Stock Annex: Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 34 (central North Sea, Devil's Hole)

Stock-specific documentation of standard assessment procedures used by ICES

Stock:	Norway lobster
Working Group:	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak **(**WGNSSK)
Created:	
Authors:	
Last updated:	27 February 2013
Last updated by:	Helen Dobby & Adrian Weetman (WKNEPH2013)

A. General

A.1. Stock definition

Nephrops are dependent on particular types of seabed sediment with a preference for fine muddy sediments (silt & clay content of 10-100%) suitable for excavating burrows (Farmer, 1975; Afonso-Dias, 1998). Therefore, there is a close relationship between the distribution of *Nephrops* stocks and sediment type. A British Geological Survey (BGS) map of the North Sea (Figure A.1) shows a number of patches of muddy sand (10-50 % silt and clay) in the central North Sea, to the south of the Fladen (total area 4000 km^2). This area is known as the Devil's Hole and consists of a number of narrow trenches, typically 1 – 2 km wide, running in a north-south direction with an average length of 20-30 km. These trenches fall across seven ICES rectangles: 41-43F0, 41-43F1 and 40F0.

In other areas, the sediment maps have been shown to be inaccurate (Campbell et al., 2009 and Dobby et al., 2013 – WD submitted to WKNEPH2013) and this has resulted in the spatial extent of *Nephrops* being defined using maps of fishing activity (vessel monitoring system data) instead of sediment data. A comparison of the sediment map and VMS data associated with a landing of at least 30 % *Nephrops* by weight (filtered for speeds of < 3.8 knots and 70-99 mm mesh) suggests that the spatial extent of *Nephrops* in this area (at least at densities suitable for fishing) is somewhat less than that apparent from the BGS map (Figure A.2).

Estimating the area of the spatial extent of the *Nephrops* habitat from VMS data has been carried out using the alpha-convex hull method to identify a polygon encompassing the VMS pings (using the alphahull library in R – Figure A.3). Mesquita et al. (2010) explored the sensitivity of alternative values for the alpha parameters and concluded that a value of alpha=0.01 enclosed the major areas of fishing activity, but excluded those with a low intensity of VMS pings.

While considering the fished area, a number of additional areas of fishing activity were identified to the south of the previously defined area – in statistical rectangles 39F0 and 40F0. These contribute only a small amount in terms of total area and landings (< 5 % of 41-43F0-F1) and are therefore currently not included in the spatial extent of the stock.

The spatial extent across rectangles 41-43F0-F1 is estimated as 1753 km² (based on union of VMS polygons estimated on an annual basis - See WKNEPH 2013 report for details).

A.2. Fishery

The fishery in this area is prosecuted largely by Scottish vessels operating out of ports in the northeast of Scotland, but occasionally making landings into northeast England. The fleet consists of large *Nephrops* trawlers which have the capability of operating in such offshore areas. The fishery increased during the mid-2000s (Figure A.4) and at its peak around five vessels operating out of Peterhead and another 12 from Fraserburgh were regularly visiting the areas. These vessels also fish the Fladen on a regular basis and visit the other more inshore functional units in times of poor weather or poor *Nephrops* catch rates in the offshore areas. The fishery is a mixed fishery with vessels typically landing a range of demersal fish species such as cod, haddock and whiting, in addition to *Nephrops*. Although there does not appear to be strong seasonal patterns in the fishery, *Nephrops* landings are generally lowest in quarter 1. Landings by vessels from other nations comprise < 5 % of the total.

A TAC is set for *Nephrops* in ICES Subarea IIa and IV (EC waters) which in 2012 was set at 21929 tonnes with an additional allowance of 1200 tonnes in Norwegian waters. The minimum landings size (MLS) for *Nephrops* in Subarea IV (EC) is 25 mm.

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops*, the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70-99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double.

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90 mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller than 100 mm in the North Sea south of 57°30'N – check this. Separate Scottish legislation (SSI 405/2000) prohibits the use of more than two nets by any Scottish fishing boat wherever it may be; or by any relevant UK fishing boat within the Scottish zone.

