PEI Oyster Monitoring Program

2024 Report

Technical Report # 284

By

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ACKNOWLEDGEMENTS

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INTRODUCTION

The PEI oyster industry produces world famous oysters with a landed value of approximately $24M (2023; Figure 1). Over the past 15 years, the annual landings have doubled, and the value has almost tripled. The Oyster Monitoring Program (OMP) is a technical service provided to PEI oyster growers by the Department of Fisheries, Tourism, Sport and Culture (DFTSC) to support this growing industry. The OMP has been operated annually since 2001 and is designed to provide Island oyster growers with information to assist them in oyster seed collection and the management of their oyster farms.

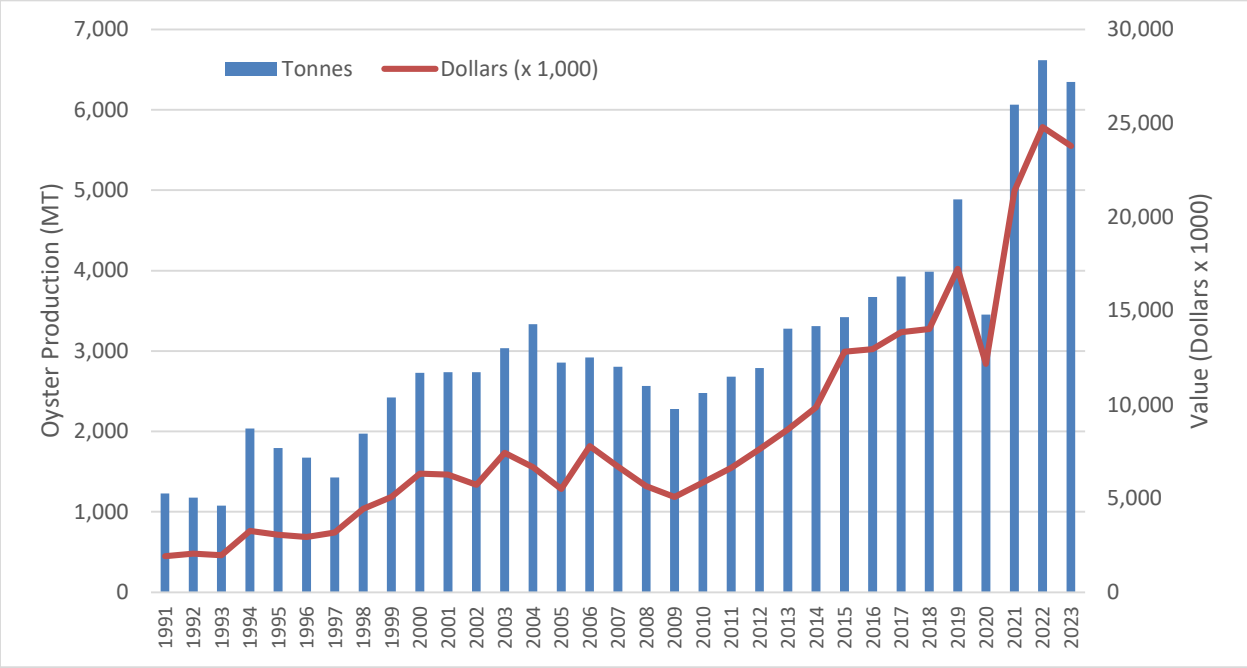


Figure 1. PEI oyster landings and values, 1991-2023.

The OMP's primary purpose is to collect and provide information on larvae abundance and size to oyster growers to assist them in deciding when to deploy their spat collectors (Figure 2). Sampling is conducted at several sites across the province; however, sampling effort is highest in Bideford River, Foxley River, East River and the Vernon-Orwell system (primary sites) which are the major oyster seed collection areas on PEI. Monitoring is typically conducted between June and August and results are communicated to growers throughout the oyster spawning season.

Figure 2. Oyster seed collectors.

As this industry has grown and developed the interest in new technologies and innovations has also increased. The adoption of off-bottom growing practices has become popular with many Island growers. This practice involves growing the oysters in floating bags or cages at or near the surface of the water (Figure 3). The bags or cages are also able to be flipped to expose them to air and sun periodically (typically every 2-3 weeks) for a short period (often 24 hours). This helps to remove most fouling and results in cleaner oysters and growing equipment. The use of off-bottom technology has proven to be an effective growing method, resulting in oysters reaching market size at a quicker rate than when grown at the bottom.

Initially, PEI was primarily leased for growing oysters on the bottom. As interest grew in off-bottom growing techniques, leases changed, and many growers purchased new leases or requested to change their existing bottom lease to an off-bottom lease (OB/Surface). Many growers raised concerns about food availability as the industry developed and wanted to ensure oyster productivity was not being adversely affected. The Foxley River area had significant adoption of these new off-bottom growing techniques. In 2013, the Oyster Growth Program was initiated to gather information on the growth rates within this area. Four locations within Foxley River (Dump Road, Portage, Lot 6 Pt, Gibb's Creek) and three other areas (Percival River, Bideford River, and Savage Harbour) were selected to gather growth data for comparison. Comparing the oyster growth in Foxley River to other regions, which had not seen as significant of a change in leasing structure, aimed to provide insight into the potential impacts of increased off-bottom oyster culture on overall oyster productivity. Prior to 2023 the Oyster Growth Monitoring program was conducted with a focus on Foxley River; monitoring changes in growth rates as bottom culture leases were being converted to off-bottom leases in that area. The data showed that there was a consistent growth rate at all sites, year to year. The Program was reviewed prior to the 2023 monitoring season and the sites were adjusted to lessen the focus on the Foxley River system and improve representation of other PEI oyster growing areas in the monitoring program.

Figure 3. Off-bottom oyster culture.

MATERIALS & METHODS

LARVAE MONITORING

Oyster Monitoring Program data was collected from 16 monitoring sites in 2024 (Figure 4). Sampling locations in Eastern/Central PEI included East River (Cranberry Wharf), Pownal Bay, Orwell River, Vernon River, and Rustico Bay. Western sampling locations included three sites in Bideford River (Station, Paugh's Creek, and Green Park), three sites in Foxley River (Goff's Bridge, Lot 6 Pt. and Gibb's Creek), Enmore River, Percival River, Dock River, Darnley Basin, and Grand River.

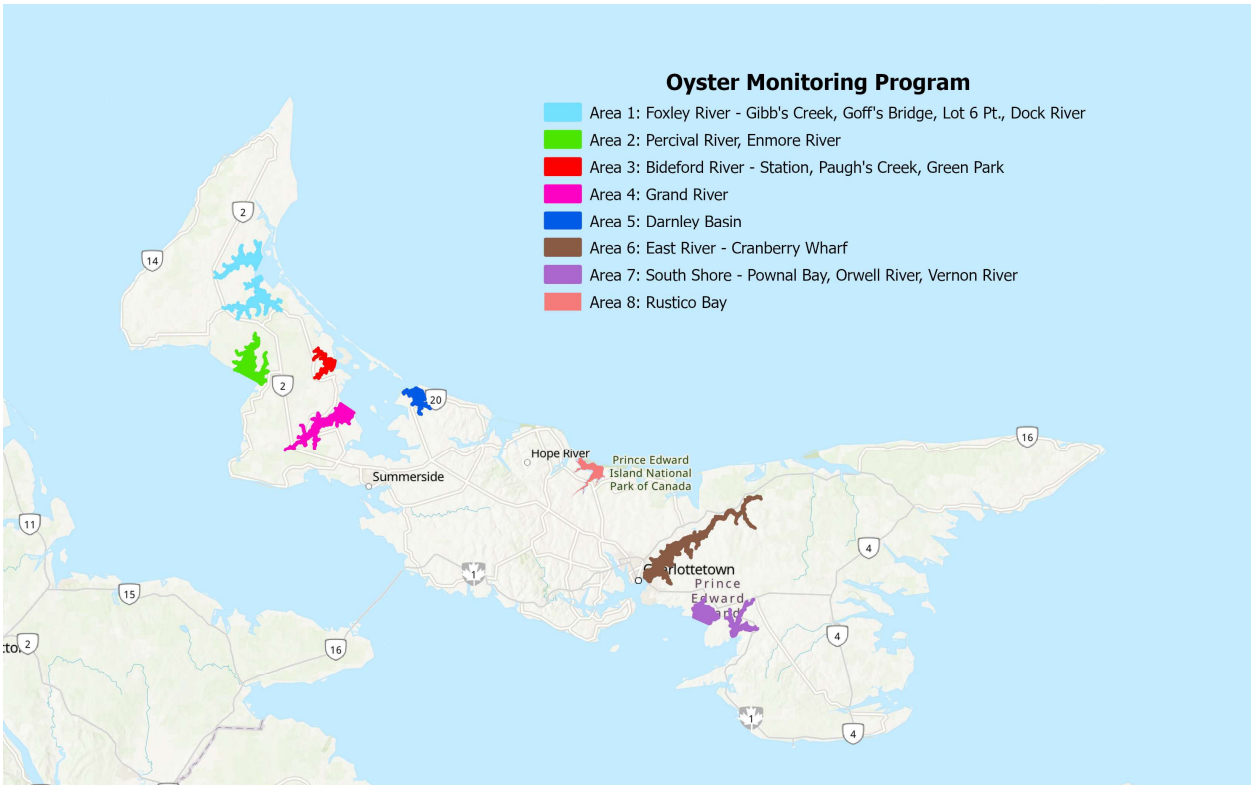


Figure 4. Map of PEI showing the general location of 2024 OMP sampling sites.

Larvae samples were collected from June 24 to August 6. Sampling frequency at each site ranged from 1-3 times per week depending on amount of collection in an area, and with more frequent sampling occurring during the peak setting period (mid-July to early August). In 2024, with the detection of MSX in Island waters, sampling frequencies were adjusted to allow adequate time for cleaning and disinfection between sample sites to reduce the risk of transferring the disease

(primary sites reduced from 3 times/week to 2 times/week; secondary sites were sampled 1-2 times/week). Samples were obtained by towing a 2.5 m (5 ft) long plankton net (30 cm diameter mouth, 63 µm mesh net and bucket), from the surface to mid water column, at idle speed for approximately 5 minutes (Figure 5, *left*). Samples were transferred to a 1 L bottle and taken to the lab for analysis. The water temperature and salinity were recorded at each site at the time of sampling. To help isolate oyster larvae in the lab, samples were sorted by size using two sieves (44 µm and 308 µm). The screened sample was then transferred to a 1 L beaker, where it was stirred to concentrate the contents at the bottom of the beaker. A 1 mL subsample was collected using a pipette and placed on a gridded slide for microscopic examination (Figure 5, *right*). The concentration, total number of larvae, size range of oyster larvae in sample and larvae >250 µm (250 µm larvae take 1-3 days to reach a setting size of 365 µm) in the subsample were measured and recorded.

Figure 5. Plankton net used for sampling (*left*) and DFTSC personnel examining oyster larvae sample in the lab (*right*).

If the subsample contained a very high number of larvae, half of the slide was examined, and an estimate provided for the total number of larvae for the 1 mL subsample. The concentration, total number, and size range for all oyster larvae and for larvae >250 µm, as well as water conditions (temperature and salinity) were uploaded to the Oyster Monitoring website (https://www.princeedwardisland.ca/en/feature/view-oyster-monitoring-results#/service/OysterMonitoring/OysterMonitoringSearch) and recorded on the OMP's voice mail system (1-888-831-5801).

SPAT-FALL

The level and timing of setting oyster larvae (i.e. spat) are normally monitored at the 'Station' site (Bideford River) and the Lot 10/Goff's Bridge site (Foxley River) and Vernon River using shell collectors consisting of ~6 ft lengths of galvanized wire with three Bar Clam shells placed at different locations on the wire: 30 cm (1 ft), 60 cm (3 ft), and 90 cm (5 ft) (Figure 6). Shell collectors are normally hung from collector lines for 7 days, retrieved and taken to the lab for analysis. Recently set oyster spat are identified and the total number for each shell counted using a dissecting microscope. In 2024, this activity was not conducted. The detection of MSX limited our ability to access all the sites in a timely manner (extra time for cleaning and disinfection required) and MSX surveillance activities were prioritized.

Figure 6. Short-term oyster spat collectors (STC) ready to be deployed (*left*) and an individual bar clam shell showing oyster spat set (*right*).

GROWTH MONITORING

In May of 2024, the study began again for its twelfth season. The methods were reviewed prior to the 2023 monitoring season and the sites were adjusted to better represent PEI oyster growing areas. Two sites were removed from the Foxley River area (Dump Road and Portage), and two sites were added (Souris River and Orwell River). Rustico Bay was added in 2024 (Figure 7).

Figure 7. Oyster Growth Monitoring locations.

Oysters for the 2024 monitoring program were available from the previous year, held in cages overwinter. The 2nd year oysters were collected in 2021 from East River, 1st year oysters were collected in 2022 from Foxley River, and seed class was collected in 2023 in Foxley River. Oysters from all areas were transported to the PEI Aquaculture Division's laboratory in May to prepare them for the upcoming monitoring season. Keeping each bay separate, mortalities were removed. As a result of finding the vase tunicate, *Ciona intestinalis*, in several bays in 2023 (see

Appendix VI) the oysters from different sites were not mixed, to reduce the risk of spreading this tunicate between sites. In 2024, each site was changed from a 6-bag cage (2 bags per age class) to a 4-bag cage (1 bag per age class). Approximately 300 seed oysters; 150 1st years, and 125 2nd years were measured for length and width using a digital caliper with USB connection (Figure 8). This provided the baseline starting size for the 2024 monitoring season. At each site, oysters that were no longer required for the program from the previous year were placed in a bag and used for a Conditional Index (CI) analysis. Conditional Index is a method that has been used to measure an oyster's overall health and nutritive status and has also been used to assess the impact of environmental factors on oyster meat quality. The main purpose of using CI for this program is to document the effect of spawning on an oyster and to determine if there are differences in CI between bays.

Figure 8. Oyster being measured with electronic caliper.

The seed oysters were then measured to 3 litres and added to individually tagged bags (3 litres of oysters a bag). The 1st and 2nd year oysters were counted and added to tagged bags (150/bag for 1st years and 125/bag for 2nd years; see Figure 9). The tags placed on the bags were color coded and numbered to differentiate the bags and identify year class. A HOBO Tibit temperature logger (MX 2203) was used at each location to measure water temperature every hour. All bags of oysters were treated with a lime/brine immersion to reduce the risk transferring aquatic invasive species (i.e. tunicates) between river systems. For CI, 15 oysters were collected from

each site at 5 different intervals throughout the growing season. These oysters were transferred to the lab where each oyster was measured (length, width, depth) and weighed (kg). Condition Index is calculated as a ratio of dry meat weight to dry shell weight (dried oyster tissue / dried oyster shell X 100). Oyster meat and shells were dried using a Thermo Scientific Laboratory Oven; 90-100°C for 24 hours.

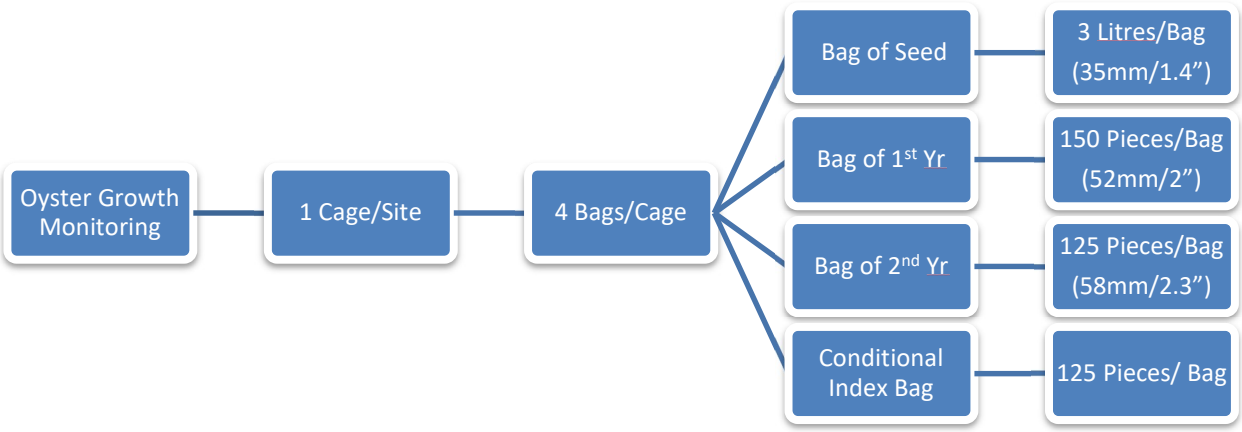


Figure 9. Site setup for the Oyster Growth Monitoring Program.

Throughout the growing season, the cages were flipped (Figure 10, *left*) every two weeks, air dried for approximately 24-48 hours and then returned to the growing position (Figure 10, *right*). This was following standard industry practices for effective management of fouling on oyster cages.

Figure 10. Oyster Growth Monitoring cages.

