Marine Institute
Foras na Mara

The Labadie, Jones and Cockburn Banks *Nephrops* Grounds (FU20-21) 2018 UWTV Survey Report and catch scenarios for 2019.

Jennifer Doyle[1], Mikel Aristegui[1], Orla Hanniffy[1], Jonathan White[1], Dermot Fee[1] and Peter McCorriston[2].

[1] Fisheries Ecosystems Advisory Services, Marine Institute, Renville, Oranmore, Galway, Ireland.
[2]Agri-Food and Biosciences Institute (AFBI), Fisheries and Aquatic Ecosystems Branch, Newforge Lane, BT9 5PX, Belfast, Northern Ireland (UK).

Version October 2018

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara

EUROPEAN MARITIME AND FISHERIES FUND

Abstract

This report provides the main results of the 2018 underwater television survey on the 'Labadie, Jones and Cockburn Banks' ICES assessment area; Functional Unit 20-21. This was the fifth survey to achieve full coverage of the full area. The 2018 survey was multi-disciplinary in nature collecting UWTV, and other ecosystem data. A total of 96 UWTV stations were completed at 6 nm intervals over a randomised isometric grid design. The mean burrow density was 0.27 burrows/m^2 compared with 0.44 burrows/m^2 in 2017. The 2018 geostatistical abundance estimate was 2.7±0.006 billion, a 39% decrease on the abundance for 2017, with a CV of 4% which is well below the upper limit of 20% recommended by SGNEPS 2012. High densities were observed throughout the ground, and also close to boundaries. Using the 2018 abundance estimate and updated stock data implies catch of 5,320 t and landings of 4,325 t in 2019 when MSY approach is applied (assuming that discard rates and fishery selection patterns do not change from the average of 2015–2017). One species of sea-pen (*Virgularia mirabilis*) were recorded as present at the stations surveyed. Trawl marks were observed at 33% of the stations surveyed.

Key words: *Nephrops norvegicus,* Celtic Sea, stock assessment, geostatistics, underwater television (UWTV), CTD, benthos.

Suggested citation:
Doyle, J., Aristegui, M., Hanniffy, O., White, J., Fee, D., and McCorriston, P. 2018. The Labadie, Jones and Cockburn Banks *Nephrops* Grounds (FU20-21) 2018 UWTV Survey Report and catch scenarios for 2019. Marine Institute UWTV Survey report.

Introduction

The prawn (*Nephrops norvegicus*) are common in the Celtic Sea occurring in geographically distinct sandy/muddy areas were the sediment is suitable for them to construct their burrows. The *Nephrops* fishery in ICES sub-area 7 is extremely valuable with Irish landings in 2017 worth around €54 million at first sale. The Celtic Sea area (Functional Units 19-22; Figure 1) supports a large multi-national targeted *Nephrops* fishery mainly using otter trawls and yielding landings in the region of ~5,000 t annually over the last decade (ICES, 2018). The 2017 reported landings from FU20-21 were ~1,850 t and estimated to be worth in the region of €6.9 m at first sale. This ground has become increasingly important to the Irish demersal fleet, which now accounts for around 70% of the total FU20-21 *Nephrops* landings (ICES, 2017). Good scientific information on stock status and exploitation rates are required to inform sustainable management of this resource.

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced by several factors: time of day, time of year, light intensity, tidal strength, etc. Underwater television surveys and assessment methodologies have been developed to provide a fishery independent estimate of stock size, exploitation status and catch advice (ICES, 2009a & 2012a). This is the sixth UWTV survey in the Celtic Sea FU20-21 grounds carried out by the Marine Institute, Ireland.

The survey was multi-disciplinary in nature and also covered TV stations in FU19 the results of which are presented elsewhere (Aristegui *et. al.,* 2018).

The 2018 specific objectives are listed below:

1. To complete ~96 UWTV stations with 6.0 nautical mile (nm) spacing on the Labadie, Jones and Cockburn *Nephrops* ground (FU20-21).
2. To obtain 2018 quality assured estimates of *Nephrops* burrow distribution and abundance, and compare them with those from previous surveys.
3. To collect ancillary information from the UWTV footage collected at each station such as the occurrence of sea-pens, other macro benthos and fish species and trawl marks on the sea bed.
4. To collect oceanographic data using a sledge mounted CTD.
5. To collect sediment samples for PSA analysis.

This report details: the survey design, the final UWTV results of the 2018 survey and also documents other data collected during the survey. Operational survey details are available in the form of a survey narrative from the scientist in charge (JD). The 2018 abundances are used to generate catch advice scenarios for 2019 in line with the recommendations and procedures outlined in the stock annex for FU20-21 (ICES, 2018).

Material and methods

The knowledge about the distribution of suitable *Nephrops* habitat in this area has been developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age. The area of the ground was revised by WKCELT (ICES,

2014) with the inclusion of both French and Irish integrated logbook VMS data (Gerritsen & Lordan, 2011) and is now calculated at 10 014 km^2. This value is used for the survey. The 2018 randomised isometric grid resulted in 86 planned stations and was generated using the "spsampl" function in the "sp" package (Pebesma & Bivand, 2005) in "R" (R Core Team, 2017). Stations depths varied from 78 m to 149 m and the completed stations ranged from 55 to 135 nm offshore (Figure 2). The 2018 survey took place on the RV. Celtic Voyager: from the 2nd to 12th July.

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and employed on other UWTV surveys in Irish waters. These protocols can be summarised as follows: At each station the UWTV sledge was deployed. Once stable on the seabed a 10 minute tow was recorded onto DVD. Time referenced video footage was collected from a video camera with field of view or 'FOV' of 75 cm. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 2 seconds. The navigational data was quality controlled using an "R" script developed by the Marine Institute (ICES, 2009b). The USBL navigational data was used to calculate distance over ground or 'DOG' for 95 % of stations and corrected ship navigation data used for 5 stations.

In line with recommendations of the Study Group on *Nephrops* Surveys (SGNEPS), all scientists were trained/re-familiarised using training material and validated using reference footage for this area, prior to counting at sea (ICES, 2009b). All recounts were conducted by two trained "burrow identifying" scientists independent of each other on board the research vessel during the survey. During the review process the visibility, ground type and speed of the sledge during one-minute intervals were subjectively classified using a classification key. In addition, the numbers of *Nephrops* burrows complexes (multiple burrows in close proximity which appear to be part of a single complex and counted only once), *Nephrops* activity in and out of burrows were counted by each scientist for each one-minute interval recorded. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

Notes were also recorded each minute on the occurrence of trawl marks, fish species and other species. Abundance categories of sea-pen species were also recorded due to an OSPAR Special Request (ICES 2011) using the scale provided in Table 1. Finally, if there was any time during the one-minute where counting was not possible, due to sediment clouds or other reasons, this was also estimated so that the time window could be removed from the distance over ground calculations. The "R" quality control tool allowed the quality of data for each station to be checked: navigation, speed, visual clarity and consistency in counts (Figure 3).

