WORKING GROUP ON NEPHROPS SURVEYS (WGNEPS; outputs from 2019)

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Contents

i Executive summary

The Working Group on Nephrops Surveys (WGNEPS) is the international coordination group for Nephrops underwater television and trawl surveys within ICES. This report summarizes the national contributions on the results of the surveys conducted in 2019 together with time series covering all survey years, problems encountered, data quality checks and technological improvements as well as the planned for survey activities for 2020. In total, 19 surveys covering 25 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.

A new survey summary template by FU/GSA has been developed and adopted for future reports, which shall allow the data end users to extract the most relevant information on the survey results in a more easy way.

Necessary actions and reviewer comments were addressed on the draft version of the Series of ICES Survey Protocols (SISP). Similarly, the working group reviewed the specifications for a Nephrops underwater TV database to be established at the ICES data centre and agreed on further action on this issue.

First results from field studies on behaviour aspects of burrow emergence using bottom cages monitored by an automated camera system and on short-range migration using acoustic tracking are now available.

Comparison of standard definition (SD) and high definition (HD) indicates the change to HD system mounted with a different camera angle may affect the detection rate and may thus require a revision of bias correction factors. New image reviewing software allows an easier way of annotation of burrows than previous mosaicking methods, which has further advantages for interpreting the results from different counters and for providing quality assured material for deep learning methods. The WG members agreed to collect information on burrow diameter size using HD images and burrow annotation or mosaicking software because a change in the burrow size distribution may indicate recruitment events and the size of the burrow has an effect on bias correction factors in general.

Automatic burrow detection based on deep learning methods applied to a test data set with annotated burrow counts from a HD camera system showed promising results. The WG members were encouraged to provide more material with annotated burrow counts for further development of machine learning tools.

ii Expert group information

Expert group name	Working Group on *Nephrops* Surveys (WGNEPS)
Expert group cycle	Multiannual fixed term
Year cycle started	2019
Reporting year in cycle	1/3
Chair(s)	Jennifer Doyle, Ireland
Meeting venue(s) and dates	12-14 November, Split, Croatia (20 participants)

WGNEPS attendees in Split (6 WG members joined part time via Skype)

1 Survey coordination (ToR a)

In total, 19 surveys covering 25 functional units (FU's) in the ICES area and 1 geographical sub-area (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 are provided in annex 3.

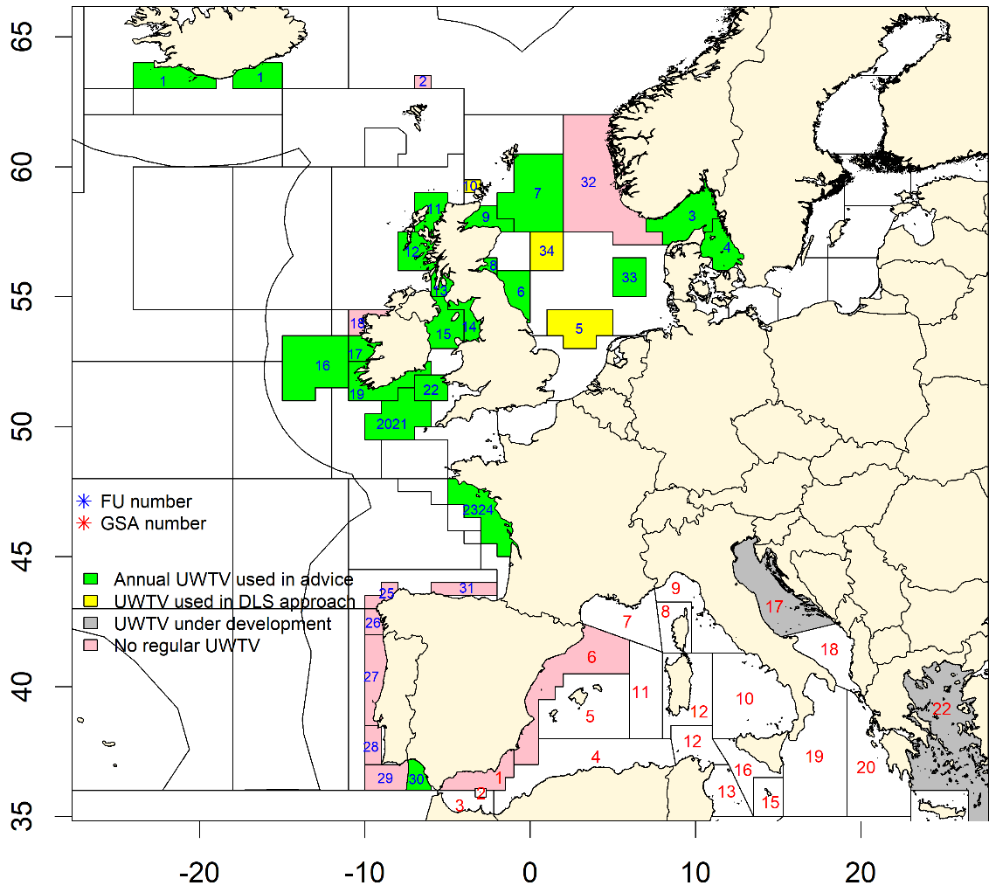
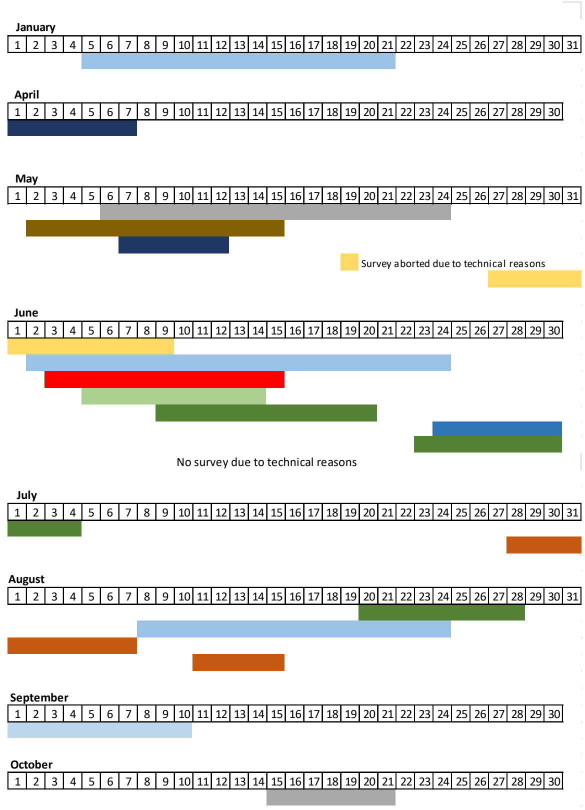


Figure 1.1 *Nephrops* UWTV survey coverage in 2019 (FU: Functional Unit, GSA: Geographical Sub Area, DLS: Data Limited Stock).

An overview over the timing of the survey conducted in 2019 and the tentative survey schedule for 2020 is given in Figure 1.2. Time series of *Nephrops* abundance for the single FU's are shown in Figure 1.3a-c.

2019:

Institute	Survey Type	Survey Area	Vessel
MSS-Scotland	UWTV	West Coast Sealochs	Alba na Mara
DTUAqua-Denmark	UWTV	FU3&4	Havfisken
Italy/Croatia	UWTV	Pomo Pit - GSA17	G.Dallaporta
Ifremer-Lorient	UWTV	FU23-24	Celtic Voyager
DTUAqua-Denmark	UWTV	FU33	Havfisken
SLU-Sweden	UWTV	FU3&4	Asterix
SLU-Sweden	UWTV	FU3&4	Havfisken
SLU-Sweden	UWTV	FU3&4	Havfisken
MSS-Scotland	UWTV	FU7, 11-13, 34, 10	Scotia
IEO-Cadiz	UWTV	FU30 (and FU 29 exploratory)	Angeles Alvarino
HAFRO-Iceland	UWTV	FU1	Bjarni Sómundsson
MI-Ireland	UWTV	FU16, FU17	Celtic Voyager
CEFAS-UK	UWTV	FU6	Endeavour
MI-Ireland	UWTV	FU19, FU20-21, FU22	Celtic Voyager
IPMA-Portugal	Trawl	FU28-FU29	Noruega
MI-Ireland	UWTV	FU19, FU20-21, FU22	Celtic Voyager
AFBI-Belfast	UWTV	FU15 and FU14	Corystes
MI-Ireland	UWTV	FU19, FU20-21, FU22	Celtic Voyager
MSS-Scotland	UWTV	FU8, FU9	Alba na Mara
AFBI-Belfast	UWTV	FU15 and FU14	Corystes
AFBI-Belfast	Trawl	FU15 and FU14	Corystes
MSS-Scotland	UWTV	FU8, FU9	Alba na Mara
Italy/Croatia	Trawl	Pomo Pit - GSA17	G.Dallaporta



2020:

Institute	Survey Type	Survey Area	Vessel
MSS-Scotland	UWTV	West Coast Sealochs	Alba na Mara
DTUAqua-Denmark	UWTV	FU3&4	Havfisken
Ifremer-Lorient	UWTV	FU23-24	Celtic Voyager
Italy/Croatia	UWTV	Pomo Pit - GSA17	G.Dallaporta
Ifremer-Lorient	UWTV	FU23-24	Celtic Voyager
DTUAqua-Denmark	UWTV	FU33	Havfisken
IEO-Cadiz	UWTV	FU30	Angeles Alvarino
SLU-Sweden	UWTV	FU3&4	Svea
IEO-Cadiz	UWTV	FU30	Angeles Alvarino
HAFRO-Iceland	UWTV	FU1	Bjarni Sómundsson
MI-Ireland	UWTV	FU16, FU17	Celtic Voyager
CEFAS-UKE&W	UWTV	FU6	Endeavour
MSS-Scotland	UWTV	FU7, 11, 12, 13, 34	Scotia
IPMA-Portugal	Trawl	FU28-FU29	*new vessel*
MI-Ireland	UWTV	FU16, FU17	Celtic Voyager
AFBI-Belfast	UWTV	FU15 and FU14	Corystes
MI-Ireland	UWTV	FU19, FU20-21, FU22	Celtic Voyager
MI-Ireland	UWTV	FU19, FU20-21, FU22	Celtic Voyager
MSS-Scotland	UWTV	FU8, FU9	Alba na Mara
SLU-Sweden	UWTV	FU3&4	Svea
AFBI-Belfast	Trawl	FU15 and FU14	Corystes
SLU-Sweden	UWTV	FU3&4	Svea
MSS-Scotland	UWTV	FU8, FU9	Alba na Mara
Italy	Trawl	Pomo Pit - GSA17	G.Dallaporta

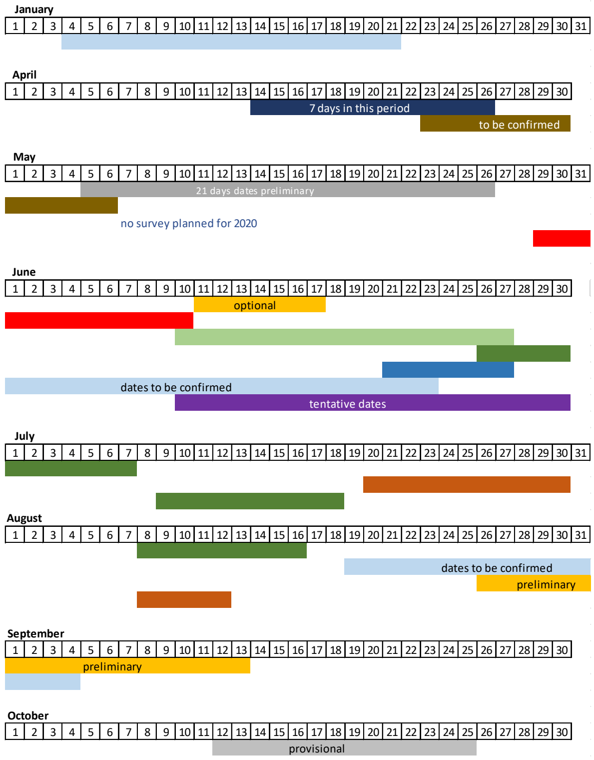


Figure 1.2 *Nephrops* surveys conducted in 2019 and survey schedule for 2020.

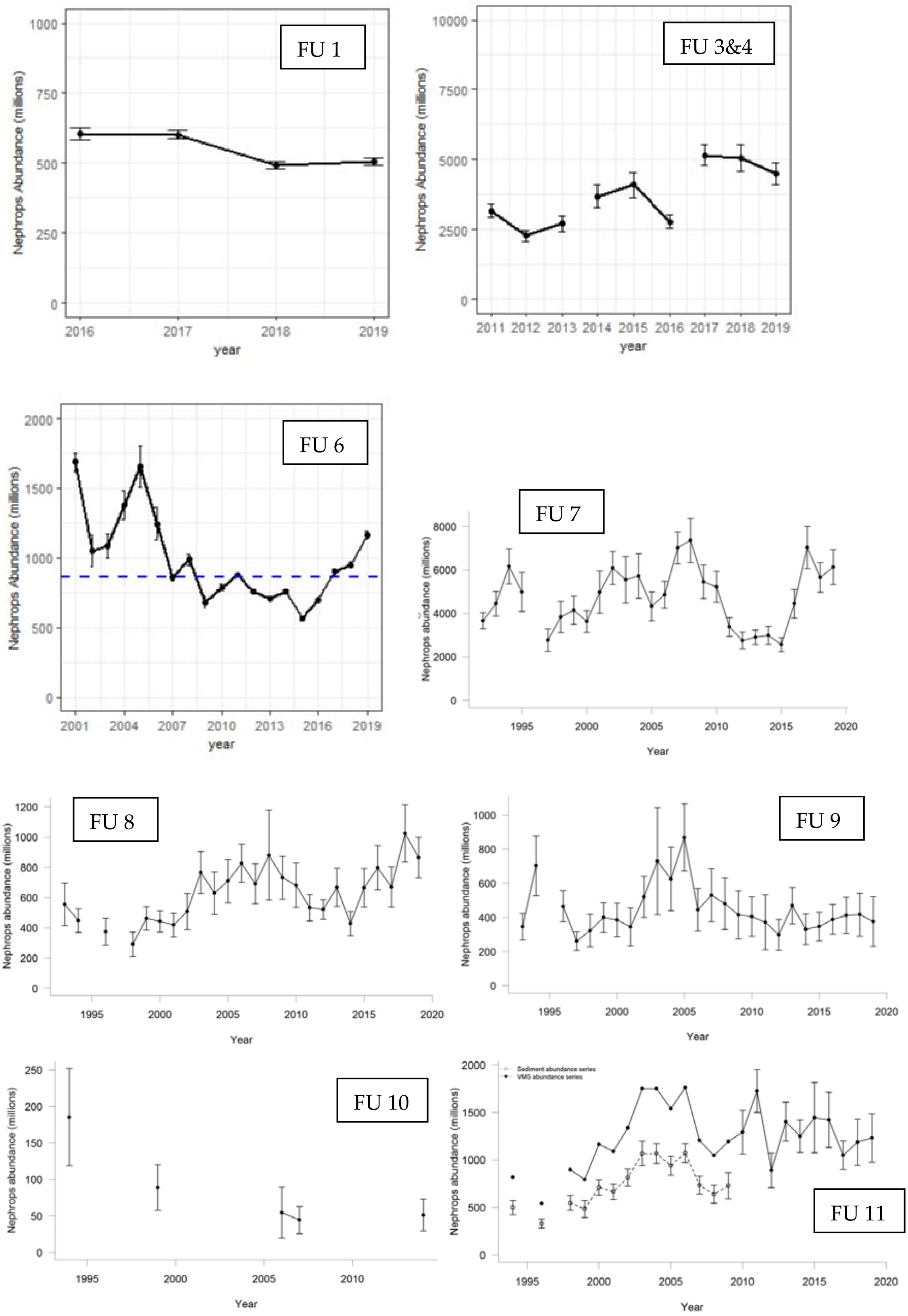


Figure 1.3a *Nephrops* abundance (with 95 % confidence interval) in FU 1, FU 3&4 (breaks indicate extension of the survey area), FU 6 (dashed line shows proxy for MSY Btrigger), FU 7, FU 8, FU 9, FU 10 and FU 11.

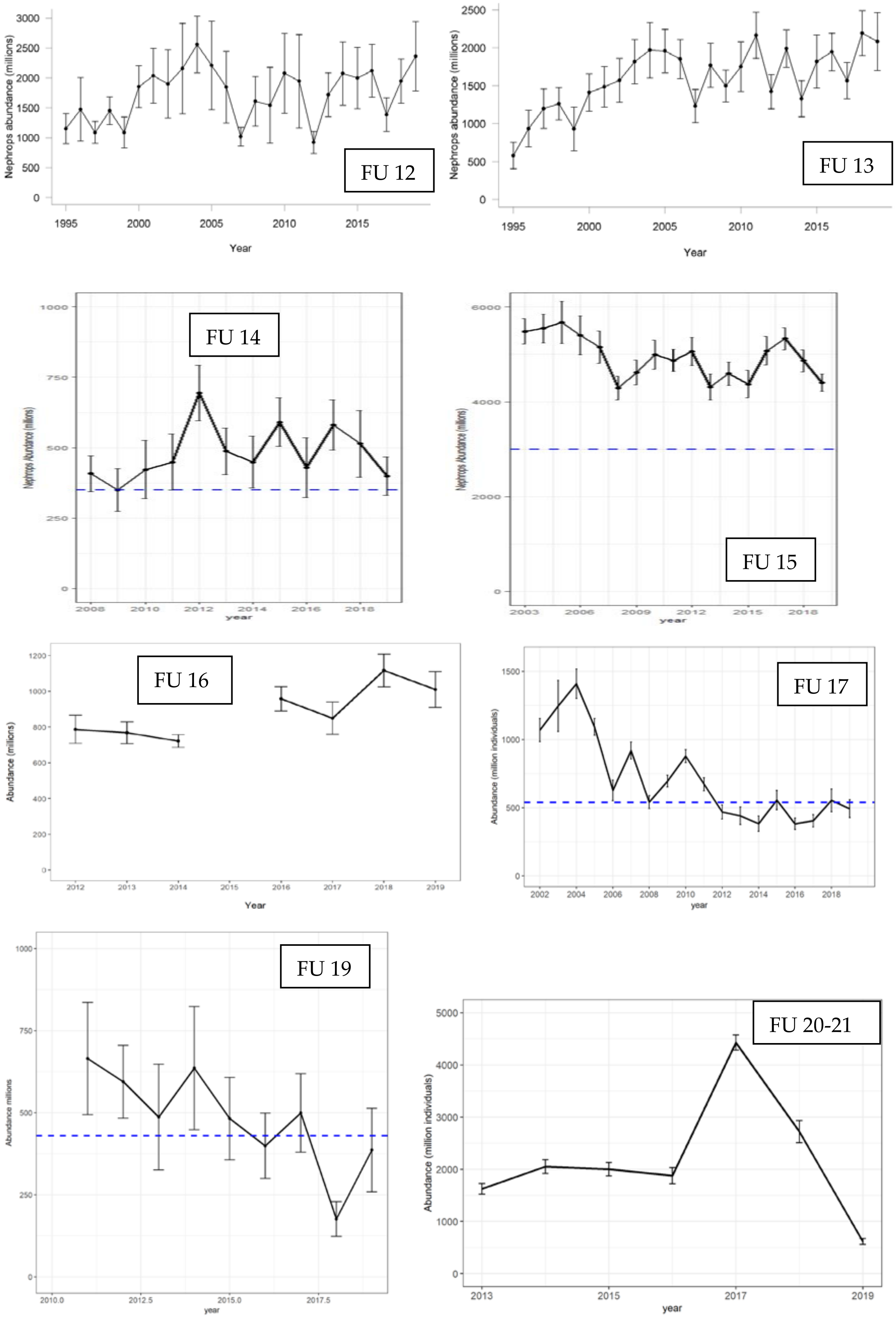


Figure 1.3b *Nephrops* abundance (with 95 % confidence interval) in FU 12, FU 13, FU 14, FU 15, FU 16, FU 17, FU 19 and FU 20-21, and FU 22 (dashed lines show proxy for MSY $B_{trigger}$).

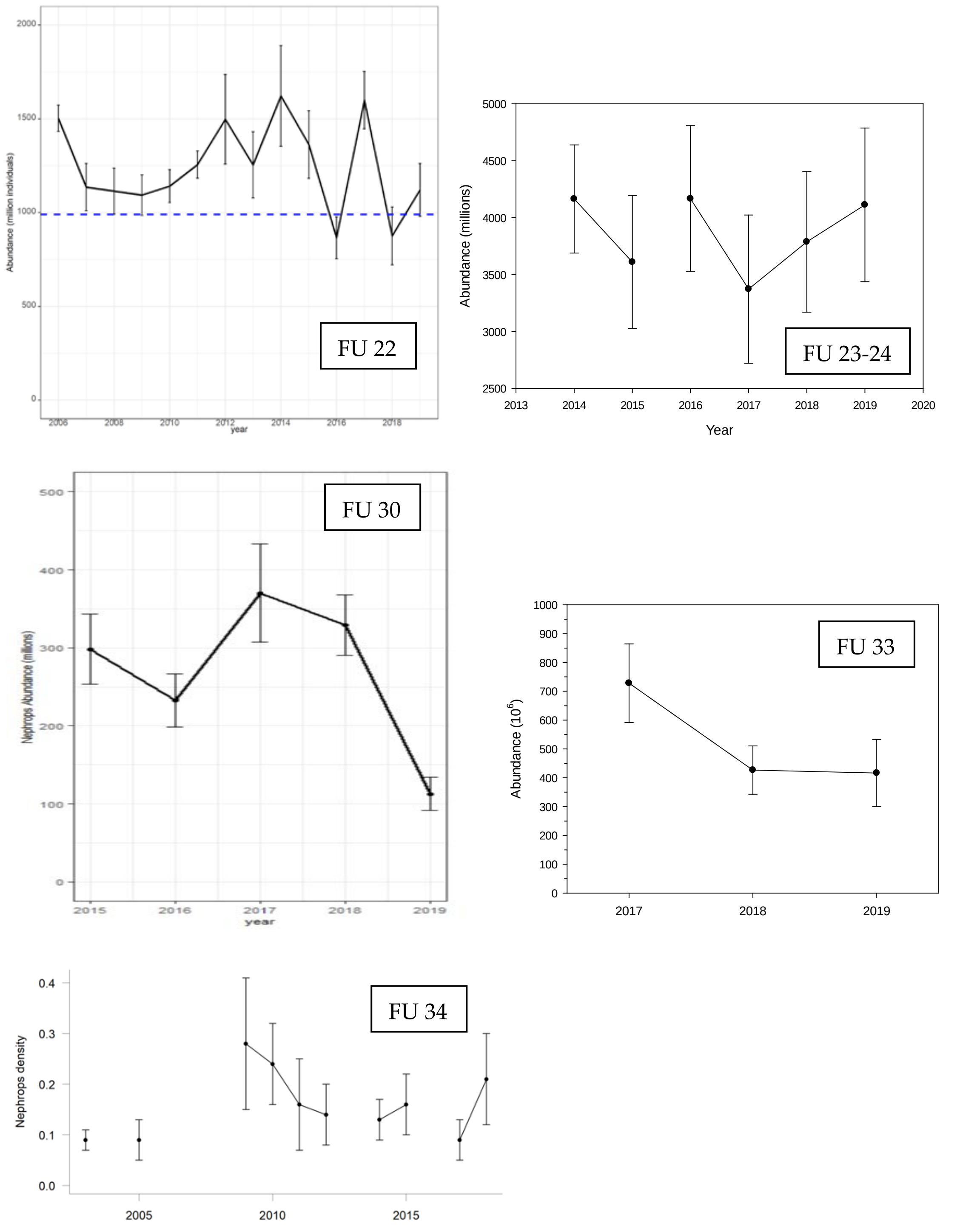


Figure 1.3c *Nephrops* abundance (with 95 % confidence interval) in FU 22 (dashed line shows proxy for MSY $B_{trigger}$), FU 23-24 (break indicate extension of survey area), FU 30, FU 33 and FU 34 (Density plot instead of abundance plot because Data Limited Stock).

Several institutes have moved from standard definition (SD) to high definition camera systems and a comparison of SD and HD data indicates the change to HD system mounted with a different camera angle may affect the detection rate and may thus require a revision of bias correction factors. Hence, a new ToR (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) has been added to the WGNEPS work plan.

The conclusions for future work are as follows:

- WGNEPS recommends continuing with the use of high definition camera systems and still images with the objective to mosaic images so that deep learning algorithms can be developed in future to identify features.
- WGNEPS recommends promoting and facilitating when possible on UWTV surveys, staff exchange from national laboratories.
- WGNEPS recommends promoting and facilitating when possible on UWTV surveys, staff exchange from other institutes who may use survey data.

WGNEPS recommends that national laboratories invest effort in calculating mean burrow size for specific grounds. The edge effect calculation is based on field of view (FOV) and burrow diameter. Mean burrow diameter can vary a lot over time for most grounds and this could potentially have an impact on the edge effect.

2 Technological developments (ToR d)

2.1 Creel fishing and acoustic tracking trials in the No-Take zone off Palamós-Roses (Northwester Mediterranean Sea) at 350-420 m depth

(Aguzzi J., Navarro J., Bahamon N., García J.A., Rotllant, G., Gomáriz S., Masmitja I., Vigo M., Carreras M., del Río J., Company J.B.; Instituto de Ciencias del Mar (ICM-CSIC), Barcelona, Universidad Politécnica de Cataluña (UPC), Barcelona, University of Girona (UdG), Girona, Spain)

The OBSEA as testing site for acoustic tracking technologies

Fixed-point cabled observatories provide highly-integrated biological and environmental data measurements that are continuous (i.e. benefitting from nearly unlimited power supply), and at very high frequencies, allowing species counts to be corrected by intrinsic species-specific biorhythmic fluctuations in response to environmental cycles (reviewed by Aguzzi et al., 2012; Danovaro et al., 2017). The dataset of images acquired by the camera installed on the OBSEA observatory (www.obsea.es) was used to track burrow emergence in 3 *Nephrops norvegicus* specimens (**Figure 2.1.1**), hosted in artificial burrows (i.e. the deployment depth of the infrastructure is shallower than the populations range of distribution in the Mediterranean) (**Figure 2.1.2**).




Figure 2.1.1. Images of the artificial reef area where *Nephrop*'s burrowing behavioural video-observations and creeling capture tests were performed at 20 m depth, off Vilanova I la Gertrú (Barcelona, Spain).

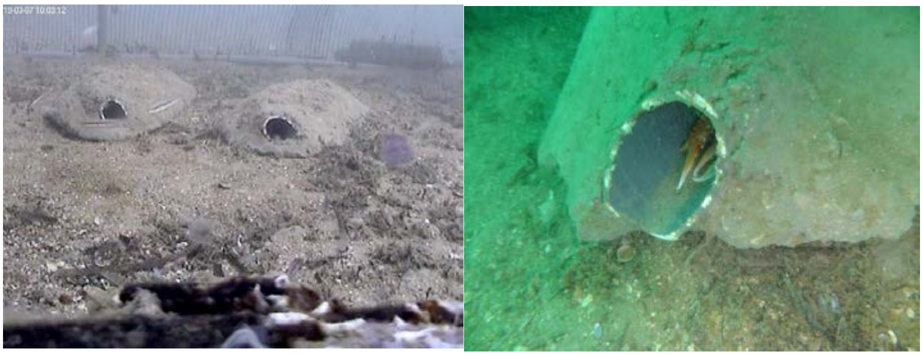


Figure 2.1.2. Images of the created enclosure in PVC material holding a contention net plus PVC tunnels embedded in concrete material, as deployed in front of the small satellite camera of the OBSEA platform. A frame depicting an animal in "door-keeping" behaviour (*sensu* Aguzzi et al., 2007) is also reported.

Nephrops individuals were released in February 2019, when the water superficial temperature is below 14 ºC (close to the optimum temperature for this crustacean). Ten individuals were released by a canister (**Figure 2.1.3**). At the end of the experiment, all animals were eliminated by natural predators (probably an octopus) and their corpses were visible in the enclosure area.

Figure 2.1.3. The canister and the presence of alive and dead animal in the OBSEA monitored enclosure. *Nephrops* specimens were also endowed with plastic black and white geometric tags to facilitate automated video-imaging approaches to track their movement (procedure yet to be developed).

All the behavioural information is being currently processed, in order to evaluate tracking procedures of utility for other ongoing actions such as the EMSO-Link Transnational Access (TNA) Project "SmartLobster" at the other coastal video-cabled observatory, SmartBay in the Galway Bay area (www.smartbay.ie; Dr. A Berry as IP), as one of the major fishery ground for the species in the European Atlantic. In that project, Smartbay camera and a new autonomous imaging device (Marini et al., 2018) are being used for monitoring the burrow emergence behaviour in N. *norvegicus*, through a continuous day-night video and multiparametric environmental data collection, in collaboration with the Irish members of the WGNEPS (Dr. C. lordan and Dr. J. Doyle).

The field acoustic tracking

Nephrops individuals (n=33) were tagged with VEMCO transmitters connected by cyanoacrylate on the upper part of the cephalothorax. These tags are capable to reveal the position of each animal, since they operate on unique individualized frequencies (Rotllant et al., 2015). Tagged animals were deployed in June 2018 at 350-420 m depth, in a no take zone off Palamós-Roses Coast (**Figure 2.1.4**). The deployment area was equipped with 4 mooring lines, each holding a receiver for tracking signal presence (emergence)-absence (burial) and for triangulating animals' movement (competition for burrows and spatial movements) and efficiency in restoration procedures (i.e. tracking displaced ranges tom better tune the no-take zone surface area.

