WORKING GROUP ON NEPHROPS SURVEYS (WGNEPS; outputs from 2023 meeting)

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Contents

i Executive summary

The Working Group on *Nephrops* Surveys (WGNEPS) is the international coordination group for *Nephrops* underwater television and trawl surveys within ICES. This report summarizes the national contributions on the results of the surveys conducted in 2023 together with time series covering all survey years, problems encountered, data quality checks and technological improvements as well as the planning for survey activities for 2024.

In total, 24 surveys covering 27 functional units (FU's) in the ICES area and 1 geographical subarea (GSA) in the Adriatic Sea were discussed and further improvements in respect to survey design and data analysis standardization and the use of most recent technology were reviewed.

The group agreed to hold a workshop in 2025 to address burrow size estimations to update correction factors and terms of reference for this to be agreed at next meeting.

Automatic burrow detection based on deep learning methods continues to show promising results where datasets from multiple institutes were used.

Plans are being progressed for an international *Nephrops* UWTV database to be established at the ICES data centre with a sub-group.

ii Expert group information

Expert group name	Working Group on Nephrops Surveys (WGNEPS)
Expert group cycle	Multiannual fixed term
Year cycle started	2022
Reporting year in cycle	2/3
Chair(s)	Jónas Jónasson, Iceland
Meeting venue(s) and dates	15-17 November 2022, Cádiz, Spain (24 participants)
	12-14 December 2023, Barcelona, Spain (23 participants)
	19-21 November 2024, Edinburgh, United Kingdom

1 Survey coordination (ToR a)

The 2023 meeting was the second hybrid (MS Teams) meeting held in Barcelona, Spain since the pandemic. In total, 24 surveys covering 27 functional units (FU's) in the ICES area and 1 geographical subarea (GSA) in the Adriatic Sea (Figure. 1.1) were discussed and further improvements in respect to survey design and data analysis, standardization and the use of most recent technology were reviewed. Survey details for each FU/ GSA are provided in annex 3.

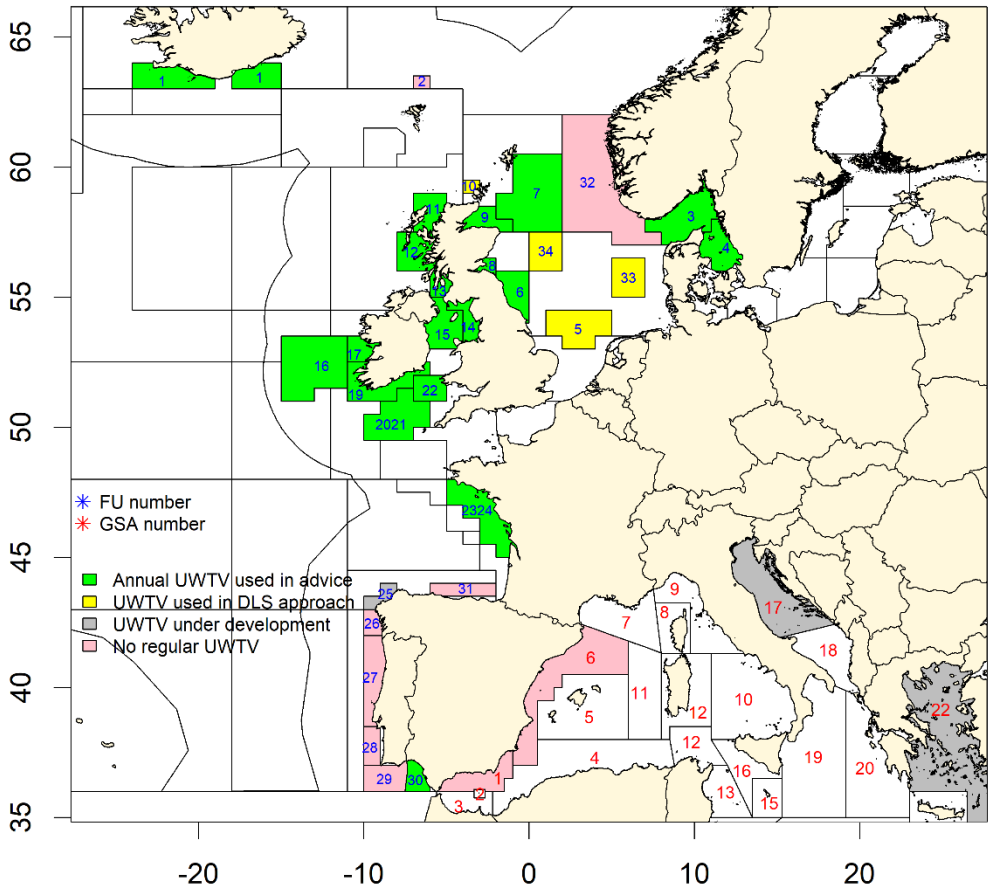


Figure. 1.1 Nephrops UWTV survey areas and use in stock assessment (FU: Functional Unit, GSA: Geographical Sub Area, DLS: Data Limited Stock).

There were some disruptions to 2023 survey operations, and these are summarised below:

- Only few UWTV stations were carried out in Pomo Pits GSA 17 during 2023.

Survey series by Functional Unit / GSA are shown in Figure 1.2. Tentative survey schedule for 2024 is given in Figure. 1.3. Time series of *Nephrops* abundance estimates for the FU's are shown in Figure. 1.4a-d.

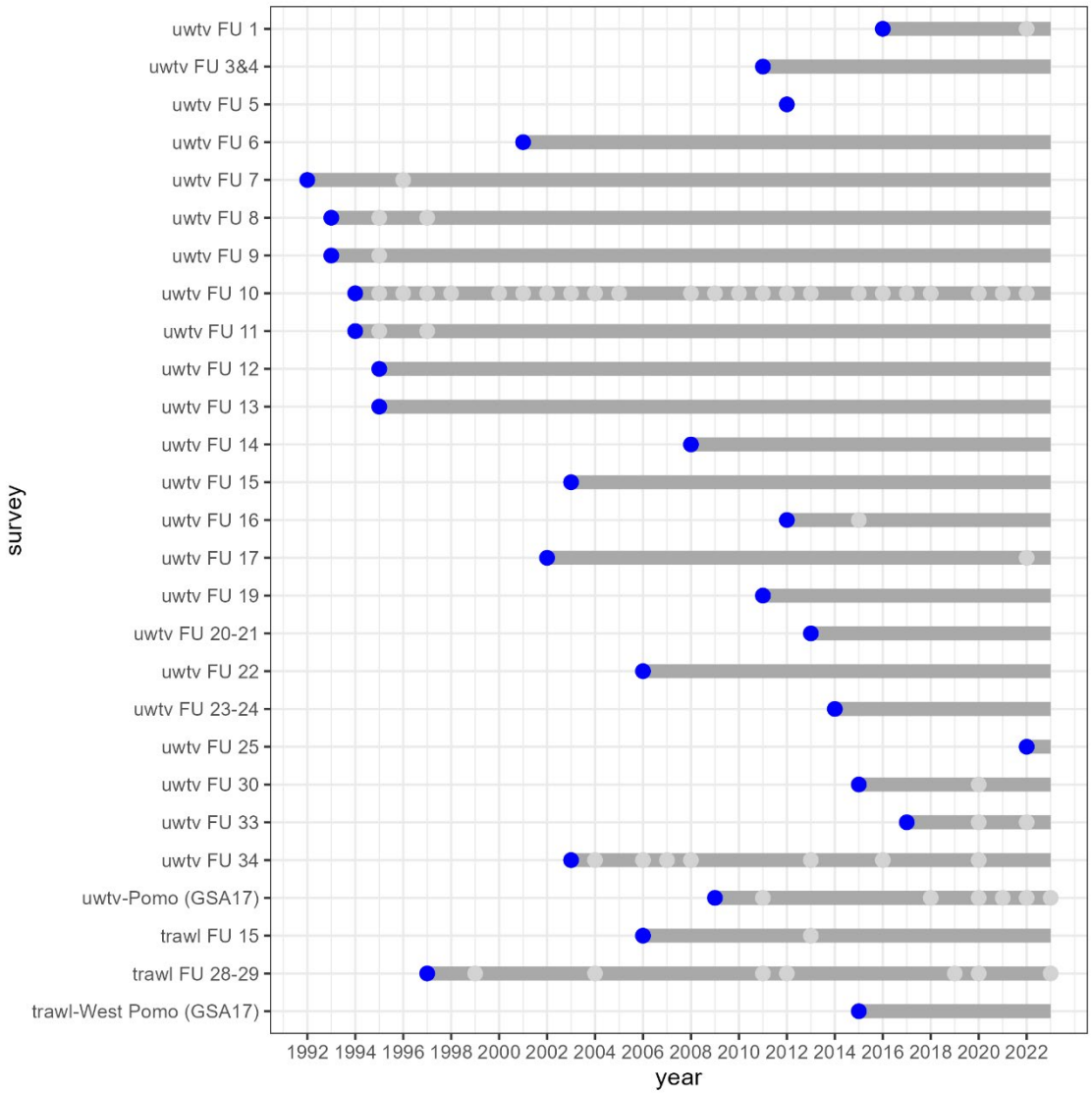


Figure. 1.2 Survey series by Nephrops Functional Units / GSA. Blue dot indicates first year of survey, light grey dot indicates year in which survey was not conducted and grey line shows the survey series.

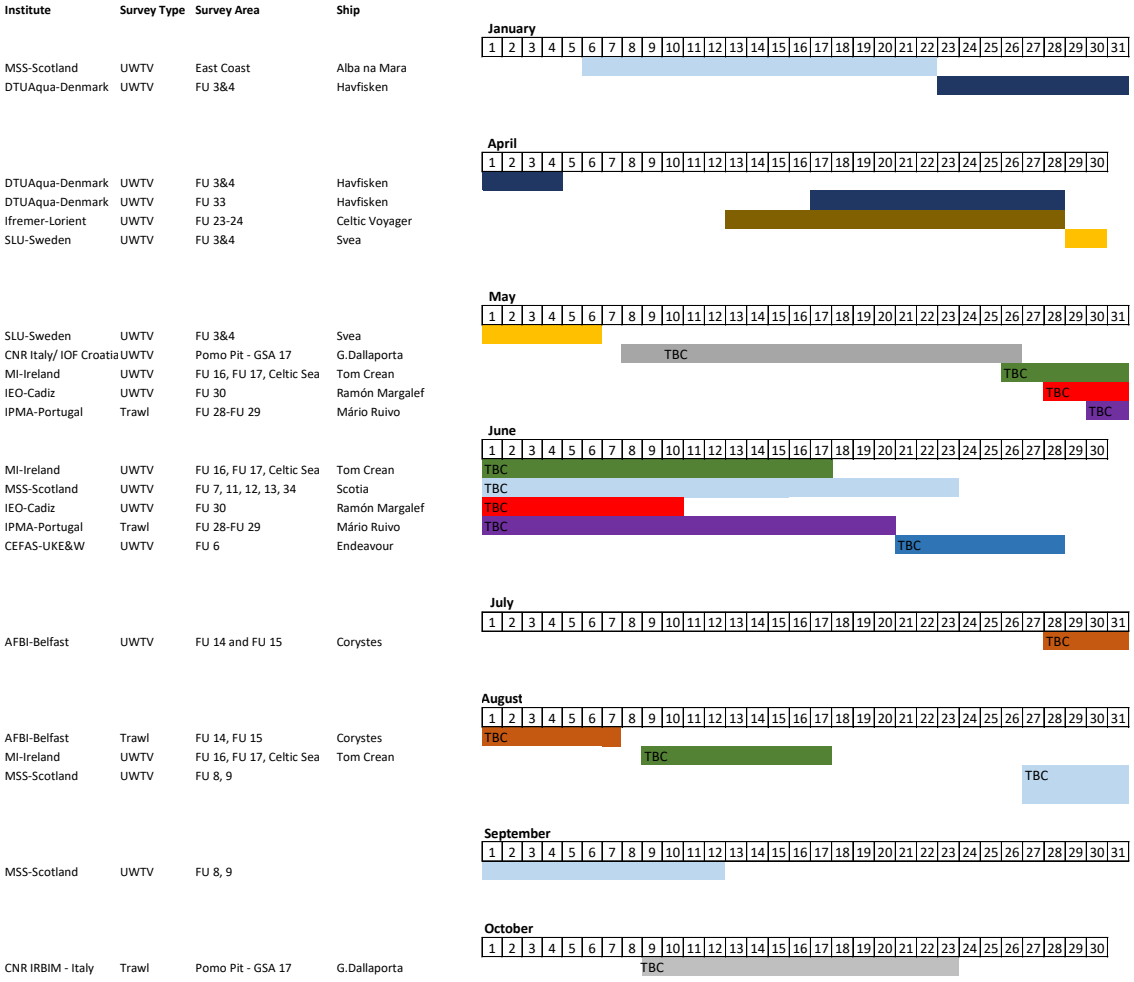


Figure. 1.3 Nephrops survey schedule for 2023. [Update]

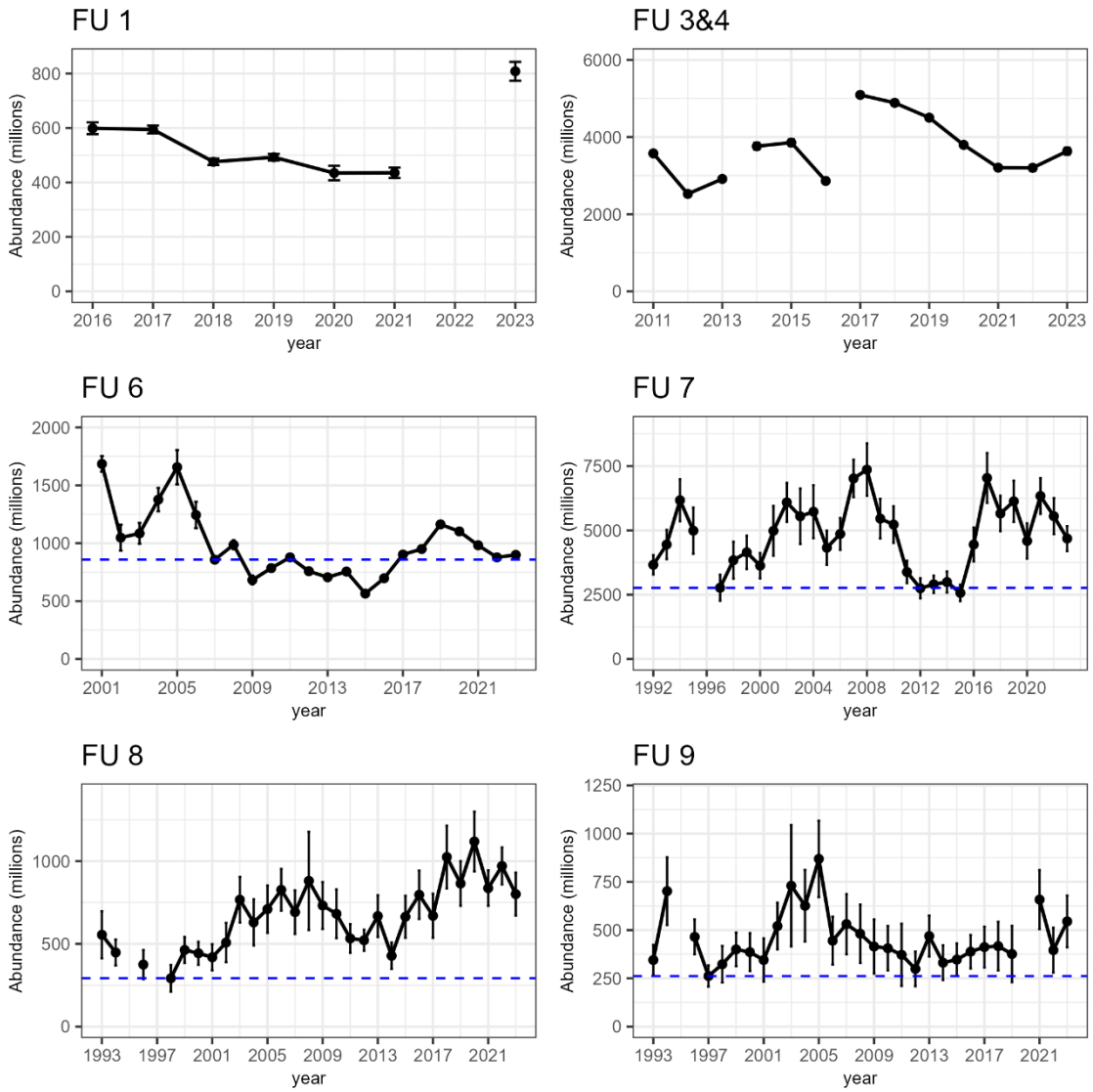


Figure. 1.4a. *Nephrops* abundance (with 95 % confidence interval) in FU 1, FU 3&4 (breaks indicate extension of the survey area), FU 6 to FU 9. Dashed line shows proxy for ICES MSY reference point $B_{trigger}$..

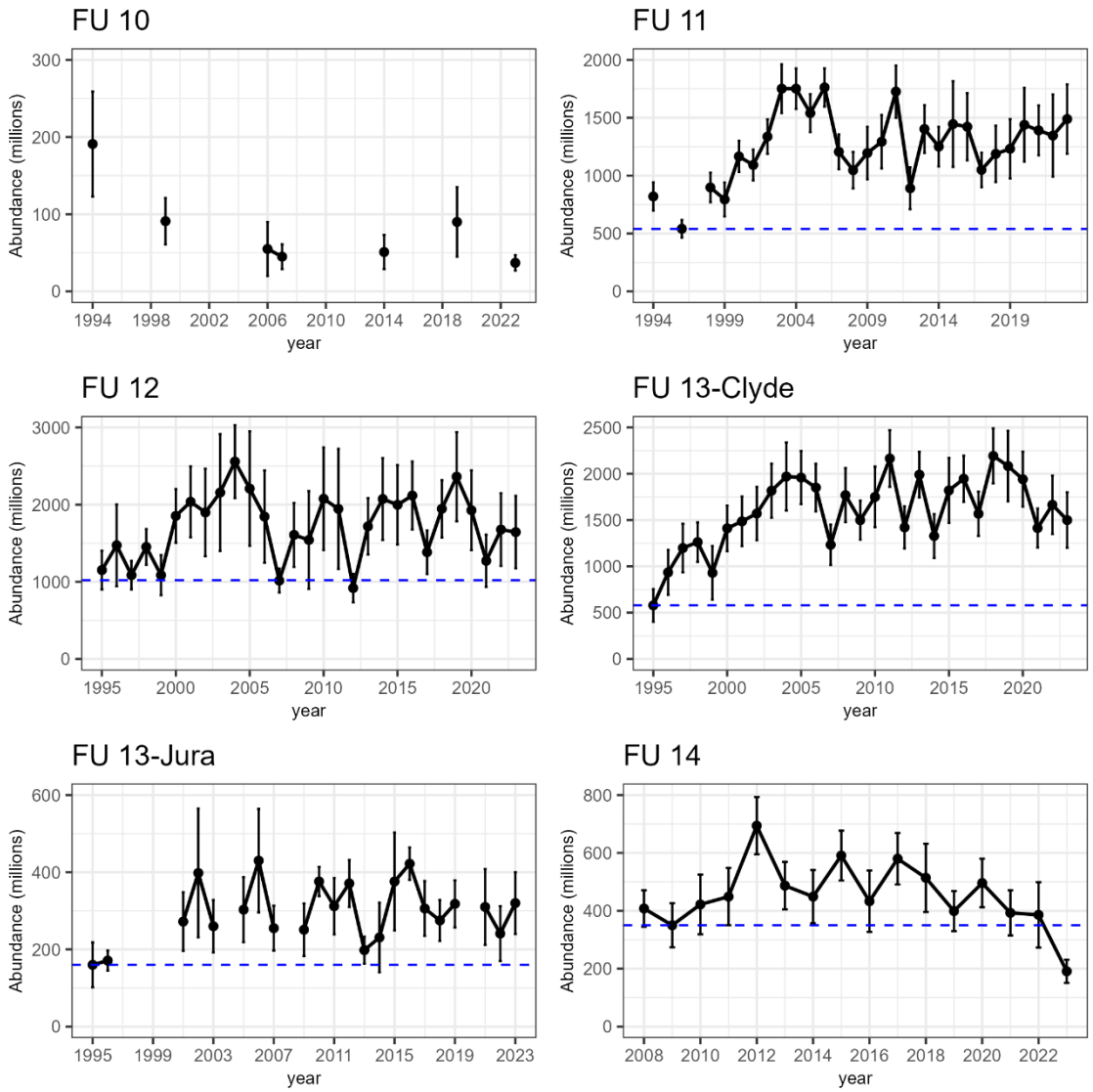


Figure. 1.4b *Nephrops* abundance (with 95 % confidence interval) in FU 10, FU 11, FU 12, FU 13-Clyde , FU 13-Jura and FU 14. Dashed line shows proxy for ICES MSY reference point $B_{trigger}$.

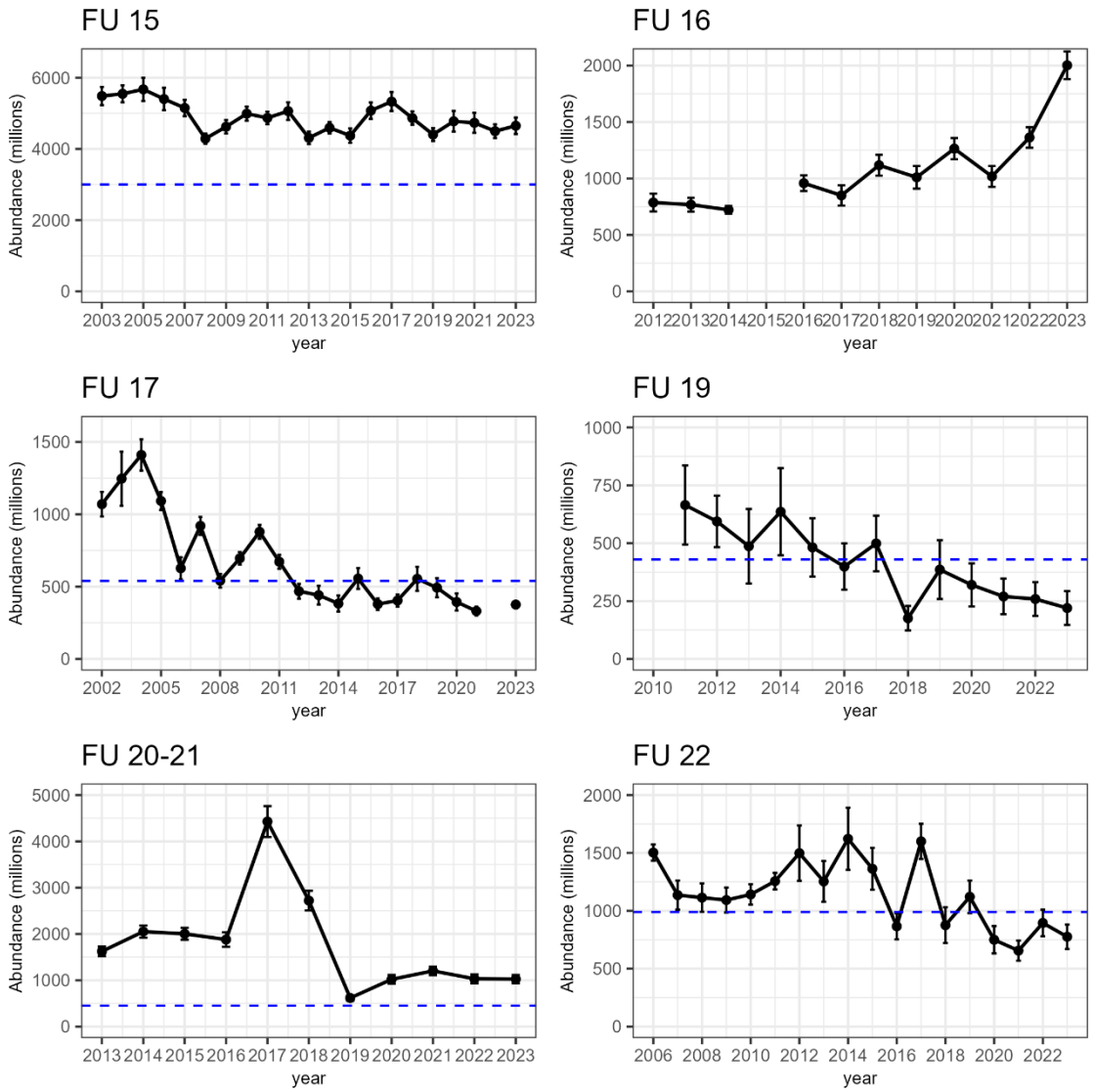


Figure. 1.4c *Nephrops* abundance (with 95 % confidence interval) in FU 15, FU 16, FU17, FU 19, FU 20-21 and FU 22. Dashed lines show proxy for ICES MSY reference point $B_{trigger}$.

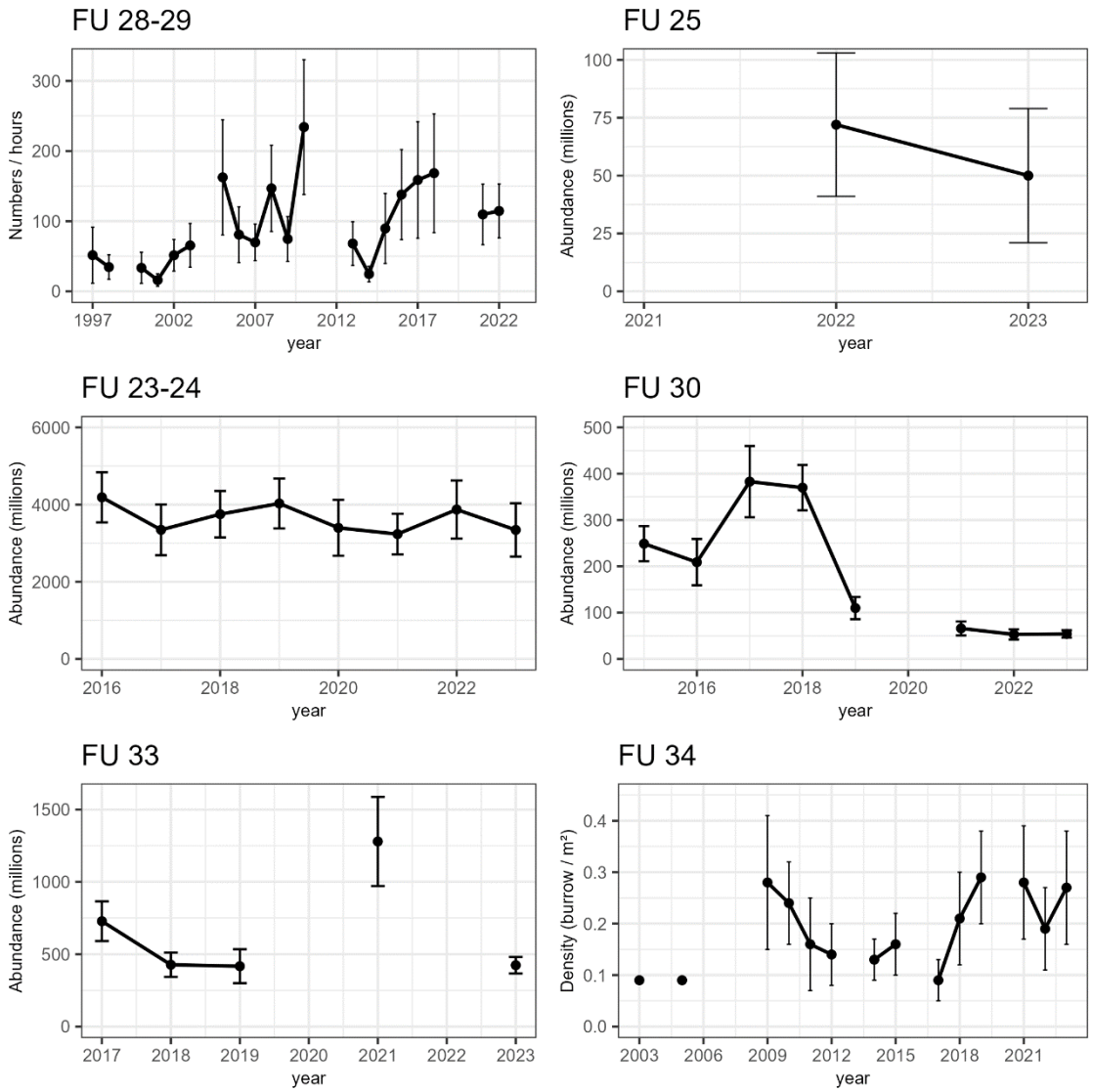


Figure. 1.4d *Nephrops* abundance (with 95 % confidence interval) in FU 23-24, FU 25, FU 30, FU 33. *Nephrops* numbers per hour trawled in FU 28-29. *Nephrops* density (burrow / m²) with 95 % confidence interval in FU 34.

WGNEPS recommends that:

- the outputs of the variography and settings used for the kriging process to be presented as part of the annual update of the survey at subsequent meetings.
- scenario planning for surveys to be reviewed in light of the recent workshop on unavoidable survey effort reduction (WKUSER2).
- promoting and facilitating when possible on UWTV surveys, staff exchange from national laboratories.

1.1 Proposal to define a new FU and investigations of data sources for habitat area.

Jennifer Doyle.

Landings data presented to WGCSE 2023 May meeting show an increasing trend in the recent 3 years for the nep 7 outside functional unit stock (ICES, 2023). This stock is currently deemed ICES category 5; landings only stock. The increase in landings is mainly from one country is reported from specific ICES statistical rectangles where a new fishery is being developed (Figure 1.1.1). These rectangles (27D8, 28D8, 29D8, 28D9, 29D9, 30D8 and 31D8) are proposed for the new FU 35 "SW Deeps".

WGCSE recommended that WGNEPs look at defining the possible *Nephrops* habitat in this FU. This was investigated from a cursory look at existing data sources such as VMS linked to *Nephrop*s landings with a threshold to detect fishing operations with a 30% by weight of *Nephrops* landings. Figure 1.1.2 shows that there is a distinct patch visible of VMS pattern in the SW slope. VMS linked to logbook landings can be deemed as a proxy for sediment data in the absence of available particle size analysis (PSA) data and has been used to define ground boundaries for a range of *Nephrops* stocks such as, FU 20-21 and FU 22. However, the use of this data source alone may not reflect the complete population.

Bathymetry data from Ireland's INFOMAR mapping programme shows that this is a deep water grounds ranging from ~ 420 to 560 metres which then slopes off and has many deep run offs, which are probably related to the deglaciation of the Irish ice sheet at the end of the last ice age (Figure 1.1.3).

WGNEPs recommended that other data sources to be used such as: catch data from IBTS surveys, observer data, landings data from other countries in this area following the recommendations in the ICES Cooperative Research Report (Leocádio *et al*., 2018). This should then re-assessed for ground definition and area calculation and be presented to both working groups in 2024.

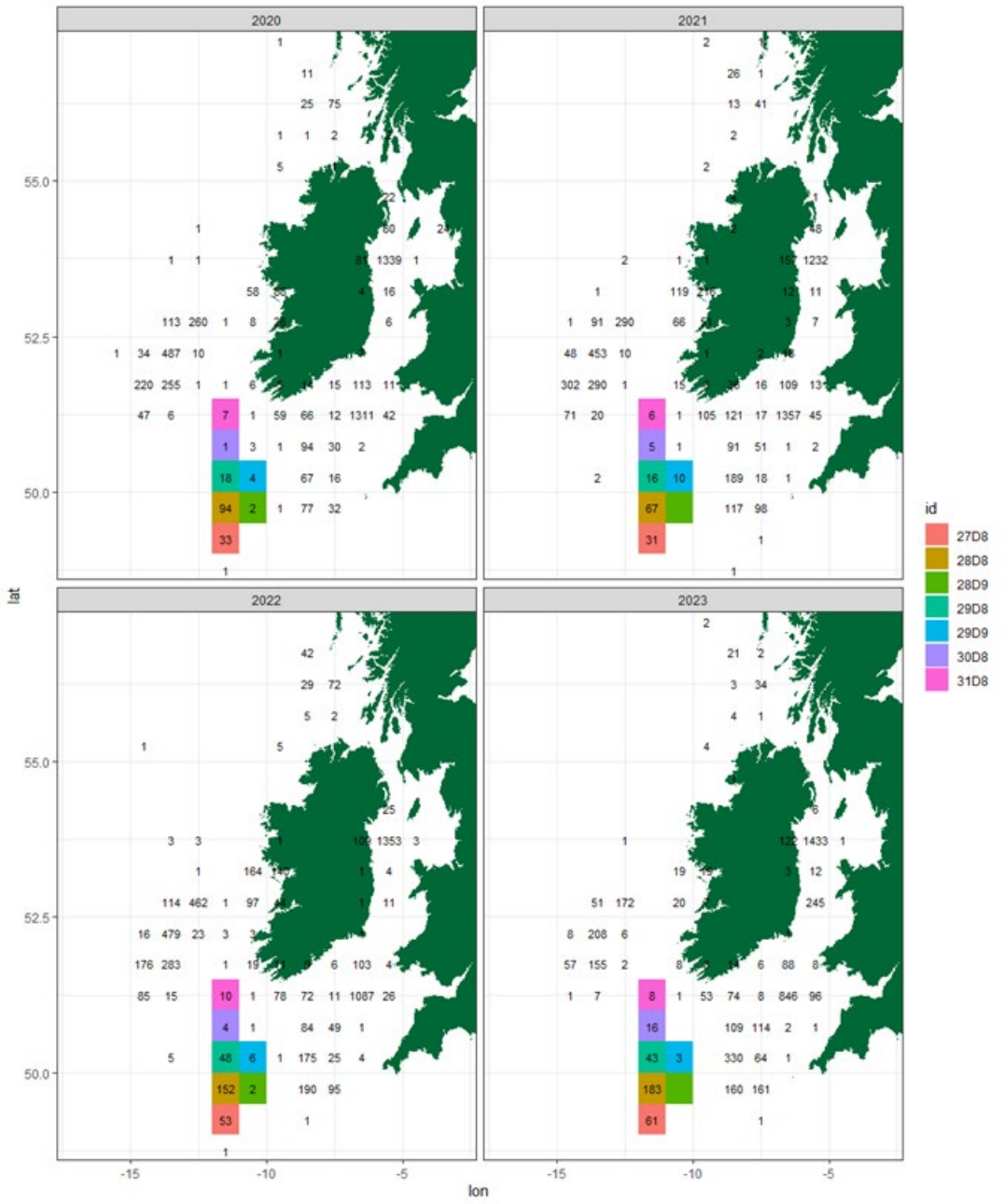


Figure 1.1.1. *Nephrops* landings (tonnes) reported by ICES statistical rectangles in sub-area 7, with the aggregation of statistical rectangles highlighted for the proposed new Functional Unit.

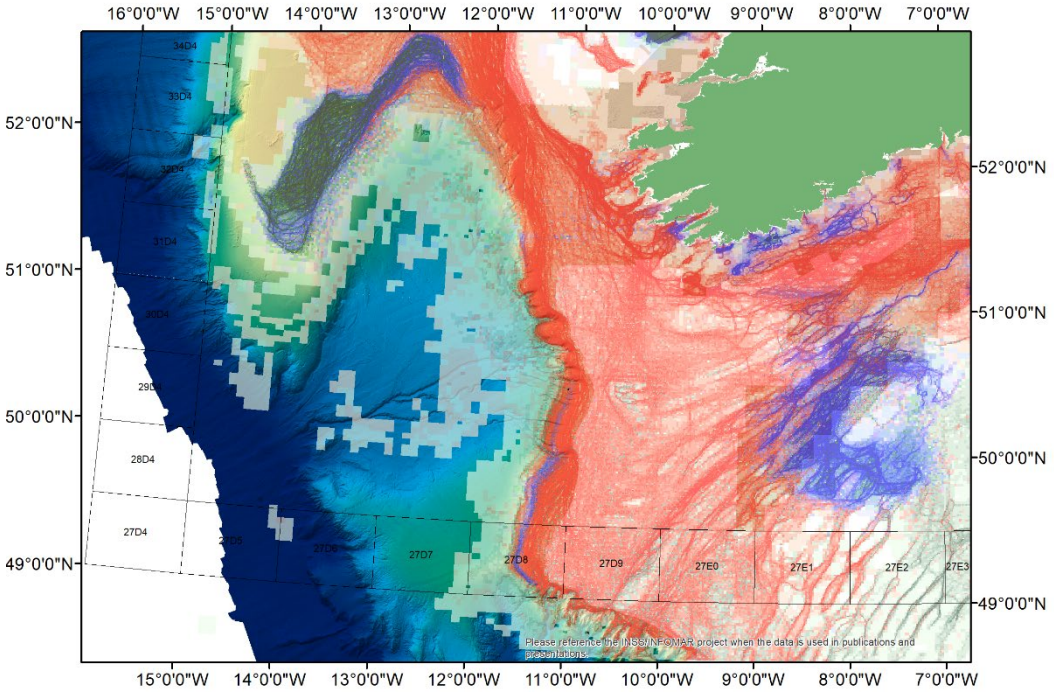


Figure 1.1.2. Proportion of *Nephrops* in the Irish landings overlaid on OTB effort (red=0% *Nephrops*; blue=50-60% *Nephrops*; green = , grey=unknown (no Irish landings). SW deep habitat visible as an elongated strip.

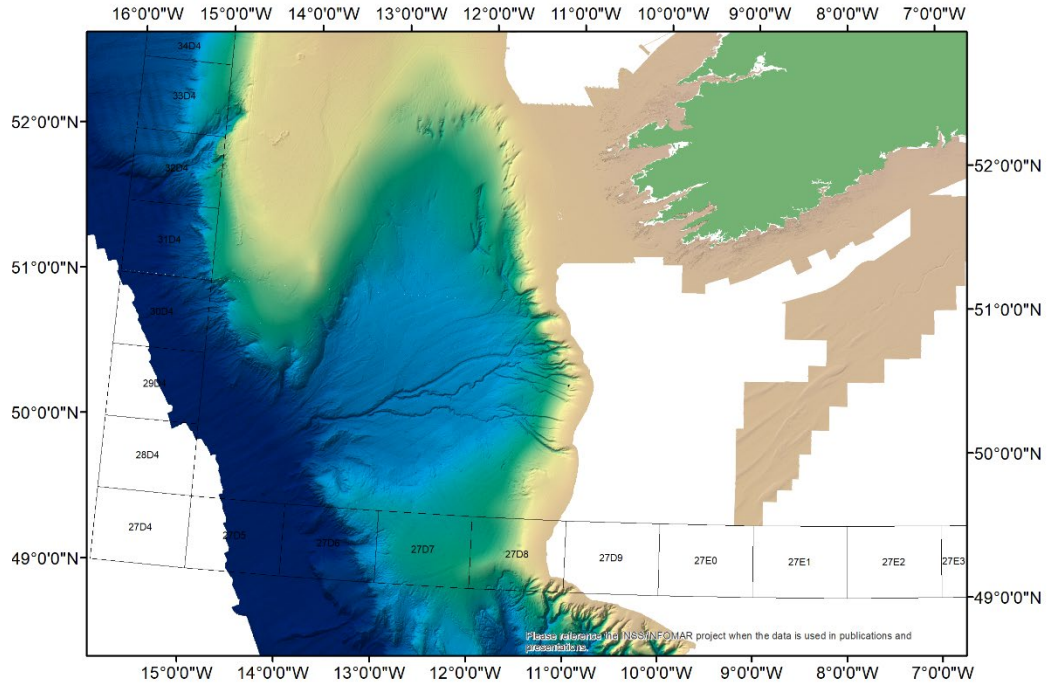


Figure 1.1.3. Bathymetry data from INFOMAR mapping programme to date.

Source: 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.

2 International database for UWTV survey data (ToR b)

The group discussed the level of data to be held by the international database that is achievable and it was agreed that this to be at the station level. Further meetings to be held with ICES to progress this in a subgroup. WGNEPS is committed to publishing a perspective review paper on the historical UWTV *Nephrops* dataset based on the newly developed ICES UWTV database.

3 Reference Set evaluations (ToR d)

3.1 FU15 Western Irish Sea

Jennifer Doyle, Pia Schuchert, Peter McCorriston, Jessica Graham, Matthew Devine, Kerry Falloona and Conall Hamill.

Background

The UWTV camera system used by AFBI has been upgraded to a High definition camera system since 2020 with the camera angle being maintained at 45 degrees. This change in data acquisition required an update to the reference set used to train counters (Dobby, H., *et al*, 2021). A HD reference set was compiled following guidelines set out at the last workshop WKNEPS held in Aberdeen (ICES, 2019). This HD set has been used to train counters prior to reviewing the survey data using a range for each station. However, it was deemed necessary to develop and evaluate reference counts per station minute using this HD set. This work was initiated during the annual UWTV survey and finished prior to the WGNEPs meeting for presentation to the group.

Code and data formats.

https://github.com/ices-eg/wg_WGNEPS/tree/master/A_Developing_a_reference_set

Station selection for FU15 Reference set

Stations for reference set compilation followed guidelines set out by the last workshop (ICES, 2018):

- 9 stations of good quality – to test under optimum conditions.
- Range of densities (3 x low, 3 x moderate, 3 x high).

Generate Reference counts for FU15 Reference set

Figure 3.1.1 shows the decision tree in how to use Lin's Concordance Correlation Coefficient (CCC) to independently assess and generate the reference counts (Lin, 1989). Each station was counted twice and independently by six national and one international reviewers. Intra-reviewer performance was checked using Lin's CCC with a threshold of 0.5. When a reviewer did not pass the threshold for any of the stations, this resulted in their counts being dismissed for those stations (Figure 3.1.1, step 1). Only three stations out of 63 (seven reviewers by nine stations) were dismissed by this process (Figure 3.1.2)

Mean counts per minute from each reviewer were calculated, and inter-reviewer correlations were checked using Lin's CCC with a threshold of 0.5. When a reviewer failed more than 50% of its inter-reviewer pairings, all the counts of this reviewer were dismissed (Figure 3.1.1, step 2). Following this, two sets of national reviewer's counts were dismissed. (Figure 3.1.3).

In order to calculate the reference counts for station, only counts that passed at least against another reviewer were used (Figure 3.1.1, step 3). The matrix in Figure 3.1.4 shows a different scenario for each of the stations reviewed. For example, for station numbers 1, 2 and 9, counts from all the included reviewers were used to generate the reference counts. For station number 5 only two reviewers were used to generate the reference count; this is deemed acceptable by the WKNEPS, as it is the current quality control method of survey counts. No reference count could

be generated for station 7; as the included reviewer data did not pass at least against another reviewer. The line plot of mean count data was analysed further and showed that there were three views of station 7; extreme low and high trend with a similar trend in the middle for the remaining counters (Figure 3.1.5). WGNEPS discussed this further where it was noted that a consensus count for this station could have a conservative effect on the outcome. It was deemed appropriate that the survey review team invest time to review and discuss the images for station 7 on day 1 of the 2024 survey where there could be other potential issues such as interactions with other benthic megafauna causing such variation in trends.

The average of the counts per minute of all the reviewers who passed the previous steps were used to generate the reference counts for FU15 for all stations except station 7 and was deemed appropriate for use.

Testing the Reference counts

This step to be processed and will revert back to the survey team and WGNEPs on the progress.

Conclusion

The Lin's process is a useful method to objectively assess and generate reference counts. However, the method is very sensitive to low numbers and slight deviations in trends.

The fact that the two national reviewers did not perform well for this reference set can be partly explained by the fact that there can be "test" effect when undergoing such a process and also one of the counter was a novice.