In 2018 the survey count data were screened to check for any unusual discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a threshold of 0.5. Lin's CCC (Lin, 1989) measures the ability of counters to exactly reproduce each other's counts on a scale of 1 to –1 where 1 is perfect concordance (i.e. a pairwise plot will have all points lying along the 1:1 line, a value of –1 would be generated by all points lying on the –1:1 line and a value of 0 indicates no correspondence at all). For those stations that did not pass the threshold it was deemed appropriate to inspect the CCC plots and then to use the 4 counters in the final counts. Lin's CCC quality control plots of count data for stations 120 to 122 are shown in Figure 4. Consistency and bias between individual counters was examined (Figure 5). There is moderate variability between counters but no obvious bias or excessive deviations. The moderate variability between counters is because burrow counting in this area is particularly difficult (see discussion).

Mean density was calculated by dividing the total number of burrow systems by the survey area observed. The USBL data were used to calculate distance over ground of the sledge. The field of view of the camera at the bottom of the screen was estimated at 75cm assuming that the sledge was flat on the seabed (i.e. no sinking). This field of view was confirmed during the 2018 survey using lasers. Occasionally the lasers were not visible at the bottom of the screen due to sinking in very soft mud, the impact of this is a minor under estimate of densities at stations where this occurred.

Due to technical problems CTD data was not collected on this survey.

Sediment samples were collected using the Shipex grab after completion of TV station and if survey time allowed. A photograph of the sediment was logged and approximately 1 kg of sediment was taken for PSA analysis. 39 samples were successfully collected and the data will be processed at a later stage. This data will be used to generate sediment maps for this area and also to ground truth any sea-bed mapping programmes.

The approach to work up the abundance estimates each year has been documented in previous survey reports. Since 2015 the geostatistical analysis was carried out using the "RGeostats" package (Renard D., *et al*, 2015) and is available as an "R" markdown document. The same steps were carried out as in previous years; construction of experimental variogram, a model variogram produced with an exponential model, create krigged grid file using all data points as neighbours, same boundary used to estimate the domain area, mean density, total burrow abundance and calculate survey precision.

Results

All 96 stations were completed successfully on the FU20-21 *Nephrops* grounds (Figure 2). Figure 6 shows bubble plots of the variability between minutes and operators. These show that the burrow estimates are fairly consistent between minutes and counters. The variability is slightly higher between minutes then between counters.

The adjusted burrow densities from 2013 to 2018 are shown in Figure 7 as a combined violin and box plot. These show that density has decreased in 2018 from 2017. There were two observations of high densities (>0.7/m^2) while the majority were in the range of 0.15 to 0.6/m^2. The 2018 mean adjusted[1] density of 0.27 burrows/m^2 is the second highest in the time series to date and was 40% lower than the 2017 estimate of 0.44 burrows/m^2.

[1] Note the "adjusted" density estimates in this report are adjusted by dividing by 1.3 (Table 2) to take account of edge effect over estimation of area viewed during UWTV transects (see Campbell et al 2009).

Combined bubble and contour plots of the krigged densities from 2013 to 2018 are presented in Figure 8. Highest densities were towards the centre of the ground in years 2013 - 2014 while for 2015 - 2016 high densities were found in the northern and southwestern area. In 2017 high densities were generally observed throughout the ground but the highest were to the northwest. In 2018 high densities were observed throughout the ground. There were also high densities observed close to boundaries in several areas.

The summary empirical and geo-statistical results are given in Table 2. Stations surveyed in 2006 and 2012 should be viewed as exploratory and have not been used to extrapolate total abundance. The 2013 survey had partial coverage of the area (<60%) scaling the mean density to the total area (10,014 km^2) resulted in an abundance estimate of 1.6±0.3 billion. The 2018 geo-statistical abundance estimate is 2.7±0.006 billion which is 39% lower than in 2017 (Figure 9). The geo-statistical CVs were in the order of 3 to 5 %. These are well below the upper limit recommended of 20% (ICES, 2012).

The UWTV abundance data together with data from the fishery; landings, discards and removals in number are used to calculate the harvest rate (dead removals/TV abundance) in 2017 this was 1.7%. The mean weight in the landings and the discards and the proportions of removal retained are also shown (Table 3). The mean weights are variable between 2012 - 2017 and are based on available sampling data (ICES, 2018). The basis to the catch scenarios is given in Table 4. The catch scenarios and associated harvest rates are presented in Table 5. Fishing at the Fmsy of 6.0 % in 2019 would result in total catches of 5,319 t which implies landings of 4,325 t (Table 5).

Sea-pen distribution across the *Nephrops* grounds is mapped in Figure 10. All sea-pens were identified from the video footage as *Virgularia mirabilis*. Trawl marks were noted at 33% of the stations surveyed.

Discussion

The 2018 survey achieved full coverage of the stock area for the fifth time. The density estimates in 2013 - 2016 are relatively similar and would be considered low (mainly ~0.2m^2). In 2017 there was a large increase in the densities across the whole ground, with a large increase also observed in FU22 also in the Celtic Sea (O'Brien et al., 2017). In 2018 density across FU20-21 decreased. There was also a general decrease in density in the Celtic Sea *Nephrops* grounds in FU19 and FU22 (Aristegui, 2018). It is likely that the recruitment to *Nephrops* populations in the Celtic Sea are linked through oceanographic process (O'Sullivan *et. al*, 2015). It may well be that oceanographic conditions have resulted in the observed density decreases in the Celtic Sea.

Nephrops fisheries in this area have been covered under the landings obligation since 2016. There has also been a *de minimis* clause in place, allowing up to 6% of catch to be discarded in 2018. Discard rates in weight for this FU have been around 19% in recent years, which is above the Landing Obligation *de minimis* of 6%.

The provision of catch advice and scenarios for 2019 based on the MSY approach assumes that discard rates and fishery selection patterns do not change from the average of 2015–2017.

The introduction of the landings obligation to *Nephrops* fisheries in 2016 should result in changes in selectivity. This is not taken into account in any of the catch advice because it is not possible to predict exactly what might happen. The main message is that any improvements in selectivity in the fishery and reductions in discards will result in increased mean weight in the catches. This will in turn reduce overall mortality on the stocks and allow for catch increases in the future.

An important objective of this UWTV survey is to collect various ancillary information. The occurrence of trawl marks on the footage is notable for two reasons. Firstly, it makes identification of *Nephrops* burrows more difficult as the trawl marks remove some signature features making accurate burrow identification more difficult. Secondly, only occupied *Nephrops* burrows will persist in heavily trawled grounds and it is assumed that each burrow is occupied by one individual *Nephrops* (ICES 2008).

Monitoring the occurrence and frequency of sea-pens observed on these *Nephrops* patches is important in the context of OSPAR's designations of sea-pen and burrowing megafauna communities as threatened. The sea-pen species *Virgularia mirabilis* which was seen in 2018 have been observed on previous surveys of FU20-21. Monitoring *Nephrops* stock and the benthic habitat is also important in the context of the MFSD indicators (e.g. sea floor integrity).

