Foras na Mara
Marine Institute

FU19 *Nephrops* Grounds 2022 UWTV Survey Report and catch scenarios for 2023.

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Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union
An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine
EUROPEAN MARITIME AND FISHERIES FUND

Abstract

This report provides the main results of the twelfth underwater television survey of the various *Nephrops* patches in Functional Unit 19. The survey was multi-disciplinary in nature collecting UWTV and other ecosystem data. In 2022 a total 42 UWTV stations were successfully completed. The mean density estimates varied considerably across the different patches. The 2022 raised abundance estimate showed a 4% decrease from the 2021 estimate and at 259 million burrows is below the MSY $B_{trigger}$ reference point (430 million). Using the 2022 estimate of abundance and updated stock data implies catch in 2023 that correspond to the F ranges in the EU multi annual plan for Western Waters are between 302 and 338 tonnes (assuming that discard rates and fishery selection patterns do not change from the average of 2019–2021). One species of sea pen was observed; *Virgularia mirabilis* which has been observed on previous surveys of FU19. Trawl marks were observed at 12% of the stations surveyed.

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

Suggested citation:

Doyle, J., Aristegui, M., Ryan, G., Bentley, K., Graham, J., Oliver, P., O'Brien, B., Sullivan, M., O'Connor, S., Kinneen, M., Sugrue, S., and Derbyshire, C. 2022. FU19 *Nephrops* Grounds 2022 UWTV Survey Report and catch scenarios for 2023. Marine Institute UWTV Survey report.

Introduction

Nephrops norvegicus are common in the Celtic Sea occurring in geographically distinct sandy/muddy areas were the sediment is suitable for them to construct their burrows. The *Nephrops* fishery in ICES sub-area 7 is extremely valuable with Irish landings in 2021 worth around €54 million at first sale. The Celtic Sea area (Functional Units 19-22) 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 reported landings from FU19 have been at around 520 t (ICES, 2022a). The *Nephrops* fishery in FU19 occurs on several spatially discrete patches of suitable habitat which are spread out over a large area (Figure 1).

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced by many factors; time of year, light intensity and tidal strength. Underwater television surveys and assessment methodologies have been developed to provide a fishery independent estimate of stock size, exploitation status and catch advice for several *Nephrops* stocks around Ireland (ICES, 2009a, 2009b, 2011).

The 2022 survey was multi-disciplinary in nature and also covered Underwater TV (UWTV) stations in FU17, FU20-21 and FU22 the results of which are presented elsewhere (Aristegui *et al.,* 2022, Doyle *et. al*., 2022a&b). The specific objectives of 2022 survey are listed below:

1. To obtain 2022 quality assured estimates of *Nephrops* burrow densities from several of the discrete mud patches of *Nephrops* ground in FU19.
2. To compare burrow density estimates with those made by 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.

This report details the UWTV results of the 2022 FU19 survey and also documents other data collected during the survey. Operational survey details are available in the form of a survey narrative from the scientists in charge. The 2022 abundances are used to generate catch scenarios for 2023 in line with the recommendations and procedures outlined in the stock annex for FU19 (ICES, 2022a).

Material and methods

The spatial extent of the *Nephrops* grounds in FU19 was defined using 2006-2014 integrated VMS-logbook data using the methods described in Gerritsen and Lordan (2011) along with multi-beam backscatter data from seabed mapping programmes (ICES, 2015). The discrete patches have been named as: Bantry Bay, Galley Grounds 1 to 4, Cork Channels and Helvick 1 & 2 (Figures 1 and 2). The area of each ground polygon is shown in Table 1 as defined by WKCELT (ICES, 2015). *Nephrops* also occur outside these defined polygons in areas such as Kenmare Bay, which was surveyed for the seventh time this year (2 stations completed). Two exploratory stations were also carried out in Dunmanus Bay in 2022.

In 2022 UWTV stations were randomly picked within each patch using the "spsample" function from the "R" library "sp" (Pebesma & Bivand, 2005) of "R" (R Core Team, 2017). The survey stations are shown in Figure 2. The sampling effort, i.e. the numbers of stations, on each ground were determined relative to the spatial extent of each patch, as in previous years.

The 2022 FU19 survey took place over two legs on RV. *Celtic Voyager*, from the 23rd May – 4th June and 6th – 17th June. Surveys in other years were generally between June to September.

In 2022 image data were collected by a custom built camera system recording High Definition (HD) 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 ashore through an in-house developed image annotation R Shiny app (Aristegui, M., 2020). This app allows each reviewer to annotate burrows for each randomly assigned station in an efficient manner. The survey process is now paperless.

The operational protocols used were those reviewed by WKNEPHTV 2007 (ICES, 2007) and follow internationally agreed standards as recommended in the Manual for the *Nephrops* Underwater TV Surveys (TIMES) (Dobby H., *et al*., 2021) on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (Leocádio A., *et al.,* 2018). These protocols are employed on other UWTV surveys in Irish waters and 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 HD image data with field of view or 'FOV' of 1.00 metre. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 3 seconds. The navigational data were quality controlled using an "R" script developed by the Marine Institute (ICES, 2009b). In 2022 the USBL navigational data was used to calculate distance over ground for 100% of the stations. Station depths ranged from 36 metres on the Helvick grounds to 106 metres on the Galley Grounds.

In line with recommendations of the Workshop on *Nephrops* Burrow Counting (WKNEPS), all scientists were trained/re-familiarised (ICES, 2018). All counts were conducted by trained scientists independent of each other onboard. The numbers of *Nephrops* burrows systems were counted, where multiple burrows in close proximity which appear to be part of a single system were counted as one. *Nephrops* activity in and out of burrows were counted and recorded for each station. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

Presence / absence for the occurrence of trawl marks, fish and other species were also recorded at each station. Presence / absence of sea-pen species were recorded to fulfil an OSPAR Special Request (ICES 2011).

