COMMON WHELK
Buccinum undatum

COMMERCIAL FISHING

Experimental fishing for whelk started in 1996 in the bay of Breiðafjörður where they fished 500 tonnes. The catch peaked the year after, reaching 1300 tonnes but has fluctuated since, ranging from 0 to 1000 tonnes. In 2019, 351 tonnes were landed, compared to 195 tonnes in 2018 (Figure 1). The catch depends highly on economic factors and the number of boats fishing each year. In 2020, no whelk fishery was active, and no whelk was landed. In 2021, the whelk fishery started again and in 2022, 291 tonnes were landed. The minimum landing size in the fishery is 50 mm. Discard mortality is believed to be minimal as the whelks are sorted in hydraulic drums. The selection in one of the drums used has been estimated, where L50 was 53.54 mm and selection range 4.2 mm. Landing of undersized whelk (<50 mm) is infrequent.

Since 2005, whelk has only been fished in whelk pots and in 2006, five boats took part in the whelk fishery. In recent years, only one boat has been active in the fishery.

The CPUE (kilogrammes per pot) has fluctuated between years and was highest in 2003 when it reached 4.8 kg/pot. Since then, the CPUE decreased steadily, but since 2017, it has been increasing. As the CPUE does not reflect the abundance or changes in stock size (the CPUE does not account for difference in fishing effort between spatial and temporal fishing patterns), the CPUE was standardized by applying month and area factors with a Generalized Linear Model (GLM).

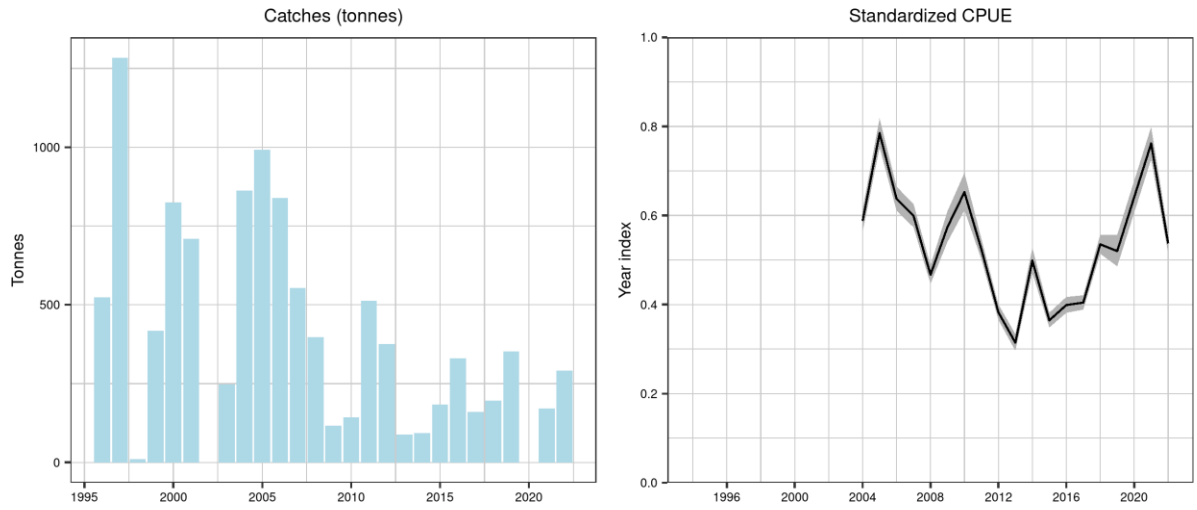

Figure 1. Common whelk. Total catch (tonnes) and standardized catch per unit effort in Breiðafjörður

In 2021, only one boat was active in the fishery and the total catch was 171 tonnes. In 2022, catches increased and were 291 tonnes. The fishery was mainly in southern part of the fjord, but the distribution pattern has varied over time. In 2013 and 2014, there was little fishing activity in the whole area, compared to 2011 and 2012 (Figure 2). In 2014 to 2016 the fishing was mainly active in the southern areas of the fjord, but the fishery distributed to the north in the following years. However, in 2021 and 2022 most of the catch is in the south (Figure 3) and fishing mainly took place in June-September (Figure 4). No fishing was conducted in 2020.

