WORKING GROUP ON NEPHROPS SURVEYS (WGNEPS, outputs from 2022 meeting)

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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 2022 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 2023.

In total, 21 surveys covering 26 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 first exploratory UWTV survey on the FU 25 *Nephrops* grounds was also presented to the group.

The results of the evaluation of reference sets for FU3&4 Skagerrak/Kattegat were accepted following the process set down by the 2018 workshop (WKNEPS).

An alternative method estimate *Nephrops* abundance was shown to the group using the recently published R package sdmTMB.

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
Year cycle started	2022
Reporting year in cycle	1/3
Chair	Jennifer Doyle, Ireland
Meeting venue(s) and dates	15-17 November 2022, Cádiz, Spain (24 participants)

iii Terms of Reference

ToR	Description	Background	Science Plan topics addressed	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	Recurrent annual update	Document and R packages for UWTV survey data on github site.
d	To review video enhancement, video mosaicking, 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 2	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	Recent behaviour aspects have been investigated in the laboratory. Important to investigate correlation with field data.	1.3	Year 3	Review paper

	Nephrops (e.g. currents and light)				
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.	3.2	Year 2&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.

iv Work Plan Summary

Year	Summary
Year 1	All ToRs will be adressed in this year but the 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 adressed in this year. In addition to this focus will be on ToR e in year 2
Year 3	All ToRs will be adressed 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)

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2022	15-17 November	Cádiz, Spain	1st Interim report by 6 January to EOSG	Change of chairs: Outgoing: Jennifer Doyle Incoming: Jónas Páll Jónasson
Year 2023	17-19 November	To be confirmed	2nd Interim report by TBC to EOSG	Jónas Páll Jónasson
Year 2024	To be confirmed	To be confirmed	Final report TBC	Jónas Páll Jónasson

1 Survey coordination (ToR a)

The 2022 meeting was the first hybrid (MS Teams) meeting held in Cádiz, Spain since the pandemic. In total, 21 surveys covering 26 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.

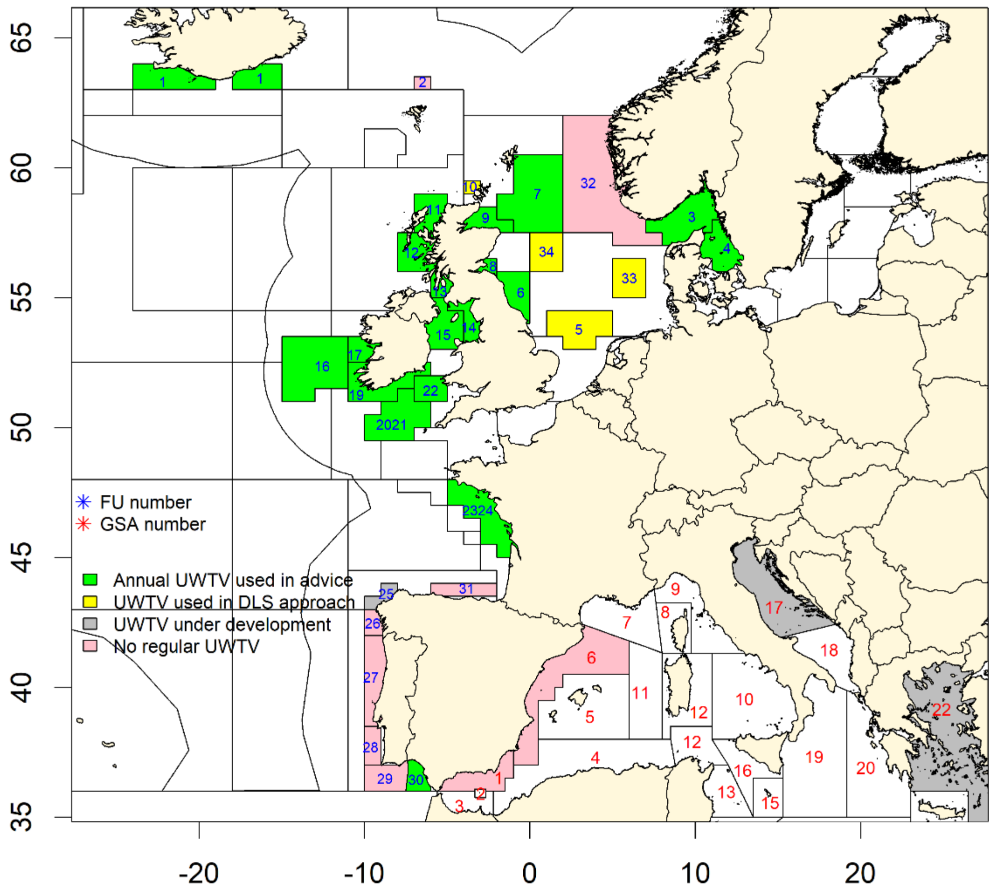

Figure. 1.1 Nephrops UWTV survey areas and use in stock assessment (FU: Functional Unit, GSA: Geographical Sub Area, DLS: Data Limited Stock).

There were some disruptions to 2022 survey operations and these are summarised below:

- UWTV survey Pomo Pits GSA 17 was not completed due to logistics.
- UWTV survey FU 17 on the Aran and Slyne head grounds not completed due to weather downtime.
- UWTV FU 1 not completed due to institute resource decision.
- UWTV Survey FU 10 not completed where this is only carried out if time allows on annual programme as is offshore and low yielding fishery.
- FU 33 due to be carried out in 2023 as is bi-annual survey.
- Reduced survey sampling on UWTV FU 16 due to weather downtime.
- Reduced survey sampling on FU 8 and FU 34 due to weather downtime.

The first exploratory UWTV survey was carried out on FU 25 *Nephrops* grounds by IEO (by the regional institutes: A Coruna and Vigo with technical support by Cádiz).

Survey series by Functional Unit / GSA are shown in Figure 1.2. Tentative survey schedule for 2023 is given in Figure. 1.3. Time series of *Nephrops* abundance estimates for the FU's are shown in Figure. 1.4a-d.

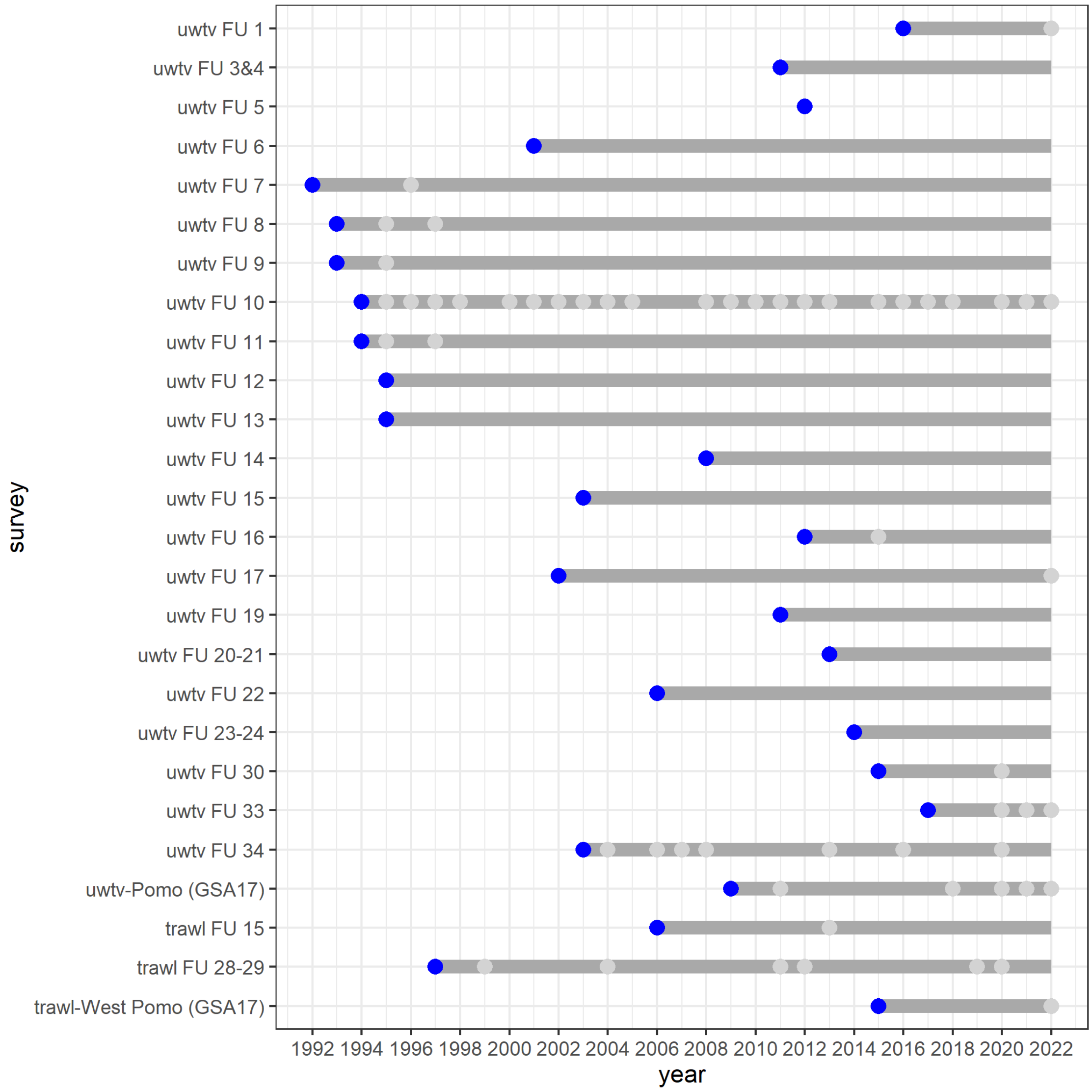

Figure. 1.2 Survey series by Nephrops Functional Units / GSA. Blue dot indicates first year of survey, light grey dot indicates year in which survey was not conducted and grey line shows the survey series.

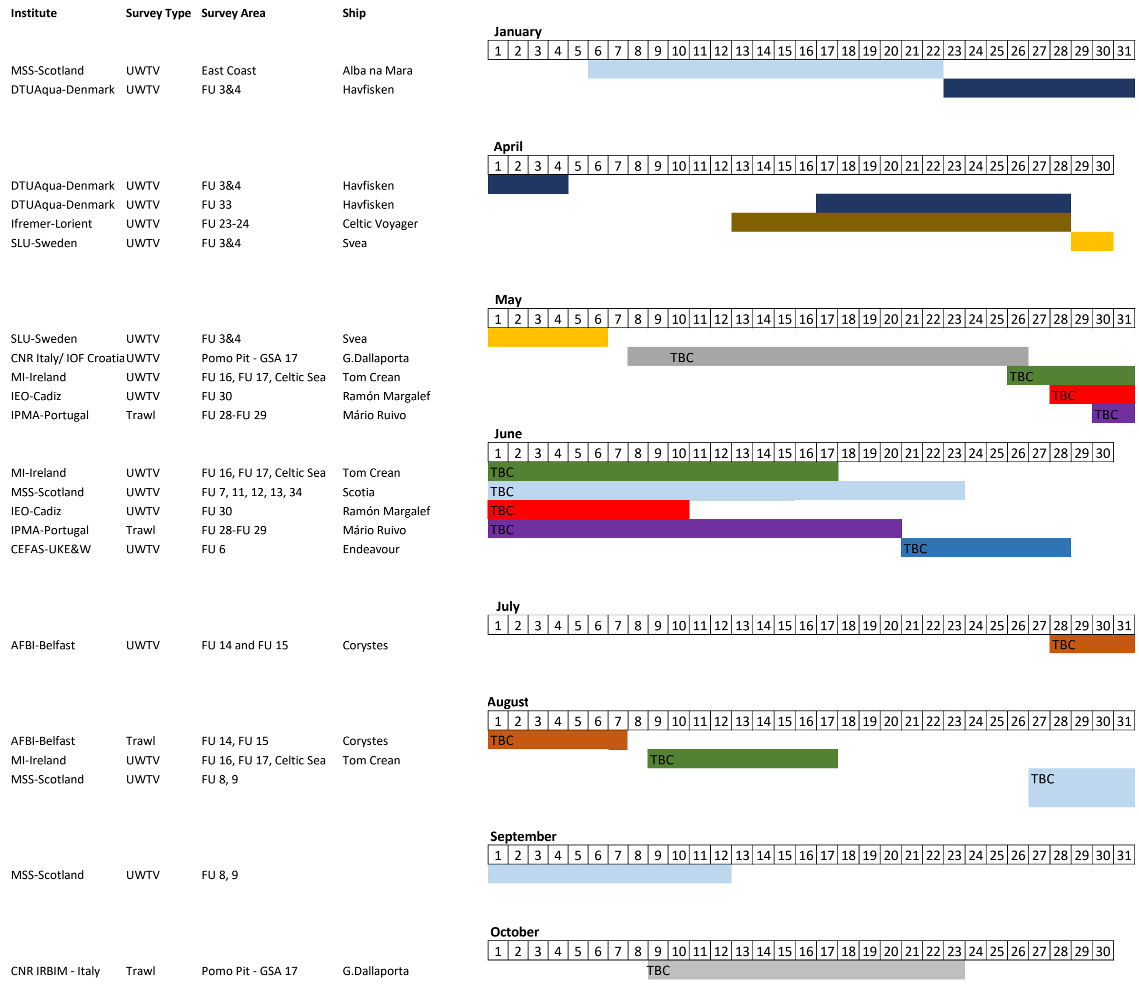

Figure. 1.3 *Nephrops* survey schedule for 2023.

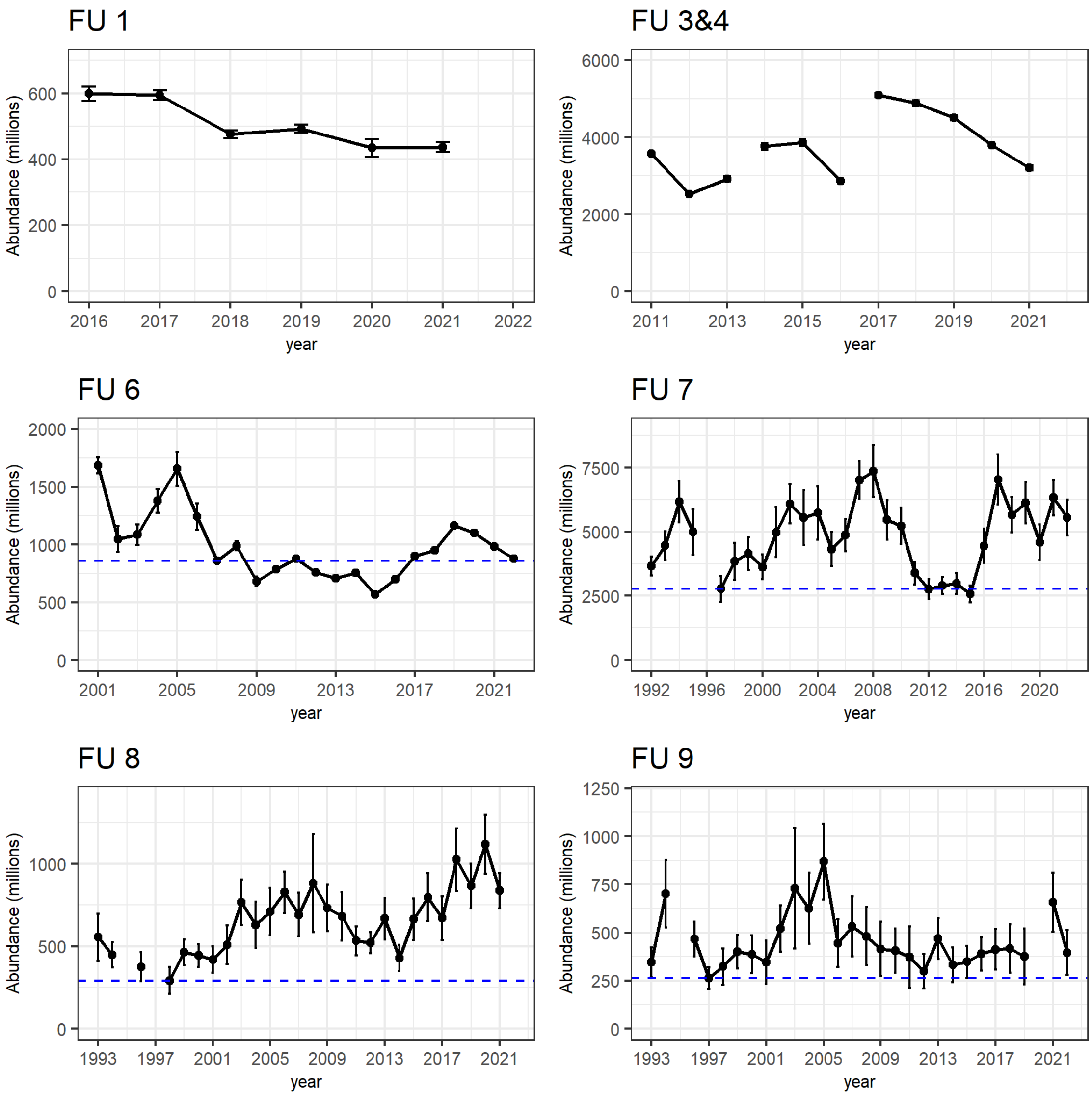

Figure. 1.4a. Nephrops abundance (with 95 % confidence interval) in FU 1, FU 3&4 (breaks indicate extension of the survey area), FU 6 to FU 9. Dashed line shows proxy for ICES MSY reference point Btrigger. FU 3&4 data for 2022 not available as considered preliminary.

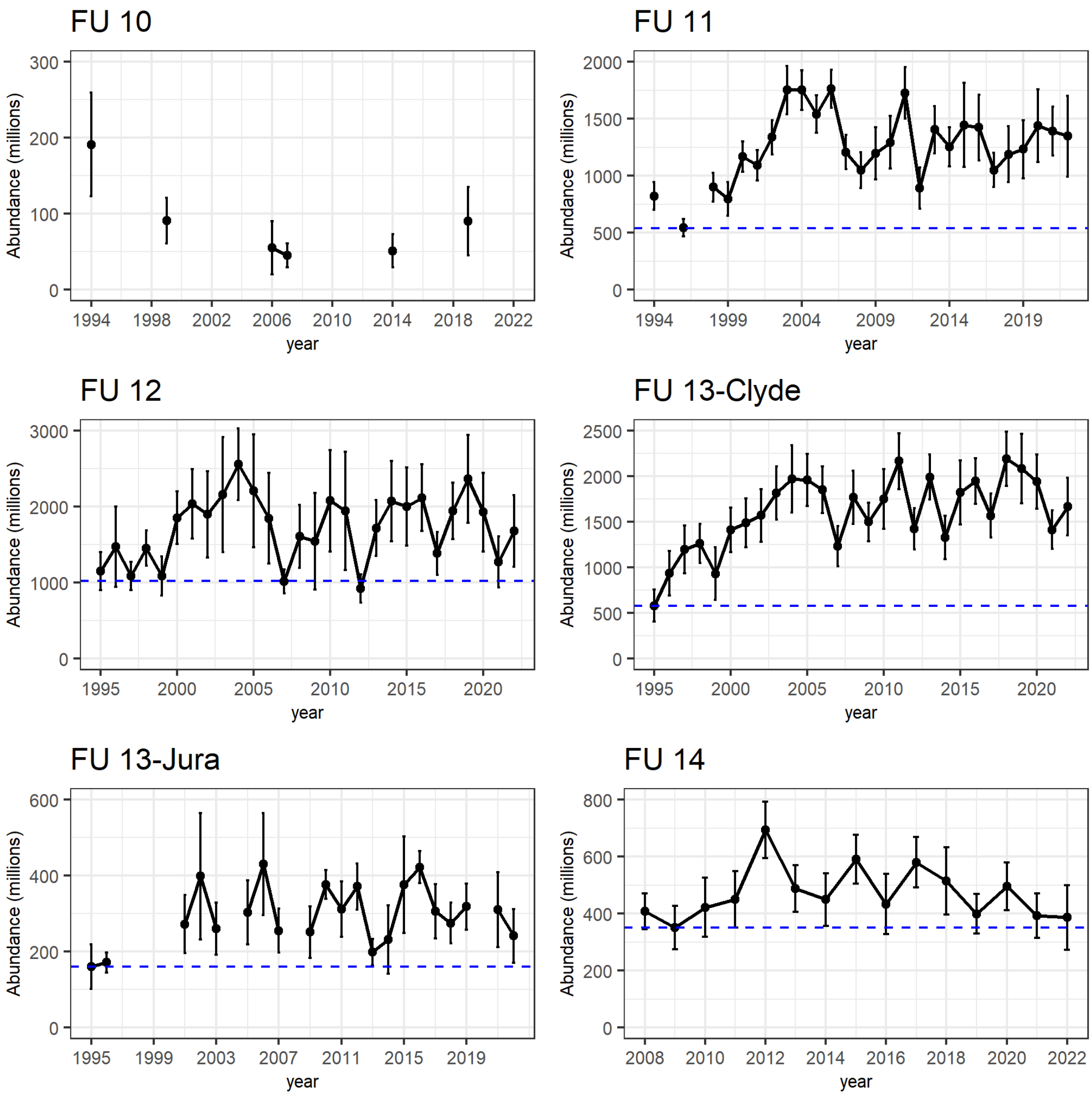

Figure. 1.4b Nephrops abundance (with 95 % confidence interval) in FU 10, FU 11, FU 12, FU 13-Clyde , FU 13-Jura and FU 14. Dashed line shows proxy for ICES MSY reference point $B_{trigger}$.

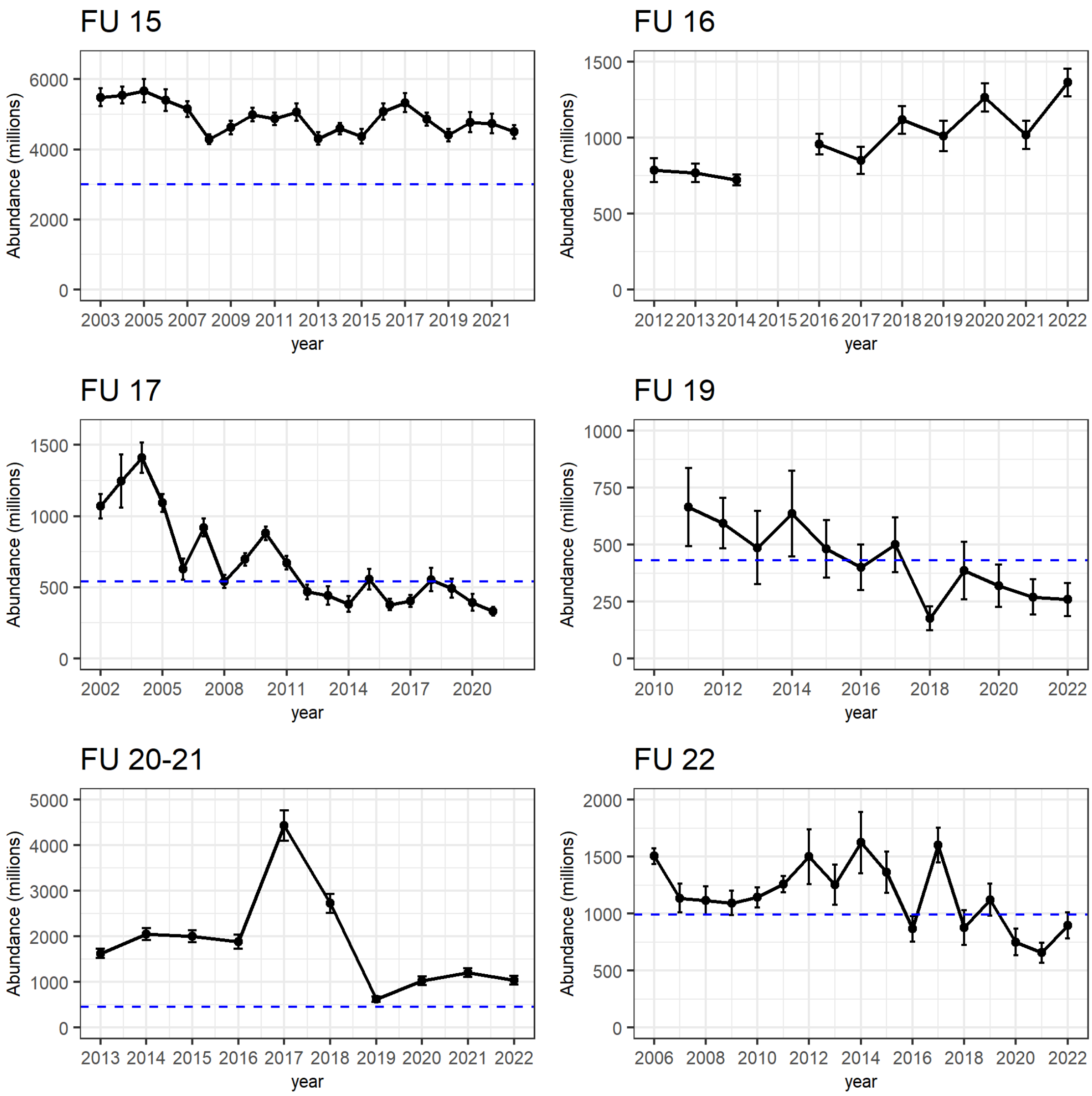

Figure. 1.4c *Nephrops* abundance (with 95 % confidence interval) in FU 15, FU 16, FU17, FU 19, FU 20-21 and FU 22. Dashed lines show proxy for ICES MSY reference point $B_{trigger}$.

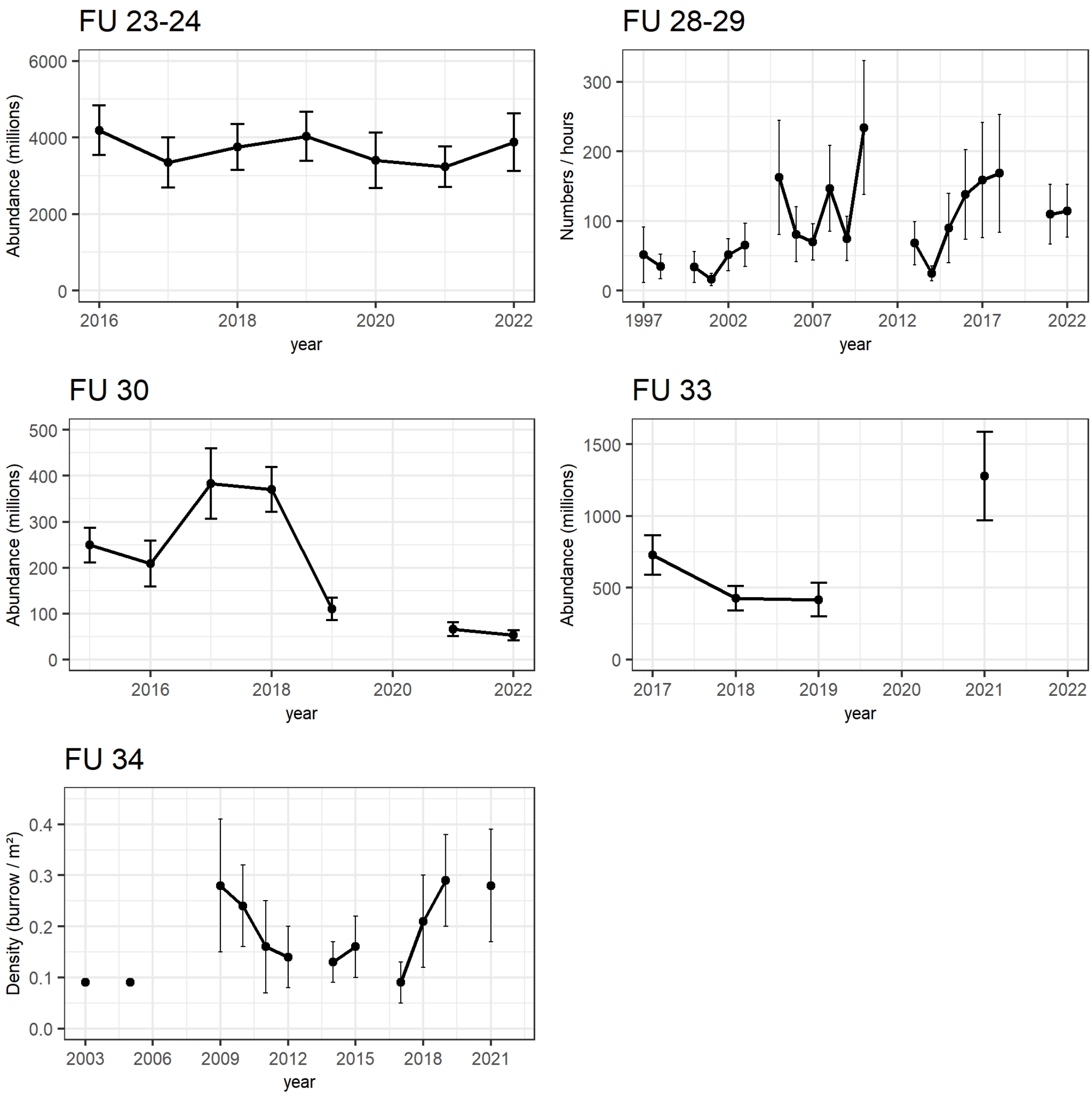

Figure. 1.4d Nephrops abundance (with 95 % confidence interval) in FU 23-24, FU 30, FU 33. Nephrops numbers per hour trawled in FU 28-29. Nephrops density (burrow / m²) with 95 % confidence interval in FU 34.

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.

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 evauations (ToR d)

3.1 FU3&4 Skagerrak/Kattegat Reference Sets

Kai Wieland and Patrik Jonsson

The survey in FU 3&4 is conducted in close cooperation by Denmark and Sweden and follows a stratified random design with 10 different strata of which 9 strata are used in the regular survey analysis, 8 strata are used for the stock assessment (S1-S7 and S9), one stratum (S8) is a very low-density area which is rarely visited by commercial vessels and one stratum (S10) is the creel area in Swedish coastal waters. The area coverage is shared between Denmark and Sweden in which Denmark covers predominantly the western part and Sweden the eastern part of the area with an almost equal total number of stations allocated to each of the two countries. There is no spatial overlap between the two countries despite of a share of three strata (S2, S5 and S8) in which Sweden takes the few easternmost located stations in Swedish territorial waters.

Five stations from the Danish part and six stations from the Swedish part were selected by the national survey coordinators. The reference set covered in total 6 of 8 strata used in the assessment and one station from the creel area. The reference set does not cover two strata from the Swedish survey area (S9: high density area close to the Swedish coast; S3: southern Kattegat for which no stations with video quality have yet been found).

Each of the five Danish and the six Swedish footages were independently counted twice by three Danish and three Swedish and two external readers. The work was done in spring 2022 by the different readers in their home laboratories. The readings from the two sets were analyzed separately by the national survey coordinators and will be kept independent for future use of calibration of the readers from the two countries, at least unless allocation of the survey area to the two countries will change towards a higher degree of mixed spatial coverage in the different strata.

The procedures followed the guidelines established during the ICES workshop on *Nephrops* burrow counting in 2018 (ICES 2018).

Danish reference files

Five stations covering 4 different survey strata in the western part of the survey area and densities from low to high were chosen as the reference set. The footages were shot with a HD camera during the regular survey in 2018. The quality of the footages was good in terms of towing speed, ground contact and visibility. The reference set readings were not timestamped as no appropriate annotation software had been available.

Two counters did not pass the intra-reader Lin's CCC test for the low-density station RefDK 5 (Tab. 3.1.1) although the average counts per minute for the two readers were quite similar for the two readers (DK3: 1.9 and 1.3 cts/min, Lin's CCC 0.24; SW3: 3 cts/min, Lin's CCC 0.41). However, the data from these two counters for this station were dismissed.

Several pairings in the inter-reader comparisons resulted in Lin's CCC values below 0.5 (Tab. 3.1.1) and again the low-density stations RefDK2 and RefDK5 revealed highest discrepancies.

Tab.3.1.1: Inter reviewer Lin's CCC comparisons (+: Intra comparison passed, -: Intra comparison failed).

File:	Ref**DK1**	Stratum S1, high density						
	DK1	DK2	DK3	EX1	SW1	SW2	SW3	EX2
DK1	+	0.84	0.83	0.82	0.44	0.53	0.22	0.82
DK2		+	0.96	0.82	0.65	0.76	0.35	0.80
DK3			+	0.79	0.62	0.80	0.38	0.81
EX1				+	0.39	0.49	0.18	0.85
SW1					+	0.83	0.44	0.34
SW2						+	0.61	0.51
SW3							+	0.27
EX2								+

File:	Ref**DK2**	Stratum S1, low density						
	DK1	DK2	DK3	EX1	SW1	SW2	SW3	EX2
DK1	+	0.96	0.91	0.17	0.34	0.62	0.06	0.52
DK2		+	0.82	0.14	0.30	0.46	0.04	0.40
DK3			+	0.24	0.39	0.61	0.06	0.71
EX1				+	0.13	0.31	-0.01	0.28
SW1					+	0.32	0.25	0.27
SW2						+	0.05	0.25
SW3							+	0.07
EX2								+

File:	Ref**DK3**	Stratum S2, high density						
	DK1	DK2	DK3	EX1	SW1	SW2	SW3	EX2
DK1	+	0.99	0.98	0.51	0.89	0.79	0.63	0.90
DK2		+	0.97	0.54	0.86	0.76	0.65	0.89
DK3			+	0.55	0.86	0.79	0.68	0.94
EX1				+	0.41	0.36	0.90	0.58
SW1					+	0.96	0.49	0.75
SW2						+	0.44	0.69
SW3							+	0.77
EX2								+

File:	Ref**DK4**	Stratum S2, medium density						
	DK1	DK2	DK3	EX1	SW1	SW2	SW3	EX2
DK1	+	0.89	0.83	0.63	0.64	0.70	0.67	0.63
DK2		+	0.94	0.43	0.54	0.61	0.48	0.55
DK3			+	0.32	0.35	0.42	0.34	0.45
EX1				+	0.82	0.75	0.93	0.90
SW1					+	0.90	0.89	0.80
SW2						+	0.89	0.75
SW3							+	0.90
EX2								+

File:	Ref**DK5**	Stratum S7, very low density						
	DK1	DK2	DK3	EX1	SW1	SW2	SW3	EX2
DK1	+	0.80		0.56	-0.08	0.71		0.33
DK2		+		0.07	-0.07	0.21		0.31
DK3			-					
EX1				+	-0.06	0.79		0.20
SW1					+	0.02		0.01
SW2						+		0.16
SW3							-	
EX2								+

The overall Lin's CCC were below 0.5 in more than 50% of the pairings for three readers (Fig. 3.1.2) and average counts were calculated from the data of the remaining five readers (Fig. 3.1.3) to establish the final reference set.

