# WORKING GROUP ON NEPHROPS SURVEYS (WGNEPS; outputs from 2021)

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ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

# 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 2021 together with time series covering all survey years, problems encountered, data quality checks and technological improvements as well as the planning for survey activities for 2022.

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 recent technologies were reviewed. Due to the COVID-19 pandemic there were minimal disruptions to survey operations where one survey was not completed (GSA 17). A trial trawl *Nephrops* survey offshore Portugal was carried out on the new research vessel.

Preliminary work on how to measure burrow system size was presented using high definition (HD) and standard definition (SD) image data. Further work on comparison of SD and HD indicates the change to HD system mounted with a different camera angle was not significantly different for two survey areas (FU 16 and FU 20-21).

Automatic burrow detection based on deep learning methods continues to show promising results where datasets from multiple institutes were used. The working group members have agreed to draft a roadmap for automatic system technology requirements with links to the Working Group on Machine Learning in Marine Science (WGMLEARN) and current researchers.

The working group is progressing plans for an international *Nephrops* Underwater television (UWTW) database to be established at the ICES Data Centre. End-users of UWTV datasets for epifauna reporting presented their work and showed the potential for adding value to the survey data, where many of the institutes are involved in providing data for similar research purposes.

# ii Expert group information

| | |
|---|---|
| **Expert group name** | Working Group on *Nephrops* Surveys (WGNEPS) |
| **Expert group cycle** | Multiannual |
| **Year cycle started** | 2019 |
| **Reporting year in cycle** | 3/3 |
| **Chair(s)** | Jennifer Doyle, Marine Institute, Ireland |
| **Meeting venue(s) and dates** | 16-18 November 2021, Online Meeting (MS Teams), 26 participants |
| | 17-19 November 2020, Online Meeting (Webex), 26 participants |
| | 12-14 November 2019, Split, Croatia, 20 participants |

# iii Terms of Reference

| ToR | Description | Background | Science Plan topics addressed | 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 database for *Nephrops* UWTV survey data | Improving standardisation of data QC and data processing. Support new developing surveys on data analysis. | 3.1 | Recurrent annual update | Document and R packages for UWTV survey data on github site. |
| d | To review video enhancement, video mosaicking, automatic burrow detection and other new technological developments applied in *Nephrops* UWTV surveys 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 conclusions 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. | Recent changes from SD to HD technology for many survey areas. Important to investigate edge effects and correction factors with field data on burrow system size. | 3.2 | Year 2&3 | To update the SISP based on conclusions if necessary. Other publications when appropriate. |

# iv Work Plan Summary

| Year | Summary |
|---|---|
| Year 1 | All ToRs will be adressed in this year but the the main task in year 1 will be to establish the UWTV database and to provide updated shape files of Nephrops FUs and survey domains (ToR b) |
| Year 2 | All ToRs will be adressed in this year. In addition to this focus will be on ToR e in year 2 |
| Year 3 | All ToRs will be adressed in this year. Focus in year 3 will be on new technologies and, if appropriate, an update of the SISP (ToR b) as well on the review of field date on factors affecting burrow emergence and occupancy (ToR f) |

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|---|---|---|---|---|
| Year 2019 | 12-14 November | Split, Croatia | 1st Interrim report by 6 January to EOSG | Election of new chair(s) |
| Year 2020 | 17-19 November | Online meeting (Webex) | 2nd Interrim report by 17 December 2020 to EOSG | Change of chairs:<br>Outgoing: Kai Wieland and Adrian Weetman<br>Incoming: Jennifer Doyle |
| Year 2021 | 16-18 November | Online meeting (MS Teams) | Final report by 1 February 2022 to EOSG | |

# 1 Summary of achievements of WGNEPS during 3-year term

- Review of changes to design, coverage and equipment for the various *Nephrops* Underwater TV (UWTV) and trawl surveys.
- Applying recent technology developments such as HD cameras and fibre optic cables and annotation software in *Nephrops* UWTV surveys.
- Update from research work using AI – deep learning models to detect and classify *Nephrops* burrows from UWTV survey images.
- Completion of ICES Survey Protocols "Manual for *Nephrops* Underwater TV Surveys, coordinated under ICES Working Group on *Nephrops* Surveys" (TIMES #65) https://doi.org/10.17895/ices.pub.8014
- Further planning and organising the data structure and requirements process for the international UWTV database for *Nephrops* with the ICES datacentre with the set-up of a subgroup.
- Development and organisation of r-scripts for data processing, quality control of *Nephrops* survey data and developing reference sets on the WGNEPS GitHub.
- Consideration of the results of experimental field work on *Nephrops* burrow emergence to improve the interpretation of the survey results.
- Update of reference sets from HD image datasets following guidelines by recent workshop (WKNEPS 2018).
- Overview of projects and meeting with end users that utilise UWTV survey data for epi-fauna monitoring showing potential and limitations of these datasets.

# 2 Survey coordination (ToR a)

The 2021 meeting was held online (MS Teams) due to the COVID-19 pandemic situation. In total, 19 surveys covering 25 functional units (FU's) in the ICES area and 1 geographical subarea (GSA) in the Adriatic Sea (Figure. 1.1) were discussed and further improvements in respect to survey design and data analysis, standardization and the use of most recent technology were reviewed. Survey details for each FU/GSA are provided in annex 3.

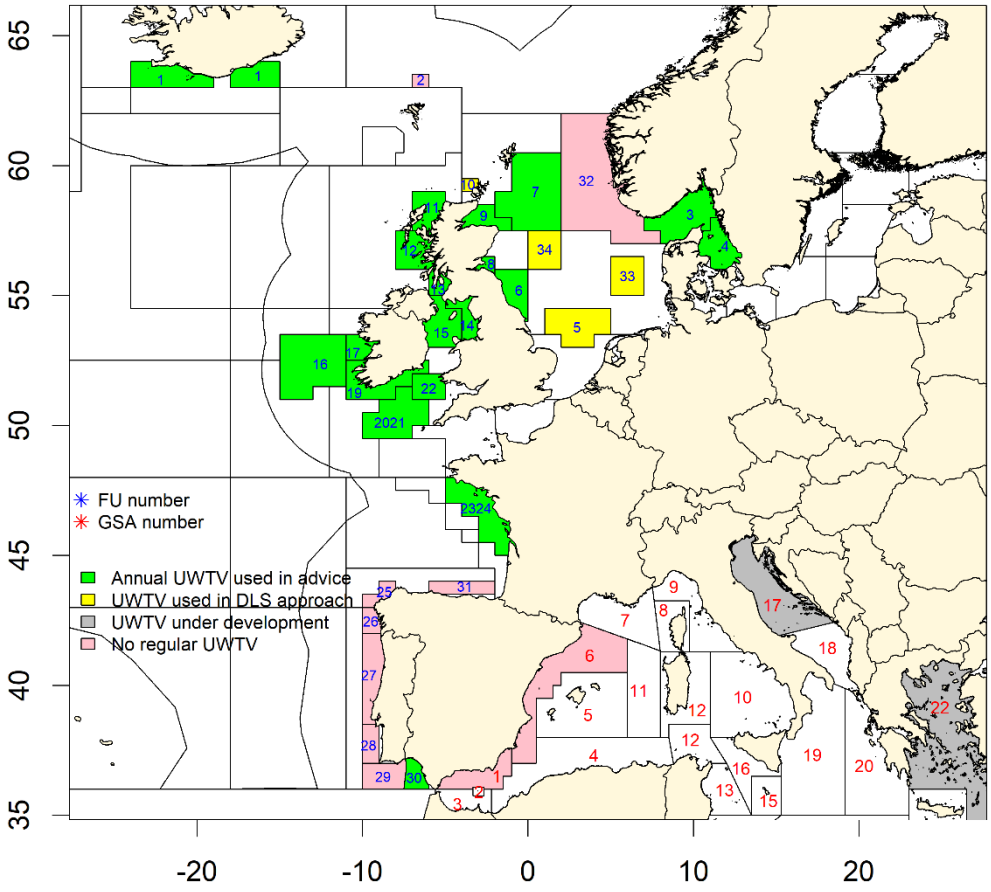


**Figure. 1.1 *Nephrops* UWTV survey areas and use in stock assessment (FU: Functional Unit, GSA: Geographical Sub Area, DLS: Data Limited Stock).**

There were some disruptions to 2021 survey operations and these are summarised below:

- Due to COVID-19 pandemic situation, UWTV survey Pomo Pits GSA 17 was not completed in 2021
- UWTV Survey was not completed (FU 10) where this is usually only undertaken when time and weather allows
- Reduced survey sampling due to on-board survey logistics (FU 33 and 34).

Survey series by Functional Unit / GSA are shown in Figure 1.2. Tentative survey schedule for 2022 is given in Figure. 1.3. Time series of *Nephrops* abundance estimates for the FU's are shown in Figure. 1.4a-d.

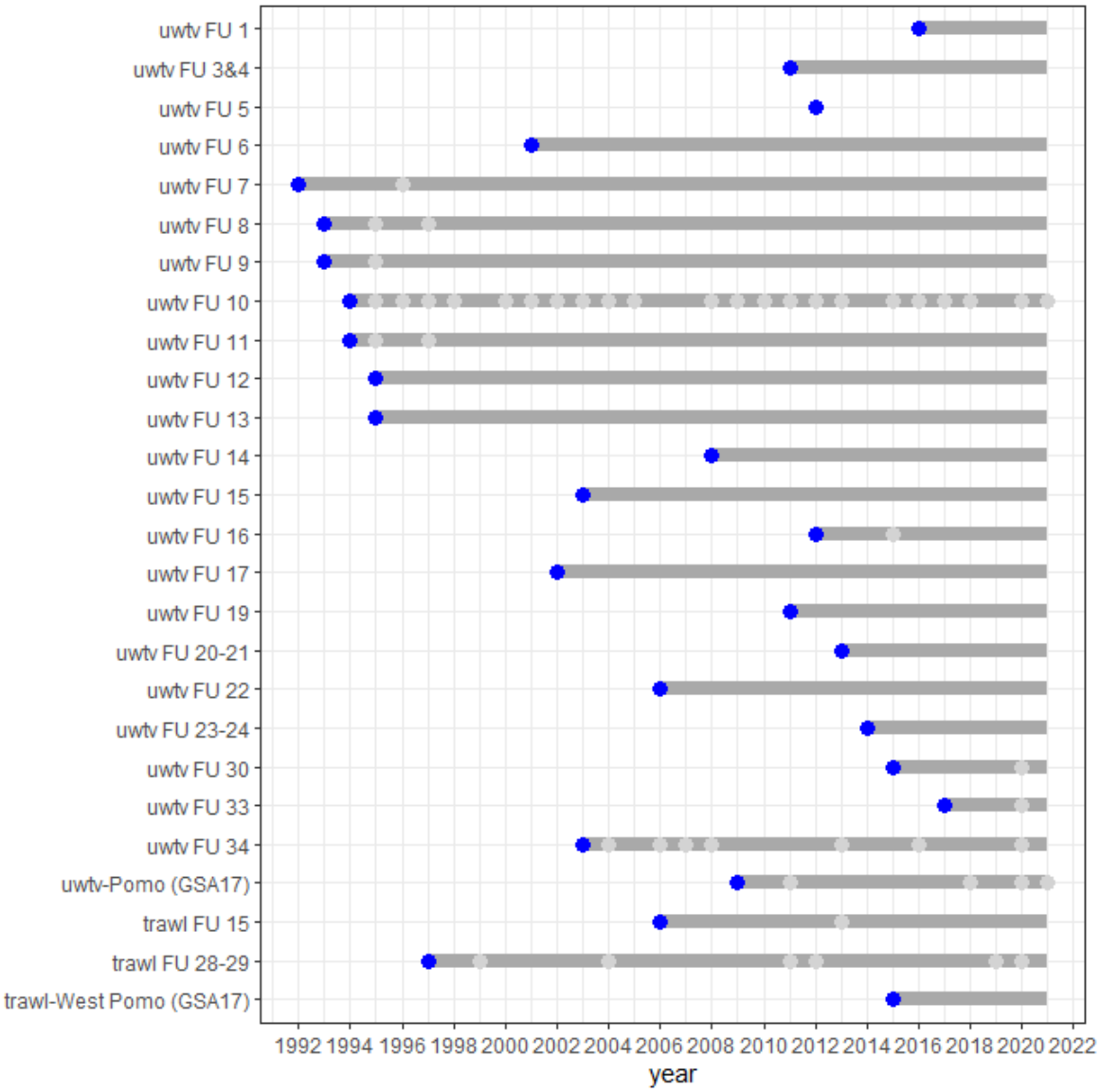


**Figure. 1.2 Survey series by *Nephrops* Functional Units / GSA. Blue dot indicates first year of survey, light grey dot indicates year in which survey was not conducted and grey line shows the survey series.**

**Survey plans for 2022**

| Institute | Survey Type | Survey Area | Ship |
|---|---|---|---|
| MSS-Scotland | UWTV | East Coast | Alba na Mara |
| DTUAqua-Denmark | UWTV | FU 3&4 | Havfisken |
| DTUAqua-Denmark | UWTV | FU 3&4 | Havfisken |
| Ifremer-Lorient | UWTV | FU 23-24 | Celtic Voyager |
| SLU-Sweden | UWTV | FU 3&4 | Svea |
| SLU-Sweden | UWTV | FU 3&4 | Svea |
| Italy/Croatia | UWTV | Pomo Pit - GSA 17 | G.Dallaporta |
| MSS-Scotland | UWTV | FU 7, 11, 12, 13, 34 | Scotia |
| IEO-Cadiz | UWTV | FU 30 | Angeles Alvarino |
| MI-Ireland | UWTV | FU 16, FU 17 | Celtic Voyager |
| HAFRO-Iceland | UWTV | FU 1 | Bjarni Sómundsson |
| IPMA-Portugal | Trawl | FU 28-FU 29 | Mário Ruivo |
| MI-Ireland | UWTV | FU 19, FU 20-21, FU 22 | Celtic Voyager |
| CEFAS-UKE&W | UWTV | FU 6 | Endeavour |
| AFBI-Belfast | UWTV | FU 14 and FU 15 | Corystes |
| AFBI-Belfast | Trawl | FU 14, FU 15 | Corystes |
| MI-Ireland | UWTV | FU 19, FU 20-21, FU 22 | Tom Crean |
| MSS-Scotland | UWTV | FU 8, 9 | |
| MSS-Scotland | UWTV | FU 8, 9 | |
| CNR IRBIM - Italy | Trawl | Pomo Pit - GSA 17 | G.Dallaporta |

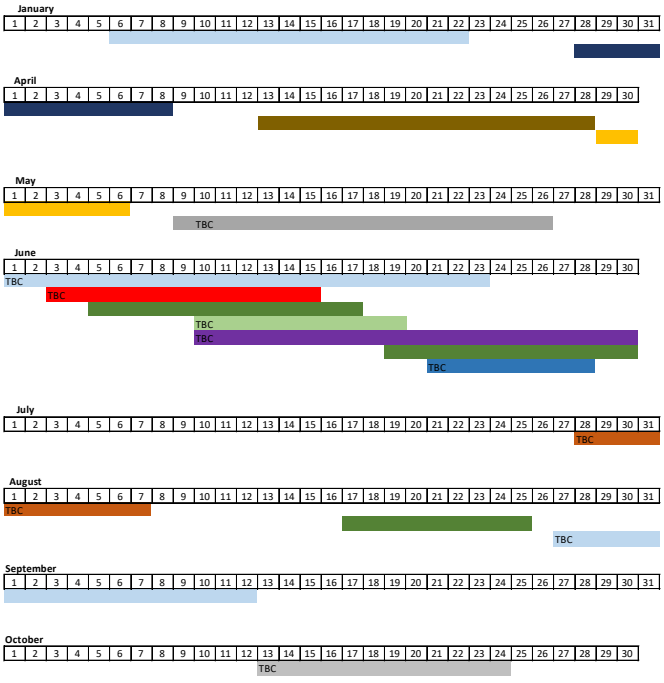


**Figure. 1.3 *Nephrops* survey schedule for 2022.**

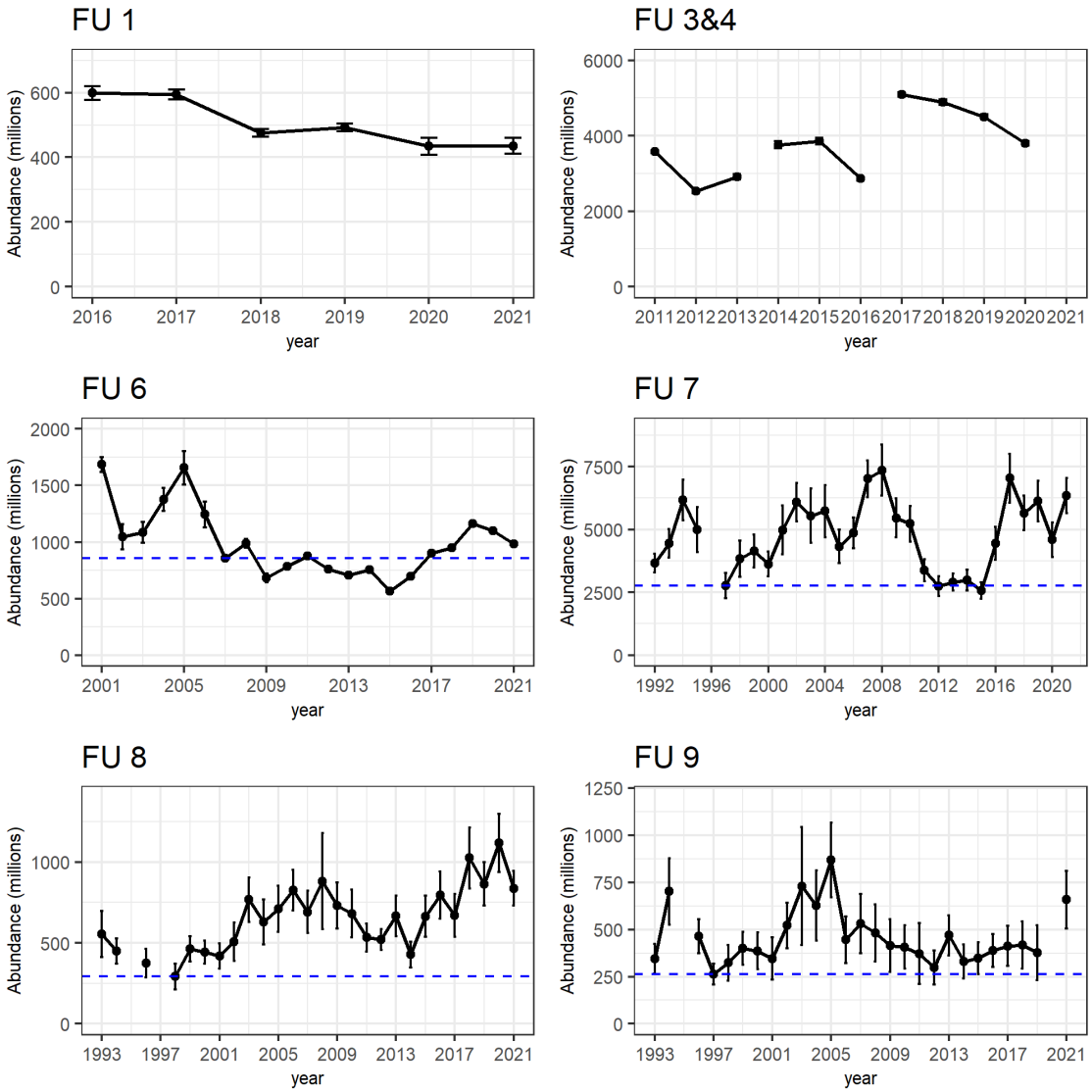


**Figure. 1.4a. *Nephrops* abundance (with 95 % confidence interval) in FU 1, FU 3&4 (breaks indicate extension of the survey area), FU 6 to FU 9. Dashed line shows proxy for ICES MSY reference point $B_{trigger}$. FU 3&4 data for 2021 not available as considered preliminary**

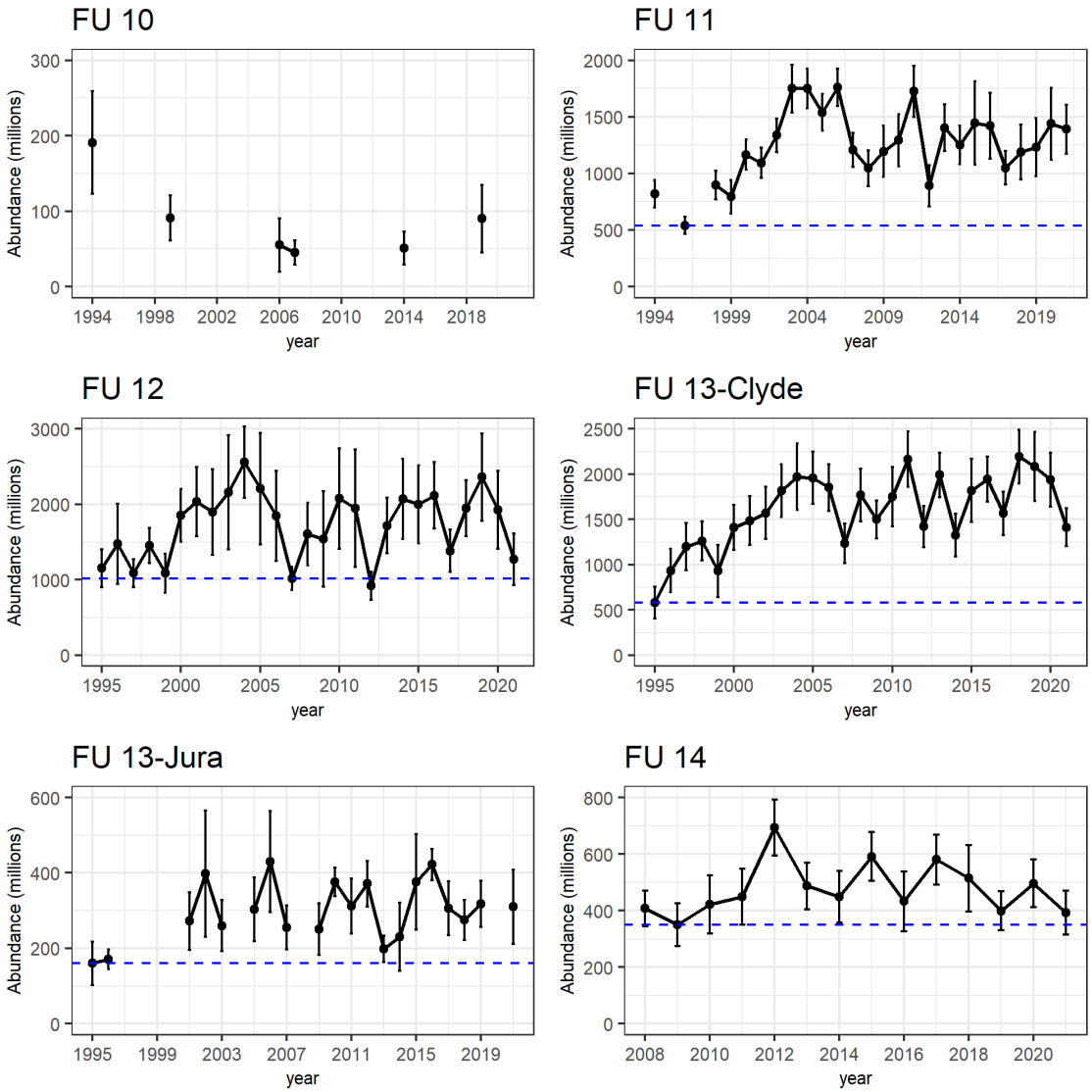


**Figure. 1.4b *Nephrops* abundance (with 95 % confidence interval) in FU 10, FU 11, FU 12, FU 13-Clyde , FU 13-Jura and FU 14. Dashed line shows proxy for ICES MSY reference point $B_{trigger}$.**

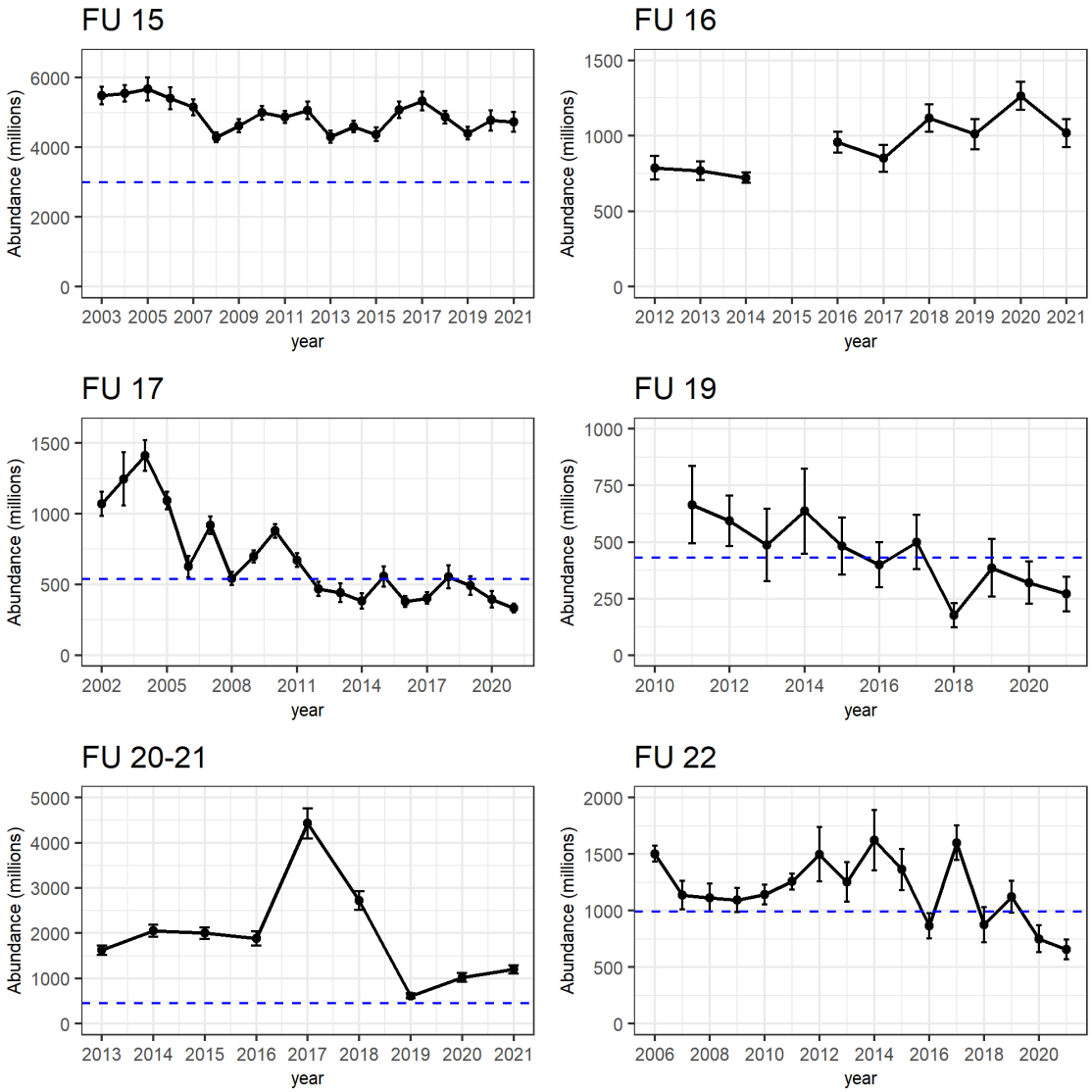


**Figure. 1.4c *Nephrops* abundance (with 95 % confidence interval) in FU 15, FU 16, FU17, FU 19, FU 20-21 and FU 22. Dashed lines show proxy for ICES MSY reference point $B_{trigger}$.**

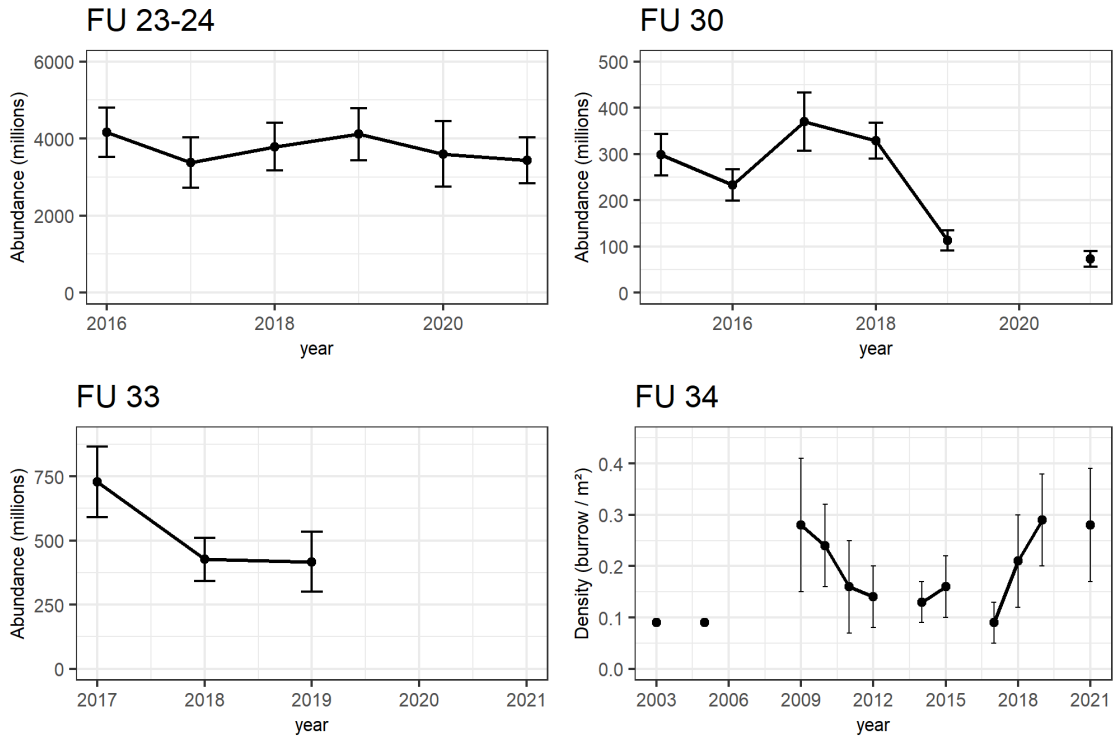


**Figure. 1.4d *Nephrops* abundance (with 95 % confidence interval) in FU 22, FU 23-24, FU 30, FU 33. Dashed lines show proxy for MSY reference point $B_{trigger}$. FU 33 data for 2021 not available as considered preliminary. *Nephrops* density (burrow / m²) with 95 % confidence interval in FU 34.**

The conclusions for future work are as follows:

- WGNEPS agrees to continuing with the use of high definition camera systems and still images with the objective to annotate images so that deep learning algorithms can be developed in future to identify features as part of a road map.
- WGNEPS agrees to promoting and facilitating when possible on UWTV surveys, staff exchange from national laboratories.
- WGNEPS recommends that national laboratories invest effort in calculating mean burrow system size for specific grounds. The edge effect calculation is based on field of view (FOV) and burrow diameter. Mean burrow system diameter can vary a lot over time for most grounds and this could have an impact on the edge effect.
- WGNEPS suggests exchange of technical expertise so that new and developing surveys may benefit from others.
- WGNEPS agrees that it is mandatory that each station is read by at least two readers in accordance with agreed survey data processes. If there are any deviations to survey data work-up this is to be flagged prior to the time the data are to be used for assessment to the stock co-ordinator and chair of the relevant assessment working group.
- WGNEPS recommends at least 3 counters per institute to retain skillset for reviewing survey data.

# 3 International database for UWTV survey data (ToR b)

The annual Working Group for underwater *Nephrops* television surveys (WGNEPS) is routinely represented by colleagues from 12 national laboratories. Each country has a vested interest in the highly valuable commercial *Nephrops* fishery and invests a considerable amount of time and money in providing stock assessment and management advice. WGNEPS provides reflection and guidance on annual *Nephrops* underwater *Nephrops* television (UWTV) surveys and ensures the quality of both the data collection and processing is to the highest standard across all the surveys.

With the exception of two national laboratories (Iceland and the UK), these surveys and the associated staff time is partially funded by the DCF/DMAP, and as such this work remains one of the last significant areas of internationally important research not have a database hosted by ICES.

By providing such a facility, the publicly held data will then become available to peers, researchers, stakeholders and others, allowing direct and free access to carry out bespoke queries, to apply the data to novel analyses and replicate assessments. Significantly, this will reduce the burden of individual institutes providing this frequently requested information, but also it will allow the collation of UWTV data in a standard format from all surveys in one location – allowing a more efficient way to access the complete data set.

Each institute will be responsible for ensuring the formatting and uploading of the data on an annual basis to the ICES database. A representative will be nominated by each institute as the point of contact in relation to managing their institute's data.

The design and content of the database will be finalised by members of WGNEPS and relevant associates, with guidance from the ICES datacentre but will essentially hold data at the lowest reasonable level available, without compromising accuracy or statistical robustness. Caveats in using the data will need to be applied as well as, where applicable, copyrights and acknowledgments for any data used and published. Permission to use the data will not be required but out of courtesy, notification to the relevant institute would be expected. Institutes should be permitted to review draft reports prior to publication.

ICES Datacentre (Neil Holdsworth and Carlos Pinto) presented to the group an overview of the data policy within ICES where it was agreed that a CC.BY 4.1 license would be appropriate. As there are many steps in the process to progress the international database a subgroup was set-up to address these.

Progress to date:

- WGNEPS have discussed and agreed metadata fields for lowest level of data final mean density estimates by station.
- ICES datacentre has discussed an approach with the ICES head of Advisory Support through a remit of a Special Request to DGMARE.

Next steps for subgroup:

- Review the time requirements to provide the data at agreed metadata fields.
- Set up meeting with ICES datacentre to review the metadata and further develop if required.
- Progress special request with ICES datacentre and Head of Advisory support.

- Check naming conventions for shapefiles for *Nephrops* FUs and survey area polygons with ICES secretariat.

**METADATA agreed to date:**

**1. Definition of metadata – General table (general details)**

| Description | Data Type | Comments |
|---|---|---|
| **FU NUMBER** | Numeric and character – max 15 including hyphen | Drop down list available numbers, use CRR as ref, incl 'Outside 12', '20-21' |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **ICES SURVEY CODE** | Character – MAX?? | ICES standard survey code |
| **COUNTRY** | Alphabetic, u/case - max 40 incl spaces | Drop down list, abbreviated? |
| **INSTITUTE** | Alphabetic, u/case - max 40 incl spaces or 6 | Drop down list, institute 's name anacronym? |
| **YEAR** | Integer – 4 | Year data related to |
| **START YEAR UWTV SURVEY** | Integer – 4 | Start of the data series – LIST YEARS? WHAT IF MISSING YEARS? |
| **SURVEY DESIGN** | Alphabetic, u/case –max 28 incl spaces | DROP DOWN LIST? |
| **SURVEY DESIGN – YEAR OF IMPLEMENTATION** | Integer – 4 | To track changes |
| **TOTAL GROUND AREA ($Km^2$)** | Numerical – 8 incl decimal point, 2 decimal places? | To be the same as in assessment – WG to confirm DP's |
| **TOTAL GROUND AREA – YEAR OF IMPLEMENTATION** | Integer – 4 | To record if changes over time |
| **SEASON** | Alphabetic and hyphen – max 13 | Flagged if this changes, date definition, options for survey to cross season eg SPRING-SUMMER See comments below DROP DOWN LIST? |
| **VESSEL** | Alphabetic – max 15 | |
| **YEARS VESSEL USED** | Numeric, hyphens, commas – max 30 | |
| **FU NUMBER GIS** | Alphabetic – max 3 | YES/NO DROP DOWN LIST? |
| **FU NUMBER GIS LINK** | Character | (Link) |
| **FU NAME GIS FILES** | Alphabetic – max 3 | YES/NO DROP DOWN LIST?SAME AS STORED BY ICES |
| **FU NAME GIS FILES LINK** | Character – MAX?? | (Link) |
| **SURVEY REPORT PUBLISHED** | Alphabetic – max 3 | YES/NO DROP DOWN LIST? |
| **SURVEY REPORT LINK** | Character – MAX?? | (Link) |

## 2. Definition of metadata – Density table

| Parameter | Data Type | Comments |
|---|---|---|
| **FU NUMBER** | Numeric and character – 15, incl hyphen | Drop down list available numbers |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **SURVEY** | Character – MAX?? | ICES standard survey code |
| **GROUND** | Alphabetic and characters – 25, u/case | Local name, sub-area of FU eg Jura in FU 13 |
| **DATE** | Numeric and forward slash - 10 | dd/mm/yyyy |
| **STATION** | Alpha-numerical – ?? | Free text to allow for variations between institute's as standardising would affect scripts, take time, etc |
| **START OF TV TRACK LONGITUDE** | Numeric and decimal point - 7 incl decimal place | Decimal degrees, 4 decimal places, eg 57.1234 |
| **START OF TV TRACK LATITUDE** | Numeric and decimal point–max 8 including decimal place and hyphen (west stations) | Decimal degrees, 4 decimal places, eg -03.1234 |
| **DEPTH AT START OF TV TRACK (m)** | Numeric and decimal point – MAX?? | SAME FORMAT AND DPs AS DATRAS? |
| **END OF TV TRACK LONGITUDE** | Numeric and decimal point - 7 incl decimal place | Decimal degrees, 4 decimal places, eg 57.1234 |
| **END OF TV TRACK LATITUDE** | Numeric and decimal point–max 8 including decimal place and hyphen (west stations) | Decimal degrees, 4 decimal places, eg -03.1234 |
| **DEPTH AT END OF TV TRACK (m)** | Numeric and decimal point – MAX?? | SAME FORMAT AND DPs AS DATRAS? |
| **ADJUSTED DENSITY** | Numeric and decimal point – MAX 5?? | adjusted ($n/m^2$), SAME FORMAT AND DPs AS DATRAS? |
| **MEAN BURROW COUNT** | Numeric and decimal point – 5, 1 decimal place | Un/adjusted(?) mean number of burrows per station – agreed should only only be adjusted |
| **TOTAL NUMBER BURROWS** | Numeric and decimal point – 5, 1 decimal place | To ensure transparency and provide all raw data |
| **DISTANCE OVERGROUND (m)** | Numeric and decimal point – 6, 2 decimal places | Total DOG covered per station in metres – max 999.99m |
| **SOURCE OF CALCULATED DISTANCE** | Alphabetic – 9 | Dropdown list: SHIP, Estimated, USBL, Layback, odometer |
| **TRACK AREA SURVEYED ($m^2$)** | Numeric and decimal point – 6, 2 decimal places | station area surveyed in $metres^2$ – max $999.99m^2$ |
| **MEAN FIELD OF VIEW FOR TRACK – FOV (m)** | Numeric and decimal point – 4, 2 decimal places | This may vary between stations Format eg 1.23 |
| **FoV FORMAT** | Alphabetic – 8 | Drop down option – 'FIXED' or 'VARIABLE' |
| | | |

### 3. Definition of metadata – Abundance table

| Parameter | Data Type | Comment |
|---|---|---|
| **FU NUMBER** | Numeric and character – max 15 icluding hyphen | Drop down list available numbers |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **SURVEY** | Character – MAX?? | ICES standard survey code |
| **YEAR** | Integer – 4 | Year data related to |
| **NUMBER OF STATIONS - PLANNED** | Integer – 4 | |
| **NUMBER OF STATIONS - SURVEYED** | Integer – 4 | |
| **ABSOLUTE CORRECTED ABUNDANCE** | Numeric and decimal point – 12 max | |
| **95% CI** | Numeric | Confidence interval in million/billion |
| **CV-RELATIVE STANDARD ERROR (%)** | Integer - 3 max | Percentage |

### 4. Definition of metadata – Correction factors table

| Parameter | Data Type | Comment |
|---|---|---|
| **FU NUMBER** | Numeric and character – max 15 icluding hyphen | Drop down list available numbers |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **SURVEY** | Character – MAX?? | ICES standard survey code |
| **YEAR LAST MODIFIED** | Integer – 4 | Year data related to, track changes, link to ICES report where changes proposed/agreed |
| **EDGE EFFECT** | Numerical and decimal point - 5 | To 2 decimal places |
| **BURROW IDENTIFICATION** | Numerical and decimal point - 5 | To 2 decimal places |
| **BURROW OCCUPANCY** | Numerical and decimal point - 5 | To 2 decimal places |
| **BURROW DETECTION** | Numerical and decimal point - 5 | To 2 decimal places |
| **CUMULATIVE BIAS CORRECTION FACTOR** | Numerical and decimal point - 5 | To 2 decimal places |

**5. Definition of metadata – GIS Shapefiles by FU Number (based on ICES rectangles)**

| Parameter | Data Type | Comment |
|---|---|---|
| **FU NUMBER** | Numeric and character – max 15 icluding hyphen | Drop down list available numbers |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **SURVEY** | Character – MAX?? | ICES standard survey code |
| **YEAR** | Integer – 4 | Year data related to |
| **FID** | ? | Object ID |
| **SHAPE** | ? | Geometry, polygon |
| **KRIGING USED** | Alphabetic - 3 | Drop down list – YES/NO |
| **REFERENCE** | ? | String, ICES WG/Benchmark acronym link |

**6. Definition of metadata – GIS Shapefiles by FU Name (area polygons)**

| Parameter | Data Type | Comment |
|---|---|---|
| **FU NUMBER** | Numeric and character – max 15 icluding hyphen | Drop down list available numbers |
| **FU NAME** | Alphabetic and characters – 25, u/case | Drop down list of available names |
| **SURVEY** | Character – MAX?? | ICES standard survey code |
| **YEAR** | Integer – 4 | Year data related to |
| **FID** | ? | Object ID |
| **SHAPE** | ? | Geometry, polygon |
| **KRIGING USED** | Alphabetic - 3 | Drop down list – YES/NO |
| **REFERENCE** | ? | String, ICES WG/Benchmark acronym link |
| **AREA ($Km^2$)** | Numerical – 8 incl decimal point, 2 decimal places? | To be the same as in assessment – WG to confirm DP's |

# Github code repository (ToR c)

ToR-c addresses the necessity to update R scripts for *Nephrops* UWTV survey data processing, including: functions to quality control, analyse and visualize data, and interface the tools with the international database for *Nephrops* UWTV survey data.

There was no major update to this ToR since the last meeting where it was restructured.

UWTV survey equipment list by national laboratory was last updated at the 2016 meeting. It was decided to host this list on WGNEPS GitHub so that regular updates can be made.

# 4 Technological developments (ToR d)

## 4.1 Towards monitoring and recovery of fishery impacted species in deep-sea marine ecosystems: a joint effort between biology and technology within the Mediterranean BITER, PLOME and LIFE-ECOREST projects.

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The trawling fishing activity constitutes today half of all EU fisheries and its use is one of the main drivers of ecosystem degradation of demersal ecosystems (Puig et al., 2012). Trawling removes the sediments and endangers demersal fragile sessile organisms, being long-lived species replaced by short-lived ones. In the Mediterranean, many demersal stocks are overexploited, reducing the economic benefits of fisheries and the ecosystem services associated with cultural aspects of iconic species.

Given this situation, ecological networks of Marine Protected Areas (MPAs) as no-take reserves, are being created to preserve *Nephrops norvegicus* stocks, according to the principles of habitat connectivity, with appropriate scales of geographic proximity for larval dispersal (Vigo et al. 2021). Although the primary aim of MPAs is the conservation of *Nephrops* stocks, they also allow the recovering of the associated sessile fauna, that trapping the sediment accelerates the whole habitat restoration process. The repopulation of soft bodied cold water corals by badminton technique is the main goal of the LIFE-ECOREST Project.

Marine robotic is increasingly allowing the monitoring of benthic and pelagic ecosystems by means of cabled video-observatories, stand-alone landers and Internet Operated Vehicles (IOVs) as crawlers or AUVs (Aguzzi et al. 2019). These platforms can be used for synergetic data collection on *Nephrops* stocks demography and their environment, when organized into local networks (Masmitjia et al., 2020). In this scenario, cabled video-observatories, acquiring multidisciplinary oceanographic and biogeochemical data without power and bandwidth constraints, has been a key element to monitor marine ecosystems via the use of HD cameras (del Rio et al. 2020). However, the area of study is circumscribed to the deployment location, and the monitoring radius can be expanded by docked mobile platforms. The major goal of the BITER project is to use an autonomous lander for the advanced environmental monitoring, to gather video (i.e. optoacoustic) and environmental multiparametric information on *Nephrops* stocks recovery at a high-frequency and over prolonged duration (i.e. over diel, seasonal and multiannual scales). Information is transmitted to shore by pop-up buoys to enforce autonomous and remote measuring

procedures. In a second step, the PLOME project has been conceived to add to this lander up to 5 satellite fixed optoacoustic video-stations, plus a docking for AUVs (Girona 1000) battery recharge and data transmission. Future research will use docked crawlers and to reduce the seabed tracked wheels' footprint, also biomimicking crab-like platforms (e.g. Silver2; Picari et al., 2020).

Such a spatially-replicated image and environmental data collection will be used for the extraction of ecological indicators related to the fishery of *Nephrops* (e.g. abundances and biomasses through the counting and sizing of individuals) in an ecosystem-based compliant fashion; i.e. by gathering information not only for *Nephrops* but also of all its predators and preys (Aguzzi et al. 2020). Produced data could be in the next future complemented with standard UWTV surveys, performed in the NW Mediterranean according to the guidelines set by the WGNEPS.

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## 4.2 Acoustic tracking of *Nephrops norvegicus* update

Jónas Pall Jónasson

Behavior of *Nephrops* was investigated during the autumn of 2020 on two areas in Jökuldjúp ground in SW Iceland at depths of 115 and 195 m (Fig. X). On each ground 16 animals were tagged with acoustic tag, glued to the back of the carapace. Nine hydrophones were put down on a grid with 100 m distance. An acoustic doppler current profiler was put down to monitor currents and temperature in each area. The animals were tagged at the end of August and hydrophone retrieved in the end of November. Data was received from all tags, but 10 to 11 animals were estimated to be alive on each area. Six animals on each location were estimated to have

survived the whole period. Activity pattern differed with depth. Animals in deeper area were more active during the night but in shallower area during the day and at twilight hours (Fig X). Most animals moved within the area during the first weeks and stayed after that in the same locations with some exceptions. Tidal currents were stronger at the deeper area and fewer animal were active in stronger current.

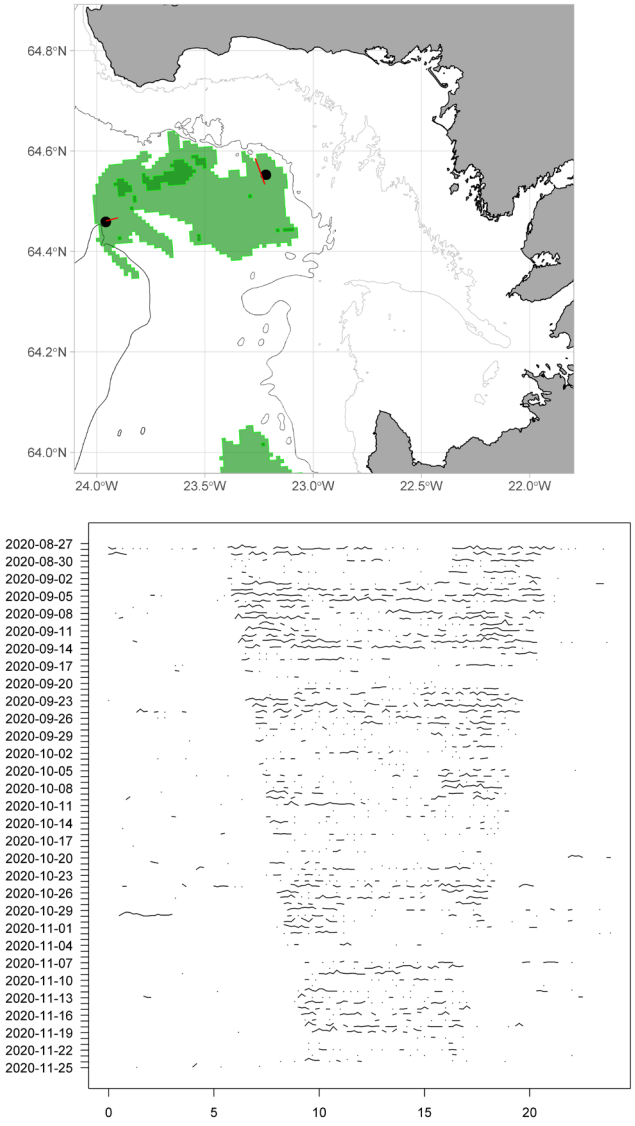


**Fig 5.2.1. Top Panel: tagging locations in Jökuldjúp SW Iceland (black dots). Light green areas are *nephrops* ground. Bottom panel: An actogram of animal from the shallow area (115m), 52.2 mm CL male. Activity patterns for each day through the experiment (from August to Nov). Each dot or line is cumulative detection every 10 minutes**

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

Atif Naseer

### 1. Introduction

The 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 using special equipment and underwater cameras. A 10-12 minute 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 burrow entrances manually by reviewing the video frame by frame in multiple parallel sessions and conclude the results on consensus of all members. This exercise costs a 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* have been counted manually (counting from TV surveys) from underwater videos which is a very tedious and time-consuming task. These species usually live under the seabed and leaving behind some pattern of burrows. To identify this species in underwater, one needs 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:

1. 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.
2. 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.
3. *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. 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 object detection and classification. To improve the detections, the models require some fine tuning and the addition of more layers. In this work, the *Nephrops* surveys from Cadiz and Ireland are analyzed using Faster RCNN deep neural networks. The results show some good true positive detections from Cadiz and Ireland data. A spatial-temporal analysis-based detection refinement algorithm is proposed to suppress the false positive and identify the missing true positive from the detections. Also, the trained algorithm is tested on different datasets from Iceland, Italy and UK.

### 2. Research Methodology

The system main objective is to develop an auto detection mechanism to classify and count the *Nephrops* burrows systems. Figure 1. Shows the research methodology used in our work.

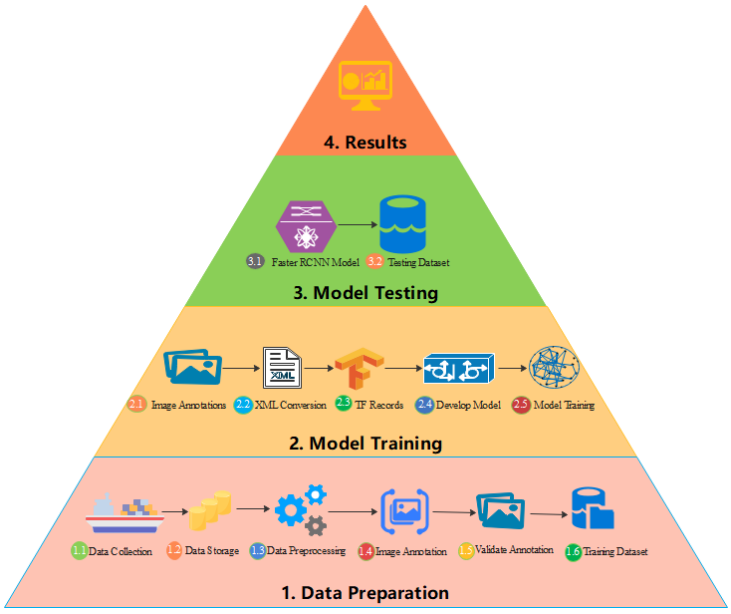


**Figure 1: Research Methodology**

## Data Preparation

a) Data Collection

The data used for experimentation and model training is from Cadiz and Ireland stations. The data collected from Cadiz is in the form of High-Definition videos from the survey of 2018 and 2019.The data collected from Ireland is in the form of HD quality images. More than 1000 images were collected from Ireland. Table 1. Shows the raw dataset and its attributes.

**Table 1: Dataset Attributes**

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

b) Data Preprocessing

In the initial step all the images from Cadiz and Ireland were studied and removed if the lightening conditions and contrast of images are too bad to recover. Also, the repeated frames from the same video will not be considered in the dataset used for annotations. The available data require preprocessing due to its heterogeneous nature. The quality of videos will be improved by improving the lightening effects, noise mitigation, color compensation and image contrast enhancement.

c) Image Annotation

The major step to prepare a good dataset is to annotate the *Nephrops* burrows. The ground truth annotations are the key for model training. To annotate the images, the Visual Object Tagging Tool (VOTT) from Microsoft has been used. VOTT helps in end to end machine learning pipeline. The tool allows to download the annotation in various format like csv, Jason, XML etc. From the Ireland dataset, out of 1650 images, 1133 images annotated and recorded 1699 annotations of *Nephrops* burrows

in these images. From the Cadiz dataset only 266 images annotated and recorded 350 annotations.

d) Testing and Validation of annotations
Once all the ground truth annotations are recorded, now it's time to validate the annotations before preparing the dataset for model training. The annotation validation is only possible from experts of *Nephrops*. Marine experts from Cadiz and Ireland helped in validating the ground truth annotations.

e) Data preparation for Model Testing
The last step of this phase is to prepare the dataset for training the model. The dataset from Cadiz and Ireland are used for model training and testing.

**Model Training**

In model training phase, a deep neural model will be trained using the prepare dataset. We used Faster RCNN object detection algorithms. Faster RCNN is an object detection architecture presented by Ross Girshick, Shaoqing Ren, Kaiming He and Jian sun in 2015, and is one of the famous object detection architectures that uses convolution neural networks. We trained more complex and denser model based on Faster RCNN, those are:

i. MobileNet v2
ii. Inception v2
iii. Resnet50
iv. Resnet101
v. YOLO v3

With these complex models, we used combination of our available dataset from Cadiz and Ireland for training and testing. To train the models following combination of datasets are used.

i. Cadiz Dataset
ii. Ireland Dataset
iii. Hybrid Dataset (Combination of Cadiz and Ireland)

Each model is trained with 100k iterations and precision are calculated on every 10k iteration.

**3. Detection refinement using Spatial-Temporal analysis**

In the post processing analysis of results, we identify some problems which makes impact on the results. The major problems are:

i. Suppression of False Positive detections
ii. Identification of missing detections

We develop a **Detection Refinement Algorithm** based on **Spatial-Temporal analysis** to find the missing detections in frames and rule out the False Positive detections. The refinement algorithm is currently tested on Cadiz videos to find out the missing detections in frames and elimination of False Positive.

### i. Suppression of False Positive detections

During the post processing analysis, we found many false positive detections in the videos tested using our trained algorithm. These false positives make a significant impact on the accuracy of results. Using our proposed spatial-temporal algorithm we suppress many false positives from the results. Figure 2. shows the original detections from our detection algorithms and the detection refinements after running the proposed detection refinement algorithm.

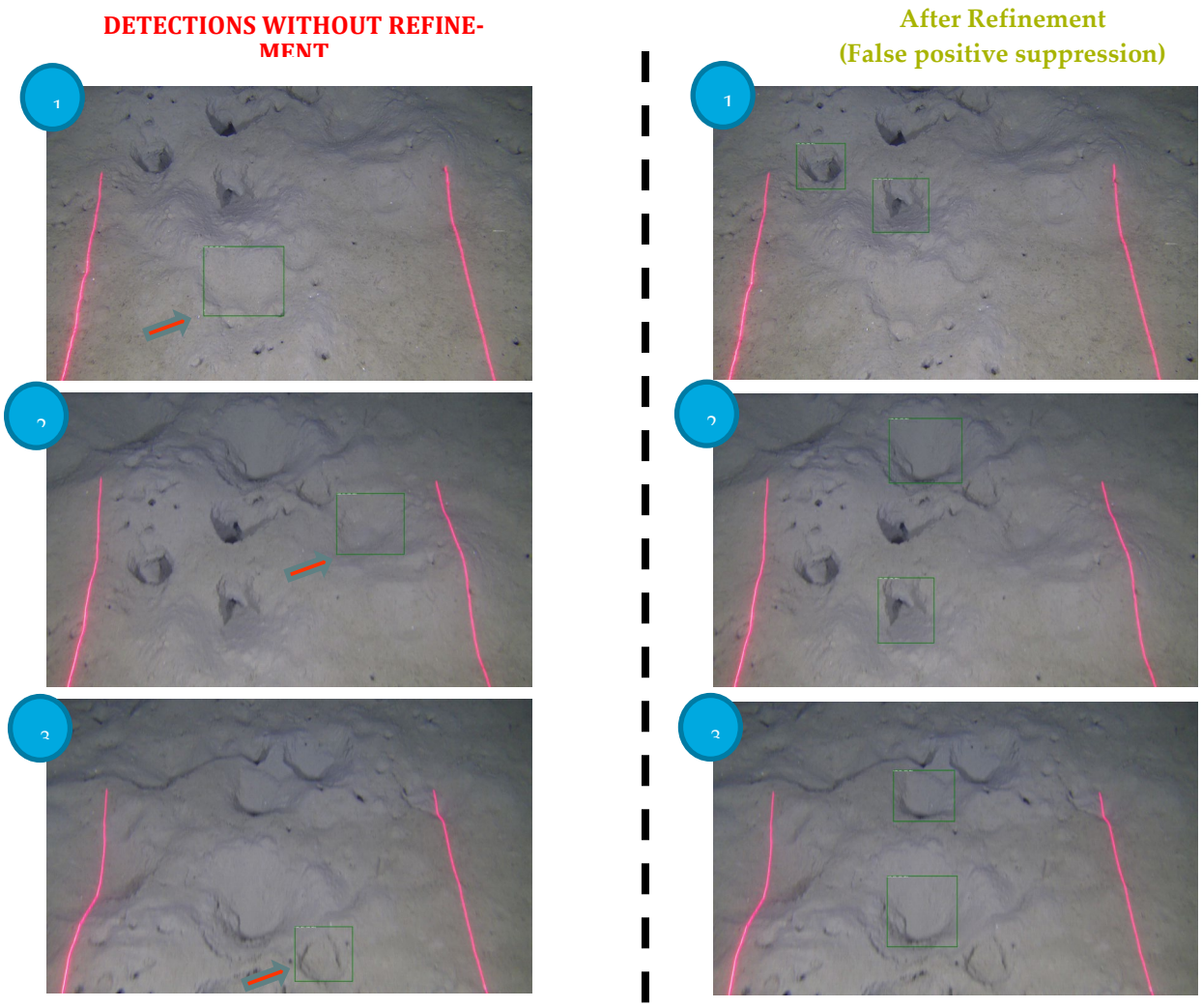


**Figure 2: Original Detections vs False positive suppression**

### ii. Identification of missing detections

Along with the false positives, lot of missing true positive detections were detected during the post processing analysis of the testing videos. These missing detections also impact the accuracy of the detector. After identifying these detections, the accuracy of the algorithms increases. Our proposed detection refinement algorithm identifies these detections. Figure 3. shows the original detections and refinement after identification of missing detections.