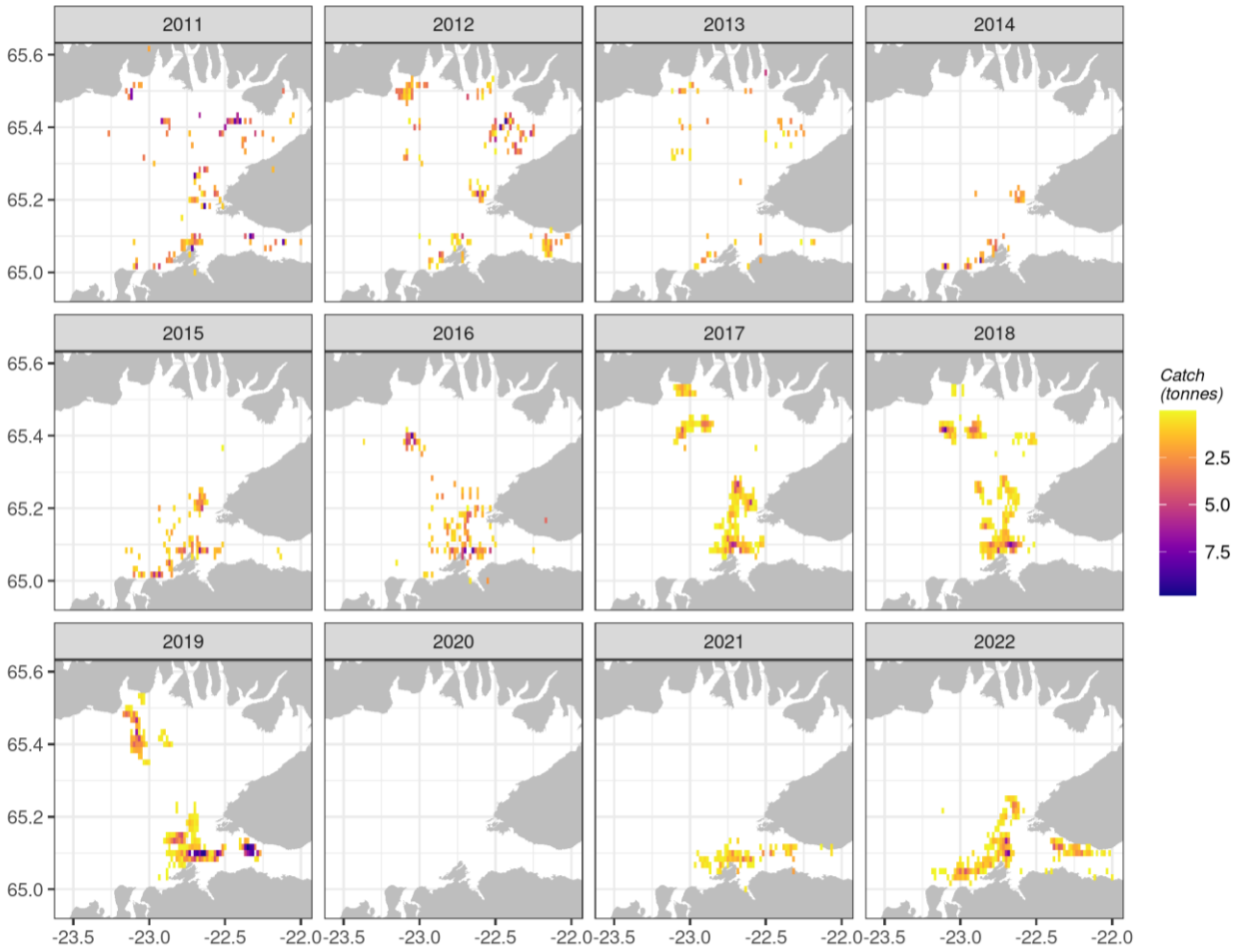

Figure 2. Common whelk. Distribution of catch in Breiðafjörður from 2011-2022.

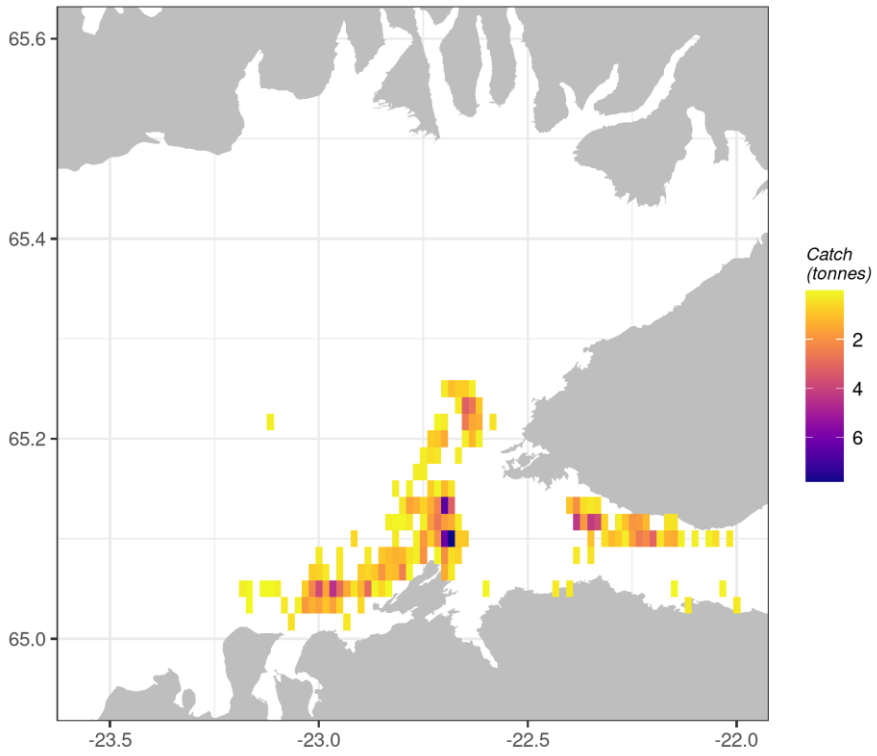

Figure 3. Common whelk. Distribution of catches (tonnes) in 2022.

