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Draft Statistical CPUE standardizations for selected SESSF species (data to 2022)

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Australian Fisheries Management Authority

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Commercial in confidence

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Introduction

Commercial catch-per-unit-effort (CPUE) data are used in many fishery stock assessments in Australia as an index of relative abundance. This assumes there is a direct relationship between CPUE and exploitable biomass. However, many other factors can influence CPUE, including vessel, gear, depth, season, area and time of fishing (e.g., day or night). The use of CPUE as an index of relative abundance requires the removal of the effects of variation due to changes in these factors on the assumption that what remains will provide a better estimate of the underlying biomass dynamics. This process of adjusting the time series for the effects of other factors is known as standardization and the accepted way of doing this is to use statistical modelling procedures that focus attention on the annual average CPUE adjusted for the variation in the averages brought about by all the other factors identified. The diversity of species and methods in the Southern and Eastern Scalefish and Shark Fishery (SESSF) means that each fishery/stock for which standardized catch rates are required entails its own set of conditions and selection of data. This report updates standardized CPUE indices (based on data to 2022 inclusive) for 47 (non-shark) species-stocks combinations within Australia's SESSF.

The Limits of Standardization

The use of commercial CPUE as an index of the relative abundance of exploitable biomass can be misleading when there are factors that significantly influence CPUE but cannot be accounted for in a generalized linear model (GLM) standardization analysis. Over the last two decades there have been various major management interventions in the SESSF including the introduction of the quota management system in 1992 and that of the Harvest Strategy Policy (HSP) and associated structural adjustment in 2005 – 2007. The combination of limited quotas and the HSP is now controlling catches in such a way that many fishers have been altering their fishing behaviour to account for the availability of quota and their own access to quota needed to land the species taken in the mixed species SESSF.

There may be situations where fishers report the need to avoid catching certain species, to avoid having to discard and to stay within the bounds of their own quota holdings. Such influences on CPUE would tend to bias CPUE downwards, or at very least add noise to any CPUE signal, which could lead to misinformation passing to any assessment. Currently, there is no way to handle this issue, but care needs to be taken not to provide incorrectly conservative advice or inappropriately high catch targets. Included in the management changes is the ongoing introduction of numerous area closures imposed for a range of different reasons.

Methods

CPUE Standardization

Preliminary Data Selection

The methods used when standardizing commercial catch and effort data in the SESSF continue to be discussed in the Commonwealth stock assessment Resource Assessment Groups (RAGs) because the CPUE time series (and associated standardized indices) are very influential in many of the assessments. Data were initially selected from the ORACLE database by CAAB code to obtain all data relating to a given species. Then selections were made using R (R Core Team, 2022) with respect to fishery (e.g., SET, GHT, GAB, etc.), within a specified depth range and method (e.g., trawl, auto-line, Danish seine etc.) in specified statistical zones (e.g., Figure 1) within the years specified for each analysis.

General Linear Modelling

In each case, CPUE, generally as kilograms per hour fished (though sometimes as catch per shot e.g., School Whiting caught by Danish seine, or catch-per-hook for Blue-eye Trevalla), were natural log-transformed. A General Linear Model was used rather than using a Generalized Linear Model with a log-link; this has advantages in terms of normalizing the data while stabilizing the variance, which the Generalized Linear Model approach does not always achieve appropriately (Venables and Dichmont 2004). This relatively simple analytical approach means that the exact same methods can be applied to all species in a relatively robust manner. The statistical models were variants on the form: Ln(CPUE) = Year + Vessel + Month + Depth Category + Zone + DayNight. In addition, there were interaction terms which could sometimes be fitted, such as Month:Zone and/or Month:DepthCategory. Thus, the CPUE, conditioned on positive catches of the species of interest, was statistically modelled with a normal GLM on log-transformed CPUE data:

$$Ln(CPUE_i) = \alpha_0 + \alpha_1 x_{i,1} + \alpha_2 x_{i,2} + \sum_{j=3}^{N} \alpha_j x_{i,j} + \varepsilon_i$$

where Ln($CPUE_i$) is the natural logarithm of the CPUE (usually kg/hr, but sometimes kg/shot) for the *i*-th shot, x_{ij} are the values of the explanatory variables j for the *i*-th shot and the α_j are the coefficients for the N factors j to be estimated (where α_0 is the intercept, α_1 is the coefficient for the first factor, etc.).

The Mean Year Estimates

For the lognormal model the expected back-transformed year effect involves a bias-correction to account for the log-normality; this then focuses on the mean of the distribution rather than the median:

$$CPUE_t = e^{(\gamma_t + \sigma_t^2/2)}$$

where γ_t is the Year coefficient for year *t* and σ_t is the standard deviation of the log transformed data (obtained from the analysis). The year coefficients were all divided by the average of all the Year coefficients to simplify the visual comparison of CPUE changes.

$$CE_t = \frac{CPUE_t}{(\sum CPUE_t)/n}$$

where $CPUE_t$ is the yearly coefficients from the standardization, ($\sum CPUE_t$)/*n* is the arithmetic average of the yearly coefficients, *n* is the number of years of observations, and CE_t is the final time series of yearly index of relative abundance.

Model Development and Selection

In each case an array of statistical models are fitted sequentially to the available data, with the order of the non-interaction terms being determined by the relative contribution of each term to model fit.

This sequential development of the standardization models for each species simplifies the search for the optimum model and requires a consideration of different performance statistics such as the AIC (Akaike's Information Criterion, the smaller the better; Burnham and Anderson, 2002) or adjusted R^2 (the larger the better; Neter et al., 1996). In addition, the examination of the various diagnostic plots and tables allows for an improved interpretation of the observed trends.

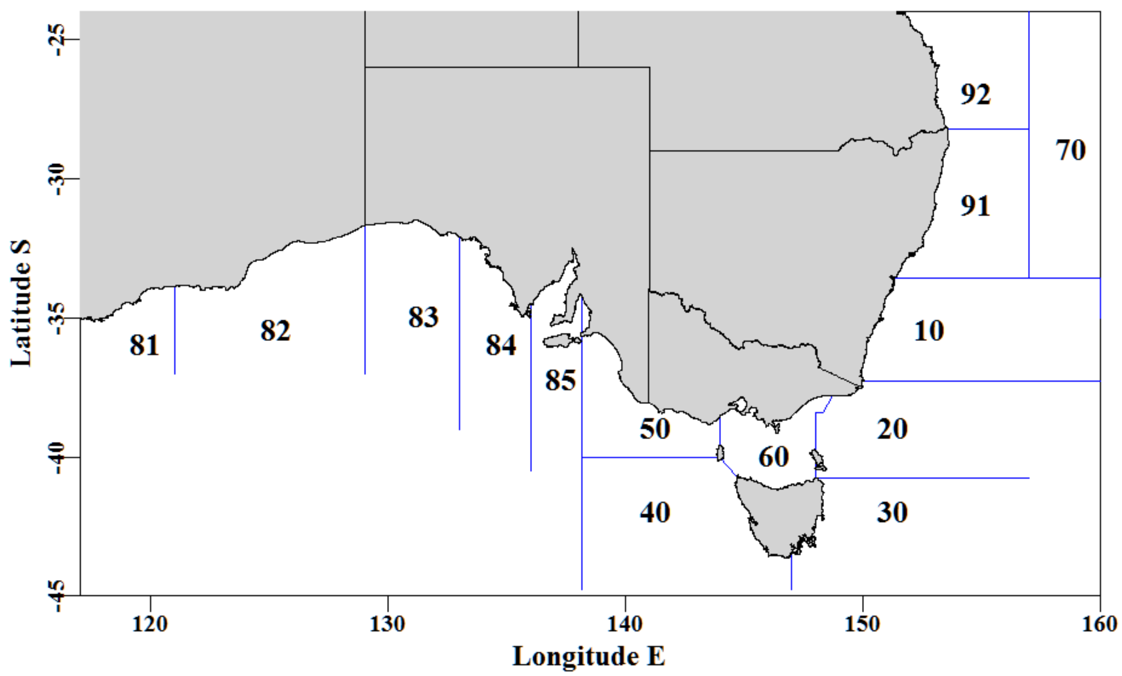

Figure 1: The statistical reporting zones in the SESSF.

John Dory 10 - 20

John Dory (DOJ– 37264004 – *Zeus faber*) have been primarily caught by trawl in zones 10 and 20 between the years 1986 - 2022. Small catches have also been recorded by gillnet and Danish seine. Initial data selection was based on criteria provided in Table 1 from the Commonwealth logbook database. A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

A significant proportion of shots each year were < 30 kg, which suggests this is rarely a targeted species, has low availability or there are high levels of small fish (Figure 3).

The terms Year, Vessel and DayNight had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 5). The qqplot suggests the assumed Normal distribution is valid, with small deviations at the upper tail of the distribution (Figure 5).

Standardized CPUE has been below the long-term average since 1997. Also, there has been a gradually declining trend since at least 1996, with a small increase in CPUE in the last three years relative to 2019, but with a marked increase in the 2022 CPUE (Figure 2). The total catch in 2022 was the lowest in the series.

Action Items and Issues

A potential change in fishing behaviour is suggested to have occurred since about 2014, which is evidenced by changes in the distribution of log-transformed CPUE each year. From 2014 a number of widely spread spikes in the histograms have become apparent, especially between 2015 and 2021. The underlying driver for these changes is not immediately apparent.

