# The "Smalls" *Nephrops* Grounds (FU22) 2018 UWTV Survey Report and catch scenarios for 2019.


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**Abstract**

This report provides the main results and findings of the thirteenth 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 42 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 9%, was well below the upper limit of 20% recommended by SGNEPS (ICES, 2012). The 2018 abundance estimate was 45% lower than in 2017 and at 876 million is below the MSY $B_{trigger}$ reference point (990 million). Using the 2018 estimate of abundance and updated stock data implies catch of 2,084 tonnes and landings of 1,780 tonnes in 2019 when the MSY approach is applied (assuming that discard rates and fishery selection patterns do not change from the average of 2015–2017). Two species of sea pens were recorded as present at the stations surveyed: *Virgularia mirabilis* and *Pennatula phosphorea*. Trawl marks were observed at 55% of the stations surveyed. Nine 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 Irish landings in 2017 worth around €54 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, 2018). The 2017 reported landings from the Smalls (~2814 t) were estimated to be worth in the region of €15.1 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 and 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 thirteenth in a time series of UWTV surveys in the Celtic Sea FU22 "Smalls" ground has been carried out by the Marine Institute, Ireland.

The survey was multi-disciplinary in nature and the specific objectives of the 2018 survey are listed below:

1. To complete a survey of 42 randomised fixed isometric grid UWTV stations, with 4.5 nautical mile (nmi) spacing, on the "Smalls" *Nephrops* ground (FU22).
2. To obtain 2018 quality assured estimates of *Nephrops* burrow distribution and abundance on the "Smalls" *Nephrops* ground (FU22) and compare them with those collected in 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 sample *Nephrops* and macro benthos using a 4 m beam trawl deployed at 9 stations.

This report details the final UWTV results of the 2018 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 (MA). The 2018 abundance estimate is used to generate catch scenarios for 2019 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 of *Nephrops*, a survey grid of 4.5 nm spacing has been used since 2012. The 2018 randomised isometric grid, which resulted in 42 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 used 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 2018 Celtic Sea survey took place on RV Celtic Voyager between the 18th August and the 26th 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 were quality controlled using an “R” script developed by the Marine Institute (ICES, 2009b) an example is shown in Figure 3. In 2018 the USBL navigational data were used to calculate distance over ground for 95% of stations, while adjusted ship position was used for two stations.

In line with recommendations of the Study Group on *Nephrops* Surveys (SGNEPS; ICES 2009b) all scientists were trained/re-familiarised using training material and then were tested by counting reference footage for FU22 prior to recounting 2018 footage (ICES, 2009b). Individual’s counting performance against the reference counts was measured by Lin’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 recorded due to OSPAR Special Request (ICES 2011). A key was devised to categorise the densities of sea-pens based on the SACFOR abundance scale (Table 1) after ICES (2011). Finally, if there was any time during the one-minute block where counting was not possible, due to sediment clouds or other reasons, this was also estimated so that the time could be removed from the distance over ground calculations.

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 0.6. 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 plots of survey count data for stations 120 to 122 is shown in Figure 4. Consistency and bias between individual counters was also examined using Figure 5. There was 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 2018 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 the "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 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.

For each UWTV station a CTD profile was logged for the duration of each tow using a sled mounted and calibrated Seabird SBE37. This data will be processed at a later stage.

Nine 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 from 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, weighed (g) and counted. The UWTV station positions and tracks for the nine beam trawl tows are shown in Figure 2.

## Results

In 2018 42 stations were completed successfully on the Smalls. A summary of the results is presented in Table 2. The density and estimated abundance decreased by around 45% in 2018. The average density and the abundance were the second lowest 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. However in 2018, as in 2016, this inter-quartile range is in the region of 0.1 - 0.4. In 2018 the mean adjusted[1] burrow density was 0.31 burrows/m$^2$. No adjusted burrow densities > 1.0 burrows/m$^2$ were observed in 2018.

The krigged and point density data for 2006-2018 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, densities are higher towards the south and central area of the ground.

The summary statistics from this geo-statistical analysis are given in Table 2 and Figure 9. The 2018 estimate of 876 million burrows is below the geometric mean of the series (geomean [2006-2018]: 1232 million burrows) and is also below the MSY $B_{trigger}$ reference point of 990 million. The estimation of variance of the 2018 survey as calculated by RGeostats is low (with a CV or RSE of 9%), 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 this size. A strong cohort was apparent in the 2006 catches of around 17mm and can be tracked in catches in subsequent years. There was a shift to larger sizes in 2011 and 2012, with a shift back again to smaller sizes in 2016 to 2018.

Table 3 summarises the fish catches. *Hippoglossoides platessoides* (long rough dab) was the most common species, with catches in every tow. The highest catch of 5.8 kgs of *Lophius piscatorius* (white bellied monkfish) was recorded in tow 9. Figure 11 is a heatmap combined with a dendrogram which shows the proportional counts of benthic species. A threshold was used which removed species with a maximum relative abundance less than 1% as. 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. *Goneplax rhomboids,* a burrowing crab species, was also recorded in all but one of the tows. *Eledone cirrhosa* (curled octopus), a noted predator of crustaceans was recorded and observed lying close to *Nephrops* burrow entrances on the Smalls ground (FU22).

Sea-pen distribution across the Smalls *Nephrops* grounds is mapped in Figure 12. Two sea-pens were identified from the video footage; *Virgularia mirabilis* and *Pennatula phosphorea*. Trawl marks were noted at 55% of the stations surveyed.

The UWTV abundance data together with data from the fishery; landings, discards and removals in number, were used to calculate the harvest rate for 2017 of 12.1%. The mean weight in the landings and discards and the proportions of removal retained are also shown (Table 4).

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[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).

The basis to 2019 catch scenarios are given in Table 5. The catch and landings scenarios at various different fishing mortalities were calculated in line with the stock annex of the Report of the Working Group on Celtic Seas Ecoregion (ICES, 2018) using the 2018 survey abundance (Table 6). The latest estimate of stock abundance (value from August 2018 survey, 876 million) is below the MSY $B_{trigger}$ value (990 million). The ICES MSY approach states that under such conditions the $F_{MSY}$ harvest rate (12.8% for FU22 Norway lobster) should be reduced by multiplying it by the ratio of current abundance to MSY $B_{trigger.}$ This corresponds to a harvest rate of 12.8 x 876 ÷ 990 = 11.3% for the catch advice in 2019. Fishing at the MSY approach in 2019 would result in catches of 2084 tand landings of 1780 t assuming that discard rates and fishery selection patterns do not change from the average of 2015–2017.

## 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 decreased significantly in 2018 to a similar level observed in 2016. Density estimates throughout the ground were lower with relatively few high density estimates in the central area. A general decrease in density has also been observed in the adjacent FU20-21 and FU19 this year (Doyle *et. al*, 2018 and Aristegui *et. al,* 2018). 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 have been covered under the landings obligation since 2016. Discard rates in weight for this FU have been around 15% in recent years, which is above the 2018 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 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 CTD data collected during the survey will augment the knowledge base on habitat and oceanographic regime.

Monitoring the occurrence and frequency of sea-pens observed on this ground is important in the context of OSPAR's designations of sea-pen and burrowing megafauna communities as threatened. Two sea-pen species (*Virgularia mirabilis* and *Pennatula phosphorea*) which was seen in 2018 have been observed on previous surveys of FU22. Monitoring *Nephrops* stock and the benthic habitat is also important in the context of the MFSD indicators (e.g. sea floor integrity).

