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Report of the Study Group on *Nephrops* Surveys (SGNEPS)

6–8 March 2012

Acona, Italy

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive summary

The Study Group on *Nephrops* Surveys (SGNEPS) met in Ancona, Italy from 6–8 March 2012. The group consisted of 12 scientists from Ireland, Scotland, England, Northern Ireland, Spain, Denmark, Portugal and Italy under the chairmanship of Colm Lordan, Ireland. SGNEPS has an important role as the international coordination group for *Nephrops* UWTV surveys in the North Atlantic and Mediterranean. Heretofore SGNEPS has focused on planning, protocols, quality control, design and survey development issues. At the 2012 meeting group compiled a table summarizing the station densities and precision levels of most annual *Nephrops* UWTV surveys. Large variations in survey station densities occur across the grounds currently surveyed. Station density, accuracy and precision trade-offs were investigated and discussed in detail for the two main survey design types (random stratifies and grids). The main outcome of these deliberation was that a minimum precision level of <20% CV (also known as Relative Standard Error) should be attained for these types of surveys. There may be operational reasons why individual surveys should aim for higher precision than that (e.g. to ensure good coverage and accurate burrow surfaces). In some areas station densities could be reduce to allow for improved coverage to previously unsurveyed *Nephrops* grounds. Progress towards integrated stock assessments for *Nephrops* which make use of all sources of fisheries dependent and independent information was reported to the group. There was consensus that the current ICES framework for assessing and providing catch options based on the UWTV surveys remains the most appropriate methodology for the moment. There has been significant progress since WKNEPH (ICES, 2007) in addressing many of the perceived uncertainties in the methodology. The remaining assumptions on burrow occupancy, burrow size, growth, discard survival can only be addressed through dedicated research projects of which there have been few. Several video enhancement and technological developments were presented to the group and these look very promising in terms of improving certainty of burrow identification and facilitating validation counts. The group also discussed the various *Nephrops* trawl surveys and biological sampling requirements under the DCF and concluded that the role of the group should be expanded to cover these in future.

1 Introduction

The Study Group on *Nephrops* Surveys (SGNEPS) met in Ancona, Italy from 6–8 March 2012. The group was chaired by Colm Lordan, Ireland and was tasked with the following ToRs:

a) Look at optimum density of stations to prescribe a precision level;

b) Instigate projects to address key uncertainties such as burrow occupancy, burrow and animal size;

c) Investigate the impact of uncertainty in estimates of growth, natural mortality and discard survival on raised survey estimates;

d) To explore the use of alternative assessment models incorporating survey and fishery data sources e.g. CASAL, SS2, SCA;

e) Review the technological developments on the various *Nephrops* surveys.

The meeting was hosted at AdM Aula del Mare di Ancona which proved an excellent location for the meeting. The chair and all participants extended their thanks to Michela Martinelli and her colleagues at ISMAR-CNR sede di Ancona for the excellent arrangements and the refreshments provided to the group throughout the meeting.

2 Agenda and Presentations given

The meeting commenced at 9:30 on the 6th and discussions continued until 18:00 each day. Participants were encouraged to present an update of their work to the group and the following presentations were given and are available on the SharePoint site:

- Investigating station density, accuracy and precision for Irish *Nephrops* UWTV surveys. Jennifer Doyle, Marine Institute, Galway Ireland.
- Optimum number/density of stations to prescribe a precision level in Scottish *Nephrops* UWTV surveys Carlos Mesquita, Marine Scotland Science, Aberdeen
- The results of a new *Nephrops* UWTV survey in FU19. Colm Lordan, Marine Institute, Galway Ireland.
- *Nephrops* surveys for FUs 28 and 29, Cristina Silva, IPIMAR, Portugal.
- Adriatic Sea UWTV Survey. Michela Martinelli, ISMAR-CNR Ancona, Italy.
- Progress towards a CASAL assessment for Firth of Forth *Nephrops*. Helen Dobby, Marine Scotland – Science, Aberdeen
- UWTV survey in IIIa: Sweden and Denmark, Bo Solgaard Andersen, National Institute of Aquatic Resources, Denmark.
- *Nephrops norvegicus* of the Bay of Biscay (FU 23–24) LANGOLF surveys, Spyros FIFAS, Michèle SALAUN, Joël DIMEET Ifremer, presented at the meeting by the chair.
- Size at onset of sexual maturity in male *Nephrops* estimated by the morphometric measurement of the appendix masculina. Ana Leocádio, Cefas, Lowestoft.
- A proposal to estimate *Nephrops* abundance through TV surveys in the Gulf of Cádiz (FU30), Yolanda Vila, IEO Cadiz, Spain.

- Towards Identifying *Nephrops* Burrows Automatically from UWTV Video. Ken Sooknanan, Trinity College Dublin, Ireland.

Several of the above presentations informed the discussions on how to address the TORs. Other presentations on the wider topics of *Nephrops* biology and trawl surveys were also highly relevant to the ongoing work of assembled experts albeit probably not directly relevant to the ToRs of the group.

3 Station density, accuracy and precision trade-offs

There are two main UWTV survey design approaches currently in use; randomized fixed grid or pseudo-random stratified design where normally there is a buffering between stations to ensure better spatial coverage (Table 3.1). The randomized fixed grid approach allows abundance estimates and estimation uncertainties to be estimated using geostatistics. Normally the grid is extended in an adaptive way until boundaries are established. The random stratified approach uses a priori data on sediment type to define strata with more similar densities. The accuracy of the stratification is also a potential issue when using the random stratified design. Up to now the survey co-efficient of variation (CV – relative standard error) using geostatistical methods are less than 5% whereas CVs using the random stratified approach can be as high as 20% (ICES, 2011a,b and Table 3.1).

Table 3.1. Summary statistics for UWTV *Nephrops* surveys giving recent average numbers of stations, ground area, density design and Relative standard error (CV).

Name	FU	Recent average Number of Stations (2005-2011)	Area of Ground (km2)	Stations/ 1000km2	Design	CV-Relative Standard Error
Aran Grounds	FU17	74	926	79.9	Grid	2.2%
Firth of Forth	FU8	46	915	50.3	Random Stratified	10.4%
Farn Deeps	FU6	108	2750	39.3	Grid	3.0%
Botney Gut & Silver Pit	FU5	43*	1000	43.0	Grid	na
Irish Sea East	FU14	36*	1043	34.5	Grid	10.0%
Smalls	FU22	91	2800	32.5	Grid	4.9%
Irish Sea West	FU15	145	5331	27.2	Grid	3.2%
SW & South of Ireland	FU19	35*	1572	22.3	Random Stratified	na
North Minch	FU11	37	1775	20.8	Random Stratified	8.7%
Moray Firth	FU9	45	2195	20.5	Random Stratified	15.5%
Clyde	FU13	40	2083	19.2	Random Stratified	8.4%
Noup	FU10	6	400	15.0	Random Stratified	na
Kattegat & Skaggerak	FU3-4	72	9842	7.3	Grid with random station selection	5.9%
South Minch	FU12	34	5072	6.7	Random Stratified	17.5%
Fladen Ground	FU7	71	28153	2.5	Random Stratified	6.2%
Labadie	FU20-21	na	~4271	na	No survey Currently	na
Porcupine Bank	FU16	na	~7000	na	No survey Currently	na

The appropriate level of sampling effort to apply in a survey in order to obtain a precise measure of burrow density is an important issue for *Nephrops* UWTV surveys. Table 3.1 illustrates very large differences in station densities in the different surveys. The lowest survey densities are on the Fladen ground with 2.5 stations/1000km^2 whereas highest densities are on the Aran Grounds 79.9 stations/1000km^2.

The optimal survey density is linked to the underlying density distributions and their inherent variability. This question was first addressed at WKNEPHTV 2007 using a bootstrapping approach on 2006 Cefas Farn Deeps survey data (ICES, 2007). For random designs where a station can be placed anywhere within the sediment strata, a decision has to be made on the number of stations to be sampled in each strata. The variance of the estimated burrow density decreases with an increasing sample size n, therefore a higher sampling effort will generate more accurate estimates with narrower confidence intervals and lower relative standard errors (RSE). For grid designs the exploratory variograms can give clues as to optimal station density.

3.1 Stratified random surveys

For stratified random surveys the aim is to provide an estimate which is as close as possible to the true value with a high probability. This can be achieved by specifying a relative error r so that the percentage difference between the estimated and true value has a small probability α:

$$P\left(\frac{\hat{\theta}-\theta}{\theta} > r\right) < \alpha$$

Using information available on the average burrow density and variance from past surveys, it can be shown (Thompson, 2002) that the minimum number of stations n to achieve a relative error r for a significance level α is given by:

$$n = \frac{1}{\frac{r^2u^2}{z^2\sigma^2} + \frac{1}{N}}$$

where u is the estimated average burrow density, σ2 the estimated variance, z the α/2 quantile for the standard normal distribution and N the total number of stations that would have to be carried out to cover the entire ground. In a *Nephrops* UWTV survey, where only a small area is surveyed compared to the total area ground, the term 1/N tends to zero and can be ignored.

This method was applied to the "Scottish Functional Units" (FUs) Fladen, Firth of Forth, Moray Firth, North Minch, South Minch and Firth of Clyde (Clyde and Sound of Jura) using 2010 survey data. This gives an indication on how sampling effort can be adjusted in relation to the relative error which is a proxy for the relative standard errors used in the confidence intervals calculation for the survey.

Results are shown in Figures 3.1–3.7. The relation between sampling effort and the achieved precision level depends on the variance profile of the input data. All FUs showed projected relative errors lower than 30% with Fladen and Firth of Clyde estimates being less than 20%. The more heterogeneous grounds in the west coast, where there are a higher uncertainty on the sediment boundaries distribution, may explain the higher relative error values in the North Minch and South Minch.

