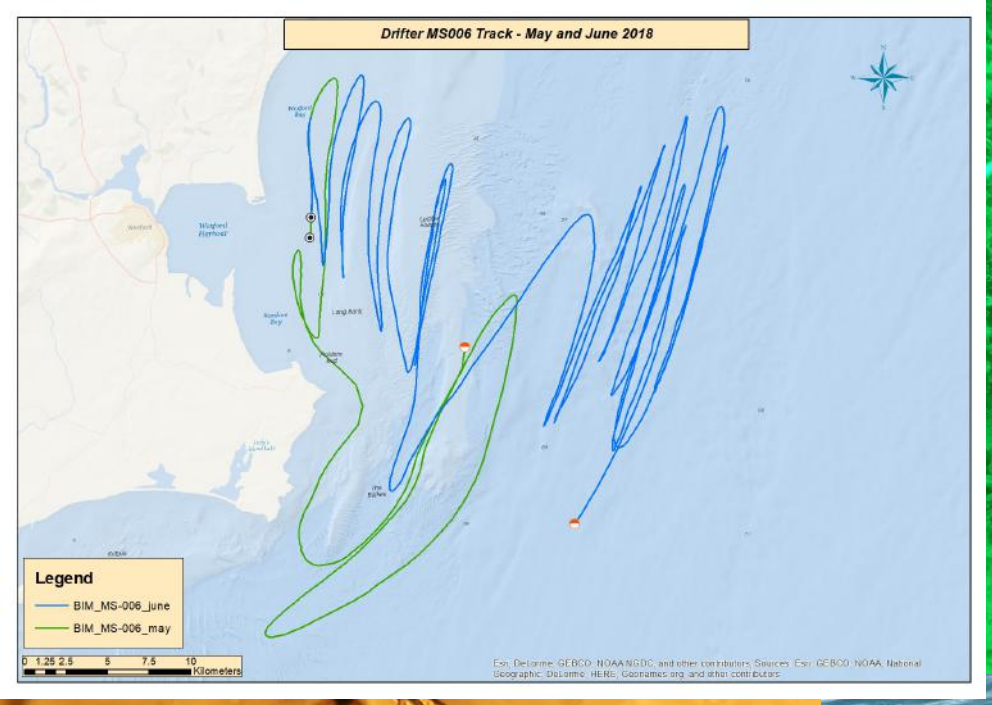

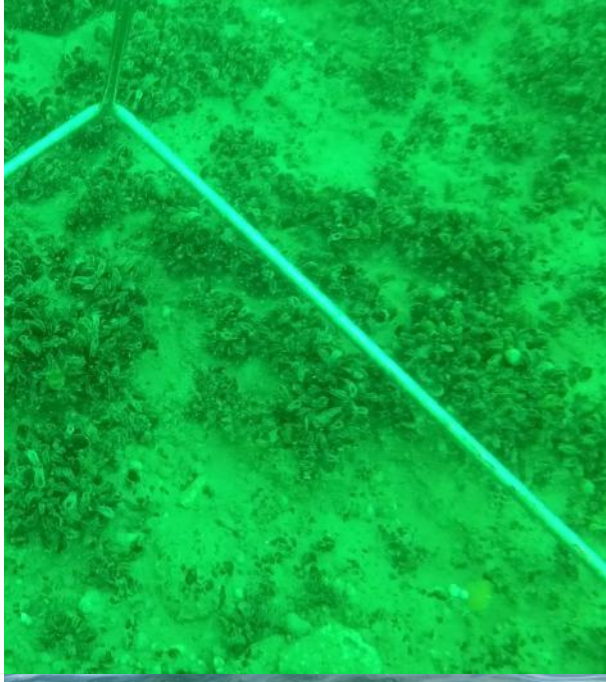

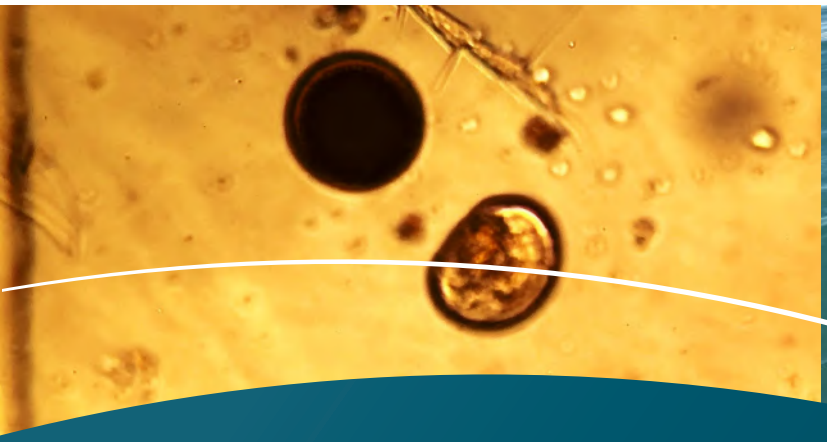

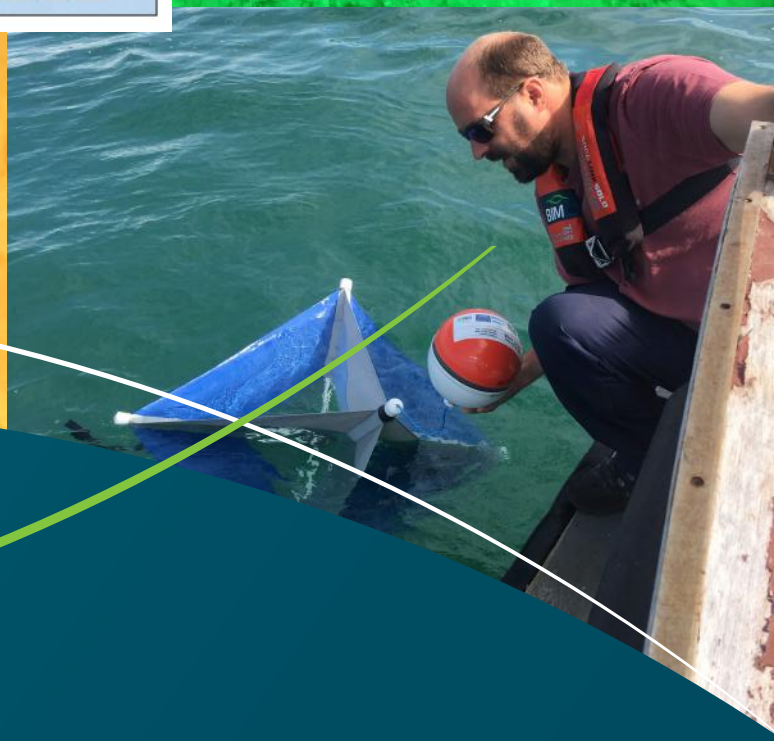

2018 Spring Mussel Larvae Monitoring

Aquaculture Technical Shellfish Report

Growth Ireland Wales Knowledge
The Irish Sea Portal Pilot

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2018 Spring Mussel Larvae Monitoring

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2018 Spring Mussel Larvae Monitoring

The 2018 campaign was carried out through the INTERREG Project Irish Sea Portal Pilot (ISPP), a joined venture between BIM and Bangor University (Wales).

2018 Spring Mussel Larvae Monitoring

Background

This report relates the results obtained during the 2018 mussel larvae monitoring as well as meat yield monitoring from two husbandry areas (Wexford Harbour and Castlemaine Harbour). This work seeks to improve our understanding of factors affecting mussel seed settlements and recruitment to the fisheries. It also provides for a comparison with previous years findings to establish a possible pattern in the data collected.

The data collected since the year 2015 has shown high variability in adult mussel conditioning, water temperature, larval abundance for each stations and larvae age class distribution throughout the year. Although, seed mussel tonnage fished has remained similar over those three years (between 7,000 and 8,000 tonnes following BIM survey estimations for 2015, 2016 and 2017). Equally, the survey data collected showed that the number of samples taken doesn't relate to the overall number of larvae per stations. The only possible relationship observed was between the number of larvae and the area covered by the seed mussel, however this must be taken cautiously as not all settlements can be mapped.

In the year 2018 GPS drifters were launched in various locations to study water movements around the coast and these demonstrated interesting tracks that may be related to larval movements.

Objectives

The purpose of this mussel monitoring program is to study the reproduction, larval development and settlement of mussels, allowing for better planning of mussel production.

The key objectives being:

- monitoring of seawater temperatures and salinities which can have a major influence on mussel condition (meat yield) and growth
- the quantification of mussel larval stages in the plankton
- the location, mapping and estimation of seed mussel tonnage

To achieve these goals, samples of adult mussels were collected to assess their state of maturity by performing meat yield measurements. Plankton hauls were taken for cohort analysis of mussel larvae and seed beds located using side scan sonar.

Samples of settled seed mussels found were measured, quantified and mapped. The information collected on the seed beds is available on the BIM website. Some pertinent findings from those reports are included to provide a more complete picture of the life stages of the mussels within the study areas.

Sampling Locations

The stations remained the same as 2017.

Table 1: Sampling locations coordinates (WGS84)

Location	Latitude	Longitude
Wexford Bar	52° 19.741' N	006° 18.351' W
Rusk Channel	52° 28.689' N	006° 12.067' W
Arklow	52° 50.580' N	006° 03.450' W
Castlemaine Harbour	52° 05.583' N	009° 57.676' W
North Howth	53° 25.850' N	006° 05.173' W

Figure 1 depicts the geographical locations of the five study areas around Ireland. Figures 2, 3, 4 and 5 illustrate the detail locations of the sampling sites.

Figure 1: Sampling locations around Ireland

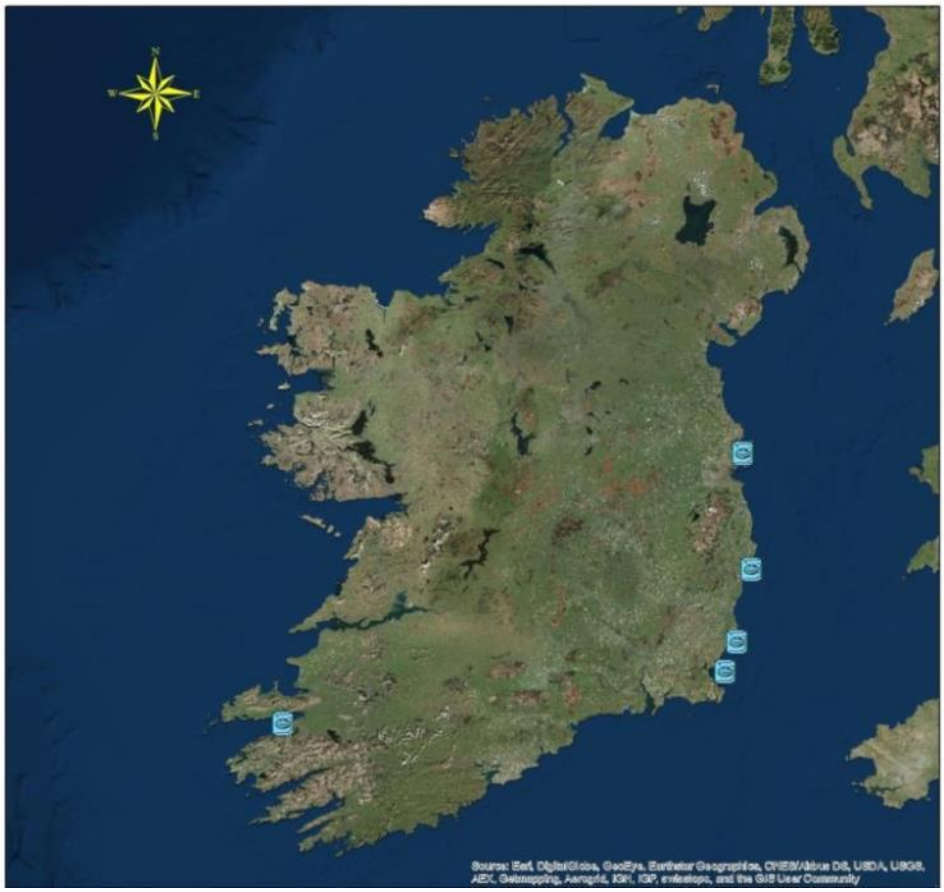


Figure 2: Sampling Station on the Wicklow Coast

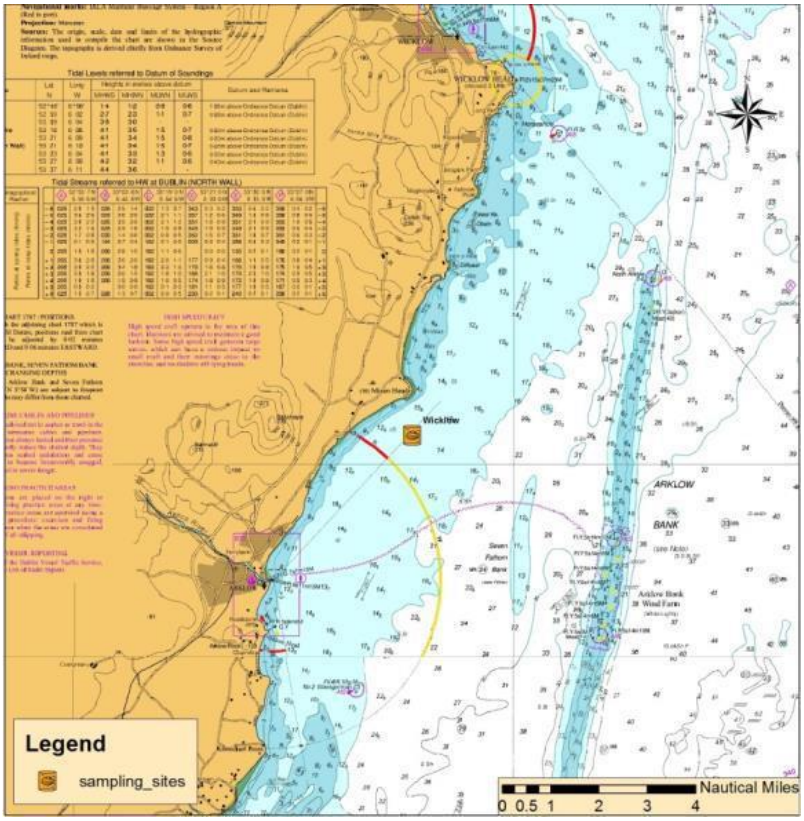


Figure 3 Sampling Stations on the Wexford Coast (Wexford Bar and Rusk Channel)

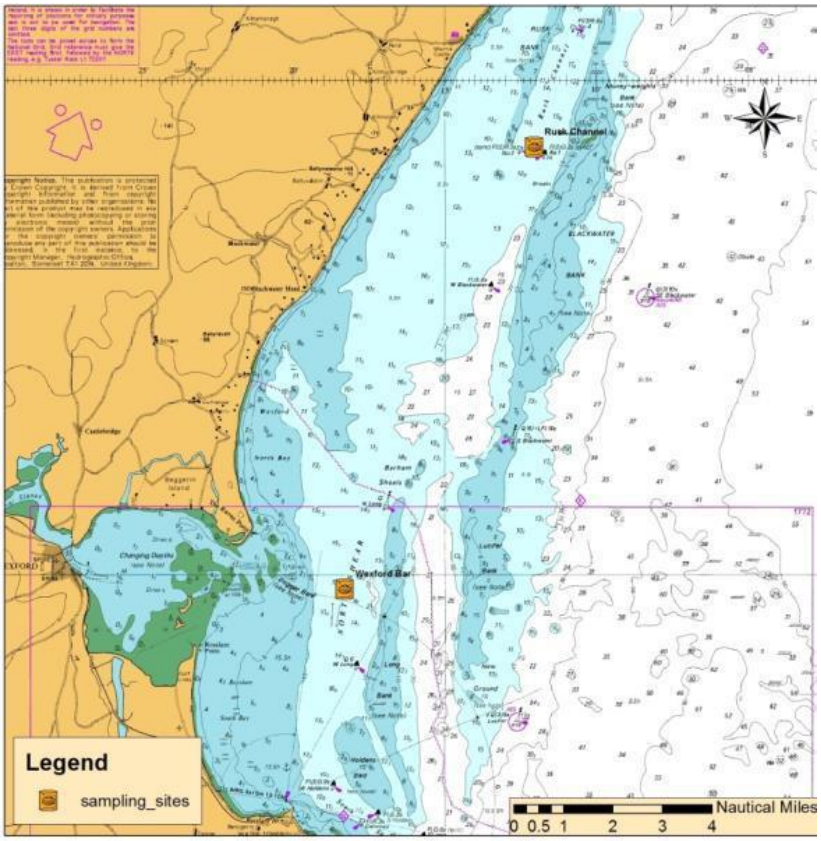


Figure 4: Sampling Station in Castlemaine Harbour

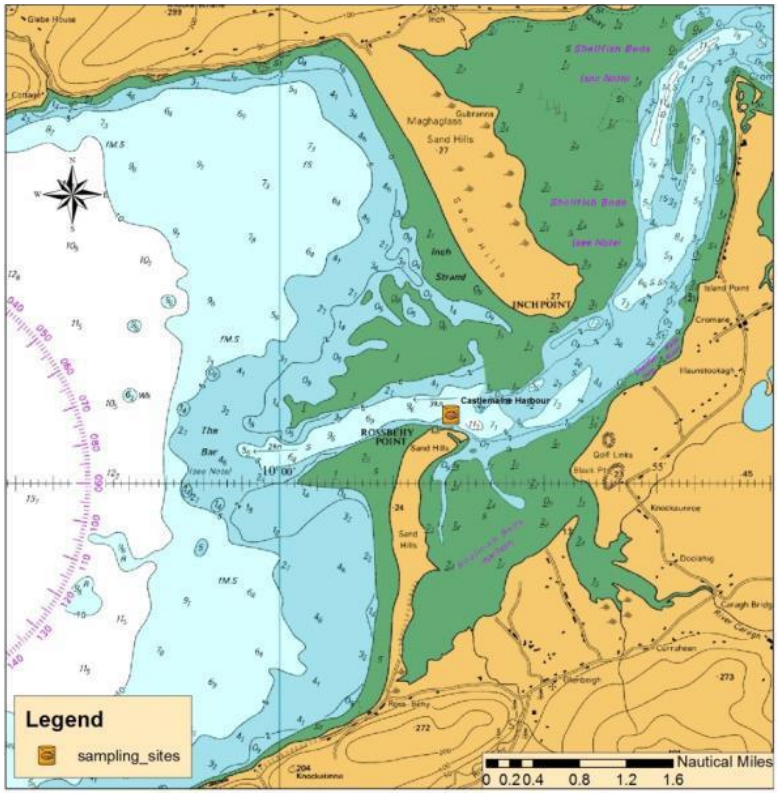
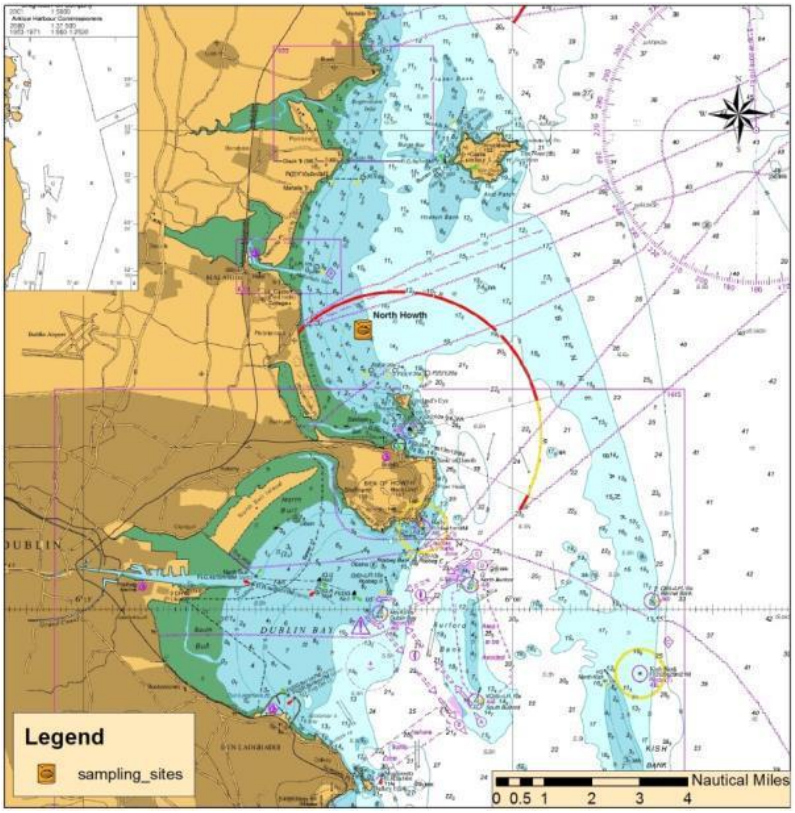


Figure 5: Sampling Station for North Howth



Sampling Method

It was planned to take weekly plankton samples at most of the sites. Local fishermen undertook the sampling at the Wexford Bar, Rusk Channel, South Wicklow and North Howth. A mussel farmer collected the samples in Castlemaine Harbour.