By late August, the oysters had grown substantially, and as a result, the bags of seed needed to be thinned out. The bag of seed at each site was removed from the water, randomly divided, and 3 liters of oysters were measured and returned to their original bag. The extra oysters were bagged and held for future work.

At the end of the monitoring season in the fall, oysters from all year classes were retrieved from the cages and measured. Oysters from each bag were randomly divided and approximately 50 per bag were measured. The oysters were returned to the water and held in bags for future work. The lease holders sank the DFTSC cages for winter when sinking their own cages.

TUNICATE MONITORING

Oyster and mussel farming operations in several Island rivers were examined by Aquaculture Division staff to collect information on tunicate densities and monitor for new aquatic invasive species. Monitoring efforts focused on important seed collection areas and high risk non-infested areas.

WATER QUALITY MONITORING

Water temperatures were recorded using a YSI during the OMP Season (late June – mid August). These temperatures were recorded from 1m below the surface after every oyster larvae tow. In addition, in 2021, automatic temperature recording devices (Figure 11), set to record hourly temperature readings, were placed approximately 1m below the surface attached to the rope of an oyster growth cage in seven of the oyster growing areas. The hourly temperature data provided additional information on surface water temperature profiles from May until November. From November to May, the temperature devices are placed into a bag inside the cage and sunk (as per industry practice for overwintering oyster gear). The temperature (hourly) data provides information on bottom temperatures during this time, and this allows us to collect data throughout the year.

Figure 11. HOBO Tibit temperature devices (MX 2203).

In 2023, four Innovasea live data platforms (Figure 12; Foxley River, Bideford River, Orwell River & Souris River) were added to the oyster growth monitoring program to help provide additional water quality data (temperature, salinity, dissolved oxygen, and chlorophyll red) during the growing season. Rustico Bay was added in 2024. These were accessed through a collaboration with DFOs Marine Spatial Planning and Marine Environmental Water Quality group. Areas were selected based on location (distributing equipment throughout the Island) and proximity to an oyster growth cage. Foxley River and Bideford River were selected because they are both significant collection and growing areas on the northwest end of Island. Souris River and Rustico Bay were chosen because they have a significant growing area on the southeast side and north side of the Island. Orwell River was a central area on the south side of the Island that is a significant seed collection area.

Figure 12. Innovasea Live Data Platform (*left*) and associated water quality instruments (*right*).

RESULTS AND DISSCUSION

LARVAE MONITORING

A total of 158 larvae samples were collected between June 24 and August 6 in 2024. The size ranges, total numbers of larvae above 250µm and the water temperature at each site are shown in Appendix II. Due to the presence of MSX, sampling frequencies were reduced to reduce the risk of unintentionally spread of the disease. The pattern of seasonal abundance of oyster larvae >250µm for all primary (sampled 2 times a week) and secondary sites (sampled 1-2 times per week) are shown in Appendix III. Oyster larvae were first observed between June 24th and June 27th at most sites across PEI; larvae >250µm were first observed on July 9th. In general, larvae >250µm appeared later at some of the secondary sites compared to the primary sites. Peak numbers of larvae >250µm were observed between July 12th and July 25th in all areas. Bideford River was the area that larvae >250µm were first observed.

The first observation of oyster larvae and peak numbers of larvae >250µm was consistent with historical trends. Overall, the onset of the presence and peaks in abundance of oyster larvae in Island waters (mid July – early August) remain consistent with historical OMP data trends. Fall inspection of oyster spat collector lines by DFTSC personnel, as well as anecdotal reports from oyster growers, indicated that 2024 was an average year for many growers. As with most years, some areas performed better than others. There are several environmental factors, as well as grower and husbandry factors, that play a role in spatfall; however, identifying a specific cause for poor or more abundant spatfall is challenging because oyster spawning is initiated by a sudden increase in water temperature.[1] It is possible that interruptions in water temperature can affect spawning conditions and larval survival. In comparing 2023 to 2024 in Rustico Bay, larvae counts >250µm showed a significant increase in abundance. This could be related to anoxic events that occurred in each year. In 2023 the anoxic event happened in early to mid July,

[1] Medcof, J.C. (1939), Larval Life of the Oyster (Ostrea virginica) in Bideford River. Journal of Fisheries Board of Canada

whereas in 2024, the event happened in mid to late June before spawning had occurred. Results from 2024 show that there remains considerable variation in larvae numbers and timing of peak larvae abundance between Island river systems, particularly eastern areas versus western areas. Anti-fouling treatments (lime dipping) continue to be an important measure against unwanted gear fouling for the successful collection of oyster spat for most growers. While there were no major problems reported of fouling organisms or predators in 2024, the high concentrations of newly settled barnacles (*Balanus crenatus*) on collectors continues to be a concern for many growers.

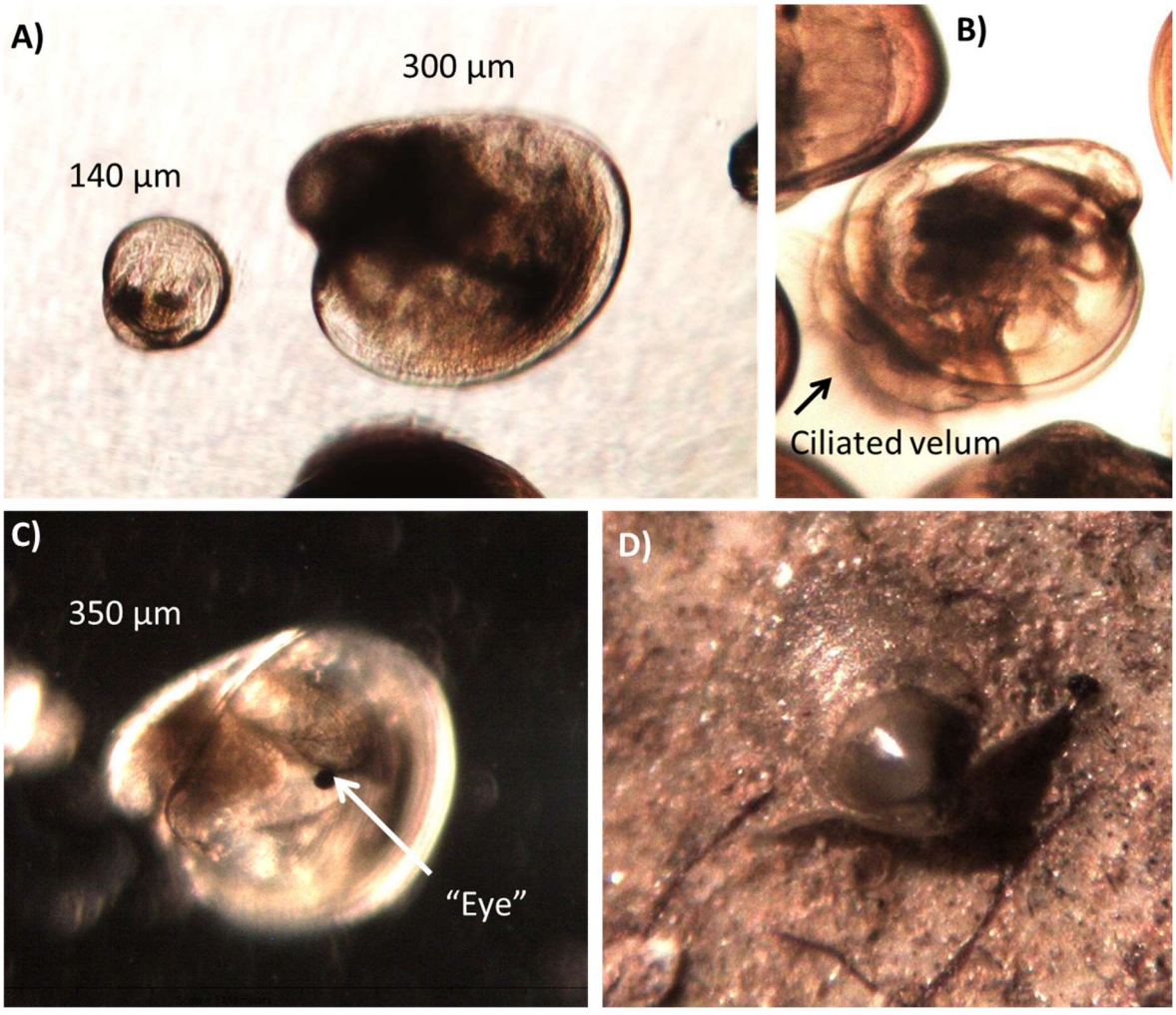


Figure 13. Oyster larvae at different stages of development. A) 140 and 300µm larvae, B) Free swimming larvae showing ciliated velum, C) Eyed larvae ready to set, and D) Settled larvae (spat) on collector shell.

Several factors make oyster larvae sampling difficult to standardize. Larvae concentrations are not typically evenly distributed vertically in the water column or within river systems and are influenced heavily by tidal flow. Hence, tows that are conducted at specific times irrespective of tidal stage may lead to over or underestimation of oyster larvae concentrations. Furthermore, fresh water influences the vertical distribution of larvae by causing larvae to move lower in the water column to find suitable salinity levels. Therefore, precipitation events can affect the number of oyster larvae in tow samples. Although efforts are made to maintain a consistent flow of water through the plankton net, current and boat speeds can potentially affect the volume of water filtered and thus numbers of larvae captured. Lastly, the sampling interval (sampling may occur as often as every 2 days in some areas but only once or twice a week in others) may make it difficult to compare larvae concentrations between river systems.

SPAT-FALL

In 2024, this activity was not conducted. The detection of MSX limited our ability to access all the sites in a timely manner (extra time for cleaning and disinfection required) and MSX surveillance activities were prioritized.

GROWTH MONITORING

In 2024, the monitoring program focused on gathering data throughout the Island to monitor for changes in productivity between growing areas and annual variation within growing areas. The seed oysters had the most growth, followed by the first years and then second years in 2024 (Figure 14). Annual variability is expected as environmental conditions vary from year to year. The average annual growth between 2013-2023 is compared to 2024 growth at each location, based on year class (Figures 15, 16, 17). Overall, results from the 2024 growth monitoring are similar to past growth data with slight increases or decreases observed at the individual sites for seed and first years. Changing the methods at the start of monitoring season (not mixing the oysters from each bay together) potentially contributed to the decreased growth observation in the 2nd year oysters, as compared to previous years.

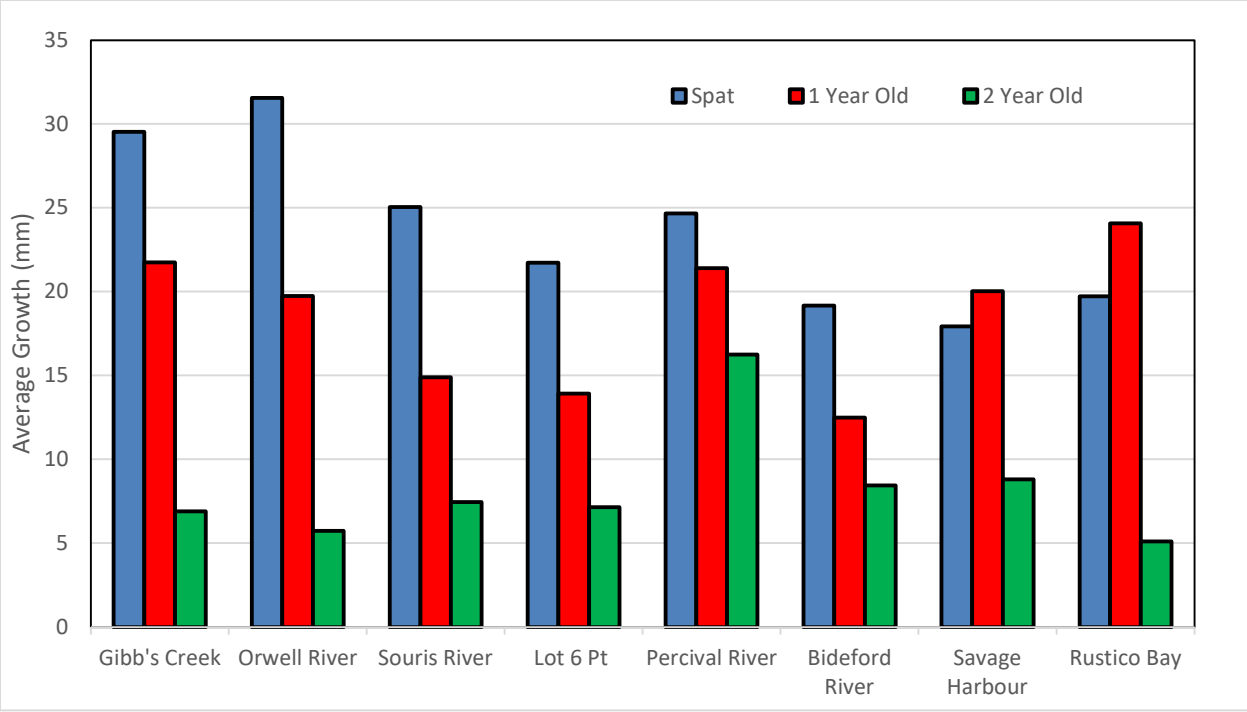


Figure 14. Oyster shell length growth in 2024.

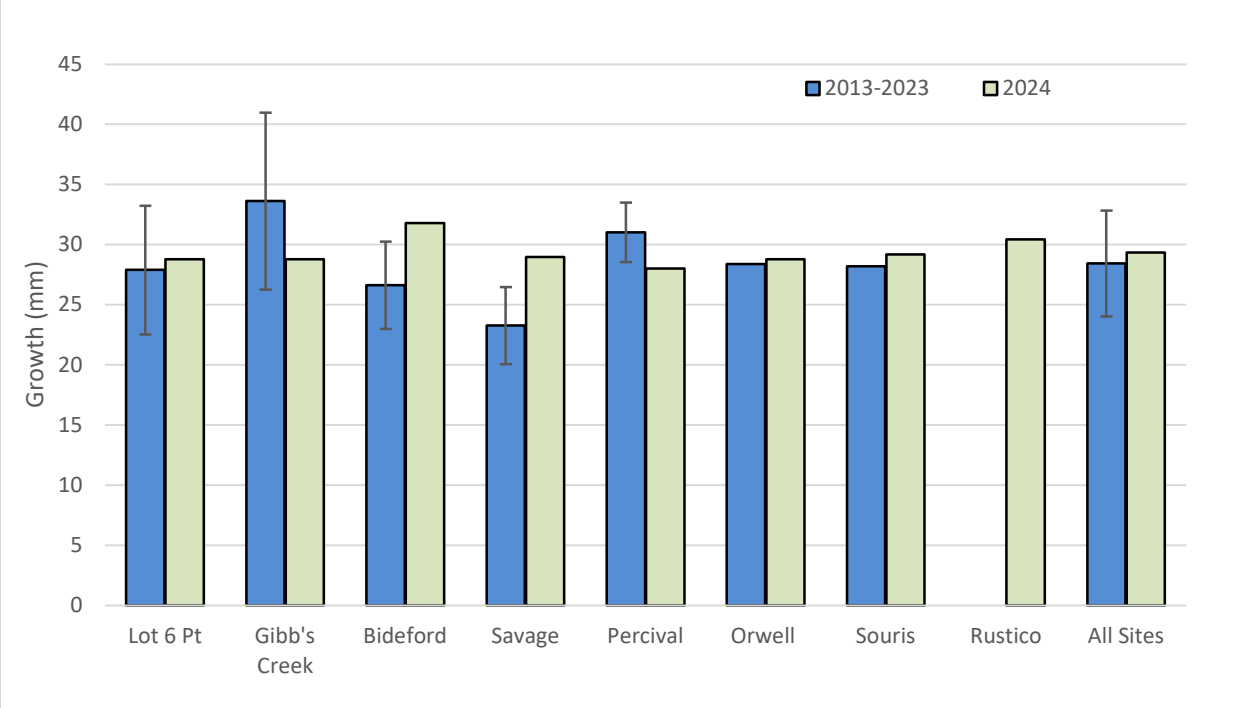


Figure 15. Annual growth of seed oysters; 2013-2023 vs 2024.

