Stock Annex for Sole in 7.a

Stock	Irish Sea Sole (Division 7.a)
Working Group	WGCSE
Date	6 Feb 2011 (WKFLAT 2011)
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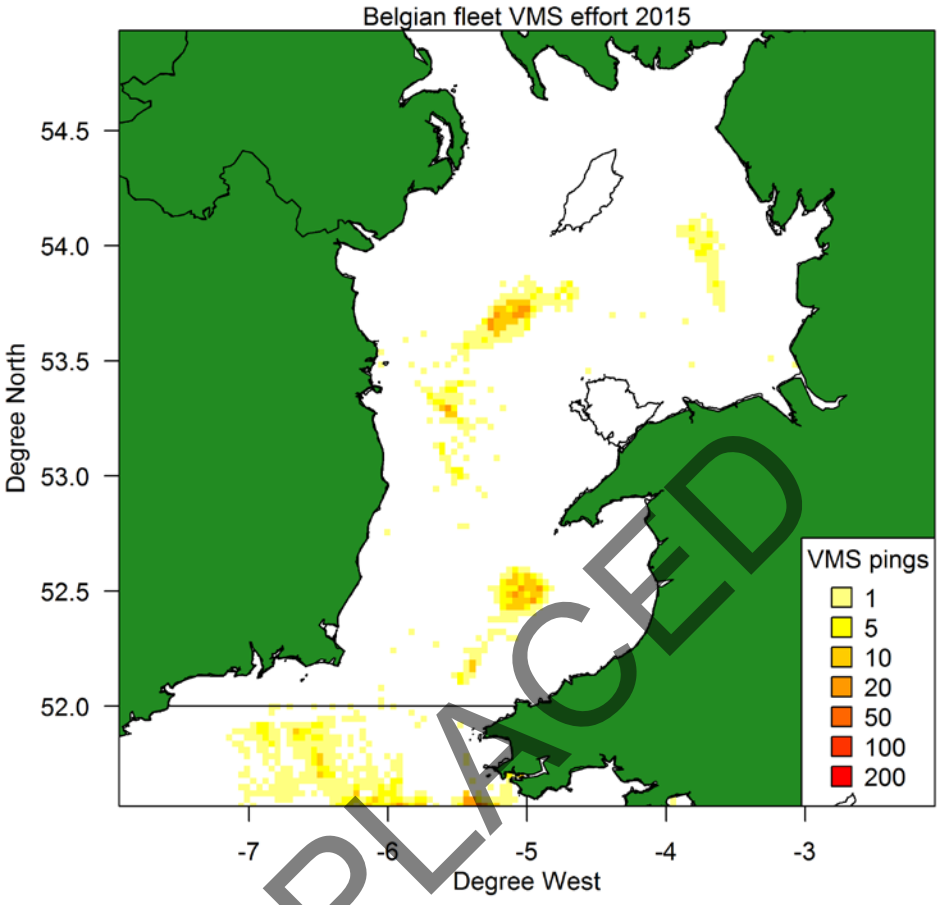
A General

A.1 Stock definition

Sole occur throughout the Irish Sea, but are found more abundant in depth less than 60 m. Recent information on stock identity, distribution and migration issues is included in the report of WKFLAT 2011. Cuveliers *et al*. (2011) combined the results obtained from ten microsatellite markers (long-term estimate of population structure) with results from otolith microchemistry analyses (short-term estimate of connectivity) on adult sole populations in the Northeast Atlantic area. Major large scale differentiation was detected between three distinct regions (Baltic transition area, North Sea, Irish/Celtic Seas) with both types of markers. The assignment success of individuals to their collection location was much higher based on otolith edge microchemistry compared to the genetic assignments at all sampling locations, except for the Irish Sea. Only 28.6% of individuals (n = 30) caught in the Irish Sea could be assigned to their catch location based on otolith edge microchemistry, whereas this region showed high genetic self-assignment scores (ca. 60% of 91 individuals) suggesting a spawning population that is genetically distinct. 32% of the misclassifications based on otolith microchemistry were allocated to the neighbouring Celtic Sea. These results are consistent with tagging studies of sole in the Irish Sea and Bristol Channel, showing mainly local recruitment and limited movement of sole outside the management areas (Horwood 1993; Williams 1965). Therefore, the management unit is considered to correspond to the stock unit for Irish Sea sole.

