PEI Oyster Monitoring Report

2023 Report

Technical Report # 282

By

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ACKNOWLEDGEMENTS

The PEI Department of Fisheries, Tourism, Sport and Culture would like to acknowledge the cooperation and support of Island oyster growers in the development and implementation of Oyster Monitoring Program and Oyster Growth Monitoring Program. Also, the Department would like to acknowledge Jeff MacEwan, Mark MacLeod and Emily Currah for their work in sample collection.

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INTRODUCTION

The PEI oyster industry produces world famous oysters with a landed value of over $24M (2022; Figure 1). Over the past 10 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 farm.

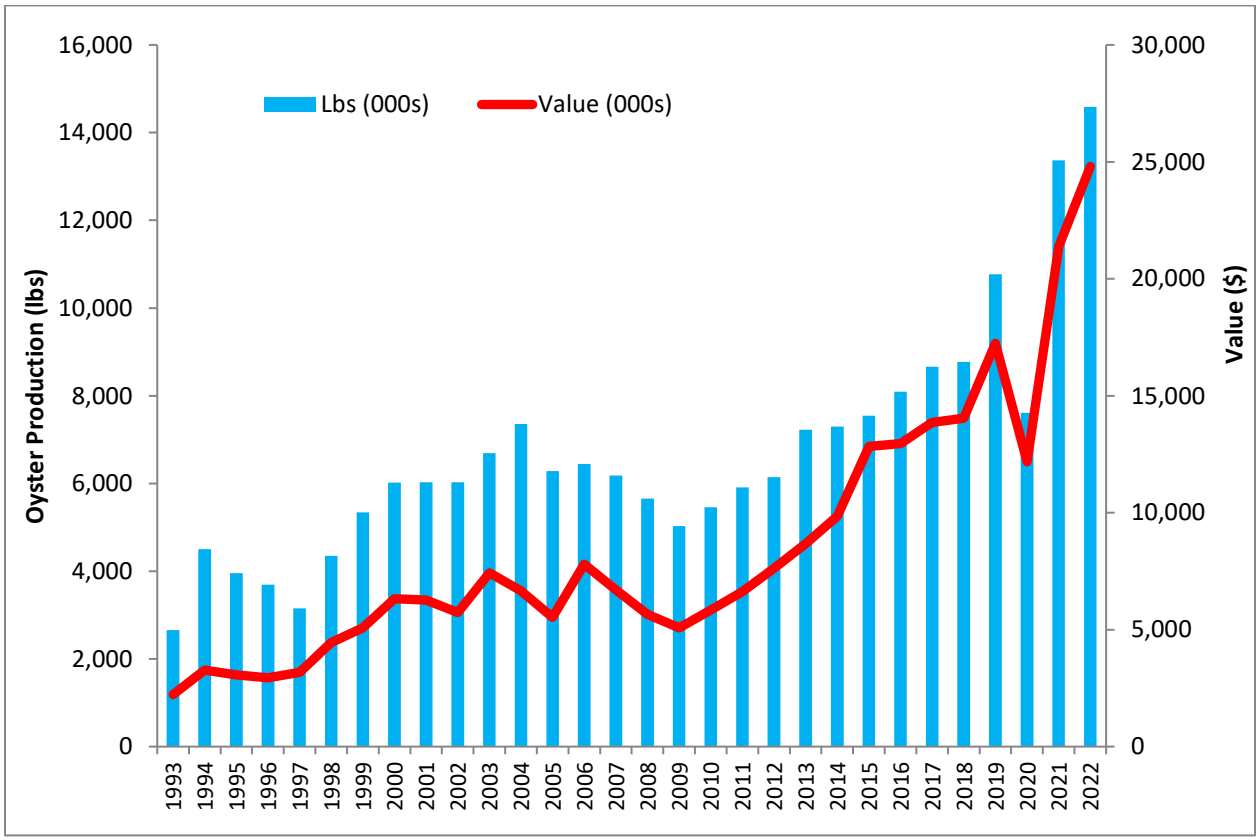


Figure 1. PEI oyster landings and values, 1991-2022.

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 on 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. 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 have 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 for 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. Oyster Growth Sites

MATERIALS & METHODS

LARVAE MONITORING

Oyster Monitoring Program data was collected from 17 monitoring sites in 2023 (Figure 4). Sampling locations in Eastern/ Central PEI included East River (Cranberry Wharf), Pownal Bay, Orwell River, Vernon River, Rustico Bay and Southwest River. Western sampling locations included three sites in Bideford River (Station, Paugh's Creek, and Green Park), three sites in Foxley River (Lot 10, Lot 6 and Gibb's Creek), Enmore River, Percival River, Dock River, Darnley Basin, and Grand River.

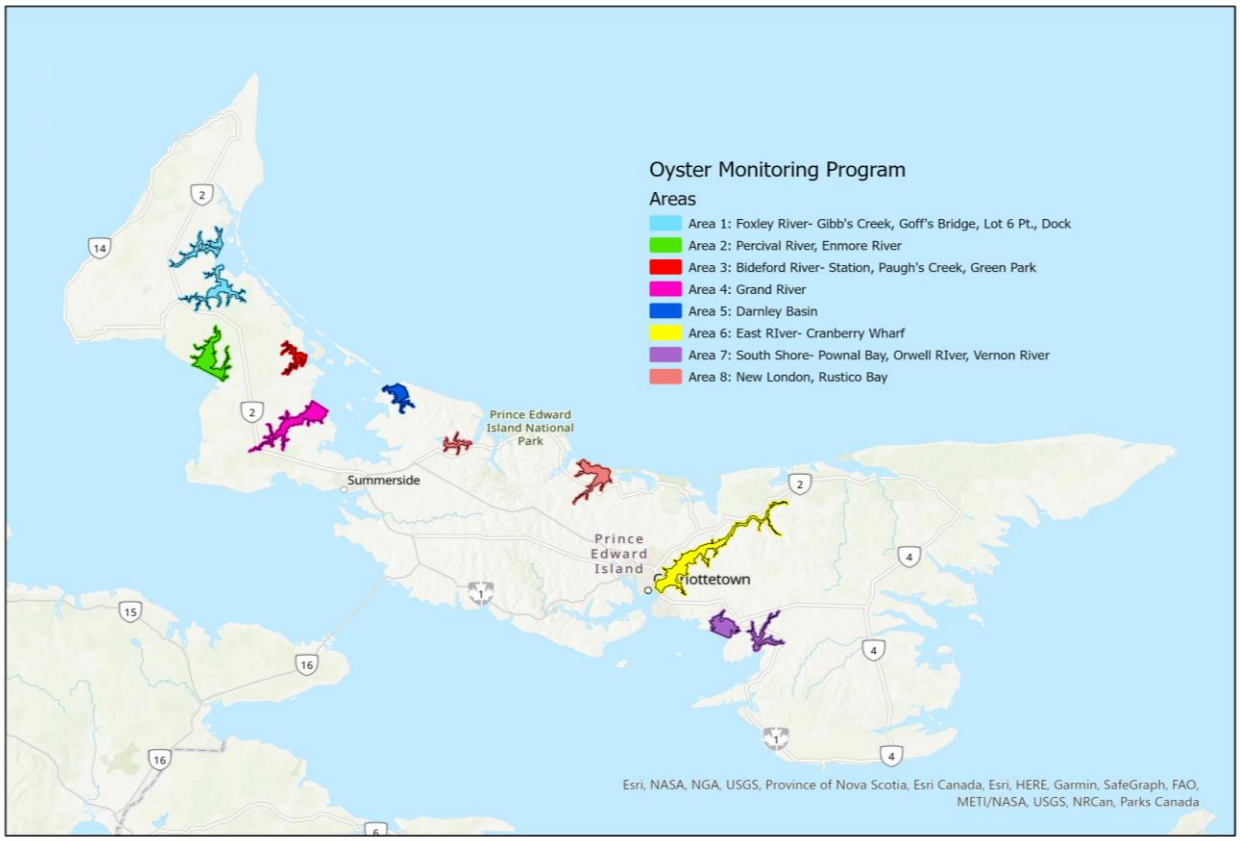


Figure 4. Map of PEI showing general location of 2023 OMP sampling sites.

Larvae samples were collected from June 28 to August 9. 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). 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. 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 (low = 1-5, medium = 6-19, high = 20-99 and very high >100), 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 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) were monitored at the Station site (Bideford River) and the Lot 10/Goff's Bridge site (Foxley River) using shell collectors consisting of ~6 ft lengths of galvanized wire with three scallop 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 were hung from collector lines for 7 days, retrieved and taken to the lab for reading. Recently set oyster spat were identified and the total number for each shell counted using a dissecting microscope.

Figure 6. Short-term oyster spat collectors (STC) ready to be deployed (*left*), prepared for reading in lab (*upper right*) and individual scallop shell showing oyster spat set (*lower right*).

GROWTH MONITORING

In May of 2023, the study began again for its eleven 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). Percival River and Orwell River are sites which are on the Northumberland Strait side of PEI; Savage Harbour and Souris River are on North side, but are much farther East, and Bideford River was another developed river system with a significant amount of off-bottom technology being utilized (see Figure 7).

Figure 7. Oyster Growth Monitoring locations.

Oysters for the 2023 monitoring program were available from the previous year, held in cages overwinter. The 2nd year oysters were collected in 2020 from Bideford River (a different seed

source than in the past number of years), 1st year oysters were collected in 2021 from East River, and seed class was collected in 2022 from 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 year class separate (1st year and 2nd year), mortalities were removed and the remaining oysters were mixed to ensure the oysters were standardized. 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 2023 monitoring season.

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 per 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). Each bag was also weighed and recorded. 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 lime/ brine dipped to reduce

the risk transferring aquatic invasive species (i.e. tunicates) between river systems. The bags of oysters were then randomly assigned to each location, with two bags from each year class going to each location to be housed in the 6-bag cages.

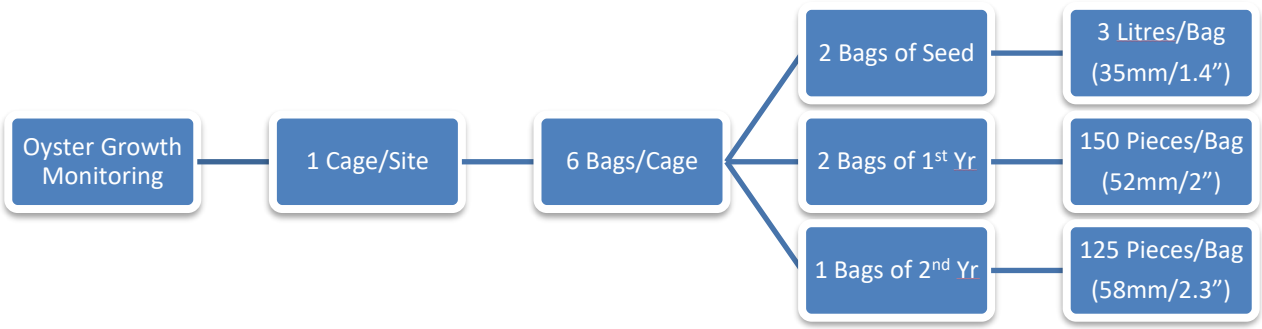


Figure 9. Breakdown of site setup.

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 Cages.

By late August, the oysters had grown substantially, and as a result, the bags of seed needed to be thinned out. The bags of seed at each site were removed from the water, randomly divided,

and 3 liters of oysters were measured and returned to their original bag. The extra oysters were removed from the site, donated to the lease holder or 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, providing a sample of 100 oysters per age class per location. The 2nd year oysters were given to the lease holder and the remaining oysters were either returned to the water or held in other 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 1 metre below the surface attached to the rope of 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 put 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) 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. 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 was chosen because it was a significant growing area on the southeast side of the Island. Orwell River was a central area on the southside that is a significant seed collection area.

Figure 12. Innovasea Water Quality Platform.

RESULTS AND DISSCUSION

LARVAE MONITORING

A total of 201 larvae samples were collected between June 28 and August 9 in 2023. The size ranges, total numbers of larvae above 250µm collected and the water temperature at each site are shown in Appendix II. The pattern of seasonal abundance of oyster larvae >250 µm for all primary (sampled 3 times a week) and secondary sites (sampled 1-2 times per week) are shown in Appendix III. Oyster larvae were first observed between July 4th and July 5th at most sites across PEI; Southwest River and Rustico Bay were July 11th. Larvae >250 µm were first observed July 12th In general, larvae >250 µm appeared later at some of the secondary sites compared to the primary sites. Peak numbers of larvae >250 µm were observed between July 17th and July 25th in all areas.

The first observation of oyster larvae and peak numbers of larvae >250 µm 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 2023 was an average year for many growers. In 2023, because of an excellent first set in some areas, grower began thrashing collectors in late August to avoid a second set. 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. Results from 2023 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.

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

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 2023, the high concentrations of newly settled barnacles (*Balanus crenatus*) on collectors continues to be a concern for many growers.