Finally, if there was any time during each minute where counting was not possible due to sediment clouds or other reasons, this time was recorded and removed from the distance over ground calculations. An "R" quality control tool allowed for the data quality of navigation, speed, visual clarity and consistency in counts to be checked (an example is given in Figure 3).

In 2022 the survey count data were screened to check for any unusual discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a threshold of 0.5. Lin's CCC (Lin, 1989) measures the ability of counters to 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 count data for stations stations 282, 286 and 289 are 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. The USBL positional data was used to calculate distance over ground of the sledge. The field of view (FoV) of the camera at the bottom of the screen was estimated by extrapolation 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.

Mean density and summary statistics (number of stations, standard deviation, standard error, 95% confidence intervals and CV) were estimated for all stations. Mean density was multiplied by the total area given in Table 1 to estimate the raised abundance along with confidence intervals. All analysis was carried out using "R" (R Core Team, 2017). The same approach has been used since 2015. Prior to 2013 some other adjustments were made to account for incomplete survey coverage. Details of these are given in previous survey reports (Lordan, *et al.*, 2013).

Results

The summary statistics for the various discrete *Nephrops* patches within FU19 are given in Table 2. The 2022 mean adjusted[1] burrow density estimates vary considerably, from the lowest observed in Kenmare Bay of 0.04 (burrows/m²) to the highest of 0.39 (burrows/m²) in Galley Grounds 2. The mean density for most patches showed a decrease compared with 2021. Bubble plots of densities over the time-series by discrete patch show variability across the grounds and years (Figure 5). The adjusted burrow densities for each *Nephrops* patch from 2006 to 2022 are

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

shown in Figure 6 as violin and box plots. For most grounds the observed densities in 2022 were equivalent to or lower than those seen in the previous year.

The adjusted mean burrow densities for the combined FU19 grounds from 2006 to 2022 are shown in Figure 7. The 2022 mean density of 0.13 burrows/m^2 was 4% lower than 2021.

The time series of summary statistics for FU19 are given in Table 3. The 2022 raised abundance estimate of 259 million burrows is a 4% decrease from the 2021 estimate (Figure 8), and below the MSY $B_{trigger}$ reference point (430 million). The CV or RSE (relative standard error) for the 2022 survey was 14% which is below the upper limit of 20% recommended by SGNEPS (ICES, 2012).

Sea-pen distribution across the FU19 *Nephrops* grounds is mapped in Figure 9. One species; *Virgularia mirabilis* was identified from the image data. Trawl marks were noted at 12% 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 in 2021 of 8.9%. The mean weight in the landings and the discards and the proportions of removal retained are also shown (Table 4). The basis to the catch scenarios is 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, 2022a) using the 2022 survey abundance (Table 6). The latest estimate of stock abundance is below the MSY $B_{trigger}$ (value 430 million). The EU MAP and ICES MSY approach states that under such conditions the F_{MSY} harvest rate (9.3% for FU 19 Norway lobster) should be reduced by multiplying it by the ratio of the current abundance to MSY $B_{trigger.}$ This corresponds to a harvest rate of [9.3 × (259/430)] = 5.6% for the catch advice in 2023. Fishing at the EU MAP F ranges in 2023 would result in catches between 302 tonnes and 338 tonnes assuming that discard rates and fishery selection patterns do not change from the average of 2019–2021.

Discussion

The time series of UWTV survey information is developing for this Functional Unit. Several discrete mud patches with fished *Nephrops* populations have been identified and the survey coverage and precision since 2011 has been reasonable. It is clear that there are consistent differences in density in the different patches but most patches seem to vary annually in a similar way. Scientific knowledge of the spatial distribution of the *Nephrops* habitat in this area is developing thanks to new multi-beam data (www.infomar.ie), more extensive VMS data and information from the fishing industry particularly for inshore areas.

Nephrops fisheries in this area have been covered under the landings obligation since 2016 with several exemptions. Irish discard survival experiments indicate that

the trawl discard survival may be around 64% (BIM, 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. Discard rates for this FU are estimated to be relatively high at approximately 49% by number and 32% by weight in the last three years. The provision of catch advice and scenarios for 2023 based on the EU MAP (EU, 2019) F ranges assume that discarding will continue at the average rate estimated between 2019 and 2021.

The implementation of the landings obligation on *Nephrops* fisheries since 2016 should result in changes in selectivity in the fisheries with high discard rates like FU19. This is not taken into account in the catch advice because it is not possible to predict impacts exactly. 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 should 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, 2008).

Monitoring the occurrence and frequency of sea-pens observed on these *Nephrops* patches is important in the context of OSPAR's designation of sea-pen and burrowing megafauna communities as threatened. One sea-pen species: *Virgularia mirabilis* was seen in 2022. This sea-pen has been observed on previous surveys of FU19. Monitoring *Nephrops* stocks 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 twelfth time. The UWTV image data quality was excellent in 2022 and all of the *Nephrops* patches within FU19 were successfully surveyed. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

We would like to express our sincere thanks and gratitude to the Master and crew of the RV. *Celtic Voyager*. Thanks also to the P&O Maritime IT & Instrumentation Technician Ian Murphy who maintained the UWTV system throughout the survey. Thanks to Aodhán Fitzgerald, Rosemarie Butler and Tricia McManus (RVOPs) and Dave Tully (FEAS) at the Marine Institute for organising survey logistics. Thanks to Gordon Furey, Damian Crean, Barry Kavanagh, John Barry (P&O Maritime) for shore side support. Thanks to Chris Allsop (OCIS/FEAS) for supporting the UWTV database management.

Photography credits

Photograph used on the cover has been provided by © Marine Institute.