The main objectives of the survey were successfully met for the thirteenth successive year. The UWTV coverage and footage quality was excellent throughout the survey. This was mainly due to good survey planning to coincide with slack tides. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

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## 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.

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., 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.

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

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

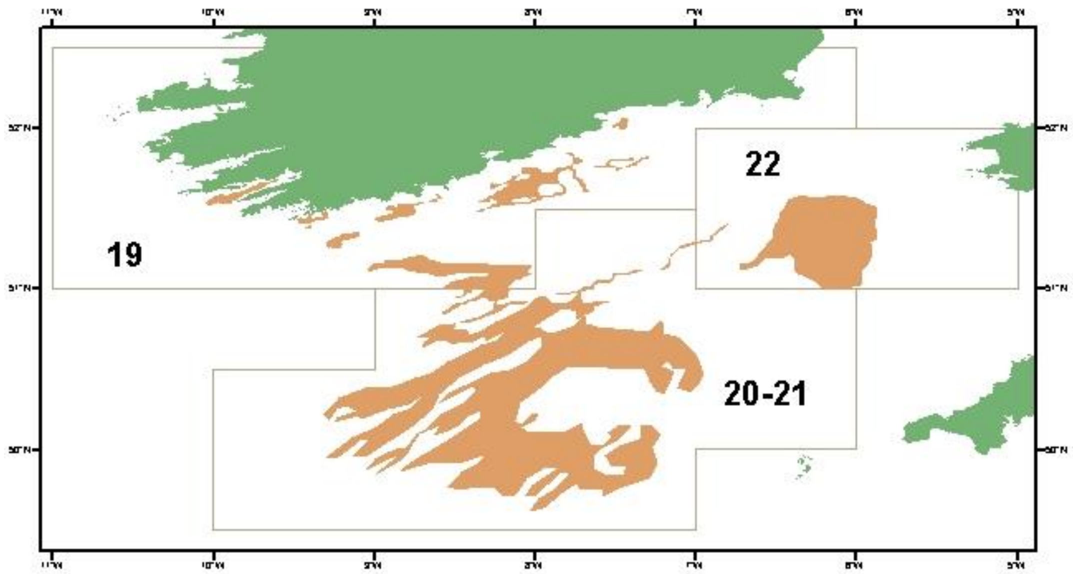


**Figure 1**: FU22 Smalls grounds: *Nephrops* Functional Units (FUs) and *Nephrops* grounds in the greater Celtic Sea and area polygons.

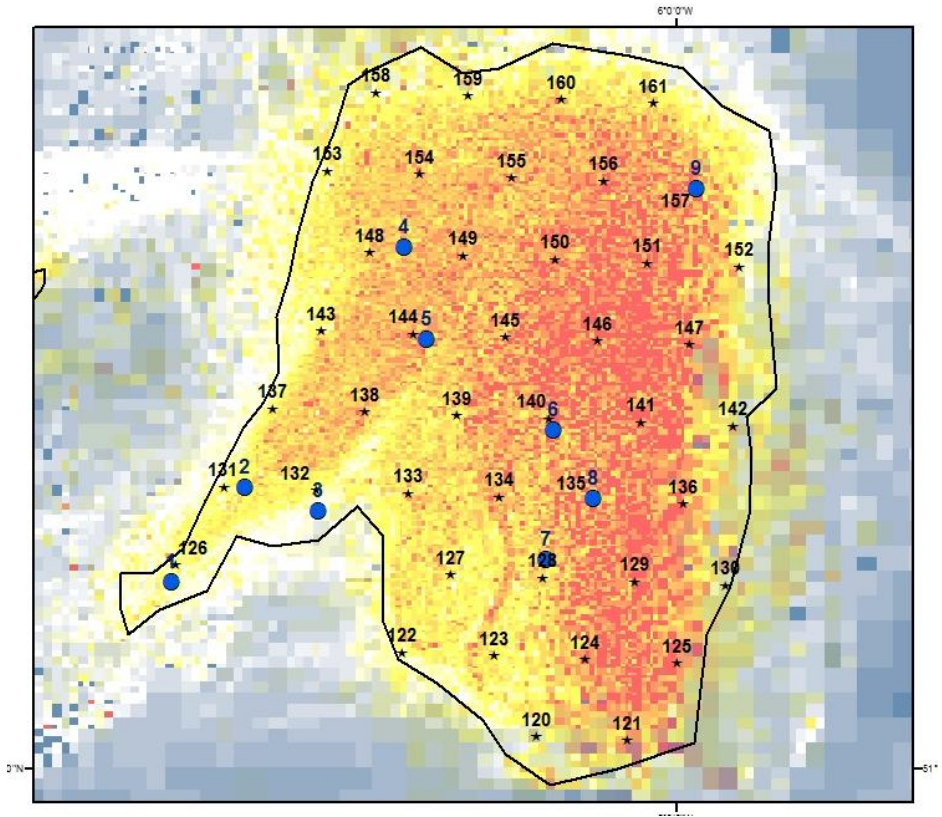


**Figure 2**: FU22 Smalls grounds: TV stations completed on the 2018 survey overlaid on a heat map of *Nephrops* directed Irish fishing activity 2006-2017. * denotes TV stations and blue dots beam trawl stations.

