

WGNEPS 2017 REPORT

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REF ACOM AND SCICOM

Interim Report of the Working Group on Nephrops Surveys (WGNEPS)

28 November - 1 December 2017

Heraklion, Greece



ICES

International Council for
the Exploration of the Sea

CIEM

Conseil International pour
l'Exploration de la Mer

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

H. C. Andersens Boulevard 44-46

DK-1553 Copenhagen V

Denmark

Telephone (+45) 33 38 67 00

Telefax (+45) 33 93 42 15

www.ices.dk

info@ices.dk

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Contents

Executive summary	5
1 Administrative details	6
2 Terms of Reference a) – h).....	7
3 Summary of Work plan	10
4 List of Outcomes and Achievements of the WG in this delivery period	11
5 Progress report on ToRs and workplan	12
5.1 ToR a and ToR b. To review any changes to design, coverage, and equipment for the various <i>Nephrops</i> UWTV surveys, and to review the design, coverage, results and uses of <i>Nephrops</i> trawl surveys in consultation with WGISDAA.	12
5.1.1 Ireland	12
5.1.2 UK Northern Ireland.....	17
5.1.3 UK Scotland	19
5.1.4 UK England.....	22
5.1.5 Denmark and Sweden	26
5.1.6 Spain.....	29
5.1.7 Italy and Croatia.....	34
5.1.8 France.....	36
5.1.9 Iceland.....	40
5.1.10 Portugal	42
5.1.11 Outcomes from 2016 benchmark.....	44
5.1.12 Survey plans for 2018.....	46
5.1.13 Other information relevant for <i>Nephrops</i> surveys coordinated by WGNEPS	46
5.2 ToR c. To review video enhancement, video mosaicking, automatic burrow detection and other new technological developments.....	49
5.2.1 Reference footages.....	49
5.2.2 Mosaicking and annotated footage.....	50
5.2.3 Other technologies and experimental work	50
5.3 ToR e. Discuss the utility of UWTV and trawl <i>Nephrops</i> surveys as platforms for the collection of data for OSPAR and MFSD indicators.	53
5.4 ToR f. Develop an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys.	53
5.5 ToR g. Review of existing datasets to evaluate possible factors affecting (i.e. currents, light, etc.) burrow emergence.	54
Dominance hierarchy in group of male <i>Nephrops</i>	54
5.6 ToR h. Developing R scripts for UWTV survey data processing including functions to QC, analyse and visualize data	54

6	Revisions to the work plan and justification.....	55
7	Next meeting.....	56
8	References	57
	Annex 1: List of participants.....	60
	Annex 2: Recommendations	63
	Annex 3: Agenda.....	64
	Annex 4: Action list.....	68
	Annex 5: List of presentations.....	69
	Annex 6: Survey activities in 2018.....	70
	Annex 7: FUs 28 and 29 (Southwest and South Portugal) <i>Nephrops</i> offshore Survey (NepS).....	71



WGNEPS attendees 2017

Executive summary

The Working Group on *Nephrops* Surveys (WGNEPS), is the international coordination expert group for *Nephrops* underwater Television (UWTV) and trawl surveys within ICES areas and in a preliminary and exploratory way in some Geographical subareas (GSA) in the Mediterranean and has a quality assurance and development role.

The WGNEPS 2017 meeting took place on 28 November – 1 December 2017 and was kindly hosted by Nadia Papadopoulou and Chris Smith (Hellenic Centre for Marine Research, HCMR) at Hotel Astoria Capsis in Heraklion, Greece. The meeting was chaired by Kai Wieland (DTU Aqua, Denmark) and Adrian Weetman (Marine Scotland, UK) included the participation of 19 colleagues from the following countries: Greece, Ireland, Portugal, Denmark, Sweden, Northern Ireland, Scotland, Iceland, Spain, France, Croatia, Italy and New Zealand. Additionally, 5 WG members attended part time via Skype.

This year's meeting was focused to review any changes to design, coverage and equipment for the various *Nephrops* UWTV and trawl surveys (ToR a) and ToR b); to review video enhancement, video mosaicking, automatic burrow detection and other new technological developments (ToR c); and to continue discussions to develop an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys (ToR f). The other ToR's were at least briefly covered. Furthermore, the final version of a Cooperative Research Report (CRR) on *Nephrops* UWTV Surveys has been discussed, and the draft for UWTV survey manual (SISP) was revised.

To address ToRs a) and b) the group presented the national survey updates on survey design and gear changes for 2016–2017 and planning for 2018. Additionally, *Nephrops* benchmarks outcomes were presented for the Gulf of Cadiz, Bay of Biscay and Kattegat/Skagerrak. This allowed the expert group to ensure quality and coverage are maintained as well as to endorse proposed changes to the design for the surveys coordinated by WGNEPS. Coordination between surveys across countries and laboratories was also carried out at the meeting as part of the role of WGNEPS is to support and coordinate survey activity and improve collaborations. To address ToR c) a review was given on the latest developments on video enhancement, video mosaicking, and automatic burrow detection. As a preparation for next year work there was an initial discussion to formulate the requirements to the ICES Data Centre for an UWTV meta-database, this will address ToR f).

1 Administrative details

Working Group name

WGNEPS - Working Group on *Nephrops* Surveys

Year of Appointment within the current cycle

2016

Reporting year within the current cycle

2

Chair(s)

Kai Wieland, DTU Aqua, Denmark and Adrian Weetman, Marine Scotland, UK

Meeting venue

Hotel Astoria Capsis, Heraklion, Greece

Meeting dates

28 November - 1 December 2017

Reference Map

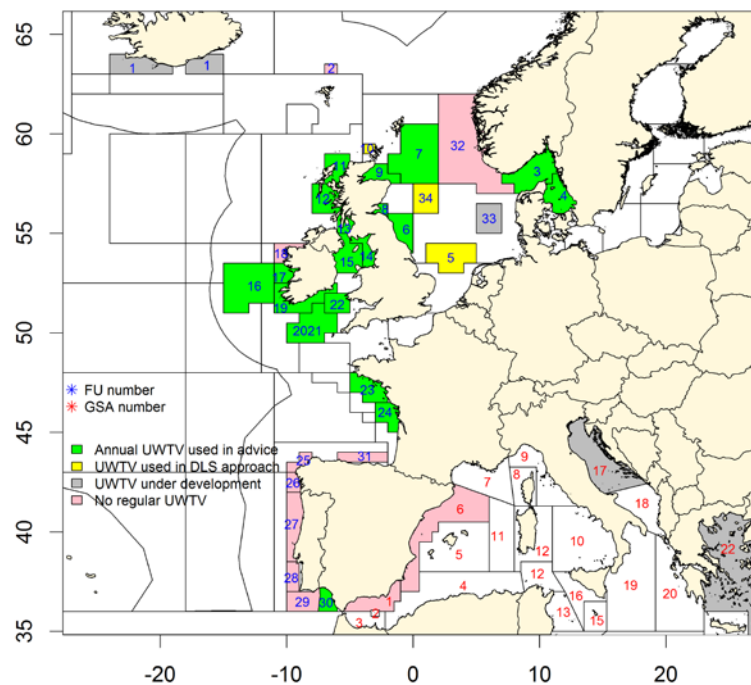


Figure 1.1 *Nephrops* UWTV survey coverage in 2017 (FU: Functional Unit, GSA: Geographical Sub Area).

2 Terms of Reference a) – h)

ToR descriptors	Description	Background	Science Plan Topics addressed	Duration	Expected Deliverables
	Review SISP guidelines	SSGIEOM have developed guidelines for the SISPs, and it is important to update those guidelines to reflect the use of the protocol by the EGs	28,31	Year 1	Review the current SISP guidelines.
a	To review any changes to design, coverage and equipment for the various <i>Nephrops</i> UWTV surveys.	To ensure surveys used by WKNEPH, WGCSE, and WGNSSK are fit for purpose.	28,31	Recurrent annual update	Survey summary including and description of alterations to the plan, to relevant assessment-WGs (WKNEPH, WGCSE, WGNSSK,) and SCICOM. Planning of the upcoming surveys for the survey coordinators and cruise leaders, and update the SISP accordingly.
b	To review the design, coverage, results and uses of <i>Nephrops</i> trawl surveys in consultation with WGISDAA.	There are trawl surveys for <i>Nephrops</i> in some area and trawling activity also takes place with UWTV surveys. These activities need review and coordination.	28,31	Recurrent annual update	Survey summary including and description of alterations to the plan, to relevant assessment-WGs (WKNEPH, WGCSE, WGNSSK, WGHMM,) and SCICOM.

					Planning of the upcoming surveys for the survey coordinators and cruise leaders, and update the SISP accordingly.
c	To review video enhancement, video mosaicking, automatic burrow detection and other new technological developments.	WGNEPS should periodically review emerging technologies that might improve survey methodologies.	28	Recurrent annual update	To update the SISP based on conclusions. Other publications when appropriate.
e	Discuss the utility of UWTV and trawl <i>Nephrops</i> surveys as platforms for the collection of data for OSPAR and MFSD indicators.	<i>Nephrops</i> UWTV surveys have a role in relation to benthic habitat monitoring and the collection of other environmental and ecosystem variables.	9	Year 2	To update the SISP based on conclusions
f	Develop an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys. Develop an international database on trawl surveys.	There is a need to centralize UWTV data in a single international database. Ensure data are available externally.	25	Year 2/3	ICES database

g	Review of existing datasets to evaluate possible factors affecting (i.e. currents, light, etc.) burrow emergence.	Recent behaviour aspects have been investigated in the laboratory. Important to investigate correlation with field data.	25	Year 2/3	Review paper
h	Developing R scripts for UWTV survey data processing including functions to QC, analyse and visualize data, and interface the tools with the database (ToR f).	Improving standardisation of data QC and data processing. Support new developing surveys on data analysis.	25,27	Year 3	Document and R packages for UWTV survey data.

3 Summary of Work plan

Year 1	The main task will be to carry out a burrow counting training workshop at a European level, this will take place in Reykjavík, Iceland. This WG will be extended for 1 day to accommodate the training course in the same week. Around 2 days will be allocated to review any changes to design, coverage and equipment for the various <i>Nephrops</i> UWTV/trawl surveys and to review video enhancement, video mosaicking, automatic burrow detection and other new technological developments and the remaining 3 days will be allocated to the burrow counting training workshop. The facilities and equipment will be provided by the Marine Research Institute in Iceland; additional equipment might be provided by other Institutes if required.
Year 2	TOR a, b and c will be addressed annually. This year will focus on exploring the utility of UWTV and trawl <i>Nephrops</i> surveys as platforms for the collection of data for OSPAR and MFSD indicators (ToR e). Additionally, ToRs f and g will also be addressed and plans for ToR h will be made. Decision will be made in relation to the need of further training on burrow counting. If necessary, this will take place on year 3.
Year 3	TOR a, b, and c will be addressed annually. Work will focus on ToRs f, g, and h as well as reviewing any relevant changes to survey procedures. SISP will be updated accordingly.

4 List of Outcomes and Achievements of the WG in this delivery period

- Review of changes to design, coverage and equipment for the various *Nephrops* UWTV and trawl surveys.
- Review outcomes from 2016 benchmarks
- Update of the mosaicking work currently being undertaken by DTU Aqua (Denmark) to create video mosaics from UWTV survey footage.
- Complete Cooperative Research Report (CRR)
- Draft of data structure and requirements for the UWTV database for *Nephrops*.
- Review of the current Survey Manual (Series of ICES Survey Protocols - SISP).

5 Progress report on ToRs and workplan

5.1 ToR a and ToR b. To review any changes to design, coverage, and equipment for the various *Nephrops* UWTV surveys, and to review the design, coverage, results and uses of *Nephrops* trawl surveys in consultation with WGISDAA.

This section provides an update for the various UWTV and trawl surveys currently undertaken on a regular basis in the North Sea and Mediterranean. This includes any modifications done on survey design, coverage, and procedures. Updates are provided by country with conclusions and respective recommendations.

5.1.1 Ireland

(Jennifer Doyle, Colm Lordan)

Review of the results of existing surveys:

Since 2012 Ireland has modified sampling intensity and increased survey coverage based on the recommendations of WGNEPS (formerly SGNEPS) (ICES, 2012). The total numbers of stations for 2017 remains broadly similar ~300 to previous years (Figure 5.1.1.1).

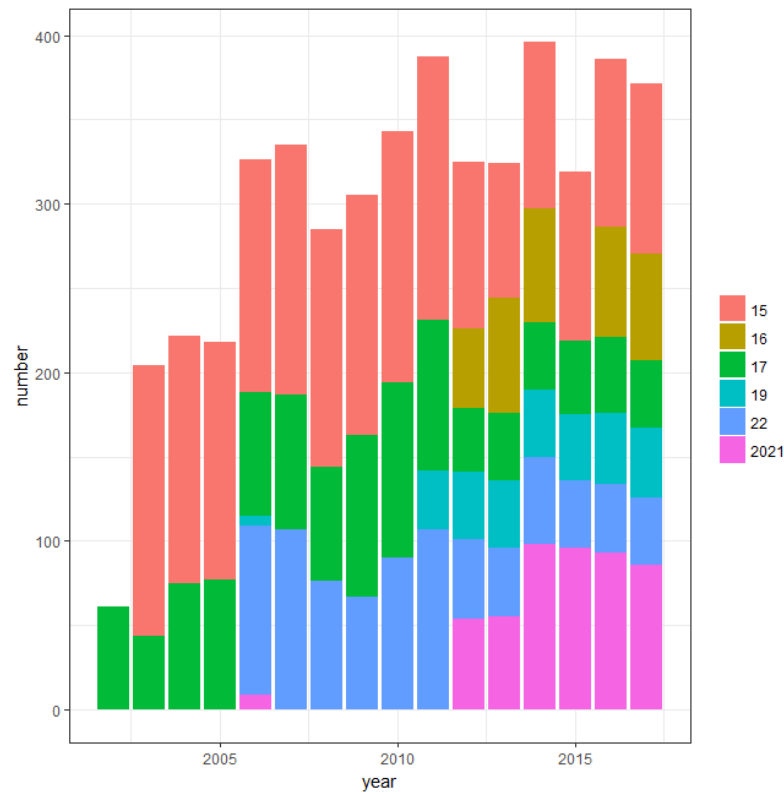


Figure 5.1.1.1. Time series of the total number of UWTV stations carried out by Ireland in each Functional Unit (Stations in FU15 are carried out in collaboration with AFBI in UK-Northern Ireland).

The numbers of stations in FU15, FU17 and FU22 were reduced since 2012 to allow for survey development in FU16, FU19 and FU20-21. 100% coverage of all the *Nephrops* grounds was achieved in 2017. In

addition, the survey design was changed from a randomised square grid to a randomised isometric grid where all stations were equidistant. 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 2012 precision (Table 5.1.1.1). In 2017 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 SISP (Series of ICES Survey Protocols) for *Nephrops* UWTV survey (ICES, in prep.) for FU20-21 and FU19 and 0.6 for FU16, 17 and 22.

Table 5.1.1.1 2017 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/m ²)	Final Abundance Estimate (millions individuals)	CV (Relative standard error)	Lin's Concordance Correlation Coefficient Threshold to screen survey Counts
FU16	0.12	850	5%	0.6
FU17 Aran Grounds only	0.31	377	4%	0.6
FU19	0.25	499	12%	0.5
FU2021	0.44	4428	4%	0.5
FU22	0.55	1600	5%	0.6

The adjusted mean density for each station in ICES Subarea 7 is presented in Figure 5.1.1.2 and it shows the general overall pattern, which is mainly higher densities observed in FU15 and lower densities in FU16.

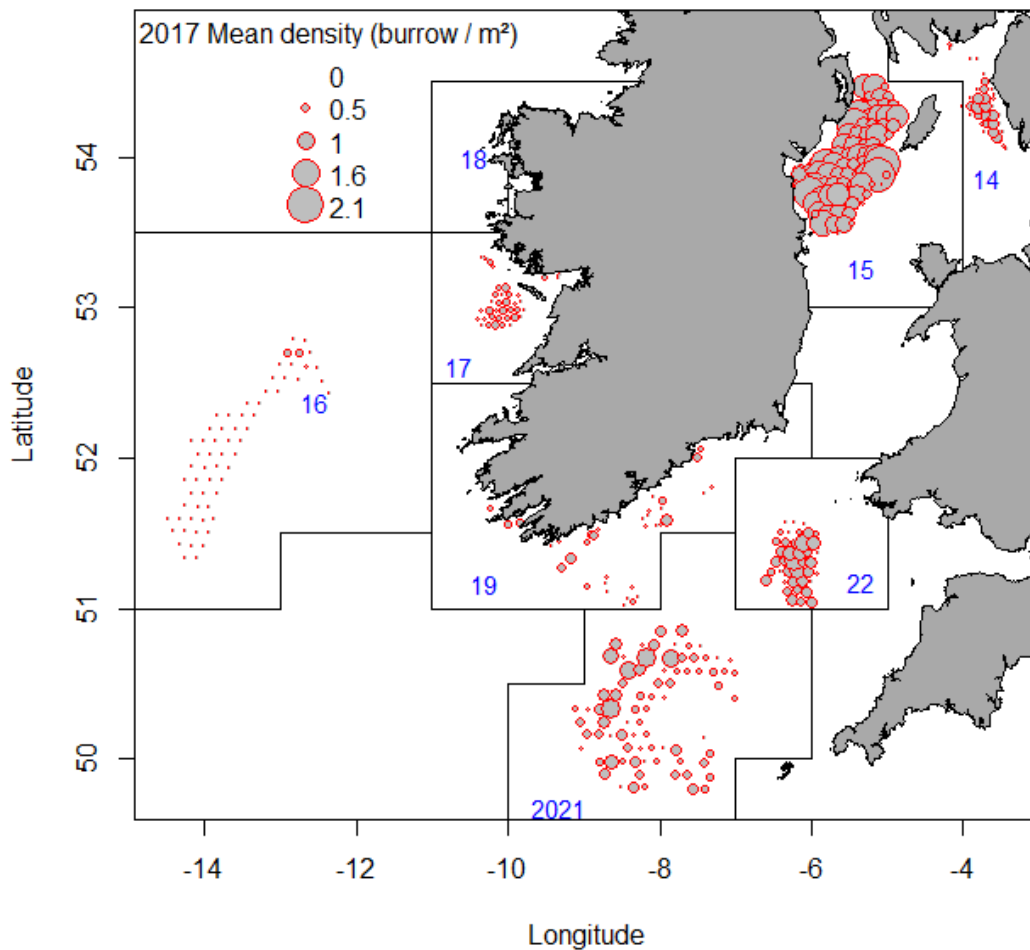


Figure 5.1.1.2. 2017 Mean adjusted density estimates (burrow/m²) by station for *Nephrops* grounds in ICES Subarea 7.

In recent years, there has been a good flow of staff exchange on UWTV surveys in ICES Subarea 7 on the collaborative UWTV survey in the Irish Sea (FU14 and FU15). In 2017, staff from Ifremer joined one survey and MI staff also joined the Irish Sea survey where this promotes protocol and technology transfer.

Geostatistical analysis was carried out using RGeostats package (Renard D., *et al.*, 2015) and is available as an R markdown document for UWTV surveys in FUs 16, 17, 20-21 and 22.

The individual survey reports and further details of the survey design and numbers of stations are available from the Marine Institute Open Access Repository at <http://oar.marine.ie/handle/10793/59>

UWTV Survey FU16: Porcupine Banks

This is the fifth survey of the Porcupine Banks *Nephrops* grounds. The survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. In 2017 63 UWTV stations were successfully completed in a randomised 6 nautical mile isometric grid covering the full spatial extent of the stock. The mean burrow density observed in 2017, adjusted for edge effect, was 0.12 burrows/m². The final krigged abundance estimate was 850 million burrows with a relative standard error of 5% and an estimated

stock area of 7,134 km². The 2017 abundance estimate was 11% lower than in 2016. The three species of sea-pen; *Virgularia mirabilis*, *Funiculina quadrangularis* and *Pennatula phosphorea*, were all observed during the survey. The deep-water sea-pen *Kophobelemnon stelliferum* was also observed and its presence/absence mapped from the available time-series. Trawl marks were also observed on 43% of the stations surveyed. Further details on this survey available at: <http://hdl.handle.net/10793/1334>

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

In 2017 the fifteenth annual underwater television on the Aran, Galway Bay and Slyne head *Nephrops* grounds, ICES assessment area; Functional Unit 17 was successfully completed. The survey was multi-disciplinary in nature collecting UWTV, fishing, CTD and other ecosystem data. In 2017 a total of 40 UWTV stations were successfully completed, 31 on the Aran Grounds, 5 on Galway Bay and 4 on Slyne Head patches. The mean burrow density observed in 2017, adjusted for edge effect, was medium at 0.31 burrows/m². The final krigger burrow abundance estimate for the Aran Grounds was 377 million burrows with a CV (or relative standard error) of 4%. The final abundance estimate for Galway Bay and Slyne Head was 16 and 11 million burrows with CVs of 4% and 4% respectively. The total abundance estimates have fluctuated considerably over the time series. The 2017 combined abundance estimate was a 6% increase compared to 2016 and at 404 million and is below the MSY B_{trigger} (540 million). *Virgularia mirabilis* was the only sea-pen species observed on the UWTV footage. Trawl marks were present at 20% of the Aran stations surveyed. The results of the CTD data collection show the bottom temperature on the Aran grounds was mainly between 10-11°C and Galway Bay bottom temperatures were a couple of degrees warmer. A heat map and dendrogram of proportional counts of the benthic catch from the beam trawls identifies stations that which have similar benthic compositions. Further details on this survey available at: <http://hdl.handle.net/10793/1335>

UWTV Survey FU19

This was the eighth survey of the various *Nephrops* patches in Functional Unit 19. The survey was multi-disciplinary in nature collecting UWTV, CTD, multi-beam and other ecosystem data. UWTV stations were randomly picked within each patch using `spsample` function from the R library (`sp`) (Pebesma and Bivand, 2005) of `r` (R Core Team, 2017). Previously stations were randomly chosen using the “Create Random Points” tool in ArcToolbox of ArcGIS10. The sampling effort, i.e. numbers of stations, on each ground was determined by relative area as in previous years. In 2017 a total 41 UWTV stations were successfully completed. The mean density estimates varied considerably across the different patches. The 2017 raised abundance estimate was a 25% increase from the 2016 estimate and at 499 million burrows is above the MSY B_{trigger} (430 million). Two species of sea pen were observed; *Virgularia mirabilis* and *Pennatula phosphorea* which have been observed on previous surveys of FU19. Trawl marks were observed at 10% of the stations surveyed. Further details on this survey available at: <http://hdl.handle.net/10793/1332>

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

WKCELT (Benchmark workshop on Celtic Sea stocks; ICES, 2014) concluded that full survey coverage was needed before *Nephrops* in FU20-21 could be moved into a full UWTV survey category for assessment and advice (ICES, 2014). The 2017 survey achieved full coverage of the stock area for the fourth successive time. Area of this ground is calculated at 10 014 km² which is the largest *Nephrops* ground in ICES area 7 (ICES, 2014). The 2017 survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. A total of 86 UWTV stations were completed at 6 nautical mile intervals over a randomised isometric grid design. The mean burrow density was 0.44 burrows/m² compared with 0.18 burrows/m² in 2016. The 2017 geostatistical abundance estimate was 4.4 ± 0.01 billion a 236% increase

on the abundance for 2016 with a CV of 4% which is well below the upper limit of 20% recommended by SGNEPS 2012. Highest densities were generally observed throughout the ground, and there were also high densities observed close to boundaries. Reference set was available and used to train counters prior to counting survey footage. One species of sea-pen (*Virgilaria mirabilis*) was recorded as present at the stations surveyed. Trawl marks were observed at 32% of the stations surveyed. Further details on this survey available at: <http://hdl.handle.net/10793/1330>

UWTV Survey FU22: Smalls

This report provides the main results and findings of the twelfth annual underwater television survey on the 'Smalls grounds'. The survey was multi-disciplinary in nature collecting UWTV, CTD and other ecosystem data. A total of 40 UWTV stations were surveyed successfully (good quality video footage) carried out over an isometric grid at 4.5nmi or 8.3km intervals. The precision, with a CV of 5%, was well below the upper limit of 20% recommended by SGNEPS 2012. The 2017 abundance estimate was 16% higher than in 2016 and at 1600 million is above the new MSY $B_{trigger}$ (990 million). Only one species of sea-pen *Virgilaria mirabilis* was recorded as present at the stations surveyed. Trawl marks were observed at 59% of the stations surveyed. Ten beam trawl tows were carried out providing important data on the benthic communities and size structure of the *Nephrops* population. Further details on this survey available at: <http://oar.marine.ie/handle/10793/1331>

UWTV Data Management

On completion of each UWTV survey the data (such as: counts, distance over ground, ship and sledge tracks and descriptive data) which are held in MS Access local database are quality controlled using r-scripts. When the data has passed quality control procedures it is then uploaded to the MI SQL server database. Prior to 2017 queries in the local database were used to calculate the final mean adjusted burrow densities as the input data to the kriging analysis. In 2017 a comparison of the outputs of the local MS Access queries and the SQL server script queries was carried out for each FU survey and year. The results of these comparisons showed no major differences in the outputs of number of TV stations, final burrow counts and distance over ground. Therefore it was deemed acceptable to use the SQL scripts to calculate final density data for 2017. The results of the comparisons are available as Rmark-down documents for FU17 as an example.

