The "Smalls" *Nephrops* Grounds (FU22) 2017 UWTV Survey Report and catch options for 2018.

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Abstract

This report provides the main results and findings of the twelfth annual underwater television survey on the 'Smalls grounds' ICES assessment area; Functional Unit 22. The survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. A total of 40 UWTV stations were surveyed successfully (good quality video footage) carried out over an isometric grid at 4.5nmi or 8.3km intervals. The precision, with a CV of 5%, was well below the upper limit of 20% recommended by SGNEPS 2012. The 2017 abundance estimate was 16% higher than in 2016 and at 1600 million is above the new MSY $B_{trigger}$ (990 million). Using the 2017 estimate of abundance and updated stock data implies catch of 4,332 tonnes and landings of 3,784 tonnes in 2018 when MSY approach is applied (assuming that discard rates and fishery selection patterns do not change from the average of 2014–2016). Only one species of sea-pen *Virgilaria mirabilis* was recorded as present at the stations surveyed. Trawl marks were observed at 59% of the stations surveyed. Ten beam trawl tows were carried out providing important data on the benthic communities and size structure of the *Nephrops* population.

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

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Introduction

The prawn (*Nephrops norvegicus*) are common in the Celtic Sea occurring in geographically distinct sandy/muddy areas where the sediment is suitable for them to construct their burrows (Figure 1). The *Nephrops* fishery in ICES sub-area 7 is extremely valuable with landings in 2016 worth around € 107 m at first sale. The Celtic Sea area (Functional Units 19-22 see 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, 2017). The 2016 reported landings from the Smalls (~3276 t) were estimated to be worth in the region of €18.2 million at first sale. The Smalls ground is particularly important to the Irish demersal fleet accounting for around 13% of the fishing effort by all demersal vessels >15m between 2006 - 2009 (Gerritsen, et al., 2012). The Irish demersal fleet now account for over 90% of the FU22 *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 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 & 2012). This is the twelfth in a time series of UWTV surveys in the Celtic Sea FU22 "Smalls" ground carried out by the Marine Institute, Ireland.

The survey was multi-disciplinary in nature and the specific objectives of the 2017 survey are listed below:

1. To complete randomised fixed isometric survey grid of 40 UWTV with 4.5 nautical mile (nmi) spacing stations on the "Smalls" *Nephrops* ground (FU22).

2. To obtain 2017 quality assured estimates of *Nephrops* burrow distribution and abundance on the "Smalls" *Nephrops* ground (FU22 these will be compared with those collected previously).
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 sample *Nephrops* and macro benthos using a 4 m beam trawl deployed at ~10 stations.

This report details the final UWTV results of the 2017 survey and documents other data collected during the survey. Operational survey details are available in form of a survey narrative available from the scientist in charge (SO'B). The 2017 abundance estimate is used to generate catch options for 2018 in line with procedures outlined in the stock annex for FU22 (ICES, 2017).

Material and methods

To maintain a CV < 20%, to achieve good spatial coverage over the ground and to generate burrow surface that reflects the underlying abundance a grid spacing of 4.5nmi has been used since 2012. The 2017 randomised isometric grid which resulted in 40 planned stations was generated using using the “spsampl” function in the “sp” package (Pebesma & Bivand, 2005) in “r” (R Core Team, 2017). These are overlaid on *Nephrops* directed fishing activity in Figure 2 (Gerritsen & Lordan, 2011). The boundary use to delineate the edge of the ground was based on information from VMS, habitat maps, and previous UWTV observations. The same boundary has been used through the time series.

The 2017 Celtic Sea survey took place on RV Celtic Voyager between the 9th August to 17th August. The survey normally takes place in either July or August each year.

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 by one video camera with a field of view or ‘FOV’ of 75 cm. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 1 to 2 seconds. The navigational data was quality controlled using an “r” script developed by the Marine Institute (ICES, 2009b) an example is shown in Figure 3. In 2016 the USBL navigational data was used to calculate distance over ground for 100% of stations.

In line with SGNEPS recommendations all scientists were trained/re-familiarised using training material and then were tested by counting reference footage for FU22 prior to recounting 2017 footage (ICES, 2009b). Individual’s counting performance against the reference counts was measured by Linn’s concordance correlation coefficient (CCC). A threshold of 0.5 was used to identify counters who needed further training. Once this process had been undertaken, all recounts were conducted by two trained “burrow identifying” scientists independent of each other on board the research vessel during the survey.

During this verification process the visibility, ground type and speed of the sledge during one-minute intervals were subjectively classified using a standard classification key. In addition to the numbers of *Nephrops* burrows complexes (multiple burrows in close proximity which appear to be part of a single complex which are only counted once) the *Nephrops* activity in and out of burrows were also counted and recorded for each one-minute interval. 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. Numbers of sea-pen species were also recorded due to OSPAR Special Request (ICES 2011). A key was devised to categorise the densities of sea-pens based SACFOR abundance scale (Table 1) after ICES (2011). 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.

In 2017 the survey count data was screened to check for any unusual discrepancies using Lin’s Concordance Correlation Coefficient (CCC) with a threshold of 0.6. 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. Lin's CCC quality control plot of survey count data for stations 233 to 255 is shown in Figure 4. Consistency and bias between individual counters was also examined using Figure 5. There is some variability between counters but no obvious bias or excessive deviations.

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 using lasers during the 2017 survey. 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). From 2006-2014 the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out using SURFER Version 10.7.972. From 2015 the geostatistical analysis was carried out using RGeostats package (Renard D., *et al*, 2015) and is available as a separate "r markdown" document. The same basic steps were carried out as in previous years; construction of experimental variogram, a model variogram, was 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.

No CTD data was collected during this survey due to technical problems.

Ten beam trawl tows were conducted randomly across the Smalls grounds. All *Nephrops* caught were sorted by sex and maturity category, weighed and measured using the NEMESYS electronic measuring system. A length stratified sub-sample of *Nephrops* was taken for each haul where individual length, whole weight and maturity were recorded. The fish catch was identified to species level and sampled by weight (kgs) only. The benthic catch was identified and weighed (g) and counted. The UWTV station positions and tracks for the ten beam trawl tows are shown in Figure 2.

Results

In 2017 40 stations were completed successfully on the Smalls. A summary of the results is presented in Table 2. The density and estimated abundance increase by around 80% in 2017. The average density was the highest in the time series and the abundance was close to the highest in the time series. Figure 6 shows bubble plots of the variability between minutes and operators. These show that the burrow estimates are very consistent between minutes and counters. A combined violin and box plot of the observed burrow densities is presented in Figure 7. This shows that median and mean burrow densities are similar in most years. The inter-quartile range is between 0.2- 0.7 in most years. In most years two modes are apparent at relatively high density (~0.7 burrows/m^2) and at moderate density

(0.25 burrows/m^2). In 2017 the mean adjusted[1] burrow density was 0.55 burrows/m^2. There was one observation of adjusted burrow density > 1.0 burrows/m^2.

The blanked krigged contour plots and posted point density data for 2006-2017 are shown in Figure 8. The krigged contours correspond well to the observed data. Highest densities are in the centre of the ground in all years. In general the densities are higher towards the south and central area of the ground. In 2017 relatively high densities were observed throughout the ground.

The summary statistics from this geo-statistical analysis are given in Table 2 and Figure 9. The 2017 estimate of 1600 million burrows is above the geometric mean of the series (1267 million burrows) and is well above MSY $B_{trigger}$ (value of 990 million). The estimation of variance of the 2017 survey as calculated by RGeostats is relatively low (with a CV or RSE of 5%) which is well below the SGNEPS recommendation for a CV <20% (ICES, 2012).