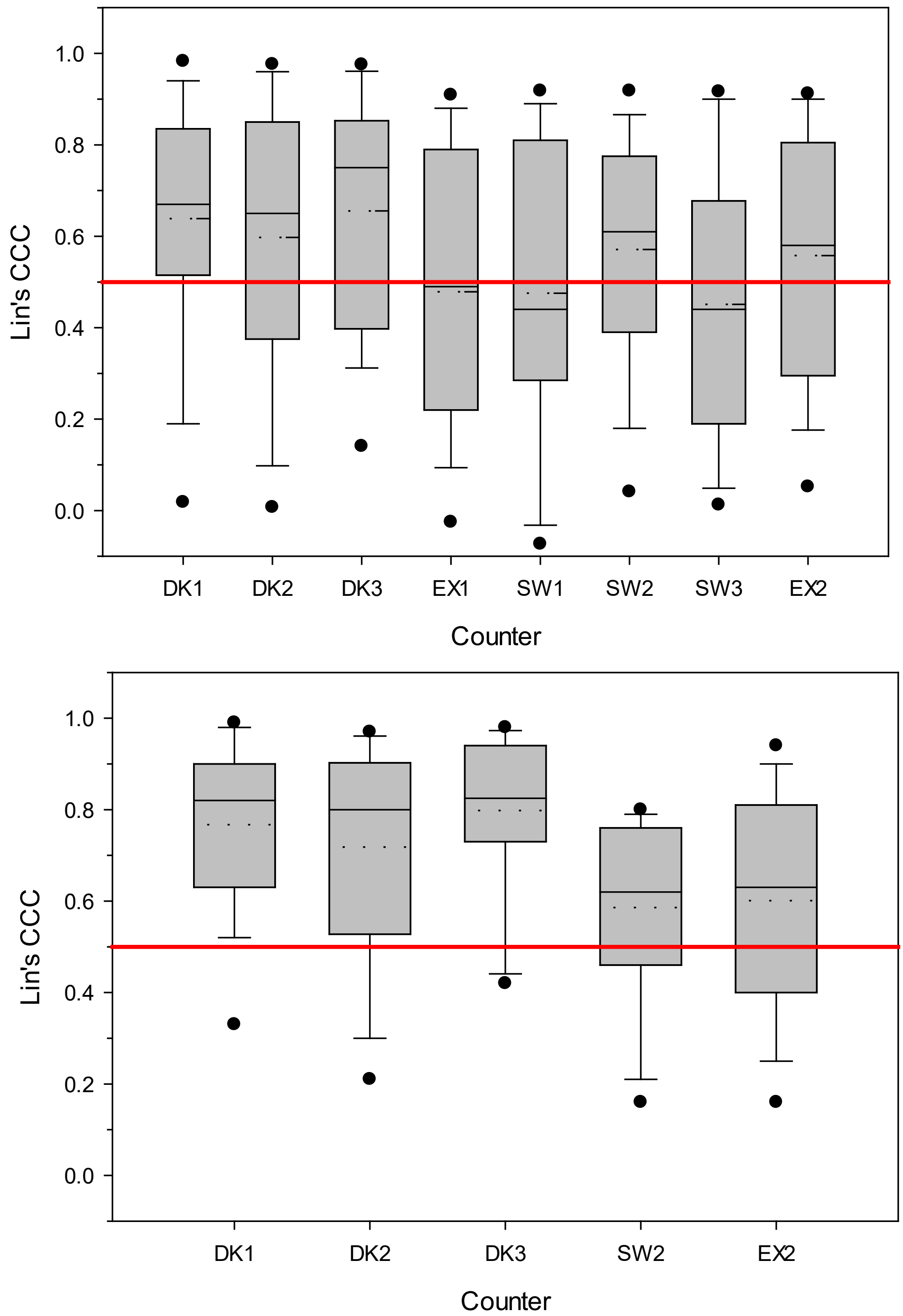

Fig. 3.1.2: Lin's CCC values for each of the reviewer's pairings (solid black lines: median, dashed black lines: arithmetic mean, black dots: 5th and 95th percentile; red line: 0.5 Lin's CCC threshold).

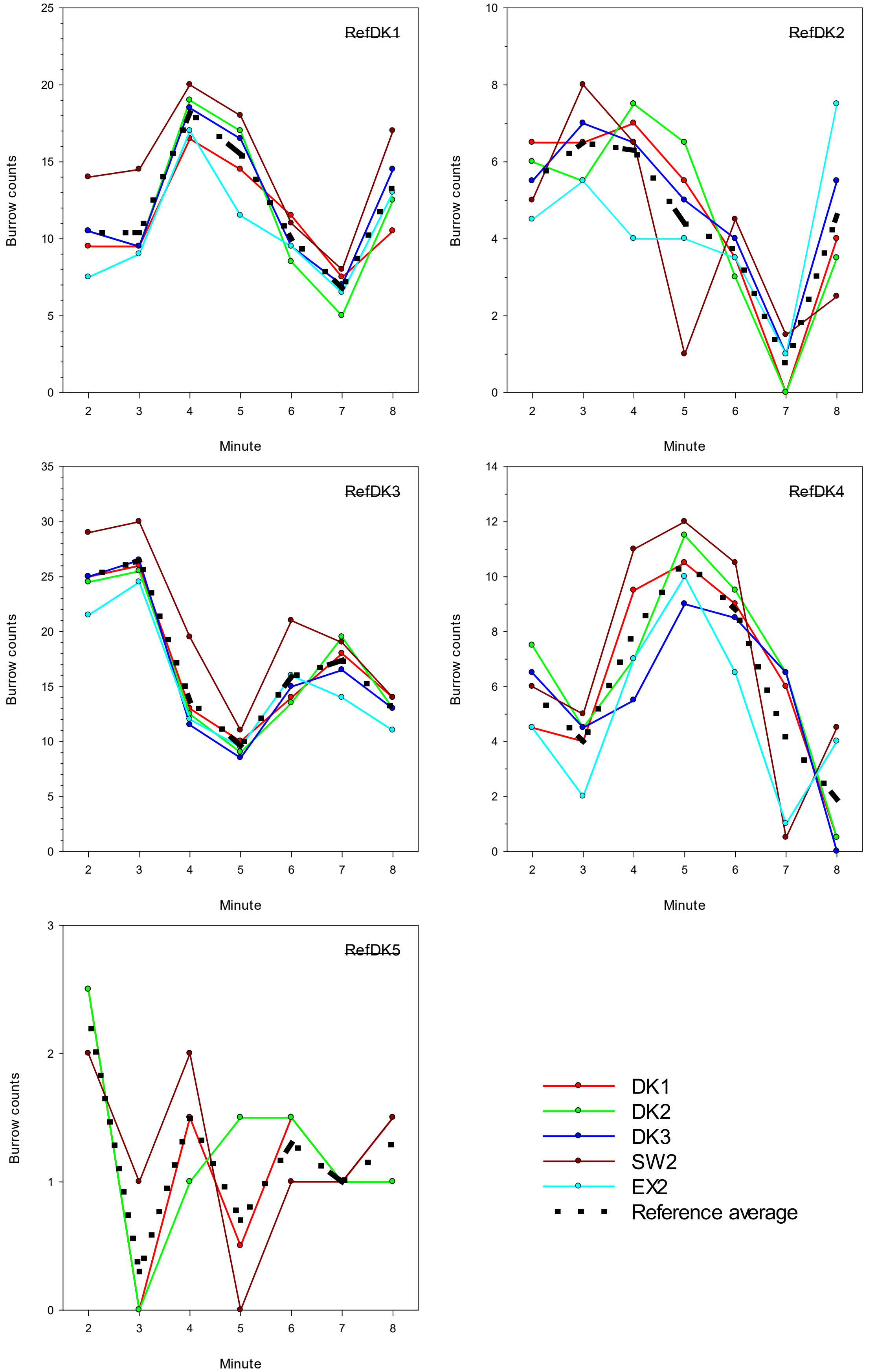

Fig. 3.1.3: Burrow counts used to estimate the reference file averages.

Sweden reference files

Six stations covering 4 different survey strata in the eastern part of the survey area and densities from low to high were chosen as the reference set (see Tab. 3.1.2). The footages were shot with a full-HD camera during the regular survey in 2021. Unfortunately, during the 2021 survey the subarea 3 was not possible to include due to severe visibility problems in southern Kattegat during the survey period. The quality of the selected footages was good in terms of towing speed (using the dynamic positions system), ground contact and visibility. The reference set readings were annotated in the open source software Boris, creating time stamped data (Friard and Gamba, 2016). The video and a short introduction to the software were distributed via a share-point to all readers and readings were conducted at the home or home lab.

Readings were conducted during winter/spring 2022 prior to the survey. The final analysis were conducted during autumn 2022.

Tab. 3.1.2: The selected Swedish reference stations. All stations were from the 2021 survey.

Stn	Density	Area
Ref1	High	Creel
Ref2	Med	S2
Ref3	Med	S4
Ref4	Low	S6
Ref5	Med/High	S6
Ref6	Med/High	S6

At two of the Swedish reference movies some of the counters failed on individual repeatability. The counter “DK3”, “SE1” and “SE3” were excluded from further analysis on reference movie #1 and the international counter “INT2” failed repeating counts on reference movie #2 (Fig. 3.1.5). When comparing all counters, only one “INT2”, who was consistently low on counts, was discarded from the subsequent analysis (Fig. 3.1.6).

However, during the process of recounts and warm up for the survey one of the junior Swedish counters “SE2”, experienced a qualitative shift in his interpretation of the burrow system and started to doubt his counting’s, especially in high density area, represented by reference movie #1. Despite showing repeatability it was decided to exclude all his readings from the reference movie creations. For the sake of completeness and to aid the discussion average counts were also calculated including “SE2”.

The exclusion phase was then redone and “INT2” were excluded from further analysis also with “SE2” reader excluded. After the second step of the inter-reader comparisons (Fig. 3.1.7) all remaining reviewers were included in the final averages except for reference movie #1. In this high density area only two readers were included in the average counts but their paired Lin’s value was 0.5. Given the fact the total burrow count varied considerably between readers, this was the station with highest percentage of failed counter repeatability and the overall trends were more inconsistent compared to the other reference movies (Fig. 3.1.5) it was decided to totally discard this station from the final reference set. Further analysis of the time stamped data, but also joint discussions would be needed to produce a proper reference movie form this area. It is hypothesized that the creel areas are less disturbed and/or older burrows with a higher number of entrances. The large variability is seen in the big difference between including or excluding the "SE2" in the averages. Including "SE2" would lead to including also "DK2" who also counted very high in ref1. The inclusion of "SE2" did not however shift the average ref2-ref6 counts (Fig. 3.1.5).

In conclusion following the proposed workflow of reference set creation we have a set of five new Swedish reference videos (ref2-ref6). In posteriori comparisons of each reader to the average minute counts all readers passed Lin's ccc except counter "DK3" at ref4 (Lin's CCC: 0.45).

The creel area has to be further investigated to reduce uncertainties and additional reference movies from subarea 3 will be produced to get better coverage of southern Kattegat.

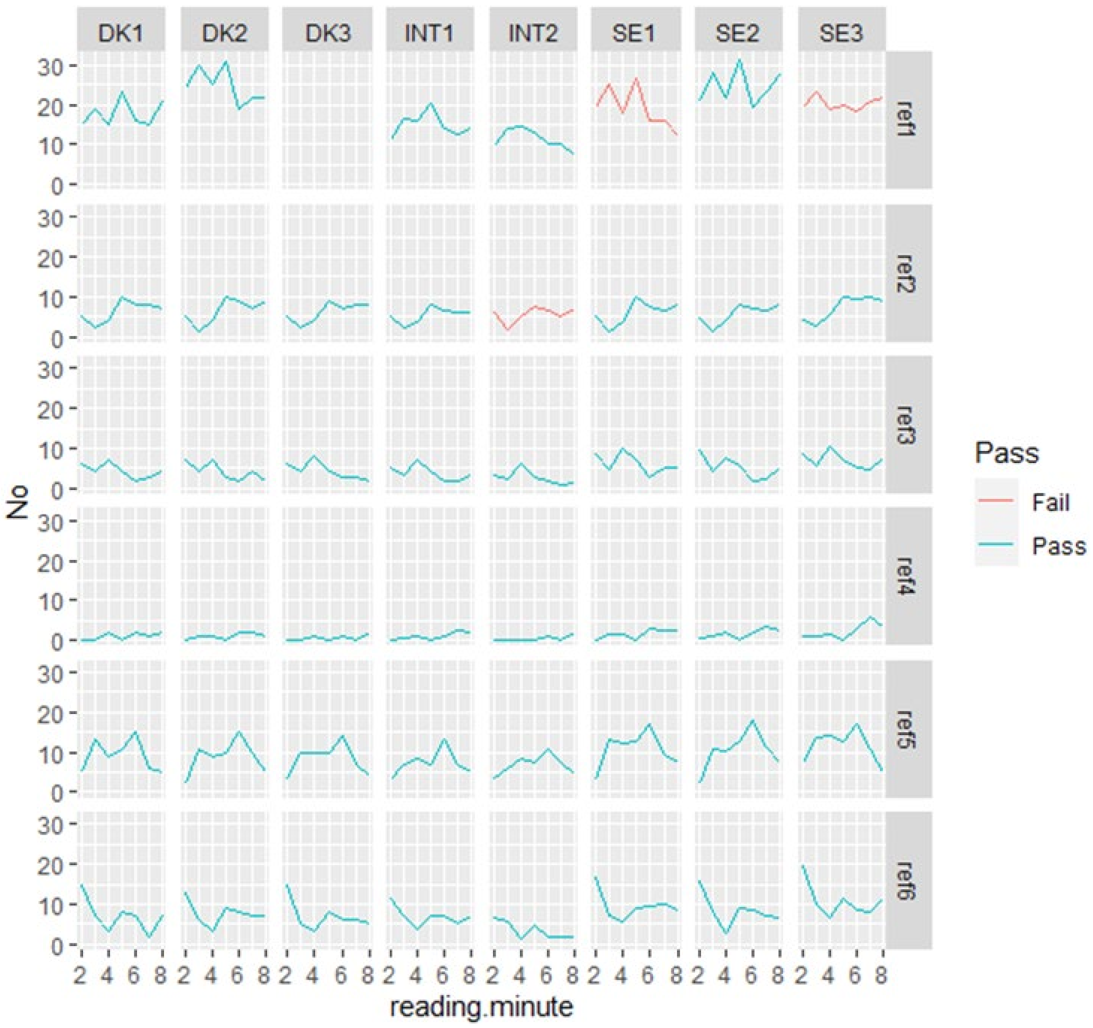

Fig. 3.1.5: Intra reader consistency. Lines are the average of each readers' counts by reference movie. Blue line indicates a Lin's CCC >0.5, while a read line indicates a fail to meet the Lin's CCC criteria. The average from reader "DK3" at ref1 is missing but were not calculated as Lin's CCC was 0.35.

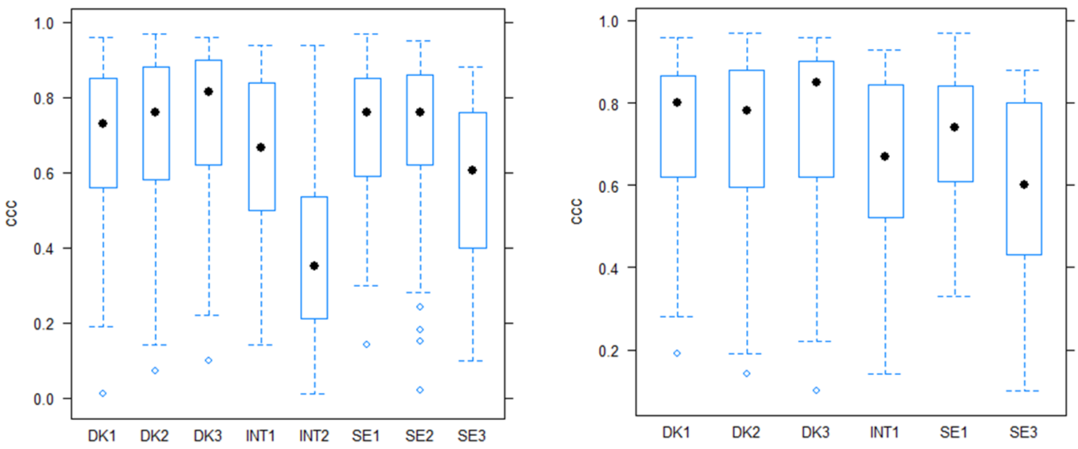

Fig. 3.1.6: Boxplot of inter-reader comparisons of all stations and to all readers. A median value (black dot) above 0.5 means that more than half of a reader's comparisons pass the Lin's threshold at 0.5. (Left panel). Values including all counters. (Right panel) Counters included in final selections. Reader "INT2" did not pass the overall number of valid comparisons. The counter "SE2" were excluded due to a shift in general perception of burrow systems during the process.

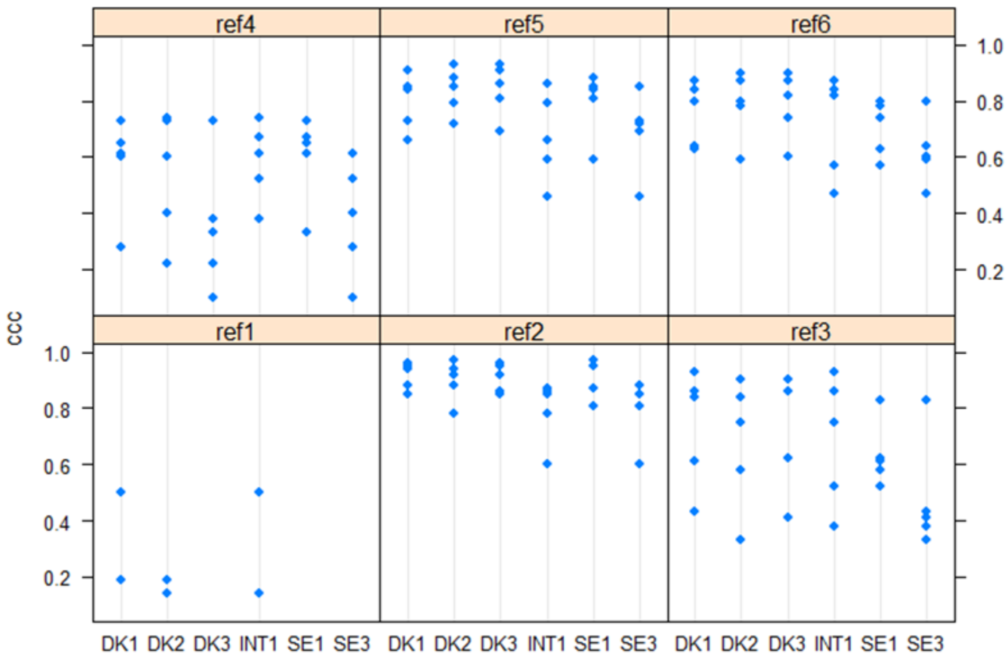

Fig. 3.1.7: Reference movie inter reader comparison. To be included in the final selection of reader to create average counts per minute the reader has to pass Lin's to at least one other reader. For the reference movies #2-#6 all readers are included but reference movie #1 the "DK2" is excluded as the reader is far off the "DK1" and "INT1". Note that they pass with little margin as Lin's CCC is 0.5.

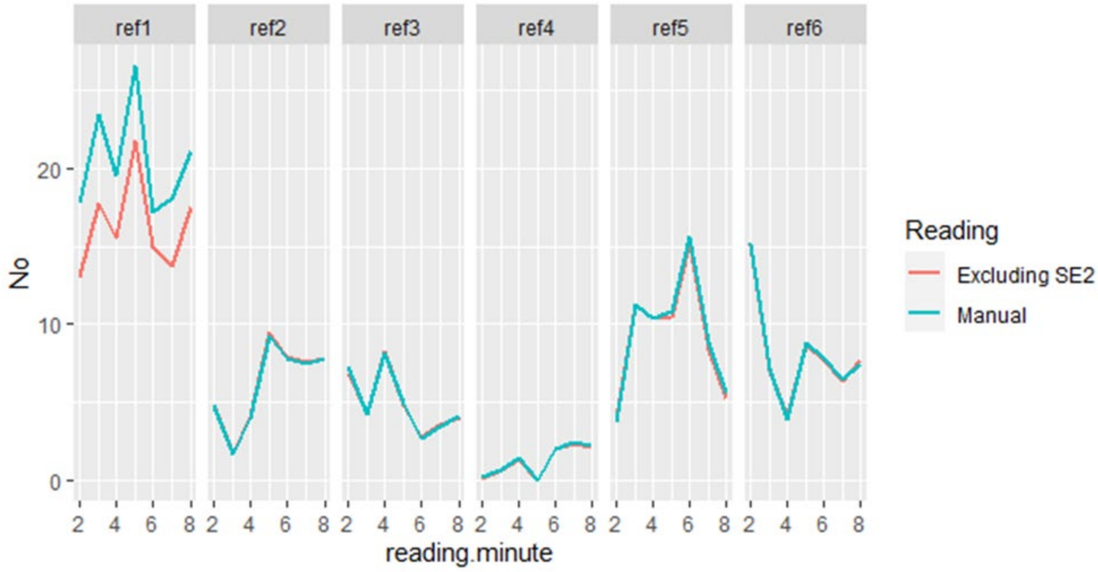

Fig. 3.8: Final reference counts of the Swedish selected movies. The ref #1 is discarded as a ref movie based on the ambiguity and lack of proper consensus reading, but the averages based on the two valid readers (red line) and including all according to Lin's criteria is blue for sake of completeness.

References:

Friard, O., & Gamba, M. (2016). BORIS: a free, versatile open-source event-logging software for video/audio coding and live observations. Methods in Ecology and Evolution, 7(11), 1325–1330.

ICES. 2018. Report of the Workshop on *Nephrops* Burrow Counting (WKNEPS). 2-5 October. Aberdeen, UK. ICES CM 2018/EOSG:25. 44 pp.

3.2 U23-24 Bay of Biscay Reference Sets

Jean Philippe Vacherot

Data outputs were presented to WGNEPS following the process outlined by WKNEPS workshop in 2018. The reference set was composed from data from 2019 and 5 national counters reviewed the set. As the process did not include any international count data it was decided by the group that at least one international count data to be included before final evaluation of the reference counts. Intersessional work is planned for early 2023 so that the reference set can be completed before the survey commences.

4 Technological developments (ToR d)

4.1 *Update Nephrops norvegicus* detection and classification from underwater videos using Deep Neural Network.

Atif Naseer

1. Introduction

Spanish Institute of Oceanography has a research group working on *Nephrops norvegicus* identification and counting. They are conducting the survey on yearly basis. The survey is conducted through special equipment and underwater camera. A 10-12 minutes video was made on each point of interest and the whole survey has more than 20-30 points of interest yearly. Currently they are counting the holes manually by reviewing the video frame by frame in multiple parallel session and conclude the results on consensus of all members. This exercise cost lot of resources in terms of time, human and cost. There is no system available that can help them in solving their current problem.

During the past many years *Nephrops* are counted manually (counting from TV surveys) from underwater videos which is very tedious and time-consuming task. These species are usually lived under the seabed and leaving behind some pattern of burrows. To identify this specie in underwater, one need to identify these patterns and judge the availability of *Nephrops*.

The objective of this research project is to develop a deep learning model to automatically detect, classify and count the *Nephrops* burrows.

With the recent advancement in artificial intelligence and computer vision technology, many researchers employ AI-based tools to analyze marine species. Some people use feature extraction mechanisms to count and identify the species while others use some advanced techniques such as neural networks. Convolutional neural networks (CNN) bring a revolution in object detection. Deep convolutional neural networks gain tremendous success in the tasks of object detection, classification, and segmentation. These networks are data-driven and require a huge amount of labelled data for training.

In our previous work [1], we developed a deep learning model based on state-of-the-art Faster RCNN [2] models Inceptionv2 [3] and MobileNetv2 [4] for the detection of *Nephrops* openings. Those models were trained on FU 30 and FU 22 datasets. These models achieved good results in detecting the burrows from the image test data. However, when these trained models were tested on a video from Gulf of Cadiz, the accuracy of the detectors degraded. We figured out many false positive (FP) and missed true positive (TP) detections that adversely affect the accuracy of these models.

In this work, we proposed a detection refinement mechanism based on spatial–temporal information to enhance the detection of missed true positive and suppress the false positive detections. In our approach we are using the spatial and temporal information to suppress the false positives and recover the missed detections. Our work is divided into two parts. At first, we trained the model using state-of-the-art Faster RCNN models Inceptionv2, ResNet50 [5], and ResNet101 [6] for the detection of *Nephrops* burrows. We built the dataset for training and testing the models. In the second part of our work, we presented a spatial–temporal-based detection refinement algorithm. We detected the burrows in each frame in a video sequence and then obtained the spatial and temporal information across the multiple frames to refine the *Nephrops* burrows detections. The spatial–temporal mechanism helped in suppressing the FP burrows and allowed us to find the missed TP detection that led us to achieve a better accuracy as well as tracking and counting burrows in a video sequence. Figure 4.1.1 shows the result of the detector that we trained using the Inception model. The bounding boxes in blue color show the ground truth, while the red color bounding boxes show the detections from the Inception model. Due to variation in camera direction and appearance of burrows, the detector accumulates FPs and missed detection in some frames. The figure clearly shows the missed detection in the intermediate frames.

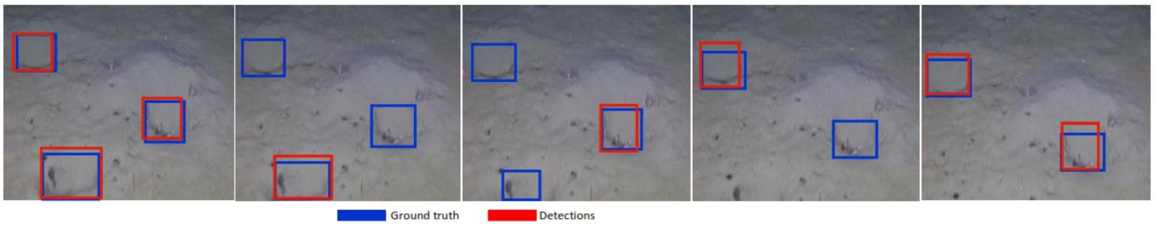

Figure 4.1.1: Ground truth (blue color, bounding boxes). The result of detector (Inception) (red color, bounding boxes). Due to camera angle variation and burrows appearance, the detector missed detections in consecutive frames.

The rest of the sections of this report is organized as follows: the detection refinement research methodology is presented in section 2, followed by proposed detection refinement algorithm in section 3 and their results in section 4. Section 5 discusses about the development of new dataset that is prepared for future use in the tracking and counting of burrows.

2. Research Methodology

The objective of the current work is to develop a detection refinement mechanism that can identify the missing TP and suppresses the FP. Figure 4.1.2. shows the research methodology used in our work.

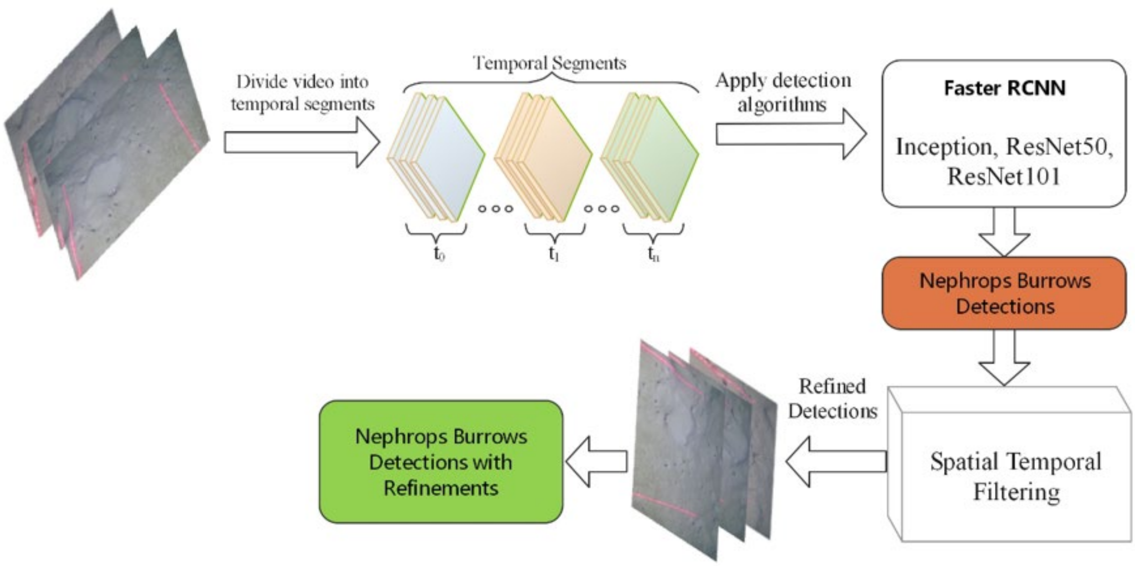

Figure 4.1.2: Detection Refinement Research Methodology

3. Detection Refinement Algorithm

The algorithm is divided into two sections, i.e., suppression of false positives and identification of missed detections. Figure 4.1.3. shows the basic processing steps of false positive suppression and missed detection identification and recovery. The first step towards the refinement of detections is to suppress the FP. While the next step is to identify the missed detections that were missed by the detector. The algorithm receives three inputs: an input video with detections *V*, threshold value λ, and temporal window size *W*. For each detection in the current frame $b \in B_j$ at frame F_i, we first identify the current detection location in the next frame of *sF* and then compute δ_k = IoU value of current detection with consecutive *k* frame's detection in *sF* using *Compare_Displacement_Vector*(f_{b_Index}, fc_{b_Index}) method ($k = 1,\ldots,W$). Then, $\delta_{avg} = 1/W \sum \delta_k$ is the estimated average within the temporal window. We marked the detection as FP if $\delta_{avg} < \lambda$, and as TP if otherwise, suppressing the FP. We process the whole video *V* detections in the same way.

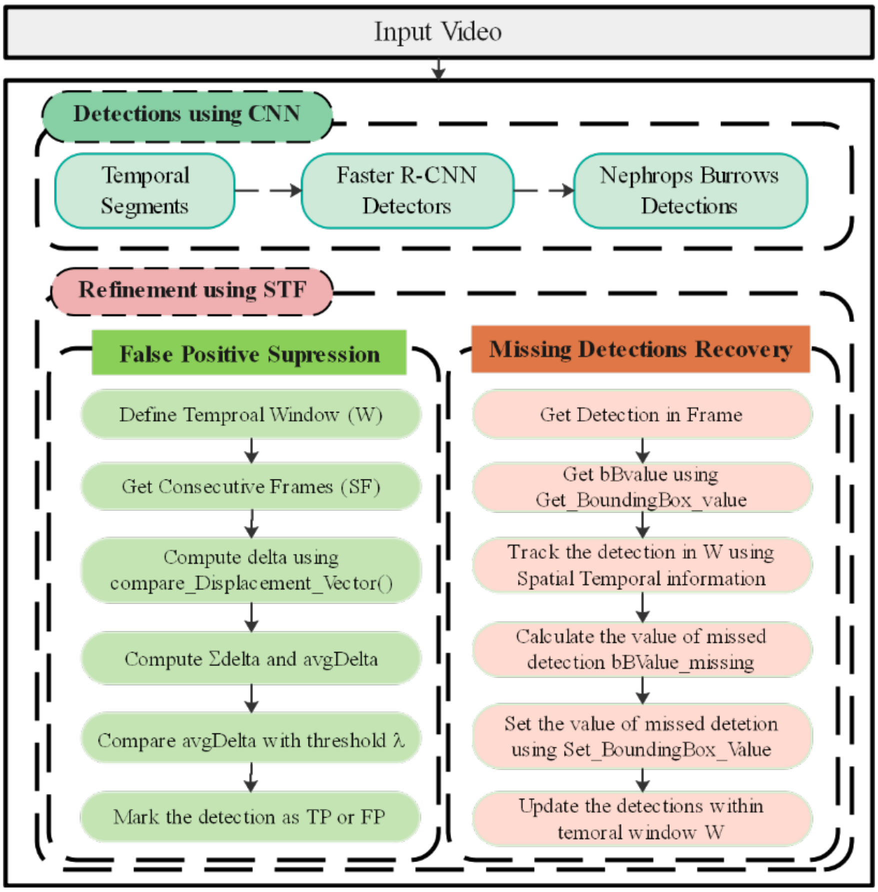

Figure 4.1.3: Detection refinement algorithm

4. Experiments and Results

We evaluate the results of different experiments performed using the proposed detection refinement algorithm. We performed the quantitative and qualitative analysis of our work. Table. 4.1.1 shows the precision, recall and F1 score results of all temporal segments by detector and their corresponding improvement by the proposed detection refinement algorithm. The algorithm is run with W = 8, 12, and 16. In each temporal window, the algorithm is tested with $\lambda = 0.3$ and 0.4 (λ is a threhold value) and finds out the number of TP, FP, missed detection, and F1-score (geometric mean of precision and recall metrics) in each minute of the video.

Table 4.1.1: Detections of all temporal segments with refinements. Detections are refined using W = 8, 12, and 16 with λ = 0.3 and 0.4. The refined detection shows total number of TP, FP, and missed detections and F1-score.

	GT = 2359					Recall		Precision		F1-Score	
	W	λ	TP	FP	Miss	%Age Before	%Age After	%Age Before	%Age After	%Age Before	%Age After
Inception	8	0.3	1380	115	256	58.5	69.4	92.3	93.4	71.6	79.6
	8	0.4	1150	345	204	48.7	57.4	76.9	79.7	59.7	66.7
	12	0.3	1316	179	277	55.8	67.5	88.0	89.9	68.3	77.1
	12	0.4	899	596	170	38.1	45.3	60.1	64.2	46.7	53.1
	16	0.3	1308	187	374	55.4	71.3	87.5	90.0	67.9	79.6
	16	0.4	804	691	209	34.1	42.9	53.8	59.4	41.7	49.9
ResNet50	8	0.3	1619	163	356	68.6	90.6	90.9	92.9	78.2	91.8
	8	0.4	1389	393	274	58.9	87.2	77.9	84.0	67.1	85.5
	12	0.3	1557	225	400	66.0	92.5	87.4	90.7	75.2	91.6
	12	0.4	1069	713	239	45.3	85.7	60.0	73.9	51.6	79.4
	16	0.3	1495	287	506	63.4	97.0	83.9	88.9	72.2	92.7
	16	0.4	962	820	260	40.8	86.6	54.0	71.3	46.5	78.2
ResNet101	8	0.3	1894	180	336	80.3	94.5	91.3	92.5	85.5	93.5
	8	0.4	1720	454	262	72.9	84.0	79.1	81.4	75.9	82.7
	12	0.3	1874	265	340	79.4	93.9	87.6	89.3	83.3	91.5
	12	0.4	1267	907	209	53.7	62.6	58.3	61.9	55.9	62.3
	16	0.3	1754	296	421	74.4	92.2	85.6	88.0	79.6	90.1
	16	0.4	1154	1020	228	48.9	58.6	53.1	57.5	50.9	58.1

Also, we qualitatively analyze the performance of the proposed detection refinement algorithm by applying it to the results obtained from different detection models. The red bounding boxes on the images shown in this section are the original detections obtained from the models; green bounding boxes are the recovered missed detections after applying the refinement algorithm, and ground truth data are marked with blue bounding boxes. The figures 4.1.4 and 4.1.5 shows the qualitative results obtained after applying the detection refinement algorithm.

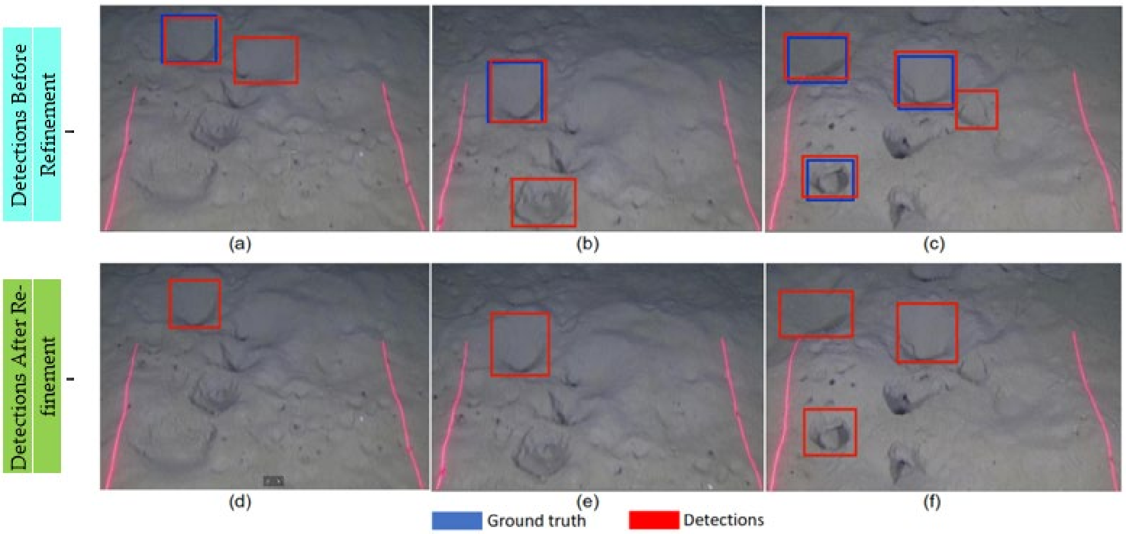

Figure 4.1.4: False positive suppression using detection refinement algorithm (a–c) are the ground truth (blue color bounding boxes), and original detections from Inception model (red color bounding boxes) (d–f) are the refined detections.

