Stock Annex: *Nephrops* FU12, South Minch

Stock specific documentation of standard assessment procedures used by ICES.

Stock	South Minch *Nephrops* (FU 12)
Date	09 March 2009 (WKNEPH2009)
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Revised by	Lynda Blackadder

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the South Minch area the *Nephrops* stock inhabits a generally continuous area of muddy sediment extending from the south of Skye to the Stanton Bank, to the south of the Outer Hebrides. The South Minch functional unit (FU12) is located off the west coast of Scotland, and is bounded to the north and south by the 56°00′ and 57°30′ circles of latitude, and to the west by the 8°W meridian. Out with the functional unit, a mixed fishery for gadoids and *Nephrops* takes place on Stanton Bank, to the south-west of the Outer Hebrides.

A.2. Fishery

The South Minch *Nephrops* fishery is predominantly exploited by *Nephrops* trawlers, although about 20% of landings are made by creel vessels, which has increased in recent years. About 90% of trawler landings are made by vessels targeting *Nephrops*, and 25% of landings were made by twin-rig vessels in 2012.

All the creel vessels are local, and roughly half of the trawl landings are made by vessels based between Mallaig and Campbeltown. Visiting vessels originate from the North Minch and the Scottish east coast. The east coast vessels tend to be larger than the local ones, and carry out longer trips. Mean engine power of the local vessels is 200 kW, and their mean length 15.0 m. Most vessels were built between the 1960s and the 1980s. The major landing ports are Oban and Mallaig. The smaller vessels usually have a trip duration of 1–3 days, while larger boats may stay out for 5–6 days.

The minimum landing size for *Nephrops* in the South Minch is 20 mm CL and less than 1% of animals are landed under size. Discarding takes place at sea and landings are made by category for whole animals (small and large) and as tails. The main bycatch species are whiting and haddock, with whiting in particular featuring heavily in discards. Of the non-commercial species caught, poor cod, Norway pout and long rough dab contribute significantly to the discards.

The fishery is exploited throughout the year, with the highest landings usually being made in the spring and summer. A seasonal sprat fishery often develops in November and December, which is targeted by vessels of all sizes (including those that usually target *Nephrops*). Some vessels also turn to scallop dredging when

Nephrops catches or prices drop, although the scope for this has been limited in recent years with ASP and PSP closures of the scallop fishery in some areas.

The current legislation governing *Nephrops* trawl fisheries on the West coast of Scotland was laid down by the North Sea and West of Scotland cod recovery plan (EC 2056/2001), which established measures additional to EC 850/98. This regulation was amended in 2003 by Annex XVII of EC 2341/2002, which establishes fishing effort and additional conditions for monitoring, inspection and surveillance for the recovery of certain cod stocks. For 2012, this regulation effectively limits vessels targeting *Nephrops* with 80–99 mm mesh size to 200 days at sea per year. The use of square mesh and headline panels are compulsory in this fishery.

Additional Scottish legislation (SSI No 2000/226) applies to twin trawlers operating North of 56^0N, A mesh size of 100 mm or above must be used without a lifting bag and with not more than 100 meshes round the circumference but with up to 5 mm double twine. By comparison, vessels using a single trawl may use 80–89 mm mesh with a lifting bag and 120 meshes round the codend but with 4 mm single twine. From 2009 onwards under the west coast emergency measures a square meshed panel of 120 mm was also required (Council Reg. (EU) 43/2009).

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Length and sex compositions of *Nephrops* landed from the South Minch are estimated from port sampling in Scotland. Length data from Scottish sampling are applied to all catches and raised to total international landings. Rates of discarding by length class are estimated for Scottish fleets by on-board sampling, and extrapolated to all other fleets. The proportion of discarded to landed *Nephrops* changes with year, often determined by strong year classes. Discard sampling started in 1990, and for years prior to this estimates have been made based on later data. Landings and discards at length are combined (assuming a discard survival rate of 25%) to removals. The differences in catchability between sexes have led to the two sexes being assessed separately. And hence removals are raised separately for each sex.

Reported *Nephrops* trawl effort in 2007 was similar to the four previous years, whilst total landings show a marked increase since 2006 (Figure B1-1, Table B1-1), possibly as a result of more accurate reporting since the introduction of the "buyers and sellers" regulations in the UK in this year.

