Stock Annex: Plaice (*Pleuronectes platessa*) in Division 7.d (eastern English Channel)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Plaice, (ple.27.7d)
Working Group:	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Created:	5 March 2003
Authors:	Richard Millner (r.s.millner@cefas.cu.uk) and Joël Vigneau
Last revised:	May 2018
Main revision:	
Last updated by:	Raphaël Girardin (Raphael.girardin@ifremer.fr) (WGNSSK, 2018), Marie Savina (Marie.Savina.Rolland@ifremer.fr) and Youen Vermard (Youen.Vermard@ifremer.fr) (WKPLE, 2015), and Joël Vigneau (Joel.Vigneau@ifremer.fr) and Youen Vermard (WKFLAT, 2010)

A. General

A.1. Stock definition

The management area for this stock is strictly that for ICES Division 7.d called the eastern Channel, although the TAC area includes the smaller component of 7.e (western Channel).

Major spawning centres were found in the eastern English Channel, the Southern Bight, the central North Sea and the German Bight. Other less important local spawning centres were found in the western English Channel and off the UK coast from Flamborough Head northwards to Moray Firth (Houghton and Harding, 1976< Harding and Nichols, 1987 in ICES, 2003). The regions of plaice spawning are generally confined within the 50-meter depth contour (Harding *et al.*, 1978, in ICES, 2003).

The stocks of plaice in the Channel and North Sea are known to mix greatly (Figure 1), especially during the spawning season (January-February). At this time many western Channel and North Sea plaice may be found in the eastern Channel. The comparable lack of spawning habitat in the western Channel alone suggests that this migration from 7.e to 7.d during the first quarter may be of considerable importance.

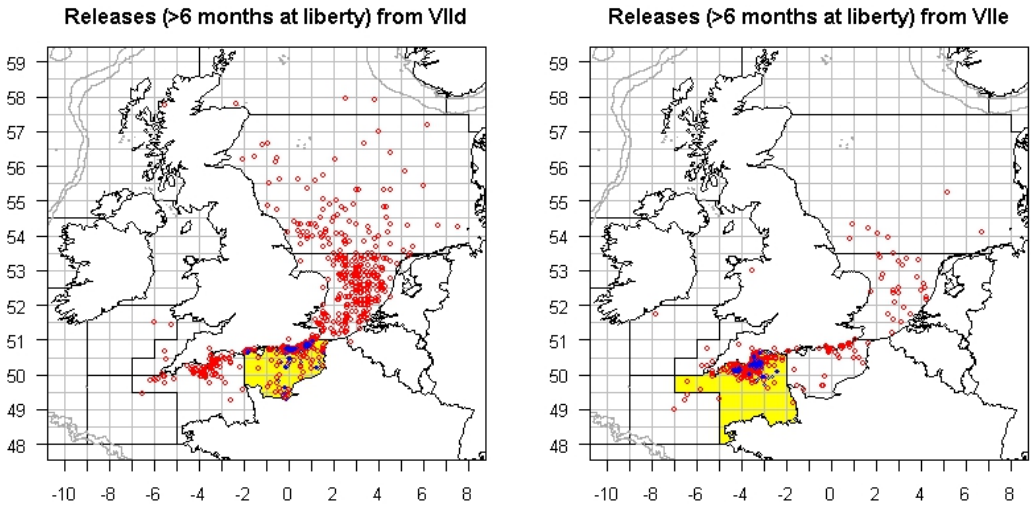


Figure 1 : Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (7.d) Channel and bottom right, released in western (7.e) Channel.

From tagging experiments, it was possible to derive estimates of the proportion of fish in quarter 1 in 7.d that would return, if not caught by the fishery, to 7.e and 4 (Table 1). In summary, 14% of males and 9% of females would migrate to 7.e, while 52% of males and 58% of females would migrate to 4. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in 7.d should be allocated to 7.e, while between 50 and 60% of the catch in Q1 in 7.d should be allocated to 4. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in 7.e and 7.d spend the summer in 7.e, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned, the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern English Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*., 2004).

Release Information		period			WEIGHTED BY INTN CATCH AND SSB pr(recap) after 6 or more months at liberty			
DIV	Sex	Release	Recapture	N	7A	7E	7D	4
VIIe	B	ALL		**564**	0.001	**0.90**	0.06	0.04
	M	Jan-Mar		**2**	0	**0.74**	0.26	0
	F			**3**	0	**0.60**	0.40	0
	M	Apr_Dec		**180**	0	**0.91**	0.05	0.03
	F			**224**	0.001	**0.93**	0.03	0.04
	M	Jan-Mar	Apr_Dec	**17**	0	**0.66**	0.11	0.23
	F			**8**	0	**0.67**	0.24	0.09
	M	Apr_Dec	Jan-Mar	**68**	0	**0.83**	0.12	0.05
	F			**62**	0	**0.88**	0.07	0.06
VIId	B	ALL		**990**	0.00	0.10	**0.54**	0.36
	M	Jan-Mar		**31**	0	0.04	**0.73**	0.22
	F			**86**	0	0.08	**0.58**	0.34
	M	Apr_Dec		**144**	0	0.10	**0.76**	0.14
	F			**180**	0	0.09	**0.79**	0.12
	M	Jan-Mar	Apr_Dec	**144**	0	0.14	**0.35**	0.52
	F			**305**	0	0.09	**0.33**	0.58
	M	Apr_Dec	Jan-Mar	**31**	0	0.20	**0.57**	0.23
	F			**63**	0	0.11	**0.72**	0.17
IVc	B	ALL		**812**	0	0.01	0.06	**0.93**
	M	Jan-Mar		**54**	0	0	0.03	**0.97**
	F			**17**	0	0	0.28	**0.72**
	M	Apr_Dec		**172**	0	0.01	0.06	**0.92**
	F			**235**	0	0.01	0.04	**0.95**
	M	Jan-Mar	Apr_Dec	**102**	0	0	0	**1**
	F			**38**	0	0	0	**1**
	M	Apr_Dec	Jan-Mar	**54**	0	0.02	0.05	**0.93**
	F			**71**	0	0.01	0.18	**0.80**

Table 1 : Summary of estimated movement probabilities for plaice (≥ 270mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

A.2. Fishery

Plaice is mainly caught in two offshore fisheries, i.e. the beam trawl sole fishery and the mixed demersal fishery using otter trawls.

In the first one, the Belgian beam trawlers used to fish mainly in the 1st (targeting spawning concentrations in the central Eastern Channel) and 4th quarter and their area of activity covers almost the whole of 7.d south of the 6 miles contour off the English coast. In the last years however, due to high sole abundance in the Celtic Sea, this fleet changed its fishing pattern, spending less time in the Eastern Channel in the first quarter, resulting in a lesser importance of that quarter in the total catches.

The second offshore fleet is mainly large otter trawlers from Boulogne, Dieppe and Fecamp. The target species of these vessels are cod, whiting, plaice, gurnards and cuttlefish and the fleet operates throughout 7.d.

There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. The inshore trawlers and netters are mainly vessels <12 m operating on a daily basis within 12 miles of the coast. There are a large number of these vessels (in excess of 400) operating from small ports along the French and English coast. These vessels target sole, plaice, cod and cuttlefish.

The otter trawl mixed demersal fishery and the inshore fishery are active when plaice is spread over the whole area and 4.c.

The minimum landing size for plaice is 27 cm. Minimum mesh sizes for demersal gears permitted to catch plaice are 80 mm for beam trawling and 100 mm for otter trawlers. Fixed nets are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

There is widespread discarding of plaice, especially from beam trawlers. The 25 and 50% retention lengths for plaice in an 80 mm beam trawl are 16.4 cm and 17.6 cm respectively, which are substantially below the MLS. Routine data on discarding is now available, and show plaice discards ratio between 20 and 60% depending on the métier. Discard survival from small otter trawlers can be in excess of 50% (Millner *et al*., 1993). In comparison discard survival from large beam trawlers has been found to be between less than 20% after a 2 h haul and up to 40% for a one-hour tow (van Beek *et al.,* 1989).

A.3. Ecosystem aspects

Biology: Adult plaice feed essentially on annelid polychaetes, bivalve molluscs, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel, spawning occurs from December to March between 20 and 40 m depth. At the beginning, pelagic eggs float at the surface and then progressively sink into deeper waters during development. Hatching occurs 20 (5–6 °C) to 30 (2–2.5 °C) days after fertilization. Larvae spend about 40 days in the plankton before migrating to the bottom and moving to coastal waters when metamorphosing (10–17 mm). The fry undergo relatively fast growth during the first year (Carpentier *et al., 2005*).

Environment: This bentho-demersal species prefers living on sand but also gravel or mud bottoms, from the coast to 200 m depth. The species is found from marine to brackish waters in temperate climate (Carpentier *et al., 2005*).

Geographical distribution: Northeast Atlantic, from northern Norway and Greenland to Morocco, including the White Sea; Mediterranean and Black Seas (Carpentier *et al., 2005*).

Vaz *et al*. (2007) used a multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature (Vaz *et al*, 2004). One Group was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry. It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

Community evolution over time: (From Vaz *et al*., 2007). The community relationship with its environment was remarkably stable over the 17 years of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

More details on biology, habitat and distribution of plaice in 7.d from the Interreg 3a project CHARM II, may be found in Annex 1.

B. Data

B.1. Commercial catch

The landings are taken by three countries Belgium (22% of combined TAC), France (14.9%), and England (8%). Quarterly catch numbers and weights were available for a range of years depending on country; the availability is presented in the text table below. Levels of sampling prior to 1985 were poor and these data are considered to be less reliable. In 2001 international landings covered by market sampling schemes represented the majority of the total landings.

Belgian commercial landings and effort information by quarter, area and gear are derived from logbooks. Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium). Quarterly sampling of landings takes place at the auctions of Zeebrugge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours. Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level. The ALK is used to obtain the quarterly age distribution from the length distribution. From 2003, an on-board sampling program is routinely carried out following the provision of the EU Regulation 1639/2001.

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10 m and from sales declaration forms for vessels under 10 m. These self-declared production data are then linked to the auction sales in order to have a complete and precise trip description. The length measurements were done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne until 2008. From 2009, concurrent sampling by métier was initiated following the provisions of EU Regulation 95/2008. Otoliths samples are taken by quarter throughout the length range of the landed catch for quarters 1 to 3 and from the October GFS survey in quarter 4. These are aged and combined to the quarterly level and the age-length key thus obtained is used to transform the quarterly length compositions. The lengths not sampled during one quarter are derived from the same year in the nearest available quarter. Weight, sex and maturity-at-length and at-age are obtained from the fish sampled for the age-length keys. The collection of discard data began in 2003 within the EU Regulation 1639/2001. This first year of collection was incomplete in terms of time coverage, therefore the use of these data should be considered only from 2005.