Equipment Developments

In early 2017 Marine Institute trialled existing HD cameras however, the quality of the footage obtained was not an improvement on current analogue / composite feed and not of sufficient quality for mosaics. Later in 2017 it was decided to cancel the tender to mosaic the current footage and then to redirect funds into purchasing an alternative imaging system. A CathX Ocean Ivanov custom built camera system was purchased. The features of this system are: high intensity strobing light, HD video and UHD stills produced, range finding laser and integrated geolocation metadata associated with each image. Sea trials were carried out in October and while there are various teething problems the system has great potential to provide high quality images for post-processing into mosaics. Next steps are to find optimum camera angle, light set-up and camera configurations for the new camera system. Mosaicking the UHD stills should result in significantly better quality images than mosaicking HD video alone. These high quality mosaics can be used to annotate and measure burrow systems and other features of interest. In the future it is envisaged to use feature detection algorithms and deep learning to automatically identify *Nephrops* burrow systems and other features of interest.

Conclusions / Recommendations

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

5.1.2 UK Northern Ireland (Annika Clements)

This was the 15th annual survey in a time-series of UWTV surveys in the Irish Sea (ICES Division VIIa) carried out jointly by the Agri-Food and Biosciences Institute (AFBI), Northern Ireland (UK), the Marine Institute, Ireland, and Cefas, UK. The survey took place on RV *Corystes* between 31st July and 9th August 2017. The survey covered the western Irish Sea (FU15) (reported in this section) and the eastern Irish Sea (FU14) (reported under UK-England).

The specific objectives of the survey are listed below:

1. To complete a randomised fixed isometric survey grid of 100 UWTV with 4.5 nautical mile (nmi) spaced stations on the western Irish Sea *Nephrops* ground (FU15);
2. To obtain 2017 quality assured estimates of *Nephrops* burrow distribution and abundance for FU15. These will be compared with those collected previously;
3. To collect ancillary information from the UWTV footage at each station such as the occurrence of sea-pens, other macro benthos and fish species, and trawl marks on the seabed;
4. Technology, staff and protocol transfer between AFBI, the Marine Institute and Cefas.
5. To implement the application of Lin's concordance correlation coefficient (CCC) with a threshold of 0.5 agreement between recounts per station to determine which stations required third (or further) recounts to ensure agreement between counts.

From 2003 to 2017 a randomised fixed square grid for the western Irish Sea (FU15) *Nephrops* ground has been used. An adaptive approach is taken whereby stations are continued past the known perimeter of the ground until the burrow densities are zero or very close to zero. The initial ground perimeter has been established using a combination of integrated logbook-VMS data (using the methods described in Gerritsen and Lordan, 2011), British Geological Survey (BGS) and other sediment maps, and previously collected UWTV data. The same ground boundaries have been used throughout the time-series. The grid spacing from 2003 to 2011 was 3.5 nautical miles (nmi). Following a review (Doyle *et al.*, 2013) the grid design was changed from a 3.5 nmi to 4.5 nmi in 2012. In 2013, the grid spacing was increased further to a 5.0 nmi isometric grid, whereas a 4.5 nmi isometric grid was used again in 2014 - 2017 to ensure all edge of ground areas were represented adequately.

The main motivation to increase the grid spacing was to achieve full spatial coverage of FU15 while giving the option to reallocate ship time to increase coverage in other Functional Units (FU16, FU20-21 and FU19); also in line with SGNeps recommendations (ICES, 2012). Reducing the number of stations was not expected to significantly affect the accuracy of the survey estimate, supported by the apparent strong spatial autocorrelation in density across the area (Doyle *et al.* (2013)). The precision (measured by the coefficient of variation) indeed has not been significantly reduced in 2012 - 2017 by comparison

to earlier years, with a CV of 3% which was in line with previous estimates (varying between 2 – 4%), all of which are well below the SGNEPS 2012 recommendation of 20%.

The 2017 design consisted of a randomized isometric grid of 100 stations at 4.5 nautical mile intervals out over the full known extent the stock.

At each station, the UWTV sledge equipped with standard definition camera with a known field of view (0.75 m, as measured by point lasers and checked daily on survey) was deployed and once stable on the seabed a 10-minute tow was recorded onto DVD. Vessel position (dGPS) and position of sledge (using an USBL) were recorded every 1 to 2 seconds. All stations were successfully surveyed with five re-do stations due to visibility issues on first attempts. Due to high abundances at stations near the ground edge particularly in the southwest of the ground, a further three exploratory stations were added in the region to attempt to redefine the edge. Nine additional tows were completed opportunistically in Belfast Lough over grounds identified as *Nephrops* ground from the 2015 survey; together with data gathered in the Lough over the previous two years it is planned that the ground in the Lough will be defined before the 2018 survey and an appropriate number of stations determined for long-term monitoring.

The navigational data were quality controlled using an “R” script developed by the Marine Institute (ICES, 2009). In 2017, the USBL navigational data were used to calculate distance over ground for 100% of stations. An updated database and ship server was used during the survey which streamlined some of the data QC and development of a survey ‘dashboard’ enabled rapid progress evaluation. An updated SQL database is now in use at AFBI to store all *Nephrops* UWTV data.

Lin’s CCC was applied during the survey to all recounts to identify those stations which required a third count, with a threshold of 0.5 used. 50% of stations required a third count, however following this 75% of stations passed. The remaining stations had ‘problem minutes’ identified and these were then consensus counted. Certain areas within the ground are problematic from a burrow detection and identification perspective due to the presence of multiple burrowing species: training to improve discrimination in such areas will be a focus in future surveys.

Within the western Irish Sea, the average burrow density (adjusted to account for bias factors) was 0.90 burrows/m². This is a 7% increase from the 2016 figure of 0.84 burrows/m². The summary statistics from the geo-statistical analysis show in 2017 a final abundance estimate (adjusted to account for bias factors) of 5.3 billion burrows, which is close to that estimated in 2006. The overall burrow abundance trend is fairly stable although the abundance did decline between 2007 and 2008, and between 2012 and 2015. 2016 and 2017 has shown an increase in abundance. The survey precision as measured by the coefficient of variation for 2017 was 3% indicating a very precise survey in line with CVs observed previously. A comparison of geostatistical analysis using “R-Geostats” and the usual “Surfer” method was made, with a consistent trend agreement observed between the Surfer based estimate and R-Geostats, however, with a positive bias (mean = 0.23). It is suggested that transition to analysis using R-Geostats should take place following inter-benchmarking.

From the UWTV footage, notes were also recorded on the occurrence of trawl marks, fish species and other species. Semi-quantitative assessment of sea-pen species were also recorded according to OSPAR Special Request (ICES, 2011). All sea-pens were identified from the video footage as *Virgularia mirabilis*; 16% of the 2017 survey stations had *V. mirabilis* present (very similar pattern to 2017). Trawl marks were noted at 36% of the stations surveyed.

Within Belfast Lough, average burrow density was 0.23 burrows/m² (adjusted to account for bias factors using FU 15 correction factor) and sea-pens (*V. mirabilis*) were present in two of the stations. Burrow systems appeared notably larger in size than those viewed over the majority of the western Irish Sea.

A trawl survey was also completed from 13th – 17th August, with 24 trawl stations across FU15 sampled by *Nephrops* trawl and 21 stations sampled by a 2m beam trawl: 11,183 *Nephrops* were measured to generate length frequencies for males and females and establish the sex ratio.

A new UWTV exploratory survey for *Nephrops* abundance assessment was commenced in 2017 within Strangford Lough, using a drop frame system coupled with two fan lasers and HD camera. Potential *Nephrops* ground was provisionally defined based on multibeam sonar data and grab sampling, and any available creel data. As the Lough is protected (as a Marine Conservation Zone and Special Area of Conservation) with a non-disturbance zone covering part of the subtidal area, a drop frame was necessary. 34 stations were surveyed and these data are being used to design and refine subsequent surveys. Counting burrow systems from a drop frame presents different challenges due to the angle of view and lighting, and some further refinement of the equipment set up may be needed to facilitate burrow identification.

Future developments:

The FU15 survey still uses a standard definition/analogue camera, with a non load-bearing cable which requires cable-tying to the winch wire for each deployment. Procurement is underway to update the camera system availing of newer high definition (HD) technology, and replace the cable with a load-bearing cable and new winch. The new system is hoped to enable future use of stills mosaics and image classification/tagging.

5.1.3 UK Scotland

(Katie Boyle, Adrian Weetman)

All three annual cruises in 2017 took part aboard Marine Scotland's marine research vessels (MRV). Fladen, Devils Hole and the west coast of Scotland was surveyed in early summer aboard MRV Scotia, whilst the Moray Firth and Firth of Forth were surveyed later in the summer aboard MRV Alba-na-Mara. Alba-na-Mara was also used to carry out the west coast sea loch work in January. With a number of new and returning colleagues on the Scotia cruise, some of whom had not been involved in this work for six years, they observed marked changes in the way the survey was undertaken since their last survey. This included the noticeable increase in work-load to be completed whilst at sea, especially in relation to data processing and video reviewing. Although the approach of allocating different tasks and footage to individuals, as well as using Lin's CCC for training and identifying footage requiring third counts, was seen as very positive and efficient developments.

On all three surveys each the objectives set out in the cruise programmes were met, with all the footage worked up and the data processed before the end of the surveys. Although Lin's CCC was run on the counts produced whilst on Alba-na-Mara, as there were only two reviewers on board the vessel, any third counts that were required had to be completed when the footage was returned to the laboratory where there were staff available to assist in this work.

The survey aboard Alba-na-Mara in January continued the work carried out in the South Minch which started in 2014. Using same approach as in previous years, the aim of the survey was to use a drop frame to map the extent of the muddy habitat within the Inner Sound and the area to the east and

southeast of Raasay in the South Minch which are not currently mapped by the British Geological Survey (BGS), as seen in Figure 5.1.3.1. . The outcome of this work was to be able to calculate an evidence based value of muddy habitat from within the survey area.

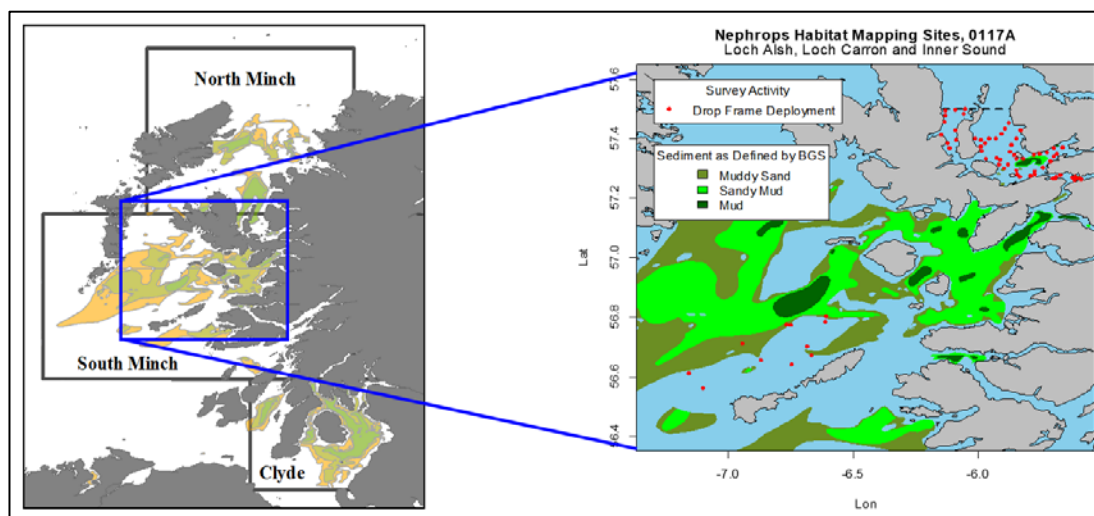


Figure 5.1.3.1 Plot showing the areas on the west coast of Scotland surveyed during 0117A where drop frame deployments were made to map *Nephrops* habitat that is not currently charted by BGS.

This work will complement earlier surveys in this series and it is envisaged that it will be possible to calculate the total surface area of mud from all the sea lochs and areas of open water on the west coast that are currently not included in the main assessment surveys or included on BGS charts. This has the potential to increase the surface area in which to raise abundance values to, but as seen from earlier surveys in the North Minch sea lochs the area represented an insignificant overall increase in surface area and would generate considerable associated problems for the assessment models (due to different fishing practices, *Nephrops* population structure different to open water populations, etc).

Once analysed, the habitat mapping data collected from this survey will be merged with the comparable data gathered from cruises 0114A, 0115A and 0116A to provide a more accurate calculation as to the complete surface area of *Nephrops* habitat in the South Minch. These results will be presented at a future WGNEPS meeting for consideration.

Due to increased pressure for ship time it is becoming more important to maximise time efficiency while at sea. Significant progress was made in relation to this objective when a script was written in the open source programming language R, that calculated the most efficient route between stations. First used on MRV Scotia this proved especially effective in Fladen where the route calculated saved approximately twenty hours compared to the route originally proposed which was created through discussion. This method however was redundant in the North and South Minch areas where the survey is split, doing half on the way south and the remaining half on the way north, resulting in a very linear route. Similarly, the Clyde survey area is a simple circular route around Arran.

For the first time during the summer Alba cruise Lin's CCC was used on the counts whilst at sea. This was done not only to highlight runs for third counts (which had to be completed at the Laboratory as there were not sufficient reviewers whilst at sea) but to indicate if further training was required to minimise the necessity for third counts at a later stage. If counts were significantly different a refresher session took place whilst at sea, where both counters would watch footage together and discuss burrow

identification in different sediment types, visibility and abundances. It is hoped this approach combined with the reference footage training will be continued on future surveys.

Due to issues encountered during the January Alba cruise, the data logging software was amended to provide alternative versions. This provided a more robust, secure approach to gathering the data and would avoid potential data loss in the future.

New reference sets for the six main Scottish functional units were compiled using the 2016 footage, and were partly reviewed during the two summer cruises. This was required as the previous reference sets were ten years old and the video quality had improved in that time as the lights and camera were updated. In addition, there was agreement between the reviewers that benthic conditions in some areas appeared to have changed, and the new reference sets would address this disparity between the training footage and what was being observed. It is hoped the new values will be ready for training purposes in the 2018 survey season.

Along with the TV survey providing essential evidence on *Nephrops* abundance, the surveys also collected data for a number of supplementary projects. On the Scotia survey biological samples from 100 *Nephrops* (50 males and 50 females) were collected from the trawls carried out on the east coast. The samples were forwarded to University College Dublin as part of a polygenetic study to determine which populations of *Nephrops* in the Northeast Atlantic may have evolved together. The results of the study are due to be released in 2019.

All marine litter collected during trawling operations was measured, recorded and disposed of in the correct manner. The resultant data were presented in electronic format to the relevant co-ordinator post-cruise. This process is in line with OSPAR and MSFD agreements, and is now standard practice during all MSS cruises.

In addition, the bycatch caught during the trawls was collected and used to supply the Aberdeen Marine Laboratory's Fish Behaviour Unit, where a number of aquariums support experiments using live fish.

Throughout 2017 two projects suggested at earlier Working Groups were undertaken, both relating to, and using footage from, UWTV surveys. The first task involved reviewing historical video footage to establish if any trends in the way counters reviewed had developed over time, e.g. over or under counting; and the second involved video annotation.

At random, four stations from five functional units were selected from both 2008 and 2011. The footage was reviewed according to present protocols which resulted in data from only seven minutes of footage although ten minutes data were available from the original footage, as the method for reviewing had changed over time. The minute by minute mean of original two reviewers' data were compared to the mean values of the 2016 reviewers, and the data assessed using Lin's CCC. This generated a number of plots with mixed outcomes. However, after examination it was agreed that these data were not truly reflective of any changes in counting trends, as the datasets had different reviewers.

The data were then assessed a second time, only using footage where the same counter was present in the original dataset and in the 2016 exercise. This reduced the valid number of datasets available but illustrated a more accurate outcome of what was trying to be achieved. In this approach the mean count for each run was used to assess the results, rather than minute by minute, in line with the WG assessment methods. All available data were plotted and found to show a strong correlation between the original values and those generated in 2016 an example of this can be seen in Figure 5.1.3.2. The data were examined in more detail by clustering data by area and also by abundance, with counts of less than ten burrows per run and those over. However this reduced the dataset further and meant that there were too few samples to form sound conclusions. The findings from 2017 were presented at WGNeps 2017 but further work in this area is planned for 2018. This future work will include footage

from surveys carried out early in the Scottish UWTV time series as well as more recent footage where reviewers with a shorter history of being involved in the surveys will be examined. Analysis of all future comparative work will only be carried out where the same reviewer's data are available in both datasets.

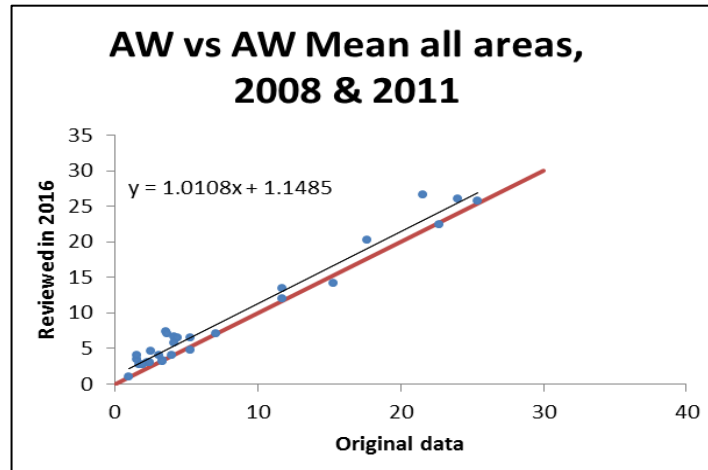


Figure 5.1.3.2 Scatterplot analysis of the mean burrow counts derived from footage originally reviewed by AW (Adrian Weetman) in 2008 and 2011, compared to AW reviewing the same footage in 2016.

To assist in the training of reviewers and in agreeing burrow abundance in reference footage, previous WGNEPS meetings had discussed the potential of annotating video. Trying to address this, the editing package Powerdirector 15 produced by the developer Cyberlink was trialled in 2017. This software used the feature Motion Tracking where a selected object was identified (e.g. *Nephrops* burrow or sea pen), marked and then tracked by the software as the video was played in real time. Once an object has been tracked across the field of view various overlays could be applied including a spotlight effect, imported icons (arrows, circles, etc.) or text. This overlay then tracked the selected object across the field of view in real time. Multiple objects could be selected within the same frame and variations could be applied to the marker (font, colour, size, etc.) to assist in identifying complexes. A simple example of this work was presented at WGNEPS 2017 and Marine Scotland Science (MSS) will carry out further work with this software in 2018.

5.1.4 UK England (Robin Masfield)

UK England is currently responsible for the assessment of 3 different FU, although only two have regular UWTV surveys (FU6 and FU14), being FU5 classified as data-limited stock.

FU5: Botney Gut - Silver Pit

Due to funding constraints Cefas (UK) is no longer covering this ground, although the possibility of having a collaborative survey in future is being discussed with the Netherlands. More information regarding future options to reinstate this survey will be discussed in the near future and this information will be passed on to the WGNEPS.

FU6: Farn Deeps

The gear for the 2017 survey was the same as for the 2016 survey, using OLED monitors (Sony 25-inch professional PVM-A250) a Kongsberg camera (720p, 24fps), green fan lasers (rated to 3000m, 520nm wavelength), lights (20w LEDs) and on-board control system. The Rochester armoured cable was used as in previous years, although only the coax components were required for delivery of power and control of all peripherals. It is anticipated that we will go over to fibre optic umbilical for the 2018 survey. The 2017 survey was conducted from 19th to 26th June, sampling all 110 stations of the survey grid. An additional 16 stations were completed, not forming part of the standard survey (Figure 5.1.4.1). These additional stations form part of an UWTV survey conducted by NEIFCA (Northeast Inshore Fisheries and Conservation Authority) in autumn each year on grounds within 6 nm from the coast. The stations were included to allow comparisons of the burrow densities before and after the peak moulting period, this analysis has not yet been completed, the results of which will be presented at a future working group. The work was all undertaken according to the standard protocols which include pre-survey training and standardisation of counter's performance. All counters must count the reference footage to a pre-determined standard before being given access to the current survey footage.

