

6 Herring in the Celtic Sea (divisions 7.a South of 52°30'N and 7.g, 7.h and 7.j)

The assessment year for this stock runs from 1st April until 31st March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2021 refers to the 2021–2022 season.

The WG notes that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout the report. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks such as this one, there is a difference of one year between “age” and “rings”. Further elaboration on the rationale behind this, specific to each stock, can be found in the individual Stock Annexes. It is the responsibility of any user of age-based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

6.1 The Fishery

6.1.1 Advice and management applicable to 2021–2022

The TAC is set by calendar year. In 2019, the EC requested ICES to advise on the minimum level of catches (tonnages) required in a sentinel TAC, which would provide sufficient data for ICES in order to continue providing scientific advice on the state of the stock (ICES, 2019). ICES advised that at least 17 samples from the main and the sentinel fleet would be required to provide advice on similar bases as with a commercial fishery. Those samples could be obtained through a monitoring catch of 869 t. As a result, the monitoring TAC agreed by the Council of the European Union for 2021 and 2022 was 869 t.

6.1.2 The fishery in 2021–2022

In 2021, the Irish fishery took place in 7.g in Q3 and in 7.g and 7.a.S in Q4 as in previous years. There was also catch taken from 7.j in Q1 2022.

The Irish fishery is divided into two fleets, the main fleet and the sentinel fleet. The Celtic Sea Herring Management Advisory Committee (CSHMAC) provide input to the management of the Celtic Sea Herring. Fishing began in 7.g in September and continued until early November, with over 500 t landed in total. The fishery in 7.a.S started in late November and continued until mid-December. In Q1 2022 all of the catch was taken in 7.j.

The Netherlands, Germany, France and the UK did not utilize their quota. The area 7.h is part of the management area, but it is unclear if it is part of the stock area.

The spatial distribution of the 2021 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2021.

The estimated catches from 1988–2021 for the combined areas (7.a.S, 7.g, 7.h, 7.j) by quota year and by assessment year (1 April–31 March) are given in tables 6.1.2.1 and 6.1.2.2 respectively. The catch taken during the 2021–2022 season increased from 132 t in 2020 to 745 t in 2021 (Figure 6.1.2.2).

The catch data include discards in the directed fishery until 1997. An independent observer study of the Celtic Sea herring fishery was conducted annually from 2012 to 2017. This observer programme was discontinued in 2018. Discards from these trips were raised to the total international catch using a weighted average for each year from 2012 to 2017.

Regulations and their effects

Under the previous rebuilding plan, the closure of Subdivision 7.a.S from 2007-present, except for a sentinel fishery, meant that only small dry hold vessels, no more than 50 feet total length, could fish in that area. In 2012, local quota management arrangements were adopted to restrict fishing in 7.a.S to vessels under 50 feet, but the total quota allocation increased from 8% to 11%. Therefore, from 2012 there was a slight increase in landings from this area. There is evidence that closure of Subdivision 7.a.S under the rebuilding plan helped to reduce fishing mortality (Clarke and Egan, 2017). The exact mechanisms for this are unclear.

6.1.3 Changes in fishing patterns

In 2019, the high prevalence of fish <MCRS (<20 cm) limited the main fleet to 5 days and prevented it from catching the quota. There were no issues with < MCRS fish in 2021 and 745 t of the 869 t available was taken.

Vessels greater than 50 feet total length are excluded from 7.a.S under local Irish legislation. This has shifted effort onto The Smalls/Celtic Deep ground, south of the 52°N line, in an area which straddles the boundary between the Irish and UK exclusive economic zones (EEZs).

6.1.4 Discarding

As in all pelagic fisheries, estimation of discarding is very difficult. Individual instances of discarding may be quite infrequent in occurrence. However individual slippages could result in considerable quantities of herring being discarded. The estimates produced by the HAWG in 2012 provided a sensitivity analysis of the assessment to maximum possible discarding. The risk of discarding (slippage induced by restrictive vessel quotas) is now reduced, due to the flexibility mechanism introduced in quota allocation since 2012. Available evidence is that the discard rate is negligible in directed fisheries. In 2021 two observer trips were carried out during the Celtic Sea herring fishery by the Marine Institute with no discarding observed.

Estimates of discarding from observer trips for the purposes of marine mammal bycatch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014), 1.4% in 2015 in the main fishery and 1.5% in the 7.a.S small boat fishery (Pinfield and Berrow, 2015), 1.13% in 2016 (O'Dwyer *et al.*, 2016) and 1.19% in 2017 (O'Dwyer and Berrow, 2017). This observer programme was discontinued in 2018; no discard estimates are available for subsequent years.

Since 2015, this stock is covered by the landings obligation.

6.2 Biological composition of the catch

6.2.1 Catches in numbers-at-age

Catch numbers-at-age are available for the period 1958-2021. Two winter ringers were the dominant age class in 2020 (61%), and this year class is again dominant in 2021 at 3 ring (61%) (Table 6.2.1.1.). In 2021 the proportion of 2 ringers is 25% followed by 4 ringers at 9%. The yearly

mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Older ages 6, 7, 8 and 9 were barely observed in the catch. Truncation of ages is again evident in this stock.

The overall proportions-at-age in the catch and the survey are presented in Figure 6.2.1.2. There is generally good agreement between the data sources. The Q4 acoustic survey picks up 1-wr fish in larger proportions than the catch data in some years. The 2018-year class is being tracked by the catch and the survey. A high proportion of 1 ringers were found in the catch and the survey in 2019 and these have been caught as 2 ringers in 2020 and 3 ringers in 2021.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. In 2019 a significant amount of fish less than the MCRS (<20 cm) in the Q3 catches of 7.g led to the early closure of this fishery. Catches in 7.aS Q4 in 2021 did not exhibit a high proportion of below MCRS herring. The length frequencies sampled is very similar between all ICES divisions and quarters.

6.2.2 Quality of catch and biological data

Biological sampling of the catches was carried out in the area exploited by the Irish fishery (Table 6.2.2.1) in 2021. The 23 samples obtained from the monitoring TAC for the main and sentinel fleets in 2021 exceeded the 17 sample minimum advised by ICES in order to provide advice on a similar basis to a commercial fishery.

6.3 Fishery-Independent Information

6.3.1 Acoustic Surveys

The Celtic Sea herring acoustic survey (CSHAS) time-series currently used in the assessment runs from 2002 to 2021, excluding 2004 (no survey) and 2017 (insufficient biological data). The full survey time-series is presented in Table 6.3.1.1. The internal consistency between ages 1–9 from the acoustic survey is good and presented in Figure 6.3.1.4.

The acoustic survey of the 2021–2022 season was carried out from 8 to 28 October 2021, on the Celtic Explorer (O'Donnell *et al.*, 2021, <https://oar.marine.ie/handle/10793/1732>). Geographical coverage was comparable to 2020 (+2%). The herring stock was considered contained within the Celtic Sea survey area with no aggregations observed along the survey periphery, inshore or offshore. The acoustic survey track is shown in Figure 6.3.1.1.

The 2021 survey again consisted of laddered replicate surveys (two broad-scale passes and adaptive mini-surveys) covering the same area. Pass 1, the pass with the largest geographical coverage, provided the biomass and numbers-at-age that were used as input data to tune the assessment model. NASC distribution plots from the broad-scale survey are presented in Figure 6.3.1.2. The herring stock was considered contained within the Celtic Sea survey area with no aggregations observed along the survey periphery, inshore or offshore. Immature herring were observed primarily in coastal waters and were well represented in the survey estimate. Mature herring were observed in two main areas; offshore in a discreet patch and inshore within the confines of Waterford Harbour. In previous years herring were only found inshore.

Herring TSB (total-stock biomass) and abundance (TSN) estimates from the 2021 survey were 9,877 t and 310 million individuals respectively. This is an increase on the low 2020 values of 4,717 t and a total abundance of 67.3 million individuals.

A total of 27 trawl hauls were carried out during the survey in 2021, with twelve containing herring. Herring were observed either within 10 nmi of the coast and made up of immature

individuals or as offshore aggregations clustered around one particular area and composed of mature fish. Ten hauls contained immature herring from 1-14% of the catch by weight.

The survey estimate is dominated by 3-wr fish representing over 43% of the total biomass. This 2018 year-class is now considered recruited to the spawning stock and has been successfully tracked across surveys. A significant proportion of 0 wr fish were found in the 2021 survey representing 33% of the total stock biomass and 82% of total stock numbers. The potential of this year class will be monitored through successive summer and autumn surveys.

6.4 Mean weights-at-age and maturity-at-age and Natural Mortality

The mean weights in the catch and mean weights in the stock at spawning time are presented in Figure 6.4.1.1 and Figure 6.4.1.2 respectively. There has been an overall downward trend in mean weights-at-age in the catch since the early 1980s. After a slight increase around 2008, they have declined again. In 2018 slight increases in mean weights at some ages were observed but subsequent years exhibited further decreases for almost all year classes. In 2021 increases in mean weight can be seen for all age classes. Mean weights in the stock at spawning time were calculated from biological samples from Q4 (Figure 6.4.1.2). The overall trends in stock weights are the same as the catch weights with increases also seen across all ages in 2021.

In the assessment, 50% of 1-wr fish are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-wr fish are mature (Lynch, 2011). However, the 2014 benchmark (ICES, 2014) concluded that there was insufficient information to change the maturity ogive.

Following the final procedure of HAWG 2015, natural mortality values used in the final assessment incorporated the SMS run as obtained in 2011.

The time-invariant natural mortalities and maturities-at-age are presented in the text table below.

	1	2	3	4	5	6	7	8	9+
Maturity	0.5	1	1	1	1	1	1	1	1
Natural mortality	0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

6.5 Recruitment

At present there are no independent recruitment estimates for this stock.

6.6 Assessment

This stock was benchmarked in 2015 by WKWEST (ICES, 2015) and inter-benchmarked by WKPELA 2018.

6.6.1 Stock Assessment

This update assessment was carried out using ASAP. The assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS) ages 2–7 winter rings and excluding the 2004 and 2017

surveys. The input data are presented in tables 6.6.1.1 and 6.6.1.2. The ASAP settings are as per the 2018 inter-benchmark (Table 6.6.1.3). The stock summary is presented in Table 6.6.1.4.

Figure 6.6.1.1 shows the catch proportions-at-age residuals. The residuals are large for the young ages, which is to be expected because these are estimated with low precision. Larger residuals can be seen in recent years. Overall there is no consistent pattern in the residuals. Figure 6.6.1.2 shows the observed and predicted catches. The model closely followed the observed catches. The observed and predicted catch proportions-at-age are shown in Figure 6.6.1.3. There is some divergence in the most recent years, most notable at 9-wr, with a larger proportion predicted than observed catches. Overall the fits are good throughout the full time-series.

The selection pattern in the fishery for the final assessment run is shown in Figure 6.6.1.4. Selection is fixed at 1 for 3-wr which is the age that Celtic Sea herring are considered to be fully selected. Selection at all other ages is estimated by the model. This gives a dome-shaped selection pattern which is considered appropriate to this fishery. The model predicts a drop in selection at-age 9-wr. This may be the case given the low abundance of 9-wr in the catch data.

Figure 6.6.1.5 shows the residuals of the index proportions-at-age. In previous years the largest residuals can be seen at the younger ages. The index fit shows generally good agreement with the exception of the very large survey index in 2012 (Figure 6.6.1.6). The selectivity parameters were adjusted at the inter-benchmark. Selection is now fixed for ages 3–5. This gives a more dome-shaped selection pattern with selection declining at older ages (6 and 7 wr) (Figure 6.6.1.7).

The analytical retrospective for SSB, fishing pressure and recruitment is shown in Figure 6.6.1.8. The Mohn's Rho on SSB calculated by ASAP is 1.34 over a five-year peel. This is another significant increase compared to the previous update assessments (1.39 in 2021) and it is significantly higher than the 0.2 threshold. Regarding SSB (top panel of Figure 6.6.1.8), 2 of the last 5 peels were out of the 95% CI bounds. This is most likely due to the current low level of the stock, the low level of the survey index (associated with high CV) and the absence of index for the year 2017. Following the decision tree provided by WKFORBIAS, advice was given for this stock because SSB is less than B_{lim} .

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates. Overall, the uncertainty is higher at the start and at the end of the time-series. Recruitment exhibits the highest uncertainty from 2013 to 2021. This may be related to the lack of a fisheries-independent estimate of recruitment.

State of the stock

The stock summary plots from the final assessment in 2021 and the update assessment in 2022 are presented in Figure 6.6.1.10 and the stock summary in Table 6.6.1.4. The assessment shows SSB is very low and is estimated to be 15 084 t in 2021, still well below B_{lim} (34 000 t). The 2022 assessment shows a similar SSB trajectory to the 2021 assessment but with SSB in 2020 revised downwards. An increase can be seen in 2021. The assessment indicates that the stock has been below B_{lim} since 2016.