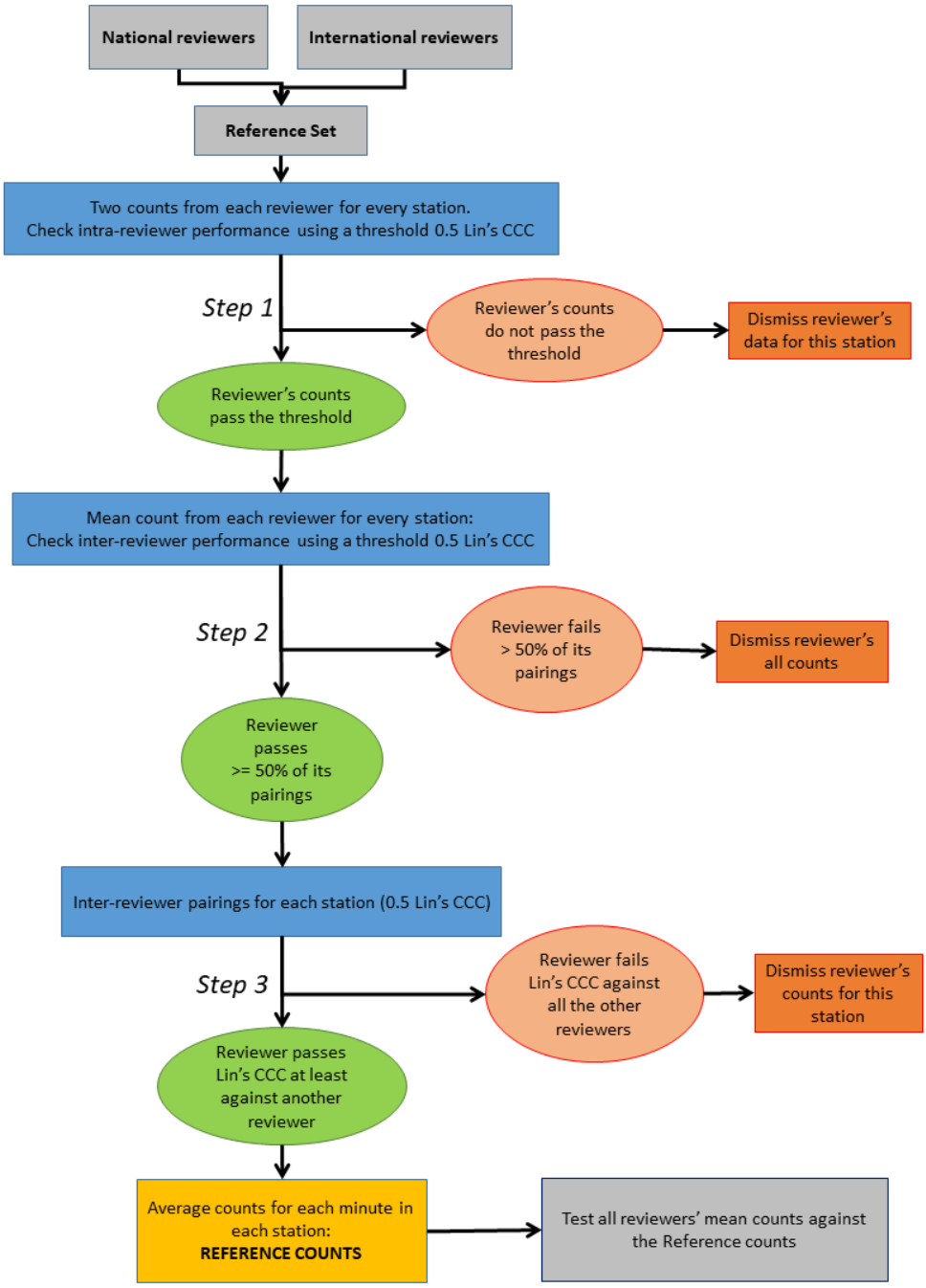


Figure 3.1.1. decision tree in how to use Lin's Concordance Correlation Coefficient (CCC) to independently assess and generate the reference counts.

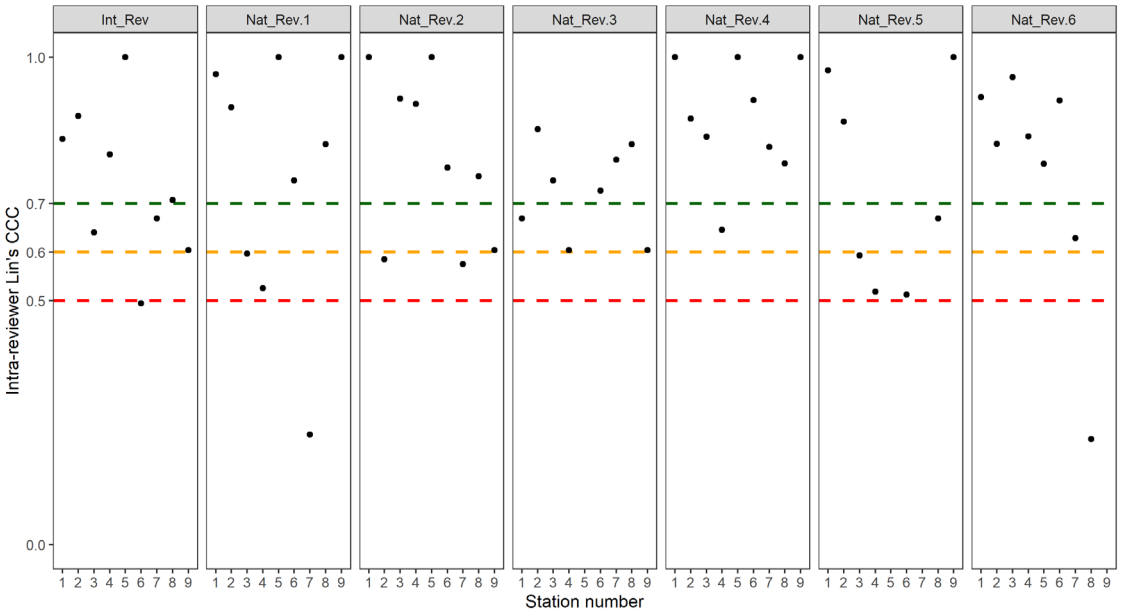


Figure 3.1.2. Step 1. Intra-reviewer Lin's CCC performance check for each of the reviewers (in panels) and each of the stations (x axis). Dashed lines show different possible thresholds for the Lin's CCC.

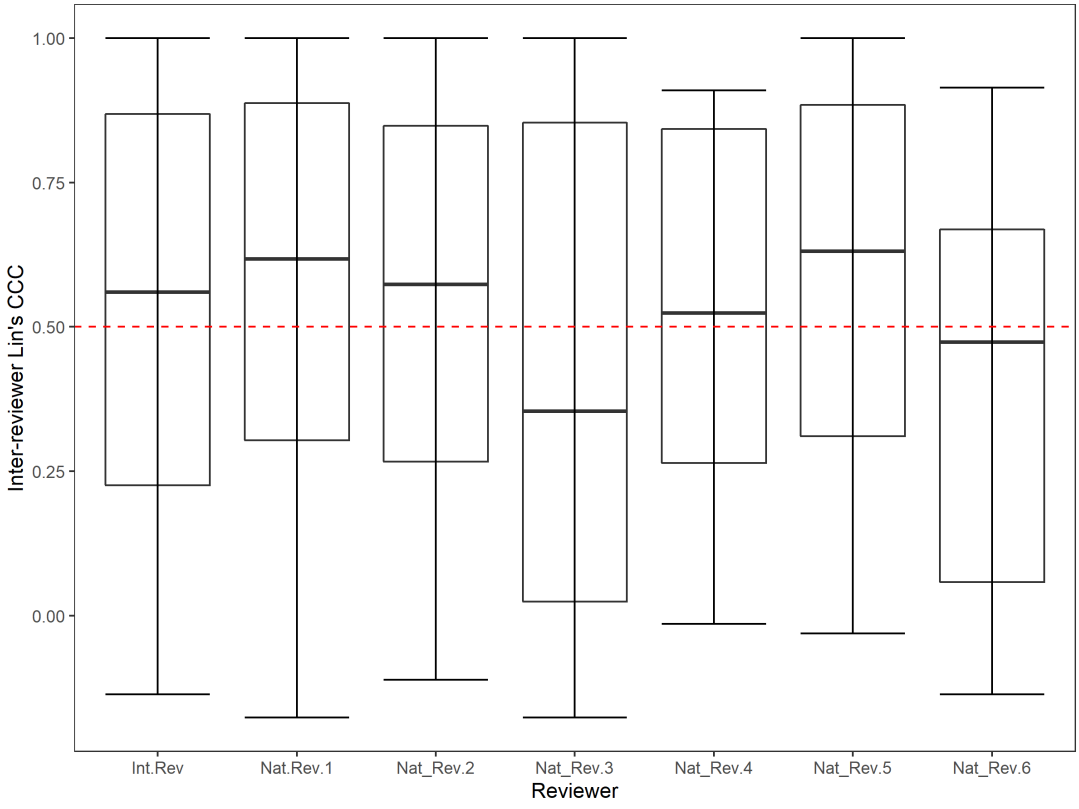


Figure 3.1.3. Step 2. Inter-reviewer Lin's CCC performance check. Boxplot of the distribution of Lin's CCC values for each of the reviewer's pairings.

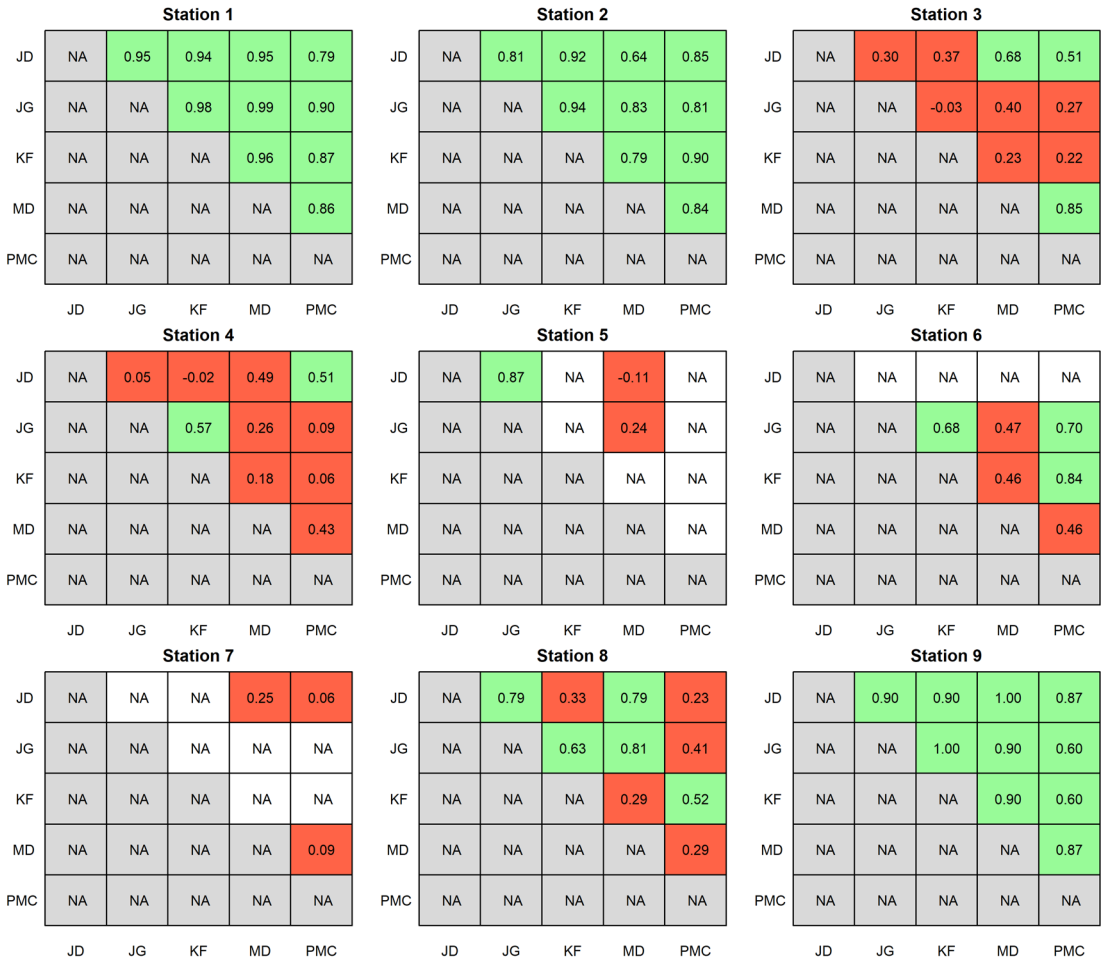


Figure 3.1.4. Step 3. Inter-reviewer Lin's CCC performance for each station. Pairings which passed the 0.5 threshold (in green) where later used for generating the reference counts. Pairings which did not pass the 0.5 threshold are shown in red. Counts which were dismissed in Step 1 are shown in white cells.

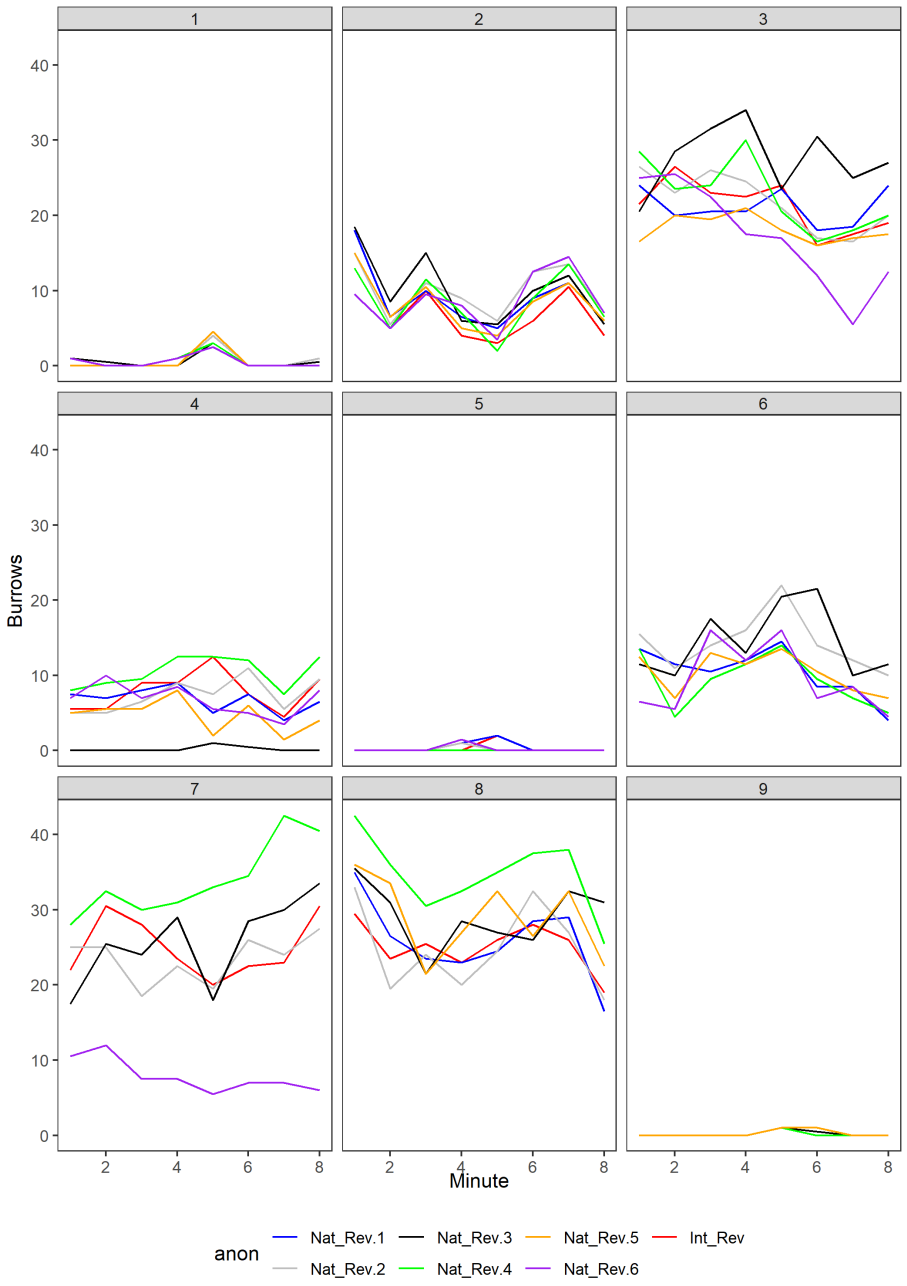


Figure 3.1.5. Line plot of the mean counts for the national reviewers number 1 to 6 and international reviewer.

3.2 FU16 Quality control of survey count data for 2022 and 2023

Mikel Aristegui, Jennifer Doyle and Mairéad Sullivan

A substantial change in *Nephrops* abundance estimates (47% increase) for FU 16 from 2022 to 2023 (from 1,363 million to 2,002 million) was detected on completion of the analysis of the 2023 survey data. Following the recommendation that additional quality checks of survey count data be

conducted to determine if this change was the result of a year effect on the counting behaviour (Dobby et al, 2021; ICES, 2019).

All the analyses carried out by the Marine Institute are fully documented and available in an R-markdown document available on the WGNEPS 2023 sharepoint (refer to working document section).

The station selection procedure for the review is summarised here. Only stations with more than 15 burrows were pre-selected. The stations with highest counts were selected for the review (two outliers from each year); additionally, a random 20% from the other pre-selected stations were selected. This process resulted in a total of 25 stations (11 from 2022 and 14 stations from 2023) to be reviewed.

The review process was conducted back in the laboratory. Following standard procedure, all counts were undertaken once the reference footage was passed by all the counters. The 25 review stations were interspersed and distributed equally among the 3 counters. Each station was counted by two reviewers independently.

All review 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 measures the ability of counters to exactly reproduce each other's counts on a scale of 1 to -1, where 1 is perfect concordance (Lin, 1989). When a station did not pass this test, a third review was undertaken. For those stations that did not pass the threshold it was deemed appropriate to use the average of the three reviewers for the analysis.

The initial results showed a low decrease in the QC review counts for 2023 stations comparing them with the survey counts (6 % decrease), and a high increase in the QC review counts for 2022 stations comparing them with the survey counts (33 % increase). Next the paired t-test shows that there is a significance difference between original and QC reviewed counts for 2022 stations, with no significant difference for the 2023 data set (Figure 3.2.1).

The result of this review process underlines that the change in abundance in 2023 is not down to some year effect on the counting behaviour, whereas there could have been an underestimate in 2022 survey process. However, there could be a QC review counting bias also in this process that should also be considered.

The additional quality review is a fairly large piece of work to conduct and finalise in advance of the ICES Advice drafting group. Survey leaders should take account of this potential additional quality check when scheduling and processing data.

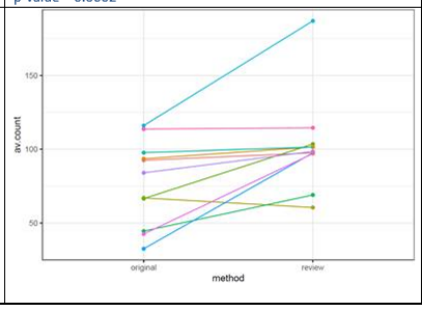
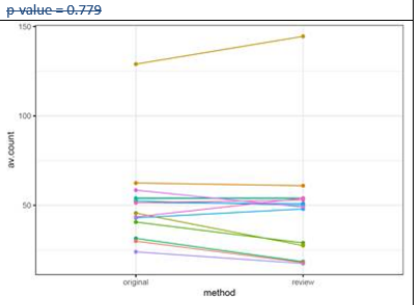
Method	2022 stations (11 stations)	2023 stations (14 stations)
Paired t-test	p-value = 0.01233	p-value = 0.2485
Unpaired Wilcoxon	p-value = 0.06582	p-value = 0.6283
~~Paired Wilcoxon (no need, we have t-test)~~	~~p-value = 0.006836~~	~~p-value = 0.2212~~
~~Unpaired t-test~~	~~p-value = 0.06635~~	~~p-value = 0.779~~
~~ANOVA~~	~~p-value = 0.0662~~	~~p-value = 0.779~~
Visual plot		

Figure 3.2.1. Results of statistical paired tests for qc review process.

4 Technological developments (ToR d)

4.1 Computer vision to support *Nephrops norvegicus* imagery annotation.

Marco Reggiannini, Enrico Cecapolli, Filippo Domenichetti, Michela Martinelli, Oscar Papini, Gabriele Pieri, Lorenzo Zacchetti

Introduction

This document reports about the implementation of a computer vision procedure to estimate Nephrops norvegicus burrows density by analysing Underwater Television (UWTV) surveys (see Figure 4.1.1**).** This activity, developed in cooperation with the ICES WGNEPS group [3], aims at providing an automatic system to support (i) the detection of the N. norvegicus openings, (ii) their grouping into systems (i.e. burrows) and (iii) the count of the distinct burrows. This could represent a relevant tool to simplify and optimise the stock assessment process.

The quality of the data captured in this context is strongly affected by environmental factors such as water turbidity, light absorption and reduced luminosity. Moreover, the detector must deal with task-specific challenges, such as the presence of objects resembling the sought one (sand aggregations, shadows, burrows made by other species), and be able to recognise a burrow by distinctively grouping the respective system of openings.

Figure 4.1.1: Example of an UWTV survey frame recorded in the Central Adriatic Sea. Burrows related to various species are visible.

Concerning the classification stage, this is usually addressed through the extraction of image features that represent specific properties of the image content. These quantities are later exploited to train an algorithm in charge of assigning a class label. Regardless of the adopted approach (i.e. traditional machine learning or modern neural network algorithms), the availability of an annotated dataset is a basic prerequisite for the training stage. This dataset, the so-called ground truth, is typically generated by experts that manually annotate

a small subset of frames from the captured videos. Instead, an extended ground truth, also including multiple views of the same object, is a key factor for the model performance, as shown in the following section.

An intermediate objective of this work is to develop a method that allows to obtain the largest possible ground truth dataset while exploiting a minimum effort from human experts. The key observation is the fact that objects in the UWTV video appear in multiple consecutive frames. In a nutshell, a correlation-based method can exploit one annotated object in the video stream as a template to be detected in neighbouring frames (see Figure 4.1.2). Iterating this procedure for each annotated object will return a novel ground truth dataset, with a meaningfully increased size.

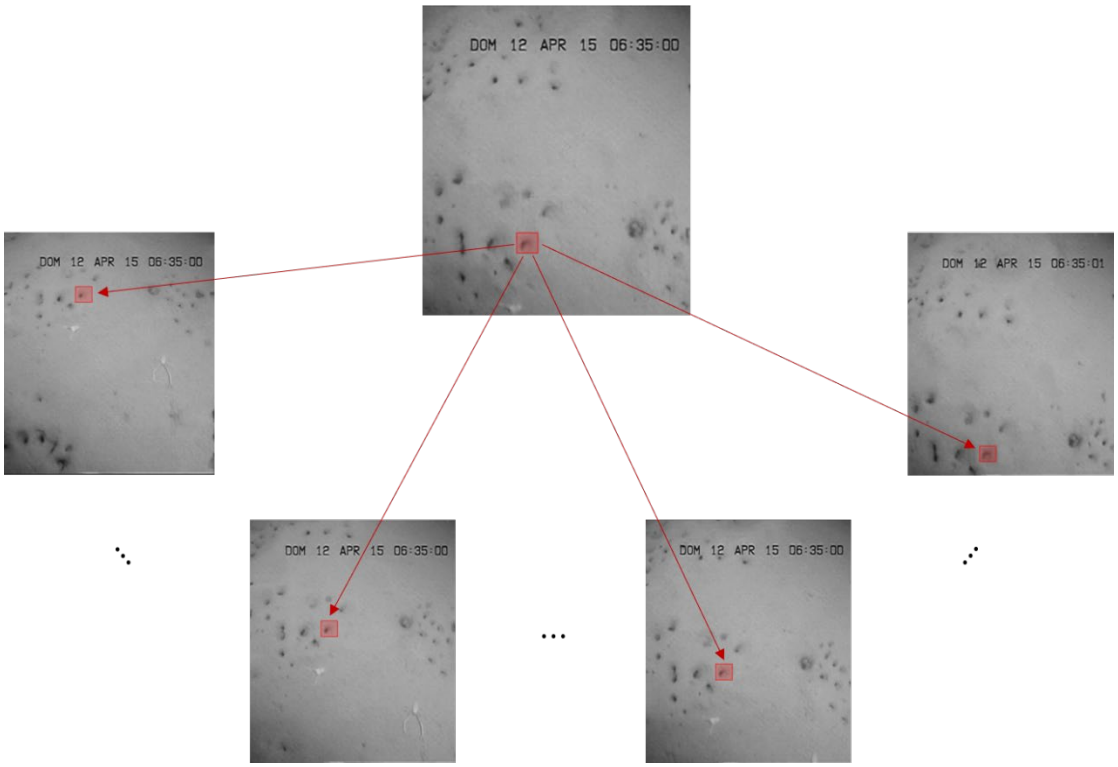


Figure 4.1.2: Template matching concept.

Experiments

An annotated dataset has been prepared starting from video footage from the Adriatic UWTV surveys carried out jointly by IRBIM-CNR (Ancona, Italy) and IOF (Split, Croatia) in the Pomo/Jabuka Pits area (Central Adriatic Sea) [2], [4].

In particular, the source material consists of four 1-minute-long videos with a resolution of 768×576 pixels and a frame rate of 25 FPS. A set of 484 images has been obtained by extracting one frame every half second (including extremes) from each video. These images have been analysed and manually annotated with labelled bounding boxes belonging to two possible classes (see Figure 4.1.3): the class “Opening”, used to mark the single entrances of a N. norvegicus burrow (in green in the figure), and the class “Burrow” that groups all the openings of a single burrow (in purple). This annotation process resulted in a dataset with a total of 429 boxes, divided into 332 “Openings” and 97 “Burrows”. From this dataset, which will be called “original” from now on, a new “extended” dataset, which contains

8054 objects (6530 “Openings” and 1524 “Burrows”), has been created using the above-mentioned technique.

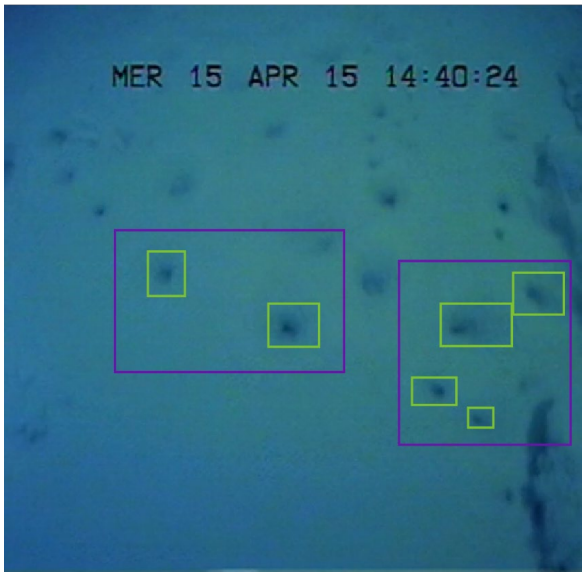


Figure 4.1.3: Example of ground truth annotation on the frame in Figure 4.1.1. Individual N. norvegicus openings are tagged by green boxes while burrows are annotated through purple boxes.

Both the original and the extended datasets were used to train two separate instances of YOLOv4 [1], a deep neural network designed for the object detection task, obtaining two detection models M_{orig} and M_{ext}. These models take as input an image, e.g. a frame from UW footage, and return a list of bounding boxes, each labelled with either “Opening” or “Burrow” and a score, i.e. a number between 0 and 1 that represents how much the model is confident that the box actually identifies an object, with higher numbers corresponding to higher levels of certainty. A box that receives a score below 0.25 is not considered as a detection.

The performance of an object detection model is usually assessed with a parameter known as mean average precision (mAP), that is a number between 0 and 1 computed by running the model on a test set of images and comparing their ground truth bounding boxes with the predicted ones; a higher mAP corresponds to a more precise model. The red plots in Figure 4 and Figure 4.1.5 show the trend of the mAP computed during the training process. The difference really stands out: the mAP of the network trained with the original dataset never exceeds 40%; furthermore, it seems to decrease with the number of training iterations, eventually falling below 20%. On the other hand, the mAP of the network trained with the extended dataset shows a more regular trend, constantly increasing (albeit with some oscillations) up to about 70%. The blue plots represent the values of the loss function, i.e. a measure of the error made by the network during its training: in both cases this error decreases, as expected, and there is no significant difference between the two trends.

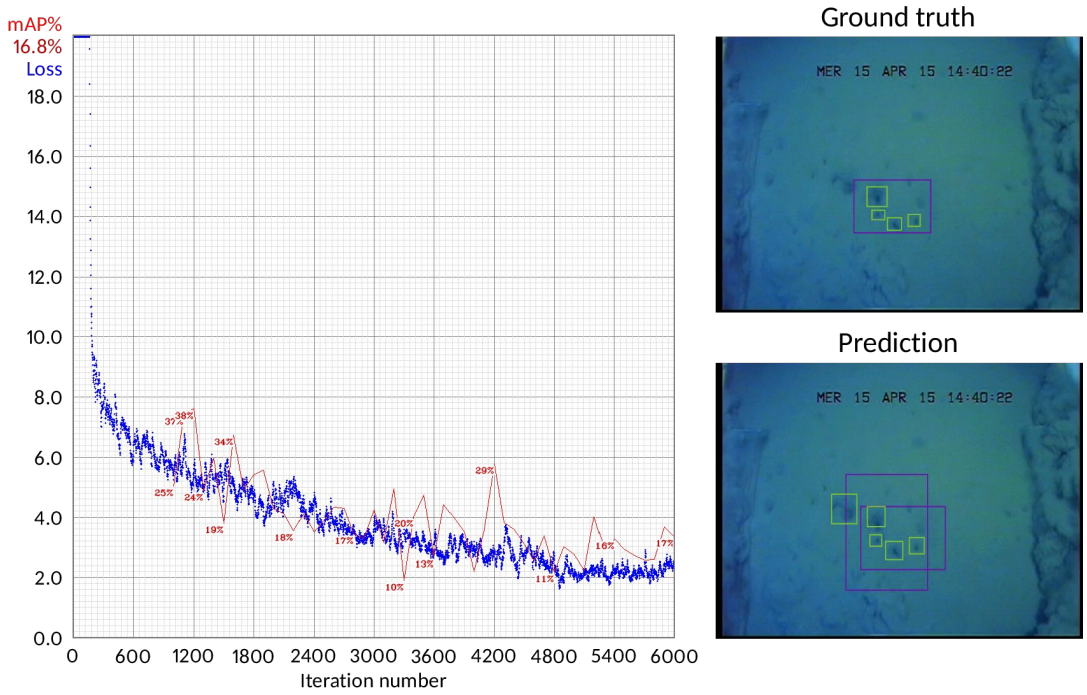


Figure 4.1.4: Left: plots of the loss function and the mAP trend during the training with the original dataset. Right: example of ground truth in the validation set (top) and corresponding prediction (bottom).

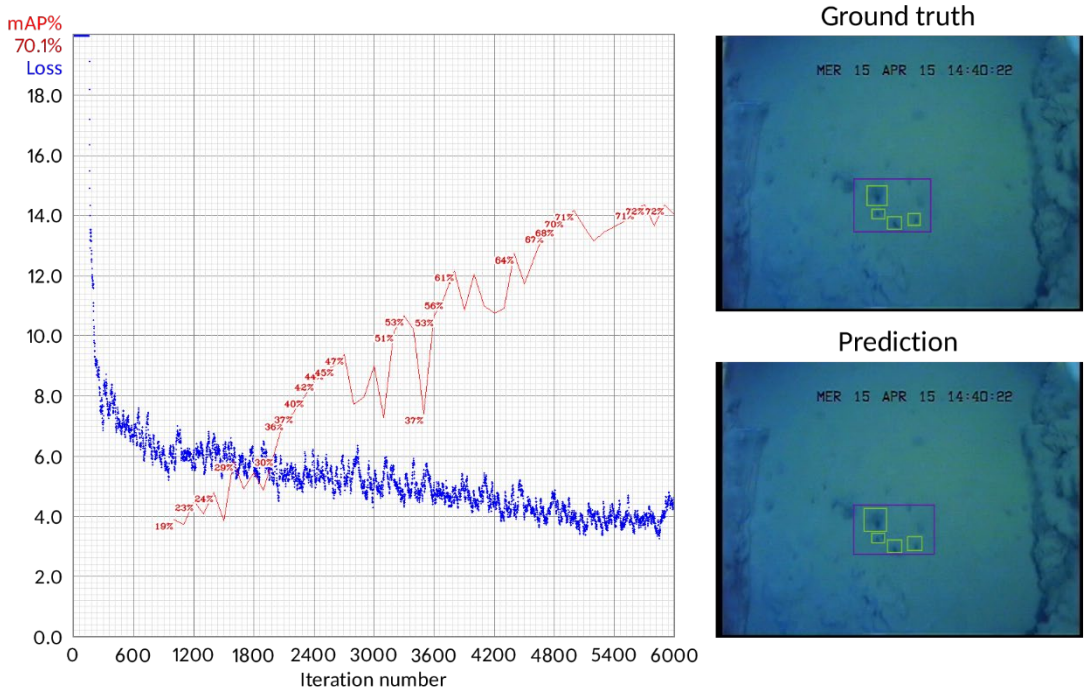


Figure 4.1.5: Left: plots of the loss function and the mAP trend during the training with the extended dataset. Right: example of ground truth in the validation set (top) and corresponding prediction (bottom).

It is interesting to compare the different objects detected by the two models in the same picture. A first analysis shows that M_{orig} suffers from a high count of false positives, of which some examples are reported in Figure 4.1.6.

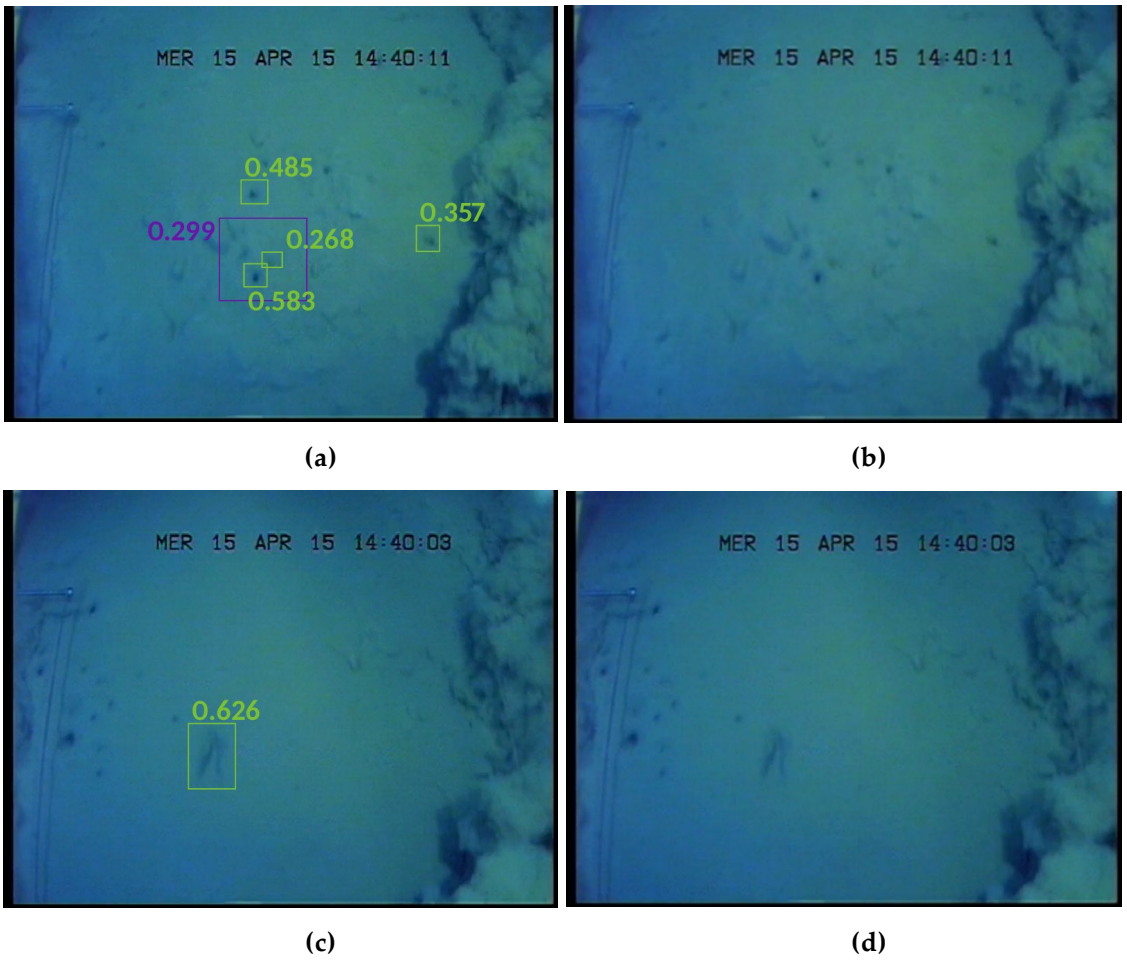


Figure 4.1.6: Some examples of false positives predictions from the network trained with the original dataset (a) and (c); and trained with the extended dataset (b) and (d). In both cases no objects were tagged in the frames in the ground truth datasets (neither in the original nor in the extended one).

Figure 4.1.7 provides two examples of model predictions. In the first one (Figure 4.1.7 (a) and (b)), M_{orig} detects more objects, but the scores are generally low; on the other hand, M_{ext} identifies only one object, but with a higher level of certainty. In other words, it seems that M_{orig}, despite being able to identify reasonable candidate burrows, is less "confident" in its choices by giving the corresponding boxes a mid-range score. This is more evident in the second example (Figure 4.1.7 (c) and (d)): both models identify the same two boxes, among which there is a false positive (the "opening" in the lower left corner is actually a shadow cast by the dust cloud), but M_{ext} is much more certain that the middle box is a true opening, and also gives a very low score to the lower left box.

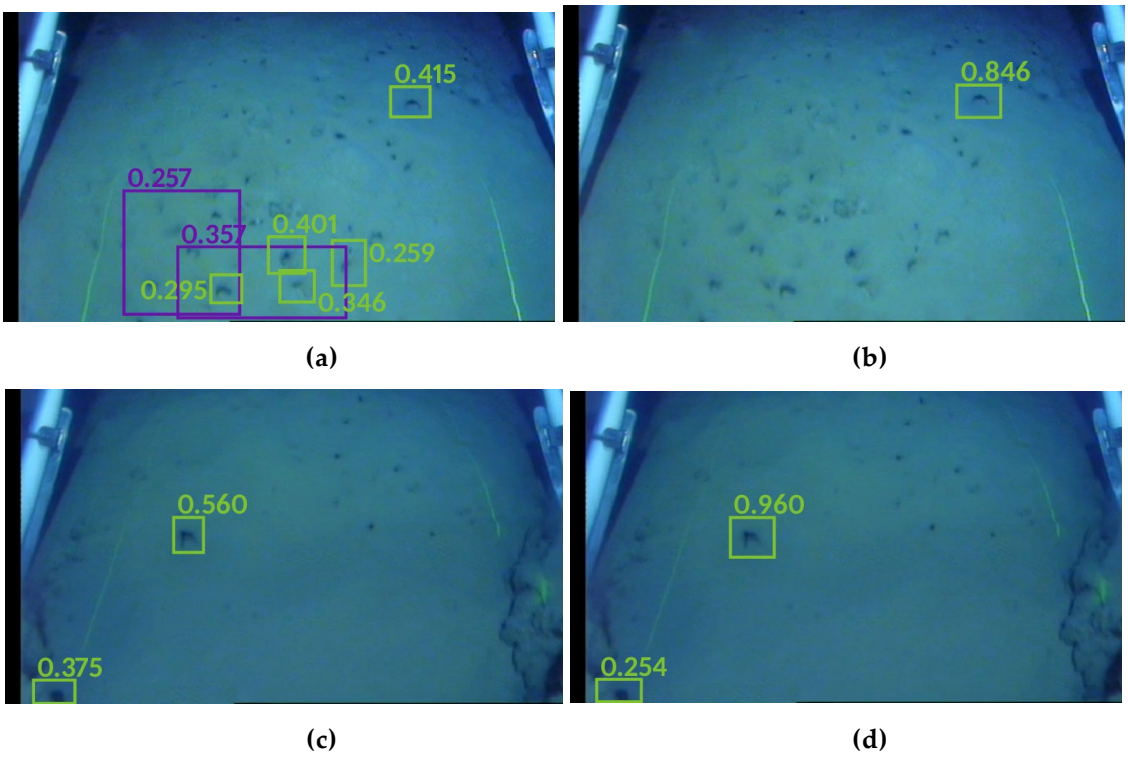


Figure 4.1.7: Some examples of detected burrows.

Conclusions

This document reports on the development of a computer vision technique to support the estimation of N. norvegicus burrows density through automatic analysis of UWTV videos. Given a set of annotated frames extracted from an UWTV video, the number of ground truth annotations was extended roughly by an order of magnitude thanks to an automatic correlation-based method. This allowed to generate a large ground truth dataset to train a deep neural network model, as described in Section 2.

Possible next steps include further analysis of the classifier performances. In detail, several datasets, collected under varying circumstances in terms of turbidity level, environmental biodiversity and sensor set-up, will be considered for the training step, with the purpose of increasing the model's generalisation. To this aim, collaboration with any interested member of the WGNEPS community is strongly recommended and encouraged. A statistical analysis will be carried out to identify the most relevant and informative imaging features for the burrow recognition purpose. N. norvegicus burrows recognition and counting requires the capability of the model to perform multi-frame detection and tracking of the same object. In future experiments, mosaicking techniques will be considered to transform this problem to an object recognition task performed directly on a single input image.

This work is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000825 – NAUTILOS Project (https://www.nautilos-h2020.eu).

5 Review and report on the utility of UWTV and trawl Nephrops surveys as platforms for collecting data for purposes other than Nephrops assessment (ToR e)

5.1 Evaluation of changes in density and distribution of the Sea pen, Funiculina quadrangularis, in the Central Adriatic Sea (Mediterranean Basin) in response to variations in trawling intensity.

Michela Martinelli, Lorenzo Zacchetti, Andrea Belardinelli, Filippo Domenichetti, Paolo Scarpini,

Pierluigi Penna, Damir Medvešek, Igor Isajlović and Nedo Vrgoč

The UWTV methodology has been consistently used to assess *Nephrops norvegicus* burrow densities in the Pomo/Jabuka Pits area (Central Adriatic Sea) since 2009 (Martinelli et al 2013). Along with this information, UWTV instruments and collected footage were also used to collect environmental variables measurements (Chiarini et al., 2022a; Penna et al., 2022) and ancillary data on seabed features as trawl marks and on other ecologically relevant species (Martinelli et al., 2013, 2023).

Bottom trawling for marine resource exploitation has notable repercussions on marine ecosystems (Clark et al., 2016; Farella et al., 2021). Consequently, effective management strategies should incorporate the identification of sensitive species as indicators of ecosystem health. Epibenthic organisms, such as sea pens, serve as valuable tools for assessing benthic conditions, especially in areas where trawling intensity is high, leading to a decline in their populations (Bastari et al., 2018; Mačić et al., 2022). Criteria under Descriptor 6 (Sea-floor integrity) of the European Union's Marine Strategy Framework Directive (MSFD; EC, 2017) address the impact of fishing activities on the seabed, including effects on benthic communities. Specifically, criterion D6C3 mandates Member States to investigate the detrimental effects of physical disturbance on each habitat type, along with resulting changes in biotic and abiotic structures and functions. Epibenthic organisms, such as sponges, and sea pens, play a crucial role in assessing benthic conditions (Burgos et al., 2020; Serrano et al., 2022). Sea pens, which are colonial cnidarians belonging to the subclass Octocorallia, order Pennatulacea (Williams, 2011), form sea pen forests that serve as three-dimensional habitats for fish and invertebrate species. Consequently, they contribute significantly to preserving ecosystem functions in marine benthic ecosystems (Cogswell et al., 2011; Felder and Camp, 2009; Hughes, 1998). Sea pen forests are capable of hosting eggs and larvae, providing a secure habitat for young fish (Wright et al., 2015). The Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) highlighted the potential use of UWTV in the assessment of sea pens (OSPAR, 2018).

