"home" burrow then sperm limitation should not be an issue, however the possibility does appear to exist. The threshold between full mating success and very low mating success has been demonstrated here to be potential quite narrow. This presents management with two basic options, one is to invest in the determination of the missing biological information (e.g. search radius, multiple mating capacity, size ratio limitations) so as to better understand where a critical threshold might be, and the other is to ensure that fishery practice does not induce significant skews in the sex-ratio of the population. For *Nephrops* stocks, where survivability may not be particularly high, management which involves trying to balance the sex-ratio of the output would not necessarily deliver the desired results. An alternative approach would be to temporally limit the fishery to times when the sex ratio of the landings are more balanced, however this might mean imposing limits on fisheries when they are at their traditional peak.

Annex 4.2 Porcupine Bank (FU 16) Norway lobster (*Nephrops norvegicus*) distribution and biological data; Spanish Porcupine Survey (2001–2012)

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Introduction

The Spanish fleet fishes in the Porcupine Bank since 1927 (Paz Andrade, 1958; Anonymous, 2002). In 2009, 137 Spanish vessels operated in the Functional Unit 16, obtaining 8500 tons of hake, megrim, monkfish, Norway lobster and other species (González Herraiz, 2011). 76% of landings came from bottom trawlers and 21% from longliners. Regarding trawlers, there were trips directed to hake, to flat fish and to *Nephrops*, but no vessel was targeting only *Nephrops*. In the trips directed to hake or flat fish, *Nephrops* is a by catch. In 2009, 33 Spanish bottom trawlers (35 m LOA, 456 KW) fished 348 t (around 5 million € in auction) of *Nephrops* in the FU16. The importance of *Nephrops* does not lie in the volume of its landings, but it is a product consolidated in market with high and stable prices (18 €/kg in 2012) (Xunta de Galicia, 2013).

The knowledge of the spatial distribution on the fisheries resources is essential to their study and management. Some studies about the *Nephrops* Irish landings showed differences in length, sex ratio and growth between the western and eastern *Nephrops* populations of the Bank (Hillis, 1988; 1990). There is a *Nephrops* spatial close season in the Porcupine Bank since 2010 (EU, 2010).

The information on the reproductive aspects of the fisheries species population is also crucial in the resources management. Minimum landing sizes and other management technical measures need this kind of information.

Distribution data and data of size-at-maturity according to the spermatophore presence, ovary characteristics and eggs presence from the Spanish Porcupine surveys are presented in this working document.

Material and methods

The Spanish Institute of Oceanography (IEO) performs the Porcupine bottom-trawl survey each autumn/summer since 2001 to assess the demersal resources in the area. This survey is coordinated within the ICES IBTSWG. The survey is carried out on board the research vessel Vizconde de Eza. The gear used is a Porcupine baca; 40/52 with 90 mm mesh size and an inner codend of 20 mm (ICES, 2010). Besides fishing hauls themselves several other data are recorded using CTD Seabird 25, boxcorer, SeaPath 200 system and EK60 echosound. All *Nephrops* individuals caught on the survey were measured and sexed on board. Some individuals were taken to the laboratory, where the presence of spermatophore in thelycum and eggs in the pleopods (ovigerous females) and the ovary maturity stage were recorded. The ovary maturity was classified in five stages, 1 transparent/white and thin ovary, 2 ovary with a salmon colour, 3 soft green ovary, 4 very dark green ovary and 5 salmon and green ovary. If a female was ovigerous or had a maturity stage over 1, it was considered mature. Spatial fishery data were analysed through geostatistics (variograms, kriging) with Surfer software. The L50% of females with spermatophore and mature females were calculated through binary logistic regressions.

Results and discussion

Distribution

The distribution of *Nephrops* abundance per haul allows identifying three distinct patches (western, central and eastern) in the Porcupine area, ranging in depths between 400 and 600 m (Figure 1). Western patch is below 52°N of latitude and around 14°W of longitude, central patch is between 53°N and 52°N and between 13°W–14°W while the eastern patch is over 52°N and under 13°W. Each patch has around 2400 km^2 (± 80 x 30 km).