Males contribute more to the landings than females (Figure B1-2), as in all other functional units. Effort is normally highest in the 2nd quarter in this fishery, and generally lowest in the 4th quarter. Lpue has remained relatively stable over the time-series prior to 2005, but shows a marked increase in 2006 and 2007, possibly as a result of the aforementioned introduction of the "buyers and sellers" regulations.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates averaged over the period 2010 to 2012 for this stock were 9% by number. This represents a decrease on the 2000 to 2009 period.

Mean length data for *Nephrops* above and below 35 mm CL, are shown in Figure B1-2. This size was chosen for all the Scottish stocks examined as the general size limit above which the effects of discarding practices and the addition of recruits were likely to be small. Trawl and creel fisheries are sampled separately.

B.2. Biological

Mean weights-at-age for this stock are estimated from fixed Scottish weight–length relationships (Howard *et al*., 1988 (citation required)). Relevant biological parameters are as follows: natural mortality was assumed to be 0.3 for males (Morizur, 1982) of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

Summary

Parameter	Value	Source
Discard Survival (trawl)	25%	Charuau *et al.*, 1982; Sangster *et al.*, 1997; Wileman *et al.*, 1999
Discard Survival (creel)	100%	Wileman *et al.*, 1999; Harris and Ulmestrand (2004); Chapman,1981
MALES		
Growth – K	0.16	Adapted from Bailey and Chapman (1983)
Growth - L(inf)	66 mm	Adapted from Bailey and Chapman (1983)
Natural mortality - M	0.3	Morizur, 1982
Length/weight - a	0.00028	Howard and Hall (1983)
Length/weight - b	3.24	Howard and Hall (1983)
Size at maturity	25 mm	Adapted from Bailey and Chapman (1983)
FEMALES		
Immature Growth		
Growth – K	0.16	Adapted from Bailey and Chapman (1983)
Growth - L(inf)	66 mm	Adapted from Bailey and Chapman (1983)
Natural mortality - M	0.3	As for males
Size at maturity	25 mm	Adapted from Bailey and Chapman (1983)
Mature Growth		
Growth – K	0.06	Adapted from Bailey and Chapman (1983)
Growth - L(inf)	59 mm	Adapted from Bailey and Chapman (1983)
Natural mortality - M	0.2	
Length/weight - a	0.00074	Howard and Hall (1983)
Length/weight - b	2.91	Howard and Hall (1983)

Proportion of F and M prior to spawning was specified as zero to give estimates of spawning–stock biomass at January 1.

B.3. Surveys

Abundance indices are available from the following research-vessel surveys:

Underwater TV survey: years 1995–present. The survey usually occurs in June. The burrowing nature of *Nephrops*, and variable emergence rates mean that trawl catch rates may bear little resemblance to population abundance. An underwater TV survey has been developed, estimating *Nephrops* population abundance form burrow density raised to stock area. A random stratified sampling design is used, on the basis

of British Geological Survey sediment strata. The survey provides a total abundance estimate, and is not age or length structured (Figure B1-3).

UWTV relative to absolute conversion factors

A number of factors are suspected to influence the ability of the surveys to map directly to absolute abundance. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion (ICES, 2009). The biases associated with the estimates of *Nephrops* abundance in the South Minch are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative absolute conversion factor
FU 12: South Minch	<=2009	1.37	0.85	1.1	1	1.32

B.4. Commercial cpue

Landings-per-unit-of-effort time-series are available from the following fleets:

Scottish trawl gears: Landings and effort data for Scottish trawl gears are used to generate a non-standardized lpue index. Lpue is estimated using officially recorded effort (days absent from port). Effort data are available for the trawl fleet from 2000. There is no account taken of any technological creep in the fleet. Effort data for the creel fleet are not available.

B.5. Other relevant data

C. Assessment: data and method

Model used: UWTV Based Approach to generate catch options

In 2009 WKNEPH debated the use of the surveys as either an absolute measure of abundance or a relative index (ICES, 2009). Ultimately this led to a consensus that bias corrected survey abundance estimates could be used directly in the formulation of catch advice. Two modelling approaches were used to estimate sustainable stock-specific Harvest Ratio reference points; SCA (a separable LCA model Bell) & Age-Structured Simulation model (Dobby) (ICES, 2009).

