Stock Annex: Norway lobster (*Nephrops norvegicus*) in divisions 8.a and 8.b, functional units 23–24 (northern and central Bay of Biscay)

Stock-specific documentation of standard assessment procedures used by ICES.

Stock:	Norway lobster
Working Group:	Working Group for the Bay of Biscay and the Iberic waters Ecoregion (WGBIE)
Created:	August 2005
Authors:	WGHMM (2005–2013)
Last update:	October 2016
Last updated by:	WGBIE

A. General

A.1. Stock definition

This section is already presented in previous Stock Annex (ICES, 2015). The Central Mud Bank of the Bay of Biscay described by Bourillet *et al.* (2006) and Dubrulle *et al.* (2005) extends for 11 676 km² of surface if only the typical muddy strata are taken into account whereas more recent studies (UWTV surveys; see below) suggest to incorporate in the whole area some rough sea grounds crossed by muddy channels and also included in the external outline of the area (surface increasing up to 16 164 km²).

A.2. Fishery

A.2.1. General description

The description is detailed in previous Stock Annex (ICES, 2015). Some recent unpublished explorations (WGBIE 2016; WKNEP 2016) reported information on the standardised fleet operating in the extreme northern part of the stock: the most *Nephrops* directed fleet in the Bay of Biscay involving in a various number of vessels (55–95 throughout years 2003–2015, i.e. 35–45% of the overall fleet) is composed from two subgroups of length (≈30–35% 12 m long and ≈65–70% m long).

A.2.2. Management regulations

Already detailed in previous Stock Annex (ICES, 2015). From 2010 onwards, TAC remained unchanged (3899 t) whereas the French landings were 3398 t in 2010, 3559 t in 2011, 2520 t in 2012, 2380 t in 2013, 2807 t in 2014 and 3569 t in 2015.

A.3. Ecosystem aspects

Already detailed in previous Stock Annex (ICES, 2015).

B. Data

B.1. Commercial catch

B.1.1. Landings

See previous Stock Annex (ICES, 2015). In 2015 landings steeply increased compared to 2014 (3569 t against 2807 t; +27%). Landings since 2008 have been reached under the new selectivity regulations. Males predominate in the landings (sex ratio of 31–47% during the overall time-series 1987–2015).

Data coverage and quality

No change from previous Stock Annex.

B.1.2. Discards

No significant change from previous Stock Annex.

Data coverage and quality

The spatial coverage was improved for recent years by a higher sampling rate for the fleet operating in the southern part of the fishery which is more multi-purpose than the northern one.

B.1.3. Recreational catches

Not relevant.

B.2. Biological sampling

B.2.1. Maturity

Maturity for females is estimated on the basis of a yearly conducted on-board sampling design since 2004 owing to the DCF plan. The first years' dataset (2004–2006) allowed to slightly revise the maturity ogive for females (L50 of 22.43 mm CL instead of 25 mm CL previously used: Jegou, 2007). Maturity for males was studied using a dataset on years 2004–2005 and size of functional maturity was set at 26 mm CL (Jegou, 2007).

B.2.2. Natural mortality

No recent experiment on natural mortality estimation was carried out. The reference of Morizur (1982) was used throughout the time-series and instantaneous coefficients of 0.3 for males (and immature females) and of 0.2 for mature females were applied. Current explorations (WKNEP, 2016) seem to demonstrate that the actual natural mortality should be higher for both sexes.

B.2.3. Length composition for landings and discards

B.2.3.1. Sampling

Landings: See previous Stock Annex (ICES, 2015).

Discards: For recent years, discards have been estimated from sampling catches programme on board *Nephrops* trawlers (522 trips and 1513 hauls have been sampled over the period 2003–2015).

The overall programme is based on a stratified random sampling by ratio estimator using the total landings as auxiliary variable (Talidec *et al.*, 2005) although for recent years under the selectivity devices since 2008 the total landings do not seem to substantially improve the accuracy for the estimates. Discard sampling from the southern part of the fishery was carried out only once up to the middle of 2000s, but it has been routinely sampled since 2009, thus the sampling plan is better balanced among subareas and harbours. However, the total CVs for landings and discards are not fairly stable from year to year either if the quarterly stratification for estimates is retained or not.

Table 1. Sampling plan for landings (auction and on board) and discards (on board). Example for years 2014 and 2015. Upper part by year: total and sampled fishing operations (hauls); lower part: total numbers of sampled *Nephrops*.

