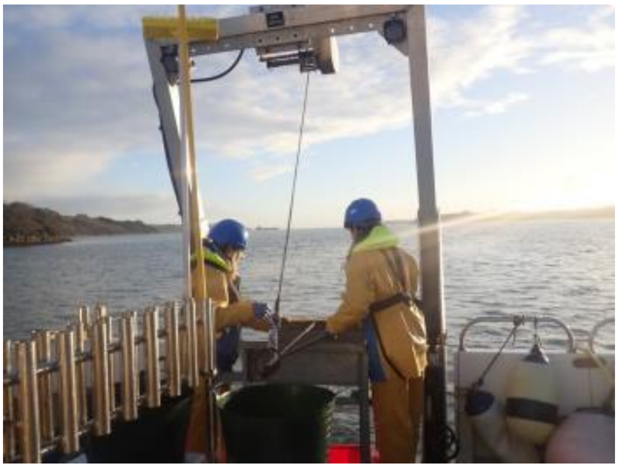
Fal Oyster Survey 2019



Final report for the 2019 Fal Oyster Survey
(2019_CIFCA_SAC_FAL_FOS)

Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA)

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Document History			
Version	Date	Author	Change
0.1	18/02/2019	A Jenkin	First draft
0.2	12/03/2018	K Owen	Addition of bycatch data
0.3	02/04/2019	C Trundle	Addition of GIS plots
0.4	10/04/2019	K Owen and S Sturgeon	QA
0.5	28/05/2019	C Trundle	QA
Final	30/05/2019	A Jenkin	Final amendments

Cited as:

Jenkin, A., Trundle, C., Owen, K., Sturgeon, S. and Naylor, H. 2019. Fal Oyster Survey. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

This document has been produced by Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA)

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Contents

List of Figures

List of Tables

Glossary of Terms and abbreviations

Area A	North Bank, Mylor Bank and Parsons Bank
Area B	East Bank and St.Just Flats
Area C	North of a line drawn due east from Pill Point to the coast on Turnaware Point
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
FFMC	Fal Fishery Management Committee
FOS	Fal Oyster Survey
H	Harbour section
IFCA	Inshore Fisheries and Conservation Authority
MLS	Minimum Landing Size
OH	Outer harbour
R	River

1 Introduction

Cornwall Inshore Fisheries and Conservation Authority (IFCA) has been responsible for the management of the Fal Oyster Fishery since July 2014. Prior to this, Cornwall Council (Port of Truro), as the grantee under the Truro Port Fishery Order 1936 (as amended), was responsible for the management fishery until the Order expired in July 2014. Cornwall IFCA initially authorised access under the Closed Areas (European Marine Sites) Byelaw 2 then as Regulator of the Fal Fishery Regulating Order 2016. As part of the management of the fishery the Authority assumed responsibility for monitoring the stock of oysters by continuing the yearly surveys of the fishery. Previous Cornwall IFCA surveys have been reported on since 2015 (Jenkin *et al*., 2018; Jenkin *et al*., 2017; Latham *et al*., 2016; and Latham and Trundle, 2015).

The oyster stocks were monitored intermittently by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in the 1950s and 1960s. An annual survey was started in 1971 and continued until 1984, when they were discontinued due to low stock levels resulting from mortalities caused by the oyster parasite, *Bonamia ostrea*. Following recovery of the stock, joint CEFAS/ Cornwall Council Maritime Division oyster surveys were restarted in 2002 and have been undertaken annually since. These surveys initially targeted 95 sample sites, spread across the River (R), Harbour (H) and Outer Harbour (OH) sections. The abundance and size of the oysters were recorded, with oysters allocated into size classes that reflected recruitment to the fishery in future seasons.

The three sections of the survey are as follows; the R section covers Malpas to Turnaware Point, fished by oyster punts using haul tow methods; the H section covers Turnaware Point to the old fishery limit line (Penarrow Point – Messack Point), fished predominantly by sail; and the OH section which lies outside the Port of Truro limit. The number of sites which are surveyed has decreased over time. This is because some sites were located where sensitive habitats such as maerl were found and some of the sites in the R section were set up as clusters, with three sites located very close to each other, so these have been replaced with just one location being surveyed.

A number of changes were made to the Fal Fishery Order 2016 Regulations prior to the 2016 fishing season starting due to expressions of interest made through the Fal Fishery Management Committee (FFMC). Previously under the regulatory order, a person that retained on board or landed native species of bivalve or gastropod shellfish had to ensure that the combined weight of species other than oysters (*Ostrea edulis*) and mussels (*Mytilus edulis*) (bycatch) did not exceed 20% of the weight of all the native species retained on board or landed. In the Fal Fishery Order 2016 this was removed which has changed the previously non-target species such as the queen scallop, *Aequipecten opercularis*[1] and the variegated scallop, *Mimachlamys varia*[2] (queenie scallops) to target species. It is thought that the species referred to as 'queenies' within the Fal Fishery Area are thought to be primarily the variegated scallop (*M. varia*) as opposed to the queen scallop (*A. opercularis*). The queenie scallops have been included as part of the survey since 2016. For the remainder of this report they are referred to as scallops.

The minimum size of native oysters which can be removed from the fishery is 67 mm and the minimum size of queen scallops (*Chlamys* spp.) is 40 mm under Council Regulation 850/98 Annex XII.

[1] Synonymised name: *Chlamys opercularis* (unaccepted) http://www.marinespecies.org/aphia.php?p=taxdetails&id=152997

[2] Synonymised name: *Chlamys varia* (unaccepted) http://www.marinespecies.org/aphia.php?p=taxdetails&id=140696

In 2018, an addition to the survey was made to record the number of individual slipper limpets (*Crepidula fornicata*) at each site instead of the subjective broad approach of a SACFOR style recording system which was used prior to this. This was continued as part of the survey in 2019.

In 2019, a detailed study of the bycatch species was carried out per sample and a much more comprehensive list was made of all species observed for each site.

1.1 Aims and objectives

1.1.1 Aims

- To investigate the abundance and distribution of native oysters, *O. edulis*, within the Fal Oyster Fishery located in the Fal Estuary, Cornwall.
- To investigate the abundance and distribution of scallops (queen scallop, *A. opercularis*; variegated scallop, *M. varia*) within the Fal Oyster Fishery.
- To investigate the abundance and distribution of slipper limpets (*C. fornicata)* within the Fal Oyster Fishery.
- To investigate the distribution of substrate types across the fishery.
- To investigate the species of bycatch present during each dredge sample.

1.1.2 Objectives

- To re-survey Fal oyster survey sites, as previously surveyed by Cornwall Council/ CEFAS, recording abundance and size of native oysters.
- To record the abundance and size of scallops.
- To count the number of slipper limpets per site.
- To record bycatch retained within each dredge sample.
- To record the substrate within each dredge sample.
- To record any invasive species observed during the survey.
- To provide recommendations for future survey work.

2 Methodology

2.1 Survey Area

The survey was carried out within the Fal Oyster Fishery Area, in the Fal Estuary on the south coast of Cornwall.

2.2 Vessel Specifications

Research vessel (R/V) Tiger Lily VI is Cornwall IFCA's research survey vessel (Figure 1). She is a South Boats 11 m Island MkII catamaran with twin IVECO 450hp engines; her Callsign is MRWR7. Due to her size and power towing the oyster dredge was not an option (minimum speed in gear is approximately 4 knots); therefore a haul tow methodology (outlined in Section 2.5) was adopted. This required the use of her hydraulic anchor winch on the starboard side which provided towing capabilities and use of the A frame on her stern from which the dredge was towed. The general layout of Tiger Lily is shown in Annex 1. Tiger Lily has been refitted for survey work and includes a purpose built survey station within the wheelhouse, fitted with an uninterruptable power supply (UPS) and a dedicated Global Positioning System (GPS) with NMEA outputs.

Figure 1: R/V Tiger Lily – Cornwall IFCA's research survey vessel.

2.3 Personnel

The crew during the surveys consisted of the skipper and up to five scientific officers. The crew roles rotated during the surveys and included data recording, operating the winch, deploying and recovering the dredge, measuring bivalves and the ID of bycatch species.

2.4 Personal Protective Equipment (PPE)

Life jackets, steel toe capped waterproof boots and waterproofs were worn while working on deck. Hard hats were worn whilst the A frame was being used. Thick, waterproof gloves provided protection against sharp shell edges and any anthropogenic debris whilst sorting through the dredge sample. There were no reported accidents or near misses during the survey.

2.5 Survey methodology

Each survey station was transferred to the vessel's Olex navigation plotter for navigation purposes and into HYPACK MAX 2018 software for data logging. The dredge used was a 72 cm blade, Essex-style oyster dredge, rigged with 34 mm diameter steel belly rings and a 45 mm (twin 3 mm nylon twine) mesh back. It varies slightly from those used within the fishery but was used previously by Cornwall Council and CEFAS for the survey work within the fishery. The dredge was deployed and recovered using the newly fitted A frame on the stern of Tiger Lily. In order to complete the survey a tow haul method was adopted, similar to that used by the oyster punts. This allowed the dredge tow to be of a known distance and to be easily and consistently replicated. Previous surveys have used a towing method where the dredge is towed for approximately 1 minute at around 1.6 knots (3 kph). This equates to a tow distance of 50 m, the same as the new method, but with less consistency over speed and direction. At each survey site the survey vessel was anchored and 60 m of anchor line was let out. The dredge was shot by hand and the vessel's slave hauler winch was used to take up 50 m of marked anchor line, resulting in a 50 m dredge tow at a steady 0.5 to 1 knots. The towing warp was run via the A frame mounted hydraulic winch. The towing warp was marked off so that the length (m) of cable deployed at any time was known; this was generally fixed for an average depth and altered only if a depth change was sufficient to cause the dredge to fish too heavily or lightly. During recovery, the dredge was lifted using the hydraulic winch and A frame, then tilted and emptied into the sorting table which was positioned beneath the frame. A deck wash was available to aid in sorting muddier samples, particularly from sites within the R section. The set up for the dredge tow, A frame and sorting table is shown in Figure 2 below and the methodology discussed in Section 2.5.

A target was created in HYPACKMAX 2018 to indicate the start of line (SOL); this was repeated at the end of line (EOL). The position of the vessel was logged continuously for all survey days to enable a track of the vessel to be created. All positions were recorded using WGS84 projection and sourced from the dedicated survey GPS (Furuno GP-32). All times are recorded as Coordinated Universal Time (UTC) and taken from the same source as the position data. The data was transferred to a WD passport hard drive at the end of each survey day.

In previous years the a fix position of the dredge was taken using the Olex navigation plotter and a time stamp was taken for the SOL and EOL positions.

If the dredge did not fish, due to being blinded or flipped over, or the sample appeared smaller than it should be for particular areas, the dredge haul was repeated.

During the survey, photographs were taken using an Olympus Tough TG-5 digital camera and a printed image identification plate ('clapper' board) was used for sample identification. All measurements (mm) were taken using Vernier callipers. Footage of the dredge in action was collected for two sites using a ThiEYE Action Camera Sports HD Camcorder. The camera was placed in dustproof, shakeproof, waterproof housing.

Figure 2: Survey set-for the Fal Oyster Survey 2019 on the deck of R/V Tiger Lily.

Each sample was photographed on the sorting table alongside the clapper board prior to sorting. Live native oysters, scallops (queen/ variegated scallop) and slipper limpets were removed and set aside as the sample was sorted (Figure 3).

Figure 3: Samples sorted into buckets containing native oysters, scallops and slipper limpets from the 2019 Cornwall IFCA Fal Oyster Survey.

All live oysters were then counted and measured across the widest point, to the nearest mm using callipers. All queen or variegated scallops were counted and measured along the length of the valve (from the hinge to the outer edge), to the nearest mm using callipers. All slipper limpets were counted, this included live individuals or live individuals which were part of a chain (Figure 4). The weight (g) was recorded for oysters where possible. If shell or stone was attached to the individual or they were joined a weight was not taken.

Figure 4: Examples of slipper limpets (*Crepidula fornicata)* growing on substrate as individuals or chains of two or a longer chain of individuals as observed on the 2019 Cornwall IFCA slipper limpet survey.

Observations of substrate were recorded for each dredge sample. An abundance scale was used to categorise substrate content (Table 1). Substrate categories included mud, shell, stone, mixed sediments and sticks. Dead maerl was recorded on an abundance scale and live maerl was recorded as the number of live fragments.

Table 1: The substrate abundance scale used to record substrates present in the dredge sample.

Scale	Description
1	Rare
2	Occasional
3	Frequent
4	Abundant
5	Very Abundant

Each sample was sorted once recovered and checked for all species of bycatch which were recorded per site. In previous years recording bycatch was a fairly minor part of the oyster survey but in 2019 a comprehensive list of all species present at each site was made. Before the dredge sample was sorted into separate buckets for native oysters, scallops and slipper limpets, scientific officers sorted through the sample to check for all species of bycatch per site.

These were placed in a separate bucket which was added to as species were observed in the catch. Photographs were taken of species when it wasn't possible to identify them on the spot.

The values for all measurements recorded were relayed verbally to a member of staff in the wheelhouse who was recording the data into a Microsoft Excel spreadsheet.

2.6 Data handling

Data was entered *in situ* into a recording sheet which was set up in Microsoft Excel. This enabled data to be easily transferred into data analysis Excel spreadsheets in the office.

The measurements for oysters were tallied into four size ranges (≥ greater than or equal to, ≤ less than or equal to);

- ≥ 65 mm
  Oysters of a size to be fished this season. Currently oysters removed from the fishery must not pass through a ring of 67 mm.
- ≥ 50 to ≤ 64 mm
  Oysters of a size likely to enter the fishery within the next two seasons.
- ≥ 35 to ≤ 49 mm
  Small oysters unlikely to attain fishable size within the next two seasons.
- ≤ 35 mm
  Spat, oysters spawned within the last 18 months. It is acknowledged that oysters of this size are not efficiently sampled using this method.

The measurements for scallops were tallied into seven size ranges;

- ≥ 80 mm
- ≥ 70 to ≤ 79 mm
- ≥ 60 to ≤ 69 mm
- ≥ 50 to ≤ 59 mm
- ≥ 40 to ≤ 49 mm
- ≥ 30 to ≤ 39 mm
- ≤ 29 mm

2.7 Data analysis

From the oyster and scallop tally data, abundances (actual and as a proportion of the total) were calculated, and size frequency distributions for the three sections were calculated and graphed. The average size (mm) and the average number of oysters and scallops for each of the three sections were calculated. The analysis was split into geographic sections; H, OH and R sections and management areas; Areas A, B and C.

All photographs taken as part of the survey were transferred to Cornwall IFCA's servers, labelled with the survey name, date, site number and replicate, [Name]_[Date]_[Site]_[Photograph Reference] ([Replicate]).jpg, e.g. FOS_20190115_22OH_DSCF3391 (2).JPG and filed. To compare the dredge sample photographs across 2014, 2015, 2016, 2017, 2018 and 2019 a document was created with a page per site and site survey photos alongside one another, for all 83 sites surveyed in at least one of those years. This was used for a visual comparison of the site characteristics and sample volume. An example is shown in Annex 2.

The GPS derived locations of all sample sites were plotted in MapInfo Pro Version 17.0 over hydrographic charts of the area. For the North and East Bank sites, where dredge samples were arranged in a dense grid, density maps were created for oyster, scallops and slipper limpets. Density maps were not created for the R section (except the sites around Turnaware Point which were included in the East Bank sites) as the R section survey sites are randomly spaced along the stretch of river between Turnaware and Malpas and not in a grid pattern which is used in other sections of the survey area. The mooring areas around Mylor were deliberately excluded from the density maps as there is a small area which includes the marina and the moorings that does not have classification as a bivalve mollusc production area. Therefore this area is not fished and not sampled. Oyster, scallop and slipper limpet densities per sample were converted to densities per 10 m^2. Vertical Mapper Version 3.7 and Mapinfo Pro Version 12.0 were used to create a colourised grid of the selected values from each sample station. The colourised grid was generated by using the Natural Neighbour interpolation function. A pre-generated standardised .vcp colour palate was applied to the grid to allow the corrected density contouring to be viewed. This was used across all density grids. From this modified colourised grid, it was possible to estimate the distribution of oyster and scallop size-classes within the fishery, identify hotspots and make a comparison with previous years. The same approach was applied to the substrate data to create plots showing areas of high and low distribution of mud, shell and mixed sediment.

The oyster and scallop size composition charts were produced using the Thematic Mapping function in Mapinfo Pro Version 12.0. The size frequency data for each sample station were grouped into four size ranges for oysters (≥65 mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤34 mm) and seven size ranges for scallops (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) . This data was then used to calculate the proportion of each size range of the whole sample at each site. The data was displayed as pie charts with the size of the pie chart being indicative of the overall oyster abundance at each station.

Pie charts were also created for the bycatch species for families of species which were thought to have an influence on the oyster and scallop distribution. Families included were Arthropods, Molluscs, Porifera, Tunicata and all other families

3 Results

3.1 Survey stations and survey area

A number of the original 95 sample sites have been dropped during recent years due to sensitive habitats or sample replication. The dropped sites are located in the OH section where live maerl has been recorded and in the R section where sites were originally clustered together. A total of 83 sites were completed in 2019 (Table 2). The positions of the survey stations surveyed during the 2019 survey are shown in Figure 7 and in more detail in Annex Table A.

Table 2: The number of sites surveyed from 2015 to 2019 during the Fal oyster survey.

Year	Number of sites surveyed
2019	83
2018	83
2017	80
2016	89
2015	79

3.2 Previous survey metadata

The time of year that previous surveys have been carried out has varied (Table 3) but they are usually completed in the second half of the oyster fishery season. The timing of the 2019 survey was consistent with previous years and carried out in mid-January. The survey is normally planned over consecutive days for consistency.

Table 3: Dates of previous Fal oyster surveys from 2015 to 2019 during the Fal oyster survey.

Year	Dates of surveys
2019	15th to 18th January
2018	9th to 13th January
2017	22nd to 24th January
2016	17th to 19th January
2015	11th to 18th February

A summary of the dates of the survey, the sites sampled and the members of staff on each survey day are shown in Table 4. The daily logs are shown in Annex Table B, Annex Table C, Annex Table D and Annex Table E.

Table 4: A summary of the dates, sites completed and the staff involved in the Fal oyster survey 2019.

Date	Sites Completed	Number of completed sites	CIFCA staff	Skipper	Visitors
15/01/2019	OH 16_A, OH 18_B, OH 44_B H 51_B, H 57_B, H 62_B, H 75_B, H 76_B, H 77_B, H 78_B, H 86_B, H 93_B, H 94_B, H 99_B, H 100_B, H 105_B, H 106_B, H 111_B, H 123_B,	19	Colin Trundle, Annie Jenkin, Steph Sturgeon, Hilary Naylor, Kate Owen	Chris Lowe	None
16/01/2019	H 63_B, H 64_B, H 65_B, H 72_B, H 73_B, H 74_B, H 79_B, H 80_B, H 83_A, H 84_A, H 85_B, H 88_C, H 89_A, H 92_B, H 97_B, H 98_B, H 103_B, H 104_B	18	Colin Trundle, Annie Jenkin, Steph Sturgeon, Kate Owen	Chris Lowe	Kate Sugar (Natural England)
17/01/2019	H 23_A, H 22_A, H 45_A, H 46_A, H 47_A, H 52_A H 53_A, H 54_A, H 55_A, H 56_A, H 58_A, H 59_A, H 60_A, H 61_A, H 109_B, H 110_B, OH 19_A, OH 20_A, OH 21_A	19	Colin Trundle, Annie Jenkin, Steph Sturgeon, Kate Owen	Chris Lowe	None
18/01/2019	H 48_A, H 49_A, H 50_A, H 66_A, H 67_A, H 68_A, H 69_A, H 70_A, H 71_A, H 81_A, H 82_A, H 24_C, H 87_B, R 26_C, R 27_C, R 28_C, R 29_C, R 30_C, R 31_C, R 32_C, R 33_C, R 34_C, R 36_C, R 40_C, R 41_C, R 42_C, R 43_C,	27	Colin Trundle, Annie Jenkin, Steph Sturgeon, Hilary Naylor, Kate Owen	Chris Lowe	Matt Slater (Cornwall Wildlife Trust)

An invitation to join the survey was sent out to a number of organisations in Cornwall and the offer was taken up by Natural England and Cornwall Wildlife Trust.

A chart showing the geographic areas H, OH and R is shown in Figure 5 and the management areas A, B and C is shown in Figure 6. Area A represents North Bank, Mylor Bank and Parsons Bank, Area B represents East Bank and St Just flats and Area C represents the area north of a line drawn due east from Pill Point to the coast on Turnaware Point.

A total of 83 sites were surveyed, 63 were in the H section, 6 in the OH section and 14 in the R section, as shown in Figure 7.

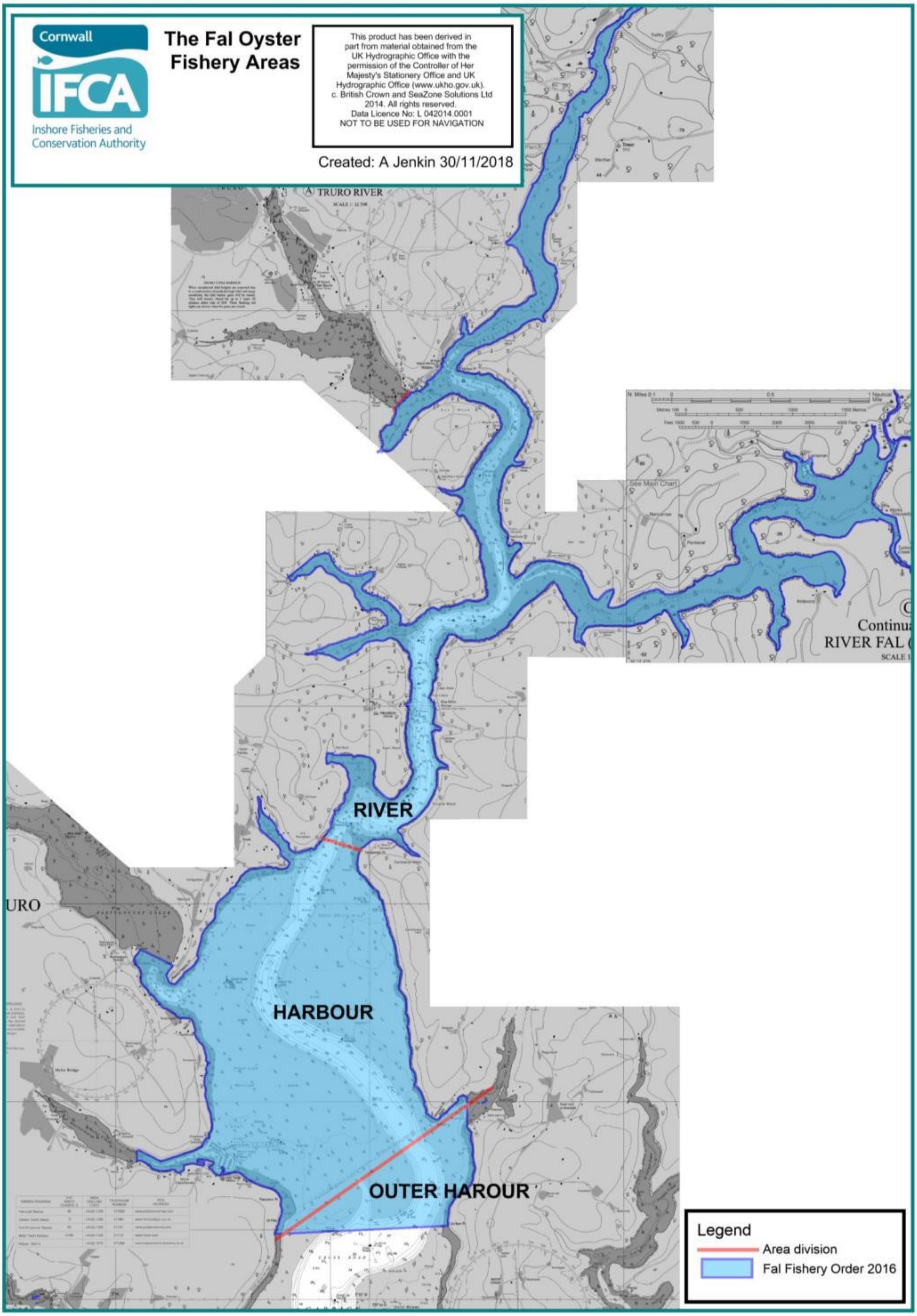


Figure 5: The River, Harbour and Outer Harbour areas of the Fal oyster survey.

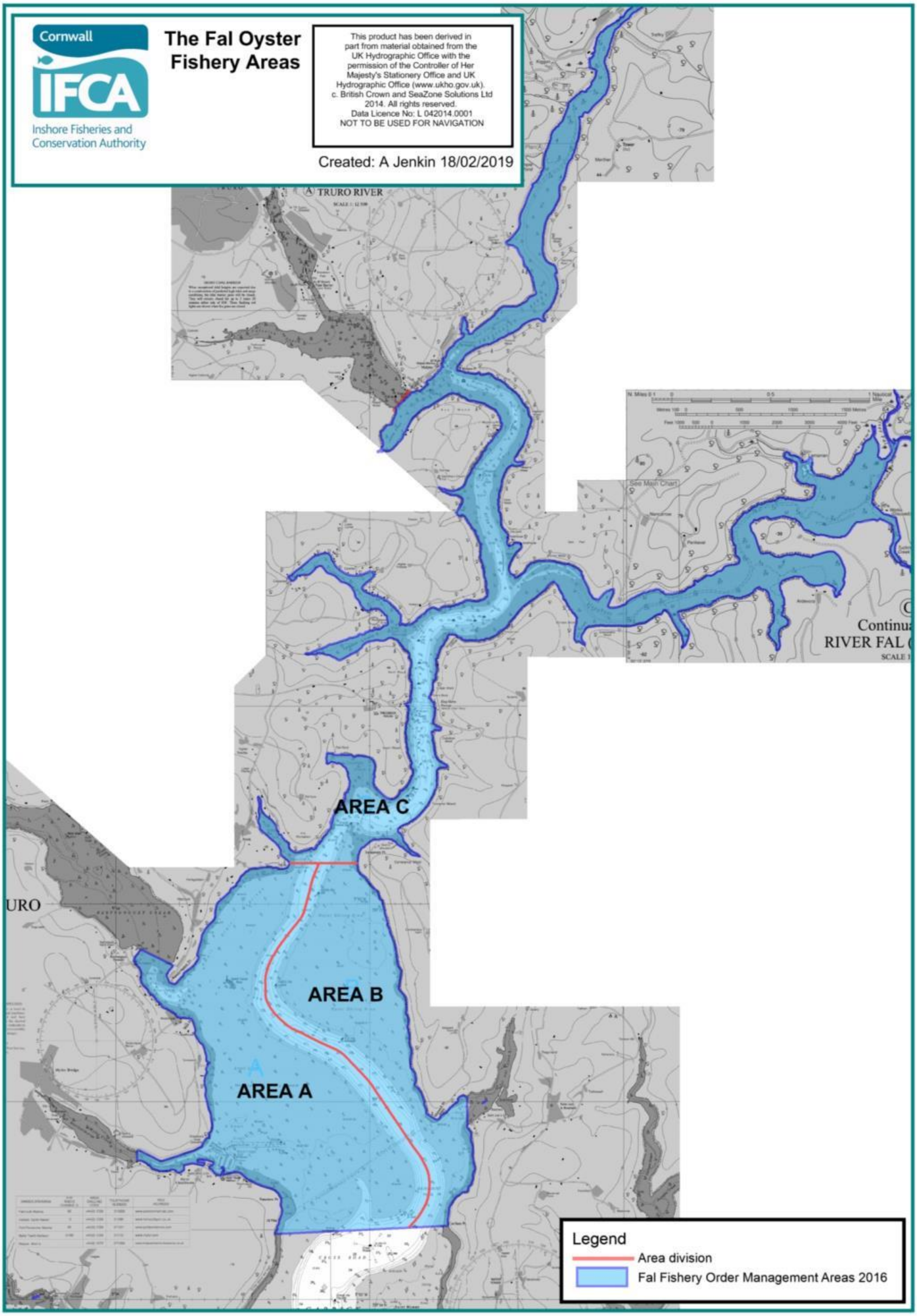


Figure 6: The management areas, Area A, B and C of the Fal oyster survey.

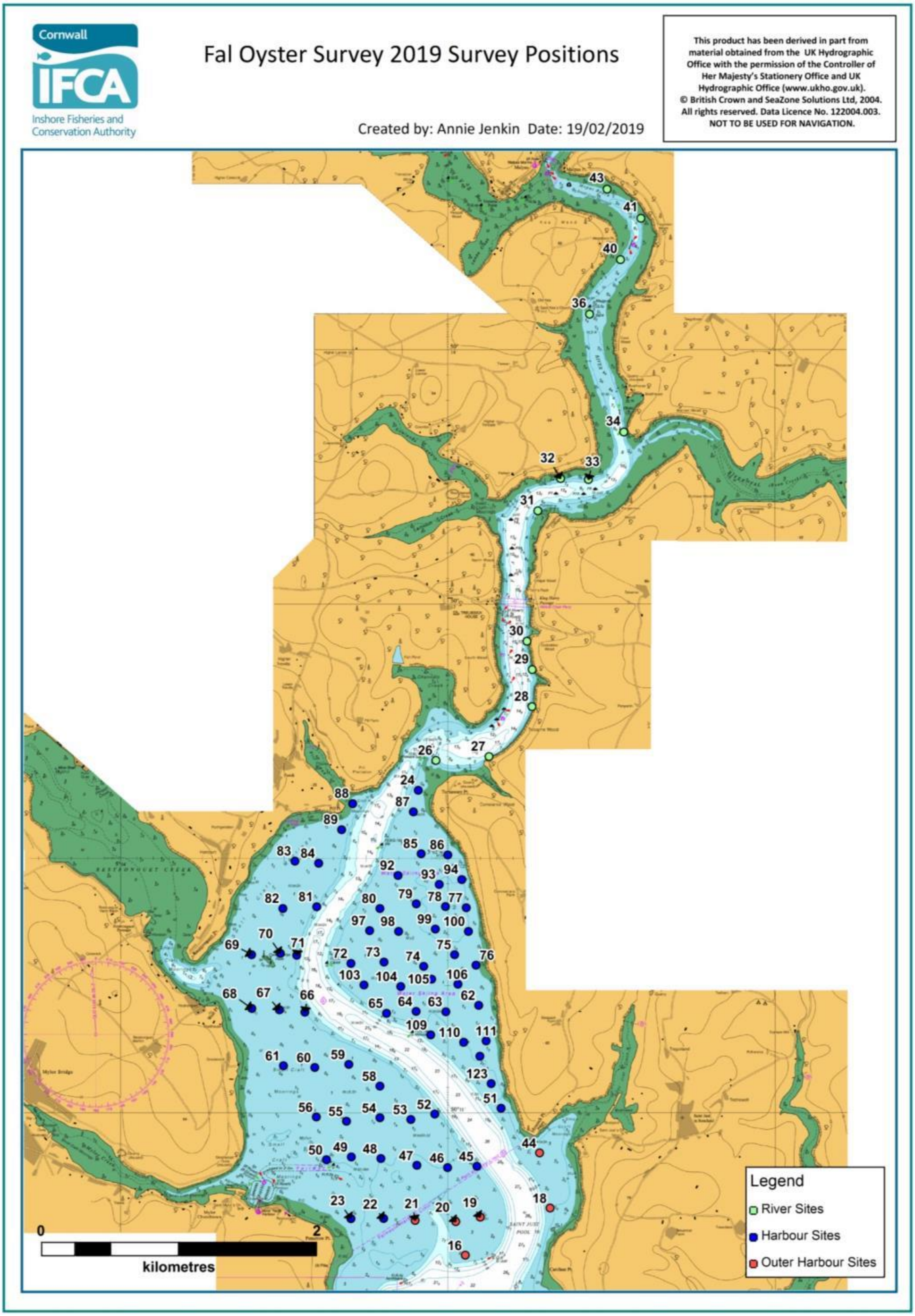


Figure 7: The Fal Oyster Survey area and survey stations in the Fal (Outer Harbour, Harbour and River areas) from the 2019 survey.

Of the 83 sites, valid tows were completed at all sites. The dredge flipped over at three sites (H52, R41 and R31) and the tow had to be repeated.

Visual comparison of the survey photos from 2014 to 2019 indicates that the dredged volumes for samples are reasonably consistent between the surveys, despite the slight change in dredging method between 2014 and 2015 and the revised method in 2017.

3.3 Native oysters (*Ostrea edulis*)

In total, 1,710 oysters were measured and recorded. Previous oyster counts are shown in Table 5. The number of survey stations changed year on year so the numbers recorded across the years are not directly comparable. The 2014 data has not been included for further analysis because the method was different and the results are not comparable.

Table 5: The number of native oysters (*Ostrea edulis)* recorded during the Fal oyster survey between 2015 and 2019

Year	Number of native oysters	Number of sites sampled
2019	1,710	83
2018	1,501	83
2017	1,481	80
2016	1,665	89
2015	769	79

3.3.1 Oyster Size Class Composition

The total number of native oysters has varied by size class year by year (Figure 8). The size classes used were ≤ 35 mm, ≥36 to ≤49 mm, ≥50 to ≤64 mm and ≤65 mm. The number of oysters in the ≥65 mm and ≥50 to ≤64 mm size classes increased steadily from 2015 to 2019. For the ≥65 mm size class the number of oysters increased from 502 in 2016 to 683 in 2019 and in the ≥50 to ≤64 mm size class the number increased from 272 in 2015 to 751 in 2019. Whereas the number of oysters in the ≥36 to ≤49 mm and ≤35 mm size classes decreased from 2016 to 2019, from 390 in 2016 to 219 in 2019 for the ≥36 to ≤49 mm size class and from 369 to 57 oysters in the ≤35 mm size class.

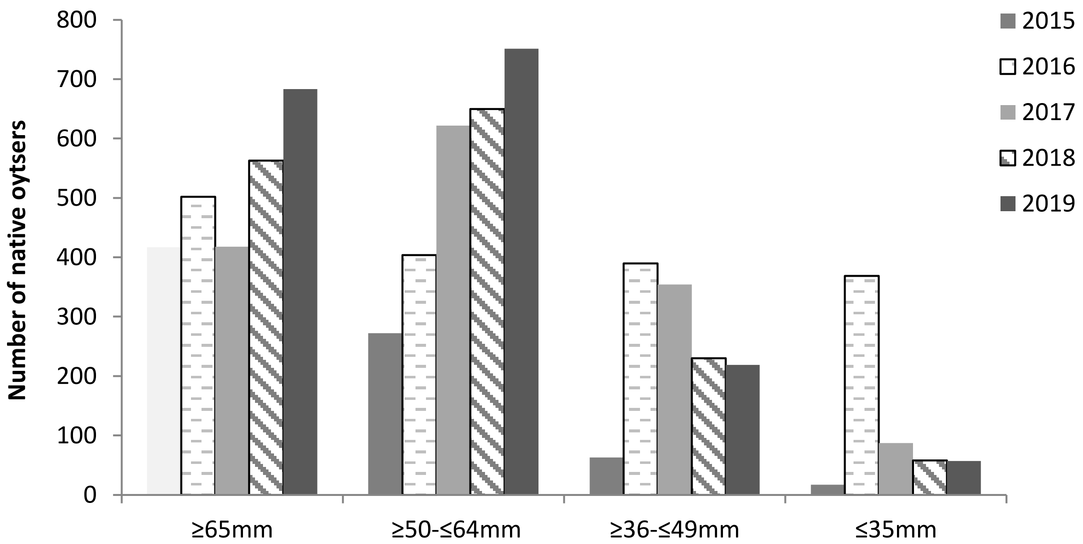


Figure 8: The total number of native oysters (*Ostrea edulis)* per size class (≥65 mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35 mm) from 2016 to 2018.

The size distribution of native oysters by year (2016 to 2019) is shown in Figure 9. The largest oyster recorded during the survey was 116 mm and the smallest was 9 mm. The greatest proportion of oysters from 2017 to 2019 was the ≥50 to ≤64 mm size class, followed by the ≥65 mm size class. The smallest proportion for these three years was the ≤35 mm size class with percentages of 3 % to 5 %. In 2016 the distribution of oysters by size class was more evenly spread. The total number of oysters per size class per site is shown in Annex Table F.

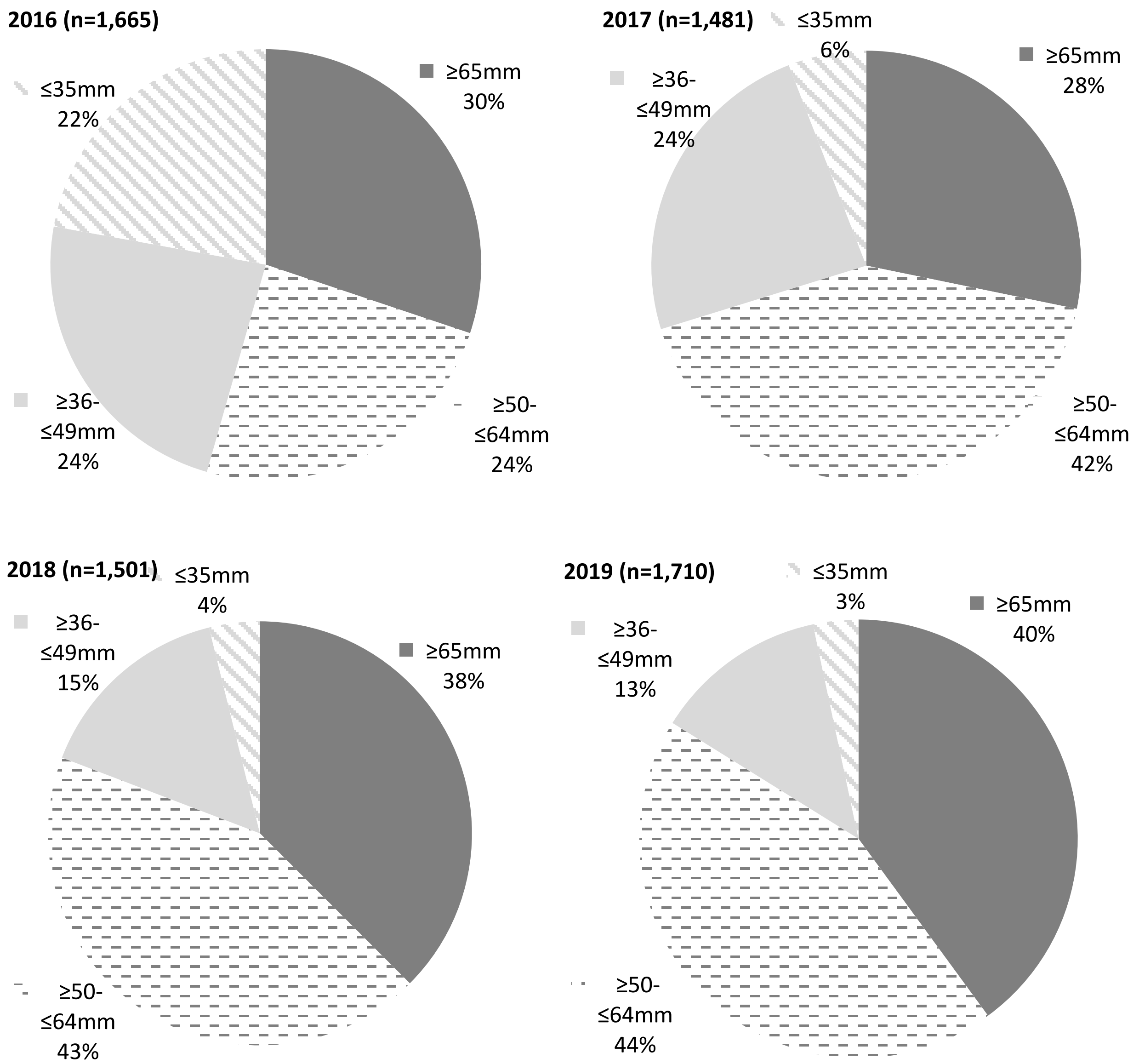


Figure 9: The size class distribution (≥65 mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35 mm) of native oysters (*Ostrea edulis)* from the Fal Oyster Survey in 2016, 2017, 2018 and 2019.

The composition of size classes of oysters for sample sites has varied from 2016 to 2019 (Figure 10 and Figure 11). Most samples contained a range of size classes, but the composition of samples changed year on year. In 2016, the oyster size class composition for most samples consisted of all four size classes including a large proportion of oysters in the ≤35 mm size class. From 2017, the size class composition became dominated by the ≥50 to ≤64 mm size class which was dominant in 2019 along with the ≥65 mm size class which was present in similar quantities. For all four years a very low number of oysters were recorded in the 'basin', an area of deeper water on the East

Bank, this is likely due to be large amounts of red weed (*Soliera chordalis*) in this area reducing the number of oysters. Oysters ≤35 mm were recorded in scattered samples across the fishery in 2019.

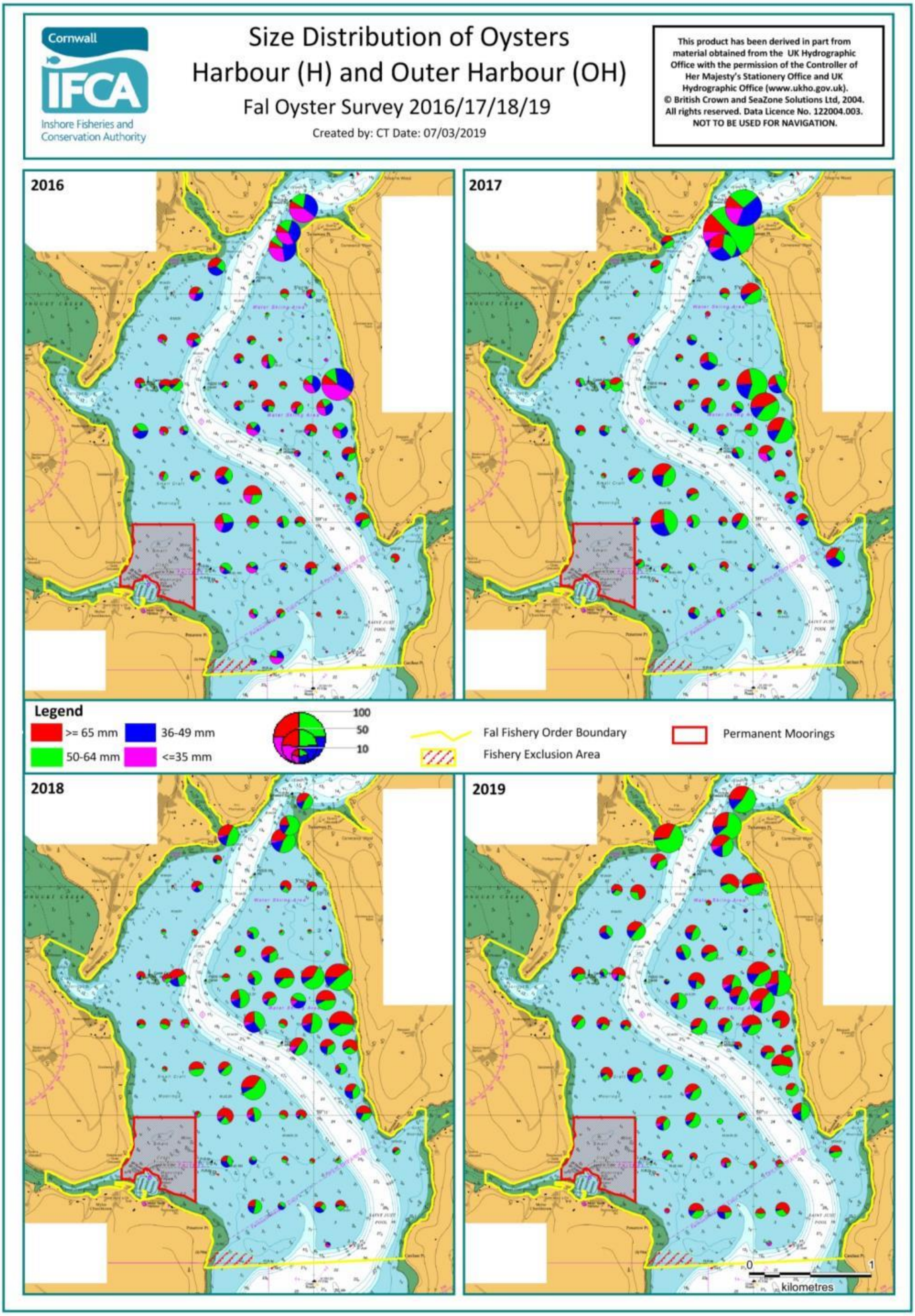


Figure 10: The composition of size classes (≥65 mm, ≥50 to ≤64 mm, ≥36 to ≤49 mm and ≤35 mm) of native oysters (*Ostrea edulis*) per survey station within the Harbour and Outer Harbour sections for 2016, 2017, 2018 and 2019.

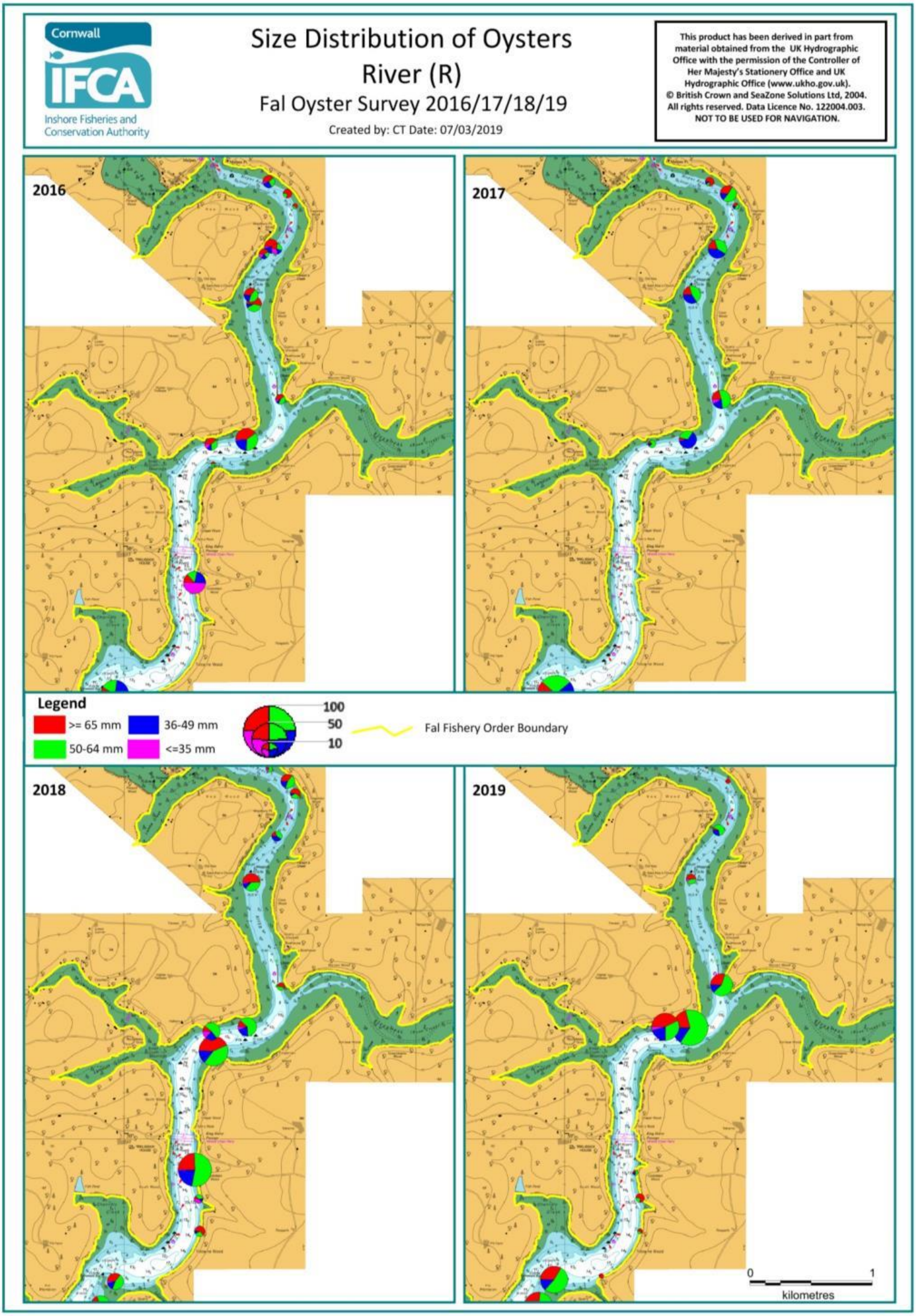


Figure 11: The composition of size classes (≥65 mm, ≥50 to ≤64 mm, ≥36 to ≤49 mm and ≤35 mm) of native oysters (*Ostrea edulis*) per survey station within the River section as surveyed for 2016, 2017, 2018 and 2019.