The update assessment estimated mean F (2–5 ring) in 2021 to be 0.069, decreasing from the high of 1.2 for 2018 and increasing in from 0.02 in 2020. F was estimated to be above F_{pa} (0.27) and F_{MSY} (0.26) from 2014 until 2019 and above F_{lim} (0.45) from 2015 until 2019. The sharp increase in F in 2016 and 2017 that was seen in the 2021 assessment is again evident in the 2022 assessment.

Recruitment was good for several years with strong cohorts in 2005, 2007, 2009, 2010, 2011, and 2012 having entered the stock. However, since 2013, recruitment has been below average and no strong cohort has entered the fishery. The uptick in recruitment for 2020 predicted by the model in the 2021 assessment was revised downwards in 2022. An increase in recruitment can be seen in 2021.

6.7 Short-term projections

6.7.1 Deterministic Short-Term Projections

The short-term forecast followed the procedure agreed at the 2014 benchmark (ICES 2014/ACOM 43).

Recruitment (final year, interim year and advice year) in the short-term forecast is to be set to the same value based on the segmented stock–recruit relationship, based on the SSB in the forecast year-2 (2020). As this SSB value (8 741 t) is below the change-point (16 887 t), the following adjustment is applied.

$$Recruitment_{forecast\ year} = plateau\ recruitment \times \frac{SSB_{forecast\ year-2}}{SSB_{changepoint}}$$

$$Recruitment_{2022} = 380686.6 \times \frac{8740.64}{16886.81} = 197044$$

Interim year catch was taken to be the monitoring TAC (869 t), which has been agreed for 2022. No carryover on the national quotas was used as it is a monitoring TAC. Non-Irish intermediate year catches were not adjusted based on recent quota uptake as done in recent years.

The deterministic short-term forecast was performed in FLR. The input data are presented in Table 6.7.1.1.

The results of the short-term projection are presented in Table 6.7.1.2. Fishing in accordance with the MSY approach implies a zero catch in 2023.

6.7.2 Multiannual short-term forecasts

No multiannual simulations were conducted in 2021.

6.7.3 Yield-per-recruit

No yield-per-recruit analyses were conducted in 2021.

6.8 Long-term simulations

Long-term simulations were carried out as part of the ICES evaluation of the long-term management plan for Celtic Sea herring. ICES advised that the harvest control rule was no longer consistent with the precautionary approach. The management plan resulted in >5% probability of the stock falling below B_{lim} in several years throughout the 20 year simulated period. The simulations indicated the management plan could not ensure that the stock is fished and maintained at levels that can produce maximum sustainable yield as soon as or by 2020. The long-term management plan is no longer used to give advice for this stock.

In the framework of the development of a monitoring TAC for the CSH, long-term simulations were carried out to study the recovery of the stock under 2 scenarios, no catch and monitoring TAC (869 t). A shortcut approach implemented in SimpSim was used (ICES, 2016). The operating model was the update assessment agreed by the HAWG in 2019 (ICES, 2019). The simulations showed that in the no catch scenario, the stock would recover in 2023 (risk to B_{lim} < 5%). The recovery would be delayed by one year if the monitoring TAC would be taken. (ICES, 2019, special request monitoring TAC).

6.9 Precautionary and yield-based reference points

Reference points were re-estimated by WKPELA 2018.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY B_{trigger}	54 000 t	B_{pa}	ICES (2018a)
	F_{MSY}	0.26	Stochastic simulations using segmented regression stock–recruitment relationship from 1970–2014	ICES (2018a)
Precautionary approach	B_{lim}	34 000 t	B_{loss} = the lowest observed SSB (1980)	ICES (2018a)
	B_{pa}	54 000 t	$B_{\text{pa}} = B_{\text{lim}} \times \exp(1.645 \times \sigma B)$, with $\sigma B = 0.29$.	ICES (2018a)
	F_{lim}	0.45	Equilibrium F maintaining SSB > B_{lim} with 50% probability	ICES (2018a)
	F_{pa}	0.26*	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{\text{p},0.5}$ with advice rule)	ICES (2018a)

*F_{pa} changed in 2021; F_{pa} now equal to F_{p0.5} (ICES 2021)

6.10 Quality of the Assessment

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates for the three key parameters (SSB, recruitment and F). The CVs for each of the parameters are between 0.1 and 0.3 for the majority of the time-series; uncertainties have increased in the final years. Recruitment estimates in the final year show the highest uncertainty.

The SSB and F values based on the assessment and forecast in 2021 are compared with the assessment outputs in 2022 and are shown in the table below. The assessment in 2022 shows SSB revised upward in 2019 but downwards in 2020 and 2021. F is revised down in 2019 and upwards in 2020 and 2021. This can also be seen in the historical retrospective plot in Figure 6.10.1.

2021 Assessment				2022 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2019	5790	1841	0.77	2019	6168	1841	0.73	7%	-5%
2020	11680	132	0.02	2020	8741	132	0.02	-25%	4%
2021	19278*	869*	0.06*	2021	15084	745	0.07	-22%	11%

* from intermediate year in STF.

The 2021 acoustic survey estimate is an increase on the 2020 estimate but is still at a very low level with an SSB estimate of 6,634 t. The survey time-series used in the assessment includes data from 2002 to 2021 (no survey in 2004 and the 2017 survey excluded). The 2018 year class was the strongest encountered in the survey and the catch in 2021. Beginning in 2014 herring had been observed close to the bottom in the acoustic dead-zone of the echosounder meaning the survey estimate was less reliably. This issue was not as pronounced in 2020 and 2021 although the number of herring marks seen was again very low.

Estimates of recruitment are uncertain and this may be related to the lack of a fisheries-independent recruitment estimator. In the Irish Sea, mixing occurs between juvenile winter spawned Celtic Sea fish and autumn spawned Irish Sea fish but the level of mixing is unquantified.

6.11 Management Considerations

The stock has declined substantially from a high in 2012, as older cohorts have moved through the fishery. Recruitment has been below average since 2013. The stock is again forecast to be below B_{lim} in 2023. F is now below F_{MSY} (0.26) and F_{lim} (0.45). The advice provided for this stock for 2023 is based on the ICES MSY approach, as in recent years. The Council of the European Union set the 2020–2022 TACs based on the response to a special request where ICES advised that monitoring catches of 869 t would be required to collect sufficient information to provide advice on similar bases as with a commercial fishery.

The change in fish behaviour that was observed by the acoustic survey since 2014, whereby fish were located close to the bottom and therefore difficult to detect acoustically, seems to have dissipated.

The closure of the Subdivision 7.aS as a measure to protect first-time spawners has been in place since 2007–2008, with limited fishing allowed. Currently only vessels of no more than 50 feet in registered length are permitted to fish in this area. A maximum catch limitation of 11% of the Irish quota is allocated to this fishery.

6.12 Ecosystem considerations

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish.

The spawning grounds for herring in the Celtic Sea are well known and are located close to the coast (O'Sullivan *et al.*, 2013). These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging, sand and gravel extraction, dumping of dredge spoil, waste from fish cages, and the erection of structures such as wind turbines. There has been an increase in marine anthropogenic activity. Activities that have a negative impact on the spawning habitat of herring are a cause for concern (see for example Groot, 1979, 1996; ICES, 2003, 2015a).

Herring fisheries are considered to be clean with little bycatch of other fish. Mega-fauna bycatch is unquantified, though anecdotal reports suggest that seals, blue sharks, tunas, and whitefish are caught from time to time. In the 2017 observer study of the Celtic Sea herring fishery, whiting was the most frequently recorded bycatch species followed by haddock and mackerel. No marine mammals or seabirds were recorded as bycatch in the fishery, with only one elasmobranch (an unidentified dogfish species) recorded. A total of 26 marine mammal sightings were recorded during observer trips (O'Dwyer and Berrow, 2017).

6.13 Changes in the environment

Weights in the catch and in the stock at spawning time have shown fluctuations over time (figures 6.4.4.1 and 6.4.1.2), but with a decline to lowest observations in the series at the end. The declines in mean weights are a cause for concern, because of their impact on yield and yield-per-recruit. Harma (unpublished) and Lyashevskaya *et al.* (2020) found that global environmental factors, reflecting recent temperature increases (AMO and ice extent) were linked to changes in the size characteristics during the 1970s–1980s. Outside this period, size-at-age patterns were correlated with more local factors (SST, salinity, trophic and fishery-related indicators). Generally, length-at-age was mostly correlated with global temperature-related indices (AMO and Ice),

and weight was linked to local temperature variables (SST). There was no evidence of density-dependent growth in the Celtic Sea herring population, which is in accordance with previous studies (Molloy, 1984; Brunel and Dickey-Collas, 2010; Lynch, 2011). Rather, stock size exhibited a positive relationship with long-term size-at-age of Celtic Sea herring (Harma, unpublished).

In the Celtic Sea, a change towards spawning taking place later in the season has been documented by Harma *et al.* (2013). The causes of this are likely to be environmental, though to date they have not been elucidated (Harma *et al.*, 2013). The study noted that declines in mean weights are not explained by the relative contribution of heavier-at-age autumn spawners. Rather, both autumn and winter spawners experienced concurrent declines in mean weights in recent years.

A shift towards later spawning has also been reported by local fishers in this area. WKWEST received a submission from the Celtic Sea Herring Management Advisory Committee of substantial spawning aggregations in Division 7.j in January 2015. This area is mainly an autumn spawning area (O'Sullivan *et al.*, 2012).

Analyses of productivity changes over time in European herring stocks was examined by ICES (HAWG, 2006). It was found that this stock was the only one not to experience a change in productivity or so-called regime shift. This is also seen in the surplus production per unit stock biomass using information from the 2013 assessment. Evidence from the new ASAP assessment, in terms of recruits per spawner, does not alter this perception (ICES, WKWEST 2015).

Table 6.1.2.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2021. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
1988	-	-	-	16 800	-	-	-	2400	19 200
1989	-	+	-	16 000	1900	-	1300	3500	22 700
1990	-	+	-	15 800	1000	200	700	2500	20 200
1991	-	+	100	19 400	1600	-	600	1900	23 600
1992	-	500	-	18 000	100	+	2300	2100	23 000
1993	-	-	-	19 000	1300	+	-1100	1900	21 100
1994	-	+	200	17 400	1300	+	-1500	1700	19 100
1995	-	200	200	18 000	100	+	-200	700	19 000
1996	-	1000	0	18 600	1000	-	-1800	3000	21 800
1997	-	1300	0	18 000	1400	-	-2600	700	18 800
1998	-	+	-	19 300	1200	-	-200	-	20 300
1999	-		200	17 900	1300	+	-1300	-	18 100
2000	-	573	228	18 038	44	1	-617	-	18 267
2001	-	1359	219	17 729	-	-	-1578	-	17 729
2002	-	734	-	10 550	257	-	-991	-	10 550
2003	-	800	-	10 875	692	14	-1506	-	10 875
2004	-	801	41	11 024	-	-	-801	-	11 065
2005	-	821	150	8452	799	-	-1770	-	8452
2006	-	-	-	8530	518	5	-523	-	8530
2007	-	581	248	8268	463	63	-1355	-	8268
2008	-	503	191	6853	291	-	-985	-	6853
2009	-	364	135	5760	-	-	-499	-	5760
2010	-	636	278	8406	325	-	-1239	na	8406
2011	-	241	-	11 503	7	-	-248	na	11 503
2012	-	3	230	16 132	3135	-	2104	161*	21 765
2013	-	-	450	14 785	832	-	-	118	16 185
2014	-	244	578	17 287	821	-		644	19 574
2015	-	-	477	15 798	1304	+	-	247	17 826
2016	-	-	419	15 107	1025	559	-451	182	16 841
2017	-	-	298	10 184	648	64		130	11 324
2018	-			4398	436		-245		4589

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
2019	-	-	-	1803	38	-	-	-	1841
2020	-	-	-	132	+	-	-	-	132
2021	1	-	-	608	-	-	-	-	609

* Added in 2014 after report of 1% discarding.

