2017 Spring Mussel Larvae Monitoring

The 2017 campaign was carried out through the INTERREG Project Irish Sea Portal Pilot (ISPP), a joined venture between BIM and Bangor University (Wales).

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Background

This report relates the results obtained during the 2017 mussel larvae monitoring as well as meat yield monitoring from two husbandries (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 finding in order to establish a possible pattern in the data collected.

The larval monitoring program from 2015 and 2016 showed interesting variations over those two years; primarily a decrease in the amount of larvae in some stations (over 70% less for the Wexford Bar), possibly due to an early spawning following a mild winter (2 to 3 weeks earlier than for the 2015 season). The second observation is an increase of the seawater temperature for the same period: four degrees more in 2016 (16^{o}C during week 25) than 2015 (12^{o}C for the same week). Nevertheless, the tonnage of seed collected over those two years is very similar, the main difference being the improved quality of the seed mussel in 2016. In 2017, an extra station was created following the findings of intertidal brood stock in Malahide. Unfortunately, due to adverse weather conditions the GPS drogues were not deployed.

Objectives

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

The key objectives being:

- the 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

In order to achieve these goals, samples of 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 were located using side scan sonar.

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 here to provide a more complete picture of the life stages of the mussels within the study areas.

Sampling Locations

An extra station was created in the Irish Sea (North Howth) and the sampling station south of Wicklow Head has been relocated further south following the appointment of a new person to take the samples for the area. The station at Wexford Bar, Rusk Channel and Castlemaine harbour remained at the same location.

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
Wicklow	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 (New)

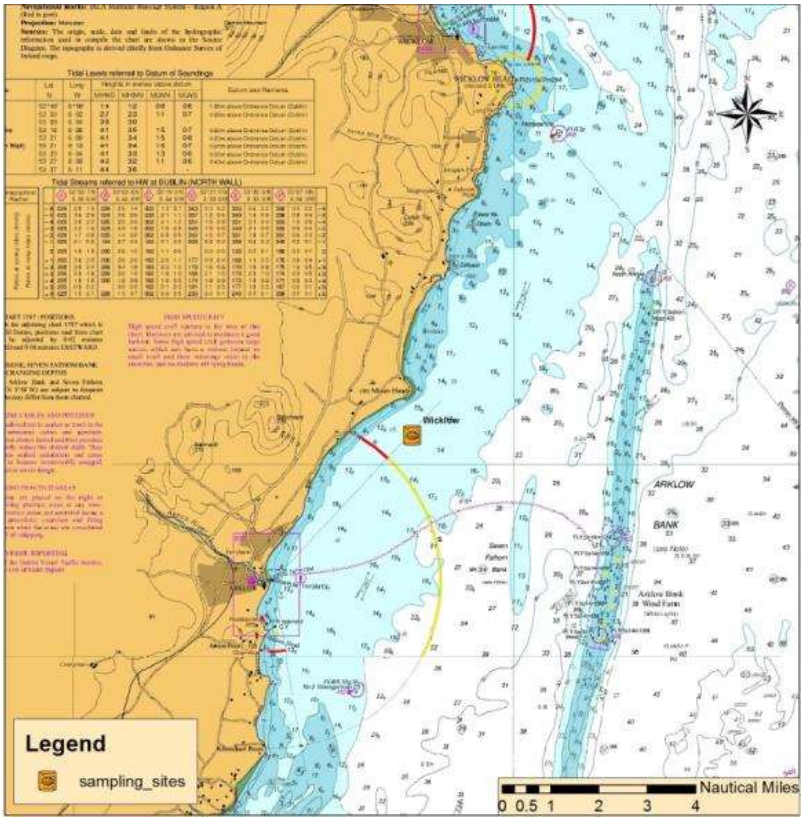


Figure 3: Sampling Stations on the Wexford Coast (Wexford Bar and Rusk Channel)

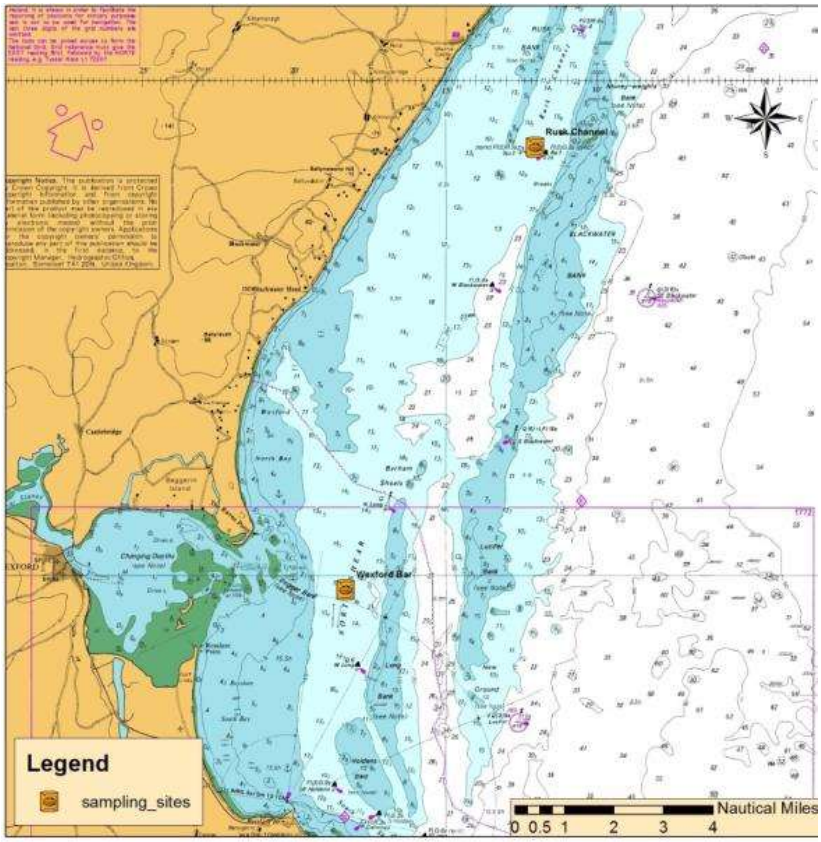


Figure 4: Sampling Station in Castlemaine Harbour

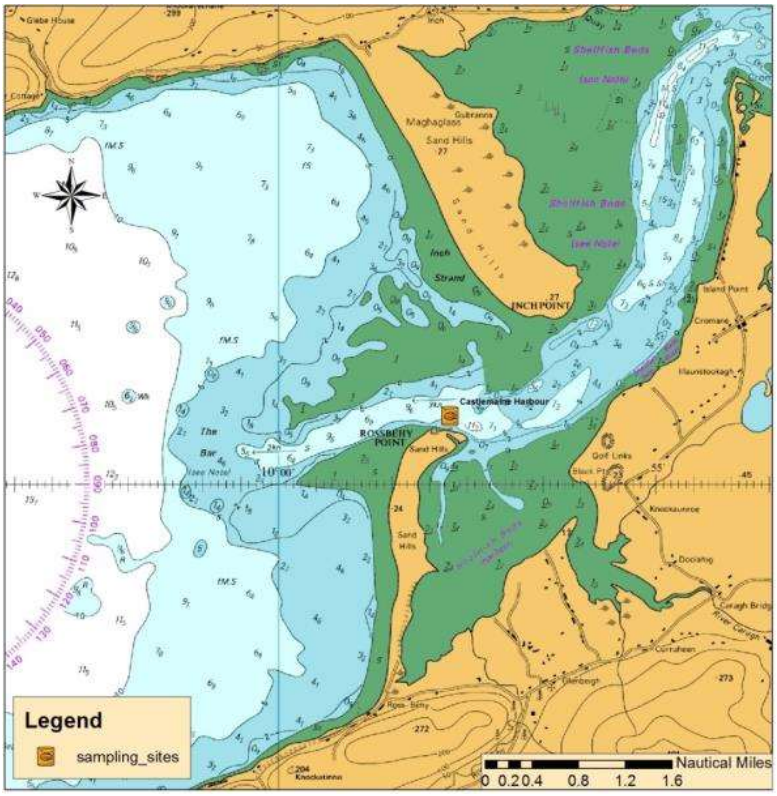
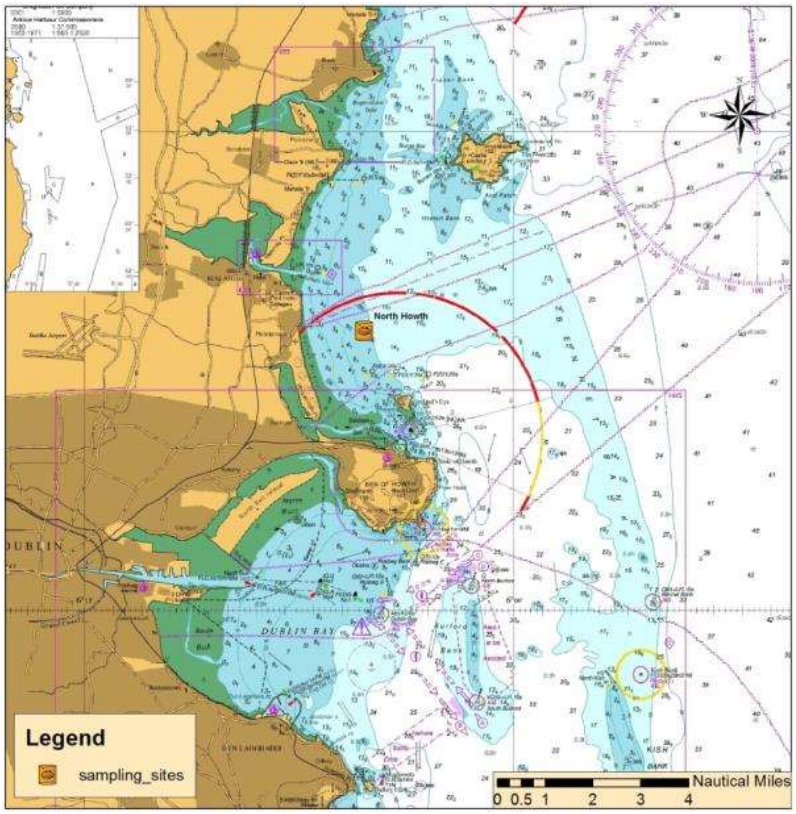


Figure 5: Sampling Station for North Howth



Sampling Method

At most of the sites it was planned to take weekly plankton samples. A fisherman undertook the sampling for the Wexford Bar and at the Rusk Channel, while the Wicklow samples were collected by an angling charter boat operator. 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 to allow for a 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 for analysis. This involved the use of microscopy to identify

mussel larvae and also to classify their age according to their stage of development (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 spawners.

To monitor the maturity of adult mussels, samples were collected from licensed sites with industry support in Wexford and Castlemaine Harbour/Cromane. Sampling was undertaken from February 13th (week 7) to June 4th (week 21). However, due to adverse weather conditions and other issues some sampling events were missed. The meat yields measured and the weeks in which they were sampled are shown in Table 2.

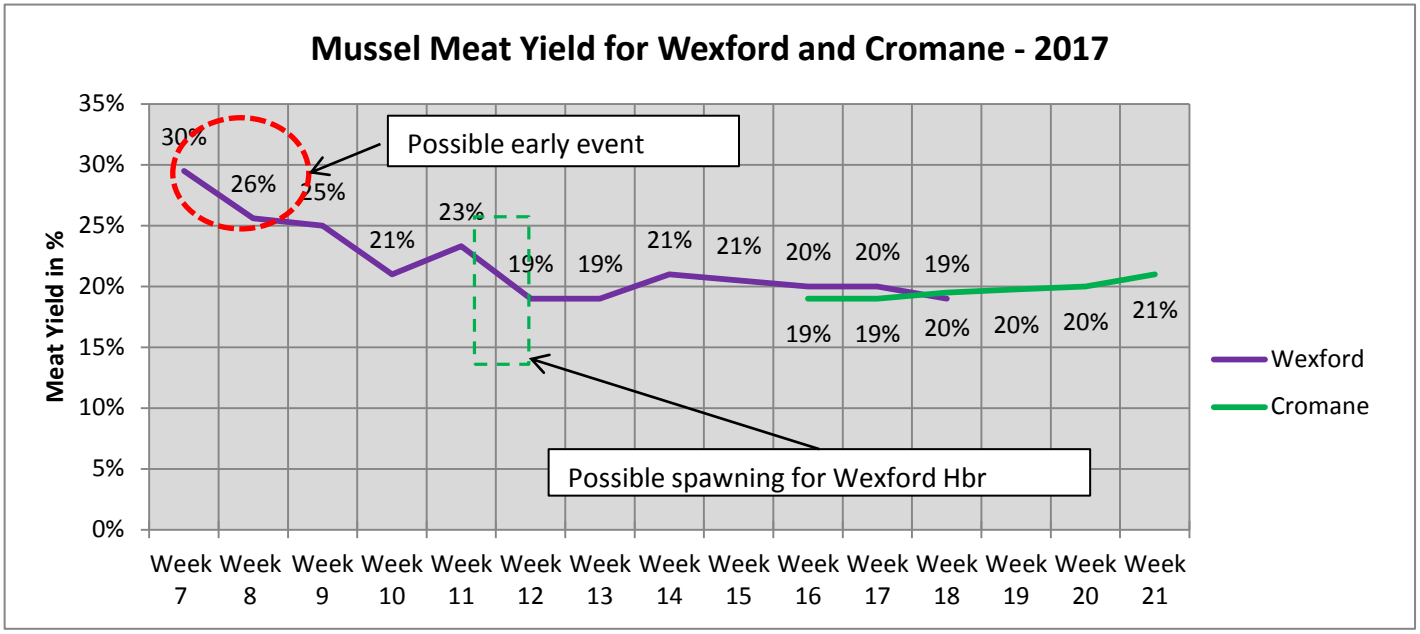
Following 2015 and 2016 sampling, it was expected to see conditioning of the husbandry until week 16/ week 17 with a possible spawning around week 18 (1st week of May).