English commercial landings in tonnes by quarter, area and gear are derived from the sales notes statistics for vessels under 12 m that do not complete logbooks. For those over 12 m (or >10 m fishing away for more than 24 h), data is taken from the EC logbooks. Effort and gear information for the vessels <10 m is not routinely collected and is obtained by interview and by census. No information is collected on discarding from vessels <10 m. Discarding from vessels >10m has been obtained since 2002 under the EU Data Collection Regulation. The gear group used for length measurements are beam trawl, otter trawl and net. Separate-sex length measurements are taken from each of the gear groupings by trip. Trip length samples are combined and raised to monthly totals by port and gear group. Months and ports are then combined to give quarterly total length compositions by gear group; unsampled port landings are added in at this stage. Quarterly length compositions are added to give annual totals by gear. These are for reference only, as ALK conversion takes place at the quarterly level. Otoliths samples are taken by 2 cm length groups separately for each sex throughout the length

range of the landed catch. These are aged and combined to the quarterly level, and include all ports, gears and months. The quarterly sex-separate age-length keys are used to transform quarterly length compositions by gear group to quarterly age compositions.

A minimum of 24 length samples are collected per gear category per quarter. Age samples are collected by sexes separately and the target is 300 otoliths per sex per quarter. If this is not reached, the 1st and 2nd or 3rd and 4th quarters are combined.

The text table below shows which country supplies which kind of data:

COUNTRY	NUMBERS	WEIGHTS–AT–AGE
Belgium	1981–present	1986–present
France	1989– present	1989–present
UK	1980– present	1989–present

Data are uploaded in InterCatch and include quarterly numbers-at-age, weight-at-age, length-at-age and total landings. The files are aggregated by the stock coordinator to produce a FLR stock object. SOP corrections are applied to the data.

B.2. Biological sampling

Natural mortality: Estimated with Peterson and Wroblewski's estimator, based on weight (Peterson and Wroblewski, 1984)

AGE	1	2	3	4	5	6	7
M	0.3531	0.3132	0.292	0.2749	0.2594	0.2474	0.2329

Maturity ogive: assumes that 15% of age 2, 53% of age 3 and 96% of age 4 are mature and 100% for ages 5 and older.

Weights-at-age: prior to 2001, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. From 2001, second quarter catch weights were used as stock weights in order to be consistent with North Sea plaice. The database was revised back to 1990.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

B.3. Surveys

A dedicated 4 m beam trawl survey for plaice and sole has been carried out by England using the RV Corystes since 1988 in July. The survey covers the whole of 7.d and is a depth stratified survey with most samples allocated to the shallower inshore stations where the abundance of sole is highest.

In addition, inshore small boat surveys using 2 m beam trawls were undertaken along the English coast and in a restricted area of the Baie de Somme on the French coast. In 2002, The English and French Young Fish Surveys were combined into an International Young Fish Survey. The dataset was revised for the period back to 1987. The two surveys operate with the same gear (beam trawl) during the same period (September) in two different nursery areas. Previous analysis (Riou *et al*, 2001) has shown that asynchronous spawning occurs for flatfish in Division 7.d. Therefore both surveys were combined based on weighting of the individual index with the area nursery surface

sampled (Cf. Annex 1). Taking into account the low, medium, and high potential area of recruitment, the French YFS got a weight index of 55% and the English YFS of 45%. The UK Young Fish Survey ceased in 2006, disrupting the ability to derive an International YFS.

A third survey consists of the French otter trawl groundfish survey (FR GFS) in October. Prior to 2002, the abundance indices were calculated by splitting the survey area into five zones, calculating a separate index for each zone, and then averaging to obtain the final GFS index. This procedure was not thought to be entirely satisfactory, as the level of sampling was inconsistent across geographical strata. A new procedure was developed based on raising abundance indices to the level of ICES rectangles, and then by averaging those to calculate the final abundance index. Although there are only minor differences between the two indices, the revised method was used in 2002 and subsequently.

B.4. Commercial CPUE

One commercial fleet was used in tuning: the Belgian Beam Trawlers. Only trips where sole and/or plaice have been caught are accounted for. The effort of the Belgian Beam Trawlers is corrected for engine power. This tuning series is no longer used due to concerns on changes in fishing practices over time (including discarding practices), and poor performance to track cohorts.

B.5. Other relevant data

C. Assessment: Data and methods

Benchmark 2015

This stock was 'benchmarked' at the WKPLE 2015 (ICES, 2015a) meeting where the following main issues have been under review: (i) the inclusion of a discards time-series in the assessment and (ii) an attempt to overcome the problematic retrospective pattern.

All on-board samples from Belgium, France and UK from 2003 to 2013 had been uploaded to InterCatch prior to the benchmark. An estimate of annual discards at age was produced for the period 2006 – 13 and the flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) has been tested for reconstructing discards prior to 2006.

In addition to the Aarts and Poos' model, two others models were run during the benchmark. First the XSA model which has been used until 2014 (cf. section H.1), as well as a model developed using the a4a modelling framework (Jardim *et al.*, 2015). This framework relies on the specification of three log-linear submodels, one each for fishing mortality, survey catchability and recruitment. The catchability and stock recruitment submodel was a year effect model with independently varying recruitment and age effect for catchability. The fishing mortality submodel investigated was a year and age effect.

The inclusion of discards data and the testing of different combinations of tuning series (and age range in them) did not solve the issues associated with the use of the XSA method. The a4a assessment in its specification did neither improve the assessment. In both cases, the inclusion of discards estimated from the Aarts and Poos model in other models was not considered satisfactory by the benchmark panel. The results obtained with the Aarts and Poos model on the other hand were judged acceptable, although the

panel recommended further explorations of the high estimated discard volumes in the 1990s and early 2000s. The removal of 65% of Q1 catches to account for spawning migrations) was maintained, but the calculation was changed such as only the mature age classes are affected now.

The scenario retained for the analytical assessment has:

- A discard time-series spanning from 2006 to 2013. Prior to 2006 the discards are estimated by the Aarts and Poos model;
- The catch-at-age matrix is corrected for spawning migrations (only mature age classes),
- Peterson and Wroblewski's mortality, and two surveys: UK BTS and FR GFS.

The Belgian Beam trawl tuning was rejected as input to this assessment.

In summary, the Aarts and Poos model (ADMB and R) takes a design matrix for a tensor spline that will describe the F matrix. The dimension of that design matrix is defined by the parameters in the model (see table below). It assumes that the F-at-age is constant after a given age, which is a parameter to the model. It assumes that the q-at-age for the indices is a smooth function of age, using a spline smoother. The number of knots is a parameter to the model. Also, q-at-age is constant after a given age, which is a parameter to the model. It assumes that the discards fraction of the catch is a logistic curve, described by two parameters. This curve is constant over time. The sigma values in the log-likelihood are 3 parameter polynomials of the form a + b*age + c*age^2, one for each data source. Finally, recruitment is estimated as a single parameter per year.

Model parameters	code	Values
Age from which F is constant	qplat.Fmatrix	6
Dimension of the F matrix	Fage.knots	4
	Ftime.knots	14
	Wtime.knots	5
Age from which q is constant	qplat.surveys	5

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year
Caton	Catch in tonnes	1980-Last year	1–7+	No
Canum	Catch-at-age in numbers	1980-Last year	1–7+	No
Weca	Weight-at-age in the commercial catch	1980-Last year	1–7+	No
West	Weight-at-age of the spawning stock at spawning time.	1980-Last year	1–7+	No
Mprop	Proportion of natural mortality before spawning	1980-Last year	1–7+	No

Fprop	Proportion of fishing mortality before spawning	1980-Last year	1–7+	No
Matprop	Proportion mature-at-age	1980-Last year	1–7+	No
Natmor	Natural mortality	1980-Last year	1–7+	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	UK BeamTrawl	Excluded	
Tuning fleet 2	BE Beam Trawl	Excluded	
Tuning fleet 3	FR Otter Trawl	Excluded	
Tuning fleet 4.	UK BTS	1988 – Last year	1–6
Tuning fleet 5	FR GFS	1988 – Last year	1–6
Tuning fleet 6	Int YFS	Excluded	1

D. Short-Term Forescast

Short term projection were done using the ICES (2012) recommendations

Model used: Age structured

Software used: FLR package

Initial stock size:

1) the survivors at age 2 and greater from the Aarts and Poos assessment
2) N at age 1 = Geometric mean of the estimated recruitment from y-5 to y-2, y being the final assessment year. In 2018, the geometric mean of the whole time-series (1980–2017) was used instead, as the recruitment had significantly decreased from 20114 to 2017.

Maturity: same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages and all years

Weight-at-age in the stock and catch: average stock and catch modelled weights over the preceding 3 years.

Exploitation pattern: The F vector used will be the average F-at-age in the last 3 years, scaled by the Fbar (3–6) to the level of last year.

Discarding pattern: The numbers discarded/numbers landed ratio used will be the average ratio in the last 3 years.

Intermediate year assumptions: The whole TAC is assumed to be used. The proportion of the TAC (7.d and e) consumed in 7.d is calculated using the long-term average proportion of landings taken in Area 7 over the total catches (2003 – assessment year). Then, the proportion of the TAC consumed in 7.d relating to the 7.d plaice stock is calculated using the long-term average ratio "65% of Q1 landings/total 7.d landings" (2003 – assessment year). In 2018, a status quo option was used (F2018 = F2017) to account for the fact that the TAC will not be used entirely in 2018.

E. Medium-Term Forescast

F. Long-Term Forecast

G. Biological Reference Points

In 2016, ICES requested precautionary and limit reference points for all stocks. The expert group proposed values, which were reviewed by RGPA and finalized in the ADG_NorthSea_2016. These are the reference points used in the 2016 advice. More information is available in the expert group report (ICES, 2016).

The updated reference points and their technical bases are as follows.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Btrigger	25 826 t	Bpa	ICES,2015b
	FMSY	0.25	FMSY computed with EqSim, based on the 2015 assessment and the segmented regression and on Beverton and Holt relationships.	ICES,2015b
Precautionary approach	Blim	18 447 t	Break point of the segmented regression SRR.	ICES,2015b
	Bpa	25 826 t	Bpa = Blim*exp(1.645 σB); σB = 0.20	ICES,2015b
	Flim	0.5	F that in equilibrium will maintain the stock above Blim with a 50% probability	ICES, 2016
	Fpa	0.36	Fpa = Flim*exp(−1.645 σF); σF = 0.20	ICES, 2016
Management plan	SSBMGT	Not defined.		
	FMGT	Not defined.		

Prior to 2016, reference points were as follows.

Blim = 18 447 t.

Bpa = 25 826 t.

Stock – Plaice 7.d	without Btrigger
Reference point	Value
FMSY (median)	0.25
FMSY lower	0.18
FMSY upper	0.34
New FP.05 (5% risk to Blim without Btrigger)	0.347
FMSY upper precautionary with note of whether conditional	0.34

H. Other Issues

H.1 Historical overview of previous assessment methods

This stock was 'benchmarked' at the WKFLAT 2010 (ICES, 2010) meeting where two main issues have been under review, (i) inclusion of a discards time-series in the assessment and (ii) an attempt to overcome the problematic retrospective pattern. Solutions explored included making an 'allowance' for migration patterns between the two Channel plaice stocks and the southern North Sea.