2014

quarter	sampled FO	total FO	nb_trp	nb_trp_tot
1	7	13	4	2689
2	25	91	13	5615
3	21	99	12	5274
4	10	27	8	3973
year	63	230	37	17551

	land			disc
quarter	auction	board	total	
1	3774	855	4629	377
2	5400	3662	9062	1146
3	4957	2321	7278	712
4	4642	1115	5757	436
TOTAL	18773	7953	26726	2671

2015

quarter	sampled FO	total FO	nb_trp	nb_trp_tot
1	16	28	7	2785
2	36	124	14	5598
3	28	131	13	4999
4	7	31	3	3480
year	87	314	37	16862

	land			disc
quarter	auction	board	total	
1	5347	1488	6835	655
2	5520	2760	8280	1334
3	5695	2835	8530	747
4	4906	345	5251	194
TOTAL	21468	7428	28896	2930

Table 2. CVs (%) for landings and discards by sex. Example from years 2014 and 2015. No stratified estimates (left column by sex) or stratified on a quarterly basis (right column by sex).

		males		females	
2014	LAN	21.53	13.36	22.72	19.03
	DIS	29.87	28.42	35.63	34.97
2015	LAN	13.53	10.78	14.42	14.34
	DIS	16.85	15.91	15.89	15.89

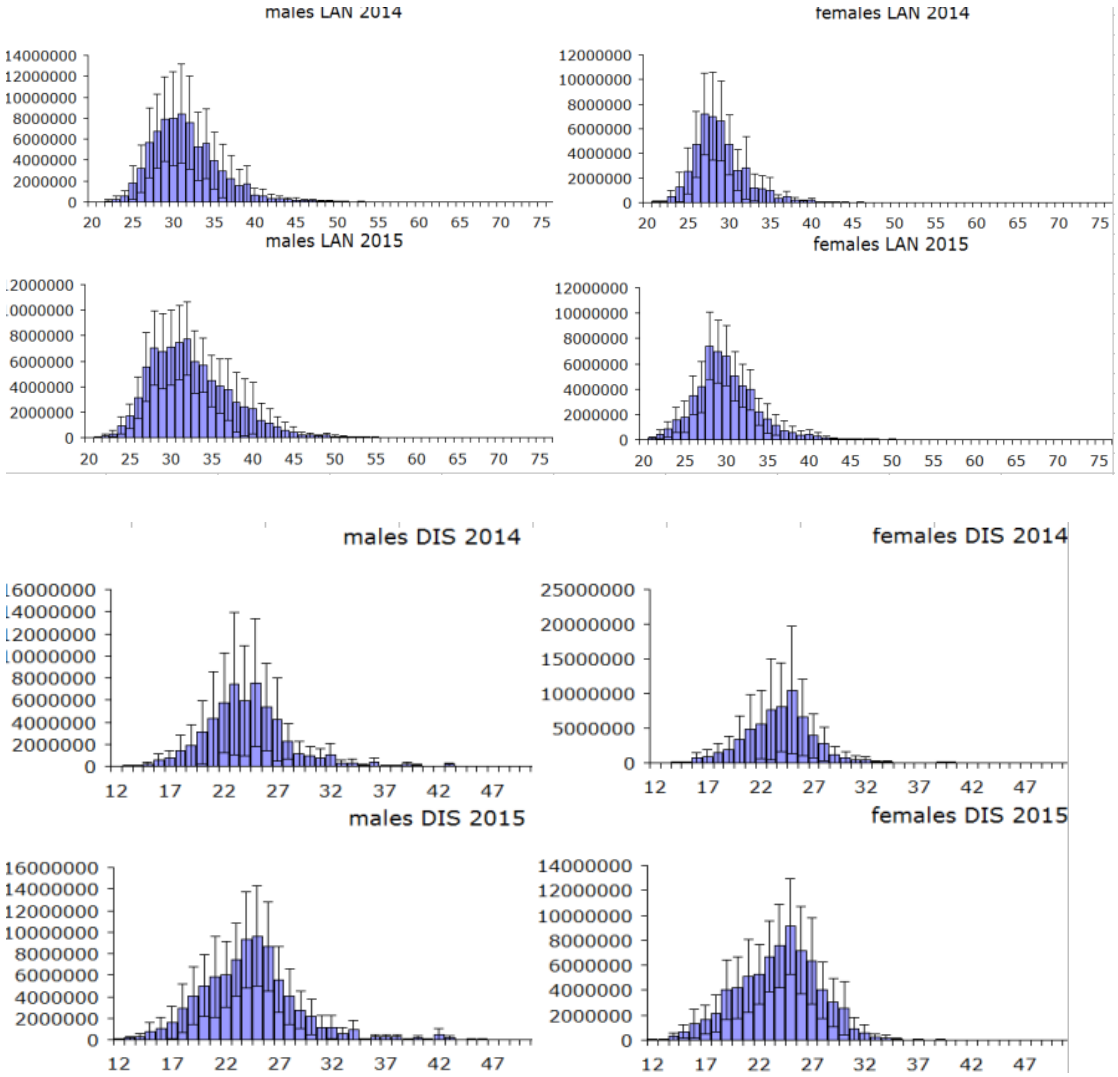

Figure 1. LFDs for yearly landings (above) and discards (below) by sex. Numbers of individuals vs. carapace length, mm and CVs by size. Years 2014 and 2015.

B.2.3.2. Years with no sampling on board

Probabilistic approach developed in ICES WGs (WGSSDS 2006; WGHMM 2007) is already explained by previous Stock Annex (ICES, 2015). This method was adopted by IBP *Nephrops* 2012.