The sediment sample data collected during the survey will increase the knowledge base on habitat mapping in time.

The main objectives of the survey were successfully met for the fifth successive year. The UWTV coverage and footage quality was excellent throughout the survey. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

We would like to express our thanks and gratitude to Colin McBrearty (Master) and crew of the RV. Celtic Voyager for their good will and professionalism throughout the survey. Thanks also to the P&O Maritime IT & Instrumentation Technician Lukasz Pawlikowski who maintained the UWTV system throughout the survey. Thanks to Aodhán Fitzgerald and Rosemarie Butler RVOPs and Rob Bunn and Dave Tully FEAS at the Marine Institute for organising survey logistics. Thanks to Gordon Furey, Barry Kavanagh, John Barry and Tom O'Leary P&O Maritime for shore side support.

References

Aristegui, M., O'Brien, S., Blaszkowski, M., O'Connor, S., Fitzgerald, R., and Doyle, J. 2018. FU19 *Nephrops* Grounds (FU19) 2018 UWTV Survey Report and catch scenarios for 2019. Marine Institute UWTV Survey report.

Aristegui, M., O'Brien, S., Blaszkowski, M., O'Connor, S., Fitzgerald, R., and Doyle, J. 2018. The "Smalls" *Nephrops* Grounds (FU22) 2018 UWTV Survey Report and catch scenarios for 2019. Marine Institute UWTV Survey report.

Campbell, N., Dobby, H., and Bailey, N. 2009. Investigating and mitigating uncertainties in the assessment of Scottish *Nephrops norvegicus* populations using simulated underwater television data. ICES Journal of Marine Science 66: 646–655. doi: 10.1093/icesjms/fsp046.

Doyle, J., Lordan, C., Hehir, I., O'Sullivan, D., O'Connor, S., Blaszkowski, M., and Stewart, P. 2013. FU20-21 2013 UWTV Survey Report. Marine Institute UWTV Survey report.

Doyle, J., Fitzgerald, R., O'Brien, S., Ryan, G., McGeady, R., and Lordan, C. 2017. FU19 *Nephrops* Grounds (FU19) 2017 UWTV Survey Report and catch options for 2018. Marine Institute UWTV Survey report.

Gerritsen, H., and Lordan, C. 2011. Integrating vessel monitoring systems (VMS) data with daily catch data from logbooks to explore the spatial distribution of catch and effort at high resolution. ICES Journal of Marine Science: Journal du Conseil 68: 245–252. doi: http://dx.doi.org/10.1093/icesjms/fsq137.

ICES 2007. Report of the Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (WKNEPHTV). ICES CM: 2007/ACFM: 14 Ref: LRC, PGCCDBS.

ICES 2008. Report of the Workshop and training course on *Nephrops* burrow identification (WKNEPHBID). ICES CM: 2008/LRC: 3 Ref: LRC, ACOM.

ICES 2009a. Report of the Study Group on *Nephrops* Surveys (SGNEPS). ICES CM 2009/LRC: 15. Ref: TGISUR.

ICES 2009b. Report of the Benchmark Workshop on *Nephrops* assessment (WKNEPH). ICES CM: 2009/ACOM:33

ICES 2011. Report of the ICES Advisory Committee 2011. ICES Advice.2011. Book 1: Introduction, Overviews and Special Requests. Protocols for assessing the status of sea-pen and burrowing megafauna communities, section 1.5.5.3.

ICES 2012. Report of the Study Group on *Nephrops* Surveys (SGNEPS). ICES CM 2012/SSGESST: 19. Ref: SCICOM, ACOM

ICES. 2014. Report of the Benchmark Workshop on Celtic Sea stocks (WKCELT), 3–7 February 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014\ACOM:42. 194 pp.

ICES 2018. Report of the Working Group for Celtic Seas Ecoregion (WGCSE). ICES CM: 2018/ ACOM:13 in draft.

ICES 2016b. EU request to ICES to provide FMSY ranges for selected stocks in ICES subareas 5 to 10. *In* Report of the ICES Advisory Committee, 2016. ICES Advice 2016, Book 5, Section 5.2.3.1.

O'Brien, S., Blaszkowski, M., Butler, R., Fee, D., Hernon, P., Santana, C., Lordan, C. and Doyle, J. 2017. The "Smalls" *Nephrops* Grounds (FU22) 2017 UWTV Survey Report and catch options for 2018. Marine Institute UWTV Survey report.

O'Sullivan D, Lordan C, Doyle J, Berry A, Lyons K. 2015. Metapopulation connectivity via larval transport of the Norway lobster *Nephrops norvegicus* in waters around Ireland: a modelled approach. Mar Ecol Prog Ser 534:95-106.

Pebesma, E.J., R.S. Bivand, 2005. Classes and methods for spatial data in R. R News 5 (2), https://cran.r-project.org/doc/Rnews/

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Renard D., Bez N., Desassis N., Beucher H., Ors F., Laporte F. 2015. RGeostats: The Geostatistical package [version:11.1.1]. MINES ParisTech. Free download from: http://cg.ensmp.fr/rgeostats

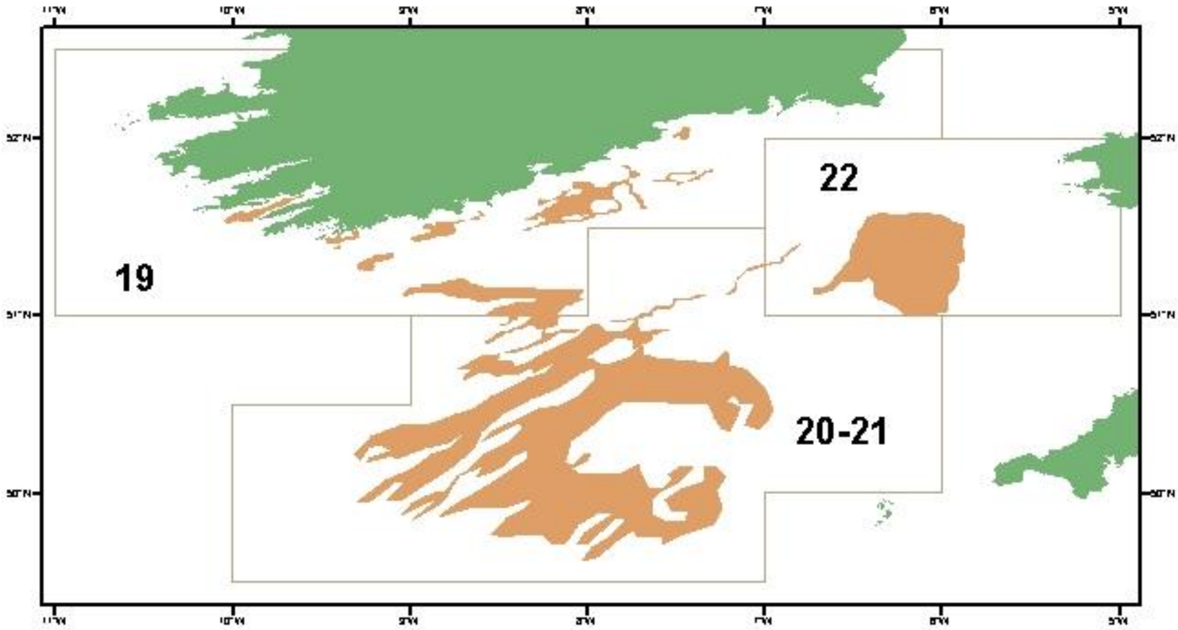


Figure 1: FU20-21 grounds: *Nephrops* Functional Units (FUs) and *Nephrops* area polygons in the greater Celtic Sea.