B. Data

B.1. Commercial catch

Landings and effort data from logbooks are available from the Scottish fleet. Other nations supply landings data. As in other *Nephrops* functional units, the reliability of the landings data is likely to have improved since the introduction of UK buyers and sellers legislation in 2006.

The following table shows the nations supplying data for this FU.

Country	Landings weight	Landings length composition	Discards length composition	Length composition in catch
Denmark	X			
Netherlands	X			
UK(E & W)	X			
UK (Scotland)	X	X	X	X

Length compositions of Scottish landings and catch (both landed & discarded components) are obtained during market sampling and on-board observer sampling respectively. In 2011, length frequency samples of marketable and discarded *Nephrops* have been limited to a single observer trip and sampling was also relatively poor in 2010. Table B.1 shows the number of samples by year.

Within MSS, sampled *Nephrops* landings length frequencies are raised to trip level and then to fleet level. Since 2011, these fleets have been defined according to aggregations of metiers as agreed under the WGNSSK/WGMIXFISH data call and uploaded to Intercatch where the international raised data are calculated.

The recent length frequency information (Table B.2) are considered of insufficient quality for deriving an exploitation pattern for use in per-recruit analysis. Instead the mean weights in the landings have been calculated over the years 2007-10 (31.76 g) for use in the *Nephrops* data limited approach (Table B.3). This should be used until there is evidence to indicate that this has changed such as when adequate data are available.

Data on the landed and discarded component of catches obtained from observer trips have been used to estimate a discard rate. Annual rates have been averaged over 2008-11 (WKNEPH 2013) to provide an estimate of discard rate (12.9 %) to be used in the data limited approach to the provision of advice.

B.2. Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Parameters applied in to inform the catch forecast process were taken as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years (Morizur, 1982). Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

The calculations of mean weight make use of the length weight parameters of Fladen *Nephrops* (FU7). In future, it is likely that the assessment will require other biological parameters (as in the full UWTV survey approach). WKNEPH 2013 considered that it would be most appropriate to use those from the Fladen – an offshore geographical neighbouring FU.

Parameter	Value	Source
MALES		
Length/weight - a	0.0003	Howard and Hall (1983)
Length/weight - b	3.25	Howard and Hall (1983)
Growth - L∞	66 mm	Adapted from Bailey and Chapman (1983)
Growth - k	0.16 yr-1	Adapted from Bailey and Chapman (1983)
Size at maturity	25 mm	Adapted from Bailey (1984)

Natural Mortality - M	0.3	Morizur (1982)
FEMALES		
Length/weight - a	0.00074	Howard and Hall (1983)
Length/weight - b	2.91	Howard and Hall (1983)
Immature growth - L∞	66 mm	Adapted from Bailey and Chapman (1983)
Immature growth - k	0.16 yr-1	Adapted from Bailey and Chapman (1983)
Immature natural mortality - M	0.3	Morizur (1982)
Size at maturity	25 mm	Adapted from Bailey (1984)
Mature growth - L∞	56 mm	Adapted from Bailey and Chapman (1983)
Mature growth - k	0.10 yr-1	Adapted from Bailey and Chapman (1983)
Mature natural mortality - M	0.2	Based on Morizur (1982) ; assuming lower rate for mature females

Discard survival

The patchy nature of the ground at the Devil's Hole and the behaviour of the fleet (moving between suitable *Nephrops* patches) may mean that discarded *Nephrops* are not returned to the sea over suitable sediment. In such circumstances, it is assumed that there is no discard survival. This is in line with previous assumptions for the Farn Deeps.

B.3. Surveys

Prior to 2009, UWTV surveys were conducted at the Devil's Hole on an opportunistic basis. Station locations on these early surveys were randomly selected from the BGS sediment map. Since 2009, the survey has used a fixed station design, with station locations chosen from the set of 2008 VMS pings (Figure B.1).