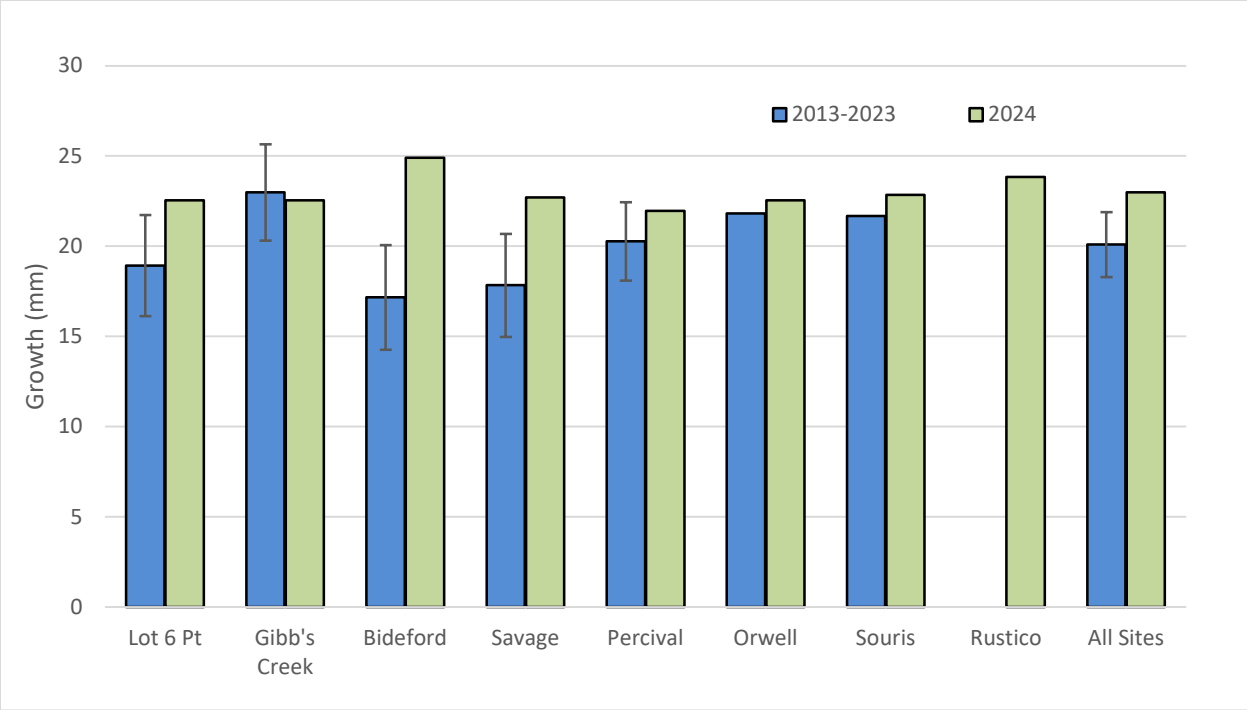


Figure 16. Annual growth of 1st year oysters; 2013-2023 vs 2024.

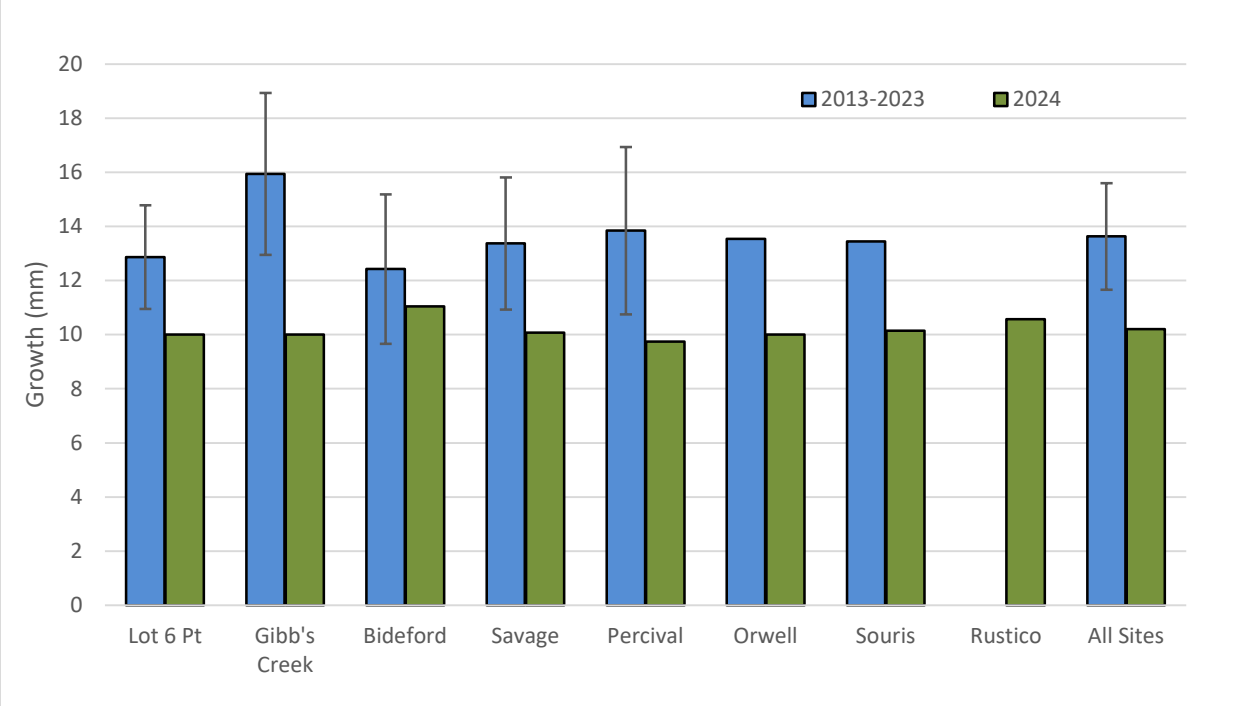


Figure 17. Annual growth of 2nd year oysters; 2013-2023 vs 2024.

The goals of this study have broadened from its original intent to gather data on oyster productivity in relation to increases in off-bottom culture techniques being used. The study now aims to gather productivity-related data at multiple farming locations throughout PEI to document growth trends. This had been identified by industry as useful information and was also seen to support and enhance other research efforts being conducted in the system. This data collection is increasingly important as the topic of climate change and its potential impacts are discussed.

Average monthly temperatures during the summer months (July and August) did not vary by more than three degrees when looking at the year over year or from location to location. In examining historical data, on average, for July and August, the lowest monthly temperature observed was 16.5^{o}C (Souris River) and the highest temperature observed was at 26.7^{o}C (Percival River).

Growth can be impacted by many variables year over year. The quality of the seed and the overwintering practices can be a factor. Salinity, temperature, rainfall, food availability and other water parameters will impact growth. High winds or extreme weather events can change the growth and may even tumble the oysters to remove some growth, depending on the timing of these events. As PEI is in a temperate climate, the time of year when ice enters the river system may also have an impact as it can reduce the number of days oysters can grow every year. The length of winter can impact on the health and condition of oysters in the spring as well. It is expected to observe variation in growth year over year. From the beginning, the oyster industry was interested in ensuring that growth rates remain suitable to maintain the profitability of their operations. The intention of this program is to provide additional information to industry and help evaluate and assess the development of this industry.

Due to the presence of MSX in some PEI bays/rivers and the resulting preventative steps to avoid spreading the parasite, not all sites were able to be sampled for CI in a timely manner and some periods were missed. Going forward, the DFTSC plans to revisit this process and gather a more complete data set for all areas.

TUNICATE MONITORING

Current distribution maps of invasive tunicates (Clubbed & Vase) on PEI are shown in Appendix VI. Clubbed and vase tunicates are now in several oyster growing areas. The process of regular air drying (every 2-3 weeks) as a normal husbandry practice appears to be sufficient for management of these invasive species on oyster grow-out gear, though some fouling on oyster spat collection gear has created some issues for growers. In 2024, there have been new confirmed detections of the vase tunicate in Lennox Channel and Foxley River; as well as reports of it being present in the March Water area of Malpeque Bay. The clubbed tunicate has been confirmed present in St. Peter's Bay and there are reports of its presence in Tracadie Bay. Invasive tunicate species, as well as native fouling organisms, continue to be a concern for the Island's aquaculture industry. However, the ability to control gear fouling by air-drying oyster growing equipment has proven to be very effective and is widely used by PEI oyster growers.

Figure 18. Vase tunicates observed on an oyster and oyster gear.

WATER QUALITY MONITORING

The department continues to gather more water quality information in several oyster producing areas. Since 2021, HOBO Tibits (MX 2203) temperature devices have been attached to each growth site about one meter beneath the surface. This allowed for the temperature to be recorded all year at one-hour intervals. Figure 19 shows the temperature from all eight sites throughout the growing season in 2024. In Appendix V, year over year data can be seen from

each individual site. Most of the sites follow a relatively similar trend to previous years. This temperature data can be accessed through the Oyster Monitoring Website (https://www.princeedwardisland.ca/en/feature/view-oyster-monitoring-results) or directly on this website https://dfc.modailmara.ca/.

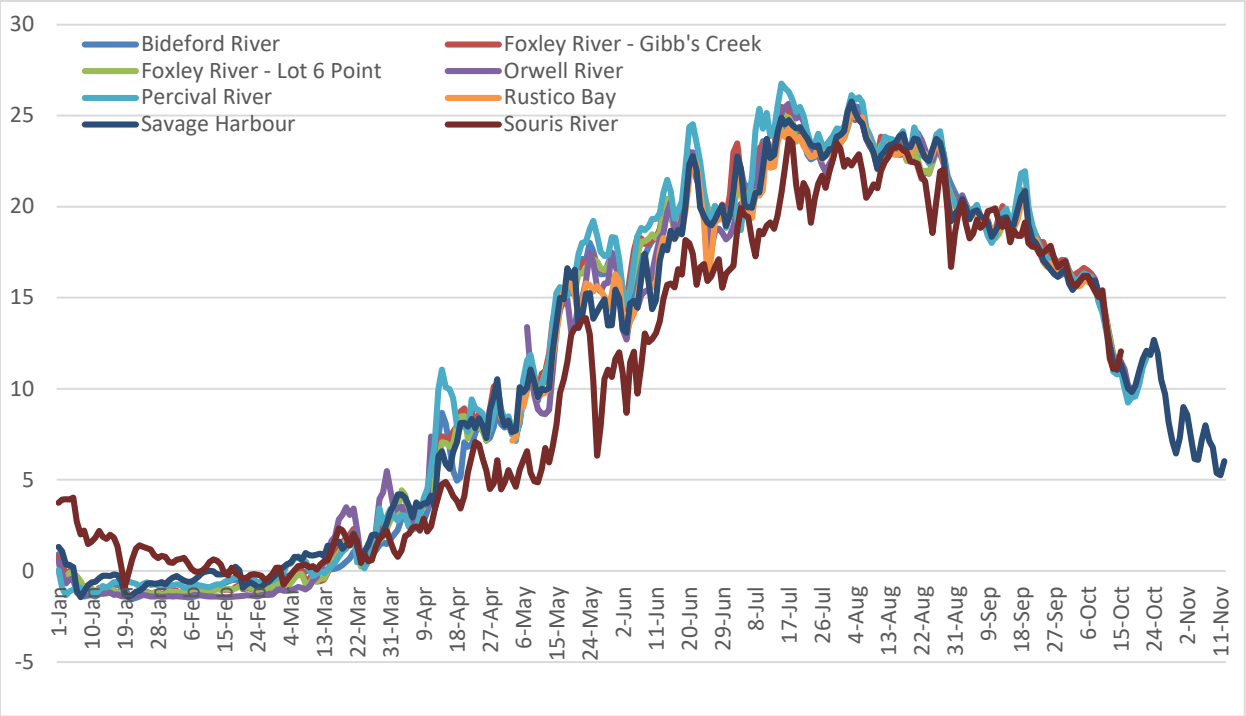
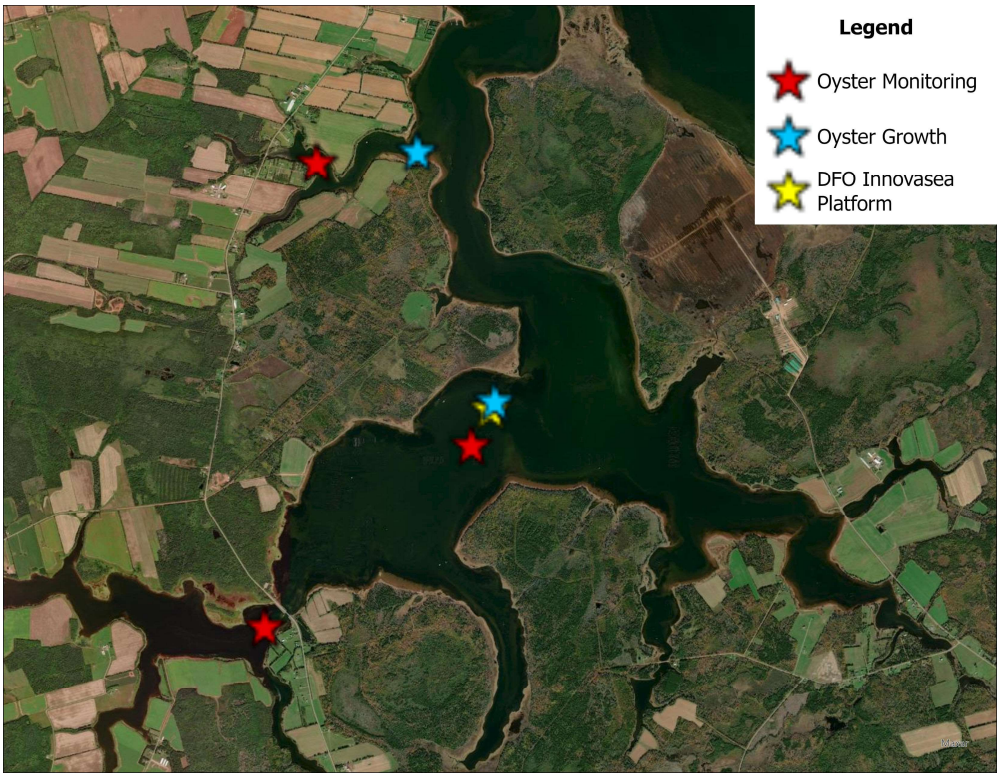


Figure 19. Oyster Growth Temperature Data.

With the addition of the Innovasea Water Quality Platforms the department was able to collect additional water quality data in some of the oyster growth areas. At the five sites (Souris River, Foxley River, Bideford River, Orwell River, and Rustico Bay) additional water quality parameters (dissolved oxygen, temperature, salinity and chlorophyll red) were collected. As additional information is collected, comparisons year-over-year and between sites can be made, and its potential effect on oyster growth.

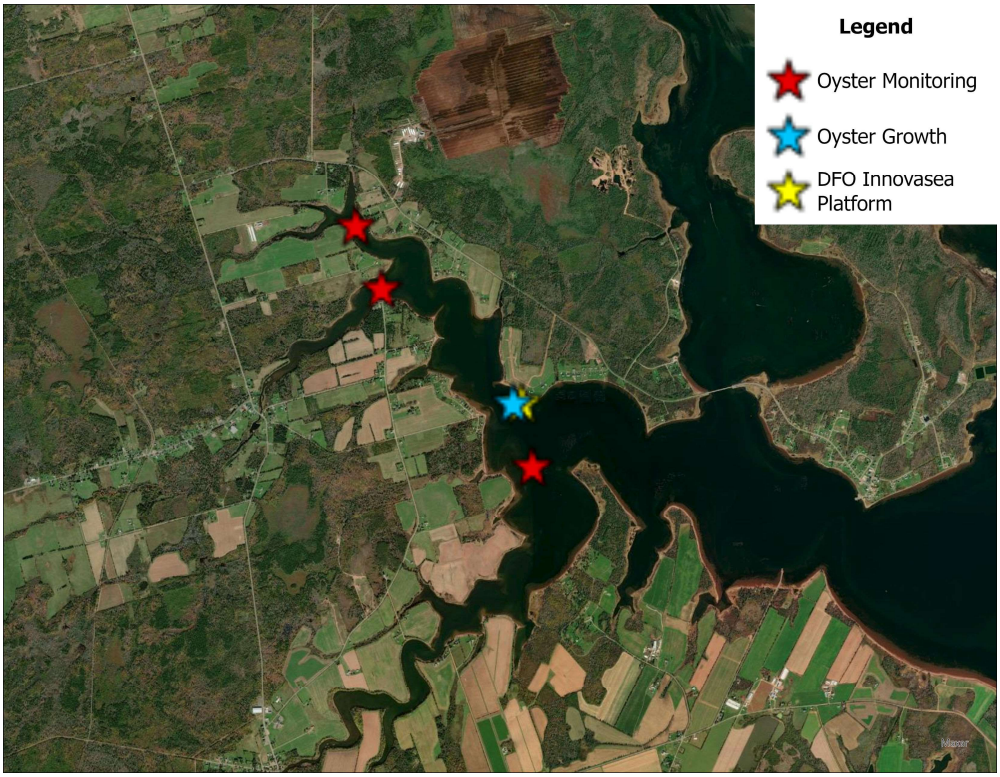
APPENDIX I: 2024 MONITORING SITE LOCATIONS



