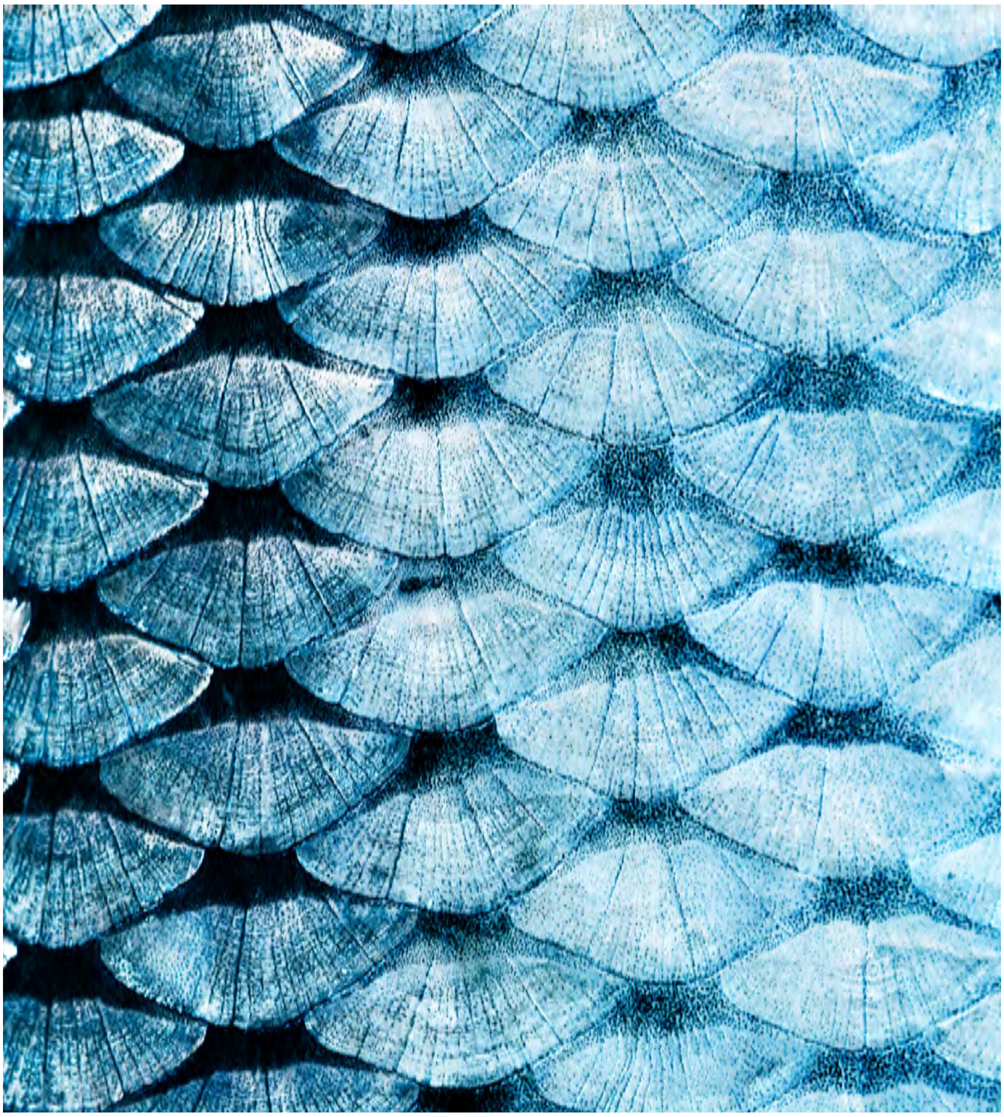
Hake (*Merluccius merluccius*) in Subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d, Northern stock

August 2024

ICES STOCK ANNEXES



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Changes since the last version

This stock annex updates (give previous edition/version citation).

Location	Summary of changes
Whole document	Minor edits

1 General

1.1 Stock definition

European hake (*Merluccius merluccius*) is widely distributed over the Northeast Atlantic shelf, from Norway to Mauritania, with a larger density from the British Islands to the south of Spain (Casey and Pereiro, 1995) and in the Mediterranean and Black Sea. In the last decade the population has expanded into the North Sea (Staby *et al*., 2018), it is not clear, however, if the expansion has been motivated by environmental change (i.e. climate change or a decrease in the abundance of gadoids) or by the huge increase in the biomass of the population (Staby *et al*., 2018; Gullestad *et al*., 2020). Although, previous genetic studies (Plá and Roldán, 1994; Roldán *et al*., 1998), show no evidence of multiple populations in the Northeast Atlantic, a most recent study (Leone *et al*., 2019) indicates that the population in the Norwegian sea is genetically different from that in the Bay of Biscay. However, ICES assumes since the end of the 1970s two different stock units: the so-called Northern stock, in Division 3.a, subareas 4, 6 and 7 and divisions 8.a, 8.b, and 8.d and the Southern stock in divisions 8.c and 9.a, along the Spanish and Portuguese coasts. The main argument for this choice was that the Cap Breton canyon (close to the border between the Southern part of Division 8.b and the more Eastern part of Division 8.c, i.e. approximately between the French and Spanish borders) could be considered as a geographical boundary limiting exchanges between the two populations.

Hake spawn from February through to July along the shelf edge, the main areas extending from the north of the Bay of Biscay to the south and west of Ireland (Figure 1). The main spawning season in the North Sea is shorter and happens later in the year, from July and September (Staby *et al*., 2018). After a pelagic life, 0-group hakes reach the bottom in depths of more than 200 m, then move to shallower water with a muddy seabed (75–120 m) by September. There are two major nursery areas: in the Bay of Biscay and off the coast of southern Ireland.

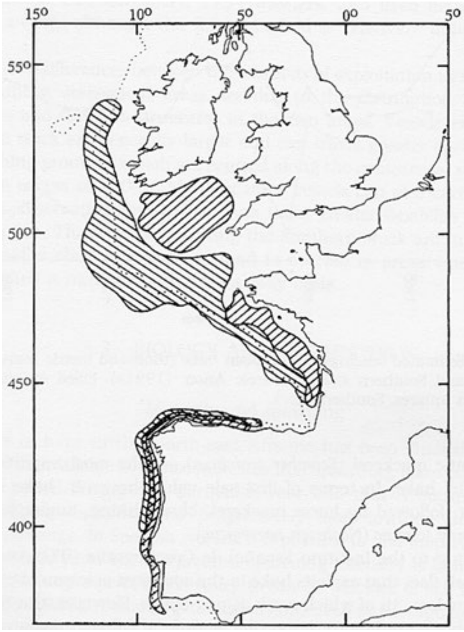

Figure 1 Main spawning and nursery areas. Spawning areas sloping downwards from left to right; Nursery areas sloping downwards from right to left. (from Casey and Pereiro, 1995).

1.2 Fishery

A set of different Fishery Units (FU) has been defined by the ICES Working Group on Fisheries Units in subareas 7 and 8 in 1985, in order to study the fishing activity related to demersal species (ICES, 1991a). To take into account the hake catches from other areas, a new Fishery Unit was introduced at the beginning of the nineties (FU 16: Outsiders). This Fishery Unit was created on the basis of a combination between mixed areas and mixed gears (trawl, seine, longline, and gillnet). The current FUs are defined as follows:

Fishery Unit	Description	Subarea
FU1	Longline in medium to deep water	7
FU2	Longline in shallow water	7
FU3	Gillnets	7
FU4	Non-*Nephrops* trawling in medium to deep water	7
FU5	Non-*Nephrops* trawling in shallow water	7
FU6	Beam trawling in shallow water	7
FU8	*Nephrops* trawling in medium to deep water	7
FU9	*Nephrops* trawling in shallow to medium water	8
FU10	Trawling in shallow to medium water	8
FU12	Longline in medium to deep water	8

FU13	Gillnets in shallow to medium water	8
FU14	Trawling in medium to deep water	8
FU15	Miscellaneous	7 and 8
FU16	Outsiders	3.a, 4, 5 and 6
FU00	French unknown	

The main part of the fishery is currently conducted in six Fishery Units, three of them from Subarea 7: FU 4, FU 1 and FU 3, two from Subarea 8: FU 13 and FU 14 and one in subareas 3.a, 4, 5 and 6: FU16.

From the information reported to the Working Group, France accounted in recent years for the main part of the landings (around 42%) followed by Spain (around 30%), before the proportions were just the opposite. The rest of the catch is divided as follows: UK (14%), Ireland (5%), Denmark (4%), Norway (4%), and Germany, Netherlands, Belgium, and Sweden contributing with less than 1% to the total catch in average.

The minimum landing size for fish caught in subareas 4, 6, 7 and 8 is set at 27 cm total length (30 cm in Division 3.a).

1.2.1 Fishery management regulations

From 14 June 2001, an Emergency Plan was implemented by the Commission for the recovery of the Northern hake stock (Council Regulations N°1162/2001, 2602/2001 and 494/2002). In addition to a TAC reduction, 2 technical measures were implemented:

- A 100 mm minimum mesh size has been implemented for otter trawlers when hake comprises more than 20% of the total weight of marine organisms retained on board. This measure did not apply to vessels less than 12 m in length and which return to port within 24 hours of their most recent departure.
- Two areas have been defined, one in Subarea 7 and the other in Subarea 8, where a 100 mm minimum mesh size is required for all otter trawlers, whatever the amount of hake caught.

Council Regulation (EC) No. 1954/2003 established measures for the management of fishing effort in a biologically sensitive area in subareas 7.b, 7.j, 7.g, and 7.h. Effort exerted within the biologically sensitive area by the vessels of each EU Member State may not exceed their average annual effort (calculated over the period 1998–2002).

There are explicit management objectives for this stock under the EC Reg. No 811/2004 implementing measures for the recovery of the northern hake stock. It is aiming at increasing the quantities of mature biomass to values equal to or greater than 140 000 t. This is to be achieved by limiting fishing mortality to 0.25 and by allowing a maximum change in TAC between years of 15%.

According to ICES in 2007, the northern hake stock met the SSB target in the recovery plan of 140 000 t for two consecutive years (2006 and 2007). Article 3 of the recovery plan indicates that, in such a situation, a management plan should be implemented.

An annual one-month fishing activity stop has been implemented by the Spanish administration since 2004. In 2008, a specific national regulation established a 90-days stop to be distributed from August 2008 to December 2009.

In Subarea 8, for 2006, 2007 and 2008, otter trawlers using a square mesh panel are allowed to use 70 mm mesh size in the area, mentioned above, where 100 mm minimum mesh size is required for all otter trawlers. (EC Reg. No. 51/2006; EC Reg. 41/2007).

Furthermore, there was a ban on gillnets in divisions 6.a, 6.b and 7.b, 7.c, 7.j, 7.k fishing at more than 200 m of depth (EC Reg. No 51/2006) during the first semester of 2006.

Since 2019, there is an agreed multi-annual management plan for mixed fisheries implemented in EU waters (Regulation (EU) 2019/472). Hake is included in this plan which, among other things, it establishes an upper and lower limit to fishing mortality around the fishing mortality at maximum sustainable yield target (F_{MSY}). The upper and lower limits (F_{upp} and F_{low}) are defined in such a way that the catch produced in the long term is not lower than 95% of maximum sustainable yield catch.