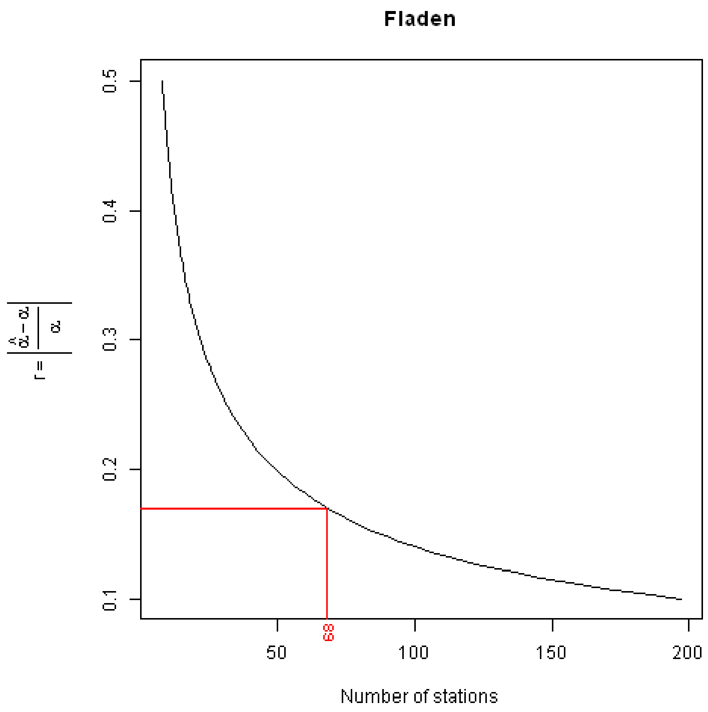

Figure 3.1. Relation between relative error and sampling effort (number of stations) using 2010 Fladen UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

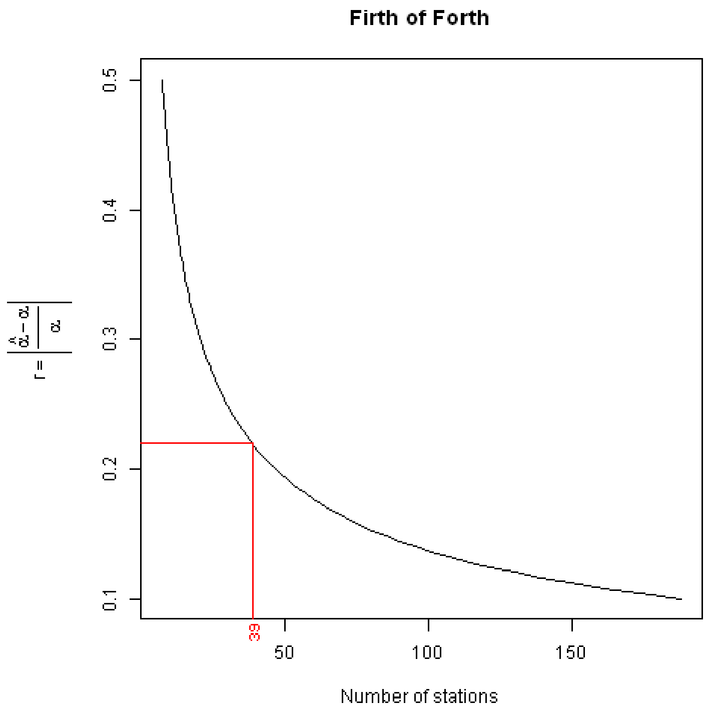

Figure 3.2. Relation between relative error and sampling effort (number of stations) using 2010 Firth of Forth UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

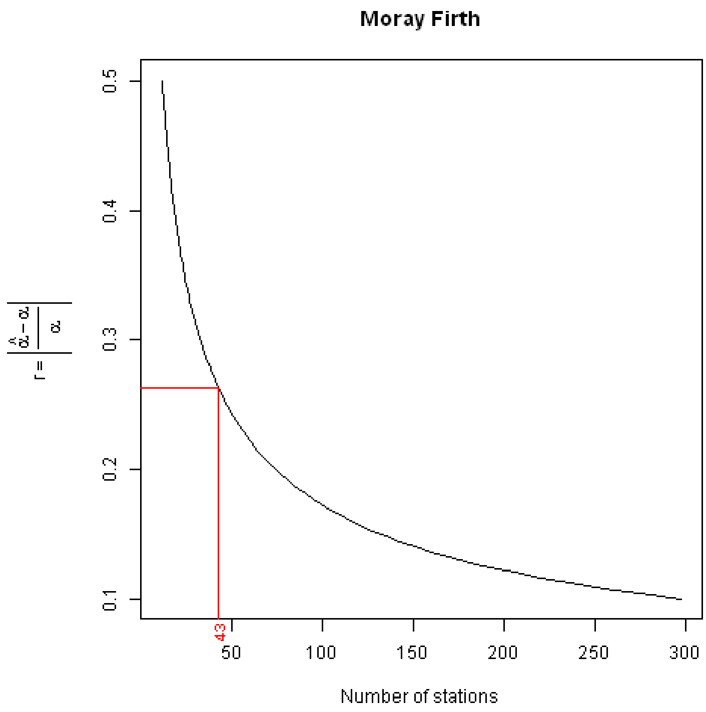

Figure 3.3. Relation between relative error and sampling effort (number of stations) using 2010 Moray Firth UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

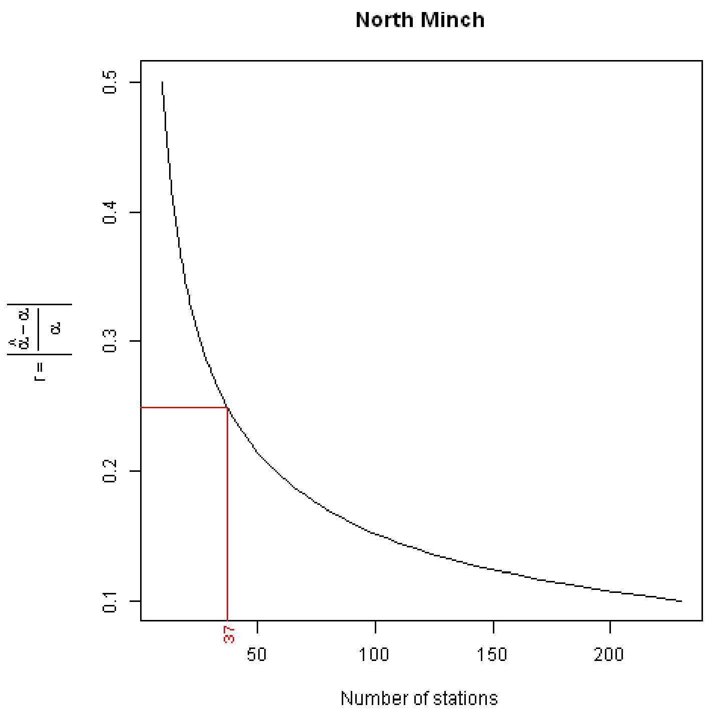

Figure 3.4. Relation between relative error and sampling effort (number of stations) using 2010 North Minch UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

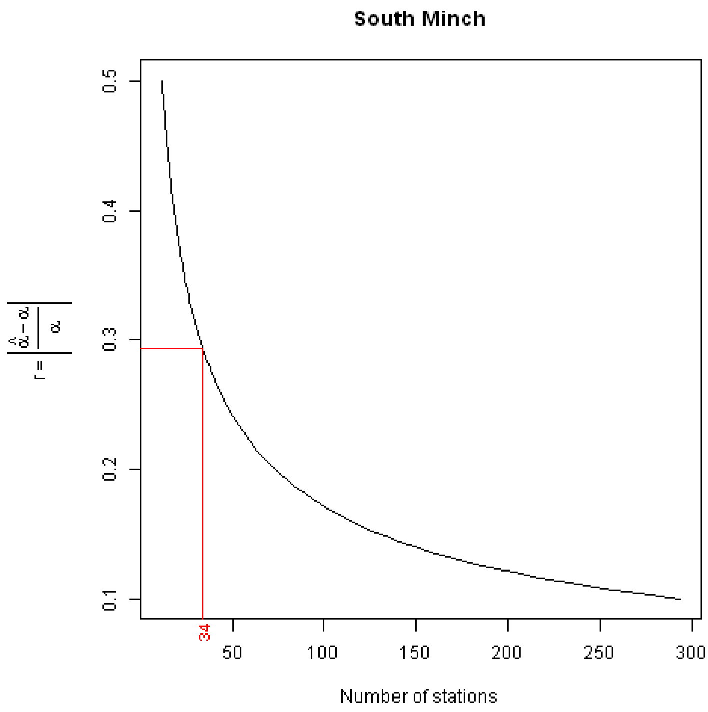

Figure 3.5. Relation between relative error and sampling effort (number of stations) using 2010 South Minch UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

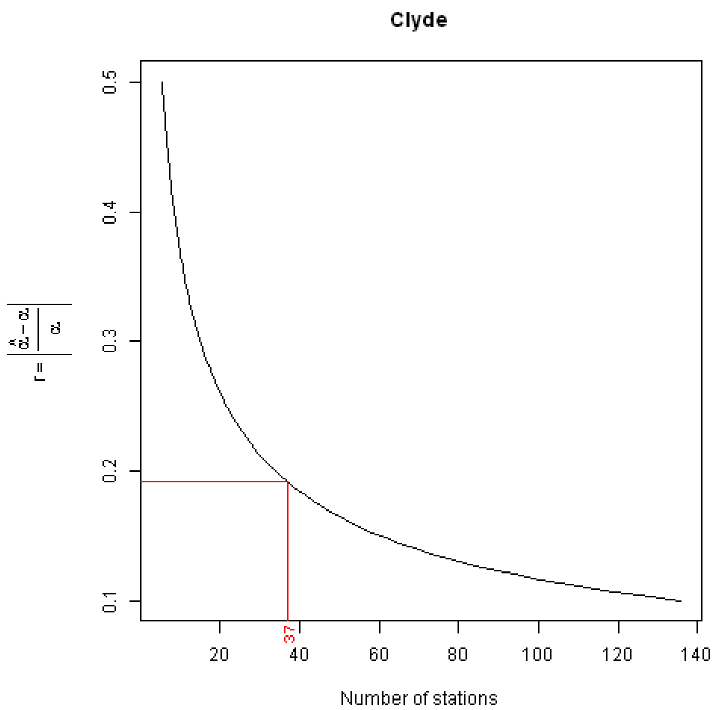

Figure 3.6. Relation between relative error and sampling effort (number of stations) using 2010 Clyde UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