Software used: Age-Structured Simulation model per recruit analysis in R

1) Survey indices are worked up annually resulting in the TV index.

2) Apply the Absolute Conversion Factor (see Section B3). The combined effect of these biases is to be applied to the new survey index.

3) Generate mean weight in landings. Check the time-series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use an average taken over an appropriate time scale. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in the future).

4) The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}. These values are estimated by Benchmark

Workshops but may be revised if there are indications of changes to fisheries or biological factors.

5) Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{MAX}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6) Multiply the survey index by the harvest ratios to give the number of total removals.

7) Create a landings number by applying the discard ratio (dead discard rate).

8) Produce landings biomass by applying mean weight.

E. Medium-term projections

None presented.

F. Long-term projections

None presented.

G. Biological reference points

Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of overfishing) have been evaluated and proposed for each *Nephrops* functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} have been determined. Three stock-specific candidates for F_{MSY} ($F_{0.1}$, $F_{35\%SPR}$, and F_{MAX}) were derived from a length-based per recruit analysis (these may be modified following further data exploration and analysis).

There may be strong differences in relative exploitation rates between the sexes in many stocks. To account for this, values for each of the candidates have been determined individually for males, females, and the two sexes combined. The combined sex F_{MSY} proxy should be considered appropriate, provided that the resulting percentage of virgin spawner-per-recruit for males or females does not fall below 20%. If this happens a more conservative sex-specific F_{MSY} proxy should be picked instead of the combined proxy.

In the South Minch the absolute density observed on the UWTV survey is medium (~0.42 burrow/m^2). Historical harvest ratios in this FU have been above that equivalent to fishing at F_{MAX} and landings have been relatively stable in the last thirty years. $F_{35\%SpR}$ (combined between sexes) is expected to deliver high long-term yield with a low probability of recruitment overfishing and therefore is chosen as a proxy for F_{MSY}. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium. The MSY $B_{trigger}$ proposed for South Minch was based on the lowest observed UWTV abundance time-series.

The F_{MSY} proxy harvest rate values were calculated at the WKNEPH (ICES 2009) from the per-recruit analysis based on input parameters from a combined sex length cohort analysis of 2007–2009 catch-at-length data. All F_{MSY} proxy harvest rate and MSY $B_{trigger}$ values remain preliminary and may be modified following further data exploration and analysis.

Harvest ratio reference points:

	Male	Female	Combined
F_{MAX}	13.3	26.8	16.1
$F_{0.1}$	7.8	13.8	8.7
$F_{35\%SpR}$	9.6	18.3	12.3

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	1016 million individuals	Bias-adjusted lowest observed UWTV survey estimate of abundance
Approach	F_{MSY}	12.3% harvest rate	Equivalent to $F_{35\%SpR}$ combined sex. F_{MSY} proxy based on length-based Y/R.

H. Other issues

A reworking of the UWTV survey abundance series for Division VIa was presented to the *Nephrops* benchmark workshop (WKNEPH) in 2009 (ICES, 2009) and further details of the technical changes to the camera can be found in the report of that workshop. The revised abundance estimates for FU 12 from 1999 onwards were presented for the first time at WGCSE 2009 and are slightly higher than the previous values due to the field of view being smaller than previously calculated.

I. References

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.

Chapman C.J. 1981. Discarding and tailing *Nephrops* at sea. Scott Fish Bull 46: 10–13.

Charuau A., Morizur Y., Rivoalen J.J. 1982. Survival of discarded *Nephrops norvegicus* in the Bay of Biscay and in the Celtic Sea, ICES-CM-1982/B:13.

Harris, R. R. and Ulmestrand, M. 2004. Discarding Norway lobster (*Nephrops norvegicus* L.) through low salinity layers - mortality and damage seen in simulation experiments. ICES Journal of Marine Science 61, 127-139.

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. 2009. Report of the Benchmark Workshop on *Nephrops* assessment (WKNEPH). ICES CM: 2009/ACOM:33.

Morizur, Y. 1982. Estimation de la mortalité pour quelques stocks de la langoustine, *Nephrops norvegicus* (L.). ICES, Doc. Shellfish Comm., CM 1982/K:10 (mimeo).

