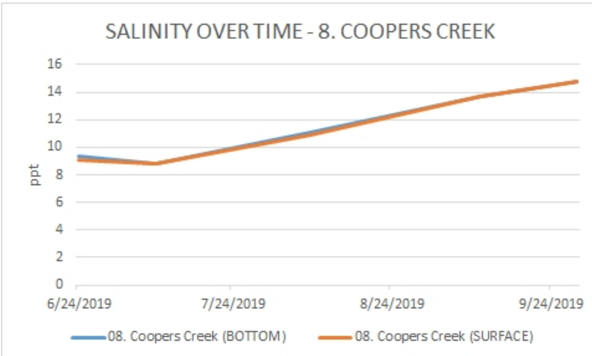


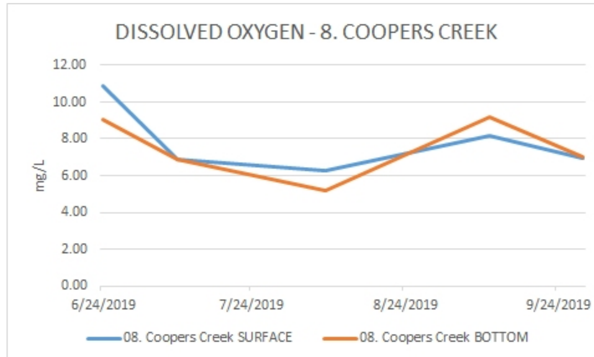
Figures 38 & 39. Salinity and Dissolved Oxygen at Green Pond

Site 8. Cooper Creek is located along the western shore 2.7 kilometers south of the southern sanctuary boundary and 1.3 kilometers west of Chancellor's Point. Traps were placed in water depth of 8.5 feet MLW. The bottom was firm mud/shell fragments bottom type. Existing oyster density was 3 oysters in the one square meter sample; all of them more than two years old. No SAV was present in the near vicinity; there were broad dense patches of SAV near shore in 3 to 4 feet MLW. Salinity (bottom) at this site was 9.4 ppt on June 24th, 11.1 ppt on August 8 and 14.8 ppt on September 29. Dissolved oxygen (bottom) dipped during the summer months although not as much as areas upriver. (DO was 6.91 mg/L on July 9 and 5.17 on August 8) Spatfall was 57 total of which 66% were over 25mm; the largest one measured 54mm and the smallest measured 7mm. Spat 10mm and under (4) represented 7% of the total showing that a late spawn in the area was somewhat successful.



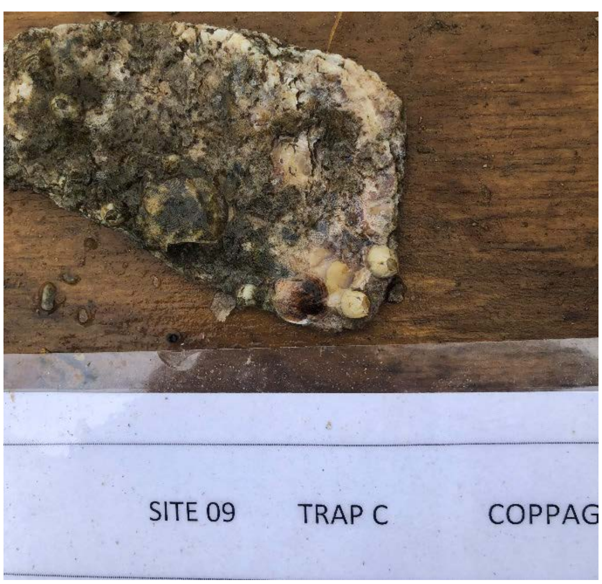
Figures 40 & 41. Photos of spat from Coopers Creek

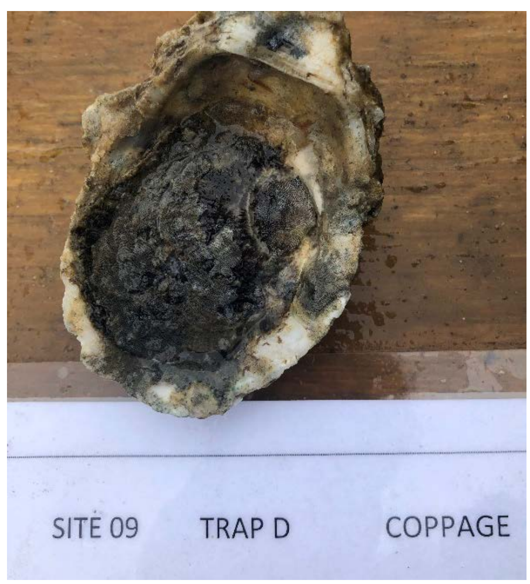




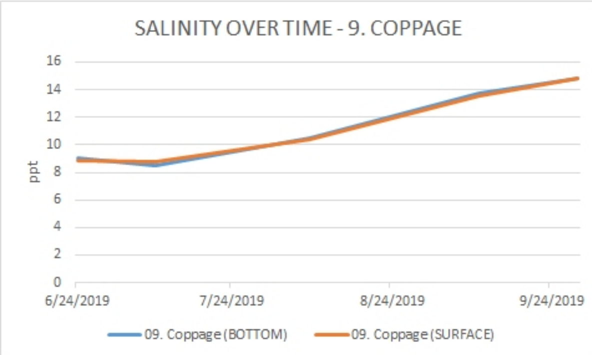
Figures 42 & 43. Salinity and Dissolved Oxygen at Coopers Creek