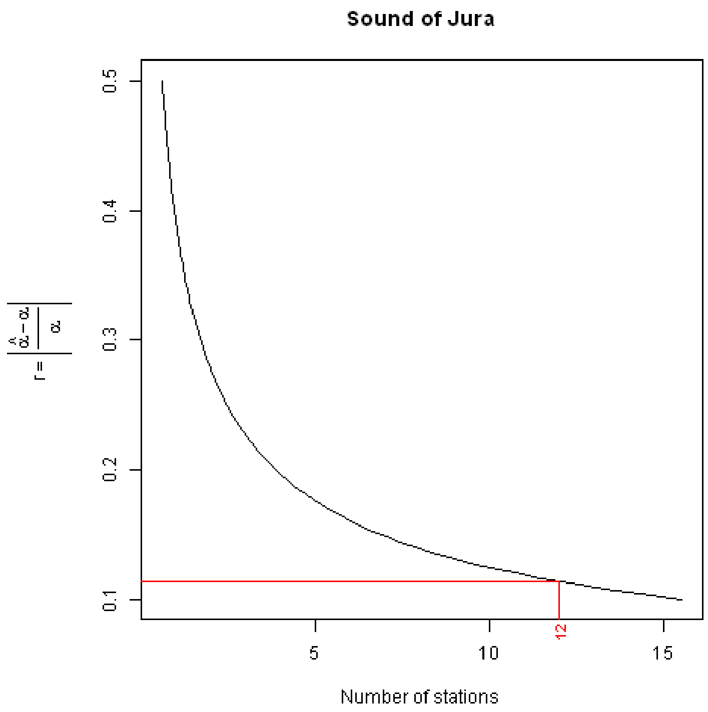

Figure 3.7. Relation between relative error and sampling effort (number of stations) using 2010 Sound of Jura UWTV survey data. The red line projects the number of stations surveyed in the last survey to get a relative error.

For simplicity, in this investigation the total number of burrow densities were pooled together ignoring the stratification design used in Scottish surveys. This is likely to have an impact on the relative errors leading to some degree of overestimation. If considered, the stratification would reduce the variability within strata leading to lower relative errors for a given sampling effort level.

It is concluded that relative standard errors (CVs) projected from the analysis of the 2010 survey give a reasonable indication on how the number of stations surveyed could be adjusted in relation to a target precision level for future surveys.

3.2 Grid Designs

Exploration of the variograms for the Aran grounds and Irish Sea do not suggest that the survey density should be reduced although the current survey precisions are relatively high (the 95% CIs are typically less than +/-5%). To date there has not been much investigation into the optimal survey density but given the relatively high sampling intensity and precision there maybe scope to reduce sampling levels to allow for an expansion of surveys to other *Nephrops* areas. Prior to SGNEPS 2012 as sensitivity study was carried using the UWTV survey data from FU17 Aran Grounds using years 2005, 2010–2011.

Currently a randomized fixed grid design is used for all Marine Institute UWTV surveys. For the Aran grounds a point is picked at random and stations are carried out at a fixed distance north–south and east-west. The distance between stations has varied somewhat in the past but is currently 2.25 nautical miles (nmi). Over the past 10 years of surveying an adaptive approach has taken whereby stations are continued past the known perimeter of the ground until the burrow densities are at or close to zero. The perimeter of the stock is fairly well known at this stage.

For this sensitivity study the station spacing for the years 2005, 2010-–2011 was increased to 4.5 nmi which generated four grid options and also a spacing of 6.75 nmi which generated one grid option for each year. Figure 3.8, shows the various grid options at station spacing of 2.25 nmi, 4.5 nmi and 6.75 nmi and also density data obtained in the 2005 UWTV survey.

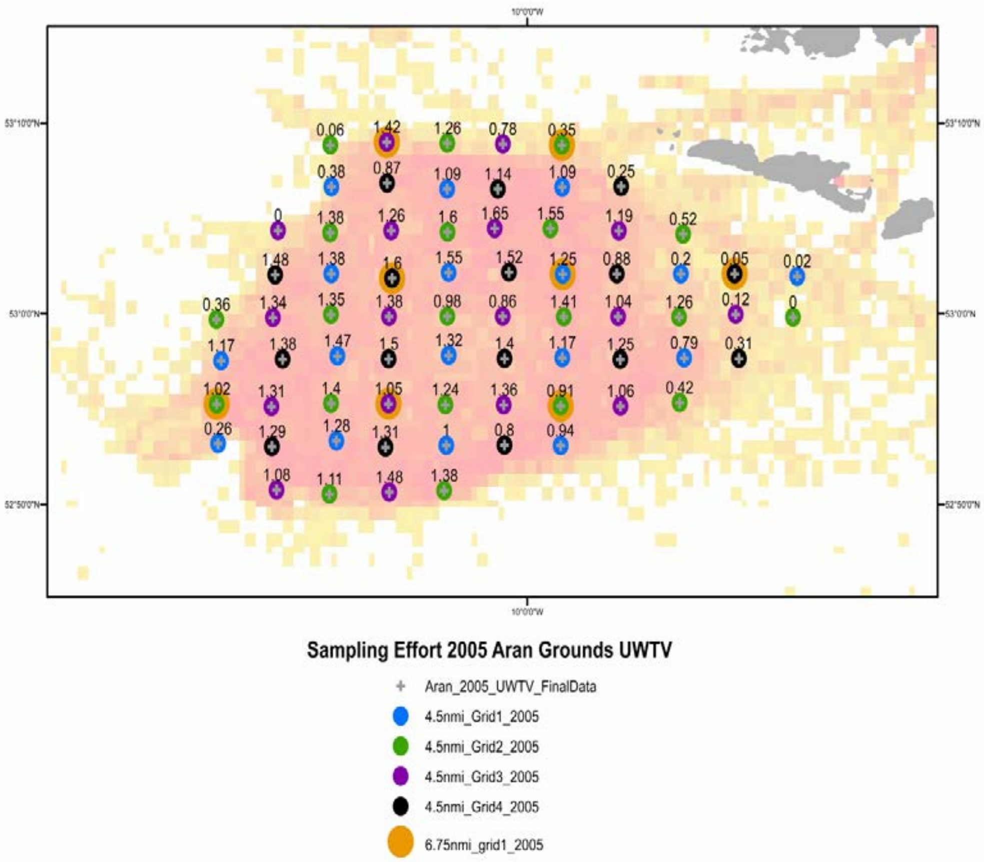

Figure 3.8. Grid options for station spacing of 2.25, 4.5 and 6.75 nmi and density data results obtained in the 2005 UWTV survey FU17 Aran grounds.

As in other years to account for the spatial covariance and other spatial structuring a geo-statistical analysis of the mean and variance was carried out using SURFER Version 8.02 for stations within the main fishing area the Aran Grounds. The spatial structure of the density data were studied through variograms. Initially the mid-points of each UWTV transect were converted to UTMs. In addition to the survey stations various boundary positions were included in the analysis. The assumption at these boundary positions was that the *Nephrops* abundance was zero. These stations were outside the known distribution of *Nephrops* or suitable sediment and were approximately equidistant to the spacing within the main grid each year. An unweighted and unsmoothed omnidirectional variograms were constructed, with a lag width of approximately 909 and maximum lag distance of between 20–25 km. A model variogram $\gamma(h)$, was produced with a linear component (Equation 8). Model fitting was via the SURFER algorithm using the variogram estimation option. Various

other experimental variograms and model setting were examined before the final model choice was made.

Equation 8: Linear Variogram Model

$\gamma(h) = Co + S \cdot h$

Where *Co* is the unknown nugget effect and *S* is the unknown slope.

The resulting annual variograms were used to create krigged grid files and the resulting cross-validation data were plotted. If the results looked reasonable then surface plots of the grids were made using a standardized scale. The final part of the process was to limit the calculation to the known extent of the ground using a boundary blanking file. The resulting blanked grid was used to estimate the mean, variance, standard deviation, coefficient of variation, domain area and total burrow abundance estimate. Although SURFER was used to estimate the burrow abundance this does not provide the krigged estimation variance or CV (relative standard error). This was carried out using the EVA: Estimation VAriance software (Petitgas and Lafont, 1997). The EVA burrow abundance estimates were all close to the Surfer estimate (+- 165 million burrows).

The geostatistical structural analysis for 2005 is shown in the form of variograms in Figure 3.9. There are a few outliers apparent but they appear have little leverage on the variogram models observed.

The blanked krigged contour plot and posted point density data are shown in Figures 3.10 and 3.11. The 4.5 nmi krigged contours correspond well to the observed data and depending on the density data the contours pick up the hot spots (Figure 3.10). However the increased station spacing of 6.75 nmi does not pick up the varying density levels and the contour plot is more smooth (Figure 3.11). In general the densities are higher towards the western side of the ground rather and there is the notable trend towards lower densities towards the east. On the southwestern boundary there are indications of high densities close to the boundary. In this area there is a sharp transition from mud to rocky substrate.

The summary statistics from this geo-statistical analysis for the various grid options are given in Table 7.1. The estimates of abundance from the 4.5 nmi station spacing grid options are not significantly different from the estimate from the 2.25 nmi grid. Whereas the estimates from the 6.75 nmi grid is a decrease for all the years investigated. The estimation of variance from the 4.5 nmi grids as calculated by EVA is relatively low (CVs in the order ~10%) for all years (2005, 2010-2011). The estimation of variance for the 6.75 nmi grid option increases (CVs in the order 14–24%) for all years.

Using a station spacing of 4.5 nmi results in an increase in the uncertainty of the abundance estimate. The resulting burrow surfaces do not fully reflect the underlying variation in abundance that one observers with a grid spacing of 2.25 nmi. Ultimately however the key uncertainty is in the overall abundance estimate and the analysis here shows that the abundance estimates with a 4.5nmi grid remain reasonably precise with CVs in the order of 10%. This is lower than some of the other uncertainties inherent in the approach especially the edge effect. Spacing the stations at 6.75 nmi results significantly in higher uncertainty and appears to result in a bias in the abundance estimates (CVs in the order 14–24%).

