Stock Annex: Horse mackerel (*Trachurus trachurus*) in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, e–k (the Northeast Atlantic)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Horse mackerel

Working Group: Working Group on Widely Distributed Stocks (WGWIDE)

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Authors:

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A. General

A.1. Stock definition

Stock Identity

For many years, ICES considered horse mackerel (*Trachurus trachurus*) in the north-east Atlantic to be separated into three stocks. Prior to the conclusion of the project HOMSIR in 2003, this separation was motivated mainly on the basis of temporal and spatial distributions of the fishery and observed egg and larval distributions (ICES 2008/ACOM:13), but early on was also supported by information from acoustic and trawl surveys, and from parasite infestation rates in horse mackerel (ICES 1989/Assess:19, 1990/Assess:24, 1991/Assess:22). The southern stock was defined as that found in the Atlantic waters of the Iberian Peninsula, the North Sea stock in the eastern English Channel and North Sea area, and the western stock on the northeast continental shelf of Europe, stretching from the Bay of Biscay in the south to Norway in the north.

The occurrence of the large 1982 year class in the eastern part of the North Sea during the latter half of 1987, which resulted in the commencement of a sizeable Norwegian fishery for horse mackerel in the third and fourth quarters from the late 1980s, led to questions about the distribution of the North Sea stock (ICES 1989/Assess:19). A combination of commercial catch and bottom trawl survey data indicated that western horse mackerel had a similar migration pattern to mackerel, so that outside the spawning season bigger fish migrate north to reach the northern North Sea in the latter half of the year (Iversen *et al*. 2002). Differences were also noted in the development of the fishery and in the parasite infestation rates of horse mackerel in Divisions 2.a and 4.a compared to Divisions 4.b-c and the English Channel, suggesting that fisheries in these two areas were exploiting fish from two different spawning areas (ICES 1990/Assess:24, 1991/Assess:22). Therefore, since 1989 ICES has allocated catches taken in Division 2.a and in Division 4.a (in later years only during the third and fourth quarters of the year for 4.a, and including the western part of Division 3.a) to the western stock (ICES 1989/Assess:19).

A Study Group on stock identity held in 1992 (ICES 1992/H:4) found that, although there were clear centres of egg production, there were no major discontinuities in the distribution of eggs between the western and southern areas, bringing into question the separation between these stocks (ICES 1992/Assess:17). It was hoped a tagging program launched in Spain and Portugal in 1994 (ICES 1995/Assess:2), and two studies conducted in 1997 using allozyme differentiation and morphometric characteristics (ICES 1998/Assess:6) would shed further light on stock identity, but none of the tags were ever recovered (ICES 1996/Assess:7, 1997/Assess:3, 1998/Assess:6, 1999/ACFM:6, 2000/ACFM:5, 2001/ACFM:06), and neither study provided a basis for changing the stock separation previously defined (ICES 1998/Assess:6).

Further refinements of the definitions of stock units were made based on the results from HOMSIR (EU-funded project: QLK5-CT1999-01438), which integrated a variety of approaches to investigate horse mackerel stock identification (ICES 2005/ACFM:08, Abaunza *et al*. 2008). The project investigated the stock structure of horse mackerel from a holistic point of view within the western, southern, North Sea and Mediterranean areas. It included various genetic approaches (multilocus allozyme electrophoresis, mitochondrial DNA analysis, microsatellite DNA analysis and single stranded conformation polymorphysm SSCP analysis), the use of parasites as biological tags, body morphometrics, otolith shape analysis and the comparative study of life history traits (growth, reproduction and distribution). The project concluded in June 2003, and some of the main results from this project, which are of relevance to the western stock, were as follows (ICES 2005/ACFM:08):

i) Horse mackerel from the west Iberian Atlantic coast can be distinguished from the rest of the Atlantic areas.

ii) In the Atlantic Ocean, the northern boundary of the so called "southern stock" ought to be revised, and accordingly, the southern boundary of the so called "western stock". The body morphometrics and the otolith shape analysis joined the northwest of the Iberian Peninsula (North Galicia) to the areas located more to the North in the Atlantic Ocean, Bay of Biscay and Celtic Sea. On the other hand, the genetic results from SSCP associated the northwest of Iberian Peninsula to the Portuguese sampling sites. These differences between the techniques suggested that North Galicia may correspond to a transition area between two possible stock units. Therefore, it was proposed to move the actual boundary of the "Southern" and "Western" stocks from Cape Breton Canyon (southeast of Bay of Biscay) to the northwest of Iberian Peninsula (Galician coasts) and specifically to Cape Finisterre at 43º N latitude, which could be considered also as a boundary for certain hydrographic features, like the influence of North-Atlantic Central Water (Fraga *et al*., 1982).