1.3 Ecosystem aspects

Although a comprehensive study on the role of hake in its ecosystem has not yet been carried out, some partial studies are available. Hake belongs to a very extended and diverse community of commercial species including megrim, anglerfish, *Nephrops*, sole, sea bass, ling, blue ling, greater forkbeard, tusk, whiting, blue whiting, *Trachurus* spp, conger, pout, cephalopods (octopus, *Loligidae*, *Ommastrephidae* and cuttlefish), and rays. The relative importance of these species in the hake fishery varies largely in relation to the different gears, sea areas, and countries involved.

Hake is preyed upon by sharks and other fish. Cannibalism on juveniles by adults is also quoted. Adults feed on fish (mainly on blue whiting and other gadoids, sardine, anchovy, and other small pelagic fish); juvenile hake prey mainly upon planktonic crustaceans (above all euphausids, copepods, and amphipods).

Ecological factors or environmental conditions impacting hake population dynamics are not taken into account at present in the assessment or the management. However, synchronous changes have been observed in hake recruitment success and several global, regional and local parameters, which suggest that environmental conditions may be influential for hake (Goikoetxea and Irigoien, 2013). An ecological regime shift occurred in the Northeast Atlantic shelf system in 1988/89, which was detected at a global scale (NAO, Gulf Stream and northern hemisphere temperature anomaly), as well as regionally (climatology of the Northeast Atlantic and copepod variability in the Celtic Sea). The region went from a period of cool temperatures and relatively weak winds (1978–1989) to a period of warmer temperatures and stronger westerly winds (1990–2006). Given the synchronous stepwise increase in hake recruitment success, it was concluded that the environment shifted to a regime that was favourable for northern hake. Early life stages of hake were found to benefit from a warming trend (either through the widening of the optimal environmental window or/and higher growth rates). In addition, coastward transport avoided vulnerable stages from their dispersion to oceanic areas and helped in their transport from spawning areas to nursery grounds (Goikoetxea, 2011). Other previous studies also highlighted the influence of environmental parameters such as water temperature and wind-driven transport on northern hake stock (Fernandes *et al.*, 2010; Álvarez *et al.*, 2001).

2 Data

In 2013, a data call was run by ICES to obtain more precise data on discards since 2003. Discard and landing data were uploaded into InterCatch by most of the countries that exploit the stock. The disaggregation level varied by country and year, from season, métier and length disaggregation level to total landings or discards by year.

2.1 Commercial catch

2.1.1 Landings

Until 2010, the Spanish landings data were based on sales notes and Owners Associations records compiled by the National laboratories (IEO and AZTI). From 2011, the Spanish data are derived from official statistics provided by the Spanish Fishery Administration derived from logbook and sale notes. French landings data are based on logbook and auction hall sales.

From 1978 to 1989, landings in weight are available by year, gear (trawl, gillnets and longline), country (UK, France and Spain) and ICES divisions (Division 4.a, Subarea 6, Division 7, and divisions 8.a and 8.b). From 1990 to the present, for most of the years, landings in weight by FUs and countries are available on a quarterly basis. In 1992, only data from Spain is available by FU and on a quarterly basis (Table 1).

Table 1 Landings-in-weight (and their level of aggregation) available to the Working Group.

	1978 to 1989	1990–1991	1992	1993 to Present
By Gear, Country and ICES divisions	X			
By FU		X	X	X
By year	X		X	
By quarter		X	X*	X

*** For Spain only**

From 1978 to 1989, length–frequency distributions are available by year, gear, country and ICES divisions. From 1990 to the present, length compositions of the landings are not available for all Fishery Units, quarters and countries. Only the main FUs/Countries are sampled. Table 2 presents, as an example, the length distributions available for 2019.

Table 2 Length–frequency distributions provided to the Working Group in 2019.

FU	France	Ireland	Spain	UK(EW)	Scotland	Denmark
01			Quarterly			
03	Quarterly		Quarterly	Quarterly		
04			Quarterly	Quarterly		
05	Quarterly			Quarterly		

06				Quarterly		
09	Quarterly					
10	Quarterly					
12	Quarterly		Quarterly			
13	Quarterly		Quarterly			
14			Quarterly			
15		Quarterly				
16			Quarterly		Quarterly/Yearly	Yearly

In 2014, the length frequency distribution, from 2003 to 2012, of the landings outside areas 6 and 7 (the landings of OTHERS fleet in Stock Synthesis) was recalculated using the data in InterCatch. The allocation schemes to disaggregate unsampled data (data without length information) in InterCatch were defined by year taking into account the area, season, and gear.

In Stock Synthesis (SS) it is not needed to allocate a length frequency distribution to all the landing and discard data. The model uses the available data in each fleet segment and assigns it to the whole landing and discard data automatically. In this case, as the fleets are disaggregated by gear and season the disaggregation level is considered detailed enough for all the fleets except the TRAWLOTH fleet. In this fleet, there are trawlers that target demersal species and trawlers that target crustaceans and both have different selection pattern. Hence, to weight the length frequencies coming from the two segments properly first the allocations are done for each of the segments and them the overall length frequency distribution is calculated as the sum of the length frequency distributions coming from the two segments.

2.1.2 Discards

Until 2002, the only discards series available and used by the WG were those of the French artisanal and coastal trawl fisheries in the Bay of Biscay, estimated on the basis of the length compositions obtained during FR-RESSGASC surveys. The RESSGASC survey used for their estimation ended in 2002.

EU countries are now required under the EU Data Collection regulation to collect data on discards.

A new sampling programme of discards in the French *Nephrops* trawlers fishery of the Bay of Biscay started in June 2002. Estimates obtained by this programme (see Table 3 below) were significantly different (by a factor 2 to 10) from previous estimates for that fishery (estimates are from 532 t in 2006 to 1597 t in 2005). Such discrepancies could be explained by changes in the sampling, changes in the discarding practices, variations in the abundance of small fish or by a combination of the three. The CVs associated with these estimates are around 20%. A huge number of discards (~1000 t) was estimated for French Gillnetters since 2012. The discards estimates on this fleet were negligible in previous years.

Discards are available for Danish trawlers, seiners and gillnetters fishing in Subarea 4 from 1995 to present and for gillnetters in subareas 7 and 8 since 2012. Their values are quite variable from year to year from 100 to more than 1000 t.

Additional information on discards was available for the Irish otter trawlers fishery in subareas 6 and 7 from 1999 to 2001, for 2004 and 2005 and for 2009 to present (values from 32 to 700 t, between 2006 and 2008 the discards were not raised because they were not available at the requested métier level). UK-EW discards were only available from 2000 to present (raised only to the trip level).

Estimates of discards for the Spanish trawl fleets operating in the ICES Subarea 7 and divisions 8.a, 8.b, and 8.d are available for 1988, 1989, 1994, from 1999 to 2001 and from 2003 to present. In Subarea 7, a significant increase in the estimated discards rate was observed from 2010 to 2018 when compared with previous years. Discards were estimated to vary from very small amounts to more than 1000 t in 2003–2005 and over 5000 t since 2010. CVs were highly variable from 20% to more than 100%. Fixed gears were also sampled in order to design the Spanish Discards Sampling Programme, but no relevant discards were observed (Pérez *et al*., 1996).

During the 2003 assessment, the Working Group noted that, although some improvement in discard data availability had been observed (number of fleets sampled and area coverage), sampling does not cover all fleets contributing to hake catches and discard rates of several fleets are simply not known. Furthermore, when data are available, it was not possible to incorporate them into the assessment in a consistent way. As reconstructing a historical series was found problematic, discard estimates were removed from the full time-series of catch data. From 2003 to 2008, the assessment was thus conducted on landings only. After the 2008 Working Group assessment, discards estimates from several sampled fleets were used in the assessment. This includes the French *Nephrops* trawl in 8abd discards data from 2003 to present, the Spanish trawl in 7 in 1994, 1999, 2000, 2003 to present and the Spanish trawl in 8abd from 2005 to present. Since 2010 the stock is assessed using SS and discard data is partly included into the model.

During the last benchmark ICES (2022) the discards data since 2014 are raised externally before being introduced in SS. SS estimates discards, but as the observed discards are considered an overestimation of the real ones, the model estimates will be an overestimation. To correct this bias, to some extent, a procedure developed by Ireland scientist form Marine Institute (MI) was applied. This procedure identifies the strata without discard observations and assigns them a discard rate based on segments with available data considering the year, gear, country and season. The observed and estimated discards, the ratio between discards and catch and the raising multiplier since 2014 by fleet (as used in SS) are presented in Table 3.

Table 3 Table 3. Summary of the discard data available since 2014.

SS Fleet	Indicador	2014	2015	2016	2017	2018	2019	2020	2021
FRNEP8	Observed	391	1134	2310	1819	889	816	1193	144
FRNEP8	Estimated	395	1194	2324	2200	995	1004	1440	662
FRNEP8	Ratio Disc/Catch	0.20	0.50	0.70	0.66	0.49	0.47	0.57	0.48
FRNEP8	Raising multiplier	1.01	1.05	1.01	1.21	1.12	1.23	1.21	4.58
GILLNET	Observed	55	857	1175	728	1014	333	444	626
GILLNET	Estimated	86	2780	1993	1320	1726	728	1028	1721
GILLNET	Ratio Disc/Catch	0.00	0.14	0.07	0.05	0.06	0.03	0.04	0.07
GILLNET	Raising multiplier	1.56	3.24	1.70	1.81	1.70	2.19	2.31	2.75
NS-TRAWL	Observed	4838	4158	4687	2680	1943	1817	948	1478
NS-TRAWL	Estimated	8375	7127	8057	4346	3677	2821	2143	2670
NS-TRAWL	Ratio Disc/Catch	0.24	0.23	0.20	0.12	0.13	0.11	0.10	0.15
NS-TRAWL	Raising multiplier	1.73	1.71	1.72	1.62	1.89	1.55	2.26	1.81
SPTRAWL7	Observed	1467	2064	616	651	903	318	157	87
SPTRAWL7	Estimated	1493	2065	1438	1316	1632	845	948	222
SPTRAWL7	Ratio Disc/Catch	0.43	0.51	0.41	0.43	0.47	0.31	0.29	0.11
SPTRAWL7	Raising multiplier	1.02	1.00	2.33	2.02	1.81	2.66	6.05	2.56
SPTRAWL8	Observed	183	589	656	906	347	586	310	153
SPTRAWL8	Estimated	230	611	656	910	416	586	350	155
SPTRAWL8	Ratio Disc/Catch	0.08	0.12	0.15	0.16	0.11	0.17	0.11	0.07
SPTRAWL8	Raising multiplier	1.26	1.04	1.00	1.00	1.20	1.00	1.13	1.02
TRAWLOTH	Observed	2591	1565	1669	1013	1937	1070	205	596
TRAWLOTH	Estimated	3301	2035	2220	1496	3196	1905	1230	2118
TRAWLOTH	Ratio Disc/Catch	0.28	0.17	0.16	0.12	0.30	0.24	0.20	0.29
TRAWLOTH	Raising multiplier	1.27	1.30	1.33	1.48	1.65	1.78	5.99	3.55
Total	Observed	9525	10367	11113	7797	7034	4940	3257	3084
Total	Estimated	13881	15812	16689	11588	11642	7889	7140	7548
Total	Ratio Disc/Catch	0.15	0.17	0.16	0.11	0.14	0.10	0.10	0.11
Total	Raising multiplier	1.46	1.53	1.50	1.49	1.65	1.60	2.19	2.45

2.2 Biological sampling

Most of the biological parameters were borrowed from a Mediterranean hake stock and the southern stock. Initially, these values were used to focus on the structural part of the model, with the idea of updating later. However, the time available did not allow to update the biological component. It is expected to have an inter benchmark to update the biological component in the coming years. The values used are listed in Table 4.