The mussel larvae samples were collected with 100 µm mesh plankton net, which was weighted at the cod end and used to take vertical haul through the water column. The net was deployed within several meters of the seabed and hauled slowly to the surface. Once on the boat deck, the contents of the net were gently washed into a labelled jar and fixed with Lugol's iodine. At each sampling station the following information was recorded:

- Date and time of sampling
- Depth (from the sounder reading)
- Weather conditions (wind) and sea state
- Water temperature
- Current speed and direction

The larval samples were then posted to a laboratory for analysis, which involved the use of microscopy to identify mussel larvae and also to classify their development state and age (See Appendix 1 for the calculation of larval numbers collected in a plankton net). In addition to larval sampling, the industry samplers were also provided with an Oxyguard Temperature and Salinity probe with a 6 m cable to measure these parameters.

Meat Yield

The condition index or meat yield of mussels is a recognised methodology for assessing the maturity of adult mussels and their propensity to spawn. The meat yield is the relationship between the total weight of edible mussel tissue and shell (see Appendix 2). Typically, the percentage meat yields are seen to increase over the autumn and winter months followed by a notable decline in weight when a spawning event occurs in the spring. However, it should be noted that mussels may also release gametes at other times of year and are known to be trickle spawning.

To monitor the maturity of adult mussel, samples were collected from licenced sites with industry support in Wexford and Castlemaine Harbour/Cromane. Sampling in 2018 was undertaken from January 8th (week 2) to July 6th (week 2). Following possible early spawning in 2017, the sampling period started earlier and was extended to assess possible late spawning. The meat yields measured and the weeks in which they were sampled are shown in Table 2. Unfortunately, only a limited number of samples were collected from Cromane and as a result have not been included in this report.

Table 2: Mussel Meat Yield (%) for Wexford Harbour

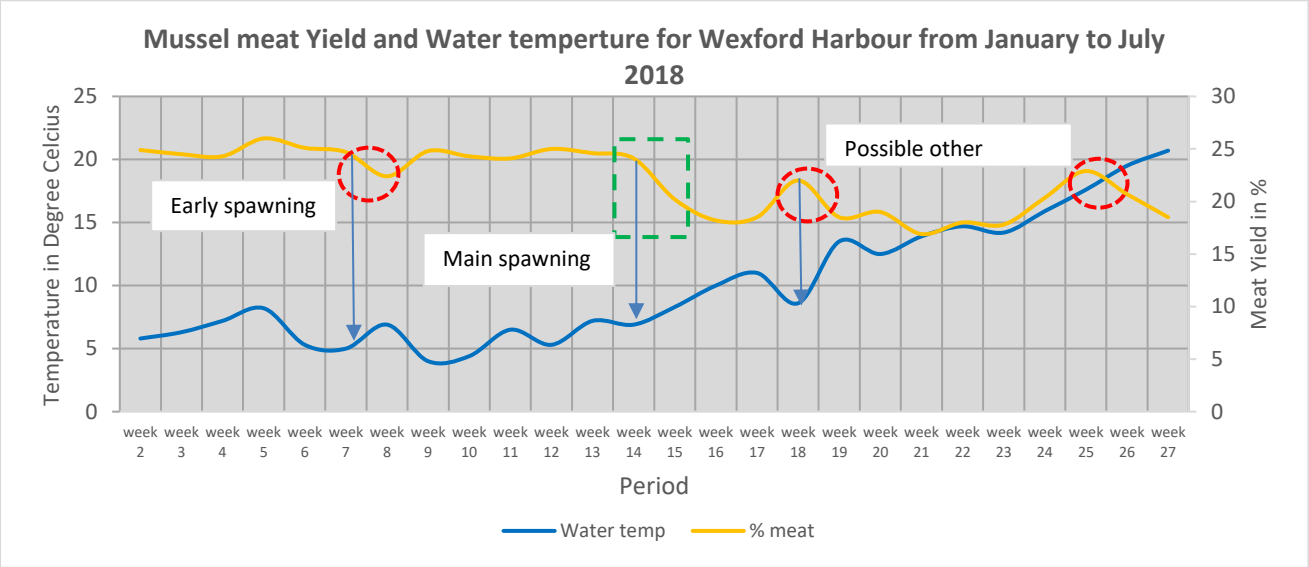
	date	% meat	temp
week 2	08-01-18	24.9	5.8
week 3	15-01-18	24.5	6.3
week 4	23-01-18	24.3	7.2
week 5	30-01-18	26	8.2
week 6	05-02-18	25.1	5.3
week 7	12-02-18	24.7	5
week 8	19-02-18	22.4	6.9
week 9	26-02-18	24.8	4
week 10	05-03-18	24.3	4.4
week 11	12-03-18	24.1	6.5
week 12	20-03-18	25	5.3
week 13	26-03-18	24.6	7.2
week 14	05-04-18	24.1	6.9
week 15	10-04-18	20.2	8.3
week 16	19-04-18	18.2	10
week 17	25-04-18	18.5	11
week 18	04-05-18	22	8.6
week 19	09-05-18	18.5	13.5
week 20	15-05-18	19	12.5
week 21	22-05-18	16.9	13.9
week 22	28-05-18	18	14.7
week 23	08-06-18	17.8	14.2
week 24		20	15.9
week 25	22-06-18	22.9	17.6
week 26	29-6-2018	20.7	19.5
week 27	06-07-18	18.5	20.7

No sample was collected, and an estimated value has been used for graphical purposes.

Following experience of early sampling in previous years it was possible to detect potential early spawning and adult mussel reconditioning (see Figure 6). As in the year 2017, it appears that there may have been some early spawning between week 7 and week 8. At that time the condition index fell by 2.3% while water temperature increased by nearly two degrees. This possible early spawning was followed by a cold period where the water temperature in the harbour dropped by approximately 4 ^{o}C and partial freezing of the river Slaney between week 9 and week 10. Nevertheless, the cold temperature doesn't seem to have influenced the conditioning index (0.7% drop from week 9 to week 11).

The main spawning event appears to have happened between week 14 and week 16: the condition index dropped by nearly 6% while water temperature increased by more than 3^{o}C.

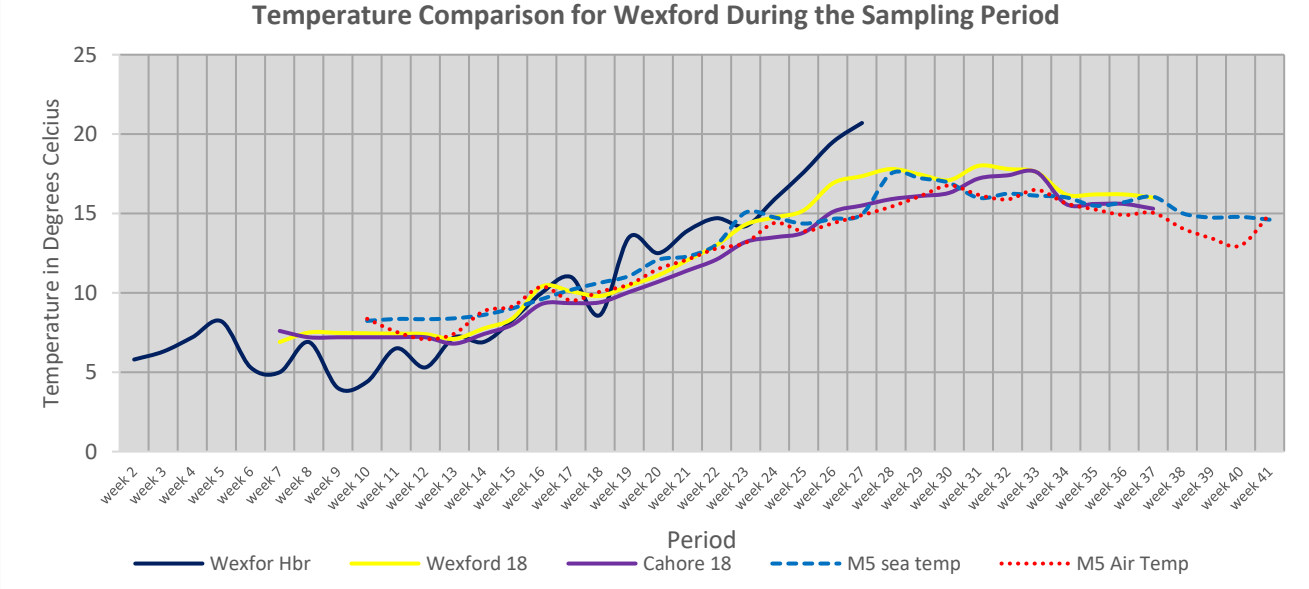
Figure 6: Percentage meat yield for mussels from Wexford and Cromane in 2018



It appears that the mussels reconditioned from week 17 to week 18 and that this was followed by another possible spawning. The index dropped by 3.5% while the water temperature increased by nearly 5 °C.

The last event of the year may have occurred between week 25 and week 27 when the index dropped by 4.4 % over two weeks while temperature increased by over 3 °C.

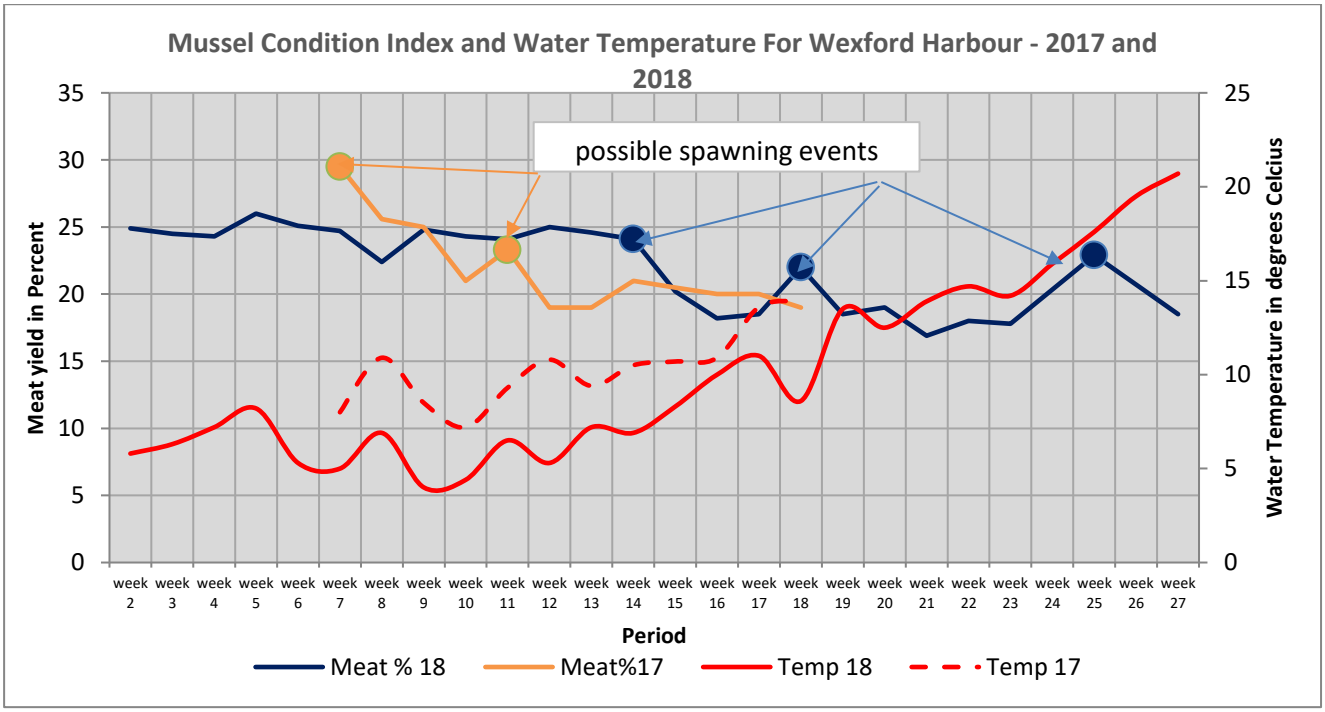
Figure 7: Air and seawater temperature recordings at Wexford in 2018



As in the year 2017, the water temperature within Wexford harbour varied a lot more than in open water areas such as the larval sampling stations and the Weather Buoy M5. The range between the lowest and the highest temperature in the harbour was 16.7 °C (lowest 4 °C on week 9 and highest 20.7 °C on week 27).

Overall, the water temperature in the harbour was colder by an average of 3.3 ^{o}C in comparison with those recorded in 2017 for the same period. This difference also appears to have reflected in the numbers of larvae observed in 2018. Although, small quantities of larvae were observed after the first spawning on week 7, there was little to no larvae observed after the possible main spawning event. There was a similar situation on the third event on week 17, however there were a few older larvae, two to three weeks old were observed on week 20 and week 22 at the Wexford Bar station. Finally, there was no sign of early larvae after the last possible spawning recorded on week 25; 1 to 2 weeks old larvae were found at the Wexford Bar station on the same week.

Figure 8: Mussel meat yield and water temperature for Wexford harbour in 2017 and 2018



Results

A total of 100 samples were collected over the 5 sampling stations in the year 2018. The monitoring period was extended to 36 weeks following previous years' results: from mid-February to mid-October. Sampling in the Irish Sea has been limited in 2018 due to the prevalence of fresh northeast winds, the overall success rate was slightly above 55% (including Castlemaine harbour samples). Samples preservation appeared to have been an issue possibly due to the amount of suspended material in the water.

Despite good weather condition in the summer, the number of larvae in the water remained low in comparison with previous years. Only the station in Howth reached above 500 larvae /m^3 during week 28. Very low numbers were observed at the Wexford Bar and in the Rusk Channel. Some early larvae were observed at the Arklow/South Wicklow station. Small amounts were observed before week 23, but the bulk of the larvae population appeared from week 23 (start of June) to week 29 (3rd week of July). No larvae were found in Cromane possible due to the sampling station location.

Figure 9: Number of mussel larvae per m^3 at Wicklow, Wexford Bar, Cromane/ Castlemaine Harbour and North Howth in 2018

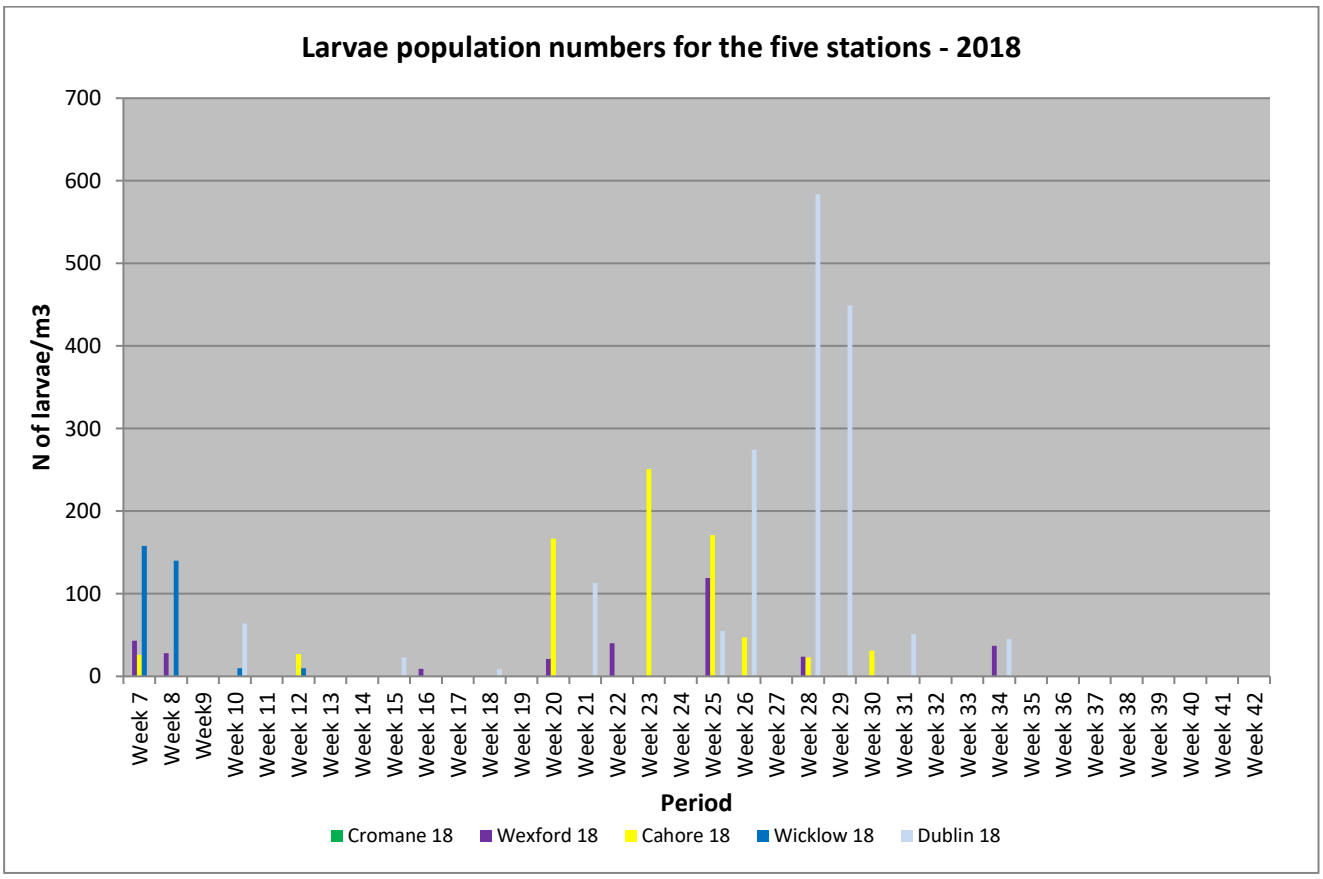


Table 3: Numbers of larvae per m^3 at Wexford Bar, Rusk Channel, Wicklow, Cromane and North Howth 2017

	Cromane 18	Wexford 18	Cahore 18	Wicklow 18	Dublin 18
Week 7	**NS**	43	26	158	**NS**
Week 8	**NS**	28	0	140	**NS**
Week9	**NS**	**NS**	**NS**	**NS**	**NS**
Week 10	**NS**	**NS**	**NS**	10	64
Week 11	0	**NS**	**NS**	0	**NS**
Week 12	0	0	27	10	0
Week 13	0	0	0	0	**NS**
Week 14	0	**NS**	**NS**	0	0
Week 15	0	0	0	0	23
Week 16	0	9	0	**NS**	0
Week 17	0	**NS**	**NS**	0	0
Week 18	0	**NS**	0	0	9
Week 19	0	**NS**	**NS**	0	**NS**
Week 20	0	21	167	0	**NS**
Week 21	0	**NS**	**NS**	0	113
Week 22	0	40	0	**NS**	0
Week 23	0	0	251	0	**NS**
Week 24	0	**NS**	**NS**	0	0
Week 25	0	119	171	0	55
Week 26	**NS**	0	47	0	274
Week 27	**NS**	**NS**	**NS**	0	**NS**
Week 28	**NS**	24	23	0	**584**
Week 29	**NS**	0	0	0	**449**
Week 30	**NS**	0	31	0	**NS**
Week 31	**NS**	0	0	0	51
Week 32	**NS**	**NS**	**NS**	**NS**	**NS**
Week 33	**NS**	0	**NS**	0	**NS**
Week 34	**NS**	37	**NS**	0	45
Week 35	**NS**	**NS**	**NS**	**NS**	**NS**
Week 36	**NS**	0	0	0	0
Week 37	**NS**	0	0	0	**NS**
Week 38	**NS**	**NS**	**NS**	0	**NS**
Week 39	**NS**	**NS**	**NS**	0	**NS**
Week 40	**NS**	**NS**	**NS**	0	**NS**
Week 41	**NS**	**NS**	**NS**	0	**NS**
Week 42	**NS**	**NS**	**NS**	0	**NS**
NS - No Samples	***21***	***17***	***18***	***5***	***19***

