Aran, Galway Bay and Slyne Head *Nephrops* Grounds (FU17) 2019 UWTV Survey Report and catch scenarios for 2020.

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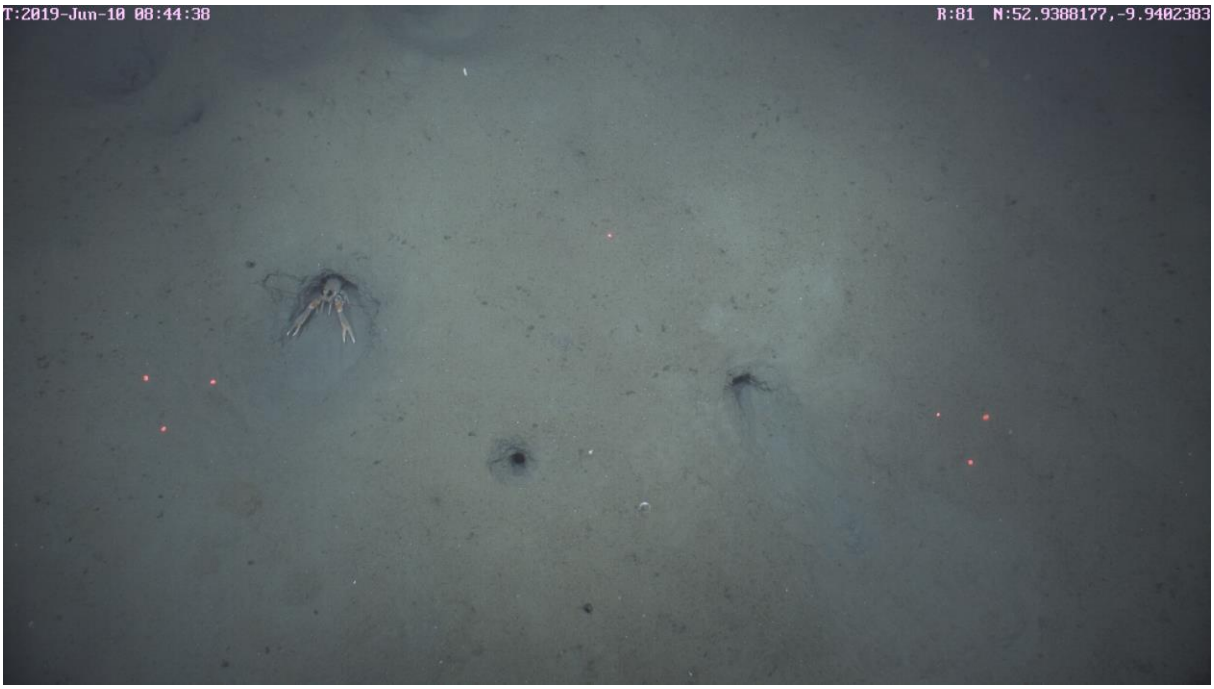

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Abstract

This report provides the main results and findings of the seventeenth annual underwater television on the Aran, Galway Bay and Slyne head *Nephrops* grounds, ICES assessment area; Functional Unit 17. The survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. In 2019 a total of 41 UWTV stations were successfully completed, 31 on the Aran Grounds, 5 on Galway Bay and 5 on Slyne Head patches. The mean burrow density observed in 2019, adjusted for edge effect, was medium at 0.38 burrows/m². The final krigged burrow abundance estimate for the Aran Grounds was 458 million burrows with a CV (relative standard error) of 4%. The final abundance estimate for Galway Bay was 23 million and for Slyne Head was 12 million, with CVs of 11% and 8% respectively. The total abundance estimates have fluctuated considerably over the time series. The 2019 combined abundance estimate (493 million burrows) is 11% lower than in 2018, and it is below the MSY $B_{trigger}$ reference point (540 million burrows). Using the 2019 estimate of abundance and updated stock data implies catches between 696 and 800 tonnes in 2020 that correspond to the F ranges in the EU multi annual plan for Western Waters, assuming that discard rates and fishery selection patterns do not change from the average of 2016–2018. *Virgularia mirabilis* was the only sea-pen species observed on the UWTV footage. Trawl marks were present at 7% of the Aran stations surveyed.

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

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Introduction

Nephrops norvegicus are common around the Irish coast occurring in geographically distinct sandy/muddy areas where 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 2018 worth around €56 million at first sale. The *Nephrops* fishery 'at the back of the Aran Islands' can be considered the mainstay of the Ros a Mhíl fleet. Estimated landings of 494 t in 2018 were worth approximately €3.2 million at first sale. Without this *Nephrops* fishery the majority of vessels in the fleet would cease being economically viable (Meredith, 1999). Given these socio-economic realities 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 & 2013).

This is the eighteenth annual UWTV survey of the 'Aran grounds'. The survey covers three geographically discrete mud patches; the Aran Ground, Galway Bay and Slyne Head all of which lie within the ICES assessment area Functional Unit 17 (Figure 1). The 2019 survey was multi-disciplinary in nature and also covered TV stations in FU19, FU2021 and FU22; the specific objectives are listed below:

1. To complete a survey of 31 UWTV randomised fixed isometric grid stations, with 3.5 nautical mile (Nmi) spacing on the "Aran" *Nephrops* ground.
2. To carry out ≥ 5 UWTV indicator stations on the Galway Bay and Slyne Head *Nephrops* ground.
3. To obtain 2019 quality assured estimates of *Nephrops* burrow distribution and abundance on the "Aran" *Nephrops* ground (FU17). These will be compared with those collected previously.
4. To collect ancillary information from the UWTV footage collected at each station such as the presence of sea-pens, other macro benthos and fish species and trawl marks on the sea bed.
5. To collect oceanographic data using a sledge mounted CTD.
6. 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 2019 survey and also documents other data collected during the survey. Operational survey details are available in form of a survey narrative from the scientist in charge (JD). The 2019 abundance are used to generate catch options for 2020 in line with the recommendations and procedures outlined in the stock annex for FU17 (ICES, 2015).

Material and methods

Since 2012 the Aran survey design has been based a randomised isometric grid with stations every 3.5 Nmi or 6.5km. This spacing was used to achieve good spatial coverage over the known extent of the ground and to generate a burrow surface that reflect the underlying abundance. The randomised grid and random stations on the Galway Bay and Slyne grounds were generated using the "spsampl" function in the "sp" package (Pebesma & Bivand, 2005) of "R" (R Core Team, 2017). The ground boundary used for the Aran, Galway Bay and Slyne grounds was revised by an ICES inter-benchmark process (ICES, 2015). In the past stations in Galway Bay and Slyne Head were randomly picked from an area defined by previously collected UWTV data, VMS data (Gerritsen & Lordan, 2011) and multi-beam backscatter data (Figure 1 & Figure **2**). Not all stations completed in 2019 and in previous years fell within the polygons demarking the defined grounds and these were excluded from the analysis.

Survey timing was generally standardised to June each year. In 2003, poor weather and technical problems meant that coverage was poor compared with the other years. In 2004, bad weather prevented the completion of the survey in June so approximately 50% of the stations were carried out one month later in July. In 2003 and 2008 due to weather downtime stations could not be completed at Slyne Head. In 2015 the Galway Bay and 14 Aran stations were surveyed on June 10th and 11th on RV Celtic Voyager. The vessel then broke down and the remaining stations (20 Aran and 5 Slyne) were carried out on RV Prince Madog on the 1st and 2nd of July.

The 2019 FU17 survey took place on RV Celtic Voyager between the 9th and 20th of June.