The visibility was, as with the previous two years, very good. 93 % of footage was classed as "Good" and 7% as "Moderate".

Of the 110 stations completed, 40 % failed the CCC threshold of 0.7. All stations were used in the assessment

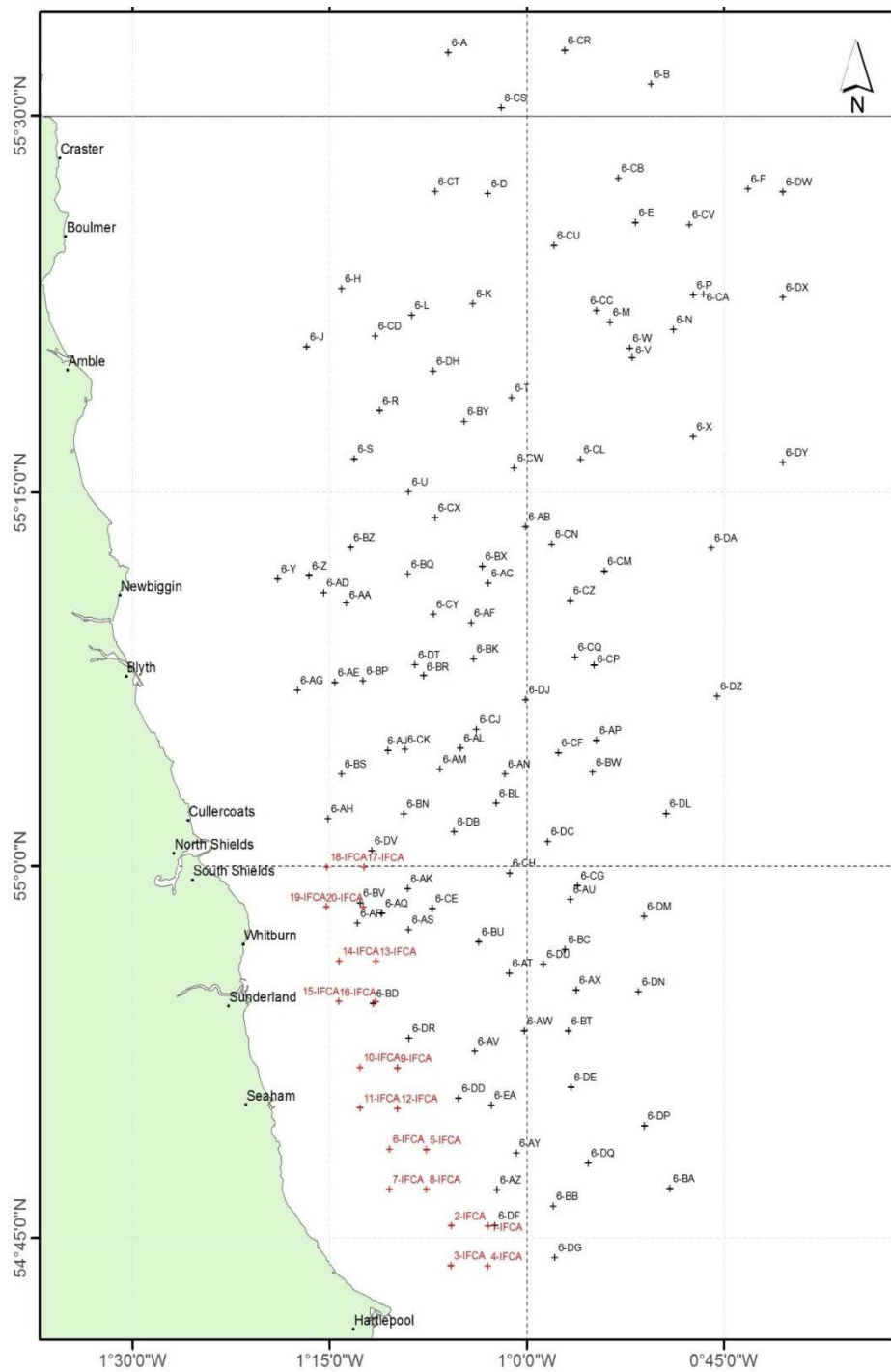


Figure 5.1.4.1 FU 6 UWTW survey stations (black) and the additional stations (red) surveyed during the 2017 survey.

FU 14: East Irish Sea

The 2017 Irish Sea *Nephrops* UWTW survey took place on “RV Corystes” between 3rd to 11th August. The departure and arrival port was Belfast. This survey covered both western (FU15) and eastern (FU 14)

side of the Irish Sea. The survey in the East Irish Sea area is of a fixed grid design and is carried out using the same protocols used in UWTV surveys in the western Irish Sea.

A burrow counting training day was set up on Monday 3rd August to brief scientific staff with procedures and revised reference counts results.

As in 2016, three new stations added in Wigtown bay (Figure 5.1.4.2). This was done to account for an increase in effort in this area, the result of effort displacement from an area at the southern boundary of FU 14 where Walney offshore windfarm has been developed.

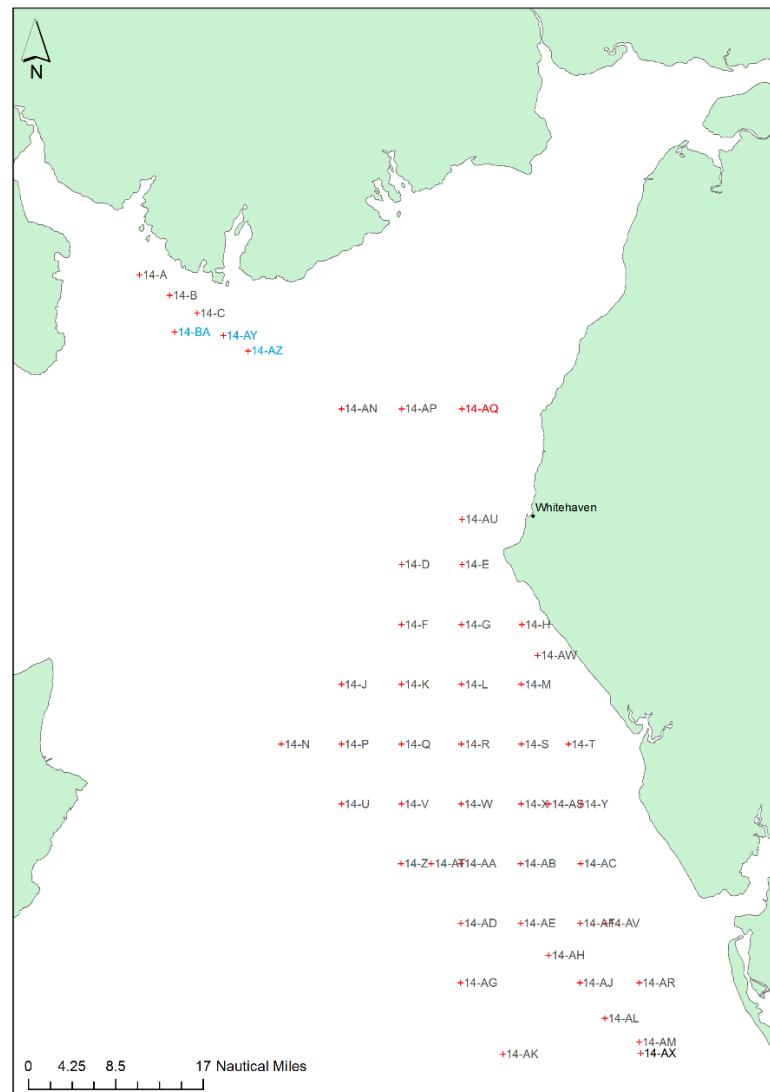


Figure 5.1.4.2 Sampling locations on August 2016 for the FU 14 survey, the new stations added in 2016 in Wigtown Bay are included (blue).

The effort in Wigtown Bay increased from 1.9 to 6.6 % of the overall fishing effort in FU 14 from 2015 to 2016. This brings the additional survey stations in Wigtown Bay up to six.

Of the 39 stations forming the standard survey grid 37 stations were surveyed. Five of the six additional stations in Wigtown Bay and the three additional stations off Workington were also surveyed. 60% of

the stations surveyed were survey in good clarity conditions and 40% in moderate to poor conditions. Deterioration of the water clarity was mainly related with strong tides as no fishing vessels were present at the time of this survey. Two stations (14-AG and 14-AK) were dropped as they were in an area currently being developed as an offshore windfarm, these will be dropped from the survey grid permanently. The third station missed was 14-AZ, despite revisiting this station three times it wasn't possible to get readable footage due to poor visibility.

- 45% of stations fell under the CCC threshold of 0.5
- Training section was done for the stations where agreement could not be made to identify issues on burrow identification.
- Main factors identified in no agreement were due to: existence of multi-species burrows in the ground - high burrow density but not necessary for *Nephrops*, small burrows, visibility, overall not clear *Nephrops* signatures.
- To avoid discarding stations an average count was used per station to get final densities per station.
- 37 of the 39 stations were used in the assessment.

Conclusions / Recommendations

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

- For FU 14 and FU 6 more accurate mapping of the spatial extent of the grounds and fisheries, this includes having positional data for < 12 meter vessels and more survey data in the boundary areas to better define these grounds.
- For FU 14 there is a need to improve the spatial coverage and sampling of landings and discards, this includes increasing the sampling levels to covers Northern Irish vessels, as the current sampling is mainly focused on local vessels from Whitehaven port.
- For FU 14 there is a need to get area specific length-weight and maturity data to validate the parameters used for this FU.
- For FU 14 better knowledge is required of the difference in growth and population structure across the area.

5.1.5 Denmark and Sweden

FU3-4: Skagerrak and Kattegat (Kai Wieland, Mats Ulmestrand)

The 2016 survey was carried by Denmark mainly during May in subareas 1, 2, 5 and 7 with RV Havfisken and by Sweden during June in subareas 3, 4 and 6 with RV Asterix (Figure 5.1.5.1). Denmark completed 105 stations but a few of them were not suitable for analysis due to poor visibility. Similarly, Sweden encountered difficulties with water clarity and rocky bottom, and the overall achieved coverage for both countries together with stations suitable for analysis was 89 % of the planned stations. For all subareas, the CV was below 22 %. With the inclusion of subarea 7, which was sampled the first time in

2014, the total survey area amounted to 9535 km² and the average bias corrected *Nephrops* burrow density was 0.31 burrows/m² with an overall relative standard error (OECV) of 4.7 %.

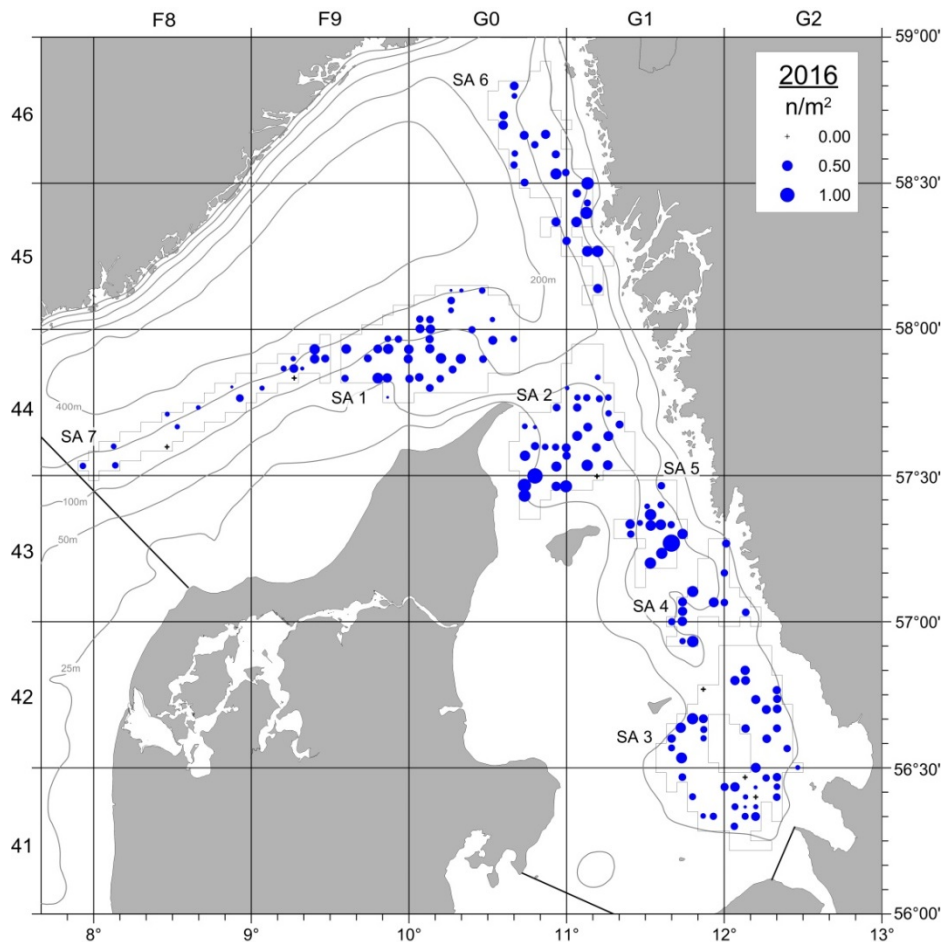


Figure 5.1.5.1. Sampling locations and *Nephrops* burrow density in UWTV survey in the Skagerrak and Kattegat in 2016 (SA: subarea).

For 2017, a several modifications were implemented following the results of the 2016 benchmark for FU 3-4 (ICES, 2017a; see also section 5.1.11). Based on updated VMS information the total survey area was increased, stratum boundaries were re-defined, two new strata were introduced and the spatial resolution of the grid of possible element positions was increased from 2 nautical miles to 0.7 nautical miles spacing resulting in a total area of 14093 km² and 9720 sample elements. Consequently, pure random selection of sampling positions was considered to be no longer appropriate due to the high risk for clustered stations and buffered sampling was introduced in which the buffer around a selected position depends on the area of the stratum and the total number of stations allocated to this stratum (Kingsley et al., 2004).

Denmark conducted the 2017 survey with RV Havfisker mainly during April. Sweden used also DTU Aqua's RV Havfisker with the Danish HD camera and sledge equipment outside the Swedish 4 nautical mile limit and used inside this limit RV Asterix with the old video recording system. Denmark achieved 98 % of the planned stations in strata 1, 2, 5, 7 and 8 and Sweden achieved 85 % of the planned stations

in strata 3, 4, 6, 9 and 10. The resulting area coverage is shown in Figure 5.1.5.2. Counting has been completed but the analysis of the survey data are yet not completed.

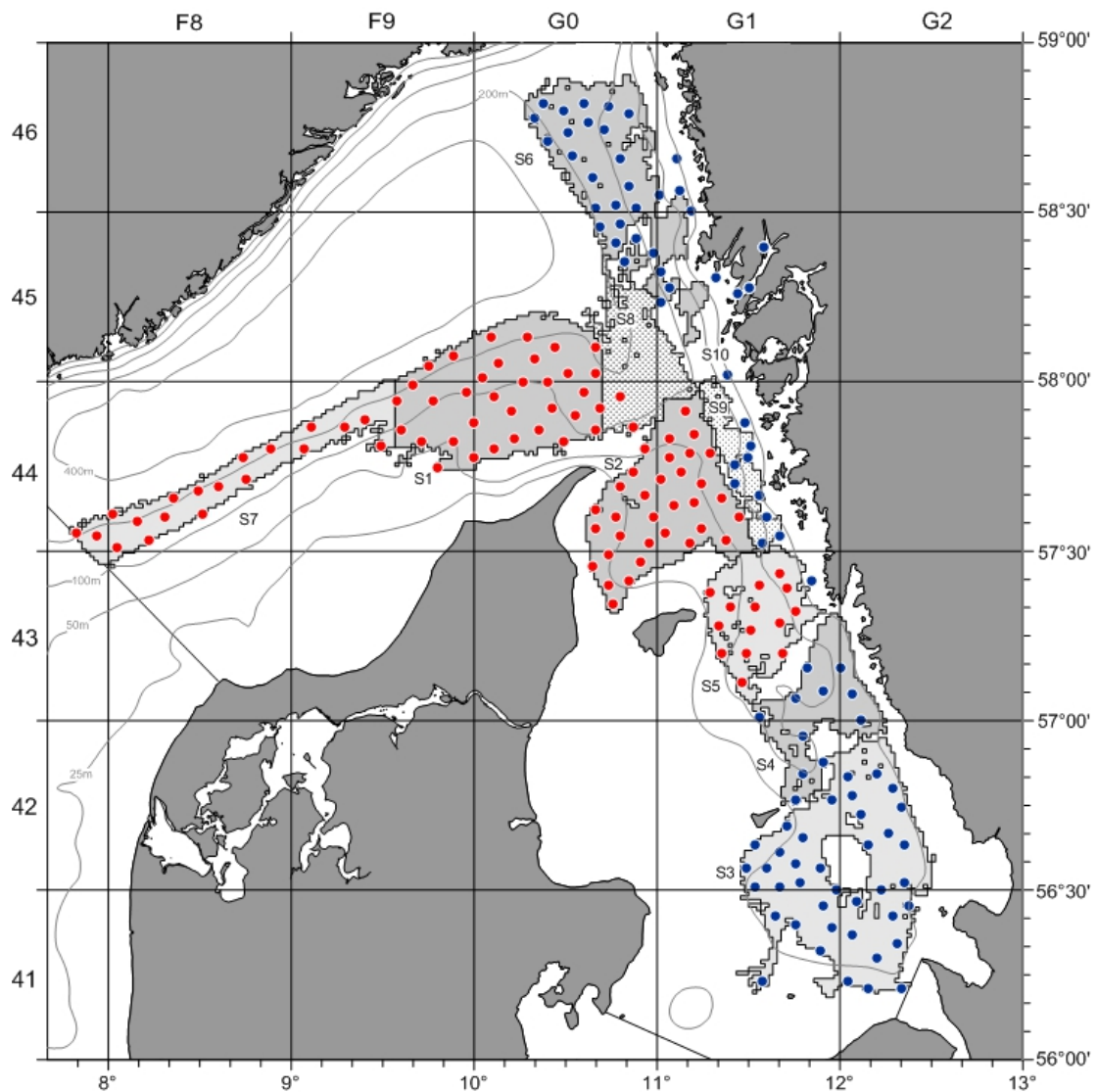


Figure 5.1.5.2 Achieved area coverage in the joint Danish/Swedish UWTV survey in 2017 (S: Stratum; boundary for S10 (Creel area) not drawn, S8 and S9: new strata, poor coverage in S8 (just 4 stations planned because low *Nephrops* density expected based on VMS and logbook data but only 2 stations achieved (Sweden did not accomplish sampling there)).

Conclusions / Recommendations

- No further changes of survey design except for a possible increase of stations in the new strata S8
- Establish a new set of reference footages which should then also include strata sampled by Sweden (the existing set contains only Danish stations) preferably sampled with a HD system
- The collaboration between the readers of the two countries should continue whereby the stations read by the two countries may be randomized

FU33: Off Horns Rev (Kai Wieland)

An exploratory UWTV survey was carried out by Denmark with RV Havfisken in June 2017. The survey domain defined by VMS data and sediment information has an area of 5737 km² and was considered as one stratum. Similar to the approach used in FU3-4 the station positions were randomly selected applying buffered sampling based on a grid of 3322 sample elements with a spacing of 0.7 nautical miles. In total, 70 positions were chosen of which 66 stations were achieved in the 2017 survey (Figure 5.1.5.3). Counting of burrows and survey data analysis have yet not been completed.

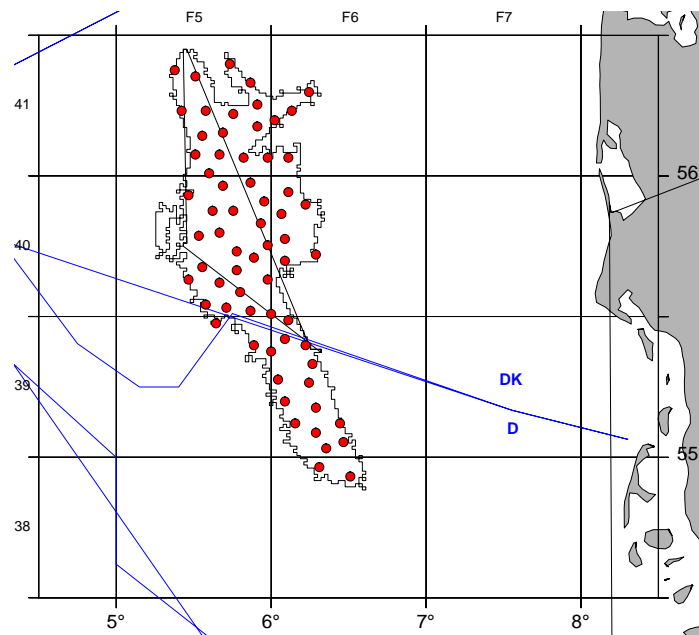


Figure 5.1.5.3 Achieved area coverage in the Danish UWTV survey Off Horns Rev in 2017.

Conclusions / Recommendations:

- Establish set of reference footages
- Determine bias correction factor

5.1.6 Spain

(Yolanda Vila, Candelaria Burgos)

Spanish Oceanographic Institute (IEO) carried out the fourth *Nephrops* UWTV survey on the Gulf of Cadiz fishing grounds in 2017 although UWTV survey in 2014 was considerate only exploratory. This survey took place on board RV Angeles Alvariño from 18-31 of May, about fifteen days before than previous years because of problems in the calendar of vessel. The specific objectives are listed below:

6. To obtain estimates of *Nephrops* burrows densities
7. To confirm the boundaries of the *Nephrops* area distribution

8. To obtain estimates of macro benthos species and the occurrence of trawl marks and litter on the sea bed
9. To collect oceanographic data using a sledge mounted CTD.

The design of the survey followed a randomized isometric grid at 4 nm spacing. Since 2016, stations are allocated in the grid in a rhomboidal way. A total of 64 stations were planned covering the *Nephrops* area distribution established in the last benchmark (ICES, 2017a; Figure 5.1.6.1a). The ground perimeter has been established using a combination of VMS and logbook data (Vila et al., 2016). The *Nephrops* area corresponds to 3000 km². Some stations were lightly moved to avoid the morphology of the bottom such a deep channel in the southwest part and a submarine pipeline in the shallowest limit. Stations ranged from 90 to 650 m depth. A few stations were re-done due to problems with the visibility from the recent fishing activity (4 stations) and only 2 stations were considered definitely null. In addition, 3 stations were carried out beyond the deeper *Nephrops* limit and considered as exploratory (blue squares in the Figure 1a). In this area, there is no fishing activity according to the VMS information available but the IBTS information shows presence of *Nephrops*. A total of 27 hauls from beam trawl were carried out in order to know the presence of other burrowing megafauna which co-occurring with *Nephrops* and that could be source of confusion in the identification of *Nephrops* burrows (Figure 5.1.6.1b).