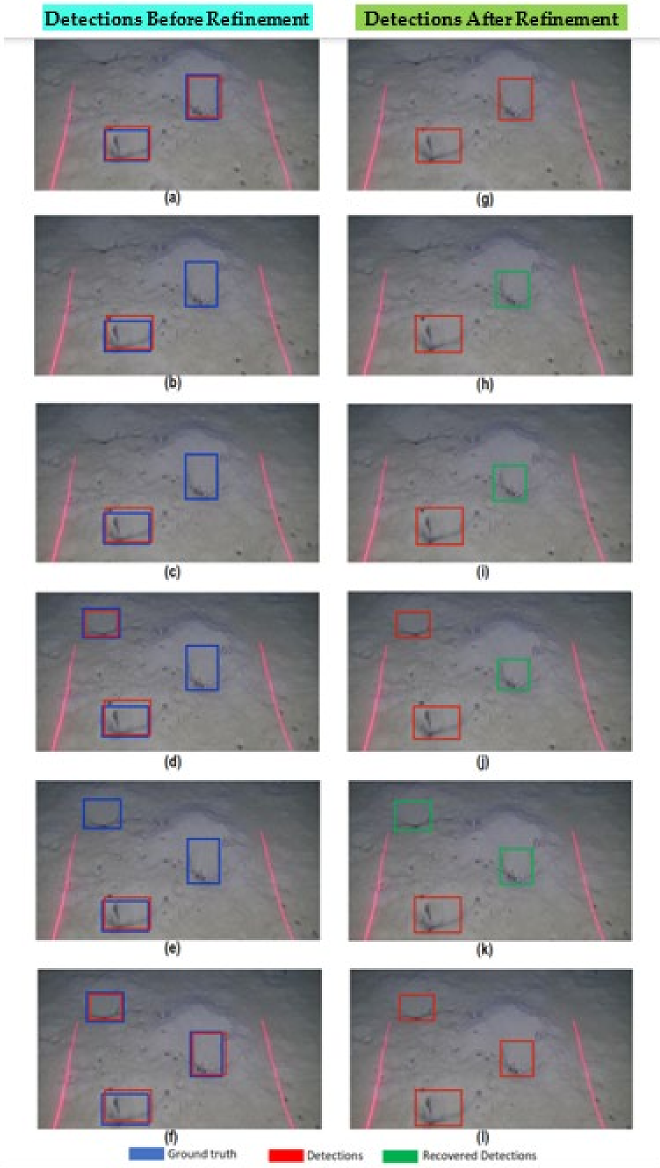

Figure 4.1.15: Identification of true positive missed detections. Panels (a–f) are the original detections from the Inception model, and (g–l) are the identification of missed detections in the consecutive frames.

5. New Dataset Preparation

This section shows the new dataset that is prepared for improved model training and analysis. The data is obtained from three different sources, i.e., Gulf of Cadiz, Ireland and Adriatic sea (Italy). A total of 2382 images has been annotated but all the annotations are not validated yet. Table.4.1.2 shows the preparation of dataset and their distribution for training and testing. Four different sets are prepared as shown in the table. the first set contains the 718 images from the Cadiz station. The second set contains 513 images from the Adriatic (Italy), The third set have 1133 images from the Ireland station. While the last set combined all the stations and having 2382 images for training and testing the hybrid models.

Table 4.1.2: New Dataset distribution

Station	Annotated Images	Annotation Validation	Dataset Distribution	
			Training	Testing
Cadiz (2018+2022)	718	248	595 (82%)	123 (18%)
Italy	531	Nill	431 (82%)	100 (18%)
Ireland	1133	1133	793 (70%)	340 (30%)
Combined	2382	1381	1787 (75%)	595 (25%)

6. Conclusion

During the past many years *Nephrops* are counted manually (counting from TV surveys) from underwater videos which is very tedious and time-consuming task. In the current study, proposed a detection refinement algorithm based on spatial-temporal analysis that suppresses the false positive and identify the missing detections. The trained algorithms are tested on many different datasets and record the preliminary results. New datasets are prepared from Gulf of Cadiz, Ireland and Adriatic sea (Italy) stations for future model training and analysis of *Nephrops*.

In future the work will focus on improving the *Nephrops* detection accuracy by training the model using more complex neural network. A tracking and counting mechanism will be proposed. We will build a system that can analyze the burrow sizes.

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4.2 Investigation of sdmTM geostatisitics to provide abundance estimates.

Mikel Aristegui

Several *Nephrops* stock assessments use a kriging geostatistical procedure to provide *Nephrops* abundance estimates (Dobby *et al.*, 2021). Here we explore a new methodology to estimate *Nephrops* abundances by using the recently published R package sdmTMB (Anderson *et al.*, 2022).

sdmTMB fits spatial and spatiotemporal Generalized Linear Mixed Effects Modes (GLMM) using Template Model Builder (TMB) for model fitting and R-INLA to setup Stochastic Partial Differential Equation (SPDE) matrices. Other packages that use similar approaches are TMB (Kristensen *et al.*, 2016), lme4 (Bates *et al.*, 2015), glmmTMB (Brooks *et al.*, 2017), VAST (Thorson, 2019) and inlabru (Bachl *et al.*, 2019). However, the developers of sdmTMB focused on providing a fast, flexible and more user-friendly interface than previous alternatives.

Following the steps of a vignette on Index standardization from sdmTMB's GitHub repository (https://pbs-assess.github.io/sdmTMB/articles/index-standardization.html), the Marine Institute managed to fit GLMMs for FU16, FU17, FU2021 and FU22. All the steps are detailed on the online template vignette. The FU16 practical example is also uploaded to the WGNEPS Sharepoint. Here we summarise the main steps of the process, presenting also the R function needed for each step:

1. Create the SPDE matrix using the following function:

   make_mesh(datFU, c("X", "Y"), cutoff = 2)

   Where "datFU" is the dataset containing adjusted burrow densities for every UWTV station along all the data series. "X" and "Y" are UTM coordinates. "cutoff" represents the minimum distance between points before a new mesh vertex is added (in km).

2. Fit a GLMM using the following function:

   sdmTMB(data = datFU, formula = adj.density ~ 0 + as.factor(year),

   time = "year", mesh = datFU_spde, family = tweedie(link = "log"))

   We include "0 + as.factor(year)" so that there is a factor predictor that represents the mean estimate for each time slice. "year" is the name of the time column in the dataset "datFU". "datFU_SPDE" is the name we gave to our SPDE matrix in step 1.

3. Prepare a prediction grid. We built a 1km fine-scale prediction grid from the shapefiles of our Functional Units.
4. Use the GLMM to predict new data over the prediction grid

   predict(m, newdata = grid_1000, return_tmb_object = TRUE)

   Where "m" is our GLMM and "grid_1000" is our prediction grid.

The predicted *Nephrops* densities along the data series and the FU ground (fixed + random effects) (Figure 4.2.1.A) are similar to the ones from the kriging methodology. However, one of the benefits of this model is that we can investigate independently the fixed and the random effects. The fixed effects maps show the average density for each year (Figure 4.2.1.B). The spatial random effects maps represent the consistent deviations in space through time that are not accounted for by the fixed effects (Figure 4.2.1.C). Finally, the spatiotemporal random effects show the deviation from the fixed effect predictions and the spatial random effect deviations (Figure 4.2.1.D).

The abundance estimates from sdmTMB are in range with the historical abundance estimates calculated with the kriging methodology for FU16, FU17, FU2021 and FU22 (Figure 4.2.2). There are some obvious differences between the two estimates. For example, in FU16 in year 2012, when all the UWTV stations were not completed, zero stations were assumed around the Southern boundary of the ground for the kriging process; however, these zero stations are not included in the sdmTMB model. Another difference is the wider confidence intervals of the sdmTMB model in FU2021 along the whole data series.

In conclusion, sdmTMB is a package with high potential for species distribution models in general, and for *Nephrops* distribution and abundance models in particular. We think that the main goal of the developers of providing a user-friendly interface for GLMMs has been accomplished. However, the application of this method needs further investigation, as the study presented here is only an exploratory work.

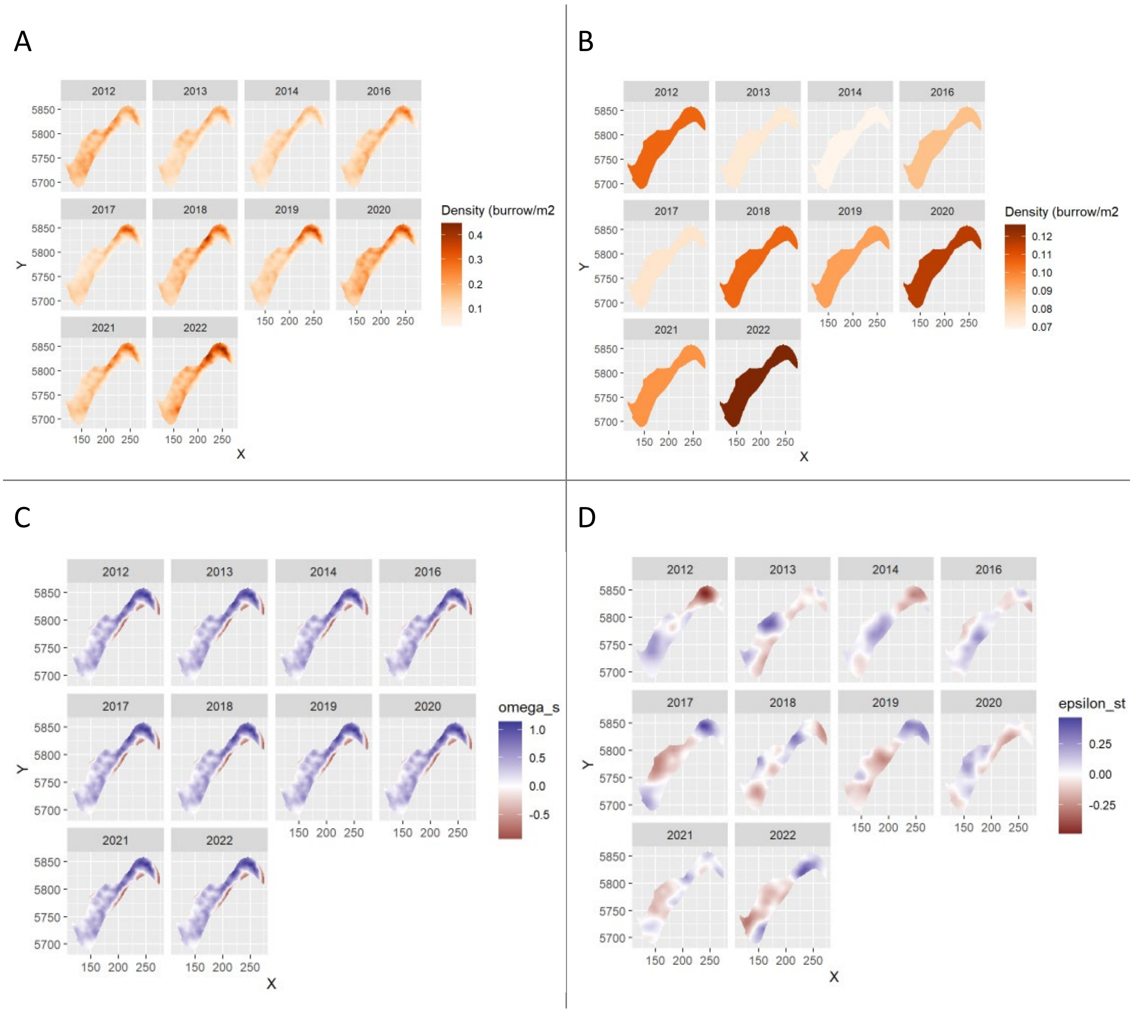

Figure 4.2.1. Prediction map outputs from fitted GLMM on FU16 *Nephrops* densities. Prediction [fixed and random effects] (A), Fixed effects (B), Spatial random effects (C), Spatiotemporal random effects (D).

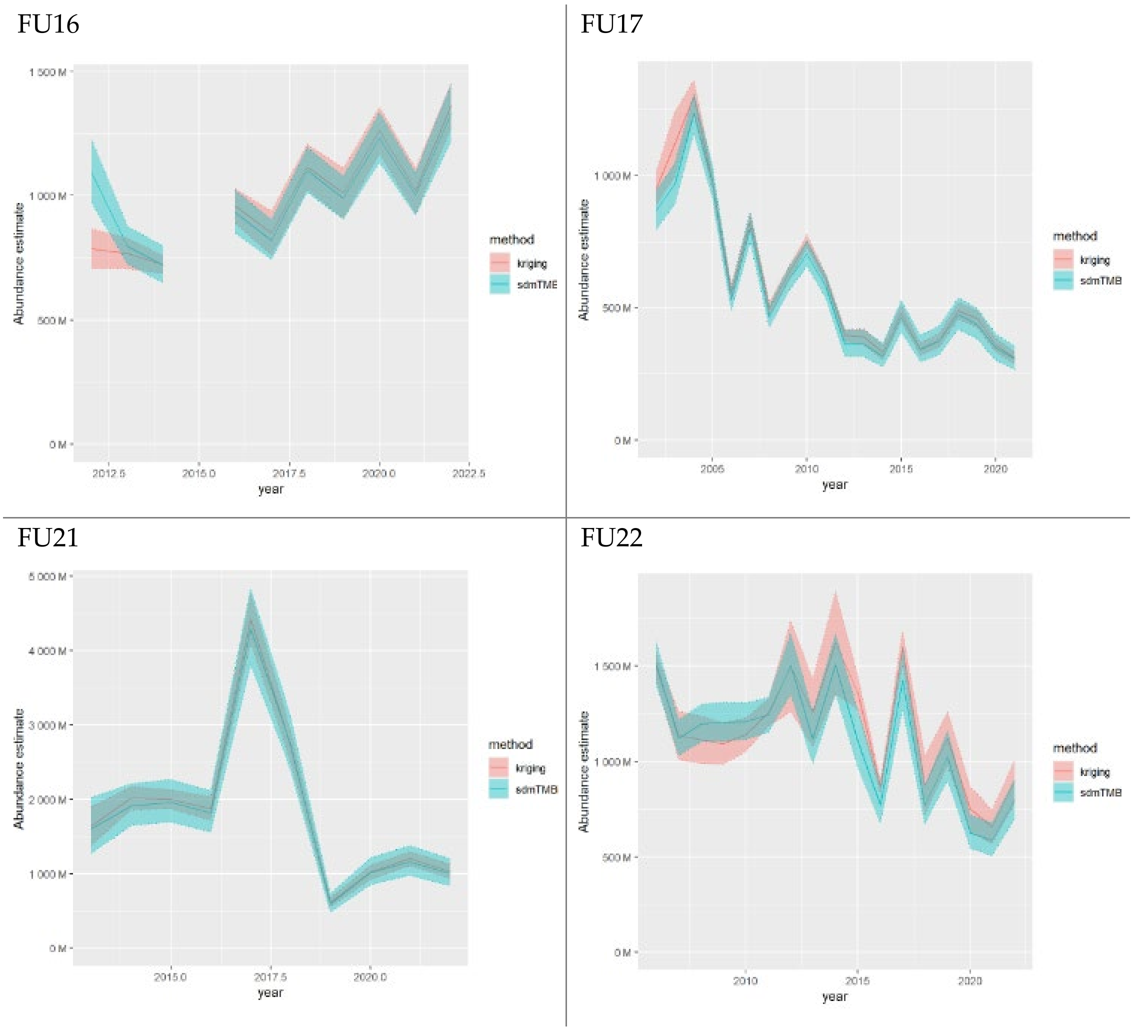

Figure 4.2.2. *Nephrops* abundance estimates of Kriging (in red) and sdmTMB (in blue) methodologies for FU16, FU17, FU2021 and FU22.

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4.3 FU 28 and 29 Nephrops Survey Offshore Portugal.

Cristina Silva and Bárbara 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. Data on biodiversity, biological and oceanographic parameters were collected, as well as data on marine litter characteristics and distribution.

In 2021, the R/V Mário Ruivo started her operation. 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 calibration was performed between the two vessels. A comparison of some technical characteristics of both vessels is presented in the table below:

<table>
<tr><th colspan="2"></th><th>R/V Noruega</th><th>R/V Mário Ruivo</th></tr>
<tr><td colspan="2">R/V type</td><td>Stern trawler</td><td>Multidisciplinary</td></tr>
<tr><td colspan="2">LOA (m)</td><td>47.5</td><td>75.6</td></tr>
<tr><td colspan="2">Gross tonnage (t)</td><td>495</td><td>2290</td></tr>
<tr><td colspan="2">Main Power (kW)</td><td>1100</td><td>2984</td></tr>
<tr><td colspan="2">Doors weight (kg)</td><td>650</td><td>500</td></tr>
<tr><td colspan="2">Doors surface (m2)</td><td>3.75</td><td>–</td></tr>
<tr><td colspan="2">Trawling speed (knots)</td><td>3</td><td>3.2 (average)</td></tr>
<tr><td rowspan="6">Gear</td><td>Gear type</td><td colspan="2">FGAV020</td></tr>
<tr><td>Floats in Headline/winglines</td><td colspan="2">9</td></tr>
<tr><td>Groundrope</td><td colspan="2">Synthetic wrapped wire core + chain</td></tr>
<tr><td>Mean vertical opening (m)</td><td>1.5 – 2.0</td><td rowspan="3">to be estimated</td></tr>
<tr><td>Mean doors spread (m)</td><td>60</td></tr>
<tr><td>Mean horizontal opening (m)</td><td>30</td></tr>
</table>

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 must be 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.

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 Potential to use eDNA for research investigations.

Maddalena Tibone, Sergio Stefanni, Luca Mirimin, Bernadette O'Neill and Jacopo Aguzzi.

The term environmental DNA (eDNA) indicates the genomic DNA deriving from many different organisms that can be found in an environmental sample. eDNA comprises DNA molecules that are released in the environment (e.g. skin cells, mucous, sperm, faeces, blood) and can be concentrated and isolated by collecting and analysing sediment, water, ice or air samples (Taberlet et al., 2012).

One of the applications of environmental DNA analysis is augmented monitoring of marine environments with potential applications in biodiversity assessment and fisheries support. While the non-invasive nature of seawater sampling for eDNA isolation is a great advantage, this technique produces the best results when coupled with other approaches, including more disruptive methodologies. In fact, integrating eDNA with data obtained from biological sampling, imaging and acoustics leads to a more comprehensive assessment (Mirimin et al., 2021).

Furthermore, emerging technologies are enabling the development of protocols for near real-time *in situ* applications of eDNA metabarcoding (Figure 5.1.1). This could lead to the development of a portable eDNA analysis pipeline to be installed for automated functioning on board robotic platforms such as cabled observatories and crawlers. In particular, Oxford Nanopore Technologies (ONT) have developed MinION, a portable high-throughput sequencer, that allows a near real-time approach, a long-term cost reduction and easy data retrieval through a user-friendly software (Srivathsan et al., 2021). These characteristics make the MinION sequencer an important tool for on-site eDNA analysis.

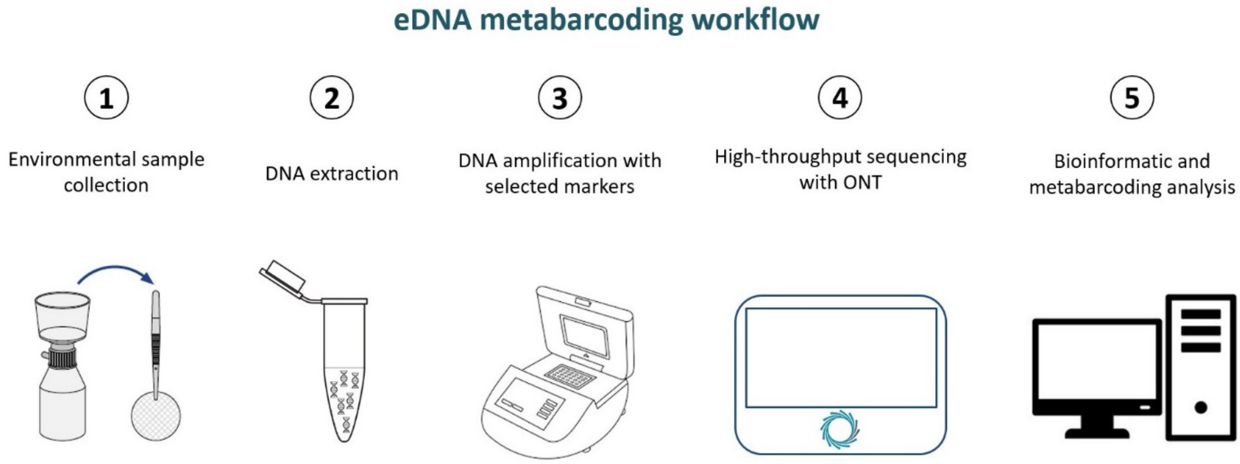

Figure 5.1.6. Overview of the eDNA metabarcoding workflow: (1) environmental sample collection and filtration of water samples, (2) DNA extraction from filters or sediment, (3) DNA amplification through Polymerase Chain Reaction (PCR) using universal or species-specific primers, (4) high-throughput sequencing using ONT's MinION portable sequencer and (5) bioinformatic data processing and metabarcoding analysis.

Multiple of our ongoing projects are testing the applicability of near real-time on site eDNA analysis on research vessels and fixed oceanographic platforms. In both cases, the aim is to integrate eDNA metabarcoding and multidisciplinary data acquired on site. On one hand, eDNA could complement acoustic and biological sampling data obtained on acoustics-based fisheries surveys (e.g. WESPAS survey carried out by the Marine Institute). On the other hand, eDNA metabarcoding data from seawater samples collected in proximity of underwater cameras (e.g. at the Acqua Alta oceanographic platform in the Northern Adriatic Sea) could be cross validated and integrated with imaging data to provide a more comprehensive local biodiversity assessment.

Considering the growing applications and potential of non-invasive eDNA sampling, an integration of this technique in *Nephrops* fisheries assessment could be beneficial. In particular, sediment collection in the proximity of burrows and subsequent eDNA extraction and analysis, could provide an overview of the community, through metabarcoding analysis, or investigate presence/absence of species occupying the burrows, through species-specific quantitative PCR (qPCR) assays. This could help better understand burrow occupancy, leading to a more comprehensive *Nephrops* fisheries assessment.

References:

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5.2 Regulations to protect sensitive deep water habitats

Mikel Aristegui

On the 15th of September of 2022 a new EU Regulation banned fishing with bottom gears in depths between 400 m and 800 m in specific Vulnerable Marine Ecosystems (VMEs) of the north-east Atlantic (Commission Implementing Regulation (EU) No 2022/1614).

One of the VME polygons (Polygon 61) included in the regulation is of special interest to *Nephrops* fisheries, as it is located in the Porcupine Bank grounds, and it is part of the *Nephrops* stock Functional Unit 16. The removal of the Polygon 61 from FU16 results in a 14% area decrease of the stock.

The fishing pressure threshold to identify the c-squares (0.05 degree) that are included in the new regulation is a Swept Area Ratio (SAR) of 0.43, assuming a trawl swath of 150 m and a speed cut off limit of 3 knots (ICES, 2022). This means that c-squares with SAR values higher than 0.43 are excluded from the fishing ban. Data from 2015 to 2018 was used in that analysis.

The Marine Institute tried to replicate that analysis using data from Irish logbooks up to 2021, and using different assumptions after expert consultations: a trawl swath of 100 m and a speed cut off limit of 4.5 knots.

In our analysis we identify visually (Figure 5.2.1) three periods of different levels of fishing effort within the Polygon 61: (1) high SAR from 2006 to 2010, with almost all the polygon above the 0.43 threshold; (2) low SAR from 2011 to 2017, with less than half of the polygon above 0.43; (3) SAR has recently increased since 2018, and almost all the polygon is above the 0.43 threshold in 2021.

Although we expected to have different results than in previous studies due to the different assumptions used, we conclude that using the most recent data available is of high importance in order to produce the best quality advice.

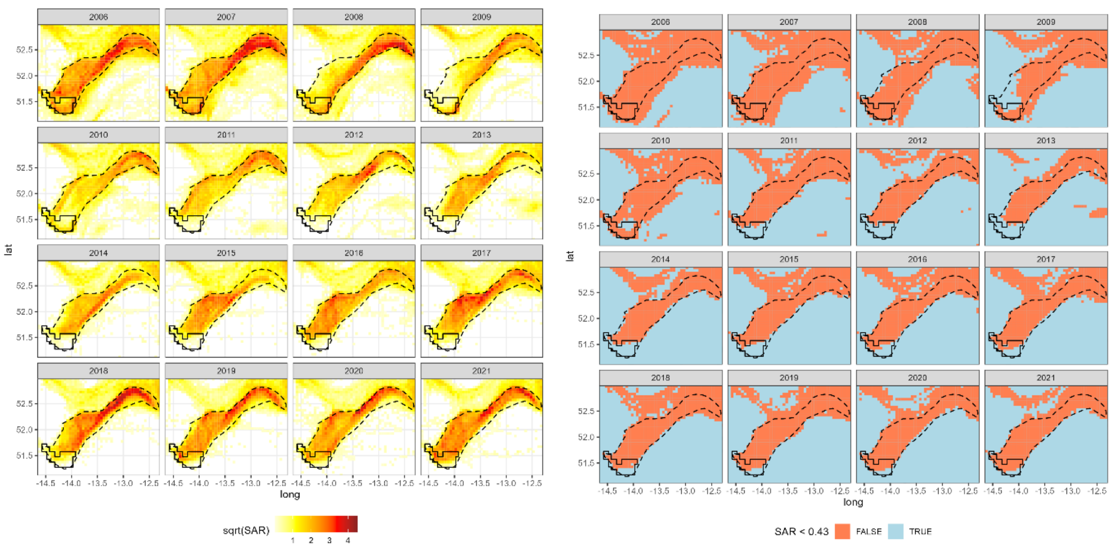

Figure 5.2.1. Fishing pressure in FU16. Dashed line represents FU16 ground. Solid line represents VME Polygon 61. Spatiotemporal distribution of c-square relative SAR values (left panel); and whether SAR value for each c-square is above (blue) or below (red) the 0.43 threshold (right panel).

References

Commission Implementing Regulation (EU) 2022/1614 of 15 September 2022 determining the existing deep-sea fishing areas and establishing a list of areas where vulnerable marine ecosystems are known to occur or are likely to occur. ELI: http://data.europa.eu/eli/reg_impl/2022/1614/oj

ICES. 2022. Benchmark Workshop on the occurrence and protection of VMEs (vulnerable marine ecosystems) (WKVMEBM). ICES Scientific Reports. 4:55. 99 pp. http://doi.org/10.17895/ices.pub.20101637

5.3 Trawl mark data investigations in FU 1 (Iceland)

Jónas Páll Jónasson

Nephrops grounds are frequently disturbed as fishing intensity with bottom trawl and other gear is usually high. Trawling has direct effect on the sea bottom as it displaces and re-suspends the sediment, damages and destructs benthic organism, but the degree and durations varies with factors like weight and angle of the trawling gear, the substrate type, current and tides (Jones, 1992). Disturbance marks are visible in UWTV surveys and in the FU1 (Iceland) they have systematically been recorded (Haase, et. al 2018). Due to poor statues and decreasing quotas in recent years the annual effort in FU1 has decreased from around 30 thousand towed hours in 2015 -16 to around 11-13 thousand during 2019 - 21 (MFRI, 2021). It was therefore expected that the frequency and freshness of trawl marks in the UWTV surveys of 2016 - 21 on FU1 should have decreased.

Trawl and other disturbance marks were classified into six different types and four different states, based on the results of the first UWTV survey in FU1 carried out in 2016 (Haase, et. al 2018). Each mark during the UWTV tow is noted, time stamped and classified. The types of marks were classified as; A: Higher hill on one side of the furrow (Door mark); B: U or V shaped mark; C: Wider and flatter bottom than the "B type" (Weight between trawl); D: Two hills or furrows close to each other; E: Wavelike furrows composed of smaller furrows (Cod end); F: Other type (See images in Haase, et. al 2018). The states of the trawl marks were classified as 1: Distinguished; 2: Started to erode; 3: Eroded; 4: Uncertain.

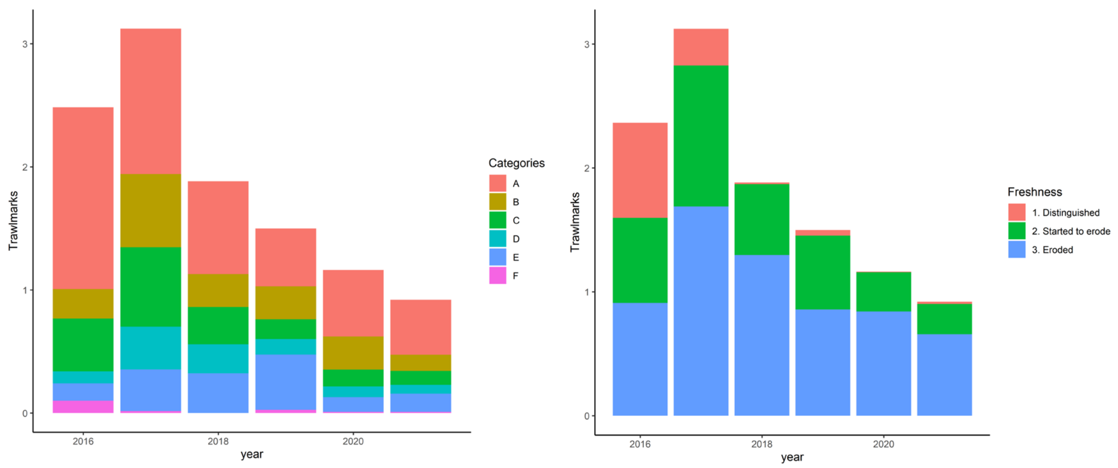

Figure 5.3.1. Average number of trawl marks by category (left) and freshness (right) per 100m² on FU1 during UWTV surveys of 2016-21.

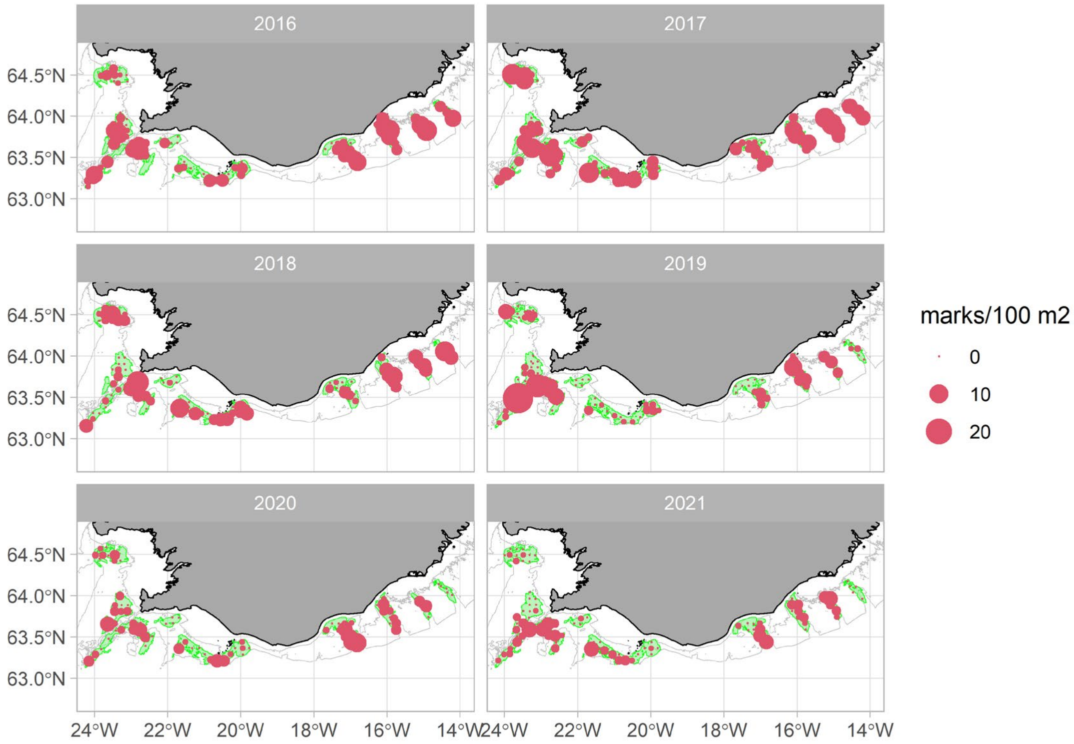

Figure 5.3.2. Distribution of trawl marks (per 100m²) on FU1 in UWTV surveys of 2016-21.

Average number of trawl marks reached a peak in the 2017 survey with 3.1 trawl marks per 100 m², but they declined to around 1 mark in the 2021 survey (Figure 5.3.1). Category A (Door mark) was the most common mark. The proportion of marks classified as eroded also increased during this period, but marks that got uncertain status were skipped in this summary. Distribution of marks are unevenly distributed with most marks generally on southwestern and southern grounds (Figure 5.3.2). The northern and easternmost grounds were closed for all trawling in 2019 (MFRI, 2021), with witnessed reduction of marks in the 2020-21 surveys. As expected, the number and freshness of trawl marks has been decreasing with less disturbance and closures in FU1. Trawl marks are easy to note during annotation of burrow counts and give important information on the anthropogenic pressure.

References

Haase, S., Einarsson, H.A. Jonasson, J.P., Burgos, J.B. (2018) Use of Underwater TV-survey to monitor trawl marks on *Nephrops* grounds. Haf og vatnarannsóknir. HV2018-24, 1-14.

Jones, J. B. (1992). Environmental impact of trawling on the seabed: A review. New Zealand Journal of Marine and Freshwater Research, 26(1), 59–67.

MFRI Assessment Reports 2021. Norway lobster. Marine and Freshwater Research Institute, 17 December 2021.

6 Factors affecting on burrow emergence (ToR f)

6.1 Coordinated, intelligent platform networks for the 4D monitoring of *Nephrops* grounds

Jacopo Aguzzi[1], Joan Batista Company[1], Nixon Bahamon[1], Damianos Chatzievangelou[1]

[1]Institut de Ciències del Mar (ICM-CSIC), Barcelona (Spain)

In the last decades, stock assessment surveys targeting the Norway lobster *Nephrops norvegicus* have been gradually moving from physical/extracting sampling (e.g., trawling surveys) towards video/imaging-based solutions such as UnderWater TeleVision (UWTV) surveys with towed sledges. However, both approaches still face operational challenges which may introduce bias when translating the basic data (individuals captured by trawling or burrow systems filmed by UWTV) to accurate densities. In the future, an ecosystem-based monitoring and assessment plan should: improve the currently used equation “1 burrow system ≈ 1 animal”; include activity rhythms in sampling; derive other ecological indicators (e.g., biodiversity); and increase automation in image/data processing. This requires deploying intelligent monitoring networks consisting of stationary and mobile platforms with distinct focus and capabilities, while integrating novel sampling methodologies (i.e., eDNA/eRNA; opto-acoustic mapping, etc.). In parallel, powerful Artificial Intelligence algorithms should be integrated to streamline data analysis and assist the extraction of ecological information in the form of hierarchically computed indicators, from animal counts and size all the way to ecosystem functioning. This rationale was detailed in a 2022 publication led by ICM-CSIC (Aguzzi et al., 2022), with the participation of several WGNEPS members.

Reference

Aguzzi J, Chatzievangelou D, Robinson NJ, Bahamon N, Berry A, Carreras M, Company JB, Costa C, del Rio Fernandez J, Falahzadeh A, Fifas S, Flögel S, Grinyó J, Jónasson JP, Jonsson P, Lordan C, Lundy M, Marini S, Martinelli M, Masmitja I, Mirimin L, Naseer A, Navarro J, Palomeras N, Picardi G, Silva C, Stefanni S, Vigo M, Vila Y, Weetman A and Doyle J (2022) Advancing fishery-independent stock assessments for the Norway lobster (Nephrops norvegicus) with new monitoring technologies. Front. Mar. Sci. 9:969071. doi: 10.3389/fmars.2022.969071.

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.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
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Annex 2: Resolutions

The **Working Group on *Nephrops* Surveys** (WGNEPS), chaired by Jennifer Doyle, Ireland, will work on ToRs and produce deliverables and meet 15–17 November 2022 in Cádiz Spain to:

Review any changes to design, coverage and equipment for the various *Nephrops* UWTV and full-scale trawl surveys;

Progress plans for an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys;

Updating R scripts for UWTV survey data processing including functions to QC, analyze and visualize data, and interface the tools with the database;

Review video enhancement, video mosaicking, automatic burrow detection and other new technological developments

Discuss the utility of UWTV and trawl *Nephrops* surveys as platforms for e.g. the collection of data for OSPAR and MFSD indicators

Review of existing datasets to evaluate possible factors affecting (i.e. currents, light, etc.) burrow emergence;

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.

WGNEPS will report by 1 February 2023 for the attention of the EOSG Committee.

Supporting information

Priority	*Nephrops* are a valuable species whose stocks are potentially sucseptible 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, coloboration, 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 experts groups that use the survey results i.e. WGCSE, WGBIE and WGNSSK. Also WGDEC and WGMLEARN.
Linkages to other organizations	FAO , OSPAR

Annex 3: Steps forward

WGNEPS 2022 to involve expertise from WGMLEARN at the next proposed workshop in 2025 when the ToRs have been agreed.