Table 1: JohnDory1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	JohnDory1020
csirocode	37264004
fishery	SET
depthrange	0 - 200
depthclass	20
zones	10, 20
methods	TW, TDO, TMO, OTT, OTB, OTM
years	1986 - 2022

Table 2: JohnDory1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	231.7	6414	202.1	90	12.1	1.9053	0.000	66.553	0.329
1987	206.1	4638	180.9	78	14.5	2.2038	0.021	43.254	0.239
1988	182.0	4532	161.2	73	13.5	2.0341	0.021	45.311	0.281
1989	217.9	4786	186.9	70	14.2	2.2275	0.021	49.093	0.263
1990	167.9	3674	135.7	60	13.0	2.0297	0.023	39.868	0.294
1991	172.3	4009	125.4	53	11.9	1.6111	0.023	43.685	0.348
1992	130.8	3889	107.9	49	9.6	1.3642	0.023	42.937	0.398
1993	240.4	5353	179.1	55	11.6	1.7168	0.022	57.555	0.321
1994	267.9	6505	207.7	55	11.1	1.6229	0.021	72.298	0.348
1995	185.7	6033	167.1	52	10.1	1.3779	0.021	68.473	0.410
1996	160.8	6339	145.0	58	8.4	1.0807	0.021	67.184	0.463
1997	87.8	4386	77.9	60	6.2	0.8359	0.023	43.209	0.555
1998	109.0	5079	98.2	53	6.9	0.8695	0.022	52.297	0.533
1999	132.8	5534	120.1	56	7.7	1.0245	0.022	57.792	0.481
2000	164.1	6955	146.6	59	7.2	0.9439	0.021	66.790	0.456
2001	129.3	6611	116.1	50	5.8	0.7942	0.021	61.558	0.530
2002	151.0	6663	135.9	49	6.7	0.7753	0.021	58.195	0.428
2003	156.9	6518	136.7	51	6.7	0.7541	0.021	59.400	0.434
2004	166.0	7051	147.0	51	6.8	0.7931	0.021	65.525	0.446
2005	107.4	4894	88.0	48	5.7	0.6540	0.022	41.054	0.466
2006	85.4	3706	71.0	43	5.8	0.7312	0.024	34.230	0.482
2007	62.5	2822	51.3	23	6.0	0.6596	0.026	25.586	0.498
2008	116.8	3800	102.1	26	8.8	1.0012	0.024	37.392	0.366
2009	91.7	3097	79.0	23	8.4	0.9291	0.025	31.271	0.396
2010	62.0	2952	51.1	24	5.4	0.5917	0.026	27.963	0.548
2011	74.8	3337	56.3	22	5.4	0.6181	0.025	31.341	0.557
2012	67.1	3336	55.9	22	5.4	0.6126	0.025	31.500	0.563
2013	63.5	2658	48.4	22	5.7	0.6393	0.026	24.778	0.512
2014	46.6	2637	35.3	23	3.8	0.4765	0.027	21.683	0.614
2015	73.6	2789	54.6	29	5.7	0.6073	0.026	24.484	0.448
2016	66.9	2227	39.4	24	5.5	0.4945	0.028	18.782	0.477
2017	68.6	1959	39.7	22	6.2	0.5548	0.029	17.737	0.447
2018	57.8	1985	33.1	21	4.7	0.4486	0.030	17.492	0.528
2019	55.9	1676	28.6	20	4.6	0.4385	0.031	13.911	0.486
2020	58.4	1376	28.9	19	5.2	0.4548	0.033	11.156	0.386
2021	40.2	1178	20.1	19	5.0	0.4657	0.035	9.864	0.490
2022	37.6	837	17.3	18	6.4	0.6576	0.041	8.577	0.495

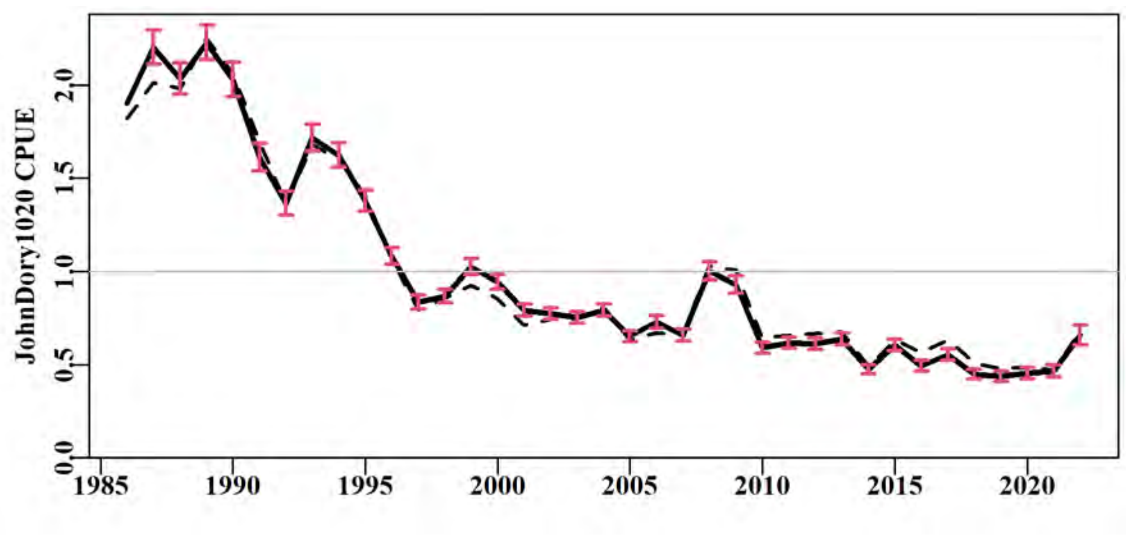

Figure 2: JohnDory1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

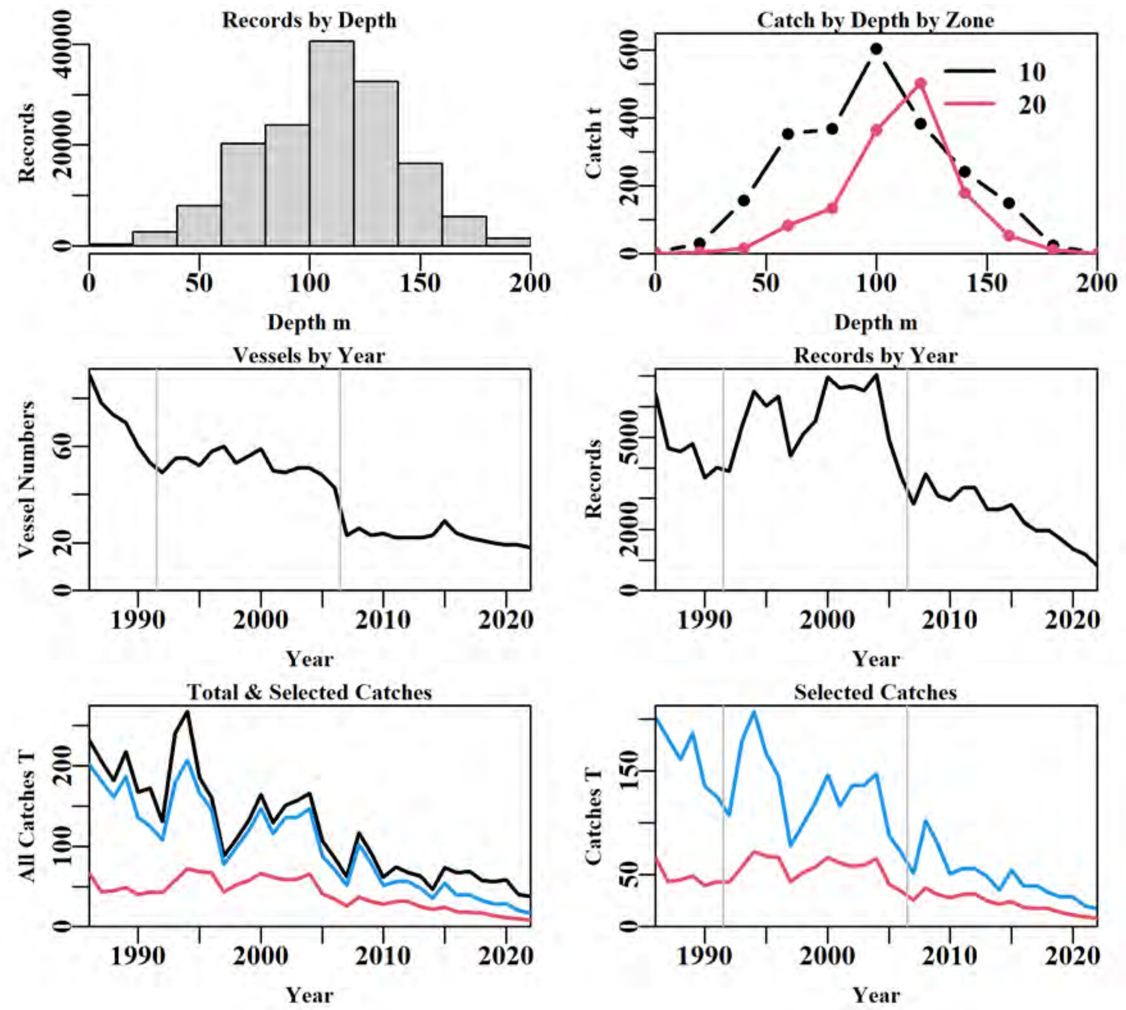

Figure 3: JohnDory1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 3: JohnDory1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	255797	233628	227436	224796	184807	152359	152235
Difference	0	22169	6192	2640	39989	32448	124
Catch	4557	4421	4274	4217	3848	3680	3678
Difference	0	136	147	57	369	168	2

Table 4: The models used to analyse data for JohnDory1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DayNight
Model4	Year + Vessel + DayNight + DepCat
Model5	Year + Vessel + DayNight + DepCat + Month
Model6	Year + Vessel + DayNight + DepCat + Month + Zone
Model7	Year + Vessel + DayNight + DepCat + Month + Zone + Zone:Month
Model8	Year + Vessel + DayNight + DepCat + Month + Zone + Zone:DepCat

Table 5: JohnDory1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	35413	192012	30090	152235	37	13.5	0.00
Vessel	18831	171810	50292	152235	208	22.5	9.01
DayNight	16339	169014	53089	152235	211	23.8	1.26
DepCat	14583	167054	55049	152235	221	24.7	0.88
Month	13331	165662	56441	152235	232	25.3	0.62
Zone	13306	165632	56470	152235	233	25.3	0.01
Zone:Month	12757	165012	57091	152235	244	25.6	0.27
Zone:DepCat	12064	164264	57838	152235	243	25.9	0.61