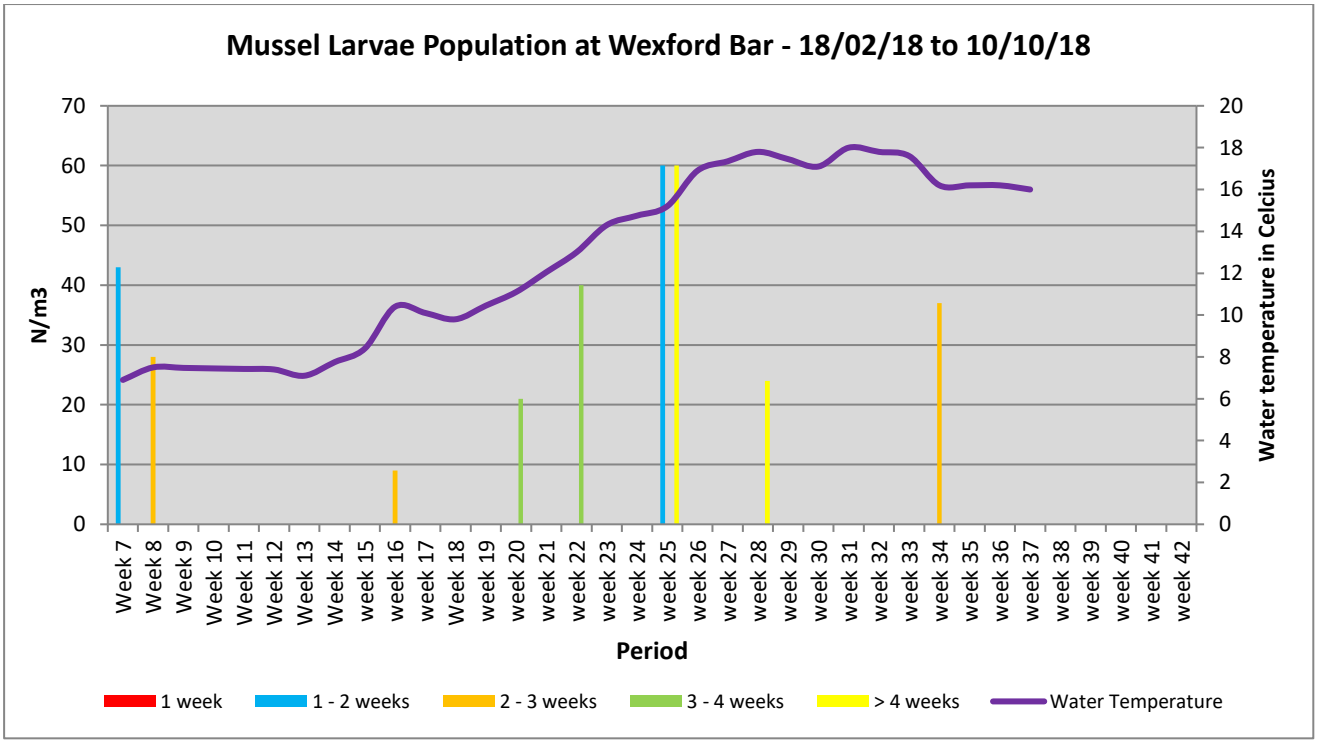
Sample sites

This section of the report deals with the specific findings for each area. As in the last three years, there were five age classes of mussel larvae identified using microscopy and these were: larvae less than 1 week old , D larvae 1 to 2 weeks old , D larvae 2 to 3 weeks old , D larvae 3 to 4 week old and D Larvae that were over 4 weeks old .

Wexford Bar

The numbers of larvae per m^3 and their estimated age are shown in Table 4 and these were then graphed in Figure 10 with ambient seawater temperatures. Nationally, there was a significant decrease of larvae population for this station in comparison with the previous years. Unfortunately 17 samples were missed due to poor weather and there was no seed mussel settlement observed within the vicinity of the Wexford Bar Station.

Figure 10: Mussel D-larvae population and seawater temperature at Wexford Bar (Week 7 to Week 42)



In 2018, there was no observation of 1-week old larvae at the Wexford bar despite extended sampling and meat yield monitoring. However, it appears that the 1 to 2 weeks old larvae observed on week 7 may be correlated to an early spawning between week 7 and 8 in Wexford Harbour. Some larvae also seemed to have stayed within the area for a week after as 2 to 3 weeks old larvae were found on week 9. It appears that the usual main annual spawning event which typically occurs between week 14 and week 16 does did not transpire in 2018 as there were only a very small number of larvae observed on week 16. The lack of samples for week 17 and 19 were due to adverse weather and there was also a high sediment content in the sample collected on week 18 which impaired preservation at a time of the possible third event. However, 3 to 4 weeks old larvae on

week 22 could have been remnant of that possible spawning as per the over 4 weeks old larvae on week 25. The other larvae on week 25 may have originated from the last possible spawning event of week 25/26. The quantities of larvae recorded in 2018 were the lowest for this station since the monitoring started in 2015.

As had occurred in the year 2017, the weather was a major limiting factor for the sampling at this location as also for the Rush Channel location. Many of the samples contained large amounts of sediment due to the action of the northeast wind against the flood tidal current. In addition, the water temperature remained under 8 °C until week 15 (2nd week of April). There was no sampling from week 38 to week 42 as there was no sampling vessel available.

Table 4: Mussel D-larvae population at the Wexford Bar (number per m³)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
Week 7		43				6.9	43
Week 8			28			7.5	28
Week 9						7.475	
Week 10						7.45	
Week 11						7.425	
Week 12						7.4	0
Week 13						7.1	0
Week 14						7.75	
week 15						8.4	0
week 16			9			10.4	9
week 17						10.1	
Week 18						9.8	
week 19						10.45	
week 20				21		11.1	21
week 21						12.05	
week 22				40		13	40
week 23						14.3	0
week 24						14.75	
week 25		60			60	15.2	120
week 26						16.9	0
week 27						17.35	
week 28					24	17.8	24
week 29						17.45	
week 30						17.1	0
week 31						18	0
week 32						17.8	
week 33						17.6	0
week 34			37			16.2	37
week 35						16.2	
week 36						16.2	0
week 37						16	0

No sample was collected, and an estimated value has been used for graphical purposes.

Rusk Channel

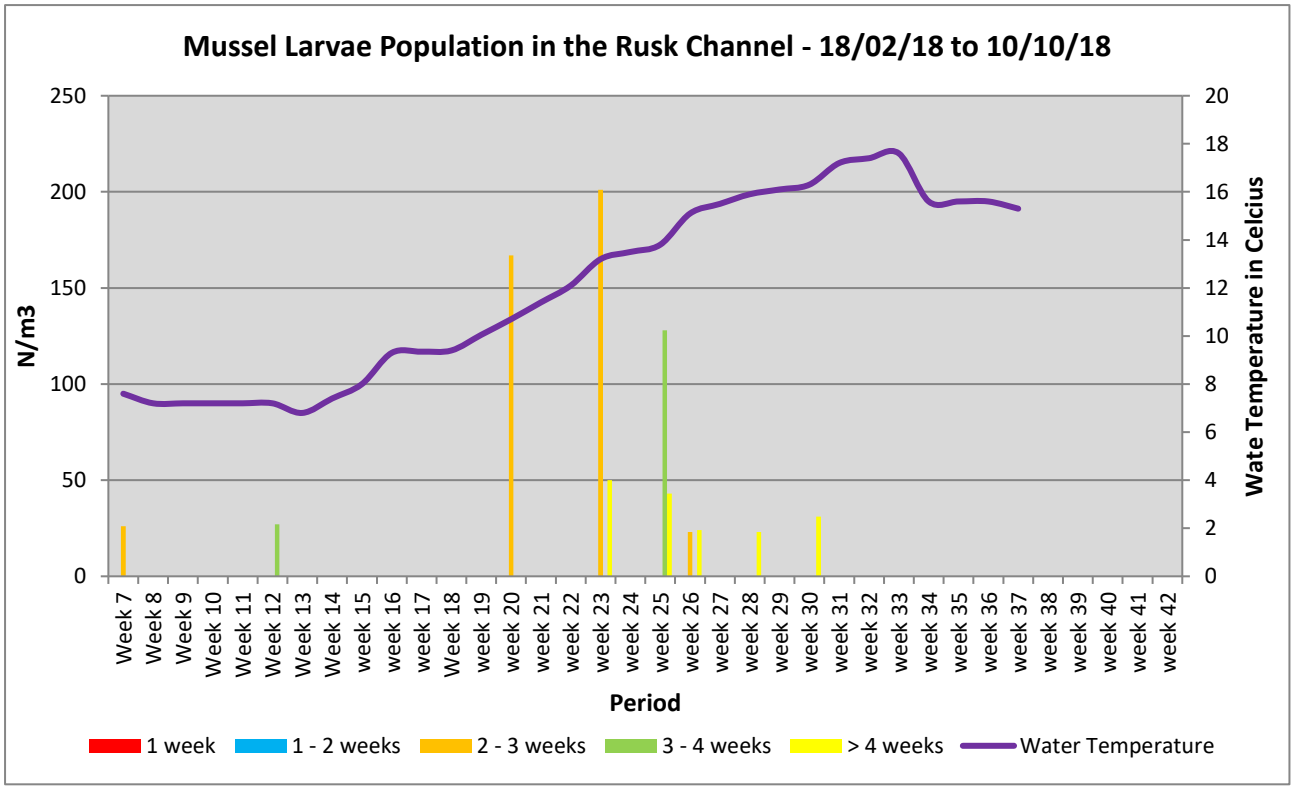
Table 5 shows a breakdown of the number and ages of larvae found at the Rusk Channel sampling station. This data has been graphed and the ambient water temperature added on Figure 11. Due to bad weather conditions, 18 sampling events were missed.

Table 5: Mussel D-larvae population in the Rusk Channel (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
Week 7			26			7.6	26
Week 8						7.2	0
Week 9						7.2	
Week 10						7.2	
Week 11						7.2	
Week 12				27		7.2	27
Week 13						6.8	0
Week 14						7.4	
week 15						8	0
week 16						9.3	0
week 17						9.35	
Week 18						9.4	
week 19						10.05	
week 20			167			10.7	167
week 21						11.4	
week 22						12.1	0
week 23			201		50	13.2	251
week 24						13.5	
week 25				128	43	13.8	171
week 26			23		24	15.1	47
week 27						15.5	
week 28					23	15.9	23
week 29						16.1	0
week 30					31	16.3	31
week 31						17.2	0
week 32						17.4	
week 33						17.6	
week 34						15.6	
week 35						15.6	
week 36						15.6	0
week 37						15.3	0

* No larvae found in the sample / NS-No Sample No sample was collected, and an estimated value has been used for graphical purposes.

Figure 11: Mussel D-larvae population and seawater temperature in the Rusk Channel (Week 7 to Week 42)



As per the Wexford Bar station, the larval numbers observed at the Rusk Channel were low for 2018. There were no early larvae and for the first time since the initiation of the sampling program, there was no observation of 1 to 2 weeks old larvae. Due to missed sampling events, there is also a lack of data up to week 20. In previous years showed that the bulk of the larvae appeared during this period in the Rusk Channel.

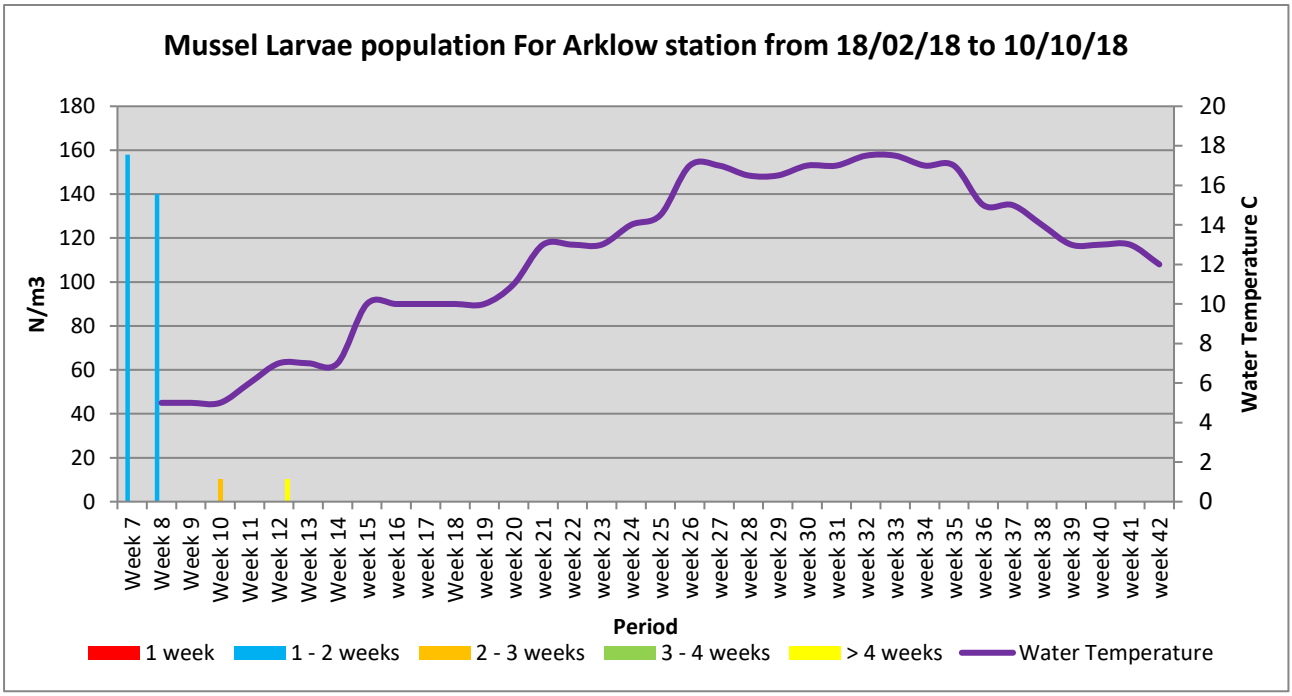
There were two main spikes observed in the larvae population, both in the 2 to 3 weeks old class, on week 20 (mid-May) and then on week 23 (start of June). The spike of 3 to 4 weeks old larvae on week 25 is probably due the remnant of the population from week 23. Those observations could be related to some of the seed mussel settlement found between the two channel buoys on the south side of the Rusk Channel during the first week of July as well as the third possible spawning event in Wexford harbour on week 18.

There was very small amounts of larvae observed after week 25.

South Wicklow/Arklow

Table 6 below shows a breakdown of the number and ages of larvae found at the South Wicklow sampling station. Again, this data has been graphed and the ambient water temperature added on Figure 14. Only 5 samples were missed during the 2018 season at this station despite weather conditions.

Figure 12: Mussel D-larvae population and seawater temperature in South Wicklow (Week 7 to Week 42)



There were no 1-week old larvae found at the Arklow station. Nevertheless, some 1 to 2 weeks old larvae were observed early in the sampling (week 7 and 8). The possible relationship between the Rusk Channel and Arklow highlighted in 2017 did not appear in 2018, therefore it is possible that the larvae observed in the north Arklow/south Wicklow area could be coming from another brood stock than Wexford Harbour. There were little to no larvae observed after those two weeks.

A small mussel seed settlement was observed later in 2018 at the same location as that in 2017 (approximately 15 Nautical miles north of the sampling station) which may be related to the larvae observed at the start of the sampling.

Table 6: Mussel D-larvae population in South Wicklow (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
Week 7		158					158
Week 8		140				5	140
Week 9						5	
Week 10			10			5	10
Week 11						6	0
Week 12					10	7	10
Week 13						7	0
Week 14						7	0
week 15						10	0
week 16						10	
week 17						10	0
Week 18						10	0
week 19						10	0
week 20						11	0
week 21						13	0
week 22						13	
week 23						13	0
week 24						14	
week 25						14.5	0
week 26						17	0
week 27						17	0
week 28						16.5	0
week 29						16.5	0
week 30						17	0
week 31						17	0
week 32						17.5	
week 33						17.5	0
week 34						17	0
week 35						17	
week 36						15	0
week 37						15	0
week 38						14	0
week 39						13	0
week 40						13	0
week 41						13	0
week 42						12	0

* No larvae were found in the sample / NS-No Sample No sample was collected, and an estimated value has been used for graphical purposes.

North Howth

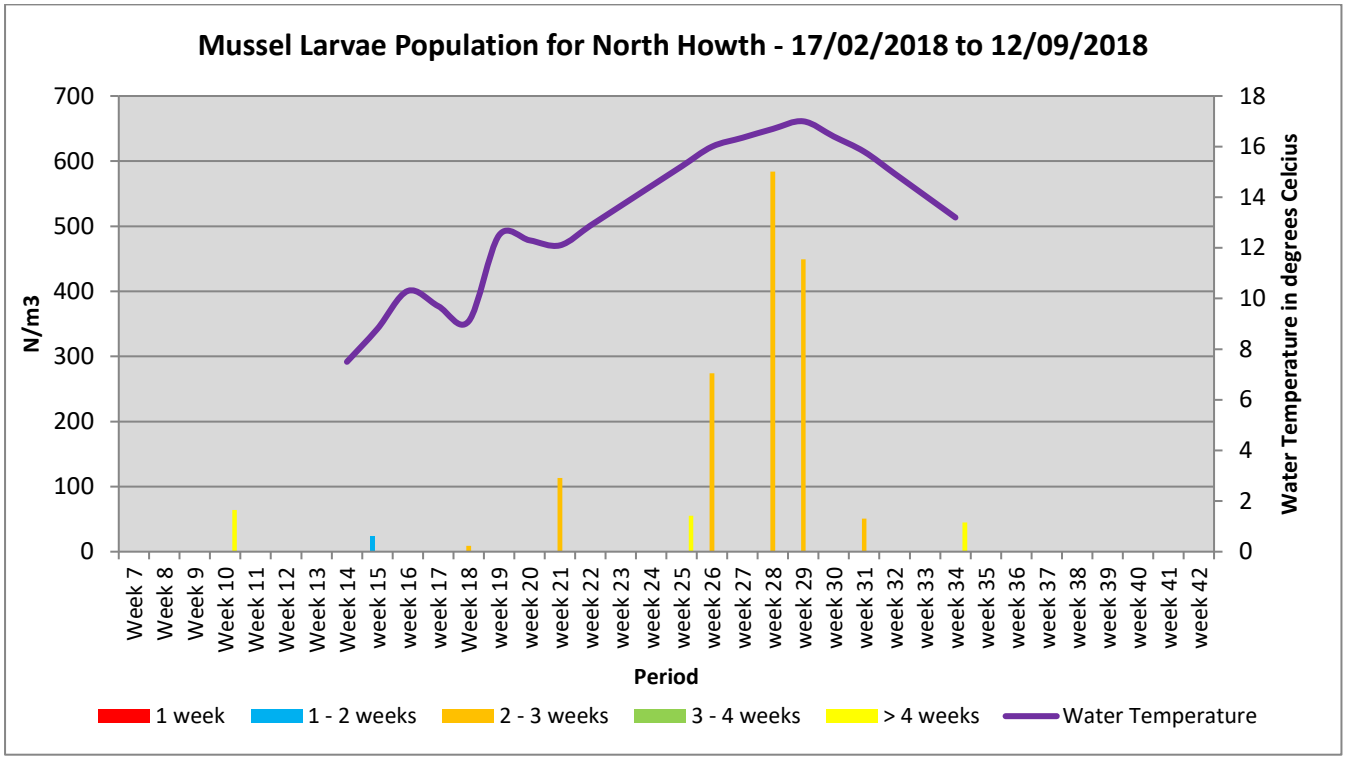
This was the second year of sampling in Howth, but due to logistical issue, condition index monitoring for the brood stock in Malahide only started in July. Sampling started on week 10 due to weather conditions that did not allow the boat to go out. 19 samples were missed in Howth, mainly due to weather conditions again. The highest number of larvae for 2018 was recorded at this station.