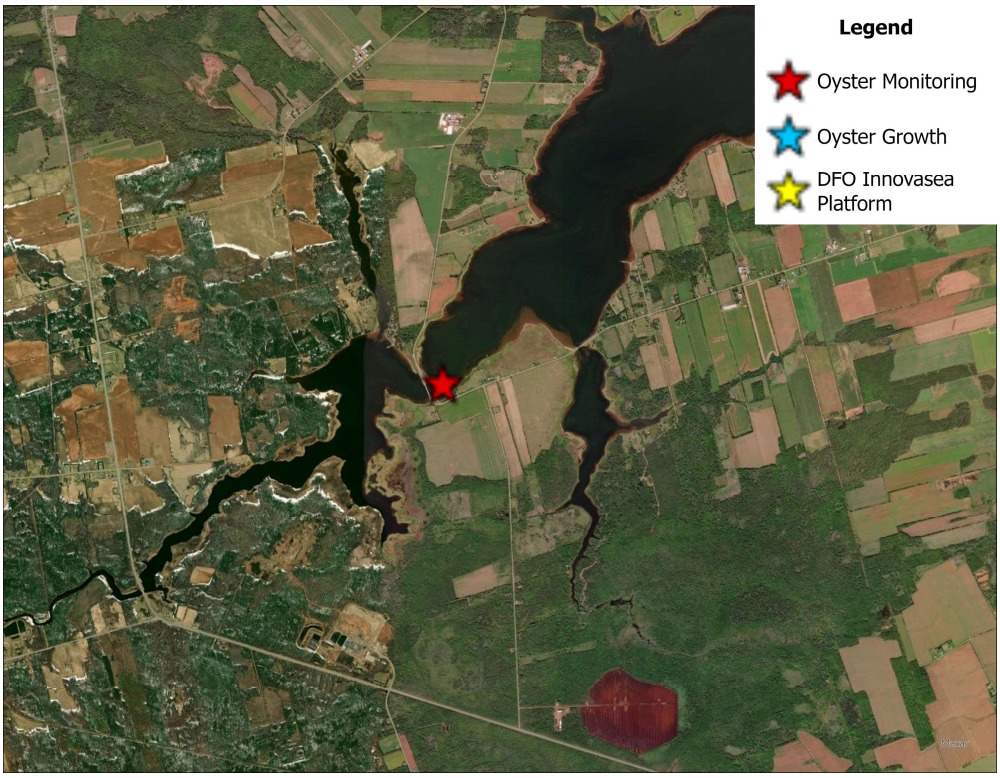
Monitoring sites in Foxley River

Monitoring site in Dock River

Monitoring sites in Percival and Enmore Rivers

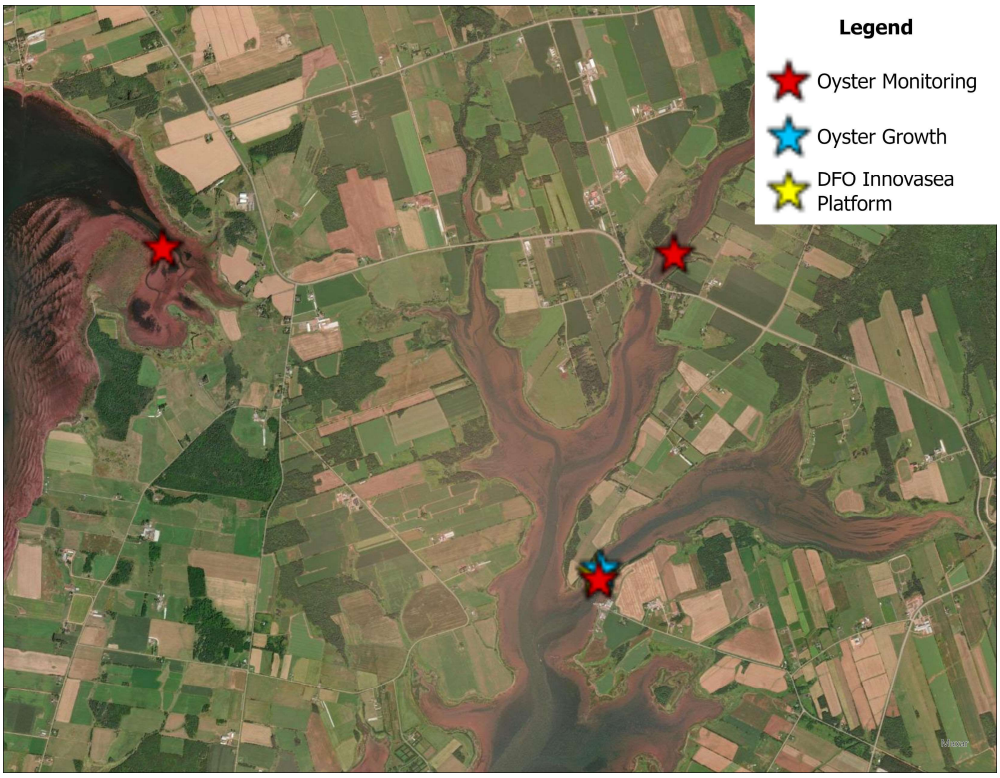


Monitoring sites in Bideford River



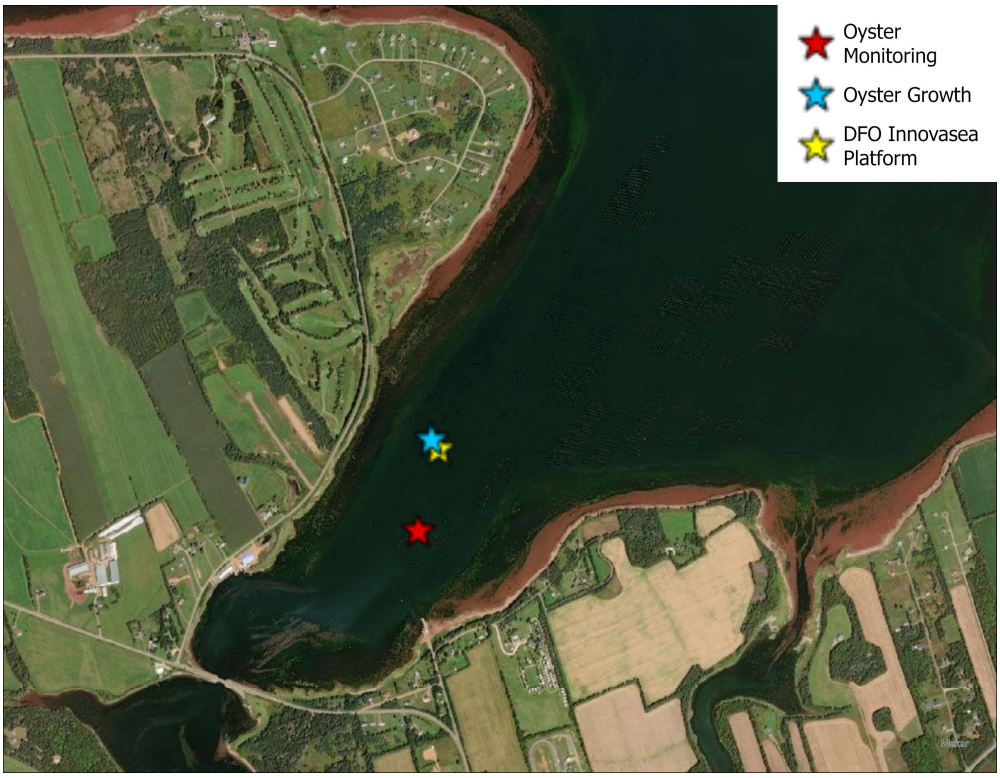
Monitoring site in Grand River

Monitoring site in East River



Monitoring sites in Pownal Bay, Vernon River and Orwell River

Monitoring site in Darnley Basin



Monitoring site in Rustico Bay

Monitoring site in Savage Harbour

Monitoring sites in Souris River

APPENDIX II: 2024 OYSTER MONITORING DATA

Dock River					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/27/2024	18.3	27.4	42	90-110	0
7/2/2024	17.8	25.7	97	90-170	0
7/8/2024	18.7	27.5	127	80*-150	0
7/15/2024	23.3	25.9	330	90-290	81
7/25/2024	22	26.3	8	290-340	8
7/29/2024	22	26.5	4	310-340	4

Foxley River - Lot 6 Pt.					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	20.4	26.4	207	85-90	0
6/27/2024	19.5	26.2	238	90-*130	0
7/2/2024	20.9	21.7	62	100-170	0
7/4/2024	20.6	22.9	22	130-260	1
7/8/2024	20.5	24.9	14	90-180	0
7/12/2024	22.8	24.6	170	90-150	0
7/15/2024	24.8	22.3	61	100-280	11
7/18/2024	23.8	24	738	100-300	264
7/22/2024	22.5	25.7	393	90-340	141
7/26/2024	23.1	25	90	210-330	64
7/29/2024	23	23.5	4	310-340	4
8/1/2024	23.6	24.7	3	120-150	0
8/6/2024	24.4	24.9	0	0	0

Foxley River - Gibb's Creek					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	21.7	26.8	214	85-90	0
6/27/2024	19.9	24.2	126	90-120	0
7/2/2024	21.9	23.5	0	0	0
7/4/2024	22.9	23.9	1	160	0
7/8/2024	22	25	18	90-210	0
7/12/2024	23.9	24	168	90-150	0
7/15/2024	24.5	25.4	33	90-280	9
7/18/2024	24.9	24.9	176	100-300	68
7/22/2024	23	24.4	126	90-340	48
7/25/2024	24.1	23.8	4	200-310	2
7/29/2024	25.9	24.2	2	320-330	2
8/1/2024	24.5	24.3	6	120-140	0
8/6/2024	25	24.7	2	330	2

Foxley River - Goff's Bridge					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	21	24.3	134	85-90	0
6/27/2024	19.6	20.5	62	90-110	0
7/2/2024	21.9	15.1	2	140-160	0
7/4/2024	21.9	19.6	7	130-200	0
7/8/2024	21.4	23.6	8	90-200	0
7/12/2024	23.5	22.8	13	90-140	0
7/15/2024	25.8	18.3	8	90-260	1
7/18/2024	24.7	27.6	55	120-290	32
7/22/2024	22.8	24.4	142	90-340	82
7/25/2024	23.4	23.8	8	220-310	4
7/29/2024	23.6	20.3	0	0	0
8/1/2024	24.3	23.2	4	310-320	4
8/6/2024	24.7	23.8	0	0	0

Percival River					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/25/2024	19.4	27	126	90-110	0
7/3/2024	22.9	23.8	3	110-180	0
7/10/2024	23.8	24.6	13	90-110	0
7/17/2024	25.3	25.7	70	90-260	1
7/24/2024	22.6	25.4	140	110-340	40
7/30/2024	23.4	25.9	6	240-320	5
8/7/2024	23.7	27.1	16	200-320	12

Bideford River - Paugh's Creek					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	20.9	27.1	16	80-90	0
6/27/2024	19.2	23.5	36	90-120	0
7/2/2024	22.5	23.2	7	100-170	0
7/4/2024	24.9	21.4	40	90-260	1
7/9/2024	24.5	25.2	301	90-270	6
7/12/2024	23.2	24.9	975	90-280	366
7/16/2024	26.6	21	660	130-330	264
7/19/2024	24.1	26.7	243	110-300	129
7/22/2024			138	90-340	62
7/26/2024	23.7	25.9	100	180-330	74
7/29/2024	24.6	25.8	4	310-330	4
8/1/2024	25.5	25.6	28	110-150	0
8/8/2024	23.7	26.3	0	0	0

Bideford River - Green Park					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	20.1	27.6	136	80-90	0
6/27/2024	19.3	23.6	62	90-130	0
7/2/2024	21.1	24.6	17	100-170	0
7/4/2024	20.3	25.5	286	90-260	3
7/9/2024	21.3	26.7	28	90-140	0
7/12/2024	22.6	25.2	669	90-280	156
7/16/2024	21.9	22.3	519	110-310	267
7/19/2024	21.9	26.2	129	90-300	93
7/22/2024			108	90-340	66
7/26/2024	22.7	25.7	38	210-340	32
7/29/2024	25.9	23.5	15	280-310	15
8/1/2024	24.5	25.9	62	110-330	6
8/8/2024	23.4	26.1	2	310	2

Bideford River - Station					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/24/2024	20.6	27.1	38	80-90	0
6/27/2024	19.4	22.7	122	90-130	0
7/2/2024	21.5	24.4	170	100-210	0
7/4/2024	23.6	22.7	120	90-260	2
7/9/2024	23.7	25.7	324	90-270	8
7/12/2024	23	24.2	456	90-280	183
7/16/2024	25.3	25.3	135	100-310	72
7/19/2024	23.8	25.8	90	120-290	48
7/22/2024			274	90-340	170
7/26/2024	23.3	25.9	100	180-330	74
7/29/2024	23.8	26.3	2	330	2
8/1/2024	24.9	25.8	22	120-180	0
8/8/2024	23.5	26.6	0	0	0

Grand River					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/25/2024	19.3	26.9	70	90-120	0
7/3/2024	22.7	21	14	120-240	0
7/10/2024	23.8	27.1	190	90-280	32
7/17/2024	23.7	25.6	54	120-280	21
7/24/2024	23	25.1	56	140-330	28
7/30/2024	23.5	25	2	330	2
8/7/2024	24.4	26.3	6	180-210	0

Darnley Basin					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/26/2024	18.5	28.1	3	90-100	0
7/3/2024	20.5	26.3	0	0	0
7/10/2024	19.6	28.5	12	90-160	0
7/17/2024	722		13	90-260	1
7/30/2024	22.8		1	320	1
8/8/2024	21.7		4	320	4

East River - Cranberry Wharf					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
7/2/2024			0	0	0
7/5/2024	20.8	22.5	2	100-160	0
7/9/2024	22.5	17.3	7	90-110	0
7/16/2024			64	90-280	4
7/19/2024			99	100-310	84
7/23/2024	23	17.9	11	140-330	7
7/30/2024			4	300-330	4
8/6/2024			0	0	0

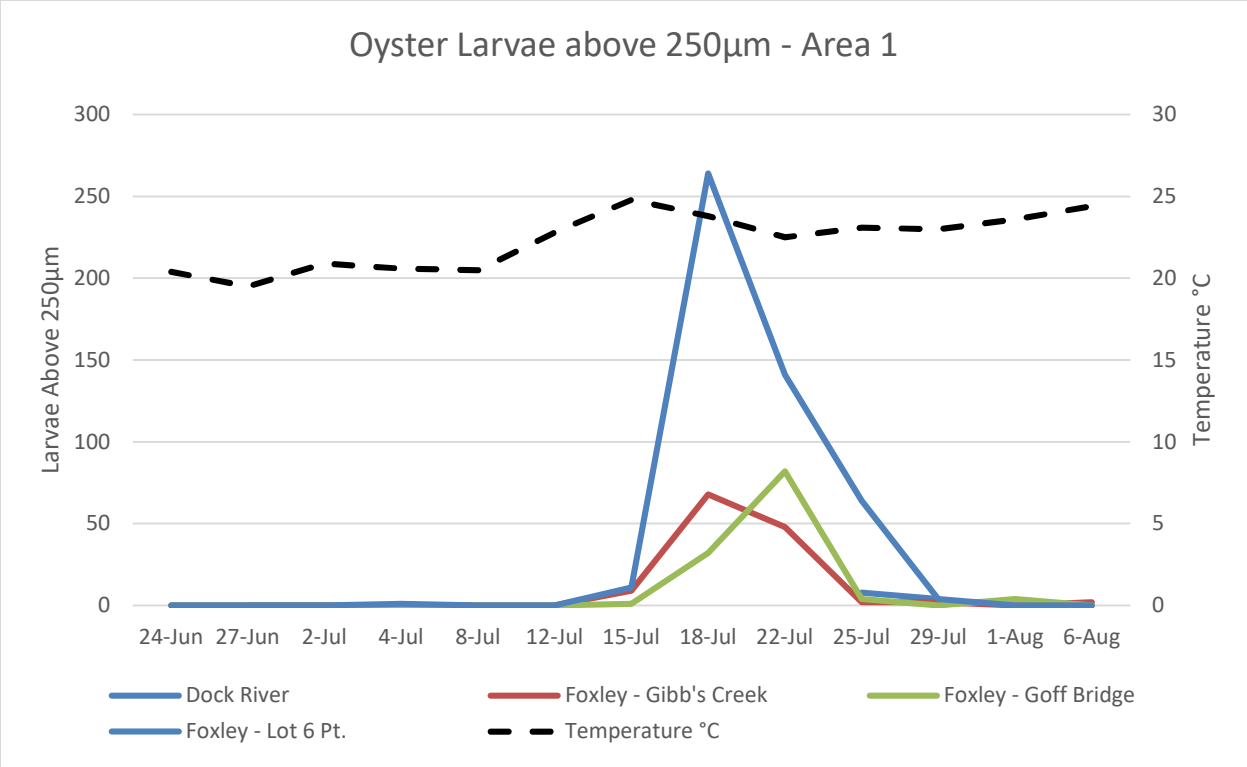
Vernon River					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/28/2024	19.4	24.3	0	0	0
7/2/2024			0	0	0
7/5/2024	20	27	0	0	0
7/8/2024	20.8	24.8	2	80-90	0
7/11/2024	19.1	24.6	3	90-100	0
7/15/2024	26	19	10	110-180	0
7/18/2024	25.4	23	81	100-260	6
7/22/2024	23.7	23.8	36	120-340	18
7/25/2024			14	180-340	6
7/29/2024	23.5	21.6	1	280	1
8/1/2024			2	310-340	2
8/7/2024			8	210-320	2