Disclaimer

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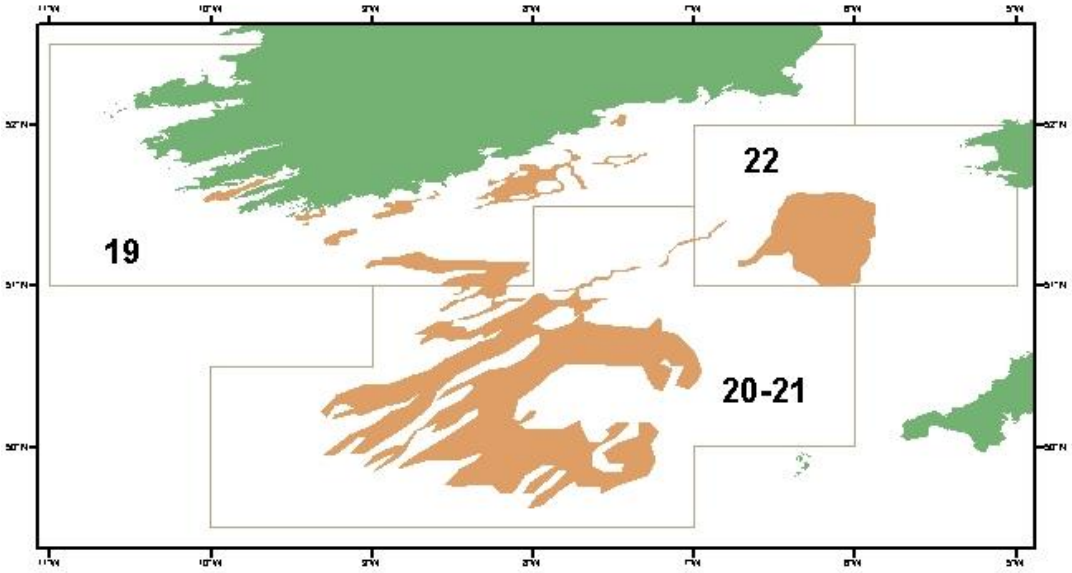


Figure 1: FU19 grounds: *Nephrops* Functional Units (FUs) and *Nephrops* grounds (area polygons) in the greater Celtic Sea.

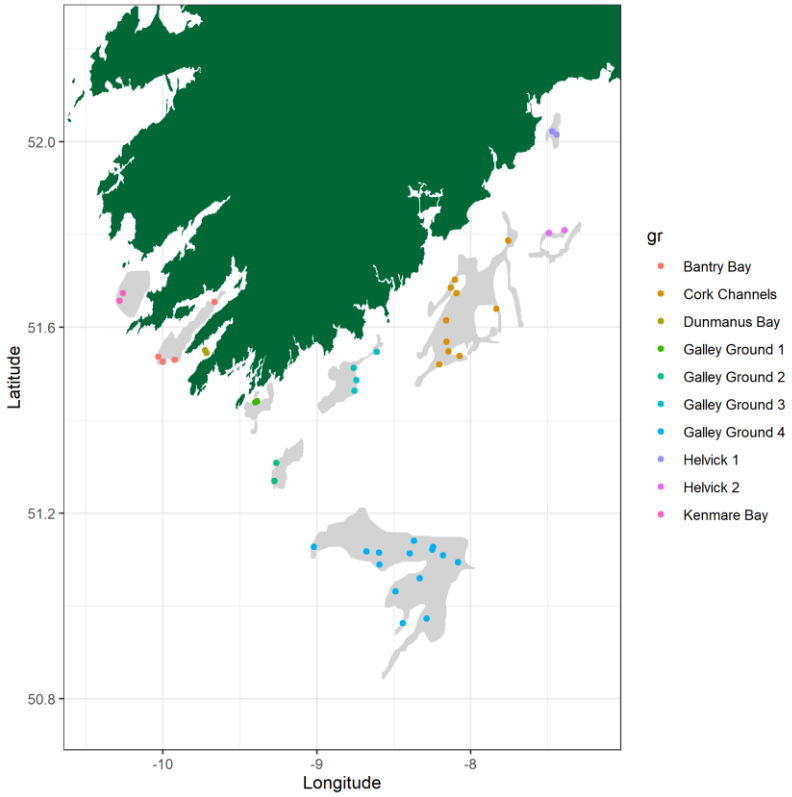


Figure 2: FU19 grounds: Stations planned and completed on the 2022 *Nephrops* UWTV survey by individual ground.