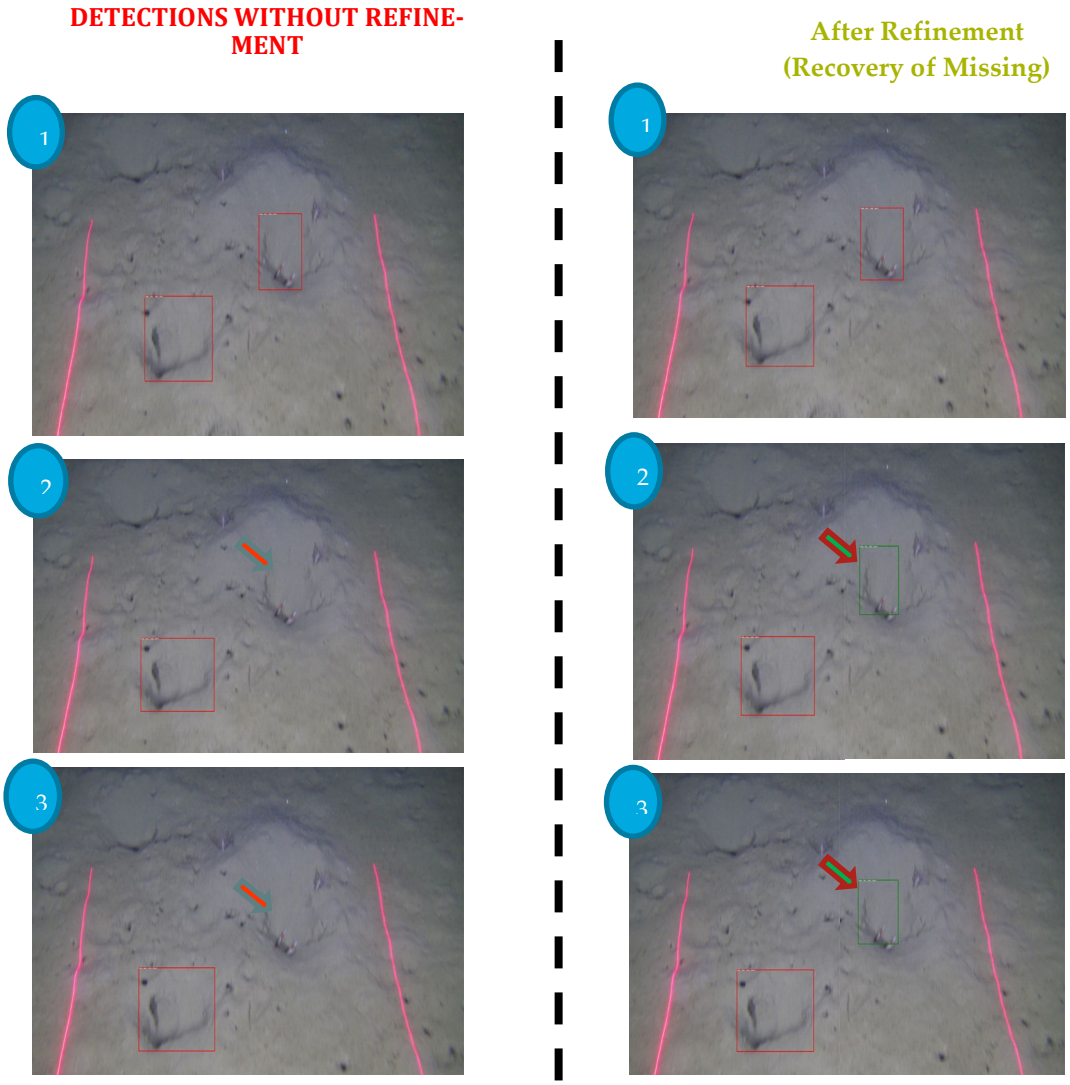


**Figure 3: Original Detections vs Identification of Missing detections**

## 4. *Nephrops* Detection on different Stations

We also performed some experiments on the dataset from stations other than Cadiz and Ireland. We tested our trained models on different dataset received from Iceland, Italy, and Aberdeen UK and record the preliminary results. The results show some good results but need a lot of improvements. Here we are showing the results from these stations.

a. Detections on ICELAND Dataset

Figure 4 shows the true positive and false positive detections of ICELAND data. The algorithm used in this dataset is trained on the Cadiz and Ireland dataset.

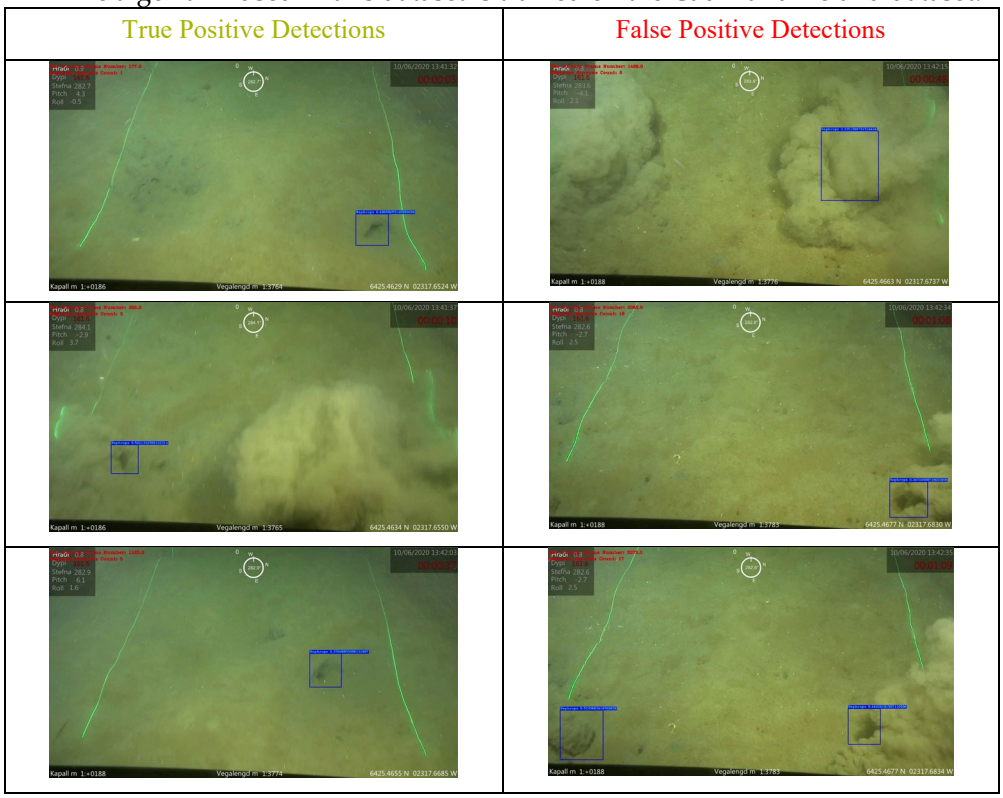


**Figure 4: Detections on ICELAND Dataset**

b. Detections on Adriatic- Italy Dataset

Figure 5 shows the true positive and false positive detections of Adriatic data. The algorithm used in this dataset is trained on the Cadiz and Ireland dataset.

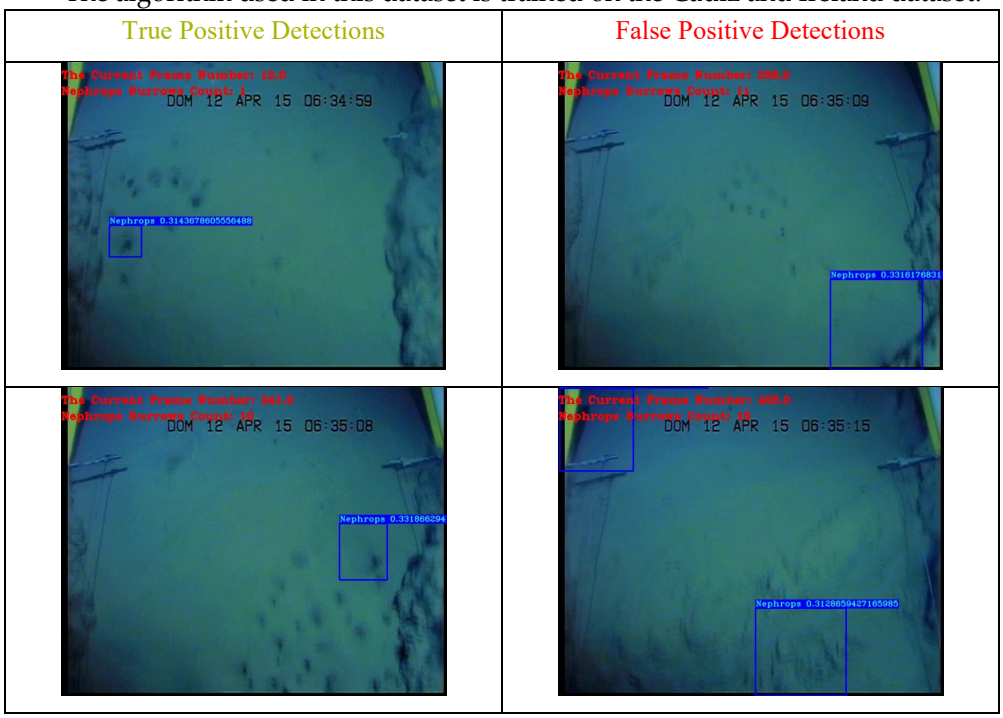


**Figure 5: Detections on Italy Dataset**

c. Detections on Aberdeen, UK Dataset

Figure 6 shows the true positive and false positive detections of Aberdeen data. The algorithm used in this dataset is trained on the Cadiz and Ireland dataset.

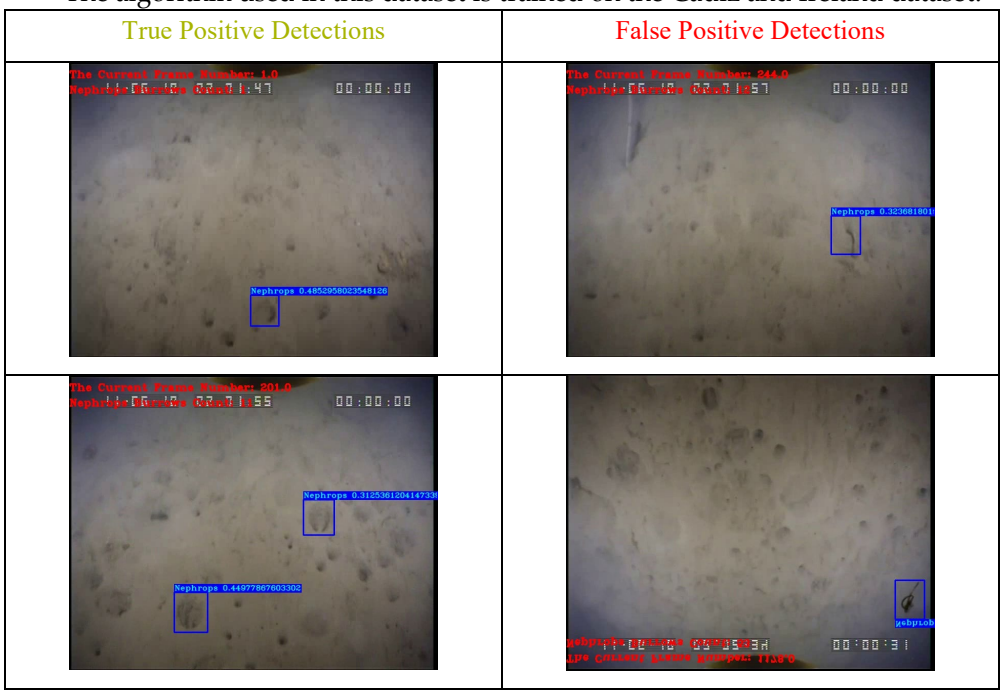


**Figure 6: Detections on Aberdeen, UK Dataset**

d. Findings on Dataset

The dataset received from Iceland, Italy and UK have different underwater environment as compared to Cadiz and Ireland data. These datasets also have some noise and poor lighting quality issues. These problems can easily be fixed by applying a preprocessing algorithm for better illumination and quality. Also, the ground truth dataset is missing for all of these stations. After preparing a ground truth, a separate model can be trained for each station.

## 5. Conclusion

During the past many years *Nephrops* are counted manually (counting from TV surveys) from underwater videos which is a very tedious and time-consuming task. In the current study, we received data from Cadiz and Ireland stations, and recorded the ground truth annotations from these images. We developed and trained deep neural models based on Faster RCNN MobileNet, Inception, resNet50 and ResNet100, and Yolo for Cadiz and Ireland stations and get the results from trained models. The results obtained from these algorithms contained many false positives and missing true positive detections. We proposed a detection refinement algorithm based on spatial-temporal analysis that suppresses the false positive and identify the missing detections. The trained algorithms are also tested on the dataset received from Iceland, Italy and UK stations and record the preliminary results.

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 positives and missing detections. A mechanism will be developed to record the ground truth of each station that will help us to train the model separately for each station.

## 4.4 FU 28 and 29 *Nephrops* Survey Offshore Portugal

Cristina Silva and Bárbara Pereira

The R/V Noruega, a stern trawler with 47.5 m of overall length (LOA) built in 1978 and used to conduct trawl and acoustic surveys on pelagic and demersal resources in Portuguese waters, ended her operation in 2018. She was used for almost 40 years in surveys and data on biodiversity, biological and oceanographic parameters and also on marine litter characteristics and distribution were collected.

In 2021, the R/V Mário Ruivo started her operation. The vessel, previously used for laying and maintenance of underwater targets, navigation marks and moorings in UK, was acquired by IPMA with support of EEA Grants Programme and suffered an extensive transformation to be used as a multidisciplinary research vessel including the capability to perform trawl operations. The 2021 *Nephrops* survey, the first survey of the vessel after the refit, was still experimental and revealed some operational issues that need to be fixed.

A comparison of some characteristics of both vessels is presented in the table below. Although the gear used is the same, the trawling speed and the doors characteristics may affect the net geometry and the performance of the fishing operation.

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

Analyses must be carried out to in order to define whether the surveys carried out with the new vessel will be considered as a new survey series or part of the previous one.

### 4.4.1 Azor drift-cam

The UWTV survey estimates are used as absolute abundance/biomass estimates after several bias corrections. The stocks in FU 28-29 are covered using a trawl survey, producing only a relative abundance index used in the assessments as an indicator. This type of survey also collects data on Norway lobster sex-ratio, length frequency distribution and maturity, besides information on other taxa (species assemblages and biological data).

In 2021, a project aiming to improve the knowledge, tools and methodologies to monitor and sustainably manage deep-sea vulnerable marine ecosystems (VMEs) in Portugal was submitted but, although well ranked, no financial support was received. The project considered the use of the Azor drift-cam (Dominguez–Carrió *et al.*, 2021), a cost-effective and easy to operate video platform (Figure 5.4.1) that can be used for a rapid appraisal of the deep seabed to 1,000 m depth, which performance was assessed in Azores on board of a 25-m research vessel and also on 12-m long fishing vessels.

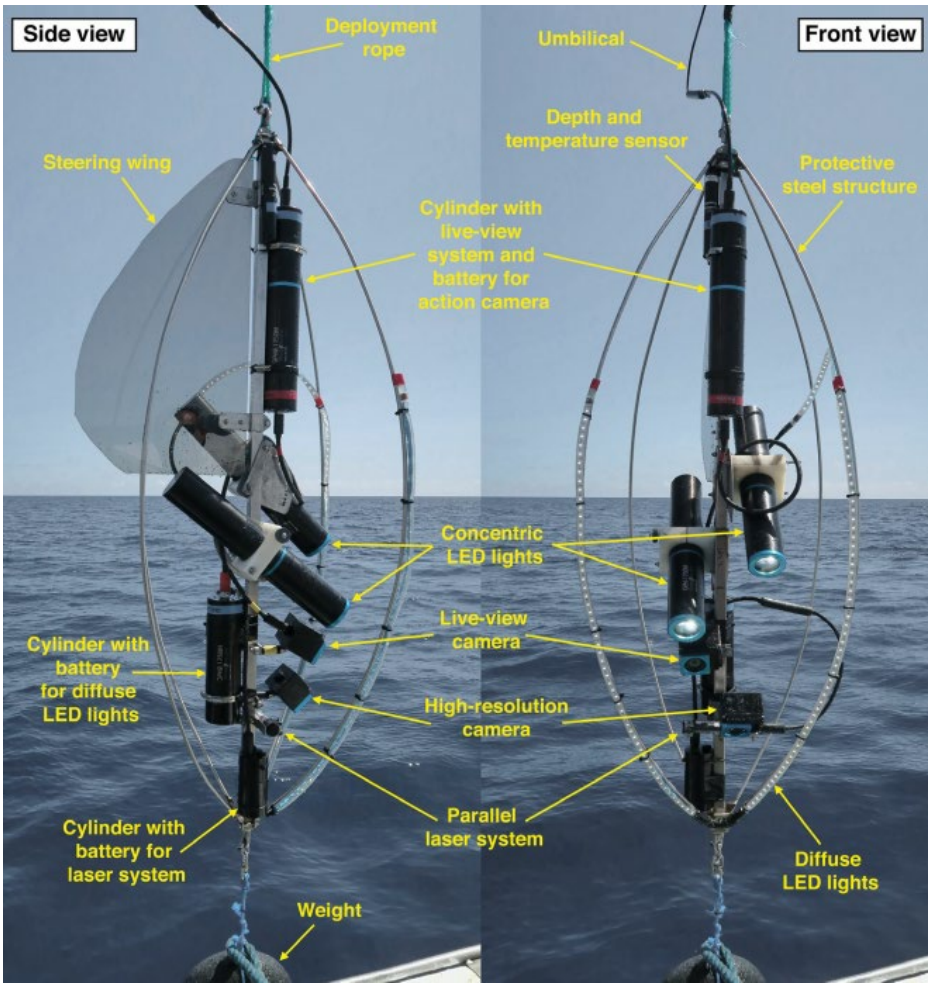


**Figure 5.4.1. Front and side views of the main body of the Azor drift-cam, with all its components mounted in the stainless-steel frame (from Dominguez–Carrió et al., 2021).**

The use of this affordable equipment could be a feasible way to combine the present trawl survey with the collection of underwater images to characterize the *Nephrops* deep fishing grounds in Portugal.

## References

Dominguez-Carrió C, Fontes J, Morato T. 2021. A cost-effective video system for a rapid appraisal of deep-sea benthic habitats: The Azor drift-cam. *Methods in Ecology and Evolution*, 12 (8): 1379-1388. https://doi.org/10.1111/2041-210X.13617.

## 4.5 Update on the review of FU 30 survey area definition

Yolanda Vila and Candelaria Burgos

ISUNEPCA UWTV survey (U9111) is carried out in the Gulf of Cadiz (UF 30) yearly in spring-summer since 2014, although the first survey is considered as exploratory. The current survey area used to obtain the *Nephrops* abundance estimate in the Gulf of Cadiz (FU30) was established in the Benchmark Workshop on *Nephrops* stocks (WKNEP) in 2016 (ICES, 2016; Vila et al., 2016). It was delimited mainly based on the combination of VMS and logbook data analysis (2011-2012) and the *Nephrops* abundance from ARSA IBTS surveys (G7511 and G4309) time series (1994-2014). Additional information obtained from sediment samples (Vila et al., 2015) and the bathymetric and morphologic information (Díaz del Río et al., 2014) was also used. This area corresponds to 3000 $Km^2$ and covers depths ranging between 90 m to 700 m, approximately.

However, data compiled and the experience acquired during ISUNEPCA UWTV survey time series suggest that the presence of *Nephrops* is very low or null in the shallowest and the Southern border of the current survey area. Besides, visibility at those depths is very poor and the presence of other species with a burrowing behavior generates a high uncertainty in the *Nephrops* burrows identification. For that reason, the stations located in the shallowest limit of the area have been considered stations with zero *Nephrops* density in the 2017-2019 period (ICES, 2018a; 2018b; 2020). That assumption was considered on the base of results obtained in ARSA IBTS surveys and beam trawls hauls carried out in those years (ICES, 2018a; 2018b; 2020). So the *Nephrops* distribution limits could be different and, as a consequence, the survey area should be probably smaller than the current area. These facts could directly affect the *Nephrops* abundance estimate.

A review of the ISUNEPCA UWTV survey area was presented during WGNEPS 2020 (ICES, 2021) since nowadays new and more accurate information is available. One of them is the Andalusian monitoring system, called SLSEPA ("*Sistema de Localización y Seguimiento de embarcaciones Pesqueras Andaluzas*"), installed in most of fleets in the Gulf of Cadiz, that transmit time and positions (provided by (GPS), course and speed to the control centre every three minutes, (instead the two hours interval of European VMS) allowing for an accurate estimate of the actual fishing activity using a quite simple method not relying on strong assumptions. Additionally, updated data from ARSA IBTS survey time series (1993-2020) and beam trawl information obtained in the ISUNEPCA UWTV survey during 2017-2019 period.

The SLSEPA information linked to sales notes analysis in 2019 for the bottom trawl fleet in the Gulf of Cadiz (FU30) shows the highest *Nephrops* catches in the Western half of the area, mainly at more than 500 m depth and between 200 and 400 m depth (Figure 1a). Nevertheless, catches ranging between 6 to 16 $Kg/nm^2$ are observed in the shallowest stratum between 100 and 200 m depth. Unlike, the Southern part shows lower catches distributed since 200 m depth.

The *Nephrops* density from ARSA IBTS surveys (G7511 and G4309) time series indicates a very few quantities of *Nephrops* in that stratum (100-200 m), as well as in the Southern border of the current UWTV survey area, with only some exceptions during the time series (1993-2020) (Figure 1b).

The results obtained from the beam trawl hauls conducted during ISUNEPCA UWTV surveys in the 2017-2019 period showed presence of burrowing crustaceans as *Goneplax rhomboids* in the 100-200 m stratum but no individuals of *Nephrops* were caught in them (Figure 2c).

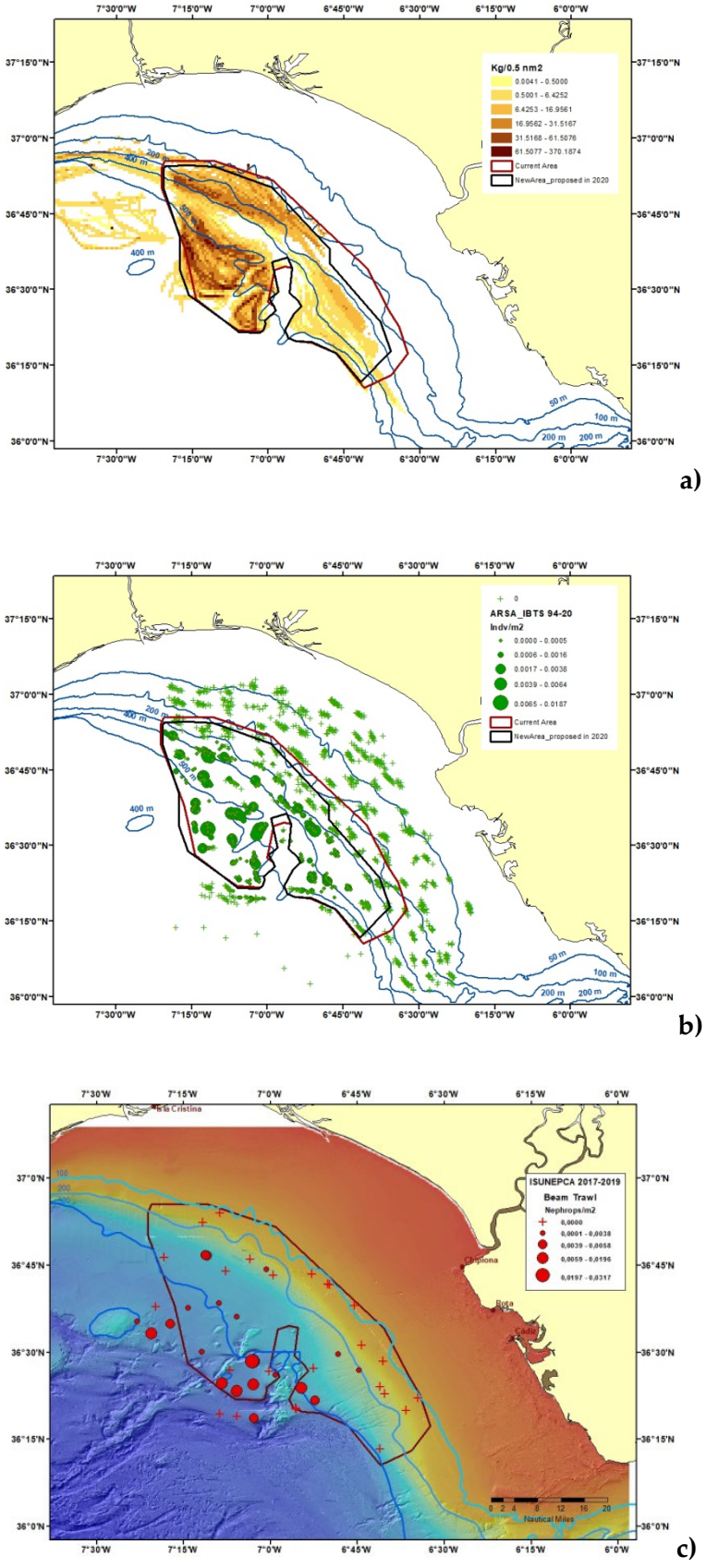


**Figure 1. Analysis of Andalusian vessel monitoring system (SLSEPA) linked to sales notes from the bottom trawl fleet in 2019 (a); *Nephrops* density from ARSA IBTS surveys (G7511 and G4309) time series (1993-2020 (b); Nephrops density**

**from beam trawl hauls carried out in the ISUNEPCA UWTV survey (U9111) time series (2017-2019) (c). Red polygon represents the current area used in ISUNEPCA UWTV surveys while the black polygon represents the provisional area proposed in 2020.**

Different geological and oceanographic processes determine the distribution of a wide of geomorphological features, habitats and species in the Gulf of Cadiz. Channels, diapiric ridges and mud volcanoes can be found in the area (Figure 2a) which harboring distinct benthic and demersal associated communities and habitats (Díaz del Río et al., 2014; Rueda et al., 2012). Some of them were taken into account to establish the *Nephrops* distribution area used to ISUNEPCA UWTV survey in 2016 (Vila et al., 2016). However, more detailed sea bed morphology information, as well as new information about sediment and habitats in the Gulf of Cadiz are now available (Lozano et al., 2019; Lozano et al., 2020), which can be very useful for this issue (Figure 2b). Figure 3 shows the results obtained from the sediment samples collected in the ISUNEPCA UWTV surveys in 2014, 2018 and 2019).

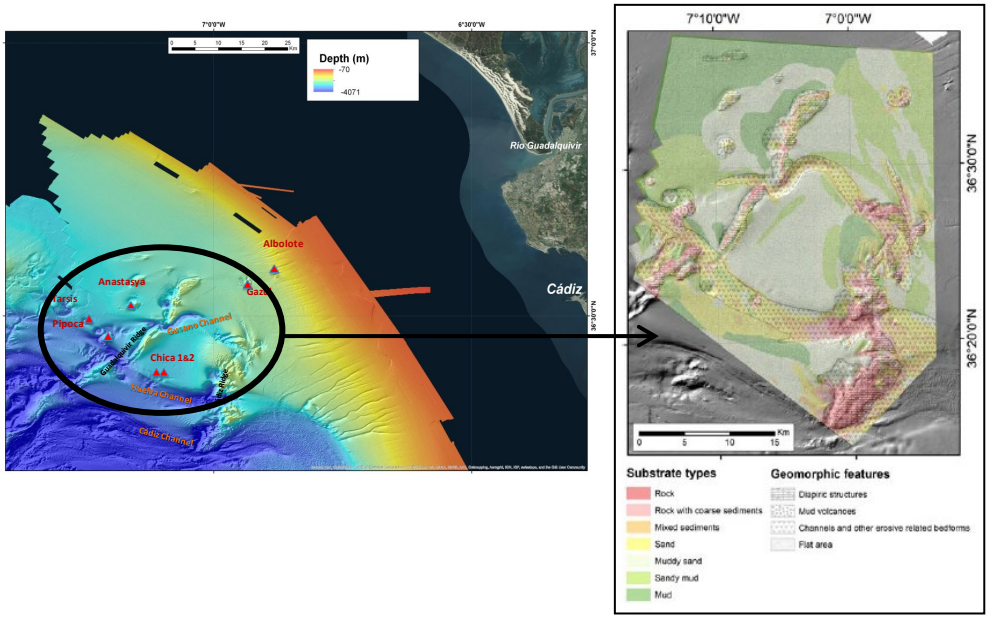


**Figure 2. Main geomorphological seafloor features and substrate types in the Gulf of Cadiz. Source: (a) INDEMARES/CHICA Project (LIFE07/NAT/E/000732); (b) Lozano et al., 2019.**

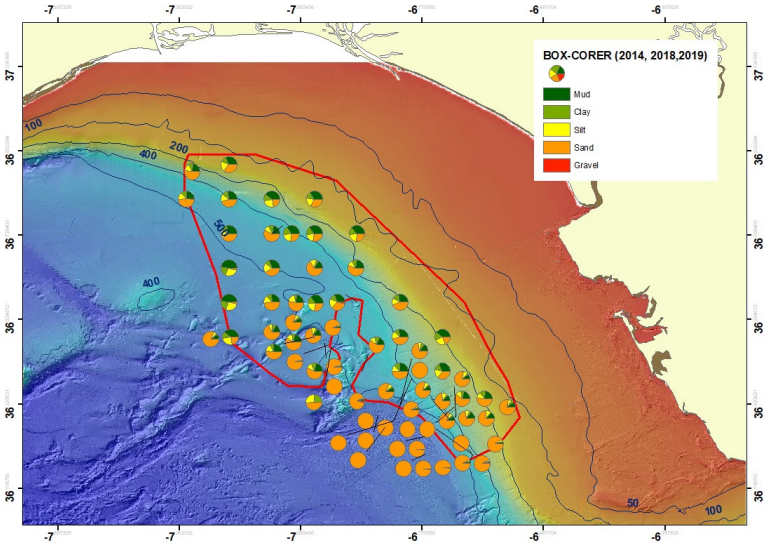


**Figure 3. Sediment types from box-corer sampling carried out in ISUNEPCA UWTV surveys 2014, 2018 and 2019. Red polygon represents the current survey area.**

The updated information about sedimentary and geomorphic seafloor features have been taken into account and a more detailed redefinition of the area has been presented in WGNEPS 2021 (Figure 4).

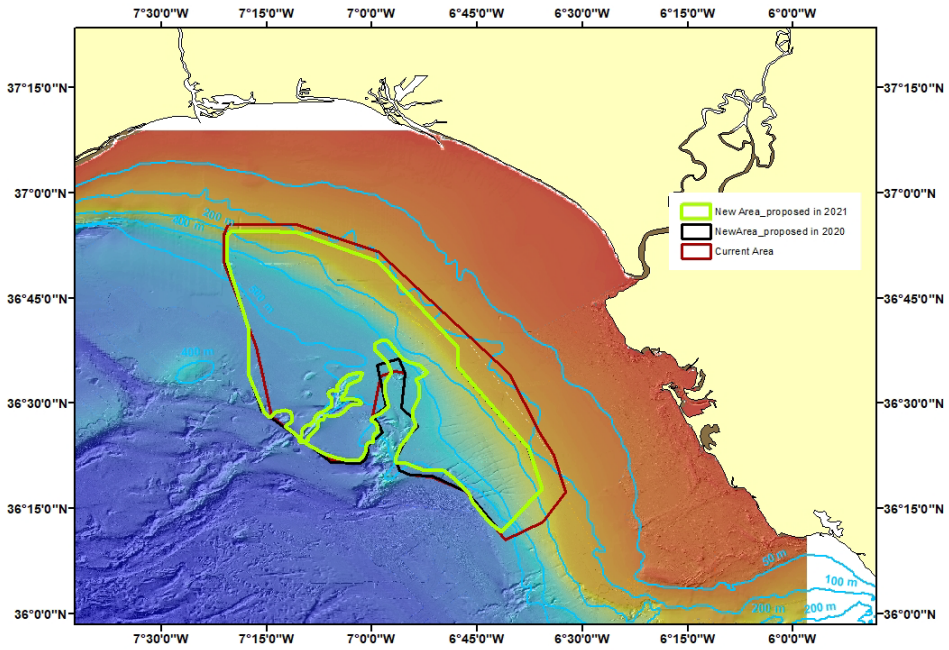


**Figure 4. Current survey area (red), provisional area proposed in 2020 (black) considering VMS analysis and ARSA IBTS and beam trawl information and in 2021 (green) taking into account besides the sedimentary and geomorphic seafloor features.**

The proposed shallowest limit in the Western part was discussed during the WGNEPS 2021. Figure 5 shows the two options considered for the new survey area overlapped to the *Nephrops* density spatial distribution obtained during the ISUNEPCA UWTV survey time series. The WG considered as the better option Figure 5b, where the stratum from 100-200 m depth is removed

of the proposed new area, based on the whole information which suggests negligible presence of *Nephrops*.

However, some stations carried out during the ISUNEPCA UWTV survey time series, where *Nephrops* burrows systems were identified, stay out of the new area proposed. This survey is relatively new, as it started in 2015. The low experience in the identification and quantification of the *Nephrops* burrows when the time series started could be the explanation for the presence of *Nephrops* in this part of the area. For this reason, a review of the *Nephrops* density in those stations is needed in order to check them.

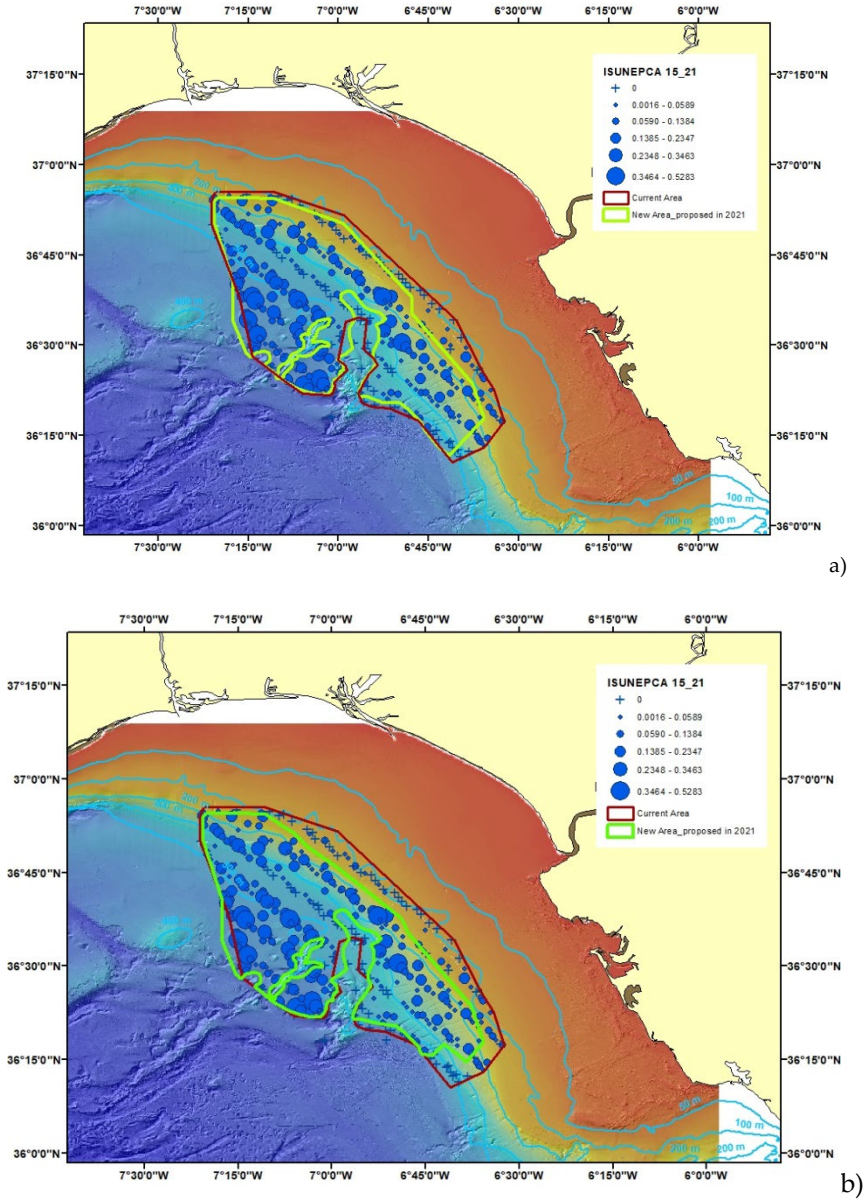


**Figure 5. *Nephrops* density spatial distribution from ISUNEPCA UWTV survey (U9111) time series (2015-2019) (blue bubbles) overlapped on the current area survey (red polygon) and new area proposed (green polygon). New area proposed keeping the 100-200 m depth stratum (a); New area proposed removing the 100-200 m depth stratum (b).**

**Conclusions and recommendations**

1. Results obtained indicate that the ISUNEPCA UWTV survey area should be reduced, mainly in the shallowest border.
2. The *Nephrops* density in those stations staying out of the proposed area must be checked.
3. A working document showing the work conducted about the redefinition the area survey in FU 30 must be presented to WGBIE 2022.
4. Geo-statistical re-estimation of the *Nephrops* burrows abundance taking into account the new area must be carried out before the advice process in October.
5. Reduce the grid size for next survey in 2022 (more stations, less distance between them).

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## 4.6 Review of FU 23-24 survey area Bay of Biscay.

Spyros Fifas

The adoption of the new HD system suggests the necessity to recalculate the edge effect correction coefficient as well as to redefine the reference footage for the stock. Additionally, the currently available survey's data have exhaustively covered the different ground types. This provides valuable information allowing to more accurately define the polygon surface actually involved by the species distribution. Stations with repetitively zero burrows should be eliminated from the yearly systematic grid.

Table 5.5.1 contains summarized information by sedimentary stratum and by latitudinal range for total number of sampled stations as well as for those involved by the absence of burrows. It is noticeable that the combination of the rough sea bottom stratum (label RO; sampled only from 2016 onwards) with the latitude 45°45-46° represented by a total number of 44 stations includes 31 (70%) stations with zero burrows whereas the zero samples for the whole area reach 11% of the total stations (135 on 1210). Moreover, latitude 45°45-46° for all strata involves on 73 total stations and among them 38 (52%) are denoted by absence of burrows. Analytical investigations by cartography tools have to be carried out before the next spring WGBIE of ICES in order to calculate the actual surface to retain for future surveys.

**Table 5.5.1. Total number of UWTV stations (Ntot) and number with no burrows (N=0) by stratum and by latitudinal range. Aggregated information on years 2014-2021.**

| **Stratum label** | **CB** | | **CL** | | **LI** | | **RO** | | **VS** | | **VV** | | ***Total*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lat range | Ntot | N=0 | Ntot | N=0 | Ntot | N=0 | Ntot | N=0 | Ntot | N=0 | Ntot | N=0 | *Ntot* | *N=0* |
| 45°15'-45°30' | | | | | | | 10 | 8 | | | | | *10* | *8* |
| 45°30'-45°45' | | | | | 6 | 2 | 15 | 8 | 7 | | 6 | 1 | *34* | *11* |
| 45°45'-46°00' | 16 | 3 | | | 6 | 1 | 44 | 31 | 7 | 3 | | | *73* | *38* |
| 46°00'-46°15' | 31 | 4 | | | 16 | 1 | 23 | 9 | | | 30 | 2 | *100* | *16* |
| 46°15'-46°30' | 8 | 3 | | | 45 | | 18 | 3 | | | 16 | | *87* | *6* |
| 46°30'-46°45' | 7 | 1 | | | 99 | 7 | 6 | 3 | | | 5 | | *117* | *11* |
| 46°45'-47°00' | 14 | 1 | | | 91 | 6 | 1 | 1 | | | 17 | | *123* | *8* |
| 47°00'-47°15' | 50 | 8 | 9 | 2 | 92 | 1 | 30 | 10 | | | 26 | 1 | *207* | *22* |
| 47°15'-47°30' | 91 | 7 | 48 | 2 | 44 | 1 | 17 | 1 | 6 | | 30 | | *236* | *11* |
| 47°30'-47°45' | 8 | | 48 | 2 | | | 9 | 1 | 39 | | 91 | | *195* | *3* |
| 47°45'-48°00' | | | 12 | | | | 4 | | | | 12 | 1 | *28* | *1* |
| ***Total*** | ***225*** | ***27*** | ***117*** | ***6*** | ***399*** | ***19*** | ***177*** | ***75*** | ***59*** | ***3*** | ***233*** | ***5*** | ***1210*** | ***135*** |

## 4.7 Reference Sets

There was no major update to any reference sets presented to the meeting. Minor update with the addition of two extra stations to the FU 16 HD reference set and a mini SD reference set was developed for FU 17 prior to the 2021 survey season.

Intersessional work is planned to develop and evaluate a reference set for FU 3&4 in advance of next survey season in 2022.

## 4.8 Annotation software

### Iceland

In Iceland an "in house" annotation software has been developed called Hafmynd (Ocean image). It is written in javascript (platform independent). The taxonomic structure is based on the World Register of Marine Species (WoRMS) database. It can be used both for photos and videos.

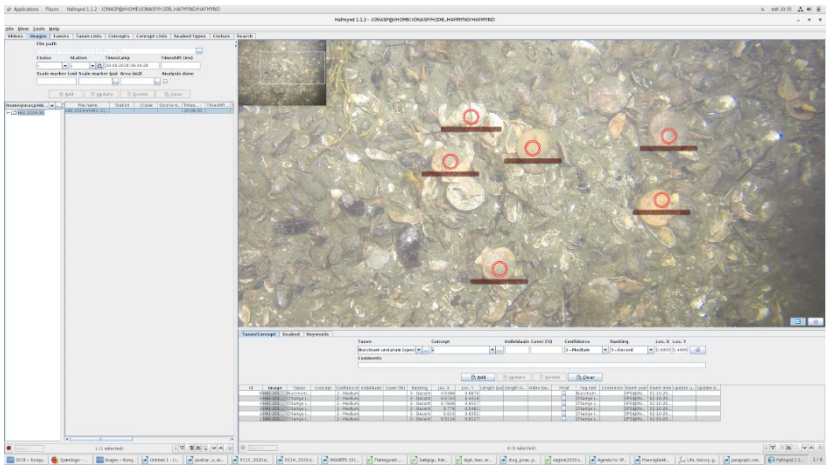


**Fig 4.8.1. Snapshot from the annotation software Hafmynd.**

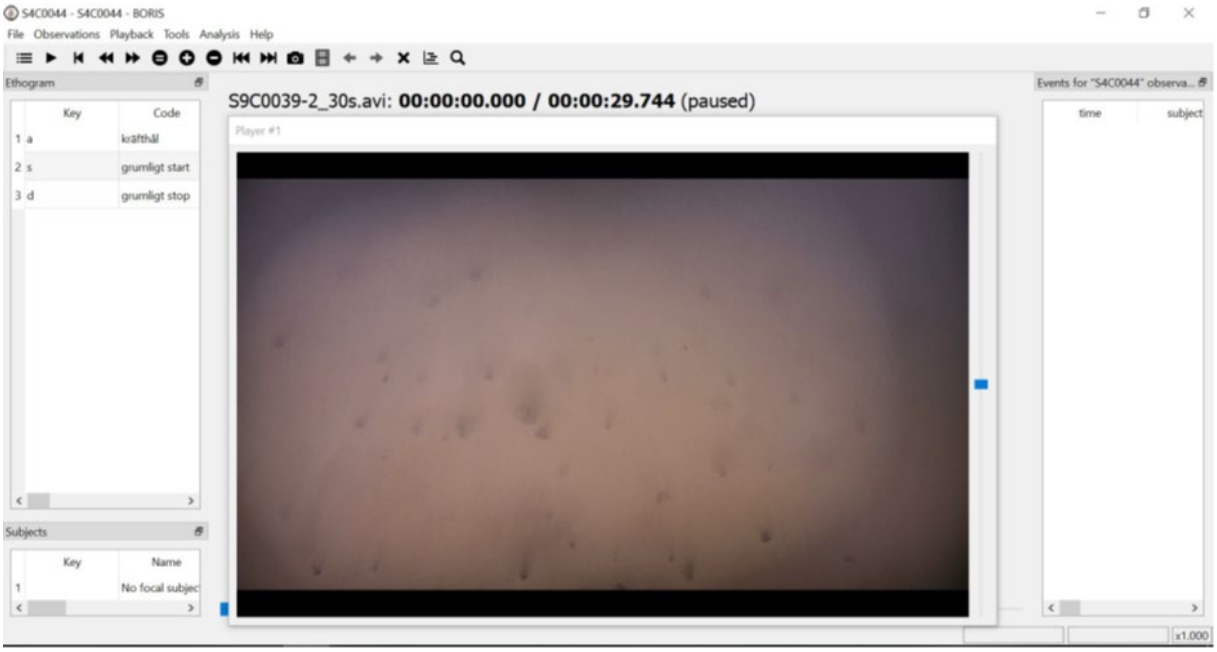
It has been used from 2019 for the UWTV survey in FU 1. The data generated are stored directly into an oracle database. Species id is based on WORMS but concept like burrows can be generated (Fig 4.8.1). It stores x-y locations, time, time intervals, size measurements, substrate, cover and more features. In FU 1, abundant species like sea fan are counted over a chosen time interval, usually twice per stations, around 100 animals per interval. Trawl marks are registered as concept in Hafmynd.

### Sweden

In 2020 Sweden upgraded the video equipment to a full HD video camera. At the same time the burrow annotation method was shifted from the minute based clicker counts to a video analysis software with the possibility to record time references arbitrary point and interval events. The free and open-source software BORIS (Friard and Gamba, 2016) is a tool for automatic coding of behavior/event from video and audio recordings. Rather than the old analogous clicker, the computer keyboard is used and key strokes are time references and simple lists of "events" such a burrow complex, a visible *Nephrops* as well portions of low visibility (a time interval) are simply stored in a long format (one event is one row) and is accessible in various output formats, including XLSX-files. By post processing the BORIS output file minute based count data are easily calculated to fit the established method of counter comparisons.

Presently the software is using VLC as the video player but the last (experimental) version includes the video player "mpv". The player functions are built in to BORIS and there are possibilities for taking snapshots, change the pace of the video (possibility to slow the video down in high density area) as well as frame by frame stepping.

Below is a snapshot of the screen during the analysis. The left panel are the user defined "ethogram", which are the various point and interval events to be recorded. The middle panel is the video screen and results are displayed in the right panel. The panel organization are flexible and the video display could be moved to a separate computer screen if one is working with a two screen set up.




Screenshot below of the resulting output file used for post processing and counting. In the example below only POINT events are recorded, hence the start and stop times are identical and duration is not defined.

A1 Observation id

| | Observation id | Observation date | Description | Media file | Total leng | FPS | Subject | Behavior | Behaviora | Modifiers | Behavior t | Start (s) | Stop (s) | Duration ( | Comment Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 4.725 | 4.725 | NA | |
| 3 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 5.400 | 5.400 | NA | |
| 4 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 8.003 | 8.003 | NA | |
| 5 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 12.176 | 12.176 | NA | |
| 6 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 15.052 | 15.052 | NA | |
| 7 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 19.050 | 19.050 | NA | |
| 8 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 20.702 | 20.702 | NA | |
| 9 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 24.876 | 24.876 | NA | |
| 10 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 29.776 | 29.776 | NA | |
| 11 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 36.603 | 36.603 | NA | |
| 12 | CRC0253_omläs | 2021-05-27 10:17:12 | | D:/UVTW_202 | 601.270 | 30 | No focal su | burrow system | | | POINT | 36.834 | 36.834 | NA | |

## Ireland

R Shiny application was built to annotate footage (HD-stills) from *Nephrops norvegicus* UWTV surveys carried out by the Marine Institute (Ireland) since 2019. The app allows the reviewer to annotate burrow systems, log ancillary data, for example, presence/absence occurrence of seapens, trawl marks, fish, marine litter and create timestamp files to log non countable time. The count, ancillary data and timestamp files are transferred to a local UWTV survey database and further data quality controlled with r-scripts. Once the survey data has passed QC it is then uploaded to SQL server. Screenshot of annotation app (Figure 4.9.2).

In 2020 a new feature was added to to compare the annotations from two surveyID_stationID_counterID_counts.csv files from the same station but different counters. App will run Lin's concordance correlation coefficient test and a recently developed new matching code, which will try to match the annotations from both counters.

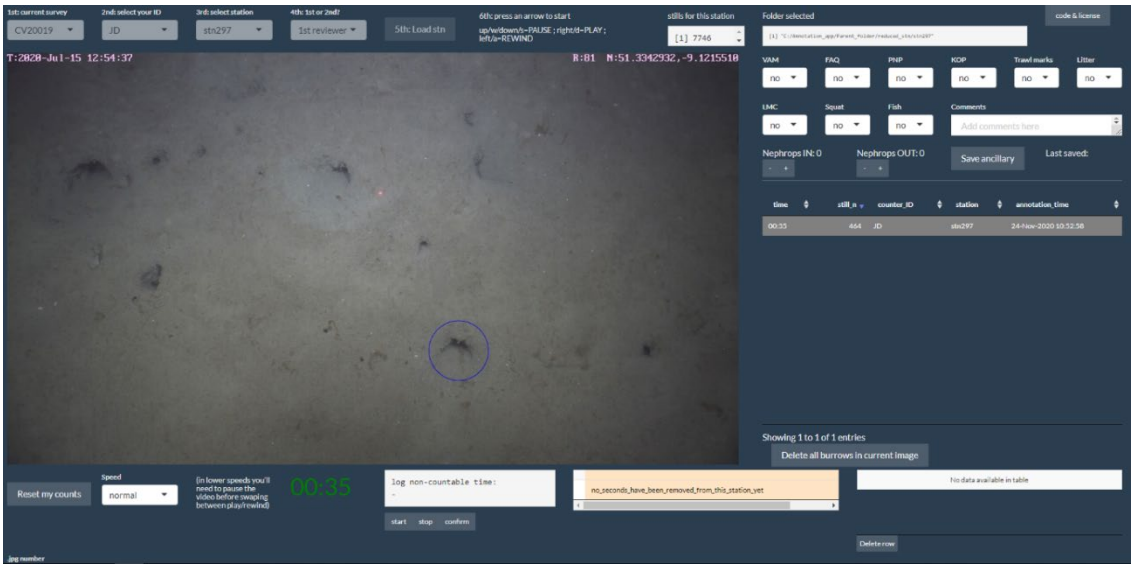



**Figure 4.9.2 Screenshot of the Image annotation R shiny app used to annotate UWTV footage during the 2021 surveys. Blue circle denotes annotated burrow system.**

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https://doi.org/10.1111/2041-210X.12584

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

## 5.1 Using UWTV surveys for epifauna monitoring in Sweden.

Mattias Sköld.

Habitats with soft bottoms with sand, silt and clay have a rich life both on the surface and down in the sediment. In deeper environments where light limit photosynthesis, different groups of animals dominate. The organisms that live on the bottoms are usually called epifauna (epi = on). At greater depth on the Swedish west coast, the epifauna on the soft bottom environments is dominated by crustaceans and soft corals. Some species are relatively large and can be both mobile like crustaceans, or anchored in the sediment like seapens. These habitats are heavily fished for Norway lobster *Nephrops norvegicus* and demersal fish species using various gear. Particularly mobile gear such as bottom trawls dominate in offshore areas and when these are pulled over and in contact with the seafloor, species can be affected in various ways either directly by physical disturbance or being caught in the nets, or indirectly by disturbance of the habitat, resuspension of the sediment or via the food web and changing competition between species. The purpose of this study is to compare in a number of case studies the species composition, the abundance of seapens and the total abundance of epifauna as possible indicators of the status of epifauna on soft bottoms in the Kattegat and Skagerrak. Seapens are anchored in the sediment, are relatively large and are generally considered to be susceptible to physical disturbance. The OSPAR Commission also includes the habitat "Seapens and burrowing megafauna communities" in its list of threatened and declining species and habitats. The method we have used to quantify the epifauna is a camera-equipped sledge that is pulled over a stretch on the seabed and films a defined width; the method is called UWTV (UnderWater TeleVision). The distribution of species of seapens differs between sea areas and depths. In all areas, different species of seapens are among the dominant species analyzed using this method. In all case studies, the total abundance of the epifauna is also higher in protected areas compared to nearby comparable areas that are fished by bottom trawling. The results also indicate different sensitivity of the epifauna to the disturbance bottom trawling and the largest impact is found for the large seapen *Funiculina quadrangularis* which was found in about 8 times higher density in the protected zones in the deep Marine Protected Area (MPA) Bratten compared to nearby trawled areas in the Bratten. In the Kattegat and the coastal Skagerrak, the seapens *Virgularia* spp. and *Pennatula phosphorea* dominated with only occasional observations of other species of seapens. In these shallower areas, *P. phosphorea* showed statistical differences with lower abundance in trawled compared to protected areas in the Kattegat but not *Virgularia* spp. The comparisons between protected and bottom trawled areas confirm previously described patterns that the sensitivity to physical disturbance from bottom trawling is greatest for large species of seapens while the smaller species are less sensitive.

Results from the studies of the epifauna show in summary that effects can be linked to the impact of physical disturbance of the seabed from bottom trawling and can be monitored quantitatively with the proven UWTV methodology which involves video filming with a camera-equipped sled. These are important prerequisites for environmental monitoring and choice of indicators. Monitoring on a larger scale, such as the Skagerrak and Kattegat or the North Sea, also demand good spatial coverage. On the other hand, monitoring of the status of conservation values in

MPA:s calls for higher resolution of sampling in delimited areas, but also comparable control areas and opportunities for comparisons with the general development of the epifauna in a sea area. Monitoring epifauna as a combination of the annual surveys that are done for estimating burrows for Norway lobster *Nephrops norvegicus* and analyzing the epifauna from this films, and the monitoring programs for epifauna in MPA:s, thus meet the requirements for both coverage and resolution. The MPA:s also contribute with sampling in the large-scale perspective by adding information from areas unaffected by bottom trawling. In the perspective of the monitoring of MPA:s, the large-scale monitoring in turn provides information on the general development in the sea area.

**References**

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## 5.2 Joint Nature Conservation Committee (JNCC) work using data from UWTV surveys (CEFAS and MSS).

Joey O'Connor.

JNCC collaborate with Cefas, Marine Scotland Science (MSS) and others to collect data to monitor UK offshore Marine Protected Areas, focusing on feature condition of seabed features. This includes for MPAs currently designated to protect Sea-pen and Burrowing Megafauna communities in Scottish and English offshore waters which overlap with UWTV survey FU7 and FU6.