In 2019 image data was collected by a custom built camera system recording High Definition still image data at 12 frames per second with a camera angle of 75°. The digital images were stored on a server and were reviewed onboard through an inhouse developed Image annotation R Shiny app (Aristegui, 2019). This application allows each reviewer to annotate burrows for each randomly assigned station in an efficient manner. The survey process onboard is now paperless.

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and employed on other UWTV surveys in Irish waters. They can be summarised as follows: At each station the UWTV sledge was deployed. Once stable on the seabed a 10 minute tow was recorded. Time referenced high definition image data was collected with a field of view or 'FOV' of 1.01 metre. 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) an example is shown in Figure 3. In 2019 the USBL navigational data was used to calculate distance over ground for 100% stations.

In line with recommendations of the Study Group on *Nephrops* Surveys (SGNEPS), all scientists were trained/re-familiarised using 2019 image data as training material (ICES, 2009b). All counts were conducted by two scientists independent of each other on board the research vessel during the survey. During this 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 systems (multiple burrows in close proximity which appear to be part of a single complex which are only counted once), *Nephrops* activity in and out of burrows were counted and recorded for each one-minute interval. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

Presence / absence notes were also recorded on the occurrence of trawl marks, fish species and other species. Presence / absence of sea-pen species were also recorded to fulfil an OSPAR Special Request (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 2019 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 plot of survey count data for stations 32 to 34 is shown in Figure 4. When the count data fell below the threshold of 0.5 a third review was carried out. The paired count data that passed the Lin's CCC threshold was used in the analysis. When the paired counts did not pass the threshold an average of the three reviewers was deemed appropriate to use in the analysis.

Mean density was calculated by dividing the total number of burrow systems by the survey area observed. In 2019 the field of view of the camera at the bottom of the screen was estimated by extrapolation at 1.01 m assuming that the sledge was flat on the seabed (i.e. no sinking). 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.

To account for the spatial co-variance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out with the "R" package, "RGeostats" 10.0.8 (Renard D. et al., 2015). The procedure used is fully documented in the stock annex.

To estimate the abundance for Galway Bay and Slyne Head grounds, the area of each ground polygon was calculated in ArcGIS10 and an average value used (Table 1). The abundance estimation is the product of the mean density and ground area. The sample variances, standard errors, t-values and 95% CI were calculated for each ground.

For each UWTV station a temperature and depth profile was logged for the duration of each tow using a sled mounted and calibrated Seabird SBE39plus. This data will be processed at a later stage.

Due to time constraints as a result of poor weather conditions beam trawl sampling was not possible during the 2019 survey.

Results

The station positions for the 31 stations on the Aran grounds, 5 in Galway Bay and 5 at Slyne head are shown in Figure 2. One further station was carried out on the zero grounds and is not used in the analysis. A combined violin and box plot of the observed burrow densities from 2006 to 2019 is presented in Figure 5. This shows relatively large inter-annual variation in mean, median and density ranges over time. Density increased in first three years of the time series but then declined significantly in 2006. Since then there has been a gradual downward trend. The mean adjusted[1] burrow density has slightly decreased in 2019 compared with 2018 from 0.40 burrows/m² to 0.38 burrows/m². It has been very noticeable since 2011 that there was a substantial reduction in density throughout the ground with no high density (> 0.7/m^2) observed. Figure 6 shows the variability in density between minutes and operators (counters) for each station. These show that the burrow estimates are fairly consistent between minutes and counters.

Combined krigged contour plots and bubble plots of density data from 2002 to 2019 are shown in Figure 7. These show that densities have fluctuated considerably over the time series and throughout the ground. The fluctuations are not limited to a single station but instead occur fairly homogeneously across the ground. In general, the densities are higher towards the western side of the ground and there is a notable trend towards lower densities towards the east. On the south western boundary there are often high densities close to the boundary. In this area there is a sharp transition from mud to rocky substrate. The decrease in densities in 2019 was mainly towards the north of the ground.

The summary statistics from this geo-statistical analysis for the Aran Grounds are given in Table 2 and Figure 8. The 2019 abundance estimate of 458 million burrows is 6% lower than in 2018. The estimation variance of the surveys is relatively low (CVs in the order <6%).

The summary statistics for the stations on Slyne head and in Galway Bay are given in Table 3. The abundance estimates for Galway Bay *Nephrops* ground and for Slyne Head *Nephrops* ground also are shown in Figure 8. The Galway Bay estimates fluctuate widely but appear to be highly correlated with the Aran ground except in 2004. Estimates for the Slyne Head ground also fluctuate considerably but show no significant correlation with the other areas except for the peaks of 2010, 2015 and 2018. The uncertainty bounds for these areas also fluctuate and inter-annual changes are only statistically significant in a few years. On average the Aran Grounds account for ~93% of the total estimated burrow abundance from FU17. Galway Bay accounts for ~5% and Slyne Head for ~2%. The 2019 combined abundance estimate (493 million) was 11% lower than in 2018 and is below the MSY Btrigger (540 million) (Table 4 and Figure 9).

The sea-pen presence/absence observations across the *Nephrops* grounds are mapped in Figure 10. All the sea-pens recorded in the video footage were identified as *Virgularia mirabilis*. Trawl marks were noted at 7% of the FU17 stations surveyed.

[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 UWTV abundance data together with data from the fishery; landings, discards and removals in number are used to calculate the harvest rate in 2018 of 5.4%. The input variables for catch scenarios such as the mean weight in the landings and the discards and the proportions of removal retained are shown in Table 5.

The basis to the catch options table is given in Table 6. The latest estimate of stock abundance (value from June 2019 survey, 493 million) is below the MSY $B_{trigger}$ value (540 million). Using the 2019 estimate of abundance and updated stock data implies catches between 696 and 800 tonnes in 2020 that correspond to the F ranges in the EU multi annual plan for Western Waters, assuming that discard rates and fishery selection patterns do not change from the average of 2016–2018 (Table 7).

Discussion

Observed burrow densities have fluctuated a lot over time in this area. The abundance shows an overall decreasing trend over time and is below MSY $B_{trigger}$ since 2012 (except 2015 and 2018). This is in contrast to the more stable burrow abundance estimates in most other *Nephrops* grounds in ICES Sub-area 7 over similar time frames.

Discard rates in weights for this FU are estimated to have reduced significantly in the in the last five years and are now estimated at around 12.7% by weight (mean between 2016 and 2018). *Nephrops* fisheries in this area have been covered under the landings obligation since 2016 with several exemptions. The provision of catch advice and scenarios for 2020 based on the EU multi annual plan for Western Waters assumes that discard rates and fishery selection patterns do not change from the average of 2016–2018.

The imposition of the landings obligation on *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 is to collect 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 2009b).

The CTD data collected during the survey will augment the knowledge base on habitat and oceanographic regime.

Monitoring the presence 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 2019 have been observed on previous surveys of FU17. Monitoring *Nephrops* stock and the benthic habitat is also important in the context of the MSFD indicators (e.g. sea floor integrity).