The combined assessment of the two Channel plaice stocks was examined. It was agreed that this would require further investigation as the inclusion of the North Sea stock would also need to be considered. Any combining of stocks would have a wide ranging impact on the assessment and any subsequent management.

The issue of including discard estimates was based on a working document provided to the benchmark workshop, where all on-board samples from Belgium, France and UK from 2002 to 2008 were gathered in an international dataset. An estimate of annual discards at age was produced for the period 2004 – 2008, and the flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) has been tested for reconstructing discards prior to 2004. The model did not succeed in providing reasonable and robust fit. The current discard time-series was considered too short and too variable to support proper model fitting. Further work on the data and method used for estimating the 2004–008 series of discards is necessary before inclusion in the statistical model is considered further.

The persistent retrospective pattern in the assessment without discards was largely reduced, when 65% of quarter 1 catches were removed as well as removal of younger ages (1, 2 and 3) from the survey UK BTS. The patterns in log q residuals, already shown in the previous assessment remained unchanged.

In conclusion, the proposed final settings (detailed below) improve the retrospective pattern, and take into account the acknowledged mixing between neighbouring areas, but the model is not entirely satisfactory in terms of quality of the assessment. The reasons are that the model still does not account for discards, removes younger ages from an internally consistent survey, and does not provide solutions for the patterns in log catchability residuals.

The recommendation from WKFLAT was that **this assessment was useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F**. However, WKFLAT did not recommend this as an analytical assessment, as it would not be useful for calculation of reference points.

Since further work on including the discard estimates, on the relevance of the commercial tuning series, and sensitivity of the assessment to the 65% adjustment to the Q1 catch-at-age need to be examined, the information concerning the settings of the assessment model was only valid for WGNSSK 2010.

Model used: XSA

Software used: IFAP / Lowestoft VPA suite for final assessment; FLR packages and SURBA software for exploratory analysis

Model Options chosen:

1) Tapered time weighting not applied

2) Catchability independent of stock size for all ages

3) Catchability independent of age for ages >= 7

4) Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

5) S.E. of the mean to which the estimate are shrunk = 1.0

6) Minimum standard error for population estimates derived from each fleet = 0.300

7) Prior weighting not applied

8) Input data types and characteristics:

9) Catch data available for 1980–present year. However, there was no French age composition before 1986 and large catchability residuals were observed in the commercial data before 1986. In the final analyses only data from 1986–present were used in tuning.

10) Removal of 65% of quarter 1 catches in tonnes, catches-at-age and weight-at-age for all years

I. References

Aarts, G., and Poos, J.J. 2009. Comprehensive discard reconstruction and abundance estimation using flexible selectivity functions. ICES Journal of Marine Science, 66: 763–771.Carpentier, A., Vaz, S., Martin, C. S., Coppin, F., Dauvin, J.- C., Desroy, N., Dewarumez, J.- M., Eastwood, P. D., Ernande, B., Harrop, S., Kemp, Z., Koubbi, P., Leader-Williams, N., Lefèbvre, A., Lemoine, M., Loots, C., Meaden, G. J., Ryan, N., Walkey, M., 2005. Eastern Channel Habitat Atlas for Marine Resource Management (CHARM), Atlas des Habitats des Ressources Marines de la Manche Orientale, INTERREG IIIA, 225 pp.

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management,final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom. http://www.ifremer.fr/docelec/doc/2009/rapport-7377.pdf

ICES, 2003. Planning Group on North Sea Cod and Plaice Egg Surveys in the North Sea (PGEGGS). 24–26 June 2003, Ijmuiden, Netherlands. ICES CM 2003/G:06 Ref. D. 45 p.

ICES, 2010. Report of the Benchmark Workshop on Flatfish (WKFLAT), 25 February-4 March 2010, ICES Headquarters, Copenhagen, Denmark. ICES CM 2010/ACOM:37.

ICES, 2012. Report of the Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). 13-17 February 2012, Lisbon, Portugal. ICES CM 2012/ACOM:36.

ICES, 2015a. Report of the Benchmark Workshop on Plaice (WKPLE). 23-27 February 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/ACOM:33.

ICES, 2015b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). 28 April-7 May 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/ACOM:13.

ICES, 2016. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). 26 April-5 May 2016, Hamburg, Germany. ICES CM 2016/ACOM:14.

Jardim, E., Millar, C. P., Mosqueira, I., Scott, F., Osio, G. C., Ferretti, M., Alzorriz, N. and Orio, A. (2015). What if stock assessment were as simple as a linear model? The a4a initiative. ICES Journal of Marine Science, 72:232-236.

Kell, L.T., Scott, R., and Hunter E. (2004) Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51: 287– 299

Millner, R.S., Whiting, C.L and Howlett, G.J. 1993. Estimation of discard mortality of plaice from small otter trawlers using tagging and cage survival studies. ICES C.M. 1993/G:24, 6pp

Pawson, M.G. (1995) Biogeographical identification of English Channel fish and shellfish stocks. Fisheries Research Technical Report No. 99. MAFF Directorate of Fisheries Research, Lowestoft.
http://www.cefas.co.uk/Publications/techrep/tech99.pdf

Peterson, I., Wroblewski, J.S. (1984) Mortality rate of fishes in the pelagic ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 41, 117-1120.

Riou, P., Le Pape, O., and Rogers, S.I. 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel : application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125-135

van Beek, F.A., van Leeuwen, P.I., and Rijnsdorp, A.D. 1989. On the survival of plaice and sole discards in the otter trawl and beam trawl fisheries in the North Sea. ICES C.M. 1989/G:46, 17pp

Vaz, S., Carpentier, A., and Coppin, F. 2007. Eastern English Channel fish assemblages: measuring the structuring effect of habitats on distinct sub-communities. ICES Journal of Marine Science, 64(2), 271-287.

Vaz, S., Carpentier, A., Loots, C., and Koubbi, P. 2004. Modelling Fish Habitat Suitability in the Eastern English Channel. Application to community habitat level. ICES ASC 2004 conference proceedings, 12pp

Appendix 1 – ELEMENTS OF BIOLOGY ON PLAICE 7.d.

Excerpts from the project InterReg 3A CHARM Phase II (Carpentier *et al.,* 2009).

Pleuronectes platessa

Linnaeus,1758

Plie commune
European plaice

Embranchement-Phylum : Chordata
Classe-Class : Actinopterygii
Ordre-Order : Pleuronectiformes
Famille-Family : Pleuronectidae

© IFREMER

Biologie - La plie commune adulte se nourrit de polychètes, de mollusques bivalves, de cœlentérés, de crustacés, d'échinodermes et de petits poissons. En Manche, la reproduction s'étale de décembre à mars sur des fonds de 20 à 40 m de profondeur, avec un pic en janvier-février. En général, les œufs flottent tout d'abord à la surface avant de s'enfoncer progressivement dans la colonne d'eau au cours du développement. L'éclosion a lieu environ 20 (à 5-6°C) à 30 jours (à 2-2.5°C) après fécondation. Les larves ont alors une vie pélagique durant une quarantaine de jours avant de se métamorphoser (lorsque 10-17 mm de longueur) et de rejoindre le fond pour migrer vers les eaux littorales. La croissance en première année est assez élevée.

Caractères démographiques - Taille maximale 100 cm ; taille commune 25-45 cm ; taille minimale de capture 22 cm sauf Skagerrak et Kattegat 27 cm (UE) ; longévité maximale 50 ans ; âge et taille à maturité 2-7 ans et 18-35 cm ; paramètres de von Bertalanffy : taille asymptotique L_{inf} =71.65 cm, taux de croissance k = 0.23 an^{-1}, âge théorique t_0 = -0.83 ; paramètres de fécondité *alpha* = 2.33 ovules.cm^{-beta} et *beta* = 3.10 (50 000 à 500 000 ovules par femelle).

Environnement - Espèce bento-démersale vivant préférentiellement sur les fonds sableux mais aussi graveleux ou vaseux de la côte jusqu'à 200 m de profondeur, et se répartissant dans les eaux salées à saumâtres tempérées.

Répartition géographique - Atlantique nord-est, du nord de la Norvège et du Groenland au Maroc ; mer Méditerranée, dont la mer Noire.

Biology - Adult plaice essentially feed on polychaetes, bivalves, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel spawning occurs from December to March at depths ranging from 20 to 40 m, with a peak in January-February. Initially, pelagic eggs generally float at the surface. They then progressively sink into deeper waters during their development. Hatching occurs around 20 (at 5-6°C) to 30 (at 2-2.5°C) days after fertilisation. Larvae spend about 40 days in the plankton before metamorphosing (when 10-17 mm in length). They then move to the bottom and migrate towards coastal waters. The fry undergoes relatively fast growth during the first year.

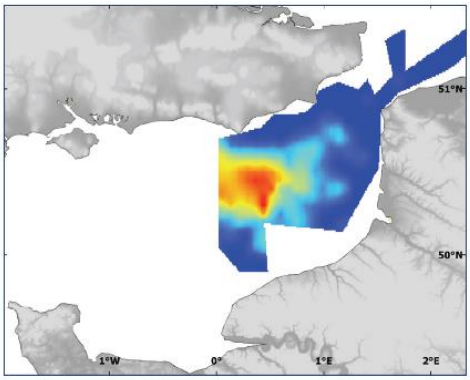
Life history parameters - Maximum length 100 cm; common length 25-45 cm; minimum landing size 22 cm except in Skaggerak and Kattegat 27 cm (EU); maximum lifespan 50 years; age and length at maturity 2-7 years and 18-35 cm; von Bertalanffy para-meters: asymptotic length L_{inf} = 71.65 cm, growth rate k = 0.23 $year^{-1}$, theoretical age t_0 = -0.83; fecundity parameters *alpha* = 2.33 oocytes.cm^{-beta} and *beta* = 3.10 (50,000 to 500,000 oocytes per female).

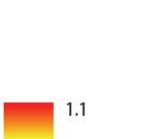
Environment - This bentho-demersal species prefers to live on sand but also on gravely or muddy substrates, from the coast to 200 m in depth. The species is found in marine to brackish temperate waters.

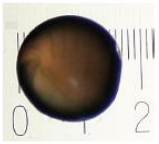
Geographical distribution - North-east Atlantic, from northern Norway and Greenland down to Morocco; Mediterranean including the Black Sea.