3.3.2 Density plots

Density plots were created for the total number of oysters per 10 m^2, the number of oysters ≥65 mm per 10 m^2 and the number of oysters between ≥50 to ≤64 mm per 10 m^2 for the H and OH sections of the survey area. Density plots of the R section of the survey area, with the exception of those sites included around Turnaware Point, were not mapped by density due to the lack of samples and their scattered distribution.

Total number of oysters per 10m^2

The distribution of the total number of oysters per 10 m^2 is shown in Figure 12. The distribution of the total number of oysters per 10 m^2 has varied slightly from 2016 to 2019. From 2016 to 2019, areas with a high density (10 oysters per 10 m^2) of oysters were recorded around Turnaware Point, the central part of East Bank and the area directly to the north-east of the moorings in Mylor. In 2019, a high density of oysters (10 oysters per 10 m^2) were recorded off Turnaware Point and the central part of East Bank and the density of oysters along most of the North Bank had increased to 5 oysters per 10 m^2. The total number of oysters has increased since 2015, as much larger areas with distributions of oysters of 5 per 10 m^2 and 10 per 10 m^2 were recorded. The areas with the lowest densities of oysters per 10 m^2 (1 per 10 m^2 or 2.5 per 10 m^2) were the northern and southern parts of North Bank, the area to the south of Turnaware Point and a small area to the south-east of the survey area from 2016 to 2018. In 2019, the area of oysters with a low density were similar, with low numbers recorded in the southern part of the survey area and the area just south of Turnaware Point where the ‘basin’ exists.

Oysters ≥ 65 mm per 10 m^2

The distribution of oysters ≥65 mm per 10 m^2 is shown in Figure 13. In 2016, the density of oysters was low across most of the survey area (1 per 10 m^2 to 2.5 per 10 m^2) with areas of high density (5 oysters per 10 m^2) to the north east of the moorings in Mylor and the central part of East Bank. In 2017, the distribution was similar with an increase in density at Turnaware Point to 5 oysters per 10 m^2. In 2018, the distribution was similar again with an increase in density in the central part of East Bank to 10 oysters per 10 m^2. In 2019, hot spots of very high density (10 oysters per 10 m^2) were no longer present but the density across other areas had increased, such as North Bank and the southern extent of the survey area, which saw an increase to 2.5 oysters per 10 m^2.

Oysters ≥50 to ≤64 mm per 10 m^2

The distribution of pre-recruits between ≥50 and ≤64 mm per 10 m^2 is shown in Figure 14. There was an increase in the density of oysters per 10 m^2 from 2016 to 2017. Areas that had a higher density in 2017 were Turnaware Point, the east side of East Bank and the area north east of the moorings at Mylor which had a density of 10 oysters per 10 m^2. The rest of the survey area had a low density of oysters of 1 per 10 m^2 to 2.5 per 10 m^2. The distribution was similar in 2018. In 2019, similar areas of high density were recorded and additionally there was an increase in the density along the west side of North Bank to 2.5 oysters per 10 m^2 and a slight decrease in the density at Turnaware Point to 5 oysters per 10 m^2.

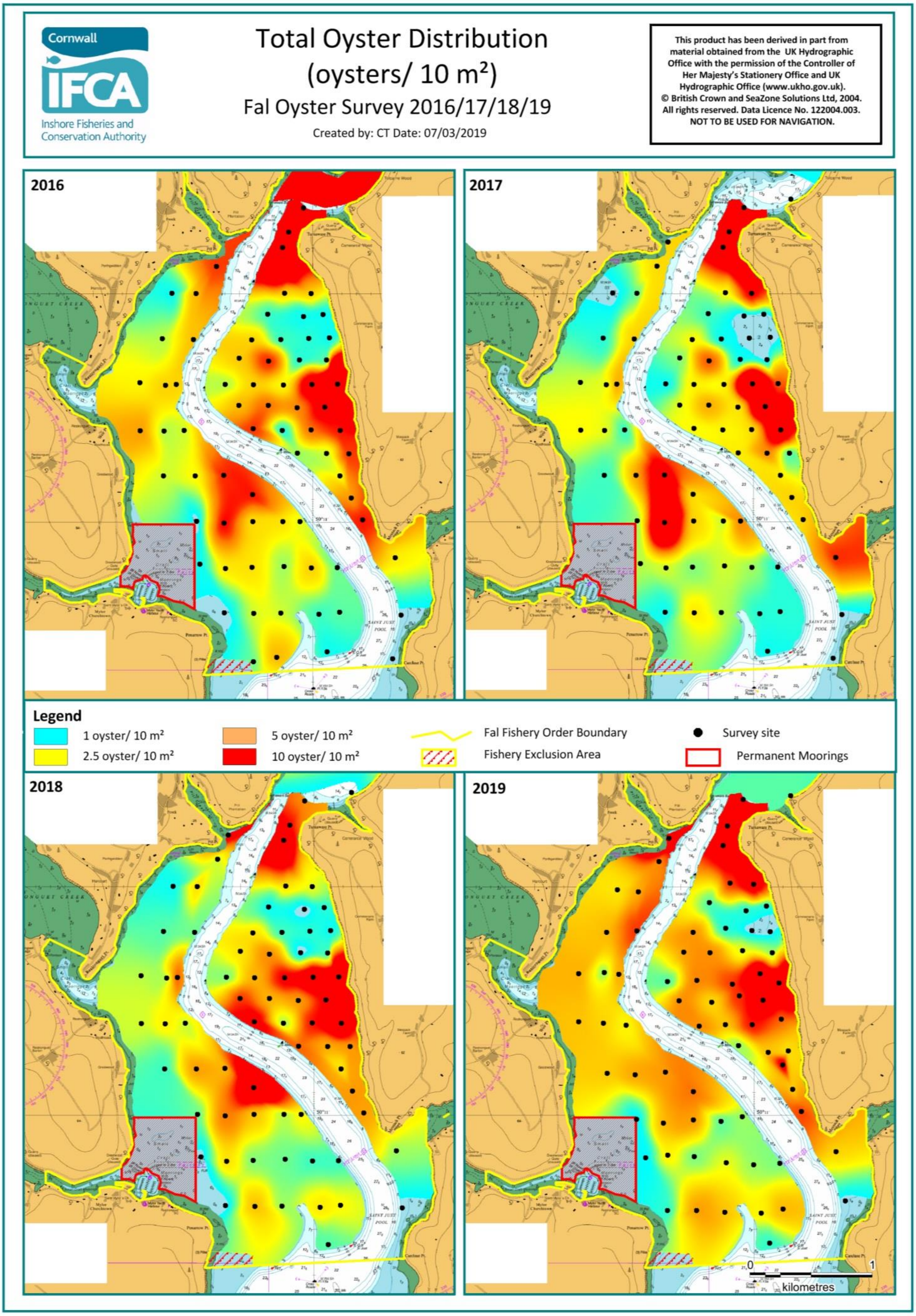


Figure 12: Oyster density map displaying the total number of native oysters (*Ostrea edulis)* per 10 m^2 within the Harbour and Outer Harbour sections for the 2016, 2017, 2018 and 2019 surveys.

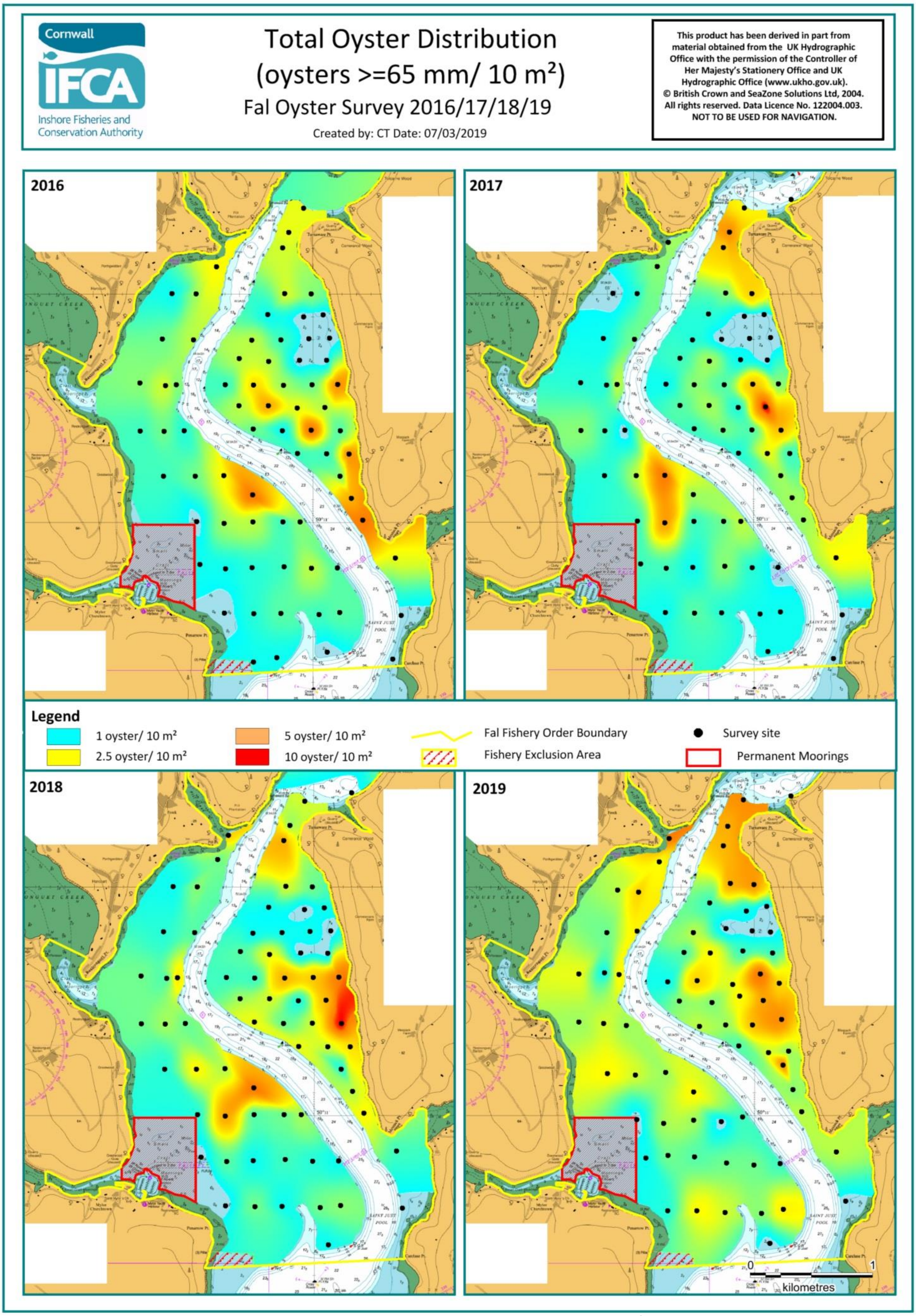


Figure 13: Oyster density maps displaying native oysters (*Ostrea edulis)* ≥65 mm per 10 m^2 within the Harbour and Outer Harbour sections for the 2016, 2017, 2018 and 2019 surveys.

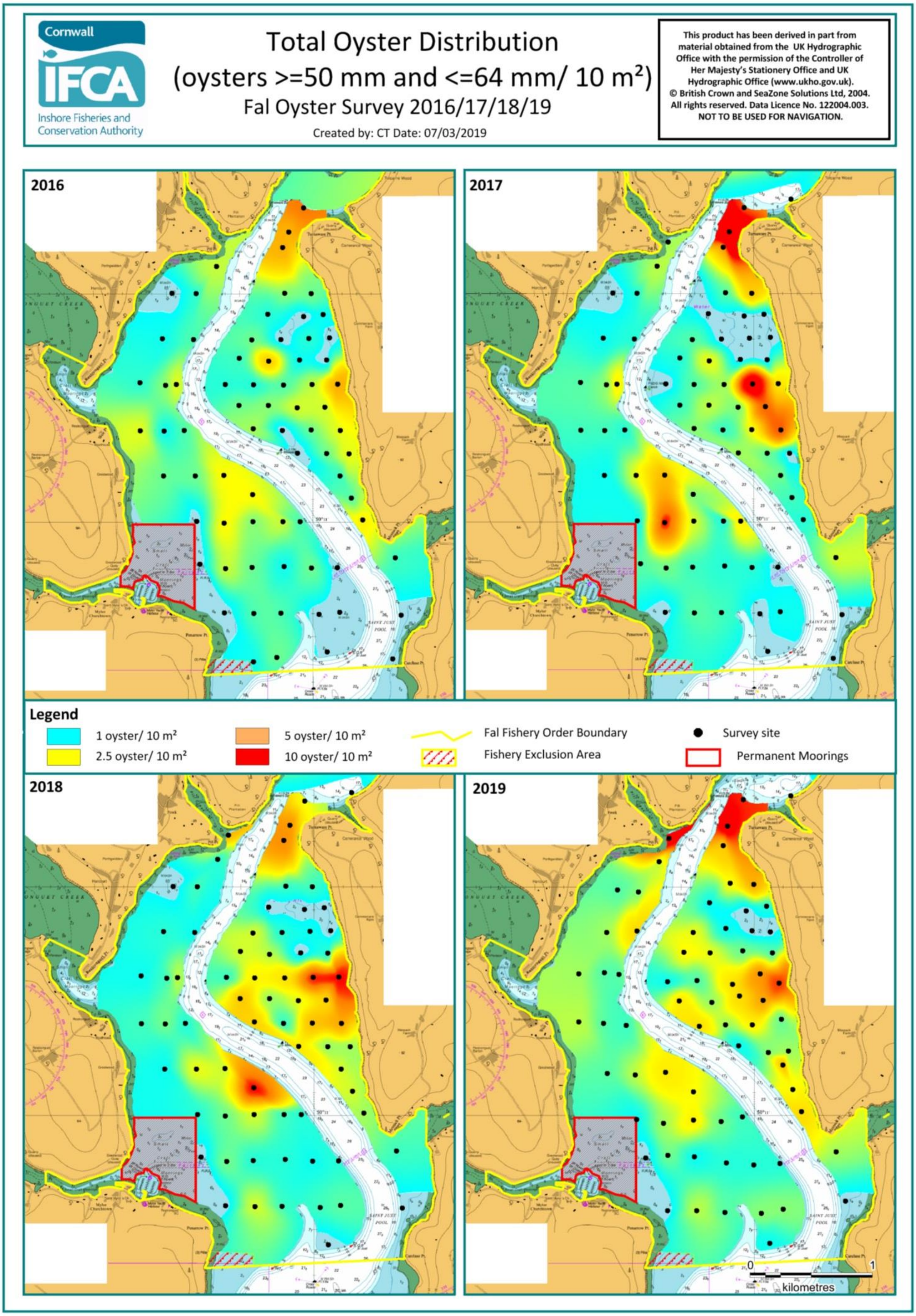


Figure 14: Oyster density maps showing native oysters (*Ostrea edulis)* between ≥50 and ≤64 mm per 10m^2 within the Harbour and Outer Harbour sections for the 2016, 2017, 2018 and 2019 surveys.

3.3.3 Geographical sections

Of the total number of oysters, 68 were from the OH sites; 1,315 from the H section and 327 from the R section. The total number of oysters per site is shown in Annex Table F. The site with the most oysters was R33 (105 oysters) followed by site H88 (73 oysters) and H24 (70 oysters). There were no oysters recorded at five sites (H77, H78, OH18, R31 and R41). Less than ten oysters (≤9) were recorded at 28 of the sites.

3.3.3.1 Average sizes

Table 6 and Figure 15 show the average size (mm) of native oysters recorded in the H, R and OH survey sections from 2015 to 2019.

For all sections of the survey, the average size (mm) of native oysters has fluctuated year by year with a general pattern of a decrease in size from 2015 to 2016 followed by a slow increase from 2016 to 2019. The size of oysters in the H section has increased from 53 mm in 2016 to 62 mm in 2019, 57 mm in 2016 in the OH section to 65 mm in 2019 and from 53 mm in the R section to 61 mm in 2019.

Table 6: The average size (mm) ± standard error of native oysters (*Ostrea edulis)* in the Harbour (H), River (R) and Outer Harbour (OH) sections of the survey from 2015 to 2019.

Year	Harbour	Outer Harbour	River
2019	61.6 mm ± 0.37 mm	64.9 mm ± 1.79 mm	60.7 mm ± 0.68 mm
2018	60.8 mm ± 0.40 mm	59.8 mm ± 2.70 mm	59.4 mm ± 0.71 mm
2017	58.2 mm ± 0.42 mm	61.3 mm ± 2.57 mm	52.0 mm ± 0.78 mm
2016	53.0 mm ± 0.53 mm	57.4 mm ± 2.86 mm	52.8 mm ± 1.02 mm
2015	66.9 mm ± 0.66 mm	75.3 mm ± 2.45 mm	64.3 mm ± 0.94 mm

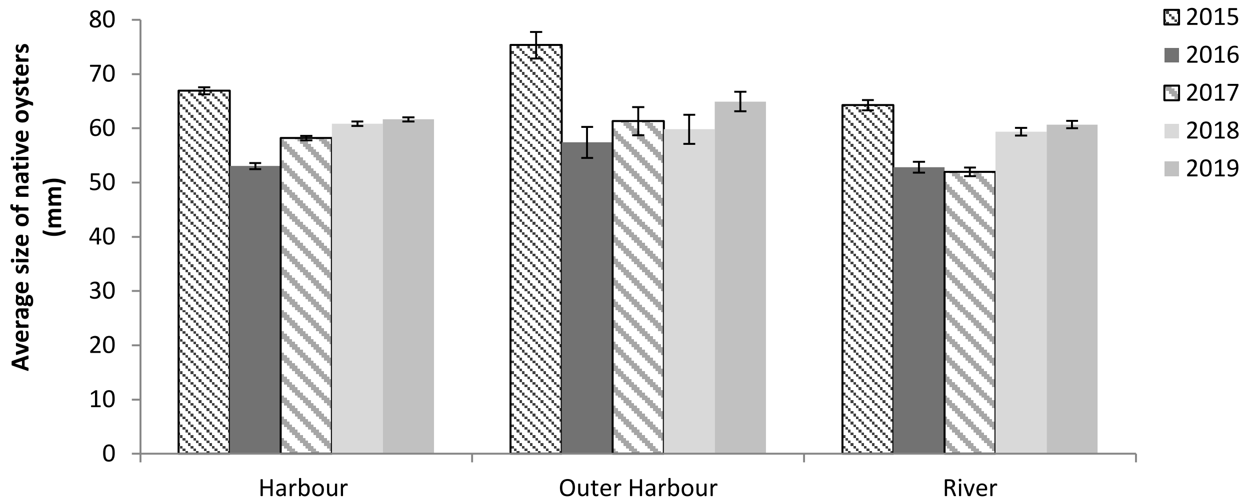


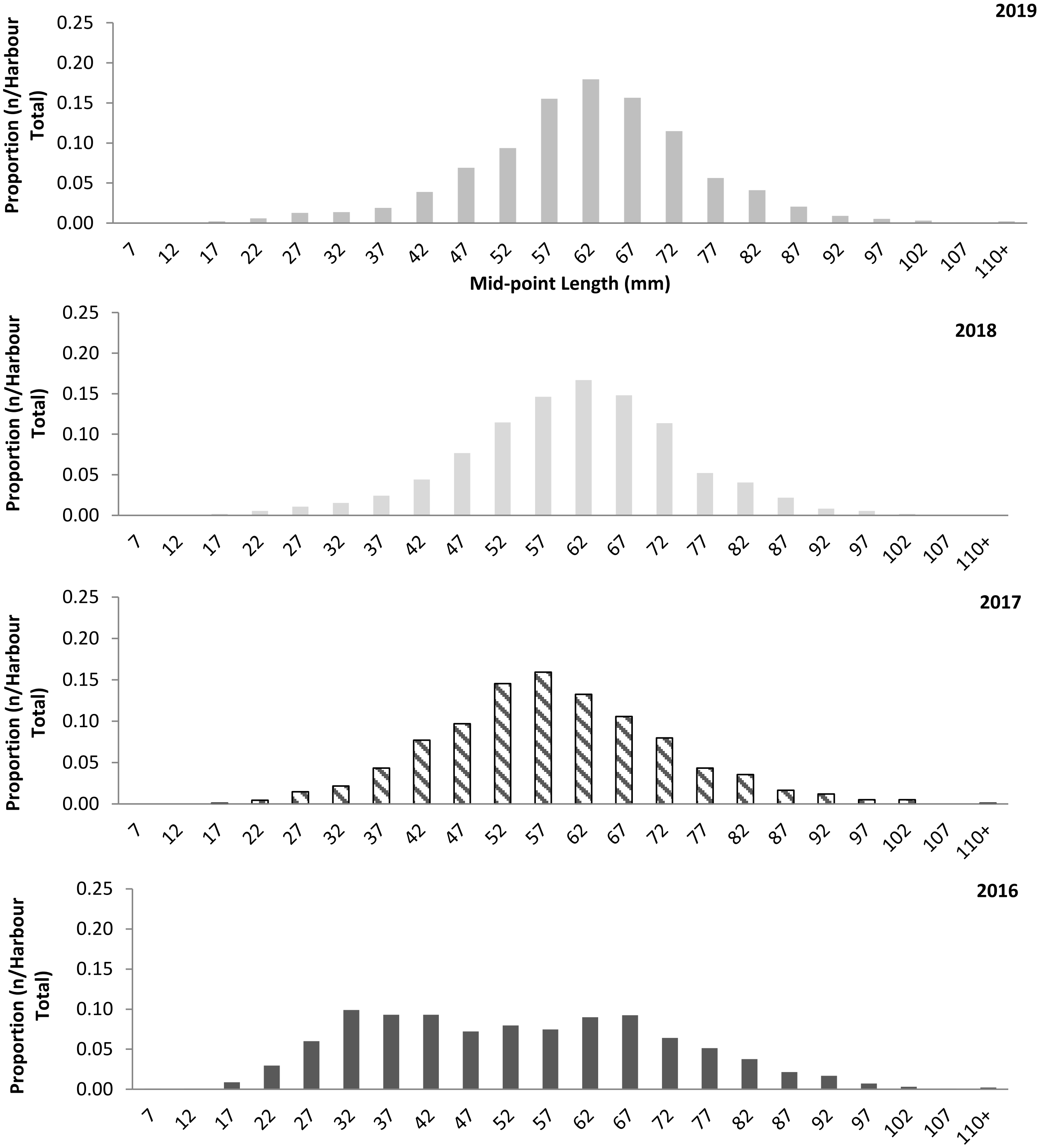
Figure 15: The average size (mm) of native oysters (*Ostrea edulis)* ± standard error for the Harbour, River and Outer Harbour sections of the survey for the years 2015, 2016, 2017 2018 and 2019.

3.3.3.2 Size frequency plots

Size frequency plots for the OH, H and R areas are given below. Care should be taken in the interpretation of the OH plots as the number of samples in this section is low, with only six or seven sites surveyed depending on the year.

The distribution for the H section was unimodal which was the same for all years except 2016 which had a bimodal distribution (Figure 16). The peak frequency was 62 mm in 2019, similar to 2018 and 2015 unlike 2017 when the peak frequency was slightly smaller at 57 mm.

Harbour



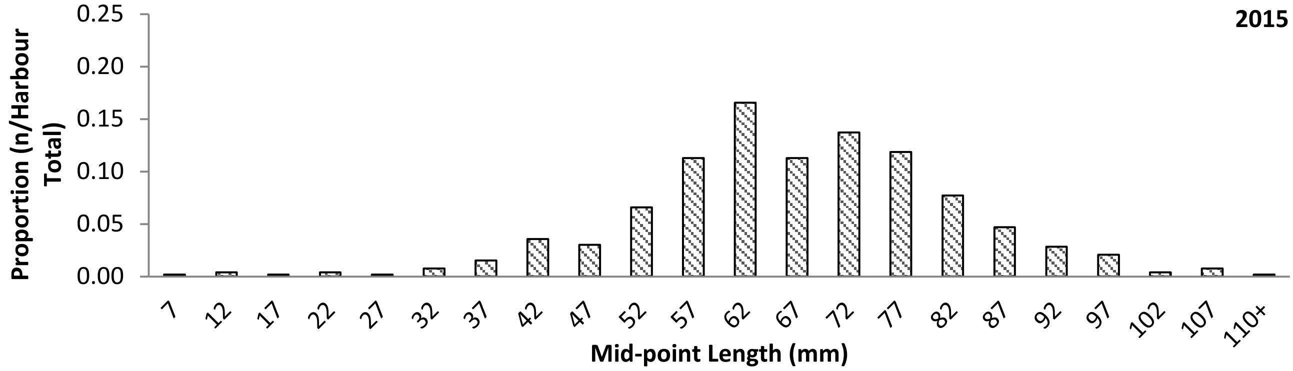
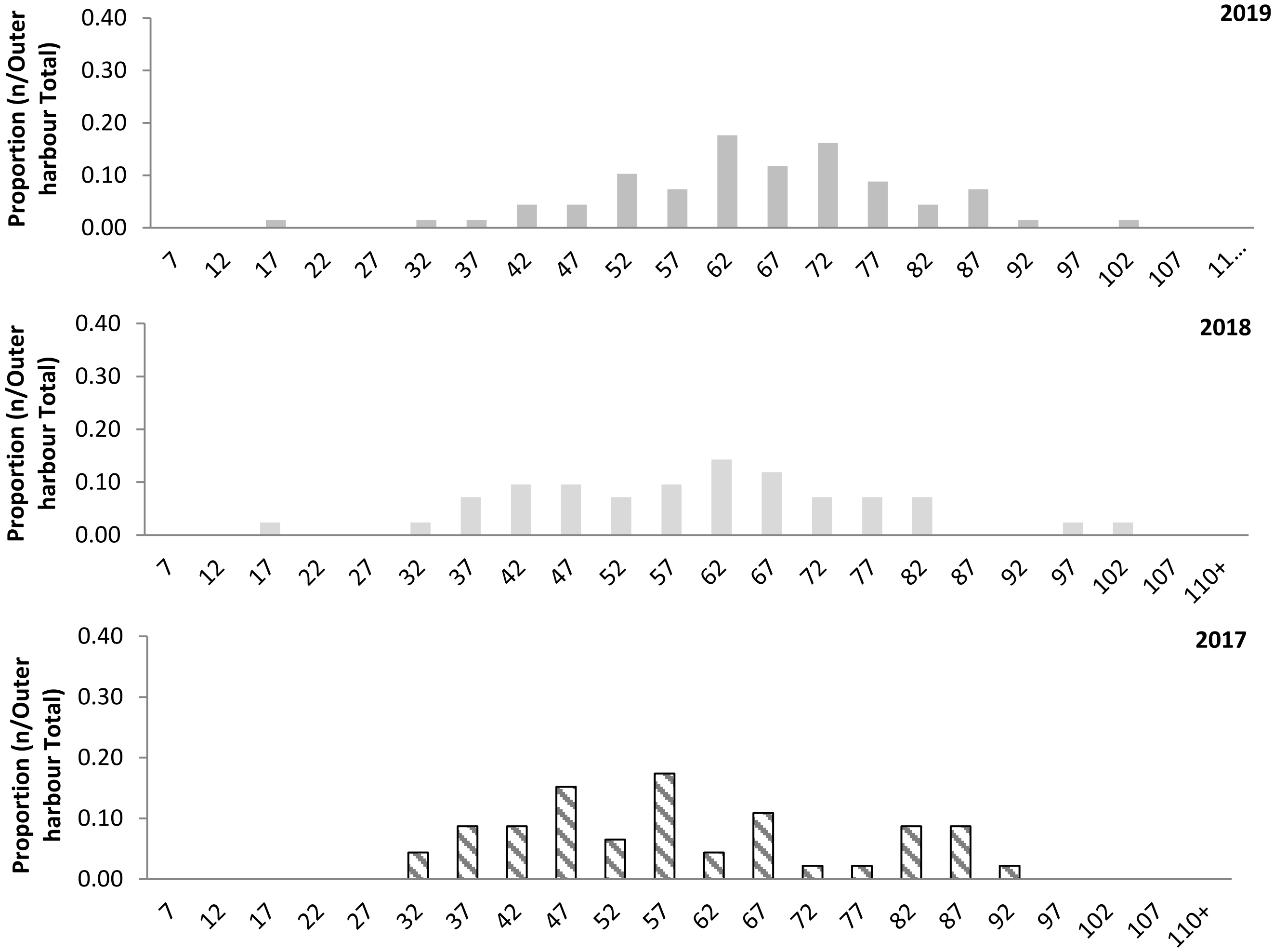


Figure 16: Size frequency distributions for native oysters (*Ostrea edulis)* for the Harbour (H) section of the fishery for 2015, 2016, 2017, 2018 and 2019.

Outer Harbour

For all years the frequency for the OH section is irregular and uneven (Figure 17). This distribution is likely to be caused by the low number of sites sampled (six in 2019 and low numbers in previous years) and the low number of oysters recorded (68) which causes the trend to be inconsistent and less reliable.



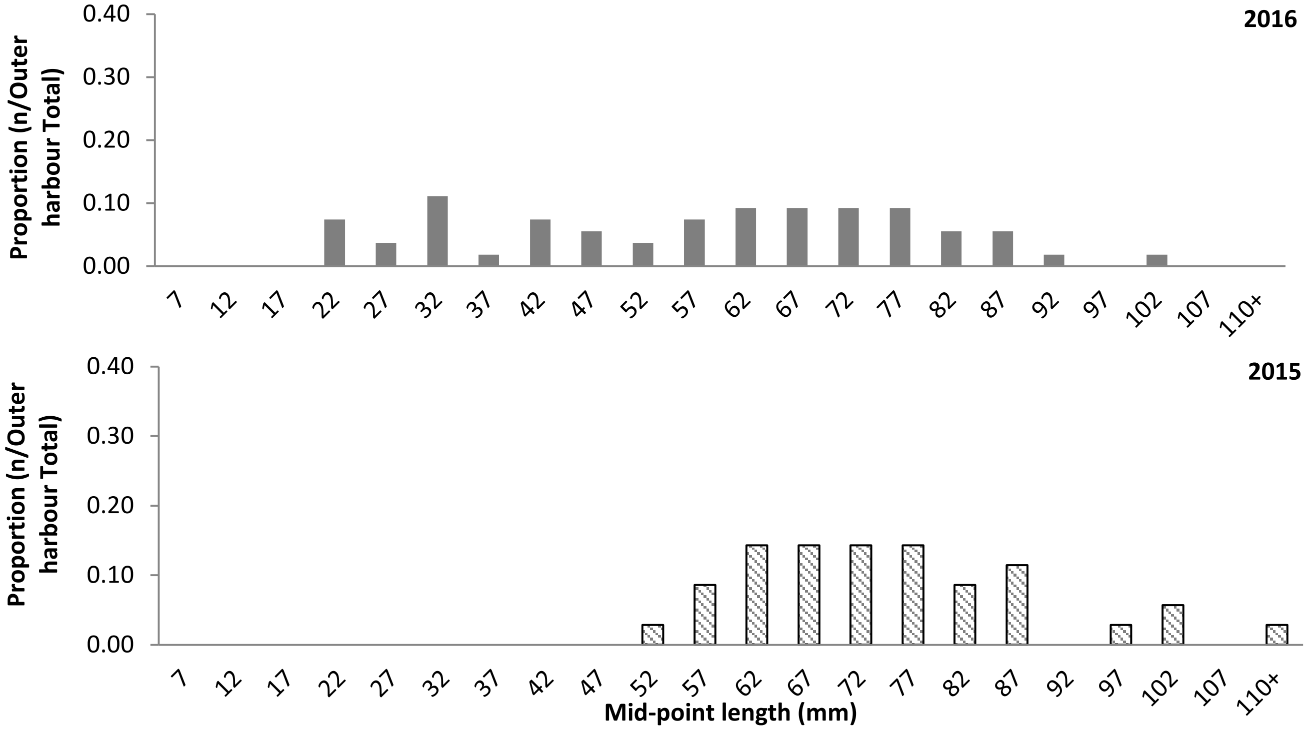
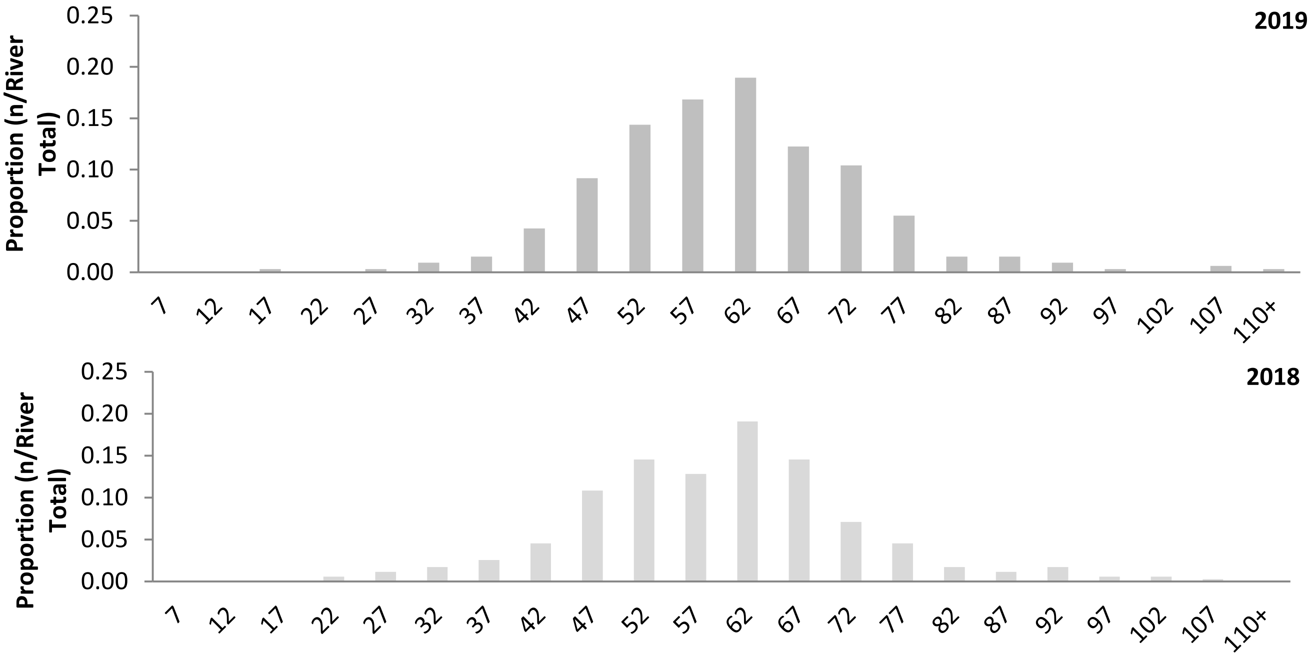


Figure 17: Size frequency distributions for native oysters (*Ostrea edulis)* for the Outer Harbour (OH) section of the fishery for 2015, 2016, 2017 2018 and 2019.

River

The 2019 size frequency data shows a unimodal distribution for the R section (Figure 18) with a peak recorded at 62 mm. This is similar to what was observed in 2015 and 2018, as well as 2017 although the peak was smaller at 47 mm and 52 mm. The distribution in 2016 is different to other years, with an irregular and uneven distribution.



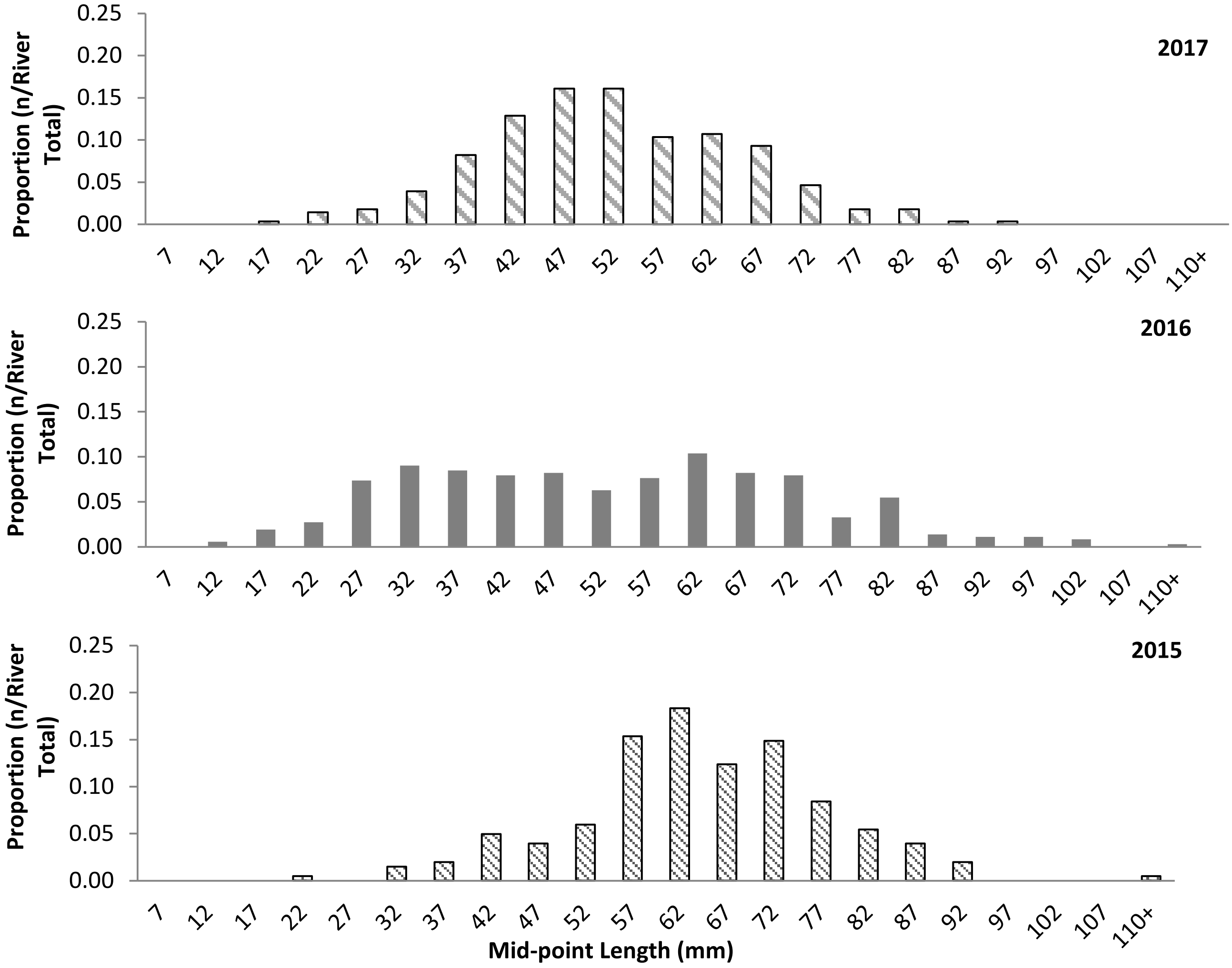


Figure 18: Size frequency distributions for native oysters (*Ostrea edulis)* for the River (R) section of the fishery for 2015, 2016, 2017, 2018 and 2019.

3.3.3.3 Average number

Table 7 and Figure 19 show the average number of native oysters per site recorded in the H, R and OH survey sections from 2015 to 2019.

The average number of native oysters has varied for all three sections of the survey year by year. For the H section, the number increased from 2016 and has remained fairly steady since then with an average of 19.8 in 2016 to 20.9 in 2019. The average number in the OH section has increased steadily from 3.9 in 2015 to 11.3 in 2019. The average number in the R section increased from 18.4 in 2015 to a peak of 28 in 2017 then decreased steadily to 23.4 in 2019.

Table 7: The average number ± standard error of native oysters (*Ostrea edulis)* per site in the Harbour (H), River (R) and Outer Harbour (OH) sections of the survey from 2015 to 2019.

Year	Harbour	Outer Harbour	River
2019	20.9 ± 2.12	11.3 ± 3.28	23.4 ± 8.81
2018	17.6 ± 2.04	7.0 ± 1.91	25.1 ± 7.17
2017	18.3 ± 3.53	6.6 ± 4.52	28.0 ± 10.2
2016	19.8 ± 3.09	6.0 ± 2.17	21.5 ± 6.61
2015	9.0 ± 1.22	3.9 ± 1.35	18.4 ± 4.36

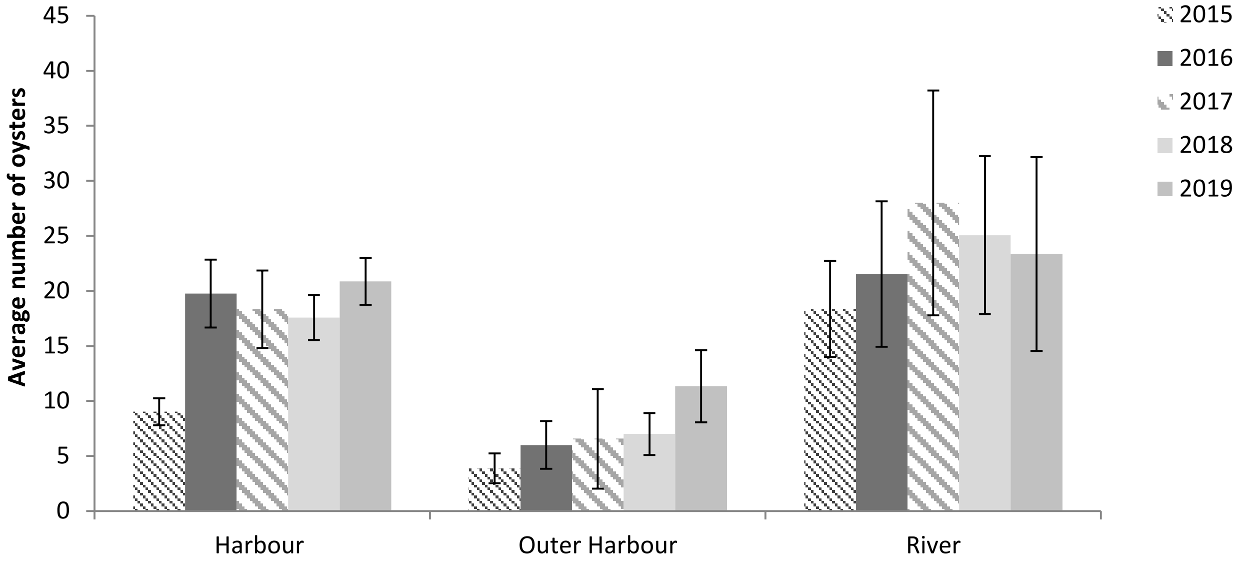


Figure 19: The average number of native oysters (*Ostrea edulis)* per dredge sample ± standard error for the Harbour, River and Outer Harbour sections of the survey for the years 2015, 2016, 2017 2018 and 2019.

3.3.3.4 Density

The density of oysters per 10 m^2 for 2019 for all three geographic areas is shown in Figure 20. The density of oysters per 10 m^2 was highest in the R section for all four years and lowest in the OH section. An increase was observed from 2015 to 2019 in the OH section. The density in the R section increased from 5.10 oysters per 10 m^2 in 2015 to 7.78 oysters per 10 m^2 2017 and decreased to 6.49 oysters per 10 m^2 in 2019. The density in the H section increased from 2015 to 2016 and has fluctuated since with a value of 5.80 oysters per 10m2 recorded in 2019.

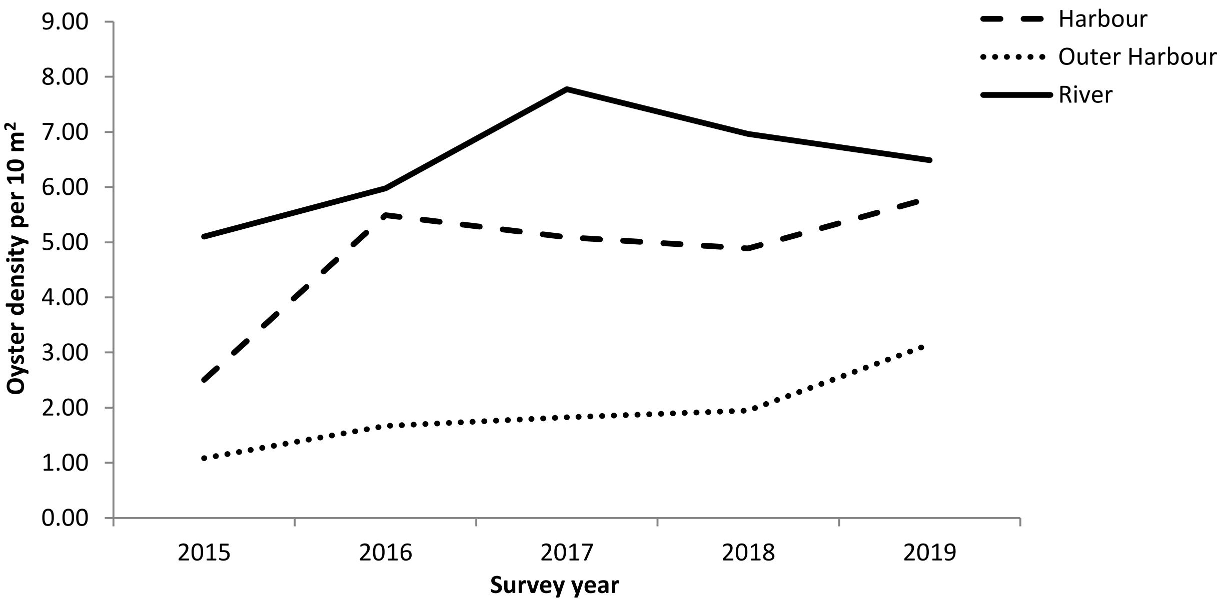


Figure 20: The density of native oysters (*Ostrea edulis)* per 10m^2 for the three geographic areas (harbour, outer harbour and river) from 2015 to 2019.

The density of oysters per 10 m^2 for 2019 for all three geographic areas by size class is shown in Figure 20. The densities of oysters in the two smallest size classes were lower than the largest size classes. In the H section the density of oysters in the two smallest size classes increased from 2015 to 2016 and has decreased since. The density of oysters in the larger size classes increased from 2017 to 2019 for the ≤65 mm class and for the ≥50 to ≤64 mm the value increased from 2015 to 2017, dipped slightly in 2018 and increased again 2019.

