# Stock Annex: Norway lobster (*Nephrops norvegicus*) in Division 4.b, Functional Unit 8 (central North Sea, Firth of Forth)

Stock aposities documentation of standard assessment procedures used by ICES

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Stock:	Norway lobster
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### 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. 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. The Firth of Forth is located close inshore to the Scottish coast, towards the west of the central part of Division 4 and defined by statistical rectangles 40-41E7 and 41E6. The mud substrate in the Firth of Forth area is mainly muddy sand and sandy mud, and there is only a small amount of the softest mud. The population of *Nephrops* in this area is composed of smaller animals. Earlier research suggested that residual currents moving southward from this area transport some larvae to the Farn Deeps – recent larval surveys have not been undertaken, however, and it is unclear how significant this effect is. Outside the functional unit, a *Nephrops* population is found on a smaller patch of mud beyond the northern boundary, off Arbroath.

### A.2. Fishery

The *Nephrops* fishery is located throughout the Firth but is particularly focussed on grounds to the east and south east of the Isle of May. Grounds located further up the Firth occur in areas closer to industrial activity and shipping.

Most of the vessels are resident in ports around the Firth of Forth, particularly at Pittenweem, Port Seton and Dunbar. Some vessels, normally active in the Farn Deeps, occasionally come north from Eyemouth and South Shields. During 2006 and 2007 the number of vessels regularly fishing in the Firth of Forth was been around 40 (23 under 10m and 19 over 10m vessels). This number varies seasonally with vessels from other parts of the UK increasing the size of the fleet. Local boats sometimes move to other grounds when catch rates drop during the late spring *Nephrops* moulting period. Traditionally, Firth of Forth boats move south to fish the Farn Deeps grounds. Single trawl fishing with 80 mm mesh size is the most prevalent method. Some vessels utilise a 90mm codend. A couple of vessels have the capability for twin rigging. Night fishing for *Nephrops* is commonest in the summer. Day fishing is the norm in winter. A very small amount of creeling for *Nephrops* takes place, this is mostly by crab and lobster boats.

*Nephrops* is the main target species with diversification by some boats to squid, and also surf clams. Only very small amounts of whitefish are landed. The area is characterised by catches of smaller *Nephrops* and discarding is sometimes high. The latest information for 2007 suggests that large catches of small *Nephrops* were taken. In the past, small prawns generally led to high tail:whole prawn ratios in this fishery but in recent years a small whole prawn 'paella' market developed.

In 2006, buyers and sellers regulations led to increased traceability and improved reporting of catches. This continued and improved further in 2007 and the reporting of landings is now considered to be much more reliable.

#### 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 compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are considered adequate for providing representative length structure of removals in the Firth of Forth. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE and CPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests that the stock is currently very abundant but the recent improvements in reporting of landings (due to 'buyers and sellers' legislation) may mean this is an artefact generated by more complete landings data. In addition, effort recording in terms of hours fished is non-mandatory which will also affect the trends in LPUE.

Males consistently make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary. Effort is generally highest in the 3<sup>rd</sup> quarter of the year in this fishery, but although the pattern was fairly stable in the early years, the pattern does not appear as strong in recent years and is 2007 was fairly evenly spread throughout the year. LPUE of both sexes has fluctuated through the time series and is currently at a high level. The comments about the quality of landings data are relevant here too. LPUE is generally higher for males in the 1<sup>st</sup> and 4<sup>th</sup> quarters, and for females in the 3<sup>rd</sup> quarter – the period when they are not incubating eggs.

CPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the size above which the affects of discarding practices were not expected to occur and the size below which recruitment events might be observed in the length composition. The data show a slight peak in CPUE for smaller individuals (both sexes) in 1999, with a decline after this, followed by a steady increase in both sexes from 2002 onwards. The CPUE for larger individuals showed a similar pattern with higher values in the most recent years.

#### **B.2. Biological**

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Assumed biological parameters are as follows: natural mortality was assumed to be 0.3 for males 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

Growth parameters Males; L $_{\infty}$  = 66mm, k = 0.163 Immature Females; L $_{\infty}$  = 66mm, k = 0.163 Mature Females; L $_{\infty}$  = 58mm, k = 0.065, Size at maturity = 26mm Weight length parameters: Males a = 0.00028, b = 3.24 Females a= 0.00085, b = 2.91 Discards Discard survival rate: 25%.

