

20 Turbot in 3.a (Kattegat, Skagerrak)

The last advice issued in 2017 for the years 2018 and 2019 was based on the “2/3 rule” for category 3 stocks, applied to the IBTS Q1 and Q3 biomass indices. In 2019 and 2020, ICES was not requested to provide advice on fishing opportunities for this stock, so the advice sheet reported only on the status of the stock. In 2021, ICES was requested to provide advice again.

The general perception is that landings have fluctuated without trends over a long period. In 2019, the survey indices were of poor quality, with low catch rates and large annual fluctuations, and they showed no clear trends. In 2017, length-based indicators (LBI) and exploratory SPiCT runs were examined, pointing out that the stock may be exploited sustainably. In 2019, the LBI indicators were not updated due to poorer length information available following reduced sampling since 2017. The stock went through benchmark in 2020 where a SPiCT assessment was accepted to provide stock status ([ICES, 2020](#)). That assessment was further used in 2021 to provide catch advice according to the precautionary approach.

20.1 Management regulations

Turbot in 3.a. is not managed using a TAC. ICES was requested to provide advice for 2022. The last advice from ICES was for 2019.

There is no official EC minimum landing size, but Denmark has a minimum size at 30 cm. In the Netherlands, various restrictions and MLS for North Sea turbot have been applied by Dutch POs over time, which may also affect the Dutch discarding of turbot caught in Skagerrak.

20.2 Fisheries data

Turbot is now only caught as by-catch in the trawl and gillnet fisheries. Table 20.1 and Figure 20.1 summarize turbot landings in ICES Division 3.a. Over the period 1975–2020, total landings (3.a) ranged from 95 t to 736 t per year. The lowest landings were recorded in the 1960s and the highest peaks are observed in the late 1970s and in the early 1990s. The peak in the 1970s is linked to exceptionally high records from the Netherlands for four years.

The Danish catches, which are present throughout the time series, have fluctuated without trends around 100–200 t per year.

In the last decades, the total annual landings of turbot in 3.a declined from 300–400 tonnes in the early 1990s to around 100 t in the early 2010s, but have increased again in the most recent years. In 2020, the total landings were 191 tonnes.

The stock was benchmarked in early 2020, which included a data call for turbot in Division 3.a that lead to new landings and discard data being uploaded into InterCatch. This allowed a compilation of information by area and metier. During the benchmark, reported discard ratios were available across 2002–2018, and the average discard ratio (10.49%) was used to reconstruct the discards for earlier years (1950–2001). Details of the benchmark are provided in the associated report ([ICES, 2020](#)).

Discard coverage in 2020 was lower this year in subdivision 3a.20 (47%), but comparable to previous years in 3a.21 (59%). The beam trawl fleet from the Netherlands and the gillnet fleet from Denmark are the largest metiers without discard information (Figure 20.2). Discarding is clearly related to fish size, most individuals below 30cm are being discarded (Figure 20.3).

As turbot in 3a is mainly a bycatch species, a change in catch over time can be influenced by changes in effort levels and targeting of the fleets in the area that catch it. Further investigation is needed into targeting of the species in the area through time.

20.3 Survey data, recruit series and analysis of stock trends

During the benchmark, a new index for exploitable biomass was developed. The index was based on a compilation of five surveys covering Division 3a. Specifically, the surveys included the beam trawl survey (BTS), the North Sea International Bottom Trawl Survey (NS-IBTS), the Baltic International Trawl Survey (BITS), a Danish national survey targeting cod and the Danish part of a Swedish-Danish survey targeting sole, all covering parts of Division 3a. (ICES, 2020). Since the index was intended for use in SPiCT, only the vulnerable sizes of the individuals caught in the surveys were included in the calculation of the index, leading to an exploitable biomass index. The standardised exploitable biomass index is shown in Figure 20.4, along with 3 retrospective runs, calculated by leaving out the last 1–3 years of available data. The SPiCT model combined the new exploitable biomass index and updated fisheries data and was approved during the benchmark (ICES, 2020).

20.4 Assessment – short term forecast

The surplus production model in continuous time (SPiCT, Pedersen and Berg 2017) is used for the assessment of the stock. The main settings are as following:

Fixed values

Shaefer model (shape parameter $n=2$)

Priors

Initial depletion: $\log(\text{bkfrac}) \sim N(\log(0.5), 0.5^2)$

Uncertainty ratio of index (observation) to biomass process: $\log(\alpha) \sim N(\log(1), 2^2)$

Ratio of catch (observation to fishing mortality process uncertainty: $\log(\beta) \sim N(\log(1), 2^2)$

Catch: 1975–2020

Index (estimated for Q1): 1983–2020

Discretisation time step (dteuler): 1/16 year

A short-term forecast is performed using SPiCT. The assumption for the short term forecast intermediate year (2021) is that the fishing mortality process continues, essentially keeping status quo fishing mortality. This leads to the following short-term forecast in the intermediate year:

Variable	Value	Notes
F_{2021}/F_{MSY}	0.88	Status quo F
B_{2022}/B_{MSY}	1.11	Short term forecast (STF) under status quo F
Catch (2021)	218	STF of catch under status quo F
Discard rate (2021, 2022)	12.1%	Average 2018–2020. Percentage
Projected landings (2021)	192	Based on the average discard rate
Projected discards (2021)	26	Based on the average discard rate

The assessment results are shown in Figure 20.5 and summarised in Table 20.5. The diagnostics of the goodness of fit of the model are based on the one-step-ahead residuals (Figure 20.6). There are some issues with autocorrelation of the residuals of the index time series. This is a result of including an already smoothed biomass index based on a GAM model. During the benchmark of the stock in 2020, an approach of removing every other index observation was used as an attempt to alleviate the autocorrelation issue. The results showed improvement in the autocorrelation, but only small differences in the estimated stock status. The decision was to include all data as it created issues with the retrospective analysis and would cause issues with the short-term forecast. Another issue with the assessment is the low estimated observation error for the exploitable biomass index ($\sigma_1 = 0.019$) which is probably unrealistic, but stems from the fact that a smoothed index is used.

The retrospective analysis shows that the relative process estimates have acceptable retrospective bias: Mohn's rho was 0.123 for B/B_{MSY} , 0.208 for F/F_{MSY} (20.7).