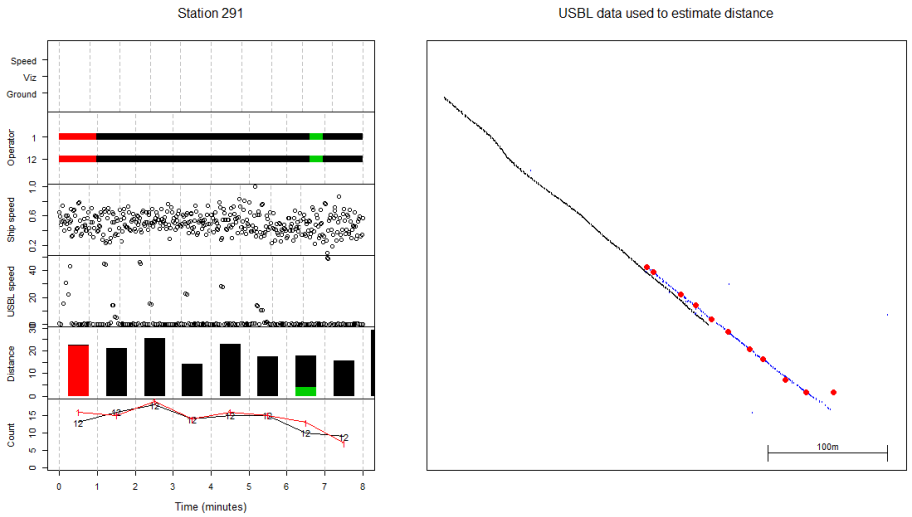
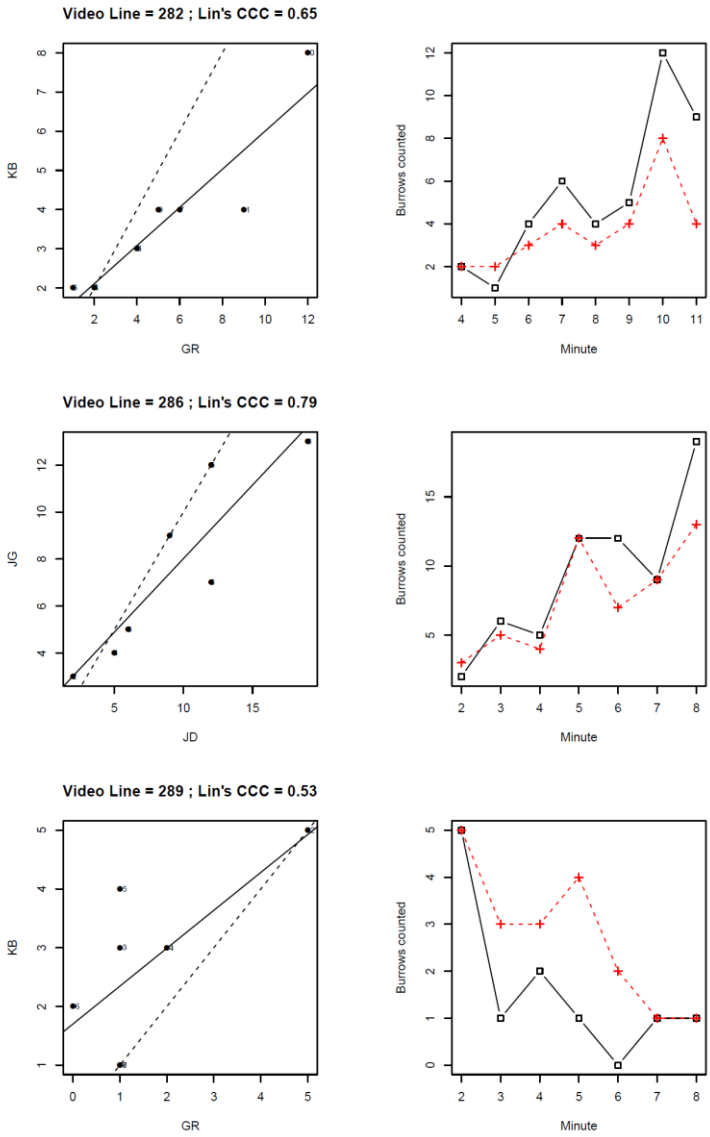


Figure 3: FU19 grounds: R - tool quality control plot for station 291 of the 2022UWTV survey.



-**Figure 4**: FU19 grounds: Lin's CCC quality control plot of count data for stations 282, 286 and 289 of the 2022 survey.