Figure 10 shows the standardised length frequency distributions of *Nephrops* caught using a beam trawl. Fishing operations were not carried out during 2010, 2013, 2014 and 2015 due to time constraints. For plotting purposes the individuals <10mm caught were split evenly between males and females as it is not possible to accurately assign sex to individuals of that size. A strong cohort was apparent in the catches in 2016 around 17mm and can be tracked in catches in subsequent years. There is a shift to larger sizes in 2011 and 2012 with as shift back again in to smaller sizes in 2016 and 2017.

Table 3 summarises the fish catches where *Trisopterus esmarkii* (Norway pout) was the most common species with catches in every tow. The highest catch of 18.2 kgs of herring recorded in tow 10. Figure 11 is a heatmap combined with a dendrogram which shows the proportional counts of benthic species. A threshold was used which removed those species with less than 1% as their maximum relative abundance. Hierarchical clustering using the complete linkage method with Euclidean distance measure identifies stations which have similar benthic compositions. *Nucula nucleus* (nut clam) was the most abundant. It is important to note that the mud burrowing shrimp *Calocaris macandrae* was also recorded in six tows. The burrow of this species can cause confusion in identification in areas of very soft mud and high densities of *Nephrops* burrows such as the western Irish Sea *Nephrops* ground, but this species is not deemed to be problematic in the Smalls ground. *Goneplax rhomboids,* a burrowing crab species, was also recorded in all tows. *Eledone cirrhosa* (curled octopus) was also recorded where this species is a noted predator of crustaceans and has been observed lying close to the *Nephrops* burrow entrances on the Smalls ground (FU22).

Sea-pen distribution across the Smalls *Nephrops* grounds is mapped in Figure 12. All sea-pens were identified from the video footage as *Virgularia mirabilis*. Trawl marks were noted at 59% of the stations surveyed.

The UWTV abundance data together with data from the fishery; landings, discards and removals in number are used to calculate the harvest ratio in 2016 of 22.9%. The mean

[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).

weight in the landings and the discards and the proportions of removal retained are also shown (Table 4).

The inputs variables for catch options in 2018 are given in Table 5. The catch and landings options at various different fishing mortalities are calculated in line with the stock annex using the 2017 survey abundance are presented in Table 6. The latest estimate of stock abundance, 1,600 million, is well above MSY $B_{trigger}$ (value 990 million). Fishing at F_{msy} in 2018 would result in catches of 4,332 tonnes and landings of 3,784 t assuming that discard rates and fishery selection patterns do not change from the average of 2014–2016 (Table 6).

Discussion

Since 2006 a dedicated annual UWTV survey has taken place which gives abundance estimates for this ground with high precision. The burrow abundance estimates have increased significantly in 2017 from the lowest level observed in the time last year. Density estimates throughout the ground were mainly moderate to high with relatively few low density estimates. Interestingly the beam trawl data does not show any indications that there is a strong year class entering the fishery. A large increase in density has also been observed in the adjacent FU20-21 this year (Doyle et. al, 2017). Sudden declines followed by large increases in abundance have also been observed in other *Nephrops* stocks in the past (e.g. FU12 and FU13 in 2012-2013).

Nephrops in this area are covered under the landings obligation since 2016. Discard rates in weight for this FU have been around 13% in recent years which is above the Landing Obligation *de minimus* of 7%. Because harvest rates are calculated on the basis of numbers and 25% of the *Nephrops* in this area are assumed to have survived discarding up to now this presents a problem in calculating catch options for 2018. Two scenarios are presented in Table 7. The first assumes that all catches will be landed in 2018 so the discards that would have survived will be landed. This is unlikely in practice. The second scenario assumes that discarding continues are the average rate estimated between 2014 and 2016. The difference in advised landings or catches between the two scenarios is relatively small ~5%.

The introduction of the landings obligation to *Nephrops* fisheries since 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 was 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).

The UWTV footage quality was very good for most stations. Future survey scheduling should be cognisant of the potential for strong tides to re-suspend sediment into the water column. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

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References

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.

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.

Gerritsen, H.D. Lordan, C. Minto, C. Kraak, S.B.M.. 2012. Spatial patterns in the retained catch composition of Irish demersal otter trawlers: High-resolution fisheries data as a management tool Fisheries Research, Volumes 129–130, October 2012, Pages 127–136. http://dx.doi.org/10.1016/j.fishres.2012.06.019

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

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

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 2016. 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.

ICES 2017. Report of the Working Group for Celtic Seas Ecoregion (WGCSE). ICES CM: 2017/ ACOM:13.

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/

Petitgas P. and Lafont, T, 1997. EVA (Estimation VAriance). A geostatistical software on IBM-PC for structure characterization and variance computation. Version 2.

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:11.0.3]. MINES ParisTech. Free download from: http://cg.ensmp.fr/rgeostats

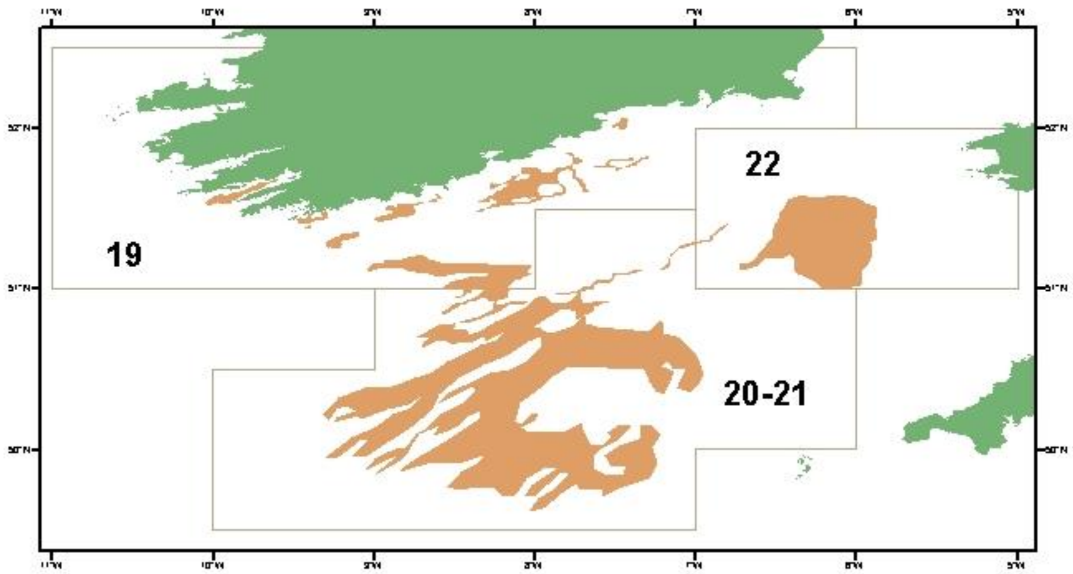

Figure 1: FU22 Smalls grounds: *Nephrops* Functional Units (FUs) and *Nephrops* grounds in the greater Celtic Sea and area polygons.