On average, about 15-20 stations have been considered valid each year in the recent period which equates to approximately 9 stations per 1000km^2 (towards the lower end of station densities across surveyed FUs). A range of density estimates covering recent values are raised to a stock area of 1753 km^2 based on the analysis of VMS data to calculate a range of abundances for use in the DL approach. General survey protocols and analysis methods for underwater TV survey data are similar for each of the Scottish surveys and follow guidelines established by SGNEPS (ICES, 2008, 2009). In the recent period, the relative standard error for the Devil's Hole density estimate has fluctuated around the level recommended as adequate by SGNEPS and averaged over 2009-2011 is 0.22 (recommended < 0.2).

Relative to absolute conversion factor

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as absolute (required for both the *Nephrops* data limited approach and the full UWTV survey approach), it is necessary to correct for these potential biases. These are based on simulation studies, preliminary experimentation and expert opinion.

For the Devil's Hole, the footage, in terms of burrow complex diameter appears very similar to those apparent at the Fladen. The edge effect was therefore estimated as 1.45 (from Campbell et al., 2009). Burrow detection rates were believed to be relatively high due to the excellent water clarity and burrow identification was believed to be 100%

due to a lack of other burrowing fauna. The cumulative correction factor for the Devil's Hole was calculated as 1.4. This is higher than the correction factor in other FUs.

	EDGE EFFECT	DETECTION RATE	SPECIES IDENTIFICATION	OCCUPANCY	CUMULATIVE BIAS
FU34	1.45	0.95	1	1	1.4

B.4. Commercial CPUE

LPUE data were available for Scottish *Nephrops* trawls. These data are available from 2000 onwards. The effort & lpue are not standardized and therefore do not account for changes in efficiency, seasonality or other factors that could influence the trend in lpue over time. (Table B.4 and Figure B.2).

C. Assessment: data and method

WKNEPH concluded that for the time being, advice should be provided for *Nephrops* in FU34 on the basis of the data limited approach (see below and category 4.1.4 of ICES DLS approach). This can provide an indication of the level of medium-term average F in relation to F_{MSY} (borrowed from neighbouring stocks with similar characteristics) and this may also provide guidance on the level of abundance relative to MSY $B_{trigger}$.

In terms of stock trends, there are currently insufficient length frequency data for use in constructing indicators. There is a commercial LPUE series extending back to 2000 which should be used (with caution) to monitor stock trends.

Input data required: **Recent absolute (bias corrected) density estimate from UWTV survey**

In the range 0.2 – 0.3 m^{-2} but should account for the most recent estimates if different

Spatial extent

1753 km^2

Landings mean weight

31.76 g (average 2007-2010)

Discard rate in number

12.9 % (average annual rate 2008-2011)

Discard survival

0 %

Model and software: see spreadsheet derived at WGNSSK 2012 ('FINAL version of Nep-IV nonTVstocks included in advice.xls'. Steps in formulating the data limited table:

1. Use absolute density & spatial extent to derive *Nephrops* abundance for a range of densities (see above)
2. Convert potential landings weight into numbers using landings mean weight for a range of total landings (10 year average, half of 10 year average, maximum of time series)
3. Convert landings numbers into total removals by dividing by (1 – discard rate in number)

4. Divide total removals (from 3) by *Nephrops* abundance (from 1) to obtain a matrix of harvest rates which can be compared to F_{MSY}.

D. Short-Term Projection

Not relevant – uses *Nephrops* data limited approach.

E. Medium-Term Projections

Not relevant – uses *Nephrops* data limited approach.

F. Long-Term Projections

Not relevant – uses Nephrops data limited approach

G. Biological Reference Points

No reference points have been calculated for this functional unit. The *Nephrops* data limited approach compares calculated harvest rates to the range of Fmsy harvest rates estimated for other North Sea Functional Units (8-15 %)

H. Other Issues

H.1.

The Devil's Hole was designated as a separate FU in 2010. ICES first provided advice for this FU in 2012. Prior to this, the landings were collated as part of the total North Sea *Nephrops* landings 'outside FUs'.

In 2012, the advice was provided on the basis of the *Nephrops* data limited approach using parameter values taken from FU7 with conclusions on stock trends drawn from LPUE data. For 2013 onwards, more appropriate parameter values have been derived from data collected from FU34.