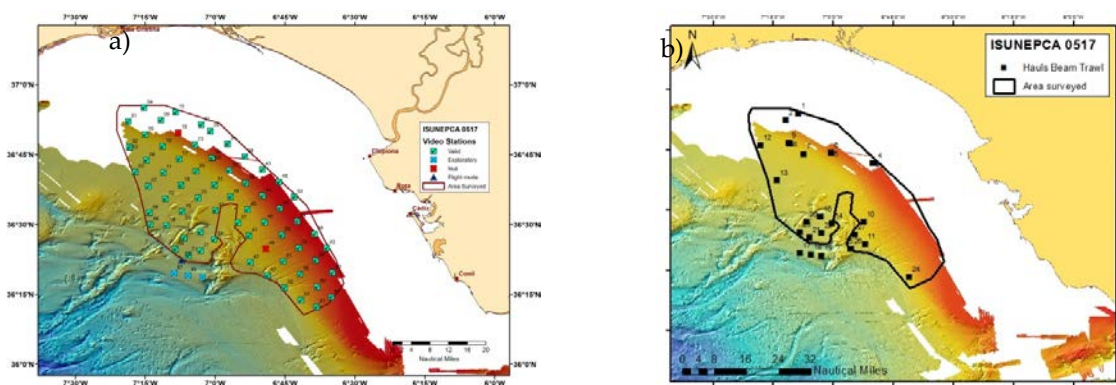


Figure 5.1.6.1. Station grid planned in UWTV survey in 2017 (a): video, b): beam trawl).

There were no significant changes to the equipment this year and only Full HD monitors were used for the *Nephrops* burrows counts for first time. At each station, the UWTV sledge equipped with Full HD camera (angle of 45°) with a known field of view (0.75 m) was deployed and once stable on the seabed a 10 minute tow was recorded. The sledge was towed at between 0.5-0.7 knots in order to obtain the best possible conditions for counting burrows. Vessel position (dGPS) and position of sledge, using a HiPAP, were recorded every 1 to 2 seconds. The distance over ground was estimated from the position of sledge in all stations.

The FU 30 reference footages were created before the UWTV survey following the recommendations done from WKNEPS in 2016 (ICES, 2017b) and according to the WKNEPHBID (ICES, 2008). Three national and one international counter from Marine Institute were involved in this process. The reference counts for each station were taken as an average per minute of the four counters. In 2017, all recounts were conducted by three trained “burrow identifying” scientists independent of each other. Lin’s CCC

R script was implemented and applied to all recounts to identify those stations which required additional counts. Only stations with a threshold lower than 0.5 were reviewed again by consensus among the three counters.

Footages were also used to count other megafauna species. The abundance was estimated using a range system composed by 6 categories from absent (0 individuals) to extremely abundant (> 100 individuals). Trawl marks and litter were recorded as presence/absent. This task has yet been not finished. Nevertheless, the results will provide very valuable information to characterize the habitat in the *Nephrops* area distribution in the Gulf of Cadiz in the framework of the Marine Strategy (MFSD).

Figure 5.1.6.2 shows the *Nephrops* density (adjusted to account for bias factors) for 2017 in this FU. The density ranged between 0 and 0.53 burrows/m² and the average burrow density was 0.13 burrows/m². The highest densities were observed in the west part of the area. In the shallowest edge the visibility is poor and the *Nephrops* density is low according to the VMS data and IBTS surveys series generating a high uncertainty in the *Nephrops* burrows identification. Additionally, the information obtained from the beam trawl activity indicated absence of *Nephrops* in hauls carried out at depth lower than 200 m. Therefore, the stations located in this edge of the area surveyed were considerate stations with zero *Nephrops* density in the geostatistical analysis.

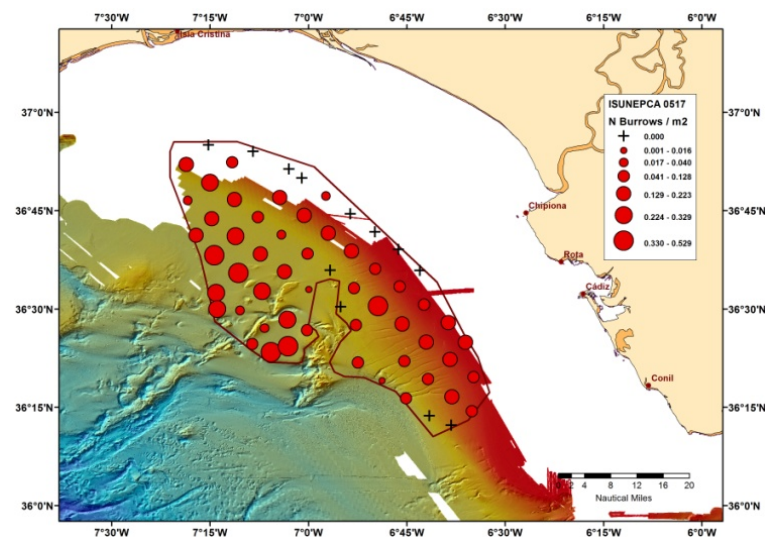


Figure 5.1.6.2. *Nephrops* bias corrected densities for 2017 UWTV survey in FU 30.

Other burrowing species observed from the hauls realized using beam trawl that cohabit with *Nephrops* were mainly *Munida* sp., *Goneplax rhomboides*, *Monadeus couchii* and *Macropipus tuberculatus* (Figure 5.1.6.3), being the squat lobster burrows which more confusion created in the identification and quantification of *Nephrops* burrows.

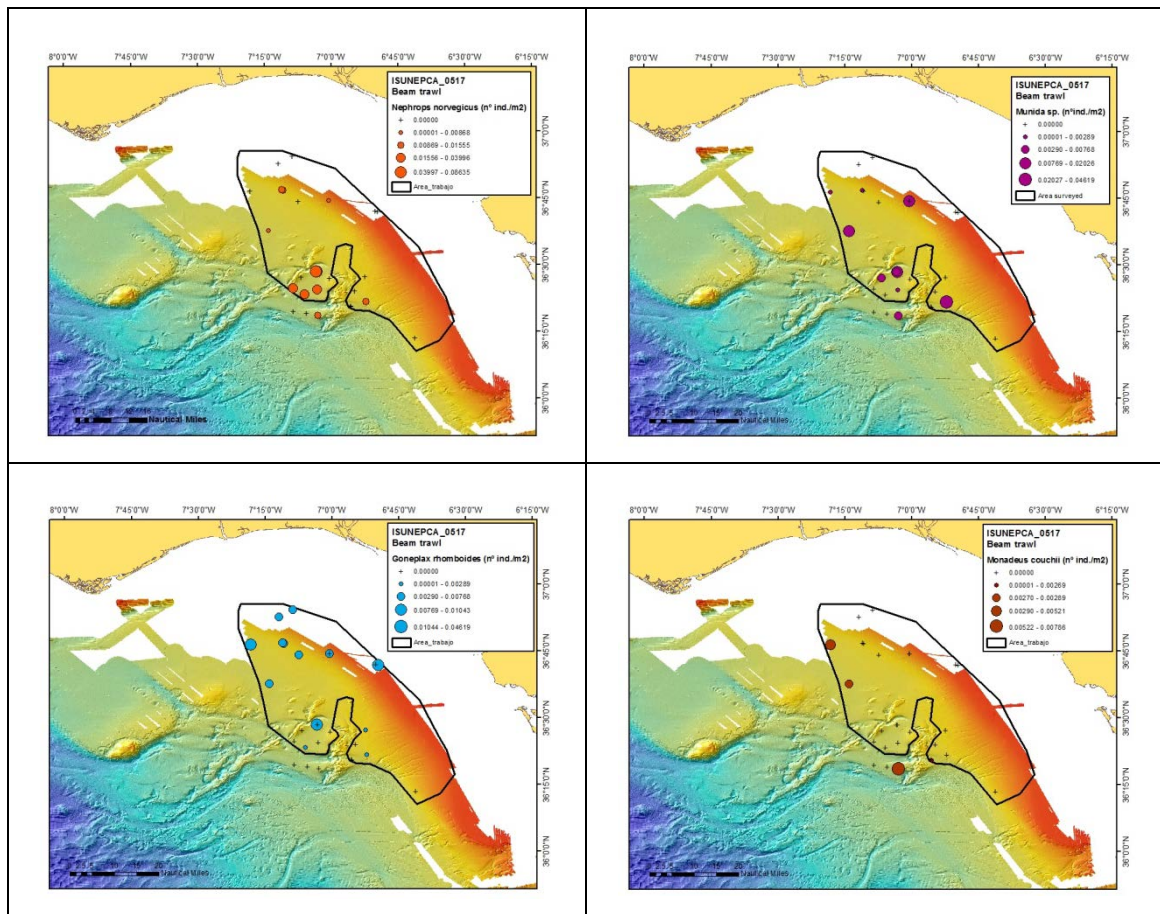


Figure 5.1.6.3 *Nephrops* and other burrowing species densities obtained from beam trawl.

The final modelled density surfaces in the UWTV surveys time series (2015-2017) are shown as a heat maps and bubble plots in Figure 5.1.6.4. Table 5.1.6.1 shows the summary statistics from the geo-statistical analysis using ArcGis. This year the number of stations used in the geostatistic analysis was higher than the previous years. The abundance estimate derived from the kriged burrow surface (and adjusted for the cumulative bias) was 271 million burrows with a CV of 8.7 % in 2017 (Table 5.1.6.2). The stock abundance is estimated to have increased more than 50% in 2017. The spatial pattern of burrow density is consistent in last two years.

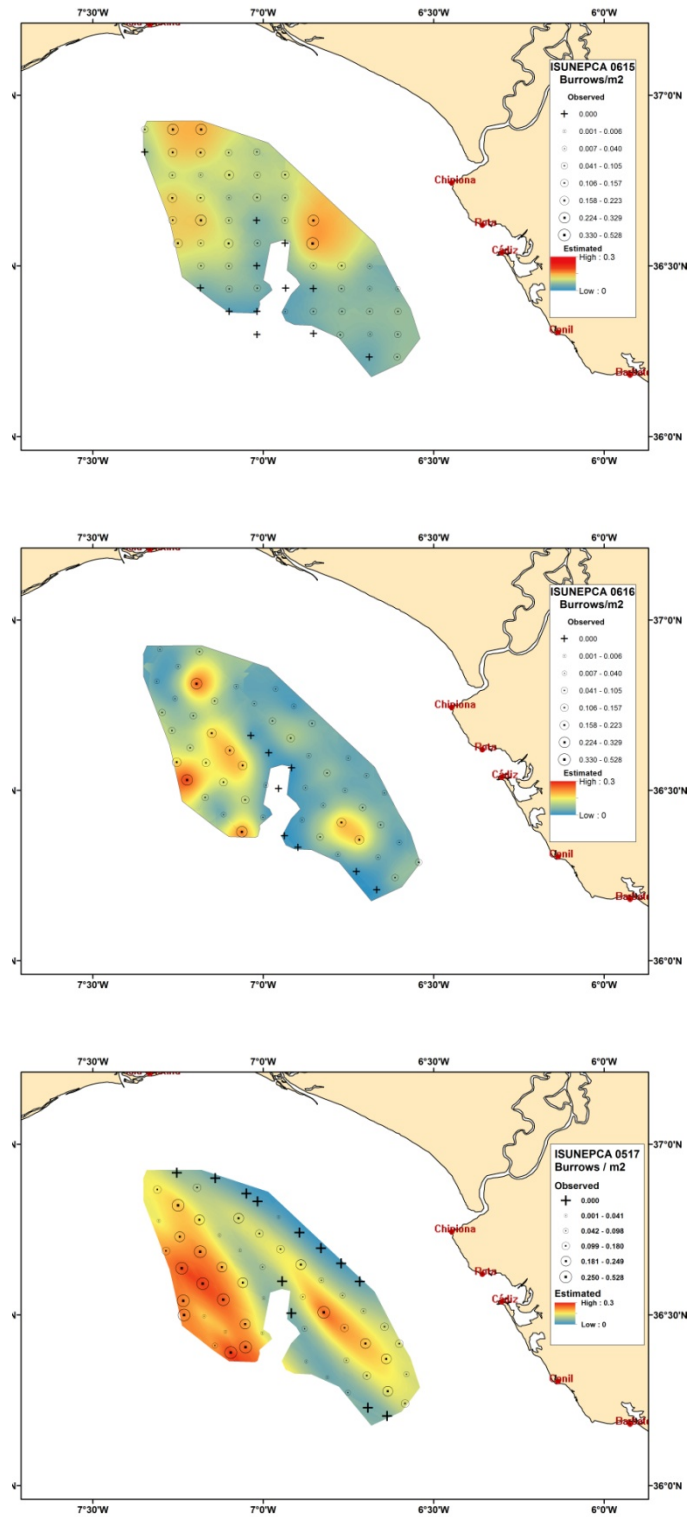


Figure 5.1.6.4. Bubble plot of the burrow density observations overlaid on a head map of the krigged burrow density surface for UWTV survey series (2015-2017). Station positions with zero density are indicated using a +.

Table 5.1.6.1. Geostatistical method summary.

Method	Kriging
Type	Ordinary
Variogram	Semivariogram
Number of lags	15
Lag size	0.034989
Nugget	0.007818
Anisotropy	Yes
Range (Major)	0.524835
Range (Minor)	0.175778
Partial sill	0.010165
Direction (angle)	135.87

Table 5.1.6.2. Results summary table for geostatistical analysis of UWTV surveys in FU30.

Year	N ^a stations	Mean density adjusted	Area Surveyed	Domine area	Geoestatistical Abundance estimate adjusted	CV on burrow estimate
		Burrow/m2	Km2	Km2	Millions burrows	
2015	58	0.0905	3000	3000	298	7.60
2016	58	0.0078	3000	3000	233	7.26
2017	62	0.1336	3000	3000	370	8.70

Conclusions / Recommendations

- Trawl data indicate co-occurring species that could be source of “burrow identification confusion”, so beam trawl activity should be continued in future surveys to validate the video observations and confirm the limits of the *Nephrops* distribution.
- Continue carrying out exploratory stations in order to confirm the *Nephrops* distribution boundaries.

5.1.7 Italy and Croatia

(Michaela Marinelli, Damir Medvešek)

The Adriatic Sea (GFCM Geographical Sub Areas 17 and 18) is one of the most important and most productive areas for the fishery of *Nephrops norvegicus* in Italian waters and in the whole Mediterranean basin (Morello et al., 2009; FAO FISHSTAT data). An important fishing ground occurs in the Central Adriatic depressions (the Pomo - or Jabuka in Croatian - Pits, part of GSA 17; Figure 5.1.7.1), which represent also a nursery for European hake (*Merluccius merluccius*) (Angelini et al. 2016). The Norway lobster stock located in this area is distinct from other Adriatic populations and is characterized by small-sized, slow-growing individuals (Frogliola and Gramitto, 1982; Vrgoč et al., 2004). Furthermore, this area represents a fishing ground shared by the Italian and the Croatian fleets (Martinelli et al., 2013; Russo et al. in press) and has been the subject of many discussions aimed at establishing there an area closed to fishery (e.g. ADRIAMED, 2008; De Juan and Leonart, 2010). Finally, from 2015 some protection measures have been implemented (changing various times in area closed and restriction measures). Thus, it is important to continue discussions and research activities in this delicate area.

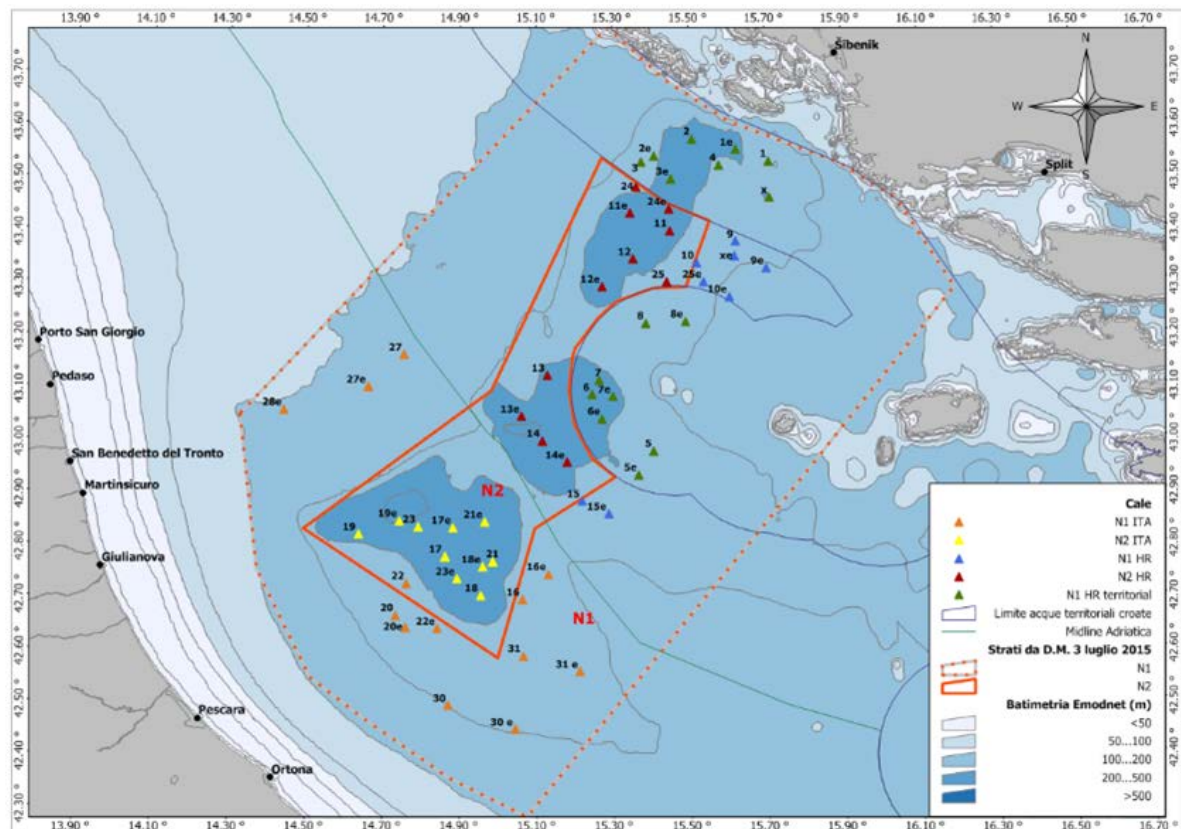


Figure 5.1.7.1 New bathymetry applied to post-stratification experiments (Batimetria EMODNET in meters), location of the trawl hauls (triangles) carried out during the surveys in the central Adriatic Sea (Pomo/Jabuka Pits) and indication of the fishing ground defined in MIPAAF D.M. 03/07/2015 (red boundaries).

After some trials carried out in 1994 and 2004 by CNR-ISMAR (Frogliata et al., 1997; Morello et al., 2007), in 2009, under the auspices of the FAO – ADRIAMED project, ISMAR-CNR of Ancona (Italy) and IOF of Split (Croatia) started a series of UWTV surveys in the Pomo Pits area. Except for 2011, a spring survey has been carried out yearly from 2009 to 2017 in the entire Pomo/Jabuka area. The footages collected during the surveys are analysed later in the institute lab by a team composed by Italian and Croatian scientists. ICES developments are strongly applied to the Adriatic UWTV survey procedures. During the survey, additional trawl hauls are carried out by means of an experimental net in order to obtain demographic and biological data relating to the *Nephrops* population and to other important species. However, the UWTV surveys are not part of the DCF for Italy and Croatia.

Thanks to the Italian National Flagship Program RITMARE, in the year 2013 the CNR-ISMAR's UWTV equipment was completely renewed, allowing the collection also of environmental parameters and to reach a very good level of technology in 2015 and 2016 (ICES, 2017c).

In 2017, a new UWTV survey has been carried out in the study area from 27 April 2017 to 16 May 2017, but unfortunately, some technical problems occurred and only 13 trawl hauls and 38 (out of 60) UWTV stations were carried out (30 valid). The collected footage will be processed in January 2018.

Recently a new database was developed making easier to perform readers' check, statistics, thresholds setups (e.g. speed, turbidity..), application of biases (e.g. edge effect, fixed bias...), post-stratification experiments (e.g. using the new regulated areas), preparation of data for an ecosystem approach etc.

From 2015, the Italian Ministry of agriculture and forestry entrusted to CNR-ISMAR of Ancona a monitoring activity in the area by means of trawling, with the aim of an evaluation of the effects of the Pomo closure. Thus, an additional trawl survey (targeting also other species of major interest in the area, such as *Merluccius merluccius* ecc.) is carried out in autumn in the Italian side, comprising the same trawl hauls of the UWTV survey, plus additional hauls outside the UWTV strata (at sunrise and sunset; Figure 5.1.7.1).

5.1.8 France

(Jean-Phillipe Vacherot, Spyros Fifas)

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.

In accordance with other routinely UWTV surveyed stocks, the sampling protocol applied since 2014 has been a systematic one advantaged by wider spatialized 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). Moreover, accordingly to the WGNEPS 2016 recommendations, the 2017 survey covered a wider area (> 28000 km²) exceeding the outline of the historical limits of the Central Mud Bank in order to accurately define the actual limits of the fishery (Figure 5.1.8.1). On this basis, 219 stations were sampled among them 197 were validated (Table 2) and 124 were strictly contained in the 2016's area retained for the stock assessment.

In 2017, LANGOLF-TV was carried out on 13 actual days (May 6th-18th). Six scientists participated on the on board work. As the project was planned owing to a partnership with the Irish Marine Institute (MI) one expert scientist and one electronics technician from Ireland joined the team. The equipment (sledge, computing hardware, screens, recorders) were provided by MI.