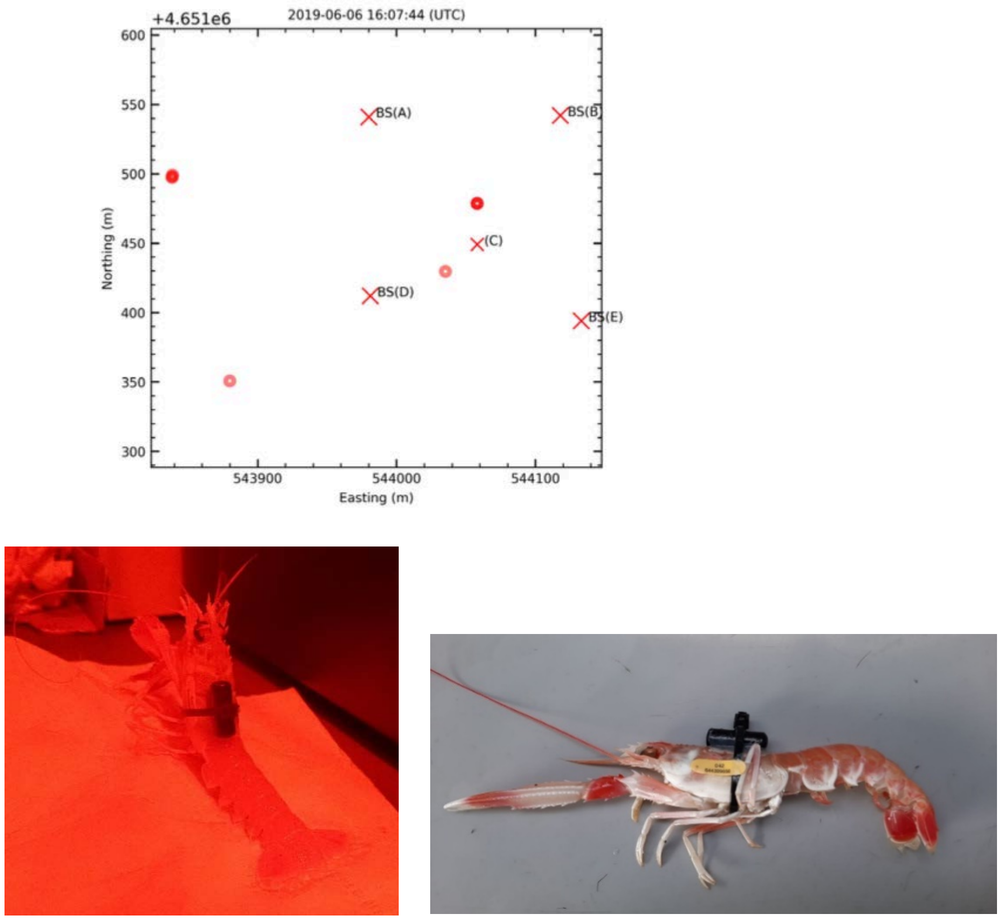


Figure 2.1.4. *N. norvegicus* with a eTag attached. The moored VEMCO listening model asset is also presented. Map of coordinates for the deployed mooring asset to track burrow emergence behaviour (x: deployed GPS point at Surface for each mooring; o: acoustically estimation of the position on the bottom).

All tagged individuals were detected and their movement tracked over a period of 4 months until the hydrophones retrieval in November the 8th of 2019. Time series of data are about to be extracted and then elaborated.

The AUV acoustic monitoring testing

A trial to track the presence of animals outside the moored polygon was performed with the Autonomous Underwater vehicle (AUV) Girona 500 (https://cirs.udg.edu/auvs-technology/auvs/girona-500-auv/) (**Figure 2.1.5**). This is a reconfigurable platform designed for a maximum operating depth of up to 500 m. The vehicle is composed of an aluminium frame which supports three torpedo-shaped hulls of 0.3 m in diameter and 1.5 m in length as well as other elements like the thrusters. This design offers a good hydrodynamic performance and a large space for housing the equipment, while maintaining a compact size which allows to operate the vehicle from small boats. The platform was equipped with a VEMCO listening unit (**Figure 2.1.4**), and carried out progressively growing concentric trajectories at 35 m depth above the monitored bottom area. That trialling was also repeated by a ROV device, the Liropus 2000, which explored the area in order to track animals' presence but also performed kriging dives to cover the whole area and determine burrow density and spatial distribution. Both the ROV (**Figure 2.1.5**) and the AUV trials showed negative results given the interference of thrusters' noise with the weaker emission intensity of VEMCO tags, according to the flying depth. This will be reduced in future cruise tests.

Figure 2.5. The Girona 500 platform and the Liropus 2000 ROV, plus a screen of envisioned seabed surface with *Nephrops* tunnel systems.

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Rotllant, G., Aguzzi, J., Sarria, D., Gisbert, E., Sbragaglia, V., Del Río, J., Simeó, C.G., Mànuel, A., Molino, E., Costa, C. & Sardà, F. 2015. Movement patterns of adult spiny lobster (*Palinurus mauritanicus*) and spider crab (*Maja squinado*) by acoustic tracking in an artificial reef. Hydrobiologia 742: 27–38. DOI: 10.1007/s10750-014-1959-5.

2.2 *Nephrops* norvegicus detection and classification from underwater videos using Deep Neural Network

(Atif Naseer)

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 species in underwater, one need to identify these patterns and judge the availability of *Nephrops*. The *Nephrops* burrows are very specific in their characteristics. Some of the major characteristics of burrows are:

At least one burrow opening is usually distinctly crescentic (half-moon) in shape. Where the angle of view permits sight of the tunnel beyond this opening, the angle of descent is usually shallow.

There is often evidence of expelled sediment, usually in a broad delta-like 'fan' at the burrow opening, and scrapes and tracks are often apparent.

Nephrops may be present (either in or out of burrow).

The objective of this research project is to develop a deep learning model to automatically detect, classify and count the *Nephrops* burrows. To achieve A deep learning based automatic system to detect, classify and count the *Nephrops* Burrow complexes will be developed.

The proposed work is using current state-of-the-art Deep neural networks for objects detection and classification. To improve the detections the models, require some fine tuning and addition of more layers. In this work, the *Nephrops* surveys from Cadiz and Ireland are analysed. The initial results show some good true positive detection from Cadiz and Ireland data.

The system main objective is to develop an auto detection mechanizm to classify and count the *Nephrops* burrows systems. Following are the main phases that are required to achieve the objective.

Data Preparation

The data used for experimentation and model training is from Cadiz and Ireland stations. The proposed deep learning model requires homogeneous data for training. The data collected from Cadiz is in the form of High Definition videos from the survey of 2018 and 2019.The duration of each video is 9-11 minutes. Each video is 25 frames per seconds. An individual video consists of 15000 frames on average. The data collected from Ireland is in the form of HD quality images. More than 1000 images were collected from Ireland. Table 2.2.1. Shows the raw dataset and its attributes.

Table 2.2.1: Dataset Attributes

Station	Year	Videos	Images
Cadiz	2018	100 minutes	150,000
Cadiz	2019	100 minutes	150,000
Ireland	2019	NA	1650

Table 2.2.2. Shows the annotated images of each station from Ireland and Cadiz that will be used in the model training and testing. Only 2018 survey of Cadiz is used in this dataset preparation. Total seven stations are annotated from Cadiz and recorded 266 annotated images. From Ireland survey, seven stations are annotated and recorded 1133 annotated images.

Table 2.2.2: Dataset Preparation

Cadiz Dataset		Ireland Dataset	
Station*	Annotations	Station	Annotations
RF01	42	Stn1	141
RF03	75	Stn10	201
RF04	34	Stn11	145
RF05	31	Stn15	179
RF07	13	Stn16	154
RF08	36	Stn26	155
RF09	35	Stn27	158
Total	266	Total	1133

Model Training

In model training phase, a deep neural model will be trained using the prepare dataset. Following are the steps required for training a model.

To train a deep neural model, the data should be divided into train, validate and test. Table 2.2.3. shows the distribution of this Cadiz and Ireland dataset.

Table 2.2.3: Dataset Distribution

Cadiz Dataset			Ireland Dataset		
Training Images	Validation Images	Testing Images	Training Images	Validation Images	Testing Images
200 (75%)	18 (7%)	48 (18%)	619 (55%)	155 (14%)	359 (31%)
Total Images = 266			Total Images = 1133		

Model Testing

From Cadiz dataset 48 images are used in the testing of model and 359 images from Ireland dataset is used in the testing. The model gives more than 90% of precision in Cadiz and Ireland data. The model trained for Cadiz is tested with Cadiz test images. Figure 2.2.1-2.2.3 shows some of the automatically detected *Nephrops* burrows from Cadiz Images.

Figure 2.2.1: *Nephrops* burrow detection- Cadiz.

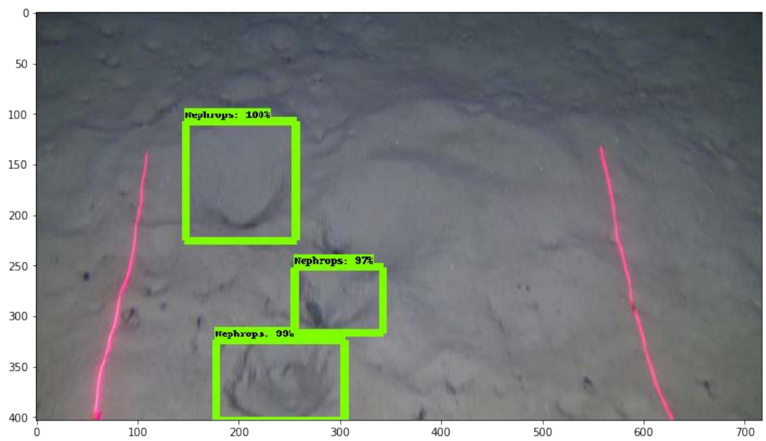

Figure 2.2.2: *Nephrops* burrow detection- Cadiz.

Figure 2.2-3: *Nephrops* burrow detection- Cadiz.

Figure 2.2.4-2.2.6 shows the *Nephrops* burrows detections from Ireland images. The confidence level is more than 97% and reaches to 100%.

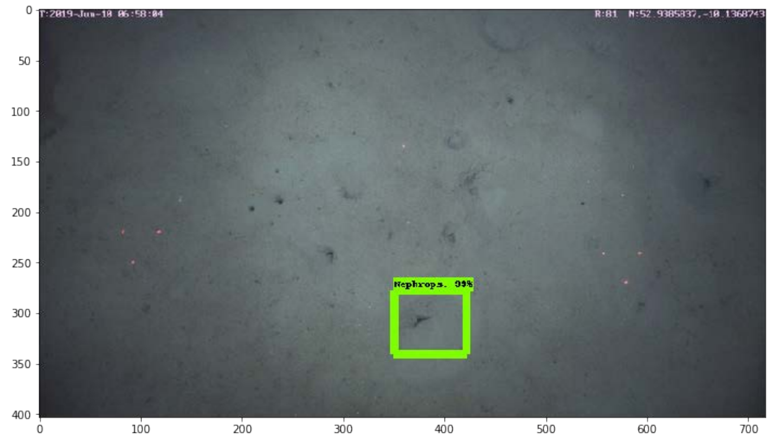

Figure 2.2.4: *Nephrops* burrow detection- Ireland.

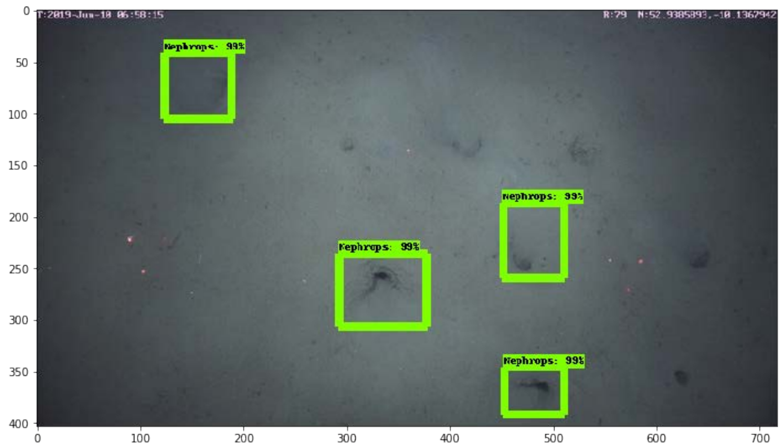

Figure 2.2.5: *Nephrops* burrow detection- Ireland.

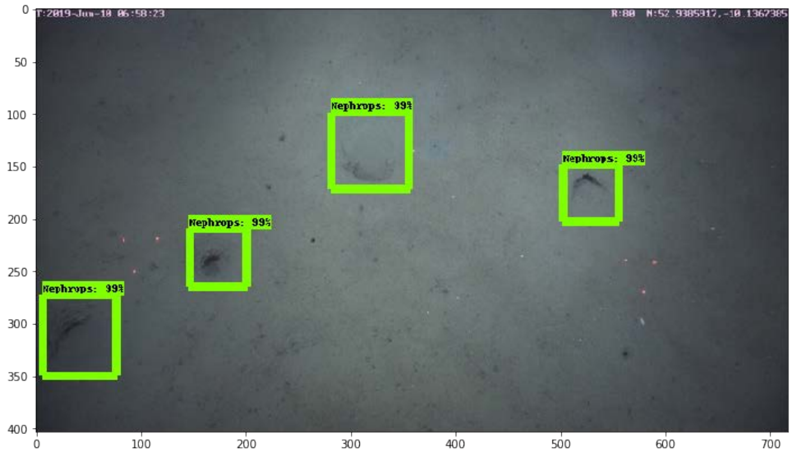

Figure 2.2.6: *Nephrops* burrow detection- Ireland.

The next set of results shows the comparison of ground-truth and detected burrows. The Intersection over Union (IoU) of ground-truth and detected burrows calculates the confidence. If the IoU is less than 50% than we consider it false positive detection else, the detection is considered as True positive. Figure 2.2.7 and 2.2.8 shows the ground-truth vs. model detection annotation.

Figure 2.2.7: Ground-truth vs. Model Detection- Cadiz.

Figure 2.2.8: Ground-truth vs. Model Detection- Cadiz.

Figure 2.2.9. shows the false positive vs. true positive detection from Cadiz data.

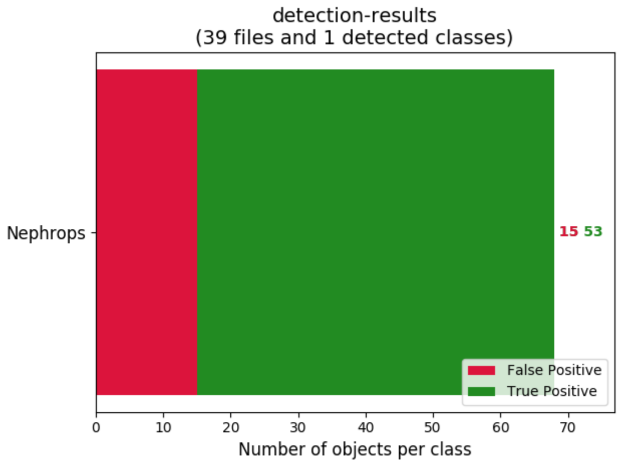

Figure 2.2.9: True Positive vs False Positive detection – Cadiz.

Figure 2.2.10 and 2.2.11 shows the Ground-truth vs Model Detection of Ireland data.

Figure 2.2.10: Ground-truth vs Model Detection – Ireland.

Figure 2.2.11: Ground-truth vs Model Detection – Ireland.

Figure 2.2.13. shows the false positive vs true positive detection from Ireland data.

Figure 2.2.12: True Positive vs False Positive detection – Ireland.

Conclusion and Future work

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 species in underwater, one need to identify these patterns and judge the availability of *Nephrops*. In the current study, we get the data from Cadiz and Ireland stations, record the ground-truth annotations from images. Based on the recorded annotation the data are divided into training, validation and testing dataset. We developed and trained deep neural models for Cadiz and Ireland stations and get the initial results from trained models. The Initial results are very promising but still need lot of improvement in the model. There are lot of False positive and missing detections.

In future the work will focus on improving the *Nephrops* detection accuracy by training the model using more complex neural network. Also, the model will be fine tuned to handle the False positive and missing detections. The work will be required to classify the complete system of *Nephrops*. At the end a fully functional system will be developed to handle inputs from all the stations of different countries.

2.3 2019 High definition camera equipment developments

(Mikel Aristegui and Jennifer Doyle)

In order to use the latest technology available, in 2019 the Marine Institute replaced the standard definition camera (SDc) used in the last years with a new high definition camera (HDc). A calibration test was conducted by the MI to compare burrow counts from both cameras.

14 stations were recorded with both cameras at the same time during the Porcupine bank *Nephrops* grounds (FU16) 2019 UWTV survey (Aristegui *et al*., 2019). Both cameras were mounted in the same sledge used in previous UWTV surveys: the SDc was set up as in previous surveys at an angle of 40° to the bottom, while the HDc was set up at an angle of 75° (Table 2.3.1). In each station 10 minutes of good quality footage were recorded by each camera, assuming that both cameras recorded exactly the same track of seafloor.

Table 2.3.1. UWTV camera calibration test. Features of the two camera systems.

	Standard Definition camera	High Definition camera
Camera angle to the bottom	40°	75°
Field of View (FOV)	0.75 m	1.01 m
Footage format	DVD	Digitalized stills (12 frames per second)
Counting method	Hand writing time stamped	Image annotation R Shiny app (Aristegui, 2019)

The HDc footage was counted at sea by five trained scientists using an inhouse developed image annotation R Shiny app (Aristegui, 2019). The SDc footage was counted back at the MI office by four of the five scientists who counted the HDc, using the same method as in previous FU16 UWTV surveys (hand writing the time stamp of each burrow). The 14 stations from each camera were assigned randomly and equally to the scientist team. Each station was counted independently by two scientists.

Both SDc and HDc count data were analysed in the same way independently one from the other. The counts were screened to check for any unusual discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a threshold of 0.6 (Lin, 1989). Those stations that did not pass the threshold were counted by a third scientist.

Count data that passed the threshold were averaged in order to get a mean burrow count per minute for each of the 28 stations. As the cameras differ in their field of views (FOV) (Table X.2), the counts were standardized dividing them by their corresponding FOV. Finally, a paired t-test was used to compare both datasets.

The standardized counts for both methods were in a similar range of burrows per minute divided by FOV: from 0.4 to 7.9 for SDc, and from 0.4 to 6.7 for HDc (Figure 2.3.1). The conducted test suggests that, in average, there is not significance difference between the two methods (p-value = 0.06563 > 0.05).

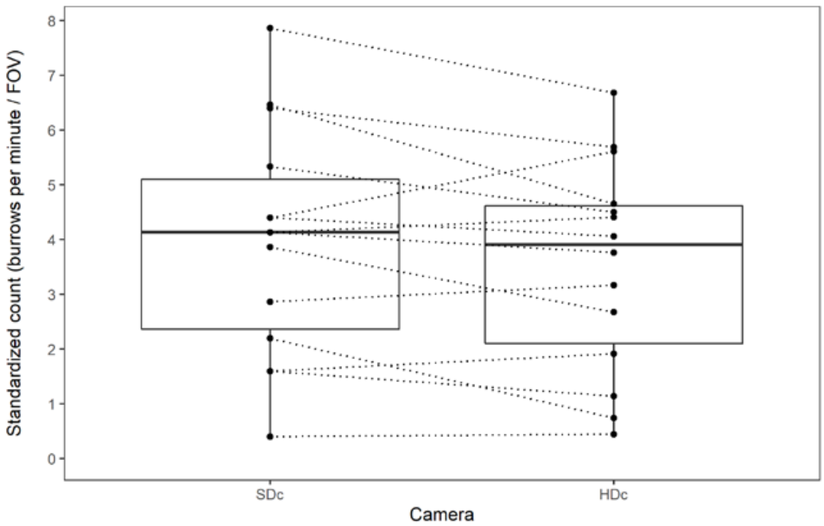

Figure 2.3.1. UWTV camera calibration test. Standardized counts of each station and boxplots. Standard Definition camera counts (left) and High Definition camera counts (right). Same stations are linked with a dotted line.

Additional results from the analysis of the annotation metadata from all the FUs, show that a scientist spends between 17 and 31 minutes to annotate a station of 8 minutes duration with the shiny app. The time spent annotating a station is affected by the burrow density of the station and by the expertise that the scientist has with the app and with the ground. Higher density stations need longer time to be annotated (Figure 2.3.2). On the other hand, the time spent in annotating footage followed the same trends for all the FUs in all the three surveys and also in the footage reviewed at the office: the time spent annotating a station was always lower at the end of the review process that at the beginning (Figure 2.3.3). This could mean that the scientists need some time to get used to the new review system and also to adapt themselves to the ground specific features.

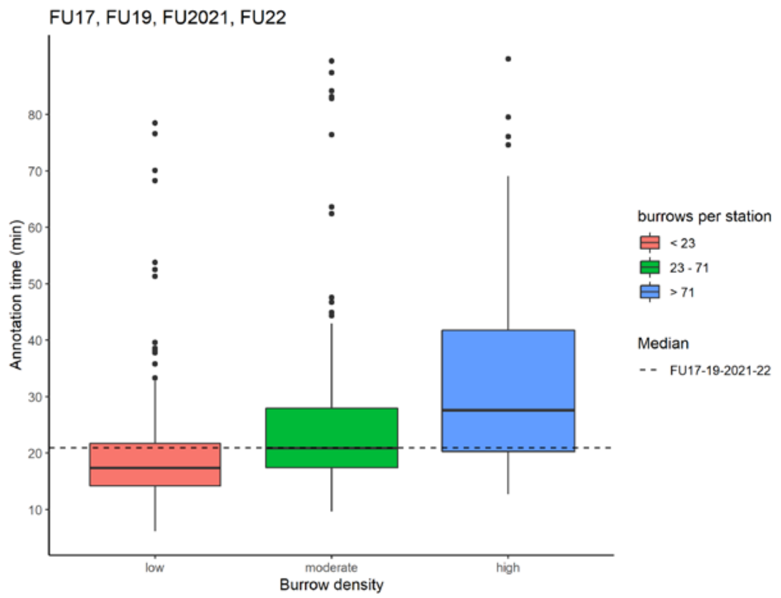

Figure 2.3.2. Time used to annotate a station. Boxplots for each burrow density type. Note that only FU17, FU19, FU2021 and FU22 stations are shown here, as the footage length is 8 minutes, contrary to the 10 minutes of FU16 stations.

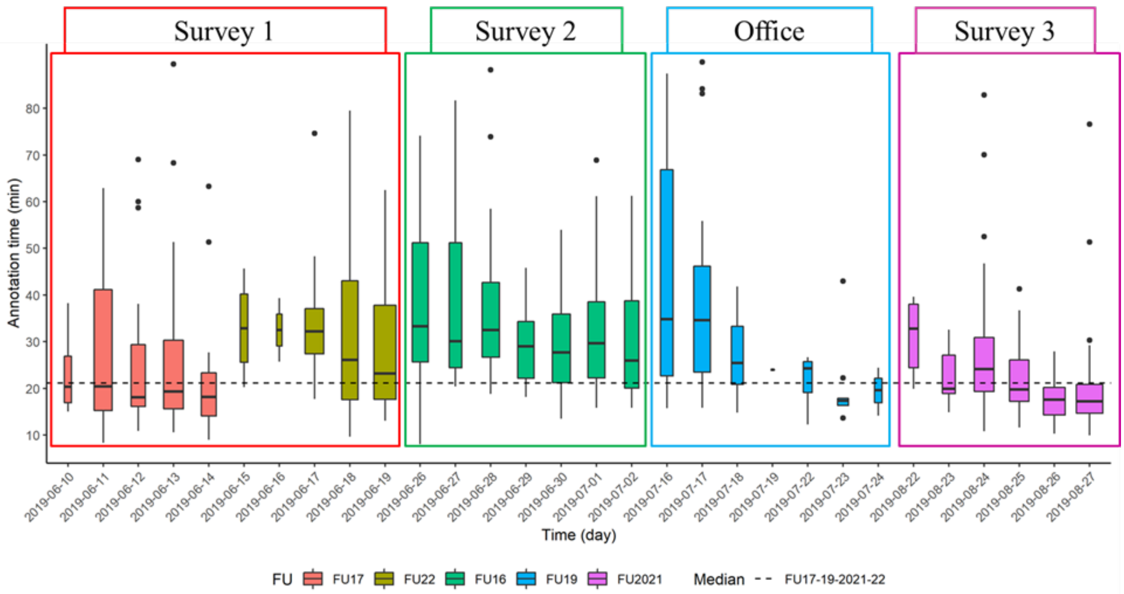

Figure 2.3.3. Time used to annotate a station. A boxplot for each day (the width of the boxplot represents the number of stations annotated that day). Note that FU16 stations' footage is 10 minutes long (contrary to the 8 minutes of the other FUs).

Although the time spent annotating footage with the new app is longer than counting burrows per minute (as in the old standard method), the new system has several benefits. Thanks to the new workflow and annotating system, UWTV surveys are now paperless. The camera is connected to a NAS where the images are stored, and the NAS is connected through a local network to all the devices needed in the process: a server (to store a backup copy of the images and reduce them to make them readable by the app) and 4 laptops (to run the app and annotate the footage) (Figure 2.3.4). The annotation app stores the data in a digital format in the server. This means that there is no more manual input of the data, making this process much faster and less prone to human errors.

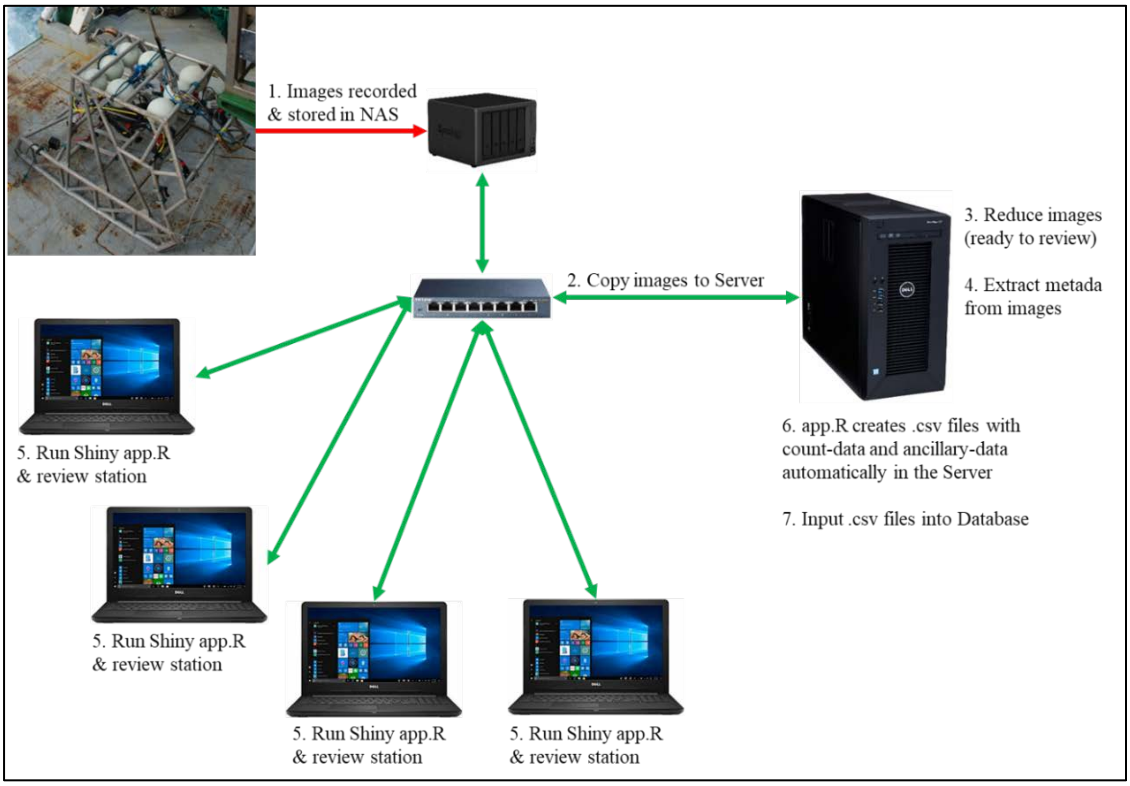

Figure 2.3.4. Diagram showing the workflow and local network of the new HD system onboard.

Moreover, the data coming now from the surveys is much more informative, as the annotated images for example can be reviewed much easier and can be used to make training material. Another achievement of the digital annotation of the footage is that we can now compare precisely annotations from different scientists. The new under development comparative method is able to look for burrows matching from two different scientists (Figure2.3.5. A and B).

This method is based on how far are two annotations from each other on the still number (y-axis) and on the x-axis of the screen (x-axis). The matching burrow method could be used as an alternative to the Lin's CCC method used in the surveys until today, which is used only to compare the number of burrows counted per minute. While developing the new matching burrow method we could see that sometimes a high Lin's CCC does not mean that the burrows annotated by each scientist are actually exactly the same (Figure 2.3.5.A). We could also see that varying any of the two variable boundaries (allowing the model to match burrows closer of further in still number or in the x-axis) could give us different results (Figure 2.3.5.A), therefore we need to define the most appropriate limits for them.

We found this method specially useful for stations with very low counts, where the Lin's CCC test cannot perform. When this happens during a survey the low counts are just accepted, but after this investigation we found that sometimes the annotated burrows can differ substantially (Figure 2.3.5.B top panel).

The matching burrow method still needs further development, but given its potential and high precision (Figure 2.3.5.B bottom panel), it could be used in coming UWTV surveys as a counting verification method.