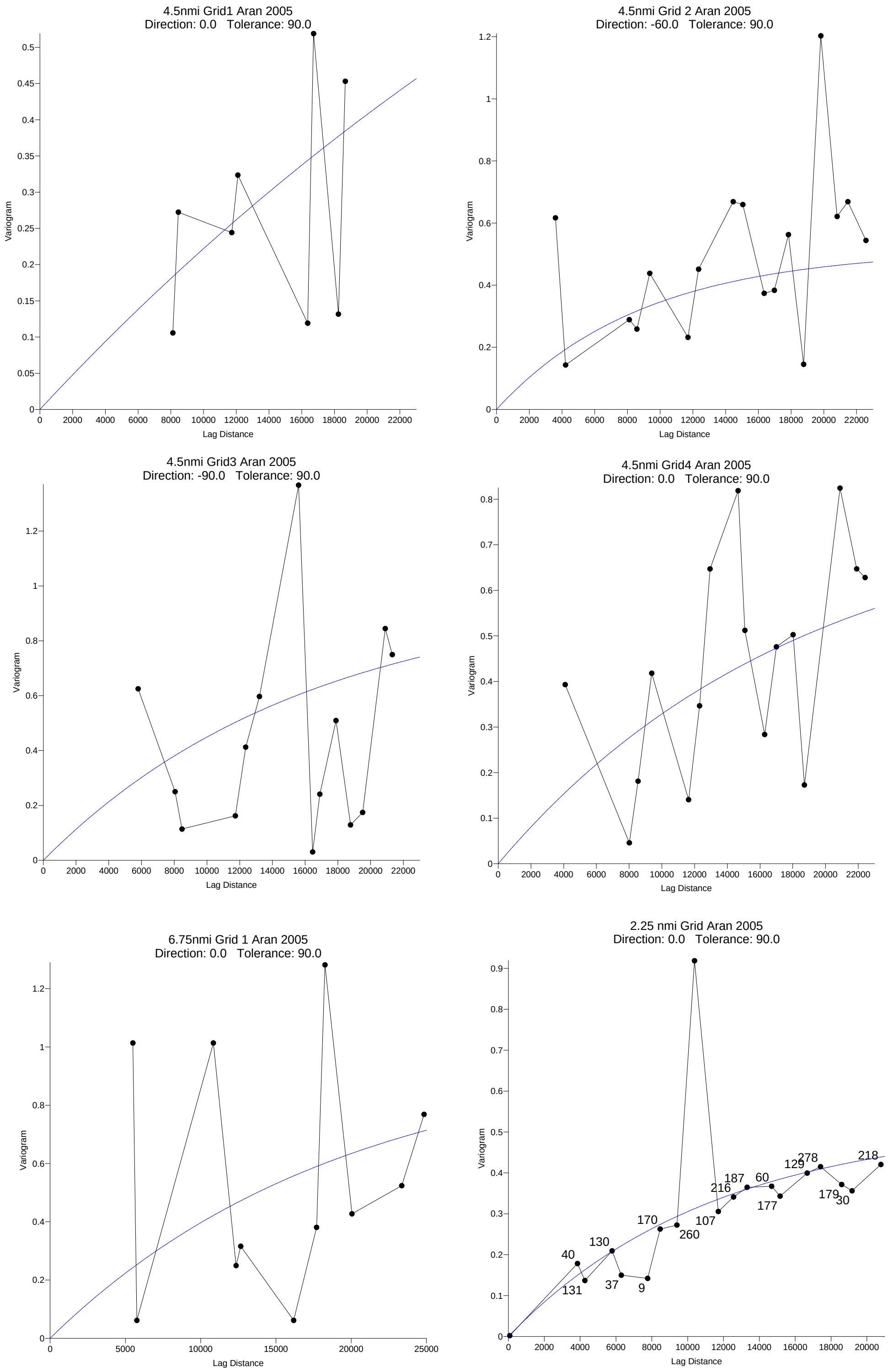

Figure 3.9. Omnidirectional mean variograms for FU17 Aran Grounds 2005 for grid options.

SGNEPS concluded that there was scope to reduce the burrow density in the Aran grounds. Increasing survey spacing from 2.25 to 4.5 nmi would reduce the number of stations from around 75 to ~20. This is a significant operation time saving from ~3 days on the grounds to ~1 day. To achieve good spatial coverage over the ground and to generate burrow surface that reflects the underlying abundance an intermediate spacing of 3.5nmi would seem like a good compromise. There are operational reasons why one might not want to increase the spacing too because mobilization

and steaming overheads to the ground and between stations would remain relatively constant.

This study will be repeated using data from the FU22 "Smalls" and FU15 "western Irish sea" UWTV survey series to determine the optimum density of stations before the 2012 UWTV survey season. Any reduction in survey time from these studies will be used to survey other *Nephrops* stocks not currently assessed using UWTV methods such as FU16 Porcupine Bank and FU19 SW and South of Ireland.

3.3 Conclusions

Defining a minimal acceptable precision level for UWTV surveys is a necessary step to ensuring that the surveys are fit for purpose. It is possible to estimate the number of stations required to achieve a target precision level for both survey design types. **SGNEPS recommend that a CV (or relative standard error) of < 20% is an acceptable precision level for UWTV survey estimates of abundance.** There may be operational reasons why individual surveys should aim for higher precision than that (e.g. to ensure good coverage and accurate burrow surfaces). But there is also some scope to reduce sampling levels on some grounds and reallocate the time saved to improving coverage or precision in other areas.

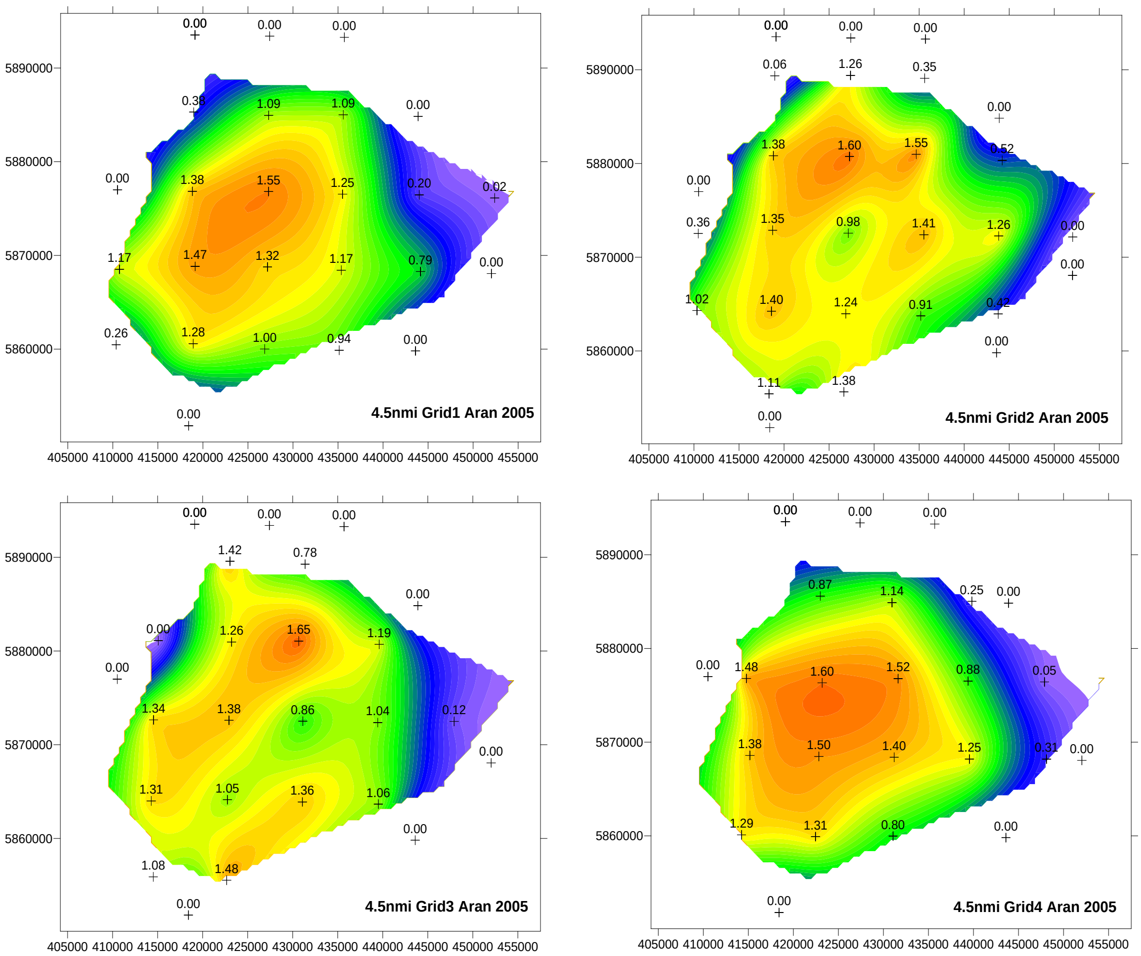

Figure 3.10. Contour plots of the krigged density estimates 4.5 nmi grid options for FU17 Aran Grounds 2005.

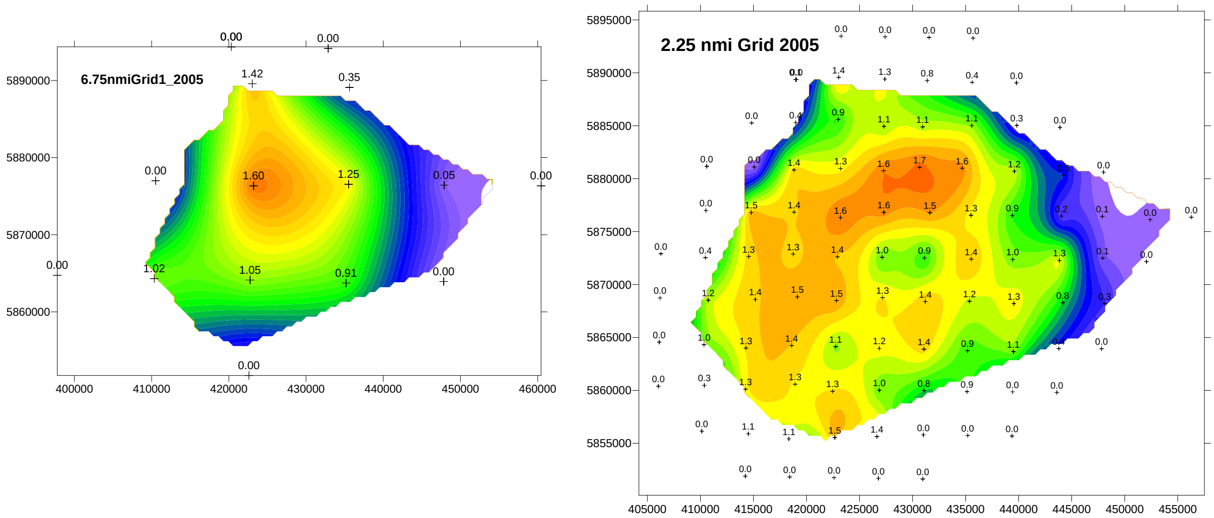

Figure 3.11. Contour plots of the krigged density estimates 6.75 nmi and 2.25 nmi grid options for FU17 Aran Grounds 2005.