The main objectives of the survey were successfully met for the seventeenth 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

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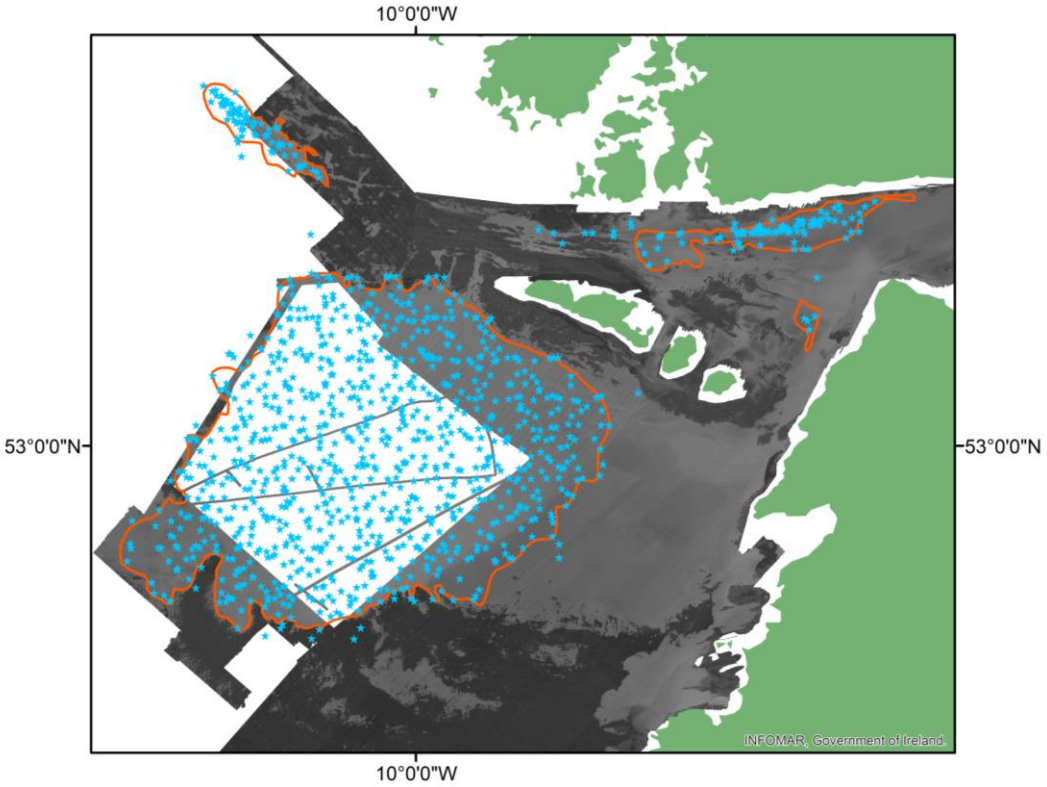

Figure 1: FU17 UWTV**.** The spatial distribution of all UWTV survey stations from 2002-2019 in Functional Unit 17 overlaid on multibeam backscatter data (source: INFOMAR* 2005-2016). Darker grey backscatter indicates harder seabed substrate.

*INFOMAR is the Department of Communications, Climate Action and Environment (DCCAE) funded national seabed mapping programme, jointly managed and delivered by Geological Survey Ireland and Marine Institute

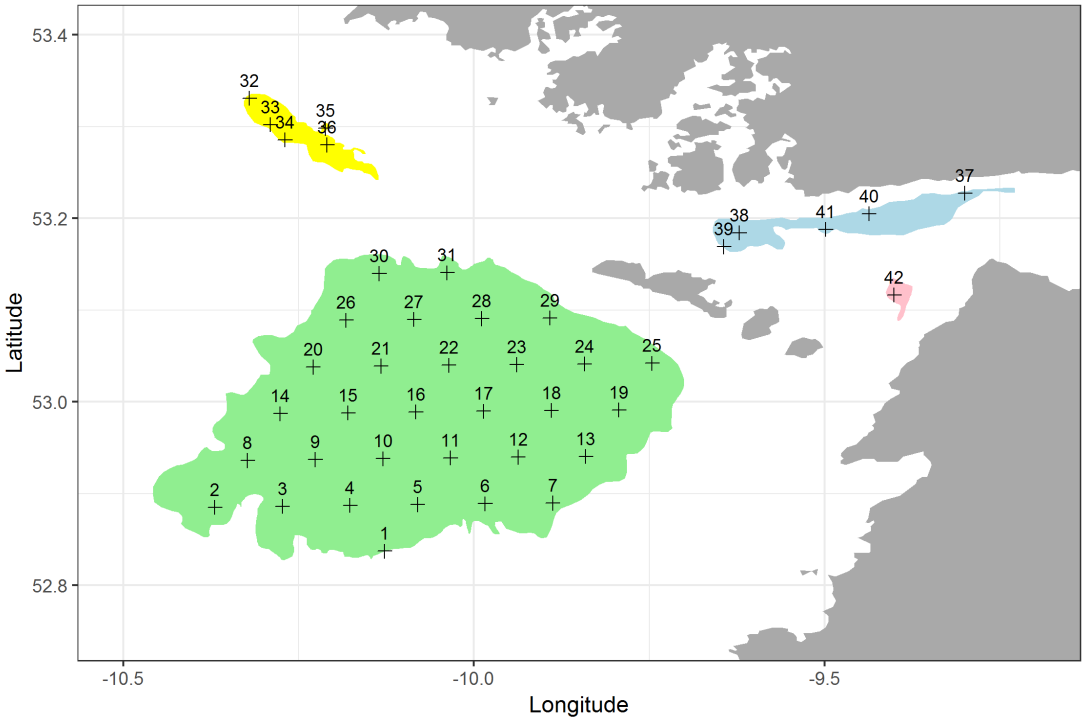

Figure 2: FU17 UWTV**.** Stations completed in 2019 in the Aran Grounds (green), Slyne Head (yellow), Galway Bay (blue) and Zero grounds (red). Stations on Zero ground are not included in final analysis.

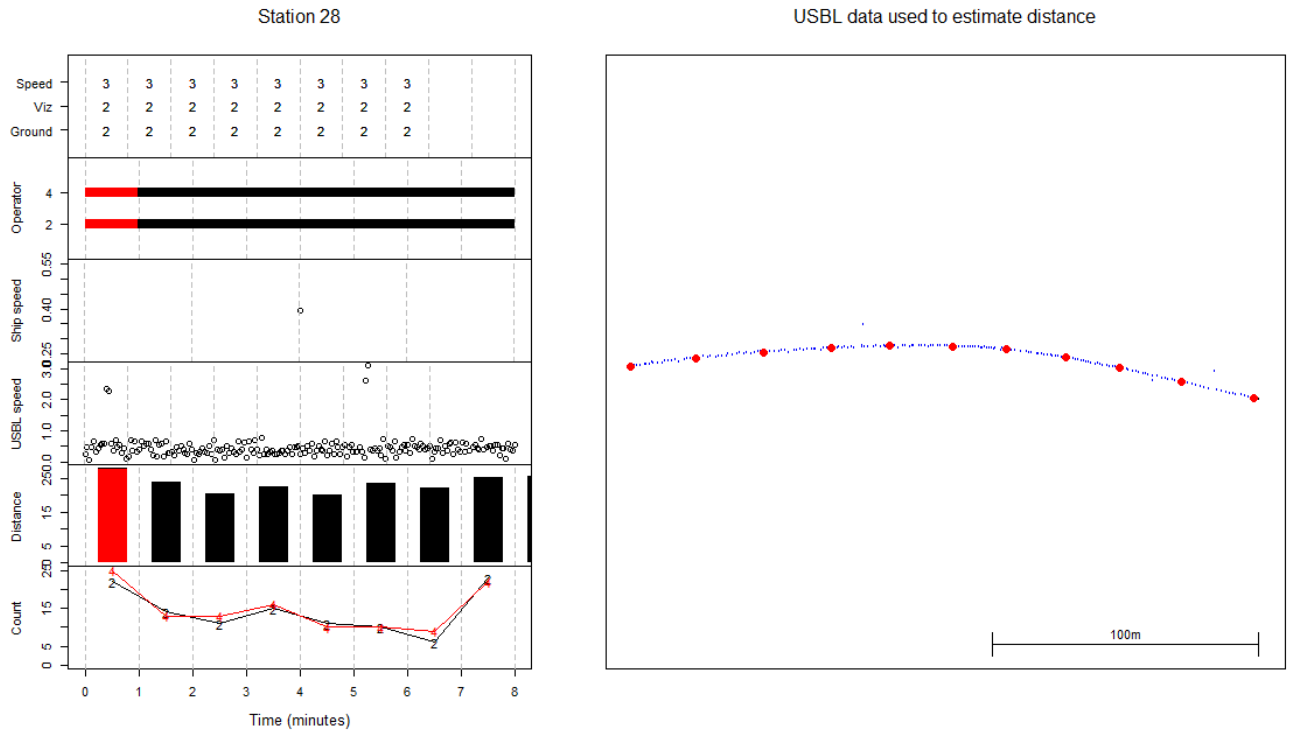

Figure 3: FU17 UWTV**.** R - tool quality control plot of station 28 of the 2019 survey.