To provide advice following the precautionary approach, the recommendation of WKLIFEX (ICES, 2020) is followed. The basis for the advice assumes fishing mortality $F=F_{MSY}$, then the TAC advice is the 35th percentile of the projected catch distribution. The use of that percentile instead of the median leads to a more precautionary advice, with no loss of long-term yield. For 2022, the catch advice is 224 tonnes. The results for the baseline scenario and alternatives that are included in the advice sheet are shown in Figure 20.8 and Table 20.4.

Alternative basis for advice

During the assessment working group meeting, an alternative option was explored, to base the advice on the 2/3 rule using the survey index (Figure 20.9). That rule requires a baseline catch, suggested to be the average catch over 2015–2020, equal to 214 tonnes (20.10). The 2/3 ratio for was equal to 0.92, following the downward trend of the index and not applying the precautionary buffer (multiplier 0.8) as the SPiCT assessment indicates that the stock is in good status and not being overexploited: alternative $TAC_{2022} = 214 \times 0.92 = 197$ t.

20.5 Issue list

The stock was benchmarked in 2020, but a number of issues remain:

- Stock identity. The benchmark indicated that Division 3.a is not a separate stock, but connected to both the North Sea and the Baltic Sea. There is genetic differentiation between the North Sea and the Baltic Sea with a genetic hybrid zone within Division 3.a. The new exploitable biomass index and the landings data indicated elevated abundances and landings on the borders between Division 3.a and the North Sea and the Baltic Sea, further supporting connectivity between Division 3.a and neighbouring areas. The stock identity of Division 3.a should therefore be evaluated.
- The amount of length distributions data has been significantly reduced since 2017. Discussions should take place within Denmark for options within the framework of the next data collection programs after 2021. Denmark is responsible for approximately 3/4 of the turbot landings in Division 3.a.
- The application of the new exploitable biomass index via SPiCT indicated residual autocorrelation issues that should be addressed.
- The index includes only Danish part of the cod survey in subdivision 3a. In the future the Swedish data should be also included.
- Cardinale *et al.* (2009) reconstructed a long time series of survey data. It would be interesting to update this time series and investigate options to include it in further SPiCT runs. The paper indicated historic declines in abundance and maximum body sizes of turbot in Division 3.a.

20.6 Summary

The turbot stock in Division 3.a was benchmarked in 2020, and the resulting SPiCT model was used for the present assessment and report. A major improvement for the SPiCT model was the development of a new index for the relative exploitable biomass based on five different surveys covering Division 3.a. The analyses indicated that the relative exploitable biomass (B/B_{MSY}) remained above the reference point of 0.5 and relative fishing mortality (F/F_{MSY}) below the reference point of 1.

Table 20.1. Turbot in 27.3a. History of commercial landings 1975–2020; official values are presented by area for each country participating in the fishery. All weights are in tonnes.

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
1975	0	2	167	0	7	0	7	183
1976	7	2	178	0	190	0	6	383
1977	7	4	331	0	389	0	5	736
1978	2	4	327	0	186	0	6	525
1979	8	0	307	0	87	0	4	406
1980	7	0	205	1	14	0	6	233
1981	2	0	183	2	12	0	8	207
1982	1	0	164	1	9	0	7	182
1983	4	0	171	0	24	0	10	209
1984	0	0	176	0	0	0	12	188
1985	1	0	224	0	0	0	16	241
1986	2	0	180	0	0	0	11	193
1987	5	0	147	0	0	0	9	161
1988	2	0	115	0	11	0	10	138
1989	2	0	173	0	0	0	9	184
1990	5	0	363	0	0	0	18	386
1991	4	0	244	0	0	7	21	276
1992	4	0	278	0	0	8	19	309
1993	3	2	336	0	0	10	0	351
1994	2	1	313	0	0	15	22	353
1995	4	1	268	0	0	17	11	301
1996	0	1	185	0	0	13	11	210
1997	0	0	200	0	0	9	11	220
1998	0	1	148	0	0	7	8	164
1999	0	1	139	0	0	10	6	156
2000	0	1	180	0	0	6	6	193
2001	0	0	227	0	0	8	3	238
2002	0	1	205	0	0	11	5	222
2003	0	0	128	0	13	14	4	159
2004	0	0	119	0	14	7	7	147
2005	0	0	108	0	7	6	6	127
2006	0	1	95	0	8	8	9	121
2007	0	1	138	0	15	7	12	173
2008	0	1	121	0	4	6	11	143
2009	0	1	94	0	2	6	17	120
2010	0	0	72	0	6	4	13	95
2011	0	1	78	0	0	7	13	99
2012	0	0	167	0	0	8	14	189
2013	0	0	91	0	0	5	15	111

Year	Belgium	Germany	Denmark	UK	Netherlands	Norway	Sweden	Total
2014	0	1	94	0	3	6	18	122
2015	0	0	135	0	20	8	11	174
2016	0	0	137	0	25	6	11	179
2017	0	0	154	0	16	7	12	189
2018	0	0	109	0	23	8	10	150
2019	0	0	118	0	68	5	7	198
2020	0	0	124	0	55	5	7	191

Table 20.2. Turbot in 27.3a: Landings and discards (in kg) by year and area after discard raising in InterCatch (using CATON estimate). No BMS nor logbook registered discards reported in InterCatch.

Year	Discards	Landings	Total	discard ratio
2002	17593	214745	232338	7.60%
27.3.a	9	135	144	6.20%
27.3.a.20	906	152506	153412	0.59%
27.3.a.21	16679	62104	78783	21%
2003	15273	153228	168501	9.10%
27.3.a	1468	14080	15548	9.40%
27.3.a.20	227	83702	83929	0.27%
27.3.a.21	13578	55446	69024	19.70%
2004	9463	146736	156199	6.10%
27.3.a	990	15674	16664	5.90%
27.3.a.20	2524	72802	75326	3.40%
27.3.a.21	5950	58260	64210	9.30%
2005	10672	125757	136429	7.80%
27.3.a	516	6928	7444	6.90%
27.3.a.20	3277	73824	77101	4.30%
27.3.a.21	6880	45005	51885	13.30%
2006	11600	116895	128495	9.00%
27.3.a	833	8838	9671	8.60%
27.3.a.20	246	55105	55351	0.44%
27.3.a.21	10522	52952	63474	16.60%
2007	32300	171442	203742	15.90%
27.3.a	1597	16098	17695	9.00%
27.3.a.20	880	100442	101322	0.87%
27.3.a.21	29823	54902	84725	35%
2008	7183	139685	146868	4.90%
27.3.a	172	4635	4807	3.60%
27.3.a.20	0	91024	91024	0.00%
27.3.a.21	7011	44026	51037	13.70%