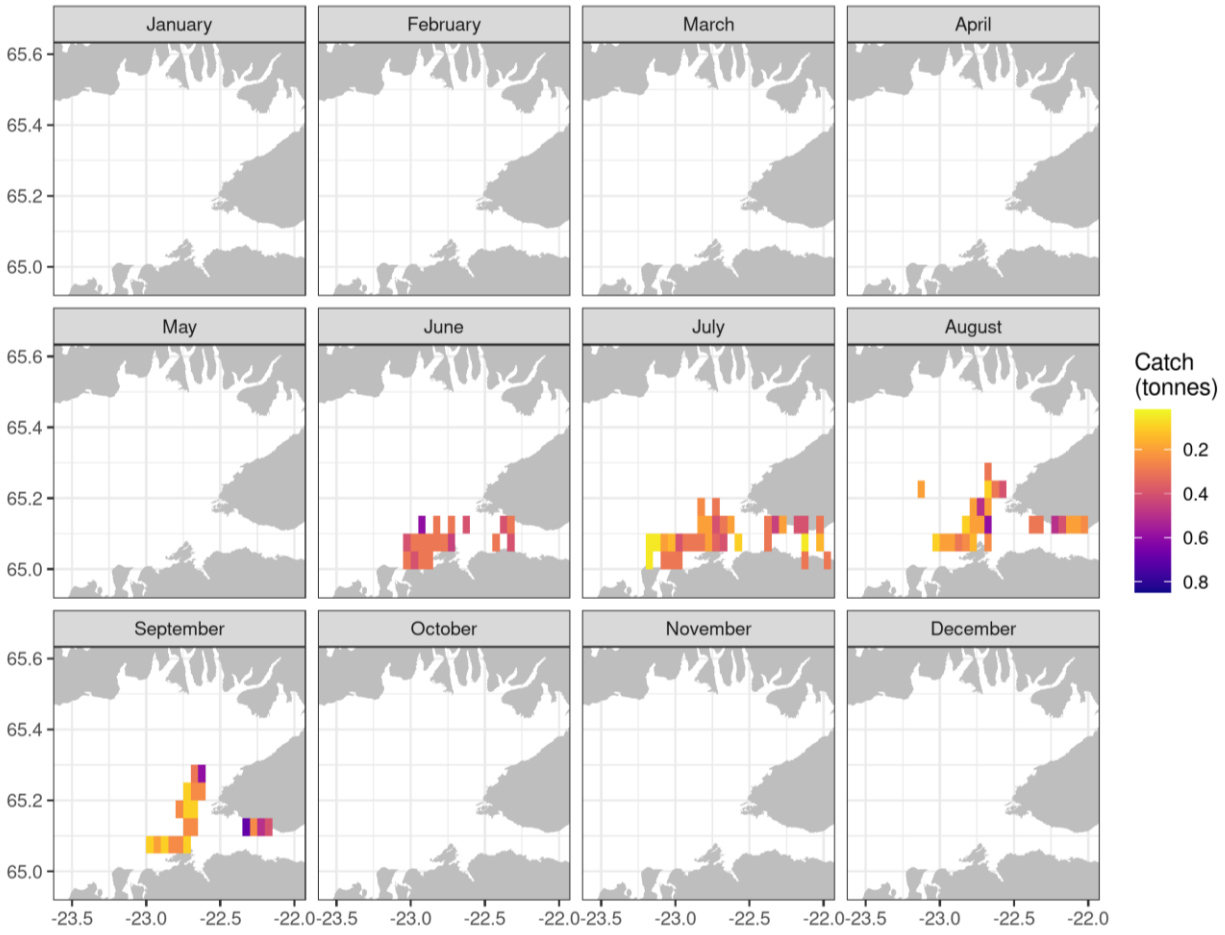

Figure 4. Common whelk. Distribution of catches (tonnes) by months in 2022. .

WHELK SURVEY

Two whelk surveys have been conducted in Breiðafjörður: in 1997/1998 during the first years of fishing and in 2012 (Figure 5). The survey index in 1997/1998 was 26.9 compared to 23.7 in 2012. The greatest decline between the surveys was in northwestern part of the fjord where negligible fishing had occurred. In contrast, there was a marked increase in whelk on fishing grounds in eastern area of the fjord between the surveys (Figure 5).