Table 4 Biological parameters that are fixed in the fit of the assessment model.

Process	Parameter	Sex	Value	Source
Growth	Linf	F	120 cm	
	Linf	M	80 cm	
	k	F	0.165	
	k	M	0.23	
Maturity	a	F	42.85 cm	(ICES, 2010b WD8).
	b	F	-0.2	
Weight	a	F and M	3.77E-06	
	b	F and M	3.168	
Natural mortality	age 0	F	1.19	Adriatic and Sicilian European hake (ICES 2019a,b))
	age 0	M	1.19	

age 1–4	F	0.64
age 1–4	M	0.64
age 5–14	F	0.34
age 5–14	M	0.415
age 15+	F	0.2
age 15+	M	0.279

Conventional tagging of European hake (de Pontual *et al.*, 2003) opened new avenues for a better understanding of the species biology and population dynamic which have remained controversial for decades (see e.g. Belloc, 1935; Hickling, 1933). The first tagging results provided evidence of substantial growth underestimation (by a factor ~2) due to age overestimation, (de Pontual *et al.*, 2006), thus challenging the internationally agreed age estimation method. More tagging efforts, both off the Northwest Iberian Peninsula (Piñeiro *et al.*, 2007) and the Mediterranean Sea (Mellon-Duval *et al.*, 2010), proved that growth underestimation was not a regional issue. More recent recaptures of tagged fishes have confirmed the growth estimated previously (de Pontual *et al.*, 2013). An ICES workshop (ICES, 2010a) confirmed that the previous internationally agreed ageing method is neither accurate nor precise and provides overestimation of age. A replacement ageing method with sufficient precision and accuracy is currently not available. Thus, in the benchmark assessment in 2010 (ICES, 2010b) the working group started to evaluate the stock using a length-based assessment model.

2.2.1 Maturity

NA

2.2.2 Length and age composition

NA

2.3 Surveys at sea

Several research-vessel surveys cover part of the geographical distribution of the Northern hake stock (Figure 2).

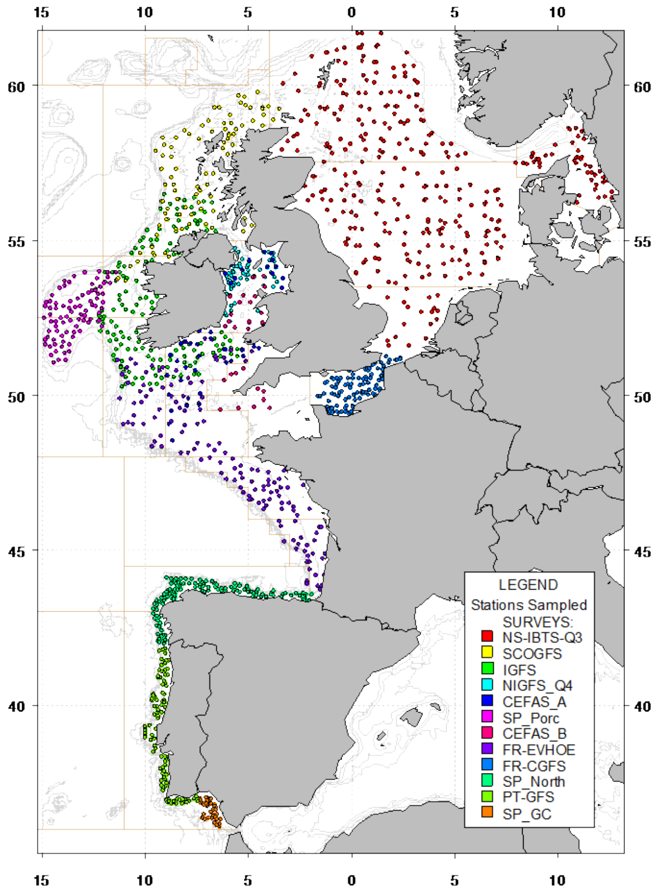

Figure 2 Map of East Atlantic groundfish surveys: stratification and trawling positions. FR-EVHOE correspond to EVHOE-WIBTS-Q4, SP Porc corresponds to SPPGFS-WIBTS-Q4 and IGFS corresponds to IGFS-WIBTS-Q4.

Abundance indices used in the SS assessment:

French Evhoe groundfish survey (EVHOE-WIBTS-Q4 [G9527]): years 1997–2016 and 2018-present. The survey occurs in autumn. The survey uses a GOV trawl with a 20 mm codend liner. It covers the shelf of both the Bay of Biscay and the Celtic Sea. In 2017 there was a technical problem in the survey and it was not possible to provide the abundance index for the stock.

French Ressgasc groundfish survey (FR-RESSGASCQ [G2537]): years 1978 to 2002. Over the years 1978–1997 the RESSGASC surveys were conducted with quarterly periodicity. They were conducted twice a year after that (in spring and autumn). Survey data prior to 1987 have been excluded, because there was a change of vessel at that time. Weather conditions encountered by RESSGASC in 2002 gives to this index a poor reliability and it was decided not to use it. The survey uses a 25 m "Vendéen type" bottom trawl. It covers the Bay of Biscay. The survey ended in 2002.

Spanish Porcupine groundfish survey (SPPGFS-WIBTS-Q4 [G5768]): years 2001 to present. The area covered by this survey is the Porcupine bank extending from longitude 12° W to 15° W and from latitude 51° N to 54° N, covering depths between 180 and 800 m. The cruises are carried out every year in September on board RV "Vizconde de Eza", a stern trawler of 53 m and 1800 Kw. Numbers-at-age for this abundance index are estimated from otoliths collected during the survey.

Irish Groundfish Surveys (IGFS-WIBTS-Q4 [G7212]): years 2003 to present. This survey is conducted on board the *R.V. Celtic Explorer* in autumn in the west of Ireland and the Celtic Sea. The survey uses GOV 36/47 (Grande Ouverture Verticale).

Irish Anglerfish and Megrim Survey (IE-IAMS [G3098]): year 2016 to present. This survey takes place in the 1st quarter each year since 2016 on the *R.V. Celtic Explorer* in the west of Ireland and Scotland. The main objective of the survey is to obtain biomass estimates for anglerfish and establish an abundance index for megrim in areas 6a (south of 58°N) and 7 (west of 8°W). However, it is also considered a good abundance index for hake and provides information on the sex-ratio.

2.4 Commercial CPUE

Commercial CPUEs indices provided to the ICES Working Group are not used in the current SS assessment. Landings-per-unit-effort time-series are available from the following fleets:

- The A Coruña trawler fleet, targeting mainly hake, operates in deeper waters close to the slope in divisions 7b-c, j–k, while the trawler fleet from Vigo, targeting megrim, works in shallower waters in Division 7j–h and catch hake as bycatch.

3 Assessment methods and settings

3.1 Model

Model currently used: Stock Synthesis (SS), (Methot and Wetzel, 2013).

Software used: Stock Synthesis V3.30 Richard Methot, NOAA Fisheries Seattle, WA.

Recent assessments and sensitivity analysis carried out.

An attempt to use a non-equilibrium surplus production model (ASPIC) was carried out in the 2004 WG (ICES, 2005) and preliminary fits of a length based stock assessment model have been presented in 2007 and 2008.

In the 1998 WG it was found that the SSB estimates for 1985–1987 were very sensitive to the q plateau options between age 5, 6, and 7 (which is the last true age). To reduce this effect, it was decided to extend the ten years window to a twelve-year period in order to tune to the longest available and well-behaved fleet data series. In the 1999 and 2000 assessments, SSB estimates for 1985–1987 were still sensitive to the extent of the tuning period, and the longest (13 years and 14 years respectively) provided the best pattern for these years, whereas other estimates were very similar for other years. In 2001 assessment, it was decided to use the whole tuning data available and a taper time weighting to reduce the influence of the older years. At that time, this choice did not change radically the estimates of trends in F and SSB and those settings were maintained in 2002 to 2003 assessments.

In 2004, the group investigated again the influence of the taper time weighting and runs were conducted without taper and compared with the base-case run using a tri-cubic taper over a 20-year period. While the group agreed on the rationale behind the use of a taper to down-weight the years for which we may have less confidence, it expressed concerns over the large influence the use of this option has on the perception of the stock dynamics and the inability of the model to account, in a satisfactory manner, for uncertainty in the data.

Due to uncertainties in hake aging, in 2005, 2006 and 2007, the group also conducted a sensitivity analysis using a simulated ALK assuming a faster growth. In each of these years, several runs were thus conducted (An Update from the previous year and a Simulated ALK, see below).

In WGHMM 2007 (ICES, 2007), an update runs from 2006 has been carried out and the SPPGFS-WIBTS Q4 survey was added to the surveys used to tune the model.

WKROUND 2010 (ICES, 2010b) implemented the first Stock Synthesis assessment model for the stock.

WKSOUTH 2014 (ICES, 2014) revised the configuration of the selectivity curves.

Current assessment
The assessment is a length-based approach using the Stock Synthesis assessment model. This approach allows direct use of the quarterly length composition data and explicit modelling of a retention process that partitions total catch into discarded and retained portions.

The underlying population can be partitioned in time to include as many seasons within a year as required. This is important where temporal aspects of biology (like growth in the case of hake), or fishing activity dictate finer than annual-level representation. However, all the basic input data must then be partitioned to the level of the underlying dynamics.

Recruitment is based on a Beverton–Holt function parameterized to include the equilibrium level of unexploited recruitment (R0) and the steepness (h) parameter, describing the fraction of the unexploited recruits produced at 20% of the equilibrium spawning biomass level. Annual deviations can be estimated for any portion of the modelled time period (or the whole period), and the expected recruitments are bias-corrected to reflect the level of variability (sigmaR, an input quantity) allowed in these deviations.

Growth is described through a von Bertalanffy growth curve with the distribution of lengths for a given age assumed to be normally distributed. The CV of these distributions is structured to include two parameters which can be estimated or fixed, defining the spread of lengths at a young and old age with a linear interpolation between. In addition to growth, the relationships between weight and length, fecundity and length as well as maturity-at-length are all generalized to allow parameters to be estimated or fixed, temporally invariant or not. All model parameters can vary over time either as a function of annual deviations about a mean level, user defined 'blocks' of years in which the parameters differ or a combination of the two.

All model expectations for comparison with data are generated as observations from a 'fleet', either a fishery or a survey/index of abundance. Each fleet has unique characteristics defining relative selectivity across age or size, and can be structured to remove catch or collect observations at a particular time of the year or season. All fleets may be considered completely independent, or parameters may be shared among fleets where appropriate via 'mirroring'.

A suite of selectivity curves including logistic-based shapes of up to eight parameters, power functions and nonparametric forms can be explored through relatively simple modification of the input files.