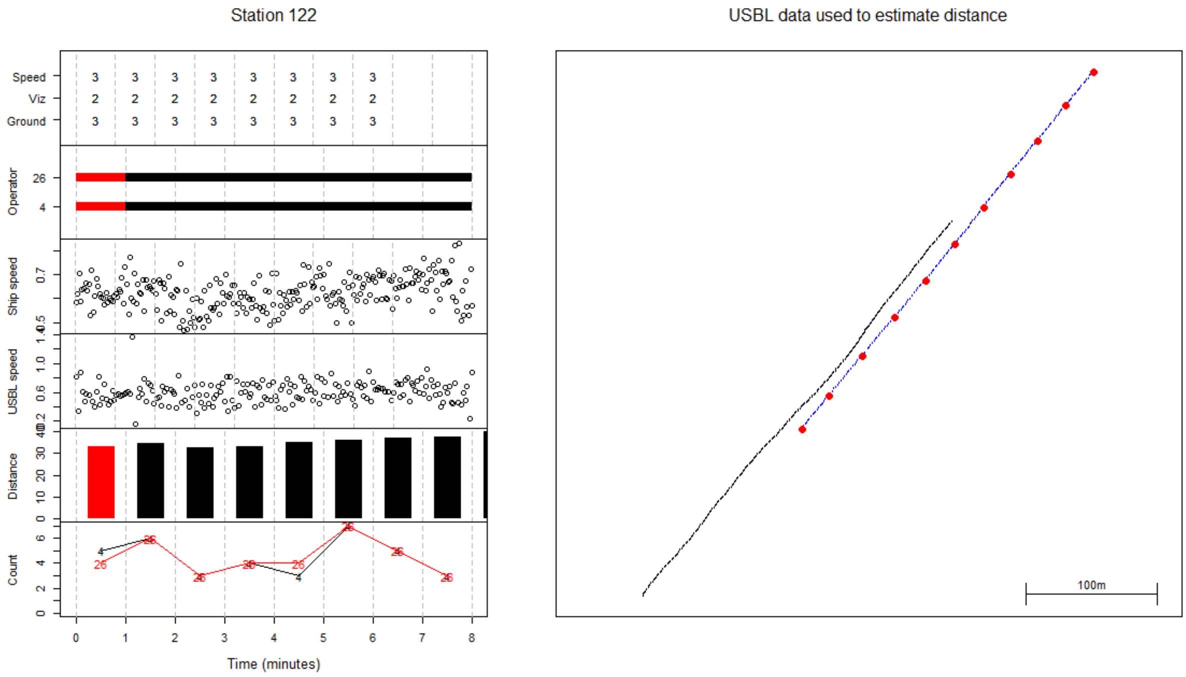


**Figure 3** : FU22 Smalls grounds: R - tool quality control plot for station 122 of the 2018 survey.

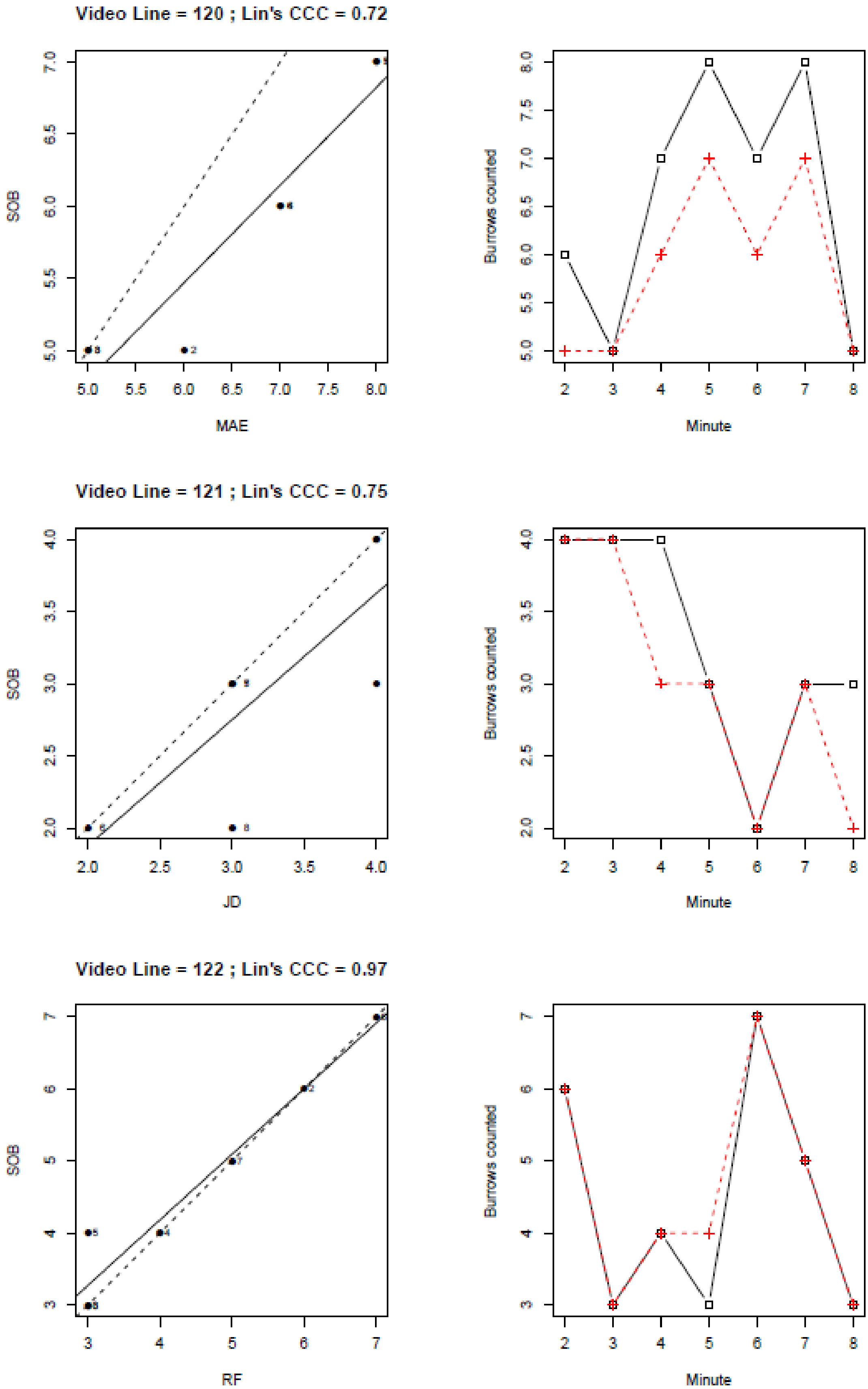


**Figure 4** : FU22 Smalls grounds: Lin's CCC quality control plots of count data for stations 120, 121 and 122 of the 2018 survey.