The Pomo Pits area serves as a nursery for *Merluccius merluccius* (European hake), hosts a dense population of Norway lobster and a high abundance of *Parapenaeus longirostris* (Deep-water rose shrimp), which share their habitat on sandy-muddy bottoms with the sea pen *Funiculina quadrangularis* (Angelini et al., 2020; Martinelli et al., 2013, 2020). This fishing ground historically

shared by the Italian and the Croatia fishing fleets, has been subjected to various management measures in time since 2015 and became a Fishery Restricted Area (FRA) in 2017 (Chiarini et al., 2022a, 2022b; GFCM, 2021). Recently, the UWTV footage collected in the Pomo Pits area from 2012 to 2019 (Martinelli et al. 2012; ICES 2022) was further analysed with the aim to derive information on the epibenthic communities subjected to physical perturbations and objects of interest in the context of Descriptor 6 of the MSFD, among which in particular is *F. quadrangularis* (Martinelli et al., 2023). Thanks to the footage collected during these UWTV surveys, it was possible to evaluate changes in the abundance and distribution of *F. quadrangularis* in response to changes in the spatio-temporal distribution of fisheries effort; the Before–Intermediate–After Multiple Sites (BIAMS) approach was adopted for this purpose (Chiarini et al., 2022b). Overall, 3244 min of video were analysed, for a total of about 85,541 m^2 of the seabed viewed. The average density (n/m^2) of sea pen colonies was calculated for the FRA zones A, B and C (Figure 5.1.1) in three distinct periods: BEFORE the implementation of measures (prior to 1 July 2015), during an INTERMEDIATE period with changing limitations (2 July 2015 to 31 August 2017), and AFTER the establishment of a Fishery Restricted Area (from 1 September 2017).

Furthermore, a spatial grid of 2 x 2 nautical mile cells (surface corresponding to 13.72 km^2 each) was built for the Pomo/Jabuka Pits area by means of a Geographic Information System (GIS). Mean density (n/m^2) of colonies per cell was calculated using all data from 2012 to 2019 and for three distinct periods in order to obtain density maps (Figure 5.1.1). The spatial grid was also used for the calculation of a persistence index consisting in a modified version of the Getis G statistic, specifically adapted for identifying spatial hotspots (Colloca et al., 2015; Getis and Ord, 1992). To obtain persistence estimates per cell, the number of surveys in which the species was detected in a specific cell was divided by the total number of surveys that included that cell. This calculation was restricted to cells visited more than once (i.e., in at least in two surveys), with *F. quadrangularis* recorded at least once. Persistence was computed over the entire period 2012-2019 and for the BEFORE period (Figure 5.1.2); in fact, a possible limitation of this index could be due to the fact that it does not account for the time sequence of the records within each cell over the different years (so it probably should not be applied to long time series when two records could paradoxically be at the beginning and end). However, in shorter (and more homogeneous) time series, as in the case of the "BEFORE" period, it can provide useful information to compare with subsequent time steps.

This work has enhanced the understanding of the geographic range of *F. quadrangularis* in the Adriatic Sea, contributing to the mapping of Vulnerable Marine Ecosystems (VMEs) and Essential Fish Habitats (EFHs). The obtained results showed in general an increase in *F. quadrangularis* density where fisheries were closed, even after a short period (for a broader description of results please refer to Martinelli et al. 2023). Therefore, this study illustrates that effective management measures can positively influence epibenthic communities and highlights the potential of sea pens as indicators for assessing the impact on and/or recovery of exploited habitats. The analysis of the colonies' persistence can provide crucial information for the proper management of the study area. Indeed, using density assessment in conjunction with the ability to locate the most persistent colonies geographically can help to identify the most vulnerable locations. These findings offer valuable insights for the planning and monitoring of sensitive marine areas. However, a more in-depth investigation, utilizing video surveys, is necessary to evaluate the long-term effects of the management strategies implemented in the Pomo/Jabuka Pits area on the sea pen community.

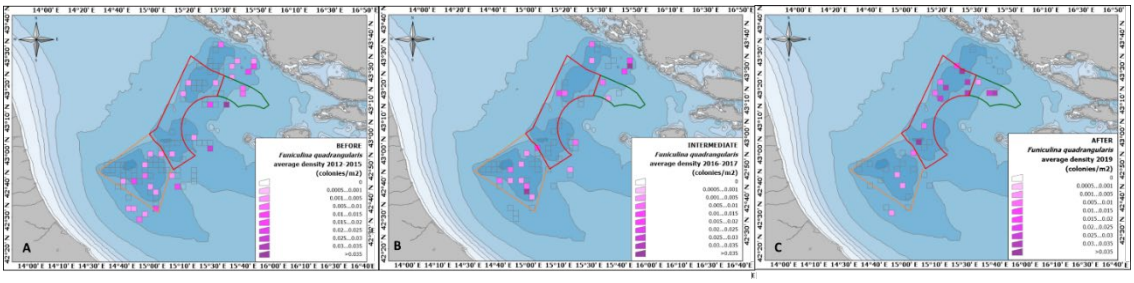


Figure 5.1.1. Map of the study area: the polygons indicate the three areas of the FRA (zones A, B and C contoured red, orange and green respectively), the nautical 2×2 millet cells coloured with a purple palette indicate the average density of *F. quadrangularis* colonies; panels (A–C) refer respectively to the three considered periods; modified from Martinelli et al. 2023.

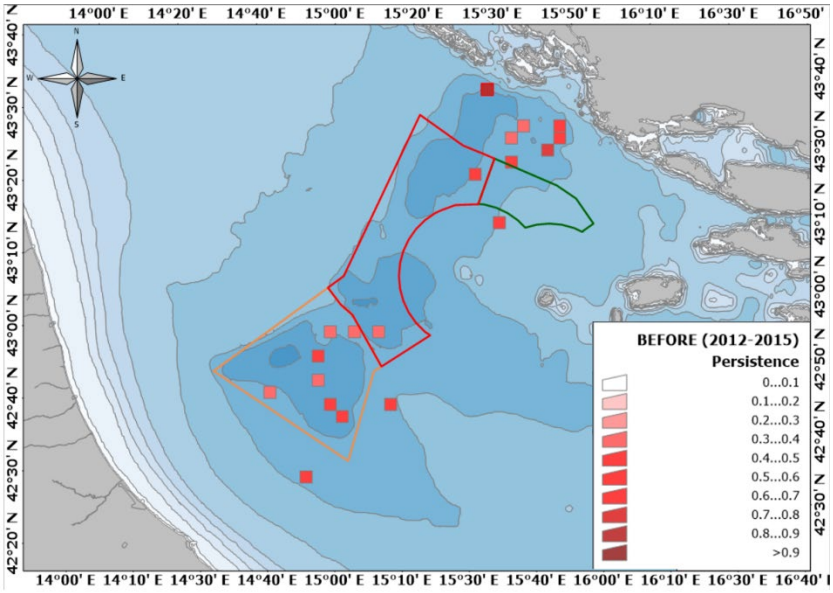


Figure 5.1.2. Map of *F. quadrangularis* colonies' persistence in the Pomo/Jabuka Pits area calculated for the BEFORE period; modified from Martinelli et al. 2023.

6 Factors affecting on burrow emergence (ToR f)

6.1 Digital Twin-sustained 4D ecological monitoring of restoration in fishery depleted areas (DIGI4ECO)

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Digital Twin of Ocean (DTO) simulates marine biological and environmental components to understand ecosystems' past and present state and make predictions about their future. In spite of the vastness of marine ecosystems, any approach to ecosystem management requires the definition of strategic areas where to repeat measurements. Therefore, DTO need to identify this space and include in its virtualization, the tools for in-situ data collection. In this framework, the main objective of DIGi4ECO is to implement robotic networks for **demo-missions** delivering real-time data to be **merged with historical and sleeping data**, allowing spatial scaling and temporal modelling. The project also aims at making all the past, current, and future biological and oceanographic data available to everybody in the same demo-mission and nearby areas. Therefore, we will use relevant sleeping data, by designing new tools and methodologies to use and process relevant data already collected for different institutions, which may come from physical and chemical sensors, or video cameras. We will also harmonize the data, promoting tools to make them the standard among researchers and data-generator actors, developing protocols and best practices, like standardization tools as PUCK among marine sensors and monitoring platforms, and unifying libraries and resources (e.g., FanthomNet or Emodnet). At the same time, we will ensure a secured, sustained and reliable data flows by developing auto correction/validation methodologies and by publishing a set of tools and pipelines to ensure the trustfulness of data. Moreover, we will be using economies of scale and enhanced standardization to conduct several pilot sea-basin scale monitoring tests using two strategies: (1) using existing relevant sleeping data form online and partner repositories, and (2) using new data collected during field test demonstrations (Figure 6.1.1).

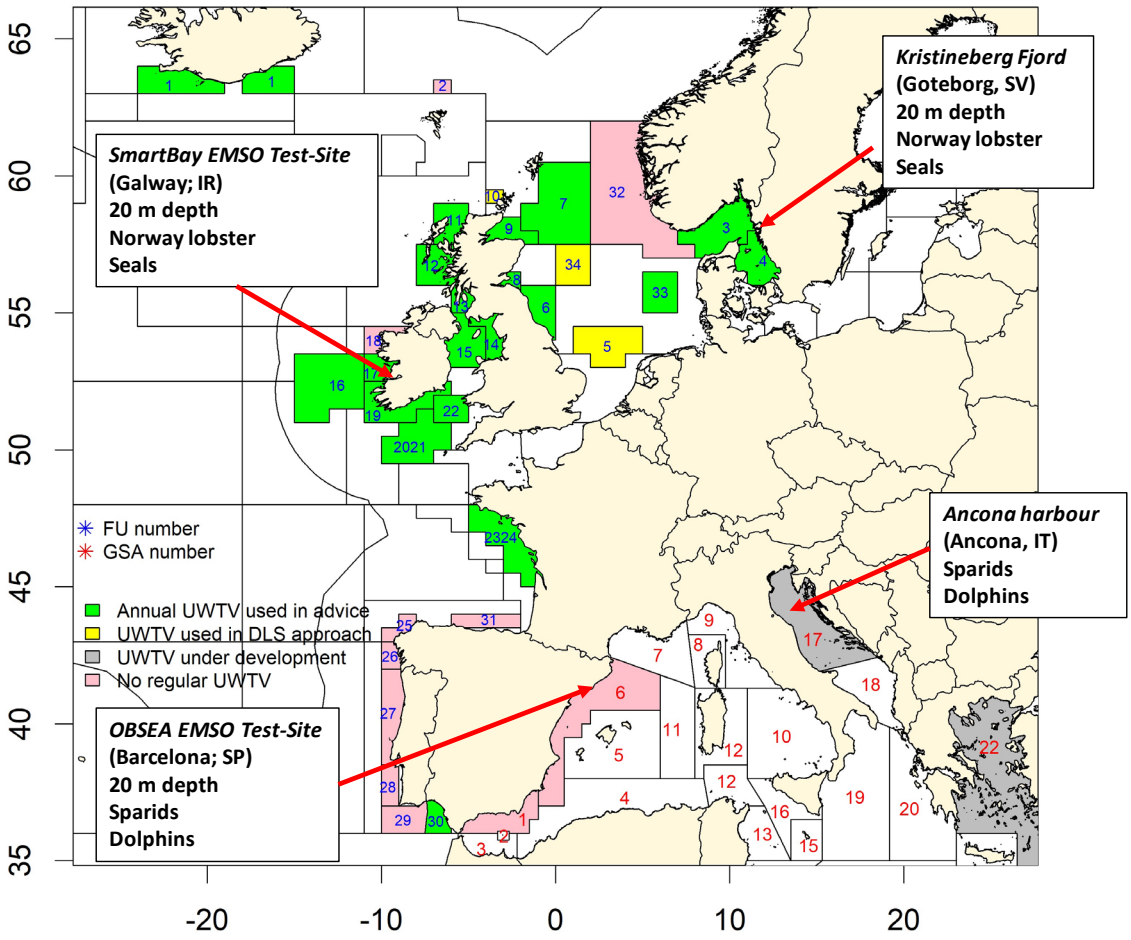

Figure 6.1.1. The 4 demo-mission areas where the network of robotic platfo0rms will be deployed in DIGI4ECO, in order to collate real-time data within the framework of historic time series acquired by institutions and private owners in the same and nearby areas.

Is in the framework of demo-mission areas selection that the collaboration of the ICES-WGNEPS covered central importance. Two out of four areas for demo-missions are those where the Nephrops fishery is well consolidated and developed (Fishery Units-FUs FUs no. 3 for Kristineberg Fjord in Goteborg and 17 for Galway Bay), with abundant institutional data and conspicuous fishery sector collaborations. In the curse of past annual meetings, the technologically-advanced monitoring strategies, enforced to achieve a better tuning of Nephrops demography, were elaborated with the expert help of country representative members.

Accordingly, DIFGI4ECO will further develop those tools to better support assessment: studying and identifying key indicators and mechanisms to extract species and ecological information from imaging and omics material/data from the data will generate the appropriate guidelines for policymaker, researchers, and socioeconomic sectors. Making those tools, methodologies, and implementations open source for the researchers and public in general will boost their utilization and improvement, even after the conclusion of the present project. With these demonstration examples, the international collaboration, and open-source resources, we aim to make our proposal by fact the standard gold to follow in the following years in Atlantic *Nephrops* FUs.

6.2 Coordinated Intelligent Networks for NEPHrops norvegicus In-situ Long-term Imaging-based Assessment.

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The fishery of the Norway lobster *Nephrops norvegicu*s is among the most prominent ones in Europe (Atlantic and Mediterranean waters). With signs of overexploitation and stock decline, standardized monitoring of populations over large areas is a priority for the authorities. However, traditional assessment methods based on fishing (trawl sampling) are expensive, highly invasive for the environment and influenced by the species' burrowing (buried individuals are not sampled). On the other hand, alternative video-based methods like UnderWater TeleVision surveys with towed cameras count burrow entrances and rely on the rough assumption that 1 entrance equals 1 individual and vice versa. Advances in monitoring technologies raise the need to transform vast amounts of multiparametric (environmental, animal counts and sizes, etc.) data to coherent ecological indicators that can be translated directly into meaningful knowledge on the status of stocks and their associated habitats. The MSCA project 101104596 "CINNEPHILIA – Coordinated Intelligent Networks for *NEPHrops norvegicus* In-situ Long-term Imaging-based Assessment", starting in September 2024, aims to semi-automate a data-processing pipeline and establish relevant ecological indicators to monitor *N. norvegicus* populations in test sites and Marine Protected Areas of the Catalan coast, pushing stock estimation accuracy beyond the current state of the art. Footage and oceanographic data from planned research cruises and lander-station deployments will be analyzed and compared with available data from local fisheries, to calculate densities per Km^2 and a more precise ratio of individuals to burrow entrances. The output (a standardized, highly automated protocol) is intended to be directly transferable to international initiatives such as the International Council for the Exploration of the Sea (ICES, responsible for *Nephrops* monitoring in the Atlantic) through the participation in the ICES Working Group on *Nephrops* Surveys (WGNEPS). Finally, the aims align to the Horizon Europe mission on "Healthy Oceans, Seas, Coastal and Inland Waters".

6.3 Lander, burrow recovery, sledge/drop frame comparative trials and mini drop frame trials in Scottish waters.

Adrian Weetman

Lander

Trials began in 2021 to utilise a re-purposed static lander frame during Scotland's annual underwater television (UWTV) survey in January to obtain still images of Nephrops grounds, to observe Nephrops activity in and around burrow entrances, bioturbation of the sea bed and benthic activity over a sustained period of time, with each image being time and date stamped.

The frame is constructed of 3 cm x 3cm box section steel, 1.3 m high with a 1.3 m x 1.3 m footprint. Each corner is loaded with two 20 kg weights to assist with a vertical touch down on deployment. The frame is equipped with a fully self-contained time lapse camera system, comprising of a

bespoke stills camera, a LED strobe, and records the data to the camera's internal SD card. Attached to the top of the frame is 100 m of polypropylene line, lashed with weighted line in sections with paired 12" and 6" buoys with a 1 m catching loop/'tripper' on the surface end of the line to assist recovery with a grappling hook.

Originally the arrangement was designed to take one image every 12 hours over a 12 month period. However, for Nephrops work, the camera and strobe are set to take one high definition image every hour, with the number of images limited only by the maximum capacity of the storage medium, as the power supply would be sufficient to outlast the duration of the survey.

Potential deployment sites are initially surveyed with a drop frame which can send a live video feed to the ship. This provides evidence that the sea bed in the survey area is of a suitable type and that there are Nephrops burrows present. With no live fed from the frame to the ship, the frame is then deployed 'blind' on the grounds. Deploying the frame is carried out from the stern of the vessel, with the weighted line being slowly fed out under control using a power block. The depth of water is obtained and the excess weighted line is coiled and tied to the top of the frame to avoid long lengths of line streaming on the surface and creating a navigation hazard.

Once on the sea bed, the marker buoys are lowered to the water and the frame remains in situ for a predetermined period of time – depending on vessel operations and environmental conditions.

On recovery, the catching loop between the marker buoys is hooked from the vessel and the weighted line fed through the power block to allow the frame to be raised from the seabed. Once on deck the images are downloaded to a laptop and the battery is recharged ready for the next deployment.

To date the frame has been deployed five times over three surveys and remained in place for up to five days at any one time. There is no way of reviewing what the camera has been recording without bringing it back on to deck. To address this and to check the system is working correctly, and to improve the probability of obtaining both useful and interesting images, the frame is recovered part way through the survey, and then redeployed in the same vicinity.

This approach has captured images from a variety of substrates which in turn illustrate the diversity on discrete grounds, which has been of interest to other parties outwith the sphere of those involved in Nephrops. Nephrops burrow entrances and some Nephrops activity has also been recorded.

Burrow recovery

It is assumed that commercial Nephrops fishing gear will, by design, disturb the seabed and potentially, partially or fully, fill in Nephrops burrow entrances. Some of these complexes may still retain uncaught Nephrops, which may have reacted the approaching trawl by retreating into the burrow complex. This work looks at the possible time it takes for a Nephrops to re-excavate an affected burrow entrance.

Started in 2022, trials were undertaken in the Moray Firth and the North Minch.

The approach used involves identifying an area of suitable Nephrops habitat not presently under any commercial fishing pressure (to avoid the trial site being disturbed), and then surveying the ground at five, evenly distanced sites along a mile linear path (providing the 'control' burrow density). The survey method and data processing replicates exactly the same procedures as described in the ICES TIMES document number 65.

The rig used in this trial is a typical Faithlie 200 ft. prawn scrapper trawl, with 6" and 8" discs and incorporating a tickler chain, connected to commercial Vee spreader doors. This gear is

towed over the ground, encompassing the five 'control' sites previously surveyed with the UWTV sledge. The cod-end of the trawl remains open throughout the tow to allow any captured Nephrops to return to near the same ground from which they were caught, allowing them to begin burrow excavation as soon as possible.

The following day, the sledge is then towed along the same tracks as those prior to the trawl being deployed, generating the first post trawling density data. This process is then repeated on consecutive days for as long as possible, with footage being reviewed to observe any changes in the burrow density over the subsequent days, with the expectation that the density progressively increases to a value similar to the 'control' density as time passes.

This work can easily be negatively affected by commercial activity, weather, navigational issues and limited days to replicate the sledge tows.

Sledge/drop frame comparative trials

Sledge and drop frame comparative trials have been carried out over several surveys, although the number of completed trials on each survey has been relatively low due to the available time, and suitable weather conditions that are required to deploy the drop frame.

All footage gathered on both the sledge or drop frame is treated as set out in the protocols generated by the governing ICES Expert Group, *Nephrops* Underwater Television Surveys Working Group (WGNEPS). This process ensures all required standards are met as set out in ICES TIMES document number 65.

The objective of this work is to establish a correlation between observed burrow densities using two different approaches – i.e. the peer reviewed, towed sledge approach and that of the drop frame. The drop frame arrangement, which is suspended from the stern of the vessel and aims to be approximately 0.25 m off the sea bed as the vessel drifts over the grounds, is used in areas which would pose a risk to the sledge, such as unidentified grounds, areas with creels (risk of entanglement) or known rocky areas. The two systems have a number of differences, but noticeably, the camera on the drop frame is mounted vertically and on the sledge is fixed at approximately 37^0, resulting in very different perception of the sea bed; and a significantly smaller, fixed field of view (FoV) from the drop frame (defined by lasers, unlike the sledge's constantly changing FoV which is calculated from various known parameters and data collected live from the sledge).

The trials are carried out on known Nephrops grounds, and each site comprises of five parallel sledge tows, 50 m apart, with each tow being 10 minutes long (resulting in a tow length of approximately 200 m). The same camera is then transferred to the drop frame where three further 10 minute passes over the ground are carried out, but at 90^0 to the direction the sledge was towed at, and within the boundary of the sledge tows.

To provide robust statistical analysis, this work requires a significant amount of replicates, in a variety of areas to include a range of burrow densities and visibility, as well as working conditions (water clarity, sea state, etc.). Therefore this work continues slowly but with limited opportunities.

Mini drop frame

The size of Nephrops burrow complexes and burrow entrance diameters has yet to be quantifiably answered for most functional units. This is due to the majority of grounds being beyond the reach of divers, although work has been carried out in the Clyde (FU 13): Marrs et al., 1996. Box

corers have previously been used in Scottish waters (2009), but usage and resultant data are constrained in many ways.

Analogue, standard definition footage, such as used by Scotland, is challenging to use with video manipulation software, and therefore a more practical approach has been developed, borne from surveys staffed without UWTV engineers being available.

Following trials with a prototype in 2020, a more robust model was constructed. This is comprised of steel box section arranged to form a pyramid. This frame is 0.95 m high and has a footprint 1.25 m by 1.25 m. This 'mini drop frame' is equipped with a Go Pro (Hero 3 Black) camera with internal recording medium, two high powered torches and a measure rule fixed across the base of the frame. The frame is attached to a ship side winch via steel wire.

During operation, sites suitable for Nephrops habitation are selected, after which the mini drop frame is lowered to the seabed where it was left for 30 seconds, a suitable time to allow any disturbed sediment to be washed clear from the field of view. The frame is then raised 7 – 10 m above the sea bed and held there for another 30 seconds as the vessel drifts over the ground. The frame was then lowered again and the process repeated for up to 30 minutes.

Although this approach can be negatively impacted by poor weather, a number of successful deployments have been achieved, where by high definition video footage of the sea bed has been obtained, frequently capturing footage of Nephrops burrow entrances which can be scaled in relation to the measure rule.

7 Review effects of HD systems on bias correction factors (Tor g)

WGNEPS agreed to hold a workshop in 2025 where burrow system size measurements will be a main output. The terms of reference for this workshop will be decided at the next WGNEPS meeting.

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Annex 1: List of participants

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Annex 2: Resolutions

WGNEPS – Working Group on Nephrops Surveys

2021/FT/EOSG06 A **Working Group on Nephrops Surveys (WGNEPS)**, chaired by Jónas Jónasson*, Iceland will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2022	15-17 November	Cádiz, Spain	1st Interim report by 13th December to EOSG	**Outgoing chair:** Jennifer Doyle
Year 2023	12-14 December	Barcelona, Spain	2nd Interim report by 25th January to EOSG	**Incoming chair:** Jónas Jónasson
Year 2024	19-21 November	Edinburgh, United Kingdom	Final report by 2nd January 2025 to EOSG	

ToR descriptors 2022 – 2024 cycle

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	Coordination and reporting reviews of any changes to design, coverage and equipment for the various *Nephrops* UWTV and full-scale trawl surveys.	To ensure surveys used by WGCSE, WGBIE and WGNSSK are fit for purpose.	3.1, 3.2	Recurrent annual update	Survey summary including and description of alterations to the plan, to relevant assessment-WGs (WGCSE, WGNSSK, WGBIE) and SCICOM. Planning of the upcoming surveys for the survey coordinators and cruise leaders.
b	Develop an international database for *Nephrops* UWTV survey data which will hold burrow counts, ground shape files and associated data.	There is a need to centralize UWTV data in a single international database. Ensure data is available externally.	3.5	Year 1-3	ICES database
c	Update R scripts for *Nephrops* UWTV survey data processing including functions to quality control, analyze and visualize data, and interface the tools with the international database for *Nephrops* UWTV survey data	Improving standardisation of data QC and data processing. Support new developing surveys on data analysis.	3.1, 3.3	Recurrent annual update	Document and R packages for UWTV survey data on GitHub site.

d	To review video enhancement, video mosaicing, automatic burrow detection and other new technological developments applied in *Nephrops* UWTV surveys.	Periodic review of emerging technologies that might improve survey methodologies.	4.1	Recurrent annual update	Roadmap and publications as appropriate, section update in annual WG report.
e	Review and report on the utility of UWTV and trawl *Nephrops* surveys as platforms for collecting data for purposes other than *Nephrops* assessment (e.g. the collection of data for OSPAR and MFSD indicators).	*Nephrops* UWTV surveys have a role in relation to benthic habitat monitoring and the collection of other environmental and ecosystem variables.	1.5	Year 3	Meetings with data end users and section report
f	Analyse existing data from UWTV and trawl *Nephrops* surveys to evaluate possible factors affecting burrow emergence of *Nephrops* (e.g. currents, light, salinity and oxygen)	Recent behaviour aspects have been investigated in the laboratory. Important to investigate correlation with field data.	1.3	Year 1-3	Review paper
g	Review differences of new HD and previous used SD camera systems and its effect on burrow detection, edge effects and bias correction factors, and explore the possibility of HD system tools for providing estimates of burrow size distributions.	Recent changes from SD to HD technology for many survey areas. Important to investigate edge effects and correction factors with field data on burrow system size.	3.3	Year 1-3	Roadmap and publications as appropriate, section update in annual WG report.
h	Update TIMES on next cycle with items from all ToRs.	The group evaluates the TIMES content at least every three years to ensure the information is kept up to date	3.1	Year 3	To update TIMES based on conclusions if necessary. Other publications when appropriate.

Summary of the Work Plan

Year 1	**All ToRs will be adressed in this year but the main task in year 1 will be to establish the UWTV database and to provide updated shape files of Nephrops FUs and survey domains (ToR b)**
Year 2	All ToRs will be addressed in this year. In addition to this focus will be on ToR e in year 2

Year 3	All ToRs will be addressed in this year. Focus in year 3 will be on new technologies and, if appropriate, an update of the SISP (ToR b) as well on the review of field date on factors affecting burrow emergence and occupancy (ToR f)

Supporting information

Priority	*Nephrops* are a valuable species whose stocks are potentially susceptible to local depletion. UWTV/Trawl surveys are an integral part of the stock assessment and management advice provided by ICES. WGNEPS is the international co-ordination group for *Nephrops* surveys focusing on planning, collaboration, quality control and survey development issues. This work is considered high priority.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 15–20 members and guests.
Secretariat facilities	ICES Data Centre
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	This group will feed into the assessment working groups and subsequently on to ACOM as well as to SCICOM
Linkages to other committees or groups	There is a very close working relationship with relevant to stock assessment expert groups that used the survey results i.e. WGCSE, WGBIE and WGNSSK. Close linkage to WGMLEARN (automatic classification systems) and WGDEC (survey data).
Linkages to other organizations	FAO , OSPAR

Annex 3: Survey summaries

Marine Institute Ireland: FU's 16 -17, 19, 20-21 and 22.

(Jennifer Doyle)

Overview of the existing surveys.

Since 2012 Ireland has modified sampling intensity and increased survey coverage based on the recommendations of SGNEPS 2012. The numbers of stations in FU 15, FU 17 and FU 22 were reduced since 2012 to allow for survey development in FU 16, FU 19 and FU 20-21 combined. The total numbers of stations for 2022 remains broadly similar ~300 to previous years (Figure 1). 100% coverage of all the *Nephrops* grounds was achieved in 2022 for stock assessment purposes for FU 19, 22 and 20-21 combined. 88% coverage of FU 16 Porcupine Bank was completed and this was deemed acceptable for stock assessment after inspection of variograms. 14% coverage of FU 17 was obtained in 2022 where the main ground Aran and smaller ground Slyne Head were not surveyed. As a result the previous year's survey result (2021) was used for stock assessment. Weather hampered the UWTV survey programme in 2022 with 36% of operation time lost due to weather.

One survey completed on new Marine Institute vessel R.V Tom Crean in August where the same UWTV set up that was employed on previous surveys was used with the exception of a new sled sensor Sonardyne.

UWTV survey reports availability and UWTV data work-up.

The individual UWTV survey reports and further details of the survey design, numbers of stations and data processing are available from the Marine Institute Open Access Repository see links in table below. The links to the ICES TAF repositories which details the UWTV statistical methods for each FU where available are also listed below.

FU	Survey Report	ICES TAF repository
20-21	http://hdl.handle.net/10793/1798	https://github.com/ices-taf/2022_nep.fu.2021_assessment/tree/main/model/model_02_kriging
22	http://hdl.handle.net/10793/1797	https://github.com/ices-taf/2022_nep.fu.22_assessment/tree/main/model/model_02_kriging
19	http://hdl.handle.net/10793/1795	https://github.com/ices-taf/2022_nep.fu.19_assessment/tree/main/model/model_02_UWTV
16	http://hdl.handle.net/10793/1794	Not available
17	http://hdl.handle.net/10793/1793	Not available

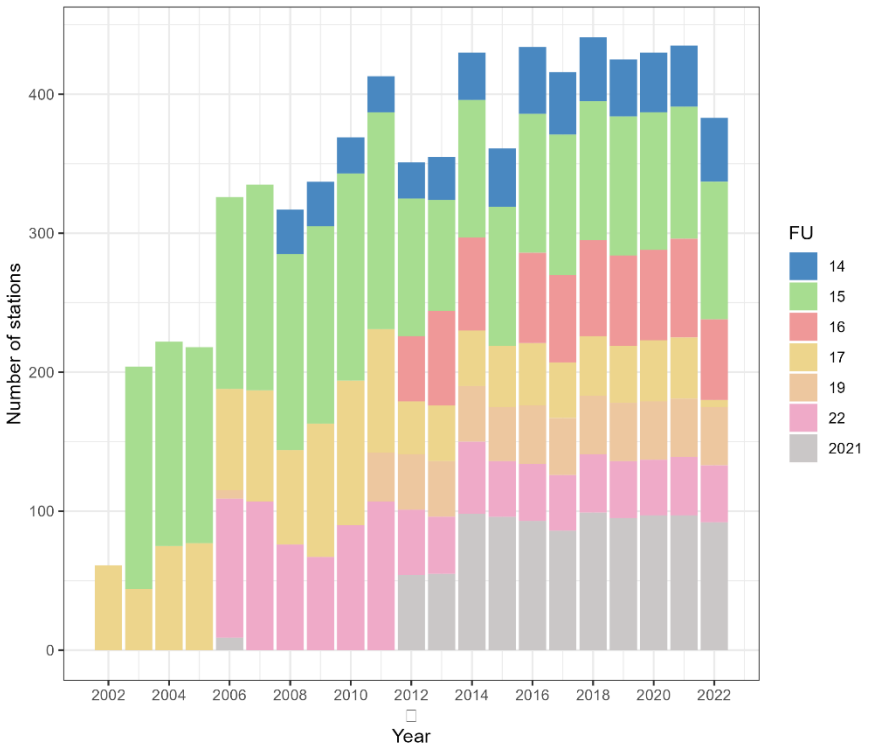


Figure 1. Time series of the total number of UWTV stations carried out by Ireland in each Functional Unit. Stations in FU 14 and FU 15 are usually carried out in collaboration with AFBI in UK-NI and CEFAS UK E&W.

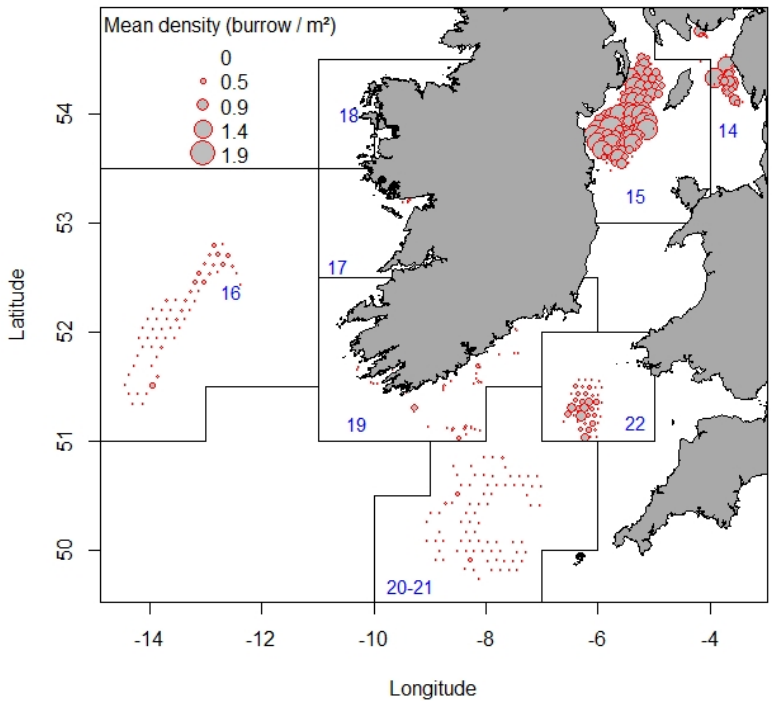


Figure 2. Mean adjusted density estimates (burrow/m²) by station for *Nephrops* grounds in ICES Subarea 7 in 2022.

Functional Unit	**16**	**Area name**	**Porcupine Bank**
Survey design	Randomised isometric grid	Previous surveys	2012 to 2014 and 2016 to 2022
Camera Type: Standard/High definition	HD Cathx	Image Data: Type / Size per station	HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station
Country (ies)	Ireland	Vessel name (s)	Tom Crean
Survey code (s)	TC23012	Dates (start/end)	30th May – 10th June 2023
Number scientific staff	9	Staff exchanges	Yes - JNCC
Number of stations (planned/completed/used in analysis)		71/71/71	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.02 m (object tracking method estimation)
Adjusted mean density	0.27 burrows /m^2	Adjusted abundance, CV	2002 million, CV = 3.1%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes (2020)	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC, threshold = 0.6	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter Marine Mammal Observer	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Storage: MI network – SQL Level: HD: annotated burrows
		CTD	Storage: MI network Level: TD profile per station
		Trawl	No
		Sediment	No
		Other	Storage: MI network – SQL

		Level: Ancillary data per station

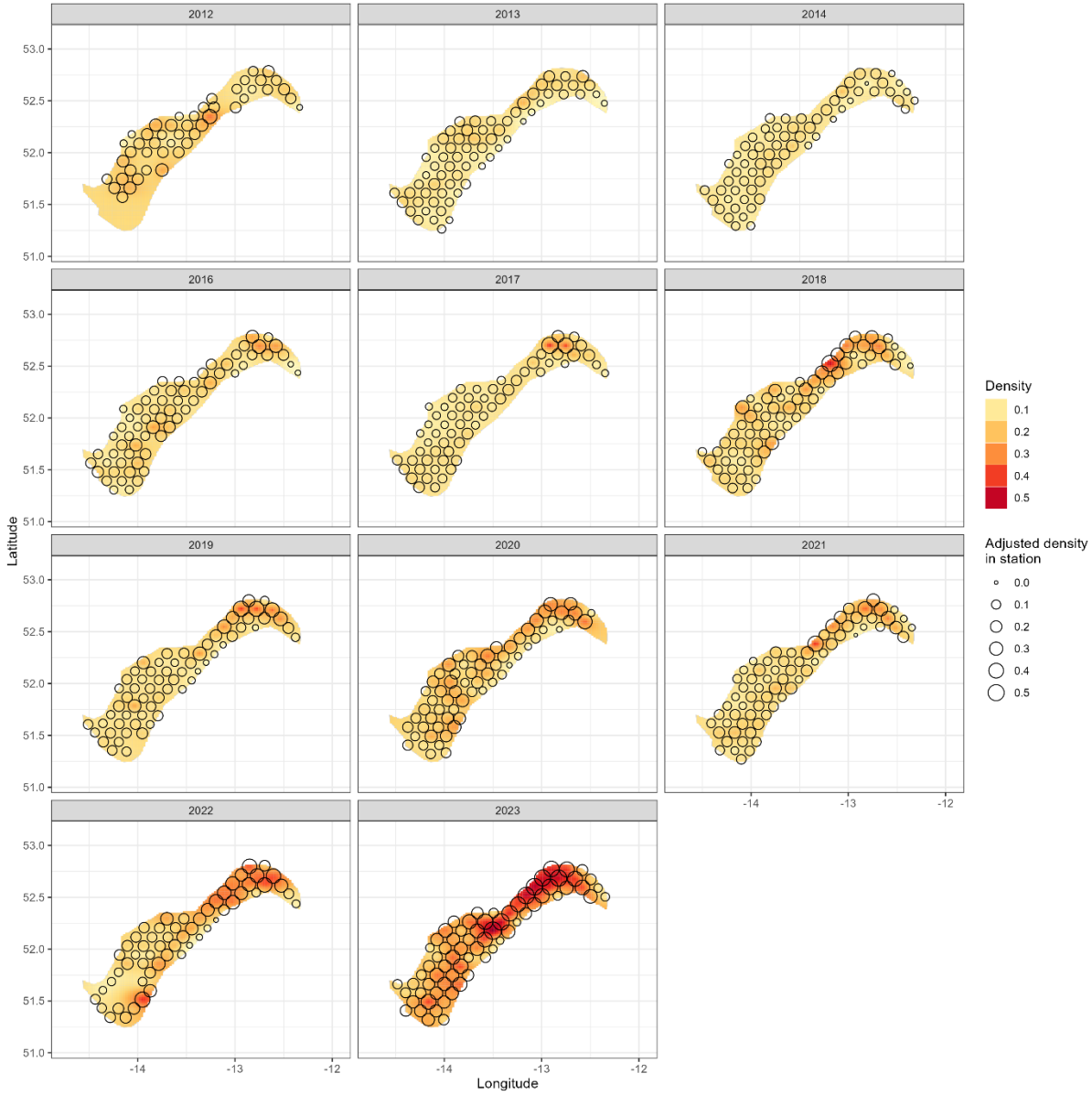


Fig. 1: FU 16. Map of density (burrow/m²) by station for each year.

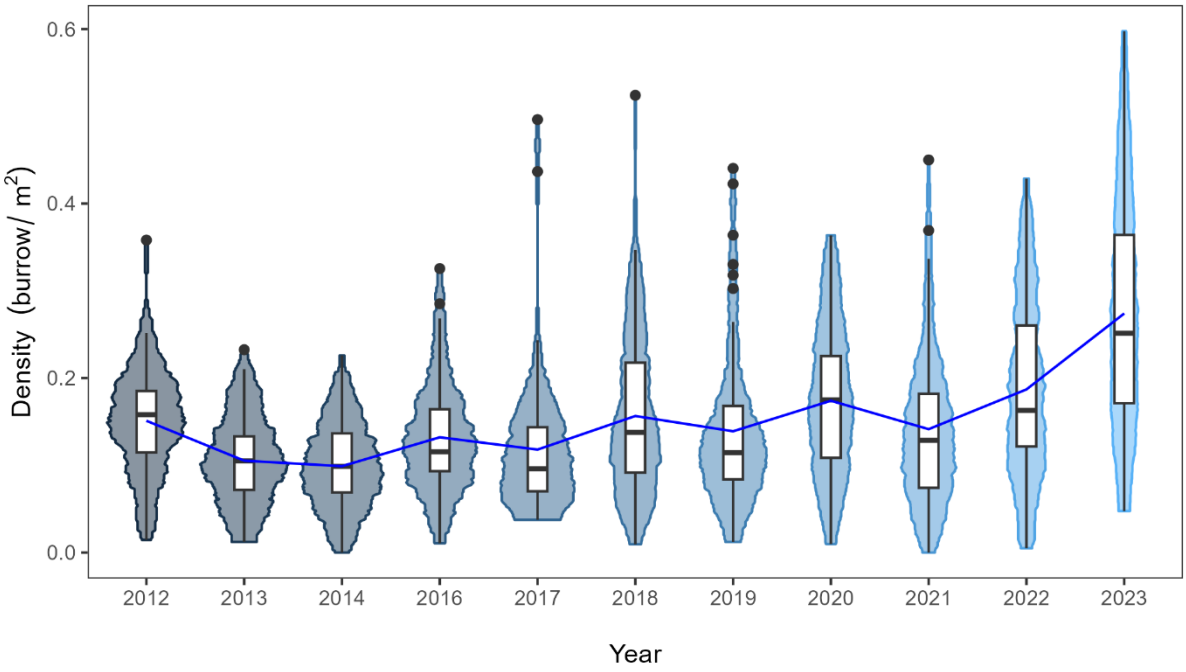


Fig. 2: FU 16. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

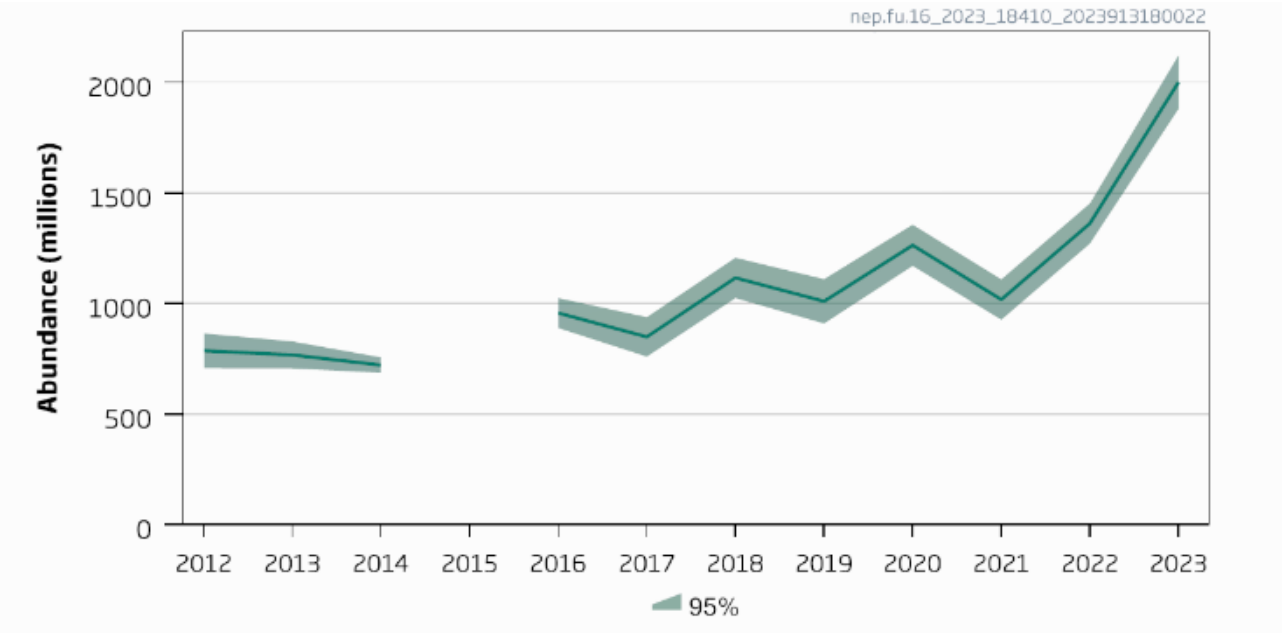


Fig. 3: FU 16. Time series of abundance (with confidence intervals).