Table 3.1. Summary geostatistics for FU17 Aran Grounds 2005 for the grid options investigated.

Aran Ground	Year	Number of stations	Number of Non-Zero stations	Mean Density (No./m2)	Estimation Standard Deviation	Domain Area (km2)	Geostatistical abundance estimate	CV on Burrow estimate
2.25 grid	2005	70	68	1.09	0.03	936	1063	3%
4.5 grid1	2005	17	17	0.99	0.05	935	964	6%
4.5 grid2	2005	20	19	1.08	0.10	936	1054	11%
4.5 grid3	2005	17	16	1.03	0.10	936	1005	10%
4.5 grid4	2005	16	16	1.06	0.07	925	1028	7%
6.75 grid1	2005	8	8	0.89	0.18	933	867	19%
2.25 grid	2010	87	73	0.85	0.01	937	827	2%
4.5 grid1	2010	22	20	0.80	0.05	939	786	7%
4.5 grid2	2010	23	19	0.79	0.07	939	771	10%
4.5 grid3	2010	21	17	0.79	0.05	939	776	8%
4.5 grid4	2010	21	17	0.73	0.08	939	712	14%
6.75 grid1	2010	10	9	0.77	0.10	939	749	14%
2.25 grid	2011	76	65	0.67	0.02	909	638	3%
4.5 grid1	2011	17	16	0.63	0.06	907	617	10%
4.5 grid2	2011	21	18	0.57	0.06	930	559	11%
4.5 grid3	2011	19	15	0.65	0.07	925	633	12%
4.5 grid4	2011	19	15	0.61	0.06	925	595	11%
6.75 grid1	2011	10	8	0.53	0.12	934	516	24%

4 Address key uncertainties and assumptions

Main perceived sources of uncertainty in generating burrow density estimates and using UWTV surveys as a basis for assessment and advice were listed in the so called "uncertainties table" (ICES, 2007). The objective of the table was to highlight and prioritize the key concerns. Since then several studies have taken place and new protocols have been implement on surveys to address and mitigate many of these uncertainties see WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009 and ICES, 2010) and WKNEPH (ICES, 2009). Burrow occupancy, burrow and animal size all require dedicated research effort and are mainly beyond the scope of the routine survey activities. At a national level various research proposals have been submitted to funding authorities to address this dedicated research need. Examples include an application entitled: "Filling the Holes in Assessment Uncertainty: Burrow Occupancy, Growth and Reproduction in *Nephrops*") which was submitted by Cefas to DEFA. Heretofore these projects have failed to attract funding.

4.1 Burrow occupancy

Each burrow system is assumed to represent one adult *Nephrops* and occupancy is assumed to be 100%. Burrows not occupied are thought to infill quickly and suspected unoccupied burrows are not counted during surveys. Burrow persistence on the seabed is likely to be quite variable. In stable low energy environments burrows will persist for a long time (months or even years). Whereas in areas with seabed stress due to trawling, currents etc., or high deposition rates or heavy bioturbation *Nephrops* burrows will only persist for a matter of days or weeks if unoccupied. Currently the only data regarding burrow occupancy currently comes from shallow sea-loch studies and are presumed to reflect the main commercial grounds.

Occupancy rates on a range of offshore grounds with different population structure and environmental conditions require investigation to: 1) the confirmation of one animal resides in one burrow system and 2) establish how quickly unoccupied burrows infill or collapse. It is anticipated that this will require significant collection of video footage from in situ camera as well as experimental manipulation of the burrow systems. Footage from either ROVs, dropframes or bathysnap apparatus are the most suitable platforms for video collection. Other apparatus such as electric shock fishing aids and animal displacement methods are also useful for examining the burrow occupancy assumption.

4.2 Burrow system morphology

The correct enumeration of burrows is the basis of the use of underwater TV technology for the *Nephrops* stock assessment. One known issue is the greater uncertainty of burrow identification on the footage edges. Burrow systems can comprise of multiple entrances. When viewed on the edge of the footage, it isn´t always clear if openings are part of one or multiple burrow systems. This is termed the Edge Effect. Work reported in SGNEPS2010 has made significant inroads into our understanding of the Edge effect, including the development of an offset for correcting data. This Edge effect correction can be further improved with a better understanding of burrow size and architecture in the main functional units.

It will be necessary to collect in situ video footage to establish the overall diameter of burrow systems. Complete casts made from material collected by boxcorers were

difficult to produce and sometimes failed to capture the burrow architecture observed in the sledge footage (ICSE, 20010). A suggested approach might be to use an ROV with coloured solution injected into burrow openings to establish the interconnectivity of observed openings. Advances in video mosaicing may also provide useful images of the orientation of openings within burrow systems and total burrow diameter. Both approaches could also yield important information on animal size associated with the burrow systems. Work establishing and linking burrow system and animal size would help improve key parameters within the stock assessment methodology and determine that fraction of the population being assessed.

Term of Reference c) asks SGNEPS to investigate the impact of uncertainty in estimates of growth, natural mortality and discard survival on the raised survey estimates. In fact these uncertainties do not directly impact on the raise survey estimates of abundance. Where these uncertainties are potentially important is in the estimation of reference points either using SCA or the age structured simulation model (ICES, 2009) and in the calculation of catch options. A certain amount of sensitivity analysis has been already carried out on these at WKNEPH (ICES, 2009). Again these parameters are not easily measured so some SGNEPS recommends further assumption testing in conjunction with benchmark explorations for individual stocks.

The consensus at SGNEPS was that despite the explicit assumptions in UWTV surveys and calculation of reference points that these methodologies are currently the best way to assess and provide catch advice for *Nephrops*. Without an international collaborative research effort to address some of the assumptions listed above the method will be open to criticism (e.g. Sarda and Aguzzi, 2011). Clearly this review has missed several of the most important developments in terms survey methodologies and the application of the approach within ICES (ICES, 2009, ICES, 2009, ICES 2011). SGNEPS recommends to the Regional Coordination Meetings of the DCF that a dedicated research project on *Nephrops* UWTV assumptions and uncertainties should be proposed for funding to the European Commission.

5 Progress towards integrate assessment models

In 2009, the ICES Benchmark Workshop on Nephrops (WKNEPH; ICES, 2009) agreed that appropriately bias-corrected underwater TV surveys indices could be used as absolute indices of abundance and they documented a process for providing advice from these abundance estimates. This decision was made due to difficulties associated with assessing non-aged species and bias in reporting of commercial data. One of the recommendations from WKNEPH (ICES, 2007) was to investigate the use of alternative modelling approaches for stock assessment which may provide an improved basis for advice as data availability improves.

Traditionally, tuned *Nephrops* stock assessments have made use of age based methods (e.g. XSA) with age-structured input data derived from the catches at length by deterministic slicing so that each length class is allocated to a particular age class on the basis of assumed von Bertalanffy growth parameters. Alternatives to age slicing exist which better accommodate variability of length/age, and include modelling formulations which allow for errors in catch, trends in catchability, or other hypotheses related to fishery and population processes. These are typically integrated approaches to stock assessment (e.g. Stock synthesis, CASAL) which allow for a wide range of assumptions about the dynamics of the stock and fishery and are able to utilize many different data types (including size or age structured commercial or survey data, abundance indices and tag recapture data) with different levels of reliability. Applications of these types of models are more common in the Southern hemisphere where a number of invertebrate stocks have been assessed in this way: *Metanephrops challengeri,* (Tuck and Dunn, 2012) and Southern rock lobster (*Jasus edwardsii*) stocks off New Zealand and Australia (Breen *et al.,* 2002; Starr *et al.,* 2003).

An application of the CASAL (C++ Algorithmic Stock Assessment Laboratory) software suite (Bull *et al.,* 2008) to Firth of Forth *Nephrops* was presented at this meeting. A model was developed which partitioned the population into male/female and mature/immature components to allow for differences in the dynamics (growth and mortality) of these sections of the population. The input data used in the model consisted of total catches, proportion at length in the commercial catch by sex and quarter, and a time-series of abundance estimates from the underwater TV survey. Initial model runs which assumed natural mortality fixed at 0.3 (0.2 for mature females; as assumed by ICES) and 100 % detection by the survey of individuals > 17 mm in length failed to converge suggesting that these assumptions are inconsistent with the data. Although the model diagnostics were not thoroughly explored, the model appeared to provide a reasonable fit the commercial catch at length data. The fit to the survey data were less convincing and although the model predicted the general trend in the data, it failed to predict the interannual fluctuations, suggesting potential model misspecification associated with survey selectivity. Due to time constraints, limited progress was made in resolving these issues.

The flexibility of integrated assessment frameworks comes with an increase in complexity in setting up and running the assessment and an associated increase in the steepness of the learning curve for the user. The main advantage of these types of approaches appears to be in situations where there is a wide range of types of fishery dependent and independent data which could contribute to an improved basis for scientific advice. Western Irish Sea *Nephrops* is one such FU which appears to fall into this category. This FU has a long time-series of both commercial and survey length frequency data, an underwater TV survey abundance index and commercial cpue

data. A future benchmark assessment of this FU may provide an opportunity to further explore the suitability of this type of approach. Given the number of model and parameter assumptions required in situations with less data, it seems unlikely that an integrated assessment approach would provide an improvement on the current underwater TV approach to assessment and advice provision.

6 Technological Developments in *Nephrops* UWTV surveys 2011–2012

6.1 Scotland

Early in 2012, Marine Scotland Science (MSS) Aberdeen, UK trialled two modifications to the standard approaches while carrying out an underwater television (UWTV) *Nephrops* burrow survey in January 2012. This involved a) using lasers to define a fixed field of view when using the drop frame and b) analysing burrow abundance with and without using video enhancement software.

The standard method for collecting video footage for *Nephrops* burrow abundance analysis involves using a camera mounted on a sledge which is towed across the seabed. The total area surveyed at each survey station is established by multiplying the distance travelled by the field of view. The field of view is calculated by using an altimeter mounted on the sledge, which continually records the distance the camera is from the seabed, and relates these values to the known field of view when the sledge is positioned on the surface of the seabed.