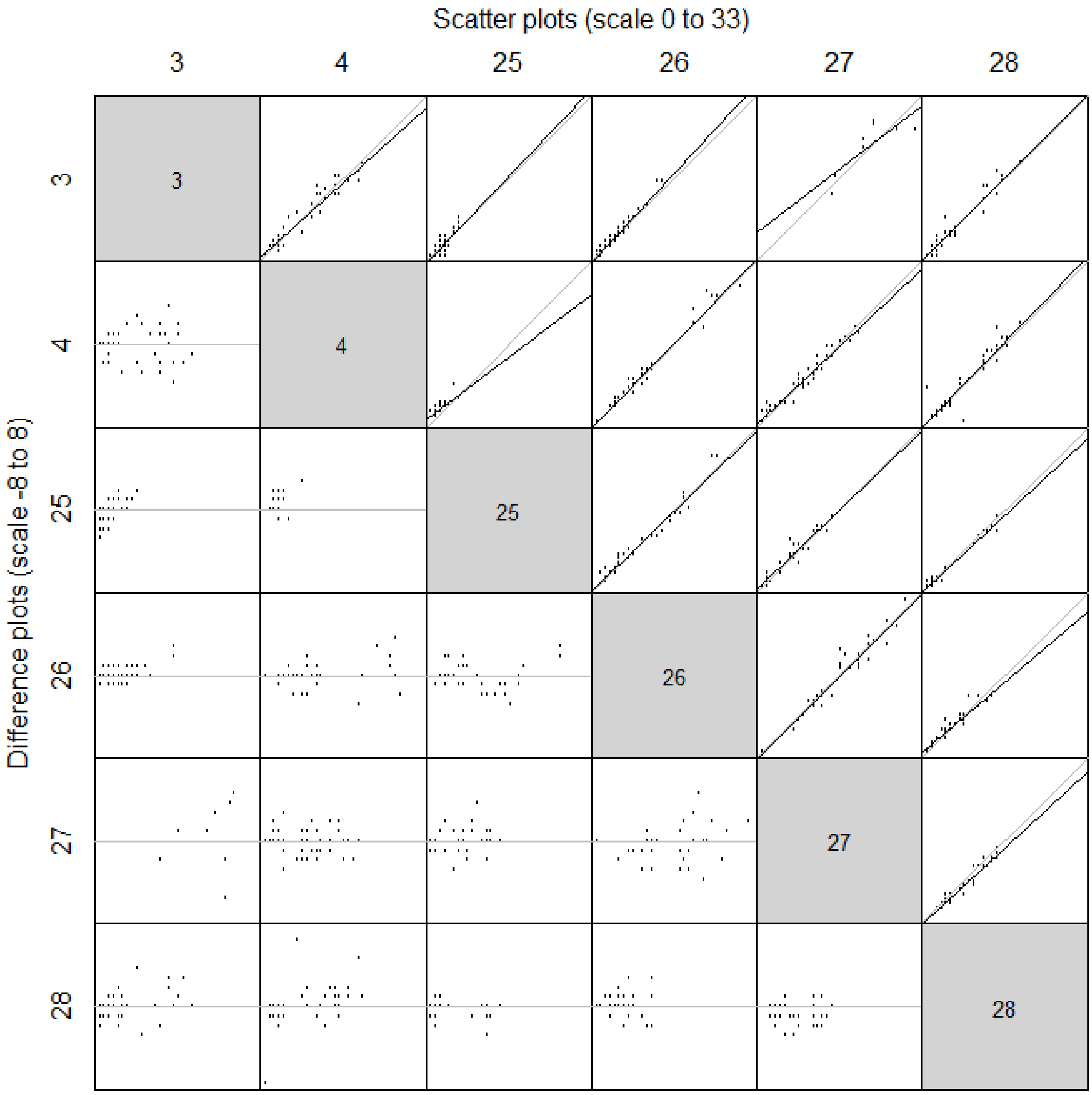


**Figure 5**: FU22 Smalls grounds: Scatter plot analysis of counter correlations for the 2018 survey.

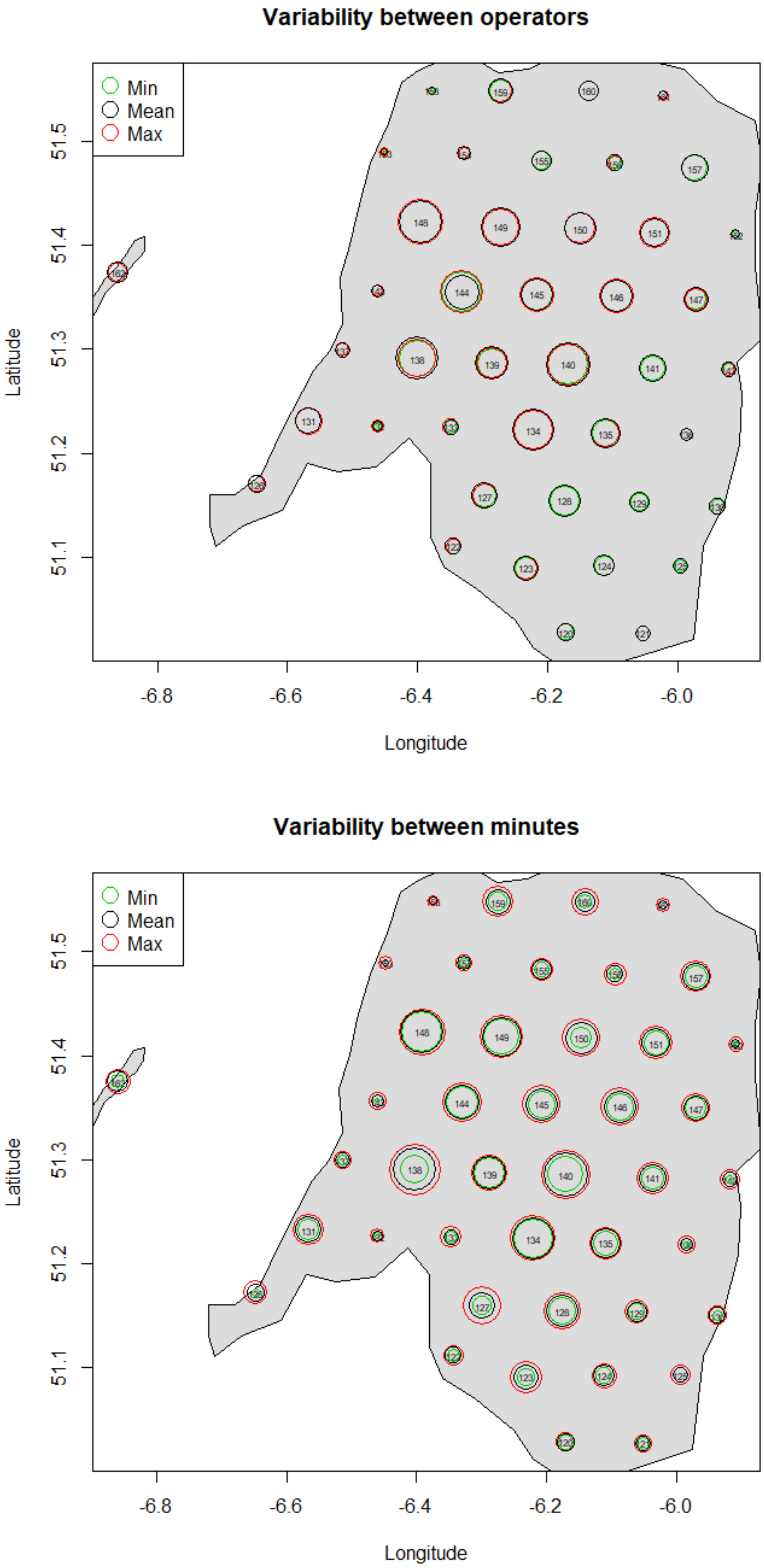


**Figure 6:** FU22 Smalls grounds: Plots of the variability in density between minutes (top panel) and between operators (counters) (bottom panel) for each station in 2018.