Sangster, G.I., Breen, M., Bova, D.J., Kynoch, R., O'Neill, F.G., Lowry. N., Moth-Poulsen, T. Hansen, U.J., Ulmestrand, M., Valentinsson, D., Hallback, H., Soldal, A.V., and Hoddevik, B. 1997. *Nephrops* survival after escape and discard from commercial fishing gear. Presented at ICES FTFB Working Group, Hamburg, Germany 14–17 April, 1997, ICES CM 1997 CM/B.

Wileman, D. A., Sangster, G. I., Breen, M., Ulmestrand, M., Soldal, A. V. and Harris, R. R. 1999. Roundfish and *Nephrops* survival after escape from commercial fishing gear. Final report to European Commission, Brussels, FAIR-CT95-0753.

Table B1-1. *Nephrops*, South Minch (FU12), Nominal Landings of *Nephrops*, 1981–2012, as officially reported.

Year	UK Scotland				Other UK	Ireland	Total
	Nephrops trawl	Other trawl	Creel	Sub-total			
1981	2965	254	432	3651	0	0	3651
1982	2925	207	420	3552	0	0	3552
1983	2595	361	456	3412	0	0	3412
1984	3228	478	594	4300	0	0	4300
1985	3096	424	488	4008	0	0	4008
1986	2694	288	502	3484	0	0	3484
1987	2927	418	546	3891	0	0	3891
1988	3544	364	555	4463	10	0	4473
1989	3846	338	561	4745	0	0	4745
1990	3732	262	436	4430	0	0	4430
1991	3597	341	503	4441	1	0	4442
1992	3479	208	549	4236	1	0	4237
1993	3608	193	649	4450	5	0	4455
1994	3743	265	404	4412	3	0	4415
1995	3442	716	508	4666	14	0	4680
1996	3107	419	468	3994	1	0	3995
1997	3519	331	492	4342	3	1	4345
1998	2851	340	538	3729	0	0	3730
1999	3165	359	513	4037	0	14	4051
2000	2939	312	699	3950	0	2	3952
2001	2823	393	767	3983	0	9	3992
2002	2234	315	742	3291	0	14	3305
2003	2812	203	858	3873	0	6	3879
2004	2865	104	880	3849	0	19	3868
2005	2810	46	953	3809	1	31	3841
2006	3569	19	922	4510	9	35	4554
2007	4436	8	958	5402	19	30	5451
2008	4432	5	895	5332	2	13	5347
2009	3347	20	900	4267	4	11	4282
2010	2801	13	889	3703	16	6	3725
2011	2878	6	783	3667	23	9	3699
2012*	3102	20	742	3864	19	6	3889

