Stock Annex: Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Norway lobster

Working Group: Working Group for Celtic Seas Ecoregion (WGCSE)

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A. General

A.1. Stock definition

The management area for this stock is delimited in area 7.f,g,h (FU 20-22; Fig. 1). The management unit is pertinent because of the sedentary feature of *Nephrops*. However, the sources of recruits are much more poorly defined. There is no evidence that the whole exploited area belongs to the same stock or that there are several patches linked in meta-population sense.

A.2. Fishery

Nephrops present particular ground features and in the FU 20-22 are known to occur in several areas of muddy sediment and the stock structure is uncertain. The *Nephrops* fisheries target different areas and have very different size structures in *Nephrops* catches and landings. These fisheries also have differences in non-*Nephrops* by-catch composition.

As for all crustaceans, *Nephrops* grow by successive moults which are to a large extent tied to reproduction. For this species moult occurs twice a year, in spring and autumn until sexual maturity. Once males are sexually mature, they continue to moult twice a year while females moult only once a year in the latter spring/summer right after the hatching of their eggs. In previous references (1970-80's), it is pointed out that maturation of females happens at a median size of 31 mm CL (10 cm of total length) which corresponds to 3.5 years old individuals. There is no specific reference for the sexual maturation of males in the FU 20-22, but biological references on close areas with similar hydrological conditions (FU 15; Western Irish Sea) indicate a first size of functional maturity of 29-31 mm CL.

As reported by the WGNEPH 2004 and the WGSSDS 2005 and 2006, *Nephrops* in FU 20-22 is mainly exploited by trawlers from France, Republic of Ireland and UK although the contribution of other countries is lower. The spatial distribution of landings by statistical rectangles are provided below (Fig. 2-5). It indicates heterogeneous spatial behaviour of the main fleets.

France

No major changes have taken place in the fishery for more than fifteen years apart from the implementation of a new mesh regulation in 2000 which increased the minimum codend mesh size from 80 to 100 mm (in fact, the regulation involves to 90 mm mesh size, but 100 mm meshes are adopted aiming to avoid problems with by-catch composition). The 100 mm mesh size also allows them to switch to finfish (cod, whiting, haddock) when *Nephrops* catch rates are low (*e.g.* because of diurnal and seasonal variations of catchability for this species or during periods of bad weather). The MLS applied by the French Producers' Organisations is fixed at 11.5 cm total length (*i.e.* 35 mm CL). The total number of vessels from the harbours of the South Brittany remains stable (more than 90 declared *Nephrops* catches from the Celtic Sea in recent years, but around 70 are actually targeting this species). A part of these units (15-20) switch to other *Nephrops* stocks (FU 16; Porcupine bank; Fig. 1) mainly in 2^{nd} and 3^{rd} quarters when the meteorological conditions are favorable. At the opposite, many trawlers (20-30) move towards the FU19 *Nephrops* (SE and SW Irish coast) mainly in autumn and winter according to difficulties due to weather.

Analytical investigations were carried out on the data collected in 2006 and 2007 involving in the French trawlers. Global indices for fishing effort and LPUE provided by this fleet (97 trawlers composed by 73 exclusive in Celtic Sea, 15 switching to Porcupine Bank *i.e.* FU 16 and 8 also targeting *Nephrops* in the Bay of Biscay *i.e.* FU 23-24) seem to be pertinent: 99% of vessels*months registered for sales at auction can also be found in logbooks (94% of French landings in 2007). In 2006, almost 50% of French landings occurred in two ICES rectangles (29E2, 30E2; the rectangle 30E2 during the 2^{nd} quarter concentrated 21% of yearly landings). In 2007, the contribution of the two rectangles 29E1 and 30E2 was 41% of yearly landings. In 2008, the rectangles 28E1 and 30E2 were represented by 44% of yearly landings. The peak of production is observed during the 2^{nd} quarter of the year (Fig. 4): in 2006, the maximum landings are obtained in June whereas a shift occurred in 2007 (maximum value in May which may be caused by bad meteorological conditions in June). In 2008, the shape of French landings vs. month was bi-modal (May and July were the mostly represented months).

The historical review of French landings shows that the contribution of the rectangle 31E3 (concentrating the major part of Irish landings) declined over the last 10 years: from 41% of total French landings registered in 1999 this contribution is currently less than 10% (Fig. 3). During the last 10 years, the most productive rectangle for French trawlers was 30E2 mainly during the late 2000's: the average annual contribution of this rectangle was around 15% in the early 2000's, but this proportion reached more than 30% during the recent years. It seems that the French fleet moved gradually from 31E3 to 30E2 under the steeply increasing concentration of Irish trawlers on the "traditional" *Nephrops* grounds (Smalls, Labadie).

Republic of Ireland

More than 60 Irish vessels target *Nephrops* in the Celtic Sea. In 2007, 95 Irish trawlers were registered as landing *Nephrops*, but 63 of them exceeded threshold of 10 t (Fig. 6). In 2008, 99 Irish vessels reported landings from this area whereas 67 of them landed more than 10 t. The fishery presents a more typical seasonal profile than the French vessels and most of the landings are made between March and July. These vessels are mid-size multi-purpose trawlers, with a length of 18-23 m and engine power between 250 and 350 kW. Many of the vessels switch between FU 15 and FU 20-22, depending on the tides in the Irish Sea. Other vessels switch from targeting finfish in the winter to *Nephrops* in the spring and early summer. The mesh size used by Irish vessels is 80 mm, and increasingly these vessels are using twin trawls. The MLS applied by Irish trawlers is the European one fixed at 8.5 cm total length (*i.e.* 25 mm CL).

The Irish landings seem to be more concentrated spatially than the French. During the period 2003-2006, 63-67% of the Irish nominal landings were provided by one ICES rectangle (31E3). The Irish fishing effort is located more northerly than the French one.

UK

The UK fishery in the Celtic Sea has generally remained unchanged. Since the early 2000's, the number of UK *Nephrops* directed vessels has increased from around 10 to 15, but their contributions in total landings remains minor (usually less than 50 t of landings). The maximum historical value of UK landings is reported in 2008 (242 t).

A.3. Ecosystem aspects

Nephrops occur in discrete patches where the sediment is suitable for them to construct their burrows. There is a larval phase of long duration where there may be some mixing with *Nephrops* from other areas depending on the oceanographic conditions, but the mechanisms for this in the Celtic Sea are not currently known.

Cod has been identified as a predator of *Nephrops* in some areas, and the generally low level of the cod stock is likely to have resulted in reduced predation on *Nephrops*.

B. Data

B.1. Commercial Catch

Landings are reported mainly by France and the Republic of Ireland. French landings fluctuated between 2000 and 3800 t. Irish landings rose from around 500 to more than 2000 t in the last 15 years. The highest value of Irish landings is observed in 2007 (more than 3200 t). A part of this trend is due to greater accuracy of reporting mainly after the end of the late 90's. The contribution of French landings has gradually decreased from 80-90% at the end of 80's to 50-60% at the beginning of 2000's. Between 2004 and 2005, French landings remained stable whilst Irish landings steeply increased and the total harvested quantity was the highest during the last decade. For the first time, in 2007, the Irish ladings exceeded the French ones (3230 t against 2080 t). This may be caused by constraints linked to the international context affecting fuel prices for fishing vessels. The overall fishing profile remains typically seasonal with a dominance of the 2nd and 3rd quarters (60-70%; the other quarters are less productive because of meteorological conditions and of less accessibility of females due to burrowing).

During the recent years, the evolution of the French fishing effort and LPUE was sometimes considerably different from the evolution of the same indicators for the Irish fleet (*e.g.* between 2004 and 2005: -5% of fishing effort and +2% of LPUE for French trawlers against +50% of fishing effort and +25% of LPUE for Irish trawlers). In 2007, an increase occurred for LPUE values of both main fleets: a slight upwards trend of French trawlers (+13% associated to a strong reduction of the fishing effort: -25% whereas the total number of vessels remained almost stable) and a steep one for the Irish fleet (+36% coinciding with +31% of the fishing effort which was displayed by an increasing number of trawlers operating in the Celtic Sea: +19% between 2006 and 2007). This underlines the divergence of features of the targeting vessels for each country and indicates the great heterogeneity of the area. A direct comparison between both countries cannot be undertaken because the fishing effort is not available in the same unit (France: otter trawlers getting at least 10% of their total landings by targeting this species; Ireland: otter trawl vessels where >30% of monthly landings in live weight were *Nephrops*). Furthermore, the actual fishing areas are different and the Irish fleet is more restricted spatially as already reported by WGSSDS 2005-2008.

B.2. Biological

Natural mortality and maturity at age.

A natural mortality of 0.3 is applied to all *Nephrops* males whereas the mortality of females changes at the size of first maturity (occurring at 31 mm CL as explained previously): a value of 0.2 is usually applied on mature individuals.

The L2AGE slicing program usually applied on *Nephrops* stocks allocates length classes into age groups by assuming Von Bertalanffy model of individual growth. This slicing is applied to length distributions by sex. All parameters, $L\infty$ and K by sex, calculated mean sizes by age for each sex, natural mortality and maturity by sex (assumed to be knife-edged for males and s-shaped for females) and combined are given below.

Table 1. *Nephrops* FU20-22 (Celtic Sea). Individual growth, natural mortality, maturity parameters by sex.

MALES AND IMMATURE FEMALES: $L\infty$=68, K=0.17; MATURE FEMALES: $L\infty$=49, K=0.10									
age		1	2	3	4	5	6	7	8+
Size (CL mm) mm	males	11	20	27	34	39	44	47	51
	females	11	20	27	32	33	35	36	37
M	males	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	females	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	combined	0.3	0.3	0.3	0.25	0.25	0.25	0.25	0.25
Maturity	males	0	0	1	1	1	1	1	1
	females	0	0	0	0.5	1	1	1	1
	combined	0	0	0.5	0.75	1	1	1	1

Biological sampling

Landings: The total French landings have been available since 1983 (on quarterly basis since 1987) whereas the Irish series began in 1987 (on quarterly basis since 1995).

LPUE and fishing effort: LPUE series are provided since 1987 in France whilst Irish data are available over 1996. It has to be noted that the French and Irish method of calculation of the fishing effort are not carried out by the same way (threshold of 10% in weight for *Nephrops* on total landings applied for French trawlers whereas 30% is the threshold used for Irish fleet), thus a direct comparison of those indices is not appropriate.

DLF of landings: French sampling plan at auction started in 1983, but only after 1986 the data can be used on quarterly basis. The Irish plan as written previously began in 2002 (in fact, solely 2003 has been entirely sampled in the FU 20-22 area; 2002's data involving the whole Management Area M: see processing by WGSSDS 2006; two quarters were not sampled in 2004 and 2005: see processing by WGSSDS 2006). For

French landings, the increasing proportion of tailed individuals (see below) and the inappropriate method of sampling before the end of 2007 provided

DLF of discards: French estimation of discards occurred only in three separate years (1985, 1991 and 1997), but only the data collected in 1997 can be included in analytical investigations. The available dataset is given for only one year of discard sampling (1997) because of unavailable quarterly data for landings for the first year of discard sampling (1985) whereas data collected in 1991 were considered as unreliable (samples sorted by fishermen). Irish sampling has been undertaken since 2002 (lack of information for two quarters in 2004; see processing by WGSSDS 2006).

Length compositions of the landings by sex are provided for the two main fleets, but the time series are different. Sampling of French landings since 1984 has provided length frequencies by sex on a monthly basis. Due to uncertainty of the older data sets, the data for 1984-86 were omitted from further analysis. The Irish sampling program was launched in 2002 under the EU DCR and gave length frequencies for the period 2002-2006 (after simulation undertaken for some missing information in 2004 as explained during WGSSDS 2006).

French estimation of discards occurred only in several separate years (1985, 1991 and 1997; in 2005, samples for two quarters, 3rd and 4th, were also provided), but only the data collected in 1997 can be included in analytical investigations because of unavailable quarterly data on landings for the first year of discard sampling (1985) whereas data collected in 1991 were considered as unreliable (samples sorted by fishermen not representative of the discarding behaviour of the whole fleet). The 1997 French plan onboard showed high spatial and temporal variability of discard size-composition vs. that of landings (CV>30 %). The Irish sampling launched under DCR gave results as presented by Table 2.

The heterogeneity of the dataset in addition to that of the harvested area by each country affects the discard rate by fleet: it was higher for French vessels: 65% in 1997 against 37% for Irish in 2003 (the only one year with sampling, but only 11% during the quarters 2 and 3 in 2004) and by sex (stronger in the case of females growing less quickly).

Table 2. FU 20-22 Irish Sampling Summary

Year	Quarter	Number of samples			Numbers Measured		
		Catch	Discards	Landings	Catch	Discards	Landings
2003	1	1	1		186	417	
	2	5	5		4057	3016	
	3	3	3		2535	3638	
	4	2	1		996	528	
2004	1	0	0		0	0	
	2	3	2		1634	2781	
	3	7	6		4284	7171	
	4	0	0		0	0	
2005	1	1	1		1330	2271	
	2	2	2		2208	3238	
	3	2	0		1634	0	
	4	2	0		1627	0	
2006	1	2	1	2	1891	1152	2252

	2	10	2	2	7241	1049	363
	3	5	1	0	3178	1101	0
	4	9	0	0	8266	0	0
2007	1	1	3	0	767	770	0
	2	12	0	0	9648	0	0
	3	15	4	2	7784	1862	411
	4	6	5	0	1959	1417	0
2008	1	2	5		680	1758	
	2	10	13		3409	5333	
	3	3	2		878	546	
	4	4	4		1356	1573	

Extrapolations

Landings: DLF of tailed *Nephrops*

The WGCSE 2009 pointed out a significantly increasing proportion of tailed individuals in French landings whereas this proportion was already high for Irish trawlers. In 2008, 20% of total French landings involved in tailed *Nephrops* (19% in 2007, 15% in 2006 and 11% in 2005; less than 5% until the beginning of 2000's). The overall upwards trend is illustrated by the Figure 7 presenting also monthly tailed fractions (after conversion of weight of tails to total one).

The seasonal variability of tailed *Nephrops* may be explained by biological features of the species (two peaks appear by year corresponding to the two moulting periods, spring and winter) and by the particular conditions of trips (12-15 days) compromising the conservation of *Nephrops*. As regards to the annual increasing proportion of tails (96% explained by using an exponential function), industry explained it by the economic difficulties of the vessels because of the rapidly increasing fuel prices. Tailed individuals are intended to compensate this loss for the crew participation at the total investment by trip. As the European MLS for FU20-22 *Nephrops* is fixed at 8.5 cm of total length (25 mm CL) and the MLS retained by the French Producers' Organizations is equal to 11.5 cm (35 mm CL), it was expected that tailed individuals should be comprised between these two sizes.

Before the end of 2007, the tailed *Nephrops* could not be sampled at auction and, as the sampling onboard remains difficult to apply routinely (long trip duration for French trawlers), the problem was partially tackled by apportioning tailed individuals to the smallest category of landings at auction. Since the end of 2007, new biometric relationships established during the EVHOE survey have been used: they allow to fit CL vs. 2nd abdominal segment of tail by sex (Fig. 8). The DLF of French landings for 2008 were estimated by two ways: one using the extrapolations from tails to CL, the other apportioning tails to the small category as for previous years. The resulting difference appears relevant (Fig. 9): in 2008, 46 million *Nephrops* were provided by the previous method whereas 58 million were estimated by including tails (+28%). Almost 30% of landed individuals were below the French Producers' Organization MLS, but no *Nephrops* was undersized compared with European MLS. Moreover, the sex ratio seems to be affected by the tailing practice: 13% of *Nephrops* (7.4 million) were females although this percentage would be 7% (3.2 million) under the previous method. The mean size of French landings for 2008 decreases at around 2.5-5 mm CL by sex when tails are involved by sampling. However, the mean CL for 2008 remains larger than the Irish one.

Table 3. ***Nephrops*** **in 7.f,g,h. Mean sizes (CL in mm) of French and Irish landings for 2008. French values are calculated (1) including the samples involving in tailed individuals and (2) using the previous method (no sampling of tails; the total tailed proportion was apportioned in the smallest category of entire** ***Nephrops*** **at auction).**

French sampling			Irish sampling		
Males	Females	Total	Males	Females	Total
37.6	34.7	37.2	32.0	29.7	31.1
40.1	39.6	40.1			

This result emphasizes the WGSSDS 2008 conclusion that the size composition may be overestimated when raised to the composition of entire individuals.

Discards: years with no sampling onboard

Generalities

As the sampling plan for both countries was not routinely undertaken, the whole time series of landings by quarter either for the French fleet (years 1987-2007) or for the Irish one (years 1995-2007, years 1987-1994 are only represented by annual landings) misses information. Therefore, a methodology of extrapolation from sampled data to years or quarters with no information was developed (see WD 1; WGSSDS 2007).

The main concepts of the derivation (back-calculation) are summarized as:

(1) The first step involves applying hand-sorting selection of retained catches which is explained by s-shaped (logistic) function vs. size. As statistically tested by fleet, the hand-sorting function is stable within-quarter for given parameters of the exploitation pattern (if mesh size and MLS remain constant within period).

(2) The second step consists in removing undersized individuals unusual in landings which can generate unreliably extreme values of discards due to sampling problems (very high CV of landings for the extreme size classes). Hence, size classes less than a tested threshold (*e.g.* 1 or 5% of cumulative landings) were eliminated.

(3) The third step allows the generation of missing size classes by applying a probability density function which can be symmetrical or not. The whole calculation is based on multiple maximum likelihood function according to the number of missing years. Relationship as between mean sizes of landings and of discards tested on the FU 23-24 *Nephrops* (Bay of Biscay; WGHMM) can also be included in the final fitting.

Particularities for FU 20-22 *Nephrops* stock

The approach summarized above was already developed on the FU 23-24 *Nephrops* stock (Bay of Biscay) and its validation was investigated during the WGHMM 2007 (Fig. 10-14). The WGSSDS 2007 examined statistical formulation and validation of this method on French (years 1987-2006) and Irish (years 2002-2006, investigation by quarter) discards for FU 20-22. There are some differences from the calculation applied on the Bay of Biscay as:

(1) The available French dataset is given for only one year of discard sampling (1997). It means that the hand-sorting s-shaped curves by quarter are calculated on only one year[1] instead of six in the case of the Bay of Biscay stock.