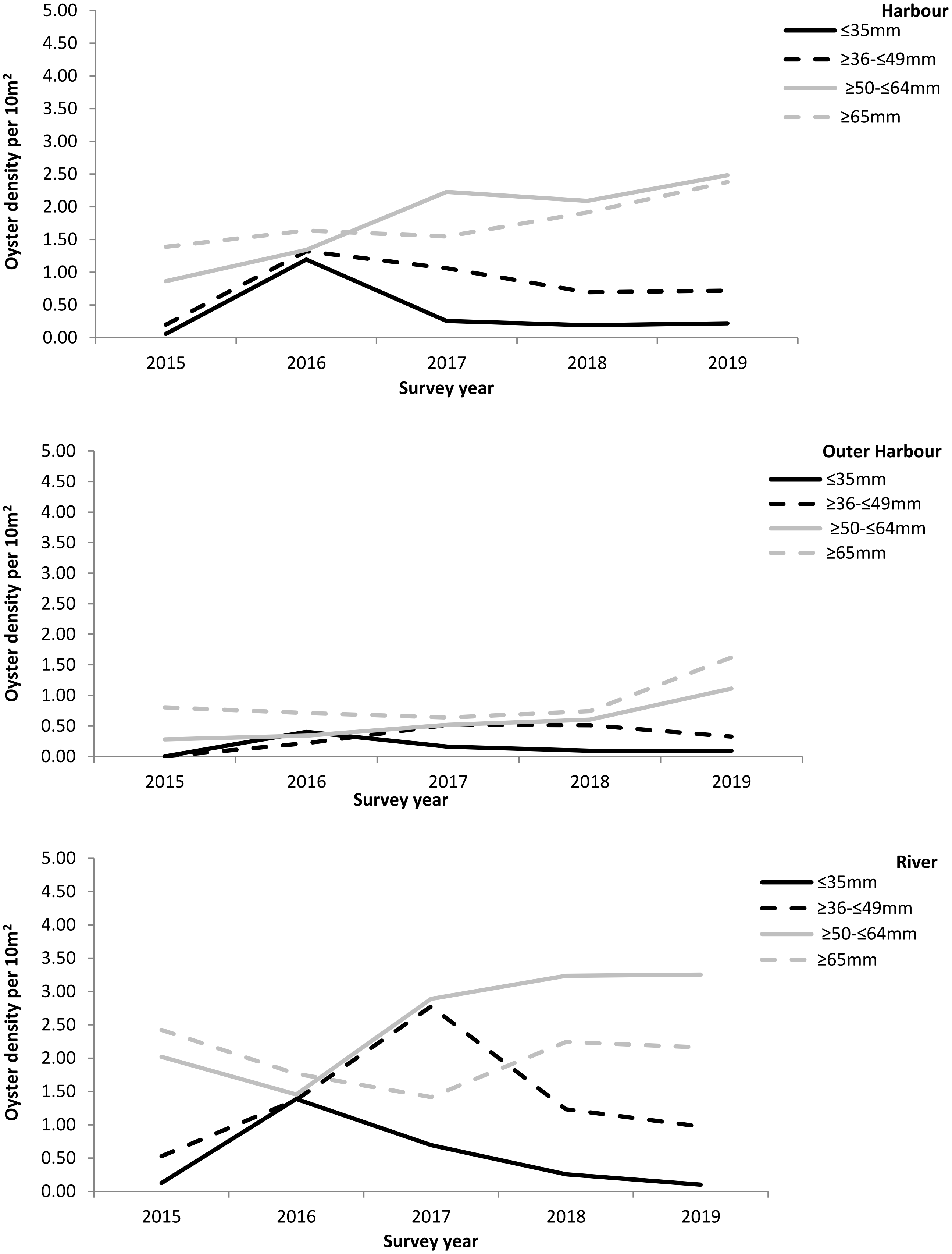


Figure 21: The density of native oysters (*Ostrea edulis)* per 10m^2 for the three geographic areas (harbour, outer harbour and river) by size class from 2015 to 2019.

3.3.3.5 Oyster Size Class Composition

The size class which made up the largest percentage of the total number of oysters was ≥50 to ≤64 mm (43.9%), then ≥65 mm (39.9%), ≥36 to ≤49 mm (12.8%) and the smallest percentage was the ≤35 mm size class (3.3%). When split by size class and section, the total number of oysters for all of the size classes was highest in the H section and lowest in the OH section (Table 8). The total number of oysters per section by size class was highest in the H section for the ≥50 to ≤64 mm size class (563) and in the ≥65 mm size class (539) and lowest in the OH section for the ≤35mm size class (2). These patterns are the same as was recorded during the 2018 survey.

Table 8: The number of native oysters (*Ostrea edulis)* recorded in the Harbour (H), Outer Harbour (OH) and River (R) sections recorded by total number, total number of oysters ≥65 mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35 mm during the Fal oyster survey 2019

Section	Total number of oysters	≥65 mm	≥50-≤64 mm	≥36-≤49 mm	≤35 mm
Harbour	1,315	539	563	163	50
Outer Harbour	68	35	24	7	2
River	327	109	164	49	5

When split by size class and section, the average number of oysters was highest in the R section and lowest in the OH section (Table 9). The average number of oysters per section by size class was highest in the R section for the ≥50 and ≤64 mm size class (11.7) and lowest in the OH section for the ≤35 mm size class (0.3). This pattern is the same as the observations in 2018.

Table 9: The average number of native oysters (*Ostrea edulis)* recorded in the Harbour (H), Outer Harbour (OH) and River (R) sections and by each size class ≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35 mm during the Fal oyster survey 2019.

Section	The average number of oysters	≥65 mm	≥50-≤64 mm	≥36-≤49 mm	≤35 mm
Harbour	20.9	8.6	8.9	2.6	0.8
Outer Harbour	11.3	5.8	4.0	1.2	0.3
River	23.4	7.8	11.7	3.5	0.4

The total number of native oysters per section by size class has varied by size class year by year (Figure 22). Noticeably the number of oysters in the smallest size class (≤35 mm) decreased from 2016 to 2017 and then remained low, level or decreased slightly year on year for all three sections.

For the H section, the total number of oysters has increased from 2015 to 2019 in the ≥65 mm and ≥50-≤64 mm size classes and decreased from 2016 to 2019 for the ≥36-≤49mm and ≤35 mm size classes. In the OH there was a marked increase in the number of oysters in 2019 compared to previous years for both the larger size classes of oyster (≥65 mm and ≥50-≤64 mm). The number of oysters in this section for the ≥36-≤49 mm size class decreased steadily from 2017 to 2019 and for the smallest size class of oysters there was a marked decrease from 2016 to 2017 and then the number levelled out since then.

The total number of oysters in the R section has remained steady for the total number of oysters recorded in 2018 for the two largest size classes and has decreased in number for the two smallest size classes of oyster.

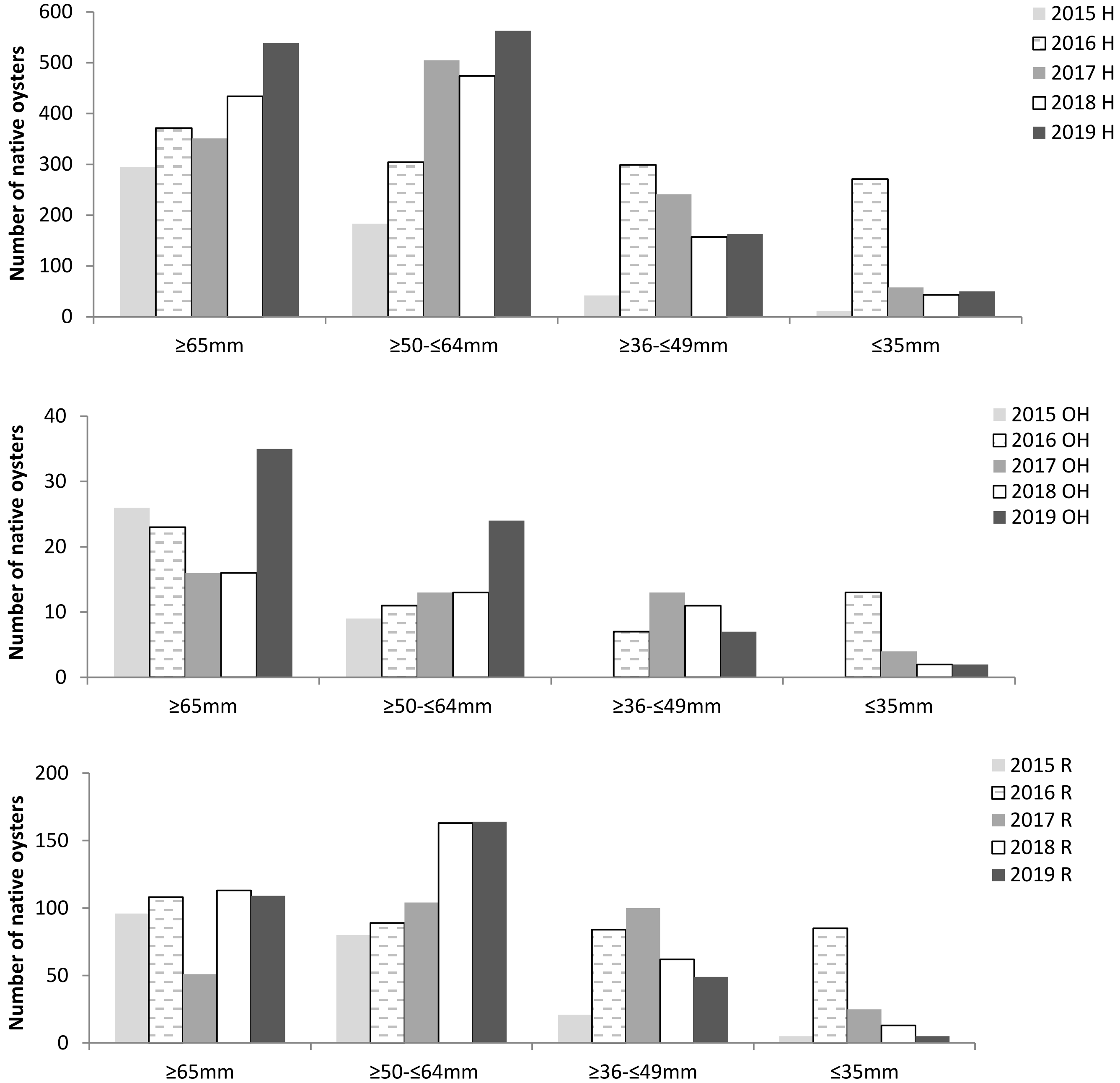


Figure 22: The total number of native oysters (*Ostrea edulis)* per size class (≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35mm) from 2015 to 2019 for the Harbour (H), Outer Harbour (OH) and River (R) sections.

The average number of native oysters per size class per year varied for all three sections (Figure 23). In the H section the average number of oysters steadily increased for the two largest size classes from 5 in 2015 to 9 in 2019 for the ≥65 mm and from 3 in 2015 to 9 in 2019 in the ≥50-≤64 mm category. The average number of oysters in the smallest size classes decreased from 5 to 3 in the ≥36-≤49 mm size class and from 4 to 1 in the ≤35 mm size class. The results were similar in the OH section, with increases in both the ≥65 mm and ≥50-≤64 mm categories. The average numbers in the R section has varied for all size classes, however a decrease in the average number of oysters ≤35 mm was observed in all three sections.

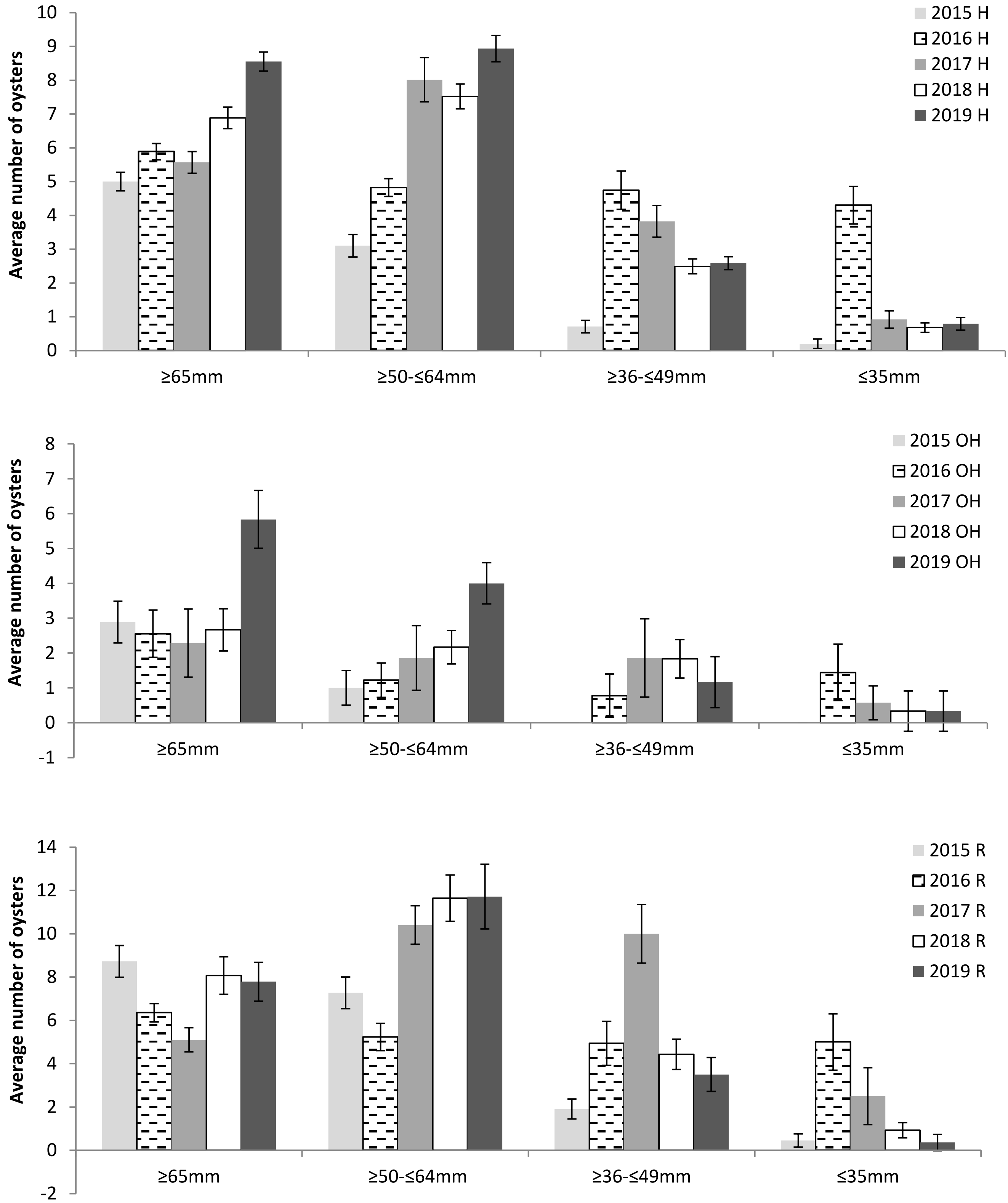


Figure 23: The average number of native oysters (*Ostrea edulis)* per size class (≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35mm) from 2015 to 2018 for the Harbour (H), Outer Harbour (OH) and River (R) sections.

3.3.3.6 Minimum landing size

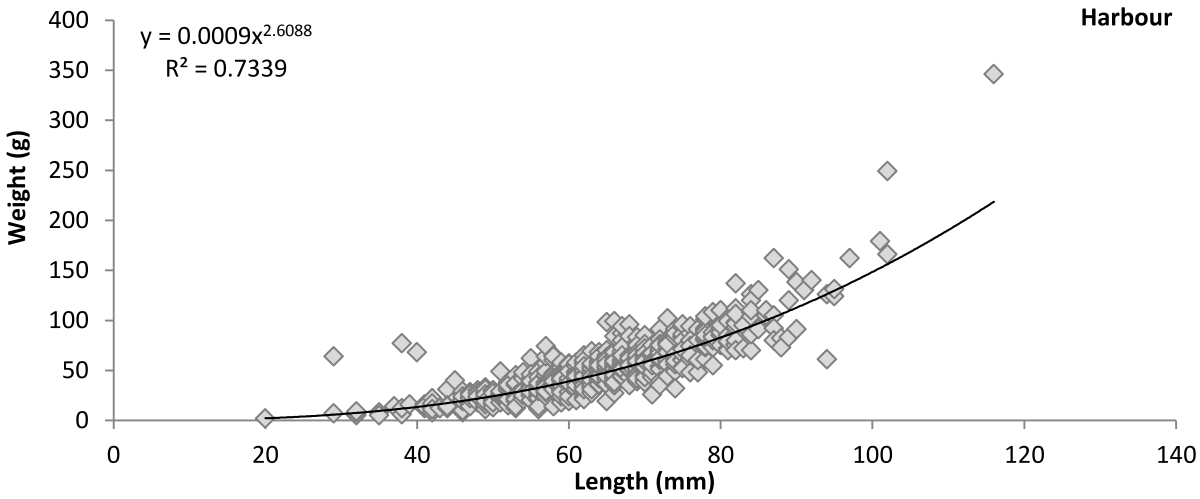
The minimum landing size (MLS) for oysters from the fishery is 67 mm. The percentage of oysters over and under the MLS is shown in Table 10 for each section of the Fal oyster survey area. The percentage for the H section and R section over the minimum size was comparable (34% in the H and 29% in the R) and a higher percentage of oysters over the MLS was recorded in the OH section of 47%.

Table 10: The percentage (%) of native oysters (*Ostrea edulis*) over and under the minimum landing size (67 mm) for all three sections (Harbour, Outer Harbour and River) of the Fal oyster survey area from 2015 to 2019.

	Harbour % under 67 mm	Harbour % over 67 mm	Outer Harbour % under 67 mm	Outer Harbour % over 67 mm	River % under 67 mm	River % over 67 mm
2019	66.24	33.76	52.94	47.06	70.95	29.05
2018	67.15	32.85	66.67	33.33	76.92	23.08
2017	74.55	25.45	73.91	26.09	86.43	13.57
2016	73.65	26.35	61.11	38.89	72.95	27.05
2015	48.87	51.13	31.43	68.57	58.42	41.58

3.3.3.7 Length weight comparison

The length weight relationship of oysters for the H and OH sections is shown in Figure 24. A total of 733 oysters had a weight (g) recorded in the H section and 54 in the OH section. The relationship of length and weight for both the H and OH sections is best described with a power curve.



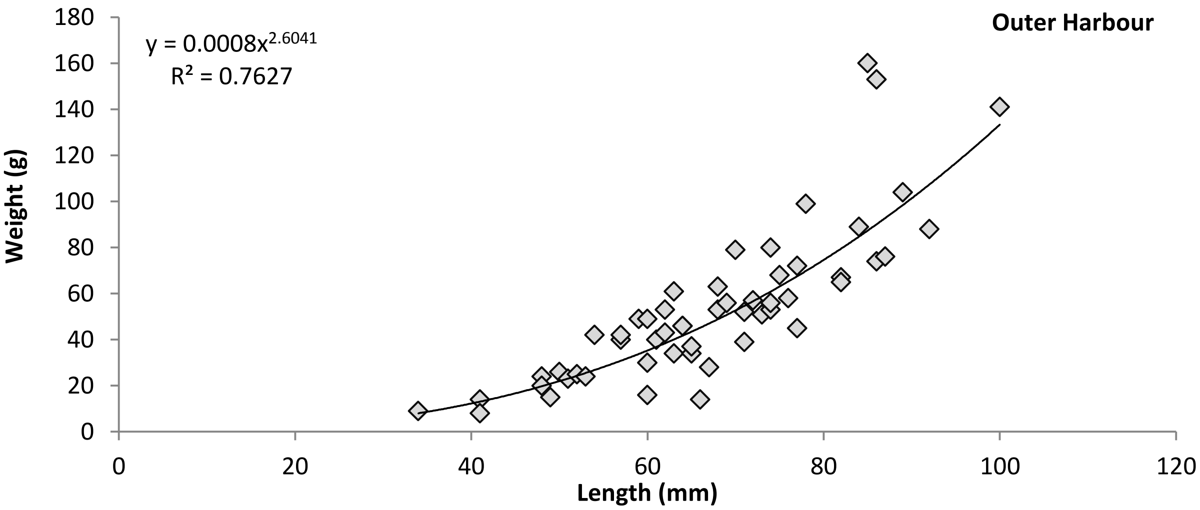


Figure 24: The length (mm) weight (g) relationship of native oysters (*Ostrea edulis)* in the harbour and outer harbour section of the Fal Oyster Survey 2019 (Harbour n=733 and Outer Harbour n=54).

3.3.4 Management sections

Of the total number of oysters, 465 were from Area A, 775 from Area B and 470 from Area C. The total number of oysters per site is shown in Annex Table F.

3.3.4.1 Average sizes

Table 11 and Figure 25 show the average size (mm) of native oysters recorded in the A, B and C management areas from 2015 to 2019.

For all sections of the survey, the average size (mm) of native oysters has fluctuated year by year, however the size decreased from 2015 and then increased in all sections from 2016 to 2019 with slight increases over the last four years. Compared to 2016, the size has increased in Area A from 53 mm to 63 mm, from 52 mm to 61 mm and from 51 mm to 61 mm.

Table 11: The average size (mm) ± standard error of native oysters (*Ostrea edulis)* in the Area A, B and C management areas from 2015 to 2019.

Year	Area A	Area B	Area C
2019	62.8 mm ± 0.72 mm	61.3 mm ± 0.46 mm	60.8 mm ± 0.54 mm
2018	61.9 mm ± 0.79 mm	61.3 mm ± 0.50 mm	59.1 mm ± 0.62 mm
2017	59.7 mm ± 0.78 mm	60.2 mm ± 0.60 mm	53.2 mm ± 0.57 mm
2016	53.2 mm ± 0.94 mm	51.8 mm ± 0.66 mm	51.1 mm ± 0.89 mm
2015	70.4 mm ± 1.03 mm	66.4 mm ± 0.89 mm	63.6 mm ± 0.82 mm

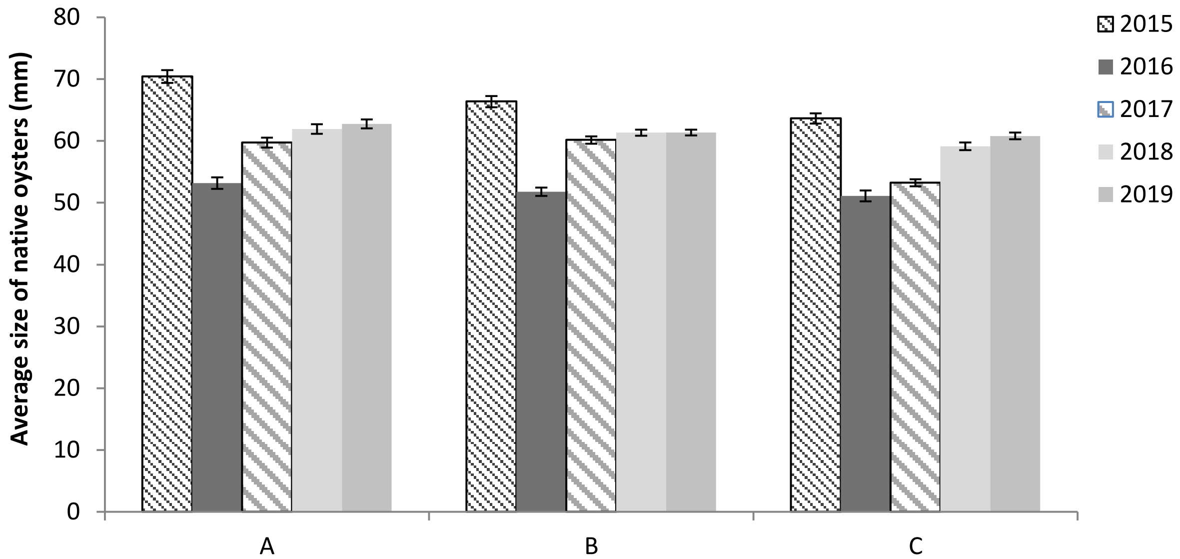


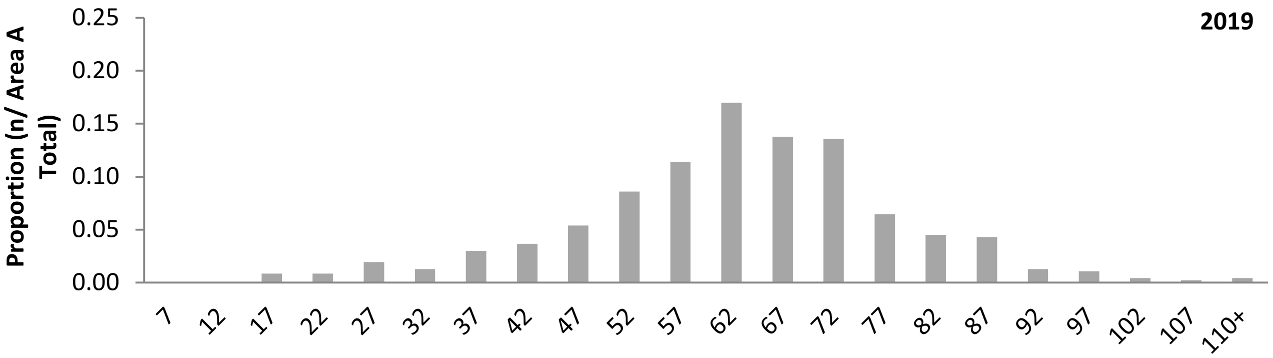
Figure 25: The average size (mm) of native oysters (*Ostrea edulis)* ± standard error for the management areas (Area A, B and C) of the survey for the years 2015, 2016, 2017 2018 and 2019.

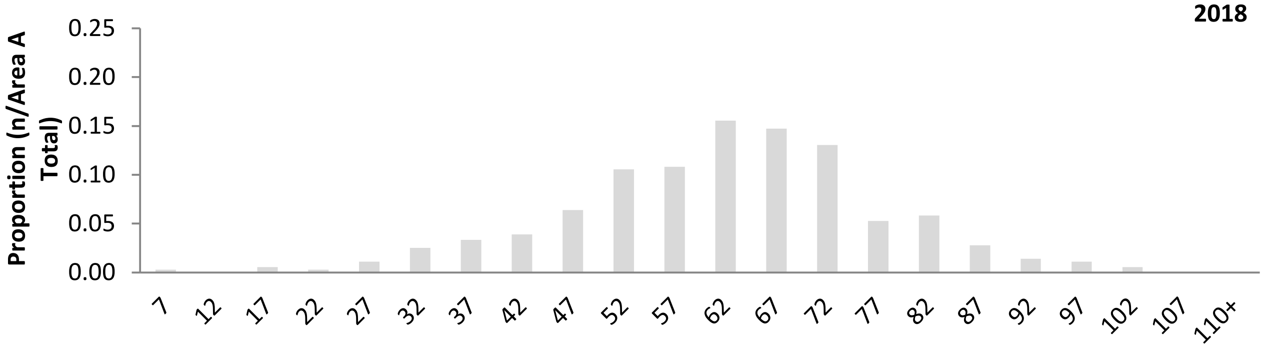
3.3.4.2 Size frequency plots

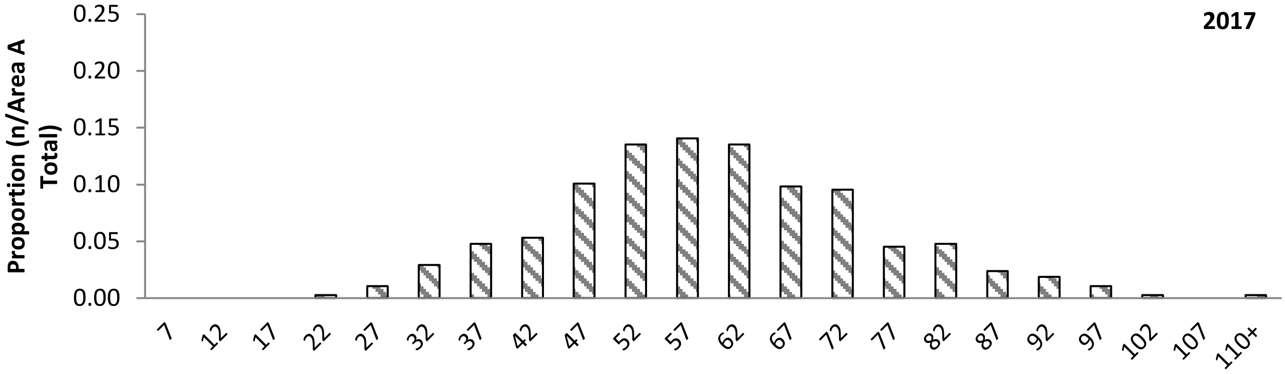
Size frequency plots for the management areas A, B and C are shown in Figure 26.

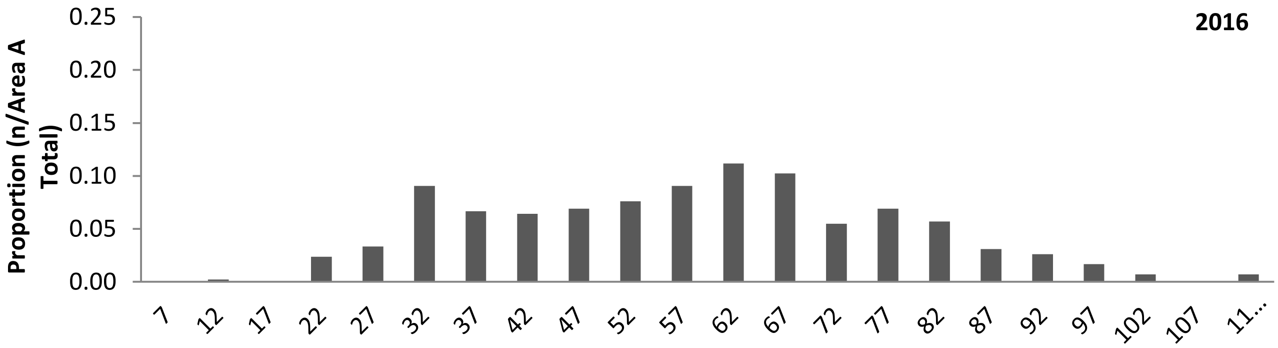
The distribution for Area A was the same for all years of the survey with a unimodal distribution, except in 2016 when the distribution was uneven and irregular. The peak in 2019 and 2018 was the same at 62 mm, whereas in 2017 the peak was 57 mm and 72 mm in 2015.

Area A


2019
Proportion (n/ Area A Total)
0.25
0.20
0.15
0.10
0.05
0.00
7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 110+


2018
Proportion (n/Area A Total)
0.25
0.20
0.15
0.10
0.05
0.00
7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 110+


2017
Proportion (n/Area A Total)
0.25
0.20
0.15
0.10
0.05
0.00
7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 110+


2016
Proportion (n/Area A Total)
0.25
0.20
0.15
0.10
0.05
0.00
7 12 17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 11…

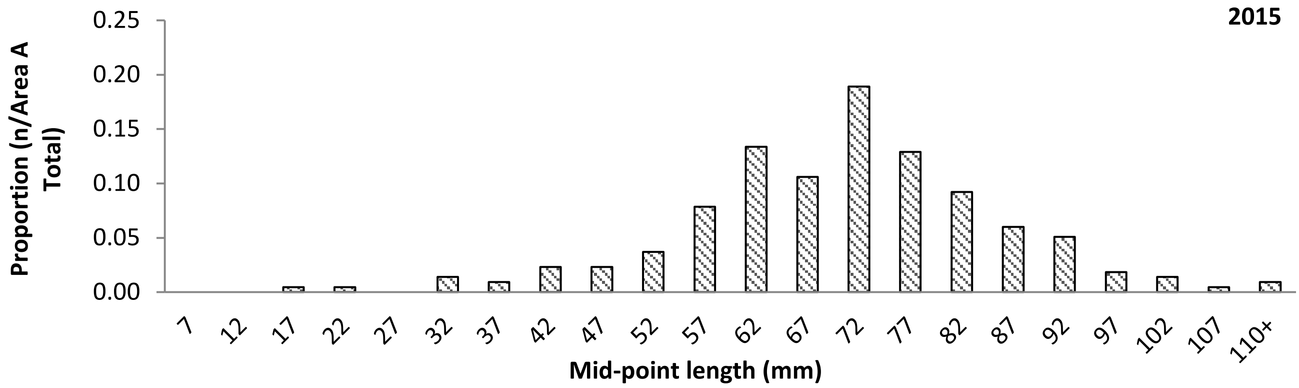
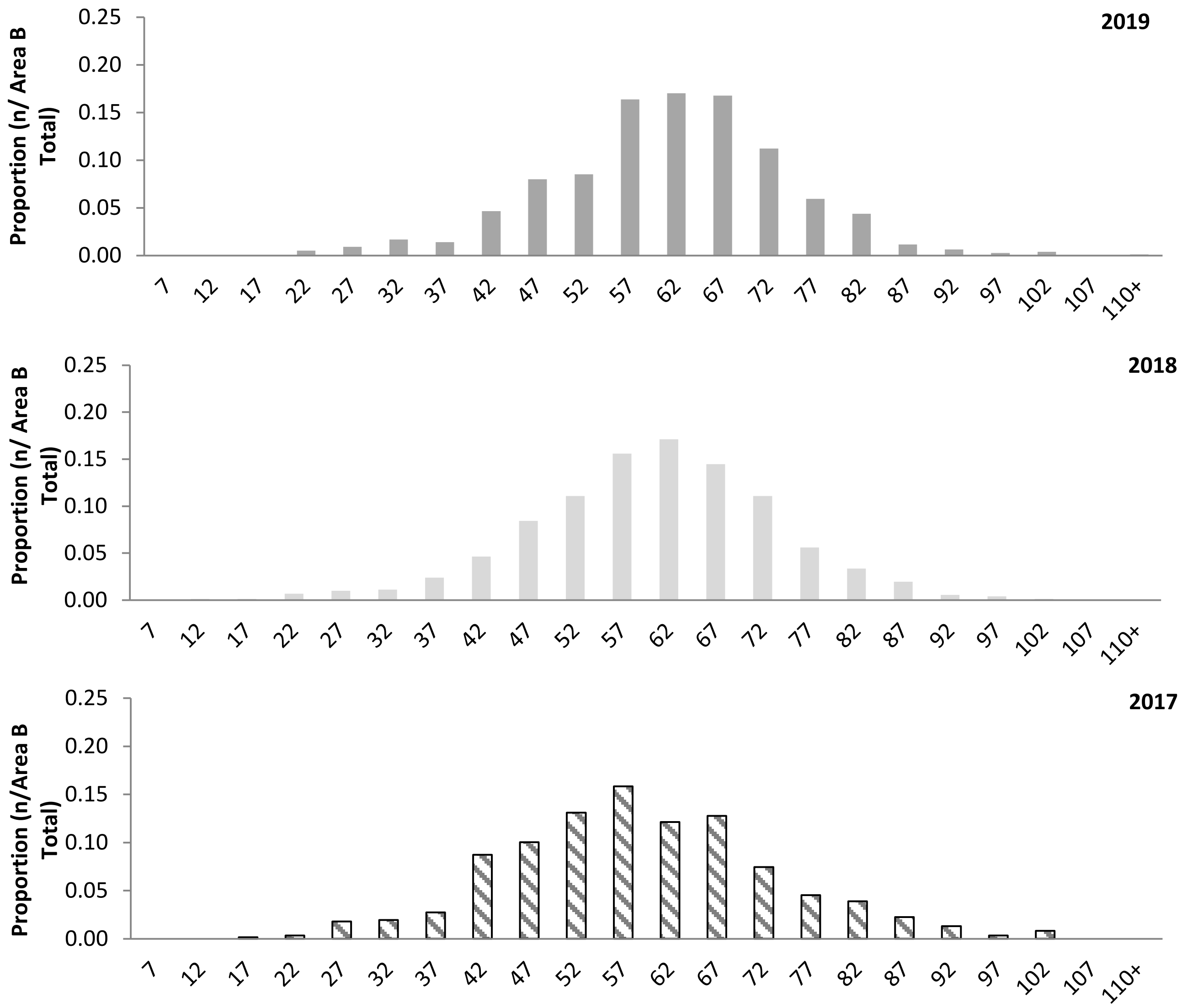


Figure 26: Size frequency distributions of native oysters (*Ostrea edulis)* for the management area, Area A of the fishery for 2015, 2016, 2017, 2018 and 2019.

Area B

The distribution for Area B in 2019 was unimodal with a peak at 72 mm (Figure 27). The distribution in 2015, 2017 and 2018 was similar, with a unimodal distribution and peaks of either 62 mm or 57 mm. Again in 2016 the distribution was uneven and irregular.



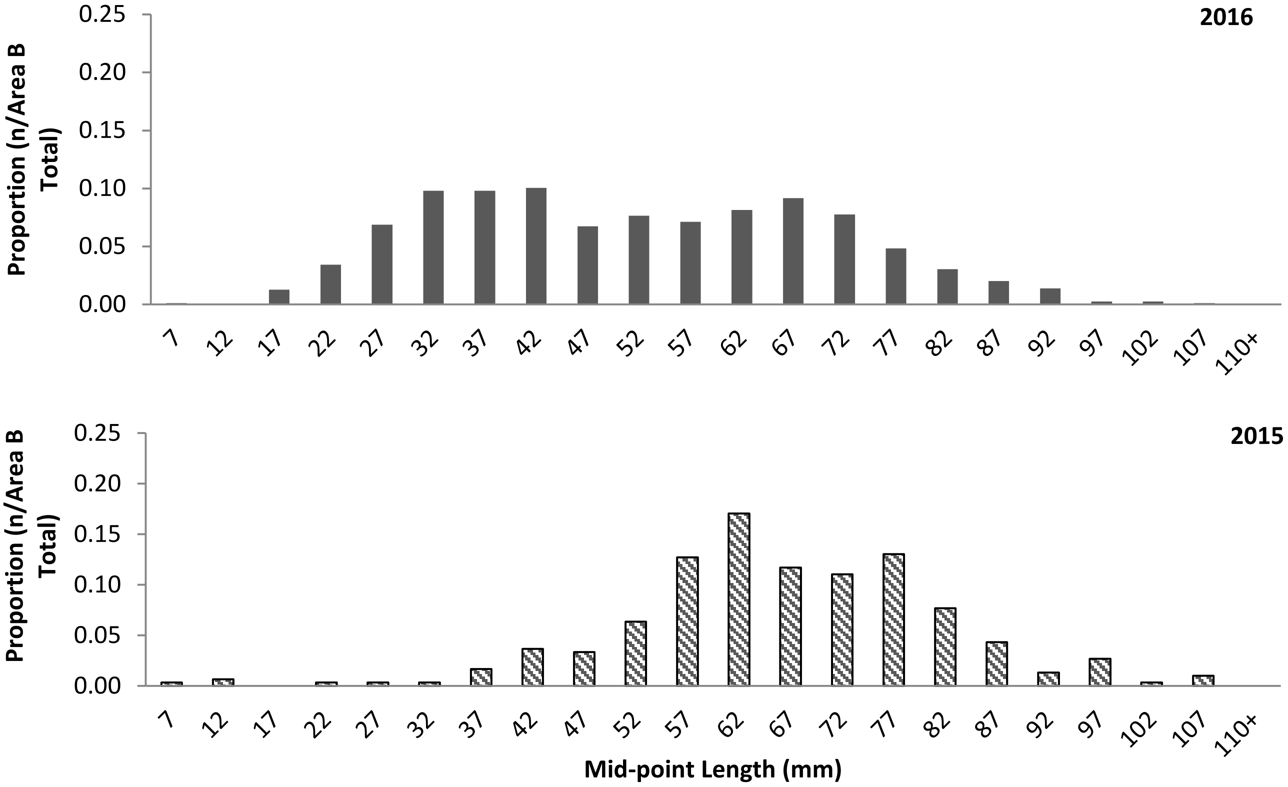
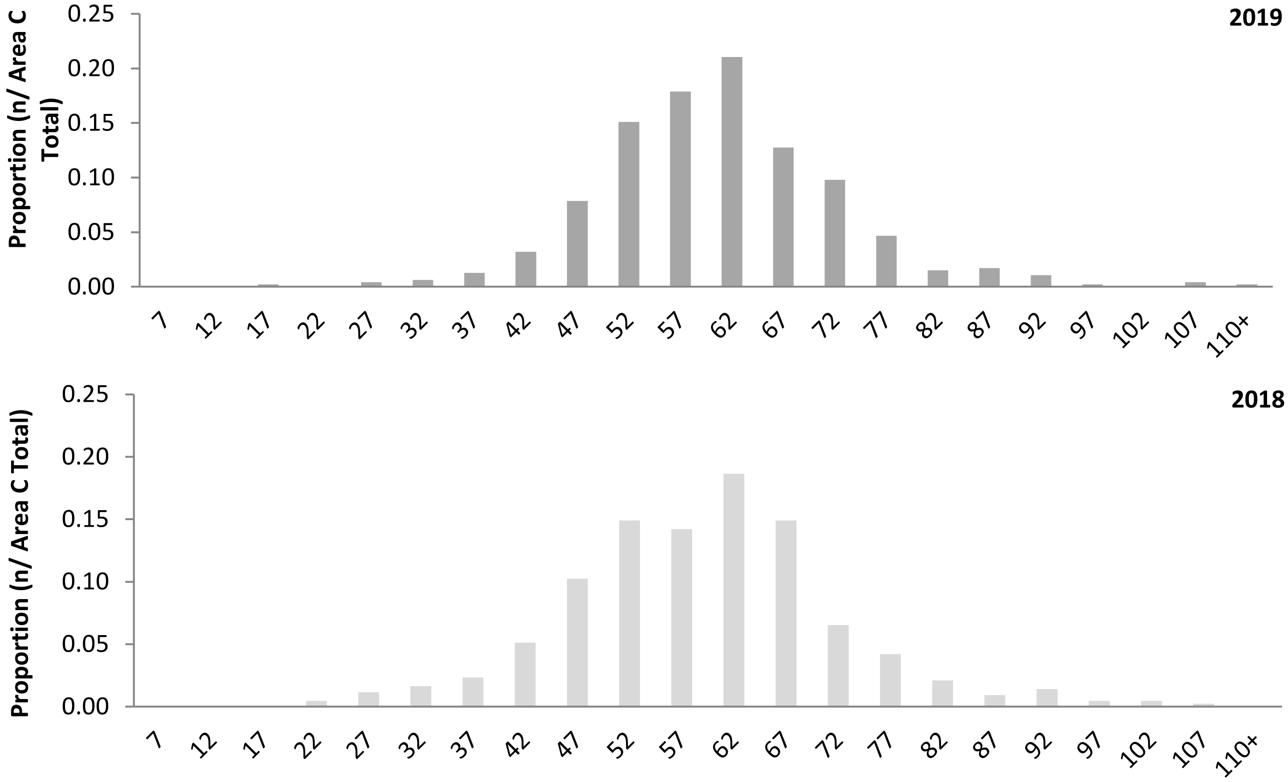


Figure 27: Size frequency distributions of native oysters (*Ostrea edulis)* for the management area, Area B of the fishery for 2015, 2016, 2017, 2018 and 2019.

Area C

The distribution for Area C was unimodal for the years 2015, 2017, 2018 and 2019 with peaks that varied between 52 mm and 62 mm (Figure 28). In 2016 the distribution was uneven and irregular.



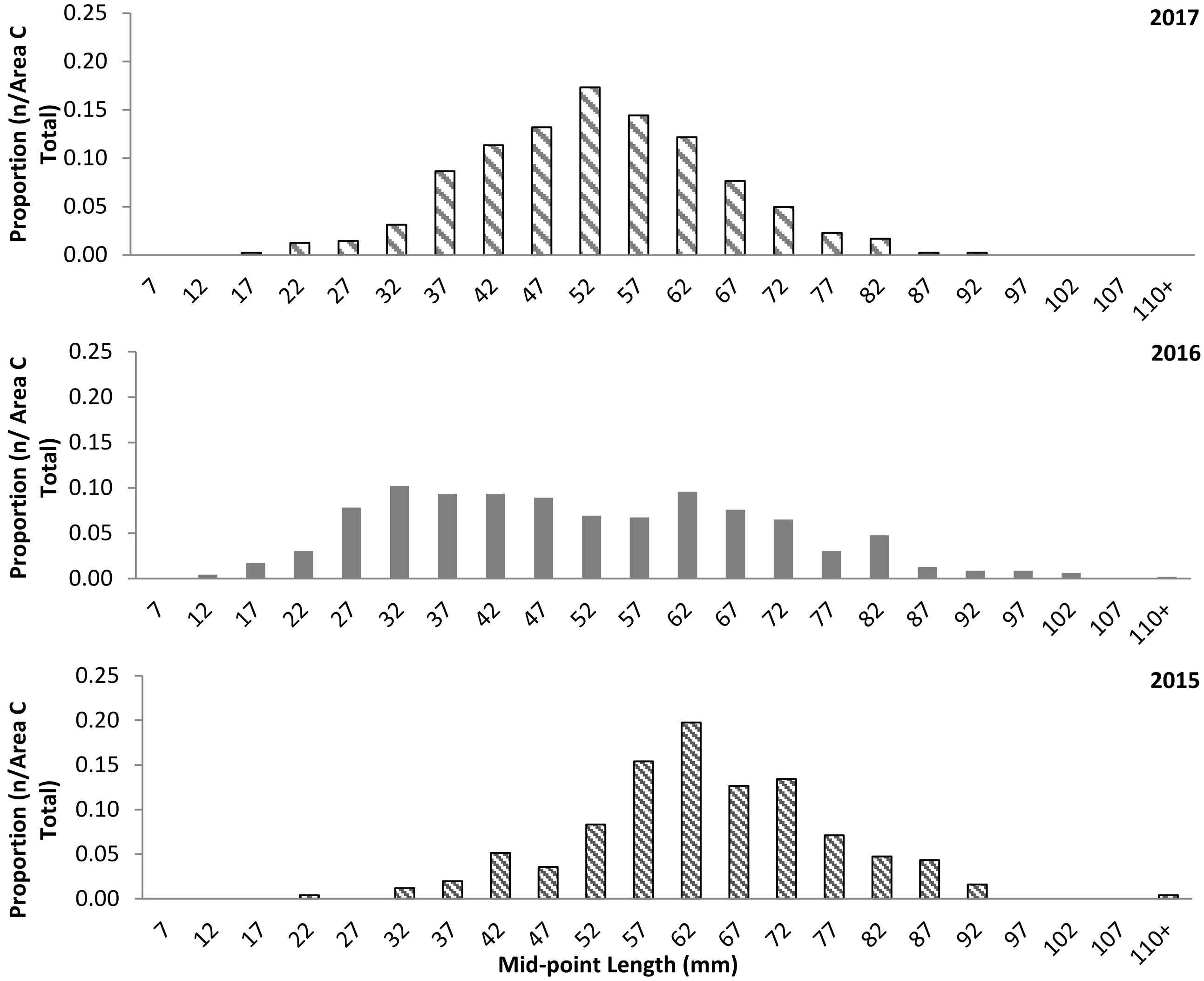


Figure 28: Size frequency distributions of native oysters (*Ostrea edulis)* for the management area, Area C of the fishery for 2015, 2016, 2017, 2018 and 2019.

3.3.4.3 Average number

The average number of oysters per dredge sample by each management section has varied for all three sections from 2015 to 2019 but was highest in Area C and lowest in Area A for all years surveyed (Figure 29). The average number of oysters per site for Area A increased from 6.4 in 2015 to a peak of 17.1 in 2016, decreased in 2017 and increased slightly to 14.5 in 2019. The average number of oysters per site for Area B followed a similar pattern with the lowest value recorded in 2015 of 9.3 oysters which increased in 2016 to 21.8, decreased in 2017 to 17.2 and slowly increased again to a value of 22.1 oysters in 2019. In Area C, the average number of oysters was lowest in 2015 at 19.5 oysters, peaked in 2017 with a value of 40.4, decreased in 2018 and increased slightly in 2019 to 29.4 oysters.

Table 12 and Figure 29 show the average number of native oysters per area recorded in the management areas, A, B and C from 2015 to 2019.

The average number of oysters per dredge sample by each management section has varied for all three sections from 2015 to 2019 but was highest in Area C and lowest in Area A for all years surveyed (Figure 29). The average number of oysters per site for Area A increased from 6.4 in 2015 to a peak of 17.1 in 2016, decreased in 2017 and

increased slightly to 14.5 in 2019. The average number of oysters per site for Area B followed a similar pattern with the lowest value recorded in 2015 of 9.3 oysters which increased in 2016 to 21.8, decreased in 2017 to 17.2 and slowly increased again to a value of 22.1 oysters in 2019. In Area C, the average number of oysters was lowest in 2015 at 19.5 oysters, peaked in 2017 with a value of 40.4, decreased in 2018 and increased slightly in 2019 to 29.4 oysters.