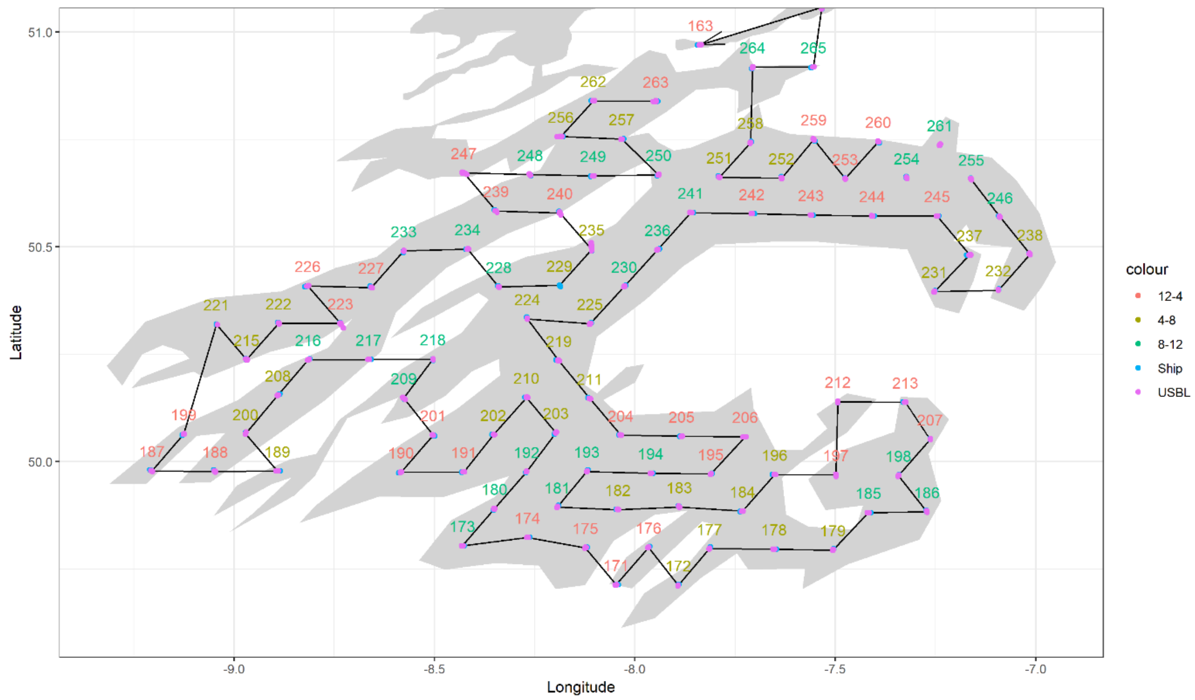


Figure 2: FU20-21 grounds: TV stations completed and navigation data recorded on the 2018 survey on each survey watch.

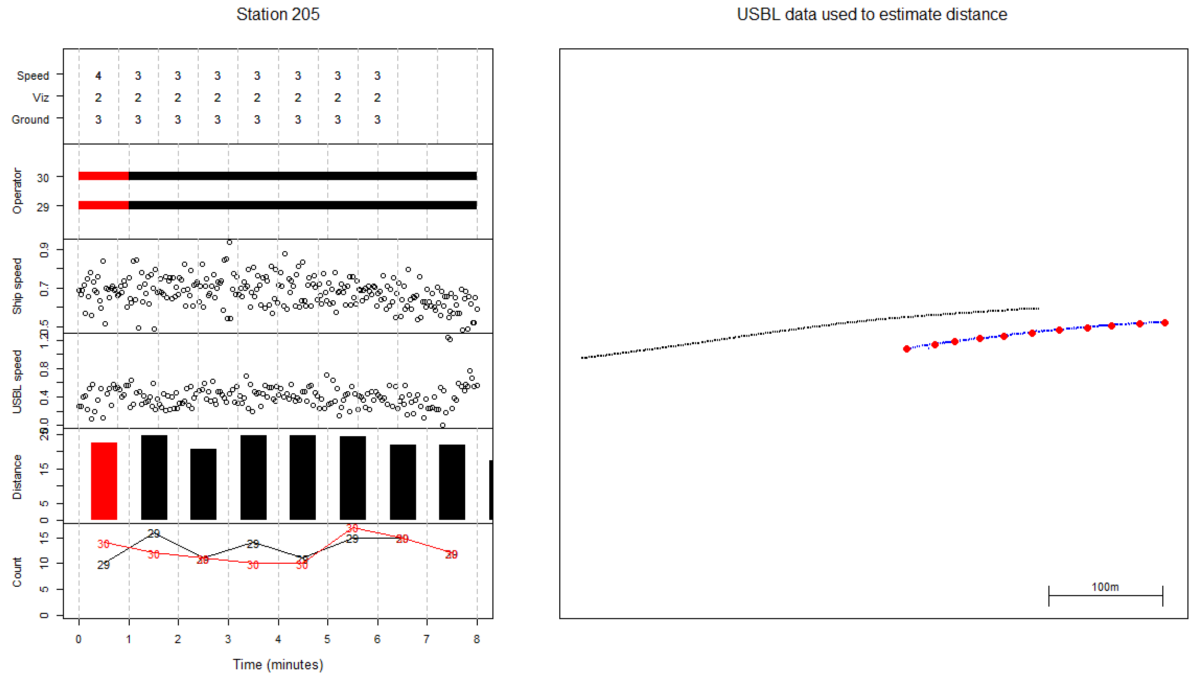


Figure 3: FU20-21 grounds: R - tool quality control plot for station 205 of the 2018 survey.