Table 2: Mussel Meat Yield (%) for Wexford and Castlemaine Harbours

	Wexford	Cromane
Week 7 (13/02 to 19/02)	30%	
Week 8 (20/02 to 26/02)	26%	
Week 9 (27/02 to 5/03)	25%	
Week 10 (6/03 to 12/03)	21%	
Week 11 (13/03 to 19/03)	23%	
Week 12 (20/03 to 26/03)	19%	
Week 13 (27/03 to 2/04)	19%	
Week 14 (3/04 to 9/04)	21%	
Week 15 (10/04 to 16/04)	21%	
Week 16 (17/04 to 23/04)	20%	19%
Week 17 (24/04 to 30/04)	20%	19%
Week 18 (1/05 to 7/05)	19%	20%
Week 19 (8/05 to 14/05)		20%
Week 20 (14/05 to 20/05)		20%
Week 21 (21/05 to 28/05)		21%

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

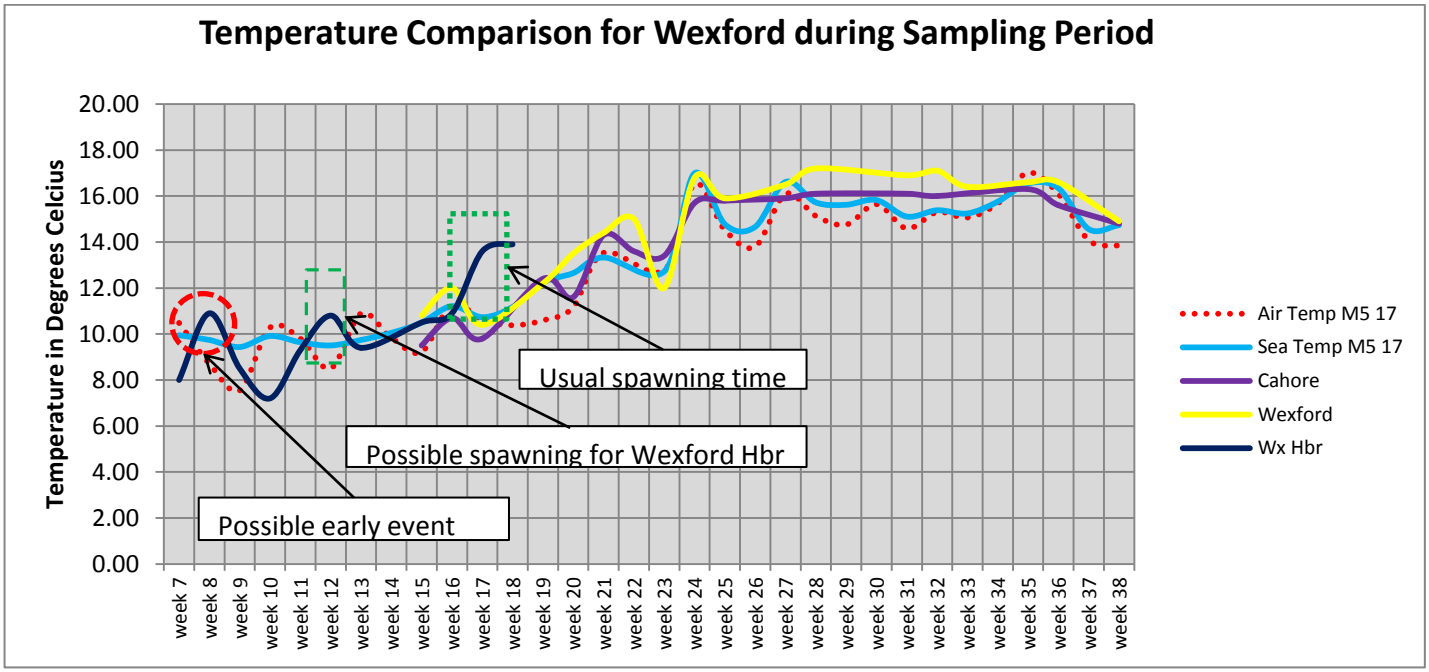
Figure 6: Percentage meat yield for mussels from Wexford and Cromane in 2017



From the data collected it appears that there could have been an early spawning in Wexford harbour between Week 7 and Week 8 and another event between week 11 and week 12, which would be at least 6 weeks earlier than the two previous years. Temperature recorded in the area show 3 degrees increase for each of those periods (see Figure 7 and Figure 8).

There was very little meat yield variation in Cromane (Castlemaine harbour) except a slight increase toward the end. Samples for Castlemaine harbour happened too late to observe any significant pattern as mussel are known to spawn earlier on the SouthWest Coast than on the East Coast.

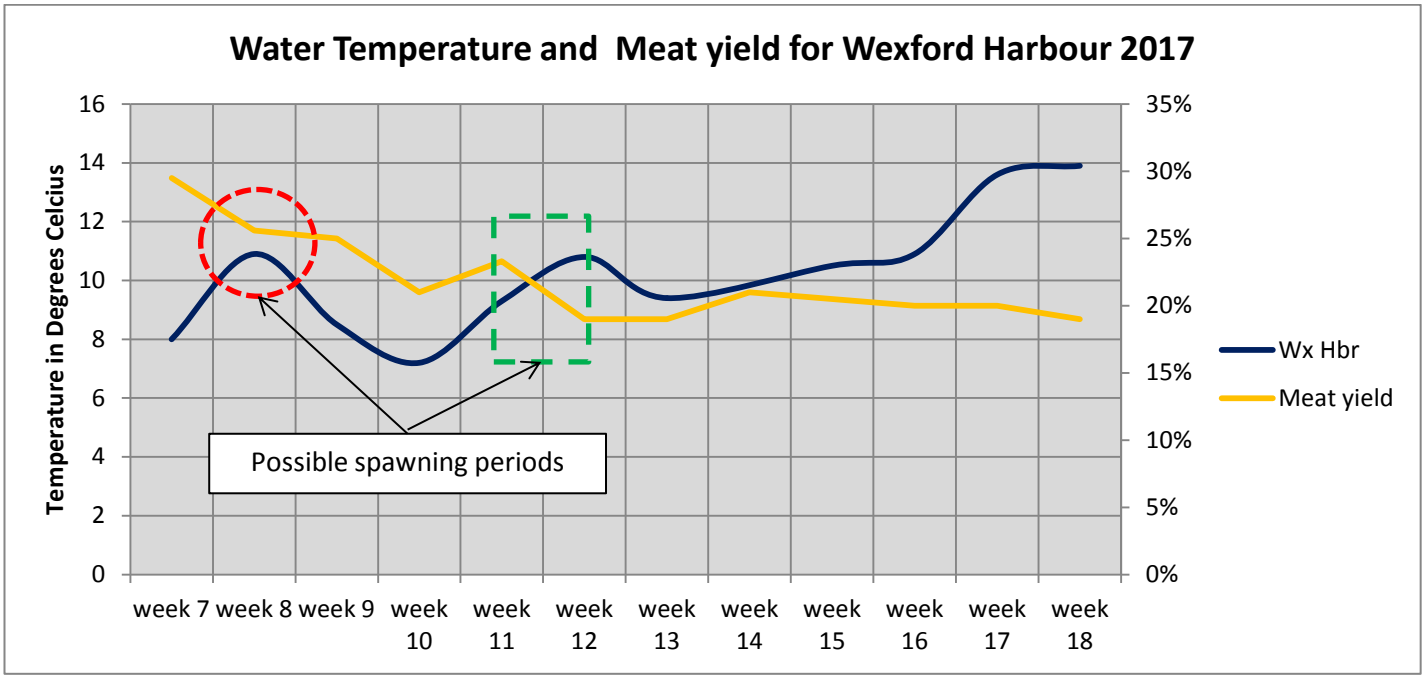
Figure 7: Air and seawater temperature recordings at Wexford in 2017



The water temperature in the harbour follows a similar pattern than the air temperature at the buoy M5, which means that the air temperature had more effect than the sea temperature at that time of the year on the water temperature within the harbour. We can observe a steep climb between week 16 and week 17 which correspond to the estimated spawning period for the previous 2 years.

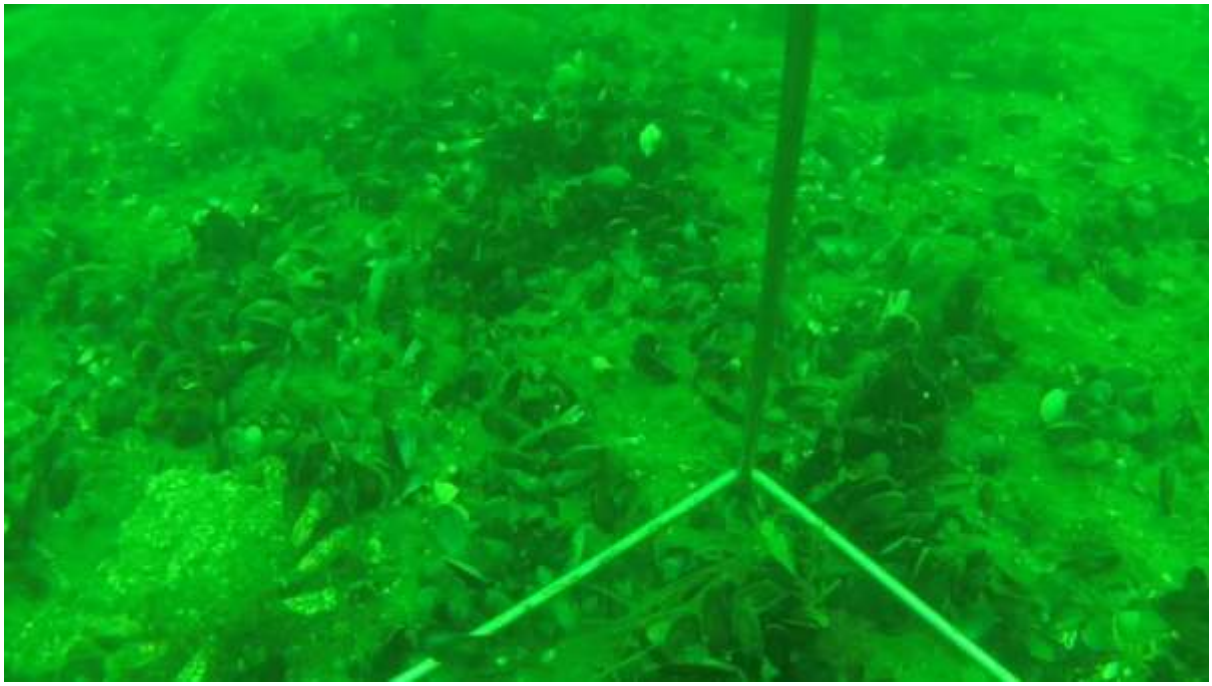
There was no larval sampling during those two possible spawning periods unfortunately and samples taken after the last temperature increase (post week 18) showed only small quantities of larvae.

Figure 8: Water temperature and mussel meat yield for Wexford Harbour



On the above graph, we can observe the correlation between rapid temperature increase (3 degrees over a week) and rapid meat yield decrease (- 4% over a week). We can clearly see that the last temperature increase had very little effect on the meat yield for that particular stock of mussel.

Figure 9: 2016 Half Grown Mussels in Rosslare



Results

There were a total of 85 plankton samples for mussel larvae collected in 2017 over the 5 stations. A total of 26 samples were scheduled for each station from week 15 (10/04 to 16/04) to week 40 (1/10 to 8/10). Due to adverse weather conditions during the sampling period, there were more missed samples in 2017 than the two previous years. Miscommunication with the station in Cromane/ Castlemaine Harbour resulted in only a short sampling period (finishing on week 22). On average, over 65% of the samples were taken around the coast, which still gives us good indication of the mussel larval population.

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

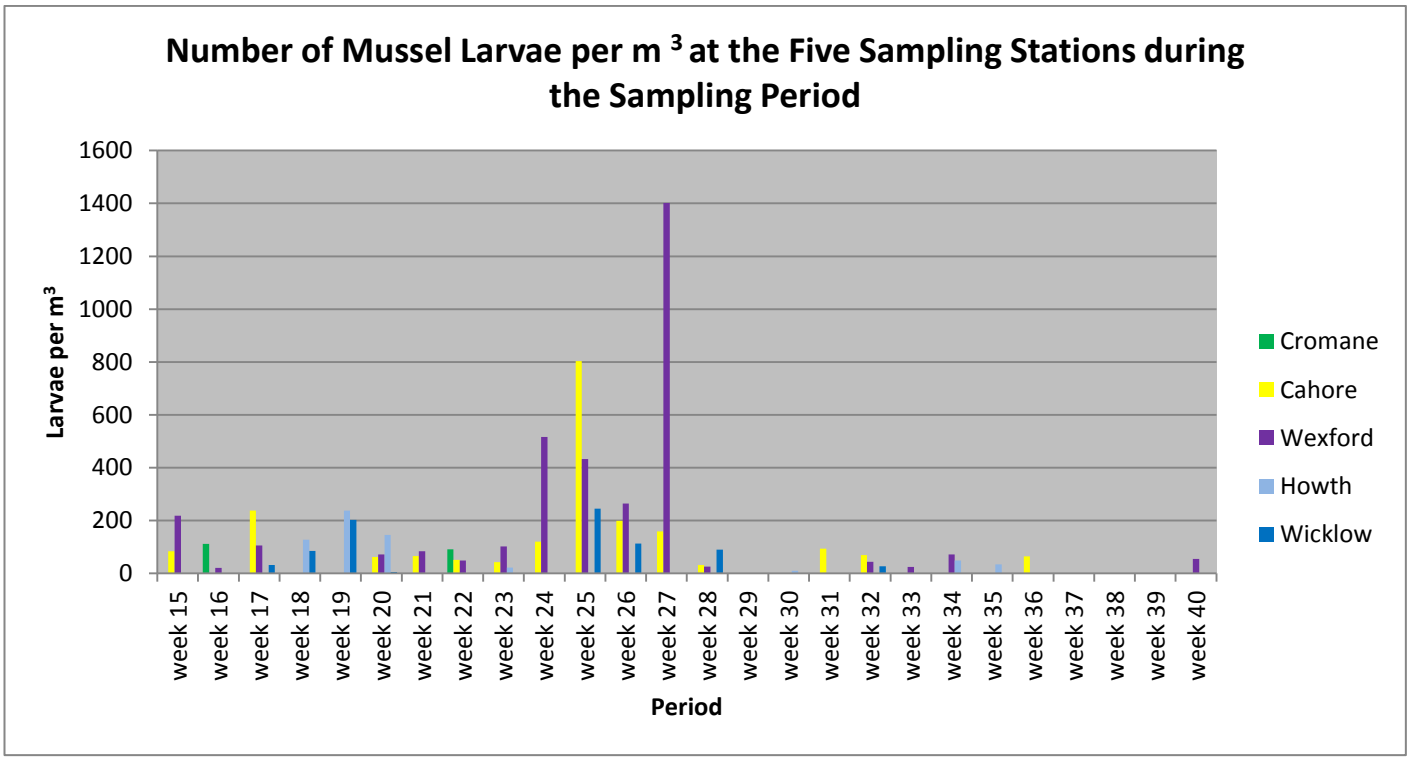
Period	Cromane	Cahore	Wexford	Howth	Wicklow
week 15	**NS**	84	218	0	0
week 16	112	0	21	0	0
week 17	0	237	105	**NS**	31
week 18	0	**NS**	**NS**	127	85
week 19	0	0	0	238	202
week 20	0	62	71	145	5
week 21	0	65	84	**NS**	0
week 22	91	51	48	**NS**	0
week 23	**NS**	42	102	22	**NS**

week 24	**NS**	120	516	**NS**	0
week 25	**NS**	**803**	433	0	245
week 26	**NS**	199	264	**NS**	113
week 27	**NS**	159	**1402**	**NS**	**NS**
week 28	**NS**	31	25	0	89
week 29	**NS**	**NS**	**NS**	**NS**	0
week 30	**NS**	**NS**	**NS**	10	0
week 31	**NS**	93	0	0	0
week 32	**NS**	69	43	**NS**	27
week 33	**NS**	**NS**	24	**NS**	0
week 34	**NS**	0	71	48	0
week 35	**NS**	**NS**	**NS**	34	0
week 36	**NS**	64	0	0	0
week 37	**NS**	**NS**	**NS**	0	0
week 38	**NS**	0	0	**NS**	0
week 39	**NS**	0	0	**NS**	0
week 40	**NS**	NS	54	0	0
NS - No Sample	***19***	***7***	***5***	***12***	***2***

Table 3 represents the amount of mussel larvae per cubic metre of seawater on the five stations throughout the sampling season, those values are plotted on Figure 10. This graph shows the comparative population of larvae for the five stations over the sampling period.

The highest amount of larvae found during the 2017 survey was at the Wexford Bar station on week 27 (3/07 to 9/07), with 1402 larvae/m^3. Prior to this, there was a spike on week 25 (19/06 to 25/06) in the Rusk Channel, reaching 803 larvae/ m^3. Otherwise, numbers were low but constant up to week 28 (10/07 to 16/07), which can indicate some trickle spawning. From week 29 onward, very little to no larvae were observed in the samples.