Year	Mean weight in landings (g)	Discard rate (%)	Area (km2)	Correction factor
2012	28 (FU7)	5 (FU 7)	1100	1 (no bias assumed)
2013	31.76 (FU34)	12.9 (FU 34)	1753	1.4

The data limited approach makes use of average densities from the UWTV survey. A number of changes have been made to survey design as knowledge of the grounds has improved. These are documented below.

Data	Pre 2009	2009-2012
UWTV survey	Opportunistic surveys with stations randomly positioned according to BGS sediment map	Fixed stations drawn from 2008 Scottish Nephrops VMS points

I. References

Afonso-Dias, M. 1998. Variability of Nephrops norvegicus (L.) populations in Scottish waters in relation to the sediment characteristics of the seabed. PhD thesis, University of Aberdeen. 282 pp.

Bailey, N. 1984. Some aspects of reproduction in *Nephrops*. ICES, Doc. Shellfish Comm., CM 1984/K:33 (mimeo).

Bailey, N., and Chapman, C. J. 1983. A comparison of density, length composition and growth of two *Nephrops* populations on the west coast of Scotland. ICES CM 1983/K:42.

Campbell, N., Allan, L., Weetman, A., and Dobby, H. 2009a. Investigating the link between Nephrops norvegicus burrow density and sediment composition in Scottish waters. ICES J. Marine Science, 66(9): 2052–2069.

Campbell, N, Dobby, H., and Bailey, N. 2009b. Investigating and mitigating uncertainties in the assessment of Scottish Nephrops norvegicus populations using simulated underwater television data. – ICES Journal of Marine Science, 66: 000–000.

Farmer, A. S. D. 1975. Synopsis of data on the Norway lobster Nephrops norvegicus (Linnaeus, 1758). FAO Fisheries Synopsis No. 112, pp. 1–97.

Howard F.G. and Hall, W.B. 1983. Some observations on the biometrics of *Nephrops norvegicus* (L.) in Scottish waters. ICES, Doc.ShellfishComm.,CM1983/K:36.

ICES. 2008. Report of the Workshop and training course on Nephrops Burrow Identification; (WKNEPHBID). ICES CM: 2008/LRC: 03 Ref: ACOM.

ICES. 2009. Report of the Study Group on Nephrops Surveys; (SGNEPS). ICES CM: 2009/LRC: 15 Ref: ACOM

ICES 2010. Report of the Study Group on Nephrops Surveys (SGNEPS). ICES CM 2010/SSGESST: 22. Ref: SCICOM, ACOM

Mesquita,C., Dobby, H. and Campbell, N. The use of sediment data vs. VMS in defining Nephrops TV survey boundaries and areas in North Minch and South Minch. Working Document for the Study Group on Nephrops Surveys (SGNEPS), 9–11 November, 2010

Morizur, Y. 1982. Estimation de la mortalité pour quelques stocks de langoustine, Nephrops norvegicus. ICES CM 1982/K:10

Pateiro-Lopez, B., and Rodriguez-Casal, A. 2009. alphahull: Generalization of the convex hull of a sample of points in the plane. R package version 0.2-0. http://CRAN.R-project.org/package=alphahull.

Pateiro-Lopez, B., and Rodriguez-Casal, A. 2010. Generalizing the Convex Hull of a Sample: The R Package alphahull. Journal of Statistical Software, 34 (5): 1-28.

Table B.1. Number of catch and landed samples obtained from Devils Hole (FU 34) by MSS.

	DATE LANDED – YEAR						
Type	2006	2007	2008	2009	2010	2011	Grand Total
Observer samples*			30	3	14	12	59
Market samples	1	5	1	5	1		13

Table B.2 *Nephrops*, Devil's Hole (FU 34): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish landings, 2006-2011.

	LANDINGS			
	< 35 mm CL		> 35 mm CL	
YEAR	Males	Females	Males	Females
2006	29.7	29.8	39.7	38.1
2007	30.4	28.7	40.5	39.2
2008	31	30.5	40.3	39.6
2009	31.7	31.1	41.3	40.6
2010	32.2	29.9	39.6	39.4
2011	31.7	30.7	43.7	40.4

Table B.3 *Nephrops*, Devil's Hole (FU34): Mean weight (g) in the landings, 2006-2011.