A.2 Fishery

There are three main countries fishing for sole in the Irish Sea; Belgium, taking the bulk of the landings (65–76% in 2011–2013 and 44–48% in 2014-2015). Ireland and UK taking about 15–27% (2011–2013), 42–44% (2014–2015) and 4–7% respectively of the sole landings. Northern Ireland, Scotland, Isle of Man, the Netherlands and France take the remainder. Belgian beam trawlers are operating in the Eastern part (Liverpool Bay and Morecambe Bay) and southwestern part of the Irish Sea. The UK trawl fleet operates predominantly in the eastern part of the Irish Sea. Sole catches from Ireland are mainly coming from bycatches in the *Nephrops* fishery (operation in the northwest of the Irish Sea).



Effort of the Belgian fleet in 2015.

When fishing in 7.a it is prohibited to use any beam trawl of mesh size range 70–90 mm unless the entire upper half of the anterior part of such a net consists of a panel of netting material attached directly to the headline of the net, extending towards the posterior of the net for at least 30 meshes and constructed of diamond-meshed netting material of which no individual mesh is of mesh size less than 180 mm. The Irish otter trawl fleet employs either a 70 mm mesh with square mesh panels or more commonly an 80 mm mesh. Similarly the Belgian and UK(E&W) beam trawls use 80 mm mesh gear. Otter trawlers targeting roundfish have, since 2000, used 100 mm mesh gear.

It was concluded at the 2000 working group and confirmed in 2001 that the cod recovery measures first enacted (EU Regulations 304/2000 and 2549/2000 + revisions in 2001–2003) in 2000 would have had little impact on the sole fishery. The closed area in 2001 covered a reduced area confined to the west of the Irish Sea and therefore is also expected to have had little effect on the level of fishing effort for sole The spawning closure for cod in 2002 is also unlikely to have had an impact on the sole fishery. The effort regulations and maximum daily uptake, implemented in 2003 will delay the uptake of the quota but is also unlikely to be restrictive for the total uptake. It is

unlikely that any measures concerning the cod management plan in the Irish Sea had restrictions on the sole fishery after 2003.

Discard are estimated to be minor (the average (2013–2015) discard rate by weight is 8%).

For 2009 Council Regulation (EC) N°43/2009 allocates different amounts of kW*days by Member State and area to different effort groups of vessels depending on gear and mesh size. The areas are Kattegat, part of IIIa not covered by Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone 7.d, ICES zone 7.a, ICES zone 6.a and EC waters of ICES zone 5.b. The grouping of fishing gear concerned are: bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≥100 mm), TR2 (≥70 and <100 mm), TR3 (≥16 and <32 mm); beam trawl of mesh size: BT1 (≥120 mm), BT2 (≥80 and <120 mm); gillnets excluding trammelnets: GN1; trammelnets: GT1 and Longlines: LL1.

For 2010–2016, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011, Council Regulation (EC) N°43/2012, Council Regulation (EC) N°40/2013, Council Regulation (EC) N°43/2014, Council Regulation (EC) N°2015/104 and Council Regulation (EC) N°2016/72 were updates of the Council Regulation (EC) N°43/2009 with new allocations, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009.