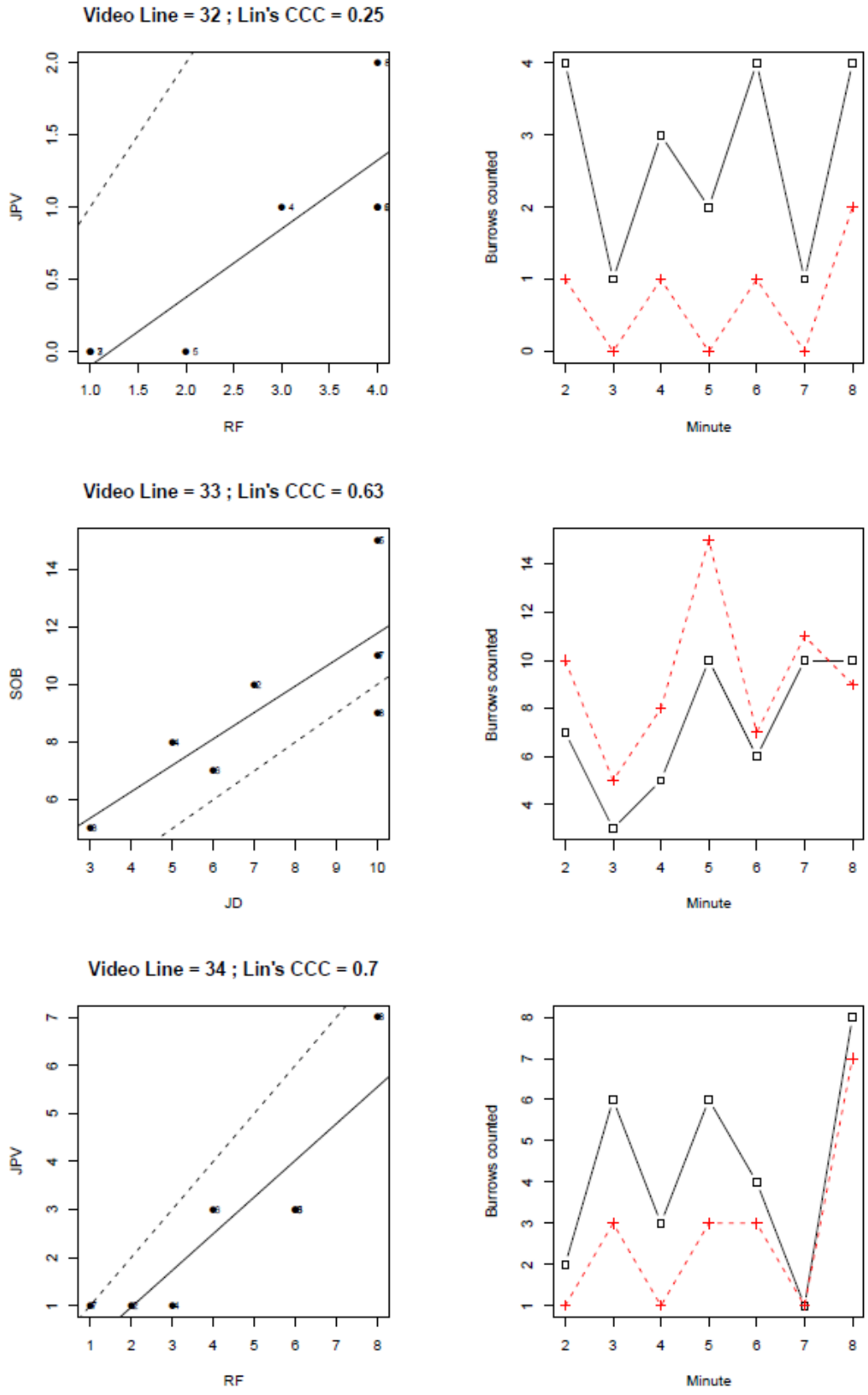

Figure 4: FU17 UWTV**.** Lin's CCC quality control plot of count data for stations 32 – 34 of the 2019 survey.