Table 6.1.2.2. Herring in the Celtic Sea. Landings (t) by assessment year (1 April–31 March) 1988/1989–2021/2022. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
1988/1989	-	-	-	17 000	-	-	-	3400	20 400
1989/1990	-	+	-	15 000	1900	-	2600	3600	23 100
1990/1991	-	+	-	15 000	1000	200	700	1700	18 600
1991/1992	-	500	100	21 400	1600	-	-100	2100	25 600
1992/1993	-	-	-	18 000	1300	-	-100	2000	21 200
1993/1994	-	-	-	16 600	1300	+	-1100	1800	18 600
1994/1995	-	+	200	17 400	1300	+	-1500	1900	19 300
1995/1996	-	200	200	20 000	100	+	-200	3000	23 300
1996/1997	-	1000	-	17 900	1000	-	-1800	750	18 850
1997/1998	-	1300	-	19 900	1400	-	-2100	-	20 500
1998/1999	-	+	-	17 700	1200	-	-700	-	18 200
1999/2000	-		200	18 300	1300	+	-1300	-	18 500
2000/2001	-	573	228	16 962	44	1	-617	-	17 191
2001/2002	-	-	-	15 236	-	-	-	-	15 236
2002/2003	-	734	-	7465	257	-	-991	-	7465
2003/2004	-	800	-	11 536	610	14	-1424	-	11 536
2004/2005	-	801	41	12 702	-	-	-801	-	12 743
2005/2006	-	821	150	9494	799	-	-1770	-	9494
2006/2007	-	-	-	6944	518	5	-523	-	6944
2007/2008	-	379	248	7636	327	-	-954	-	7636
2008/2009	-	503	191	5872	150	-	-844	-	5872
2009/2010	-	364	135	5745	-	-	-499	-	5745
2010/2011	-	636	278	8370	325	-	-1239	na	8370
2011/2012	-	241	-	11 470	7	-	-248	na	11 470
2012/2013	-	3	230	16 132	3135	-	2104	161*	21 765
2013/2014	-	-	450	14 785	832	-	-	118	16 185
2014/2015	-	244	578	17 287	821	-	-	644	19 574
2015/2016	-	-	477	16 320	1304	+	-	254	18 355

Year	Denmark	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
2016/2017	-	-	419	14 585	1025	559	-451	182	16 319
2017/2018	-	-	298	9627	648	64	-	130	10 767
2018/2019	-	-	-	4227	436	-	-245	-	4418
2019/2020	-	-	-	1803	38	-	-	-	1841
2020/2021	1	-	-	132	+	-	-	-	133
2021/2022	-	-	-	745	-	-	-	-	745

* Added in 2014 after report of 1% discarding.

Table 6.2.1.1. Herring in the Celtic Sea. Comparison of age distributions (percentages) in the catches of Celtic Sea and 7.j herring from 1970–2021/2022. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%

Year	1	2	3	4	5	6	7	8	9
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	12%	38%	30%	10%	4%	3%	2%	1%	1%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%
2010	4%	33%	13%	25%	8%	16%	1%	0%	1%
2011	7%	19%	38%	8%	15%	6%	6%	1%	0%
2012	6%	34%	24%	20%	3%	6%	3%	2%	0%
2013	5%	24%	33%	18%	13%	3%	4%	1%	0%
2014	11%	16%	25%	22%	15%	7%	2%	2%	1%
2015	0%	9%	18%	24%	21%	15%	7%	3%	2%
2016	2%	8%	20%	18%	20%	18%	8%	4%	1%
2017	1%	15%	34%	17%	12%	10%	7%	3%	2%
2018	4%	19%	51%	15%	6%	3%	1%	1%	0%

Year	1	2	3	4	5	6	7	8	9
2019	60%	18%	8%	10%	3%	1%	0%	0%	0%
2020	13%	61%	15%	4%	4%	1%	1%	0%	0%
2021	0%	25%	61%	9%	2%	2%	0%	0%	0%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2021/2022 season.

	7gQ3	7gQ4	7aSQ4	7jQ1 2022
18.5			0.31	
19			0	
19.5			0	
20			0.94	
20.5			0.63	
21		9.98	10.37	
21.5	11.35	19.96	19.49	
22	79.46	72.36	42.44	54.53
22.5	79.46	152.21	77.02	13.63
23	283.79	227.06	100.91	149.95
23.5	289.47	361.80	105.63	149.95
24	368.93	494.04	126.06	218.10
24.5	306.50	441.64	129.83	211.29
25	266.76	281.95	88.65	204.47
25.5	147.57	122.26	46.84	61.34
26	45.41	77.35	17.61	47.71
26.5	34.06	29.94	11.95	34.08
27	5.68	9.98	3.46	20.45
27.5	5.68	7.49	0.95	6.82
28	5.68		0.63	
28.5			0.31	

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2021–2022). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
7.g	2021	3	245	4	194	340	791
7.g	2021	4	273	4	200	925	733
7.aS	2021	4	90	14	600	2494	6654
7.j	2022	1	135	1	100	174	739
Total			744	23	1094	3933	1472

Table 6.3.1.1. Herring in the Celtic Sea. Revised acoustic index of abundance used in the assessment. Total stock numbers-at-age (10⁶) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes). 2–7 ring abundances are used in tuning. There was no survey in 2004. The survey in 2017 (shaded) was excluded as it was not recommended for tuning by HAWG in 2018.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	0	24	-	2	-	1	99	239	5	0	31	4
1	42	13	-	65	21	106	64	381	346	342	270	698
2	185	62	-	137	211	70	295	112	549	479	856	291
3	151	60	-	28	48	220	111	210	156	299	615	197
4	30	17	-	54	14	31	162	57	193	47	330	43
5	7	5	-	22	11	9	27	125	65	71	49	38
6	7	1	-	5	1	13	6	12	91	24	121	10
7	3	0	-	1	-	4	5	4	7	33	25	5
8	0	0	-	0	-	1		6	3	4	23	0
9	0	0	-	0	-	0		1		2	3	1
Nos.	423	183	-	312	305	454	769	1147	1414	1300	2322	1286
SSB	41	20	-	33	36	46	90	91	122	122	246	71
CV	.49	.34	-	.48	.35	.25	.20	.24	.20	.28	.25	.28

	2014	2015	2016	2017	2018	2019	2020	2021
	2015	2016	2017	2018	2019	2020	2021	2022
0	0	0	0	0	109	98	1	252.6
1	41	0	125	0	55	22	27.2	
2	117	40	21	6	16	8	32.2	17.2
3	112	48	43	3	27	0.5	5	35.3
4	69	41	40	7	6	0.3	1	3.3
5	20	38	36	5	0	0.1	0	1.2
6	24	7	25	4	0	0	0	0
7	7	6	5	1	-	0	0	0.6
8	17	5	6	1	-	0	0	0.1
9	1	0	0	0		0	0	0
Nos.	408	184	301	27	213	129	67	310

	2014	2015	2016	2017	2018	2019	2020	2021
	2015	2016	2017	2018	2019	2020	2021	2022
SSB	48	25	30	4	8	0.3	3.1	6.6
CV	0.59	0.18	0.33	-	0.49	0.55	0.51	0.44

Table 6.6.1.1. Herring in the Celtic Sea: Natural mortality inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Maturity inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.5	1	1	1	1	1	1	1	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the catch inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263

	1	2	3	4	5	6	7	8	9
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
2003	0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
2004	0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
2005	0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
2006	0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
2007	0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
2008	0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
2009	0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
2010	0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
2011	0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179
2012	0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
2013	0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
2014	0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176

	1	2	3	4	5	6	7	8	9
2015	0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182
2016	0.061	0.095	0.119	0.131	0.140	0.144	0.151	0.157	0.162
2017	0.06	0.080	0.090	0.123	0.143	0.160	0.163	0.171	0.178
2018	0.067	0.092	0.11	0.124	0.136	0.146	0.162	0.143	0.15
2019	0.06	0.085	0.109	0.123	0.131	0.155	0.153	0.156	0.163
2020	0.052	0.078	0.096	0.117	0.124	0.128	0.144	0.169	0.052
2021	0.066	0.103	0.12	0.131	0.145	0.158	0.18	0.164	0.177

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the stock inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298

	1	2	3	4	5	6	7	8	9
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223
2003	0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
2004	0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257
2005	0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
2006	0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188

	1	2	3	4	5	6	7	8	9
2007	0.068	0.101	0.122	0.138	0.156	0.159	0.163	0.167	0.251
2008	0.083	0.117	0.14	0.156	0.17	0.18	0.177	0.189	0.232
2009	0.076	0.117	0.142	0.158	0.168	0.176	0.17	0.186	0.226
2010	0.076	0.106	0.127	0.139	0.152	0.157	0.164	0.188	0.18
2011	0.067	0.108	0.127	0.138	0.148	0.16	0.17	0.194	0.197
2012	0.061	0.094	0.125	0.138	0.149	0.159	0.161	0.165	0.167
2013	0.06	0.101	0.126	0.144	0.153	0.159	0.168	0.17	0.186
2014	0.065	0.1	0.128	0.142	0.153	0.158	0.163	0.177	0.169
2015	0.065	0.098	0.119	0.133	0.14	0.146	0.153	0.16	0.162
2016	0.059	0.096	0.117	0.131	0.139	0.143	0.150	0.160	0.165
2017	0.055	0.079	0.088	0.116	0.139	0.158	0.164	0.170	0.177
2018	0.065	0.095	0.121	0.142	0.154	0.166	0.171	0.166	0.170
2019	0.055	0.087	0.106	0.122	0.127	0.141	0.15	0.161	0.16
2020	0.047	0.082	0.099	0.124	0.128	0.138	0.148	0.175	0.162
2021	0.055	0.094	0.118	0.131	0.141	0.153	0.174	0.173	0.163

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Fishery Selectivity block inputs (1–9) to the ASAP model. Age is in winter rings.

Age	Selectivity	Block	#1	Data
1	0.3	1	0	1
2	0.5	1	0	1
3	1	–1	0	1
4	1	1	0	1
5	1	1	0	1
6	1	1	0	1
7	1	1	0	1
8	1	1	0	1
9	1	1	0	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Catch numbers-at-age and total catch inputs to the ASAP model. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9	Total catch
1958	1642	3742	33094	25746	12551	23949	16093	9384	5584	22978
1959	1203	25717	2274	19262	11015	5830	17821	3745	7352	15086
1960	2840	72246	24658	3779	13698	4431	6096	4379	4151	18283
1961	2129	16058	32044	5631	2034	5067	2825	1524	4947	15372
1962	772	18567	19909	48061	8075	3584	8593	3805	5322	21552
1963	297	51935	13033	4179	20694	2686	1392	2488	2787	17349
1964	7529	15058	17250	6658	1719	8716	1304	577	2193	10599
1965	57	70248	9365	15757	3399	4539	12127	1377	7493	19126
1966	7093	19559	59893	9924	13211	5602	3586	8746	3842	27030
1967	7599	39991	20062	49113	9218	9444	3939	6510	6757	27658
1968	12197	54790	39604	11544	22599	4929	4170	1310	4936	30236
1969	9472	93279	55039	33145	12217	17837	4762	2174	3469	44389
1970	1319	37260	50087	26481	18763	7853	6351	2175	3367	31727
1971	12658	23313	37563	41904	18759	10443	4276	4942	2239	31396
1972	8422	137690	17855	15842	14531	4645	3012	2374	1020	38203
1973	23547	38133	55805	7012	9651	5323	3352	2332	1209	26936
1974	5507	42808	17184	22530	4225	3737	2978	903	827	19940
1975	12768	15429	17783	7333	9006	3520	1644	1136	1194	15588
1976	13317	11113	7286	7011	2872	4785	1980	1243	1769	9771
1977	8159	12516	8610	5280	1585	1898	1043	383	470	7833
1978	2800	13385	11948	5583	1580	1476	540	858	482	7559
1979	11335	13913	12399	8636	2889	1316	1283	551	635	10321
1980	7162	30093	11726	6585	2812	2204	1184	1262	565	13130
1981	39361	21285	21861	5505	4438	3436	795	313	866	17103
1982	15339	42725	8728	4817	1497	1891	1670	335	596	13000
1983	13540	102871	26993	3225	1862	327	372	932	308	24981
1984	19517	92892	41121	16043	2450	1085	376	231	180	26779
1985	17916	57054	36258	16032	2306	228	85	173	132	20426

Year	1	2	3	4	5	6	7	8	9	Total catch
1986	4159	56747	42881	32930	8790	1127	98	29	12	25024
1987	5976	67000	43075	23014	14323	2716	1175	296	464	26200
1988	2307	82027	30962	9398	5963	3047	869	297	86	20447
1989	8260	42413	68399	19601	8205	3837	2589	767	682	23254
1990	2702	41756	24634	35258	8116	3808	1671	695	462	18404
1991	1912	63854	38342	16916	28405	4869	2588	954	593	25562
1992	10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1993	1608	94061	9372	10221	4491	2790	5932	855	508	18618
1994	12130	35768	61737	3289	3025	4773	1713	1705	474	19300
1995	9450	79159	22591	36541	3686	3420	2651	1859	842	23305
1996	3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
1997	3849	37440	53040	31442	8318	6142	1148	827	603	20496
1998	5818	41510	27102	28274	13178	3746	2675	597	387	18041
1999	14274	34072	36086	14642	15515	8877	1865	2012	551	18485
2000	9953	77378	18952	12060	5230	6227	2320	662	578	17191
2001	15724	62153	35816	5953	4249	1774	1145	466	386	15269
2002	3495	26472	18532	5309	1416	1269	437	154	201	7465
2003	2711	37006	24444	14763	5719	3363	2335	388	542	11536
2004	4276	9470	46243	21863	8638	1412	473	191	75	12743
2005	15419	30710	5766	18666	7349	1923	435	77	60	9494
2006	1460	33894	10914	2469	6261	2331	561	57	48	6944
2007	8043	11028	36223	5509	1365	2040	410	56	4	7636
2008	1288	12468	8144	15565	2328	518	321	58	11	5872
2009	10171	4465	12859	4887	8458	971	279	247	80	5745
2010	2468	20929	8183	15917	4846	10080	919	273	321	8370
2011	6384	17151	33453	7301	13087	5347	5165	1089	141	11470
2012	11712	62528	44819	37500	6303	11811	5549	3540	347	21820
2013	6191	30471	42133	22649	16687	3305	5463	1778	535	16247
2014	16664	24120	39102	33320	22450	11165	3047	2774	1022	19574

Year	1	2	3	4	5	6	7	8	9	Total catch
2015	286	12247	23835	32140	27382	19861	9820	4207	3279	18355
2016	2023	9822	25030	22800	25310	22447	10484	4684	1464	16318
2017	707	14144	31912	16004	10718	8963	6722	2401	1473	10767
2018	1654	7646	20545	5974	2296	1011	264	380	188	4418
2019	14146	4371	1857	2265	612	212	88	73	33	1841
2020	213	979	242	57	70	24	12	3	1	132
2021	3	1550	3825	586	148	109	23	22	2	745

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Index selectivity inputs (2–7) to the ASAP model. Age is in winter rings.