iii) Parasites and body morphometrics indicated that horse mackerel in the North Sea could constitute a stock well differentiated from the rest of adjacent Atlantic areas.

iv) Horse mackerel along western European coasts, from the northwest of Spain to Norway, seem to be a unique stock. This definition is very similar to that previously used for the "western stock", except that, based on results from HOMSIR, the north coast of the Iberian Peninsula should also be included. Neither the SSCP results nor the parasite composition study showed any contradiction with this definition. Anisakid parasite species composition is homogenous throughout this area. Otolith shape analysis and body morphometrics include the sampling sites from this area in the same cluster, showing a great similarity in morphometric characteristics.

v) However, the population structure in the western European coasts could be more complicated and more research is needed to clarify the migration patterns within the Northeast Atlantic Ocean. This is especially relevant to the boundary areas between the North Sea Stock and the Western stock (Northern North Sea and English Channel).

Therefore, in many ways, results from the HOMSIR project largely supported ICES perceptions of stock units. Based on findings from the project, ICES now includes Division 8.c as part of the distribution area of the western horse mackerel stock. The boundaries for the different stocks are given in Figure B.1.

Allocation of catches to stock

Based on spatial and temporal distribution of the horse mackerel fishery the catches were allocated to the western stock as follows:

Western stock: Quarters 3&4 only: Divisions 3.a (west), 4.a
All Quarters: Divisions 2.a, 5.b, 6.a, 7.a-c, 7.e-k, and 8.a-e.

The reason why catches from only the western part of Division 3.a are allocated to the western stock is that these catches are taken in the third and fourth quarter, and are often taken in the neighbouring area of catches from the western stock in Division 4.a. ICES is not sure if catches in Divisions 4.a and 3.a during the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches in these areas during this period are small. However, in 2006 and 2007, relatively larger catches, 2 600 and 2 100 tons, were taken in Division 4.a during the first half of the year and these catches were allocated to the North Sea stock.

A.2. Fishery

Germany and the Netherlands have a directed trawl fishery and Norway a directed purse seine fishery for horse mackerel. Spain and Portugal have both directed and mixed trawl and purse seine fisheries. In earlier years most of the catches were used for meal and oil while in later years most of the catches have been used for human consumption.

The Dutch and German fleets operated mainly west of the Channel, in the Channel area, and in the southern North Sea. The Spanish and Portuguese fleets operated mainly in their respective waters. Ireland fished mainly west of Ireland and Norway in the north eastern part of the North Sea.

A.3. Ecosystem aspects

Western horse mackerel have a long spawning season with a peak in late spring/early summer (Abaunza *et al.*, 2003). They spawn in the Bay of Biscay and southwest of the

British Isles (indicated as the “juvenile area” in Figure B.1). Age and length distributions from around the British Isles suggest that, as for northeast Atlantic mackerel (*Scomber scombrus*), the largest fish tend to travel farthest and may reach areas around the Shetland Islands, the Norwegian coast, and the northern North Sea by September (Eaton, 1983).

Three species of genus Trachurus: *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in NE Atlantic waters.

Following the Working Group recommendation (ICES 2002/G:06), special care has been taken to ensure that catch and length distributions and numbers at age of *T. trachurus* supplied to the Working Group did not include *T. mediterraneus* and *T. picturatus*. Spain provided data on *T. mediterraneus* and Portugal on *T. picturatus*.

T. mediterraneus is almost exclusively landed in ports of the Cantabrian Sea in the north of Spain. The fishery for *T. picturatus* takes place in the southern part of Division 9.a and in Subarea 10. The annual landings of *T. mediterraneus* show substantial variability, ranging from about 500t to 7,000 tones. Since 2004 there has been a decrease in landings reaching the lowest level in 2007.

B. Data

B.1. Commercial catch

Catch in numbers

Commercial catch data and the associated sampling are obtained from national laboratories of nations exploiting Western horse mackerel (carried out under the DCF in EU countries). Prior 2014 the data exchange spreadsheets were submitted to the stock coordinator. The data in the exchange spreadsheets were allocated samples to catch using the SALLOC-application (Patterson, 1998). This application produced the standard outputs on sampling status and biological parameters.