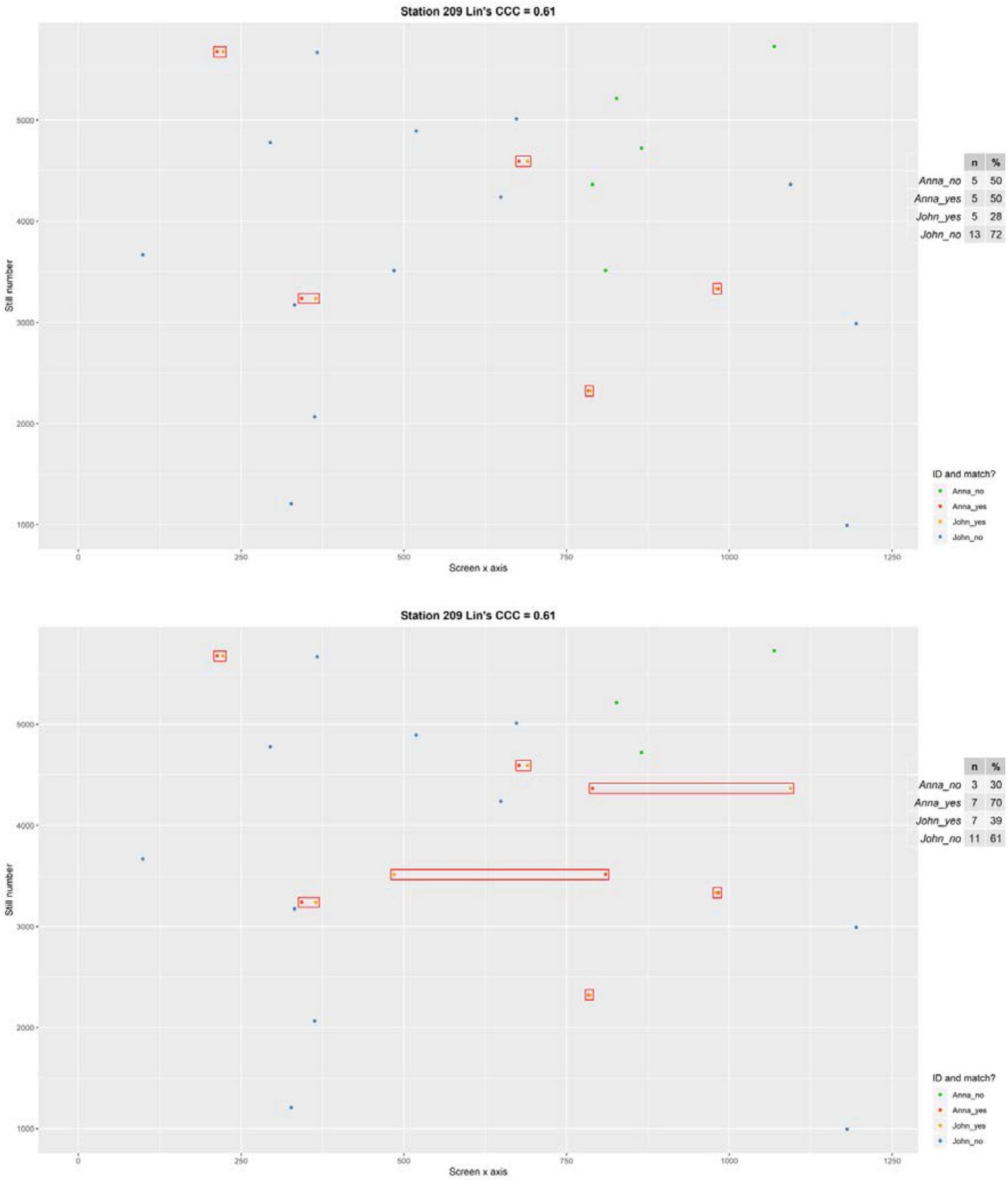

Figure 2.3.5.A. Burrow matching method. Different x-axis boundaries for the same annotations (top and bottom panel).

Title: Station number and Lin's CCC. Anna's burrows that don't match with John's (green), John's burrows that don't match with Anna's (blue). Inside individual red rectangles: Anna's burrows that match with John's (red), John's burrows that match with Anna's (yellow). The table at the right of each plot shows in number and percentage the burrows matched for each scientist.

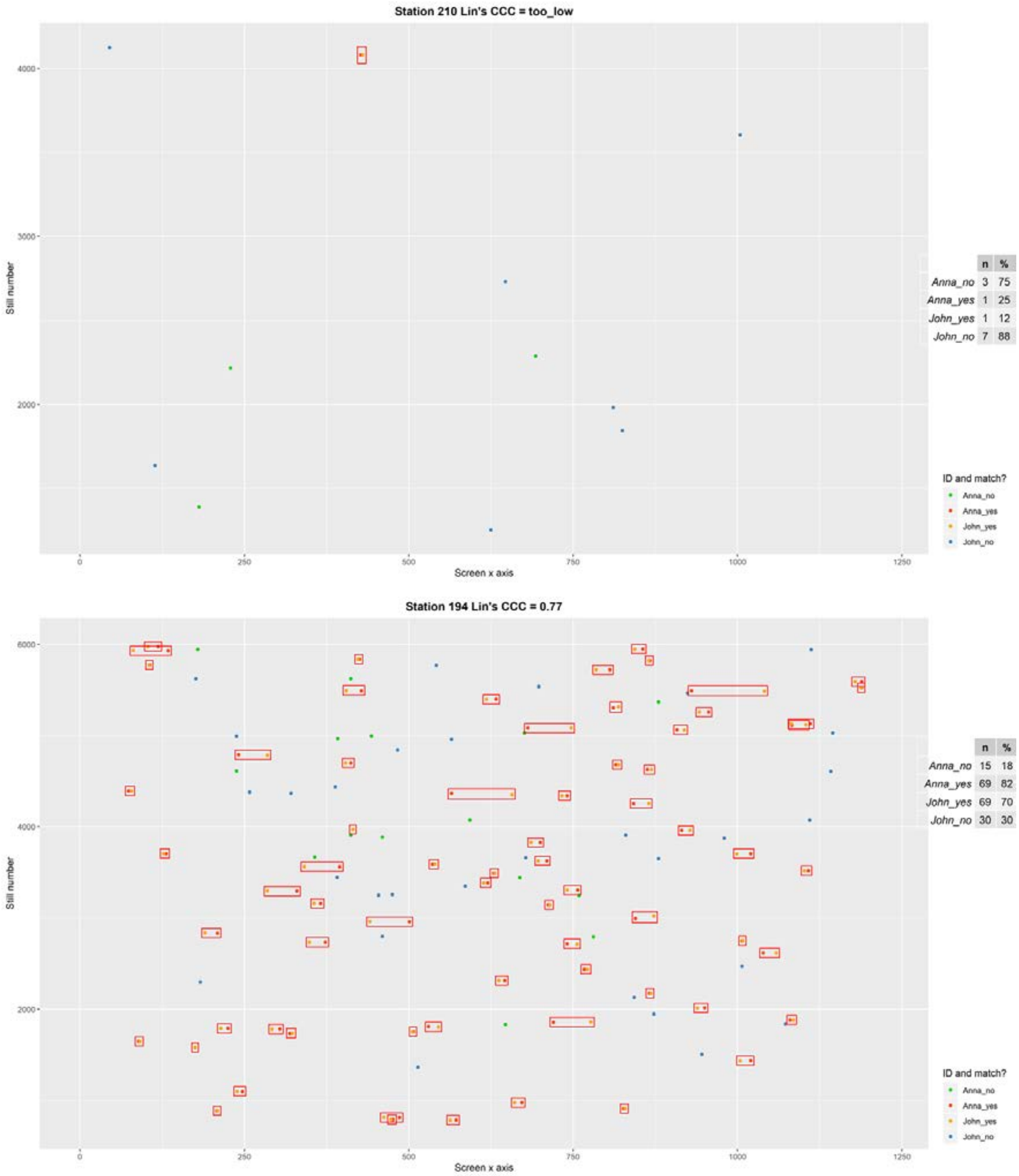

Figure 2.3.5.B. Burrow matching method. Different stations (top and bottom panel).

Title: Station number and Lin's CCC. Anna's burrows that don't match with John's (green), John's burrows that don't match with Anna's (blue). Inside individual red rectangles: Anna's burrows that match with John's (red), John's burrows that match with Anna's (yellow). The table at the right of each plot shows in number and percentage the burrows matched for each scientist.

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3 Miscellaneous

3.1 Other ToR's

The WG reviewed the specifications for a *Nephrops* UWTW database to be established at the ICES data centre and agreed on further action on this issue (ToR b) as well as on the update of R scripts and the inventory of the WGNEPS/ICES guithub (ToR c) (see Annex 5).

Work on The utility of *Nephrops* UWTV and Trawl surveys as platforms for collecting data for other purposes than the assessment of *Nephrops* stocks (ToR e) as well as on the analyses of factors affecting burrow emergence of *Nephrops* (ToR f) has been postponed.

3.2 Outcome from ICES shellfish symposium

(Jónas Jónasson)

Four talks about *Nephrops* were given at the Shellfish Symposium, in Tromsø, Norway (5-7 November, 2019). The main results of those talks were briefly introduced at the meeting. Guldborg Søvik presented two interesting papers. The first was titled: „Does population genetic structure in Norway lobster (*Nephrops norvegicus*) call for a revisison of the current management in Kattegat, Skagerak, and the Norwegian Deep?" The main results was that one genetic population exists in the Skagerrak, Kattegat and the Norwegian Deep, It was recommended to keep separate management of those stocks due to different level of fishing pressure and monitoring / stock knowledge. The second talk was titled: „Population indices of Norway lobster (*Nephrops norvegicus*) in Skagerrak and Norwegian Deep derived from trawl survey data". The Norwegian trawl survey index in Norwegian Deep was accepted in 2016 as a stock size indicator along with a Danish LPUE index. In future it was recommended to compare the index with the UWTV survey time series from the Skagerrak.

Further, a study on the trap fishery along the southwestern coast of Norway was presented at the conference and also long term data of the population fluctuations of *Nephrops* in Icelandic waters.

Annex 1: List of participants

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(remotely, part time)	Marine Fisheries Unit, Belfast		
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Annex 2: Resolutions

2018/MA2/EOSG10 A **Working Group on *Nephrops* Surveys** (WGNEPS), chaired by Kai Wieland, Denmark, and Adrian Weetman, Scotland, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	12-14 November	Split, Croatia	1st Interrim report by 6 January to EOSG	Election of new chair(s)
Year 2020	17-19 November	Cadiz, Spain	2nd Interrim report by 17 December 2020 to EOSG	**Change of chairs:** Outgoing: Kai Wieland and Adrian Weetman Incoming: Jennifer Doyle
Year 2021	TBD	TBD	Final report by TBD to EOSG	

ToR descriptors

ToR	Description	Background	Sciecne Plan codes	Duration	Expected Deliverables
a	To review any changes to design, coverage and equipment for the various *Nephrops* UWTV and full-scale trawl surveys since 2018 and to update the Series of ICES Survey Protocols (SISP) as required	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, and update the SISP accordingly if necessary.
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 data-base for *Nephrops* UWTV survey data	Improving standarisation 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 and to update the Series of ICES Survey Protocols (SISP) as required .	WGNEPS should periodically review emerging technologies that might improve survey methodologies.	4.1	Recurrent annual update	To update the SISP based on conslusions if necessary. Other publications when appropriate.
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	Joint workshop/meeting report with users
f	Analyse existing data from UWTV and trawl *Nephrops* surveys to evaluate possible factors affecting burrow emergence of *Nephrops* (e.g. currents and light)	Recent behaviour aspects have been investigated in the laboratory. Important to investigate correlation with field data.	1.3	Year 3	Review paper
g	Review differences of new HD and previous used SD camera systems and its effect on burrow detection, edge effects and bias correction factors, and explore the possibility of HD system tools for providing estimates of burrow size distributions				

Summary of the Work Plan

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)

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 group 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 used the survey results i.e. WGCSE, WGBIE and WGNSSK.
Linkages to other organizations	FAO , OSPAR

Annex 3: Survey summaries

Ireland

(Jennifer Doyle, 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 FU15, FU17 and FU22 were reduced since 2012 to allow for survey development in FU16, FU19 and FU20-21 combined. The total numbers of stations for 2019 remains broadly similar ~300 to previous years (Figure 1). 100% coverage of all the *Nephrops* grounds was achieved in 2019 for stock assessment purposes. Two exploratory UWTV stations were conducted at Dunmanus Bay mud patch in FU19 to map this ground.

Survey Design.

There were no significant changes to survey design for the surveys in 2019.

Main results summary.

The CVs for surveys where sampling intensity was reduced either had no or minor decreases in relative precision and are well below the 20% limit as recommended by SGNEPS (ICES, 2012) for precision (Table 1). In 2019 the survey count data for all FUs were screened to check for any discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a minimum threshold of 0.5 as recommended by the UWTV Survey SISP (in draft) for FU 20-21 combined and FU 19 and a threshold of 0.6 for FU 16, FU 17 and FU 22 (Lin, 1989). All image data collected was in the high definition format in 2019 where HD stills for each station captured at 12 frames per second were reviewed using an in-house developed review app (Aristegui, 2019). *Nephrops* burrow systems were annotated for all grounds in 2019 using the review app. Figure 2 shows app GUI with annotated burrow in the image.

The adjusted mean density for each station in ICES Subarea 7 is presented in Figure 3 and it shows the general overall pattern which is mainly higher densities observed in FU15 western Irish Sea and lower densities in FU16 Porcupine Bank. There was an overall decrease in observed burrow densities in the Celtic Sea and Irish Sea *Nephrops* grounds in 2019 compared to last year.

International staff exchange.

In recent years, there has been a good flow of staff exchange on UWTV surveys in ICES Subarea 7 such as the collaborative UWTV survey in the Irish Sea (FU14 and FU15). In 2019, staff from Ifremer and AFBI participated on two Irish surveys. Inter institute exchange is important as it promotes protocol and technology transfer.

Data Storage and R-scripts.

All UWTV survey data for the entire time series is housed in a SQL server database. The r-scripts for data quality control and calculations of abundance estimations using geo-statistical analyses for FU16, FU17, FU20-21 combined and FU22 and random stratified approach for FU19 are available in r markdown documents for transparency and reproducibility.

Data Management Quality Management Framework.

In February 2019, the Marine Institute received the international accreditation of its Data Management Quality Management Framework (DM-QMF) by the (UNESCO) International Oceanographic Commissions (IODE) - International Oceanographic Data and Information Exchange programme. The overall aim of the DM-QMF is to support continual improvement of the quality of the data, products and services delivered by the Marine Institute through assuring the quality of the processes and procedures used in the generation of data and products. Marine Institute *Nephrops* UWTV survey data and products are included in this framework in 2019.

UWTV survey reports availability.

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 at http://oar.marine.ie/handle/10793/59

Additional Sampling:

Sediment Sampling.

In 2019 during the UWTV surveys in the Celtic Sea (FU 19 and FU 20-21) sediment sampling was carried out using the Shipex grab when time allowed. This was undertaken as part of an in-house cross collaboration project. A photograph of the sediment was logged and approximately 1 kg of sediment was taken for particle size analysis (PSA) analyses. The processed data will be used to generate sediment maps for this area and also to ground-truth any seabed mapping programmes (www.infomar.ie).

Bottom Temperature and Depth data.

This year a temperature and depth profiler was used at each UWTV station where in previous years a CTD sensor had been used. This data are relatively easy to collect and is viewed as an emerging time series which will be used for looking at interannual and longer term variability of bottom sea temperature around the coast of Ireland. The data have been used in the past to validate the temperature field in the Marine Institute operational Northeast Atlantic hydrodynamic model.

Beam Trawling Operations.

Due to time constraints in 2019 beam trawl fishing operations were not carried out on the Aran *Nephrops* grounds (FU17) and the Smalls *Nephrops* grounds (FU22).

Other Benthic fauna distributions.

The deepwater sea-pen ***Kophobelemnon stelliferum*** has been observed during the UWTV survey on the Porcupine Banks (FU16) *Nephrops* ground. It is an easy species to identify from the image data due to its specific shape and colour.

Monitoring the occurrence and frequency of other sea-pens observed on *Nephrops* grounds is important but is dependent on national resources. An OSPAR special request to record sea pens species (*Virgularia mirabilis, Funiculina quadrangularis and Pennatula phosphorea*) using a key devised to categorize the density (ICES, 2011) exists. In 2019 presence/absence of these three species was recorded in FU 16,17,19, 20-21 and 22. Figure 4 shows the 2019 stations on the Porcupine *Nephrops* grounds where the aforementioned sea-pen species were identified and noted as present or absent.

Table 1. 2019 UWTV mean adjusted density, abundance estimate, CV (relative standard error) and Lin's Concordance Correlation Coefficient (CCC) threshold by Functional Unit.

UWTV Survey	Mean density adjusted (burrow/m²)	Final Abundance Estimate (millions individuals)	CV (Relative standard error)	Lin's Concordance Correlation Coefficient Threshold to screen survey Counts
FU16	0.14	1010	5%	0.6
FU17 Aran Grounds only	0.38	458	4%	0.6
FU19	0.2	386	17%	0.5
FU20-21 combined	0.06	617	5%	0.5
FU22	0.4	1121	6%	0.6

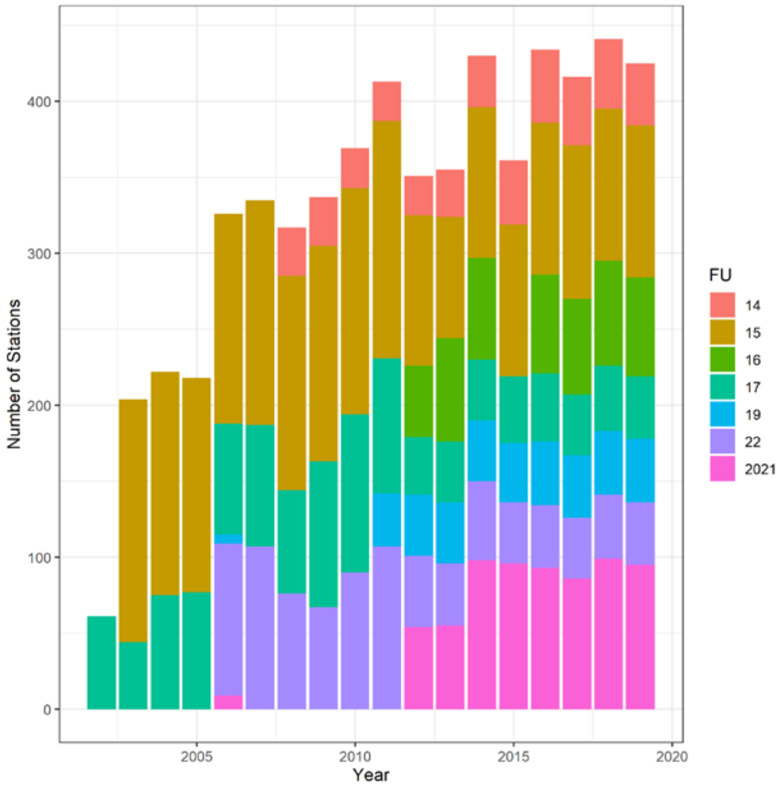


Figure 1. Time series of the total number of UWTV stations carried out by Ireland in each Functional Unit. Stations in FU 14 and FU 15 are carried out in collaboration with AFBI in UK-NI and CEFAS UK E&W.

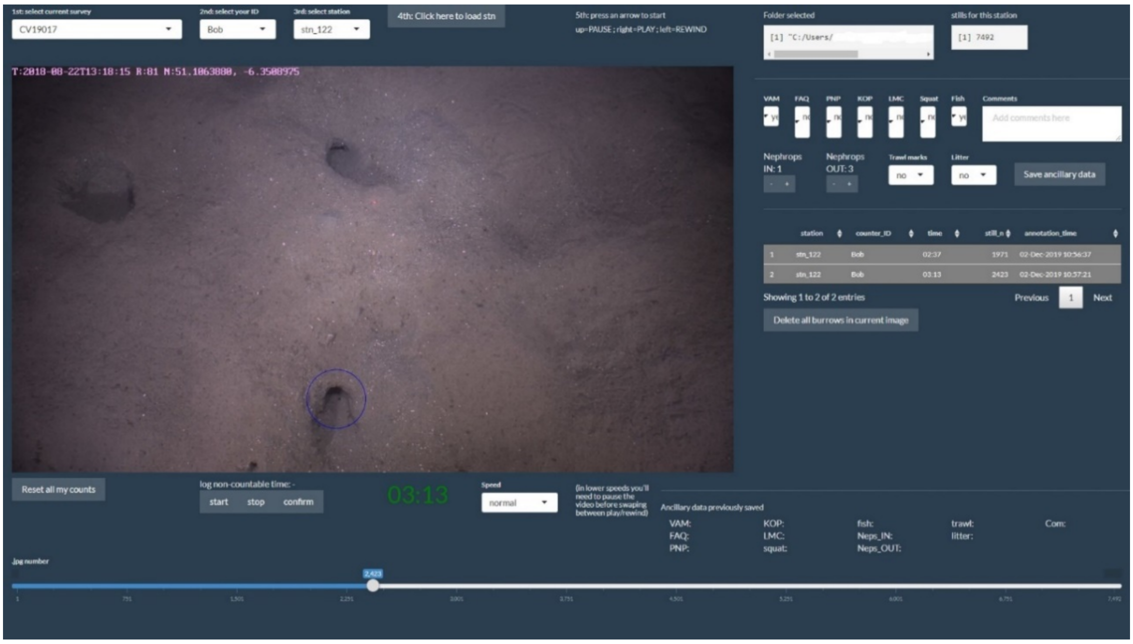


Figure 2. Screenshot of the Image annotation R shiny app used to annotate UWTV footage during the 2019 surveys. Blue circle denotes annotated burrow system.

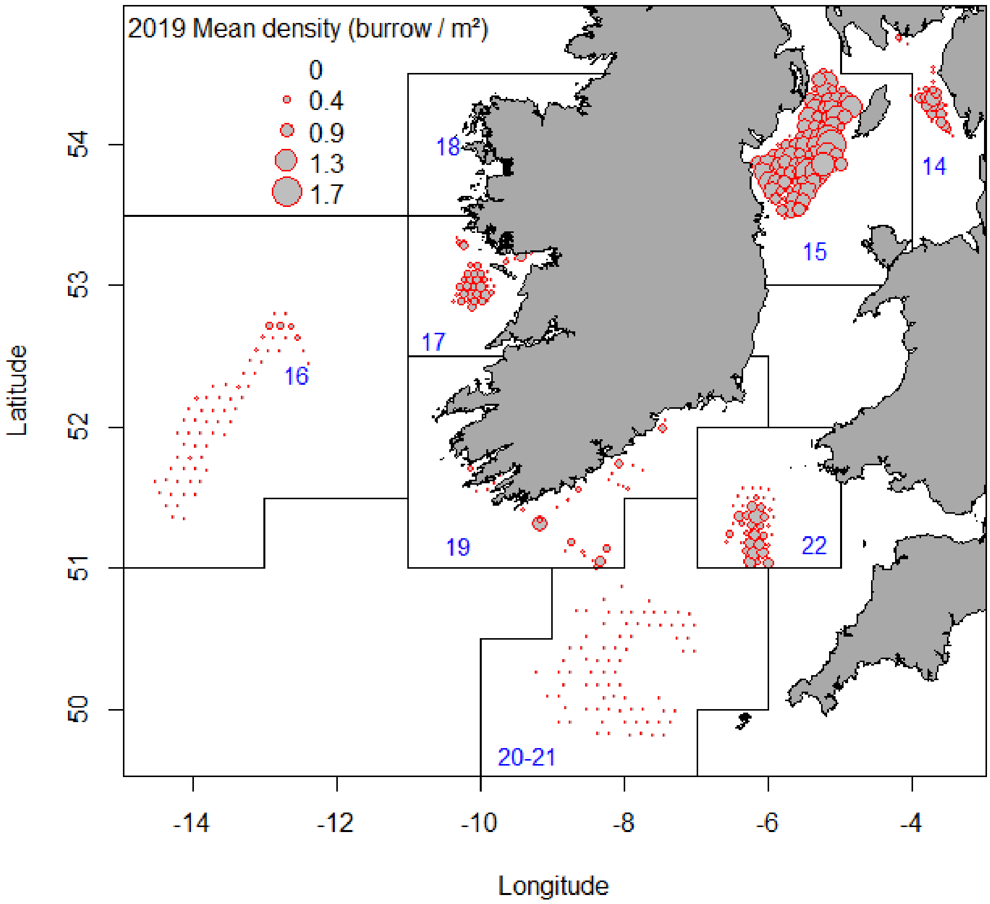


Figure 3. 2019 Mean adjusted density estimates (burrow/m²) by station for *Nephrops* grounds in ICES Subarea 7.

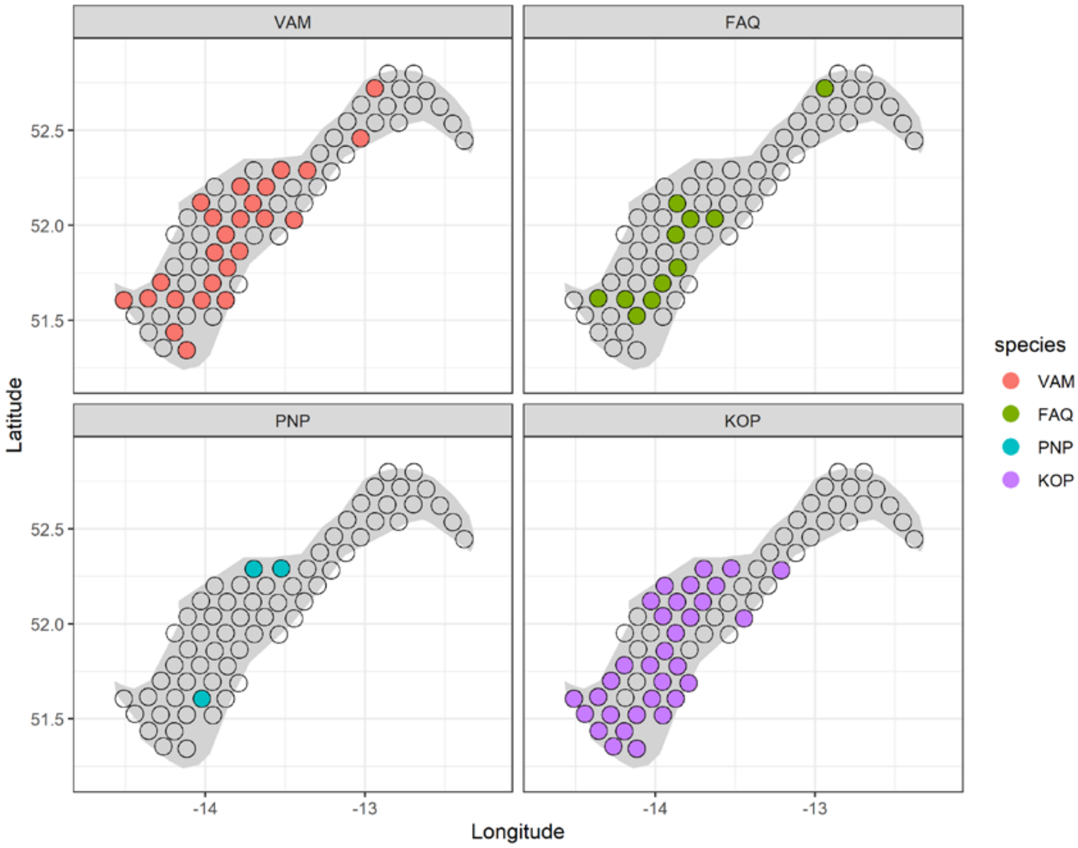


Figure 4. FU16 grounds: 2019 stations where *Virgularia mirabilis* (VAM), *Funiculina quadrangularis* (FAQ), P*ennatula phosphorea* (PNP) and *Kophobelemnon stelliferum* **(KOP) were identified and noted as present or absent. Closed circles indicated presence and open circles denotes TV stations with no sea-pen observations.**

UWTV Survey FU16: Porcupine Banks

The 2019 survey was multidisciplinary in nature collecting UWTV, CTD and other ecosystem data. This was the seventh in the time series on the 'Porcupine Bank *Nephrops* grounds' ICES assessment area; Functional Unit 16. In total 65 UWTV stations were successfully completed in a randomized 6 nautical mile isometric grid covering the full spatial extent of the stock. The mean burrow density observed in 2019, adjusted for edge effect, was 0.14 burrows/m^2. The final krigged abundance estimate was 1010 million burrows with a relative standard error of 5% and an estimated stock area of 7,130 km^2. The 2019 abundance estimate was 9.5% lower than in 2018. Four species of sea-pen; *Virgularia mirabilis*, *Funiculina quadrangularis*, *Pennatula phosphorea* and the deepwater sea-pen ***Kophobelemnon stelliferum*** were observed during the survey. Trawl marks were also observed on 31% of the stations surveyed. A combined violin and box plot of the observed burrow densities on this ground for the available time series is presented in Figure 5. This shows that median and mean burrow densities are similar in most years. The inter-quartile ranges are also similar. Further details on this survey available at: https://oar.marine.ie/handle/10793/1431

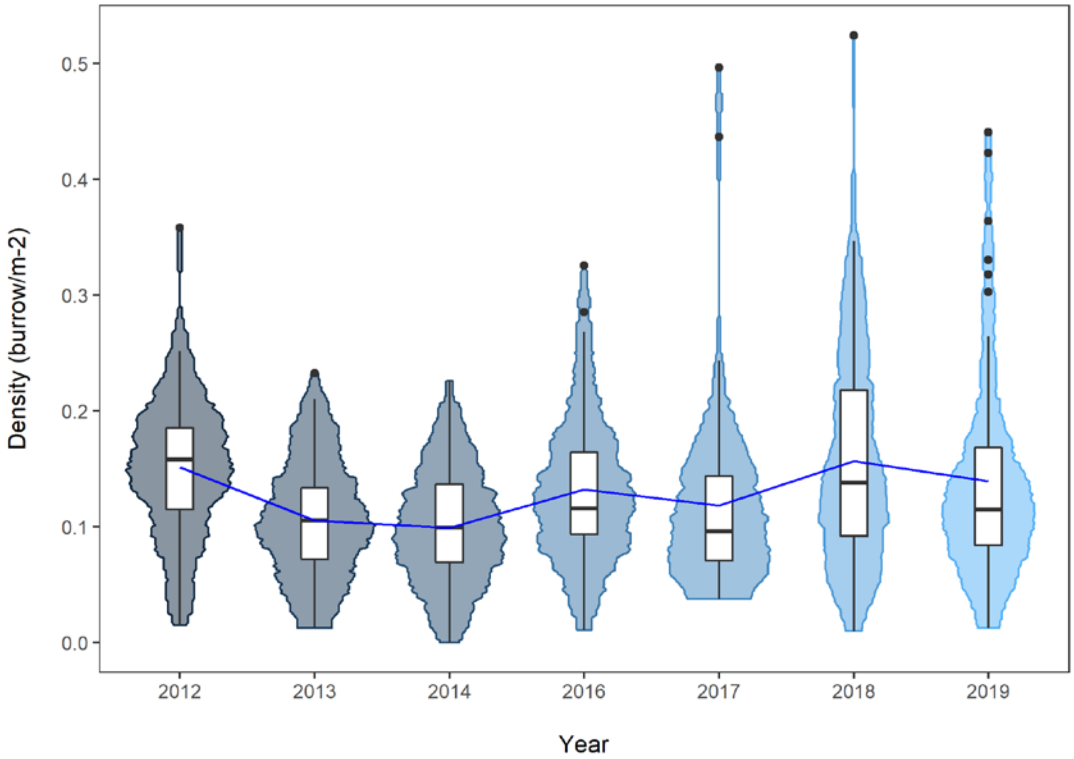


Figure 5. Porcupine Bank 2019. Violin and box plot of adjusted burrow density distributions by year for the available time series. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers. No UWTV survey in 2015.