(2) The cumulative percentage level for removing of undersized generated discards (see above: 2nd stage) is fixed at 5% for French data and 1% for Irish data (also 1% for the Bay of Biscay *Nephrops* stock). In the case of the French fishery in Celtic Sea, this can be justified by the high variability of landing samples between trips (higher coefficients of variation at auction because of higher heterogeneity of the fished area and of long duration of trips *i.e.* 12-15 days and, hence, less availability of samples at auction).

(3) For the French discards, with only one year of discard sampling, the initial value of the parameter Lm can not be assumed to be equal to any expected mean size of discards *vs.* mean size of landings (see above 3rd stage). Furthermore, the interval in which Lm should be contained is not statistically calculable. Hence, Lm is initially introduced as the size corresponding to the maximum number of discarded individuals as provided by the 2nd stage of calculation (*i.e.* after removing extremely high values of discards obtained after the 1st stage: hand-sorting logistic function). Its interval is built by using an *a priori* coefficient of variation around the initial Lm (CV of 0.10 and 0.20 were tested). For the Irish data, no constraint on relationship between mean sizes of discards and landings was set because of lack of any information on that due to the short time series.

(4) The large mesh size of the French vessels in the FU 20-22 area indicates that the distribution of length frequencies of discards is probably no symmetrical because of selectivity effects which should be more significant than for the FU 23-24 stock or for the Irish trawlers in the FU 20-22.

(4) For French discards, the absence of reference about any relationship between mean sizes of landings and discards at the opposite of the Bay of Biscay, implies that the final fitting aims to provide the more linear as possible relationship (after log-log transformation) with only one reference point (year 1997). Hence, the optimisation is more based on geometric concept than on statistical one.

1st stage: the s-shaped hand-sorting curve

Let j be a year with no dataset on discards. By quarter k, the number of discarded individuals by sex (m or f) and by size L, ND_{jklm} (or ND_{jklf}), is not calculated on data provided from other years, but from the number of landed individuals NL_{iklm} (or NL_{iklf}) during the same year, quarter k, sex (m or f) and size L:

$$ND_{jklm} = NL_{jklm}.\exp(-\alpha_k.(L-L50_k)) \quad \text{or} \quad ND_{jklf} = NL_{jklf}.\exp(-\alpha_k.(L-L50_k)) \qquad [1]$$

α_k and $L50_k$ are the parameters of the s-shaped curve (logistic model) fitted by quarter k describing the commercial *Nephrops* hand-sorting onboard. For this fitting, both sexes are combined and the dependent variable is expressed by the number of landed individuals for size L and the independent one is the total number of catches by size L for the years with discard sampling onboard.

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1 The six trips sampled in 2005 provided new s-shaped curves of hand-sorting for Q3 and Q4 which were used for simulations of the recent period since 2000 *i.e.* since the mesh size change.

The estimates α_k and $L50_k$ were calculated by assuming the stability of hand-sorting process onboard if mesh size and MLS remain unchanged. The short Irish time series 2002-2006 was considered as a common dataset, but, for the French trawlers, the overall time series was divided into three periods:

(1) *Years 1987-1990*: The results of sampling carried out in 1985 are not available on computing support. Thus, there is no formal information if the hand-sorting onboard could be approximated by the more recent parameters of 90's. α and L50 were not got fixed, but their values were estimated by the multiple likelihood function as for the parameters of the probability density by year (see below).

(2) *Years 1991-1999*: The hand-sorting was fitted on data from 1997 (1991's data were not representative of the whole fleet). The missing data of years 1991-96 and 1998-99 were therefore estimated.

(3) *Years 2000-2006*: Because of the mesh size change, the hand-sorting should be different from 1997's sampling data. However, there is no new information for the 1st and 2nd quarters (the 2005's sampling plan provided relevant results only for the 3rd and 4th quarters). Hence, α and L50 for the first two quarters were fixed equal to 1997's parameters, but the simulation for the other two quarters is based on 2005's data.

2nd stage: removing of unreliable size classes of discards

This derivation approach reduces interdependence between yearly datasets which may induce lack of contrast in recruitment time series. In spite of that, some inconveniencies of the new approach have to be taken into account: (1) the hand-sorting onboard s-shaped curve implies that, for a given size class, no calculation of discards is possible while there is no landed individuals and (2) the exponential expression gives extremely unreliable high values of discards when undersized individuals are sampled in landings (mainly because of hand-sorting deviation due to sampling rate not representative for extreme size classes).

(1) *Undersized individuals unusual in landings*. As written previously, undersized *Nephrops* sampled in landings should produce unreliable high discarded amounts by size because of the exponential calculation. All size classes representing less than a minimum cumulative percentage level in landings by year were removed (5% for French landings, 1% for Irish landings).

(2) *Discarded individuals by size exceeding observed mean ratios discards/landings*. Generated discarded numbers were removed when the calculated ratio discards/landings by size (decreasing function *vs.* size) exceeded observed mean ratios by size[2]. Almost all size classes involved by (2) were already removed by (1). This operation was added at the aim of elimination of not normally high ratios discards/landings for large sizes (which has a little impact on total discarded number due to the s-shaped function of hand-sorting).

This calculation process retains only a part of the initial hand-sorting generated distributions of discards mainly the decreasing part of discarded individuals.

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2 This procedure is performed only on Irish dataset whereas it is not pertinent for French data (only one year dataset).

3rd stage: simulation of densities of probability of discarded individuals (yearly distribution for French and quarterly for Irish discards)

Finally, the assumed distribution of discards for the whole range of sizes was calculated from the descending part. This process needs to input the probability density of discards given by:

$$\varphi(L) = \frac{\alpha}{1 + \exp(\beta.(L-Lm)}$$

[2]

where α, β, Lm are coefficients of the distribution ($\varphi(L)=\alpha/2$ when L=Lm).

Because of the assumed skewness for the French discard distribution, as explained above, the whole function of the probability density is approximated by:

$$\varphi(L) = \frac{\alpha}{1 + \exp(-\gamma\beta.(L-Lm)} \qquad \text{for} \quad L \leq Lm$$

$$\varphi(L) = \frac{\alpha}{1 + \exp(\beta.(L-Lm)} \qquad \text{for} \quad L > Lm$$

[3]

with a complementary coefficient γ: if $\gamma=1$ the whole probability density is symmetrical, if $\gamma<1$ the skewness of the distribution is positive if $\gamma>1$ the skewness is negative ($\gamma=1$ for Irish discards, $\gamma\neq1$ for French discards).

The fitting of $\varphi(L)$ is processed on two stages:

- *Lm and α are fixed*: α is initially fixed at $2^*\varphi max$ which is the maximum frequency retained after the 2nd stage of calculation (see above), Lm is fixed at the size corresponding to the maximum number of discarded individuals as provided by the 2nd stage of calculation (see previously) and, hence, β is given by:

$$\beta = \frac{1}{n}\sum_{L=L\min}^{L\min+n-1} \ln\left[2.\frac{\varphi\max}{\varphi(L)} - 1\right]^{\frac{1}{L-Lm}}$$

[4]

(Lmin= first size represented by not null individuals and n= number of total size classes with discards different from zero).

All parameters are estimated: α, β, Lm got obtained by the 1st stage are input for the final calculation using Newton cancellation of gradient and assuming stochastic approach for Lm. Lm is assumed to be included in the interval defined accordingly to an a priori CV of Lm (see above)[3].

Otherwise, the final run includes constraints as:

- The sum of frequencies for descending part of distribution is equal to that calculated by the model *i.e.* the retained values of the 2nd stage of calculation described previously are assumed to be reliable.
- Lm ≥ Lmin [$L\min=(1-Z_{1-\alpha/2}.CV)^*Lm$] (usually: $\alpha=0.05 \Rightarrow Z_{1-\alpha/2}=1.96$)

3 For French discards, are also included in the optimisation algorithm, the parameters α and L50 of the first period (1987-1990) which remained unknown.

- $Lm \le Lmax$ [$Lmax=(1+ Z_{1-\alpha/2}.CV)*Lm$]
- For French discards, the coefficient of determination of the relationship between the mean sizes of landings and the mean sizes of discards for missing years has to be as close as possible to 1 (with no possibility of statistical test because of only one year dataset).
- Statistical formulation and validation

Calculation of variances

Matrix of variances–covariances of model parameters

The Generalized Reduced Gradient and the Complex method do not give an estimate of the matrix of variances-covariances of the four (three for Irish) parameters. In this case, it is usually recommended to apply non-parametric techniques such as the Bootstrap method. The calculation can also be carried out according to parametric procedure (Lin, 1987; Fifas and Berthou, 1999; Fifas *et al.*, 2004) using Jacobian matrix (*i.e.* matrix of partial derivatives of the objective).

The matrix of variances-covariances is obtained by the following relationship:

$$[M] = s^2.[I]^{-1} \qquad [5]$$

with:

[M]= matrix of variances-covariances; $[I]^{-1}$= inverse of matrix of information; s^2= sum of mean residual squares of the fitted function (s^2=SCE/DDL[4]):

$$SCE=-\sum_{i=1}^{Lj<Lm}\left[\varphi(L_i)-\frac{\alpha}{1+\exp(-\gamma\beta.(L_i-Lm))}\right]^2+\sum_{i=j+1}^{Lj>=Lm}\left[\varphi(L_i)-\frac{\alpha}{1+\exp(\beta.(L_i-Lm))}\right]^2 \qquad [6]$$

The matrix of information is obtained by:

$$[I] = [J]'.[J] \qquad [7]$$

[J] is the Jacobian matrix (nc rows and 4 columns for French data, 3 for Irish):

$$[J]=\begin{bmatrix} \frac{\partial\varphi(L_1)}{\partial\alpha} & \frac{\partial\varphi(L_1)}{\partial\beta} & \frac{\partial\varphi(L_1)}{\partial\gamma} & \frac{\partial\varphi(L_1)}{\partial Lm} \\ \frac{\partial\varphi(L_2)}{\partial\alpha} & \frac{\partial\varphi(L_2)}{\partial\beta} & \frac{\partial\varphi(L_2)}{\partial\gamma} & \frac{\partial\varphi(L_2)}{\partial Lm} \\ . & . & . & . \\ \frac{\partial\varphi(L_{nc})}{\partial\alpha} & \frac{\partial\varphi(L_{nc})}{\partial\beta} & \frac{\partial\varphi(L_{nc})}{\partial\gamma} & \frac{\partial\varphi(L_{nc})}{\partial Lm} \end{bmatrix} \qquad [8]$$

[J]' is the transpose of [J], the partial derivatives of the equation [8], also defined as *absolute coefficients of sensitivity of order 1* written as $a(\alpha)$, $a(\beta)$, $a(\gamma)$, $a(Lm)$ are given below:

---

4 DDL is equal to nc-4 for French discards, but equal to nc-3 for Irish data (parameter γ is omitted).

$$\frac{\partial\varphi(L)}{\partial\alpha}=\frac{\varphi(L)}{\alpha}$$

[9]

$$\frac{\partial\varphi(L)}{\partial\beta}=\gamma.(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha})$$ if L ≤ Lm

[10a]

$$\frac{\partial\varphi(L)}{\partial\beta}=-(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha})$$ if L > Lm

[10b]

$$\frac{\partial\varphi(L)}{\partial\gamma}=\beta.(L-Lm).\varphi(L).(1-\frac{\varphi(L)}{\alpha})$$ if L ≤ Lm

[11a]

$$\frac{\partial\varphi(L)}{\partial\gamma}=0$$ if L > Lm

[11b]

$$\frac{\partial\varphi(L)}{\partial Lm}=-\beta.\gamma.\varphi(L).(1-\frac{\varphi(L)}{\alpha})$$ if L ≤ Lm

[12a]

$$\frac{\partial\varphi(L)}{\partial\gamma}=\beta.\varphi(L).(1-\frac{\varphi(L)}{\alpha})$$ if L > Lm

[12b]

Uncertainty of simulated discards

The matrix of variances-covariances of the four (three for Irish) parameters of the model and the use of partial derivatives of order 1 provide an approximate calculation of the variance of the variable Ψ(L) corresponding to simulated discards vs. size L. This procedure is based on limited developments of order 1 in Taylor's series (called Delta methods: Laurec, 1986; Laurec and Mesnil, 1987; Chevaillier, 1990; Chevaillier and Laurec, 1990; Fifas and Berthou, 1999; Fifas *et al.*, 2004).

By using Taylor's polynomial on a function Φ against parameters $\theta_1, \theta_2, \ldots, \theta_k$ it is possible to present the variance of Φ by:

$$V[\Phi] \approx \sum_{i=1}^{k}\left(\frac{\partial\Phi}{\partial\theta i}\right)^2.V[\theta_i] + 2.\sum_{i=1}^{k-1}\sum_{j=i+1}^{k}\frac{\partial\Phi}{\partial\theta i}.\frac{\partial\Phi}{\partial\theta j}Cov[\theta_i,\theta_j]$$

[13]

Then, the variance of simulated discards vs. size, V[Ψ(L)], is written as:

$$V[\Psi(L)] \approx a(\alpha)^2.V[\alpha] + a(\beta)^2.V[\beta] + a(\gamma)^2.V[\gamma] + a(Lm)^2.V[Lm] + 2.a(\alpha).a(\beta).Cov[\alpha,\beta] +$$

$$2.a(\alpha).a(\gamma).Cov[\alpha,\gamma] + 2.a(\alpha).a(Lm).Cov[\alpha,Lm] + 2.a(\beta).a(\gamma).Cov[\beta,\gamma] + 2.a(\beta).a(Lm).Cov[\beta,Lm]$$

$$2.a(\gamma).a(Lm).Cov[\gamma,Lm]$$

[14]

where the absolute coefficients of sensitivity of order 1 (partial derivatives) are defined above (equations [9] to [12])

Validation

The generated by simulation values are tested against discards estimated by sampling. This procedure is undertaken on French data of 1997 and also on available Irish set (all quarters of 2003, 2004-Q2, 2004-Q3, 2005-Q1, 2005-Q2, 2006 apart from Q4 *i.e.* 11 quarters). As performed for the Bay of Biscay *Nephrops* stock, this validation involves in three main stages (Fig. 10-14): (1) Examination of the total amount of discards calculated by simulation that should not be significantly different from that obtained by sampling. (2) Test by linear regression performed on simulated numbers vs. size as dependent variable against sampled numbers as independent one. The slope of this relationship should not be significantly different from 1 (bisecting line) and the intercept should not be significantly different from 0. (3) Test of cumulative frequencies of the sets, sampled and simulated, using non parametric approaches such as Kolmogorov-Smirnov.

Results

Hand-sorting s-shaped curves

The French and Irish hand-sorting logistic curves estimated by sampling are provided by Figure 15. In the Table 4, are also presented the French parameters involving in years 1987-1990 (simulated by the multiple likelihood function applied for probability density of discards; see above).

TABLE 4. SUMMARY OF PARAMETERS OF S-SHAPED HAND-SORTING CURVES.

quarter	FR (years 1987-1990)		FR (year 1997)		IRL (years 2003-2005)	
	α	L50	α	L50	α	L50
Q1	0.797	32.685	1.006	32.776	0.480	25.876
Q2	0.494	35.573	0.718	36.019	0.426	26.016
Q3	0.331	32.227	0.851	33.654	0.559	25.785
Q4	0.697	31.138	0.815	32.381	0.412	24.886

These values indicate the high heterogeneity between the two fleets which accentuates the *a priori* high spatial heterogeneity of the targeted resource. Some weak differences are observed between the simulated values α and L50 of the first French period (1987-1990) and the sampling of 1997. Nevertheless, these parameters are given by deterministic way, therefore, there is no possibility of further statistical comparison.

Estimates of French discards

Estimates of French discards (1987-2006), total number of discarded individuals, parameters α, β, γ and Lm and corresponding coefficients of variation (CV, in %), are given below (Table 5). The Table 6 and Figure 16 present discard rates by sex and combined for the overall time series.

Table 5. French Nephrops trawlers, Celtic Sea (FU 20-22). Estimates of discards, coefficients of model and coefficients of variation of parameters.

year	disc	CV(disc)	Lm	CV(Lm)	α	CV(α)	β	CV(β)	γ	CV(γ)
1987	125752	4.62	30.278	3.25	25773	13.79	0.293	32.11	0.768	44.61
1988	425396	4.88	28.917	5.28	59518	16.97	0.260	39.24	0.534	56.57

1989	99536	4.02	31.061	4.36	14417	13.86	0.221	33.01	0.740	45.69
1990	81530	8.74	30.579	8.28	12219	28.86	0.221	61.77	0.866	92.51
1991	389726	5.69	29.479	5.70	57932	18.85	0.218	40.78	0.868	60.75
1992	377075	18.48	30.752	14.57	61039	58.97	0.314	142.51	0.534	193.98
1993	118210	199.42	31.299	147.10	20679	612.24	0.258	1356.53	0.879	1956.90
1994	93687	7.62	31.438	6.77	14384	24.84	0.232	54.91	0.830	79.80
1995	131541	136.57	31.808	95.39	25096	418.52	0.273	880.20	0.808	1323.18
1996	82811	6.05	32.357	5.61	12121	20.20	0.255	49.20	0.637	66.91
1997	96612	6.21	32.403	2.11	18050	15.36	0.673	46.01	0.397	55.62
1998	30494	7.62	31.393	10.98	3453	28.85	0.161	61.94	0.893	94.65
1999	36900	12.14	31.827	10.67	5618	40.01	0.236	84.90	0.791	127.28
2000	22234	46.41	33.790	56.24	2655	171.90	0.175	359.92	0.863	552.62
2001	98962	5.59	31.766	7.43	11594	20.94	0.191	46.64	0.682	69.25
2002	34283	18.42	33.466	21.52	4223	66.86	0.193	150.64	0.762	217.87
2003	59692	4.73	34.452	3.48	9659	15.04	0.285	36.31	0.638	49.26
2004	29493	9.36	33.546	9.20	4050	32.24	0.202	69.23	0.874	103.22
2005	15097	18.92	34.739	17.57	2098	65.03	0.205	136.51	0.873	206.98
2006	17286	6.86	36.327	7.29	2350	24.93	0.238	64.77	0.530	85.17

<u>Note</u>: the sampled year 1997 is given in bold and italic fonts whereas in coloured fonts are presented the years for which the model based on the probability density seems to be inappropriate (years 1993, 1995, 2000; extremely high CV of parameters and discarded numbers). The total discarded number cited for 1997 is the value obtained by sampling.