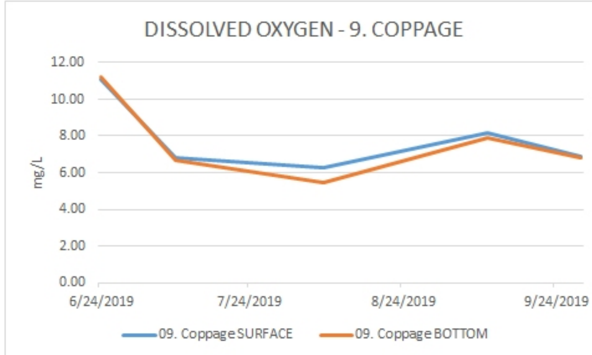
Site 9. Coppage is located along the western shore 3.0 kilometers south of the southern sanctuary boundary and 900 meters southwest of Chancellor's Point. Traps were placed in water depth of 6.5 feet MLW. The bottom was a sparse oyster bar over fine sand and shell fragments. Existing oyster density was 12 oysters in the one square meter sample; all but one of them more than two years old. No SAV was present in the near vicinity; there were broad dense patches of SAV nearer to shore in 2.5 to 5 feet MLW. Salinity (bottom) at this site was 9.0 ppt on June 24th, 10.5 ppt on August 8 and 14.8 ppt on September 29. Dissolved oxygen (bottom) dipped during the summer months although not as much as areas upriver. (DO was 6.70 mg/L on July 9 and 5.46 on August 8) Spatfall was 39 of which two-thirds were over 25mm; the largest one measured 48mm and the smallest measured 7mm.





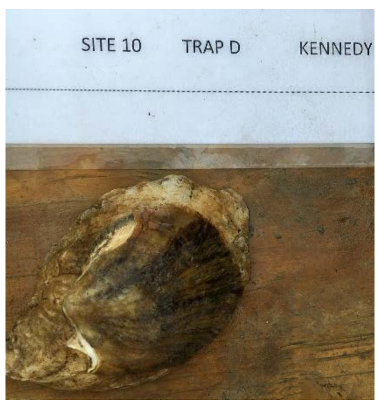
Figures 44 & 45. Photos of spat from Coppage

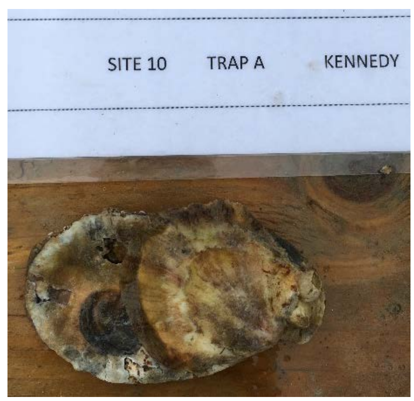




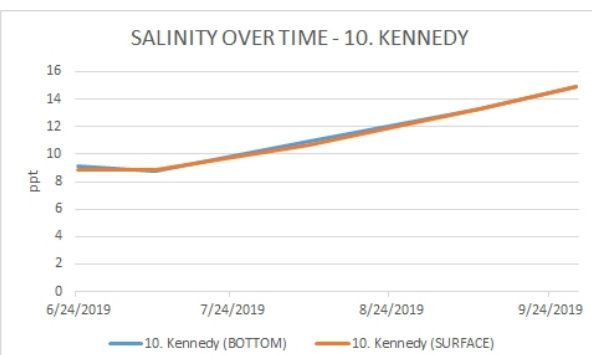
Figures 46 & 47. Salinity and Dissolved Oxygen at Coppage

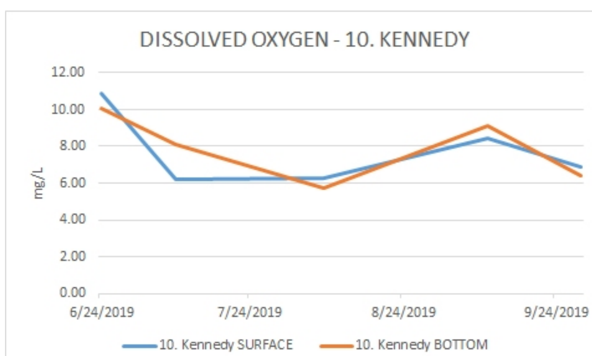
Site 10. Kennedy is located on the northern shore of St. Inigoes Creek near its mouth and is 3.4 kilometers south of the southern sanctuary boundary and 1.3 kilometers southeast of Chancellor's Point. Traps were placed in water depth of 6.5 to 7 feet MLW. The bottom was a semi firm mud with dense SAV covering 80% of the bottom area. No living oysters were found in the one square meter sample. Salinity (bottom) at this site was 9.1 ppt on June 24th, 10.9 ppt on August 8 and 14.9 ppt on September 29. Dissolved oxygen (bottom) dipped slightly during the summer month. (DO was 6.70 mg/L on July 9 and 5.46 on August 8) Spatfall was 40 of which 73% were over 25mm; the largest one measured 65mm and the smallest measured 6mm.