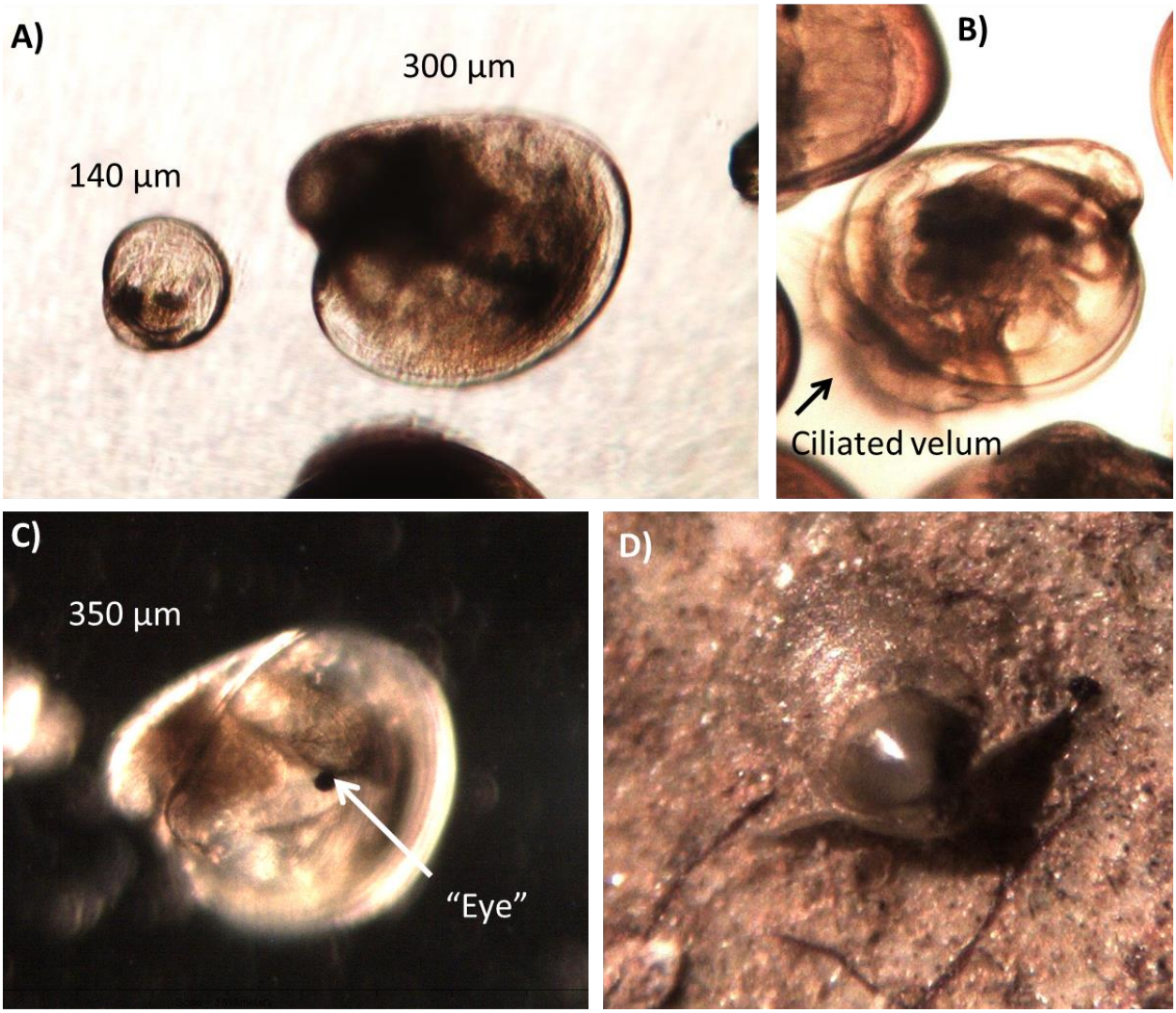


Figure 13. Oyster larvae at different stages of development. A) 140 and 300µm larvae, B) Free swimming larvae showing ciliated velum, C) Eyed larvae ready to set, and D) Settled larvae (spat) on collector shell.

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 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.

GROWTH MONITORING

In 2023, the monitoring program refocused to gather 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 each year, followed by the first years and then second years (Figure 14). Annual variability is expected as environmental conditions vary from year to year. Average annual growth between 2013-2022 is compared to 2023 growth at each location, based on year class (Figure 15, 16, 17). Overall, results from the 2023 growth monitoring are similar to past growth data with slight increases or decreases observed at the individual site.

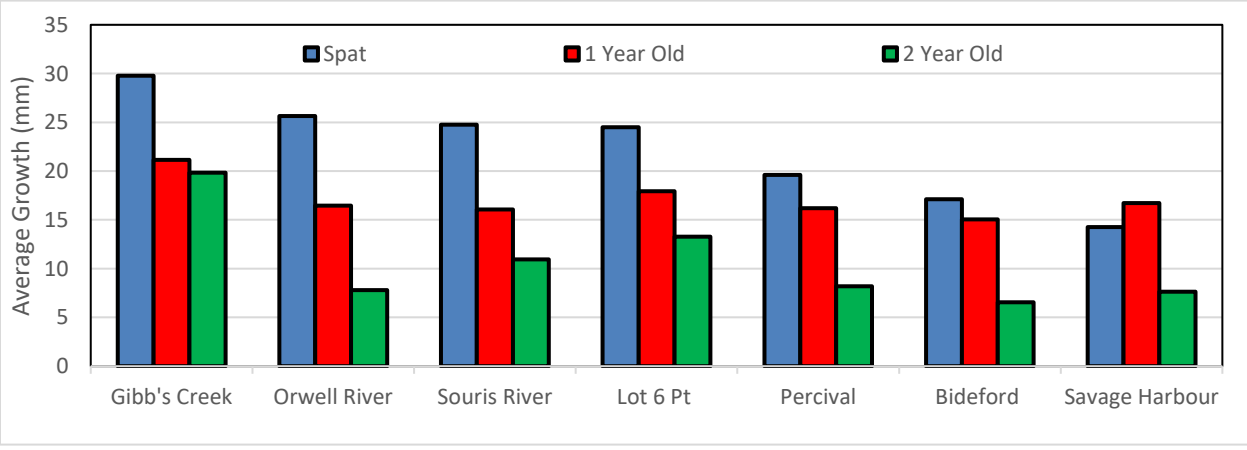


Figure 14. Oyster Shell Length Growth in 2023.

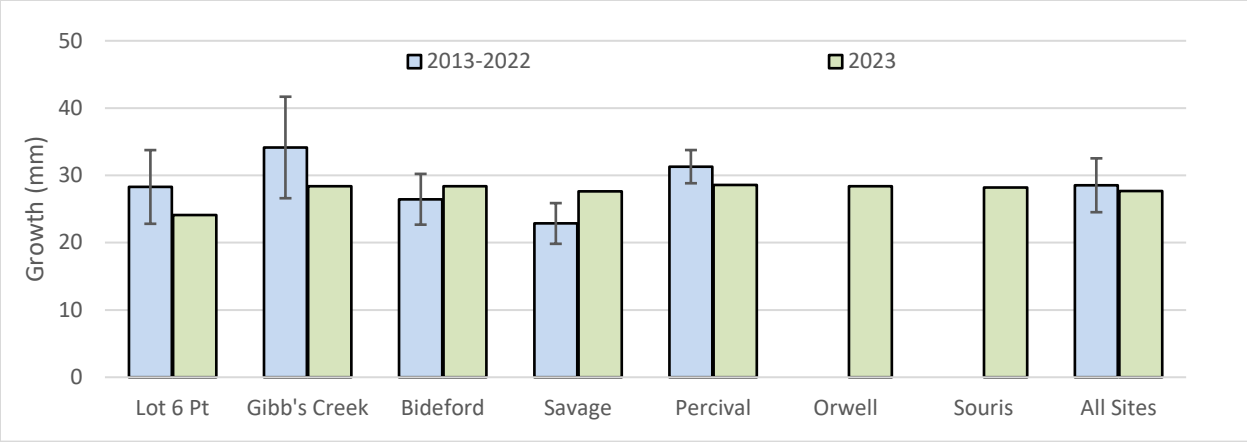


Figure 15. Annual growth of seed oysters.

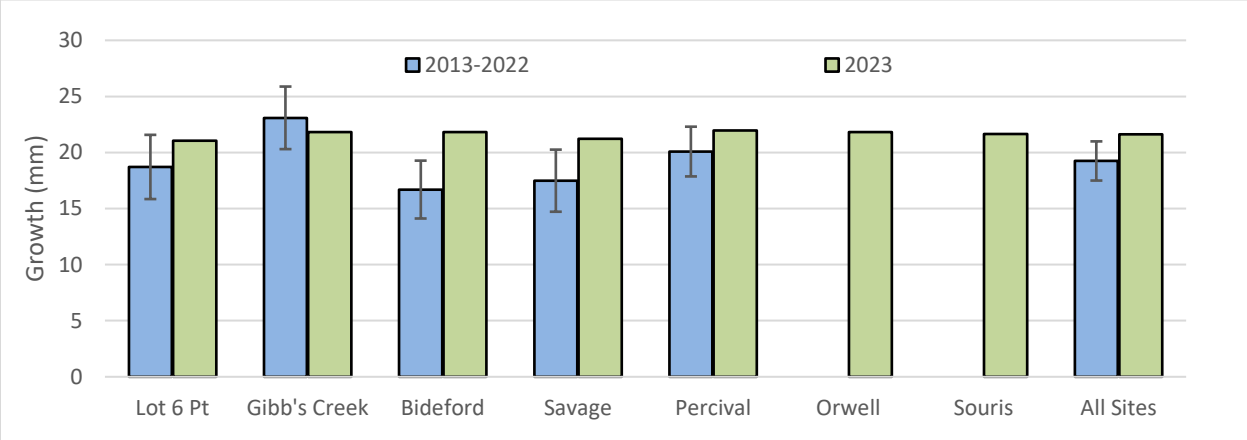


Figure 16. Annual growth of 1st year oysters.

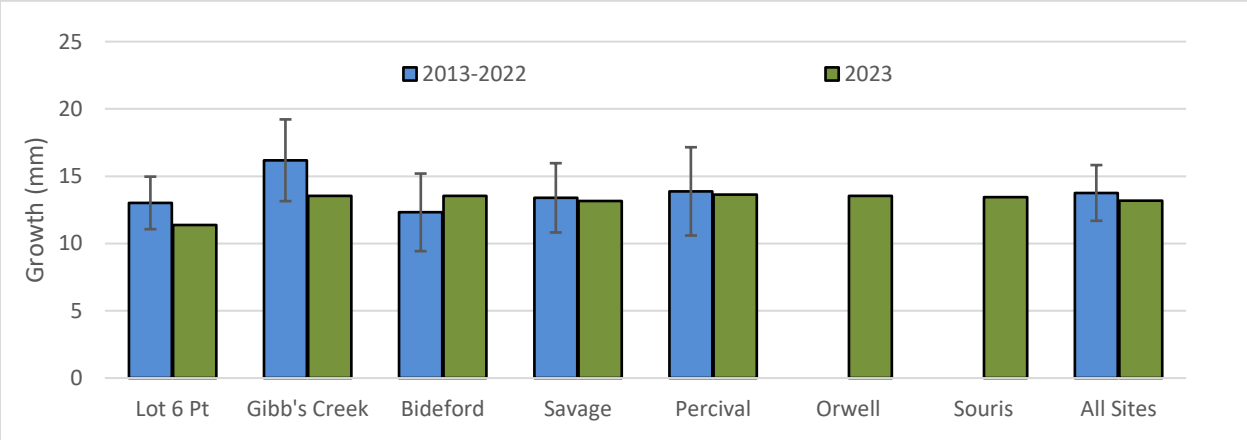


Figure 17. Annual growth of 2nd year oysters.

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 for purposes of following growth trends. This had been identified by the 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 19.1^{o}C (Souris River) and the highest temperature observed was at 23.7^{o}C (Bideford).

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 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 study is to provide additional information to industry and help evaluate and assess the development of this industry.

TUNICATE MONITORING

Current distribution maps of invasive tunicates (Clubbed & Vase) on PEI are shown in Appendix VI. Clubbed and vase tunicates are now in some 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 2023 there have been new detections of the vase tunicate (Figure 18) in New London Bay, Covehead Bay, Rustico Bay, Tracadie Bay and Savage Harbour. 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 17. 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 seven sites throughout the growing season in 2023. 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/.

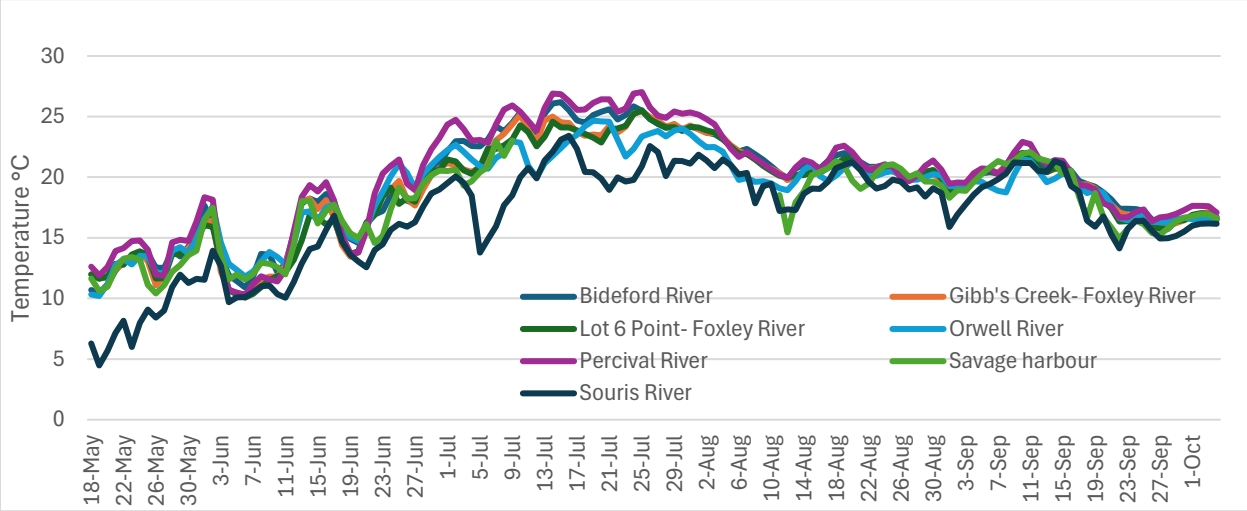
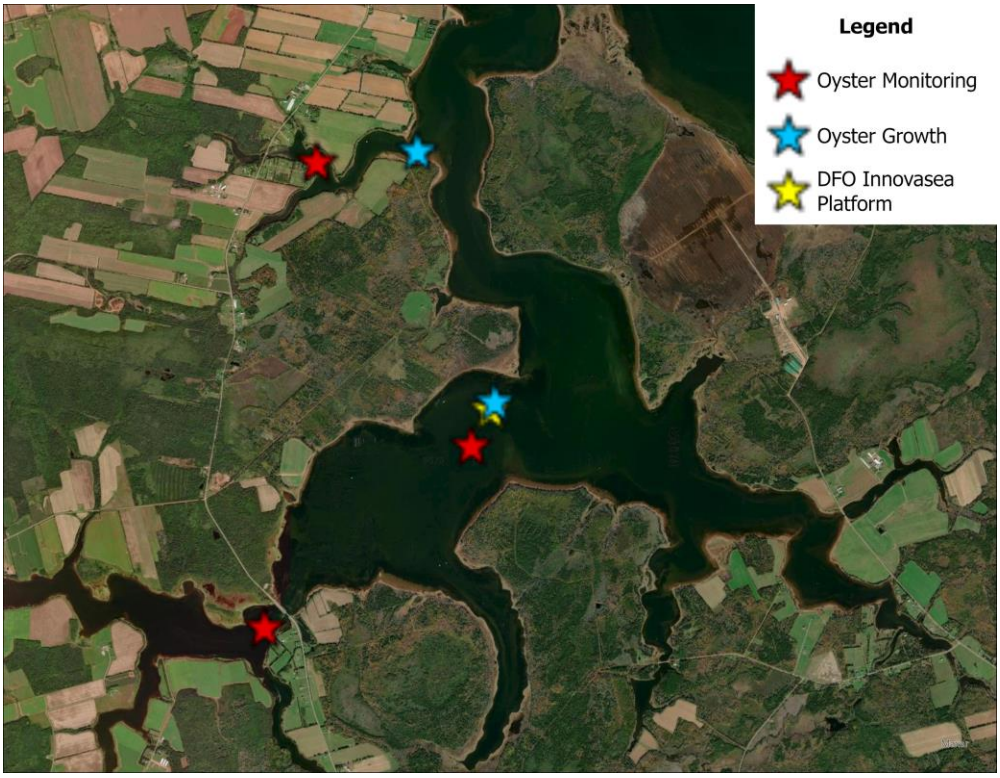


Figure 19. Oyster Growth Temperature Data.