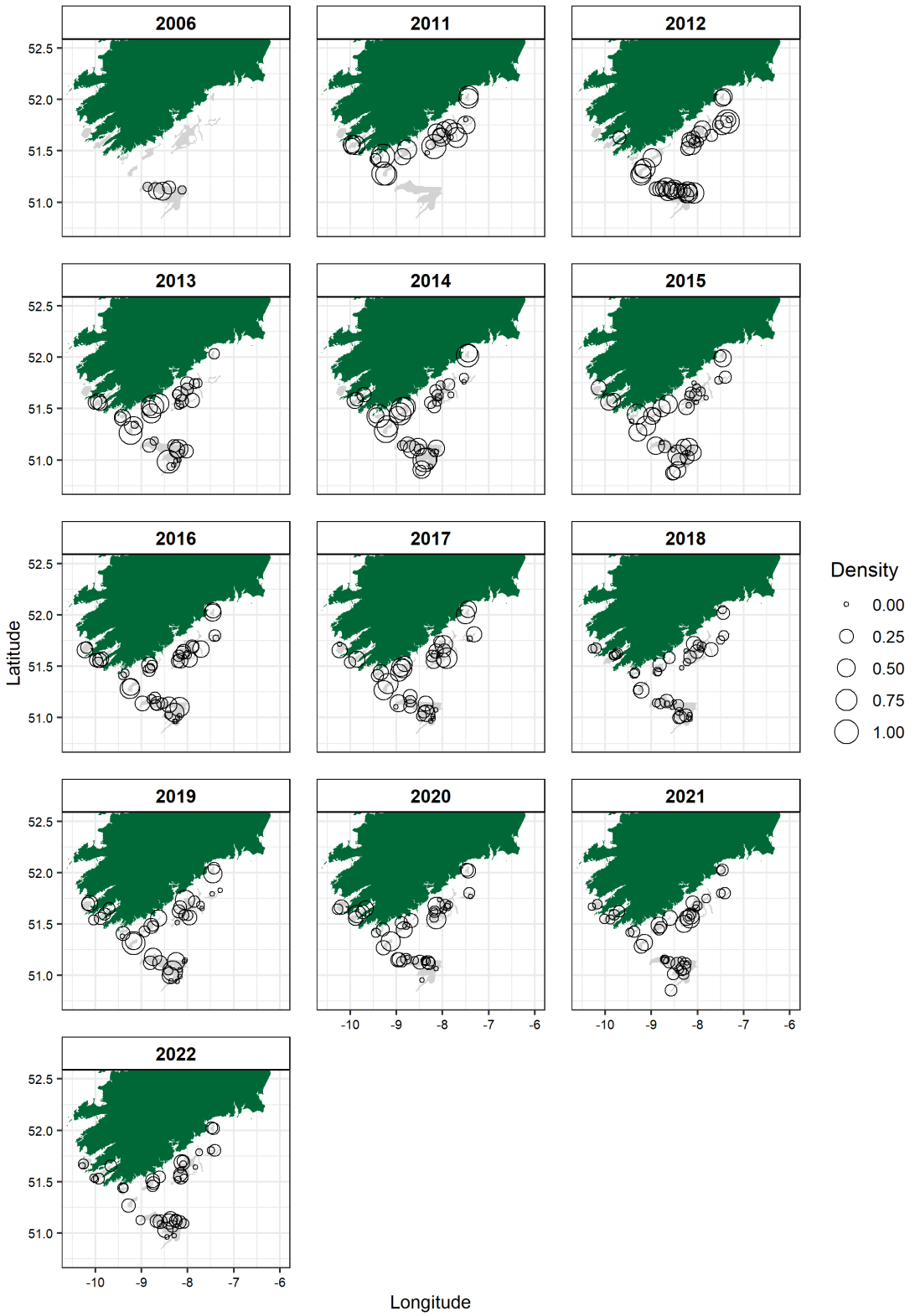


Figure 5: FU19 grounds: Bubble plot of the adjusted density (burrows/m²) from 2006 to 2022.

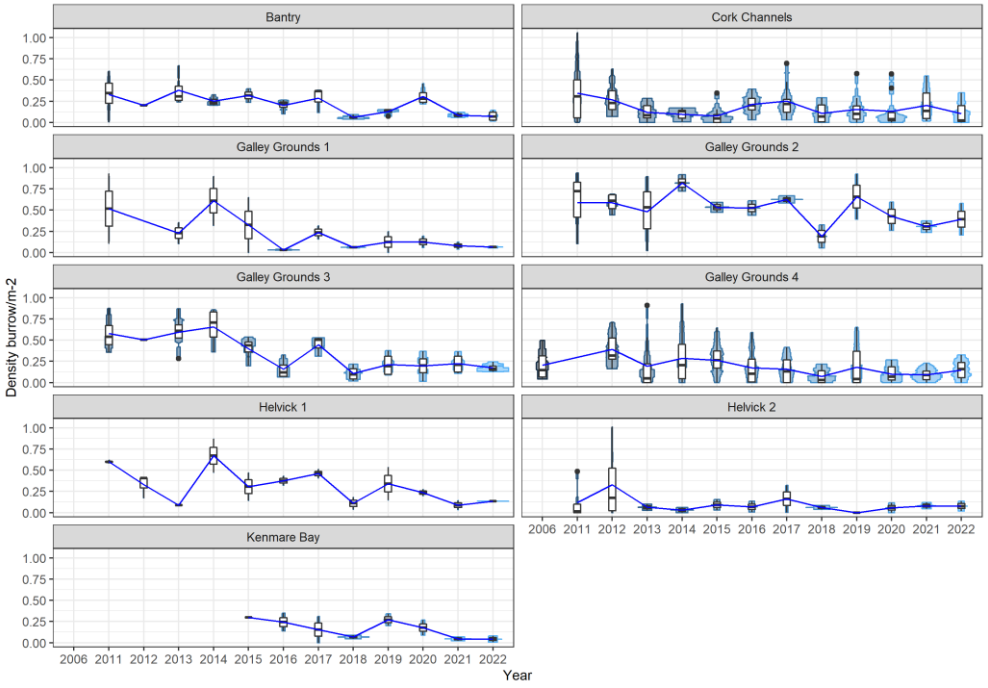


Figure 6: FU19 grounds: Violin and box plots of adjusted burrow density distributions by year for 2006-2022 for each ground. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers. No TV survey from 2007 – 2010.

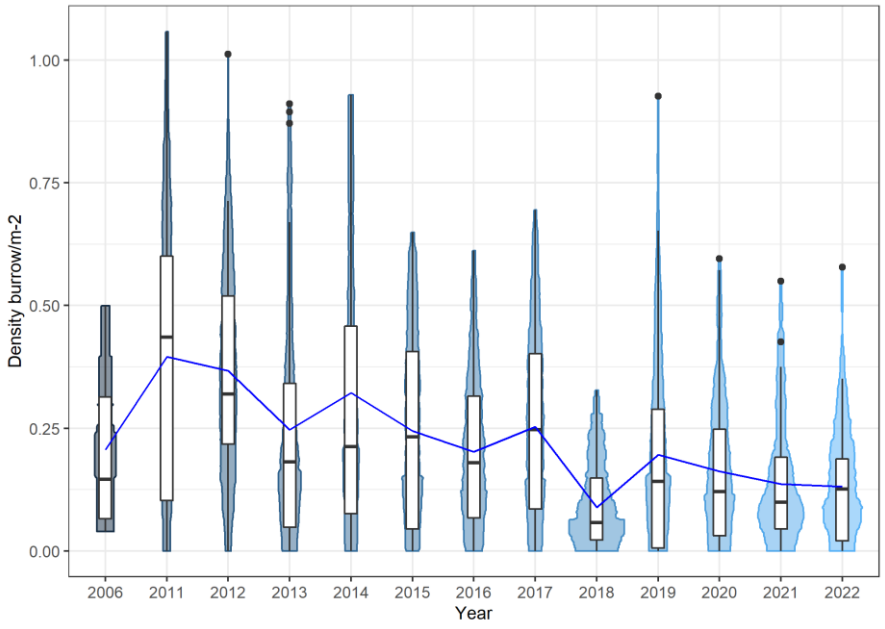


Figure 7: FU19 grounds: Combined violin and box plot of adjusted burrow density distributions by year for 2006-2022. The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers. No TV survey from 2007 – 2010.