UWTV Survey FU17: Aran grounds, Galway Bay and Slyne Head *Nephrops* grounds

In 2019 the seventeenth annual underwater television on the Aran, Galway Bay and Slyne head *Nephrops* grounds, ICES assessment area; Functional Unit 17 was successfully carried out. The survey was multidisciplinary in nature collecting UWTV, fishing, CTD and other ecosystem data. In 2019 a total of 41 UWTV stations were successfully completed, 31 on the Aran Grounds, 5 on Galway Bay and 5 on Slyne Head patches. The mean burrow density observed in 2019, adjusted for edge effect, was medium at 0.38 burrows/m^2. The final krigged burrow abundance estimate for the Aran Grounds was 458 million burrows with a CV (relative standard error) of 4%. The final abundance estimate for Galway Bay was 23 million and for Slyne Head was 12 million, with CVs of 11% and 8% respectively. The total abundance estimates have fluctuated considerably over the time series. The 2019 combined abundance estimate (493 million burrows) is 11% lower than in 2018, and it is below the MSY $B_{trigger}$ reference point (540 million burrows). A combined violin and box plot of the observed burrow densities on the main *Nephrops* ground the "Aran" from 2006 to 2019 is presented in Figure 6. This shows relatively large interannual variation in mean, median and density ranges over time. Density increased in first three years of the time series but then declined significantly in 2006. Since then there has been a gradual downward trend. The mean and median density has increased in 2019 to levels observed in 2015. It has been very noticeable since 2011 that there was a substantial reduction in density throughout the ground with no high density (> 0.7/m^2) observed. Figure 7 is the violin plot of densities for the Galway Bay and Slyne Head *Nephrops* grounds which also shows relatively large interannual variation in mean, median and density ranges over time. *Virgularia mirabilis* was the only seapen species observed on the UWTV footage. Trawl marks were present at 7% of the Aran stations surveyed.

Further details on this survey available at: https://oar.marine.ie/handle/10793/1427

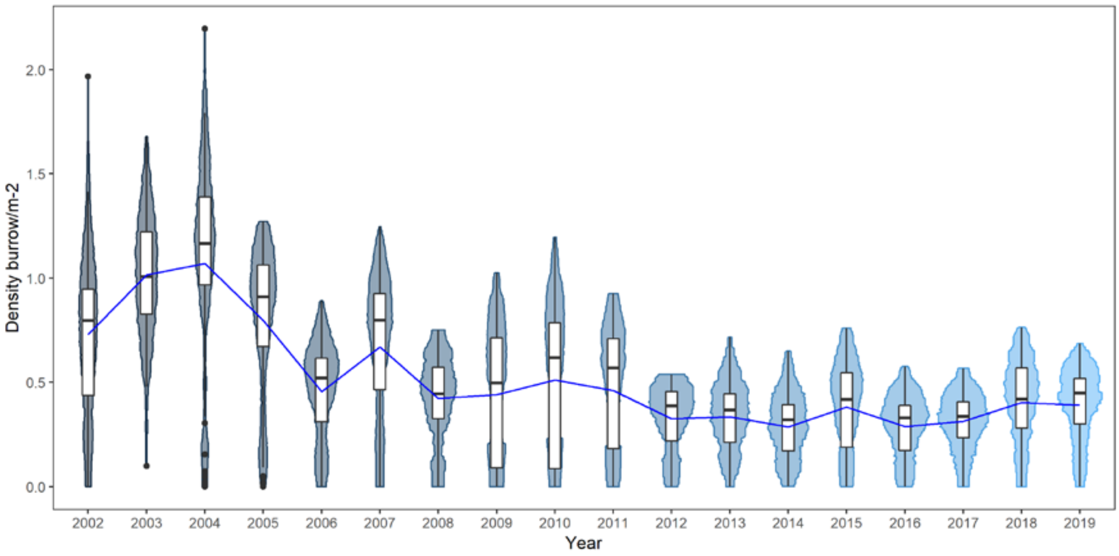


Figure 6. FU17 Aran grounds: Violin and box plot of adjusted burrow density distributions by year from 2002-2019. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

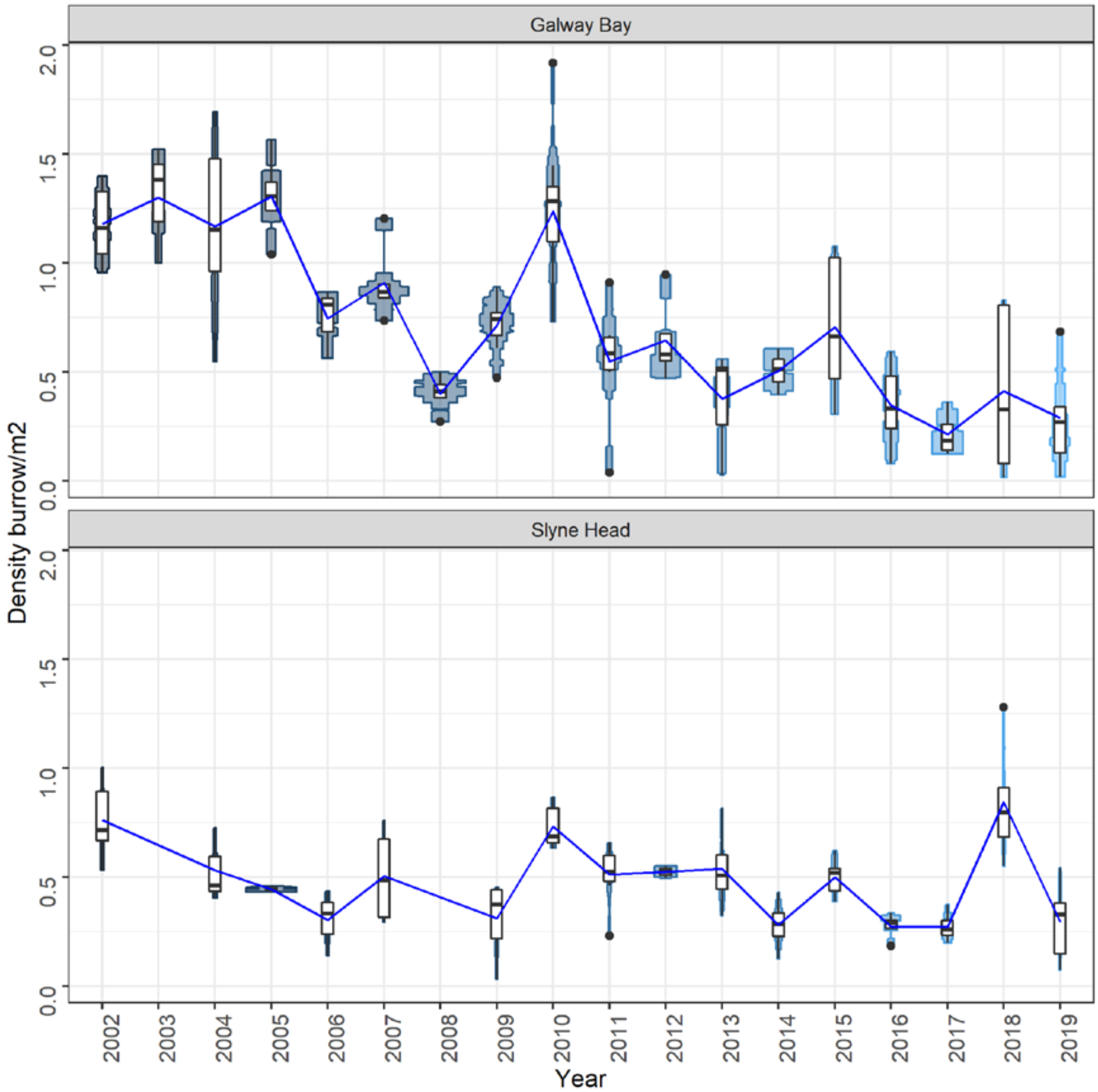


Figure 7. FU17 Galway Bay and Slyne Head: Violin and box plot of adjusted burrow density distributions by year from 2002-2019. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

UWTV Survey FU19. South and South west coast of Ireland

In 2019 the tenth underwater television survey of the various *Nephrops* patches in Functional Unit 19 was carried out. The survey was multidisciplinary in nature collecting UWTV, multibeam and other ecosystem data. In 2019 a total 44 UWTV stations were successfully completed. The mean density estimates varied considerably across the different patches. The 2019 raised abundance estimate was a 220% increase from the 2018 estimate and at 386 million burrows is below the MSY $B_{trigger}$ (430 million). Two species of sea pen were observed; *Virgularia mirabilis* and *Pennatula phosphorea* which have been observed on previous surveys of FU19. Trawl marks were observed at 12 % of the stations surveyed. Two exploratory stations were completed on Dunmanus Bay mud patch but these are not used in stock abundance estimate as the area of the ground needs to be estimated. Figure 8 is the violin plot of densities for the discrete *Nephrops* grounds which shows relatively large interannual variation in mean, median and density ranges over time.

Further details on this survey available at: https://oar.marine.ie/handle/10793/1429

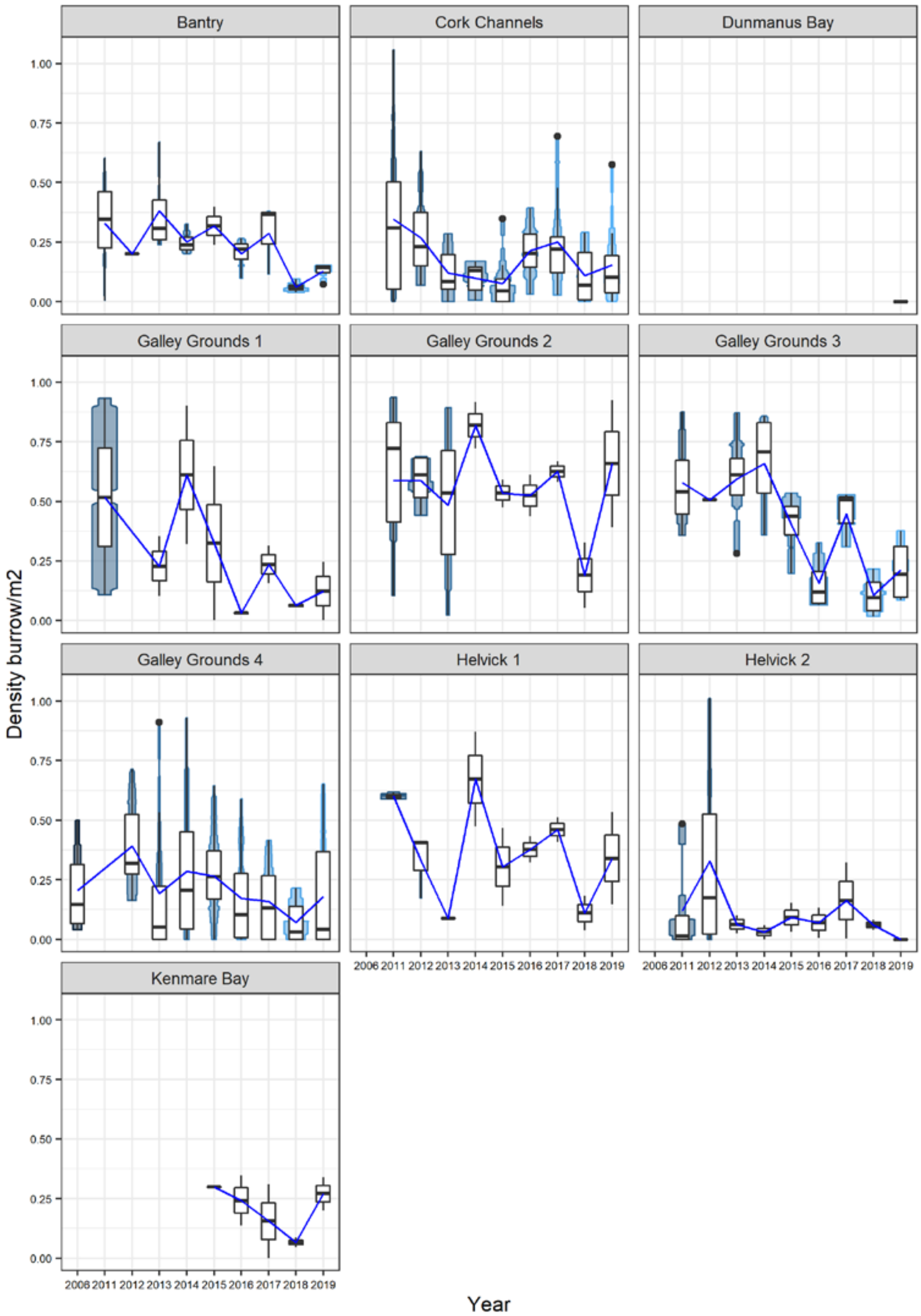


Figure 8. FU19 grounds: Violin and box plots of adjusted burrow density distributions by year for 2006-2019 for each ground. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers. No TV survey from 2007 – 2010.

UWTV Survey FU20-21: Labadie, Jones and Cockburn Banks

The 2019 survey achieved full coverage of the stock area for the sixth successive time. Area of this ground is calculated at 10 014 km² which is the largest *Nephrops* ground in ICES area 7 (ICES, 2014). The 2019 survey was multidisciplinary in nature collecting UWTV, and other ecosystem data. A total of 95 UWTV stations were completed at 6 nmi intervals over a randomized isometric grid design. The mean burrow density was 0.06 burrows/m² compared with 0.27 burrows/m² in 2018. The 2019 geostatistical abundance estimate was 617 million, a 77% decrease on the abundance for 2018, with a CV of 5% which is well below the upper limit of 20% recommended by

SGNEPS 2012. Low densities were observed throughout the ground. Due to the large reduction in abundance estimate in 2019 a random selection 20% of the UWTV stations were reviewed following the *Nephrops* UWTV SISP recommendation (ICES, 2018). This partial review process confirmed the low density observations in the 20% of stations re-counted (ICES, 2019, working document 10). One species of sea-pen (*Virgularia mirabilis*) were recorded as present at the stations surveyed. Trawl marks were observed at 32% of the stations surveyed. Figure 9 is the violin plot of densities for this *Nephrops* ground which shows relatively large interannual variation in mean, median and density ranges in the recent three years.

Further details on this survey available at: https://oar.marine.ie/handle/10793/1430

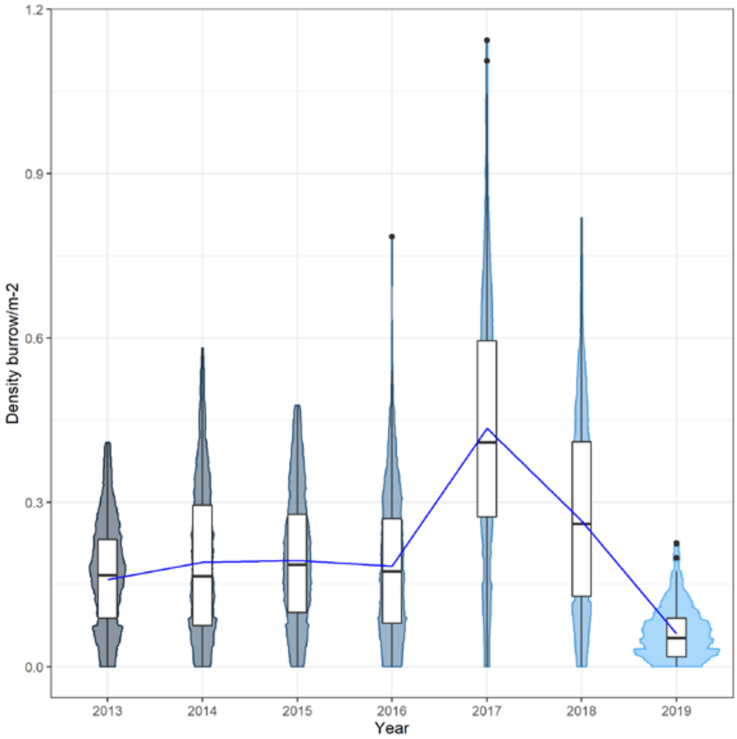


Figure 9. FU20-21 grounds: Violin and box plot of adjusted burrow density distributions by year from 2013-2019. The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.

UWTV Survey FU22: The Smalls

This was the fourteenth annual underwater television survey on the 'Smalls grounds' ICES assessment area; Functional Unit 22 in 2018. The survey was multidisciplinary in nature collecting UWTV, CTD and other ecosystem data. A total of 41 UWTV stations were surveyed successfully (high quality image data), carried out over an isometric grid at 4.5nmi or 8.3km intervals. The precision, with a CV of 9%, was well below the upper limit of 20% recommended by SGNEPS (ICES, 2012). The 2019 abundance estimate was 30% higher than in 2018 and at 1121 million is below the MSY $B_{trigger}$ reference point (990 million). One species of sea pens were recorded as present at the stations surveyed: *Virgularia mirabilis*. Trawl marks were observed at 57% of the stations surveyed. A combined violin and box plot of the observed burrow densities is presented in Figure 10. This shows that median and mean burrow densities are similar in most years. The inter-quartile range is between 0.2 - 0.7 in most years. However in 2018, as in 2016, this inter-quartile range is in the region of 0.1 - 0.4. In 2018 the mean adjusted burrow density was 0.31 burrows/m^2. One station had burrow densities > 1.0 burrows/m^2 observed in 2019.

Further details on this survey available at: https://oar.marine.ie/handle/10793/1428

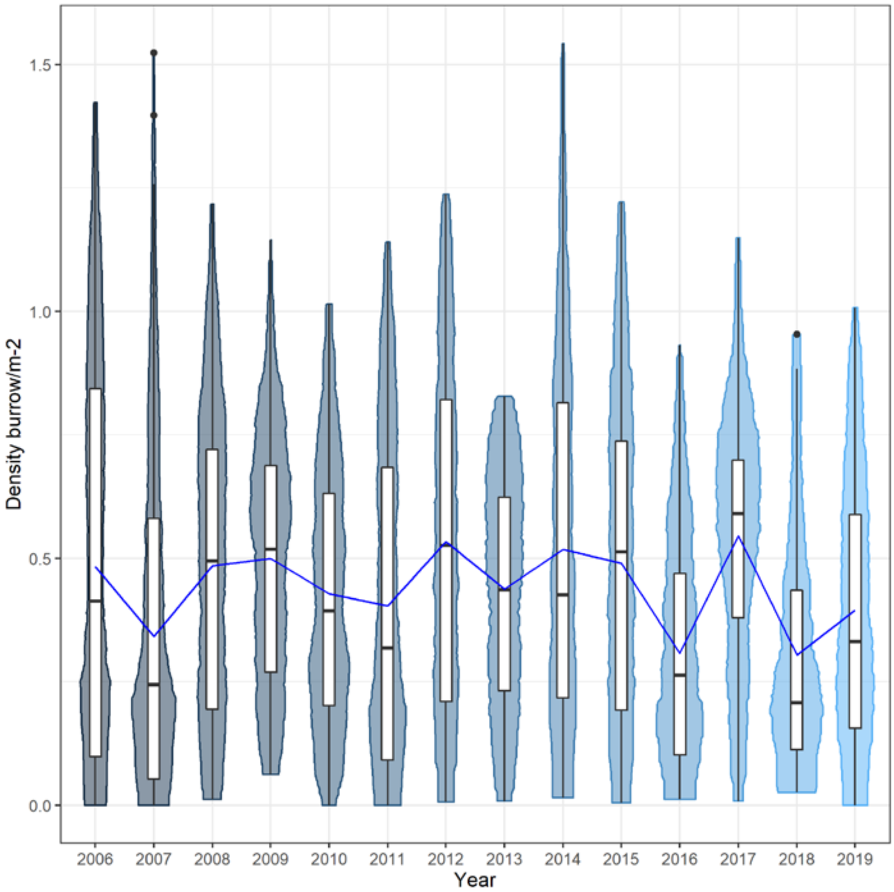


Figure 10. FU22 Smalls grounds: Violin and box plot of adjusted burrow density distributions by year from 2006-2018. The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers.

UK Northern Ireland

(Mathieu Lundy)

Functional Unit	FU 15	Area name	Western Irish Sea
Survey design	Random grid	Previous surveys	2003-2018
Country (ies)	UK & Ireland	Vessel name (s)	R/V Corystes
Survey code (s)	CO3119	Dates (start/end)	6th – 13th Aug 2019
Number scientific staff	9	Staff exchanges	1 MI & 1 Cefas + 6 AFBI
Number of stations (planned/completed/used in analysis)		100/100/100	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		No deviations. Ship position used for distance over ground as in 2018	
Distance over ground source used	Ship	Average field of view (cm)	Analogue cam: 68 cm
Adjusted mean density	0.73	Adjusted abundance, CV	4404 million, CV=2.89%
Overall footage quality (poor, medium, good)		Medium to 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.)		CTD Beam trawl hauls *Nephrops* otter trawls Presence/absence ancilliary data (sea-pen, munida and other species. *Nephrops*/munida activity	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	9706 *Nephrops* burrows counted, **storage**: DVD up to 2019, **level of analysis**: kriged estimates as for last year **dissemination**: WGCSE
		CTD	100
		Trawl	48
		Sediment	0
		Other	0

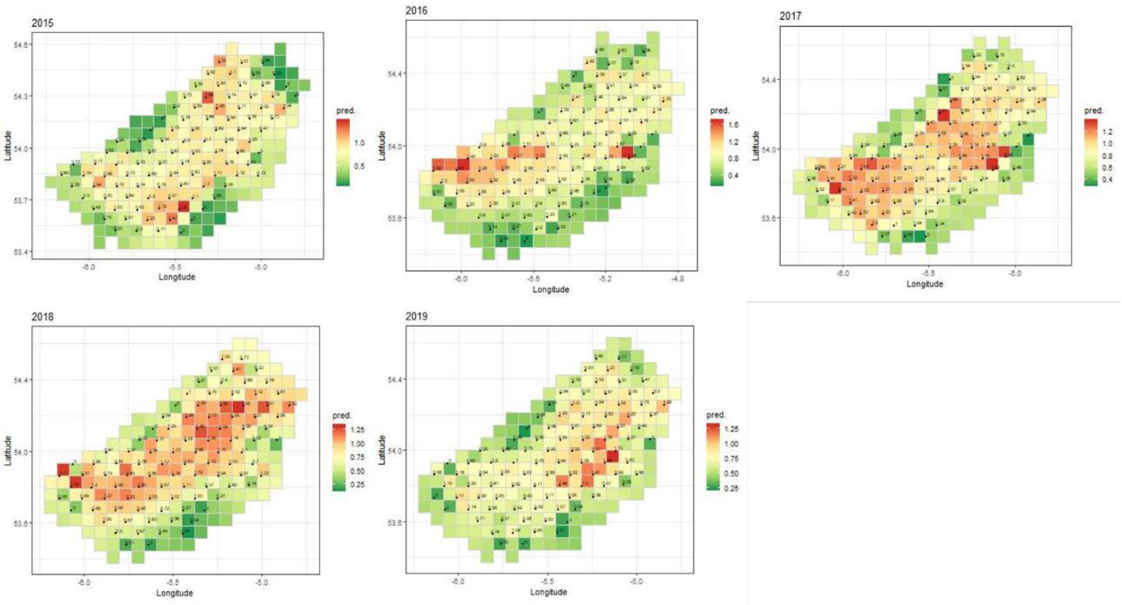


Figure 1: Map of kriged density by station for 2015 – 2019.

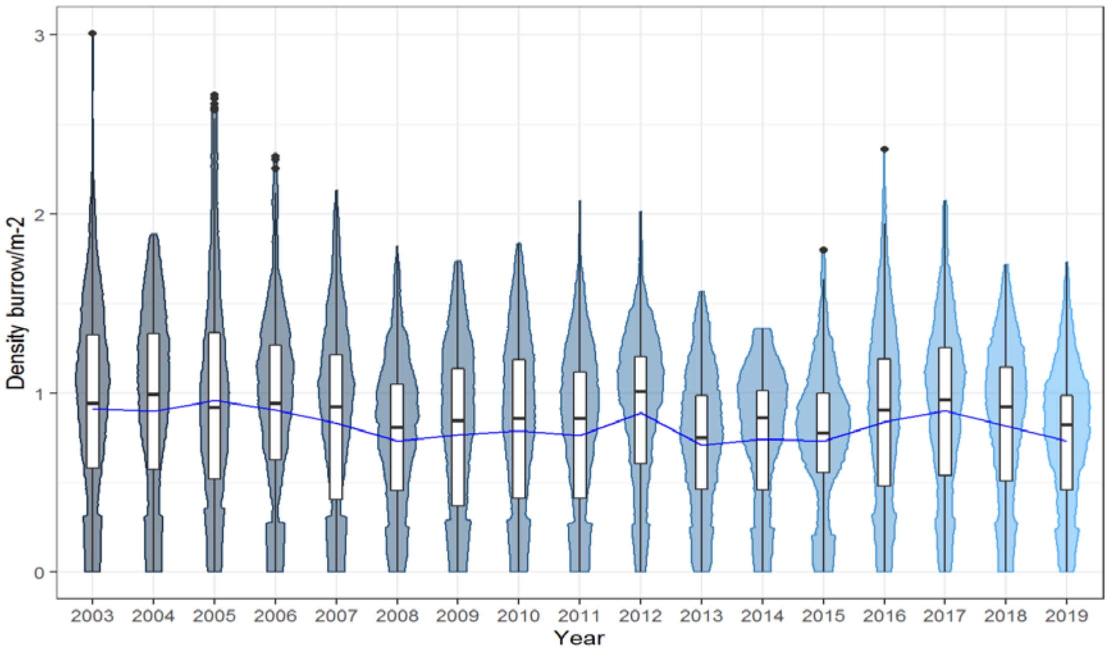


Figure 2: Times series of adjusted burrow density (Violin and box plot).

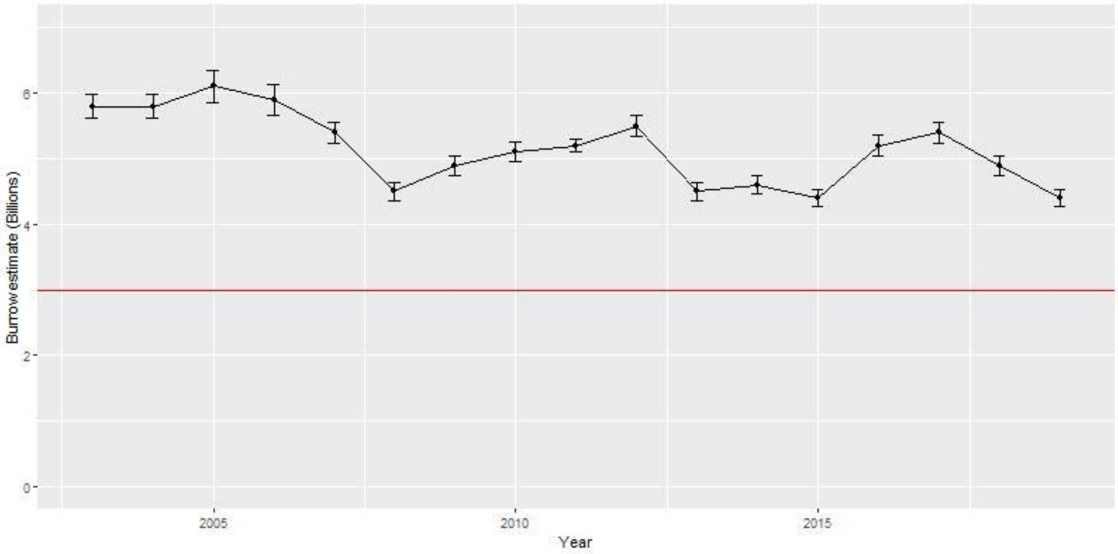


Figure 3: Time series of mean density and total abundance (with confidence intervals) with reference levels.