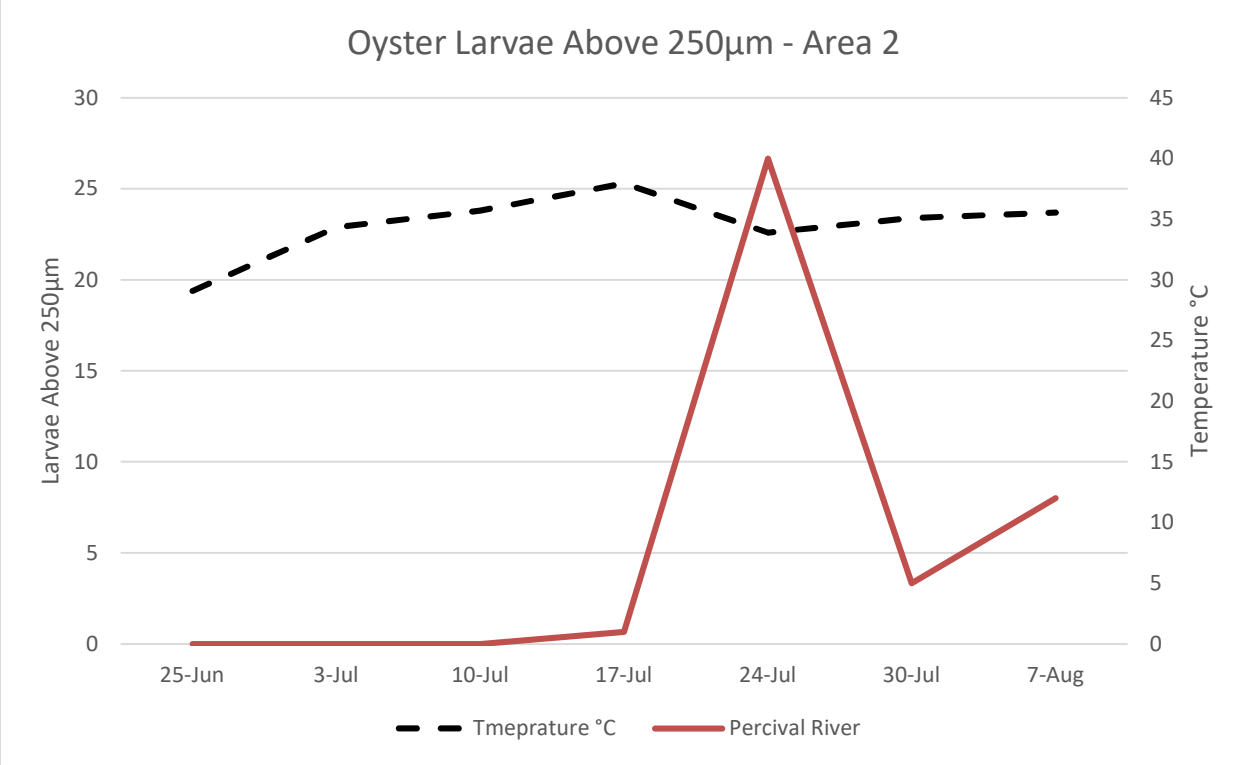
Orwell River					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/20/2024			0	0	0
6/24/2024			6	85	0
6/28/2024	18.8	27	0	0	0
7/2/2024			3	120-140	0
7/5/2024	19	28	12	80-120	0
7/8/2024	20.3	27.3	28	70-100	0
7/11/2024	24	26.7	219	80-120	0
7/15/2024	24.7	25.2	84	90-200	0
7/18/2024	25	25.1	129	90-270	5
7/22/2024	23.2	25.5	390	90-320	236
7/25/2024			39	170-340	19
7/29/2024	22.4	27.3	14	210-330	12
8/1/2024			2	310	2
8/7/2024			28	220-320	20

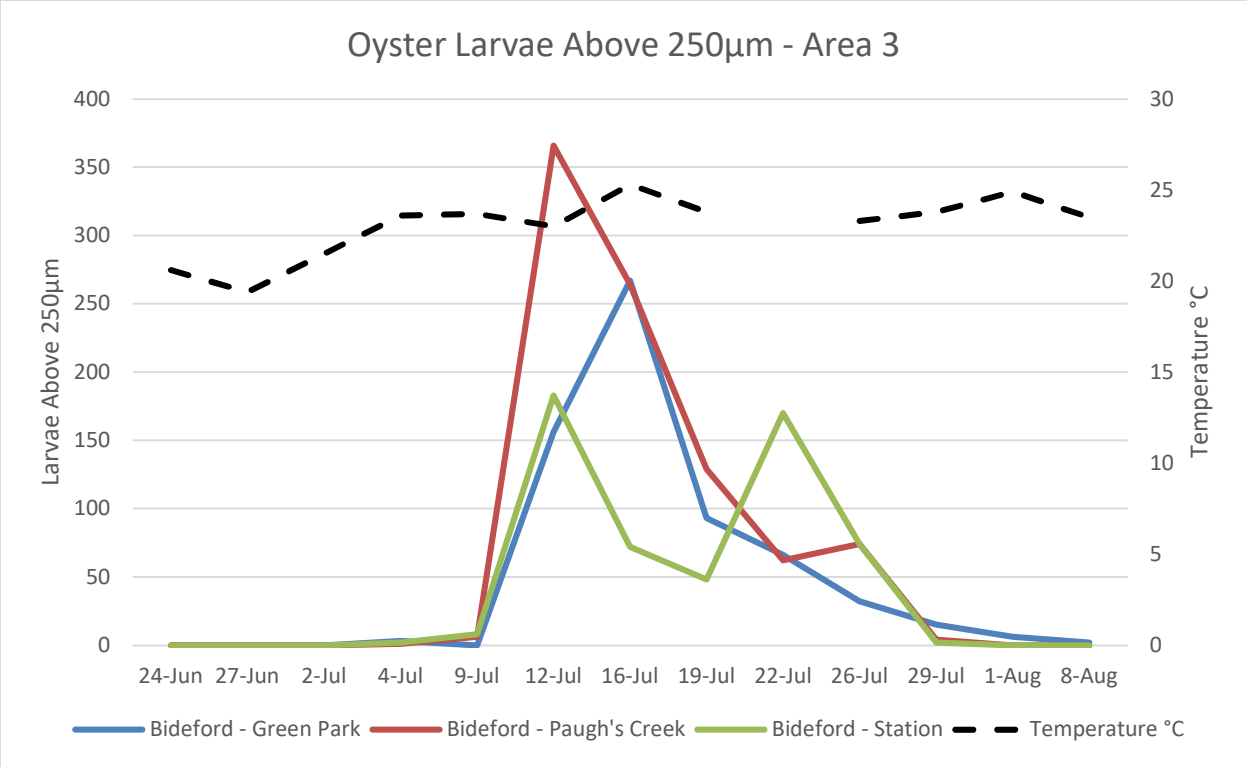
Pownal Bay					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/20/2024			0	0	0
6/24/2024			15	85	0
6/28/2024	18.8	27.5	0	0	0
7/2/2024			0	0	0
7/5/2024	20.3	28.4	3	90-120	0
7/8/2024	20.6	28.1	33	80-120	0
7/11/2024	24.4	27.9	5	90-140	0
7/15/2024	25.9	26.8	22	90-200	0
7/18/2024	26	26	72	110-270	11
7/22/2024	22.9	27.2	32	30-310	16
7/29/2024			32	220-340	30
8/1/2024			9	300-340	9
8/7/2024			0	0	0

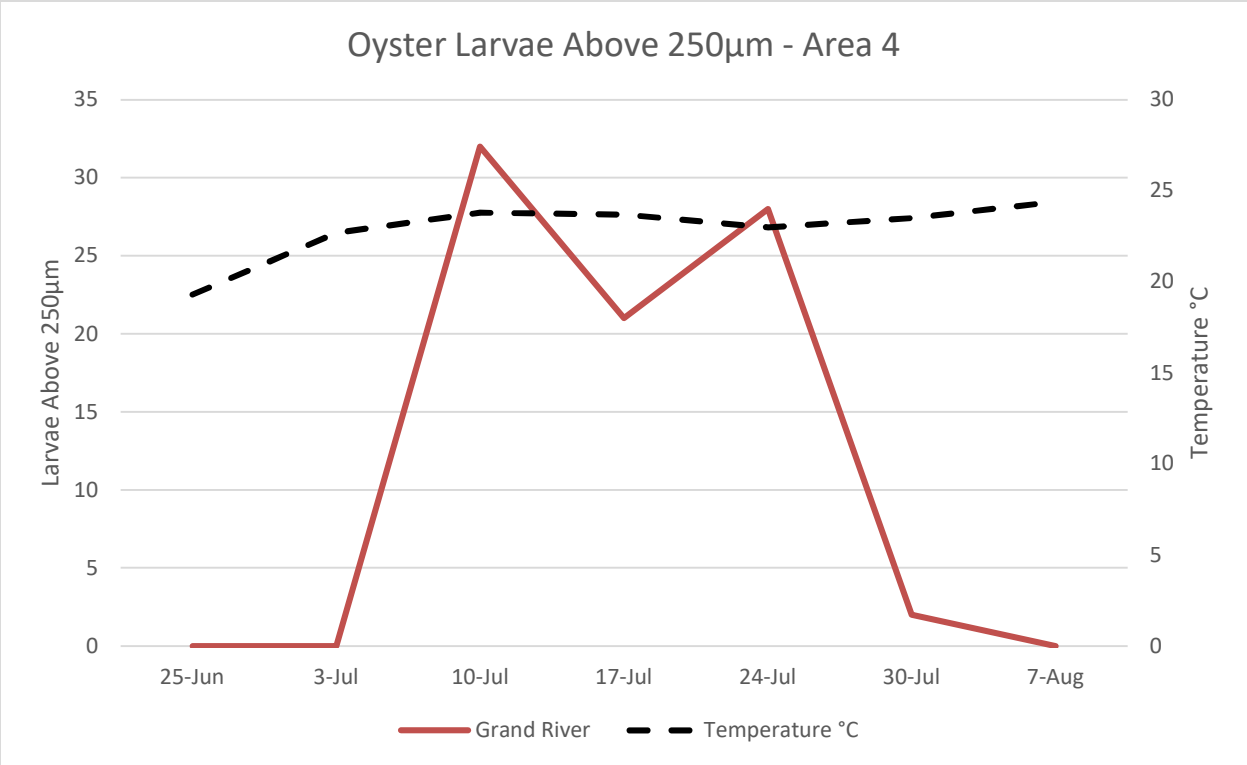
Rustico Bay					
Date	Water Temperature (°C)	Salinity (ppt)	Larvae Total	larvae Size (µm)	# Larvae Above 250 µm
6/26/2024	18.8	27.1	1	90	0
7/3/2024	21.7	26.2	0	0	0
7/9/2024	20.6	28	21	90-110	0
7/24/2024			1035	110-340	186
8/2/2024	23.8	26.9	15	120-330	12
8/5/2024			35	210-340	33

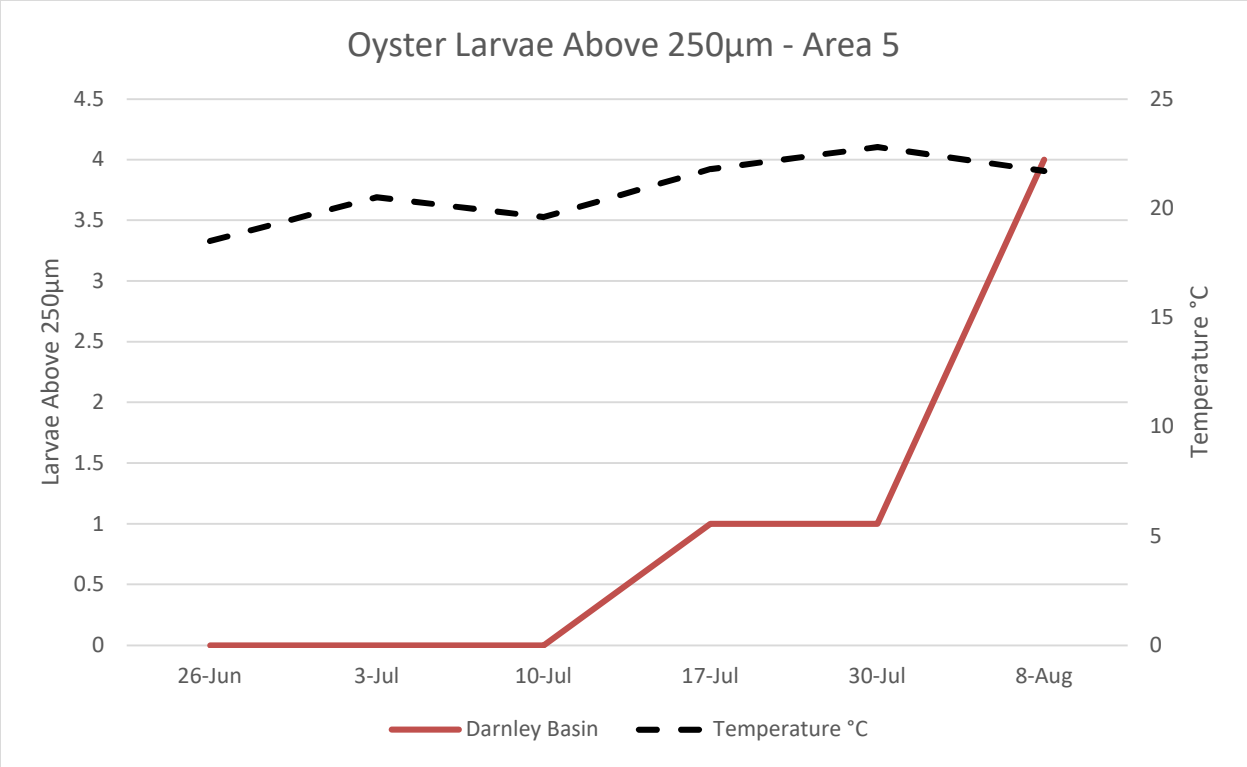
APPENDIX III: SEASONAL LARVAE ABUNDANCE AND WATER TEMPERATURE BY SITE

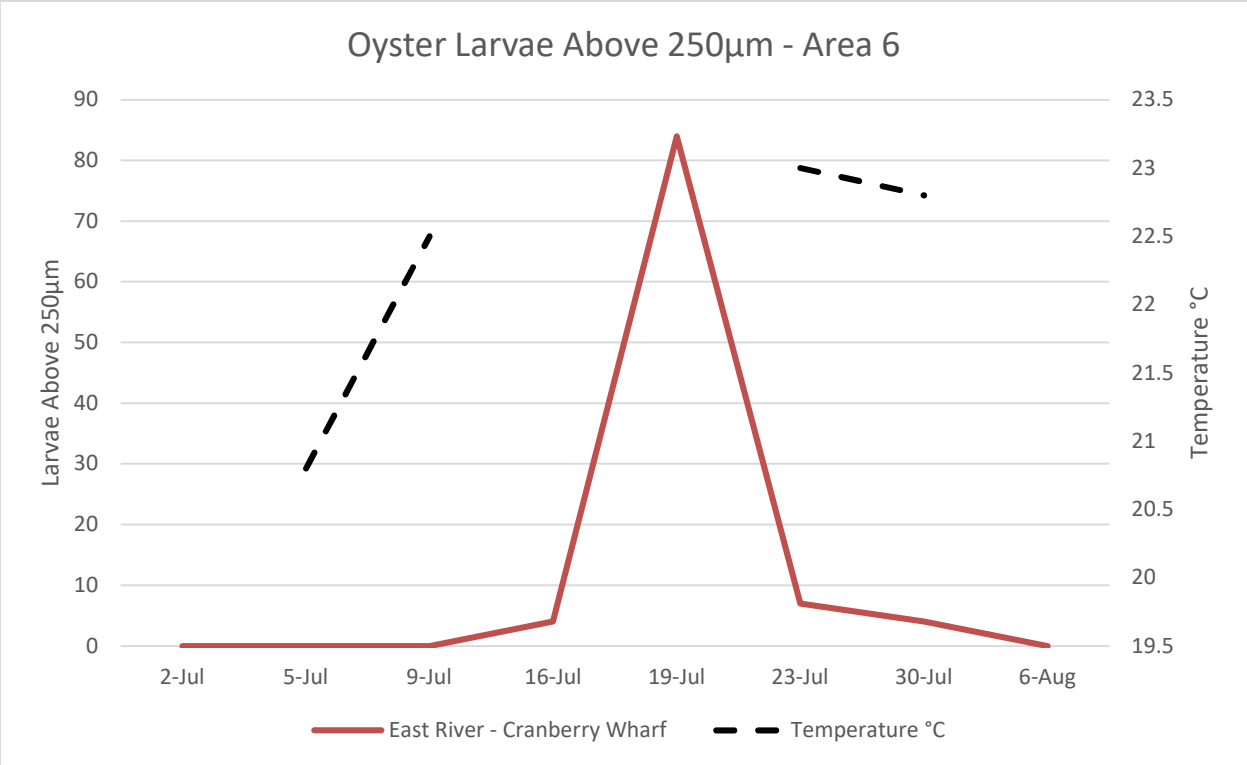

Oyster Larvae above 250µm - Area 1
Larvae Above 250µm
Temperature °C
300
250
200
150
100
50
0
30
25
20
15
10
5
0
24-Jun
27-Jun
2-Jul
4-Jul
8-Jul
12-Jul
15-Jul
18-Jul
22-Jul
25-Jul
29-Jul
1-Aug
6-Aug
Dock River
Foxley - Gibb's Creek
Foxley - Goff Bridge
Foxley - Lot 6 Pt.
Temperature °C