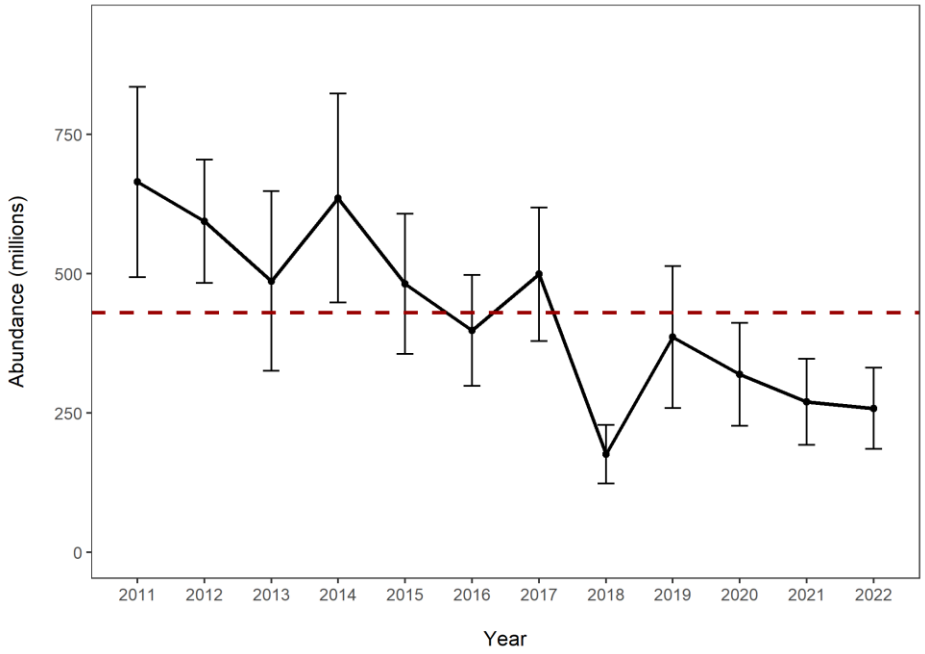


Figure 8: FU19 grounds: Time series of raised abundance estimates (in millions of burrows) for FU19. No survey data from 2007 to 2010. The error bars indicate the 95% confidence intervals and MSY $B_{trigger}$ reference point is dashed line.

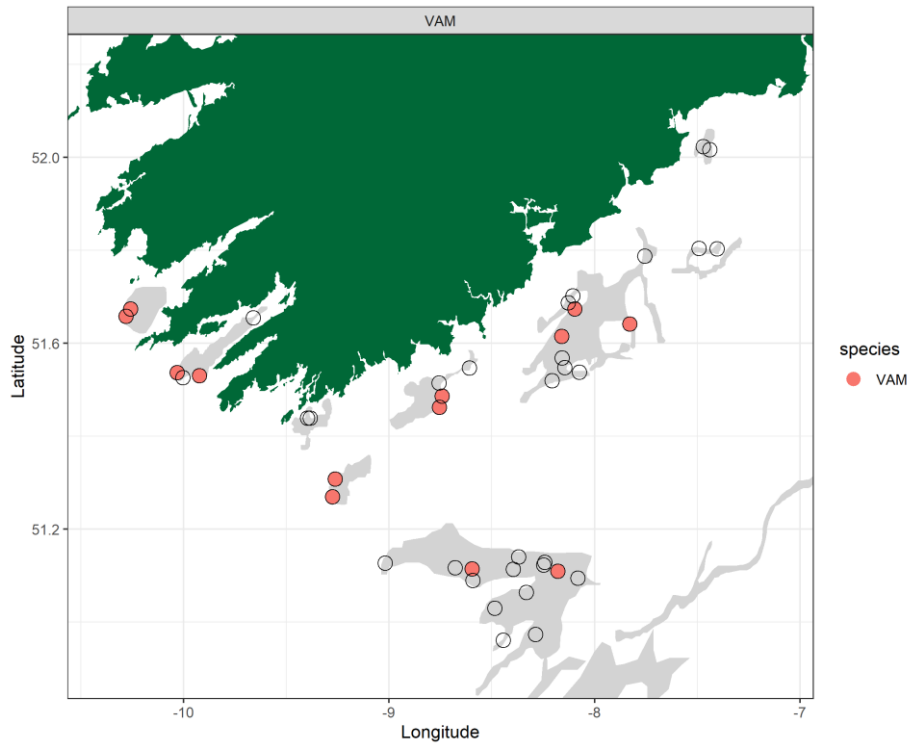


Figure 9: FU19 grounds: 2022 stations where *Virgularia mirabilis* (VAM) was identified and noted as present or absent. Closed circles indicated presence and open circles denote TV stations with no sea-pen observations.

Table 1: FU19 grounds: Area calculations for the various *Nephrops* grounds in FU19 (ICES, 2014).

Ground Name	Area (km²)
Bantry	121.52
Cork Channels	562.01
Galley Grounds 1	60.86
Galley Grounds 2	76.74
Galley Grounds 3	133.94
Galley Grounds 4	925.10
Helvick 1	33.09
Helvick 2	59.52
Total	1,972.78