JNCC have been working with Marine Scotland, NatureScot, Cefas and ICES WGNEPS members to progress the OSPAR 'Roadmap for the implementation of collective actions within the Recommendations for the protection and conservation of OSPAR listed Species and Habitats' Action Sheet 9 action plan[1] to *"evaluate the extent to which ecological data from commercial Nephrops stock assessment and commercial video footage and photographic evidence can be used to assess the status of sea-pen and burrowing megafauna communities, and as appropriate develop protocols for assessment purposes"*.

In late 2020 Marine Scotland made *Nephrops* UWTV footage collected inside and adjacent to Central Fladen MPA in 2019 and 2020 on MRV Scotia available to JNCC for analysis to support monitoring of the Sea-pen and Burrowing Megafauna communities at Central Fladen MPA in the North Sea. Marine Scotland analysed the footage for *Nephrops* stock assessment purposes (e.g. as described in ICES, 2020) and JNCC contracted Envision Ltd to analyse the footage in Biigle[2] for 'Sea-pen and burrowing megafauna communities', broadscale habitats, conspicuous species, litter and any other anthropogenic impacts (Benson et al, 2021). Burrow counts and density assessments were undertaken successfully on the Central Fladen MPA UWTV footage. The key limitation identified by this study related to difficulties in reaching higher taxonomic levels (e.g. genus/species) of identification due to low video quality. This was because the footage was collected in Standard Definition for viewing on a CRT monitor but was digitised from DVD and viewed on a computer screen by the analysts. The authors acknowledged that as UWTV surveys spatially focus on *Nephrops* grounds and are designed to collect data for *Nephrops* assessments this should be considered when determining the suitability of using UWTV data for other purposes. The report recommends when using UWTV footage for monitoring of Central

[1] https://www.ospar.org/site/assets/files/38905/0205a3_actionsheet9_nephropssurvey.pdf

[2] www.biigle.de

Fladen MPA, more targeted MPA monitoring data should be collected to validate the density counts derived from UWTV data and provide additional required information for monitoring the condition of Sea-pen and Burrowing Megafauna communities.

Evidence collected by *Nephrops* stock assessments can be used to augment dedicated MPA monitoring, however guidance and resources are required to enable wider and more efficient use of this resource for MPA monitoring and wider assessment of the status of sea-pen and burrowing megafauna communities. To that end JNCC propose to develop a user's guide and associated resources for accessing and using imagery and/or data collected and produced by UWTV surveys in 2022/2023. This would allow users to interpret and capture OSPAR T&D and MPA feature records and consider the role of these data in supporting OSPAR and MPA feature status assessments and Species Distribution Model validation. The guidance and resources produced would enhance understanding of users of how *Nephrops* data are collected, analysed and disseminated and provide a process which increases efficiencies (i.e. by reducing duplication of effort) of sharing of *Nephrops* data and products. WGNEPS members are invited to comment on and steer development of this proposal by contacting Joey O'Connor (JNCC).

JNCC have coordinated the work of the Big Picture Group since its inception in 2019. In March 2021 JNCC held the second Big Picture Workshop; a report and the workshop materials, including recordings of the workshop sessions, can be accessed from: https://jncc.gov.uk/news/big-picture-ii/. WGNEPS members are welcome to participate in the next Big Picture workshop on Image Annotation in January 2022 and are welcome to join Big Picture Project Working Groups if interested by contacting TheBigPicture@jncc.gov.uk.

## 5.3 UWTV data sets utilised by ICES Working Group on Deep Water Ecology (WGDEC)

Joey O'Connor.

The ICES Working Group on Deep Water Ecology (WGDEC) are grateful to WGNEPS members for sharing data on Vulnerable Marine Ecosystems (VMEs) in response to their annual call for new data on VME habitats and indicators. The Irish Marine Institute submitted sea-pen indicator data (i.e. presence/absence data) from UWTV surveys from 2012-2020 from the Porcupine Bank. Indicator data are passed through a 'VME Index' to identify high likelihood areas of VME and are used to support ICES advice to the EU on areas where VMEs occur and that may be impacted by deep-water fisheries[3].

These data have also been important for new advice to the EU in 2021 to support implementation of the EU deep-sea access regulations[4]. The deep-sea access regulations require implementation of bottom fisheries closures within the 400-800 m depth zone (within the existing fishing footprint) where VMEs are known or likely to occur. All new data have been vital to identifying potential areas for closures[5].

[3] https://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=38053

[4] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/Special_Requests/eu.2021.01.pdf

[5] https://www.ices.dk/community/groups/Pages/WKEUVME.aspx

## 5.4 Overview on use of UWTV survey data

Adrian Weetman

Marine Scotland Science (MSS) has be undertaking UWTV surveys since 1992, increasing the number of locations significantly over the years, often working in challenging or rarely visited areas. This has led to significant interest from parties both within MSS and outside. In addition, the nature of these surveys generate large quantities of easily shared footage from these varied and sometimes remote areas, which without dedicated surveys would otherwise not be obtained.

For a number of years UWTV surveys conducted by MSS have provided footage, associated data and advice to other organisations such as the Joint Nature Conservancy Council (JNCC) and NatureScot (previously known as Scottish Natural Heritage) most notably in relation to the distribution of the three most common types of sea pens found in similar habitats to *Nephrops*, those being *Funiculina quadrangularis*, *Virgularia mirabilis* and *Pennatula phosphorea*. These studies can be generalised spatial/temporal mapping of populations or related to a more specific area, such as within Marine Protected Areas (MPA). In 2021 MSS and JNCC collaborated in producing a paper (ref. 1) where the UWTV footage was used to investigate sea pen abundance in and around the Central Fladen MPA as well as look at the potential and limitations of using UWTV footage for such purposes. Similar work has been carried out by MSS on a larger scale over a number of years to inform conservation advice (ref. 2).

On occasion no specific singular species or habitat is being assessed, but a holistic approach is used to investigate an area where video footage is rarely obtained from, such as the Seastar/JNCC/MSS report examining the biotope of the Hebridean slope, from footage gathered when UWTV surveys were conducted in deeper water to the west of Scotland and at Rockall. (ref. 3).

UWTV surveys for *Nephrops* has led to many experienced members of the scientific community to assist and advise colleagues new to the survey approach be it for assessment purposes via various ICES working groups and workshops, or to other organisations or networks such as the JNCC Chaired Big Picture Workshops. Participants from 29 national Government institutions, Universities, private contractors and businesses gathered initially in March 2019 and then again in March 2021 to further the aim to standardise the collection, training, annotation, assessment, storage and dissemination of underwater still and video images amongst interested parties as well as developing and incorporating new technologies. These themes were common to much of the work the ICES working group on *Nephrops* surveys (WGNEPS) had previously encountered and addressed, and so representatives from UWTV surveys were able to provide a great deal of input to this workshop.

Not only is video footage gathered during UWTV surveys, and these activities lend themselves to diversifying the survey's objectives. From fishing trawls, biological samples have been gathered for DNA sequencing and mapping; sediment samples are collected to better inform habitat mapping; marine litter is collected and reported on to meet OSPAR and Scottish Government requirements (ref. 4 & 5); trawled material is been used for remote electronic monitoring machine learning and coding; and although there is a requirement to obtain *Nephrops* length frequency data on a regular basis during these surveys, additional morphometric data is gathered to inform weight length relationships and to examine sexual maturity (ref. 6).

However just having the surveys available for alternative activities, which can run in parallel to the priority work, attracts interest. Visitors from other UWTV surveys participate to improve international collaboration and understanding between surveys; students have taken part as part of their studies; mammal and bird observation specialists have sailed on UWTV surveys to areas they would not normally be able to reach; NGO's have used the platform to carry out experiments that would complement or advance the UWTV survey approach; COMPASS and MarPAMM moorings have been recovered and replaced during UWTV surveys in areas where

other surveys do not venture; and the UWTV surveys have hosted a number of interested stakeholders to provide a first-hand illustration on survey design, execution and work up to provide a better understanding of the process prior to the assessment stage.

It can be seen that UWTV surveys have a variety of uses beyond the main priority of collecting video footage to generate abundance values for stock assessment purposes. Habitat, flora and fauna protection; non-*Nephrops* observation; distribution and species modelling; research and development; education and life experiences; access to atypical locations; and data analysis on a broad spectrum of information extracted from the video footage can be obtained from UWTV surveys – and with the UWTV community expanding, the establishment of open access databases and the wider awareness of these surveys and what they can offer, the list of additional tasks will continue to grow.

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Geographical variation in size at the onset of maturity of male and female Norway lobster *Nephrops* norvegicus (L., Homarida: Decapoda) in Scottish waters

Ana M. Queirósa,∗, Adrian Weetman, H.Anne McLay, Helen Dobby

## 5.5 ISUNEPCA UWTV SURVEY (FU30) as a platform for collecting benthic habitats and environmental data in the Gulf of Cadiz

Yolanda Vila

The ISUNEPCA UWTV survey is conducted routinely in the Gulf of Cádiz (FU30) since 2015 and it is considered as a multi-disciplinary survey. The main objective is to obtain estimates of *Nephrops* burrows densities and derivate the *Nephrops* abundance in FU30 for their assessment. However, other activities are carried out for obtaining data which can improve the knowledge about the habitat and the benthic communities associated with the *Nephrops* grounds including environmental information. Footages and other data obtained in the ISUNEPCA UWTV surveys has been also used in the framework of other projects such as ATLAS, LIFE-INTEMARES or INPULSE projects which have been or are currently developed in the CN-IEO (National Center – Spanish Oceanographic Institute).

ATLAS is a European Horizon 2020 project entitled "A transatlantic assessment and deep-water ecosystem-based spatial management plan for Europe". The ATLAS project is striving to improve our understanding of complex deep-sea ecosystems and their associated species, including those that are new to science. That scientific knowledge generates the base that can help in the development of international policies to ensure deep-sea Atlantic resources are managed effectively. The ATLAS is a consortium of 24 beneficiaries from Denmark, Belgium, France, Germany, Ireland, Netherlands, Norway, Portugal (incl. Azores), Spain, the UK and USA. This project includes different Work Packages and cases studies. The CN-IEO has been implicated in the Case Study nº 7: Gulf of Cadiz/Strait of Gibraltar /Alboran Sea. This case study focuses on understanding the Atlantic-Mediterranean biodiversity and connectivity and the role of the Mediterranean waters regarding those aspects. The area supports intensive anthropogenic activity, including tourism, fisheries, aquaculture, oil and gas exploitation, wind energy and it is an important area for maritime traffic.

The LIFE IP INTEMARES project entitled "Integrated, innovative and participatory management of the Natura 2000 Network in the Spanish marine environment" is the first initiative at national level that integrates various funds, policies and actors for the management of an entire network of protected areas. It is founded by the LIFE Programme of the European Union, as well as, the European Social Fund and the European Maritime and Fisheries Fund (EMFF), among other sources of funding and it is coordinated by the Biodiversity Foundation of the Spanish Ministry for Ecological Transition. LIFE IP INTEMARES project aims to achieve a network of marine spaces of the Natura 2000 Network, managed effectively, with the active participation of the sectors involved and with research as basic tools for decision-making. This project carries out a wide program of actions based on five strategic blocks: Investigation, monitoring and surveillance, conservation, governance and communication, awareness raising and environmental education. CN-IEO is one of the organisms participating in this project and is studying different aspects of the habitats and fisheries of the Site of Community Importance "Mud volcanoes of the Gulf of Cádiz" (Volcanes de fango del golfo de Cádiz, ESZZ16002) which was included in the Natura 2000 Network in 2014.

INPULSE project called "Interaction of the oceanographic and sedimentary processes on the continental slope: environmental and habitats implications, mathematical modeling and technological development" has been funded by the Spanish Ministry for the Economy and Competitively. The aim was the characterization of the overflow related to the Mediterranean Outflow Water (MOW) and the possible link between oceanographic and sedimentary processes in the Gulf of Cadiz continental slope. Furthermore, the environmental implications of this interaction and their impact on the occurrence and development of specific habitats and on the economic activities over the seafloor were investigated. A number of researchers of a range of specialties such marine geology, physical oceanography, benthic ecology, applied mathematics, acoustic and communication engineering have been involved in this project.

The collaboration between different CN-IEO teams has contributed to a number of publications in scientific journals and books, as well as, in a communications to congress. Furthermore, some MSC-Thesis have been carried out in the framework of University of Cadiz and CN-IEO (C.O. Cadiz). These works are listed below:

***Scientific publications***

Lozano, P., Rueda, J.L., Gallardo-Núñez, M., Farias, C., Urra, J. Vila, Y., López-González, N., Palomino, D., Sánchez-Guillamón, O., Vázquez, J.T. and Fernández-Salas, L.M., 2019. Habitat distribution and associated biota in different geomorphic features within a fluid venting area of the Gulf of Cádiz (South Western Iberian Peninsula, NE Atlantic Ocean). In: Seafloor Geomorphology as Benthic habitat. GeoHAB Atlas of Seafloor Geomorphic Features and Benthic Habitats, chapter 52. 2ª edition. Eds: P. Harris & E. Baker. 10.1016/B978-0-12-814960-7.00052-X.

Lozano, P., Fernández-Salas, L.M., Hernández-Molina, F., Sánchez-Leal, R.F., Sánchez-Guillamón, O., Palomino, D., Farias, C., Mateo-Ramírez, A., López-González, N., García, M., Vazquez, J.T., Vila, Y. and

Rueda, J.L., 2020. Multiprocess interaction shaping geoforms and controlling substrate types and benthic community distribution in the Gulf of Cádiz. Marine Geology. 423. 106139. 10.1016/j.margeo.2020.106139.

Urra, J., Palomino, D., Lozano, P., González-García, E., Farias, C., Mateo-Ramírez, A.,Fernández-Salas, L.M., López-González, N., Vila, Y., Orejas, C., Puerta, P., Rivera, J., Henry, L-A., Rueda, J.L., 2021. Dee-sea habitat characterization using acoustic data and underwater imagery in Gazul mud volcano (Gulf of Cadiz, NE Atlantic). Deep Sea Research Part I 169: 2021, 103458, ISSN 0967-0637.

***Congress***

Gallardo-Núñez, M.; Rueda, J.L.; Farias, C.; González-García, E.; Sánchez-Guillamón, O.; Bárcenas, Patricia;López-González, N.; Vila, Y. 2015. Characterization of habitats and megafauna in Norway lobster (*Nephrops norvegicus*) fishing grounds using underwater images within the Gulf of Cadiz. 2015. 643-646. Volumen de Comunicaciones presentadas en el VIII Simposio sobre el Margen Ibérico Atlántico (MIA15). Díaz-del-Río-Español, V. . Servicios Integrales de Artes Gráficas.718pp.

Lozano, P., Fernández-Salas, L.M., Rueda, J.L., López-González, N., Vila, Y., López-Rodríguez, F.J., Farias, C., Vázquez, J.T., Díaz-del-Río-Español, V. 2015. Effect of fluid emissions in the acoustic response on the seabed of the Gulf of Cadiz. 651-654. Volumen de Comunicaciones presentadas en el VIII Simposio sobre el Margen Ibérico Atlántico (MIA15). Díaz-del-Río-Español, V. Servicios Integrales de Artes Gráficas.718pp.

Vila, Y., Farias, C., Burgos, C., Soriano, M., Rueda , J.L., Gallardo-Núñez, M., López-Gonzalez, N., Tuite, P. , Sobrino, I., 2015**.** Spatial distribution of the Norway lobster *Nephrops norvergicus* burrow density in the Gulf of Cadiz and its relationship with environmental variables. Volumen de Comunicaciones presentadas en el VIII Simposio sobre el Margen Ibérico Atlántico (MIA15). Díaz-del-Río-Español, V. Servicios Integrales de Artes Gráficas.718pp.

Rueda, J.L., Urra, J., Bilan, Fern Car., M., Farias, C., Fernández-Salas, L.M., Gallardo-Núñez, M., González-García, E., Henry, L.A., Hermida, N., López-González, N., Lozano, P., Mateo-Ramírez, A., Movilla, J., Palomino, D., Orejas, C., Ramalho, L.V., Rakka, M., Rivera, J., Sampaio, I., Utrilla, O., Vázquez, J.T., Vila, Y., INDEMARES-CHICA & MEDWAVES TEAMS. 2017. Vulnerable marine ecosystems and biological features of Gazul mud volcano (gulf of Cádiz): A contribution towards a potential "Gulf of Cadiz" EBSA. ATLAS 2ND General Assembly. 24-28 april 2017 Mallorca (Spain).

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*MSC Thesis*

Ribalta-Sueiro, Gonzalo. 2017. Análisis de la megafauna bentónica-demersal asociada al caladero de cigala del Golfo de Cádiz a partir de imágenes submarinas obtenidas en la campaña ISUNEPCA_0616. Analysis of the benthic-demersal megafauna associated to the Norway lobster fishing ground in the Gulf of Cádiz from underwater images obtained in the ISUNEPCA 0616 survey**.** MSC Thesis 2017. Universidad de Cádiz-CN_IEO. Supervised by Yolanda Vila.

García-Canales, Cristina., 2019. Guía identificativa de tipos de madrigueras y fauna macrobentónica asociada a los fondos de cigala a partir de imágenes submarinas. Identification guide of burrows and benthic-demersal megafauna associated to the Norway lobster grounds from underwater images. MSC Thesis 2019. Universidad de Cádiz-CN-IEO. Supervised by Yolanda Vila**.**

Jiménez-Romero, Raúl, 2019. Análisis de las formas de fondo del Golfo de Cádiz y su relación con el tipo de sustrato y las corrientes marinas usando imágenes submarinas. Analysis of the bottom forms of the Gulf of Cadiz and their relationship with the type of substrate and marine currents using underwater images. MSC Thesis 2019. Universidad de Cádiz-CN-IEO. Supervised by Desirée Palomino & Luis Miguel Fernández-Salas.

Therefore, UWTV surveys as ISUNEPCA can be an excellent platform to obtain information of benthic habitats and environmental variables in order to improve the knowledge about biodiversity, the ecosystems and their relationship to the oceanographic processes on the circa and bathyal sedimentary bottoms in the Gulf of Cadiz.

## 5.6 Larval sampling on Iceland UWTV survey.

Larval investigations were initiated in the 2018 UWTV survey in FU1. Recruitment has been poor and the last yearclass observed was estimated to have originated in 2005. Bongo-net (500 µm mesh size) were accomplished for the first time after the completion at every forth UWTV station. The objective is to estimate larval index of *Nephrops*. The bongo-net was towed in a V–shaped manner down to 40 m and up to the surface. In 2019 to 2021, 28, 25 and 25 stations were conducted, respectively (Figure 6.6.1). The average density was 15.1 larvae per 1000 $m^3$ in 2018, 24.8 larvae in 2019, 8.1 larvae in 2020 and 11.0 larvae during the 2021 survey. The distribution was wider in the 2019-2021 surveys, compared to the 2018 survey. Through the years, it was more common to find the Zoea stages II-III in the southeast region.

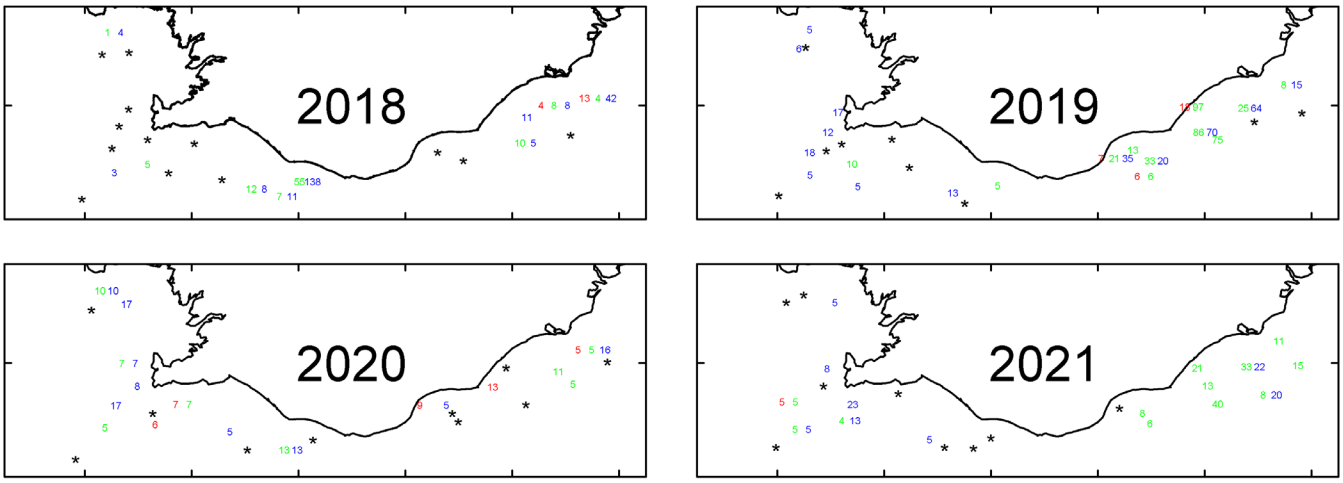


**Figure 6.6.1. Number of *Nephrops* larvae caught in bongo-net per 1000 $m^3$ from surveys conducted in 2018 to 2021. Blue numbers indicate larvae on Zoea stage 1, green Zoea stage 2, and red Zoea stage 3. Black asterisks are stations where no *Nephrops* larvae were found.**

# 6 Factors affecting on burrow emergence (ToR f)

Existing data from UWTV surveys for some areas has been investigated to determine possible factors affecting emergence. Aguzzi et al.demonstrated diel behavioural rhythms of *Nephrops* in terms of burrow emergence and door-keeping, based on observations in more than three thousand UWTV transects.

Future work is planned to collaborate on a perspective paper addressing technologies required to progress this term of reference.

Reference:

Aguzzi, J., Bahamon, N., Doyle, J., Lordan, C., Tuck, I. D., Chiarini, M., Martinelli, M., et al. 2021. Burrow emergence rhythms of *Nephrops norvegicus* by UWTV and surveying biases. Scientific Reports: 1–13. Nature Publishing Group UK. https://doi.org/10.1038/s41598-021-85240-3

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

## 7.1 UWTV Camera calibration tests

Mikel Aristegui

### Introduction

The Marine Institute (MI) has been carrying out UWTV surveys since 2002 to estimate *Nephrops norvegicus* abundances in several Functional Units (FU). These surveys are key to the stock assessment of *Nephrops*. In order to use the latest technology available, in 2019 the MI replaced the Standard Definition camera (SDc) used in the last years with a new High Definition camera (HDc).

A calibration test was conducted back in 2019, using FU16 footage from 2019 UWTV survey, where burrow counts from both cameras were compared (ICES, 2020), showing no significant difference between the two camera systems. However, in that test there was no correction factor applied to the burrow counts. In 2021, WGNEPS rerun that test applying different correction factors for each of the camera systems and presents the results here.

In addition, and following recommendations from WGNEPS and WGCSE, the MI conducted another calibration test in FU2021, which is also presented in this document.

### Material and Methods

Ahead of the two tests, a sensibility analysis was run to estimate new correction factors for the HD camera in FU2021 and FU16. Once the edge effect bias of the SD camera (Leocádio *et al.*, 2018) were reproduced using R code from Campbell *et al.* 2009, the script was run again after changing the input of the Field of View (FoV) from 0.75m to 1.01m, in order to produce the new estimated correction factors for the HD camera (Table 1).

**Table 1. Bias correction factors in FU2021 and FU16 for the Standard Definition camera (Leocádio *et al.*, 2018) and the High Definition camera.**

| FU | Camera | Edge effect | Burrow detection | Burrow identification | Burrow occupancy | Correction factor |
|---|---|---|---|---|---|---|
| FU 20-21 | SD | 1.25 | 0.90 | 1.15 | 1 | 1.30 |
| | HD | 1.19 | 0.90 | 1.15 | 1 | 1.24 |
| FU16 | SD | 1.26 | 0.95 | 1.05 | 1 | 1.26 |
| | HD | 1.20 | 0.95 | 1.05 | 1 | 1.20 |

### UWTV calibration test: FU2021

13 stations were recorded with both cameras at the same time during the FU2021 2020 UWTV survey (White *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). 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. FU 20-21 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 | Tally counter | Image annotation R Shiny app (Aristegui, 2020) |

The HDc footage was counted in 2020 at home offices by six trained scientists using an inhouse developed image annotation R Shiny app (Aristegui, 2020). The SDc footage was counted in 2021 at home offices by four scientists, using a tally counter to count burrows per minute. The 13 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 0.5 (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 26 stations. As the cameras differ in their FoVs (Table 2), the counts were standardized dividing them by their corresponding FoV (0.75 for SDc; 1.01 for HDc) and correction factor (1.30 for SDc; 1.24 for HDc). Finally, a paired t-test was used to compare both datasets.

### UWTV calibration test rerun: FU16

The only change from the analysis presented in WGNEPS 2019 (ICES, 2019) is that now the mean burrow counts per minute were treated following exactly the same procedure as in the aforementioned FU2021 test, thus dividing them by their corresponding FoV (0.75 for SDc; 1.01 for HDc) and correction factor (1.26 for SDc; 1.20 for HDc).

## Results

### UWTV calibration test: FU2021

The standardized counts for both methods are in a similar range of burrows per minute divided by FoV and correction factor: from 0.51 to 5.27 for SDc, and from 0.34 to 4.85 for HDc (Figure 1). The conducted test suggests that, in average, there is not significance difference between the two methods (p-value = 0.08853 > 0.05).

### UWTV calibration test rerun: FU16

The new standardized counts from both cameras are in a similar range: from 0.32 to 6.24 for SDc, and from 0.37 to 5.57 for HDc (Figure 2). The paired t-test suggests less differences between the two camera systems than the test conducted back in 2019, with a new p-value of 0.2505, compared to the p-value of 0.06563 from 2019.

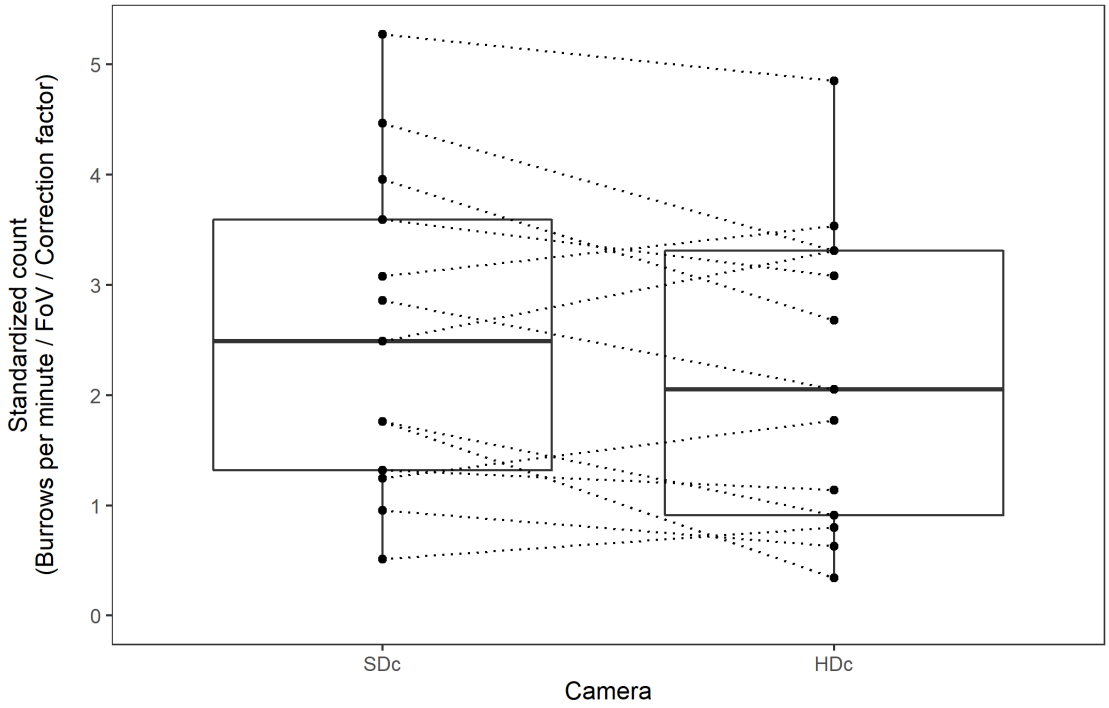


**Figure 1. FU2021 UWTV camera calibration test. Standardized counts of each station and boxplots. Standard Definition camera counts (left) and High Definition camera counts (right). Same stations are linked with a dotted line.**

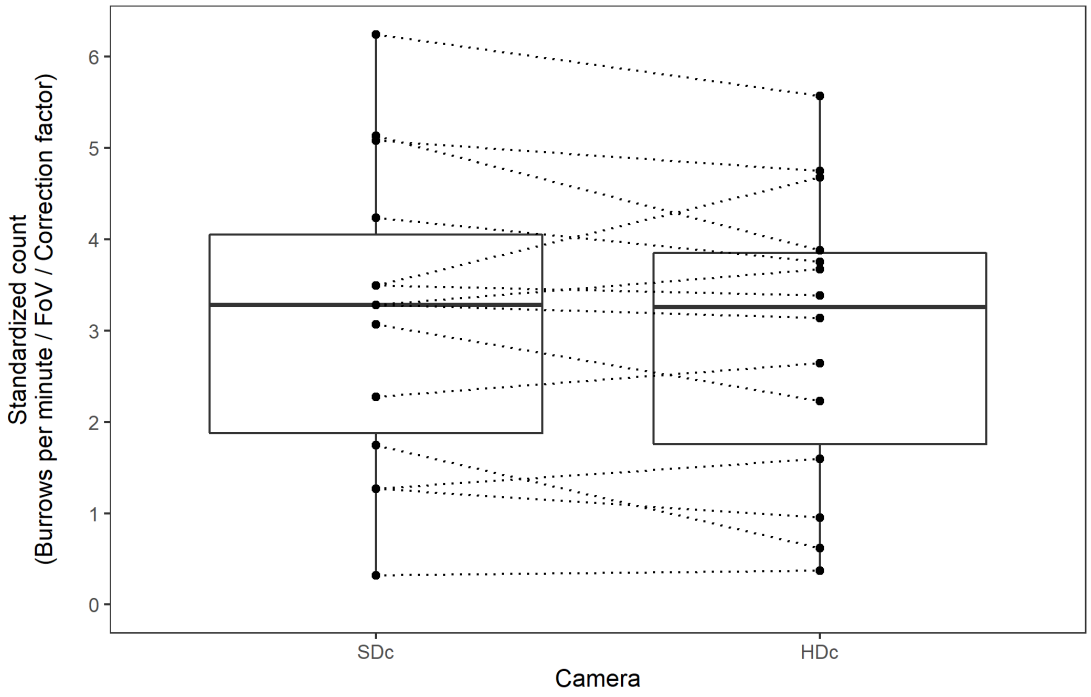


**Figure 2. FU16 UWTV camera calibration test rerun. Standardized counts of each station and boxplots. Standard Definition camera counts (left) and High Definition camera counts (right). Same stations are linked with a dotted line.**

### Conclusions

The independent results of each camera system are very similar for both tests, and the HD camera performed appropriately, in line with the SD camera. In 2021, after some technical problems with the HD camera, the Marine Institute recorded 75% of their UWTV survey stations with the SD camera, used now as a backup system. Therefore, these calibration tests have gained importance, as they ensure that using either camera system makes no difference in burrow densities.

On top of the obvious better quality of the footage, the HDc system also allows a smoother workflow onboard, as all the footage is now digitalized. Together with the image annotation app, the HDc system makes the survey process paperless and less prone to errors, as there is no need of inputting manually the count data into the databases any more.

The application of different correction factors for each dataset is appropriate and improves the quality of the camera comparison analysis. In the present study, the new correction factors for the HD camera were estimated only by updating the edge effect bias after changing the FoV input value. While this is acceptable for the calibration test, in the future, WGNEPS should work towards revising other factors (such as burrow system diameter, burrow detection and burrow identification) for each Functional Unit, which could be used to update the correction factors that are ultimately used in *Nephrops* assessments.

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## 7.2 Preliminary work on burrow size estimations

### MSS Scotland

In January 2021 aboard MRV Alba-na-Mara (Marine Research Vessel), Marine Scotland Science (MSS) undertook proof of concept trials in the Moray Firth (FU 9) in an attempt to measure the distance between the entrances associated to individual *Nephrops* burrow complexes, as discussed at WGNEPS 2020. The long term aim of the work was to corroborate, or amend, the relevant value used in the bias correction factors used in tuning abundance densities observation data and would result in improved assessment outputs.

With no technical support on this survey due to COVID restrictions, any UWTV devices had to be modified for a single, non-technical person to use. The camera arrangement involved a Go

Pro 4 and two, battery operated, modified divers torches (which could be manually switched on and off via a magnetic switch in the lens).

These three devices were mounted inside waterproof housings and attached to the inside of a steel pyramid frame (0.45m H x 0.45m W x 0.45m D; Figure 8.2.1). This arrangement was previously used to assess pelagic species in large shoals by lowering the frame via a winch. However for the *Nephrops* work, the frame had to make contact with the sea bed so that precise measurements could be taken, and the original height of the camera in relation to the sea bed provided a very narrow field of view. By building a larger, truncated pyramid frame which the smaller pyramid could be attached to, this improved the field of view significantly. The additional frame had a footprint of 1.2m x 1.2m and provided a field of view of 0.65m and was classed as a mini-drop frame.

This frame was lowered to the sea bed where it was towed along for 30 seconds filming in 4K as the ship drifted. The frame was then raised off the sea bed for a minute to allow the slack tow wire to be recoiled before repeating the operation. This procedure was carried out for 45 minutes (i.e. until the battery expired) at six sites.

From the footage obtained, a number of burrow entrances were observed on muddy habitat. A small number of complete complexes were filmed within the field of view and screen grabs were taken of these instances from which accurate measurements of complex size could be taken (Figure 8.2.2).

This approach was developed further by modifying the frame and attaching an improved scale bar. This affordable, portable, easy to operate and with no technical experience required, arrangement proved successful, achieving what it set out to do. However, it was limited to filming smaller complexes and when the weather and tidal conditions were favourable. Further use of the device is planned and also by a number of programmes within MSS for purposes unrelated to *Nephrops*.

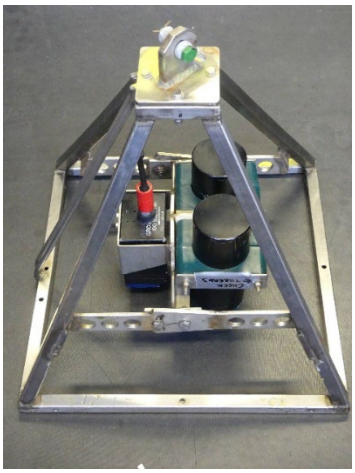

**Figure 8.2.1. The original pyramid frame with Go Pro camera (left) and two divers torches (right).**

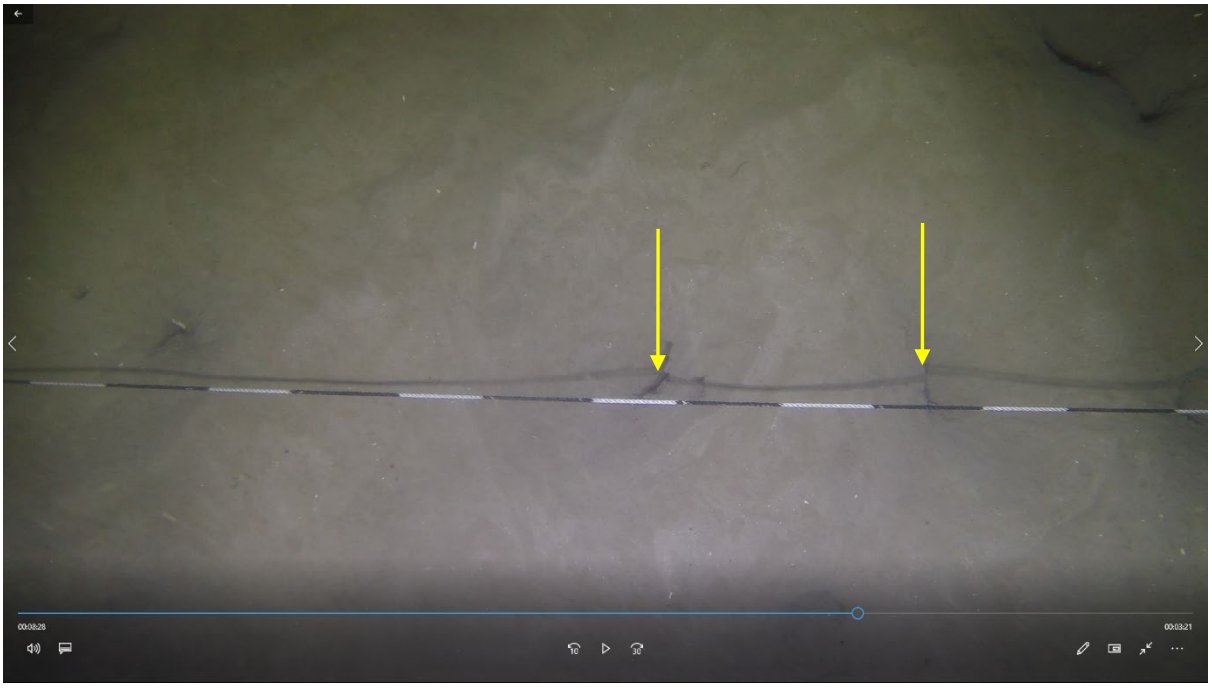

**Figure 8.2.2. Screen grab obtained from video footage captured by Go Pro camera on the mini-drop frame, showing a *Nephrops* complex measuring 0.14m across from apex to apex.**

## Ireland

Preliminary measurements using measure tools from Irfanview were undertaken on a random selection of HD still images from FU 16 Porcupine surveys in 2019 and 2020. This work was a starting point for group discussions on the feasibility of this work; in terms of where to take the measurement of a burrow system, image format, field of view considerations and time effort to do this manually. Figure 8.2.3 shows measurements taken from HD still image of a linear shaped burrow system completely within the field of view.

As a result of the this WGNEPS decided to set up a subgroup to work on an intersessional basis to discuss SOPs on what to measure and what tools can be used to do this efficiently.

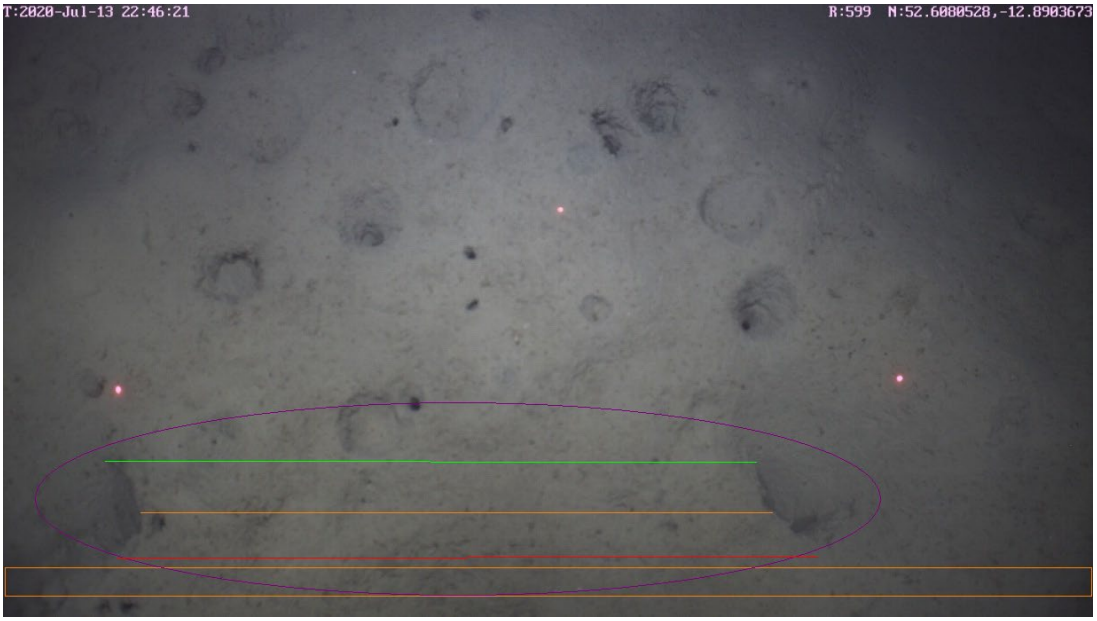


**Figure 8.2.3. HD still image of a linear burrow system showing different measurements (apex to apex orange line, ellipse purple line, burrow entrance edge green line).**

# Annex 1: List of participants for years 2019 – 2021

## List of participants 2019

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# Annex 2: Resolutions

The **Working Group on *Nephrops* Surveys** (WGNEPS), chaired by Jennifer Doyle, Ireland, will work on ToRs and produce deliverables and meet 16–18 November 2021 in Cadiz Spain to:

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

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

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

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

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

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

Review differences of new HD and previous used SD camera systems and its effect on burrow detection, edge effects and bias correction factors, and explore the possibility of HD system tools for providing estimates of burrow size distributions.

WGNEPS will report by 1 February 2022 for the attention of the EOSG Committee.

## Supporting information

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

# Annex 3: Recommendations

WGNEPS 2021 recommends that WGMLEARN reviews the road map for developing automatic seabed imagery classification systems.

*Note: This Recommendation has been uploaded to ICES Recommendation Database.

# Annex 4: Survey summaries

## Marine Institute Ireland FU 16 -17, 19, 20-22.

Jennifer Doyle and Mikel Aristegui

**Overview of the existing surveys.**

Since 2012 Ireland has modified sampling intensity and increased survey coverage based on the recommendations of SGNEPS 2012. The numbers of stations in FU 15, FU 17 and FU 22 were reduced since 2012 to allow for survey development in FU 16, FU 19 and FU 20-21 combined. The total numbers of stations for 2021 remains broadly similar ~300 to previous years (Figure 1). 100% coverage of all the *Nephrops* grounds was achieved in 2021 for stock assessment purposes.

**Survey Design.**

There were no changes to survey design for the surveys in 2021.

**Survey Equipment.**

Since 2019 HD camera system was used for all UWTV surveys.

In 2021 due to technical problems with the High Definition camera system, only 25% of the stations were completed with the HD camera; the other 75% of the stations were completed with the Standard Definition camera system (Table 1).

**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 2). In 2021 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 (Dobby et al., 2021) 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 the SD videos were recorded into DVDs and then reviewed on CRT monitors, where *Nephrops* burrow systems per minute were counted. All HD image data (HD stills captured at 12 frames per second) were reviewed using an in-house developed review app (Aristegui, 2020) where *Nephrops* burrow systems were annotated using the review app.

The adjusted mean density for each station in ICES Sub-area 7 is presented in Figure 2 and it shows the general overall pattern which is mainly higher densities observed in FU 15 western Irish Sea and lower densities in FU 16 and FU 20-21.

**International staff exchange.**

Due to the COVID-19 situation there was no international staff exchange onboard Marine Institute surveys in ICES Subarea 7 in 2021.

**Image Data counting and reviews.**

Due to COVID-19 situation survey operations in 2021 with reduced personnel were limited to data acquisition and quality control of image and navigation data only. All counting reviews were completed by the counting teams in home offices post surveys using the review app or DVD players and CRT monitors. MS Teams platform was used for training and discussion. Counting teams comprised of a minimum of five to a maximum of six individuals.

**Reference sets.**

Additional reference stations were added to FU 16 in advance of the survey season.

A mini SD reference set was developed for testing counters on FU 17 survey.

**Data Storage and R-scripts and SQL extraction.**

All UWTV survey data for the entire time series is housed in a SQL server database.

SQL script to calculate final mean density estimates was updated in 2021 to reference the specific camera system and associated field of view (FoV) estimate.

The r-scripts for data quality control and calculations of abundance estimations using geo-statistical analyses for FU 16, FU 17, FU 20-21 combined and FU 22 and also random stratified work up for FU 19 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 since 2019. Three *Nephrops* UWTV survey datasets are now available in the Marine Institute Data Catalogue. Table 1 shows the available UWTV datasets and links to these.

**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.**

Due to time constraints, in 2021 sediment samples were not collected.

**Bottom Temperature and Depth data.**

In 2021 a temperature and depth profiler was used at each UWTV station. This data is relatively easy to collect and is viewed as an emerging time series which will be used for looking at inter-annual 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 2021 beam trawl fishing operations were not carried out on the Aran grounds (FU 17) and the Smalls *Nephrops* grounds (FU 22).

**Other Benthic fauna distributions.**

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 categorise the density (ICES, 2011) exists. In 2021 presence/absence of these three species was recorded in FU 16, 17, 19, 20-21 and 22. Figure 3 shows the 2021 stations on the Porcupine *Nephrops* grounds where the aforementioned sea-pen species were identified and noted as present or absent. The deep water sea-pen *Kophobelemnon stelliferum* has been observed during the UWTV survey on the Porcupine Banks (FU 16) *Nephrops* ground (Figure 4). It is an easy species to identify from the image data due to its specific shape and colour.

Seapen presence/absence data from the FU 16 Porcupine UWTV survey was provided as part of a 2021 datacall for new information on Vulnerable Marine Ecosystems (VME) in the North Atlantic for the Joint ICES/NAFO Working Group on Deep-water Ecology (ICES, 2021).

**Table 1. Number of stations recorded with each of the camera systems in each Functional Unit during the UWTV 2021 surveys.**

| | FU16 | FU17 | FU19 | FU20-21 | FU22 |
|---|---|---|---|---|---|
| HD camera system | 0 | 1 | 8 | 24 | 42 |
| SD camera system | 71 | 43 | 34 | 73 | 0 |

**Table 2. *Nephrops* UWTV survey datasets currently available on the Marine Institute Data Catalogue.**

| *Nephrops* UWTV Survey Dataset | Marine Data Catalogue Link |
|---|---|
| FU 22 | https://tinyurl.com/yxo6ltnh |
| FU 20-21 combined | https://tinyurl.com/y3yfgzq9 |
| FU 16 | https://tinyurl.com/y2s6pbgx |

**Table 3. 2021 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 of individuals) | CV (Relative standard error) | Lin's Concordance Correlation Coefficient Threshold to screen survey Counts |
|---|---|---|---|---|
| FU 16 | 0.14 | 1018 | 5% | 0.6 |
| FU 17 Aran Grounds only | 0.26 | 311 | 4% | 0.6 |
| FU 19 | 0.14 | 270 | 15% | 0.5 |
| FU 20-21 combined | 0.12 | 1202 | 4% | 0.5 |
| FU 22 | 0.23 | 656 | 7% | 0.6 |

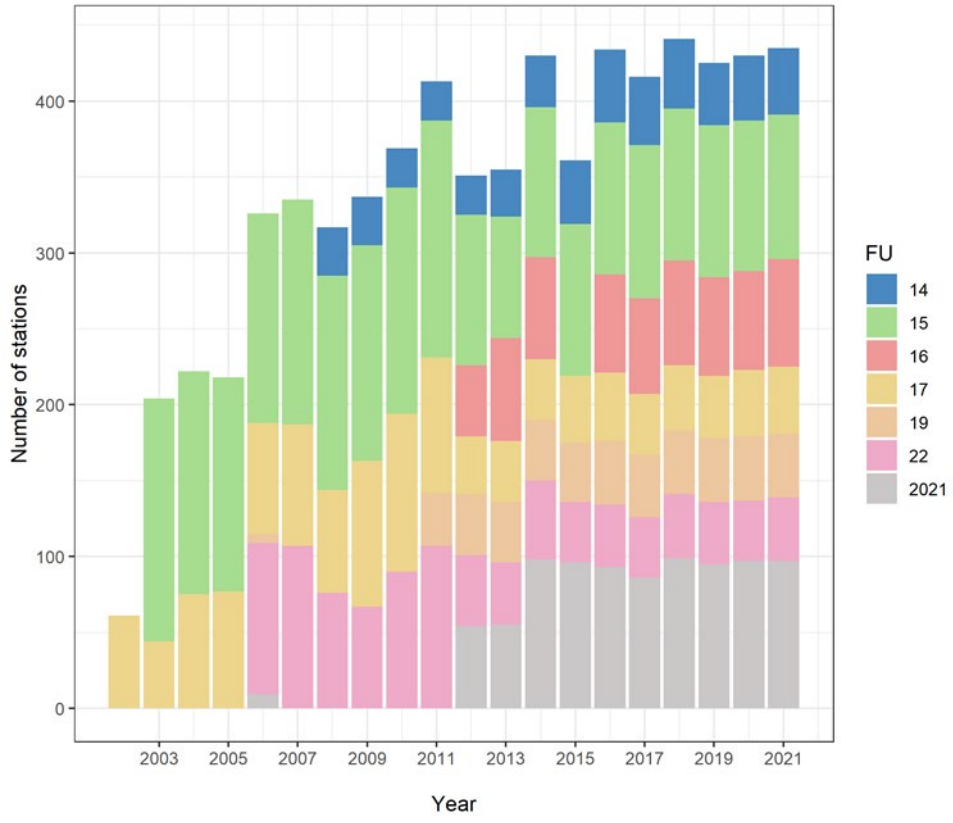


**Figure 1. Time series of the total number of UWTV stations carried out by Ireland in each Functional Unit. Stations in FU 14 and FU 15 are usually carried out in collaboration with AFBI in UK-NI and CEFAS UK E&W.**

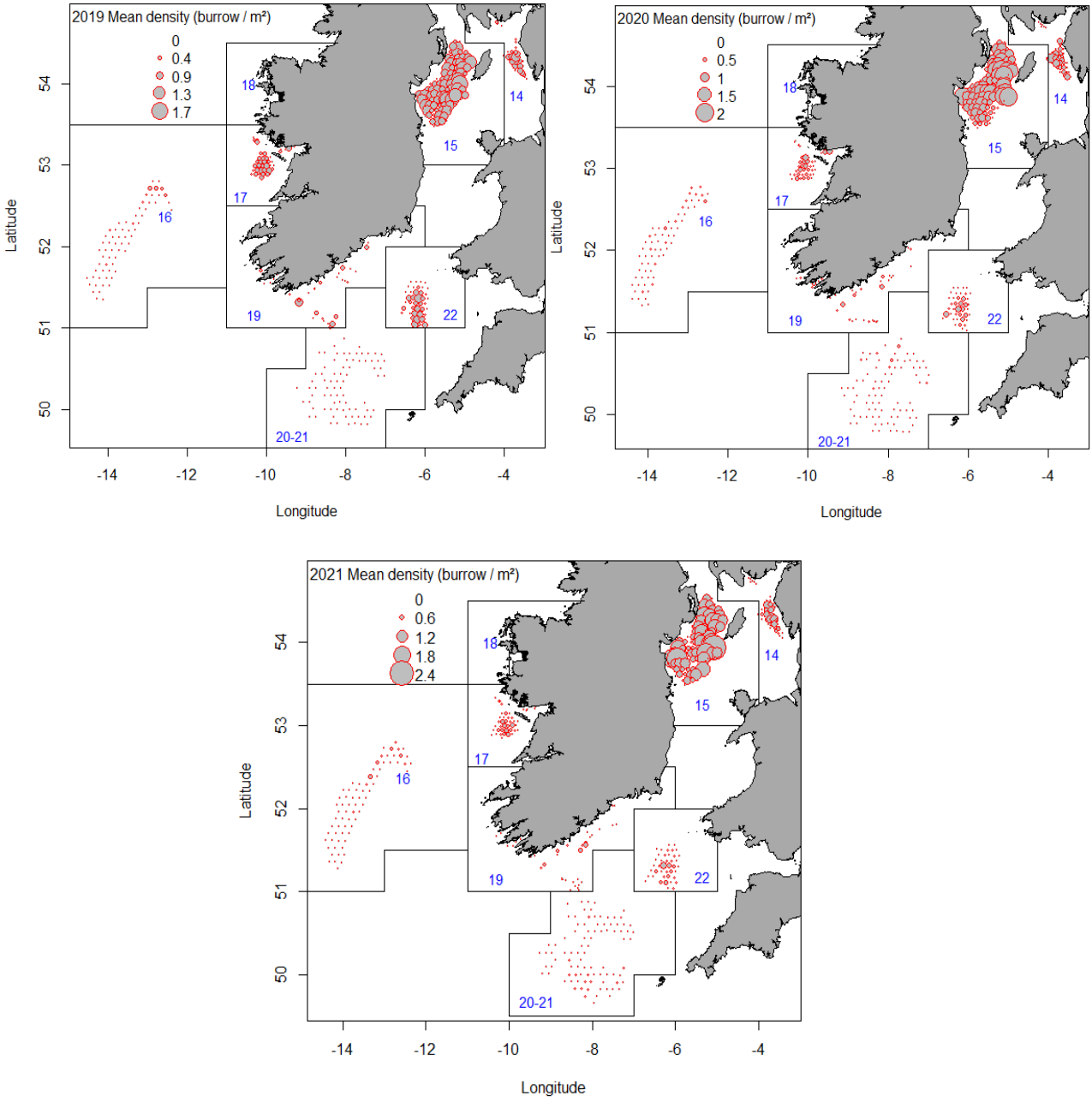


**Figure 2. Mean adjusted density estimates (burrow/m²) by station for *Nephrops* grounds in ICES Subarea 7 from 2019 to 2021.**

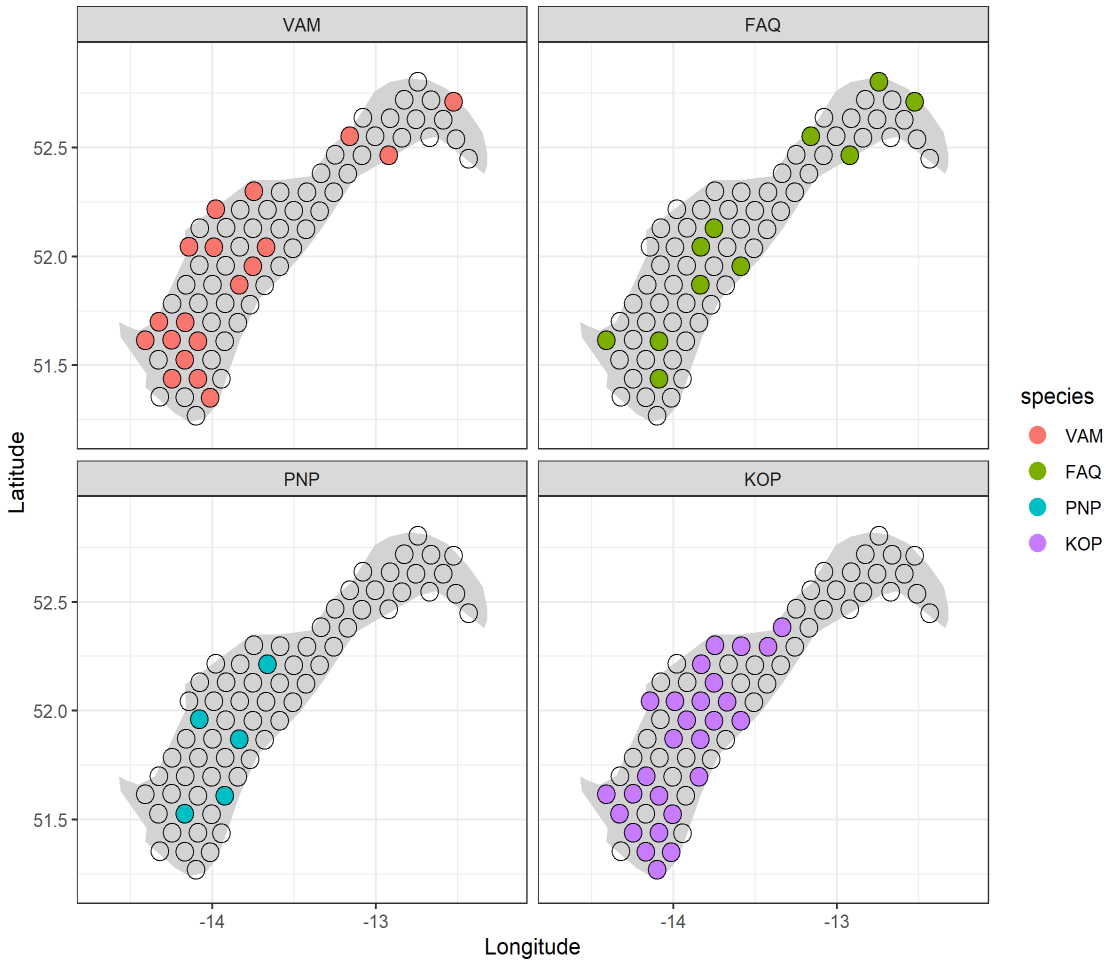


**Figure 3. FU16 grounds: 2021 stations where *Virgularia mirabilis* (VAM), *Funiculina quadrangularis* (FAQ), P*ennatula phosphorea* (PNP) and *Kophobelemnon stelliferum* (KOP) were identified and noted as present or absent. Closed circles indicated presence and open circles denotes TV stations with no sea-pen observations.**