Œufs / Eggs - Pleuronectes platessa

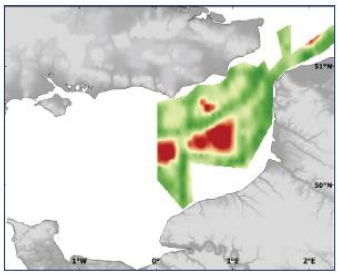
Abondance en janvier (IBTS, 2007)
Abundance in January (IBTS, 2007)



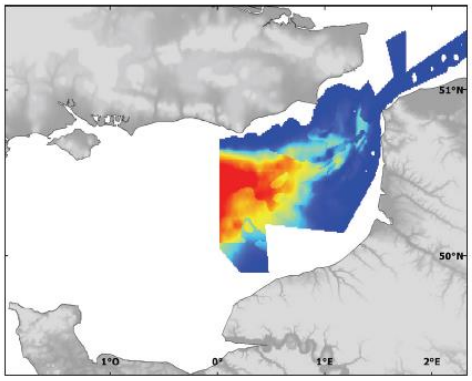


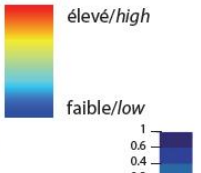


Erreur de krigeage
Kriging error

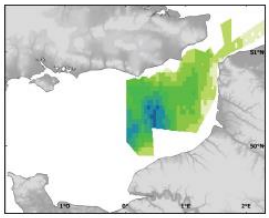


Habitat préférentiel en janvier (GLM)
Preferential habitat in January (GLM)





Erreur du modèle / *Model error*



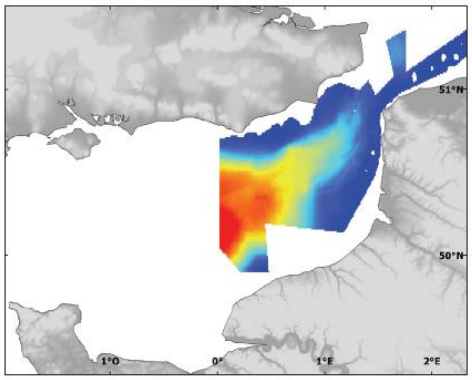
DEP	+2
STR	-
TMP	+
SAL	
CHL	+
SED	

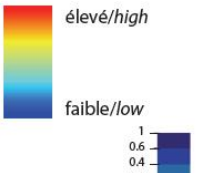
0/1 GLM

DEP	
STR	
TMP	2
SAL	
CHL	
SED	CS M - G - FS - P

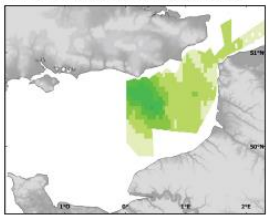
+ GLM

Habitat potentiel en janvier (RQ)
Potential habitat in January (RQ)

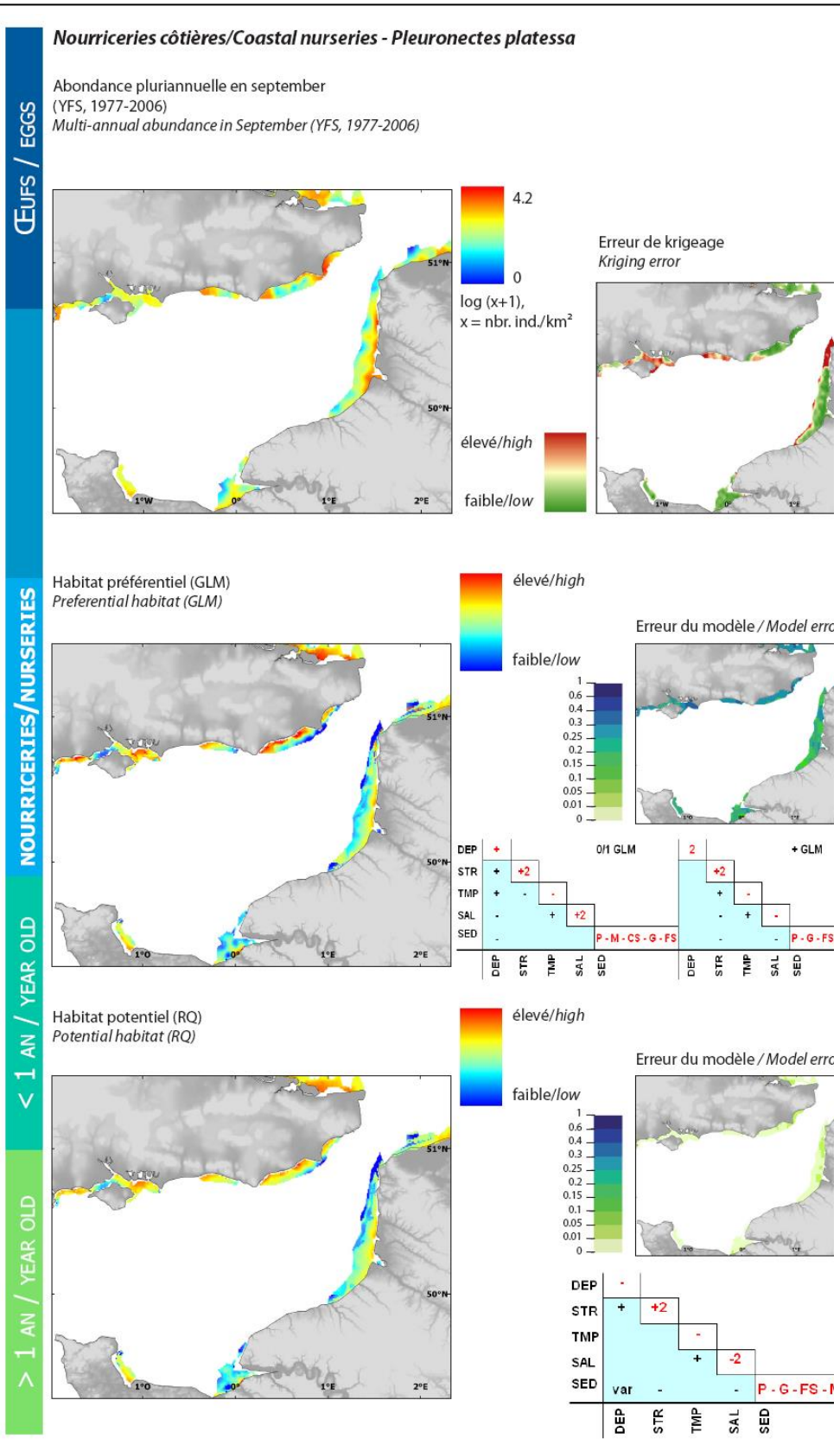




Erreur du modèle / *Model error*



DEP	+2
STR	-2
TMP	-2
SAL	-2
CHL	+2
SED	CS M - FS - G - P


Nourriceries côtières/Coastal nurseries - Pleuronectes platessa
ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
Abondance pluriannuelle en september
(YFS, 1977-2006)
Multi-annual abundance in September (YFS, 1977-2006)
4.2
0
log (x+1),
x = nbr. ind./km²
élevé/high
faible/low
Erreur de krigeage
Kriging error
Habitat préférentiel (GLM)
Preferential habitat (GLM)
élevé/high
faible/low
Erreur du modèle / Model erro
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
P - M - CS - G - FS
P - G - FS
Habitat potentiel (RQ)
Potential habitat (RQ)
élevé/high
faible/low
Erreur du modèle / Model erro
var
P - G - FS - M
51°N
50°N
1°W
0°
1°E
2°E

Pour cette espèce, les données disponibles couvrent presque l'ensemble du cycle de vie (sauf les larves) et les deux saisons pour les individus de moins et plus d'un an.

Œufs

Lors de la campagne IBTS de janvier, la plie est en pleine période de reproduction en Manche orientale. Les œufs de stade 1 récoltés alors suggèrent que les zones de frai sont situées dans les eaux centrales de la Manche orientale, dans des zones relativement profondes. Les abondances sont bien prédites par le modèle d'habitat préférentiel qui situe la zone de frai dans la partie centrale de la Manche donc dans des eaux relativement profondes mais protégées des forts courants de marées. Cependant, l'erreur du modèle est assez importante. Le modèle d'habitat potentiel montre la même zone comme favorable, avec un schéma de distribution un peu plus étendu au niveau des sédiments sableux.

Nourriceries côtières

La carte d'abondance issue des campagnes YFS (septembre) montre une répartition très côtière des individus sur presque toute la zone échantillonnée, avec toutefois des abondances plus fortes en face des baies de Somme, Canche, Authie et Rye. Les modèles d'habitats préférentiel et potentiel sont très semblables et sont en accord avec les abondances des campagnes. Ils favorisent la bande côtière et surtout le large des baies à l'exception notable de la baie de Seine. Les zones optimales pour les nourriceries sont situées dans des zones peu profondes, proches des apports d'eaux douces et froides en cette saison mais qui présentent cependant des sédiments grossiers et où les courants de marées sont relativement forts. Ces zones correspondent vraisemblablement à un front hydrologique côtier potentiellement très productif au niveau benthique.

< 1 an

Les individus de moins d'un an (< 18.0 cm) ont été séparés des autres sur la base de leur taille.

En juillet, les jeunes individus ont été échantillonnés face aux baies de Somme, Canche, Authie, autour de la presqu'île du Cotentin et un peu en baie de Seine, côté français et aux alentours de Dungeness, à l'ouest de l'île de Wight et surtout dans l'estuaire de la Tamise, coté britannique. Ces zones plutôt constantes sont plus ou moins étendues selon l'année d'étude. La carte d'habitat préférentiel n'est pas vraiment en accord avec les distributions observées. Elle favorise des zones très côtières proches des estuaires, sur les côtes française et britannique, hors dans la plupart de ces zones les abondances observées sont très faibles voire nulles. L'incertitude du modèle est plus forte sur les côtes mais très faible dans les zones centrales signifiant qu'il n'y a pratiquement aucune incertitude concernant l'absence de cette espèce à ces endroits. Le modèle d'habitat potentiel propose également des zones côtières mais qui s'étendent plus au large, ce qui est plus en accord avec les distributions observées. Le modèle d'habitat potentiel s'appuie sur de faibles température et tension de cisaillement et sur des sédiments grossiers. L'erreur est nulle sur presque toute la région sauf dans le sud-ouest de la zone étudiée où elle atteint des valeurs assez importantes.

For this species, data are available for almost the entire life cycle (except larvae), and two seasons for individuals of less and more than one year.

Eggs

The IBTS survey takes place during the reproductive period of plaice in the eastern English channel. Stage 1 eggs sampled during the survey indicate that spawning areas were located in the central eastern English channel, in relatively deep areas. Survey abundance levels were accurately predicted by the preferential habitat which showed spawning areas as being located in the central Channel, in fairly deep areas protected from strong tidal currents. Nevertheless, the model errors were high. The potential habitat model showed the same areas as favourable, though favourable habitats included sandy areas.