Analysing the mean sizes by sex and patch for the surveys with more individuals (2010, 2002 and 2001) (Table 1, Figure 2), we can observe that in 2001 and 2002 there is a mean size gradient, the further east, the smaller the individuals are, for both males and females. Nevertheless, in 2010 survey this mean size gradient is not observed, being the mean sizes very similar in the three patches that year.

Table 1.- Number of *Nephrops* individuals caught in each survey.

Survey	Number
2001	1742
2002	1972
2003	781
2004	455
2005	592
2006	420
2007	375
2008	113
2009	760
2010	3073
2011	1087
2012	856

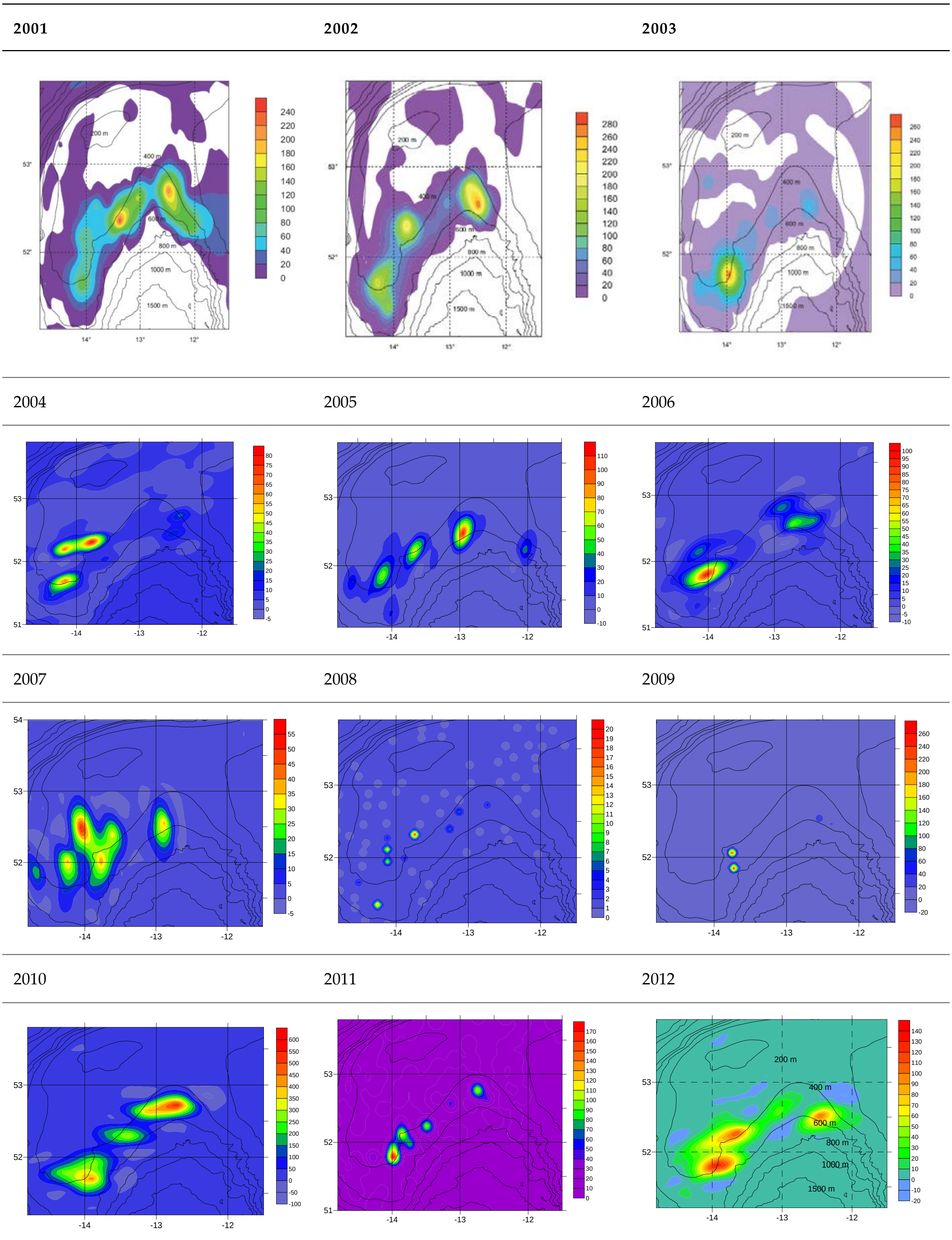
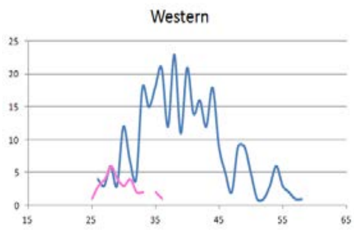