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 four sites (Souris River, Foxley River, Bideford River and Orwell River) additional water quality parameters (dissolved oxygen, temperature, salinity and chlorophyll red) were collected. As additional information is collected, comparisons year to year and between sites can be made, and its potential effect on oyster growth.

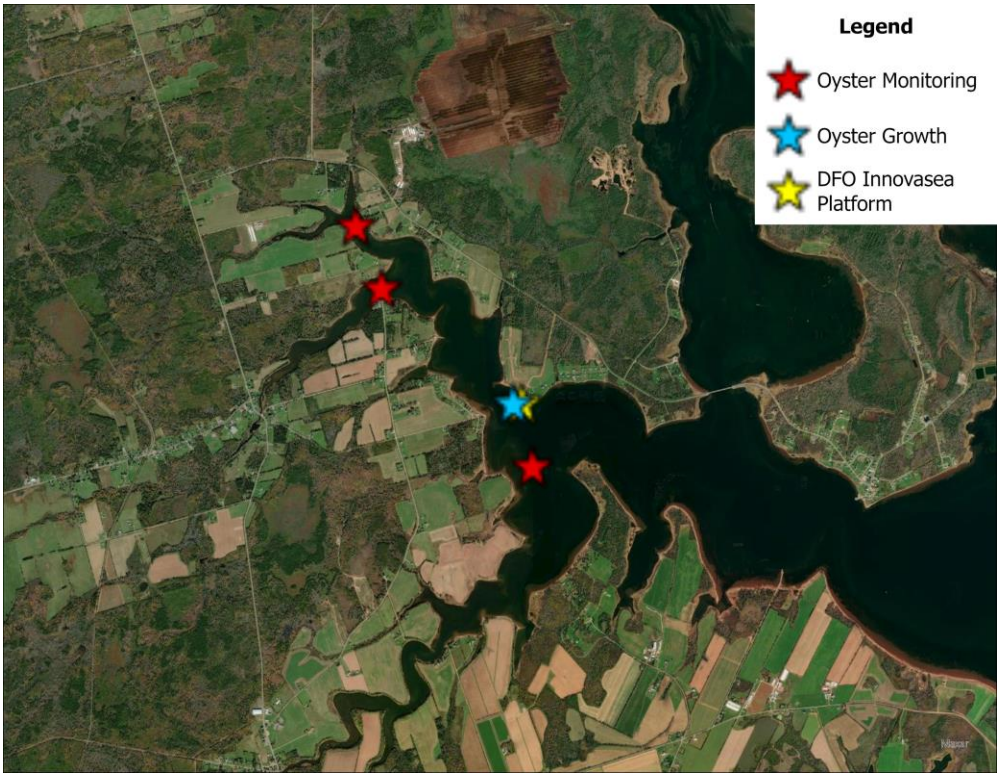
APPENDIX I: LOCATIONS OF 2023 SAMPLING SITES



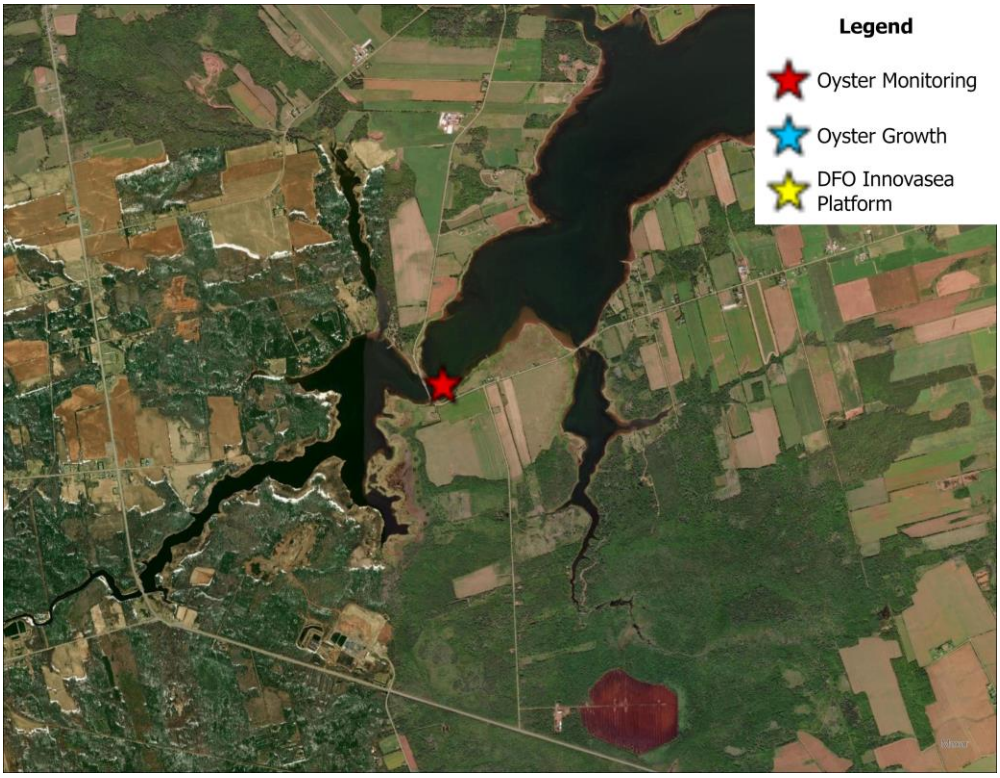
Monitoring sites in Foxley River

Monitoring site in Dock River

Monitoring sites in Percival and Enmore Rivers

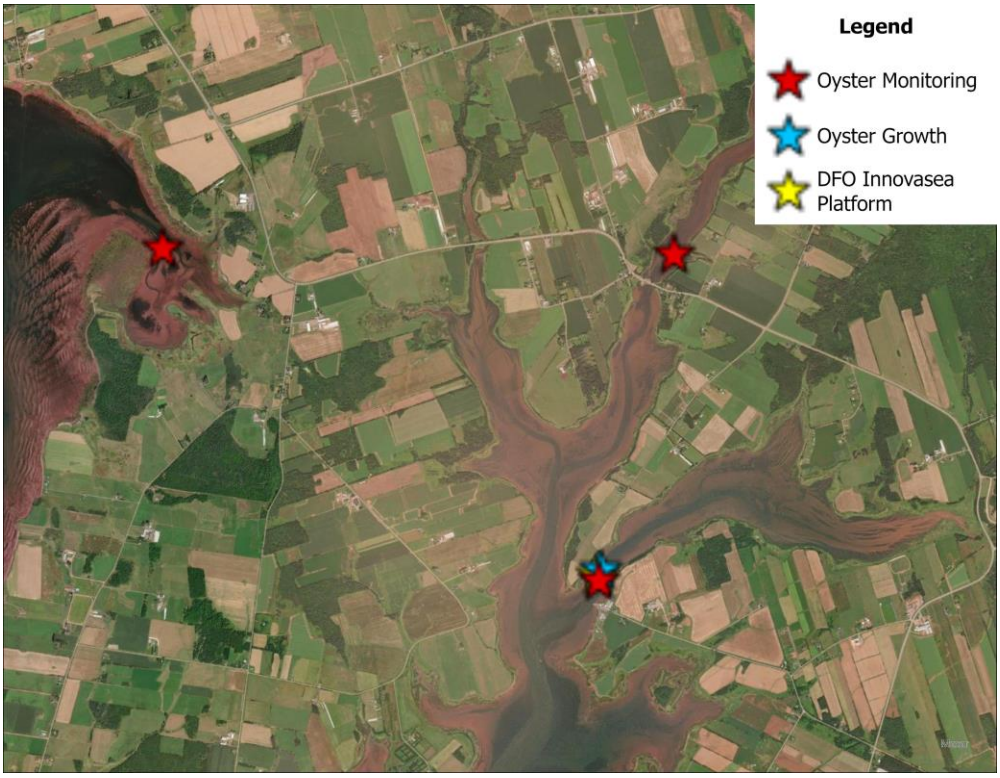


Monitoring sites in Bideford River

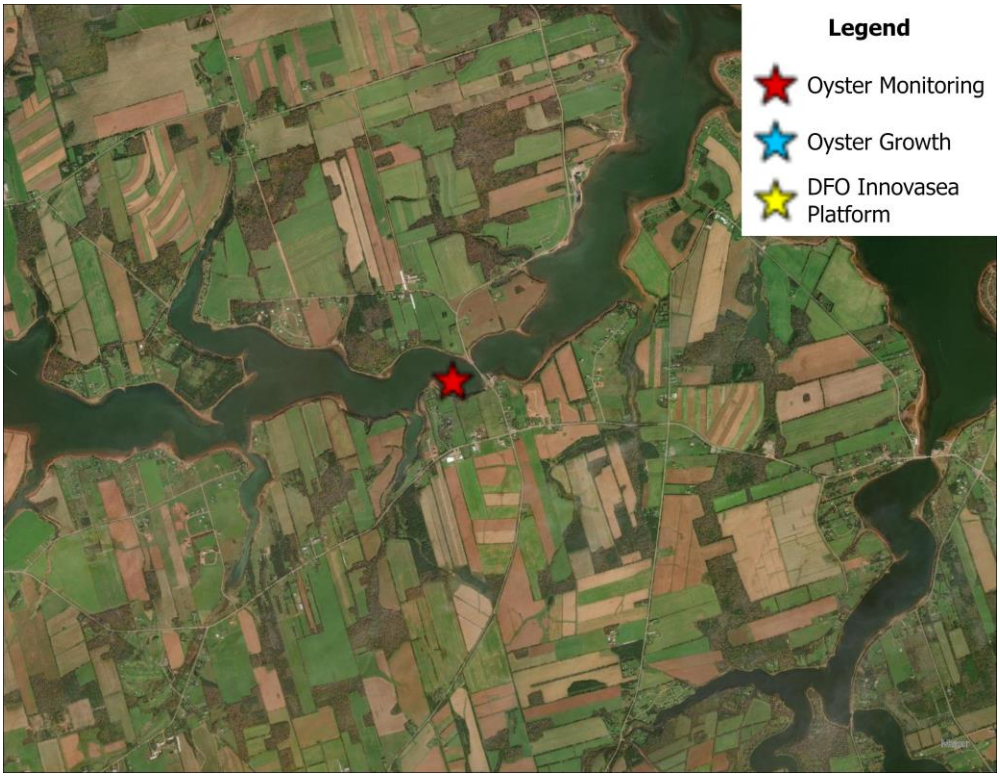


Monitoring site in Grand River

Monitoring site in East River



Monitoring sites in Pownal Bay, Vernon River, Orwell River



Monitoring site in Southwest River

Monitoring site in Darnley Basin

Monitoring site in Rustico Bay

Monitoring site in Savage Harbour

Monitoring sites in Souris River

APPENDIX II: 2023 OYSTER MONITORING DATA BY SITE

Foxley River – Gibb's Creek					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	22.4	18.3	0	0	0
7/4/2023	20.8	22.7	7	90-100	0
7/7/2023	23.2	20.2	11	90-130	0
7/10/2023	25.6	20.5	61	100-230	0
7/12/2023	23.1	21.3	68	90-280	18
7/14/2023	26.5	20.3	111	90-310	21
7/17/2023	24.3	21.7	72	90-320	12
7/19/2023	23.9	23.2	50	110-310	16
7/21/2023	25.6		9	160-340	7
7/24/2023	24.9	24.2	0	0	0
7/26/2023	25.9	24.3	2	100	0
7/28/2023	25	24.2	31	100-320	12
7/31/2023	25.5	24.4	0	0	0
8/3/2023	24	22.3	2	200-230	0
8/7/2023	23.3	23.6	0	0	0

Foxley River – Goff's Bridge					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	20.2	10.3	0	0	0
7/4/2023	21.1	16.3	22	90-100	0
7/7/2023	22.7	17.5	20	90-140	0
7/10/2023	24.4	17	11	90-160	0
7/12/2023	22.9	11.8	43	100-270	2
7/14/2023	26	16.9	81	90-310	15
7/17/2023	23.9	20.1	686	90-320	178
7/19/2023	24.2	20.7	204	110-320	72
7/21/2023	23.9		78	110-330	51
7/24/2023	24.7	22.6	23	140-340	15
7/26/2023	247	20.4	0	0	0
7/28/2023	24.3	22.3	22	100-330	8
7/31/2023	24.8	22	2	140-190	0
8/3/2023	23.4	23.2	2	90	0
8/7/2023	21.9	22	0	0	0