Annex 4: Survey summaries

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

Mikel Aristegui

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

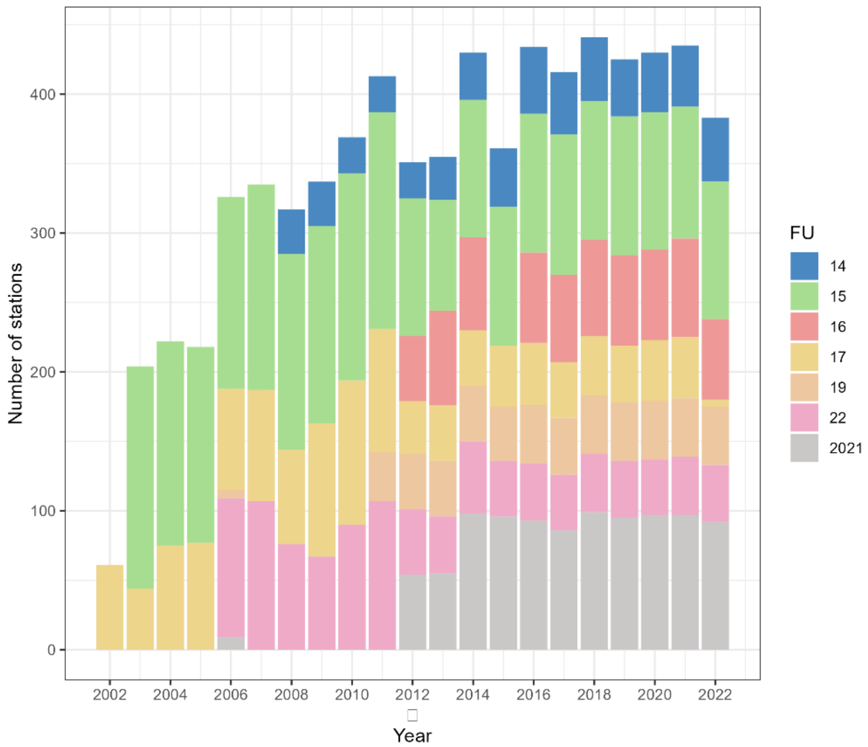

Figure 1. Time series of the total number of UWTV stations carried out by Ireland in each Functional Unit. Stations in FU 14 and FU 15 are usually carried out in collaboration with AFBI in UK-NI and CEFAS UK E&W.

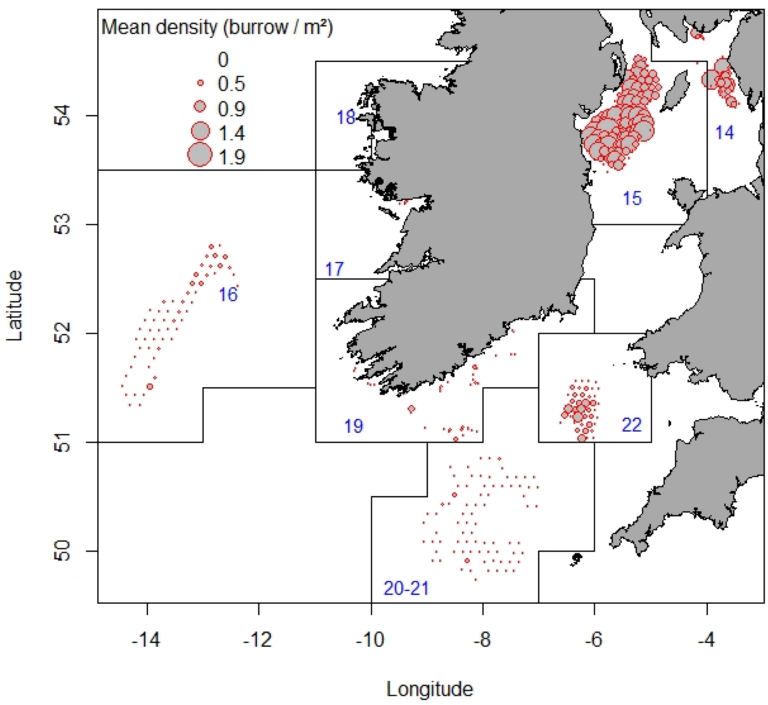

Figure 2. Mean adjusted density estimates (burrow/m²) by station for *Nephrops* grounds in ICES Subarea 7 in 2022.

Functional Unit	**FU16**	**Area name**	**Porcupine Bank**
Survey design	Randomised isometric grid	Previous surveys	2012 to 2014 and 2016 to 2021
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)	TC22004	Dates (start/end)	14 – 23 August 2022
Number scientific staff	9	Staff exchanges	CEFAS and JNCC
Number of stations (planned/completed/used in analysis)		66/58/58	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		8 stations missed due to weather downtime	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.00 m
Adjusted mean density	0.19 burrows /m^2	Adjusted abundance, CV	1363 million, CV = 3%
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)		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. Seapen presence/absence data of four species data provided to WGDEC as part of formal datacall process.

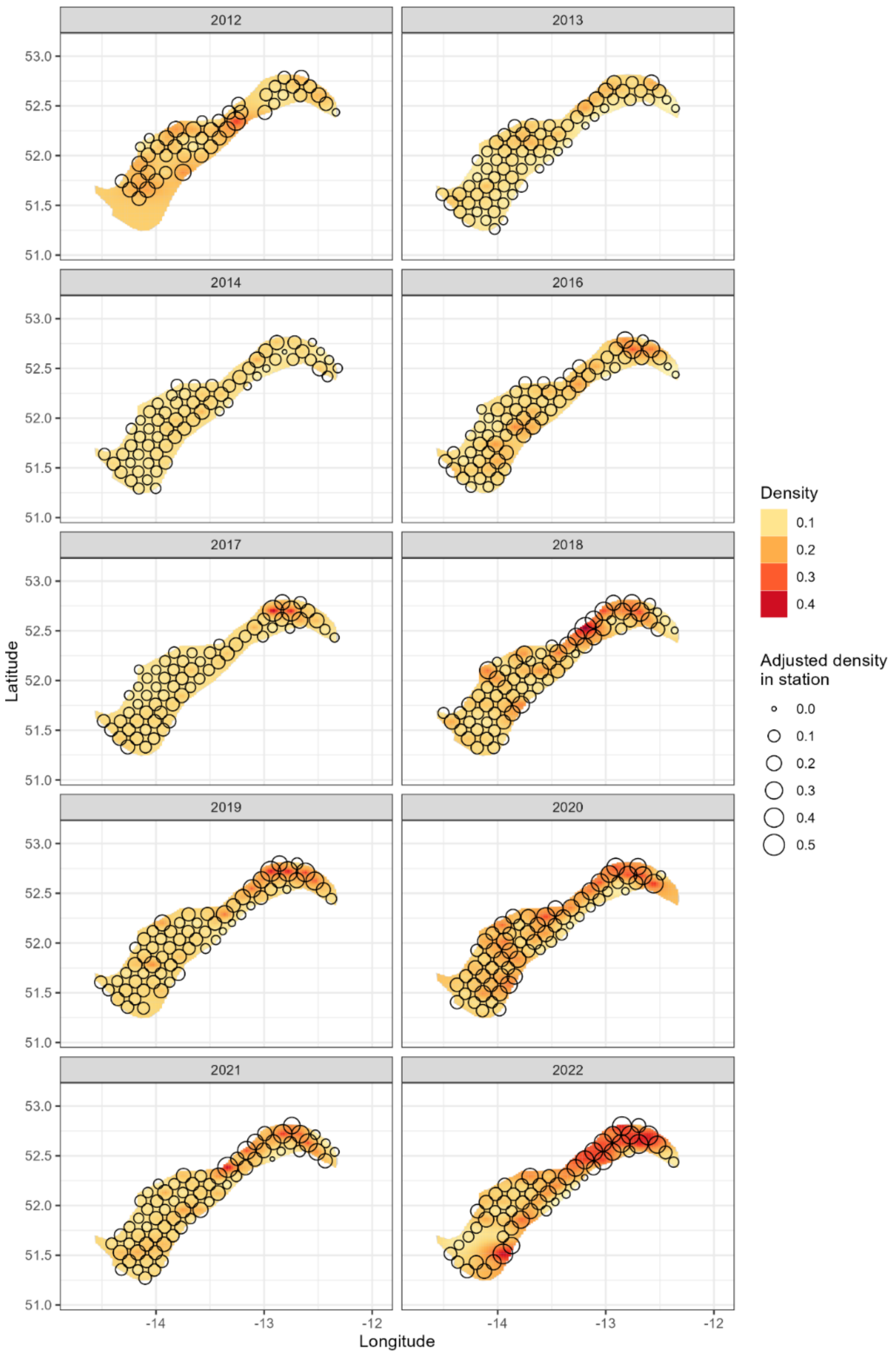

Fig. 1: FU 16. Map of adjusted density (burrows / m²) by station for each year.

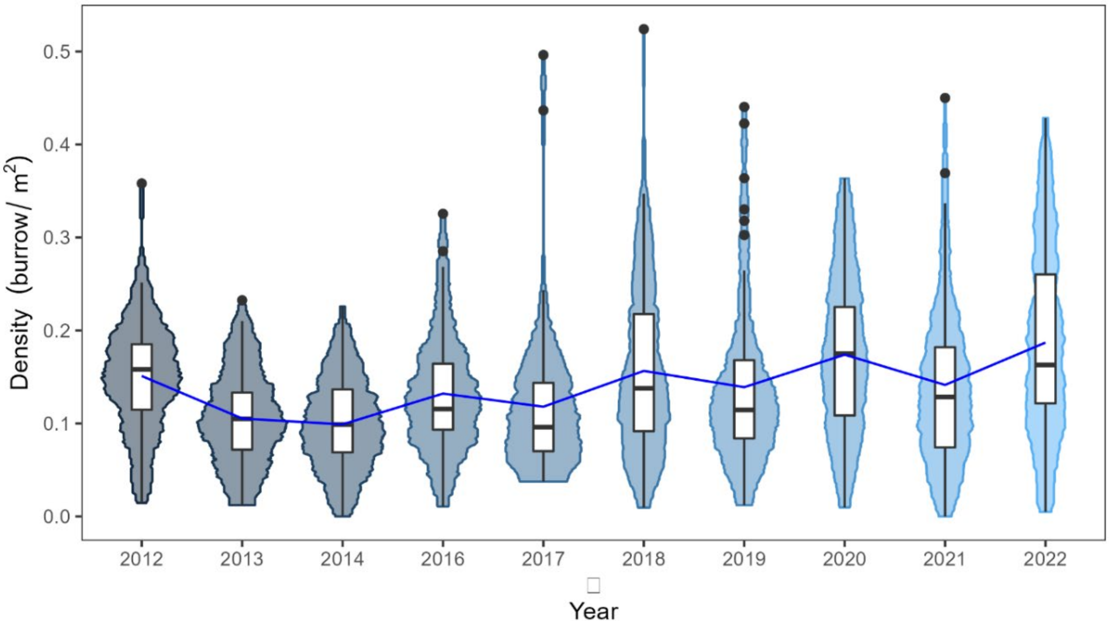

Fig. 2: FU 16. Times series of adjusted density (burrows / m²) (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**FU17**	**Area name**	**Aran Grounds, Galway Bay and Slyne Head**
Survey design	Randomised isometric grid	Previous surveys	2002 to 2021
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)	Celtic Voyager
Survey code (s)	CV22016 (internal code)	Dates (start/end)	14 June 2022
Number scientific staff	6	Staff exchanges	AFBI
Number of stations (planned/completed/used in analysis)		41/5/0	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Only Galway Bay stations completed due to weather downtime. UWTV survey 2022 not used for abundance estimate.	
Distance over ground source used	USBL	Average field of view (cm)	HD: 1.00 m
Adjusted mean density	Aran: NA	Adjusted abundance, CV	Aran: NA
	Galway Bay: 0.19 burrows /m²		Galway Bay: 15 million, CV= 3%
	Slyne Head: NA		Slyne Head: NA
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)		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

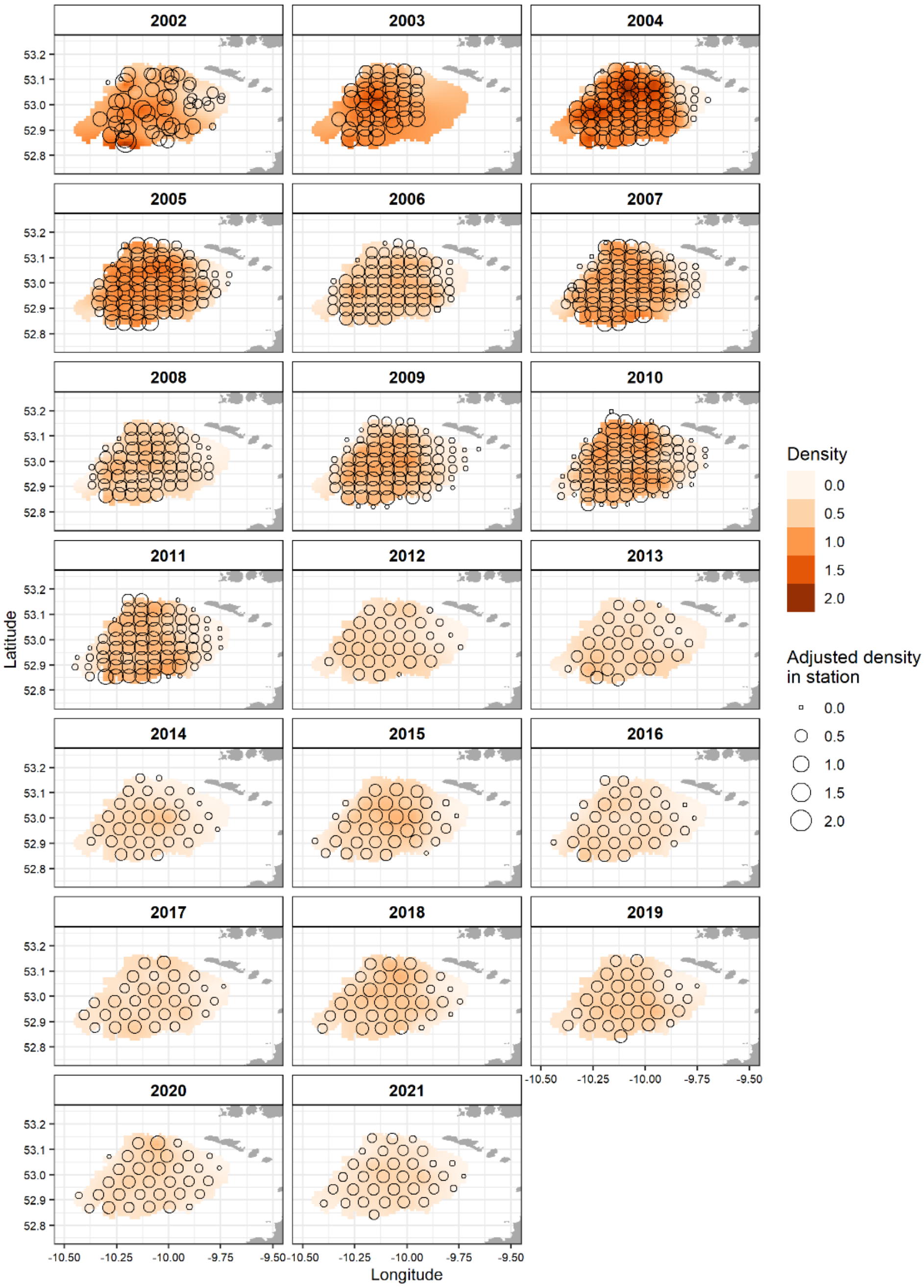

Fig. 1: FU 17 Aran grounds. Map of adjusted density (burrows / m²) by station for each year. No survey in 2022 on Aran grounds.

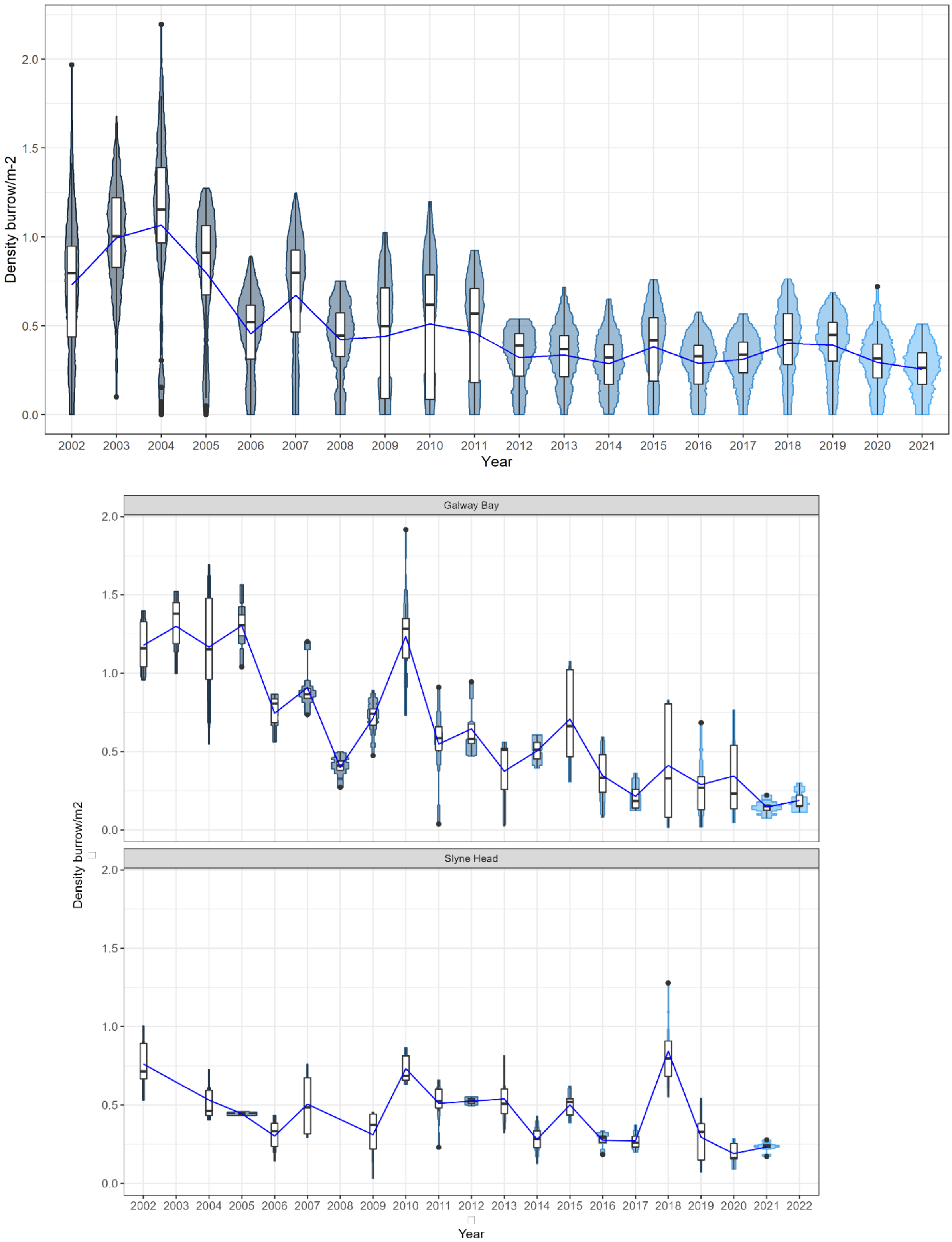

Fig. 2: FU 17 Aran grounds (top panel), Galway Bay (middle panel) and Slyne Head (bottom panel). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers. No 2022 survey on Slyne head *Nephrops* grounds.

Functional Unit	**FU19**	**Area name**	**South and Southwest of Ireland**
Survey design	Randomised stratified by area	Previous surveys	2006 and 2011 to 2021
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)	Celtic Voyager
Survey code (s)	CV21015, CV21016	Dates (start/end)	23 May – 17 June 2022
Number scientific staff	6	Staff exchanges	AFBI
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: 1.00 m
Adjusted mean density	0.13 burrows /m²	Adjusted abundance, CV	259 million, CV = 14%
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

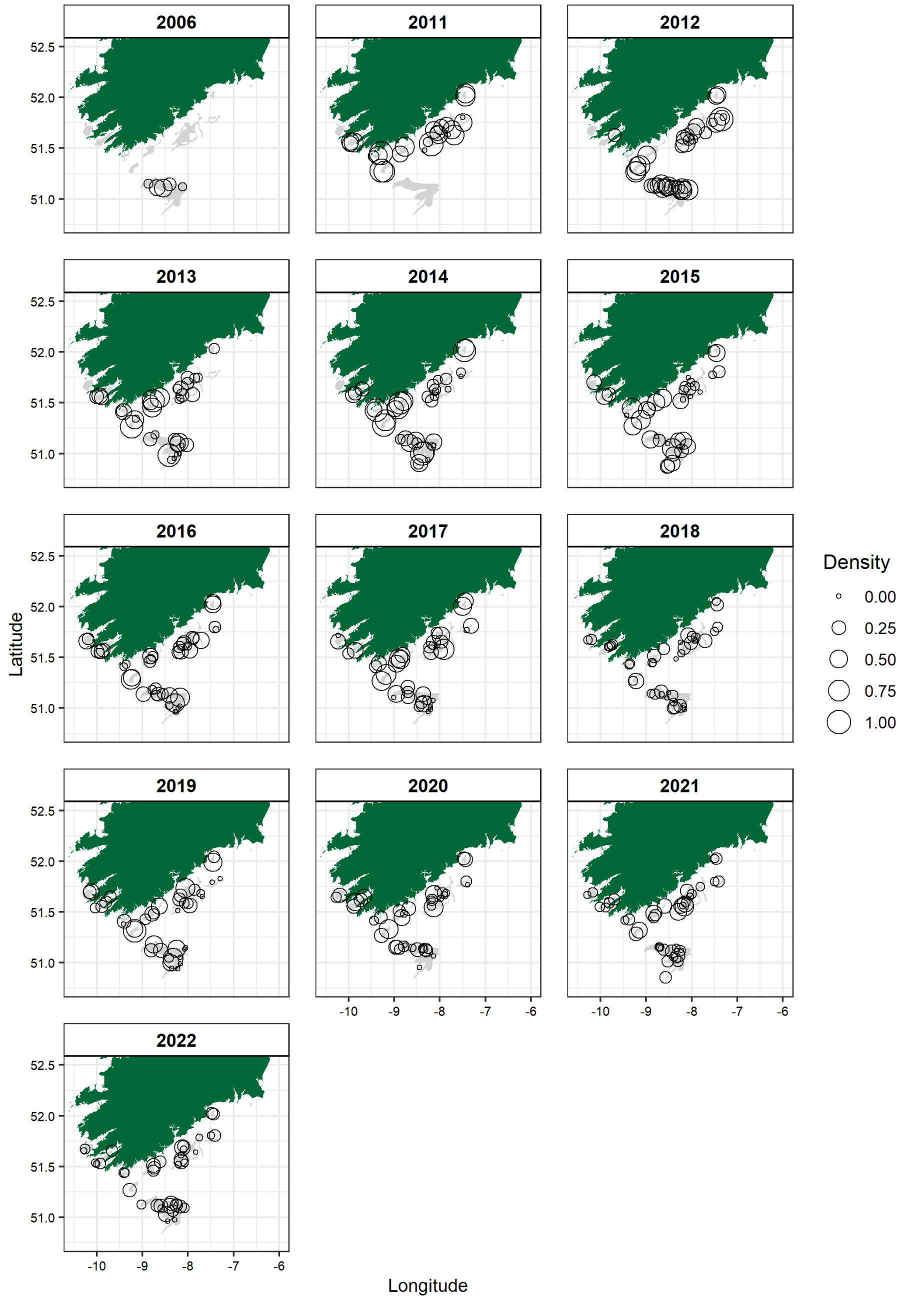

Fig. 1: FU 19. Map of adjusted density (burrows / m²) by station for each year.

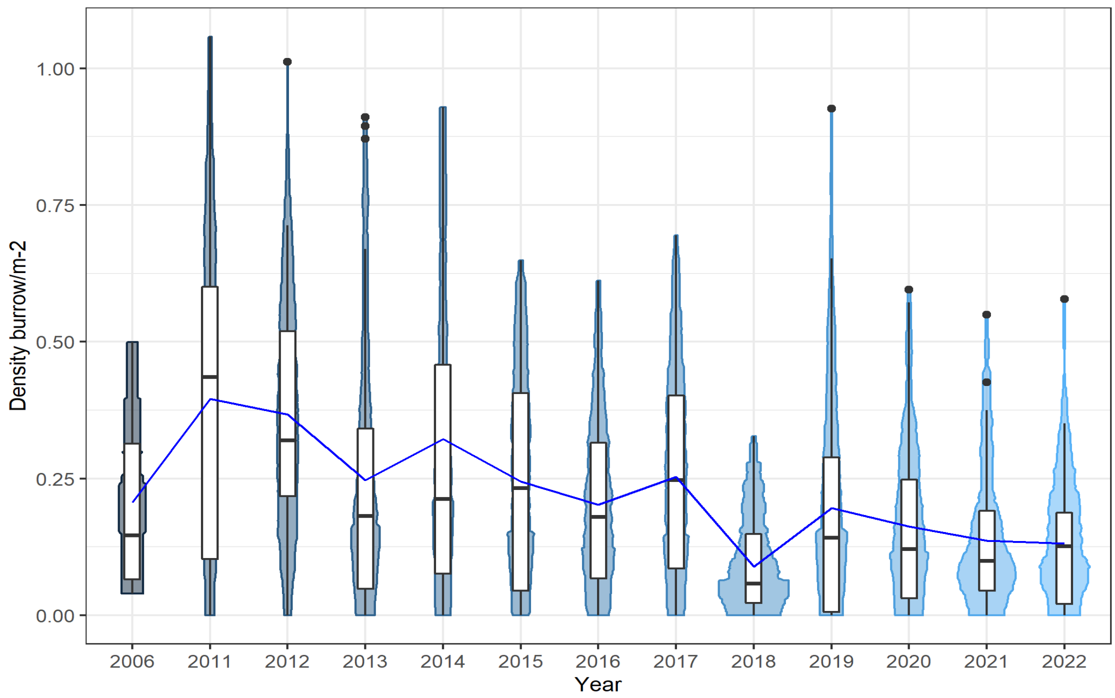

Fig. 2: FU 19. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**FU20-21**	**Area name**	**Labadie, Jones and Cockburn Banks**
Survey design	Randomised isometric grid	Previous surveys	2013 to 2021
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)	Celtic Voyager
Survey code (s)	CV22015	Dates (start/end)	23 May – 4 June 2022
Number scientific staff	6	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		92/92/92	
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: 1.00 m
Adjusted mean density	0.10 burrows /m²	Adjusted abundance, CV	1032 million, CV = 5%
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)		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

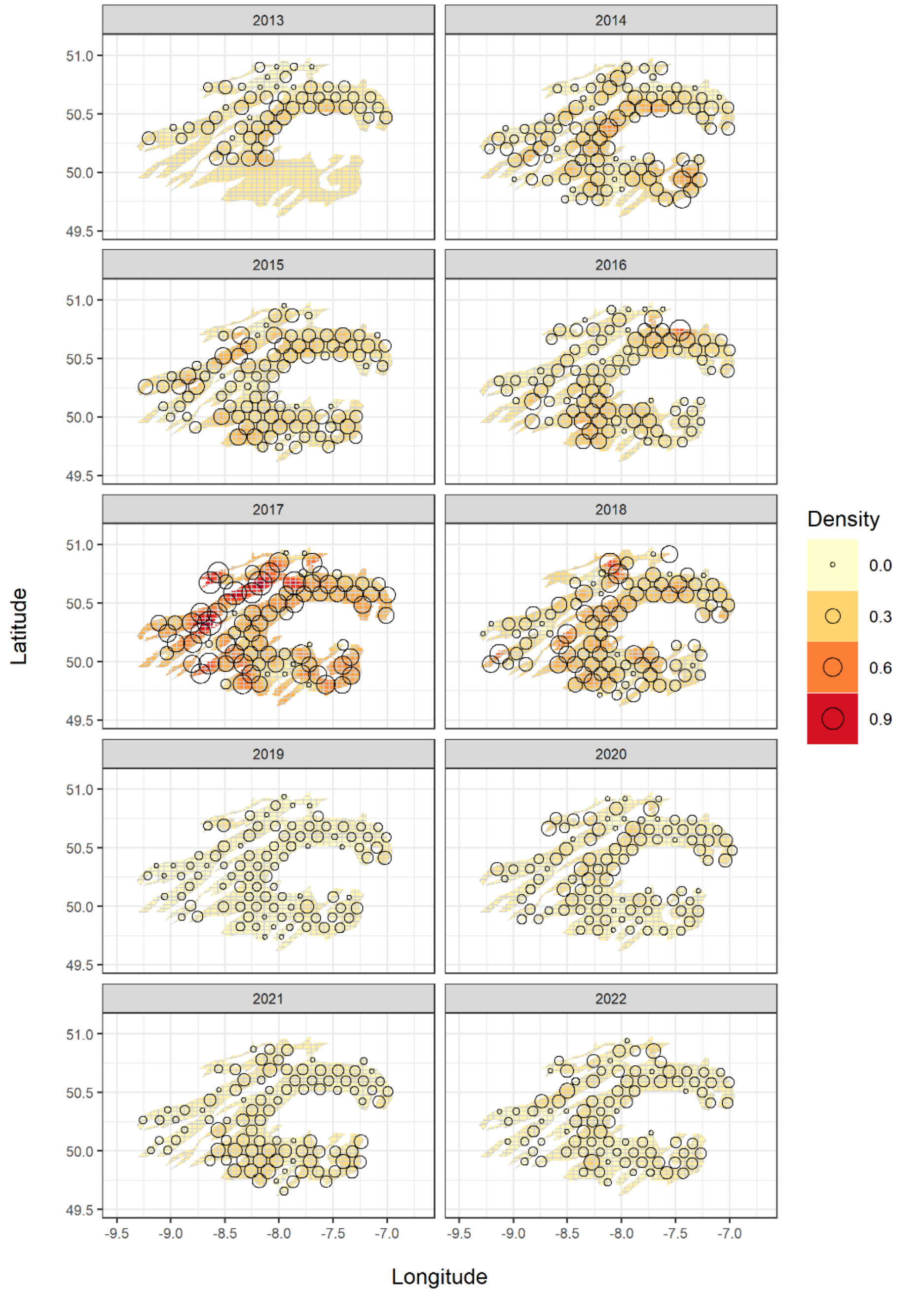

Fig. 1: FU 20-21. Map of adjusted density (burrows / m²) by station for each year.

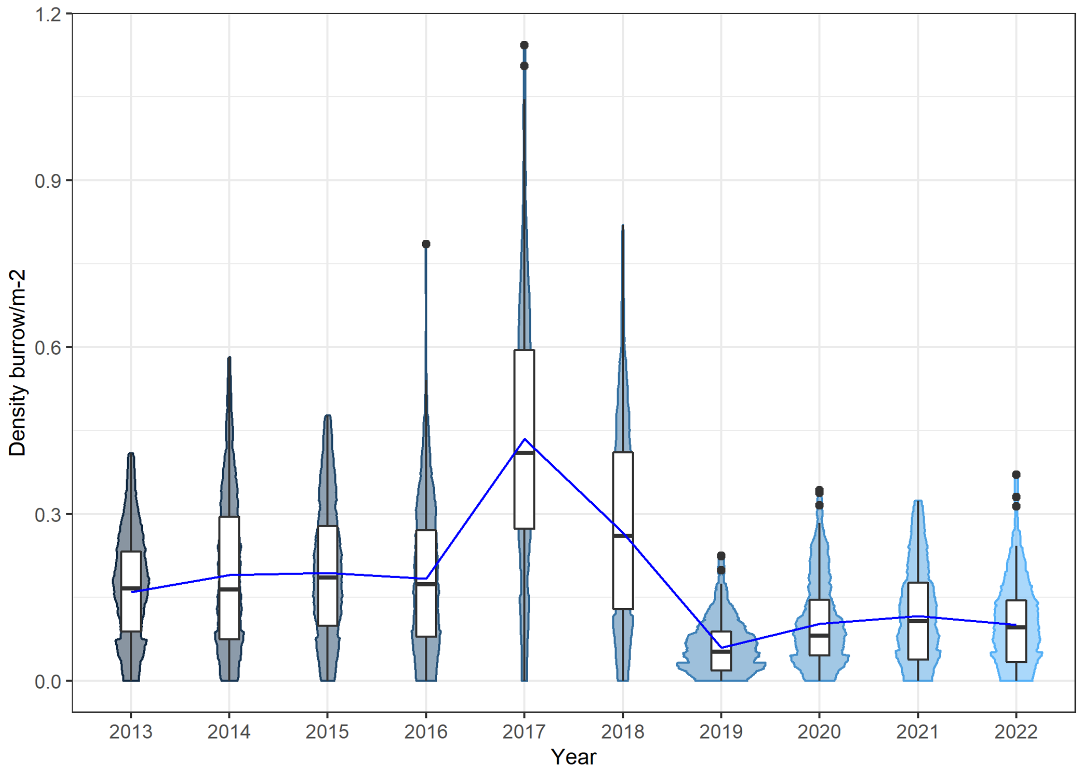

Fig. 2: FU 20-21. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**FU22**	**Area name**	**The Smalls**
Survey design	Randomised isometric grid	Previous surveys	2006 to 2021
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)	Celtic Voyager
Survey code (s)	CV21015	Dates (start/end)	23 May – 4 June 2022
Number scientific staff	6	Staff exchanges	No
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: 1.00 m
Adjusted mean density	0.31 burrows /m^2	Adjusted abundance, CV	895 million, CV = 7%
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)		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

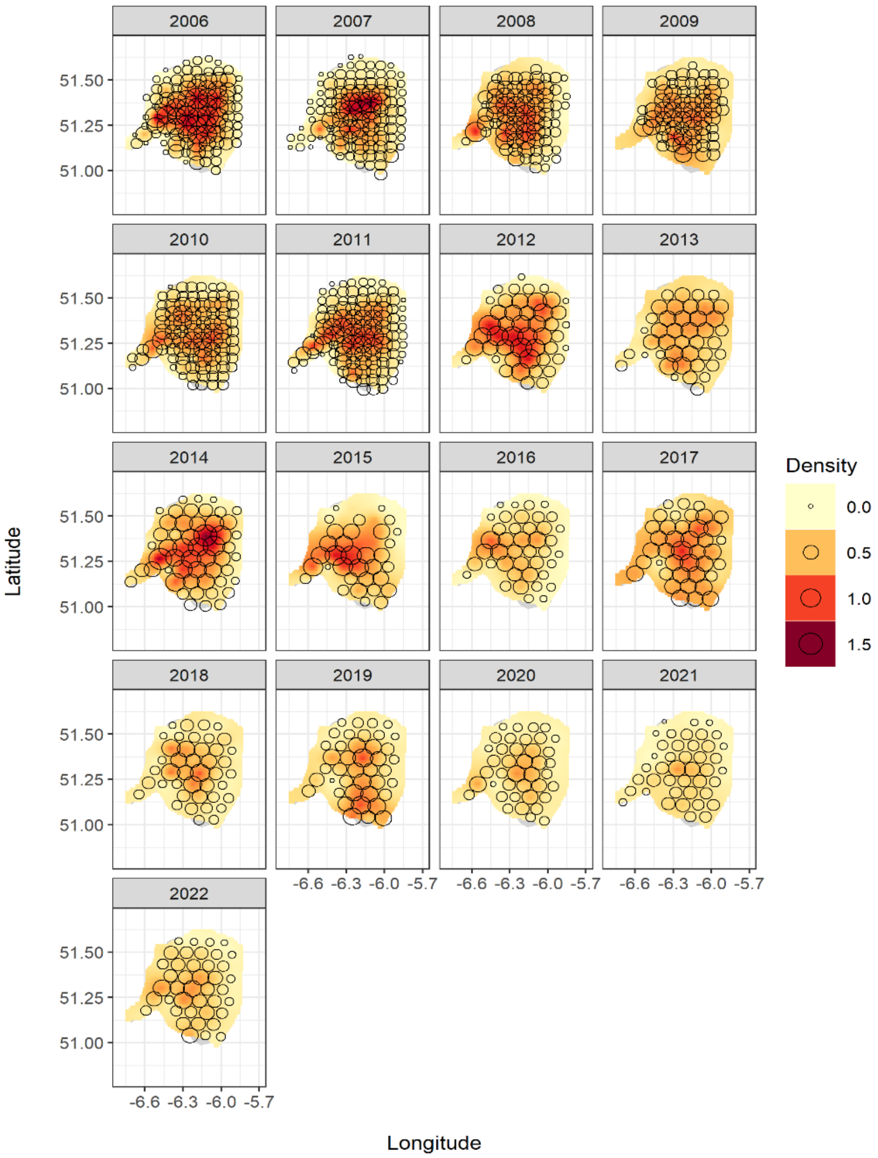

Fig. 1: FU 22. Map of adjusted density (burrows / m²) by station for each year overlaid on heat map of kriged surface density.