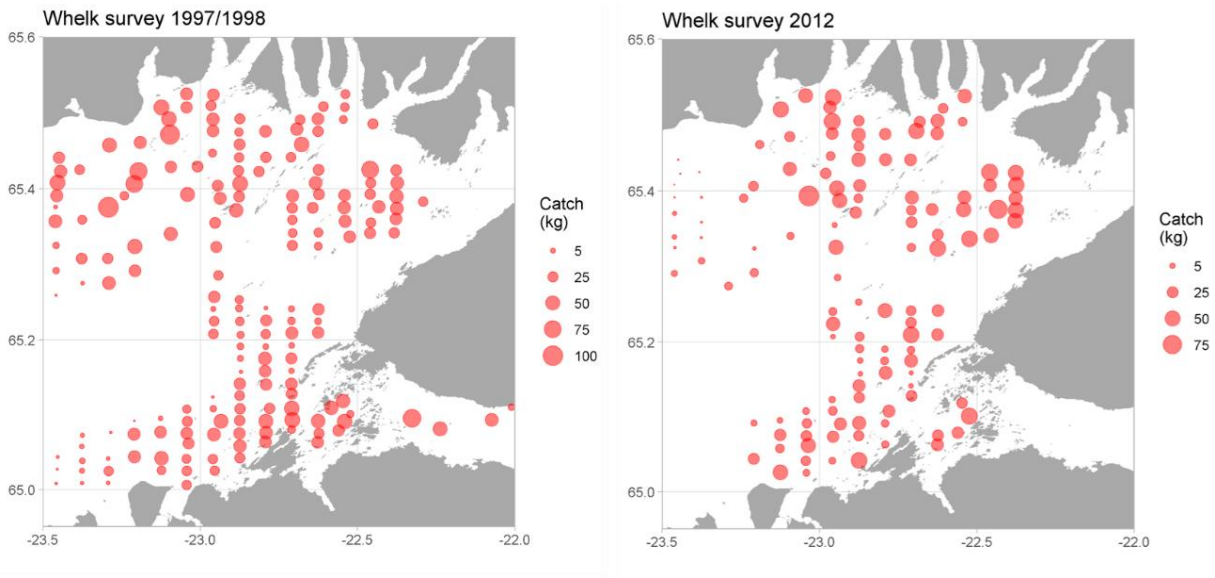

Figure 5. Common whelk. Distribution and abundance in surveys in 1997/1998 (left) and in 2012 (right).

MANAGEMENT CONSIDERATIONS

The MRI advice for whelk in 1999 to 2001 was that effort should be no more than the effort in 1997 when landings were 1287 tonnes. In the advice in 2007 it was stated that the sustainable catch level for whelk was between 800 and 1000 tonnes but there was great uncertainty about this estimate. In the advice in 2008 to 2011 there was no mention of possible magnitude of sustainable catches.

In 2012 MRI advised catches of 750 tonnes of whelk from Breiðafjörður which was unchanged until 2017. The basis of the advice was the average of annual catches during the last decade in the southern part of Breiðafjörður of 450 tonnes and additionally 300 tonnes in the northern part. In 2017 the advice is lowered to 500 tonnes for the whole of Breiðafjörður and the same advice is released in 2018. In this period (2012-2018) landed catches never exceeded 375 tonnes, therefore the advice was always more than realised catches and therefore fishing was in effect not constrained by the advice.

The advice in 2019 was based on changes in commercial CPUE (unstandardized). CPUE was relatively stable between 1996 to 2005 (Table 1) but decreased steadily to 1/3 in 2013 of the CPUE in period 1996-2005. During the decline catches of whelk where on average around 450 tonnes. It is therefore clear that fishing mortality was higher than could be sustained by whelk in Breiðafjörður. In the period between 2013 to 2018 CPUE increased again at the same time catches where on average around 190 tonnes. It can therefore be concluded that previous advice between 500 and 750 tonnes was more than the stock could sustain.

STOCK ASSESSMENT

The common whelk is considered a data limited stock and follows the ICES framework for such (category 3.1, ICES 2021). A stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017) is one of the official assessment methods for stocks in this category. The model quantifies observation and process errors and estimates stock status and reference levels with associated confidence intervals. SPiCT estimates MSY based reference levels, which can be used to calculate quantities relevant for fisheries management and ICES recommends using the 35th percentile for all quantities (Mildenberger et al., 2021)

INPUT DATA

The model synthesizes information from input priors (Woods and Jónasson 2017), catch series and biomass indices (generalized CPUE´s) from 2004-2022. The priors were made by consolidating and utilizing a variety of demographic (age-at-maturity, length-at-age, length-weight keys and length histograms) and environmental data from Breiðafjörður (See Woods and Jónasson 2017 for more details).

Priors used for the model were the carrying capacity, $\bar{K}$, intrinsic growth rate, $\bar{r}$, the medium initial biomass depletion, $\bar{P}$, the standard deviation of fishing mortality process, *sdf*, and the standard deviation of catch observation error, *sfd* (Table 1). The n is fixed at 2 to resemble the Schaefer production curve.

Table 1. Common whelk. Priors in model.