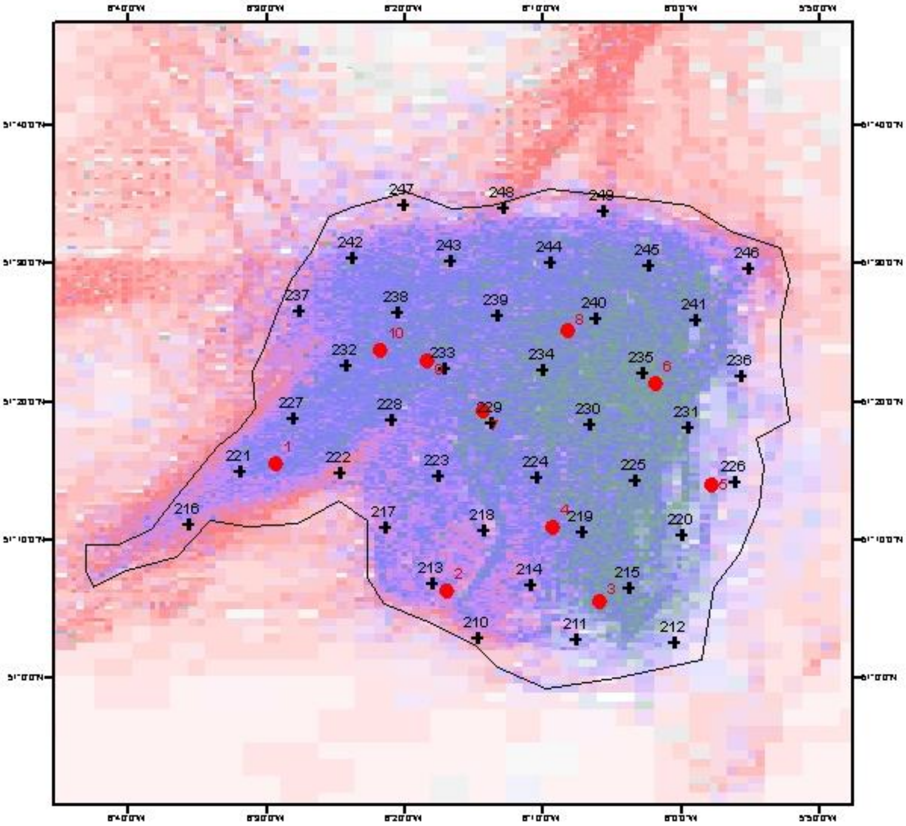

Figure 2: FU22 Smalls grounds: TV stations completed on the 2017 survey overlaid on a heat map of *Nephrops* directed Irish fishing activity 2006-2016. (+) denotes TV stations and red dots beam trawl stations.

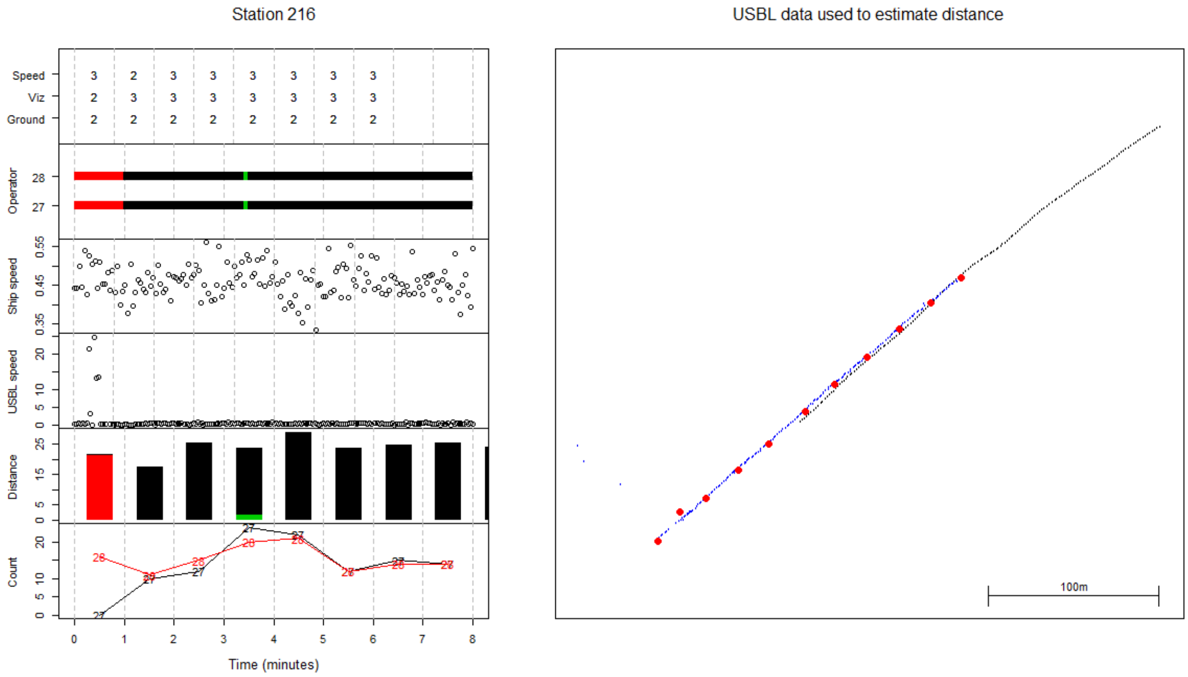

Figure 3 : FU22 Smalls grounds: r - tool quality control plot for station 216 of the 2017 survey.