Table 6. **French *Nephrops* trawlers, Celtic Sea (FU 20-22). Discard rate (%) by year.**

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
total	65.0	83.8	58.6	51.2	86.2	82.0	60.9	55.8	63.4	54.3	65.4	40.1	40.3	31.7	64.9	37.4	49.3	40.7	28.8	28.7
males	46.5	67.0	38.5	32.8	73.7	65.3	40.7	37.0	44.2	33.6	45.6	23.0	23.8	19.8	46.4	21.0	30.0	24.0	16.6	18.2
females	86.7	96.5	86.1	79.6	96.0	96.3	90.2	82.3	88.3	88.1	94.7	75.0	72.9	55.6	85.5	80.8	90.6	81.4	68.8	48.9

As presented above, the model based on probability density with skewness gives generally adequate results (see parameters' CV) except for three years on twenty of the overall time series. Nevertheless, the provided CV are estimated by the model and do not necessarily reflect the actual uncertainty because of complex organization of samples (sub-sampling stratified plan applied onboard). This is illustrated by the sampled year 1997 which showed high spatial and temporal variability of discard size-composition vs. that of landings (CV of samples>30%) although the estimated by the model CV seems unlikely (weak value of 6.21%). Moreover, the generated by the model total number of discarded *Nephrops* for 1997 was under-estimated (66 millions *i.e.* 68% of the total number estimated by sampling: 97 millions). The use of the coefficient γ in the model was justified by the expected skewness of discard distributions due to the selectivity effect: in fact, all values of γ do not exceed 1. However, using the simulated model for the year 1997 with assumed symmetrical distribution of discards and with no constraint on relationship between mean sizes in discards and in landings provided more satisfactory results (Fig. 17). The symmetrical simulation gave un estimate of 83 millions of discards *i.e.* 86% of the 97 millions calculated by sampling closer than the value generated with skewness. Moreover, the CV of parameters α, Lm and mainly β are less strong.

There is no current statistical evidence for choosing symmetrical or not distribution for simulations and there is no possibility to validate any relationship between mean sizes in discards and landings while the actual sampling is limited to only one complete year.

However, as underlined in the Stock Annex, the generated by model CPUE (including discards calculated by the probabilistic simulation with skewness) show a good agreement with EVHOE groundfish survey indices for the period 1997-2005 (R^2=0.65) whilst the relationship between LPUE and EVHOE indices seems more sparse (R^2=0.36). As also reported by WGSSDS 2007, throughout the overall time series, some high (years 1988, 2001) or low (year 1990) values of simulated discard rates coincide with increase or decrease of LPUE for 1-2 years later (increase in 1989-1990 and 2002-2003, decrease in 1991-1992). It is noticeable that no constraint was set for back-calculations on the relationship between discard rate (year i) and LPUE (years i+1/i+2).

Estimates of Irish discards

Estimates of Irish discards by quarter (since 2002), total numbers of discarded individuals, parameters α, β and Lm and corresponding coefficients of variation (CV, in %), are provided below (Table 7).

A first examination of results shows an overall better statistical adequacy than for French discards. Except for one sampled quarter (coloured fonts; 2005-Q2), the coefficients of determination are strong and the CV of model parameters remain relatively low. Despite this initial overview, the adequacy of the probabilistic approach will be tested as regards the procedure developed for the Bay of Biscay stock.

The Table 8 and Figure 18 present quarterly discard rates by sex and combined for the overall time series. Discard rates by sampling and by simulation can be directly compared for 11 quarters (Table 8): it seems that the average simulated discard percentage is slightly lower than the sampled one (26.0% against 27.3%), but for 8 quarters on 11, the simulated values are under-estimated.

The Table 9 and Figure 19 give comparisons between sampled and simulated discarded numbers. Two sampled years (2003 and 2005) for the 1st quarter give low correlations between sampled and simulated discards. Despite more good correlation levels (9 on 11), the overall conclusion is that the null hypothesis (slope=1) is refused apart from one example (2004-Q2) which although provides biased results of simulated discards (very high ratio Nexp/Nobs). It is worth noting that the descending part of simulated DLF of discards seems to be more coherent with the sampled DLF than the ascending one (except for one case on 11, 2005-Q2 which is denoted by the less good statistical consistency of simulation in regards with the low value of ϱ^2: Table 7). Introduction of some constraint between mean sizes in discards and in landings as for the French example may give different results for the ascending DLF.

Table 7. Irish Nephrops trawlers, Celtic Sea (FU 20-22). Estimates of discards, coefficients of model and coefficients of variation of parameters (bold characters=sampled quarters).

year	Q	disc	Lm	CV(Lm)	α	CV(α)	β	CV(β)	ϱ^2
2002	Q1	2664	26.039	0.95	1282	13.89	0.674	18.09	0.990
2003	Q1	6318	20.994	1.97	1476	11.52	0.319	15.53	0.855
2004	Q1	2208	24.743	1.34	998	18.48	0.625	24.42	0.960
2005	Q1	7613	25.929	0.88	3764	13.27	0.691	17.29	0.994

2006	Q1	11279	25.218	0.68	4594	8.56	0.564	11.32	0.929
2002	Q2	1670	27.891	1.10	666	14.69	0.555	19.37	0.950
2003	Q2	10236	25.119	0.72	4204	8.98	0.571	11.84	0.980
2004	Q2	4953	24.685	1.05	1003	6.39	0.278	8.59	0.951
2005	Q2	23437	25.139	1.42	3701	6.79	0.214	9.27	0.608
2006	Q2	15977	26.854	0.35	7902	5.61	0.688	7.35	0.987
2002	Q3	729	27.444	0.77	363	13.40	0.686	17.73	0.982
2003	Q3	15985	22.042	0.43	5780	4.04	0.504	5.33	0.940
2004	Q3	1291	28.143	0.26	571	3.90	0.615	5.13	0.969
2005	Q3	4795	24.751	0.64	2562	10.55	0.739	13.85	0.960
2006	Q3	2518	25.484	0.44	1144	6.48	0.626	8.60	0.927
2002	Q4	11343	24.442	0.56	5197	7.89	0.631	10.46	0.990
2003	Q4	2166	24.284	0.83	630	7.23	0.402	9.64	0.967
2004	Q4	1561	27.543	0.93	713	14.91	0.630	19.77	0.992
2005	Q4	9249	24.318	0.67	4603	10.22	0.687	13.49	0.992
2006	Q4	10394	25.289	0.67	5666	11.50	0.753	15.11	0.990

Table 8. Irish Nephrops trawlers, Celtic Sea (FU 20-22). Discard rate (%) by quarter and year (for the sampled quarters: the cited percentages in bold correspond to the sampling results; those in brackets are obtained by the simulation).

year	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
quarter	Q1	Q1	Q1	Q1	Q1	Q2	Q2	Q2	Q2	Q2	Q3	Q3	Q3	Q3	Q3	Q4	Q4	Q4	Q4	Q4
total	7.3	26.9	15.4	35.3	41.1	2.6	37.6	11.5	21.4	29.5	1.2	41.2	10.1	11.1	19.5	9.9	26.4	2.3	54.3	7.2
		(41.6)		(24.5)	(32.4)		(29.9)	(16.5)	(28.8)	(24.1)		(40.6)	(9.0)		(15.6)		(22.9)			
males	6.6	22.1	13.7	37.9	34.5	2.5	34.0	11.1	19.3	22.9	1.3	42.2	9.3	5.2	17.0	10.9	20.7	4.3	47.0	8.0
females	8.9	75.1	18.7	34.0	56.8	2.7	40.5	11.7	22.7	32.7	1.2	40.6	11.4	40.0	20.9	6.5	59.1	0.2	71.2	3.8

It would also be interesting to re-examine the comparisons after assuming skewness of discards distributions (use of coefficient $\gamma \neq 1$ as for the French fleet). It is noticeable that for 5 quarters on 11 (Fig. 19) the DLF of samples deviates from the assumed symmetry of simulations, then small sized individuals are under-estimated (however, the overestimation of the small *Nephrops* by the simulation occurs less often, but provides extremely divergent results). Although, there is no current basis for further analysis of this point because there is no evidence of any particular effect of some biological feature affecting the symmetry of distributions *i.e.* moulting which occurs in spring and autumn (example examined in the French fishery of the Bay of Biscay). The short time series and the low sampling rate do not allow to generalise this first overview.

Table 9. Irish *Nephrops* trawlers, Celtic Sea (FU 20-22). Relationships between discarded numbers by sampling (Nobs) and by simulation (Nexp).

Year/Quarter		Nexp=Ψ(Nobs)	ρ^2	p(slope)	Nexp/Nobs
2003	Q1	Nexp=0.87*Nobs+84.99	0.44	0.41	194%
2005	Q1	Nexp=0.60*Nobs-2.72	0.72	0.00*	60%
2006	Q1	Nexp=0.72*Nobs-12.49	0.89	0.00*	69%
2003	Q2	Nexp=0.72*Nobs-3.87	0.84	0.00*	71%
2004	Q2	Nexp=0.94*Nobs+45.90	0.85	0.38	152%

2005	Q2	Nexp=0.78*Nobs+267.45	0.85	0.00*	148%
2006	Q2	Nexp=0.83*Nobs-39.77	0.94	0.00*	76%
2003	Q3	Nexp=0.89*Nobs+32.24	0.94	0.00*	97%
2004	Q3	Nexp=0.86*Nobs+0.92	0.97	0.00*	88%
2006	Q3	Nexp=0.80*Nobs-2.90	0.91	0.00*	77%
2003	Q4	Nexp=0.74*Nobs+5.79	0.88	0.00*	83%

Note: *=significant result (1-α=0.95)

Conclusion

The biological sampling onboard for *Nephrops* FU 20-22 stock remains poor for both main fleets. The duration of trips for French trawlers (12-15 days) restricts possibilities of regular participation of observers. Moreover, in agreement with results of sampling design applied in 1997, the long duration of trips implies a high spatial variability of harvested areas by trip and a low total number of trips sampled by quarter. Thus, the CV of discarded numbers estimated by sampling remain high. By the way, the simulations developed on French discards are hampered by the sampling of only one year throughout a long time series. The discard practices during the whole period may change, but there is no current possibility to test the effect of such a modification on the hand-sorting onboard. In spite of that, some discard rates by year agree overall with independent indices as EVHOE groundfish survey indices (as pointed by last year's WG) and with the most notable changes in terms of LPUE during the whole time series.

The Irish dataset takes more promising because of a shorter duration of trips. Hence, conceptual problems of sampling design inherent to the French fleet should not affect the Irish data. As the Irish fleet seems to be more recruitment directed, the indices provided by the sampling onboard should improve the diagnostic accuracy. In the meantime, the simulation based on the probabilistic approach indicated an overall consistent reconstitution of discards for more sampled quarters. Many further investigations have to be carried out in the order to validate extrapolations from French catches to Irish for the period before 2002.

B.3. Surveys

Direct *Nephrops* assessment by trawling are inappropriate because of notable diurnal variations of availability which is higher during dawn and dusk. The most adapted way is based on transect with video and TV runs of burrows (combined with hauls on area and geo-statistical analysis of catches with the aim of separating burrows of *Nephrops* from those of squat lobster), but it needs heavy preliminary arrangements because the spatial heterogeneity of resource requires to well define the survey area and the sampling plan in order to avoid biased results. The current situation will be improved in the future once a data time series has been collected by the Irish specifically designed survey program launched in 2006. However, the Irish and French exploited areas are different. On FU 20-22 the French groundfish survey EVHOE while not focusing on *Nephrops* does provide an indication of the length distributions and the strength of recruitment (Fig. 20). An Irish groundfish survey giving size composition of *Nephrops* catches has also been carried out since 2003. Moreover, a UK bottom trawl survey had occurred on the same area between 1984 and 2004, but only two sampling stations were within FU 20-22 area.

A comparative analysis conducted between LPUE and CPUE of French and Irish vessels with EVHOE indices shows a good agreement between commercial French CPUE and EVHOE series for the period 1997-2005 (R^2=0.65) whilst the relationship is more sparse (R^2=0.36) when the commercial French LPUE are used (Fig. 21). The Irish data are not significantly linked to the French dataset probably due to the difference of harvested area and the short time-series.

The results of the UWTV survey initiated by Republic of Ireland in 2006 involving in the three first years, 2006-2008, are shown by Figures 20-25 and Tables 10-11. It is noticeable that the strongest values of this short time series (2006) coincide with the highest level on "Smalls" as reported by Irish industry in 2007. In a timeframe of around 2-4 years, this survey should provide valuable information to tune data for the FU20-22 *Nephrops* stock especially on the "Smalls" ground where are located more than the 2/3 of the total Irish yearly production. Nevertheless, the historical longer series of French landings in the Celtic Sea is less involved by the area covered by UWTV (the contribution of the rectangle 31E3 in the total French production fell from 41% in 1999 at less than 10% in 2008). This implies the necessity to tune data for the whole area.

B.4. Commercial CPUE

Between 2006 and 2007, the French fishing effort declined notably by –25% and the LPUE increased (+13%) although the evolution of the same indicators for the Irish fleet was different (+31% of fishing effort and +36% of LPUE). It is noticeable that the decrease of the French fishing effort was caused by the reduction of the number of trips by vessel whereas the total number of vessels remained almost stable. The evolution of the Irish fishing effort involves either in increase of the fishing vessels (95 Irish trawlers were listed in 2007 against 80 for 2006) or in increase of the number of trips by vessel.

Between 2007 and 2008, the effort of the French trawlers decreased slightly *i.e.* 99789 h against 101980 h for 2007 whereas the Irish fishing effort remained stable (59727 h against 59899 h in 2007). LPUE of both fleets increased mainly for French trawlers (+22%: 22.6 kg/h against 18.5 kg/h for 2007) and, to a lesser degree, for Irish (+11%: 55.2 kg/h against 49.4 in 2007).

C. Historical Stock Development

There is no currently specific development for analytical assessment of the stock. By the WGNEPH 2003, the FU20-22 *Nephrops* stock was analytically assessed by XSA (software VPA; Darby and Flatman, 1994). Because of the lack of long and consistent Irish series (before DCR), the analysis was limited on the male component involved by French trawlers (see input parameters: Table 1).

D. Short-Term Projection

No short-term projection is performed for this stock.

E. Medium-Term Projections

No medium-term projection is performed for this stock.

F. Long-Term Projections

No long-term projection is performed for this stock.

G. Biological Reference Points

There is no biological reference point for this stock.

H. Other Issues

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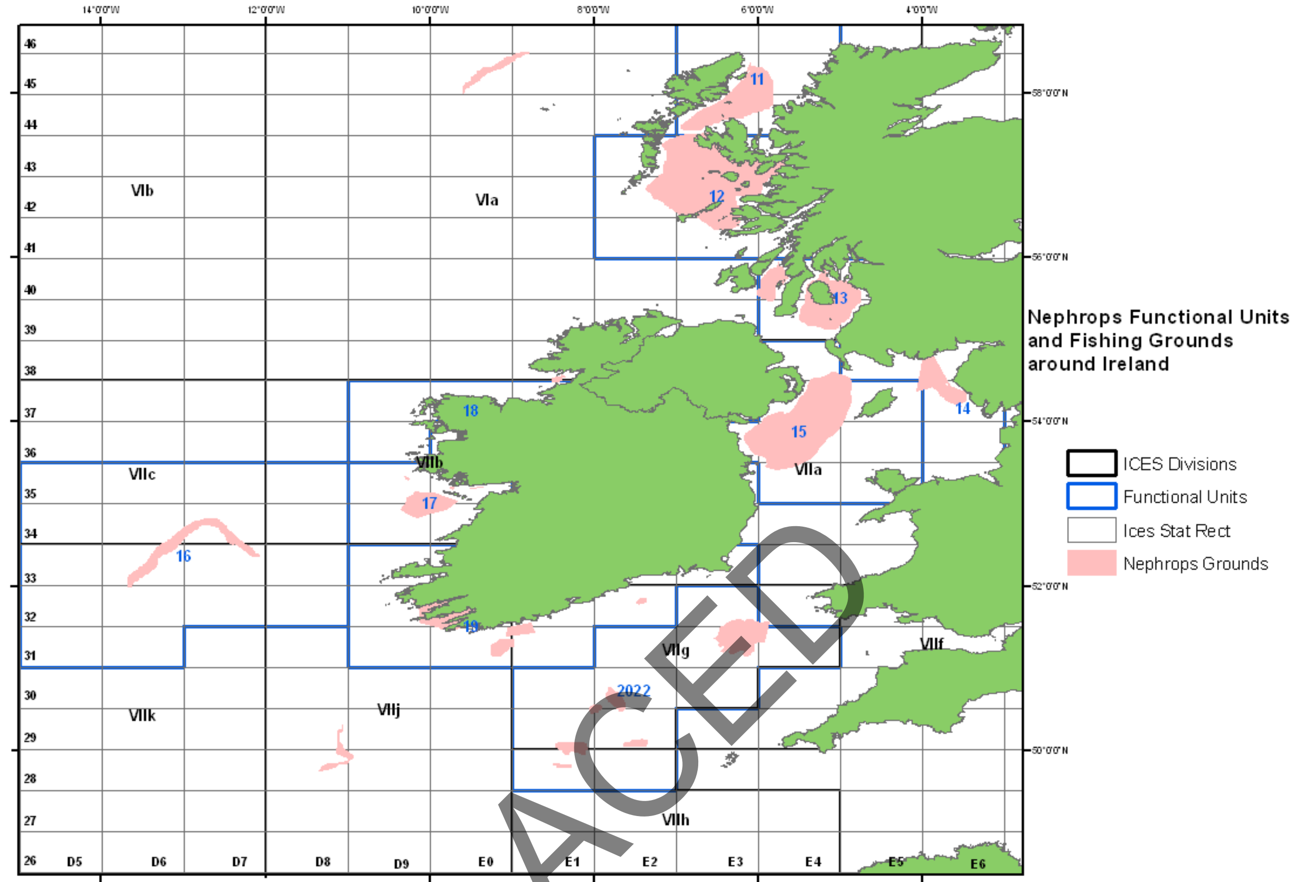


Figure 1. Functional units 20-22 (*Nephrops* grounds in Celtic Sea).