Table 8: Mussel D-larvae population in North Howth (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
Week 10					64		64
Week 11							
Week 12							0
Week 13							
Week 14						7.5	0
week 15		23				8.8	23
week 16						10.3	0
week 17						9.7	0
Week 18			9			9.1	9
week 19						12.5	
week 20						12.3	
week 21			113			12.1	113
week 22						12.88	0
week 23						13.66	
week 24						14.44	0
week 25					55	15.22	55
week 26			274			16	274
week 27						16.35	
week 28			584			16.7	584
week 29			449			17	449
week 30						16.4	
week 31			51			15.8	51
week 32						14.93333	
week 33						14.06667	
week 34					45	13.2	45
week 35							
week 36							0

* No larvae found in the sample / NS-No Sample No sample was collected, and an estimated value has been used for graphical purposes.

Figure 18: Mussel D-larvae population and seawater temperature in North Howth (Week 15 to Week 40)



Again, there were no 1-week old larvae were observed in Howth. Very small numbers of 1 to 2 week old larvae were observed on week 15 (mid-April) but the dominating age class at that station was 2 to 3 weeks old larvae, observed from week 21 (mid-May) to week 31 (end of July). The population peaked on week 26 (end of June), and on weeks 28 and 29 (mid-July). Small quantities were observed until week 34 (end of August) and sampling ended prematurely due to weather conditions on week 36 (start of September).

It is likely that those larvae were produced from the Malahide brood stock, unfortunately no drifters were deployed on the location.

A small and compact seed mussel settlement was found only a few nautical miles south of the sampling location, in the channel between Ireland Eye and Howth. This settlement can possibly be the result of the larvae observed at the sampling station as it was discovered in mid-September 2019.

Castlemaine Harbour/ Cromane

No larvae were observed at the Cromane station, in addition sampling only took place from week 11 to week 25. Those issue needs to be resolved. Despite those results, there was some larvae settlement in the Rossbeigh channel, the original settlement was estimated to be around 3,000 tonnes, unfortunately adverse weather conditions at the time of the fishery, very little amount was collected.

Drifters deployments

Another objective of the larval monitoring programme is to improve understanding of larval movements from spawning areas to settlement location. In an effort to ascertain the linkage between brood stock and seed beds. Part of the ISPP project was dedicated to developing particle tracking models of larvae dispersal. For this objective *in situ* data must be collected and integrated to the system to refine the model predictions. One innovative technique is to use drifter buoys tracked by GPS. This method was used in France during the DILEMES project ran by IFREMER in 2013.

The Microstar drifters were provided by Pacific Gyre. The drifters are composed of two parts: the buoy that housed the batteries and the transmitter (for position and water temperature), and the kite composed of a plastic tubing frame and fabric. The ensemble represents 1.5 meter when deployed, from the top of the buoy to the bottom of the kite.

Figure 19: Detail of the Microstar GPS drifter

Originally, it was planned to deploy the drifters for a full tide cycle (over a spring tide and a neap tide). There was 5 deployment done in 2018: 2 in Castlemaine harbour, 2 outside Wexford harbour and one north of Arklow.

Castlemaine Harbour Deployments

The first launch took place on May 10th, 2018. The drifter was deployed on the mussel growing ground close to high water on a neap tide.

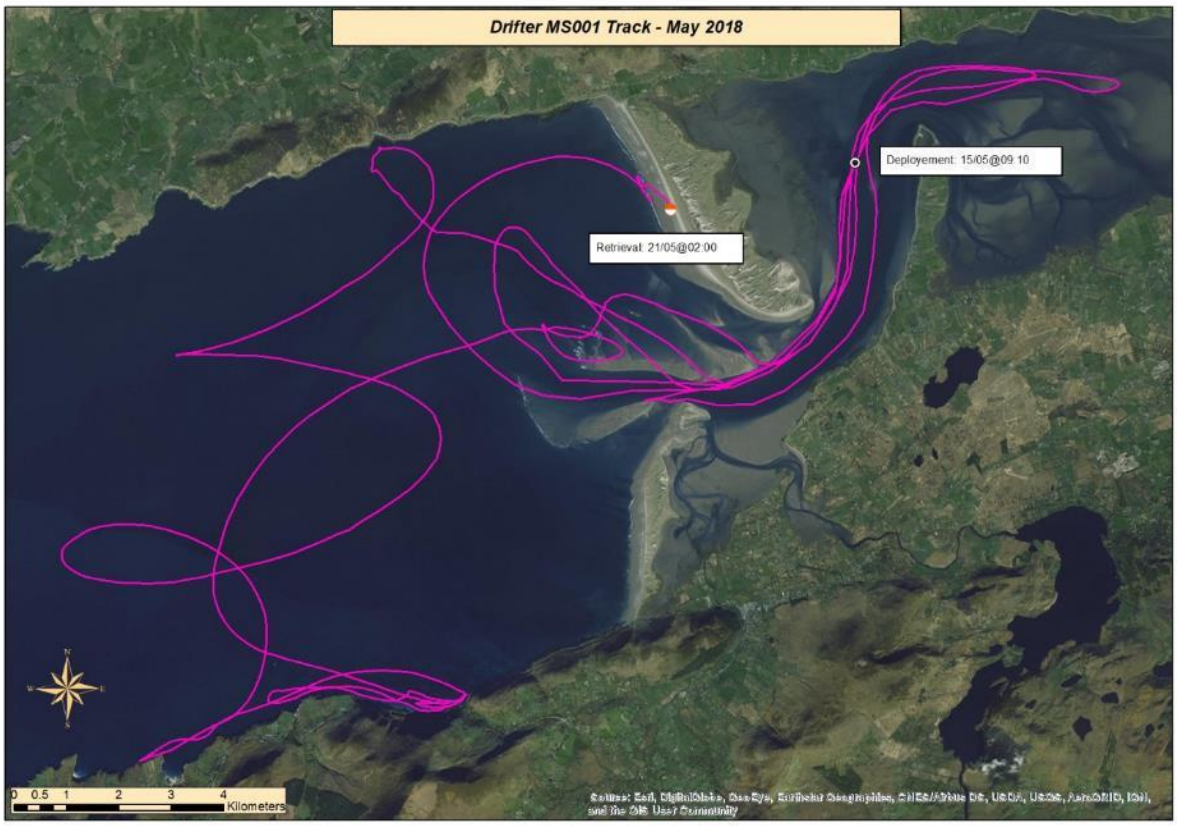
Figure 20: Microstar 007 track

The drifter stayed within the harbour from the 10th to the 12th of May. Interesting patterns were observed after low water. On the 11th, the drifter was caught in an eddy close to the bar from 17:15 to 20:50 where it swirled around four times and finally caught the flood current some 40 minutes later. It appears that there is secondary tidal current rounding Inch point; settlements are known to occur in this area as well. It then took 10 hours to move the corner of Inch beach. Shallow waters and local disturbance brought it straight on the shore where it was recovered within 36 hours on May 14th. This length of time in shallow waters extensively damage to the kite which couldn't be salvage. Nevertheless, rocks at the recovery point were covered with very dense small spat which could indicate that mussel larvae travelled from the harbour to this location before settling. The fastest speed recorded was 0.85 m/sec in the main channel between Rossbeigh and Inch. The highest speed recorded outside the harbour was 0.11 m/sec and seemed to be stable from the time the drogue left the bar to the time it reached the shore. In total, the drifter travelled 90,080 m and was deployed for a total of 92 h 15 minutes (average speed of 0.27 m/sec).

Figure 21: Small mussel spat at the drifter recovery location

The second launch in Castlemaine was carried out on May 15th. The drifter was released at the same location than the previous one but this time on a spring tide.

Figure 22: Microstar 001 track



The effect of the spring tide greatly influenced both the track and the speed of the drogue. The drifter left the channel within 24 hours after deployment passing above the north sandbank. It looped from Annascaul (North) to Kells Harbour/Kings Head (South) before returning in the channel on the 20th of June. The flood pushed the buoy beyond Cromane point and it exited again on the following ebb and reached the shore on Inch strand during the night of the 20th to the 21st. This drifter recorded the fastest speed of all the deployments: 1.67 m/sec (over 3 knots) was recorded in the channel. It travelled 154,839 m during 146 hours with the average speed of 0.29 m/sec. The speed dropped dramatically when the drifter exited the channel to 0.5 m/sec. No mussel or spat was observed at the recovery location. The drifter re-entering the channel after several days can indicate that, although larvae can likely be carried out, tidal current can bring them back to potentially settle in the usual seed mussel bed area.

In both deployments, the drifter passed several times above historical seed mussel settlement locations in Rossbeigh Channel.

Figure 23: Wind Direction Recorded at Valentia Weather Station during the Drifters Deployment

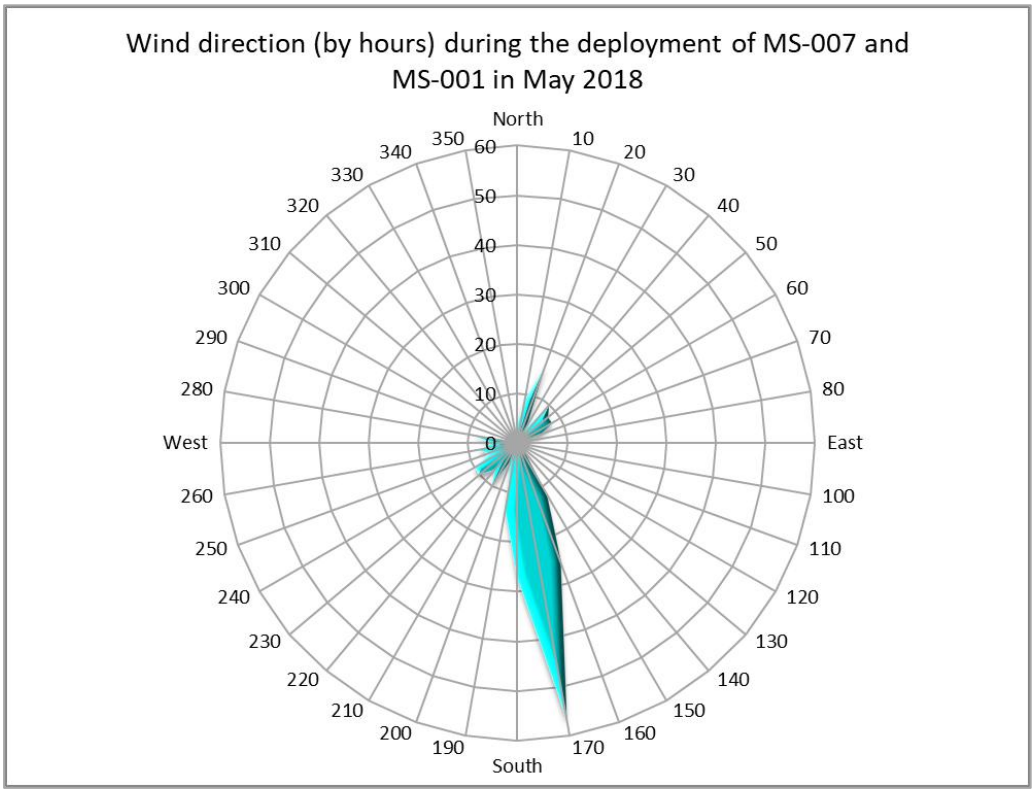
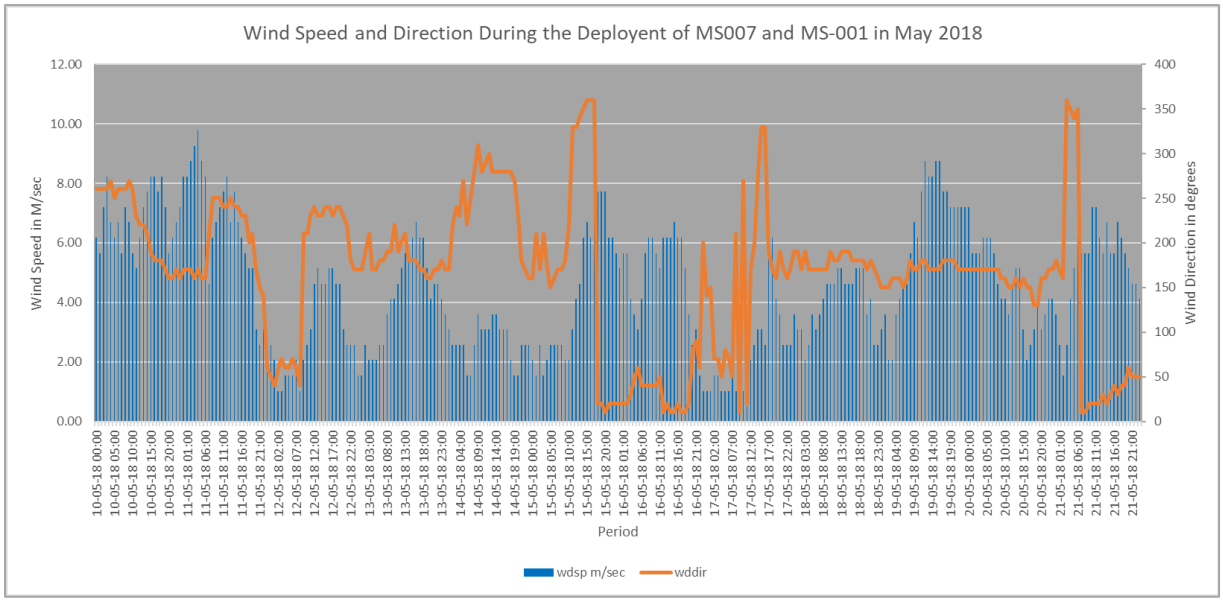


Figure 24: Wind Speed and Direction at Valentia Weather Station During the Drifters Deployment



Southeast coast deployments

Figure 25: MS 006 tracks for May and June Deployments

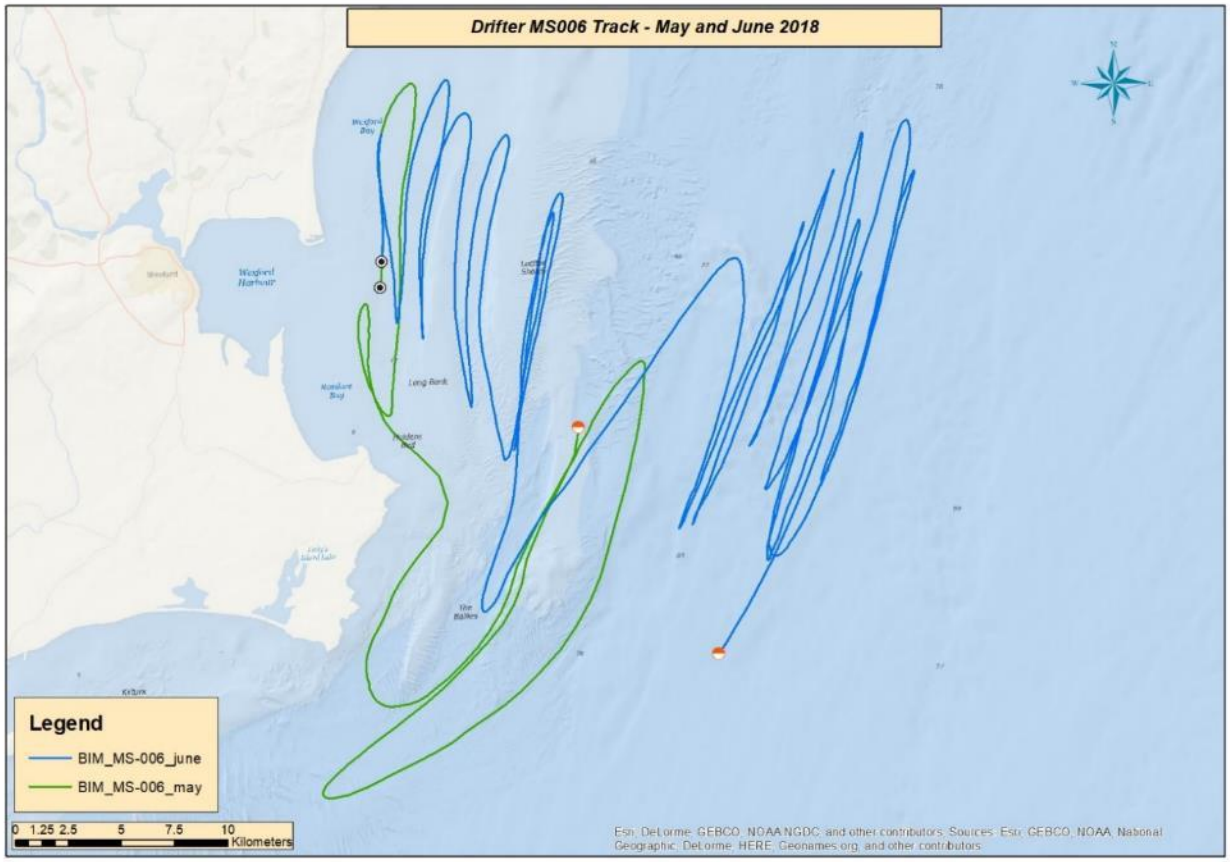
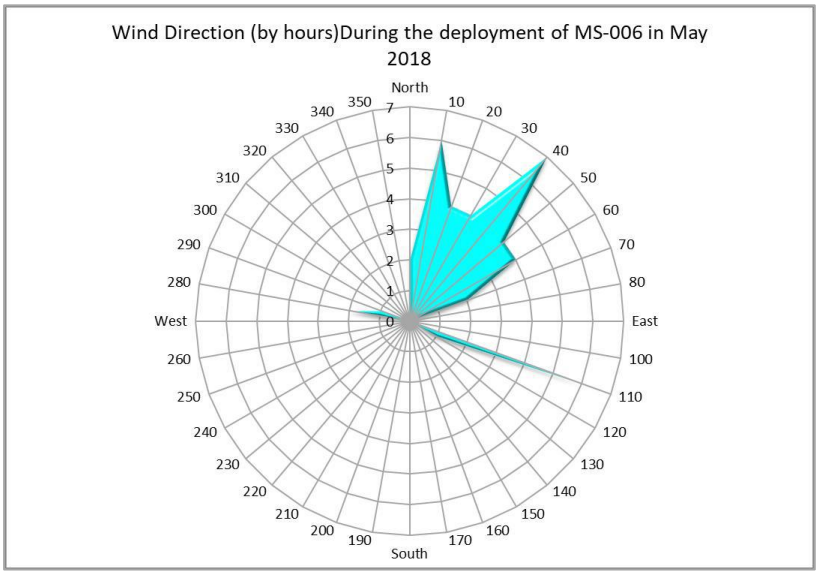


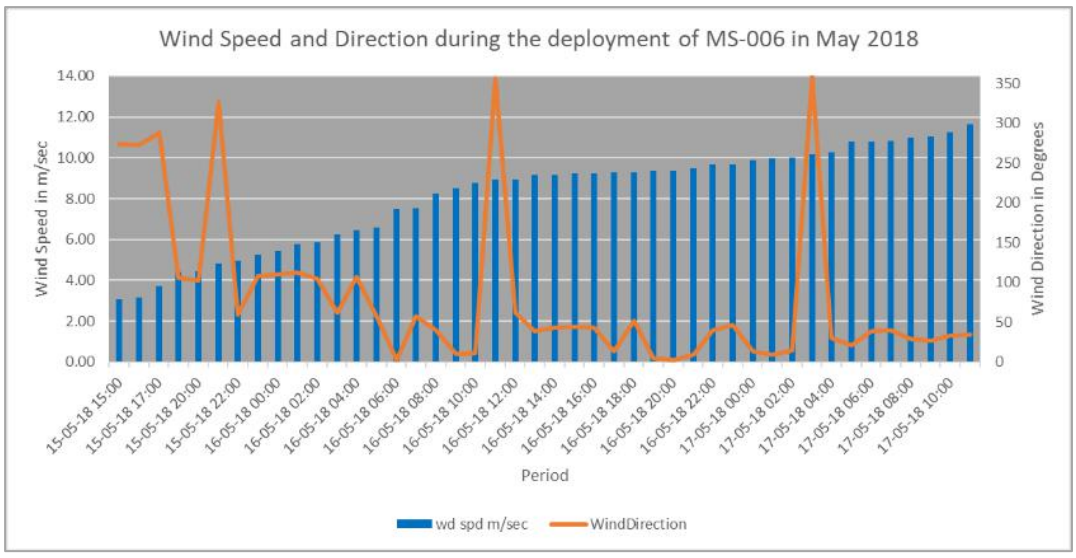
Table 9: Drifter MS-006 Summary data

Buoy	lat start	long start	date start	lat end	long end	date end	total distance	total time	av speed	max speed inner	max speed outter
MS-006 May	52 19.457 N	006 19.256 W	15-05-18 15:50	52 15.736 N	006 11.274 W	17-05-18 10:40	123,934 m	42 H 40 min	0.80 m/sec	1.15 m/sec	2.25 m/sec
MS-006 June	52 20.109 N	006 19.169 W	19-06-18 11:00	52 09.851 N	006 05.845 W	26-06-18 14:40	416,802 m	171 H 30 min	0.67 m/sec	1.09 m/sec	1.38 m/sec

There were two deployments outside Wexford harbour. The first one, in May was during a spring tide (May 15th), which was recovered after two days. The drifter was deployed at the Wexford Harbour Bar where it was thought that larvae could potentially be travelling. Known seed mussel settlements have been recorded alongside the track, however not in the year 2018. It was expected that the drifter would travel north, but the main current brought it to the south pass Carnsore Point. Looking at the speed and direction of the tide, it is likely that the drifter would have gone further west and south which would have been problematic for retrieval. The maximum speed reached during this deployment was 2.25 m/sec (over 4.3 knots) while outside of the sand bank network.