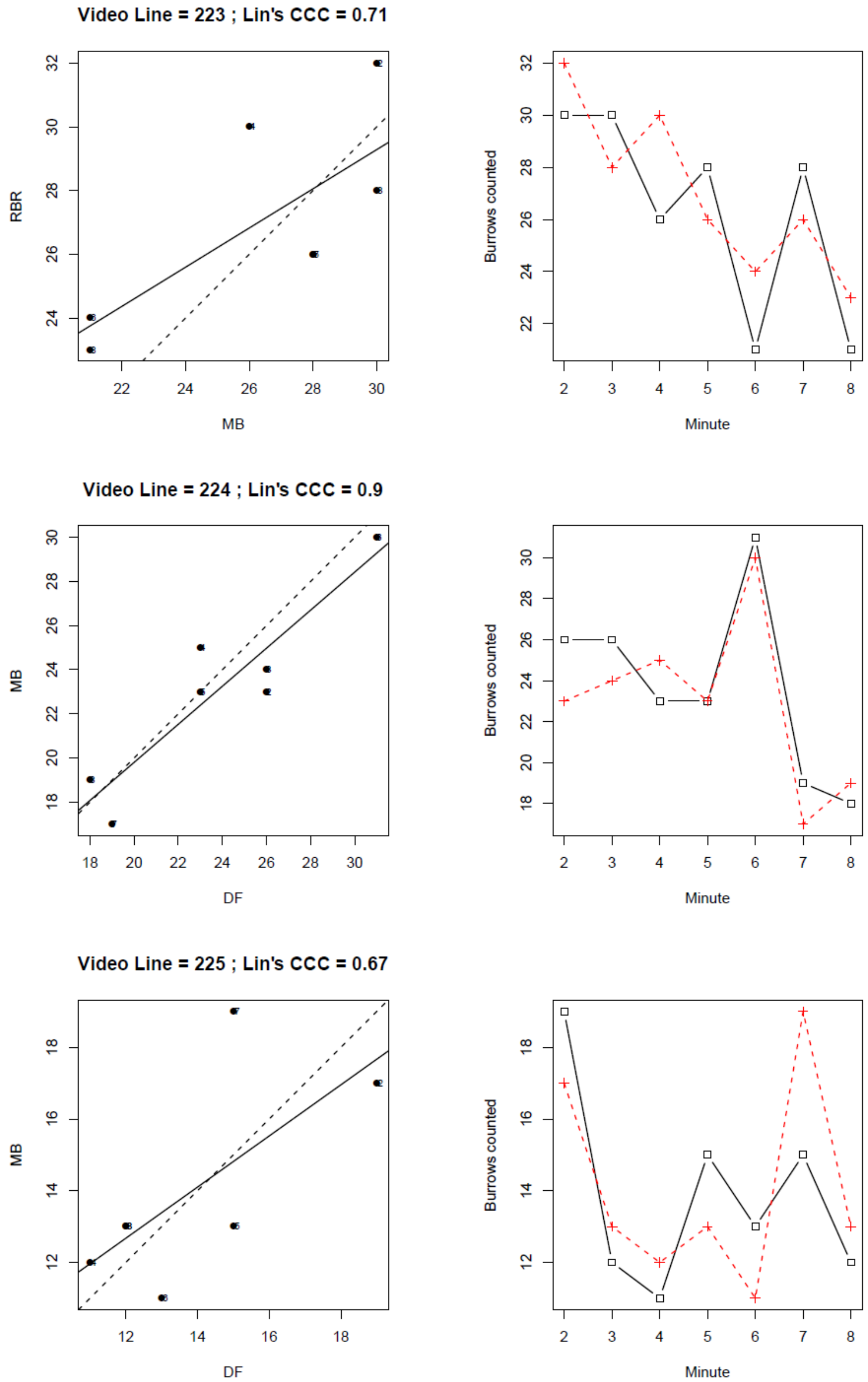

Figure 4 : FU22 Smalls grounds: Lin's CCC quality control plot of count data for stations 223 – 225 of the 2017 survey.

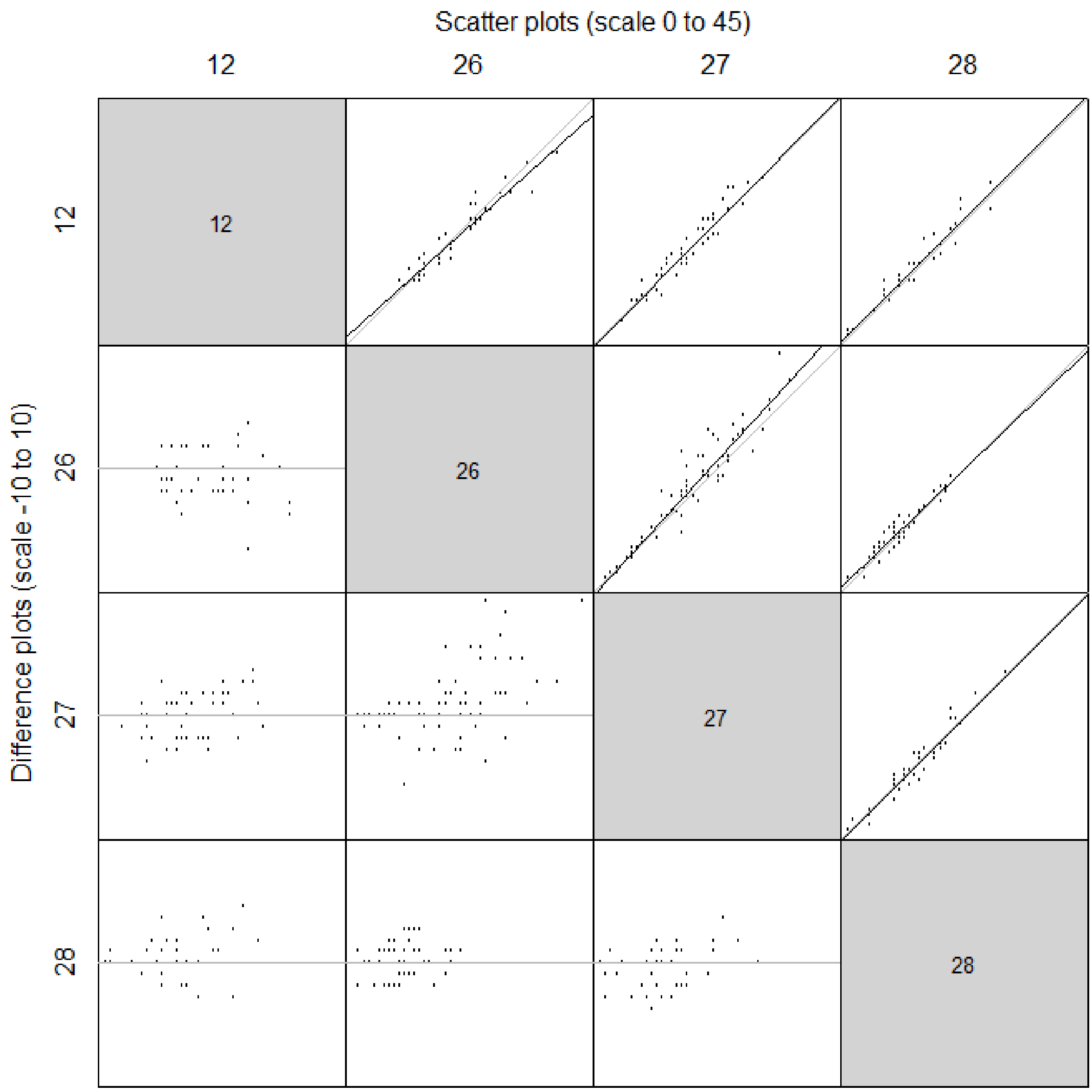

Figure 5: FU22 Smalls grounds: Scatter plot analysis of counter correlations for the 2017 survey.

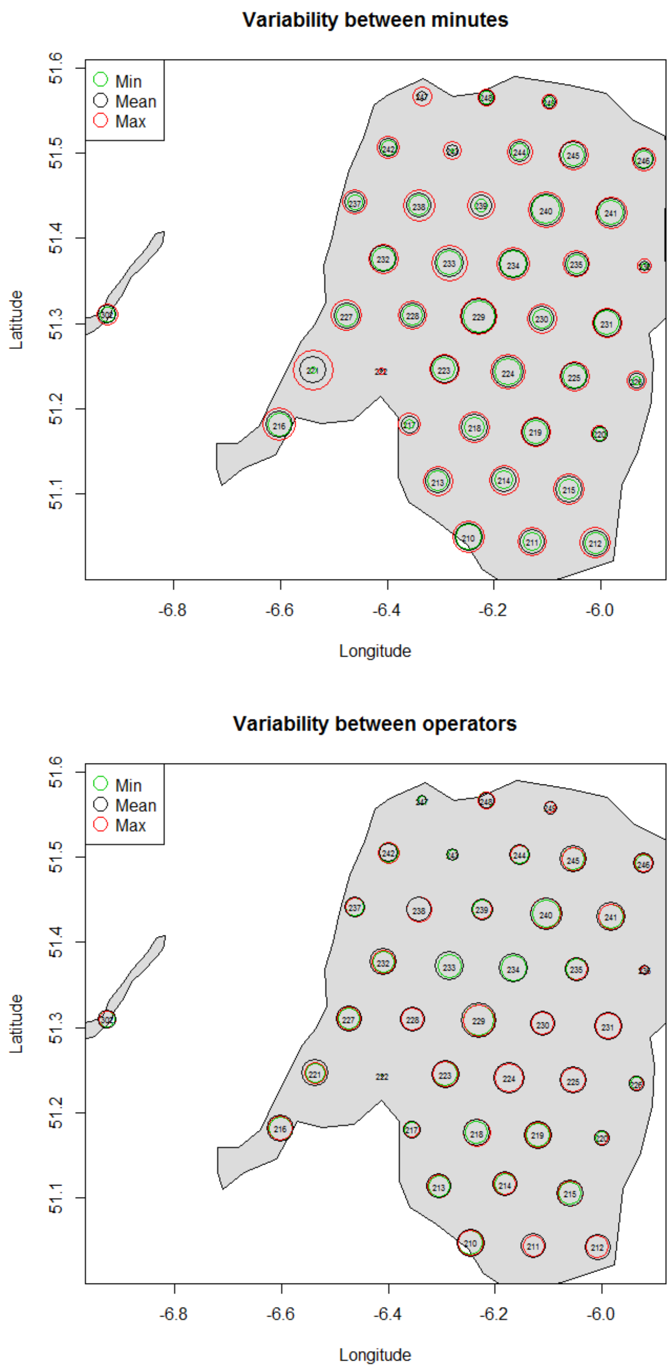

Figure 6: FU22 Smalls grounds: Plot of the variability in density between minutes (top panel) and between operators (counters) (bottom panel) for each station in 2017.