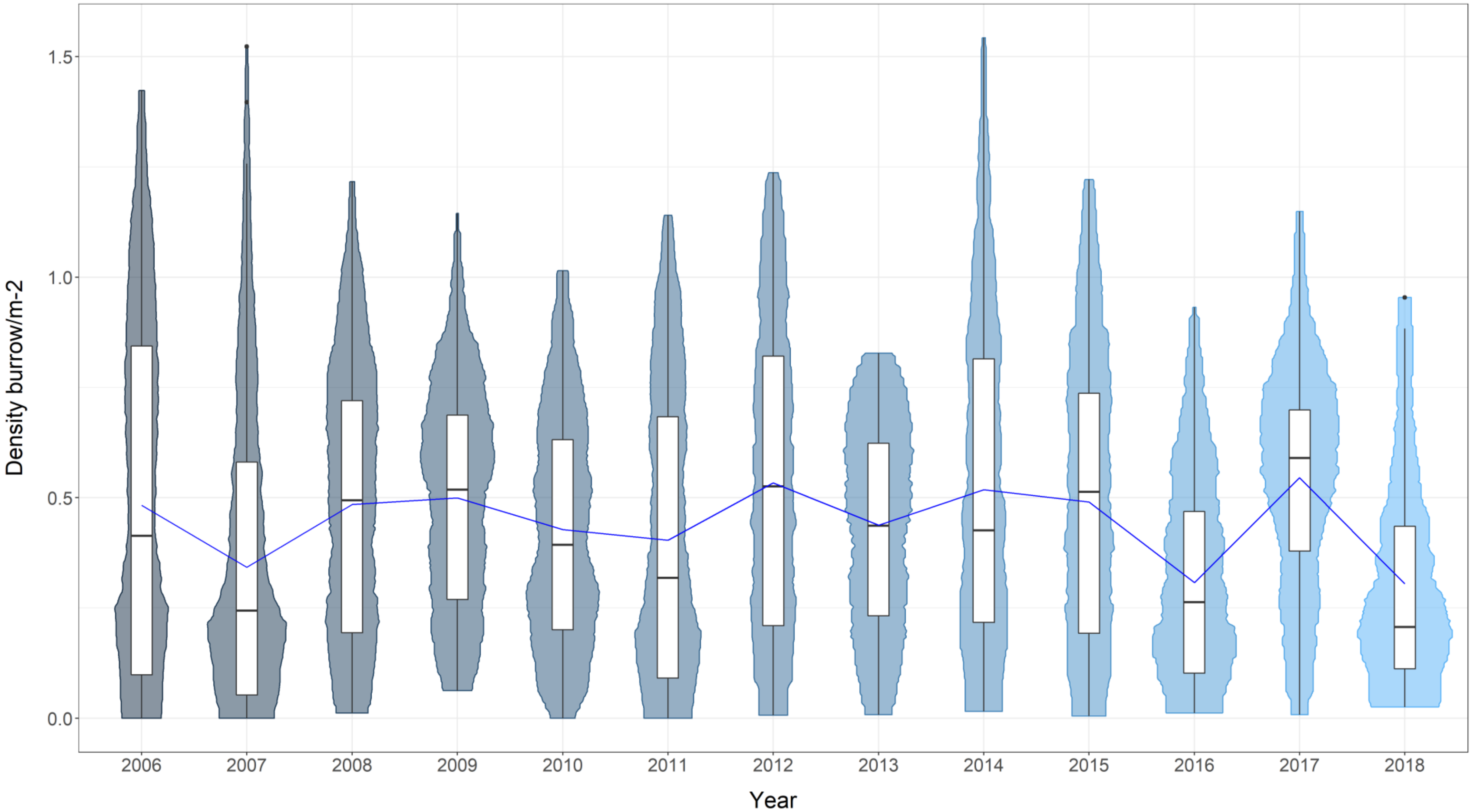


**Figure 7**: FU22 Smalls grounds: Violin and box plot of adjusted burrow density distributions by year from 2006-2018. The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

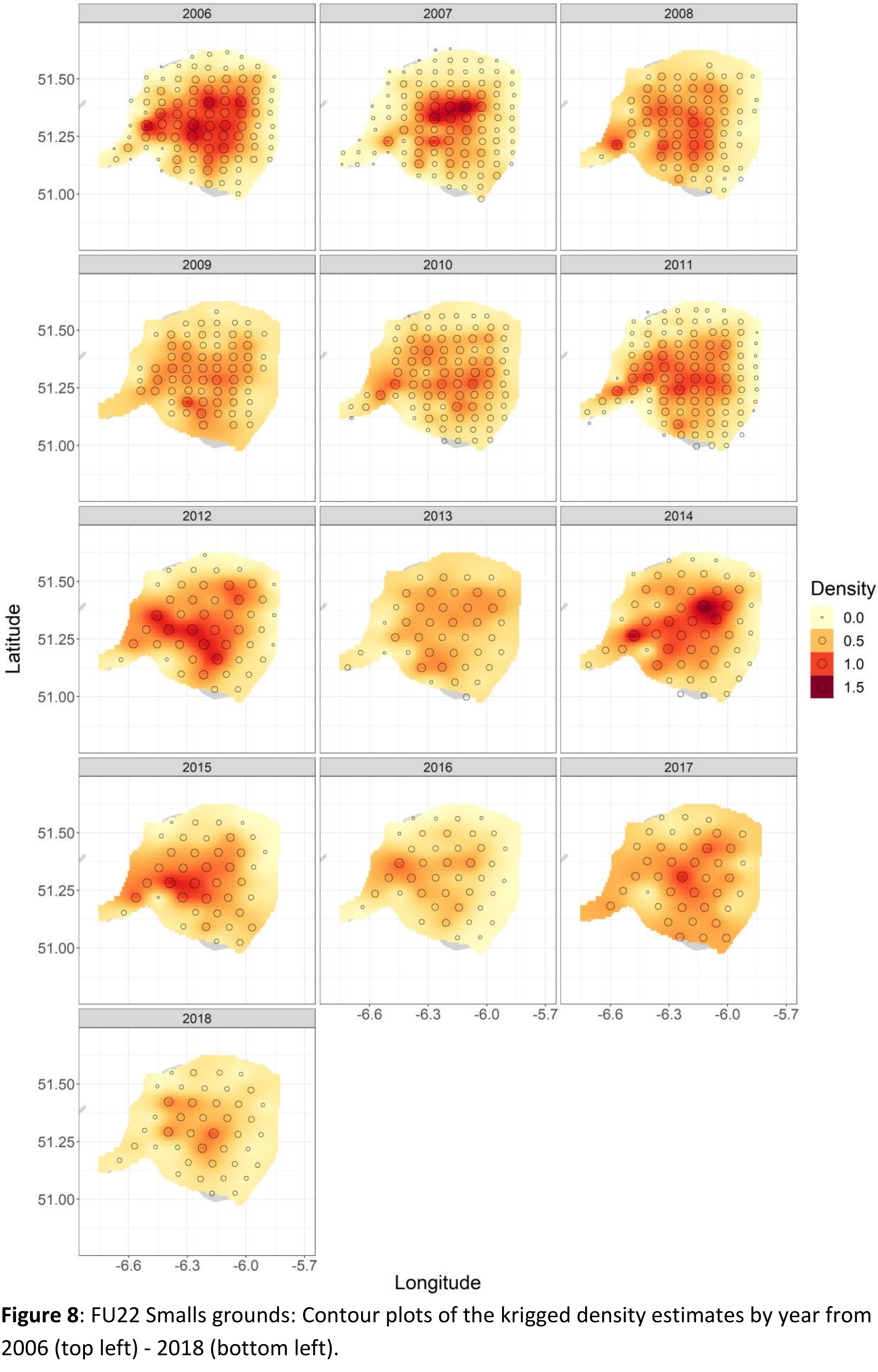


**Figure 8**: FU22 Smalls grounds: Contour plots of the krigged density estimates by year from 2006 (top left) - 2018 (bottom left).