Age (wr)	Index-1	Selectivity
2	0.8	4
3	1	-1
4	1	-1
5	1	-1
6	1	4
7	1	4

Table 6.6.1.2. Herring in the Celtic Sea. Survey data input to ASAP. Age is in winter rings.

year	value	CV	2	3	4	5	6	7	Sample Size
2002	381900	0.5	185200	150600	29700	6600	7100	2700	15
2003	146400	0.5	61700	60400	17200	5400	1400	300	15
2004	-1	-1	-1	-1	-1	-1	-1	-1	0
2005	246700	0.5	137100	28200	54200	21600	4900	700	18
2006	284999	0.5	211000	48000	14000	11000	1000	-1	17
2007	346120	0.5	69800	220000	30600	8970	13100	3650	21
2008	606000	0.5	295000	111000	162000	27000	6000	5000	21
2009	519370	0.5	112040	209850	57490	124630	11710	3650	23
2010	1060760	0.5	548940	155860	193030	65240	91040	6650	18
2011	953000	0.5	479000	299000	47000	71000	24000	33000	16
2012	1995300	0.5	856000	615000	330000	48500	121000	24800	13
2013	584900	0.5	291400	197400	43700	37900	9800	4700	9
2014	349000	0.5	117300	112100	69400	19800	23600	6800	5

year	value	CV	2	3	4	5	6	7	Sample Size
2015	179400	0.5	40100	48100	41200	37700	6800	5500	6
2016	169376	0.5	20629	42736	39835	36124	24590	5462	10
2017	-1	-1	-1	-1	-1	-1	-1	-1	0
2018	49130	0.5	16104	26831	5984	110	101	0	9
2019	8873	0.5	98229	7934	524	284	131	0	3
2020	38383	0.5	32190	4625	1348	220	0	0	4
2021	57592	0.5	17213	35326	3271	1198	0	584	12

Table 6.6.1.3. Herring in the Celtic Sea. ASAP final Run settings.

Discards Included	No
Use likelihood constant	No
Mean $F(F_{bar})$ age (wr)range	2–5
Number of selectivity blocks	1
Fleet selectivity	By Age: 1–9-wr: 0.3,0.5,1,1,1,1,1,1,1 Fixed at-age 3-wr
Index units	2 (numbers)
Index month	October (10)
Index selectivity linked to fleet	-1 (not linked)
Index Years	2002–2021 (no survey in 2004 and 2017 not included)
Index age (wr)range	2–7
Index Selectivity	0.8,1,1,1,1,1 Fixed from ages 3–5-wr
Index CV	0.5 all years
Sample size	No of herring samples collected per survey
Phase for F-Mult in 1st year	1
Phase for F-Mult deviations	2
Phase for recruitment deviations	3
Phase for N in 1st Year	1
Phase for catchability in 1st Year	1
Phase for catchability deviations	-5
Phase for Stock recruit relationship	1
Phase for steepness -	-5 (Do not fit stock–recruitment curve)
Recruitment CV by year	1
Lambdas by index	1
Lambda for total catch in weight by fleet	1
Catch total CV	0.2 for all years
Catch effective sample size	No of samples from Irish sampling programme. Down-weighted to 5 in 2015-2021
Lambda for F-Mult in 1st year	0 (freely estimated)
CV for F mult in the first year	0.5
Lambda for F-Mult deviations	0 (freely estimated)

CV for f mult deviations by fleet	0.5
Lambda for N in 1st year deviations	0 (freely estimated)
CV for N in the 1st year deviations	1
Lambda for recruitment deviations	1
Lambda for catchability in 1st year index	0
CV for catchability in 1st year by index	1
Lambda for catchability deviations	0
CV for catchability deviations	1
Lambda for deviation from initial steepness	0
CV for deviation from initial steepness	1
Lambda for deviation from unexplained stock size	0
CV for deviation from unexplained stock size	1

Table 6.6.1.4. Herring in the Celtic Sea. Update assessment stock summary table. Recruitment is at 1-winter ring.

Year	Catch	SSB	TSB	$F_{bar\ 2-5}$	Recruitment
1958	22978	206015	279910.7	0.130	408556
1959	15086	197957	324109.2	0.112	1577690
1960	18283	189253	255888.9	0.126	362961
1961	15372	159919	221516.5	0.119	393717
1962	21552	156601	253026.9	0.192	843980
1963	17349	145174	207444.2	0.153	402905
1964	10599	165103	288344.5	0.096	1381900
1965	19126	169927	239714.9	0.139	416515
1966	27030	165194	265757.7	0.199	735267
1967	27658	159041	260064.8	0.225	768497
1968	30236	162296	274660.7	0.243	899711
1969	44389	141929	229285.7	0.362	461941
1970	31727	107098	165717	0.331	248671
1971	31396	97961.8	192767.7	0.453	821309
1972	38203	85876.7	148540.5	0.559	279417
1973	26936	64565.1	118059.3	0.518	325406

Year	Catch	SSB	TSB	F _{bar} 2-5	Recruitment
1974	19940	50061.5	86055.94	0.495	160325
1975	15588	39631.1	73729.2	0.517	202064
1976	9771	36803.9	68499.4	0.388	226223
1977	7833	37415	64383.57	0.291	184803
1978	7559	36168	59015.88	0.268	145587
1979	10321	36021.9	70583.65	0.425	278555
1980	13130	33005.8	59941.31	0.544	166477
1981	17103	36516.9	86692.73	0.837	464972
1982	13000	57440	126449.6	0.458	724433
1983	24981	76388.2	158892.5	0.556	784556
1984	26779	78994.4	148574.7	0.472	666197
1985	20426	85081.3	153927	0.319	642488
1986	25024	93072.5	170578.9	0.366	654169
1987	26200	105472	211262.6	0.389	1200230
1988	20447	108978	170626	0.232	475514
1989	23254	95703.8	164342.7	0.285	575732
1990	18404	89224	147151.9	0.248	503380
1991	25562	71049.2	111654.8	0.381	207415
1992	21127	70955.4	152792.7	0.485	962480
1993	18618	73640.4	119453	0.326	359813
1994	19300	80405.3	151766.9	0.322	768796
1995	23305	81906.9	149916.5	0.388	722078
1996	18816	72427.7	116557.3	0.309	352309
1997	20496	59883.5	104813.8	0.408	372858
1998	18041	47983.6	83141.82	0.446	248780
1999	18485	41993.8	87829.46	0.624	486666
2000	17191	42058.1	87380.49	0.633	477218
2001	15269	41689.8	83394.23	0.534	493295
2002	7465	53818.3	99795.25	0.210	541125

Year	Catch	SSB	TSB	F _{bar} 2-5	Recruitment
2003	11536	42832.6	65097.02	0.307	141584
2004	12743	39041.1	70912.93	0.394	361343
2005	9494	54401.2	116887	0.309	1057130
2006	6944	67023.5	102609.6	0.133	355901
2007	7636	69764.4	116908.3	0.132	723893
2008	5872	82686.6	116763.7	0.079	294385
2009	5745	94170.2	160941.2	0.076	1011860
2010	8370	102117	160671.2	0.101	751592
2011	11470	110331	176543.3	0.130	956829
2012	21820	100126	155754.2	0.253	631242
2013	16247	88219.4	128422.2	0.213	365882
2014	19574	68224.7	105261.3	0.322	304081
2015	18355	44041	70638.95	0.460	175780
2016	16318	25999.6	49273.82	0.766	204642
2017	10767	11791	24166.33	1.176	60833.1
2018	4418	6081.53	13009.89	1.165	51314
2019	1841	6168	14465.95	0.725	180019
2020	132	8740.64	13607.22	0.023	108106
2021	745	15084.2	26967.53	0.069	260375

Table 6.7.1.1. Herring in the Celtic Sea. Input data for short-term forecast.

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197044	0.767	0.5	0.5	0.5	0.05	0.02	0.06
2	120316	0.385	1	0.5	0.5	0.09	0.21	0.09
3	32354	0.356	1	0.5	0.5	0.11	0.29	0.11
4	34559	0.339	1	0.5	0.5	0.13	0.29	0.12
5	3844	0.319	1	0.5	0.5	0.13	0.29	0.13
6	1079	0.314	1	0.5	0.5	0.14	0.29	0.15

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
7	774	0.307	1	0.5	0.5	0.16	0.28	0.16
8	196	0.307	1	0.5	0.5	0.17	0.28	0.16
9	2011	0.307	1	0.5	0.5	0.16	0.08	0.17

2023								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197043.9	0.767	0.5	0.5	0.5	0.05	0.02	0.06
2	-	0.385	1	0.5	0.5	0.09	0.21	0.09
3	-	0.356	1	0.5	0.5	0.11	0.29	0.11
4	-	0.339	1	0.5	0.5	0.13	0.29	0.12
5	-	0.319	1	0.5	0.5	0.13	0.29	0.13
6	-	0.314	1	0.5	0.5	0.14	0.29	0.15
7	-	0.307	1	0.5	0.5	0.16	0.28	0.16
8	-	0.307	1	0.5	0.5	0.17	0.28	0.16
9	-	0.307	1	0.5	0.5	0.16	0.08	0.17

2024								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	197043.9	0.767	0.5	0.5	0.5	0.052	0.019	0.059
2	-	0.385	1	0.5	0.5	0.088	0.212	0.089
3	-	0.356	1	0.5	0.5	0.108	0.293	0.108
4	-	0.339	1	0.5	0.5	0.126	0.293	0.124
5	-	0.319	1	0.5	0.5	0.132	0.293	0.133
6	-	0.314	1	0.5	0.5	0.144	0.293	0.147
7	-	0.307	1	0.5	0.5	0.157	0.278	0.159
8	-	0.307	1	0.5	0.5	0.170	0.279	0.163
9	-	0.307	1	0.5	0.5	0.162	0.081	0.166

Table 6.7.1.2. Herring in the Celtic Sea. Results of short-term deterministic forecast.

Rationale	F _{bar} (2022)	Catch (2022)	SSB (2022)	F _{bar} (2023)	Catch (2023)	SSB (2023)	SSB (2024)
Catch(2023) = Zero	0.058	869	19348.6	0.00	0.00	22746	25875
Catch(2023) = 2022 TAC	0.058	869	19348.6	0.046	869	22319	24746
Fbar(2023) = Fmsy	0.058	869	19348.6	0.260	4475	20454	20049
Fbar(2023) = Fpa	0.058	869	19348.6	0.260	4475	20454	20049
Fbar(2023) = Flim	0.058	869	19348.6	0.450	7150	18953	16914
Fbar(2023) = F2022	0.058	869	19348.6	0.058	1091	22209	24390
Fbar(2023) = Fmsy * SSB2022 /MSY Btrigger	0.058	869	19348.6	0.093	1725	21891	23546

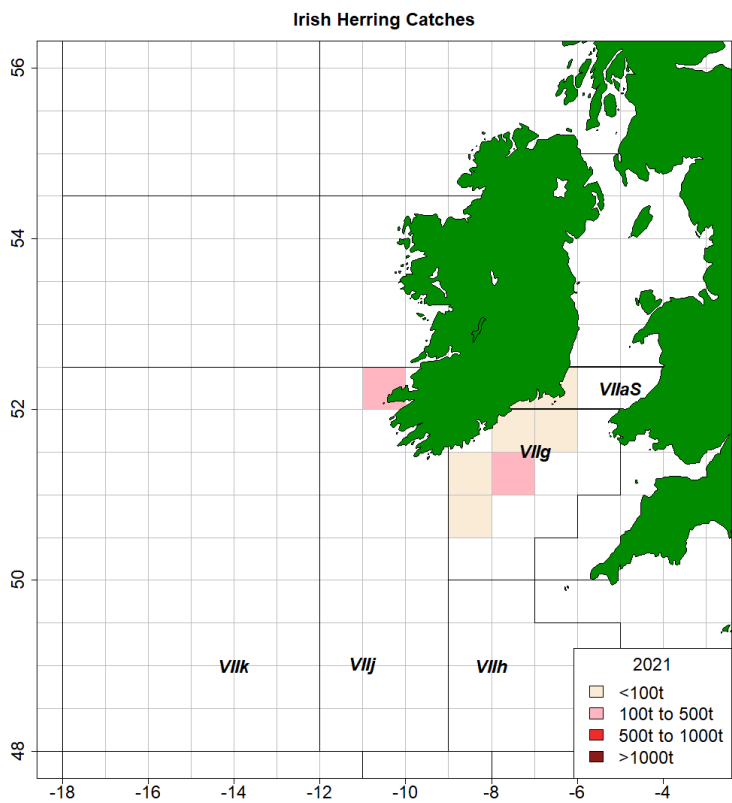


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2021/2022.