The kinds of data that model expectations can be fit to include: absolute or relative abundance, length–frequency distributions, age frequency distributions (either total or conditional by length), length-at-age, body weight, and proportion discard. Each of these can be from the retained, discarded or total removals by a specific fleet. Each source has an error distribution (either normal, lognormal or multinomial) associated with it, described by either an input sample size or standard deviation.

3.2 Input data

The overall fishery prosecuting the northern stock of hake has been categorized into 7 "fleets", 4 of which use trawl gears, whereas the remaining three use gillnet, longline and a combination of several gears (Table 5). They are based on a combination of the Fishery Units described above. For each fleet, estimates of landings in weight and length–frequency distributions are available. For some fleet only, discards in weight and length–frequency distribution are used.

Table 5 Fleets characteristics and data available for SS (Length–Frequency distribution (LFD) and weight of landings and discards).

Fleets	Description	FU	Landings (quarterly)	Discards (quarterly)
SPTRAWL7*	Spanish trawl in 7	04	Yearly : 1978–1989 (LFD+tonnage) Quarterly: 1990–(y**-1) (LFD+tonnage)	1994, 1999, 2000, 2003–(y**-1) (LFD + Weight)
FRNEP8	French trawl targeting *Nephrops* in 8	09	Yearly : 1978–1989 (tonnage) Yearly : 1985–1989 (LFD) Quarterly : 1990–(y**-1) (LFD+tonnage)	2003–(y**-1) (LFD + Weight)
SPTRAWL8	Spanish trawl in 8	14	Yearly : 1978–1989 (LFD+tonnage) Quarterly: 1990–(y**-1) (LFD+tonnage)	2005–(y**-1) (LFD + Weight)
TRAWLOTH	All other trawl	05 + 06 + 08 + 10	Yearly : 1978–1989 (LFD+tonnage) Quarterly: 1990–(y**-1) (LFD+tonnage)	2005–(y**-1) (LFD + Weight)
GILLNET	Gillnet all countries	03 + 13	Yearly : 1978–1989 (LFD+tonnage) Quarterly: 1990–(y**-1) (LFD+tonnage)	2005–(y**-1) (LFD + Weight)
LONGLINE	Longline all countries	01 + 02 + 12	Yearly : 1978–1989 (LFD+tonnage) Quarterly: 1990–(y**-1) (LFD+tonnage)	
OTHIST	Everything else all countries, up to 2012	15 + 16 + 00	Yearly : 1978–1989 (LFD+tonnage) Quarterly and Yearly: 1990–2012 (LFD+tonnage)	2003–2012 (Weight) 2003–2012 (Weight+LFD)
NSTRAWL	North Sea Trawlers since 2013	15 + 16 + 00	Quarterly and Yearly: 2013–(y**-1) (LFD+tonnage)	Quarterly and Yearly: 2013–(y**-1) (LFD+tonnage)
OTHERS	Everything else all countries since 2013	15 + 16 + 00	Quarterly and Yearly: 2013–(y**-1) (LFD+tonnage)	Quarterly and Yearly: 2013–(y**-1) (LFD+tonnage)

*** FU04 (and consequently SPTRAWL7) landings and discards contain small amount from area 6 as, in some cases, the sampling programme does not allow to make the distinction between area 7 & 6.**

**** y = assessment year**

For the two Spanish trawl fisheries, it is thought that discarding became much more substantial starting from 1998. For the French *Nephrops* fishery, discarding is thought to have occurred already from 1990. For the OTHERS fleet, since 2009 the discards are mainly formed by Scottish discards for which LFD are not available. The retention and selection of OTHERS fleet is thought to vary yearly because it is formed by a mixed of gears and countries. The remaining 3 fisheries (TRAWLOTH, GILLNET, LONGLINE) are assumed not to discard any fish.

Several surveys provide relative abundance indices of abundance and length distributions (Table 6).

Table 6 List of surveys used in SS.

Surveys	Area	Years	Quarter	Units
EVHOE-WIBTS-Q4 [G9527]	Bay of Biscay and Celtic Sea	1997–(y*-1)	4	numbers
FR-RESSGASCQ [G2537]	Bay of Biscay	1990–1997 1998–2001	1, 2 ,3 and 4 2 and 4	numbers
SPPGFS-WIBTS-Q3 [G5768]	Porcupine Bank	2001–(y*-1)	3	numbers
IGFS-WIBTS-Q4 [G7212]	North, West and South of Ireland	2003–(y*-1)	4	numbers
IE-IAMS [G3098]	Irish anglerfish and monkfish survey	2016–(y*-1)	1	biomass

*** y = assessment year**

No commercial fleet tuning data are used.

Length Frequency Distribution Data compilation (From InterCatch to SS)

In 2015 a problem with the calculation of length–frequency distributions (LFD) was detected. That year, the calculation was carried out using R statistical software instead of InterCatch. The new procedure allowed using a more detailed stratification of the data when calculating the LFDs and it solved the problem detected the previous year. In order to be consistent along time, the procedure was applied to the data since 2013 when InterCatch was first used. The LFDs obtained were in agreement with those observed before 2013.

In SS it is not necessary that all the data has a length distribution assigned, it is enough to provide the proportion at length of the catch for the whole stratum (fleet/quarter and catch category (landings or discards) combination). Furthermore, if for one stratum there is no LFD data available or the available data are not reliable the model can work without it. Hence, unlike in InterCatch in R no allocations were done in the stratums without LFD data.

For all the samples with observed LFDs, first the catch in weight by length was calculated using the weight-at-length relationship agreed for this stock (W(g)= 3.77e-6*L(cm)^3.168; ICES, 1991b). Then, for SPTRAWL7, FRNEP8, SPTRAWL8, GILLNET, LONGLINE, OTHER and OTHIST fleets all the samples within each stratum were aggregated by length class summing up the catch weight at length. The obtained length distribution of catch in weight was divided by total catch in the stratum to obtain the proportion of individuals in each length class, which was then used in SS. For TRAWLOTH fleet the data were further disaggregated. In TRAWLOTH the target species was taken into account and the data were divided in the samples coming from métiers with Nephrops as target stock and from métiers with demersal stocks as target. Within these groups the proportion by length was calculated in the same way done for the rest of the fleets. Finally, the overall proportion by length within the stratum was calculated using a weighted mean of the proportion in each group. The weighting factor was the total catch in weight in each group taking into account both sampled and non-sampled data.

The code use to produce the LFDs is available in the ICES TAF repository for hake assessment.

SS settings (input data and control files):

Years: 1978 to present, 1 area, 4 seasons, sex disaggregated.

Length Frequency Distribution are available on a yearly basis from 1978 to 1989 and on a quarterly basis from 1990 to present. No age data are used.
Initial equilibrium catch: annual average of five years (1978–1982) for each fishery.

Variability for landings, discards and survey abundance indices are entered as standard deviation in log-scale, as follows:

Landings (tonnes): 10% variability

Discards (tonnes): 50% variability

Survey abundance indices: variability externally estimated. As the latter represents only the surveys internal variability, extra variability was added (increment to CV in SS control file) according to how representative each survey was felt to be of stock abundance (i.e. the area coverage of the survey as compared to the spatial distribution of the stock). Surveys' CV were increased by 0.1 (EVHOE-WIBTS-Q4), 0.2 (RESSGASC, IGFS-WIBTS-Q4), 0.3 (SPPGFS-WIBTS-Q4).

Length compositions were assigned the following sampling sizes in the SS input data file, on the basis of how representative they were felt to be[1]:

Landings: 125 for all fleets, except SPTRAWL7 for which 50 was used for 1990–1997 and 200 was used from 1998 onwards

Discards: 50 for SPTRAWL7,SPTRAWL8, TRAWLOTH, GILLNET, OTHIST and OTHER, 80 for FRNEP8

Surveys: 125

All the sample size of all LFD was multiplied by 0.1 to reduce the contribution of the likelihood component of LFD to the overall likelihood.

---

[1] The log-likelihood for the fit to length composition observations from fishery or survey source, is defined according to a multinomial error structure. The absolute value of the sample size (which may be many thousands of fish measured) should not be interpreted literally. The input sample size scales the variance of the data. The recommended maximum level for the sample size was 400 in Fournier and Archibald (1982). In many recent synthesis applications, a value of 200 has been used (which produces an expected coefficient of variation (CV) of approximately 20% (Methot, 2000)).

Extra standard deviation is estimated for all the abundance indices.

M=0.4.

von Bertalanffy growth function is fixed: Linf=130 cm, K = 0.177319 and mean length-at-age 0.75 = 15.8392. Linf was chosen in 2010 benchmark (ICES, 2010b) and K and mean length-at-age 0.75 were fixed and chosen in 2014 benchmark using the estimates obtained in 2011 assessment (ICES, 2011). Same growth parameters apply to all fish (across morphs, years, etc)

Maturity ogive: length-based logistic, externally estimated and assumed constant over time.

Recruitment allocation for Quarter 3 estimated with respect to Quarter 2. Quarter 2 allocation is time-varying, with annual deviates. Quarter 1 and quarter 4 allocation set to 0.

Beverton–Holt stock–recruitment relationship: s sigma_R=0.4, steepness and R0 estimated.

Recruitment deviations starting in 1978 and finish in the last data year by default.
However, if the working group believes these are not accurately estimated they could be replaced with the recruitment predicted from SS stock–recruit relationship, i.e. removing recruitment deviations. Advanced options in recruitment were defined during the benchmark ICES (2023), it must be checked that they are still valid and update if necessary:

- Begin of ramp: 1974
- Begin of plateau: 1976
- Last year full bias adjustment in MPD: last data year - 1 (i.e., assessment year – 2)
- End year of ramp in MPD: last data year (i.e., assessment year - 1)
- Maximum bias adjustment in MPD: 0.95

F estimation method = 4 (fleet specific parameters, hybrid method). SPTRAWL7, TRAWLOTH, FRNEP8, SPTRAWL8, NSTRAWL and OTHERS Hybrid method and GILLNET, LONGLINE and OTHIST method 1.Surveys catchabilities constant over time.

RESSGASC survey entered as 4 separate surveys (1 per quarter). Both, catchabilities and selectivity's are quarter-specific.

Selectivity only length-based (no age selectivity considered).

Fleets' selectivity-at-length:

SPTRAWL7, FRNEP8, SPTRAWL8:

- Pattern 24 (double normal) with only the first 4 parameters estimated.
- Logistic retention
- Random walk from 1998 to the last year data in the first selectivity parameter (peak) and the L_{inf} retention.

TRAWLOTH: Pattern 1 (logistic) selectivity and retention. Random walk in the size inflection in selectivity and Linf retention, 1998-Last data year.

GILLNET: Pattern 24 (double normal) selectivity with only first and third parameters estimated, No random walk.

LONGLINE: Pattern 1 (logistic) with no random walk and no discards.

OTHIST and NSTRAWL: Pattern 1 (logistic) and discards. Random walk in the size inflection in selectivity and Linf retention, 1998-Last data year. In OTHIST random walk 2003–2012, in NSTRAWL; 2013-last data year.

OTHERS: Pattern 24 (double normal) selectivity with no discards and no random walk.

Retention patterns for fisheries with discards: length-logistic with asymptotic retention = 1 in all cases except for gillnetters. The asymptote in gillnetters, L50 and slope for all the fleets with discards are estimated by the model.