Figure 10: Number of mussel larvae per m^3 at Wicklow, Wexford Bar, Cromane/ Castlemaine Harbour and North Howth during the sampling period



Sample sites

This section of the report deals with the specific findings for each area. As in the year 2015 and 2016, 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

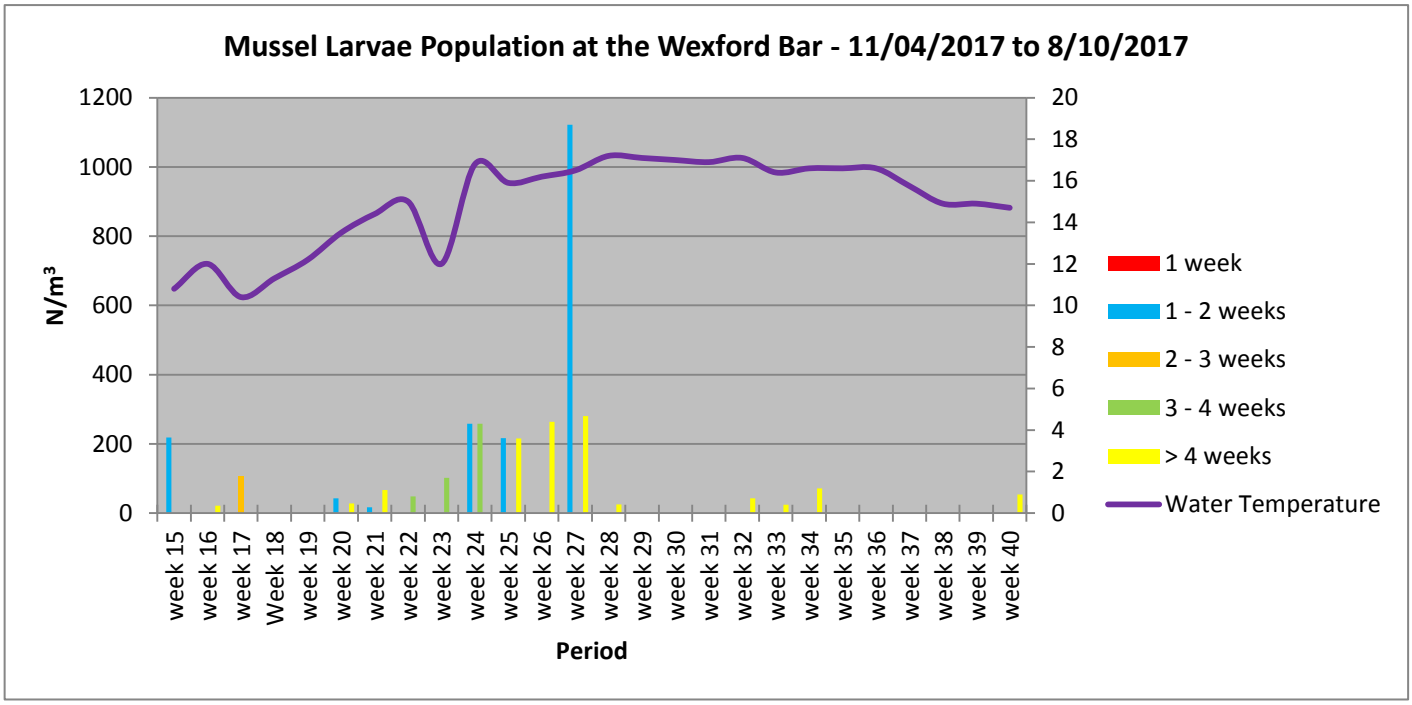
The numbers of larvae per m^3 and their estimated age are shown in Table 4 and these are then graphed in Figure 11 with ambient seawater temperatures. Globally, there were more larvae at this station in 2017 than in 2016.

Table 4: Mussel D-larvae population at the Wexford Bar (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
week 15		218				10.8	218
week 16					21	12	21
week 17			105			10.4	105
Week 18						11.3	**NS**
week 19						12.2	*0
week 20		43			28	13.5	71
week 21		17			67	14.4	84
week 22				48		15	48
week 23				102		12	102
week 24		258		258		16.8	516
week 25		217			216	15.9	433
week 26					264	16.2	264
week 27		1122			280	16.5	1402
week 28					25	17.2	25
week 29						17.1	**NS**
week 30						17	**NS**
week 31						16.9	*0
week 32					43	17.1	43
week 33					24	16.4	24
week 34					71	16.6	71
week 35						16.6	**NS**
week 36						16.6	*0
week 37						15.75	**NS**
week 38						14.9	*0
week 39						14.9	*0
week 40					54	14.7	54

* 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 at Wexford Bar (Week 15 to Week 40)



For the first time since the monitoring program started, no 1 week old larvae were recorded at the Wexford Bar. The sampling looks to have caught the last of the early spawning on week 15 (10/04 to 16/04); after this, numbers remains low until week 24 (12/06 to 18/06). The rise of the larvae population at the Wexford Bar Station in 2017 appears to be between 3 to 4 weeks later than the previous year (Week 20 in 2015 and Week 21 in 2016). The difference with previous years though, older larvae (+ 4 weeks old) appeared to remain in this area for a longer period: over 200 larvae/m^3 were observed from week 25 (19/06 to 25/06) to week 27 (3/07 to 9/07), but no settlement was found in the area unfortunately.

At the same period, a large number of young larvae (over 1000 larvae/m^3 of 1 to 2 weeks old) were present at the location. Two weeks prior to this event, the water temperature increased by 5 degrees (between week 24 and 25) from 12 degrees Celsius to 17 degrees Celsius, which could have trigger a late spawning. Such an event is expected at this station due to its proximity to the broodstock (Wexford Harbour), similar patterns were observed in the previous years: over 3000 blastula/m^3 on week 18 in 2015 and nearly 800 of 1 to 2 weeks old larvae/m^3 on week 21 in 2016. Only 5 samples showed no larvae.

Sporadic populations of + 4 weeks old larvae were observed after week 28 until week 40 (1/10 to 8/10).

Weather conditions in 2017 were a limiting factor for this station as well as the station in the Rusk Channel, as both locations are exposed to southerly and easterly winds. Both stations are subjected to very strong tidal currents as well, but nevertheless only five samples were missed.

Rusk Channel

Table 5 below shows a breakdown of the number and ages of larvae found at the Rusk Channel sampling station. Again, this data has been graphed and the ambient water temperature added on Figure 12.

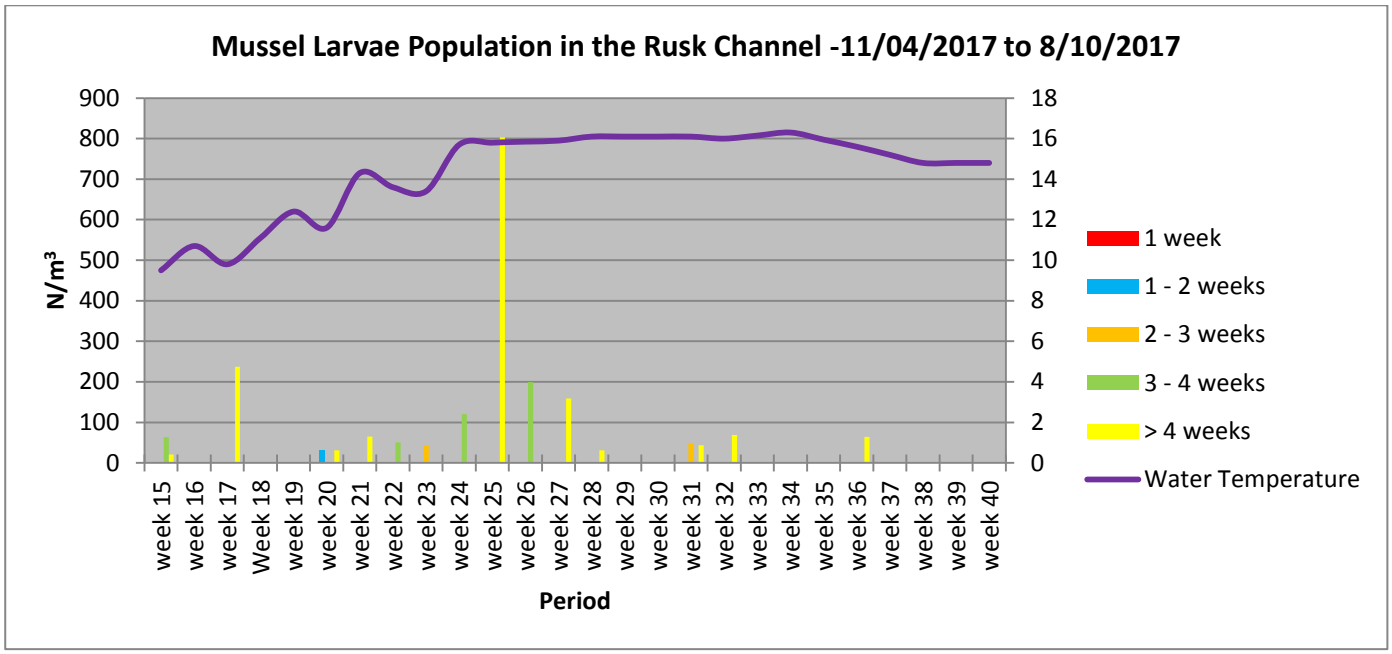
Table 5: Mussel D-larvae count in the Rusk Channel (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
week 15				63	21	9.5	84
week 16						10.7	*0
week 17					237	9.8	237
Week 18						11.1	**NS**
week 19						12.4	*0
week 20		31			31	11.6	62
week 21					65	14.3	65
week 22				51		13.6	51
week 23			42			13.4	42
week 24				120		15.7	120
week 25					803	15.8	803
week 26				199		15.85	199
week 27					159	15.9	159
week 28					31	16.1	31
week 29						16.1	**NS**
week 30						16.1	**NS**
week 31			49		44	16.1	93
week 32					69	16	69
week 33						16.15	**NS**
week 34						16.3	*0
week 35						15.95	**NS**
week 36					64	15.6	64
week 37						15.2	**NS**
week 38						14.8	*0
week 39						14.8	**NS**
week 40						14.8	*0

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

As for the Wexford Bar Station, no young larvae were observed in the Rusk Channel which indicates in this particular case, that there is no husbandry/broodstock in close proximity unlike the Wexford Bar Station. Again, poor weather was a limiting factor for sample collection but only 7 were missed out of 26.

Figure 12: Mussel D-larvae population and seawater temperature in the Rusk Channel (Week 15 to Week 40)

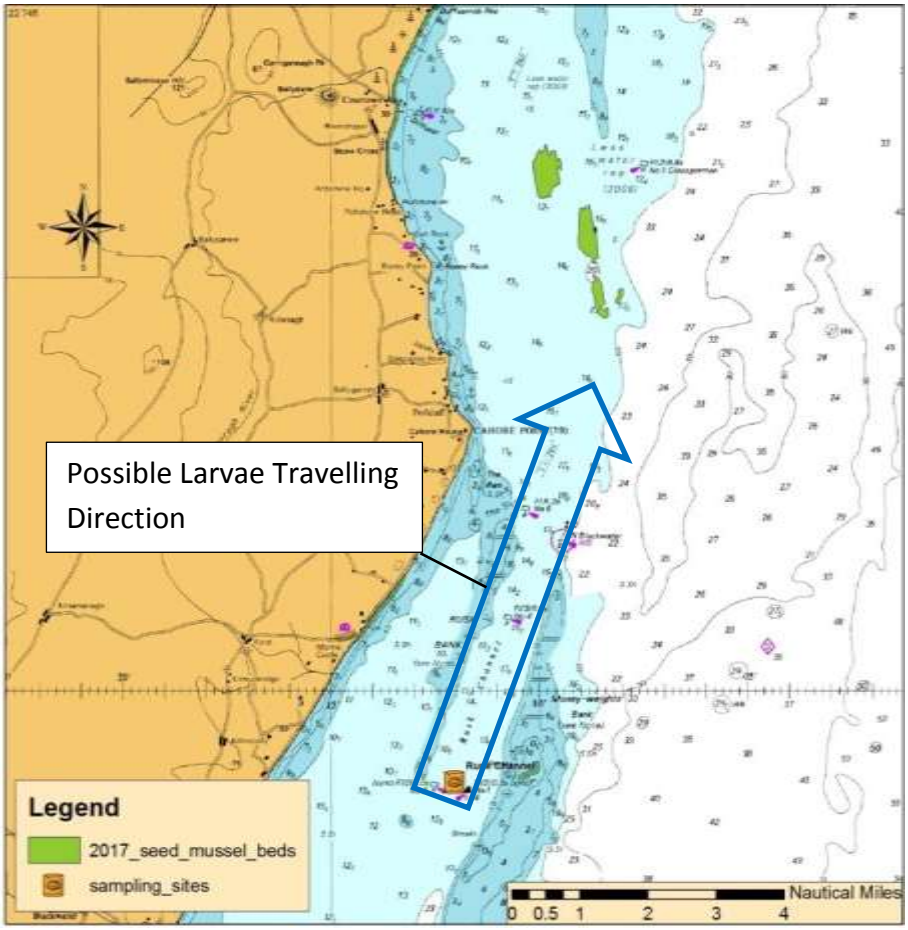


Although the amount of larvae appears to be higher than 2016, overall numbers were down in the Rusk Channel. A spike in the population on week 25 (19/06 to 25/06) reached over 800 larvae /m^3; from the analysis of the sample, it appears that those larvae were over 4 weeks old. This spike probably relates to a 3500 metric tons settlement found in late August approximately 10 Nautical North of the sampling station as seed mussel found at the location looked recent. There was no settlement with the channel itself.

Figure 13: Seed Mussel from the Courtown/ Glassgorman Settlement in 2017

Otherwise, there was very low amount of 1 to 2 weeks and 2 to 3 weeks old larvae and numbers in the other age class barely reached 200 larvae/ m^3 on week 17 (24/04 to 30/04), week 26 and week 27 (from 26/06 to 9/07). There could be a relationship between the amount found on week 17 in the Rusk Channel and the amount of 1 to 2 weeks old larvae found on week 15 at the Wexford Bar station. There could possibly a relationship between the samples taken on week 26 and week 27 as well; numbers are similar, only the class age changes: 199 Larvae/m^3 (3 to 4 weeks old) on week 26 and 159 larvae/m^3 (>4 weeks old) on week 27. No other age class pattern was observed at the location. There were only 5 samples showing no larvae.

Figure 14: Courtown/Glassgorman Seed Mussel Bed location and Rusk Channel Sampling Station



South Wicklow/Arklow

The issue encountered last year affecting the amount of sample was resolve using another supplier in the area. The sampling location was relocated closer to their operating harbour (Arklow) but following the review of the seed settlement data from 1970, the sampling location could still possibly be on the larvae distribution course. 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 15.