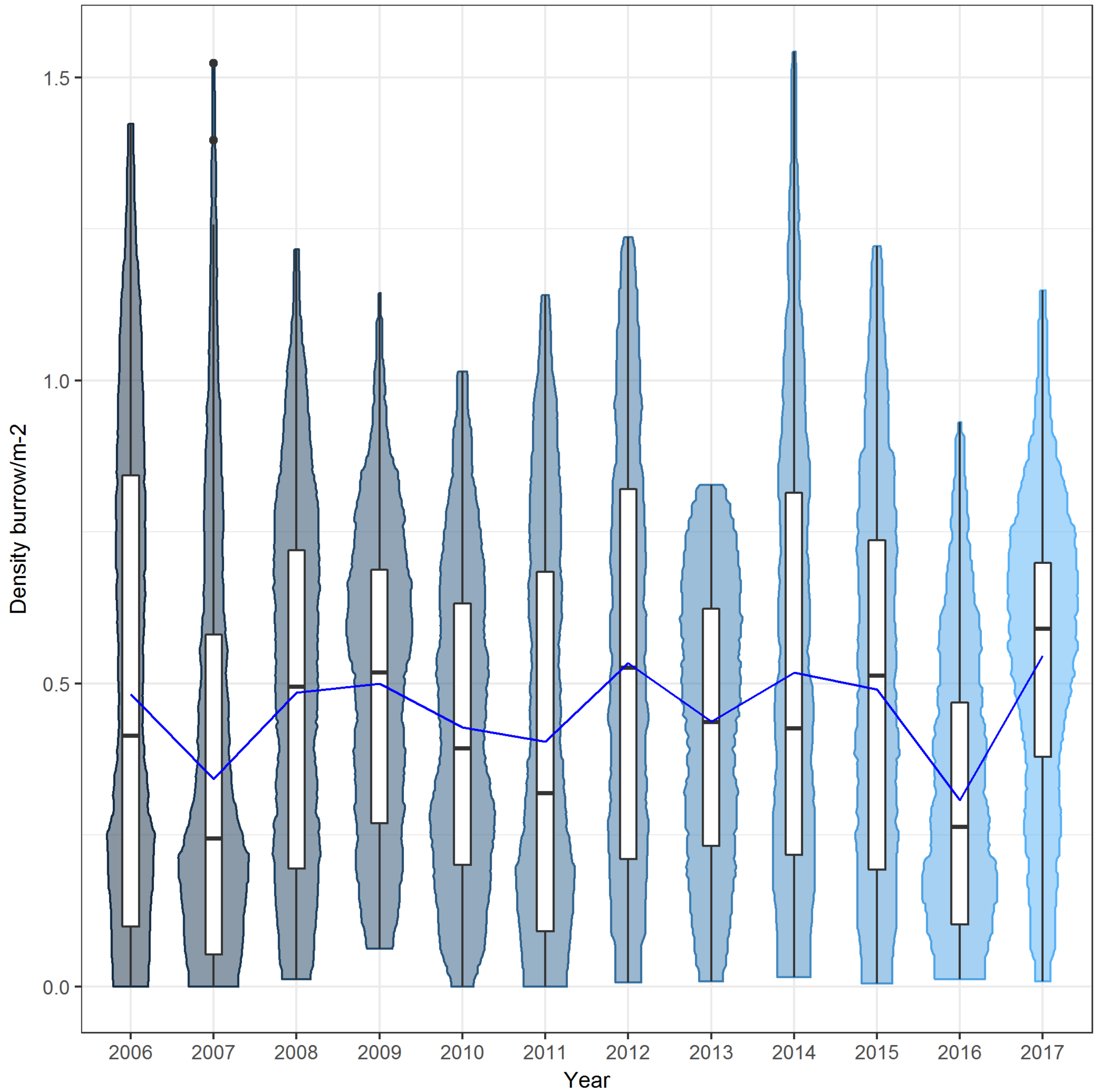

Figure 7: FU22 Smalls grounds: Violin and box plot of adjusted burrow density distributions by year from 2006-2017. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

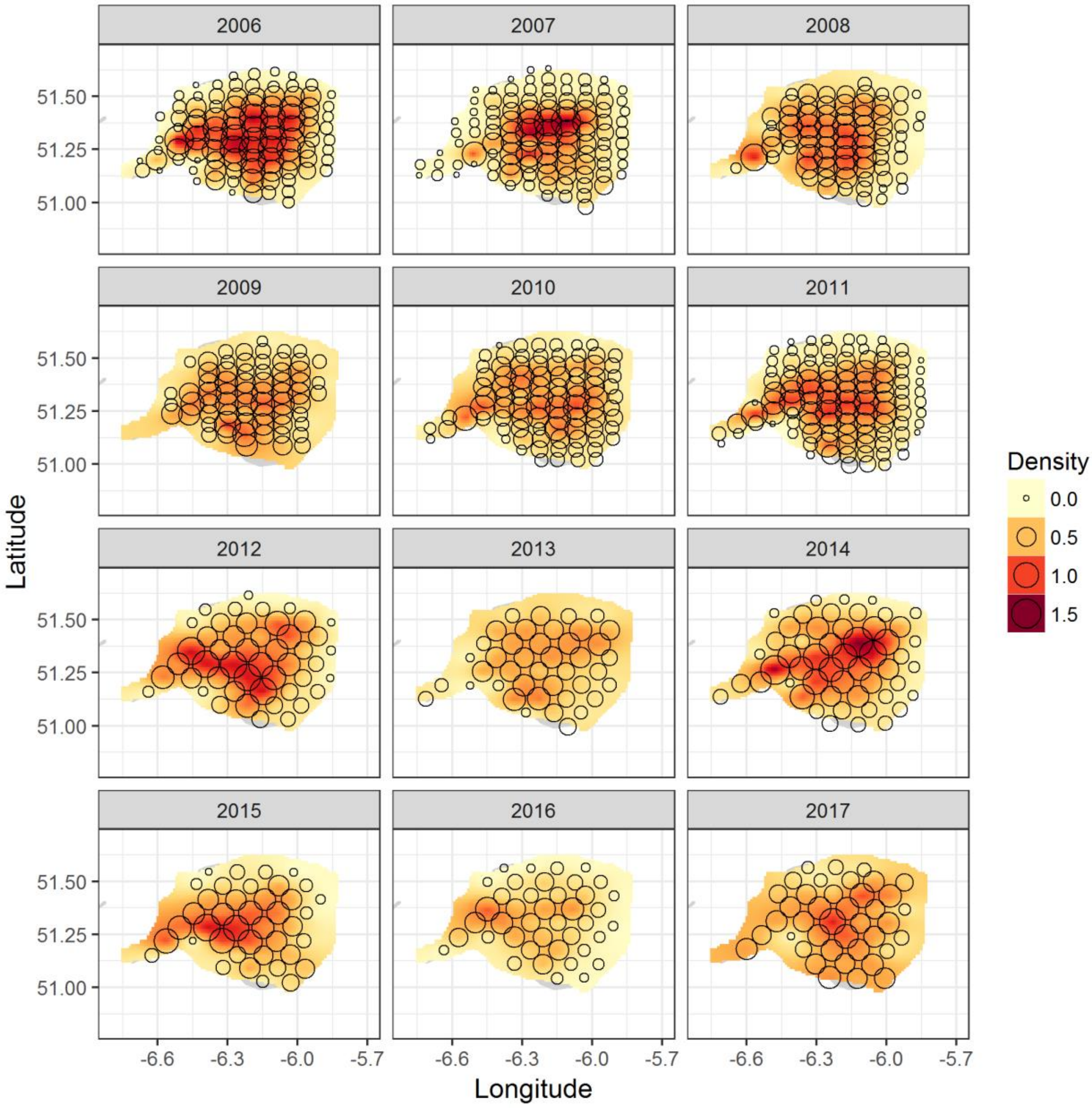

Figure 8: FU22 Smalls grounds: Contour plots of the krigged density estimates by year from 2006 (top left) - 2017 (bottom right).