Functional Unit	**17**	**Area name**	**Aran Grounds, Galway Bay and Slyne Head**
Survey design	Randomised isometric grid	Previous surveys	2002 to 2022
Camera Type: Standard/High definition	HD Cathx	Image Data: Type / Size per station	HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station
Country (ies)	Ireland	Vessel name (s)	Tom Crean
Survey code (s)	TC23012	Dates (start/end)	30th May – 10th June
Number scientific staff	9	Staff exchanges	Yes (JNCC)
Number of stations (planned/completed/used in analysis)		44/44/44	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.02 m (object tracking method estimation)
Adjusted mean density	Aran: 0.29 burrows /m²	Adjusted abundance, CV	Aran: 356 million, CV=3%
	Galway Bay: 0.19 burrows /m²		Galway Bay: 15 million, CV= 7%
	Slyne Head: 0.12 burrows /m²		Slyne Head: 5 million, CV= 5%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes (2020)	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC, threshold = 0.6	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Storage: MI network – SQL Level: annotated burrows
		CTD	Storage: MI network Level: TD profile per station

	Trawl	No
	Sediment	No
	Other	Storage: MI network – SQL Level: Ancillary data per station

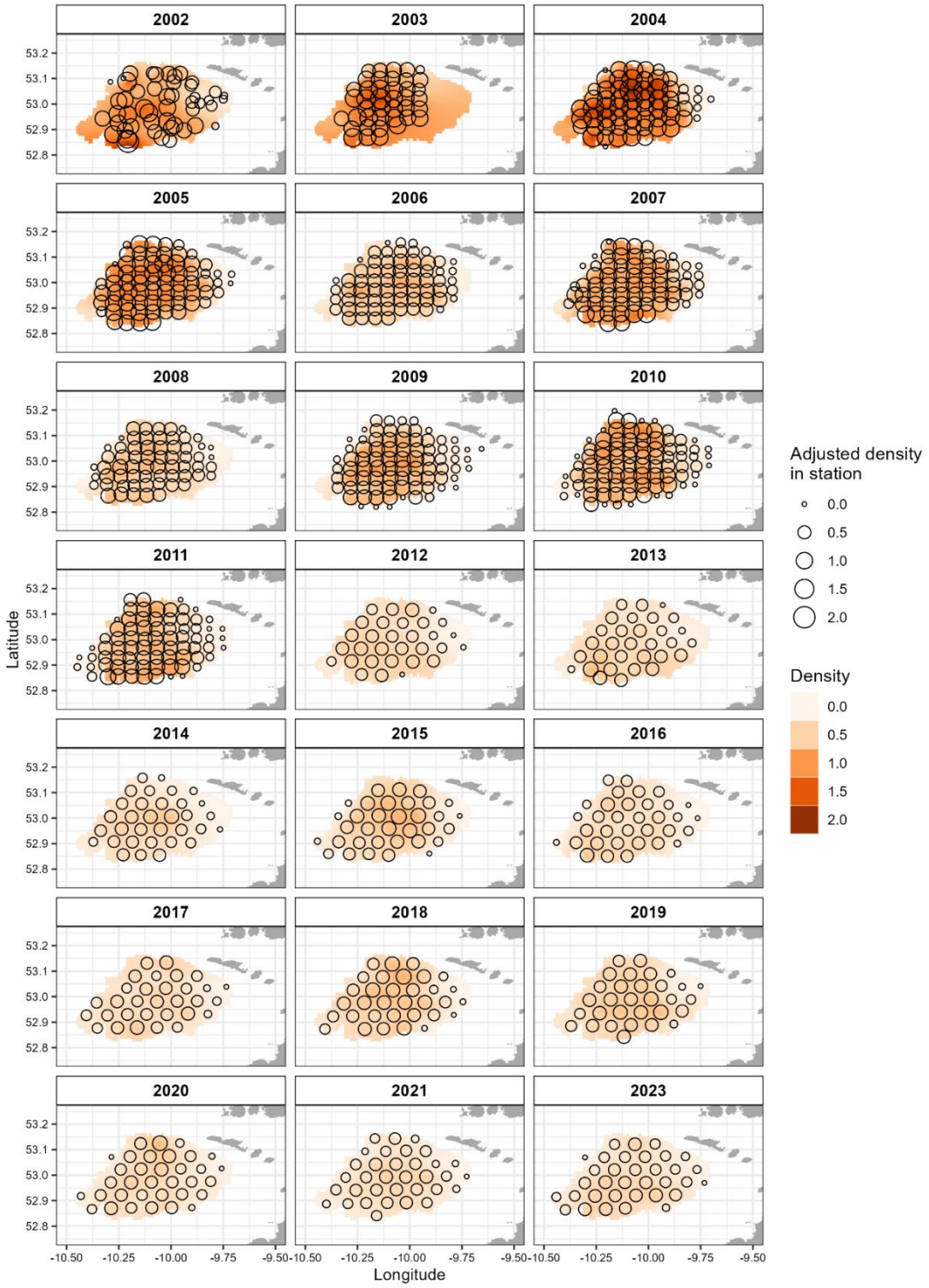


Fig. 1: FU 17. Map of density by station for each year.

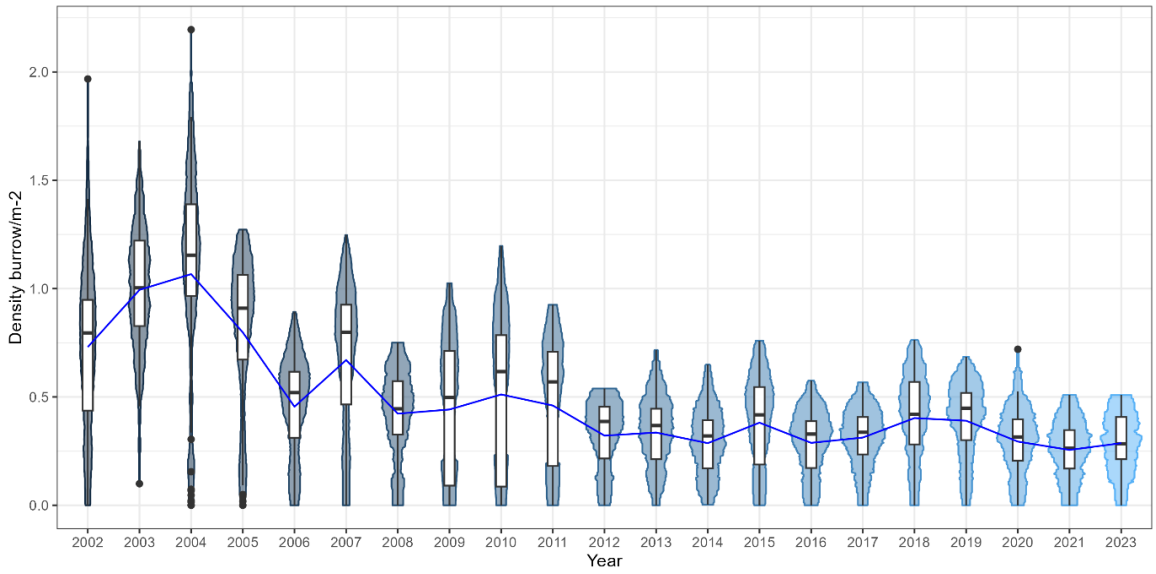


Fig. 2: FU 17. Times series of adjusted burrow density for Aran grounds (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

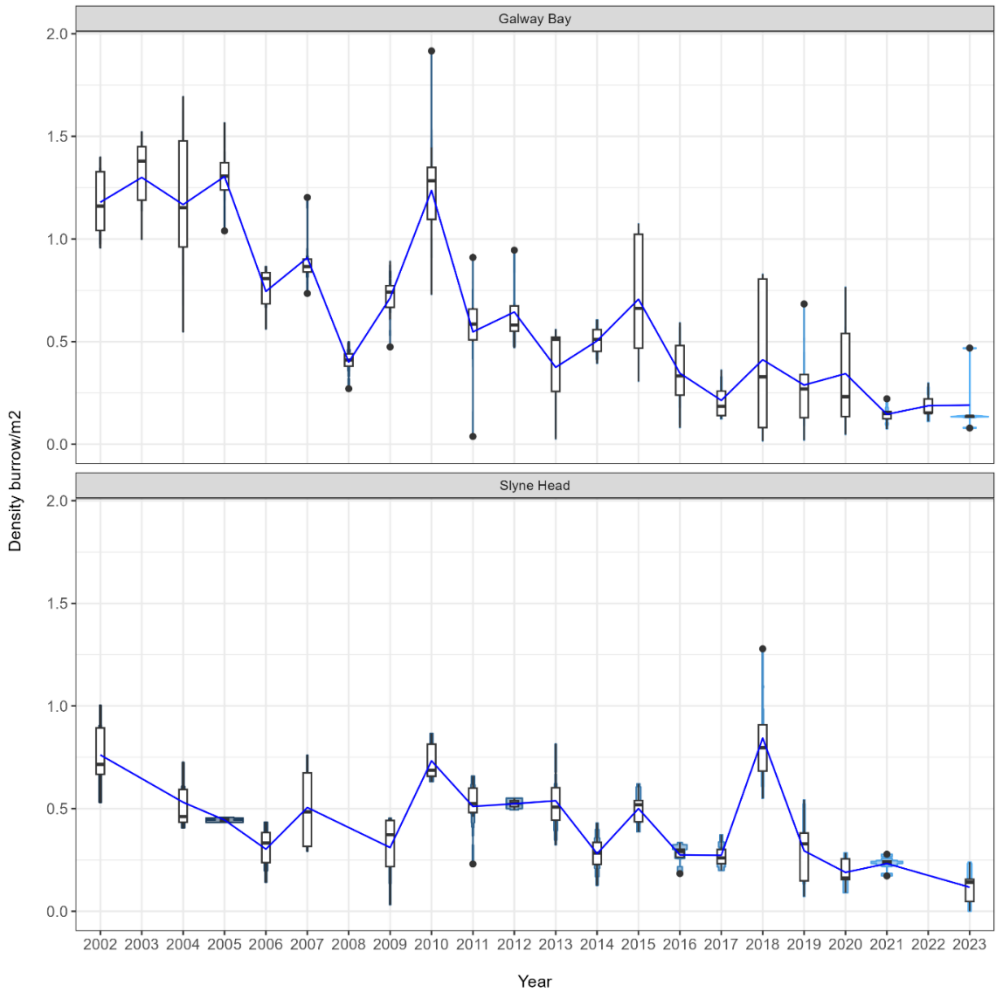


Fig. 3: FU 17. Times series of adjusted burrow density for Galway Bay and Slyne Head (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

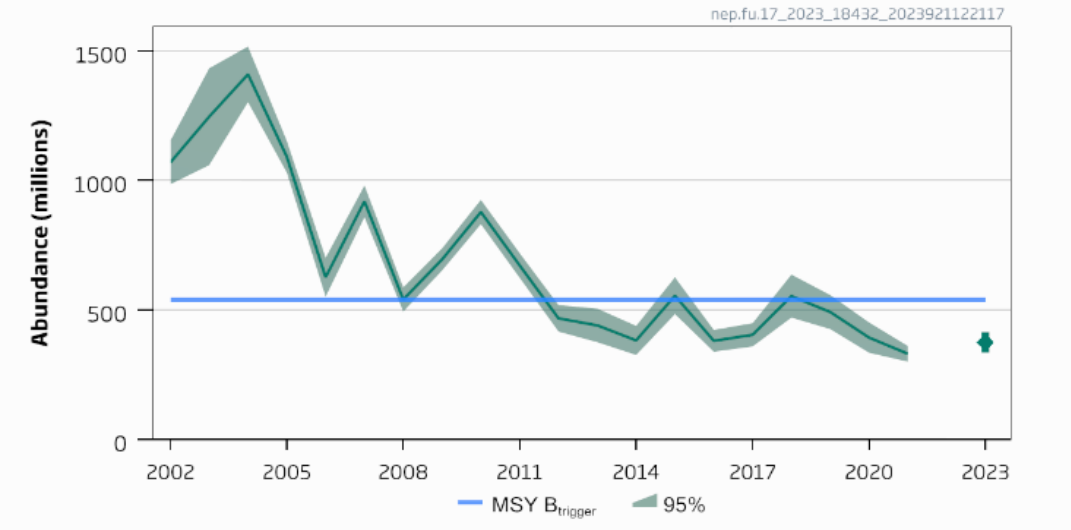


Fig. 4: FU 17. Time series of abundance (with confidence intervals) with reference levels.

Functional Unit	**19**	**Area name**	**South and Southwest of Ireland**
Survey design	Randomised stratified by area	Previous surveys	2006 and 2011 to 2022
Camera Type: Standard/High definition	HD Cathx	Image Data: Type / Size per station	HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station
Country (ies)	Ireland	Vessel name (s)	Tom Crean
Survey code (s)	TC23012,TC23013,TC23017	Dates (start/end)	30th May – 10th June, 11th – 21th June and 25 – 28th August 2023
Number scientific staff	9	Staff exchanges	Yes: AFBI and JNCC
Number of stations (planned/completed/used in analysis)		42/42/42	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.02 m (object tracking method estimation)
Adjusted mean density	0.11 burrows /m^2	Adjusted abundance, CV	220 million, CV = 17%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		No, but counted after FU2021, which has similar characteristics	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC, threshold = 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Storage: MI network – SQL Level: HD: annotated burrows
		CTD	Storage: MI network Level: TD profile per station
		Trawl	No
		Sediment	No

	Other	Storage: MI network – SQL Level: Ancillary data per station

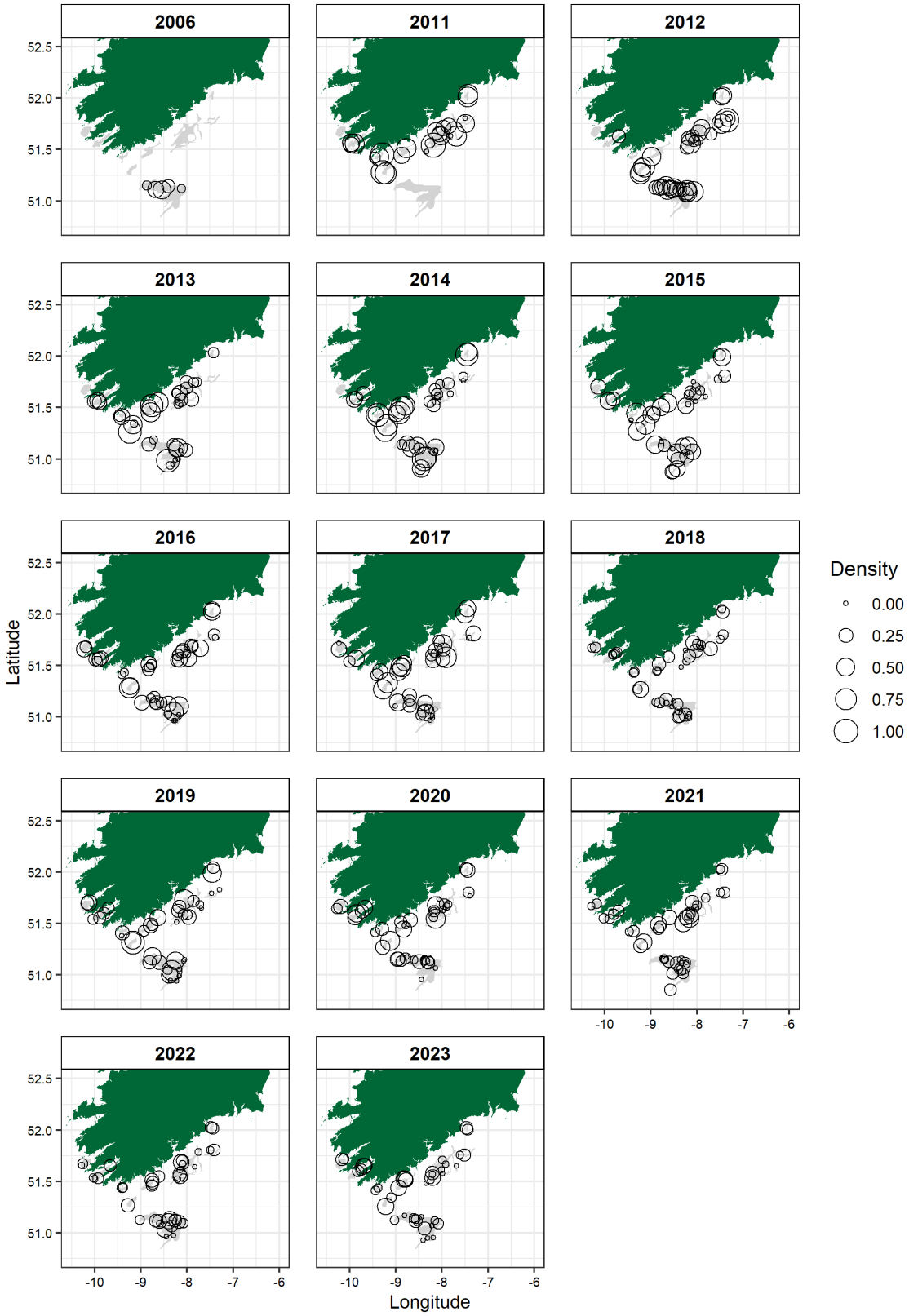


Fig. 1: FU 19. Map of density (burrow/m²) by station for each year.

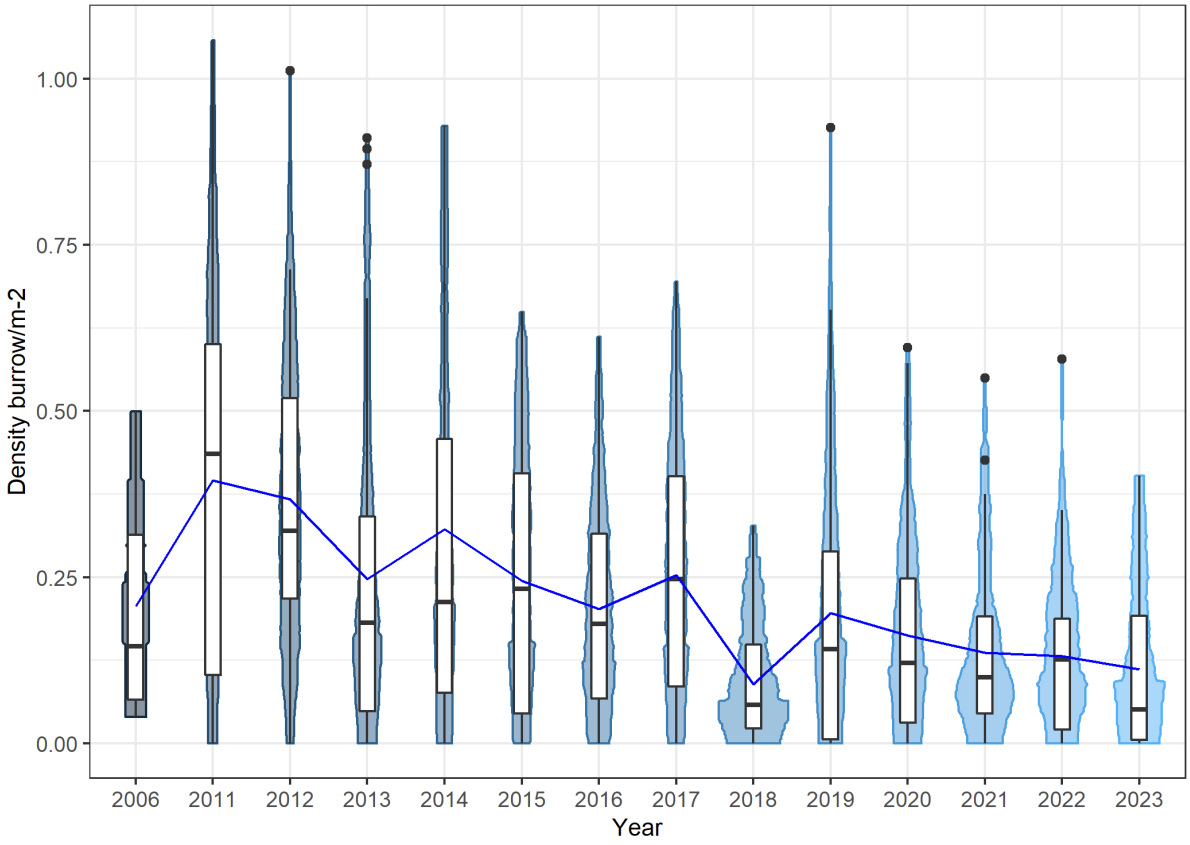


Fig. 2: FU 19. Times series of adjusted burrow density (Violin and box plot).

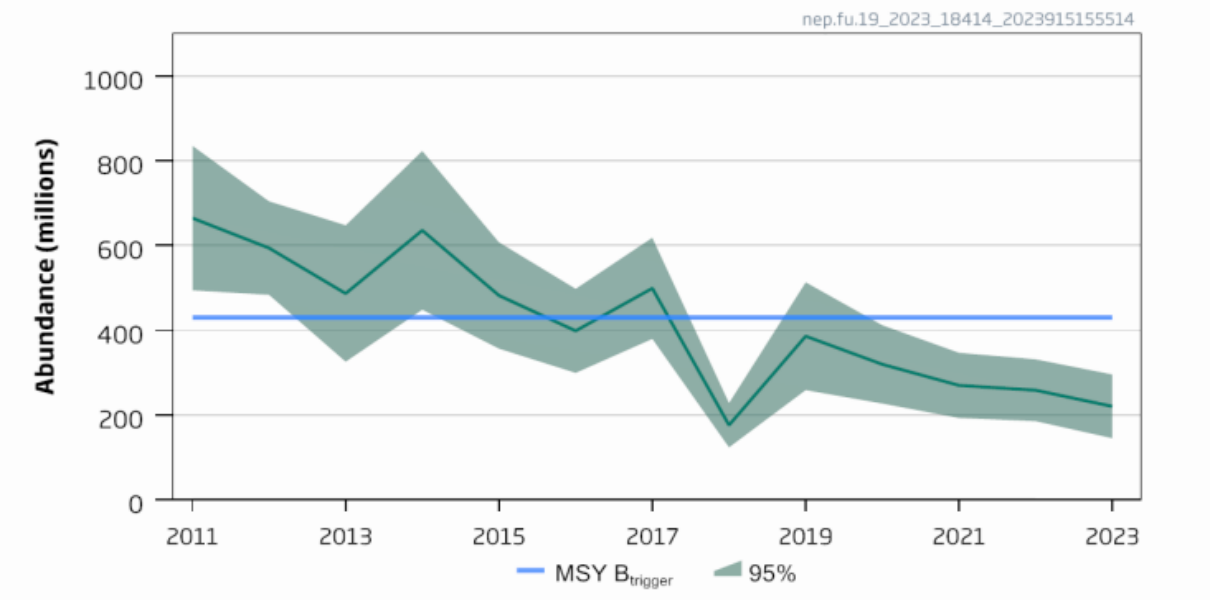


Fig. 3: FU 19. Time series of abundance (with confidence intervals) with reference levels.

Functional Unit	**20-21**	**Area name**	**Labadie, Jones and Cockburn Banks**
Survey design	Randomised isometric grid (6 nautical mile spacing)	Previous surveys	2013 to 2022
Camera Type: Standard/High definition	HD Cathx	Image Data: Type / Size per station	HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station
Country (ies)	Ireland	Vessel name (s)	Tom Crean
Survey code (s)	TC23013	Dates (start/end)	11th June - 21st June 2023
Number scientific staff	9	Staff exchanges	Yes (AFBI)
Number of stations (planned/completed/used in analysis)		100/100/100	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.02 m (object tracking method estimation)
Adjusted mean density	0.104 burrows /m2	Adjusted abundance, CV	1026 million, CV = 4.4%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes (2020)	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC, threshold = 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Storage: MI network – SQL Level: HD: annotated burrows
		CTD	Storage: MI network Level: TD profile per station
		Trawl	No
		Sediment	No
		Other	Storage: MI network – SQL

		Level: Ancillary data per station

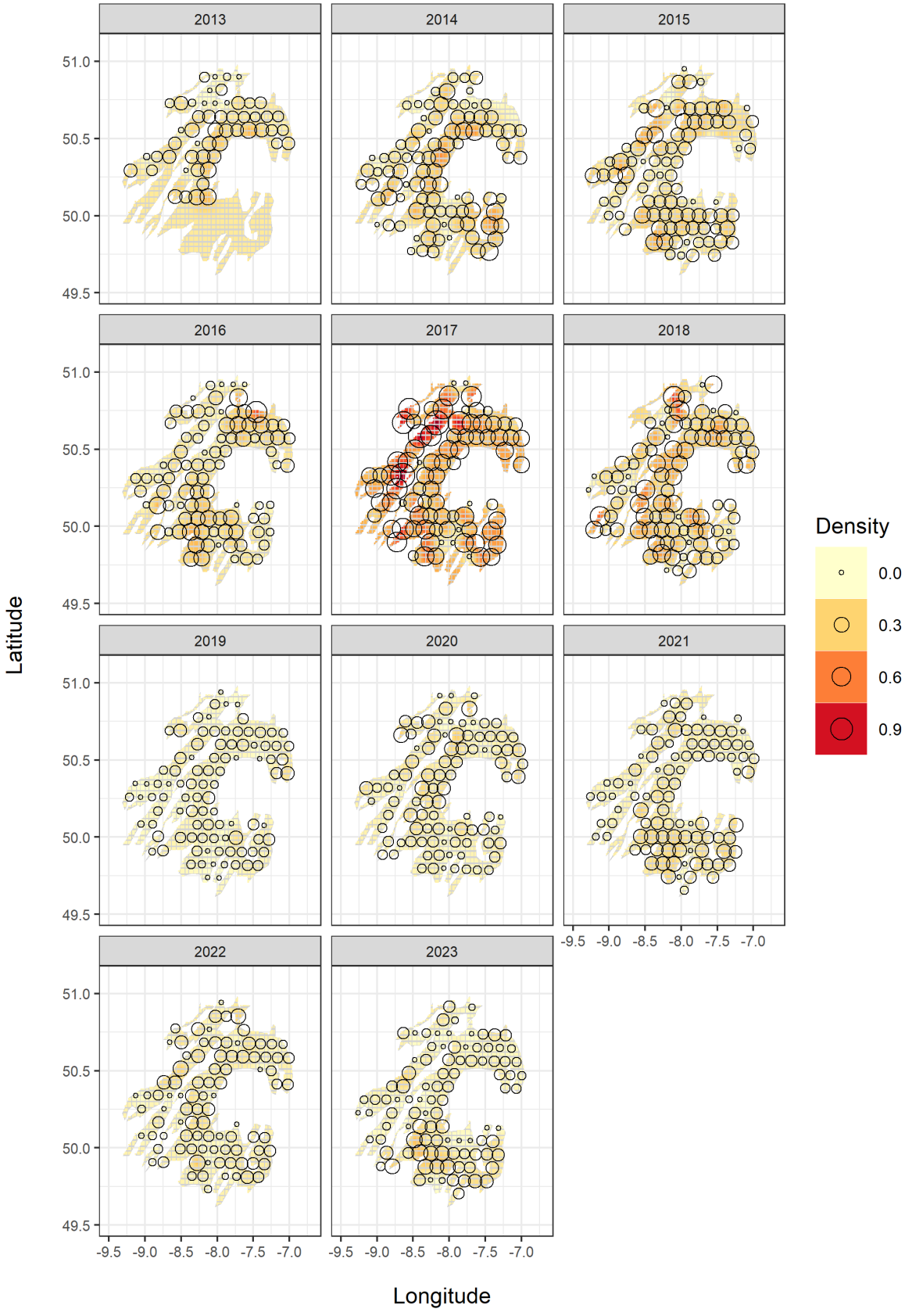


Fig. 1: FU 20-21. Map of density (burrow/m²) by station for each year.

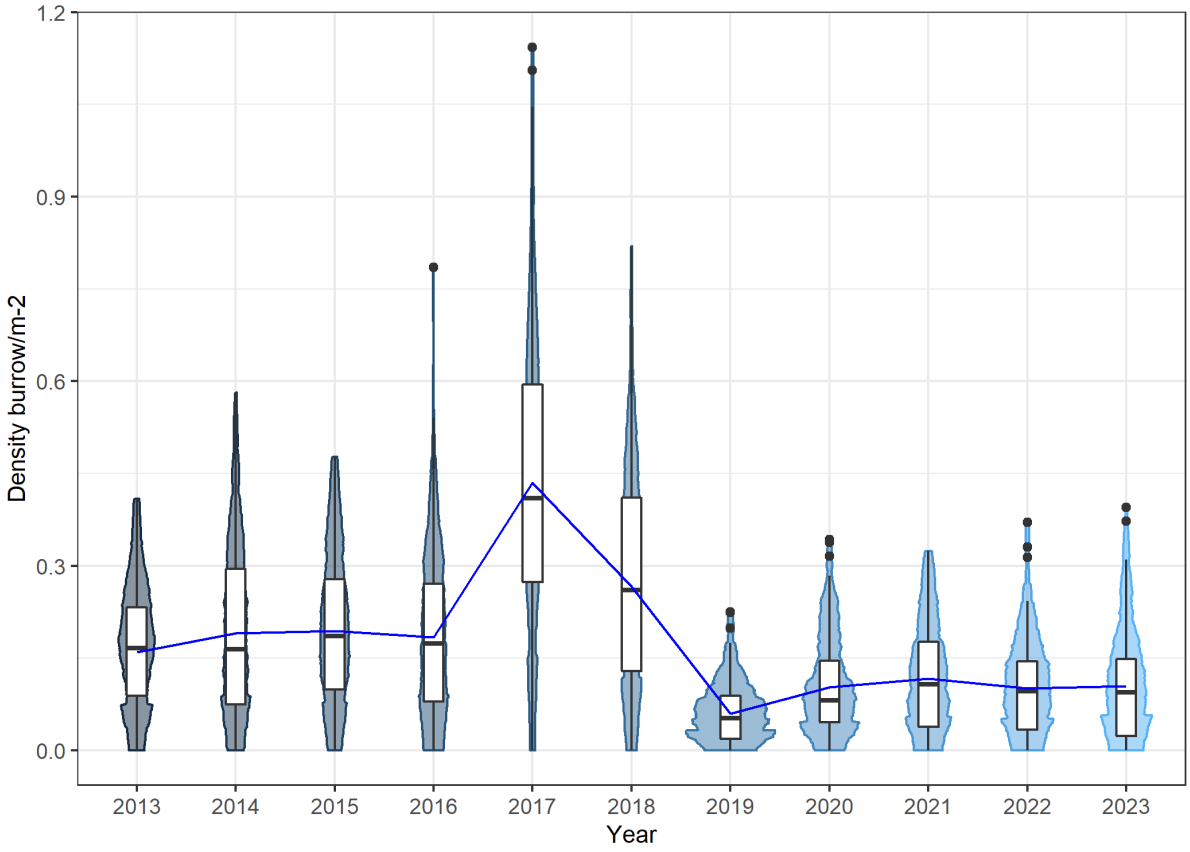


Fig. 2: FU 20-21. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

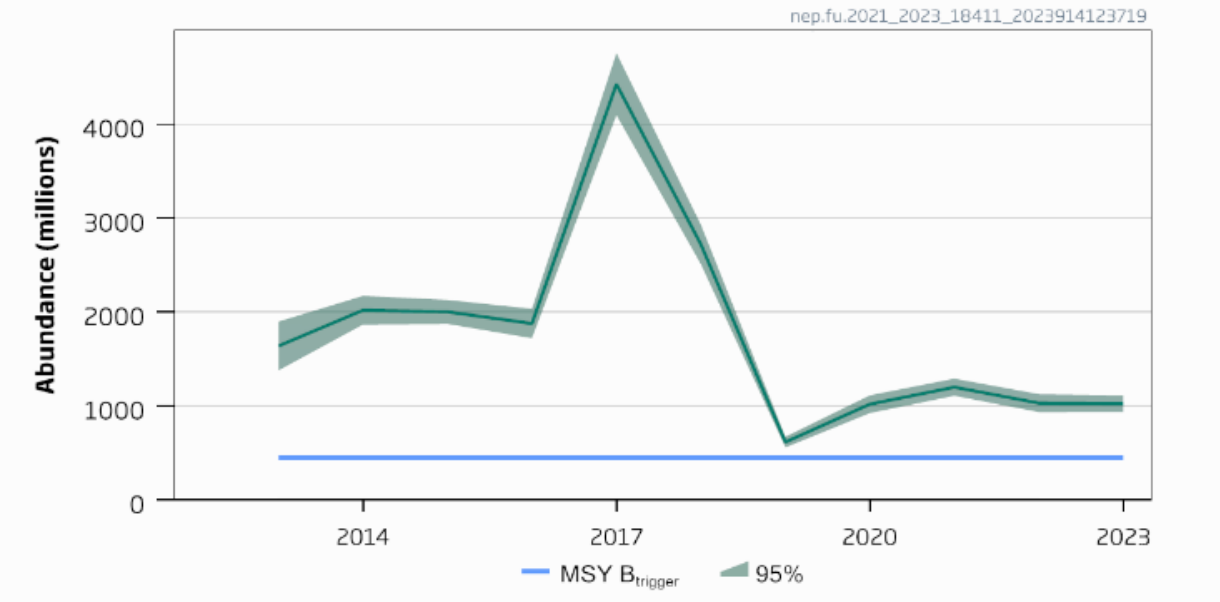


Fig. 3: FU 20-21. Time series of abundance (with confidence intervals) with reference levels.

Functional Unit	**22**	**Area name**	**The Smalls**
Survey design	Randomised isometric grid	Previous surveys	2006 to 2022
Camera Type: Standard/High definition	HD Cathx	Image Data: Type / Size per station	HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station
Country (ies)	Ireland	Vessel name (s)	Tom Crean
Survey code (s)	TC23013	Dates (start/end)	11th June - 21st June 2023
Number scientific staff	9	Staff exchanges	Yes (AFBI)
Number of stations (planned/completed/used in analysis)		41/41/41	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.02 m (object tracking method estimation)
Adjusted mean density	0.27 burrows /m2	Adjusted abundance, CV	776 million, CV = 6.9%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes (2020)	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC, threshold = 0.6	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Storage: MI network – SQL Level: HD: annotated burrows
		CTD	Storage: MI network Level: TD profile per station
		Trawl	No
		Sediment	No
		Other	Storage: MI network – SQL

		Level: Ancillary data per station

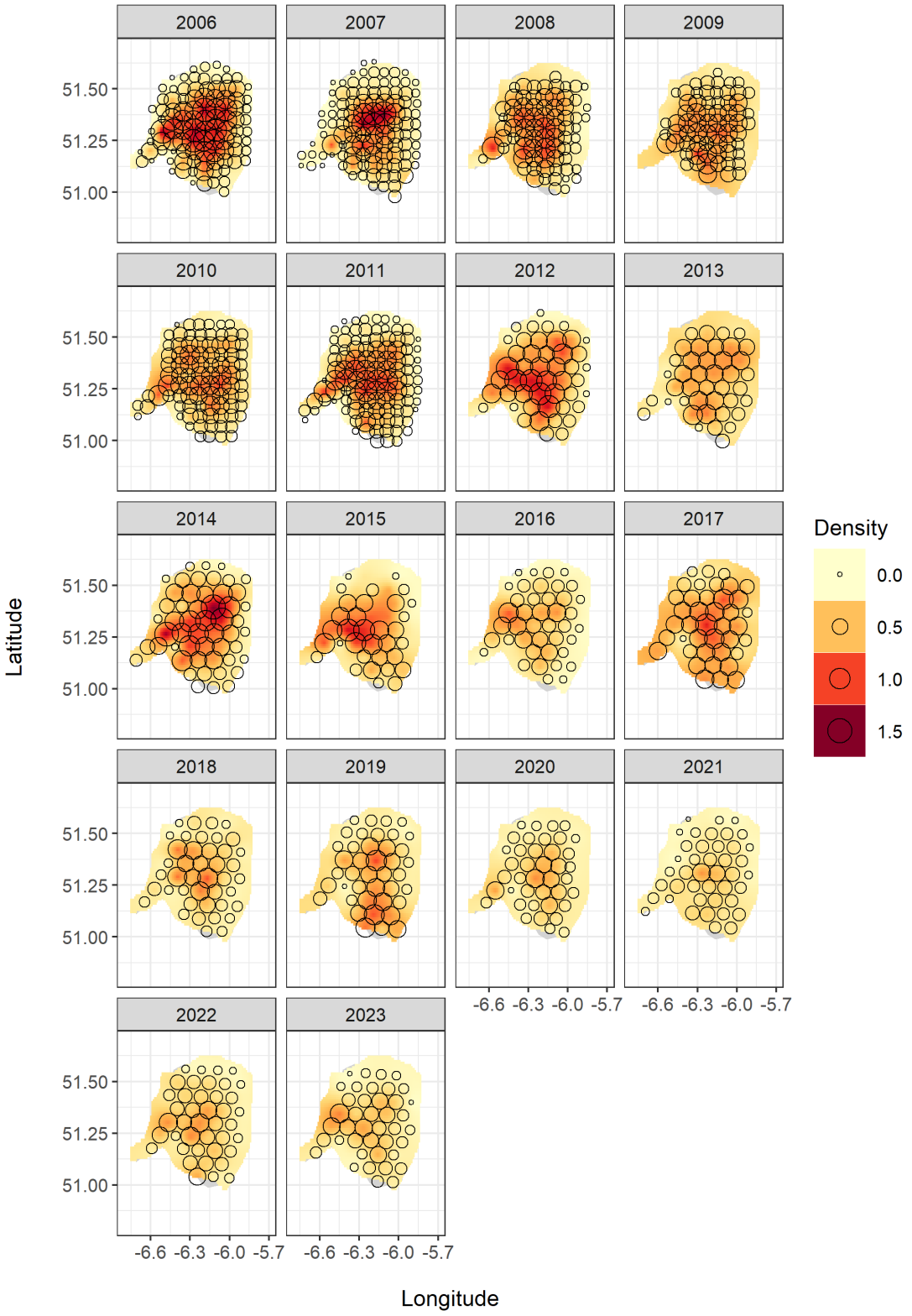


Fig. 1: FU 22. Map of density (burrow/m²) by station for each year.

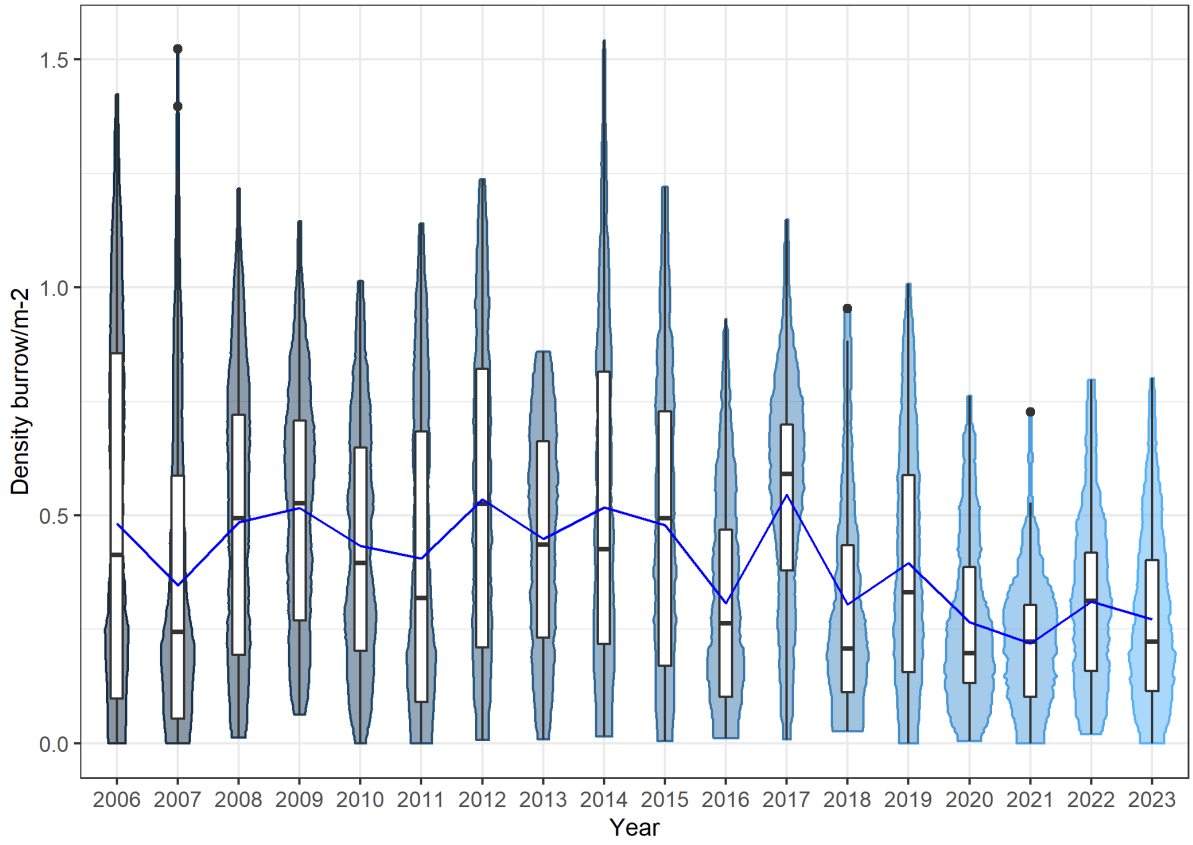


Fig. 2: FU 22. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

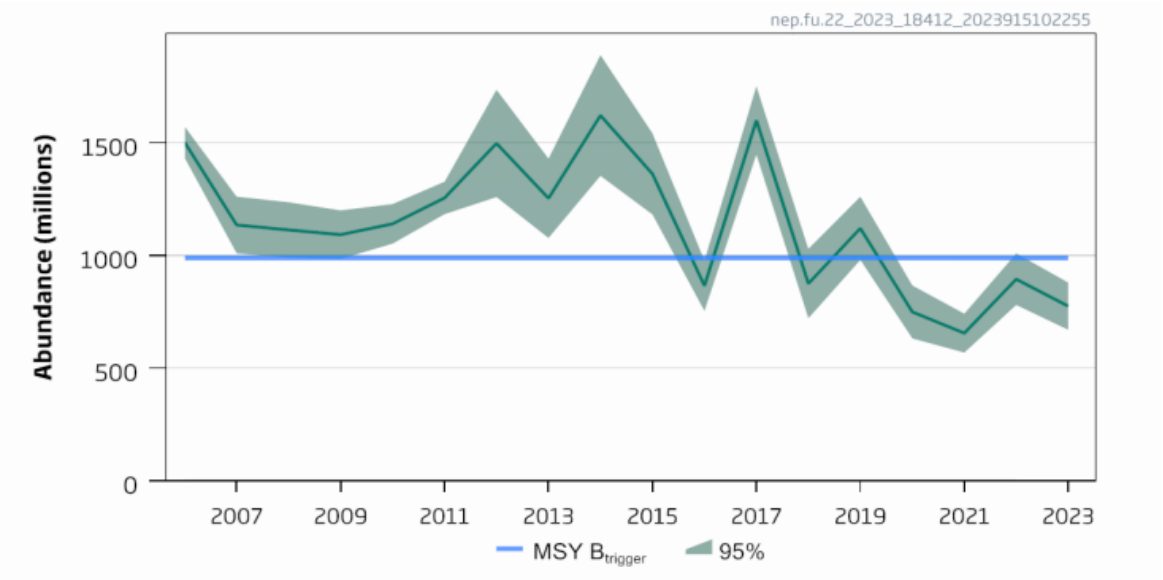


Fig. 3: FU 22. Time series of abundance (with confidence intervals) with reference levels.