Figures 48, 49, & 50. Photos of spat from Kennedy

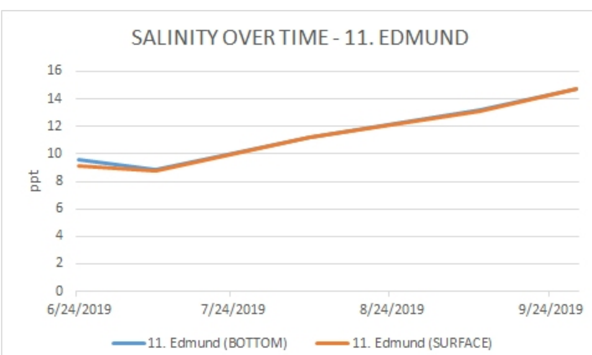


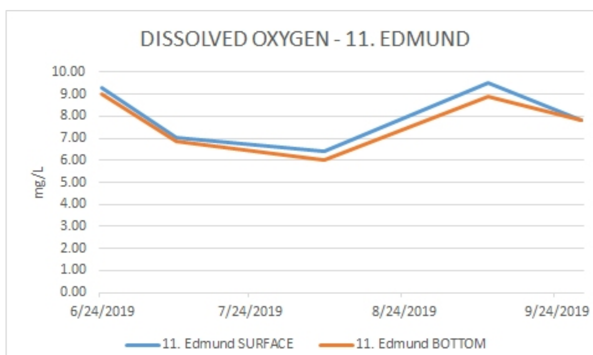


Figures 51 & 52. Salinity and Dissolved Oxygen at Kennedy

Site 11. Edmund is located along the western shore 6.0 kilometers south of the southern sanctuary boundary and 1.7 kilometers west of Fort Point. Traps were placed in water depth of 6.5 feet MLW; the area was host to over 100 crab pots and we chose a study site toward shore to create a small distance from most of the pots. The bottom was hard sand with small shell fragments. Existing oyster density was zero oysters in the one square meter sample; no oysters were spotted during the bottom surveys. Very sparse SAV was present within the study site; there were patches of SAV nearer to shore (5 feet of less MLW) and dense patches over 20% of the bottom in water 3 feet MLW. Salinity (bottom) at this site was 9.6 ppt on June 24th, 11.2 ppt on August 8 and 14.7 ppt on September 29. Dissolved oxygen (bottom) was healthy through the study timeline and averaged the highest dissolved oxygen of the thirteen study sites. (DO was 8.13 mg/L on July 9 and 5.72 on August 8) Spatfall was 11 of which ten were over 25mm; the largest one measured 58mm and the smallest measured 14mm.

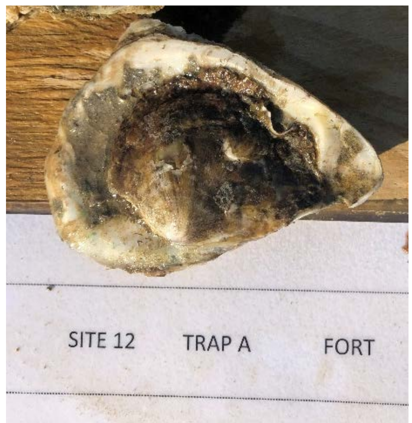
Figures 53 & 54. Photos of spat from Edmund



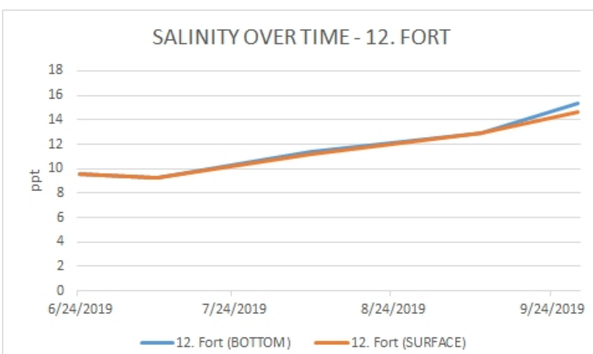


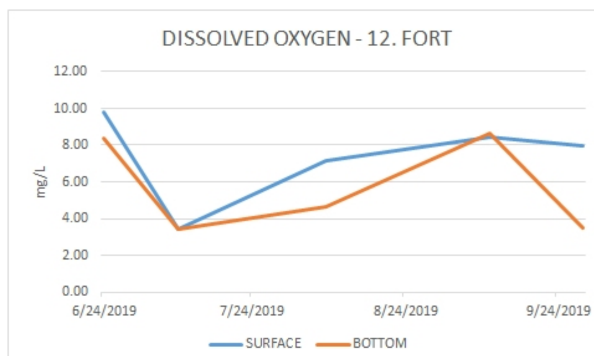
Figures 55 & 56. Salinity and Dissolved Oxygen at Edmund

Site 12. Fort is located along the eastern shore 6.7 kilometers south of the southern sanctuary boundary and 2.5 kilometers east of Cherryfield Point. Traps were placed in water depth of 7.5 to 9 feet MLW. The bottom was a soft sand with very little shell fragments. Existing oyster density was zero oysters in the one square meter sample; no oysters were seen nearby during the bottom survey. No SAV was present in the near vicinity; sparse patches was observed nearer to shore in 5.5 feet MLW. Salinity (bottom) at this site was 9.6 ppt on June 24^{th}, 11.4 ppt on August 8 and 15.4 ppt on September 29. Dissolved oxygen (bottom) dipped during the summer months to levels indicating stress to aquatic organisms. (DO was 3.43 mg/L on July 9 and 4.63 on August 8) Spatfall was 16 of which 38% were under 10mm; the largest one measured 60mm and the smallest measured 5mm.