Coastal nurseries

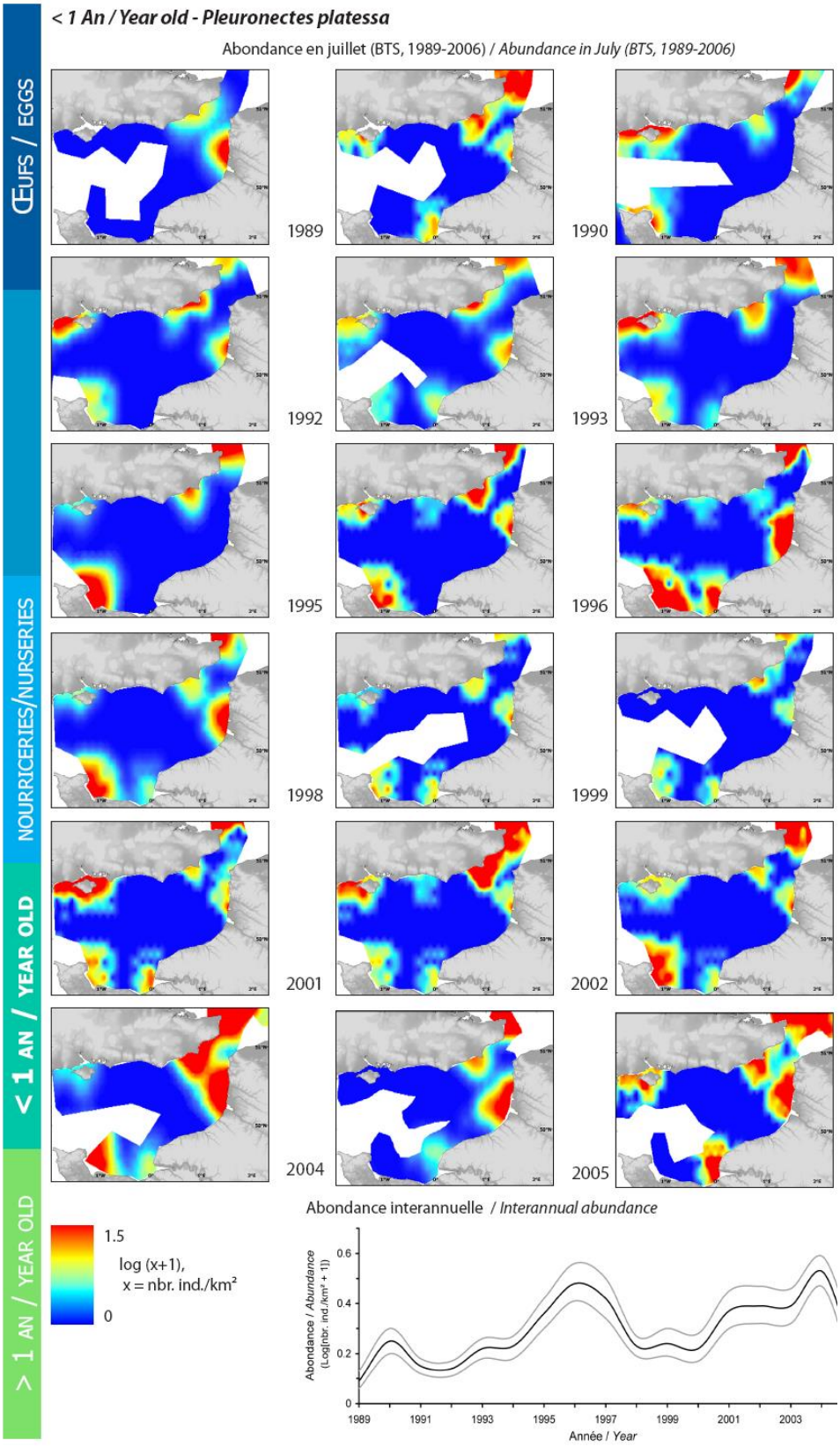
The multi-annual abundance map from the YFS surveys (September) indicates a very coastal spatial distribution of plaice across the sampled area, with some high abundance areas in front of the Bays of Somme, Canche, Authie and Rye. The potential and preferential habitat models are very similar and agree with the survey abundance levels. They both favour the coast and bays, with the exception of the Bay of Seine. Suitable sites for nurseries are located in shallow areas, close to fresh and cool seasonal water inputs. These areas are characterised by coarse sediments and strong tidal currents, i.e. corresponding to a coastal hydrological front, potentially very productive at the benthic level.

< 1 year old

Individuals of less than one year were defined as such on the basis of their length (< 18.0 cm).

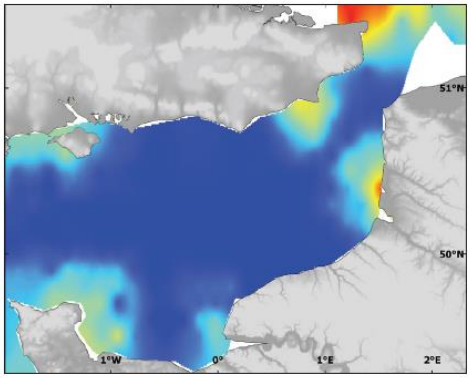
On the French side, young individuals were found off the Bays of Somme, Canche, Authie, around the Cherbourg Peninsula and a few in the Bay of Seine, in July. On the British side, they were located around Dungeness, west of the Isle of Wight and especially in the Thames estuary. The areas covered varied in size over time. The preferential habitat model did not really agree with the survey distribution. It favours very coastal zones near to estuaries on both French and British coasts but in most of these areas survey abundance levels were very low and sometimes null. The model uncertainty was higher on the coasts but very low in central areas which means that there is almost no uncertainty about the spatial extent of areas where this species is absent. The potential habitat model highlights coastal areas extending offshore as favourable, which is more coherent with survey distributions. The potential habitat model highlights areas of low temperature, weak bed shear stress and coarse sediments. The model error was almost null across the region except in the south-west, where it could reach high values.

In October, the distribution of young plaice was more spatially restricted than in July, and seemed to be concentrated the Bays of Somme, Canche, Authie and Seine. Some young individuals were also found around the Cherbourg Peninsula. Occurrence areas of young plaice did not change a lot between July and October. The kriging error was more i
in the north-west of the study area, where

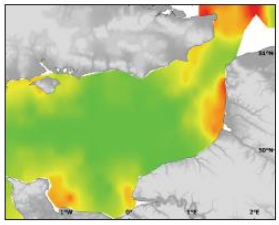

ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
< 1 An / Year old - Pleuronectes platessa
Abondance en juillet (BTS, 1989-2006) / Abundance in July (BTS, 1989-2006)
1989
1990
1992
1993
1995
1996
1998
1999
2001
2002
2004
2005
1.5
log (x+1),
x = nbr. ind./km²
0
Abondance interannuelle / Interannual abundance
Abondance / Abundance
(Log[nbr. ind./km² + 1])
0
0.2
0.4
0.6
1989
1991
1993
1995
1997
1999
2001
2003
Année / Year
314 |
Espèces et habitats / Species and habitats - Pleuronectes

< 1 An / Year old - Pleuronectes platessa

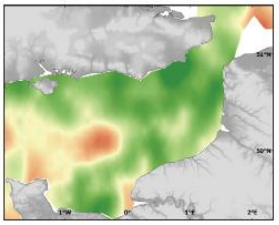
Abondance moyenne en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)



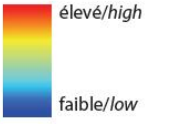
Ecart-type / *Standard deviation*

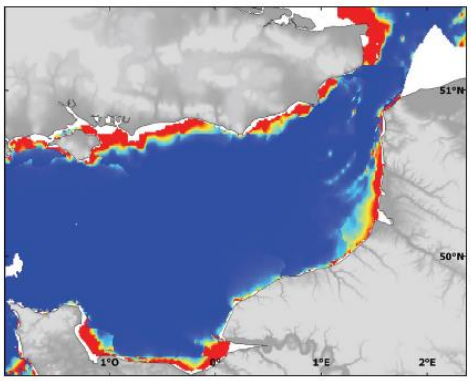


Erreur de krigeage / *Kriging error*

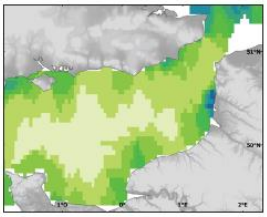


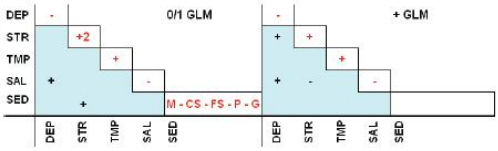
Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)