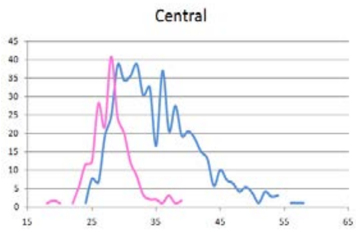
Figure 1. Spatial distribution of *Nephrops* density (number by haul) in the Porcupine Survey (2001–2012).

2001



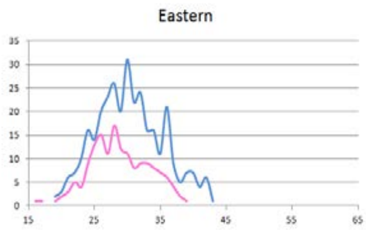
Males: 39.45 mm LC

Females: 30.15 mm LC



Males: 35.32 mm LC

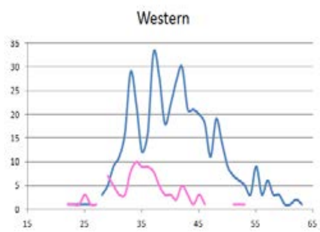
Females: 28.21 mm LC



Males: 30.39 mm LC

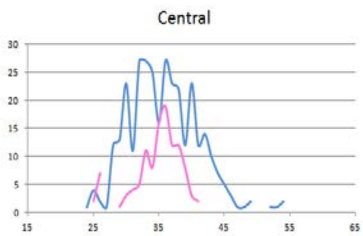
Females: 27.89 mm LC

2002



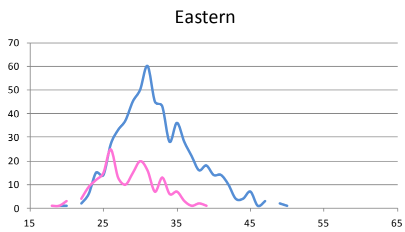
Males: 41.07 mm LC

Females: 35.46 mm LC



Males: 35.83 mm LC

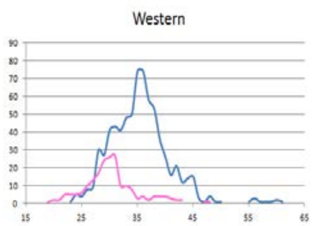
Females: 31.22 mm LC



Males: 32.35 mm LC

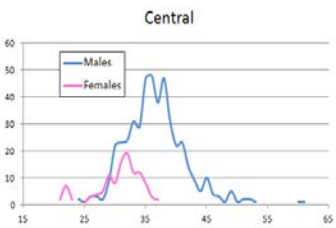
Females: 28.51 mm LC

2010



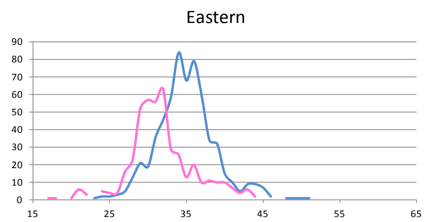
Males: 35.48 mm CL

Females: 30.33 mm CL



Males: 36.65 mm CL

Females: 31.23 mm CL



Males: 35.07 mm CL

Females: 31.85 mm CL

Figure 2. *Nephrops* length distributions (number–length in mm LC) and mean lengths by sex and patch. Porcupine Surveys with higher number of *Nephrops* (2001, 2002 and 2010).

Size-at-maturity

The presence of the spermatophore in the thelycum could be considered one criterion of sexual maturity determination. Table 2 shows the results of the analysis of the spermatophore presence data. The size at which half of the females present spermatophore (50% SP) has high variability of the different samples (i.e. surveys). In some samples all females presented spermatophore, therefore it was not possible to calculate the size at 50% SP (shown as NA in the table). In other cases it was possible to calculate the size at 50% SP, but there were not all spermatophore presence probabilities by length in the sample. Only in four samples (surveys) (2001, 2009, 2011 and

2012) was possible to do both: calculate the size at 50% SP, and have all the different probabilities of spermatophore presence (Figure 3).