Year	Discards	Landings	Total	discard ratio
2009	9363	120692	130055	7.20%
27.3.a	142	2661	2803	5.10%
27.3.a.20	727	73619	74346	0.98%
27.3.a.21	8494	44412	52906	16.10%
2010	11264	96525	107789	10.50%
27.3.a	658	6346	7004	9.40%
27.3.a.20	163	43069	43232	0.38%
27.3.a.21	10443	47110	57553	18.10%
2011	25532	94354	119886	21%
27.3.a	59	258	317	18.60%
27.3.a.20	4192	54053	58245	7.20%
27.3.a.21	21281	40042	61323	35%
2012	22621	194736	217357	10.40%
27.3.a	29	289	318	9.10%
27.3.a.20	3562	164297	167859	2.10%
27.3.a.21	19030	30150	49180	39%
2013	7110	110945	118055	6.00%
27.3.a	0	2	2	0.00%
27.3.a.20	1469	75803	77272	1.90%
27.3.a.21	5641	35140	40781	13.80%
2014	14520	122406	136926	10.60%
27.3.a	0	0	0	0.00%
27.3.a.20	3874	82446	86320	4.50%
27.3.a.21	10646	39960	50606	21%
2015	33938	179737	213675	15.90%
27.3.a	0	1	1	0.00%
27.3.a.20	8426	141894	150320	5.60%
27.3.a.21	25511	37842	63353	40%
2016	19246	190829	210075	9.20%
27.3.a	3492	34530	38022	9.20%
27.3.a.20	9617	111770	121387	7.90%
27.3.a.21	6136	44529	50665	12.10%
2017	31669	191667	223336	14.20%
27.3.a	2928	17528	20456	14.30%
27.3.a.20	17404	122493	139897	12.40%
27.3.a.21	11337	51646	62983	18.00%
2018	22528	153398	175926	12.80%
27.3.a	4000	24842	28842	13.90%
27.3.a.20	11506	82913	94419	12.20%
27.3.a.21	7022	45643	52665	13.30%

Year	Discards	Landings	Total	discard ratio
2019	41903	204356	246259	17.00%
27.3.a	15857	74430	90287	17.60%
27.3.a.20	21409	102564	123973	17.30%
27.3.a.21	4637	27362	31999	14.50%
2020	13458	201698	215156	6.3%
27.3.a	4673	65140	69813	6.7%
27.3.a.20	3210	106819	110029	2.9%
27.3.a.21	5575	29740	35315	15.8%

Table 20.3: Turbot in 27.3a. Summary of the imported/Raised data for 2020. Stock exported without length allocation. Weights are in kilograms.

Discards	13499
Imported Data	4856 36.1%
Raised Discards	8593 63.9%
Landings	201698
Imported Data	201698
Grand Total	215147

Table 20.4: Turbot in 27.3a. Forecast table for the baseline and alternative scenarios. The percent biomass change refers to the biomass in 2023 relative to 2022.

Basis	Total catch (2022)	Projected landings (2022)	Projected discards (2022)	Fishing mortality F_{2022}/F_{MSY}	Stock size B_{2023}/B_{MSY}	% B change
Precautionary approach (35 th percentile of predicted catch distribution under $F = F_{MSY}$)	224	197	27	0.90	1.11	-0.120
Other scenarios						
$F = F_{MSY}$	248	218	30	1.00	1.10	-1.08
$F = F_{sq}$	218	192	26	0.88	1.11	0.103
$F = 0$	0	0	0	0	1.21	8.1
$F = F_{MSY}$, all fractiles	194	171	23	0.77	1.13	1.07

Table 20.5: Turbot in 27.3a. Assessment results, summary table. The 2021 biomass is the short-term forecast during the intermediate year, assuming that the F process continues unchanged from the last year with observations (Fsq).

Year	Relative exploitable biomass			Landings tonnes	Discards tonnes	Relative fishing pressure		
	B/B _{MSY}	High	Low			F/F _{MSY}	High	Low
1975	1.55	2.8	0.87	183	22	1.05	2.3	0.49
1976	1.47	2.5	0.85	383	46	1.25	2.4	0.64
1977	1.38	2.3	0.83	736	88	1.37	2.7	0.69
1978	1.29	2.1	0.79	525	63	1.33	2.6	0.68
1979	1.22	1.99	0.76	406	49	1.19	2.3	0.62
1980	1.18	1.91	0.73	233	28	1.04	2.0	0.53
1981	1.16	1.88	0.72	207	25	0.93	1.88	0.46
1982	1.16	1.87	0.72	182	22	0.86	1.74	0.43
1983	1.18	1.90	0.73	209	25	0.81	1.62	0.41
1984	1.21	1.95	0.75	188	23	0.78	1.56	0.39
1985	1.26	2.0	0.78	241	29	0.76	1.57	0.37
1986	1.31	2.1	0.81	193	23	0.76	1.69	0.34
1987	1.33	2.1	0.83	161	19	0.82	1.93	0.35
1988	1.29	2.1	0.80	138	17	0.99	2.2	0.44
1989	1.19	1.91	0.73	184	22	1.29	2.6	0.66
1990	1.06	1.70	0.65	386	46	1.56	2.9	0.85
1991	0.94	1.51	0.58	276	33	1.59	2.8	0.91
1992	0.89	1.44	0.55	309	37	1.50	2.5	0.89
1993	0.90	1.46	0.56	351	42	1.43	2.4	0.85
1994	0.92	1.48	0.57	353	42	1.42	2.4	0.85
1995	0.9	1.46	0.56	301	36	1.44	2.4	0.84
1996	0.86	1.39	0.54	210	25	1.47	2.5	0.85
1997	0.80	1.29	0.50	220	26	1.46	2.5	0.83
1998	0.76	1.22	0.47	164	20	1.37	2.4	0.78
1999	0.74	1.19	0.46	156	19	1.31	2.3	0.76
2000	0.74	1.2	0.46	193	23	1.29	2.2	0.77
2001	0.75	1.21	0.47	238	28	1.27	2.1	0.76
2002	0.78	1.25	0.48	215	18	1.09	1.88	0.64
2003	0.82	1.33	0.51	153	15	0.88	1.58	0.49
2004	0.88	1.42	0.54	147	9	0.75	1.38	0.41
2005	0.93	1.49	0.57	126	11	0.67	1.30	0.34
2006	0.97	1.57	0.60	117	12	0.72	1.31	0.40
2007	1.00	1.62	0.62	171	32	0.77	1.37	0.43
2008	0.96	1.56	0.60	140	7	0.69	1.31	0.36
2009	0.89	1.43	0.55	121	9	0.64	1.25	0.32