B.3. Surveys

B.3.1. Survey design and analysis

B.3.1.1. Trawl survey LANGOLF (2006–2013)

Information for this former trawl survey is provided by previous Stock Annex (ICES, 2015).

B.3.1.2. UWTV survey LANGOLF-TV (from 2014 onwards) (details in WD XXX1, WKNEP)

The XSA previous assessment on this stock was considered as inappropriate because it was undertaken on size composition for catches and removals converted to age ones on the basis of individual growth von Bertalanffy parameters inadequate for moulting crustaceans. Therefore, the trawl survey was abandoned in 2013.

An UWTV survey named "LANGOLF-TV" conducted since 2014 aimed to demonstrate the technical feasibility of such a survey in the local context and to identify the necessary competences and equipment for its sustainability. During the first two years, 2014 and 2015, video sampling was associated to a trawl one for the purpose of providing *Nephrops* LFDs by sex and estimating the proportion of other burrowing crustaceans (mainly *Munida*) which can induce bias in the burrows counting.

The assessment method based on UWTV data requires an unbiased and accurate calculation of the actual surface of the stock and, moreover, available dataset linked to the population dynamics (LFDs by sex for landings and discards). Both criteria are satisfied in the Bay of Biscay.

The surface involving in *Nephrops* is precisely delimited owing two information: (1) on the sedimentary structure of the seabed (five spatial strata; Figure 2 below); (2) on the systematic grid of video tracks combined with VMS data for the fishery (Figure 3 below; data source: National Fisheries Direction; compilation: Ifremer). Sampling of landings and discards (on board and at auction) has provided yearly dataset since 1987 and mainly since 2003 owing to the monitoring of the European DCF plan (Tables 1 and 2; Figure 1 above).

Under these favourable conditions, the Bay of Biscay stock seems to be appropriate for an UWTV survey and analytical assessment.

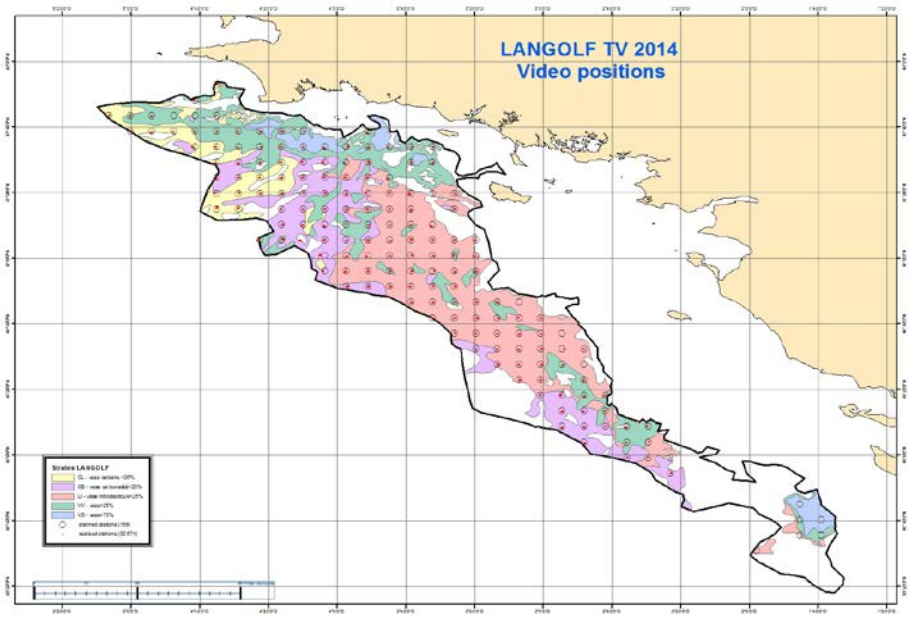

Figure 2. Spatial stratification of the Bay of Biscay according to sedimentary criteria (see § B.3.1.1 on former trawl survey LANGOLF).