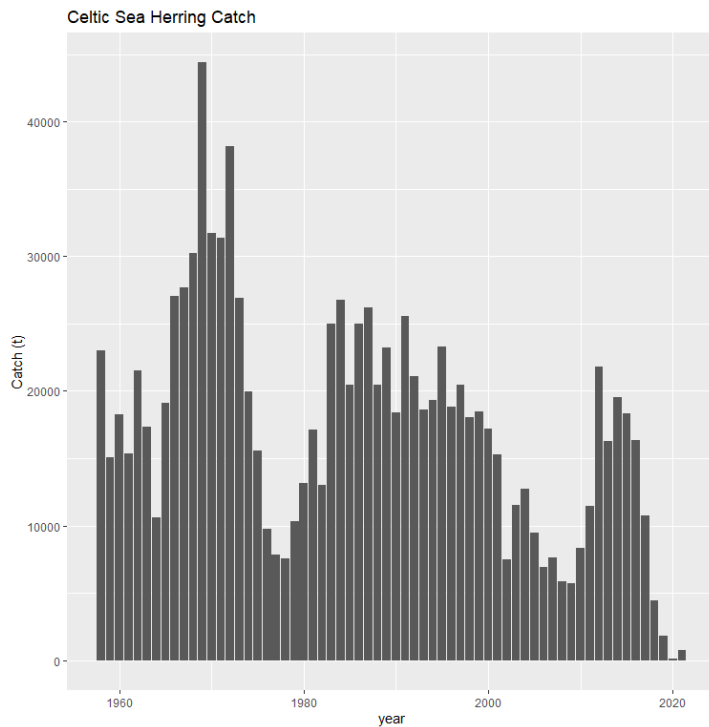


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

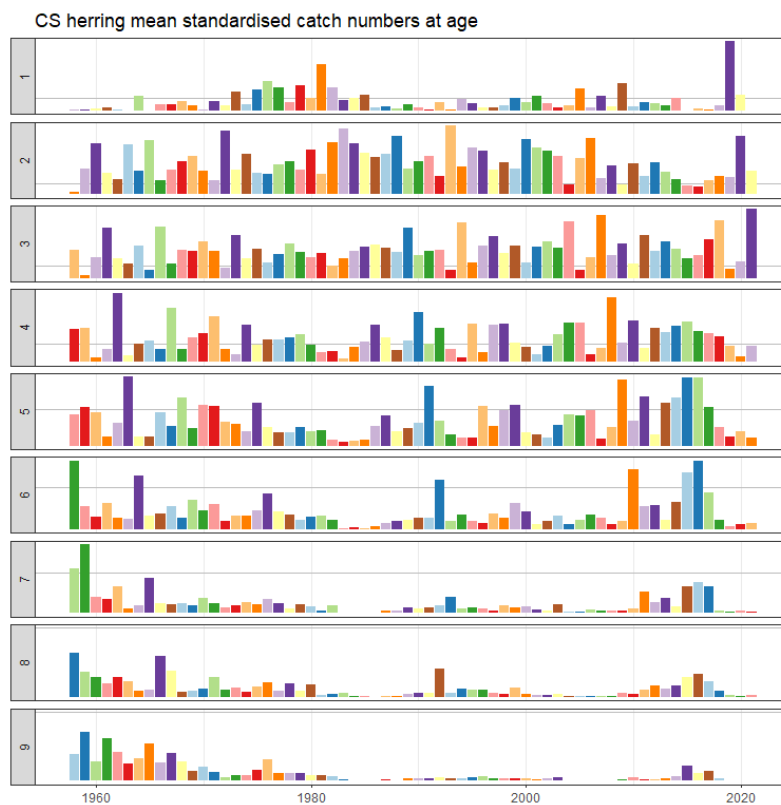


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardized by yearly mean. 9-wr is the plus group. Age in winter rings.

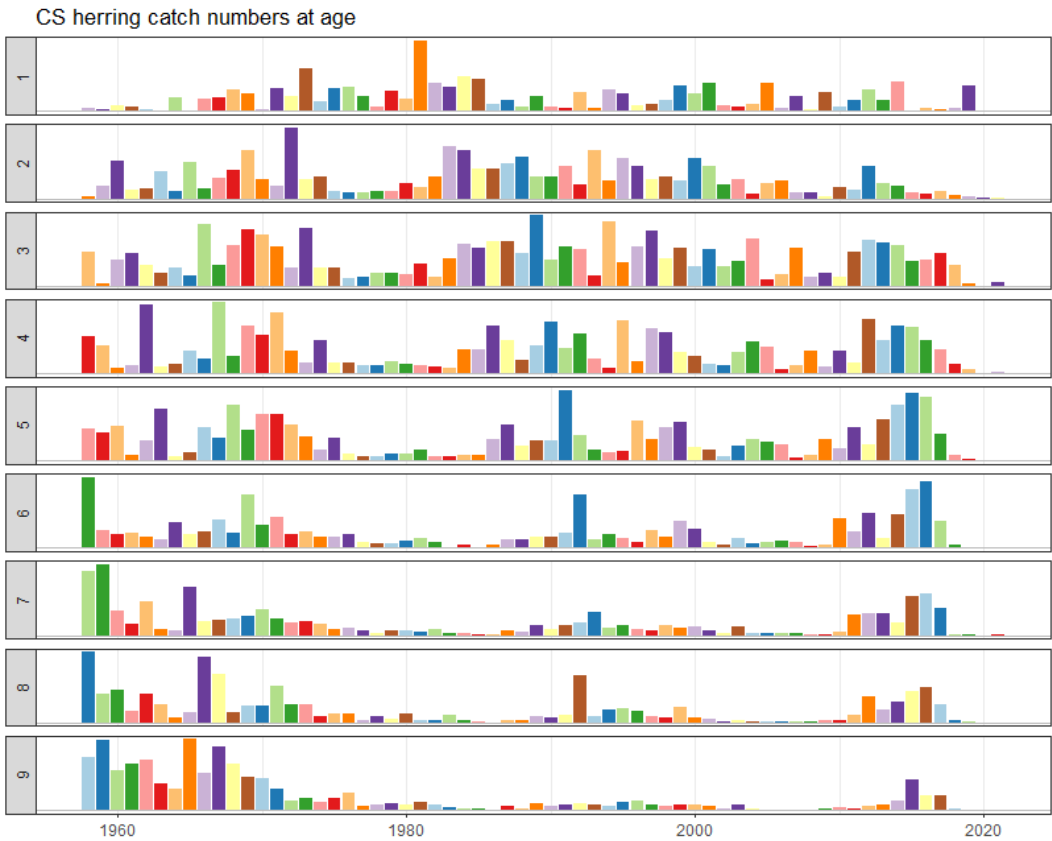


Figure 6.2.1.1 (cont.) Herring in the Celtic Sea. Catch numbers-at-age (unstandardized). 9-wr is the plus group. Age in winter rings.

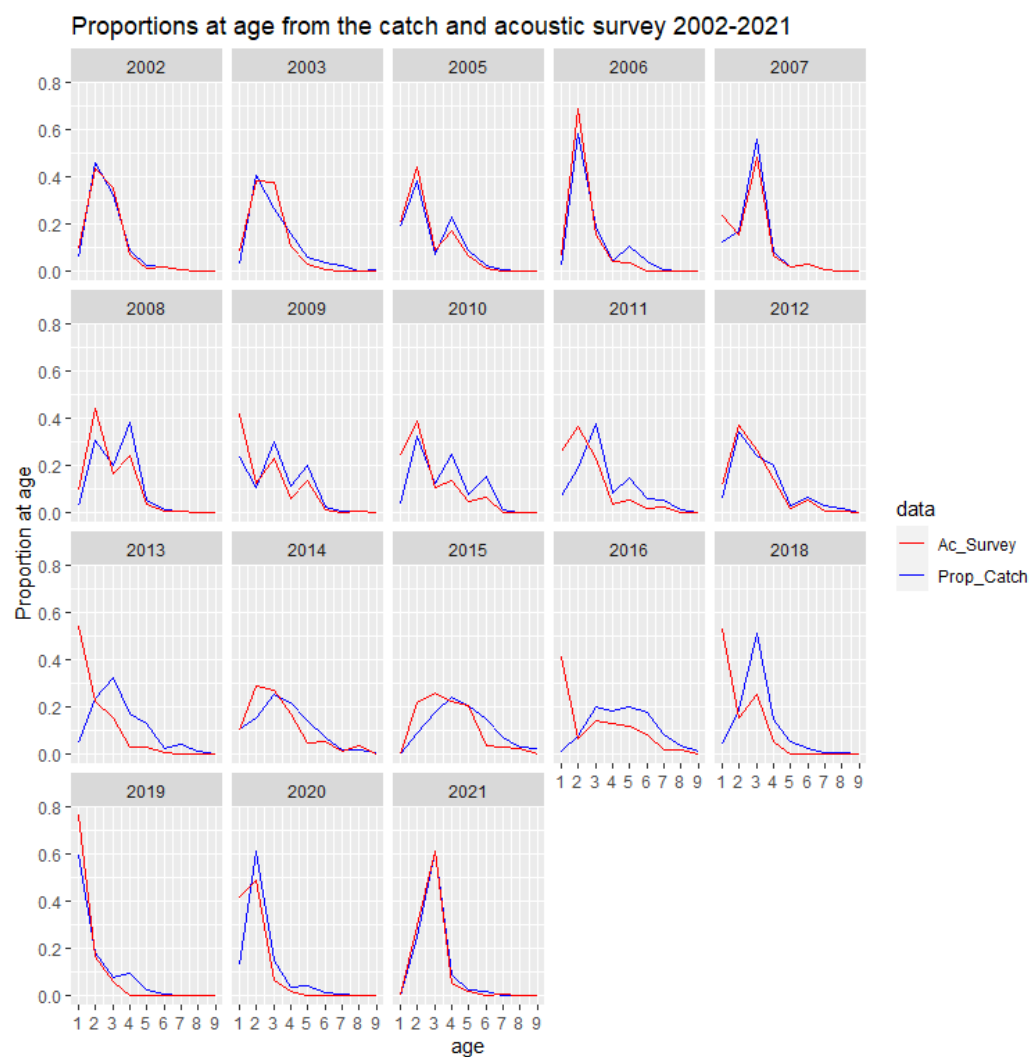


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9 yr) and the commercial fishery (1–9 yr) by year. Age in winter rings.

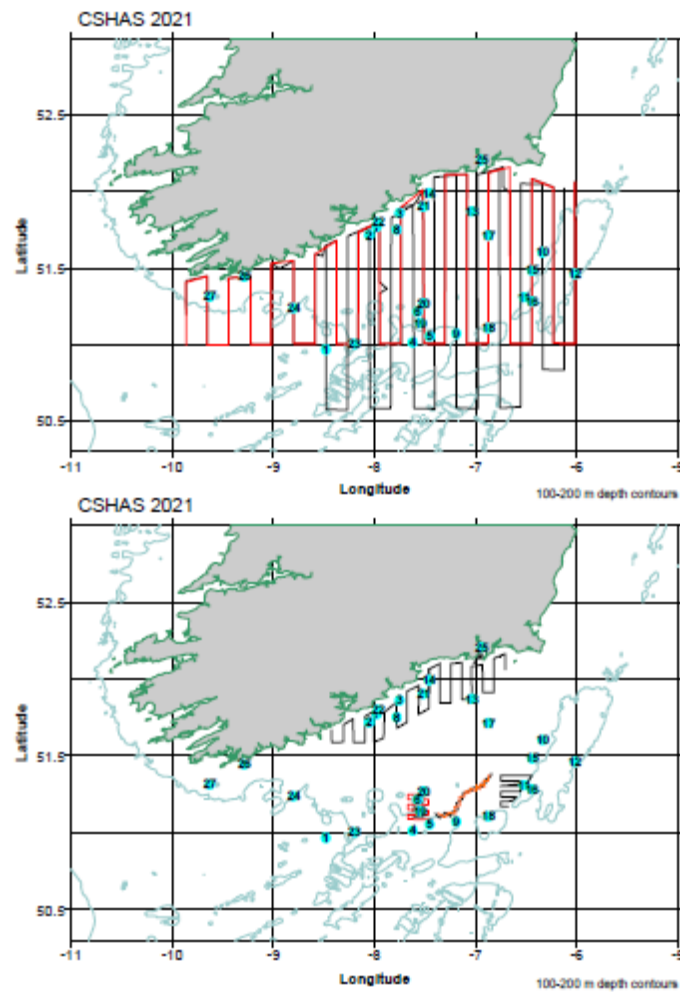


Figure 6.3.1.1. Herring in the Celtic Sea. Top panel: Core replicate acoustic survey effort cruise tracks and numbered haul stations. (Pass 1: black track, Pass 2: orange track). Bottom panel: Adaptive and scouting survey effort mini surveys 1-6. Replicate coverage shown as orange track.