*** Provisional na = not available.**

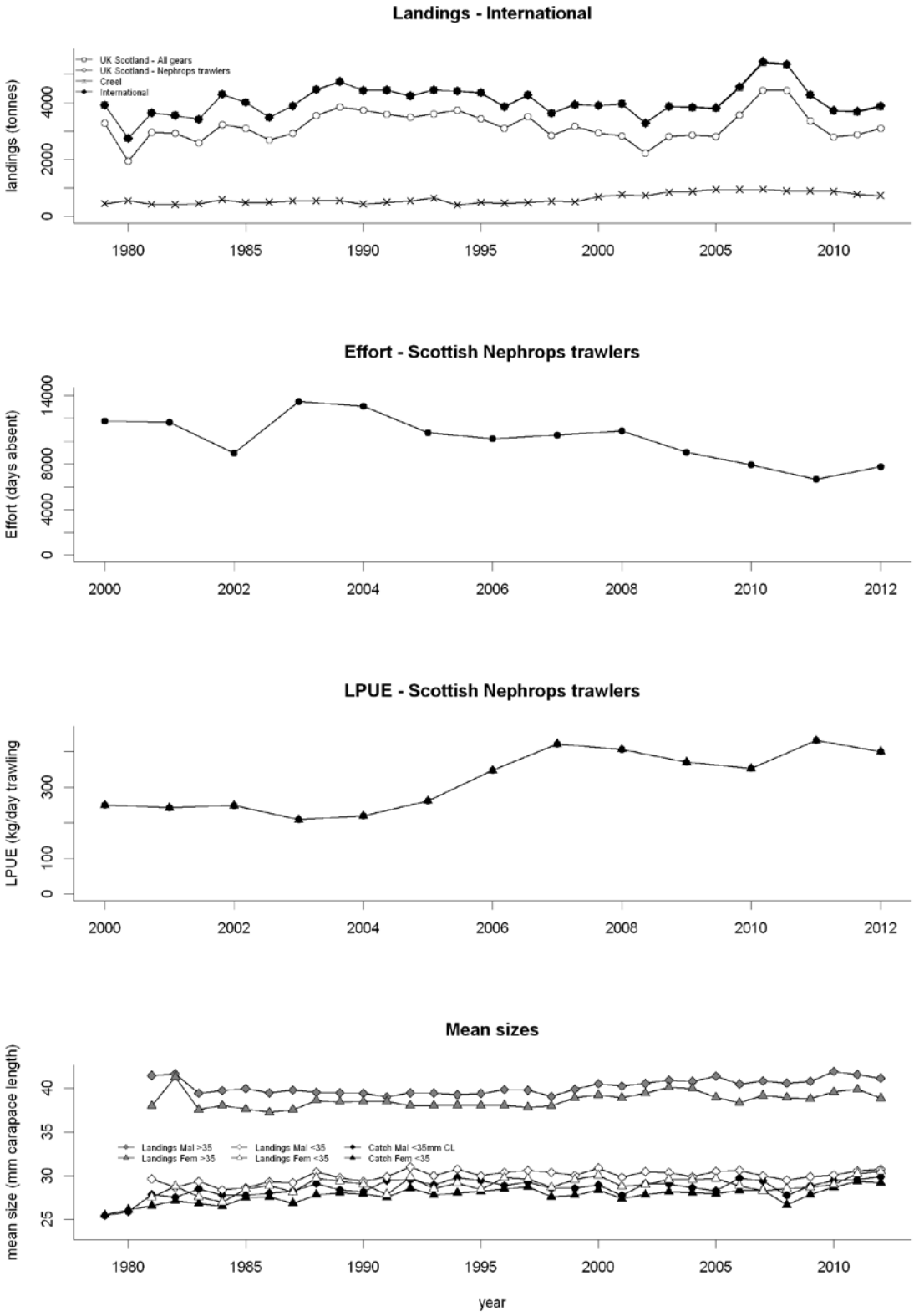

Figure B1-1. *Nephrops,* **South Minch (FU12). Long-term landings, effort, lpue and mean sizes. The interpretation of the lpue series is likely to be affected by the introduction of the "buyers and sellers" regulations in 2006.**