Figures 57 & 58. Photos of spat from Fort

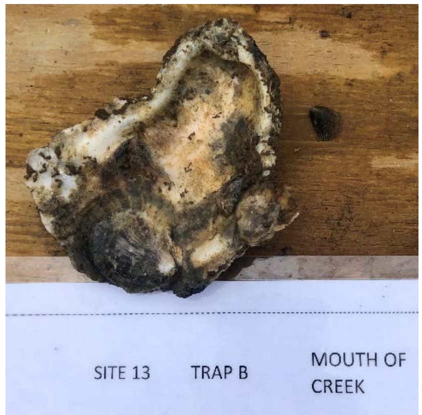




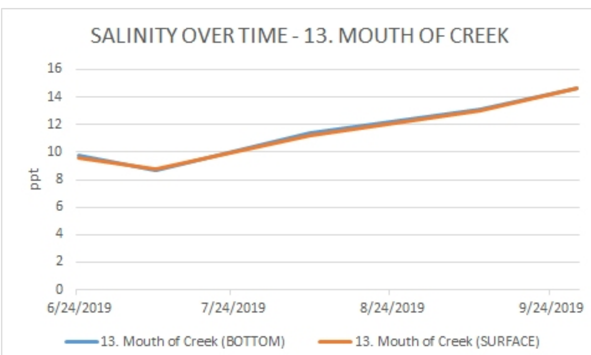
Figures 59 & 60. Salinity and Dissolved Oxygen at Fort

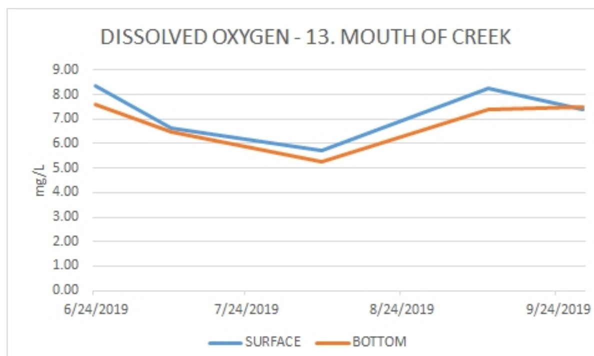
Site 13. Mouth of Creek is located along the northern shore of St. George Island 8.5 kilometers south of the southern sanctuary boundary and 720 meters southeast of Russell Point. Traps were placed in water depth of 7.5 feet MLW. The bottom was hard sand with very few shell fragments. Existing oyster density was zero oysters in the one square meter sample; no oysters were observed near the study site during the bottom survey. No SAV was present in the near vicinity. Salinity (bottom) at this site was 9.8 ppt on June 24^{th}, 11.4 ppt on August 8 and 14.6 ppt on September 29. Dissolved oxygen (bottom) remained at fairly healthy levels throughout the study timeline.(DO was 6.46 mg/L on July 9 and 5.47

on August 8) Spatfall was 14 of which 50% were over 25mm; the largest one measured 45mm and the smallest measured 6mm.



Figures 61 & 62. Photos of spat from Fort





Figures 63 & 64. Salinity and Dissolved Oxygen at Fort

Recommendations

1. The study timeline should be extended in order to evaluate any late-season spawn and spatfall. Discussions with local watermen (Brian Hite, Jeff Pharis) suggest that this recommendation is strongly supported by the county oyster committee and watermen working in the St. Mary’s system. The study methodology does not impose any significant hardship or restrictions on the harvest of oysters during the month of October, a time when only hand tongs are an authorized method for harvest. Dredging begins on November 1. Therefore we strongly recommend that the traps be deployed on the study sites through most of October and be removed to a holding site for analysis prior to November 1.
2. In order to reduce the study work load, eliminate West St. Mary’s from future studies. This site is not remarkable in any way and continues to endure heavy harvest pressure. (Dredging was occurring over several days in March 2018 – very late in the season. We observed harvest of one or two oysters per lick and the average tow time was over two minutes.) We also suggest eliminating one of the three farthest downstream sites as well – possibly adding a new site.

3. Breeding success and larval production is closely related to oyster density, expanse of oyster bar area, and prohibition from harvest. The greater the number of oysters in multiple-age classes, the greater the success in larval production. (Puckett & Eggleston. 2012) Puckett and Eggleston, in the article cited, collate a body of science in a convincing argument that sanctuaries and no-harvest zones are essential tools in the management of oysters. Their work supports the notion that effective placement and size of sanctuaries may be the most critical factor in maintaining any level of wild fishery. If no-harvest areas are left to the public fishery, bar size dwindles and oyster density remains low (under 150/square meter) thereby lacking the density and the overall area for breeding success and larval production. The lower St. Mary's River may be a useful area to study this claim as there appear to be no significant areas of high density oysters. Industry planted over 8000 bushels of shell on several acres at Green Pond this past July. Were industry to leave this area out of harvest for an extended period until its density reached at least 150 oysters per square meter and support multi-age classes, one would expect spatfall in the vicinity to increase substantially—possibly fivefold (Puckett & Eggleston. 2012).

Potential impacts that a harvest (seed or mature) could have on the no-harvest or sanctuary areas could be tremendous. According to Beck (2012), areas that have been harvested for oysters have more loose shell, more mud, and higher levels of Chlorophyll-a. From this it can be inferred that harvest from a restricted site would have detrimental impacts on the surrounding established oyster colonies. Additionally, the spawning and settlement of spat is based upon temperature, salinity, and availability of food (Dekshenieks et al. 1993). The biotic and abiotic conditions that foster strong oyster spatfall remain fairly constant throughout the St. Mary's River. The exception to this is that oyster larvae prefer to settle on hard surfaces, which are not found everywhere in the river (Kennedy et al. 1996). However, sandy bottoms with shell installations make spat settlement possible throughout the entirety of the St. Mary's River. The one that affects this ability to recruit spat nearly everywhere with firm sandy bottom and shell enhancement is that larvae settlement is greatly reduced in salinity levels below 14 ppt and becomes nominal below 8 ppt and does not occur often below 6 ppt (Dekshenieks et al. 1993). The 2018 season had higher than average rainfall causing lower than normal salinity to linger into July of 2019. This low-salinity change is consistent with long-term forecasting in the region due to climate change (Thomas et al. 2009). Therefore, it should be anticipated that lower salinity levels will become the norm. The sanctuary typically has lower salinity than the area outside the sanctuary since it is upriver where fresh waters enter the system from rainfall.