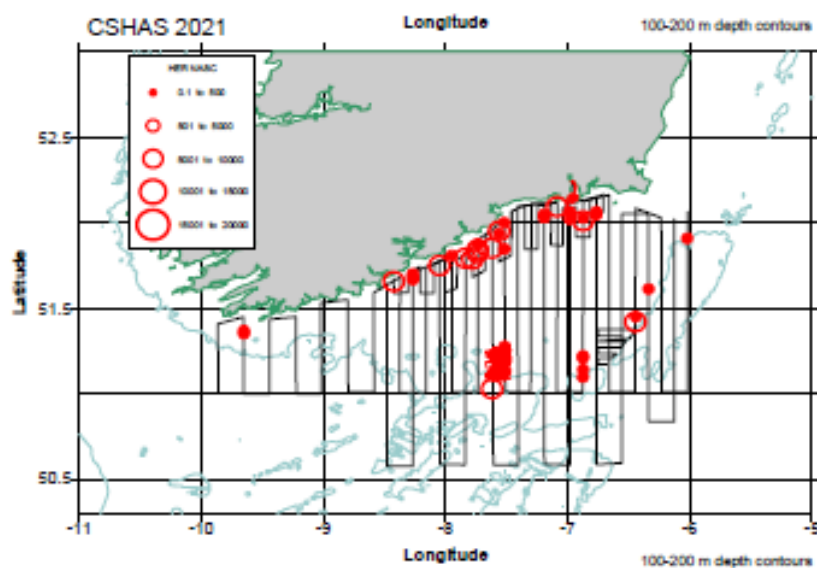


Figure 6.3.1.2. Herring in the Celtic Sea. NASC (Nautical area scattering coefficient) distribution plot of the distribution of herring in 2021 from combined survey effort.

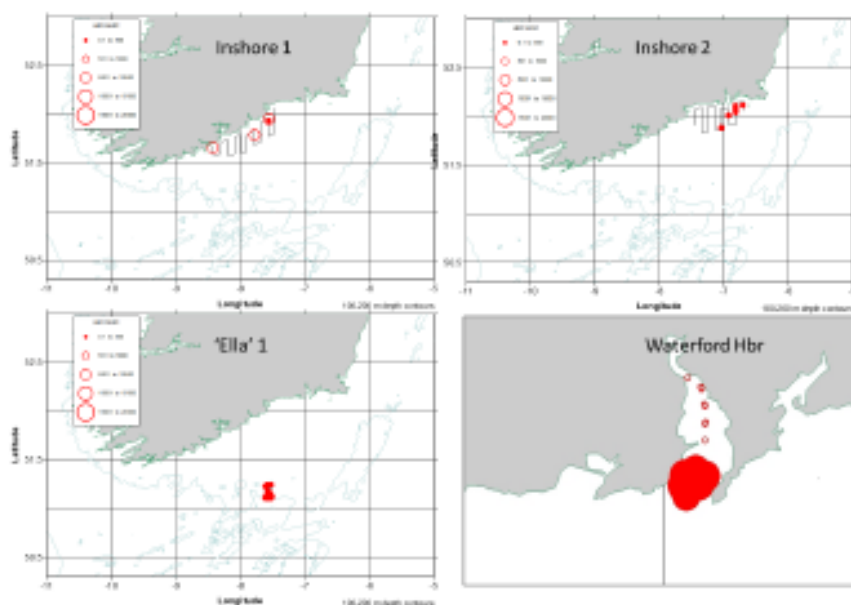


Figure 6.3.1.3. Herring in the Celtic Sea. NASC (nautical area scattering coefficient) plot of the distribution of herring in 2021 in the adaptive mini-surveys.

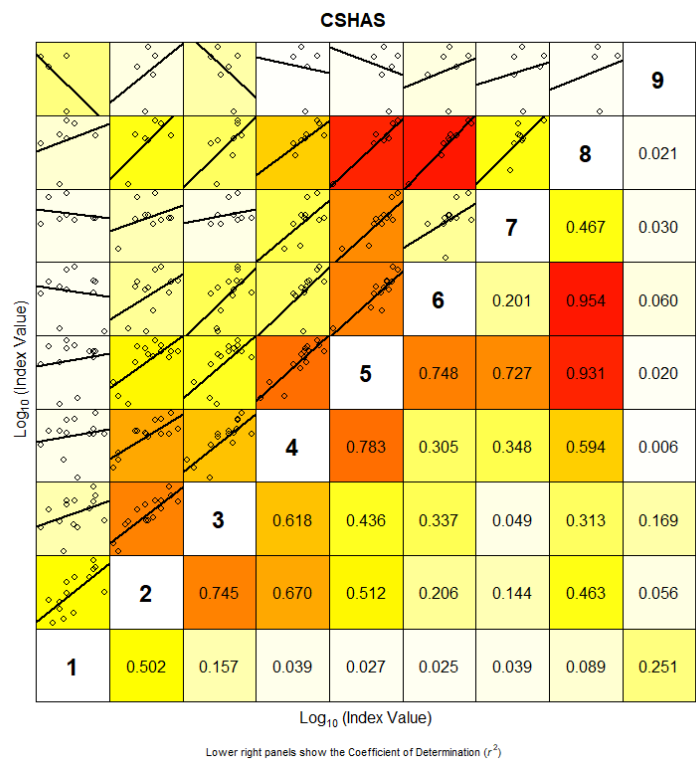


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

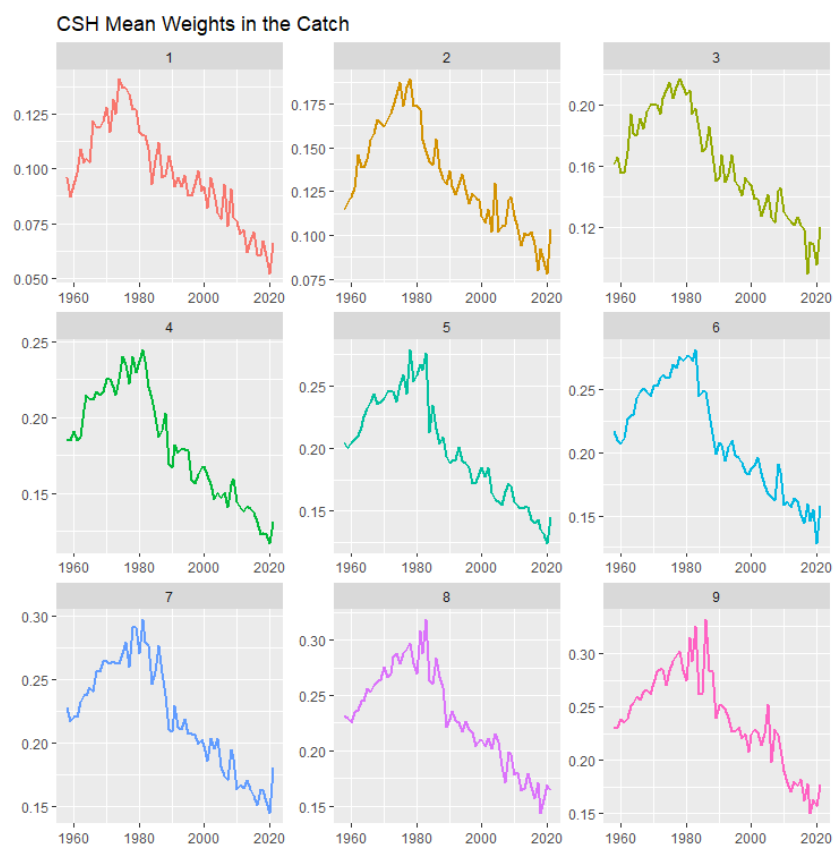


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2021 for 1–9+.

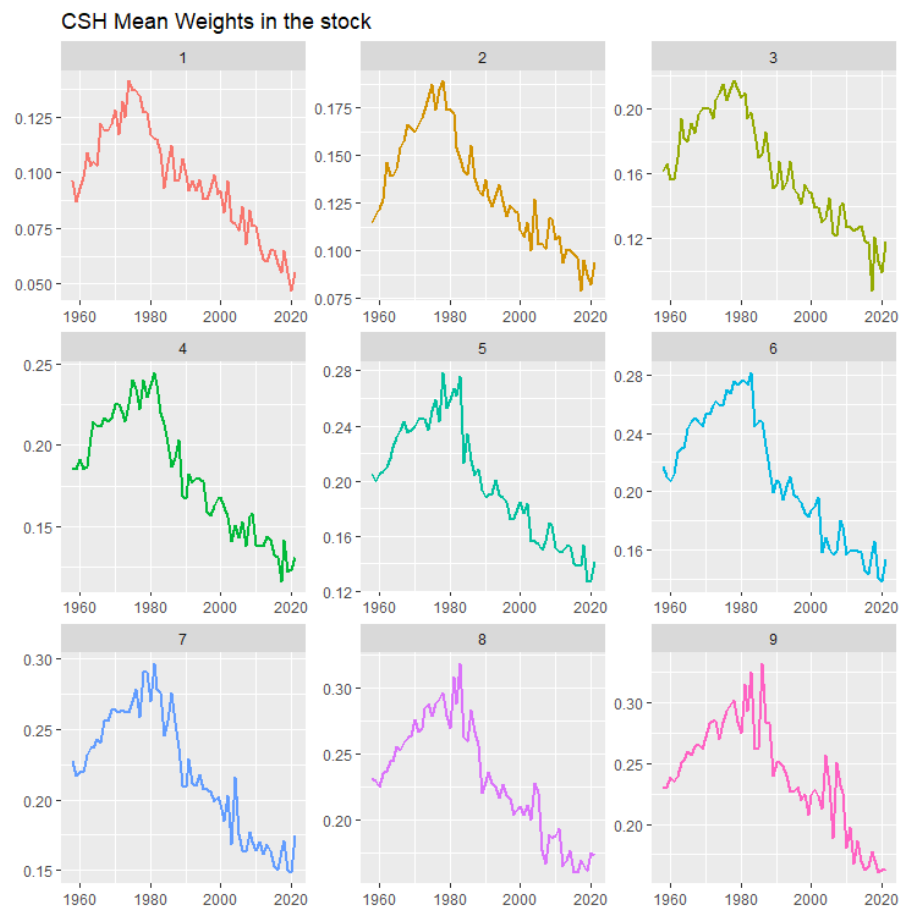


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2021 for 1–9+. Age in winter rings.