Foxley River – Lot 6 Point					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	19.5	18.3	0	0	0
7/4/2023	19.9	22.5	47	90-100	0
7/7/2023	21.7	20.6	39	90-140	0
7/10/2023	25	18.7	17	90-190	0
7/12/2023	22.5	20.4	113	90-270	6
7/14/2023	24.3	19.3	126	90-290	17
7/17/2023	23	22.1	199	90-310	26
7/19/2023	22.2	22.7	226	100-320	76
7/21/2023	23.8		34	110-330	16
7/24/2023	24.4	23	9	130-340	4
7/26/2023	24.1	23.3	51	100	0
7/28/2023	23.5	23.6	32	100-320	3
7/31/2023	23.9	24.2	4	110-190	0
8/3/2023	26.2	24.6	6	150-200	0
8/7/2023	21.7	24.4	2	320-340	2

Dock River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
7/4/2023	16.7	25.7	5	90-100	0
7/10/2023	22.5	23.9	77	90-160	0
7/19/2023	18	26.2	326	90-310	64
7/26/2023	23.2	25.1	16	100-330	2
7/31/2023	22.1	26.2	36	140-340	4

Percival River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	22	14.5	0	0	0
7/5/2023	20.5	25.6	28	90-110	0
7/11/2023	23.9	22.6	61	90-150	0
7/13/2023	24.5	22.2	57	90-280	5
7/18/2023	24.8	23.8	198	90-310	30
7/20/2023	25.3	23.9	37	100-340	23
7/25/2023	26.2	25	26	260-340	26
7/27/2023	25.3	26.5	64	100-110 260-280	2
8/2/2023	22.8	25.6	0	0	0

Enmore River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	22.8	6.2	0	0	0
7/5/2023	20.9	12.2	1	90	0
7/11/2023	23.7	19.2	4	90-110	0
7/13/2023	25.8	23.1	132	90-270	2
7/18/2023	25.1	23.9	252	90-320	64
7/20/2023	25.8	20.5	127	90-330	94
7/25/2023	26.4	22.8	25	100-340	15
7/27/2023	25.3	16	37	100-120 260-280	2
8/2/2023	23.5	21.4	5	309-330	5
8/9/2023	21.3	20.8	2	300-330	2

Bideford River – Green Park					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	18.7	25	0	0	0
7/4/2023	20.6	9.8	3	90-100	0
7/7/2023	23.5	23.3	12	90-120	0
7/10/2023	25.3	22.9	24	90-230	0
7/12/2023	23.7	22.8	776	90-310	76
7/14/2023	25.2	24.4	588	90-310	142
7/17/2023	22.6	25.3	474	90-310	210
7/19/2023	23.5	25.3	295	90-320	65
7/21/2023	25.1		96	90-340	58
7/24/2023	25.1	24.7	19	130-330	16
7/26/2023	23	25.8	28	100-320	11
7/28/2023	22.9	25.7	19	140-320	6
7/31/2023	24.1	25.3	6	160-320	4
8/3/2023	23.3	26.2	24	280-340	24
8/7/2023	22.1	24.7	1	330	1

Bideford River – Paugh's Creek					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	19.7	21.4	0	0	0
7/4/2023	22	24.7	6	90-100	0
7/7/2023	23.4	23.1	47	90-150	0
7/10/2023	27	18.1	8	90-230	0
7/12/2023	24.6	21.8	183	90-310	51
7/14/2023	27.1	21.2	168	90-320	46
7/17/2023	25.4	18.2	1239	90-330	228
7/19/2023	27.2	20.7	121	90-330	56
7/21/2023	25.3		36	130-330	28
7/24/2023	24.9	25.2	17	100-340	8
7/26/2023	25	24.6	1	320	1
7/28/2023	24.6	25.9	1	260	1
7/31/2023	24.8	26.1	12	160-320	11
8/3/2023	324	25.9	18	130-330	16
8/7/2023	22.5	25.5	1	330	1

Bideford River – Station					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	19.5	22.9	0	0	0
7/4/2023	21.9	24.9	10	90-100	0
7/7/2023	23.7	20.9	18	90-140	0
7/10/2023	26.6	18.2	8	90-180	0
7/12/2023	24.4	21.8	311	90-300	88
7/14/2023	27	20.7	79	90-300	15
7/17/2023	25.2	20.1	1014	90-320	228
7/19/2023	25.6	22.6	143	57	320
7/21/2023	25.6		17	140-340	3
7/24/2023	25.9	25	5	100-330	1
7/26/2023	24.9	24.5	4	100	0
7/28/2023	24.6	24.6	8	160-320	6
7/31/2023	24.4	26	50	160-320	44
8/3/2023	23.6	25.9	12	300-340	12
8/7/2023	22.4	25.9	0	0	0

Grand River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	21.4	24.2	0	0	0
7/5/2023	22.9	18.2	12	90-100	0
7/11/2023	23.2	24.3	134	90-210	0
7/13/2023	23.9	23.8	640	90-300	112
7/18/2023	22.9	26.2	1255	90-340	1015
7/20/2023	23.3	26	1827	100-340	1456
7/25/2023	24.1	26.2	1120	120-340	804
7/27/2023	25.7	23.8	186	130-340	105
8/2/2023	22.8	25.5	44	160-330	29
8/9/2023	21.5	25.1	0	0	0

Darnley Basin					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	18.5	26.7	0	0	0
7/5/2023	20.8	25.6	6	90-100	0
7/13/2023	20.3	27.6	112	90-270	1
7/18/2023	21.2	27.2	114	90-320	56
7/25/2023	21.9	27.7	28	130-340	5
8/2/2023	22.9	26.4	15	100-110 280-300	2

East River – Cranberry Wharf					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	21	19.1	0	0	0
7/4/2023	22.3	16.7	64	90-130	0
7/7/2023	22.4	12.4	13	90-160	0
7/10/2023	25	13.6	8	120-230	0
7/12/2023	22.6	15.7	37	120-300	15
7/14/2023	24.5	17.8	25	110-290	3
7/17/2023	24.8	17.9	10	90-220	0
7/19/2023	25.7	14.7	38	90-310	7
7/21/2023	25.2	13.9	131	110-330	65
7/24/2023	23.5	7.2	2	140-180	0
7/26/2023	24.4	10.1	2	280-320	2
7/28/2023	23.7	12.6	5	160-340	3
8/1/2023	23.5	19.1	2	170-300	1
8/3/2023	22.7	13.4	0	0	0
8/7/2023	20.8	12.7	0	0	0

Pownal Bay					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	20.5	28	0	0	0
7/4/2023	21.5	25	104	90-130	0
7/10/2023	23.4	26.8	181	90-225	0
7/12/2023	21.2	25.7	446	90-230	0
7/14/2023	23.9	26.6	325	100-280	6
7/17/2023	24.1	27.5	912	90-320	310
7/21/2023	24.4	27.3	3920	90-340	2360
7/24/2023	24	25.4	1188	160-340	1116
7/26/2023	24.8	26	241	140-340	182
7/28/2023	22.4	18.4	232	130-340	152
8/1/2023	22.5	26.1	154	180-340	149
8/3/2023	22.1	27.2	124	290-340	124
8/7/2023	20.5	24.6	14	300-340	14

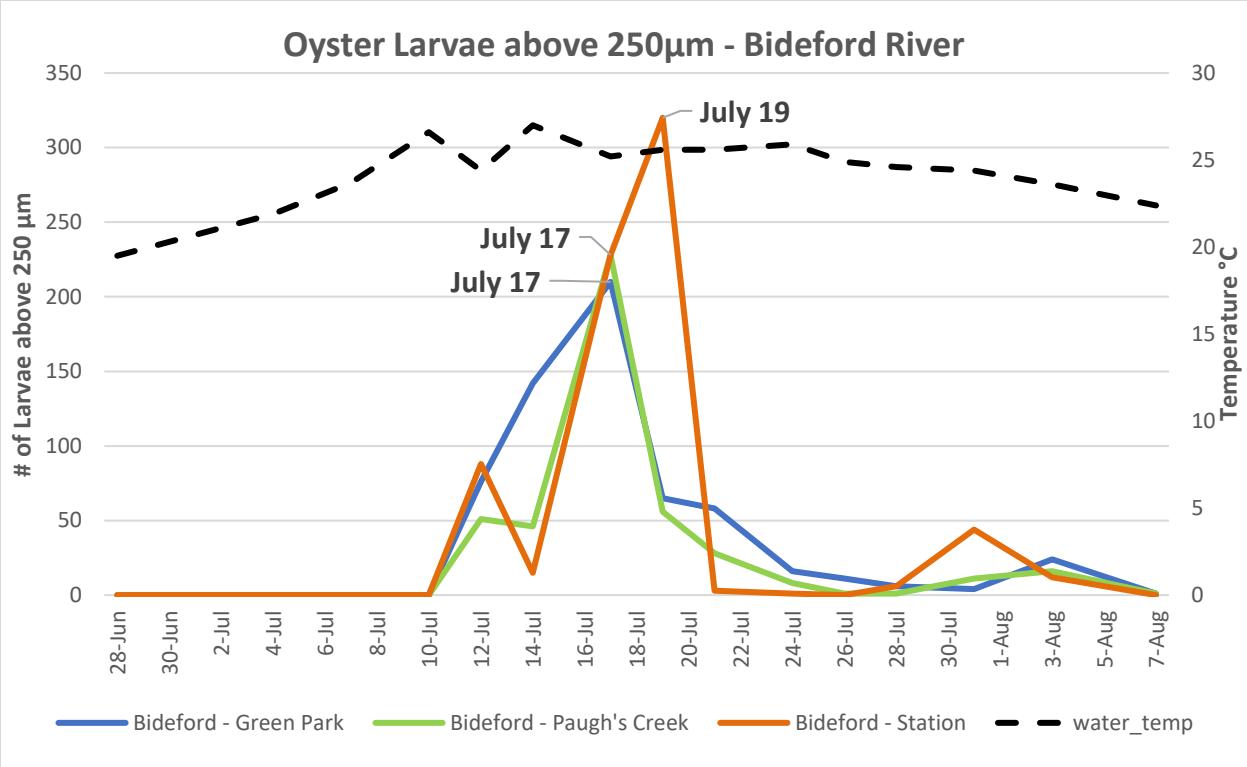
Orwell River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	20.4	26.6	0	0	0
7/4/2023	21.1	25.2	198	90-130	0
7/7/2023	21.2	25.3	77	90-160	0
7/10/2023	22.3	25.7	154	90-230	0
7/12/2023	20	25.7	1650	90-270	24
7/14/2023	21	26.5	1102	90-310	78
7/17/2023	22.4	27.4	704	90-320	130
7/19/2023	23.9	26.9	729	90-330	219
7/21/2023	24	25.7	1115	90-350	490
7/24/2023	21.4	21.2	58	140-340	26
7/26/2023	23.1	23.1	15	160-330	12
7/28/2023	22.6	18.4	92	100-340	32
8/1/2023	21.9	24.5	84	150-330	58
8/3/2023	21.6	23.4	54	190-340	52
8/7/2023	19.1	18.9	8	300-340	8

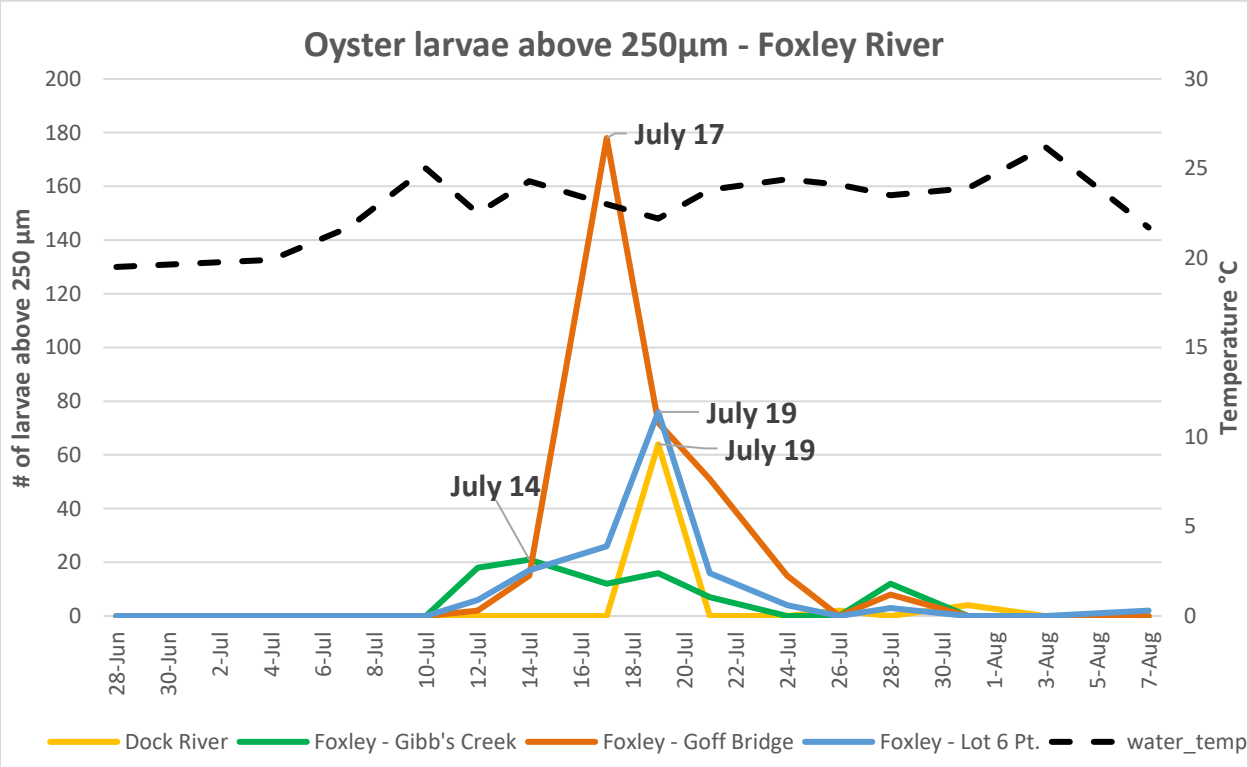
Vernon River					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/28/2023	20.9	24	0	0	0
7/4/2023	21.3	22.6	142	90-130	0
7/7/2023	21.8	18.7	4	90-140	0
7/10/2023	23.9	20.8	168	90-270	12
7/12/2023	21.4	21	250	90-260	6
7/14/2023	21.4	23.8	282	90-300	24
7/17/2023	23.4	25.7	208	90-320	43
7/19/2023	21.9	24.8	172	90-330	78
7/21/2023	24.1	21.8	79	120-350	56
7/24/2023	21.1	6.3	3	160-340	2
7/26/2023	23.3	9.9	32	150-330	27
7/28/2023	20.7	9.8	4	160-320	2
8/1/2023	21.2	23.4	27	160-330	20
8/3/2023	22	22.9	15	290-330	15
8/8/2023	19.2	14.5	2	330-340	2