Table 2. Size at 50% of females with spermatophore. NA: not available (all females presented spermatophore).

SPERMATOPHORE (SP) PRESENCE IN FEMALES								
Year	Survey		Sample					
	Total number of females	Females mean length (mm CL)	No of females with SP data	Females length range (mm CL)	Females mean length (mm LC)	Size at 50% SP (mm CL)	All % of SP by lenght in sample?
2001	467	28.4	176	15.9–45.6	30.0	24.1	YES
2002	355	31.2	328	16–46.5	30.9	21.1	No
2003	174	31.4	27	14.3–46.5	30.3	NA	No
2004	73	30.0	41	22.5–44.5	32.3	29.0	No
2005	42	33.3	25	23.6–45.2	34.3	26.1	No
2006	33	34.5	25	28.3–45.4	35.0	NA	No
2007	80	37.4	80	28.2–47.3	37.4	26.4	No
2008	39	38.2	37	29.8–46.5	38.8	NA	No
2009	354	28.3	317	10.6–48.3	29.4	38.0	YES
2010	954	31.3	392	17–49	32.9	24.6	No
2011	281	33.5	131	21–51	36.1	27.5	YES
2012	181	30.0	154	18.2–54.4	31.5	36.4	YES

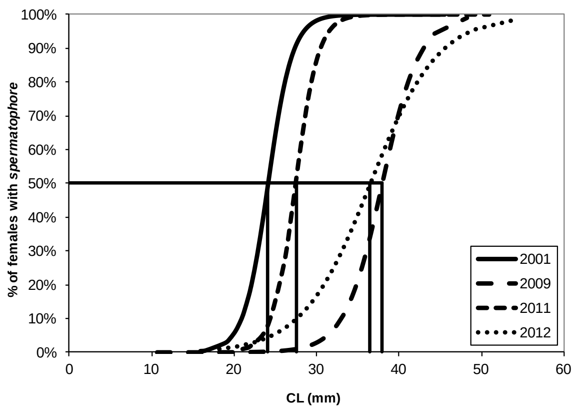


Figure 3. Binary logistic regressions that relate proportion of females with spermatophore and length for each sample. Size at 50% SP: 2001, 24.1 mm CL; 2009, 38.0 mm CL; 2011, 27.5 mm CL; 2012, 36.4 mm CL.

Table 3 shows the results of the females' maturity analyses. The size at which half of the females are mature (50% MA) has a smaller variability between different samples (= surveys) than the size of 50% SP. In some samples all the females are mature; therefore it was not possible to calculate the size at 50% MA (shown as NA in the table). In other cases it was possible to calculate the size at 50% MA, but there were not all probabilities of maturity by length in the sample. In six samples (surveys) (2001–2004, 2009 and 2012) was possible to do both: calculate the size at 50% MA, and have all range of maturity probability by length (Figure 4). A weighted average of size-at-maturity was calculated with the results of these six results, giving a size-at-maturity of 28.7 mm CL.

Table 3. Size at 50% of mature females. NA: not available (all females are matured).

FEMALES MATURITY (MA)							
Year	Survey		Sample				
	Total number of females	Females mean length (mm CL)	No of females with maturity data	Females length range (mm CL)	Females mean length (mm LC)	Size at 50% MA (mm CL)	All % of MA by length in sample?
2001	467	28.4	177	15.9–45.6	30	29.9	YES
2002	355	31.2	322	16–46.5	30.9	27.7	YES
2003	174	31.4	74	16.5–46.5	31.1	28.6	YES
2004	73	30.0	41	22.5–44.5	32.3	31.4	YES
2005	42	33.3	25	23.6–45.2	34.3	28	No
2006	33	34.5	25	28.3–45.4	35	NA	No
2007	80	37.4	80	28.2–47.3	37.4	NA	No
2008	39	38.2	37	29.9–46.5	38.8	NA	No
2009	354	28.3	317	10.6–48.3	29.4	29.4	YES
2010	954	31.3	392	17–49	32.9	24.6	No
2011	281	33.5	130	21–51	36.1	28.1	No
2012	181	30.0	158	6.5–54.4	31.5	27.2	YES
Selection average	1604	29.6	1089	6.5–54.4	30.4	28.7	