Since 2014 national data submitters have been uploading this information into InterCatch using the standard exchange files. The information is supplied aggregated to ICES subarea/division/subdivision and quarter. The total International Catch-at-Age was available through the Inter-Catch web system. The allocations for those countries reporting unsampled catches, were generally made using all available data for the same ICES division and the same quarter. In cases where this was not possible, data from the nearest divisions and the same quarter were used. The aggregated output files can then be downloaded from the stock coordinators. The files are used to provide the data necessary for the stock assessment model.

Catch at age data are provided by the Netherlands, Norway, Ireland, Germany, Scotland and Spain. Therefore adequate sampling has never been conducted in all fishing areas during the fishing season.

The available catch information for horse mackerel can be considered as good quality since 1997 forward because they include details of catches, landings, discards (although likely incomplete) and sampled catch by year, division, quarter and country.

Catch information since 1997 backward can be considered as medium or low quality because they are aggregate or not available (available from previous reports).

Discards

Over the years, the available estimates of discards have been based on information provided by only a few countries and the total discards are considered to be not representative for the total fishery. In the most recent years the majority of countries involved in the fishery submitted discard information but no data on discards were provided during 1998-2001. The overall estimate of the discard rate is variable over the time series.

Information from national data submitters suggest that discard rates for the directed fishery are low with the majority of discards from non–directed demersal fisheries although there is high uncertainty in discard estimates due to low levels of sampling.

B.2. Biological

Mean weight at age in the stock

The mean weight at age is based on mature fish sampled from Dutch freezer trawlers in the first and second quarter in Divisions 7.j,k. In some years there are only data from Division 7.j. Often there are no data for two years olds and then they are given a constant weight of 0.085 kg. The mean weight by age groups in the stock and in the catches were lower than usual in 2001, but returned to normal since 2002.

The mean weight was however not used in the stock assessment, but it was estimated inside SS using a length weight relationship.

Maturity ogive

Due to difficulties in estimating a maturity ogive (ICES 2000/ACFM:5, 2000/G:01) the working group has been unable to update the maturity ogive annually. Therefore the same maturity at age has been used since 1998.

Natural mortality

The natural mortalities applied in previous assessments of western horse mackerel are summarised and discussed in ICES (1998/Assess:6). The natural mortality is uncertain but probably low. ICES currently applies M=0.15.year^{-1}.

B.3. Surveys

Egg survey estimates of biomass

The Mackerel and Horse Mackerel Egg Survey takes place triennially with the participation of Portugal, Spain, Scotland, Ireland, The Netherlands, Norway and Germany. It is not possible to convert the horse mackerel egg production to SSB since horse mackerel is considered an indeterminate spawner.

In general the quality and reliability of the egg surveys are good. In contrast to 2007 the 2010 results display a bimodal distribution which is almost identical both in shape and scale to that seen in 1998 with peak spawning occurring in periods 3 and 5 and a significant decline in production during period 4.

Since 2003 the ICES working group WGMEGS has held an egg identification and staging workshop prior to the survey. This permits a harmonisation of egg identification and realised fecundity in mackerel as well as spawning rates in horse mackerel across the participating institutes. These activities led to an improvement in the quality of the estimate.

Even when the survey coverage is good, WGMEGS concludes that while the starting of the spawning event is fully covered for mackerel and horse mackerel, the surveys end too early to adequately cover the end of spawning in the northern areas for both mackerel and horse mackerel, and in the southern area (south of 47°N) for horse mackerel.

Bottom trawl surveys

Bottom trawl surveys are carried out in a systematic and standardized way through the Northeast Atlantic. They cover a significant part of the western horse mackerel distribution area and are carried out mainly during the autumn. These surveys are coordinated in the International Bottom Trawl Surveys Working Group (IBTSWG, ICES 2009/RMC:04) with the main objective of obtaining an index of recruitment for the most important commercial fish species. Horse mackerel is a pelagic species, but its behaviour is closer to that of a demersal species than the rest of typical pelagic species. The IBTS could therefore provide information on horse mackerel distribution, catch rates and length distributions. Taking in to consideration the problems with the abundance index used in the western horse mackerel assessment, it is useful to consider the surveys under IBTSWG in order to analyse whether they could provide an index of recruitment or abundance for western horse mackerel.