4 Projections

4.1 Short-term forecast

- Model used: SS.
- Software used: SS.
- Initial stock size. Taken from the SS in the last assessment year.
- Recruitment in the last data year(s): if the working group believes these are not accurately estimated, they can be replaced with the recruitment predicted from SS stock–recruit relationship.
- Mean weights-at-age, maturity-at-age: average last 3 year.
- Discard proportions-at-age: average last 3 years
- Exploitation pattern: average last 3 years
- F status-quo average last 3 years unless there is a clear trend in F, in which case F can be rescaled to the last year.
- F in the intermediate year: F status-quo
- Recruitment in the intermediate and forecast years: predicted from Stock Synthesis stock–recruit relationship.
- Natural mortality: Age and dex dependent and time invariant as used in the assessment.
- Growth model: von Bertalanffy model, with the same parameters used in the assessment model.
- Maturity-at-length: The same time-invariant ogive as in the assessment is used for all years. Software used: EqSim

4.2 Medium-term projections

- No medium-term projections are conducted for this stock.

4.3 Long-term projections

- Model used: EqSim
- Software used: EqSim

The default setting for the biological vectors (weights-at-age, proportion mature at age, proportion natural and fishing mortality occurring before spawning…) is a 5-year window in which values for the simulation period are taken by resampling. According to ICES guidelines, the simulations should represent the current productivity state of the stock and make no inference on the direction of future changes. Based on this guideline, the mean values for the last 5 observed years were considered appropriate.

In the absence of an estimate of F_{cv} and F_{phi}, *EqSim* assumes default values of 0.212 and 0.423 respectively. These values were used.

The simulations were based on 1000 replicates of the stock, used the value of B_{lim} and B_{pa} defined above and considered MSY $B_{trigger}$ = B_{pa} (see rational below).

The detail of the configuration of the simulation is given in the box below.

```
sim_Trig <- eqsim_run( fit_bh,
                       Fcv = 0.212, Fphi = 0.423, SSBcv = 0,
                       rhologRec = rho,
                       Btrigger = Btrigger, Blim = Blim, Bpa = Bpa,
                       Nrun = 1000, Fscan = Fscan, verbose = F)
```

5 Biological reference points

	WG 1998	ACFM 1998	ACFM 2003	ACOM 2010	WKMSYREF4 (ICES, 2016)	WGBIE (ICES, 2019b)	WKANGHKE (ICES, 2023)
MSY $B_{trigger}$				not defined	45000	56000	78405
F_{MSY}				0.24	0.28	0.26	0.24
Flim	No proposal	0.28 (= Floss WG 98)	0.35 (= Floss WG 03)	not defined	0.87	0.84	0.73
Fpa	No proposal	0.20 (= Flim*e-1.645*0.2)	0.25 (= Flim*e-1.645*0.2)	not defined	0.62	0.60	0.54
Blim	No proposal	120 000 t (~ Bloss= B94)	100 000 t (~ Bloss= B94)	not defined	32000	40000	61563
Bpa	119 000 t (=Bloss= B94)	165 000 t (= Blim*e1.645*0.2)	140 000 t (= Blim*e1.645*0.2)	not defined	45000	56000	78405
Flower	not defined	not defined	not defined	not defined	0.18	0.18	0.147
Flupper	not defined	not defined	not defined	not defined	0.45	0.40	0.37

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Annex 1: Version history

Version/ edition	Publication date	Summary of changes	DOI
01	May 2022	New assessment model: a4a	Same doi
02	May 2023	Minor edits	Same doi