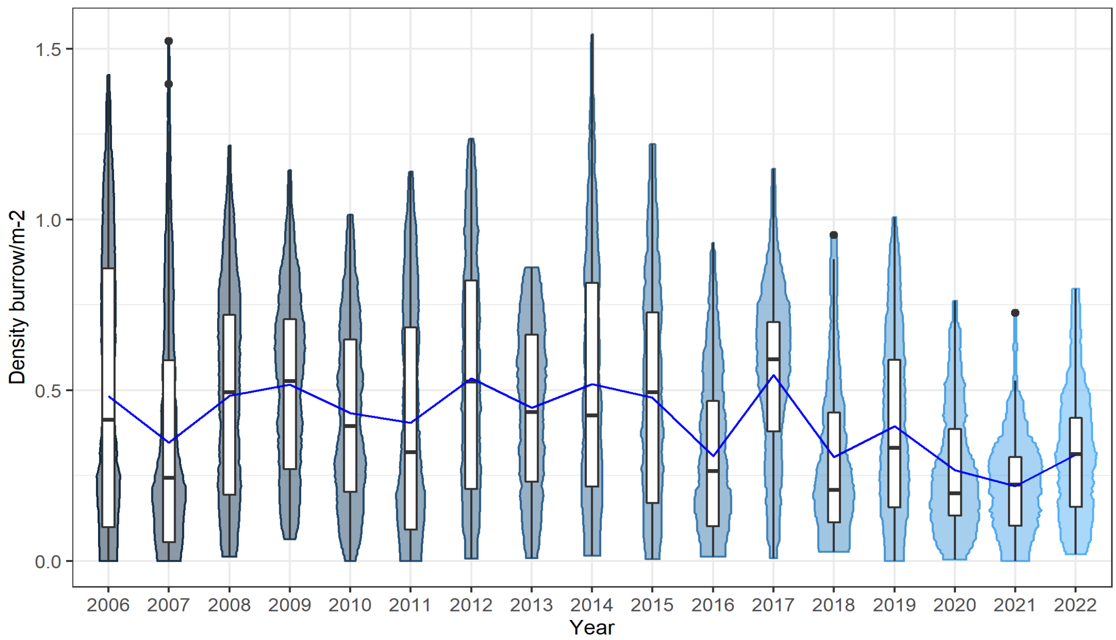

Fig. 2: FU 22. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

UK Northern Ireland: FU 15

(Mathieu Lundy)

<table>
<tr><td>Functional Unit</td><td>FU 15</td><td>Area name</td><td>Western Irish Sea</td></tr>
<tr><td>Survey design</td><td>Random grid</td><td>Previous surveys</td><td>2003-2021</td></tr>
<tr><td>Country (ies)</td><td>UK & Ireland</td><td>Vessel name (s)</td><td>R/V Corystes</td></tr>
<tr><td>Survey code (s)</td><td>CO3122</td><td>Dates (start/end)</td><td>28th – 31th July</td></tr>
<tr><td>Number scientific staff</td><td>5</td><td>Staff exchanges</td><td>NA</td></tr>
<tr><td colspan="2">Number of stations (planned/completed/used in analysis)</td><td colspan="2">100/97/97</td></tr>
<tr><td colspan="2">Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)</td><td colspan="2">97 Stations completed</td></tr>
<tr><td>Distance over ground source used</td><td>Ship</td><td>Average field of view (cm)</td><td>Analogue cam: 68 cm</td></tr>
<tr><td>Adjusted mean density</td><td>0.75</td><td>Adjusted abundance, CV</td><td>4498 million, CV=2.53%</td></tr>
<tr><td colspan="2">Overall footage quality (poor, medium, good)</td><td colspan="2">Good</td></tr>
<tr><td colspan="2">Reference footage for survey area generated</td><td colspan="2">No – New HD Still footage – Reference sets currently in development.</td></tr>
<tr><td colspan="2">Quality control of station counts (Lin’s CCC or consensus count)
State Lin’s CCC threshold</td><td colspan="2">Lin’s CCC threshold 0.5</td></tr>
<tr><td colspan="2">Other survey activities
(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)</td><td colspan="2">Beam trawl hauls
Nephrops otter trawls</td></tr>
<tr><td colspan="2" rowspan="5">Data storage, level of analysis and dissemination (by data type)</td><td>Nephrops burrow counts</td><td>11803 Nephrops burrows counted, storage: DVD up to 2020, digital in 2022 level of analysis: kriged estimates as for last year
dissemination: WGCSE</td></tr>
<tr><td>CTD</td><td>-</td></tr>
<tr><td>Trawl</td><td>24</td></tr>
<tr><td>Sediment</td><td>0</td></tr>
<tr><td>Other</td><td>0</td></tr>
</table>

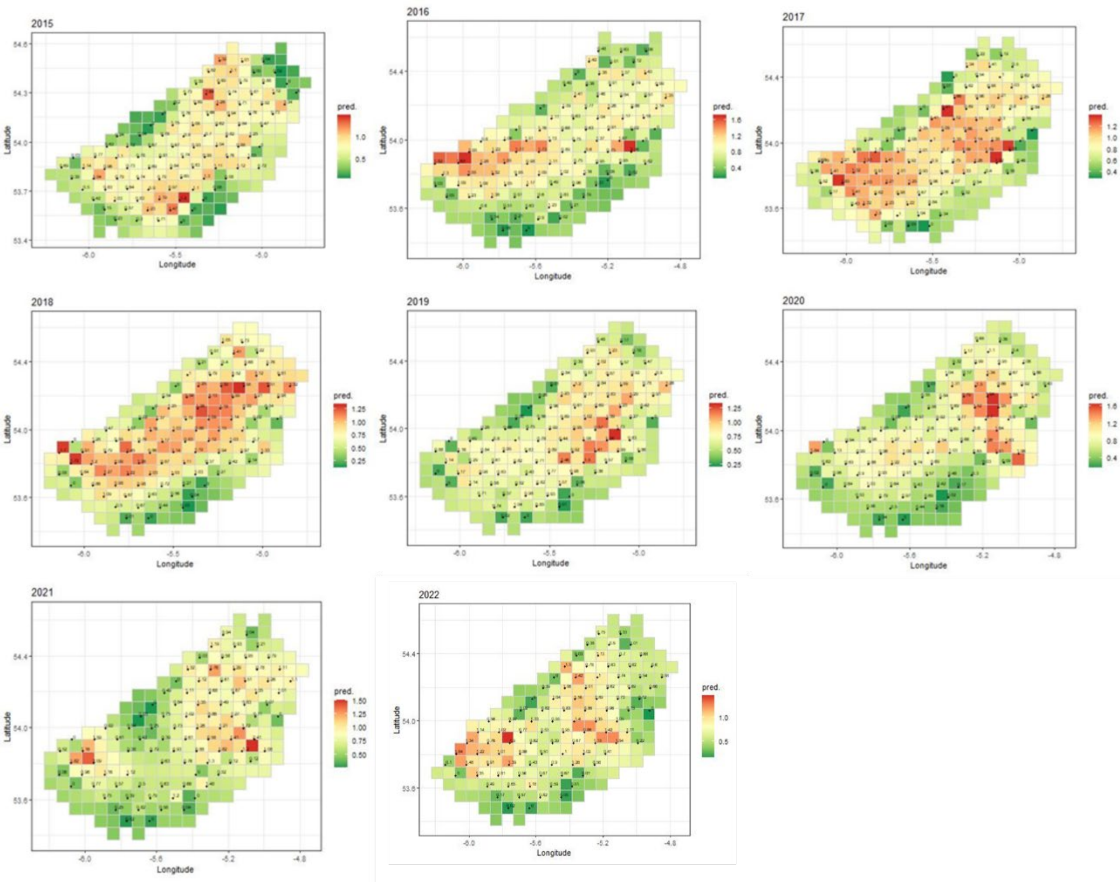

Figure. 1: Map of kriged density by station for 2015 – 2022.

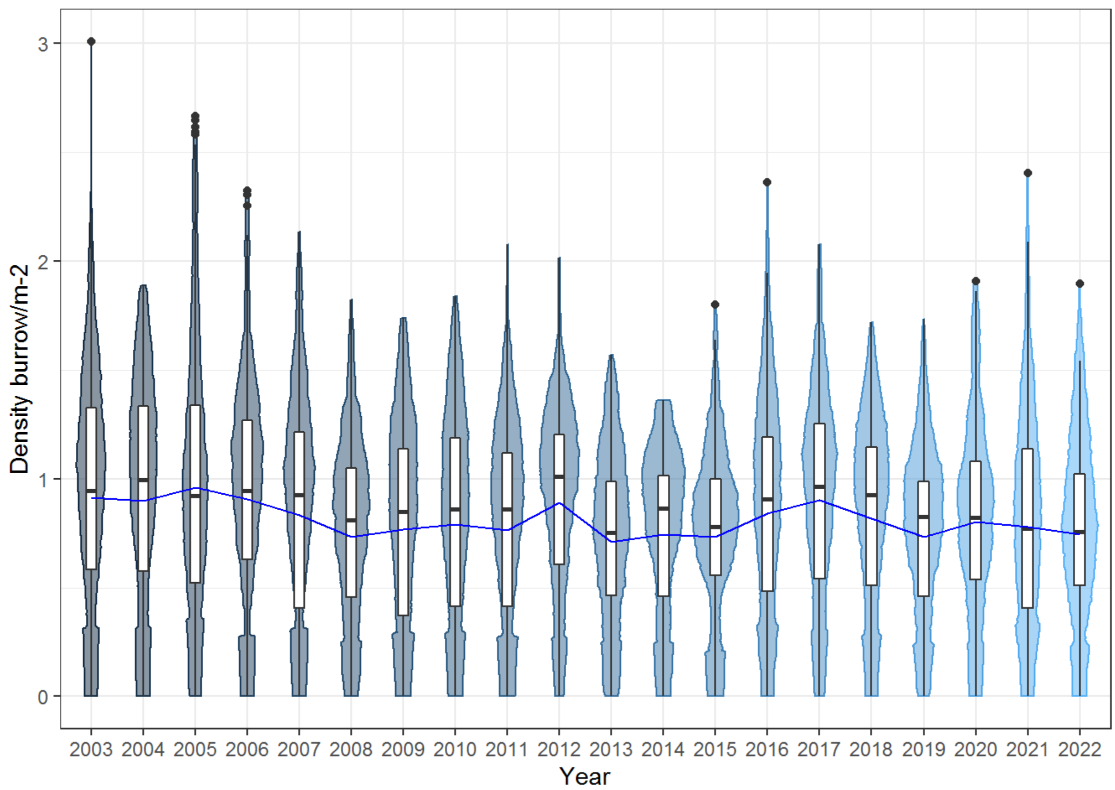

Figure. 2: Times series of adjusted burrow density (Violin and box plot).

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

Adrian Weetman

FU 10 (northern North Sea, Noup).
In 2022 due to time restrictions no survey was completed on FU 10 (northern North Sea, Noup). This survey was last conducted in 2019.

See ICES. 2020. Working Group on *Nephrops* Surveys (WGNEPS; outputs from 2019). ICES Scientific Reports. 2:16. 85pp. http://doi.org/10.17895/ices.pub.5968 for results of the previous surveys.

FU 8 (Firth of Forth).
Due to the late timing of this survey in November 2022 the data has yet to be analysed.

FU 34 (Devil's Hole).
Due to the late timing of this survey in November 2022 the data has yet to be analysed.

Functional Unit	**11**	**Area name**	**North Minch**
Survey design	Stratified Random plus 10 legacy, fixed stations	Previous surveys	1994, 1996, 1998-2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Alba-na-Mara
Survey code (s)	1222A	Dates (start/end)	19 Aug – 3 Sept 2022
Number scientific staff	3	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 39 Completed – 37 Used in analysis - 36	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to the issues on Scotia (0722S), work was reprioritised with the Alba-na-Mara rescheduled to survey the remaining South Minch stations, the Moray Firth and the North Minch, rather than the usual Moray Firth and Firth of Forth. With a limit of only 12 hours in every 24, the number of stations in the Moray Firth and North Minch were reduced slightly compared to previous years. The South Minch could not be altered without introducing a bias as this area had already been partially surveyed on 0722S.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.46	Adjusted abundance, CV	1346 mill., CV = 0.132
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 (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; turbidity meter used throughout.	
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 Scotland Science
	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 WGCSE, Marine Scotland Science, Aberdeen University, British Oceanographic Data Centre (BODC) COMPASS project and MSFD.

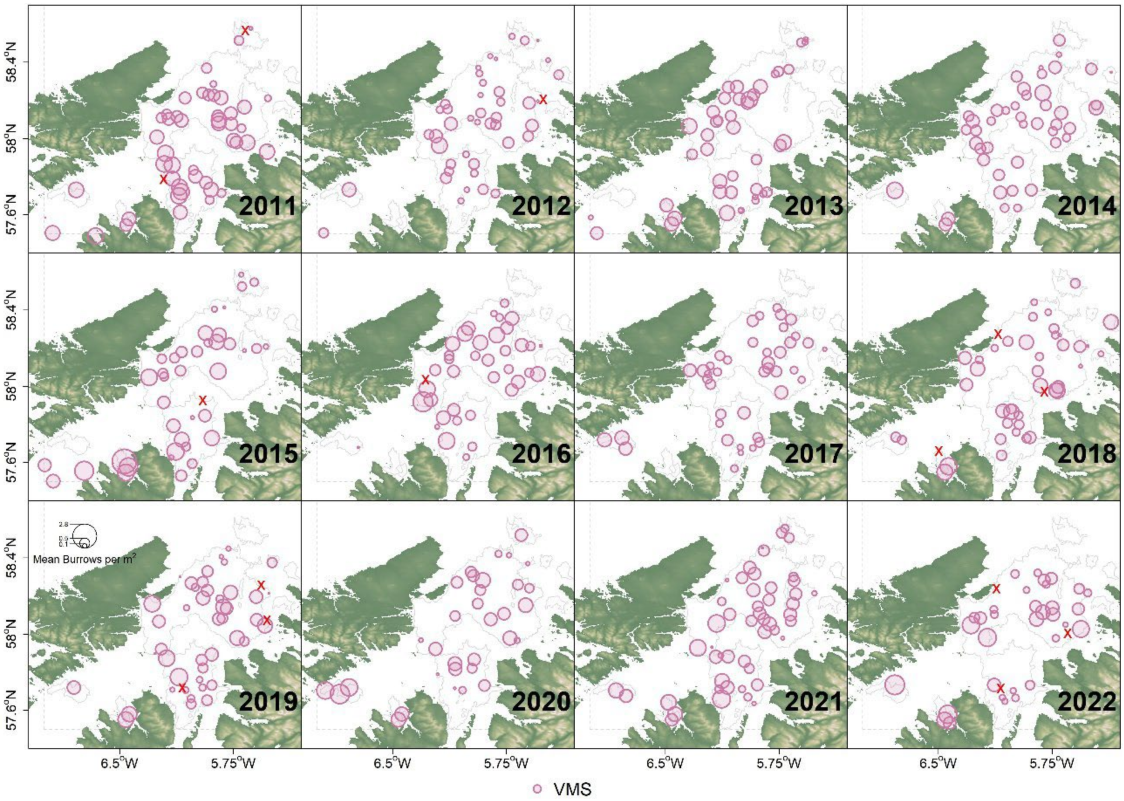

Fig 1: North Minch (FU 11). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius. (Earlier years are available on request).

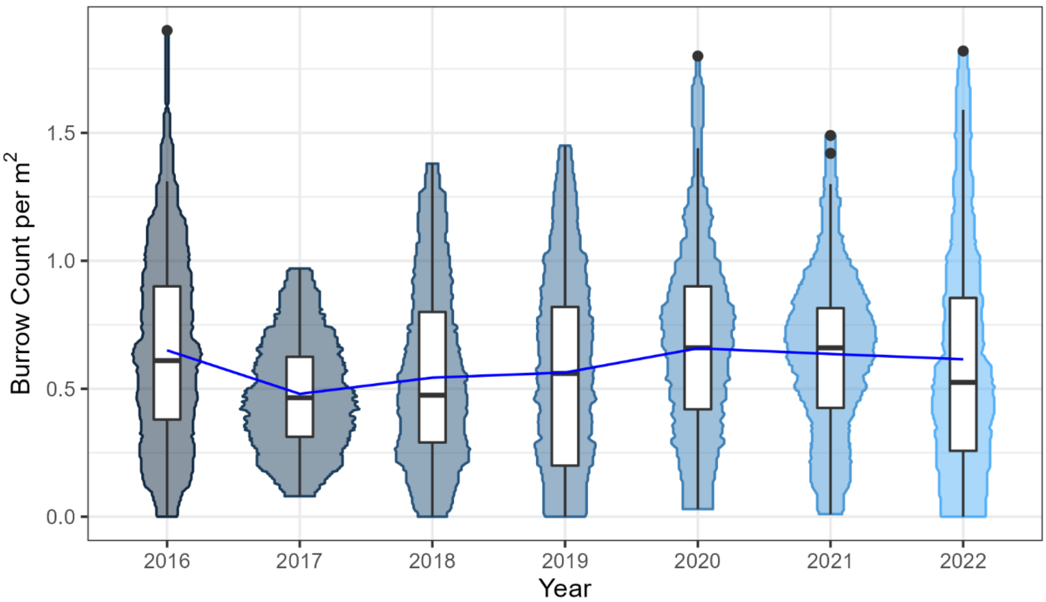

Fig. 2: North Minch (FU 11). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**12**	**Area name**	**South Minch**
Survey design	Stratified Random	Previous surveys	1995 -2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia (0722S) and MRV Alba-na-Mara (1222A)
Survey code (s)	0722S and 1222A	Dates (start/end)	0722S: 5-21 June 2022 1222A: 19 Aug–3 Sept 2022
Number scientific staff	0722S: 7 at any one time (MSS staff change at half landing) 1222A: 3	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 0722S: 42 1222A: 18 Completed – 0722S: 24 1222A: 18 Used in analysis – 41	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		**0722S:** Due to lost sea time during industrial action and an outbreak of COVID, there were only 13 work days during this survey (0722S) instead of the scheduled 21. This resulted in the Devils Hole and the North Minch not being surveyed at this time (0722S). The South Minch was only partially completed on 0722S, with the remainder of the sites, and all of the North Minch, being surveyed during 1622A. Whilst working in the South Minch, a COMPASS mooring was recovered. **1222A:** Due to the issues on Scotia (0722S), work was reprioritised with the Alba-na-Mara rescheduled to survey the remaining South Minch stations, the Moray Firth and the North Minch, rather than the usual Moray Firth and Firth of Forth. With a limit of only 12 hours in every 24, the number of stations in the Moray Firth and North Minch were reduced slightly compared to previous years. The South Minch could not be altered without introducing a bias as this area had already been partially surveyed on 0722S.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.33	Adjusted abundance, CV	1677 mill., CV = 0.129
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	

<table>
<tr><td>Other survey activities

(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)</td><td colspan="2">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; USBL and turbidity meter used throughout; trial of new HD system undertaken during 0722S.</td></tr>
<tr><td rowspan="5">Data storage, level of analysis and dissemination (by data type)</td><td>Nephrops burrow counts</td><td>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</td></tr>
<tr><td>CTD</td><td>No</td></tr>
<tr><td>Trawl</td><td>No</td></tr>
<tr><td>Sediment</td><td>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 Scotland Science</td></tr>
<tr><td>Other</td><td>Seapen, marine litter, fauna data, COMPASS recordings (0722S only), 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 WGCSE, Marine Scotland Science, Aberdeen University, British Oceanographic Data Centre (BODC), COMPASS project and MSFD.</td></tr>
</table>

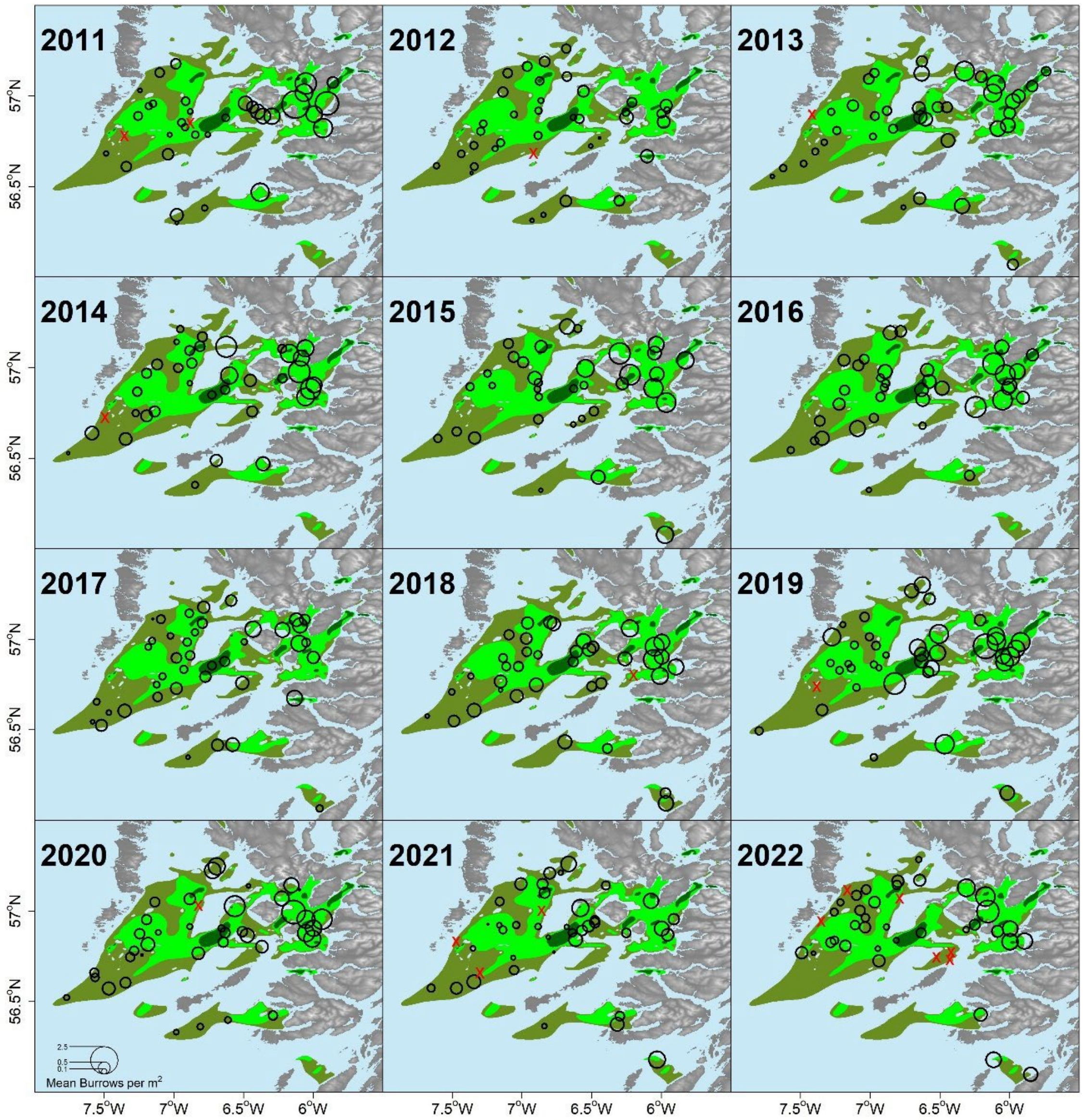

Fig. 1: South Minch (FU 12). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius. (Earlier years are available on request).

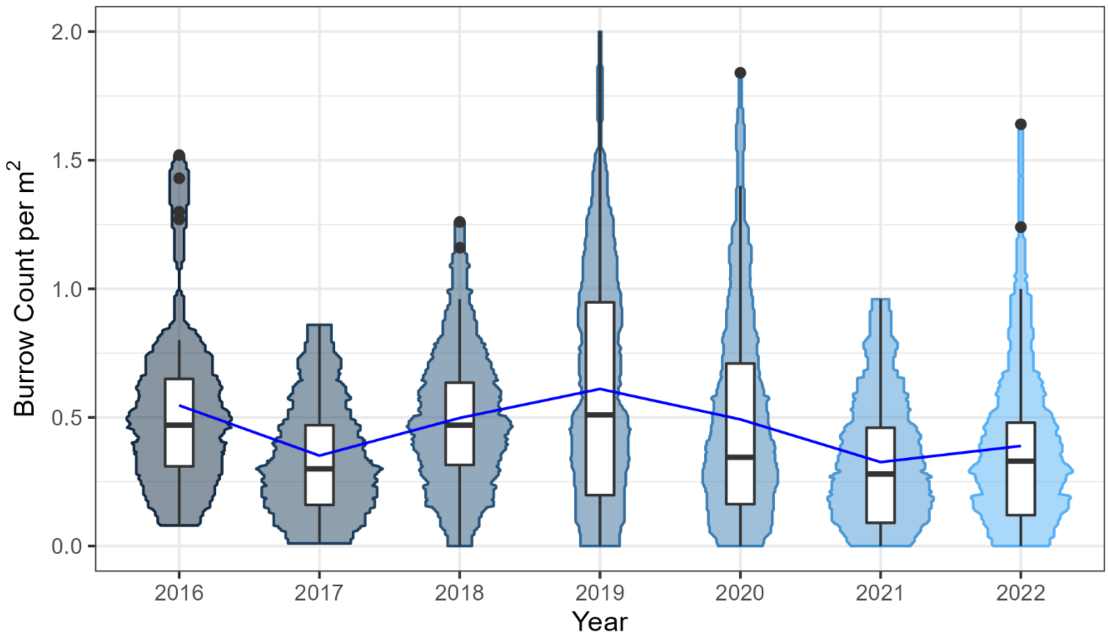

Fig. 2: South Minch (FU 12). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**13**	**Area name**	**Clyde**
Survey design	Stratified Random	Previous surveys	1995-2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0722S	Dates (start/end)	5 – 21 June 2022
Number scientific staff	7 at any one time (MSS staff change half landing)	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 industrial action, the scheduled number of stations in the Clyde were reduced compared to previous surveys, afforded by the relatively stable historical trends and good coverage of this area. In addition to losing four days to industrial action, the survey was cut short due to a COVID outbreak on the vessel, resulting in only 13 work days (instead of the scheduled 21), as well as Devils Hole and the North Minch not being surveyed. The South Minch was only partially completed on 0722S, with the remainder of the sites, and all of the North Minch, being surveyed during 1622A.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.8	Adjusted abundance, CV	1665 mill., CV = 0.088
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; USBL and turbidity meter used throughout; trial of new HD system undertaken.	
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 Scotland Science
	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. **Dissemination** – where applicable WGCSE, British Oceanographic Data Centre (BODC) and MSFD

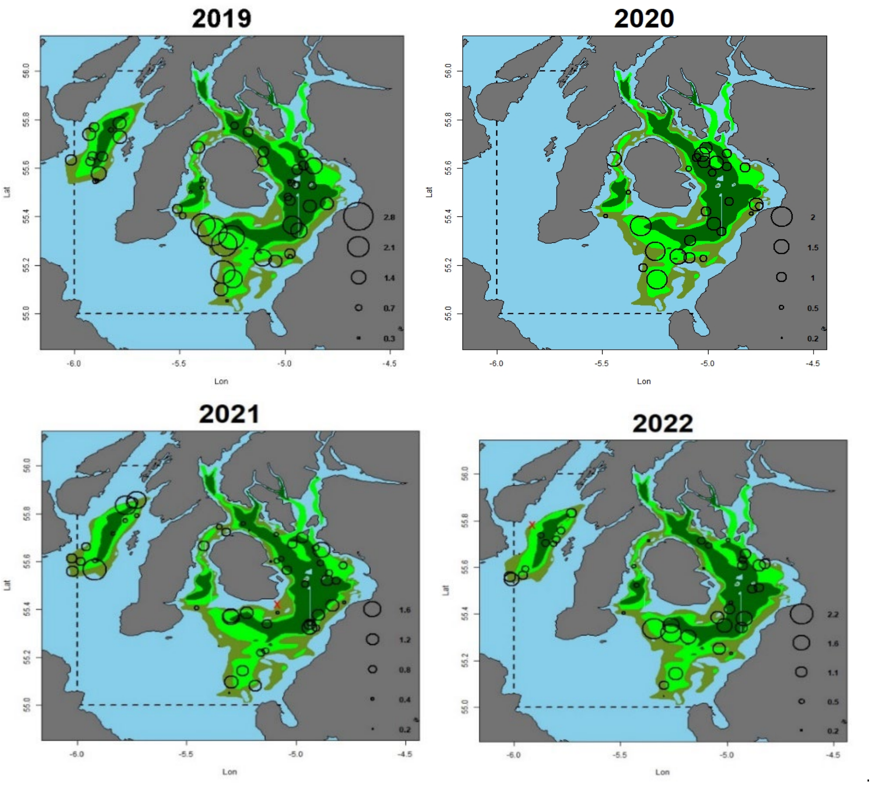

Fig. 1: Clyde and Jura (FU13) density map by station for each year (earlier years available on request).

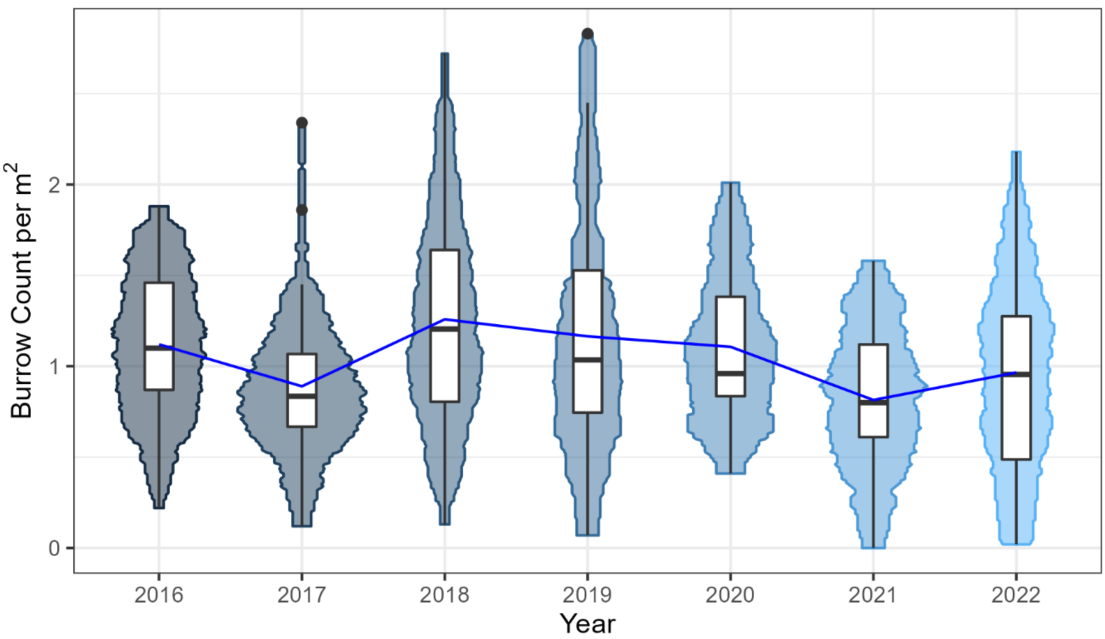

Fig. 2: FU 13 Clyde. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**13**	**Area name**	**Sound of Jura**
Survey design	Stratified Random	Previous surveys	1995-96, 2001-03, 2005-07, 2009-19, 2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0722S	Dates (start/end)	5 - 21 June 2022
Number scientific staff	7 at any one time (MSS staff change at half landing)	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 12 Completed – 12 Used in analysis - 12	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to lost sea time during industrial action and an outbreak of COVID, there were only 13 work days during this survey (0722S) instead of the scheduled 21. This resulted in the Devils Hole and the North Minch not being surveyed at this time (0722S). The South Minch was only partially completed on 0722S, with the remainder of the sites, and all of the North Minch, being surveyed during 1622A.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.632	Adjusted abundance, CV	241 mill., CV = 0.162
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 (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; USBL and turbidity meter used throughout; trial of new HD system undertaken.	
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 Scotland Science
	Other	**Seapen, marine litter, fauna data, skate samples, Survey Summary Report::** **Storage** – hard copies of records held in office environment; plus electronic copies on local network drive, backed up daily to the server. **Level of analysis** – carried out by other departments/agencies. **Dissemination** – where applicable WGCSE, British Oceanographic Data Centre (BODC) and MSFD

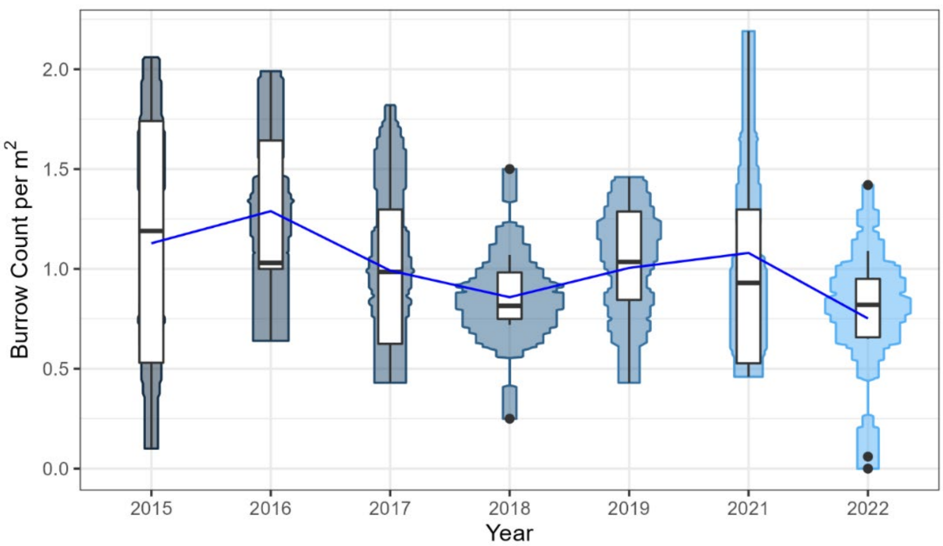

Fig. 2: FU 13 Jura. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**7**	**Area name**	**Fladen**
Survey design	Stratified Random	Previous surveys	1992-95, 1997-2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	0722S	Dates (start/end)	5 – 21 June 2022
Number scientific staff	7 at any one time (MSS staff change half landing)	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 lost sea time during industrial action and an outbreak of COVID, there were only 13 work days during this survey (0722S) instead of the scheduled 21. This resulted in the Devils Hole and the North Minch not being surveyed at this time (0722S). The South Minch was only partially completed on 0722S, with the remainder of the sites, and all of the North Minch, being surveyed during 1622A.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.197	Adjusted abundance, CV	5550 mill., CV = 0.061
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 (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; USBL and turbidity meter used throughout; trial of new HD system undertaken.	
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 Scotland Science
	Other	**Seapen, fauna data, Survey Summary Report, review footage for Maryn-Sol:** **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. **Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marynsol contractors, Marine Scotland Science, and MSFD

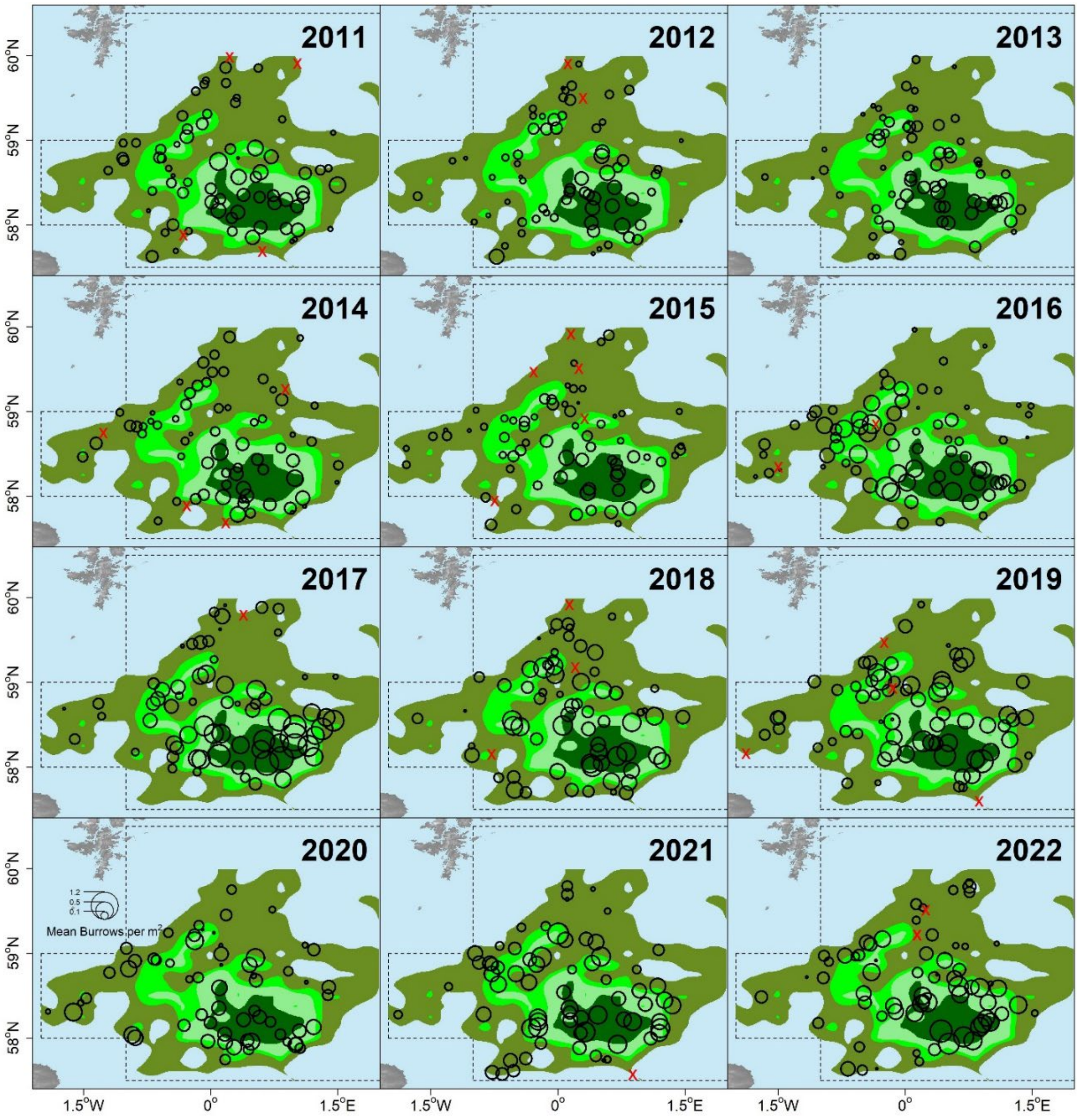

Fig. 1: Fladen (FU 7). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius. (Earlier years are available on request).