Data from the bottom trawl survey carried out in autumn in the Cantabrian Sea and Galician coasts (North of Spain, Division 8.c) were analysed in relation to horse mackerel. This survey is not used in the assessment because it covers only a small part of the western horse mackerel stock, but it provides valuable information on horse mackerel dynamics. Length distributions show a gap in length range 18-23cm that could be related to the particular exploitation pattern of this species. Juveniles are more abundant in the eastern part of the Cantabrian Sea, although the depth strata <120m, in which the young horse mackerel are also distributed, and are very poorly sampled in the Galician coasts. The recruitment in 1994 appeared to be strong in the data series (ICES 2008/ACOM:13). The evolution of the cohorts through the data matrix compiled from this survey indicated poor information on mortality. This could be due to migration to and from other areas, especially the French continental shelf (Murta *et al.*, 2008; Velasco *et al*. 2008). The information provided by this survey will be combined with the results of other bottom trawl surveys carried out in adjacent areas. Traditionally age 0 has been adopted as the recruitment age for horse mackerel in this survey; nevertheless the use of age 1 as a proxy for recruitment may be more appropriate. The years before 1997 have been revised to account for the change in the strata of the sampling design adopted in 1997 (Velasco *et al*. 2008).

The French bottom trawl survey (EVHOE-WIBTS-Q4) covers the Bay of Biscay (French continental shelf) and part of the Celtic Sea. It is carried out in autumn and it is directed at demersal resources. Information on horse mackerel distribution and length distributions are available. The survey is carried out during the recruitment season, and juveniles form the majority in the catches.

A number of approaches for the calculation of an index of juvenile abundance based on catch rates observed on IBTS surveys conducted by Ireland, France and Scotland covering the main distribution (Bay of Biscay, Celtic Sea, West of Ireland and West of Scotland) have been investigated (Campbell, 2017).

A Bayesian framework is employed; priors are as described in Thorsen and Ward (2013). MCMC methods are used to sample from the posterior distributions from the JAGS packages which is accessed through R via the R2jags package. A number of diagnostic outputs are generated by the software to examine the model convergence. 3 chains were used, each with 70,000 samples. The first 50,000 samples are discarded and the remaining 20,000 were thinned to obtain approximately 4000 independent samples. Plots of the sampling chains and the first order autocorrelation for all model parameters were examined for evidence of non-convergence.

Four separate model runs were conducted corresponding to the possible stratum-year interaction configurations. It was not possible to calculate an index for the model with fixed stratum-year effects as there are particular combinations of stratum and year where no juveniles were encountered which was the case in several years for some of the offshore (deeper) strata.

Acoustic surveys

Horse mackerel data from the French acoustic PELGAS surveys are available as independent information on the western horse mackerel stock (ICES 2006/LRC:18). This multidisciplinary survey covers Divisions 8.a and 8.b during spring, collecting information on spatial distribution and length distribution. Revised survey estimates were presented in 2008 (Massé et al. WD presented in ICES 2008/ACOM:13) and new estimations will be possibly provided in 2017.

Horse mackerel data from the Spanish acoustic PELACUS-Q4 surveys are available as independent information on the western horse mackerel stock. This multidisciplinary survey covers Divisions 8.c and 9.a (north) during spring. In some years the survey is extended to the south of Divisions 9.a (north) and 8.b. Information on distribution and abundance estimates are available since 1997, but the biomass estimates of the historical series were calculated considering Divisions 9.a (north) (actually belonging to the southern stock) and 8.c (western stock) until 2006 . Length frequency distribution from PELACUS were also available and included in the stock assessment model.

B.4. Commercial CPUE

Information on effort and catch per unit effort is only available from the southern limit of the stock distribution area. Since Division 8.c became part of the western stock in 2004 (ICES 2005/ACFM:08), the bottom trawl fleet operating in the western part of

Division 8.c (north of the Galician coast) is exploiting the western stock. This area represents a very small part of the western horse mackerel stock and therefore the fleet has not been used in the assessment.

The activity of this bottom trawl fleet is considered as mixed fisheries in which different métiers can be distinguished. Due to the assumption that CPUE is proportional to abundance, it is important that any other factors that may influence CPUE are removed from the index. The process of reducing the influence of these factors on CPUE is commonly referred to as standardizing the CPUE. Therefore, it is possible to present in the future a new revised and standardized version of this CPUE series following the métiers classification, with the objective of obtaining a more reliable CPUE at age series.