Priors	Value	Standard deviation
$\bar{K}$	log(18500)	0.0925
$\bar{r}$	log(0.075)	0.034
$\bar{P}$	log(0.467)	0.010
sdf	log(0.3)	0.25
sdc	log(0.1)	0.01

RESULTS

The output from the model is shown below in table 2 and 3. Model diagnostics are shown in Figure 6, the model results in Figure 7 and the analytical retrospective analysis in Figure 8. Following the checklist for the acceptance of SPiCT model (Mildenberger et al., 2021), no issues were found. The assessment converged and all variance parameters of the model parameters are finite. There were no violations of model assumptions based on one-step ahead residuals, the production curve is realistic (B/K = 0.5) (Figure 6) and the patterns in the retrospective analysis are consistent (Figure 8). The mohn´s rho value for F/F_{MSY} is 0.521 as there is uncertainty in catches due to no fishing in 2020 and therefore, the analytical retro should improve in future stock assessments. B_{MSY} is estimated at 8.9 kt.

Table 2. Common whelk. Summary of model results.

	Estimate	95% upper CI	95% lower CI
alpha	1.6172	6.48181	0.43347
beta	0.1044	0.18053	0.06043
r	0.07624	0.10779	0.05390
rc	0.07624	0.10779	0.05390
rold	0.07624	0.10779	0.05390
m	338.686	587.611	195.211
k	17773.1	29247.2	10800.4
q	0.00008	0.00015	0.00004
sdb	0.09415	0.25728	0.03445
sdf	0.94795	1.38744	0.64767
sdi	0.15782	0.26339	0.09456
sdc	0.09901	0.14592	0.06718

Table 3. Common whelk. Summary of model results. Estimates for deterministic reference points and stochastic reference points.

Reference points	Estimate	95% upper CI	95%
B_{MSY}	8886.56	14623.6	5400.24
F_{MSY}	0.03811	0.05389	0.02695
MSY	338.686	587.611	195.211