This argument posed by Puckett and Eggleston should inform decisions whether to allow or prohibit aquaculture in sanctuaries. The harvest of farmed oysters on areas in proximity to high density oyster bars has a detrimental effect in both areas. Sanctuaries designated for the purpose of oysters' well-being are greatly compromised by farming and lose much of what was hoped would be gained by designating the sanctuary in the first place. Moreover due to the lack of any high density, multi-age class oysters in the lower St. Mary's, it should be assumed that recruitment will remain lackluster most years. Additional sanctuary areas in the lower St. Mary's would greatly enhance the effectiveness of shelled restricted areas and likely increase overall harvests.

Additional Information Related to this Study

The ability and desire to include youth in the Association's work is shared by the College as it is their mission to serve a student body.

The Association employed two students from Great Mills High School Science Technology Engineering and Mathematics Academy during 2019. Jack O'Brien, now a graduate, studied recruitment in 2018 and returned this year to become a field supervisor and work vessel operator. Jack is currently enrolled at Vassar College. Hannah Jarboe began employment in April 2019 and is currently a senior in the GMHS STEM Academy. Jack in 2018 and Hannah in 2019 incorporated data collected in the recruitment studies in their summer capstone project, a requirement of their STEM degree. During the summer Jack and Hannah learned scuba techniques and became accomplished divers being able to effectively work under water. Mentoring by the recruitment study director, Bob Lewis, ensured scientific rigor and protocols that required data notation verification.

The College employed one student, James "Toby" Beauregard, part time for the summer and fall. Toby, already a certified scuba diver and an aspiring scientist, was able to refine his skillset and apply his learning to real-world applications. All three students were valuable assets during the study.

The Association has a working partnership with the STEM 5th graders at Lexington Park Middle School. These students learned about oysters through in-classroom presentations and one field trip during their 4th grade year. The forty-eight STEM 5th graders came to the College waterfront on September 30 to gain an understanding of how their STEM education can play into real world science and study, and how that work can inform policy and regulatory matters. Department staffers, Jodi Baxter and Laurinda Serafin, also attended this event and were able to work with the students. Students learned about water quality and test instruments, they engaged in discussions about oyster ecosystem services, they heard from this study's director and a marine scientist, Professor Christopher Tanner, about opportunities to refine their education in order to pursue their vision, their interests, and a career. *And* these students were able to be involved in this study with hands-on counting, measuring, and recording of the spatfall. While the data they collected was not included as part of this report, it is being used in their continuing classwork.

* * * * * * * * * * * *

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APPENDIX A

[The following is excerpted from the Maryland Department of Natural Resources "Oyster Spat Recruitment Study 2019 v1" – the scope of work for this study.]

Site Selection

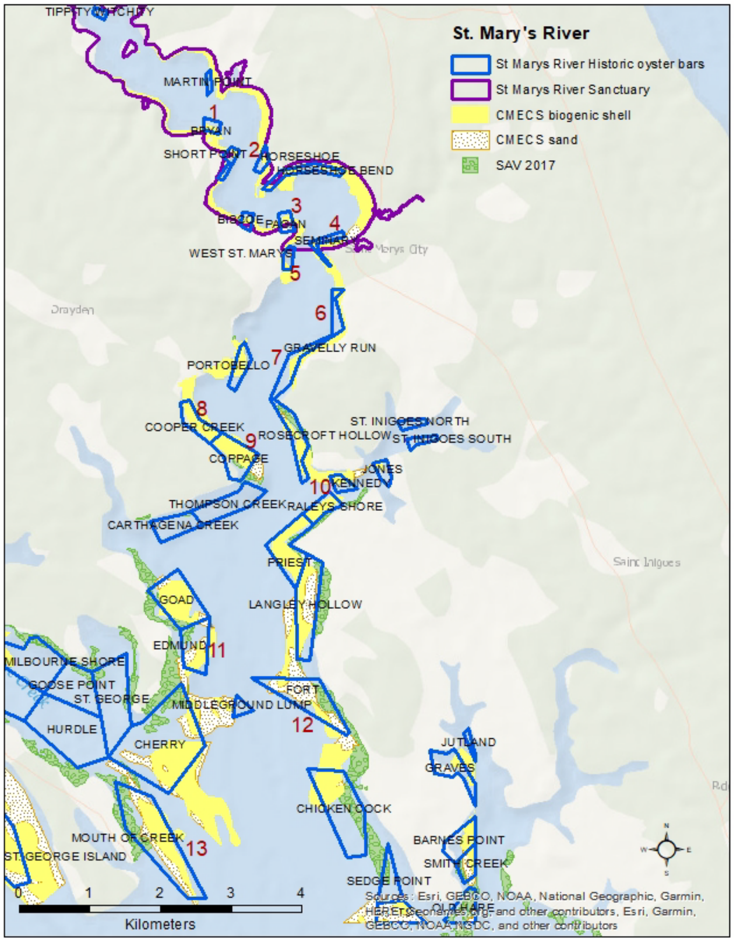
Study site locations were chosen based on a prior study conducted by the St. Mary's River Watershed Association, areas that have hard benthic substrate, areas that are on oyster bars, and the goal of evaluating sites along the entire extent of the river (Figure 1).

Past number of spat per bushel of material reported from the Annual Oyster Dredge Survey from 2009 to 2018 was examined to determine areas that have received a spatfall in the past (Figure 2). Areas with high average spatfall were considered first. Past reported harvest (average from 2010-2011 to 2017-2018 seasons) was also examined to determine productive harvest areas (Figure 3). Areas that had low levels of harvest were considered before areas of high levels of harvest. This was to avoid potential conflict with harvest if the decision was made in the future to place a seed area. Lastly, the amount of shell and oysters collected per tow area swept (average from 2010-2011 to 2017-2018 seasons) was examined to provide information about the amount of existing habitat on oyster bars (Figure 4). Areas with a high habitat area were preferred.