YEAR	MALE	FEMALE	OVERALL
2006	27.03	17.53	22.93
2007	31.19	16.94	26.27
2008	36.83	21.82	30.08
2009	46.83	24.01	39.62
2010	38.22	18.94	31.07
2011	63.25	25.47	42.05
Average (07-10)			31.76

Table B.4. ***Nephrops*****, Devils Hole (FU 34): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing** ***Nephrops*** **with codend mesh sizes of 70 mm or above, 2000-2011.**

YEAR	LANDINGS	EFFORT	LPUE
2000	185	3391	54
2001	270	3142	86
2002	343	2022	169
2003	674	2614	258
2004	489	1551	315
2005	379	1545	245
2006	448	1440	311
2007	715	1824	392
2008	937	1673	560
2009	1306	1921	680
2010	730	1465	498
2011	423	1041	406

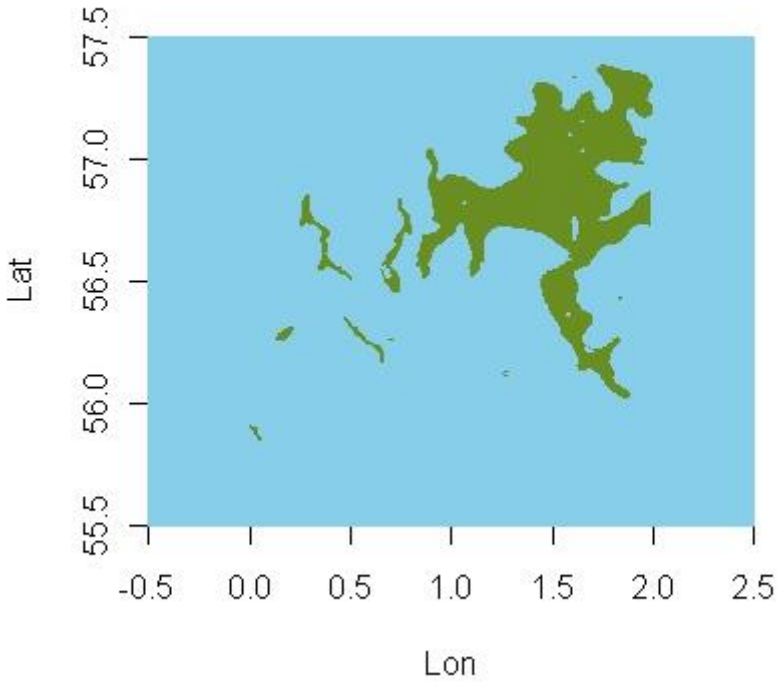

Figure A.1. Distribution of muddy sediment in the central North Sea according to British Geological Survey maps.