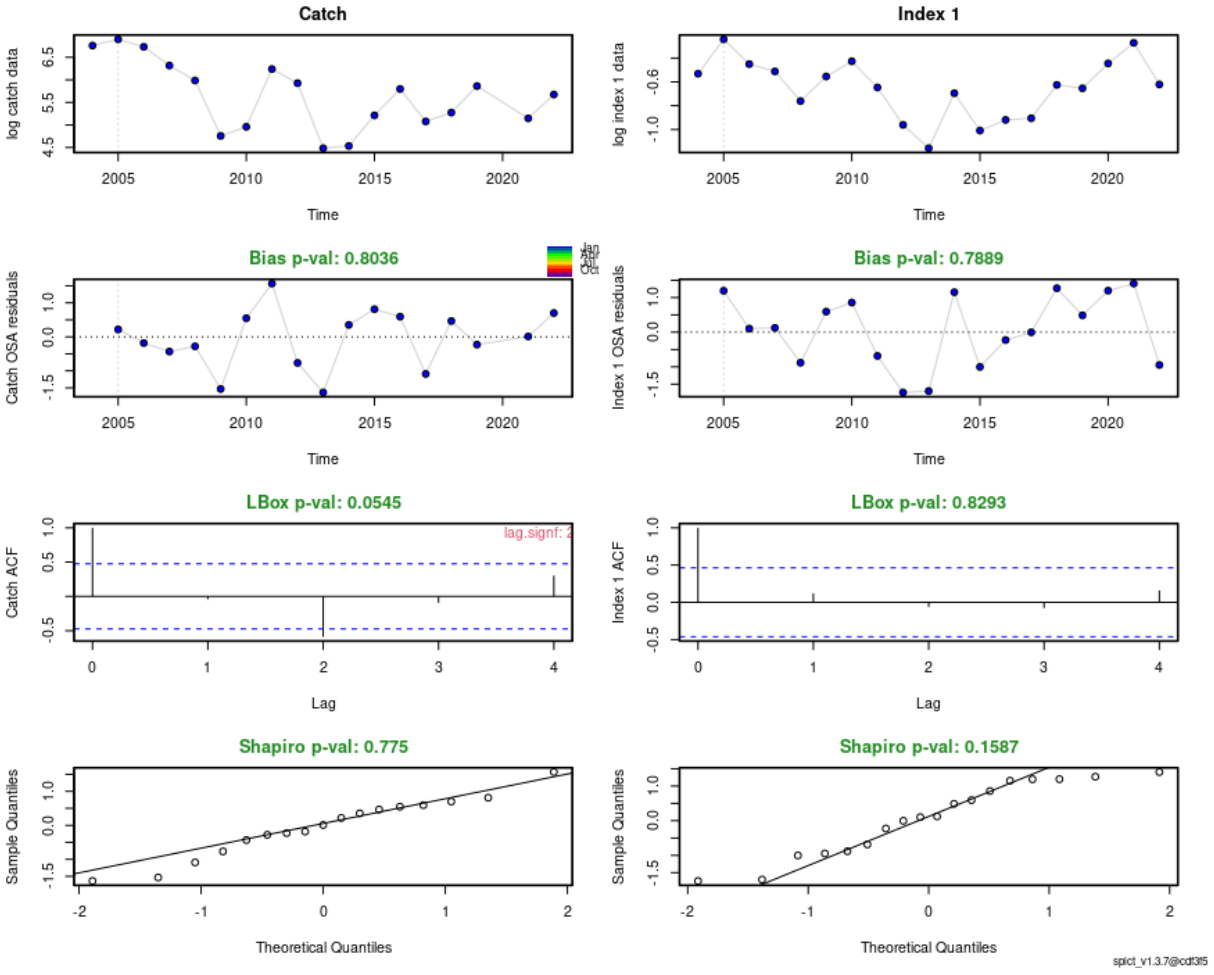

Figure 6. Common whelk. SPiCT-model diagnostics.

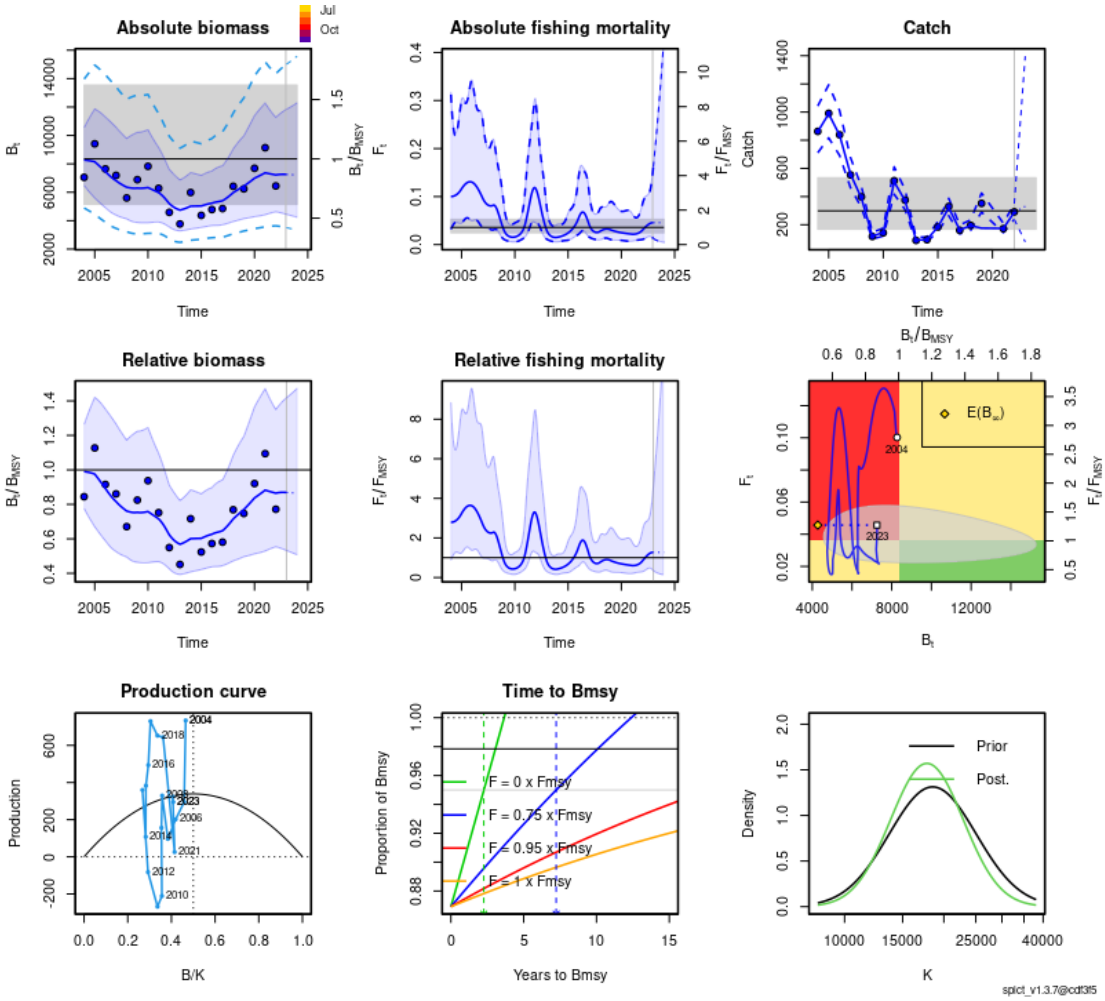

Figure 7. Common whelk. SPiCT-model results.