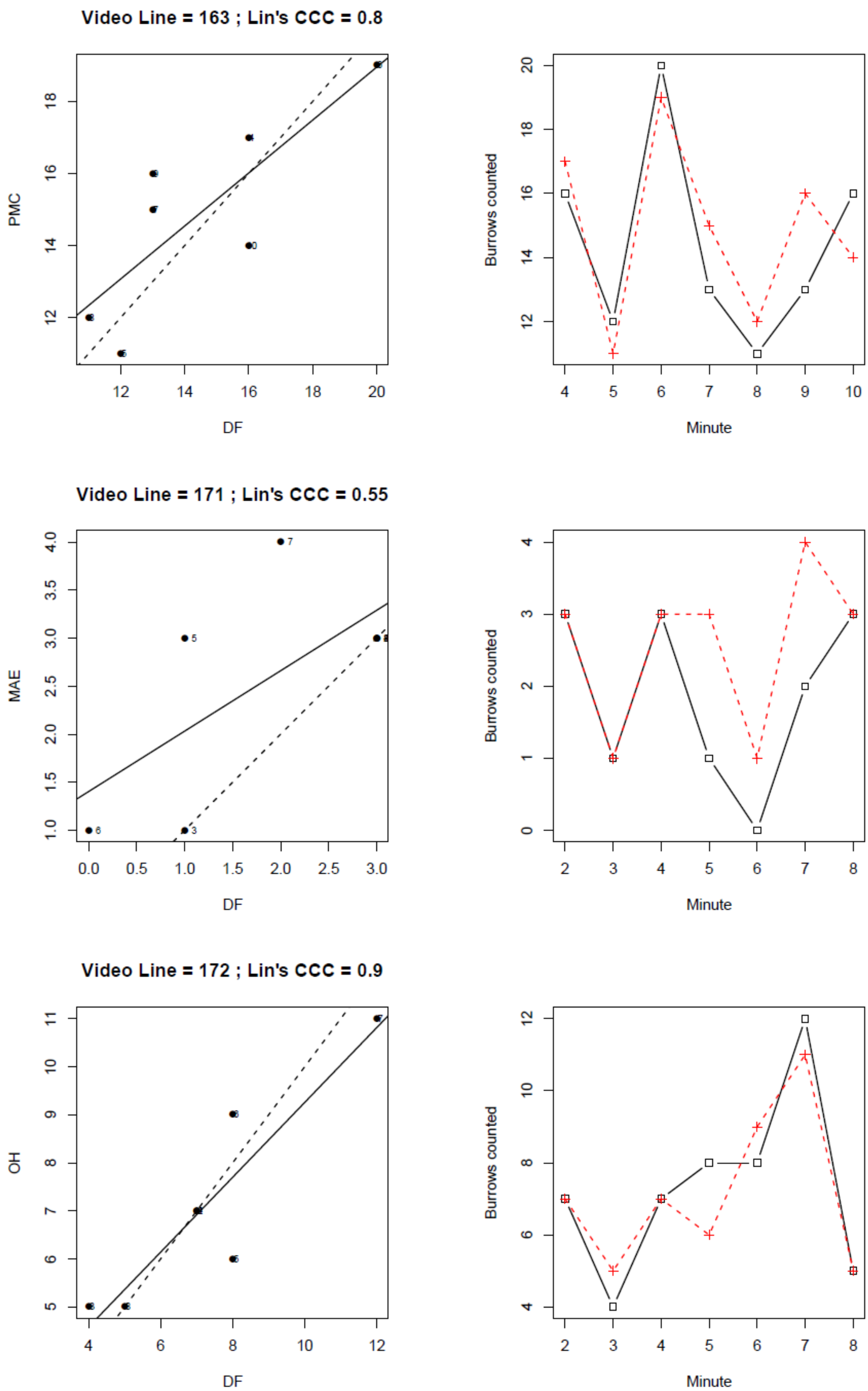


Figure 4: FU20-21 grounds: Lin's CCC quality control plots of count data for stations 120-122 from the 2018 survey.

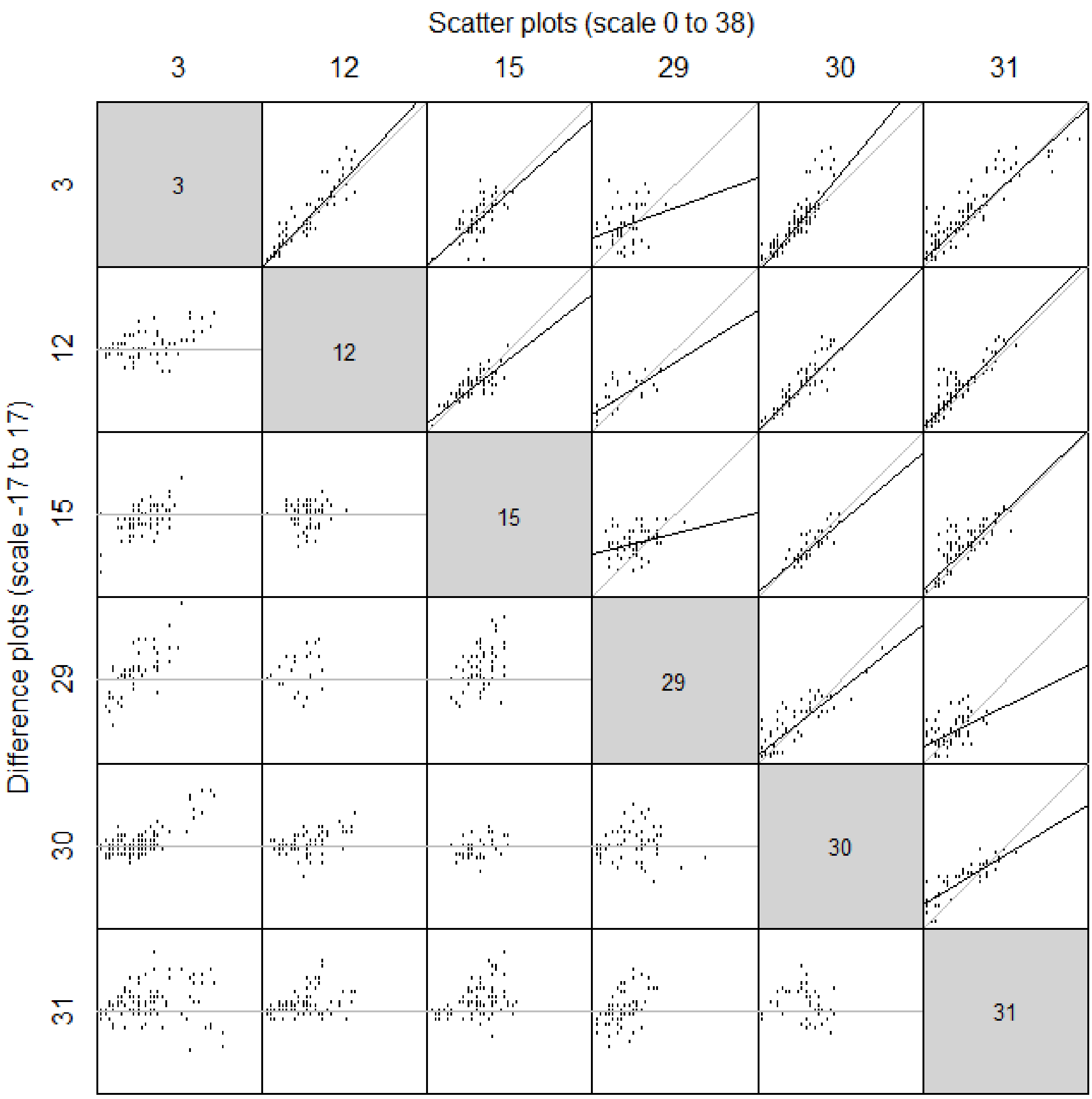
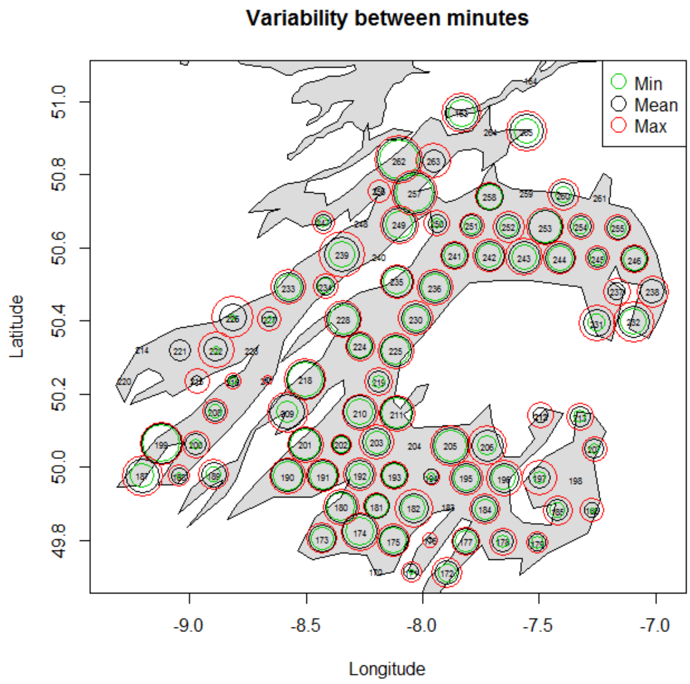