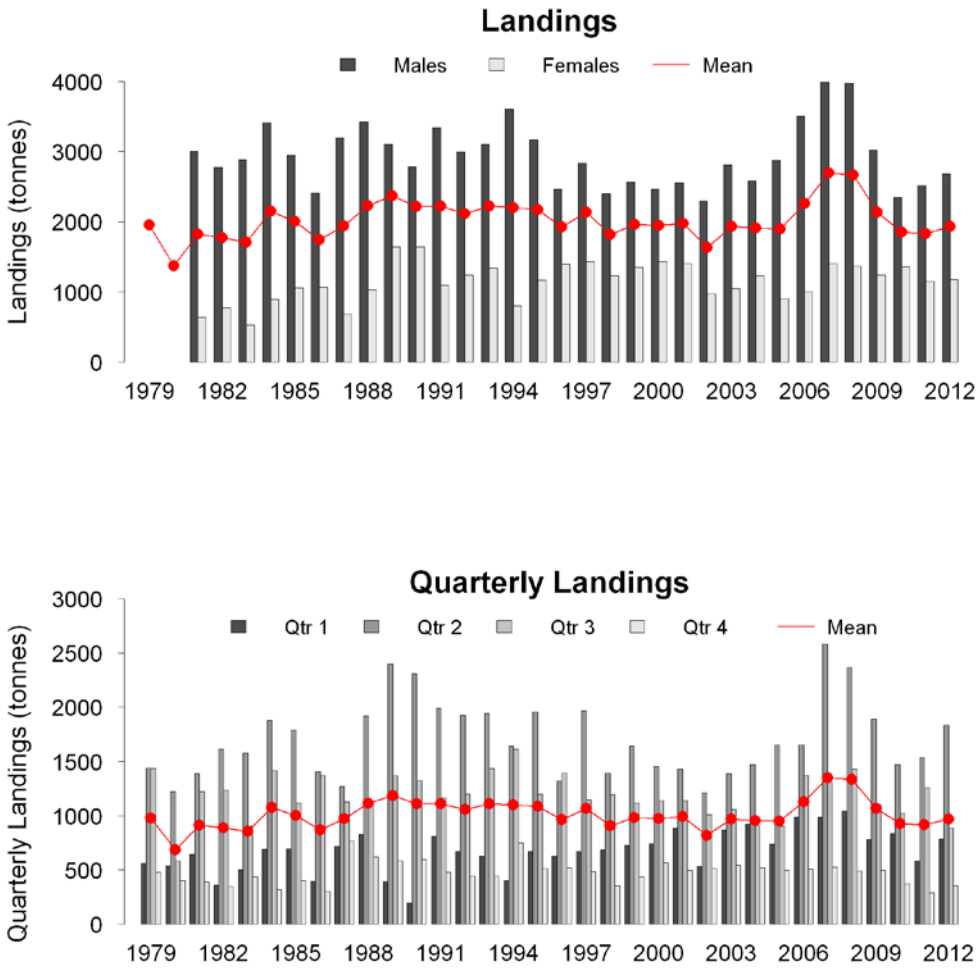

Figure B1-2. ***Nephrops,*** **South Minch (FU12). Landings by quarter and sex from Scottish trawlers.**

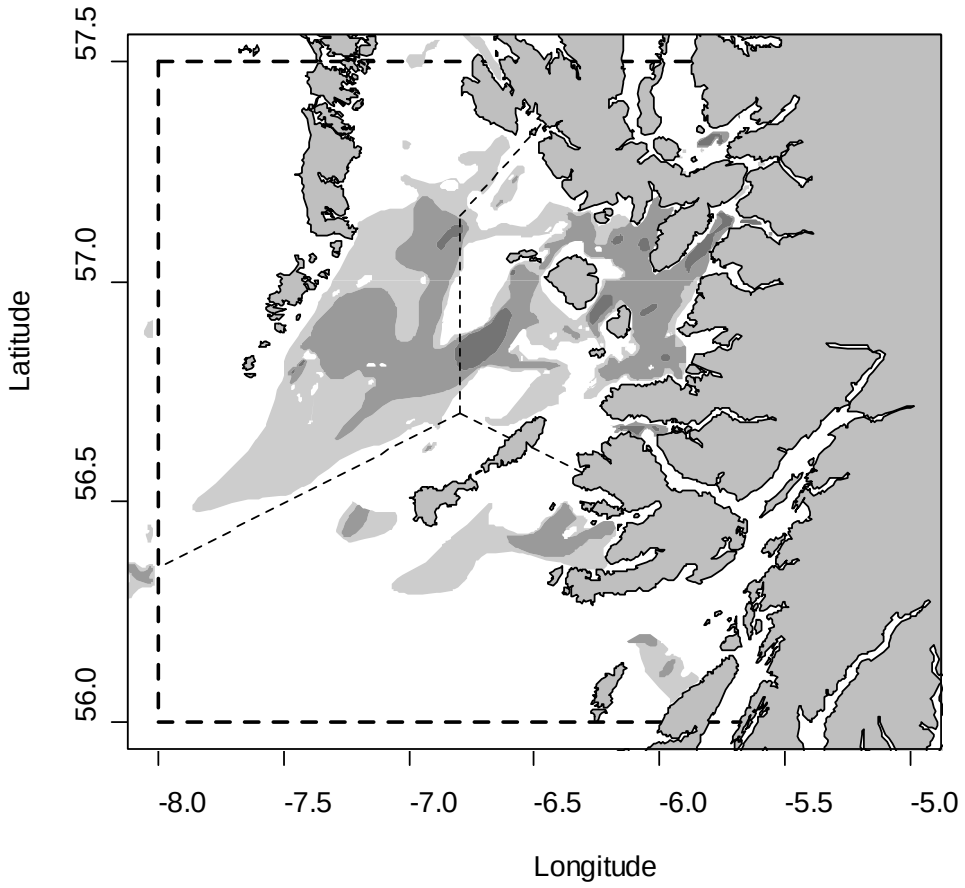

Figure B1-3. Sediment strata in the South Minch. Light Grey – Muddy sand, Grey – Sandy mud, Dark Grey – Mud. Light dashed lines represent spatial strata imposed on the sampling regime to ensure adequate spatial coverage.