Based on hard benthic substrate within existing oyster bars, areas that were studied by the St. Mary's River Watershed Association, past spatfall, past harvest, and past habitat volume, thirteen sites in total were chosen; four within the oyster sanctuary boundary and eight in the public fishing areas (Figure 1. Table 1). Study areas will be placed on hard bottom, in areas that are at least 5 feet deep of water at mean low water, and not within submerged aquatic vegetation areas (SAV).

Four sites were chosen within the sanctuary, Bryan, Horseshoe, Pagan and Seminary. Horseshoe and Pagan are Fall Survey sites and have exhibited high spatfall in the past and have a high habitat volume. Bryan was chosen for its benthic habitat and location within the river, it is the site chosen farthest upstream. Seminary was chosen due to its benthic habitat areas as well as its location being the farthest downstream, but still within the sanctuary boundary. Five sites were chosen because they were sites examined for spatfall by the St. Mary's River Watershed Association in the 2018 season. These include West St. Mary's, Gravelly Run-Green Pond, Gravelly Run, Cooper and Coppage. These sites all have areas of hard benthic bottom and cover the mid extent of the river. Gravelly Run-Green Pond has a low spatfall count from the Fall Survey, but a comparatively high habitat volume. Gravelly Run has a high spatfall from the Fall Survey and a high habitat volume. West St. Mary's had a relatively low average harvest (<100 bushels) and did exhibit some spatset in the 2018 study. Cooper exhibited the largest spatfall of the areas examined in 2018 by the SMRWA. Coppage had the second highest spatfall in the 2018 SMRWA study and has a high average spatfall from the Fall Survey data. Four additional sites were chosen to cover the lower extent of the river, Kennedy, Edmund, Fort and Mouth of Creek. Kennedy and Edmund both have had low levels of harvest and are located within the beginning lower extent of the river. Fort had an average harvest just over

100 bushels and is at a location on the lower eastern section closer to the mouth of the river. Mouth of Creek has a historic low average harvest (<100 bushels) and is at the western mouth of the river.



Site Number	Latitude	Longitude
1	38.203	-76.456
2	38.199	-76.447
3	38.192	-76.443
4	38.189	-76.437
5	38.186	-76.443
6	38.183	-76.435
7	38.174	-76.442
8	38.167	-76.459
9	38.162	-76.452
10	38.159	-76.434
11	38.136	-76.457
12	38.129	-76.437
13	38.114	-76.463

Figure 1. The study sites on historic oyster bars, areas of hard benthic bottom classification from the 2010 Maryland Geologic Survey, and areas with submerged aquatic vegetation.