Year	Relative exploitable biomass			Landings tonnes	Discards tonnes	Relative fishing pressure		
	B/B _{MSY}	High	Low			F/F _{MSY}	High	Low
2010	0.85	1.36	0.52	97	11	0.63	1.24	0.32
2011	0.88	1.41	0.54	94	26	0.74	1.28	0.43
2012	0.97	1.56	0.60	195	23	0.70	1.22	0.40
2013	1.08	1.74	0.67	111	7	0.56	1.13	0.28
2014	1.17	1.89	0.73	122	15	0.64	1.17	0.35
2015	1.23	1.99	0.76	180	34	0.74	1.32	0.42
2016	1.25	2.0	0.77	191	19	0.77	1.40	0.43
2017	1.22	1.96	0.75	192	32	0.77	1.46	0.40
2018	1.16	1.87	0.72	153	23	0.82	1.54	0.43
2019	1.12	1.80	0.69	204	42	0.90	1.62	0.50
2020	1.11	1.80	0.69	202	13	0.88	1.68	0.46
2021	1.11	1.81	0.69					

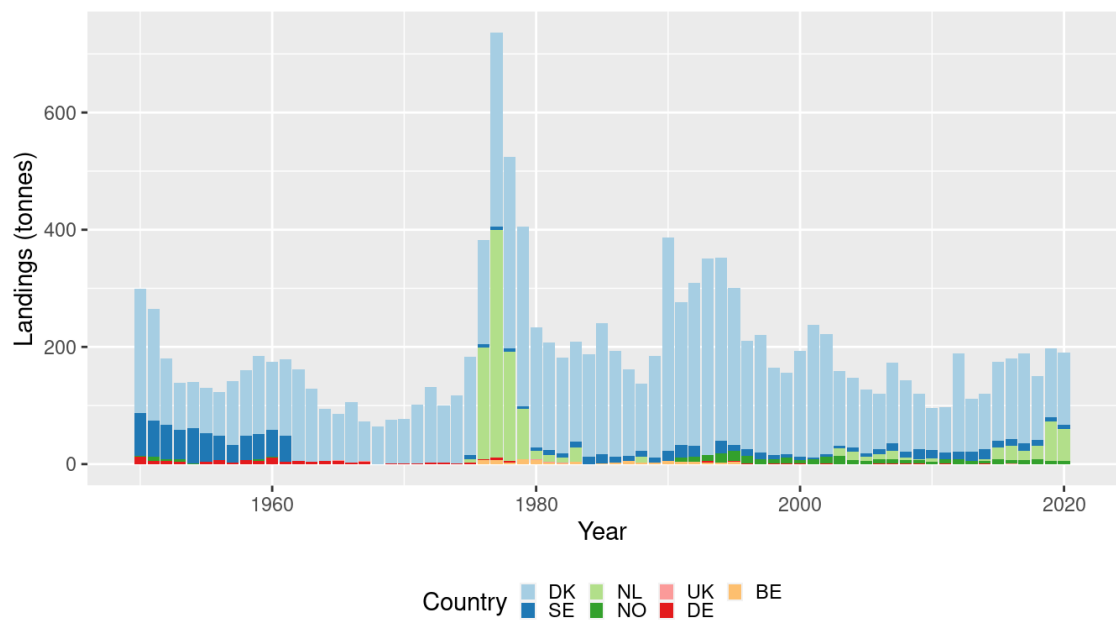


Figure 20.1. Turbot in 27.3a: Official landings by country from 1975 to 2020.

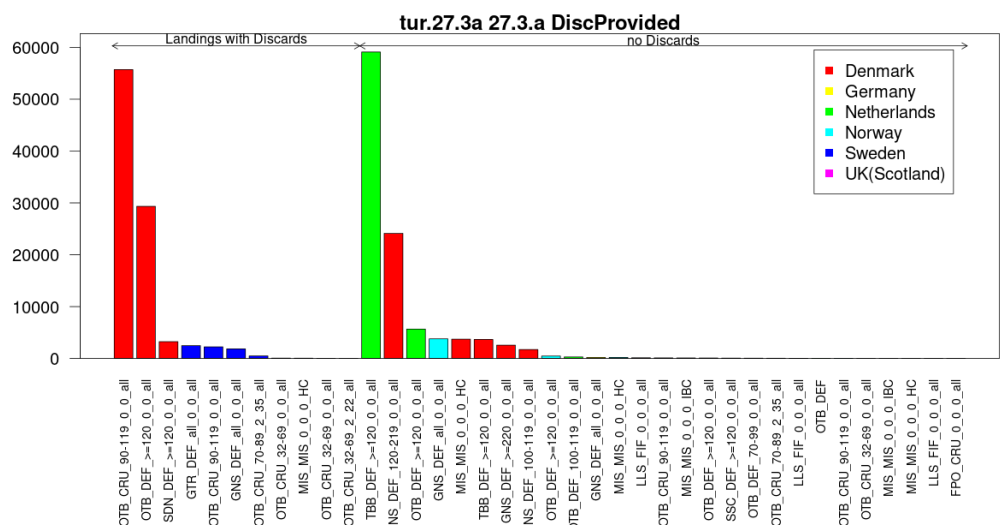


Figure 20.2. Turbot in 27.3a. Summary of the information provided to InterCatch for 2020. Landings by métier and country, distinguishing between strata with and without corresponding discard information provided.