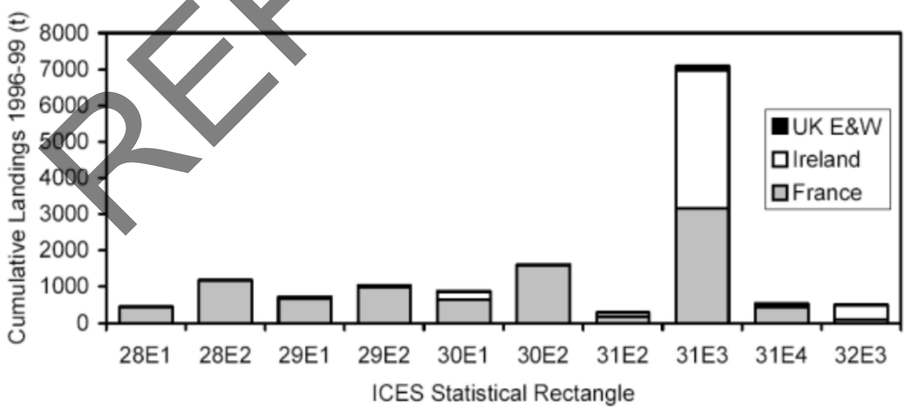


Figure 2. *Nephrops* FU 20-22 (Celtic Sea). Spatial distribution of landings of the main fleets (average value of the period 1996-1999).

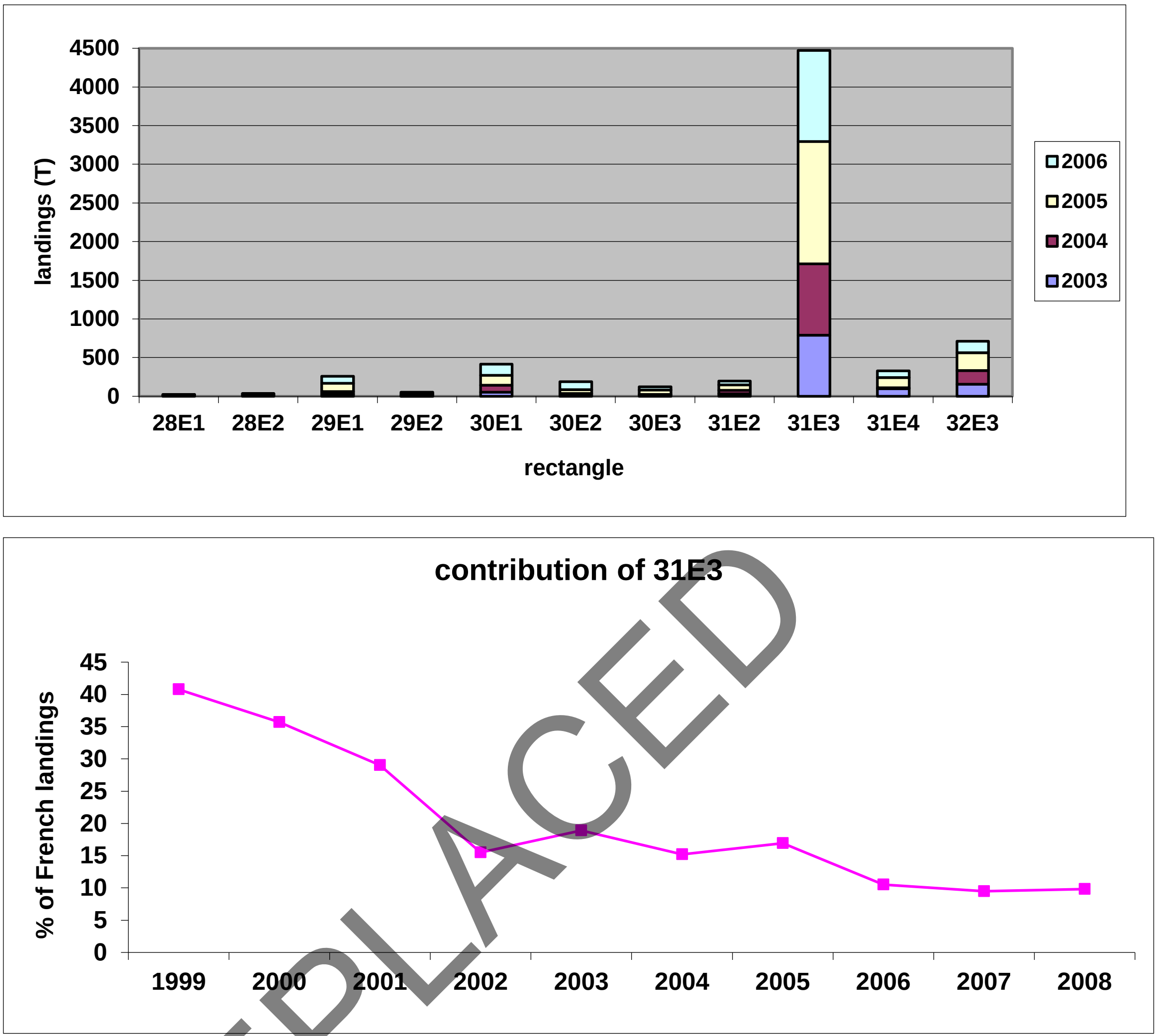


Figure 3. *Nephrops* FU 20-22 (Celtic Sea). Above: Spatial and by year distribution of Irish landings. Below: Contribution of the rectangle 31E3 (concentrating more than 2/3 of the total Irish production) in the total French landings. Years 1999-2008.

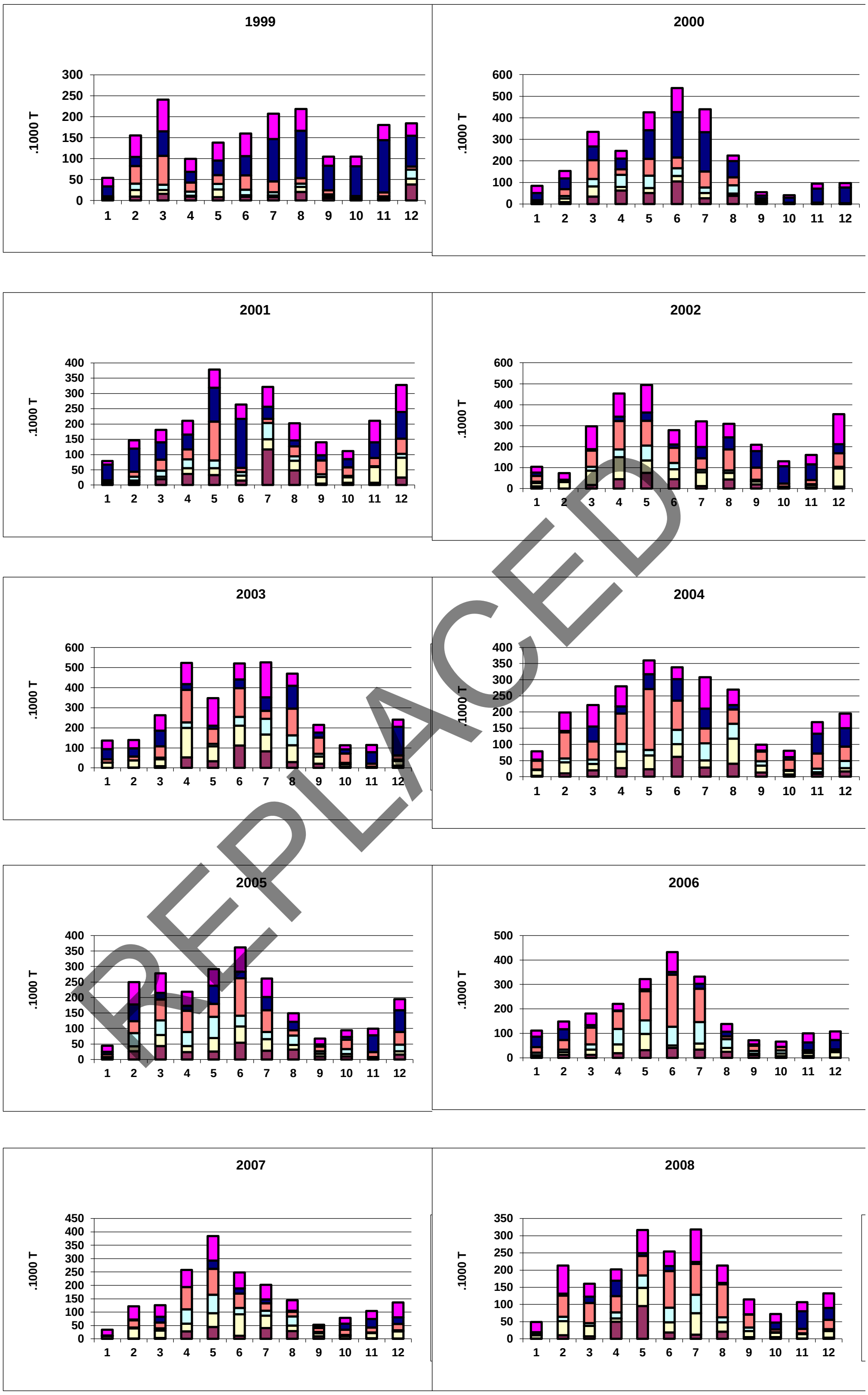


Figure 4. ***Nephrops*** **FU 20-22 (Celtic Sea). Spatial and monthly distribution of French landings.**

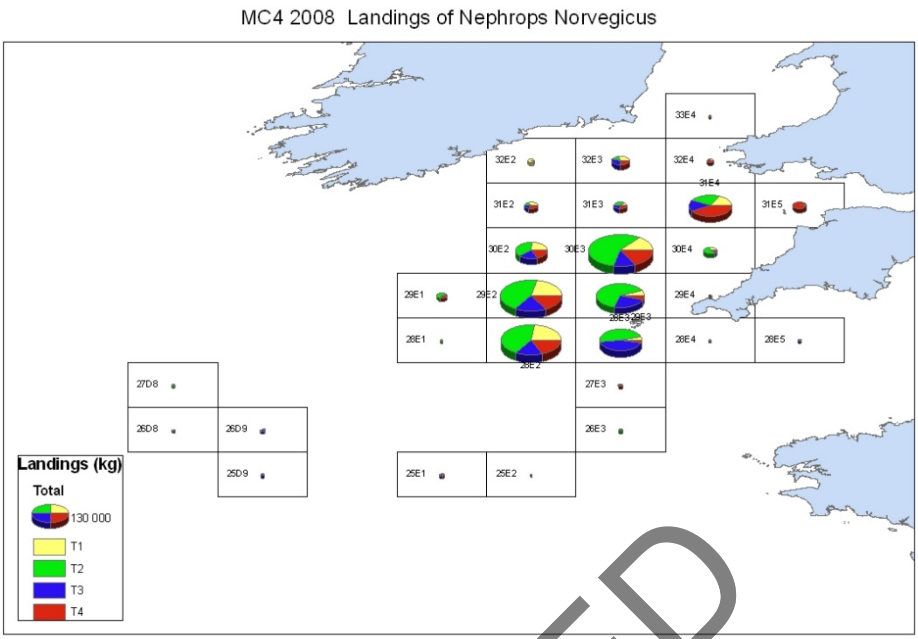


Figure 5. *Nephrops* FU 20-22 (Celtic Sea). Spatial distribution of French landings in 2007.

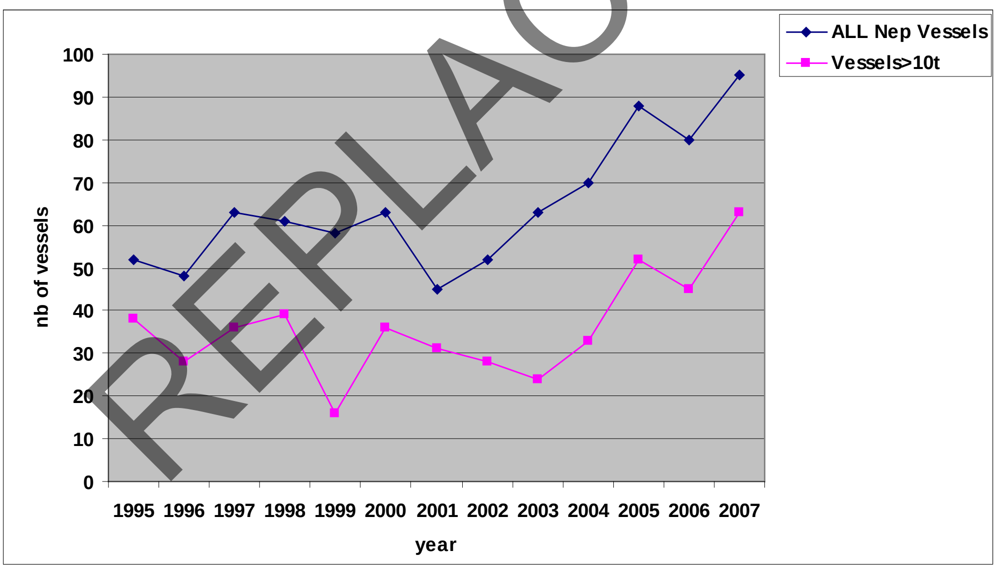


Figure 6. *Nephrops* FU 20-22 (Celtic Sea). Number of Irish trawlers involving *Nephrops* landings.

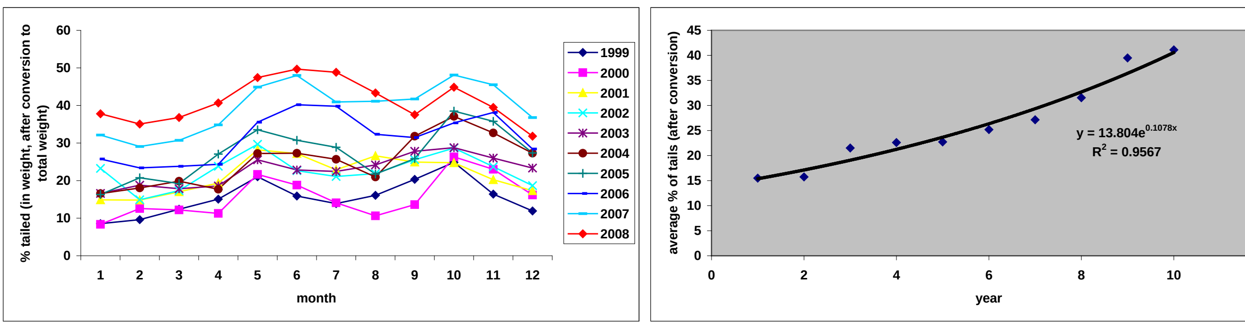


Figure 7. *Nephrops* FU 20-22 (Celtic Sea). Tailed proportion (in converted weight) in landings by month (left) and by year (right).

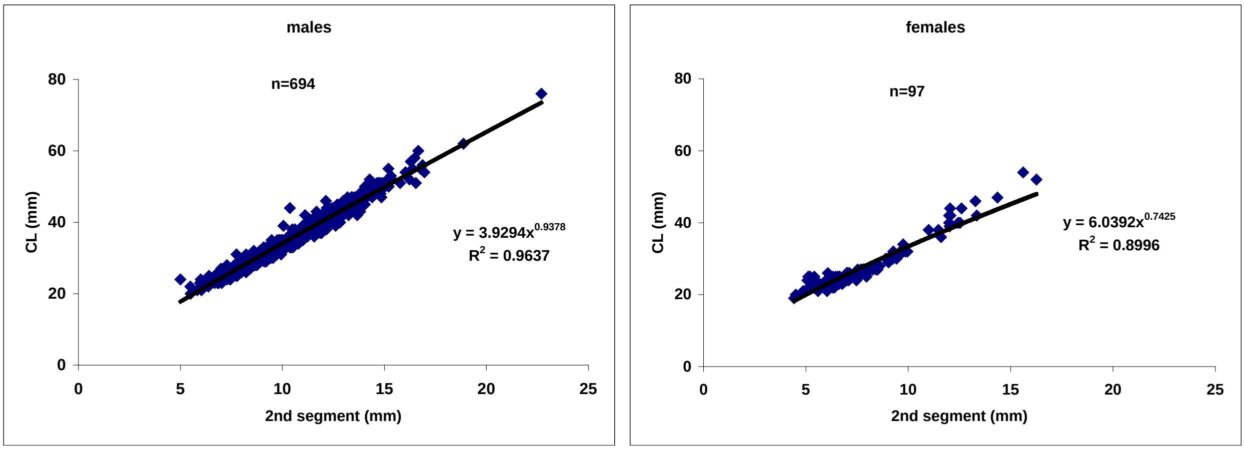


Figure 8. ***Nephrops*** **of the Celtic Sea (7.f,g,h, FU20-22). Biometric relationships (CL vs. 2nd abdominal segment by sex). Data harvested during the survey EVHOE 2007.**