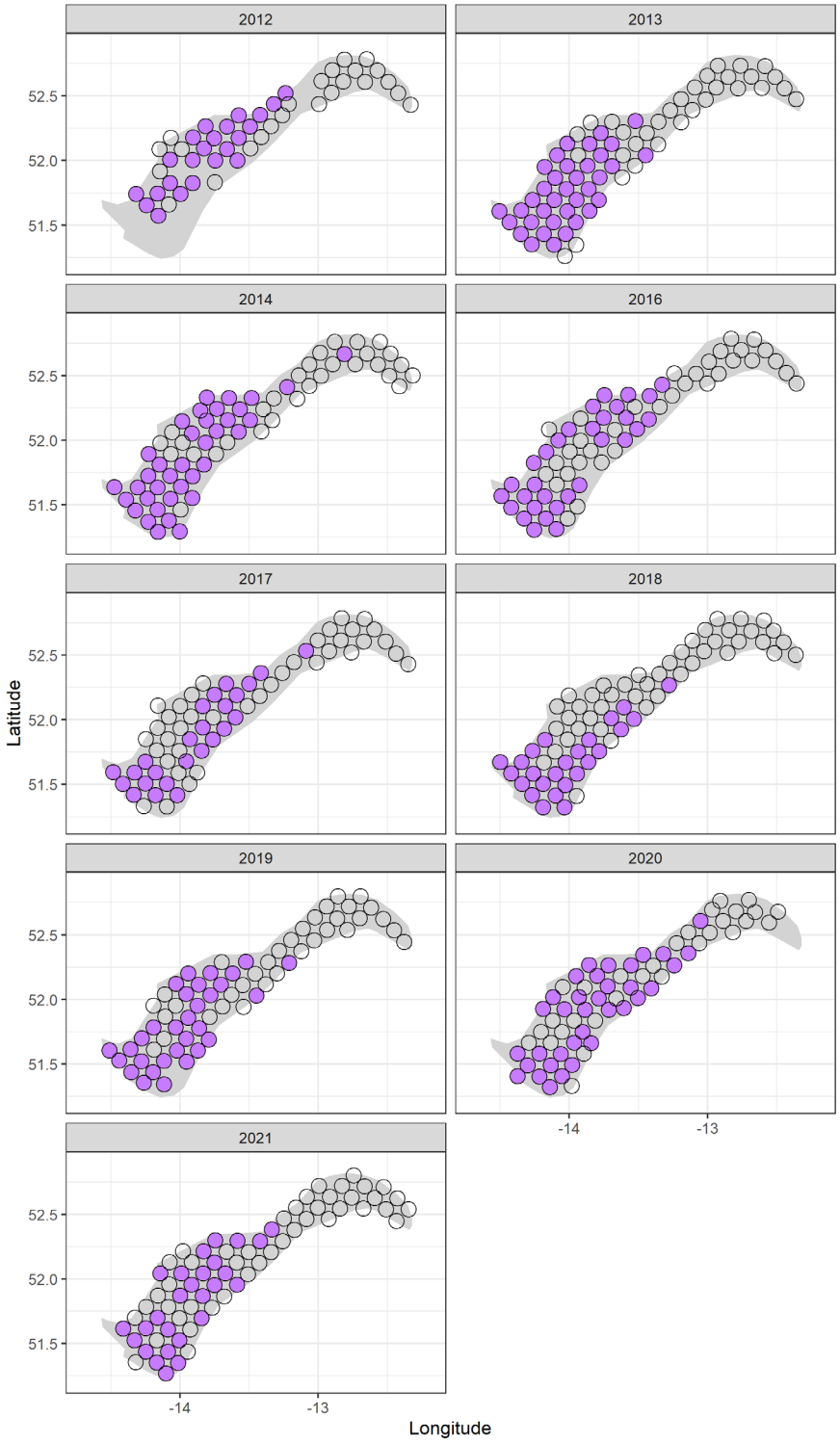


**Figure 4. FU16 grounds: Stations by year where *Kophobelemnon stelliferum* (KOP) were identified and noted as present or absent. Closed circles indicated presence and open circles denotes TV stations with no sea-pen observations. No survey in 2015.**

| **Functional Unit** | **FU 16** | **Area name** | **Porcupine Bank** |
|---|---|---|---|
| Survey design | Randomised isometric grid | Previous surveys | 2012 to 2014 and 2016 to 2020 |
| Camera Type:<br>Standard/High definition | SD Konsberg | Image Data:<br>Type / Size per station | SD: Video in DVDs. 5 stations per DVD |
| Country (ies) | Ireland | Vessel name (s) | Celtic Voyager |
| Survey code (s) | CV21023 | Dates (start/end) | 16 – 23 August 2021 |
| Number scientific staff | 2 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | 71/ 71/ 71 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | SD camera used due to technical problems with HD camera | |
| Distance over ground source used | USBL | Average field of view (cm) | SD: 0.75 m |
| Adjusted mean density | 0.14 burrows /m$^2$ | Adjusted abundance, CV | 1018 million, CV = 5% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC, threshold = 0.6 | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Temperature & Depth profiler<br>Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter | |
| Data storage, level of analysis and dissemination (by data type) | | *Nephrops* burrow counts | Storage: MI network – SQL<br>Level: SD: burrows/minute; HD: annotated burrows |
| | | CTD | Storage: MI network<br>Level: TD profile per station |
| | | Trawl | No |
| | | Sediment | No |
| | | Other | Storage: MI network – SQL<br>Level: Ancillary data per station |

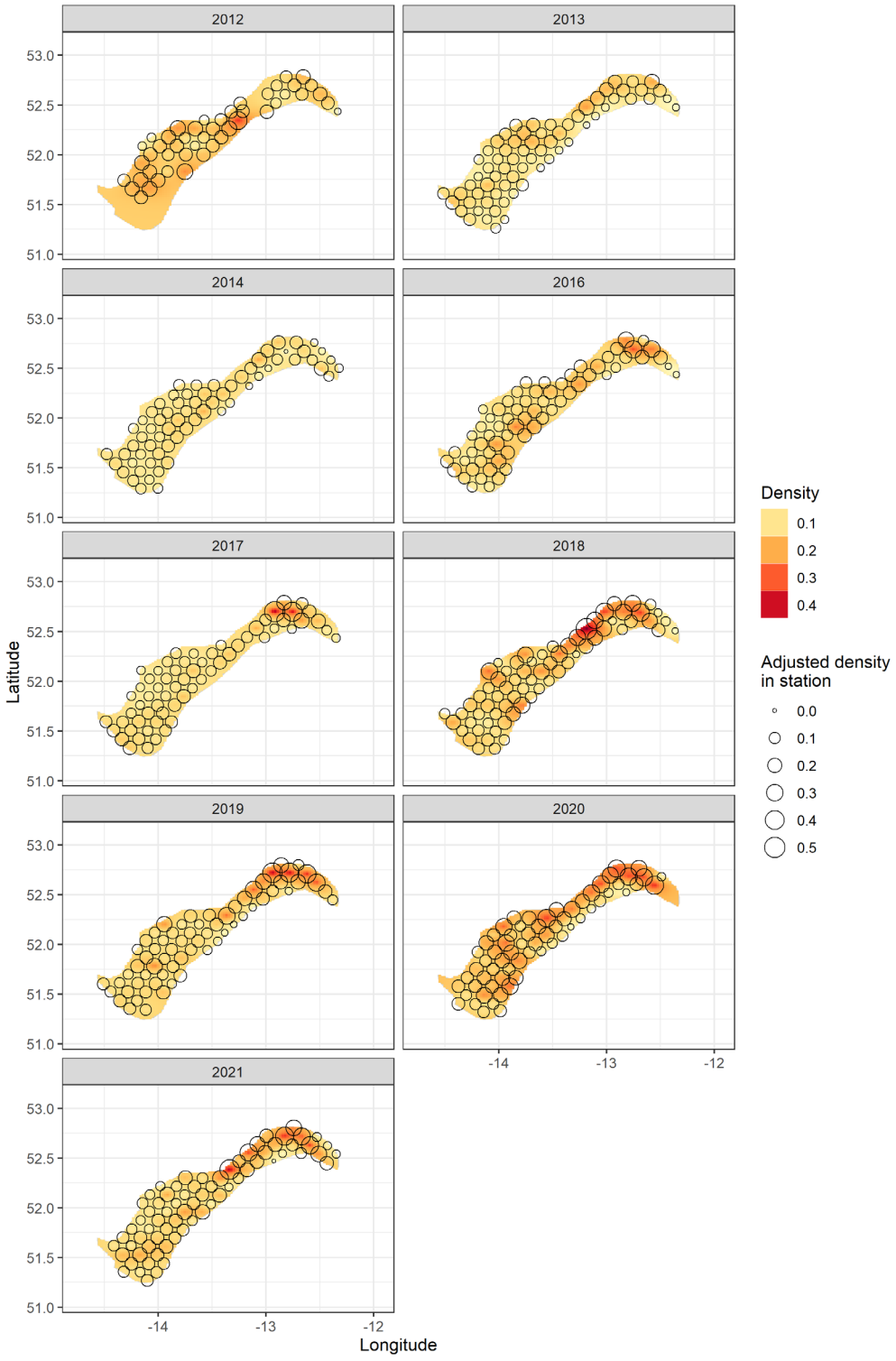


**Fig. 1: FU 16. Map of adjusted density (burrows / m²) by station for each year.**

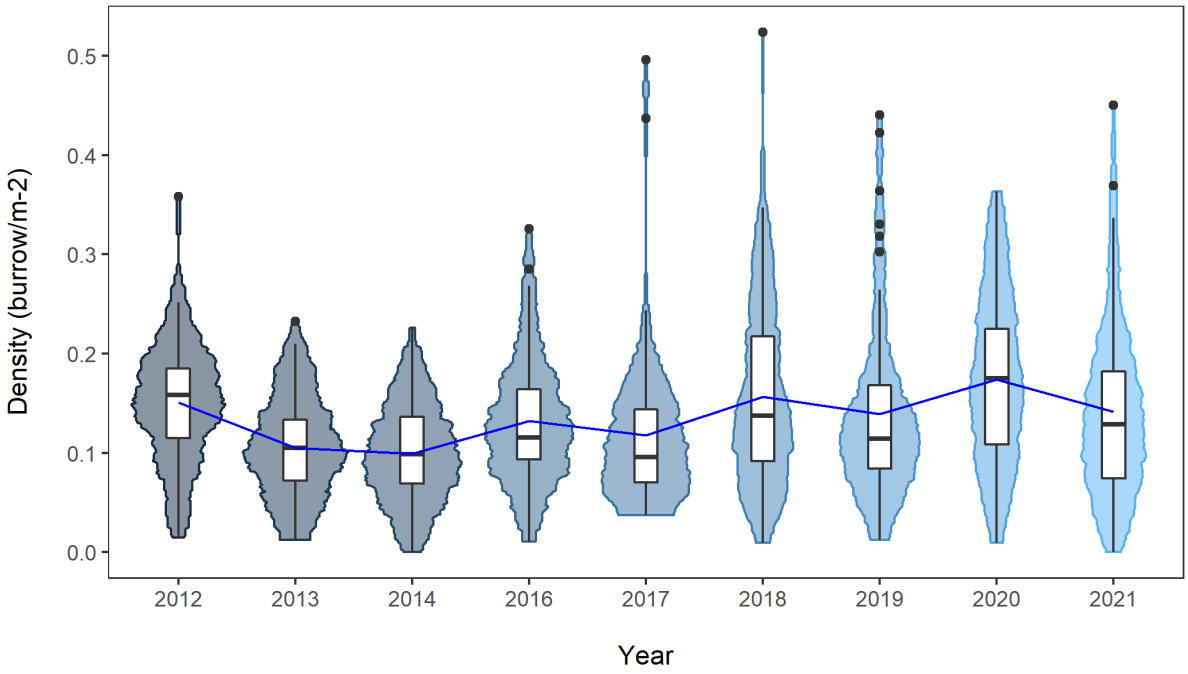


**Fig. 2: FU 16. Times series of adjusted density (burrows / m²) (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **FU 17** | **Area name** | **Aran Grounds, Galway Bay and Slyne Head** |
|---|---|---|---|
| Survey design | Randomised isometric grid | Previous surveys | 2002 to 2020 |
| Camera Type:<br>Standard/High definition | SD Konsberg: 98%<br>HD Cathx: 2% | Image Data:<br>Type / Size per station | SD: Video in DVDs. 5 stations per DVD<br>HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station |
| Country (ies) | Ireland | Vessel name (s) | Celtic Voyager |
| Survey code (s) | CV21013, CV21014 | Dates (start/end) | 5 – 28 June 2021 |
| Number scientific staff | 2 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | 44/ 44/ 44 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | SD camera used due to technical problems with HD camera | |
| Distance over ground source used | USBL | Average field of view (cm) | SD: 0.75 m<br>HD: 1.03 m |
| Adjusted mean density | Aran: 0.255 burrows /m$^2$ | Adjusted abundance, CV | Aran: 311 million, CV = 4% |
| | Galway Bay: 0.146 burrows /m$^2$ | | Galway Bay: 12 million, CV= 2% |
| | Slyne Head: 0.232 burrows /m$^2$ | | Slyne Head: 9 million, CV = 2% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Mini reference set with 2021 survey footage | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC, threshold = 0.6 | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Temperature & Depth profiler<br>Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter | |
| Data storage, level of analysis and dissemination (by data type) | | *Nephrops* burrow counts | Storage: MI network – SQL<br>Level: SD: burrows/minute; HD: annotated burrows |
| | | CTD | Storage: MI network<br>Level: TD profile per station |

| | | |
|---|---|---|
| | Trawl | No |
| | Sediment | No |
| | Other | Storage: MI network – SQL<br>Level: Ancillary data per station |

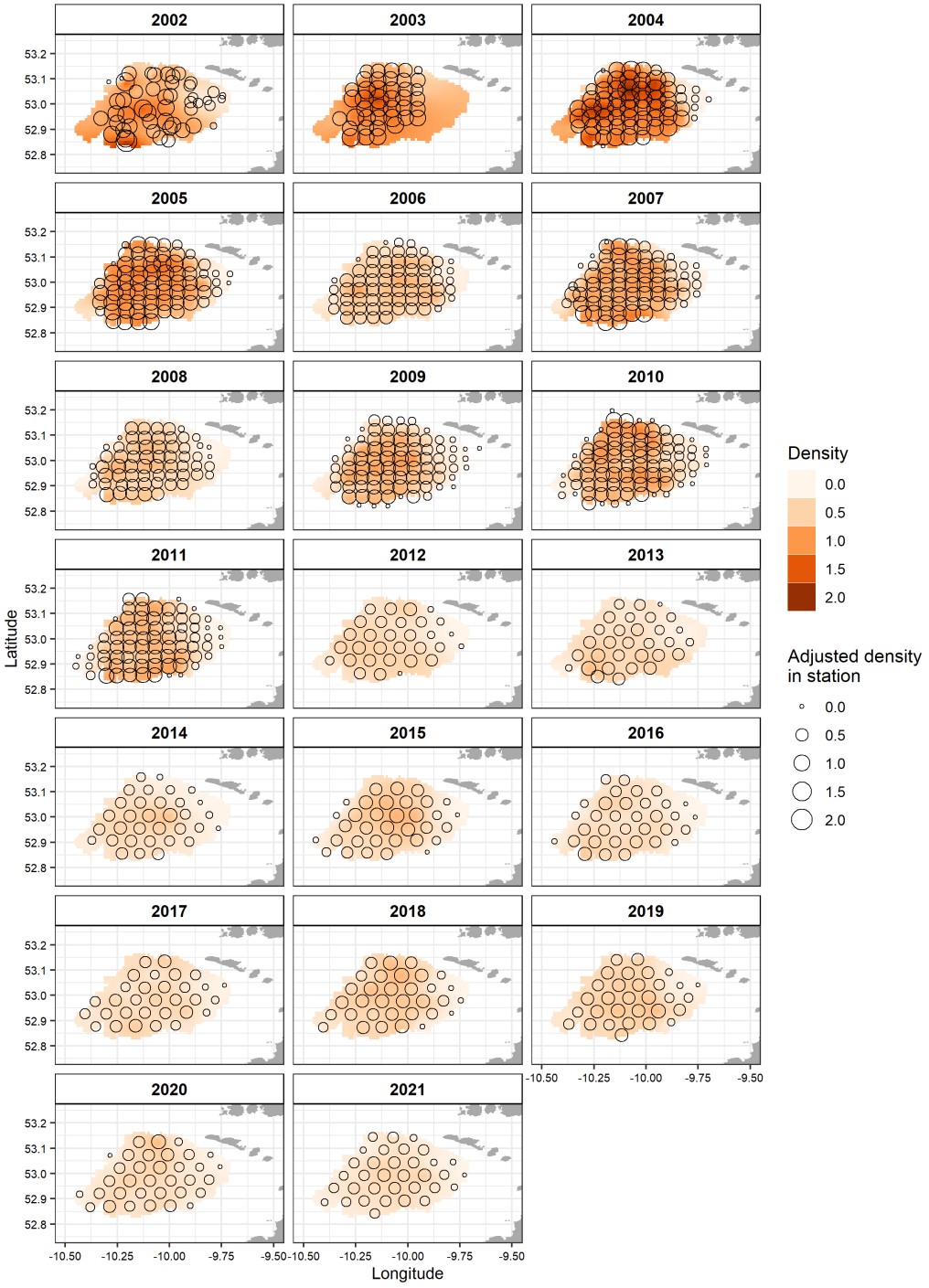


**Fig. 1: FU 17 Aran grounds. Map of adjusted density (burrows / m²) by station for each year.**

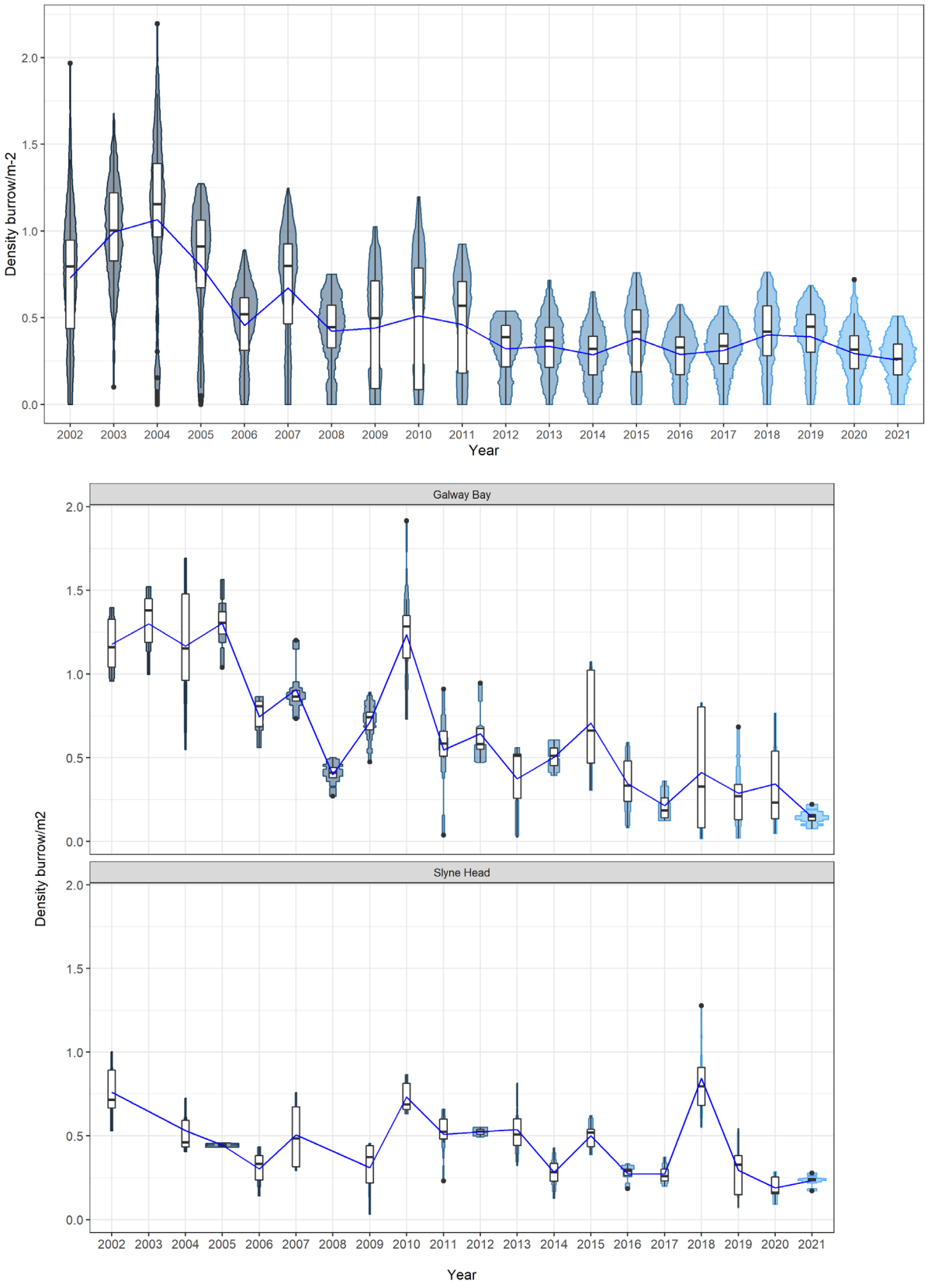


**Fig. 2: FU 17 Aran grounds (top panel), Galway Bay (middle panel) and Slyne Head (bottom panel). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **FU 19** | **Area name** | **South and Southwest of Ireland** |
|---|---|---|---|
| Survey design | Randomised stratified by area | Previous surveys | 2006 and 2011 to 2020 |
| Camera Type:<br>Standard/High definition | SD Konsberg: 81%<br>HD Cathx: 19% | Image Data:<br>Type / Size per station | SD: Video in DVDs. 5 stations per DVD<br>HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station |
| Country (ies) | Ireland | Vessel name (s) | Celtic Voyager |
| Survey code (s) | CV21013, CV21014 | Dates (start/end) | 5 – 28 June 2021 |
| Number scientific staff | 2 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | 42/ 42/ 42 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | SD camera used due to technical problems with HD camera | |
| Distance over ground source used | USBL | Average field of view (cm) | SD: 0.75 m<br>HD: 1.03 m |
| Adjusted mean density | 0.14 burrows /$m^2$ | Adjusted abundance, CV | 270 million, CV = 15% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | No, but counted after FU2021, which has similar characteristics | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC, threshold = 0.5 | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Temperature & Depth profiler<br>Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter | |
| Data storage, level of analysis and dissemination (by data type) | | *Nephrops* burrow counts | Storage: MI network – SQL<br>Level: SD: burrows/minute; HD: annotated burrows |
| | | CTD | Storage: MI network<br>Level: TD profile per station |
| | | Trawl | No |
| | | Sediment | No |

| | | |
|---|---|---|
| | Other | Storage: MI network – SQL<br>Level: Ancillary data per station |

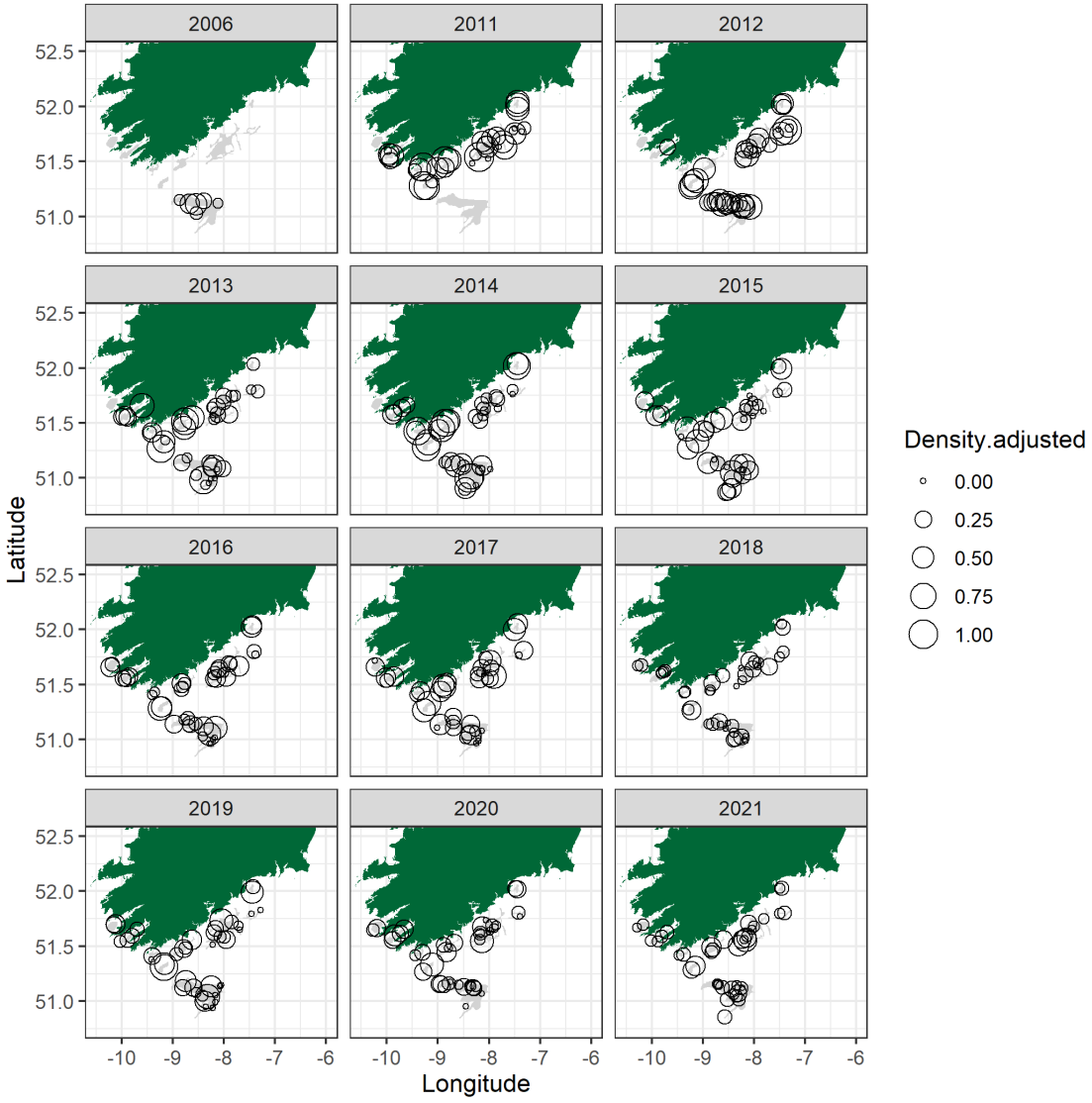


**Fig. 1: FU 19. Map of adjusted density (burrows / m²) by station for each year.**

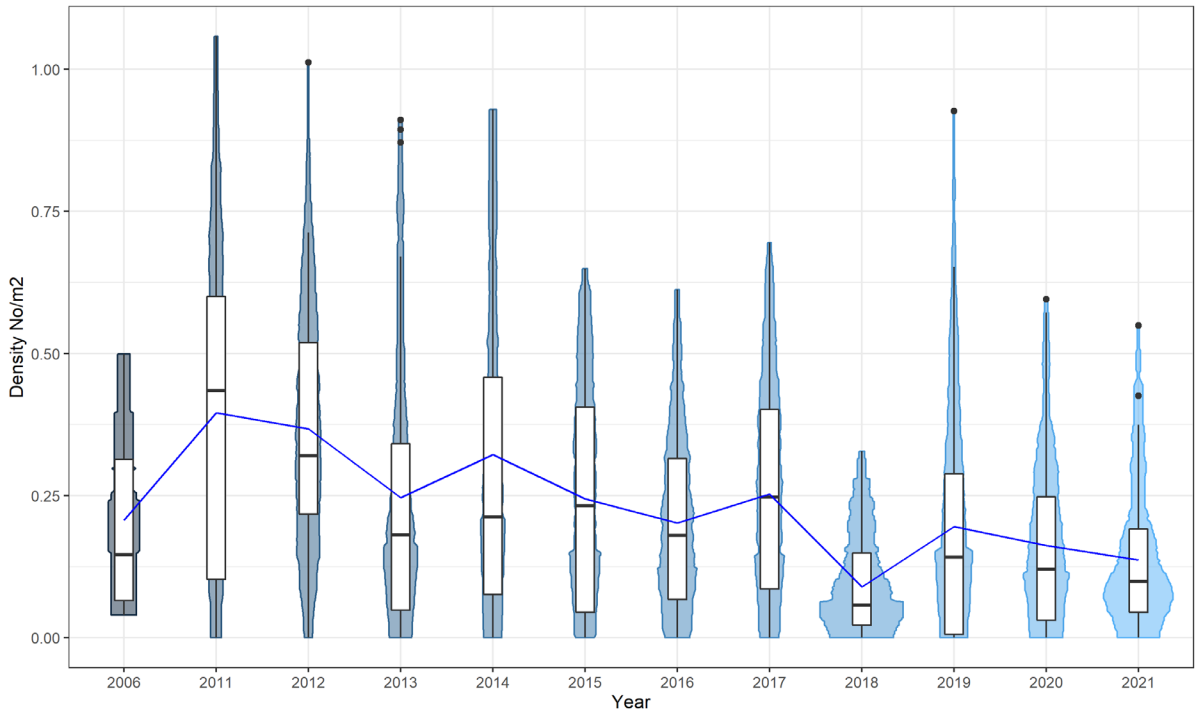


**Fig. 2: FU 19. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **FU 20-21** | **Area name** | **Labadie, Jones and Cockburn Banks** |
|---|---|---|---|
| Survey design | Randomised isometric grid | Previous surveys | 2013 to 2020 |
| Camera Type:<br>Standard/High definition | SD Konsberg: 75%<br>HD Cathx: 25% | Image Data:<br>Type / Size per station | SD: Video in DVDs. 5 stations per DVD<br>HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station |
| Country (ies) | Ireland | Vessel name (s) | Celtic Voyager |
| Survey code (s) | CV21013, CV21014 | Dates (start/end) | 5 – 28 June 2021 |
| Number scientific staff | 2 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | 97/97/97 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | SD camera used due to technical problems with HD camera | |
| Distance over ground source used | USBL | Average field of view (cm) | SD: 0.75 m<br>HD: 1.03 m |
| Adjusted mean density | 0.12 burrows /$m^2$ | Adjusted abundance, CV | 1202 million, CV = 4% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC, threshold = 0.5 | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Temperature & Depth profiler<br>Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter | |
| Data storage, level of analysis and dissemination (by data type) | | *Nephrops* burrow counts | Storage: MI network – SQL<br>Level: SD: burrows/minute; HD: annotated burrows |
| | | CTD | Storage: MI network<br>Level: TD profile per station |
| | | Trawl | No |
| | | Sediment | No |
| | | Other | Storage: MI network – SQL |

| | | |
|---|---|---|
| | | Level: Ancillary data per station |

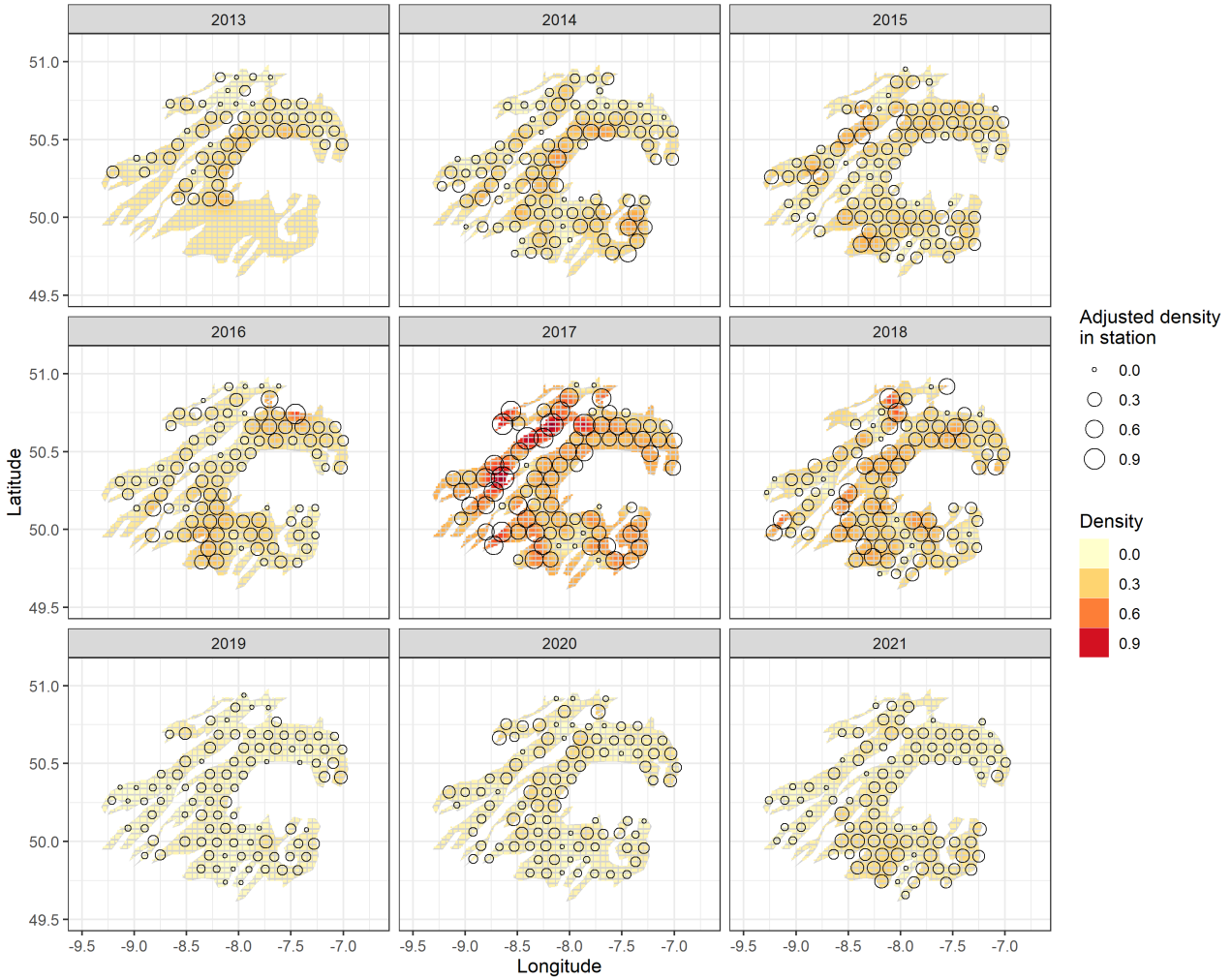


**Fig. 1: FU 20-21. Map of adjusted density (burrows / m²) by station for each year**

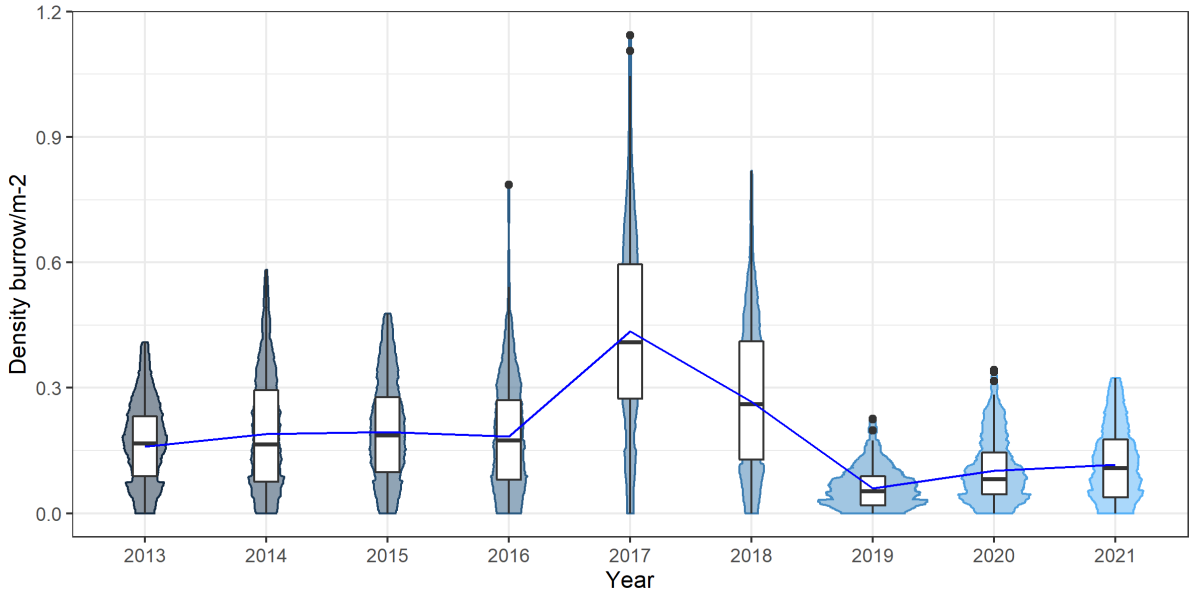


**Fig. 2: FU 20-21. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **FU 22** | **Area name** | **The Smalls** |
|---|---|---|---|
| Survey design | Randomised isometric grid | Previous surveys | 2006 to 2020 |
| Camera Type:<br>Standard/High definition | HD Cathx | Image Data:<br>Type / Size per station | HD: Still JPGs. 2.5 GB/station. Reduced: 1 GB/station |
| Country (ies) | Ireland | Vessel name (s) | Celtic Voyager |
| Survey code (s) | CV21013 | Dates (start/end) | 5 – 16 June 2021 |
| Number scientific staff | 2 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | 42/42/42 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | No | |
| Distance over ground source used | USBL | Average field of view (cm) | 1.03 m |
| Adjusted mean density | 0.23 burrows /$m^2$ | Adjusted abundance, CV | 656 million, CV = 7% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC, threshold = 0.6 | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Temperature & Depth profiler<br>Ancillary data: *Nephrops* in/out; Presence/Absence of seapens, fish, Anthozoa, squat lobsters, trawl marks, litter | |
| Data storage, level of analysis and dissemination (by data type) | | *Nephrops* burrow counts | Storage: MI network – SQL<br>Level: SD: burrows/minute; HD: annotated burrows |
| | | CTD | Storage: MI network<br>Level: TD profile per station |
| | | Trawl | No |
| | | Sediment | No |
| | | Other | Storage: MI network – SQL<br>Level: Ancillary data per station |

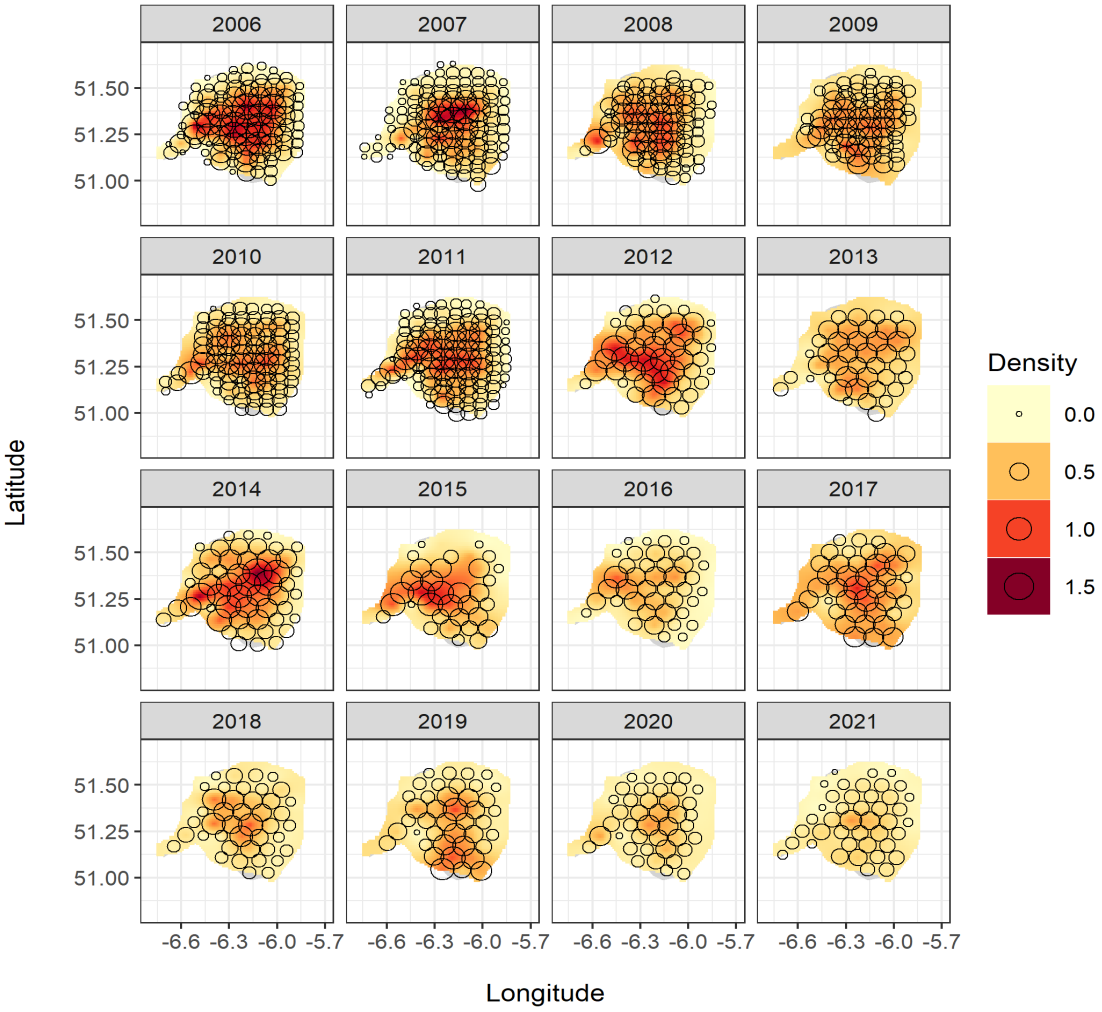


**Fig. 1: FU 22. Map of adjusted density (burrows / m²) by station for each year overlaid on heat map of kriged surface density.**

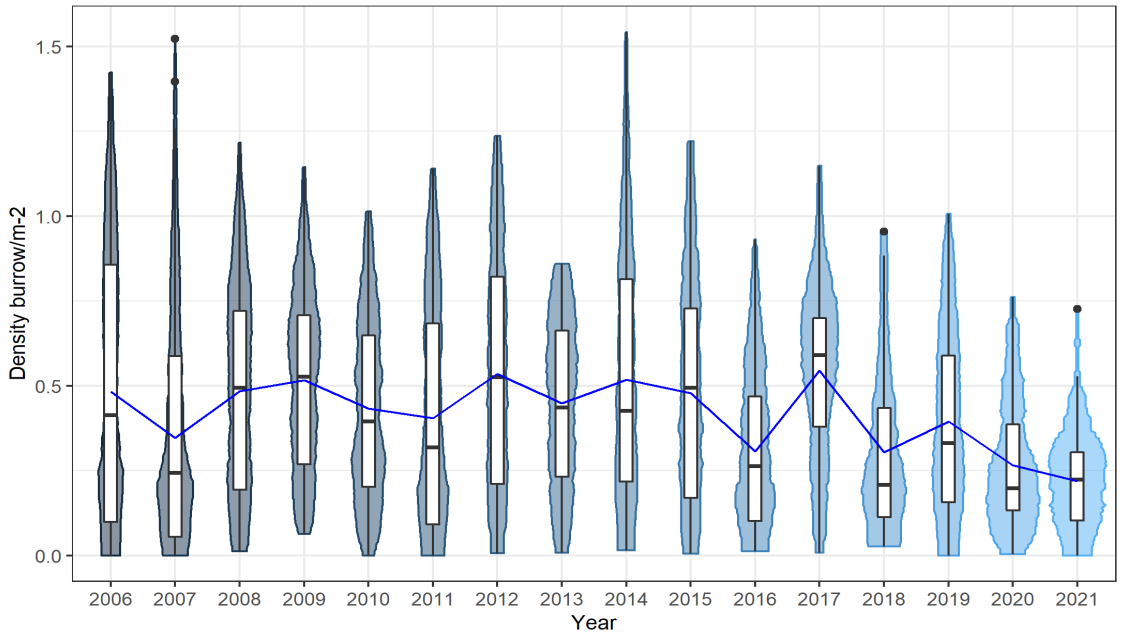


**Fig. 2: FU 22. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

## References

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## UK Northern Ireland FU 15

(Mathieu Lundy)

| | | | |
|---|---|---|---|
| Functional Unit | FU 15 | Area name | Western Irish Sea |
| Survey design | Random grid | Previous surveys | 2003-2020 |
| Country (ies) | UK & Ireland | Vessel name (s) | R/V Corystes |
| Survey code (s) | CO3121 | Dates (start/end) | 28th – 31st July // Sept 7th - 8th |
| Number scientific staff | 5 | Staff exchanges | NA |
| Number of stations (planned/completed/used in analysis) | | 100/99/95 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | 82 Stations completed during 28th – 31st of July (HD Stills)<br>17 Stations completed 7th – 8th September (Video) | |
| Distance over ground source used | Ship | Average field of view (cm) | Analogue cam: 68 cm |
| Adjusted mean density | 0.79 | Adjusted abundance, CV | 4733 million, CV=2.91% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | No – New HD Still footage | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC threshold 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Beam trawl hauls<br>*Nephrops* otter trawls | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | 17224 Nephrops burrows counted, **storage**: DVD up to 2020, digital in 2021 **level of analysis**: kriged estimates as for last year<br>**dissemination**: WGCSE |
| | | CTD | - |
| | | Trawl | 24 |
| | | Sediment | 0 |
| | | Other | 0 |

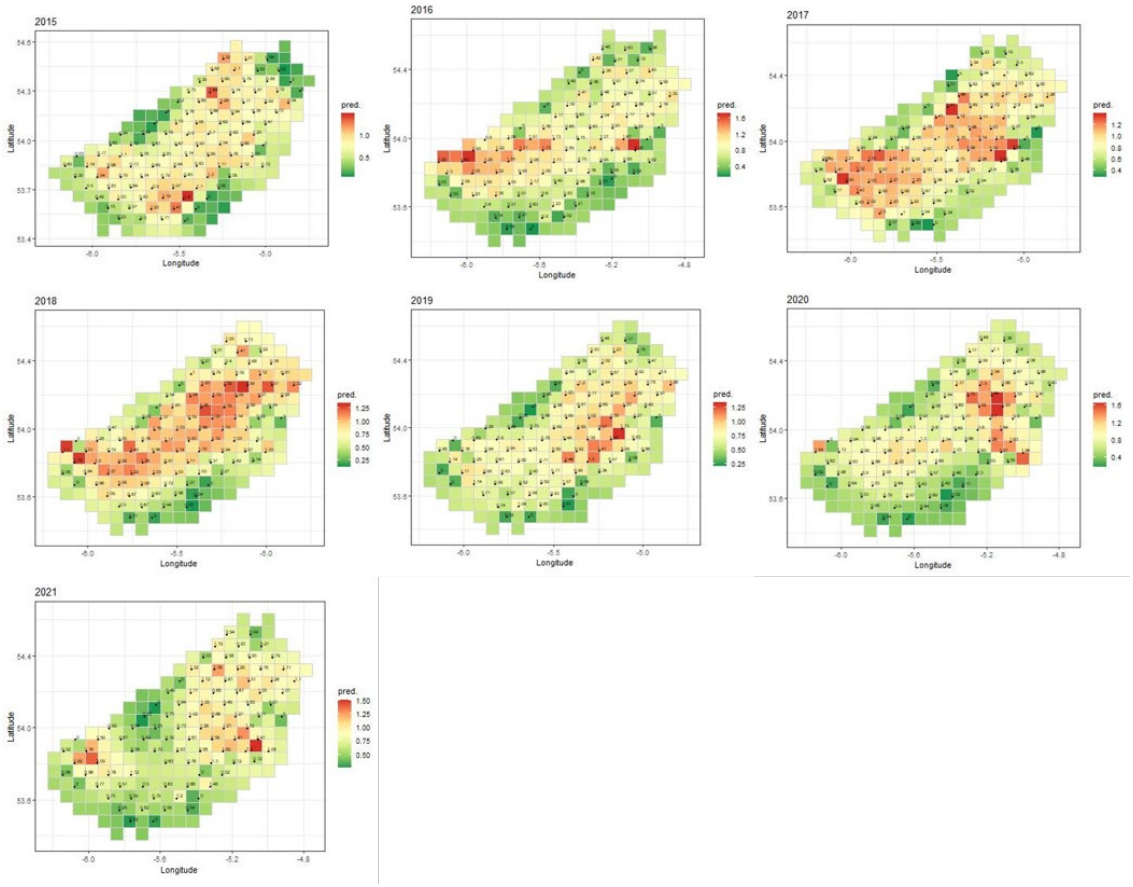



**Figure. 1: Map of kriged density by station for 2015 – 2021.**

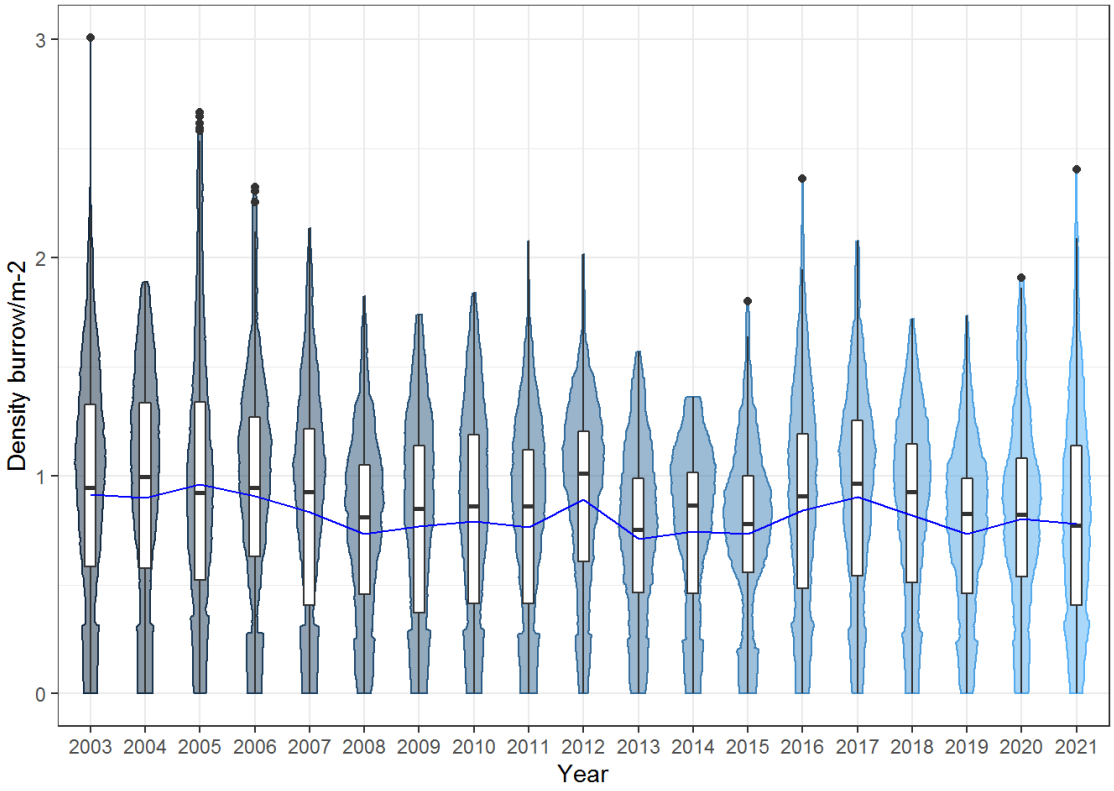



**Figure. 2: Times series of adjusted burrow density (Violin and box plot).**

## UK Scotland FU 7 – 10, 11 -13 and 34

Adrian Weetman

Marine Scotland Science (MSS) based in Aberdeen, Scotland, UK, carried out two underwater TV camera surveys (UWTV) in Scottish waters during 2021. COVID restrictions impacted both the annual survey plan and the specific surveys, with the smaller vessel, MRV Alba-na-Mara (Marine Research Vessel), being affected the most, with reduced staff numbers permitted on the vessel, allowing only one scientist at sea. These same restrictions also resulted in the cancelation of the east coast survey planned for August aboard MRV Alba-na-Mara, requiring the survey programme for MRV Scotia to be adapted to encompass the survey activities that were scheduled for MRV Alba-na-Mara, to ensure all seven of the main Functional Units (FU's) in Scottish waters were surveyed during 2021.

As illustrated in Figure 1 below, the number of stations surveyed in 2021 was slightly higher than in 2020, but with two surveys merged in to one with no additional survey time resulting in a reduction in stations in most areas to accommodate this increased workload, the tally remains noticeably lower than pre-COVID surveys.

During the stock assessment survey aboard MRV Scotia in 2021, the primary equipment utilised remained unchanged from previous recent years which included a Kongsberg 14-366 analogue video camera; four SeaLED lights; an odometer to calculate the distance travelled during each deployment and a bespoke altimeter to record the position of the camera in relation to the seabed (which is used to calculate the field of view). There were no changes to the sampling design with a stratified random approach based on sediment used in the Moray Firth, Firth of Forth, Fladen, South Minch, Sound of Jura and the in the Clyde; fixed stations at Devils Hole; and in the North Minch, random positions were generated within the VMS boundary as modelled on the 2007-11 data. A mini van Veen sediment sampler was used frequently on both surveys. The MSS drop frame was not used on either survey although additional equipment was trialled on both MRV Alba-na-Mara and Scotia as described later in this report.

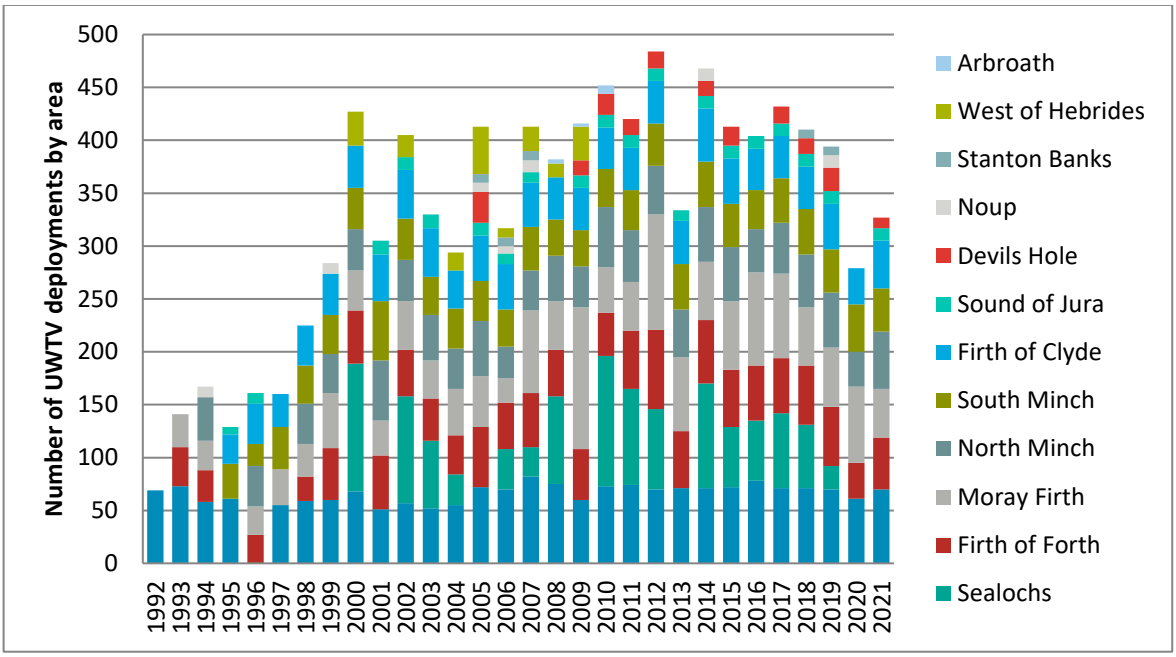



**Figure 1. Time series of UWTV sledge and drop frame deployments by MSS for all areas surveyed, in relation to *Nephrops* burrow abundance, habitat mapping and comparative trials.**

**MRV Alba-na-Mara, 6 - 22 January 2021**

The annual UWTV west coast research and support survey was carried out aboard MRV Alba-na-Mara during 6 – 22 January 2021. This survey successfully completed a number of objectives to further aid 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 different programmes within MSS. Any abundance data gathered during this trip was used for comparative trials and not used in stock assessments.

The survey was significantly impacted by social distancing restrictions and the limited facilities onboard the vessel, which resulted in reduced crew and only one scientist allowed on board, with no technical support. This meant that there were insufficient crew to permit trawling to be undertaken, and without technical support the standard UWTV sledge or drop frame could not be used. In light of these limitations, modifications to the survey were required to ensure any work undertaken remained relevant and manageable. Three objectives were established and fully met during the course of the survey.

Although the work was scheduled to be carried out on the west coast of Scotland, where scientific equipment could be guaranteed to be undisturbed by commercial trawler activity, the weather proved too poor in the short and medium term to allow the vessel safe passage west. Therefore, the survey was relocated to west Moray Firth where shelter from the weather could be provided and commercial activity was minimal (Figure 2).