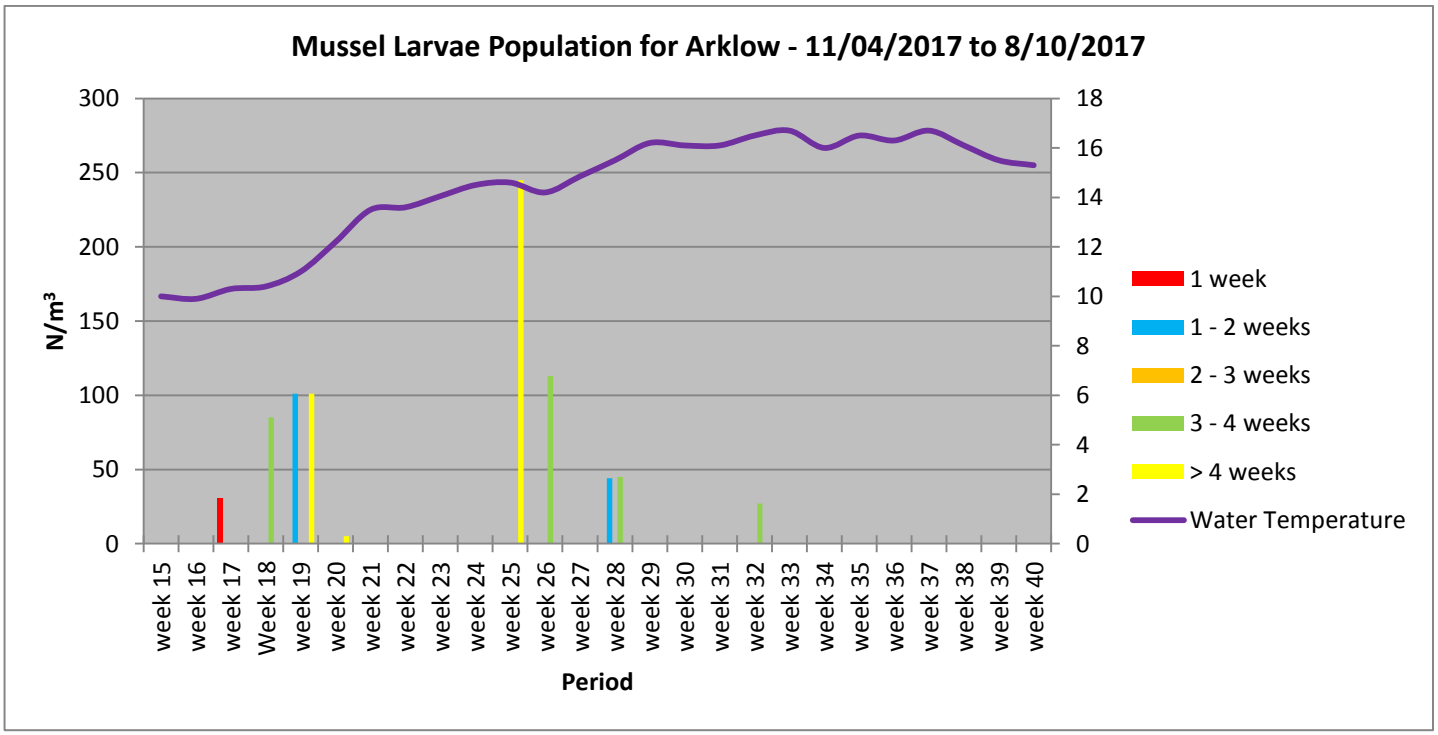
Only 2 samples were missed during the 2017 season at this station despite weather conditions.

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 15						10	*0
week 16						9.9	*0
week 17	31					10.3	31
Week 18				85		10.4	85
week 19		101			101	11	202
week 20					5	12.2	5
week 21						13.5	*0
week 22						13.6	*0
week 23						14.05	**NS**
week 24						14.5	*0
week 25					245	14.6	245
week 26				113		14.2	113
week 27						14.85	**NS**
week 28		44		45		15.5	89
week 29						16.2	*0
week 30						16.1	*0
week 31						16.1	*0
week 32				27		16.5	27
week 33						16.7	*0
week 34						16	*0
week 35						16.5	*0
week 36						16.3	*0
week 37						16.7	*0
week 38						16.1	*0
week 39						15.5	*0
week 40						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 15: Mussel D-larvae population and seawater temperature in South Wicklow (Week 15 to Week 40)



The Wicklow station was the only one in 2017 to show 1 week old larvae (on week 17 - 24/04 to 30/04) but only in very small quantities. Nothing was found on the previous sample (week 15 and 16), so these larvae are unlikely coming from a local husbandry. Sporadic amount were found after that through the various age classes until a spike at 245 larvae/ m^3 on week 25 (19/06 to 25/06) of over 4 weeks old larvae. This spike corresponds to a similar pattern on the Rusk Channel station at the same period with the same age class; it is possible to think that all those larvae were from the same batch. A total of 16 samples showed no larvae.

Although, now there is seed mussel settlement at the sampling location, a very dense bed of approximately 4000 tonnes was located 15 nautical miles up the coast (north of Brittas Bay).

Castlemaine Harbour/ Cromane

This was the second year of larvae monitoring in Castlemaine Harbour. There was some misunderstanding for the sampling schedule in Cromane as samples were only collected from week 16 (17/04 to 23/04) to week 22 (29/05 to 4/06).

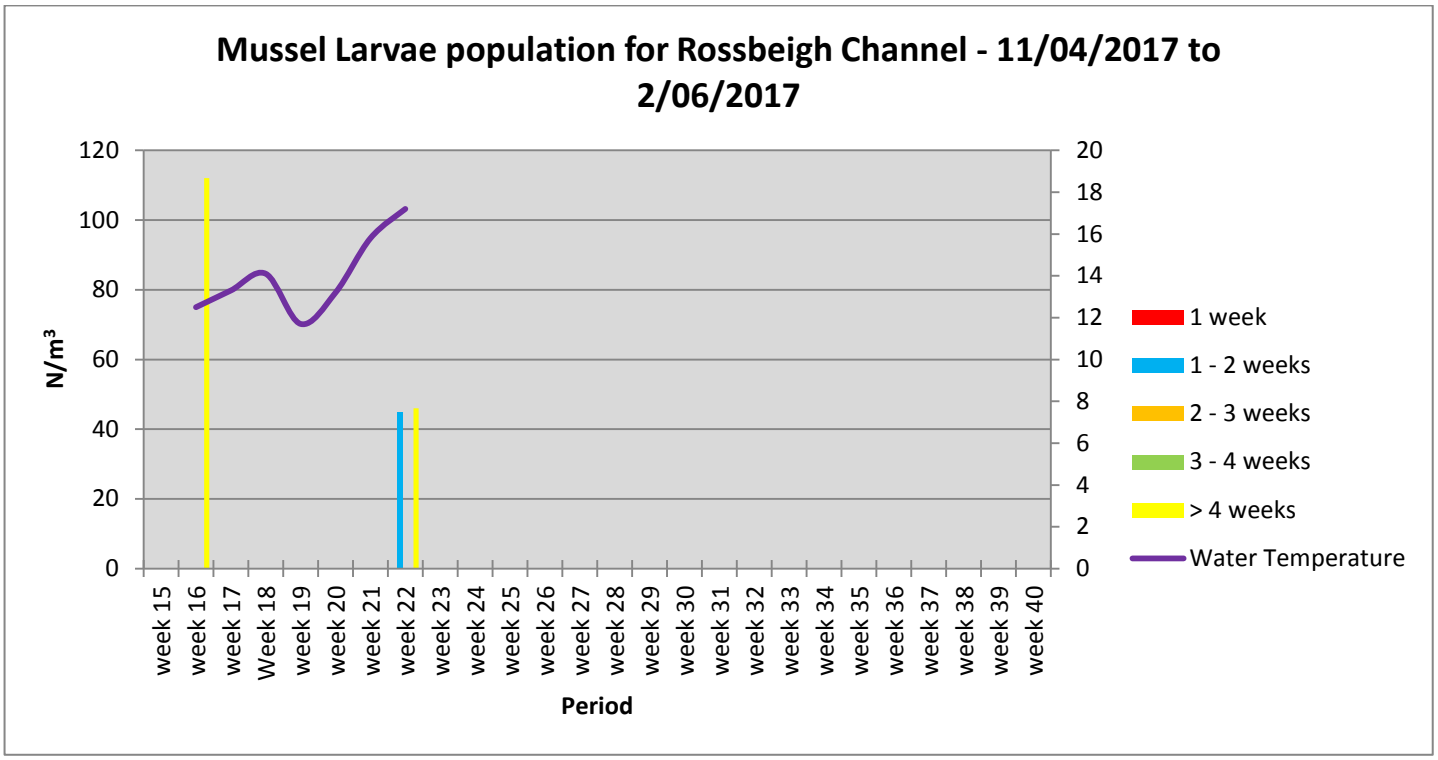
Table 7: Mussel D-larvae population in Castlemaine Harbour/Cromane (number per m^3)

Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
week 15							**NS**
week 16					112	12.5	112
week 17						13.3	*0
Week 18						14.1	*0
week 19						11.7	*0
week 20						13.2	*0
week 21						15.8	*0
week 22		45			46	17.2	91
week 23							**NS**
week 24							**NS**
week 25							**NS**
week 26							**NS**
week 27							**NS**
week 28							**NS**
week 29							**NS**
week 30							**NS**
week 31							**NS**
week 32							**NS**
week 33							**NS**
week 34							**NS**
week 35							**NS**
week 36							**NS**
week 37							**NS**
week 38							**NS**
week 39							**NS**
week 40							**NS**

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

Only very small quantities of larvae were observed in the samples taken in Castlemaine. The amount of data collected wasn't enough to analyse any possible pattern. Nevertheless, still as part of the ISPP Project, a few extra samples were collected by BIM on week 22 during a seed mussel bed survey of the area. Five extra samples were taken all along the possible larval distribution course (see Figure 17). Only one of those samples was used for plotting purpose as it was the closest to the original sampling site, Cromane Extra 2 (91 larvae per m^3).

Figure 16: Mussel D-larvae population and seawater temperature in Cromane/Castlemaine Harbour (Week 15 to Week 40)



Large quantities of settling larvae (8 weeks plus) were observed in 3 samples; those three samples were located on a current seed mussel settlements mapped later in the season. In conjunction with this extended survey, a seed mussel settlement study was carried out in the area. The objective was to identify a preferred substrate for the larvae to settle (see in Appendix for detailed report). Following those findings, the sampling station will need to be relocated for 2018.

Figure 17: Mussel D-larvae population for the Extra Samples on Week 22 in Cromane/Castlemaine Harbour

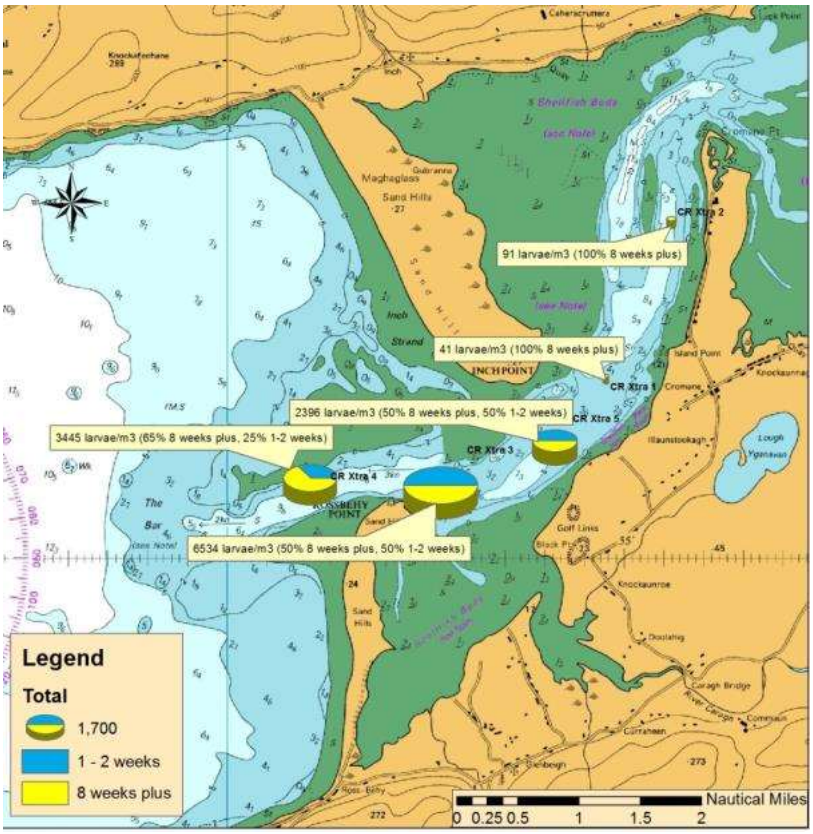
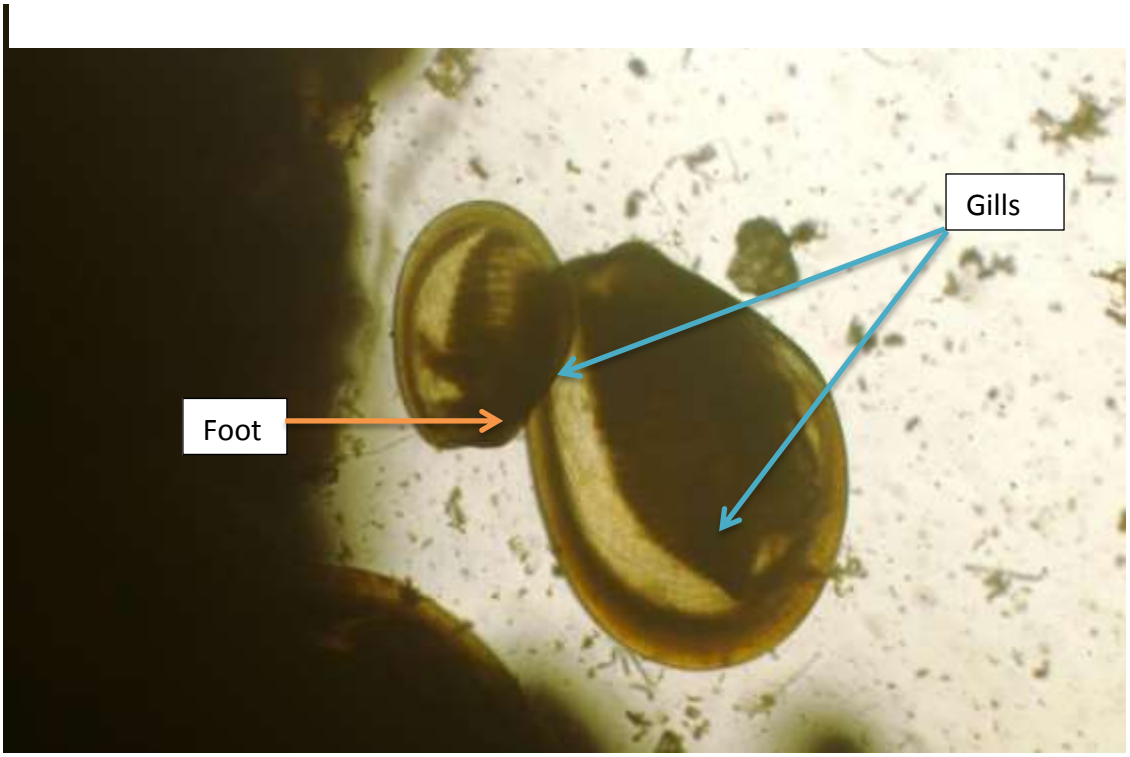


Figure 18: Larvae from Castlemaine Harbour under Microscope



North Howth

In 2017, following findings of a wild intertidal husbandry in Malahide (north Dublin), a new sampling station was established between Howth Harbour and Malahide inlet (see Figure 5 on page 10). Unfortunately, there was no meat yield recorded for the area, nevertheless relevant quantities of larvae were observed in the area (see details in Table 8 and Figure 18).