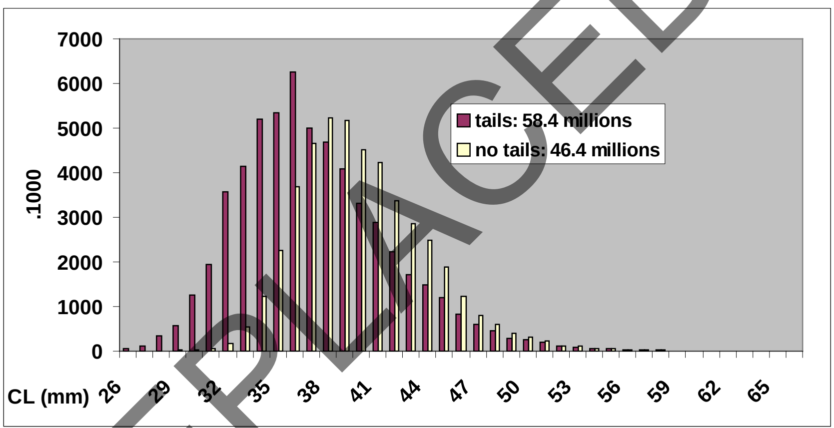


Figure 9. ***Nephrops*** **of the Celtic Sea (7.f,g,h, FU20-22). French landings for 2008. Length distributions (1) including the data on tails and (2) using the previous method (no sampling of tails; the total tailed proportion was apportioned in the smallest category of entire** ***Nephrops*** **at auction).**

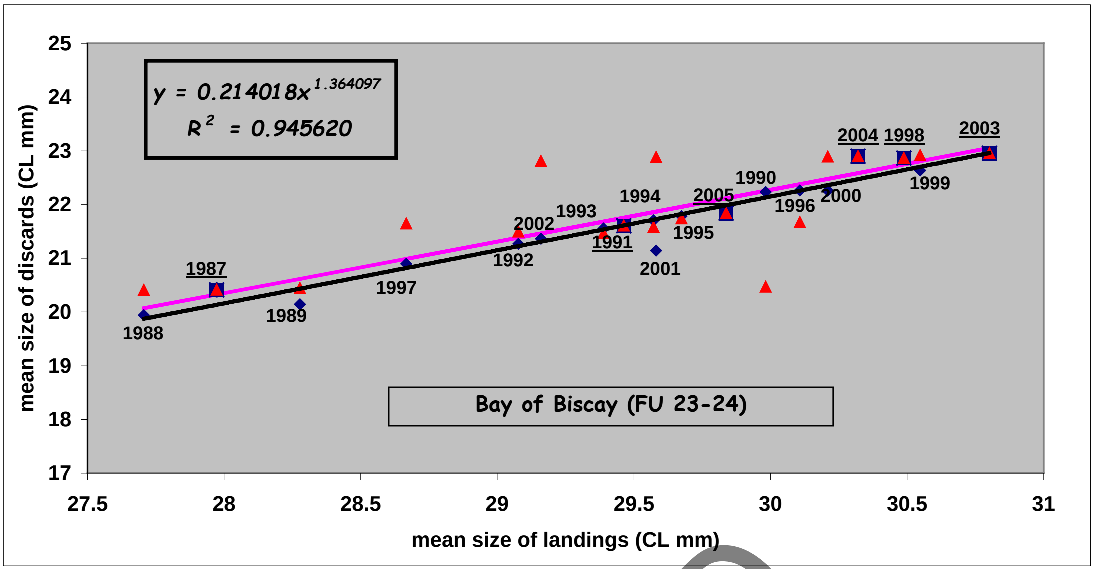


Figure 10. Nephrops of FU 23-24 (Bay of Biscay). Final results of logistic derivation of discards. Relationship between mean sizes of landings and discards. The triangular fonts represent the results of the *status quo* (proportional derivation) method. The underlined years correspond to the available datasets of sampling onboard. The rhombus fonts correspond to the logistic derivation. The dark curve is provided by the final fitting on the whole time series. The bright curve is the result of the fitting on the years with available data.

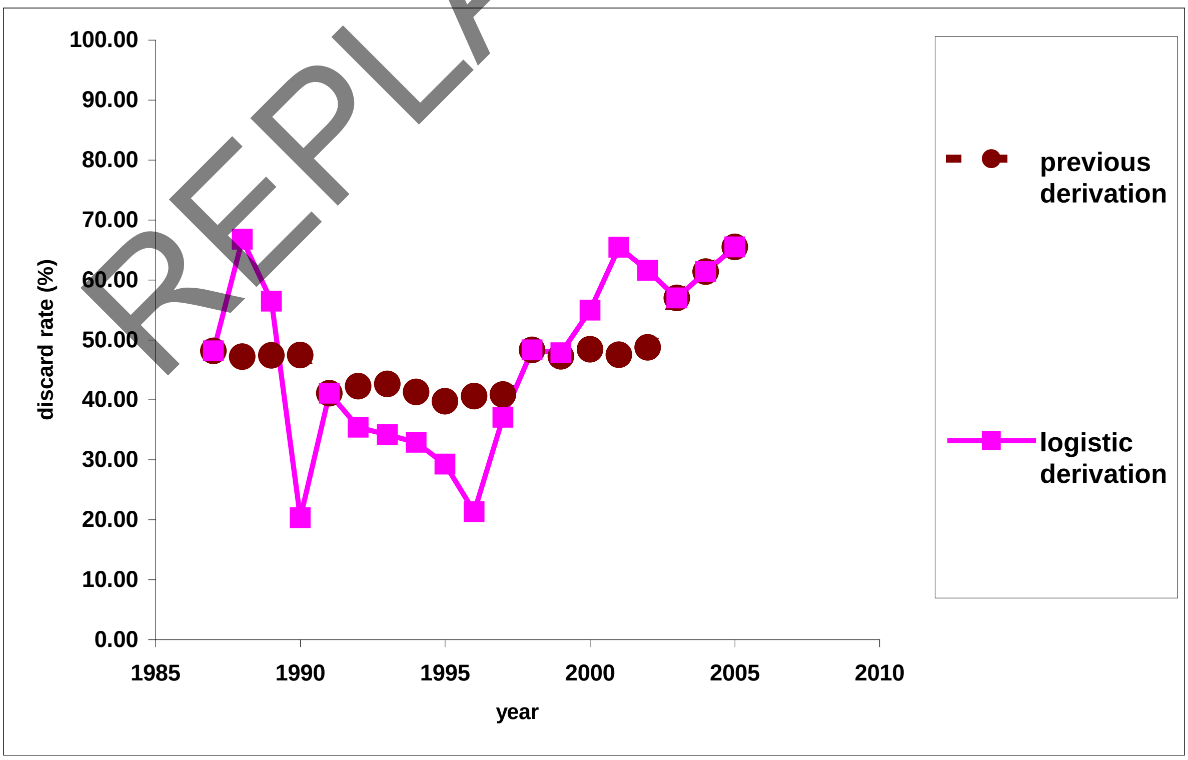


Figure 11. Nephrops of FU 23-24 (Bay of Biscay). Comparison between discard rates obtained by previous (proportional) derivation and by logistic derivation. Combined sexes and whole year datasets.

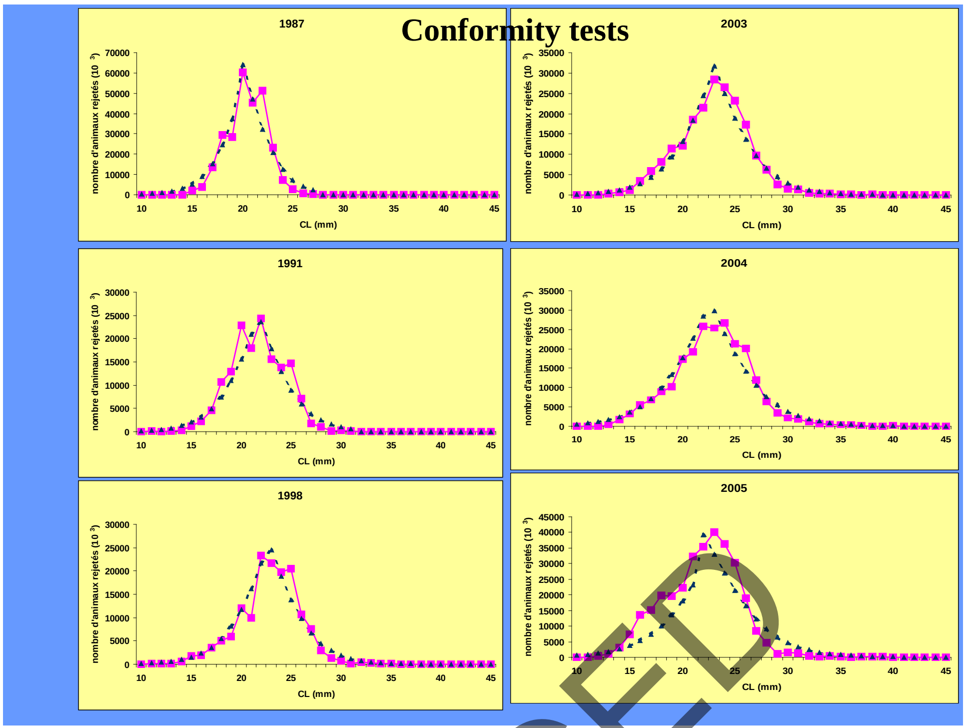


Figure 12. Nephrops of FU 23-24 (Bay of Biscay). Comparison between distributions of length frequencies (carapace length, CL in mm) of discards obtained by sampling and by simulation (broken lines).

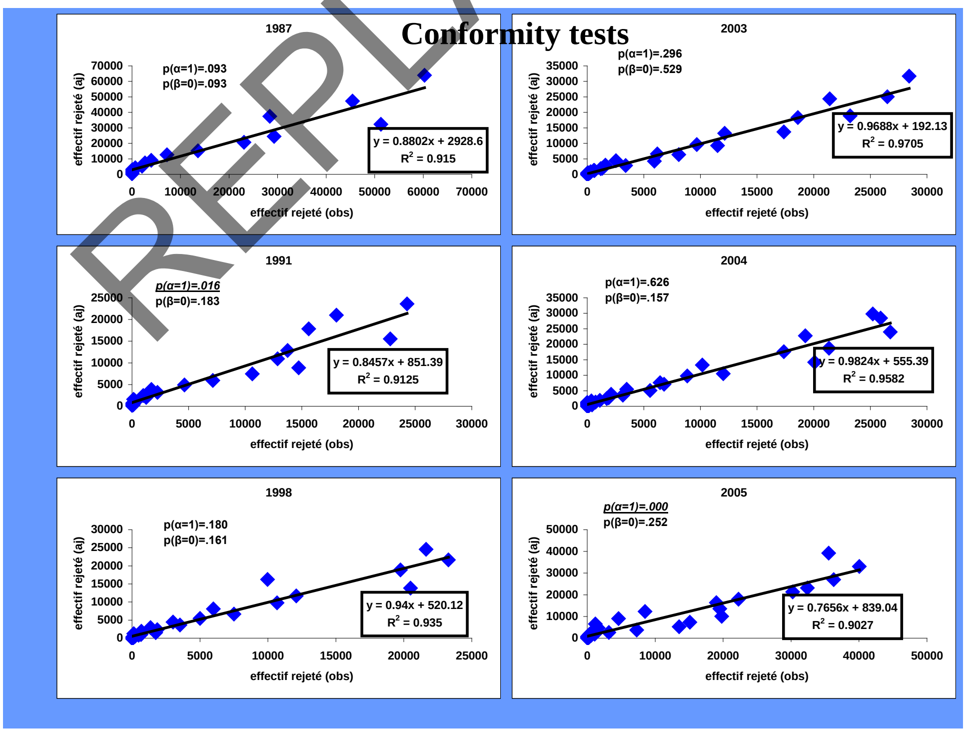
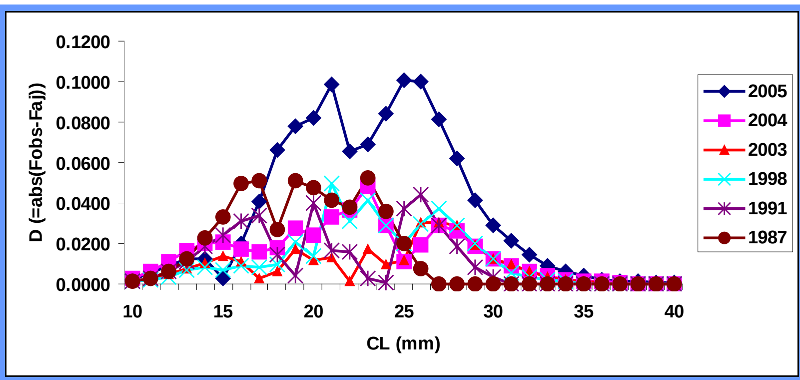


Figure 13. Nephrops of FU 23-24 (Bay of Biscay). Comparison between discarded numbers of individuals obtained by simulation (Y axis) and by sampling (X axis). Statistical tests on linear regressions of Y vs. X by year.



year	Da	Dobs	%
2005	0.113	0.101	85
2004	0.127	0.048	107
2003	0.135	0.031	100
1998	0.154	0.049	106
1991	0.157	0.044	97
1987	0.115	0.052	108

Figure 14. Nephrops **of FU 23-24 (Bay of Biscay). Statistical test (Kolmogorov-Smirnov) between cumulated frequencies of sampled and simulated discards by year.**

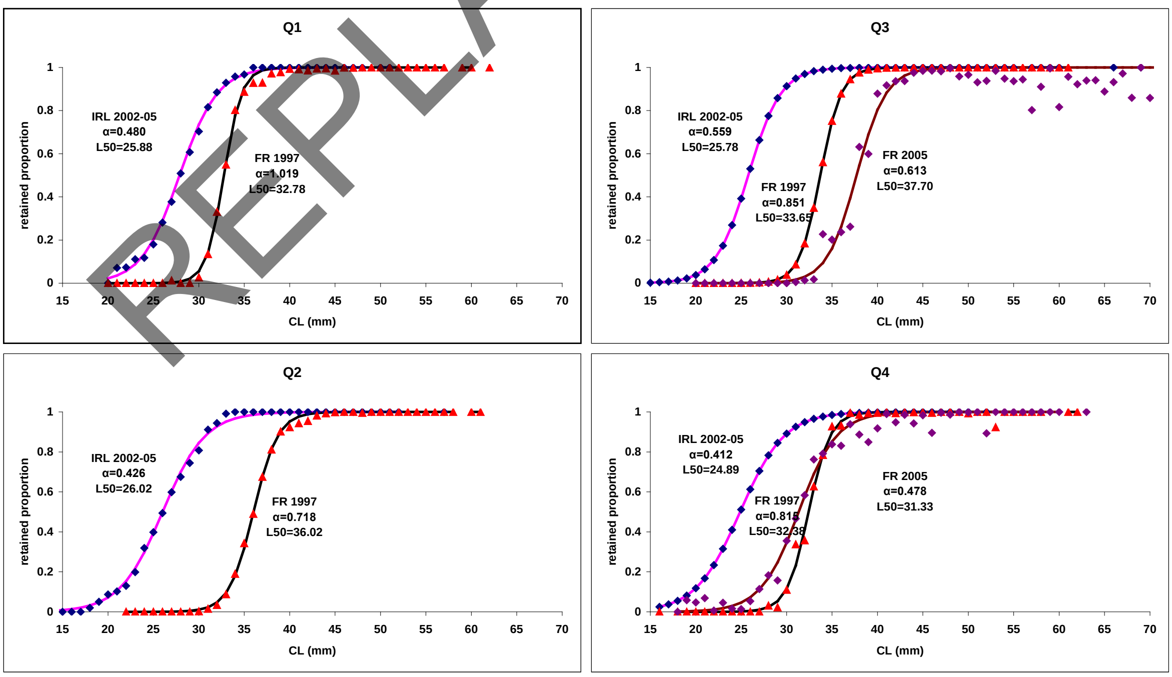


Figure 15. Nephrops **FU 20-22 (Celtic Sea). Different hand-sorting logistic curves by quarter, country and dataset. In 2005 no sample was collected in France during the 1st quarter and the 2nd quarter provided inconsistent results.**

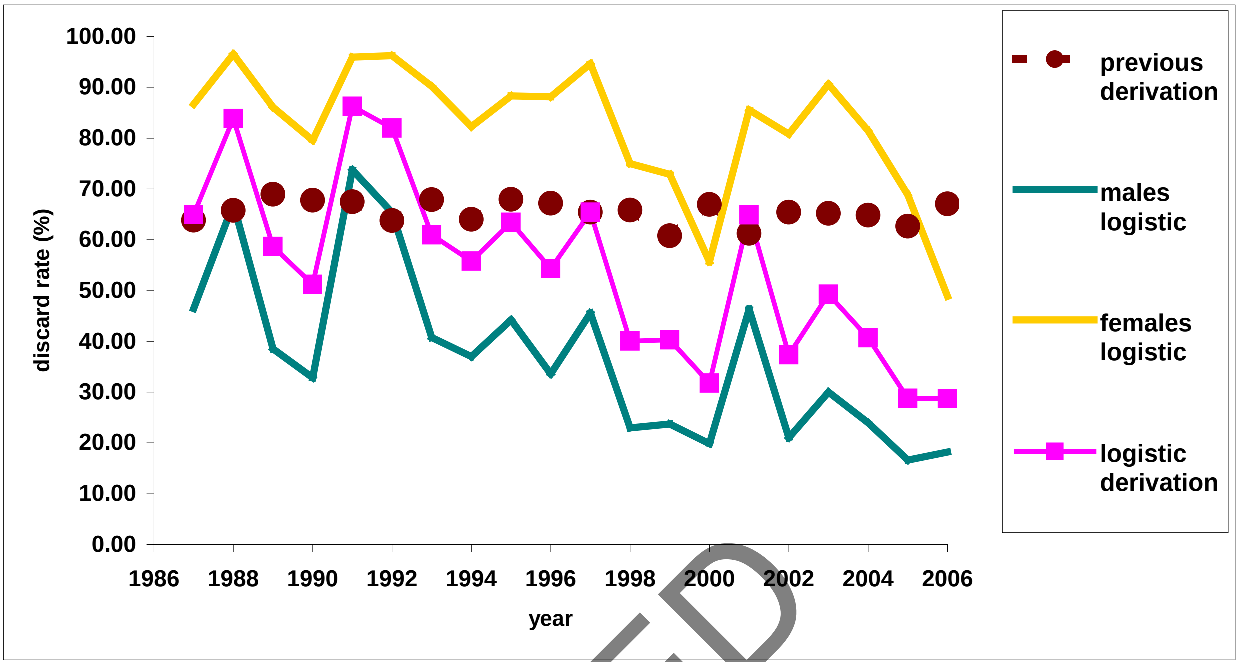
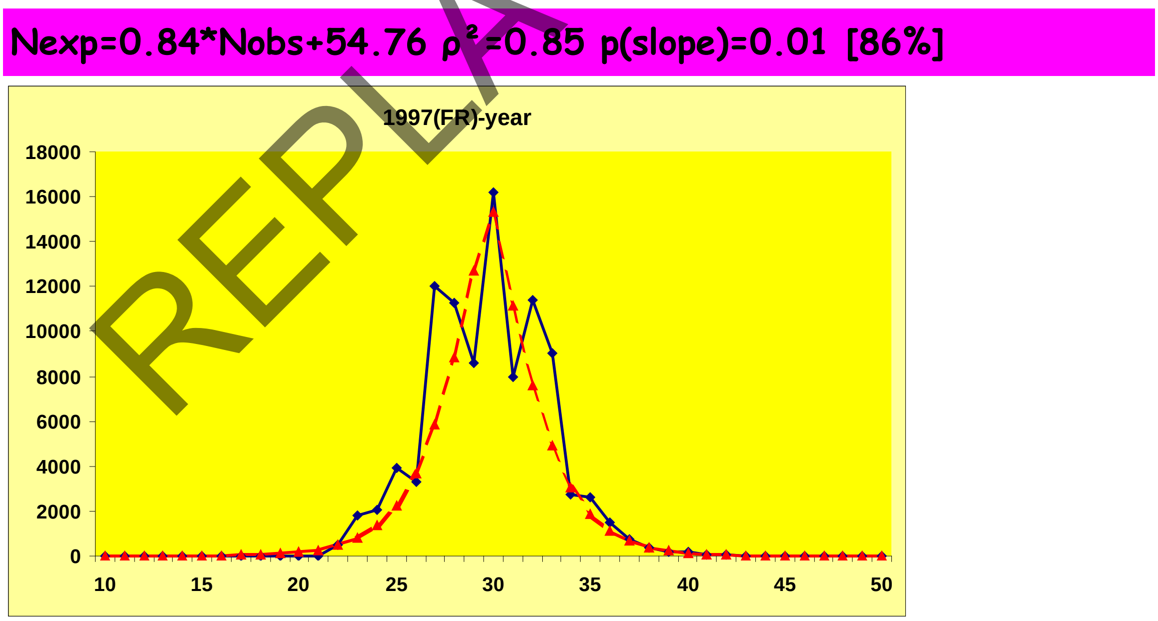