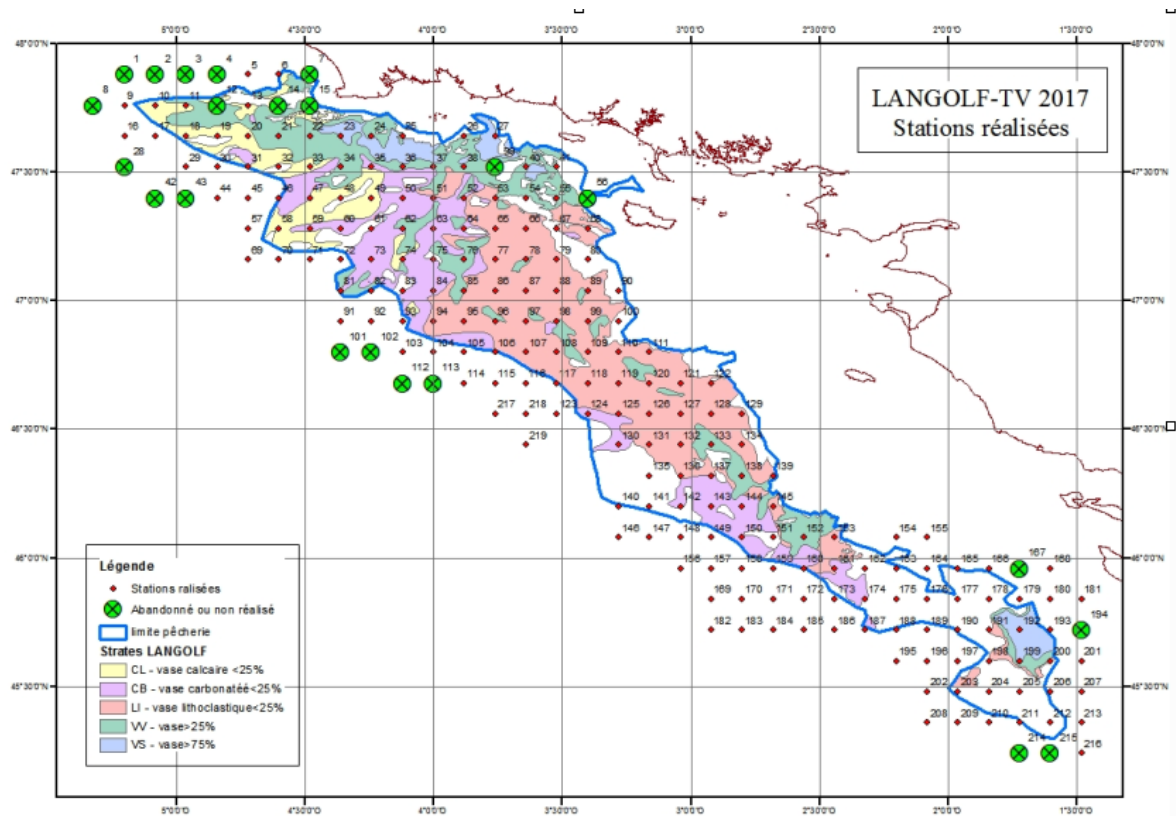


Figure 5.1.8.1 UWTV stations on a systematic grid for the 2017 survey.

The provisional absence (up to 2018) of reference footage in the Bay of Biscay implies 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) was chosen. A validation by the test CCC (Figure 5.1.8.2) allows deciding on the conformity of each reader. Acquiring images on the sea bottom requires a preliminary use of multi-beam sonar 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 confirmed and the visibility is satisfactory. Recording lasts 10 min even with no *Nephrops* burrows on the track; 7 min minimum are necessary for the validation of the footage. The whole area of the five strata was covered in 2014 although only 2/3 of the total number of stations was carried out in 2015. In 2016 and 2017, 100% of the Central Mud Bank was sampled (160 and 94 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 (see above). Table 5.1.8.1 shows the burrow densities (/m²) and the associated CVs. The results for 2017 show a decreasing trend compared to 2016's values (-22%).

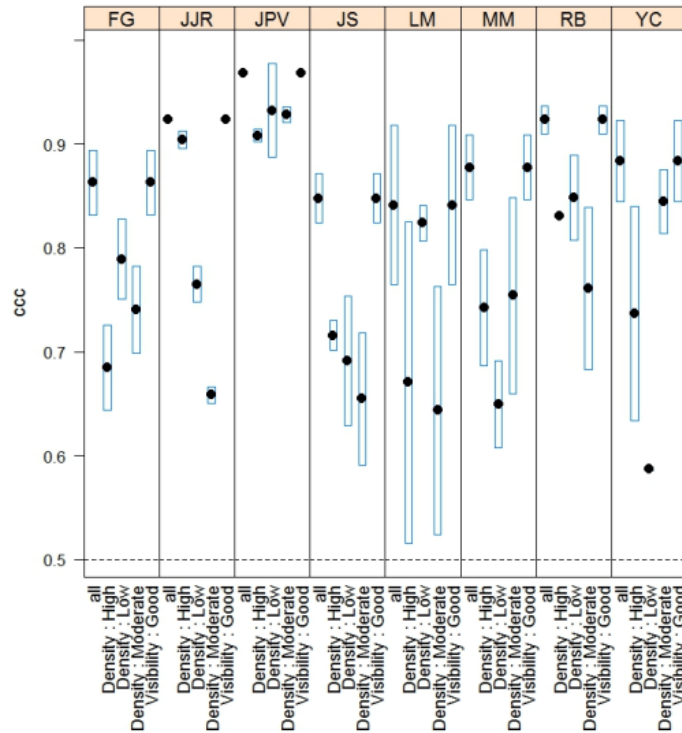


Figure 5.1.8.2. Conformity test 2017 (Lin's CCC, reference footages from FU 22 Smalls ground).

Table 5.1.8.1. Total number of burrows (10⁶), densities/m² and CVs by stratum and for the whole area.

	2014 (156 stations)				2015 (96 stations)				2016 (160 stations)				2017 (94 stations)				
	nb/m ²	total burrow	CV (%)	% burrows	nb/m ²	total burrow	CV (%)	% burrows	nb/m ²	total burrow	CV (%)	% burrows	nb/m ²	total burrow	CV (%)	% burrows	% surf
	0.442	5164.53	5.82		0.386	4501.89	8.25		0.386	4505.52	7.86		3534.20	9.85			
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%	0.152	384.49	20.10	10.88%	21.72%
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%	0.262	302.03	14.76	8.55%	9.87%
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%	0.210	978.48	14.75	27.69%	39.94%
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%	1.147	726.44	27.94	20.55%	5.42%
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%	0.425	1142.76	19.82	32.33%	23.05%

Comparisons of burrows densities are carried out by restricting the sampled area for 2014, 2016 and 2017 to that covered in 2015. The basic condition of the stratified design is respected as all five sedimentary strata were sampled: although, the total surveyed area was reduced (7935 km² instead of 11676 km² of the five historical sedimentary strata) (Table 5.1.8.2). As for the comparison on the five strata, density of burrows is characterised by a downward trend between 2016 and 2017 although in lesser degree (-11%).

The favourable weather conditions in May 2016 and 2017 allowed to cover a supplementary area assumed to not be trawled as occupied by rough ground (Table 5.1.8.3). As for the other raising options, the number of burrows seems to have declined between 2016 and 2017 (-19%). Anyway, for any year the two more compact muddy strata (VS and VV) corresponding to less than 20% of the overall surface concentrate around 45% of the total number of burrows.

Table 5.1.8.2. Total number of burrows (10⁶), densities/m² and CVs by spatial stratum and for the whole area. Years 2014-2017 after restriction to the area sampled in 2015 (7935 km² instead of 11676 km²).

	2014 (109 stations)				2015 (96 stations)				2016 (102 stations)			
	nb/m ²	total burrows	CV (%)	% burrows	nb/m ²	total burrows	CV (%)	% burrows	nb/m ²	total burrows	CV (%)	% burrows
	0.417	3305.64	7.91		0.396	3138.42	7.85		0.412	3266.09	9.98	
B	0.265	432.86	19.23	13.09%	0.151	247.63	25.66	7.89%	0.251	410.92	27.44	12.58%
L	0.171	196.49	28.30	5.94%	0.306	351.86	18.57	11.21%	0.237	272.40	20.87	8.34%
I	0.340	899.35	12.88	27.21%	0.320	847.72	16.38	27.01%	0.260	688.59	21.35	21.08%
S	1.656	665.91	11.05	20.14%	0.875	351.61	30.48	11.20%	1.058	425.20	16.20	13.02%
V	0.530	1111.04	17.90	33.61%	0.639	1339.59	10.99	42.68%	0.700	1468.99	17.20	44.98%

2017 (56 stations)					
	nb/m ²	total burrow	CV (%)	% burrows	% surf
	0.364	2891.18	11.76		
CB	0.211	345.51	21.29	11.95%	20.62%
CL	0.262	301.67	14.76	10.43%	14.51%
LI	0.271	717.67	21.84	24.82%	33.37%
VS	1.403	564.02	28.30	19.51%	5.07%
VV	0.459	962.30	25.05	33.28%	26.43%

Table 5.1.8.3 Total number of burrows (10⁶), densities/m² and CVs by spatial stratum and for the whole area. Years 2016 and 2017 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)				
	nb/m ²	total burrow	CV (%)	% burrows	nb/m ²	total burrow	CV (%)	% burrows	% surf
	0.320	5167.67	7.84		0.259	4181.95	9.87		
CB	0.258	654.41	19.84	12.66%	0.152	384.49	20.10	9.19%	15.69%
CL	0.237	272.72	20.87	5.28%	0.262	302.03	14.76	7.22%	7.13%
LI	0.283	1319.12	13.86	25.53%	0.210	978.48	14.75	23.40%	28.85%
VS	0.839	531.18	17.92	10.28%	1.147	726.44	27.94	17.37%	3.92%
VV	0.642	1728.09	14.52	33.44%	0.425	1142.76	19.82	27.33%	16.65%
RO	0.148	662.15	29.61	12.81%	0.144	647.75	34.23	15.49%	27.76%

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 (CV=11%). This value is still used for 2017's data.

Detection: Very good visibility characterized footages during the four UWTV years (e.g. in 2014, 946 minutes of reading on 1095, i.e. 86%, have 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 between *Nephrops* and *Munida* is not relevant for 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 NE Atlantic waters.

Video from the years 2014-2017 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 in a 24 h period (Figure 5.1.8.3). 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. Combining those results on footage and trawling experimental catches (for years 2014 and 2015) on both species allow proposing species identification coefficient of 1.05, 1.10 or 1.15. The third value was retained by 2016's WKNEP benchmark for the stock (ICES, 2017a).

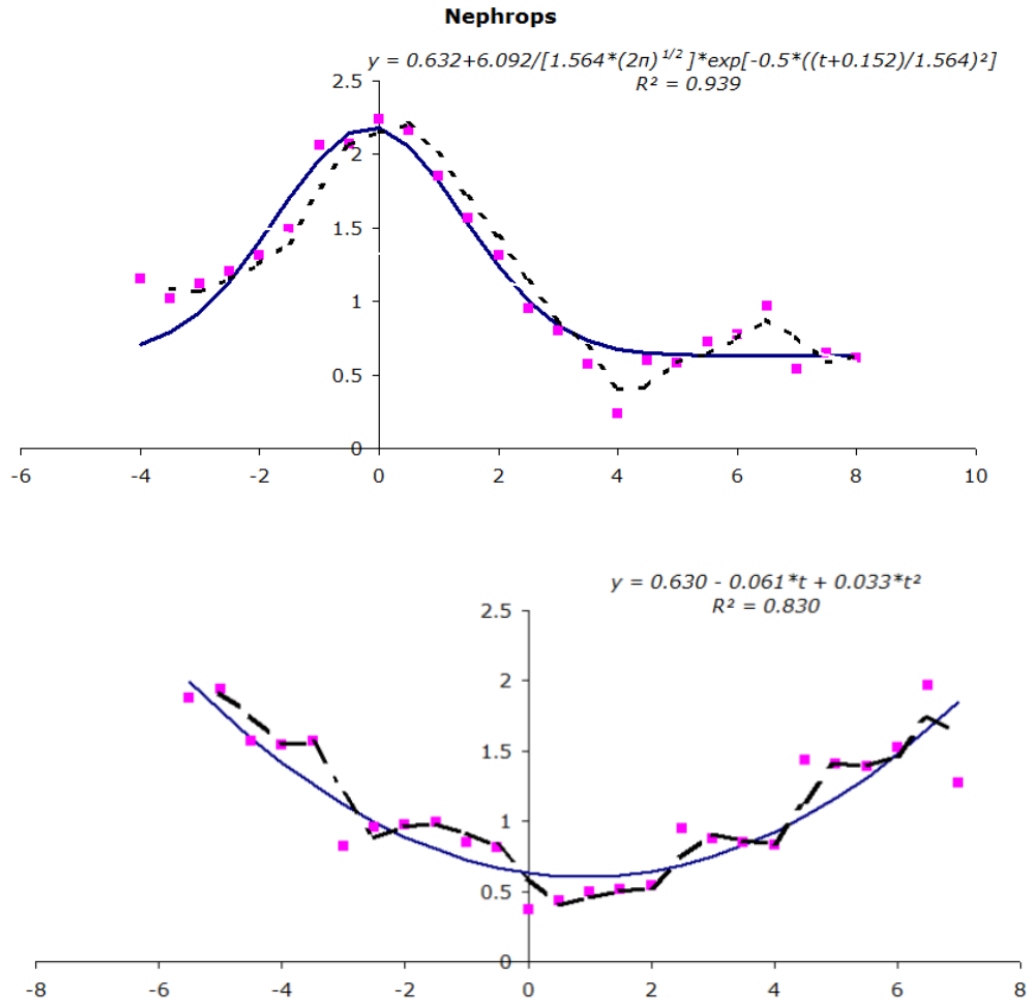


Figure 5.1.8.3 Relationship between standardised time of observation vs. sunrise/sunset and *Nephrops* (above; data 2017) and *Munida* (below; data 2014) activity. Abundance index per surface unit of video track (broken curve: data smoothed by mobile average).

The combination of the various correction factors above provides a cumulative bias coefficient of 1.24.

Conclusions / recommendations

- Establish reference footage set from the 2017 survey

5.1.9 Iceland (Jónas Jónasson)

The second UWTV survey on *Nephrops* ground in Iceland was carried out by the Marine and Freshwater Research Institute (MFRI) between 12th – 23rd of June 2017. The survey took place on RV Bjarni Sæmundsson. The survey covered all known *Nephrops* ground in FU 1.

Area definition was based on available ship AIS (Automatic Identification System) data from the period 2008 – 2016. Vessels fishing with *Nephrops* trawl and a towing speed of 1 to 4 knots were summarized on grid with a resolution of 800 m. A minimum of five trawling occurrence was chosen as a threshold value for each area within the grid. Further the minimum size of each area was set as 4 km². In total 13 distinct fishing grounds were identified and further summarized to 10 areas. In total the *Nephrops* ground in FU1 were estimated to be 5989 km². Stations were laid out in similar manner as in 2016 on a randomized fixed square grid with around 4.5 nautical miles between points, with in total of 84 stations completed. The depth of stations ranged from 106 to 280 m. The sledge was equipped with an HD camera, mounting at 45° and lasers 100 cm apart. The tow speed ranged between 0.5–1.5 knots and cable was paid in or out to obtain the best possible footage but 10 minutes were recorded on each station. Vessel position (DGPS) and odometer on the sledge was used to estimate the distance over ground (DOG).

All burrow systems were timestamped by two readers, following recommendation from WKNEPH in November 2016 (ICES 2017b) where reference footage of the FU 1 ground was established. In case of disagreement the footage was reviewed again by both readers and agreed on or left to third counter. The mean burrow density (adjusted to account for bias factors) was 0.09 burrows per m² with CV of 3.4 %. The total number of burrows was 540 million, which is only marginally different from the estimate of the first survey conducted in 2016, when the total number of burrows was 542 million. The distribution of burrow densities in the two years is shown in Figure 5.1.9.1.

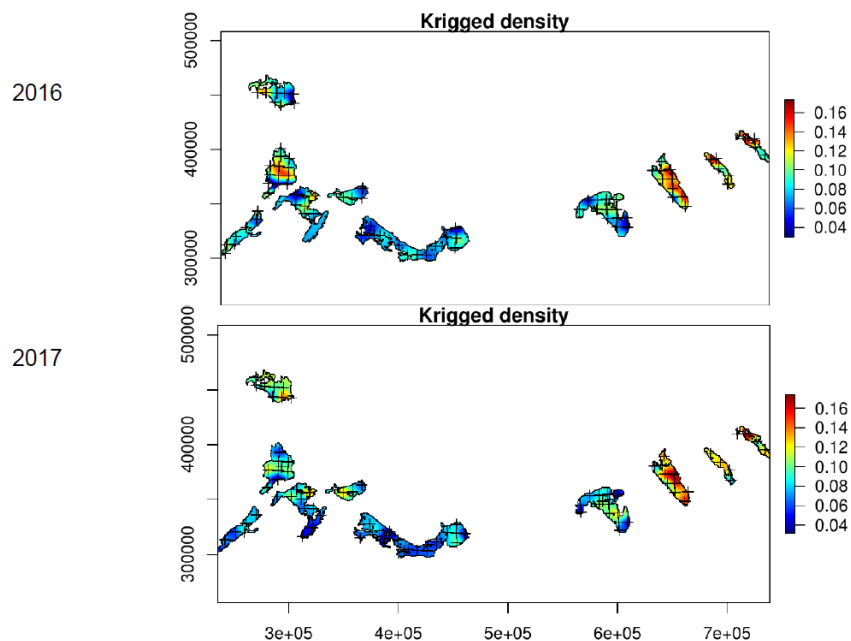


Figure 5.1.9.1 Distribution of *Nephrops* burrow densities off South Iceland (FU1) in 2016 and 2017.

From the UWTV footage, notes were also recorded on the occurrence of trawl marks, fish and other species. Trawl marks were noted at 71 % of the stations surveyed, with an average of 2.5 marks per station.

5.1.10 Portugal (Christina Silva)

The trawl survey was conducted in July 2017 with the R/V NORUEGA covering Functional Units 28 and 29 with 68 valid hauls (20 in FU 28 and 48 in FU29). As in previous years, the sampling grid included 78 rectangles, with 33 squared nautical miles each (see Annex 7).

The grid was designed to cover the main crustacean fishing grounds within the range of 200-750 m. The substrate in these grounds is characterized by muddy sediments composed by different percentages of silt and clay.

One station is carried out within each rectangle. The hauls were carried out during daytime with a speed of 3 knots and have 30 minutes of duration. Although directed at the crustacean species (Norway lobster, rose shrimp and red and blue shrimp), data from all other taxa and species are also collected, as well as marine litter.

The survey in 2017 was carried out in July, in the main fishing season, where *Nephrops* males and females are equally available to the gear and most of females are in pre-spawning state, with ripe ovaries. The trawl survey provides indices of relative abundance and biomass of *Nephrops* stocks, which have been used in the stock trends assessment.

Figure 5.1.10.1 shows the spatial distribution of the biomass index in the most recent years.

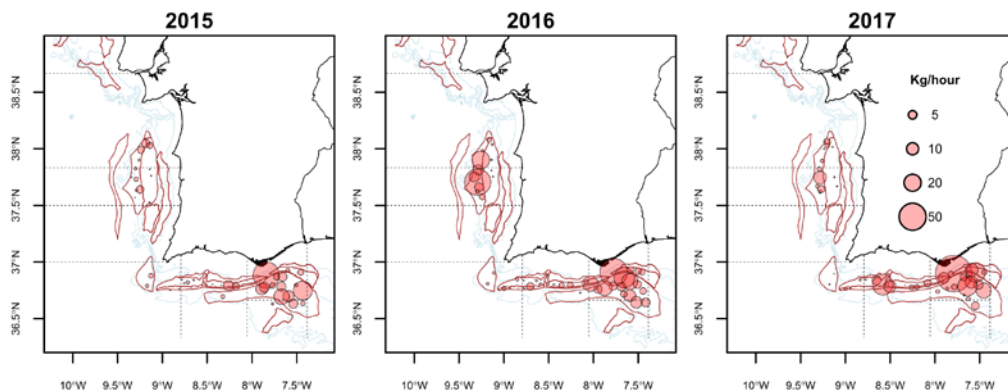


Figure 5.1.10.1 Spatial distribution of Norway lobster biomass index in 2015-2017.

At present, the abundance index is estimated based on a post-stratification of the area by zones and depth strata, to compare with previous surveys indices.

Figure 5.1.10.2 shows the abundance index time series for Norway lobster in the period 2005-2017. The CV has varied in the range of 19-28%. In general, periods of high abundance of rose shrimp alternate with periods of high abundance of Norway lobster. This pattern is observed either in surveys or in the fishery.

No estimates are presented for 1999, 2004, 2011 and 2012. In 1999 and 2004, the surveys were carried out with different vessels, only covering FU 29 in 1999 and having some problems with the gear in 2004. In 2011, due to engine failure the survey did not cover the whole area. In 2012, the vessel was under repair and no survey was conducted.

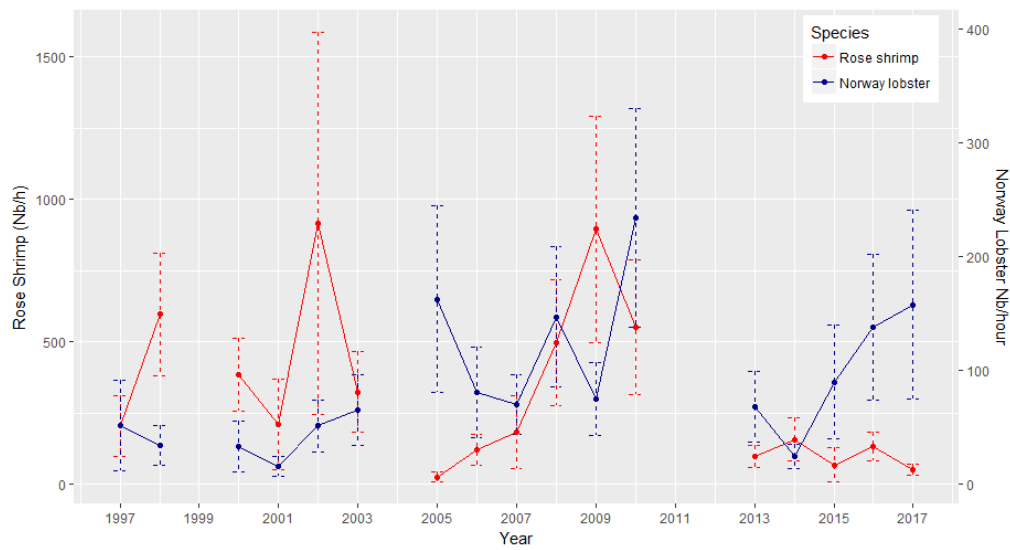


Figure 5.1.10.2 Abundance index of rose shrimp and Norway lobster with 95% CI in the period 1997-2017.

Definition of fishing grounds

VMS fishing records from the period 1999-2016, linked with logbook data, were used to define the crustacean fishing grounds (Figure 5.1.10.3).

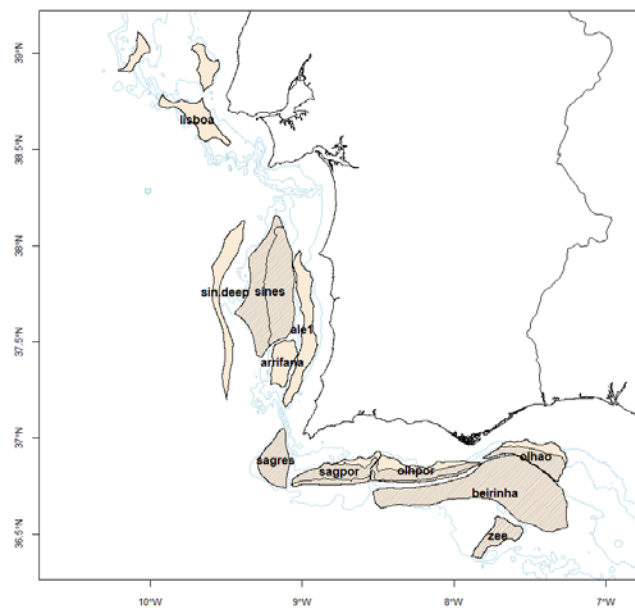


Figure 5.1.10.3 Crustacean fishing grounds based on VMS trawl data. The dashed areas (> 200 m) are the main fishing areas for *Nephrops*.