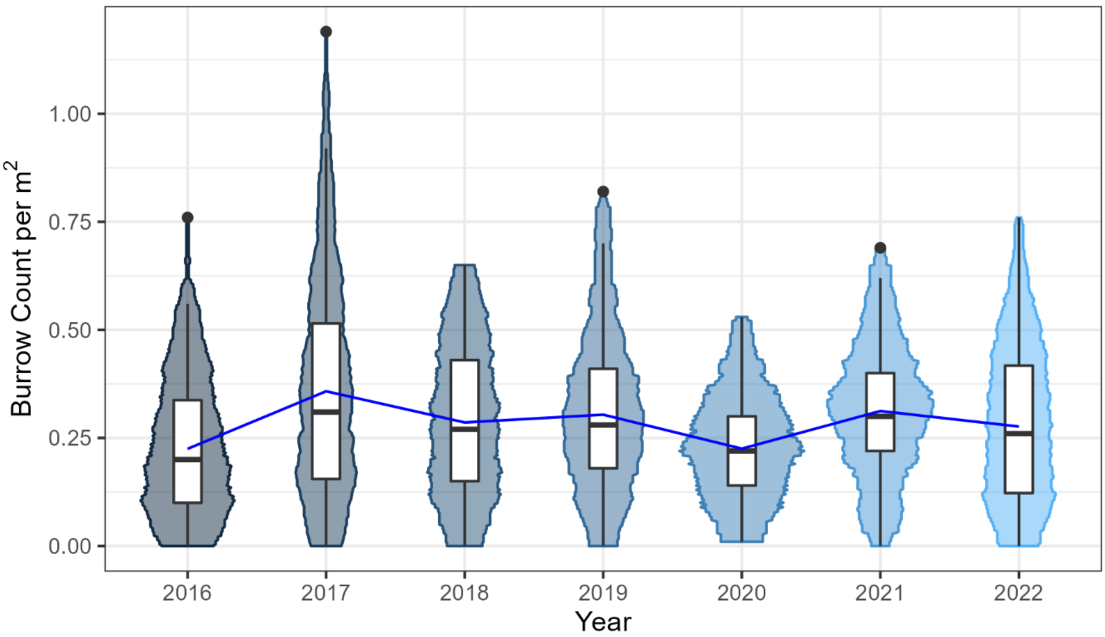

Fig. 2: Fladen (FU 7). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

Functional Unit	**8**	**Area name**	**Firth of Forth**
Survey design	Stratified Random	Previous surveys	1993-94, 1996, 1998-2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Scotia
Survey code (s)	1622S	Dates (start/end)	6 – 11 November 2022
Number scientific staff	6	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 45 Completed – 45 Used in analysis - TBC	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		This short survey was unscheduled but created to undertake the essential work earlier surveys (0722S and 1622A) were unable to complete. Due to the limited time, stations in the Firth of Forth and Devils Hole were reduced slightly compared to previous years. Due to the late timing of this survey the data has yet to be analysed.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	TBC (0.915 in 2021)	Adjusted abundance, CV	TBC (837 mill. in 2021) CV = TBC (0.064 in 2021)
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; USBL and turbidity meter used throughout.	
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 Scotland Science
	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 Scotland Science and MSFD.

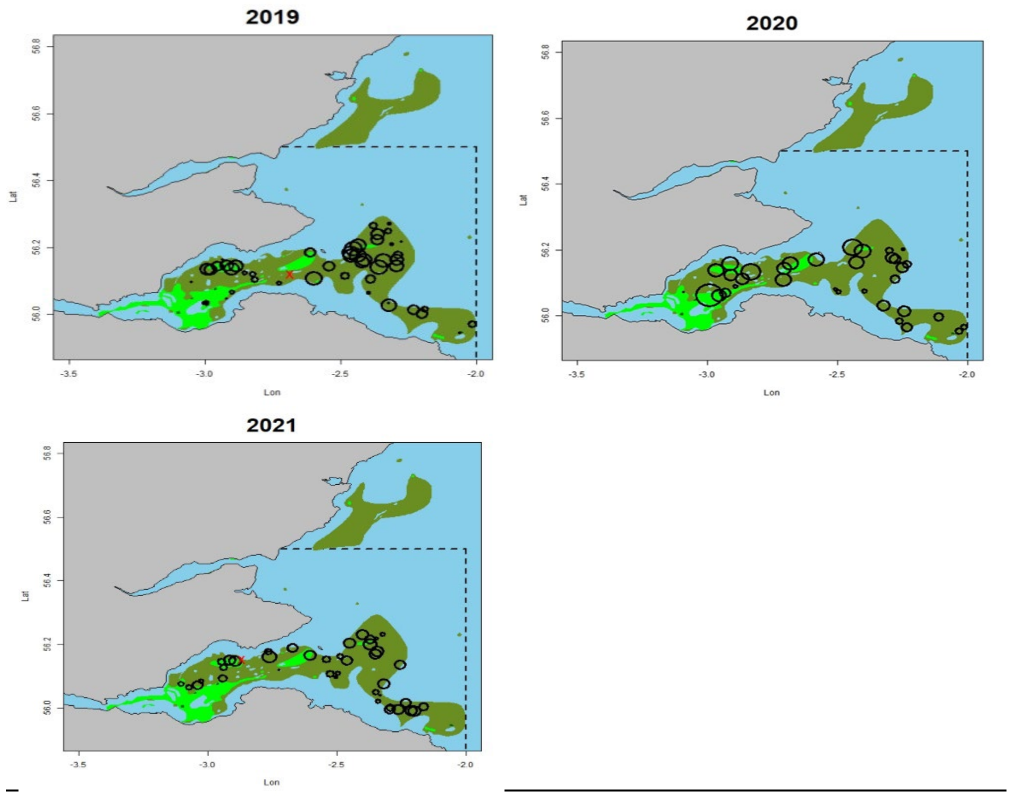

Fig. 1: Firth of Forth (FU 8). UWTV survey distribution and relative density for all years surveyed except 2022, data unavailable at this time. Density proportional to circle radius.

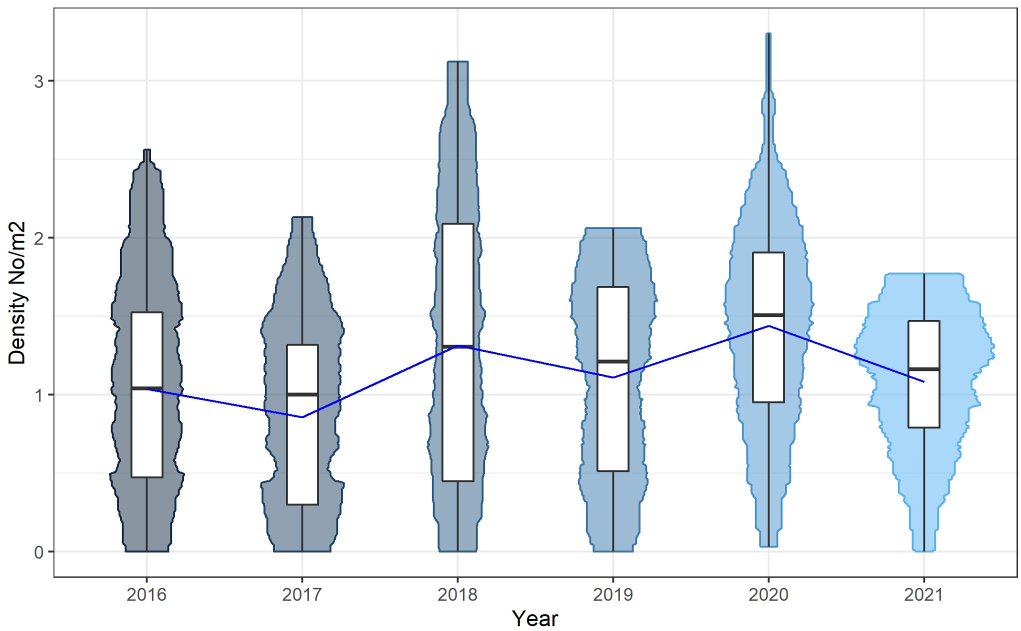

Fig. 2: Firth of Forth (FU 8). Times series of adjusted burrow density (Violin and box plot). Data for 2022 unavailable at this time.

Functional Unit	**9**	**Area name**	**Moray Firth**
Survey design	Stratified Random	Previous surveys	1993-94, 1996-2021
Country (ies)	Scotland, UK	Vessel name (s)	MRV Alba-na-Mara
Survey code (s)	1222A	Dates (start/end)	19 Aug – 3 Sept 2022
Number scientific staff	3	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 45 Completed – 45 Used in analysis – 45	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Due to the issues on Scotia (0722S), work was reprioritised with the Alba-na-Mara rescheduled to survey the remaining South Minch stations, the Moray Firth and the North Minch, rather than the usual Moray Firth and Firth of Forth. With a limit of only 12 hours in every 24, the number of stations in the Moray Firth and North Minch were reduced slightly compared to previous years. The South Minch could not be altered without introducing a bias as this area had already been partially surveyed on 0722S.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	0.18	Adjusted abundance, CV	396 mill., CV = 0.149
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 (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; USBL and turbidity meter used throughout.	
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 Scotland Science
	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 Scotland Science and MSFD.

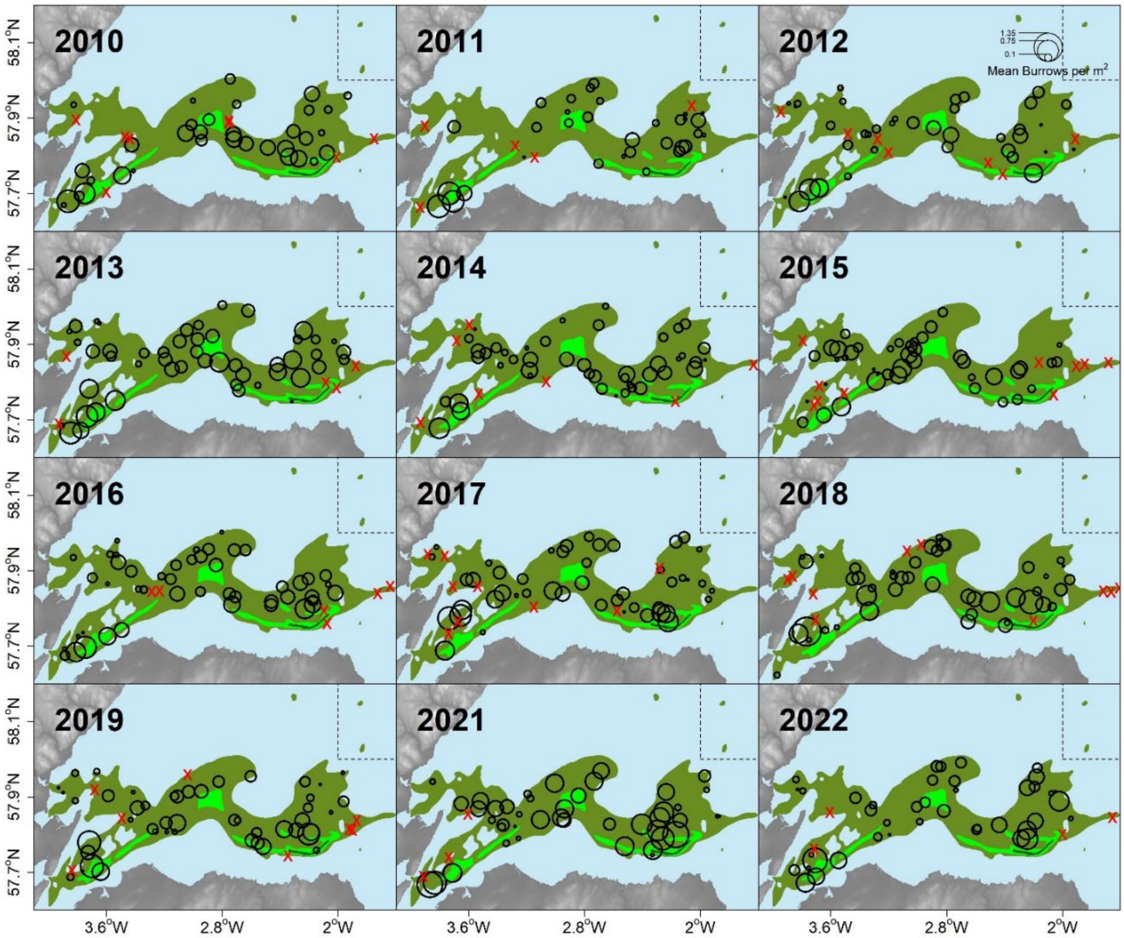

Fig. 1: Moray Firth (FU 9). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius. (Earlier years are available on request).

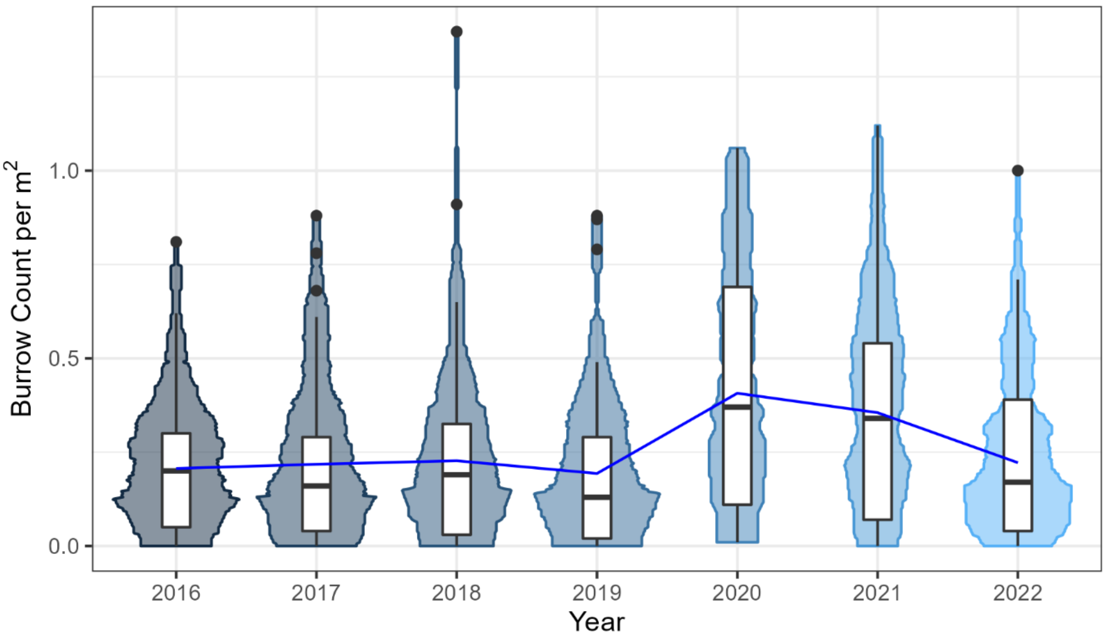

Fig. 2: Moray Firth (FU 9). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

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)	1622S	Dates (start/end)	6 – 11 November 2022
Number scientific staff	6	Staff exchanges	No
Number of stations (planned/completed/used in analysis)		Planned – 12 Completed – 7 Used in analysis - TBC	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		This short survey was unscheduled but created to undertake the essential work earlier surveys (0722S and 1622A) were unable to complete. Due to the limited time, stations in the Firth of Forth and Devils Hole were reduced slightly compared to previous years. Due to the late timing of this survey the data has yet to be analysed.	
Distance over ground source used	Odometer	Average field of view (cm)	90cm
Adjusted mean density	TBC	Adjusted abundance, CV	TBC
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 (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; USBL and turbidity meter used throughout.	
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 Scotland Science
	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, Marine Scotland Science, British Oceanographic Data Centre (BODC) and MSFD.

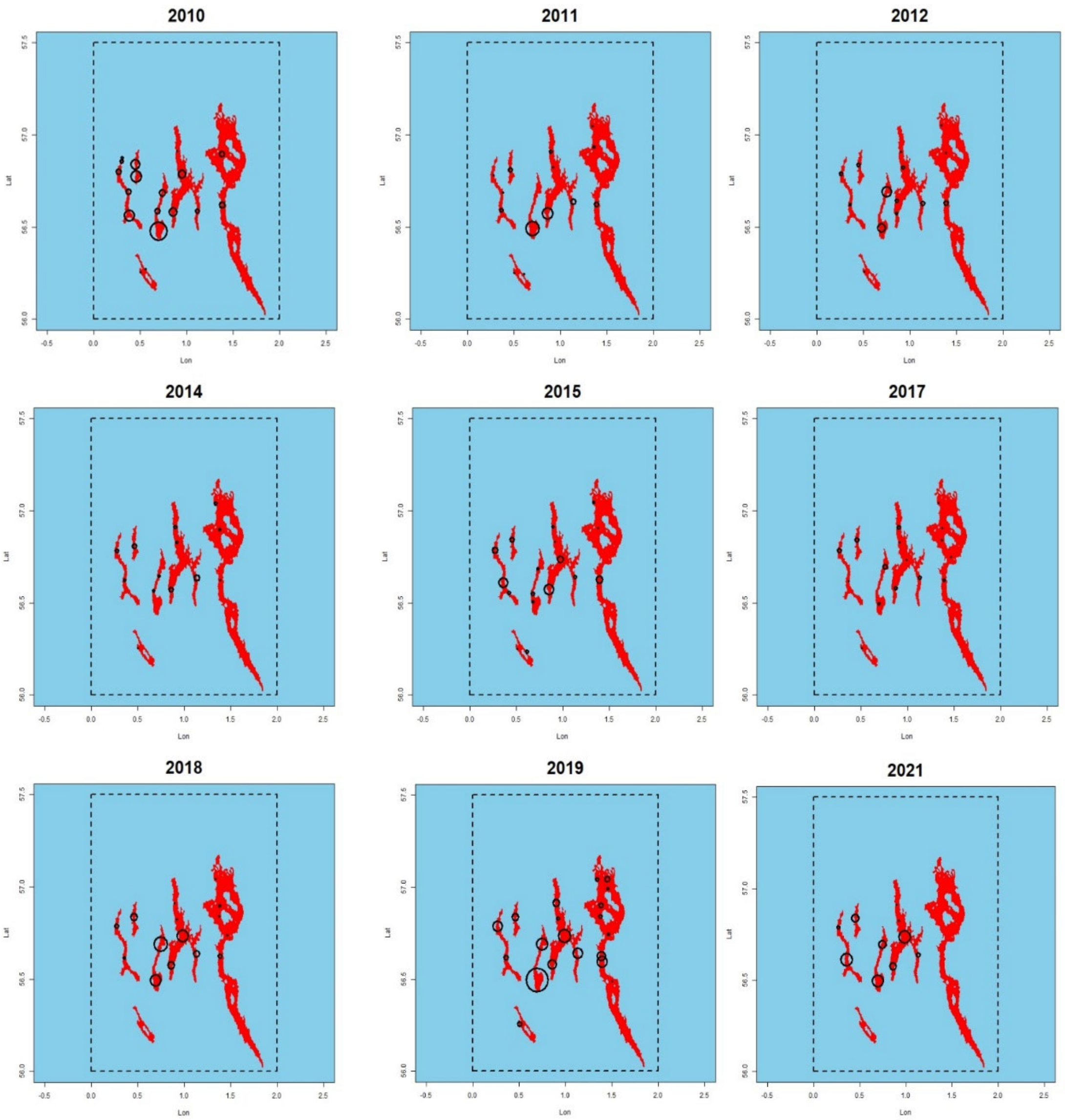

Fig. 1: Devil's Hole (FU 34). UWTV survey distribution and relative density, using the most recently worked up data. Survey station locations generated from Vessel Monitoring System (VMS) data (WKNEPH, 2013). Density proportional to circle radius. Data for 2022 unavailable at this time.

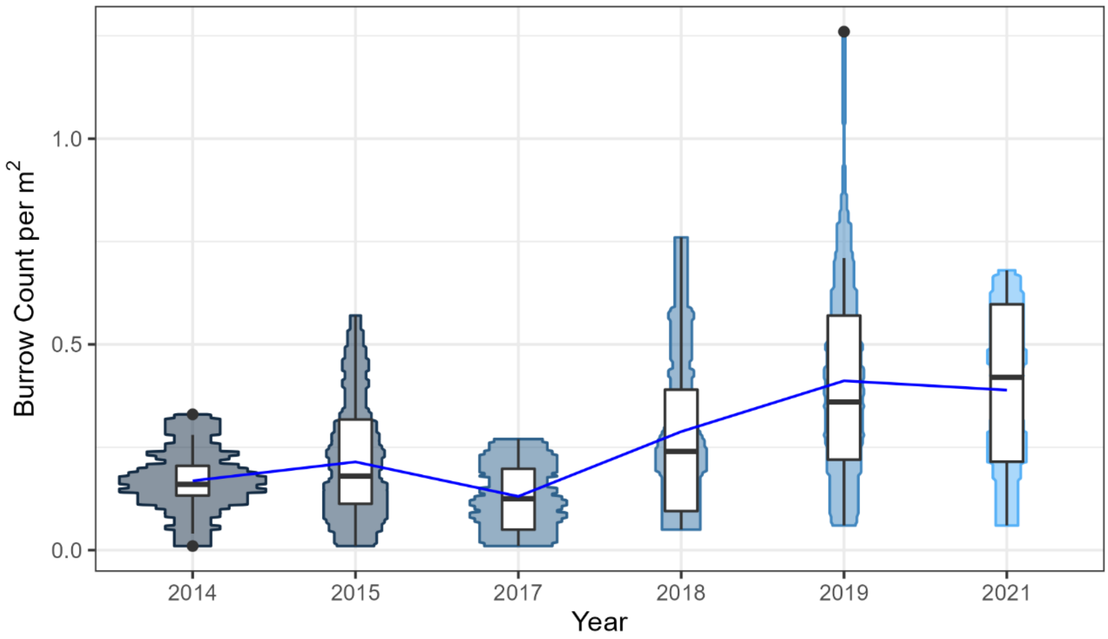

Fig. 2: Devils Hole (FU 34). Times series of adjusted burrow density (Violin and box plot). Data for 2022 unavailable at this time.

UK England: FU 6 and FU 14

Nikolai Nawri

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)	26/05/2022 01/06/2022
Number scientific staff	10	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.)		Downtime was due to weather conditions with some minor technical and operational issues relating mostly to the topside systems. Of the 110 planned stations, 1 station was abandoned after 2 attempts due to risk of damage to the camera	

		sledge from hard ground. 1 further station repeated due to issues with the topside system.	
Distance over ground source used	USBL	Average field of view (cm)	82
Adjusted mean density	0.28 burrows/m^2	Adjusted abundance, CV	878 ±20 million, 1.2%
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 to 4th counter then consensus	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		The plankton imager device was successfully trialled and viable plankton images identified and stored from the continuous feed. The system was left running fully autonomously without major issue for much of the latter part of the survey. 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

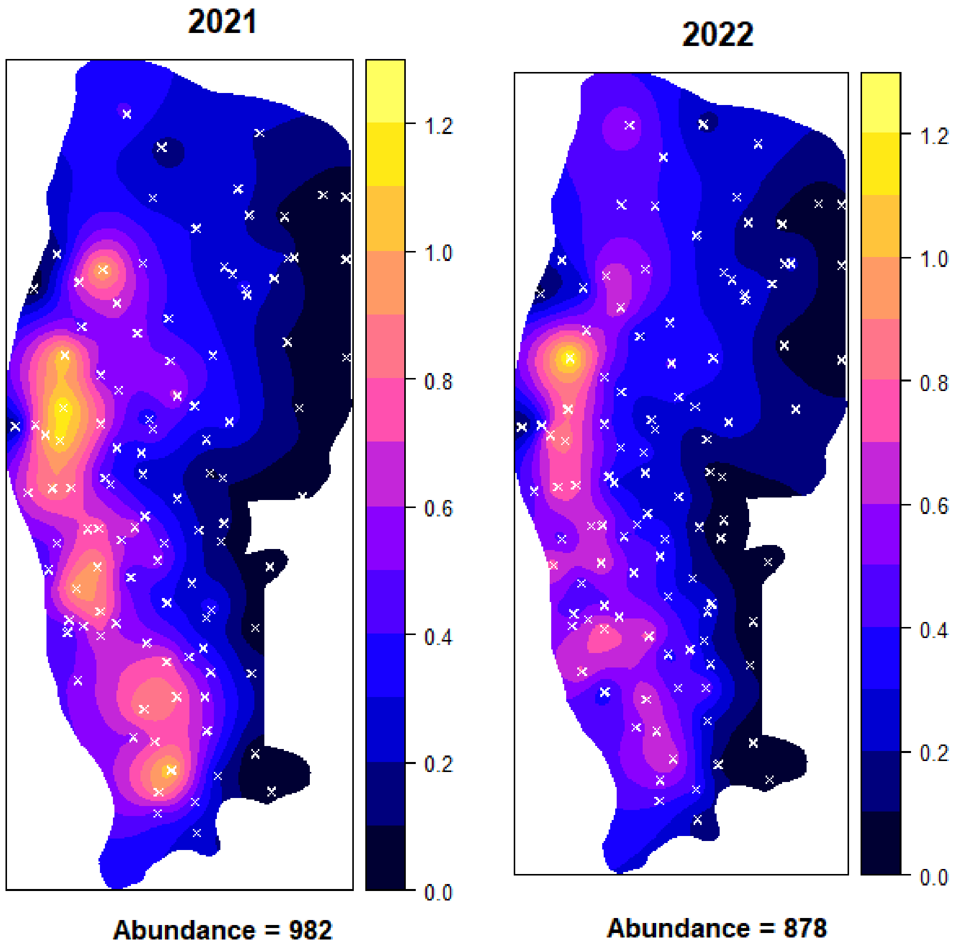

Figure 1: FU 6 Map of density by station for recent two years.

Functional Unit	**14**	**Area name**	**East Irish Sea**
Survey design	fixed	Previous surveys	2008 to present
Country (ies)	UK (NI)	Vessel name (s)	Corystes
Survey code (s)	U3016	Dates (start/end)	07/08/2022
			09/08/2022
Number scientific staff	TBC	Staff exchanges	Participation from Cefas
Number of stations (planned/completed/used in analysis)		48/46/46	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		TBC	
Distance over ground source used	USBL	Average field of view (cm)	62
Adjusted mean density	0.38 burrows/m²	Adjusted abundance, CV	386 ±110 million, 14.6%
Overall footage quality (poor, medium, good)		TBC	
Reference footage for survey area generated		using FU 15 footage from 2021	
Quality control of station counts (Lin's CCC or consensus count)		CCC (0.5 threshold)	
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 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	Not retained
		Trawl	No

	Sediment	No
	Other	No

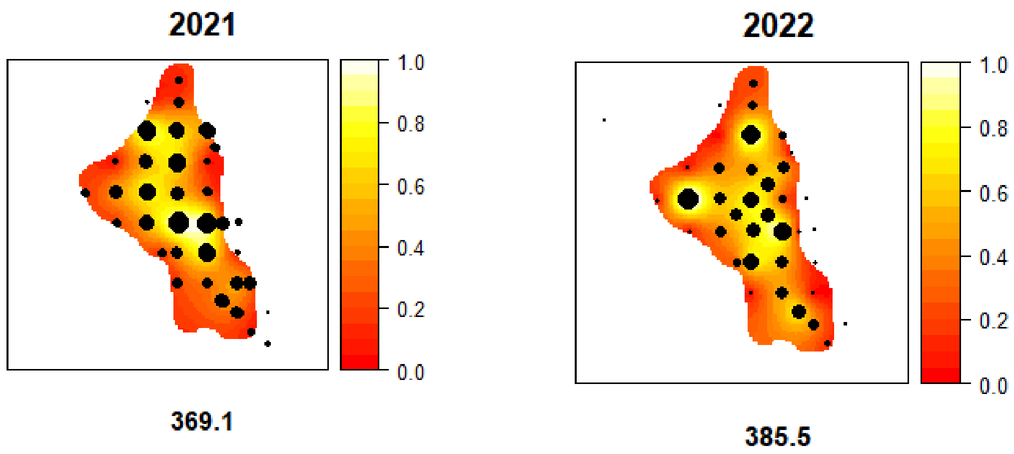

Figure 1: FU 14 Map of density by station for recent two years.

Denmark and Sweden: FU 3&4 Skagerrak and Kattegat

Kai Wieland and Patrik Jonsson

Functional Unit	**FU 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: 28/3 - 4/4 2022 SWE: 29/4 - 7/5 2022
Number scientific staff at sea	DK: 2 SWE: 5	Staff exchanges	none
Number of stations (planned/completed/used in analysis)		DK: 98/95/92 SWE: 96/94/94, without creel area	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		DK: poor visibility at 3 stations SWE: Two stations excluded at sea due to bad visibilities	
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: 76 cm RV Svea: 81cm
Adjusted mean density	0.22 burrows/m²	Adjusted abundance, CV	3202 million, 5.40 %

<table>
<tr><td>Overall footage quality (poor, medium, good)</td><td colspan="2">DK: good

SWE: Good, some stations with medium to poor visibility in eastern S3 and some coastal S6</td></tr>
<tr><td>Reference footage for survey area generated</td><td colspan="2">DK: yes

SWE: yes</td></tr>
<tr><td>Quality control of station counts (Lin’s CCC or consensus count)</td><td colspan="2">DK: Lin’s CCC.

Pre-check against reference files passed by all readers.

2022 survey stations counted by two readers. 10 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

Reference movies not finalized at survey count. Extensive warm up readings of extra stations avg. Lin’s CCC 0.53 (part of other sampling programme during survey).

Survey readings following manual:

62/94 passed Lin’s CCC at first reading

5/94 passed but low density and no valid Lin’s.

18/94 passed after third review

9/94 average of all three readers but Lin’s CCC < 0.5. One station one reader was discarded as results were too much of the two first readers (> 100%)</td></tr>
<tr><td>Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)</td><td colspan="2">DK: CTD (incl. O_2 and turbidity sensors)

SWE: CTD (incl. O_2 and turbidity sensors) at subset of stations. Stereo camera set up was tested at subset of stations to aid burrow size estimates.</td></tr>
<tr><td rowspan="4">Data storage, level of analysis and dissemination (by data type)</td><td>Nephrops burrow counts</td><td>Excel files, .csv file with R-output for DK and SWE combined</td></tr>
<tr><td>CTD</td><td>DK: Institute’s server, raw and processed data

SWE: txt-files saved at local HD.</td></tr>
<tr><td>Trawl</td><td>No</td></tr>
<tr><td>Sediment</td><td>No</td></tr>
</table>

	Other	

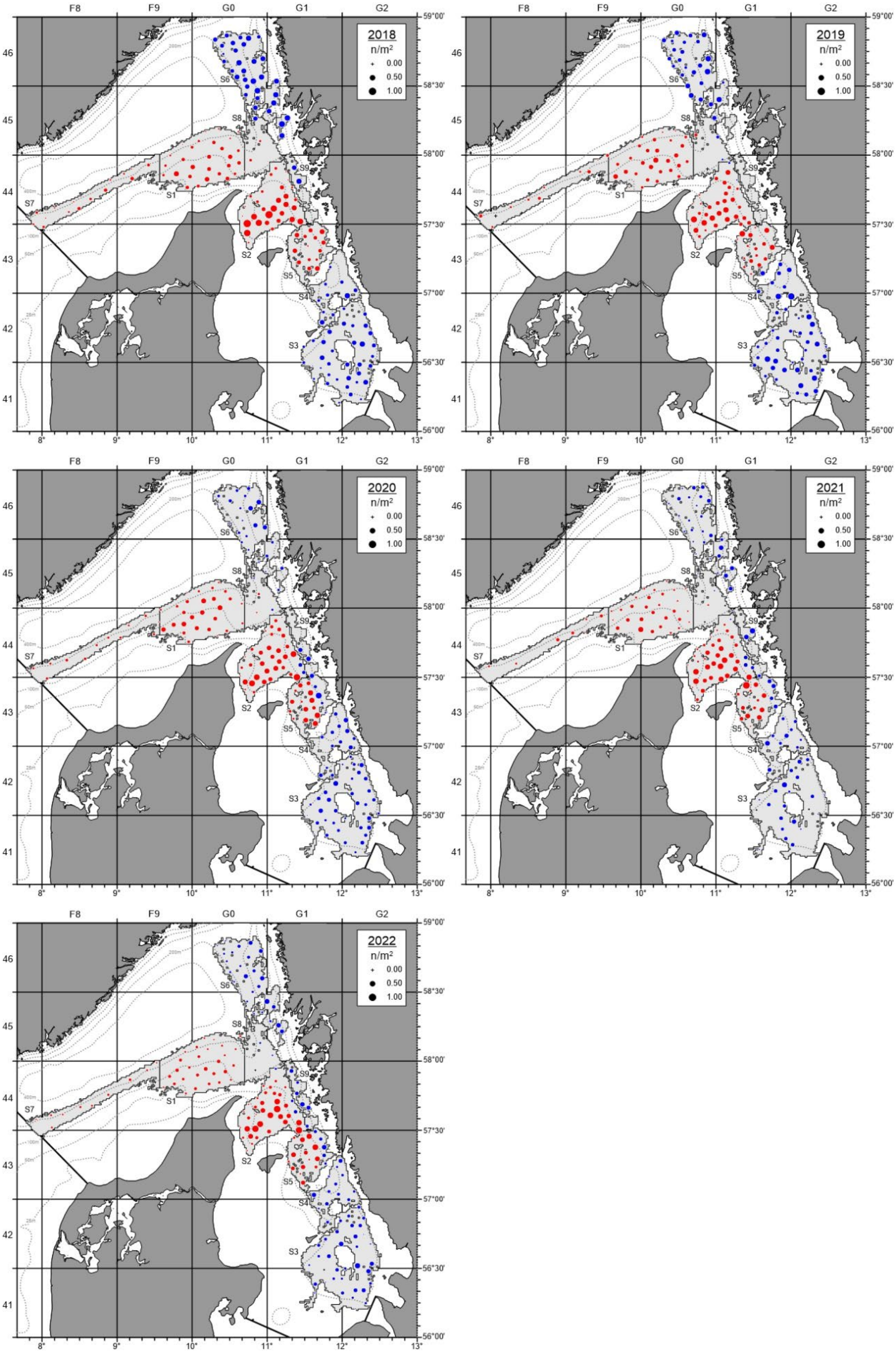

Fig. 1b: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2018 - 2022 (red: DK, blue: SWE).