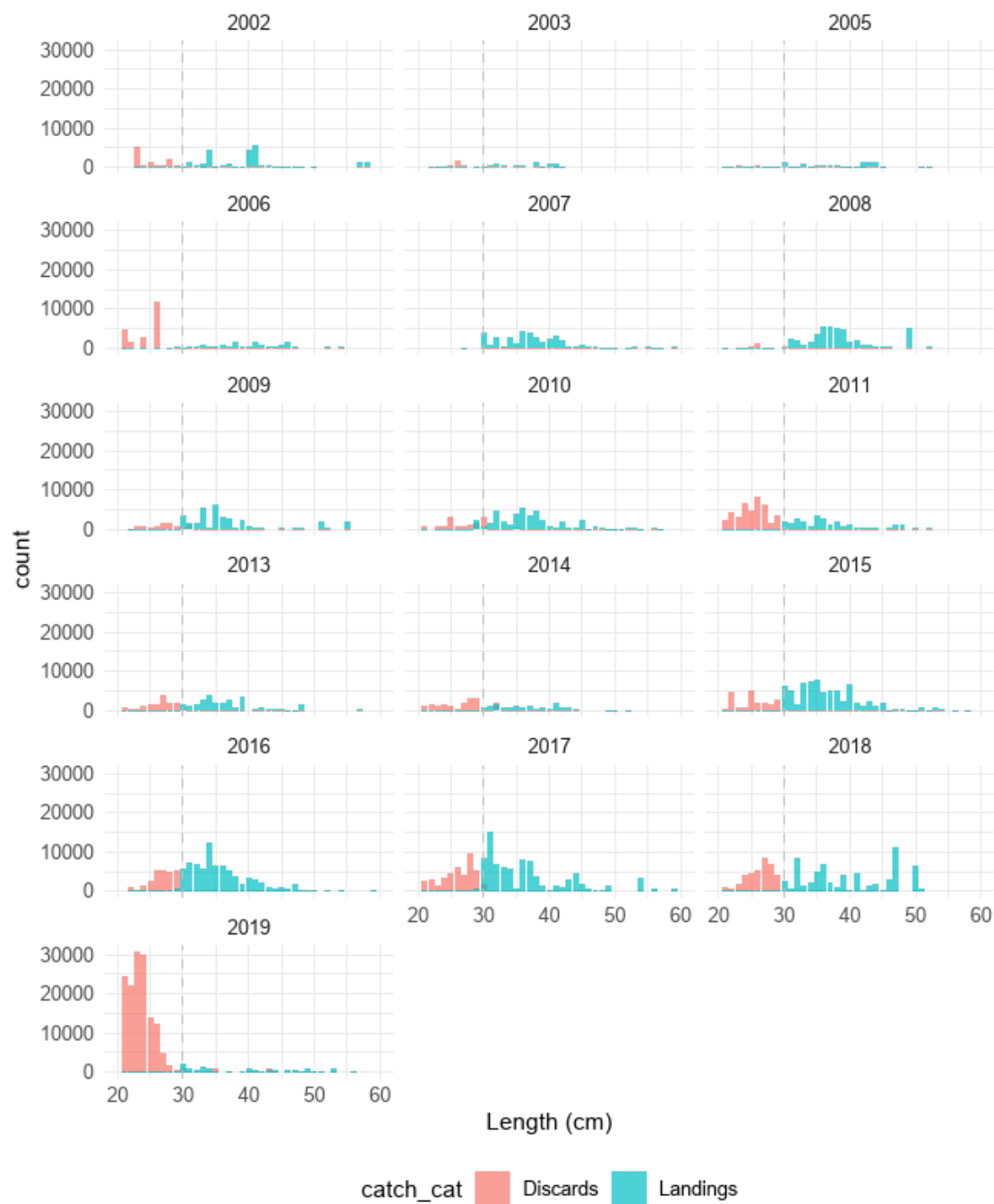


Figure 20.3. Turbot in 27.3a: Length distribution in landings and discards across 2002–2019. Most individuals below 30 cm are discarded (vertical dashed line).

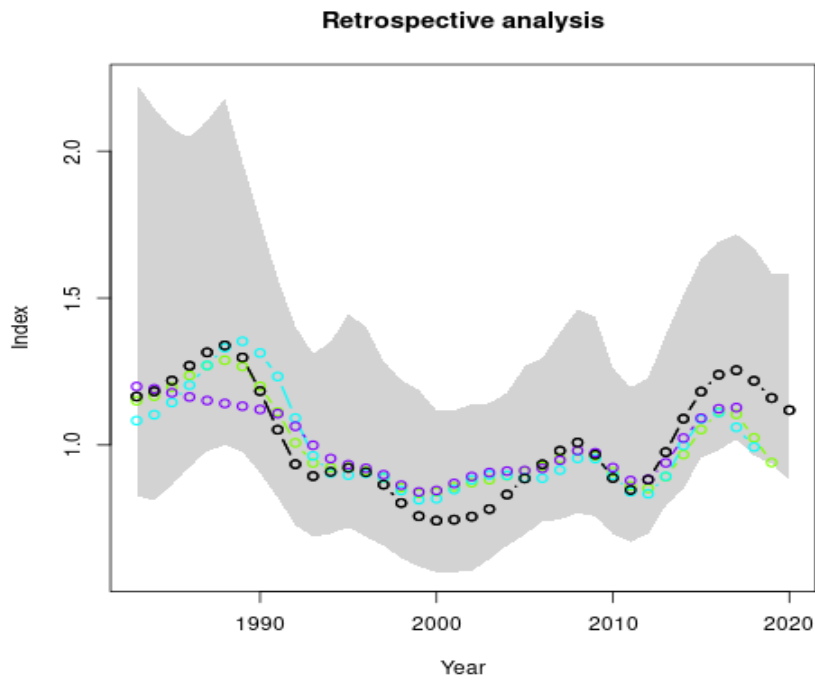


Figure 20.4. Turbot in 27.3a. Exploitable biomass survey index (black) and 3 retrospective fits (green, teal, purple). The shaded area shows 95% confidence intervals of the base run. The indices are rescaled to have mean 1.