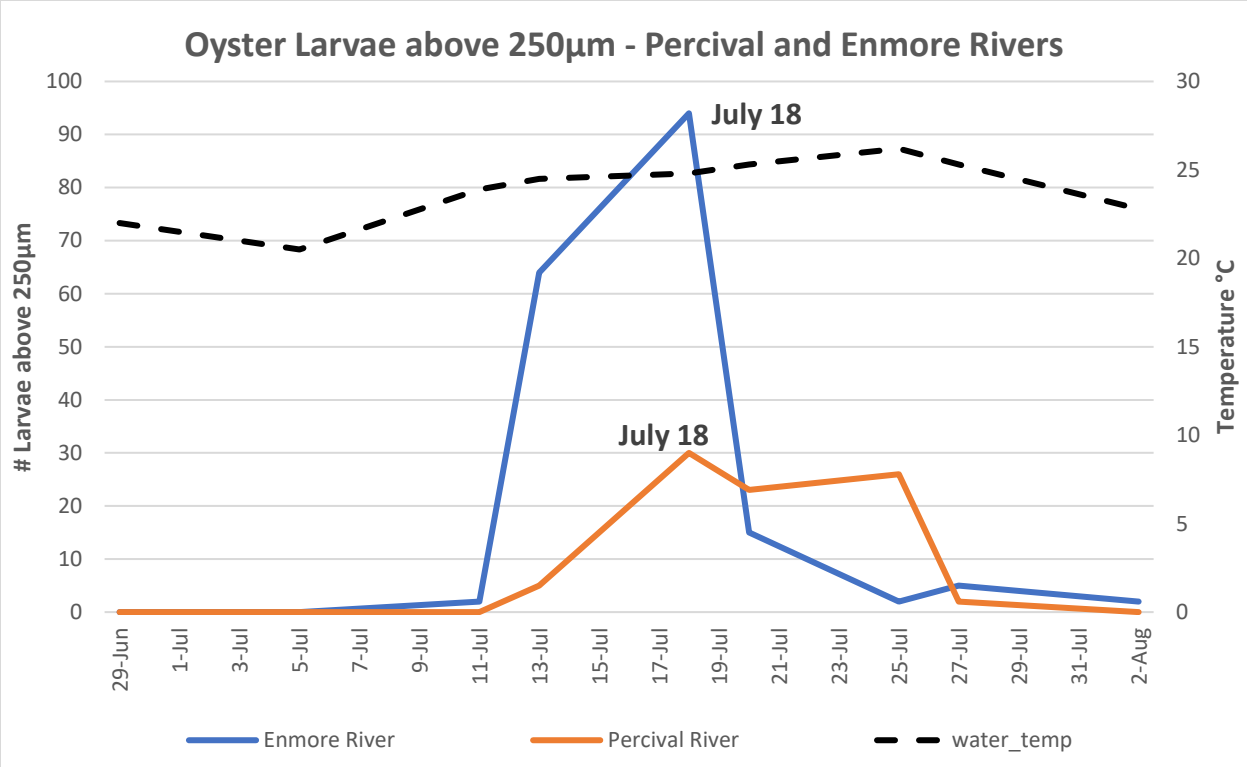
New London Bay					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	19.9	24.9	0	0	0
7/5/2023	24.2	21.2	0	0	0
7/11/2023	21	26.4	18	90-180	0
7/18/2023	22.5	25	53	90-260	3
7/25/2023	24.6	23.8	20	160-340	12
8/2/2023	23.4	25.2	6	180-6340	3
8/9/2023	20.7	26.2	4	210-330	2

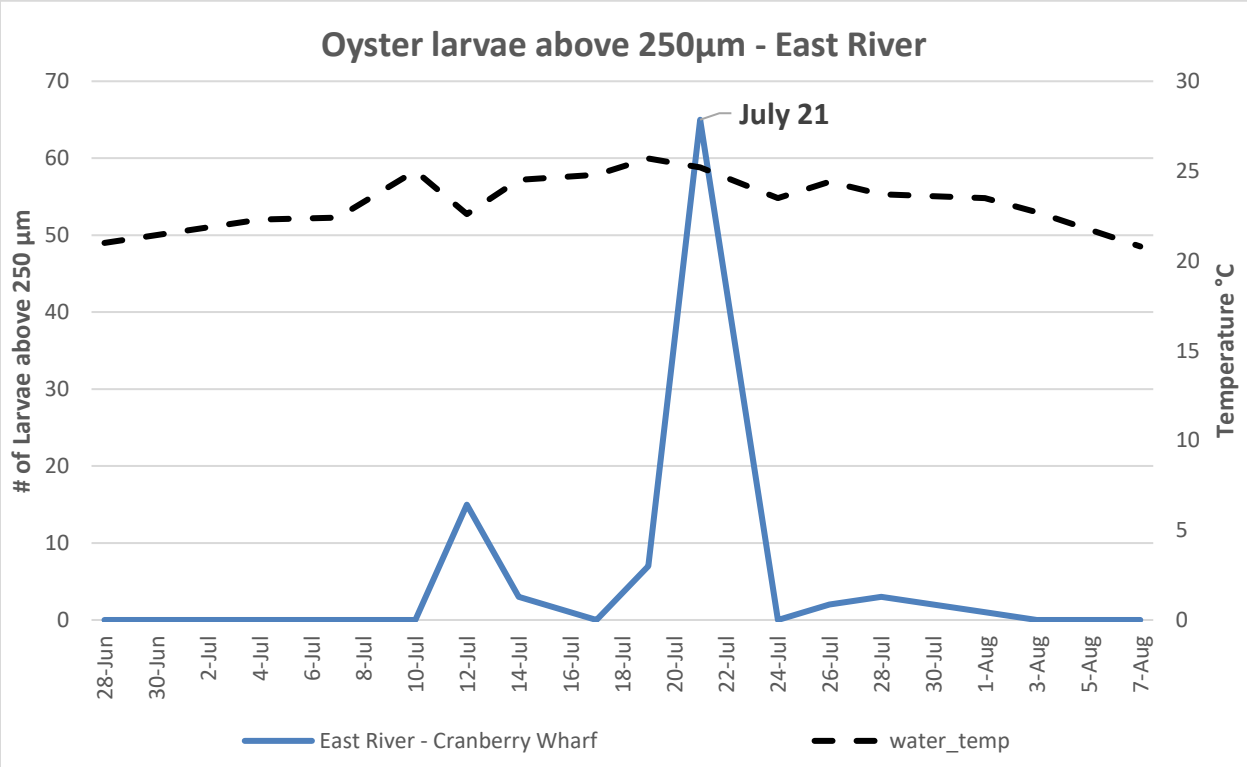
Rustico Bay					
Date	**Water Temperature (°C)**	**Salinity (ppt)**	**Larvae Total**	**Larvae Size (µm)**	**# Larvae Above 250 µm**
6/29/2023	19.4	23.9	0	0	0
7/5/2023	24.8	19.8	0	0	0
7/11/2023	22.5	25.7	17	90-130	0
7/18/2023	19.8	25.8	15	90-240	0
7/25/2023	20.7	26.1	4	160-230	0
8/2/2023	23.6	24.7	3	160-210	0

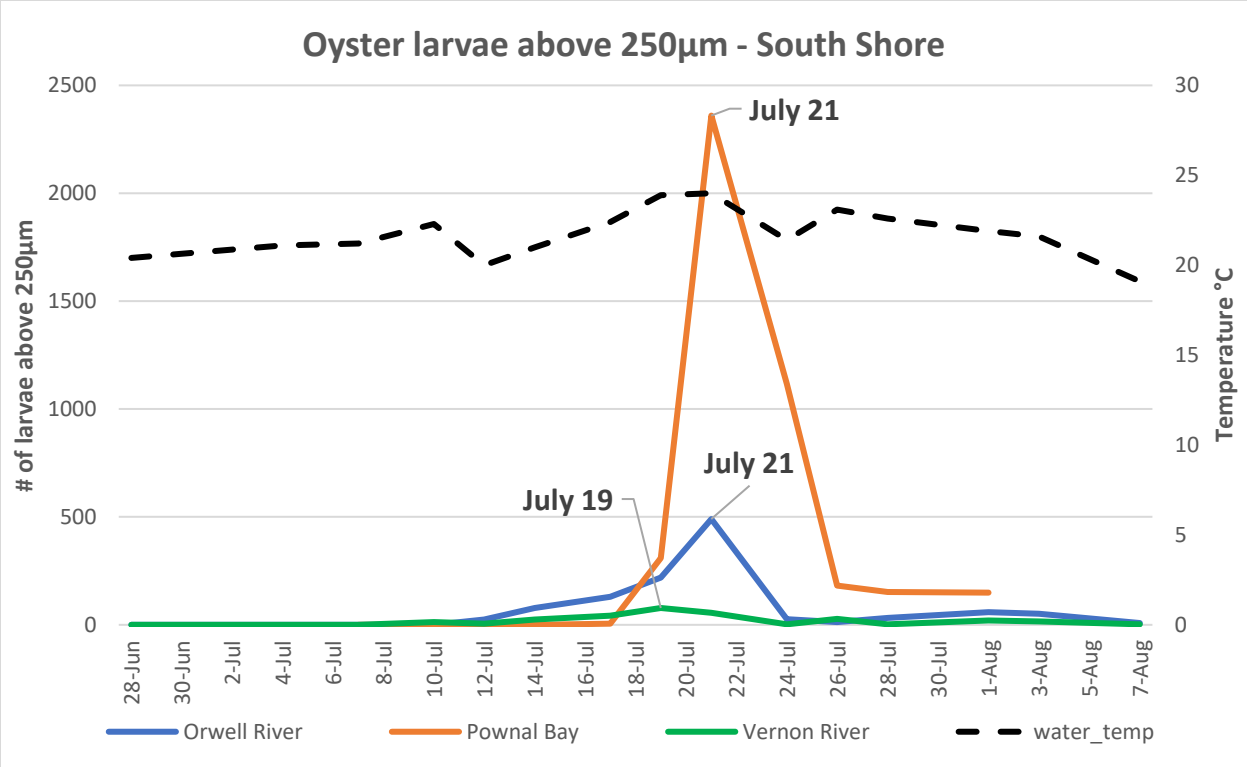
APPENDIX III: SEASONAL LARVAE ABUNDANCE AND WATER TEMPERATURE BY SITE

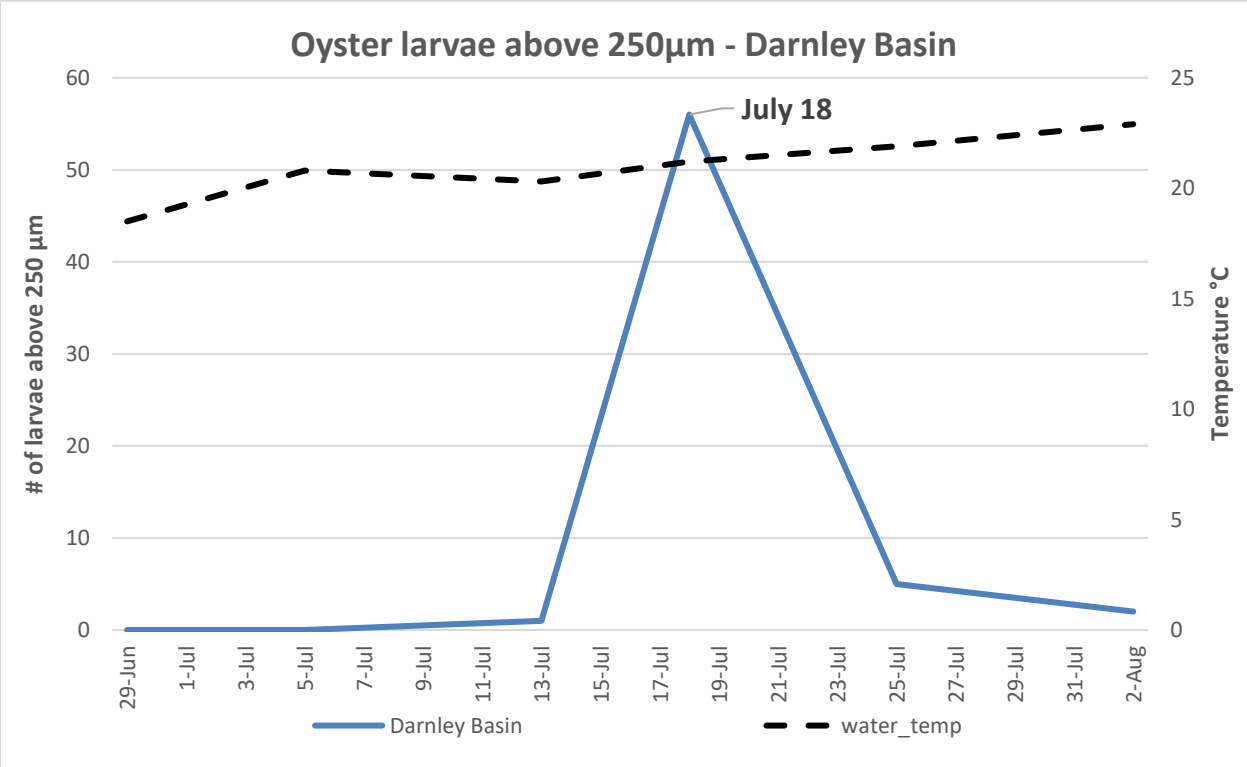

Oyster Larvae above 250µm - Bideford River
# of Larvae above 250 µm
Temperature °C
July 19
July 17
July 17
Bideford - Green Park
Bideford - Paugh's Creek
Bideford - Station
water_temp