Figure 5: FU20-21 grounds: Scatter plot analysis of counter correlations for the 2018 survey.



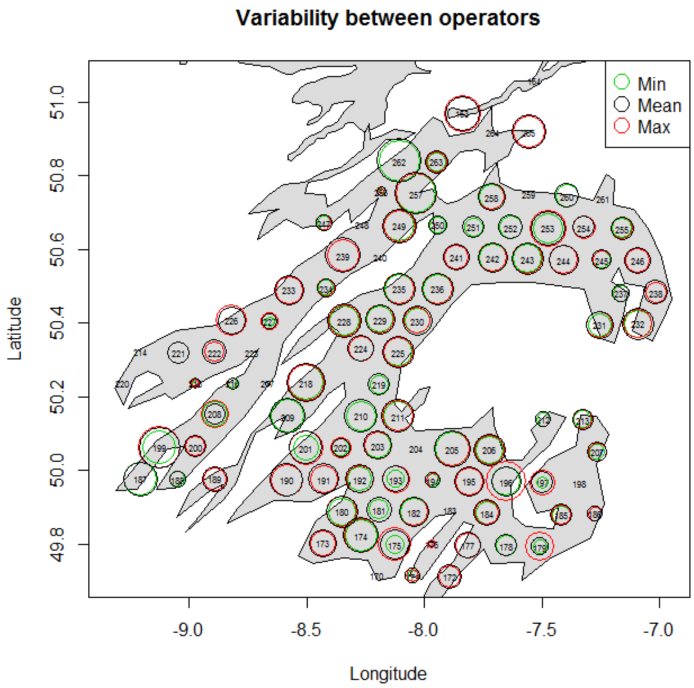


Figure 6: FU20-21 grounds: Plots of the variability in density between minutes (top panel) and between operators (counters) (bottom panel) for each station in 2018.

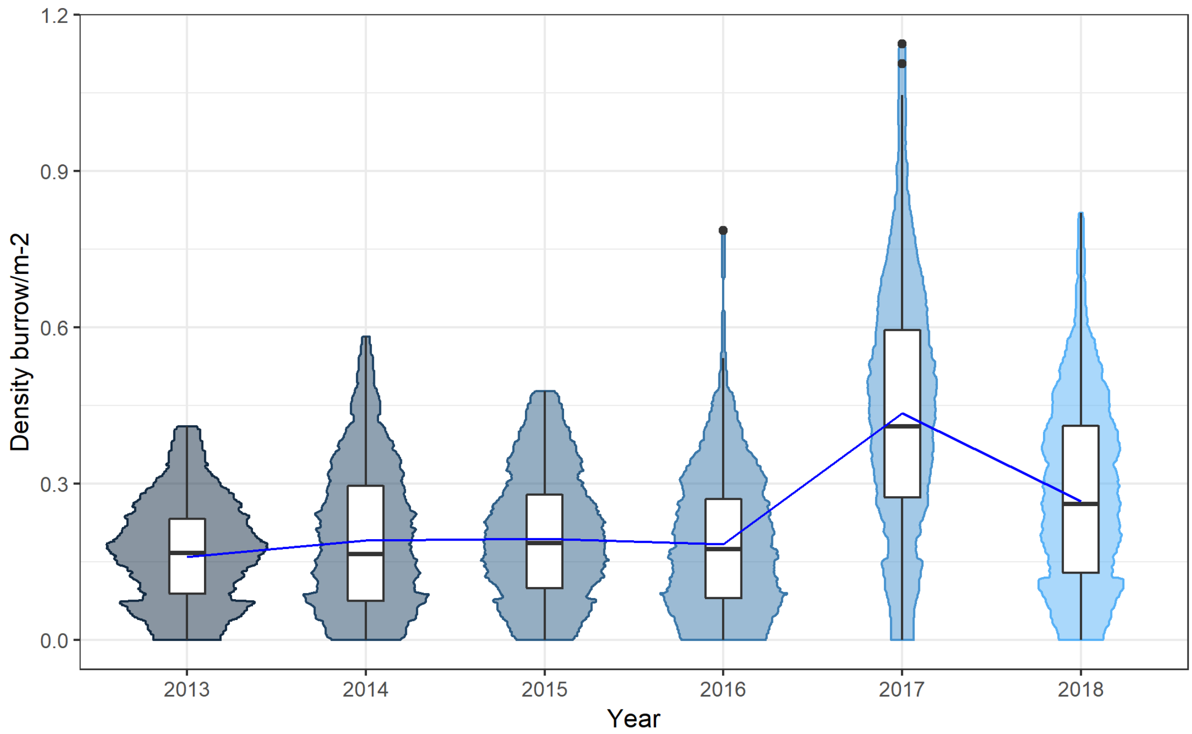


Figure 7: FU20-21 grounds: Violin and box plot of adjusted burrow density distributions by year from 2013-2018. The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