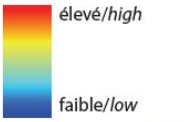


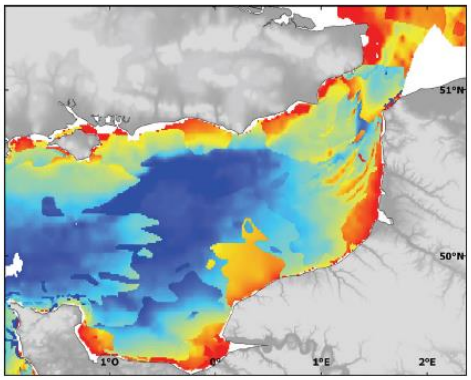
Erreur du modèle / *Model error*



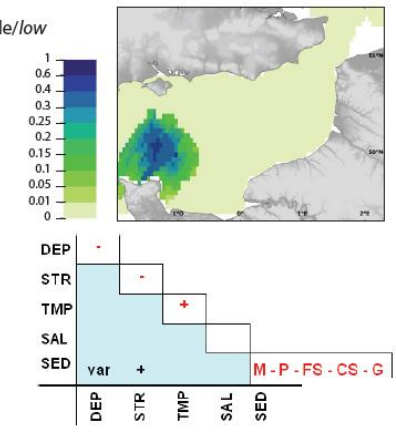


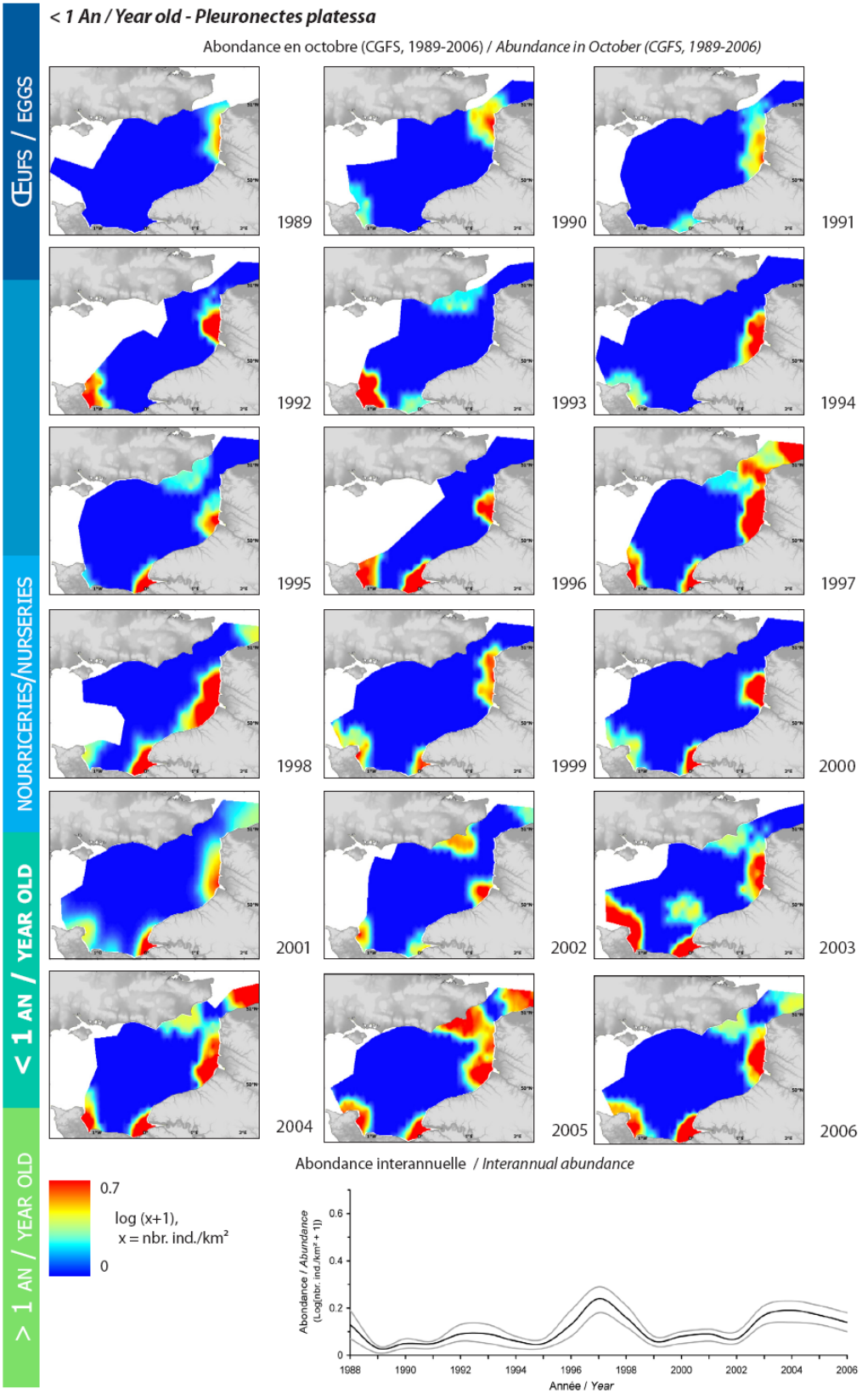
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)





Erreur du modèle / *Model error*

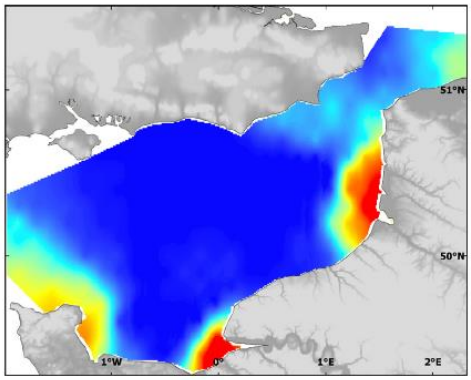


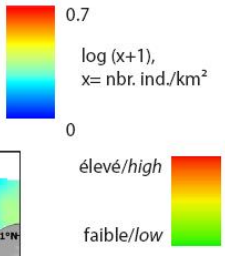


Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

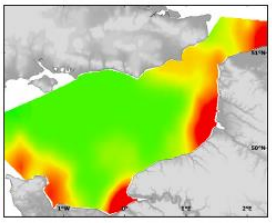
< 1 An / Year old - Pleuronectes platessa

Abondance moyenne
en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)

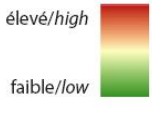


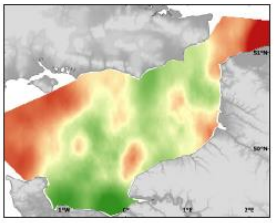


Ecart-type / *Standard deviation*

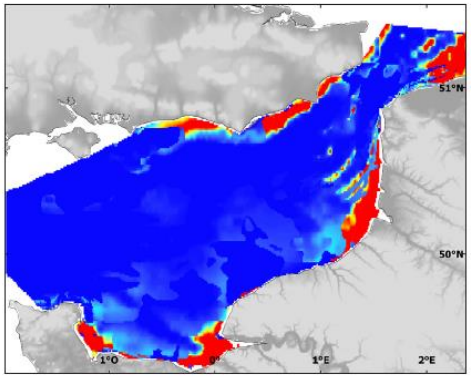


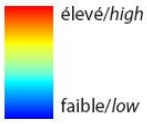
Erreur de krigeage / *Kriging error*



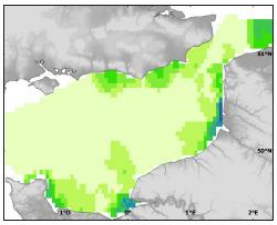


Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)

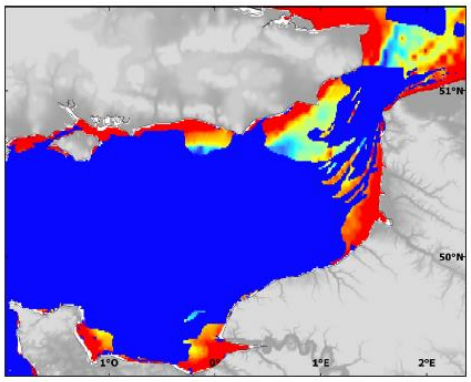


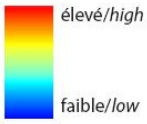


Erreur du modèle / *Model error*

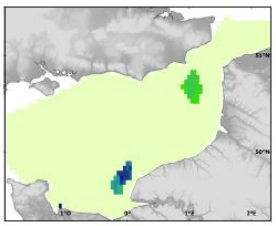


Habitat potentiel enoctobre (RQ)
Potential habitat in October (RQ)





Erreur du modèle / *Model error*



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

En octobre, la distribution des jeunes plies est moins étendue qu'en juillet et les individus semblent s'être concentrés au large des baies de Somme, Canche, Authie et Seine. On retrouve également des individus au niveau de la presqu'île du Cotentin. Les zones d'occurrence de la plie juvénile ne changent pas vraiment entre les deux saisons. L'erreur de krigeage est plus importante dans le nord-ouest de la zone où l'échantillonnage est plus clairsemé. Comme en juillet, le modèle d'habitat préférentiel favorise des habitats très côtiers au niveau des estuaires, ce qui ici concorde avec la distribution observée. Le modèle d'habitat potentiel se rapproche de celui de l'habitat préférentiel en allant un peu plus au large dans le détroit du Pas-de-Calais et le sud de la mer du Nord.

> 1 an

Les individus de plus d'un an (> 18.1 cm) sont échantillonnés dans les mêmes zones que les plus jeunes mais leur distribution s'étend plus au large.

En juillet, ils sont présents en forte proportion dans tout le détroit du Pas-de-Calais, dans le sud de la mer du Nord et dans les baies de Seine et des Veys. Aucun individu n'a été trouvé dans la partie centrale de la Manche orientale où les eaux sont plus profondes. Le modèle d'habitat préférentiel prédit bien la distribution observée, favorisant les zones à faibles profondeurs mais avec des courants de marées assez importants. Le modèle d'habitat potentiel est beaucoup plus optimiste, étendant les zones favorables, plus au large.

En octobre, la distribution semble se resserrer près des côtes. Beaucoup d'individus sont présents le long des côtes d'Opale ou belge et autour de Dungeness. Des zones d'abondance apparaissent également dans les baies de Seine et des Veys. L'erreur de krigeage est toujours associée aux zones où l'échantillonnage est plus épars. Les modèles d'habitats préférentiel et potentiel sont en accord avec les abondances de campagnes, toutefois l'erreur du modèle d'habitat préférentiel n'est pas négligeable. Le modèle d'habitat potentiel illustre l'affinité de cette espèce pour les fonds sableux à graveleux dans des zones de températures moyennes à faible profondeur et où les courants de marées se font ressentir.

tions were more sparse. As in July, the preferential habitat model strongly favoured coastal areas close to estuaries, which this time agrees with the survey data. The potential habitat model resembles the preferential habitat model but exhibits a more dispersed offshore spatial distribution in the Dover Strait as well as in the southern North Sea.

> 1 year old

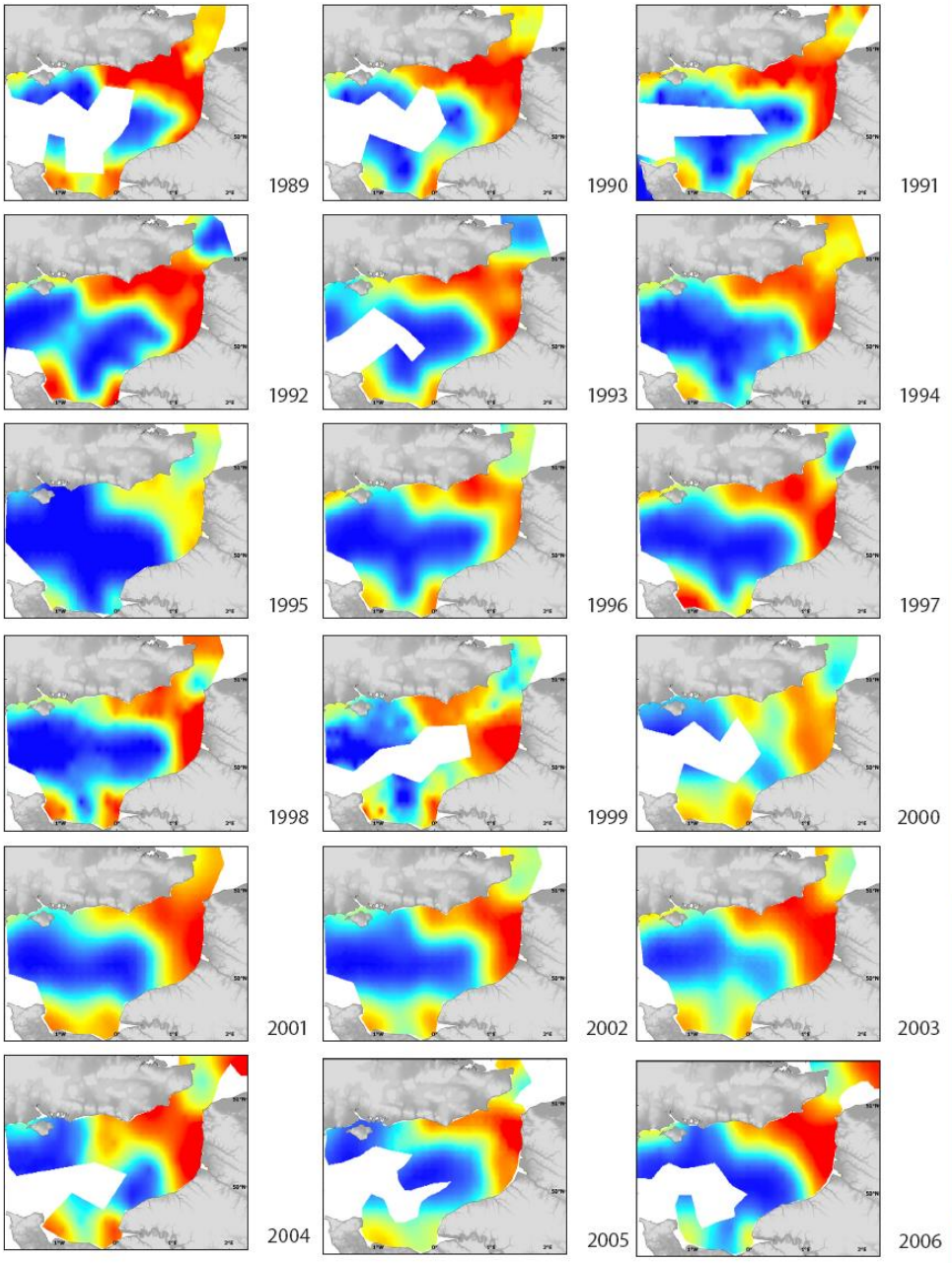
Older than one year individuals (length > 18.1 cm) were found in the same areas as younger ones but had a more offshore distribution pattern.