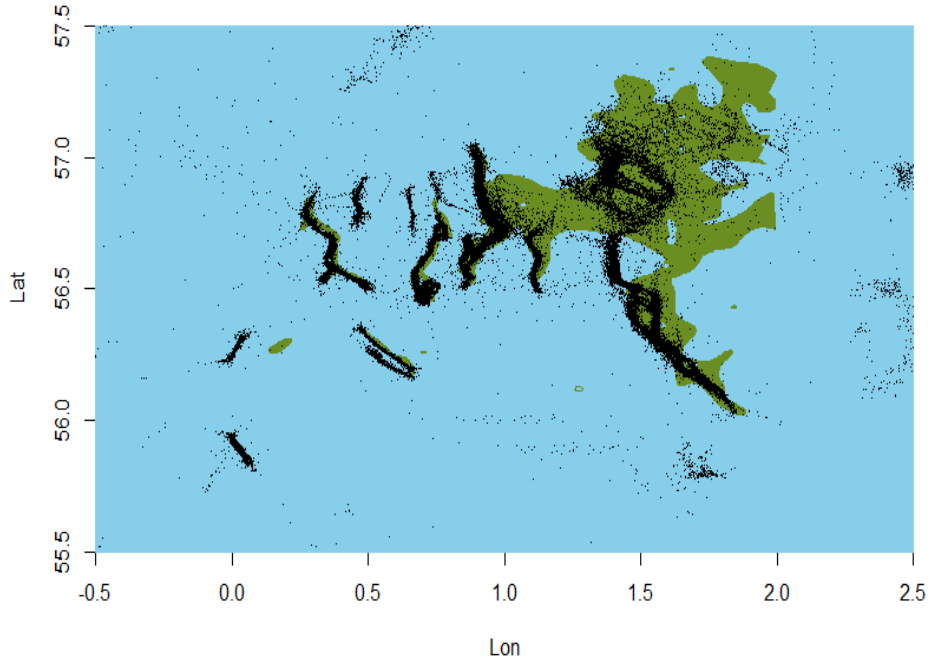

Figure A.2. Comparison of BGS sediment map with VMS data from Scottish trawlers (2007-2011) filtered for landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.

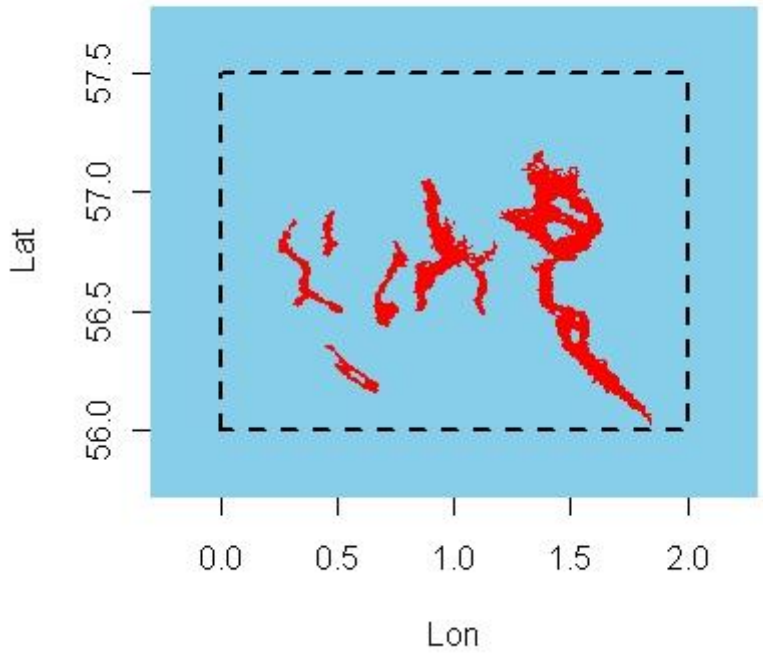

Figure A.3. The area of the spatial extent of the *Nephrops* habitat from VMS data calculated using the alpha-convex hull method.

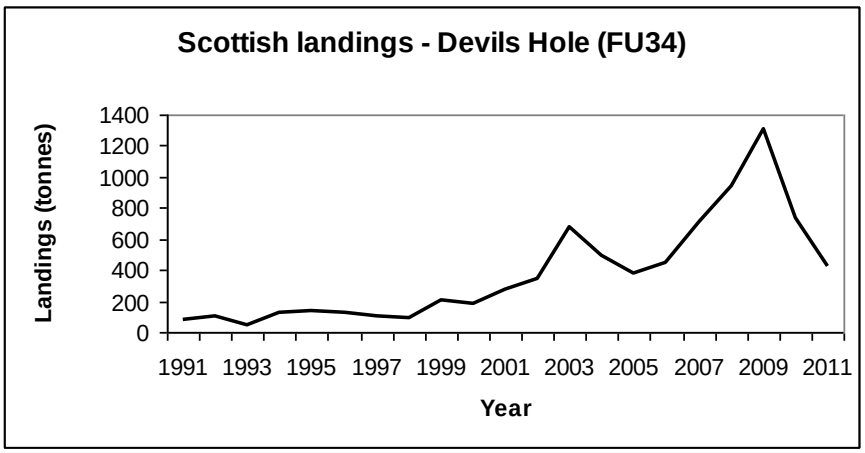

Figure A.4. *Nephrops*, **Devil's Hole (FU 34). Scottish landings from 1991 to 2011.**