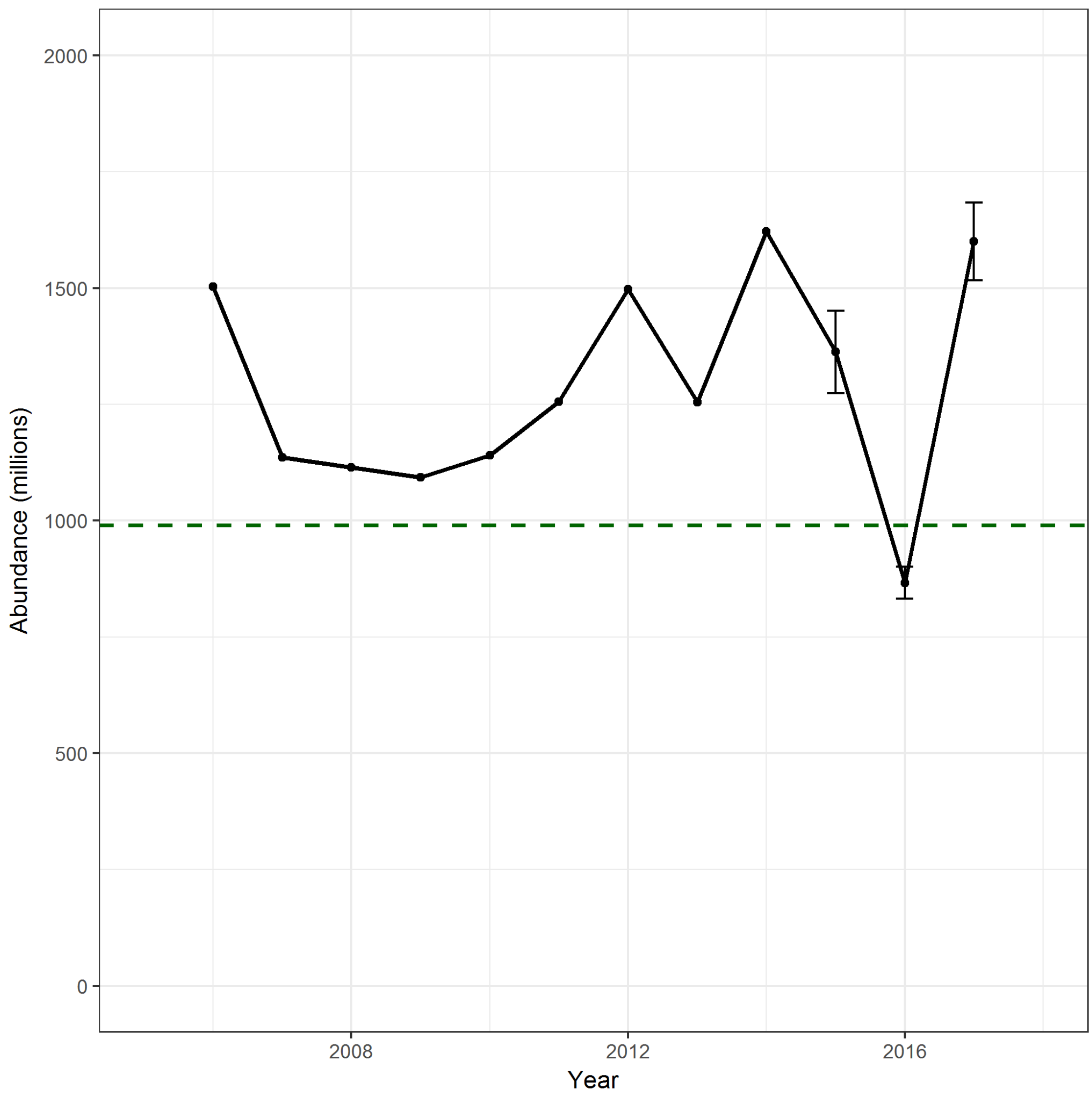

Figure 9: FU22 Smalls grounds: Time series of geo-statistical adjusted abundance estimates (in millions of burrows). The error bars indicate the 95% confidence intervals and and $B_{trigger}$ is dashed green line.