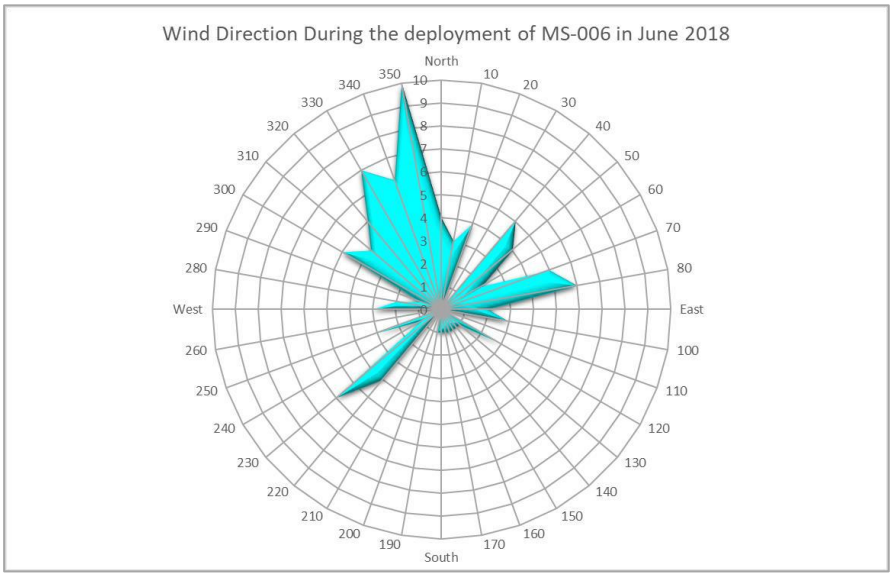
Figure 25: Wind Direction and Speed at the Met Buoy M5 During the Deployment of MS-006 in May 2018





The second deployment was carried out in June during a neap tide (June 19th). The drifter was released just outside the Wexford Bar towards the end of the flood tide. Within two days, it had passed outside the sand banks networks in the front of Wexford Harbour. Once outside the Lucifer Bank, there was little eastward movement compared with the previous two days may correspond to a wind speed decrease (see Appendix). Although the area was not surveyed for seed mussel, this tight oscillation pattern might explain settlement patterns observed at other locations. On the morning of the 22nd, the drifter travelled as far as the Tuskar Rock on the ebb, possibly due to an increase of the north-easterly winds. During the day the drifter moved over 9 kilometres eastward during its oscillation. The drifter then entered another tidal system for a further three days. The exiting of this cycle corresponded to an increase in wind and tide. The drifter was then recovered, and the total distance travelled was 416,802 m over 7 days with an average speed of 0.67 m/sec. Wind direction and strength strongly affected these deployments.

Figure 26: Wind Direction and Speed at the Met Buoy M5 During the Deployment of MS-006 in June 2018

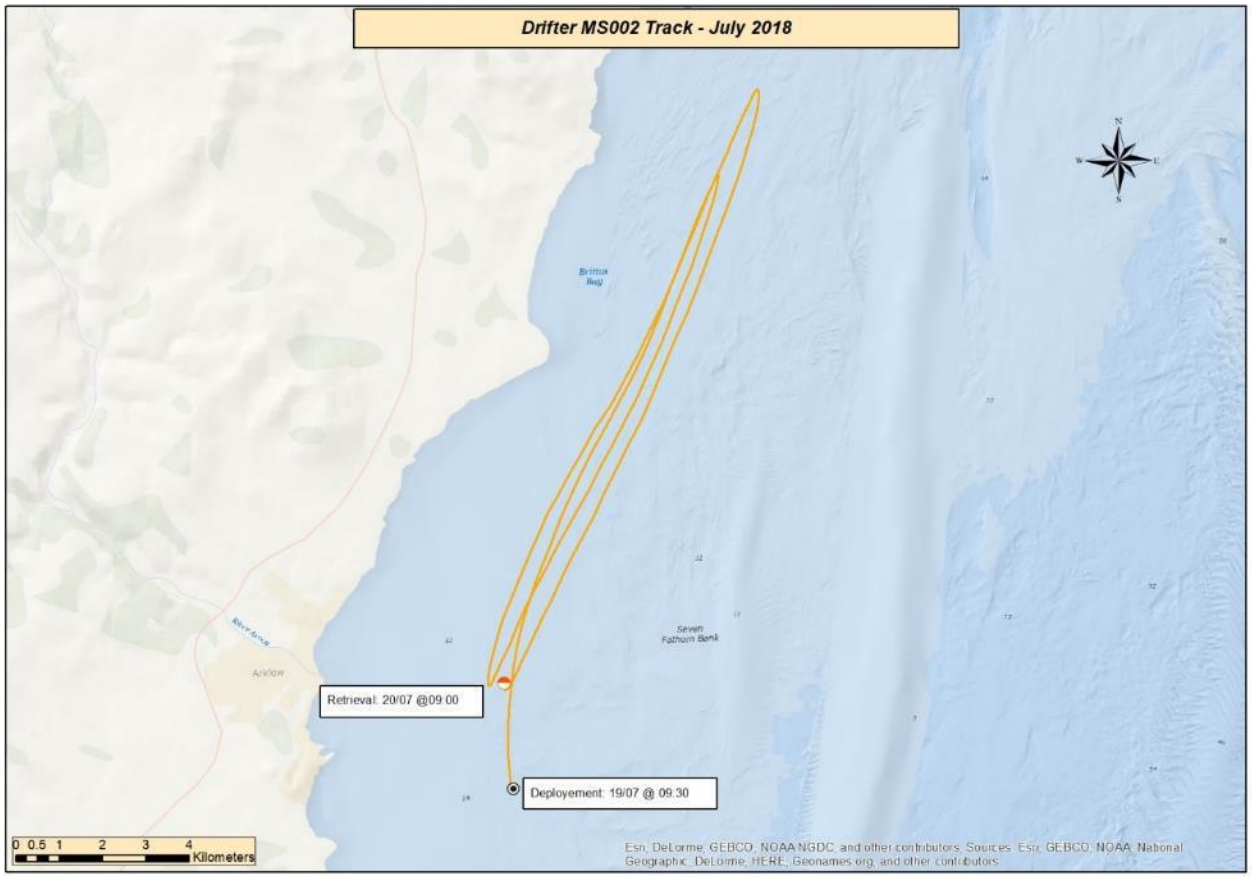


East Coast deployment

There was a deployment north of Arklow. However, due to battery problem, the drifter was only deployed for less than 24 hours. The oscillation observed looked regular like at the back the Lucifer bank and the drifter travelled 58,760 meters at an average speed of 0.69m /sec, which is the second fastest average speed recorded, despite being during a neap tide. The maximum speed reached was 1.08 m/sec. Overall, the data collected during both neap tide launches were similar.

More deployments are planned for 2019 in this area as the track passes very closed to seed mussel settlement observed north of Brittas Bay in 2017 and 2018.

Figure 27: MS002 track – July 2018

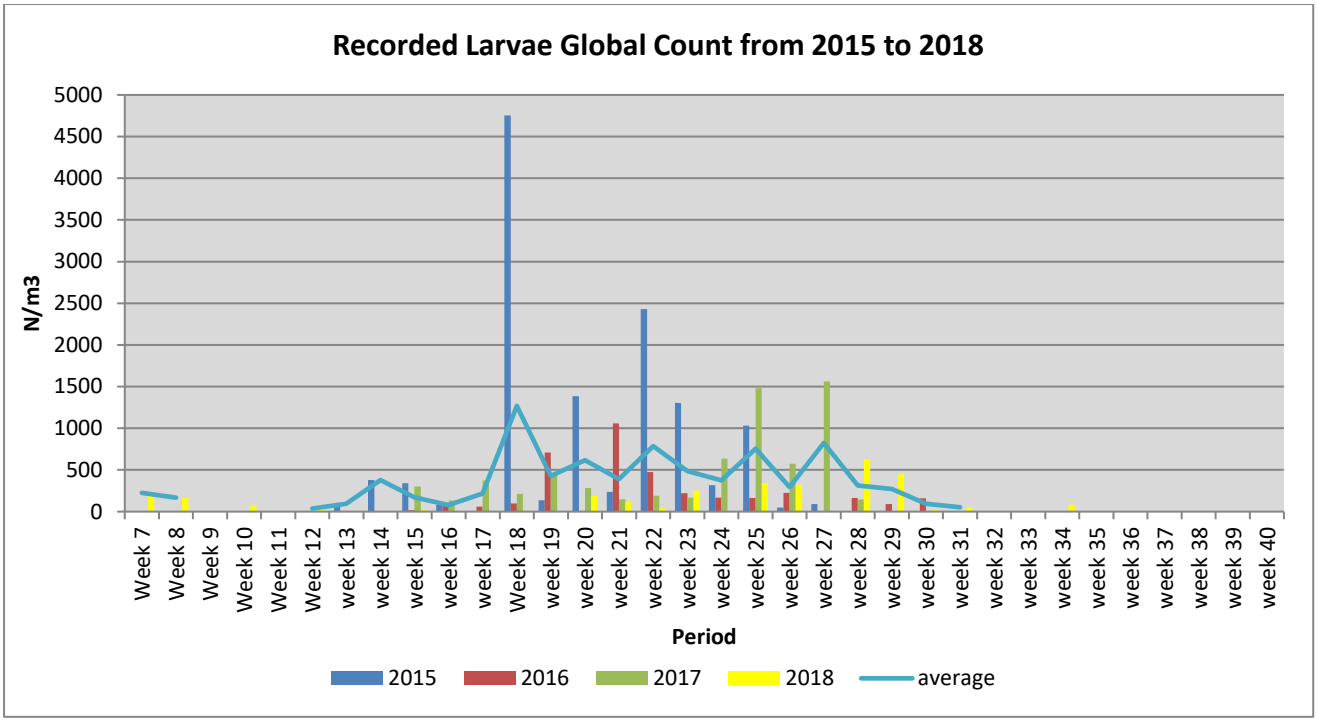


The wind direction and speed were not recorded as the drifter was only deployed for less than 24 hours.

Comparison of findings

The monitoring program has been going on for four years and to date, no obvious pattern has been observed. As for previous years, the focus was only on the three stations Wexford Bar, Rusk Channel and Wicklow due to the consistency of the data. There was a lack of information for Cromane in 2018 and sampling at the Howth station has only be going on for two years.

Figure 28: Larvae Population variation at the Three Sampling Stations



The quantity of mussel larvae observed in 2018 has been the lowest since the monitoring program started. In addition, we can see in Figure 3, that the mussel larvae population appears to have reached a peak later than that recorded for previous years. This trend was also observed in 2017 as well with the population peaking from week 24 to week 27. For 2018, population peaked from week 25 to week 29. A possible explanation for the 2018 observation is that water temperature remained nearly 2 degrees lower than that recorded in 2017 until week 24 (see Figure 28).

From week 25 until week 33, the water temperature increased steadily. The average water temperature was 0.6 degree higher in 2018 than 2017. Nationally since the year 2016, the water temperature is much higher than that recorded for 2015; on week 27 the difference between 2015 and 2018 was over 4 ^{o}C.

Nevertheless, the number of larvae in 2015 was much higher than any other year since the start of the program (see table 10). Although the estimated tonnage of seed mussel in 2015, 2016 and 2017 did not appear to have been influence by the number of larvae observed in the samples (see 2017 report); the 2018 estimated tonnage appears to correlate with the low number of larvae observed in those three stations (see Figure 29).

Figure 29: Average Water Temperature across the Sampling Stations since 2017

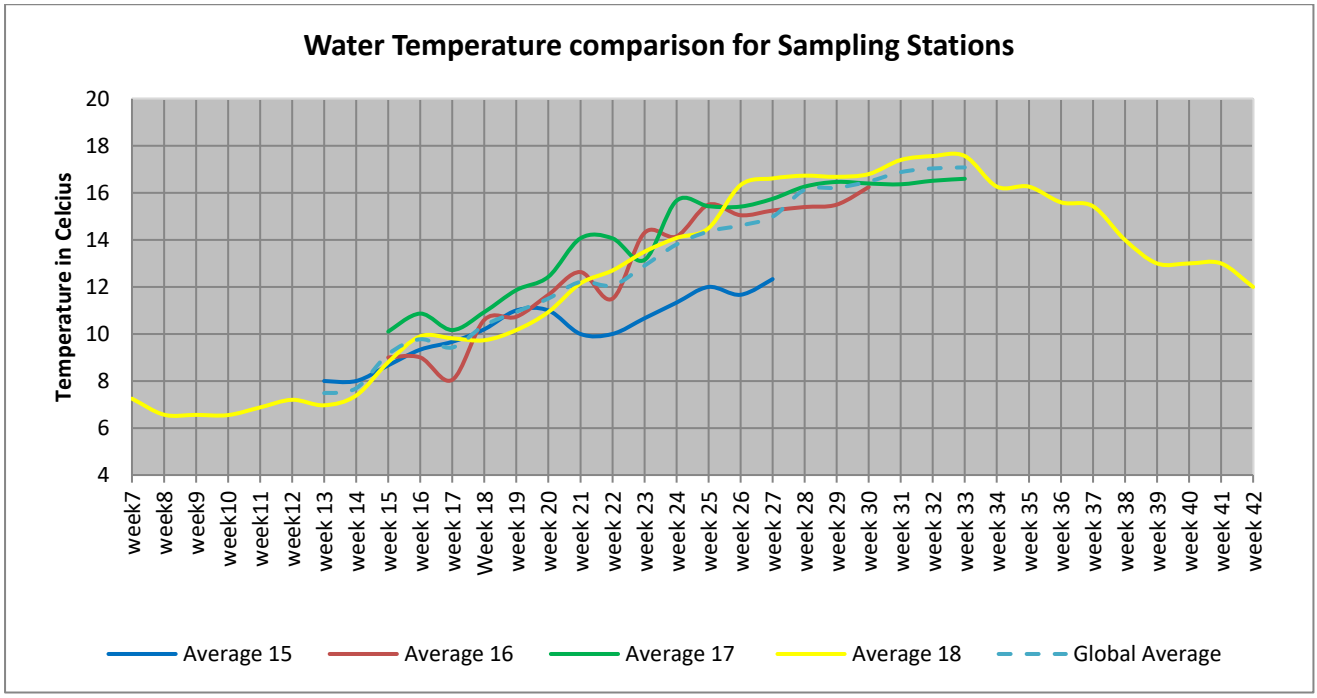
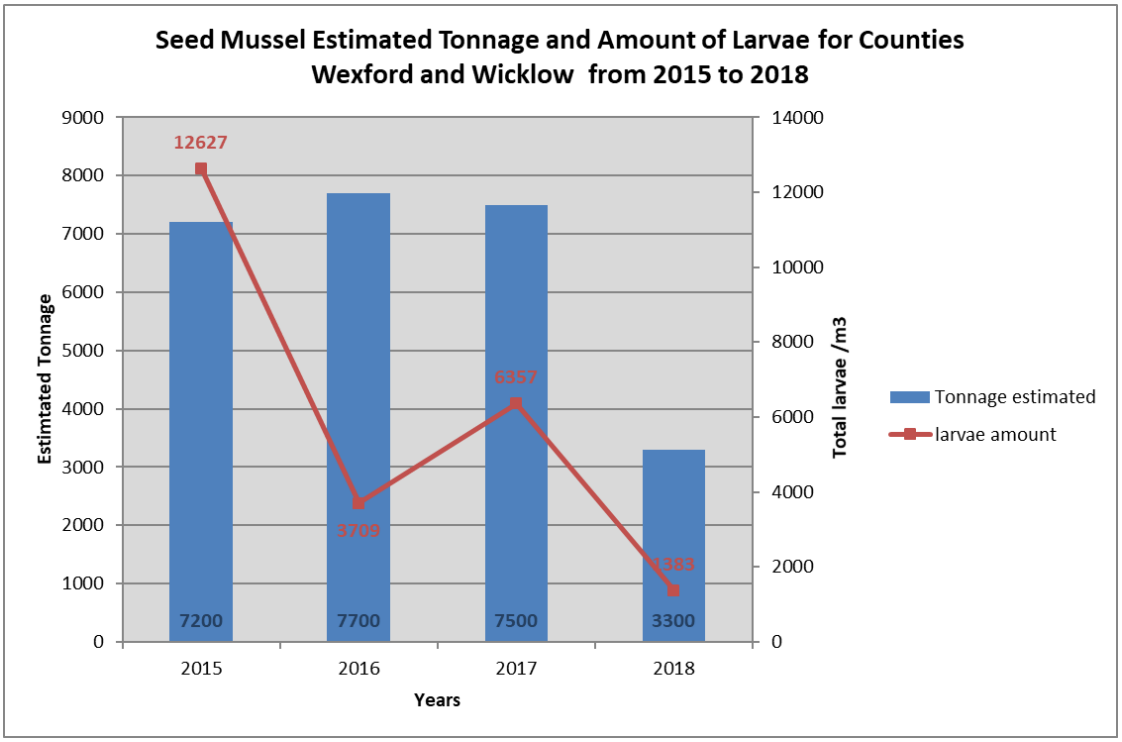