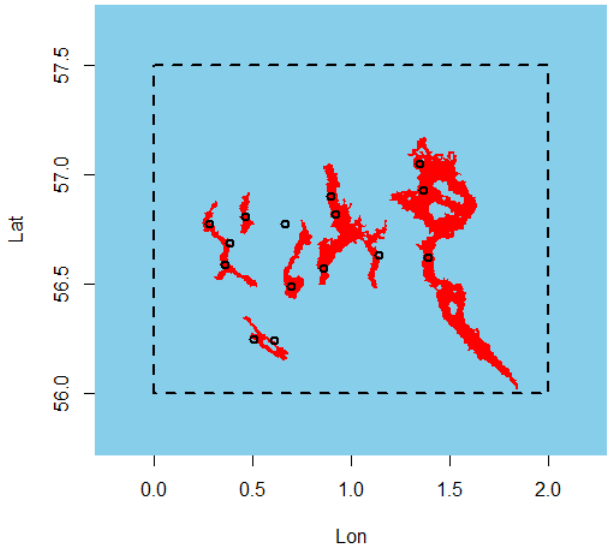

Figure B.1. Fixed UWTV survey station locations (2009 onwards) compared with estimate of spatial extent of *Nephrops* **at Devils' Hole.**

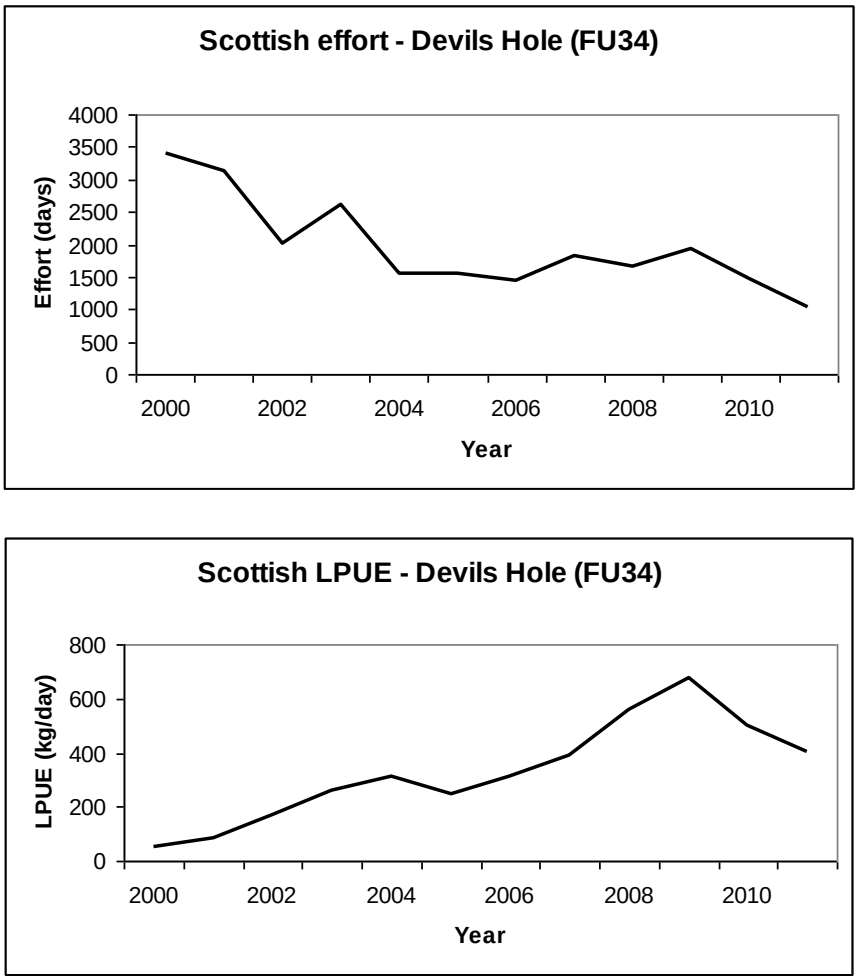

Figure B.2. ***Nephrops*****, Devil's Hole (FU 34). Effort (days) and LPUE (kg/day by Scottish trawlers)**