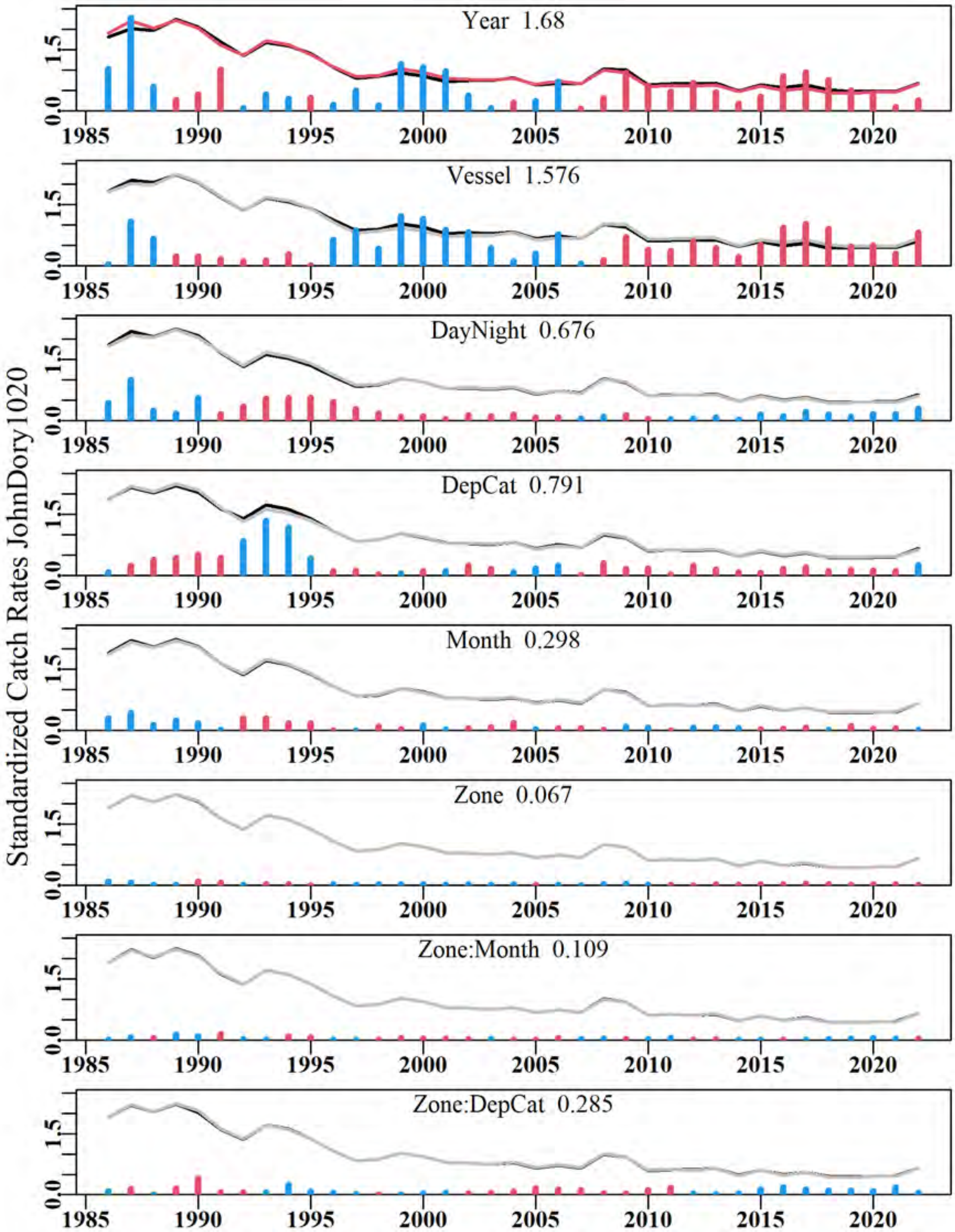

Figure 4: JohnDory1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

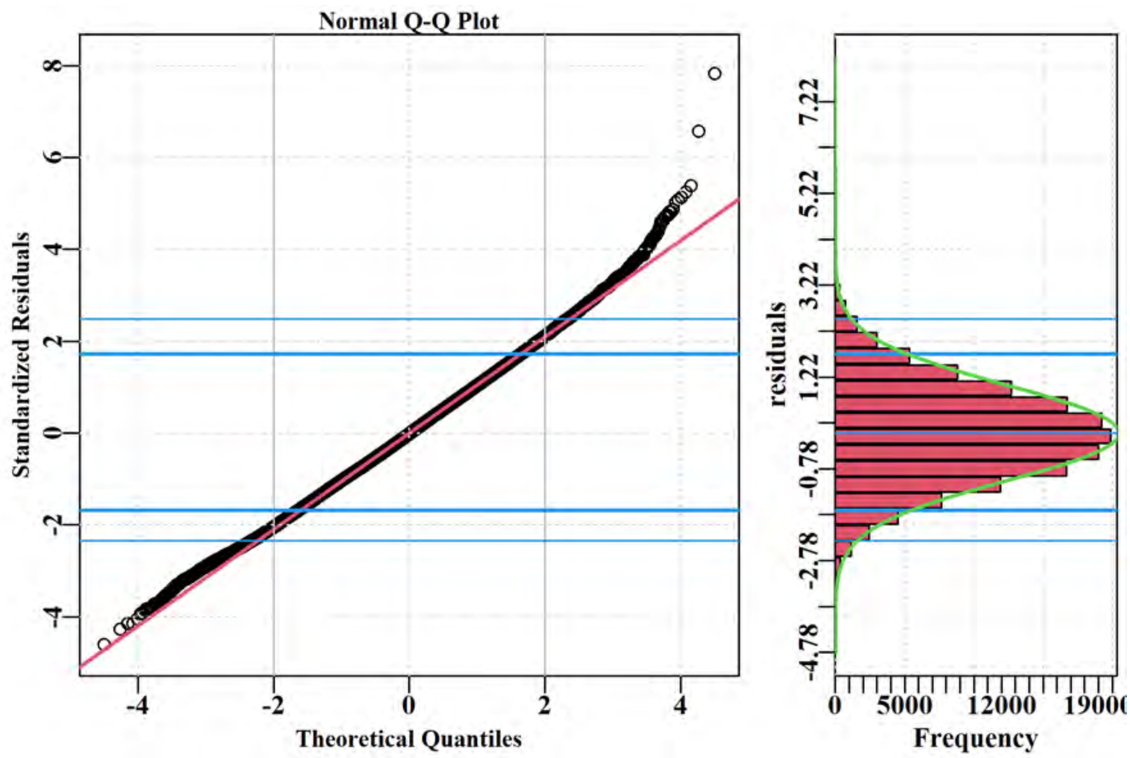

Figure 5: JohnDory1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

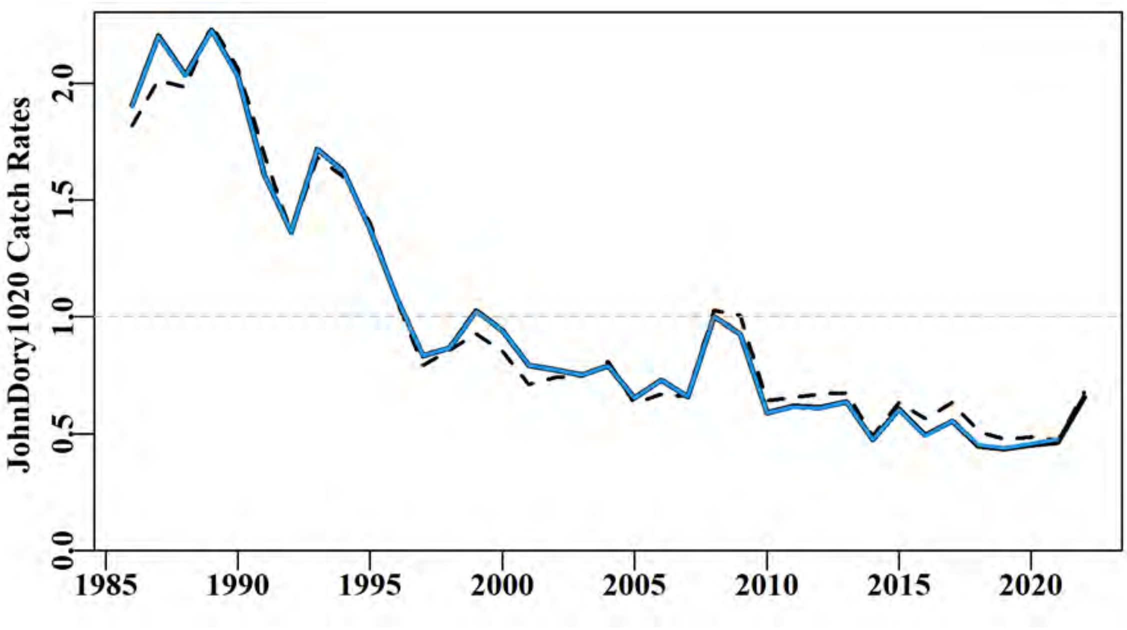

Figure 6: JohnDory1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

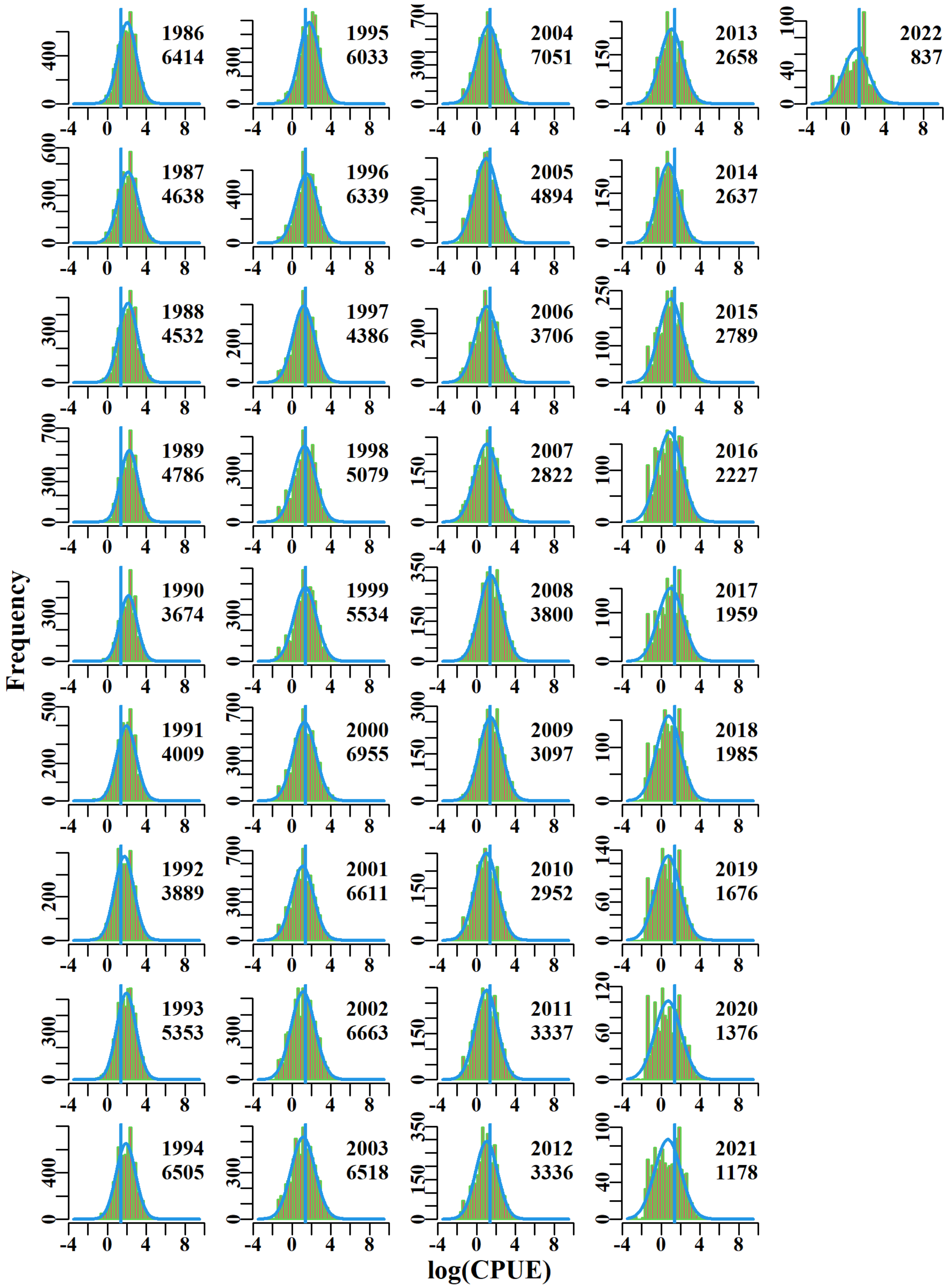

Figure 7: JohnDory1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

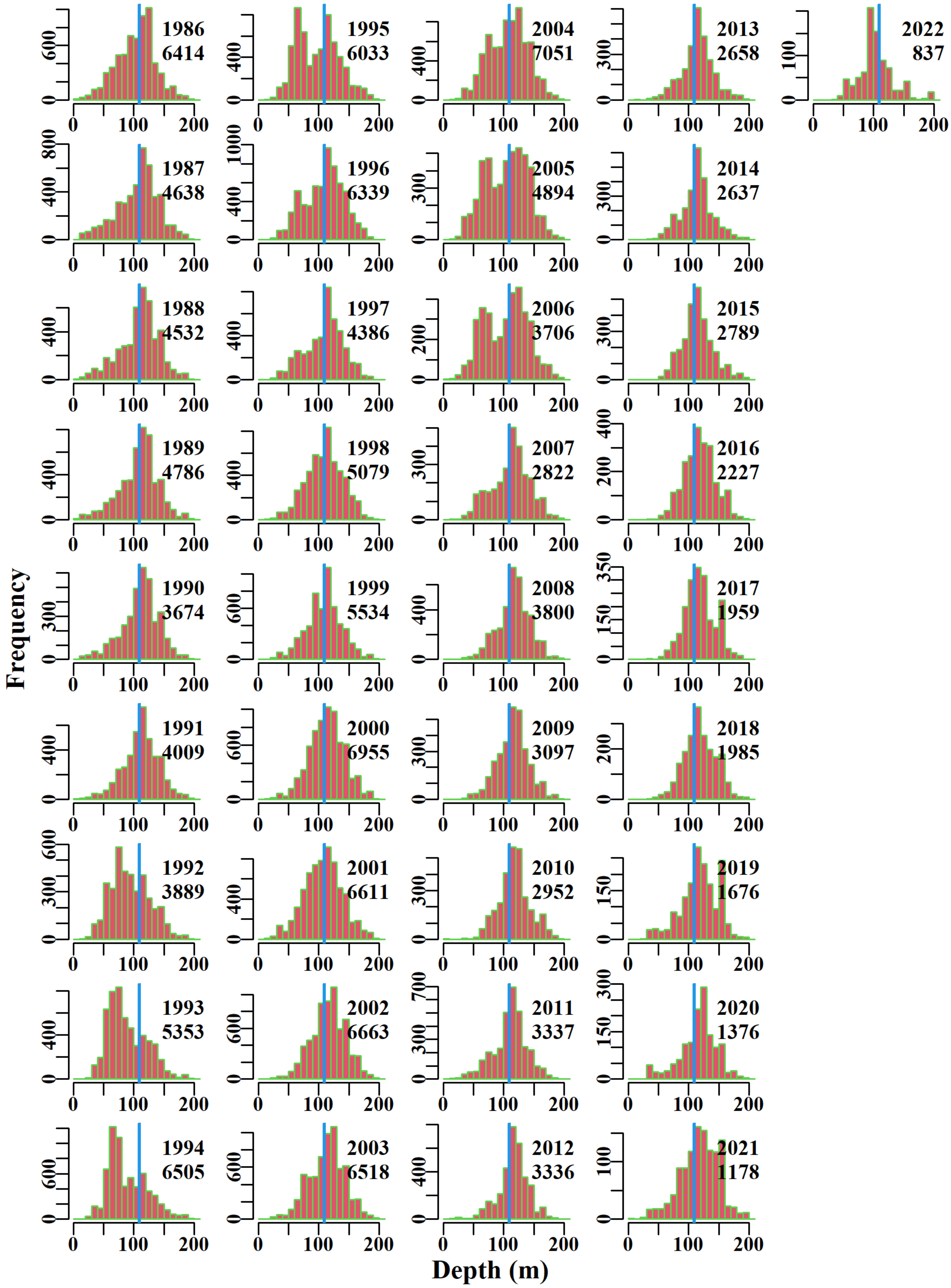

Figure 8: JohnDory1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

School Whiting DS 60

School Whiting (WHS – 37330014 – *Sillago flindersi*) are taken primarily by Danish seine (and within State waters). In Commonwealth waters, catches are primarily in zone 60, and in depths up to 100 m. CPUE was expressed as the natural log of catch per shot (catch/shot). The years used in the analysis were 1986 - 2022. Initial data selection was based on criteria provided in Table 6 from the Commonwealth logbook database. A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The early years of this data exhibit relatively large inter-annual variation, far greater than the stock itself could be undergoing. This suggests either flaws in the data or some unknown factor having a sporadic effect upon the fishery. Since a low point in 1997, CPUE have been slowly increasing and at approximately the long-term average over the 2013-2016 period. The terms Year, DayNight, Vessel and Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 10). Since 2013, there has been fewer catches in deeper waters (i.e., greater than 50 m). Standardized CPUE exhibits a flat trend over 2012-17 and has declined and dropped below the long-term average over the 2017-20 period, based on 95% confidence intervals (Figure 9). Also, there has been an increase in standardized CPUE in 2021 relative to the previous year, followed by a decrease in 2022 relative to 2021. The recorded catch of 297 t in 2022 was the lowest since 2011.

Action Items and Issues

The qqplot suggests that the assumed Normal distribution of the log-transformed CPUE, in fact log(catch per shot) may be invalid, as relatively high proportions of the tails of the distribution deviate from the expected straight line (Figure 12). Further work is required to determine the reason behind the frequent occurrence of spikes of low values of catch-per-shot and how they may best be described or explained.

The influence of vessels fishing changed in about 2003 onwards and this was reinforced by the DayNight term. The vessel effect also changed dramatically since 2014, at which time the distribution of catches among the vessels participating became more even than previously.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 6: SchoolWhiting60. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SchoolWhiting60
csirocode	37330014
fishery	SET
depthrange	0 - 100
depthclass	20
zones	60
methods	DS, SSC, RS
years	1986 - 2022