Working out of Inverness for the first five days, the first objective was to deploy two self-supported landers equipped with a time lapse camera, recorder, light source and power supply. These landers were designed to be left at specific sites for up to a year to monitor bioturbation and benthic rejuvenation during post-commercial activity (e.g. gravel extraction, oil-well capping, marine protected areas, etc.). However, having used the landers on previous surveys and being encouraged to find alternative uses for these devices, there remained the opportunity to deploy the frames on muddy sediment and potentially within sight of a *Nephrops* burrow complex, where animal activity could be monitored. Unfortunately, with greater commercial vessel activity than expected in the area, this forced the landers to be deployed in less than ideal *Nephrops* grounds to ensure their safety and that of commercial fishing gear, which resulted in a series of images of sandy habitat from one camera, as the other camera failed to operate. Both landers were located in shallow water on the south side of the Firth, west of Nairn, and remained in position for four days and the working device amassed 77 images. Although the images provided no data in relation to *Nephrops*, they were of interest to other programmes within MSS and added to the MSS image bank.

The second and main objective was to carry out a number of parallel transects taking sediment grabs across the area both within and outwith the muddy habitat as defined by the British Geographical Survey (BGS) on which the *Nephrops* assessment survey is based on in this FU. Eight north/south sample lines were carried out, with each sample taken approximately 1 mile apart. This continued until the tide at Inverness harbour no longer allowed the survey vessel access, and so the vessel sailed east to Fraserburgh after first recovering the lander.

The second leg of the survey was heavily affected by poor weather, significantly reducing the time at sea. In addition, due to the much greater depths of the eastern Moray Firth the lander could not be deployed. However, the sediment sampling continued in the same format as earlier in the survey, although some stations were avoided due to the limitations of the Day Grab and the depth at those sites (200m$^{+}$).

During this survey 196 stations were visited with 174 successful sediment samples collected. In time, the frozen samples will be assessed using a Particle Size analysis machine, and the data compared to the BGS charts and the results considered and reported on.

With no technical assistance on the survey, any video footage gathered had to be collected using a much simpler system and be operated by one person. As one of the objectives was to investigate means to measure the size of *Nephrops* burrow complexes (as considered at WGNEPS), this was achieved by modifying a small pyramidal frame used in pelagic surveys and deployed using the vessel's crane rather than the TV winch. This frame, named a mini-drop frame, housed a Go Pro camera and two lights and was deployed three times in the eastern Moray Firth. Allowing the frame to pan over the sea bed for a short period of time and then raising it as the vessel drifted, resulted in a short series of video footage over muddy sediment, capturing several incidences of *Nephrops* complexes. After the initial deployment proved the approach worked, and without technical assistance to allow to use lasers, a scale was added to the frame. Screen grabs from the 4K Go Pro footage were extracted showing a limited number of complete complexes where the size could be established.

The survey successfully met all three of the objectives and awaits processing of the sediment samples before being able to report back. The mini-drop frame will be modified to be used in future surveys and by other programmes.

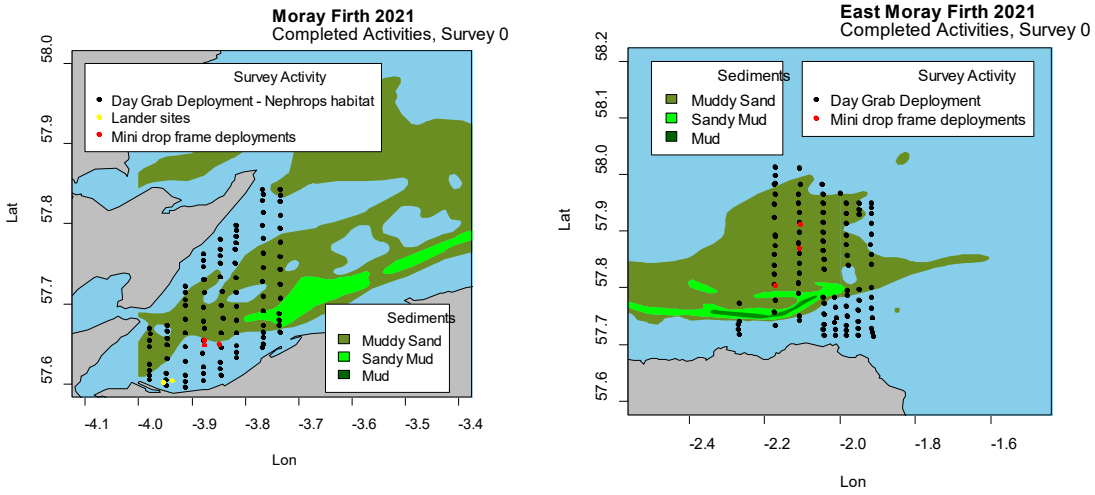



**Figure 3. Plots of the areas surveyed in the Moray Firth Functional Unit during survey 0121A, indicating the distribution of the muddy sediment and the activities undertaken during the survey.**

### MRV Scotia, 28 May - 19 June 2021

The annual Fladen and west coast UWTV survey aboard MRV Scotia was impacted for a second year due to COVID restrictions. However, in 2021 the number of MSS staff permitted onboard returned to the standard seven (two of which were new to the UWTV survey), which significantly helped with reviewing the footage and completing the associated administrative duties. As the Moray Firth and Firth of Forth survey onboard the smaller survey vessel MRV Alba-na-Mara was unable to proceed due to COVID restrictions, the summer Scotia survey had to absorb this work into the programme with no additional sea time provided. This required modifications to the normal survey programme, with a reduction in stations in some areas, much reduced trawling, and limiting any assistance with additional, non-*Nephrops* related work.

The survey first began in very foggy conditions in the Firth of Forth, one of the two areas normally surveyed by MRV Alba-na-Mara during non-COVID times. Due to the relatively homogeneous grounds and that the *Nephrops* abundance has shown a general upward trend over recent years, the number of planned stations were reduced slightly to accommodate the additional work required from the survey. Including a trawl, working 24 hours a day in three teams of two staff, the area was completed within two and a half days.

Although the Moray Firth was surveyed in 2020, time was very limited and resulted in insufficient data for WGNSSK to assess the stock satisfactorily. Therefore, this FU was a priority in 2021 and again due to the nature of the grounds and the relatively stable stock abundance over time, a slightly lower than pre-COVID but yet still statistically relevant number of stations were completed before moving on to Fladen. Due to the much larger area of this FU and the relatively low number of stations/km$^2$ compared to other areas, the number of stations remained the same as in previous years. A second trawl, and the final one of the survey, was carried out at Fladen before heading to the Minches.

Due to the variability of the grounds and the size of the areas, the planned number of stations in the Minches remained similar to pre-COVID surveys. Working down the west side of the North Minch, two COMPASS moorings were recovered and replacements deployed before moving into the South Minch, where a further two moorings were replaced. These moorings are part of a long term, Interreg project involving five institutions which aims to build cross-border capacity for effective monitoring and management of Marine Protected Areas (MPAs). The moorings associated with this survey were laid on the seabed with various acoustic devices attached to enable the monitoring of passing fauna by recording and counting the number of vocal interactions to establish the frequency and variety of cetaceans visiting the west coast of Scotland.

The South Minch, which traditionally has more variable abundances than the North Minch due to the extreme differences in the benthic composition between the west, offshore area and the shallower, eastern area peppered with many islands and rocky outcrops, showed higher densities inshore than offshore, continuing a trend observed for a number of years.

The survey then proceeded to the Sound of Jura, which due to a lack of time was not surveyed in 2020. Although a small area of relatively similar sediment, it was felt reducing the number of stations down from the standard 12 would cause issues for the assessment model, and so all 12 were completed before moving into the Clyde. The planned number of stations in the Clyde were reduced slightly due to the relatively stable stock abundance over time, but because of the number of stations with no visibility as a result of commercial trawler activity and these stations requiring to be repeated at another location, the final number of deployments were noticeably higher than planned.

The vessel then returned to the Minches working north along the eastern side, surveying the remaining stations and replacing the fifth and final COMPASS mooring before the long steam to the Devils Hole. Not surveyed since 2019, time only allowed for 10 stations to be surveyed before returning to port at the end of the trip.

In addition to the standard sledge deployments and mooring recoveries/redeployments, a number of additional tasks were undertaken, most significantly the trialling of a new high definition (HD) camera and fibre optic (FO) system installed earlier in the year. The FO was integrated into a copper/FO hybrid cable, with very similar construction characteristics as the standard copper cable. Modifications to the slip ring on the winch and the cable routing from the deck to the reviewing area worked well, although there were issues with the multiplexor which required replacing. This greatly reduced the time available to trial the camera and compare video footage with the standard analogue system, as well as the various monitors available and so no findings from this survey could be presented.

In addition to the recovery device mounted on the sledge, in 2021 a ultra-short baseline (USBL) transponder was attached to the sledge with an accompanying transceiver on the underside of the vessel. This not only provided an accurate location of the sledge if it ever parted from the cable but also allowed the towed path to be tracked and provide a distance travelled in case the odometer ever failed.

A turbidity meter was also attached to the sledge to measure the water clarity at each station. This data is being worked up and will be presented at a later date, but initial analysis shows a

clear correlation between reviewers' comments, the video footage and the values recorded by the device. It is hoped that an agreed, measured, numerical value will be available from live data to establish when a station is unsuitable to count due to the turbidity levels present, requiring the station to be relocated prior to the run being started, and so saving time and reducing the chance of having fewer suitable stations to review than expected.

Whilst working up the catch from the trawls, in addition to the *Nephrops* length frequency distribution data and morphometric data collected, observations on any skate caught were recorded and further Remote Electronic Monitoring (REM) data gathered. The skate information was collected on behalf of the Joint Nature Conservancy Council (JNCC) and is part of a project to map the distribution and correctly identify the different species of skate around the UK. The REM work required measured and sexed *Nephrops* to be passed along the sorting belt in the fish house below a permanently mounted camera. Using machine learning it was hoped the shored based system would be able to correctly measure and sex the *Nephrops* from the video footage, using the manually gathered data to corroborate the results.

Despite the heavy and varied workload, following training requirements and WGNEPS counting guidance, all video footage, was reviewed whilst at sea, with quality control being carried out on all data using Lin's CCC, with third counts applied where thresholds were not met.

All survey data was uploaded to the bespoke MSS UWTV database on return to shore.

Density bubble plots and a burrow abundance graph, by area for the complete time series, are attached in the Survey Summary Template annex which follow along with violin plots of adjusted burrow density for the last six years.

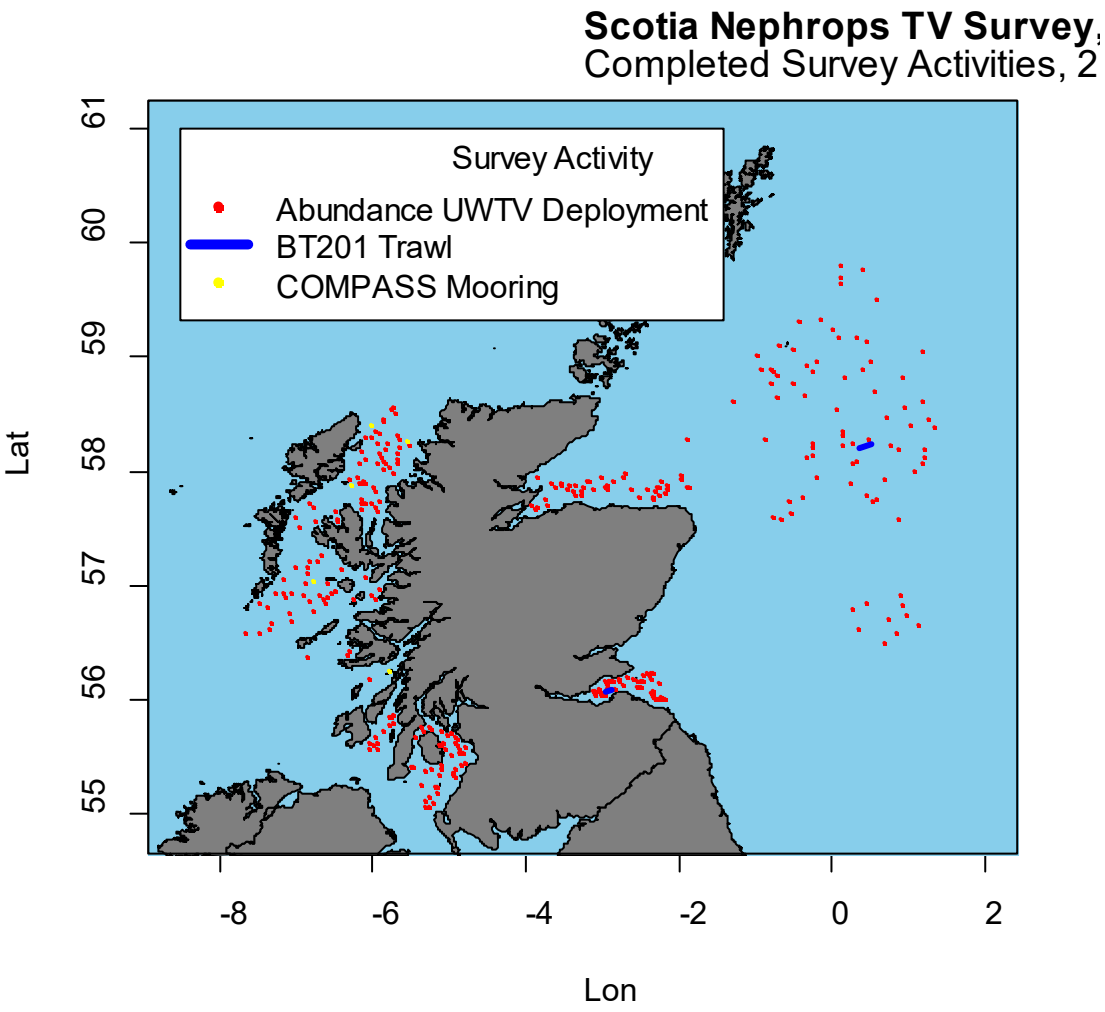



**Figure 4. Plot illustrating the location of the UWTV stations and COMPASS mooring recoveries/deployments that were conducted within the eight survey areas (seven FUs) during the MRV Scotia cruise during May/June 2021.**

**Table 1. 2021 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 of individuals) | CV (Relative standard error) | Lin's Concordance Correlation Coefficient Threshold to screen survey Counts |
|---|---|---|---|---|
| FU 7 | 0.225 | 6336 | 0.052 | 0.7 |
| FU 8 | 0.915 | 837 | 0.064 | 0.5 |
| FU 9 | 0.300 | 658 | 0.124 | 0.5 |
| FU 11 | 0.478 | 1391 | 0.077 | 0.5 |
| FU 12 | 0.251 | 1272 | 0.126 | 0.5 |
| FU 13 | 0.680 | 1414 | 0.072 | 0.5 |

**Conclusions/recommendations/:**

- Further trials of the HD camera, aiming to have comparison footage and analysis completed by November 2022.
- Use USBL to plot each tow and compare distance covered with odometer.
- To further encourage and promote national and international staff exchange, COVID restrictions permitting.
- 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 increase the number of MSS staff suitably trained to assist in UWTV surveys.
- To prepare and present at WGNEPS 2021, updated analysis of turbidity data gathered from the 2021 MRV Scotia UWTV survey.
- To continue collaborating with the Joint Nature Conservancy Council (JNCC) in analysing UWTV footage for associated studies; and continue to contribute to the UK marine image collation, processing, storage, annotation and promotion workshops (The Big Picture) chaired by JNCC.

**FU 10** (northern North Sea, Noup).
In 2021 due to time restrictions no survey was completed on FU 10 (northern North Sea, Noup). This survey was last conducted in 2019.

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

**FU 34** (Devil's Hole).
Survey was completed in 2021 and results were available for the relevant working group WGNSSK and reported here.

| **Functional Unit** | **11** | **Area name** | **North Minch** |
|---|---|---|---|
| Survey design | Stratified Random plus 10 legacy, fixed stations | Previous surveys | 1994, 1996, 1998-2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1994 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | Planned – 53<br>Completed – 54<br>Used in analysis - 50 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in no trawling. Sledge redeployments resulted in an increase on the planned number of stations. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.478 | Adjusted abundance, CV | 1391 mill., CV = 0.077 |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and |

| | | |
|---|---|---|
| | | on local network drive, backed up daily to the server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** - WGCSE |
| | CTD | No |
| | Trawl | No |
| | Sediment | Yes |
| | Other | **Seapen, marine litter, fauna data, COMPASS recordings, Cruise Summary Report:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments/agencies.<br>**Dissemination** – where applicable WGCSE, Marine Scotland Science, Aberdeen University, British Oceanographic Data Centre (BODC) COMPASS project and MSFD. |

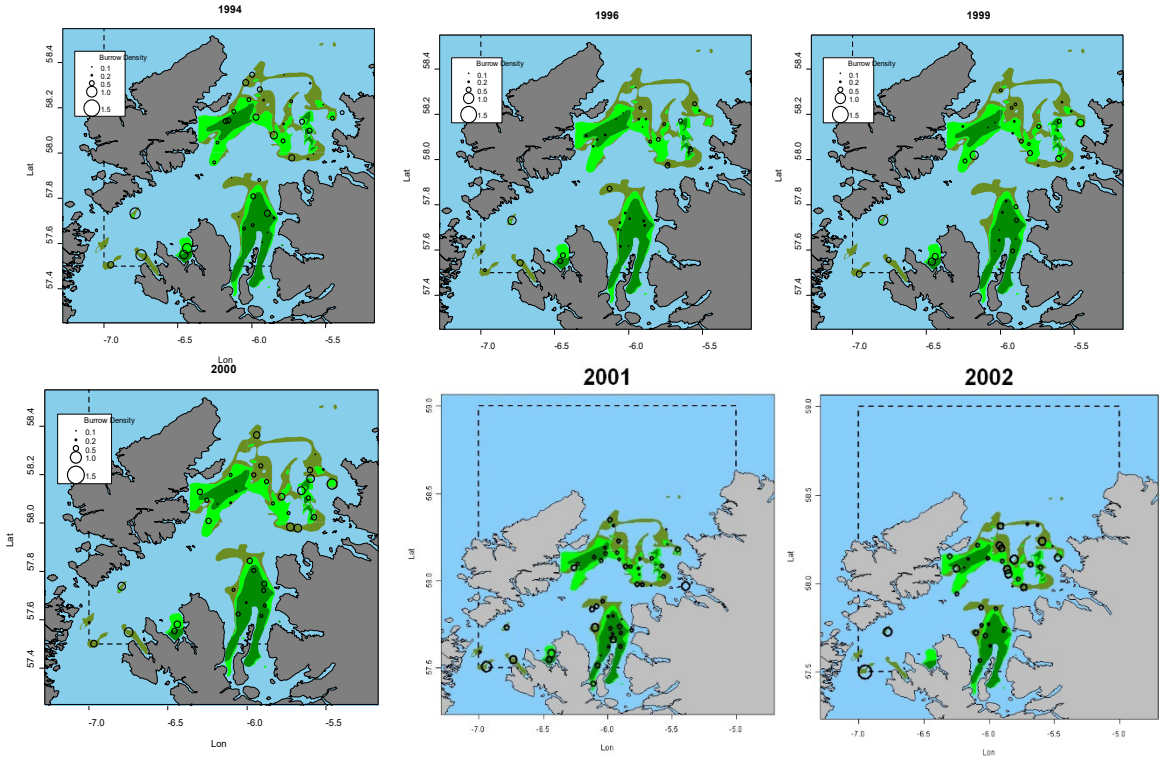



**Fig 1.a: FU 11. North Minch (FU 11). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

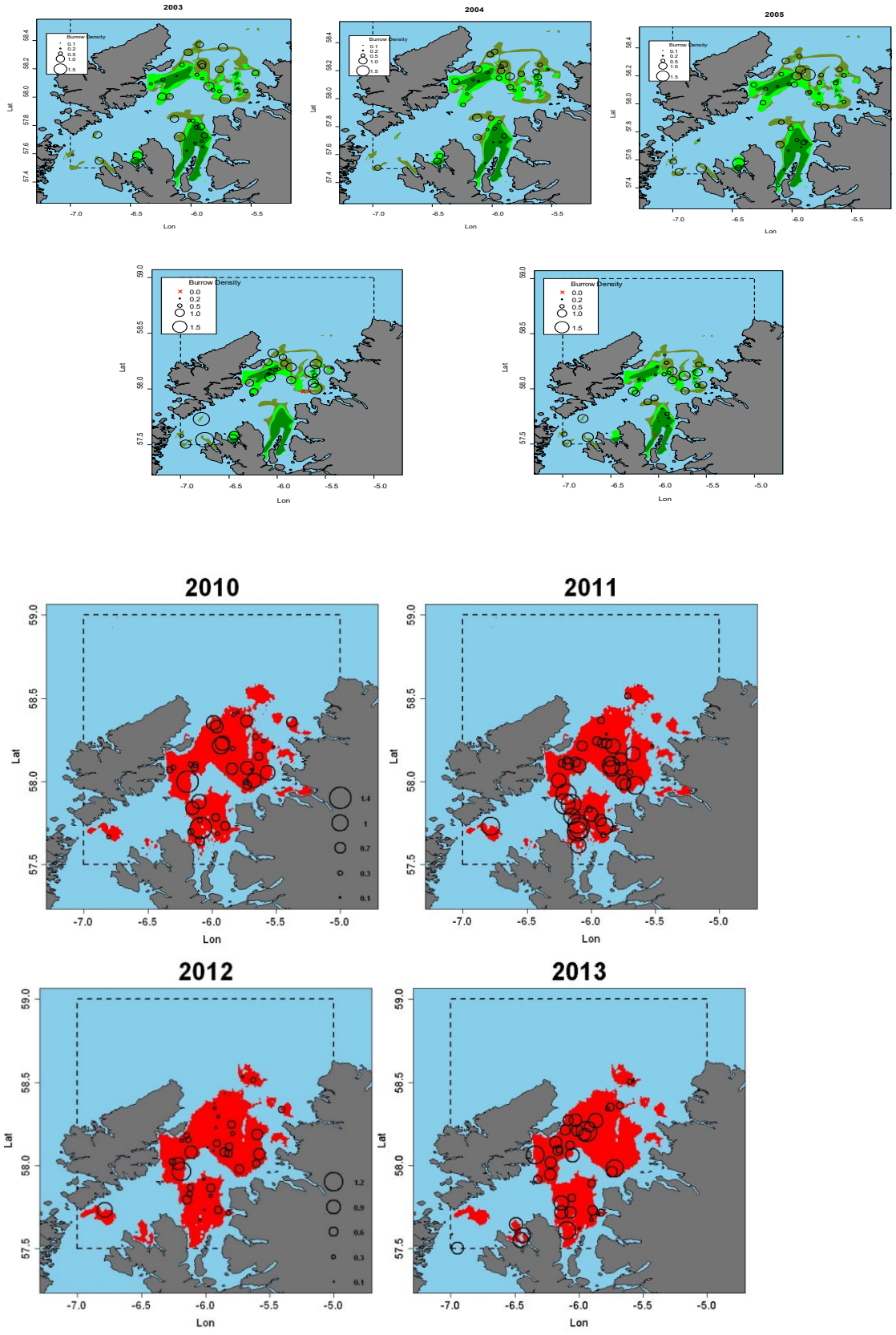



**Fig 1.b: FU 11. North Minch (FU 11). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

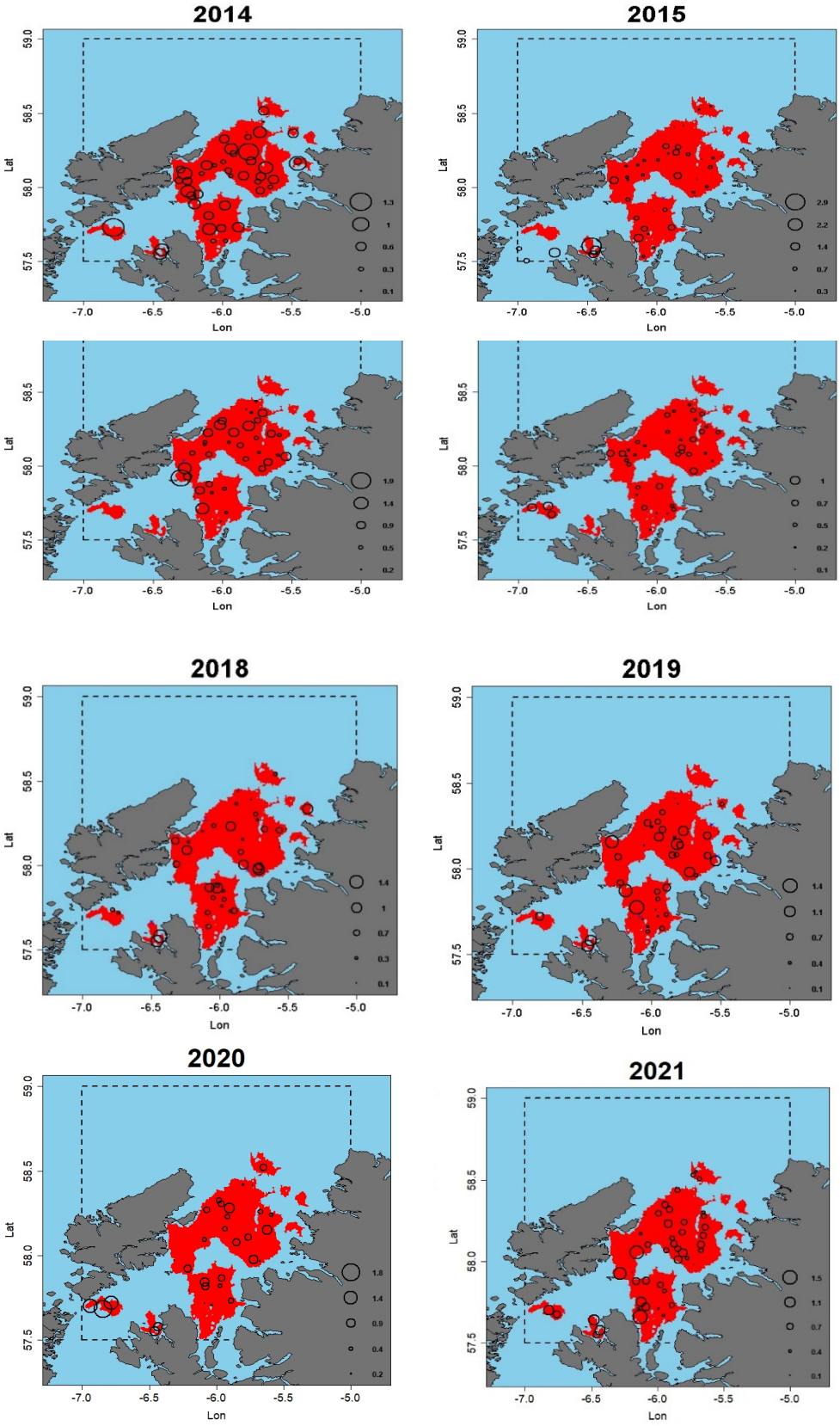



**Fig 1.c : FU 11. North Minch (FU 11). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

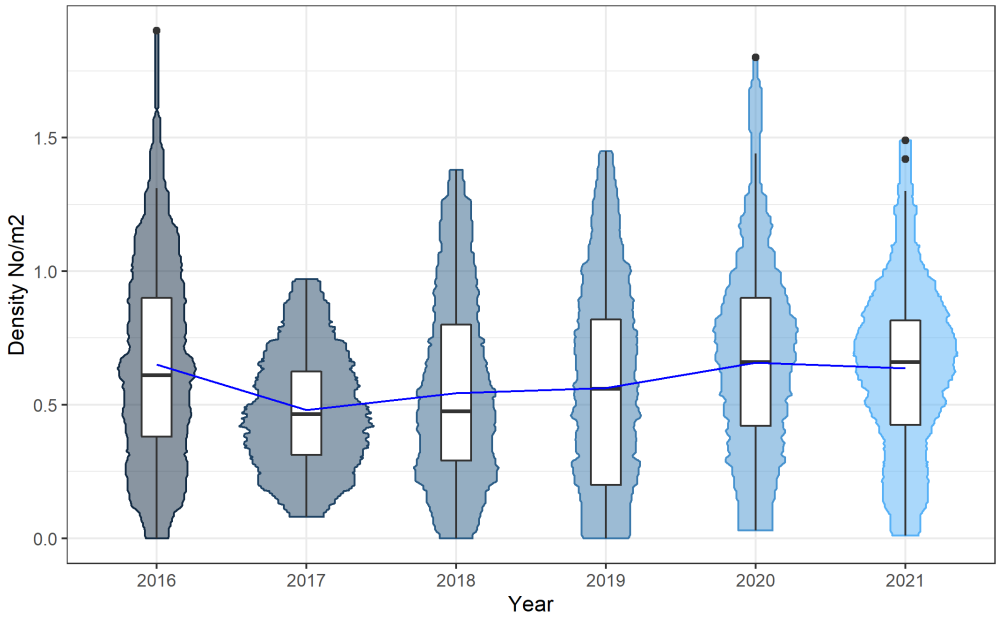



**Fig. 2: North Minch (FU 11). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **12** | **Area name** | **South Minch** |
|---|---|---|---|
| Survey design | Stratified Random | Previous surveys | 1995 -2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1995 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | Planned – 41<br>Completed – 41<br>Used in analysis - 41 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in no trawling. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.251 | Adjusted abundance, CV | 1272 mill., CV = 0.126 |
| Overall footage quality (poor, medium, good) | | Medium | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** - WGCSE |
| | | CTD | No |

| | | |
|---|---|---|
| | Trawl | No |
| | Sediment | Yes |
| | Other | **Seapen, marine litter, fauna data, COMPASS recordings, Cruise Summary Report:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments/agencies.<br>**Dissemination** – where applicable WGCSE, Marine Scotland Science, Aberdeen University, British Oceanographic Data Centre (BODC), COMPASS project and MSFD. |

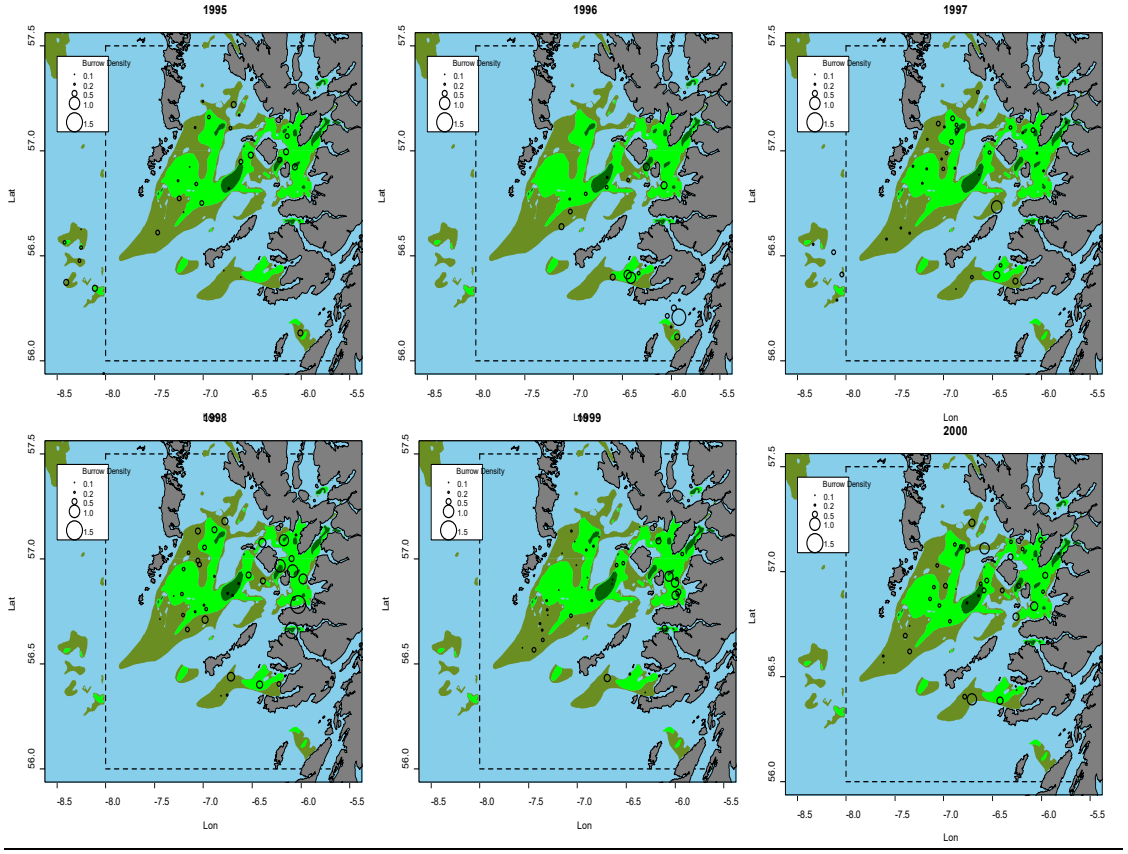



**Fig. 1a: South Minch (FU 12). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

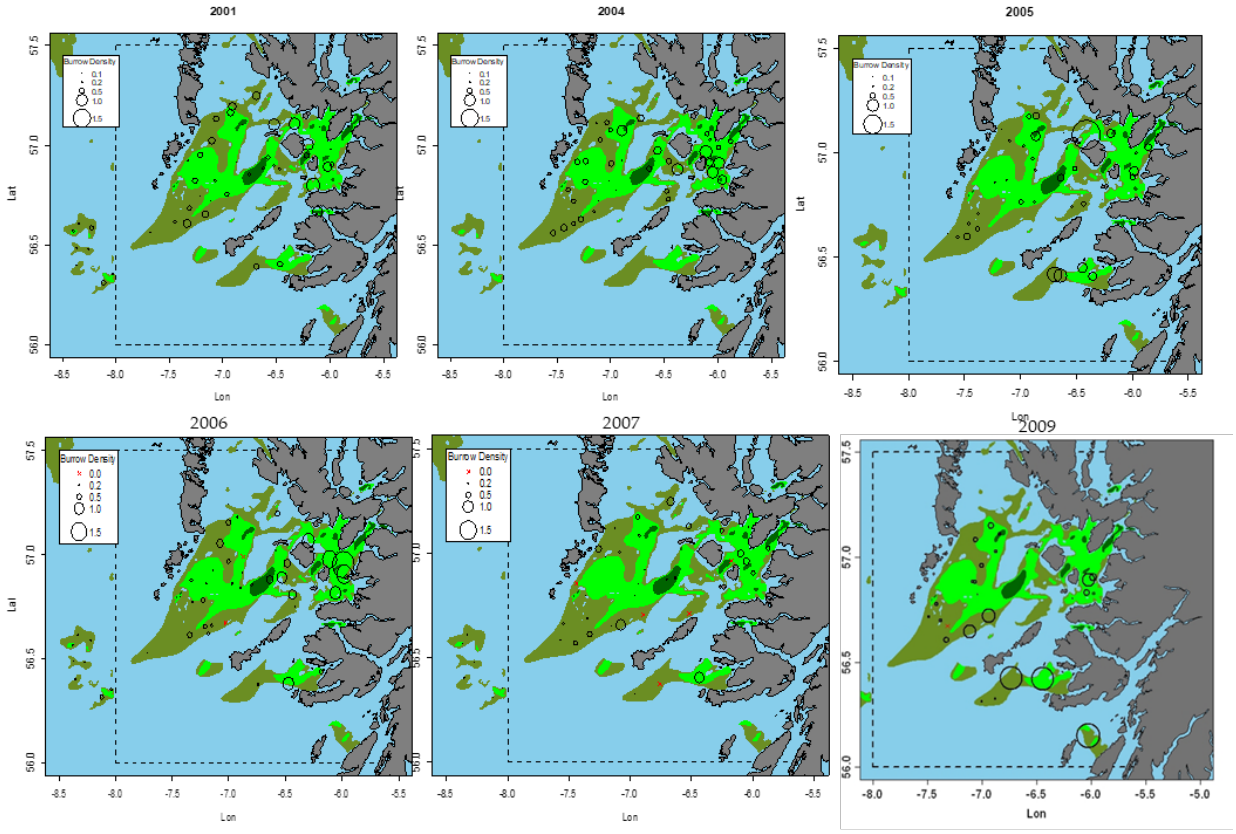



**Fig. 1b: South Minch (FU 12). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

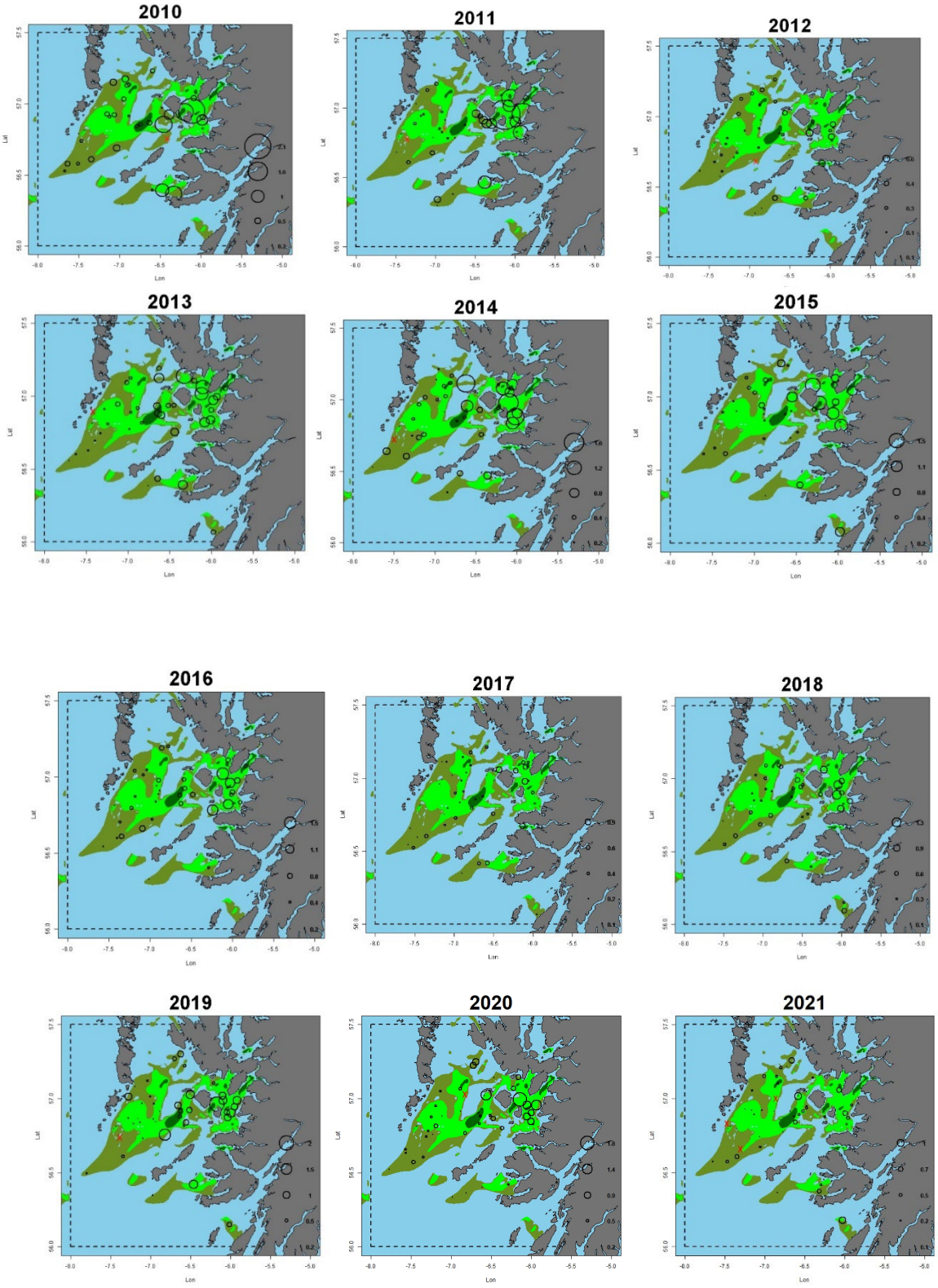



**Fig. 1c: South Minch (FU 12). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

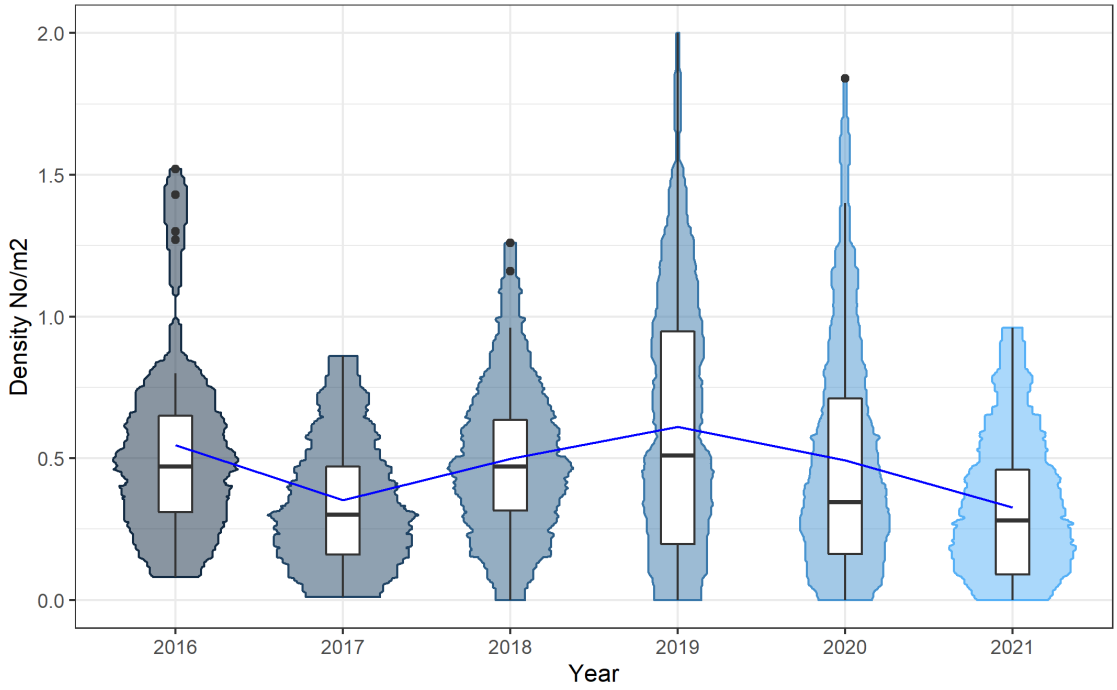



**Fig. 2: South Minch (FU 12). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **13** | **Area name** | **Clyde** |
|---|---|---|---|
| Survey design | Stratified Random | Previous surveys | 1995-2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1995 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | Planned – 43<br>Completed – 45<br>Used in analysis - 41 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in no trawling. Sledge redeployments resulted in an increase on the planned number of stations. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.68 | Adjusted abundance, CV | 1414 mill., CV = 0.072 |
| Overall footage quality (poor, medium, good) | | Medium | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** – WGCSE |
| | | CTD | No |

| | | |
|---|---|---|
| | Trawl | No |
| | Sediment | Yes |
| | Other | **Seapen, marine litter, fauna data, Cruise Summary Report:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments.<br>**Dissemination** – where applicable WGCSE, British Oceanographic Data Centre (BODC) and MSFD |

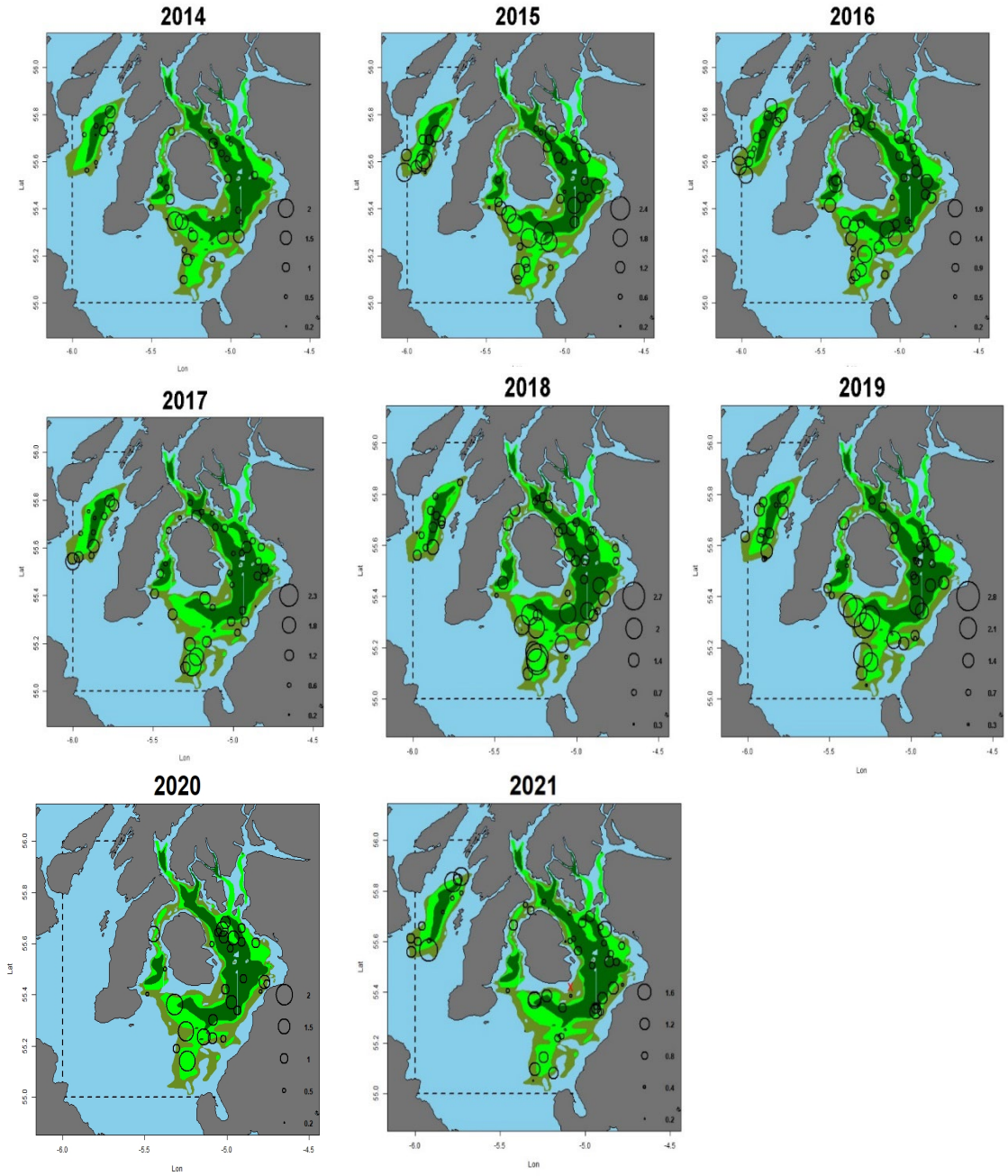



**Fig. 1: Clyde and Jura (FU13) density map by station for each year presented.**

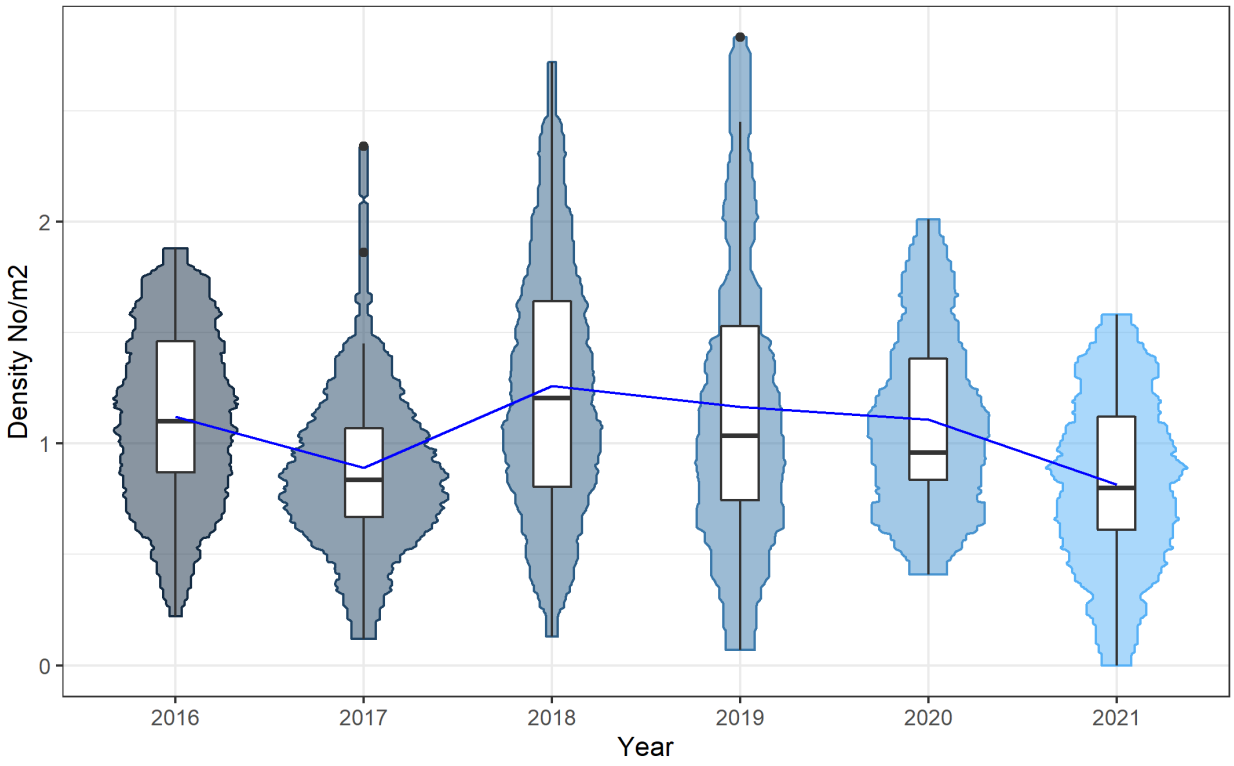



**Fig. 2: FU 13 Clyde. Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **7** | **Area name** | **Fladen** |
|---|---|---|---|
| Survey design | Stratified Random | Previous surveys | 1992-95, 1997-2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1992 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | NA |
| Number of stations (planned/completed/used in analysis) | | Planned – 70<br>Completed – 70<br>Used in analysis - 70 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in reduced trawling. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.225 | Adjusted abundance, CV | 6336 mill., CV = 0.052 |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.7 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** - WGNSSK |
| | | CTD | No |

| | | |
|---|---|---|
| | Trawl | Yes |
| | Sediment | Yes |
| | Other | **Seapen, fauna data, Cruise Summary Report, review footage for MarynSol:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments.<br>**Dissemination** – where applicable WGNSSK, British Oceanographic Data Centre (BODC), Marynsol contractors, Marine Scotland Science, and MSFD |