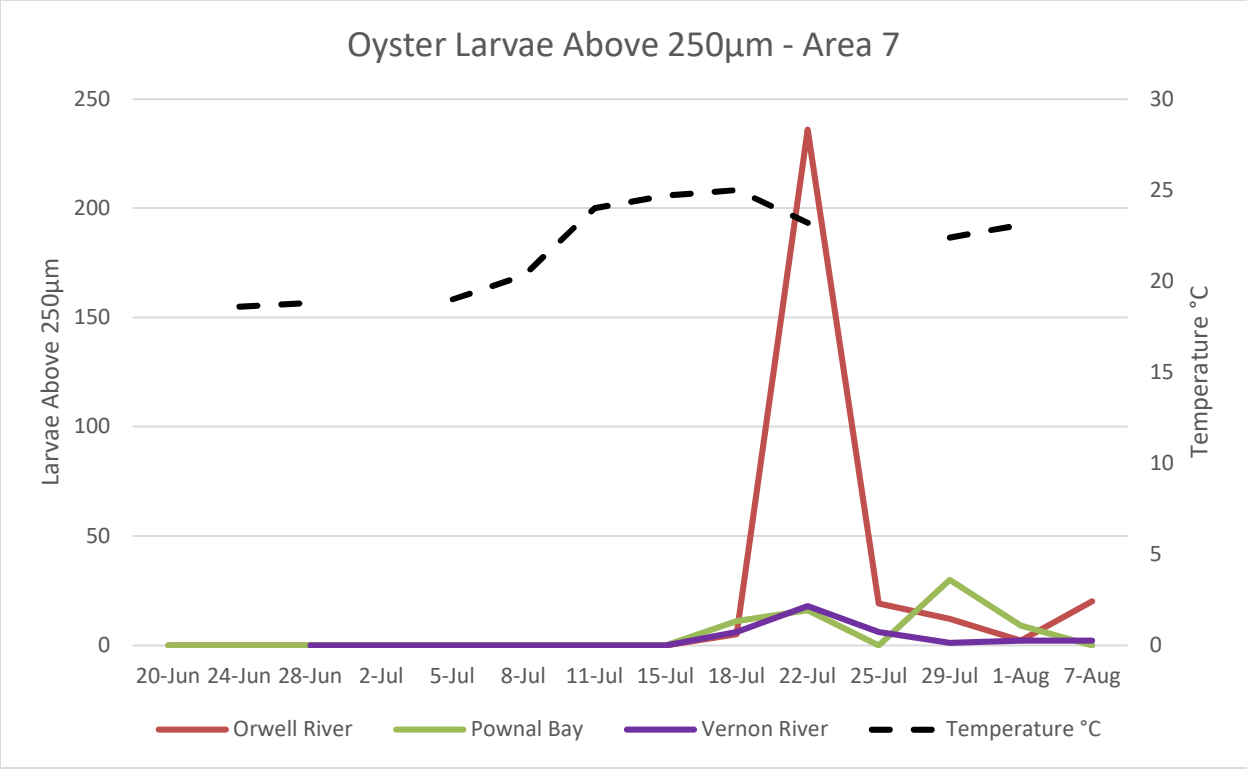

Oyster Larvae Above 250µm - Area 2
Larvae Above 250µm
Temperature °C
30
25
20
15
10
5
0
45
40
35
30
25
20
15
10
5
0
25-Jun
3-Jul
10-Jul
17-Jul
24-Jul
30-Jul
7-Aug
Tmeprature °C
Percival River

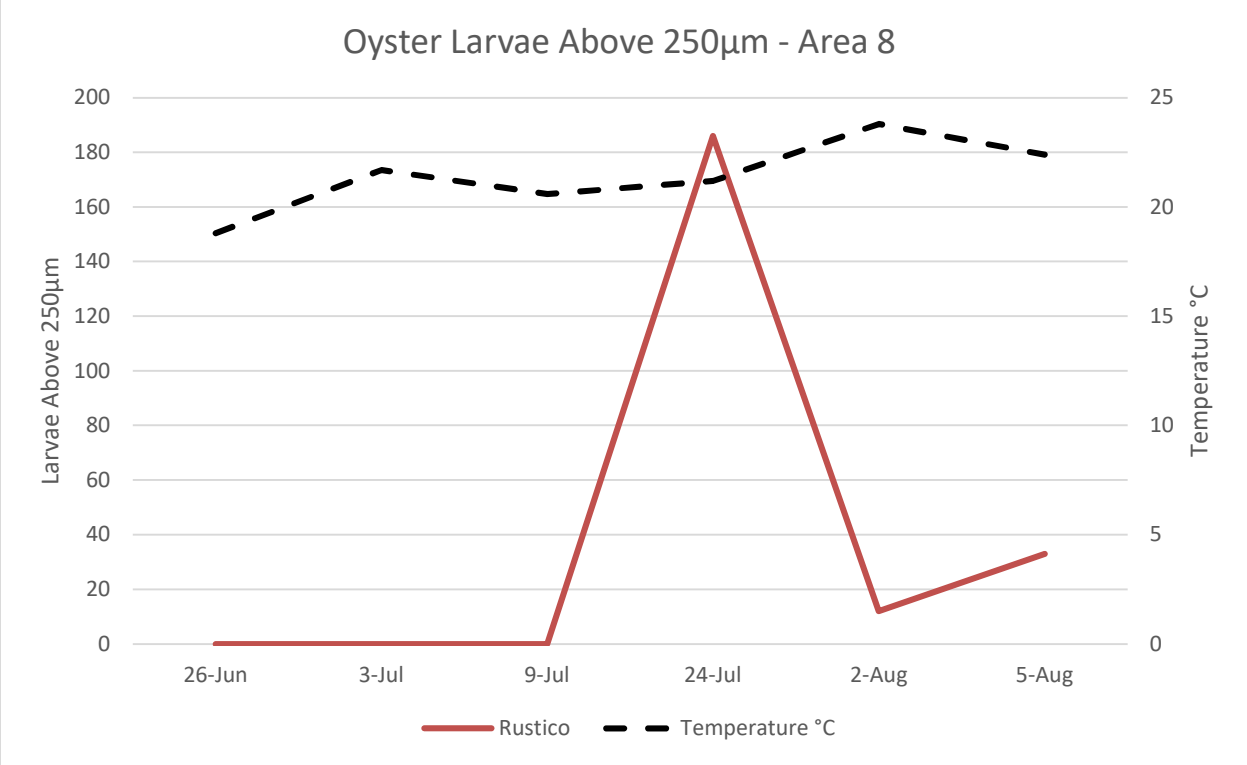

Oyster Larvae Above 250µm - Area 3
Larvae Above 250µm
Temperature °C
400
350
300
250
200
150
100
50
0
30
25
20
15
10
5
0
24-Jun
27-Jun
2-Jul
4-Jul
9-Jul
12-Jul
16-Jul
19-Jul
22-Jul
26-Jul
29-Jul
1-Aug
8-Aug
Bideford - Green Park
Bideford - Paugh's Creek
Bideford - Station
Temperature °C


Oyster Larvae Above 250µm - Area 4
Larvae Above 250µm
Temperature °C
35
30
25
20
15
10
5
0
30
25
20
15
10
5
0
25-Jun
3-Jul
10-Jul
17-Jul
24-Jul
30-Jul
7-Aug
Grand River
Temperature °C

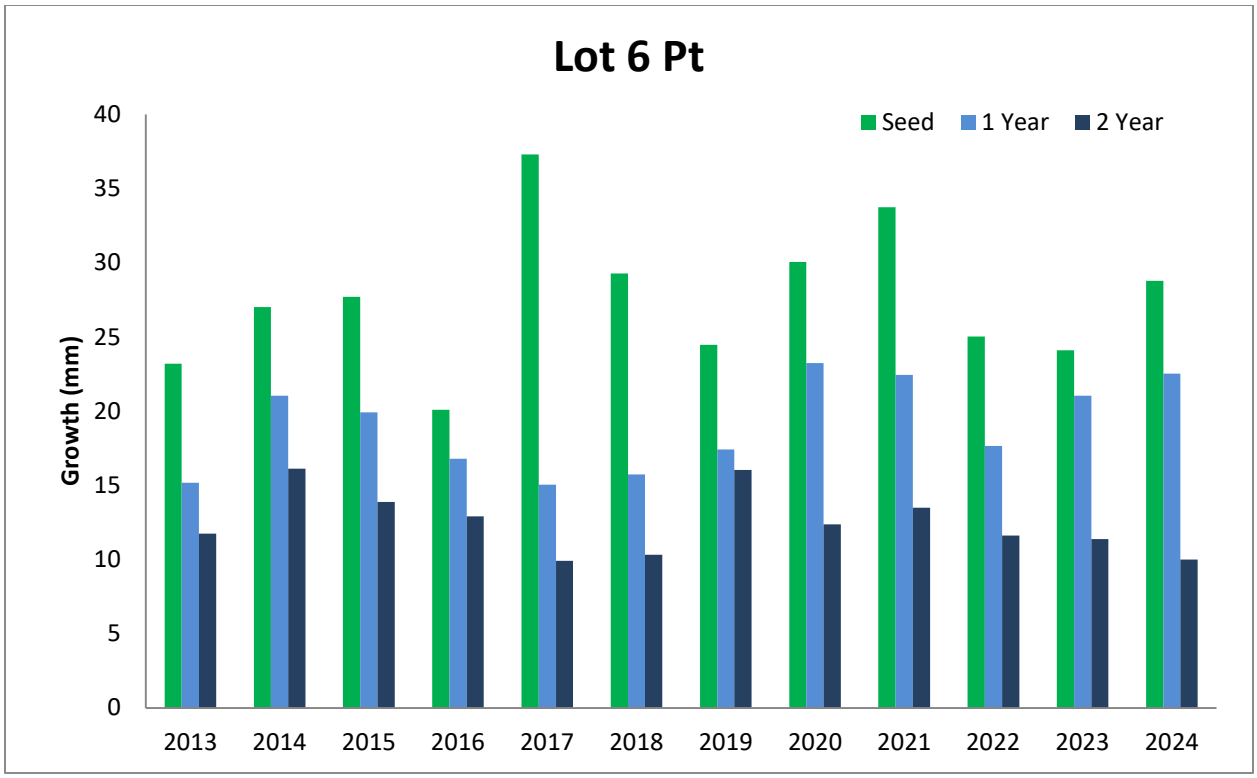

Oyster Larvae Above 250µm - Area 5
Larvae Above 250µm
Temperature °C
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
25
20
15
10
5
0
26-Jun
3-Jul
10-Jul
17-Jul
30-Jul
8-Aug
Darnley Basin
Temperature °C

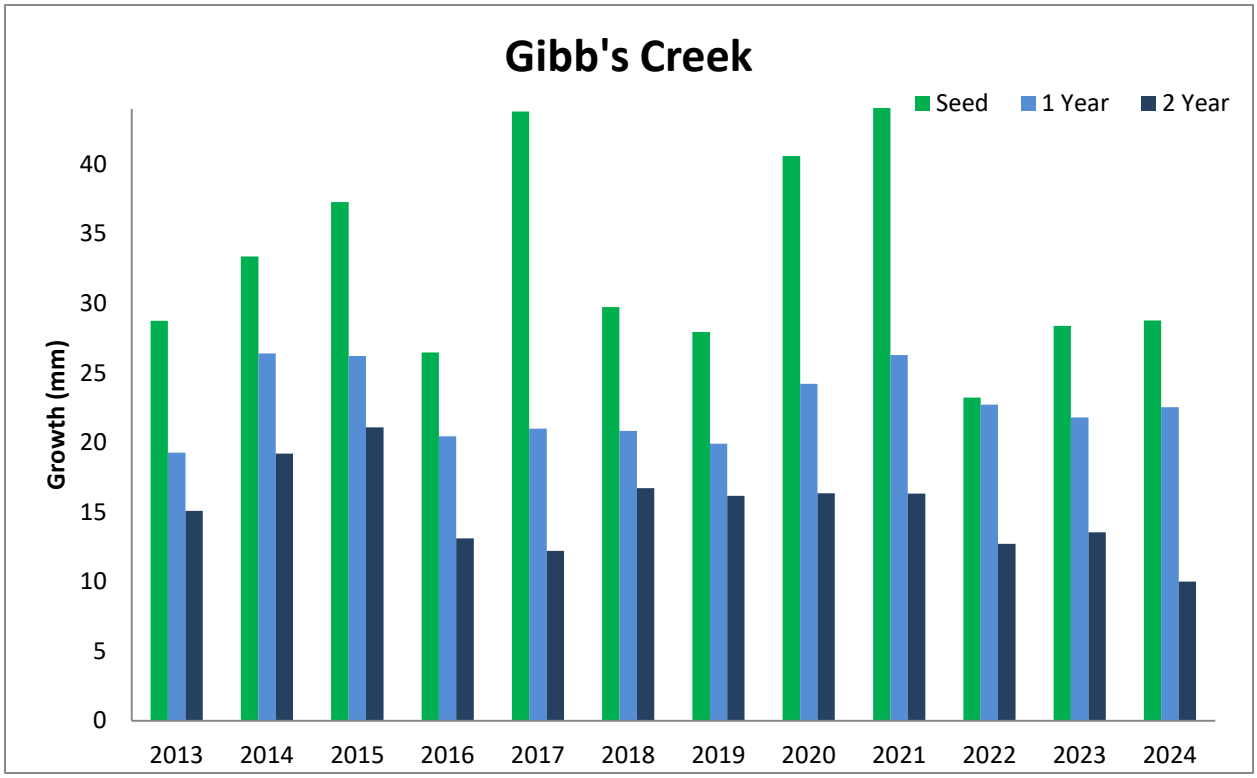

Oyster Larvae Above 250µm - Area 6
Larvae Above 250µm
Temperature °C
90
80
70
60
50
40
30
20
10
0
23.5
23
22.5
22
21.5
21
20.5
20
19.5
2-Jul
5-Jul
9-Jul
16-Jul
19-Jul
23-Jul
30-Jul
6-Aug
East River - Cranberry Wharf
Temperature °C

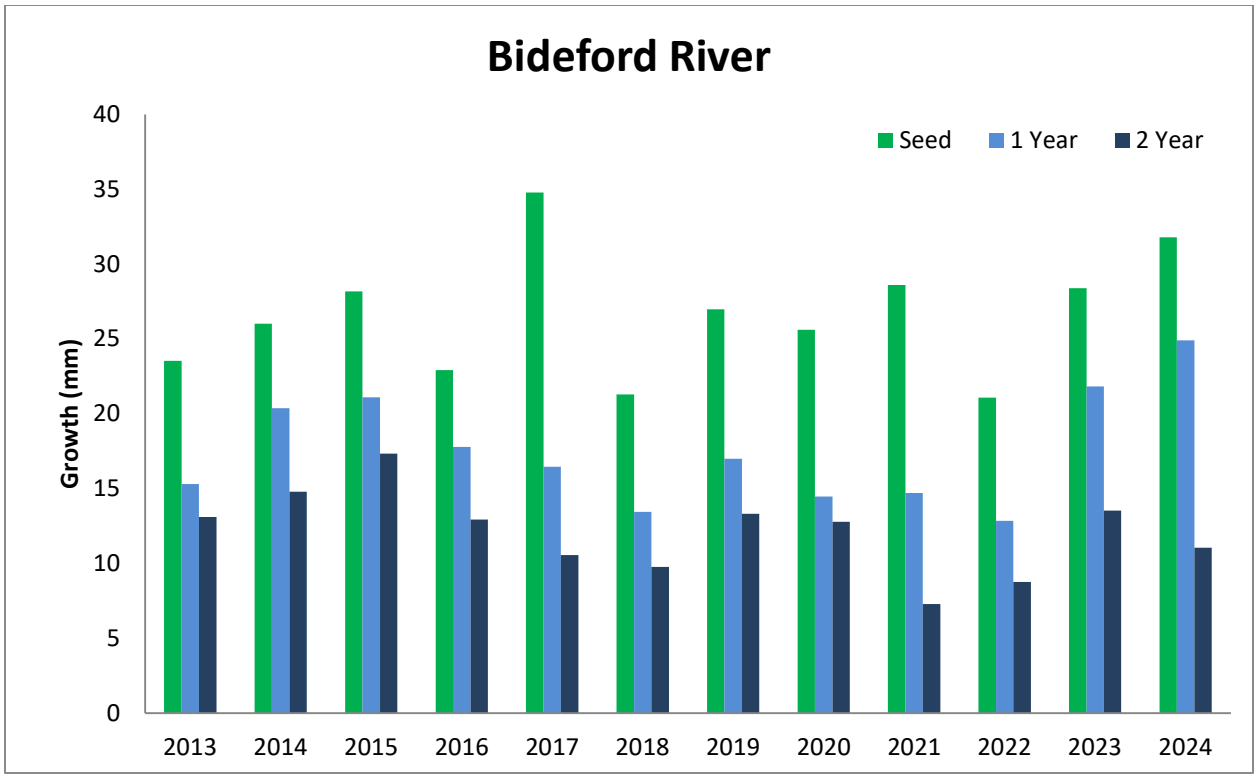

Oyster Larvae Above 250µm - Area 7
Larvae Above 250µm
Temperature °C
250
200
150
100
50
0
30
25
20
15
10
5
0
20-Jun 24-Jun 28-Jun 2-Jul 5-Jul 8-Jul 11-Jul 15-Jul 18-Jul 22-Jul 25-Jul 29-Jul 1-Aug 7-Aug
Orwell River
Pownal Bay
Vernon River
Temperature °C