Annex 2: Control File

Annex 1. Control File

```
Columna1
#V3.30.18.beta: not an official version of SS;_safe;_compile_date:_Feb 11 2022;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_12.3
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-stock-synthesis/stock-synthesis

#C growth parameters are estimated
#_data_and_control_files: bc7.dat // bc7_rw_01w.ctl
0  # 0 means do not read wtatage.ss; 1 means read and use wtatage.ss and also read and use growth parameters
1  #_N_Growth_Patterns (Growth Patterns, Morphs, Bio Patterns, GP are terms used interchangeably in SS3)
1 #_N_platoons_Within_GrowthPattern
#_Cond 1 #_Platoon_within/between_stdev_ratio (no read if N_platoons=1)
#_Cond  1 #vector_platoon_dist_(-1_in_first_val_gives_normal_approx)
#
3 # recr_dist_method for parameters:  2=main effects for GP, Area, Settle timing; 3=each Settle entity; 4=none (only when N_GP*Nsettle*pop==1)
1 # not yet implemented; Future usage: Spawner-Recruitment: 1=global; 2=by area
2 #  number of recruitment settlement assignments
0 # unused option
#GPattern month  area  age (for each settlement assignment)
 1 4 1 0
 1 7 1 0
#
#_Cond 0 # N_movement_definitions goes here if Nareas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4, age2=10
#
1 #_Nblock_Patterns
 1 #_blocks_per_pattern
# begin and end years of blocks
```

```
 1977 1977 # Block to simulate the off-set in recruitment, it was defined by RickMethot to mimic what SS3.24 did.
#
# controls for all timevary parameters
1 #_time-vary parm bound check (1=warn relative to base parm bounds; 3=no bound check); Also see env (3) and dev (5) options to constrain with base bounds
#
# AUTOGEN
 1 1 1 1 1 # autogen: 1st element for biology, 2nd for SR, 3rd for Q, 4th reserved, 5th for selex
# where: 0 = autogen time-varying parms of this category; 1 = read each time-varying parm line; 2 = read then autogen if parm min==-12345
#
#_Available timevary codes
#_Block types: 0: P_block=P_base*exp(TVP); 1: P_block=P_base+TVP; 2: P_block=TVP; 3: P_block=P_block(-1) + TVP
#_Block_trends: -1: trend bounded by base parm min-max and parms in transformed units (beware); -2: endtrend and infl_year direct values; -3: end and infl as fraction of ba
#_EnvLinks:  1: P(y)=P_base*exp(TVP*env(y));  2: P(y)=P_base+TVP*env(y);  3: P(y)=f(TVP,env_Zscore) w/ logit to stay in min-max;  4: P(y)=2.0/(1.0+exp(-TVP1*env(y) - TVP2)
#_DevLinks:  1: P(y)*=exp(dev(y)*dev_se;  2: P(y)+=dev(y)*dev_se;  3: random walk;  4: zero-reverting random walk with rho;  5: like 4 with logit transform to stay in base mi
#_DevLinks(more):  21-25 keep last dev for rest of years
#
#_Prior_codes:  0=none; 6=normal; 1=symmetric beta; 2=CASAL's beta; 3=lognormal; 4=lognormal with biascorr; 5=gamma
#
# setup for M, growth, wt-len, maturity, fecundity, (hermaphro), recr_distr, cohort_grow, (movement), (age error), (catch_mult), sex ratio
#_NATMORT
1 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate;_5=BETA:_Maunder_link_to_maturity
4 #_N_breakpoints
 0 1 5 15 # age(real) at M breakpoints
#
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_specific_K_incr; 4=age_specific_K_decr; 5=age_specific_K_each; 6=NA; 7=NA; 8=growth cessation
0.75 #_Age(post-settlement)_for_L1;linear growth below this
999 #_Growth_Age_for_L2 (999 to use as Linf)
-999 #_exponential decay for growth above maxage (value should approx initial Z; -999 replicates 3.24; -998 to not allow growth above maxage)
0  #_placeholder for future growth feature
#
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
#
```

```
1 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=disabled; 6=read length-maturity
2 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W
0 #_hermaphroditism option:  0=none; 1=female-to-male age-specific fxn; -1=male-to-female age-specific fxn
1 #_parameter_offset_approach for M, G, CV_G:  1- direct, no offset**; 2- male=fem_parm*exp(male_parm); 3: male=female*exp(parm) then old=young*exp(parm)
#_** in option 1, any male parameter with value = 0.0 and phase <0 is set equal to female parameter
#
#_growth_parms
#_ LO HI INIT PRIOR PR_SD PR_type PHASE env_var&link dev_link dev_minyr dev_maxyr dev_PH Block Block_Fxn
# Sex: 1  BioPattern: 1  NatMort :: Female natural mortality, proposed by M.Cardinale and taken from a mediterranean stock.
 0.15 3 1.19 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_1_Fem_GP_1
 0.15 1.4 0.64 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_2_Fem_GP_1
 0.15 0.4 0.34 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_3_Fem_GP_1
 0.15 0.4 0.2 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_4_Fem_GP_1
# Sex: 1  BioPattern: 1  Growth :: Female Growth params, proposed by M.Cardinale and taken from a mediterranean stock.
 4 25 21.902 16.165 0 0 2 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 60 140 120 100 0 0 -3 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.05 0.4 0.165 0.165 0 0 -3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 0.005 0.5 0.15 0.15 0 0 -6 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
 0.005 0.5 0.15 0.15 0 0 -6 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
# Sex: 1  BioPattern: 1  WtLen  :: Female weight at length parameters, borrowed from S. Hake
 -1 1 3.77e-06 6.59e-06 0 0 -3 0 0 0 0 0 0 0 # Wtlen_1_Fem_GP_1
 2 4 3.16826 3.01221 0 0 -3 0 0 0 0 0 0 0 # Wtlen_2_Fem_GP_1
# Sex: 1  BioPattern: 1  Maturity&Fecundity  :: Female maturity at length parameters, borrowed from S. Hake
 30 55 42.85 42.85 5 0 -3 0 0 0 0 0 0 0 # Mat50%_Fem_GP_1
 -1 1 -0.2 -0.2 0.5 0 -3 0 0 0 0 0 0 0 # Mat_slope_Fem_GP_1
 -3 3 1 1 0 0 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem_GP_1
 -3 3 0 0 0 0 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem_GP_1
# Sex: 2  BioPattern: 1  NatMort ::  male natural mortality, proposed by M.Cardinale and taken from a mediterranean stock.
 0 3 1.19 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_1_Mal_GP_1
 0 1.5 0.64 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_2_Mal_GP_1
 0 0.5 0.415 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_3_Mal_GP_1
 0 0.5 0.279 0.2 10 0 -3 0 0 0 0 0 0 0 # NatM_break_4_Mal_GP_1
```

```
# Sex: 2  BioPattern: 1  Growth :: male Growth params, proposed by M.Cardinale and taken from a mediterranean stock.
 4 30 15.4262 0 0 0 2 0 0 0 0 0 0 0 # L_at_Amin_Mal_GP_1
 0 120 80 -0.4 0 0 -3 0 0 0 0 0 0 0 # L_at_Amax_Mal_GP_1
 0.1 0.6 0.23 0 0 0 -3 0 0 0 0 0 0 0 # VonBert_K_Mal_GP_1
 0.1 0.7 0.15 0 0 0 -3 0 0 0 0 0 0 0 # CV_young_Mal_GP_1
 0.1 0.7 0.15 0 0 0 -3 0 0 0 0 0 0 0 # CV_old_Mal_GP_1
# Sex: 2  BioPattern: 1  WtLen :: male weigth at length parameters , same as females
 -1 1 3.77e-06 6.59e-06 0 0 -3 0 0 0 0 0 0 0 # Wtlen_1_Mal_GP_1
 2 4 3.16826 3.01221 0 0 -3 0 0 0 0 0 0 0 # Wtlen_2_Mal_GP_1
# Hermaphroditism
#  Recruitment Distribution
 -8 8 0 0 0 0 -2 0 0 0 0 0 0 0 # RecrDist_GP_1_area_1_month_4
 -12 12 -1.82923 -0.56 0 0 6 0 23 1978 2019 4 0 0 # RecrDist_GP_1_area_1_month_7
#  Cohort growth dev base
 0 2 1 1 0 0 -3 0 0 0 0 0 0 0 # CohortGrowDev
#  Movement
#  Age Error from parameters
#  catch multiplier
#  fraction female, by GP
 1e-06 0.999999 0.5 0.5 0.5 0 -99 0 0 0 0 0 0 0 # FracFemale_GP_1
#  M2 parameter for each predator fleet
#
# timevary MG parameters
#_ LO HI INIT PRIOR PR_SD PR_type  PHASE
 0.0001 2 1.5 0.5 0.5 6 -5 # RecrDist_GP_1_area_1_month_7_dev_se
 -0.99 0.99 0 0 0.5 6 -6 # RecrDist_GP_1_area_1_month_7_dev_autocorr
# info on dev vectors created for MGparms are reported with other devs after tag parameter section
#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_ LO HI INIT PRIOR PR_SD PR_type PHASE
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
```

```
3 #_Spawner-Recruitment; Options: 1=NA; 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm; 8=Shepherd_3Parm; 9=RickerPower_3parm
0  # 0/1 to use steepness in initial equ recruitment calculation
0  #  future feature:  0/1 to make realized sigmaR a function of SR curvature
#_      LO      HI      INIT      PRIOR     PR_SD    PR_type   PHASE   env-var   use_dev  dev_mnyr  dev_mxyr   dev_PH   Block   Blk_Fxn #  parm_name
       11.5    16.2    13.7896    12.9       1        0        1       0        0        0        0        0        0        0 # SR_LN(R0)
        0.2    0.999   0.927075   0.999     0.2       0        2       0        0        0        0        0        0        0 # SR_BH_steep
        0.1      2      0.4       0.4       0.2       0       -1       0        0        0        0        0        0        0 # SR_sigmaR
         -5      5        0      -0.7        2        0       -1       0        0        0        0        0        1        1 # SR_regime
          0      0        0         0        0      -99        0       0        0        0        0        0        0 # SR_autocorr
# timevary SR parameters
 -5 5 -0.207899 -0.16 2 0 6 # SR_regime_BLK1add_1977
1 #do_recdev:  0=none; 1=devvector (R=F(SSB)+dev); 2=deviations (R=F(SSB)+dev); 3=deviations (R=R0*dev; dev2=R-f(SSB)); 4=like 3 with sum(dev2) adding penalty
1978 # first year of main recr_devs; early devs can preceed this era
2019 # last year of main recr_devs; forecast devs start in following year. This is turned off in the last year to remove the impact of retrospective pattern in recruiment. Simi
using the geometric mean. Consider using for the last two assessment years.
2 #_recdev phase
1 # (0/1) to read 13 advanced options
 -6 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 4 #_recdev_early_phase
 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for Fcast_recr_like occurring before endyr+1
 1974 #_last_yr_nobias_adj_in_MPD; begin of ramp. These four years are the RAMP options and are tunned depending on the resultst. In principle
#_last_yr_fullbias_adj_in_MPD is [last data year -1] and  #_end_yr_for_ramp_in_MPD is last data year
 1976 #_first_yr_fullbias_adj_in_MPD; begin of plateau
 2019 #_last_yr_fullbias_adj_in_MPD
 2020 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS3 sets bias_adj to 0.0 for fcast yrs)
 0.95 #_max_bias_adj_in_MPD (typical ~0.8; -3 sets all years to 0.0; -2 sets all non-forecast yrs w/ estimated recdevs to 1.0; -1 sets biasadj=1.0 for all yrs w/ recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -5 #min rec_dev
 5 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options
#
```

```
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_Yr Input_value
#
(...)
#Fishing Mortality info
0.3 # F ballpark value in units of annual_F
-2001 # F ballpark year (neg value to disable)
4 # F_Method:  1=Pope midseason rate; 2=F as parameter; 3=F as hybrid; 4=fleet-specific parm/hybrid (#4 is superset of #2 and #3 and is recommended)
2.9 # max F (methods 2-4) or harvest fraction (method 1)
# read list of fleets that do F as parameter; unlisted fleets stay hybrid, bycatch fleets must be included with start_PH=1, high F fleets should switch early
# (A) fleet, (B) F_starting_value (used if start_PH=1), (C) start_PH for parms (99 to stay in hybrid, <0 to stay at starting value)
# (A) (B) (C)  (terminate list with -9999 for fleet)
 1 0.05 99 # SPTRAWL7
 2 0.05 99 # TRAWLOTH
 3 0.05 99 # FRNEP8
 4 0.05 99 # SPTRAWL8
 5 0.05 1 # GILLNET
 6 0.05 1 # LONGLINE
 7 0.05 1 # OTHIST
 8 0.05 99 # NSTRAWL
 9 0.05 99 # OTHERS
-9999 1 1 # end of list
4 #_number of loops for hybrid tuning; 4 good; 3 faster; 2 enough if switching to parms is enabled
#
#_initial_F_parms; for each fleet x season that has init_catch; nest season in fleet; count = 28
#_for unconstrained init_F, use an arbitrary initial catch and set lambda=0 for its logL
#_ LO HI INIT PRIOR PR_SD  PR_type  PHASE
 0.0001 2 0.114179 0.3 0.5 0 1 # InitF_seas_1_flt_1SPTRAWL7
 0.0001 2 0.0960197 0.3 0.5 0 1 # InitF_seas_1_flt_2TRAWLOTH
 0.0001 2 0.0370275 0.3 0.5 0 1 # InitF_seas_1_flt_3FRNEP8
 0.0001 2 0.268674 0.3 0.5 0 1 # InitF_seas_1_flt_4SPTRAWL8
 0.0001 2 0.0409992 0.3 0.5 0 1 # InitF_seas_1_flt_5GILLNET
```

```
0.0001 2 0.0387274 0.3 0.5 0 1 # InitF_seas_1_flt_6LONGLINE
0.0001 2 0.0515533 0.3 0.5 0 1 # InitF_seas_1_flt_7OTHIST
0.0001 2 0.108343 0.3 0.5 0 1 # InitF_seas_2_flt_1SPTRAWL7
0.0001 2 0.158075 0.3 0.5 0 1 # InitF_seas_2_flt_2TRAWLOTH
0.0001 2 0.086726 0.3 0.5 0 1 # InitF_seas_2_flt_3FRNEP8
0.0001 2 0.301355 0.3 0.5 0 1 # InitF_seas_2_flt_4SPTRAWL8
0.0001 2 0.0494331 0.3 0.5 0 1 # InitF_seas_2_flt_5GILLNET
0.0001 2 0.0747584 0.3 0.5 0 1 # InitF_seas_2_flt_6LONGLINE
0.0001 2 0.09452 0.3 0.5 0 1 # InitF_seas_2_flt_7OTHIST
0.0001 2 0.0798011 0.3 0.5 0 1 # InitF_seas_3_flt_1SPTRAWL7
0.0001 2 0.116473 0.3 0.5 0 1 # InitF_seas_3_flt_2TRAWLOTH
0.0001 2 0.066684 0.3 0.5 0 1 # InitF_seas_3_flt_3FRNEP8
0.0001 2 0.258577 0.3 0.5 0 1 # InitF_seas_3_flt_4SPTRAWL8
0.0001 2 0.0520433 0.3 0.5 0 1 # InitF_seas_3_flt_5GILLNET
0.0001 2 0.056406 0.3 0.5 0 1 # InitF_seas_3_flt_6LONGLINE
0.0001 2 0.103883 0.3 0.5 0 1 # InitF_seas_3_flt_7OTHIST
0.0001 2 0.0890657 0.3 0.5 0 1 # InitF_seas_4_flt_1SPTRAWL7
0.0001 2 0.102735 0.3 0.5 0 1 # InitF_seas_4_flt_2TRAWLOTH
0.0001 2 0.0332452 0.3 0.5 0 1 # InitF_seas_4_flt_3FRNEP8
0.0001 2 0.170887 0.3 0.5 0 1 # InitF_seas_4_flt_4SPTRAWL8
0.0001 2 0.0436354 0.3 0.5 0 1 # InitF_seas_4_flt_5GILLNET
0.0001 2 0.0389617 0.3 0.5 0 1 # InitF_seas_4_flt_6LONGLINE
0.0001 2 0.0598895 0.3 0.5 0 1 # InitF_seas_4_flt_7OTHIST
#
(...)
#_Q_setup for fleets with cpue or survey data
#_1:  fleet number
#_2:  link type: (1=simple q, 1 parm; 2=mirror simple q, 1 mirrored parm; 3=q and power, 2 parm; 4=mirror with offset, 2 parm)
#_3:  extra input for link, i.e. mirror fleet# or dev index number
#_4:  0/1 to select extra sd parameter
#_5:  0/1 for biasadj or not
#_6:  0/1 to float
#_   fleet     link link_info  extra_se   biasadj     float  #  fleetname
```

```
      10     1     0     1     1     1 #  EVHOE
      11     1     0     1     1     1 #  RESSGASCQ1
      12     1     0     1     1     1 #  RESSGASCQ2
      13     1     0     1     1     1 #  RESSGASCQ3
      14     1     0     1     1     1 #  RESSGASCQ4
      15     1     0     1     1     1 #  PORCUPINE
      16     1     0     1     1     1 #  IGFS
      17     1     0     1     1     1 #  IAMS
-9999 0 0 0 0 0
#
#_Q_parms(if_any);Qunits_are_ln(q)