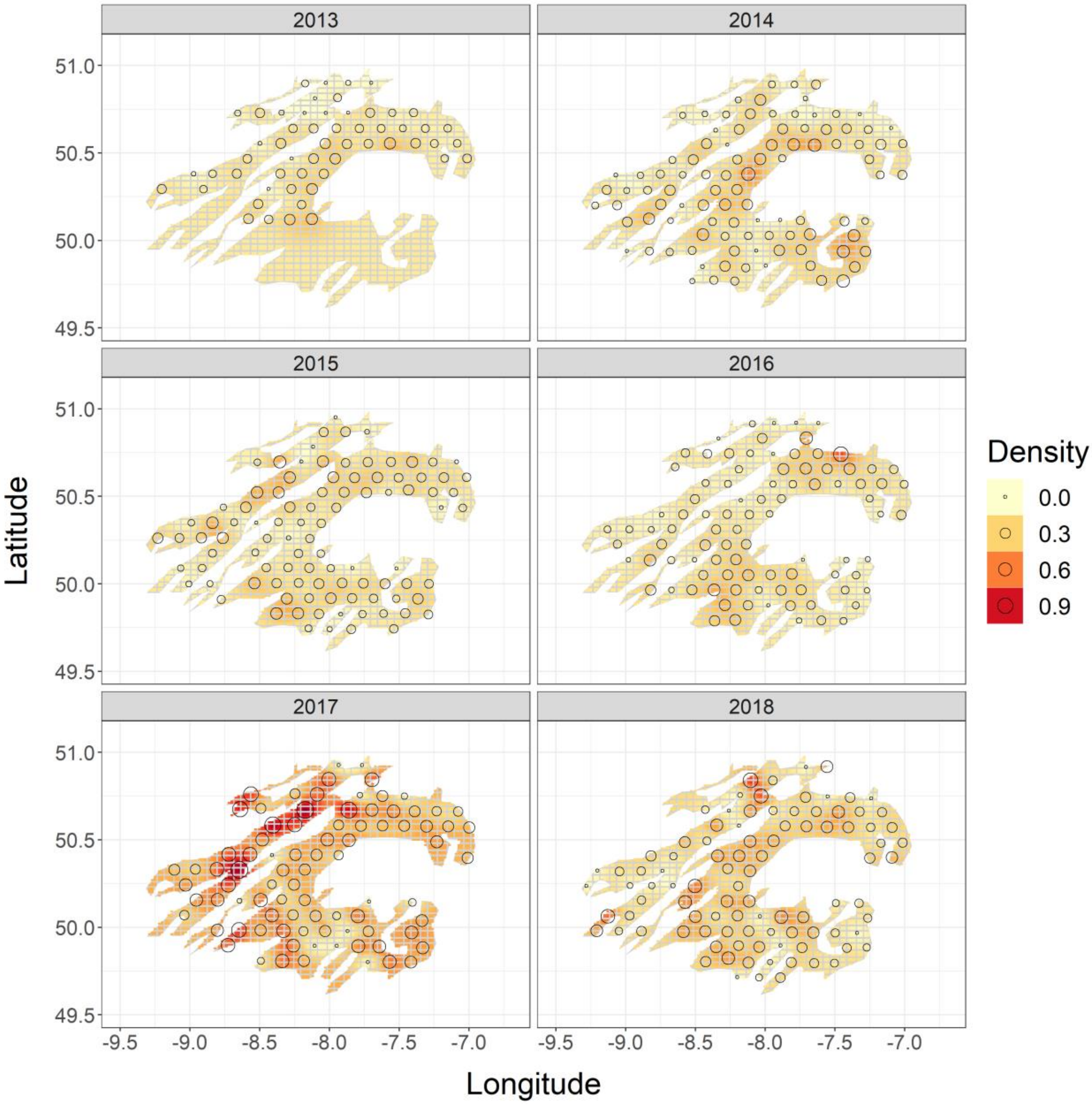


Figure 8: FU20-21 grounds: Contour plots of the krigged density estimates by year from 2013 (top) - 2018 (bottom).

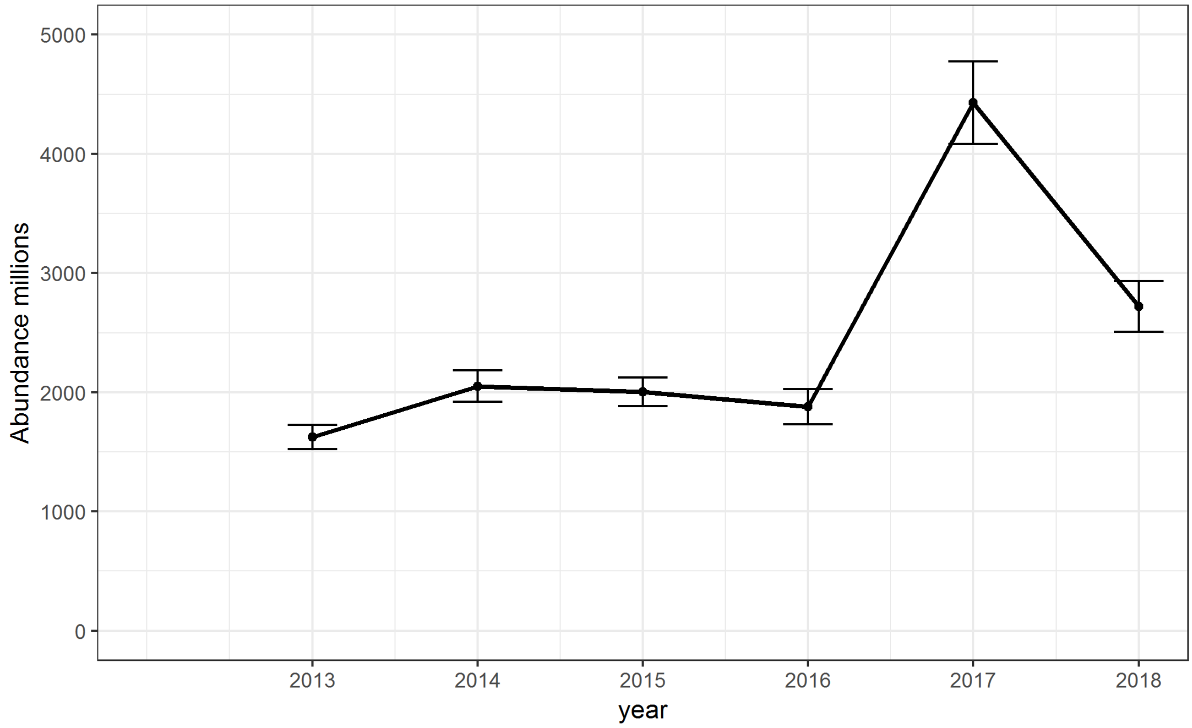


Figure 9: FU20-21 grounds: Time series of raised abundance estimates (in millions of burrows) for FU20-21. The error bars indicate the 95% confidence intervals.