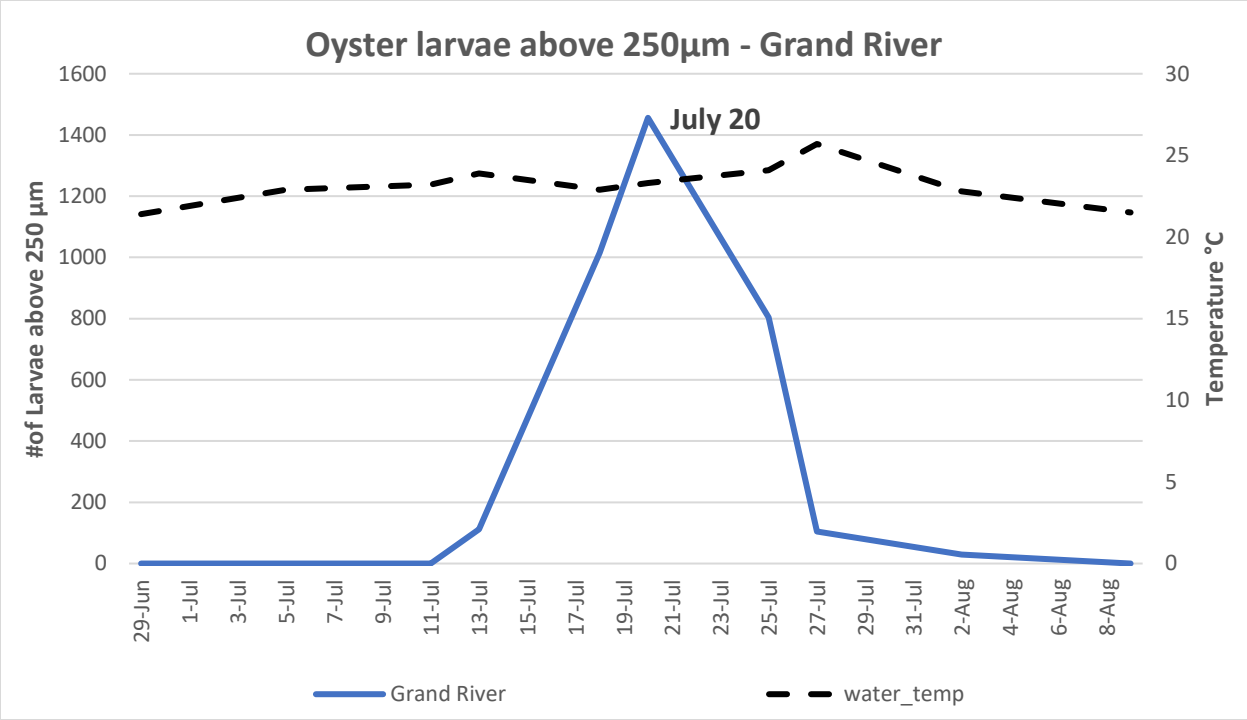

Oyster larvae above 250µm - Foxley River
# of larvae above 250 µm
Temperature °C
July 17
July 19
July 19
July 14
Dock River
Foxley - Gibb's Creek
Foxley - Goff Bridge
Foxley - Lot 6 Pt.
water_temp

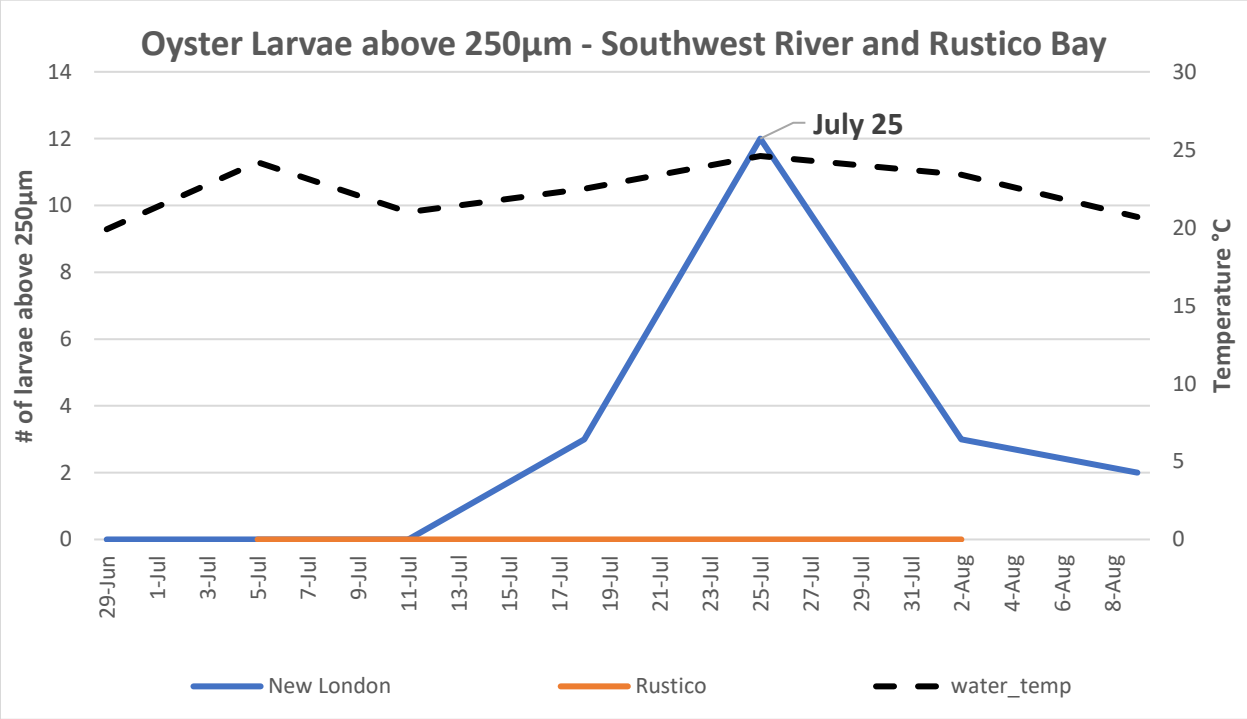

Oyster Larvae above 250µm - Percival and Enmore Rivers
Larvae above 250µm
Temperature °C
July 18
July 18
Enmore River
Percival River
water_temp


Oyster larvae above 250µm - East River
# of Larvae above 250 µm
Temperature °C
July 21
East River - Cranberry Wharf
water_temp

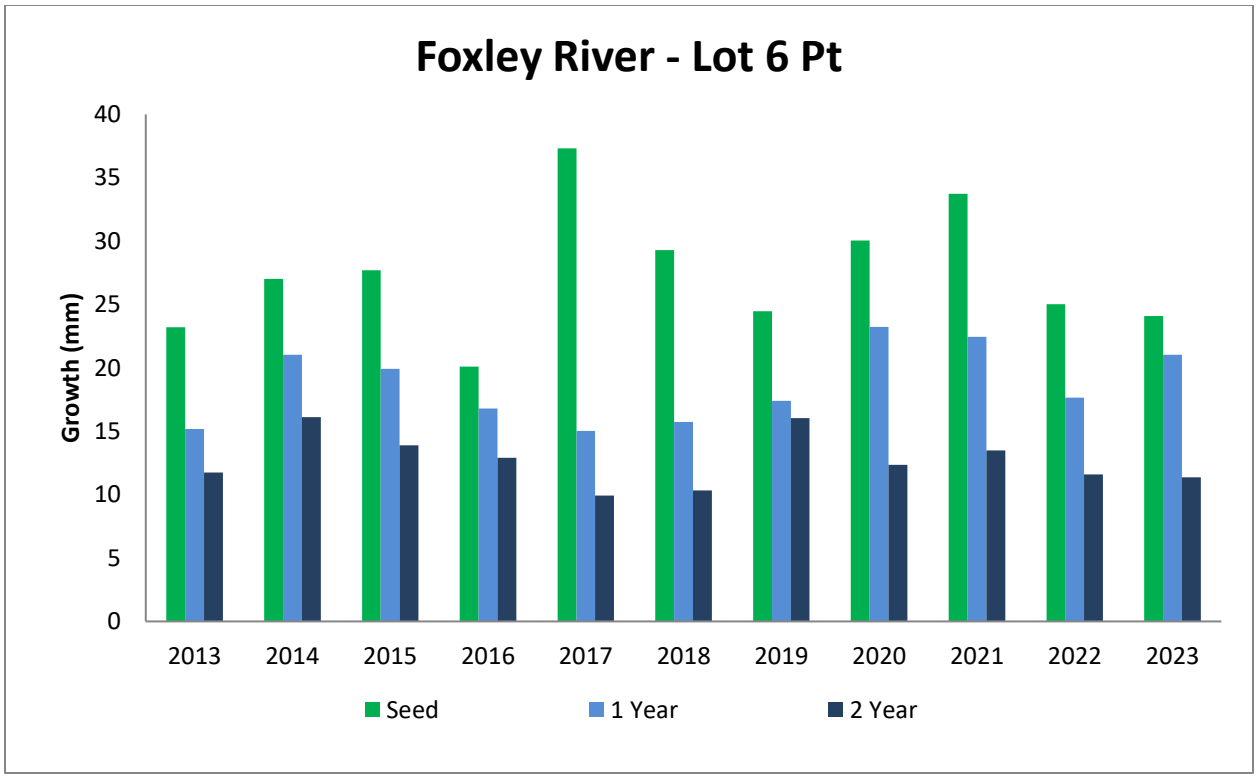

Oyster larvae above 250µm - South Shore
# of larvae above 250µm
Temperature °C
July 21
July 21
July 19
Orwell River
Pownal Bay
Vernon River
water_temp

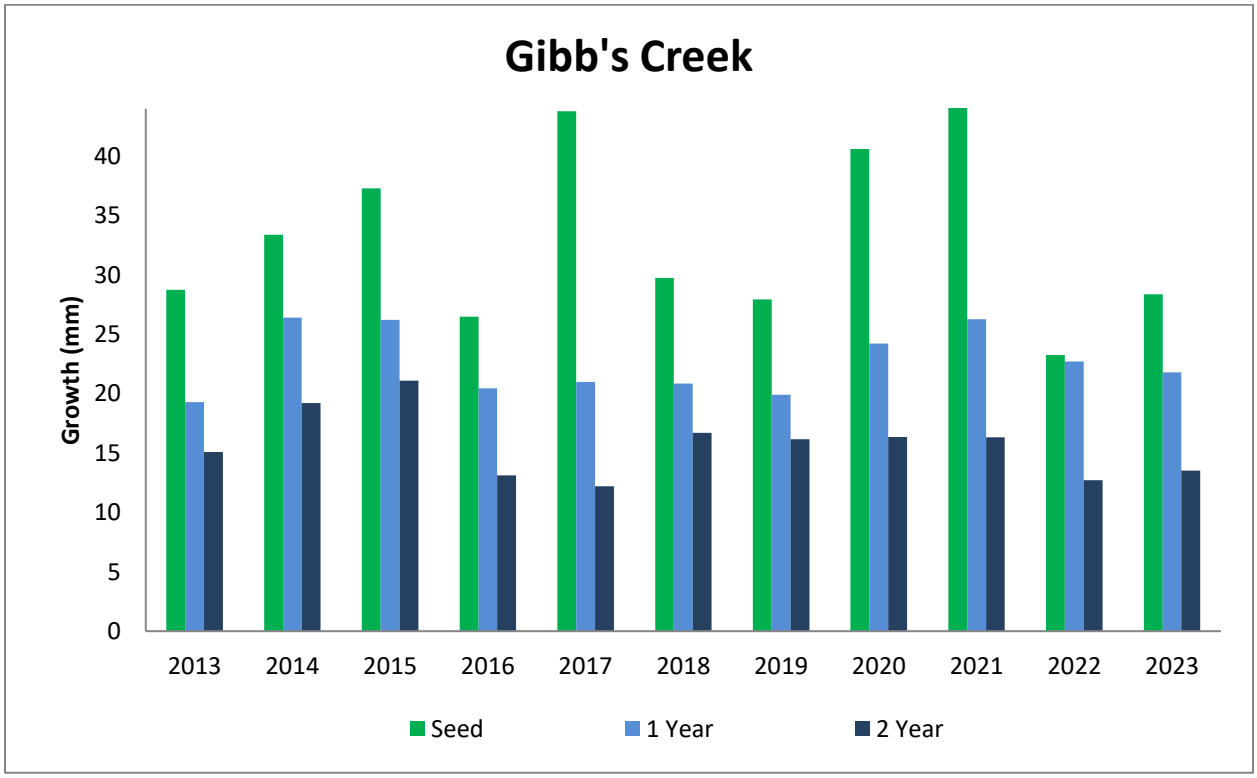

Oyster larvae above 250µm - Darnley Basin
# of larvae above 250 µm
Temperature °C
July 18
Darnley Basin
water_temp