Table 10: Mussel Larvae Population Variation from 2015 to 2018

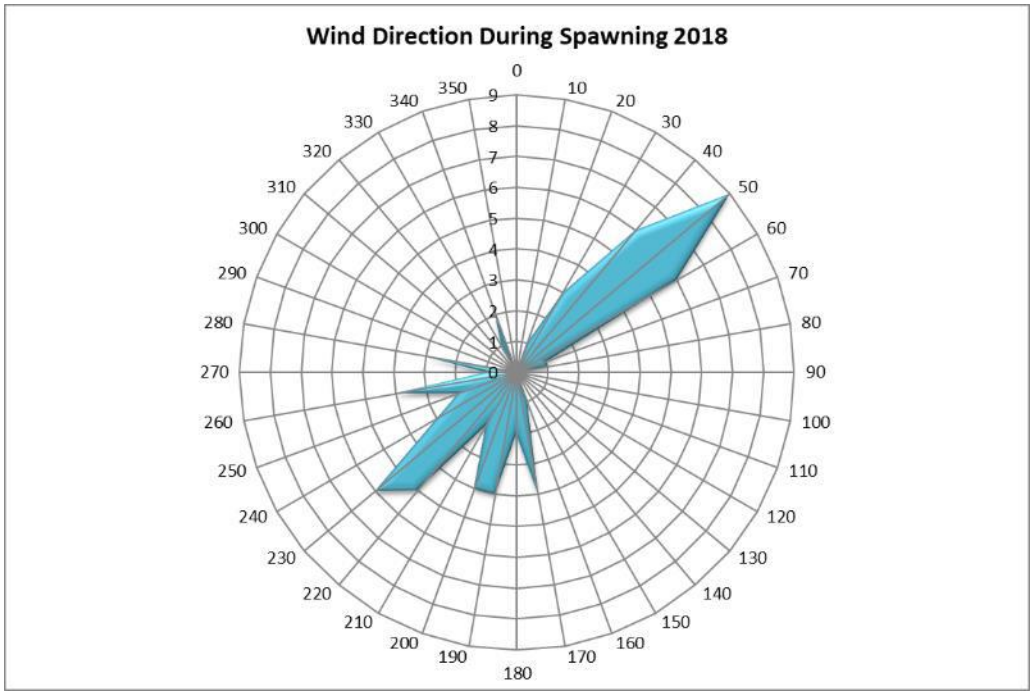
Year	Wexford Bar	Rusk Channel	Wicklow
2015	7795	3968	864
2016	2012	1503	194
2017	3481	2079	797
2018	322	743	318
Samples Taken 2015	*12*	*9*	*10*
Samples Taken 2016	*13*	*14*	*6*
Samples Taken 2017	*21*	*20*	*24*
Samples Taken 2018	*20*	*20*	*41*
Difference 15/16	*-5783*	*-2465*	*-670*
Trend 15/16	***↓74%***	***↓62%***	***↓77%***
Difference 16/17	*1469*	*576*	*603*
Trend 16/17	**↑73%**	**↑38%**	**↑310%**
Difference 17/18	*-3159*	*-1336*	*-479*
Trend 17/18	**↓91%**	**↓64%**	**↓60%**

Figure 30: Seed Mussel Estimated Tonnage and Larvae Numbers from 205 to 2018



In addition, the number of days with northerly sector winds had increased by 6 % in comparison from previous year (across the sampling period). During the spawning period, from week 14 to week 28 and although not predominant, northerly sector winds represented 33 days on 74 which could have driven larvae coming out of Wexford Harbour further south outside of the usual settlement areas (see previous chapter on Drifters Deployment).

Figure 31: Wind Direction at the Met Buoy M5 During the Spawning Period in 2018



Discussion:

The 2018 larval collection observations and seed survey findings have been the lowest recorded since the start of the monitoring program. This was a very different year from the previous three and so far over the four years of the program no repeated pattern has been observed. Nevertheless, data collection has increased; the combination of brood stock condition index monitoring, larvae sampling, temperature and wind monitoring as well as the deployment of the Microstar GPS drifters is giving a better insight on what is happening during the spawning and larval transport periods.

The most influential factors in larval numbers and seed settlement appear to have been meteorological. Low temperatures during the potential spawning season and for some time during the larval phase possibly limited or at least delayed settlement onto the seabed in all locations. A settlement occurred in Cromane but was subsequently depleted by an autumn storm. On the southeast coast, the north-easterly wind may have assisted in the transport of the larvae further south onto grounds not suitable for fishing. The wind effect was more pronounced on the southeast coast, probably due to its exposure in comparison with the nearly closed system in Cromane/Castlemaine Harbour. The deployment of the GPS tracker buoy partially confirmed this theory.

It appears from the tracking of drifters deployed outside Wexford Bar, that it is unlikely that seed mussel settlement in Wicklow is related to the Wexford Harbour brood stock. Looking at the track of the drifter in Arklow, it is possible that the larvae could be coming from a more local brood stock. There are known to be settlements on the Arklow Windfarm turbine base which might potentially feed the Wicklow larvae stock. This will need to be investigated. For Cromane, areas north (Annascaul) and south (Kells harbour, Kings Head) of Dingle Bay need to be investigated for potential settlement or wild brood stock.

There are still few issues that need to be resolved such as the situation in Cromane, the quantity of iodine per samples and the technical problem with the temperature and salinity probes. The sampling will more than likely increase in 2019. In addition to the condition index on the brood stock, it is planned to assess the mussel's gonads maturation to be able to pinpoint the spawning pattern. More drifter deployments are planned around the coast especially on other known brood stock such as Malahide and Dublin Bay. It is planned, as well, to look at the species diversity in the samples using genetic analysis.

Acknowledgements

BIM wish to thank all of those involved in the sampling and analysis without whom this report could not have been produced.

Appendix:

- Calculation method
- Graphs
- Weather graphs
- Data collection Sheet

Appendix 1: The numbers of larvae per m^3 from a sample site were calculated using the formula $\pi r^2 h$ to obtain the volume of water sampled through a plankton net (where $\pi = 3.14159$, r^2 = radius of the net squared and h = height of water/ distance the net was towed through the water column). A further calculation was then undertaken to consider the portion of the sample analysed in relation to the overall volume of sample water collected.

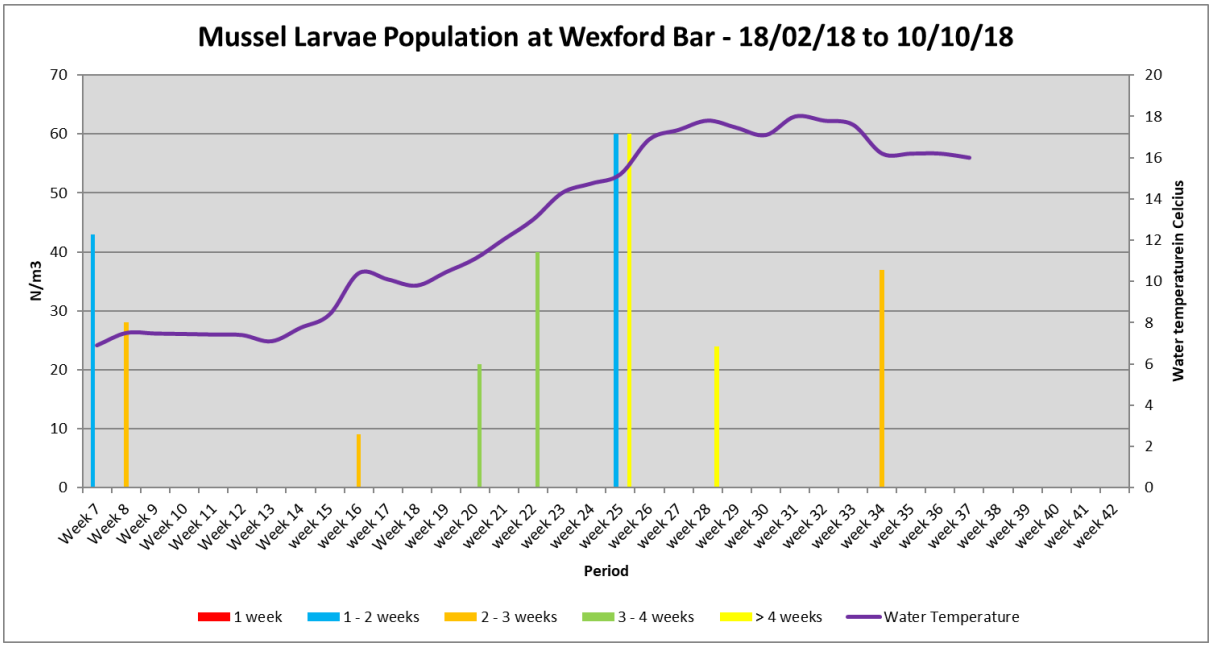
Appendix 2: The meat yield or condition index (C.I.) calculation used in these studies was based on the following calculation:

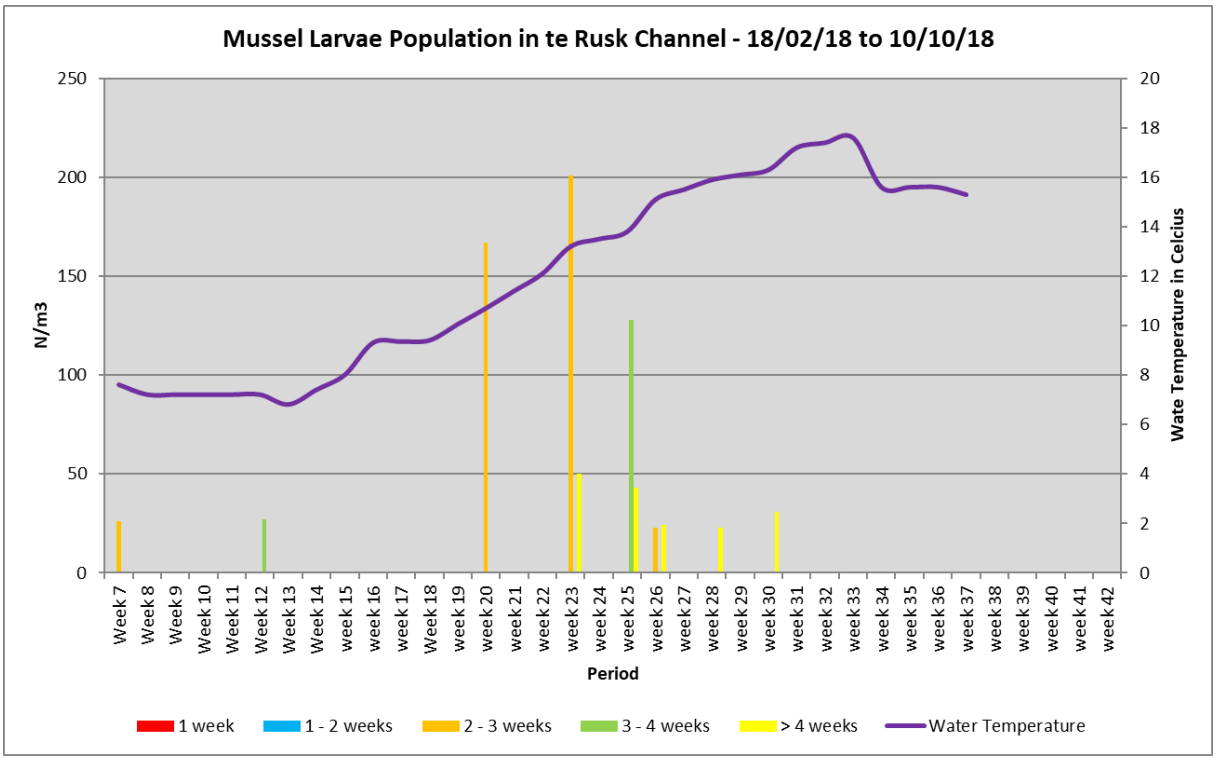
Cooked meat weight / **Total Wet Weight**	**X**	**100**	**=**	**percentage meat yield or condition index**

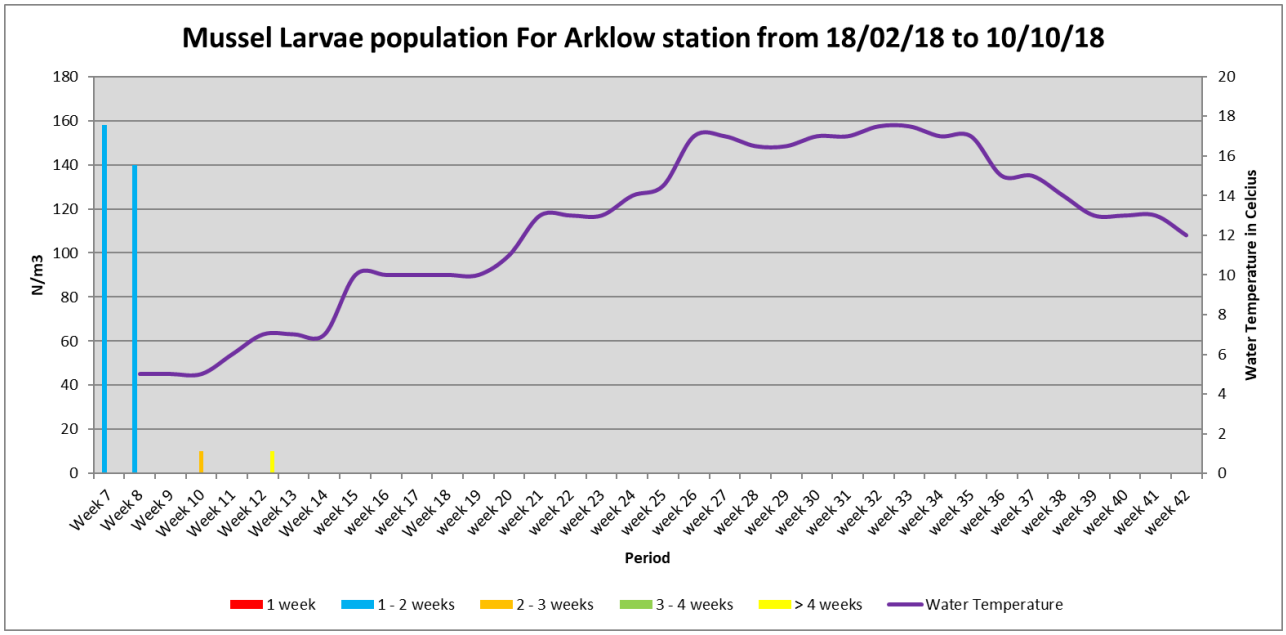
A preferred method from a statistical analysis perspective is:

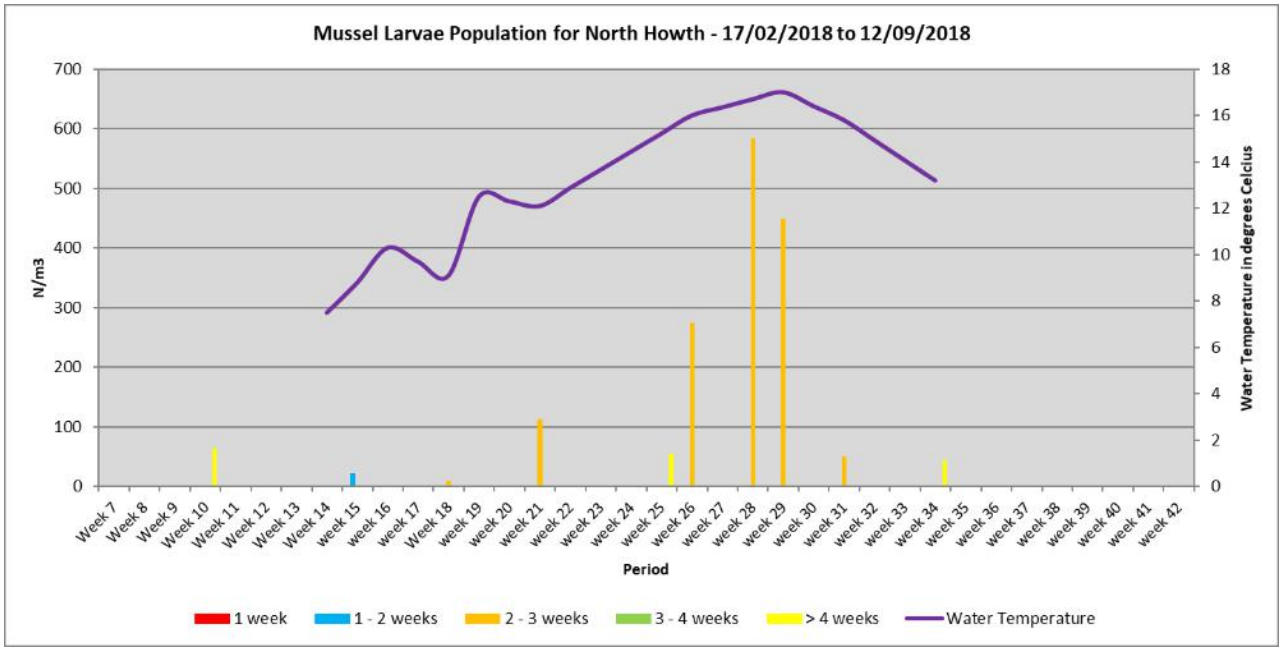
Cooked meat weight / **Cooked meat weight + Shell Weight**	**X**	**100**	**=**	**percentage meat yield or condition index (see Davenport and Chen 1987)**

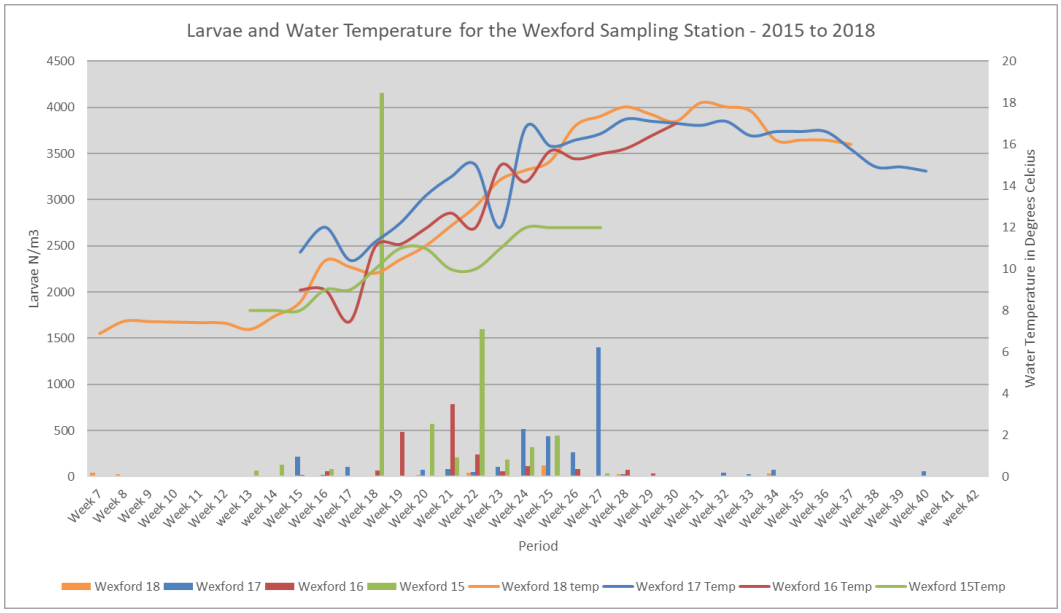
This methodology is "unaffected by prior freezing of samples" and involves the most easily measured parameters, shell weight and cooked meat weight (Davenport, J. and Chen, X. 1987. J. Moll. Stud. (1987), 53, 293-297.