Table 7: SchoolWhiting60. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DepCat:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1302.4	5616	1167.1	26	262.4	1.2094	0.000	18.476	0.016
1987	996.0	4058	909.2	23	271.6	1.3424	0.029	12.131	0.013
1988	1255.7	3767	1157.7	25	375.6	1.7143	0.030	10.303	0.009
1989	1061.5	4421	989.1	26	260.6	1.1402	0.029	14.045	0.014
1990	1930.4	6082	1803.1	24	351.5	1.7562	0.027	15.136	0.008
1991	1630.3	4645	1456.3	26	407.7	1.5461	0.029	10.954	0.008
1992	854.1	2906	751.3	23	362.0	1.1313	0.033	8.103	0.011
1993	1694.9	4809	1511.1	24	444.4	1.6146	0.029	9.958	0.007
1994	946.2	4407	864.8	23	273.8	0.9419	0.029	12.619	0.015
1995	1212.6	4198	1050.0	21	337.1	1.2020	0.030	9.197	0.009
1996	898.2	4126	692.3	22	223.6	0.7916	0.030	13.981	0.020
1997	697.4	3066	442.1	20	202.5	0.5980	0.033	11.232	0.025
1998	594.2	2913	447.6	20	211.5	0.5739	0.033	10.661	0.024
1999	681.3	1870	411.5	21	345.1	0.6565	0.039	6.013	0.015
2000	700.9	1916	343.9	18	266.9	0.6846	0.038	7.058	0.021
2001	890.9	1990	424.6	19	296.0	0.9386	0.039	6.779	0.016
2002	788.3	2186	428.2	20	258.4	0.9062	0.037	7.753	0.018
2003	866.2	2338	460.0	20	275.4	0.9482	0.037	7.942	0.017
2004	604.9	1751	332.0	20	264.4	0.8580	0.040	6.951	0.021
2005	662.7	1562	296.4	20	255.6	0.9541	0.041	4.883	0.016
2006	667.5	1404	263.4	18	258.3	0.8654	0.043	5.336	0.020
2007	535.4	1469	343.1	14	330.0	1.1532	0.042	4.479	0.013
2008	502.2	1248	313.7	15	370.2	1.1348	0.045	4.280	0.014
2009	462.6	1548	347.6	15	309.7	1.2342	0.042	5.171	0.015
2010	408.9	1167	270.8	15	339.6	1.0697	0.046	4.199	0.016
2011	373.9	1564	257.2	14	198.8	0.8566	0.042	6.430	0.025
2012	435.8	1562	302.3	14	262.7	0.9248	0.042	5.604	0.019
2013	510.6	1765	336.1	14	249.9	0.9689	0.040	6.569	0.020
2014	698.8	2047	480.8	14	336.2	1.0758	0.038	6.106	0.013
2015	741.1	2449	563.7	14	327.5	1.0465	0.036	7.530	0.013
2016	698.7	2334	557.6	15	303.8	1.0186	0.037	7.843	0.014
2017	743.3	2381	631.9	16	378.2	0.9458	0.037	6.235	0.010
2018	589.4	2646	510.0	17	242.0	0.7208	0.036	9.530	0.019
2019	479.1	2792	402.1	17	175.1	0.6179	0.035	10.879	0.027
2020	511.3	2518	410.2	18	221.7	0.5040	0.037	11.336	0.028
2021	703.5	1866	587.5	17	236.0	0.7274	0.040	7.065	0.012
2022	437.3	1795	296.9	17	207.7	0.6275	0.041	7.123	0.024

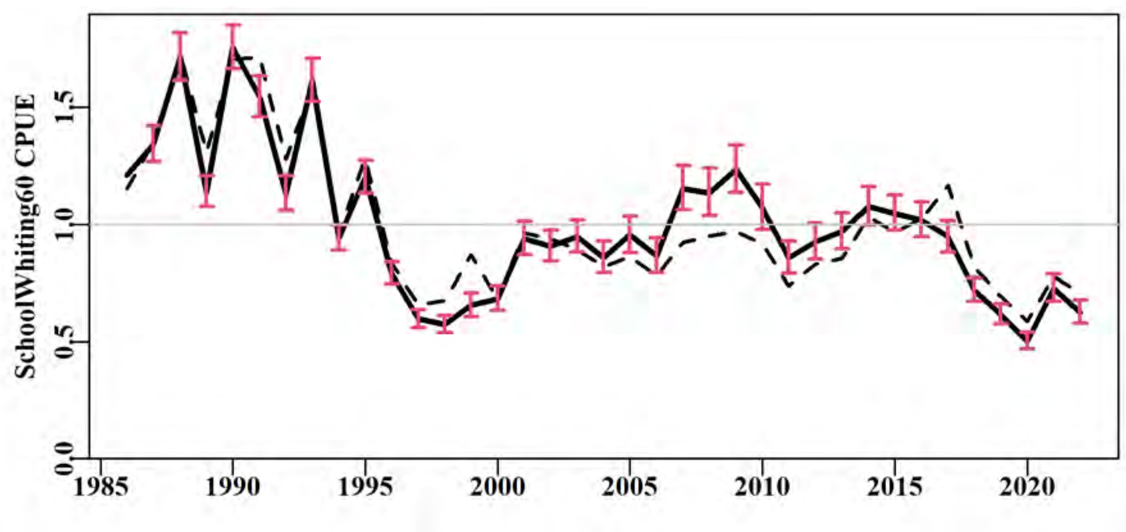

Figure 9: SchoolWhiting60 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

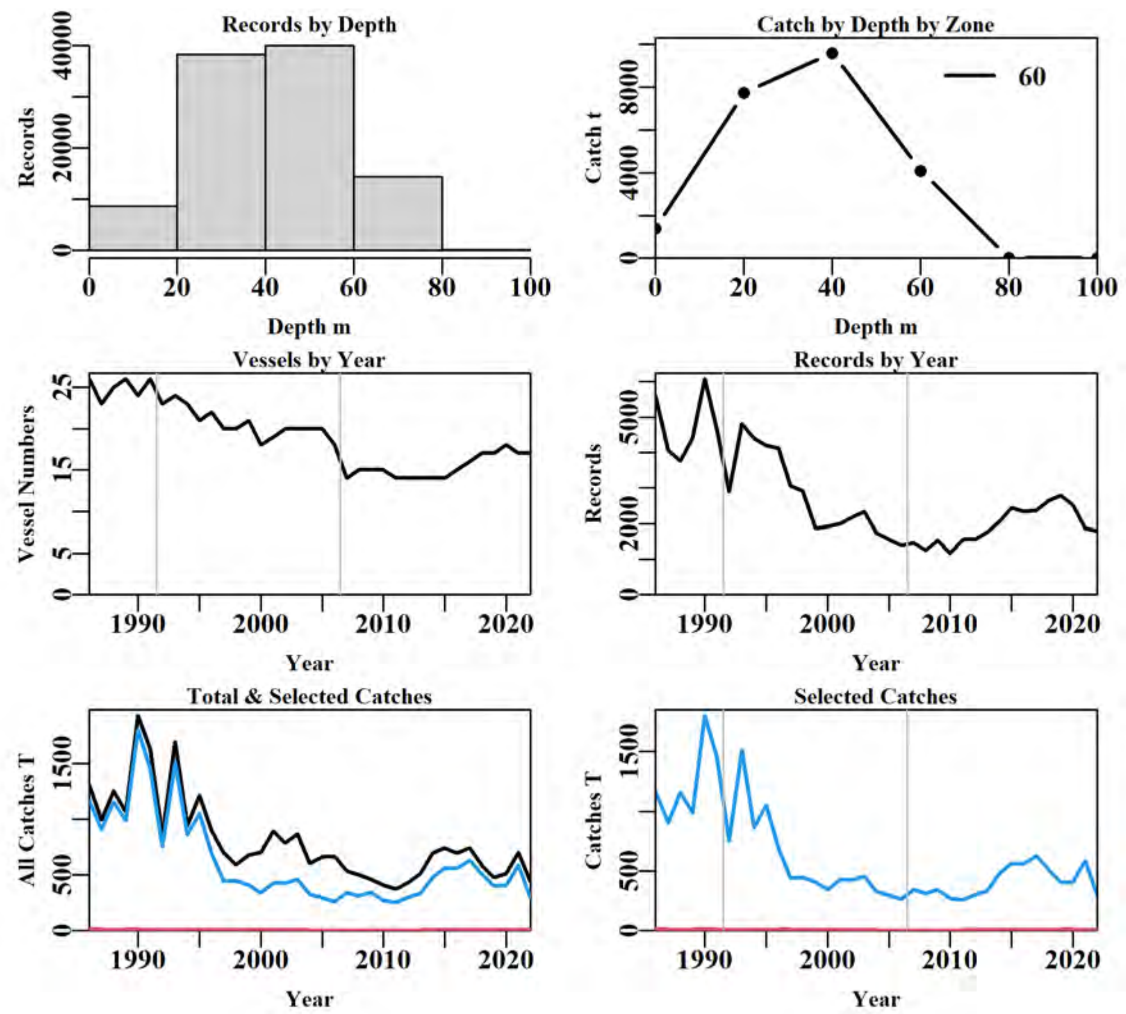

Figure 10: SchoolWhiting60 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 8: SchoolWhiting60 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156969	148163	143086	141114	106889	104111	101182
Difference	0	8806	5077	1972	34225	2778	2929
Catch	30114	30114	29373	29031	23923	23503	22813
Difference	0	0	741	342	5108	420	690

Table 9: The models used to analyse data for SchoolWhiting60.

	Model
Model1	Year
Model2	Year + DayNight
Model3	Year + DayNight + Vessel
Model4	Year + DayNight + Vessel + Month
Model5	Year + DayNight + Vessel + Month + DepCat
Model6	Year + DayNight + Vessel + Month + DepCat + DayNight:DepCat
Model7	Year + DayNight + Vessel + Month + DepCat + DepCat:Month
Model8	Year + DayNight + Vessel + Month + DepCat + DayNight:Month

Table 10: SchoolWhiting60. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DepCat:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	74665	211477	9817	101182	37	4.4	0.00
DayNight	70620	203178	18115	101182	40	8.2	3.75
Vessel	66440	194759	26534	101182	91	11.9	3.76
Month	65281	192498	28796	101182	102	12.9	1.01
DepCat	64747	191467	29826	101182	107	13.4	0.46
DayNight:DepCat	64567	191084	30209	101182	118	13.6	0.16
DepCat:Month	64057	190007	31286	101182	149	14.0	0.62
DayNight:Month	64492	190860	30433	101182	140	13.6	0.25