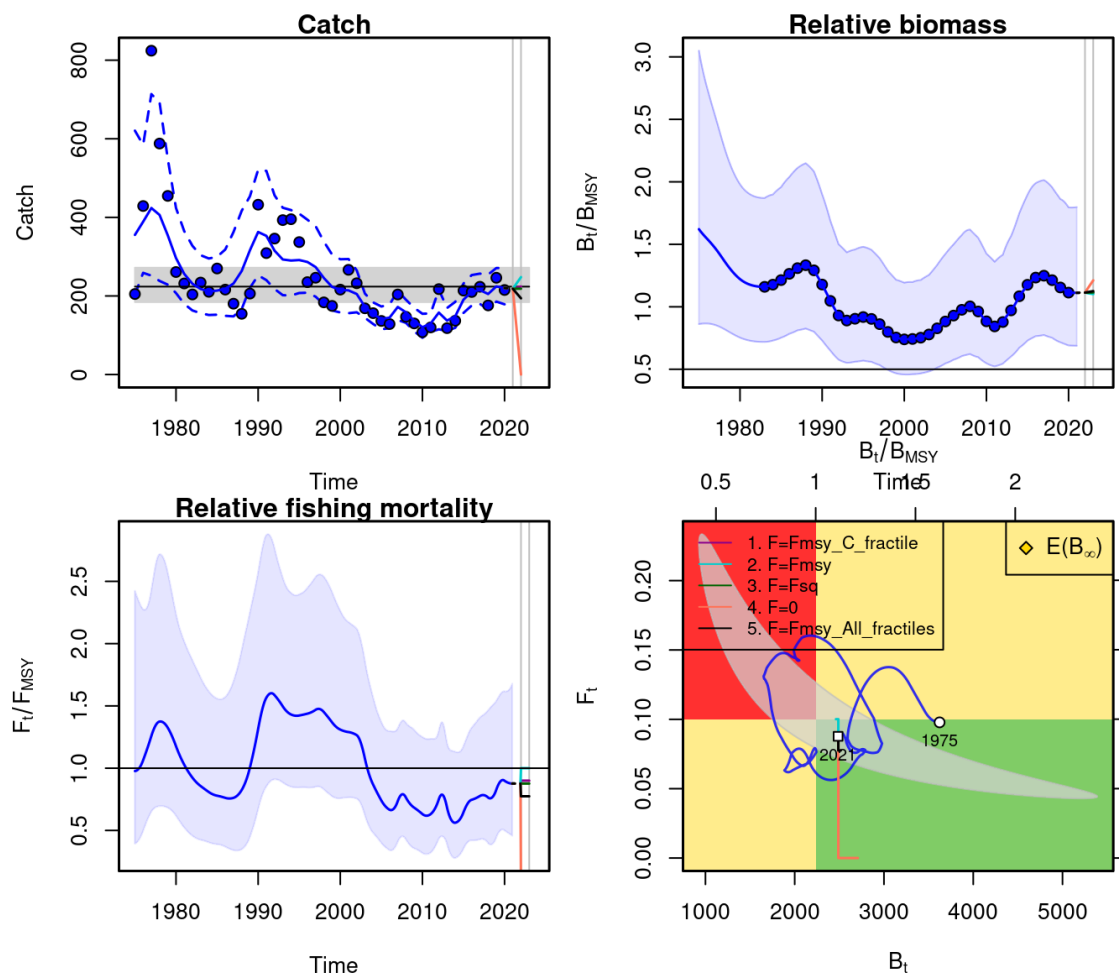


Figure 20.5. Turbot in 27.3a. SPiCT assessment running to the end of 2020, with 5 different short term forecast scenarios. The vertical grey lines in the catch, relative biomass and relative fishing mortality plots indicate the intermediate year (2021) and the horizontal lines show the corresponding reference points (MSY , $B/B_{MSY}=0.5$ and $F/F_{MSY}=1$). The shaded areas and dashed lines in all plots show 95% confidence intervals. The assessment is based on settings agreed upon during the benchmark (ICES, 2020).