Although Norway lobster and rose shrimp distributions overlap in some areas and depths, the main fishing grounds for Norway lobster are Sines in FU 28 and Olhão, Beirinha and ZEE in FU 29, while for Rose Shrimp the most important are Arrifana in FU 28 and Sagres-Portimão (sagpor) and Olhão-Portimão (olhpor) in FU 29. Rose shrimp is caught in areas shallower than 500 m and *Nephrops* in areas in

the range 200-750 m. Sediment samples collected in all area indicate that Norway lobster has preference for substrate composed by more than 80% of silt and clay.

The delimitation of the fishing grounds is being used to better define the survey area, sampling strata and design.

5.1.11 Outcomes from 2016 benchmark

The 2016 benchmark workshop WKNEP (ICES, 2017a) cover five different functional units for *Nephrops* of which UWTW or trawl surveys of four of these FU's are coordinated by WGNEPS. The outcomes with focus on data collection during future surveys for these four FU's are described below:

FU 3-4 Skagerrak/Kattegat (Mats Ulmestrand)

The major issues identified prior to the benchmark workshop were:

1. redefine the *Nephrops* grounds in FU 3-4
2. create a set of reference footage for FU 3-4
3. update the length cohort analysis for FU 3-4.

The redefinition of the UWTW survey area and its stratification has been implemented in the 2017 survey and the selection of new reference footages covering all to the current survey strata is planned for the near future (see section 5.1.5). New input data have been collected and an updated separable length based cohort analysis (SLCA) has been provided for consideration by the corresponding assessment working group, WGNSSK.

FU 23-24 Bay of Biscay (Spyros Fifas)

The UWTW 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 assessment method based on UWTW data requires an unbiased and accurate calculation of the actual surface of the stock and, moreover, available dataset linked to the population dynamics (LFDs by sex for landings and discards). Both criteria are satisfied in the Bay of Biscay.

The surface involving in *Nephrops* is precisely delimited owing two information: (1) on the sedimentary structure of the sea bottom already taken into account during the former LANGOLF trawl survey on years 2006-2013 (5 spatial strata; Figure 5.1.11.1); (2) on the systematic grid of video tracks combined with VMS data for the fishery (Figure 5.1.11-2; data source: National Fisheries Direction; compilation: Ifremer).

Under these favourable conditions, the Bay of Biscay was considered appropriate for an UWTV survey. The 2016 WKNEP benchmark (ICES, 2017a) validated the UWTV survey and the assessment combining burrows counting and the Separable Cohort Analysis (SCA) model for this stock. The change of the stock status from category 3 (Stocks for which survey-based assessments indicate trends) to category 1 (Data-rich stocks with quantitative assessments) implies annual advice instead of the biennial one applied previously.

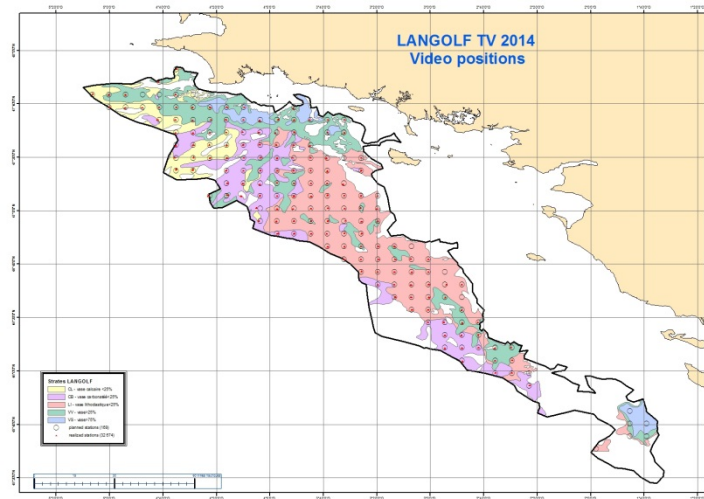


Figure 1. Spatial stratification of the Bay of Biscay according to sedimentary criteria as considered from the first UWTV survey onwards (2014).

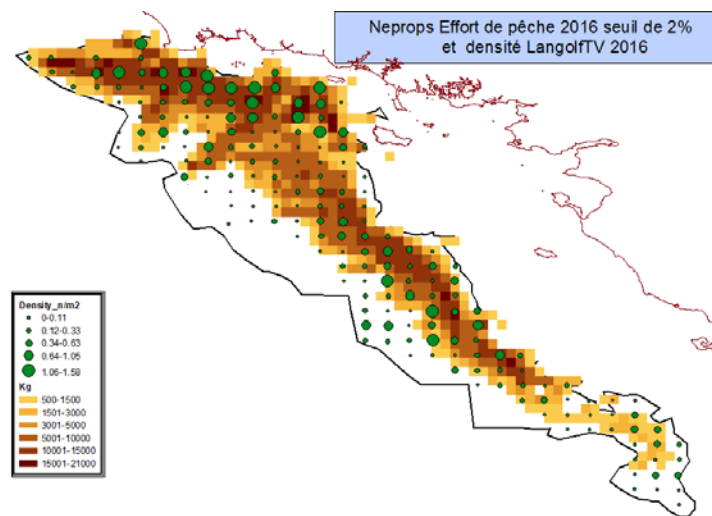


Figure 2. UWTV stations on a systematic grid and VMS data for retained catches of *Nephrops* (example of the year 2016; source: National Fisheries Direction; compilation: SIH Ifremer). A threshold of 2% was applied *i.e.* the coloured rectangles correspond to 98% of the nominal yearly landings for 2016.

FU 28-29 Portugal
(Christina Silva)

No further implications than outlined in section 5.1.10.

FU 30 Gulf of Cadiz

(Yolanda Vila, Candelaria Burgos)

Nephrops abundance in FU 30 was benchmarked in October 2016. The approach based on UWTV survey to generate catch options was proposed for this FU. WKNEP 2016 (ICES, 2017a) mainly considered in detail: the technology of the survey, including correction for edge effects, discovery rate, species identification, etc., the distribution area and coverage and the derivation of a recommended harvest rate. Regarding to first two points, WKNEP concluded that the UWTV survey based assessment as described could be standard for the future. However, some difficulties were found for the derivation of the reference points. The common length based yield-per-recruit method was not appropriated for this stock. Reference points were derived from the perception of the stock and historical experience from similar previously assessed stocks as an interim solution. However, the Advise Drafting Group for *Nephrops* (ADGNeph) in 2017 agreed that the poor fits in the length–frequency model, normally used for calculating F_{MSY} for category 1 *Nephrops* stocks, prevented its application to FU 30 (ICES, 2017d). In absence of stock specific MSY harvest rates the basis of the advice for this stock will follow the category 4 (stocks for which reliable catch data are available) approach for *Nephrops*. In the future, if stock specific MSY reference points can be estimated the stock will meet the requirements for category 1 (data-rich stock) quantitative assessment.

5.1.12 Survey plans for 2018

An overview on scheduled *Nephrops* UWTV and trawl surveys for 2018 is given in Annex 6.

5.1.13 Other information relevant for *Nephrops* surveys coordinated by WGNEPS

***Nephrops* in Greek waters**

(Chris Smith, Nadia Papadopoulou, Kostis Kapiris)

In the Mediterranean *Nephrops* is mostly found, and supports fisheries, in northern waters from the West (Spain) to East (Aegean Sea). Global FAO captures have been in the region of 50,000-75,000 and decreasing in the last 10 years whilst the General Fisheries Commission for the Mediterranean (GFCM) capture production of *Nephrops* in the same period ranges 3000-5500 tons with a generally long-term increasing trend. In Greece *Nephrops* makes up one of the many target species in the mixed demersal fishery and catches have shown a general decreasing trend in the last 25 years and a steady fall from about 400 tons in 2010 to 200 tons in 2016 (Hellenic Statistical Authority). There are some catches from trapping and set-nets. *Nephrops* is one of the named species in the National Fisheries Data Collection Programme. As such it is officially reported on, in annual work on the Discards, MEDITS (International Bottom Trawl Survey in the Mediterranean), port sampling and observer sampling programmes. Mean catch length is about 38 mm carapace length with catch size range from 14 to 90 mm. There is very little discarding, with most less than 26 mm. Greek catches are predominantly from the Aegean Sea with largest catches in the Northern Aegean and Evoikos areas. As well as restriction to certain mud types, a major delimiter is thought to be temperature with *Nephrops* restricted to colder (approximately 14 degrees) stable or deep waters generally > 90 m. *Nephrops* research has been carried out mainly through

sporadic EU research projects, including investigations of biological characteristics, video assessment methods, growth and mortality (tagging) and gear selectivity including trapping trials.

In terms of assessment work, limited assessments have been carried out in the past on a localised well-delimited population (Pagasitikos Gulf), although the scientists remain interested, there is very limited national interest and no specific funding to carry out video assessments. The HCMR equipment currently consists of an Aberdeen design sledge with standard CCD camera (recording to DVD or hard disk), quartz lights and a micro-scanning sonar for obstacle avoidance. The unarmoured umbilical coaxial cable is attached to a towing wire. Plans are to upgrade this to a winch-mounted, steel armoured fibre optic/conductor cable. The sledge is used in opportunistic surveys and will be used in MSFD monitoring for Descriptor 6. HCMR remain interested in both technological developments for better imaging of *Nephrops* grounds (e.g. 3-D imaging, mosaicking, sonar/laser imaging) as well as future developments on occupancy and burrow structure through high resolution and deep-water resin casting.

Surveys and assessments for scampi (*Metanephrops challenger*) in New Zealand

(Ian Tuck)

The New Zealand scampi fishery targets *Metanephrops challenger* within four main fishery areas (SCI 1, 2, 3 & 6A), and a more sporadically fished, but developing area (SCI 4A). Scampi fishing started in the mid to late 1980s, and all the fisheries have been managed within the New Zealand Quota Management System, using Individual Transferrable Quotas since 2004. Total annual landings (summed across all fisheries) have ranged between 600 and 1000 t. The main fishery areas are surveyed, and then assessed in the following year, on a rolling three year programme (SCI 1 & 2 surveyed together, with SCI 6A the following year, and SCI 3 the following year, and then back to SCI 1 & 2).

Surveys follow a random stratified design (stratification by depth and region), and include photographic and trawl components. The photographic survey deploys a still camera system on a trawl warp, maintaining the camera at 3 – 4 m above the seabed (measured with a net sonde unit on the camera frame), and taking images every 45 seconds. Typically, 30 - 40 useable images are collected from each station. Parallel lasers mounted on the camera frame (200 mm apart) provide a scaling distance on the image, and images have a seabed footprint of on average around 6 m².

The images from each station are randomly allocated to 3 readers (from a team of 6), with all readers also reading reference set images (developed as a growing set of images from all previous surveys from that particular region). Image reading is conducted within a bespoke software package developed from ImageJ, where images are initially initialised (scaled, and readable area defined and annotated), and then read with burrows (defined as definite major, probable major, definite minor, probable minor), and scampi (in or out) annotated on images (counts being stored in a database linked to the software). Having completed all the first reads (including the reference set), counts are checked at the image level, with all images with a count of major burrow openings (definite plus probably) across the 3 readers differing by more than one, or with any difference in the count of scampi, being re-read. On the second read, readers examine why the counts are different, and are free to change (or not) their count. These second reads replace the first reads for these images, and form the final read dataset. Counts are aggregated to the station level by reader, and combined with data from previous surveys and reference set reads for the region, and modelled within a generalised linear mixed modelling framework to estimate reader_year effects, to allow for inter reader and inter year calibration. Full details of the approach are provided in Tuck *et al.* (2017). Counts from all surveys are adjusted by the appropriate calibration factor to generate consistent annual indices. Burrow and scampi densities (counts divided by total readable

area) are averaged across strata, and raised to strata area to estimate total abundance. Uncertainty is estimated by resampling reader within station, and station within strata. At a subset of random stations within each stratum, trawl sampling is also conducted, with catches raised to stratum areas in the standard way to estimate trawl abundance and biomass estimates. Undamaged scampi from trawl catches are tagged and released, with later recaptures used to estimate growth rates.

Both photographic and trawl survey indices are used within a Bayesian length based assessment implemented with CASAL (Bull *et al.*, 2012). To provide a prior for survey catchability, acoustic tagging of scampi has been used to estimate emergence rates. In conjunction with burrow and scampi abundance estimates from photographic surveys conducted at the same time, the proportion of the stock that these counts represent (catchability) has been estimated, along with measures of uncertainty (Tuck *et al.*, 2015). The stock assessment incorporates an appropriate temporal structure to account for seasonal patterns in sex ratio, and also includes a standardised CPUE index, length data from observer and survey sampling, tag recaptures and commercial catches, and estimates B_0 , year class strengths, survey and fishery selectivities, catchabilities and growth (Tuck, 2017).

Female staging, ovary maturation and resorption in Norway Lobster (*Nephrops norvegicus*)

(Carola Becker, E. Mánus Cunningham, Mathieu G. Lundy, Jaimie T.A. Dick, Julia D. Sigwart)

A Seafish and Kilkeel Seafoods funded project based at the Queen's University Belfast Marine Laboratory has studied the ovary maturation and resorption in *Nephrops norvegicus* through macroscopic and microscopic observations with special reference to female ovary staging schemes.

Various staging schemes with different numbers and delimitations of ovary maturation stages have been adopted in previous studies on *N. norvegicus* (e.g. Farmer, 1974, Mente *et al.*, 2009, Powell and Eriksson, 2013). Ovary maturation in general is characterised by an increase in ovary size and a transition in colouration from light (white/cream) through darkening shades of green to very dark green in the fully mature ovary. Another stage, the "mottled" ovary, with both yellow and green colours, is recognised in some studies (Figueiredo, 1982). This additional stage is characterised by a speckled bi-coloured appearance (green with light cream to yellow spots or vice versa). In some studies, mottled ovaries have been overlooked (Thomas, 1964) or interpreted as the spent ovary (Farmer, 1974), but were later correctly identified as resorbing ovaries in females that skip a reproductive cycle instead of spawning (Figueiredo, 1982). The reasons females may resorb their ovaries rather than extruding eggs are unknown. Ovary resorption has been attributed to a range of possible causes, e.g. hormone deprivation, unsuitable environmental conditions, or a lack of insemination (as cited in Tuck *et al.*, 1997). To test whether ovary resorption in *N. norvegicus* is caused by a lack of insemination, we examined the female sperm storage organ (thelyum) using histological methods and light microscopy. Ovary maturation stages were studied by incorporating histological data into observations from macroscopic external observations for each stage.

The samples used in this study were collected during a trawl survey conducted by the Agri-Food and Biosciences Institute of Northern Ireland (AFBI) in the western Irish Sea in August 2016. Additional samples from creel catches from the Northumberland coast in the Farne Deeps were provided by Kilkeel Seafoods in February and March 2017. Dissected ovaries were photographed and staged macroscopically using the standardised European colour matching system (RAL chart). For the division of stages we have adopted the staging scheme used by AFBI during trawl surveys. Tissue samples were embedded and sectioned using a standard protocol for paraffin histology. Sections were subsequently stained with a trichromatic Masson Goldner stain to visualise the ova.

Ovary resorption (indicated by the frequency of individuals with mottled ovaries) was a rare phenomenon in samples from the western Irish Sea, however, in the Farne Deep, the proportion of females undergoing ovary resorption peaked at approximately 20% in February 2016. A lack of insemination was not the cause for ovary resorption in females from the Western Irish Sea or the Farne Deep as all females with mottled ovaries studied to date were inseminated and had several spermatophores in their thelyca.

Our study on the microscopic and macroscopic staging of female *N. norvegicus* is still ongoing and the details of our findings will shortly be published in a scientific journal. Based on the present data we would recommend the recognition of resorbing, mottled ovaries as a separate stage. A high incidence of resorption may lead to a reduced reproductive capacity of stocks and may serve as an indicator for vulnerability in affected populations.

After the presentation of this study, participants of the meeting discussed and compared different staging schemes (e.g. ICES, 2010 vs. Eiríksson, 2014). It was pointed out that changes in staging schemes can have an impact on the comparability and hence utility of long-term datasets for analyses. It is therefore imperative that changes in standardised schemes are documented, and consistently and explicitly reported alongside staging data, to enable the future conversion between different national and regional staging schemes. As Kai Wieland (Technical University of Denmark) pointed out, problems with changing standardised schemes and metrics has also occurred in staging of fish. Annika Clements (AFBI) brought up oxygen deficiency as a potential cause for ovary resorption in *N. norvegicus*, which we hope to examine further as a potential correlate with the regional and temporal variability in the frequency of mottled ovaries.

5.2 ToR c. To review video enhancement, video mosaicking, automatic burrow detection and other new technological developments.

5.2.1 Reference footages

(Annika Clements, Jennifer Doyle, Robin Masefield)

Currently there is no agreed methodology on how to generate reference footage counts from new or emerging survey areas since work was initially carried out at WKNEPBID (ICES, 2008). At that Workshop reference counts were generated from the available reference footage sets by consensus agreement, as illustrated in the ICES report WKNEPBID. At that time, counts were generated for FU6 and FU7 grounds weighted towards the national expert; and for the FU15 ground, the average of the 3 counters was used due to limited time and the high densities encountered. At WKNEPS (ICES, 2016) consensus counts were generated for FU1 only which is a low density ground and relatively easy to count. The intersessional work carried out to generate reference counts for FU14 in 2017 showed high variability in the counts of the three reviewers reflecting the difficulty in identifying *Nephrops* burrows in this area due to multiple burrowing species interactions. This WG discussed the utility of applying Lin's CCC statistic to develop the reference counts as an independent method. It was decided that in 2018 in advance of a burrow identification workshop each institute would carry out a counting exercise for one survey area to compare the use of Lin's CCC directed mean counts and the values obtained by consensus counts. In order to complete this, reference footage will now comprise of 9 stations covering the range of densities typically encountered in that area: that is, 3 x high density, 3 x moderate density and 3 x low density. Each station will comprise of 7 minutes to allow for robust analysis using Lin's CCC as this analysis requires a minimum of 5 observations from each of the two reviewers. The reference set will be reviewed twice by all the national counters and one international counter. It is imperative that

all counters include a familiarisation review of the reference footage. This should involve a full review of the reference set (i.e. all nine reference stations) before embarking on reviewing the footage to generate counts for analysis. These review counts will then be screened for intra counter reproducibility using Lin's CCC test. Where a counter fails using a threshold of 0.5 (for this exercise) this counter's data will not be included in the final results. The unweighted mean of the remaining reviewers' counts will be used only. Five reference stations from each reference set will be consensus agreed between counters who have passed the Lin's screening. One reference station from each of the three density groups should be used, with the two remaining stations chosen at random from any group. The consensus counts will be compared with the Lin's directed counts to identify any potential bias.

5.2.2 Mosaicking and annotated footage (Kai Wieland)

An updated version of a software package to process bottom video recordings from *Nephrops* cruises developed by Bo Lundgren (DTU Aqua) was distributed to the participants of the meeting. The software package allows transformation of the videos into mosaic and live annotation of burrow counts (ICES, 2017c). It is expected that this software will be used in particular for analysing reference footages and that results will be presented and discussed at the next workshop on *Nephrops* burrow counting (WKNEPS) planned to be held in Aberdeen during 2 – 5 October 2018.

5.2.3 Other technologies and experimental work

UTOFIA – Underwater Time Of Flight Image Acquisition system (Patrizio Mariani)

The UTOFIA project has been presented showing the latest prototypes (Figure 5.2.2.1) and most recent results from laboratory and sea trials. The UTOFIA system is composed by a pulse laser light and a synchronized camera, composing a LIDAR imaging system.

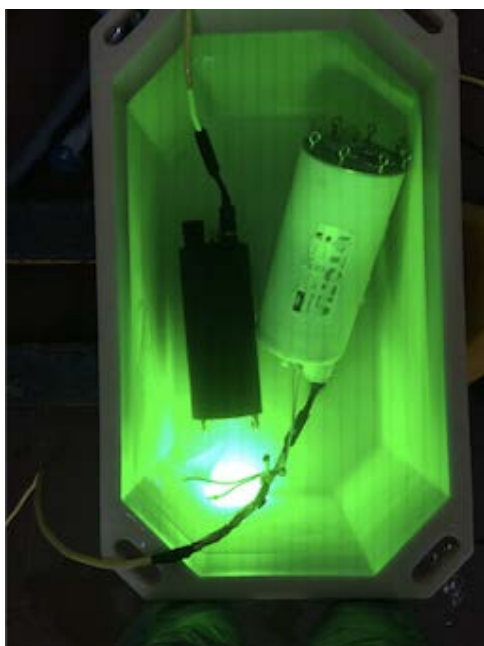


Figure 5.2.3.1. UTOFIA prototypes. In black the latest system 2 device (tested in November and December 2017) while in white system 1 (tested May June 2017). The green (wavelength) 532 nm laser light is visible (in system 2). The device is depth rated 300m, with dimension of 40 cm length and 12 cm diameter, neutrally buoyant and about 10 Kg weight in air. Voltage 25 – 40 V DC, power 300 W max, provided with a power unit and 70 m length cable.

The advantage of the system is reduction of the backscatter and distance measurements of underwater objects. The former allows for a larger field of view than regular cameras, while offering automatic measurements of the objects. This can give great potential for different type of applications including automatic measurements of biomass in aquaculture cages and sizing and depth measurements of *Nephrops* burrows. The additional features of this camera will enhance the skills of automatic (machine learning) pattern recognition in underwater environments, improving precision and reliability of *Nephrops* surveys and providing quality data for stock assessment. Collaborations between the UTOFIA team and the WGNEPS were discussed including support from WGNEPS to refine a flyer (based on the EU COLUMBUS activities) showing the potential of this new technology for *Nephrops* surveys.