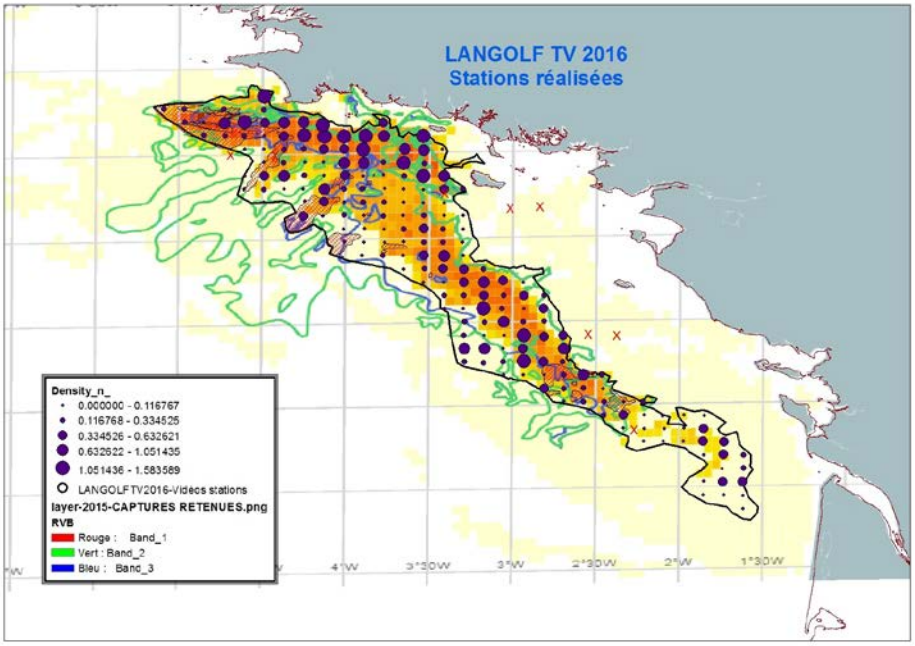

Figure 3. UWTV stations on a systematic grid (distance of stations: 4.7 nm; example of the year 2016) and VMS data for retained catches of *Nephrops* (rectangles of 3 min*3 min; example of the year 2015; source: National French Fisheries Direction; compilation: Project SIH Ifremer).

In 2014 and 2015, LANGOLF-TV was carried out on ten actual days associated to experimental trawling, stopped thereafter, whereas in 2016 the UWTV survey took place during 12 days. For each year six scientists participated on the on board work. As the project was planned owing to a partnership with the "Marine Institute" (Republic of Ireland) one expert scientist and one electronics technician from Ireland joined the team.

For the three surveys, the equipment (sledge, computing hardware, screens, recorders) were provided by the "Marine Institute". The sledge is based on the Scottish material (2.5 m*2.7 m*2.5 m; weight=80 kg); its speed is around 20 m/min.

In conformity with the recommendations of the SGNEPS (Anon, 2010) any new reader has to attend a training course in order to recognize the *Nephrops* burrows by avoiding possible confusions with other burrowing crustaceans structures. The main features for that are described during the WKNEPHTV in 2007 (Anon, 2007). After this preliminary stage, a reading test on ten videos of five minutes is carried out. The provisional absence of reference footage in the Bay of Biscay implies the use of other support coming from grounds with similar conditions (density of burrows) to the Bay of Biscay: the Smalls grounds (FU22, Celtic Sea, UWTV surveyed since 2006) was chosen (see details from the conformity test CCC in WD XXX1, WKNEP).

In accordance with other routinely UWTV surveyed stocks (Anon, 2009), the sampling protocol applied since 2014 has been a systematic one advantaged by wider spatialised explorations on collected data. A distance of 4.7 nautical miles was retained similarly to the FU22 Smalls Ground. 165 stations were planned per year: among them 156 were validated for 2014 (few tracks abandoned due to rough sea bottom), whereas for 2015 96 stations were sampled because of bad meteorological conditions. The problem was tackled in 2016 by a longer survey duration: 14 effective working days were planned and owing to favourable conditions 12 days were sufficient to complete the whole grid (204 stations carried out among them 196 validated). Moreover, this enabling context allowed to cover for the first time the area contained in the outline of the Central Mud Bank no belonging to any sedimentary stratum: this area known as not trawled due to rough sea bottom was sampled by 36 validated stations completing the 160 stations of the five strata.