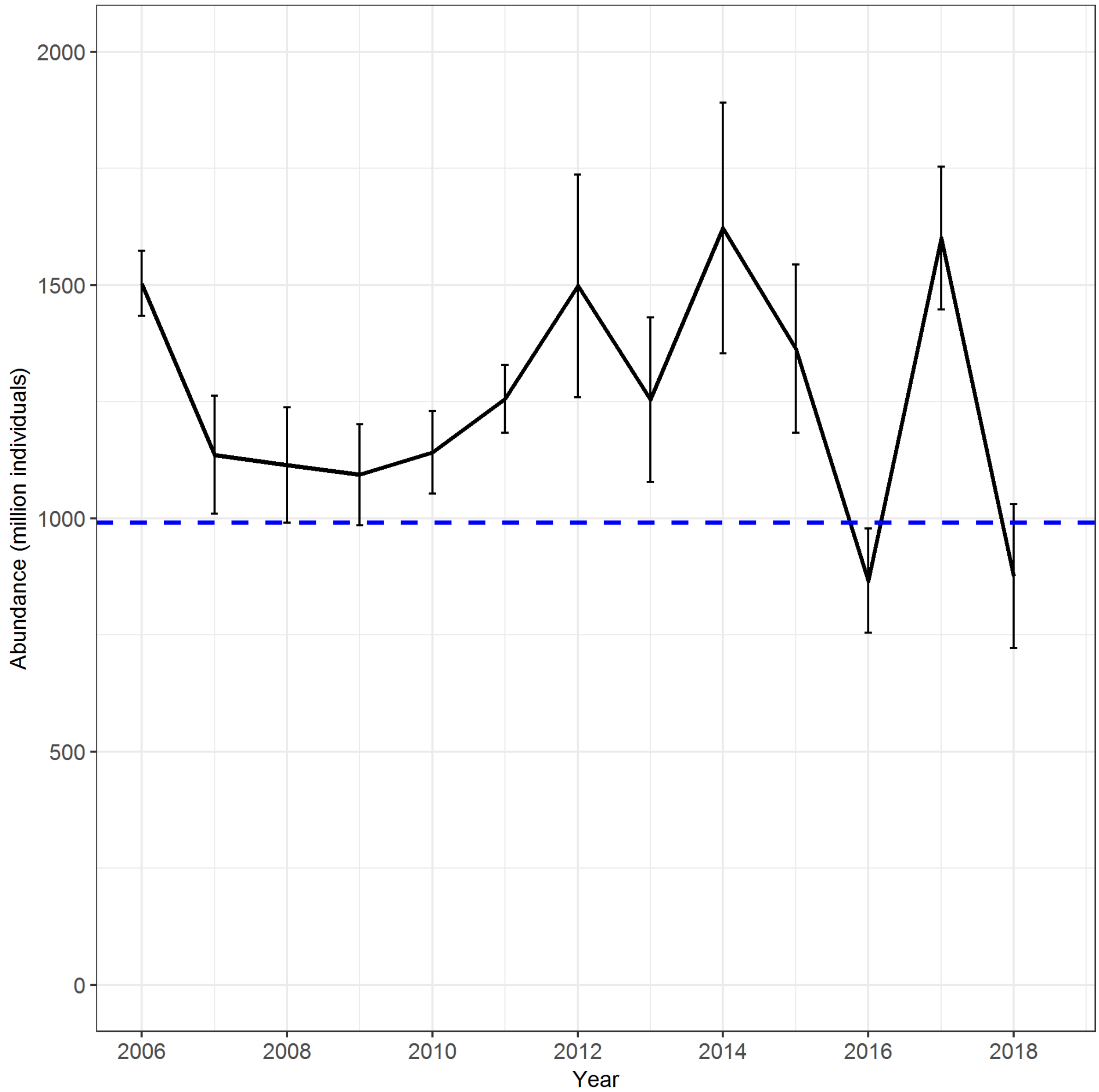


**Figure 9**: FU22 Smalls grounds: Time series of geo-statistical adjusted abundance estimates (in millions of burrows). The error bars indicate the 95% confidence intervals and $B_{trigger}$ is dashed green line.

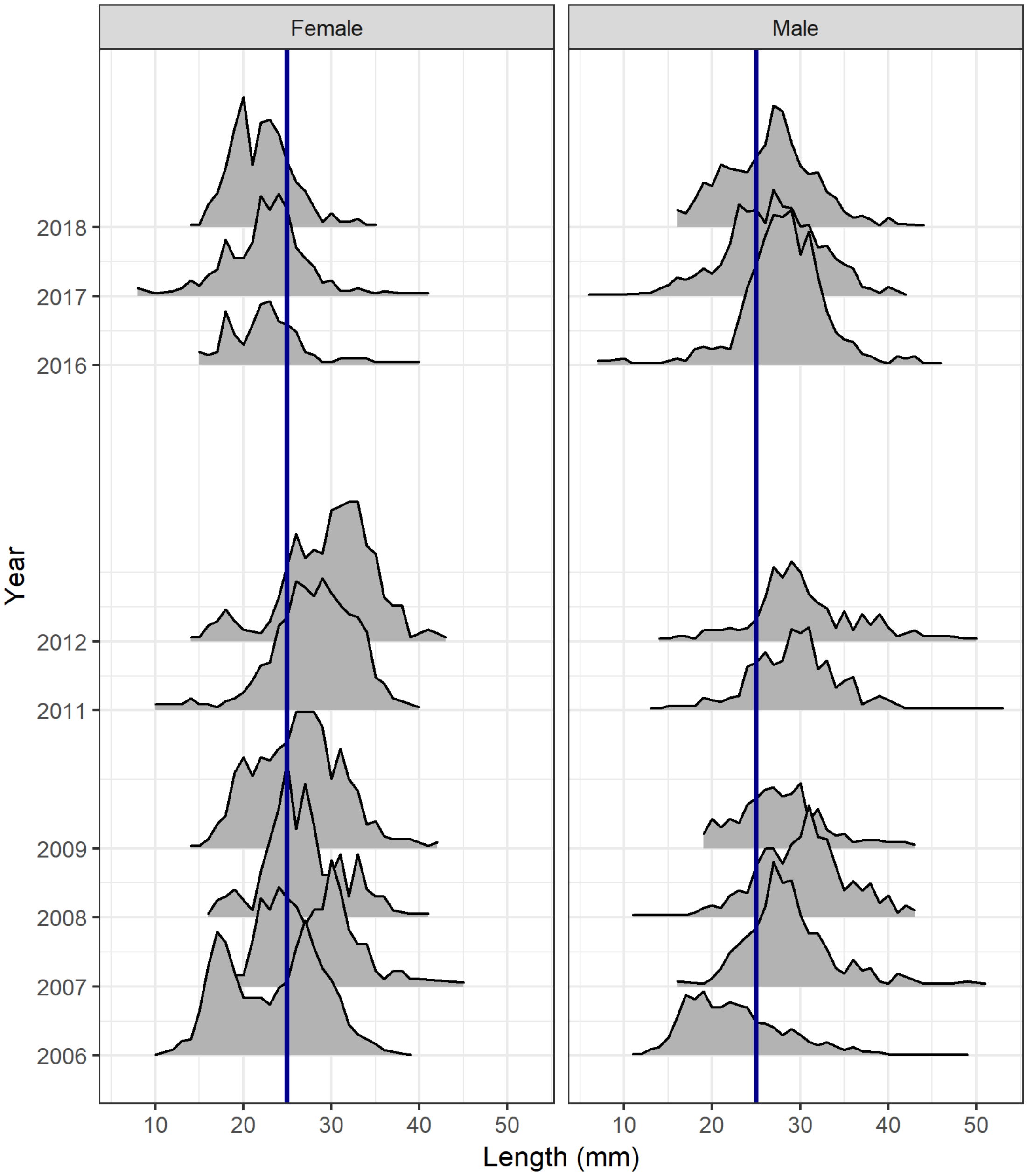


**Figure 10**: FU22 Smalls grounds: Standardised length frequency distributions for male and female *Nephrops* caught using beam trawl during 2006 to 2018 UWTV surveys (except years 2010 and 2013 - 2015).