Technological developments for population monitoring of Norway lobster (*Nephrops norvegicus*) into a marine protected area (RESNEP)

(Jacopo Aguzzi; see Annex 5 for contributors)

Beyond the potential global effect of climate change, the use of high impact fishing-gear methods has led that many populations of marine resources are actually overexploited. In fact, fishing activity is one of the main drivers of ecosystem change in the Mediterranean Sea. This situation of overexploitation has motivated that most of economical important demersal species are currently highly exploited, reducing the economic benefits and the ecosystem services associated with cultural and social aspects. A clear example of an overexploited Mediterranean iconic fishery is the Norway lobster, *Nephrops norvegicus* (Figure 5.2.3.2). The current stock assessment indices show how the Norway lobster populations are in overexploited status, probably associated to the fishing gear used (bottom-trawling). In addition to a reduction in the size of the individuals, the analysis of the time series of landing data reveals a clear reduction in the density of their populations and of their economic profitability. In the RESNEP Project, the research team intends to evaluate the use of new actions aimed at finding sustainable management options and recovery of this marine resource. The main goal of RESNEP is to assess the use of marine

No-Take zones to improve the main fishery-indices of Norway lobster stocks along the Spanish Mediterranean coast. The specific objectives of this project are: (1) to assess the effect of those zones on the population indices (abundance, biomass and individual size) inside the reserve and in the adjacent areas (spillover effect); (2) to evaluate the potential negative effect on the Norway lobster recovery due to an increase in the population of natural predators and (3) to evaluate if the chosen size and location of the No-Take zone is optimal for the Norway lobster based on activity and movement patterns, which would be measured with new *in situ* monitoring technologies. This project is conceived as made by two multidisciplinary coordinated subprojects that aim to address these objectives from a population biology (RESNEP-POP subproject) and technological (RESNEP-TEC subproject) point of view. The two research teams have a large background in the study of the fishery resources and in the use of technology for the monitoring of marine organisms, being engaged together in funded national research actions under the framework of the associated unit CSIC-UPC “*Tecnoterra*”. RESNEP-POP is led by researchers of the Department of Renewable Marine Resources from the Institute of Marine Sciences of CSIC and RESNEP-TEC is led by the marine technology team composed of engineers from the Polytechnic University of Catalonia and the Polytechnic University of Madrid. Briefly, passive acoustic technologies will be used to measure the duration and occurrence of emergence behavior within a network of moored hydrophones (Figure 5.2.3.3). In relation to the RESNEP-TEC, behavioral data would indicate burrow systems presence based on heat map analyses within the network area (i.e. high percentage of occurrence into a quadrant would correspond to a burrow entrance presence). Behavioral and spatial results will be cross-checked with temporally stratified surveys through Remote Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV) (Figure 5.2.3.3).

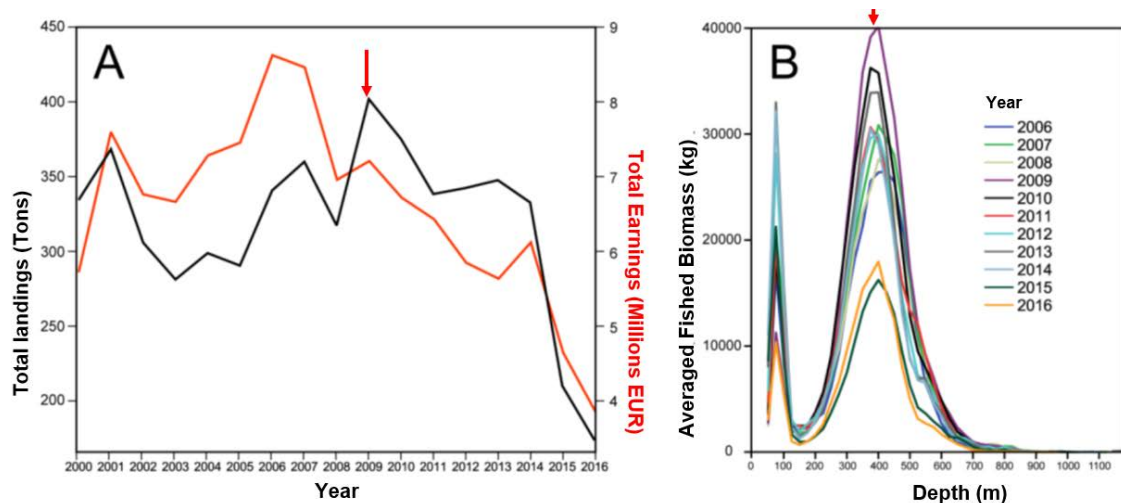


Figure 5.2.3.2 (A) Evolution of the biomass caught and total gains between 2000-2016 in the Catalan sea (NW Mediterranean); (B) Evolution of the fish biomass in the same area of A, in relation to the depth (i.e. the two peaks as the lower shelf between 70-100 m and upper slope between 400-450 m) as obtained by crossing the “Blue Boxes” as Vessel monitoring System (VMS) and daily landings in the fish market between 2006-2016. The red arrow indicates a peak in overall catches (A) in 2009 which is followed by a drop both in catches and total earnings. Those latter started decreasing before 2009 as a marker of price devaluation due to a reduction in average animal size for overfishing impact.

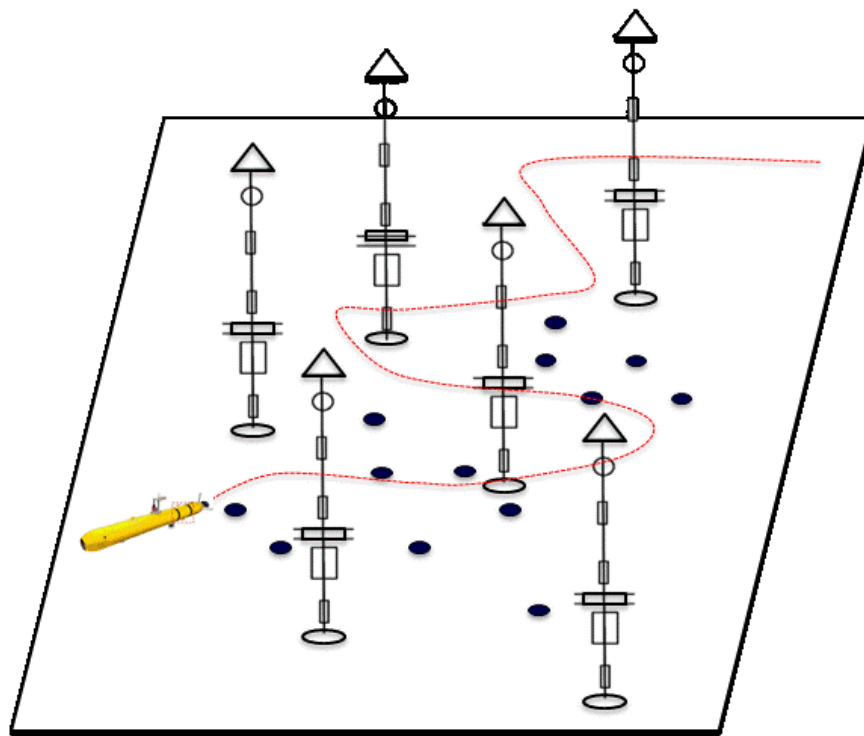


Figure 5.2.3.3 The proposed network asset based on a previous work of Tuck et al. (2015) with acoustically marked individuals of *Metanephrops challengerii* released close to moored lines of passive acoustic devices (hydrophones) detecting their presence when outside their burrows. In the proposed scheme, the Consortium members plan to deploy a minimum set of 4 moored lines to allow both emergence timing and duration quantification as well as animal reciprocal positioning determination as proxy for social interactions following Rotllant et al. (2015) at the OBSEA cabled observatory site (www.obsea.es; Aguzzi et al., 2011). Field data from acoustics will be cross-referenced with those obtained by “*Liropus*” 2000 ROV surveys as well as from AUV “*Guanay II*” autonomous transecting routines. Triangles and smaller Circles are the floaters, Small rectangles are the hydrophones, large rectangles are the acoustic release Scampi canisters. The moored lines will be endowed by an acoustic release mechanism allowing instrumentation recovery after the 2-month testing trials.

- 5.3 ToR e. Discuss the utility of UWTV and trawl *Nephrops* surveys as platforms for the collection of data for OSPAR and MFSD indicators.
Several teams involved in *Nephrops* UWTV surveys provide video recording from these surveys to other laboratories e.g. for studying distribution of sea pens or other ecological valuable information (see section 5.1.). However, usually no feedback on the results is received and WGNEPS will therefore contact these laboratories to report on their experience with the *Nephrops* UWTV and present their results during the next WGNEPS meeting.
- 5.4 ToR f. Develop an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys.
A subgroup was formed to progress with the development of the design for a UWTV database holding international metadata at ICES.

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

Dominance hierarchy in group of male *Nephrops* (Valerio Sbragaglia)

The Norway lobster (*Nephrops norvegicus*) spends most of the day in burrows and forage outside of them according to a diel (i.e. 24-h based) activity rhythm (Bell et al., 2006, Aguzzi and Sardà, 2008). Fighting behaviour over burrows has been observed in the wild (Chapman and Rice, 1971) and in the laboratory (Sbragaglia et al., 2017, Aguzzi et al., 2011). In particular, a group of male *Nephrops* provided with unlimited burrows in the laboratory establish dominance hierarchies and rank related changes in burrowing behavior. The rank position determined by open area fights predicts the outcome of fights over burrows, the time spent in burrows and the locomotor activity levels. Dominant lobsters are more likely to evict subordinate lobsters from their burrows and are more successful in defending their own burrows. They spend more time in burrows and display lower levels of locomotor activity outside the burrow (Sbragaglia et al., 2017). The understanding of how dominance hierarchies influence burrow related behavior of *Nephrops* could be important for estimating *Nephrops* abundances by underwater television surveys, where the presence of intact burrow complexes is used to assess the abundance of *Nephrops* on the basis of the postulated equivalence one burrow/one lobster (reviewed by Sardà and Aguzzi, 2012). In this context, present results suggest that in high density areas dominant lobsters may evict subordinates and control several burrows at once. Such results must be interpreted with caution because the dynamic of burrow occupancy in a closed tank could be different from the open situation in the wild. Very little is known about *Nephrops* spatial ecology in the field in relation to the size and sex. It is evident that lobsters in the wild are free to change burrows or even build new ones, rendering the field situation less competitive. However, a parallel comparison with dominance hierarchies in the American lobsters (*Homarus americanus*) suggests that the frequency and level of agonistic interactions observed in the laboratory are much higher than those found in semi-natural or natural contexts, but they still have a strong ecological significance for the species (Atema and Steinbach, 2007, Atema et al., 1979, Stein et al., 1975, Karnofsky et al., 1989). In other words, the laboratory dynamic of dominance hierarchies described here for *Nephrops* could have a strong ecological significance in the wild even if the frequency and level of agonistic interactions would be less.

5.6 ToR h. Developing R scripts for UWTV survey data processing including functions to QC, analyse and visualize data

WGNEPS members will continue to exchange R codes and are encouraged to upload the actual R codes for e.g. quality checks (QC) including Lin's CCC or density and violin plots on the WGNEPS sharepoint site.

6 Revisions to the work plan and justification

No revisions made to the current work plan.

7 Next meeting

6 – 9 November 2018, IFREMER, Lorient, France.

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Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	E-MAIL
Kai Wieland (co-Chair)	Technical University of Denmark (DTU), National Institute of Aquatic Resources, Nordsøen Forskerpark, Willemoesvej 2, 9850 Hirtshals, Denmark	Phone: +45 35883276	kw@aqua.dtu.dk
Adrian Weetman (co-Chair)	Marine Scotland Science (MSS), Marine Laboratory, 375 Victoria Road, Aberdeen, UK AB11 9DB	Phone: +44 (0)131 2444142	weetmana@marlab.ac.uk
Annika Clements	Agri-Food and Biosciences Institute (AFBI) 18a Newforge Lane, Belfast, Northern Ireland, UK BT9 5PX	Phone: +44 289 0255153	Annika.Clements@afbini.gov.uk
Candelaria Burgos	Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Cádiz Puerto Pesquero, Muelle de Levante s/n E-11006, Cádiz, Spain	Phone: +34 956 294189	caleli.burgos@ieo.es
Carola Becker	Queen's Marine Laboratory, 12-13 The Strand, Portaferry, Co. Down, Northern Ireland, UK BT22 1PF	NA	c.becker@qub.ac.uk
Chris Smith	Hellenic Centre for Marine Research (HCMR), PO Box 2214 71003, Heraklion, Crete, Greece	Phone: +30 2810337752	csmith@hcmr.gr
Cristina Silva	Instituto Português do Mar e da Atmosfera (IPMA), Av. Dr. Alfredo Magalhães Ramalho 1495-165 Lisbon Portugal	Phone: +35 121 3027000	csilva@ipma.pt
Damir Medvešek	Institute of Oceanography and Fisheries (IZOR), I. Mestrovica 63, Split 21000, Croatia	Phone: +38 5981 861865	medvesek@izor.hr

NAME	ADDRESS	PHONE/FAX	E-MAIL
Ian Tuck	National Institute of Water and Atmospheric Research (NIWA), 41 Market Place, Auckland, New Zealand	Phone: +64 93754505	Ian.tuck@niwa.co.nz
Jean-Philippe Vacherot	IFREMER Station de Lorient - 8, rue François Toullec – 56100, Lorient, France	Phone: +33 (0)297 873813	Jean.Philippe.Vacherot@ifremer.fr
Jennifer Doyle	Marine Institute (MI) Rinville, Oranmore, Co. Galway, Ireland	Phone: 353 91 387200 Fax: 353 91387201	jennifer.doyle@marine.ie
Jónas Jónasson	Marine and Freshwater Research Institute (MRI), Skulagata 4, 121 Reykjavik, Iceland	Phone: +354 575 2000	jonasp@hafro.is
Katie Boyle	Marine Scotland Science (MSS) Marine Laboratory, 375 Victoria Road, Aberdeen, UK AB11 9DB	Phone: +44 131 2444142	Katie.boyle86@gmail.com
Kostas Kapinis	Hellenic Centre for Marine Research (HCMR), 46,7km Sounion, Anavissos Av., 19013, Athens, Greece	Phone: +21 09856712	kkapir@hcmr.gr
Mats Ulmestrand	Sveriges Lantbruksuniversitet (SLU), Swedish University of Agricultural Sciences, Institutionen för Akvatiska Resurser/Department of Aquatic Resources, Havsfiskelaboratoriet, Institute of Marine Research, Turistgatan 5, S- 453 30, Lysekil, Sweden	Phone: +46 (0)10 4784048	mats.ulmestrand@slu.se
Michela Martinelli	National Research Council Institute of Marine Sciences (ISMAR-CNR), Largo Fiera della Pesca, 2 60125 Ancona – Italy	Phone: +39 071 2078851	michela.martinelli@an.ismar.cnr.it
Nadia Papadopoulou	Hellenic Centre for Marine Research (HCMR), PO Box 2214 71003, Heraklion, Crete, Greece	Phone: +30 2810337752	nadiapap@hcmr.gr
Spyros Fifas	IFREMER Centre Bretagne - ZI de la Pointe du Diable – CS29070 - 29280 Plouzané, France	Phone: +33298 2243 78 Fax: +33 298224653	spyros.fifas@ifremer.fr

NAME	ADDRESS	PHONE/FAX	E-MAIL
Yolanda Vila	Instituto Español de Oceanografía (IEO). Centro Oceanográfico de Cádiz Puerto Pesquero, Muelle de Levante s/n, E-11006, Cádiz Spain	Phone: +34 956294189 Fax: +34 956294232	yolanda.vila@ieo.es
Ewen Bell (attended remotely part time)*	Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, UK NR33 0HT	Phone:+ 44 1502524213 / +44 (0) 7767477828	ewen.bell@cefas.co.uk
Jacopo Aguzzi (attended remotely part time)**	Institute of Marine Sciences (ICM) Passeig Marítim de la Barceloneta, 37-49. E-08003 Barcelona Spain	Phone: +34 93 230 95 00 (extension 1177) Fax: +34 93 230 95 55	jaguzzi@icm.csic.es
Patrizio Mariani (attended remotely part time)**	Technical University of Denmark (DTU), National Institute of Aquatic Resources, Kemitorvet, 2800 Kgs. Lyngby, Denmark	Phone: + 45 35883353	pmar@aqua.dtu.dk
Rob Masefield (attended remotely part time)***	Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, UK NR33 0HT	Phone:+ 44 1502524213 / +44 (0) 7767477828	robin.masefield@cefas.co.uk
Valerio Sbraglia (attended remotely part time)*	Department of Biology and Ecology of Fishes (IGB), Leibniz-Institute of Freshwater Ecology and Inland Fishery, Müggelseedamm 310, 12587 Berlin, Germany	Phone: +49 (0)30 641815	valeriosbra@gmail.com

*: called in for discussion on ToR c, **: called in for presentation, ***: called in for presentations and discussion on ToR c

Annex 2: Recommendations

Recommendation	Adressed to
WGNEPS recommends that survey coverage be expanded to other important fisheries not currently assessed e.g. Botney Gut FU5 and Norwegian trench FU32.	WGNSSK, RCMs
A dedicated research project on <i>Nephrops</i> UWTV surveys has been proposed by WGNEPS; “Further developing UWTV <i>Nephrops</i> survey methodologies (DevNepS)”. WGNEPS recommends that the project proposal is updated and funding possibilities are explored	SCICOM, RCMs, EFARO
Establish a UWTV meta-database	ICES Data Centre

Annex 3: Agenda

Day 1 Tue 28/11

9:00 Welcome

ToR's and adoption of the agenda

9:30 WGNEPS 2017 review of survey activities (ToR a and b)

Nephrops in Greece waters. Christopher Smith and Nadia Papadopoulou

Nephrops in the Adriatic Sea. Michela Martinelli and Damir Medvešek

Nephrops UWTV survey in the Bay of Biscay. Spyros Fifas *et al.*

10:30 - 11:00 Coffee Break

11:00 WGNEPS 2017 review of survey activities (ToR a and b; cont.)

UWTV survey in Icelandic waters. Jónas P. Jónasson

Joint Danish/Swedish UWTV survey in the Skagerrak and Kattegat. Kai Wieland *et al.*

New Danish UWTV survey Off Horns Rev. Kai Wieland *et al.*

Developments in Scottish UWTV surveys. Katie Boyle and Adrian Weetman

13:00-14:30 Lunch

Developments on CEFAS surveys. Robin Masefield (via Skype ?)

Developments on AFBI trawl and UWTV surveys. Annika Clements

Developments on the UWTV survey in the Gulf of Cádiz. Yolanda Vila

15:45 – 16:15 Coffee Break

Developments on the trawl and UWTV survey in Portugal. Cristina Silva

Discussion on possible joined UWTV survey Portugal/Spain and linkages between the southern stocks

17:30 Adjourn

Day 2 Wed 29/11**9:00 WGNEPS 2017 review of survey activities (ToR a and b; cont.)**

Developments on Marine Institute Surveys. Jennifer Doyle and Colm Lordan

Summing up on survey activities and plans for 2018***Nephrops* Benchmarks outcomes (WKNEP 2016) and progress**

FU28-29 (Portugal), FU30 (Gulf of Cadiz), FU23-24 (Bay of Biscay) and FU3-4 (Skagerrak/Kattegat)

10:30-11:00 Coffee Break**Review of existing datasets to evaluate possible factors affect burrow emergence (ToR g)**

Technological development for population monitoring of Norway lobster (*Nephrops norvegicus*) into a marine reserve. Jacopo Aguzzi *et al.* (via Skype)

Emergence of dominance hierarchy of *Nephrops*. Valerio Sbragaglia (via Skype)

13:00-14:30 Lunch**Plenary Review of SISP****15:45 – 16:15 Coffee Break**

UTOFIA (Underwater Time of Flight Image Acquisition system. Thomas Thøgersen, Ivo Grigorov, Patrizio Mariani (via Skype)

Recent developments of surveys for *Metanephrops challenger* in New Zealand waters. Ian Tuck

Commercially exploited decapod crustaceans: Ovary staging, ovary resorption and size of maturity in UK waters. Carola Becker

Drafting parts for the report**17:30 Adjourn**

Day 3 Thu 30/11

9:00 Status and plans for ToR c (To review video enhancement, video mosaicking, automatic burrow detection and other new technological developments)

Methodology for generating reference footages – an example for FU 14. Robin Masefield (via Skype)

Software package to process recordings from *Nephrops* surveys – update. Kai Wieland

Status and for plans for ToR e (Discuss the utility of UWTV and trawl *Nephrops* surveys as platforms for the collection of data for OSPAR and MFSD indicators)

10:30-11:00 Coffee Break

11:00 Status and plans for ToR f (Develop an international database which will hold burrow counts, ground shape files and other data associated with UWTV surveys, Develop an international database on trawl surveys)

Status and plans for ToR h (Developing R scripts for UWTV survey data processing including functions to QC, analyse and visualize data, and interface the tools with the database (ToR f))

Recommendations from other expert groups to WGNEPS

- **WKNEPS 2016 (Burrow counting)**
- **Others (if there are any)**

13:00-14:30 Lunch

Plenary on SISP

15:45 – 16:15 Coffee Break

Plenary on CRR

18:00 Adjourn

Day 4 Fri 1/12

9:00 Follow up - The DevNepS project proposal

Update of MA (MultiAnnual) ToR's if necessary

Workshop on burrow counting in 2018 (venue, dates and chair)

Meeting in 2018 (venue and dates)

10:30-11:00 Coffee Break

11:00 Plenary on draft report, action list and recommendations

13:00 Official closure

Annex 4: Action list

	Action	Addressed to	Action latest before
1	Provide outstanding parts of the WG report	All WGNEPS participants	At latest 11/12-2017
2	Revise and submit CRR	Jennifer (section 5) Adrian (new figure for section 3.4) Kai (section 4.2, circulate revised version and submit to ICES)	11/12-2017 11/12-2017 asap
3	Inform ICES on status, plans and progress on UWTV meta-database	Adrian contact ICES Data Centre (Neil Holdsworth, Carlo Pinto)	Done during meeting
4	Clear with National laboratories data share for the UWTV meta-database	National WGNEPS members	15/12-2017
5	Update draft specifications for the UWTV meta-database	Jennifer, Annika, Adrian, Karen (and Kai)	15/12-2017
6	Identify national FU coordinators for submitting the data to the UWTV database	National WGNEPS members	Done during meeting
7	Arrange meeting with ICES Data Centre on UWTV meta-database	Kai / Adrian	15/1-2018
8	Populate UWTV meta-database and provide shape files to ICES	National WGNEPS members	
9	Update SISP	Jonas, Nadia, Chris	Before 2018 meeting
10	Submit SISP to ICES	Adrian / Kai	After 2018 meeting
11	Upload R scripts for UWTV survey data analysis and quality control to WGNEPS SharePoint	WGNEPS members	Ongoing
12	Contribute to preparation of burrow counting workshop in October 2018	WGNEPS members	August 2018
13	Contact and invite user's of UWTV survey data for ecosystem studies to provide feedback	Annika	Before March 2018

Annex 5: List of presentations

(in order of appearance)

- Chris Smith, Nadia Papadopoulou, Kostis Kapiris: *Nephrops* in Greek Waters.
- Martinelli M., Medvešek D., Isajlović I., Belardinelli A., Angelini S., Morello E.B., Croci C., Domenichetti F., Penna P., Scarpini P., Guicciardi S., Micucci D., Santojanni A., Vrgoč N., Arneri E.: ADRIATIC UWTV SURVEYS and Pomo monitoring activity.
- Jean-Philippe Vacherot, Spyros Fifas, Michèle Salaün, Jean-Jacques Rivoalen: LANGOLF-TV 2017 RV CELTIC VOYAGER FU 23 – 24.
- Spyros FIFAS, Jean-Philippe VACHEROT, Michèle SALAUN : FU23-24 *Nephrops* - Preliminary analysis of UWTV survey 2017 results.
- Jónas Páll Jónasson, Julian Burgos, Haraldur Einarsson, Stefanie Haase, Hjalti Karlsson: Development of UWTV survey in Icelandic waters.
- Kai Wieland, Mats Ulmestrand, Jordan Feekings, Patrick Jonsson, Sven Koppetsch, Annegrete Dreyer-Hansen, Maria Jarnum, Gert Holst, Ronny Sørensen, Eik Britsch: *Nephrops* UWTV survey in the Skagerrak and Kattegat (FU 3&4) in 2016 and 2017.
- Kai Wieland, Jordan Feekings, Annegrete Dreyer-Hansen, Maria Jarnum, Gert Holst, Ronny Sørensen, Eik Britsch: *Nephrops* UWTV survey Off Horns Rev (FU 33) in 2017.
- Katie Boyle: Developments on the MSS 2017 UWTV surveys.
- Annika Clements: FU15 Western Irish Sea *Nephrops* surveys.
- Robin Masefield: Survey results and Assessment summary FU 6 and FU 14.
- Y. Vila, C. Burgos and M.M. Soriano: Developments on the UWTV survey in the Gulf of Cadiz (FU 30).
- Christina Silva: FU 28 – 29 (SW and S Portugal).
- Jennifer Doyle and Colm Lordan: 2017 Update on Marine Institute Ireland *NEPHROPS* UWTV SURVEYS.
- Christina Silva: *Nephrops* FU 28 – 29 (assessment update).
- Yolanda Vila: IEO FU 30 _ Gulf of Cadiz benchmark advice.
- Spyros FIFAS, Jean-Philippe VACHEROT, Michèle SALAUN : FU23-24 *Nephrops* Fishery status in 2017.
- Mats Ulmestrand: Assessment issues for *Nephrops* in Functional Unit 3 and 4.
- Aguzzi J., del Río J., Gomarriz S., Navarro J., García J.A., Rottlant G., Masmitja I., Company J.B.: Technological development for population monitoring of Norway lobster (*Nephrops norvegicus*) into a marine reserve.
- Valerio Sbragaglia: Dominance hierarchy in group of male *Nephrops*.
- Patrizio Mariani: UTOFIA for WGNEPS.
- Ian Tuck: Scampi surveys and assessments in New Zealand.
- Carola Becker: *Nephrops* female staging, ovary resorption and size of maturity in UK waters.
- Robin Masefield: FU14 New reference set.