Table 12: The average number ± standard error of native oysters (*Ostrea edulis)* for the management areas (Area A, B and C) of the survey from 2015 to 2019.

Year	Area A	Area B	Area C
2019	14.5 ± 1.44	22.1 ± 2.89	29.4 ± 8.70
2018	11.3 ± 1.93	20.3 ± 3.02	26.8 ± 6.36
2017	11.8 ± 2.38	17.2 ± 3.37	40.4 ± 15.74
2016	17.1 ± 3.96	21.8 ± 4.79	24.2 ± 7.21
2015	6.4 ± 1.08	9.3 ± 1.56	19.5 ± 4.46

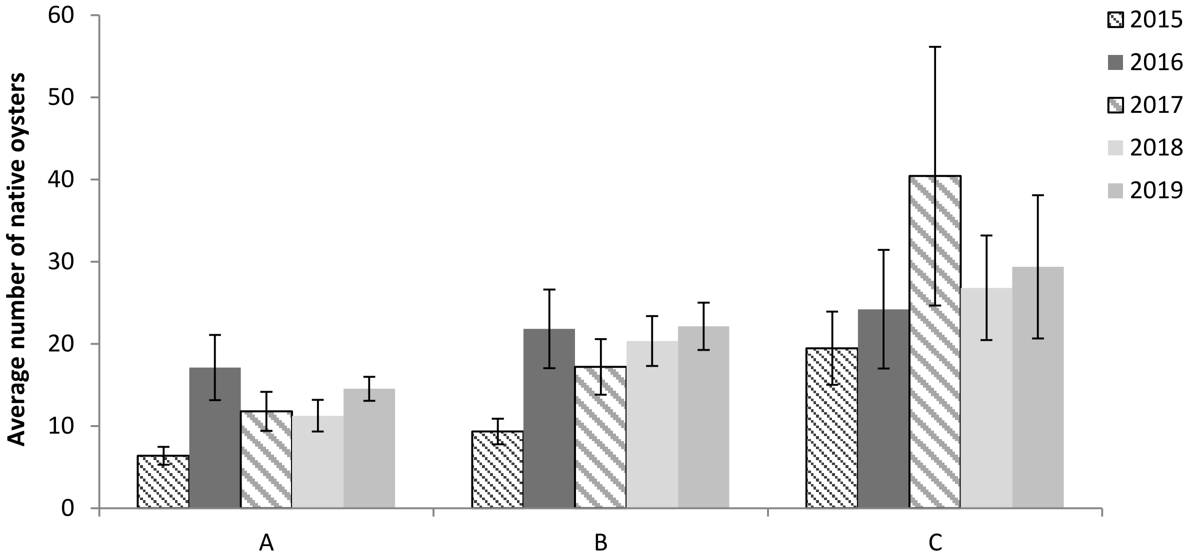


Figure 29: The average number of native oysters (*Ostrea edulis)* ± standard error for the management areas (Area A, B and C) of the survey for the years 2015, 2016, 2017 2018 and 2019.

3.3.4.4 Density

The density of oysters per 10 m^2 for 2019 for all three management areas is shown in Figure 30. The density of oysters in Areas B and C has fluctuated steadily since 2016. In Area C, the density was 5.41 per 10 m^2 in 2015 and increased in 2016, before it increased in 2017 to a peak of 11.23 oysters per 10 m^2, then decreased in 2018 to 7.45 and increased slightly in 2019.

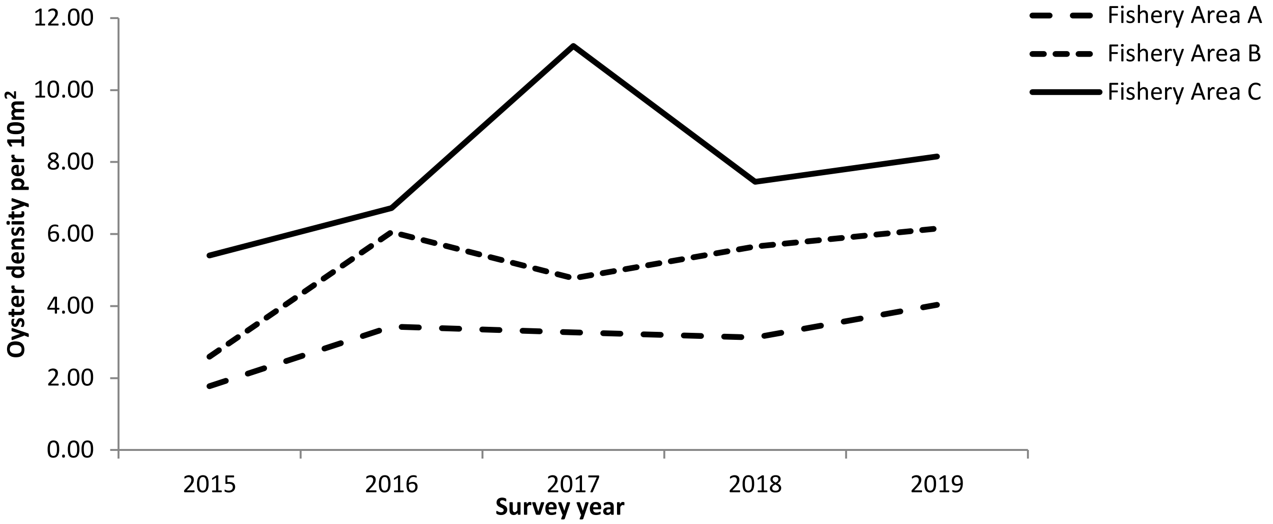
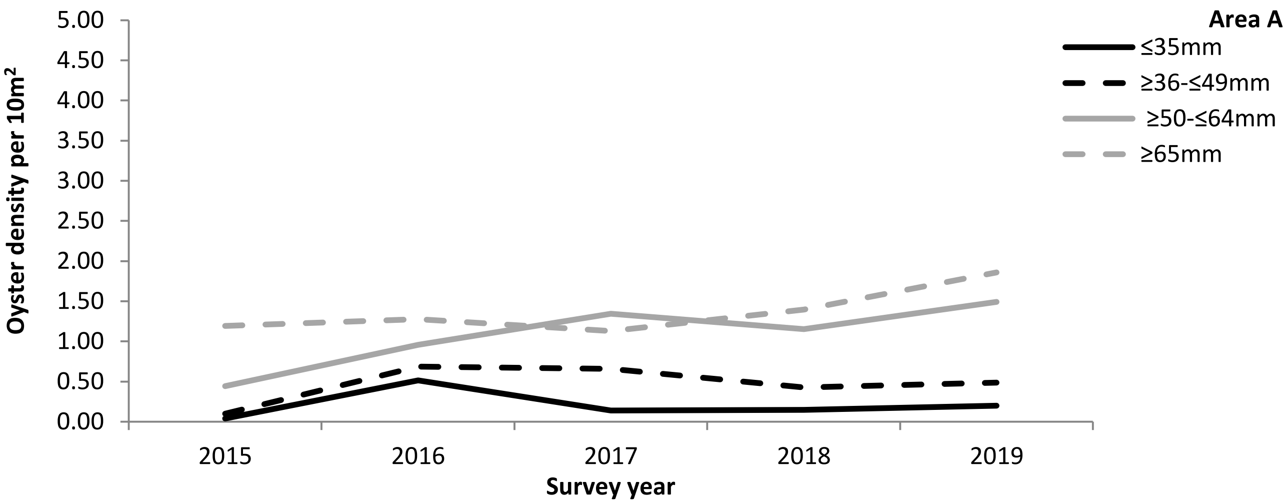
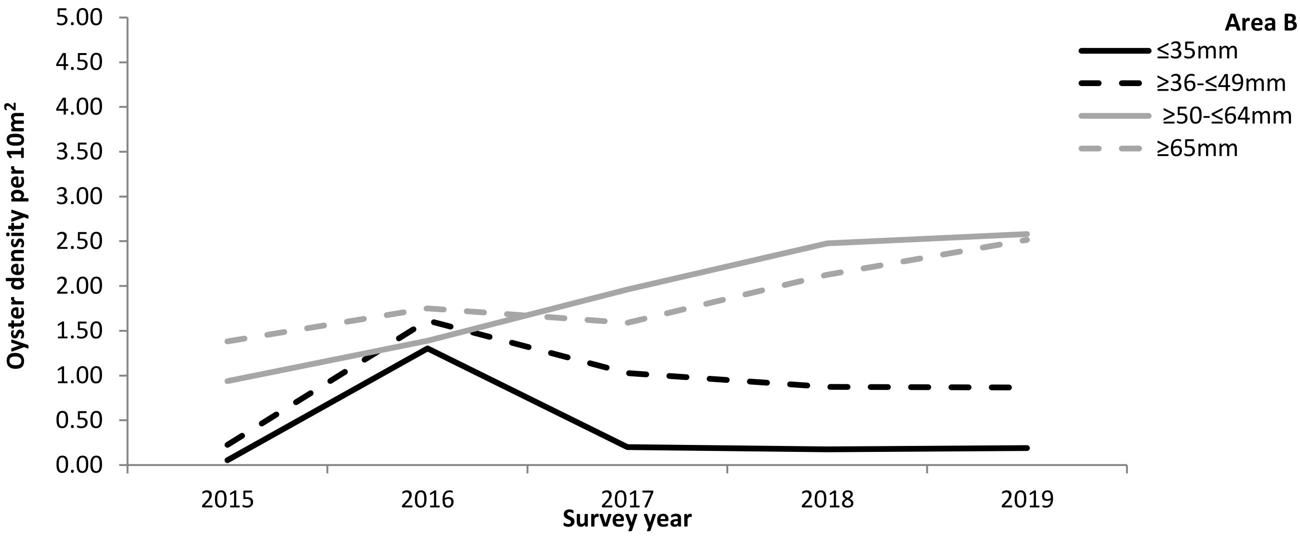


Figure 30: The density of native oysters (*Ostrea edulis)* per 10m^2 for the three management areas (Area A, B and C) from 2015 to 2019.

The density of oysters per 10 m^2 for 2019 for all three management areas per size class is shown in Figure 31.





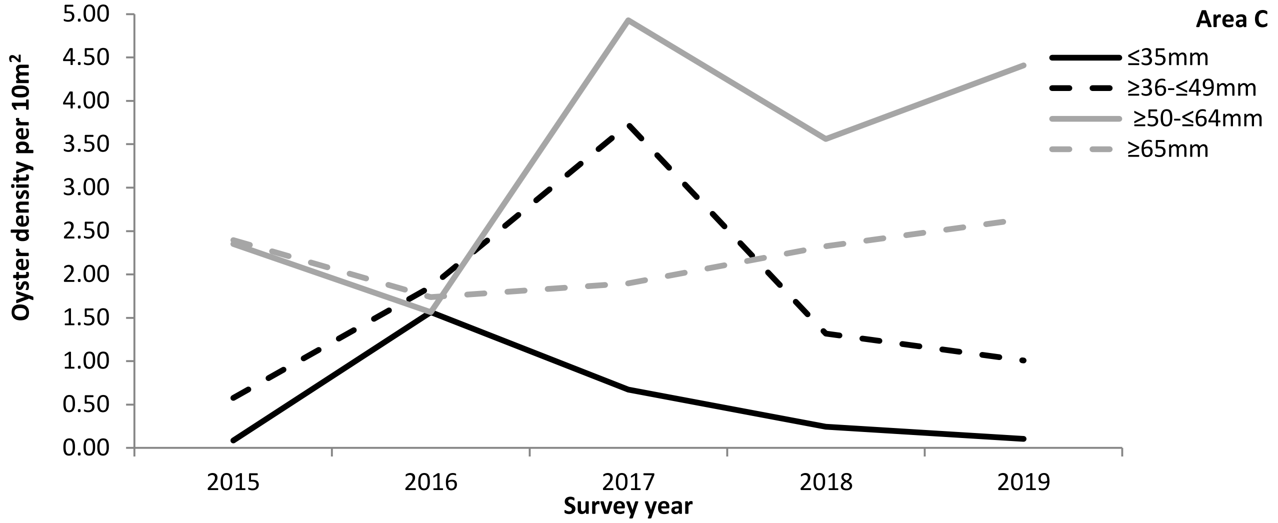


Figure 31: The density of native oysters (*Ostrea edulis)* per 10m^2 for the three management areas (Area A, B and C) per size class from 2015 to 2019.

3.3.4.5 Oyster Size Class Composition

When split by size class and management area, the total number of oysters for all of the size classes was highest in Area B (Table 8). The total number of oysters by management area by size class was highest in Area B for the ≥50-≤64 mm size class (325) and in the ≥65 mm size class (317) and lowest in Area C for the ≤35 mm size class (6).

Table 13: The number of native oysters (*Ostrea edulis)* recorded in the three management sections (Area A, B and C) recorded by total number, total number of oysters ≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35mm during the Fal oyster survey 2019

Section	Total number of oysters	≥65 mm	≥50-≤64 mm	≥36-≤49 mm	≤35 mm
A	465	214	172	54	25
B	775	317	325	107	26
C	470	152	254	58	6

When split by size class and management area, the average number of oysters by section was highest in Area C and lowest in Area A (Table 14). The average number of oysters per section by size class was highest in Area C for the ≥50-≤64 mm size class (15.9 mm) and lowest in Area C for the ≤35 mm size class (0.4 mm).

Table 14: The average number of native oysters (*Ostrea edulis)* recorded in the three management sections (Area A, B and C) by each size class ≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35mm during the Fal oyster survey 2019.

Section	The average number of oysters	≥65 mm	≥50-≤64 mm	≥36-≤49 mm	≤35 mm
A	14.5	6.7	5.4	1.7	0.8
B	22.1	9.1	9.3	3.1	0.7
C	29.4	9.5	15.9	3.6	0.4

The total number of native oysters per management area by size class varied by size class year by year (Figure 32). Noticeably the number of oysters in the smallest size class (≤35 mm) decreased from 2016 to 2017 and then remained low, level or decreased slightly year on year.

For all three areas, the total number of oysters increased from 2015 to 2019 in the ≥65 mm and ≥50-≤64 mm size classes and decreased from 2016 to 2019 for the ≥36-≤49mm and ≤35 mm size classes.

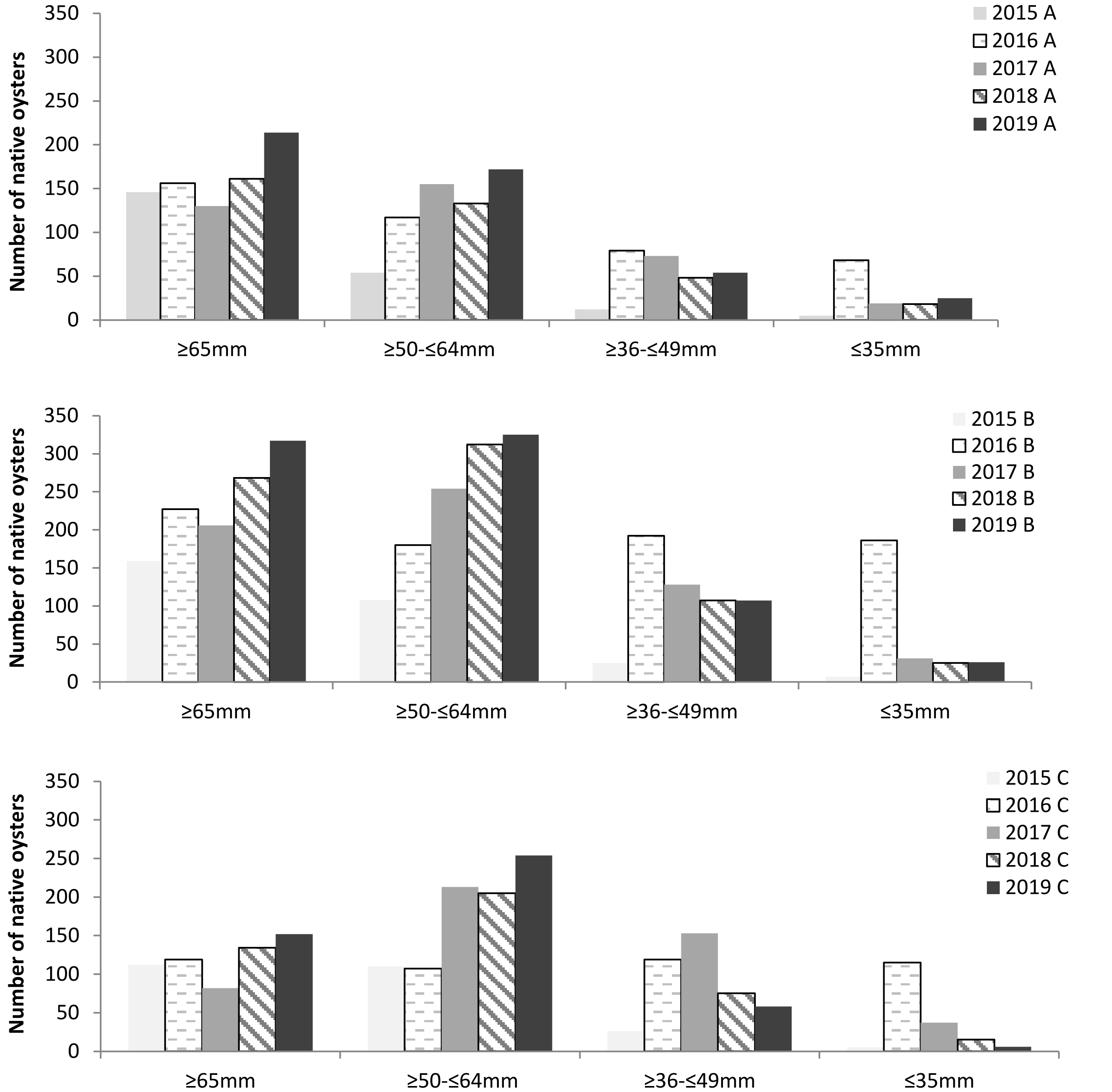


Figure 32: The total number of native oysters (*Ostrea edulis)* per size class (≥65mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35mm) for the management areas (Area A, B and C) from 2015 to 2019.

The average number of native oysters per management area (Figure 33) varied for all three areas year by year. The pattern for both Areas A and B was similar with a steady increase in the average number of oysters recorded from 2015 to 2019 for the ≥65 mm and ≥50-≤64 mm size classes and a decrease in the average number of oysters from 2016 to 2019 for the ≥36-≤49 mm and ≤35 mm size classes. In Area C the number increased slightly for the ≥65mm size class from 2016 to 2019. For the ≥50-≤64 mm and ≥36-≤49 mm size classes the peak average number of oysters was in 2017. For the ≤35 mm size class the peak was recorded in 2016 and has decreased steadily ever since with an average of 0.4 oysters recorded in 2019.

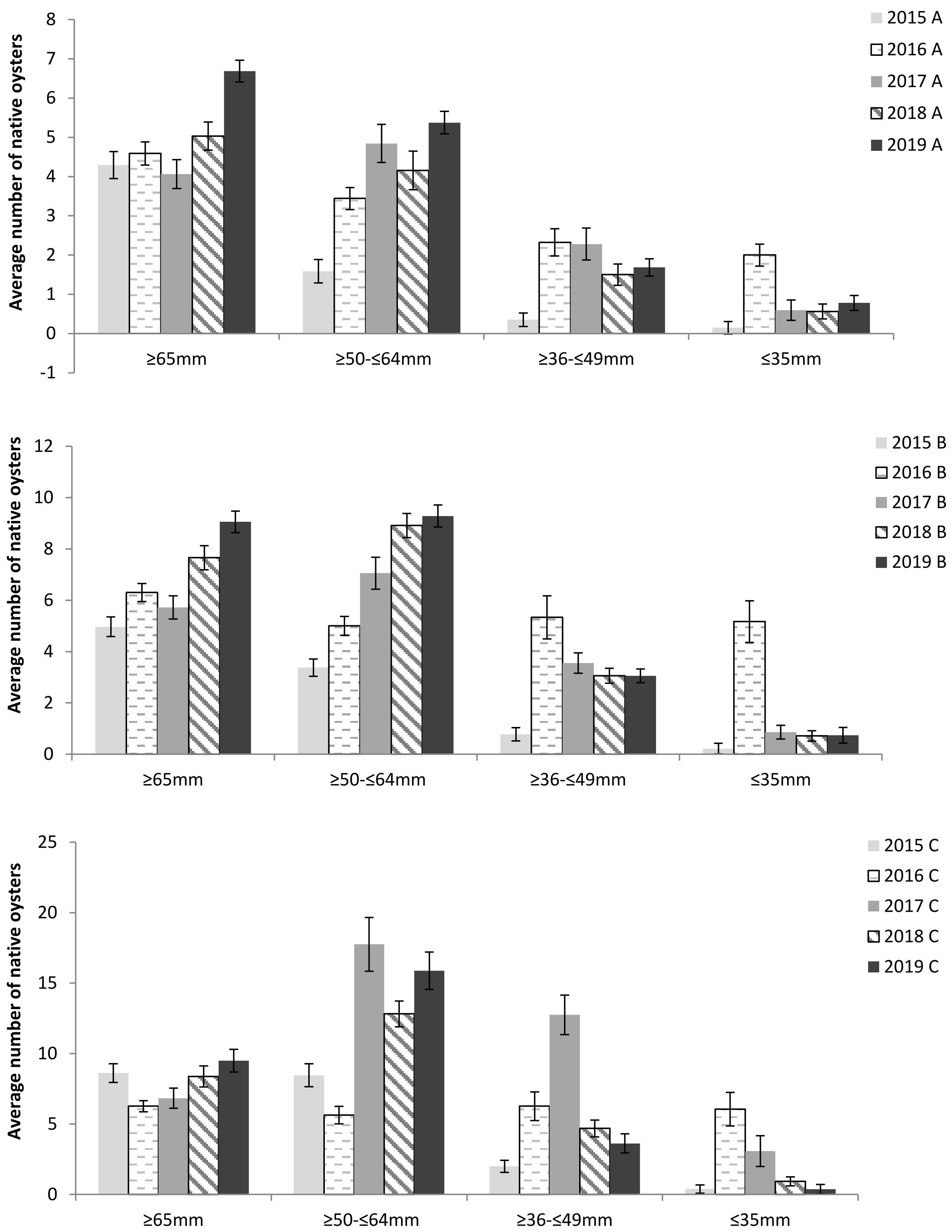


Figure 33: The average number of native oysters (*Ostrea edulis)* per size class (≥65 mm, ≥50-≤64 mm, ≥36-≤49 mm and ≤35 mm) from 2015 to 2018 for the management areas (Area A, B and C.

3.3.4.6 Minimum landing size

As mentioned previously, the MLS for oysters from the fishery is 67mm. The percentage of oysters over and under the MLS for the management areas, A, B and C is shown in Table 15. For all three areas the percentage under the

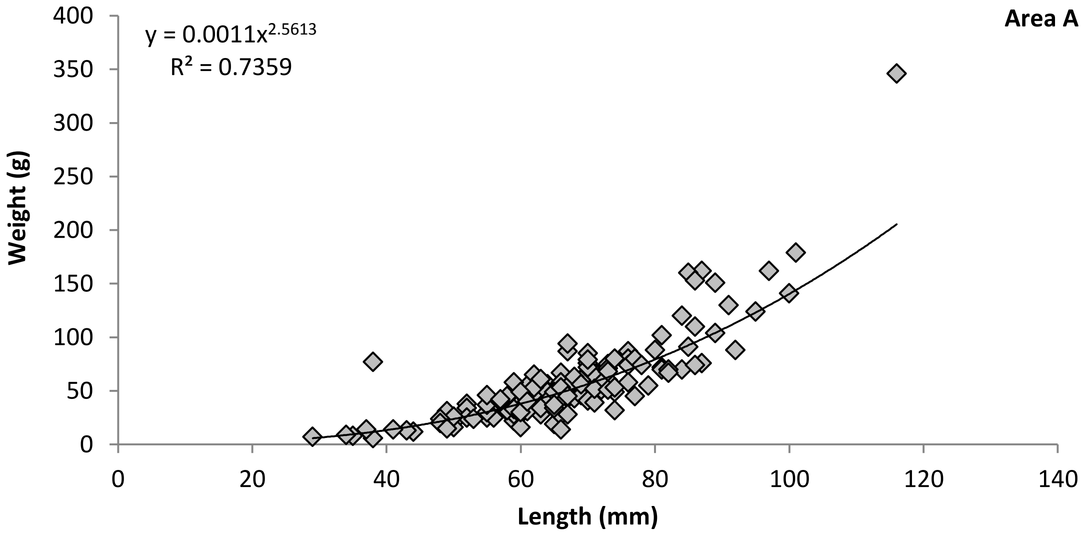
MLS was greater than over the MLS, except in 2015 for Area A. The percentage over and under the MLS was more even in Area A in 2019, with 60% under the MLS and 40% over the MLS.

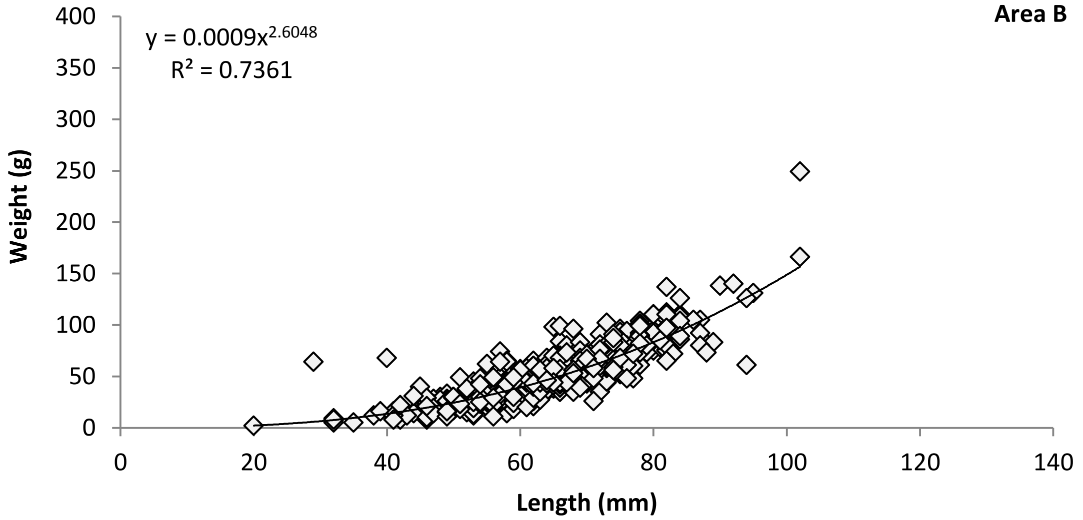
Table 15: The percentage (%) of native oysters (*Ostrea edulis*) over and under the minimum landing size (67 mm) for all three management areas (Area A, B and C) of the Fal Oyster Survey area from 2015 to 2019.

	Area A % under 67 mm	Area A % over 67 mm	Area B % under 67 mm	Area B % over 67 mm	Area C % under 67 mm	Area C % over 67 mm
2019	59.78	40.22	67.10	32.90	72.55	27.45
2018	61.11	38.89	68.40	31.60	78.09	21.91
2017	70.03	29.97	72.37	27.63	87.63	12.37
2016	67.14	32.86	74.39	25.61	76.30	23.70
2015	36.41	63.59	51.51	48.49	61.66	38.34

3.3.4.7 Length weight comparison

The length weight relationship of oysters for all three management areas is shown in Figure 34. A total of 154 were measured for weight (g) in Area A, 583 in Area B and 50 in Area C. The relationship of length weight for Areas A, B and C is best described with a power curve.





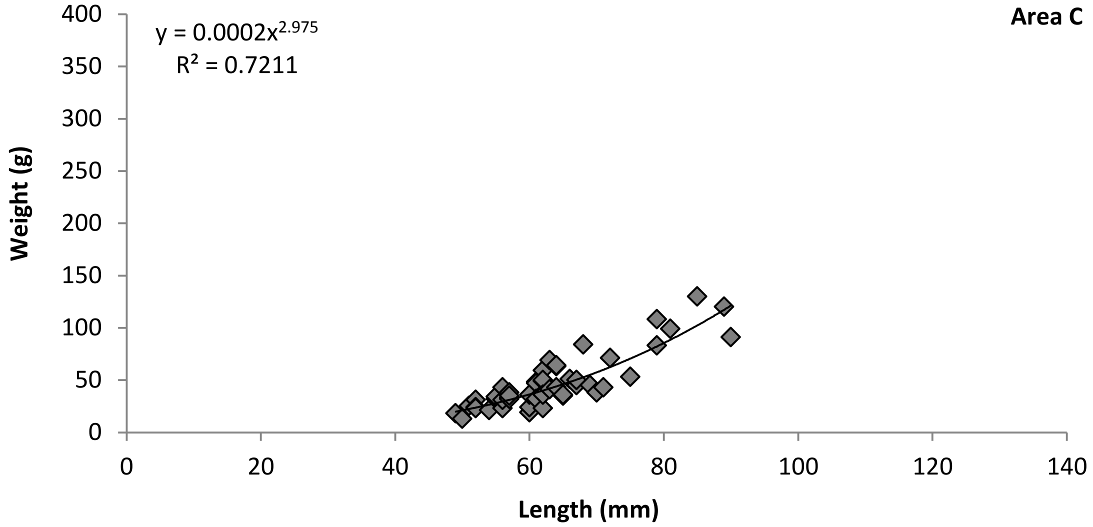


Figure 34: The length (mm) weight (g) relationship of native oysters (*Ostrea edulis)* in the management sections, Area A, B and C of the FaL Oyster Survey 2019 (Area A n = 154, Area B n=583, Area C n =50).

3.4 Scallops (queen or variegated scallop)

In total, 7,015 scallops were measured and recorded. Previous scallop counts are shown in Table 16. The number of survey sites changed year on year so the numbers recorded across the years are not directly comparable.

Table 16: The number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) recorded during the Fal oyster survey between 2016 and 2019

Year	Number of scallops	Number of sites sampled
2019	7,015	83
2018	4,145	83
2017	2,952	80
2016	3,257	89

3.4.1 Scallop Size Class Composition

The total number of scallops has varied by size class between 2017 and 2018 (Figure 35). The size classes used were ≤ 29 mm, ≥30 to ≤39 mm, ≥40 to ≤49 mm, ≥50 to ≤59 mm, ≥60 to ≤69 mm, ≥70 to ≤79 mm and ≥80 mm. Very few scallops were recorded in the ≥80 mm size class for all four years. The number of scallops in the ≥70-≤79 mm remained fairly similar for the last four years, however for the ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm and ≥30-≤39 mm size classes the number of scallops increased slightly in 2019. The most noticeable increase was in the ≤29 mm size class, with an increase from 627 scallops in 2018 to 2,452 in 2019.

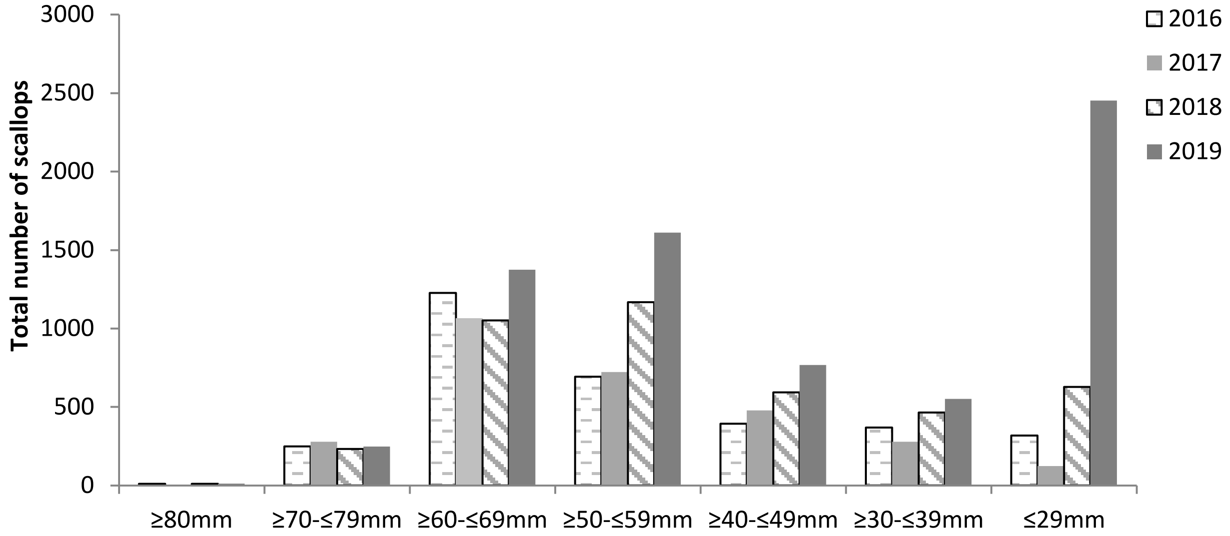
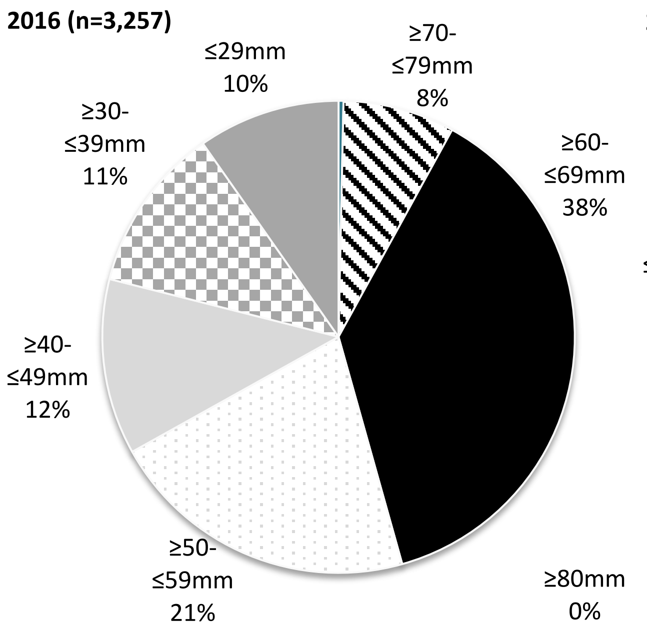
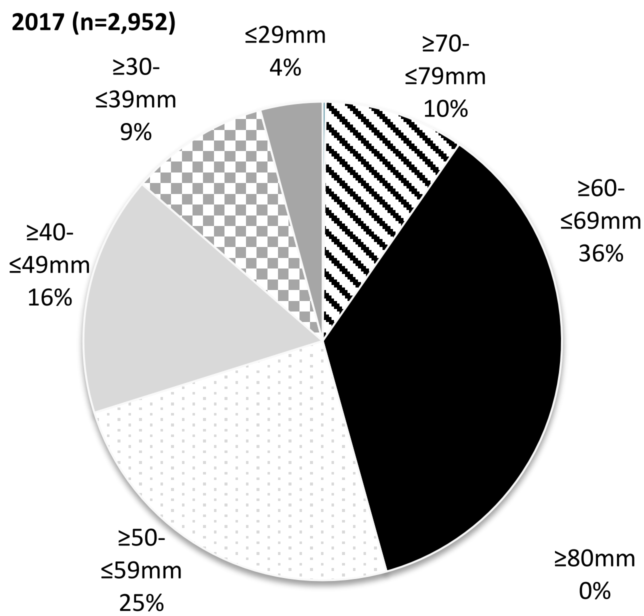


Figure 35: The total number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per size class (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) from 2016 to 2019.

The distribution of size classes is shown in Figure 36. The size class distribution was very similar in 2016 and 2017 and the largest percentage was for the ≥60-≤69 mm size class with 38 % in 2016 and 36 % in 2017. The distribution in 2018 changed and the percentage of scallops in the ≥60-≤69 mm size class was lower at 26 %. For this year, the ≥50-≤59mm size class had the largest percentage with 28 %. In 2019, the number of small scallops ≤29 mm increased and had the largest distribution of scallops at 35 %. The ≥80 mm size class had less than 1 % of scallops each year. The total number of scallops per size class per site is shown in Annex Table F.





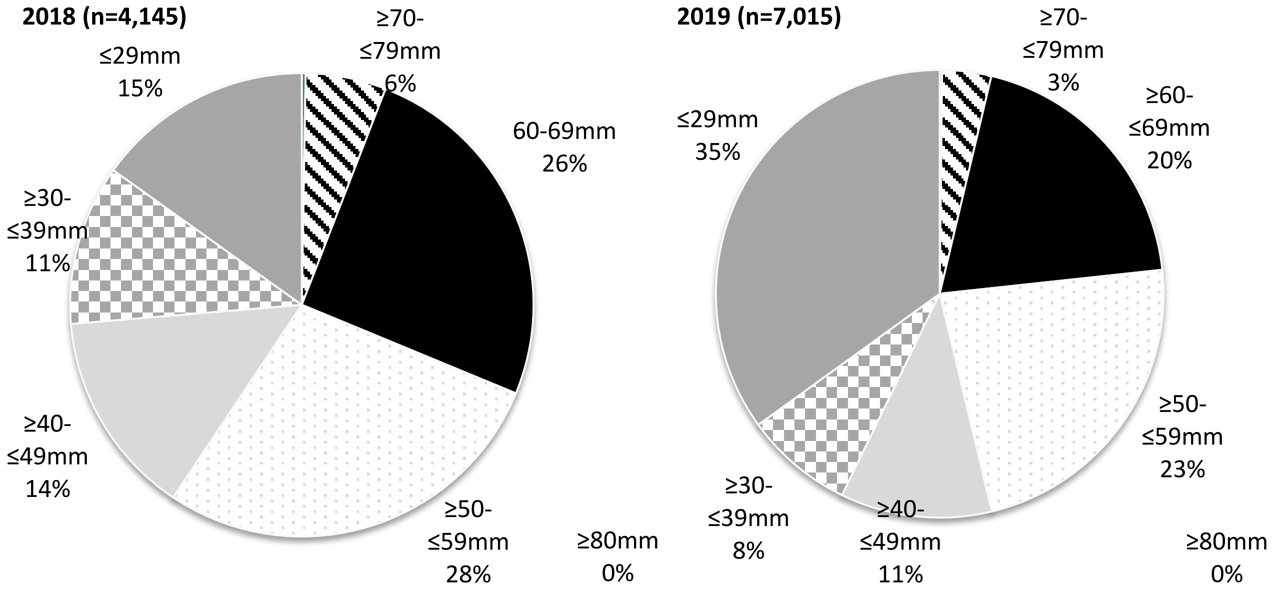


Figure 36: The size class distribution (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) from the Fal oyster survey from 2016 to 2019.

The size composition and distribution of size classes (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) of scallops for each site is shown in Figure 37 and Figure 38. The plots show a clear difference from 2016 to 2019 with a larger number of scallops recorded in most of the sites in the H and OH section and a much larger proportion of small scallops in most samples.

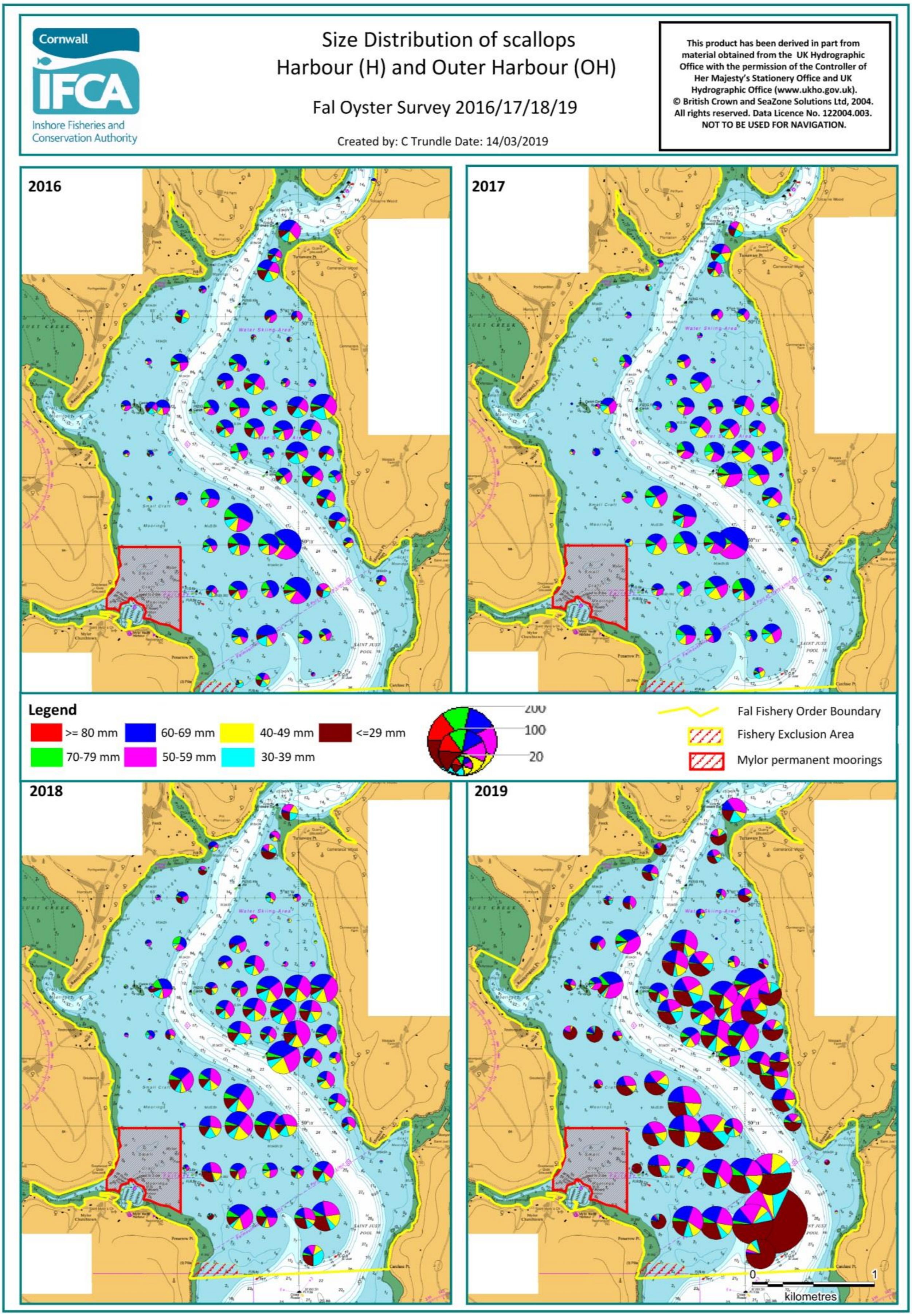


Figure 37: The size composition and distribution of size classes (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) for each site within the Outer Harbour and Harbour from the 2016, 2017, 2018 and 2019 surveys.

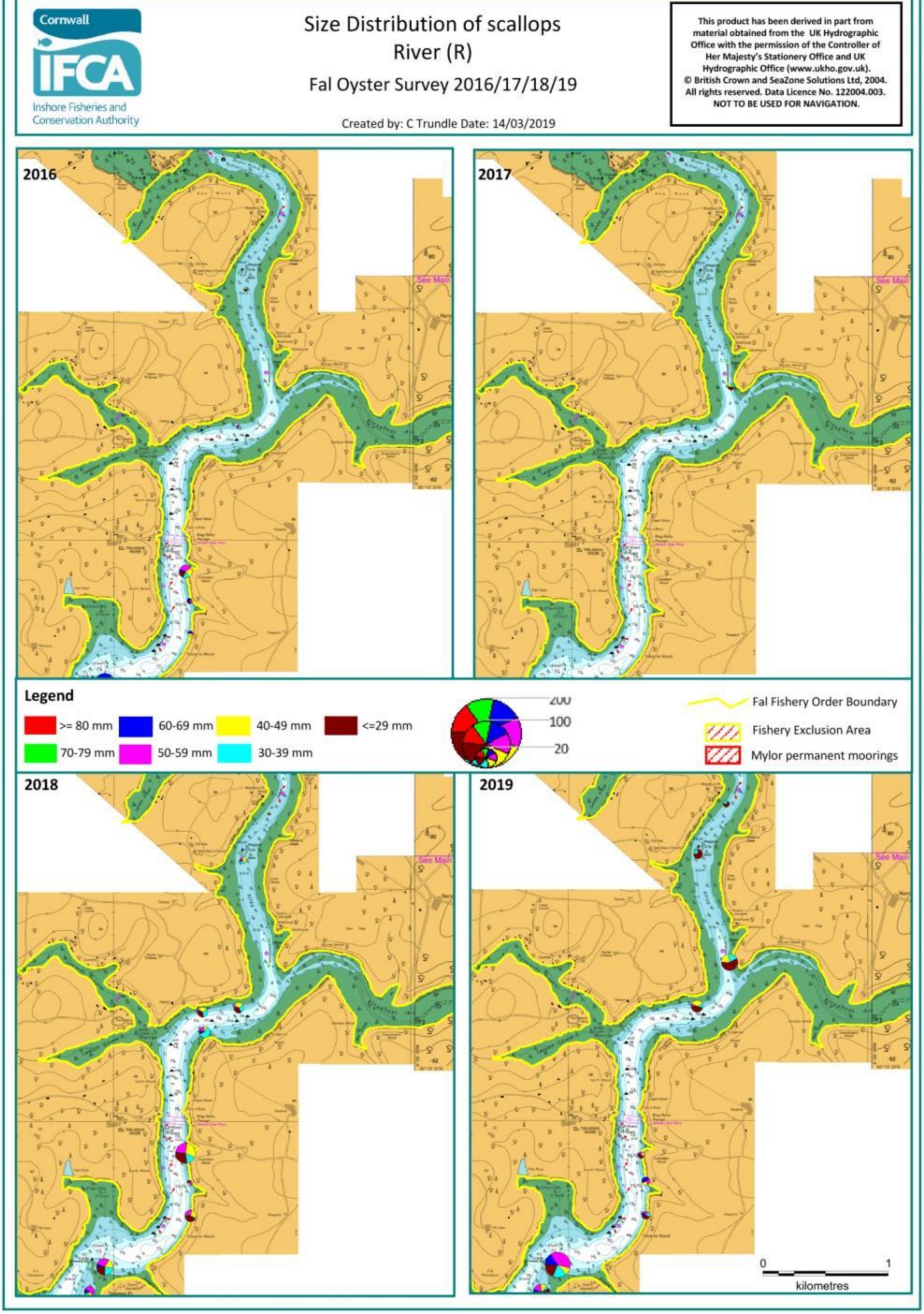


Figure 38: The size composition and distribution of size classes (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) for each site within the River section from the 2016, 2017, 2018 and 2019 surveys.

3.4.2 Density plot

The distribution of total number of scallops recorded from 2016 to 2019 is shown in Figure 39. The density around the edges of the estuary has remained low with a value of 10 scallops per 10 m^2. In 2016 and 2017, the density increased to 50 scallops per 10 m^2 in the central part of the survey area. In 2018, the density remained similar but increased in one small area to the eastern edge of the channel in the southern part of the East Bank to 100 scallops per 10 m^2. In 2019, the density around the edges remained similar with a low value, however there were further increases in areas of high density in the central part of East Bank of 100 scallops per 10 m^2 and in the southern section of East Bank with a density of 150 scallops per 10 m^2.

The distribution of scallops from 2016 to 2019 for the ≤29 mm size class is shown in Figure 40. The density of scallops has remained low across the fishery with a value of 10 per m^2. However, in 2018 a small area in the southern part of the survey boundary on the western edge of the channel had a higher density of 50 scallops per 10 m^2. In 2019, the density had increased in this one area to 150 scallops per 10 m^2. The density in 2019 had also increased in parts of the central section of East Bank to 50 scallops per 10 m^2.