Table 2: FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (burrows/m²) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (burrows/m²)	sd	se	ci
2006	Galley Grounds 4	6	0.21	0.18	0.08	0.19
2011	Bantry	5	0.33	0.23	0.1	0.28
2011	Cork Channels	12	0.35	0.32	0.09	0.2
2011	Galley Grounds 1	3	0.52	0.41	0.24	1.02
2011	Galley Grounds 2	3	0.59	0.43	0.25	1.07
2011	Galley Grounds 3	4	0.58	0.22	0.11	0.35
2011	Helvick 1	3	0.6	0.01	0.01	0.04
2011	Helvick 2	5	0.12	0.21	0.09	0.26
2012	Bantry	1	0.2	NA	NA	NA
2012	Cork Channels	9	0.27	0.17	0.06	0.13
2012	Galley Grounds 2	4	0.59	0.12	0.06	0.19
2012	Galley Grounds 3	1	0.51	NA	NA	NA
2012	Galley Grounds 4	16	0.39	0.16	0.04	0.09
2012	Helvick 1	3	0.33	0.13	0.08	0.33
2012	Helvick 2	6	0.33	0.41	0.17	0.43
2013	Bantry	4	0.38	0.2	0.1	0.31
2013	Cork Channels	11	0.12	0.1	0.03	0.07
2013	Galley Grounds 1	2	0.23	0.18	0.13	1.59
2013	Galley Grounds 2	3	0.48	0.44	0.25	1.09
2013	Galley Grounds 3	4	0.59	0.24	0.12	0.38
2013	Galley Grounds 4	13	0.19	0.27	0.07	0.16
2013	Helvick 1	1	0.09	NA	NA	NA
2013	Helvick 2	2	0.06	0.05	0.04	0.48
2014	Bantry	4	0.25	0.05	0.03	0.09
2014	Cork Channels	10	0.1	0.06	0.02	0.04
2014	Galley Grounds 1	2	0.61	0.41	0.29	3.69
2014	Galley Grounds 2	2	0.82	0.14	0.1	1.23
2014	Galley Grounds 3	4	0.66	0.23	0.12	0.37
2014	Galley Grounds 4	14	0.29	0.29	0.08	0.17
2014	Helvick 1	2	0.67	0.28	0.2	2.53
2014	Helvick 2	2	0.03	0.04	0.03	0.39
2015	Bantry	2	0.32	0.11	0.08	1.02
2015	Cork Channels	10	0.08	0.11	0.03	0.08
2015	Galley Grounds 1	2	0.32	0.46	0.32	4.12
2015	Galley Grounds 2	2	0.53	0.08	0.06	0.74

Table 2 (cont.): FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (burrows/m²) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (burrows/m²)	sd	se	ci
2015	Galley Grounds 3	4	0.4	0.14	0.07	0.23
2015	Galley Grounds 4	14	0.27	0.19	0.05	0.11
2015	Helvick 1	2	0.3	0.23	0.16	2.08
2015	Helvick 2	2	0.09	0.09	0.06	0.79
2015	Kenmare Bay	1	0.3	NA	NA	NA
2016	Bantry	4	0.2	0.07	0.04	0.12
2016	Cork Channels	10	0.21	0.11	0.03	0.08
2016	Galley Grounds 1	2	0.03	0.01	0.01	0.08
2016	Galley Grounds 2	2	0.53	0.12	0.09	1.11
2016	Galley Grounds 3	4	0.16	0.12	0.06	0.19
2016	Galley Grounds 4	14	0.17	0.2	0.05	0.12
2016	Helvick 1	2	0.38	0.08	0.06	0.7
2016	Helvick 2	2	0.07	0.09	0.06	0.81
2016	Kenmare Bay	2	0.24	0.15	0.11	1.33
2017	Bantry	3	0.29	0.15	0.09	0.37
2017	Cork Channels	10	0.25	0.20	0.06	0.14
2017	Galley Grounds 1	2	0.24	0.11	0.08	1.00
2017	Galley Grounds 2	2	0.63	0.06	0.04	0.55
2017	Galley Grounds 3	3	0.45	0.12	0.07	0.30
2017	Galley Grounds 4	15	0.16	0.16	0.04	0.09
2017	Helvick 1	2	0.46	0.07	0.05	0.66
2017	Helvick 2	2	0.16	0.23	0.16	2.03
2017	Kenmare Bay	2	0.16	0.22	0.16	1.97
2018	Bantry	4	0.06	0.02	0.01	0.04
2018	Cork Channels	10	0.11	0.11	0.04	0.08
2018	Galley Grounds 1	2	0.06	0.01	0.01	0.10
2018	Galley Grounds 2	2	0.19	0.19	0.14	1.75
2018	Galley Grounds 3	4	0.11	0.09	0.05	0.14
2018	Galley Grounds 4	14	0.07	0.08	0.02	0.05
2018	Helvick 1	2	0.11	0.10	0.07	0.92
2018	Helvick 2	2	0.06	0.03	0.02	0.28
2018	Kenmare Bay	2	0.07	0.03	0.02	0.25
2019	Bantry	4	0.13	0.04	0.02	0.06
2019	Cork Channels	10	0.16	0.17	0.06	0.13
2019	Galley Grounds 1	2	0.12	0.17	0.12	1.57
2019	Galley Grounds 2	2	0.66	0.38	0.27	3.40
2019	Galley Grounds 3	4	0.21	0.14	0.07	0.23
2019	Galley Grounds 4	14	0.18	0.23	0.06	0.13
2019	Helvick 1	2	0.34	0.27	0.19	2.46