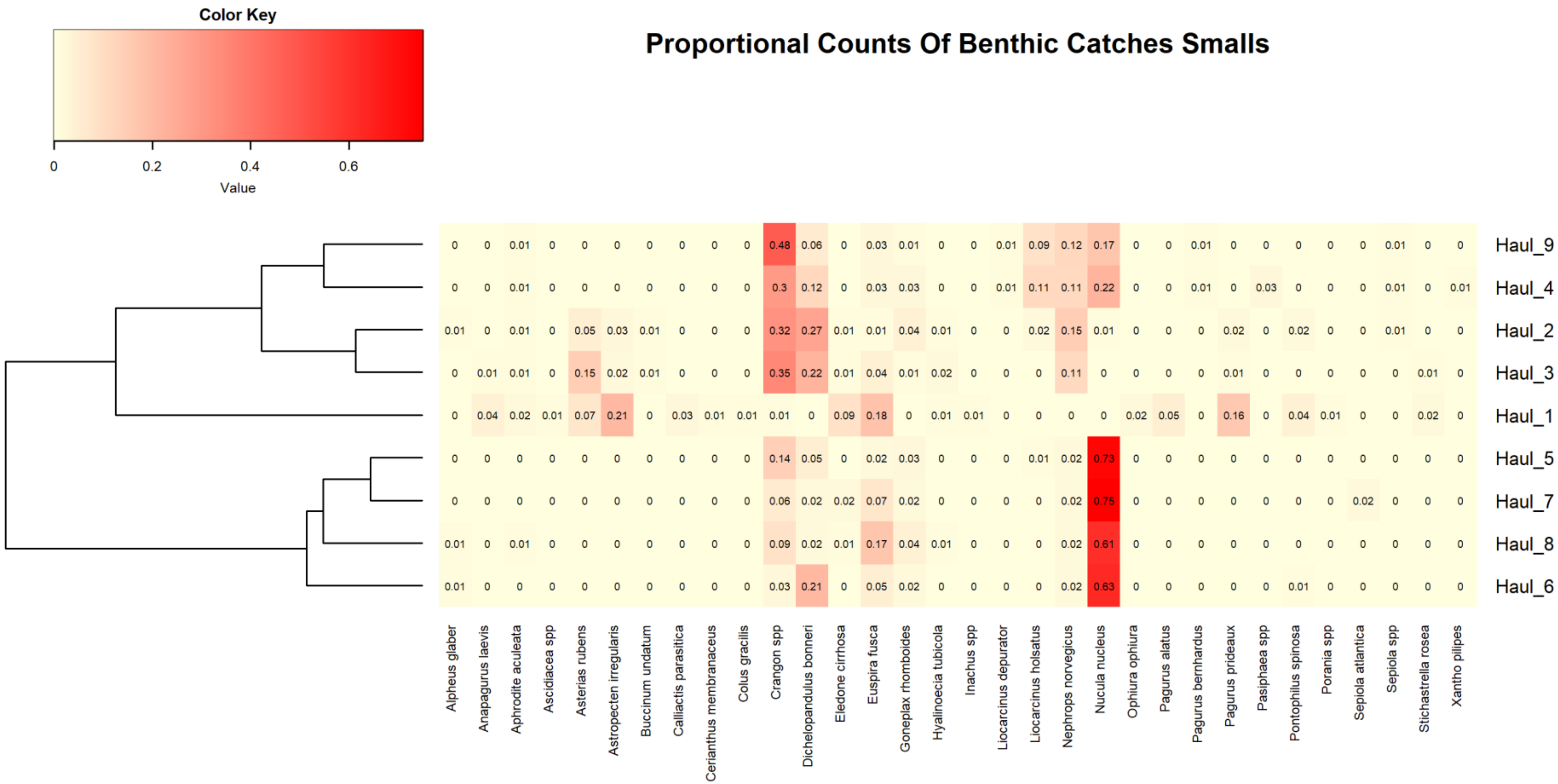


**Figure 11:** FU22 Smalls grounds: 2018 Heat map of proportional counts of benthic species and dendrogram.

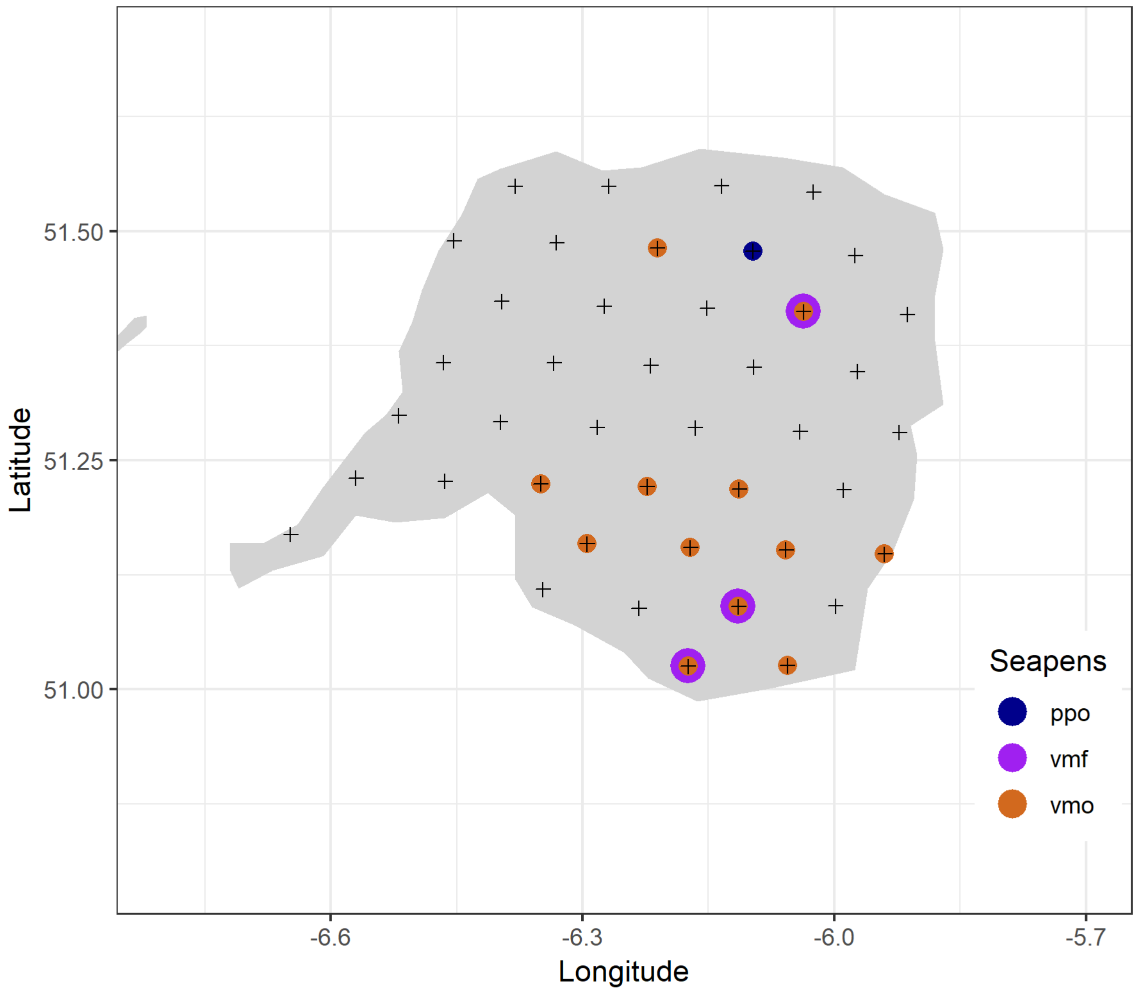


**Figure 12:** FU22 Smalls grounds: 2018 stations where *Virgularia mirabilis* (vm) and *Pennatula phosphorea* (pp) were identified and classified according to abundance key - occasional (o), frequent (f), common (c). Single (+) denotes TV stations with no sea-pen observations.