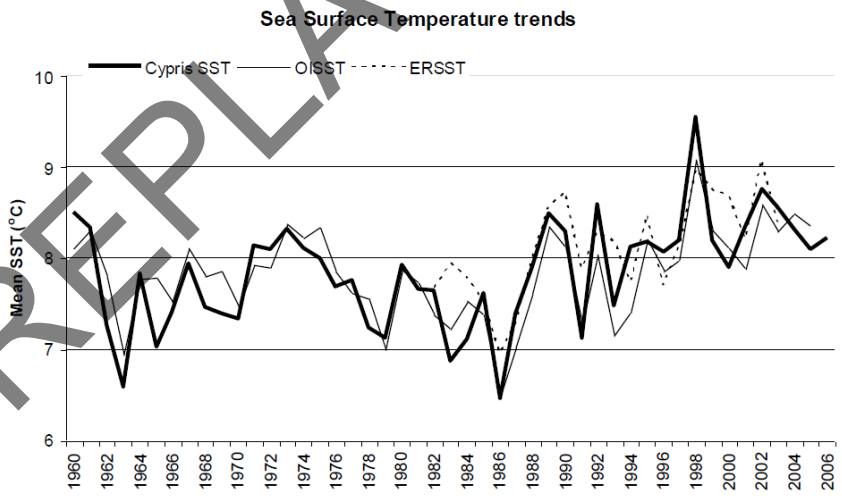
A.3 Ecosystem aspects

(1) Ecosystem overview for the Irish Sea

Physics	
Bathymetry	Shallow sea (less than 100m deep in most places), largely sheltered from the winds and currents of the North Atlantic.
Circulation	An inshore coastal current carries water from the Celtic Sea and St. Georges' Channel northwards through the North Channel, mixing with water from the outer Clyde. A seasonal gyre operates as a local retention mechanism in the western Irish Sea.
Fronts	The Celtic Sea front is situated at the southern entrance to the Irish Sea and the Islay Front is found between Islay and the Malin Shelf.
Temperature ***Salinity***	Time series from the SW coast of the Isle of Man (the Cypris station), western Irish Sea (Gowen, AFBI, Belfast), and two series of combined satellite and ship-records indicate a general warming trend in the Irish Sea since 1960, with particularly high temperatures in 1998 (see figure on following page).

Biology	
Benthos, larger invertebrate, biogenic habitats	The main commercial invertebrate species is Norway-lobster (*Nephrops norvegicus*). There are distinct benthic assemblages with plaice and dab on fine substrates in inshore waters and sea urchins and sun-stars on coarser substrates further offshore. Thickback sole (*Microchirus variegates*) and hermit crabs dominate the transitional zone, while Norway-lobster and Witch (*Glyptocephalus cynoglossus*) dominate on the muddy sediments in the central Irish Sea. Beds of *Alcyonium digitatum* (Dead man's fingers) occur on coarse substrates throughout. Biogenic reefs of horse mussels *Modiolus modiolus*, maerl and Serpulid worms occur in specific locations.
Fish Community	There are commercial fisheries for cod (*Gadus morhua*), plaice (*Pleuronectes platessa*) and sole (*Solea solea*). The most abundant species in trawl surveys are dab (*Limanda limanda*), plaice (*Pleuronectes platessa*), solenette (*Buglossidium luteum*) and common dragonet (*Callionymus lyra*) along with large numbers of poor-cod, whiting and sole. In recent years, abundance of dab, solenette and scaldfish (*Arnoglossus laterna*) and red gurnards *Aspitrigla cuculus* increased, whereas hake, dragonets and pogge *Agonus cataphractus* decreased. Lesser spotted dogfish *Scyliorhinus canicula* is abundant throughout. There are also ray assemblage on sand hills in Southern Irish Sea, and Cardigan Bay. Herring and sprat are the main pelagic species in the eco-region, with important spawning grounds for herring in the south.
Birds, Mammals & Elasmobranches	Basking sharks (*Cetorhinus maximus*) occur from April through to October but the stock seems severely depleted. Grey seals (*Halichoerus grypus*) are common and 5000-7000 individuals are thought to exist in the Irish and Celtic Seas. Gulls predominate the seabird populations, in particular black-headed, lesser black-backed and herring gulls as well as guillemots.

Environmental signals & implications	There has been a steady warming of sea surface temperatures (SSTs) in the area and this can potentially affect the recruitment and productivity of stocks. Herring recruitment has fluctuated widely, however studies to date have not been able to demonstrate any relationship to environmental changes. Irish Sea cod recruitment exhibited a decline in the 1990s. There is some indication that this reduction in cod recruitment may be due to a combination of small spawning-stock biomass and poor environmental conditions, coinciding with a shift towards above-average sea temperatures There has been a northward shift in the distribution of some fish such as an increase of seabass (*Dicentrarchus labrax*) and red mullet (*Mullus surmuletus*) populations around British coasts
Fishery effects on benthos and fish communities	This area has a number of severely depleted stocks e.g. cod, whiting and sole. Significant proportion of the catch of the demersal fleets is discarded these include a range of non-commercial or low value species together with undersized individuals of commercial species. Although a number of gear selectivity devices such as square mesh panels are mandatory, their effectiveness is variable in mixed fisheries. Sole and plaice are primarily targeted by beam trawl fisheries. Beam trawling, especially using chain-mat gear, is known to have a significant impact on the benthic communities, although less so on soft substrates and in areas which have been historically exploited by this fishing method. Some beam trawlers are using benthic drop-out panels that release about 75% of benthic invertebrates from the catches. Full square mesh codends are being tested in order to reduce the capture of benthos further and improve the selection profile of gadoids. The high mud content and soft nature of *Nephrops* grounds means that trawling readily marks the seabed, trawl marks remaining visible for some time. Despite the high intensity of fishing (some areas are impacted >7 times/year) burrowing fauna can be seen re-emerging from freshly trawled grounds, implying that there is some resilience to trawling.