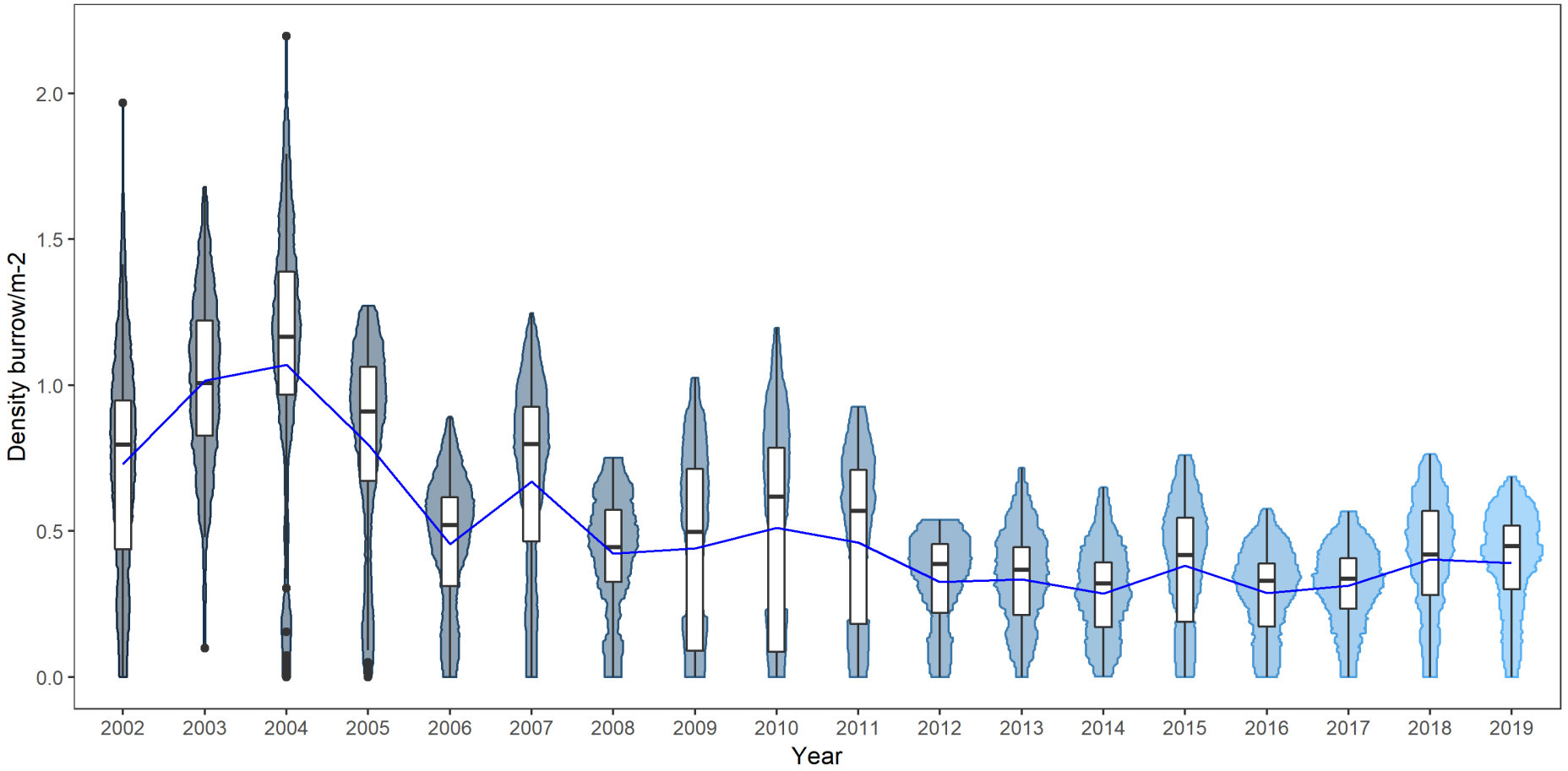

Figure 5: FU17 UWTV**.** Violin and box plot of adjusted burrow density distributions by year from 2006-2019. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

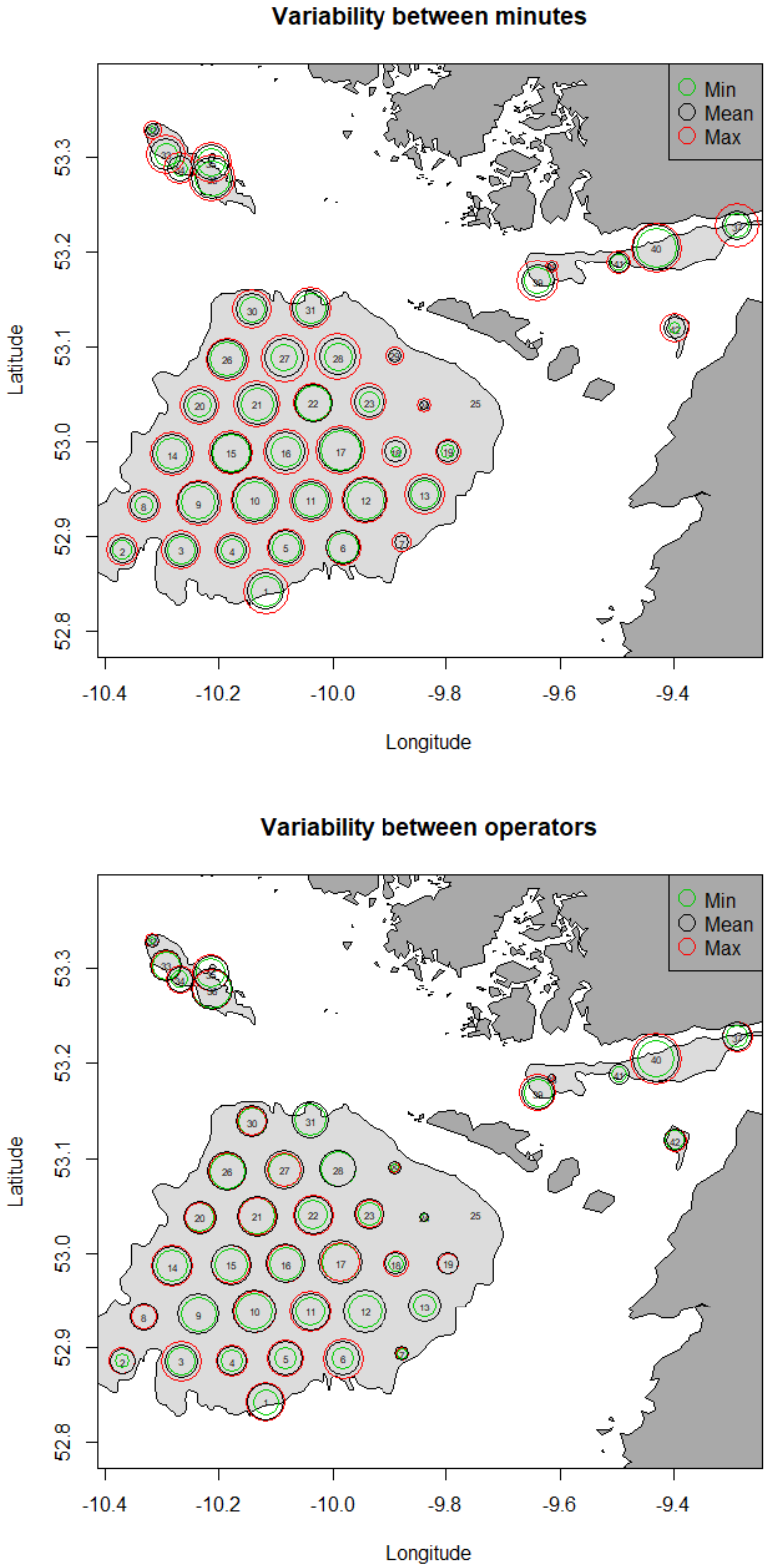

Figure 6: FU17 UWTV**.** Plot of the variability in density between minutes (top panel) and between operators (counters) (bottom panel) for each station in 2019.