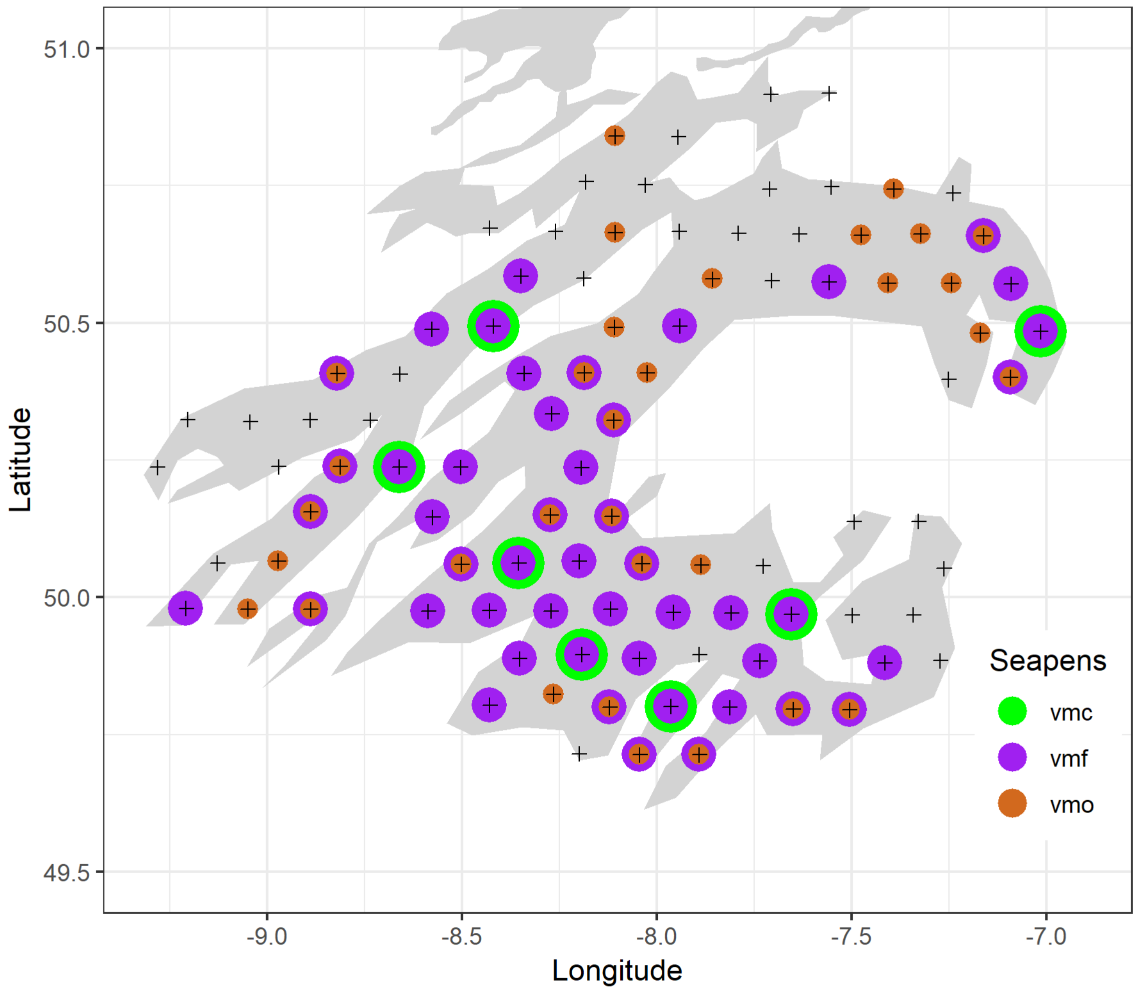


Figure 10: FU20-21 grounds: 2018 stations where *Virgularia mirabilis* (VM) were identified and classified according to abundance key - occasional (o), frequent f), common (c).
(+) denotes TV stations with no sea-pen observations.

Table 1: Key for classification of sea-pen abundance as used on Irish UWTV surveys.

	Number/Min
Common	20-200
Frequent	2-19
Ocasional	<2

Species
Virgularia mirabilis
Pennatula phosphorea
Funiculina quadrangularis

Sea Pens								
V. mirabilis			*P. phosphorea*			*F. quadrangularis*		
C	F	O	C	F	O	C	F	O

Table 2: Summary of UWTV results; number of stations, mean density observed, standard deviation, absolute abundance estimates with 95% confidence intervals, estimated area of the stock and coefficient of variation on the abundance.

Year	Number of stations	Mean Density adjusted (burrow /m²)	Standard Deviation	Absolute abundance estimate (million burrows)	95 % CI on Abundance	Domain area	CVs %
2006	9	0.44	0.31	nr			
2012	54	0.57	0.25	nr			
2013	55	0.16	0.11	942	60	5701	3
2013*				1624	103	9835,	
2014	98	0.19	0.14	2051	131	9835	3
2015	96	0.20	0.02	2003	118	9835	3
2016	93	0.18	0.02	1879	147	9835	5
2017	86	0.44	0.08	4428	347	9835	4
2018	96	0.27	0.04	2721	212	9835	4

* the 2013 survey achieved partial coverage ~60% of the total area. The abundance has been scaled up to the entire area since densities in the unsurveyed part of the ground were not significantly different in 2014.
nr= no reliable abundance estimate could be calculated because survey coverage was partial.

Table 3: The inputs for the catch scenarios.

Year	Landings in number	Total discards in number	Removals in number	UWTV abundance estimates	95% Conf. intervals	Harvest rate	Mean weight in landings	Mean weight in discards	Discard rate	Dead discard rate
	millions	millions	millions	millions	millions	%	grammes	grammes	%	%
2012	38.2	36.1	65.3				31.1	15.0	49	41
2013	34.8	19.2	49.2	1624	103	3.0	39.9	17.0	36	29
2014	50.6	55.5	92.2	2051	131	4.5	36.3	15.0	52	45
2015	59.4	28.1	80.5	2003	118	4.0	35.7	15.7	32	26
2016	60.2	37.5	88.3	1879	147	4.7	40.7	21.4	38	32
2017	60.1	19.2	74.3	4428	347	1.7	30.8	15.9	23	14
2018				2721	212					

Table 4: The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2019)	2721 million individuals	UWTV survey 2018
Mean weight in wanted catch	35.7 g	Average 2015–2017
Mean weight in unwanted catch	17.7 g	Average 2015–2017
Unwanted catch	31.6%	Average 2015–2017 (proportion by number).
Discard survival	25%	Proportion by number.
Dead unwanted catch	25.8%	Average 2015–2017 (proportion by number).

Table 5: Catch advice and scenarios for 2019; Discarding assumed to continue at recent average. All weights are in tonnes.

Basis	Total catch	Dead removals	Wanted catch*	Dead unwanted catch	Surviving unwanted catch	Harvest rate*	% advice change **
	WC+DUC+SUC	WC+DUC	WC	DUC	SUC	for WC+DUC	
ICES advice basis							
MSY approach	5320	5071	4325	746	249	6.0	-38.7
Other options							
$F_{MSY\ lower}$	5239	4994	4260	734	245	5.9	-39.6
$F_{MSY\ upper}$	5320	5071	4325	746	249	6.0	-38.7
F_{2017}	1492	1422	1213	209	70	1.7	-82.8

* Calculated for dead removals and applied to total catch.

** Advice value 2019 relative to advice value 2018.