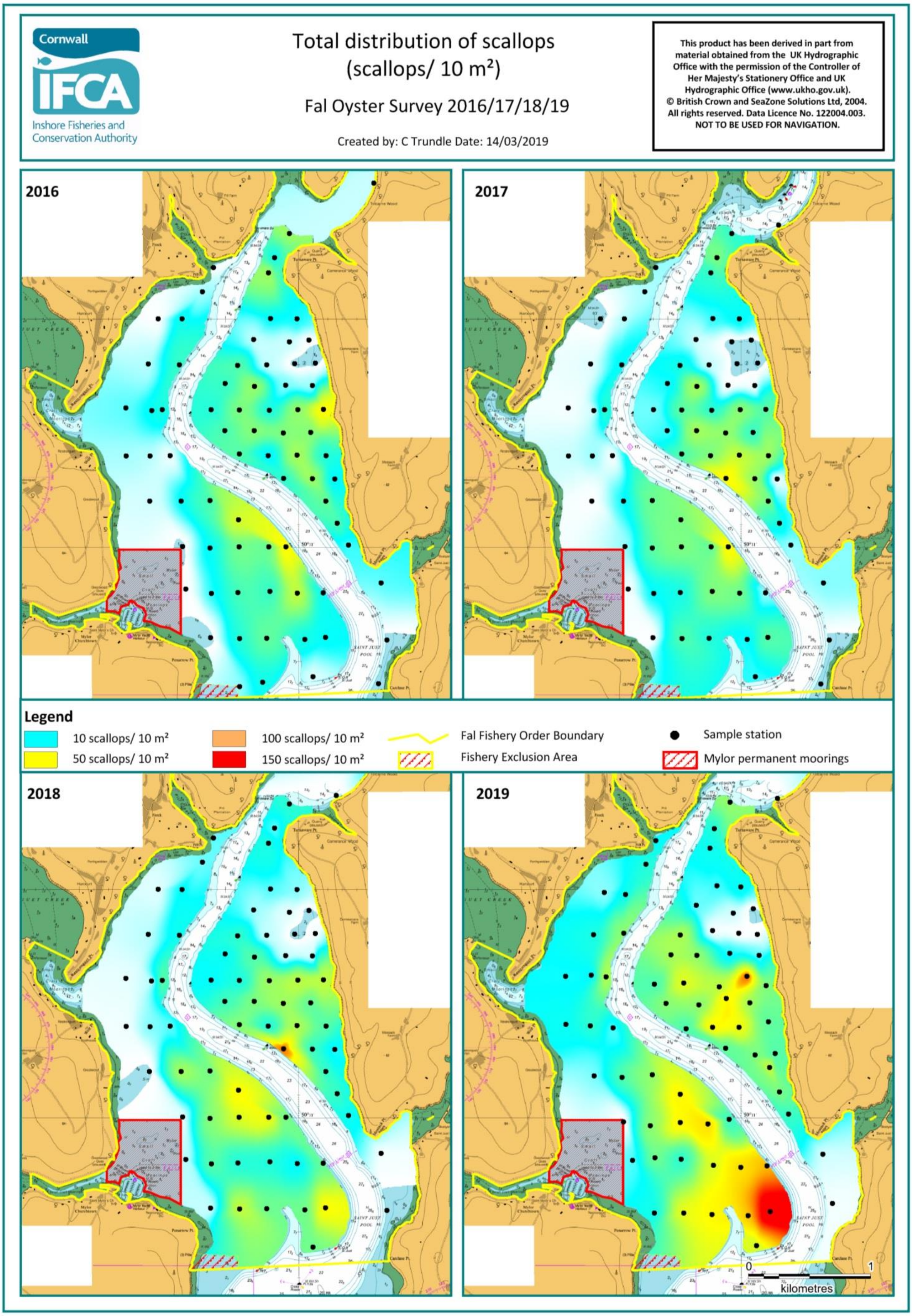


Figure 39: Density map displaying the total number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per 10 m^2 (*Chlamys* spp.) recorded within the Harbour and Outer Harbour sections for the 2016, 2017, 2018 and 2019 surveys.

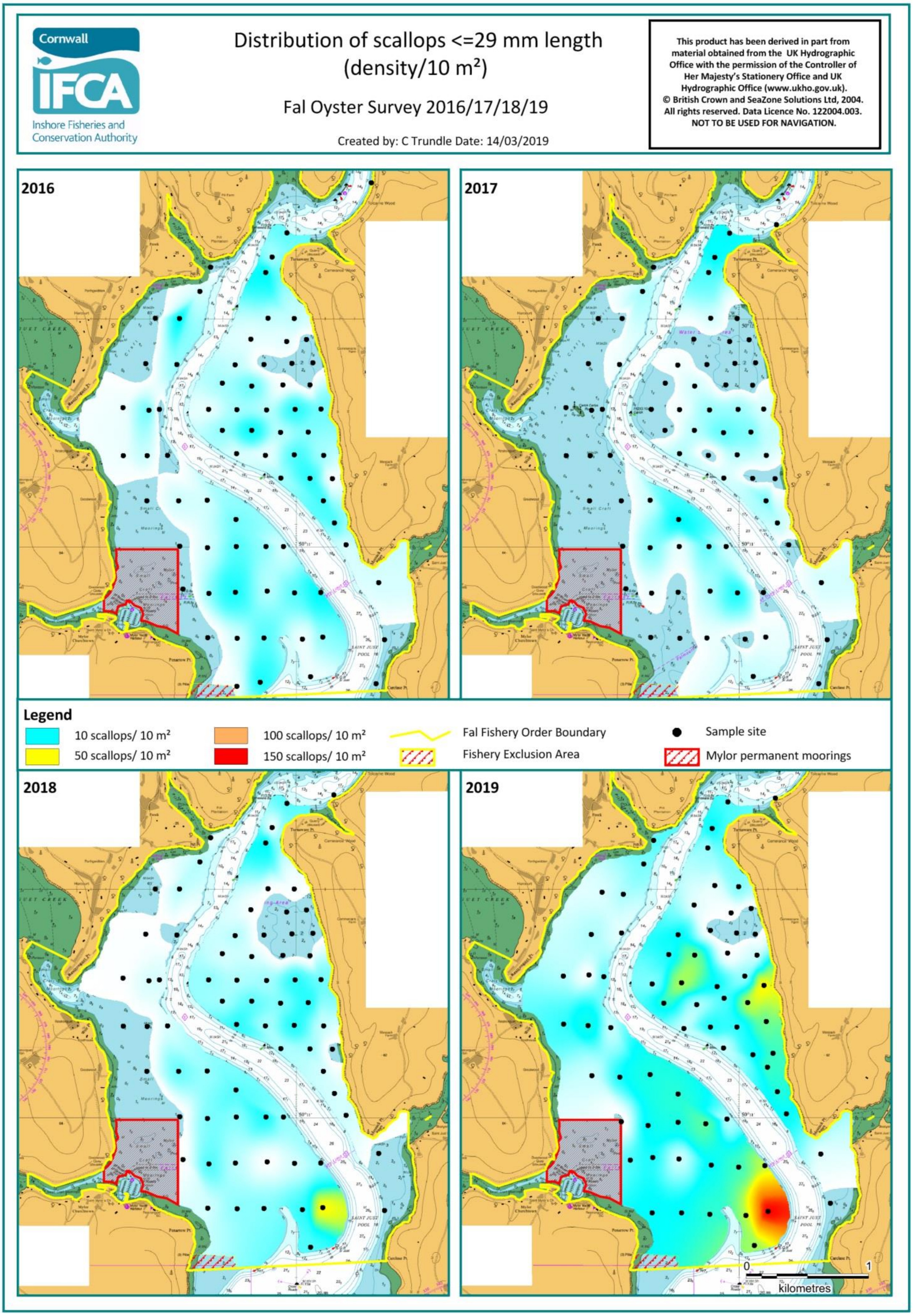


Figure 40: Density map displaying the total number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) ≤29 mm per 10 m^2 recorded within the Harbour and Outer Harbour sections for the 2016, 2017, 2018 and 2019 surveys.

3.4.3 Geographical sections

Of the total number of scallops measured, 1,254 were from the OH section; 5,448 from the H section and 313 from the R section. A table of scallop counts per site is shown in Annex Table F. The site with the most scallops was OH19 (649 scallops), followed by H45 (277 scallops) and OH20 (260 scallops). There were no scallops recorded at three sites (H94, R31 and R41). Less than ten scallops were recorded at 14 of the sites.

The largest scallop recorded during the survey was 87 mm and the smallest was 2 mm. The size class which made up the largest percentage of the total number of scallops was the ≤29 mm size class with 35.0 %. This was followed by the ≥50-≤59 mm size class with 23 %, ≥60-≤69 mm size class with 19.6%, ≥40-≤49 mm size class with 10.9 % and the rest were under 10 % of the total; 7.9% in the ≥30-≤39 mm size class, 3.5% in the ≥70-≤79 mm size class and the smallest percentage was 0.2 % in the ≥80 mm size class.

3.4.3.1 Average sizes

Table 17 and Figure 41 show the mean sizes of scallops recorded in the H, R and OH survey areas from 2016 to 2019.

For all sections of the survey, a shift was recorded from 2016 to 2019 to a smaller average size of scallop, from 53.5 mm to 42.7 mm in the H section, 51.9 mm to 27.0 mm in the OH section and 47.1 mm to 36.0 mm in the R section. The analysis includes all scallops recorded and the shift to a smaller size of scallop in recent years is likely to be due to the larger number of smaller scallops which were recorded.

Table 17: The mean size (mm) ± standard error of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) in the Harbour (H), River (R) and Outer Harbour (OH) section of the survey

Year	H	OH	R
2019	42.7 mm ± 0.29 mm	27.0 mm ± 0.63 mm	36.0 mm ± 0.29 mm
2018	49.9 mm ± 0.30 mm	42.8 mm ± 1.08 mm	37.0 mm ± 0.97 mm
2017	55.4 mm ± 0.25 mm	56.2 mm ± 0.94 mm	39.7 mm ± 1.55 mm
2016	53.5 mm ± 0.28 mm	51.9 mm ± 1.02 mm	47.1 mm ± 1.25 mm

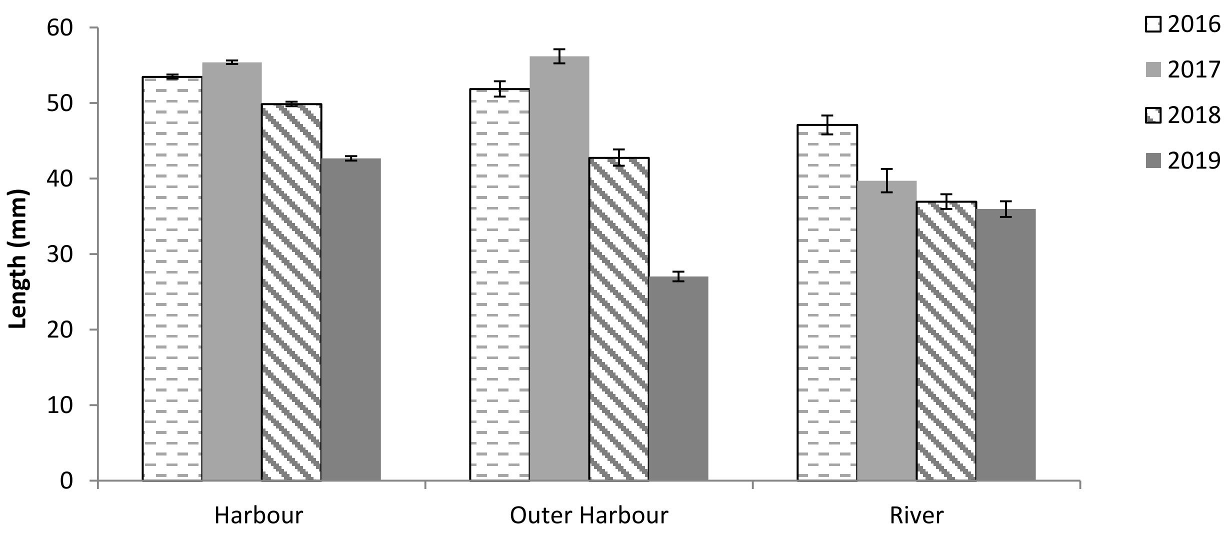


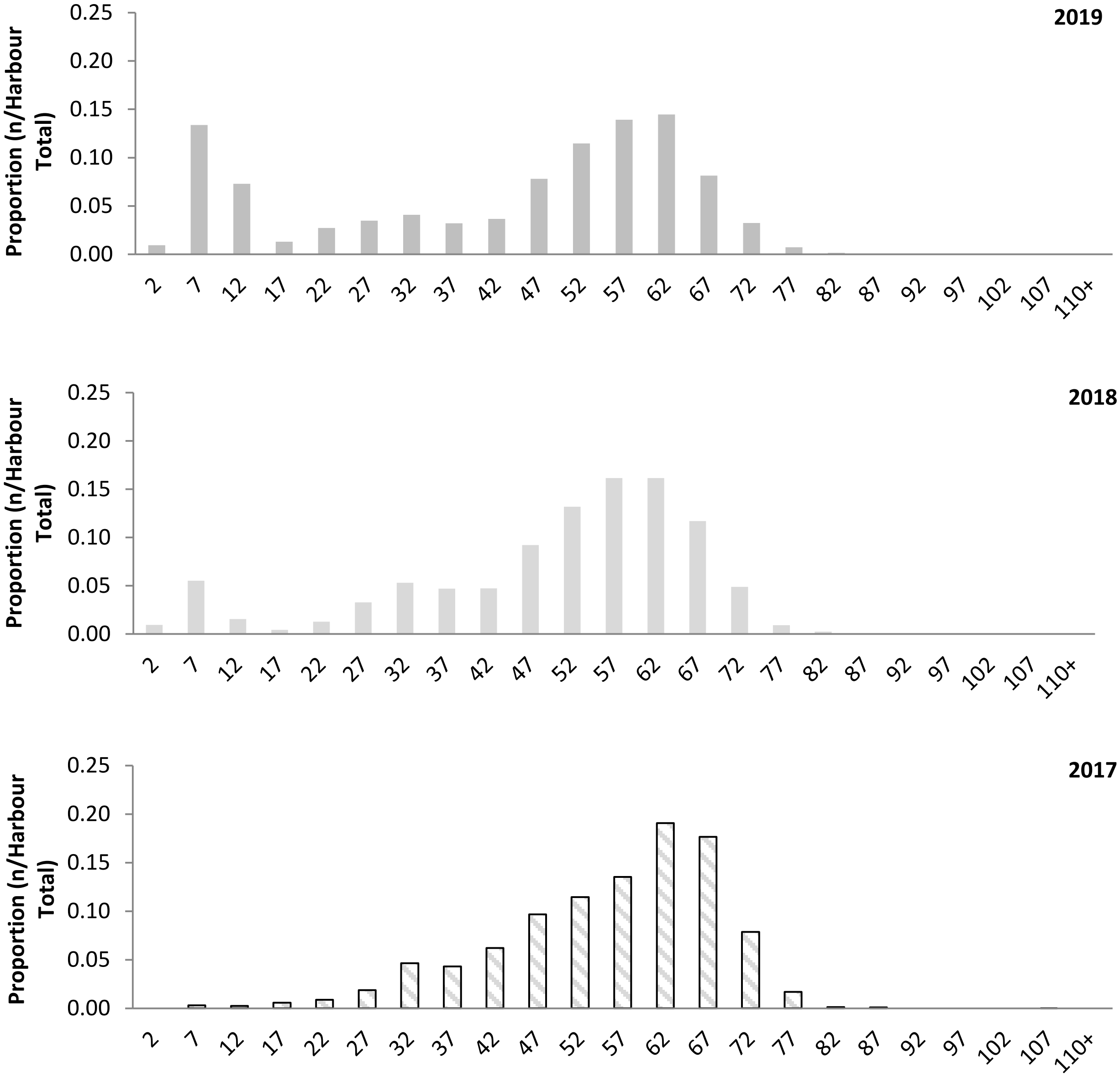
Figure 41: The average size (mm) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) ± standard error for the Harbour, River and Outer Harbour sections of the survey for the years 2016, 2017, 2018 and 2019.

3.4.3.2 Size frequency plots

The size distribution of scallops was graphed for the H (Figure 42), OH (Figure 43) and R (Figure 44) areas.

Harbour

The frequency distribution for the H section was normal in 2016 and 2017 with a peak at 62 mm. In 2018 and 2019 the distribution was widespread and uneven with peaks at 57 mm in 2018 and 62 mm in 2019 but both years also had a large number of scallop spat, in particular the 7 mm size class which was 6% of the total in 2018 and had increased to 13% in 2019.



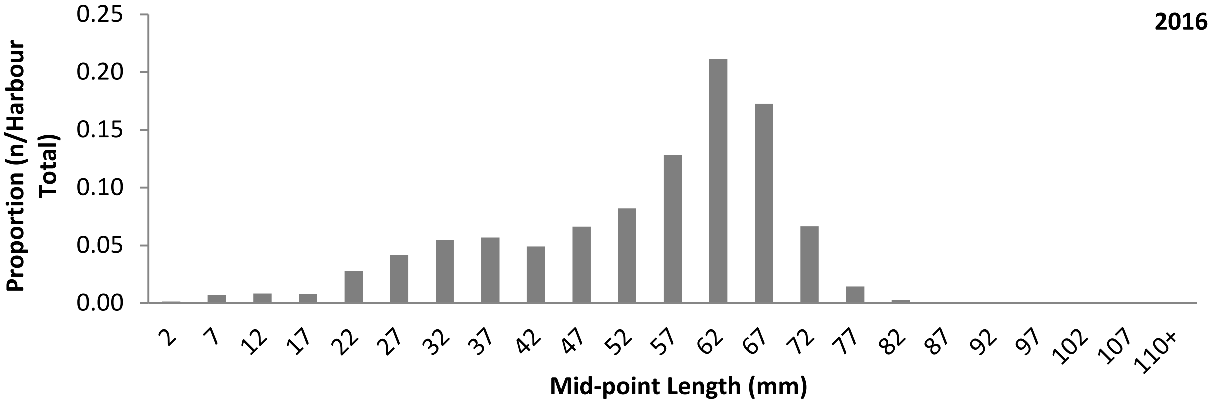
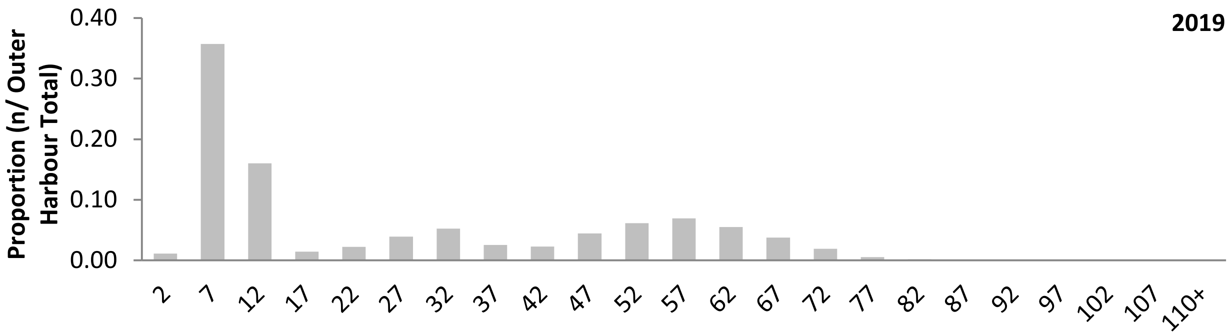
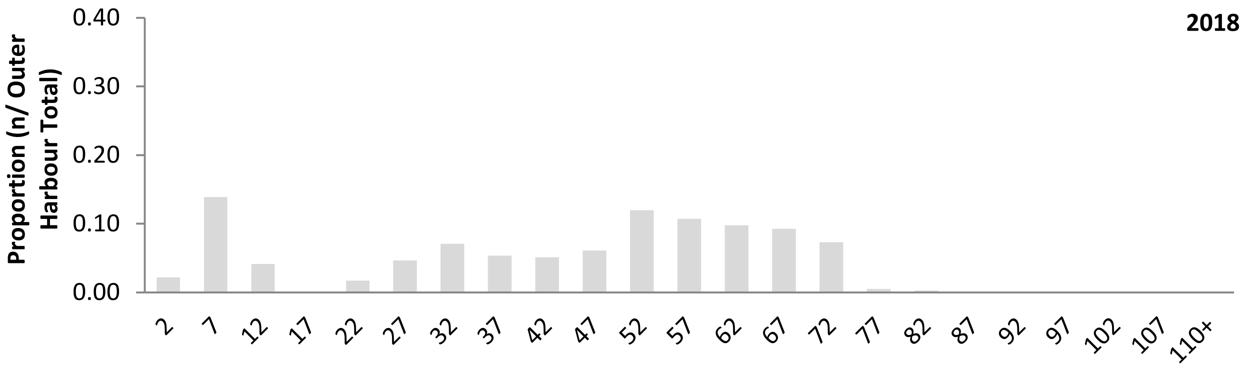


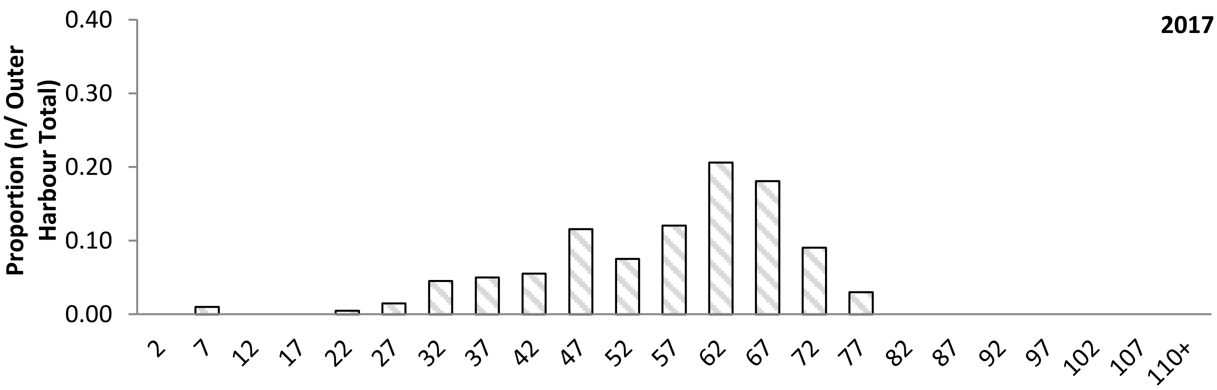
Figure 42: Size frequency distributions for scallops for the Harbour (H) section of the fishery from 2016 to 2019.

Outer Harbour

The frequency distribution for the OH section was uneven and bimodal for 2016 and 2017. In 2018 and 2019 there was a greater distribution of scallops and a greater frequency of scallop spat with the largest size class of 7 mm for both years.







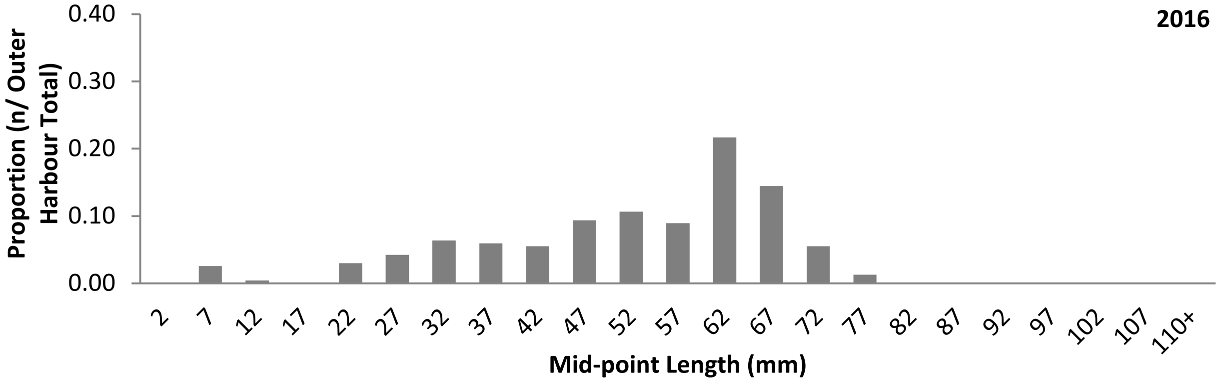
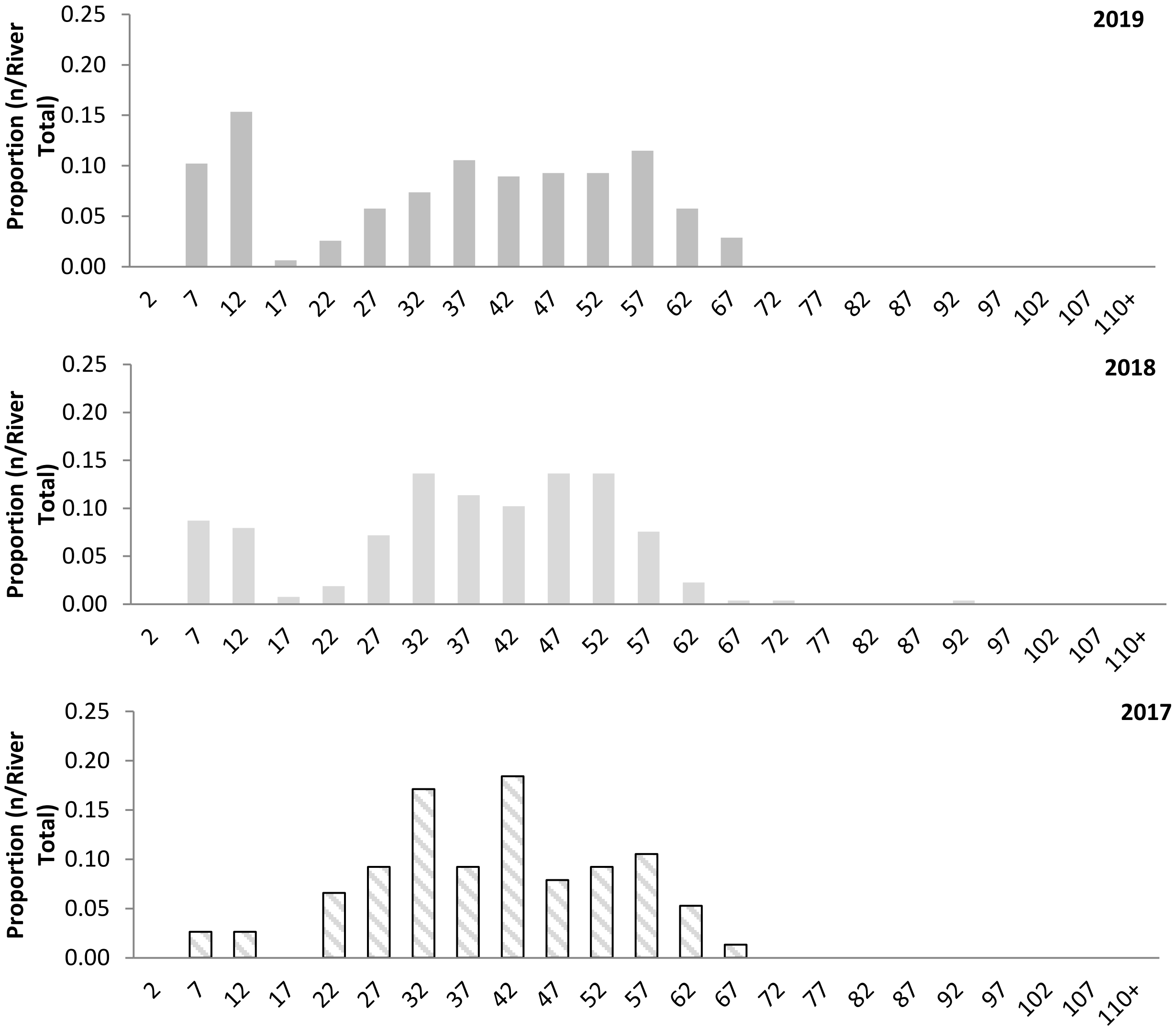


Figure 43: Size frequency distributions for scallops for the Outer Harbour (OH) section of the fishery from 2016 to 2019.

River

The frequency distribution for the R section for all four years was uneven and showed a wide size distribution of scallops (Figure 44). In 2015 there was a greater percentage of adult scallops with a peak at 62 mm. In 2016 the distribution was bimodal with peaks at 32 mm and 42 mm. The distribution in 2018 and 2019 was similar with a wide size distribution with many scallops that were less than 32 mm.



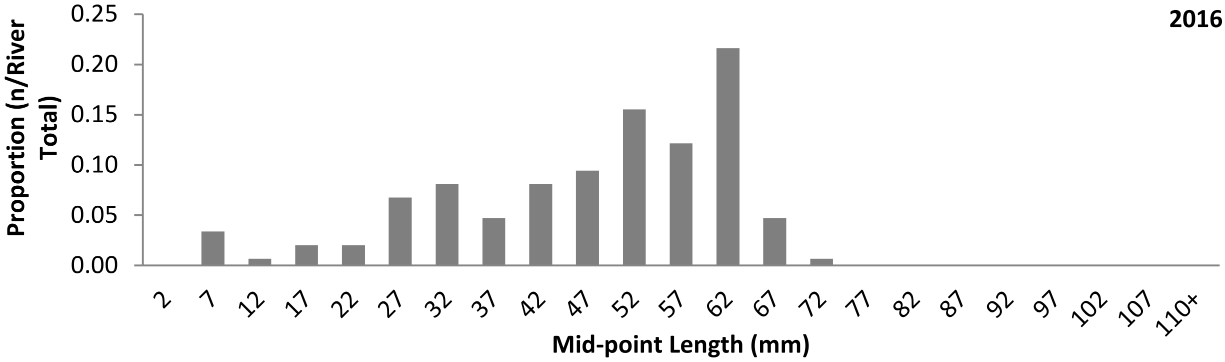


Figure 44: Size frequency distributions for scallops for the River (R) section of the fishery from 2016 to 2019.

3.4.3.3 Average number

Table 18 and Figure 45 show the average number of scallops recorded in the H, R and OH survey sections from 2016 to 2019.

The average number of scallops has varied for all three sections of the survey year by year. For all three sections the average number of scallops increased from 2016 to 2019. The largest increase was in the OH section with an increase from 26.1 in 2016 scallops to 209 scallops.

Table 18: The average number ± standard error of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) in the Harbour (H), River (R) and Outer Harbour (OH) sections of the survey from 2015 to 2019.

Year	Harbour	Outer Harbour	River
2019	86.5 ± 8.12	209.0 ± 97.30	22.4 ± 8.47
2018	55.1 ± 6.02	68.3 ± 23.76	18.9 ± 5.77
2017	42.5 ± 4.93	30.7 ± 11.36	8.3 ± 4.43
2016	45.6 ± 4.72	26.1 ± 8.66	8.7 ± 5.30

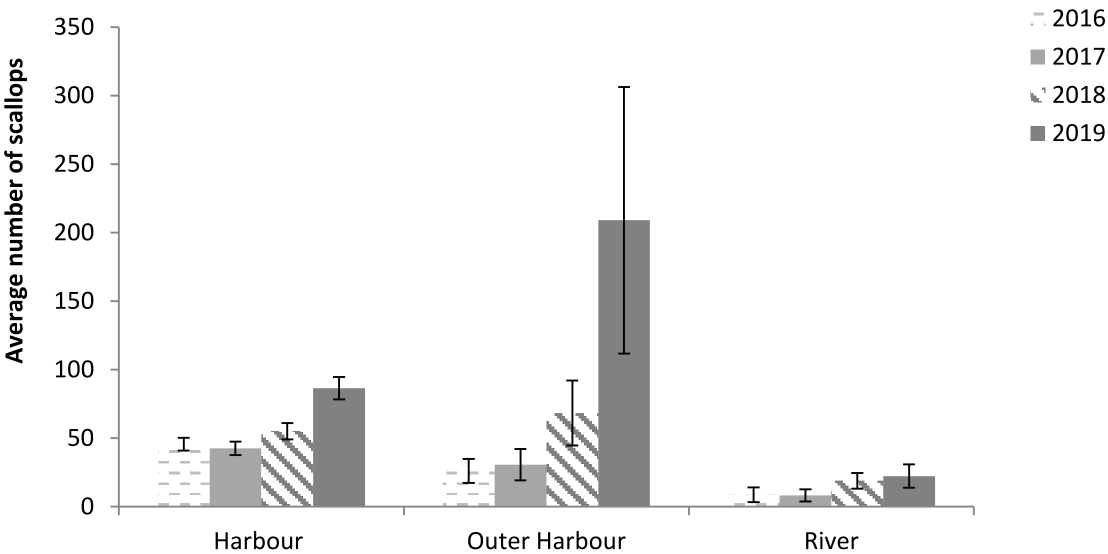


Figure 45: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) ± standard error for the Harbour, River and Outer Harbour sections of the survey for the years 2016, 2017, 2018 and 2019.

3.4.3.4 Density

The density of scallops per 10 m^2 for 2019 for all three geographic areas is shown in Figure 46. The density of scallops per 10 m^2 was highest for all years in the H section. The OH and R sections followed a similar trend with low levels in 2016 and 2017 and an increase from 2018 onwards.

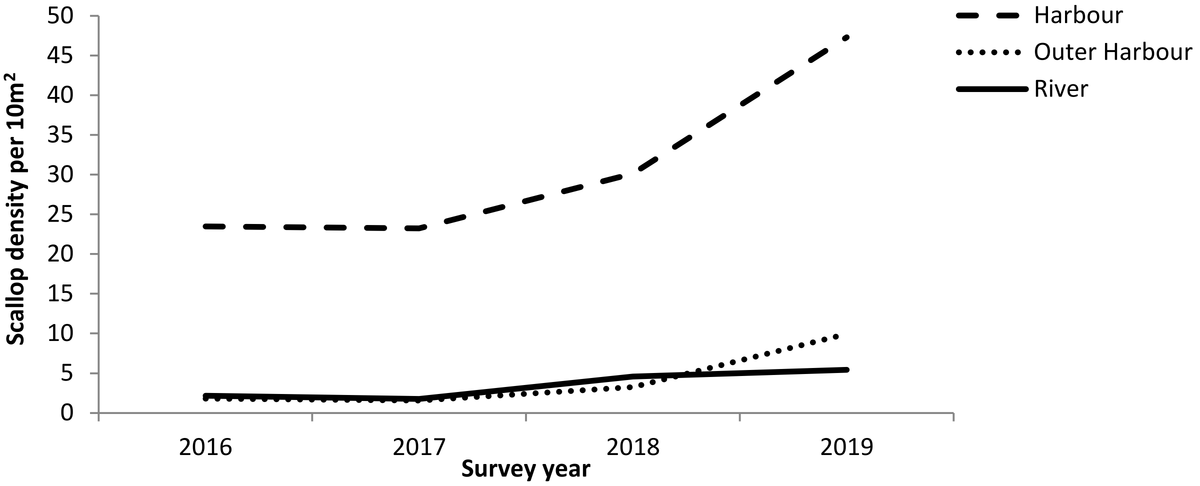
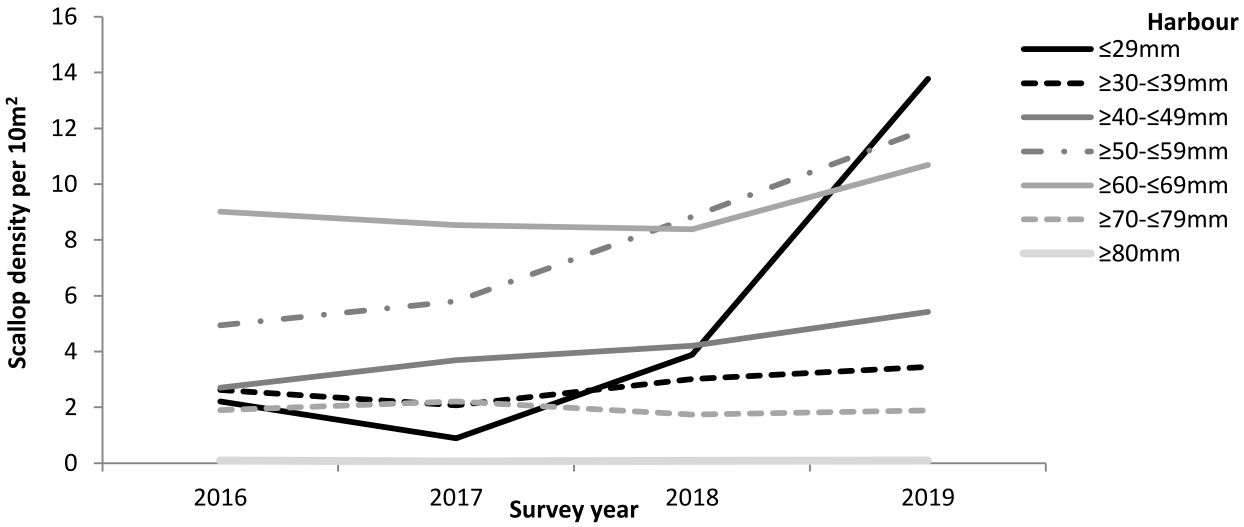


Figure 46: The density of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per 10m^2 for the three geographic areas (harbour, outer harbour and river) in 2016, 2017, 2018 and 2019.

The density of scallops per 10 m^2 for 2019 for all three geographic areas per size class is shown in Figure 47. In the H section the density of scallops per 10 m^2 for most size classes fluctuated steadily, however from 2017 to 2019 the density increased from 5.8 to 12.0 in the ≥50-≤59 mm size class and from 0.89 to 13.77 in the ≤29 mm size class. In the OH section the density was low for all size classes for all years except the ≤29 mm size class which increased from 0.87 in 2018 to 6.02 in 2019. The density in the R section remained consistently low throughout all years although a slight increase was seen in the smallest size class from 2018 to 2019.



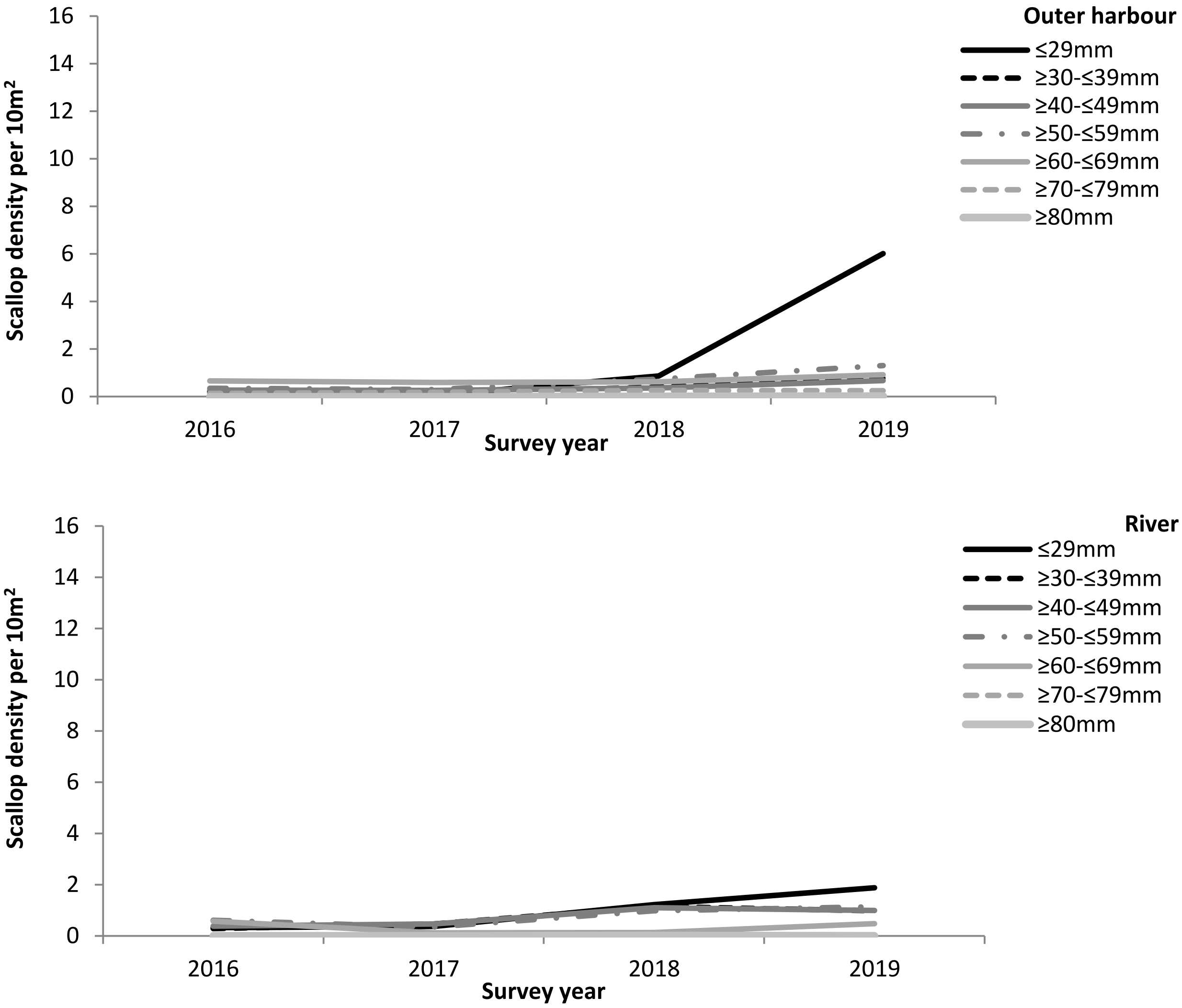


Figure 47: The density of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per 10 m^2 for the three geographic areas (harbour, outer harbour and river) by size class from 2016 to 2019. N.B. Y axis scales are the same.

3.4.3.5 Scallop Size Class Composition

When split by size class and section, the total number of scallops for all of the size classes was highest in the H section and lowest in the R section (Table 19). The number of scallops per section by size class was highest in the H section for the ≤29 mm size class (1,586) and in the ≥50-≤59 mm size class (1,382) and lowest in the R section for two size classes (≥80 mm and ≥70-≤79 mm) where no scallops were recorded.

Table 19: The number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) recorded in the Harbour (H), Outer Harbour (OH) and River (R) sections recorded by total number of scallops, total number of scallops ≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm during the Fal oyster survey 2019.

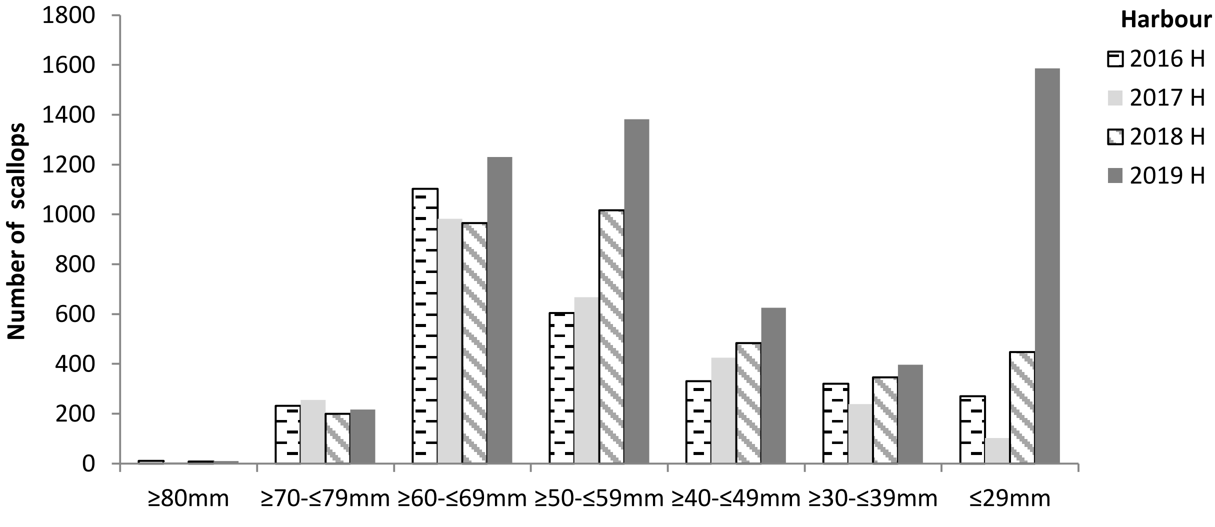
Section	Total number of scallops	≥80 mm	≥70-≤79 mm	≥60-≤69 mm	≥50-≤59 mm	≥40-≤49 mm	≥30-≤39 mm	≤29 mm
H	5,448	10	217	1,231	1,382	625	397	1,586
OH	1,254	2	31	116	164	85	98	758
R	313	0	0	27	65	57	56	108

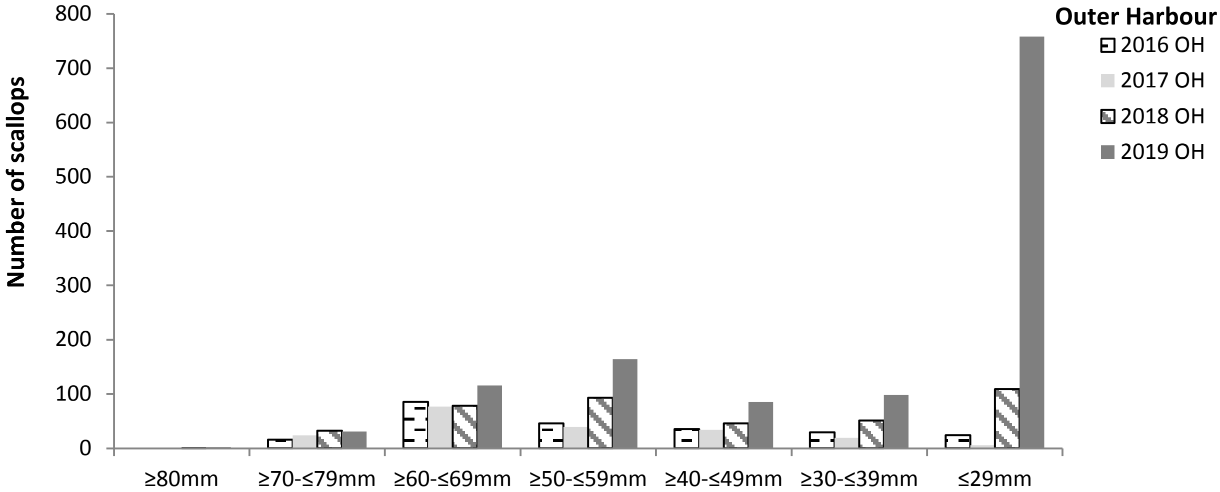
When split by size class and section, the average number of scallops was highest in the OH section and lowest in the R section (Table 20). The average number of scallops by size class per section was highest in the OH section for the ≤29 mm size class (126 scallops). In 2018, the highest average was for the same size class and section but the average number of scallops was a lot lower (18.2 average). The lowest average was in the river section when no scallops were recorded (≥80 mm and ≥70-≤69 mm). Apart from the size classes with no scallops recorded the other sections or size classes with a low average number of scallops were H - ≥80 mm, 0.2 and OH - ≥80 mm, 0.3 scallops.

Table 20: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) recorded in the Harbour (H), Outer Harbour (OH) and River (R) sections recorded by total number, total number of scallops ≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm during the Fal oyster survey 2019.

Section	Average number of scallops	≥80mm	≥70-≤79 mm	≥60-≤69 mm	≥50-≤59 mm	≥40-≤49 mm	≥30-≤39 mm	≤29mm
H	86.5	0.2	3.4	19.5	21.9	9.9	6.3	25.2
OH	209.0	0.3	5.2	19.3	27.3	14.2	16.3	126.3
R	22.4	0.0	0.0	1.9	4.6	4.1	4.0	7.7

The total number of scallops per section by size class varied between 2016 and 2019 (Figure 48). In the H section number of scallops has remained relatively similar for the ≥70-≤79 mm, ≥60-≤69 mm and ≥30-≤39 mm size classes. The number of scallops in the ≥50-≤59 mm, ≥40-≤49 mm and ≤29 mm size class has increased from 2016 to 2019. The largest difference was in the ≤29 mm size class with an increase from 102 in 2017 to 1,586 in 2019. In the OH section the number of scallops remained relatively similar for the two largest size classes of scallops and increased from 2016 to 2019 all other size classes with the largest difference in the ≤29 mm size class from 6 in 2017 to 758 in 2019. In the R section, the number of scallops decreased from 2016 to its lowest values in 2017 in most size classes. The number of scallops increased in 2018 and either decreased or increased slightly in 2019 for the smaller size classes except the ≤29 mm size class which observed a large increase from 16 in 2017 to 108 in 2019.