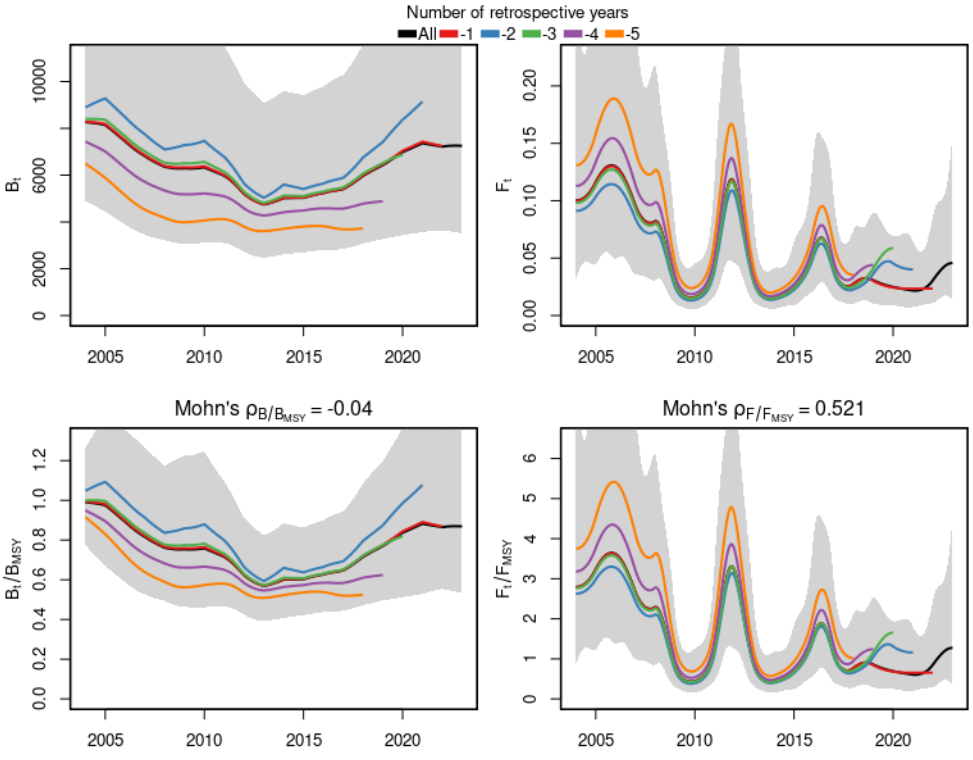

Figure 8. Common whelk. Analytical retrospective analysis from the SPiCT-model.

Table 4. Common whelk. Recommended TAC in Breiðafjörður, total landings, a standardized CPUE index and CPUE (kg per pot).

YEAR / FISHING YEAR	ADVICE	LANDINGS	CPUE INDEX[1)]	CPUE[1)]
1996	-	500	-	4.3
1997	-	1 284	-	2.7
1998	-	10	-	3.5
1999	-	417	-	3.3
2000	-	825	-	3.7
2001	-	709	-	3.6
2002	-	0	-	-
2003	-	248	1.00	4.8
2004	-	869	0.59	3.0
2005	-	991	0.78	4.0
2006	-	839	0.63	2.9
2007	-	554	0.60	2.9
2008	-	398	0.46	1.9
2009	-	116	0.57	2.6
2010	-	142	0.65	3.2
2011	-	512	0.52	2.6
2012/13	750	269	0.38	1.7
2013/14	750	0.1	0.31	1.1
2014/15	750	166	0.50	2.3
2015/16	750	332	0.36	1.4
2016/17	750	186	0.39	1.6
2017/18	500	171	0.40	2.0
2018/19	500	324	0.56	2.6
2019/20	220	133	0.52	2.3
2020/21	264	88	0.64[2]	-
2021/22	264	172	0.76	3.6
2022/23	254		0.53	2.9

1) Calendar year

2) Average of 2019 and 2021

Table 5. Common whelk. Estimates of B/Bmsy and F/Fmsy with 95% confidence intervals from the SPiCT model.

Year	95% lower CI	B/B_{msy}	95% upper CI	95% lower CI	F/F_{msy}	95% upper CI
2004	0.7767531	0.9905791	1.2632676	0.8813192	2.7920733	8.845459
2005	0.6697290	0.9754507	1.4207298	1.2419477	3.2364932	8.434243
2006	0.5886670	0.8925098	1.3531823	1.3728764	3.6145789	9.516648
2007	0.5262105	0.8164898	1.2668991	0.9926100	2.6677680	7.169972
2008	0.4944790	0.7610613	1.1713628	0.8584535	2.2909256	6.113715
2009	0.4642972	0.7539335	1.2242497	0.2966580	0.8026449	2.171655
2010	0.4614418	0.7583367	1.2462560	0.1567646	0.4445858	1.260849
2011	0.4671058	0.7156382	1.0964069	0.4706522	1.2700184	3.427046
2012	0.4258565	0.6230689	0.9116097	1.2457639	3.2014304	8.227206
2013	0.3933604	0.5688431	0.8226106	0.3070203	0.8192802	2.186240
2014	0.4084098	0.6010574	0.8845772	0.1551965	0.4286369	1.183852
2015	0.4220603	0.6027445	0.8607796	0.2492277	0.6771091	1.839590
2016	0.4376582	0.6265586	0.8969916	0.5921795	1.5600542	4.109851
2017	0.4448574	0.6474269	0.9422383	0.4221493	1.1175702	2.958582
2018	0.4717931	0.7153066	1.0845081	0.2802518	0.7707524	2.119734
2019	0.4967095	0.7703203	1.1946487	0.2912380	0.8568629	2.521011
2020	0.5132530	0.8371788	1.3655414	0.2468460	0.6922087	1.941101
2021	0.5293370	0.8824527	1.4711286	0.2031610	0.6064214	1.810125
2022	0.5538946	0.8647019	1.3499126	0.2986411	0.8526124	2.434186
2023	0.5325202	0.8689118	1.4178012	0.3538097	1.2720357	4.573291
2024	0.5075531	0.8646532	1.4729990	0.1332746	1.2720404	12.141001