Sea surface temperature in the Irish Sea (1960 – 2006)

(Source: ICES 2006).

(Connolly, P.L. *et al.*, 2009)

B Data

B.1 Commercial catch

Quarterly age compositions are available from UK(E&W), Belgium and Ireland, as well as quarterly landings from France, Northern Ireland, Isle of man and Scotland. The total international age composition is obtained using a combined ALK from UK(E&W), Belgium and Ireland raw data, responsible for around 95% of the total

international sole landings. The combined ALK is applied to the length distributions of the separate countries to obtain an aggregated age composition.

Catch weights were obtained from the combined AWK (UK(E&W), Belgium and Ireland raw data).

Stock weights were obtained using the Rivard weight calculator (http://nft.nefsc.noaa.gov./) that conducts a cohort interpolation of the catch weights.

B.2 Biological

Currently there are no direct (from tagging) or independent (from survey information) estimates of natural mortality. Therefore, annual natural mortality (M) is assumed to be constant over ages and years, at 0.1 yr^{-1}.

The maturity ogive used in this and previous assessments is based on survey information for this stock:

Age	1	2	3	4	5	6 and older
Mat.	0.00	0.38	0.71	0.97	0.98	1.00

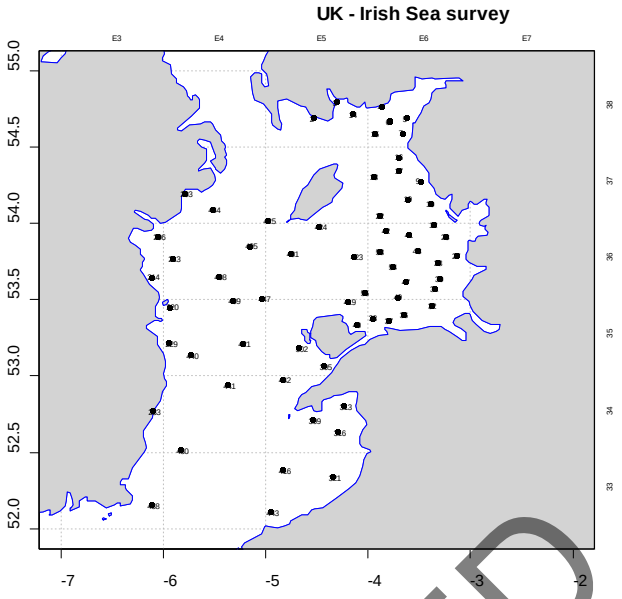
Proportions of M and F before spawning were set to zero, as in previous years.

Males and females of this stock are strongly dimorphic, with males showing much reduced rates of growth after reaching maturity, whilst females continue to grow. Given the minimum landing size of 24 cm the majority of landings represent mature females.

B.3 Surveys

One survey is used in the assessment of 7.a sole: the UK beam-trawl survey (UK (BTS-3Q)).

Area covered: Irish Sea; 52^{0}N to 55^{0}N; 3^{0}W to 6^{0}30'W.



Target species

Flatfish species, particularly juvenile plaice and sole. Length data recorded for all finfish species caught; samples for age analysis taken from selected species.

Time period

1988–2015: September (continuing)

Gear used

Commercially-rigged 4 m steel beam trawl; chain matrix; 40 mm codend liner.