Table 2 (cont.): FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (burrows/m²) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (burrows/m²)	sd	se	ci
2019	Helvick 2	2	0	0	0	0
2019	Kenmare Bay	2	0.27	0.10	0.07	0.88
2019	Dunmanus Bay*	2	0	0	0	0
2020	Bantry	4	0.31	0.11	0.05	0.17
2020	Cork Channels	10	0.13	0.20	0.06	0.14
2020	Galley Grounds 1	2	0.13	0.10	0.07	0.87
2020	Galley Grounds 2	2	0.43	0.24	0.17	2.14
2020	Galley Grounds 3	4	0.20	0.15	0.08	0.24
2020	Galley Grounds 4	14	0.10	0.10	0.03	0.06
2020	Helvick 1	2	0.24	0.05	0.04	0.48
2020	Helvick 2	2	0.06	0.08	0.06	0.73
2020	Kenmare Bay	2	0.18	0.12	0.09	1.11
2021	Bantry	4	0.09	0.03	0.01	0.04
2021	Cork Channels	10	0.20	0.19	0.06	0.14
2021	Galley Grounds 1	2	0.08	0.06	0.04	0.54
2021	Galley Grounds 2	2	0.31	0.10	0.07	0.87
2021	Galley Grounds 3	4	0.22	0.13	0.06	0.20
2021	Galley Grounds 4	14	0.09	0.07	0.02	0.04
2021	Helvick 1	2	0.09	0.08	0.05	0.69
2021	Helvick 2	2	0.08	0.05	0.04	0.48
2021	Kenmare Bay	2	0.05	0.03	0.02	0.30
2022	Bantry	4	0.08	0.06	0.03	0.10
2022	Cork Channels	10	0.10	0.13	0.04	0.09
2022	Galley Grounds 1	2	0.06	0.01	0.01	0.13
2022	Galley Grounds 2	2	0.39	0.26	0.19	2.35
2022	Galley Grounds 3	4	0.17	0.05	0.03	0.08
2022	Galley Grounds 4	14	0.15	0.11	0.03	0.07
2022	Helvick 1	2	0.14	0.00	0.00	0.02
2022	Helvick 2	2	0.08	0.08	0.06	0.74
2022	Kenmare Bay	2	0.04	0.05	0.04	0.46

*exploratory stations

Table 3: FU19 grounds: Final of results for UWTV surveys in FU19 for 2006-2022. No UWTV survey in years 2007 to 2010.

FU	Year	Number of stations	Mean Density adjusted (burrow /m²)	Standard Deviation	Raised abundance estimate adjusted (million burrows)	Upper 95%CI on Abundance	Lower 95%CI on Abundance	CVs (%)
FU19	2006	6	0.21	0.18	408	789	26	36
	2007				No Survey Data			
	2008							
	2009							
	2010							
	2011	35	0.34	0.26	665	836	494	13
	2012	40	0.3	0.18	594	705	484	9
	2013	40	0.25	0.26	487	648	326	17
	2014	40	0.32	0.31	636	823	448	15
	2015	39	0.24	0.2	482	608	356	13
	2016	42	0.2	0.17	399	498	299	13
	2017	41	0.25	0.20	499	619	379	12
	2018	42	0.09	0.09	176	229	124	15
	2019	42	0.20	0.21	386	514	259	17
	2020	42	0.16	0.16	320	412	227	15
	2021	42	0.14	0.13	270	347	193	15
	2022	42	0.13	0.12	259	332	185	14

Table 4: FU19 grounds: Inputs to catch scenarios table.

Year	low	UWTV abundance estimate	high	Landings in number	Total discards in number *	Removals in number	Harvest rate (by number)	Landings	Total discards *	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
		millions					%	tonnes		%		grammes	
2008				25	5	29		851	105	17.7	13.9	33.7	19.4
2009				28	19	42		868	269	40	33	30.5	14.5
2010				23	19	37		687	257	45	38	29.6	13.5
2011	494	665	836	26	32	50	7.5	643	409	56	49	24.9	12.6
2012	484	594	705	32	37	60	10.1	849	473	54	46	26.3	12.7
2013	326	487	648	29	36	57	11.7	794	436	55	48	26.9	11.9
2014	448	636	823	16	11	25	3.9	468	161	41	34	28.6	14.1
2015	356	482	608	17	12	26	5.4	507	167	41	34	29.8	14.1
2016	299	399	498	20	14	30	7.5	590	193	41	34	29.9	14.2
2017	379	499	619	15	10	22	4.4	420	139	40	33	28.8	14.5
2018	124	176	229	8	4	11	6.7	238	71	35	29	28.2	15.7
2019	259	386	514	9	8	15	4.0	249	112	48	41	27.4	13.3
2020	227	320	412	10	10	17	5.4	249	136	51	44	25.8	13.5
2021	193	270	347	15	13	24	8.9	415	173	46	39	28.5	13.6
2022	185	259	332										

* Dead + surviving discards.

Table 5: FU19 grounds: The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2023)	259	UWTV survey 2022; individuals in millions
Mean weight in projected landings	27.2	Average 2019 – 2021; grammes
Mean weight in projected discards	13.5	Average 2019 – 2021; grammes
Projected discards	48.6	Average 2019 – 2021; percentage by number of the total catch
Discards survival*	25	Proportion by number of the discards

Table 6: Catch advice and scenarios for 2023. Discarding assumed to continue at recent average. All weights are in tonnes.

Basis	Total catch	Dead removals	Projected landings	Projected dead discards	Projected surviving discards	% harvest rate*	% advice change **
	PL + PDD + PSD	PL + PDD	PL	PDD	PSD	for PL + PDD	
ICES advice basis							
EU MAP^: F_{MSY} × Stock abundance 2023 / MSY $B_{trigger}$	338	311	230	81	27	5.6	−10.6
EU MAP^: $F_{MSY\ lower}$ × Stock abundance 2023 / MSY $B_{trigger}$	302	278	206	72	24	5.0	−10.4
Other scenarios							
$F_{MSY\ upper}$ × Stock abundance 2023 / MSY $B_{trigger}$***	338	311	230	81	27	5.6	−10.6
F_{MSY}	562	517	383	134	45	9.3	−49
$F_{MSY\ lower}$	502	462	342	120	40	8.3	−33
$F_{MSY\ upper}$***	562	517	383	134	45	9.3	−49
F_{2021}	539	496	367	129	43	8.9	−43

* By number.

** Advice values for 2023 relative to the corresponding 2022 values (MAP advice of 378, 337, and 378 tonnes, respectively); other option values are relative to 378 tonnes.

*** $F_{MSY\ upper} = F_{MSY}$ for this stock.

^ EU multiannual plan (MAP) for the Western Waters (EU, 2019).