Figure 16. Nephrops of FU 20-22 (Celtic Sea). Comparison between discard rates obtained by previous (proportional) derivation (used by WGNEPH until 2004) and by logistic derivation. Combined sexes and whole year datasets.



year	*disc*	*Lm*	*CV(Lm)*	*α*	*CV(α)*	*β*	*CV(β)*	*ρ²*
1997	83306	29.807	1.29	32335	9.42	0.538	6.43	0.913

Figure 17. Nephrops of FU 20-22 (Celtic Sea). French fleet. Results of the discard simulation on theyear 1997. The distribution is assumed symmetrical and no constraint was set on relationship between mean sizes in discards and landings. Simulated number (Nexp) illustrated by broken line are compared to sampled one (Nobs).

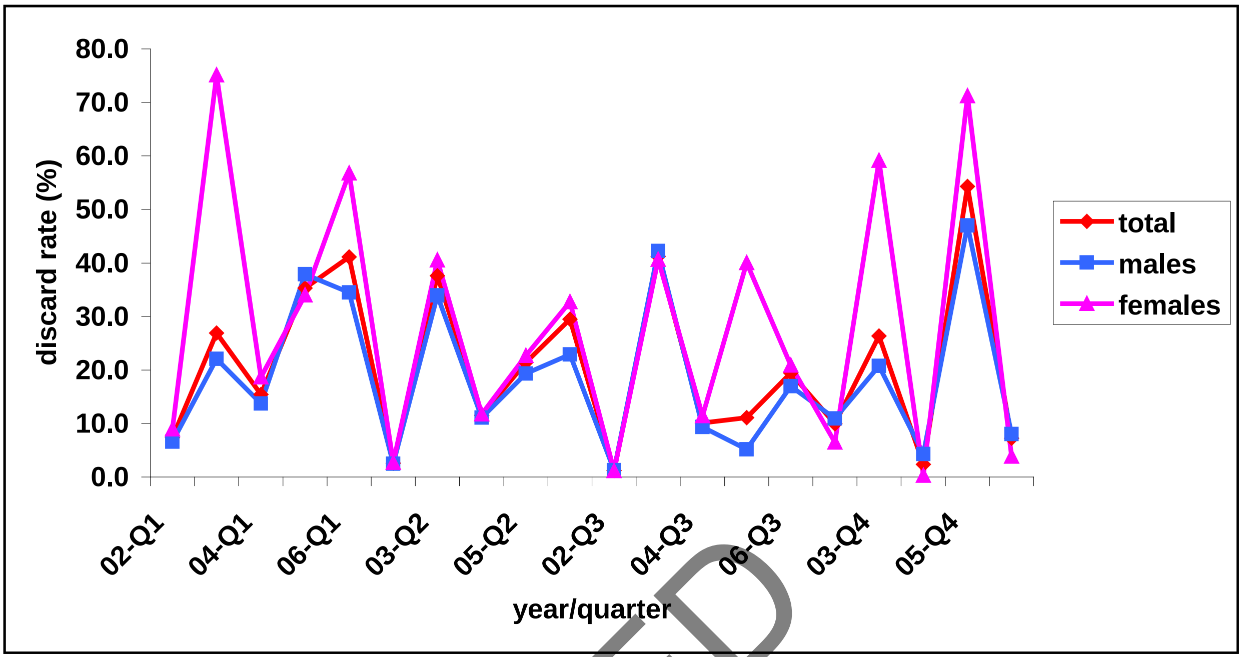


Figure 18. Nephrops of FU 20-22 (Celtic Sea). Discard rate (%) of Irish trawlers by year and quarter.

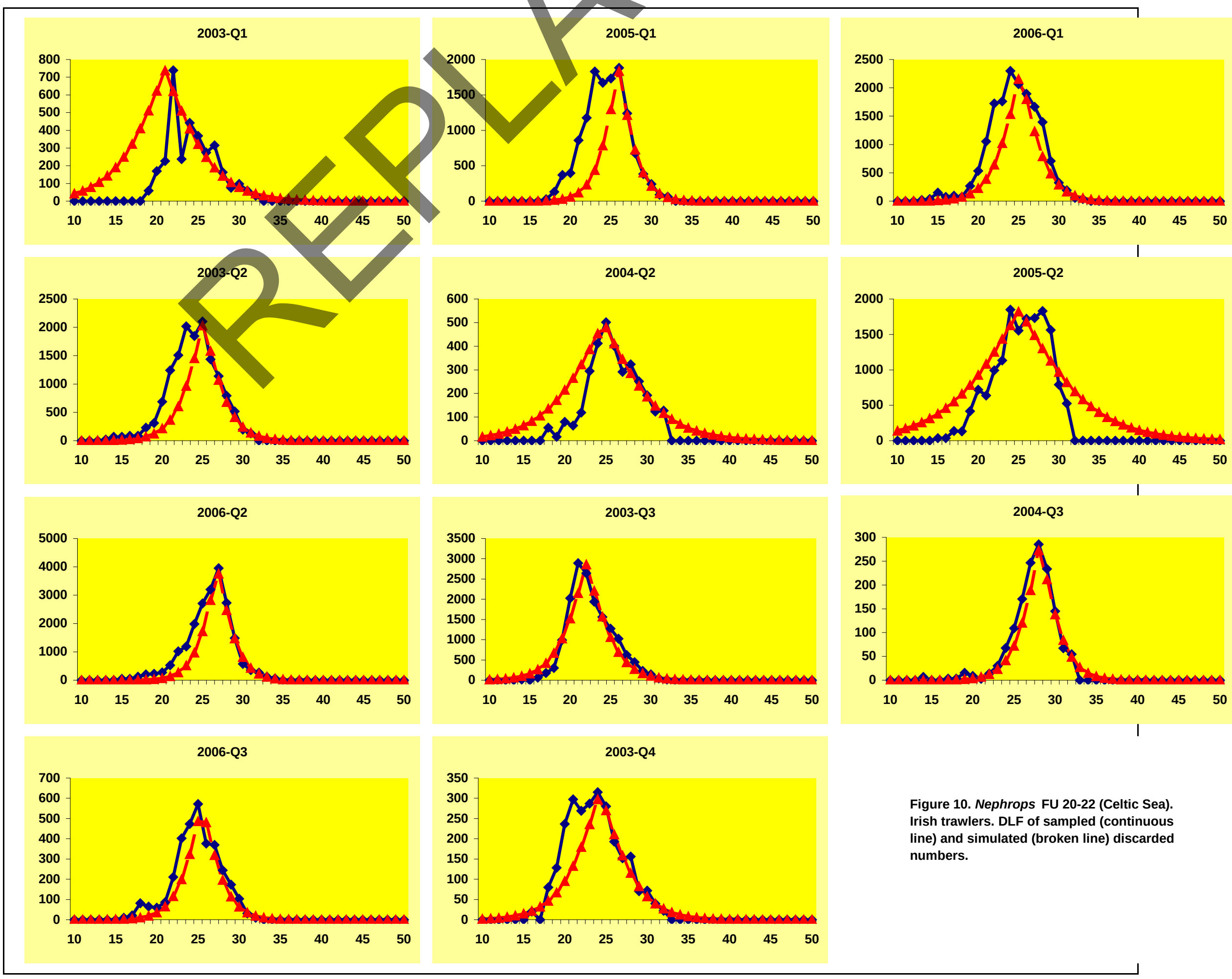


Figure 10. *Nephrops* FU 20-22 (Celtic Sea). Irish trawlers. DLF of sampled (continuous line) and simulated (broken line) discarded numbers.

Figure 19. ***Nephrops*** **FU 20-22 (Celtic Sea). Irish trawlers. DLF of sampled (continuous line) and simulated (broken line) discarded numbers.**

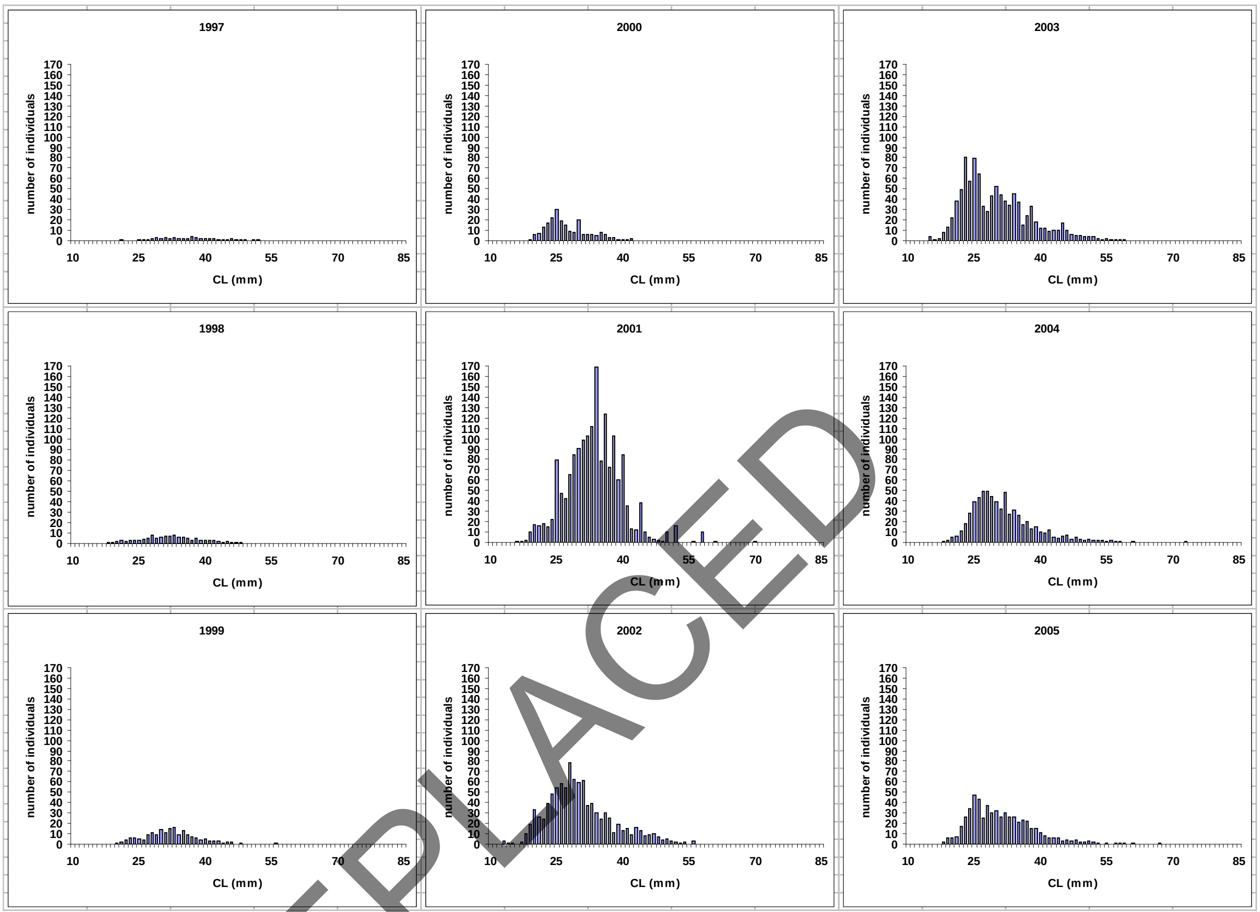


Figure 20. ***Nephrops*** **FU 20-22. Indices of the French groundfish survey EVHOE.**

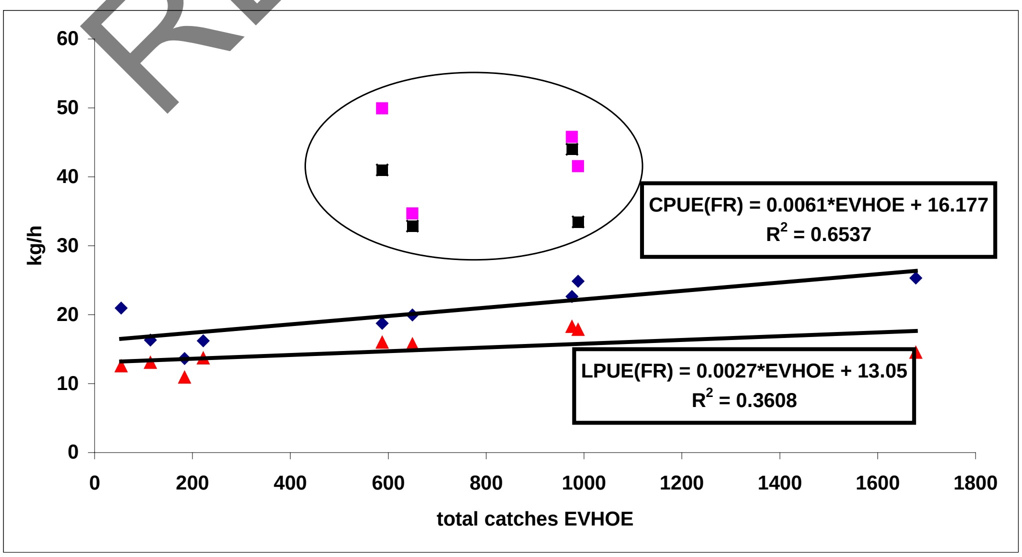


Figure 21. ***Nephrops*** **FU 20-22. Comparison of indices EVHOE and of commercial LPUE and CPUE for French and Irish trawlers.**

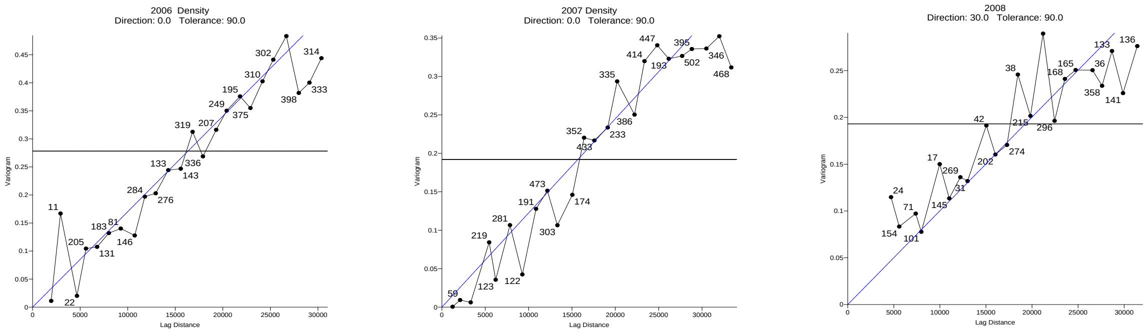


Figure 22. Omnidriectional mean variograms for the Celtic Sea FU20-22 by year from 2006-2008

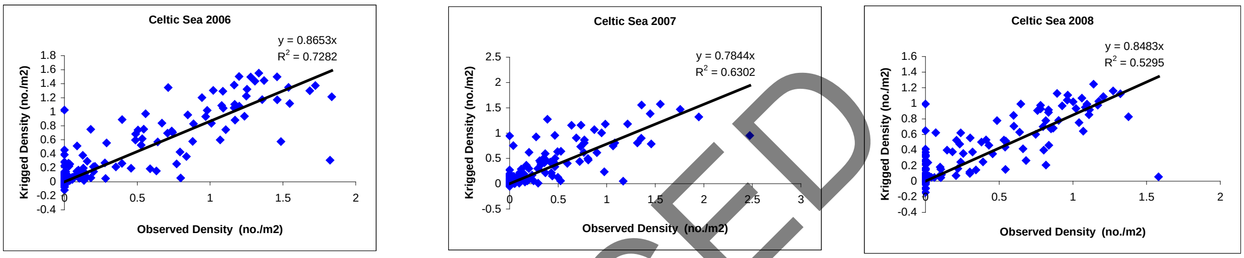


Figure 23. Cross validation plots for the Celtic Sea FU20-22 by year from 2006-2008

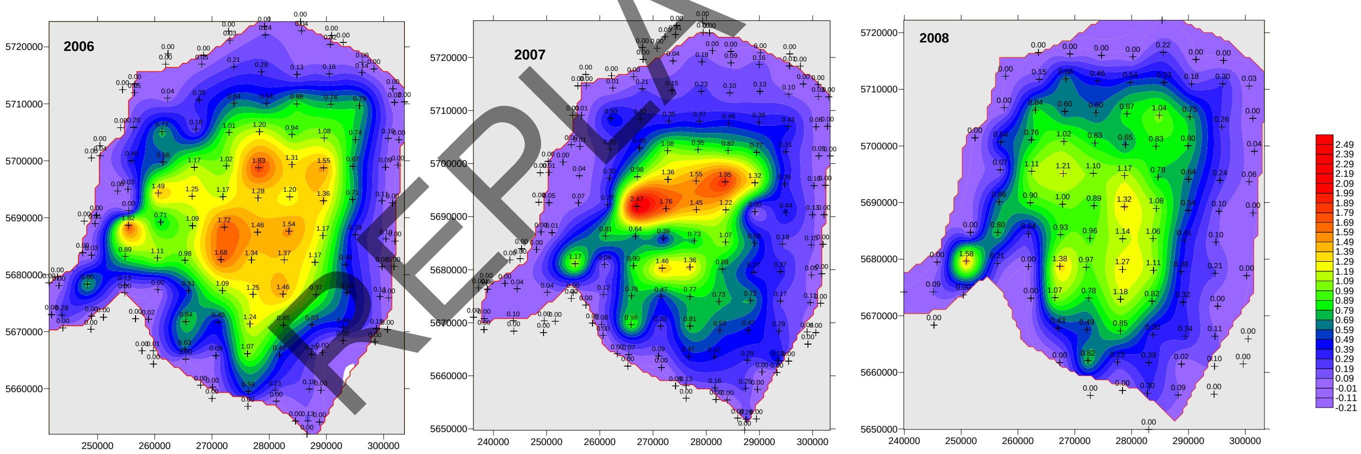


Figure 24. Contour plots of the krigged density estimates for the Celtic Sea FU20-22 by year from 2006-2008.