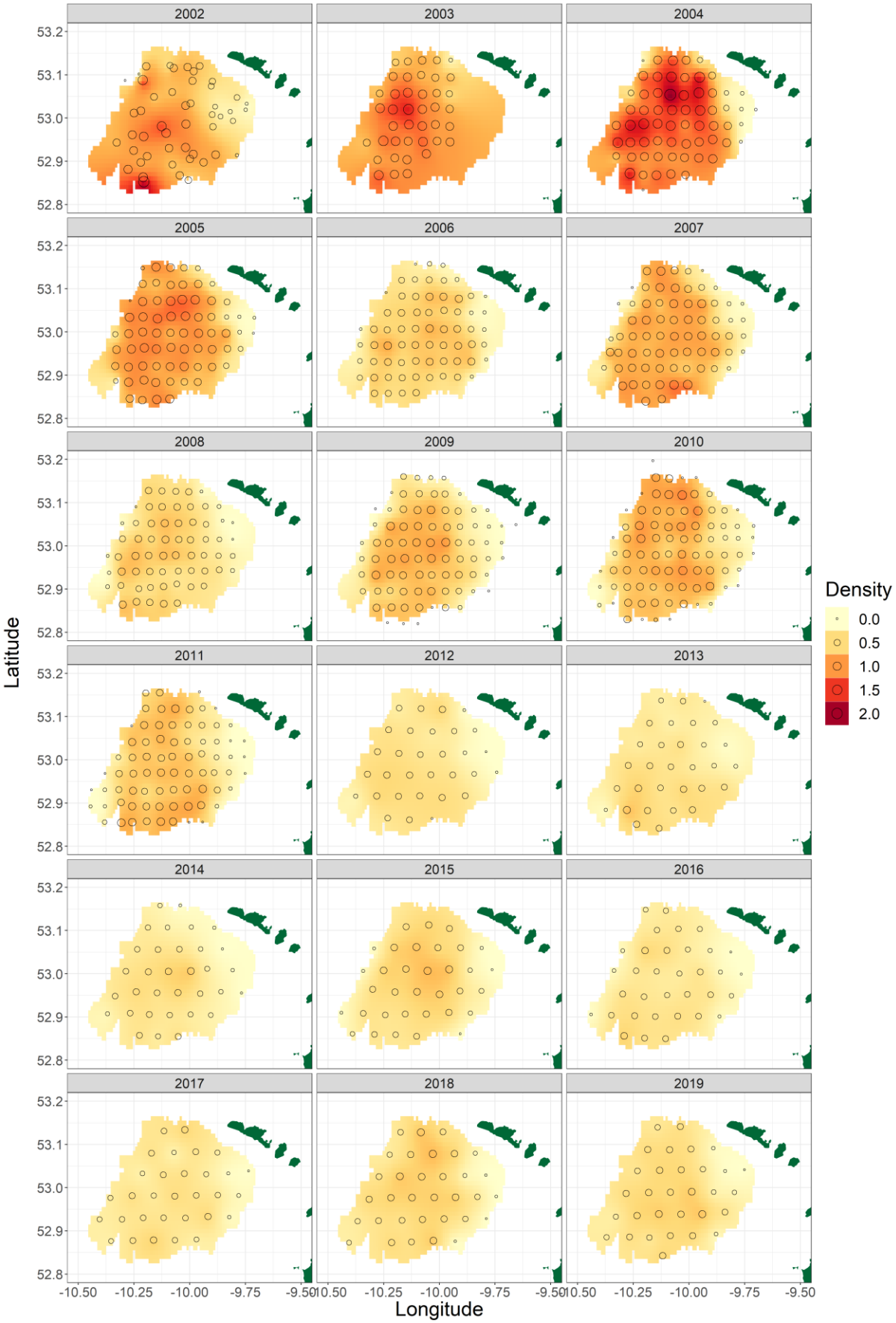

Figure 7: FU17 UWTV**.** Contour plots of the krigged density estimates by year from 2002 (top left) - 2019 (bottom right).

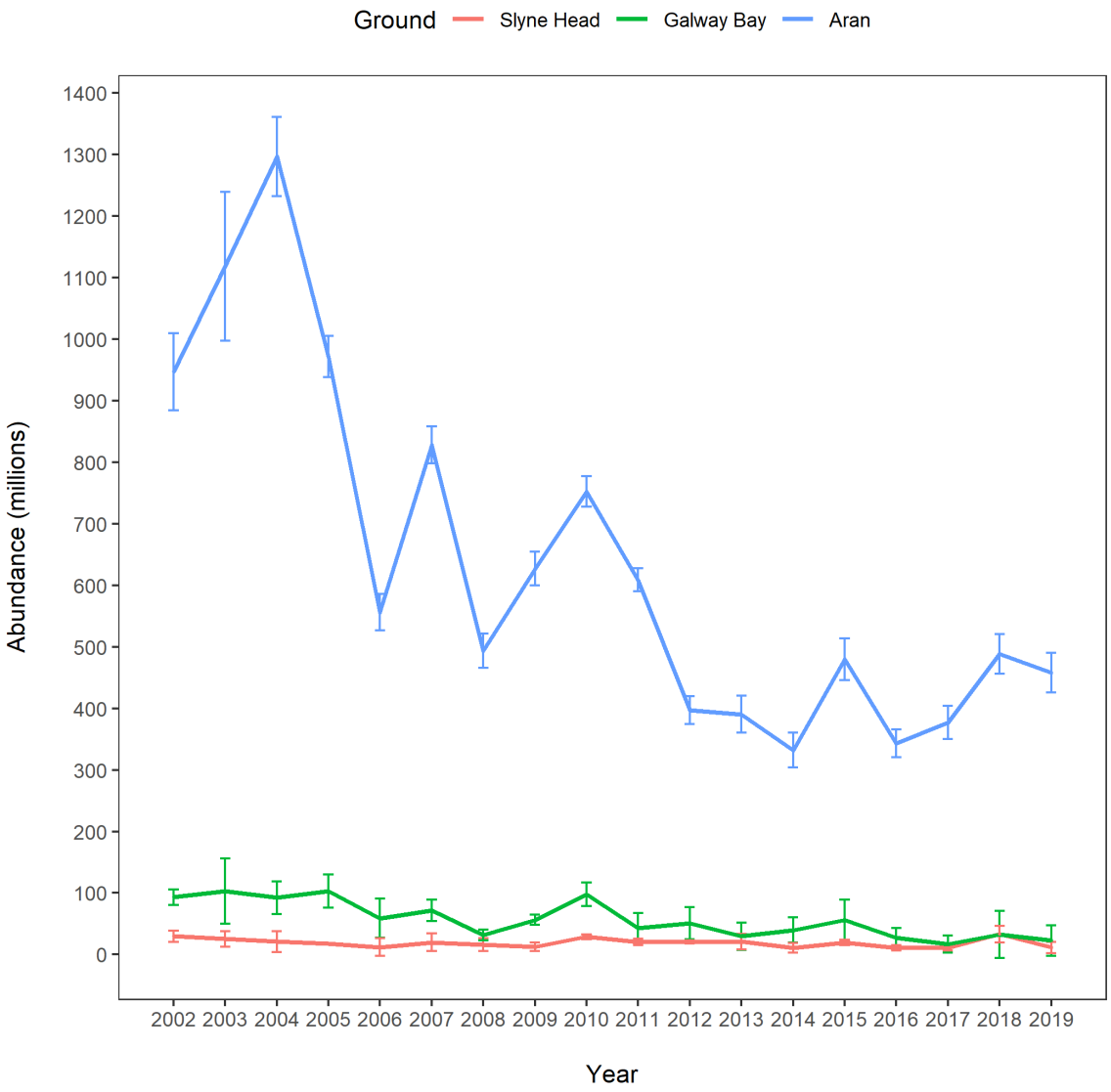

Figure 8: FU17 UWTV**.** Time series of abundance estimates for the Aran Grounds, Galway Bay and Slyne Head (error bars indicate 95% confidence intervals).