UK Northern Ireland: FU 15

(Pia Schuchert, Jessica Graham)

Functional Unit	**15**	**Area name**	**Western Irish Sea**
Survey design	Random grid	Previous surveys	2003-2022
Country (ies)	UK & Ireland	Vessel name (s)	R/V Corystes, R/V Tom Crean
Survey code (s)	CO2923, TC23017	Dates (start/end)	23rd July –1st August, 25-30 August
Number scientific staff	6	Staff exchanges	yes
Number of stations (planned/completed/used in analysis)		100/96/96	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		64 Stations completed on Corystes, 32 on Tom Crean	
Distance over ground source used	USBL (sledge) where available, Ship where not available	Average field of view (cm)	87 cm/102 cm
Adjusted mean density	0.80	Adjusted abundance, CV	4650 million, CV=2.53%
Overall footage quality (poor, medium, good)		Good footage July, poor in late August	
Reference footage for survey area generated		No – New HD Still/video footage – Reference sets currently in development.	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC threshold 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		*Nephrops* otter trawls	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	9991 Nephrops burrows counted, **storage**: DVD up to 2020, digital since 2021 **level of analysis**: kriged estimates as for last year **dissemination**: WGCSE
		CTD	-
		Trawl	18
		Sediment	0
		Other	0

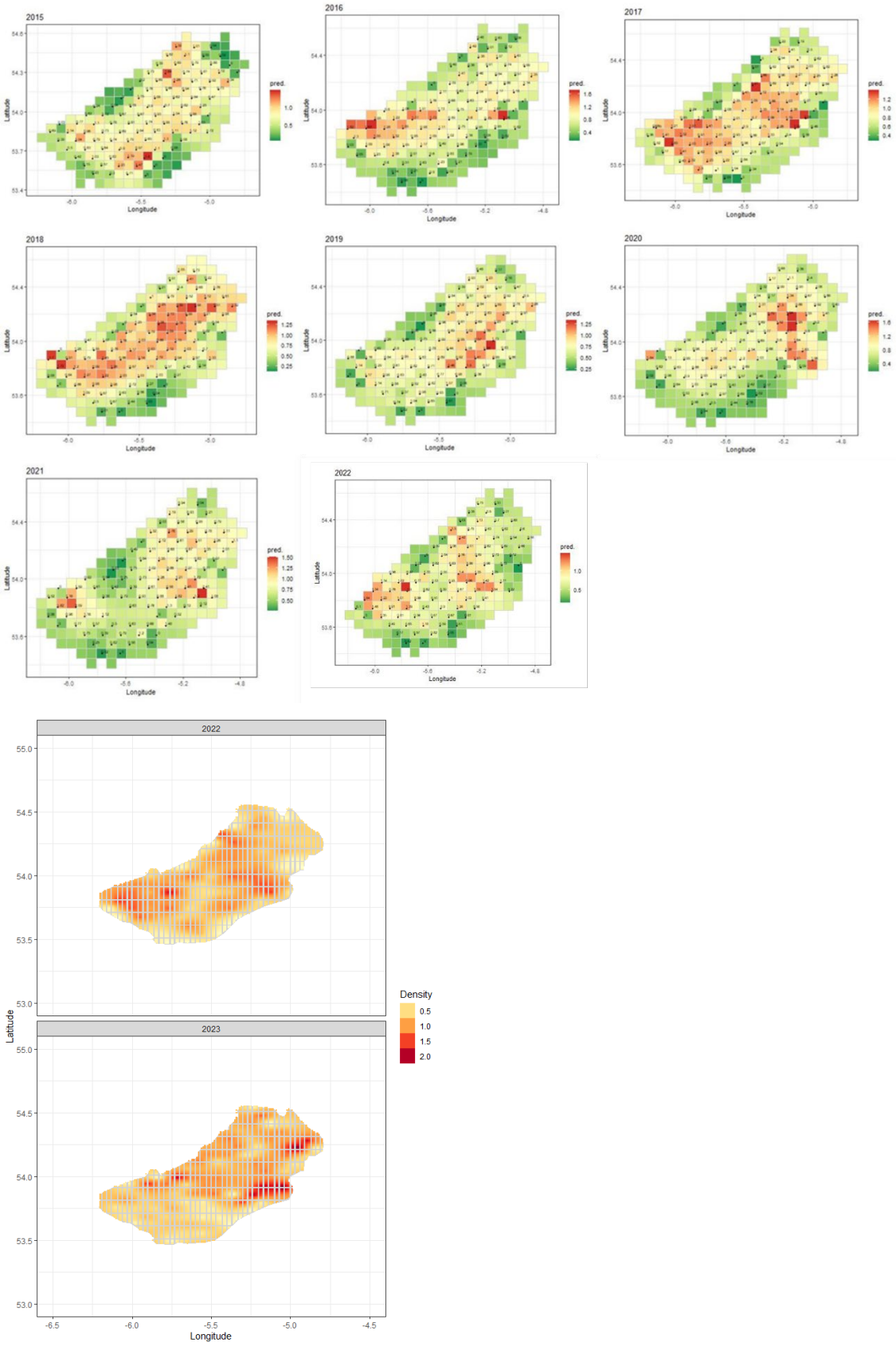


Figure. 1: FU 15. Map of kriged density by station for 2015 – 2023.

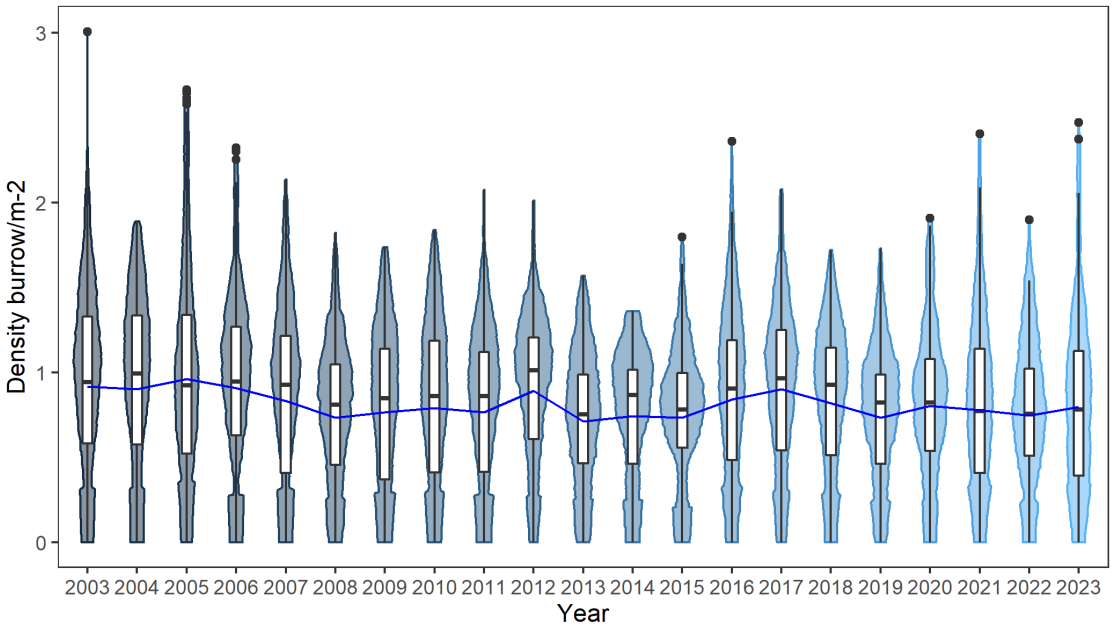


Figure. 2: FU 15. Times series of adjusted burrow density (Violin and box plot).

UK Scotland: FU's 7 – 10, 11 -13 and 34

(Adrian Weetman)

Functional Unit	**11**	Area name	**North Minch**
Survey design	Stratified Random plus 10 legacy, fixed stations	Previous surveys	1994, 1996, 1998-2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 50 Completed – 48 Used in analysis - 47	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.512	Adjusted abundance, CV	1489 mill., CV = 0.0094
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on	

(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)	visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)	Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** - WGCSE
	CTD	No
	Trawl	**Storage** – hard copies of data held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – local, maturity staging **Dissemination** - Marine Directorate of the Scottish Government
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the

		Scottish Government, and MSFD

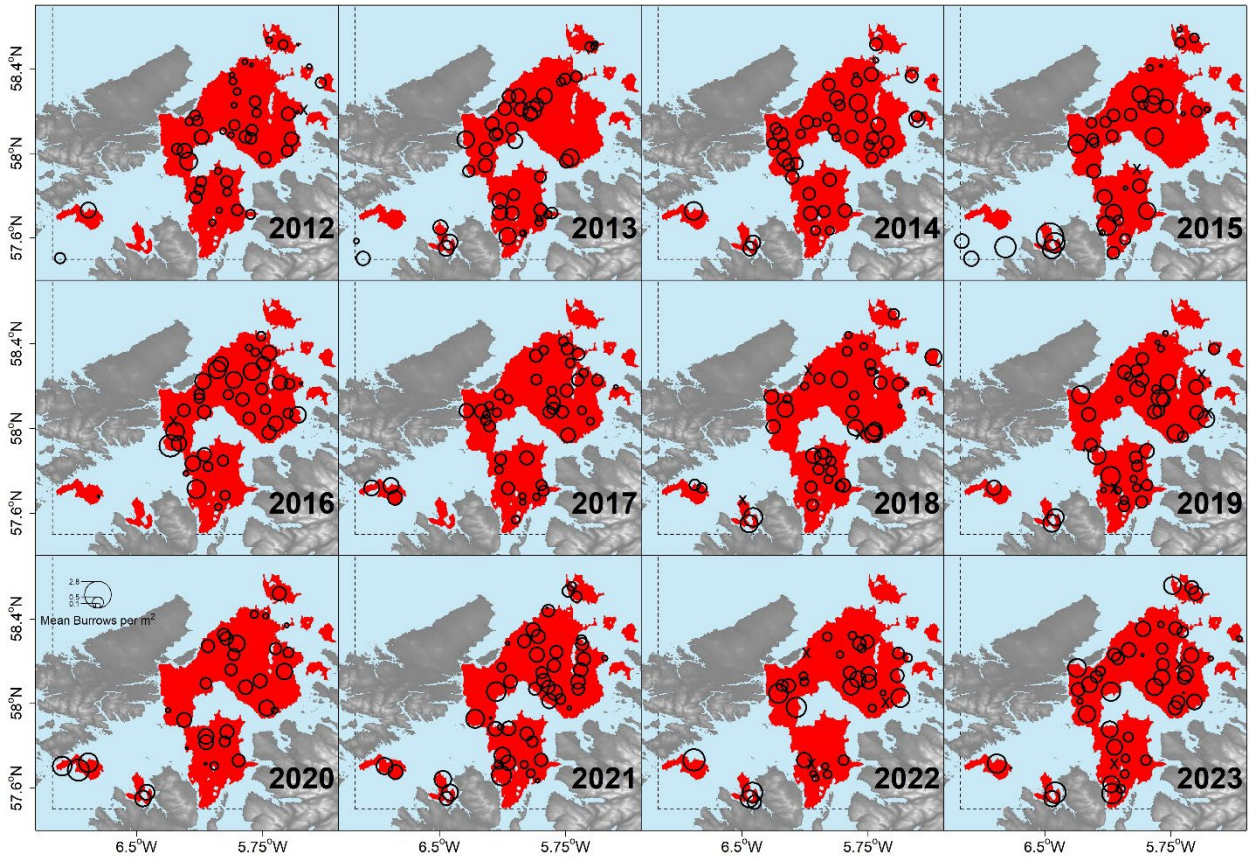


Fig. 1: North Minch (FU 11). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

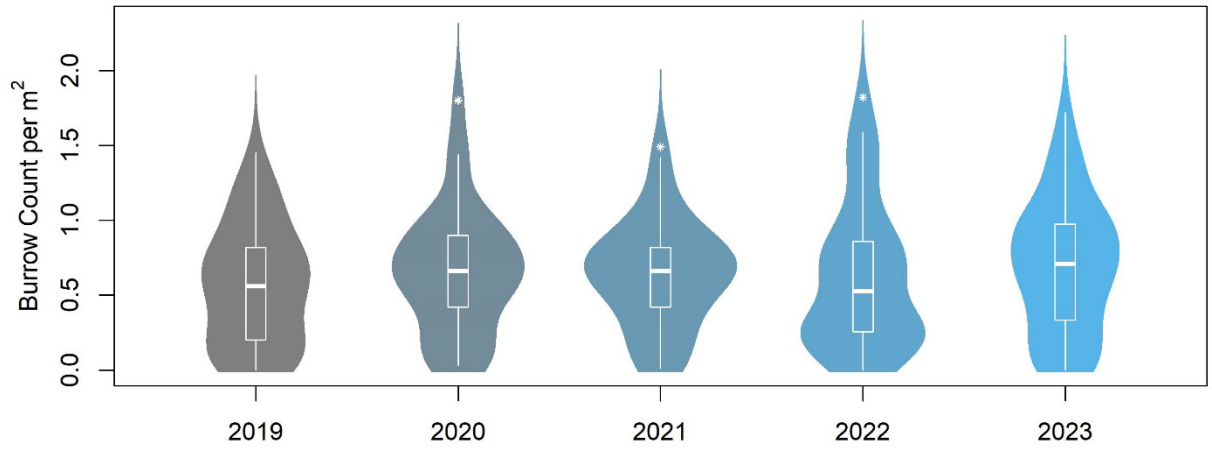


Fig. 2: North Minch (FU 11). Times series of adjusted burrow density (Bean plot).

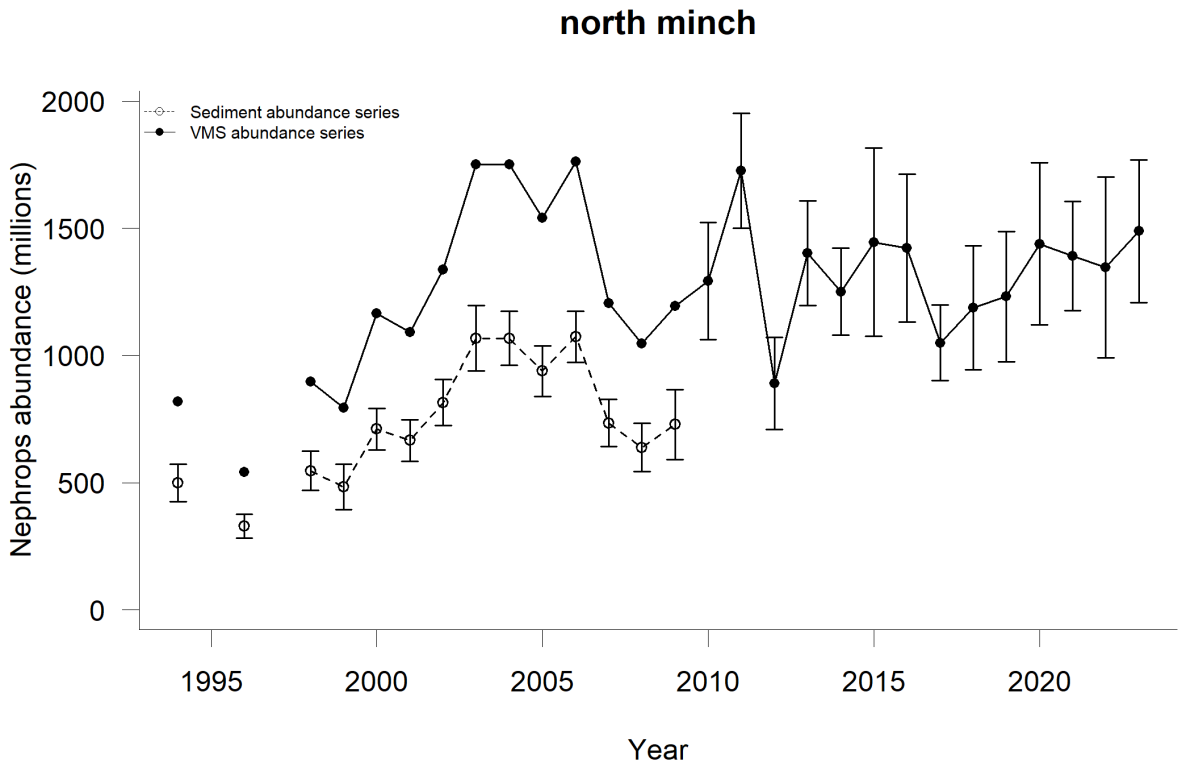


Fig. 3: North Minch (FU 11). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**12**	Area name	**South Minch**

Survey design	Stratified Random	Previous surveys	1995 -2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 41 Completed – 41 Used in analysis – 41	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.324	Adjusted abundance, CV	1644 mill., CV = 0.161
Overall footage quality (poor, medium, good)		Medium	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data stored locally and on local

		network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** - WGCSE
	CTD	No
	Trawl	No
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

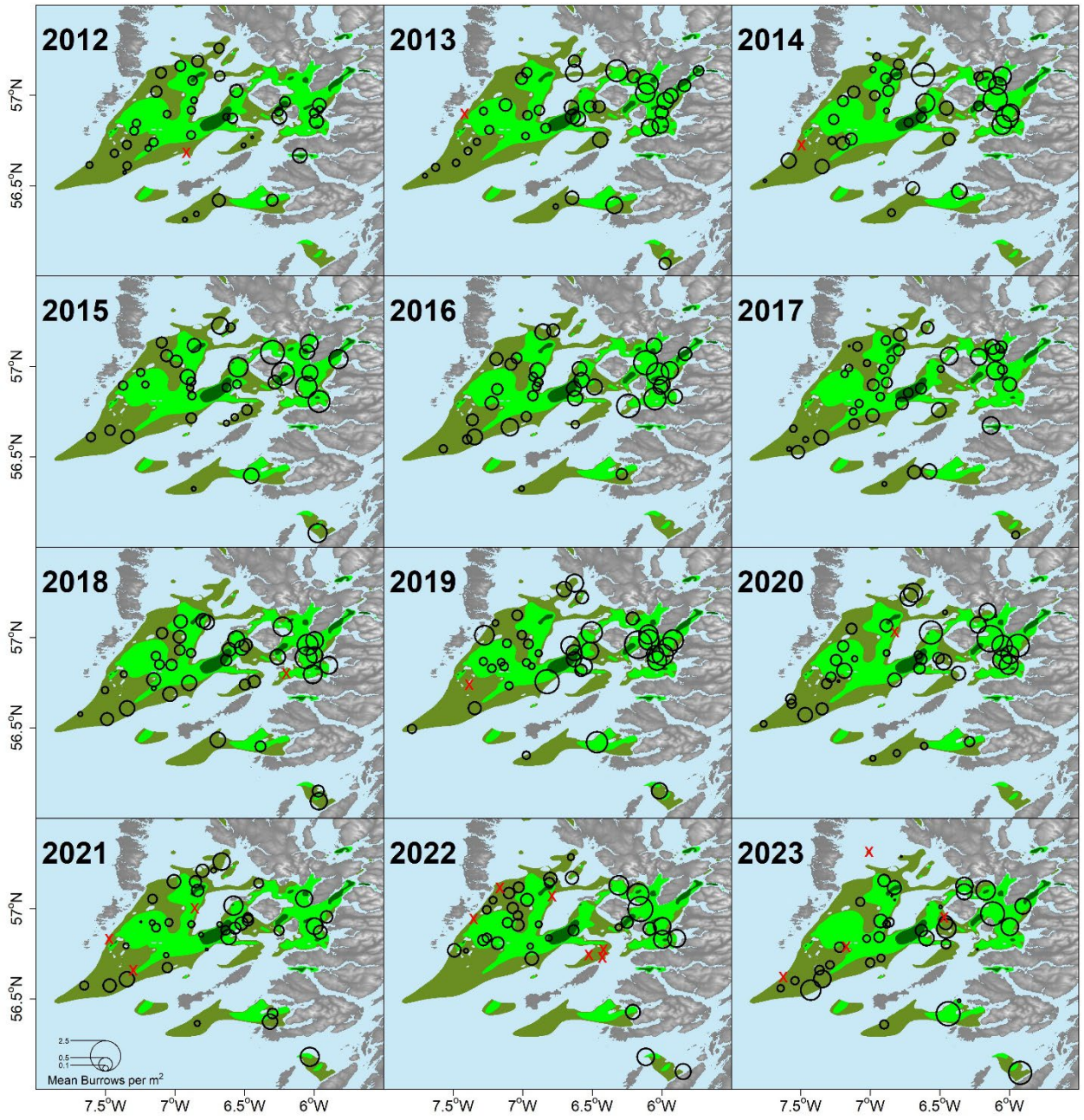


Fig. 1: South Minch (FU 12). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

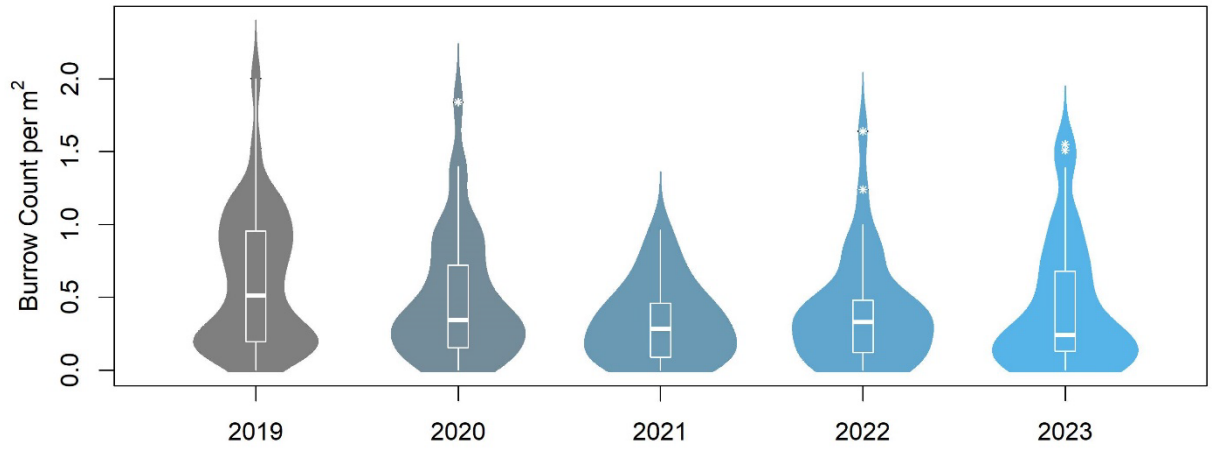


Fig. 2: South Minch (FU 12). Times series of adjusted burrow density (Bean plot).

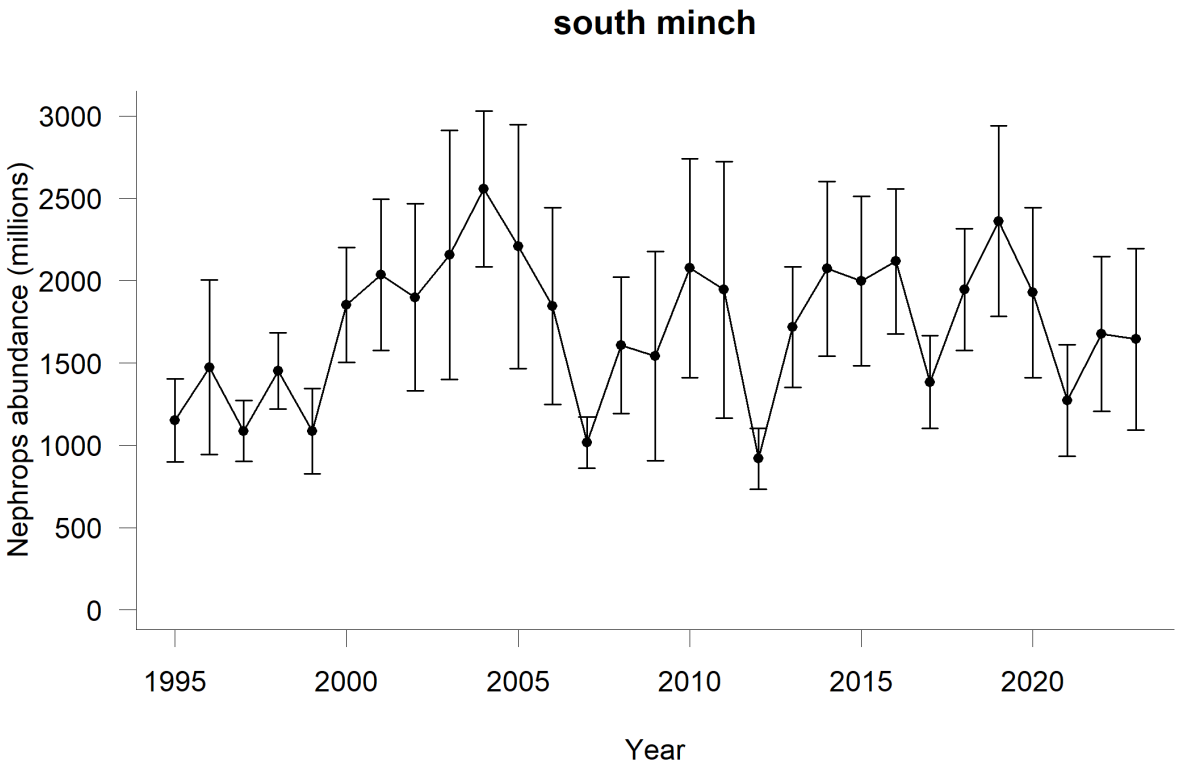


Fig. 3: South Minch (FU 12). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**13**	**Area name**	**Clyde**
Survey design	Stratified Random	Previous surveys	1995-2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 30 Completed – 30 Used in analysis - 30	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.721	Adjusted abundance, CV	1500 mill., CV = 0.102
Overall footage quality (poor, medium, good)		Medium	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data

		stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** – WGCSE
	CTD	No
	Trawl	**Storage** – hard copies of data held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – local, maturity staging **Dissemination** - Marine Directorate of the Scottish Government
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

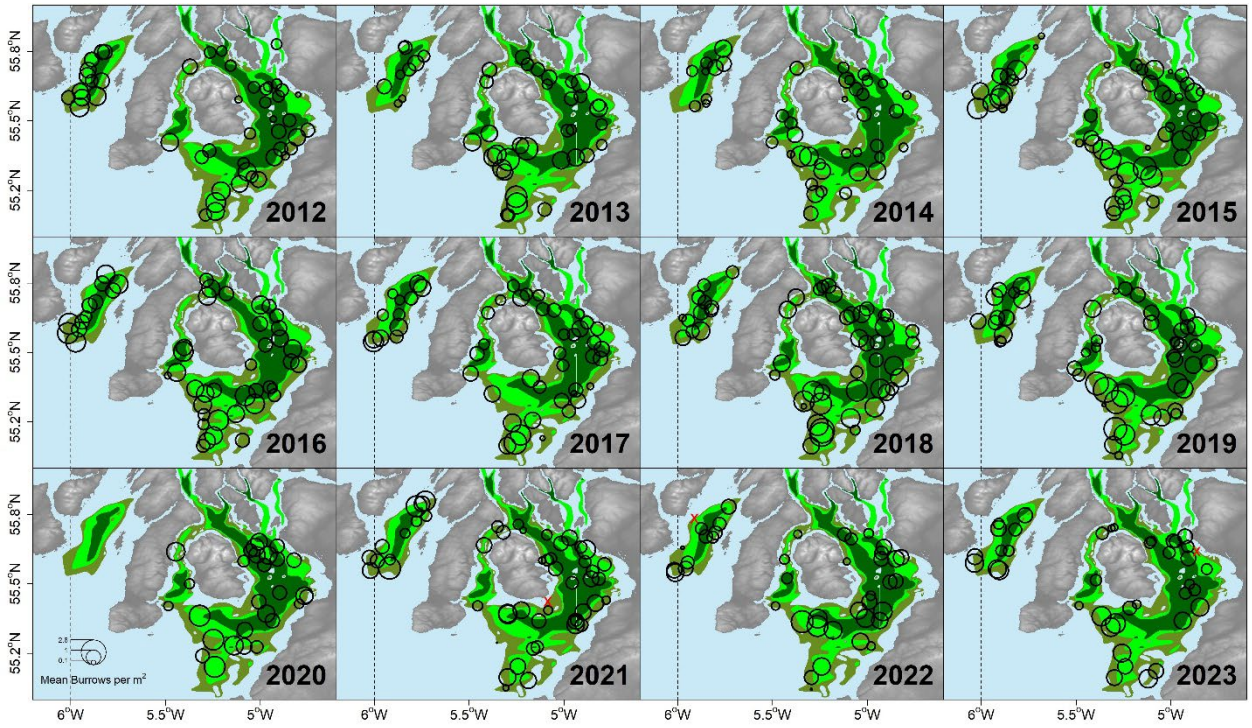


Fig. 1: Clyde (FU13). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

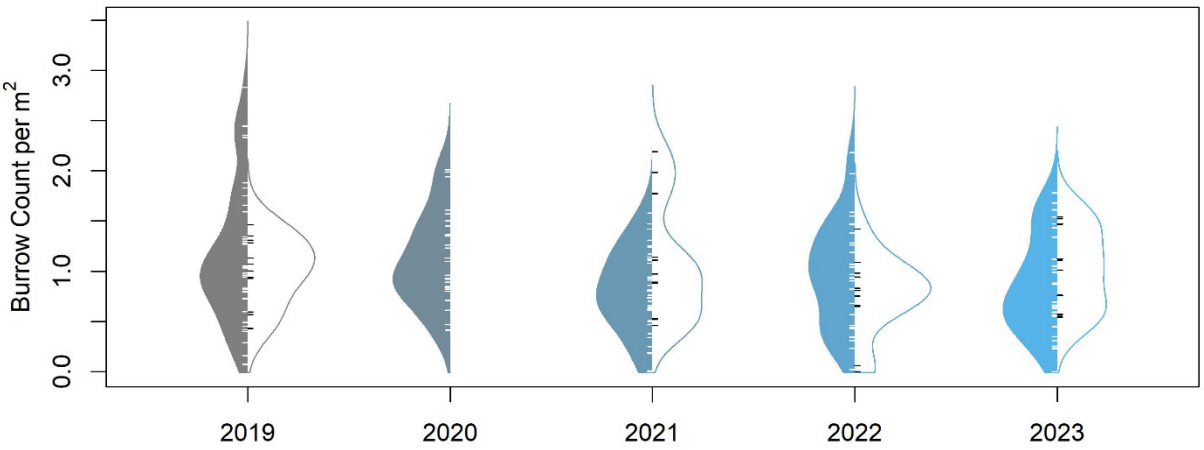


Fig. 2: Times series of adjusted burrow density (Bean plot), with Clyde on the left in grey/blue and Jura on the right (unfilled).

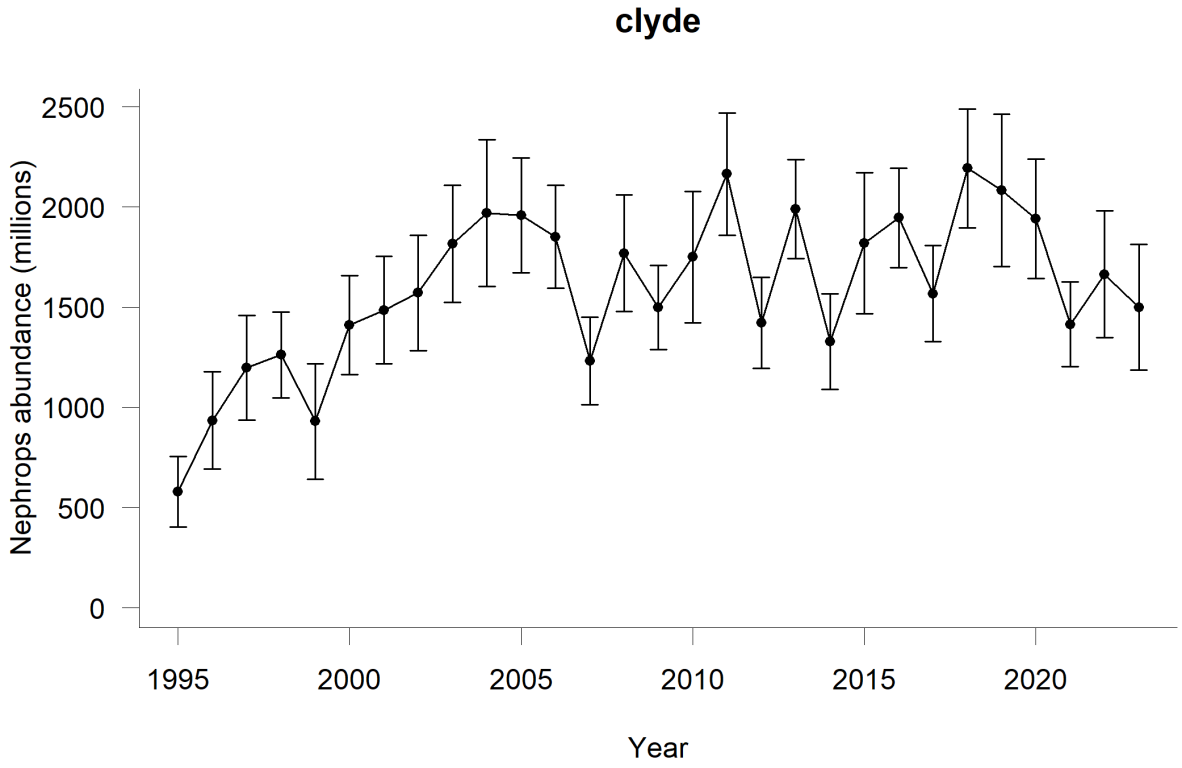


Fig. 3: Clyde (FU13): Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**13**	**Area name**	**Sound of Jura**
Survey design	Stratified Random	Previous surveys	1995-96, 2001-03, 2005-07, 2009-19, 2021-22
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 10 Completed – 10 Used in analysis - 10	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite	

		reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.838	Adjusted abundance, CV	320 mill., CV = 0.074
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** – WGCSE
		CTD	No
		Trawl	No
		Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
		Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:**

		Storage – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

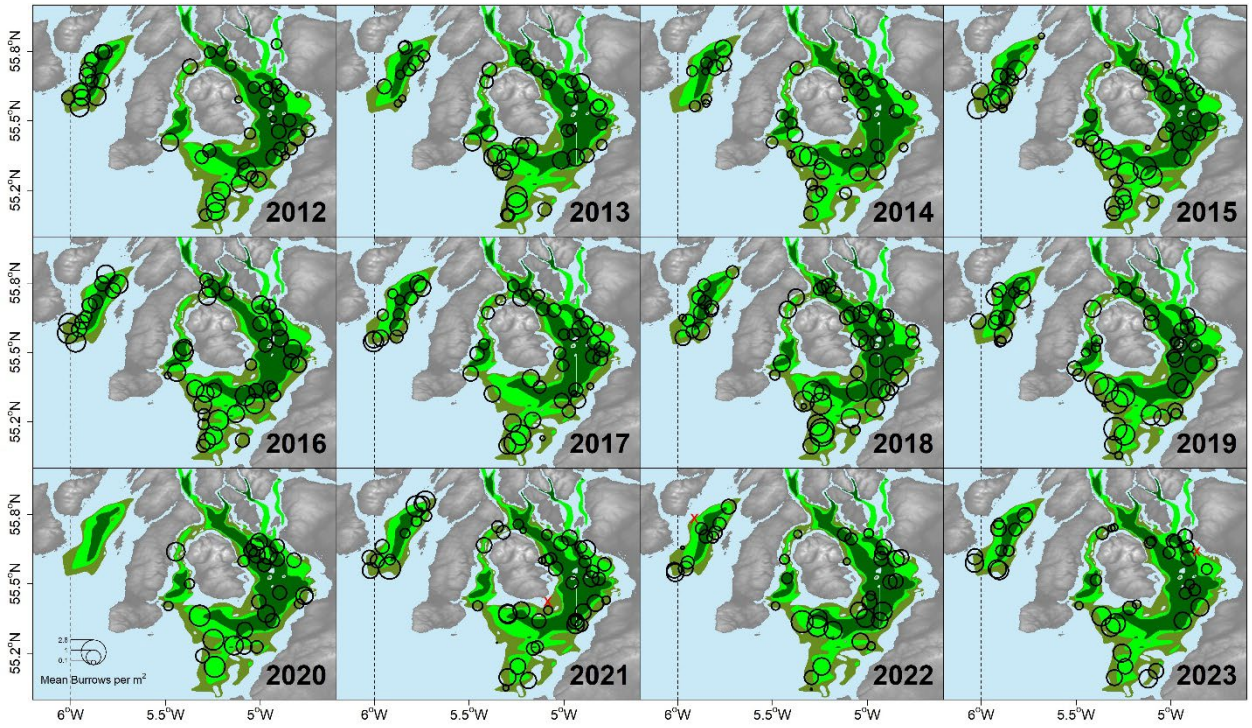


Fig. 1: Sound of Jura (FU 13). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

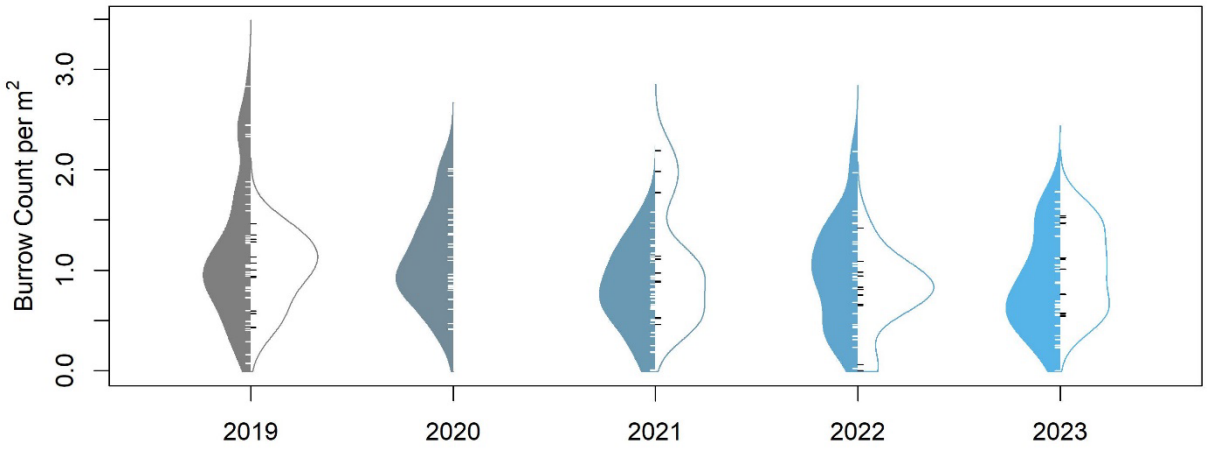


Fig. 2: Sound of Jura (FU 13). Times series of adjusted burrow density (Bean plot), with Clyde on the left in grey/blue and Jura on the right (unfilled).

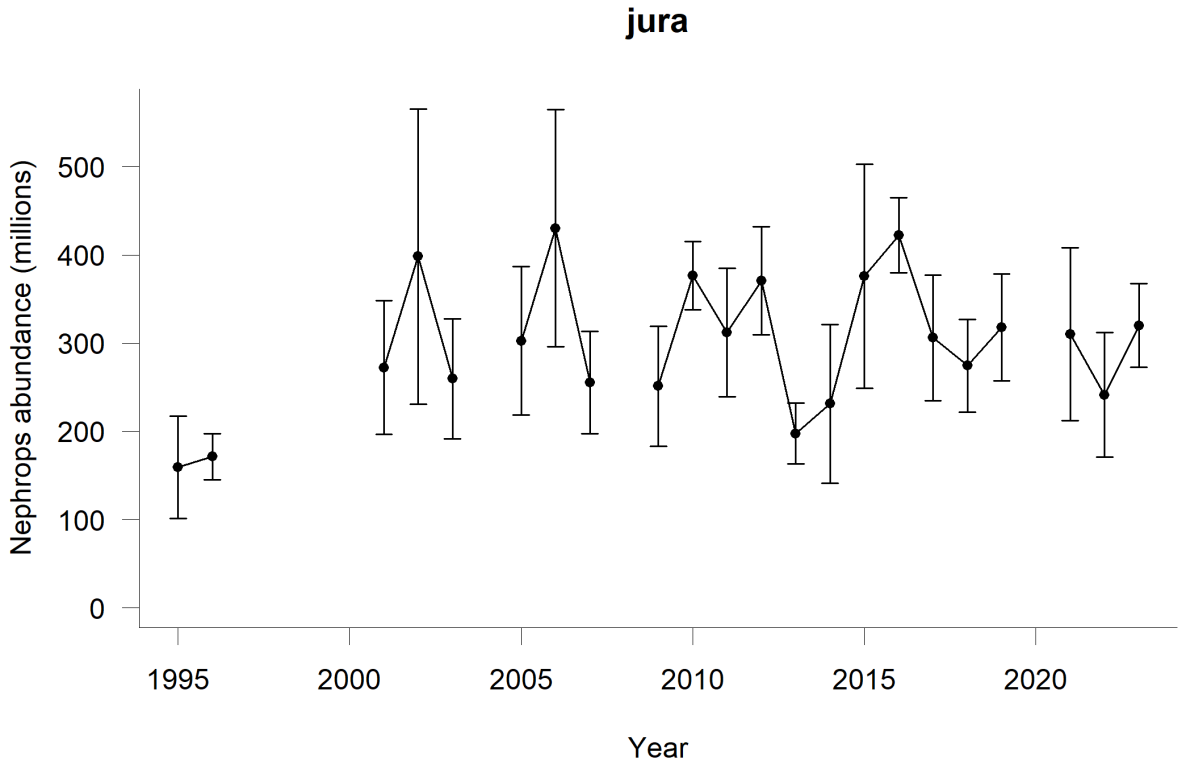


Fig. 3: Sound of Jura (FU 13). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**7**	**Area name**	**Fladen**
Survey design	Stratified Random	Previous surveys	1992-95, 1997-2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 70 Completed – 70 Used in analysis - 70	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction	

		in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.167	Adjusted abundance, CV	4683 mill., CV = 0.053
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.7	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** - WGNSSK
		CTD	No
		Trawl	No
		Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** – Marine Directorate of the Scottish Government
		Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office

		environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

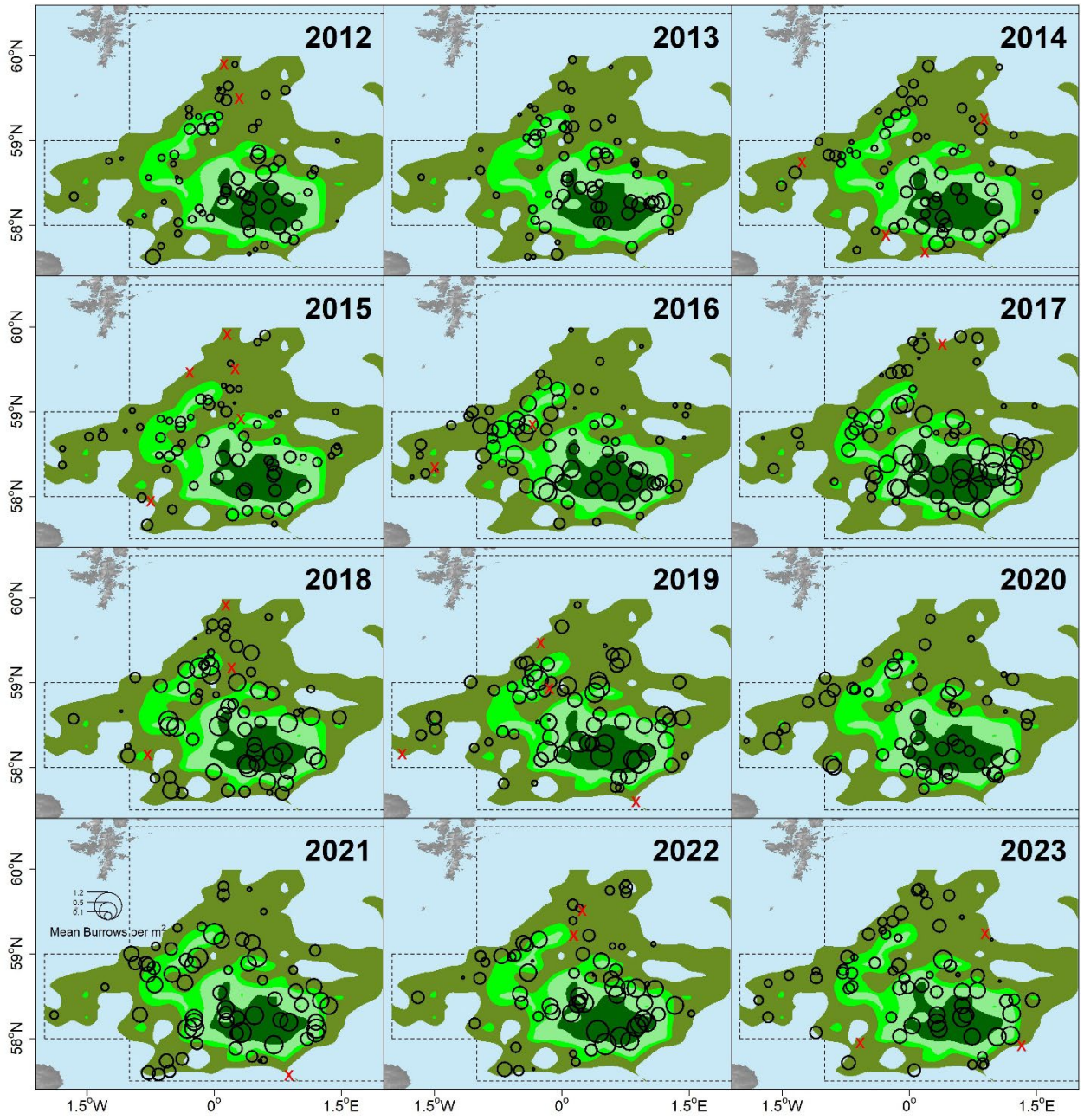


Fig. 1: Fladen (FU 7). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

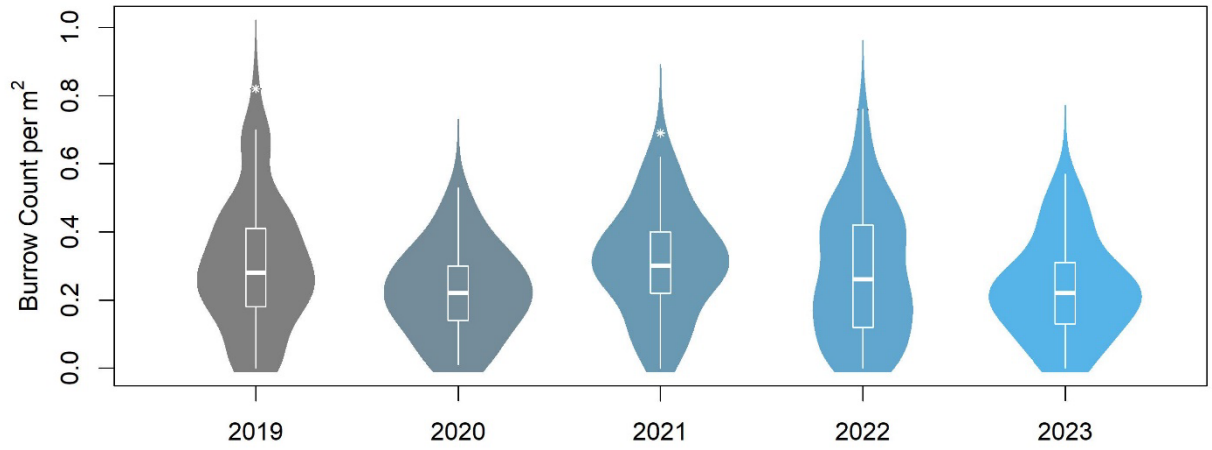


Fig. 2: Fladen (FU 7). Times series of adjusted burrow density (Bean plots).