Discard rate: 3 year average (34.6% at Benchmark WG)

#### **B.3.** Surveys

TV surveys using a stratified random design are available for FU 8 since 1993 (missing surveys in 1995 and 1997). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*. On average, about 40 stations have been considered valid each year with more stations sampled in the last three years. The survey in 2006 was conducted in December so that densities may not be strictly compatible with the remainder of the series. Abundance data are raised to a stock area of 915 km<sup>2</sup>. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground is predominantly of coarser muddy sand (Figure B3–1). Depending on the year, high variance in the survey is associated with different strata and there is no clear distributional or sedimentary pattern in this area. Abundance is generally higher towards the central part of the ground and around the Isle of May. In recent years higher densities have been recorded over quite wide areas. Confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. 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, the biases associated with the estimates of *Nephrops* abundance in the Firth of Forth are:

	Time period	EDGE EFFEC T	DETECTIO N RATE	SPECIES IDENTIFICATIO N	OCCUPANC Y	CUMULATIV E BIAS
FU 8: Firth of					_	
Forth	<=2009	1.23	0.9	1.05	1	1.18

### **B.4. Commercial CPUE**

Scottish *Nephrops* trawl gears: Landings, discards and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

## B.5. Other relevant data

# C. Historical Stock Development

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

Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

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 the average of the three most recent years. 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).

# **D. Short-Term Projection**

Catch options are provided for a range harvest ratios associated with potential  $F_{msy}$  proxies which are obtained from per-recruit analysis (See below on reference points).

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.

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

Create a landings number by applying a discard factor. A conversion factor was estimated by the Benchmark Workshop, however subsequent WGs have found the discard rate to have changed substantially and a 3 year mean value has since been adopted.

Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

		IMPLIED FISHERY					
Harvest rate	Survey Index	Retained number	Landings (tonnes)				
0%	12345	0	0.00				
2%	"	247	123.45				
4%	"	494	246.90				

	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

# E. Medium-Term Projections

# F. Long-Term Projections

## **G. Biological Reference Points**

Under the new ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of stock overfishing) have been explored and proposed for each functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F<sub>msy</sub> directly and hence proxies for F<sub>msy</sub> are determined. Three candidates for F<sub>msy</sub> are F<sub>0.1</sub>, F<sub>35%SpR</sub> and F<sub>max</sub>. Owing to the strong difference in relative exploitation rates between the sexes, values for each of the candidates are determined for males, females and the two sexes combined. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm. The appropriate F<sub>msy</sub> candidate has been determined for each Functional Unit independently according to the nature of the fishery (relative exploitation of the sexes and historical Harvest Rate vs stock status).

At the 2010 WG, preliminary estimates of these reference points were provided and used in the provision of advice, based on per-recruit analysis which made use of catchat-length frequency data which had been made available to the Benchmark WG in 2009. These are presented below.

	Fbar(20-40 мм)			_	_	SPR (%)	
WGNSSK 2010		М	F	HR (%)	М	F	Т
	М	0.13	0.06	7.5	42.3	64.5	51.7
F0.1	F	0.29	0.13	14.2	23.0	44.8	32.2
	Т	0.16	0.07	8.7	37.3	60.0	46.9
	М	0.24	0.11	12.3	26.9	49.5	36.5
Fmax	F	0.54	0.24	23.4	12.1	29.0	19.2
	Т	0.31	0.14	15.0	21.6	43.0	30.6
	М	0.18	0.08	9.7	34.1	57.0	43.8
F35%SpR	F	0.42	0.19	19.3	15.8	35.0	23.9
	Т	0.26	0.12	13.1	25.1	47.4	34.5

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	Fbar(20-40 mm)					SPR (%)	)
WGNSSK 2011		М	F	HR (%)	М	F	Т
F0.1	М	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29.0
	Т	0.17	0.07	9.4	34.6	56.6	43.9
	М	0.25	0.11	12.7	25.3	46.8	34.4
Fmax	F	0.64	0.28	26.7	9.1	22.9	14.9
	Т	0.34	0.14	16.3	18.8	38.5	27.1
F35%SpR	М	0.17	0.07	9.4	34.6	56.6	43.9
	F	0.39	0.17	18.3	16.0	34.5	23.9
	Т	0.25	0.11	12.7	25.3	46.8	34.4