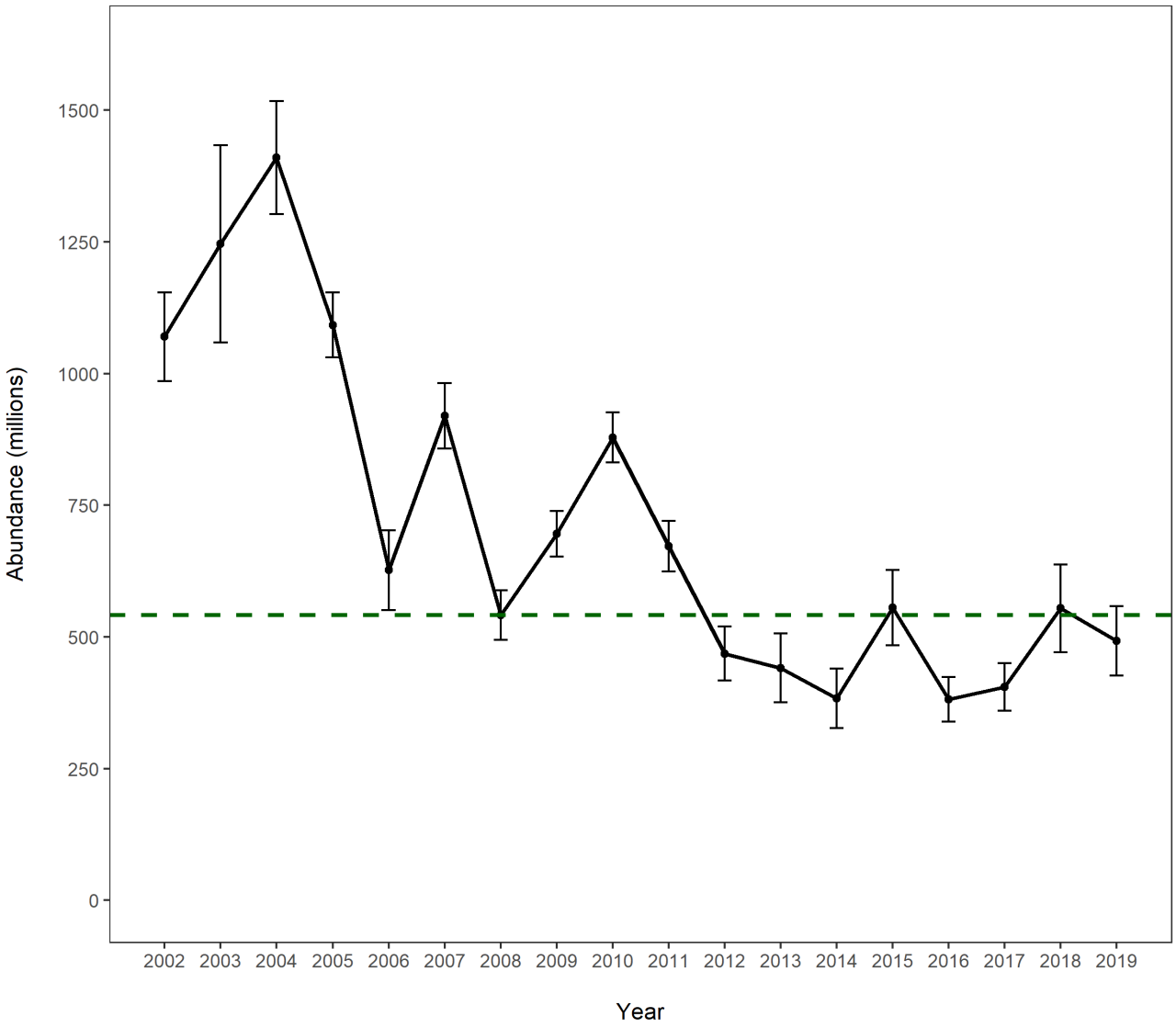

Figure 9: FU17 UWTV**.** Time series of total abundance estimates for FU17 (error bars indicate 95% confidence intervals) and $B_{trigger}$ (540 million) is dashed green line.

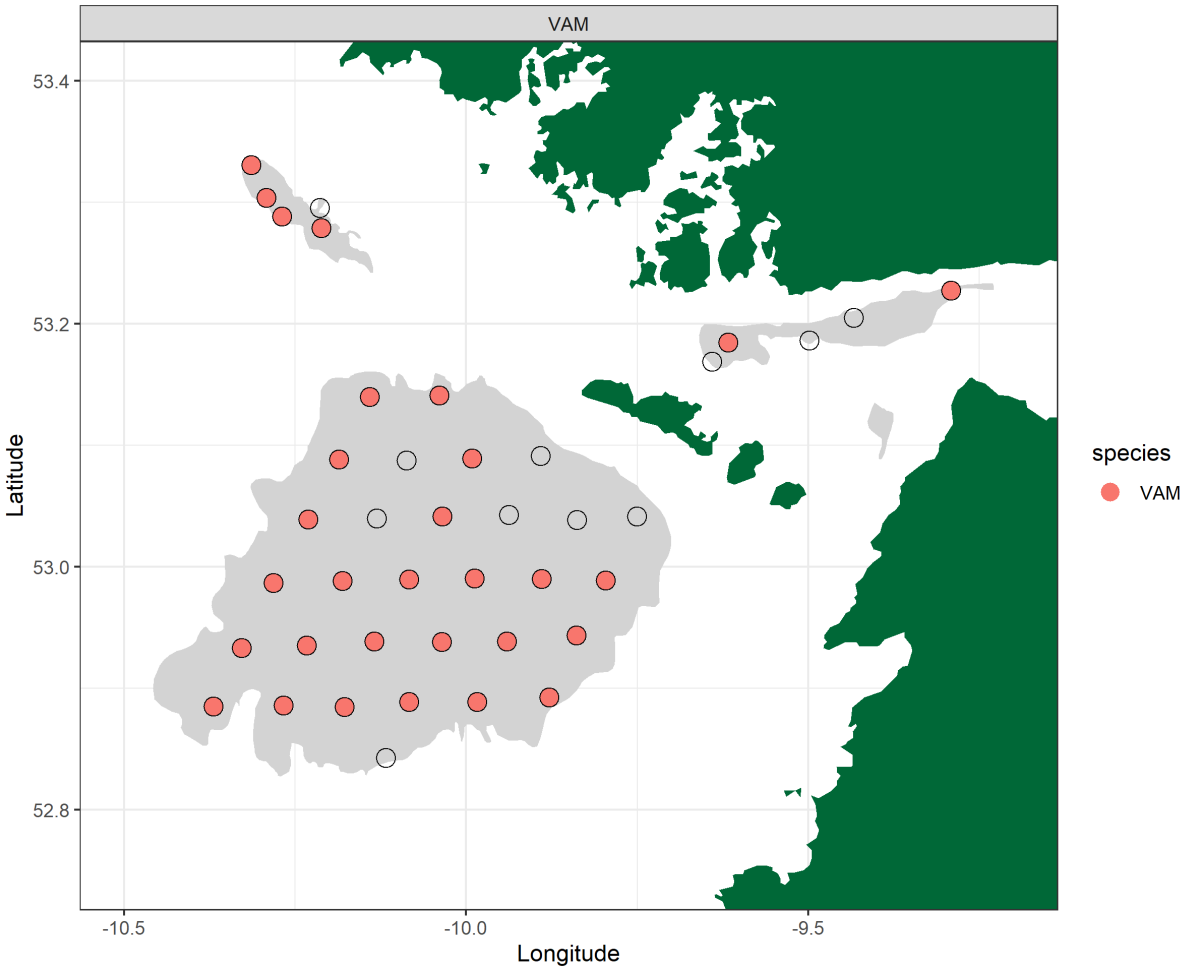

Figure 10: FU17 UWTV**.** 2019 stations where *Virgularia mirabilis* (VAM) were identified from video footage. Coloured circles denote presence in the TV station and empty circles denote TV stations with no sea-pen observations.

Table 1: FU17 UWTV**.** Area calculations for Aran grounds, Galway Bay and Slyne Head *Nephrops* grounds in ArcGIS10.

Ground	Area (km²)
Aran	1202
Galway Bay	79
Slyne Head	39.1
Total	1320.1

Table 2: FU17 UWTV**.** Overview Aran of geostatistical results from 2002-2019.

Year	Number of Stations	Mean Density (burrows/m²)	Estimation Standard Deviation	Area (km²)	Geostatistical abundance estimate (millions of Burrows)	CV on Burrow estimate %
2002	49	0.79	0.17	1196	947	3
2003	41	0.94	0.09	1196	1118	6
2004	64	1.08	0.27	1196	1297	3
2005	70	0.81	0.12	1196	972	2
2006	67	0.46	0.06	1196	556	3
2007	71	0.69	0.12	1196	828	2
2008	63	0.41	0.05	1196	494	3
2009	82	0.52	0.1	1196	627	2
2010	87	0.63	0.1	1196	752	2
2011	76	0.51	0.09	1196	609	2
2012	31*	0.33	0.03	1196	397	3
2013	31*	0.33	0.03	1196	390	4
2014	33*	0.28	0.03	1196	332	4
2015	34*	0.40	0.06	1197	480	4
2016	34*	0.29	0.03	1196	343	3
2017	31*	0.31	0.02	1196	377	4
2018	33*	0.40	0.05	1196	488	3
2019	31*	0.38	0.04	1196	458	4

* Reduced isometric grid

Table 3: FU17 UWTV**.** Summary statistics for the Galway Bay and Slyne Head *Nephrops* grounds from 2002-2019.