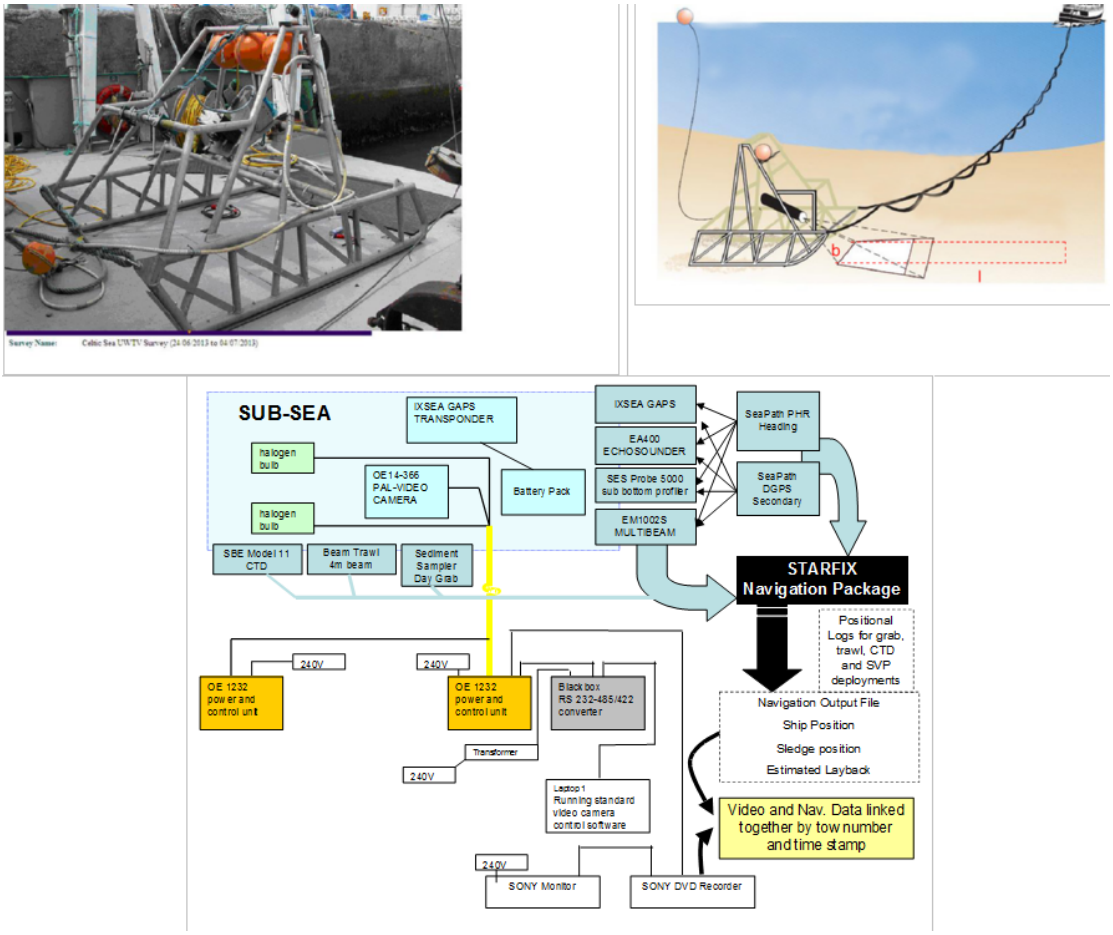

Figure 4. Schematic diagram of the sledge and traction on the seabed. Mechanism for acquiring process on board. ***Source: Marine Institute, Ireland***

B.3.2. Survey data used

B.3.2.1. Former LANGOLF trawl survey

These results are already developed by previous Stock Annex (ICES, 2015). This series was included in the stock assessment for years 2012–2014 (intermediate year 2013 with no advice as the Bay of Biscay *Nephrops* stock is biennially advised under category 3).

B.3.2.2. UWTV survey LANGOLF–TV (see details in WD XXX1, WKNEP)

Two data processing methods were developed, based on stratified statistics or on geostatistics tools. As written above, the whole area of the five strata was covered in 2014 although only $^{2}/_{3}$ of the total number of stations were carried out in 2015. In 2016 100% of the Central Mud Bank was sampled.

B.3.2.2.1. Stratified estimates (see details in WD XXX1, WKNEP)

The overall trend involves in maximum densities in the extreme northern limit of the area. As explained below on geostatistical investigations, this point could theoretically be a disadvantage for the accurate definition of the stock boundaries although no fishing activity seems to have been developed more northerly as shown by the VMS

available dataset. Table 3 shows results of raising for years 2014–2016 of burrow densities (/m²)[1] associated to their CVs by stratum.

Table 3. Total number of burrows (10^6), densities/m^2 and CVs by spatial stratum and for the whole area. Years 2014-2016.

	2014 (156 stations)				*2015 (96 stations)*				*2016 (160 stations)*				
	nb/m²	total burrows	CV (%)	% burrows	nb/m²	total burrows	CV (%)	% burrows	nb/m²	total burrows	CV (%)	% burrows	% surf
	0.442	**5164.53**	**5.82**		**0.386**	**4501.89**	**8.25**		**0.386**	**4505.52**	**7.86**		
CB	0.317	802.68	15.68	15.54%	0.151	383.85	25.66	8.53%	0.258	654.41	19.84	14.52%	21.72%
CL	0.171	196.72	28.30	3.81%	0.306	352.28	18.57	7.83%	0.237	272.72	20.87	6.05%	9.87%
LI	0.354	1651.31	8.69	31.97%	0.320	1492.89	16.38	33.16%	0.283	1319.12	13.86	29.28%	39.94%
VS	1.656	1048.72	11.05	20.31%	0.875	553.75	30.48	12.30%	0.839	531.18	17.92	11.79%	5.42%
VV	0.544	1465.10	13.19	28.37%	0.639	1719.13	10.99	38.19%	0.642	1728.09	14.52	38.35%	23.05%

Comparisons of burrows densities are carried out by restricting the sampled area for 2014 and 2016 to that covered in 2015. The basic condition of the stratified design is respected as all five sedimentary strata were sampled; although, the total surveyed area was reduced (7935 km² instead of 11 676 km²).

Table 4. Total number of burrows (10^6), densities/m^2 and CVs by spatial stratum and for the whole area. Years 2014-2016 after restriction to the area sampled in 2015 (7935 km^2 instead of 11676 km^2).