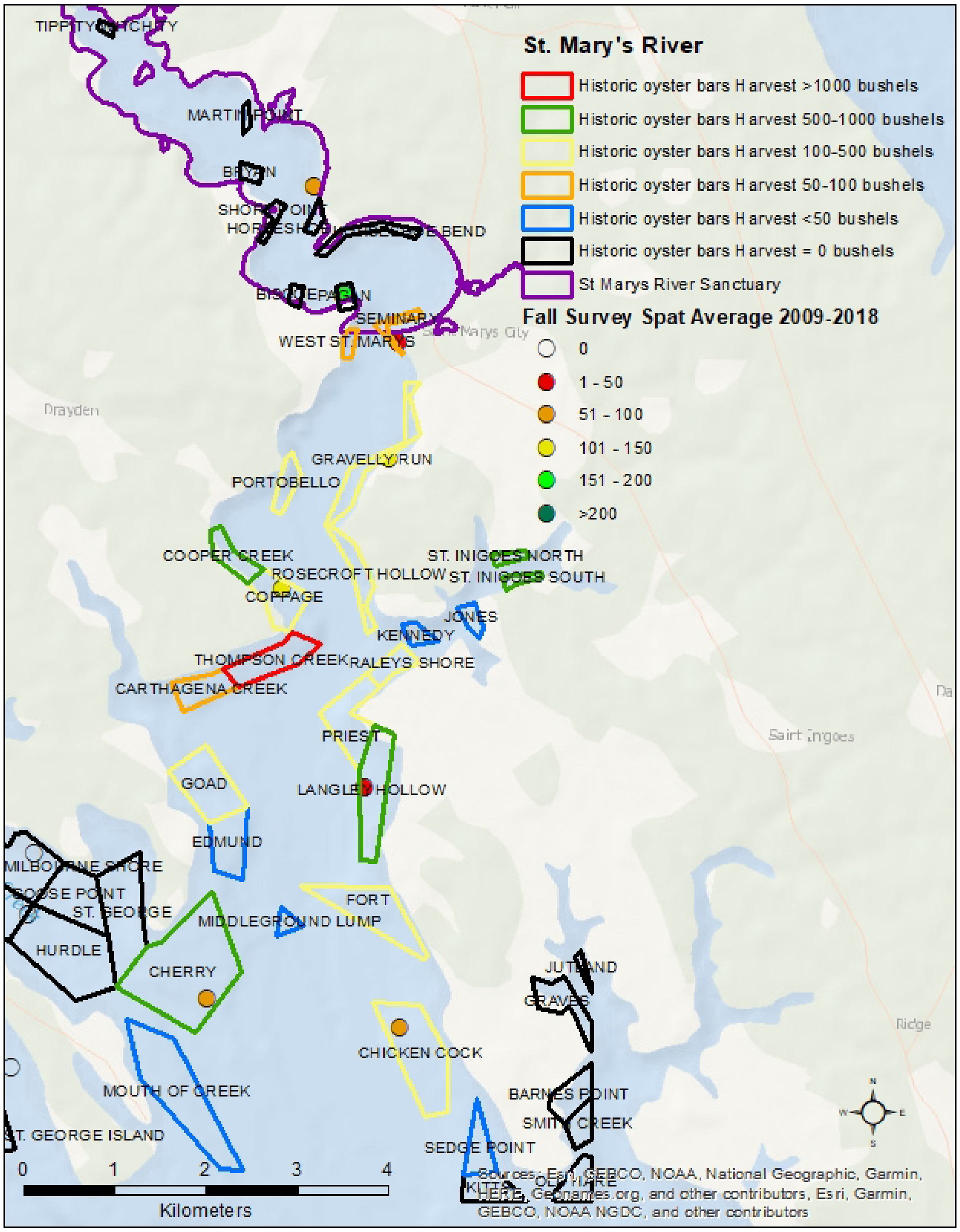


Figure 2. The 2018-2019 oyster harvest by Yates bars and the average spat from 2009-2018 from the MD DNR Fall Oyster Survey in the St. Mary's River.

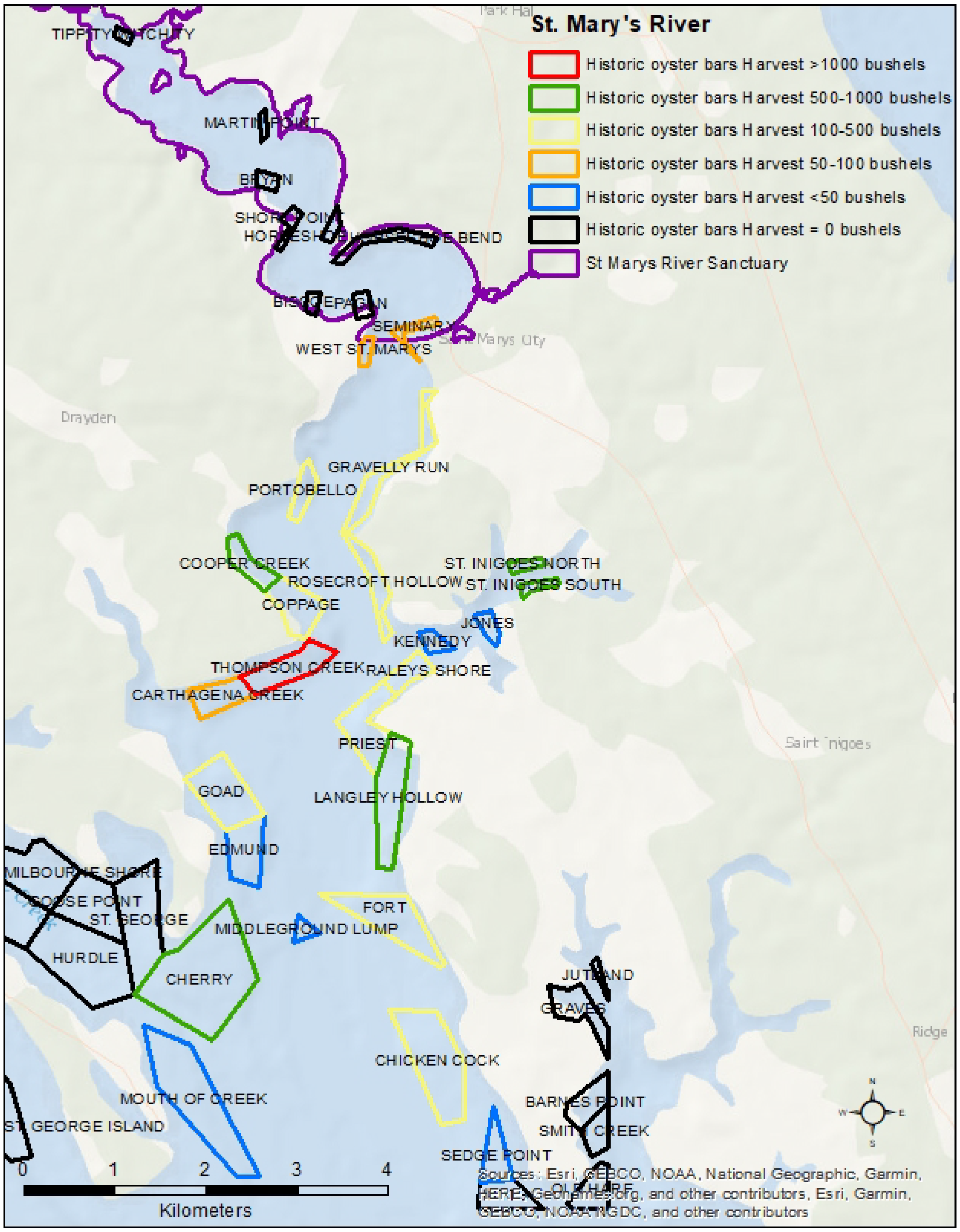


Figure 3. The average bushels of oyster harvested from the 2010/2011-2017/2018 seasons on historic oyster bars in the St. Mary’s River.