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

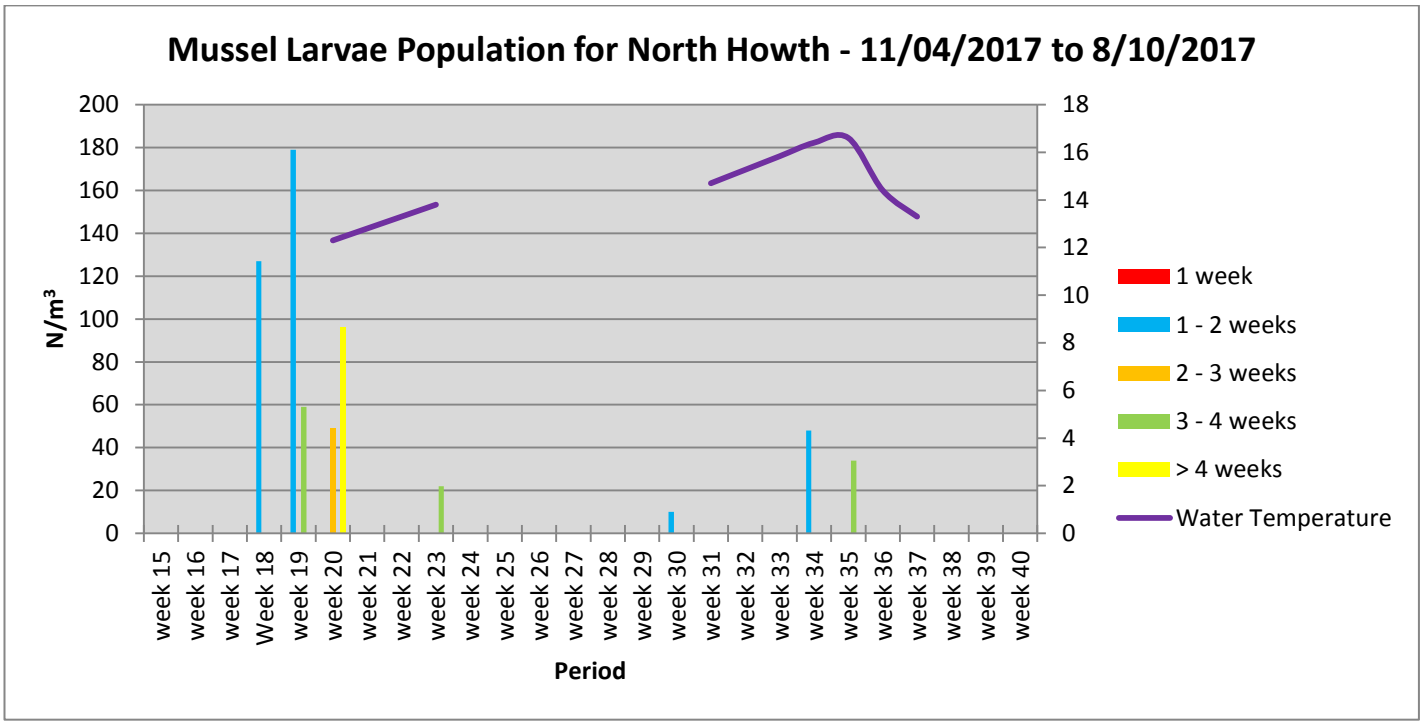
Period	1 week	1 - 2 weeks	2 - 3 weeks	3 - 4 weeks	> 4 weeks	Water Temperature	Total Larvae/ week
week 15							*0
week 16							*0
week 17							**NS**
Week 18		127					127
week 19		179		59			238
week 20			49		96	12.3	145
week 21						12.8	**NS**
week 22						13.3	**NS**
week 23				22		13.8	22
week 24							**NS**
week 25							*0
week 26							**NS**
week 27							**NS**
week 28							*0
week 29							**NS**
week 30		10					10
week 31						14.7	*0
week 32						15.26667	**NS**
week 33						15.83333	**NS**
week 34		48				16.4	48
week 35				34		16.6	34
week 36						14.4	*0
week 37						13.3	*0
week 38							**NS**
week 39							**NS**
week 40							*0

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

As for the other sites, no 1 week old larvae were observed despite the proximity of the husbandry. Samples were missed 11 times and no larvae were found in 8 samples. The larvae

were concentrated other 3 weeks at the start of the monitoring from week 18 (1/05 to7/05) to week 20 (15/05 to21/05). Sporadic amount were observed after this.

Figure 19: Mussel D-larvae population and seawater temperature in North Howth (Week 15 to Week 40)



There was no report of seed mussel settlement around Howth in 2017. Again, no clear age class distribution pattern was observed. A problem occurred with the temperature and salinity probe which explain the break in the data.

Figure 20: Intertidal Mussel Husbandry in Malahide inlet (2016)

Comparison of findings (2015, 2016 and 2017)

Following the lack of results for the Castlemaine Harbour/Cromane station, the comparison findings are focused on the station with the most history, namely Wexford Bar, Rusk Channel and Wicklow. Table 9 below details the amount of larvae for the 3 station over the three years.

Table 9: Mussel D-larvae Population for Wicklow, the Rusk Channel and Wexford (2015, 2016 and 2017

Period	Wexford 17	Rusk 17	Wicklow 17	Wexford 16	Rusk 16	Wicklow 16	Wexford 15	Rusk 15	Wicklow 15
week 13							68	27	0
week 14							132	245	**NS**
Week 15	218	84	*0	17	0	**NS**	**NS**	**NS**	340
Week 16	21	*0	*0	55	42	0	83	0	**NS**
Week 17	105	237	31	0	59	**NS**	**NS**	**NS**	**NS**
Week 18	**NS**	**NS**	85	65	35	**NS**	4156	320	277
Week 19	*0	*0	202	481	215	12	0	136	0
Week 20	71	62	5	**NS**	**NS**	**NS**	574	752	59
Week 21	84	65	*0	784	254	21	204	**NS**	33
Week 22	48	51	*0	241	235	0	1596	779	56
Week 23	102	42	**NS**	58	164	**NS**	186	1118	0
Week 24	516	120	*0	114	0	53	317	**NS**	**NS**
Week 25	433	803	245	**NS**	57	108	442	591	**NS**
Week 26	264	199	113	84	143	**NS**	**NS**	**NS**	47
Week 27	1402	159	**NS**	**NS**	**NS**	**NS**	37	**NS**	52
Week 28	25	31	89	76	87	**NS**			
Week 29	**NS**	**NS**	*0	37	54	**NS**			
Week 30	**NS**	**NS**	*0	0	158	**NS**			
Week 31	*0	93	*0						
Week 32	43	69	27						
Week 33	24	**NS**	*0						
Week 34	71	*0	*0						
Week 35	**NS**	**NS**	*0						
Week 36	*0	64	*0						
Week 37	**NS**	**NS**	*0						
Week 38	*0	*0	*0						
Week 39	*0	NS	*0						
Week 40	54	*0	*0						
NS - No sample	5	6	2	3	2	10	3	6	5

Figure 21: Larvae Population variation at the Sampling Stations (2015, 2016 and 2017)

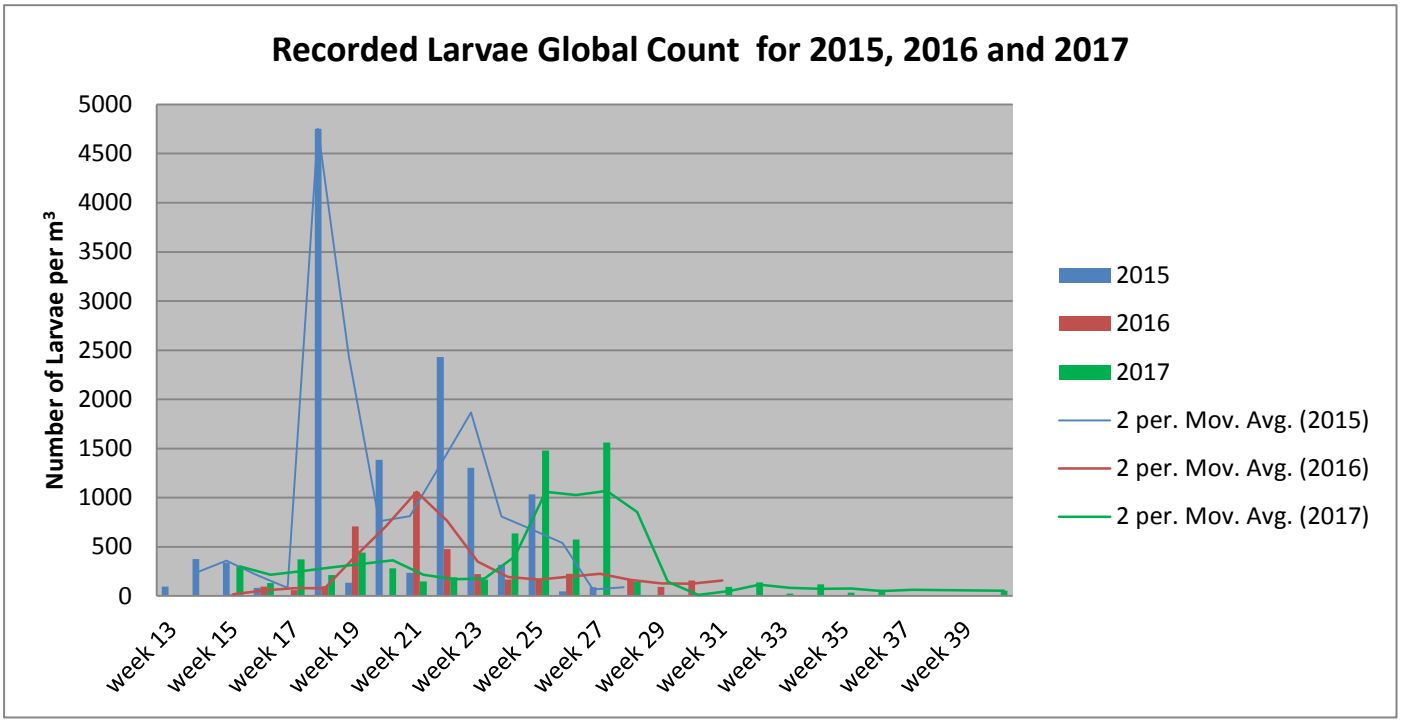
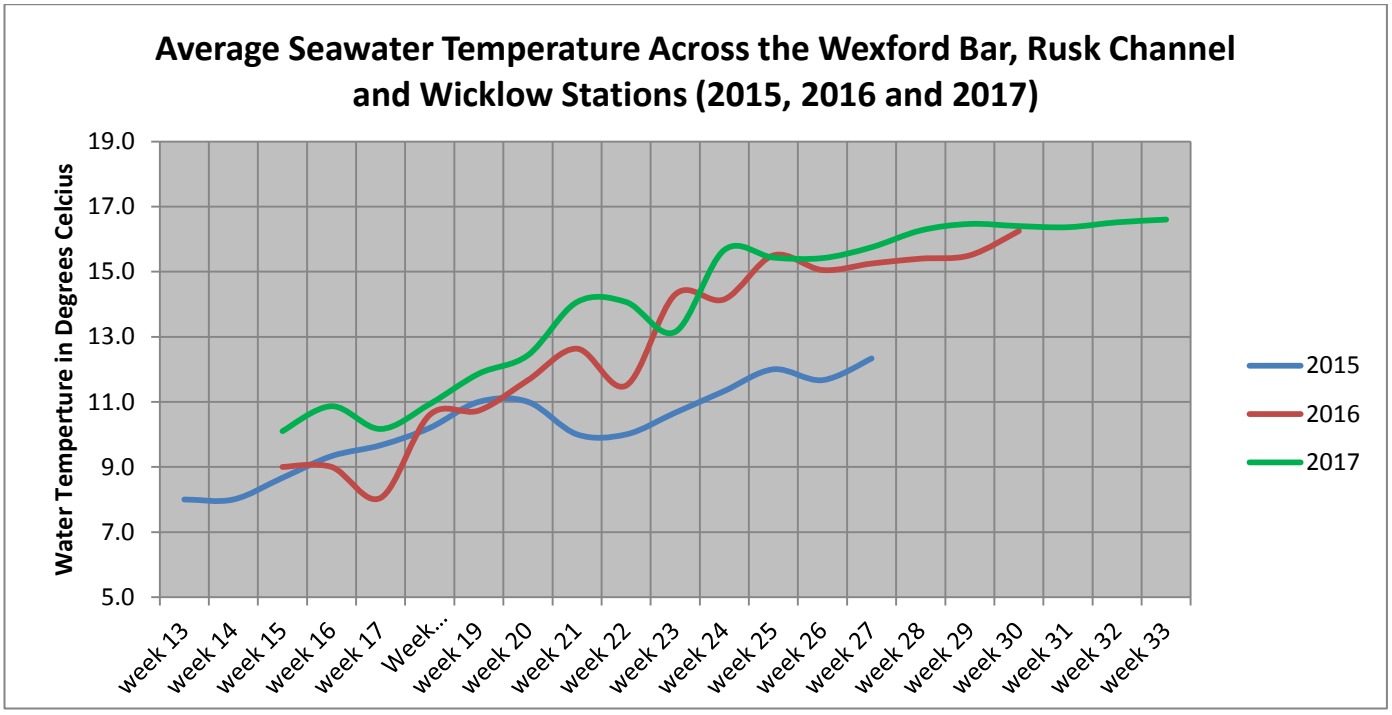


Figure 22: Average Water Temperature across the Sampling Stations (2015, 2016 and 2017)



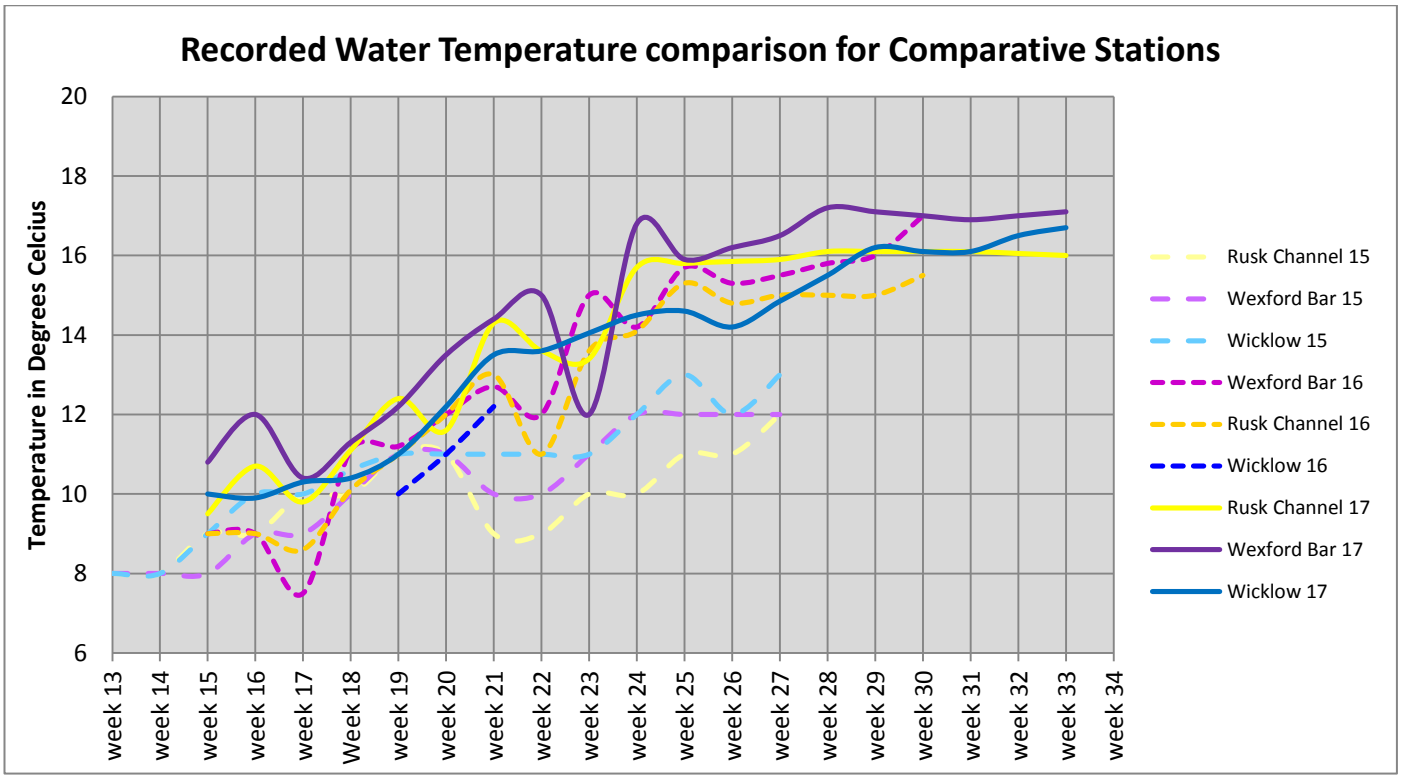
In Figure 21, we can clearly see an increase in 2017 in comparison with 2016 but we are still below the 2015 level. The main difference is the bulk of the larvae appeared later in 2017 than in the two previous years (between week 18 an week 22 for 2015 and 2016; between week 24 and

week 27 for 2017) although water temperatures were at a three years' high (Figure 22).