B.5. Other relevant data

C. Historical Stock Development

Model used: SS (Stock Synthesis; Methot, 2011).

Software used: Stock Synthesis, v3.24U.

Description of SAD

Stock synthesis replaced the SAD model, that have been used by the working group since 2000.

The main changes compared to the previous SAD model are:

- Increased the plus-group from 11+ to 15+.
- Inclusion of new survey indices.
- Inclusion of length data and conditional age at length data.

The data included in the final assessment are the following:

DATA	TYPE	1 FLEET SET UP	
		FLEET	PERIOD
	Biomass		
	Biomass		
	Numbers of recruits	IBTS	2003-2015
	Numbers of eggs (SSB)	Egg survey	1992-2015
	Biomass	PELACUS	1992-1993, 1995, 1997-2015
		Overall	2000-2014
		PELACUS	1992-1993, 1995, 1997-2007, 2013-2015

Age composition data	Numbers at age	Overall	1982-2015*
	Conditional Age at length	Overall	2003-2015

* from 2003 to 2015 left in as a ghos fleet.

Summary of the main features of the SS model used for the assessment of western horse mackerel:

Model structure

- Temporal unit: annual based data (landings, survey indices, age–frequency and length–frequency);
- Spatial structure: One area;
- Sex: Both sexes combined.

Fleet definition

1 fleet defined: all countries and all gears combined.

Landed catches

Annual landings in tonnes from 1982 to final year for the fleet from ICES Subdivisions 2a, 4a, 3a, 5b, 6a, 7a-c, 7e-i, 8.

Abundance indices

Triennial egg survey from 1992 to 2013. Input CV for survey provided by year.

Bottom trawl survey for the whole area, recruitment index from 2003 to 2015. Standardized through log-Gaussian Cox model. CV from model by year.

PELACUS acoustic survey, 1992-2015, sub-division 8c. Length composition data from 1992 to 2007 and from 2013 till 2015. CV = second highest CV from the PELGAS survey.

Fishery landings age composition data: commercial fleet

Age bins: 0 to 14 with a plus group for ages 15 and over. Age compositions for the commercial fleet expressed as fleet-raised numbers-at-age for the years 1982 to 2002, and as conditional age at length for the years 2003 to present.

Length composition data: commercial fleet

The length bin was set from 5 to 50 cm by 1 cm intervals. Length compositions for the commercial fishing fleets were used from 2000 to present.

Model assumptions and parameters

Table 1 summarises key model assumptions and parameters. Other parameter values and input data characteristics are defined in the SS control file WHOM.ctl, the forecast file Forecast.SS and the data file WHOM.dat as used by WKWIDE 2016.

Ageing error was not included in the final run and would need further investigation.

Table 1: Key model assumptions and parameters from the western horse mackerel final run

Characteristic settings	
Starting year	1982
Ending year	2015
Equilibrium catch for starting year	20,000
Number of areas	1
Number of seasons	1
Number of fishing fleets	1
Number of surveys	3 surveys: Egg survey; IBTS, PELACUS acoustic.
Individual growth	von Bertalanffy, parameters estimated.
	Initial values (same for both sexes):
	L_at_Amin_GP_1 = 5
	Linf = 40
	k = 0.205
Number of active parameters	71
Population characteristics	
Maximum age	20
Genders	1
Population length bins	2–50, 1 cm bins
Ages for summary total biomass	0–20
Data characteristics	
Data length bins (for length structured fleets)	5–50, 1 cm bins
Data age bins (for age structured fleets)	0–15+
Minimum age for growth model	1.2
Maximum age for growth model	Linf
Maturity	Age Logistic 2-parameters fixed – females; A50 = 3.5 yr, slope = -2.
Fishery characteristics	

Fishery timing	-1 (whole year)
Fishing mortality method	Hybrid
Maximum F	3
Fleet 1: commercial fleet	Double normal, length-based
Survey characteristics	
IBTS timing (yr)	0.91
Egg survey timing (yr)	0.33
PELACUS survey timing (yr)	0.34
Catchabilities (all surveys)	Analytical solution
Fleet 2: IBTS survey	Recruitment selectivity
Fleet 3: Egg survey	SSB selectivity
Fleet 4: PELACUS	Double normal, length based
Fixed biological characteristics	
Natural mortality	0.15
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00000585
Weight–length exponent	3.087

D. Short-Term Projection

Software used: FLR (Deterministic Short term projections)

Initial stock size: Stock numbers from the assessment

Recruitment: At the 2015 working group recruitment estimates for input to the short term forecast were based on the geometric mean of the estimated time series for the period 1983 to 2015. There is no indication that a large recruitment similar to that of 1982 will enter the stock.