Mean towing speed: 4 knots over the ground. Tow duration: 30 minutes. Tow duration for trips in 1988–1991 was 15 minutes; in 1992 comparative tows of 15 and 30 minutes length were carried out, and subsequent cruises used a standard 30 minute tow. The data from earlier years were converted to 30 minutes tow equivalent using relationships for each species derived from the comparative work in 1992.

Vessel used: R.V. *Endeavour* (CEFAS).

Survey design

Survey design is stratified by depth band and sector (Depth bands are 0–20, 20–40, 40+). Station positions are fixed. Number of stations = 35 in the eastern Irish Sea, 15 in the western Irish Sea, and 16 in St. George's Channel (primary stations). Sampling intensity highest in the eastern Irish Sea, in the main flatfish nursery and fishery areas.

Method of analysis

Raised, standardized length frequencies for each station combined to give total length distribution for a stratum (depth band/sector). Sector age–length keys applied to stratum length distributions 1988–1994; stratum age–length keys applied 1995 onwards. Mean stratum cpue (kg per 100 km and numbers-at-age per 100 km) are calculated. Overall mean cpue values are simple totals divided by distance in metres (or hours

fished). Population number estimates derived using stratum areas as weighting factors.

The September beam-trawl survey has proven to estimate year-class strength well, and providing 50% to over 90% of the weighting to the total estimates of the incoming year classes.

B.4 Commercial lpue

Lpue and effort series were available from the Belgium beam trawlers, UK(E&W) beam and otter trawlers, the Irish otter trawlers.

B.5 Other relevant data

No information.

C Assessment: data and method

Model used: XSA

Software used: IFAP/Lowestoft VPA suite

Model Options chosen since 2004:

ASSESSMENT YEAR	2004	2005	2006	2007–2010
Assessment Model	XSA	SURBA	XSA	XSA
Fleets				
BEL-CBT	1975–2003 4–9		omitted	omitted
UK-CBT	1991–2003 2–9		omitted	omitted
UK (BTS-3Q)	1988–2003 2–9	1988-2004 1-9	1988–rec yr 2–7	1988–rec yr 2–7
UK (BTS-1Q)	1993-1999 2–9		1993–1999 2–7	1993–1999 2–7
Time Ser. Wts	tricubic 20yrs		linear 20 yrs	linear 20 yrs
Power Model	none		none	none
Q plateau	5		5	7
Shk se	0.8		1.5	1.5
Shk Age-yr	5 yrs 5 ages		5 yrs 3 ages	5 yrs 3 ages
Pop Shk se	0.3		0.3	0.3
Prior Wting	none		none	none
Plusgroup	10		8	8
F_{bar}	4–7		4–7	4–7

ASSESSMENT YEAR	2011 WKFLAT 2011	2012–2016
Assessment Model	XSA	XSA
Fleets		
BEL-CBT	omitted	omitted
UK-CBT	omitted	omitted
UK(E&W)-BTS-Q3	1988–assessment year-1 (ages 2–7)	1988–assessment year-1 (ages 2–7)
UK(E&W)-BTS-Q1	omitted	omitted
Time Ser. Wts	uniform	uniform
Power Model	none	none
Q plateau	4	4
Shk se	1.5	1.5
Shk Age-yr	5 yrs 3 ages	5 yrs 3 ages
Pop Shk se	0.3	0.3
Prior Wting	None	None
Plusgroup	8	8
F_{bar}	4–7	4–7

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1970–last data year	2–8+	Yes
Canum	Catch-at-age in numbers	1970–last data year	2–8+	Yes
Weca	Weight-at-age in the commercial catch	1970–last data year	2–8+	Yes
West	Weight-at-age of the spawning stock at spawning time	1970–last data year	2–8+	Yes-but based on back calculated catch weights
Mprop	Proportion of natural mortality before spawning	1970–last data year	2–8+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1970–last data year	2–8+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1970–last data year	2–8+	No-the same ogive for all years
Natmor	Natural mortality	1970–last data year	2–8+	No-set to 0.1 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	UK (BTS-3Q)	1988–last data year	2–7

Note: several other commercial tuning fleets – BEL-CBT (Belgian beam-trawl fleet), UK-CBT (UK beam-trawl fleet), UK-COT (UK otter trawl fleet), IRL-COT (Irish otter trawl fleet) – and two other surveys (UK (BTS-1Q) and Irish Juvenile Plaice Survey) have been used or made available in the past. A thorough investigation of the utility of these tuning indices was conducted at the 2002 working group. The results are summarized in the stock annexes of the reports of WGNSDS 2002–2008 and WGCSE 2009.