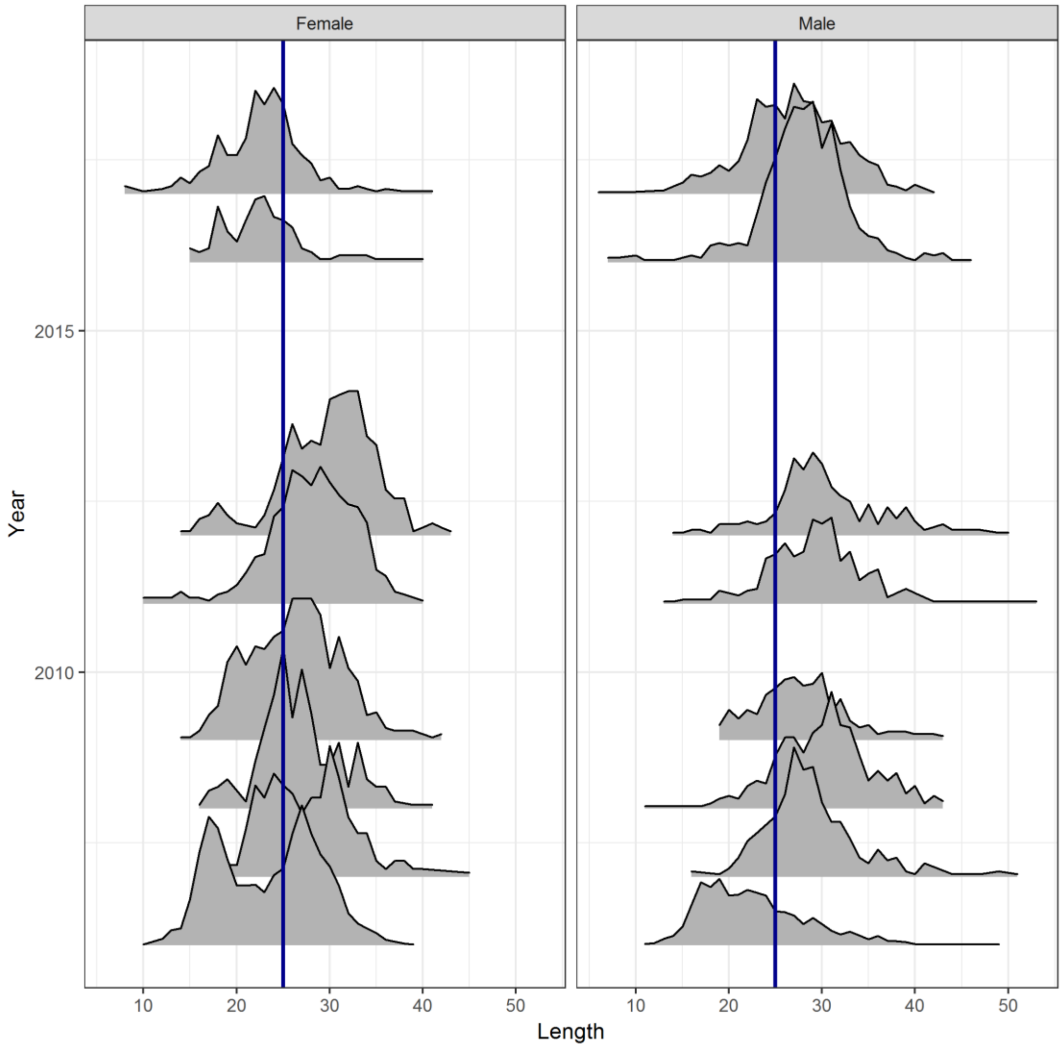

Figure 10: FU22 Smalls grounds: Standardised length frequency distributions for male and female *Nephrops* caught using beam trawl during 2006 to 2017 UWTV surveys (except years 2010 and 2013 - 2015).

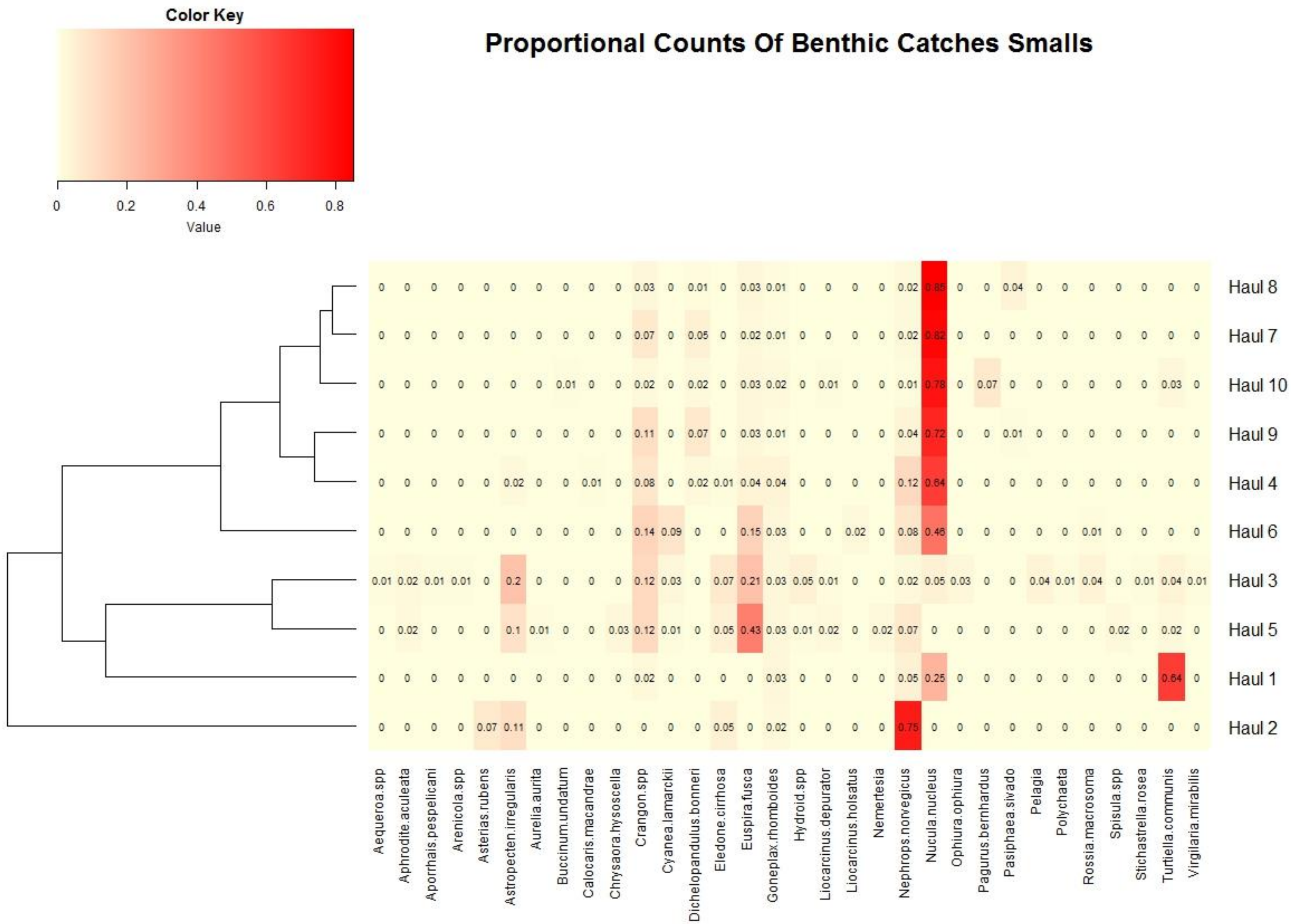

Figure 11: FU22 Smalls grounds: 2017 Heat map of proportional counts of benthic species and dendrogram.

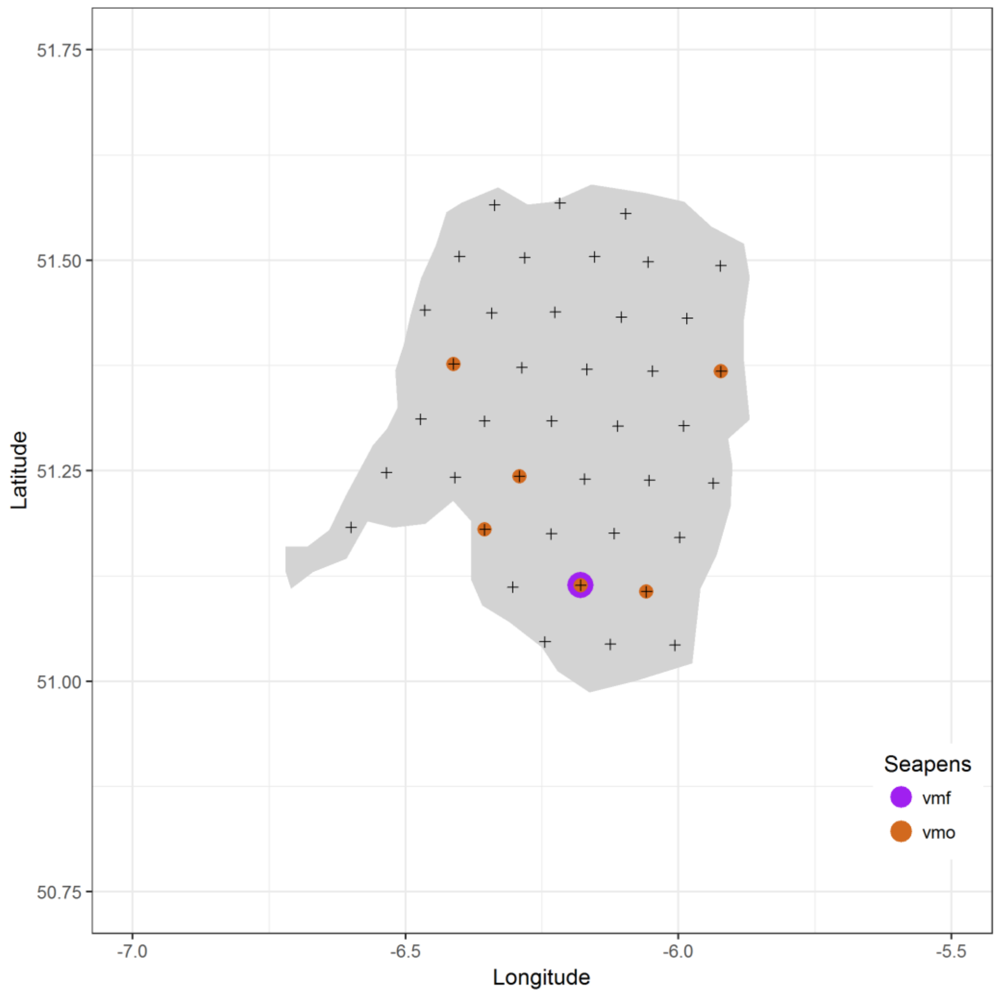

Figure 12: FU22 Smalls grounds: 2017 stations where *Virgilaria mirabilis* (vm) were identified and classified according to abundance key - occasional (o), frequent (f), common (c). (+) denotes TV stations with no sea-pen observations.