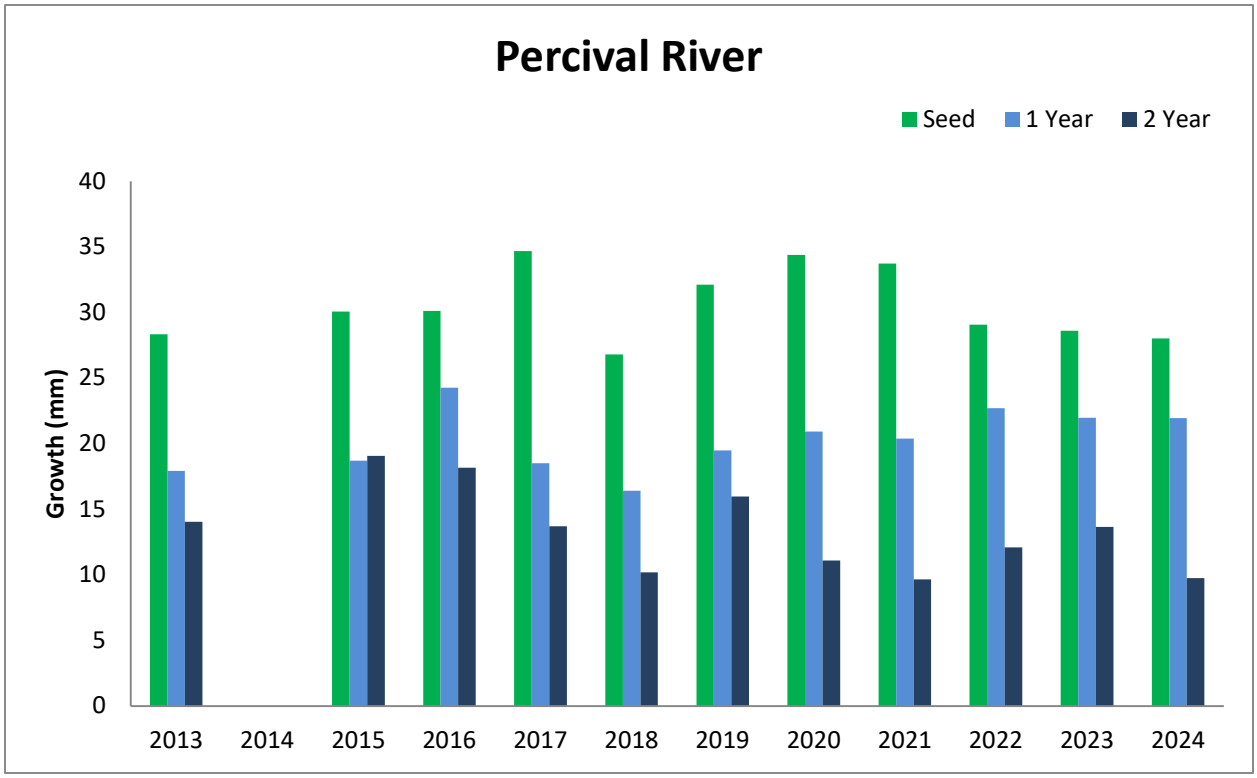

Oyster Larvae Above 250µm - Area 8
Larvae Above 250µm
Temperature °C
200
180
160
140
120
100
80
60
40
20
0
25
20
15
10
5
0
26-Jun 3-Jul 9-Jul 24-Jul 2-Aug 5-Aug
Rustico
Temperature °C