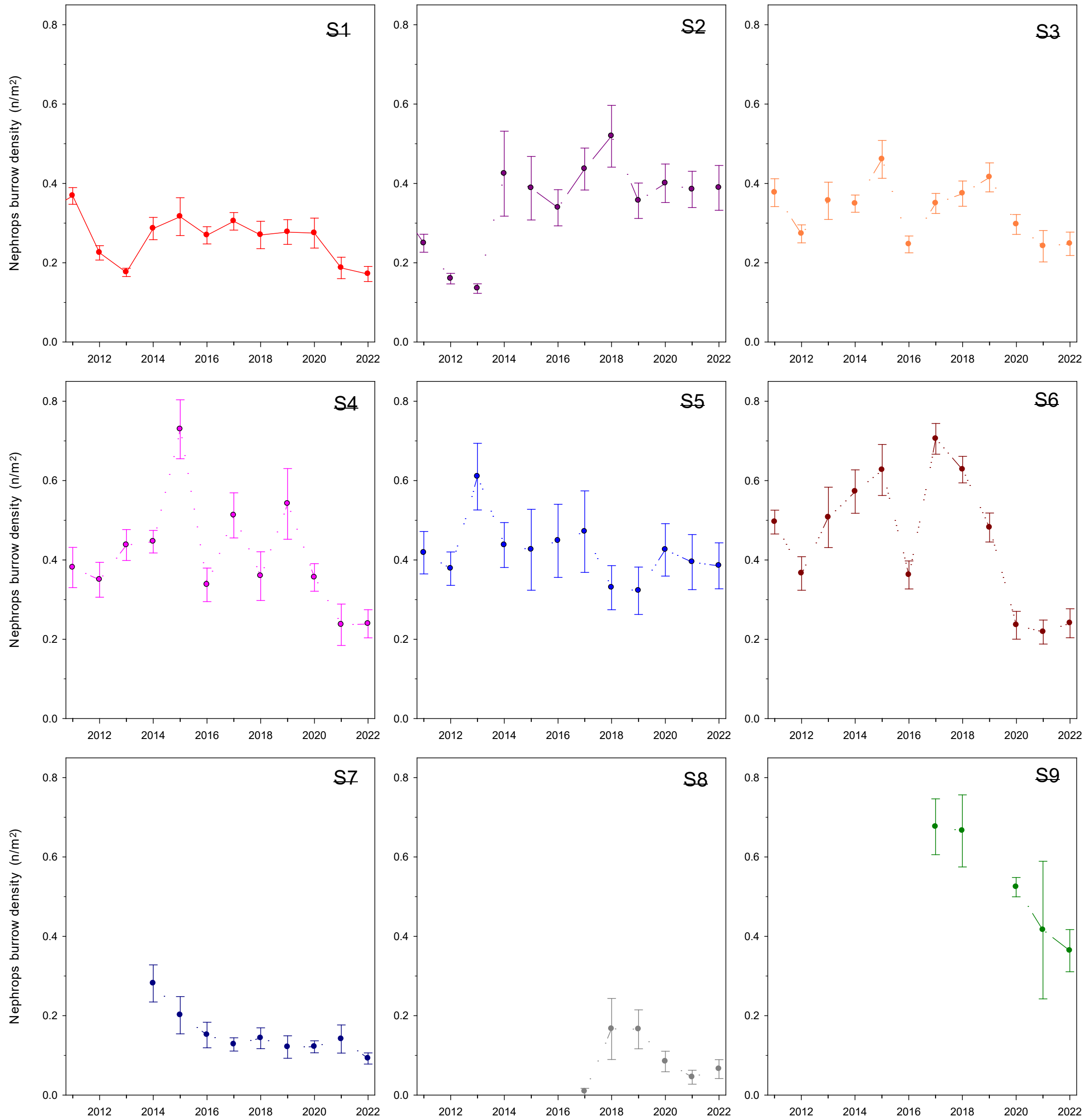

Fig. 2: FU 3&4 (Skagerrak/Kattegat) time series of *Nephrops* burrow density by stratum (mean, standard error).

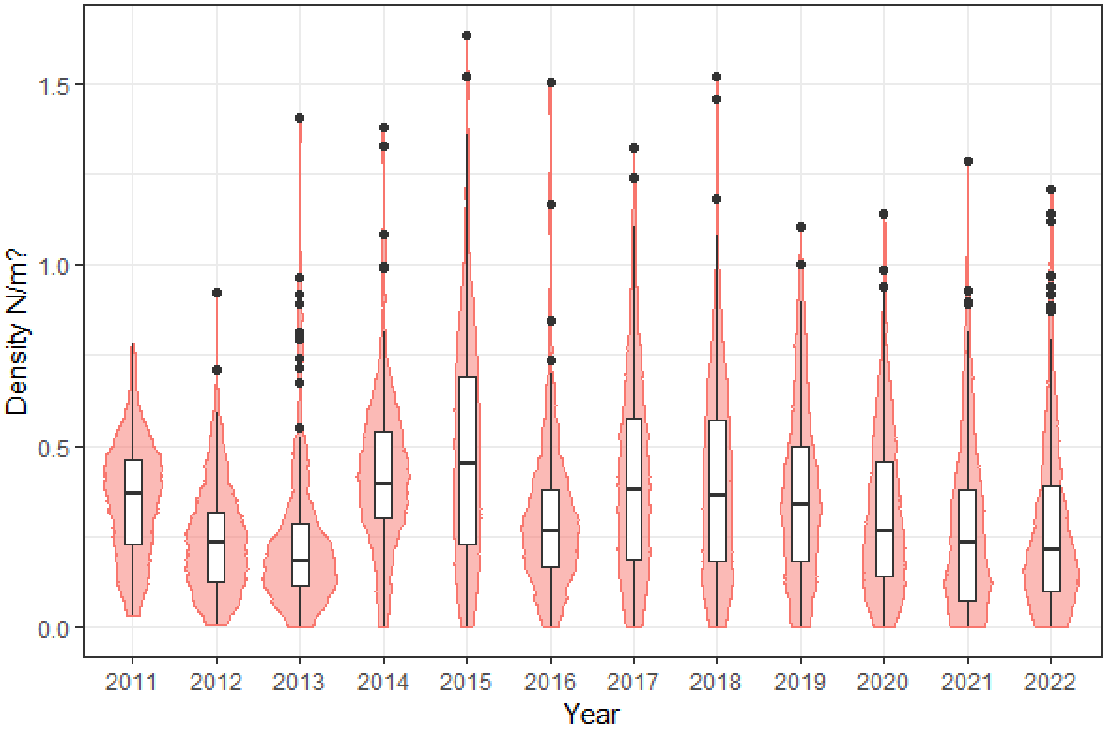

Fig. 3: FU 3&4 (Skagerrak/Kattegat) times series of *Nephrops* burrow density (The horizontal lines represent the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).

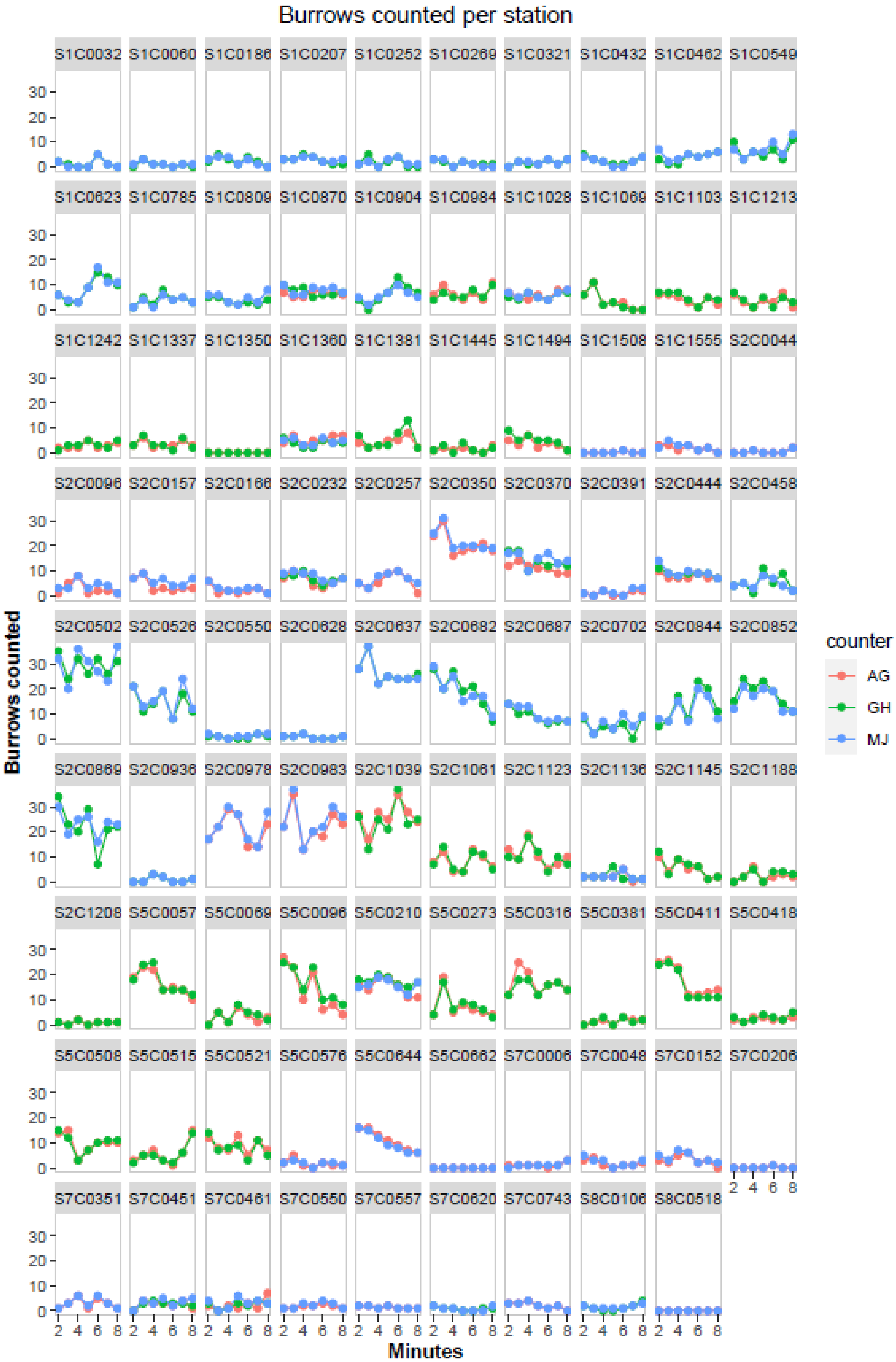

Fig. 4: FU 3&4 (Skagerrak/Kattegat) comparison of Danish readers, survey stations 2022.

Fig. 5: FU 3&4 (Skagerrak/Kattegat) comparison of Swedish readers – survey stations 2022.

Denmark : FU 33 -Off Horns Rev

(Kai Wieland)

Bi-annual survey.

No survey planned in 2022.

Next survey scheduled for 17 – 28 April 2023.

See ICES. 2022. Working Group on Nephrops Surveys (WGNEPS; outputs from 2021) ICES Scientific Reports. 4:29. 183pp. http://doi.org/10.17895/ices.pub.19438472 for results of the previous surveys.

Spain: FU 30 - Gulf of Cadiz

Yolanda Vila and Candelaria Burgos

<table>
<tr><td>Functional Unit</td><td>FU 30</td><td>Area name</td><td>Gulf of Cadiz</td></tr>
<tr><td>Survey design</td><td>Randomized isometric grid at 3.5 nm spacing</td><td>Previous surveys</td><td>2015-2019 & 2021-2022
2020 Not conducted (COVID-19 DISRUPTION)</td></tr>
<tr><td>Country (ies)</td><td>Spain</td><td>Vessel name (s)</td><td>Ramón Margalef</td></tr>
<tr><td>Survey code (s)</td><td>ISUNEPCA_0522
UWTV_FU30
U9111</td><td>Dates (start/end)</td><td>24 May-4 June</td></tr>
<tr><td>Number scientific staff</td><td>12</td><td>Staff exchanges</td><td>Yes. IEO-CSIC-Coruña</td></tr>
<tr><td colspan="2">Number of stations (planned/completed/used in analysis)</td><td colspan="2">PLANNED: 81
COMPLETED: 71
USED: 67</td></tr>
<tr><td colspan="2">Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)</td><td colspan="2">- Technical problems with sledge
- 10 stations not carried out for lack of time due the time consumed by those technical problems.
- Poor visibility in 4 stations due recent fishing activity and not possibility to revisited them.
- Probably effect of the stations not carried out in the shallowest eastern part of the survey area in the abundance estimation on that area.</td></tr>
<tr><td>Distance over ground source used</td><td>Transponder (HiPAP)</td><td>Average field of view (cm)</td><td>75</td></tr>
<tr><td>Adjusted mean density</td><td>0.021</td><td>Adjusted abundance, CV</td><td>53 millions burrows
CV= 10.8%</td></tr>
<tr><td colspan="2">Overall footage quality (poor, medium, good)</td><td colspan="2">Good</td></tr>
<tr><td colspan="2">Reference footage for survey area generated</td><td colspan="2">Yes (Created in WKNEPS 2018)</td></tr>
<tr><td colspan="2">Quality control of station counts (Lin’s CCC or consensus count)
State Lin’s CCC threshold</td><td colspan="2">- Counts by minute in 2022 were very low and Lin’s CCC R code does not work well.
-Using timestamp by minutes and consense between readers for 100% footages.</td></tr>
<tr><td colspan="2">Other survey activities</td><td colspan="2"></td></tr>
</table>

(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)	Videos are also used to estimates macro benthos species and the occurrence of trawl marks and litter on the sea bed. 18 Sediment samples using Box-corer. 5 beam trawl hauls CTD failed	
Data storage, level of analysis and dissemination (by data type)	Nephrops burrow counts	**Storage** – hard copies of data held in office environment; **Level of analysis** – as required for ICES WG **Dissemination** – WGNEPS,WGBIE, CN_IEO internal report
	CTD	Not available in 2022
	Trawl	**Storage** – hard copies of data held in office environment; **Level of analysis** – as required for IEO internal report. **Dissemination** – CN-IEO internal report.
	Sediment	**Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on hard disk. **Level of analysis** – carried out by other departments. Awaiting work up **Dissemination** – CN-IEO internal report.
	Other	

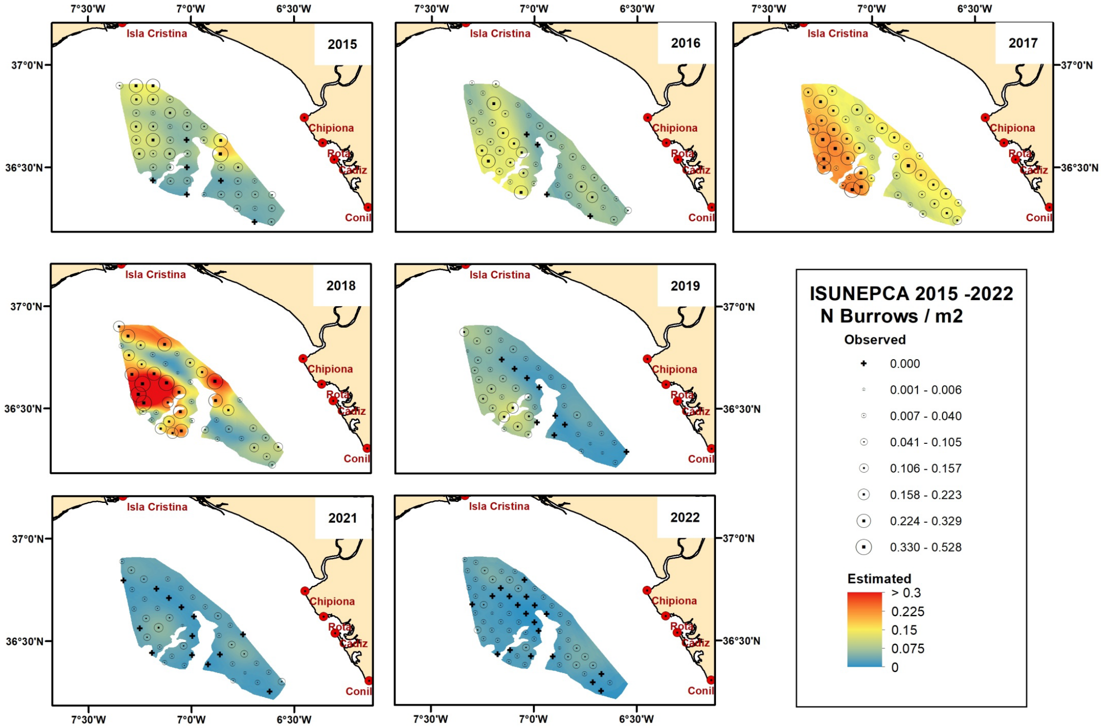

Fig. 1: Map of density by station for each year. Data updated after re-definition of the UVTV survey area. Bubble plot of the burrow density observations overlaid on a head map krigged burrow density surface for UWTV survey series (2015-2022; 2020 not available due COVID-19 pandemic). Station positions with zero density are indicated using a +.

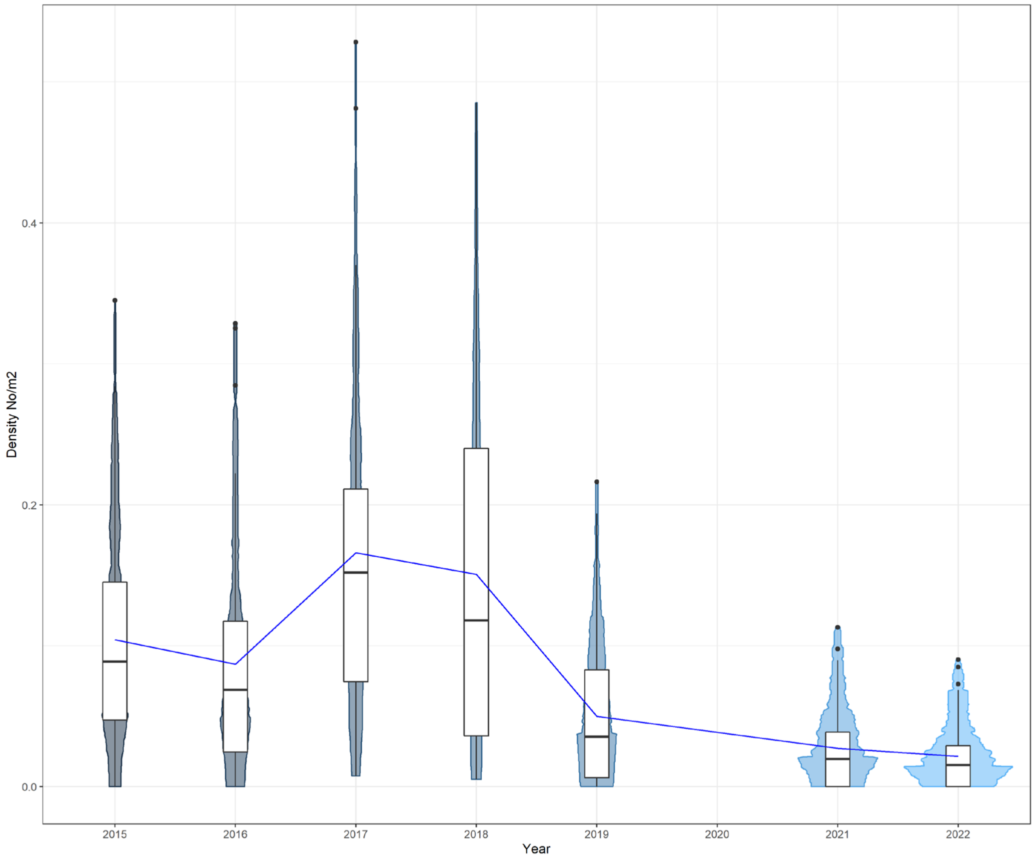

Fig. 2: Times series of adjusted burrow density (Violin and box plot).

Spain: FU 25

Isabel González-Herraiz and Julio Valerias

Functional Unit	**FU 25**	**Area name**	**North Galicia**
Survey design	Randomised isometric grid at 5 nm spacing	Previous surveys	None
Country (ies)	Spain	Vessel name (s)	Miguel Oliver
Survey code (s)	ISUNEP25_0922 UWTV_FU25_xx	Dates (start/end)	01/09/2022-12/09/2022
Number scientific staff	6	Staff exchanges	None
Number of stations (planned/completed/used in analysis)		47/24/24	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		This survey was considered a trial, with operational equipment to be fixed in next surveys. The survey was delayed from June to September due to vessel availability. A camera in towed 'Horus' sled was used (same sled used in UWTV_FU30). RV Miguel Oliver is not equipped with HIPAP transponder, so there are not sled GPS data. Poor weather in the area for 8 days. 5 effective days of total UWTV effort during good weather. Electronic technical problems affecting the operation of 4K main recording camera. Videos recorded by a HD auxiliary camera COOAU in aluminium underwater housing (1000m depth)	
Distance over ground source used	Marport depth recorder, real-time camera	Average field of view (cm)	80, camera angle 170º
Adjusted mean density	Not calculated yet	Adjusted abundance, CV	Not calculated yet
Overall footage quality (poor, medium, good)		Good	
Reference footage for survey area generated		Not yet	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Not yet	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.)		No CTD 24 sediment samples using Box-corer dredge. Sediment images	

	Videos are also used for macrobenthic species determination, trawling marks and bottom litter occurrence. 1 beam trawl. No more due to not fishing days availability because poor weather	
Data storage, level of analysis and dissemination (by data type)	*Nephrops* burrow counts	Storage: hard copies of files in office environment. Level of analysis: not analysed yet Dissemination: WGNEPS2023, WGBIE2023, CN_IEO Internal Report
	CTD	-
	Trawl	Storage: hard copies of files in office environment. Level of analysis: not analysed yet. Dissemination: CN_IEO Internal Report used by project ISUNEP25.
	Sediment	Storage: cold storage onboard and at the lab. Data files hard copies. Level of analysis: not analysed yet. Carried out by Benthos Research Group. Dissemination: CN_IEO Internal Report used by project ISUNEP25.
	Other	

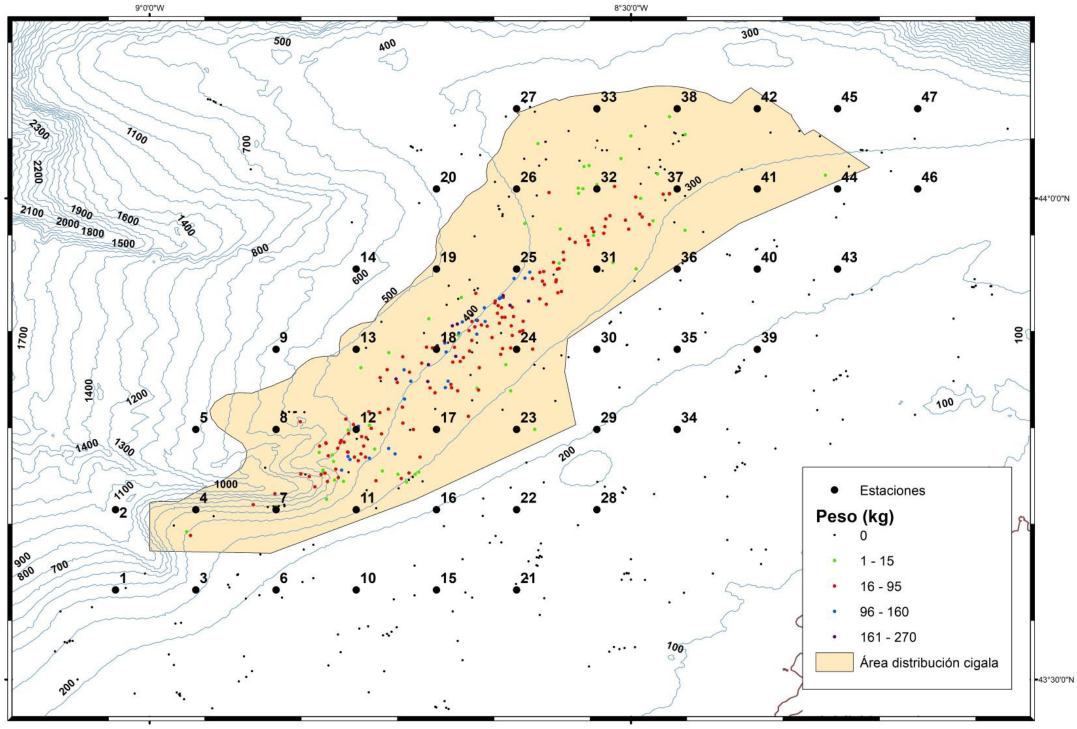

Fig.1 Map of exploratory UWTV stations.

Portugal: FU 28-29 southwest and south Portugal

Survey Name	*Nephrops* Survey offshore Portugal (NepS)		
Functional Unit	28 and 29	Ground Name	SW and S Portugal
Country	Portugal	Vessel Name	Mário Ruivo
Survey design	Grid	Previous surveys	1997 – 2004 (stratified) 2005 – 2018 (grid)
Survey code	G2913	Dates (start/end)	07/06/2022 – 03/07/2022
Nb of scientific staff	13	Nb of students	4
Objectives		Main objectives: – To estimate the relative abundance of *Nephrops* and deepwater rose shrimp for use in the assessment and advice process, with a CV (relative standard error) of less than 20%. – To study their geographical distribution in space and time. – To collect data for the determination of biological parameters (sex-ratio, length-weight relationships, maturity, growth), meet DCF sampling requirements and provide LFD time series. Secondary objectives: – To monitor the distribution and relative abundance of the accompanying fish and invertebrate species and collect biological data for selected species – To collect data for biodiversity studies and information on marine litter distribution to comply with MSFD requirements.	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, etc.)		Oceanographic data and sediments samples were not collected due to the lack of appropriate winch (still to be installed).	
Number of fishing stations (planned/completed/used in analysis)		Planned – 76 Completed – 73 Used in analysis – 73 (18 in FU 28 and 55 in FU 29)	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Second survey carried out with R/V Mário Ruivo, after her transformation for trawl survey use. Calibration not conducted. FU 28 and FU 29 fully covered.	
Distance over ground source used	Odometer	Average trawl speed	3.2 nautical miles
Gear details	Gear Type	Shrimp trawl (FGA020)	
	Codend mesh size	20 mm	
	Doors weight	500 kg	
	Floats in head/wing lines	9	
	Groundrope	Synthetic wrapped wire core + chain	
Geometry of the net monitored by		Scanmar sensors	
Trawl horizontal opening (m) / Doors and Wings spread	--	Trawl vertical opening (m)	--
Abundance/biomass index (target and secondary species)		Provisional mean estimates: *Nephrops norvegicus* – 3.476 kg or 115 ind per hour *Parapenaeus longirostris* – 7.053 kg or 866 ind per hour	
CV (Relative standard error) (target and secondary species		Provisional estimates: *Nephrops norvegicus* – 17% (for both weight and number) *Parapenaeus longirostris* – 22% and 29% for the indices in weight or number, respectively.	
Data storage, level of analysis and dissemination (by data type)		**Storage:** Hauls sampling data (data on catch by species, biological data): hard copies of data held in office environment; electronic data stored in a database on local server. **Level of analysis** – as required for ICES WG	

	Dissemination – survey report published at IPMA Survey Report Series (Relatórios de Campanha), used by WGBIE and for MSFD analyses.

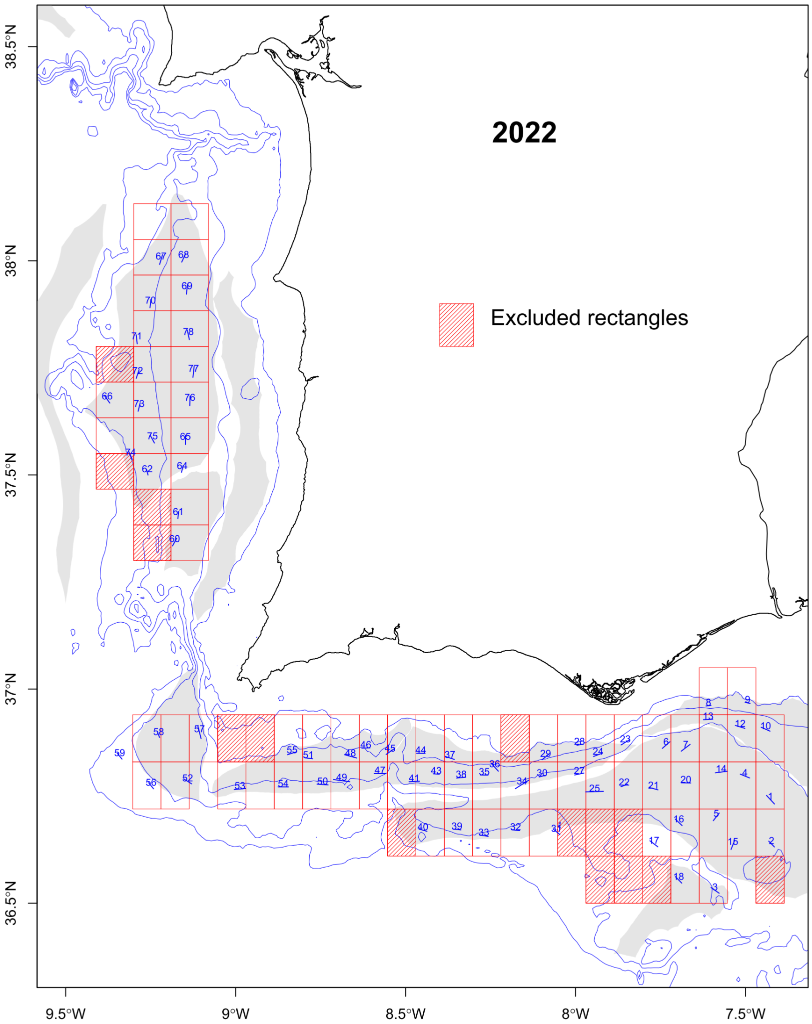

Figure 7. Sampling grid and hauls performed in June – July 2022

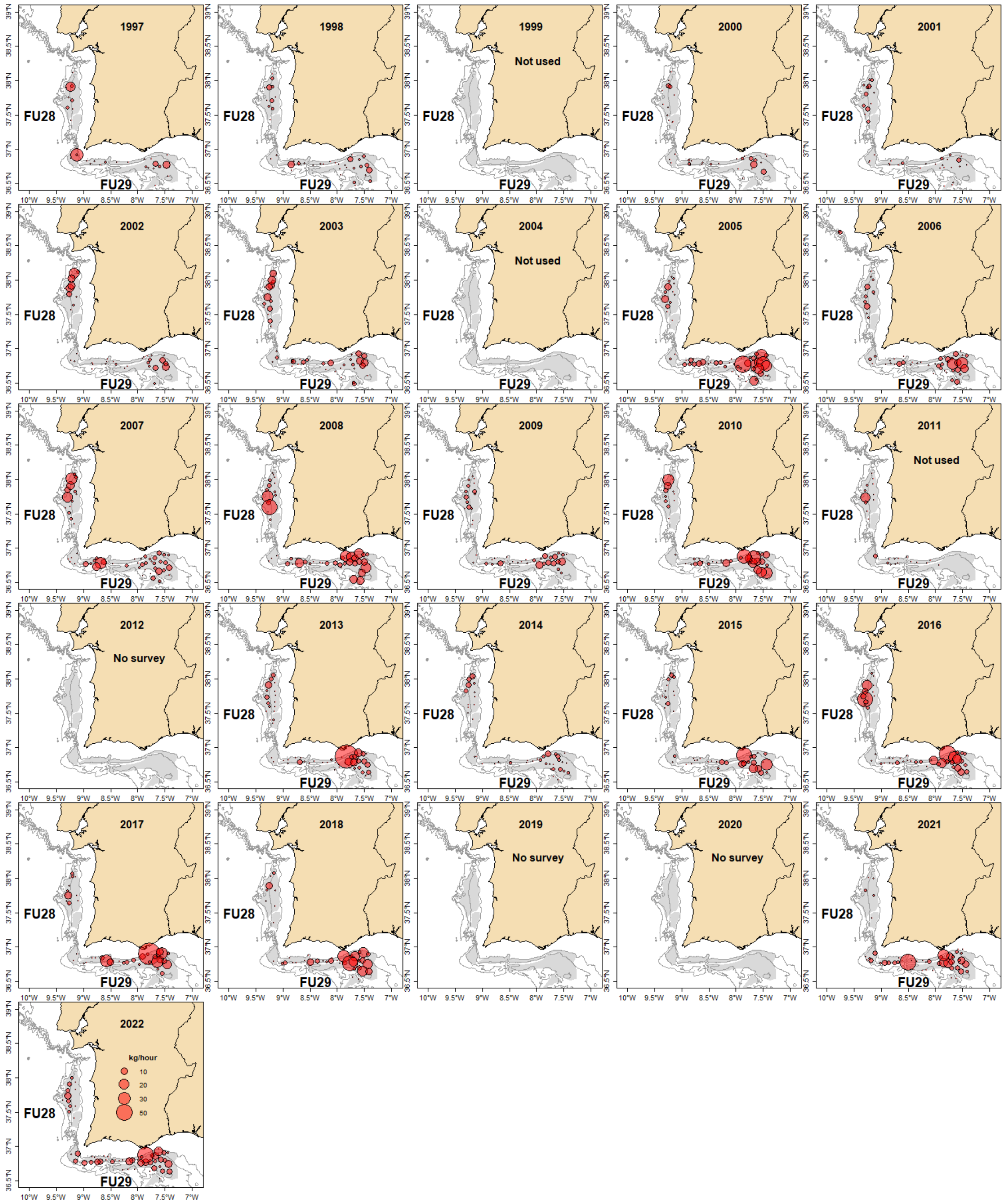

Figure 8. Biomass index (kg/hour) spatial distribution in 1997-2018 (surveys conducted with R/V "Noruega") and in 2021-2022 (survey conducted with R/V "Mário Ruivo"). Fishing grounds shaded in grey. Notes: 1) incomplete coverage in 2011 and 2021; 2) missing surveys in 2012, 2019 and 2020; 3) surveys in 1999 and 2004 conducted with a different vessel, and not included in the survey time series.

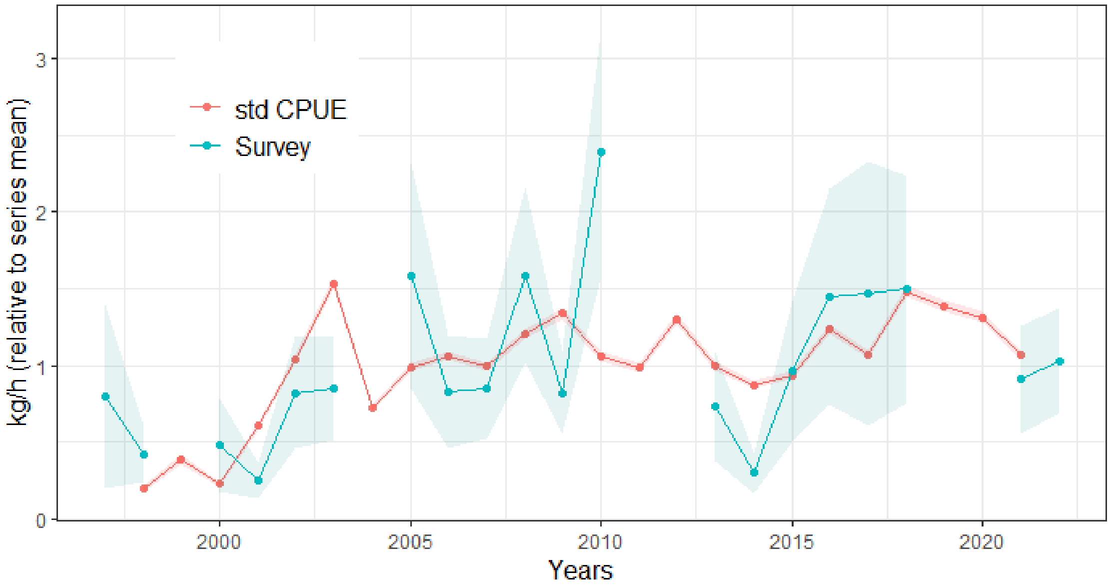

Figure 9. Time series of Norway lobster biomass indices from surveys and from the trawl fishery CPUE standardization model. Values plotted for each series are relative to its respective long-term average biomass index.

France: FU 23-24: Bay of Biscay

Spyros Fifas and Jean-Philippe Vacherot

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.

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).