However in areas with a risk of entanglement with creels, for example in the sealochs on the west coast of Scotland, a drop frame is used (see Figure 6.1). This vertically mounted camera system is suspended off the stern of the research vessel and is drifted across the survey area approximately 1m off the seabed. However there is limited control of the camera with this method and although the distance travelled can be measured using the ship's GPS data, the field of view and angle in which the video passes over the screen constantly varies due to environmental conditions; therefore accurate calculations of the surveyed area has proved very difficult.

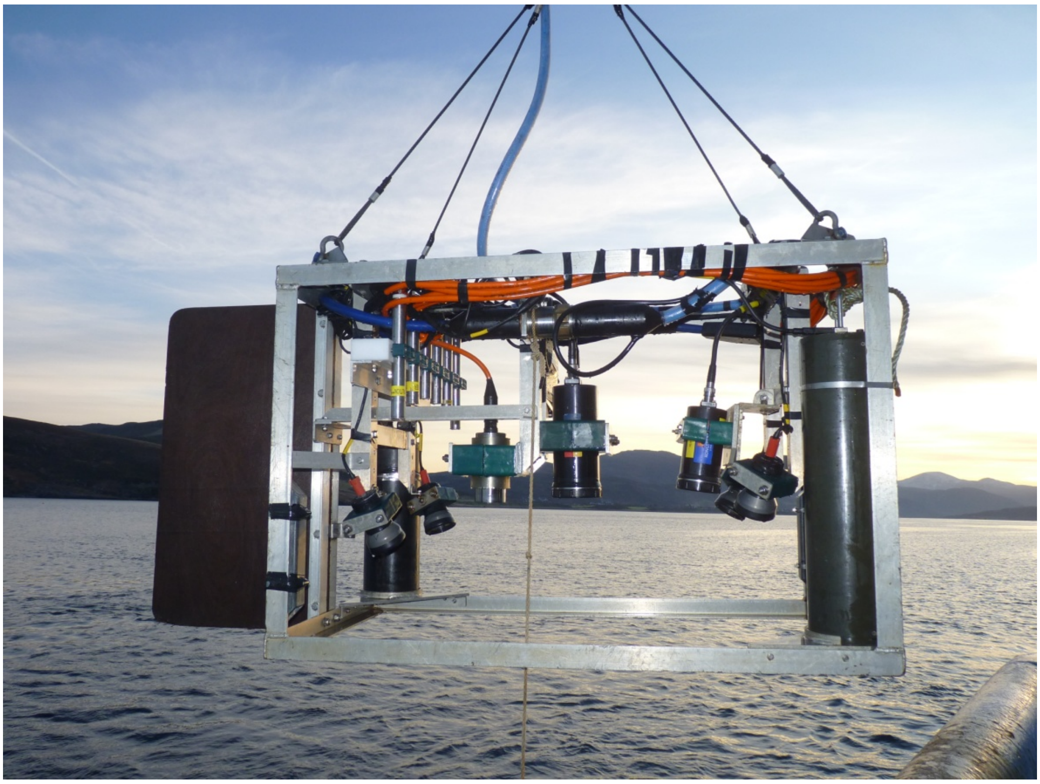

Figure 6.1. The Marine Scotland Science drop frame.

Following trials in 2011, six lasers were mounted in a line on to the drop frame parallel with each other and at a fixed distance apart; however after the first deployment four of the red lasers were removed leaving just two green lasers at the maximum extent the bracket. The distance between the light emitted from lasers was measured in water using a metal grid and this formed a known fixed field of view when using the drop frame, which would remain constant whatever height off the seabed the camera system was at and despite the direction from which the footage appeared on the screen (see Figure 6.2).

Figure 6.2. A frame grab from drop frame footage illustrating the location and effect of the lasers to provide a fixed field of view.

Four survey sites, with a range of burrow densities, were identified in the Moray Firth on the Northeast coast of Scotland at which UWTV work was carried out at. Five, ten minute parallel tows with the UWTV sledge were undertaken to established SGNEPS protocols, to calculate a mean burrow density in each specific study area. Within the boundaries of where the sledge work was undertaken, three 10 minute 'runs' with the drop frame were carried out, again to SGNEPS agreed standards.

The footage from both approaches was analysed by an experienced member of staff, with only *Nephrops* burrow complex entrances that passed between the lasers being counted on the drop frame footage. Burrow densities from each method were calculated and raised to the stratum, and compared. The sledge approach estimated a population of 74 x 10^6 whereas using the drop frame resulted in a population of 85 x 10^6. Reassuringly these values are not dissimilar to each other and fall within the values submitted at WGNSSK 2011.

A second analysis, although related, was carried out to establish if there was a significant difference between the two recording methods rather than the abundance. An adapted mixed model approach was used and a 'p' value of 0.018 was calculated, indicating that there was neither a significant nor insignificant difference.

This result could be improved by increasing the number of survey sites and by including the burrow counts from a second expert observer, which was not possible prior to the analysis of these data. Both of these suggested improvements will be included in the cruise programme for the West coast sea loch survey to be carried out in January 2013. The second novel approach utilized by MSS in 2012 was to use video enhancement on Scottish video footage to compare the results with the original values to investigate if there was an observed bias in the results.

The Moray Firth reference set, comprised of 10 five minute video clips with a variety of burrow densities and water clarity, were reviewed twice in its original format. Then the video was manipulated by software contained in a commercially available T38 system manufactured by the Swedish company Lyyn (see details below). After the enhanced video was reviewed the burrow counts for each minute were plotted against those from the unenhanced/original footage (see Figure 6.3). It was hoped that the Lyyn device would provide greater clarity and allow previously unidentifiable burrows to be observed in footage that contained high levels of turbidity. However due to the speed the camera was travelling over the ground (approximately 0.75 knots), the relatively poor lighting, the use of a non-HD camera and the very limited tonal range of the footage, this aspiration was not fulfilled. However the observer noted there was a great improvement in clarity and definition on good to poor quality footage, and this vastly assisted the counting procedure.

Figure 6.3. A frame grab from drop frame footage with Lyyn video enhancement applied to the lower central part of the image, demonstrating the improved contrast, clarity and exposure. Under normal circumstances the enhancement would be applied to the whole of the frame.

The data from the three reviews were plotted and the results showed no specific trends. Despite the improvement in the clarity of the footage, no significant additional burrows were counted. Conversely the results also indicated that burrows that were counted with the original footage were not being dismissed once the footage

was enhanced. It is the intention of MSS on future UWTV *Nephrops* burrow surveys to record the video footage in the original, unenhanced format but to use the Lyyn device when analysing the footage for assessment purposes. However this will require the purchase of additional unit so that there is one device at each viewing station.

The Lyyn device is available from:

Mr C. Foll, Atlantas Marine Ltd, 1st Floor Telstar House, Yeovil, Somerset, UK. BA22 8RT. Tel. +44 1935 426 000) www.lyyn.com/products/lyyn-hawk-portable

6.2 Northern Ireland (AFBI) Update

AFBI will continue to work with the Marine Institute on the underwater TV survey of the Western Irish Sea, and with Cefas on the Eastern Irish Sea survey. There are no anticipated changes to the underwater TV methodology for 2012. It is anticipated that extra work will be conducted during the night-time of the trawl survey. A multibeam echosounder grid survey will be undertaken to examine the mud patch distribution. Backscatter will also be collected to examine acoustic characteristics in areas of varying burrow density and particle size. Cefas have offered AFBI use of a Sediment Profiling Camera for the night shifts during the trawl phase.

Some equipment upgrades are complete or planned such as a new higher resolution Kongsberg Simrad video camera, higher accuracy Sonardyne USBL and a survey-grade dual frequency DGPS for sub-decimeter positioning. New protocols are now in place for more thorough USBL calibration and association with the ship's dimension frame.

6.3 Ireland (Trinity College Dublin and Marine Institute)

Four image processing based techniques/tools were presented at the 2012 SGNEPS meeting to improve the current *Nephrops* identification method. The first two, lighting and colour correction, were geared to improve the visibility of the recorded videos. The third tool, a mosaic, will provide scientists with a wide area view of the section of the seabed captured in the respective survey video. The last tool automatically identifies all burrows in the generated mosaic, and is the first stage in a larger scheme geared towards identifying *Nephrops* clusters. These tools along with sample results are briefly summarized as follows:

Lighting Correction. The high intensity light sources employed in these surveys leave a distinctive footprint of their beam on the seabed (see Figure 6.4). Within this footprint the illumination remains relatively constant, but beyond its boundary, it is plagued with heavy vignetting (i.e. radially fades away). The lighting correction algorithm removes this vignetting phenomenon by estimating the light source footprint on the seabed, and the parameters for our degradation model, based on point correspondences from consecutive frames. Within the footprint, we leave the image contents as is, whereas outside this region, we perform vignetting correction. An example of the result obtained with this technique is shown in Figure 6.4.

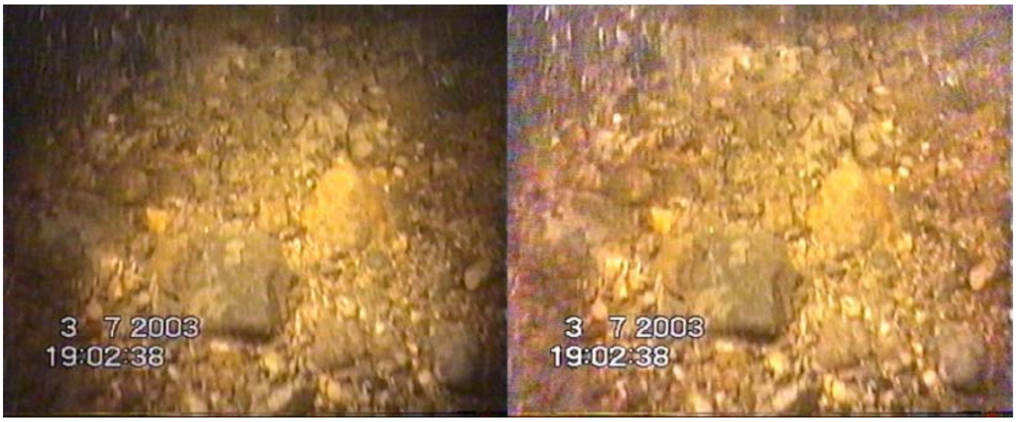

Figure 6.4. Original (Left) and Light Corrected (Right) Images.