UK Scotland

(Gerald McAllister, Adrian Weetman)

Marine Scotland Science (MSS) based in Aberdeen, Scotland, UK, carried out three underwater camera based TV surveys (UWTV) in Scottish waters in 2019. Each survey was completed on one of MSS' own research vessels and continues work which first began in 1992. The data collected adds to the growing dataset in both number of deployments but also the variety of grounds visited as seen in Figure 5.1.3.1 below.

The equipment used in 2019 remained unchanged from previous years with a Kongsberg 14-366 analogue video camera; four SeaLED lights; an odometer to calculate the distance travelled; an altimeter to record the position of the camera in relation to the seabed (which is used to calculate the field of view) and a mini van Veen sediment sampler. Each of the devices was used on the TV sledge, with the drop frame only requiring the Kongsberg camera and four SeaLED's. Only the sledge was used to carry out *Nephrops* abundance work, and all three surveys fully met their planned objectives.

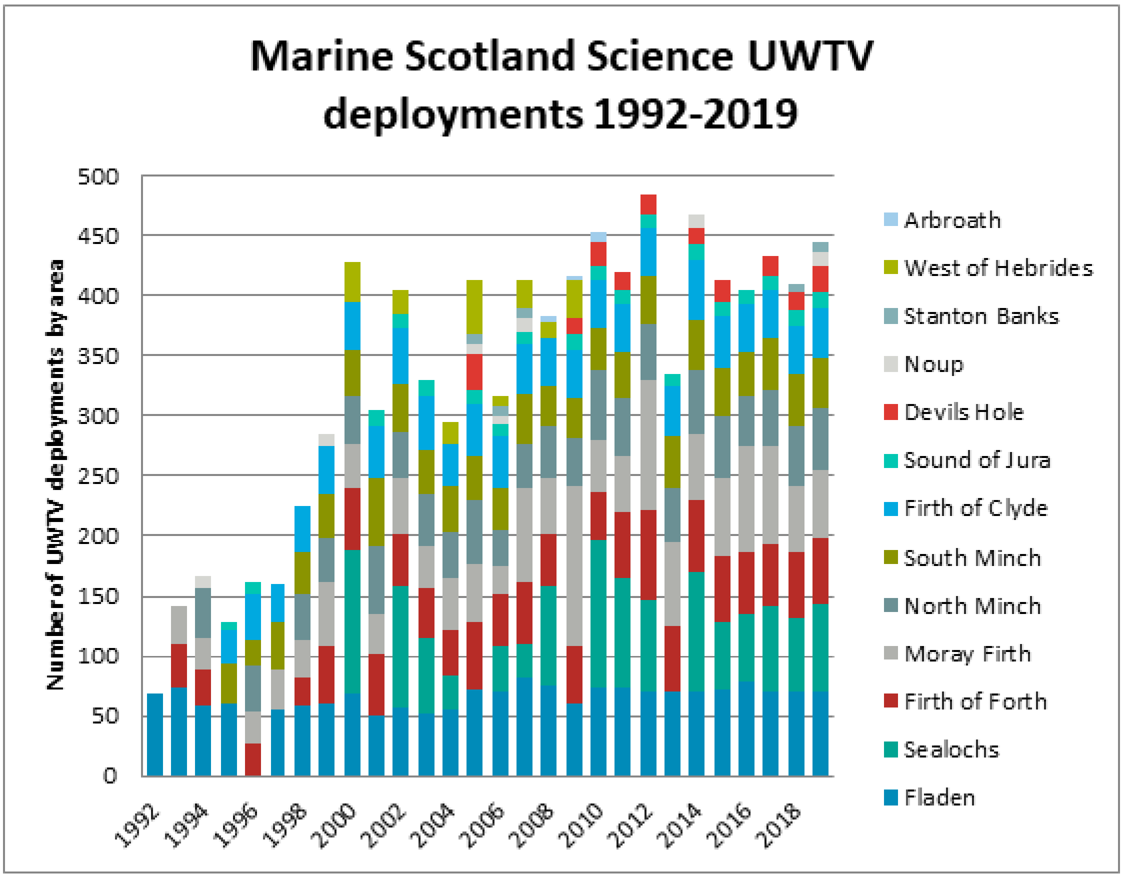


Figure 5.1.3.1. Time series of UWTV sledge and drop frame deployments by MSS for all areas surveyed, in relation to *Nephrops* burrow abundance, habitat mapping and comparative trials.

Alba-na-Mara, 5 – 21 January 2019

The annual underwater television (UWTV) west coast research support survey was carried out aboard MRV Alba-na-Mara during 5 - 21 January 2019. This non-Data Collection Framework funded survey carried out five objectives to further support the annual assessment surveys carried out in the summer months and to address issues raised both at the *Nephrops* UWTV survey Working Group (WGNEPS) and from within Marine Scotland Science (MSS).

The first activity involved releasing a self-contained time lapse camera system into Loch Torridon (FU 11, North Minch). Previous field trials of this device had been limited to 72 hours but with a long term aim to leave such devices *in situ* in areas to monitor bio-turbation and benthic rejuvenation post-commercial activity (e.g. gravel extraction, oil-well capping, marine protected areas, etc.) for up to a year, further proof of concept was required. Using local knowledge the camera equipment, mounted inside a large frame, was lowered to the muddy seabed in a safe area away from commercial fishing activity. The aim was to view the benthic faunal activity over a period of time, taking one high definition photograph every hour. Due to the high density of *Nephrops* in this area, the lander captured images of *Nephrops* activity in and around a burrow entrance. The camera frame remained in position for seven days before being relocated to Loch Ewe (FU 11, North Minch) to repeat the exercise for a further five days, generating 181 images in total. This work will be continued on future surveys.

Whilst the time-lapse frame was left unattended, two trawl areas were surveyed with the sledge for obstructions prior to carrying out five UWTV deployments along a linear track at each site. This data provided *Nephrops* abundance data prior to trawling over both sites with a commercial Jackson *Nephrops* trawl. Over the following three days the UWTV sledge was deployed along the original tracks, frequently observing sledge tracks created from the previous deployments, confirming the exact same grounds were being re-examined. The aim was to determine the time required for *Nephrops* to re-establish burrow entrances following commercial fishing activity. To ensure the trawling had as little impact on the local *Nephrops* population as possible, both in removals and relocation of individuals, the codend of the trawl was left open. All the footage was reviewed at sea in accordance with WGNEPS guidelines, and the statistical analysis of these data are due to be completed in 2020.

Following a MSS staff exchange, the second half of the survey focused on comparative work between the UWTV towed sledge and the MSS drop frame. Previously this work, which started in 2012, was opportunistic and completed when the weather conditions allowed and all scheduled work had been completed; whereas during this survey it was an activity built in to the programme. This work was carried out at three sites in Loch Ewe (FU 11, North Minch) before the weather forced the vessel east into the Moray Firth (FU9), where a further two sites were surveyed. The exercise involved deploying the sledge five times at each site, with each deployment being parallel and 50m apart, and towed over a distance of approximately 200m. Following this, three drop frame deployments were carried out at 90^0 to the path the sledge took, and within the survey extent of that which was surveyed by the sledge, ensuring the same grounds were surveyed. The footage was reviewed in accordance with WGNEPS guidance. Further datasets are required before analysis can be carried out.

Whilst carrying out these activities two ancillary trials were also undertaken. The first was to trial a stand-alone high definition (HD) camera (i.e. without the use of a fibre optic cable), and to compare the quality of the video with to existing analogue systems. The use of upgraded flat screen monitors since the last time this work was carried out resulted in much improved results, however the HD footage was unavailable without compromising the physical and logistical arrangements already in place during the survey. The conclusion was that this approach could be used if all options using the existing analogue system failed, but that there could potentially be an impact on the data gathering and processing aspects of this work. The second ongoing trial involved mounting two lasers on the front of the sledge to measure the size of burrows that could be clearly recognized as belonging to *Nephrops.* Calculations showed burrow entrances with an opening diameter of 2.5cm could be confidently identified by all reviewers involved. It was also believed that smaller entrances could be correctly observed, but the physical limitations of the lasers could not provide the accuracy required. This provided confidence in the abilities of the reviewers in their reviewing technique.

Scotia, 2 – 24 June 2019

The 2019 UWTV survey aboard MRV Scotia involved nine members of staff, including an Aberdeen University MSc student. In addition to the standard objectives of surveying the *Nephrops* grounds at Fladen, Devil's Hole, the Noup, in the North and South Minches, the Clyde and off Jura, this survey was charged to recover and then redeploy six COMPASS moorings on the west coast. To facilitate this extra work, the trip was extended to 23 days, and despite losing a significant amount of time due to poor weather and considerable equipment issues, all the objectives were met. As required a pre-survey training session was held with further advice provided throughout the trip. All video footage was reviewed in accordance with WGNEPS guidance, with quality control being carried out on all data using Lin's concordance correlation coefficient (Lin's CCC), with third counts applied where thresholds were not met (see Table 2 below). Variable weather conditions and poor subsurface visibility were experienced throughout the trip, and this was reflected in the QC outputs.

A number of trawls were completed on this survey given the additional vessel time and catches were worked up for length frequency distribution, sex ratio, weights, morphometrics and maturity data as required. Any marine litter appearing in the catch was recorded and disposed of as per OSPAR guidance. Sediment samples for PSA were obtained at 84% of the TV stations using the sledge mounted mini van Veen. A day grab had been used in past surveys where the sledge mounted mini van Veen had failed but in the interest of time management it was deemed that this approach would not be taken during this survey.
The six moorings which required visiting on the west coast formed part of the long term COMPASS project which aims to identify areas around Scotland in high use by cetaceans, by attaching devices to moorings to both record the sounds of passing fauna and count the number of vocal interactions. The location and favourable weather conditions of one COMPASS mooring allowed the survey to conduct further UWTV work on the *Nephrops* grounds at Stanton Bank for the second time since 2002.

Additional work also conducted during this survey included:

- As part of the Remote Electronic Monitoring (REM) project there are a number of cameras fitted above the fish house belt which feed live footage back to a server on land, where species contained in the catch are identified and measured automatically. The trial on this survey was to assist in calibrating the REM system using actual measurements taken by staff and the measurements calculated by the REM software. Following three of the trawls, 100 male and 100 female *Nephrops* were selected and their carapace length measured and recorded. These animals, separated by sex, were then placed (in the order they were measured) in a line on the conveyor belt where they were then filmed passing under the camera.
- To assist in a PhD study to directly estimate the connectivity and distribution of common skate populations, data were collected from all 32 animals caught during the survey. The weight, length and width were recorded, as well as photographing the eyes to provide confirmation of the species identification. To provide material for DNA testing, mucus from the gills was taken from the first 20 animals that were caught.
- Following on from the work carried out in 2017, further reviewing of historical footage was completed whilst at sea. This involved an additional reviewer and footage from 2012 which had not previously been used. Further statistical analysis is required to allow any precise conclusions to be made.

- Due to the equipment and environmental changes that had taken place since the original reference set of training videos was created in 2009, it was recognized that there was a requirement to update the existing reference footage. New reference sets were created for three areas (North Minch (FU 11), South Minch (FU 12) and Fladen (FU 7)) using 2018 footage, with the North Minch data being assessed during WKNEPS (October 2018). Reference sets for the remaining three main grounds (Firth of Forth (FU 8), Moray Firth (FU9) and Clyde (FU 13) will be produced by April 2020.

Table 5.1.3.2. Summary of *Nephrops* burrow abundance related activities carried out within the seven survey areas during the MRV Scotia cruise in June 2019. Survey design: RS – S, random stratified based on sediment; RS – E, random stratified based on VMS effort; Fixed, survey stations are fixed due to the challenging topography.

Area	Number of TV sledge deployments	Number of fishing trawls	Number of sediment samples	Linn's CCC threshold	Lin's CCC pass rate	Survey design type
Fladen	70	4	50	0.7	68.5%	RS -S
North Minch	52	1	43	0.5	76%	RS - E
South Minch	41	1	37	0.5	57.5%	RS -S
Clyde	43	2	40	0.5	62.1%	RS -S
Stanton Bank	8	1	7	0.5	87.5%	Fixed
Jura	12	1	12	0.5	80%	RS -S
Devils Hole	22	1	21	0.5	63.6%	Fixed
Noup	12	1	9	0.5	50%	Fixed
Totals	260	12	219	NA	NA	NA

On completing the survey, all footage having been reviewed and passed the standards required for assessments purposes, and all count, sediment, observations of other fauna (e.g. sea pens, fish, crustaceans, etc.), haul, biological and station data had been entered into the required format for uploading into the bespoke MSS database on returning to shore.

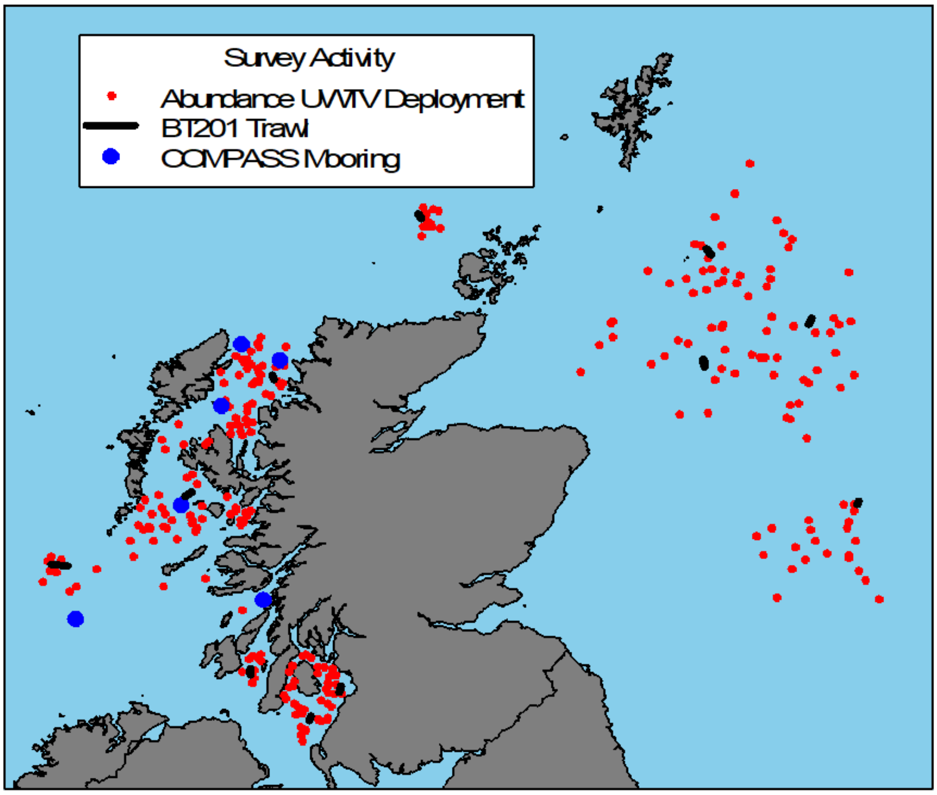


Figure 5.1.3.3. Map illustrating the location of the various UWTV activities, ACDP deployments and COMPASS mooring recoveries that were conducted within the seven survey areas during the MRV Scotia cruise in June 2019.

Alba-na-Mara, 8 - 24 August 2019

The annual 17 day UWTV survey to the Firth of Forth (FU8) and Moray Firth (FU9) was completed from 8th to 24th August aboard MRV Alba-na-Mara. This survey complemented the work carried out in June by MRV Scotia and ensured all of the main *Nephrops* fishing grounds around Scotland had been surveyed by the internationally accepted UWTV method and to the standards set out by WGNEPS.

In methodology, process and outcomes this survey mirrored the MRV Scotia survey, allowing the results to be directly comparable, and fully met all that was required to provide data for the stock assessment process.

Although the weather proved to be a challenging force during the survey, no further issues were encountered. The UWTV sledge was used throughout this survey. The vessel initially surveyed the Firth of Forth, followed by the Moray Firth, maintaining the same core staff of 3 scientific crew. On occasion, stations had to be relocated due to no visibility (but still remaining within the same sediment type and spatial zone) and the survey concluded by achieving its objectives by surveying the required number of stations and acquiring sufficient data for analysis necessary to carry out assessments in these two areas, to generate stock management advice.
All footage was gathered and reviewed in line with WGNEPS guidance, with a high pass rate when Lin's CCC was applied (see Table 3 below). Due to the limited number of staff on-board, it was not possible to complete third counts at sea so these were carried out onshore.

The *Nephrops* component of the five trawls was sampled for length frequency distribution, sex ratio, weights, morphometrics and maturity data. All marine litter appearing in the catch was recorded and disposed of as per OSPAR guidance.

Sediment samples for PSA were obtained at 83% of the TV stations using the sledge mounted mini van Veen. A day grab had been used in past surveys where the sledge mounted mini van Veen had failed but in the interest of time management it was deemed that this approach would not be taken during this survey.

On completing the survey, all footage having been reviewed and passed the standards required for assessments purposes, and all count, sediment, observations of other fauna (e.g. sea pens, fish, crustaceans, etc.), haul, biological and station data had been entered into the required format for uploading into the bespoke MSS database on returning to shore.

Table 5.1.3.3. Summary of *Nephrops* burrow abundance related activities, carried out the MRV Alba-na-Mara cruise during August 2019 within the Firth of Forth (FU 8) and the Moray Firth (FU 9).Survey design: RS – S, random stratified based on sediment.

Area	Number of TV sledge deployments	Number of fishing trawls	Number of sediment samples	Linn's CCC threshold	Percentage pass rate	Survey design type
Firth of Forth	56	2	48	0.5	86.2%	RS - S
Moray Firth	55	3	45	0.5	78.1%	RS - S
Totals	111	5	93	NA	NA	NA

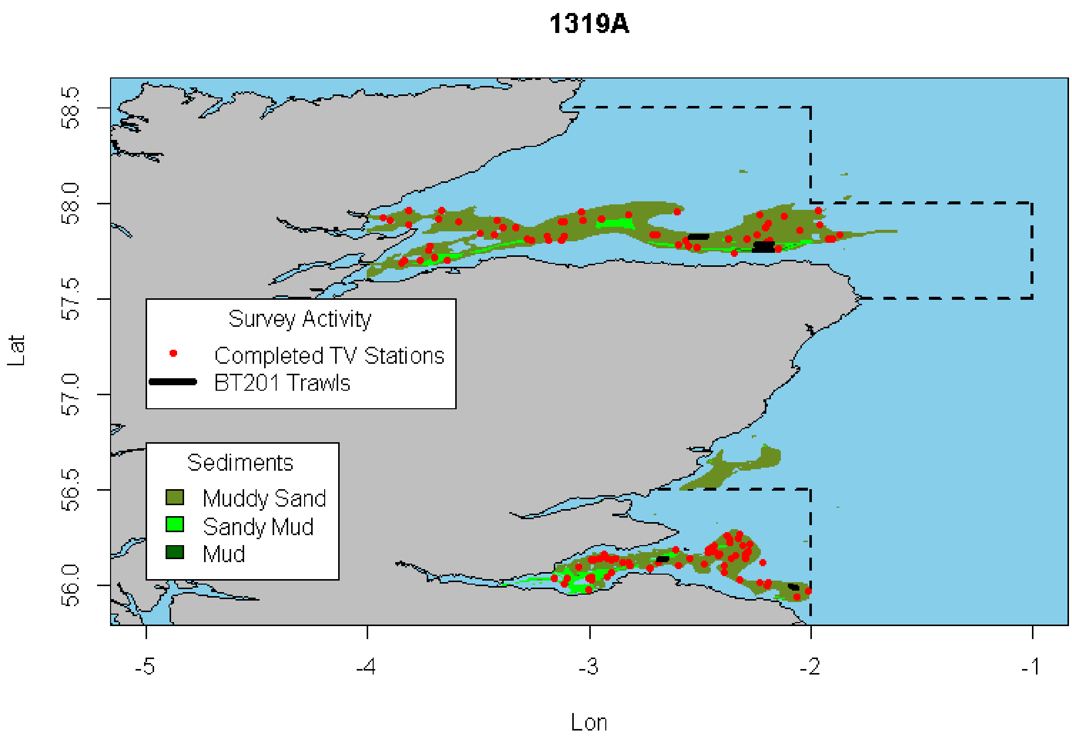


Figure 5.1.3.4. Map illustrating the location of the various UWTV activities carried out during the MRV Alba-na-Mara cruise during August 2019 within the Firth of Forth (FU 8) and the Moray Firth (FU 9).

Conclusions/recommendations:

- To further encourage and promote national and international staff exchange.
- To continue to promote the UWTV surveys to being open to alternative, but appropriate and collaborative, use of staff experience and ship's time to improve cost and time efficiencies, widen the survey remit and increase staffs' skill base.
- To produce reference sets for the Firth of Forth (FU 8), the Moray Firth (FU 9) and the Clyde (FU 13).

UK England

(Charlotte Reeve)

<u>FU 6</u>

The Farn Deeps survey design is based on a randomized fixed grid and includes a total of 110 stations (Figure 1). The initial ground perimeter has been delimited by the combination of VMS data and BGS sediment maps. An additional 16 stations were completed during the past three years surveys, not forming part of the standard survey, however these stations were not completed in 2019 due to time limitations. These additional stations form part of a UWTV survey planned to take place by NEIFCA (Northeast Inshore Fisheries and Conservation Authority) in autumn of each year on grounds within 6 nm from the coast. The stations were included to allow comparisons of the burrow densities before and after the peak moulting period. To date NEIFCA have been unable to carry out the survey so analysis hasn't taken place. These stations will be removed for the 2020 survey.

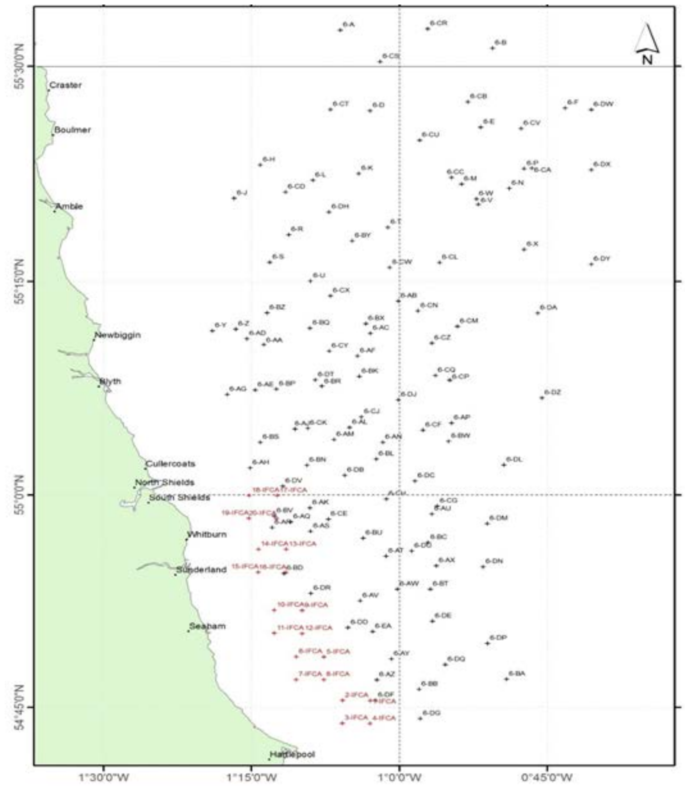


Figure 1 – Map showing the location of the surveyed area in the Function Unit 6 area (110 stations) and the 15 additional NEIFCA stations.

At each station a sledge mounted TV camera was deployed and a clear 10 minute tow was recorded to MP4 video files, recorded directly to two separate drives to provide a backup. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 10 seconds.

Survey gear used for the FU6 UWTV survey has remained the same for the last three years (2017-2019), using OLED monitors (Sony 25-inch professional PVM-A250) a Kongsberg camera (720p, 24fps), green fan lasers (rated to 3000m, 520nm wavelength), 6 LED lights (20w) and on-board control system. The Rochester armoured cable was used as in previous years, although only the coax components were required for delivery of power and control of all peripherals. It was anticipated that we would be using a fibre optic umbilical for the 2019 survey, however we were unable to get the system working. We anticipate usage of the fibre optic umbilical for the 2020 survey. The swept-area is calculated using the ships positioning rather than the sledge position (USBL) for FU6.

The work was all undertaken according to the standard protocols which include pre-survey training and standardization of counter's performance. All counters must count the reference footage for FU6 to a predetermined standard (0.5 Lins CCC threshold) before being given access to the current survey footage.

A summary of the surveys for the last three years is provided below (Table 1).

Table 1. A summary of Cefas UWTV surveys for FU6

Year	2017	2018	2019
Dates	19th – 26th June	19th – 26th June	24th June – 1st July
Vessel	RV Cefas Endeavour	RV Cefas Endeavour	RV Cefas Endeavour
Stations used in assessment	110	109	91
Visibility	93% Good	97% Good	96% Good
Average lins CCC	0.7	0.66	0.66
Method	Geostatistics	Geostatistics	Geostatistics
Absolute abund (millions)	902	950	1163
2 standard deviations (millions)	21	23	26

The last three years have seen a year on year increase in stock abundance, with abundance being just above the MSYB trigger (858 million) in 2017 and 2018 (Figure 2).

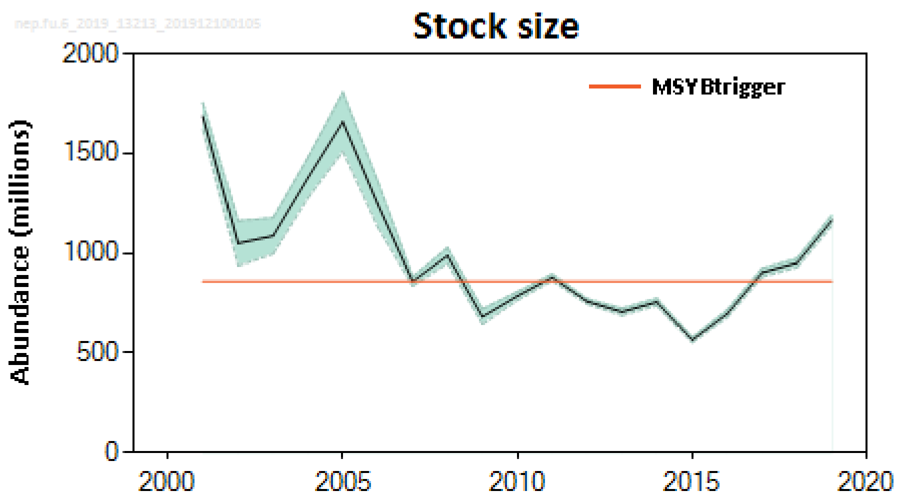


Figure 5.1.4.2 – *Nephrops* abundance for 2001 – 2019.

Burrow densities have shown the same general distribution across the ground to previous years, with an area of higher density towards the southwest of the ground. This year's survey showed a additional area of high density towards the west of the grounds (Figure 3).

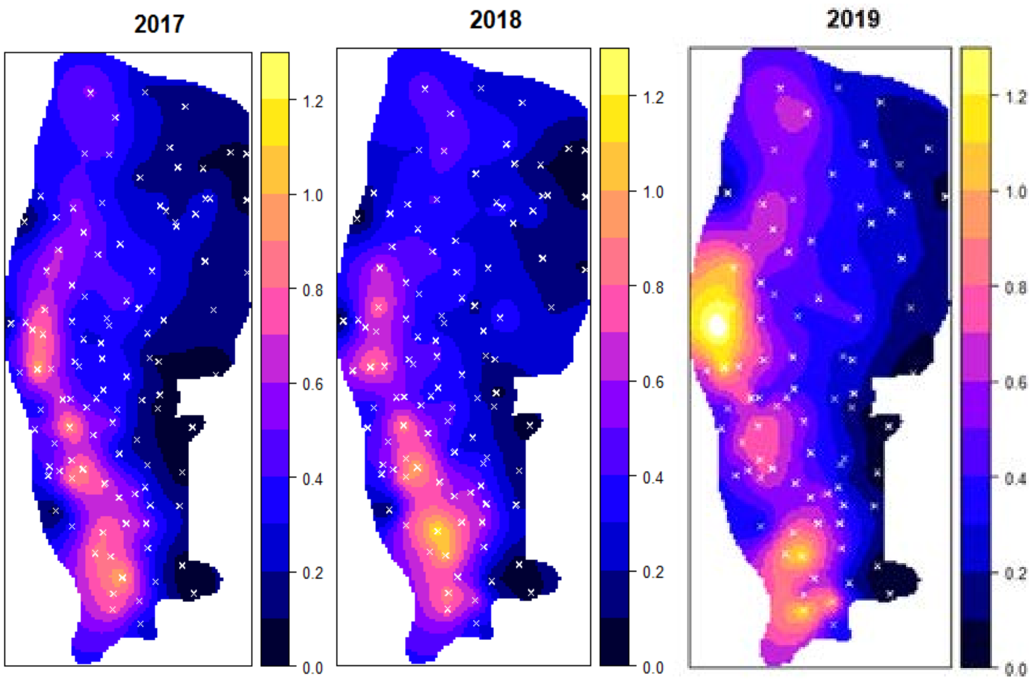


Figure 3 – Geostatistical outputs 2017 – 2019, maps of *Nephrops* density distribution (m²).

FU14

The FU14 survey design is based on a randomized fixed grid. In 2019 this included a total of 46 stations (Figure 4). The initial ground perimeter has been delimited by the combination of VMS data and BGS sediment maps.