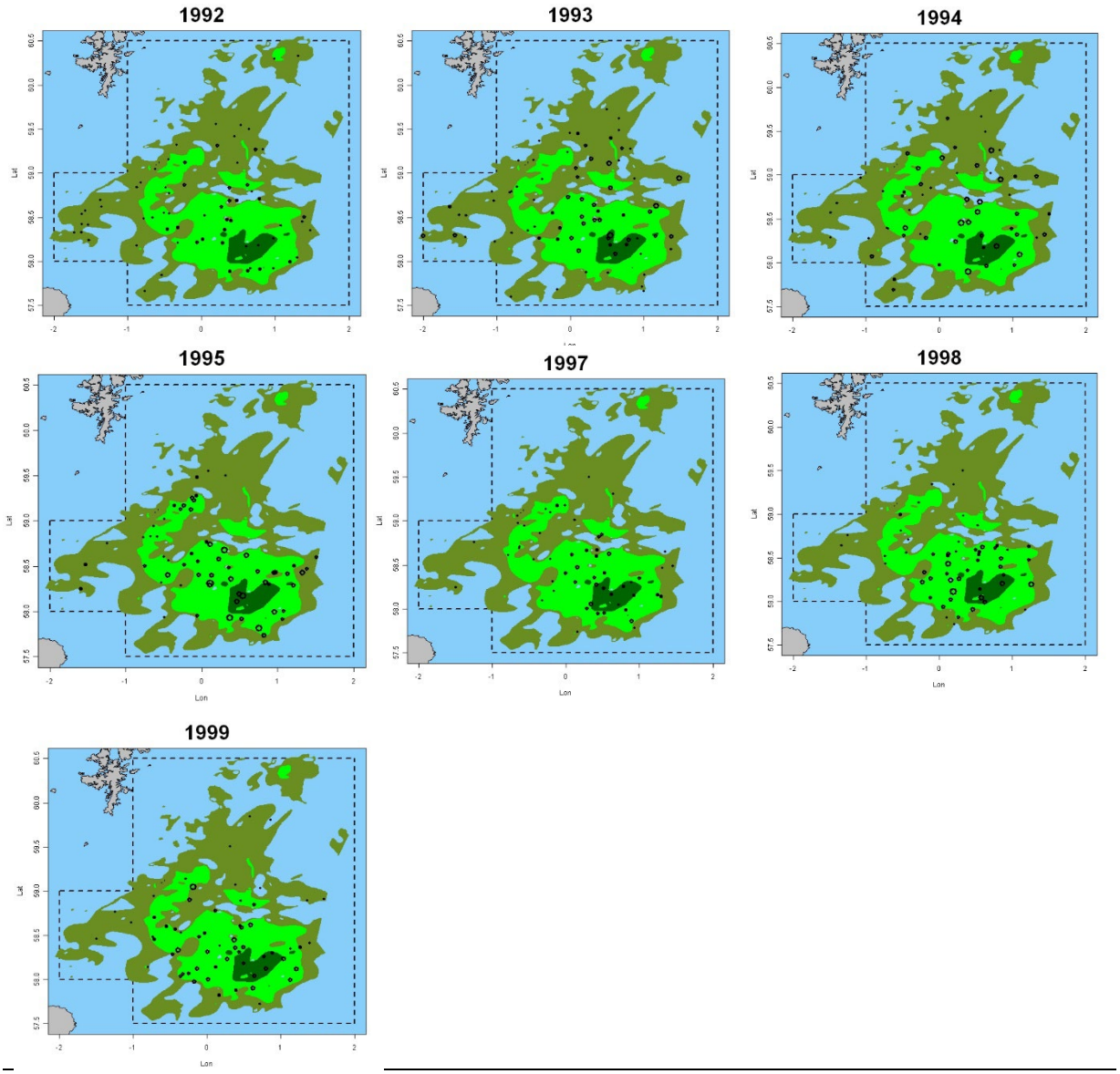



**Fig. 1a: Fladen (FU 7). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

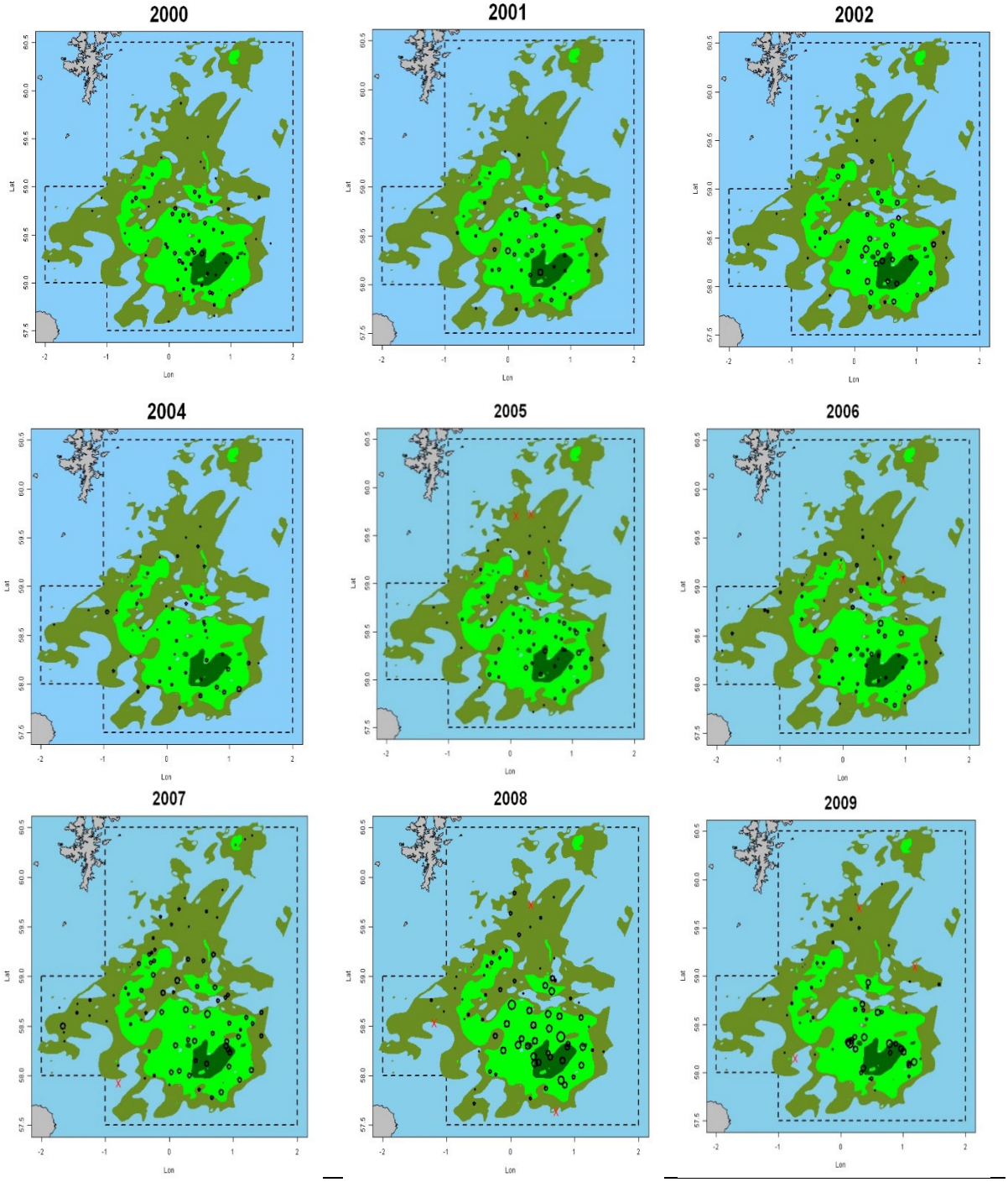



**Fig. 1b: Fladen (FU 7). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

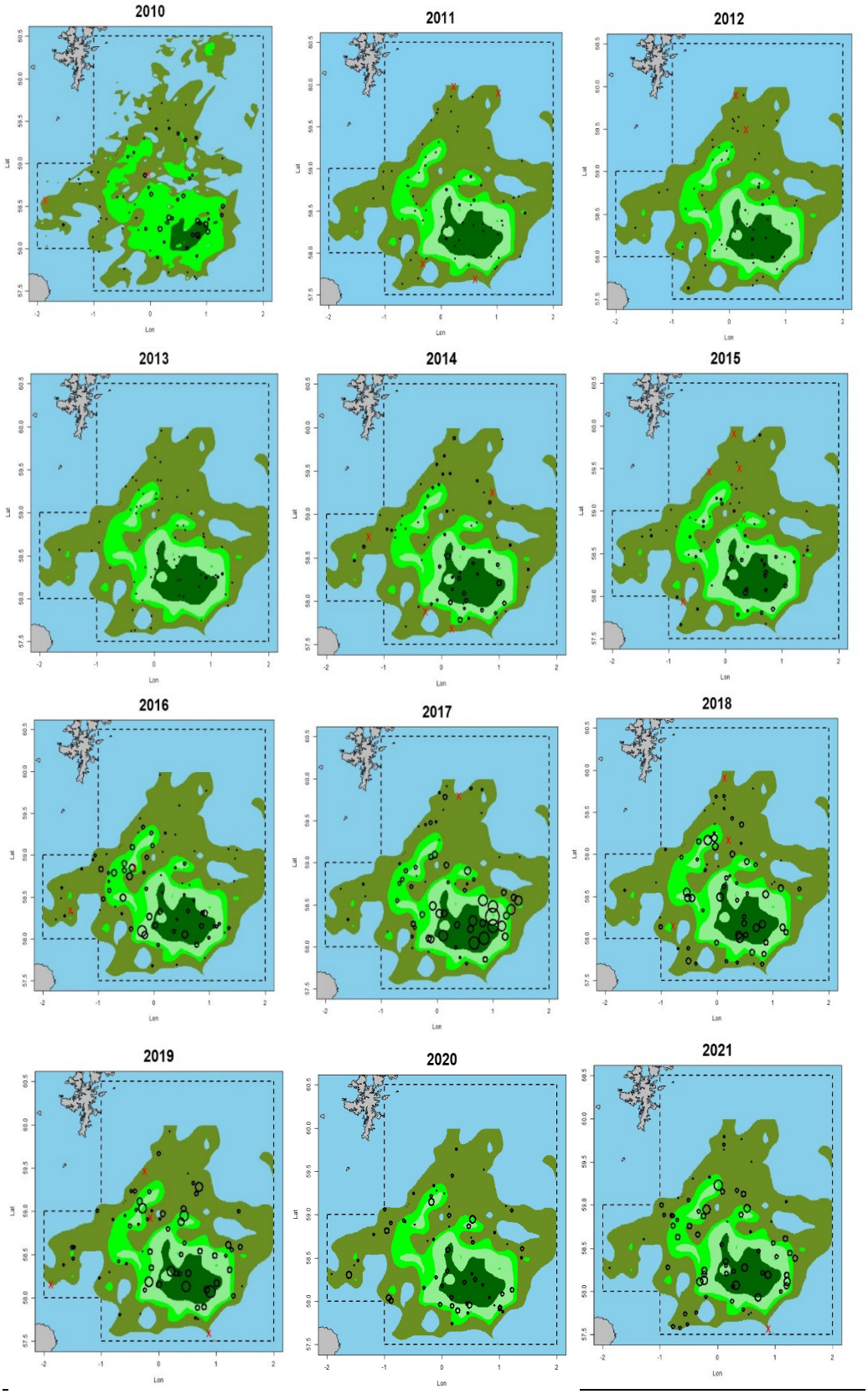



**Fig. 1c: Fladen (FU 7). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

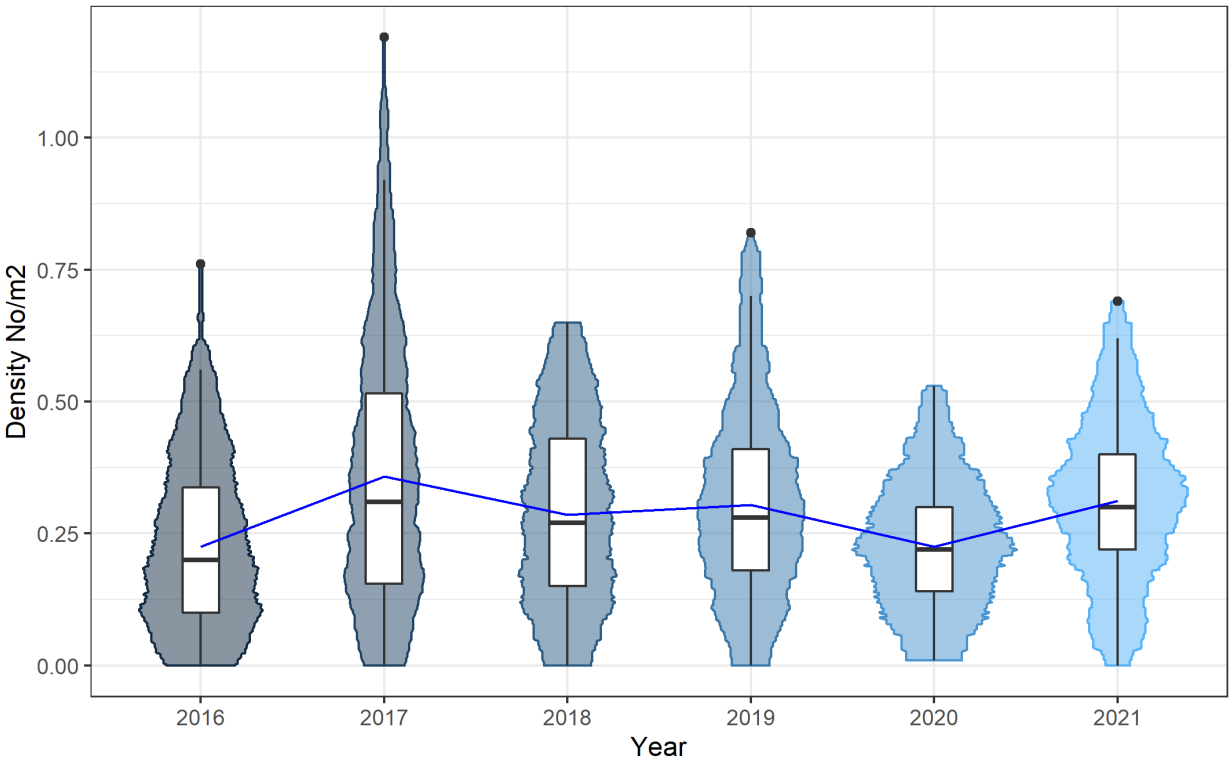



**Fig. 2: Fladen (FU 7). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| | | | |
|---|---|---|---|
| **Functional Unit** | **8** | **Area name** | **Firth of Forth** |
| Survey design | Stratified Random | Previous surveys | 1993-94, 1996, 1998-2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1993 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | Planned – 45<br>Completed – 49<br>Used in analysis - 42 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in reduced trawling. Sledge redeployments resulted in an increase on the planned number of stations. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.915 | Adjusted abundance, CV | 837 mill., CV = 0.064 |
| Overall footage quality (poor, medium, good) | | Medium | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** – WGNSSK |

| | | |
|---|---|---|
| | CTD | No |
| | Trawl | Yes |
| | Sediment | Yes |
| | Other | **Seapen, marine litter, fauna data, Cruise Summary Report:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments\agencies<br>**Dissemination** – where applicable: WGNSSK, British Oceanographic Data Centre (BODC), Marine Scotland Science and MSFD. |

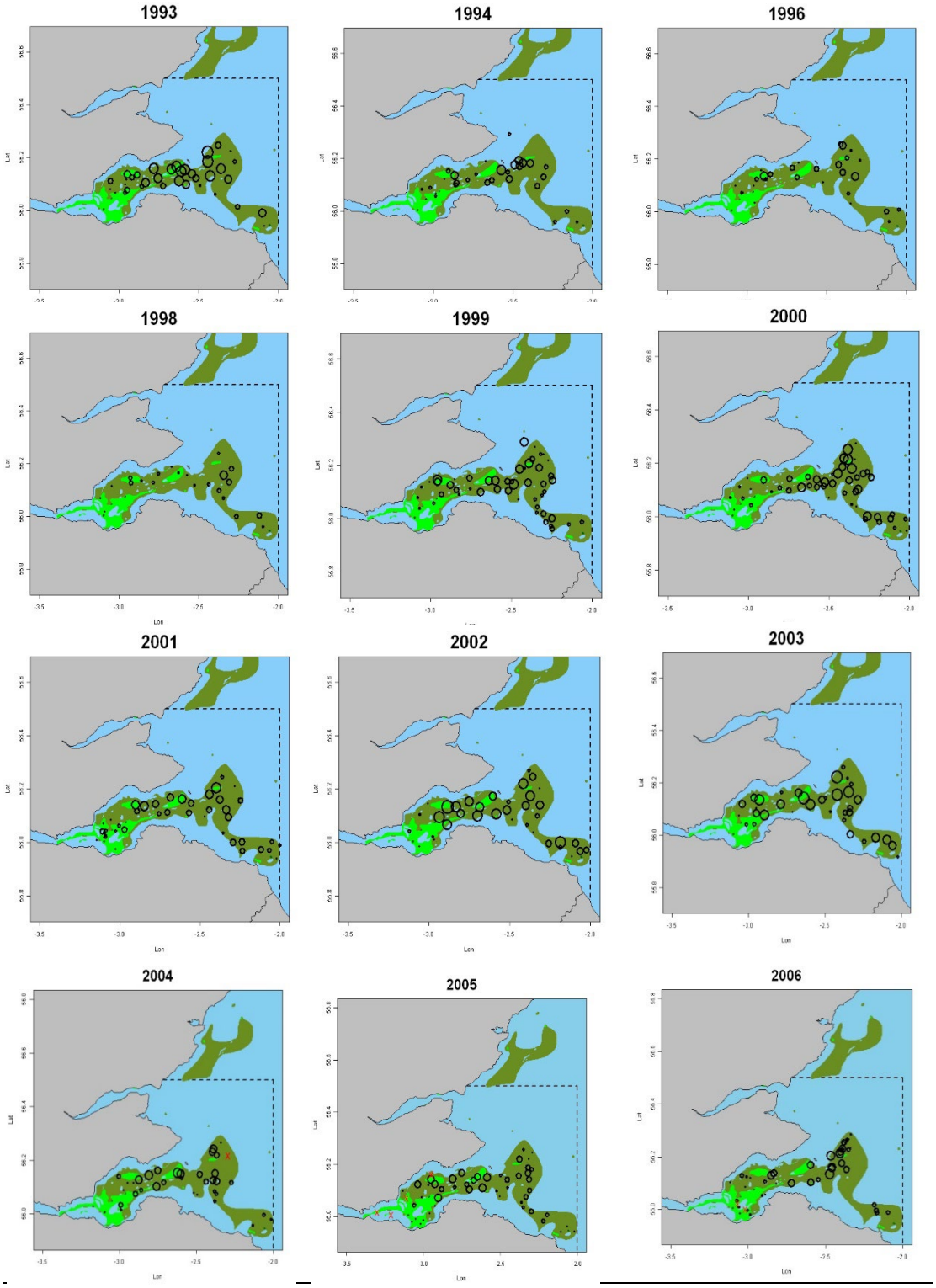



**Fig. 1a: Firth of Forth (FU 8). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

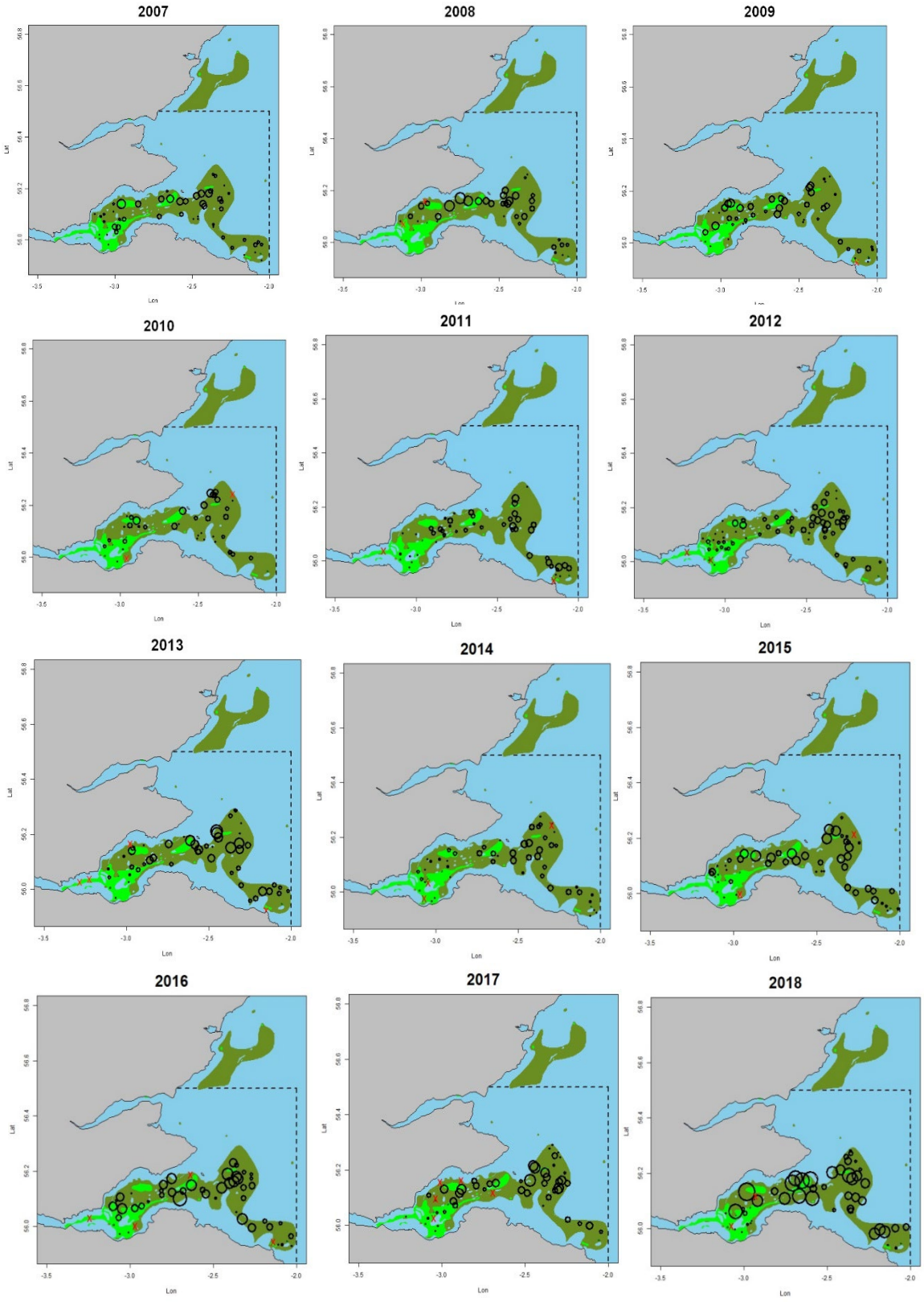



**Fig. 1b: Firth of Forth (FU 8). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

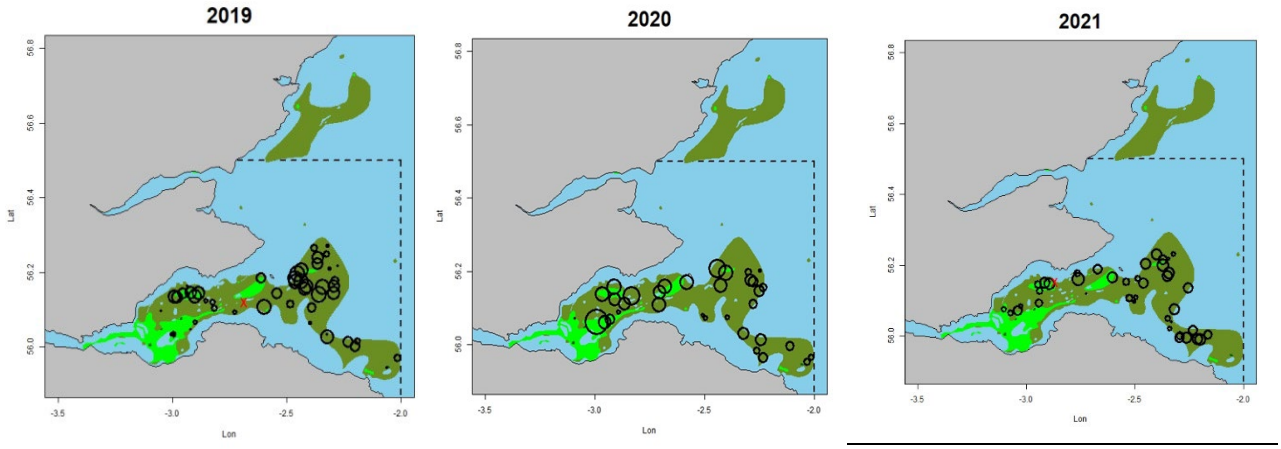



**Fig. 1c: Firth of Forth (FU 8). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

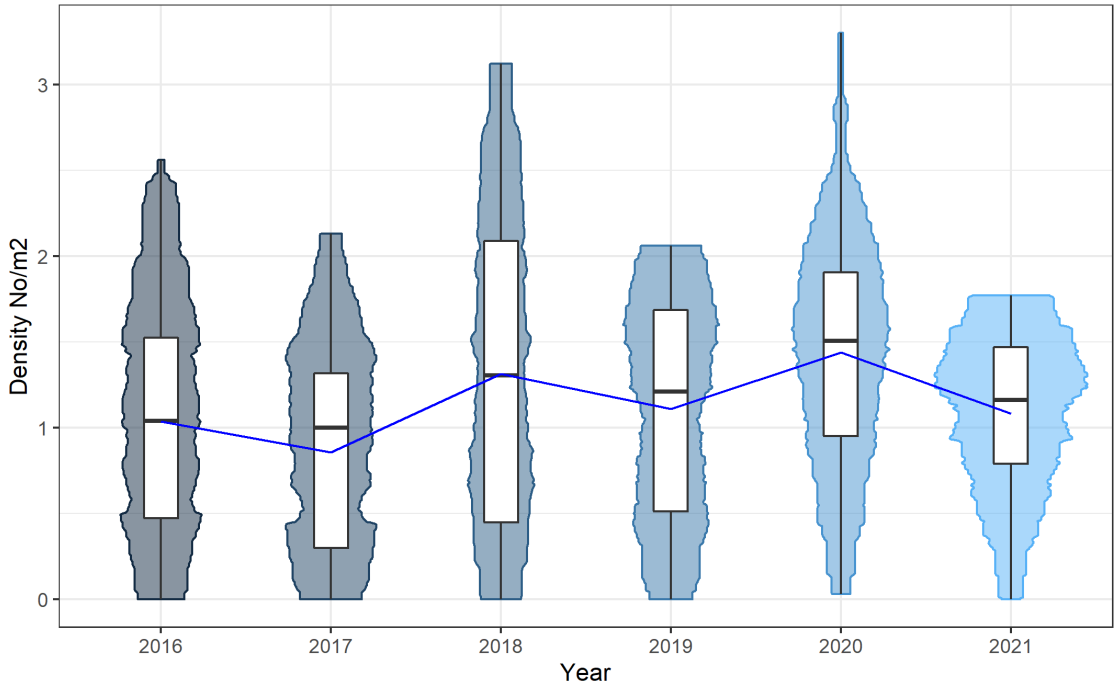



**Fig. 2: Firth of Forth (FU 8). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

| **Functional Unit** | **9** | **Area name** | **Moray Firth** |
|---|---|---|---|
| Survey design | Stratified Random | Previous surveys | 1993-94, 1996-2020 |
| Camera Type:<br>Standard / High definition | Standard definition since 1993 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Analogue, video, approx. 0.8GB per station |
| Country (ies) | Scotland, UK | Vessel name (s) | MRV Scotia |
| Survey code (s) | 0721S | Dates (start/end) | 28 May – 19 June 2021 |
| Number scientific staff | 7 | Staff exchanges | No |
| Number of stations (planned/completed/used in analysis) | | Planned – 45<br>Completed – 46<br>Used in analysis – 46 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | Impacted by COVID-19, reduced sea time in real terms as two annual surveys were merged with no additional days provided resulted in no trawling. Sledge redeployments resulted in an increase on the planned number of stations. | |
| Distance over ground source used | Odometer | Average field of view (cm) | 90cm |
| Adjusted mean density | 0.3 | Adjusted abundance, CV | 658 mill., CV = 0.124 |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count)<br>State Lin's CCC threshold | | Lin's CCC<br>Threshold – 0.5 | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, presence/absence sea-pen distribution etc.) | | Presence/absence and distribution of sea pens (by three main species) recorded; presence/absence trawl marks; trawl door marks; gadoids, flat fish, other fauna also recorded; comments on visibility and subjective ground type recorded; sediment samples taken; USBL and turbidity meter used throughout; trial of new HD system undertaken. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | **Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.**Level of analysis** – as required for ICES WG **Dissemination** – WGNSSK |
| | | CTD | No |

| | | |
|---|---|---|
| | Trawl | No |
| | Sediment | Yes |
| | Other | **Seapen, marine litter, fauna data, Cruise Summary Report:**<br>**Storage** – hard copies of data held in office environment; electronic data stored locally and on local network drive, backed up daily to the server.<br>**Level of analysis** – carried out by other departments\agencies<br>**Dissemination** – where applicable: WGNSSK, British Oceanographic Data Centre (BODC), Marine Scotland Science and MSFD. |

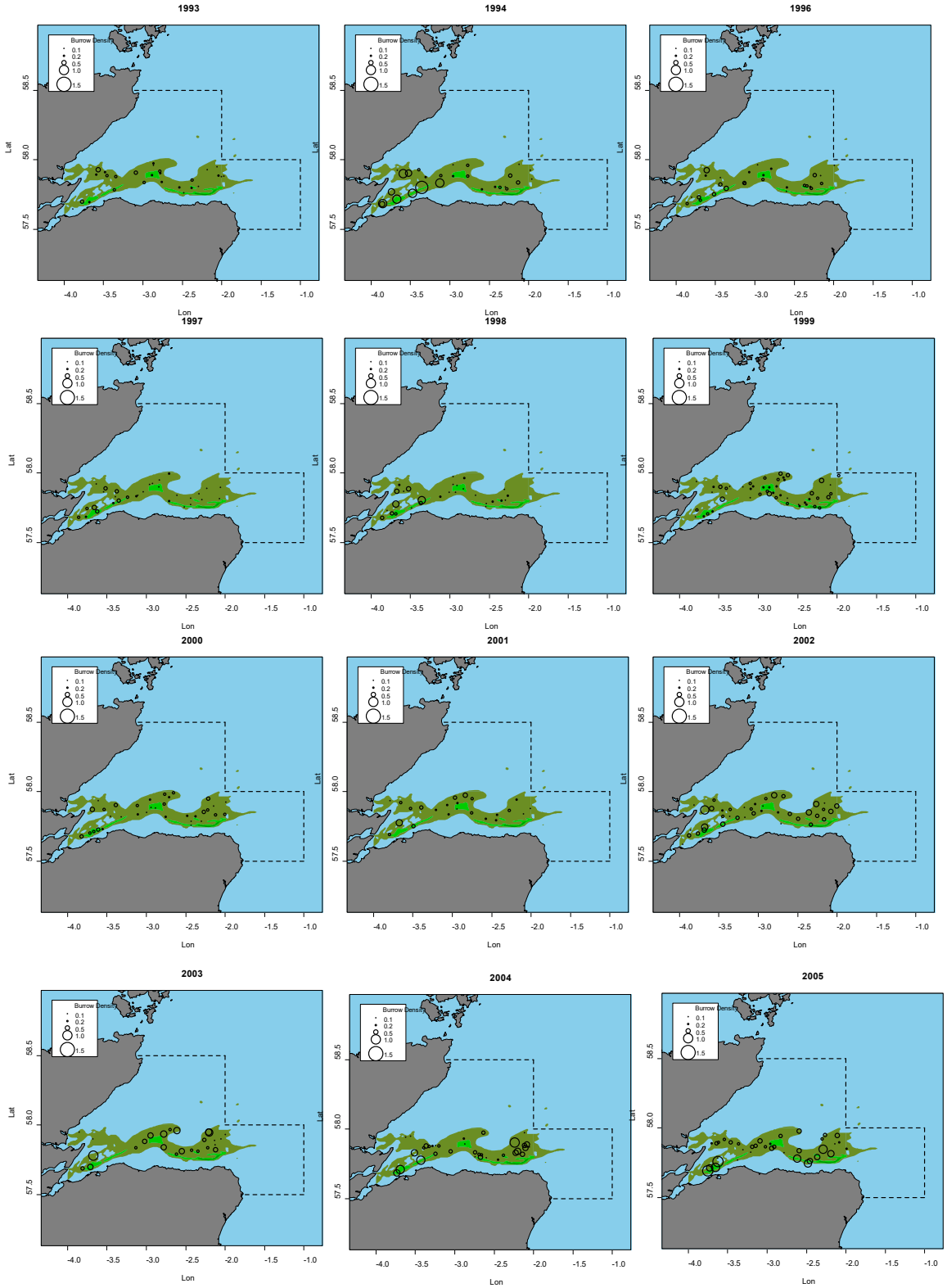



**Fig. 1a: Moray Firth (FU 9). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

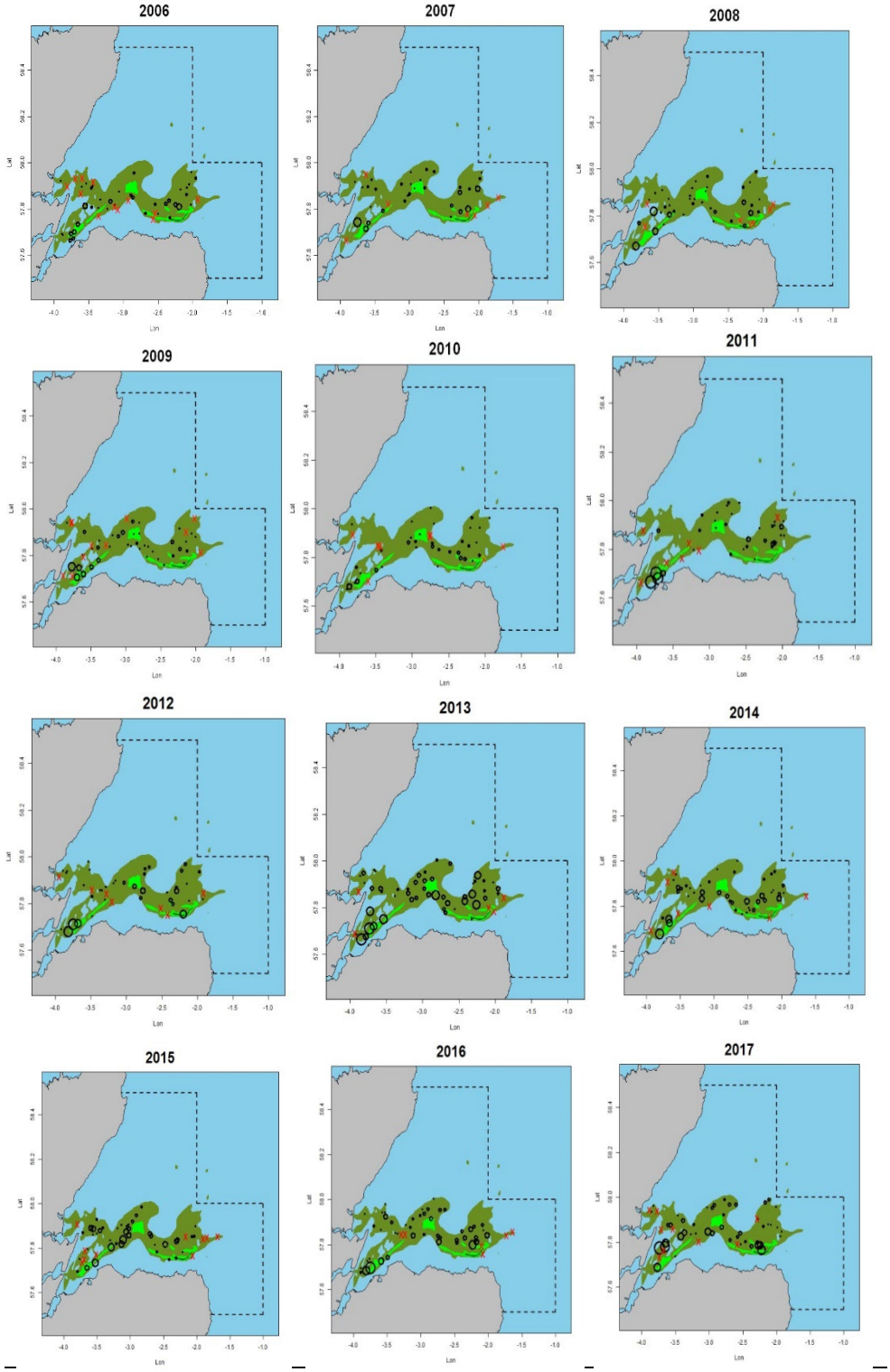



**Fig. 1b: Moray Firth (FU 9). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

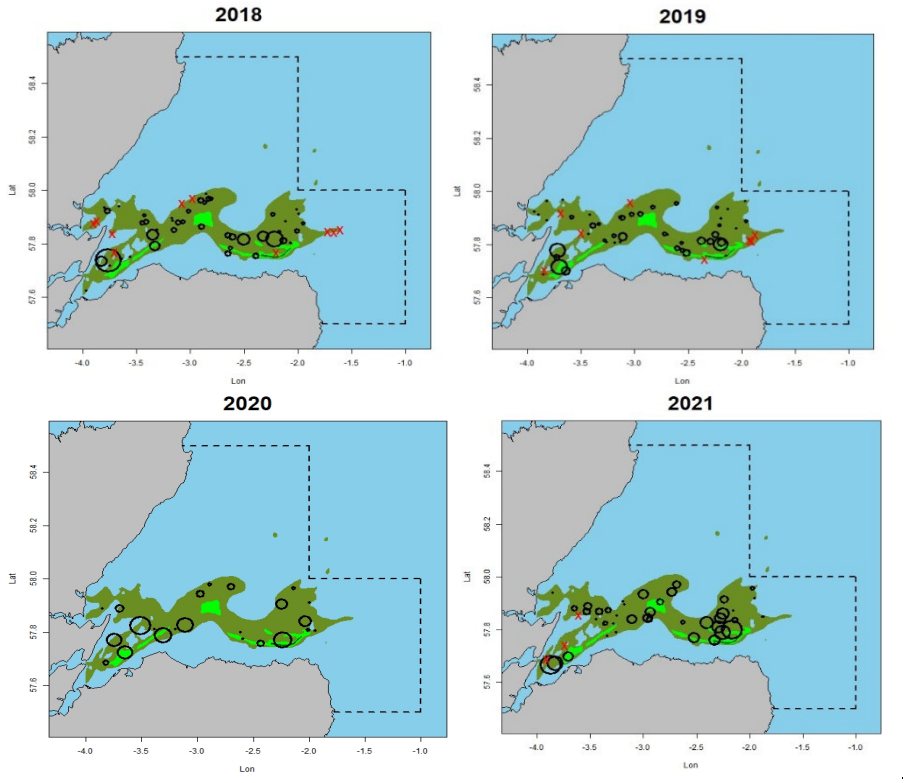



**Fig. 1c: Moray Firth (FU 9). UWTV survey distribution and relative density for all years surveyed. Density proportional to circle radius.**

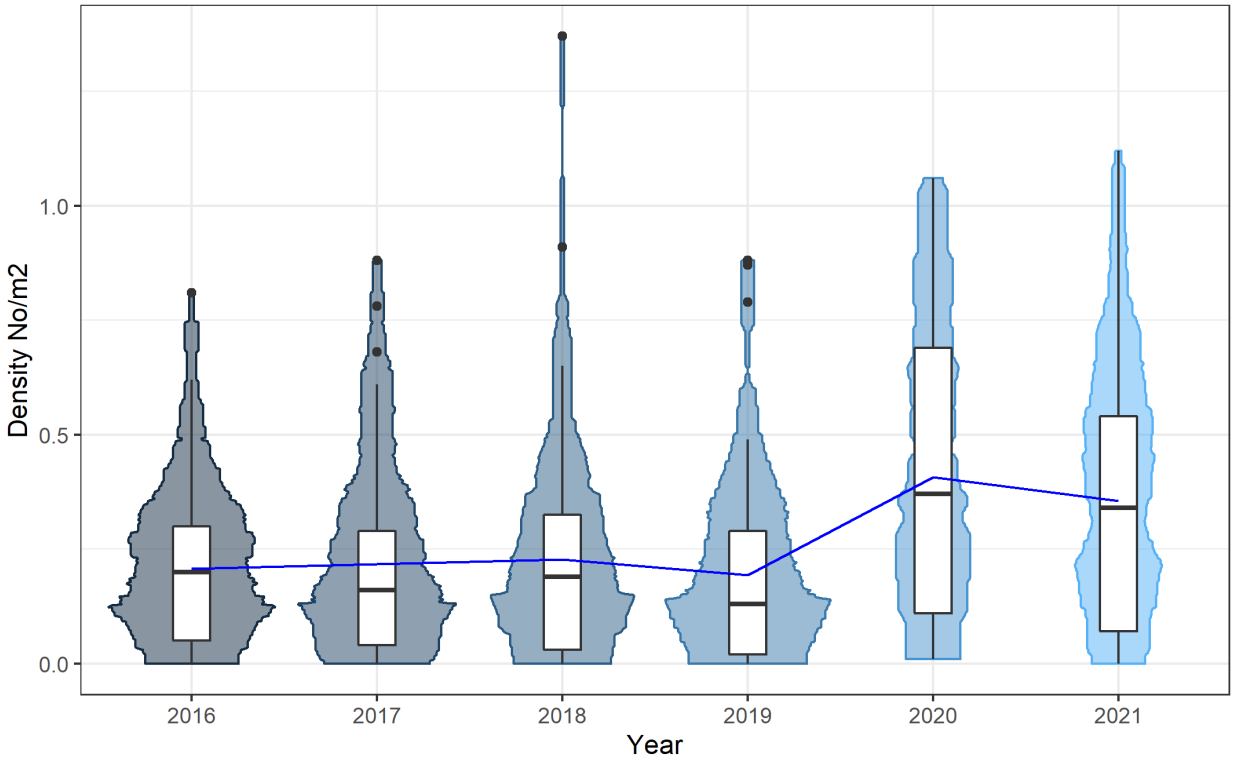



**Fig. 2: Moray Firth (FU 9). Times series of adjusted burrow density (Violin and box plot). The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

## UK England FU 6 and FU 14

Chris Firmin

| **Functional Unit** | **6** | **Area name** | **Farn Deeps** |
|---|---|---|---|
| Survey design | fixed | Previous surveys | 1997, 1999, 2002 - present |
| Format (HD / SD)<br>(from year)<br>(video / stills)<br>(resolution) | HD video<br>(from 2020)<br>1920 x 1080 | | |
| Country (ies) | UK (E) | Vessel name (s) | Endeavour |
| | | | |
| Survey code (s) | U8672 | Dates (start/end) | 21/5/2021 |
| | | | 28/5/2021 |
| Number scientific staff | 7 | Staff exchanges | None |
| | | | |
| Number of stations<br>(planned/completed/used in analysis) | | 110/110/110 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | 10 stations repeated due to visibility; 10 stations surveyed with IP camera after broken fibre-optic termination | |
| Distance over ground source used | dGPS Ship's Position | Average field of view (cm) | 82 |
| Adjusted mean density | 0.31 | Adjusted abundance, CV | 982 million<br>2% (22 million) |
| Overall footage quality (poor, medium, good) | | good | |
| Reference footage for survey area generated | | 2020 | |
| Quality control of station counts (Lin's CCC or consensus count) | | CCC to 3rd then consensus | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Single calibration dip of CTD; Salinity, temperature and turbidity recorded by logger each station; notes made of trawl marks, basic ground type and presence / absence of macrofauna | |

| | | |
|---|---|---|
| Data storage, level of analysis and dissemination (by data type) | Nephrops burrow counts | Footage stored as mp4 on 2 HDDs. Station, count and observation data on in-house Access DB.<br>Processing of station, count and ship dGPS data in R; analysis in R geostats |
| | CTD | Single deployment at start of survey, stored as .csv |
| | Trawl | No |
| | Sediment | No |
| | Other | Environmental data (salinity, temperature, turbidity) , navigation (dGPS ship / USBL sledge position, time, depth) files stored as .csvs |

**Table 1: UWTV Summary FU 6.**

| Year | Number of Stations (used in the analysis) | Abundance adjusted estimate (millions of burrows) | CV on Burrow estimate % |
|---|---|---|---|
| 1997 | 87 | 1500 | 4.3 |
| 1998 | 91 | 1090 | 4.2 |
| 1999 | - | - | - |
| 2000 | - | - | - |
| 2001 | 180 | 1685 | 2.0 |
| 2002 | 37 | 1048 | 5.5 |
| 2003 | 73 | 1085 | 4.2 |
| 2004 | 76 | 1377 | 3.7 |
| 2005 | 105 | 1657 | 4.6 |
| 2006 | 105 | 1244 | 4.7 |
| 2007 | 105 | 858 | 1.4 |
| 2008 | 95 | 987 | 2.0 |
| 2009 | 76 | 682 | 2.8 |
| 2010 | 95 | 785 | 1.4 |
| 2011 | 97 | 878 | 1.0 |
| 2012 | 97 | 758 | 0.9 |
| 2013 | 110 | 706 | 1.3 |
| 2014 | 110 | 755 | 0.9 |
| 2015 | 110 | 568 | 1.3 |
| 2016 | 110 | 697 | 1.2 |
| 2017 | 110 | 909 | 1.4 |
| 2018 | 109 | 950 | 1.2 |
| 2019 | 91 | 1163 | 1.2 |
| 2020 | 110 | 1102 | 1.1 |
| 2021 | 110 | 982 | 2.2 |

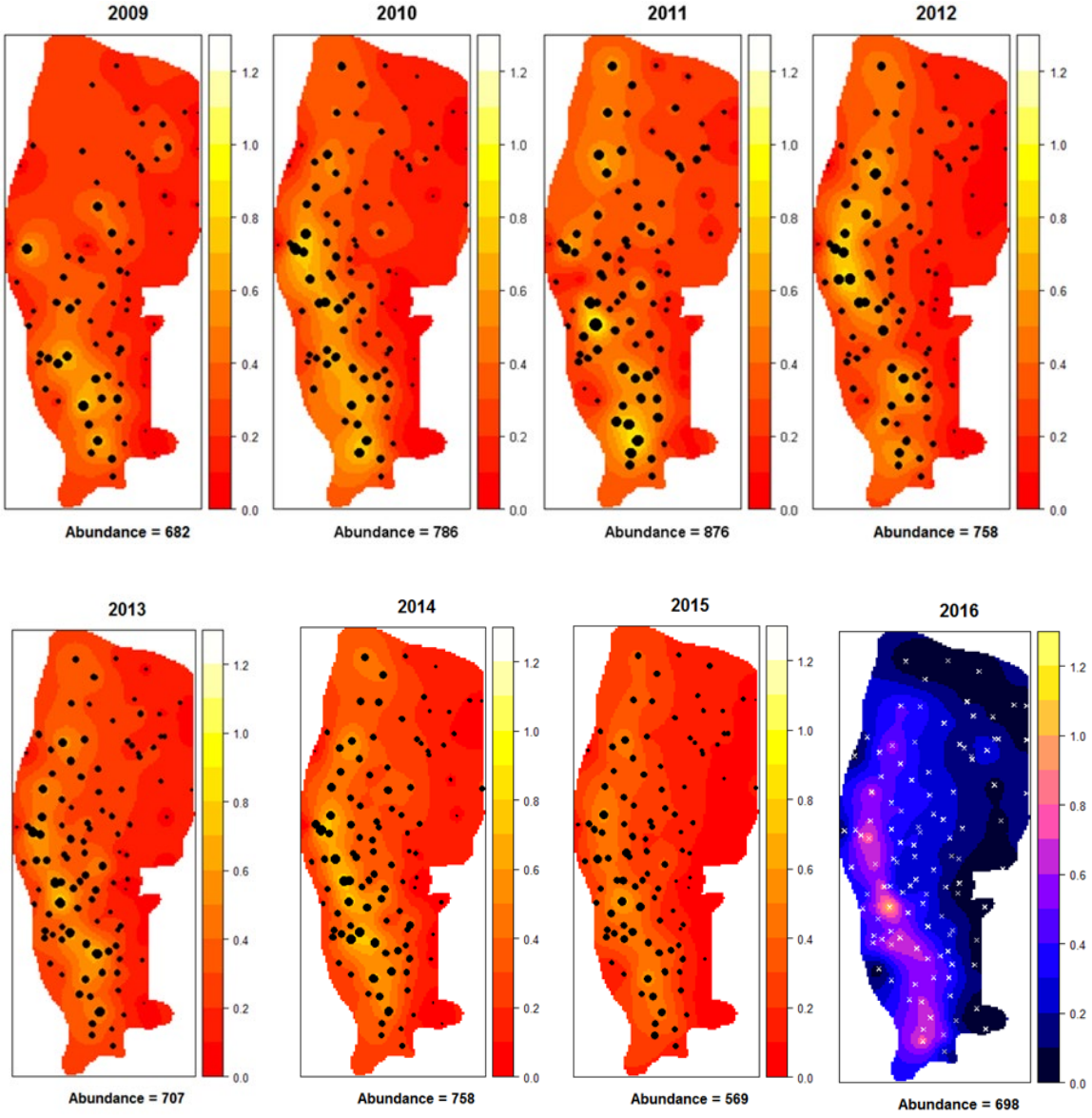



**Figure 1a: FU 6 Map of density by station for each year.**

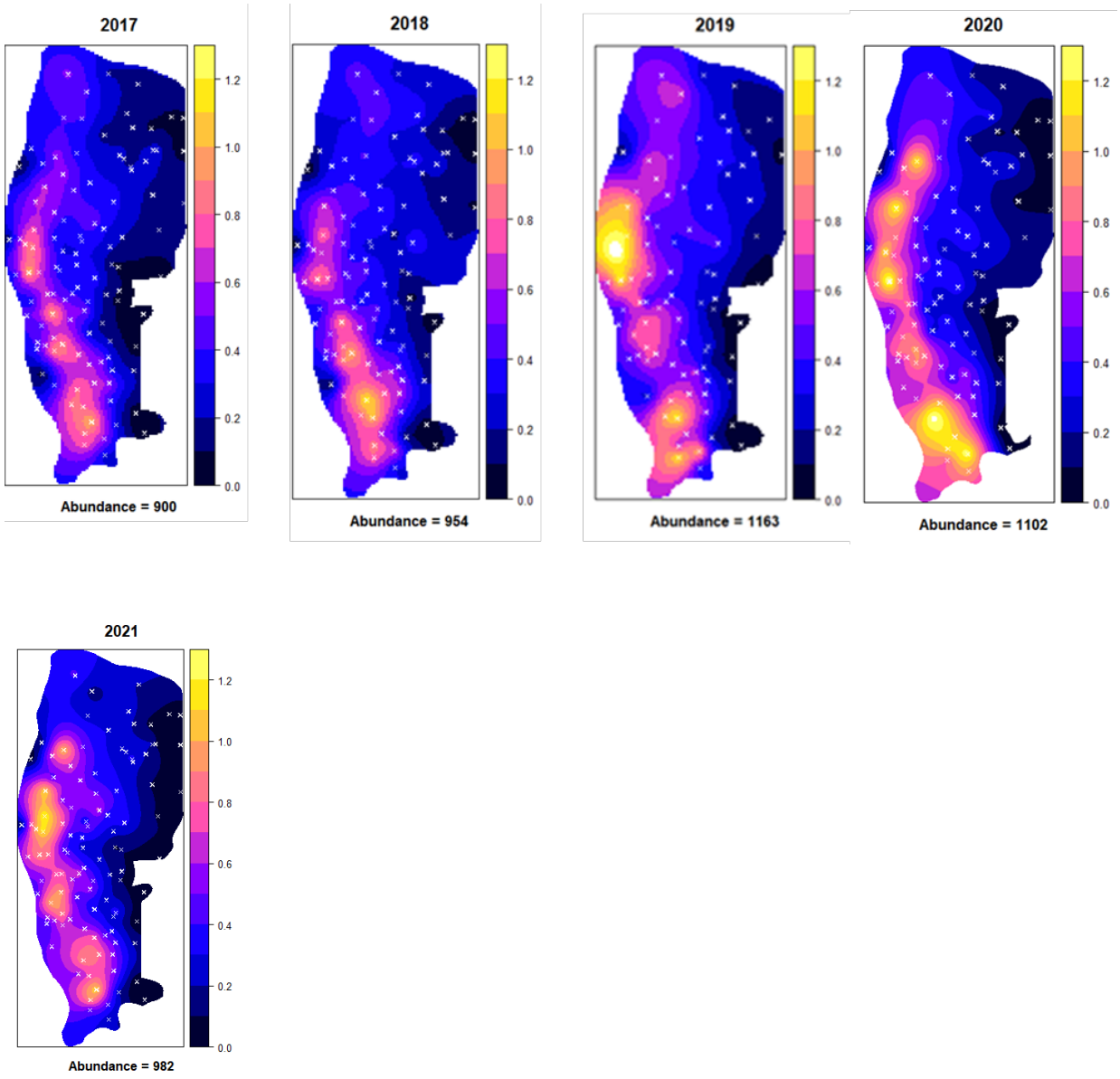



**Figure 1b: FU 6 Map of density by station for each year.**

| **Functional Unit** | **14** | **Area name** | **East Irish Sea** |
|---|---|---|---|
| Survey design | fixed | Previous surveys | 2008 to present |
| Format (HD / SD)<br>(from year)<br>(video / stills)<br>(resolution) | SD video (to 2020)<br>720 x 576<br>HD stills (from 2020)<br>1920 x 1080 @12.5fps | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Digital stills<br>~350KB per still<br>~2.7GB per station |
| Country (ies) | UK (NI) | Vessel name (s) | Corystes |
| Survey code (s) | U3016 | Dates (start/end) | 30/7/2021<br>1/8/2021 |
| Number scientific staff | 6 | Staff exchanges | None |
| Number of stations<br>(planned/completed/used in analysis) | | 48/44/44 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | 4 stations not surveyable due to presence of wind turbine installations | |
| Distance over ground source used | USBL | Average field of view (cm) | 62 |
| Adjusted mean density | 0.36 | Adjusted abundance, CV | 393 million (including Wigtown Bay<br>10% (78 million) |
| Overall footage quality (poor, medium, good) | | good | |
| Reference footage for survey area generated | | For 2021 using FU15 footage | |
| Quality control of station counts (Lin's CCC or consensus count) | | CCC (0.5 threshold) | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | CTD on sledge (data not collected every haul) | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | Footage stored as mp4 on 2 HDDs. Station, count and observation data on in-house Access DB. Environmental data and nav files stored as .csvs<br>Processing of station, count and nav file data in R; analysis in R geostats |
| | | CTD | Not retained |
| | | Trawl | No |

| | | |
|---|---|---|
| | Sediment | No |
| | Other | (dGPS ship / USBL sledge position, time, depth) files stored as .csvs. |

**Table 1: FU 14 UWTV Summary.**

| **Year** | **Number of Stations (used in the analysis)** | **Abundance adjusted estimate (millions of burrows)** | **CV on Burrow estimate** % |
|---|---|---|---|
| 2007 | - | - | - |
| 2008 | 32 | 407 | - |
| 2009 | 32 | 350 | - |
| 2010 | 26 | 422 | - |
| 2011 | 26 | 449 | 11.8 |
| 2012 | 26 | 693 | 7.8 |
| 2013 | 31 | 487 | 9.1 |
| 2014 | 34 | 449 | 10.7 |
| 2015 | 42 | 590 | 7.9 |
| 2016 | 48 | 429 | 12.6 |
| 2017 | 45 | 579 | 7.8 |
| 2018 | 46 | 513 | 12.6 |
| 2019 | 46 | 399 | 9.3 |
| 2020 | 43 | 496 | 8.6 |
| 2021 | 44 | 393 | 10.1 |

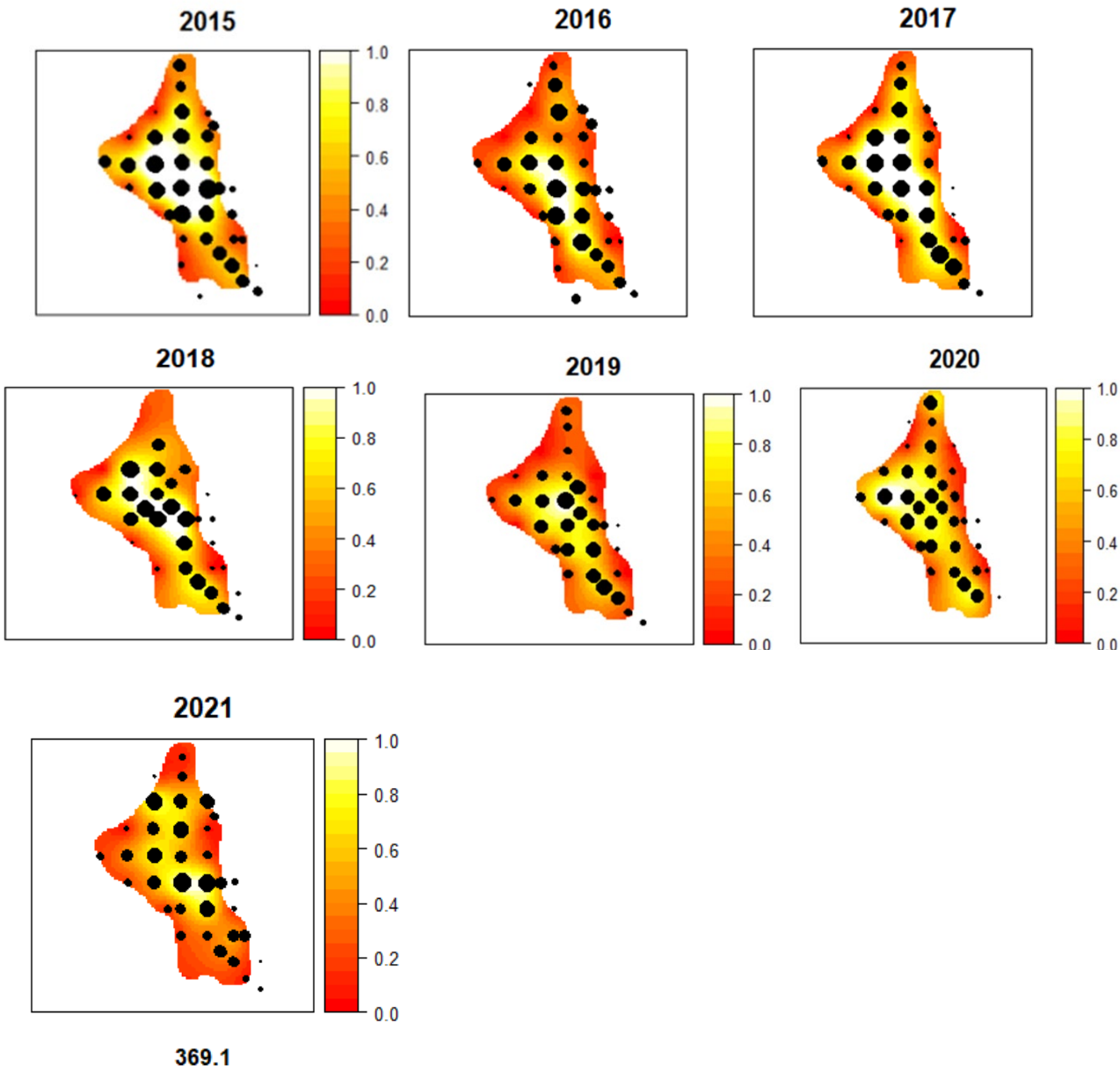



**Figure 1: FU 14 Map of density by station for each year.**

## Denmark and Sweden FU 3-4: Skagerrak and Kattegat

Kai Wieland and Patrik Jonsson

| **Functional Unit** | **FU 3&4** | **Area name** | **Skagerrak/Kattegat** |
|---|---|---|---|
| Survey design | Stratified random, with buffer since 2017 | Previous surveys | 2008-2010: DK only, exploratory<br>2011-2013: 6 strata<br>2014-2016: 7 strata<br>since 2017: 9 strata |
| Camera Type:<br>Standard / High definition | HD since 2017 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Video<br>appr. 1 GB per station |
| Country (ies) | Denmark and Sweden | Vessel name (s) | DK: RV Havfisken<br>SWE: RV Svea |
| Survey code (s) | UWTV3-4 | Dates (start/end) | DK: 8/4 and 10/4 - 15/4/2021<br>SWE: 22/4 - 29/4 2021 |
| Number scientific staff at sea | DK: 2<br>SWE: 5 | Staff exchanges | none |
| Number of stations (planned/completed/used in analysis) | | DK: 96 / 93 / 93<br>SWE: 95/95/79 (79 is a preliminary result), without creel area | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | DK: poor visibility at 3 stations<br>SWE: Extreme marine snow in southern Kattegat. | |
| Distance over ground source used | DK: Vessel GPS,<br>SWE: Vessel GPS | Average field of view (cm) | RV Havfisken: 69 cm<br>RV Svea: 81cm |
| Adjusted mean density | 0.24 burrows/m$^2$ | Adjusted abundance, CV | 3250 mill., 5.84 % |
| Overall footage quality (poor, medium, good) | | DK: medium<br>SWE: good in Skagerrak, poor in Kattegat | |
| Reference footage for survey area generated | | DK: yes (6 footages from 2018 survey), but yet no checked by external expert or a Swedish reader<br>SWE: still to come for the new system | |
| Quality control of station counts (Lin's CCC or consensus count) | | DK: Average from 2 readers for each station | |

| | | |
|---|---|---|
| | SWE: Preliminary average from 2 readers. Lin's CCC when critical stations have been read by international reader. | |
| 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 | |

2020 Swedish UWTV data not available at meeting due to COVID-19 disruption. This dataset will be analysed in 2021.

Future work

- Sweden to establish 6 reference footages from the 2020 survey
- Identify the most appropriate annotation tool for analyzing reference footages for both countries
- Swedish and Danish readers to count the 6 Danish references footage established from the 2018 survey and the 6 Swedish reference footages from the 2020 survey using an agreed annotation tool, and analyzing the results prior to work up the 2021 survey videos
- Report on Lin's CCC analyses together with the 2021 survey results to WGNEPS 2021 meeting