	2014 (109 stations)				*2015 (96 stations)*				*2016 (102 stations)*			
	nb/m²	total burrows	CV (%)	% burrows	nb/m²	total burrows	CV (%)	% burrows	nb/m²	total burrows	CV (%)	% burrows
	0.417	**3305.64**	**7.91**		**0.396**	**3138.42**	**7.85**		**0.412**	**3266.09**	**9.98**	
CB	0.265	432.86	19.23	13.09%	0.151	247.63	25.66	7.89%	0.251	410.92	27.44	12.58%
CL	0.171	196.49	28.30	5.94%	0.306	351.86	18.57	11.21%	0.237	272.40	20.87	8.34%
LI	0.340	899.35	12.88	27.21%	0.320	847.72	16.38	27.01%	0.260	688.59	21.35	21.08%
VS	1.656	665.91	11.05	20.14%	0.875	351.61	30.48	11.20%	1.058	425.20	16.20	13.02%
VV	0.530	1111.04	17.90	33.61%	0.639	1339.59	10.99	42.68%	0.700	1468.99	17.20	44.98%

The favourable weather conditions in May 2016 allowed to cover a supplementary area assumed to not be trawled as occupied by rough ground (Table 5).

[1] Rough results not yet corrected by the cumulative bias factor (see below; details in WD XXX1, WKNEP, WKNEP).

Table 5. Total number of burrows (10^6), densities/m^2 and CVs by spatial stratum and for the whole area. Year 2016 after including rough sea bottom contained in the outline of the Central Mud Bank (16164 km^2 instead of 11676 km^2 for the five sedimentary strata *sensu stricto*).

	2016 (160 stations)				
	nb/m²	total burrows	CV (%)	% burrows	% surf
	0.386	**4505.52**	**7.86**		
CB	0.258	654.41	19.84	14.52%	21.72%
CL	0.237	272.72	20.87	6.05%	9.87%
LI	0.283	1319.12	13.86	29.28%	39.94%
VS	0.839	531.18	17.92	11.79%	5.42%
VV	0.642	1728.09	14.52	38.35%	23.05%

	2016 (196 stations)				
	nb/m²	total burrows	CV (%)	% burrows	% surf
	0.320	**5167.67**	**7.84**		
CB	0.258	654.41	19.84	12.66%	15.69%
CL	0.237	272.72	20.87	5.28%	7.13%
LI	0.283	1319.12	13.86	25.53%	28.85%
VS	0.839	531.18	17.92	10.28%	3.92%
VV	0.642	1728.09	14.52	33.44%	16.65%
RO	0.148	662.15	29.61	12.81%	27.76%

B.3.2.2.2. Geostatistics (see details in WD XXX1, WKNEP)

The variographic analysis on the burrows densities revealed an anisotropy corresponding to the directions 45° and 135° i.e. orthogonal and parallel to the shape of the Central Mud Bank. In 2014, the map produced on the basis of the ordinary kriging shows that the strongest densities for burrows (>0.94/m²) are located on the northern part of the area (district of Le Guilvinec; Figure 6). Intermediate levels of density (>0.47/m² and <0.94/m²) occupy the medium latitude of the Central Mud Bank (at the front of the La Loire estuary) and also in the southern limit.

The kriging error indicates the overall pertinence of the method with stable values apart from some patches (SD>0.38). In 2015, the kriging error illustrates the partly surveyed area.

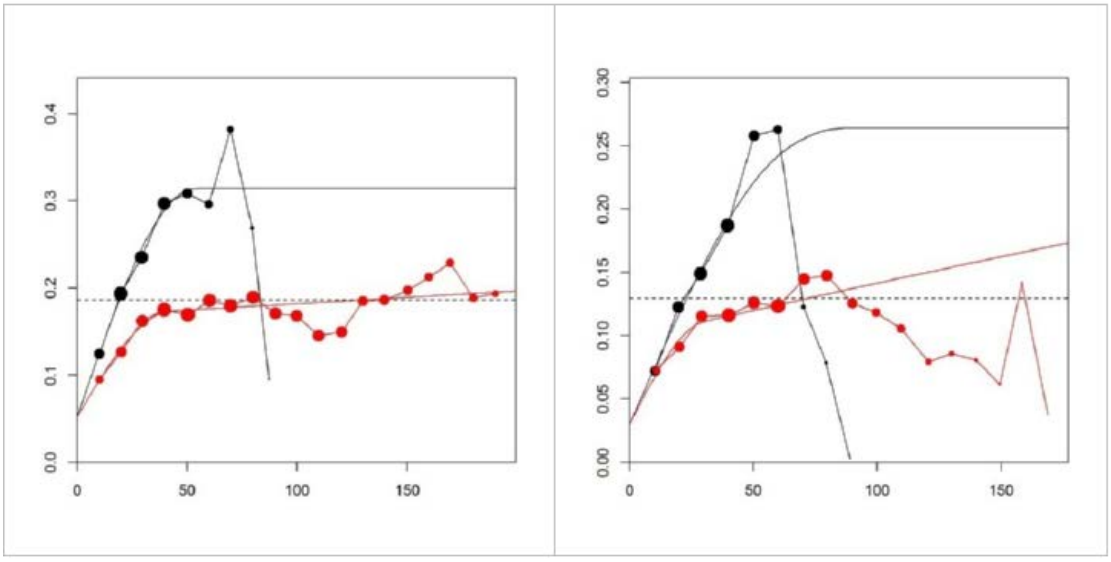

Figure 5. Experimental variograms (circles proportional to the number of pairs) and models (continuous curves) for the main anisotropic directions (red: NW->SE, black: SW->NE).