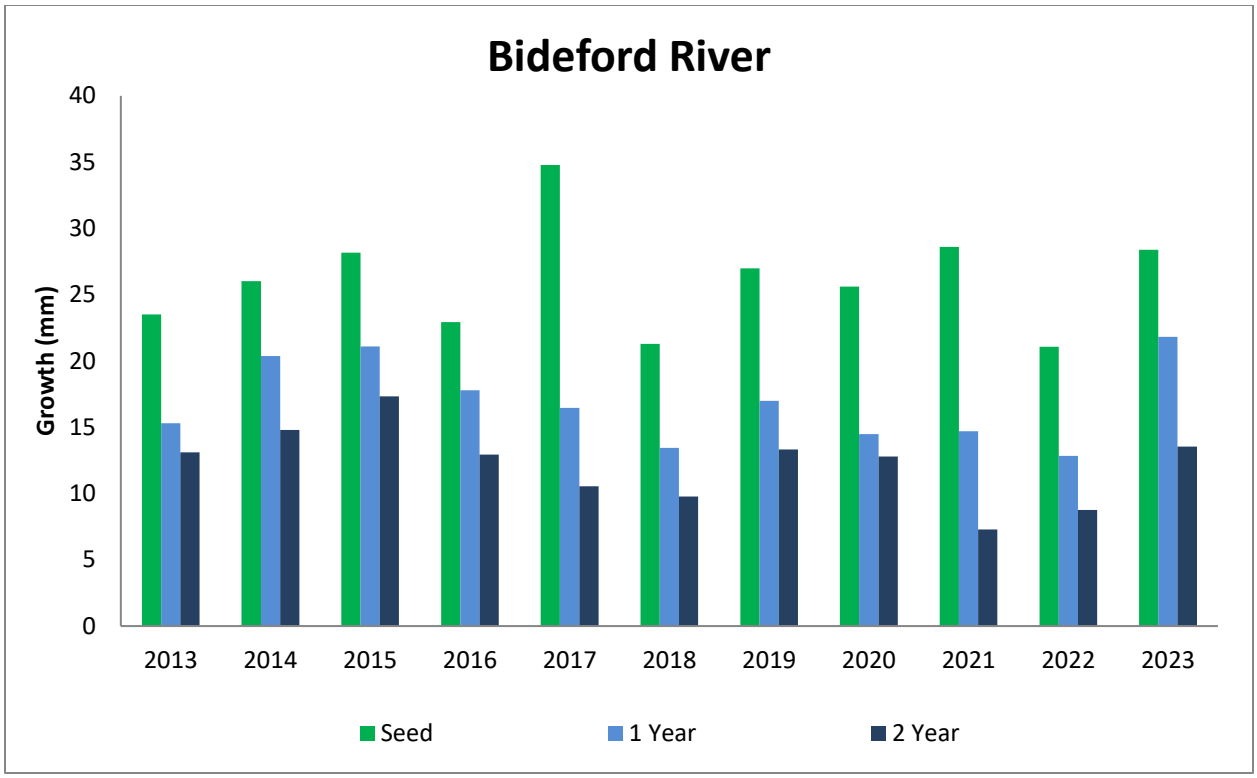

Oyster larvae above 250µm - Grand River
#of Larvae above 250 µm
Temperature °C
July 20
1600
1400
1200
1000
800
600
400
200
0
30
25
20
15
10
5
0
29-Jun
1-Jul
3-Jul
5-Jul
7-Jul
9-Jul
11-Jul
13-Jul
15-Jul
17-Jul
19-Jul
21-Jul
23-Jul
25-Jul
27-Jul
29-Jul
31-Jul
2-Aug
4-Aug
6-Aug
8-Aug
Grand River
water_temp

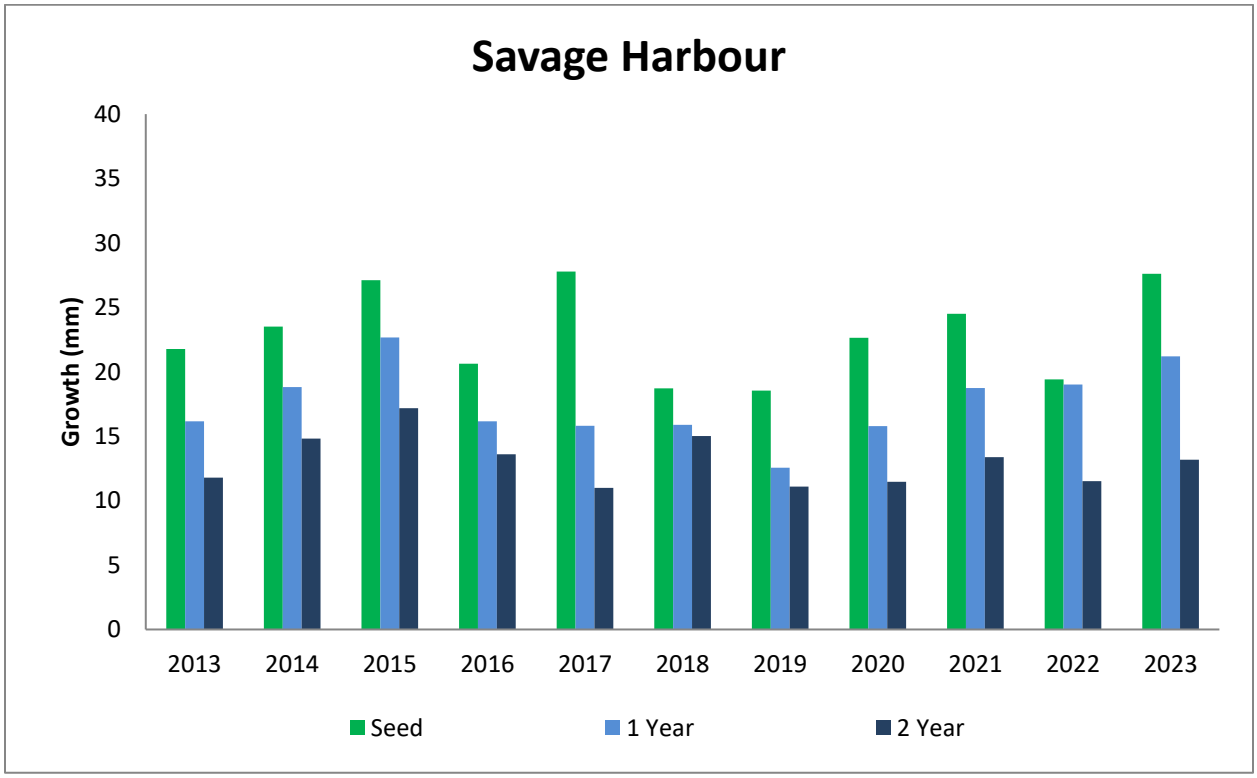

Oyster Larvae above 250µm - Southwest River and Rustico Bay
# of larvae above 250µm
Temperature °C
July 25
14
12
10
8
6
4
2
0
30
25
20
15
10
5
0
29-Jun
1-Jul
3-Jul
5-Jul
7-Jul
9-Jul
11-Jul
13-Jul
15-Jul
17-Jul
19-Jul
21-Jul
23-Jul
25-Jul
27-Jul
29-Jul
31-Jul
2-Aug
4-Aug
6-Aug
8-Aug
New London
Rustico
water_temp

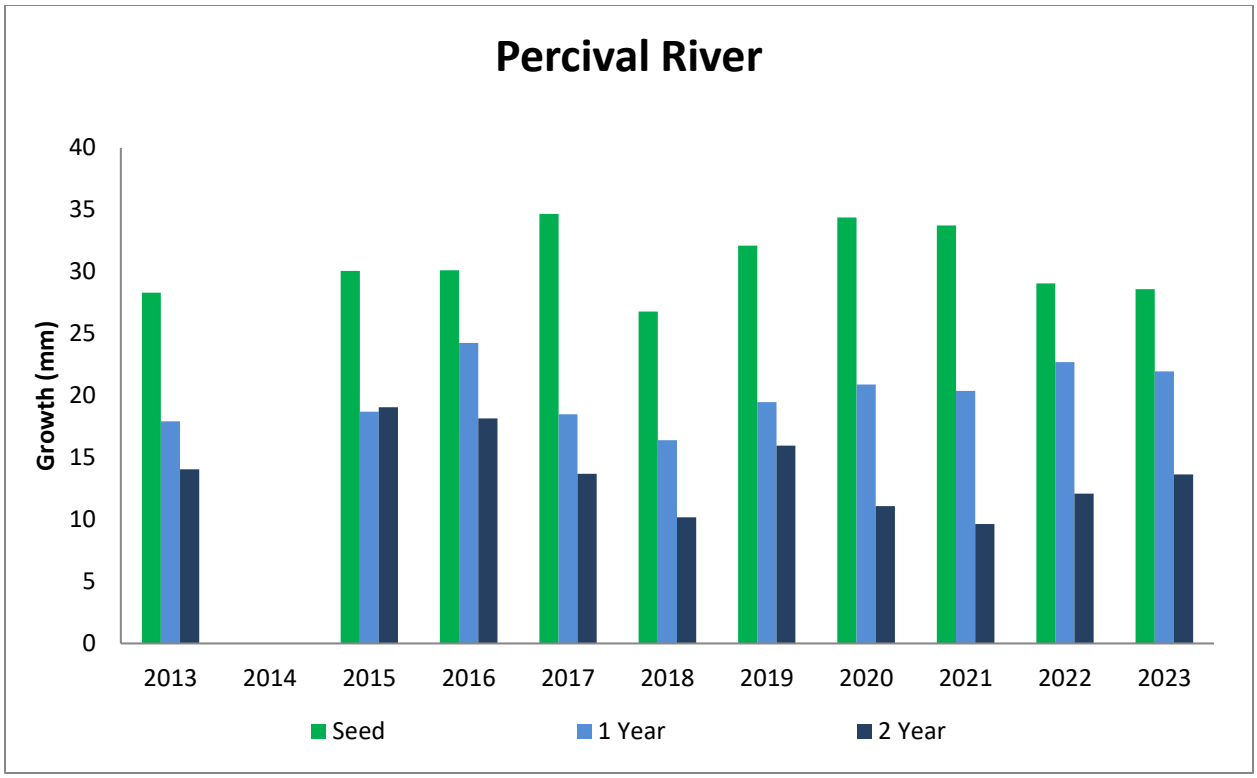
APPENDIX IV: ANNUAL OYSTER GROWTH

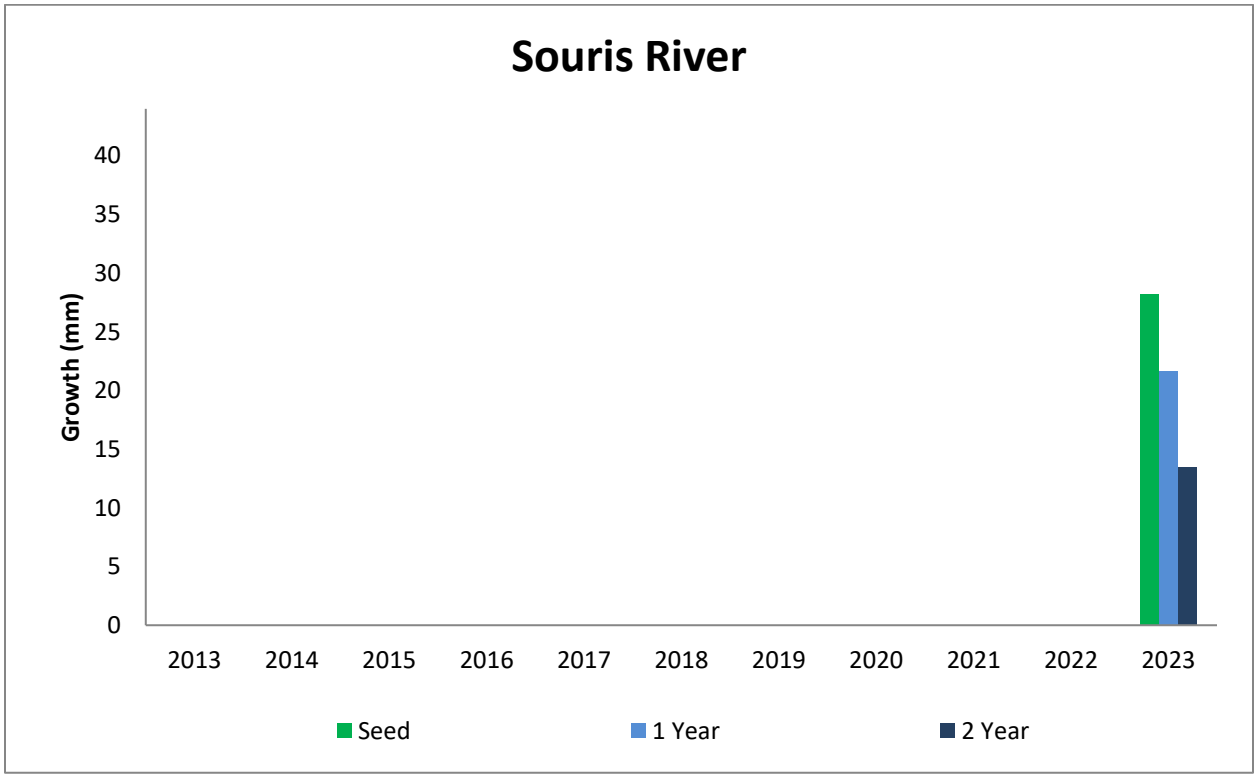

Foxley River - Lot 6 Pt
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year