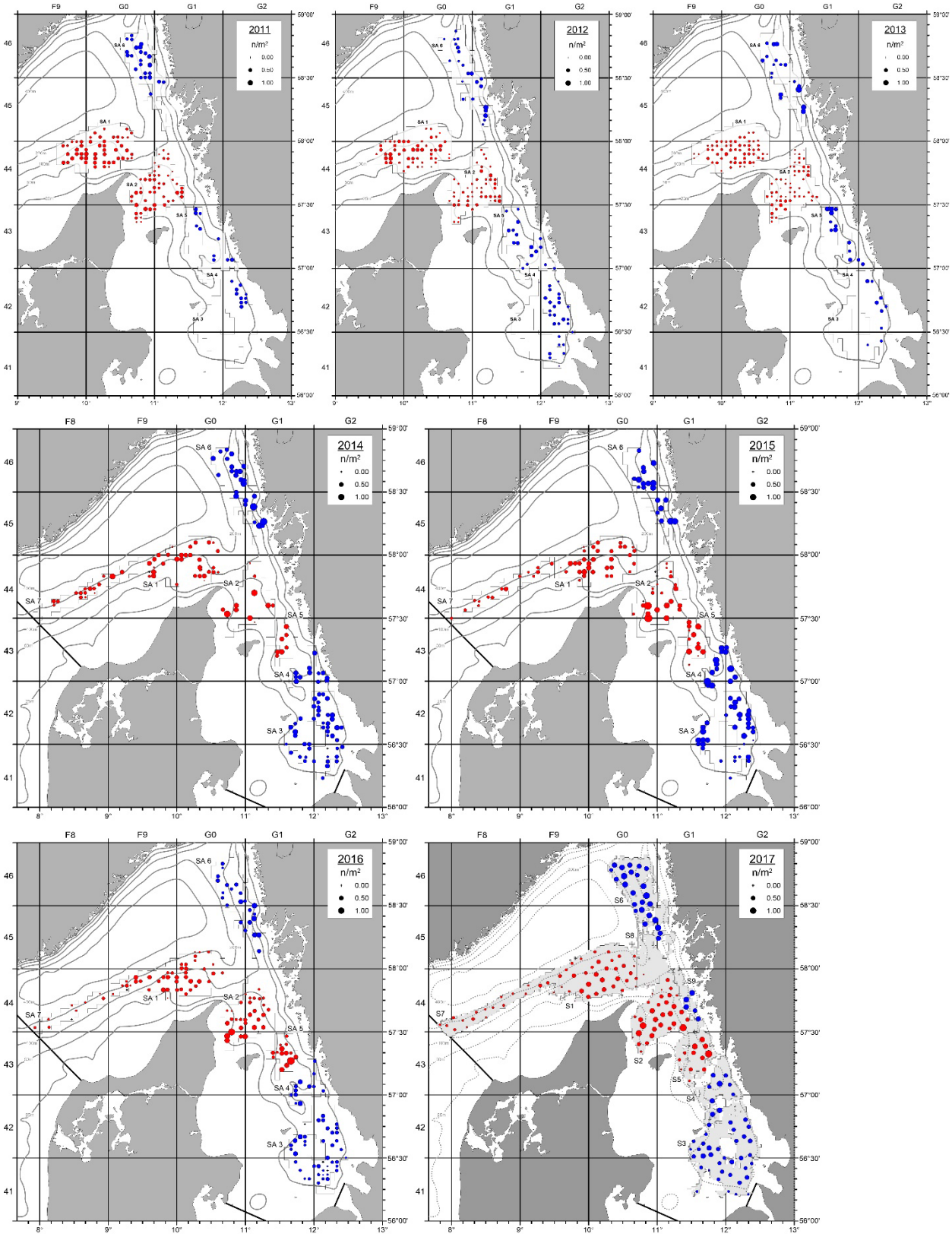



**Figure. 1a: FU 3&4 (Skagerrak/Kattegat) *Nephrops* burrow density by station 2011 - 2017 (red: DK, blue: SWE).**

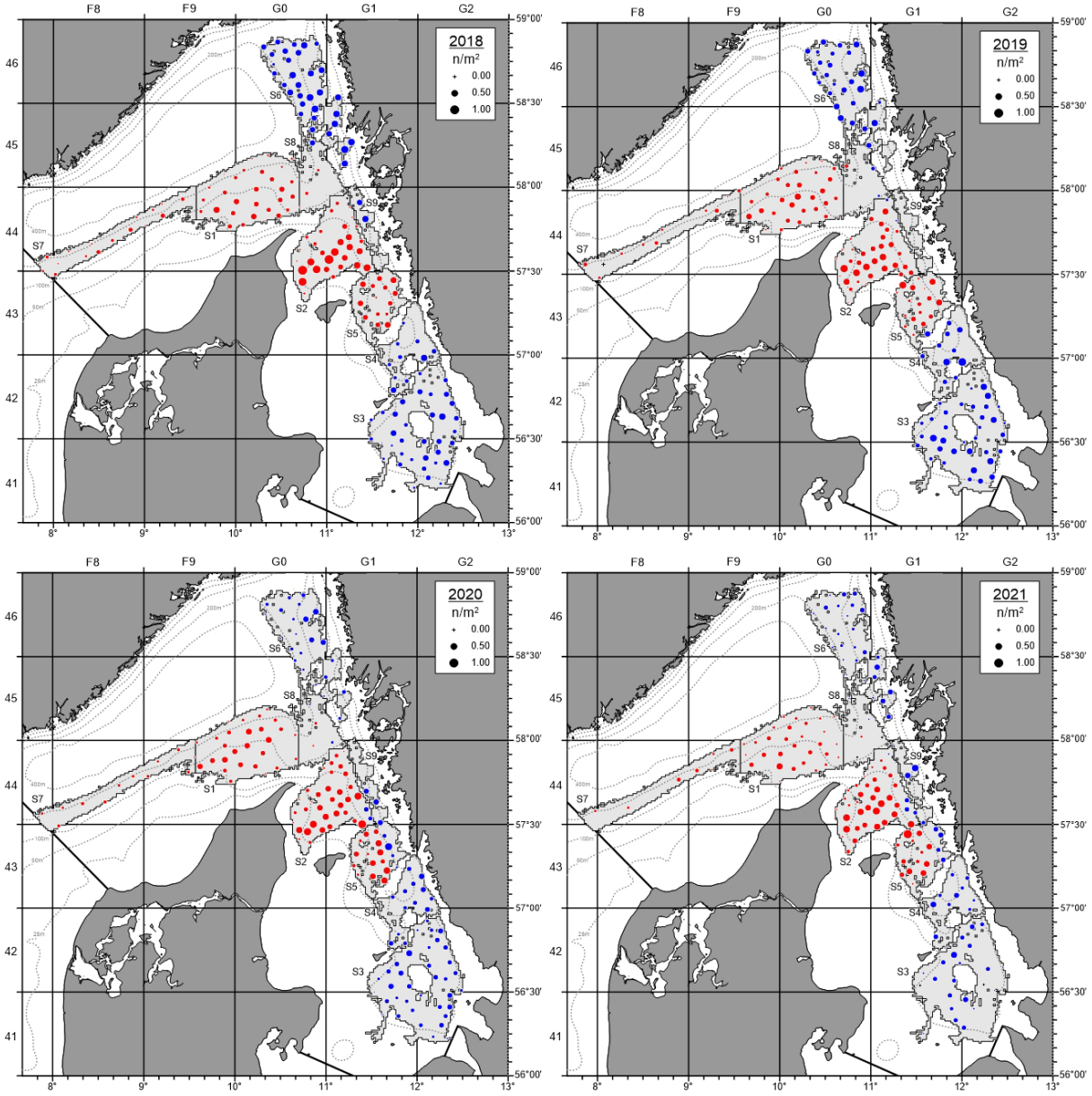



**Figure. 1b: FU 3&4 (Skagerrak/Kattegat) Nephrops burrow density by station 2018 - 2021 (red: DK, blue: SWE).**

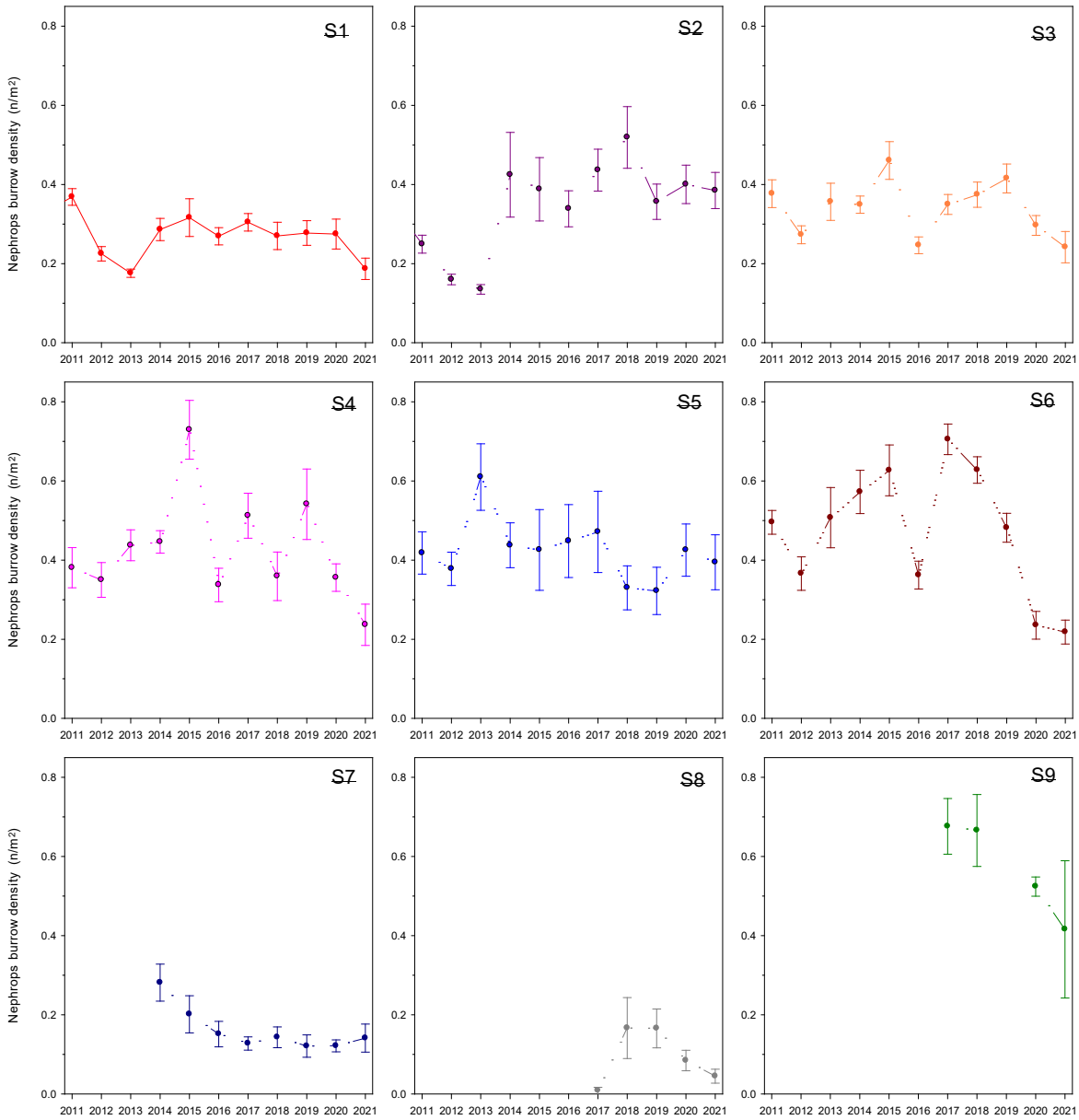



**Fig. 2: FU 3&4 (Skagerrak/Kattegat) time series of *Nephrops* burrow density by stratum (mean, standard error).**

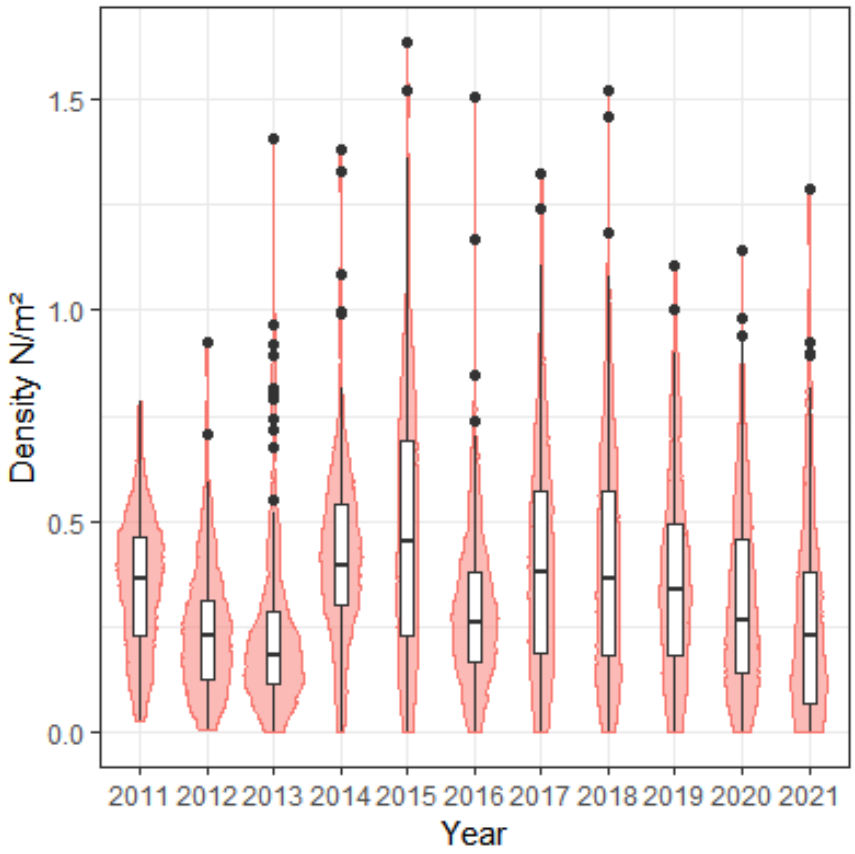



**Figure. 3: FU 3&4 (Skagerrak/Kattegat) times series of *Nephrops* burrow density (The horizontal lines represents the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).**

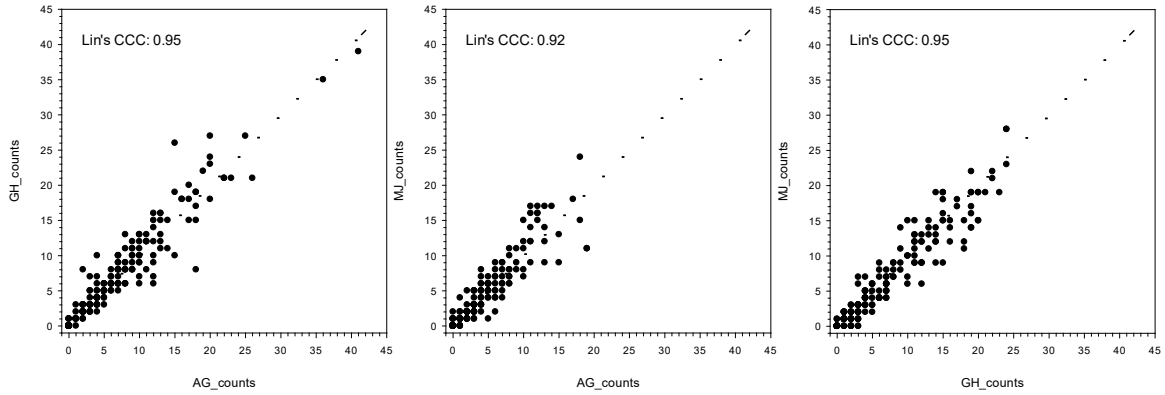



**Fig. 4: FU 3&4 (Skagerrak/Kattegat) Nephrops burrow count quality check with Lin's CCC values for Danish readings.**

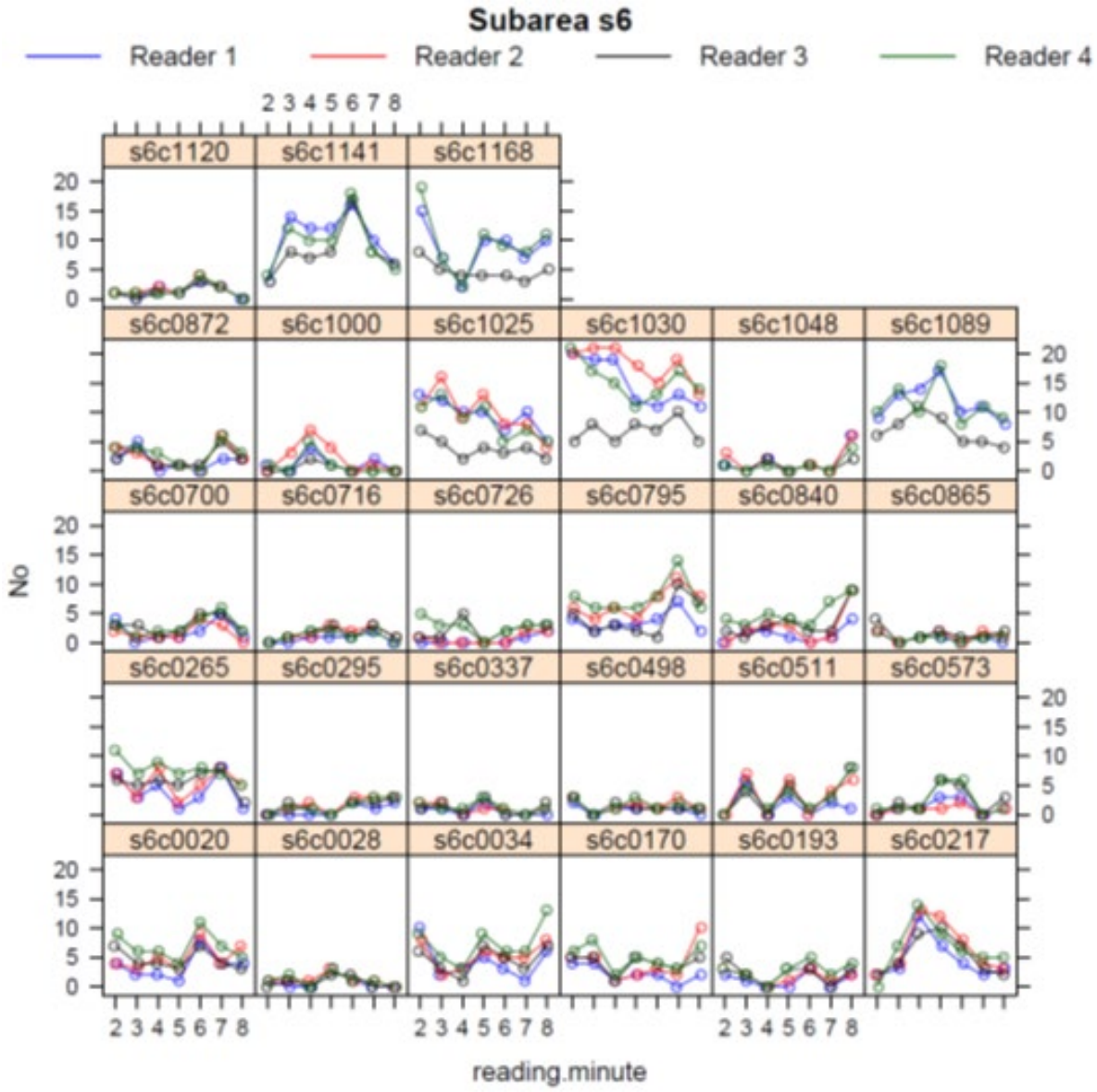



**Fig. 5: FU 3&4 (Skagerrak/Kattegat) comparison of Swedish readers – Examples for stratum 6.**

Future work

- Cross-reading of 6 stations from the Swedish 2021 survey by external and Danish readers in December 2021 / January 2022
- Identify the most appropriate annotation tool for analyzing reference footages for both countries
- Establish references footage set from recent surveys in which HD cameras were used, in total 9 stations, Swedish stations to be read by Danish readers (January 2022), and Danish reference footages to be read by Swedish readers and both to be read by external expert(s) (December 2021 / January 2022
- Revise survey 2021 data analysis prior to WGNSSK in spring 20022
- Report in detail on Lin's CCC analyses together with update of 2021 survey results to WGNEPS 2022 meeting

## Denmark FU 33: Off Horns Rev

Kai Wieland and Tiago Malta

| | | | |
|---|---|---|---|
| Functional Unit | FU 33 | Area name | Off Horns Rev |
| Survey design | Random with buffer, 1 stratum | Previous surveys | 2017-2019,<br>No survey scheduled for 2020 |
| Camera Type:<br>Standard / High definition | HD since 2019 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Video<br>Appr. 1 GB per station |
| Country (ies) | Denmark | Vessel name (s) | RV Havfisken |
| Survey code (s) | UWTV FU33 | Dates (start/end) | 30/4 - 8/5/2021 |
| Number scientific staff at sea | 2 | Staff exchanges | none |
| Number of stations (planned/completed/used in analysis) | | 80/80/28*<br>*: see Tab. 1 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | 48 stations not readable due to unusual poor visibility and/or technical problems with the camera setup,<br>4 stations did not pass Lin's CCC | |
| Distance over ground source used | Vessel GPS | Average field of view (cm) | 69 |
| Adjusted mean density | 0.2229<br>(se: 0.0274) | Adjusted abundance, CV | 1279 mill., 12.29 % |
| Overall footage quality (poor, medium, good) | | poor | |
| Reference footage for survey area generated | | Yes but not checked by an external expert | |
| Quality control of station counts (Lin's CCC or consensus count) | | Lin's CCC | |
| Other survey activities<br>(CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | 3 trawl hauls | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | Excel file, .csv file with R – output |
| | | CTD | |
| | | Trawl sample | Institute's database, processed |

| | |
|---|---|
| Other | Cruise Summary Report (CSR) submitted to German Oceanographic Data Centre |


**Fig. 1: FU 33 (Off Horns Rev) Counter comparison.**

**Tab. 1: FU 33 (Off Horns Rev) Results of Lin's CCC analysis (numbers in red: counter or station excluded from further analysis).**

| Station | Counter 1 x Counter 2 | Counter 1 x Counter 3 | Counter 2 x Counter 3 | Action |
|---|---|---|---|---|
| H1C0089 | 0.82 | 0.77 | 0.60 | |
| H1C0093 | 0.85 | 0.52 | 0.76 | |
| H1C0244 | | | 0.87 | |
| H1C0254 | | | 0.84 | |
| H1C0492 | 0.85 | 0.81 | 0.83 | |
| H1C0557 | 0.71 | | | |
| H1C0718 | 0.43 | 0.59 | 0.86 | Counter 2 removed |
| H1C0734 | | 0.83 | | |
| H1C0780 | | 0.55 | | |
| H1C0902 | | | 0.84 | |
| H1C1044 | | 0.89 | | |
| H1C1140 | 0.89 | | | |
| H1C1180 | | 0.70 | | |
| H1C1386 | | 0.82 | | |
| H1C1441 | 0.59 | | | |
| H1C1865 | | | 0.83 | |
| H1C1968 | | | 0.57 | |
| H1C2006 | | | 0.72 | |
| H1C2107 | | | 0.58 | |
| H1C2274 | 0.32 | 0.12 | 0.25 | Station discarded |
| H1C2327 | -0.07 | -0.11 | 0.22 | Station discarded |
| H1C2388 | 0.21 | 0.22 | 0.61 | Counter 1 removed |
| H1C2436 | -0.12 | 0.07 | 0.04 | Station discarded |
| H1C2453 | 0.85 | | | |
| H1C2502 | | | 0.59 | |
| H1C2564 | | | 0.82 | |
| H1C2602 | | 0.67 | | |
| H1C2650 | 0.76 | 0.85 | 0.79 | |
| H1C2688 | 0.62 | | | |
| H1C2749 | -0.26 | 0.14 | 0.30 | Station discarded |
| H1C2966 | 0.63 | | | |
| H1C3214 | 0.83 | | | |

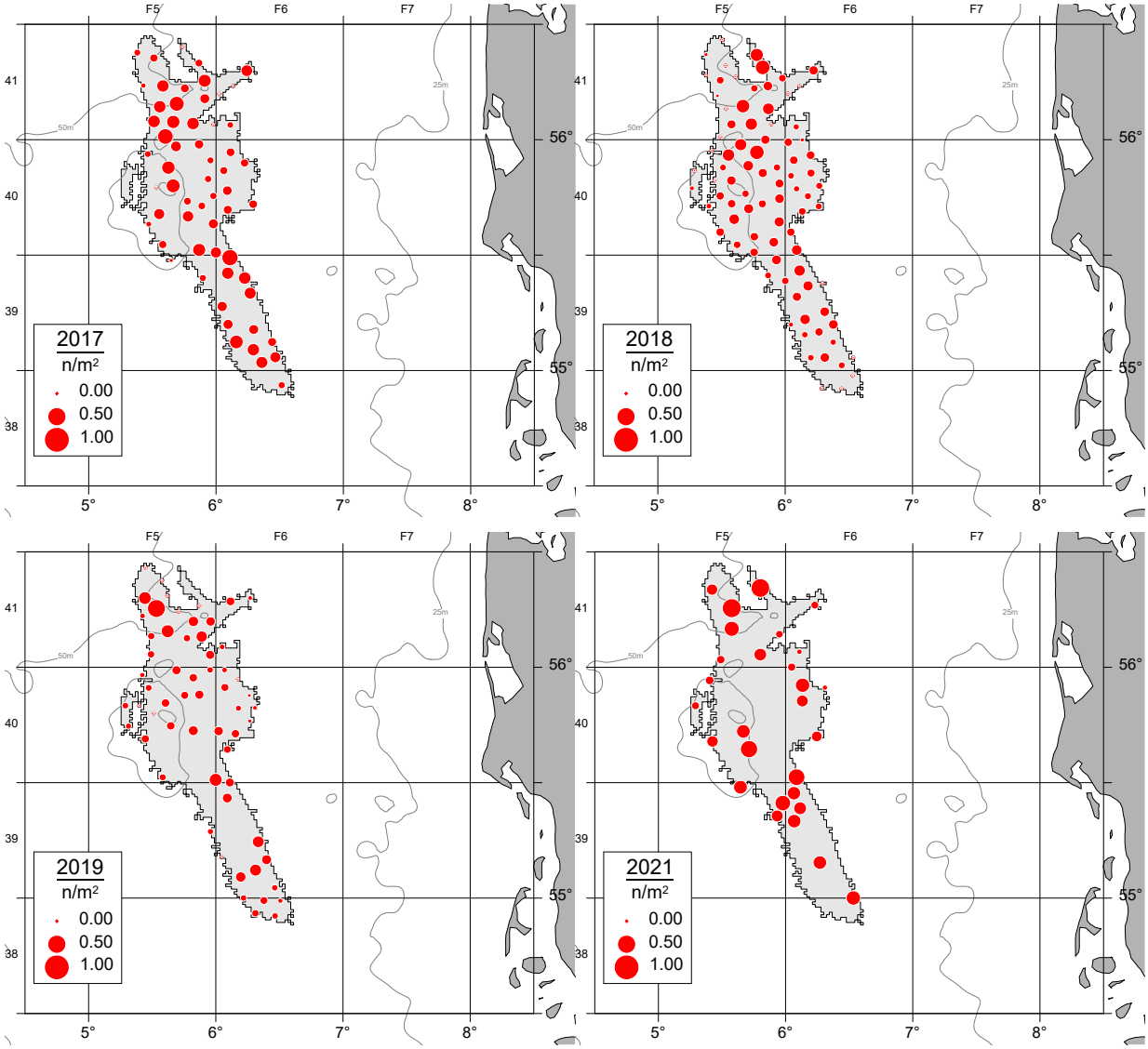



**Fig. 2: FU 33 (Off Horns Rev) Nephrops burrow density by station for each year.**

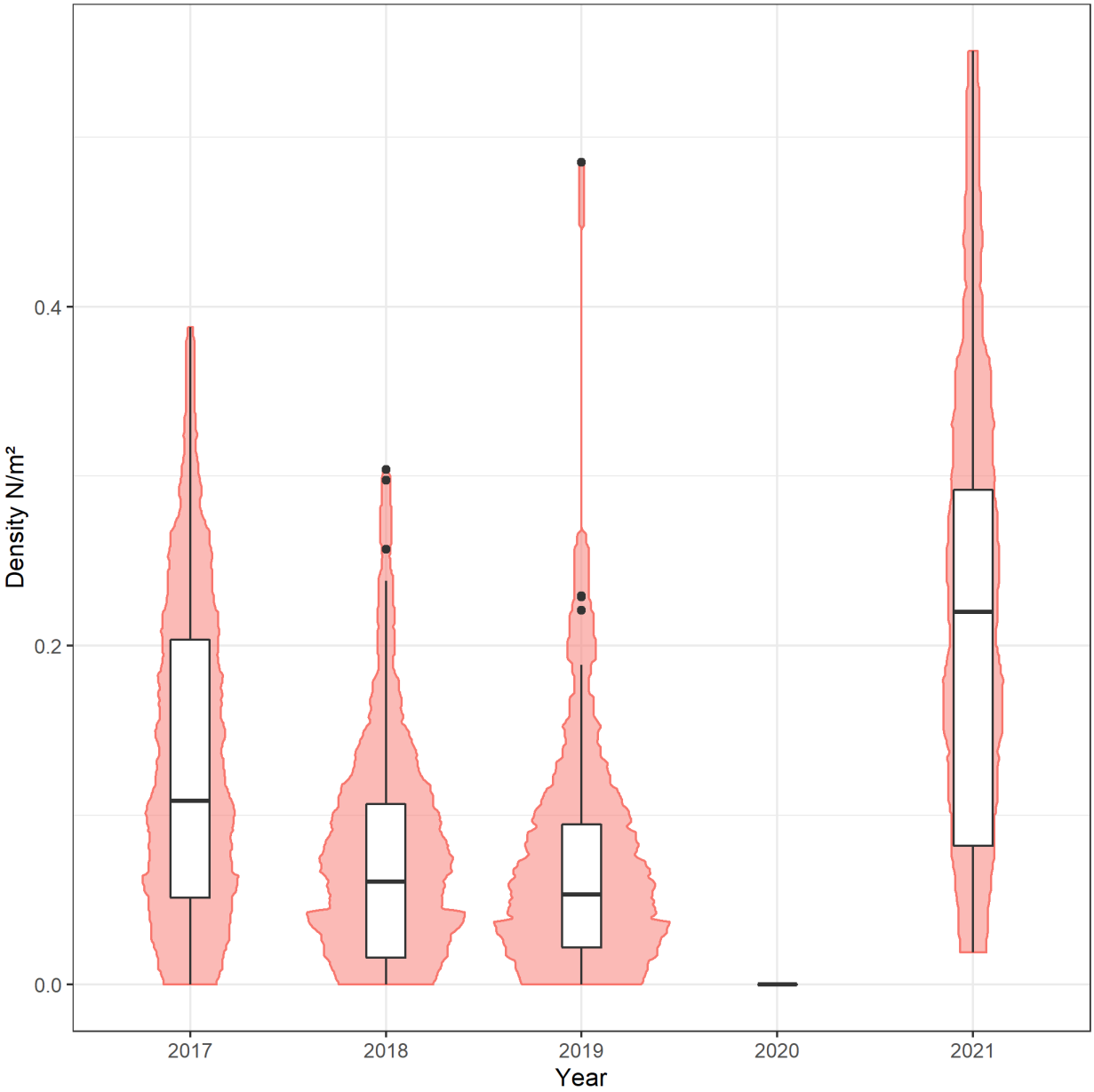



**Fig. 3: FU 33 (Off Horns Rev) times series of Nephrops burrow density (The horizontal lines represents the medians, the boxes are the inter quartile range, the shaded areas show the kernel probability densities of the data at different values and the black dots are potential outliers).**

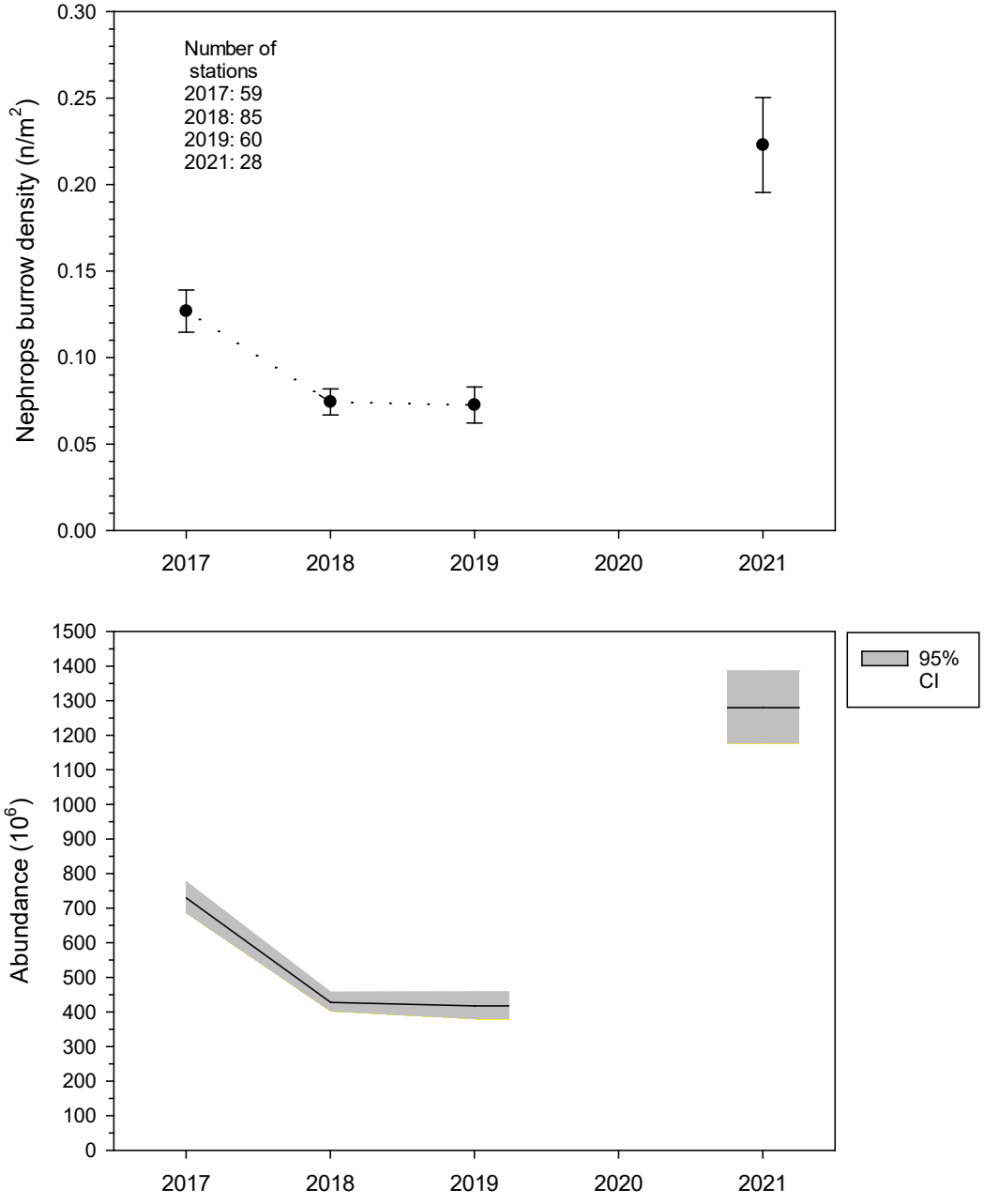



**Fig. 4: FU 33 (Off Horns Rev) time series of Nephrops burrow mean density and total abundance with reference levels (error bars in upper panel represent standard error of the mean and the shaded area in the lower panel represents the 95% confidence interval; reference points are not defined for this stock).**

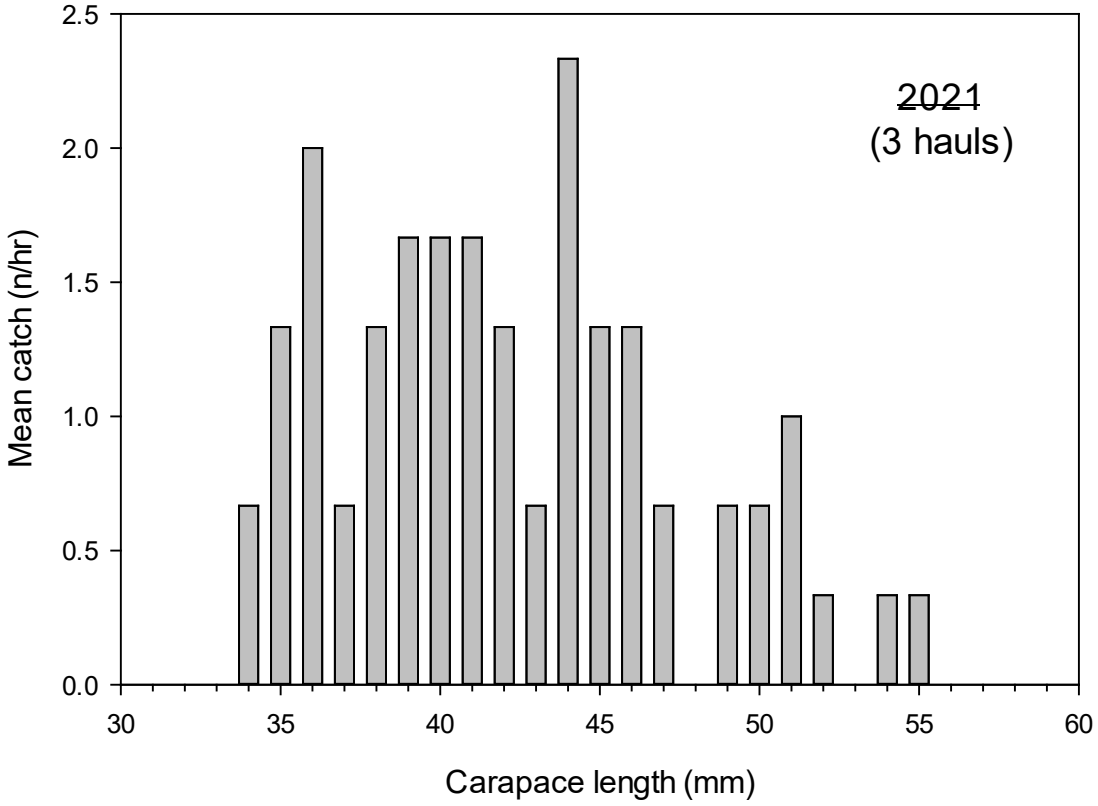



**Fig. 5: FU 33 (Off Horns Rev) length frequency of Nephrops for one trawl haul in 2021 in the central and northern part of the survey area.**

Future work

- Contact EU RCG whether this bi-annual survey is worth to continue by Denmark (next time in 2023) or not

## Spain FU 30: Gulf of Cadiz

Yolanda Vila and Candelaria Burgos

| **Functional Unit** | **FU30** | **Area name** | **Gulf of Cadiz** |
|---|---|---|---|
| Survey design | Randomized isometric grid at 4 nm spacing | Previous surveys | 2015-2019 & 2021<br>2020 Not conducted (COVID-19 DISRUPTION) |
| Camera Type:<br>Standard / High definition | HD 2015-2017<br>Ultra HD since 2018 | Image Data:<br>Type / Size per station eg, video / stills , 1GB | Video<br>MP4<br>4GB |
| Country (ies) | Spain | Vessel name (s) | Ángeles Alvariño |
| | | | |
| Survey code (s) | ISUNEPCA_0721<br>UWTV_FU30<br>U9111 | Dates (start/end) | START:<br>Planned: 02/06/2021<br>Delayed to 07/07/2021 |
| | | | END:<br>Planned: 14/06/2021<br>Delayed to 19/07/2021 |
| Number scientific staff | 3 | Staff exchanges | None |
| | | | |
| Number of stations<br>(planned/completed/used in analysis) | | 65 / 65 / 59 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | -Survey delayed 1 month approximately. It could have had an effect on the 2021 abundance estimation because in July the *Nephrops* fishing effort is higher than in June when the UWTV survey is traditionally carried out.<br>-Poor visibility in 6 stations due recent fishing activity. | |
| Distance over ground source used | Transponder (HiPAP) | Average field of view (cm) | 75 |
| Adjusted mean density | 0.024 | Adjusted abundance, CV | 73 millions burrows<br>CV=11.5% |

| | | |
|---|---|---|
| Overall footage quality (poor, medium, good) | Good | |
| Reference footage for survey area generated | Yes (Created in WKNEPS 2018) | |
| Quality control of station counts (Lin's CCC or consensus count) | Lin's CCC<br>Threshold = 0.5<br>Counts with Lin's CCC<0.5 were reviewed by consensus (49 stations)<br>Counts by minute in 2021 were very low and Lin's CCC R code work well only in 30% stations. | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | 46 CTD on the sledge. CTD failed in some stations.<br>Videos are also used to estimates macro benthos species and the occurrence of trawl marks and litter on the sea bed.<br>28 Sediment samples using Box-corer. | |
| Data storage, level of analysis and dissemination (by data type) | Nephrops burrow counts | **Storage** – hard copies of data held in office environment;<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** – WGNEPS,WGBIE, CN_IEO internal report |
| | CTD | **Storage** – hard copies of data held in office environment;<br>**Level of analysis** – completed<br>**Dissemination** – WGNEPS, CN-IEO internal report. |
| | Trawl | |
| | Sediment | **Storage** – physical samples in cold storage; plus electronic copies of data relating to samples on hard disk.<br>**Level of analysis** – carried out by other departments. Awaiting work up<br>**Dissemination** – CN-IEO internal report. |
| | Other | |

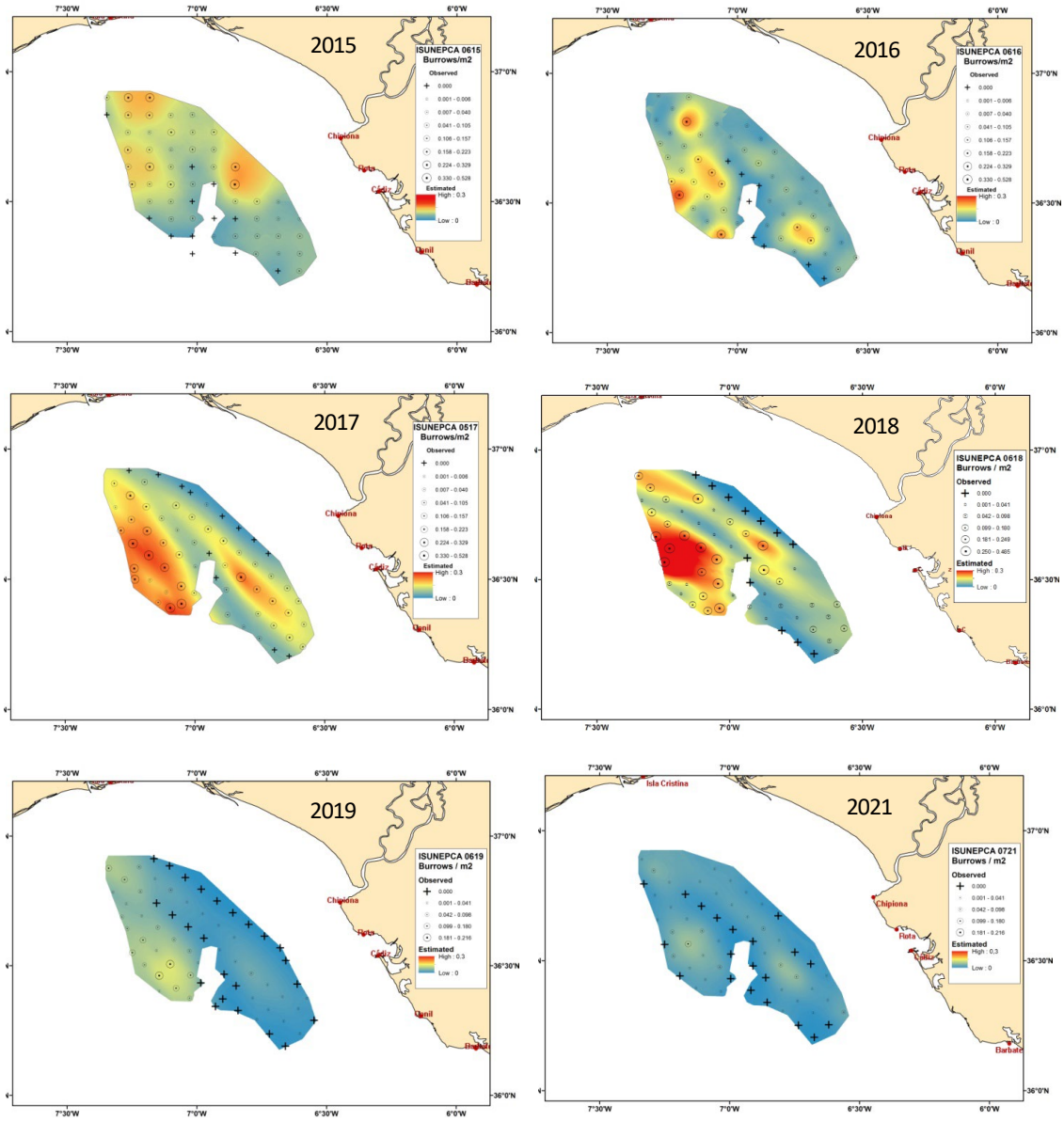



**Fig. 1: Gulf of Cadiz (FU 30). Bubble plot of the burrow density observations overlaid on a heat map krigged burrow density surface for UWTV survey series (2015-2021; 2020 not available due COVID-19 pandemic). Station positions with zero density are indicated using a +.**

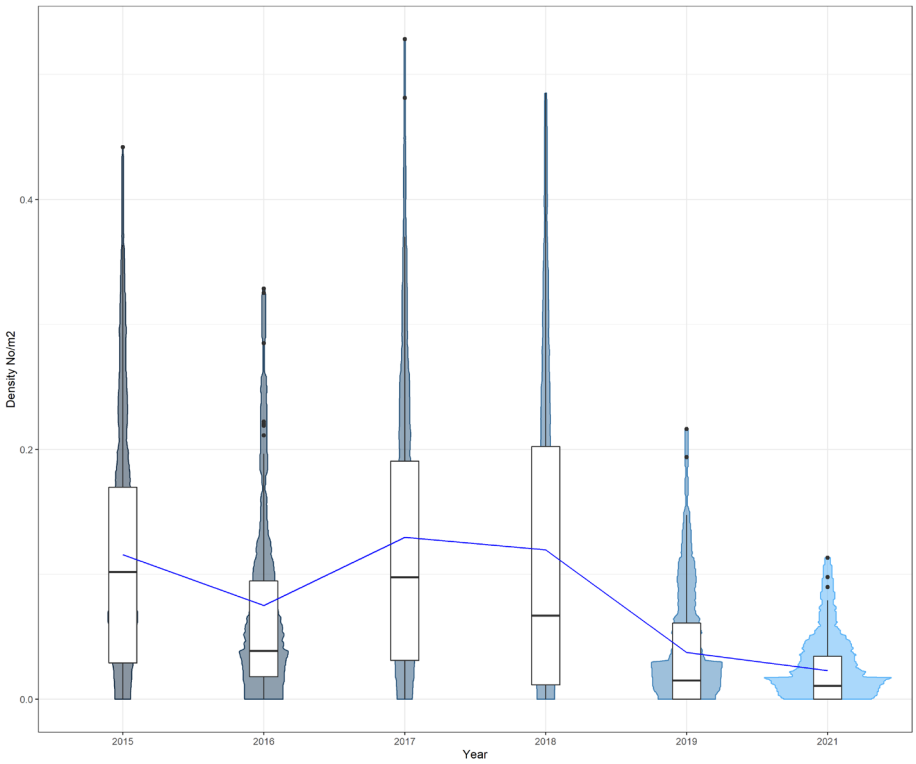



**Fig. 2: Gulf of Cadiz (FU 30). Adjusted burrow density from ISUNEPCA UWTV survey time series (violin plot and box plot). 2020 UWTV survey was not conducted due the COVID-19 pandemic. The blue line indicates the mean density over time. The horizontal blacks line represents medians, white boxes the inter quartile ranges, the black vertical lines are the range and the black dots are outliers.**

## Portugal FU 28-29: southwest and south Portugal

(Cristina Silva and Bárbara Pereira)

Due to COVID-19 pandemic and vessel issues the trawl survey was not carried out in 2020.

| | | | |
|---|---|---|---|
| Survey Name | *Nephrops* Survey offshore Portugal (NepS) | | |
| Functional Unit | 28 and 29 | Ground Name | SW and S Portugal |
| Country | Portugal | Vessel Name | Mário Ruivo |
| Survey design | Grid | Previous surveys | 1997 – 2004 (stratified)<br>2005 – 2018 (grid) |
| Survey code | G2913 | Dates (start/end) | 14/06/2021 – 06/07/2021 |
| Nb of scientific staff | 13 | Nb of students | 4 |
| Objectives | | Main objectives:<br>– To estimate the relative abundance of *Nephrops* and deepwater rose shrimp for use in the assessment and advice process, with a CV (relative standard error) of less than 20%.<br>– To study their geographical distribution in space and time.<br>– To collect data for the determination of biological parameters (sex-ratio, length-weight relationships, maturity, growth), meet DCF sampling requirements and provide LFD time series.<br>Secondary objectives:<br>– To monitor the distribution and relative abundance of the accompanying fish and invertebrate species and collect biological data for selected species<br>– To collect data for biodiversity studies and information on marine litter distribution to comply with MSFD requirements. | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, etc.) | | Oceanographic data only collected with a net-mounted CTD and no sediments samples were collected due to the lack of appropriate winch (still to be installed) | |
| Number of fishing stations (planned/completed/used in analysis) | | Planned – 78<br>Completed – 67<br>Used in analysis – 65 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | First survey carried out with R/V Mário Ruivo, after her transformation for trawl survey use. This survey is considered a trial, with gear and equipment operational issues to be fixed. FU 28 not completely covered (36% of the planned stations) due to engine problems in the third week of the survey. FU 29 fully covered. | |
| Distance over ground source used | Odometer | Average trawl speed | 3.2 nautical miles |
| Gear details | Gear Type | Shrimp trawl (FGA020) | |
| | Codend mesh size | 20 mm | |
| | Doors weight | 500 kg | |
| | Floats in head/wing lines | 9 | |
| | Groundrope | Synthetic wrapped wire core + chain | |
| Geometry of the net monitored by | | Scanmar sensors | |
| Trawl horizontal opening (m) / Doors and Wings spread | -- | Trawl vertical opening (m) | -- |
| Abundance/biomass index (target and secondary species) | | Provisional mean estimates:<br>*Nephrops norvegicus* – 3.066 kg or 110 ind per hour<br>*Parapenaeus longirostris* – 7.003 kg or 849 ind per hour | |
| CV (Relative standard error) (target and secondary species | | Provisional estimates:<br>*Nephrops norvegicus* – 20% (for both weight and number)<br>*Parapenaeus longirostris* – 23% and 22% for the indices in weight or number, respectively. | |

| | |
|---|---|
| Data storage, level of analysis and dissemination (by data type) | **Storage:** Hauls sampling data (data on catch by species, biological data): hard copies of data held in office environment; electronic data stored in a database on local server.<br>**Level of analysis** – as required for ICES WG<br>**Dissemination** – survey report published at IPMA Survey Report Series (Relatórios de Campanha), used by WGBIE and for MSFD analyses. |

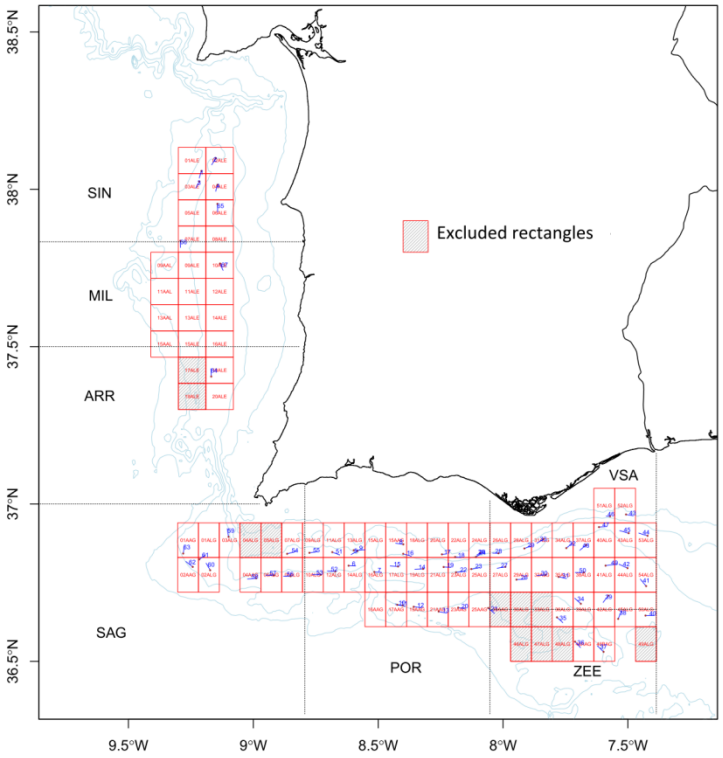



**Figure 7. Sampling grid and hauls performed in June – July 2021.**

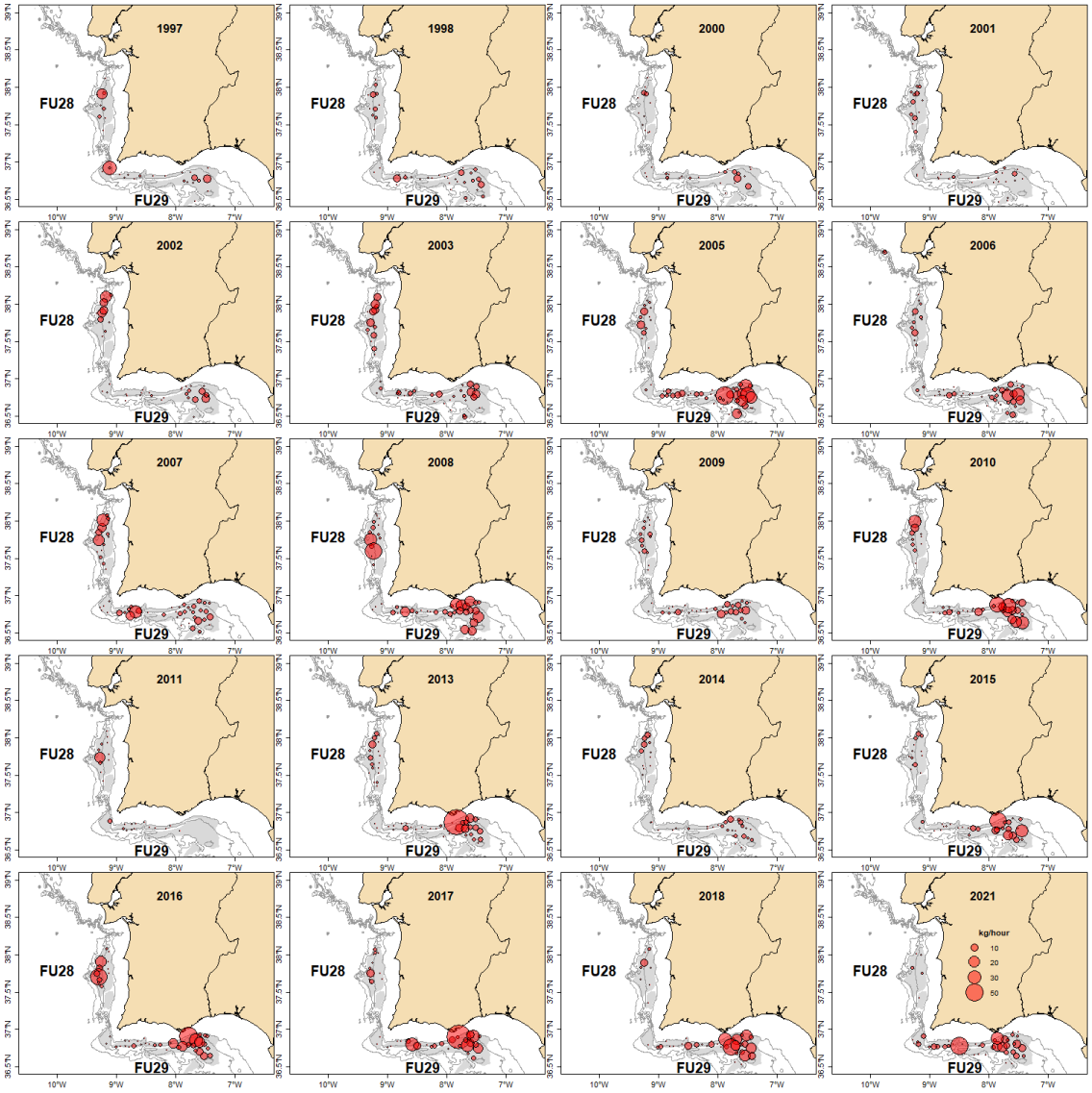



**Figure 8. Biomass index (kg/hour) spatial distribution in 1997-2018 (surveys conducted with R/V "Noruega") and in 2021 (survey conducted with R/V "Mário Ruivo"). Fishing grounds shaded in grey. Notes: 1) incomplete coverage in 2011 and 2021; 2) missing surveys in 2012, 2019 and 2020; 3) surveys in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

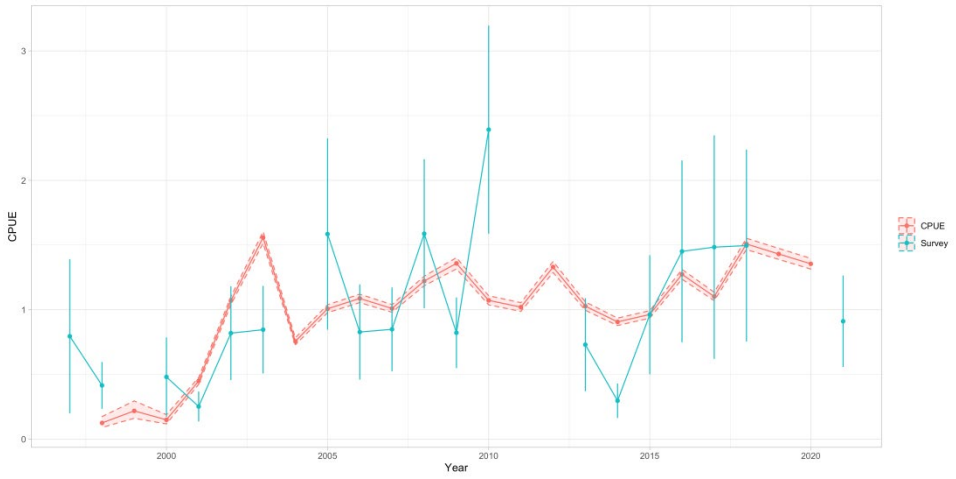



**Figure 9. Time series of Norway lobster biomass indices from surveys and from the trawl fishery CPUE standardization model. Values plotted for each series are relative to its respective long-term average biomass index.**

## France FU 23-24: Bay of Biscay

(Spyros Fifas, Jean-Philippe Vacherot)

**Historical context**

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

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

The 2016's WKNEP benchmark validated the UWTV survey and the assessment combining burrows counting and the SCA model for this stock. The change of the stock status from category 3 to 1 implies annual advice instead of the biennial one applied previously.