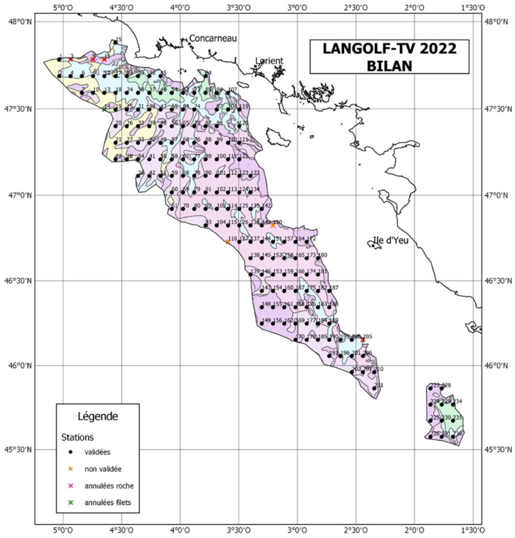

Figure 1. Spatial stratification of the Bay of Biscay according to sedimentary criteria as considered from the first UWTV survey onwards (2014) and sampling design 2022.

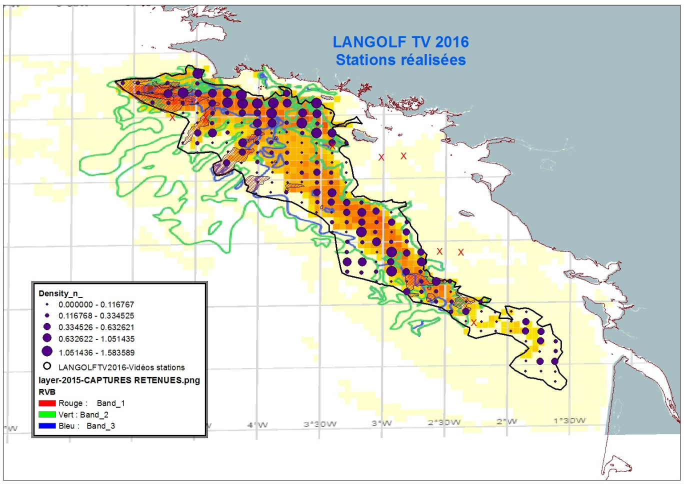

Figure 2. UWTV stations on a systematic grid and VMS data for retained catches of *Nephrops* (example of the year 2016; source: National Fisheries Direction; compilation: SIH Ifremer).

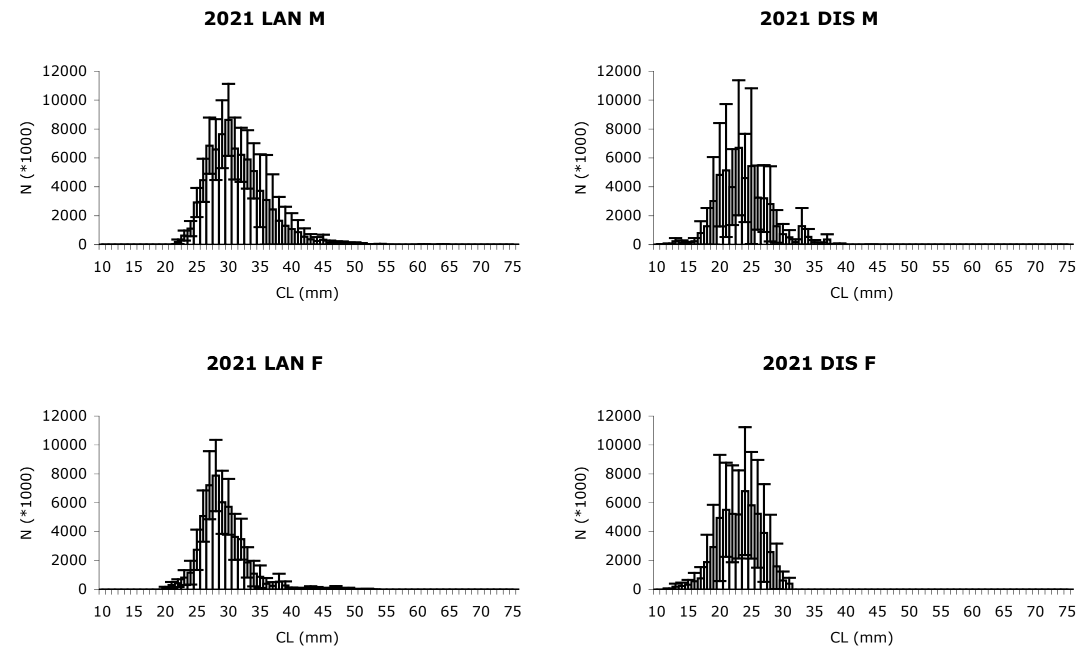

Figure 3. LFDs (size in carapace length, mm) for landings and discards by sex. Example of dataset 2021.

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 km^2 were covered by sampling instead of 11 676 km^2 of the historical five sedimentary strata). In the 2018's UWTV survey, an additional area of ◎2200 km^2 was investigated with 31 validated stations added to the 184 ones contained in the 2016's benchmarked area of 16164 km^2. In 2019 a supplementary area of ◎930 km^2 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 (10^3 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

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:

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

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:

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

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

Raising[2]

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 (/m^2) 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

[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.

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

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).

Table 2. Total number of burrows (106), densities/m² and CVs by spatial stratum and for the whole area. Years 2014-2022.

	2014 (156 stations)				*2015 (96 stations)*				*2016 (159 stations)*			
	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows
	0.356	**4157.46**	**5.83**		**0.311**	**3630.55**	**8.25**		**0.313**	**3650.67**	**7.83**	
CB	0.255	656.52	15.68	15.79%	0.120	309.55	25.66	8.53%	0.208	535.25	19.84	14.66%
CL	0.138	158.65	28.30	3.82%	0.246	284.09	18.57	7.83%	0.191	219.95	20.87	6.02%
LI	0.286	1314.56	8.69	31.62%	0.262	1203.94	16.38	33.16%	0.233	1073.44	13.67	29.40%
VS	1.336	845.69	11.05	20.34%	0.705	446.57	30.48	12.30%	0.677	428.34	17.92	11.73%
VV	0.439	1182.04	13.19	28.43%	0.515	1386.39	10.99	38.19%	0.518	1393.69	14.52	38.18%

	2017 (94 stations)				*2018 (148 stations)*				*2019 (116 stations)*			
	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows
	0.244	**2844.43**	**9.86**		**0.289**	**3376.88**	**8.43**		**0.305**	**3561.45**	**8.59**	
CB	0.122	314.48	20.10	11.06%	0.209	537.30	19.56	15.91%	0.143	367.86	25.43	10.33%
CL	0.211	243.58	14.76	8.56%	0.417	480.35	23.64	14.22%	0.325	374.87	43.28	10.53%
LI	0.169	778.94	14.75	27.38%	0.187	862.28	13.17	25.53%	0.236	1085.63	14.34	30.48%
VS	0.925	585.80	27.94	20.59%	0.678	429.35	23.30	12.71%	0.473	299.12	21.46	8.40%
VV	0.342	921.63	19.82	32.40%	0.397	1067.60	17.30	31.61%	0.533	1433.98	12.12	40.26%

	2020 (117 stations)				*2021 (146 stations)*				*2022 (145 stations)*				
	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows	nb/m²	total burrov	CV (%)	%burrows	% surf
	0.239	**2790.59**	**9.70**		**0.245**	**2860.25**	**8.34**		**0.301**	**3509.10**	**10.54**		
CB	0.070	180.46	19.18	6.47%	0.112	288.09	24.23	10.07%	0.103	263.82	29.33	7.52%	21.72%
CL	0.191	219.72	43.03	7.87%	0.202	232.60	24.87	8.13%	0.245	282.69	27.73	8.06%	9.87%
LI	0.164	755.55	17.91	27.08%	0.178	821.38	15.17	28.72%	0.195	896.03	14.48	25.53%	39.94%
VS	0.748	473.67	18.91	16.97%	0.616	390.26	25.88	13.64%	0.917	580.77	31.74	16.55%	5.42%
VV	0.431	1161.19	16.51	41.61%	0.419	1127.93	13.44	39.43%	0.552	1485.80	18.28	42.34%	23.05%

Raising including the rough sea bottom.

From 2016 supplementary area assumed to not be trawled as occupied by rough ground was also covered (Table 3). This additional stratum concentrating a moderate fishing pressure level as illustrated by VMS data was included in the five strata considered since the former trawl survey 2006-2013.

Table 3. Total number of burrows (10^6), densities/m^2 and CVs by spatial stratum and for the whole area. Years 2016-2022 after including rough sea bottom contained in the outline of the Central Mud Bank (16 164 km^2 instead of 11 676 km^2 for the five sedimentary strata sensu stricto). The total area of 16 164 km^2 was replaced by 14 640 km^2 accordingly to the 2021's WGBIE revision.

	2016 (179 stations)				*2017 (113 stations)*				*2018 (175 stations)*			
	nb/m^2	total burrows	CV (%)	%burrows	nb/m^2	total burrows	CV (%)	%burrows	nb/m^2	total burrows	CV (%)	%burrows
	0.286	**4188.80**	**7.90**		**0.229**	**3346.12**	**10.03**		**0.256**	**3751.64**	**8.20**	
CB	0.208	535.25	19.84	12.78%	0.122	314.48	20.10	9.40%	0.209	537.30	19.56	14.32%
CL	0.191	219.95	20.87	5.25%	0.211	243.58	14.76	7.28%	0.417	480.35	23.64	12.80%
LI	0.233	1073.44	13.67	25.63%	0.169	778.94	14.75	23.28%	0.187	862.28	13.17	22.98%
VS	0.677	428.34	17.92	10.23%	0.925	585.80	27.94	17.51%	0.678	429.35	23.30	11.44%
VV	0.518	1393.69	14.52	33.27%	0.342	921.63	19.82	27.54%	0.397	1067.60	17.30	28.46%
RO	0.180	538.13	31.02	12.85%	0.168	501.69	36.80	14.99%	0.125	374.75	31.11	9.99%

	2019 (139 stations)				*2020 (132 stations)*				*2021 (175 stations)*			
	nb/m^2	total burrows	CV (%)	%burrows	nb/m^2	total burrows	CV (%)	%burrows	nb/m^2	total burrows	CV (%)	%burrows
	0.275	**4029.92**	**8.19**		**0.232**	**3398.54**	**10.87**		**0.221**	**3235.76**	**8.31**	
CB	0.143	367.86	25.43	9.13%	0.070	180.46	19.18	5.31%	0.112	288.09	24.23	8.90%
CL	0.325	374.87	43.28	9.30%	0.191	219.72	43.03	6.47%	0.202	232.60	24.87	7.19%
LI	0.236	1085.63	14.34	26.94%	0.164	755.55	17.91	22.23%	0.178	821.38	15.17	25.38%
VS	0.473	299.12	21.46	7.42%	0.748	473.67	18.91	13.94%	0.616	390.26	25.88	12.06%
VV	0.533	1433.98	12.12	35.58%	0.431	1161.19	16.51	34.17%	0.419	1127.93	13.44	34.86%
RO	0.157	468.47	26.35	11.62%	0.204	607.95	41.32	17.89%	0.126	375.52	32.98	11.61%

	2022 (174 stations)			
	nb/m^2	total burrows	CV (%)	%burrows
	0.265	**3872.31**	**9.91**	
CB	0.103	263.82	29.33	6.81%
CL	0.245	282.69	27.73	7.30%
LI	0.195	896.03	14.48	23.14%
VS	0.917	580.77	31.74	15.00%
VV	0.552	1485.80	18.28	38.37%
RO	0.122	363.21	28.28	9.38%

In the period 2016-2022, the number of burrows seems to oscillate around an average level. It declined steeply between 2016 and 2017 (-20%) then increased by +12% and +7% respectively in 2018 and 2019. In 2020, a reduction of –16% was observed and a lesser decrease occurred in 2021 (-5%). In 2022, a significant increase by +20% was observed. Anyway, for any year the two more compact muddy strata (labels VS and VV) corresponding to less than 20% of the overall surface concentrate around 40-45% of the total number of burrows.

1. Correction Factors

Edge effect: the edge effect calculated on 2014's data is represented by a corrective coefficient of 1.15 and it is associated to a low uncertainty (relative precision≈11%). This value is still used for 2016-2022's data. The integration of the rough sea bottom stratum and the adoption of the HD system since 2019 suggest the necessity to update this coefficient.

Detection: a very good visibility generally characterized footage (*e.g.* in 2014, 946 minutes of reading on 1095, *i.e.* 86%, have very high quality of image) and a correction factor of 0.94 is retained.

Species identification: The coexistence between Norway lobsters (*Nephrops norvegicus*) and squat lobsters (*Munida sp.*) and a certain capacity of the second species to colonise *Nephrops* burrows affect the correction factor of the "species identification". The interaction *Nephrops* and *Munida* is not relevant for many other *Nephrops* stocks already routinely video surveyed either because of the depth (Iberic stocks, bank of Porcupine) or due to the latitude as *Munida* is more southerly spread than *Nephrops* in the NW Atlantic waters.

Video on years 2014-2022 allows to investigate the basic differences of dial activities for both species: *Nephrops* is active during a more restrictive time interval within a day whereas the activity of *Munida* is more widely spread on 24 h. The intuitively expected case of *Nephrops* activity around dawn and dusk was observed on data collected in September 2014, in May 2016, 2017, 2019 and 2021 as well as in July 2020, although 2015’s, 2018's and 2022's data showed no relevant pattern to be fitted. Moreover, for five years (2014, 2016, 2018-2020) the dominant profile reveals more dawn than dusk activity. *Munida* showed wider profile of emergence with two close study cases of minimized activity near dawn and dusk (September 2014, May 2017); at the opposite, 2016's and 2021's observations do not correspond to the same scheme whereas 2015's, 2018's and 2022's data are not relevant. Years 2019 and 2020 reveal similar pattern for both crustaceans modelled according to Gauss curves (Fig. 6 and 7). The observed active individuals fluctuated a lot: for *Nephrops* in the range 235-1369 (minimum in 2019, maximum in 2016) and for *Munida* in the range 151-2653 (minimum in 2018, maximum in 2014). It is noticeable that *Munida* was systematically represented by higher numbers in the beginning of the survey series but this feature was not verified in recent years. Combining those results on footage and trawling experimental catches (for years 2014 and 2015) on both species allow to propose species identification coefficient of 1.05, 1.10 or 1.15. The third value was retained by 2016’s WKNEP benchmark for the stock. The combination of the correction factors above provides a cumulative bias coefficient of 1.24.

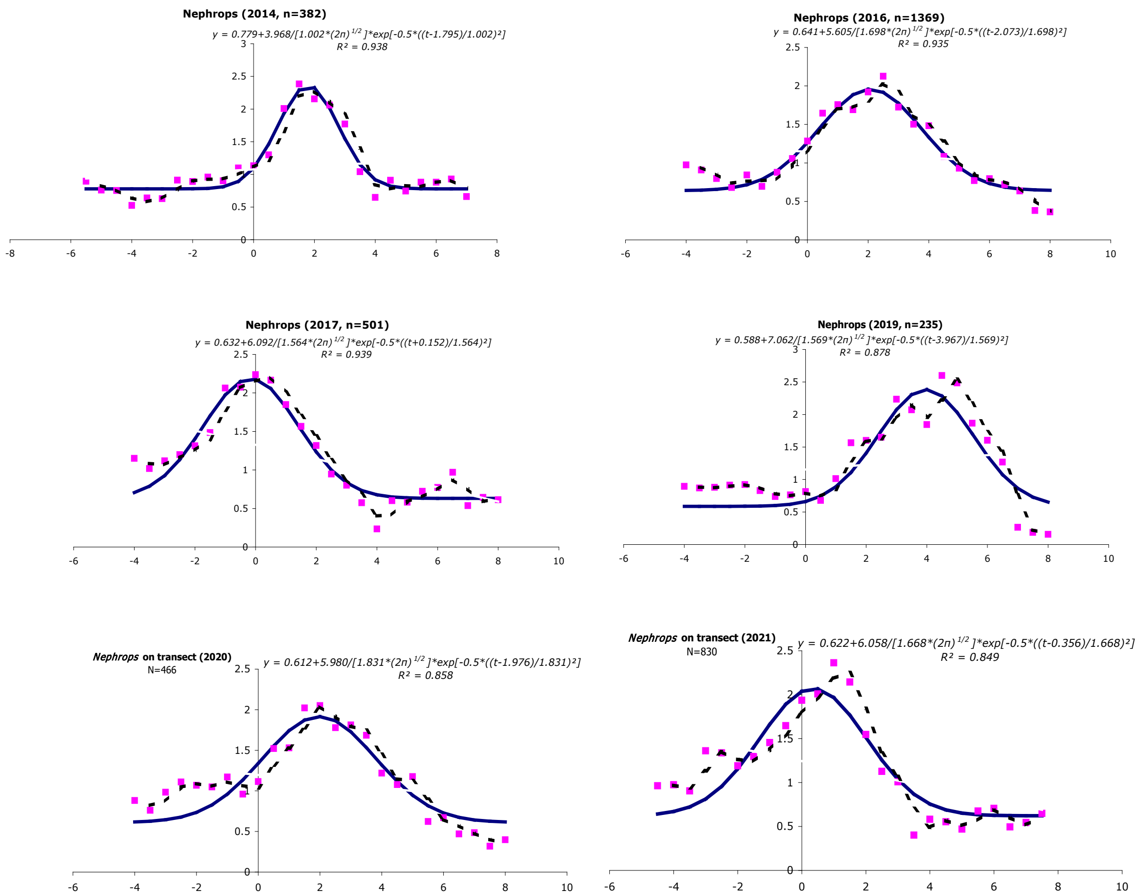

Figure 6. Relationship between standardised time of observation *vs.* sunrise/sunset and *Nephrops* activity for years with relevant pattern (2014, 2016-2017, 2019-2021). Abundance index per surface unit of video track *(broken curve: data smoothed by mobile average).*

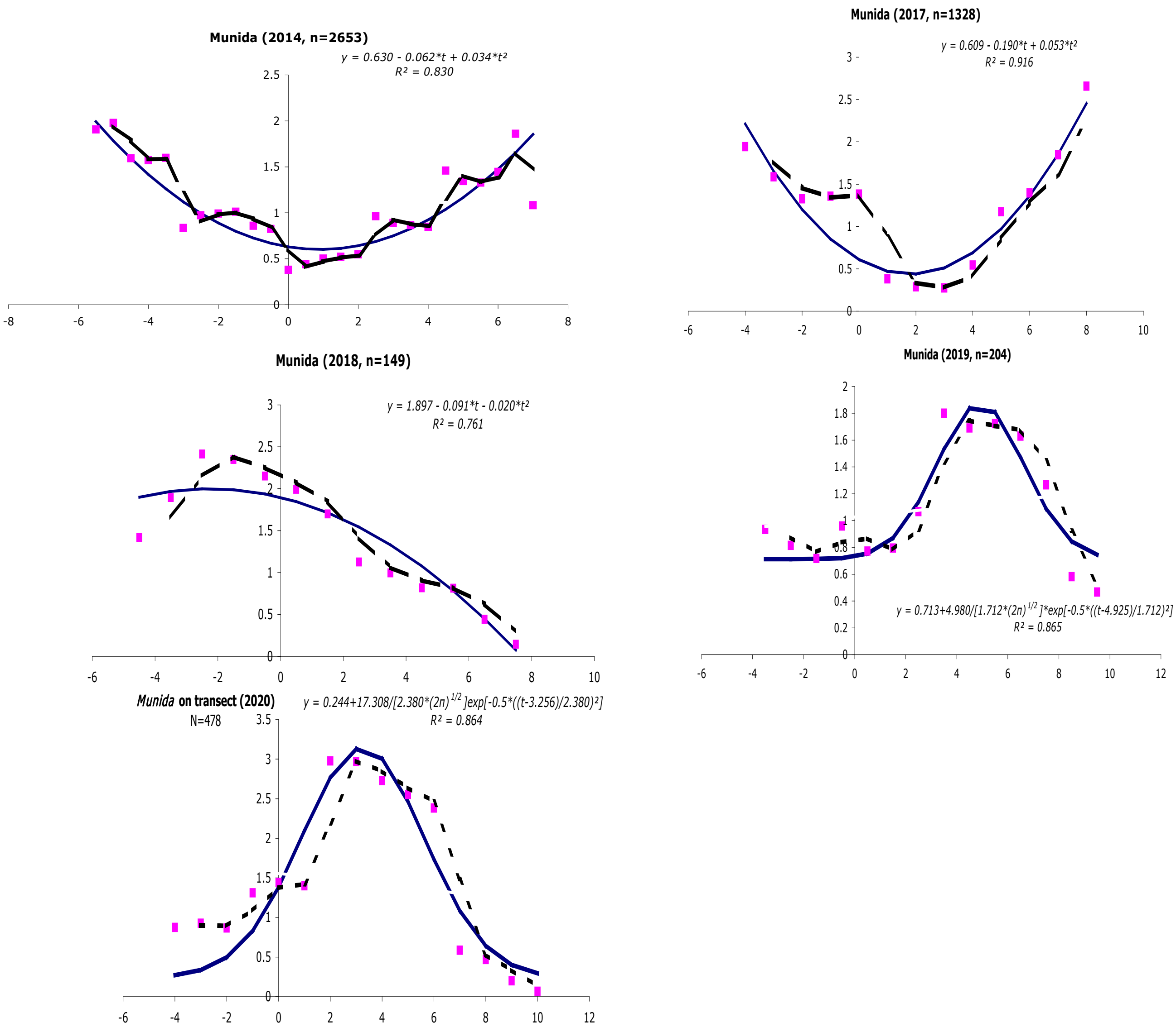

Figure 7. Relationship between standardised time of observation *vs.* sunrise/sunset and *Munida* activity for years with relevant pattern (2014, 2017-2020). Abundance index per surface unit of video track *(broken curve: data smoothed by mobile average).*

Iceland: FU 1 Off South Iceland

Jónas Páll Jónasson

Annual survey.

No survey conducted in 2022 due to budget constraints and poor status of the stock (Recruitment failure).

No survey scheduled in 2023 due to budget constraints.

See ICES. 2022. Working Group on *Nephrops* Surveys (WGNEPS; outputs from 2021). ICES Scientific Reports. 4:29. 183pp. http://doi.org/10.17895/ices.pub.19438472 for results of the previous surveys.

Italy and Croatia : Pomo Pits, Central Adriatic Sea (GSA 17)

ADRIATIC UWTV SURVEYS and Pomo monitoring activity

Martinelli M., Medvešek D., Domenichetti F., Canduci G., Giuliani G., Zacchetti L., Pieri G., Belardinelli A., Chiarini M., Guicciardi S., Grilli F., Penna P., Scarpini P., Cvitanić R., Isajlovic I., Vrgoc N.

In terms of landings, from 1990 to 2015 *Nephrops norvegicus* was the second crustacean exploited in the Adriatic Sea (Mediterranean basin), then becoming the fourth in 2020; besides, it showed a steep decreasing trend passing from 2195 tonnes in 2005 to around 482 tonnes in 2020 (FAO-GFCM 2022). In the Adriatic, *N. norvegicus* lives on muddy grounds at depths from 50m to over 400m, with important concentrations off the coast of Ancona, in the Pomo Pits area, and inside the Croatian channels (Morello et al. 2007; Russo et al. 2018).
The Pomo (or Jabuka in Croatian) Pits fishing ground, located in the central Adriatic Sea (Figure 1) and historically shared by Italian and Croatian fleets (Russo et al., 2018), is characterized by peculiar oceanographic conditions (e.g. periodic water mass renewal which can have an impact on the state of local benthic communities; Marini et al., 2016; Taviani et al., 2015). Vulnerable Marine Ecosystems indicators (as sea pens, etc.) were recorded in the area (Martinelli et al., 2013); moreover, the Pomo Pits represents one of the main nursery for *Merluccius merluccius* in the Adriatic Sea (Angelini et al. 2016) and the main spawning area for *N. norvegicus* (which supports itself and the areas south-west of it; Melaku Canu et al. 2021). Despite no genetic confirmation to date (e.g. Stevens and Jenkins 2020), the area hosts a subpopulation of *N. norvegicus* which differs from others in the Northern Adriatic due to the presence of small-sized mature individuals (Colella et al. 2018; Angelini et al. 2020). Since 2015, a series of management measures was implemented in the area by the Italian and Croatian governments, and then in 2017 the General Fisheries Commission for the Mediterranean (GFCM) established there a Fishery Restricted Area (FRA; GFCM 2017; EU 2019; GFCM 2021).
From 2009 to 2019 (except 2011 and 2018), a spring UWTV survey was conducted in the Pomo Pits area jointly by CNR-IRBIM Ancona and IOF Split, on board the CNR R/V Dallaporta (Martinelli et al. 2013, 2016, 2017; Chiarini et al. 2022a). Unfortunately, due to a combination of pandemic restrictions, R/V unavailability, and lack of funding, there have been no UWTV surveys in the area in the period 2020-2022. However, taking into account the latest applied adjustments (Martinelli et al. 2022) and the outcomes of a recent study on burrow emergence rhythms (Aguzzi et al. 2021), the Pomo Pits UWTV time series has been recently included, as a tuning index, in new modeling approaches tested for the Adriatic *N. norvegicus* stock assessment (e.g. GFCM 2022). Furthermore, trials on automatic burrow tracking and counting have also been recently conducted on the Adriatic UWTV footage (Figure 2), in the framework of Task 8.5 "Automatic Image Analysis" of the EU H2020 NAUTILOS (New Approach to Underwater Technologies for Innovative, Low-cost Ocean obServation; grant n. 101000825) project (Pieri et al. 2021).

In order to obtain demographic and biological information on *N. norvegicus* and other relevant species, trawl hauls at sunrise and sunset were also carried out by means of an experimental net during the UWTV Adriatic surveys; furthermore, the sledge was equipped with a CTD (Conductivity, Temperature, and Depth) profiler and other environmental sensors (Martinelli et al. 2017a). Since 2015, an additional autumn trawl survey has been carried out by CNR IRBIM in the western side of the Pomo Pits area (strata B, ext ITA and ext ITA north in Figure 1); in this survey the same net and sampling protocol are applied and CTD casts are as well executed (Martinelli et al. 2017b, 2019, 2020). The catch per unit effort (CPUE) datasets obtained for the period 2012-2019 were used to perform a short-term evaluation of the effects of changes in fisheries management measures that occurred in the area (Chiarini et al. 2022b). The same CPUE time series were also used, in combination with environmental information (i.e. depth, bottom temperature, salinity, oxygen saturation), to build generalized additive models (GAMs) accounting for both environmental and fishery management factors; in fact, GAMs may allow a better understanding of the local distribution and abundance variations of *N. norvegicus*, and furthermore to obtain standardized CPUE time series to be used as input for stock assessment models (Chiarini et al. 2022a). In general, the total closure to bottom trawling in the no-take area, corresponding to FRA zone A, showed a positive, albeit mostly local, effect on the CPUE of *N. norvegicus*, while depth, bottom salinity and oxygen saturation levels revealed to be the most influential environmental parameters (Chiarini et al. 2022a,b).

Experimental spring and autumns trawl surveys in the western side of the Pomo Pits area were carried out also in 2020 and 2021 to continue the medium-term evaluation of the effects of the management measures enforced (activity carried out in the framework of an agreement between the Italian Ministry of Agriculture and Forestry and CNR-IRBIM; Martinelli et al. 2021). In 2022, CNR IRBIM conducted spring and autumn sampling in the western side under the umbrella of an agreement with the Italian Institute for Environmental Protection and Research to collect information for Descriptor 6 (Sea-floor Integrity) of the Marine Strategy Framework Directive; within the latter, the possible use of historical UWTV footage to map Vulnerable Marine Ecosystems indicators was also hypothesized (Scarcella et al. 2022).

In 2021 and 2022 IOF Split carried out summer and winter surveys in the eastern side of the Pomo Pits area, using the MEDITS (Mediterranean International Trawl Survey) experimental net, which substantially confirmed a strong increase in CPUE of *N. norvegicus* in zone A of Pomo FRA, but also showed some increases on the eastern (Croatian) side of the Pomo Pits region, in the area adjacent to the no-take zone.

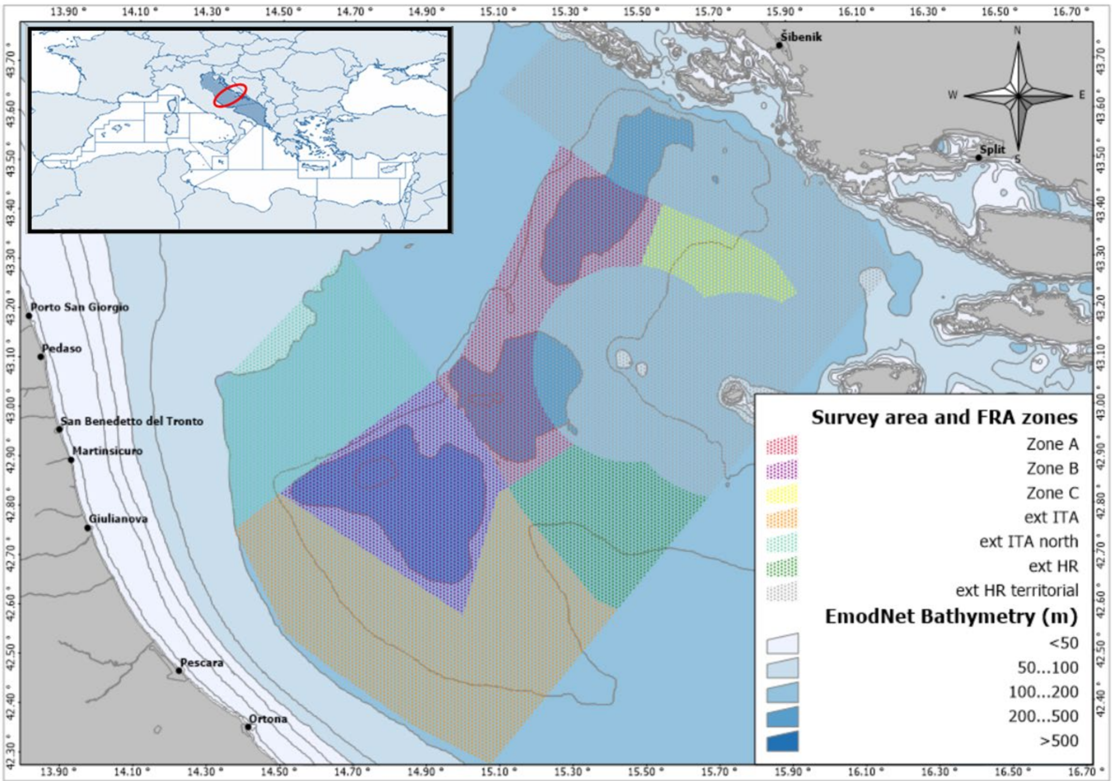

Figure 1: Map of the Pomo (Jabuka) Pits area with indication of bathymetry (EMODnet 2016) and sampling strata (including FRA zones: zone A closed to fishing activity, zones B and C subject to fisheries limitations).

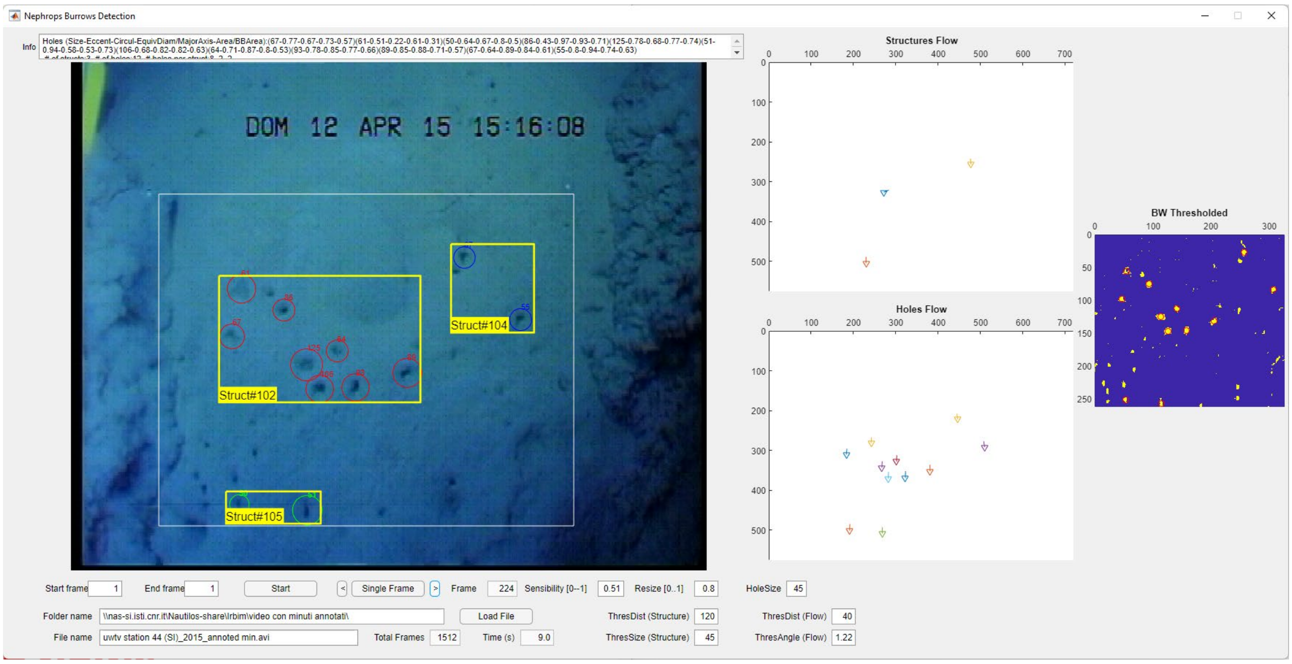

Figure 2: NAUTILOS Graphical User Interface and trials of structure detection based on optical flow and image tracking carried out on Pomo Pits UWTV footage.

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Annex 5: 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) 2022.
- Kai Wieland, Patrik Jonsson: *Nephrops* UWTV survey in the Skagerrak and Kattegat (FU 3&4) in 2022.
- Cristina Silva and Bárbara Serra-Pereira: *Nephrops* survey Offshore Portugal Nep S (FU 28-29) Trawl Surveys.
- Adrian Weetman: Marine Scotland Science 2022 UWTV surveys summary.
- Jónas Páll Jónasson, Julian Burgos, Arnþór Kristjánsson, Anna Ragnheiður Grétarsdóttir, Arnar Björnsson, Auður Bjarnadóttir & Hjalti Karlsson: UWTV survey and *Nephrops* advice in Icelandic waters.
- Kai Wieland: Danish UWTV survey Off Horns Reef.
- Mathieu Lundy: AFBI Western Irish Sea *Nephrops* Grounds (FU 15) 2022 UWTV Survey and Trawl survey.
- Mikel Aristegui et al.: 2022 Update on Marine Institute Ireland *Nephrops* UWTV surveys.
- Nikolai Nawri : CEFAS Survey results and assessment summary for FU 6 and FU14.
- Martinelli M., Medvešek D., Chiarini M., Domenichetti F., Canduci G., Zacchetti L., Guicciardi S., Grilli F., Penna P., Giuliani G., Scarpini P., Belardinelli A., Cvitanić R., Isajlovic I., Vrgoc N.: Adriatic UWTV surveys and Pomo monitoring activity.
- Isabel González- Herraiz and Julio Valeiras: Update on new UWTV survey in FU 25.
- Niall Fallon: Update to Geostatistical estimations to improve precision of abundance estimates from FU 12.
- Mikel Aristegui: *Nephrops* abundance estimates with sdmTMB.
- Maddalena Tibone: Developing novel eDNA metabarcoding tools for in situ fisheries and megafauna biodiversity.
- Jacopo Aguzzi and Damianos Chatzievangelou :Coordinated, intelligent platform networks for the 4D monitoring of *Nephrops* grounds
- Atif Naseer: Update on PhD research work on N*ephrops norwegicus* detection and classification from underwater videos using deep neural network.
- Spyros Fifas and Jean-Philippe Vacherot: Ifremer FU23-24 *Nephrops* Analysis of UWTV Survey 2022 results and overview of stock status and technical operations.

- Mikel Aristegui: Regulations to protect sensitive deep water habitats FU 16.
- Jónas Páll Jónasson: Trawl Marks and other Biological Data Iceland.
- Kai Weiland: Update from WKUSERS2 workshop.
- Kai Weiland: Results from Danish Reference set (FU3&4) evaluation process.
- Patrik Jonsson: Results from Swedish Reference set (FU3&4) evaluation process.
- Jennifer Doyle on behalf of Jean-Philippe Vacherot: Results from French Reference set (FU 23-24) evaluation process.