Colour Correction. In addition to lighting degradations, underwater imagery also suffers from colour distortions, due to particles in the water medium absorbing light rays at various wavelengths differently. This distortion increases with wavelength and also depth between the camera and the respective object. The colour correction algorithm corrects this degradation by estimating parameters for our degradation model separately for each colour channel. This estimation takes into account depth measurements, and is also estimated with point correspondences from consecutive frames, similarly to the lighting correction algorithm. An example of the result obtained with this technique is shown in Figure 6.5.

Figure 6.5. Original (Left) and Colour Corrected (Right) Images.

Mosaic Generation. Another problem scientist face in these surveys is the restricted field of view of the seabed available from the recorded video. The mosaic algorithm solves this problem by generating a large picture of the entire seabed area captured from the survey video. It accomplishes this task on a frame-by-frame basis by first locating the new area of the seabed captured in the current frame, and then stitching it together with the existing area captured from previous frames. To preserve as much image detail as possible, the algorithm could limit the generated mosaic to only use specific sections of the video frames e.g. the well-lit areas or the bottom area of the screen where geometric distortion is minimal. An example of the result obtained with this technique is shown in Figure 6.6.

Burrow Detection. The last tool currently being researched is the automatic identification of *Nephrops* clusters from the generated mosaic. This problem was broken up into three main parts, i) detecting all burrows, ii) identifying the *Nephrops* burrows, and

iii) cluster close by *Nephrops* burrows according to their respective characteristic features. Currently only the first part has been investigated, and is accomplished in three main steps. First, the difference between two blurred versions of the mosaic is used to highlight dark regions in the seabed, which are then segmented into objects. Second, close by objects that were segmented together were then split, and lastly these segmented regions were classified as burrows based on their colour, size and shape features. The performance of our algorithm was evaluated with 2 video sequences of real seabed survey footage, each being 1 minute (1500 frames), and detected approximately 85\% of all the burrows present in the mosaic. An example of the result obtained with this technique is shown in Figure 6.6.

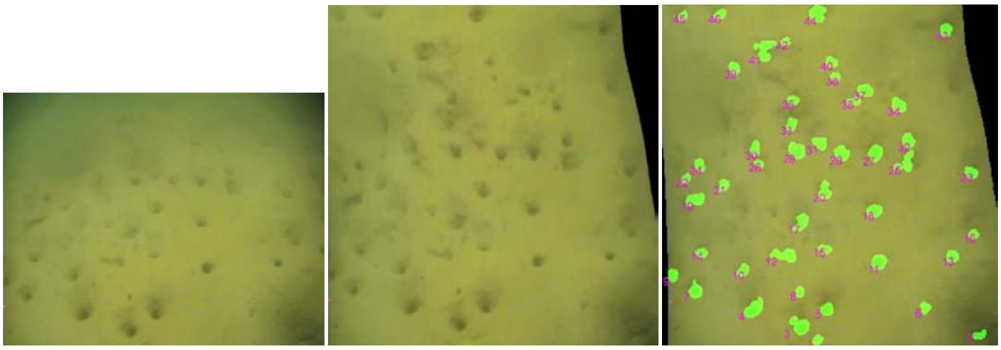

Figure 6.6. First frame from survey video (Left), the corresponding mosaic generated (Middle) using the first 200 frames, and the respective burrows detected (Right).

7 *Nephrops* Trawl Surveys

7.1 FU 23–24 (Bay of Biscay)

A survey specially designed to evaluate abundance indices of *Nephrops* in the Bay of Biscay commenced in 2006, in the most appropriate season (2nd quarter), with the hauls being carried out at the highest emergence period for the species, i.e. around dawn and dusk. In future, this survey should provide an independent tuning dataset for the assessment of *Nephrops* stocks in this area. The survey is carried out by Ifremer with twin trawl on the area of the Central Mud Bank of the Bay of Biscay (≈ 11680 km²). The whole area was divided into five sedimentary strata according to the mud composition of sediment and to its origin (Figure 7.1).

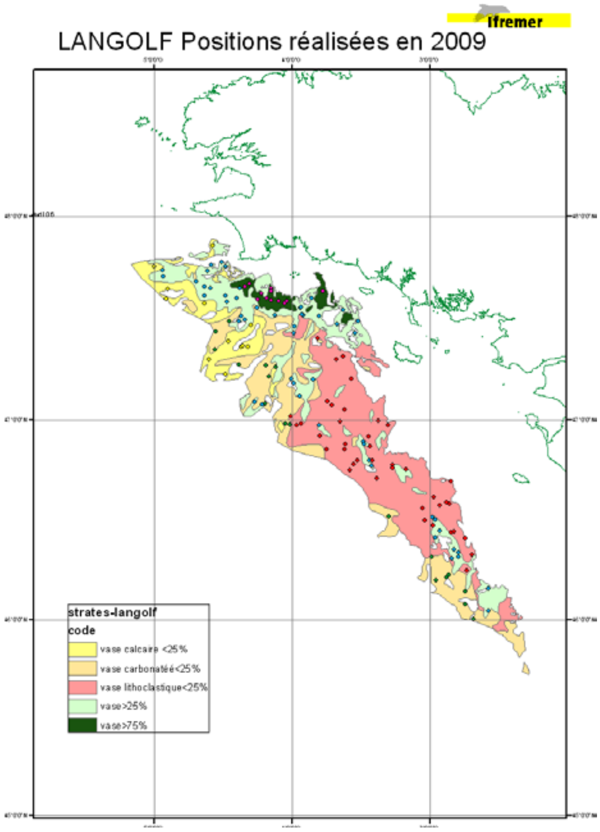

Figure 7.1. Nephrops of the Bay of Biscay (FU 23–24). The Central Mud Bank, the five spatial strata and the distribution of sampling units for 2009's survey.

The survey effort allocation by stratum was made upon the distribution of fishing effort based on sampling data onboard the commercial vessels and VMS available data for the period 2003–2005. Abundance estimates for *Nephrops* males and females are presented for the period 2006–2011. The 2006 survey was in April and shows a lesser abundance than the others that were carried out in May. The CV varied between 12% and 22% with the exception of the 2011 survey which was higher than 30%.

	males		females	
year	number (10^3)	CV	number (10^3)	CV
2006	30827	16.09	32185	16.15
2007	69003	17.99	82385	17.24
2008	49086	19.07	67859	22.65
2009	43254	12.35	50791	12.85
2010	67038	14.54	83876	14.47
2011	66991	33.18	81616	32.71

Differences in *Nephrops* length composition were found among the strata either for males or females. This survey also provides data on other species as hake (the first bycatch species), white and black anglerfish, sole and red mullet.

7.2 FU 28-29 (Southwest and South Portugal)

The Portuguese crustacean surveys have been conducted since 1981, in different areas and seasons. The areas surveyed in each cruise varied, extending from 36º 59′ N northwards to 41º 51′ N and 7º 51′ W to 9º 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 2nd quarter, covering the southwest and south coasts of Portugal, which correspond to the FUs 28 and 29 of ICES Division IXa, respectively. The sampling design was adapted from the bottom-trawl surveys (stratified random sampling) and formed the basis for data collection for the crustacean surveys in the period 1997–2004. The southwest and south coasts of Portugal were divided in sectors and each sector split in depth strata (100–200 m, 200–500 m and 500–750 m). 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.

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 geostatistical 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. It is assumed that the abundance observed at a particular point within the rectangle reflects the relative abundance of the resource at that geographical area and it is assigned to the centre of the rectangle. The stations might be grouped *a posteriori* in the strata used previously and the results compared with the former surveys. The 77-rectangle grid was further expanded to 81 rectangles to include some deep areas, based on fishermen information.

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. 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 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. In 2010 and 2011, no images were collected due to technical problems of the research vessel. It is not guaranteed that this method can be used for abundance estimation.

Figure 7.2 shows the previous stratification and present sampling design overlaid on the fishing areas defined by the crustacean bottom trawlers VMS data available for

the period 1998–2010. *Nephrops* is not the only species targeted by these vessels. This is a mixed crustacean fishery with the rose shrimp (*Parapenaeus longirostris*) as the most important species in weight and value. The importance of *Nephrops* increases in years of lesser abundance of rose shrimp.

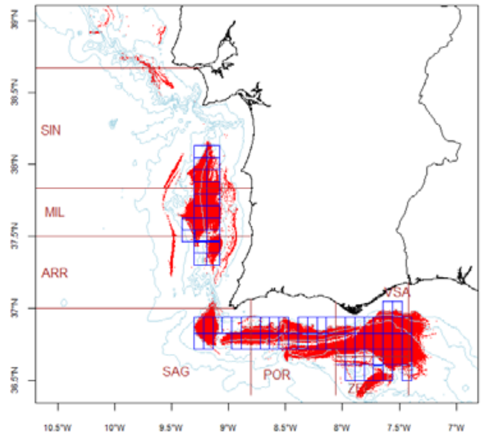

Figure 7.2. FU 28–29 survey stratification and sampling grid used in the periods 1997–2004 and 2005–2011, respectively, overlaid on the fishing areas. Sectors are represented in brown and the depth strata defined by the bathymetric lines of 100, 200, 500 and 750 m.

Spatial distribution of *Nephrops* and rose shrimp biomass indices were presented for the years 1997–2011 (*Nephrops* shown in Figure 7.3). The 2004 survey, carried out with a different vessel, was excluded due to malfunctioning of the sampling gear. In the year 2010, due to some technical problems of the vessel and gear in covering areas deeper than 600m, the survey plan had to be adjusted. In 2011, the survey did not cover the whole area due to engine failure. The research vessel «NORUEGA» is reaching the limit of her lifetime and must be replaced.

The distribution of survey indices are in very good agreement with the fishery cpue spatial distribution obtained merging VMS records, landings and logbook data. The correlation between the annual cpue from the fishery and the annual biomass index from the Crustacean survey is high. The values for the years 2010 and 2011 have to be corrected to be comparable with former years. The *Nephrops* biomass index series has been used as a tuning fleet in the assessment of FU 28–29 stocks.