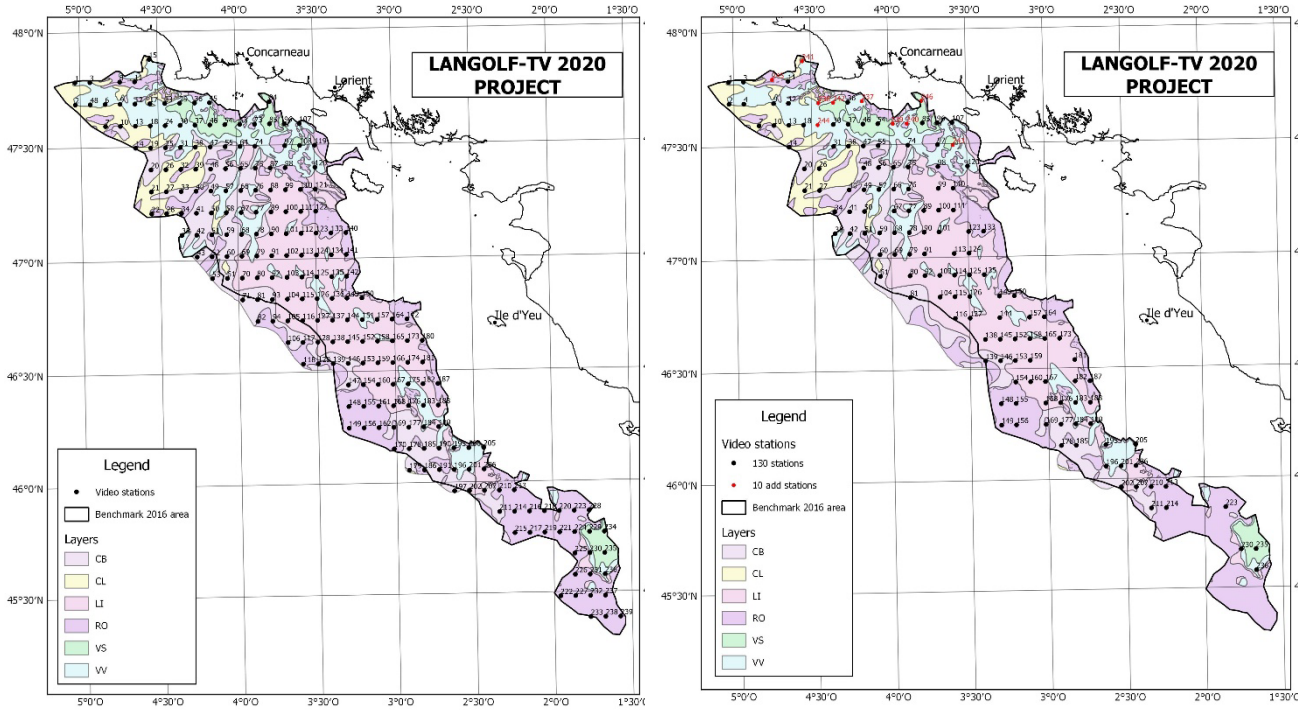



**Figure 1. Spatial stratification of the Bay of Biscay according to sedimentary criteria as considered from the first UWTV survey onwards (2014) and sampling design 2020 before COVID-19 crisis (left) and finally retained (right).**

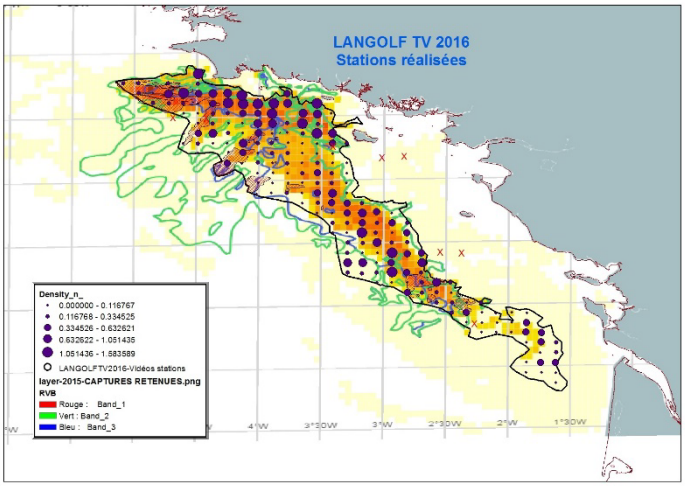



**Figure 2. UWTV stations on a systematic grid and VMS data for retained catches of *Nephrops* (example of the year 2016; source: National Fisheries Direction; compilation: SIH Ifremer).**

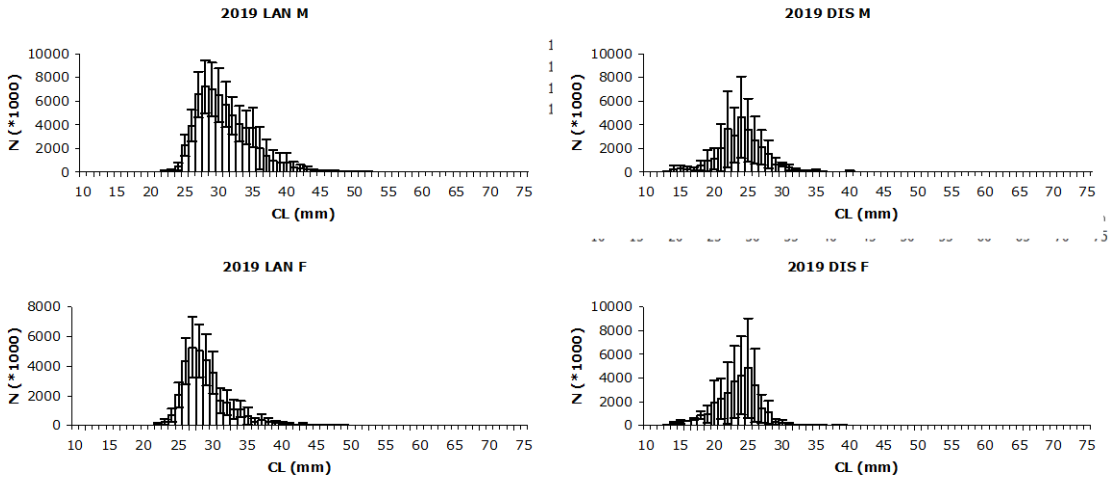



**Figure 3. LFDs (size in carapace length, mm) for landings and discards by sex. Example of dataset 2019.**

## Sampling Protocol

In accordance with other routinely UWTV surveyed stocks, the sampling protocol applied since 2014 has been a systematic one advantaged by wider spatialised explorations on collected data. A distance of 4.7 nautical miles was retained similarly to the FU22 Smalls Ground. From 2016 onwards the survey duration has been longer than previously: 14 effective working days were planned (instead of 10). Thus, it has been allowed to cover for the first time the area contained in the outline of the Central Mud Bank no belonging to any sedimentary stratum: this area known as not trawled due to rough sea bottom concentrate moderate fishing effort targeting *Nephrops* (16164 km² were covered by sampling instead of 11676 km² of the historical five sedimentary strata). In the 2018's UWTV survey, an additional area of ≈2200 km² was investigated with 31 validated stations added to the 184 ones contained in the 2016's benchmarked area of 16164 km². In 2019 a supplementary area of ≈930 km² was sampled with 7 validated stations whereas the standard benchmarked area contained 145 ones. In 2020, due to the COVID-19 pandemic, the survey initially scheduled at late April/early May was strongly compromised, before being re-scheduled from 22nd July to 4th August, with only two Irish scientists experienced in this type of mission in order to respect the obligatory social distancing on board (31 m vessel: "Celtic Voyager"; Irish company P&O). It was decided to reduce the sampling plan to 130 stations allowing to obtain statistically acceptable precision level of estimates and to make all video interpretations by Ifremer agents in lab after the end of the survey. The basis of the 2020's plan was the 2018's survey because its coverage was more complete than in 2019. Among the 2018's 184 validated stations contained in the Central Mud Bank benchmarked outline, 10 corresponding to zero burrows counted in 2018 as well as in 2019 were erased. The choice of 130 stations was ended by a random process eliminating 44 stations among the 174 remaining ones. Owing to favourable meteorological conditions, the initial goal was exceeded and 134 validated stations were finally sampled.

**Table 1. *Nephrops* in the Bay of Biscay (VIIIab). Above: Landed and discarded weights since the DCF routinely conducted sampling onboard. Below: Discards and landings in numbers ($10^3$ individuals) obtained by sampling onboard and at auction. Only years with sampling onboard are presented.**

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

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

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

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

In 2020, LANGOLF-TV was carried out on 10 actual days (July 22nd-31st). The equipment (sledge, computing hardware, screens, recorders) were provided by the "Marine Institute". The sledge is based on the Scottish material (2.5 m*2.7 m*2.5 m; weight=80 kg); its speed is around 20 m/min. As for 2019's survey, the new HD system CathX was adopted this year.

The reduction in the number of stations was based on the 2018 campaign (239 stations also including the area outside the benchmarked edge of the Central Mud Bank; 184 stations in the stock validated area and 55 elsewhere) as follows:

- 10 stations to zero burrows in 2018 and 2019
- 7 rocky stations in 2018
- 5 stations not validated in 2018
- 12 stations intentionally abandoned in 2018 on sandy areas with no appearance of burrows in previous years
- 31 stations outside the Benchmark 2016 framework
- 44 stations removed by random draw and including all strata

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

Up to 2019's survey, the provisional absence of reference footage in the Bay of Biscay implied the use of other support coming from grounds with similar conditions (density of burrows) to the Bay of Biscay: the Smalls grounds (FU22, Celtic Sea, UWTV surveyed since 2006) was chosen. A validation by the test CCC (Figure. 4) allows to decide on the conformity or not of each reader. The delay of the survey in 2020 and the impossibility to read footage onboard induced lack of time between the end of the survey and the deadline for stock assessment and advice. There was additionally unavailability of sufficient experienced Ifremer agents having the readers agreement because of many other oceanographic surveys. As consequence of that, the recordings were read by only one person (8 minutes counted per station, 7 taken into account for processing) apart from 10 common stations. Accordingly to recommendations of the WGNEPS, all readings will be doubled before the next year's survey.

**Method**

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

$$Y = \sum_{h=1}^{ns} Y_h = \sum_{h=1}^{ns} S_h \frac{\sum_{i=1}^{nh} x_{ih}}{\sum_{i=1}^{nh} s_{ih}}$$

With:

h= stratum [h=1,…,ns]; i= station by stratum h [i=1, …, $n_h$]; $S_h$= total surface of the stratum h; $s_{jh}$= surface for the station i, stratum h; $x_{ih}$= total number of burrows by station i in the stratum h (by adding the total recorded and validated minutes by station averaged according to the number of observers usually equal to 2)[6] The variance of Y, noted V[Y], is given by:

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

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

[6] The stratified estimator was also investigated under a sub-sampling plan (primary unit: station; secondary unit: observer*minute). It was proved that including the 2nd level increases the total variance only by 1.8-2.2% for years 2014-2018 (but ≈5.5% in 2019 and ≈8.6% in 2020); thus, the stratified plan is further developed on only one sampling level.

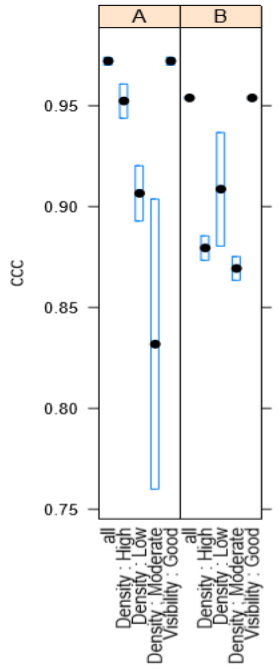



**Figure 4. Conformity test CCC. 2020's results.**

## Raising

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

The whole area of the five historical strata was covered in 2014 although only 2/3 of the total number of stations were carried out in 2015. In the period 2016-2020, 100% of the Central Mud Bank was sampled (respectively 160, 94, 148, 116 and 117 validated stations). The 2017's lower sampling level is explained by the coverage of a wide area exceeding the actual Central Mud Bank of the Bay of Biscay whereas the additional sampling effort outside the edge in 2018 affected the sampling level in the 2016's benchmarked area in a lesser degree. In 2019, the sampling coverage was also impacted by the weather conditions. Table 2 shows results of raising of burrow densities (/m²)² associated to their CVs by stratum for years 2014-2020. Results for 2020 show a steep decrease by -24% compared to 2019 (+18% between 2017 and 2018, +6% between 2018 and 2019).

**Table 2. Total number of burrows ($10^6$), densities/m² and CVs by spatial stratum and for the whole area. Years 2014-2020 *(values not corrected by the cumulative bias factor)*.**

| | *2014 (156 stations)* | | | | *2015 (96 stations)* | | | | *2016 (160 stations)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows |
| | **0.442** | **5164.53** | **5.82** | | **0.386** | **4501.89** | **8.25** | | **0.386** | **4505.52** | **7.86** | |
| CB | 0.317 | 802.68 | 15.68 | 15.54% | 0.151 | 383.85 | 25.66 | 8.53% | 0.258 | 654.41 | 19.84 | 14.52% |
| CL | 0.171 | 196.72 | 28.30 | 3.81% | 0.306 | 352.28 | 18.57 | 7.83% | 0.237 | 272.72 | 20.87 | 6.05% |
| LI | 0.354 | 1651.31 | 8.69 | 31.97% | 0.320 | 1492.89 | 16.38 | 33.16% | 0.283 | 1319.12 | 13.86 | 29.28% |
| VS | 1.656 | 1048.72 | 11.05 | 20.31% | 0.875 | 553.75 | 30.48 | 12.30% | 0.839 | 531.18 | 17.92 | 11.79% |
| VV | 0.544 | 1465.10 | 13.19 | 28.37% | 0.639 | 1719.13 | 10.99 | 38.19% | 0.642 | 1728.09 | 14.52 | 38.35% |

| | *2017 (94 stations)* | | | | *2018 (148 stations)* | | | | *2019 (116 stations)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows |
| | **0.303** | **3534.20** | **9.85** | | **0.357** | **4172.82** | **8.44** | | **0.378** | **4413.87** | **8.59** | |
| CB | 0.152 | 384.49 | 20.10 | 10.88% | 0.259 | 656.93 | 19.56 | 15.74% | 0.259 | 436.35 | 25.39 | 9.89% |
| CL | 0.262 | 302.03 | 14.76 | 8.55% | 0.517 | 595.61 | 23.64 | 14.27% | 0.517 | 464.82 | 43.28 | 10.53% |
| LI | 0.210 | 978.48 | 14.75 | 27.69% | 0.228 | 1064.10 | 13.27 | 25.50% | 0.228 | 1363.72 | 14.34 | 30.90% |
| VS | 1.147 | 726.44 | 27.94 | 20.55% | 0.841 | 532.43 | 23.30 | 12.76% | 0.841 | 370.94 | 21.46 | 8.40% |
| VV | 0.425 | 1142.76 | 19.82 | 32.33% | 0.492 | 1323.75 | 17.30 | 31.72% | 0.492 | 1778.04 | 12.12 | 40.28% |

| | *2020 (117 stations)* | | | | |
|---|---|---|---|---|---|
| | nb/m² | total burrows | CV (%) | %burrows | % surf |
| | **0.286** | **3343.31** | **10.18** | | |
| CB | 0.072 | 182.34 | 24.46 | 5.45% | 21.72% |
| CL | 0.229 | 263.73 | 44.46 | 7.89% | 9.87% |
| LI | 0.195 | 911.55 | 18.76 | 27.26% | 39.94% |
| VS | 0.903 | 571.69 | 20.14 | 17.10% | 5.42% |
| VV | 0.525 | 1414.01 | 16.96 | 42.29% | 23.05% |

### *2. Raising including the rough sea bottom.*

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

**Table 3. Total number of burrows ($10^6$), densities/m² and CVs by spatial stratum and for the whole area. Years 2016-2020 after including rough sea bottom contained in the outline of the Central Mud Bank (16164 km² instead of 11676 km² for the five sedimentary strata *sensu stricto*).**

| | *2016 (196 stations)* | | | | *2017 (124 stations)* | | | | *2018 (184 stations)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows |
| | **0.320** | **5167.67** | **7.84** | | **0.259** | **4181.95** | **9.87** | | **0.291** | **4696.84** | **8.30** | |
| CB | 0.258 | 654.41 | 19.84 | 12.66% | 0.152 | 384.49 | 20.10 | 9.19% | 0.259 | 656.93 | 19.56 | 13.99% |
| CL | 0.237 | 272.72 | 20.87 | 5.28% | 0.262 | 302.03 | 14.76 | 7.22% | 0.517 | 595.61 | 23.64 | 12.68% |
| LI | 0.283 | 1319.12 | 13.86 | 25.53% | 0.210 | 978.48 | 14.75 | 23.40% | 0.228 | 1064.10 | 13.27 | 22.66% |
| VS | 0.839 | 531.18 | 17.92 | 10.28% | 1.147 | 726.44 | 27.94 | 17.37% | 0.841 | 532.43 | 23.30 | 11.34% |
| VV | 0.642 | 1728.09 | 14.52 | 33.44% | 0.425 | 1142.76 | 19.82 | 27.33% | 0.492 | 1323.75 | 17.30 | 28.18% |
| RO | 0.148 | 662.15 | 29.61 | 12.81% | 0.144 | 647.75 | 34.23 | 15.49% | 0.117 | 524.02 | 31.79 | 11.16% |

| | *2019 (145 stations)* | | | | *2020 (134 stations)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | nb/m² | total burrows | CV (%) | %burrows | nb/m² | total burrows | CV (%) | %burrows | | % surf |
| | **0.316** | **5100.64** | **8.34** | | **0.263** | **4247.08** | **12.74** | | -16.73% | |
| CB | 0.172 | 436.35 | 25.39 | 8.55% | 0.072 | 182.34 | 24.46 | 4.29% | -58.21% | 15.69% |
| CL | 0.403 | 464.82 | 43.28 | 9.11% | 0.229 | 263.73 | 44.46 | 6.21% | -43.26% | 7.13% |
| LI | 0.292 | 1363.72 | 14.34 | 26.74% | 0.195 | 911.55 | 18.76 | 21.46% | -33.16% | 28.85% |
| VS | 0.586 | 370.94 | 21.46 | 7.27% | 0.903 | 571.69 | 20.14 | 13.46% | 54.12% | 3.92% |
| VV | 0.661 | 1778.04 | 12.12 | 34.86% | 0.525 | 1414.01 | 16.96 | 33.29% | -20.47% | 16.65% |
| RO | 0.153 | 686.77 | 28.17 | 13.46% | 0.201 | 903.76 | 46.57 | 21.28% | 31.60% | 27.76% |

As for the other raising options, the number of burrows seems to have steeply declined between 2016 and 2017 (-19%) then increased by +12% and +9% respectively in 2018 and 2019. In 2020, a reduction of –17% was observed. Anyway, for any year the two more compact muddy strata (VS and VV) corresponding to less than 20% of the overall surface concentrate around 40-45% of the total number of burrows.

**Correction factors.**

***Edge effect:*** The edge effect calculated on 2014's data are represented by a corrective coefficient of 1.15 and it is associated to a low uncertainty (relative precision≈11%). This value is still used for 2016-2020's data. The adoption of the HD system since 2019 suggests the necessity to update this coefficient.

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

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

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

The advice 2021 for the stock was performed on the basis of the 2020's UWTV survey results corrected by the cumulative bias coefficient combined with the harvest rate for the year 2019 (LFDs and mean weights for landings and discards, discard survival rate fixed at 50% since the WKNephrops 2019 which revised the historical value of 30%) (Table 4).

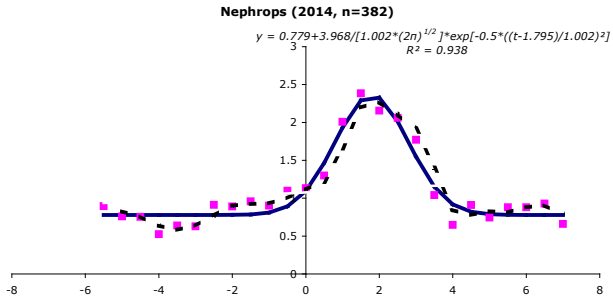
**Table 4. Catch option table for the FU23-24 Nephrops including information from the 2020's UWTV survey.**

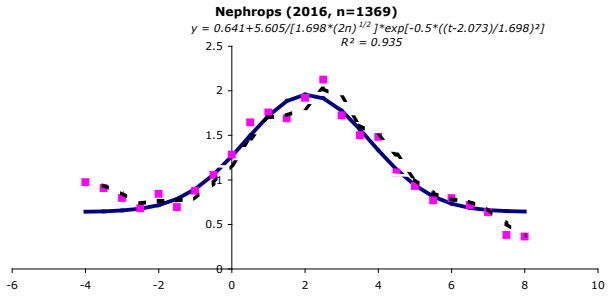
| Variable | Value | Notes |
|---|---|---|
| Stock abundance (2021) | 3425.061 | Number of individuals (millions); UWTV Survey 2020 |
| Mean weight in projected landings | 23.82 | Average 2017–2019; in grammes |
| Mean weight in projected discards | 10.99 | Average 2017–2019; in grammes |
| Projected discards | 53.6 | Average 2017–2019; percentage by number |
| Discard survival * | 50 | Percentage by number |
| Dead projected discards | 37.4 | Average 2017–2019; percentage by number |

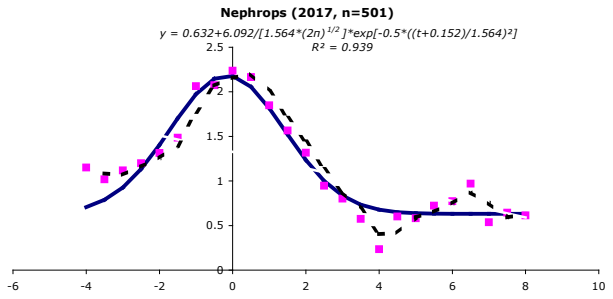
** Only applied in scenarios where discarding is allowed.*

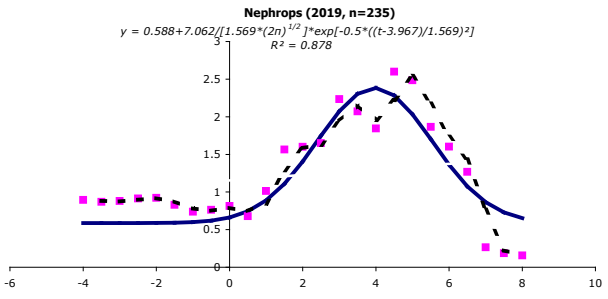
**Catch scenarios assuming recent discard rates**

| Basis *** | Total catch | Dead removals | Projected landings | Projected dead discards | Projected surviving discards | Harvest rate * % | % advice change ** |
|---|---|---|---|---|---|---|---|
| | PL + PDD + PSD | PL + PDD | PL | PDD | PSD | for PL + PDD | |
| ICES advice basis | | | | | | | |
| MSY approach: $F_{MSY}$ | 6105 | 5044 | 3984 | 1060 | 1060 | 7.70 | −7.1 |
| Other scenarios | | | | | | | |
| $F_{2019}$ | 2438 | 2014 | 1591 | 423 | 423 | 3.07 | −63 |
| EU MAP ^: $F_{MSY}$ | 6105 | 5044 | 3984 | 1060 | 1060 | 7.70 | −7.1 |



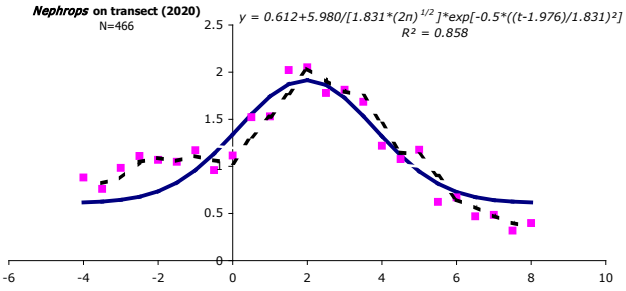



**Figure 6. Relationship between standardised time of observation *vs.* sunrise/sunset and *Nephrops* activity for years with relevant pattern (2014, 2016, 2017, 2019 and 2020). Abundance index per surface unit of video track *(broken curve: data smoothed by mobile average).***

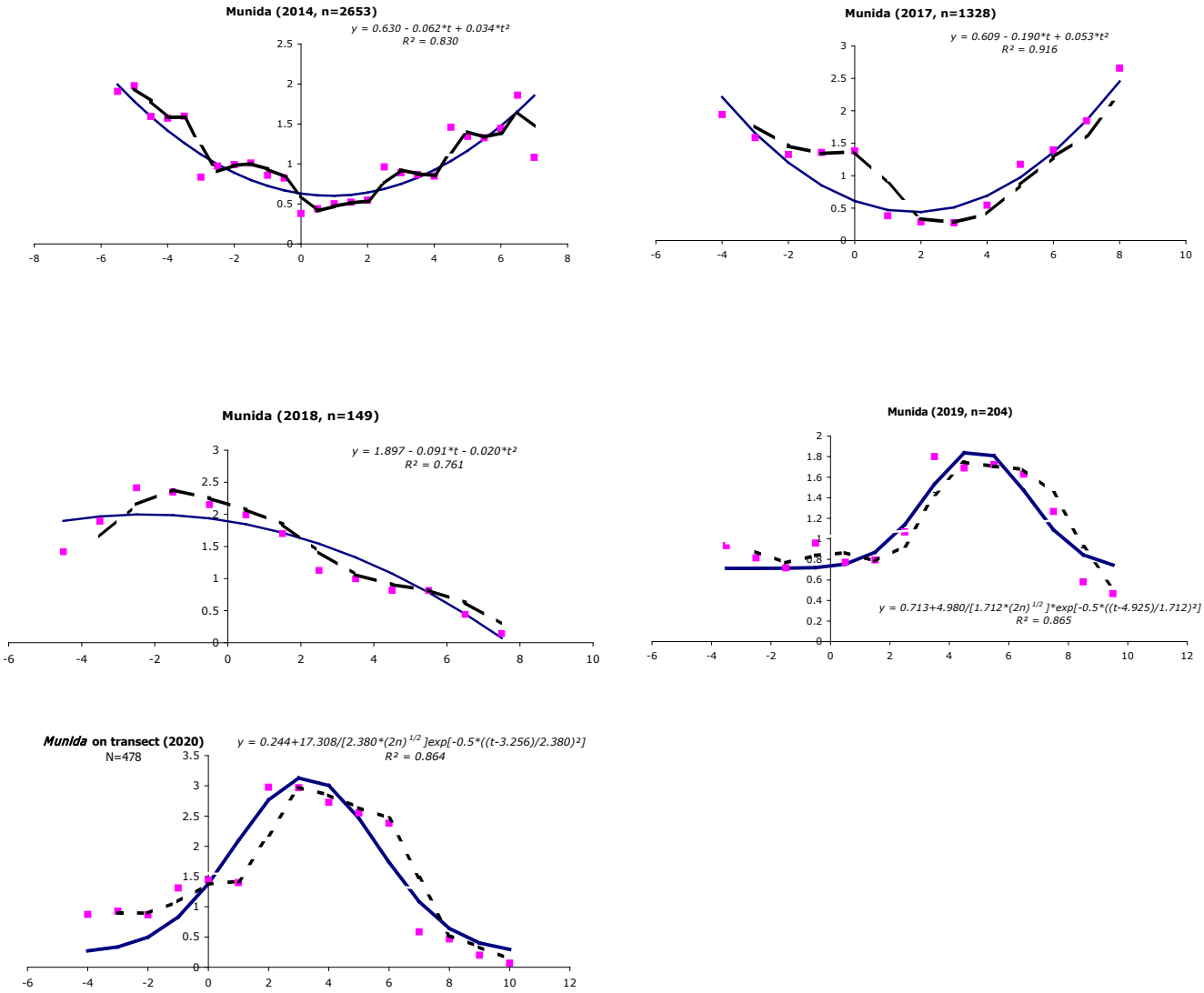



**Figure 7. Relationship between standardised time of observation *vs.* sunrise/sunset and *Munida* activity for years with relevant pattern (2014, 2017-2020). Abundance index per surface unit of video track *(broken curve: data smoothed by mobile average).***

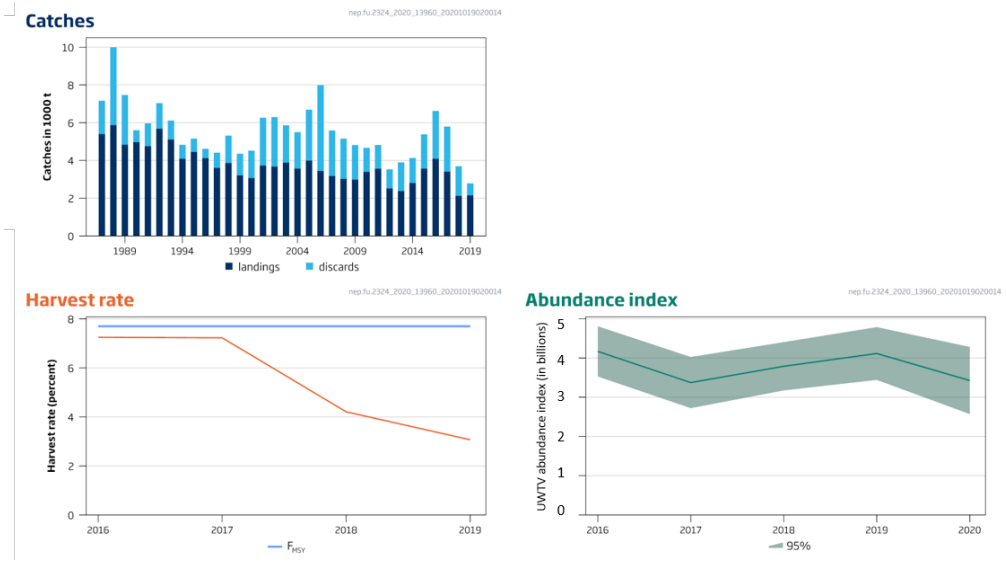



**Figure 8. *Nephrops* FU2324 (Bay of Biscay). Standard graphs for the stock advice 2021.**

## Iceland FU 1: Off South Iceland

Jónas Páll Jónasson

| | | | |
|---|---|---|---|
| Functional Unit | FU 1 | Area name | Iceland |
| Survey design | Gridded design | Previous surveys | 2016-2020 |
| Country (ies) | Iceland | Vessel name (s) | RS Bjarni Sæmundsson |
| Survey code (s) | | Dates (start/end) | 09/06 - 18/06 2021 |
| Number scientific staff | 4 | Staff exchanges | N/A |
| Number of stations (planned/completed/used in analysis) | | 97/93/93 | |
| Deviations from the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.) | | The weather was bad considering the season and hindered full coverage. | |
| Distance over ground source used | Ship position, adjusted by cable | Average field of view (cm) | 100 |
| Adjusted mean density | 0.066 $m^2$ | Adjusted abundance, CV | 435 million, CV= 5.6% |
| Overall footage quality (poor, medium, good) | | Good | |
| Reference footage for survey area generated | | Yes | |
| Quality control of station counts (Lin's CCC or consensus count) | | Consensus count | |
| Other survey activities (CTD, Trawl, sediment samples, sediment profile images, % stations with trawl marks recorded, etc.) | | Bongo-net for nephrops larvae, stations, Nephrops trawl stations. Trawl marks recorded and other biota counted. | |
| Data storage, level of analysis and dissemination (by data type) | | Nephrops burrow counts | 1728 Nephrops burrows counted. Stored on hard drives, 163 GB. |
| | | CTD | 0 |
| | | Trawl | 5 |
| | | Sediment | 0 |
| | | Bongo net | 25 |

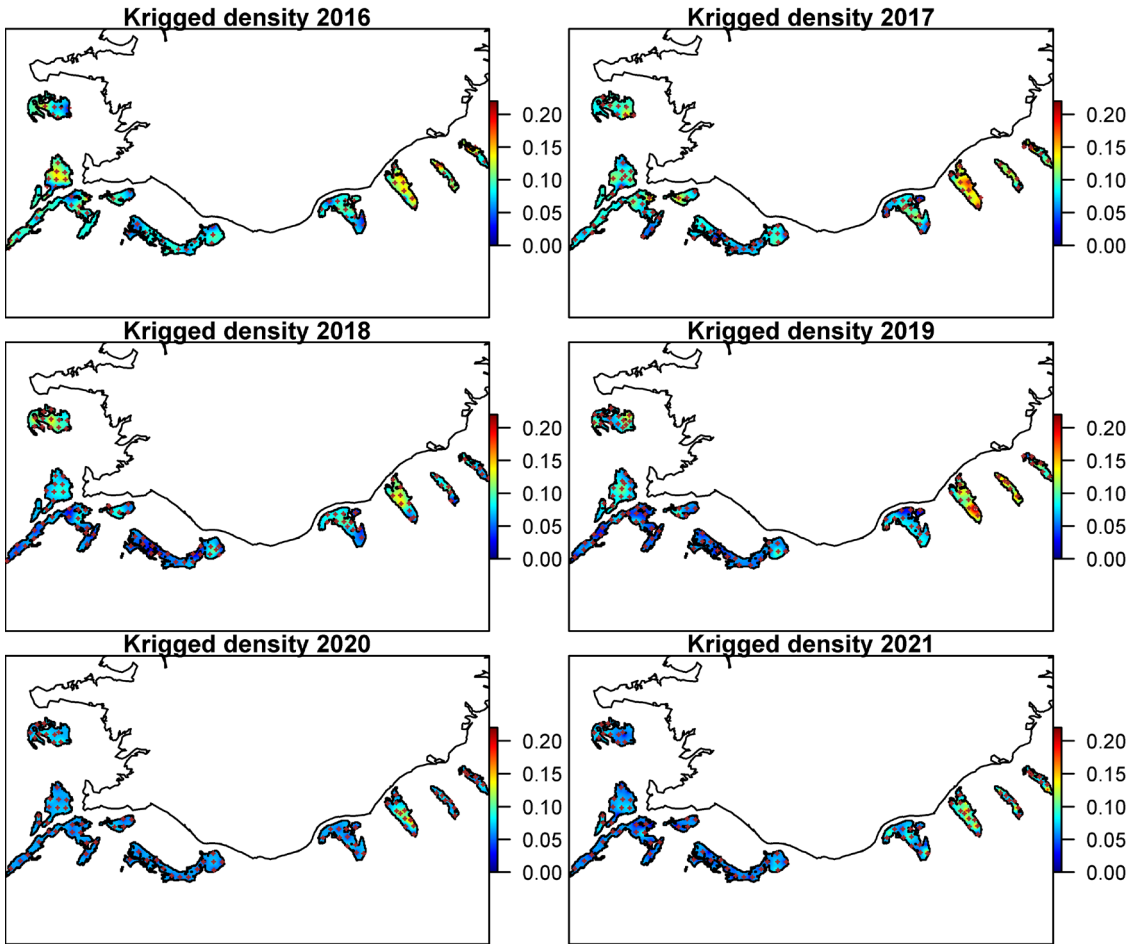



**Figure 1. FU1 grounds: Map of kriged density by station for 2016-2021.**

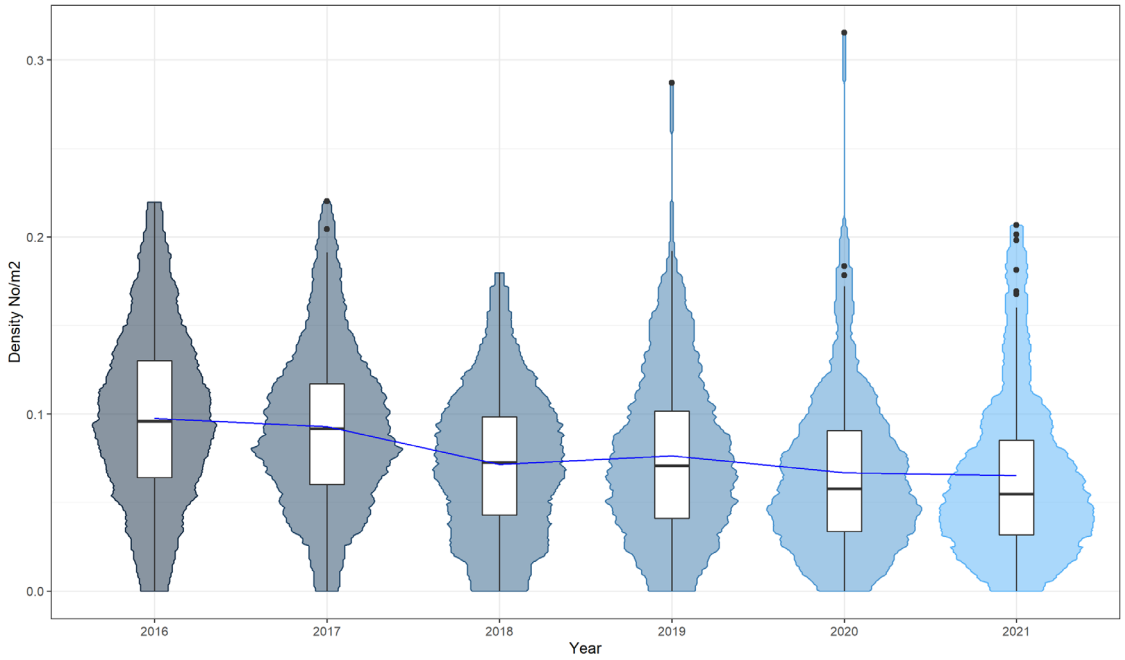



**Figure 2. FU1 Iceland: Violin and box plot of adjusted burrow density distributions by year from 2016 - 2021. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers.**

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

## ADRIATIC UWTV SURVEYS and Pomo monitoring activity

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

After a series of management measures implemented since 2015 by the Italian and Croatian governments, a temporary Fishery Restricted Area (FRA) was established in 2017 by the General Fisheries Commission for the Mediterranean (GFCM) in the Jabuka/Pomo Pits zone within the Adriatic Sea, as described in Figure 1 (GFCM 2017). On the basis of a proposal tabled by the European Union, GFCM recently confirmed the permanent duration of the Pomo Pits FRA (EU 2019; GFCM 2021).

In addition to being characterized by a very peculiar bathymetry and oceanographic characteristics (Artegiani et al., 2001; Marini et al. 2016), this area hosts one of the main nursery for the European hake *Merluccius merluccius* within GSA 17 (Northern and Central Adriatic Sea; Angelini et al. 2016) and a population of *Nephrops norvegicus*, characterized by small-sized mature individuals (Froglia and Gramitto 1982; Vrgoć et al. 2004; Colella et al. 2018; Angelini et al. 2020; Melaku Canu et al. 2021); furthermore, this area historically represented one of the main fishing ground shared by Italian and Croatian fleets targeting both species, which showed a decline in landing in the last decades (Russo et al. 2018; FAO-GFCM 2021).

Although non-Data Collection Framework funded and not covered by any other multi annual program, following early trials (Froglia et al. 1997; Morello et al. 2007) a spring UWTV survey was carried out in the Pomo Pits on board R/V Dallaporta from 2009 to 2019 (except for 2011 and 2018) by CNR-IRBIM of Ancona (formerly part of CNR-ISMAR), jointly with IOF of Split and under the auspices of the FAO – AdriaMed regional project (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea; Martinelli et al. 2013). Unfortunately, due to the COVID-19 pandemic, the survey was not conducted in 2020 and 2021. The latest equipment improvements are dated 2016 (Martinelli et al. 2016).

Aiming to produce an index of abundance to be used as a tuning for stock assessment models, the Adriatic team is constantly working to address the uncertainties still linked to the application of this method within the study area. Therefore, some specific thresholds (e.g. on speed and turbidity) settled for the Adriatic footage are usually applied to the time series in addition to the traditional cumulative bias application (Martinelli et al. 2016; Martinelli et al. 2017a). In 2019 a revision of the time series acquired since 2012 was carried out in order to comply as much as possible with ICES standards (ICES 2017, 2019, 2020). Furthermore, a new bias has been recently calculated to account for the difference in bottom surface covered by the sledge and vessel route; indeed, the surface covered in each station was usually calculated on the basis of the vessel GPS, instead in 2019 a transductor was mounted on the sledge in order to obtain its relative position. This allowed the preliminary estimation of a correction factor to be applied to each observation minute, but further application of this technology should allow to refine this approach (Figure 2). Furthermore, while using the obtained index in stock assessment models for the Pomo area, the outcomes of a recent study on burrow emergence rhythms and consequent availability of *N. norvegicus* to fishery will be taken in account (Aguzzi et al. 2021).

Usually during the UWTV Adriatic surveys, along with CTD casts, trawl hauls at sunrise and sunset are also carried out by means of an experimental net, in order to obtain demographic and biological data specifically on *N. norvegicus* and other species relevant for the area (Martinelli et al. 2017a). Since 2015, an additional autumn trawl survey (using the same net and CTD) is carried out only in the western side of the Pomo Pits area (strata B, ext ITA and ext ITA north in Figure 1); the latter was designed as part of an agreement between the Italian Ministry of Agriculture and Forestry (MIPAAF) and CNR-IRBIM and aims to evaluate the effects of the management measures enforced in the area (Martinelli et al. 2017b). In the framework of the same agreement,

in spring 2021 a similar trawl survey including additional trawl hauls has been carried out as well in the western side of the area (Martinelli et al. 2021).

The obtained catch per unit effort (CPUEs) datasets were analyzed in order to statistically detect possible early effects of the Pomo FRA implementation on the main target species, in terms of biomass and distribution; these were preliminary reported to the AdriaMed Working Group on Demersal Fisheries Resources (18 May 2020) and recently submitted to MIPAAF (Martinelli et al. 2021). Furthermore, aiming to explore the possible effects on *N. norvegicus* of the different management levels implemented in the Pomo area, together with those of local variations in environmental parameters (i.e. bottom temperature, salinity, oxygen saturation), and to use the obtained CPUE time series as well as input for stock assessment models, standardization exercises through generalized additive models (GAM) were performed; more detailed scientific publications are in preparation (Chiarini et al. Manuscript submitted for publication).

Figure 1: Pomo (Jabuka) Pits FRA within GSA 17 with indication of bathymetry (EMODNET bathymetry in meters), location of the UWTV stations (points) planned during the spring surveys and considered strata, including FRA zones (zone A closed to any professional fishing activity, zones B and C subject to fisheries limitations).

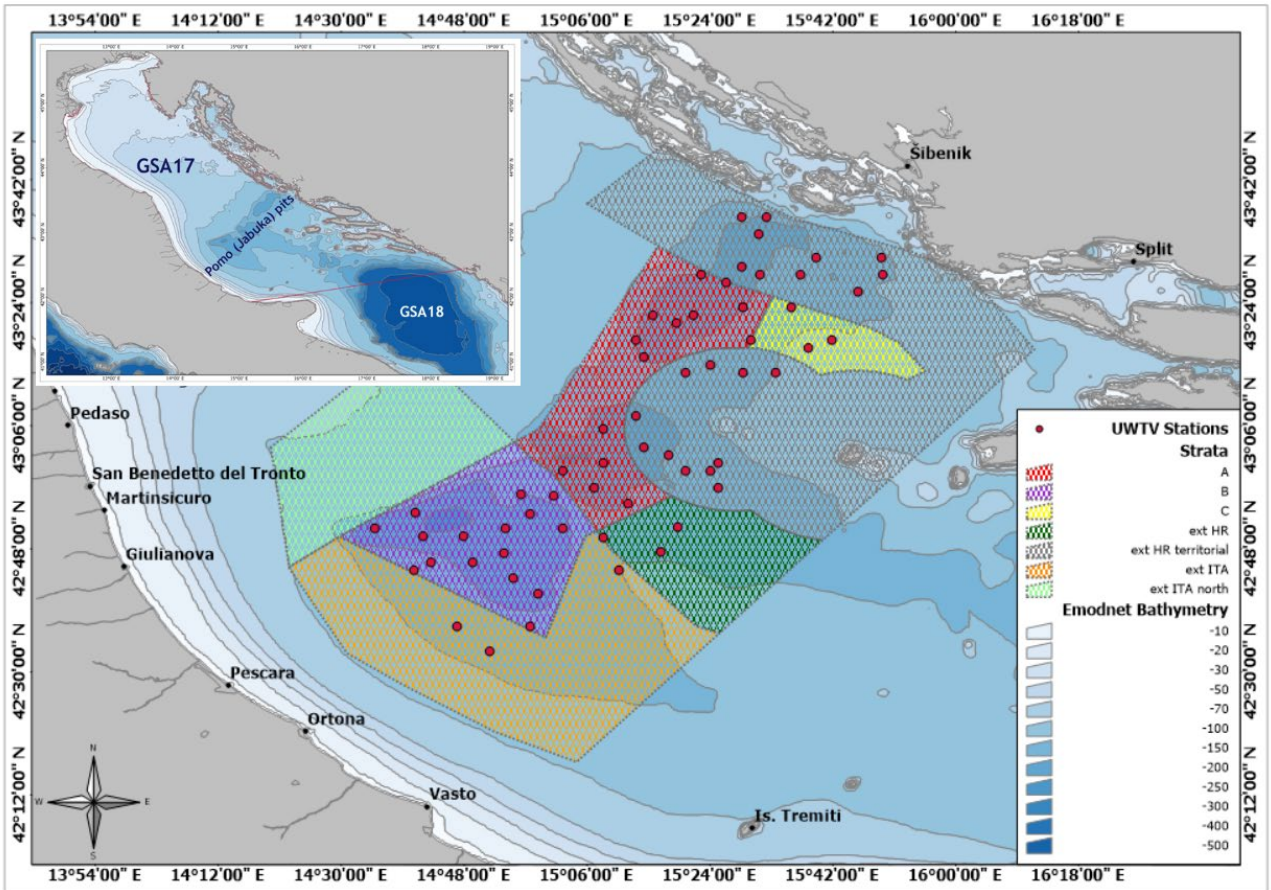
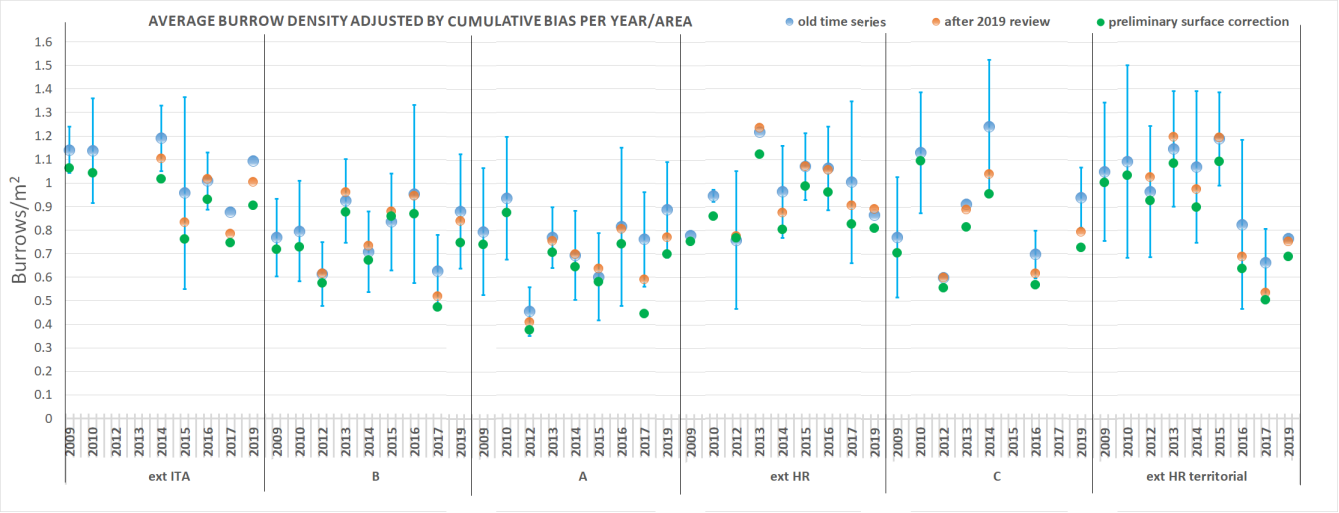



**Figure 2: Average burrow density adjusted by cumulative bias per year and stratum: blue dots represent values (± standard deviation) previously considered for the time series, orange dots are the values obtained after the revision carried out in 2019 and green dots refer to the preliminary application of a surface bias accounting for the difference in sledge and vessel relative positions.**

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Martinelli M., Angelini S., Belardinelli A., Canduci G., Chiarini M., Domenichetti F., Giuliani G., Grilli F., Guicciardi S., Penna P., Zacchetti L. 2021. Accordo tra MIPAAF e CNR-IRBIM Ancona in merito alla proposta progettuale relativa alle attività di monitoraggio periodico delle fosse di Pomo e all'attuazione di misure che, nel rispetto dei piani di gestione, comportino il mantenimento delle condizioni ambientali idonee alla vita e all'accrescimento dei molluschi bivalvi, ponendo in essere misure supplementari tese a proteggere le diverse fasi del ciclo biologico delle specie interessate (CUP J41F19000080001). Parte Monitoraggio Fosse di Pomo periodo 2019-2020, esteso 2021. Report finale.

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# Annex 5: List of presentations

(in order of appearance)

Mattias Sköld, Emil Ren, Patrik Jonsson, Anders Wernbo, Andreas Wikström och Håkan Wennhage, Swedish University of Agricultural Sciences, Department of Aquatic Resources:
Using UWTV for epifauna monitoring. 10 pp.

Kai Wieland, Patrik Jonsson, Mats Ulmestrand, Sven Koppetsch, Annegrete Dreyer-Hansen, Maria Jarnum, Gert Holst, Ronny Sørensen, Christian Petersen, Per Christensen, Flemming Thaarup, Baldvin Thorvaldsson Anders Wernbo, Peter Wickström and Baldvin Thorvalsson:
*Nephrops* UWTV survey in the Skagerrak and Kattegat (FU 3&4) in 2021. 16 pp.

Cristina Silva and Bárbara Serra-Pereira: *Nephrops* survey Offshore Portugal Nep S (FU 28-29) Trawl Surveys. 12 pp

Mikel Aristegui and Jennifer Doyle *et al.:* 2021 Update on Marine Institute Ireland *Nephrops* UWTV surveys. 19 pp.

Adrian Weetman: Marine Scotland Science 2021 UWTV surveys summary. 21 pp.

Jónas Páll Jónasson, Julian Burgos, Arnþór Kristjánsson, Anna Ragnheiður Grétarsdóttir, Arnar Björnsson, Auður Bjarnadóttir & Hjalti Karlsson: UWTV survey and Nephrops advice in Icelandic waters. 13 pp.

Mathieu Lundy : AFBI Western Irish Sea *Nephrops* Grounds (FU 15) 2021 UWTV Survey and Trawl survey. 19 pp.

Chris Firmin : CEFAS Survey results and assessment summary for FU 6 and FU14. 11 pp.

Martinelli M., Medvešek D., Chiarini M., Domenichetti F., Canduci G., Zacchetti L., Guicciardi S., Grilli F., Penna P., Giuliani G., Scarpini P., Belardinelli A., Cvitanić R., Isajlovic I., Vrgoc N.:
Adriatic UWTV surveys and Pomo monitoring activity. 11 pp.

Yolanda Vila and Candelaria Burgos: IEO Developments on the UWTV survey in the Gulf of Cadiz (FU 30) 2021. 22 pp.

Spyros Fifas and Jean-Philippe Vacherot: Ifremer FU23-24 *Nephrops* Analysis of UWTV Survey 2021 results and overview of stock status and technical operations. 16 + 13 pp.

Jennifer Doyle: Summary of where we are with WGNEPs database Nov 2021: 1 pp.

Neil Holdsworth, Head of Data and Information, ICES: Data and Information Services. 25 pp.

Jacopo Aguzzi and Joan Navarro et al.: Towards monitoring and recovery of fishery-impacted species in deep-sea marine ecosystems: a joint effort between biology and technology within the BITER, PLOME and LIFE-ECOREST actions. 19 pp.

Atif Naseer: Update on PhD research work on *Nephrops norwegicus* detection and classification from underwater videos using deep neural network. 57 pp.

Joey O'Connor: UWTV surveys and UK MPA monitoring. 30 pp.

Adrian Weetman: The utility of UWTV and trawl Nephrops surveys as platforms for collecting data for purposes other than Nephrops assessment. 6 pp.

Yolanda Vila: ISUNEPCA UWTV SURVEY (FU30) as a platform for collecting benthic habitats and environmental data. 17 pp.

Jennifer Doyle: Discussions of Preliminary work of burrow size measurements. 8 pp.

Mikel Aristegui: UWTV camera comparison test: FU 20- 21 and FU 16. 13 pp.

Jónas Páll Jónasson: Assessing the unseen Behavioral study on the Norway lobster (*Nephrops norvegicus*) Tagging studies update Iceland. 30 pp.

# Annex 6: Action list

| | Action | Addressed to | Action latest before |
|---|---|---|---|
| 1 | Provide outstanding parts of the WG report | All WG members | At latest 15/12-2021 |
| 2 | Review and comment on completed draft report | All WG members | At latest 15/1-2022 |
| 3 | Subgroup lead by PJ to meet intersessionally to implement workplan to obtain burrow system size information | PJ/All WG members | Jan 2022 |
| 4 | WGNEPS core group to meet intersessionally with ICES database centre | JD/One member per institute | Jan 2022 & ongoing |
| 5 | Check FU's shapefiles and provide feedback to Rui Catarino at ICES | All WG member | asap |
| 6 | Update/Upload R scripts for UWTV survey data analysis and quality control on Github | All WG members | Ongoing |
| 7 | Develop reference sets for other FU's and report to WGNEPS ( FU 3 &4) | National Institutes | Jan 2022 |
| 8 | Draft road map for automatic system technology requirements with links to WGMLEARN and current researchers | ML / all WG members | Dec 2021 & ongoing |
| 9 | Attend Marine imagery annotation standard workshop run by JNCC | One WG member | 20TH Jan 2022 |
| 10 | Perspective review paper on *Nephrops* emergence with a road map of how best to investigate | JA / all members | Dec 2021 |
| 11 | Redefining survey area grounds working document reviewed in advance of WGBIE (FU 23-24 and FU 30). | SF/YV/CB | April 2022 |
| 12 | Develop reference sets for other FU's and report to WGNEPS (FU 23-24, FU 14 & FU 15) | National Institutes | In advance of 2022 surveys |