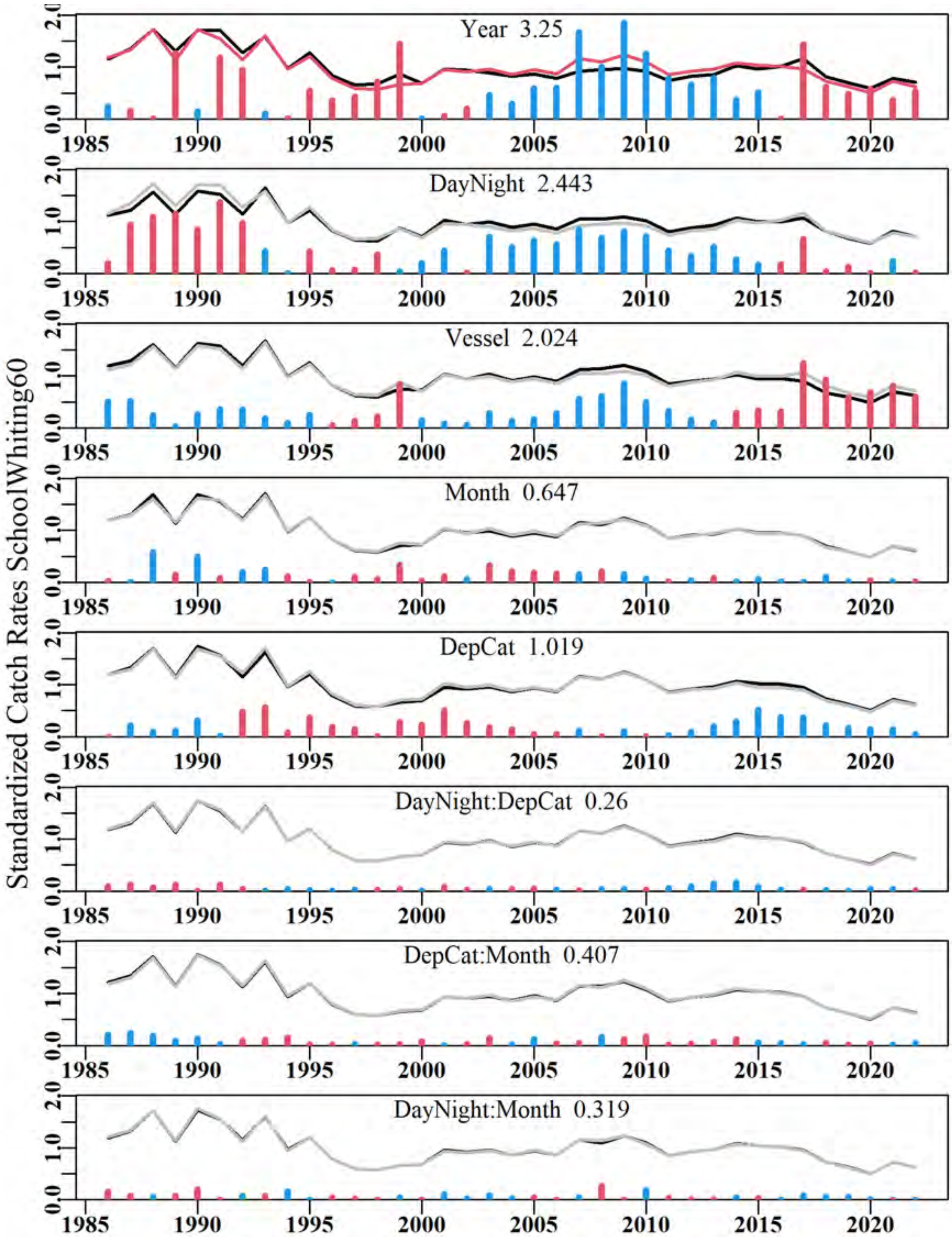

Figure 11: SchoolWhiting60. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

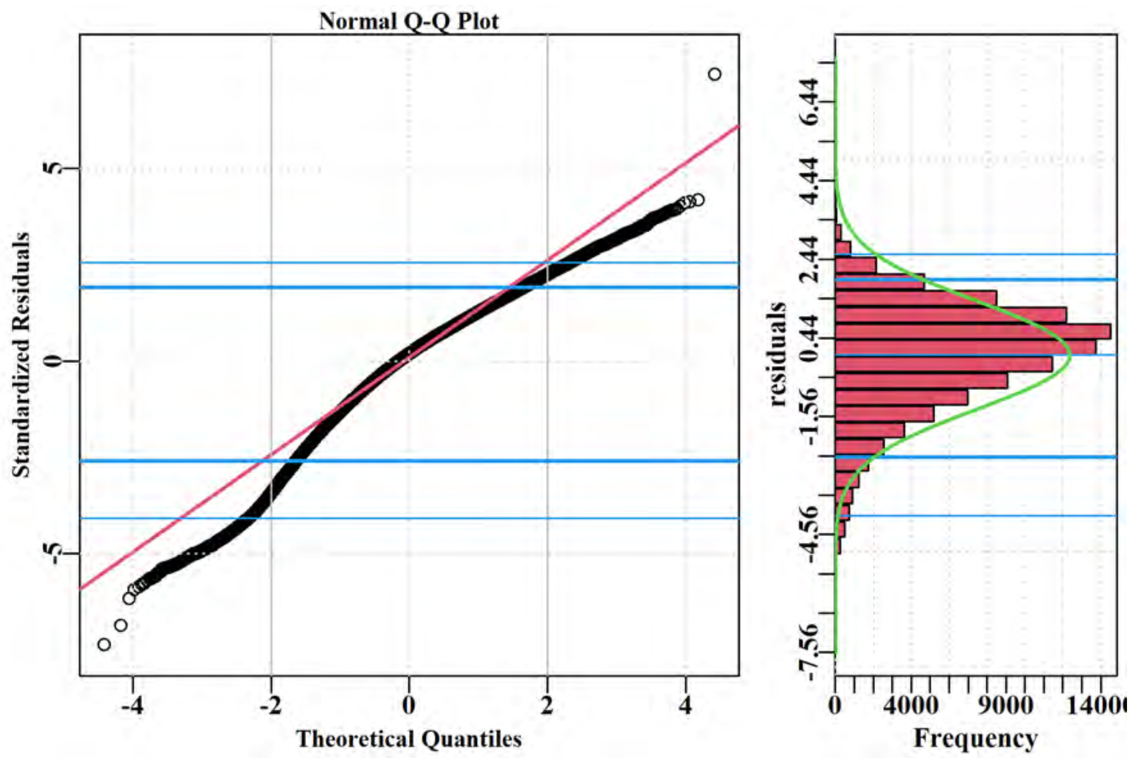

Figure 12: SchoolWhiting60. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

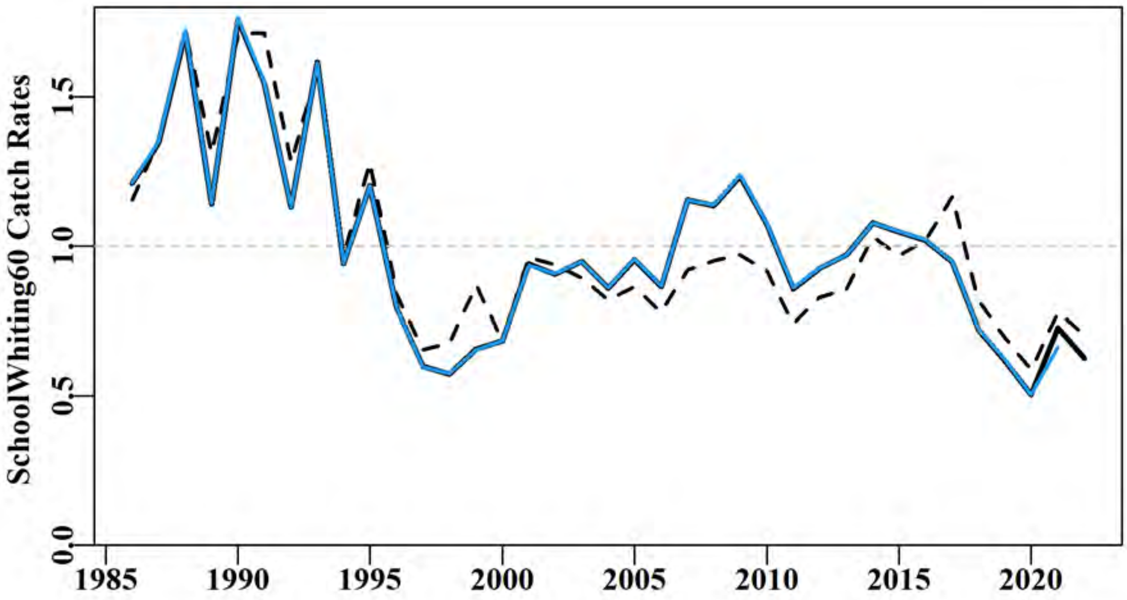

Figure 13: SchoolWhiting60. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

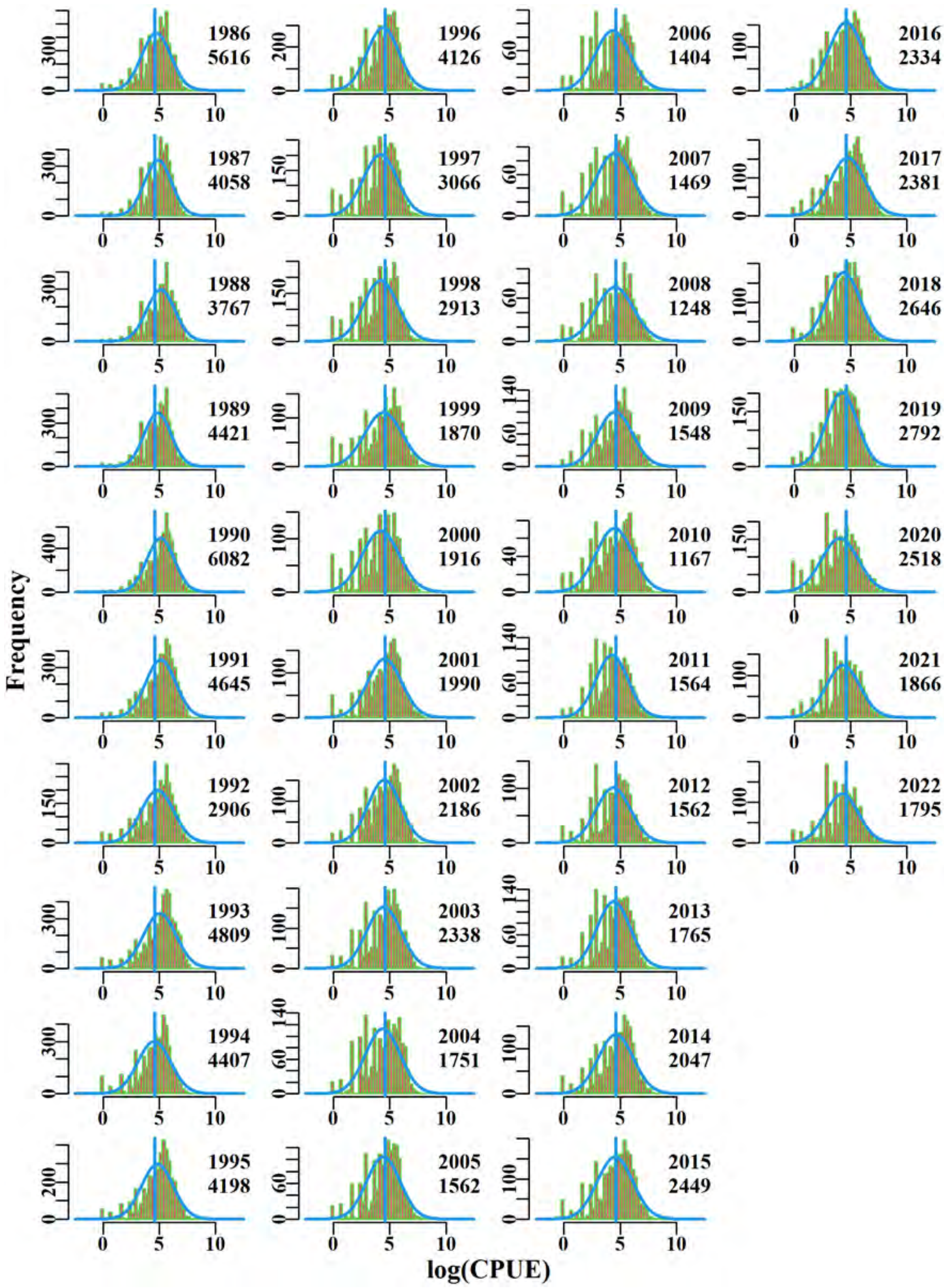

Figure 14: SchoolWhiting60. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

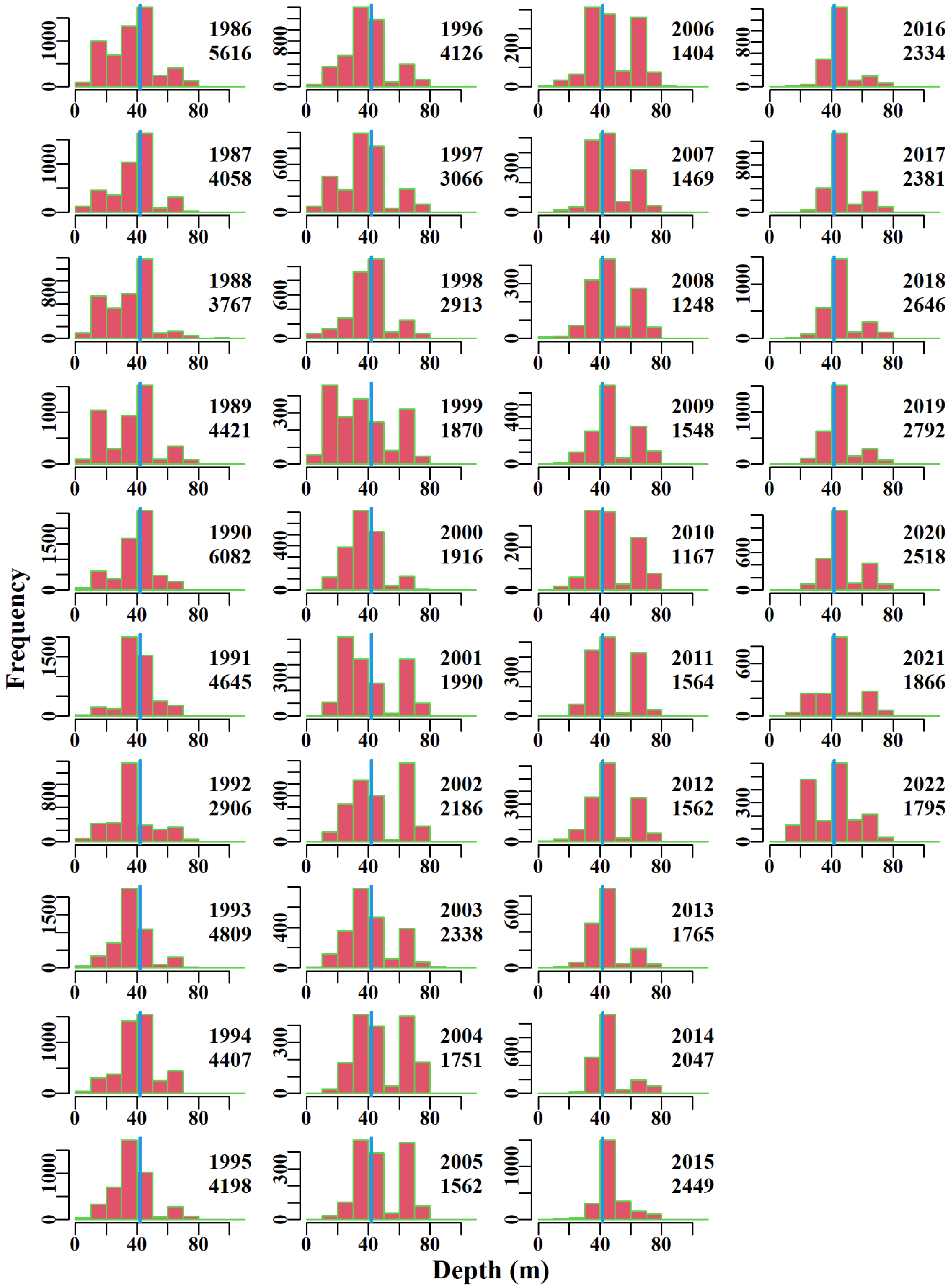

Figure 15: SchoolWhiting60. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

School Whiting Trawl 10 20 91

School Whiting (WHS - 37330014 - *Sillago flindersi*) are taken by trawl in zones 10, 20 and 91. All vessels and all records were employed in the analysis for the years 1995 - 2022. CPUE was expressed as the natural log of catch per hour (catch/hr). A total of 8 statistical models were fitted sequentially to the available data. Only minor catches are taken in zone 20 but maximum catches by depth category illustrate that catches in zones 10 and 91 are of the same order. Zone 91 catches are strictly State catches and while included here are excluded in the next analysis (i.e., School Whiting Trawl 10 20) for comparison.

A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Most trawl caught school whiting occur between approximately 40 - 60 m, extending out to 150 m. Since 2014, catches have also been reported in deeper waters. The 2021 catch of 88 t was the highest since 2008.

The terms Year, Vessel, DayNight, and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 15). The qqplot suggests that the assumed Normal distribution is valid, with small deviations at the tails (Figure 19).

Standardized CPUE has exceeded the long-term average in 2016, 2017 and between 2019-2022 based on the 95% confidence intervals (Figure 16). Also, there have been consistent increases since after 2018.

Action Items and Issues