Year	Ground	Number of stations	Mean Adjusted Density (burrow/m²)	CViid (Relative SE) %	Area (km²)	Raised abundance estimate (million burrows)	Upper CI on abundance	Lower CI on abundance
2002	Galway Bay	7	1.18	7	78.966	93.1	105.9	80.3
2003	Galway Bay	3	1.3	16	78.966	102.6	155.7	49.6
2004	Galway Bay	8	1.17	14	78.966	92.2	119.1	65.3
2005	Galway Bay	4	1.3	11	78.966	103	130	76
2006	Galway Bay	3	0.74	9	78.966	58.8	90.4	27.2
2007	Galway Bay	5	0.91	8	78.966	71.8	89	54.6
2008	Galway Bay	5	0.4	4	78.966	31.6	39.9	23.3
2009	Galway Bay	8	0.71	4	78.966	56.3	64.6	48
2010	Galway Bay	10	1.24	11	78.966	97.6	116.5	78.7
2011	Galway Bay	6	0.55	12	78.966	43.2	67.1	19.4
2012	Galway Bay	4	0.64	10	78.966	50.9	76.9	24.9
2013	Galway Bay	5	0.37	10	78.966	29.6	52	7.2
2014	Galway Bay	3	0.5	6	78.966	39.8	60.6	19
2015	Galway Bay	5	0.71	15	78.966	55.8	88.8	22.8
2016	Galway Bay	7	0.32	7	78.966	25.1	41.8	8.4
2017	Galway Bay	5	0.20	4	78.966	15.8	25.4	6.1
2018	Galway Bay	5	0.41	17	78.966	32.5	70.5	-5.5
2019	Galway Bay	5	0.29	11	78.966	22.8	47.6	-2.0
2002	Slyne Head	5	0.76	8	39.146	29.8	38.9	20.7
2003*	Slyne Head	0	0.65	0	39.146	25.3	38.1	12.4
2004	Slyne Head	3	0.53	10	39.146	20.8	37.4	4.2
2005	Slyne Head	3	0.44	1	39.146	17.4	18.6	16.2
2006	Slyne Head	3	0.3	9	39.146	11.8	26.3	-2.6
2007	Slyne Head	4	0.51	12	39.146	19.8	34.3	5.3
2008*	Slyne Head	0	0.41	0	39.146	16	26.7	5.2
2009	Slyne Head	6	0.31	7	39.146	12.2	19.2	5.1
2010	Slyne Head	7	0.73	4	39.146	28.7	32.3	25.1
2011	Slyne Head	7	0.51	5	39.146	20	25.1	14.8
2012	Slyne Head	3	0.52	2	39.146	20.5	23.3	17.7
2013	Slyne Head	4	0.54	10	39.146	21.1	33.8	8.3
2014	Slyne Head	4	0.28	6	39.146	11	18.8	3.2
2015	Slyne Head	5	0.5	4	39.146	19.6	24	15.2
2016	Slyne Head	4	0.3	3	39.146	10.8	16.0	5.5
2017	Slyne Head	4	0.24	4	39.146	10.7	15.3	6.7
2018	Slyne Head	5	0.84	12	39.146	33.0	46.5	19.6
2019	Slyne Head	5	0.29	8	78.966	11.5	20.7	2.4

* mean density estimated

Table 4: FU17 UWTV**.** Results summary table for analysis of UWTV survey for the combined grounds.

Year	Abundance (Millions)	Upper bound	Lower bound
2002	1070	1154	985
2003	1246	1434	1059
2004	1410	1517	1302
2005	1092	1154	1030
2006	627	703	551
2007	920	982	858
2008	541	588	494
2009	696	739	653
2010	879	926	831
2011	672	720	624
2012	468	520	417
2013	441	506	376
2014	383	440	327
2015	556	627	484
2016	379	420	339
2017	404	445	362
2018	554	637	471
2019	493	558	427

Table 5: FU17 UWTV**.** Inputs to catch scenarios table.

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)	Landings	Total discards*	Discard proportion (by number)	Dead discard proportion (by number)	Mean weight in landings	Mean weight in discards
	Millions					%	tonnes		%		grams	
2002	1070	84	55	18	68	6.3	1154	192	24.5	19.6	21.2	10.8
2003	1246	187	44	18	58	4.6	933	183	29.3	23.7	21.2	10.0
2004	1410	108	29	11	38	2.7	525	112	28.2	22.9	18.1	9.9
2005	1092	62	42	20	57	5.2	778	182	31.7	25.9	18.4	9.2
2006	627	76	n/a	n/a	50	7.9	637	n/a	n/a	n/a	n/a	n/a
2007	920	62	n/a	n/a	57	6.2	913	n/a	n/a	n/a	n/a	n/a
2008	541	47	48	22	65	12.0	1057	248	31.4	25.6	21.94	11.23
2009	696	43	25	9	32	4.6	625	129	27.6	22.2	25.12	13.63
2010	879	47	37	15	49	5.6	939	224	29.0	23.4	25.16	14.70
2011	672	48	32	9	38	5.7	659	92	21.1	16.7	20.62	10.75
2012	468	52	61	8	67	14.4	1246	86	12.0	9.2	20.40	10.39
2013	441	65	60	12	69	15.7	1295	129	16.7	13.1	21.59	10.73
2014	383	57	34	5	38	9.8	766	48	12.9	10.0	22.62	9.56
2015	556	71	18	2	19	3.4	370	15	8.4	6.4	20.91	9.13
2016	379	41	30	6	35	9.2	641	69	17.4	13.7	21.21	10.85
2017	404	41	13	4	16	4.0	295	38	21.4	16.9	22.23	10.46
2018	554	83	22	10	30	5.4	536	106	32.2	26.3	24.33	10.11
2019	493	66										

Table 6: FU17 UWTV**.** The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2020)	493 million	UWTV survey 2019 (number of individuals).
Mean weight in wanted catch	22.4 g	Average 2008–2018.
Mean weight in unwanted catch	11.04 g	Average 2008–2018.
Unwanted catch	23.6%	Average 2016–2018 (proportion by number).
Discards survival	25.0%	Proportion by number.
Dead unwanted catch	18.9%	Average 2016–2018 (proportion by number).

Table 7: FU17 UWTV**.** 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 **
ICES advice basis							
MSY approach; F = EU MAP^: F_{MSY} × Stock Abundance 2019 / MSY $B_{trigger}$	800	773	694	80	27	7.8	-20
MAP $F_{MSY\ lower}$ × Stock Abundance 2019/MSY $B_{trigger}$	696	673	604	69	23	6.7	-31
MAP $F_{MSY\ upper}$ × Stock Abundance 2019/MSY $B_{trigger}$	800	773	694	80	27	7.8	-20
Other scenarios							
F = MAP F_{MSY}	877	848	761	87	29	8.5	-12.5
F = MAP $F_{MSY\ lower}$	764	738	662	76	25	7.4	-24
F = MAP $F_{MSY\ upper}$***	877	848	761	87	29	8.5	-12.5
F_{2018}	557	539	483	55	18	5.4	-44

^ EU multiannual plan (MAP) for Western Waters (EU, 2019).
* By number.
** Advice value for 2020 relative to advice value for 2019 (1002 tonnes).
*** $F_{MSY\ upper} = F_{MSY}$ for this stock.