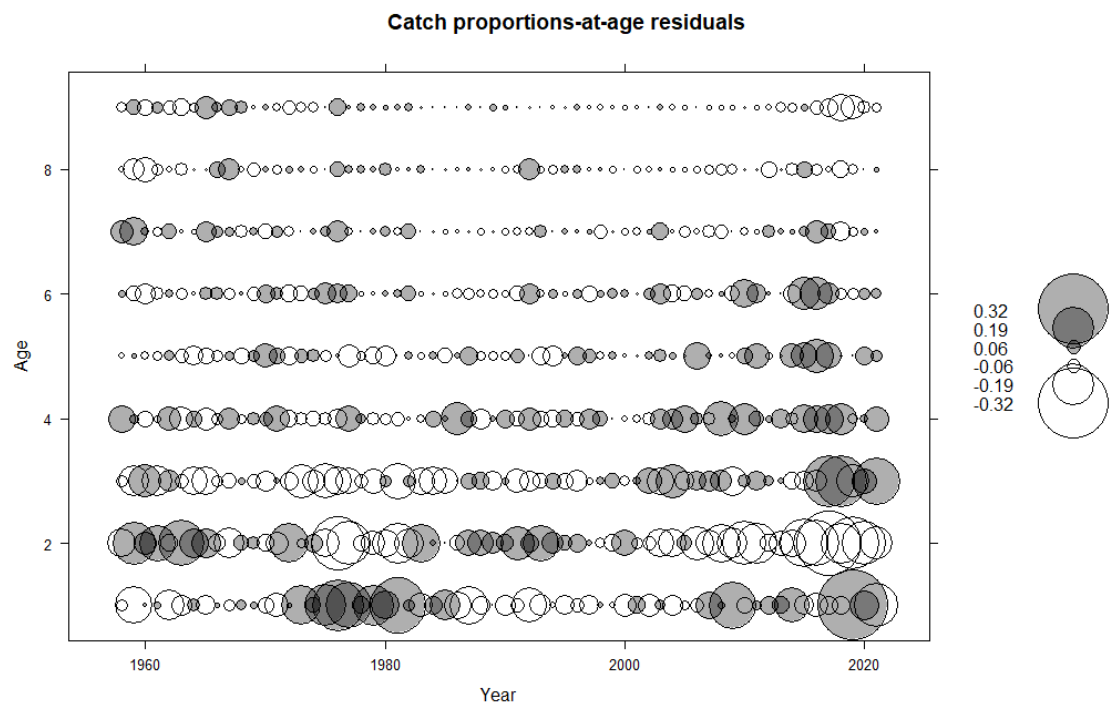


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

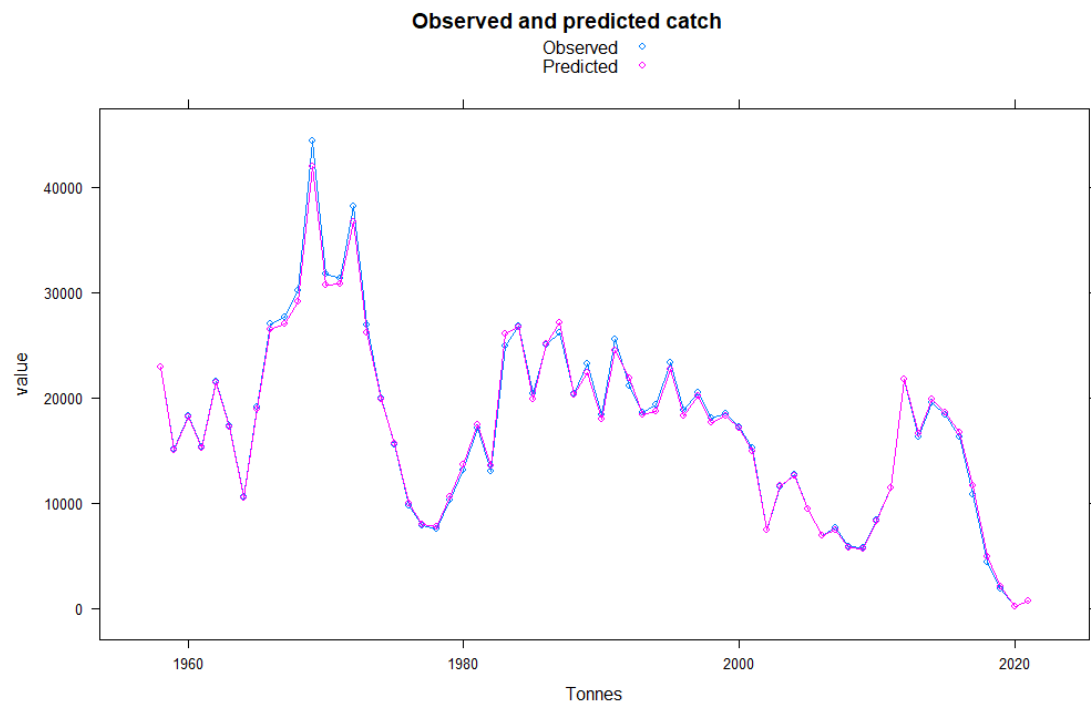


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

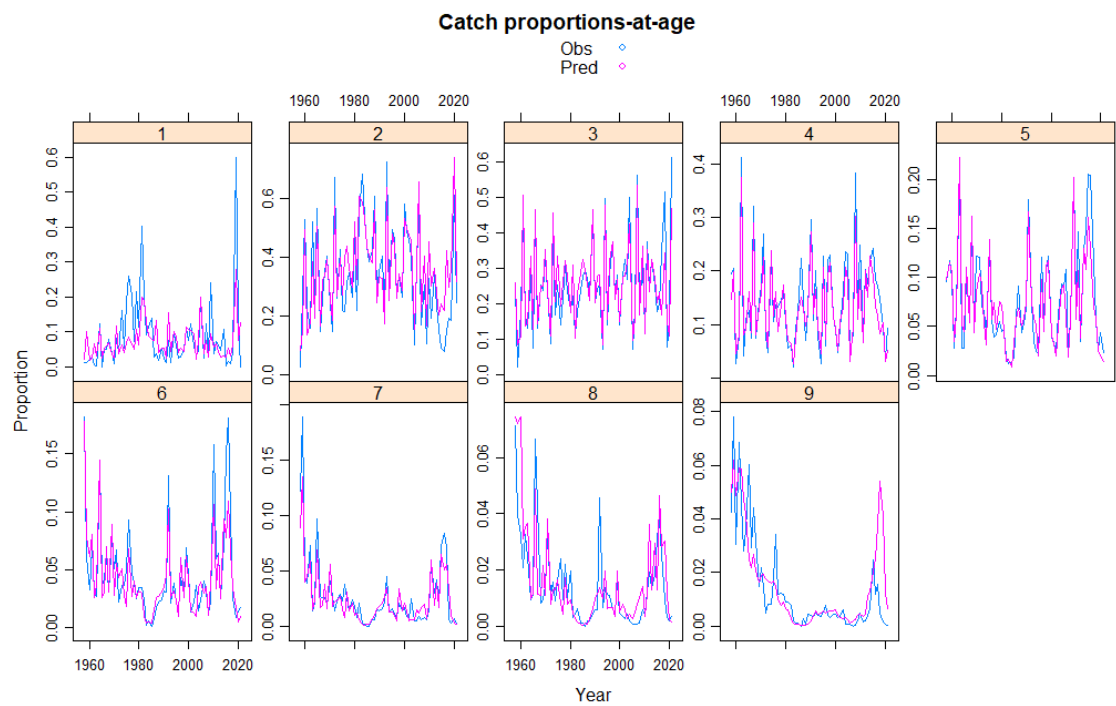


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

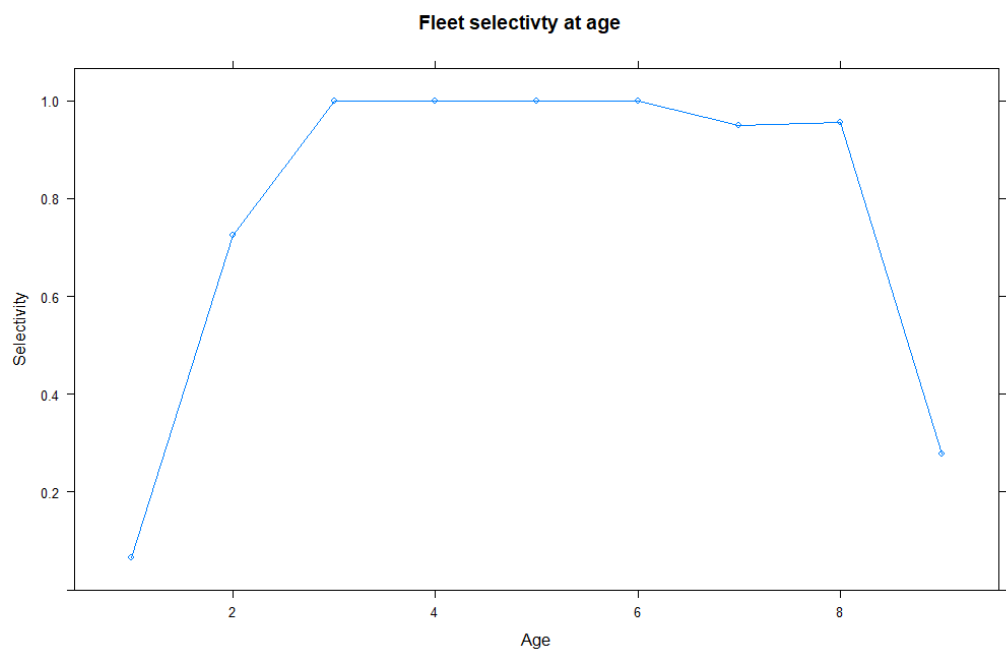


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

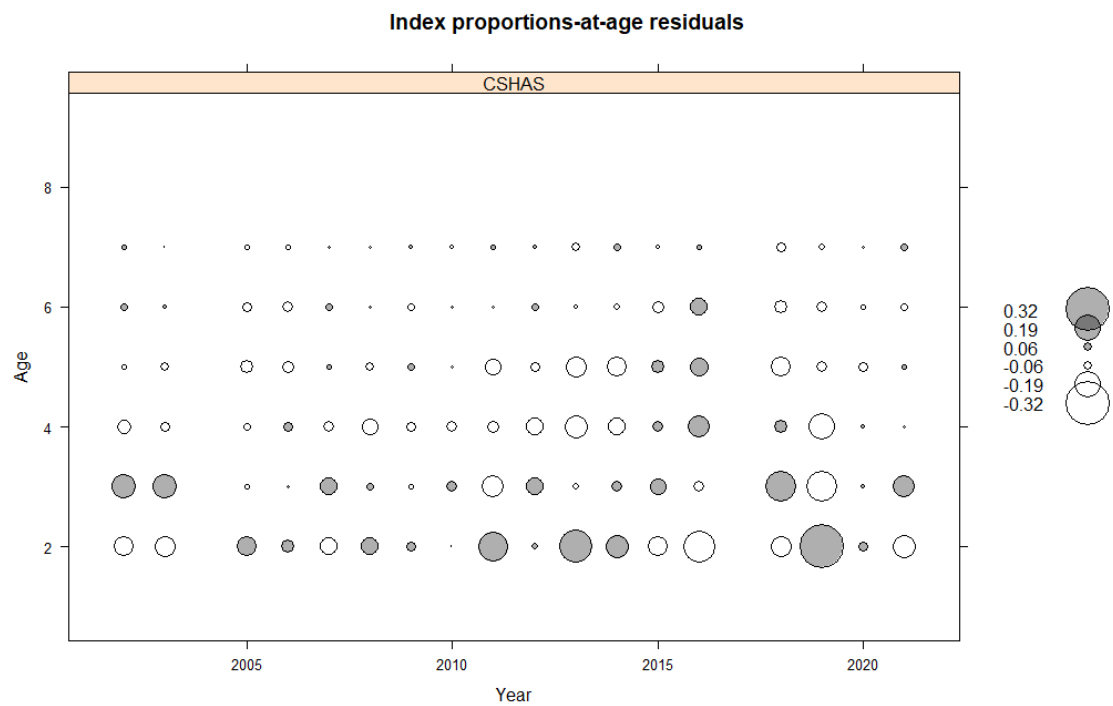


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

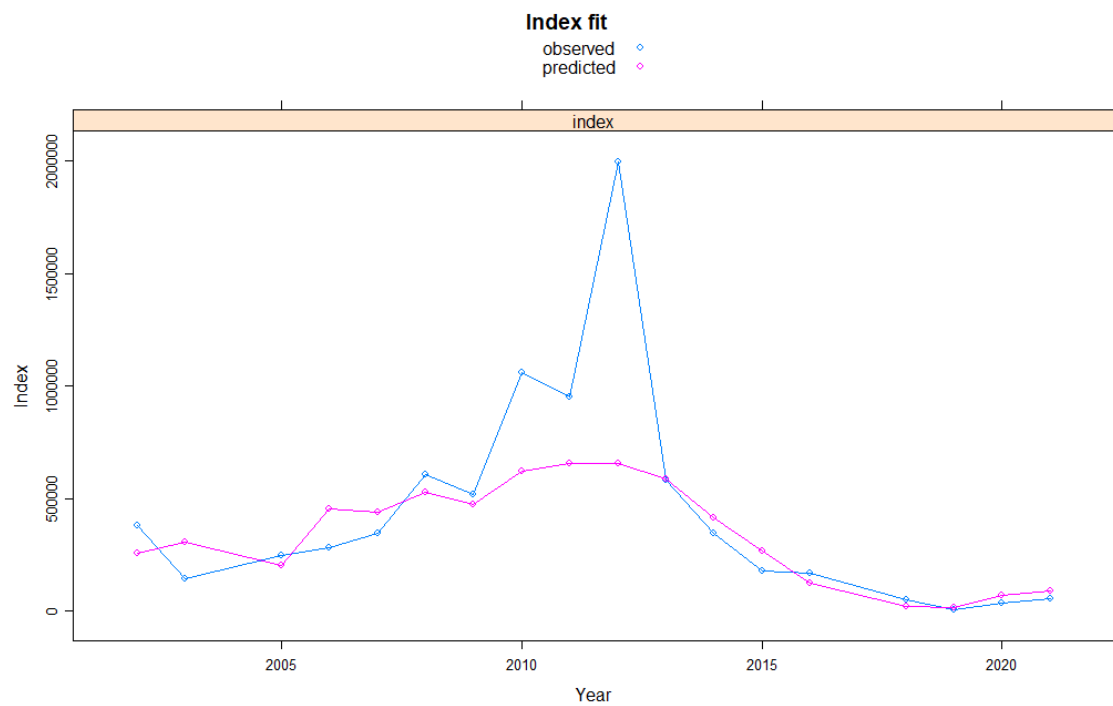


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

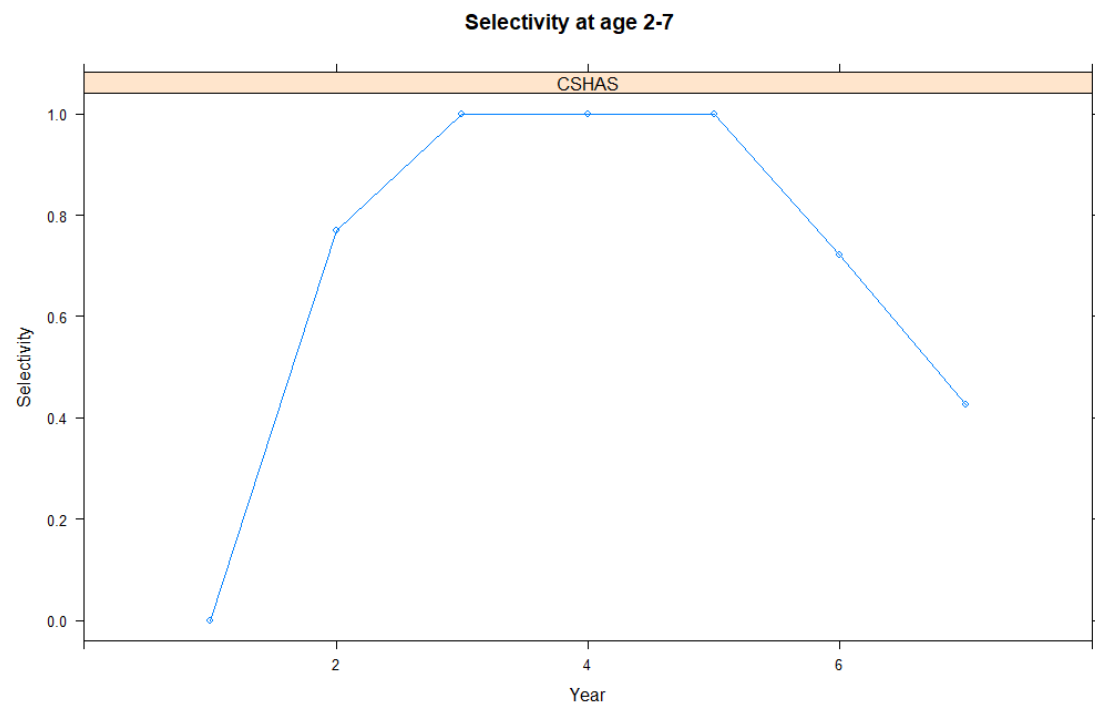