The years 2017 - 2022 appear to have exhibited a change in fishing behaviour as evidenced by the changing distributions of records at depth, why this has occurred in these years remains unknown.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 11: SchoolWhitingTW. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SchoolWhitingTW
csirocode	37330014
fishery	SET
depthrange	0 - 150
depthclass	10
zones	10, 20, 91
methods	TW, TDO, OTB
years	1995 - 2022

Table 12: SchoolWhitingTW. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DepCat:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1995	1212.6	277	40.7	16	64.8	1.1523	0.000	1.046	0.026
1996	898.2	437	75.1	21	83.3	1.2936	0.094	0.806	0.011
1997	697.4	824	97.0	23	68.0	0.8900	0.085	2.771	0.029
1998	594.2	710	81.1	25	54.6	0.9082	0.087	2.844	0.035
1999	681.3	886	107.1	27	63.2	1.0915	0.085	2.809	0.026
2000	700.9	1229	154.4	30	69.6	1.0816	0.082	3.735	0.024
2001	890.9	2101	309.2	34	92.7	1.2006	0.079	7.896	0.026
2002	788.3	1662	172.1	36	73.2	0.9993	0.081	6.024	0.035
2003	866.2	2426	291.3	40	68.7	0.9509	0.079	9.290	0.032
2004	604.9	2037	186.2	39	48.0	0.7339	0.079	9.837	0.053
2005	662.7	1953	250.4	37	71.4	1.0250	0.080	7.556	0.030
2006	667.5	1437	225.6	28	75.4	1.4252	0.082	5.825	0.026
2007	535.4	495	86.7	15	105.5	1.4334	0.094	2.110	0.024
2008	502.2	841	107.4	15	68.1	0.8817	0.086	3.724	0.035
2009	462.6	444	36.8	17	46.7	0.7520	0.095	2.629	0.071
2010	408.9	463	47.6	17	60.4	0.9076	0.095	2.282	0.048
2011	373.9	494	64.5	15	83.4	0.7901	0.094	2.313	0.036
2012	435.8	509	45.3	16	49.7	0.5824	0.093	3.115	0.069
2013	510.6	663	57.0	14	44.4	0.5162	0.089	4.006	0.070
2014	698.8	815	71.4	18	52.2	0.7234	0.087	4.168	0.058
2015	741.1	767	55.2	18	36.7	0.6555	0.088	4.944	0.090
2016	698.7	618	66.6	14	64.8	0.8661	0.091	3.387	0.051
2017	743.3	391	45.8	12	65.7	1.0032	0.099	2.252	0.049
2018	589.4	406	28.7	15	30.3	0.6177	0.101	2.421	0.084
2019	479.1	377	33.2	6	48.3	0.9028	0.101	1.424	0.043
2020	511.3	425	59.0	9	73.7	1.3450	0.100	1.670	0.028
2021	703.5	637	88.0	13	79.4	1.4882	0.094	2.855	0.032
2022	437.3	498	77.9	12	99.1	1.7827	0.101	1.851	0.024