The Irish Sea *Nephrops* UWTV survey takes place onboard "RV Corystes" as part of a collaborative survey with AFBI and MI. This survey covered both the western (FU15) and eastern (FU14) side of the Irish Sea. The survey in the East Irish Sea area is carried out using the same protocols used in UWTV surveys in the western Irish Sea. For details on gear, training and survey protocol, see the section on FU15.

In 2016 new stations were added to the Wigtown Bay area (14-BA, 14-AY, 14-AZ). This was done to account for an increase in effort in this area, the result of effort displacement from an area at the southern boundary of FU14 where Walney offshore windfarm has been developed. The effort in Wigtown Bay increased from 1.9% in 2015 to 6.6% in 2016 of the overall fishing effort in FU14.

Two stations have been dropped from the survey area (14-AK, 14-AG) in 2016 due to the construction of Walney offshore windfarm extension. As of 2019 these have been permanently removed from the survey grid in 2019 due to these being located in the Walney offshore windfarm extension therefore can no longer be surveyed.

In 2018 three stations were removed from an area offshore from Workington (not shown on current map) as recent VMS data showed little effort in this area. These stations were relocated in the main grid (14-BB, 14-BC, 14-BD) to better sample an area of the FU which consistently has high densities from year-to-year.

FU14 2019 Grid

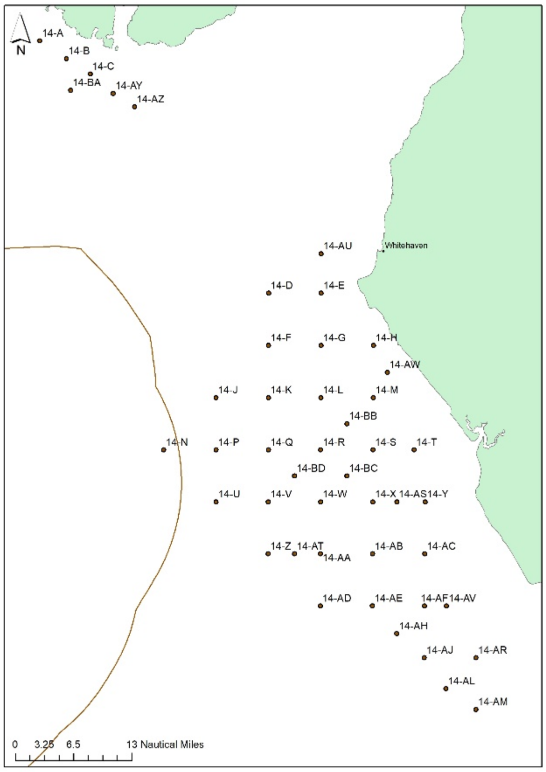


Figure 4 – Map showing the location of the surveyed area in the Function Unit 14 area for 2019 (46 stations).

A summary of the surveys for the last three years is provided below (Table 2).

Table 2. A summary of Cefas UWTV surveys for FU14.

Year	2017	2018	2019
Dates	6th – 8th Aug	6th – 8th Aug	13th -14th Aug
Vessel	RV Corystes	RV Corystes	RV Corystes
Visibility	87% Good, 13% Moderate/Poor	60% Good, 40% Moderate/Poor	93% Good, 7% Moderate/Poor
Method	Geostatistics	Geostatistics	Geostatistics
Absolute abund (millions)	579	513	399
95% confidence interval (millions)	89	118	69

The last three years have seen a stock abundance remaining above MSYBtrigger (Figure 5), with the current estimate of abundance being 399 million.

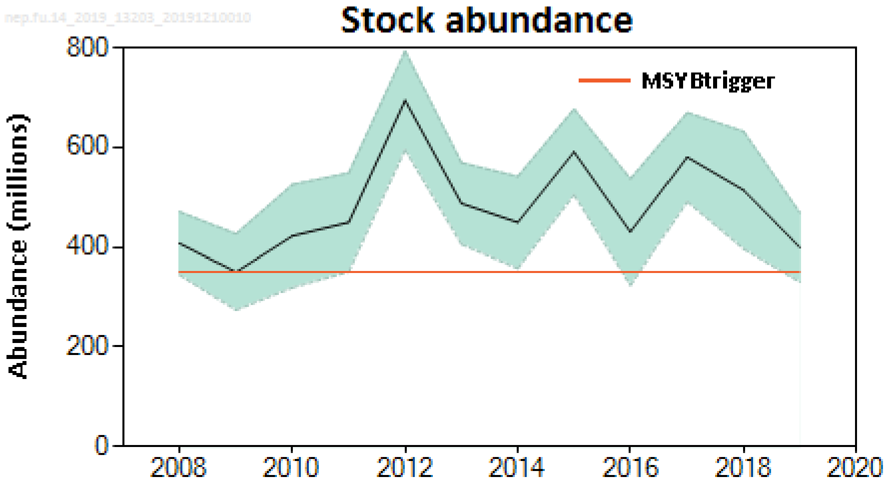


Figure 5 – *Nephrops* abundance for 2009 – 2019.

Burrow densities have shown the same general distribution across the ground to previous years, with an area of higher density towards the centre of the ground (Figure 6).

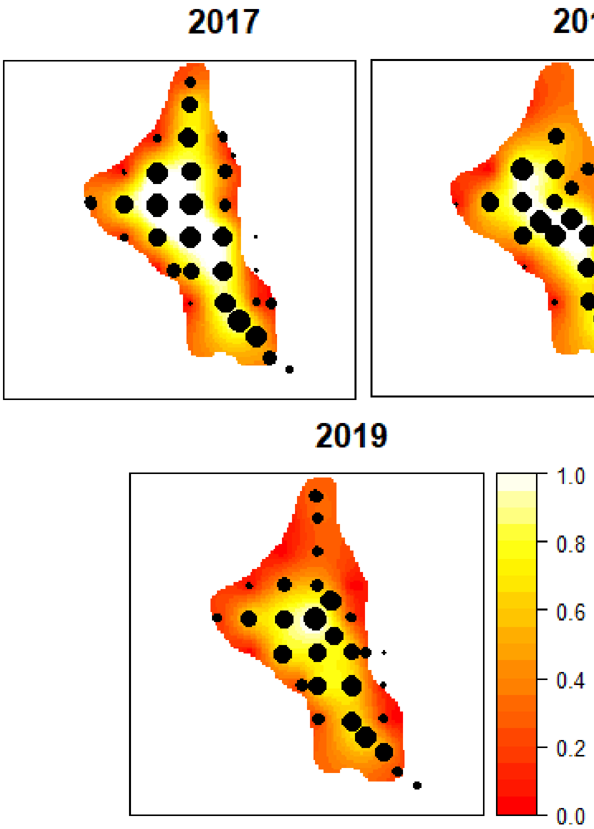


Figure 6 – Geostatistical outputs 2017 – 2019, maps of *Nephrops* density distribution (m²).

Conclusions/Recommendations

As in other *Nephrops* stock there are a number of generic research questions related to occupancy and edge effect bias that needs still to be investigated.

- For FU 14 and FU6 more accurate mapping of the spatial extent of the grounds and fisheries, this includes having positional data for < 12-meter vessels and more survey data in the boundary areas to better define these grounds.
- For FU 14 there is a need to improve the spatial coverage and sampling of landings and discards, this includes increasing the sampling levels to covers Northern Irish vessels, as the current sampling is mainly focused on local vessels form Whitehaven port.
- For FU14 there is a need to get area specific length-weight and maturity data to validate the parameters used for this FU.

Denmark and Sweden FU 3-4: Skagerrak and Kattegat

(Kai Wieland, Mats Ulmestrand)

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, SWE: additional stations in creel area (not included in the analysis)
Country (ies)	Denmark and Sweden	Vessel name (s)	DK: RV Havfisken SWE: RV Havfisken, RV Asterix
Survey code (s)		Dates (start/end)	DK: 1/4 - 7/4/2019 SWE: 27/5 – 9/6/2019 (Havfisken), 20/5/2019 (Asterix)
Number scientific staff	DK: 2 SWE: 2	Staff exchanges	none
Number of stations (planned*/completed/used in analysis) *: Strata 1 to 9, i.e. without creel area		DK: 106 / 105 / 100 SWE: 97/80/77	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		DK: uneven bottom and/or poor visibility at 5 stations SWE: 8 stations not taken because of rocky bottom, 4 stations not suitable for analysis because of too poor visibility, 5 stations not taken because of technical problems on RV Asterix ⇒ No valid stations in stratum 9	
Distance over ground source used	Vessel GPS	Average field of view (cm)	Havfisken: 66 cm Asterix: na (no valid station)

Adjusted mean density	0.34 burrows/m^2	Adjusted abundance, CV	4487 mill., 4.55 % (without stratum 9)
Overall footage quality (poor, medium, good)			
Reference footage for survey area generated		DK: yes (6 footages from 2018 survey), but yet no checked by external expert or a Swedish reader SWE: yes (from 2016 survey)	
Quality control of station counts (Lin's CCC or consensus count)			
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		DK: CTD	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Excel files, .csv file with R-output for DK and SWE combined
		CTD	DK: Institute's server, unprocessed raw data
		Trawl	
		Sediment	
		Other	

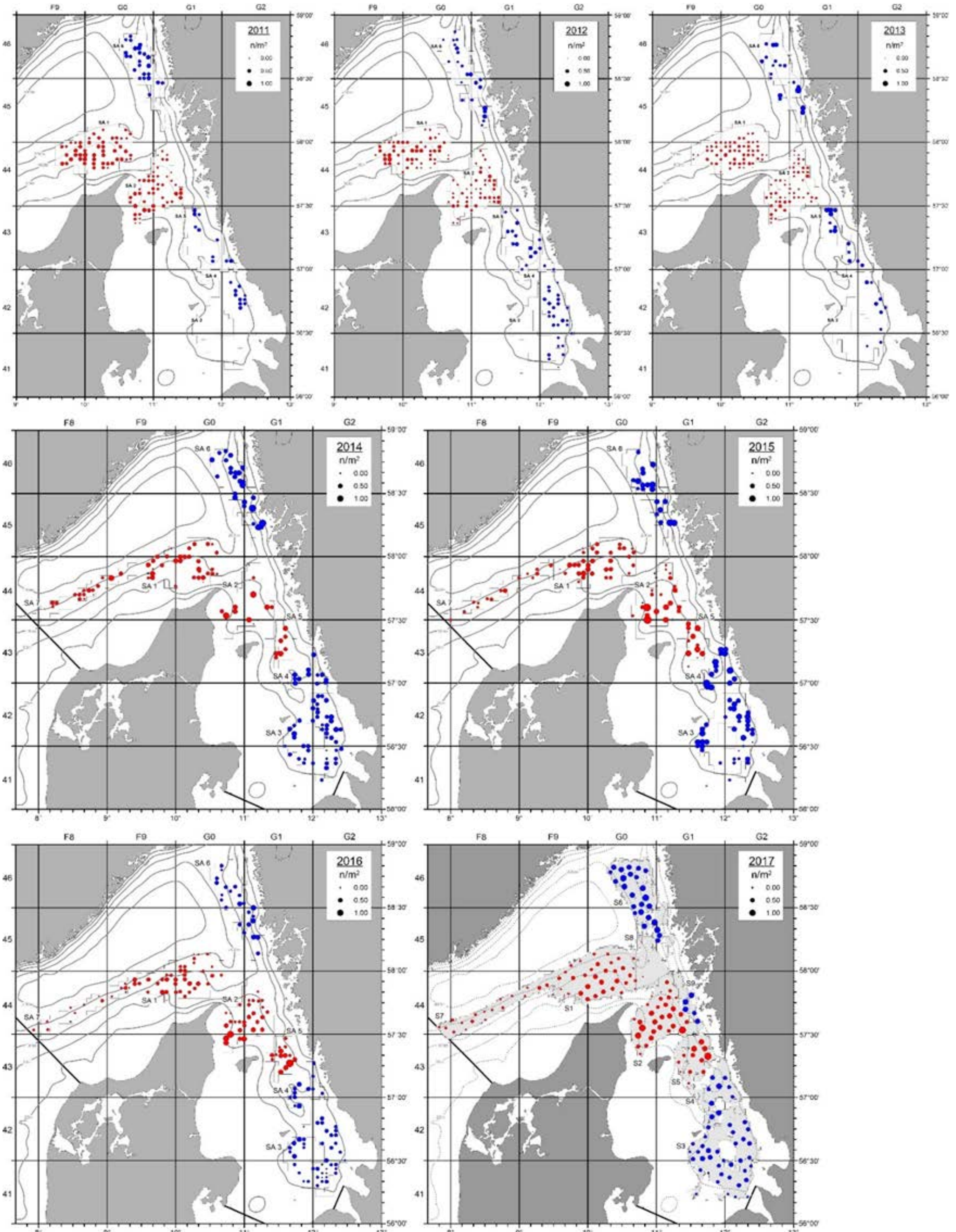


Figure 1a: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2011 - 2017 (red: DK, blue: SWE).

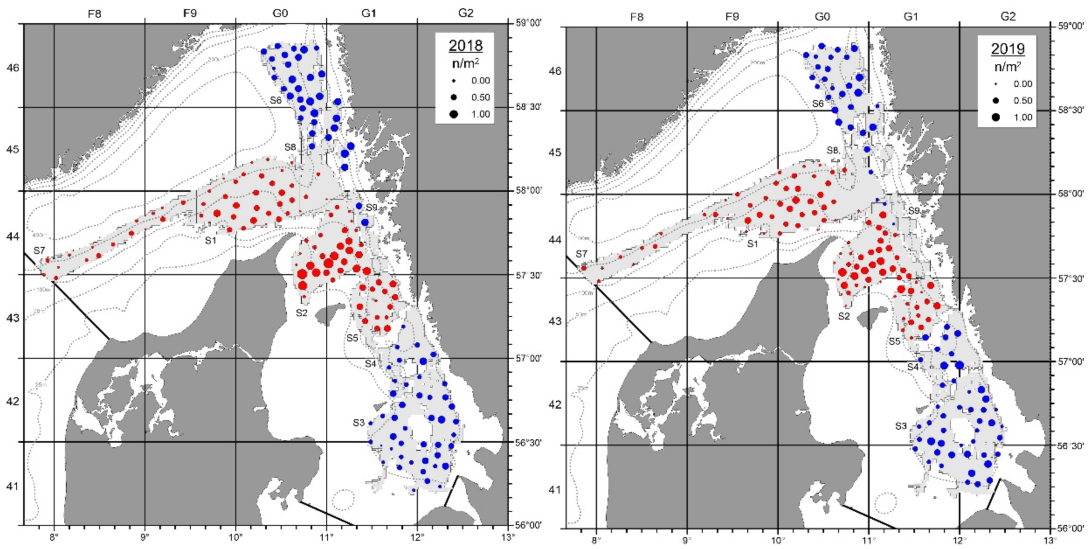


Figure 1b: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2018 - 2019 (red: DK, blue: SWE).

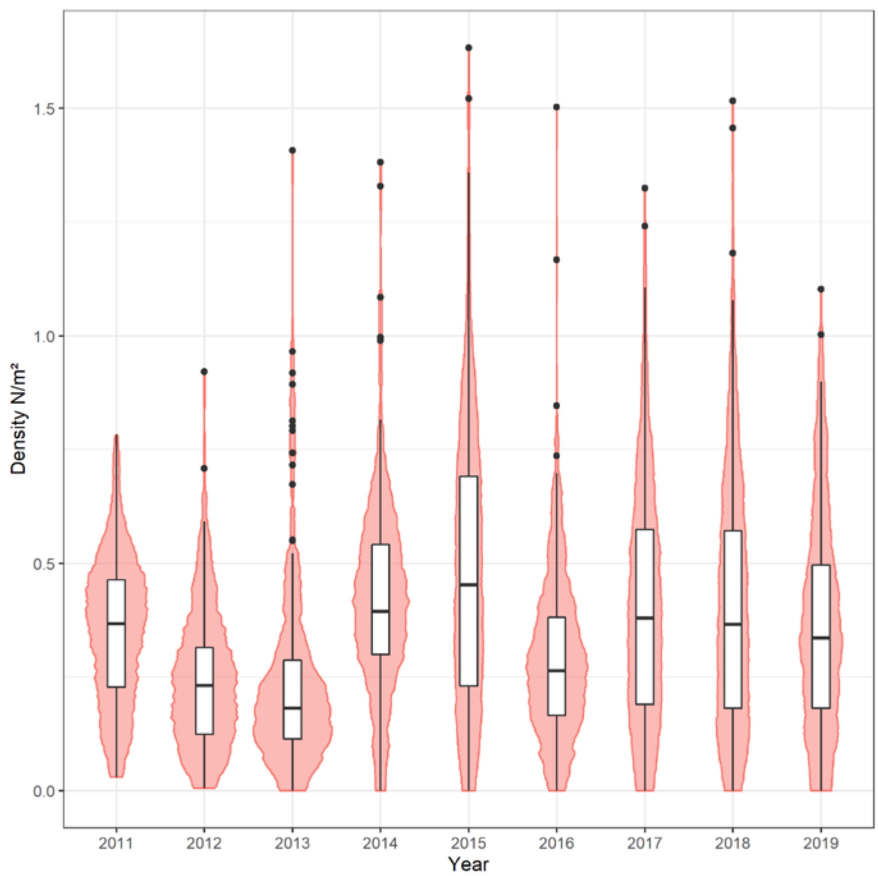


Figure 2: FU 3&4 (Skagerrak/Kattegat) times series of *Nephrops* burrow density (The horizontal lines represents the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).

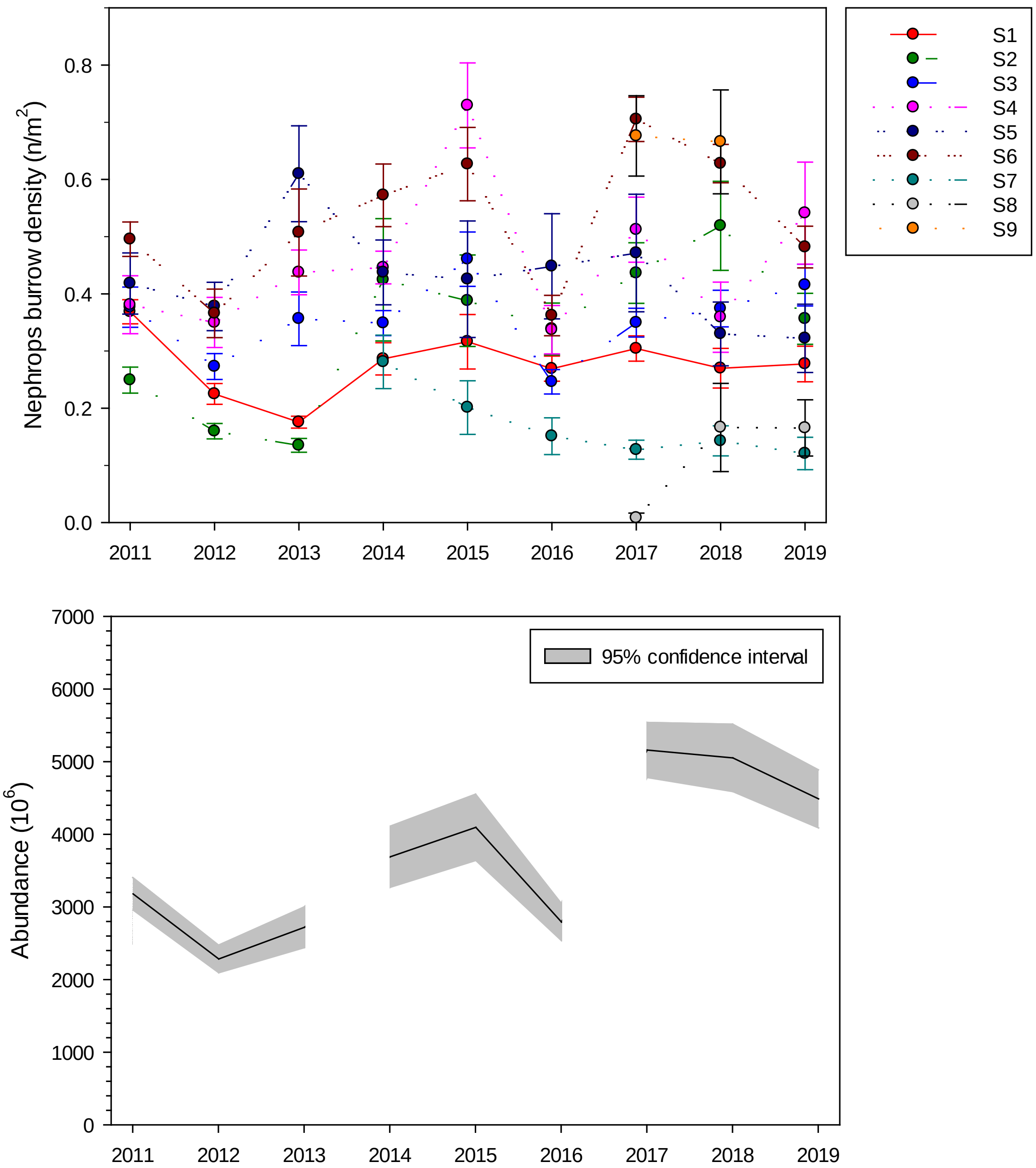


Figure 3: FU 3&4 (Skagerrak/Kattegat) time series of *Nephrops* burrow mean density by stratum and total abundance with reference levels (error bars in upper panel represent standard error of the mean; shaded area in the lower panel represents the 95% confidence interval; note change in survey area and stratification between 2013 and 2014 and between 2016 and 2017; reference points for stock size are not defined for this stock).

Denmark FU 33: Off Horns Rev

(Kai Wieland)

Functional Unit	FU 33	Area name	Off Horns Rev
Survey design	Random with buffer, 1 stratum	Previous surveys	2017-2018
Country (ies)	Denmark	Vessel name (s)	RV Havfisken
Survey code (s)		Dates (start/end)	7/5-12/5/2019 (without transit)
Number scientific staff	2	Staff exchanges	none
Number of stations (planned/completed/used in analysis)		80 / 79 / 60	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		19 stations not readable due to unusual poor visibility	
Distance over ground source used	Vessel GPS	Average field of view (cm)	66 cm
Adjusted mean density	0.0726	Adjusted abundance, CV	417 mill., 14.35 %
Overall footage quality (poor, medium, good)			
Reference footage for survey area generated		Yes but not checked by an external expert	
Quality control of station counts (Lin's CCC or consensus count)			
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.)		CTD (all stations) 1 trawl haul	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	Excel file, .csv file with R –output
		CTD	Institute's server, unprocessed raw data
		Trawl sample	Institute's database, processed
Other		Cruise Summary Report (CSR) submitted to German Oceanographic Data Centre	

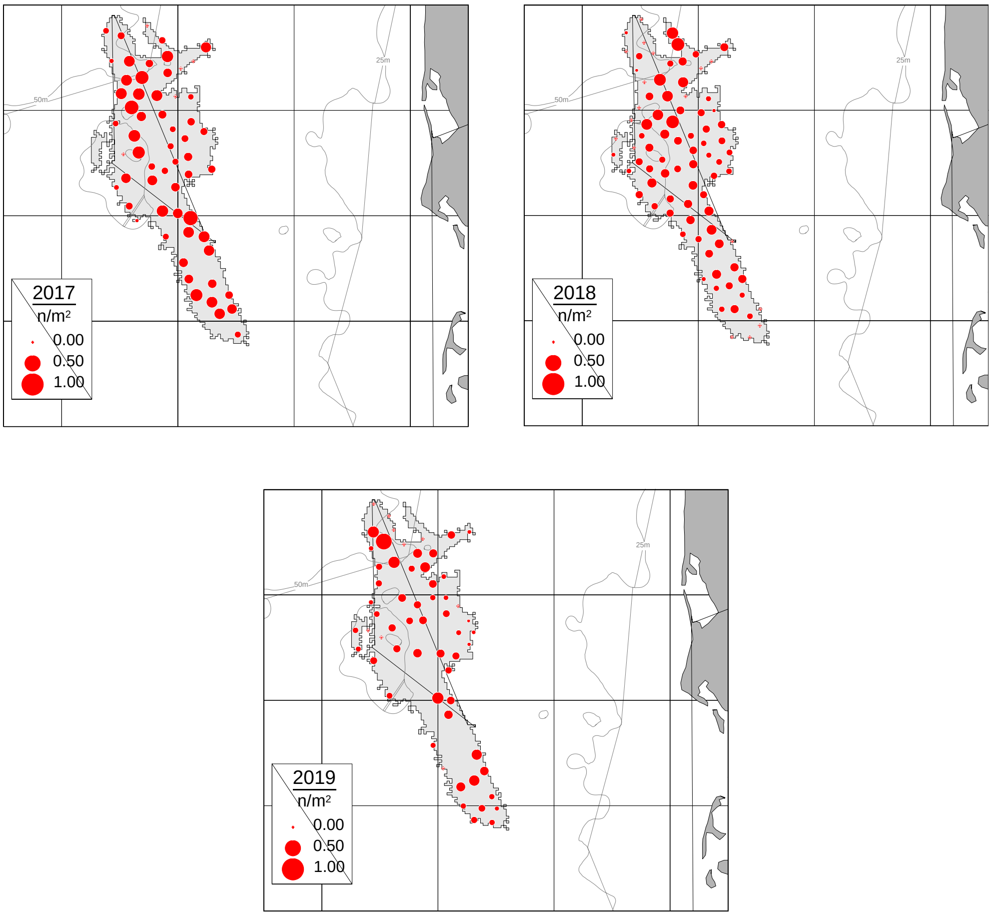


Figure 1: FU 33 (Off Horns Rev) *Nephrops* burrow density by station for each year.

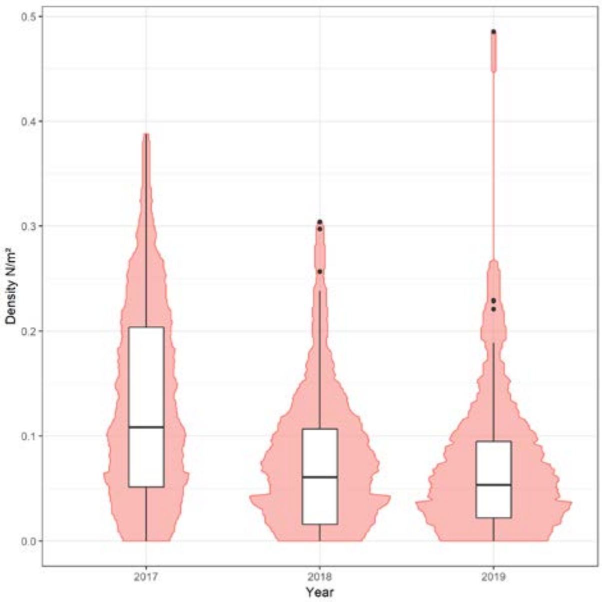


Figure 2: FU 33 (Off Horns Rev) times series of *Nephrops* burrow density (The horizontal lines represents the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).