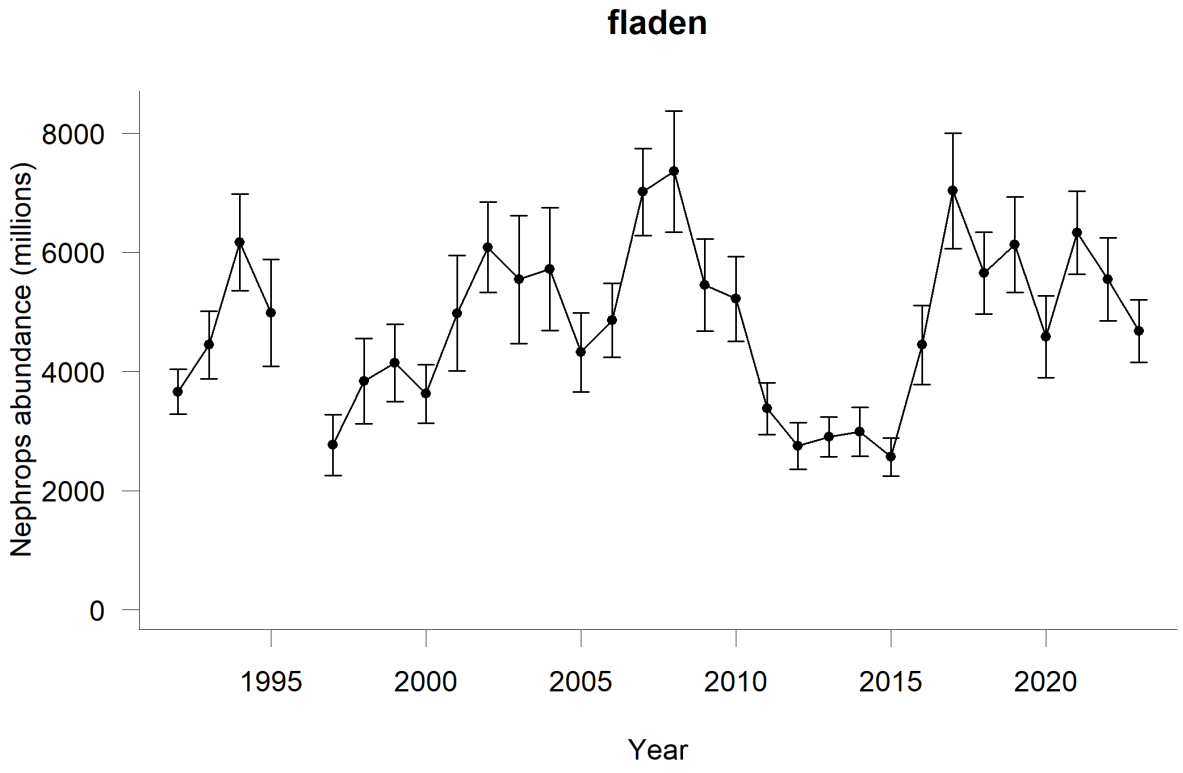


Fig. 3: Fladen (FU 7). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**8**	**Area name**	**Firth of Forth**
Survey design	Stratified Random	Previous surveys	1993-94, 1996, 1998-2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Alba-na-Mara
Survey code (s)	1223A	Dates (start/end)	24 Aug - 1 Sept 2023
Number scientific staff	Planned 3 at any one time, 4 in total involved, but reduced to two after accident	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 56 Completed – 59 Used in analysis - 54	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		As the Moray Firth was surveyed earlier in the year on MRV Scotia, this survey was undertaken solely to assess the Firth of Forth, which is normally surveyed alongside the Moray Firth in late summer.	
Distance over ground source used	Odometer	Average field of view (cm)	94 cm
Adjusted mean density	0.875	Adjusted abundance, CV	801 mill., 0.083
Overall footage quality (poor, medium, good)		Medium	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** – WGNSSK
		CTD	No
		Trawl	**Storage** – hard copies of data held in office environment; plus electronic copies on local network

		drive, backed up daily to the server. **Level of analysis** – local, maturity staging **Dissemination** - Marine Directorate of the Scottish Government
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments\agencies **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD.

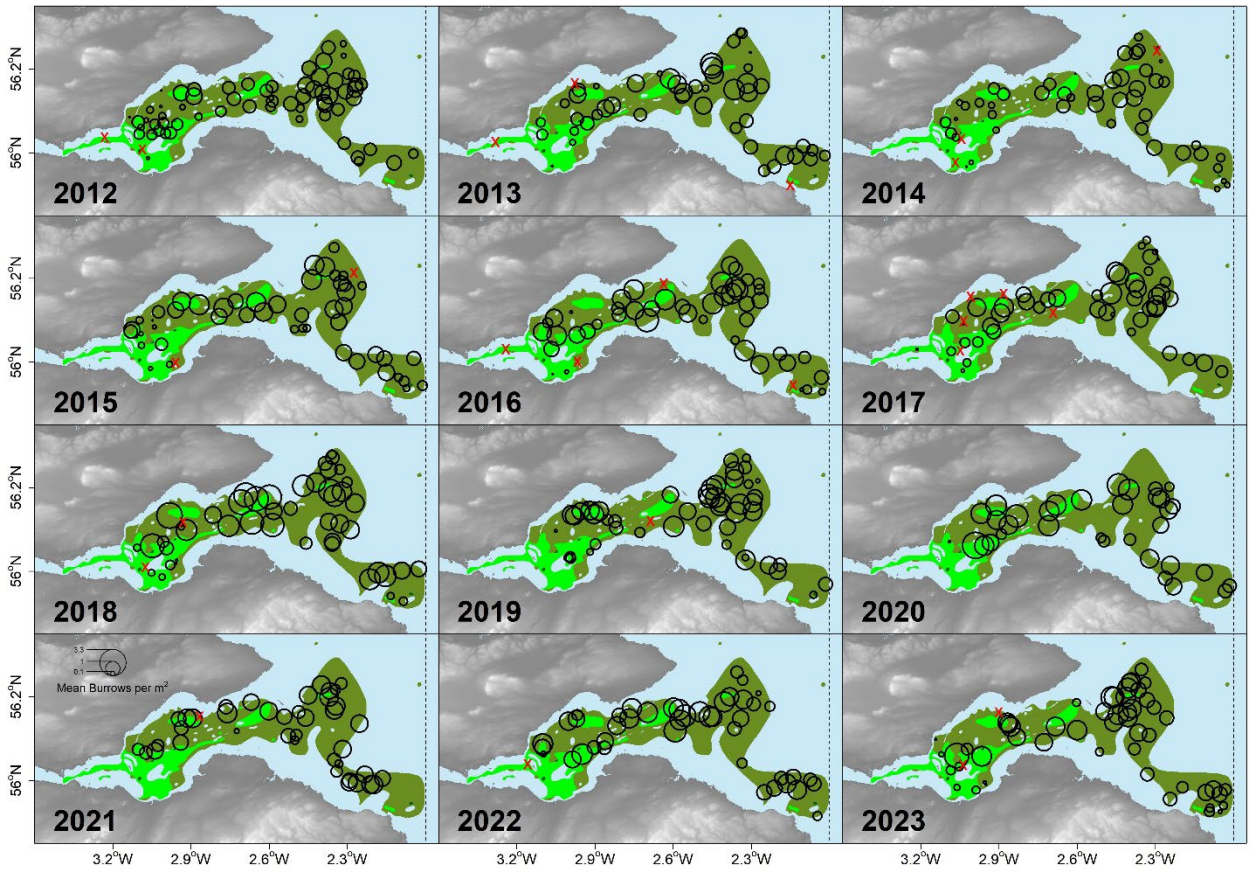


Fig. 1: Firth of Forth (FU 8). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

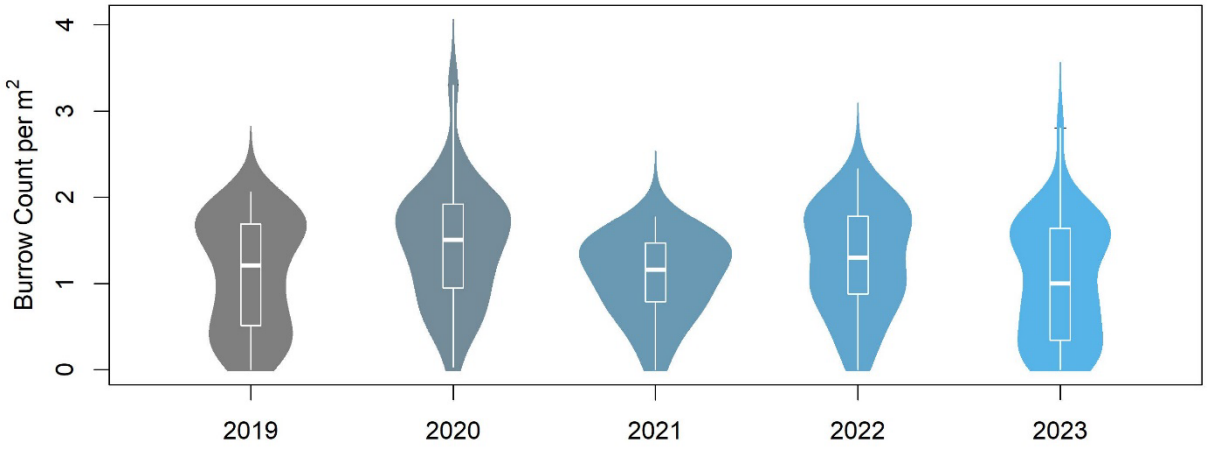


Fig. 2: Firth of Forth (FU 8). Times series of adjusted burrow density (Bean plot).

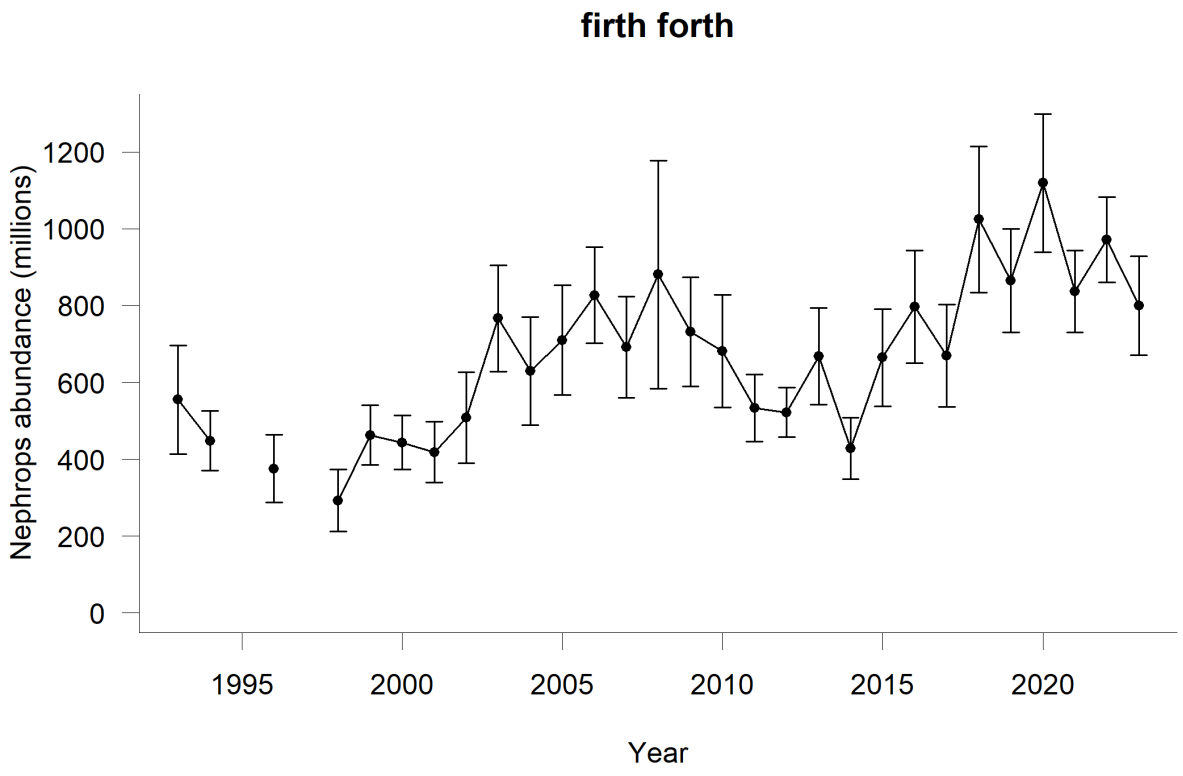


Fig. 3: Firth of Forth (FU 8). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**9**	**Area name**	**Moray Firth**
Survey design	Stratified Random	Previous surveys	1993-94, 1996-2022
Country (ies)	Scotland, UK	Vessel name (s)	MRV Alba-na-Mara
Survey code (s)	0623S	Dates (start/end)	18 May - 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 55 Completed – 55 Used in analysis – 55	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the	

		Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.249	Adjusted abundance, CV	545 mill., CV = 0.125
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** - WGNSSK
		CTD	No
		Trawl	No
		Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** – Marine Directorate of the Scottish Government
		Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data

		stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

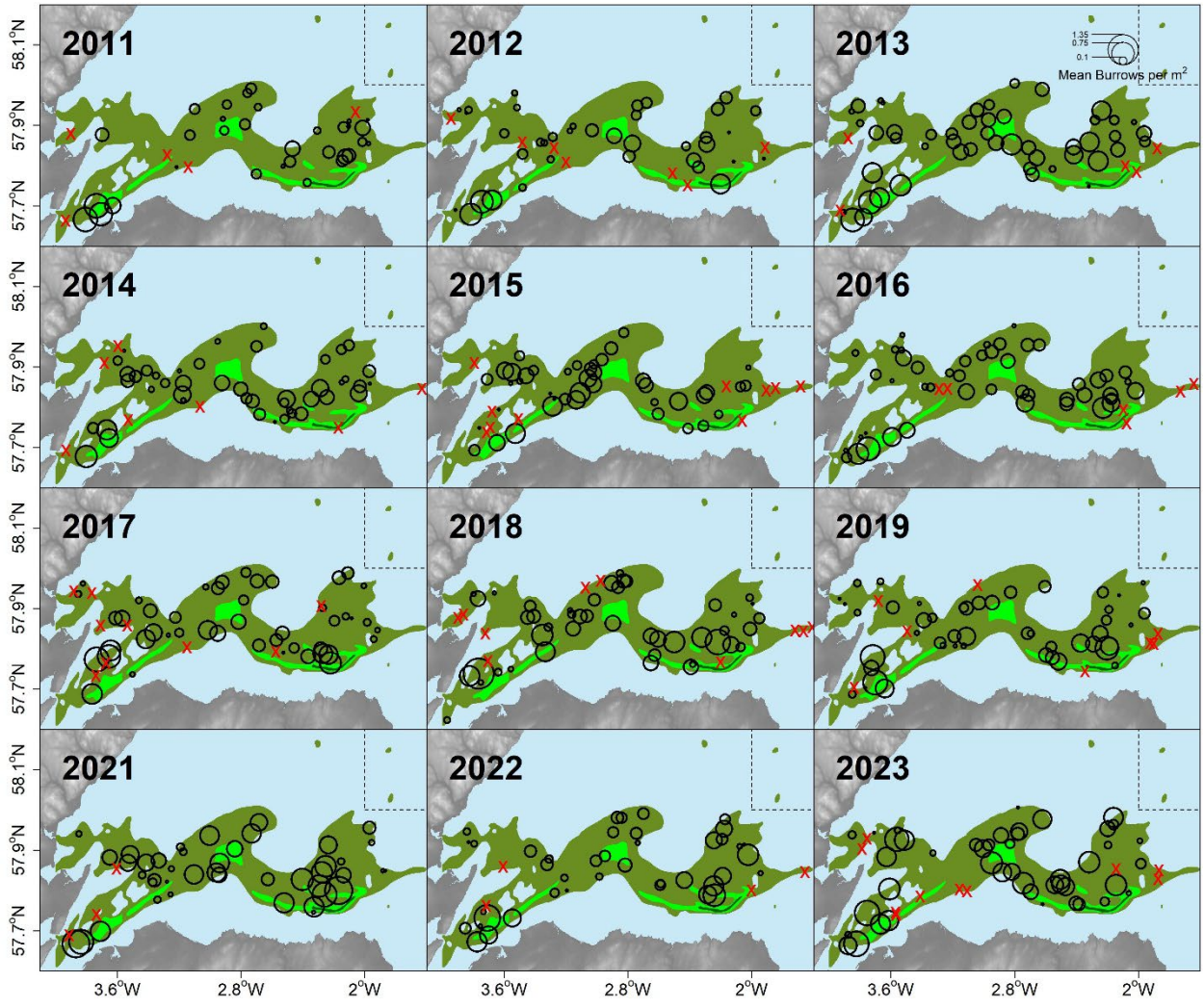


Fig. 1: Moray Firth (FU 9). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request).

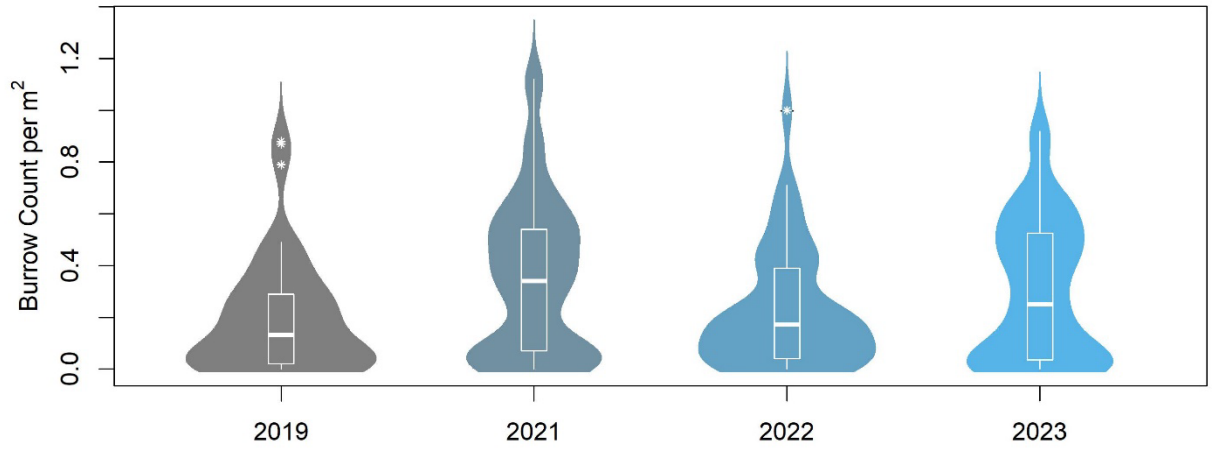


Fig. 2: Moray Firth (FU 9). Times series of adjusted burrow density (Bean plot).

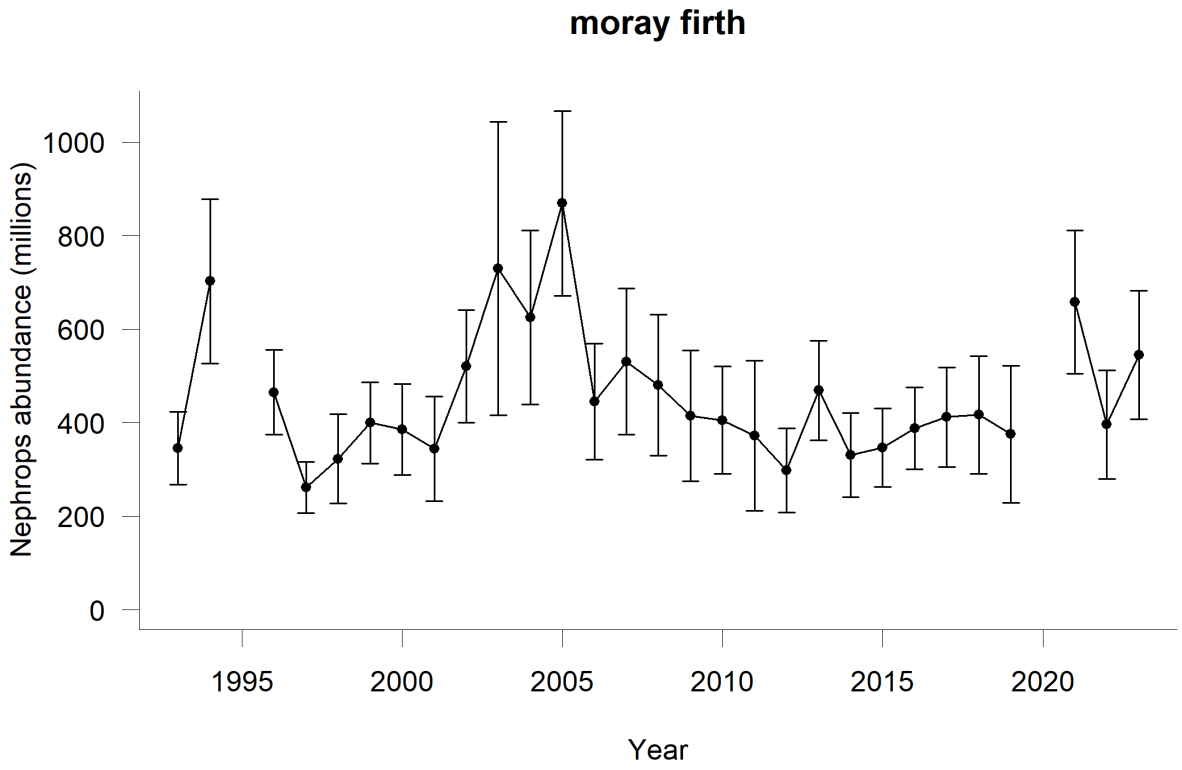


Fig. 3: Moray Firth (FU 9). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**34**	**Area name**	**Devils Hole**
Survey design	Fixed	Previous surveys	2003, 2005, 2009-12, 2014-15, 2017-19, 2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 16 Completed – 17 Used in analysis - 17	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	94cm
Adjusted mean density	0.27	Adjusted abundance, CV	473 mill., 20.5
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		No – Fladen reference footage used as grounds are similar	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	

Data storage, level of analysis and dissemination (by data type)	Nephrops burrow counts	**Storage –** hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** – WGNSSK
	CTD	No
	Trawl	**Storage** – hard copies of data held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – local, maturity staging **Dissemination** - Marine Directorate of the Scottish Government
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** - Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

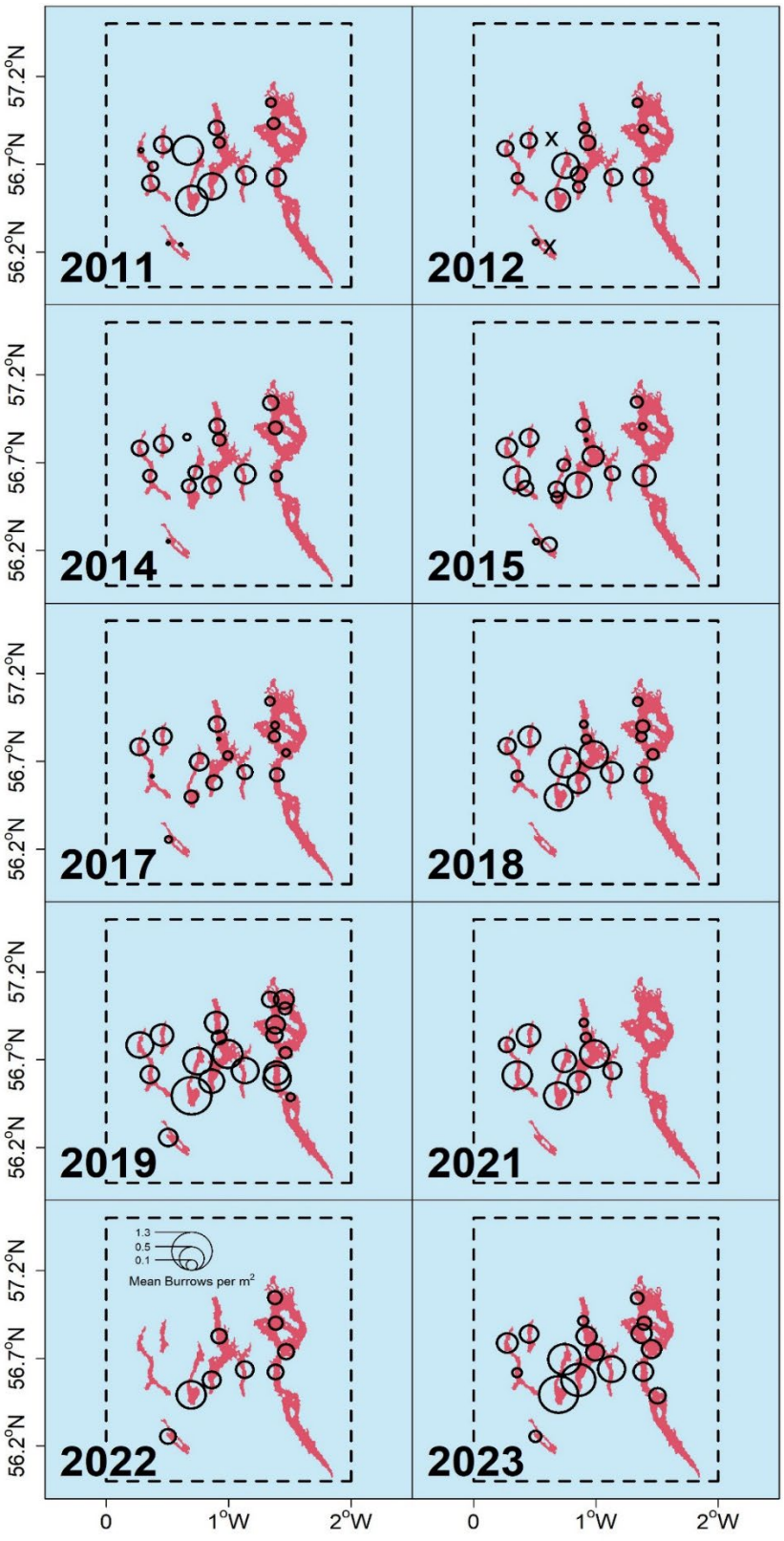


Fig. 1: Devil's Hole (FU 34). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius. (Earlier years are available on request). Survey station locations generated located within boundary of Vessel Monitoring System (VMS) data (WKNEPH, 2013).

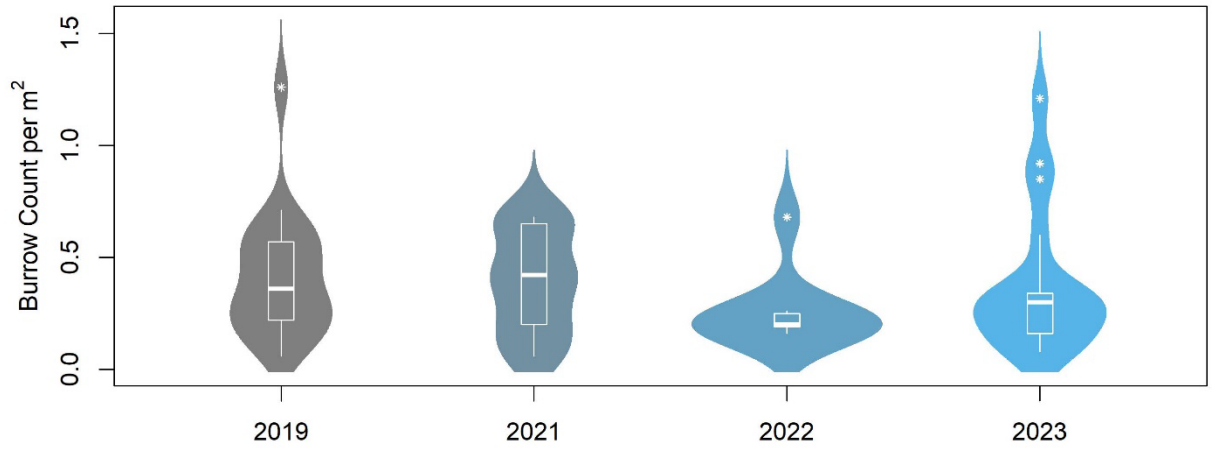


Fig. 2: Devils Hole (FU 34). Times series of adjusted burrow density (Bean plot).

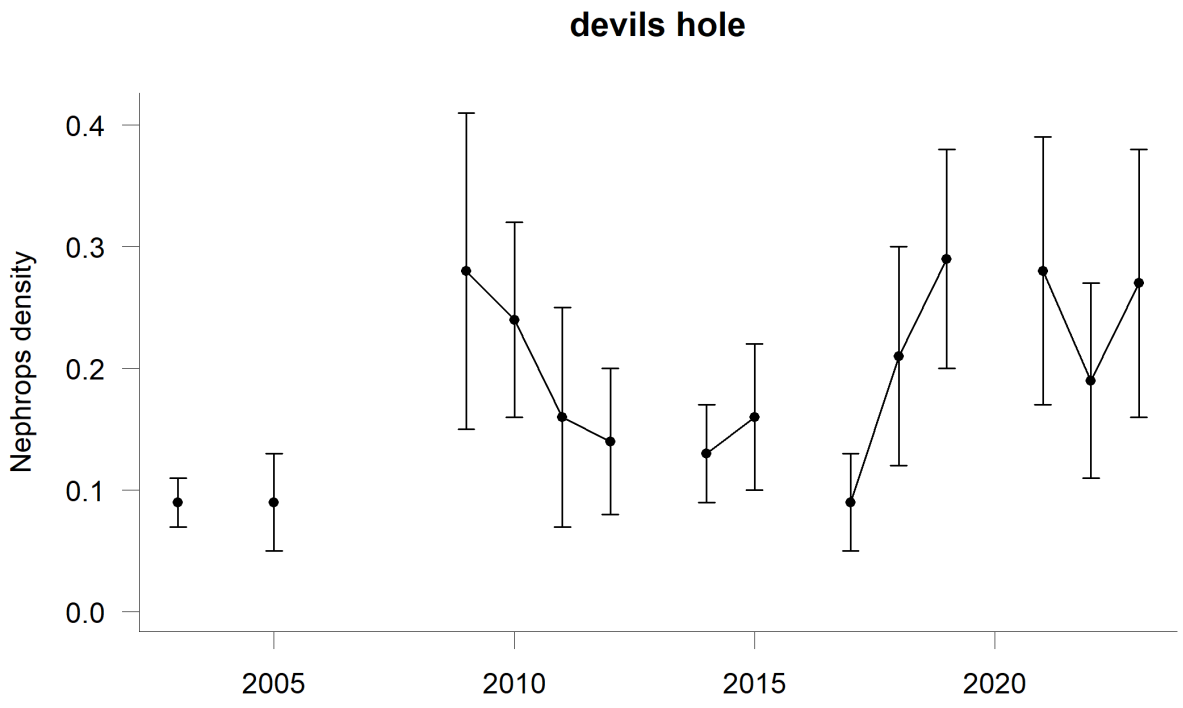


Fig. 3: Devil's Hole (FU 34). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

Functional Unit	**10**	**Area name**	**Noup**
Survey design	Stratified Random	Previous surveys	1994, 1999, 2005-07, 2014, 2019
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0623S	Dates (start/end)	18 May – 13 June 2023
Number scientific staff	6 at any one time, 9 in total involved, multiple staff changes in port and at sea	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 12 Completed – 10 Used in analysis - 10	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to a serious incident in port involving a separate vessel, MRV Scotia was unable to sail for a protracted period of time in early 2023, which significantly impacted the annual survey schedule, with surveys cancelled, compressed or merged. This survey was the first to sail once the vessel was released from harbour and was requested to cover all FUs during this one trip, with a minimal increase in days at sea. Despite reducing the number of stations in the Clyde and at Jura (the areas least impacted by a reduction in stations), it was possible to cover all except the Firth of Forth during this slightly extended trip (which was surveyed later in the year).	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.091	Adjusted abundance (millions), CV	37 mill., CV = 0.246
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		Presence/absence and distribution of sea pens recorded by three main species; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; trawl caught litter recorded and retained; comments on visibility and subjective ground type recorded; sediment samples taken; USBL used throughout; deployment and recovery of Scottish Passive Acoustic Network (SPAN) moorings.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	**Storage** – hard copies of data held in office environment; plus electronic

		copies on local network drive, backed up daily to the server. **Level of analysis** – as required for ICES WG **Dissemination** - WGNSSK
	CTD	NA
	Trawl	**Storage** – hard copies of data held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – local, maturity staging **Dissemination** - Marine Directorate of the Scottish Government
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on local network drive, backed up daily to the server. **Level of analysis** – awaiting work up **Dissemination** – Marine Directorate of the Scottish Government
	Other	**Seapen, marine litter, fauna data, SPAN related data, Survey Summary Report:** **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marine Directorate of the Scottish Government, and MSFD

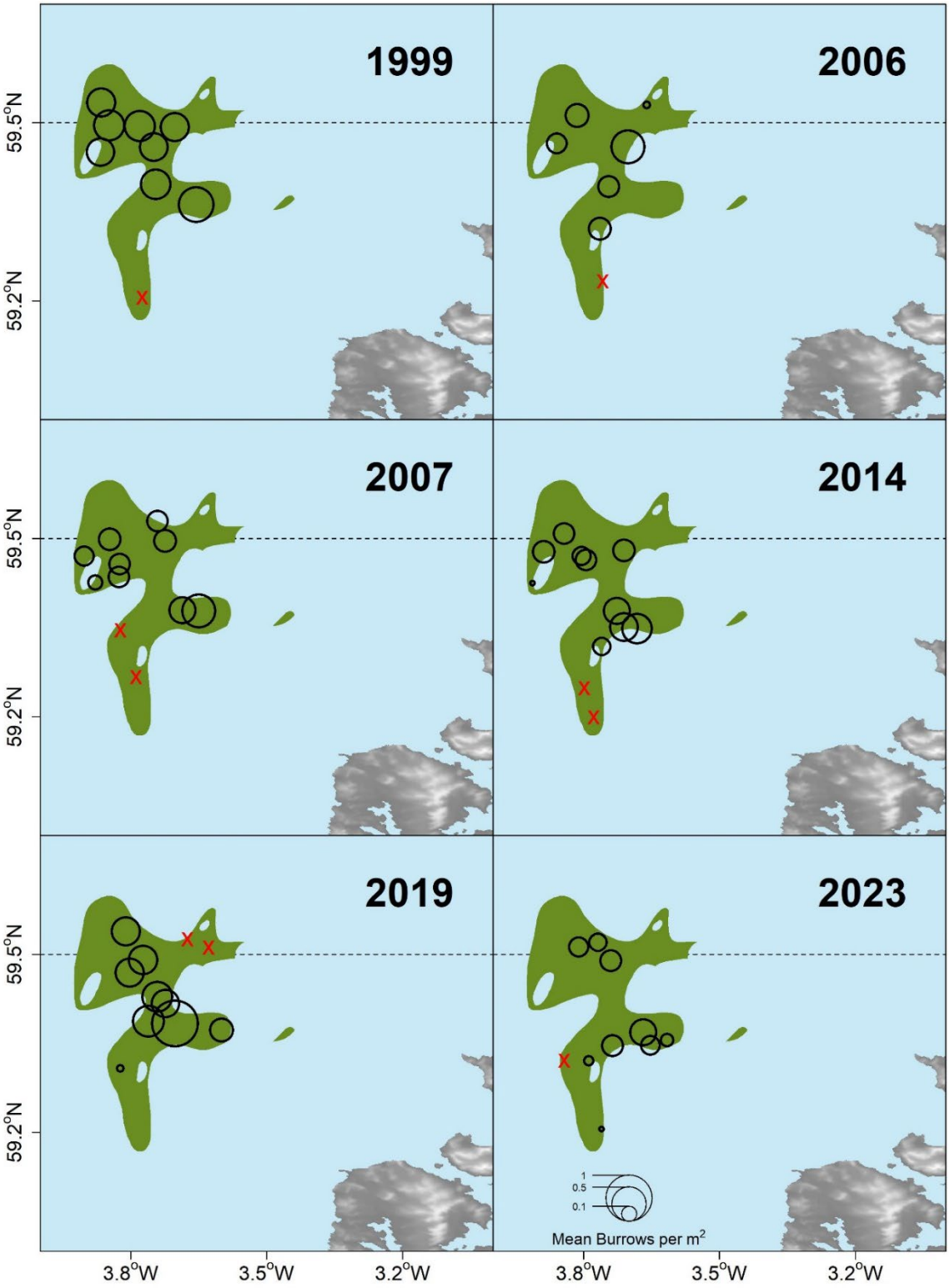


Fig. 1: Noup (FU 10). UWTV survey distribution and relative density for the most recent years surveyed. Density proportional to circle radius.

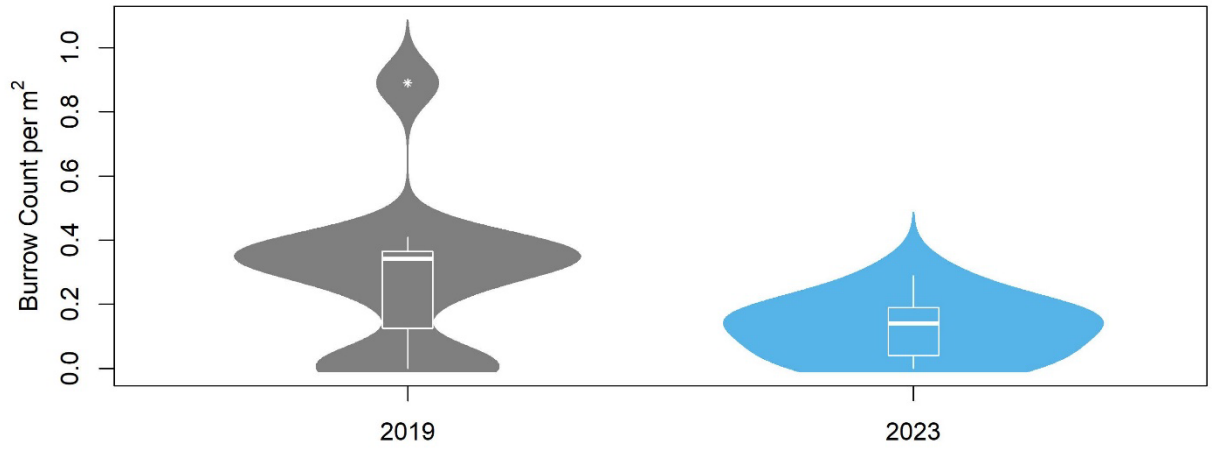


Fig. 2: Noup (FU 10). Times series of adjusted burrow density (Bean plot).

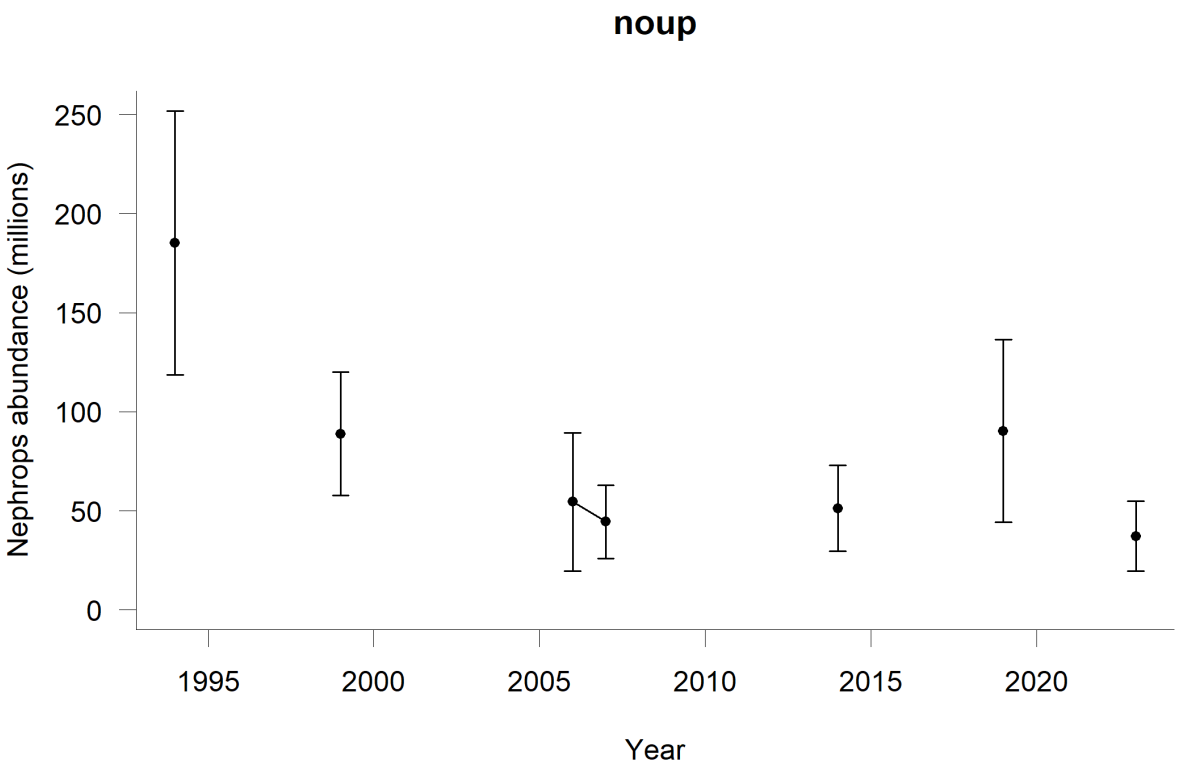


Fig. 3: Noup (FU 10). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

UK England: FU 6 and FU 14

(Chris Firmin)

Functional Unit	**6**	**Area name**	**Farn Deeps**
Survey design	fixed	Previous surveys	1997, 1999, 2002 - present
Country (ies)	UK (E)	Vessel name (s)	Cefas Endeavour
Survey code (s)	U8672	Dates (start/end)	12/06/2023
			18/06/2023
Number scientific staff	11	Staff exchanges	None
Number of stations (planned/completed/used in analysis)		110/109/109	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Of the 110 planned stations, 109 were completed. 1 station (6-W) was abandoned due to proximity to an undersea cable and due to no viable near-by position being available. 20 further stations were moved up to 1 mile to adhere to exclusion zones in place around other marine cables and pipes. 1 station was repeated due to a general power failure aboard. 1 further station was repeated as no GPS logging data were collected	
Distance over ground source used	USBL	Average field of view (cm)	82
Adjusted mean density	0.29 burrows/m²	Adjusted abundance, CV	899 ±17 million, 1.9%
Overall footage quality (poor, medium, good)		good	
Reference footage for survey area generated		2020	
Quality control of station counts (Lin's CCC or consensus count)		CCC (threshold >= 0.5) to 4th counter then consensus	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Plankton imager device was unsuccessfully deployed, suffering hardware failure on its 1st day of operation.	