#_      LO      HI     INIT     PRIOR    PR_SD    PR_type    PHASE  env-var  use_dev  dev_mnyr  dev_mxyr  dev_PH  Block  Blk_Fxn  #  parm_name
       -25      25   -8.55299       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_EVHOE(10)
         0       1  0.224903   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_EVHOE(10)
       -25      25   -4.95836       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_RESSGASCQ1(11)
         0       1  0.270315   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_RESSGASCQ1(11)
       -25      25   -3.90854       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_RESSGASCQ2(12)
         0       1  0.220105   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_RESSGASCQ2(12)
       -25      25   -4.15764       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_RESSGASCQ3(13)
         0       1  0.0729454  0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_RESSGASCQ3(13)
       -25      25   -5.07421       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_RESSGASCQ4(14)
         0       1   0.28681   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_RESSGASCQ4(14)
       -25      25   -8.26472       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_PORCUPINE(15)
         0       1  0.159159   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_PORCUPINE(15)
       -25      25   -9.11494       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_IGFS(16)
         0       1  0.248736   0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_IGFS(16)
       -25      25   -7.70231       0       1       0    -1     0     0     0     0     0     0     0 #  LnQ_base_IAMS(17)
         0       1  0.0117695  0.0001    0.01       0     4     0     0     0     0     0     0     0 #  Q_extraSD_IAMS(17)
#_no timevary Q parameters
#
#_size_selex_patterns
#Pattern:_0;  parm=0; selex=1.0 for all sizes
#Pattern:_1;  parm=2; logistic; with 95% width specification
```

```
#Pattern:_2;  parm=6; modification of pattern 24 with improved sex-specific offset
#Pattern:_5;  parm=2; mirror another size selex; PARMS pick the min-max bin to mirror
#Pattern:_11; parm=2; selex=1.0  for specified min-max population length bin range
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_6;  parm=2+special; non-parm len selex
#Pattern:_43; parm=2+special+2;  like 6, with 2 additional param for scaling (average over bin range)
#Pattern:_8;  parm=8; double_logistic with smooth transitions and constant above Linf option
#Pattern:_9;  parm=6; simple 4-parm double logistic with starting length; parm 5 is first length; parm 6=1 does desc as offset
#Pattern:_21; parm=2+special; non-parm len selex, read as pairs of size, then selex
#Pattern:_22; parm=4; double_normal as in CASAL
#Pattern:_23; parm=6; double_normal where final value is directly equal to sp(6) so can be >1.0
#Pattern:_24; parm=6; double_normal with sel(minL) and sel(maxL), using joiners
#Pattern:_25; parm=3; exponential-logistic in length
#Pattern:_27; parm=special+3; cubic spline in length; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=special+3+2; cubic spline; like 27, with 2 additional param for scaling (average over bin range)
#_discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead;_4=define_dome-shaped_retention
#_Pattern Discard Male Special
 24 1 0 0 # 1 SPTRAWL7
 1 1 0 0 # 2 TRAWLOTH
 24 1 0 0 # 3 FRNEP8
 24 1 0 0 # 4 SPTRAWL8
 24 1 0 0 # 5 GILLNET
 1 0 0 0 # 6 LONGLINE
 1 1 0 0 # 7 OTHIST
 1 1 0 0 # 8 NSTRAWL
 24 0 0 0 # 9 OTHERS
 24 0 0 0 # 10 EVHOE
 24 0 0 0 # 11 RESSGASCQ1
 24 0 0 0 # 12 RESSGASCQ2
 24 0 0 0 # 13 RESSGASCQ3
 24 0 0 0 # 14 RESSGASCQ4
 24 0 0 0 # 15 PORCUPINE
 24 0 0 0 # 16 IGFS
```

```
 24 0 0 0 # 17 IAMS
#
#_age_selex_patterns
#Pattern:_0; parm=0; selex=1.0 for ages 0 to maxage
#Pattern:_10; parm=0; selex=1.0 for ages 1 to maxage
#Pattern:_11; parm=2; selex=1.0  for specified min-max age
#Pattern:_12; parm=2; age logistic
#Pattern:_13; parm=8; age double logistic
#Pattern:_14; parm=nages+1; age empirical
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_16; parm=2; Coleraine - Gaussian
#Pattern:_17; parm=nages+1; empirical as random walk  N parameters to read can be overridden by setting special to non-zero
#Pattern:_41; parm=2+nages+1; // like 17, with 2 additional param for scaling (average over bin range)
#Pattern:_18; parm=8; double logistic - smooth transition
#Pattern:_19; parm=6; simple 4-parm double logistic with starting age
#Pattern:_20; parm=6; double_normal,using joiners
#Pattern:_26; parm=3; exponential-logistic in age
#Pattern:_27; parm=3+special; cubic spline in age; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=2+special+3; // cubic spline; with 2 additional param for scaling (average over bin range)
#Age patterns entered with value >100 create Min_selage from first digit and pattern from remainder
#_Pattern Discard Male Special
 0 0 0 0 # 1 SPTRAWL7
 0 0 0 1 # 2 TRAWLOTH
 0 0 0 1 # 3 FRNEP8
 0 0 0 1 # 4 SPTRAWL8
 0 0 0 1 # 5 GILLNET
 0 0 0 1 # 6 LONGLINE
 0 0 0 1 # 7 OTHIST
 0 0 0 1 # 8 NSTRAWL
 0 0 0 1 # 9 OTHERS
 0 0 0 1 # 10 EVHOE
 0 0 0 1 # 11 RESSGASCQ1
 0 0 0 1 # 12 RESSGASCQ2
```

```
 0 0 0 1 # 13 RESSGASCQ3
 0 0 0 1 # 14 RESSGASCQ4
 0 0 0 1 # 15 PORCUPINE
 0 0 0 1 # 16 IGFS
 0 0 0 1 # 17 IAMS
#
#_   LO   HI   INIT   PRIOR   PR_SD   PR_type   PHASE   env-var   use_dev   dev_mnyr   dev_mxyr   dev_PH   Block   Blk_Fxn  #  parm_name
# 1  SPTRAWL7 LenSelex
# In the lines hihglighted the last year must be equal to the last data year, it controls de random walk in the selectivities.
 5   60   43.1905   15   0.01   0   2   0   23   1998   2020   3   0   0  #  Size_DblN_peak_SPTRAWL7(1)
 -6   2   -1.7129   -2   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_top_logit_SPTRAWL7(1)
 -6   14   5.69899   4   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_ascend_se_SPTRAWL7(1)
 1   50   6.60887   10   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_descend_se_SPTRAWL7(1)
 -999   -999   -999   -999   0   0   -2   0   0   0   0   0   0  #  Size_DblN_start_logit_SPTRAWL7(1)
 -999   -999   -999   -999   0   0   -2   0   0   0   0   0   0  #  Size_DblN_end_logit_SPTRAWL7(1)
 0.001   60   21.5299   27   0.01   0   4   0   23   1998   2020   3   0   0  #  Retain_L_infl_SPTRAWL7(1)
 0.61   10.01   3.26221   0.81   0.01   0   4   0   0   0   0   0   0  #  Retain_L_width_SPTRAWL7(1)
 -10   999   999   -10   0.01   0   -3   0   0   0   0   0   0  #  Retain_L_asymptote_logit_SPTRAWL7(1)
 0   0   0   0   0.01   0   -3   0   0   0   0   0   0  #  Retain_L_maleoffset_SPTRAWL7(1)
# 2  TRAWLOTH LenSelex
 5   60   26.0866   35   0.01   0   2   0   23   1998   2020   3   0   0  #  Size_inflection_TRAWLOTH(2)
 1   30   5.09762   15   0.01   0   2   0   0   0   0   0   0  #  Size_95%width_TRAWLOTH(2)
 1   50   14.649   27   0.01   0   4   0   23   1998   2020   3   0   0  #  Retain_L_infl_TRAWLOTH(2)
 0.61   30.01   7.10239   0.81   0.01   0   4   0   0   0   0   0   0  #  Retain_L_width_TRAWLOTH(2)
 -10   999   999   -10   0.01   0   -3   0   0   0   0   0   0  #  Retain_L_asymptote_logit_TRAWLOTH(2)
 0   0   0   0   0.01   0   -3   0   0   0   0   0   0  #  Retain_L_maleoffset_TRAWLOTH(2)
# 3  FRNEP8 LenSelex
 5   30   15.6367   15   0.01   0   2   0   23   1998   2020   3   0   0  #  Size_DblN_peak_FRNEP8(3)
 -16   2   -14.2255   -2   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_top_logit_FRNEP8(3)
 -15   14   0.952542   4   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_ascend_se_FRNEP8(3)
 1   50   6.63876   10   0.01   0   2   0   0   0   0   0   0  #  Size_DblN_descend_se_FRNEP8(3)
 -999   -999   -999   -999   0   0   -2   0   0   0   0   0   0  #  Size_DblN_start_logit_FRNEP8(3)
 -999   -999   -999   -999   0   0   -2   0   0   0   0   0   0  #  Size_DblN_end_logit_FRNEP8(3)
```

```
      10      40  23.2954      27    0.01    0    4    0   23  1998  2020    3    0    0 # Retain_L_infl_FRNEP8(3)
    0.61   10.01  1.29307    0.81    0.01    0    4    0    0     0     0    0    0    0 # Retain_L_width_FRNEP8(3)
     -10     999      999     -10    0.01    0   -3    0    0     0     0    0    0    0 # Retain_L_asymptote_logit_FRNEP8(3)
       0       0        0       0    0.01    0   -3    0    0     0     0    0    0    0 # Retain_L_maleoffset_FRNEP8(3)
# 4   SPTRAWL8 LenSelex
       5      30  19.6159      15    0.01    0    2    0   23  1998  2020    3    0    0 # Size_DblN_peak_SPTRAWL8(4)
     -10       2 -5.99816      -2    0.01    0    2    0    0     0     0    0    0    0 # Size_DblN_top_logit_SPTRAWL8(4)
     -20      14  4.91908       4    0.01    0    2    0    0     0     0    0    0    0 # Size_DblN_ascend_se_SPTRAWL8(4)
       1      50  6.68281      10    0.01    0    2    0    0     0     0    0    0    0 # Size_DblN_descend_se_SPTRAWL8(4)
    -999    -999     -999    -999       0    0   -2    0    0     0     0    0    0    0 # Size_DblN_start_logit_SPTRAWL8(4)
    -999    -999     -999    -999       0    0   -2    0    0     0     0    0    0    0 # Size_DblN_end_logit_SPTRAWL8(4)
       1      40  12.5067      27    0.01    0    4    0   23  1998  2020    3    0    0 # Retain_L_infl_SPTRAWL8(4)
  0.0001   10.01   1.0226    0.81    0.01    0    4    0    0     0     0    0    0    0 # Retain_L_width_SPTRAWL8(4)
     -10     999      999     -10    0.01    0   -3    0    0     0     0    0    0    0 # Retain_L_asymptote_logit_SPTRAWL8(4)
       0       0        0       0    0.01    0   -3    0    0     0     0    0    0    0 # Retain_L_maleoffset_SPTRAWL8(4)
# 5   GILLNET LenSelex
      25      95  88.3068      45    0.01    0    2    0    0     0     0    0    0    0 # Size_DblN_peak_GILLNET(5)
     -15       0      -15      -3    0.01    0   -2    0    0     0     0    0    0    0 # Size_DblN_top_logit_GILLNET(5)
     -10      10  6.78573     5.5    0.01    0    2    0    0     0     0    0    0    0 # Size_DblN_ascend_se_GILLNET(5)
       0      20       20       7    0.01    0   -2    0    0     0     0    0    0    0 # Size_DblN_descend_se_GILLNET(5)
    -999    -999     -999    -999       0    0   -2    0    0     0     0    0    0    0 # Size_DblN_start_logit_GILLNET(5)
    -999    -999     -999    -999       0    0   -2    0    0     0     0    0    0    0 # Size_DblN_end_logit_GILLNET(5)
      10      40  28.1014      27    0.01    0    4    0    0     0     0    0    0    0 # Retain_L_infl_GILLNET(5)
    0.61   10.01  4.51957    0.81    0.01    0    4    0    0     0     0    0    0    0 # Retain_L_width_GILLNET(5)
     -10      10  3.31966 3.89182    0.01    0    3    0    0     0     0    0    0    0 # Retain_L_asymptote_logit_GILLNET(5)
       0       0        0       0    0.01    0   -3    0    0     0     0    0    0    0 # Retain_L_maleoffset_GILLNET(5)
# 6   LONGLINE LenSelex
       5      60  52.7027      35    0.01    0    2    0    0     0     0    0    0    0 # Size_inflection_LONGLINE(6)
       1      30  11.0154      15    0.01    0    2    0    0     0     0    0    0    0 # Size_95%width_LONGLINE(6)
# 7   OTHIST LenSelex
       5      80  42.7769      35    0.01    0    2    0   23  2003  2012    3    0    0 # Size_inflection_OTHIST(7)
       1      30  21.5181      15    0.01    0    2    0    0     0     0    0    0    0 # Size_95%width_OTHIST(7)
      10      60  26.6056      27    0.01    0    4    0   23  2003  2012    3    0    0 # Retain_L_infl_OTHIST(7)
```

```
0.61   30.01   4.17745   0.81   0.01   0   4   0   0   0   0   0   0   0 # Retain_L_width_OTHIST(7)
-10   999   999   -10   0.01   0   -3   0   0   0   0   0   0   0 # Retain_L_asymptote_logit_OTHIST(7)
0   0   0   0   0.01   0   -3   0   0   0   0   0   0   0 # Retain_L_maleoffset_OTHIST(7)
# 8  NSTRAWL LenSelex
5   70   55.397   35   0.01   0   2   0   23   2013   2020   3   0   0 # Size_inflection_NSTRAWL(8)
1   30   29.4026   15   0.01   0   2   0   0   0   0   0   0   0 # Size_95%width_NSTRAWL(8)
10   60   55.6092   27   0.01   0   4   0   23   2013   2020   3   0   0 # Retain_L_infl_NSTRAWL(8)
0.61   10.01   5.53678   0.81   0.01   0   4   0   0   0   0   0   0   0 # Retain_L_width_NSTRAWL(8)
-10   999   999   -10   0.01   0   -3   0   0   0   0   0   0   0 # Retain_L_asymptote_logit_NSTRAWL(8)
0   0   0   0   0.01   0   -3   0   0   0   0   0   0   0 # Retain_L_maleoffset_NSTRAWL(8)
# 9  OTHERS LenSelex
25   120   96.3399   45   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_peak_OTHERS(9)
-15   0   -8.75477   -3   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_top_logit_OTHERS(9)
-10   10   6.96775   5.5   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_ascend_se_OTHERS(9)
-10   20   0.153214   7   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_descend_se_OTHERS(9)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_start_logit_OTHERS(9)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_end_logit_OTHERS(9)
# 10  EVHOE LenSelex
5   30   11.2083   15   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_peak_EVHOE(10)
-16   2   -12.9598   -2   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_top_logit_EVHOE(10)
0   10   1.80622   4   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_ascend_se_EVHOE(10)
1   50   6.17039   10   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_descend_se_EVHOE(10)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_start_logit_EVHOE(10)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_end_logit_EVHOE(10)
# 11  RESSGASCQ1 LenSelex
5   30   17.2805   15   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_peak_RESSGASCQ1(11)
-16   2   -12.0497   -2   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_top_logit_RESSGASCQ1(11)
0   10   2.63862   4   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_ascend_se_RESSGASCQ1(11)
1   40   5.64662   10   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_descend_se_RESSGASCQ1(11)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_start_logit_RESSGASCQ1(11)
-999   -999   -999   -999   0   0   -2   0   0   0   0   0   0   0 # Size_DblN_end_logit_RESSGASCQ1(11)
# 12  RESSGASCQ2 LenSelex
5   30   8.39748   15   0.01   0   2   0   0   0   0   0   0   0 # Size_DblN_peak_RESSGASCQ2(12)
```