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: FU22 Smalls grounds: Overview of geostatistical results from 2006-2017.

Year	Number of stations	Mean Density adjusted (burrow/m²)	Domain Area (km²)	Geostatistical Abundance adjusted (millions of burrows)	CV on Burrow estimate
2006	100	0.49	2962	1503	2%
2007	107	0.37	2955	1136	6%
2008	76	0.36	2698	1114	6%
2009	67	0.36	2824	1093	5%
2010	90	0.37	2861	1141	4%
2011	107	0.41	2881	1256	3%
*2012	47	0.49	2934	1498	8%
*2013	41	0.41	2975	1254	7%
*2014	52	0.53	2970	1622	8%
*2015	40**	0.49	3064	1363	7%
*2016	41	0.31	3063	866	7%
*2017	40	0.55	3063	1600	5%

*reduced randomised isometric grid

** In 2015 7 of the stations were filled in with an estimate based on the mean density of historical stations within 2nmi of the planned station.

Table 3: FU22 Smalls grounds: Summary of fish catch by tow in weight (kg) from 2017 fishing operations.

Species	**Weight (kg)**									
	Tow1	**Tow2**	**Tow3**	**Tow4**	**Tow5**	**Tow6**	**Tow7**	**Tow8**	**Tow9**	**Tow10**
ARGENTINA SPHYRAENA			0.002	0.004	0.002	0.002				
ARNOGLOSSUS LATERNA			0.02							
CALLIONYMUS LYRA		0.072	0.072		0.088	0.02				
CALLIONYMUS MACULATUS			0.044		0.072	0.008				
CLUPEA HARENGUS								0.11	0.184	18.2
CONGER CONGER							0.04			
EUTRIGLA (CHELIDONICTHYS) GURNARDUS			0.024	0.042	0.332	0.106	0.004	0.002	0.004	0.002
GADHUS MORHUA							4.226			
GLYPTOCEPHALUS CYNOGLOSSUS		0.15	0.518	0.074	0.976			0.026		
GOBIUS SPP.	0.002				0.001	0.001	0.002		0.002	
Hippoglossoides platessoides		0.082	0.344	0.05	0.732	0.102	0.104	0.002	0.03	0.002
LEPIDORHOMBUS WHIFFIAGONIS		0.268	1.106	0.001	2.25	0.178				
LOPHIUS BUDEGASSA										
LOPHIUS PISCATORIUS			0.014	1.996	10.1		0.352			0.502
MELANOGRAMMUS AEGLEFINUS		0.128	0.128	0.028	0.31	0.03	0.454	0.654	0.542	0.772
MERLANGIUS MERLANGUS	0.822	0.212	0.01		0.59	1.452	0.842	1.248	0.496	1.552
MERLUCCIUS MERLUCCIUS		0.162	0.822		0.61		0.078			
MICROCHIRUS VARIEGATUS		0.018	0.292	0.068	0.538	0.008	0.008		0.006	
MICROMESISTIUS POUTASSOU	0.266						0.02			
MICROSTOMUS KITT					0.312					
MOLVA MOLVA		0.028				0.036	0.002	0.022	0.002	
PLUERONECTES PLATESSA					0.48					
SCYLIORHINUS CANICULA		0.016	0.324	0.616	2.104	0.728	0.544			0.372
SOLEA SOLEA					0.996					
TRACHURUS TRACHURUS									0.6	
TRISOPTERUS ESMARKI	1.24	0.3	0.46	0.008	0.156	0.572	3.615	0.336	0.66	2.052
TRISOPTERUS MINUTUS			0.136				0.198		0.064	
ZEUS FABER						0.004				
Total Weight (kg)	2.33	1.436	4.316	2.887	20.649	3.247	10.489	2.4	2.59	23.454

Table 4 : FU22 Smalls grounds: Inputs to short-term catch option table.

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	%	%
2003	96	54	136				21.4	9.9	36%	30%
2004	72	9	78				25.5	8.9	11%	8%
2005	115	91	183				21.1	7.1	44%	37%
2006	97	55	138	1503	70	9%	18.0	10.8	36%	30%
2007	165	150	277	1136	126	24%	17.5	10.1	48%	41%
2008	132	61	177	1114	123	16%	23.6	12.6	31%	26%
2009	93	31	116	1093	108	11%	24.2	19.0	25%	20%
2010	124	27	144	1141	88	13%	21.9	14.2	18%	14%
2011	62	7	67	1256	72	5%	26.3	21.7	10%	7%
2012	124	24	142	1498	239	9%	21.3	10.7	16%	13%
2013	97	31	120	1254	177	10%	23.3	11.8	24%	19%
2014	105	30	127	1622	268	8%	25.0	13.7	23%	18%
2015	123	20	138	1363	180	10%	19.3	8.9	14%	11%
2016	158	53	198	866	35	23%	20.8	9.7	25%	20%
2017				1600	83					

Table 5 : The basis for the catch options.

Variable	Value	Source	Notes
Stock abundance	1600 million	ICES (2017)	UWTV 2017
Mean weight in landings	22.1 g	ICES (2017)	Average 2003–2016.
Mean weight in discards	12.0 g	ICES (2017)	Average 2003–2016.
Discard rate	20.7 %	ICES (2017)	Average 2014–2016 (by number). Calculated as discards divided by landings + discards.
Discard survival rate	25.0 %	ICES (2017)	Only applies in scenarios where discarding is allowed.
Dead discard rate	16.4 %	ICES (2017)	Average 2014–2016 (by number). Calculated as dead discards divided by removals (landings + dead discards). Only applies in scenarios where discarding is allowed.

Table 6 : FU22 Smalls grounds: Short-term management option table giving catch options for 2018 using 2017 UWTV estimate.

a) Catch options for 2018 assuming zero discards.

Basis	Total catch	Wanted catch*	Unwanted catch*	Harvest rate**
ICES advice basis				
MSY approach; F_{MSY}	4098	3590	509	12.8%
Other options				
$F_{current}$ (2014–2016)	4355	3814	541	13.6%

* "Wanted" and "unwanted" catch are used to describe *Nephrops* that would be landed and discarded in the absence of the EU landing obligation, based on the average estimated discard rates for 2014–2016.
** Calculated for dead removals and applied to total catch.

b) Catch options for 2018 assuming discarding to continue at recent average.

Basis	Total catch	Dead removals	Landings	Dead discards	Surviving discards	Harvest rate*
	L+DD+SD	L+DD	L	DD	SD	for L+DD
ICES advice basis						
MSY approach; F_{MSY}	4322	4187	3784	403	134	12.8%
Other options						
$F_{current}$ (2014–2016)	4592	4449	4021	428	143	13.6%

* Calculated for dead removals and applied to total catch.