	Outline methodology was produced for labelling *Nephrops* UWTV footage using Python scripting and VIAME labelling software Chlorophyll samples were collected twice daily at dawn and dusk using the surface water flow pipe. Water samples were filtered then stored in the -80˚C freezer onboard.	
Data storage, level of analysis and dissemination (by data type)	Nephrops burrow counts	Footage stored as mp4 on 2 HDDs. Station, count and observation data on in-house Access DB. Environmental data and nav files stored as .csv spreadsheets. Processing of station, count and nav file data in R; analysis in R geostats
	CTD	Single dip at start of survey, stored as .csv
	Trawl	No
	Sediment	No
	Other	Nav files (GPS / depth) stored as .csv

Functional Unit	**14**	**Area name**	**East Irish Sea**
Survey design	fixed	Previous surveys	2008 to present
Country (ies)	UK (NI)	Vessel name (s)	RV Corystes
Survey code (s)	U3016	Dates (start/end)	24/07/2023
			25/07/2023
Number scientific staff	6	Staff exchanges	Participation from MI
Number of stations (planned/completed/used in analysis)		48/44/40	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		4 stations not completed due to weather constraints; 4 stations not processed (2 due to no consensus, 2 due to no GPS track data) Field of view (FoV) increase from previous surveys due to new stills camera system. Significant reduction (50%) in estimated abundance, triggering review	
Distance over ground source used	USBL (Ship)	Average field of view (cm)	114cm
Adjusted mean density	0.21 burrows/m²	Adjusted abundance, CV	191 ±40 million, 10.8%
Overall footage quality (poor, medium, good)		good	
Reference footage for survey area generated		using FU 15 footage from 2021, new reference set in development	
Quality control of station counts (Lin's CCC or consensus count)		CCC (0.5 threshold) to 4th counter then consensus	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		CTD on sledge (data not collected every haul)	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	Footage stored as .jpg stills on 2 HDDs. Station, count and observation data in .xls files. Environmental data and nav files stored as .csv spreadsheets. Processing of station, count and nav file data in R; analysis in R geostats
		CTD	Not retained
		Trawl	No

	Sediment	No
	Other	No

Denmark and Sweden: FU 3&4 Skagerrak and Kattegat

(Kai Wieland and Patrik Jonsson)

Functional Unit	**3&4**	**Area name**	**Skagerrak/Kattegat**
Survey design	Stratified random, with buffer since 2017	Previous surveys	2008-2010: DK only, exploratory 2011-2013: 6 strata 2014-2016: 7 strata since 2017: 9 strata
Camera Type: Standard / High definition	HD since 2017	Image Data: Type / Size per station eg, video / stills , 1GB	Video DK: appr. 1 GB per station SWE: approx. 5 GB per station
Country (ies)	Denmark and Sweden	Vessel name (s)	DK: RV Havfisken SWE: RV Svea (since 2021; RV Havfisken and RV Asterix in earlier years)
Survey code (s)	UWTV3-4	Dates (start/end)	DK: 22/3 - 29/3 2023 SWE: 28/4 - 5/5 2023
Number scientific staff at sea	DK: 2 SWE: 5	Staff exchanges	none
Number of stations (planned/completed/used in analysis)		DK: 93/93/88 SWE: 104/103/95, without creel area	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		DK: 5 stations unreadable due to poor visibility SWE: One station dropped due to naval exercise, seven stations dropped due to poor visibility.	
Distance over ground source used	DK: Vessel GPS (USBL installed but not working properly) SWE: Vessel GPS (dynamic positioning system)	Average field of view (cm)	RV Havfisken: 72 cm RV Svea: 83cm

Adjusted mean density	0.24 burrows/m²	Adjusted abundance, CV	3634 million, 5.70 %
Overall footage quality (poor, medium, good)		DK: good SWE: Good, except at eastern part of subarea 2 – poor visibility due to marine snow and strong bottom currents.	
Reference footage for survey area generated		DK: yes SWE: yes	
Quality control of station counts (Lin's CCC or consensus count)		DK: Lin's CCC. Pre-check against reference files passed by all readers. 2023 survey stations counted by two readers. 8 stations which did not passed Lin's CCC in first run counted by a third counter and original counts from one of the counters removed. Final set pass Lin's CCC for all stations. SWE: Lin's CCC Pre survey warm up 6 stations from 2022 counted twice. Good intra reader repeatability 17/18 counts repeatability (CCC >0.5) on the three counters. Post survey three readers passed all five reference stations (CCC>0.5). Survey readings following manual: 55/95 passed Lin's CCC at first reading 4/95 but low density and no valid Lin's. 21/5 passed after third review 15/95 no Lin's above 0.5 average of all (exept at 4 stations, one counter above others excluded)	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		DK: CTD (incl. O_2 and turbidity sensors) SWE: CTD (incl. O_2 and turbidity sensors) at subset of stations.	
Data storage, level of analysis and dissemination (by data type)		Nephrops burrow counts	Excel files, .csv file with R-output for DK and SWE combined
		CTD	DK: Institute's server, raw and processed data SWE: txt-files saved at local HDs.

	Trawl	
	Sediment	
	Other	

Survey dates for 2024

DK RV Havfisken 19/3 - 25/3 2024

SWE: RV Svea 18/4 -25/4 2024

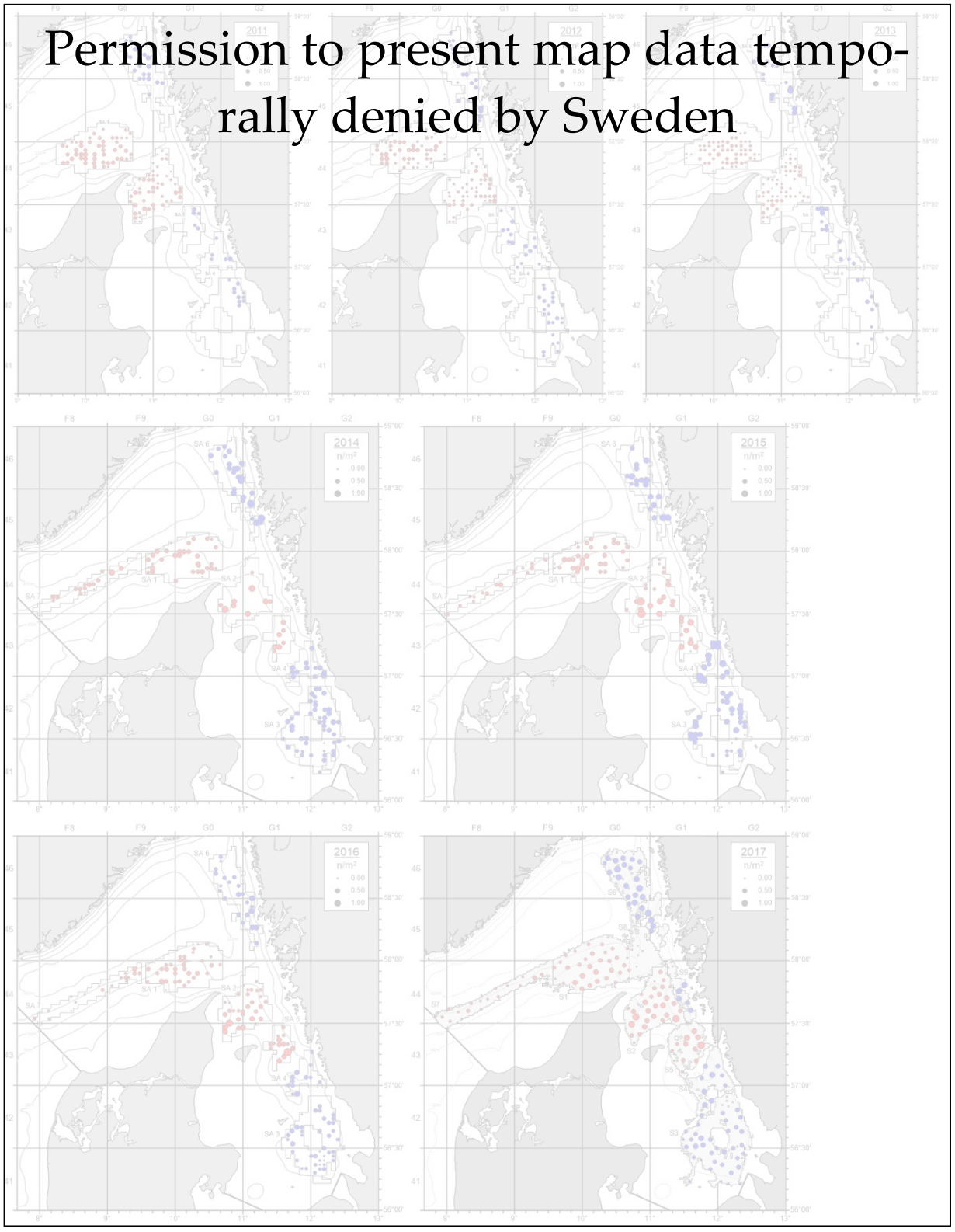


Fig. 1a: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2011 - 2017 (red: DK, blue: SWE).

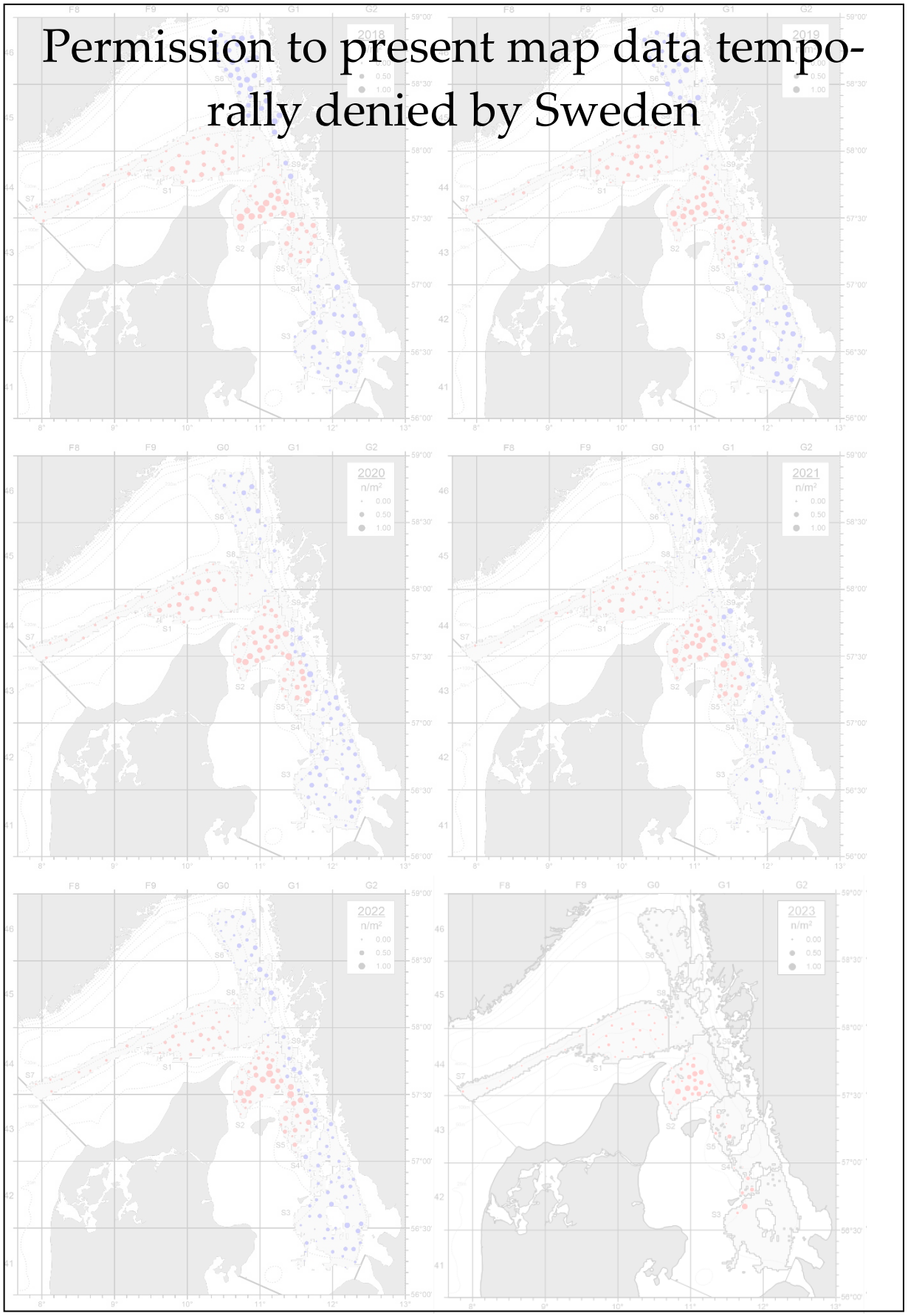


Fig. 1b: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2018 - 2023 (red: DK, blue: SWE; Swedish data for 2023 not shown on request by Sweden).

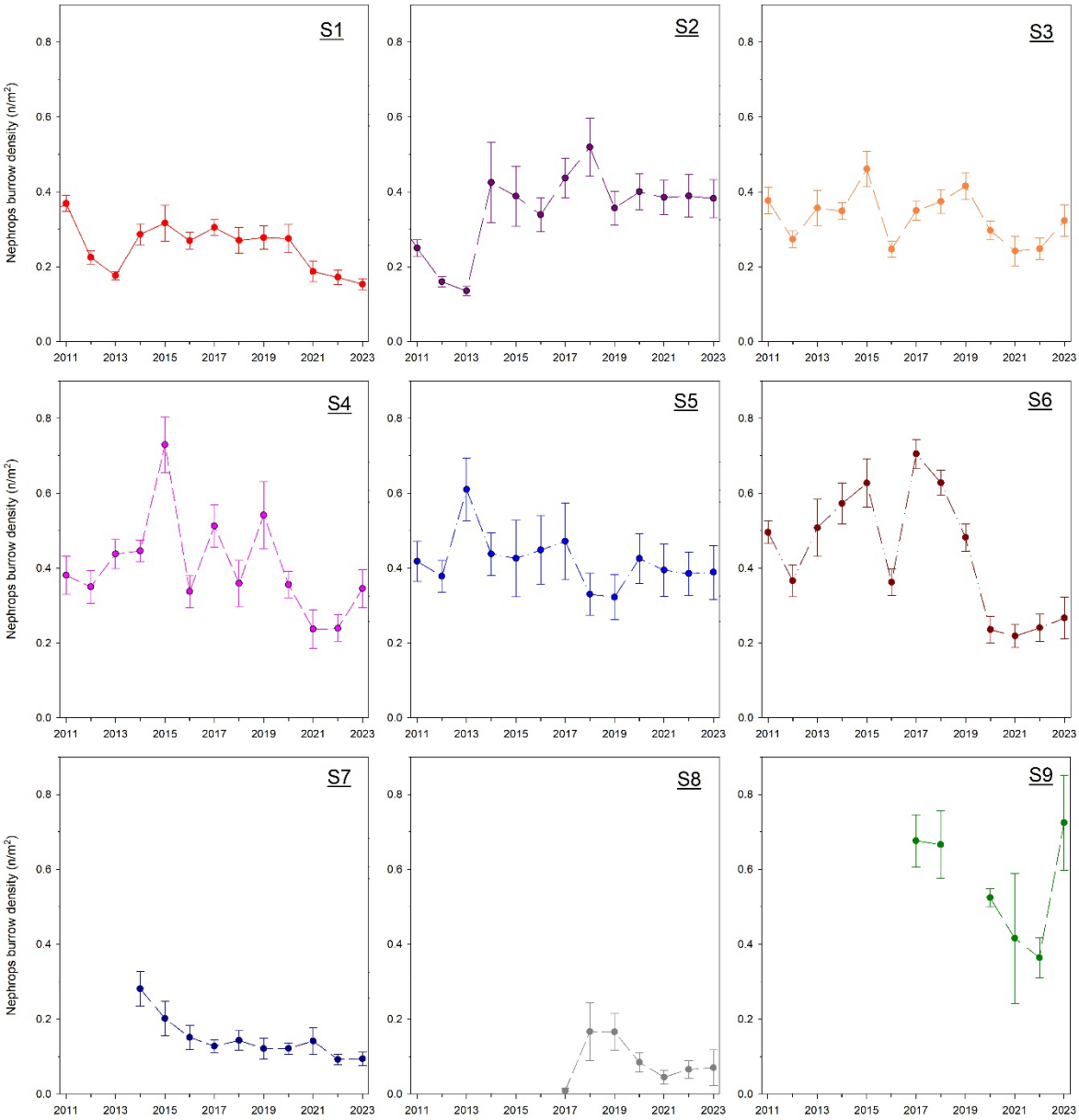


Fig. 2: FU 3&4 (Skagerrak/Kattegat) time series of *Nephrops* burrow density by stratum (mean, standard error), 2011 - 2023.

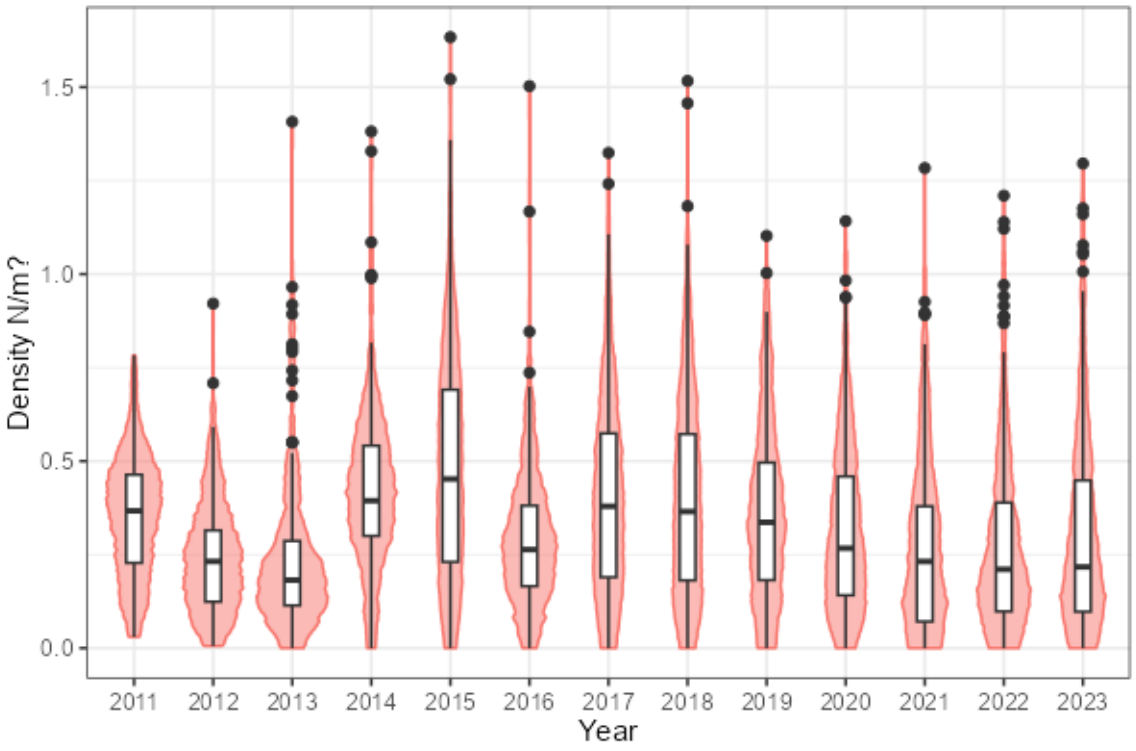


Fig. 3: FU 3&4 (Skagerrak/Kattegat) times series of *Nephrops* burrow density (The horizontal lines represent the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers), 2011 - 2023.

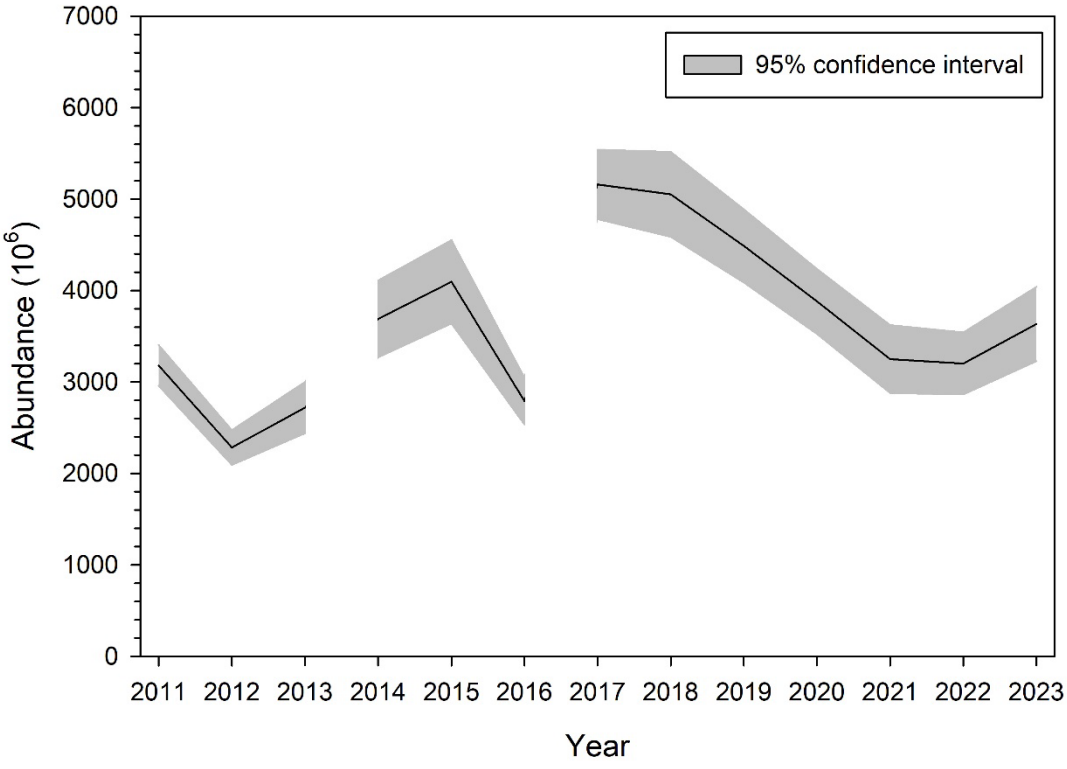


Fig. 4: FU 3&4 (Skagerrak/Kattegat) time series of *Nephrops* total abundance with reference levels (shaded area represents the 95% confidence interval; note change in survey area and stratification in 2014 and in 2017; reference points for stock size are not defined for this stock), 2011 - 2023.

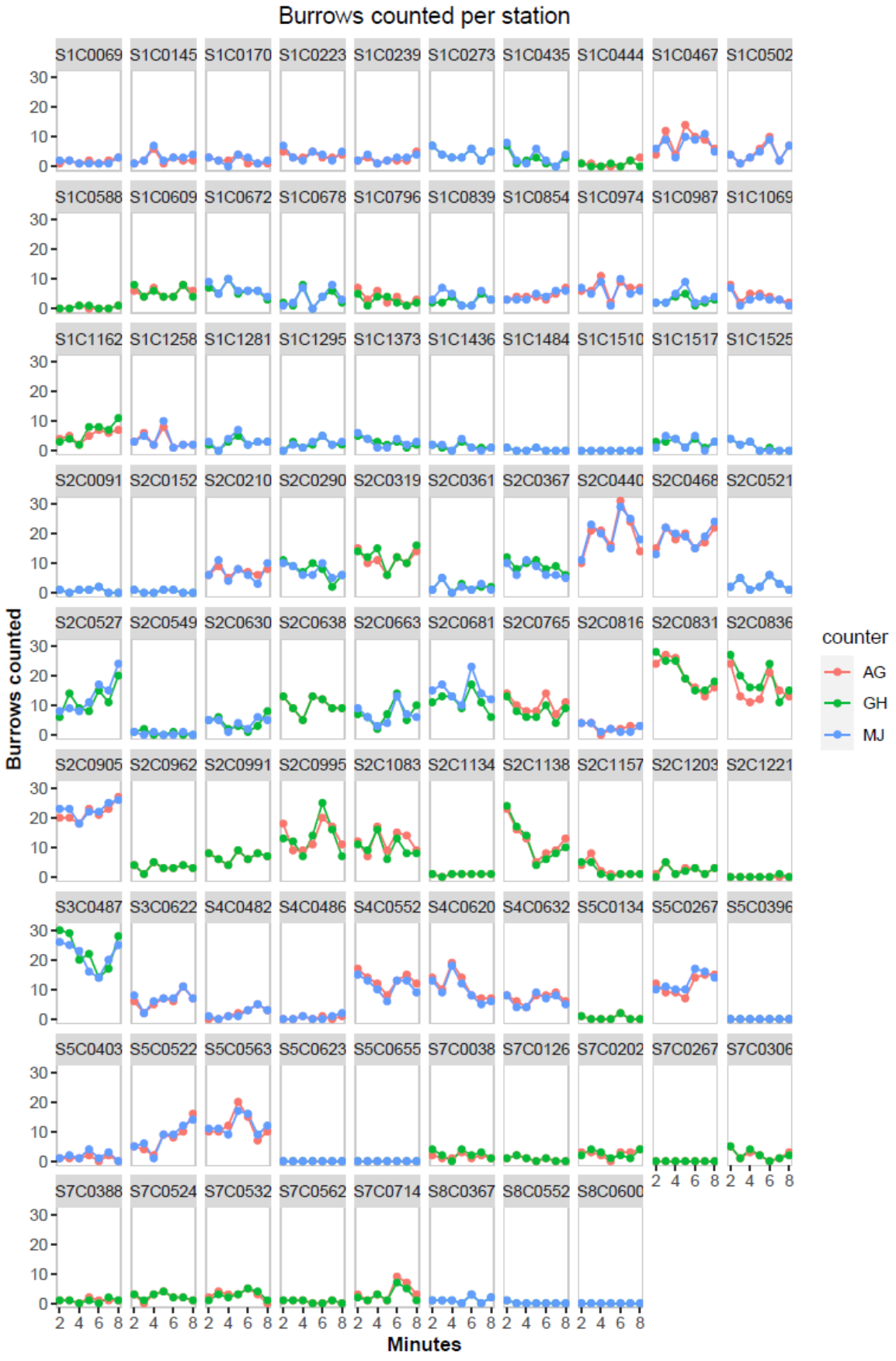


Fig. 5: FU 3&4 (Skagerrak/Kattegat) comparison of Danish readers, survey stations 2023, final run.

Fig. 6: FU 3&4 (Skagerrak/Kattegat) comparison of Swedish readers – survey stations 2023.

Denmark : FU 33 -Off Horns Rev

(Kai Wieland)

Functional Unit	**33**	**Area name**	**Off Horns Rev**
Survey design	Random with buffer, 1 stratum	Previous surveys	2017-2019, 2021 No surveys scheduled for 2020 and 2022
Camera Type: Standard / High definition	HD since 2019	Image Data: Type / Size per station eg, video / stills , 1GB	Video Appr. 1 GB per station
Country (ies)	Denmark	Vessel name (s)	RV Havfisken
Survey code (s)	UWTV FU33	Dates (start/end)	17/4 - 22/4/2023
Number scientific staff at sea	2	Staff exchanges	none
Number of stations (planned/completed/used in analysis)		80/79/75	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		1 station dropped due unsuitable bottom (shipwreck) 2 stations unreadable due to poor visibility	
Distance over ground source used	Vessel GPS	Average field of view (cm)	72
Adjusted mean density	0.0738 (se: 0.0051)	Adjusted abundance, CV	424 mill., 6.86 %
Overall footage quality (poor, medium, good)		medium	
Reference footage for survey area generated		Yes, but not checked by an external expert	
Quality control of station counts (Lin's CCC or consensus count)		Lin's CCC. Pre-check against internal reference files passed by all three readers. 2023 survey stations counted by two readers. 16 stations which did not passed Lin's CCC in first run counted by a third counter and original counts from one of the counters removed. Final set pass Lin's CCC for all except for 2 stations which were then removed from the final analysis.	

Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)	CTD (incl. O_2 and turbidity sensors)	
Data storage, level of analysis and dissemination (by data type)	Nephrops burrow counts	Excel file, .csv file with R – output
	CTD	Institute's server, raw and processed data
Other		

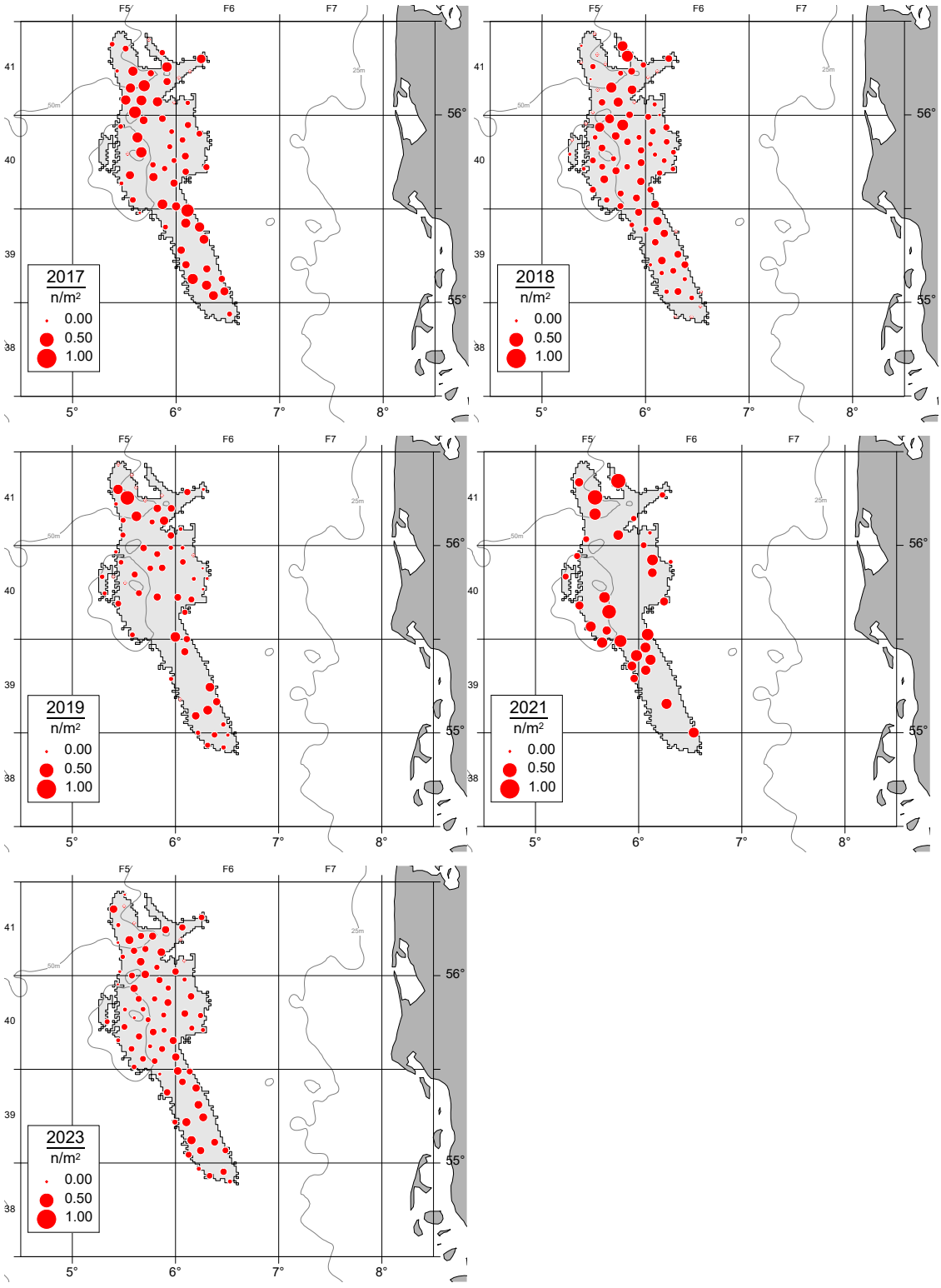


Fig. 1: FU 33 (Off Horns Rev) *Nephrops* burrow density by station for each year (no survey in 2020 and 2022).

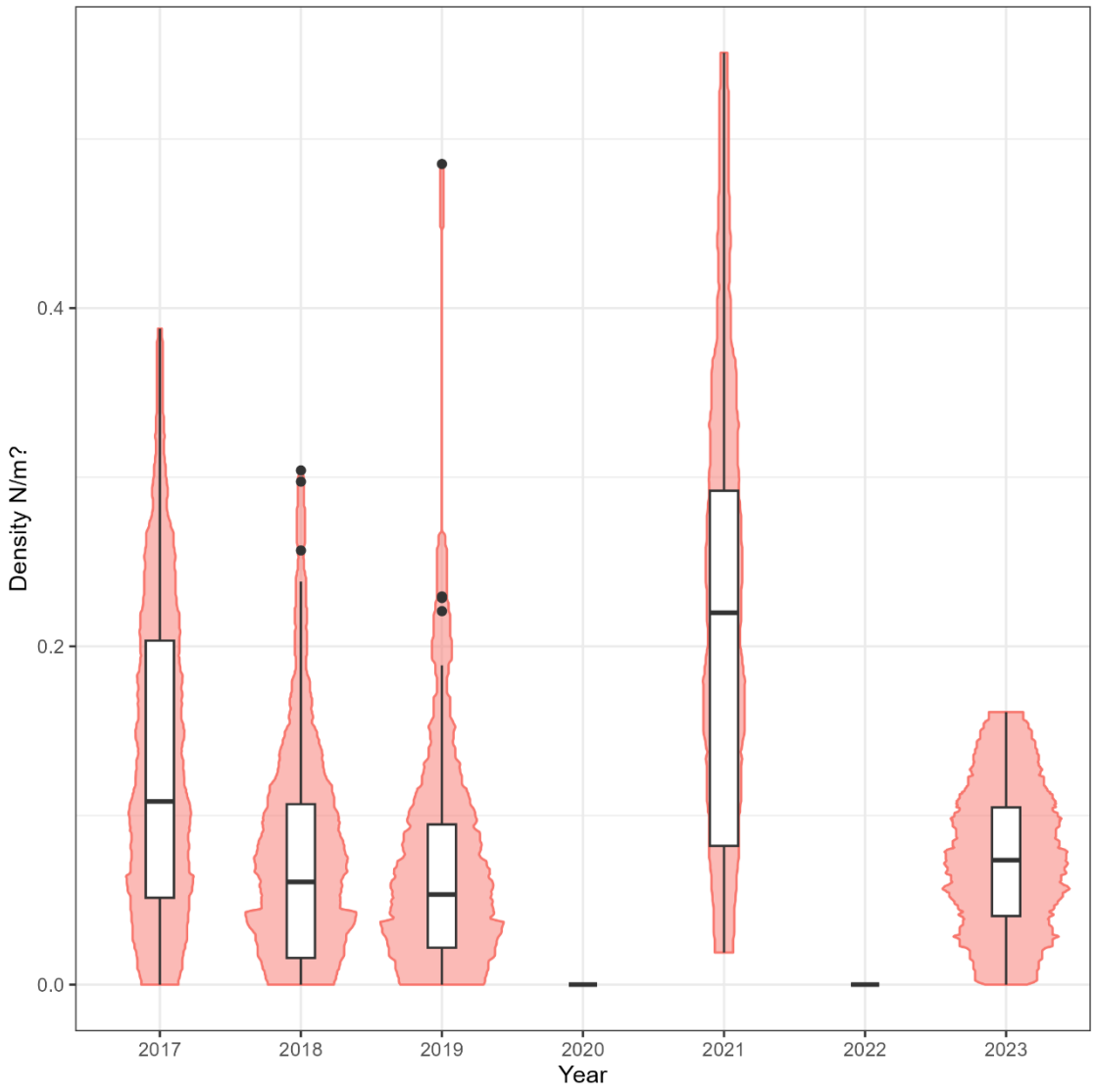


Fig. 2: FU 33 (Off Horns Rev) times series of *Nephrops* burrow density (The horizontal lines represent the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).

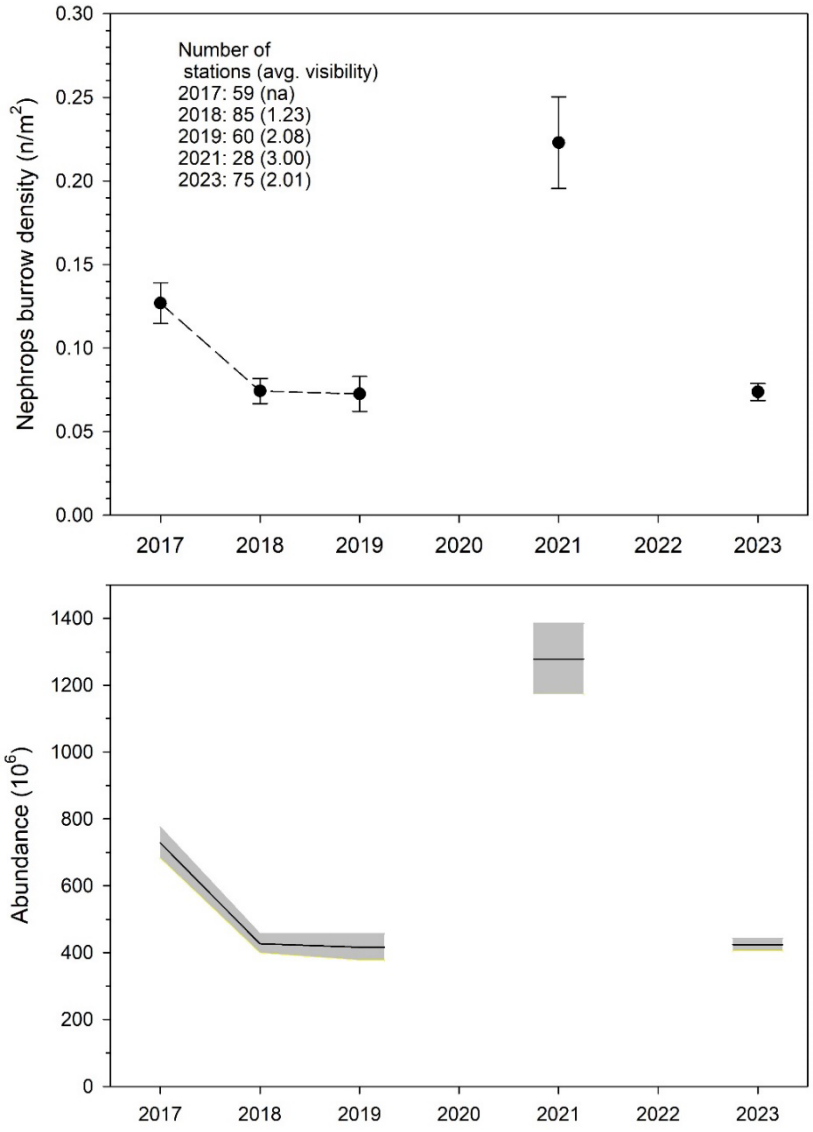


Fig. 3: FU 33 (Off Horns Rev) time series of *Nephrops* burrow mean density and total abundance with reference levels (error bars in upper panel represent standard error of the mean and the shaded area in the lower panel represents the 95% confidence interval; reference points are not defined for this stock).

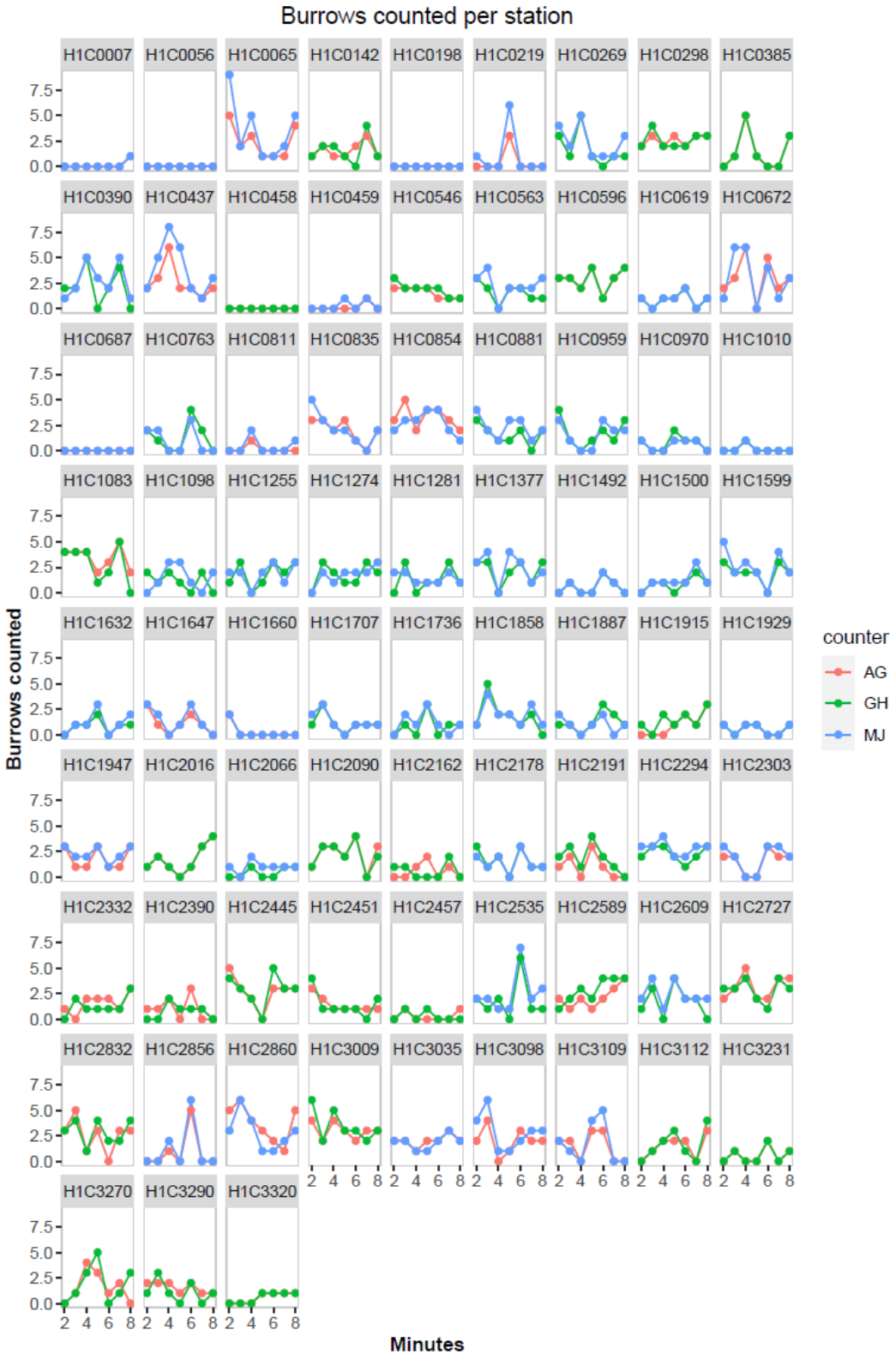


Fig. 4: FU 33 (Off Horns Rev) reader comparison, survey stations 2023, final run.

Future work

- Contact EU RCG whether this bi-annual survey is worth to continue (next time in 2025) or not.