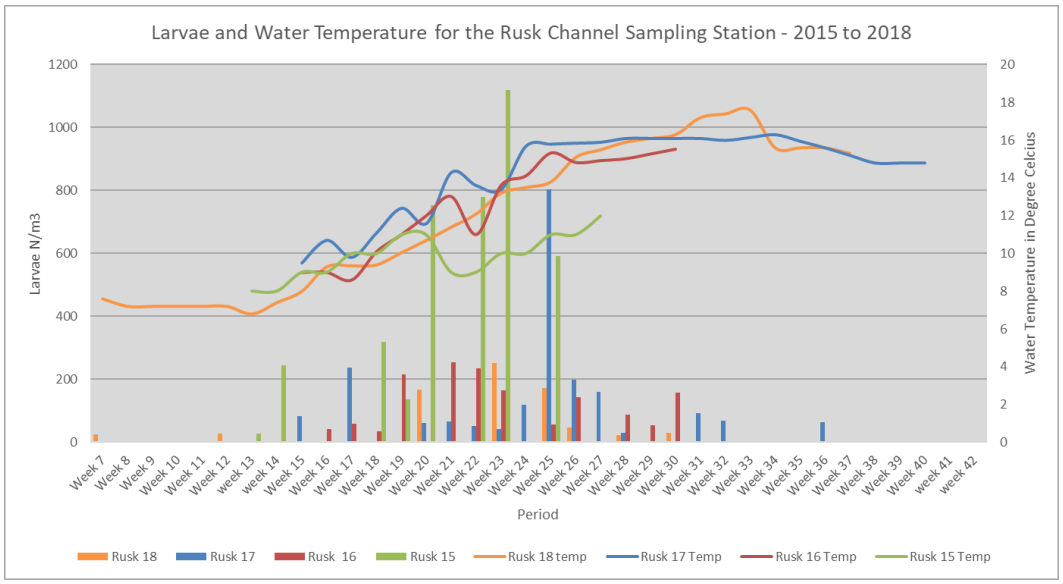

Mussel Larvae Population at Wexford Bar - 18/02/18 to 10/10/18
N/m3
Water temperaturein Celcius
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

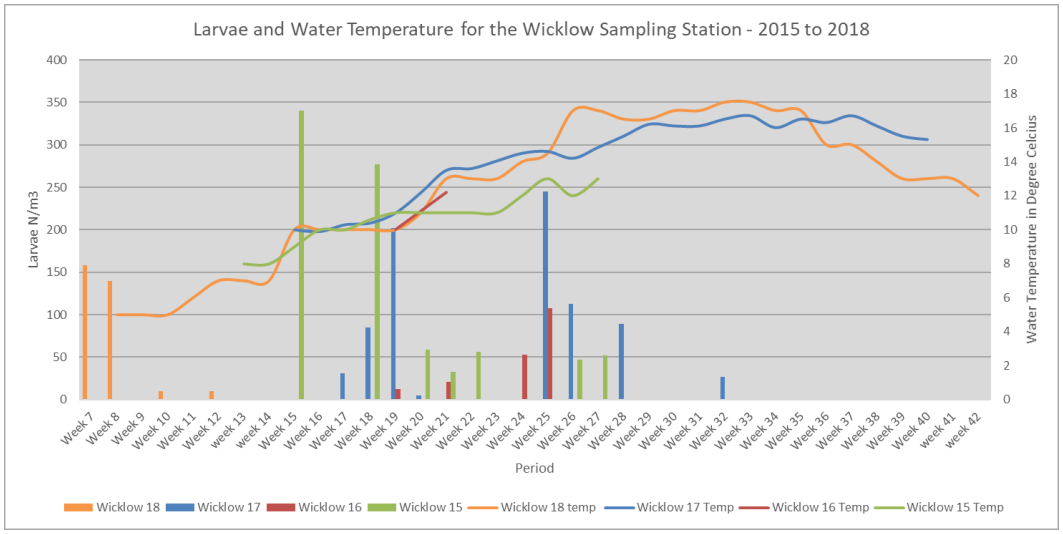

Mussel Larvae Population in te Rusk Channel - 18/02/18 to 10/10/18
N/m3
Wate Temperature in Celcius
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

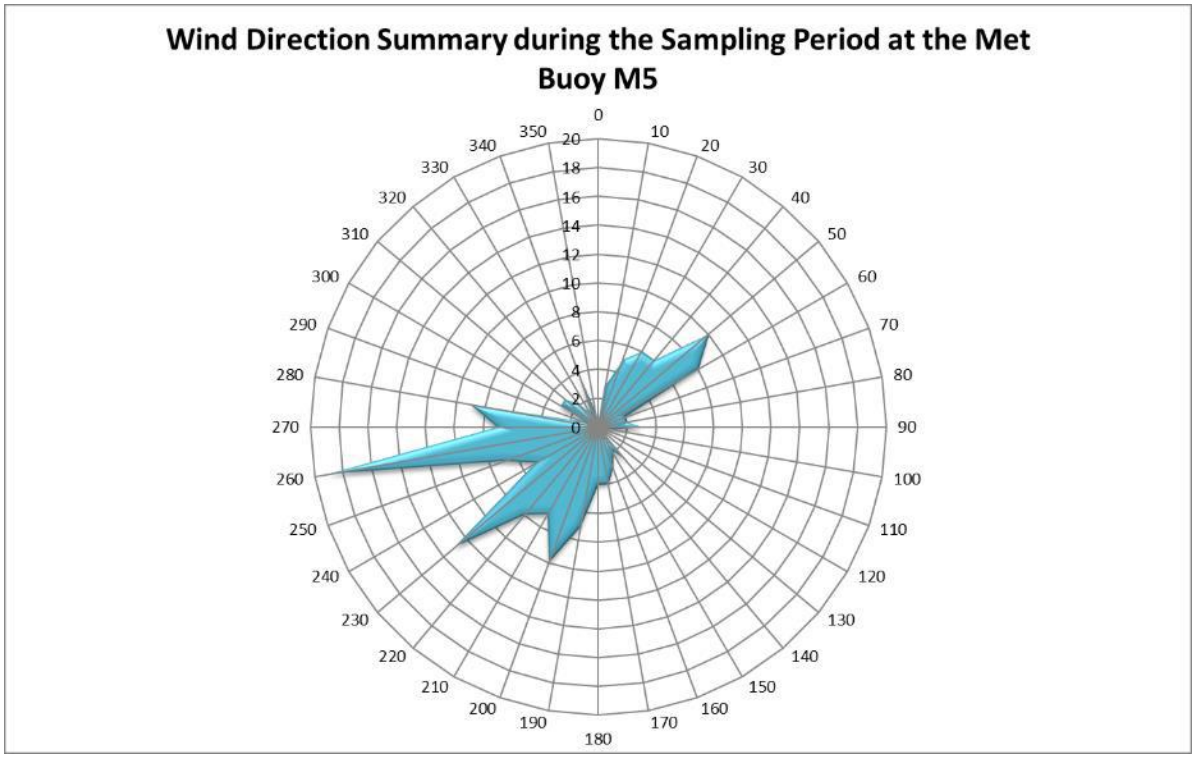

Mussel Larvae population For Arklow station from 18/02/18 to 10/10/18
N/m3
Water Temperature in Celcius
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature


Mussel Larvae Population for North Howth - 17/02/2018 to 12/09/2018
N/m3
Water Temperature in degrees Celcius
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature


Larvae and Water Temperature for the Wexford Sampling Station - 2015 to 2018
Larvae N/m3
Water Temperature in Degrees Celcius
Period
Wexford 18
Wexford 17
Wexford 16
Wexford 15
Wexford 18 temp
Wexford 17 Temp
Wexford 16 Temp
Wexford 15Temp


Larvae and Water Temperature for the Rusk Channel Sampling Station - 2015 to 2018
Larvae N/m3
Water Temperature in Degree Celcius
Period
Rusk 18
Rusk 17
Rusk 16
Rusk 15
Rusk 18 temp
Rusk 17 Temp
Rusk 16 Temp
Rusk 15 Temp


Larvae and Water Temperature for the Wicklow Sampling Station - 2015 to 2018
Larvae N/m3
Water Temperature in Degree Celcius
Period
Wicklow 18
Wicklow 17
Wicklow 16
Wicklow 15
Wicklow 18 temp
Wicklow 17 Temp
Wicklow 16 Temp
Wicklow 15 Temp


Wind Direction Summary during the Sampling Period at the Met Buoy M5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
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280
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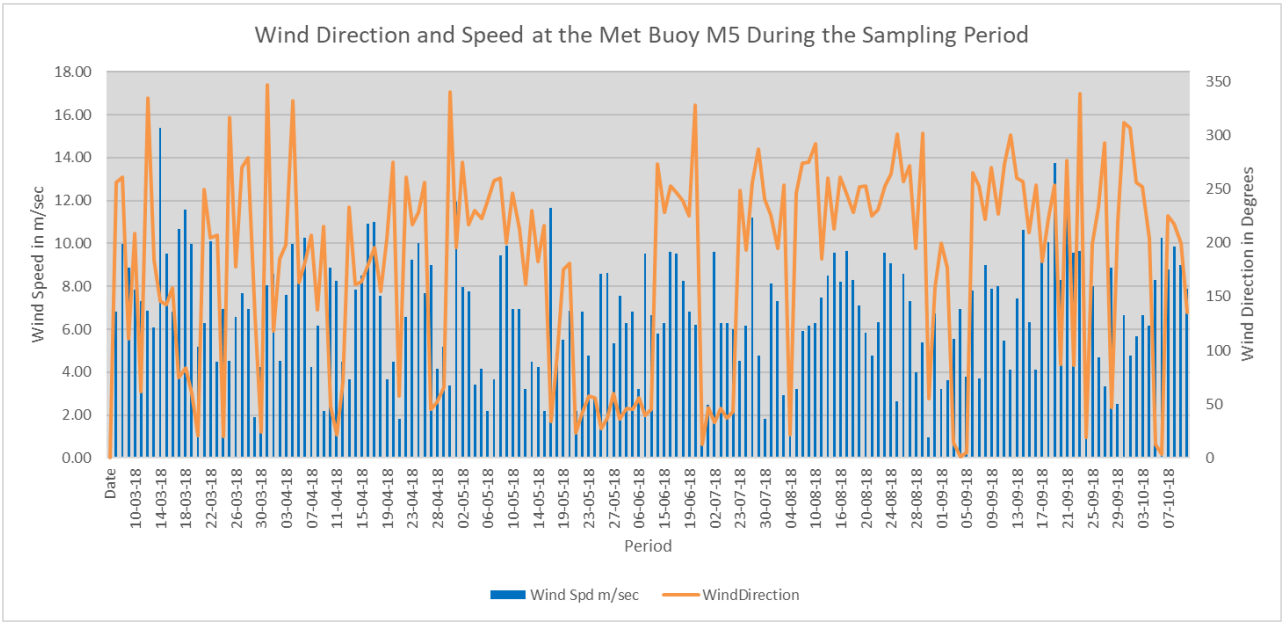
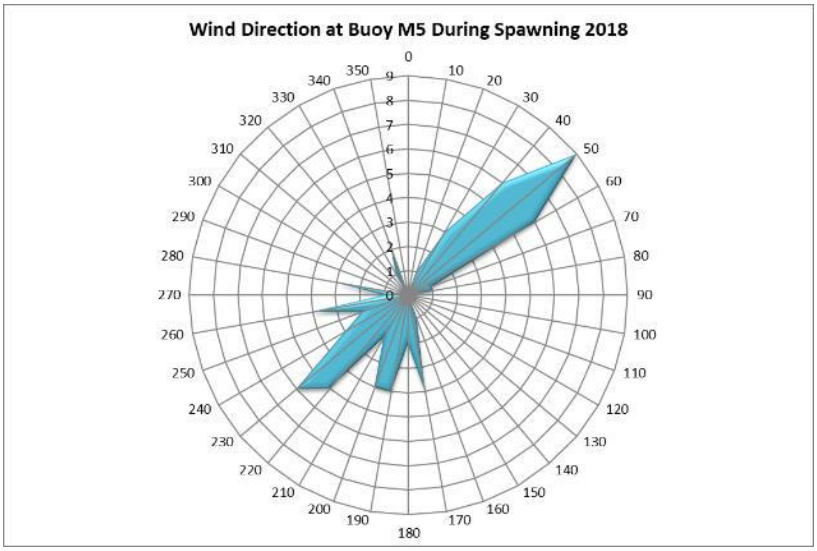
300
310
320
330
340
350
0
2
4
6
8
10
12
14
16
18
20


Wind Direction and Speed at the Met Buoy M5 During the Sampling Period
Wind Speed in m/sec
Wind Direction in Degrees
Period
Wind Spd m/sec
WindDirection


Wind Direction at Buoy M5 During Spawning 2018
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
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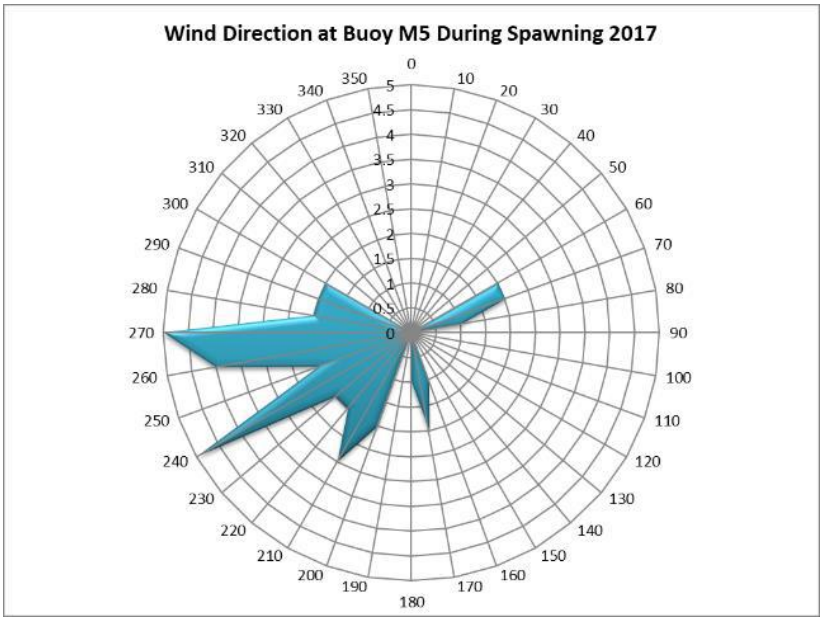
350
9
8
7
6
5
4
3
2
1
0