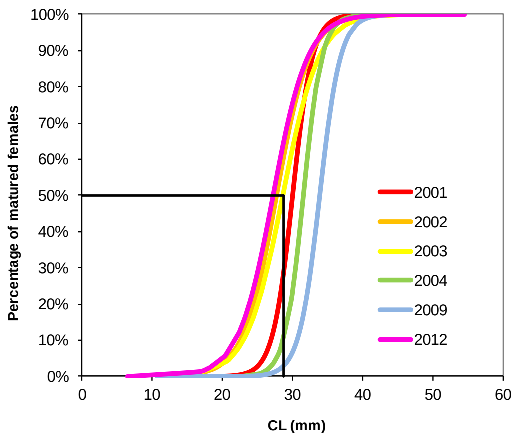


Figure 4. Binary logistic regressions that relate proportion of matured females with length for each sample. Average size-at-maturity: 28.7 mm CL.

Size-at-maturity **by patch** was calculated with the most recent data available (2012) and the results show very low variability (western patch 24.3 mm CL, central patch 26 mm CL and eastern patch 24.6 mm CL). In the case of the central patch not all the range of maturity probabilities by length were found.

The results show variability of the size-at-maturity (higher when the spermatophore presence criterion is used). This variability could be the related with the own variability of a survey based sampling process or with environmental or population aspects. Further analyses must be carried out to clarify these questions.

Acknowledgements

To Begoña Castro Löehmann and Francisco Baldó from the A Coruña and Cádiz Oceanographic Centers (IEO), respectively, and to the people involved in the Porcupine Surveys between 2001 and 2012. Also to our colleagues from the Irish Marine Institute that always are keen to collaborate.

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Annex 4.3 West of Scotland sea loch sediment area

Working Document for the Benchmark on *Nephrops* Stocks in FU 11 (North Minch), Lysekil, Sweden, 25 February–1 March 2013.

Adrian Weetman, David Tulett and Lynda Blackadder, Marine Scotland Science, Aberdeen, Scotland, UK.

Introduction

Marine Scotland Science (MSS) carries out an annual *Nephrops* underwater TV survey in the North Minch (Functional Unit 11) to determine the abundance of *Nephrops* in this area. The results are used to provide management advice in terms of total allowable catch (TAC) for this functional unit. The estimate of absolute abundance is currently believed to be an underestimate as there are additional, unsurveyed areas of *Nephrops* within the sea lochs along the west coast of Scotland.

Both spatial extent of *Nephrops* habitat and burrow density are required to calculate an absolute abundance. Until now MSS had no indication of either value relating to the west coast Scottish sea lochs.

These inshore areas are particularly difficult to survey compared to the more open water areas of the North Minch. These difficulties include:

- a lack British Biological Survey data on sediment distribution within the lochs;
- fishing effort being conducted mostly by small vessels (<12 m) that are not fitted with Vessel Monitoring System (VMS), and so effort and fishing patterns cannot be calculated;
- these areas are geographically small and often densely fished with creels, both of which create a hazard and limit the survey opportunities at each site if the standard towed sledge was to be used.

This paper sets out the methods in which MSS has tried to overcome the first of these issues relating to sediment distribution, to map the spatial extent of *Nephrops* habitat in the west of Scotland sea lochs and presents the findings for consideration.

Methods

Three surveys aboard MRV Alba-na-Mara were carried out in the winters of 2010, 2011 and 2012 (see Figure 1). It was envisaged that over the period of the project all the fished sea lochs in the North Minch on the west coast of Scotland would be surveyed using video cameras and that all available UWTV survey sediment samples would be utilized to help define the boundaries of the muddy sediment within each loch. Using both these datasets the calculated surface area of the viable *Nephrops* habitat would then be merged to provide a more accurate total muddy area within the functional unit for which to calculate *Nephrops* abundance values.

Identifying the edges between the hard and muddy ground in the sealochs using underwater television (UWTV) systems required a different approach to the standard techniques used on *Nephrops* abundance UWTV surveys. Due to the possibility of entanglement with creels and the fact that hard ground was actively being sought out, the sledge could not be used due to the strong likelihood of damage to the