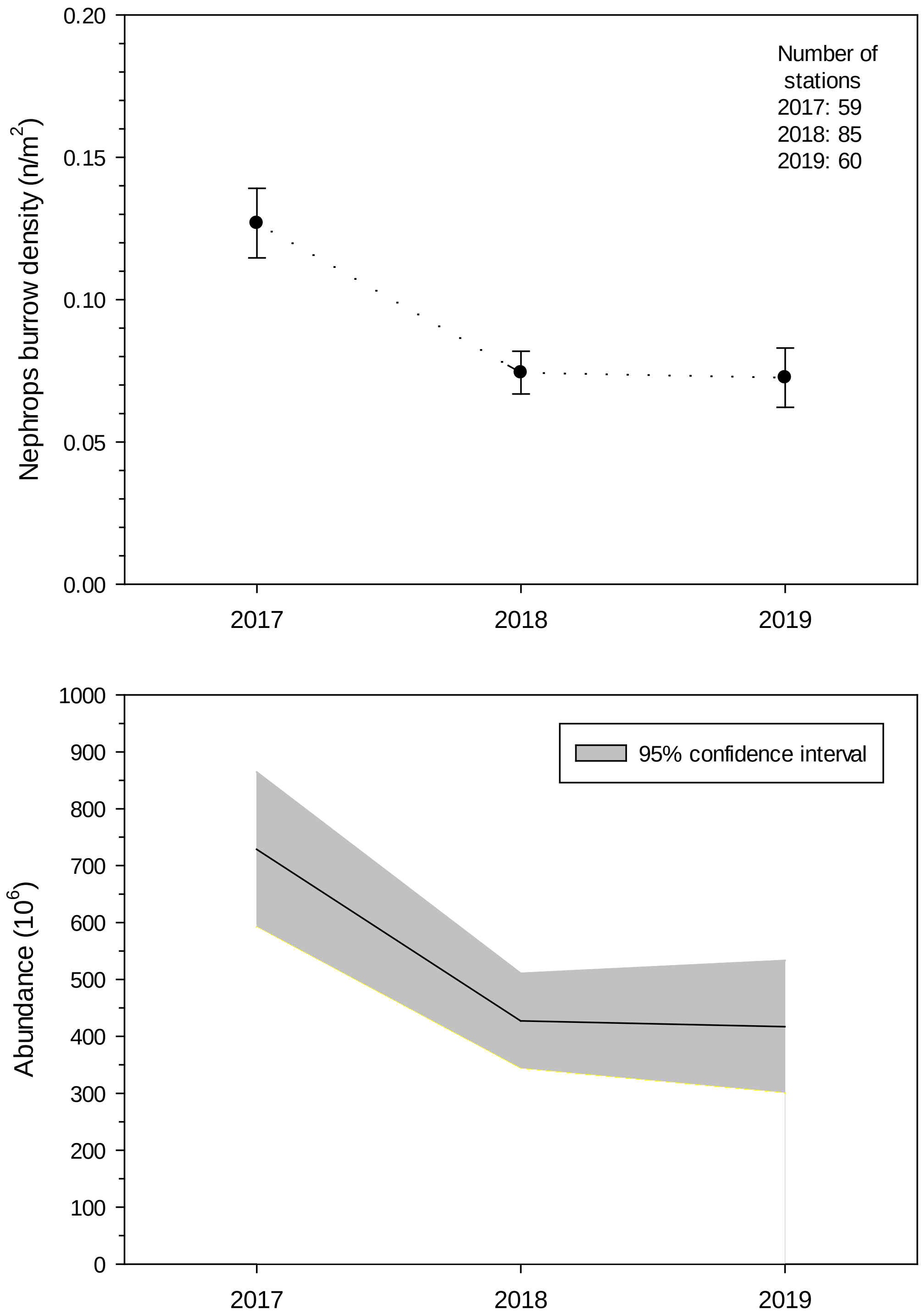


Figure 3: FU 33 (Off Horns Rev) time series of *Nephrops* burrow mean density and total abundance with reference levels (error bars in upper panel represent standard error of the mean and the shaded area in the lower panel represents the 95% confidence interval; reference points are not defined for this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

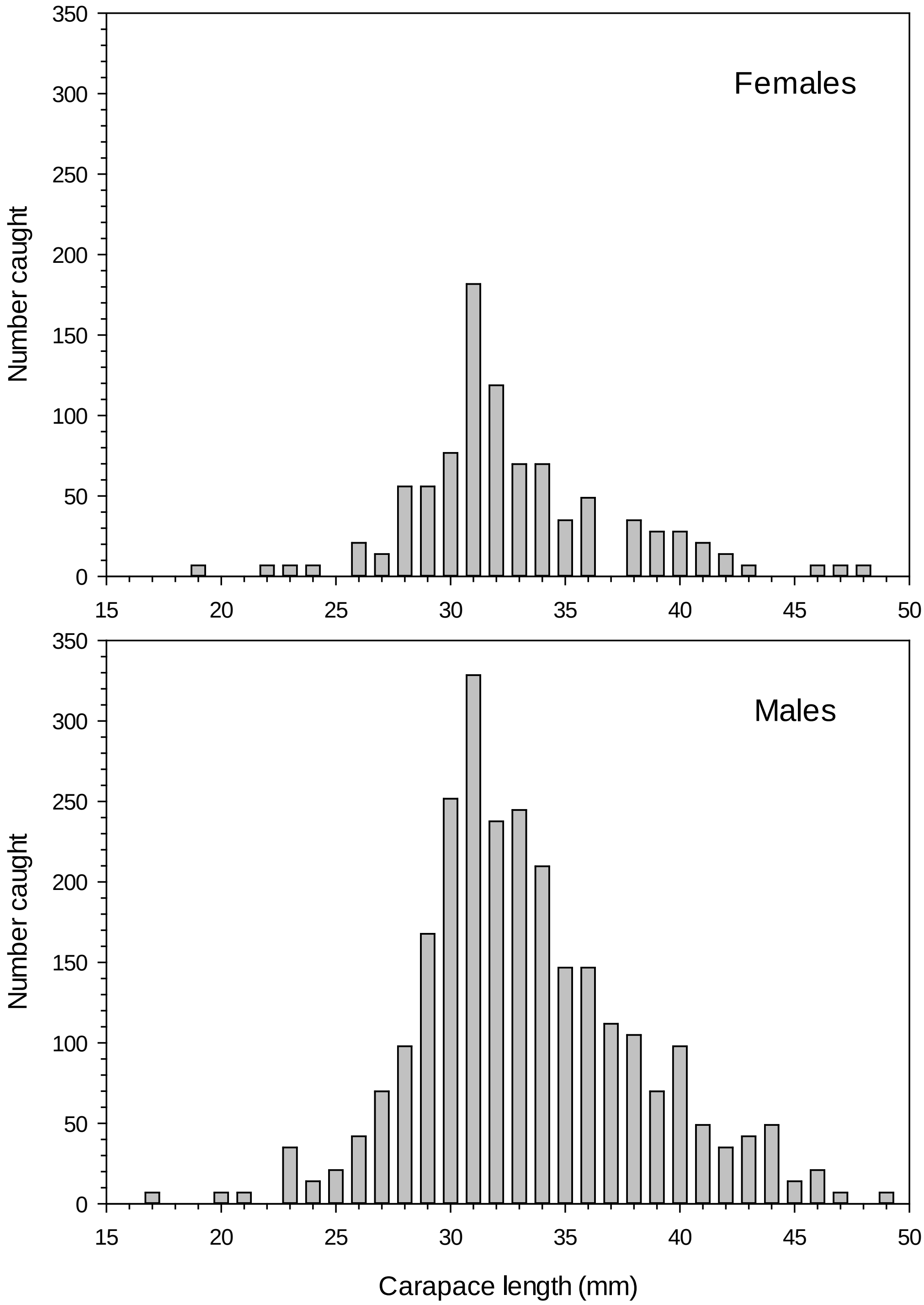


Figure 4: FU 33 (Off Horns Rev) length frequency by sex of *Nephrops* for one trawl haul in 2019 (Catch rate: 30.6 kg/h, both sexes combined) in the northern part of the survey area.

Spain FU 30: Gulf of Cadiz

(Yolanda Vila, Candelaria Burgos)

Functional Unit	30	Area name	Gulf of Cadiz
Survey design	Randomized isometric grid at 4 nm spacing	Previous surveys	2015-2019
Country (ies)	Spain (SP)	Vessel name (s)	Ángeles Alvariño
Survey code (s)	ISUNEPCA_0619	Dates (start/end)	3-15 June 2019
Number scientific staff	10 (3 for *Nephrops* burrows counts)	Staff exchanges	1 Portuguese
Number of stations (planned/completed/used in analysis)		Planned: 69 + 6 exploratory in Portuguese waters Completed: 55 + 5 exploratory in Portuguese waters Used in analysis: 65 (12 were assumed zero) (only Spanish stations)	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Many technical problems occurred this year, which were related to the communication between the sledge and the desk unit by the coaxial cable of the vessel. The new equipment used since 2018 is probably more sensible to electronic noises of the vessel than the previous one. This resulted in a reduction of the effective time of the survey and stations planned had to be priorized. 12 stations located on the shallower border were sacrificed and could not carry out. These stations were assumed as stations with zero *Nephrops* density on the base of the available information from beam trawl hauls carried out in the 2017-2019 period, VMS (2011-2012) and IBTS series (1994-2014). This information indicates no *Nephrops* or very very low density. Probably the *Nephrops* area is smaller than the current *Nephrops* area established. A redefinition of the survey area must be carried out. 2 stations were considered null because the recent fishing activity the visibility was very poor.	
Distance over ground source used	Transponder (HiPAP)	Average field of view (cm)	75cm
Adjusted mean density	0.04	Adjusted abundance, CV	113 millions of burrows; CV=9.7%
Overall footage quality (poor, medium, good)		Good-Excellent	
Reference footage for survey area generated		Yes (Created in WKNEPS 2018)	
Quality control of station counts (Lin's CCC or consensus count) State Lin's CCC threshold		Lin's CCC Threshold – 0.5 Counts with Lin's CCC<0.5 were reviewed by consensus (12 stations)	
Other survey activities		CTD on the sledge Beam trawl hauls in order to know the presence of *Nephrops* and other burrowing fauna which co-occurring together and delimit the shallowest border of the survey area.	

(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 bead Sediment samples and Seabed morphological and backscatter analysis	
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** - WGBIE
	CTD	**Storage** – hard copies of data held in office environment; **Level of analysis** – In process **Dissemination** – IEO internal report
	Beam Trawl	**Storage** – hard copies of data held in office environment; **Level of analysis** – Only presence of *Nephrops*. Other species awaiting work up. **Dissemination** – IEO internal report
	Sediment and morphological and backscatter analysis	**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** – IEO internal report. MSFD
	Other	**Macrobenthic abundance, trawl marks and litter** **Storage** – hard copies held in office environment **Level of analysis** – carried out by other departments. Awaiting work up. **Dissemination** – IEO internal report; MSFD.

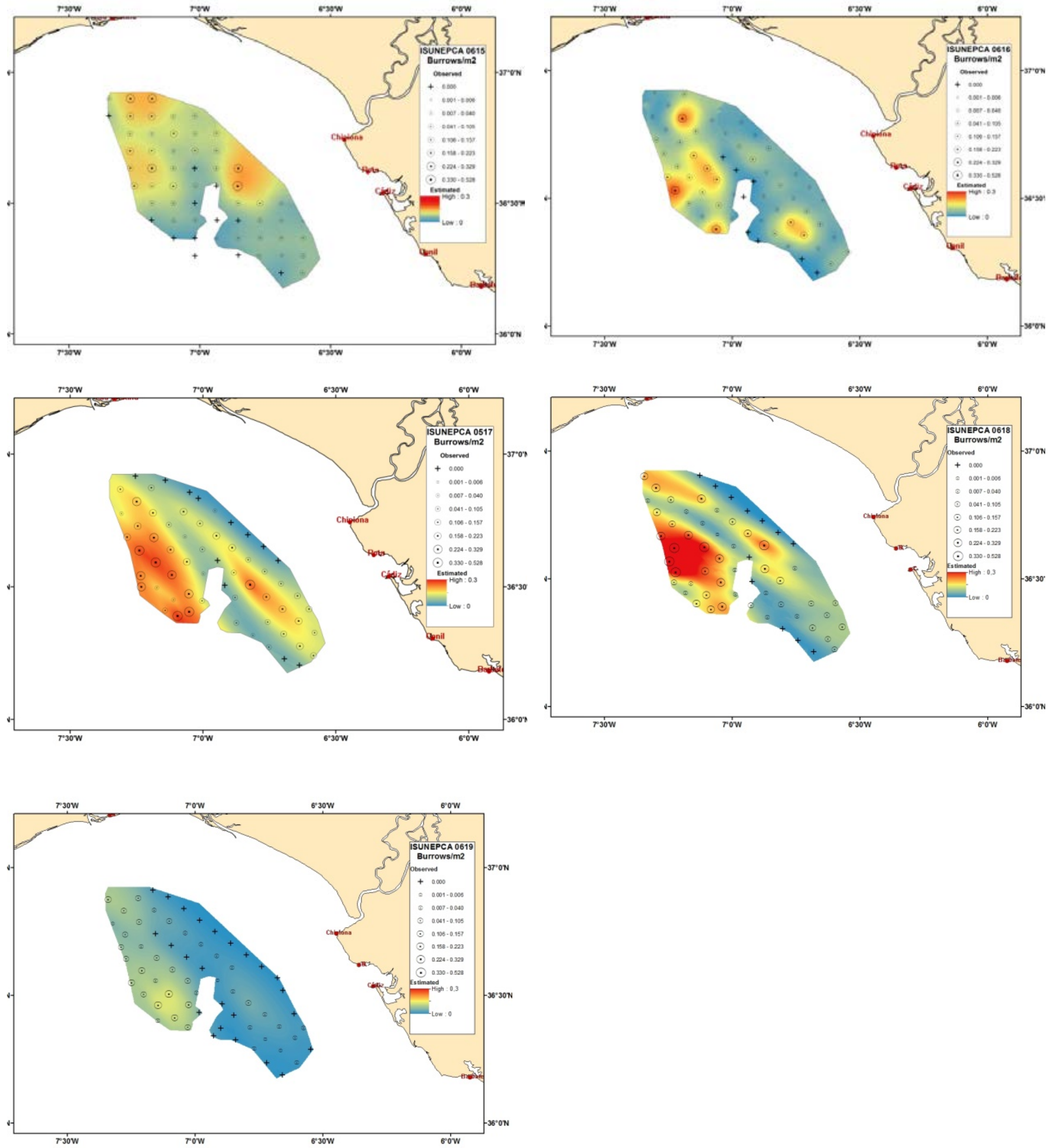


Figure 1: Gulf of Cadiz (FU 30). Bubble plot of the burrow density observations overlaid on a head map krigged burrow density surface for UWTV survey series (2015-2019). Station positions with zero density are indicated using a +.

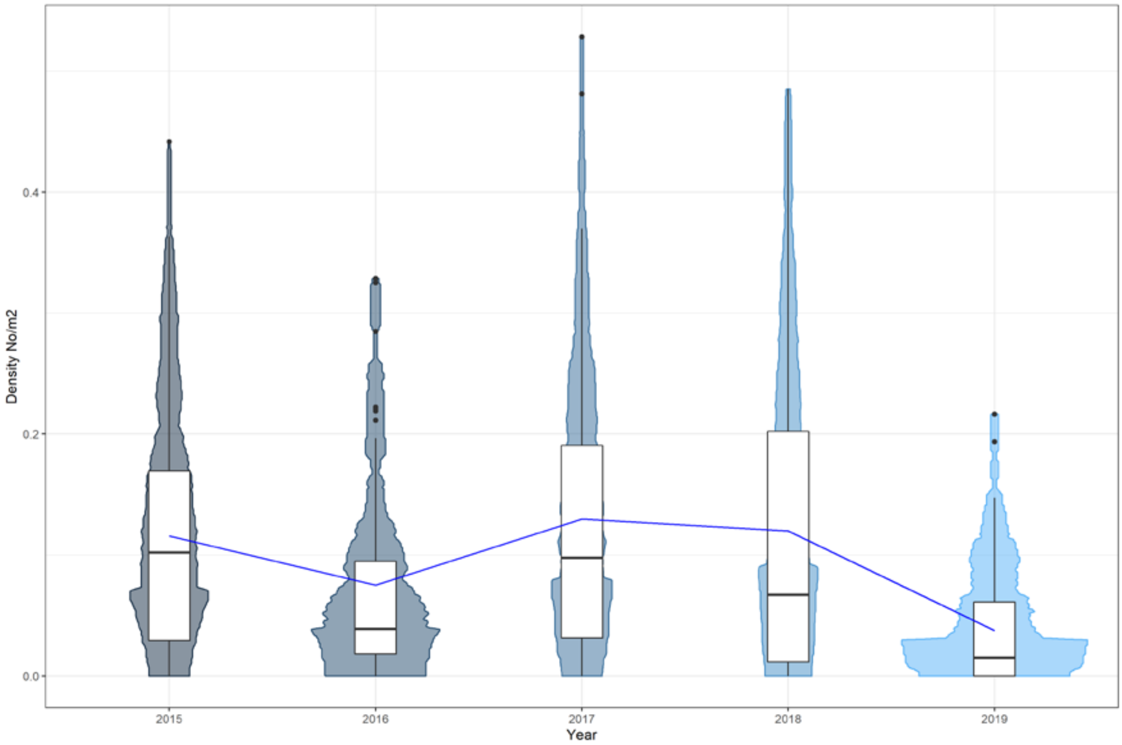


Figure 2: Gulf of Cadiz (FU 30) times series of adjusted burrow density (Violin and box plot).

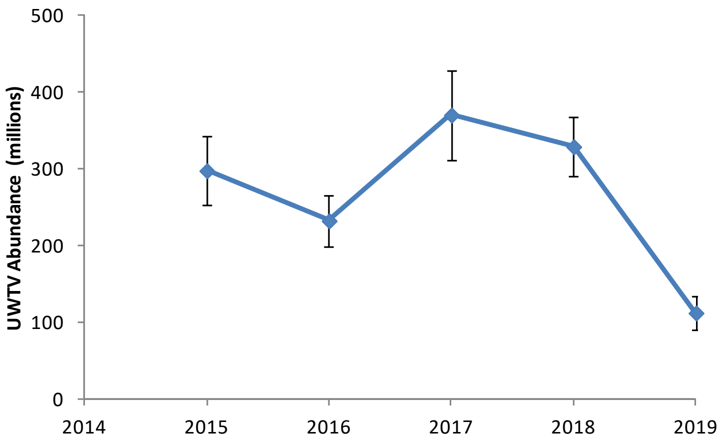


Figure 3: Gulf of Cadiz (FU 30). Time series of UWTV survey abundance estimates with 95 % confidence intervals.

France FU 23-24: Bay of Biscay

(Jean-Phililipe Vacherot, Spyros Fifas)

Functional Unit	FU 23-24	Area name	Bay of Biscay
Survey design	Stratified grid	Previous surveys	2014-2018
Country (ies)	France	Vessel name (s)	R/V Celtic Voyager
Survey code (s)	CV19013	Dates (start/end)	2-15 May 2019
Number scientific staff	6	Staff exchanges	Yes 1 MI
Number of stations (planned/completed/used in analysis)		215/152/145	
Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)		Stop over 3 days bad weather. Technical problems on HD system after 10 days. HD: 107 validated stations (70%). Analogue: 45 validated stations (30%)	
Distance over ground source used	USBL	Average field of view (cm)	HD cam: 102 cm Analogue cam: 75 cm
Adjusted mean density	0.255	Adjusted abundance, CV	4113 million, CV=8.34%
Overall footage quality (poor, medium, good)		Medium to good – some excellent !	
Reference footage for survey area generated		Yes with HD standard in 2019	
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.)		CTD Planned beam trawl hauls Presence/absence ancilliary data (sea-pen, munida and other species. *Nephrops*/munida activity	
Data storage, level of analysis and dissemination (by data type)		*Nephrops* burrow counts	14915 *Nephrops* burrows counted, **storage**: DVD up to 2019, hard drive with HD system in 2019, **level of analysis**: stratified estimates as for last year **dissemination**: WGBIE
		CTD	152
		Trawl	0
		Sediment	0
		Other	0

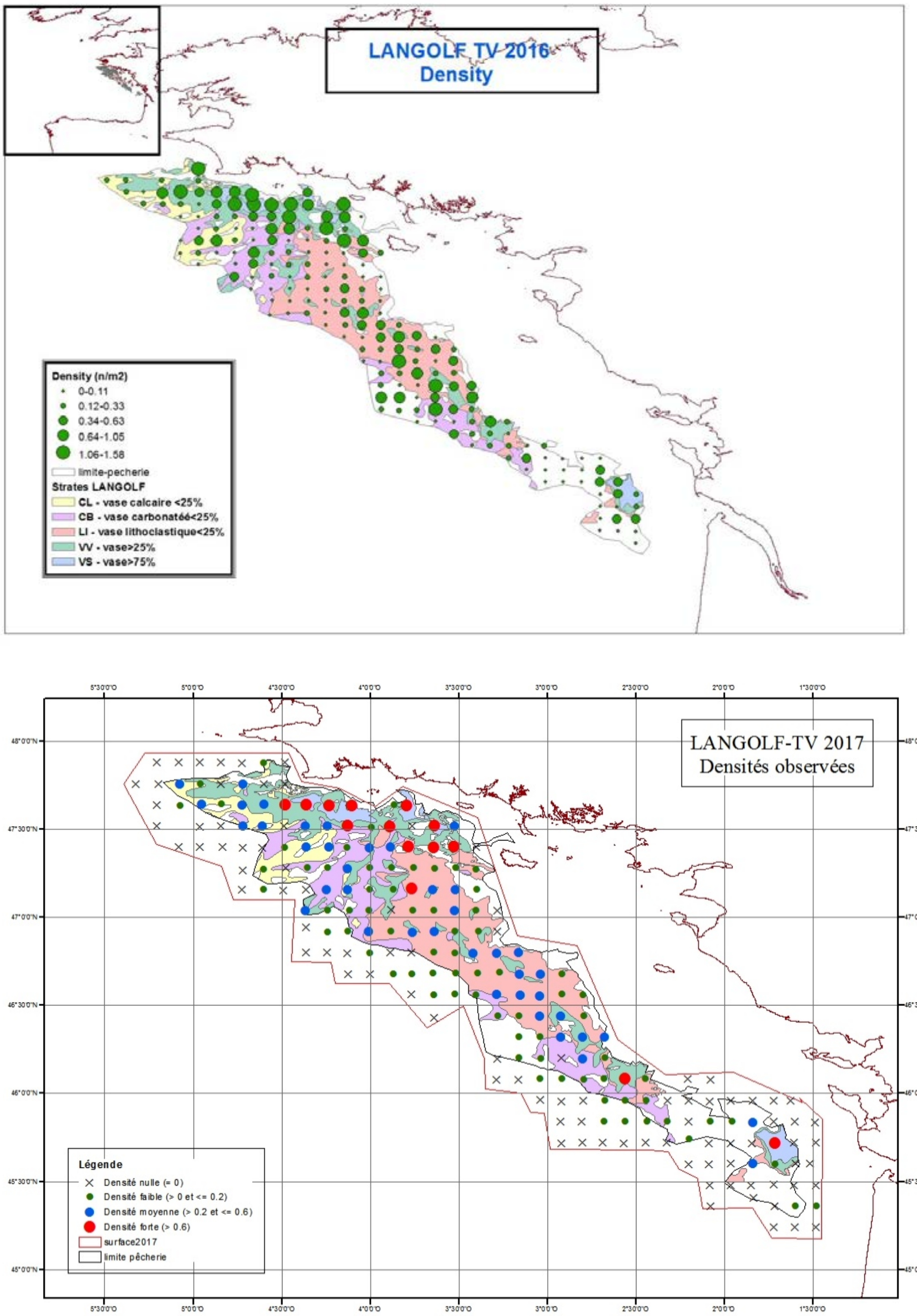
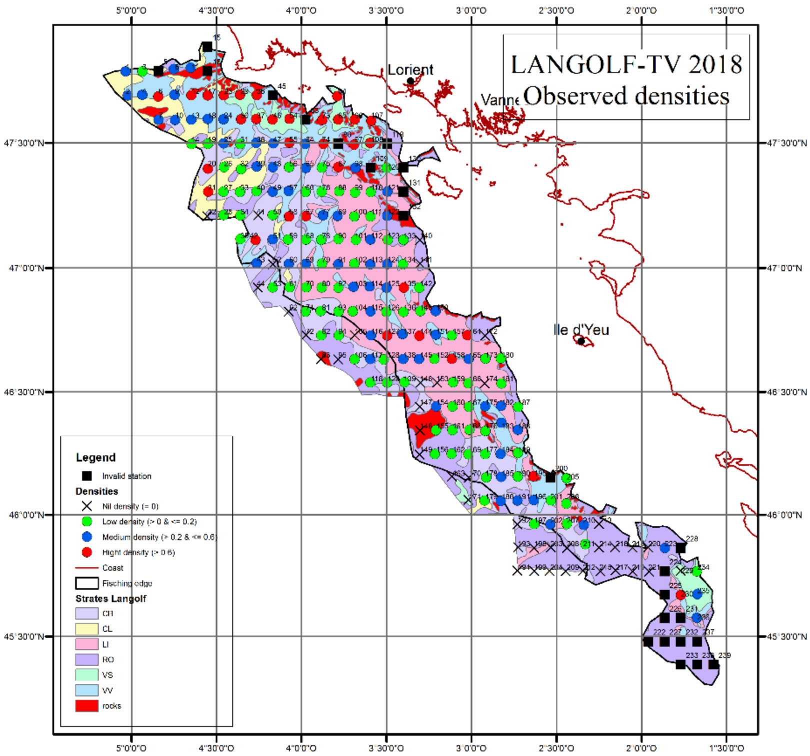


Figure 1: Map of density by station for each year



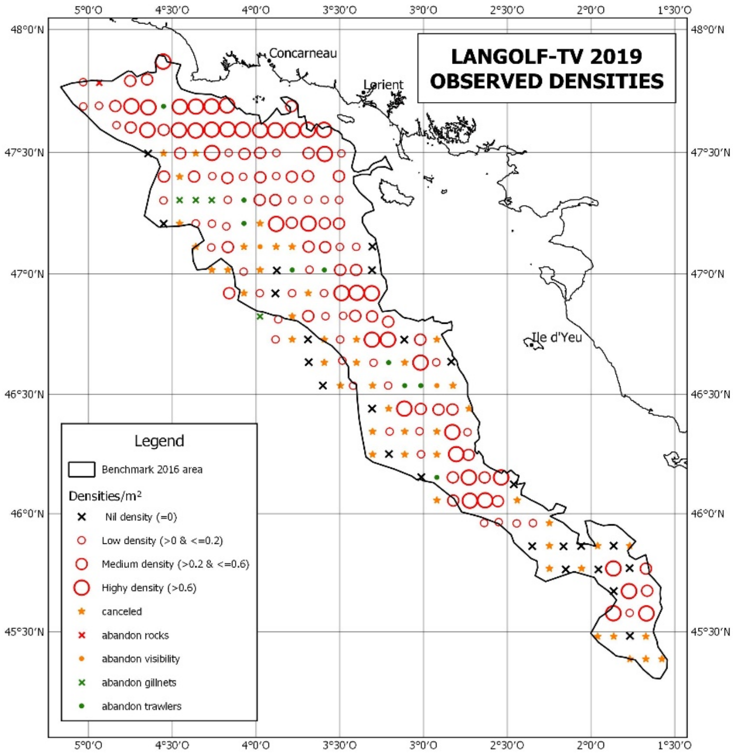


Figure 1. Continued: Map of density by station for each year

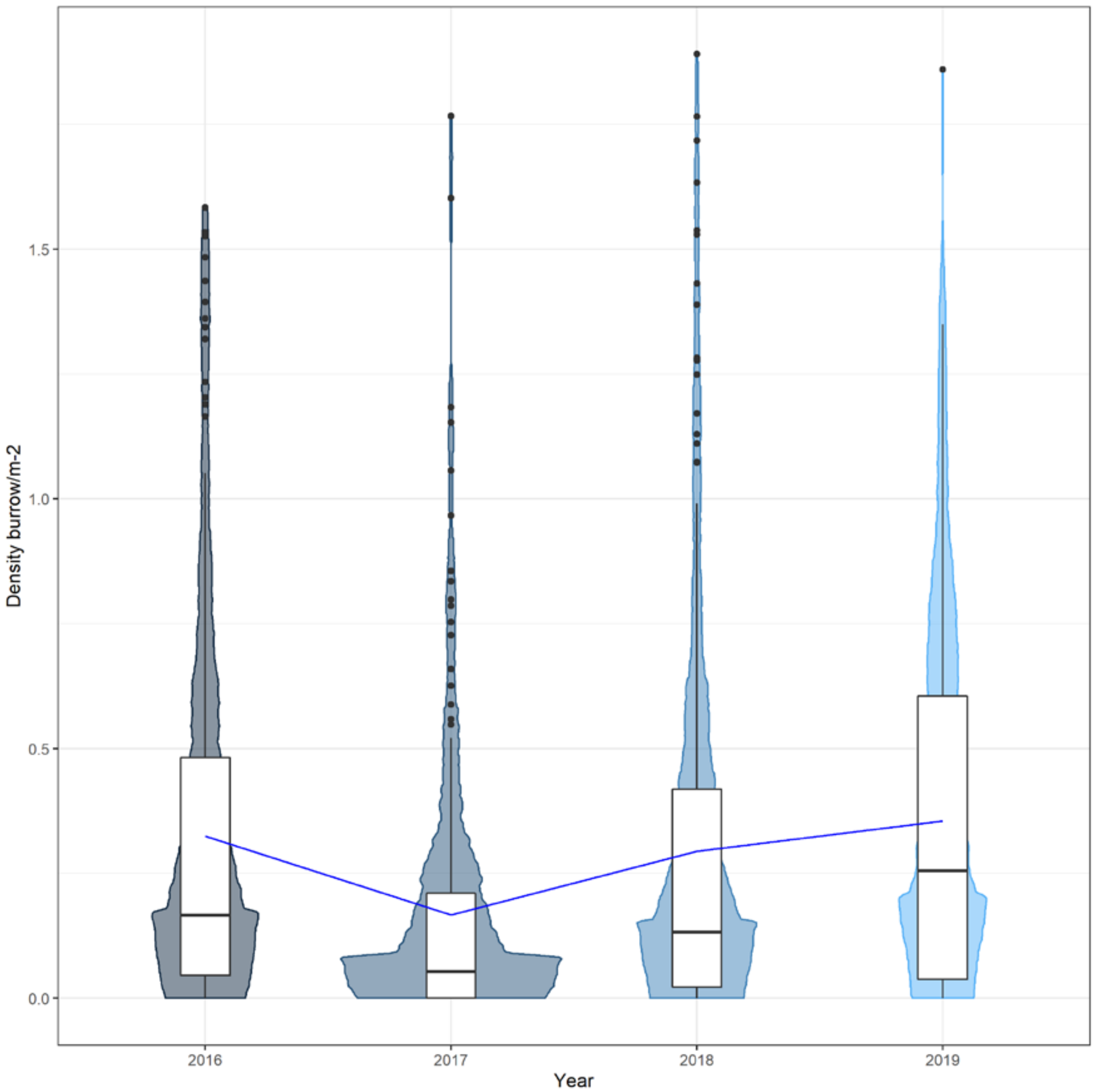
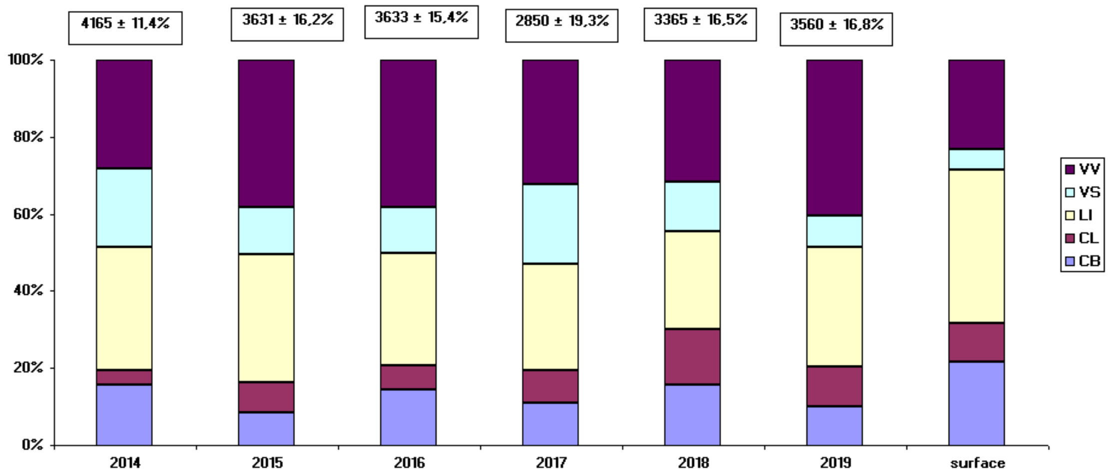


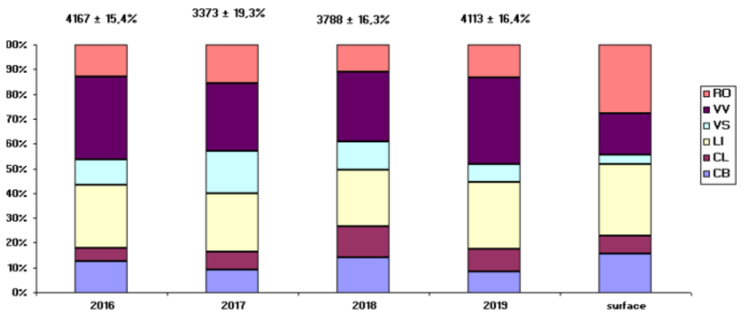
Figure 2: Times series of adjusted burrow density (Violin and box plot).