Maturity: The proportion mature for this stock is assumed constant over the years. The maturity ogive used in the short term forecast is the same as the ogive used in the assessment for 2009.

F and M before spawning: Spawning is assumed to take place in April/March.

Weight at age in the stock: Weight at age in the stock are the average of the last three years weight at age estimates in the catch for periods 1 and 2 in areas 7.j.

Weight at age in the catch: Weight at age in the catch are the average of the last three years weight at age estimates in the catch for all periods and all areas.

Exploitation pattern: This is based on F in the final year, where the final year of data is calculated from the most recent assessment. The assessment assumes a fixed selection from 2005 to the final year of data.

Natural Mortality: Natural mortality is assumed to be 0.15 across all ages.

E. Medium-Term Projections

A medium-term forecast is not conducted for western horse mackerel because a management plan is in place.

F. Long-Term Projections

Long-term projections are not carried out for western horse mackerel.

G. Biological Reference Points

The stock is characterised by infrequent, extremely large recruitments.

Reference point	Blim	Bpa	Flim	Fpa	F0.1
Value	1.4 mill t	1.8 mill. t			0.13
Basis	Biomass that produced the extraordinary 1982 year class	Blim* exp(1.645* σ), with σ= 0.16.	Not defined	Not defined	Yield per recruit (ICES, 2010/ACOM:15)

Biomass reference points

B_{lim} – there is no evidence of significant reduction in recruitment at low SSB within the time series hence B_{lim} is taken as B_{loss}, the lowest estimate of spawning stock biomass from the revised assessment. This was estimated to have occurred in 2015 with B_{loss} = 661917 t.

B_{pa} – the ICES basis for advice requires that the assessment uncertainty in the estimate of spawning stock biomass is taken into consideration. This leads to a precautionary reference point B_{pa}, which is a biomass reference point designed to avoid reaching Blim. Consequently, Bpa was calculated from

$$B_{pa} = B_{lim} * \exp(1.645\sigma_{SSB})$$

Where σ_{SSB} (0.19456) was taken as the uncertainty in the assessment SS estimate of the (log) spawning stock biomass in the most recent assessment year (2015). This results in a B_{pa} value of 911587 t.

Fishing mortality reference points

F_{lim} – F_{lim} is derived from B_{lim} and is determined as the fishing mortality that, on average would bring the stock biomass to B_{lim}. The value for F_{lim} is derived from long term simulations as the F that, in stochastic equilibrium will result in the median SSB equal to B_{lim}. The value estimated at the benchmark workshop was 0.151 (see below for further details).

F_{pa} – the value of the estimated fishing mortality which ensures that the true F has a less than 5% probability of being above the reference point F_{lim}. Since the F estimated by SS is different from the Fbar ICES uses to describe the exploitation of the stock, it was not possible yet to derive an estimate of the uncertainty. Hence F_{pa} is calculated from

$$F_{pa} = F_{lim}/1.4$$

This leads to an estimate for F_{pa} of 0.108.

MSY reference points

At WGWIDE 2010 (ICES 2010/ACOM:15) stochastic equilibrium analyses were carried out using the EqSim tool in R . Stock-recruit pairs from the period 1983-2015, as estimated from the most recent SAD assessment of the stock, were used together with 10-year averages of selectivity, weight and maturity at age , F refers to the mean for ages 1 – 10. Segmented regression ('smooth hockey stick') with breakpoint at Blim was used for the stock recruimtnet relationship.

Simulations were first run assuming zero assessment error and without implementing the ICES MSY advice rule (*i.e.* setting MSY $B_{trigger}$ = 0 in the simulations) in order to estimate F_{lim}. The F value for which the median of the SSB across replicates was equal to B_{lim} was 0.151.

Additional simulations were then run including estimates of assessment error, but still without the ICES MSY advice rule. The median of the yield across iterations reached a maximum for a F value of 0.12 (figures 5.4.2-3). This F value was higher than Fpa and therefore lowered to Fpa (0.107). Based on these simulations, the lower SSB value (5% quantile for the distribution across iterations) observed when fishing constantly at the candidate F_{MSY} value of 0.107 was 624 098 tonnes. This value was a candidate value for MSY Btrigger. Following ICES guidelines, however, implies than MSY Btrigger should be set equal to B_{pa} in the case of the WHOM, since this value is lower than Bpa.