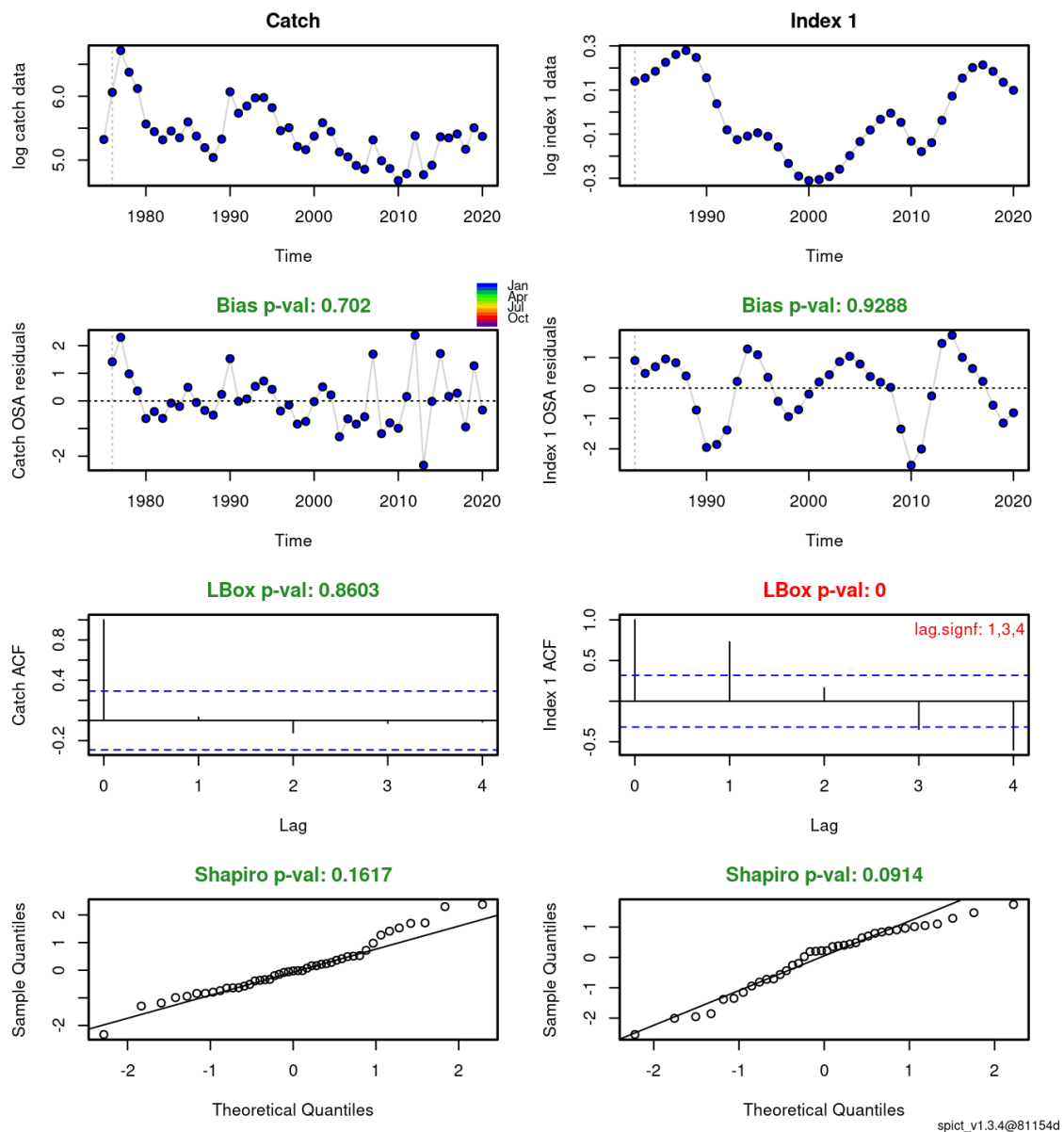


Figure 20.6. Turbot in 27.3a. Evaluation of SPiCT assessment running to the end of 2020. The residual diagnostics are shown for the two input time series (catch: left, exploitable biomass index: right). From the top to bottom it is shown: the log-transformed input time series, the one-step-ahead residuals with a bias test, the autocorrelation function with a Ljung-Box test, and a QQ-plot with a Shapiro test for normality. The application of the new exploitable biomass index via SPiCT indicated residual autocorrelation issues.

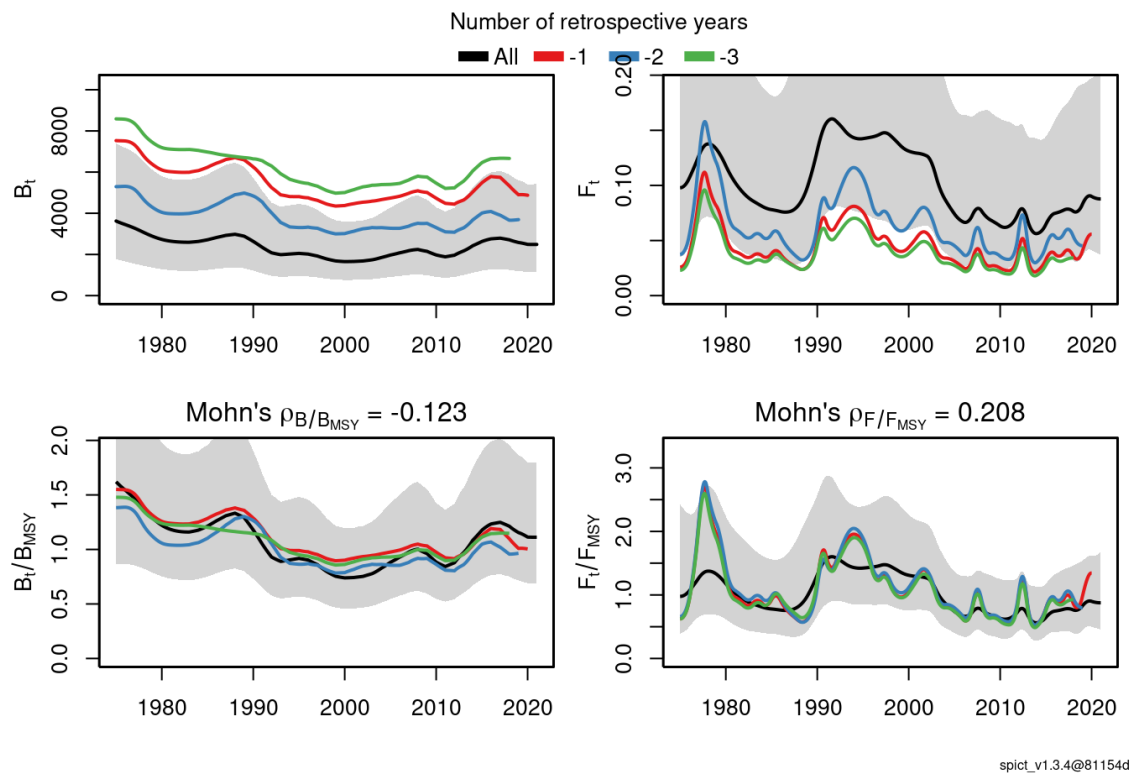


Figure 20.7. Turbot in 27.3a. Retrospective analysis showing the baseline (black lines) with 95% confidence intervals (shaded area) and 5 peels in different colours. The Mohn's rho for the relative quantities is shown on top of their corresponding panels.