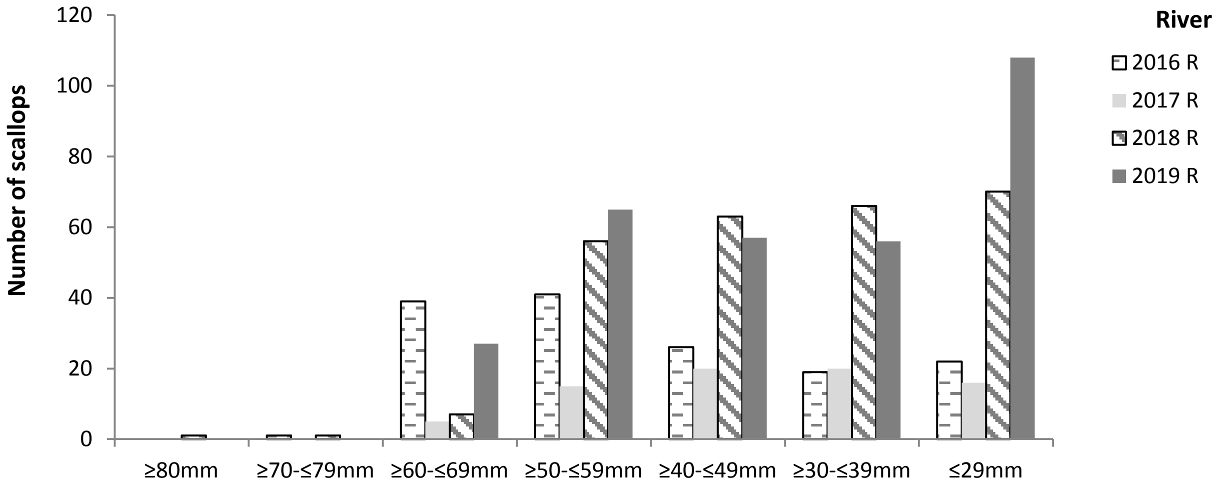


Figure 48: The total number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per size class (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) from 2016 to 2019 for the Harbour (H), Outer Harbour (OH) and River (R) sections.

The average number of scallops per section by size class varied between 2017 and 2018 (Figure 49) and follows a similar trend to what was observed in the data for the total number of scallops. For all sections a low number of large scallops in the ≥70-≤79 mm and ≥80 mm size classes were recorded and the number of small scallops in the ≤29 mm size class increased dramatically for all three sections. In sections H and OH, the average number of scallops increased for all other size classes in 2019, the increase was either from 2016 or 2017. In the R section, the values increased for the ≥60-≤69 mm and ≥50-≤59 mm size classes and decreased for the ≥40-≤49 mm and ≥30-≤39 mm size classes.

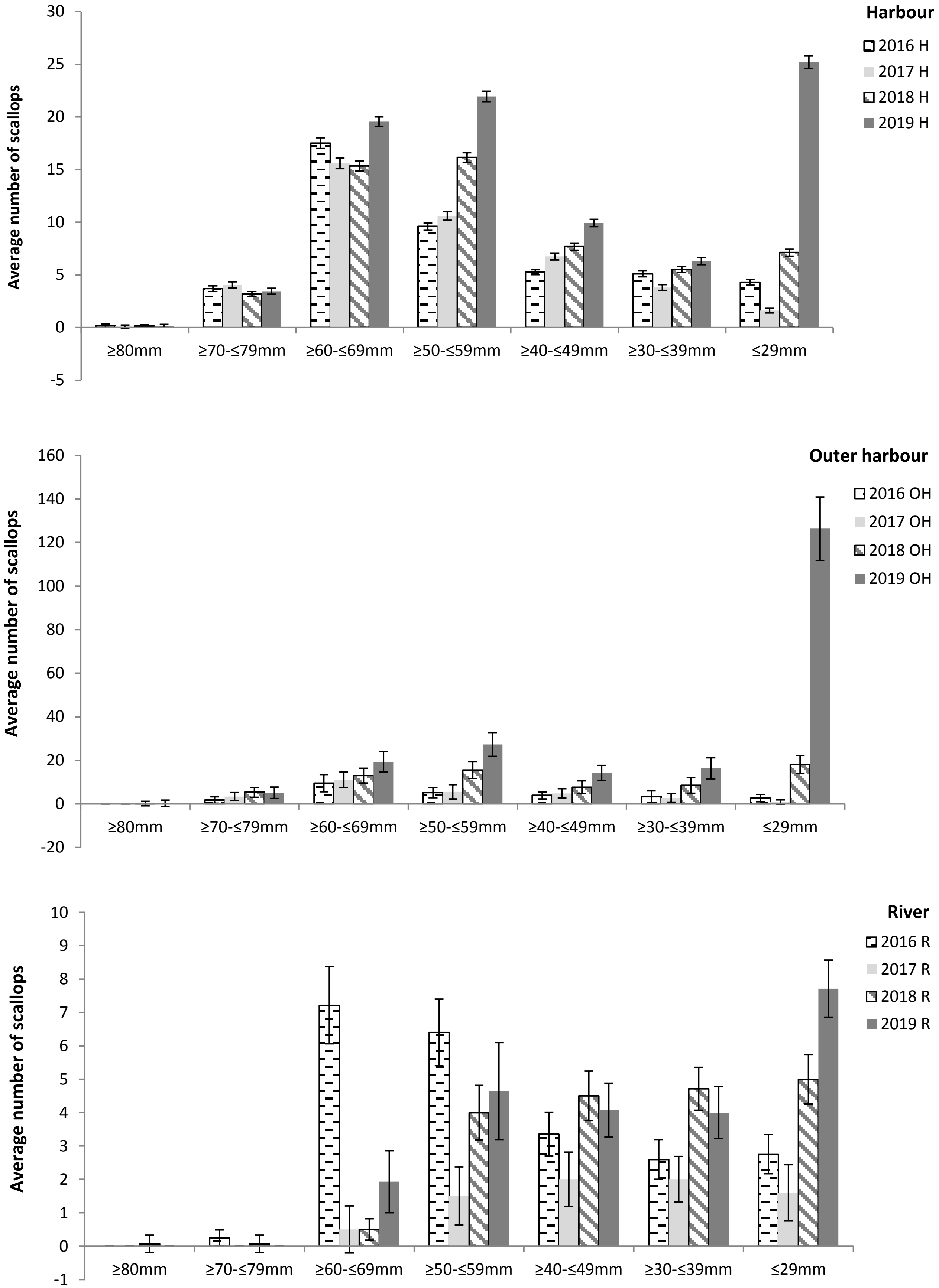


Figure 49: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per size class (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) from 2016 to 2019 for the Harbour (H), Outer Harbour (OH) and River (R) sections.

3.4.3.6 Minimum landing size

The MLS for scallops from the fishery is 40 mm. The percentage of scallops over and under the MLS is shown in Table 21. In the H section, in previous years there was a much larger number of scallops over the MLS than under, however in 2019 this changed and 68% of scallops were under the MLS. In the OH section, the numbers have remained similar since 2016 with a larger percentage over the MLS . In the R section the percentages were more even which has been the trend since 2017.

Table 21: The percentage (%) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) over and under the minimum landing size (40 mm) for all three sections of the Fal Oyster Survey area (Harbour, Outer Harbour and River sections) from 2015 to 2019.

	Harbour % under 40 mm	Harbour % over 40 mm	Outer Harbour % under 40 mm	Outer Harbour % over 40 mm	River % under 40 mm	River % over 40 mm
2019	68.26	31.74	36.40	63.60	52.40	47.60
2018	22.90	77.10	39.02	60.98	51.52	48.48
2017	12.74	87.26	12.56	87.44	47.37	52.63
2016	20.60	79.40	22.55	77.45	27.70	72.30

3.4.4 Management sections

Of the total number of scallops, 6,243 were from Area A, 459 from Area B and 313 from Area C. The total number of scallops per site is shown in Annex Table F.

3.4.4.1 Average sizes

Table 22 and Figure 50 show the average size (mm) of scallops recorded in the A, B and C management areas from 2016 to 2019.

For the management areas of the survey, the average size (mm) of scallops has varied yearly. In Area C, the length of scallops steadily decreased from 47.6 mm in 2016 to 34.0 mm in 2019 and for Areas A and B the size has decreased since 2017, from 56.5 mm in 2017 to 36.6 mm in 2019 for Area A and from 54.9 mm in 2017 to 44.4 mm in 2019 for Area B. The analysis includes all scallops recorded and the shift to a smaller size of scallop in recent years is likely to be due to the larger number of smaller scallops which were recorded.

Table 22: The average size (mm) ± standard error of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) in the management areas, Area A, B and C from 2015 to 2019.

Year	Area A	Area B	Area C
2019	36.6 mm ± 0.37 mm	44.4 mm ± 0.42 mm	34.0 mm ± 0.98 mm
2018	47.8 mm ± 0.46 mm	50.4 mm ± 0.36 mm	38.6 mm ± 0.93 mm
2017	56.5 mm ± 0.34 mm	54.9 mm ± 0.33 mm	44.7 mm ± 1.24 mm
2016	55.3 mm ± 0.38 mm	51.8 mm ± 0.39 mm	47.6 mm ± 1.13 mm

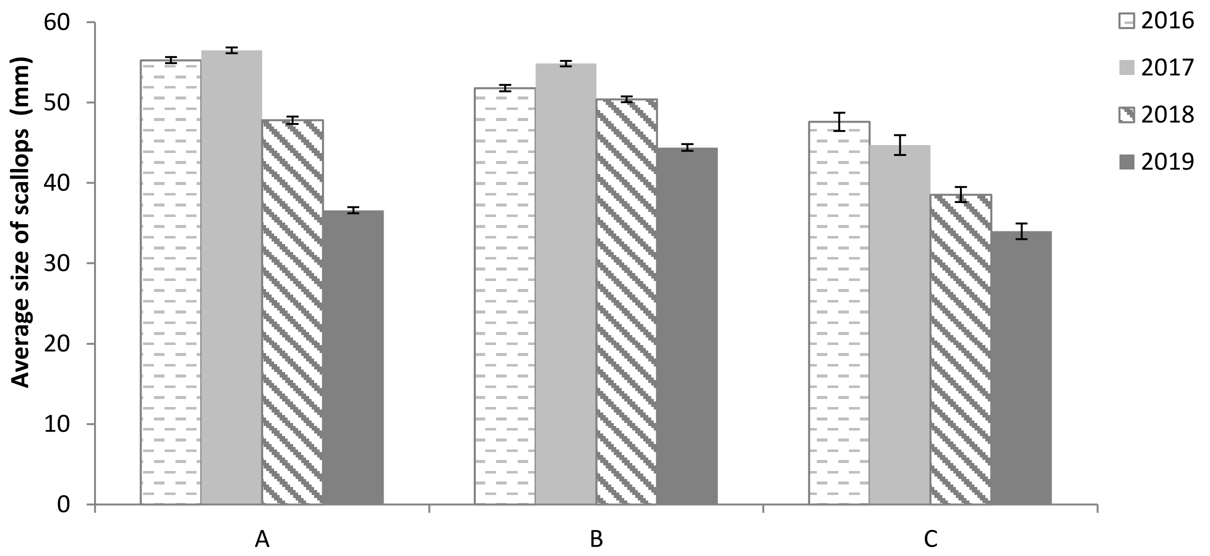


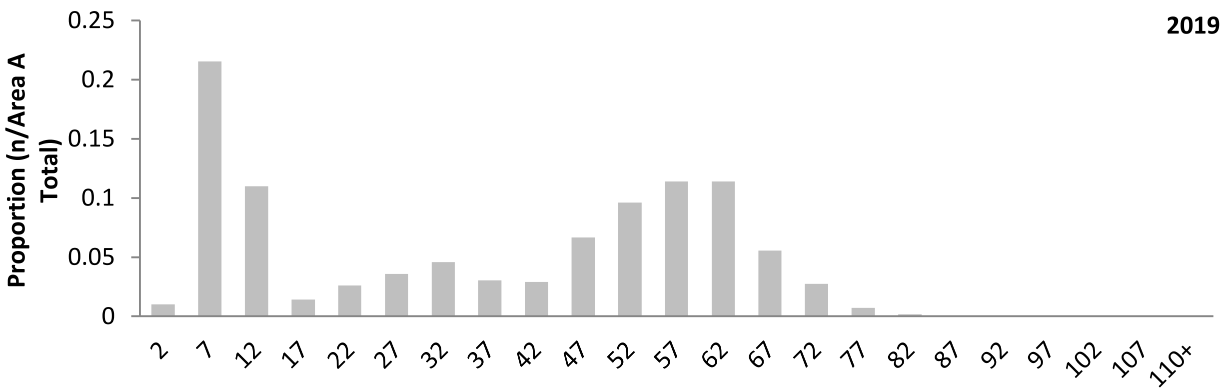
Figure 50: The average size (mm) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) ± standard error for the management areas (Area A, B and C) of the survey for the years 2016, 2017 2018 and 2019.

3.4.4.2 Size frequency plots

The size distribution of scallops was graphed for the management areas; Area A (Figure 51), B (Figure 52) and C (Figure 53).

Area A

The frequency distribution in Area A is shown in Figure 51. The frequency distribution for Area A was normal in 2016 and 2017 with a peak at 62 mm. In 2018 and 2019 the distribution was uneven and widespread with a large number of scallops over 57 mm and scallop spat recorded. In 2018 the 7 mm size class was 9% and in 2019 this increased to 22%.



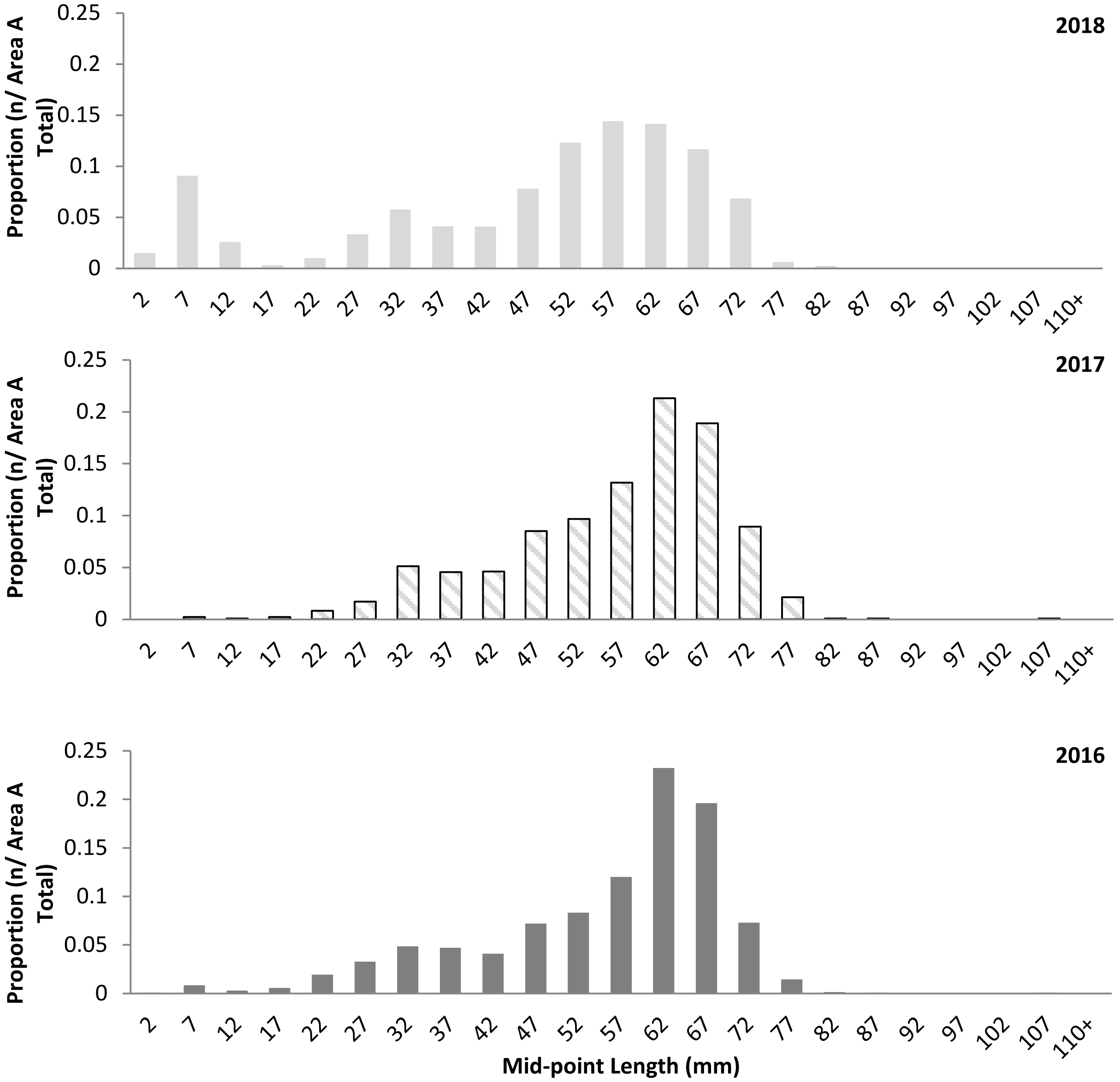
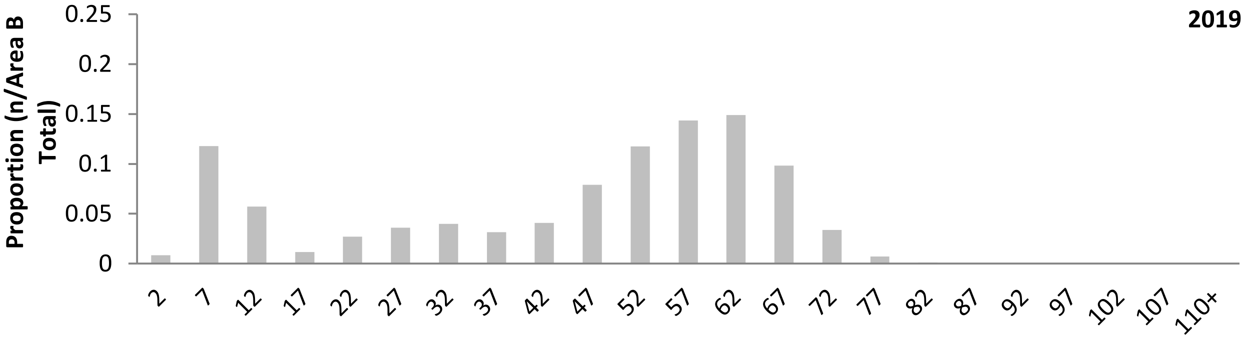


Figure 51: Size frequency distributions for scallops for the management section Area A of the fishery from 2016 to 2019.

Area B

The frequency distribution in Area B is shown in Figure 52. The frequency distribution for Area B was normal in 2016 and 2017 with a peak at 62 mm for both years. In 2018 the distribution was similar but there was an increase in the number of small scallops of 7 mm to 4%. In 2019, the distribution was similar again with a peak at 62 mm of 15% but the number of scallops in the 7 mm size class had increased to 13%.



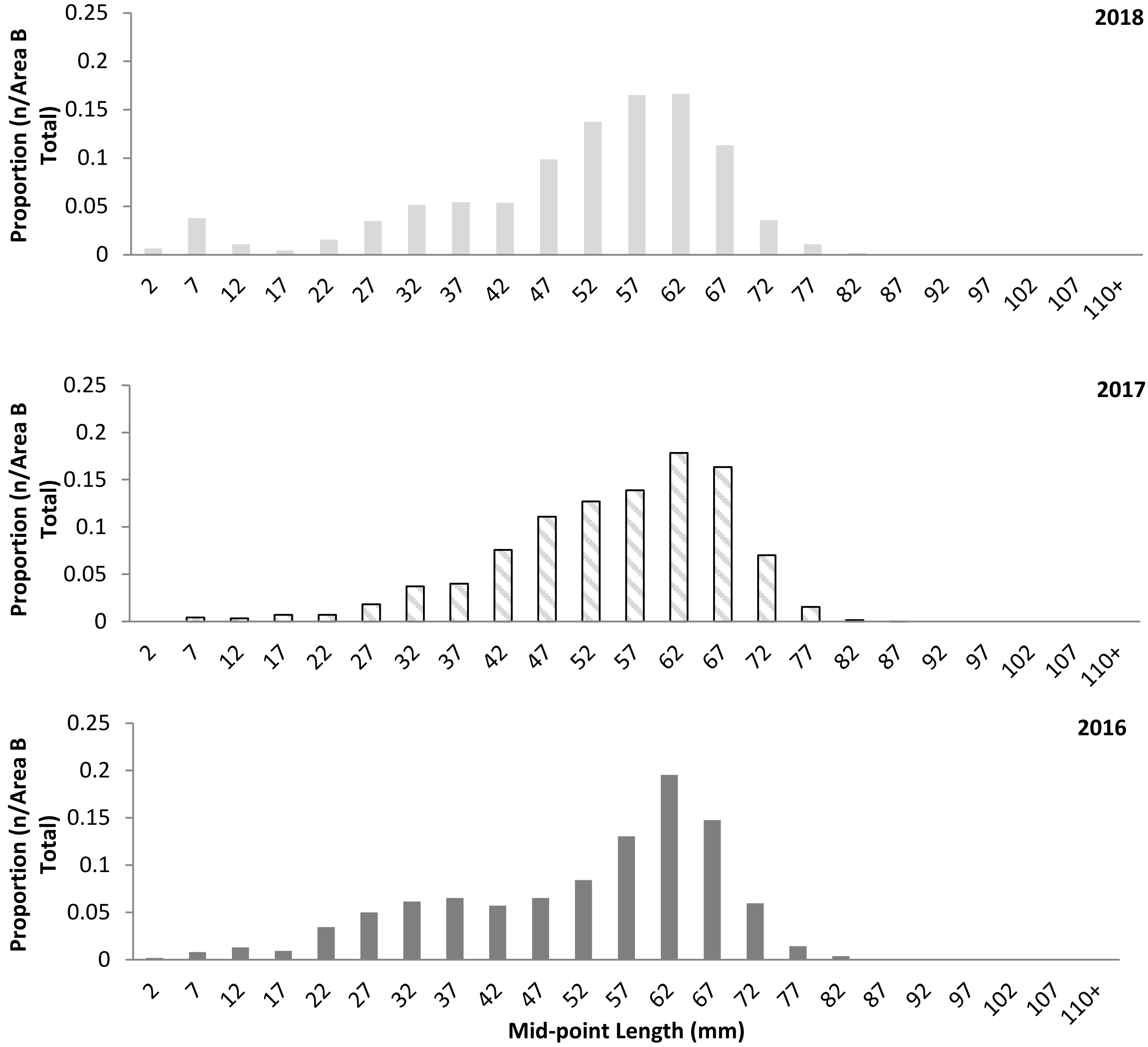


Figure 52: Size frequency distributions for scallops for the management section Area B of the fishery from 2016 to 2019.

Area C

The frequency distribution in Area C is shown in Figure 53. The frequency distribution for Area C was uneven in 2016 and 2017 with a peak at 62 mm in 2016 and 32 mm in 2017. In 2018 and 2019 the distribution was widespread with a lower number of scallops of 57 mm compared to previous years and a much larger number of scallop spat with high proportions in the 7 mm and 12 mm size classes.

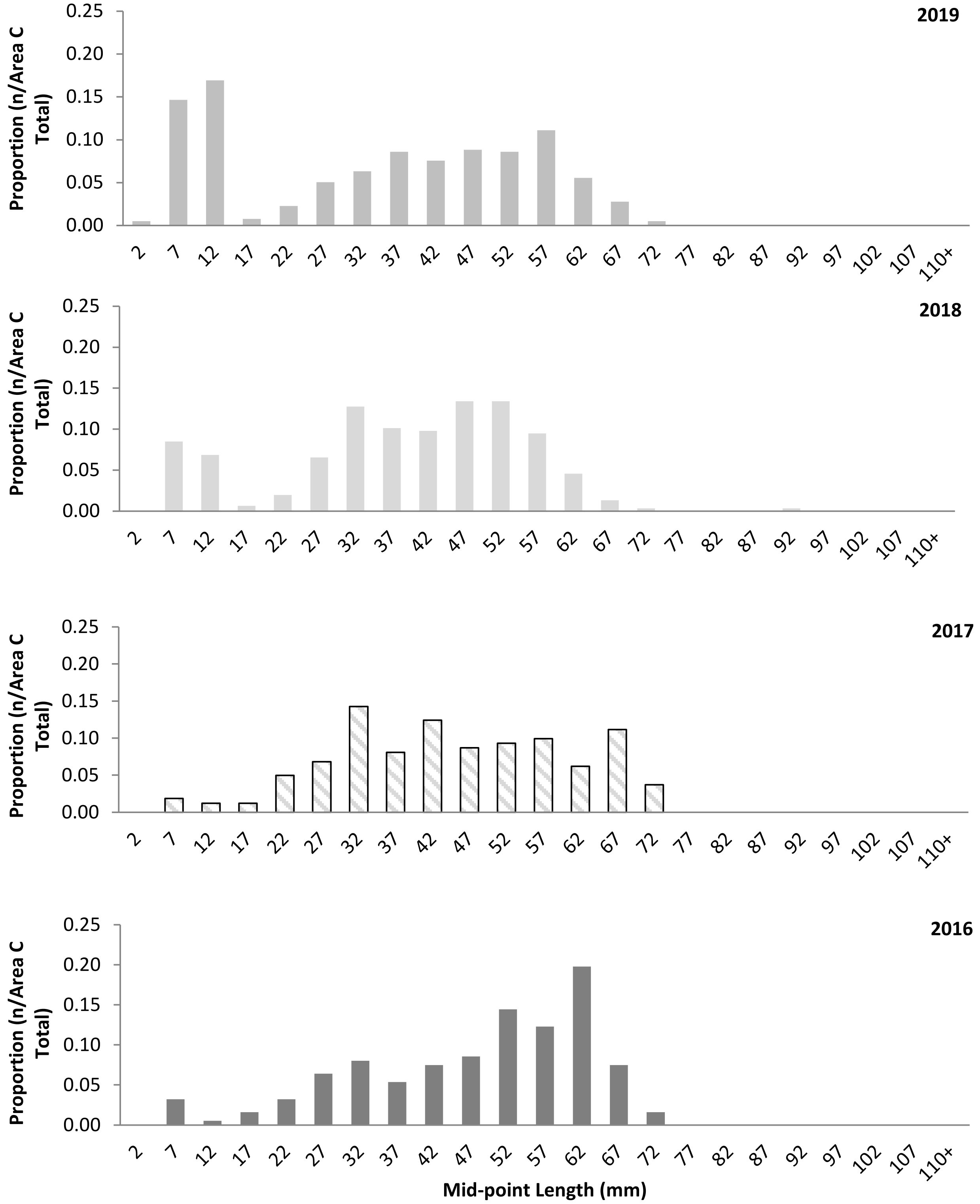


Figure 53: Size frequency distributions for scallops for the management section, Area C of the fishery from 2016 to 2019.

3.4.4.3 Average number

Table 23 and Figure 54 show the average number of scallops recorded in the management areas (Area A, B and C) from 2016 to 2019.

The average number of scallops has increased for all three sections from 2017 to 2019. The largest increased has been observed in Area A with an increase from 42.7 in 2017 to 119 in 2019.

Table 23: The average number ± standard error of oysters in the management areas (Area A, B and C) of the survey from 2016 to 2019.

Year	Area A	Area B	Area C
2019	119 ± 21.8	80.3 ± 10.1	24.8 ± 7.62
2018	58.9 ± 8.69	55.8 ± 8.3	19.1 ± 5.02
2017	42.7 ± 7.66	39.6 ± 5.71	13.4 ± 6.56
2016	42.4 ± 6.99	45.2 ± 5.55	9.8 ± 5.00

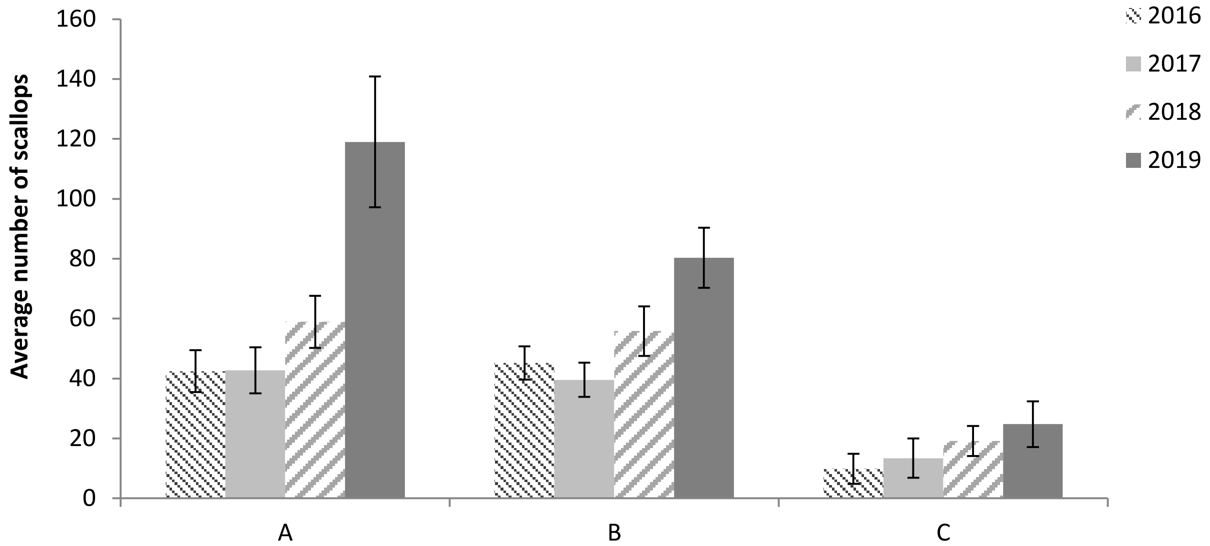


Figure 54: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) ± standard error for the management areas (Areas A, B and C) of the survey for the years 2016, 2017 2018 and 2019.

3.4.4.4 Density

The density of scallops per 10 m^2 for 2019 for all three management areas is shown in Figure 55. The density of scallops per 10 m^2 in Area C remained low, steadily increased from 2.73 in 2016 to 6.88 in 2019. In Areas A and B the density was very similar from 2016 to 2019, increased for both areas, with a greater increase observed in Area A.

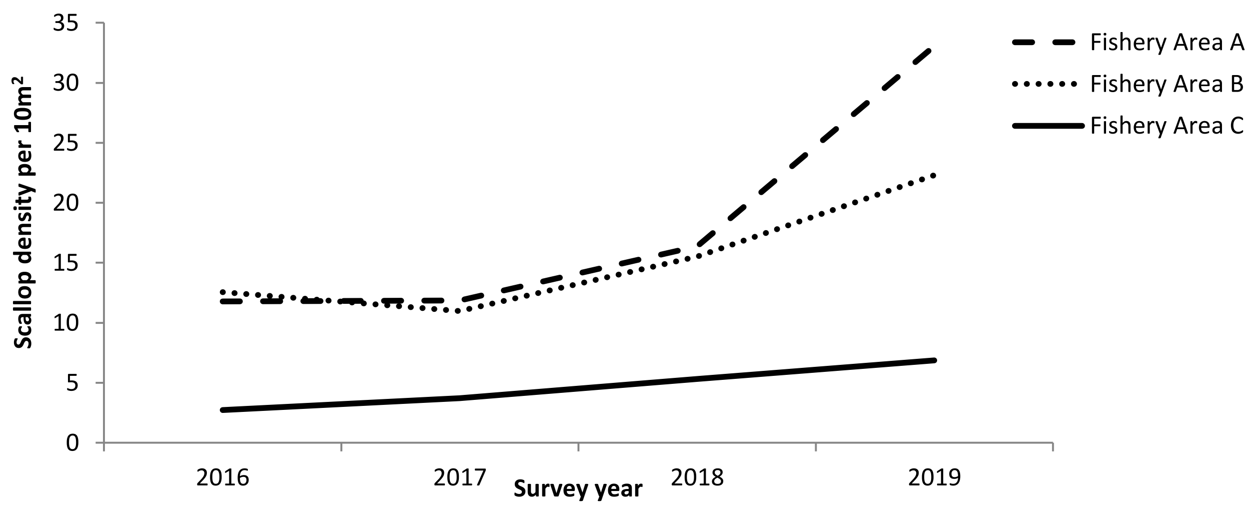


Figure 55: The density of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per 10 m^2 for the three management areas (Area A, B and C) from 2016 to 2019.

The density of scallops per 10 m^2 for 2019 for all three management areas per size class is shown in Figure 47. The density of scallops for all size classes has varied for all three areas but has remained low in Area C, fluctuated steadily in Area B and fluctuated steadily for all size classes in Area A except the ≤29 mm size class which increased from 2.92 in 2018 to 13.60 scallops per 10 m^2 in 2019.

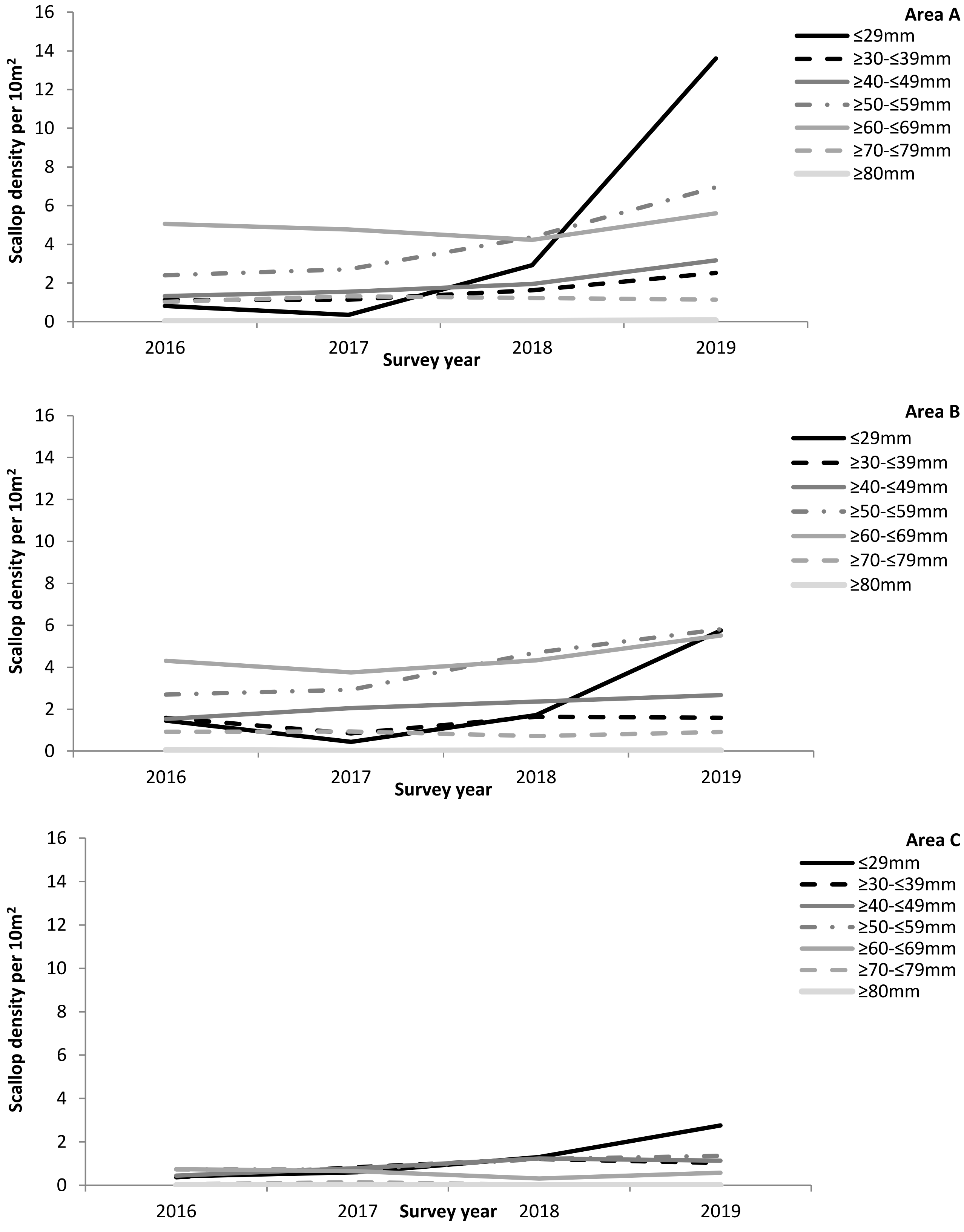


Figure 56: The density of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per 10 m^2 for the three management areas (Area A, B and C) per size class from 2016 to 2019. N.B All scales are identical.

3.4.4.5 Scallop Size Class Composition

When split by size class and management area, the total number of scallops for all the size classes was highest in Area A, except for the ≥60-≤69 mm size class which had the highest number in Area B, and lowest in Area C (Table 24). The total number of scallops by management area by size class was highest in Area A for the ≤29 mm size class (1,567 scallops) and lowest in Area C for the ≥80 mm size class when no scallops were recorded.

Table 24: The number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) recorded in the management areas (Areas A, B and C) recorded by total number of scallops, total number of scallops ≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm during the Fal oyster survey 2019.

Section	Total number of scallops	≥80 mm	≥70-≤79 mm	≥60-≤69 mm	≥50-≤59 mm	≥40-≤49 mm	≥30-≤39 mm	≤29 mm
A	3,808	8	131	646	800	365	291	1,567
B	2,811	4	115	695	733	337	201	726
C	396	0	2	33	78	65	59	159

When split by size class and management area, the average number of scallops for all the size classes was highest in Area A and lowest in Area C (Table 25). The total number of scallops by management area by size class was highest in Area A for the ≤29 mm size class (an average of 49 scallops) and lowest in Area C for the ≥80 mm size class when no scallops were recorded.

Table 25: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) recorded in the in the management areas (Areas A, B and C) recorded by total number, total number of scallops ≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm during the Fal oyster survey 2019.

Section	Average number of scallops	≥80 mm	≥70-≤79 mm	≥60-≤69 mm	≥50-≤59 mm	≥40-≤49 mm	≥30-≤39 mm	≤29 mm
A	119	0.3	4.1	20.2	25.0	11.4	9.1	49.0
B	80.3	0.1	3.3	19.9	20.9	9.6	5.7	20.7
C	24.8	0.0	0.1	2.1	4.9	4.1	3.7	9.9

The total number of scallops per section by size class has varied between 2016 and 2019 (Figure 57). Very few scallops were recorded in the ≥70-≤79 mm and ≥80 mm size classes. For all areas there was a large increase in the number of scallops in the ≤29 mm size class in 2019. In Areas A and B, there was a slight increase in the number of scallops in 2019 for the remaining size classes, with the exception of ≥30-≤39mm in Area B, where there was a slight decrease. Area C had a decrease in the number of scallops in the ≥30-≤39 mm and ≥40-≤49 mm size classes.

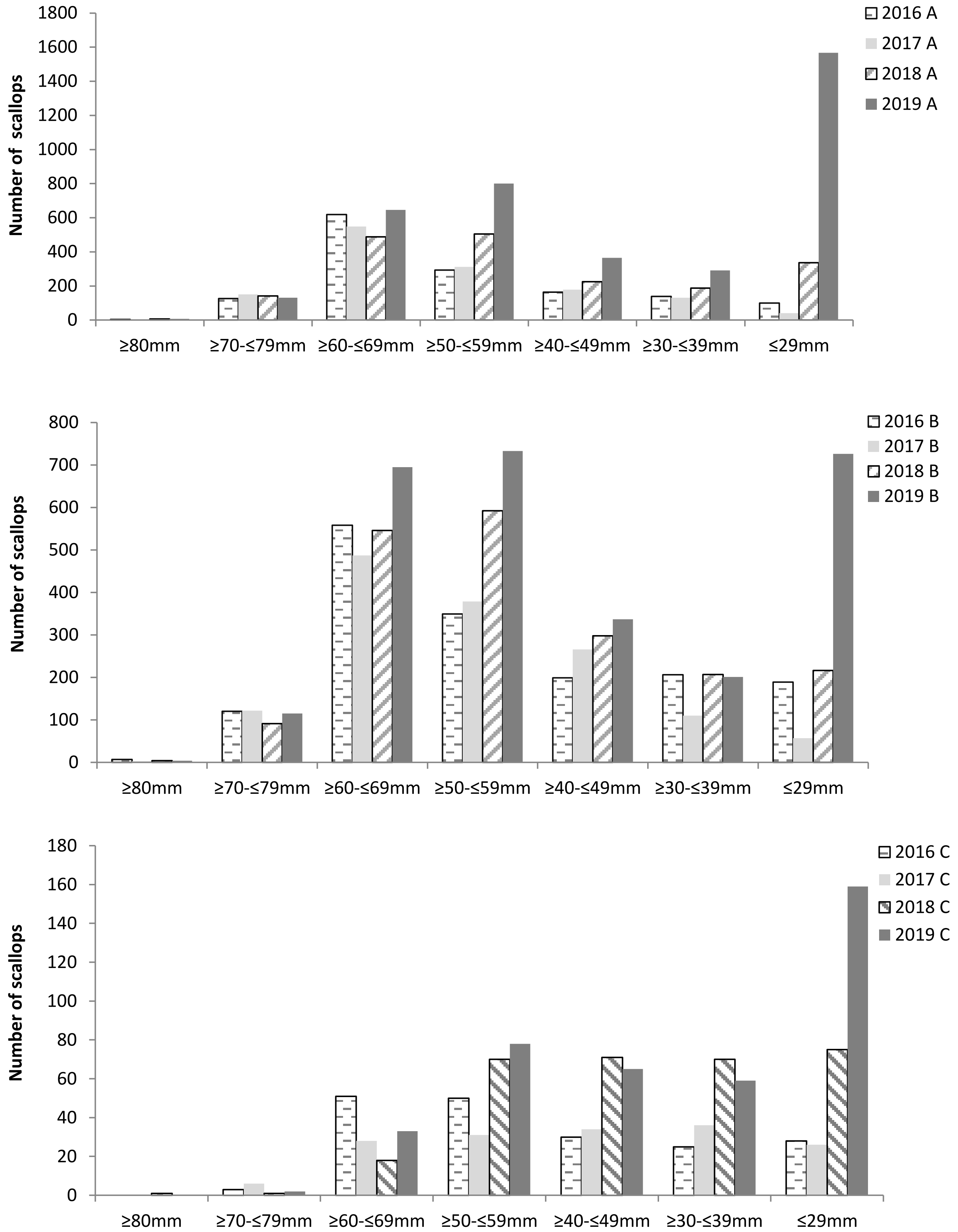


Figure 57: The total number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per size class (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) from 2016 to 2019 for the management areas, Area A, B and C.

The average number of scallops per section by size class has varied between 2016 and 2019 (Figure 58) and follows a similar trend to what was observed in the data for the total number of scallops. Very few scallops were recorded in the ≥70-≤79 mm and ≥80 mm size classes and for all areas there was a large increase in the number of scallops in the ≤29 mm size class in 2019. In Areas A and B, there was a slight increase in the number of scallops in 2019 for the remaining size classes, with the exception of ≥30-≤39mm in Area B. Area C had the average number of scallops decrease slightly in the ≥30- ≤39 mm and ≥40-≤49 mm size classes.

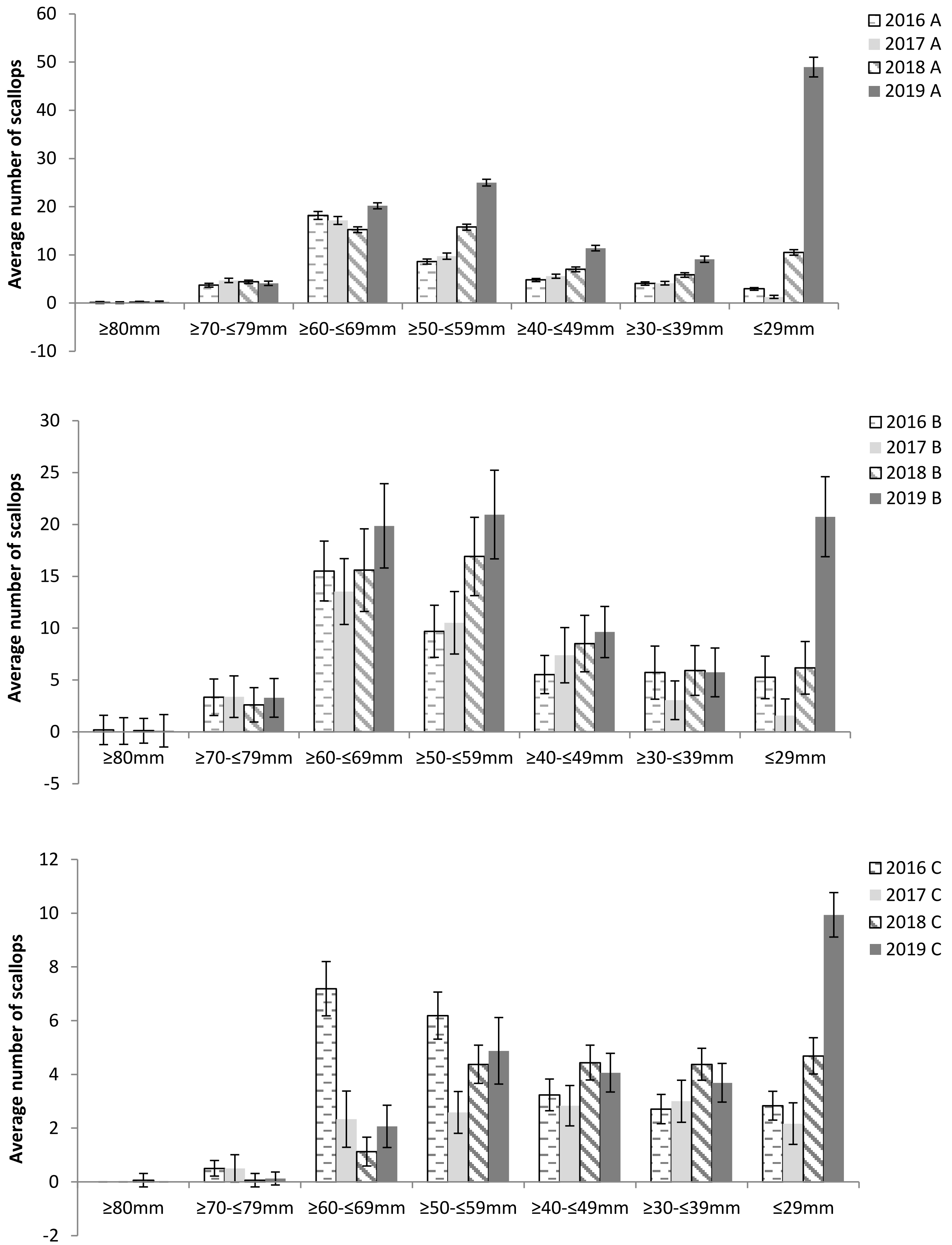


Figure 58: The average number of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) per size class (≥80 mm, ≥70-≤79 mm, ≥60-≤69 mm, ≥50-≤59 mm, ≥40-≤49 mm, ≥30-≤39 mm and ≤29 mm) from 2016 to 2019 for the management areas, Area A, B and C.

3.4.4.6 Minimum landing size

As mentioned previously, the MLS for queen scallops (*Chlamys* spp.) from the fishery is 40 mm. The percentage of scallops over and under the MLS is shown in Table 26. The percentage over and under the MLS for Area A was similar in 2019, whereas in previous years the percentage over the MLS was a lot greater. In Area B the percentages in 2019 were simialar to previous years with a greater number of scallops over the MLS recorded. In Area C the percentages were similar to Area A, with a similar number recorded over and under the MLS, which was the same in 2018.