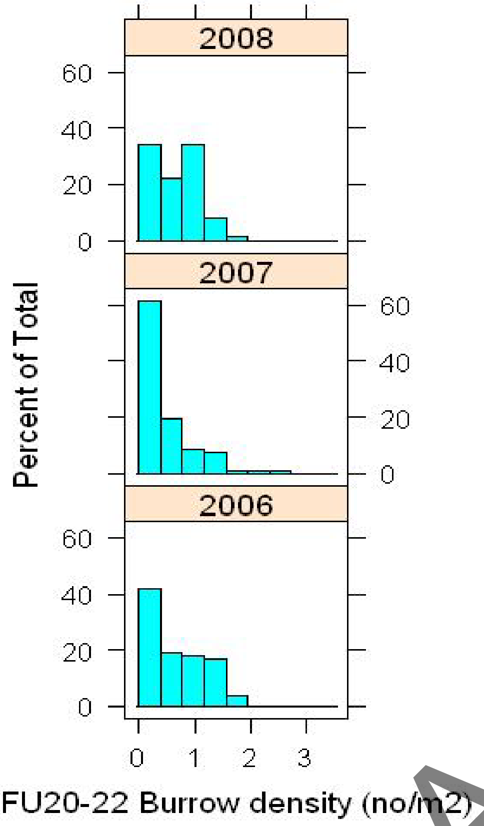


Figure 25. Burrow density distributions for the Celtic Sea FU20-22 by year from 2006-2008.

Table 10. Summary geostatistics for the *Nephrops* UWTV surveys of the Celtic Sea from 2006-2008.

Ground	Year	Number of stations	Number of boundary points	Mean Density (No./M2)	Standard Deviation	CVgeo (%)	Var	Domain Area (m2)	Raised abundance estimate (million burrows)
Smalls	2006	100	50	0.62	0.50	80%	0.25	2847	1914
Smalls	2007	107	63	0.46	0.44	96%	0.19	2915	1402
Smalls	2008	76	31	0.47	0.40	85%	0.16	2698	1448

Table 11. Summary statistics for the *Nephrops* UWTV survey indicator stations of the Labadie and Nymphe Bank and Seven Heads Grounds from 2006-2008.

Ground	Year	Number of stations	Mean Density (No./M2)*	Area Surveyed (M2)	Burrow count	Standard Deviation	95%CI	CV
Labadie Bank	2006	9	0.42	1,322	760	0.37	0.28	29%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-
Nymphe Bank	2006	2	0.27	195	89	0.39	3.47	100%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-
Seven Heads	2006	7	0.23	995	293	0.25	0.23	41%
	2007	-	-	-	-	-	-	-
	2008	-	-	-	-	-	-	-

*random stratified estimates are given for the Labadie Bank, Nymphe Bank and Seven Heads grou

- Area not surveyed in 2007 to 2008 due to weather

Table 7.7.3. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2002. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

- The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

- The Irish data reported from the whole MA M (See Stock Annex).

CL	Q1			Q2			Q3			Q4			YEAR		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17											1			1	
18											1			1	
19			4			5					2	24		2	33
20			13			6					3	126		3	145
21			37			4					5	172		5	213
22		1	72			17					7	564		8	653
23		1	124		1	85			6		12	1124		13	1340
24		2	236		1	136			67	81	78	1804	81	81	2243
25		3	421		2	216			75		30	1533		35	2245
26		5	538		4	245		1	182		47	1495		57	2459
27		10	778		7	326		2	202		75	1110		94	2417
28		17	760	83	71	577		5	607		120	1516	83	213	3459
29	21	48	639		22	776		11	470		289	1220	21	369	3104
30	41	88	510		39	741		23	1125	242	613	1107	283	763	3483
31	47	339	589		70	1075		51	1685	242	667	1284	289	1125	4632
32	132	399	565		125	1199		110	1558	242	626	1002	375	1260	4325
33	140	433	453	83	283	1624	37	266	1551	404	694	995	664	1676	4624
34	236	511	419	122	801	1654	165	791	1455	404	718	753	927	2822	4281
35	366	612	326	540	1436	1654	401	1427	1152	678	857	782	1985	4332	3913
36	503	693	256	995	2001	1376	1125	1745	599	601	777	512	3223	5217	2742
37	648	767	221	1541	2247	1361	706	1359	711	823	914	412	3718	5288	2705
38	797	832	198	1603	2131	1156	1603	1761	580	1146	1096	526	5150	5821	2460
39	847	827	198	2230	2404	820	1463	1504	341	824	849	270	5364	5584	1628
40	1078	963	116	2901	2690	907	1466	1320	313	1618	1388	270	7063	6361	1606
41	817	730	47	2757	2381	380	1028	896	249	1377	1156	171	5978	5163	847
42	1114	926	140	2365	1929	322	1186	958	207	669	578	156	5334	4391	825
43	509	434	12	2070	1598	249	781	629	129	836	671	85	4196	3332	474
44	604	493	47	1003	794	234	1076	837	129	771	625	28	3454	2749	438
45	352	288	23	1157	882	132	605	476	74	612	527	71	2727	2174	300
46	144	122		467	371	132	893	692	37	306	281	14	1811	1466	183
47	179	150		345	302	15	470	371	97	247	238	14	1241	1061	126
48	78	68	23	472	390	102	422	331	55	175	161	14	1147	949	195
49	87	74	12	133	124	59	202	164	37	55	59	14	477	420	121
50	73	62		242	207	15	158	129		87	91	14	560	490	29
51	48	41		166	142		126	106	18	95	83		435	371	18

52	32	29		72	73		120	100	18	94	74		318	276	18
53	30	28		76	77		45	43		24	25		175	172	
54	31	29		57	57		65	54	18	23	24		176	165	18
55	24	24		53	53		99	80	18	17	17		192	175	18
56	18	18		40	41		19	18		8	9		85	85	
57	11	11		42	42		9	9	18	15	15		77	78	18
58	11	11		23	23		8	8	18				42	42	18
59	10	10		12	12		2	2		1	1		25	26	
60	12	13		14	14		7	6	18	1	1		34	34	18
61	3	3		18	18		7	7		1	1		28	28	
62	4	4		20	21		1	1		1	1		26	26	
63	2	2					1	1		8	8		11	11	
64	2	2								1	1		2	2	
65	2	2					1	1					3	3	
66															
67															
68	1	1					1	1					2	2	
69															
70															
71															
72															
73															
74															
75															
Total	9056	10126	7774	21703	23884	17600	14293	16297	13821	12732	14516	19184	57783	64823	58378

Table 7.7.4. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2003. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

CL	Q1			Q2			Q3			Q4			Year		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18						2									2
19						10									10
20			124			26			71			49			270
21			556			72			271		1	172		1	1071
22			567			169			399		1	198		1	1333
23			1452			319			596		1	211		2	2578
24			446		1	848		1	608		2	239		4	2141
25			150		1	1110		1	737		3	477		6	2474

26			2334		3	1836		3	1072		5	586		11	5827
27			321		5	1894		6	1644		8	514		19	4372
28		1	1675		9	1967		12	2065		13	948		35	6654
29		1	450		16	1895		25	2331		20	901		63	5578
30		2	372		29	1744		52	2545		31	445		115	5106
31	25	23	831		54	1682		107	1906	25	66	828	50	250	5247
32		7	1002	47	133	1796	211	370	1810	99	257	1307	357	767	5915
33		13	548	47	215	2035		1152	1360	99	273	437	146	1653	4380
34		24	428	328	1228	1565	739	2297	1374	124	427	477	1191	3975	3845
35	77	188	238	516	1412	1293	1689	3101	868	496	756	240	2778	5457	2639
36	75	310	190	563	1534	856	1901	2690	510	545	812	254	3083	5345	1809
37	298	494	190	1220	1892	639	1478	2008	378	595	776	233	3591	5169	1441
38	323	533	285	1313	1794	492	2649	2548	391	694	774	206	4979	5649	1374
39	497	666	95	1360	1691	359	2745	2356	434	694	703	137	5297	5415	1026
40	828	915		2224	2200	158	1496	1296	179	620	616	158	5168	5027	495
41	1024	1022	48	2499	2268	257	2217	1691	219	942	790	69	6683	5771	592
42	1044	978	95	2385	2054	197	1409	1078	223	697	593	34	5535	4703	549
43	1096	959	48	2478	2024	228	1224	925	112	737	582	27	5535	4490	415
44	761	660		1734	1410	80	1472	1100	96	501	401	27	4467	3570	203
45	751	627		1532	1242	70	1229	974	20	459	364	21	3971	3206	110
46	462	389	48	1692	1365	50	1193	931	20	312	270	14	3659	2954	131
47	298	267		1008	858	20	391	336	120	243	218	27	1941	1679	167
48	308	274		674	588	10	313	286	60	204	181		1498	1329	70
49	243	224		392	379	30	180	183	40	142	133	7	958	919	77
50	99	105		313	295	20	108	110	20	156	154		676	663	40
51	79	83		212	219	20	81	82	40	78	81		450	465	60
52	42	44		119	123	10	90	91		57	59	14	308	317	24
53	25	26		93	96		54	55		27	28		199	204	
54	12	13		86	89		18	18		9	9		126	129	
55	25	26		40	41		9	9		21	21		94	97	
56	10	10		33	34		36	36		3	3		82	84	
57	10	10		27	27	10	36	36		3	3		75	77	10
58	5	5		20	20								25	26	
59	2	3		13	14		9	9					25	25	
60															
61				7	7								7	7	
62	5	5											5	5	
63															
64															
65															
66															
67															
68															
69															
70															
71															

72															
73															
74															
75															
Total	8424	8907	12492	22977	25366	23767	22978	25977	22516	8581	9438	9258	62959	69688	68034

Table 7.7.5. ***Nephrops*** **in 7.f,g,h. Length distribution of landings by country in 2004. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.**

- The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

- The missing Irish data of the 1st and 4th quarters were calculated by likelihood function as explained (Stock Annex).

CL	Q1			Q2			Q3			Q4			Year		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17												1			1
18			3									2			6
19			16									4		1	20
20			30			1			1			8		1	40
21			46			11		1	1			19		2	77
22		1	69			8		2			1	57		3	134
23		1	108			25		3	4		1	107		6	245
24		2	161		1	100		6	13		2	207		11	480
25		4	213		1	189		12	37		3	368		19	807
26		6	298		2	446		22	107		4	565		35	1416
27		11	390		3	578		42	286		7	799		64	2053
28		19	443		6	705		80	699		12	1091		117	2938
29		34	538		10	1013		152	1126		20	1360		215	4037
30		59	681		16	1402		290	1652		32	1521		397	5255
31		102	737		27	1965	73	880	1798		53	1563	73	1063	6063
32	80	402	783	64	88	2493	254	1227	1606		88	1542	398	1805	6424
33	321	669	800	64	119	2870	363	1114	1403		145	1386	748	2047	6459
34	351	797	746		350	3038	327	983	1336	161	312	1144	838	2442	6264
35	728	978	634	191	592	2299	689	1193	988	183	589	908	1792	3352	4829
36	618	823	553	318	1177	1906	1161	1336	708	688	1078	738	2785	4414	3905
37	763	825	444	1080	1723	1702	871	978	449	1009	1224	544	3723	4749	3138
38	827	786	373	1080	1745	1302	1161	999	353	596	817	397	3664	4346	2426
39	537	514	298	1652	1741	799	798	674	224	688	700	297	3675	3628	1618
40	695	584	216	826	1027	499	980	747	134	573	558	223	3074	2916	1072
41	486	412	150	1525	1348	448	1161	841	135	573	508	162	3745	3109	894
42	612	487	105	1789	1421	249	762	547	82	688	543	118	3852	2998	554
43	516	409	68	837	699	162	726	509	57	575	437	79	2653	2054	366
44	461	369	41	1218	895	74	635	449	59	392	296	59	2706	2009	234

45	470	366	31	1092	831	50	527	370	30	482	345	46	2571	1912	156
46	129	119	21	827	603		142	111	22	432	298	29	1530	1130	72
47	309	249	16	457	370	50	408	310	24	90	75	17	1264	1004	107
48	178	166	11	661	570	25	278	225	11	182	136	14	1299	1099	61
49	178	166	9	352	320	25	282	229	11	123	102	6	935	816	51
50	125	120	5	395	361		149	155	5	69	63	4	739	698	14
51	149	143	4	193	198		145	151	3	54	56	3	541	548	10
52	117	118	2	215	219		126	131	3	58	60	3	516	528	7
53	81	81	2	204	208		114	106	8	81	83	2	479	478	12
54	60	60	2	129	131		37	39	3	61	63	2	287	293	6
55	60	60		64	66		37	39	3	48	49	3	209	214	6
56	36	37		54	55		37	39		36	37	3	164	167	3
57	26	26		54	55		37	39	16	17	18	3	134	137	19
58	18	18		11	11		26	27		12	12	3	66	68	3
59	3	3		32	33		4	4	5	10	10	3	48	49	8
60	3	3					15	15		6	6	1	23	24	1
61							15	15		2	2	1	17	17	1
62							11	12					11	12	
63							4	4					4	4	
64															
65										2	2		2	2	
66									3						3
67												1			1
68										2	2	1	2	2	1
69									3						3
70												1			1
71												1			1
72									3						3
73															
74															
75															
Total	8938	10029	9048	15381	17020	24434	12354	15106	13409	7892	8850	15412	44565	51005	62303

Table 7.7.6. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2005. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

CL	Q1			Q2			Q3			Q4			Year		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18															

19														1	
20						17			12		1	73		1	102
21						74			29		1	355		2	459
22						92			46		1	415		2	553
23		1				271			110	1	3	783	1	4	1164
24		1	101		1	791			272		3	1565		5	2730
25		2	202		1	1833			381		5	1897		9	4313
26		4	378		2	2656		1	596	8	13	3003	8	20	6634
27	9	14	1088		3	4305		2	781	1	14	2380	10	33	8554
28		12	949		6	5367		3	849	2	24	1749	2	45	8913
29		21	1059		10	6785		6	816	1	35	1270	1	73	9930
30	9	42	1403		19	7049		13	945	4	63	1021	13	136	10418
31		61	2076		33	7768		25	974	21	109	998	21	228	11816
32	70	156	1655		60	7758	8	54	926	70	239	628	148	509	10966
33	44	355	1059	10	114	5684	18	108	788	162	468	423	233	1045	7954
34	131	506	1655		194	4222	58	593	615	471	826	624	660	2119	7116
35	289	734	1312	69	698	3430	196	804	609	769	1131	246	1323	3366	5597
36	464	845	933	223	1210	2467	297	931	412	1076	1309	323	2060	4294	4134
37	525	799	851	429	1394	1308	515	941	444	1188	1273	123	2656	4408	2726
38	578	762	936	483	1306	1356	558	859	261	1109	1076	191	2728	4004	2745
39	814	839	760	598	1132	862	761	832	245	934	830	177	3106	3634	2045
40	658	657	631	615	936	421	696	662	135	731	611	68	2700	2867	1255
41	735	654	296	617	788	378	545	475	94	589	460	40	2487	2377	809
42	780	646	166	744	725	233	493	392	62	415	323	27	2432	2087	488
43	570	465	268	588	545	64	412	312	34	450	324	13	2021	1647	380
44	613	480	166	598	491	40	276	214	24	288	216		1775	1401	230
45	547	423		746	554	17	247	193	8	271	201	13	1812	1371	38
46	520	406	129	701	502	47	161	135	25	182	141		1563	1183	201
47	400	314		752	520	17	199	164	3	135	111		1486	1109	19
48	258	219		757	516		158	136	11	75	67		1248	938	11
49	271	239		677	465		177	135		49	48		1174	886	
50	241	220		698	491	23	302	226	1	34	35		1275	973	24
51	263	240		476	351		271	203		40	42		1051	835	
52	179	171		349	278		215	165		21	22		764	636	
53	153	139		332	263		198	144		23	24		707	570	
54	101	101		241	194		181	133	1	20	20		543	448	1
55	89	88		193	167		205	149		16	16		502	421	
56	50	51		132	114		85	64		9	9		276	238	
57	58	56		140	106		73	56		9	9		280	228	
58	33	33		64	53		68	50		4	5		169	141	
59	31	32		48	41		48	35		5	5		133	113	
60	15	15		8	8		13	14		4	4		39	41	
61	15	15		9	9		18	13		1	1		43	39	
62	3	3		5	5		4	7					11	15	
63	3	3		3	3		10	8		1	1		17	15	
64							1	2					1	2	