On week 27, the average seawater temperature has over 4 degrees difference between 2017 and 2015 (16 degrees in 2017 and 12 degrees in 2015), there is a bit less of a difference between 2016 and 2017 (slightly above 15 degrees in 2016 against 16 degrees in 2017). The rapid temperature variations observed in 2016 (weeks 17, 22 and 24) have slightly amplified in 2017. 2017 was overall much warmer than the two previous years: 2.5 degrees more on average with 2015 and 1 degree more on average with 2016.

The details larvae variation and temperature comparison for the three stations is included in the Appendix.

Figure 23: Comparative Graph of the Recorded Water Temperature for the 3 Stations over 2015, 2016 and 2017



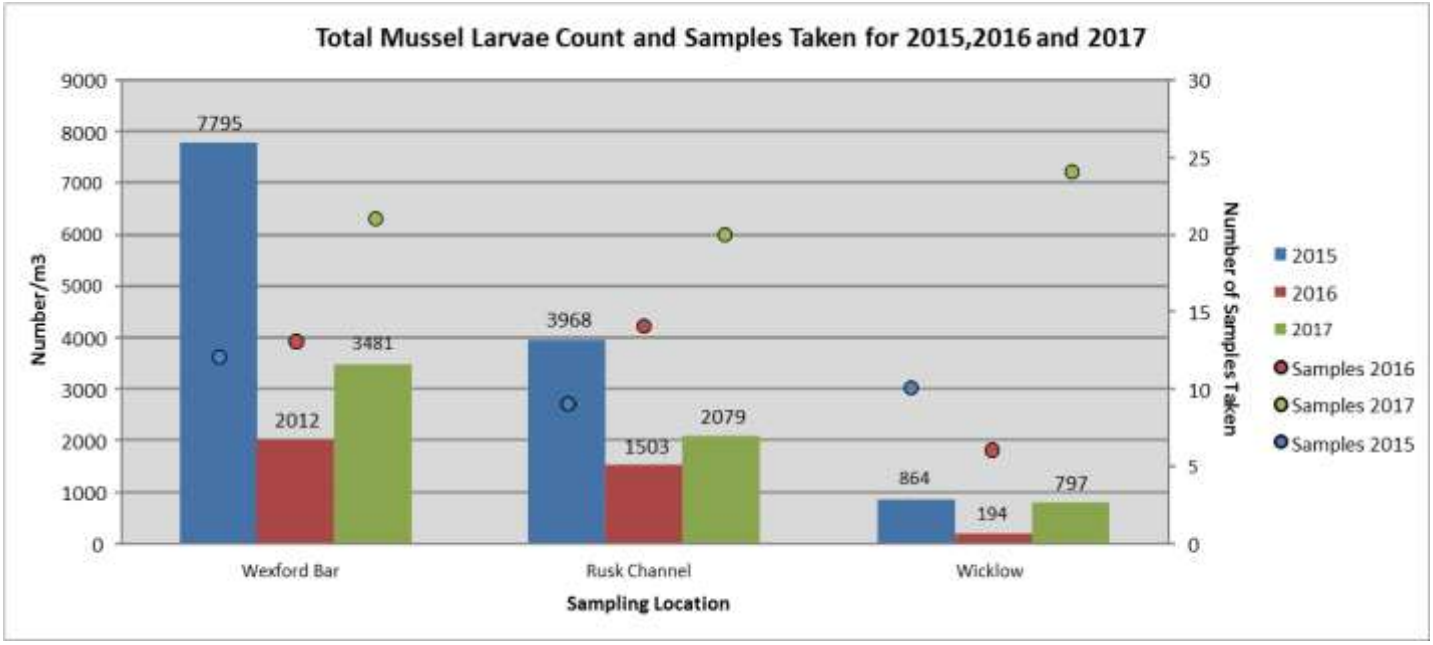
The following Table 10 shows the overall variation of the population of larvae over the three

years, after a drop from 2015 to 2016, levels have gone back up in 2017. For Wicklow in 2017, the population has increased more than three fold in comparison with 2016 although levels remain well below the other two stations. For the Rusk Channel and Wexford Bar, overall the amount of larvae has increased but they are still below the 2015 levels.

Table 10: Mussel Larvae Population Variation from 2015 to 2017

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

Figure 24: Total Number of Mussel Larvae Sampled and Sample Taken from 2015 to 2017

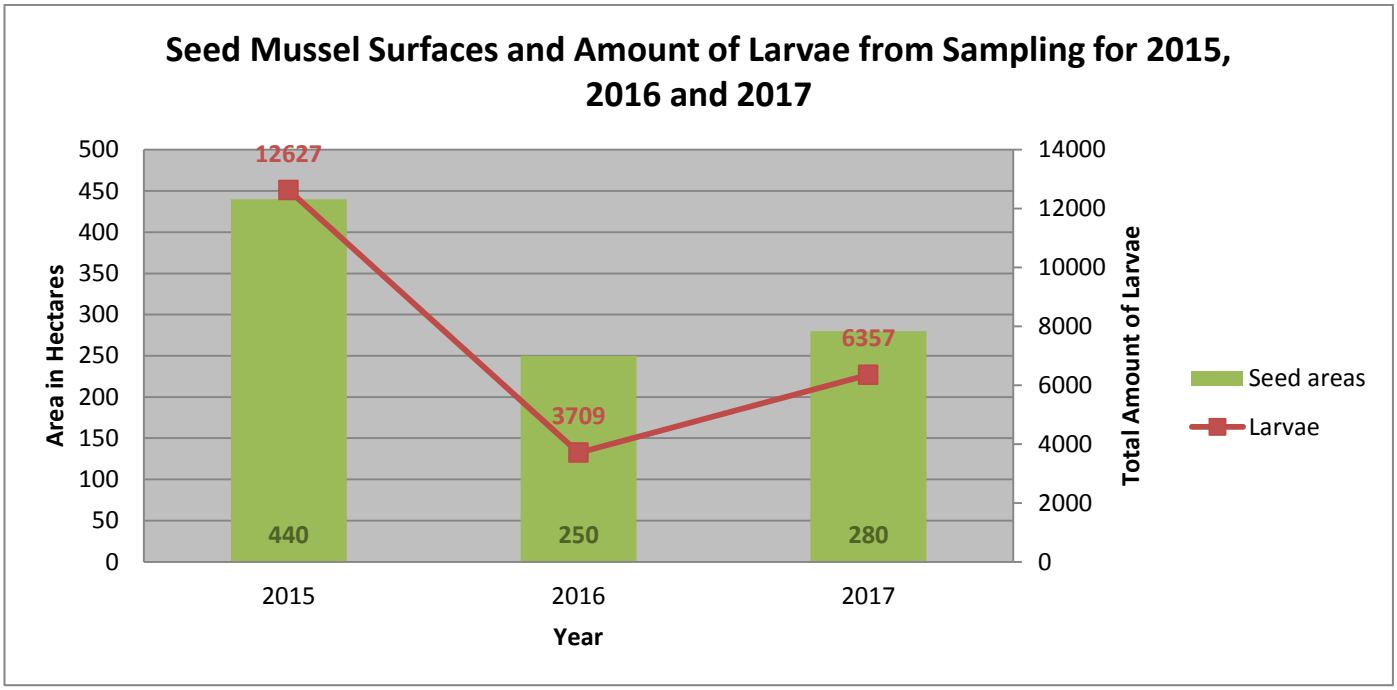


In Figure 24, we can see that there are no obvious relation between the amount of samples taken and the amount of larvae found. Although we took significantly more samples, we are not getting more larvae.

The relation is more evident when we compare the amount of larvae and the seed mussel

settlement area. Considering the data collected by BIM seed mussel surveys, we can see that in 2015 a total of 440 hectares were marked as seed mussel beds. In 2016 this number falls to 220 hectares and in 2017 the total of the marked areas comes to 280 hectares.

Figure 25: Seed Mussel Areas and Total Amount of Larvae (2015, 2016 & 2017)



The positive relationship between estimated tonnage of seed mussel, based on BIM seed mussel survey reports, and the seed mussel settlement area was not evident (see Figure 23). In addition, those surveys have highlighted variations in terms of seed mussel quality; this has been corroborated by the bottom mussel industry. The seed mussel collected in 2015 had a lighter shell than the one collected in 2016. The seed mussel collected in Courtown in 2017 had the same characteristics AS the 2015 population. In comparison, the seed mussel collected in Wicklow in 2017 had much stronger shell and more resistance out of the water similar to the seed collected at the Bar Buoy and in Rosslare in 2016. Estimated tonnages are affected by the seed mussel weight: a large seed mussel settlement with lighter/weaker individuals can have a similar estimated tonnage than a smaller compact settlement with stronger seed mussel.

Figure 26: Seed Mussel Estimated Tonnage and Total Amount of Larvae (2015, 2016 & 2017)

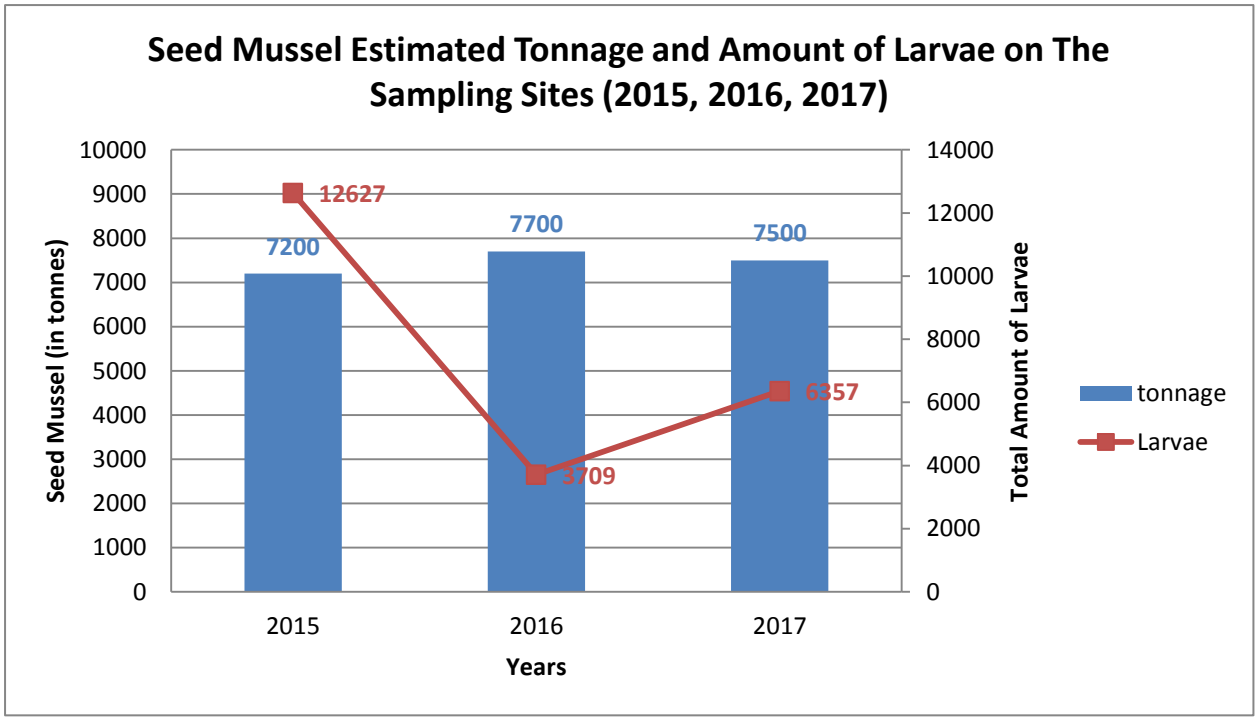


Figure 27: Seed Mussel from the South Wicklow Area

Conclusion:

The issues highlighted at the end of the 2016 report were partially resolved as:

- The sampling problems in Wicklow have been dealt with.
- Another sampling station was put in place near Malahide.

There are still a few problems with the station in Cromane and following the early spawning, the drift buoys weren't deployed.

2017 was a very different year from the previous two: a very warm early spring followed by a cooler period affected the spawning time. Although meat yield was monitored, this particular weather event happened before any husbandry or larvae samples were taken and therefore, the correlation observed in the previous, was not witnessed in 2017.

Larvae amounts were back to higher level in comparison with 2016 but again this was not synonymous of more seed mussel beds (in terms of tonnage) like in 2015. Seed mussel quality was very different between the two main settlements: light and spread for the Courtown bed, tough and compact for the bed in South Wicklow. There could be various hypotheses for this:

- The larvae/ seed mussel quality varies with the seabed type (smooth and sandy in Courtown, coarser sediment and stones in South Wicklow).

- The larvae in South Wicklow are coming from a different husbandry than Wexford Harbour.

For 2018, improvements need to be made at:

- Earlier husbandry monitoring
- Earlier larvae monitoring
- Deployment of the drift buoy in Cromane, Wexford and other stations
- Fix sampling problems in Cromane

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
- Data collection Sheet
- Weather graphs

Appendix 1: The numbers of larvae per m^3 from a sample site were calculated using the formula $\pm^2h$ 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 take into account the portion of the sample analysed in relation to the overall volume of sample water collected.

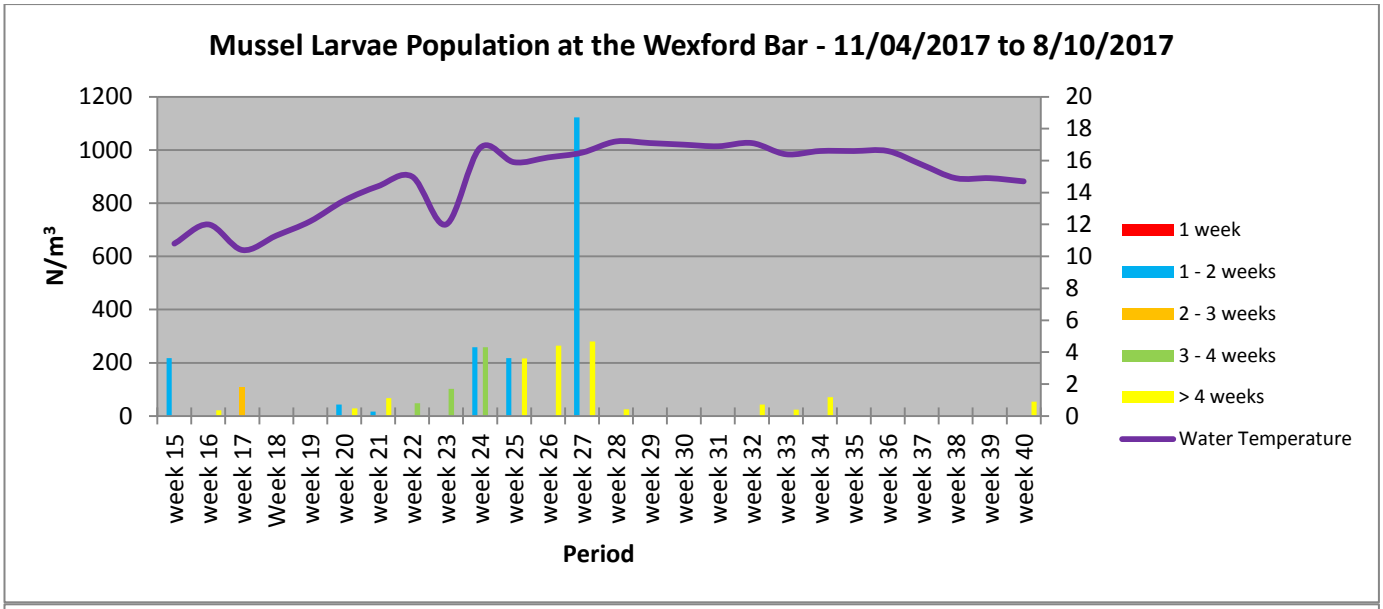
Appendix 2: The meat yield or condition index (C.I.) calculation used in these studies was based on the following calculation:

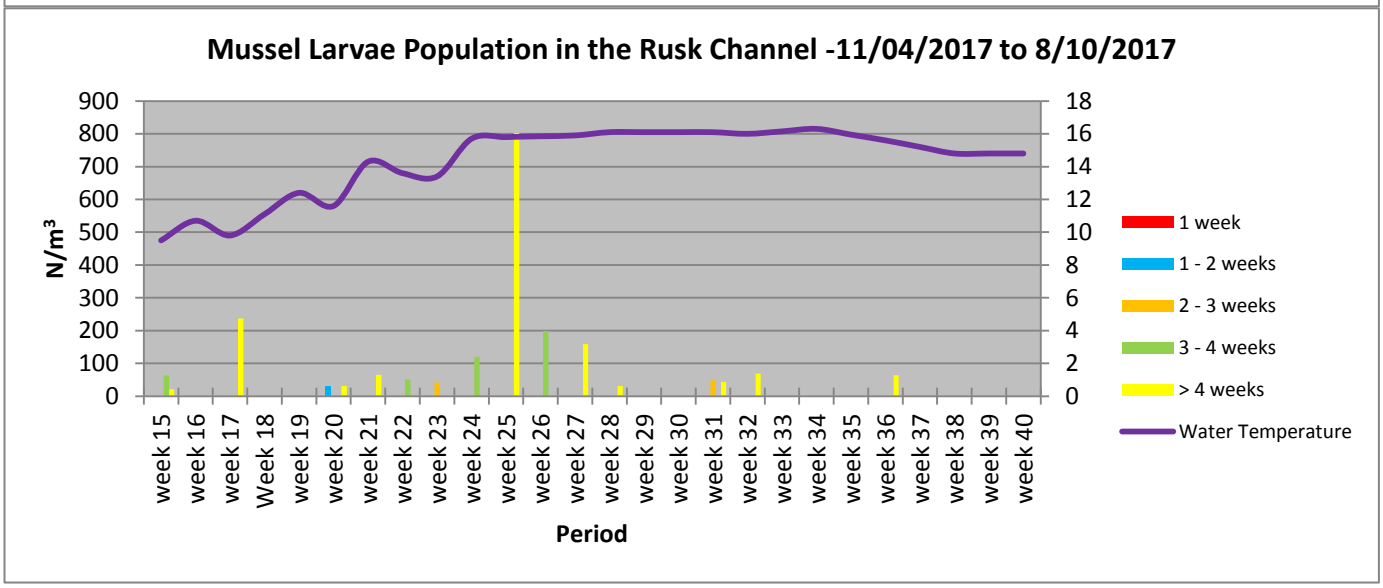
Cooked meat weight / **Total Wet Weight**	**X**	**100**	**=**	**percentage meat yield or condition index**

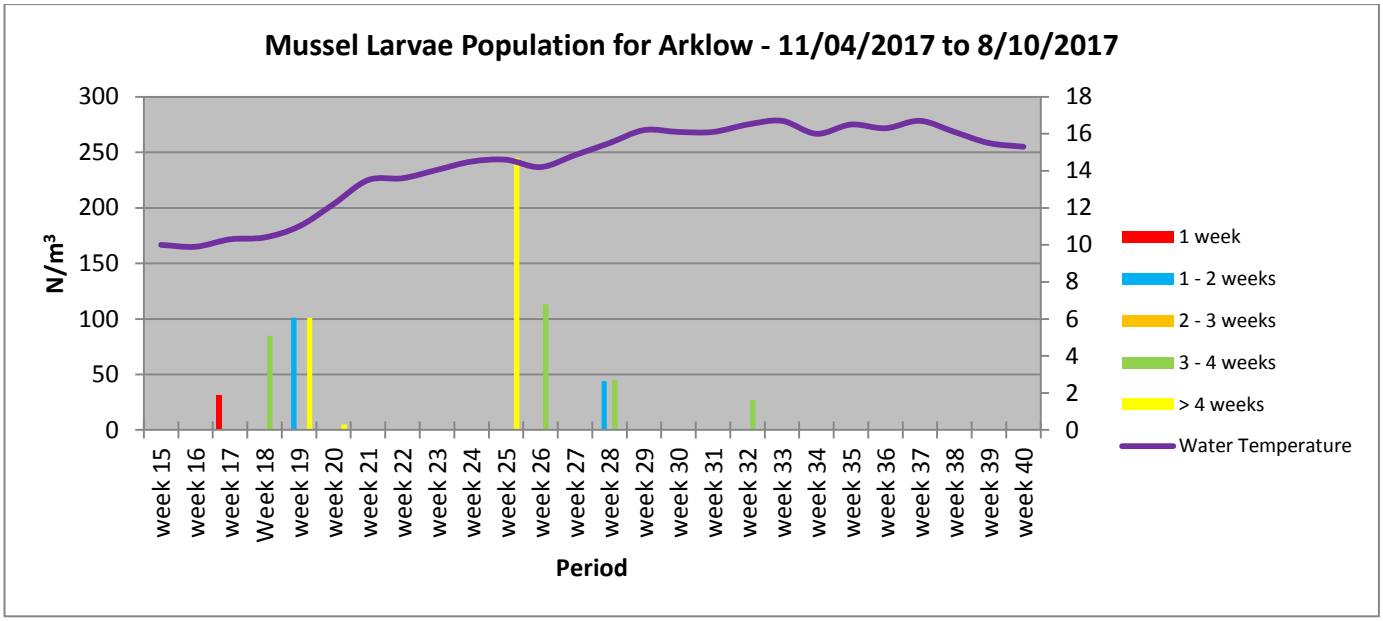
A preferred method from a statistical analysis perspective is:

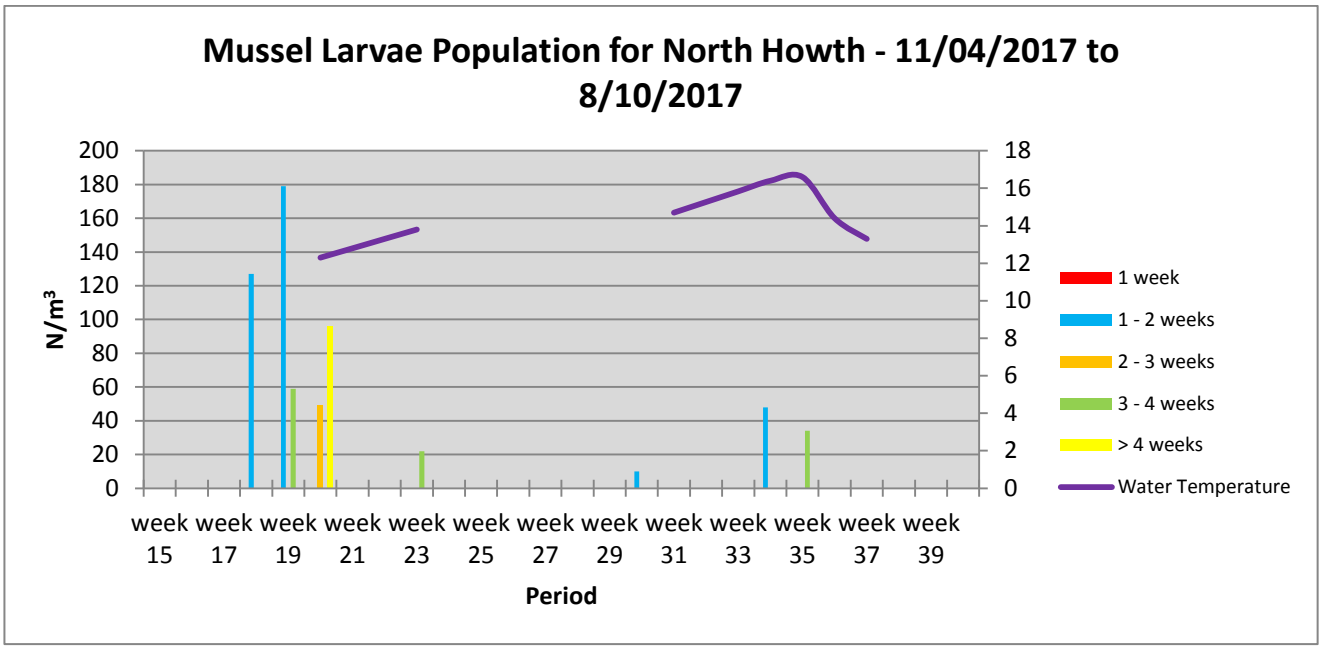
Cooked meat weight / **Cooked meat weight + Shell Weight**	**X**	**100**	**=**	**percentage meat yield or condition index (see Davenport and Chen 1987)**

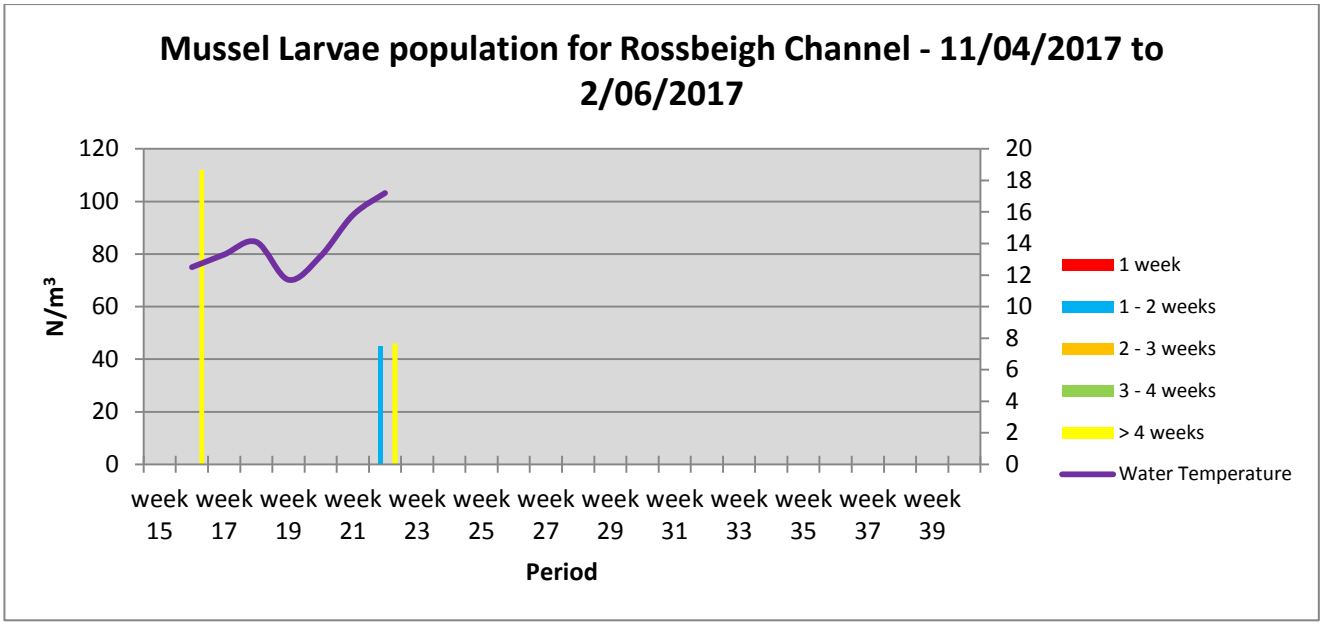
This methodology is "unaffected by prior freezing of samples" and involves the most easily measured parameters, shell weight and cooked meat weight (Davenport, J. and Chen, X. 1987. J. Moll. Stud. (1987), 53, 293-297.

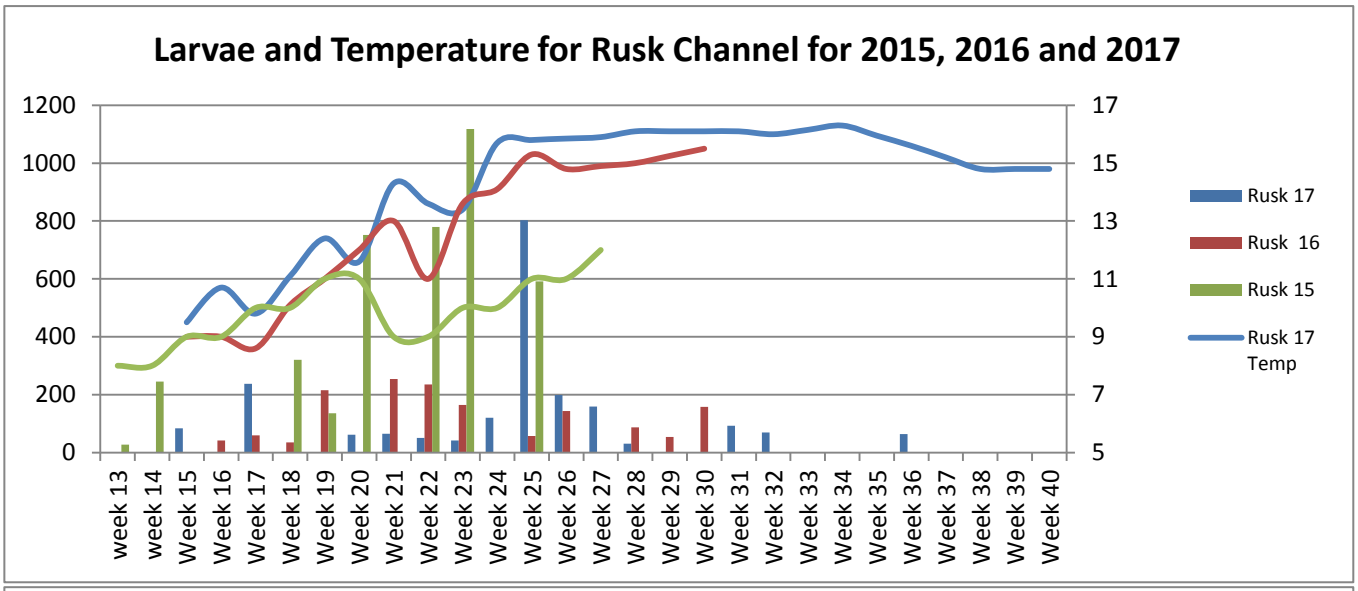

Mussel Larvae Population at the Wexford Bar - 11/04/2017 to 8/10/2017
N/m³
1200
1000
800
600
400
200
0
20
18
16
14
12
10
8
6
4
2
0
week 15
week 16
week 17
Week 18
week 19
week 20
week 21
week 22
week 23
week 24
week 25
week 26
week 27
week 28
week 29
week 30
week 31
week 32
week 33
week 34
week 35
week 36
week 37
week 38
week 39
week 40
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