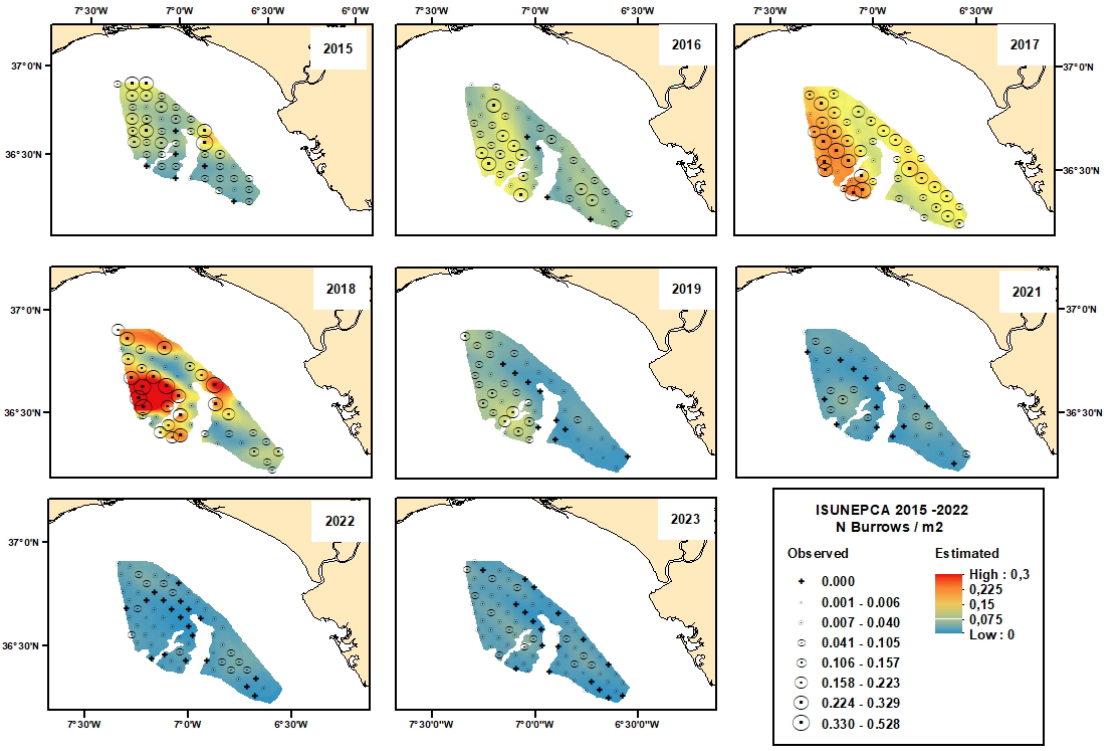
Spain: FU 30 - Gulf of Cadiz

(Yolanda Vila and Candelaria Burgos)

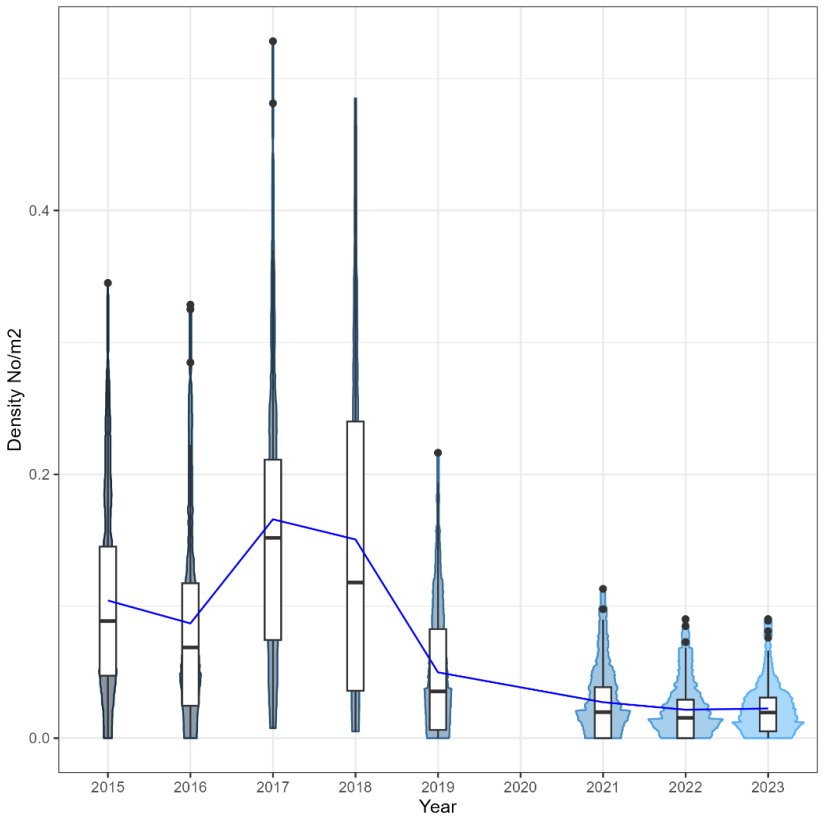
Functional Unit	**30**	**Area name**	**Gulf of Cadiz**
Survey design	Randomised isometric 3.5 nm grid	Previous surveys	2015- 2019 and 2021-2023
Camera Type: Standard/High definition	4 K (UHD)	Image Data: Type / Size per station	4 K (UHD): 4 GB/station
Country (ies)	Spain	Vessel name (s)	Ramón Margalef
Survey code (s)	ISUNEPCA_0623 UWTV_FU30 U9111	Dates (start/end)	31th May – 12th June 2023
Number scientific staff	9	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		86/86/85	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		One TV station in the shallower survey limit null due the very bad visibility conditions (99% coverage).	
Distance over ground source used	HiPAP	Average field of view (cm)	0.75 cm
Adjusted mean density	0.0225 burrows /m^2	Adjusted abundance, CV	54 million, CV = 8%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Yes (2018)	
Quality control of station counts (Lin's CCC or consensus count)		Counts by minute in 2023 were very low and Lin's CCC R code does not work well. Using timestamp by minutes and consensus between readers for 100% footages.	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler. *Nephrops* in/out; Presence/Absence of trawl marks, litter; quantification of macro benthos. 22 Beam Trawl hauls. 23 Sediment samples using Box-corer; sediment profile images by sample.	

Data storage, level of analysis and dissemination (by data type)	*Nephrops* burrow counts	Storage: hard copies of data held in office environment; Level: annotated burrows Dissemination: WGNEPS, WGBIE, IEO-CSIC internal report.
	CTD	Storage: hard copies of data held in office environment Level: TD profile per station Dissemination: WGNEPS, IEO-CSIC internal report.
	Trawl	Storage: hard copies of data held in office environment Level: Abundance taxon/specie per station Dissemination: WGNEPS, IEO-CSIC internal report
	Sediment	Storage: physical samples in cold storage; plus electronic copies of data relating to samples on hard disk. Level: carried out by other departments. Awaiting work up. Dissemination: WGNEPS, IEO-CSIC internal report.
	Other	

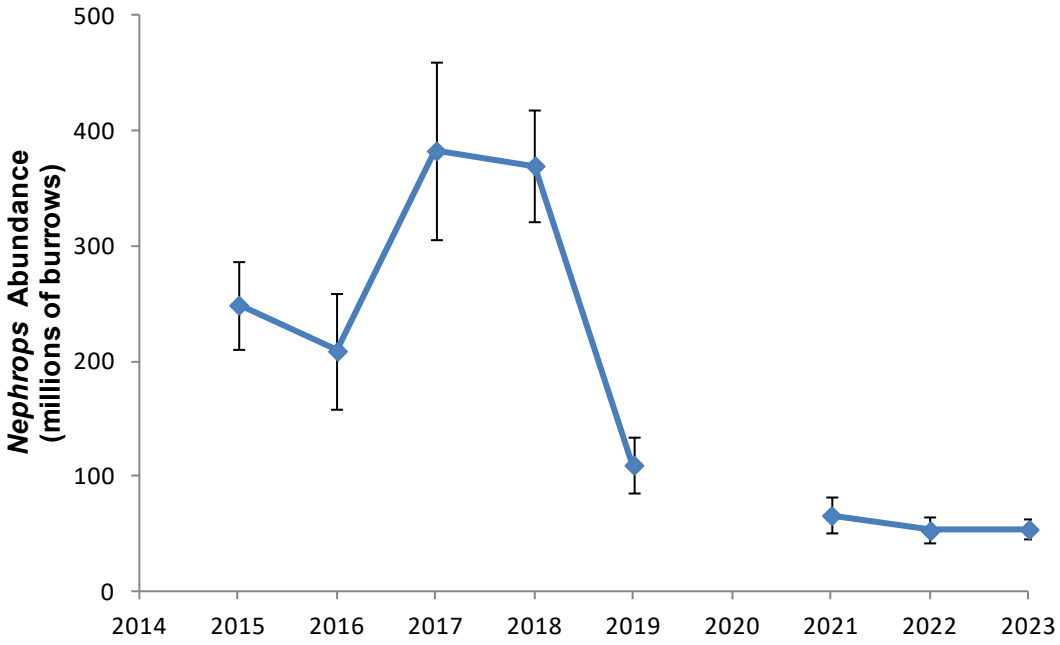
-



- **Fig. 1: FU 30. Map of density (burrow/m²) by station for each year. Station positions with zero density are indicated using a +.**



- **Fig. 2: FU 30. Times series of adjusted burrow density (Violin and box plot). 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.**



- **Fig. 3: FU 30. Time series of abundance (with 95% confidence intervals).**

Spain: FU 25

(Isabel González-Herraiz and Julio Valerias)

Functional Unit	**25**	**Area name**	**North Galicia**
Survey design	Randomised isometric 4.7 nm grid	Previous surveys	2022
Camera Type: Standard/High definition	4 K (UHD)	Image Data: Type / Size per station	4 K (UHD): 4 GB/station
Country (ies)	Spain	Vessel name (s)	RV Ramón Margalef
Survey code (s)	ISUNEP25_0623	Dates (start/end)	17/06/2023-28/06/2023
Number scientific staff	11	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		80/80/80	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Two stations in rocky bottom (= zero burrow *Nephrops*). 100% coverage of planned sampling area.	
Distance over ground source used	HiPAP	Average field of view (cm)	0.75 cm
Adjusted mean density	0.008 burrows/m^2	Adjusted abundance, CV	50.05 million, CV = 10%
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Not	
Quality control of station counts (Lin's CCC or consensus count)		Counts by minute in 2023 were very low and Lin's CCC R code does not work well maybe due to majority of stations have zero burrows. Using timestamp by minutes and consensus between 3 readers for 100% footages.	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		Temperature & Depth profiler. *Nephrops* in/out; Presence/Absence of trawl marks, litter; quantification of macro benthos. 27 Beam Trawl hauls.	

	32 Sediment samples using Box-corer; sediment profile images by sample.	
Data storage, level of analysis and dissemination (by data type)	*Nephrops* burrow counts	Storage: hard copies of data held in office environment; Level: annotated burrows Dissemination: WGNEPS, IEO-CSIC internal report. 2023 stations map in SIMERPE2 congress in 2023. 2022 and 2023 results in the next WGBIE (2024).
	CTD	Storage: hard copies of data held in office environment Level: TD profile per station Dissemination: WGNEPS, IEO-CSIC internal report.
	Trawl	Storage: hard copies of data held in office environment Level: Abundance taxon/specie per station. Litter identification and quantification. Dissemination: WGNEPS, IEO-CSIC internal report and in the next WGBIE (2024).
	Sediment	Storage: physical samples in cold storage; plus electronic copies of data relating to samples on hard disk. Level: carried out by other departments. Awaiting work up. Dissemination: WGNEPS, IEO-CSIC internal report. 2022 grading results and 2023 reflectivity results in SIMERPE2 congress in 2023. Granulometry, organic matter, bathymetry, reflectivity and sedimentary structure results in the next WGBIE (2024).
	Genetics	Storage: physical samples in cold storage. Level: carried out. Expected results in the medium term

		Dissemination: WGNEPS, IEO-CSIC internal report and in the next WGBIE (2024).

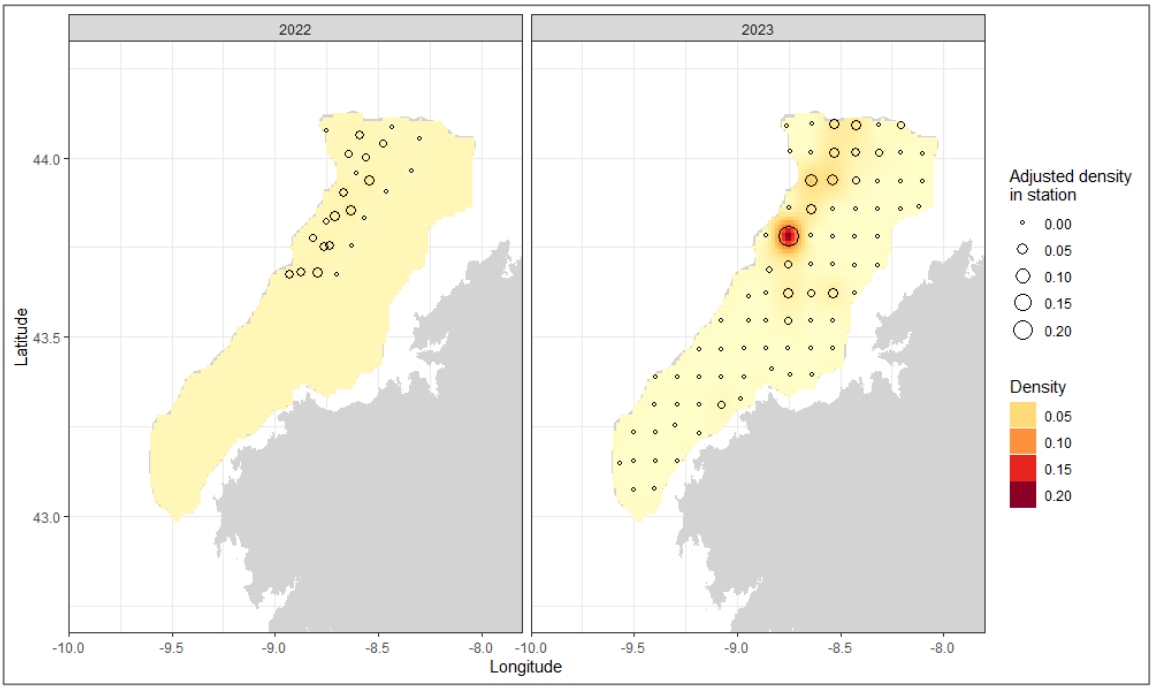


Fig. 1: Map of density (burrow/m²) by station for each year. Station positions with zero density are indicated using a point.

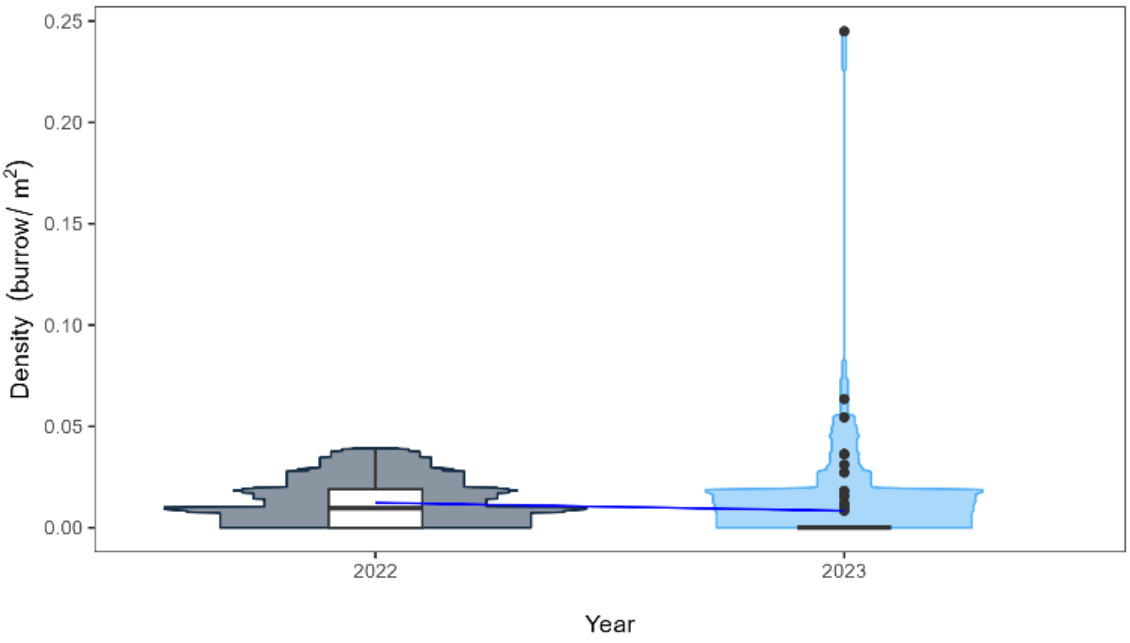


Fig. 2: Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

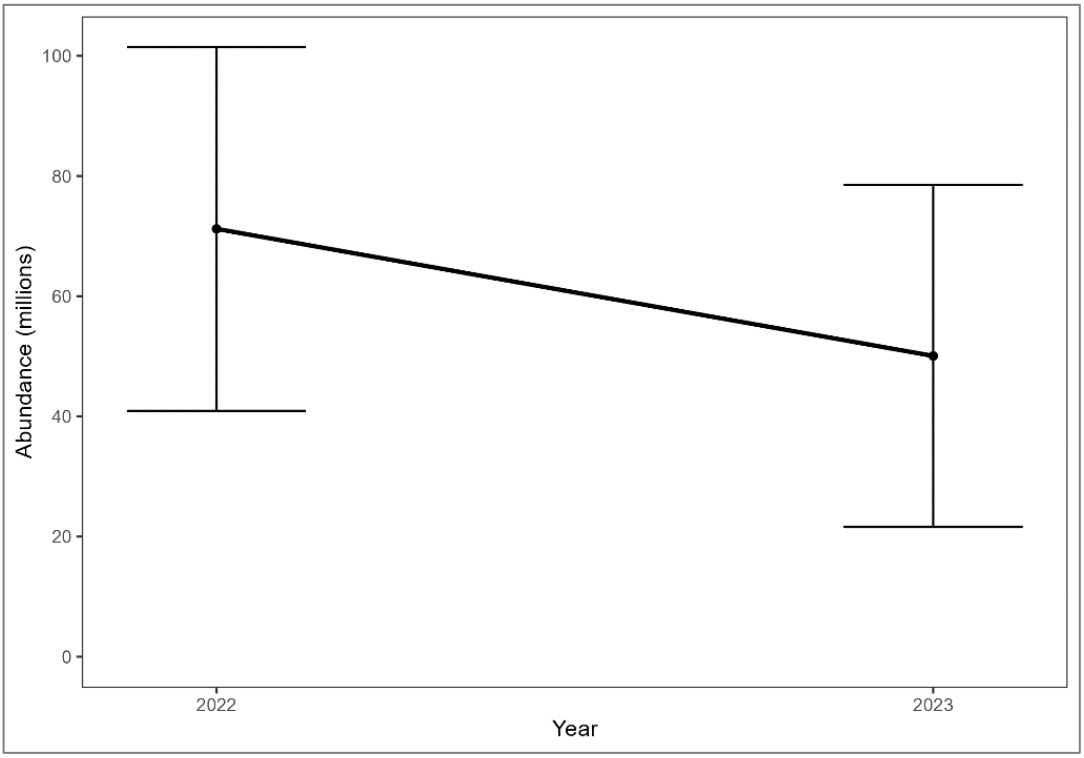


Fig. 3: Time series of abundance (with 95% confidence intervals).

Portugal: FU 28-29 southwest and south Portugal

(Barbara Serra Pereira)

The R/V Noruega, a stern trawler with 47.5 m of overall length (LOA) built in 1978 and used to conduct trawl and acoustic surveys on pelagic and demersal resources in Portuguese waters, ended her operation in 2018. She was used for almost 40 years in surveys, and from 1997 to conduct the *Nephrops* Survey Offshore Portugal (NepS). Data on biodiversity, biological and oceanographic parameters are collected in this survey, as well as data on marine litter characteristics and distribution.

In 2021, the R/V Mário Ruivo started her operation and replaced R/V Noruega to conduct IPMA' surveys. The vessel, previously used for laying and maintenance of underwater targets, navigation marks and moorings in UK, was acquired by IPMA with support of EEA Grants Programme and suffered an extensive transformation to be used as a multidisciplinary research vessel including the capability to perform trawl operations.

The survey in 2022 was carried out with less operational issues than in 2021. Yet, the winch is still to be installed in the R/V, so that the CTD and box-corer can be used for oceanographic and sediment data collection. No survey was conducted in 2023 due to vessel and administrative issues.

No calibration was performed between the two vessels. Although the gear used is the same, the trawling speed and the doors characteristics may affect the net geometry and the performance of the fishing operation. Analyses are being carried out to define whether the surveys carried out with the new vessel will be considered as a new survey series or part of the previous one. A comparison of some technical characteristics of both vessels is presented in the table below:

		R/V Noruega	R/V Mário Ruivo
R/V type		Stern trawler	Multidisciplinary
LOA (m)		47.5	75.6
Gross tonnage (t)		495	2290
Main Power (kW)		1100	2984
Doors weight (kg)		650	500
Doors surface (m2)		3.75	–
Trawling speed (knots)		3	3.2 (average)
Gear	Gear type	FGAV020	
	Floats in Headline/winglines	9	
	Groundrope	Synthetic wrapped wire core + chain	
	Mean vertical opening (m)	1.5 – 2.0	to be estimated
	Mean doors spread (m)	60	
	Mean horizontal opening (m)	30	

In 2024, we aim to conduct the first trial using UWTV in this FU. A collaboration with IEO-CSIC was already established, and depending on vessel and scientific team availability in both institutes, and also the technical requirements to use IEO-CSIC HORUS sledge in R/V Mário Ruivo, trials are planned to occur under one of two scenarios: (i) onboard IPMA's RV Mário Ruivo using the IEO-CSIC HORUS sledge and with collaboration of IEO-CSIC scientific team onboard; or (ii) onboard an IEO-CSIC' RV. Training of IPMA's team onboard ISUNEPCA and/or ISUNEPCA25 and in UWTV surveys conducted in other FUs is also planned for 2024.

France: FU 23-24: Bay of Biscay

(Spyros Fifas, Jean-Philippe Vacherot, Yann Coupeau, Jean-Jacques Rivoalen, Damien Delaunay, Frank Armstrong)

1. Historical context

The UWTV survey named "LANGOLF-TV" has been conducted since 2014 aiming to demonstrate the technical feasibility of such a survey in the local context and to identify the necessary competences and equipment for its sustainability. During the first two years, 2014 and 2015, video sampling was associated to a trawl one for the purpose of providing *Nephrops* LFDs by sex and estimating the proportion of other burrowing crustaceans (mainly *Munida*) which can induce bias in the burrows counting.

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The surface involving in *Nephrops* is precisely delimited owing two information: (1) on the sedimentary structure of the sea bottom already taken into account during the former LANGOLF trawl survey on years 2006-2013 (5 spatial strata; fig. 1); (2) on the systematic grid of video tracks combined with VMS data for the fishery (fig. 2; data source: National Fisheries Direction; compilation: Ifremer). Sampling of landings and discards (onboard and at auction) has provided yearly dataset since 1987 and mainly since 2003 owing to the monitoring of the European DCF plan (Table 1; Fig. 3).

The 2016's WKNEP benchmark validated the UWTV survey and the assessment combining burrows counting and the SCA model for this stock. The change of the stock status from category 3 to 1 implies annual advice instead of the biennial one applied previously. A WD was presented and validated by the WGBIE 2022 aiming to more accurately define the actual polygon surface of the stock by eliminating area with repetitively zero burrows. The updated surface (14 640 km² instead of 16 164 km² considered by the benchmark workshop 2016) was included in the assessment and advice process 2023. The main excluded area involves in combination of the rough sea bottom stratum (label RO; sampled only from 2016 onwards) with the latitude 45°45-46°: on years 2014-2021, that is represented by a total number of 44 stations including 31 (70%) stations with zero burrows whereas the zero samples for the whole area reach 11% of the total stations on the whole time series (135 on 1210).

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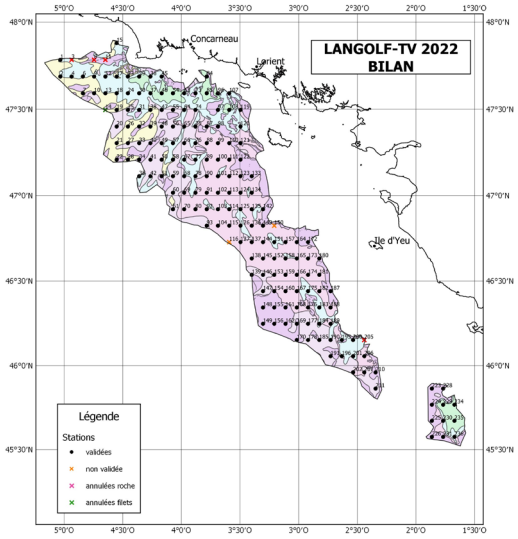

Figure 1. Spatial stratification of the Bay of Biscay according to sedimentary criteria as considered from the first UWTV survey onwards (2014) and sampling design 2022.

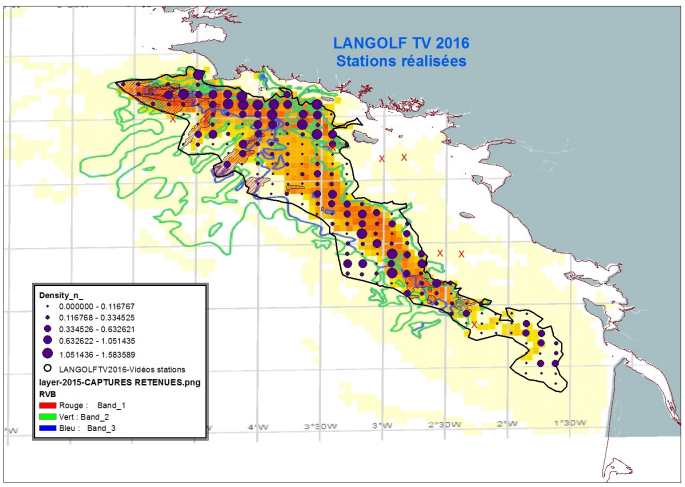

Figure 2. UWTV stations on a systematic grid and VMS data for retained catches of *Nephrops* (example of the year 2016; source: National Fisheries Direction; compilation: SIH Ifremer).

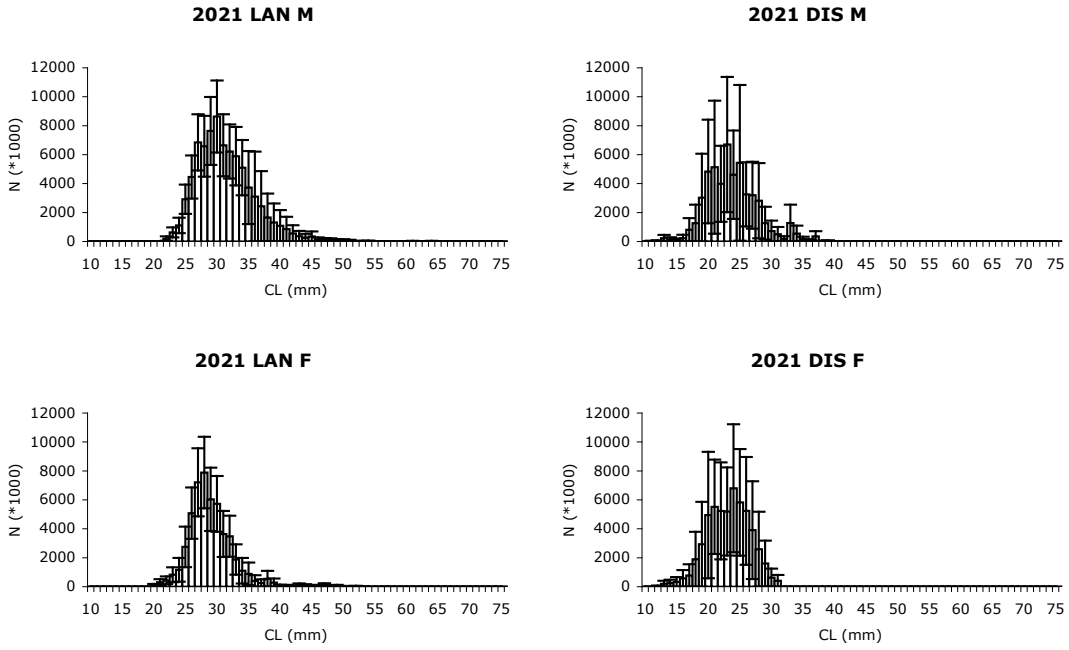

Figure 3. LFDs (size in carapace length, mm) for landings and discards by sex. Example of dataset 2021.

2. Sampling protocol

In accordance with other routinely UWTV surveyed stocks, the sampling protocol applied since 2014 has been a systematic one advantaged by wider spatialised explorations on collected data. A distance of 4.7 nautical miles was retained similarly to the FU22 Smalls Ground. From 2016 onwards the survey duration has been longer than previously: 14 effective working days were planned (instead of 10). Thus, it has been allowed to cover for the first time the area contained in the outline of the Central Mud Bank no belonging to any sedimentary stratum: this area known as not trawled due to rough sea bottom concentrate moderate fishing effort targeting *Nephrops* (16 164 km² were covered by sampling instead of 11 676 km² of the historical five sedimentary strata). In the 2018's UWTV survey, an additional area of ◎2200 km² was investigated with 31 validated stations added to the 184 ones contained in the 2016's benchmarked area of 16164 km². In 2019 a supplementary area of ◎930 km² was sampled with 7 validated stations whereas the standard benchmarked area contained 145 ones. In 2020, due to the COVID-19 pandemic, the survey initially scheduled at late April/early May was strongly compromised, before being re-scheduled in late July, with only two Irish scientists experienced in this type of mission in order to respect the obligatory social distancing on board (31 m vessel: "Celtic Voyager"; Irish company P&O); 134 validated stations were sampled. In 2021, the pandemic context remained constraining although the survey was carried out in the initially scheduled period (April 20th-May 2nd) with 175 finally validated stations. Two scientists (from Ifremer and from Marine Institute) conducted the survey onboard whereas the whole interpretation of the footage was carried out after the end of the survey by eight specialized agents of Ifremer. After the adoption of the updated stock surface, the number of sampling units was reduced by less than –9%: in years 2016-2020, 179, 113, 175, 139 and 132 stations instead of 196, 124, 184, 145 and 134 ones are respectively contained in the new stock polygon whereas the overall perception of the stock abundance remained unchanged.

In 2022, the survey was also undertaken by a reduced team (3 scientists from Ifremer, 1 from Marine Institute with the participation of the crew) and the interpretation of the footage was carried out either onboard or in lab.

Table 1. ***Nephrops*** **in the Bay of Biscay (VIIIab). Above: Landed and discarded weights since the DCF routinely conducted sampling onboard. Below: Discards and landings in numbers (10³ individuals) obtained by sampling onboard and at auction. Only years with sampling onboard are presented.**

Year	Landings (1)					Total Discards	Catches
	FU 23-24 (2)	FU 23	FU 24	Unallocated (MA N)(3)	Total VIIIa,b used by WG	FU 23-24	Total
	VIIIa,b	VIIIa	VIIIb			VIIIa,b	VIIIa,b
2003	1	3564	322	49	3886	1977	5863
2004	na	3223	348	5	3571	1932	5503
2005	na	3619	372	na	3991	2698	6689
2006	na	3026	420	na	3447	4544	7990
2007	na	2881	292	na	3176	2411	5587
2008	na	2774	256	na	3030	2123	5154
2009	na	2816	212	na	2987	1833	4820
2010	na	3153	245	na	3398	1275	4673
2011	na	3240	319	na	3559	1263	4822
2012	na	2290	230	na	2520	1012	3532
2013	na	2195	185	na	2380	1521	3900
2014	na	2699	108	na	2807	1326	4133
2015	na	3425	144	na	3569	1822	5391
2016	na	3873	217	na	4091	2531	6622
2017	na	3283	129	na	3412	2387	5799
2018	na	2038	86	na	2125	*1571*	*3696*
2019	na	2065	89	na	2154	634	2789
2020	na	2200	73	na	2273	1908	4181
2021	na	2925	81	na	3006	1126	4132

(1) WG estimates (2) landings from VIIIa and VIIIb aggregated until 1974 (3) outside FU 23-24

Italic font: revised value between WGBIE 2019 and 2020 (from 1627 t to 1571 t)

Year	*Discards*	*Landings*	*% discarding*
1987	268 244	288 974	48
1991	151 634	217 338	41
1998	150 995	161 549	48
2003	201 841	152 485	57
2004	222 089	139 753	61
2005	315 346	166 165	65
2006	487 288	127 942	79
2007	214 788	117 273	65
2008	198 031	115 274	63
2009	174 480	123 504	59
2010	113 530	138 120	45
2011	121 603	108 011	53
2012	117 935	101 424	54
2013	154 914	114 853	57
2014	117 930	121 594	49
2015	156 400	138 921	53
2016	200 973	161 371	55
2017	200 600	143 502	58
2018	151 926	83 463	65
2019	59 102	96 919	38
2020	154 401	100 704	61
2021	**105 925**	**130 114**	**45**

In 2022, LANGOLF-TV was carried out on 12 actual days (April 15th-26th; only 18 hours lost due to bad meteorological conditions). The equipment (sledge, computing hardware, screens, recorders) were provided by the Marine Institute. The sledge is based on the Scottish material (2.5 m*2.7 m*2.5 m; weight=80 kg); its speed is around 20 m/min. As for surveys from 2019 onwards, the new HD system CathX was adopted this year.

As for the last year's survey, the location of stations in 2022 was based on the 2018 campaign. 181 stations were planned for this year's survey, 174 were realized and validated, among them: 127 were validated from the first two operators' review *i.e.* 72%, a third reviewer was requested for 46 stations *i.e.* 26%, a fourth reader was necessary for 1 station (1%), 28 stations were represented by zero density *i.e.* 16% and squat lobster (*Munida sp.*) wad present at 17 stations *i.e.* 10%.

Acquiring images on the sea bottom requires a preliminary use of multi-beam sounder aiming to determine the nature of the sediment and to avoid technical problems due to rough ground. The recording starts when the sledge reaches the adequate speed (≈0.8 knots), the contact with the sediment is conform. Recording lasts 10 min even with no *Nephrops* burrows on the track; 7 min minimum are necessary for the validation of the footage.

Up to 2019's survey, the provisional absence of reference footage in the Bay of Biscay implied the use of other support coming from grounds with similar conditions (density of burrows) to the Bay of Biscay: the Smalls grounds (FU22, Celtic Sea, UWTV surveyed since 2006) was chosen. A validation by the test CCC (fig. 5) allows to decide on the conformity or not of each reader.

3. Results

3.1 Method:

More details can be found in Cochran (1977), Frontier (1983). The stratified sampling plan allows to calculate a ratio estimator (noted Y) of two variables, the numbers of burrows by video track and the surface of the track:

$$\boldsymbol{Y} = \sum_{\boldsymbol{h=1}}^{\boldsymbol{ns}} \boldsymbol{Y_h} = \sum_{\boldsymbol{h=1}}^{\boldsymbol{ns}} \boldsymbol{S}.\frac{\sum_{\boldsymbol{i=1}}^{\boldsymbol{nh}} \boldsymbol{x}_{ih}}{\sum_{\boldsymbol{i=1}}^{\boldsymbol{nh}} \boldsymbol{s}_{ih}}$$

With:

h= stratum [h=1,…,ns]; i= station by stratum h [i=1, …, n_h]; S_h= total surface of the stratum h; s_{jh}= surface for the station i, stratum h; x_{ih}= total number of burrows by station i in the stratum h (by adding the total recorded and validated minutes by station averaged according to the number of observers usually equal to 2)[1]

The variance of Y, noted V[Y], is given by:

$$V[Y] = \sum_{h=1}^{ns} = V[Y_h] = \sum_{h=1}^{ns} \left[\frac{S_h}{\sum_{i=1}^{nh} s_{ih}}\right]^2 . [nh.\left(\frac{Y_h}{S_h}\right)^2 .V[s]\left(\frac{Y_h}{S_h}\right).\mathrm{Cov}[x_{ih}, s_{ih}]$$

with $V[x_{ih}]$, $V[s_{ih}]$ and $\mathrm{Cov}[x_{ih},s_{ih}]$ variances and covariance of x_{ih} and s_{ih}.

[1] The stratified estimator was also investigated under a sub-sampling plan (primary unit: station; secondary unit: observer*minute). It was proved that including the 2nd level increases the total variance only by 1.6-2.6% for years 2014-2018 (but ≈5.4% in 2019, ≈4.2% in 2020, ≈5.9% in 2021 and ≈4.4% in 2022); thus, the stratified plan is further developed on only one sampling level.

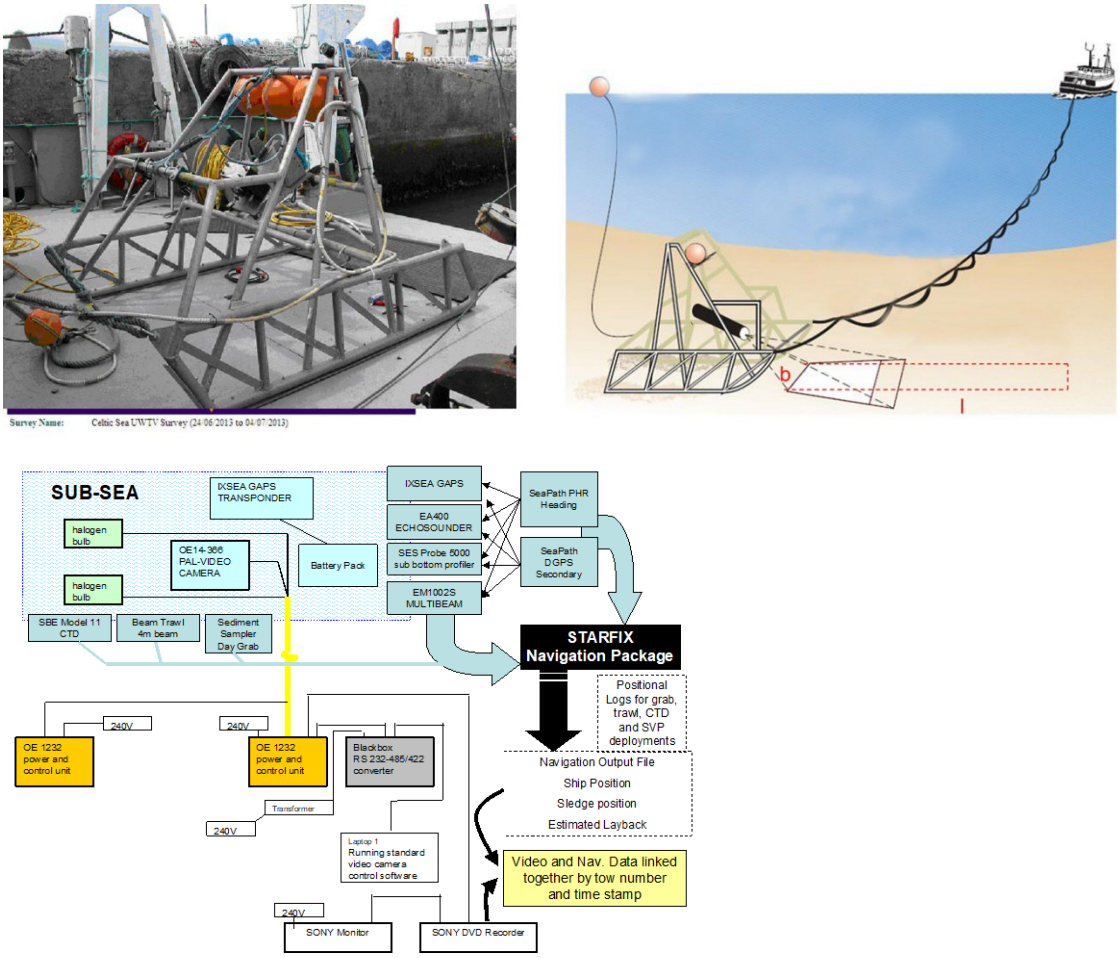

Figure 4. Schematic diagram of the sledge and traction on the sea bottom. Mechanism for acquiring process onboard. ***Source: Marine Institute, Ireland.***

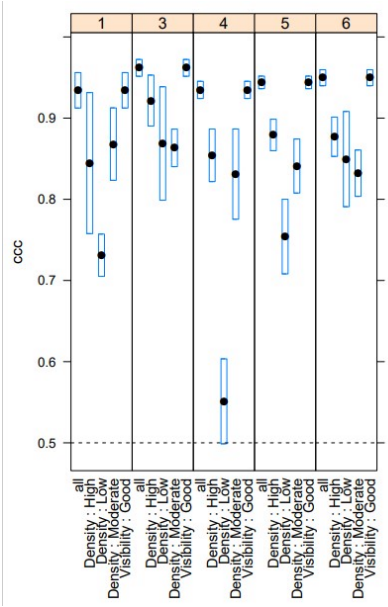

Figure 5. Conformity test CCC. 2022's results.

3.2 Raising[2]

1. Raising to the five historical sedimentary strata (from the former trawl survey 2006-2013).

The whole area of the five historical strata was covered in 2014 although only 2/3 of the total number of stations were carried out in 2015. In the period 2016-2021, 100% of the Central Mud Bank was sampled. The 2017's lower sampling level is explained by the coverage of a wide area exceeding the actual Central Mud Bank of the Bay of Biscay whereas the additional sampling effort outside the edge in 2018 affected the sampling level in a lesser degree. In 2019 and 2021, the sampling coverage was also impacted by the weather conditions. Table 2 shows results of raising for burrow densities (/m²) associated to their CVs by stratum for years 2014-2022. After the steep decrease by -22% between 2019 and 2020 subsequently to two consecutive years of increase (respectively +19% for 2017-2018 and +5% for 2018-2019) 2021's results reveal a very slight increase (2.5%). In 2022, number of burrows increased strongly (+23% compared to 2021).

[2] All cited results for numbers of burrows involve in the updated stock surface replacing that from the benchmark workshop 2016.

Annex 4: List of presentations

(in order of appearance)

- Yolanda Vila and Candelaria Burgos: IEO Developments on the UWTV survey in the Gulf of Cadiz (FU 30) 2023
- Kai Wieland, Patrik Jonsson: *Nephrops* Joint Danish/Swedish UWTV survey in the Skagerrak and Kattegat (FU 3&4) in 2023.
- Bárbara Serra-Pereira: Developments on the trawl and UWTV survey in Portugal.
- Adrian Weetman: Update on Scottish UWTV surveys.
- Jónas Páll Jónasson: UWTV survey and *Nephrops* advice in Icelandic waters.
- Kai Wieland: Danish UWTV survey Off Horns Reef.
- Pia Schubert: Developments on AFBI trawl and UWTV surveys (FU 15).
- Jennifer Doyle: Update on Marine Institute Ireland Surveys.
- Spyros Fifas: *Nephrops* UWTV survey in the Bay of Biscay.
- Michela Martinelli and Damir Medvešek: *Nephrops* UWTV and trawl surveys in the Adriatic Sea.
- Isabel Herriz, Patricia Verisimo Amor and Julio Valeiras: Update on newly developed UWTV survey FU 25.
- Alina Wieczorek (Online): Overview of New Zealand surveys (*Metanephrops challengeri).*
- Chris Firmin (Online): Update on CEFAS surveys (FU 6 & FU 14).
- Chris Firmin (Online): FU14 preliminary review, findings and potential next steps.
- Jennifer Doyle: New FU definition.
- Jennifer Doyle: Joint AFBI-MI Reference Set Update
- Jennifer Doyle: FU 16 QC review (MAE).
- Marco Reggiannini: Artificial vision to support image annotation.
- Jacopo Aguzzi: Digital Twin-sustained 4D ecological monitoring of restoration in fishery depleted areas.
- Damianos Chatzievangelou: Coordinated Intelligent Networks for *NEPHrops norvegicus* In-situ Long-term Imaging-based Assessment**.**
- Pia Schubert (online): EOSG Update.

- Michela Martinelli: Utility of UWTV and trawl *Nephrops* surveys as platforms for collecting data for purposes other than *Nephrops* assessment: the case of Adriatic Surveys.
- Julian Burgos (online): WGMHM - Possible usage of biological data from UWTV surveys .
- Patrik Jonsson: Field of View (FOW) – burrow size.
- Lois Flounders: PhD project Introduction.