**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 |
| *2018 | 42 | 0.31 | 3063 | 876 | 9 |

*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 |
| *ARGENTINA SPHYRAENA* | 0.082 | 0 | 0.096 | 0 | 0 | 0.028 | 0 | 0 | 0 |
| *CALLIONYMUS LYRA* | 0 | 0 | 0.068 | 0.006 | 0 | 0 | 0.052 | 0 | 0 |
| *CALLIONYMUS MACULATUS* | 0.006 | 0 | 0.136 | 0 | 0 | 0 | 0 | 00 | 0 |
| *CONGER CONGER* | 0 | 0 | 0 | 0.06 | 0 | 0.236 | 0 | 0.154 | 0 |
| *EUTRIGLA (CHELIDONICTHYS) GURNARDUS* | 0.112 | 0.06 | 1.026 | 0.002 | 0.05 | 0.004 | 0.174 | 0.008 | 0.1 |
| *GAIDROPSARUS VULGARIS* | 0.044 | 0.024 | 0.02 | 0.142 | 0.052 | 0 | 0 | 0 | 0.038 |
| *GLYPTOCEPHALUS CYNOGLOSSUS* | 3.356 | 1.606 | 1.172 | 0.03 | 0 | 0 | 0.338 | 0 | 1.295 |
| *GOBIUS SPP.* | 0.004 | 0 | 0 | 0 | 0 | 0 | 0 | 0.004 | 0 |
| *HIPPOGLOSSOIDES PLATESSOIDES* | 1.641 | 0.113 | 1.126 | 0.05 | 0.192 | 0.762 | 0.622 | 1.022 | 0.658 |
| *LEPIDORHOMBUS WHIFFIAGONIS* | 1.578 | 0 | 1.596 | 0 | 0 | 0 | 1.98 | 1.806 | 1.25 |
| *LIMANDA LIMANDA* | 0 | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 |
| *LOPHIUS BUDEGASSA* | 3.448 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *LOPHIUS PISCATORIUS* | 0 | 0 | 1.31 | 3.975 | 0 | 1.32 | 0 | 0.556 | 5.855 |
| *MELANOGRAMMUS AEGLEFINUS* | 0.08 | 0 | 0.462 | 0.182 | 0 | 1.332 | 0.066 | 0.128 | 0.114 |
| *MERLANGIUS MERLANGUS* | 0 | 0.024 | 0.048 | 4.958 | 1.084 | 0.042 | 0.01 | 0.032 | 0.192 |
| *MERLUCCIUS MERLUCCIUS* | 0.504 | 0.512 | 1.478 | 1.28 | 0 | 0.896 | 3.8 | 0.87 | 0.158 |
| *MICROCHIRUS VARIEGATUS* | 0.31 | 0 | 0.056 | 0 | 0 | 0 | 0.016 | 0 | 0.046 |
| *MICROMESISTIUS POUTASSOU* | 0 | 0.024 | 0.034 | 0.274 | 0.472 | 0.438 | 0.044 | 0.034 | 0.03 |
| *MICROSTOMUS KITT* | 0 | 0 | 0.242 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MOLVA MOLVA* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.438 |
| *PLUERONECTES PLATESSA* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.276 |
| *RAJIDAE* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.13 |
| *SCYLIORHINUS CANICULA* | 0.166 | 0.128 | 4.564 | 0.104 | 0 | 0.036 | 0.096 | 0.106 | 0.584 |
| *SOLEA SOLEA* | 0.576 | 0 | 0.074 | 0 | 0 | 0.144 | 0 | 0.448 | 1.208 |
| *SPRATTUS SPRATTUS* | 0 | 0 | 0 | 0 | 0 | 0.004 | 0 | 0 | 0 |
| *TRISOPTERUS ESMARKI* | 0.242 | 0.314 | 1.812 | 1.158 | 1.232 | 2.42 | 0.216 | 0.184 | 0.05 |
| *TRISOPTERUS MINUTUS* | 0 | 0.116 | 1.434 | 0.382 | 0.21 | 0 | 0.046 | 0.026 | 0.052 |
| *ZEUS FABER* | 0 | 0 | 0 | 0 | 0 | 0 | 0.002 | 0 | 0 |
| Total Weight (kg) | 12.149 | 2.921 | 16.814 | 12.603 | 3.292 | 7.662 | 7.462 | 5.378 | 13.474 |

**Table 4:** FU22 Smalls grounds: Inputs to catch scenarios 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 | 112 | 23 | 20.8 | 9.7 | 25 | 20 |
| 2017 | 164 | 39 | 194 | 1600 | 153 | 12.1 | 21.7 | 10.8 | 19 | 15 |
| 2018 | | | | 876 | 154 | | | | | |

**Table 5:** The basis for the catch scenarios.

| Variable | Value | Notes |
|---|---|---|
| Stock abundance (2019) | 876 million | UWTV 2018 |
| Mean weight in wanted catch | 22.2 g | Average 2003–2017. |
| Mean weight in unwanted catch | 11.9 g | Average 2003–2017. |
| Unwanted catch | 24.1 % | Average 2014–2017 (proportion by number). |
| Discards survival | 25 % | Proportion by number |
| Dead unwanted catch | 19.3 % | Average 2014–2017 (proportion by number). |

**Table 6:** FU22 Smalls grounds: Annual catch advice and scenarios; Discarding assumed to continue at recent average.

| 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; F = $F_{MSY}$*(Stock Abundance 2019)/MSY $B_{trigger}$ | 2084 | 2008 | 1780 | 228 | 76 | 11.3 | -51.8 |
| Other options | | | | | | | |
| $F_{MSY}$ | 2355 | 2269 | 2011 | 258 | 86 | 12.8 | -45.5 |
| $F_{MSY\ lower}$ | 1876 | 1808 | 1603 | 205 | 68 | 10.2 | -56.6 |
| $F_{MSY\ lower}$ *(Stock Abundance 2019)/MSY $B_{trigger}$ | 1656 | 1595 | 1414 | 181 | 60 | 9 | -61.7 |
| $F_{MSY\ upper}$ | 2355 | 2269 | 2011 | 258 | 86 | 12.8 | -45.5 |
| $F_{MSY\ upper}$ *(Stock Abundance 2019)/MSY $B_{trigger}$ | 2084 | 2008 | 1780 | 228 | 76 | 11.3 | -51.8 |
| $F_{2017}$ | 2227 | 2146 | 1903 | 244 | 81 | 12.1 | -48.5 |

* Calculated for dead removals and applied to total catch.
** Advice value 2019 relative to advice value 2018.