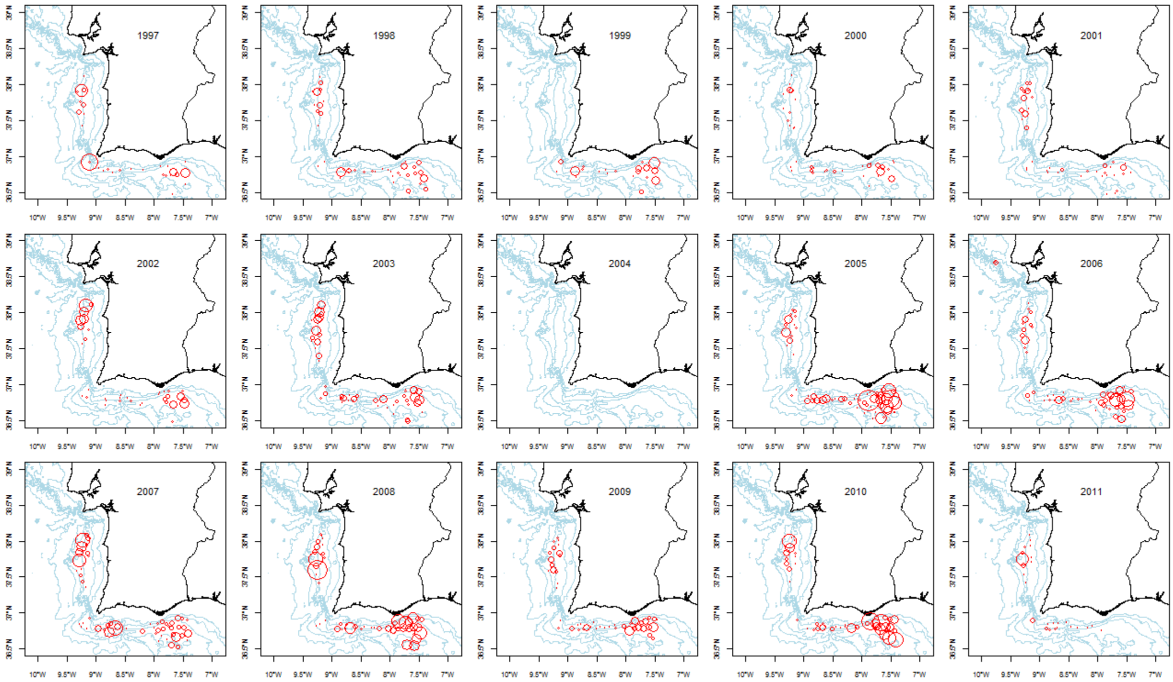

Figure 7.3. Spatial distribution of *Nephrops* biomass survey index in the period 1997–2011.

8 Planned or Proposed Surveys in 2012/2013.

All Institutes are open to taking any interested personnel on their surveys please contact the relevant scientist – details provided in participant list. Most surveys are conducted on an annual basis but dates for 2013 are not fixed and can be checked with relevant Institute.

The main changes to previous years' surveys are the planned expansion of survey coverage in Irish waters to FU16, 19 and 20–21 weather permitting. SGNEPS encourages the expansion of UWTV surveys to these areas since it will provide a stronger scientific basis for the management advice.

9 Conclusions of SGNEPS 2012

SGNEPS made the following conclusions some of which are for internal consumption and will be followed up internally by the group itself through revised ToRs (Annex 3). Recommendations to other ICES expert groups, committees or clients are also listed in Annex 4:

- The remit of SGNEPS should be broadened to review and coordinate *Nephrops* trawl surveys and biological sampling under the DCF.
- SGNEPS recommends to the Regional Coordination Meetings of the DCF that a dedicated research project on *Nephrops* UWTV assumptions and uncertainties should be proposed for funding to the European Commission.
- SGNEPS recommend that a CV (or relative standard error) of < 20% is an acceptable precision level for UWTV survey estimates of abundance. There may be operational reasons why individual surveys should aim for higher precision than that (e.g. to ensure good coverage and accurate burrow surfaces).
- Survey coverage should be extended to other important fished grounds such as Porcupine Bank FU16, South Coast of Ireland FU19, Labadie, Cockburn and Jones banks in the Celtic Sea FU20–21, Horns Reef FU33 and Gulf of Cadiz FU30.
- SGNEPS recommends continued collaboration between surveys including staff exchange, international validation of reference footage, training etc.
- There is definitely scope to develop the video enhancement and analysis technologies further and SGNEPS would promote further research in this area.
- Although there has been progress towards integrated stock assessments for *Nephrops* which make use of all sources of fisheries dependent and independent information the current ICES framework for assessing and providing catch options based on the UWTV surveys remains the most appropriate.

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Annex 1: List of participants

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Annex 2: Surveys planned for 2012/13

Dates	Vessel	Institute	FU / Sea area	Survey Type	Coordination	Comment
Apr-12	Endeavour	Cefas UK-E&W	North Sea: FU5 Botney Gut	UWTV & beam trawl	Space available for other participants	
Oct-12	Endeavour	Cefas UK-E&W	North Sea: FU5 Botney Gut & FU6 Farn Deeps	UWTV & beam trawl	Space available for other participants	
Jun-12	Celtic Voyager	MI-Ireland	FU17 Aran Grounds	UWTV & beam trawl		
Jul-12	Celtic Voyager	MI-Ireland	FU22 Smalls	UWTV & beam trawl		
Aug-12	Celtic Voyager	MI-Ireland	FU 15 Western Irish Sea	UWTV	In conjunction with AFBI & Cefas	
Jun-12	Celtic Voyager	MI-Ireland	FU16 Porcupine Bank	UWTV	As an extension of the FU17 survey	Weather dependant
Nov-12	Celtic Explorer	MI-Ireland	FU19 SW & South of Ireland	UWTV	Space available for other participants	In conjunction with IR-WIBTS
Nov-12	Celtic Explorer	MI-Ireland	FU20-12 Labadie	UWTV	Space available for other participants	In conjunction with IR-WIBTS
Aug-12	Corystes	AFBI - UKNI	FU14,15	UWTV & beam trawl	In conjunction with MI & Cefas	
Apr-12	Havfisken	DTU Aqua – Dk	FU3,4 Kattegat & Skaggerak	UWTV		
May-12	Asterix	SLU – Sweden	FU3,4 Kattegat & Skaggerak	UWTV		
Jun-12	Scotia	MSS- UK Scot	FU7, 11, 12, 13 and Jura and Devils Hole.	UWTV & Nephrops trawl	Space available for other participants	
Aug-12	Alba na Mara	MSS- UK Scot	FU8, 9	UWTV & Nephrops trawl		
Jan-13	Alba na Mara	MSS- UK Scot	West coast sealochs	UWTV & Nephrops trawl		

Dates	Vessel	Institute	FU / Sea area	Survey Type	Coordination	Comment
Apr-12	Dallaporta	ISMAR - CNR - Italy	Central Adriatic Sea - Pomo Pits	UWTV & Nephrops trawl	In conjunction with IOF Croatia.Non DCF.	
Jun-12	Noruega	IPIMAR - Pt	FU 28 & 29 (Southwest and South Portugal)	Trawl and UWTV	Space available for other participants	
Nov-13	Ramon Margalef	IEO - Sp	FU 39 Gulf of Cadiz	UWTV, ROV.		Proposal not yet accepted
May-12	GwenDrez	Ifremer - Fr	FU23 & 24 Bay of Biscay	Trawl		

Annex 3: SGNEPS terms of reference for the next meeting

The **Study Group on *Nephrops* Surveys (SGNEPS)**, chaired by Colm Lordan, Ireland, will meet in Barcelona or Lisbon November 2013 to:

a) To review any changes to design, coverage and equipment for the various *Nephrops* UWTV surveys.

b) To ensure common approaches to quality control quality and assurance of UWTV data and make recommendations in relation to standard operating procedures as necessary.

c) Report on progress made by to address various uncertainties or assumptions in the UWTV surveys, assessment and advice framework

d) To review the design, coverage, results and uses of *Nephrops* trawl surveys

e) To evaluate the results survey and DCF biological sampling and or other *Nephrops* studies.

f) To discuss the utility of *Nephrops* UWTV surveys in support to the MFSD and EAFM (Ecosystem Approach Fishery Management) and as platforms for collection of other environmental data.

g) To review video enhancement, video mosaicing and automatic burrow detection

SGNEPS will report by XXXX 2014 (via SSGESST) to the attention of SCICOM and ACOM.

Supporting Information

Priority	High. Nephrops are a valuable species whose stocks are potentially sucseptible to local depletion. UWTV surveys are an integral part of the stock assessment and management managment advice provided by ICES. SGNEPS is the international coordination group for Nephrops surveys focusing on planning, coloboration, quality control and survey development issues.
Scientific justification	Nephrops surveys, particularly underwater TV surveys, are currently being used as the primary source of data in stock assessment for many areas and several new surveys are planned. There is a move towards making the TV surveys mandatory elements withn the EU's survey schedule which would necessitate formal international collaboration. Unlike the IBTS surveys there is no formal mechanism for standardization of practises and interchange of data between surveys. The formation of this group would help put these surveys on the same level of scientific rigour and credence as the IBTS. WKNEPHTV identified a number of uncertainties in the use of underwater TV surveys for Nephrops. This group will act as the parent to a series of workshops designed to tackle these issues and subsequently to monitor progress in any modifications to survey practises in response to the workshop findings.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	Nephrops groups typically attract 15–20 participants.
Secretariat facilities	None.
Financial	No financial implications.

Linkages to advisory committees	This group will feed into the assessment working groups and subsequently on to ACOM
Linkages to other committees or groups	This group will feed into the assessment working groups WGNSSK, WGCSE, WGHMM.
Linkages to other organizations	

Annex 4: Recommendations

Recommendation	Adressed to
1. Broaden the remit of the group to review and coordinate Nephrops trawl surveys and biolgical sampling under the DCF	SCICOM
2. A dedicated research project on Nephrops UWTV assumptions and uncertainties should be proposed for funding to the European Commission.	Regional Coordination Meeting of the DCF
3. SGNEPS recommends that a CV (or relative standard error) of < 20% is an acceptable precision level for UWTV survey estimates of abundance.	ACOM, WGCSE, WGNSSK
4. SGNEPS recommends that survey coverage be expanded to other improtant fisheries not currently assessed e.g. Porcupine Bank FU16, South Coast of Ireland FU19, Labadie, Cockburn and Jones banks in the Celtic Sea FU20–21, Horns Reef FU33 and Gulf of Cadiz FU30.	Regional Coordination Meeting of the DCF