-16	2	-2.33989	-2	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_top_logit_RESSGASCQ2(12)
0	10	0.353514	4	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_ascend_se_RESSGASCQ2(12)
1	40	5.33148	10	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_descend_se_RESSGASCQ2(12)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_start_logit_RESSGASCQ2(12)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_end_logit_RESSGASCQ2(12)
# 13 RESSGASCQ3 LenSelex														
5	30	16.8253	15	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_peak_RESSGASCQ3(13)
-16	2	-12.0865	-2	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_top_logit_RESSGASCQ3(13)
0	10	3.42839	4	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_ascend_se_RESSGASCQ3(13)
1	40	6.26865	10	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_descend_se_RESSGASCQ3(13)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_start_logit_RESSGASCQ3(13)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_end_logit_RESSGASCQ3(13)
# 14 RESSGASCQ4 LenSelex														
5	30	17.5283	15	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_peak_RESSGASCQ4(14)
-16	2	-11.9695	-2	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_top_logit_RESSGASCQ4(14)
0	10	3.15434	4	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_ascend_se_RESSGASCQ4(14)
1	40	6.49983	10	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_descend_se_RESSGASCQ4(14)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_start_logit_RESSGASCQ4(14)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_end_logit_RESSGASCQ4(14)
# 15 PORCUPINE LenSelex														
4	80	66.7212	15	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_peak_PORCUPINE(15)
-16	2	-11.5368	-2	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_top_logit_PORCUPINE(15)
0	10	6.67701	4	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_ascend_se_PORCUPINE(15)
0	40	4.6908	10	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_descend_se_PORCUPINE(15)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_start_logit_PORCUPINE(15)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_end_logit_PORCUPINE(15)
# 16 IGFS LenSelex														
4	30	12.5129	15	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_peak_IGFS(16)
-16	2	-11.3737	-2	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_top_logit_IGFS(16)
0	10	2.4533	4	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_ascend_se_IGFS(16)
1	40	6.71597	10	0.01	0	2	0	0	0	0	0	0	0	# Size_DblN_descend_se_IGFS(16)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_start_logit_IGFS(16)
-999	-999	-999	-999	0	0	-2	0	0	0	0	0	0	0	# Size_DblN_end_logit_IGFS(16)

```
# 17  IAMS LenSelex
   4     70    52.909     15    0.01    0    2    0    0    0    0    0    0    0  # Size_DblN_peak_IAMS(17)
 -16      2  -7.00004     -2    0.01    0    2    0    0    0    0    0    0    0  # Size_DblN_top_logit_IAMS(17)
   0     10   6.08455      4    0.01    0    2    0    0    0    0    0    0    0  # Size_DblN_ascend_se_IAMS(17)
   5     40   22.4291     10    0.01    0    2    0    0    0    0    0    0    0  # Size_DblN_descend_se_IAMS(17)
-999   -999      -999   -999       0    0   -2    0    0    0    0    0    0    0  # Size_DblN_start_logit_IAMS(17)
-999   -999      -999   -999       0    0   -2    0    0    0    0    0    0    0  # Size_DblN_end_logit_IAMS(17)
# 1  SPTRAWL7 AgeSelex
# 2  TRAWLOTH AgeSelex
# 3  FRNEP8 AgeSelex
# 4  SPTRAWL8 AgeSelex
# 5  GILLNET AgeSelex
# 6  LONGLINE AgeSelex
# 7  OTHIST AgeSelex
# 8  NSTRAWL AgeSelex
# 9  OTHERS AgeSelex
# 10  EVHOE AgeSelex
# 11  RESSGASCQ1 AgeSelex
# 12  RESSGASCQ2 AgeSelex
# 13  RESSGASCQ3 AgeSelex
# 14  RESSGASCQ4 AgeSelex
# 15  PORCUPINE AgeSelex
# 16  IGFS AgeSelex
# 17  IAMS AgeSelex
#_No_Dirichlet parameters
# timevary selex parameters
#_     LO     HI   INIT  PRIOR  PR_SD  PR_type  PHASE  #  parm_name
   0.0001      2    1.5      5    0.5        6     -5  # Size_DblN_peak_SPTRAWL7(1)_dev_se
    -0.99   0.99      0      0    0.5        6     -6  # Size_DblN_peak_SPTRAWL7(1)_dev_autocorr
   0.0001      2    1.5      1    0.5        6     -5  # Retain_L_infl_SPTRAWL7(1)_dev_se
    -0.99   0.99      0      0    0.5        6     -6  # Retain_L_infl_SPTRAWL7(1)_dev_autocorr
   0.0001      2    1.5      5    0.5        6     -5  # Size_inflection_TRAWLOTH(2)_dev_se
    -0.99   0.99      0      0    0.5        6     -6  # Size_inflection_TRAWLOTH(2)_dev_autocorr
```

```
 0.0001    2     1.5   5   0.5   6    -5  # Retain_L_infl_TRAWLOTH(2)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Retain_L_infl_TRAWLOTH(2)_dev_autocorr
 0.0001    2     1.5   5   0.5   6    -5  # Size_DblN_peak_FRNEP8(3)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Size_DblN_peak_FRNEP8(3)_dev_autocorr
 0.0001    2     1.5   1   0.5   6    -5  # Retain_L_infl_FRNEP8(3)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Retain_L_infl_FRNEP8(3)_dev_autocorr
 0.0001    2     1.5   5   0.5   6    -5  # Size_DblN_peak_SPTRAWL8(4)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Size_DblN_peak_SPTRAWL8(4)_dev_autocorr
 0.0001    2     1.5   5   0.5   6    -5  # Retain_L_infl_SPTRAWL8(4)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Retain_L_infl_SPTRAWL8(4)_dev_autocorr
 0.0001    2     1.5   5   0.5   6    -5  # Size_inflection_OTHIST(7)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Size_inflection_OTHIST(7)_dev_autocorr
 0.0001    2     1.5   1   0.5   6    -5  # Retain_L_infl_OTHIST(7)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Retain_L_infl_OTHIST(7)_dev_autocorr
 0.0001    2     1.5   1   0.5   6    -5  # Size_inflection_NSTRAWL(8)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Size_inflection_NSTRAWL(8)_dev_autocorr
 0.0001    2     1.5   1   0.5   6    -5  # Retain_L_infl_NSTRAWL(8)_dev_se
 -0.99   0.99    0     0   0.5   6    -6  # Retain_L_infl_NSTRAWL(8)_dev_autocorr
# info on dev vectors created for selex parms are reported with other devs after tag parameter section
#
0  #  use 2D_AR1 selectivity(0/1)
#_no 2D_AR1 selex offset used
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read and autogen if tag data exist; 1=read
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
# deviation vectors for timevary parameters
#  base   base first block   block  env  env   dev   dev   dev   dev   dev
#  type  index  parm trend pattern link  var  vectr link _mnyr  mxyr phase  dev_vector
# (...)
# Input variance adjustments factors:
 #_1=add_to_survey_CV
```

```
 #_2=add_to_discard_stddev
 #_3=add_to_bodywt_CV
 #_4=mult_by_lencomp_N
 #_5=mult_by_agecomp_N
 #_6=mult_by_size-at-age_N
 #_7=mult_by_generalized_sizecomp
#_Factor  Fleet  Value
 -9999   1    0  # terminator
#
1 #_maxlambdaphase
1 #_sd_offset; must be 1 if any growthCV, sigmaR, or survey extraSD is an estimated parameter
# read 17 changes to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch; 9=init_equ_catch;
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin; 17=F_ballpark; 18=initEQregime
#like_comp fleet  phase  value  sizefreq_method
 4 1 1 0.1 1
 4 2 1 0.1 1
 4 3 1 0.1 1
 4 4 1 0.1 1
 4 5 1 0.1 1
 4 6 1 0.1 1
 4 7 1 0.1 1
 4 8 1 0.1 1
 4 9 1 0.1 1
 4 10 1 0.1 1
 4 11 1 0.1 1
 4 12 1 0.1 1
 4 13 1 0.1 1
 4 14 1 0.1 1
 4 15 1 0.1 1
 4 16 1 0.1 1
 4 17 1 0.1 1
-9999  1  1  1  1  #  terminator
```