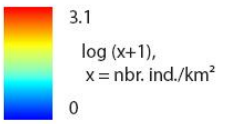
In July, high abundance levels were found in all of the Dover Strait, in the southern North Sea and in the Bays of Seine and Veys. No individual was found in the central Channel where waters are deeper. The preferential habitat model predicts the survey distribution well, favouring shallow waters with quite strong tidal currents. The potential habitat model was more optimistic, extending favourable habitats further offshore.

In October, the distribution pattern seemed to contract along the coasts. Many individuals were found along the Opale and Belgium coasts and around Dungeness. Some patches occured in the Bays of Seine and Veys. The kriging error was again associated with more sparse observations. The preferential and potential habitat models agreed with survey abundance levels though the preferential habitat model error was not negligible. The potential habitat model illustrates the affinity of this species for the sandy to gravely sediment types, shallow areas displaying average temperature conditions and where tidal currents can be strong.

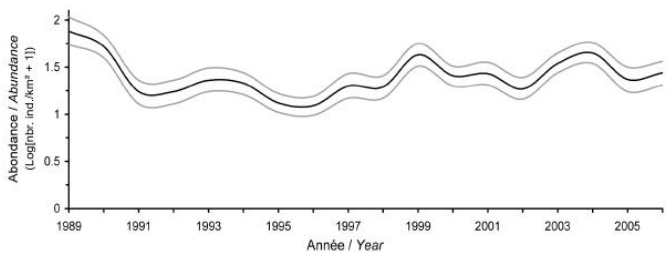
> 1 An / Year old - Pleuronectes platessa