Annex 6: Survey activities in 2018

Institute	Survey Type	Survey Area	Ship																																																																																																																																						
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Annex 7: FUs 28 and 29 (Southwest and South Portugal) *Nephrops* offshore Survey (NepS)

1 Introduction

The Norway lobster, *Nephrops norvegicus* (herein after referred as *Nephrops*), is distributed along the continental slope in these FUs, at depths ranging from 200 to 800 m. Its distribution is limited to muddy sediments, with a silt and clay content of between 10–100% where *Nephrops* excavates its burrows, this meaning that the distribution of suitable sediment defines the species spatial distribution.

In FUs 28 and 29, *Nephrops* is caught in a mixed trawl fishery directed at crustacean species (Figure 1), which the most important is the rose shrimp *Parapenaeus longirostris*. Although the rose shrimp has a shallower distribution, the fishing grounds for these species overlap in the depth range of 200 - 400 m. The distribution of *Nephrops* extends further to deeper grounds down to 800 m.

Other target species are *Aristeus antennatus* (blue and red shrimp) and *Aristaeomorpha foliacea* (giant red shrimp), in areas deeper than 400 m and *Aristaeopsis edwardsiana* (scarlet shrimp), in very deep grounds (600 - 1000 m).

The fish bycatch species include hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*), blackbelly rosefish (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) and catsharks (*Scyliorhinus canicula* and *Galeus melastomus*).

The Portuguese crustacean surveys have been conducted since 1981, in different areas and seasons. The areas surveyed in each cruise varied, extending from 36° 59' N northwards to 41° 51' N and 7° 51' W to 9° 57' W and covering depths from 150 down to 750 m off the continental shelf. Since 1997, the crustacean survey has been conducted once a year, during the second quarter, covering the whole area of FUs 28 and 29.

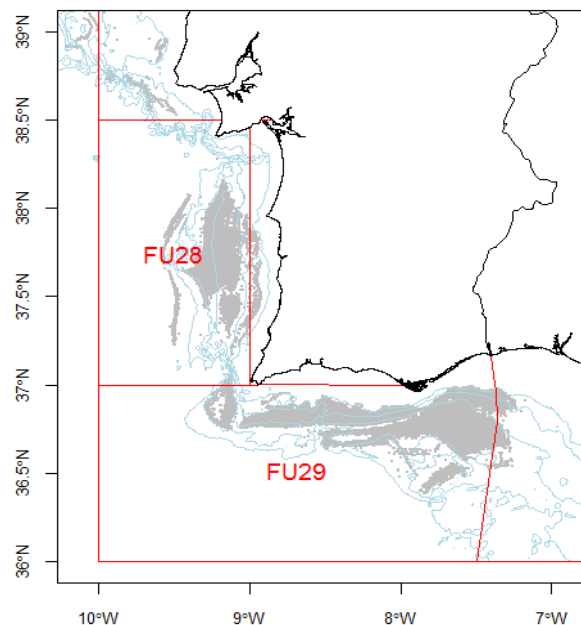


Figure 1. *Nephrops* fishing grounds in FU 28 and 29, based on VMS data (grey area).

2 Objectives

Main objectives:

To estimate the relative abundance of *Nephrops* and deep-water rose shrimp for use in the assessment and advice process, with a CV (relative standard error) of less than 20%.

To study their geographical distribution in space and time.

To collect data for the determination of biological parameters (sex-ratio, length-weight relationships, maturity, growth), meet DCF sampling requirements and provide LFD time series.

Secondary objectives:

To monitor the distribution and relative abundance of the accompanying fish and invertebrate species.

To collect data for the determination of biological parameters for selected fish species.

To collect data for biodiversity studies and information on marine litter distribution to comply with MSFD requirements.

To collect hydrographic and environmental parameters (e.g. Temperature, salinity, turbidity, oxygen, etc.)

To collect sediment data to improve the definition of *Nephrops* habitat.

3 Survey sampling design

The Portuguese crustacean surveys have been conducted since 1981, in different areas and seasons. The surveys were carried out with the research vessels «Mestre Costeiro» and «Noruega» and the areas surveyed in each cruise varied, extending from 36° 59' N northwards to 41° 51' N and 7° 51' W to 9° 57' W and covering depths from 150 down to 750 m off the Portuguese mainland coast. Prior to 1997, the surveys were mainly exploratory with no clearly defined survey design.

Since 1997, the crustacean survey has been conducted once a year, covering the southwest and south coasts of Portugal, which correspond to the Functional Units 28 and 29 of ICES Subarea 9a, respectively.

In 1997, the sampling design was adapted from the bottom trawl surveys (stratified random sampling) and formed the basis for the survey data collection in the period 1997-2004. The southwest and south coasts of Portugal were divided in sectors and each sector split in depth strata. The number of trawling stations in each stratum was dependent on *Nephrops* and rose shrimp abundance variance, with a minimum of 2 stations per stratum. The average number of stations in the period was 60. These surveys were carried out in May-July and had a total duration of 20 days.

Due to the small number of samples in some strata and to the random selection of the positions, this design does not allow the use of geo-statistical methods. For this purpose, a regular grid composed by 77 rectangles is used since 2005, with one station within each rectangle. Each rectangle has 6.6 minutes of latitude x 5.5 minutes of longitude for the SW coast and vice-versa for the south coast, corresponding approx. to 33 nm². The abundance observed at a particular point within the rectangle will reflect the relative abundance of the resource at that geographical area and it is assigned to the centre of the rectangle.

The total duration of the survey was the same (20 days) and the haul duration had to be reduced from 60 to 30 minutes in order to cover all the rectangles of the grid. The stations could be grouped *a posteriori* in the previously used strata and the results compared with the former surveys.

The grid has been updated to include areas where fishing is known to occur and to exclude others where the target species do not occur or non-trawlable areas, based on the definition of the fishing grounds through VMS fishing records and it currently includes 78 rectangles, with 21 in FU 28 and 57 in FU 29. The areas deeper than 750 m, where the scarlet shrimp occurs in FU 28, are not covered (Figure 2). Table

2 presents the summary statistics for the *Nephrops* trawl surveys for the period 2005-2017, after the change to the grid sampling design.

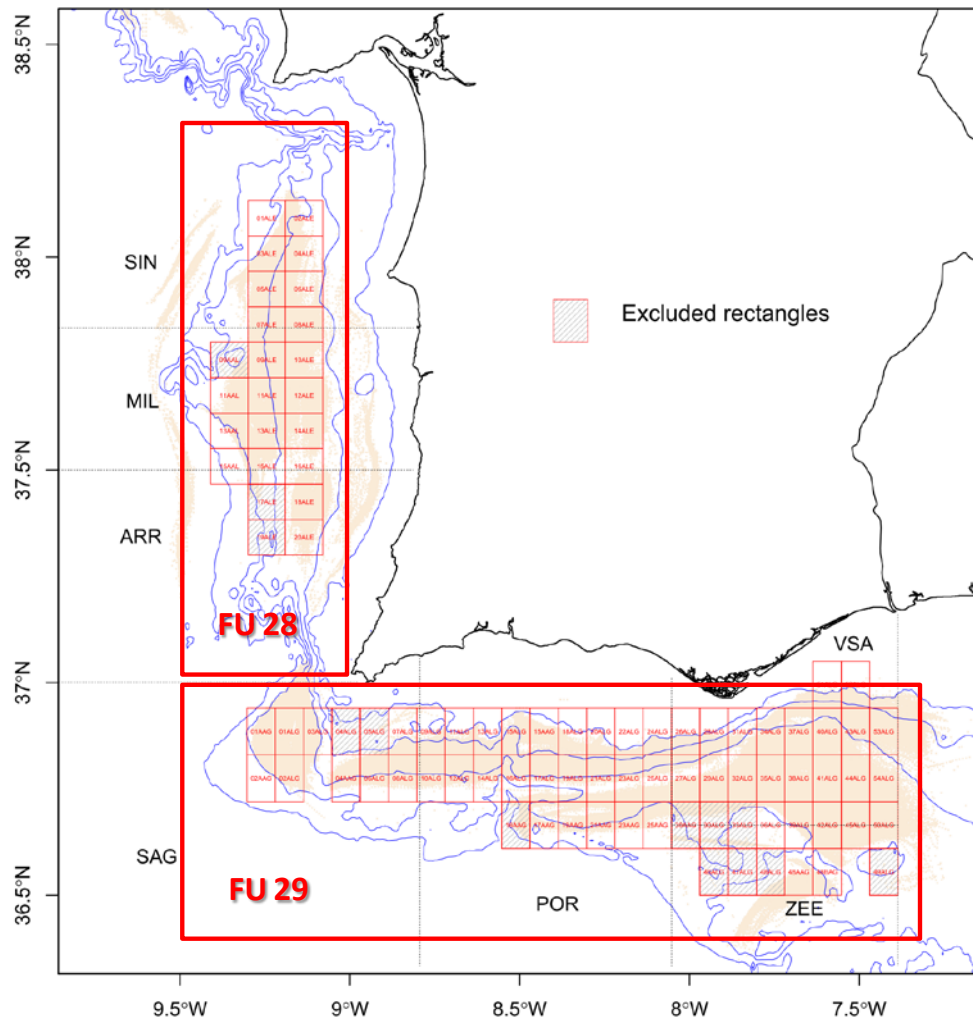


Figure 2. Survey grid in FUs 28 and 29 overlaying the crustacean fishing grounds represented by VMS fishing records. The grey-dashed rectangles were removed from the grid survey. The sectors used in the previous stratified design are also shown, delimited by dotted lines and labeled.

Table 2. Summary statistics for *Nephrops* surveys giving recent average numbers of stations (2005 - 2017), ground area, station density, design and relative standard error (CV).

Name	FU	Nb Stations (average 2005-2017)	Ground (km ²)	Stations/ 1000 km ²	Design	CV (%)
Southwest Portugal	28	21	1,925	~11	Grid (2005-2017)	19-28
South Portugal	29	52	4,502	~11		
Total	28-29	73	6,426	~11		

4 Observation methodologies

4.1 Protocol for sampling gear and instrumentation

The surveys are carried with the RV “Noruega”, which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT. The fishing gear used is a shrimp trawl (type FGAV020) with a 20 mm codend mesh size. The main characteristic of this gear is the groundrope with synthetic wrapped wire core and chain. The vertical opening is 1.5 – 2.0 m and the mean horizontal opening between doors is 60 m. The polyvalent trawl doors used are rectangular (2.7 m x 1.58 m) with an area of 3.75 m² and weighting 650 Kg. Figure 3 shows the gear design.

The following table summarizes the characteristics of the research vessel, gear and haul operation in *Nephrops* Trawl surveys in FU 28-29

Characteristics of the gear	FU 28 - 29
Research Institute	IPMA
Research Vessel	Noruega
Type	Stern Trawler
GRT	495
KW	1100
Overall Length (m)	47.5
Gear Type	Shrimp trawl FGAV020
Codend mesh size (mm)	20
Depth range (m)	150-750
Trawling speed (knots)	3
Haul duration (minutes)	30
Doors weight (kg)	650
Doors surface (m ²)	3.75
Floats in Headline/winglines	9
Average vertical opening (m)	1.5-2.0
Average doors spread (m)	60
Average horizontal opening (m)	30
Groundrope	Synthetic wrapped wire core + chain

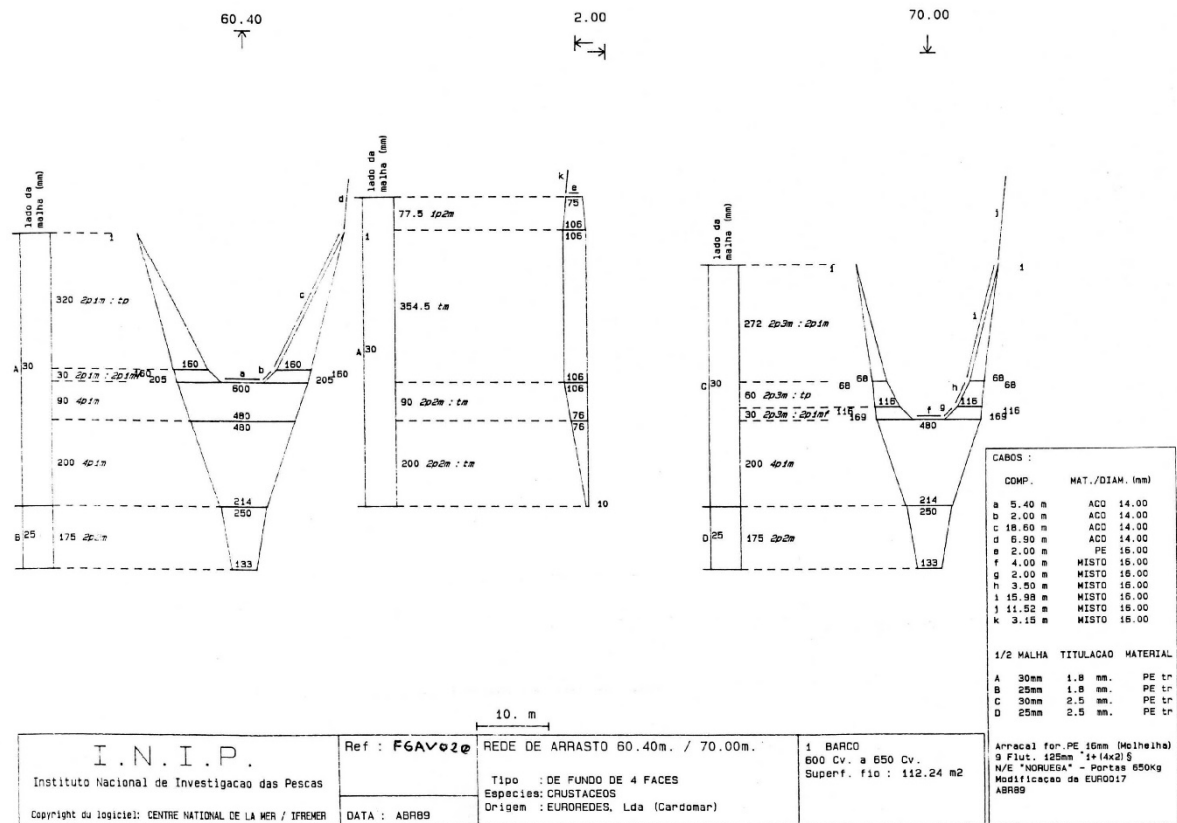


Figure 3. Scheme of the shrimp trawl gear used in Portuguese crustacean surveys.

Start time of the haul is defined as the moment when the vertical net-opening and door spread are stable. Stop time is defined as the start of pull back. The haul duration is 30 minutes. Hauls with duration lower than 15 minutes are not considered valid. Hauls are carried during daylight at a mean speed of 3.0 knots. SCANMAR sensors to monitor the trawlnet parameters (wings/doors spread, horizontal and vertical openings) are used in FU 28 and 29 on an irregular basis.

UWTV experiments with a net camera

In 2005 and 2007, some experiments to collect UWTV images from the *Nephrops* fishing grounds were made with a camera hanged from the trawl headline. A SeaCorder (composed of a MD4000 high resolution colour camera, a MP4 video recorder and a 30 Gb hard drive) was hanged at the central point of the headline, pointing forward onto the sea floor with an angle of 45 degrees, approximately. In 2008, the images collected from 9 stations in FU 28 with the same procedure looked very promising. In 2009 survey, a two-beam laser pointer was attached to the camera and UWTV images were recorded from 58 of the 65 stations. The video images were recorded in AVI format for the whole duration of each haul. These files were edited and divided in smaller files for better observation. The trawling speed and the turbidity were the main problems affecting the clarity of the image and the high variation of the height of the camera to the ground resulted in a variable field of view. It was concluded that this method could not be used for abundance estimation and it was abandoned.

4.2 Protocol for collecting biological samples

It is recommended that the catch from all valid hauls be sorted fully where practicable. Wherever possible, the entire catch is sorted, with fish and shellfish species identified to the lowest taxonomic level possible. In the case of a large catch of one dominant species, or larger catches in which a small number of species are sufficiently abundant, these can be subsampled, appropriately, with the rest of the catch fully examined for 'rare' species and any exceptionally small or large individuals of the species that are subsampled.

Length distributions are recorded for all commercial crustaceans, fish and other species caught. Length is measured to the:

- 1 mm below for commercial crustaceans (cephalothorax or carapace length/width and total length)
- 1 mm below for commercial cephalopods (mantle length)
- 0.5 cm below for small pelagic fish (total length)
- 1 cm below for all other fish species (total length).

Biological data (i.e. sex, length, weight, maturity stage) are collected. Hard structures (otoliths and illia) are collected for some of fish species.

5 Caveats

Nephrops inhabits the muddy bottom of continental shelves and slopes in the Atlantic and Mediterranean Europe, where it digs burrows of complex architecture. The burrowing lifestyle of *Nephrops* conditions its behaviour and physiology (Aguzzi and Sardà, 2007). Animals mainly emerge to feed but also, most social interactions, such as mating and moulting, occur outside the burrow. Animals can be captured by trawl hauls only while they are out of their burrows and catch patterns can be used as a proxy of animal emergence rhythms. Trawling surveys repeated continuously during 24 hrs on the Atlantic upper (< 30 m) and lower shelf (50-200 m) showed that peaks in captures took place at different times of day for increasing depths. On the upper shelf, peaks occurred at night, while they were crepuscular (i.e. at sunset and sunrise) on the lower shelf. Catches at 100 m were still crepuscular, but these became fully diurnal at 400 m (Aguzzi and Sardà, 2007).

The swept-area method using trawling is a direct and simple method for abundance estimation because catchability relies on individuals actively emerging from their burrows. The proportion of the biomass that is taken by the trawl depends on the depth (related to light penetration which conditions the emergence pattern), and on the catchability of the gear. Therefore, the trawl survey does not provide an estimate of total absolute biomass but an index of relative biomass/abundance.

A good estimation of the population density based on catchability data can be produced only when surveys are conducted in identical circumstances with special reference to the time of the day and the season. Biases in the estimation of population demographic size are likely to occur if the timing of sampling is not properly taken into account. In spring and summer, catches usually increase because animals spend more time out of the burrow to moult and then mate. This increase in emergence duration provokes a corresponding rise in the chance of an animal's capture by trawling over this period (Bell *et al.*, 2006; Aguzzi and Sardà, 2008). A consequent underestimation in assessment by trawling occurs in autumn/winter for the opposite reason. In autumn and winter, berried females do not emerge for feeding and their availability is largely reduced. Emergence is modulated not only by the stage of the reproductive cycle but also by size. Juveniles rarely emerge within the first year, and therefore, instances of their capture are consistently low (Sardà and Aguzzi, 2012). This unavailability of small size individuals may be compared to the bias pointed out in UWTV surveys relative to multiple occupancy of the burrows with juvenile and adult *Nephrops* cohabitating.

In the deep grounds of FUs 28 and 29, the hauls are carried out in spring-summer during daytime, where the emergence is higher.

6 Analysis

The analysis of the survey data have been done by subarea and depth strata.

7 Reporting of results

7.1 Survey summary sheet

A survey summary sheet should be provided for each survey. The following may serve as an example:

Country		Vessel Name	
Survey Name		Dates (start/end)	
FU / Ground Name			
Number of staff			

Objectives:

Survey Design	
Gear details	
Number of stations (planned/completed)	
Trawl horizontal opening (m)	
Trawl vertical opening (m)	
Doors / Wings spread	
Geometry of the net monitored by	
Deviations for the survey plan (e.g. coverage/weather related problems, technical problems, potential biases, etc.)	
Final abundance/biomass index (target and secondary species)	
CV (Relative standard error) (target and secondary species)	
Other survey activities (CTD, Trawl, sediment samples, sediment profile images, etc.)	
Figures: Survey area map, spatial distribution of main species abundance index, LFDs, etc.	

8 References

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- Sardà, F., Aguzzi, J. (2012). A review of burrow counting as an alternative to other typical methods of assessment of Norway lobster populations. *Reviews in Fish Biology and Fisheries*, 22 (2): 409-422.