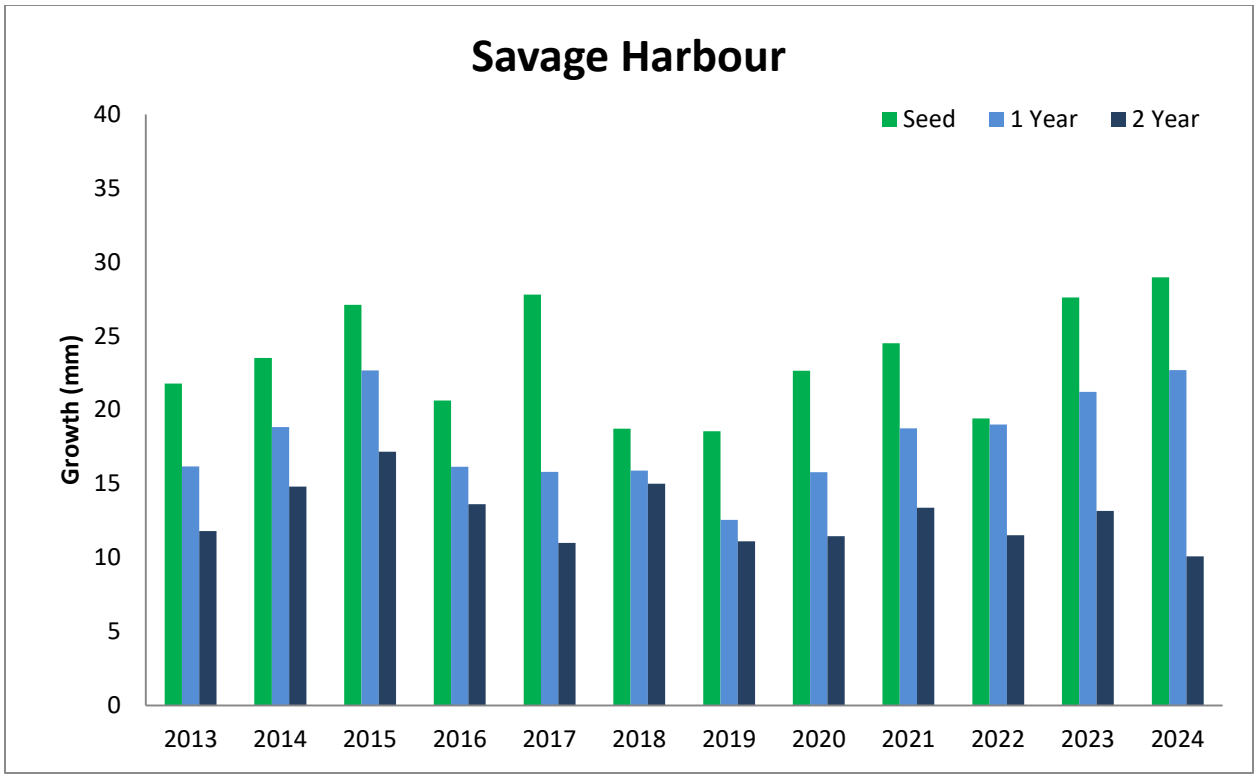
APPENDIX IV: ANNUAL OYSTER GROWTH

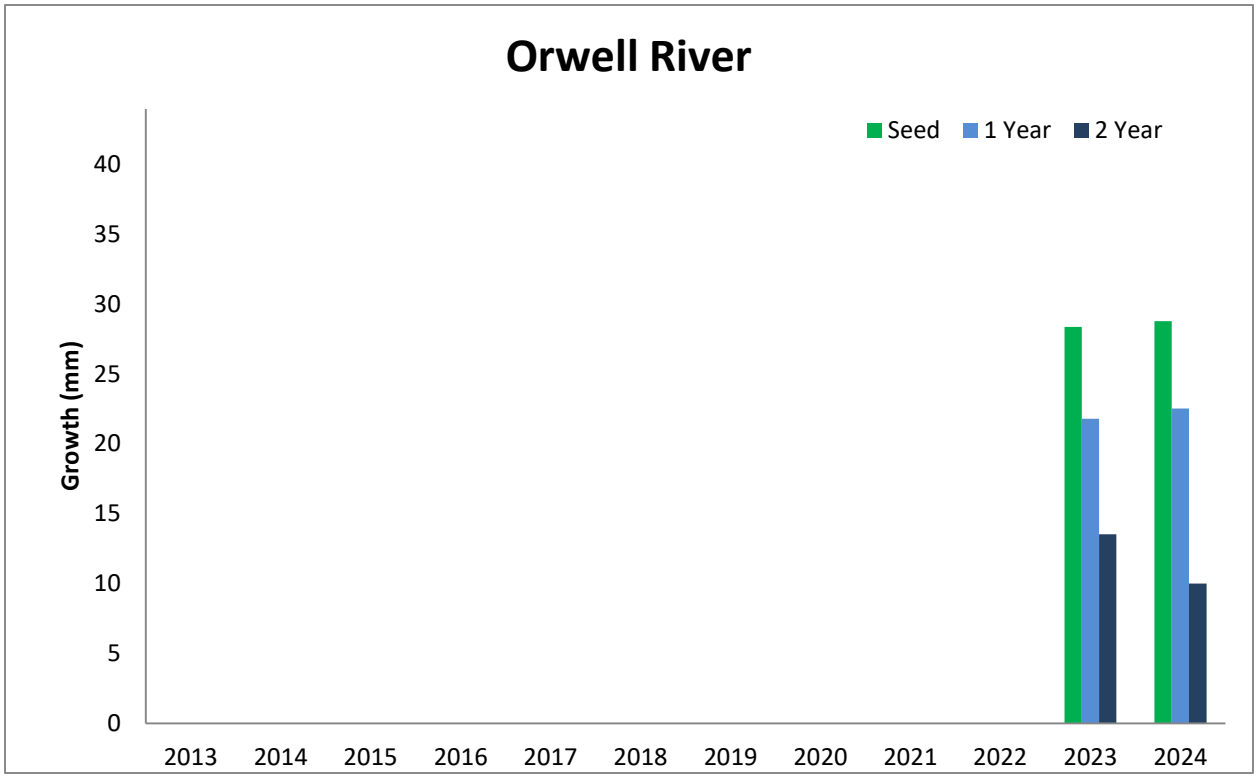

Lot 6 Pt
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

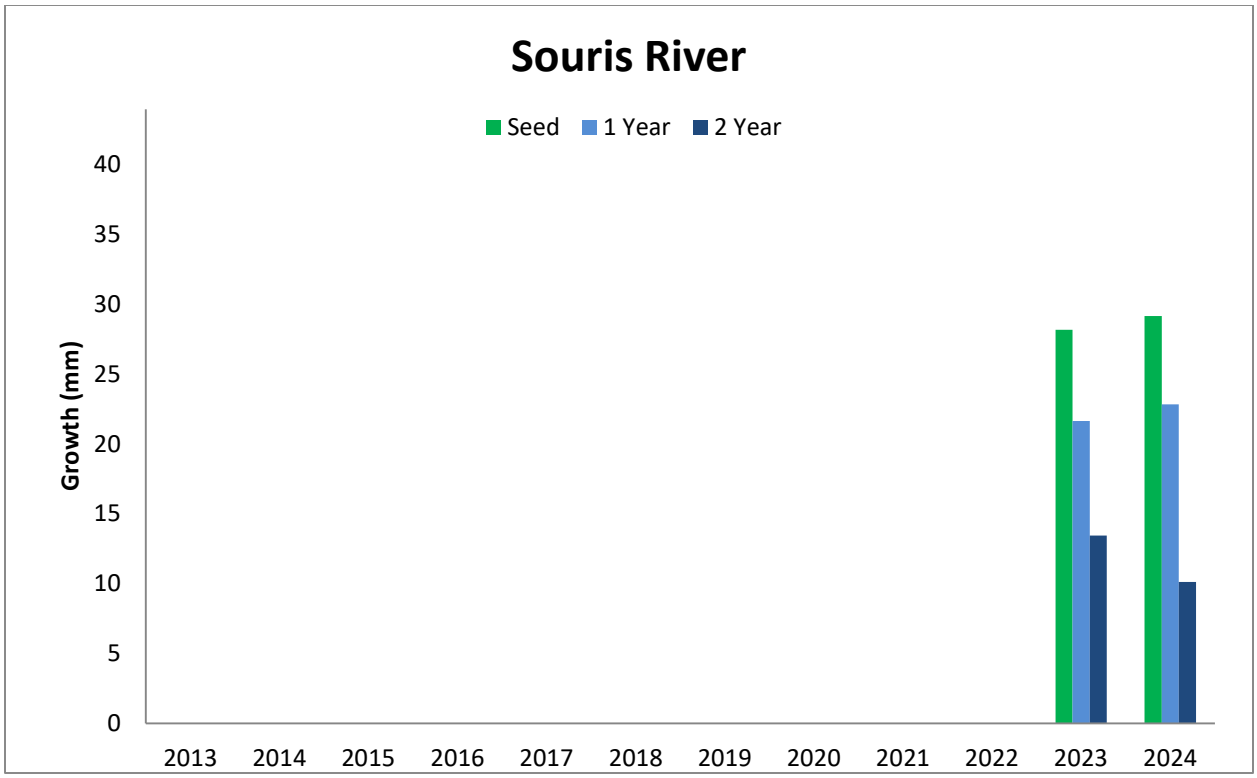

Gibb's Creek
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

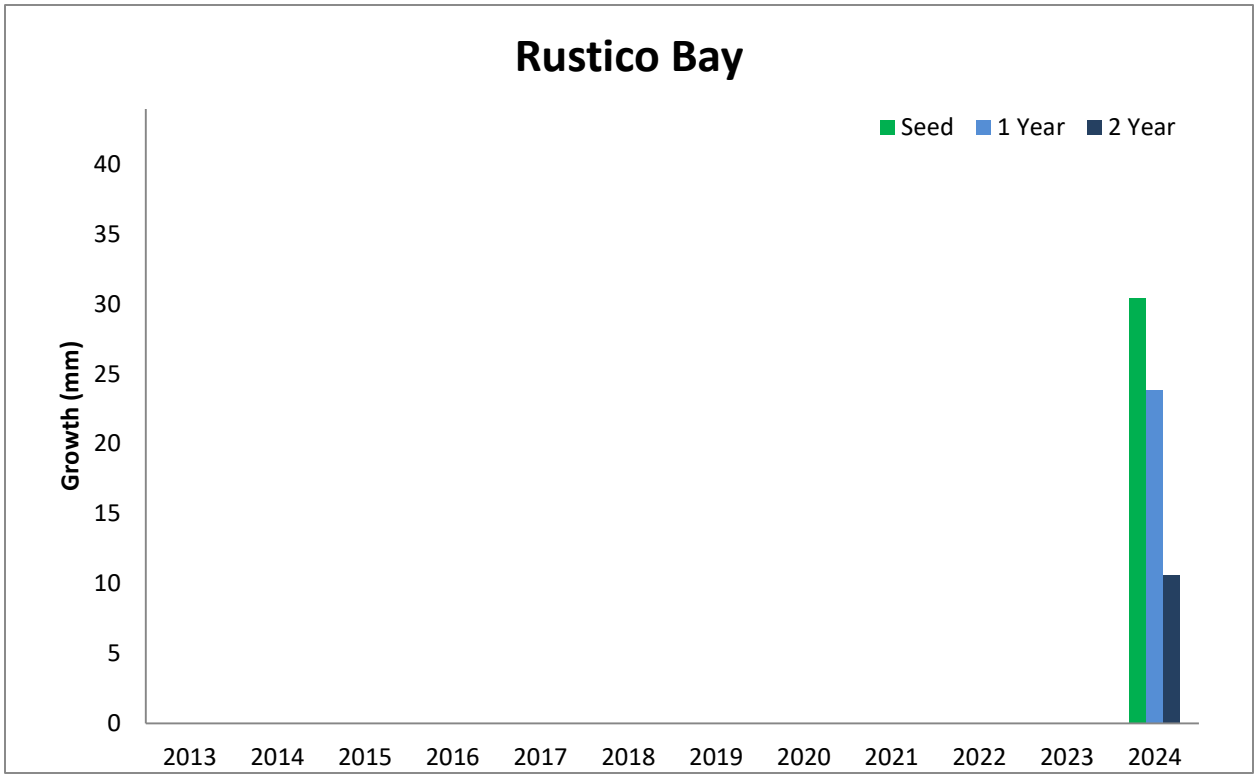

Bideford River
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024


Percival River
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

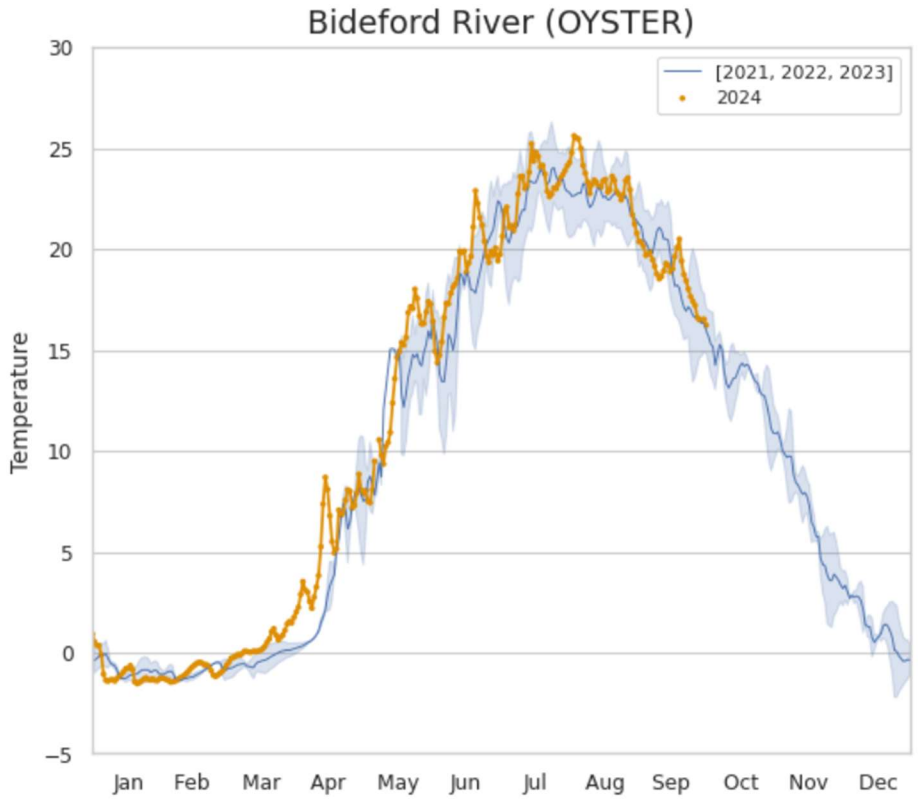

Savage Harbour
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

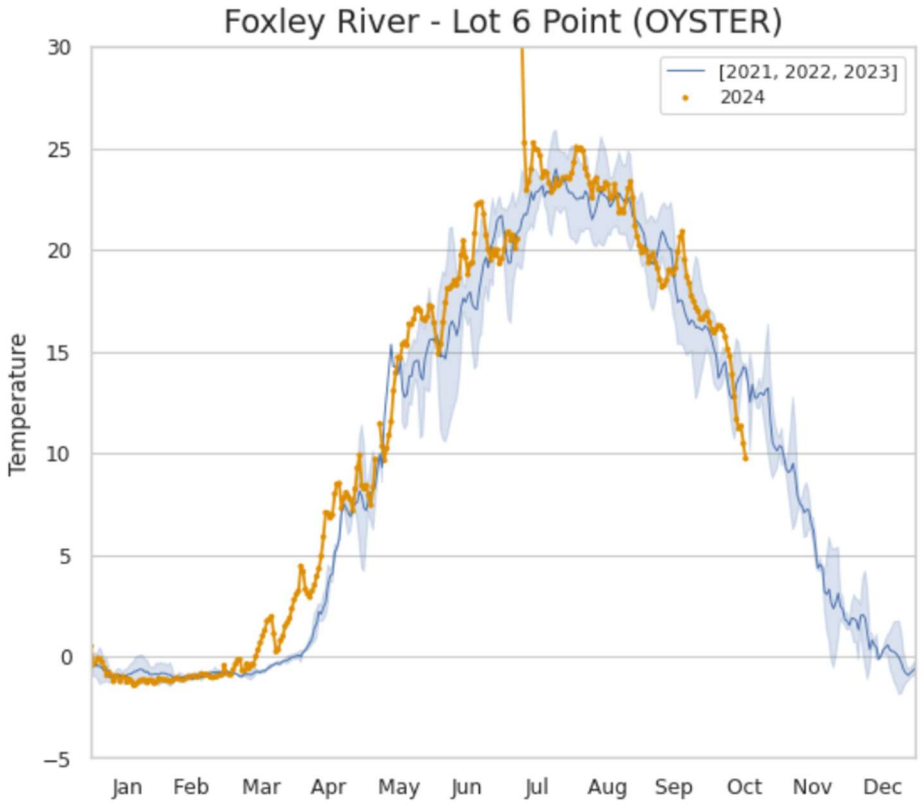

Orwell River
Seed
1 Year
2 Year
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

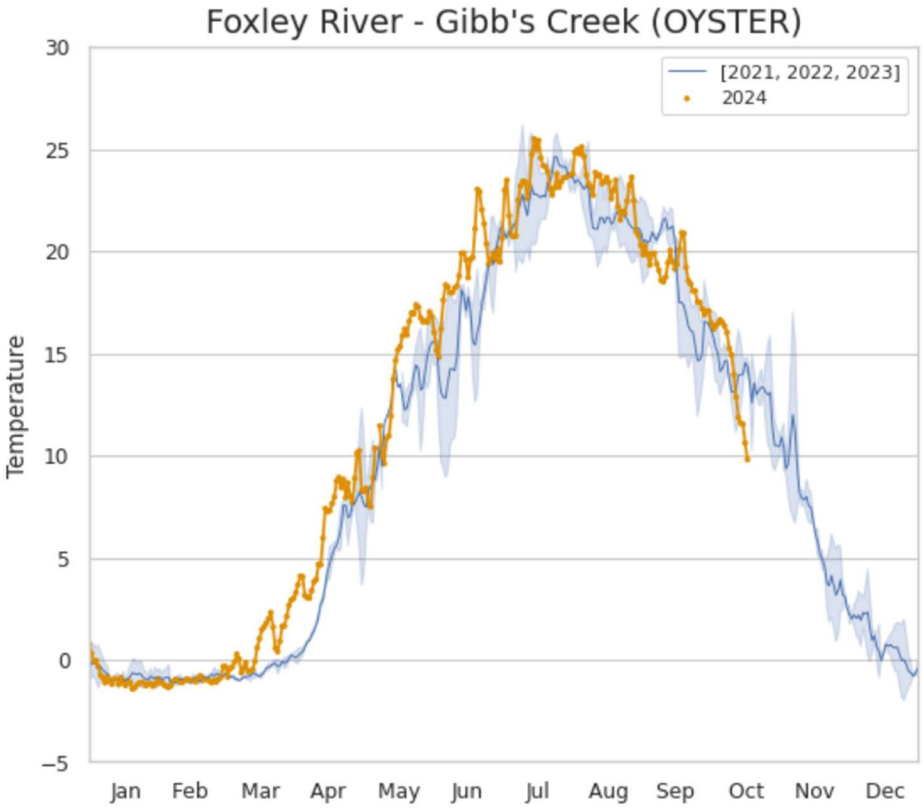

Souris River
Seed
1 Year
2 Year
Growth (mm)
0
5
10
15
20
25
30
35
40
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

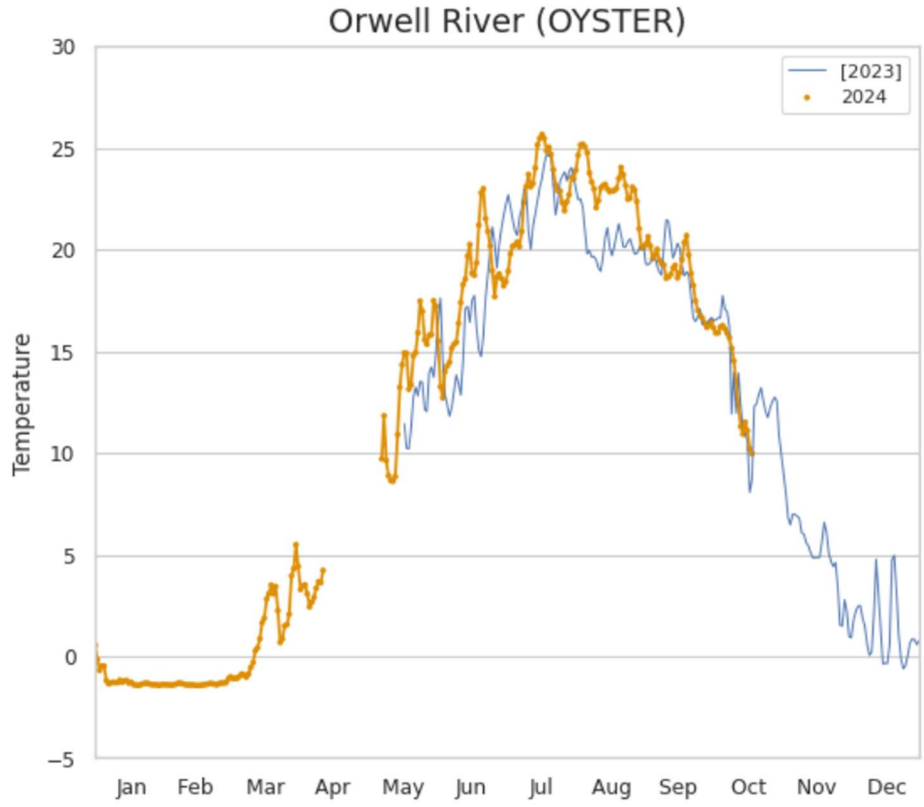

Rustico Bay
Seed
1 Year
2 Year
Growth (mm)
0
5
10
15
20
25
30
35
40
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

APPENDIX V: TEMPERATURE DATA BY LOCATION


Bideford River (OYSTER)
[2021, 2022, 2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

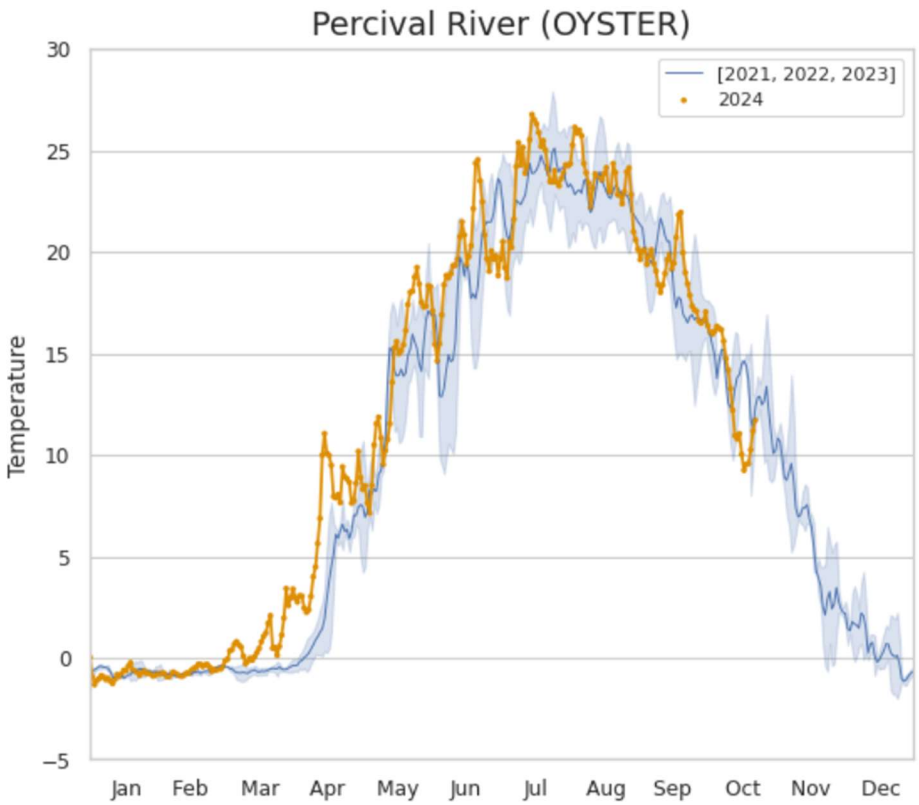

Foxley River - Lot 6 Point (OYSTER)
[2021, 2022, 2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

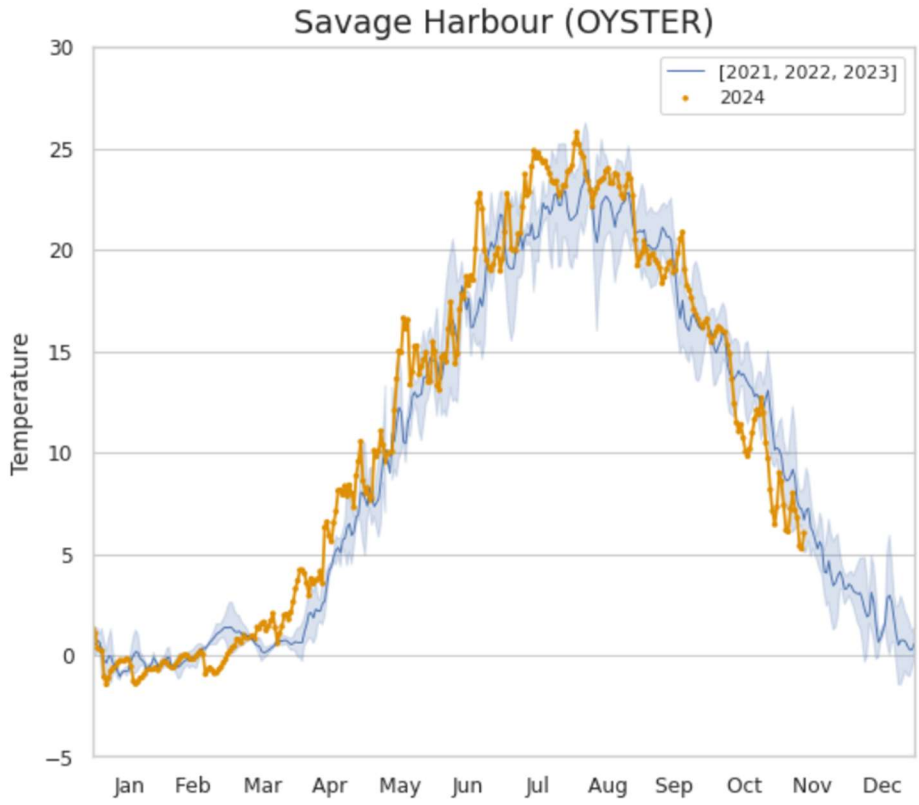

Foxley River - Gibb's Creek (OYSTER)
[2021, 2022, 2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Orwell River (OYSTER)
[2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Rustico Bay (OYSTER)
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

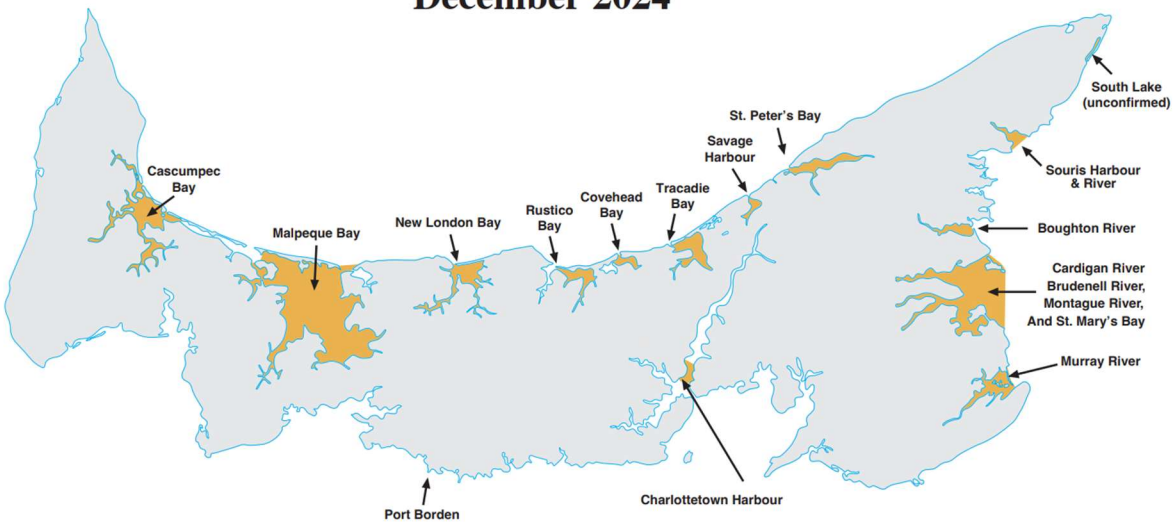

Souris River (OYSTER)
[2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Percival River (OYSTER)
[2021, 2022, 2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Savage Harbour (OYSTER)
[2021, 2022, 2023]
2024
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

APPENDIX VI: CURRENT DISTRIBUTION MAPS OF AQUATIC INVASIVE SPECIES

Known Range of Vase Tunicate December 2024



Known Range of Clubbed Tunicate December 2024