Abondance en juillet (BTS, 1989-2006) / *Abundance in July (BTS, 1989-2006)*





Abondance interannuelle / *Interannual abundance*



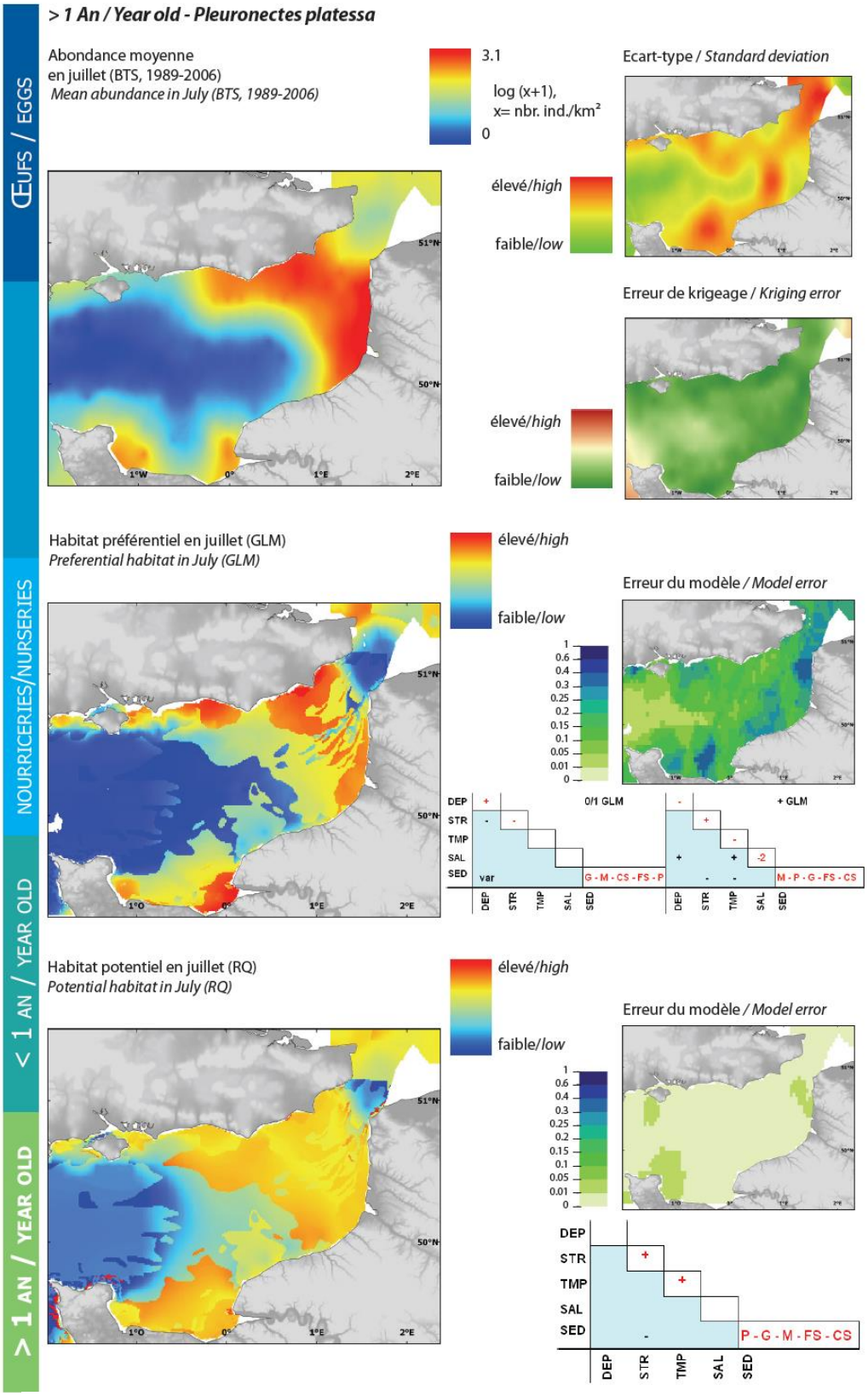
ŒUFS / EGGS

NOURRICERIES/NURSERIES

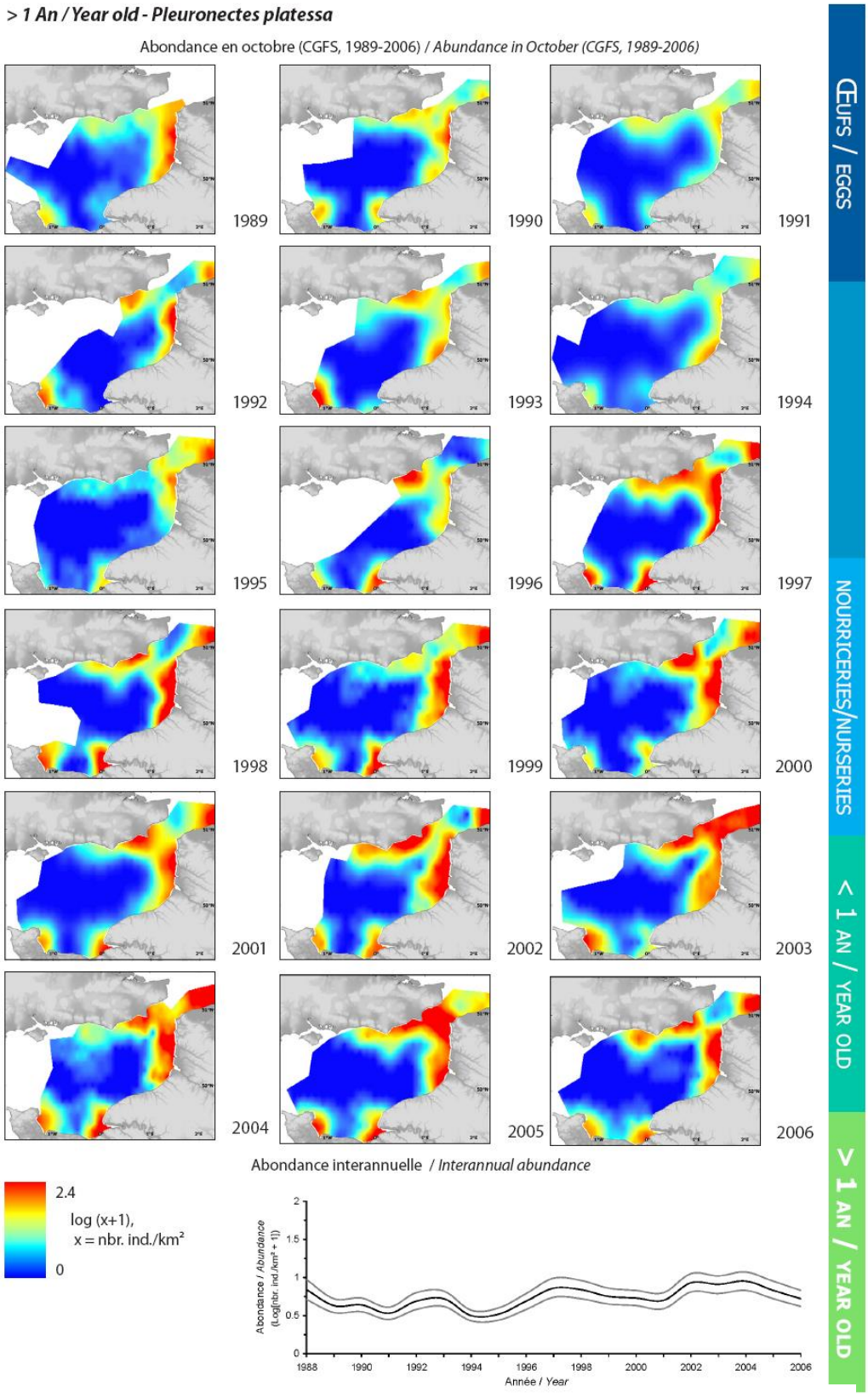
< 1 AN / YEAR OLD

> 1 AN / YEAR OLD

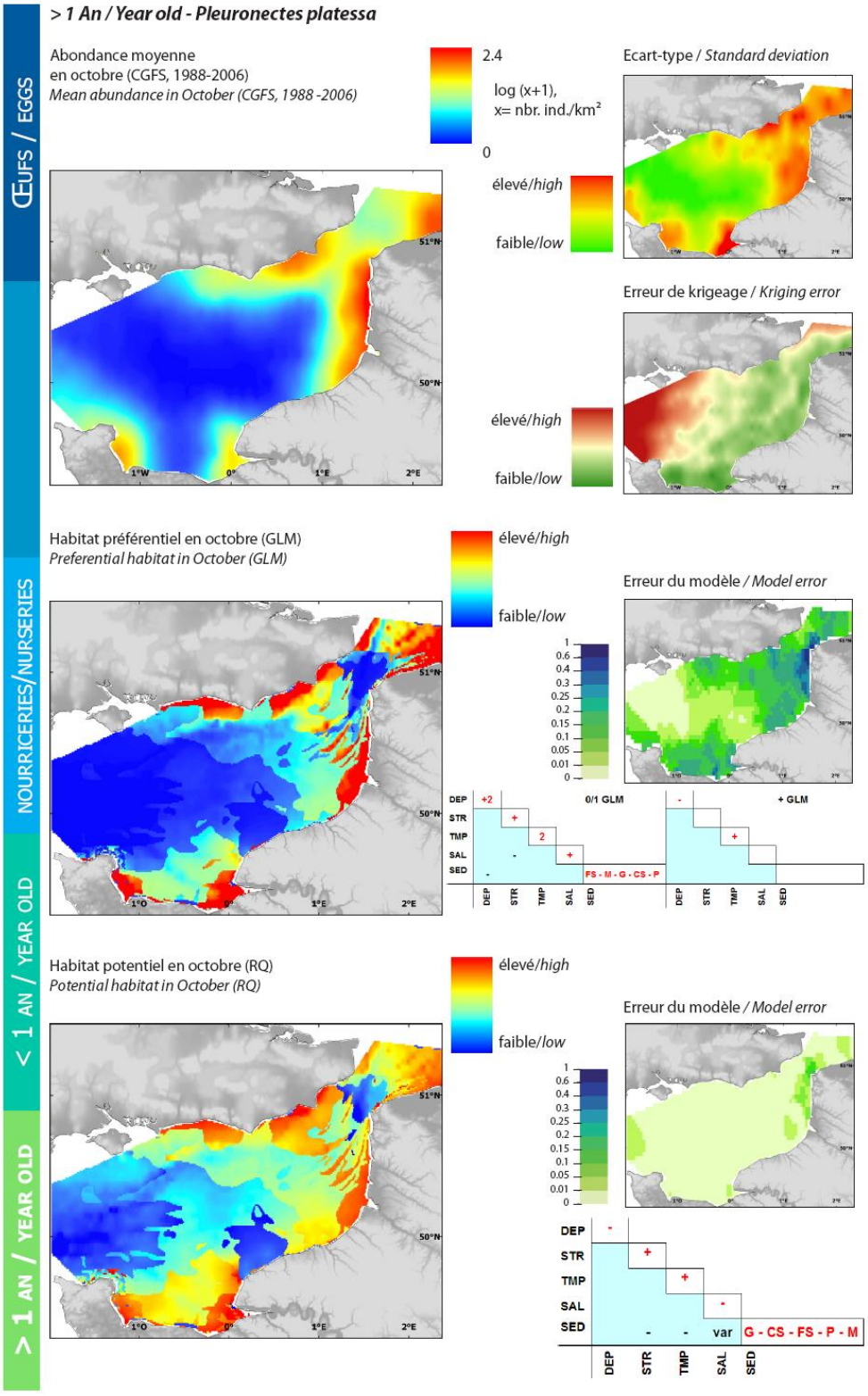
Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

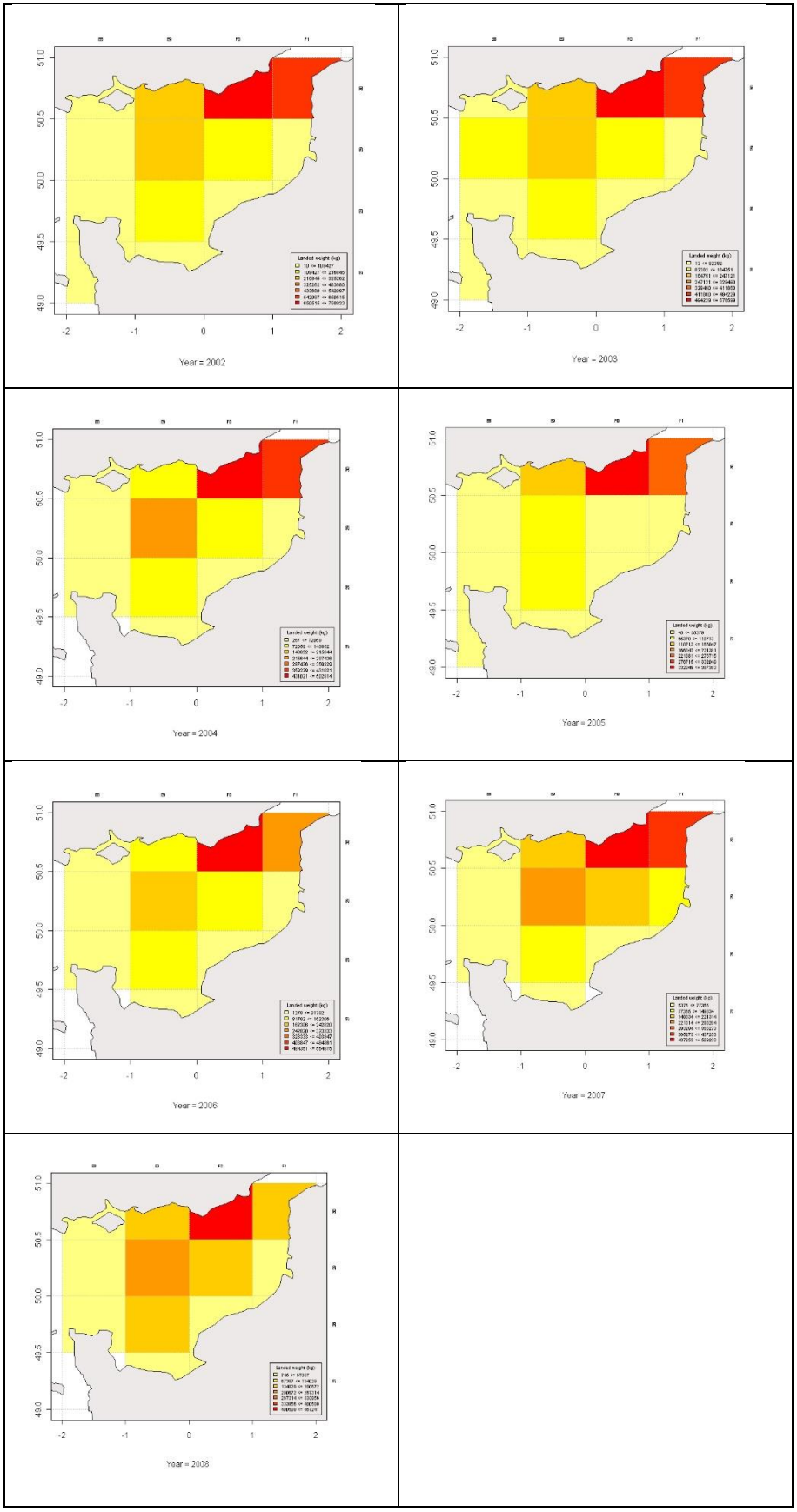


Figure . Plaice in 7.d. - International landings from 2002 to 2008.

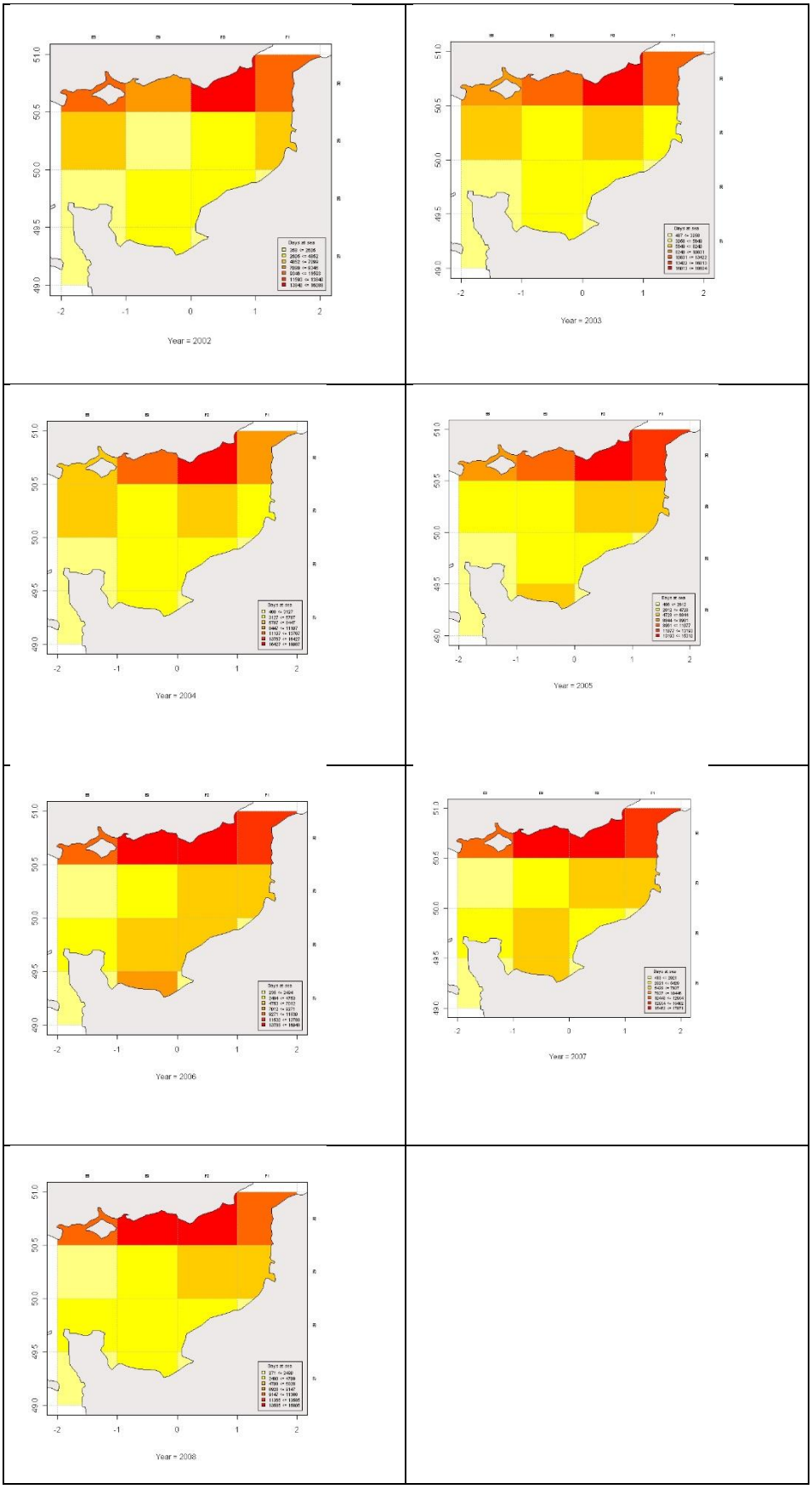


Figure Plaice in 7.d - International effort in days at sea from 2002 to 2008.