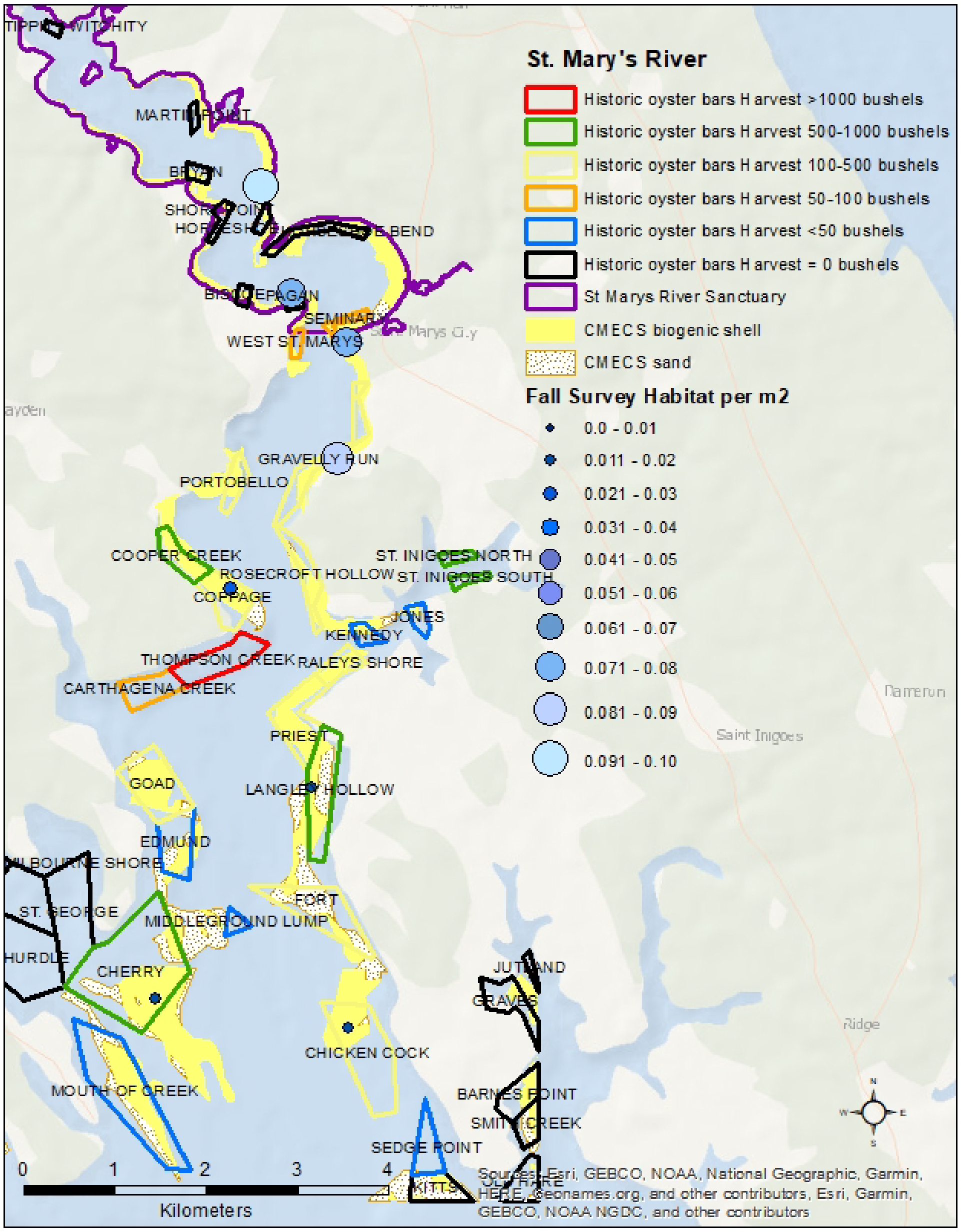


Figure 4. The 2018-2019 oyster harvest by Yates bars and the average habitat per meter squared calculated from dredge tow distance and dredge volume for the MD DNR Fall Oyster Survey in the St. Mary’s River.

Table 1. Study sites, historic oyster bars, and factors for their consideration. Bold factors contributed to their being chosen.

Study Site	Historic Oyster Bar	Within Sanctuary Boundary	SMRWA Prior Site	Benthic Habitat	FS habitat (per m^2)	FS Spatset (per bushel)	SMRWA spat (#/site)	Harvest (bushels)	River Extent
1	Bryan	**Yes**	No	**Biogenic shell**	N/A	N/A	N/A	N/A	**Upper West**
2	Horseshoe	**Yes**	No	**Biogenic shell**	**0.1**	**95**	N/A	N/A	Upper East
3	Pagan	**Yes**	No	**Biogenic shell**	**0.08**	**161**	N/A	N/A	Upper West
4	Seminary	**Yes**	No	**Biogenic shell**	N/A	N/A	N/A	N/A	**Upper East**
5	West St. Mary's	No	**Yes**	**Biogenic shell**	N/A	N/A	~33	83.3	Upper West
6	Gravelly Run- Green Pond	No	**Yes**	**Biogenic shell**	**0.08**	47	~20	(reported with Gravelly Run)	Mid East
7	Gravelly Run	No	**Yes**	**Biogenic shell**	**0.09**	**122**	**~55**	394.7	Mid East
8	Cooper Creek	No	**Yes**	**Biogenic shell**	N/A	N/A	**~62**	793	Mid West
9	Coppage	No	**Yes**	**Biogenic shell**	0.03	**130**	**~52**	213.2	Mid West
10	Kennedy	No	No	**Biogenic shell**	N/A	N/A	N/A	17.3	**Mid East**
11	Edmund	No	No	**Biogenic shell**	N/A	N/A	N/A	16	**Lower West**
12	Fort	No	No	**Biogenic shell / sand**	N/A	N/A	N/A	107	**Lower East**
13	Mouth of Creek	No	No	**Biogenic shell / sand**	N/A	N/A	N/A	17.5	**Lower West**