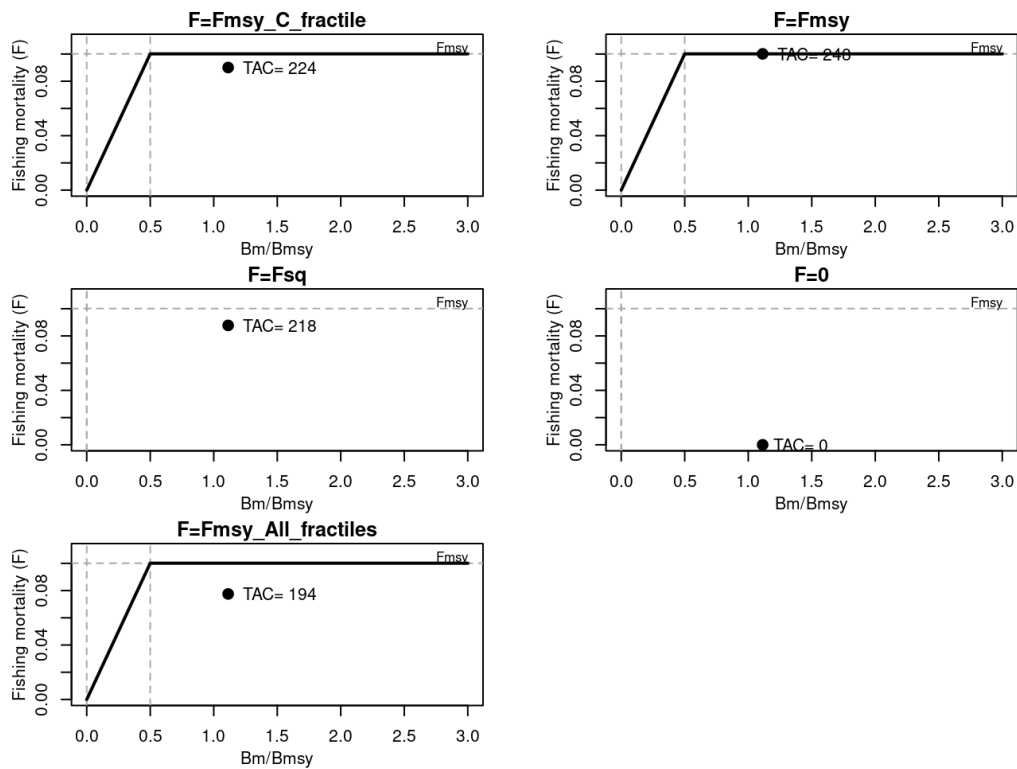


Figure 20.8. Turbot in 27.3a management scenarios. The solid line shows the harvest control rule for each scenario. Scenarios that are based on a specific fishing mortality ($F = F_{sq}$ and $F = 0$) do not have a HCR. The vertical lines show B_{lim} and $B_{trigger}$. The basis for the advice follows that recommendation of WKLife X (ICES, 2020) and is shown in the top left corner.

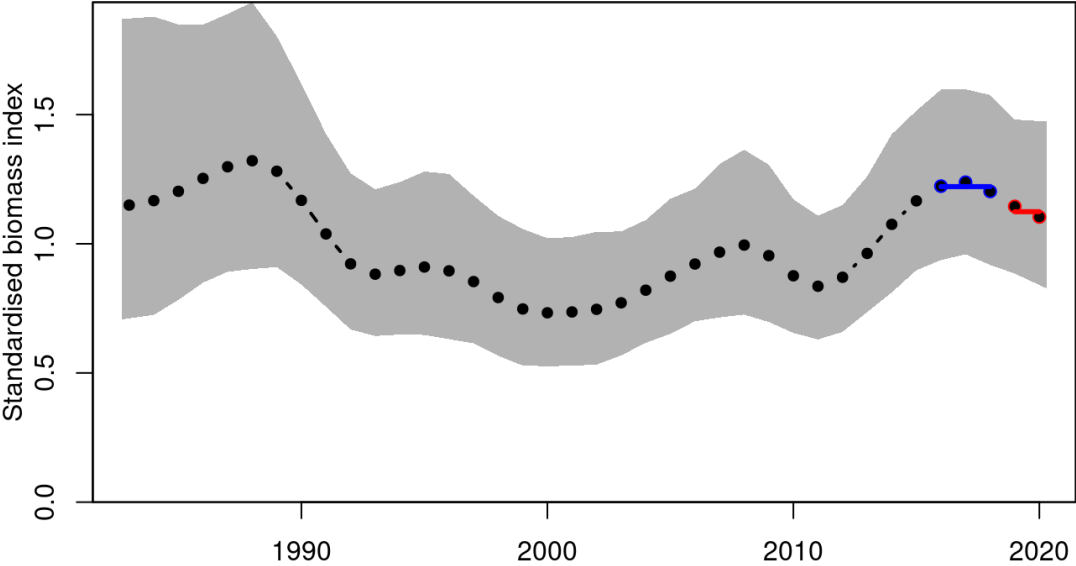


Figure 20.9. Turbot in 27.3a. Standardised exploitable biomass index. The average of the index in the last 2 and previous 3 years are shown horizontal lines in red and blue, respectively.

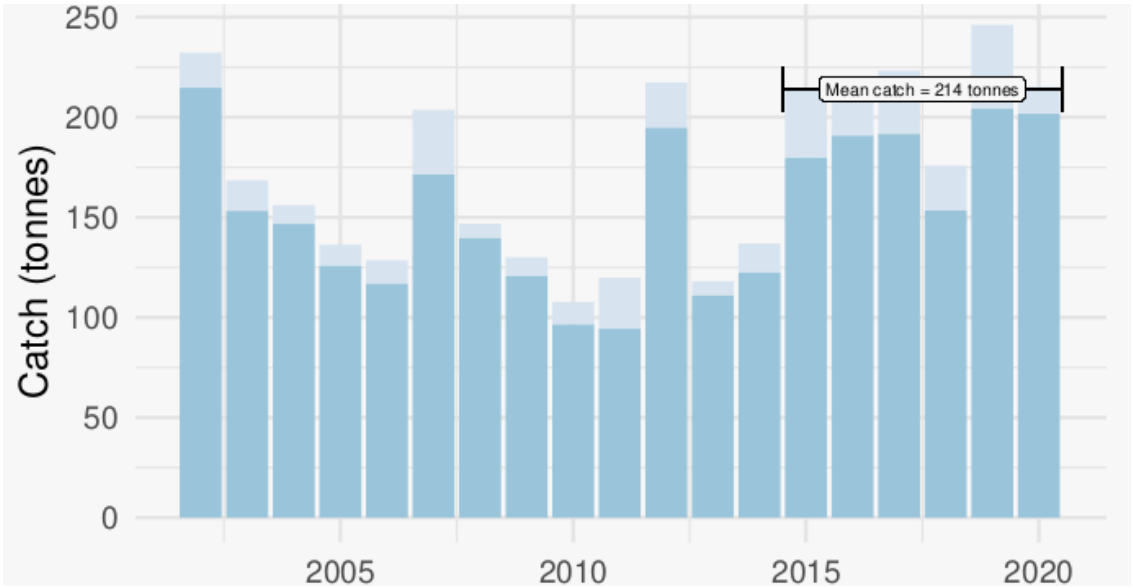


Figure 20.10. Turbot in 27.3a. Catch in 2002–2020 comprised of Intercatch landings (darker blue) and imported and raised discards (lighter blue). The mean catch in 2015–2020 is 214 tonnes; that could be used for basing a TAC advice with the 2/3 rule.