65				2	2		1	2					2	3	
66				2	2		1	2					3	4	
67							1	2					1	2	
68							1	2					1	2	
69															
70							1	2					1	2	
71															
72							1	1					1	1	
73								1						1	
74								1						1	
75							1	3					1	3	
Total	9519	10828	18072	11307	14310	65334	7474	9276	10511	9190	10123	18409	37491	44537	112326

Table 7.7.7. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2006. Quarterly and total values (10³). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

CL	Q1			Q2			Q3			Q4			YEAR		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18									4						4
19						7			8						15
20			80			21			11			123			235
21			93			57			12			335		1	497
22			266			195		1	70		1	582		1	1113
23			559			488		1	123		1	1141		3	2312
24			1543		1	852		2	429		2	1705		5	4529
25		1	2000		1	1501		4	692		3	2210		8	6403
26		1	2946		2	3065		8	1333		5	2705		15	10050
27		2	3263		3	4601		15	1722		8	2869		28	12454
28		4	3245		6	5701	10	35	2049	6	17	2354	15	62	13349
29		7	2825		12	6459		58	1689		22	1442		99	12415
30		14	1951	13	30	6443	10	119	1437	11	43	1119	34	205	10950
31		25	1740		41	4632	20	234	1012		60	731	20	359	8115
32	18	58	990	26	91	4577	68	715	706	34	109	577	146	972	6849
33	53	319	673	13	148	3302	78	904	647	85	291	431	229	1662	5053
34	152	524	398	208	840	2438	205	907	573	312	538	346	877	2809	3755
35	286	676	412	312	1404	1679	254	982	269	431	729	332	1283	3791	2693
36	397	783	178	845	2036	1190	488	1055	274	738	915	265	2468	4789	1907
37	642	880	123	1430	2520	826	714	1160	144	772	880	248	3558	5440	1343
38	648	808	96	1963	2519	518	1143	1235	110	755	752	173	4509	5314	897

39	788	799	82	1769	2052	355	1133	1025	92	590	560	140	4281	4435	668
40	735	680	14	2015	1839	276	918	745	19	568	483	96	4237	3747	405
41	636	552	14	1755	1449	261	1026	709	51	540	420	67	3957	3130	393
42	722	577		1496	1121	126	791	525	11	319	250	52	3329	2474	189
43	674	518	14	1257	879	98	815	507	7	315	227	32	3061	2131	151
44	486	370		965	652	85	519	322	11	211	151	38	2181	1495	133
45	429	321		897	585	56	335	208	7	119	89	17	1781	1202	80
46	346	262		696	462	14	468	284	4	119	85	14	1629	1093	32
47	297	231	27	529	365	28	287	183		86	65	14	1198	844	69
48	262	209		465	333	7	138	107		48	38	12	913	687	19
49	168	145		248	203	14	138	98		66	51	3	619	497	17
50	87	84		216	185		117	89		23	22	6	443	381	6
51	71	72		100	98		115	92		27	25		313	286	
52	68	68		156	127	14	70	63		19	18		313	276	14
53	62	64		114	101		46	52		10	11		231	228	
54	42	44		72	69		42	39		9	10		166	161	
55	34	35		63	59		27	28		10	10		134	133	
56	33	35		39	41		23	24		8	9		105	108	
57	29	30		38	39		13	14		5	5		85	87	
58	17	18		38	39		12	12		5	5		71	74	
59	11	11	14	26	27		8	9		3	4		49	50	14
60	7	7		15	15		12	12		2	2		36	37	
61	4	4		10	11		6	6		1	1		21	22	
62	3	3		3	3		4	4		1	1		10	11	
63	1	1					1	1		1	1		3	3	
64	2	2		2	2		2	2					7	7	
65				1	1		1	1					2	2	
66															
67															
68															
69		1												1	
70															
71															
72															
73															
74															
75															
Total	8209	9244	23545	17796	20408	49887	10060	12597	13515	6249	6918	20179	42315	49167	107126

Table 7.7.8. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2007. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (simulation of hand-sorting s-shaped curve vs. CL: see Stock Annex).

CL	Q1			Q2			Q3			Q4			Year		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18															
19						29									29
20			105			148			10			204			468
21			211			354			36						601
22			495			1048			167			650		1	2360
23			916		1	2897			539			3669		1	8021
24			2757		1	3975			1307		1	5096		2	13135
25		1	4218		2	5684			2576		1	5667		4	18144
26		2	5320		4	8822			2946		2	5620		7	22708
27		3	6276	21	18	9507		1	3386		3	3055	21	25	22225
28		6	5458	21	25	11331		2	4067		5	3630	22	37	24486
29		10	4525		25	11794		5	4174	5	10	3528	5	50	24021
30	5	21	1767	42	69	10040		10	3040		13	4662	47	113	19509
31	5	36	916		87	6477		22	2013	5	25	3376	10	170	12783
32	15	72	357	64	195	4084	22	60	1192	25	51	3386	125	378	9018
33	81	373	105	127	861	2757	54	504	1007	45	248	2526	307	1986	6395
34	161	490		255	1541	1430	194	917	383	121	407	2196	731	3354	4009
35	218	538	105	806	2141	1118	517	1286	288	226	544	1797	1768	4509	3309
36	328	563		1125	2539	707	862	1543	168	301	640	1697	2616	5286	2573
37	385	581		1804	2644	441	1412	1562	69	453	738	1248	4053	5525	1757
38	603	648		1973	2313	352	1121	1111	49	592	811	1073	4290	4883	1474
39	522	520		1783	1860	293	1013	812	32	744	801	823	4063	3993	1148
40	461	407		2295	1768	322	884	624	39	597	630	548	4238	3429	909
41	410	331		1490	1134	233	766	492	27	646	556	678	3312	2513	938
42	363	277		1429	946	72	540	332		515	413	374	2848	1967	447
43	334	245		1399	854	116	423	250	16	353	272	349	2510	1620	481
44	317	226		866	539	87	267	159	6	335	232	50	1784	1156	143
45	233	167		973	575	73	278	167		293	198	75	1777	1107	148
46	264	184		569	370	57	196	122	6	253	168	75	1282	844	138
47	116	88		328	242	14	98	72		205	135	50	747	537	64
48	136	100		391	281		72	60		176	115	50	774	555	50
49	91	71		158	147	14	46	44		126	89	75	421	350	89
50	68	56		160	125		38	35		86	60		352	275	
51	44	40		73	77		35	32		44	32		196	181	
52	34	31		70	62		19	20		20	19		142	132	
53	22	21		39	41		11	12		25	19	24	98	93	24
54	18	17		21	22		9	9		27	19		76	67	
55	19	18		17	18		8	8		6	6		50	50	
56	9	9		18	19		5	5		19	12		51	46	
57	7	7		7	7		2	2		8	6		24	22	
58	11	10		6	6	14	2	2		2	2		21	20	14

59	4	4		5	5					1	1		10	10	
60	5	5		6	6		1	1		2	2		13	13	
61	2	2		5	5		1	1		1	1		8	9	
62	2	2		3	4		1	1					7	7	
63	1	1		2	2								3	4	
64				1	1								2	2	
65													1	1	
66															
67															
68															
69															
70															
71															
72															
73															
74															
75															
Total	5296	6180	33532	18354	21584	84288	8897	10287	27541	6256	7289	56252	38803	45339	201614

Table 7.7.9. *Nephrops* in 7.f,g,h. Length distribution of landings by country in 2008. Quarterly and total values (10[3]). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (as performed since WGCSE 2009).

CL	Q1			Q2			Q3			Q4			YEAR		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18															
19															
20															
21						28									28
22						296									296
23						651			69			539			1258
24						1475			410			1736			3621
25			18			2557			913			3494			6981
26			958		27	4475		22	1136			5829		49	12397
27			1011		82	5408		22	1782			1578		104	9779
28		26	3759		218	6541		89	1582		10	2856		343	14738
29	6	4	3033		463	6436	10	72	2256	6	43	1777	22	582	13502
30	6	162	3336	12	742	7257		245	2116		108	1878	18	1256	14588
31	19	275	980	13	1042	7312		467	2969	18	167	1419	50	1951	12680
32	38	497	1087	61	1774	6648	20	989	3241	55	307	1460	174	3567	12436

33	89	752	1319	280	1527	4916	30	1372	3063	146	488	1520	544	4140	10817
34	247	1058	1123	536	1789	4829	181	1629	2363	273	721	1698	1236	5198	10013
35	438	977	1462	925	1818	4573	441	1720	1221	450	817	1939	2253	5332	9194
36	554	1167	1123	1448	1993	3000	941	2116	1383	753	979	1219	3697	6254	6725
37	668	920	677	1692	1596	2042	1422	1589	718	863	897	900	4645	5001	4337
38	647	751	659	1814	1383	1224	1682	1525	666	1087	1032	999	5231	4690	3548
39	669	567	356	1583	1242	915	2063	1434	244	844	828	780	5159	4071	2294
40	597	444	339	1558	1148	562	1462	965	213	911	750	600	4528	3306	1713
41	654	465	267	1418	946	378	1382	856	282	772	619	679	4226	2886	1606
42	560	383	178	1027	671	393	1052	595	182	744	566	439	3383	2215	1192
43	576	367	89	1044	607	267	703	368	91	521	378	280	2845	1720	726
44	511	316	89	812	471	321	782	414		374	291	60	2480	1493	470
45	598	371	53	568	342	84	455	245		255	233	160	1876	1190	297
46	345	225		405	259	84	277	180		198	171	40	1225	835	123
47	290	206		219	151		184	112		118	123	40	812	593	40
48	209	144		201	173	41	105	76		84	62	40	600	456	81
49	102	74		128	97	167	100	76		65	50	40	395	298	207
50	117	84		93	81	125	55	45		44	36	40	308	247	165
51	49	39		56	56	41	74	60		50	37	20	229	192	61
52	28	25		47	40	41	30	30		17	14		120	109	41
53	36	29		28	28		23	23		14	12		102	92	
54	11	11		21	21		16	16		6	16		55	65	
55	13	11		17	17		12	12		3	3		46	43	
56	8	8		12	12		7	7		1	1		28	28	
57	12	10		7	7		5	5		2	2		27	24	
58	14	12		4	4		1	1		1	1		20	17	
59	4	4		3	3		1	1					8	8	
60	1	1		3	3		1	1					4	4	
61				1	1								2	2	
62				1	1								1	1	
63				1	1								1	1	
64															
65															
66															
67															
68															
69															
70															
71															
72															
73															
74															
75															
Total	8117	10387	21914	16039	20836	73086	13516	17380	26900	8676	9763	34056	46348	58365	155956

Table 7.7.10. ***Nephrops*** **in 7.f,g,h. Length distribution of landings by country in 2009. Quarterly and total values (10³). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.**

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (as performed since WGCSE 2009).

CL	Q1			Q2			Q3			Q4			YEAR		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18															
19															
20			116						11						127
21			167												167
22			399			35			31			102			566
23			1017			217			103			306			1643
24			2582			505			364			756			4207
25			3963			1284			879			1279			7405
26			6524			1969			1536			1495			11525
27			5825			3351			2396		4	759		4	12331
28			4684			3619		14	2953		21	489		35	11744
29			5095		107	3889		14	2804		30	831		151	12619
30		15	3619		253	3852		153	2735		68	658		490	10865
31		169	2509		587	3759		334	1813	5	161	549	5	1251	8630
32	12	238	2044		773	3074	10	646	2361	9	151	754	31	1808	8234
33	35	315	1671	32	898	2872	42	746	1716	23	292	472	132	2251	6731
34	127	606	1799	204	1370	2222	10	715	1273	92	367	400	434	3058	5694
35	197	697	1285	486	1453	2003	251	998	1117	129	479	242	1063	3627	4647
36	486	1008	1003	675	1762	1839	429	1024	774	268	433	417	1859	4228	4032
37	683	1013	1119	1160	1827	1433	639	1039	603	346	454	242	2828	4334	3397
38	857	1065	1054	1707	1821	1369	911	977	502	420	443	181	3895	4305	3106
39	1089	1093	694	1878	1732	1339	921	788	380	526	446	157	4414	4059	2569
40	1044	925	411	1832	1533	808	1141	906	209	466	398	199	4482	3761	1627
41	950	802	823	1963	1371	724	997	649	236	411	331	48	4322	3153	1831
42	927	695	308	1568	1075	420	840	481	113	491	340	24	3826	2592	864
43	744	531	334	1432	959	288	845	528	175	346	246		3367	2264	797
44	715	564	154	1201	748	231	658	427	84	315	217	48	2888	1957	517
45	503	341	102	687	447	89	304	201	25	173	140	24	1667	1129	240
46	495	380	77	409	302	160	334	222	44	192	135	12	1430	1039	293
47	280	207	77	445	331	29	193	162	8	118	95	24	1035	796	137
48	238	200	102	146	126	43	135	106		62	51	24	581	483	169
49	144	120		174	154	29	138	108		67	52	12	523	434	40
50	79	75		100	87	43	112	78	8	30	28		320	267	51
51	37	53		96	89	29	37	33		20	20		191	194	29
52	33	33		51	51	57	22	22	11	10	10		115	115	68
53	18	18		37	37	43	16	16		9	9		80	80	43

54	10	10		24	24	171	12	12		5	9		50	55	171
55	10	10		34	28	86	5	5		2	2		51	45	86
56	6	6		9	9	171	3	3		1	1		20	20	171
57	1	1		8	8	57	1	1		1	1		11	11	57
58	1	1		1	1	86	1	1		1	1		4	4	86
59	1	1		1	1	57				1	1		3	3	57
60	3	3		1	1	86							4	4	86
61				1	1	71				1	1		2	2	71
62						43									43
63						29									29
64						57									57
65						14									14
66															
67															
68						14									14
69						14									14
70						14									14
71															
72															
73															
74															
75															
Total	9725	11195	49557	16360	19967	42590	9010	11410	25263	4538	5438	10505	39633	48010	127915

Table 7.7.11. ***Nephrops*** **in 7.f,g,h. Length distribution of landings by country in 2010. Quarterly and total values (10^3). The reported size is the carapace length (CL). Conversion of CL to TS (total size) is done by multiplication by 3.3.**

The French data are presented by 2 ways: (1) Previous method (tails not sampled and systematically apportioned in the smallest category of entire *Nephrops* at auction). (2) Tails are included (as performed since WGCSE 2009).

CL	Q1			Q2			Q3			Q4			Year		
(mm)	F		IRL	F		IRL	F		IRL	F		IRL	F		IRL
	no tails	tails		no tails	tails		no tails	tails		no tails	tails		no tails	tails	
17															
18															
19															
20															
21						43			34			92			169
22			181			97			59			228			564
23			699			301			207			319			1526
24			1032			691			481			360			2564
25			3177			1381			949			839			6346
26			5951		17	2344			1623		7	1128		24	11047
27		13	7952		17	3558		4	2014		2	1663		36	15188

28		9	5362		41	5352		8	1984		11	2048		69	14745
29		13	5254		70	6136		8	2736		45	1811		136	15938
30		28	3887		169	6558		76	2385		77	2570		350	15399
31		57	2667		256	6066		136	1915	2	141	1706	2	590	12355
32		94	2222		484	5360		236	1706	8	149	1586	8	962	10875
33		129	1968	6	522	4262		296	1337	25	162	1036	31	1109	8603
34	6	243	2079	18	430	3673	20	292	737	49	200	844	93	1165	7333
35	40	224	1151	121	606	2834	66	439	467	94	164	409	322	1432	4861
36	91	313	1559	200	610	2306	158	462	323	113	172	316	562	1557	4504
37	233	363	1596	400	545	1853	286	470	247	139	146	82	1058	1524	3778
38	335	447	1518	388	509	1375	449	460	99	168	145	122	1340	1561	3115
39	460	442	928	509	515	941	541	551	88	164	127	122	1674	1635	2079
40	443	412	705	588	484	627	557	508	24	219	169	20	1807	1573	1375
41	460	388	482	485	373	420	587	443	7	185	159	20	1717	1362	929
42	552	450	593	661	422	698	450	337	20	159	118	41	1822	1328	1352
43	473	351	441	548	340	331	508	384	7	167	105	20	1695	1180	800
44	518	385	441	548	378	224	503	343		132	101		1701	1208	665
45	326	257	441	357	248	89	391	256		127	101		1201	863	530
46	268	234	148	237	179	107	228	181		118	86		851	680	255
47	216	203	74	259	179	79	136	104		92	73		703	559	152
48	130	132	111	252	185	54	138	123		46	44		567	483	164
49	107	108	111	196	151	35	117	98		55	53		474	409	146
50	58	65		119	95	35	56	60		28	28		261	248	35
51	59	60		101	76	79	44	40		20	24		224	200	79
52	30	30	74	34	34	35	24	28		13	17		100	109	109
53	17	17		29	29		19	23		10	10		76	80	
54	14	14		23	23		12	12		5	5		54	54	
55	10	10		16	22	17	8	8		3	3		37	43	17
56	3	3	36	5	5	17	3	3		3	3		14	14	53
57	4	4		4	4		1	1					9	9	
58				3	3		1	1					3	3	
59	1	1		1	1								2	2	
60															
61				2	2								2	2	
62															
63				2	2								2	2	
64				1	1								1	1	
65				1	1								1	1	
66															
67															
68				1	1								1	1	
69				1	1								1	1	
70				1	1	17							1	1	17
71															
72															
73															

74															
75				1	1								1	1	
Total	4853	5498	52839	6120	8033	57994	5303	6392	19450	2145	2647	17384	18420	22571	147667