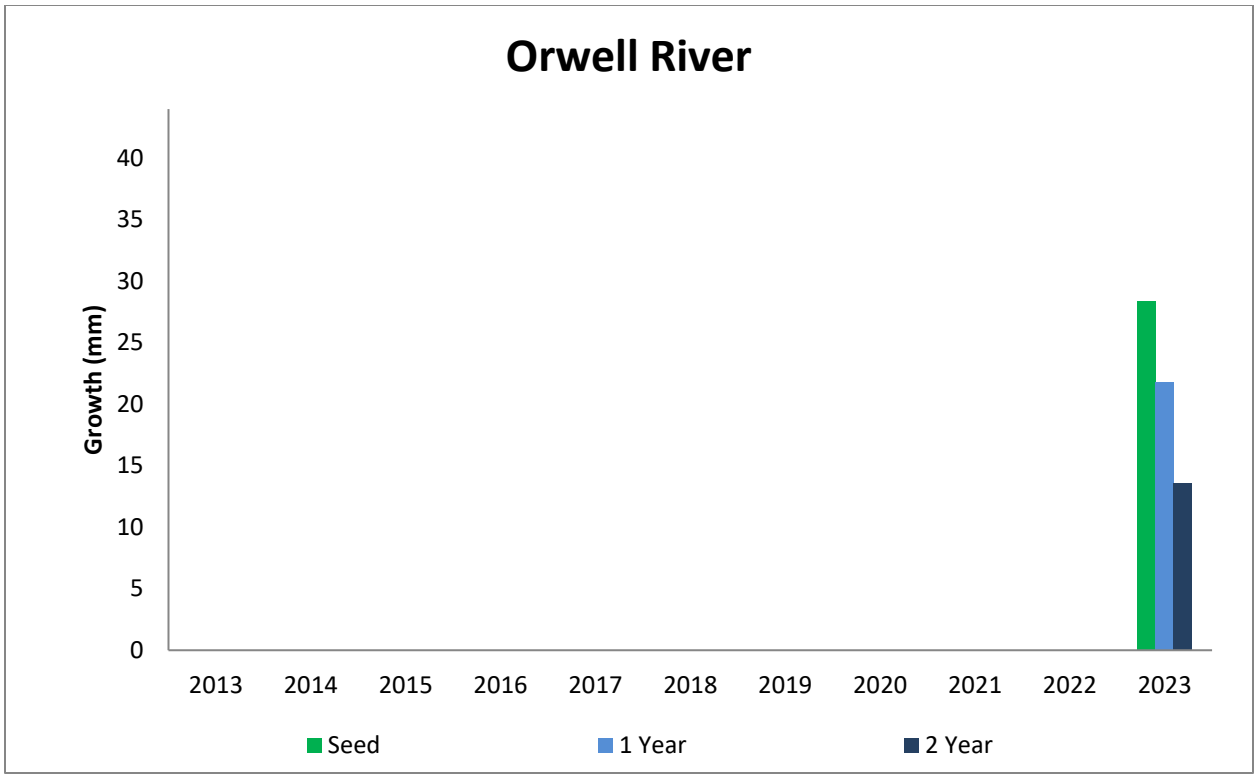

Gibb's Creek
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year


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

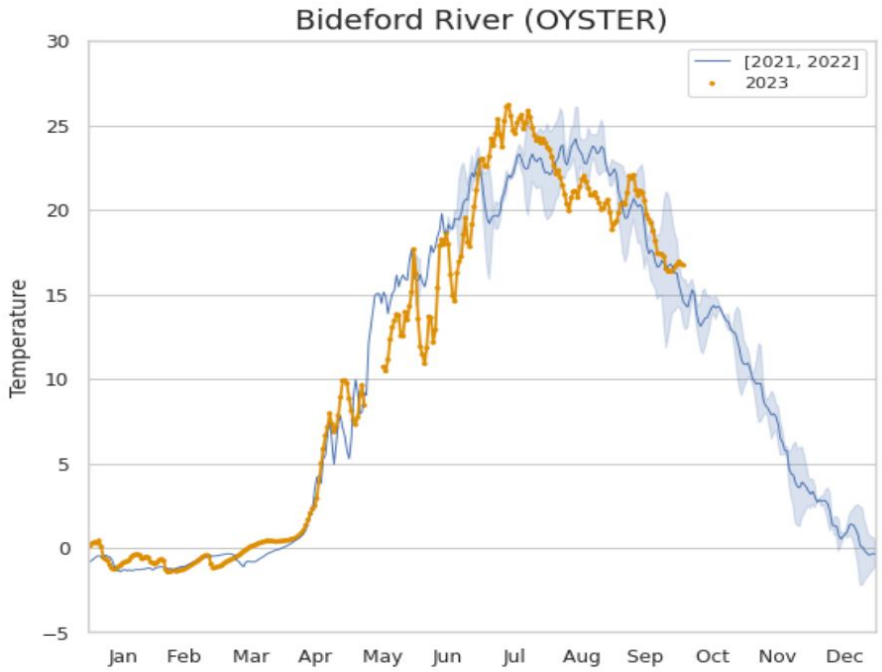

Savage Harbour
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year

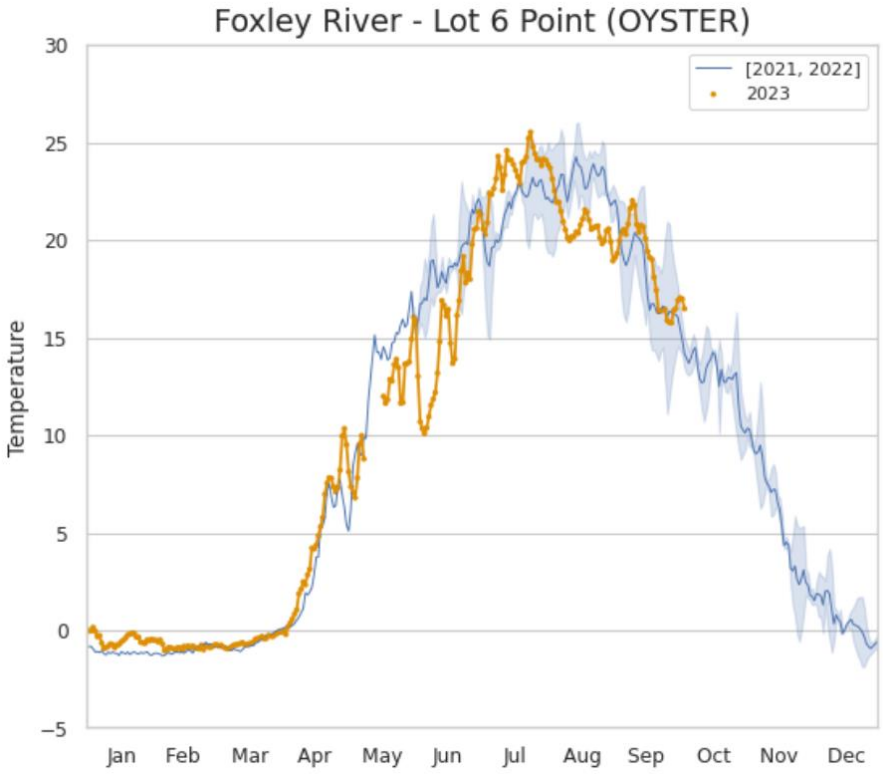

Percival River
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year

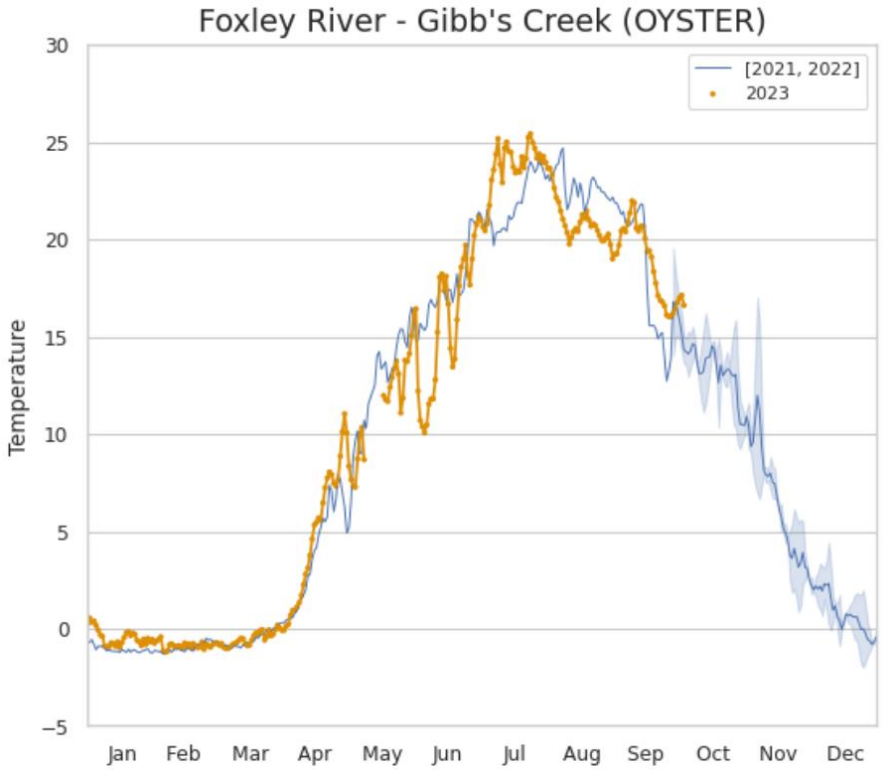

Souris River
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year

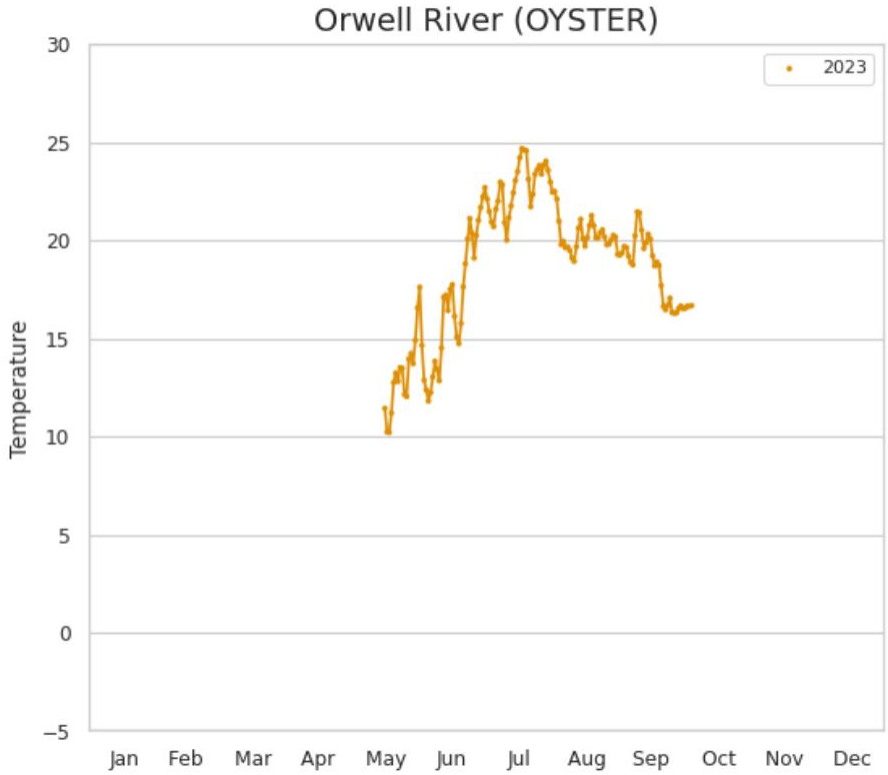

Orwell River
Growth (mm)
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Seed
1 Year
2 Year

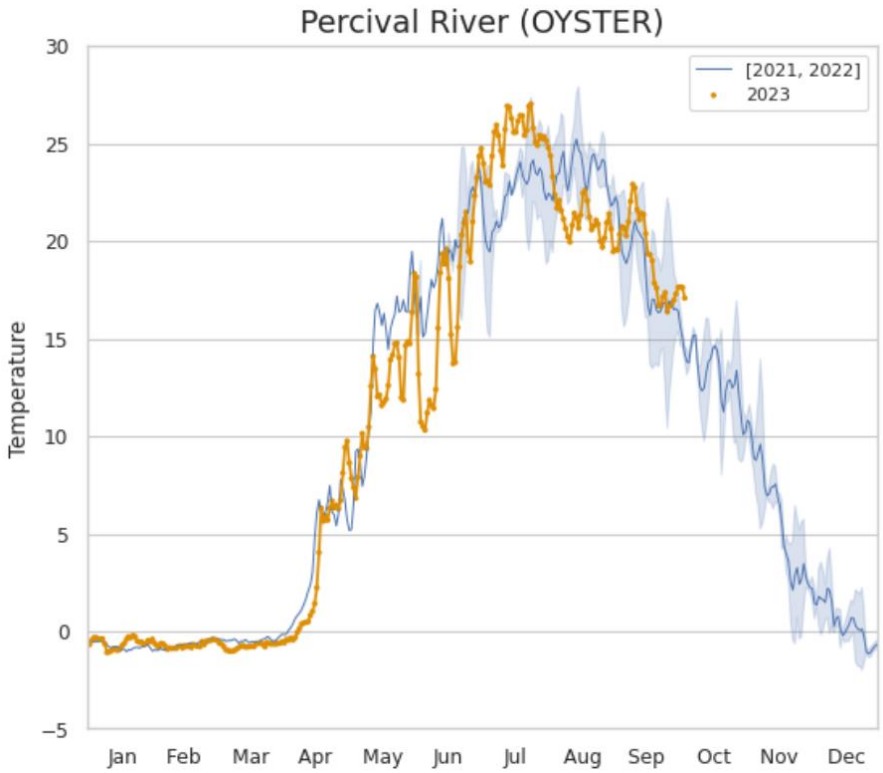
APPENDIX V: TEMPERATURE DATA BY LOCATION

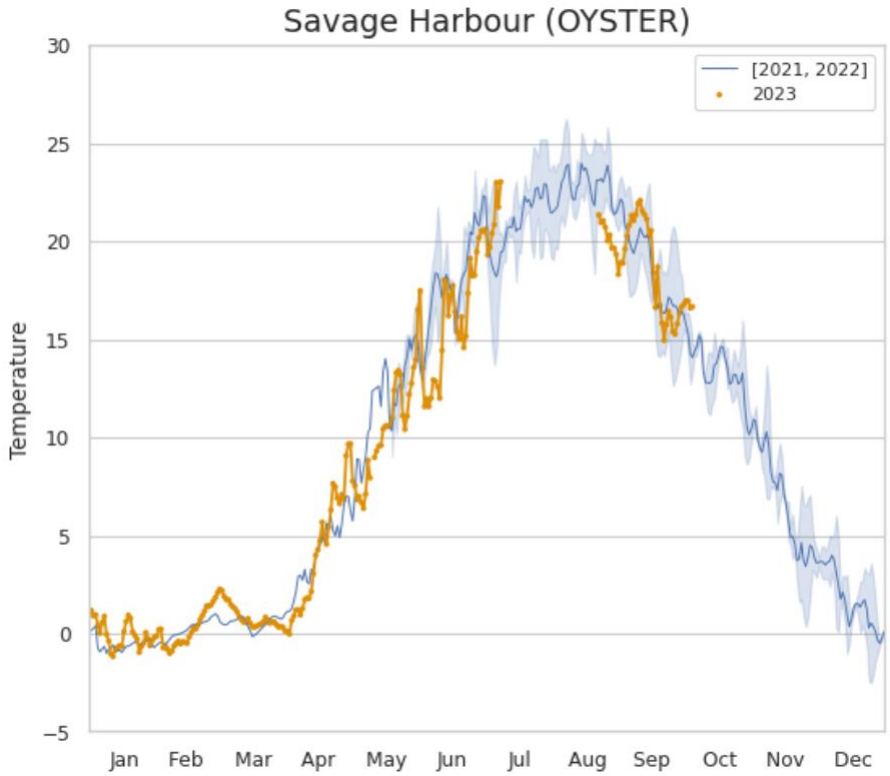

Bideford River (OYSTER)
[2021, 2022]
2023
Temperature
30
25
20
15
10
5
0
−5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Foxley River - Lot 6 Point (OYSTER)
[2021, 2022]
2023
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
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
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
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
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
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 KNOWN AQUATIC SPECIES IN PEI

Known Range of Clubbed Tunicate December 2023

Vase Tunicate December 2023