Taking into account the sixth stratum (rough sea bottom) since 2016

	2016 (196 stations)				2017 (124 stations)			
	nb/m²	total terriers	CV (%)	%terriers	nb/m²	total terriers	CV (%)	%terriers
	0.320	**5167.67**	**7.84**		**0.259**	**4181.95**	**9.87**	
CB	0.258	654.41	19.84	12.66%	0.152	384.49	20.10	9.19%
CL	0.237	272.72	20.87	5.28%	0.262	302.03	14.76	7.22%
LI	0.283	1319.12	13.86	25.53%	0.210	978.48	14.75	23.40%
VS	0.839	531.18	17.92	10.28%	1.147	726.44	27.94	17.37%
VV	0.642	1728.09	14.52	33.44%	0.425	1142.76	19.82	27.33%
RO	0.148	662.15	29.61	12.81%	0.144	647.75	34.23	15.49%

	2018 (184 stations)				2019 (145 stations)			
	nb/m²	total terriers	CV (%)	%terriers	nb/m²	total terriers	CV (%)	%terriers
	0.291	**4696.84**	**8.30**		**0.316**	**5100.64**	**8.34**	
CB	0.259	656.93	19.56	13.99%	0.172	436.35	25.39	8.55%
CL	0.517	595.61	23.64	12.68%	0.403	464.82	43.28	9.11%
LI	0.228	1064.10	13.27	22.66%	0.292	1363.72	14.34	26.74%
VS	0.841	532.43	23.30	11.34%	0.586	370.94	21.46	7.27%
VV	0.492	1323.75	17.30	28.18%	0.661	1778.04	12.12	34.86%
RO	0.117	524.02	31.79	11.16%	0.153	686.77	28.17	13.46%



-19% from 2016 to 2017

+12% from 2017 to 2018

+9% from 2018 to 2019

Figure 3: Time series of mean density and total abundance (with confidence intervals) with reference levels.

Iceland FU 1: Off South Iceland

(Jónas Jónasson)

The fourth UWTV survey on *Nephrops* ground in Iceland was carried out by the Marine and Freshwater Research Institute (MFRI) between 5th – 14th of June 2019. The survey took place on RV Bjarni Sæmundsson. Like previous surveys it covered all known *Nephrops* ground in FU1.

Area definition was based on available AIS data (2008 – 2018). Vessel fishing with *Nephrops* trawl and at towing speed (1 – 4 nm) were summarized on grid with a resolution of 800 m. A minimum of five trawling occurrence was chosen as a threshold value for each area within the grid. Further the minimum size of each area was set as 4 km2. In total 13 distinct fishing grounds were identified and further summerized to 9 areas (Fig X1). In total the *Nephrops* grounds in FU1 were estimated to be 6588 km2 com-pared to 6353 km2 based on VMS data from 2008-2017. The increase between years is mostly due to new fishing areas being exploited in south-western part of the grounds.

Stations were laid out in similar manner as previous years on a randomized fixed square grid with around 4.5 nautical miles between points, with in total of 100 stations completed. The depth of stations ranged from 100 to 280 m. The sledge was equipped with an HD camera, mounting at 45° and lasers 100 cm apart. The tow speed ranged be-tween 0.5–1.5 knots and cable was payed in or out to obtain the best possible footage, but 10 minutes were recorded on each station. Vessel position (DGPS) and odometer on the sledge was used to estimate the distance overground (DOG).

All burrow system were timestamped by two readers, following recommendation from WKNEPH (November 2016) where reference footage of the FU1 ground was established. In case of disagreement the footage was reviewed again by both readers and agreed on or left to third counter.

From the UWTV footage, the occurrence of trawl marks, seapens, fish and other species, were also noted. The data were analysed with a new annotation software that stores all the observation directly into database.

The mean burrow density (adjusted to account for bias factors) was 0,07 burrows per m2 with CV of 3.4% (Fig 1). The total number of burrows in 2019 was 507 million (adjusted values). That is only marginally different from the burrow count in 2018 which was slightly below 500 million (Fig 2 and 3).

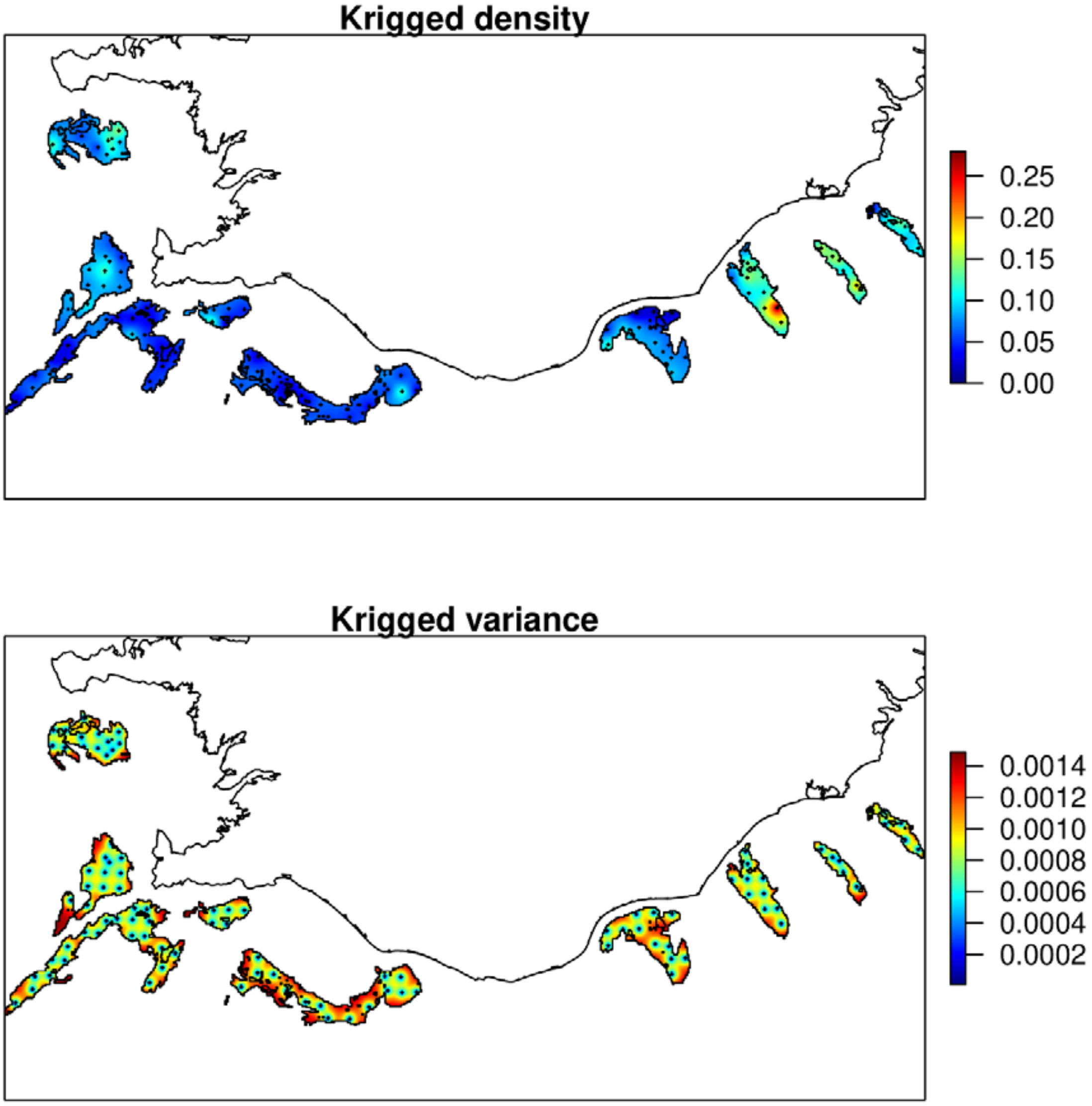


Fig 1. FU1 grounds: Contour plots of the krigged burrow density (per 100m²) estimates (above) and krigged variance (below), from the 2019 survey. Black crosses represent the stations.

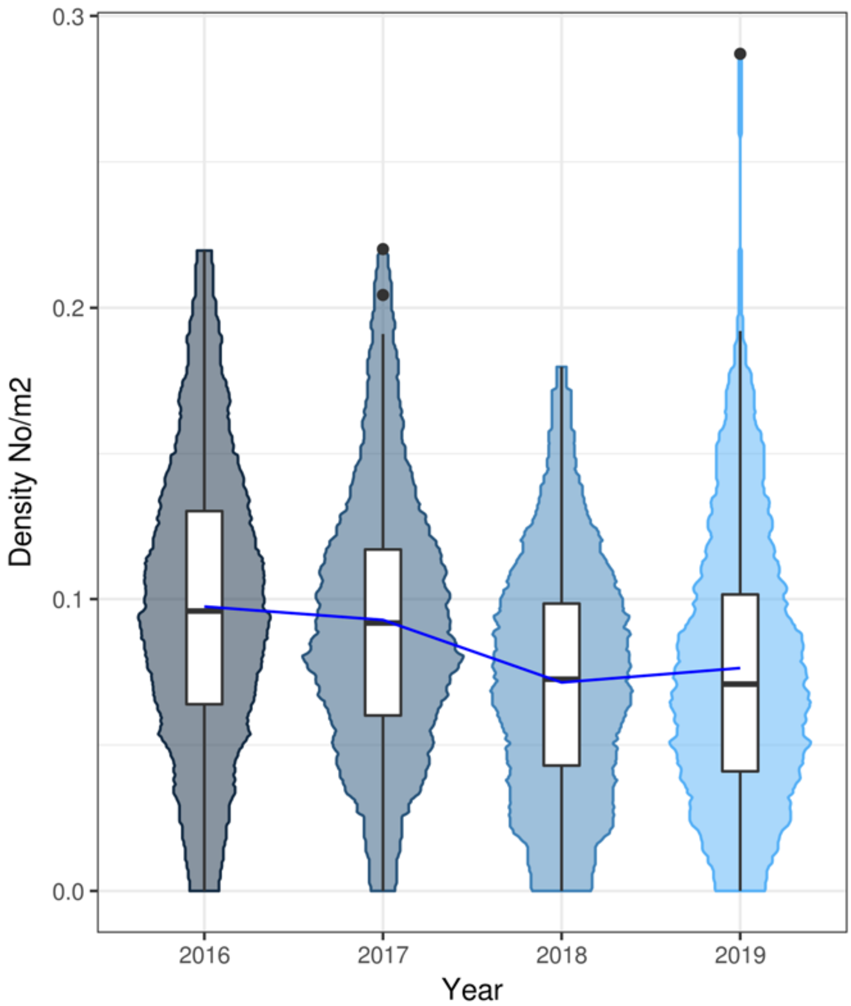


Fig 2. FU1 Iceland: Violin and box plot of adjusted burrow density distributions by year from 2016 - 2019. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.

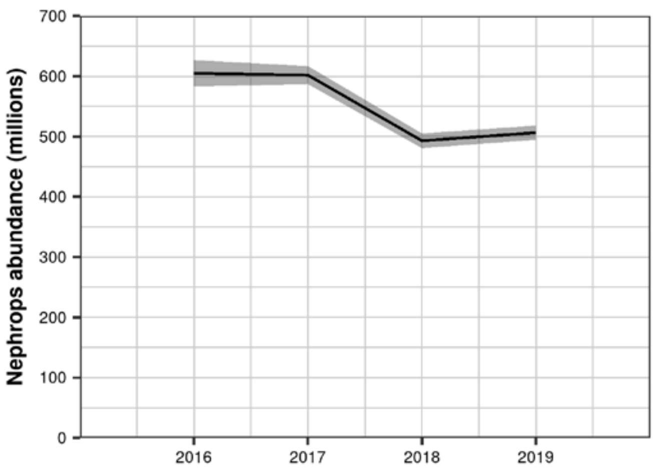


Fig 3. FU1 Iceland: Stock abundance (Underwater TV, millions; SSB proxy, 95% confidence intervals).

Italy and Croatia GSA 17 and 18: Adriatic Sea

(Michela Martinnelli, Damir Medvešek, Matteo Chiarini)

The Adriatic Sea (GFCM Geographical Sub Areas 17 and 18) is one of the most important and productive fishing areas of the Mediterranean basin. Until 2014, *Nephrops norvegicus* represented here the second crustacean (after mantis shrimp) in terms of abundance in commercial catches, showing however a decreasing trend from 2005; from 2015 it has instead been surclassed by a sudden increase of pink shrimp (FAO-GFCM 2019). An important fishing ground for the Norway lobster *N. norvegicus* occurs in the Central Adriatic depressions (the Pomo - or Jabuka in Croatian - Pits, part of GSA 17; Figure 1), which represent also a nursery for European hake (*Merluccius merluccius*) (Angelini et al. 2016).

The Norway lobster stock located in this area is distinct from other Adriatic populations and is characterized by small-sized mature individuals (Froglia and Gramitto 1982; Vrgoć et al. 2004; Colella et al. 2018, Angelini et al. 2020). Furthermore, this area represents a fishing ground shared by the Italian and the Croatian fleets (Martinelli et al. 2013; Russo et al. 2018) and has been the subject of many discussions aimed at establishing there an area closed to fishery (e.g. ADRIAMED 2008; De Juan and Lleonart 2010). Indeed, from 2015 the Italian and the Croatian governments implemented some protection measures (changing various times in definition of the closed area and the restriction measures). Eventually in 2018, the GFCM established a Fishery Restricted Area (FRA) lasting for 3 years and stated the necessity to monitor it (GFCM 2017). The FRA is composed by three different parts: zone A closed to any professional fishing activity, zones B and C subject to fisheries limitations (Figure 1; GFCM 2017).

After some trials in 1994 and 2004 (Froglia et al. 1997; Morello et al. 2007), in 2009 CNR-IRBIM of Ancona (formerly known as CNR-ISMAR of Ancona, Italy), in collaboration with IOF of Split (Croatia) and under the auspices of the FAO – AdriaMed (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea) regional project, started a series of UWTV surveys in the Pomo Pits area (Martinelli et al. 2013). Also thanks to the Italian National Flagship Program RITMARE, in 2013 the UWTV equipment owned by CNR was completely renewed and enriched with new sensors allowing the collection of environmental parameters (Martinelli et al. 2016). The UWTV surveys are not part of the DCF for Italy and Croatia. However, except for 2011 and 2018, a spring survey has been carried out yearly from 2009 to 2019 in the study area on board the CNR's R/V Dallaporta. Often the number of achieved stations (compared to the planned ones) has been reduced because of bad weather conditions and limited available ship time.

The footage collected during the surveys is usually analysed later in the institute lab by a team composed by Italian and Croatian scientists. Before starting the reading session, all the readers go through a training (or re-training) process aimed at familiarizing with the characteristics of the footage. The training is carried out using ICES standard materials as well as reference set footage specifically produced for the Pomo Pits area (ICES 2017). Furthermore, the Adriatic team is constantly working to address all the possible uncertainties linked to the application of this methodology in the study area (characterized by high density of *Nephrops* and other organism's burrows). The objective is to produce an index of abundance to be used as tuning for a length-based integrated stock assessment model to be carried out in the near future by means of the CASAL software (Bull et al. 2005).

Therefore, the latest reading session was held in Ancona from the 9th to the 20th of September 2019. As suggested by the WGNEPS (ICES 2019), the Lin's Concordance Correlation Coefficient test (Lin's CCC; Leocádio et al. 2018) was applied for the first time to carry out: i) training on Adriatic Reference set and test on readers' performances, ii) 2019 footage analysis and validation of stations during the readings, iii) revision of the 2012-2017 time series.

After application of speed and turbidity thresholds (Martinelli et al. 2016; Martinelli et al. 2017a; ICES 2017), all stations collected from 2012 to 2017 with a minimum of 7 readable minutes and evaluation from at least two readers (169 out of 250 stations) were tested for validation. Stations were considered valid when Lin's CCC was ≥ 0.5 for at least one couple of readers. In case of non-valid stations, 2 strategies were applied in order to save as more stations as possible: i) new readings were performed in order to generate more couples to be tested via Lin's CCC, ii) first and last minutes (considered less reliable minutes) were removed before running a new Lin's CCC. The last criterium was also applied to 2019 footage when no other trained readers were available during the session. In 2009 and 2010 only *consensus* reading was used on all stations, therefore the validation process through Lin's CCC was not applicable. Figure 2 shows the number of validated stations at the end of the process.

The obtained dataset was then integrated in the CNR database built by means of the Manifold® System Release 8 software (Martinelli et al. 2017a); the database allows setting of thresholds and application of biases along with the possibility to re-analysed all the time series according to new stratifications, such as the one based on the GFCM Pomo FRA zones.

Figure 2 shows a comparison between the time series of average adjusted burrow densities obtained before and after the validation process. Biases used to adjust densities are still under revision, thus should be considered preliminary calculations; cumulative bias embedding different edge effect by area and year were used and applied in the same way to both time series, as well as to 2009 and 2010 values.

In the last survey, the use of a sledge position (compared to the vessel one) sensor was tested; an analysis of the obtained dataset will be carried out soon. A possible effect on the calculation of the viewed surface could be expected, resulting in the need for a further update of the bias calculation. Thus all the results should still be considered preliminary.

During the surveys, additional trawl hauls are carried out by means of an experimental net (at sunrise and sunset) in order to obtain demographic and biological data on the *Nephrops* population and on other important species (Martinelli et al. 2017a). Since 2015, an additional autumn trawl survey (by means of the same experimental net) is carried out in the western side of the Pomo Pits area; the latter is planned in the framework of an agreement between the Italian Ministry of agriculture and forestry and CNR-IRBIM of Ancona, and is aimed at evaluating the effects of the management measures enforced in the area (Figure x0; Martinelli et al. 2017b). Autumn survey is meant also to assess the status and the recruitment of species with defined (blue whiting), multiple or longer (hake and white shrimp) breeding season. All the collected data are currently under analysis in order to statistically detect possible effects of the Pomo FRA implementation on the main target species, in terms of biomass and distribution (Martinelli et al. 2019). Additional investigations (e.g. ecosystem approach, standardization of time series, marine litter distribution, biological parameters estimation…) are on going.

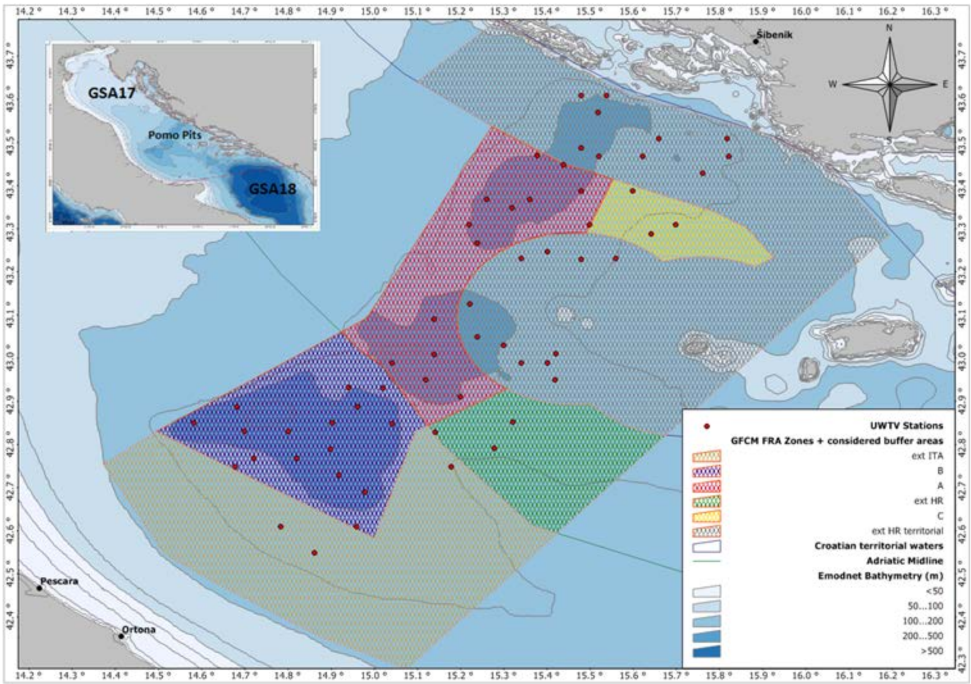


Figure 1 Pomo (Jabuka) Pits area in GSA 17 with indication of bathymetry (EMODNET bathymetry in meters), FRA zones defined by GFCM and location of the trawl hauls (triangles) and UWTV stations (points) carried out during the UWTV surveys.

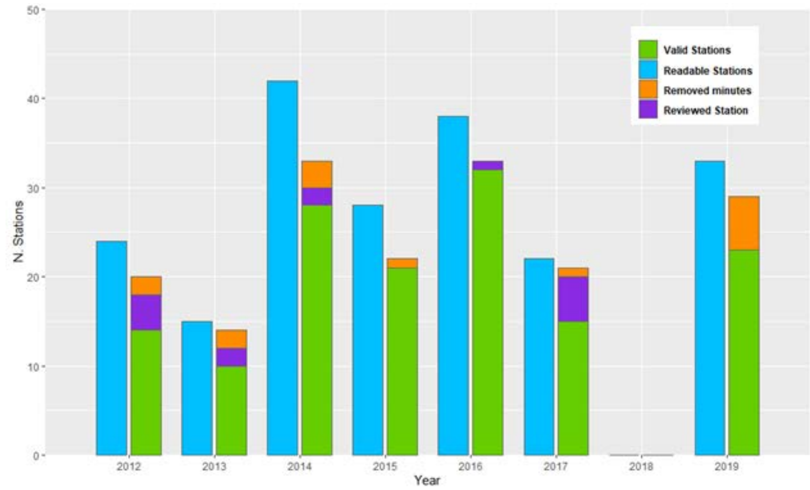


Figure 2. Number of readable stations against number of validated stations by year (in green stations validated after first Lin's CCC test run; in purple stations validated after addition of a new reader, in orange station validated after removal of the first and last minute). A station was considered valid if Lin's CCC was above 0.5 for at least one couple of readers.

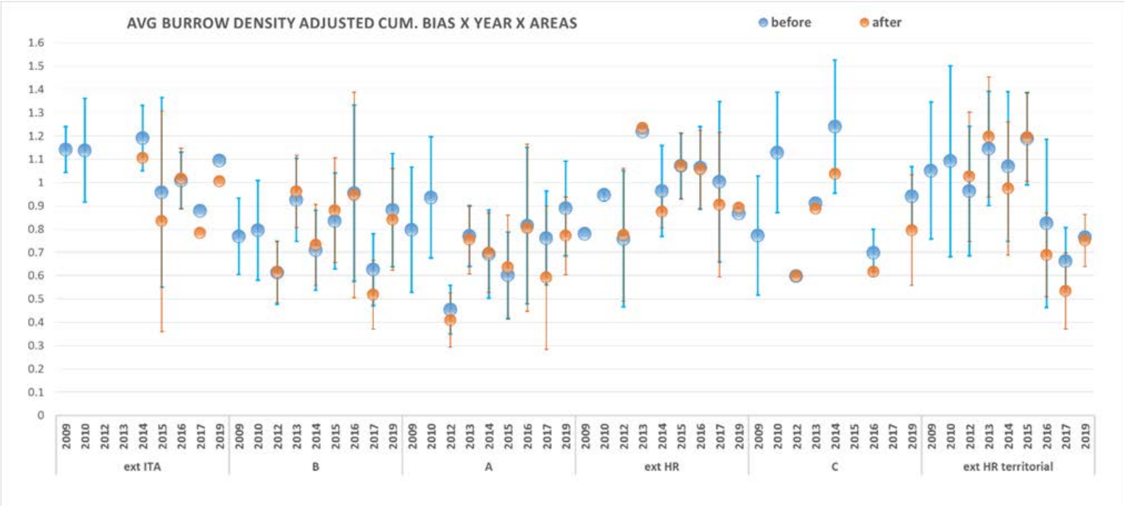


Figure 3. Average adjusted burrow densities (± standard deviation) by area (western to eastern) and year calculated before and after the validation process for the Pomo UWTV time series. Biases used to adjust densities should be considered preliminary.

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Annex 4: List of presentations

(in order of appearance)

Martinelli M., Medvešek D., Chiarini M., Belardinelli A., Domenichetti F., Guicciardi S., Angelini S., Croci C., Cvitanić., Isajlovic I., Penna P., Scarpini P., Santojanni A., Vrgoc N. et al.: Adriatic UWTV surveys and Pomo monitoring activity. 26 pp.

Jónas Páll Jónasson, Julian Burgos, Haraldur Einarsson, Arnþór Kristjánsson, Anna Ragnheiður Grétarsdóttir, Arnar Björnsson, Auður Bjarnadóttir & Hjalti Karlsson: Development of UWTV survey in Icelandic waters. 13 pp.

Kai Wieland, Mats Ulmestrand, Sven Koppetsch, Annegrete Dreyer-Hansen, Maria Jarnum, Gert Holst, Ronny Sørensen: *Nephrops* UWTV survey in the Skagerrak and Kattegat (FU 3&4) in 2019. 7 pp.

Charlotte Reeve: Survey results and assessment summary for FU 6 and FU14. 9 pp.

Gerald McAllister: MSS 2019 UWTV surveys. 15 pp.

Jennifer Doyle and MikelAristegui et al.: 2019 Update on Marine Institute Ireland *Nephrops* UWTV surveys. 22 pp.

Spyros FIFAS, Jean-Philippe VACHEROT, Yann COUPEAU, Jean-Jacques RIVOALEN: LANGOLF-TV 2019 FU23-24 bay of Biscay & FU23-24 *Nephrops* preliminary analysis of UWTV survey 2019 results. 11 + 21 pp.

Kai Wieland, Annegrete Dreyer-Hansen, Maria Jarnum, Gert Holst, Ronny Sørensen: *Nephrops* UWTV survey Off Horns Rev (FU 33) in 2019. 7 pp.

Y. Vila and C. Burgos: Developments on the UWTV survey in the Gulf of Cadiz (FU 30). 15 pp.

Mathieu Lundy: Western Irish Sea *Nephrops* Grounds (FU15) 2019 UWTV Survey. 11 pp.

Jacopo Aguzzi, Joan Navarro, Joan Batista Company (ICM-CSIC), Joaquin del Rio, IvanMasmitja (SARTI-UPC): Update on creel fishing/acoustic tracking trials in the No-Take zone off Blanes (North of Barcelona, 400 m depth). 25 pp.

Atif Naseer: *Nephrops* norwegicus detection and classification from underwater videos using deep neural network. 57 pp.

Kai Wieland, Annegrete Dreyer-Hansen, Gert Holst, Maria Jarnum, Bo Lundgren: Video mosaicking for analyses of reference footages. 11 pp.

Mikel Aristegui and Jennifer Doyle: Calibration test: UWTV camera system and reviewing method. 21 pp.

Annex 5: Action list

	Action	Addressed to	Action latest before
1	Provide outstanding parts of the WG report	All WG members	at latest 15/12-2019
	Review and comment on completed draft report	All WG member	at latest 21/1-2020
2	Update and extend ToR's (e.g. bias correction factor, diameter of *Nephrops* burrows)	Adrian, Kai, Jennifer	15/11-2019
3	Comment on draft outline of the UWTV database and report back to Adrian	All WG member	at latest 1/2-2020
4	Inform ICES on status, plans and progress on UWTV meta-database	Adrian contact ICES Data Centre (Neil Holdsworth, Carlo Pinto)	7/2-2020
5	Contact ICES (EOSG chair) / submit resolution on WK on the UWTV database	Kai	asap
6	Check FU's shapefiles and provide feedback to Rui Catarino at ICES	All WG member	asap
7	Submit revised version of SISP to ICES / EOSG chair	Jennifer, Patrik, Adrian	to be published definitely before next meeting
8	Update/Upload R scripts for UWTV survey data analysis and quality control on github	Mikel, Jennifer	ongoing
9	Exchange Danish/Swedish reference footages for FU 3&4, conduct analysis and report back to WGNEPS	Mats, Kai, Patrik	before next meeting
10	Develop reference sets for other FU's and report to WGNEPS	National Institutes	ongoing
11	Provide more annotated footages for machine learning	National representatives	asap