Year		2014		2015
Number of data	204	204	114	114
Method of estimate for average (A=arithmetic; KO=ordinary kriging)	A	KO	A	KO
Estimation	0.415930	0.425463	0.410321	0.414796
CV geo	0.052829	0.046598	0.180002	0.183475
CV iid	0.072647	-	0.082643	-
Surface (km²)	11 676	11 676	11 676	11 676
Abundance (Estimation * Surface)	4 856	4 968	4 791	4 843

Sélectionner les lignes du tableau

Table 6. Estimation of the abundance of *Nephrops* burrows (10^6) by UWTV for years 2014 and 2015.

B.3.2.2.3. Sources of bias (see details in WD XXX1, WKNEP)

The WKNEPHTV 2007 report (Anon, 2007), provides detailed description of the bias sources: (1) uncertainty about the stock boundaries: a reply is given above (Figure 1) as the Central Mud Bank's outline seems to accurately define the stock limits; (2) edge effect correcting estimations according to the burrows entirely or not contained on the observation width; (3) detection rate associated to visibility conditions; (4) occupancy rate generally assumed equal to 1 (or 100%) because observations under enabling conditions (Scotland) showed that an unoccupied burrow is quickly filled by sediment; (5) confusion with other species burrows ("species identification"): some crustaceans (*Goneplax, Coelocaris*) or fishes (Gobiidae) are able to build structures in the ground and, additionally, other species such as *Munida* can use *Nephrops* burrows.

Edge effect

The current knowledge level on the Bay of Biscay ground does not allow to model edge effect *vs.* all factors affecting the edge effect. The "two pass counting" method used by the "Marine Institute" presented in the report WGNEP2010 (Anon, 2010) was applied on the FU23–24 *Nephrops*. Estimates of this correction factor were obtained by stratum and for the whole area. The re-sampled units tracks*minutes (2nd reading) were selected against sediment type and density level. A ratio estimator was preferred to an average of ratios because of its property to be convergent in probability.

The total estimator is equal to 1.145±11%. The ratios are similar for four strata on five (values 1.11–1.13). The singularity of the lithoclastic stratum (LI) could be explained by the size (diameter) of the burrow structures although this assumption cannot yet be confirmed. It is noticeable that the ratios by sample (by track*minute) are independent of densities.

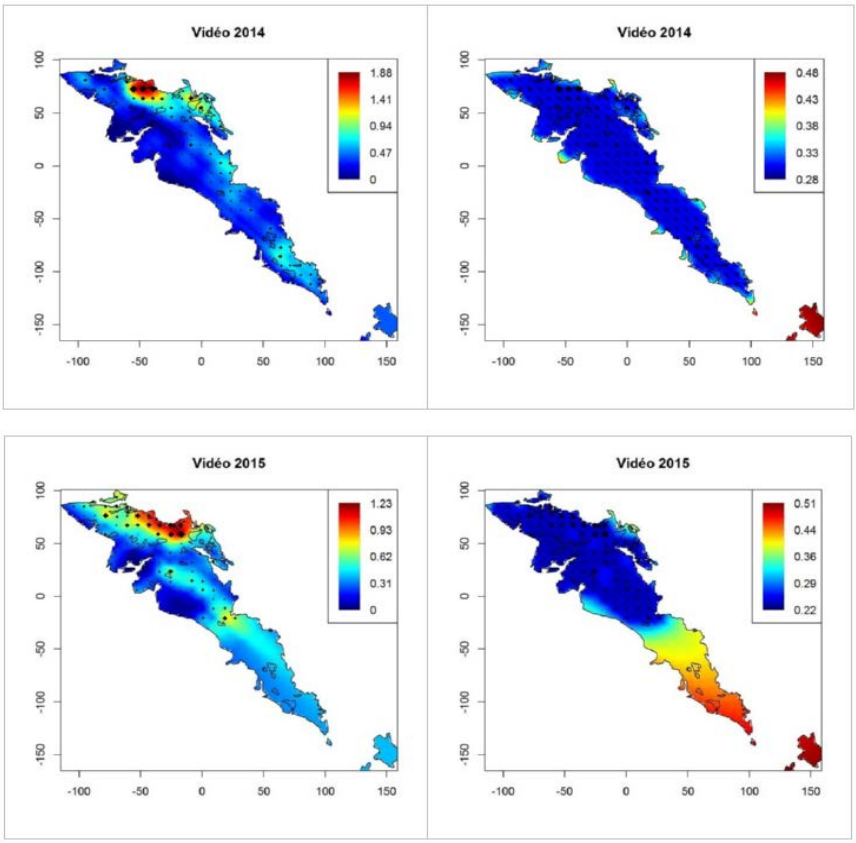

Figure 6. Years 2014 and 2015. Estimation of the burrows densities /m² using ordinary kriging (left column) error of kriging (right column).