Following ICES guidelines, simulations were run again implementing assessment errors and the ICES MSY advice rule using an MSY $B_{trigger}$ = B_{pa} (911 588 t) to check if the candidate F_{MSY} (0.107) is still found to be precautionary, which was the case.

	Flim	Fpa	FMSY	Fp05	Btrigger
Segmented S-R	0.1510	0.1079	0.1079	0.1203	911588

H. Other Issues

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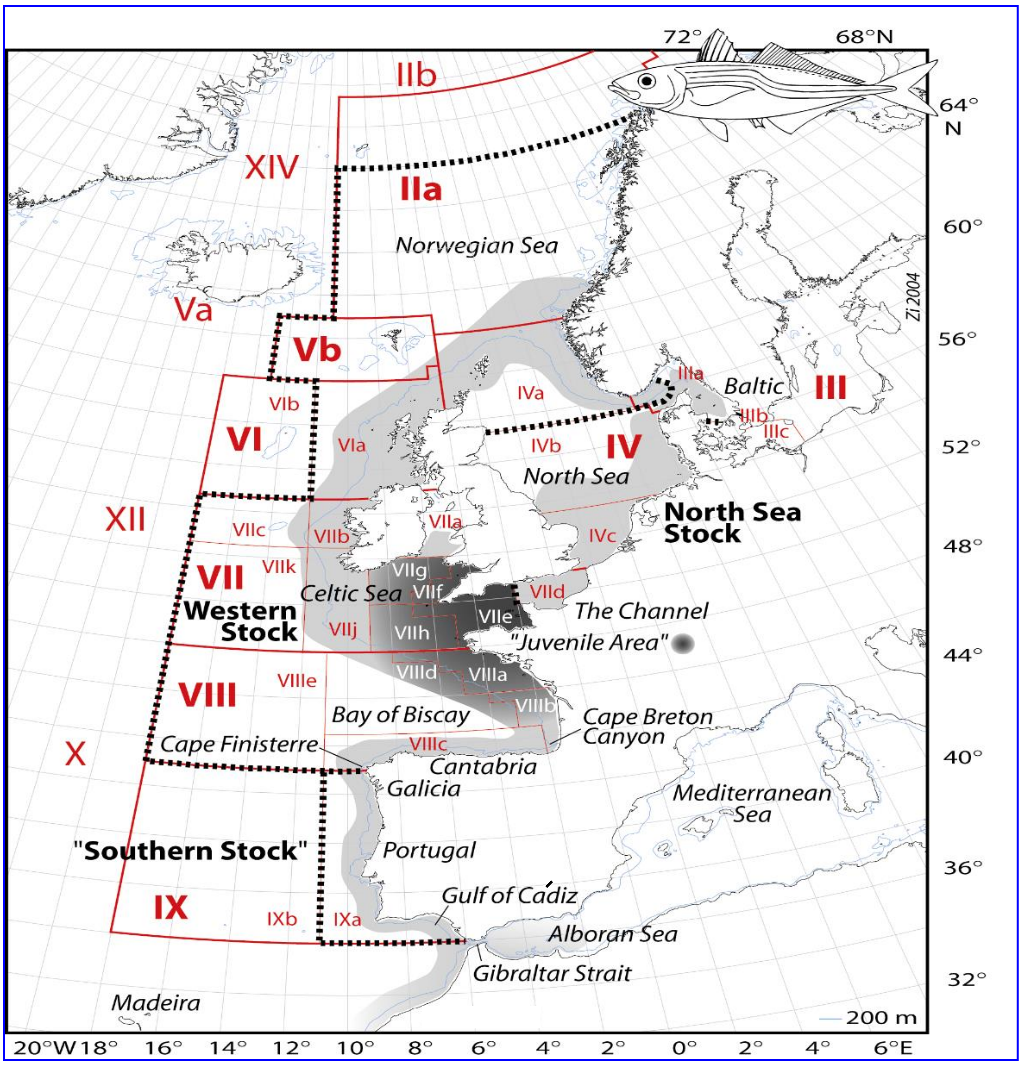

Figure B.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by ICES (ICES CM 2005/ACFM:08). Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. 7.d). Map source: GEBCO, polar projection, 200m depth contour drawn.