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

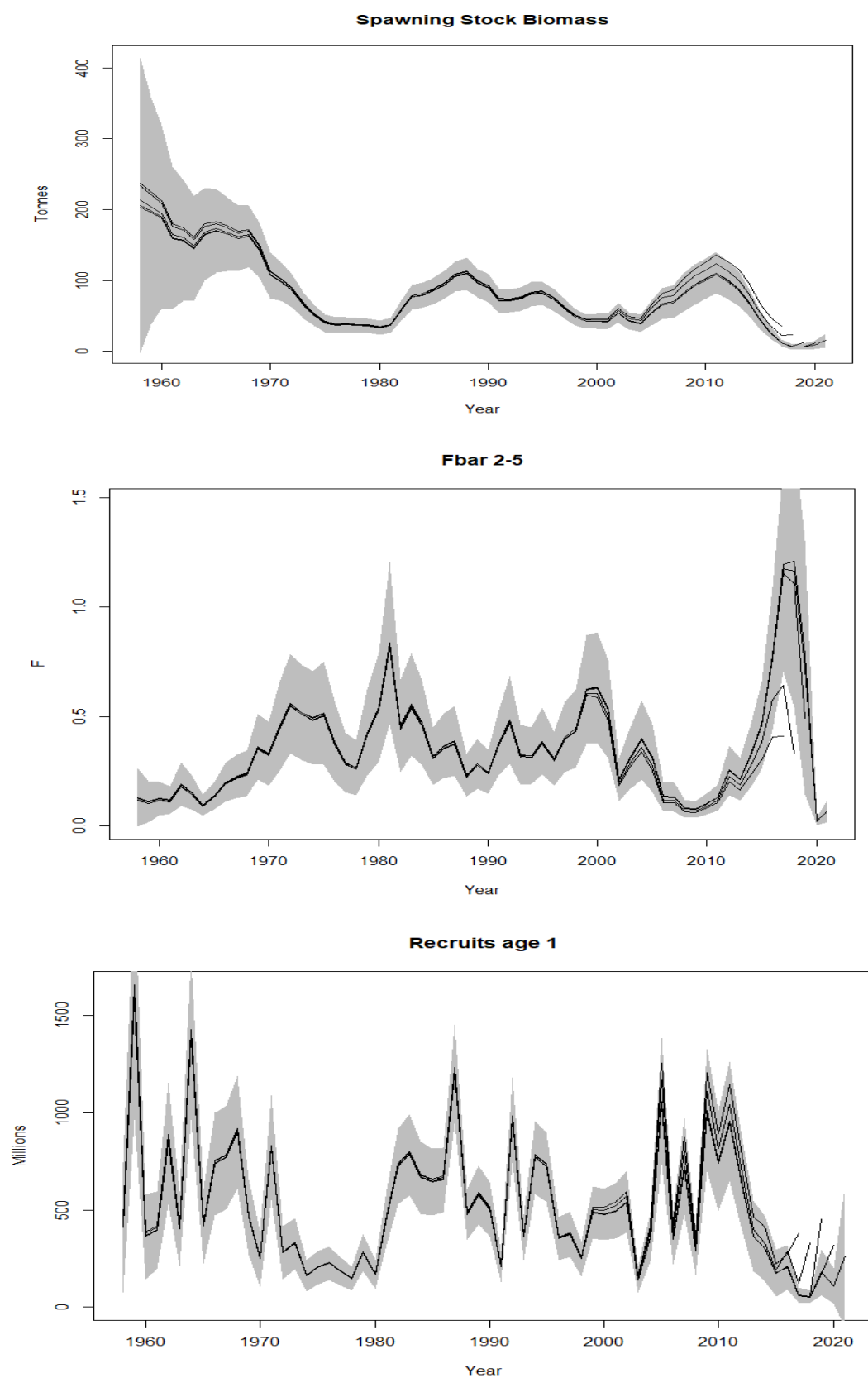


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), and Recruitment (bottom). The shaded area is the 95% confidence interval.

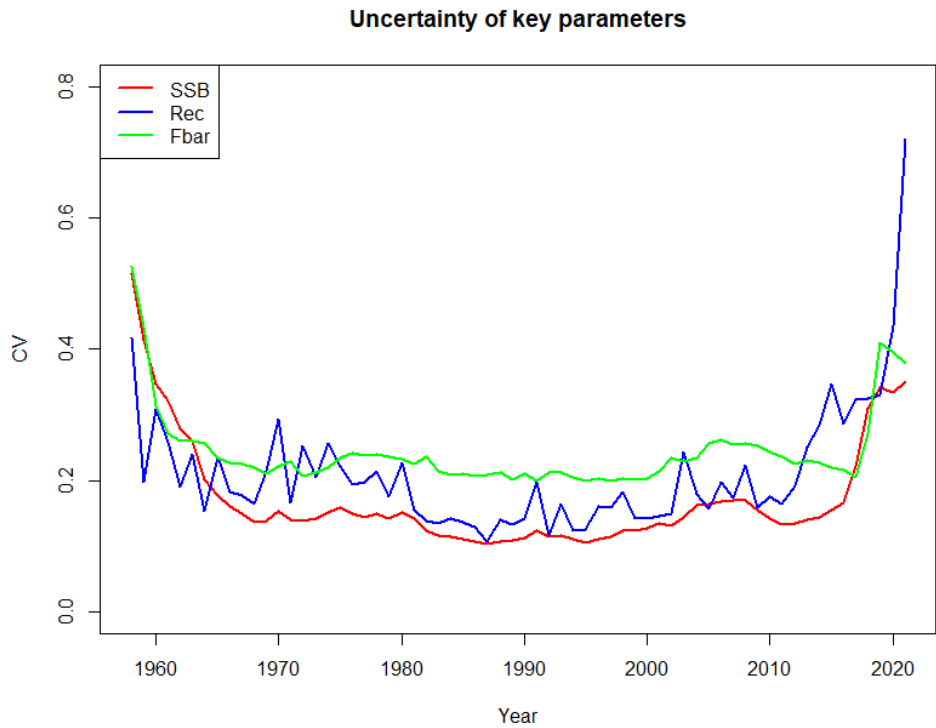


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

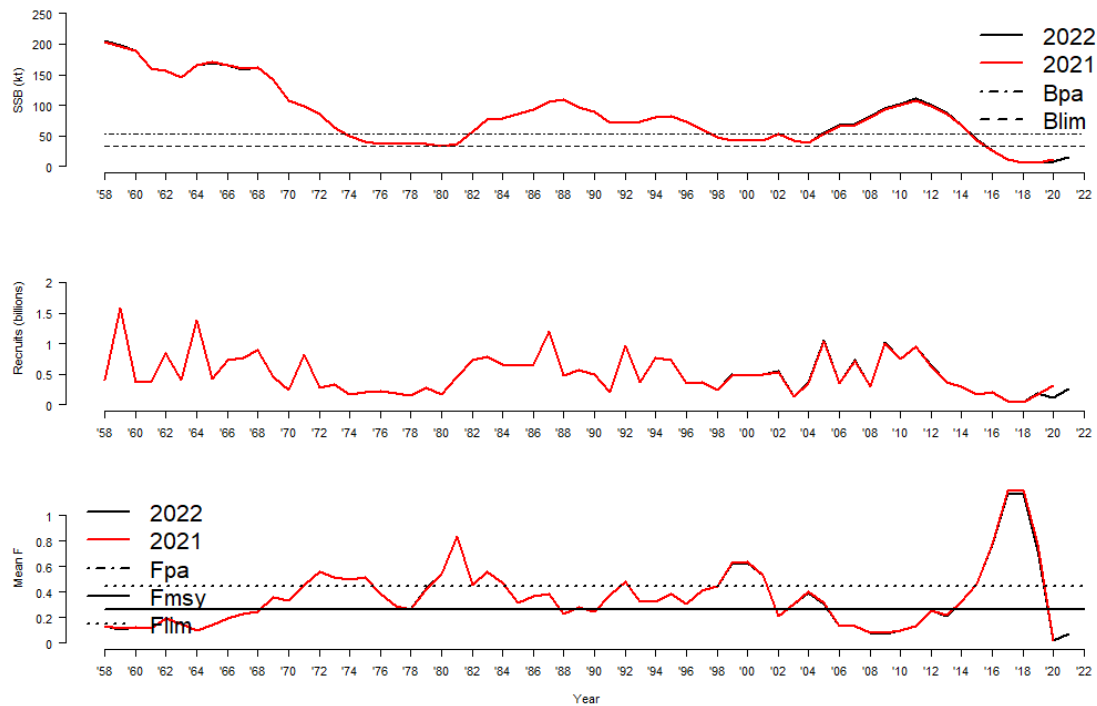


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top), Recruitment (middle) and Mean F2-5 (bottom)

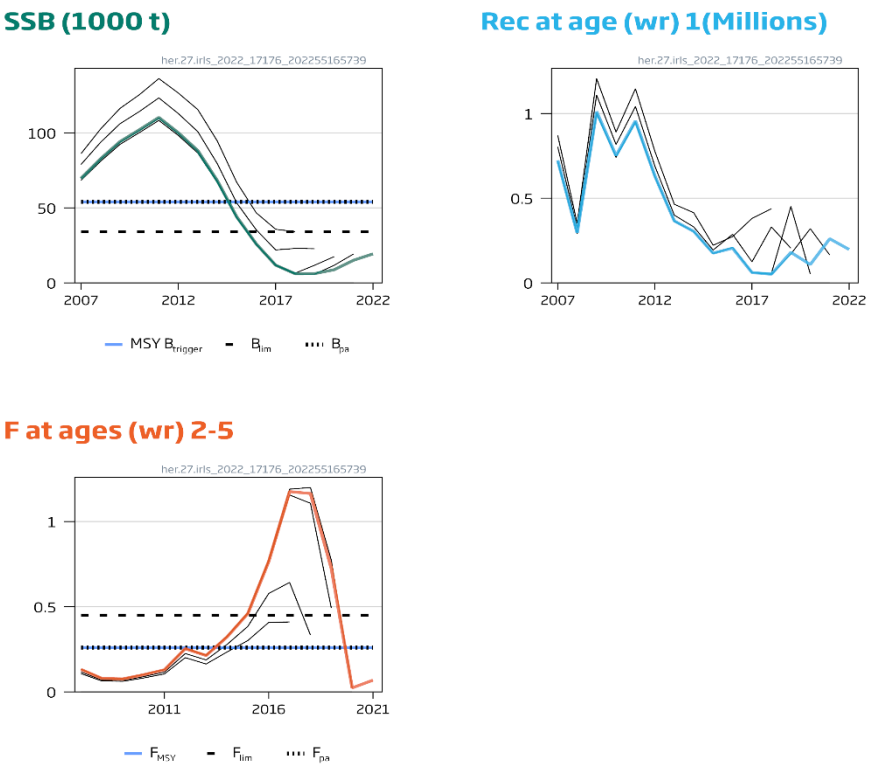


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospectives from the final assessments 2016–2022