Table 26: The percentage (%) of queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) over and under the minimum landing size (40 mm) for all three management areas (Area A, B and C) of the Fal oyster survey area from 2015 to 2019.

	Area A % under 40 mm	Area A % over 40 mm	Area B % under 40 mm	Area B % over 40 mm	Area C % under 40 mm	Area C % over 40 mm
2019	48.79	51.21	32.98	67.02	55.05	44.95
2018	27.75	72.25	21.65	78.35	47.39	52.61
2017	12.66	87.34	11.73	88.27	38.51	61.49
2016	16.50	83.50	24.26	75.74	28.34	71.66

3.5 Slipper limpets

The number of slipper limpets per dredge sample was recorded again during the 2019 survey. A total of 11,412 slipper limpets were recorded during the survey which is a slight decrease from the 11,525 that were recorded in 2018. All slipper limpets recorded during the survey were retained onboard Tiger Lily in sacks and not returned to the fishery. An example of a dredge with a large number of slipper limpets is shown in Figure 59.

Figure 59: A dredge with a high number of slipper limpets (*Crepidula fornicata*) recorded during the 2019 Fal oyster survey.

3.5.1 Geographical section

The total number of slipper limpets recorded for 2018 and 2019 is shown in Figure 60. The numbers for the H and OH sections was relatively similar, with slight increases in 2019 compared to 2018. In the R section there was a decrease from 2,370 in 2018 to 1,840 slipper limpets in 2019.

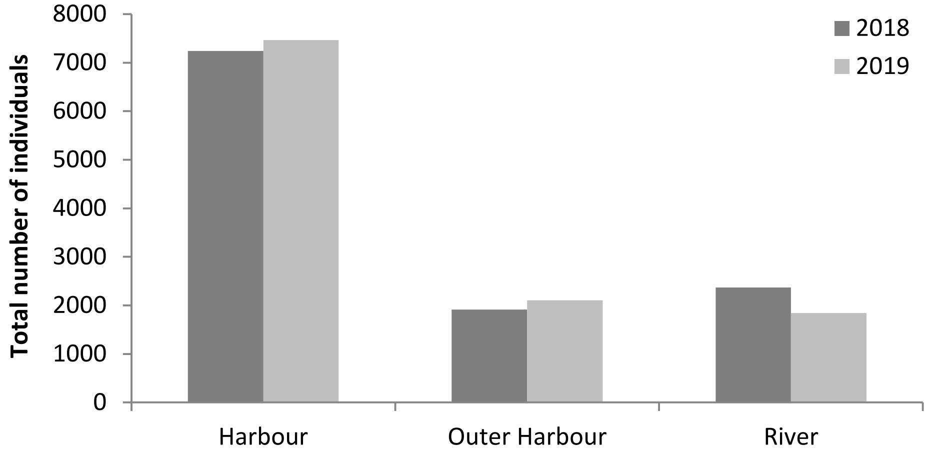


Figure 60: The total number of slipper limpets (*Crepidula fornicata*) for the Harbour, River and Outer Harbour sections of the survey for the years 2018 and 2019.

The average number of slipper limpets per section is shown in Figure 61. The average number of slipper limpets for all three sections has been relatively similar for both years of the survey, with a slight increase in the OH section from 319 to 351 slipper limpets and a slight decrease in the R section from 169 to 131.

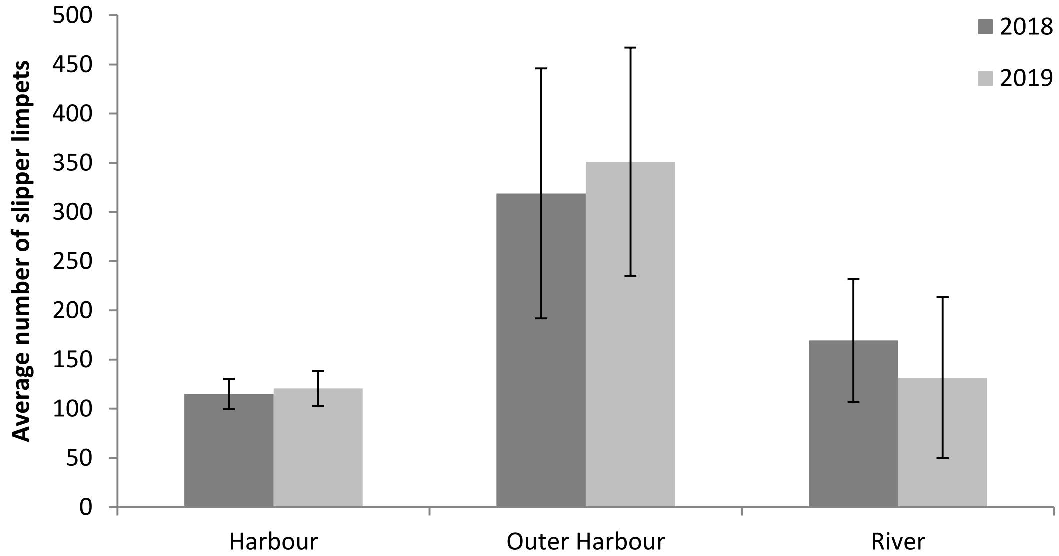


Figure 61: The average number of slipper limpets (*Crepidula fornicata*) ± standard error for the Harbour, River and Outer Harbour sections of the survey for the years 2018 and 2019.

3.5.2 Management sections

The total number of slipper limpets recorded for 2018 and 2019 by management area is shown in Figure 62. The numbers of slipper limpets in Area A increased from 5,295 to 6,364. The number in areas B and C decreased from 2018 to 2019, from 3,830 to 3,166 in Area B and from 2,400 to 1,882 in Area C.

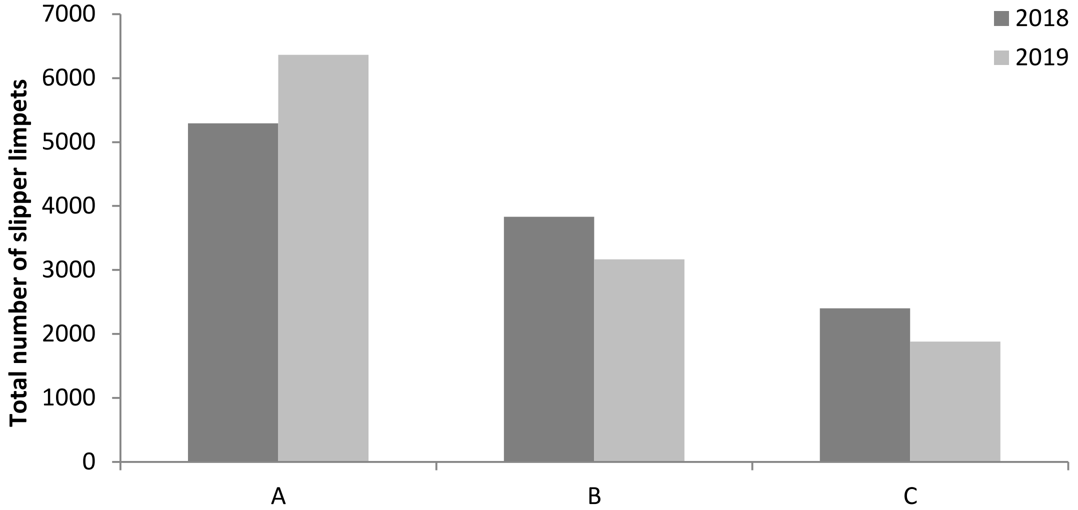


Figure 62: The total number of slipper limpets (*Crepidula fornicata*) for the management areas, Area A, B and C of the survey for the years 2018 and 2019.

The average number of slipper limpets per section is shown in Figure 63. The average number of slipper limpets for Area A increased from an average of 165 to 199 and decreased in Areas B and C from 109 to 90 and 150 to 118 respectively.

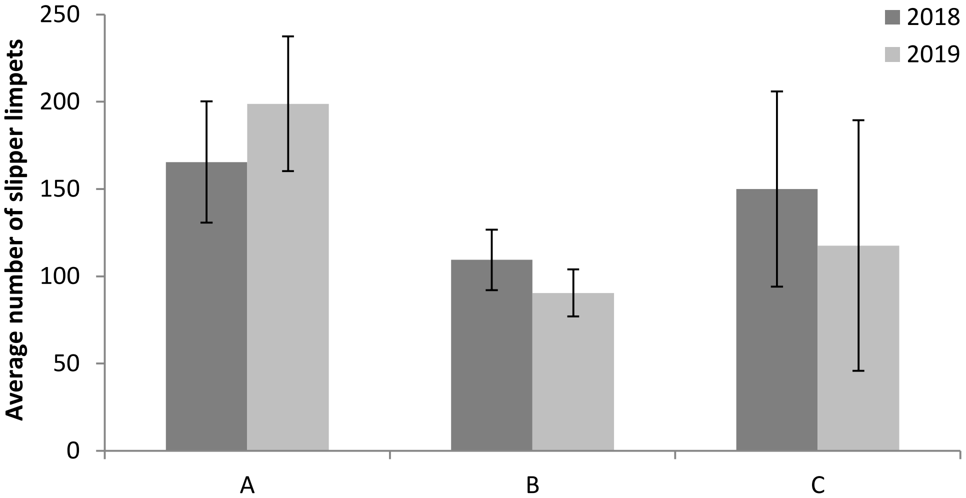


Figure 63: The average number ± standard error of slipper limpets (*Crepidula fornicata*) for the management areas, Area A, B and C of the survey for the years 2018 and 2019.

The distribution of slipper limpets is shown in Figure 64. The distribution of slipper limpets observed in 2019 was similar to 2018. Areas with a high density (5-10 and 10.1 – 25 per m^2) were either side of the channel running between the East Bank and North Bank as well as the central part of the R section. Care should be taken when interpreting the density in the R section as the sites are spread in clumps which could cause a misrepresentation of the density in this section. The number of slipper limpets was lowest (0.1-2.4 slipper limpets per m^2) to the west of North Bank along the section closest to the shore, the area to the south of Turnaware Point, a small area in the south-east of the survey area and the northern part of the R section.

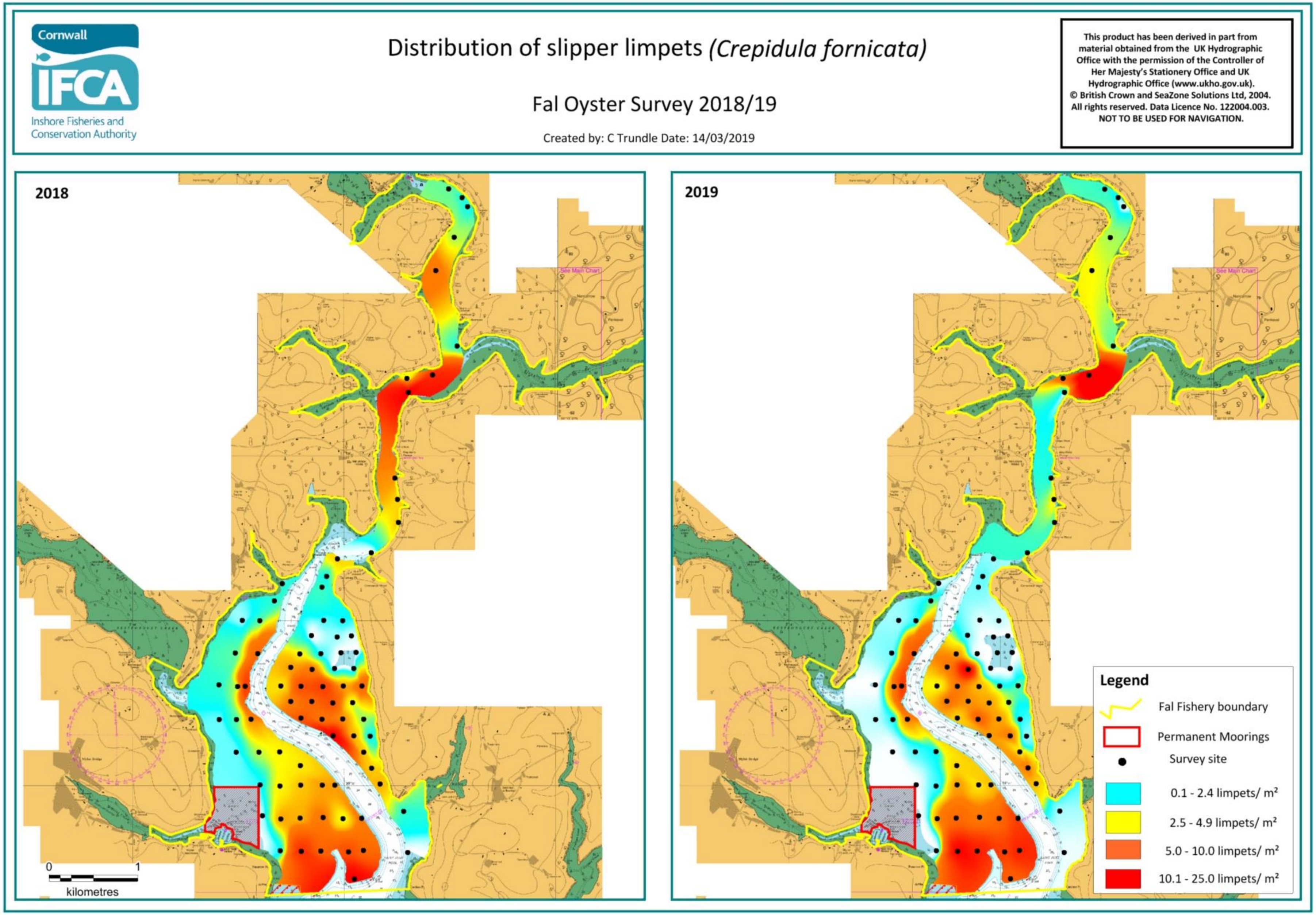


Figure 64: The distribution of slipper limpets (*Crepidula fornicata*) within the Harbour and Outer Harbour sections of the Lower Fal as surveyed in 2018 and 2019.

3.6 Bycatch

Bycatch species were present in all 83 dredge samples. A total of 97 were identified down to species level, with others identified to genus, or family level. These are listed in full in Annex Table G, with the number of sites each species were present at. Matt Slater (Cornwall Wildlife Trust) joined Cornwall IFCA for the last day of the survey which was a huge benefit to the survey and for the ID of species. Due to the light footprint of the dredges and short tow durations bycatch species were good condition and returned alive to the water straight away.

Arthropods and molluscs were the most commonly observed families in the bycatch (Figure 65). Six species of crab were regularly seen; common shore crab (*Carcinus maenas*), navigator crab (*Liocarcinus navigator*), harbour crab (*Liocarcinus depurator*), long-legged spider crab (*Macrapodia* sp.), hermit crab (*Pagurus bernhardus)* and long-clawed porcelain crab (*Pisidia longicornis)*. Of these, the navigator crab and hermit crab were particularly noticeable, recorded in 54 and 51 of the 83 dredge samples respectively. Commonly seen molluscs included; slipper limpets (*Crepidula fornicata*), saddle oysters (*Anomia ephippium)*, topshells (*Gibbula* spp.), chitons (*Lepidochitona cinerea)*, mussels (*Mytulis edulis*) and spiral shells (*Turitella / Bittium* sp.). Two species of red algae; coralline algae (*Lithophyllum* sp.) (which was likely under-recorded) and red string weed (*Soliera chordalis*) were also commonly seen. Sponges were noticeable throughout the survey, but often couldn't be identified to species level and will therefore be under-reported in Figure 65. One particular species that was under-recorded is *Suberites ficus,* seen as an orange layer on the shells of scallops, but only positively identified on the final day. The most notable species recorded was a short snouted seahorse (*Hippocampus hippocampus*). This species hadn't been recorded by Cornwall IFCA during a survey previously and only one official record exists for the Fal estuary, with another diver record confirmed (pers. comms, Natural England). Concerns about the number of spiny starfish (*Marthasterias glacialis*) had been raised via the FFMC in 2018 so a record was made per site if any were recorded. Only one was recorded throughout the survey, at site H 59.

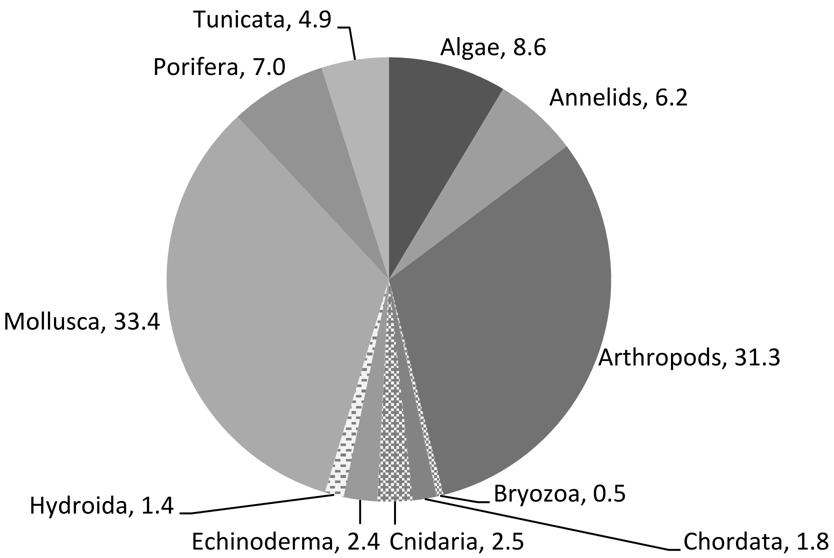


Figure 65: Percentage composition of bycatch across the whole Fal oyster survey, shown by biological family. NB. This data has been calculated on the number of species present from each family, rather than the number of individuals of each species present.

The distribution of the number of species per family for Arthropods, Molluscs, Porifera, Tunicata and all other families is shown in Figure 66. This shows that the Fal Oyster Fishery supports a high number of other species and they are distributed across the fishery.

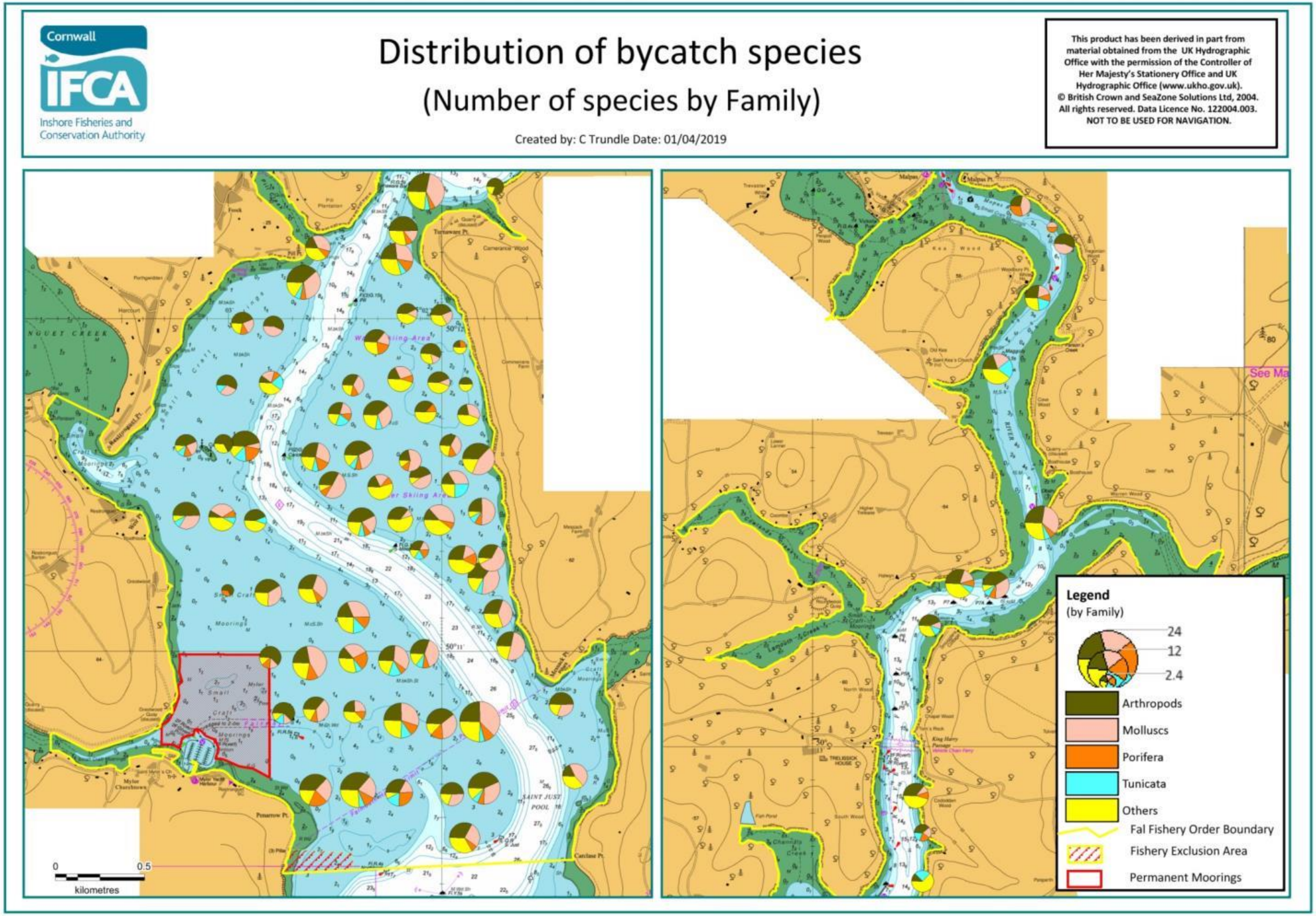


Figure 66: The composition of the number of species per family of Arthropoda, Mollusca, Porifera, Tunicata and other for each survey site during the 2019 Fal oyster survey 2019.

In previous years a species of red macroalage, *Solieria chordalis* was recorded in abundance at many sites. In 2019, this species wasn't present in such large quantities or at many sites. It has been reported that the weed is present after southerly swells when the weed is pushed up the estuary. Figure 67 shows sites with a great abundance of the red weed in 2018 and Figure 68 shows samples that were considered to have a high abundance of the weed in 2019.

Figure 67: A species of red weed (*Solieria chordalis)* in a recovered sample recorded during the Fal oyster survey 2018.

Figure 68: A species of red weed (*Solieria chordalis)* in a recovered sample recorded during the Fal oyster survey 2019.

The distribution of *S. chordalis* was recorded on an abundance scale of 1-5 and is shown across the fishery in Figure 69. The areas with a high abundance of red weed were the northern part of East Bank and North Bank. No weed was recorded in the R section and no weed or very little weed was recorded in the southern section of the fishery.

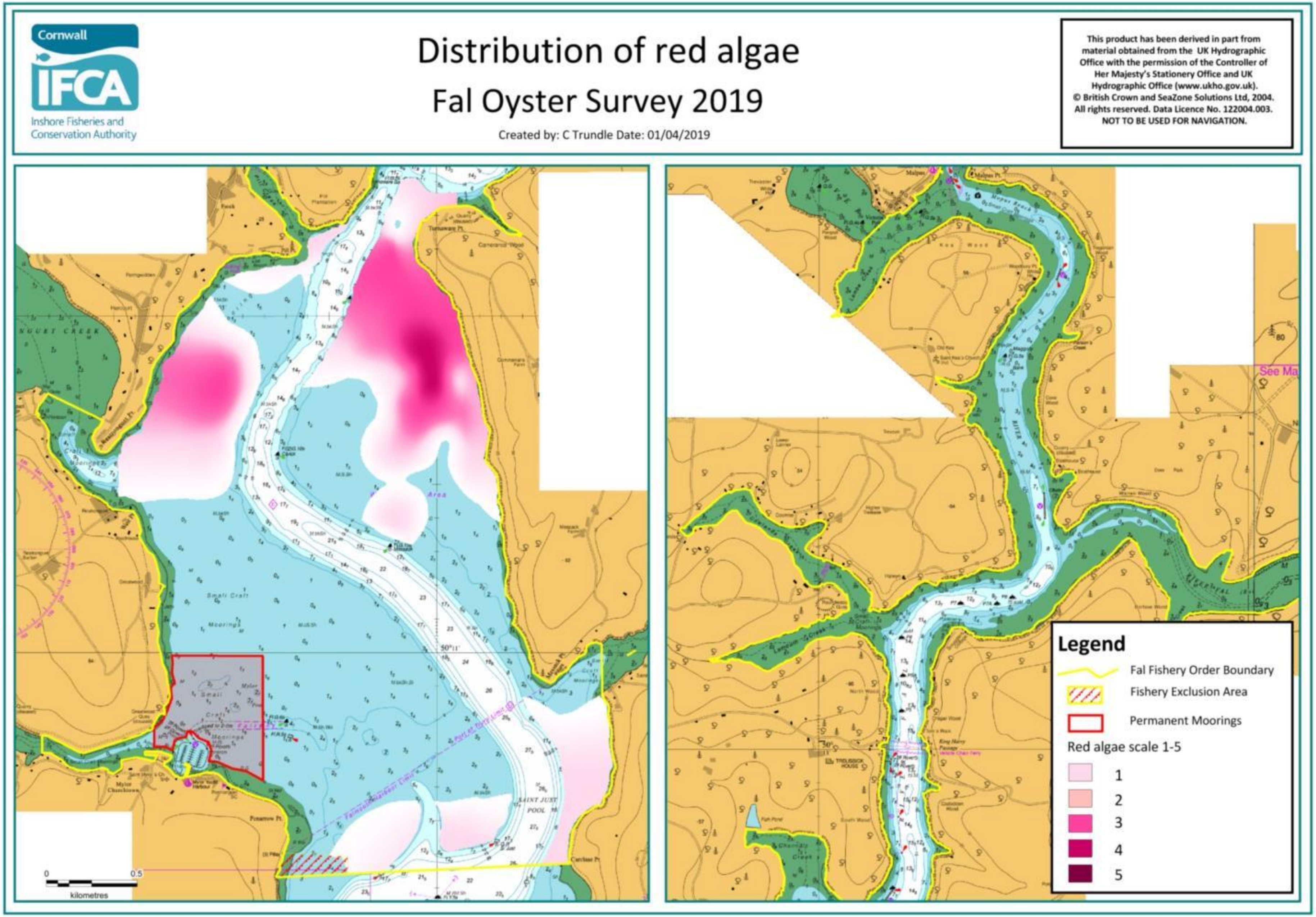


Figure 69: The distribution of red algae (*Solieria chordalis*) recorded on a scale of 1-5 during the Fal oyster survey 2019.

3.6.1 Maerl

3.6.1.1 Live maerl

Live maerl was recorded in sites H 22, H 45, H 47, H 53, H 79, OH 19, OH 20 and OH 21. At all of these sites there was one fragment of live maerl, except site H 22 which had five fragments of live maerl. Cornwall IFCA will consider discontinuing this site from previous surveys. The distribution of live maerl (shown in pink) is shown in Figure 70. Most of the fragments of live maerl were recorded in the southern part of the fishery.

3.6.1.2 Dead maerl

Fragments of dead maerl were recorded in more sites than in previous years. In 2018, dead maerl was recorded at two sites (OH 19 and H 51). The distribution of dead maerl was recorded on a scale of 0-5 and is shown in Figure 70. In 2019, dead maerl was recorded at the following sites; H 22, H 45, H 46, H 47, H 52, H 53, H 111, H 123, OH 19, OH 20 and OH 44. The dead maerl was in very low numbers or amounts, recorded as 1 or 2 on the substrate categories, but at two sites (OH 19 and H 47) the deal maerl was in larger quantities and recorded as a 4 on the substrate categories. It is possible that in previous years the dead maerl would have been categorised as shell/ gravel fragments. The dead maerl was recorded in the southern part of the fishery and coincides with records of live maerl.

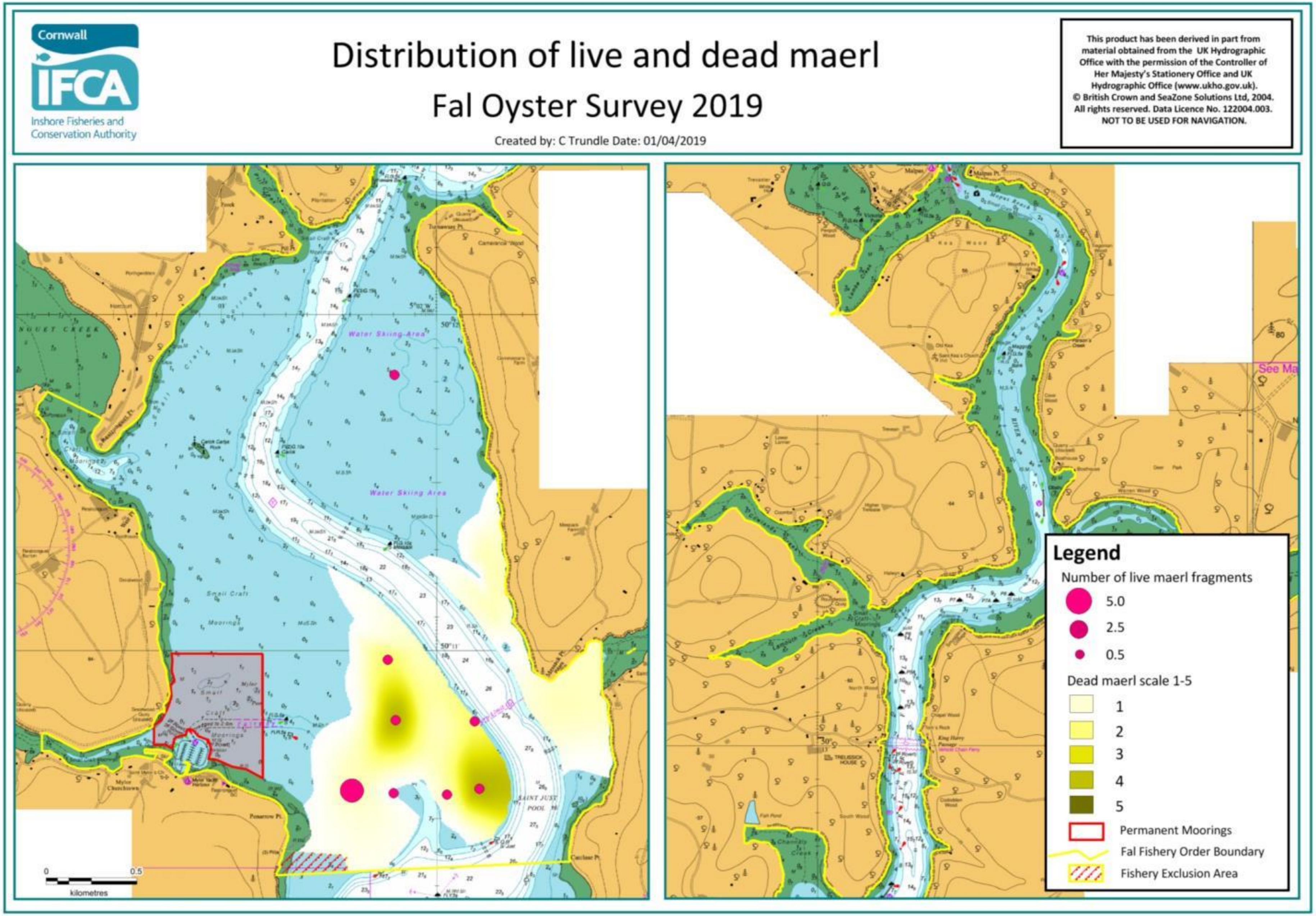


Figure 70: The distribution of fragments of live maerl (count) and dead maerl on a scale of 1-5 recorded during the Fal oyster survey 2019.

3.6.2 Non-native species

Two non-native species were found during the survey; slipper limpets, *Crepidula fornicata*, and leathery sea-squirts, *Styela clava*. The distribution and abundance of slipper limpets is explained in more detail in section 3.5. No pacific oysters (*Magallana gigas* - previously *Crassostrea gigas)* were recorded during the survey. All non-native species recorded during the survey were kept onboard and removed from the fishery. A business collected the slipper limpets to turn them into compost.

3.7 Substrate

Cornwall IFCA collected substrate data for mud, shell, stone, mixed sediments and maerl based on a scale of 1 – 5 for each category. The distribution of mud, shell and mixed sediment is shown in Figure 71, Figure 72 and Figure 73. Mud was prevalent across the fishery except the central part of the H section where none was recorded. Shell was prevalent across the fishery with high abundances across the fishery except the lower and upper parts of the R section. Mixed sediment was recorded across the H section of the fishery with a high abundance on the east side of East Bank and none was recorded in the R section.

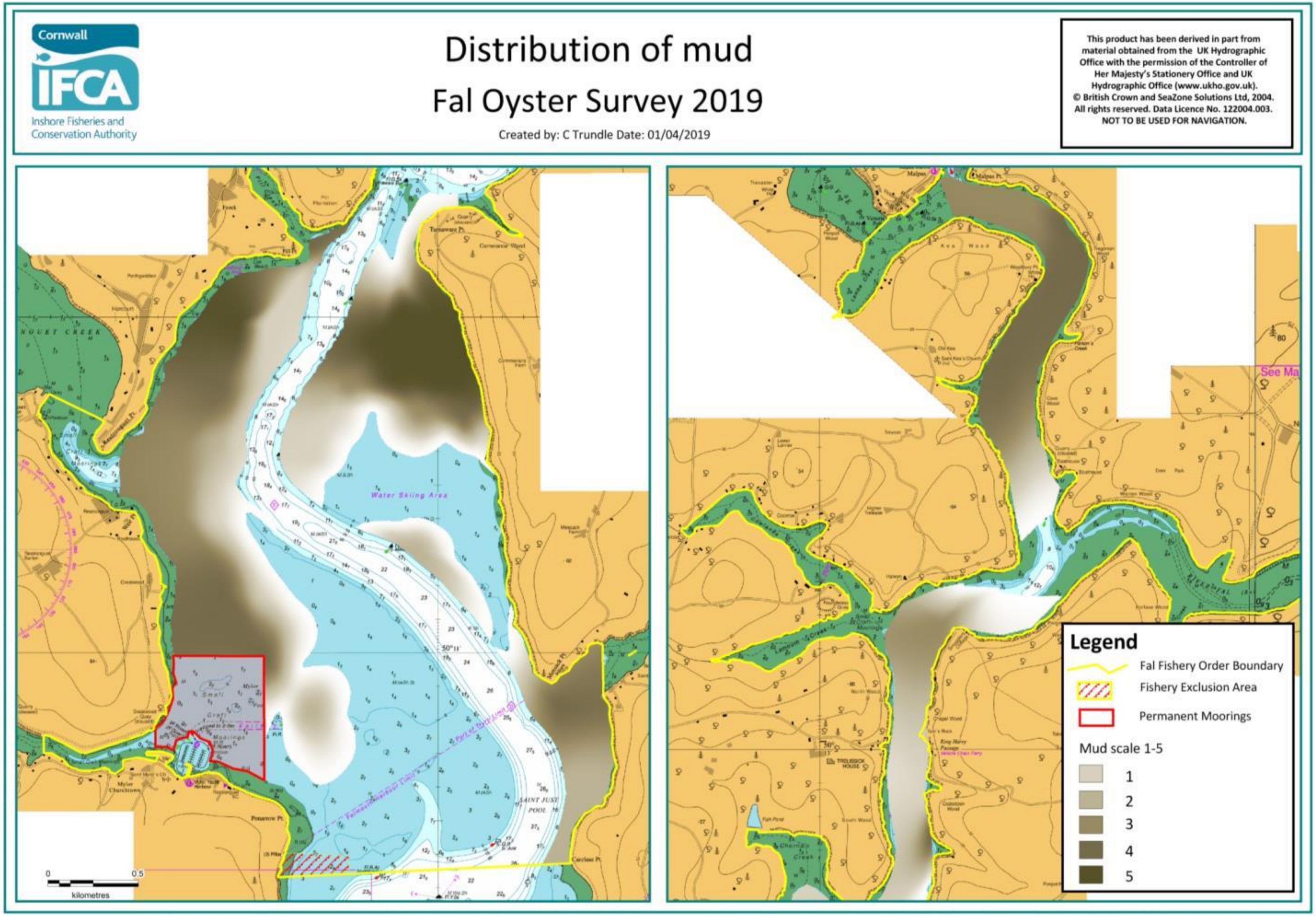


Figure 71: The distribution of mud recorded on a scale of 1-5 during the Fal oyster survey 2019.

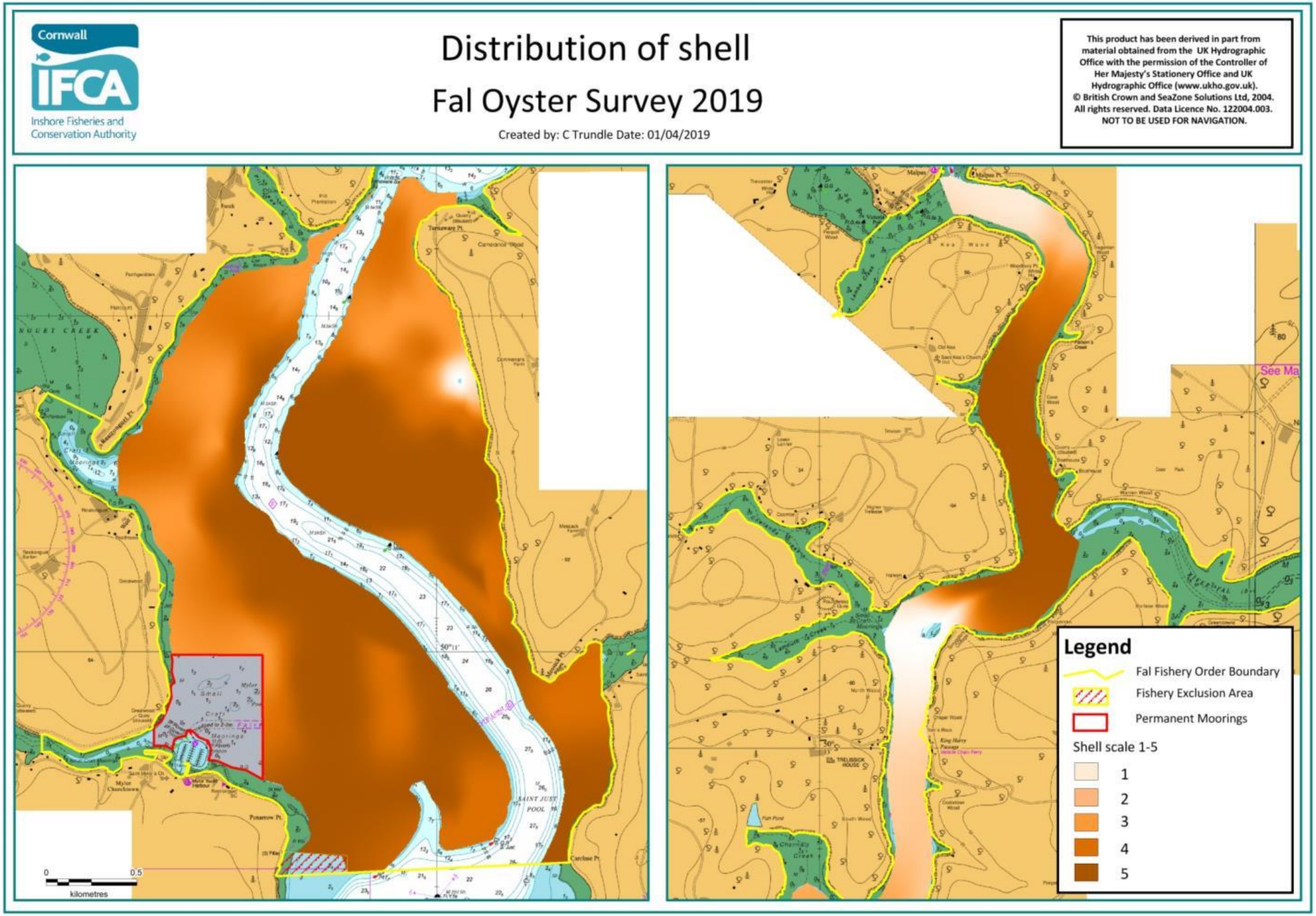


Figure 72: The distribution of shell (live and dead) recorded on a scale of 1-5 during the Fal oyster survey 2019.

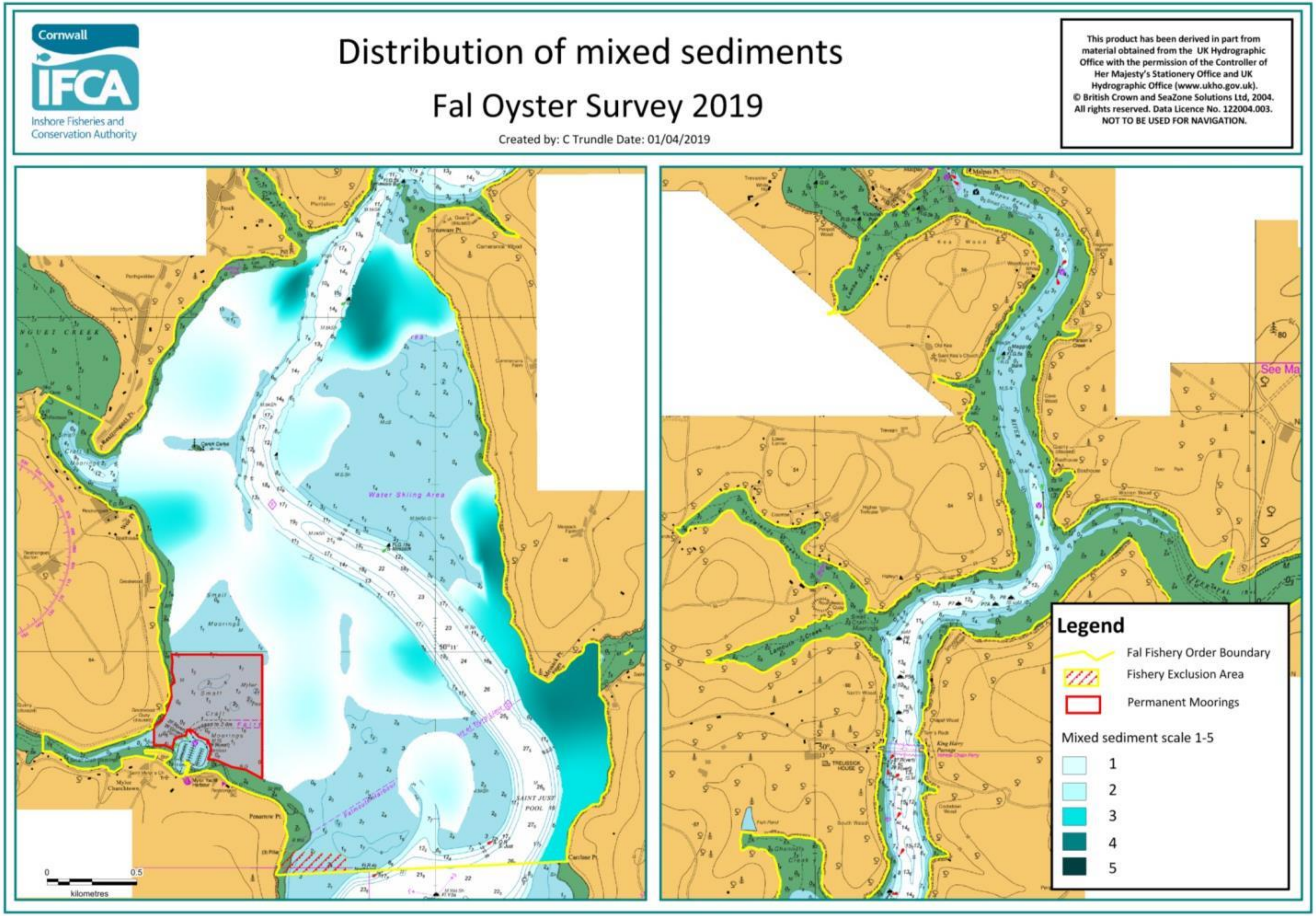


Figure 73: The distribution of mixed sediments recorded on a scale of 1-5 during the Fal oyster survey 2019.

3.8 Underwater footage

The ThiEYE cameras were successful at capturing videos of the dredge in action. The footage is useful in providing images of the dredge operating correctly and at a suitable depth (Figure 74).

Figure 74: Screenshots taken from the ThiEYE cameras attached to the oyster dredge used during the Fal oyster survey 2019.

4 Discussion

Cornwall IFCA has completed yearly surveys of the Fal Oyster Fishery since the 2013-14 season. This data has enabled a temporal comparison to be made to assess the abundance of oysters and their distribution in the fishery over a number of years and more recently the abundance and distribution of scallops and distribution of slipper limpets.

Overall, the 2018-19 season has been a frustrating year for the fishery with very little market for oysters locally. The oysters are normally sent to France but the market in France is currently saturated and so the value of oysters is very low. Some fishermen have stopped fishing for oysters altogether and are focusing solely on scallops. The 2017-18 season was the first year that scallops could be removed from the fishery with no restrictions. Prior to that, the 2016-17 season was a bad spell after two good seasons in 2014-15 and 2015-16, with reported landings of 88 and 66 tonnes respectively.

The visual comparison plot showed that the dredged volumes for samples were relatively consistent at each site for all years from 2014 to present.

<u>Oysters</u>

The survey found a greater number of oysters in 2019 than any previous year. The number of sites sampled has varied in previous years but was the same in 2018. A larger number of large oysters (≥50-≤64 mm and ≥65 mm size classes) were recorded during this year's survey and the number of oysters in these size classes have increased year by year. A slightly lower number of small oysters (≥36-≤49 mm and ≤35 mm size classes) were recorded suggesting a lower number of oyster spat on the ground and a poor recruitment of native oysters. Fluctuations in the abundance of shellfish are mostly caused by variations in recruitment (Sissenwine, 1984) which is caused by several factors including the size of the spawning stock (Shepherd, 1982; Beverton and Holt, 1957; Ricker, 1954) and environmental conditions (Le Pennec *et al*., 2003; Hofmann and Powell, 1998; Neill *et al*., 1994; Caputi, 1993). Past studies investigating recruitment in invertebrates have proposed that variation is often independent of the abundance of high spawners and is mainly influenced by variability in environmental conditions (Hancock, 1973; Drinkwater and Myers, 1987; Caputi, 1993). A number of previous studies have investigated abiotic factors including temperature

(Dickie, 1955; Fogarty, 1988; Mackenzie and Köster, 2004), salinity (Nell and Holliday, 1988; Laing, 2002), suitability of habitat (Stokesbury and Himmelman, 1995), and biotic factors, including food availability (Jackson *et al*., 1995), indirect fishing mortality (Shepard and Auster, 1991), and predator abundance and competition (Thouzeau, 1991). All of these factors vary spatially and temporally, which can explain why recruitment is often inconsistent (Vause *et al*., 2007).

Oyster settlement is highly sporadic, and native oyster spat can suffer up to 90% mortality (Cole, 1951). Factors which affect mortality include, but are not limited to; temperature, food availability, suitable settlement areas, and the presence of predators (Lancaster, 2014; Kennedy and Roberts, 1999; Cole, 1951; Spärck, 1951). The larvae respond to environmental signals which lead them to settling within the most suitable locations (Woolmer *et al.,* 2011; Walne, 1974).

The slight increase in the number of larger oysters could be promising for future stocks as the amount of adult spawning oysters on the ground remains high.

Cornwall IFCA is hoping to carry out a study to investigate larval production of native oysters and scallops to assess their abundance in the water column. This will be carried out by weekly plankton tows from fixed sampling points in the fishery. An addition to this survey might be the analysis of mature native oysters for gonad stage analysis. Both of these pieces of information will help inform Cornwall IFCA’s management of the fishery.

<u>Scallops</u>

The most notable difference for scallops in 2019 was the increase in scallop spat ≤29 mm in all areas of the survey signifying a good year for recruitment. A large number of dead shells had a high number of scallop spat attached to them, an example of which is in Figure 75.

The increase in juvenile scallops (≤12 mm) is likely to be a ‘real’ increase. In 2018 the research team had an extra day to carry out the survey enabling more time to carefully check each shell (dead and alive) for scallop spat which could have led to an increase in the number of juveniles recorded in 2018.