At the 2011 WG, the analysis was updated using data from 2008-10 to account for the apparent changes in the discard pattern in this fishery. The complete range of the current per-recruit  $F_{msy}$  proxies is given in the table below:

The reduction in discard rate results in  $F_{0.1}$  and  $F_{max}$  occurring at a higher level of fishing mortality and higher harvest rate in this new analysis (maximising yield-per-recruit NOT catch). The small reduction in  $F_{35\% SpR}$  harvest rates appears to be the result of a small change in the estimated selection pattern.

For this FU, the absolute density observed n the UWTV survey is relatively high (average of ~ 0.8 m<sup>-2</sup>). Harvest ratios (which are likely to have been underestimated prior to 2006) has been well above  $F_{max}$  and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at  $F_{max}$ ) suggesting a productive stock. For these reasons, it is suggested that  $F_{max(T)}$  is chosen as the  $F_{msy}$  proxy which is estimated to be 16.3 %.

The B<sub>trigger</sub> point for this FU (bias adjusted lowest observed UWTV abundance) is calculated as 292 million individuals.

# H. Other Issues

# I. References

Veen	All Nephr	All Nephrops gears combined			Single rig Multirig			g Multirig		
rear	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE	
1981	945	42.6	22.2	945	42.6	22.2	na	na	na	
1982	1138	51.7	22.0	1138	51.7	22.0	na	na	na	
1983	1681	60.7	27.7	1681	60.7	27.7	na	na	na	
1984	2078	84.7	24.5	2078	84.7	24.5	na	na	na	
1985	1908	73.9	25.8	1908	73.9	25.8	na	na	na	
1986	2204	74.7	29.5	2204	74.7	29.5	na	na	na	
1987	1582	62.1	25.5	1582	62.1	25.5	na	na	na	
1988	2455	94.8	25.9	2455	94.8	25.9	na	na	na	
1989	1833	78.7	23.3	1833	78.7	23.3	na	na	na	
1990	1901	81.8	23.2	1901	81.8	23.2	na	na	na	
1991	1359	69.4	19.6	1231	63.9	19.3	128	5.5	23.3	
1992	1714	73.1	23.4	1480	63.3	23.4	198	8.5	23.3	
1993	2349	100.3	23.4	2340	100.1	23.4	9	0.2	45.0	
1994	1827	87.6	20.9	1827	87.6	20.9	0	0.0	0.0	
1995	1708	78.9	21.6	1708	78.9	21.6	0	0.0	0.0	
1996	1621	69.7	23.3	1621	69.7	23.3	0	0.0	0.0	
1997	2137	71.6	29.8	2137	71.6	29.8	0	0.0	0.0	
1998	2105	70.7	29.8	2105	70.7	29.8	0	0.0	0.0	
1999	2192	67.7	32.4	2192	67.7	32.4	0	0.0	0.0	
2000	1775	75.3	23.6	1761	75.0	23.5	14	0.3	46.7	
2001	1484	68.8	21.6	1464	68.3	21.4	20	0.5	40.0	
2002	1302	63.6	20.5	1286	63.3	20.3	16	0.3	53.3	
2003	1115	53.0	21.0	1082	52.4	20.6	33	0.6	55.0	
2004	1651	63.2	26.1	1633	62.9	26.0	18	0.4	49.7	
2005	1973	66.6	29.6	1970	66.5	29.6	3	0.1	58.8	
2006	2437	61.4	39.7	2432	61.0	39.9	5	0.4	14.2	
2007	2622	57.6	45.5	2601	57.1	45.6	21	0.5	43.2	

Table B1-1. *Nephrops*, Firth of Forth (FU 8): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).



Figure B1-1. Nephrops, Firth of Forth (FU 8), Long term landings, effort, LPUE and mean sizes.



Figure B1-2. *Nephrops*, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.



Figure B1-3. *Nephrops*, Firth of Forth (FU 8), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.



Figure B3–1. Distribution of *Nephrops* sediments in the Firth of Forth (FU 8). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.