Detection rate (see WD XXX1, WKNEP). Visibility conditions for recording footage were optimum for the three surveys. Only two samples were cancelled throughout the whole period. We can note the problem caused for one track where reading was interfered with *Nephrops* directed trawling inducing sediment suspension. Irish experts advice to put off stations when fishing activity occurs nearby. The detection rate by minute*track (1095 observations during the survey 2014) is calculated by weighting by a factor comprised between 0 and 1. A value of 0.94 is provided for the Bay of Biscay. 86% of the total minutes*tracks were sampled under excellent visibility conditions.

Species identification (see WD XXX1 and WD XXX2, WKNEP). Three values are applied for the correction factor due to the *Nephrops*/*Munida* possible coexistence: 1.05, 1.10 or 1.10. Those values were calculated by the difference of the slopes between the spatialised relationships of the ranks for the number of burrows as independent variable and the number of *Nephrops* or the number of *Nephrops* and *Munida* caught by experimental trawling 2014 and 2015 as dependent variable. Taking into *Munida* caused increase of slopes by +4 to +14%. These explorations are independent of any possible confusion about the identity and shape of a *Nephrops* burrow reliably recognisable by the readers' team: "1. crescentiform entrance. 2. Sediment ejecta and radial scrapings around entrance. Claw or perieopod indents. 'Drive-way' 3. Single to multiple entrances, focussing on an apparent 'raised' centrum".

Tables 7 and 8 below provide the main results of UWTV survey (correction factors, abundance indices) and attempt some preliminary explorations on the harvest rate.

Calculations are carried out on the 2014 data[2]. Comparative values are given for the FU22 Smalls ground which was used as standardised stock reference.

[2] 2014 was chosen because the area sampled in 2015 does not represent the whole Central Mud Bank whereas 2016 nominal statistics and LFDs on landings and discards are not yet available.

Table 7. Correction factors for the number of burrows on the basis of the UWTV survey. Comparative examples between Bay of Biscay and Smalls Ground (FU22).

FU	Stock	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
23–24	Gascogne	1.145	0.94	1.05	1	1.13
				1.10		1.18
				1.15		1.24
22	Smalls	1.35	0.9	1.05	1	1.28

Table 8. Input parameters for the "harvest rate" calculation.

Landed numbers (10^3)		121 594	
Mean weight on landings (g)		23.08	
Survival rate (SR)	0.30[3]		0.55[4]
Dead discarded numbers(10^3)	82 551		53 069
Mean weight on discards (g)		11.25	
Numbers of removals (10^3)	204 145		174 663
Mean weight on removals (g)	18.30		19.49
Number of burrows (stratified statistics, 10^6)		5165	
Number of burrows (geostatistics, arithmetic mean, 10^6)		4856	
Number of burrows (kriging, 10^6)		4968	

[3] See Charuau *et al*. (1982).

[4] See Méhault *et al.* (2015).

On the basis of the values above the number of *Nephrops* burrows for the Bay of Biscay in 2014 is comprised in the interval 3916 and 4571 million individuals. Therefore, the preliminary estimate of the harvest rate taking into account different survival rate for discards should be between 3.82% and 5.21%. Developments of the SCA model (WKNEP, 2016) provide the same range of *status quo* harvest rate (≈5–7.5%).

B.4. Commercial cpues

No relevant change compared to previous Stock Annex (ICES, 2015). Lpues of the standardised commercial fleet GV-Q2 reached their historically highest level in 2015 (19.5 kg/h).

B.5. Other relevant data

Selectivity parameters were provided in previous Stock Annex (ICES, 2015).

C. Assessment methods and settings

C.1. Choice of stock assessment model

Previous developments using L2AGE slicing program and XSA assessment with the tuning fleet of "Le Guilvinec District" (GV-Q2) (years 1987–2011) with an additional second one (trawl survey LANGOLF 2006–2013) as adopted by IBP *Nephrops* 2012 are explained by Stock Annex (ICES, 2015).

C.2. Model used for basis of advice

New approach based on UWTV survey undertaken since 2014 is investigated (WKNEP, 2016) in order to be validated as analytical assessment method.

D. Short-term projections

As the XSA assessment is no longer adopted for this stock short-term projections previously carried out (on the basis of MFDP and MFYPR modules) are not relevant.

E. Medium-term projections

F. Long-term projections

Not relevant.

G. Biological reference points

There is no reference point for this stock. WKNEP 2016 investigated proposition for new reference points on the basis of the new UWTV surveys (LANGOLF-TV) combining with the SCA model.

H. Other issues

I. References

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