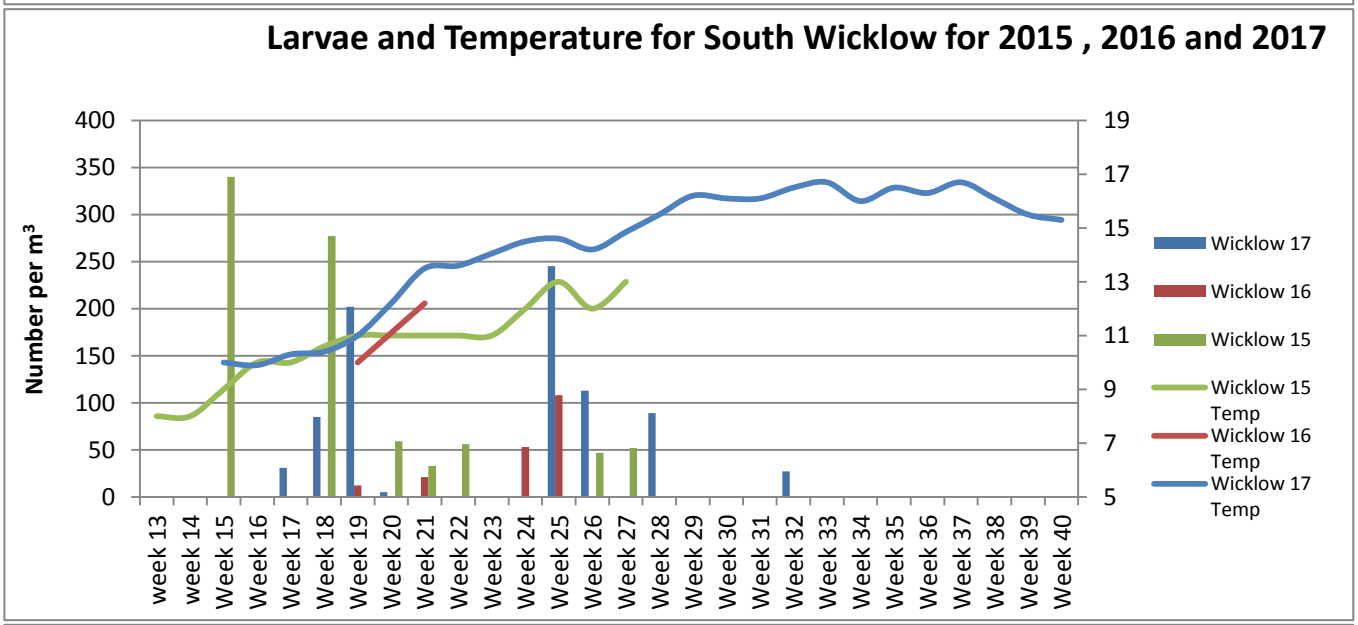

Mussel Larvae Population in the Rusk Channel -11/04/2017 to 8/10/2017
N/m³
900
800
700
600
500
400
300
200
100
0
18
16
14
12
10
8
6
4
2
0
week 15
week 16
week 17
Week 18
week 19
week 20
week 21
week 22
week 23
week 24
week 25
week 26
week 27
week 28
week 29
week 30
week 31
week 32
week 33
week 34
week 35
week 36
week 37
week 38
week 39
week 40
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

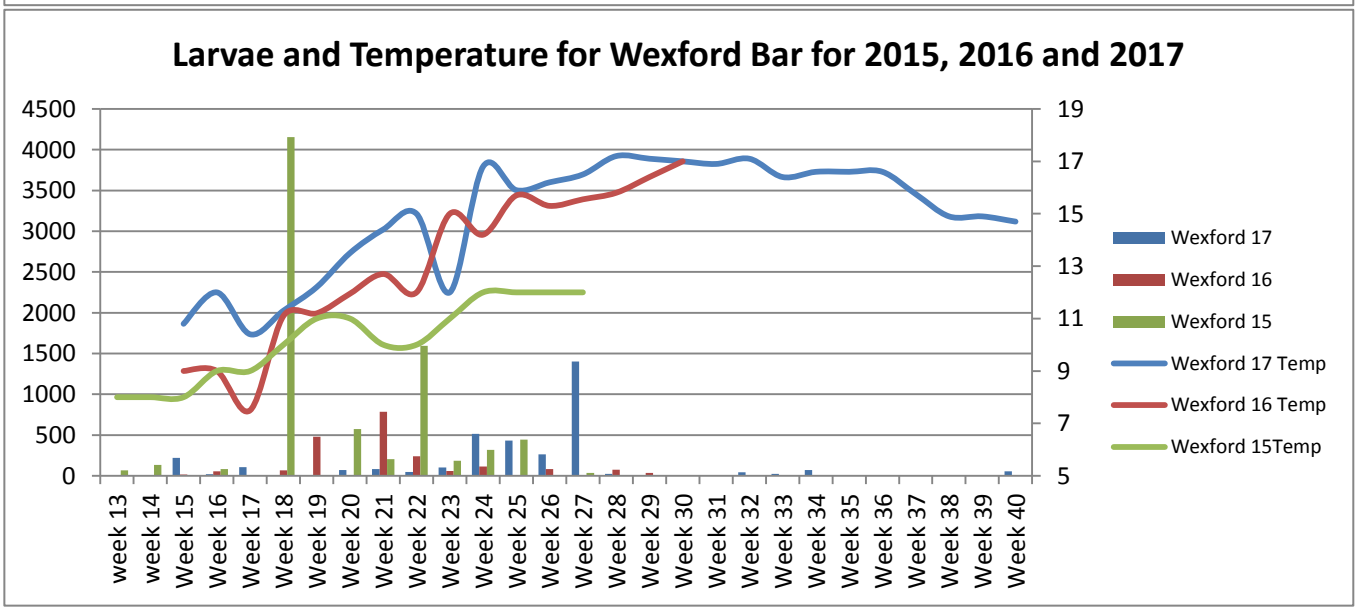

Mussel Larvae Population for Arklow - 11/04/2017 to 8/10/2017
N/m³
300
250
200
150
100
50
0
18
16
14
12
10
8
6
4
2
0
week 15
week 16
week 17
Week 18
week 19
week 20
week 21
week 22
week 23
week 24
week 25
week 26
week 27
week 28
week 29
week 30
week 31
week 32
week 33
week 34
week 35
week 36
week 37
week 38
week 39
week 40
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

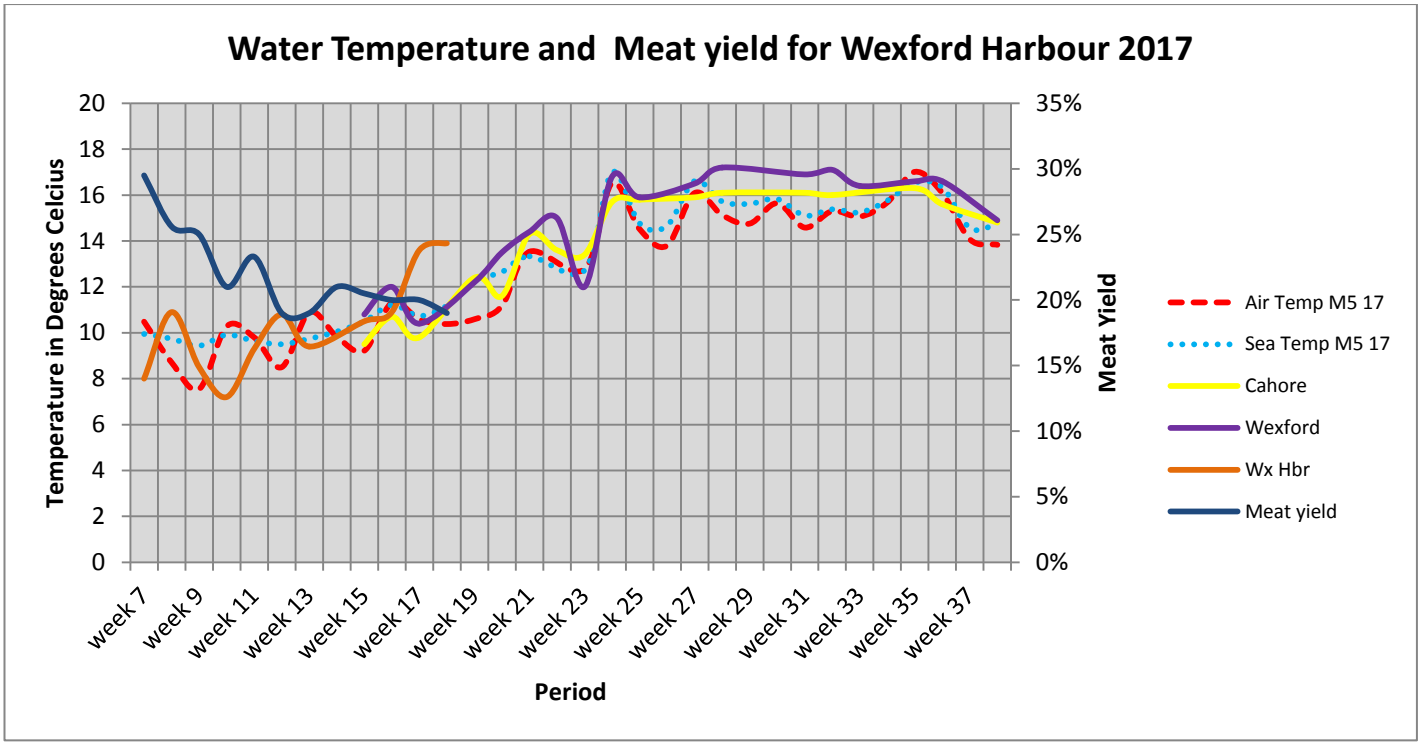

Mussel Larvae Population for North Howth - 11/04/2017 to 8/10/2017
N/m³
200
180
160
140
120
100
80
60
40
20
0
18
16
14
12
10
8
6
4
2
0
week 15
week 17
week 19
week 21
week 23
week 25
week 27
week 29
week 31
week 33
week 35
week 37
week 39
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature

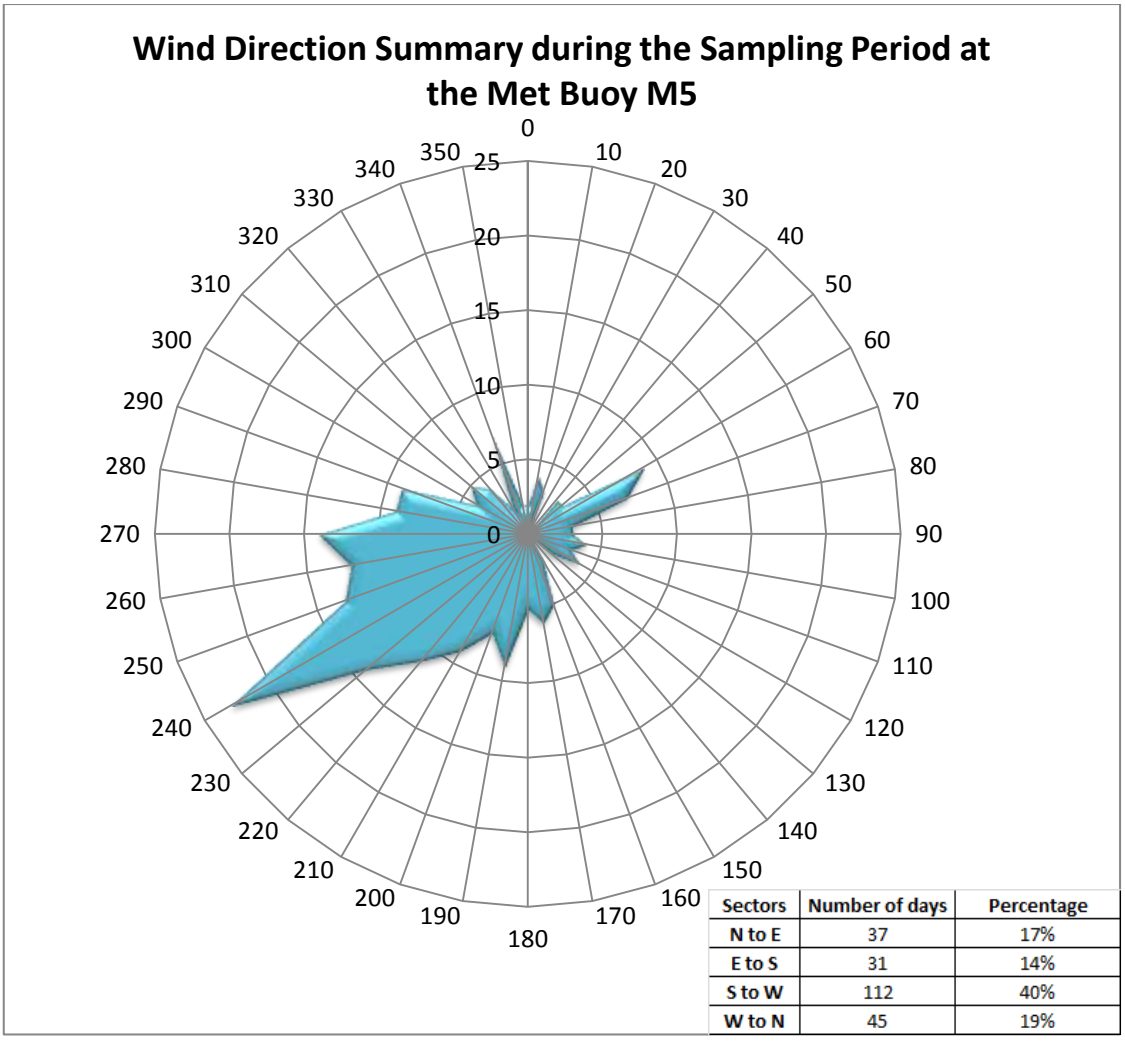

Mussel Larvae population for Rossbeigh Channel - 11/04/2017 to 2/06/2017
N/m³
120
100
80
60
40
20
0
20
18
16
14
12
10
8
6
4
2
0
week 15
week 17
week 19
week 21
week 23
week 25
week 27
week 29
week 31
week 33
week 35
week 37
week 39
Period
1 week
1 - 2 weeks
2 - 3 weeks
3 - 4 weeks
> 4 weeks
Water Temperature


Larvae and Temperature for Rusk Channel for 2015, 2016 and 2017
1200
1000
800
600
400
200
0
17
15
13
11
9
7
5
week 13
week 14
Week 15
Week 16
Week 17
Week 18
Week 19
Week 20
Week 21
Week 22
Week 23
Week 24
Week 25
Week 26
Week 27
Week 28
Week 29
Week 30
Week 31
Week 32
Week 33
Week 34
Week 35
Week 36
Week 37
Week 38
Week 39
Week 40
Rusk 17
Rusk 16
Rusk 15
Rusk 17 Temp


Larvae and Temperature for South Wicklow for 2015 , 2016 and 2017
Number per m³
400
350
300
250
200
150
100
50
0
19
17
15
13
11
9
7
5
week 13
week 14
Week 15
Week 16
Week 17
Week 18
Week 19
Week 20
Week 21
Week 22
Week 23
Week 24
Week 25
Week 26
Week 27
Week 28
Week 29
Week 30
Week 31
Week 32
Week 33
Week 34
Week 35
Week 36
Week 37
Week 38
Week 39
Week 40
Wicklow 17
Wicklow 16
Wicklow 15
Wicklow 15 Temp
Wicklow 16 Temp
Wicklow 17 Temp


Larvae and Temperature for Wexford Bar for 2015, 2016 and 2017
4500
4000
3500
3000
2500
2000
1500
1000
500
0
19
17
15
13
11
9
7
5
week 13
week 14
Week 15
Week 16
Week 17
Week 18
Week 19
Week 20
Week 21
Week 22
Week 23
Week 24
Week 25
Week 26
Week 27
Week 28
Week 29
Week 30
Week 31
Week 32
Week 33
Week 34
Week 35
Week 36
Week 37
Week 38
Week 39
Week 40
Wexford 17
Wexford 16
Wexford 15
Wexford 17 Temp
Wexford 16 Temp
Wexford 15Temp


Water Temperature and Meat yield for Wexford Harbour 2017
Temperature in Degrees Celcius
Meat Yield
Period
20
18
16
14
12
10
8
6
4
2
0
35%
30%
25%
20%
15%
10%
5%
0%
week 7
week 9
week 11
week 13
week 15
week 17
week 19
week 21
week 23
week 25
week 27
week 29
week 31
week 33
week 35
week 37
Air Temp M5 17
Sea Temp M5 17
Cahore
Wexford
Wx Hbr
Meat yield



Sectors	Number of days	Percentage
N to E	37	17%
E to S	31	14%
S to W	112	40%
W to N	45	19%