D Short-term projection

Model used: Age-structured deterministic projection

Software used: MFDP

Initial stock size: Taken from the XSA for ages 3 and older. The short-term geometric mean recruitment (2006–2014) is used for age 2 in 2016 and the other projection years. Given the consecutive low recruitments in recent years, the short-term GM was assumed for the 2014 year class (and subsequent year classes) instead of the RCT3 value (5725 thousand fish) or the long-term GM (1970–2013, 4314 thousand fish). Maturity: the same ogive as in the assessment is used for all years (see table above).

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

Weight-at-age in the stock: average weight of the last three years

Weight-at-age in the catch: average weight of the three last years

Exploitation pattern: average of the three last years, scaled to the last year's F_{bar} (4–7)

Intermediate year assumptions: *status quo* scaled F in 2017–2018 and TAC constraint in 2016

Stock–recruitment model used: none

Procedures used for splitting projected catches: not relevant

E Medium-term projections

Medium-term projections were not conducted at WKFLAT 2011. The last medium-term projections were carried out in 2008. The settings used are described below.

Model used: Age structured

Software used: IFAP single option prediction

Initial stock size: Same as in the short-term projections.

Natural mortality: Set to 0.2 for all ages in all years

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

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

Weight-at-age in the stock: Assumed to be the same as weight-at-age in the catch

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years, scaled by the F_{bar} (3–6) to the level of the last year

Intermediate year assumptions: F-factor from the management option table corresponding to the TAC

Stock–recruitment model used: None, the long-term geometric mean recruitment at age 2 is used

Uncertainty models used: @RISK for excel, Latin Hypercubed, 500 iterations, fixed random number generator:

- Initial stock size: Lognormal distribution, LOGNORM(mean, standard deviation), with mean as in the short-term projections and standard deviation calculated by multiplying the mean by the external standard error from the XSA diagnostics (except for age 2, see recruitment below)
- Natural mortality: Set to 0.2 for all ages in all years
- Maturity: The same ogive as in the assessment is used for all years
- F and M before spawning: Set to 0.2 for all ages in all years
- Weight-at-age in the stock: Assumed to be the same as weight-at-age in the catch
- Weight-at-age in the catch: Average weight of the three last years
- Exploitation pattern: Average of the three last years, scaled by the F_{bar} (3–6) to the level of the last year
- Intermediate year assumptions: F-factor from the management option table corresponding to the TAC
- Stock–recruitment model used: Truncated lognormal distribution, TLOGNORM(mean, standard deviation, minimum, maximum), is used for recruitment age 2, also in the initial year. The long-term geometric mean, standard deviation, minimum, maximum are taken from the XSA for the period 1960; 4th last year.

F Long-term projections

Model used: age-structured deterministic projection

Software used: MFYPR

Inputs as for Short-Term Projection.

G Biological reference points

ICES carried out and evaluation of MSY and PA reference points for this stock in 2015 at WKMSYREF4 (ICES, 2016a). The results have been published earlier this year (ICES, 2016b).

Previous and current biological reference point values are given in the text table below:

REFERENCE POINTS	ACFM 2007 ONWARDS	2016 ONWARDS
F_{MSY}	0.16 (PLOTMSY, WG2010)	0.20 (Eqsim, WKMSYREF 4)
F_{lim}	0.4 (based on F_{loss})	0.29 (based on simulated recruitment to give median biomass = B_{lim})
F_{pa}	0.3 (high probability of avoiding F_{lim})	0.21 (Flim*1.4)
B_{lim}	2200 t (B_{loss} estimated in 2007)	2500 t (lowest value with above average recruitment)
B_{pa}	3100 t (B_{pa}~B_{lim}*1.4)	3500 t (B_{lim} *1.4)
$B_{trigger}$	B_{pa}	3500 t

H. Other issues

A management plan for Irish Sea sole could be developed, also taking into account the dynamics of the plaice stock in that area.

I References

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