Figure 75: A dead scallop shell with numerous queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) spat attached.

Scallop stocks are known for being temporally and spatially variable, and the main causes of this can be put into three groups; recruitment variability, catastrophic mortality and the longevity of species; (Vause *et al.,* 2007) scallops are a short lived species with rapid early growth and they have no buffer zone if there is a period of poor recruitment (Vause *et al.,* 2007).

The scallops have been a target species of the fishery since the 2017/18 season and are no longer subject to bycatch restrictions and a higher number of larger scallops are being removed from the fishery. Queen scallops are broadcast spawners, therefore a decrease in density is likely to rapidly reduce the fertilisation efficiency of the larger scallops (Stoner and Ray-Culp, 2000). A study carried out in the northern Irish Sea queen scallop fishery showed that the fishery there is heavily reliant on recruiting two year olds and less so on three year olds making the fishery potentially vulnerable to recruitment overfishing (Vause *et al*., 2007).

The market for native oysters is currently so low that some fishermen are only fishing for scallops and there is an oversupply of scallops on the market. A survey carried out in the Isle of Man found that there was a significant relationship between the density of one year olds caught on survey and the commercial catch rates the following year (Vause *et al*., 2007). Monitoring of a fishery by assessing the juvenile scallop density therefore allows the prediction of recruitment and differences in the fishery at least one year in advance (Vause *et al*., 2007). Cornwall IFCA will continue to monitor the abundance of scallops to ensure the scallop fishery is sustainable.

Slipper limpets

The number of slipper limpets was comparable with the data from 2018 and slipper limpets were present in high densities in similar areas. Areas with a high density were either side of the channel running between East Bank and North Bank as well as the southern part of the R area. The distribution is similar to what was reported by Fitzgerald in 2006.

All slipper limpets recorded during the survey were removed from the fishery by Cornwall IFCA. The presence of slipper limpets are a threat to native oysters as they compete with oysters by reducing the amount of food available which can slow oyster growth, and overcrowding which traps suspended silt, faeces and pseudo faeces which can smother oysters (Invasive Species Ireland, 2019; Cornwall Good Seafood Guide, 2017; Naylor, 2011). It is for this reason that Cornwall IFCA will continue to remove all slipper limpets recorded during the survey in 2020.

Bycatch

The bycatch part of the survey was much more comprehensive than in previous years and a much greater number of species were recorded. The large number of bycatch species present during the survey suggests the Fal Oyster Fishery area provides a habitat for a diverse number of species. Oyster beds have been known to support a diverse epifauna consisting of protozoa, sponges, hydroids, the benthic stages of *Aurelia* sp., flatworms, ribbon worms, nematodes polychaetes, amphipods and ostracod crustaceans, crabs, sea spiders, gastropod molluscs, ascidians, bryozoans, starfish and sea urchins (Yonge, 1960; Korringa, 1951). Dead shells which are present on the oyster beds make up a substantial portion of the substratum. The clumps of dead shell can support a large number of sponges, polychaetes and seaweeds, as well as scavengers such as hermit crabs and common whelks – all of which were recorded during the survey (Perry and Tyler-Walters, 2016). A number of predators also feed on the oyster beds including starfish, slipper limpets, dog whelks and some species of crab (Perry and Tyler-Walters, 2016). A survey carried out in the early 1900's found that lots of the cultch in the fishery was overgrown with marine organisms, including sponges and *Lithothamnion* (a genus of thalloid red algae) (Orton, 1927).

The red macroalgae (*S. chordalis*) was much less abundant than in previous years. The red macroalgae is normally present after windy conditions from the south which blows this weed straight up the Fal. The calmer conditions during the winter of 2019 are likely to explain why this species was less abundant.

Concerns had been raised in 2017 by the FFMC about the number of spiny starfish (*M. glacialis*) present in the fishery. A total of six individuals were recorded in 2018 and only one individual was recorded in 2019.

Live maerl was recorded in a number of samples but only as very sparse fragments (one fragment per site) except one site in the harbour (H 22) where five fragments were recorded. Cornwall IFCA will consider dropping this site in 2020. Dead maerl was present in a greater number of samples. Maerl thalli are frequently loose and mobile, which is how they were recorded in the Fal Oyster survey. This form of maerl prevents colonisation by other species (Perry and Tyler-Walters, 2018).

All non-native species recorded during the survey were removed from the fishery, the most dominant non-native species recorded during the survey was the slipper limpet (*Crepidula fornicata*). No pacific oysters were recorded during the survey.

Substrate

Native oysters have a planktonic dispersal stage, therefore suitable substratum is a key habitat feature which influences settlement and recruitment (Bromley *et al*., 2016; Caddy and Stamatopolous, 1990). The oyster larvae will only settle out and metamorphose where suitable hard substratum is available (Brown *et al*., 2010; Walne, 1974; Waugh, 1972). The fishery is composed of a mix of substrates including shell, mud and mixed sediment. The shell and mixed sediment recorded will provide a hard substratum for plankton to settle. However in areas with a high number of slipper limpets there is often an accumulation of mud, as recorded during the survey. Mud can prevent spat from settling out as there is no surface to settle on.

5 Recommendations

5.1 Recommendations for 2020

- Habitat mapping of the area - The Fal Fishery area comprises a diverse array of habitats, which are part of the Fal and Helford Special Area of Conservation (SAC). Mapping the distribution of these habitats within the Fal Fishery may help to determine their influence on the distribution of oysters. Habitat mapping would also be beneficial to mapping the distribution of live maerl within the Outer Harbour area.
- Continue to count the number of slipper limpets recorded during the survey at it provides a more accurate representation of the distribution of the species and to dispose of any slipper limpets recorded during the survey.
- Consider dropping site H 22 from the survey in 2020 due to the presence of five fragments of live maerl recorded in 2019.
- Make a box with a ruler and colour card to take better macro photos of the bycatch species found.
- Review survey sites within the R section with the aim of achieving better coverage. The river reaches are important fishery areas for tow haul fishing and a more consistent approach to cover this section is needed. Due to the low number of sites within the R section it is not possible to create density maps for this part of the fishery.
- Continue to analyse the data by management area as well as geographic area to allow data from the oyster survey to be considered in relation to the Fishery landings data (permit returns data) which is submitted as part of the permit requirements.
- Improve recording of substrate data. In previous years the substrate data was collected using a scale of 1-5 for each substrate type, so one sample could have a 5 for both mud and shell for example. For future years it is recommended that each sample is categorised so a percentage contribution can be created for each sample site.
- Collect weight data for each individual oyster.
- Improve the bycatch part of the survey. A comprehensive analysis of the bycatch species present within the fishery was done in 2019 and now scientific officers feel confident with the ID of these species it is hoped that the accuracy of this part of the survey will be improved for following years.
- The Cornwall IFCA research team are hoping to carry out a plankton survey within the oyster fishery to provide an indication of the level of *O. edulis* and *M. varia* larvae in the water column. Spawning occurs in the summer months of June to September and coincides with new or full moons (Yonge, 1960; Korringa, 1952).
- Monitor the temperature within the fishery via a temperature logger.
- Continue to remove any non-native species which are brought onboard during the survey including slipper limpets.

6 References

Beverton, R. J. H., and Holt, S. J. 1957. On the dynamics of exploited fish populations. Fisheries Investigations Series 2, 19. Ministry of Agriculture Fisheries and Food, London, UK. 533 pp.

Bromley, C., McGonigle, C., Ashton, E.V. and Roberts. D. 2016. Restoring degraded European native oyster, *Ostrea edulis*,habitat: is there a case for harrowing? Hydrobiologia (2016) 768:151–165.

Brown, S., S. Handley, K. Michael & D. Schiel, 2010. Annual pattern of brooding and settlement in a population of the flat oyster *Ostrea chilensis* from central New Zealand. New Hydrobiologia (2016) 768:151–165 163 123 Zealand Journal of Marine and Freshwater Research 44(4): 37–41.

Caddy, J. F. & C. Stamatopoulos, 1990. Mapping growth and mortality rates of crevice-dwelling organisms onto a perforated surface: the relevance of 'cover' to the carrying capacity of natural and artificial habitats. Estuarine and Coastal Shelf Science 31: 87–106.

Caputi, N. 1993. Aspects of spawner recruit relationships, with particular reference to crustacean stocks—a review. Australian. Journal of Marine and Freshwater Research, 44: 589–607.

Cole, H.A., 1951. The British oyster industry and its problems. Rapports and Proces-Verbaux des Reunions. Conseil Permanent International pour l'Exploration de la Mer, 128, 7-17.

Cornwall Good Seafood Guide, 2017. Slipper limpet, *Crepidula fornicate*. http://www.cornwallgoodseafoodguide.org.uk/fish-guide/slipper-limpet.php [Accessed: 22.03.2019]

Dickie, L. M. 1955. Fluctuations in abundance of the giant scallop,*Placopecten magellanicus* (Gmelin), in the Digby area of the Bay of Fundy. Journal of the Fisheries Research Board of Canada, 12: 797–857.

Drinkwater, K. F., and Myers, R. A. 1987. Testing predictions of marine fish and shellfish landings from environmental variables. Canadian Journal of Fisheries and Aquatic Sciences, 44: 1568–1573.

Fal Fishery Order 2016. Available from**:** https://secure.toolkitfiles.co.uk/clients/17099/sitedata/Fal_Fishery/Fal-Fishery-Order-2016.pdf [Accessed: 18.05.2017]

Fitzgerald, A. 2006. Slipper limpet utilisation and management. Final Report.

Fogarty, M. J. 1988. Time series models of the Maine lobster fishery: the effect of temperature. Canadian Journal of Fisheries and Aquatic Sciences, 45: 1145–1153.

Hancock, D. A. 1973. The relationship between stock and recruitment in exploited invertebrates. Rapports et Proce`s-Verbaux des Re´unions du Conseil International pour l'Exploration de la Mer,164: 113–131.

Hofmann, E. E., and Powell, T. M. 1998. Environmental variability effects on marine fisheries: four case histories. Ecological Applications, 8: S23–S32.

Invasive Species Ireland, 2019. Slipper limpet, *Crepidula fornicata*. Available from: http://invasivespeciesireland.com/species-accounts/established/marine/slipper-limpet [Accessed: 21.03.2019]

Jackson, D. L., Chisholm, L. S., Merry, H., and O'Dor, R. K. 1995. Influences of food availability, salinity, and temperature on growth response of larval sea scallops, *Placopecten magellanicus*. Tenth International Pectinid Workshop, Book of Abstracts, Cork, Ireland, 26 April–2 May 1995: 99–100.

Jenkin, A., Trundle, C., Street, K. and Naylor, H. 2017. Fal Oyster Survey report 2017. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

Jenkin, A., Trundle, C., Street, K. and Naylor, H. 2018. Fal Oyster Survey 2018. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

Kennedy, R.J. and Roberts, D. 1999. A survey of the current status of the flat oyster Ostrea edulis in Strangford Lough, Northern Ireland, with a view to the restoration of its Oyster Beds.. Biology and Environment: Proceedings of The Royal Irish Academy. 99B, 79–88.

Korringa, P. 1951. The shell of Ostrea edulis as a habitat. Archives Néerlandaises de Zoologie, 10, 33-152.
Korringa, P. 1952. Recent advances in oyster biology. Quarterly Review of Biology, 27, 266-308 & 339-365.

Laing, I. 2002. Effect of salinity on growth and survival of king scallop spat (*Pecten maximus*). Aquaculture, 205: 171–181.

Lancaster, J. (ed), McCallum, S., A.C., L., Taylor, E., A., C. & Pomfret, J., 2014. Development of Detailed Ecological Guidance to Support the Application of the Scottish MPA Selection Guidelines in Scotland's seas. Scottish Natural Heritage Commissioned Report No.491 (29245), Scottish Natural Heritage, Inverness, 40 pp.

Latham, H. and Trundle, C. 2015. Fal Oyster Survey. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

Latham, H., Jenkin, A., Trundle, C., Naylor, H. and Mathews, R. 2016. Fal Oyster Survey. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

Le Pennec, M., Paugam, A., and Le Pennec, G. 2003. The pelagic life of the pectinid Pecten maximus—a review. ICES Journal of Marine Science, 60: 211–223.

Mackenzie, B. R., and Köster, F.W. 2004. Fish production and climate: sprat in the Baltic Sea. Ecology, 85: 784–794.

Naylor, 2011. Great British Marine Animals. 3rd Edition. Sound diving publications.

Neill, W. H., Miller, J. M., van der Veer, H. W., and Winemiller, K. O.1994. Ecophysiology of marine fish recruitment—a conceptual framework for understanding interannual variability. Netherlands. Journal of Sea Research, 32: 135–152.

Nell, J. A., and Holliday, J. E. 1988. Effects of salinity on the growth and survival of Sydney rock oyster (*Saccostrea commercialis*) and Pacific oyster (*Crassostrea gigas*) larvae and spat. Aquaculture, 68: 39–44.

Orton, 1927. Report on the survey of the Fal Estuary Oyster Beds (November 1924) with notes on the biology of the oyster, Falmouth, 1926. Summary in the Journal of Marine Biological Association,. V XIV, pp. 615-628.

Perry, F. & Tyler-Walters, H., 2016. *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 21-03-2019]. Available from: https://www.marlin.ac.uk/habitat/detail/69.

Perry, F. & Tyler-Walters, H., 2018. Maerl beds. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 21-03-2019]. Available from: https://www.marlin.ac.uk/habitat/detail/255.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada, 11: 559–623.

Shepherd, J. G. 1982. A versatile new stock–recruitment relationship for fisheries, and the construction of sustainable yield curves. Journal du Conseil International pour l'Exploration de la Mer, 40: 67–75.

Shepard, A. N., and Auster, P. J. 1991. Incidental (non-capture) damage to scallops caused by dragging on rock and sand substrates. In An International Compendium of Scallop Biology and Culture, pp. 219–230. Ed. by S. E. Shumway and P. A. Sandifer. World Aquaculture Society, Baton Rouge.

Sissenwine, M. P. 1984. Why do fish populations vary? In Exploitation of Marine Communities, pp. 59–95. Ed. by R. M. May. Springer, Berlin.

Spärck, R., 1951. Fluctuations in the stock of oyster (Ostrea edulis) in the Limfjord in recent time. Rapports et Procès-verbaux des Réunions. Conseil Permanent International pour L'exploration de la Mer, 128, 27-29.

Stokesbury, K. D. E., and Himmelman, J. H. 1995. Biological and physical variables associated with aggregations of the giant scallop Placopecten magellanicus. Canadian Journal of Fisheries and Aquatic Sciences, 52: 743–753.

Stoner, A. W., and Ray-Culp, M. 2000. Evidence for Allee effects in an over-harvested marine gastropod: density-dependent mating and egg production. Marine Ecology Progress Series, 202: 297–302.

Thouzeau, G. 1991. Experimental collection of postlarvae of *Pecten maximus* (L.) and other benthic macrofaunal species in the Bay of Saint-Brieuc, France. 1. Settlement patterns and biotic interactions among the species collected. Journal of Experimental Marine Biology and Ecology, 148: 159–179.

Vause, B. J., Beukers-Stewart, B. D., and Brand, A. R. 2007. Fluctuations and forecasts in the fishery for queen scallops (*Aequipecten opercularis*) around the Isle of Man. – ICES Journal of Marine Science, 64: 1124–1135.

Walne P., 1974. Culture of Bivalve Molluscs: 50 years' experience at Conwy. Fishing News Books Ltd (No. Ed. 2), Oxford.

Waugh, G. D., 1972. Settlement of Ostrea edulis (L.) related to the cultivation of oyster grounds, Vol. 27. Ministry of Agriculture, Fisheries & Food Fishery Investigations Series II, London: 21–33.

Woolmer, A.P., Syvret, M. & Fitzgerald, A., 2011. Restoration of Native Oyster, Ostrea edulis, in South Wales: Options and Approaches. CCW Contract Science Report, no: 960, pp. 93.

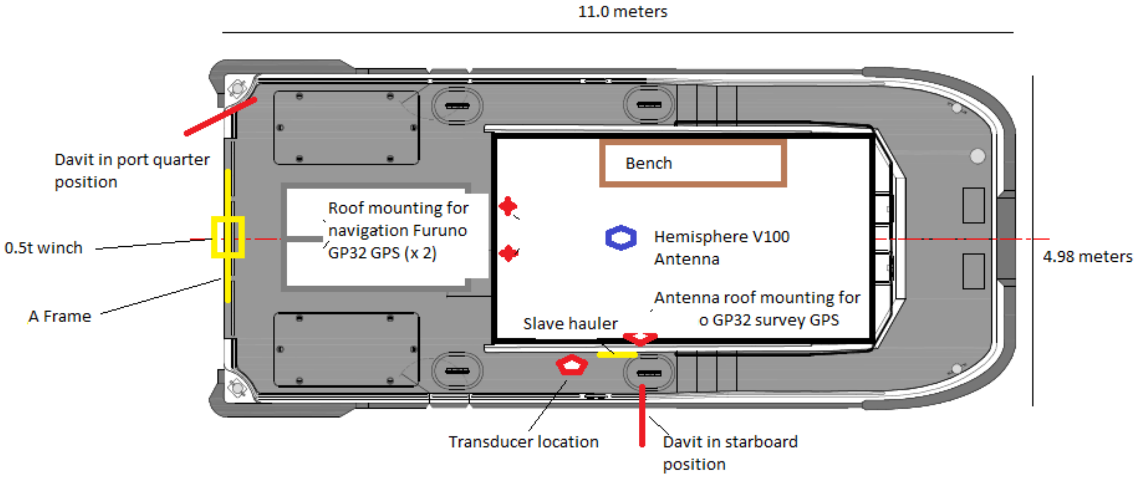
Yonge, C.M., 1960. Oysters. London: Collins.

7 Appendices

Annex 1 – R/V Tiger Lily Deck Plan & Offsets

Builder	South Boats Ltd
Model	Island MkII
Built	2007
LOA	11.0m
Beam	4.98m
Draught	1.1m (aft)
Tonnage	c.10 tonnes
Area of operation	MCA Category 2
Call sign	MRWR7
MMSI Number	235054954
MECAL Certification number	M07WB0111059
Complement	14 (including min 2 crew)
Propulsion	2 x 450hp Iveco NEF series
Speed	Cruising: 16 – 18 knots Top: 24 – 26 knots
Range	c. 400 nautical miles
240v AC supply	Victron 3Kw power inverter 5KvA Volvo-Perkins generator (All 240 AC power is accessed via APC Smart UPS C1500)
Stern Gantry	500kg SWL
Winch (on stern gantry)	Spencer Carter 0.5t with scrolling level wind
Slave hauler	Sea Winch 200m dia.
Electric line hauler	12v Spencer Carter Bandit
Positioning	Hemisphere V100 GNSS 3 x Furuno GP32
NMEA data outputs	4 x USB 4 x Serial 4 x banjo
Navigation	Olex with data export Knockle Hypack Max

Tiger Lily VI General Layout - Plan view



			Offset (m)		
NMEA Device	**Make/Model**	**Offset Name**	**X (f'wd)**	**Y (port)**	**Z (+/-)**
Sounder	Furuno Navnet	Transducer	7.0	4.2	-0.5
GPS	Furuno GP32	GPS 1	4.8	3.48	+2.2
GNSS	Hemisphere V100	GNSS 1	5.0	2.5	+2.35

Annex 2 – Data comparison sheets

Fal Oyster Survey – Site 50 Harbour

2014

2015

2016

2017

2018

2019

Annex 3 – Site positions

Annex Table A: Positions of sites surveyed in 2019

Site	Latitude (decimal degrees)	Longitude (decimal degrees)
H 22_A	50.176373	-5.039815
H 23_A	50.176368	-5.043145
H 24_C	50.204430	-5.036310
H 45_A	50.179802	-5.030308
H 46_A	50.179703	-5.033298
H 47_A	50.179862	-5.036422
H 48_A	50.180305	-5.040093
H 49_A	50.180412	-5.043107
H 50_A	50.180223	-5.045637
H 51_B	50.183602	-5.027855
H 52_A	50.183213	-5.034612
H 53_A	50.182862	-5.037042
H 54_A	50.182973	-5.040197
H 55_A	50.182748	-5.043608
H 56_A	50.183025	-5.046680
H 57_B	50.187008	-5.030000
H 58_A	50.185048	-5.040190
H 59_A	50.186470	-5.043378
H 60_A	50.186272	-5.046840
H 61_A	50.186385	-5.050032
H 62_B	50.190340	-5.030140
H 63_B	50.189923	-5.033478
H 64_B	50.189940	-5.036523
H 65_B	50.189818	-5.039537
H 66_A	50.189895	-5.047862
H 67_A	50.190042	-5.050450
H 68_A	50.190138	-5.053260
H 69_A	50.193653	-5.053283
H 70_A	50.193740	-5.050357
H 71_A	50.193622	-5.048685
H 72_B	50.193082	-5.043152
H 73_B	50.193172	-5.039795
H 74_B	50.192898	-5.035747
H 75_B	50.193650	-5.032587
H 76_B	50.192972	-5.030413
H 77_B	50.196727	-5.031410
H 78_B	50.196808	-5.033525
H 79_B	50.196983	-5.036513
H 80_B	50.196677	-5.040213
H 81_A	50.196792	-5.046645
H 82_A	50.196685	-5.050100
H 83_A	50.199788	-5.048873
H 84_A	50.199640	-5.046462
H 85_B	50.200267	-5.036005
H 86_B	50.200190	-5.033302
H 87_B	50.203010	-5.036805
H 88_C	50.203555	-5.042988
H 89_A	50.201840	-5.044115
H 92_B	50.198842	-5.038367
H 93_B	50.198260	-5.034167
H 94_B	50.198582	-5.031860
H 97_B	50.195227	-5.041267
H 98_B	50.195185	-5.038300
H 99_B	50.195333	-5.034557
H 100_B	50.195182	-5.031192
H 103_B	50.191677	-5.041825
H 104_B	50.191575	-5.038087
H 105_B	50.192048	-5.034942
H 106_B	50.191717	-5.032258
H 109_B	50.188407	-5.035025
H 110_B	50.187922	-5.031647
H 111_B	50.188012	-5.029367
H 123_B	50.185215	-5.028865
OH 16_A	50.173978	-5.031488
OH 18_B	50.177060	-5.022842
OH 19_A	50.176465	-5.029952
OH 20_A	50.176168	-5.032460
OH 21_A	50.176247	-5.036592
OH 44_B	50.180667	-5.023915
R 26_C	50.206380	-5.034517
R 27_C	50.206640	-5.029107
R 28_C	50.209903	-5.024713
R 29_C	50.212337	-5.024710
R 30_C	50.214193	-5.025233
R 31_C	50.222742	-5.024147
R 32_C	50.224850	-5.021825
R 33_C	50.224778	-5.018992
R 34_C	50.227903	-5.015393
R 36_C	50.235623	-5.018880
R 40_C	50.239188	-5.015732
R 41_C	50.241897	-5.013652
R 42_C	50.242745	-5.014617
R 43_C	50.243805	-5.017103

Annex 4 – Daily logs

Daily log 1

Annex Table B: Daily log for 15th January 2019.

Project information			
Project	Fal Oyster Survey 2019		
Survey code	2019_CIFCA_SAC_FAL_FOS		
Location	Fal Estuary		
Date	15th January 2019		
Vessel	Tiger Lily		
Staff			
Survey role	**Company**	**Name**	
Principal Scientific Officer	Cornwall IFCA	Colin Trundle	
Scientific Officer	Cornwall IFCA	Annie Jenkin	
Scientific Officer	Cornwall IFCA	Stephanie Sturgeon	
Scientific Officer	Cornwall IFCA	Kate Owen	
Scientific Officer	Cornwall IFCA	Hilary Naylor	
Skipper	Independent	Chris Lowe	
Weather and tides			
High water time:	11:17		
High water (m)	4.26m		
Wind direction	SW		
Wind speed	6mph		
Beaufort scale	1		
Cloud coverage	7/8		
Time weather recorded	07:45		
Safety			
Toolbox talk time	07:30		
Induction	None required		
Summary of operations			
Time start (UTC)	**Time end (UTC)**	**Type**	**Activity**
07:15			Onboard setting up
08:12			Depart Mylor
08:31	08:32	Dredge	OH 16
09:03	09:05	Dredge	OH 18
09:19	09:20	Dredge	OH 44
			Lost anchor overboard
			Recovered anchor
09:57	09:58	Dredge	H 51
10:13	10:14	Dredge	H 123
10:46	10:47	Dredge	H 57
11:14	11:16	Dredge	H 111
11:35	11:37	Dredge	H 62
12:00	12:01	Dredge	H 106
13:31	13:33	Dredge	H 76
14:07	14:08	Dredge	H 100
14:24	14:25	Dredge	H 77
14:35	14:37	Dredge	H 94
14:49	14:51	Dredge	H 86
15:13	15:15	Dredge	H 93
15:29	15:30	Dredge	H 78
15:44	15:45	Dredge	H 99
16:00	16:01	Dredge	H 75
16:33	16:34	Dredge	H 105
17:00			Arrive Mylor
Overall progress			
Action	**Sites total**	**Sites completed**	**Remaining sites**
Dredge	83	19	64

Daily log 2

Annex Table C: Daily log for 16th January 2019.

Project information			
Project	Fal Oyster Survey 2019		
Survey code	2019_CIFCA_SAC_FAL_FOS		
Location	Fal Estuary		
Date	16th January 2019		
Vessel	Tiger Lily		
Staff			
Survey role	**Company**	**Name**	
Principal Scientific Officer	Cornwall IFCA	Colin Trundle	
Scientific Officer	Cornwall IFCA	Annie Jenkin	
Scientific Officer	Cornwall IFCA	Stephanie Sturgeon	
Scientific Officer	Cornwall IFCA	Kate Owen	
Scientific Officer	Cornwall IFCA	Hilary Naylor	
Skipper	Independent	Chris Lowe	
Visitor	Natural England	Kate Sugar	
Weather and tides			
High water time:	11:56		
High water (m)	4.5m		
Wind direction	SW		
Wind speed	5mph		
Beaufort scale	1		
Cloud coverage	8/8		
Time weather recorded	08:00		
Safety			
Toolbox talk time			
Induction	13:00		
Summary of operations			
Time start (UTC)	**Time end (UTC)**	**Type**	**Activity**
07:30			Depart Mylor
08:02	08:03	Dredge	H 85
08:20	08:22	Dredge	H 92
08:36	08:38	Dredge	H 80
09:00	09:01	Dredge	H 79
09:17	09:19	Dredge	H 98
10:05	10:07	Dredge	H 97
10:31	10:33	Dredge	H 74
10:57	10:58	Dredge	H 88
11:31	11:32	Dredge	H 89
11:49	11:51	Dredge	H 84
12:06	12:07	Dredge	H 83
13:34	13:35	Dredge	H 73
13:58	13:59	Dredge	H 72
14:17	14:18	Dredge	H 104
14:39	14:41	Dredge	H 103
15:05	15:06	Dredge	H 63
15:36	15:37	Dredge	H 64
16:03	16:04	Dredge	H 65
16:30			Arrive Mylor
Overall progress			
Action	**Sites total**	**Sites completed**	**Remaining sites**
Dredge	83	18	46

Daily log 3

Annex Table D: Daily log for 17th January 2019.

Project information			
Project	Fal Oyster Survey 2019		
Survey code	2019_CIFCA_SAC_FAL_FOS		
Location	Fal Estuary		
Date	17th January 2019		
Vessel	Tiger Lily		
Staff			
Survey role	**Company**	**Name**	
Principal Scientific Officer	Cornwall IFCA	Colin Trundle	
Scientific Officer	Cornwall IFCA	Annie Jenkin	
Scientific Officer	Cornwall IFCA	Stephanie Sturgeon	
Scientific Officer	Cornwall IFCA	Kate Owen	
Skipper	Independent	Chris Lowe	
Weather and tides			
High water time:	13:09		
High water (m)	4.6m		
Wind direction	NW		
Wind speed	20mph		
Beaufort scale	4		
Cloud coverage	4/8		
Time weather recorded	08:00		
Safety			
Toolbox talk time			
Induction	None required		
Summary of operations			
Time start (UTC)	**Time end (UTC)**	**Type**	**Activity**
07:30			Depart Mylor
08:00	08:02	Dredge	H 23
08:13	08:15	Dredge	H 22
08:44	08:46	Dredge	OH 21
09:14	09:17	Dredge	OH20
09:52	09:53	Dredge	OH19
10:55	10:57	Dredge	H45
11:32	11:34	Dredge	H46
12:03	12:05	Dredge	H47
13:24	13:26	Dredge	H52a
13:29	13:31	Dredge	H52b
13:47	13:48	Dredge	H53
14:10	14:12	Dredge	H54
14:36	14:37	Dredge	H55
14:57	14:58	Dredge	H56
15:08	15:09	Dredge	H58
15:31	15:33	Dredge	H59
15:54	15:55	Dredge	H60
16:09	16:10	Dredge	H61
16:22	16:23	Dredge	H109
16:39	16:40	Dredge	H110
17:00			Arrive Mylor
Overall progress			
Action	**Sites total**	**Sites completed**	**Remaining sites**
Dredge	83	19	27

Daily log 4

Annex Table E: Daily log for 18th January 2019.

Project information	
Project	Fal Oyster Survey 2019
Survey code	2019_CIFCA_SAC_FAL_FOS
Location	Fal Estuary
Date	18th January 2019
Vessel	Tiger Lily

Staff		
Survey role	**Company**	**Name**
Principal Scientific Officer	Cornwall IFCA	Colin Trundle
Scientific Officer	Cornwall IFCA	Annie Jenkin
Scientific Officer	Cornwall IFCA	Stephanie Sturgeon
Scientific Officer	Cornwall IFCA	Kate Owen
Scientific Officer	Cornwall IFCA	Hilary Naylor
Skipper	Independent	Chris Lowe
Visitor	Cornwall Wildlife Trust	Matt Slater

Weather and tides		
High water time:	14:12	
High water (m)	4.9m	
Wind direction	SE	S
Wind speed	30-40mph	5mph
Beaufort scale	5	1
Cloud coverage	7/8	8/8
Time weather recorded	08:00	13:00

Safety	
Toolbox talk time	
Induction	07:00

Summary of operations			
Time start (UTC)	**Time end (UTC)**	**Type**	**Activity**
07:45			Depart Mylor
08:00	08:00	Dredge	H 50
08:10	08:13	Dredge	H 49
08:29	08:31	Dredge	H 48
08:44	08:46	Dredge	H 66
09:03	09:05	Dredge	H 67
09:24	09:26	Dredge	H 68
09:38	09:40	Dredge	H 71
10:01	10:03	Dredge	H 70
10:15	10:17	Dredge	H 69
10:28	10:29	Dredge	H 82
10:46	10:47	Dredge	H 81
11:11	11:13	Dredge	R 27
11:20	11:21	Dredge	R 28
11:30	11:31	Dredge	R 29
11:46	11:47	Dredge	R 30
12:52	12:53	Dredge	R 43
13:06	13:07	Dredge	R 42
13:17	13:18	Dredge	R 41a – dredge flipped
13:22	13:23	Dredge	R 41b
13:35	13:36	Dredge	R 40
13:50	13:51	Dredge	R 36
14:07	14:09	Dredge	R 34
14:22	14:23	Dredge	R 33
14:43	14:44	Dredge	R 32
15:08	15:09	Dredge	R 31a – dredge flipped
15:12	15:14	Dredge	R 31b – dredge flipped

15:17	15:18	Dredge	R 31c
15:36	15:37	Dredge	R 26
15:56	15:57	Dredge	H 24
16:10	16:11	Dredge	H 87
16:40			Arrive Mylor
Overall progress			
Action	**Sites total**	**Sites completed**	**Remaining sites**
Dredge	83	27	0

Annex 5 – Survey data

Annex Table F: Native oysters (*Ostrea edulis)*, queen scallop (*Aequipecten opercularis*) and variegated scallop (*Mimachlamys varia*) and slipper limpet (*Crepidula fornicata*) counts for the Fal oyster survey 2019.

Section	Site Code	Date	No. of Oysters				Total Oyster Count	No. of Scallops							Total Scallop Count	Slipper Limpet Count
			≥65mm	≥50-≤64mm	≥36-≤49mm	≤35mm		≥80mm	≥70-≤79mm	≥60-≤69mm	≥50-≤59mm	≥40-≤49mm	≥30-≤39mm	≤29mm		
Harbour (H)	22	17/01/2019	11	8	3	0	22	0	7	43	47	17	15	34	163	792
	23	17/01/2019	2	0	0	1	3	0	1	5	2	1	3	32	44	0
	24	18/01/2019	19	43	7	1	70	0	1	2	9	7	3	30	52	35
	45	17/01/2019	3	2	0	1	6	0	5	28	40	36	26	142	277	488
	46	17/01/2019	5	2	0	0	7	1	20	51	37	22	21	67	219	284
	47	17/01/2019	5	2	1	2	10	1	10	38	50	12	12	34	157	201
	48	18/01/2019	4	1	1	0	6	0	2	19	15	10	6	7	59	275
	49	18/01/2019	5	5	1	1	12	0	1	21	24	12	7	28	93	159
	50	18/01/2019	1	0	0	0	1	0	0	0	1	0	0	22	23	0
	51	15/01/2019	8	15	6	2	31	0	4	6	13	6	3	31	63	126
	52	17/01/2019	3	3	1	0	7	0	3	12	26	7	9	10	67	134
	53	17/01/2019	0	5	0	0	5	0	3	28	45	27	31	79	213	108
	54	17/01/2019	7	12	2	1	22	1	4	38	50	32	10	45	180	159
	55	17/01/2019	7	7	3	2	19	1	0	17	34	15	8	35	110	42
	56	17/01/2019	0	1	0	0	1	0	0	1	1	1	0	0	3	2
	57	15/01/2019	22	18	1	0	41	0	7	34	34	18	11	38	142	103
	58	17/01/2019	11	11	3	2	27	0	3	39	51	27	10	52	182	118
	59	17/01/2019	7	13	2	1	23	0	1	16	28	16	9	45	115	57
	60	17/01/2019	9	8	4	0	21	0	1	14	22	9	1	28	75	39
	61	17/01/2019	11	4	2	0	17	0	0	4	6	1	0	7	18	1
	62	15/01/2019	22	5	2	0	29	0	1	10	16	9	6	44	86	51
	63	16/01/2019	17	12	4	2	35	0	11	45	55	21	8	26	166	156
	64	16/01/2019	7	7	4	0	18	0	10	39	57	27	15	27	175	201
	65	16/01/2019	8	14	2	0	24	0	7	25	19	12	6	8	77	123
	66	18/01/2019	7	3	2	0	12	0	0	4	8	3	1	8	24	177
	67	18/01/2019	9	4	2	1	16	0	3	6	2	1	3	40	55	46
	68	18/01/2019	7	8	1	2	18	1	0	2	7	2	0	25	37	15
	69	18/01/2019	10	7	2	1	20	0	3	7	6	3	1	10	30	0
	70	18/01/2019	1	4	2	0	7	0	3	12	11	2	2	1	31	183

71	18/01/2019	11	4	2	3	20	0	16	42	44	4	4	17	127	492
72	16/01/2019	1	1	2	0	4	0	5	28	12	10	5	16	76	93
73	16/01/2019	15	4	6	0	25	0	3	25	38	20	20	50	156	185
74	16/01/2019	10	14	5	3	32	0	9	42	35	18	6	29	139	141
75	15/01/2019	24	23	9	0	56	0	8	73	77	16	4	14	192	63
76	15/01/2019	15	32	10	4	61	0	0	6	17	5	16	61	105	66
77	15/01/2019	0	0	0	0	0	0	0	0	1	0	0	0	1	0
78	15/01/2019	0	0	0	0	0	0	0	0	0	1	0	0	1	0
79	16/01/2019	0	1	1	0	2	0	0	2	0	0	0	0	2	2
80	16/01/2019	8	10	5	0	23	0	4	32	39	15	6	31	127	162
81	18/01/2019	12	15	5	0	32	1	10	36	44	10	5	4	110	344
82	18/01/2019	5	7	6	1	19	0	1	17	11	4	2	10	45	30
83	16/01/2019	8	4	1	1	14	0	1	4	2	1	3	5	16	22
84	16/01/2019	15	6	0	0	21	0	0	11	15	2	1	10	39	46
85	16/01/2019	19	11	2	0	32	0	2	5	8	2	3	4	24	8
86	15/01/2019	21	20	2	1	44	0	0	9	7	4	1	15	36	12
87	18/01/2019	18	17	8	4	47	0	1	7	9	4	5	13	39	29
88	16/01/2019	24	47	2	0	73	0	1	4	4	1	0	21	31	7
89	16/01/2019	11	9	2	3	25	0	2	15	10	4	3	16	50	67
92	16/01/2019	3	1	0	0	4	0	0	5	4	3	3	4	19	29
93	15/01/2019	1	0	1	0	2	0	0	1	2	0	2	1	6	0
94	15/01/2019	0	2	0	0	2	0	0	0	0	0	0	0	0	0
97	16/01/2019	4	11	7	0	22	3	2	30	37	18	7	28	125	184
98	16/01/2019	11	10	3	0	24	0	2	15	24	15	13	44	113	261
99	15/01/2019	3	5	2	0	10	0	2	5	12	7	0	1	27	0
100	15/01/2019	3	4	0	0	7	0	2	3	6	2	0	7	20	0
103	16/01/2019	6	13	4	1	24	0	2	21	24	7	18	36	108	192
104	16/01/2019	6	7	2	1	16	1	7	38	23	21	11	11	112	170
105	15/01/2019	11	15	6	1	33	0	8	54	65	17	9	22	175	153
106	15/01/2019	20	21	6	7	54	0	1	24	19	16	12	51	123	79
109	17/01/2019	4	1	2	0	7	0	6	36	22	13	2	8	87	162
110	17/01/2019	9	6	3	0	18	0	7	26	23	12	3	29	100	183
111	15/01/2019	7	7	1	0	15	0	3	19	13	5	1	38	79	23
123	15/01/2019	6	11	0	0	17	0	1	30	19	12	5	35	102	186

H Sub-total	**63**		539	563	163	50	1315	10	217	1231	1382	625	397	1586	5448	7466
	16	15/01/2019	0	1	0	2	3	0	0	3	5	13	11	121	153	339
	18	15/01/2019	0	0	0	0	0	0	0	0	1	1	0	0	2	4
Outer Harbour (OH)	19	17/01/2019	12	6	1	0	19	2	11	39	68	36	53	440	649	614
	20	17/01/2019	6	6	0	0	12	0	7	30	48	17	21	137	260	488
	21	17/01/2019	9	4	5	0	18	0	13	44	40	18	13	56	184	642
	44	15/01/2019	8	7	1	0	16	0	0	0	2	0	0	4	6	19
OH Sub-total	**7**		35	24	7	2	68	2	31	116	164	85	98	758	1254	2106
	26	18/01/2019	22	34	9	0	65	0	0	18	44	10	20	22	114	23
	27	18/01/2019	4	0	0	0	4	0	0	0	0	0	1	0	1	24
	28	18/01/2019	2	1	0	0	3	0	0	2	3	0	3	6	14	28
	29	18/01/2019	6	2	0	0	8	0	0	5	3	3	0	1	12	98
	30	18/01/2019	1	2	1	0	4	0	0	1	2	2	0	4	9	18
	31	18/01/2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	32	18/01/2019	27	20	13	3	63	0	0	1	11	19	11	13	55	255
River (R)	33	18/01/2019	22	66	16	1	105	0	0	0	2	11	3	13	29	1169
	34	18/01/2019	14	26	6	0	46	0	0	0	0	11	10	28	49	41
	36	18/01/2019	5	4	0	1	10	0	0	0	0	1	3	12	16	91
	40	18/01/2019	1	9	4	0	14	0	0	0	0	0	4	7	11	63
	41	18/01/2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42	18/01/2019	3	0	0	0	3	0	0	0	0	0	0	1	1	5
	43	18/01/2019	2	0	0	0	2	0	0	0	0	0	1	1	2	25
R Sub-total	**14**		109	164	49	5	327	0	0	27	65	57	56	108	313	1840
Total	**83**		**683**	**751**	**219**	**57**	**1710**	**12**	**248**	**1374**	**1611**	**767**	**551**	**2452**	**7015**	**11412**

Annex 6 – Bycatch

Annex Table G: List of bycatch species recorded during the Fal oyster survey 2019

Species Name	Common Name / Descriptions	Species recorded in previous years	Non-native species	Number of sites recorded
ALGAE - CHLOROPHYTA				
Ulva sp.	Sea lettuce			6
ALGAE – OCHROPHYTA				
Ascophyllum nodosum	Knotted wrack	Y		5
Fucus serratus	Serrated wrack	Y		6
Fucus vesiculosus	Bladder wrack			1
Laminaria hyperborea and *Laminaria ochroleuca*	Kelp	Y		2
Laminaria saccharina	Sugar kelp			1
Brown seaweed sp. unidentified				1
ALGAE - RHODOPHYTA				
Chondrus crispus	Irish Moss	Y		1
Lithothamnion corallioides	Maerl	Y		0
Lithophyllum sp.	Encrusting coralline algae	Y		37
Phymatolithon calcareum	Maerl	Y		1
Solieria chordalis	Red string weed	Y		21
Red weed species 2				2
Rhodophyta spp. unidentified				4
ANNELIDA				
Amphitritides spp.	Strawberry Terebellid worm			16
Chaetopterus variopedatus	Parchment tube worm			4
Lanice conchilega	Sand mason worm	Y		5
	Ragworm species			14
Polychaete spp. *unidentified*				3
Polynoidae spp. *unidentified*	Scale worms			5
Pomatoceros triqueter	Keel worm			8
Prostheceraeus vittatus	Candy striped flatworm			1
Sabella pavonica	Peacock worm tubes			3
Serpula vermicularis	Fan worm / red tube worm	Y		3
Spirorbis spirorbis	Spiral worm			1
ARTHROPODA				
Austrominius modestus	Darwins barnacle			3
Cancer pagurus	Edible crab	Y		11

Species Name	**Common Name / Descriptions**	**Species recorded in previous years**	**Non-native species**	**Number of sites recorded**
Carcinus maenas	Common shore crab	Y		26
Crangon crangon	Brown shrimp	Y		5
Galathea squamifera	Squat lobster	Y		12
Liocarcinus navigator	Navigator crab / Arch			54
Liocarcinus depurator	Harbour crab	Y		25
Liocarcinus holsatus	Flying crab			2
Liocarcinus spp.				4
Necora puber	Velvet swimming crab	Y		2
Portumnus latipes	Pennant swimming crab			2
Macropodia spp.	Long legged spider crabs	Y		40
Inachus spp.	Spider crabs			2
Pagurus bernhardus	Hermit crab	Y		51
Pagurus prideaux	Hermit crab (with anemone)			3
Pilumnus hirtellus	Hairy crab			9
Pisidia longicornis	Long clawed porcelain crab	Y		36
Porcella platycheles	Broad Clawed porcelain crab			1
Xantho pilipes	Risso's crab (distinctive hair on legs)			2
Xantho hydrophilus	Montagu's crab			7
Palaemon serratus	Common prawn	Y		2
Sacculina carcini	Crab hacker barnacle	Y		10
Semibalanus balanoides	Acorn Barnacle	Y		1
Balanus crenatus	Leaning barnacle			6
Athropoda spp.				4
BRYOZOA				
Bryozoa	An encrusting bryozoan	Y		5
CHORDATA				
Callionymus lyra	Common dragonet	Y		5
Goby spp.				6
Hippocampus hippocampus	Short snouted seahorse			1
Lepadogaster lepadogaster	Shore clingfish			1
Nerophis lumbriciformis	Worm pipefish	Y		2
Solea solea	Sole	Y		1
Syngnathus acus	Greater pipefish	Y		1
Taurulus bubalis	Long-spined sea scorpion	Y		1
CNIDARIA				

Species Name	Common Name / Descriptions	Species recorded in previous years	Non-native species	Number of sites recorded
Actinaria spp.				9
Actinia equina	Beadlet anemone			1
Adamsia carciniopados	Cloak anemone			3
Anemonia viridis	Snakelocks anemone			7
Calliactis parasitica	Parasitic anemone	Y		6
ECHINODERMS				
Marthasterias glacialis	Spiny starfish	Y		1
Psammechinus miliaris	Green sea urchin	Y		5
Ophiura spp.	Brittle star	Y		18
Asteroidea sp.				1
MOLLUSCA				
Anomia ephippium	Saddle oyster	Y		42
Acanthorcardia aculeata	Spiny cockle			1
Acanthocardia tuberculata	Rough cockle	Y		3
Buccinum undatum	Common whelk (or whelk eggs)	Y		11
Chamelia gallina	Striped venus			2
Chlamys varia	Variegated scallop			0
Cerastoderma edule	Common cockle	Y		9
Crepidula fornicata	Slipper limpet (count)	Y	Y	72
Calliostoma zizyphinum	Painted top shell	Y		12
Gibbula cineraria	Grey top shell	Y		25
Gibbula magus	Turban topshell			14
Hiatella arctica (probable)	Wrinkled rock borer			1
Lepidochitona cinerea	Chiton	Y		23
Littorina obtusata	Flat periwinkle			2
Mytilus edulis	Mussels	Y		28
Nucella lapillus	Dog whelk (or dog whelk eggs)			1
Ocenebra erinaceus	European sting winkle			1
Pecten maximus	Great scallop	Y		2
Tectura virginea	White tortoiseshell limpet			1
Tritia reticulate	Netted dog whelk	Y		12
Turitella / Bittium sp. (Possibly retuculatum)	Spiral shell	Y		25
	Angular small cockle (species unidentified)			7
Unidentified bivalves				4
Unidentified white bivalve sp. (see photo H63 and H45)				5

Species Name	**Common Name / Descriptions**	**Species recorded in previous years**	**Non-native species**	**Number of sites recorded**
Acanthodoris pilosa	White fluffy nudibranch			1
Aeolidia papillosa	Sheep sea slug			1
Akera bullata	Sea slug with shell			2
Aplysia punctate	Sea hare	Y		9
Aplysia punctate eggs	Sea hare eggs	Y		0
Archidoris pseudoargus	Sea lemon	Y		6
Berthella plumula	Yellow sea slug	Y		0
Goniodoris nodosa	Small white nudibranchs			1
Lamellaria perspicua (probable)	Sea snail			1
Onchidoris bilamellata	Rough mantled doris nudibranch			3
Onchidoris bilamellata / Pleurobranchus membranaceus	Sea slug			5
Rostranga rubra	Red sea slug			9
Nudibranch sp. unidentified				1
Nudibranch egg				1
PORIFERA				
Amphilectus fucorum	Shredded carrot sponge			1
Cliona celata	Yellow boring sponge	Y		19
Dysidea fragilis	Goosebump sponge			2
Porifera *sp*. 1	Sponge associated with *Nemertesia* hydroids (Photo H83)			10
Grantia compressa	Purse sponge			1
Haliclona sp.				1
Hymenaciodon perlevis				1
Porifera spp.				26
Sycon cilliatum	Purse sponge			2
*Suberites carnosus (*probable)				2
Suberites ficus	Orange sponge on queens			3
Suberites spp.	Sponge	Y		3
*Ulosa stuposa (*probable)				1
TUNICATA				
Ascdiella aspersa	European sea squirt			17
Ascidia mentula	Red sea squirt	Y		6
Botrylloides leachi	Orange colonial ascidian (photo H58)			1
Ciona intestinalis	Sea vase (sea squirt)			7
Styela clava	Leathery sea squirt	Y	Y	14
Ascidian spp. unidentified				5

Species Name	Common Name / Descriptions	Species recorded in previous years	Non-native species	Number of sites recorded
Hydroida				
Hydractinia echinata	Hermit crab fir (hydroid which grows on hermit crab shells)			1
Nemertesia/Hydractinia antennia)	Often found with sponges on shells			12
Hydroida sp.				1
Species identified by Matt Slater but unsure which site they were recorded at				
Calyptraea chinensis	Chinaman's hat shell			1
Flustrellidra hispida	Fleshy bryozoan			1