DIAGNOSTICS OF INDICES

Table 6. Analysis of deviance table. Response variable is square root of catch per unit effort (CPUE).

	df	deviance	resid. df	resid. dev	f	pr(>f)
NULL			4414	669.64		
factor(Year)	18	248.441	4396	421.20	154.657	< 2.2e-16 ***
factor(Month)	11	19.655	4385	401.55	20.021	< 2.2e-16 ***
factor(Area)	6	10.743	4379	390.80	20.063	< 2.2e-16 ***

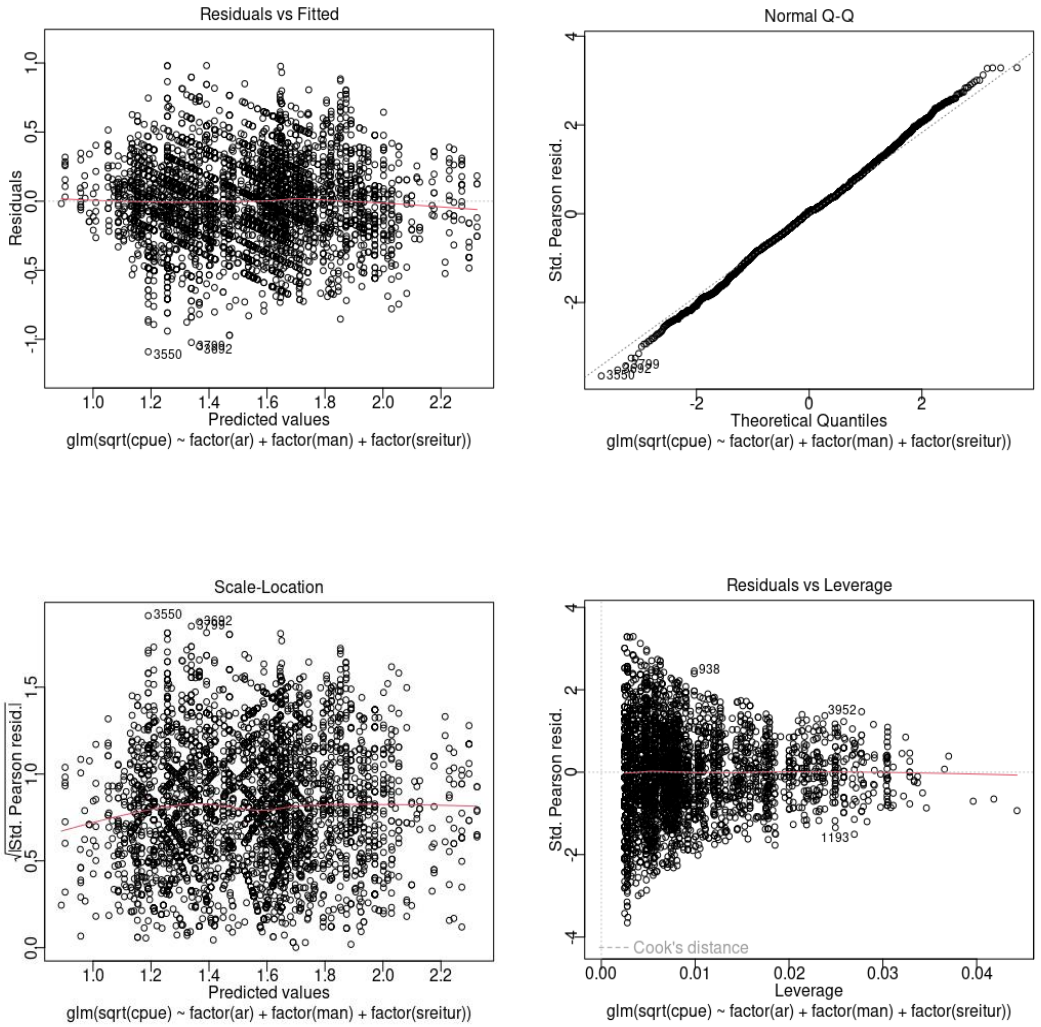

Figure 6. Common whelk. Diagnostics plots from the Generalized linear model (glm).

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