Wind Direction at Buoy M5 During Spawning 2017
0
10
20
30
40
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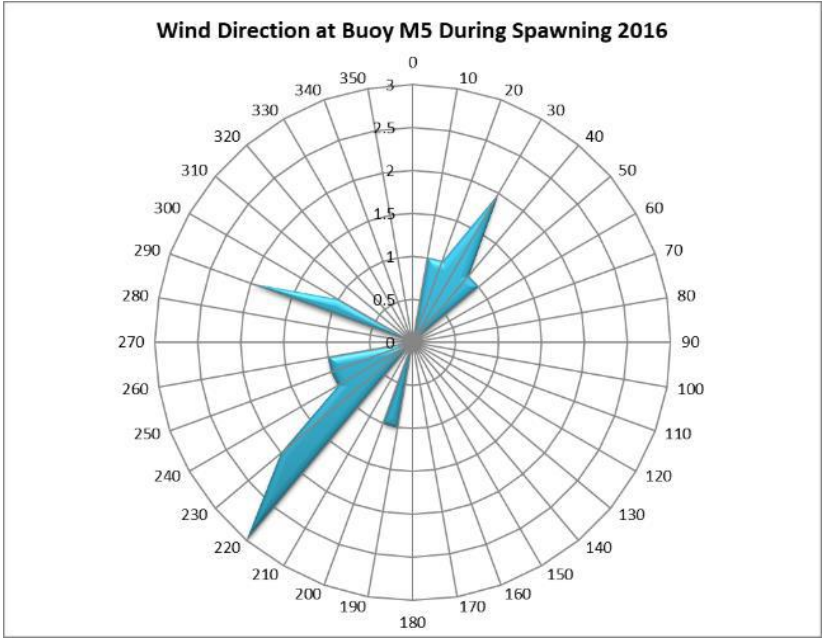
Wind Direction at Buoy M5 During Spawning 2016
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Period	Code	Tide	Weather	Depth under the boat	Sea Conditions	time	Date	Water temperature	salinty	Spat/m3	Larvae stage/age	Comments
	CR1											
	WX1	1 kt S	10 kts SW	14.3	choppy	15:45	18-02-18	6.9	33.4	43	1-3 wks	Borderline rejected due to excessive sand, organic debris.Pollen, clam type larvae, nematodinium.Mixed Coscinodiscus spp and benthic diatoms dominant.Winkle larvae present.
Week 7	CH1	0.5 kt N	10 kts SW	15.5	choppy	10:50	18-02-18	7.6	34	26	2-3 wks	Preservation issue. High organic debris and sand. Paralia spp. and Coscinodiscus grp dominant.Pollen, sea matting, barnacles, nematodinium sp.perriwinkle larvae.2nd clam type d larvae present.
	WW1			10			18-02-18			158	1-2wks	Inadequate preservation issue.High organic debris,clumping.Coscinodiscus/Paralia sp dominant.Low 2nd sp. bivalve and barnacle larvae.
	ND1	0.5 kt N	light westerly		calm	07:30	17-02-18					
	CR2											
	WX2	1.5 kt S	10 kts SE	13.6	choppy	15:35	21-02-18	7.5	33.8	28	2-3 wks	Excessive sand,debris.Winkles,clam type larvae,barnacle larvae,pollen. Coscinodiscus grp and Paralia spp. dominant.
Week 8	CH2	1.5 kt N	5 kts E	15.1	calm	10:30	21-02-18	7.2	34.2	0	n/a	Preservation issue, Sand,excessive organic debris.High pollen, mixed zooplankton,perriwinkle larvae, nematodinium,benthic centric diatoms and Coscinodiscus spp. Poss bounce off bottom sample.
	WW2	1 kt S	light SE	10	calm	17:06	20-02-18	5		140	1-2 wks	12m- Excessive debris,pollen,nematodes.High sea matting larvae,benthic diatoms, Coscinodiscus grp and centric diatoms. Preservation issues.
	ND2											
	CR3											
	WX3											
Week 9	CH3											
	WW3	slack	4 East	12	choppy	18:00	26-02-18	5			n/a	rejected due to excessive debris.Millimeters of debris depth visible in original container recieved.
	ND3											
	CR4											
	WX4											
Week 10	CH4											
	WW4	1kt N	light variable	13	calm	16:00	05-03-18	5		10	2-3 wks	High organic debris.Paralia sp., Coscinodiscus grp, Pollen dominant.
	ND4	2 kts N	4 southwest	11	choppy	11:00	08-03-18		36.8	64	4-5wks	Low content.Ditylum brightwelli, Odonatella sp. Pseudonitzschia sp, Pennate diatoms.Fish scales.
	CR5									0	n/a	S.costatum high. Very low zooplankton species.Not standard net contents?
	WX5											
Week 11	CH5											
	WW5	1 kt S	light variable	14	calm	16:00	12-03-18	6		0	n/a	12m?Excessive clumped organic debris- borderline reject.High Pollen.Low centric marine diatoms.
	ND5											
	CR6			3				26.5	9.4	0	n/a	Excessive debris and organic material , borderline rejected.A.glacialis and thalassionema sp. high.WPollen, Winkle and barnacle larvae present.
	WX6	0.5 kt N	10 kts S	14.2	calm	15:20	25-03-18	7.4	32.9	0	n/a	High organic debris, high Coscinodiscus grp, Odonatella sp.Low zooplankton.
Week 12	CH6	1 kt N	5 kts NW	15	calm	12:40	25-03-18	32.5	7.2	27	3-5 wks	High mixed debris.Coscinodiscus grp mixed and Pseudonitzschia sp. dominant.Low copepods and general zooplankton.
	WW6	slack	light variable	12	calm	16:00	20-03-18	7		10	6 wks plus	Debris and organic material high. Paralia, Odonatella sp high. Pollen and tube worm larvae present.Low copepods and zooplankton .
	ND6	0.5 kt N	west 4	11	choppy	10:15	23-03-18			0	n/a	Not net type sample. High fine organic debris, V. low centric diatoms. Paralia sp . dominant. O zooplankton.
	CR7			1.5m?				8.5	26.2	0	n/a	A.glacialis very high.Rhizosolenia,Navicula high.Barnacle and 2nd bivalve species moderate.
	WX7	slack	15 kts W	15	choppy	14:50	28-03-18	33.6	7.1	0	n/a	Coscinodiscus, Odonatella sp.copepods and debris high.
Week 13	CH7	slack	20 kts SW	14.8	choppy	07:55	28-03-18	34.3	6.8	0	n/a	Coscinodiscus and Odonatella sp. high. High biomass. High debris.Low squirts and copepods.Preservation issue.
	WW7	1 kt N	light variable	9	calm	12:00	26-03-18	7		0	n/a	7-4-18, Pollen, clumped organic debris high. Odonatella sp and Coscinodiscus grp moderate . O zooplankton.Nte type?
	ND7											
	CR8			2			08-04-18	9.2	26.9	0	n/a	Asterionellopsis sp. and Pseudonitzschia sp. low. Low biomass. Squirts, barnacles and crad larvae low.Organic debris high.
	WX8											
Week 14	CH8											
	WW8	1 kt S	Strong NW	9	choppy	14:00	05-04-18	7		0	n/a	10m?9 C ?High biomass, Coscinodiscus grp, Odonatella, Thalassiosira spp.Excessive organic debris, pollen. Low squirts.
	ND8	2 kt S	SE 2	12	choppy	07:15	07-04-18	7.5	30.2	0	n/a	Mixed Coscinodiscus and Odenatella medium.Copepods medium.Sea matting low. Moderate particulate debris.
	CR9			2				10	24.2	0	n/a	Rhizosolenia sp,Pseudo nitzschia, Asterionellopsis spp. Low barnacle larvae. O other zooplankton.
	WX9	1 kt N	10 kts S	15.4	choppy	15:25	09-04-18	8.4	32.2	0	n/a	Very high mixed diatoms, Coscinodiscus wailessi dominant. Odonatella sp. present. Low pollen. Moderate debris. High organic particles.Low barnacles. sea squirts and copepods.
Week15	CH9	1.5 kt S	calm	15.1	calm	08:10	09-04-18	8	33.7	0	n/a	High Coscinodiscus and Odonatella sp.Low general biomass. Moderate debris. O zooplankton.
	WW9	slack	calm	11	calm	15:00	10-04-18	10		0	n/a	Excessive organic debris. Coscinodiscus and Odonatella high. Pollen moderate. Very low copepods and zooplankton.
	ND9	1 kt S	Southerly 1	11.5	calm	14:00	13-04-18	8.8	30	23	1-2 wks	Low second bivalve species.Moderate copepods.Low seamatting. Coscinodiscus grp and Ditylum and Odonatella sp. dominant.
	CR10			2				8.6	24.8	0	n/a	V.low phyto Paralia sp and Pseudo nitzschia sp dominant.High organis debris plus sand. Not net type sample.
	WX10	0.5 kt S	5 kts S	13.8	calm	07:50	20-04-18	10.4	32.2	9	2-3wks	V. high mixed Coscinodiscus wailesii, Odonatella sp and mixed diatoms. Pollen. Moderate organic debris. Low copepods.
Week 16	CH10	slack	10 kts S	15.1	calm	14:35	20-04-18	9.3	33.2	0	n/a	15.1M,9.3C,33.2ppt.Bacillaria and Coscinodiscus grp ,Odontella high.Pollen high.Excessive organic debris.Preservation issues.
	WW10	1 kt N	light SW	12	calm	17:00	13-04-18	10			n/a	Moderate to high Coscinodiscus and Odonatella grps.High debris. Low Pollen. 0 zooplankton.
	ND10	0.5 kt N	S 2	12.8	calm	15:00	21-04-18	10.3	30	0	n/a	Odonatella sp. dominant. Coscinodiscus grp low. High organic debris. Sea matting and barnacles moderate. Seamatting low.low other species d. larvae.
	CR11			1.5				10.8	23.4	0	n/a	Guinardia, L.danicus, pseudo nitzschia sp. Low to moderate debris. No net type sample?
	WX 11											
Week 17	CH 11											
	WW 11	slack	light variable	7	calm	18:00	23-04-18	10		0	n/a	Very high Coscinodiscus grp bloom. Wailessi dominant. O zooplankton present. Preservation issues.
	ND 11									0	n/a	Preservation issues.No details. Excessive sand. Coscinodiscus grp and centric diatoms high.
	CR 12			2				13.7	17	0	n/a	Guinardia sp.Asteroniellaopsis sp. dominant. Moderate Biomass. Heterocapsa sp. present.Not net type sample. O zooplankton.
	WX 12	1.5 kt S	25 kts W	13.7	choppy	15:50	02-05-18	9.8	33.4	xxx	xxx	Excessive sand and debris. Bad or no preservation.
Week 18	CH 12	0.5 kts S	25 kts NW	14.2	choppy	13:25	02-05-18	9.4	33.5	0	n/a	Coscinodiscus grp very high- wailesii typ. Serious preservation issue. Barnacle larvae low.
	WW12	1 kt N	fresh SW	9	choppy	14:00	04-05-18	10		0	n/a	Preservation issues.10m, 10C, High organic debris, high mixed Coscinodiscus, Paralia and Odonatella sp.V.low copepods.
	ND 12	2 kts S	southerly 4	13	choppy	10:00	01-05-18	9.1	31.8	9	2-3 wks	D.brightwelli dominant.Mixed pennate diatoms high.High mixed copepods.Pollen , sand , squirts moderate.
	CR13			2			xxx	13.3	23.3	0	n/a	Skeletonema sp., Heterocapsa sp , Paralia sp. very low. No significant species - not typical net sample?Debris moderate.
	WX13											
Week 19	CH13											
	WW13	slack	light	10	calm	18:00	09-05-18	10		0	n/a	14-5-18,11m, 11C,Mixed Coscinodiscus grp, Odonatella sp. moderate. Barnacle larvae and low copepods. Preservation lacking.Excessive organic debris.
	ND13	1 kt N	southerly 2	10.8	calm	16:30	10-05-18	12.5	29.8			
	CR14			2				14.2	23.6	0	n/a	very low species in general incl phyto. Not net sample ?Leptocylindrus minimus dominant. 1 barnacle larvae.
	WX14	slack	calm	14.5	calm	16:25	15-05-18	11.1	33.3	21	2-3 wks	Coscinodiscus grp,Halosphera, Odonatella sp. dominant.Preservation issues. Excessive sand.Copepods crab, squirts low.
Week 20	CH14	2 kts N	calm	15.4	calm	08:00	15-05-18	10.7	33.6	167	2-3 wks	Coscinodiscus grp, centric diatoms, Odonatella sp.Excessive sand and deris.Low iodine . Low copepods.
	WW14	0.5 k N	light	11	calm	18:00	16-05-18	11		0	na	Very high debris,, Odontella species dominant . Barnacle larvae low.
	ND14											
	CR15			2				13.3		0	n/a	Low mixed diatoms. Low debris. O zooplankton. Net type sample ?
	WX15											
Week 21	CH15											
	WW15	1 kt S	calm	14	calm	18:00	23-05-18	13		0	n/a	Coscinodiscus grp high.Excessive debris. Preservation issues. Odonatells sp.Barnacle larvae low.
	ND15	0.5 k S	notherly 4	10	choppy	13:00	22-05-18	12.1	31.1	113	2-4 wks	Excessive sand . High copepods .Coscinodiscus grp dominant. Excessive iodine.Equal levels spat and squirts.Low 2nd bivalve species.
	CR16			2			23-5-18	15.2		0	n/a	Moderate sand. Low Thalassiosira spp. Not net type sample.
	WX16	1 kt S	calm	14.3	calm	14:40	28-05-18	13	33.2	40	3-4 wks	Phaeocystis, Coscinodiscus species dominant. Sand particulate high. Copepods, winkles and barnacles present. Noctiluca sp low. Excessive Phaeocystis. low squirts.
Week 22	CH16	0.5 kt N	Calm	15.2	Calm	07:55	28-05-18	12.1	32.8	0	N/a	Mixed Coscinodiscus, Rhizosolenia and Odonatella sp.Pollen low. High sand. Low copepods and nematodinium, Low sea squirts.
	WW16	slack	calm	14	calm	19:00	29-05-18	13				
	ND 16	2 kts N	Notherly 2	11.5	calm	09:50	30-05-18			0	na	Excessive organic debris.Moderate seasquits. mixed diatoms and Ceratium dominant. Moderate coverage of copepods.
	CR17			2				15.8	23.7	0	n/a	Cell contents negligible. Not net type. V.low phyto and o zooplankton
	WX17	slack	10 kts NE	14.3	choppy	10:10	06-06-18	14.3	33.4	0	n/a	Phaeocystis sp excessive. Coscinodiscus , Odonatella and Ceratium very low. Copepods low.Sea squirts low.
Week 23	CH17	0.5 kt N	10 kts NE	15	choppy	13:15	06-06-18	13.2	33.1	251	0% 2-4 wks, 20% 4-6 w	Coscinodiscus, Phaeocystis and Odonatella sp dominant. V. high organic debris. low second species bivalve.
	WW17	1 kt S	NE fresh	14	choppy	18:00	07-06-18	13		0	na	Very high organic debris, low copepods and sea cucumber.
	ND17											
	CR18			2m				17.1	24.3ppt	0	na	Not typical net content.Prorocentrum micans, Ceratium sp low. Very low cell contents.
	WX18											

Week 24	CH18											
	WW18	slack	calm	8	calm	16:00	12-06-18	14		xx	na	11-6-18? Black anoxic sludge on arrival. Sorry rejected.
	ND18	0.5 kt S	Easterly 2	10.5	calm	14:00	11-06-18			0	na	Not typical net type sample contents. Chaetoceros, Rhizosolenia and Phaeocystis spp dominant.. Moderate sand.
	CR19			2m				16.1	23.8	0	na	Not typical net. High fine debris.Very low contents- Navicula and pennate diatoms. 0 zooplankton.
	WX19	1 kt S	5 kts S	14.5	calm	12:20	23-06-18	15.2	33.1	119	0%1-2 wks,50%4-6wks	Not typical net content. High debris. Noctiluca and Rhizosolenia species low.Low sea squirts and copepods.
Week 25	CH19	0.5 kt N	5 kts NW	14.8	calm	05:40	23-06-18	13.8	33.5	171	5% 3-4wks, 25% 5-6 wk	Not standard net type contents. Rhizosolenia spp. V. low phytoplankton and zooplankton.Low large sized bivalve 2 nd species.
	WW19	1 kt N	light westerly	10	calm	18:00	19-06-18	14.5		0	N/A	Excessive Phaeocystis sp. Moderate sand type debris. Very low zooplankton and copepods. Net ?
	ND19	slack	Notherly 4	9.4	calm	12:30	21-06-18			55	4-6 wks	Mixed Rhizosolenia sp bloom. Noctiluca sp moderate . Copepods low.Spat and sea squirts equal levels.
	CR20											
	WX20	slack	10 kts NE	14.4	choppy	12:50	30-06-18	16.9	33	0	na	High sea squirts. Low phytoplankton - mixed diatoms.High copepods.
Week 26	CH20	1 kt N	10 kts NE	15.2	choppy	07:20	30-06-18	15.1	32.8	47	:1 2-3wks and 6wks plu	Cysts, Copepods, sea matting, tube worm moderate. Rhizosolenia and Ceratium species low but dominant. High clam type D larvae.
	WW20	slack	light variable	14	calm	15:00	26-06-18	17		0	n/a	Coscinodiscus, Phaeocystis,Chaetoceros sp present. Sand.Preservation issue.
	ND20	slack	East 4	12.5	choppy	13:00	30-06-18	16	31.7	274	2-4 wks	V.high mixed bloom and Seaweed plantlets. High mixed zooplankton incl echinoderms.Low second bivalve species. High Rhizosolenia, Noctiluca and tube worm.
	CR21											
	WX21											
week 27	CH21											
	WW21	1 kt N	light	13	calm	09:00	5-7-2018	17		0	na	17C, 10 m. Preservation issue. High clumped organic debris. Moderate copepods. Mixed Rhizosolenia and Coscinodiscus species dominant.
	ND21											
	CR22											
	WX22	0.5 kt S	10 kts NE	14.2	calm	11:50	09-07-18	17.8	32.7	24	4-5 wks	Very high seasquirts, copepods and phytoplankton- Rhizosolenia sp. dominant.
week 28	CH22	1 kt S	5 kts N	14.4	calm	06:05	09-07-18	15.9	32.8	23	4 wks approx	Excessive copepods, sea squirts and high mixed diatoms - Rhizosolenia species dominant.
	WW22	slack	NE fresh	12	choppy	19:00	10-07-18	16.5		0	na	Low other species Bivalve.Rhizosolenia, seasquirts and copepods high.
	ND22	0.5 kt N	Northely 2	9.5	calm	07:00	13-07-18	16.7	32.9	584	2-4 wks mixed	V high copepods, barnacles,tubeworm Noctiluca, Urchin and starfish and general zooplankton.Pollen and sand moderate. 2 other species of D larvae also present.Rhizosolenia species high and dominant.
	CR23											
	WX23	1 kt N	SE 5 kts	15	calm	13:50	19-07-18			0	na	Inadequate preservation. High cysts, Rhizosolenia and Coscinodiscus bloom.High organic debris.Barnacle,copepods and zooplankton low.
Week 29	CH23	1.5 kt S	calm	14.8	calm	07:15	19-07-18			0	na	Inadequate preservation.Exfcessive sand and organic debris. V.low visible phytoplankton and copepods.Coscinodicus species dominant.
	WW23	slack	SE 3	10	choppy	18:00	18-07-18	16.5		0	na	Inadequate preservation.High mixed sand and organic debris.Very high pollen and mixec copepods.Coscinodiscus species low but dominant.
	ND23	1 kt N	southerly 2	12	calm	12:55	17-07-18	17	32.2	449	2-4 wks	Excessive organic debris and sand. High barnacles, sea matting and crab larvae.High diatoms - Rhizosolenia species dominant,2 other species of d larvae present at low levels.
	CR24											
	WX24	1.5 kt S	10 kts SW	14.3	choppy	12:00	25-07-18	17.1	33.1	0	na	17.5 C Preservation issue. High sand and organic debris.Mixed diatoms dominant.
Week 30	CH24	1.5 kt N	5 kts NW	15.1	calm	06:35	25-07-18	16.3	33	31	6wks plus	Inadequate preservation. Moderate sand and organic debris.High Rhizosolenia species.Low barnacles, cysts, tubeworm larvae.
	WW24	0.5 kt N	light	14	calm	16:00	24-07-18	17		0	na	Inadequate preservation. Excessive organic debris and sand particulates.High copepods, low pollen. Low phytoplankton, Coscinodiscus species dominant.
	ND24											
	CR25											
	WX25	1 kt N	calm	14.8	calm	13:35	04-08-18	18	32.5	0	na	Inadequate preservation. Excessive organic debris.V.low phytoplankton. Seaweed plantlets high.
Week 31	CH25	1 kt S	10 kts NE	15	choppy	07:10	04-08-18	17.2	33.2	0	na	Inadequate preservation. Excessive organic debris and sand particulates.Low second species of D larvae, very low phytoplankton - Navicula species dominant.
	WW25			12				17		0	na	Preservation issue. Excessive debris and sand. Pollen high. Low copepods and Coscinodiscus genera dominant.
	ND25	1.5 kt N	southerly fresh	11.2	choppy	11:02	31-07-18	15.8	32.2	51	2-4 wks mixed	High organis debris and seaweed plantlets.Low zooplankton,sea matting, tube worm and echinoderms. Low phytoplankton- Rhizosolenia species dominant.
	CR26											
	WX26											
Week32	CH26											
	WW26	slack	calm	12	calm	15:00	07-08-18	17.5				
	ww26			17				17.5		0	na	Preservation issue - High organic debris. Low copepods and pollen. V. low phytoplankton - Pennate diatoms dominant.
	ND26											
	CR27											
	WX27	1 kt N	5 kts NW	14.8	calm	13:55	14-08-18	17.6	32.2	0	na	Preservation issue. High sand and organic particulate debris. High copepods. Low mixed phytoplankton.14.2m
week33	CH27	1.5 kt S	calm	14.2	calm	06:25	14-08-18	17.6	33.2			Black anoxic sample.Excessive sand and organic debris. Degrdation too far to identify clearly.14.8m
	WW27			11				17		0	na	Inadequate preservation. V, high copepods and clumped organic debris. High pollen, sand and mixed Odonatella and Coscinodiscus species blooms.
	ND27											
	CR28											
	WX28	1.5 kt N	10 kts NW	15.2	calm	06:50	25-08-18	16.2	33.4	37	2-3 wks	Preservation issue. High tube worm, sand, copepods, and pennate diatoms.
week34	CH28	1.5 kt S	calm	14.3	calm	13:30	25-08-18	15.6	33.1			
	WW28	slack	fresh SW	13	choppy	15:00	22-08-18	17				
	ND28	1 kt N	Westerly 4	10.6	calm	07:00	24-08-18	13.2	33.8	45	6ks plus	Bottom debris excessive re sand etc.Pollen etc low, Reject type due to excessive debris.
	CR29											
	WX29											
Week35	CH29			14.3				15.6	33.1			Black anoxic.Excessive sand. debris and copepods. High barnacles.high large 2nd species bivalve.
	WW29	1 kt N	Calm	12	calm	18:00	27-08-18	15		0	na	Inadequate preservation. Excessive organic debris and sand.Odonatella species low but dominant.
	ND29											
	CR30											
	WX30	1 kt S	10 kts W	14.4	calm	13:55	09-09-18	16.2	33	0	na	Anoxic **black. Low content. Lauderia species dominant. Low tubeworm.**
Week36	CH30	1 kt S	10 kts NW	15	calm	07:40	09-09-18	15.6	33.4	0	na	Black anoxic. Preservation issue. V. High biomass- Guinardia, Odonatella species bloom. Sand and zooplankton moderate. Clam type d larvae and copepods low.
	WW30	slack	calm	15	calm	17:00	07-09-18	15		0	na	Black anoxic. Preservation issue. V. High biomass- Excessive organic material- impossible to determine contents.
	ND30	slack	westerly 4	13	choppy	09:30	07-09-18			0	na	High phytoplankton (Rhizosolenia, Coscinodiscus , diatoms).Low clam type larvae. High copepods, Barnacle and tube worm types.
	CR31											
	WX31	1.5 kt S	5 kts W	13.4	calm	14:50	12-09-18	16	33.2	0	na	Black anoxic sample- preservation issue.Excessive sand and debris. Pollen,moderate mixed zooplankton and Guinardia species dominant.
Week37	CH31	1 kt N	calm	15.2	calm	07:45	12-09-18	15.3	33.6	0	na	Black anoxic sample - preservation issue. Very high mixed diatoms, Odonatella /Rhizosolenia species dominant bloom.High copepods and pollen.Sand particulates high.
	WW31	1 kt S	calm	16	calm	16:00	12-09-18	14		0	na	14m and 15 C. Preservation issue. Odonatella species dominant - high, Low zooplankton. High debris and sand.
	ND31											
	CR32											
	WX32											
Week38	CH32											
	WW32	slack HW	SW stong	12	choppy	19:00	20-09-18	13		0	na	16m and 14 C.Black anoxic sample. Preservation issue. Excessive debris. Diatombloom- Odonatella and Coscinodiscus species dominant. High copepods- crab high.
	ND32											
	CR33											
	WX33											
Week39	CH33											
	WW33	1 kt N	Fresh SW	16	choppy	15:00	26-09-18	13		0	nd	Preservation issue.High organic debris and sand particulates.Seaweed plantlets, crab larvae, limpet , pollen and barnacles present.Coscinodiscus and Odonatella species low but dominant.
	ND33											
	CR34											
	WX34											
Week40	CH34											
	WW34			16				13		0	na	Excessive organic debris. High Pollen and sand. Moderate mixed copepods. Odonatella and Coscinodiscus species dominant but low.
	ND34											
	CR35											
	WX35											
Week41	CH35											
	WW35			15				12		0	na	Preservation issue. Mixed diatoms- Odonatella species dominant. Moderate Ceratium. Low copepods.Debris.
	ND35											