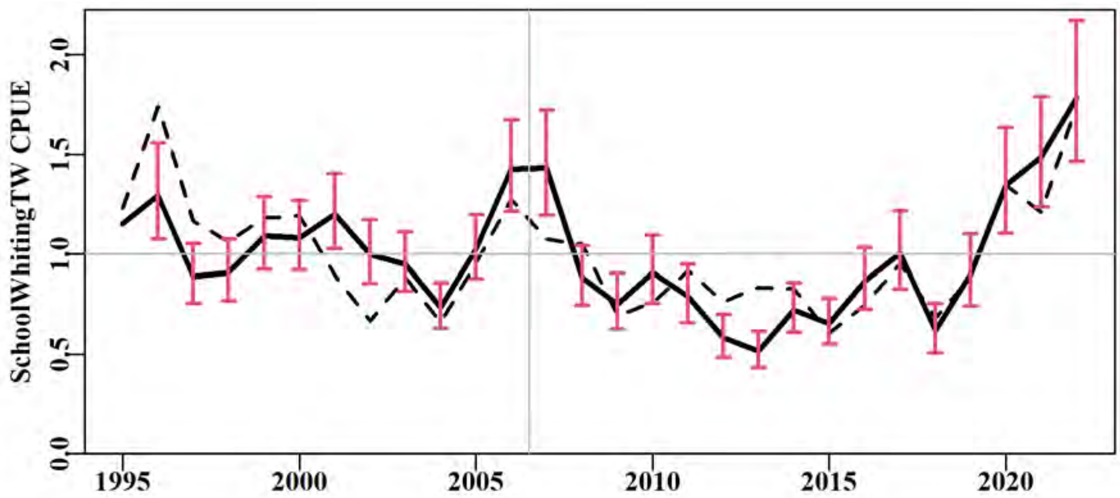

Figure 16: SchoolWhitingTW standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

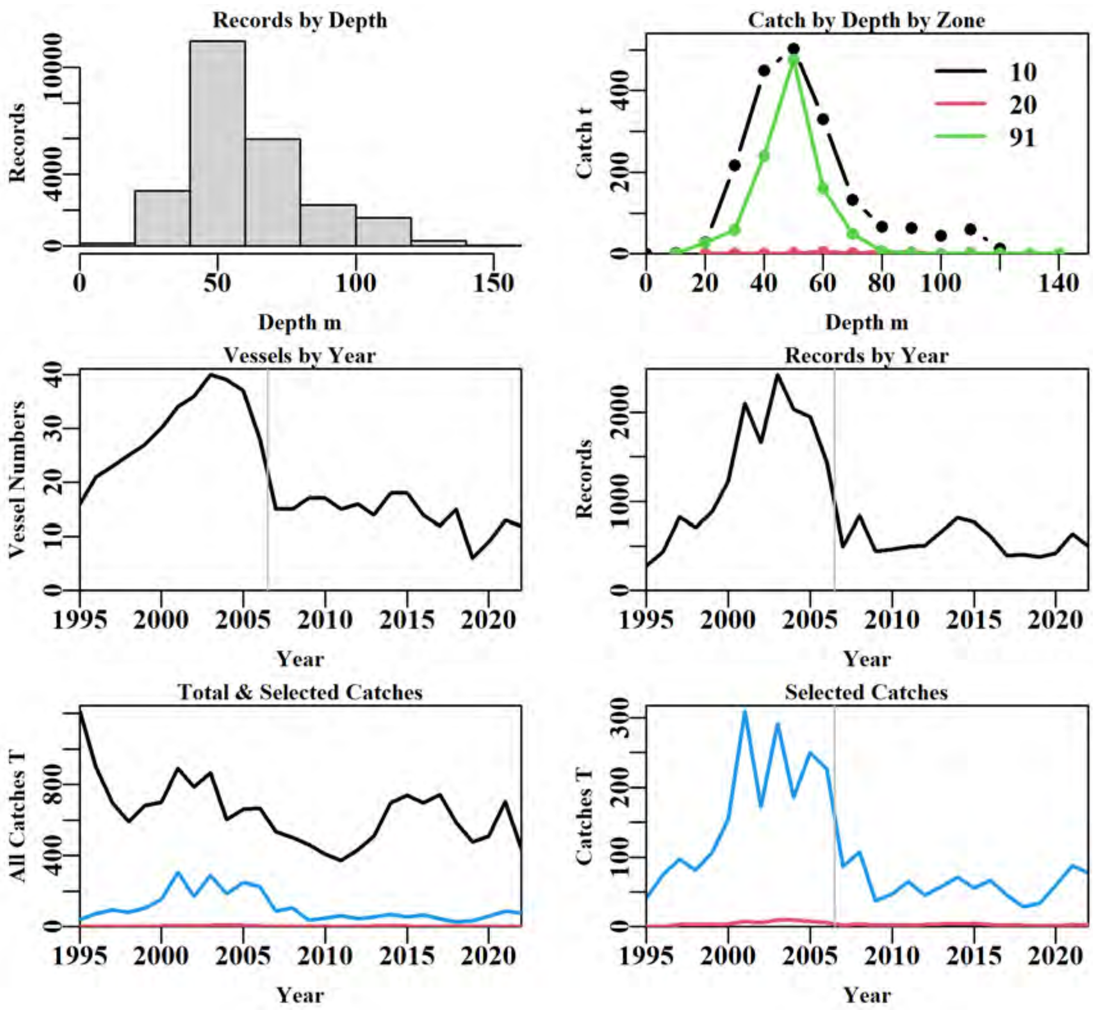

Figure 17: SchoolWhitingTW fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 13: SchoolWhitingTW data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156969	123020	121056	77752	26473	24849	24822
Difference	0	33949	1964	43304	51279	1624	27
Catch	30114	25133	24725	13910	3211	2964	2961
Difference	0	4981	408	10815	10699	248	2

Table 14: The models used to analyse data for SchoolWhitingTW.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DayNight
Model4	Year + Vessel + DayNight + DepCat
Model5	Year + Vessel + DayNight + DepCat + Month
Model6	Year + Vessel + DayNight + DepCat + Month + DayNight:DepCat
Model7	Year + Vessel + DayNight + DepCat + Month + DepCat:Month
Model8	Year + Vessel + DayNight + DepCat + Month + DayNight:Month

Table 15: SchoolWhitingTW. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DepCat:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	21642	59227	1577	24822	28	2.5	0.00
Vessel	13083	41714	19090	24822	99	31.1	28.64
DayNight	10899	38191	22613	24822	102	36.9	5.81
DepCat	9942	36706	24098	24822	116	39.4	2.42
Month	9877	36576	24228	24822	127	39.5	0.19
DayNight:DepCat	9551	36015	24789	24822	156	40.4	0.86
DepCat:Month	9623	35795	25009	24822	268	40.5	0.95
DayNight:Month	9817	36418	24386	24822	151	39.7	0.20

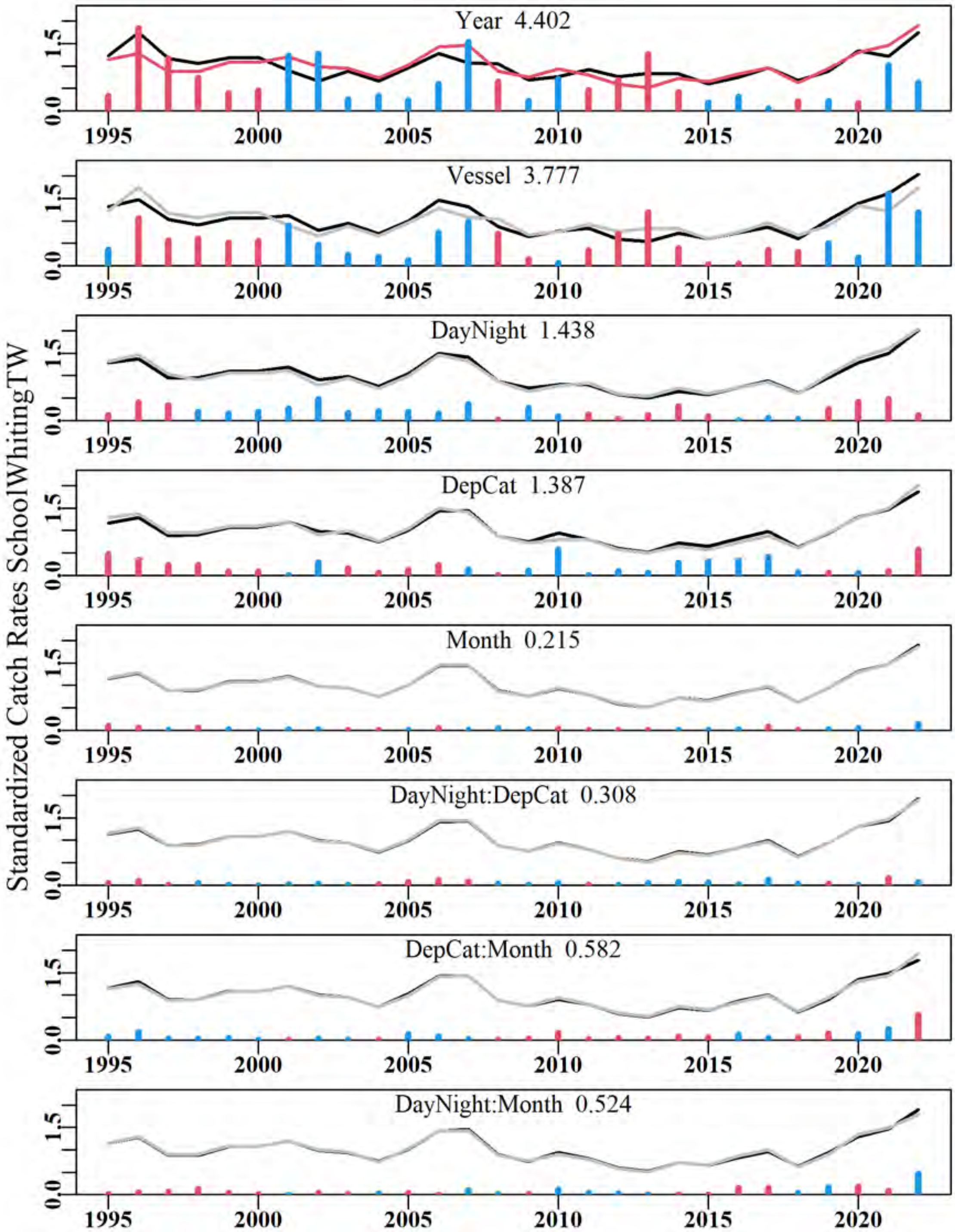

Figure 18: SchoolWhitingTW. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

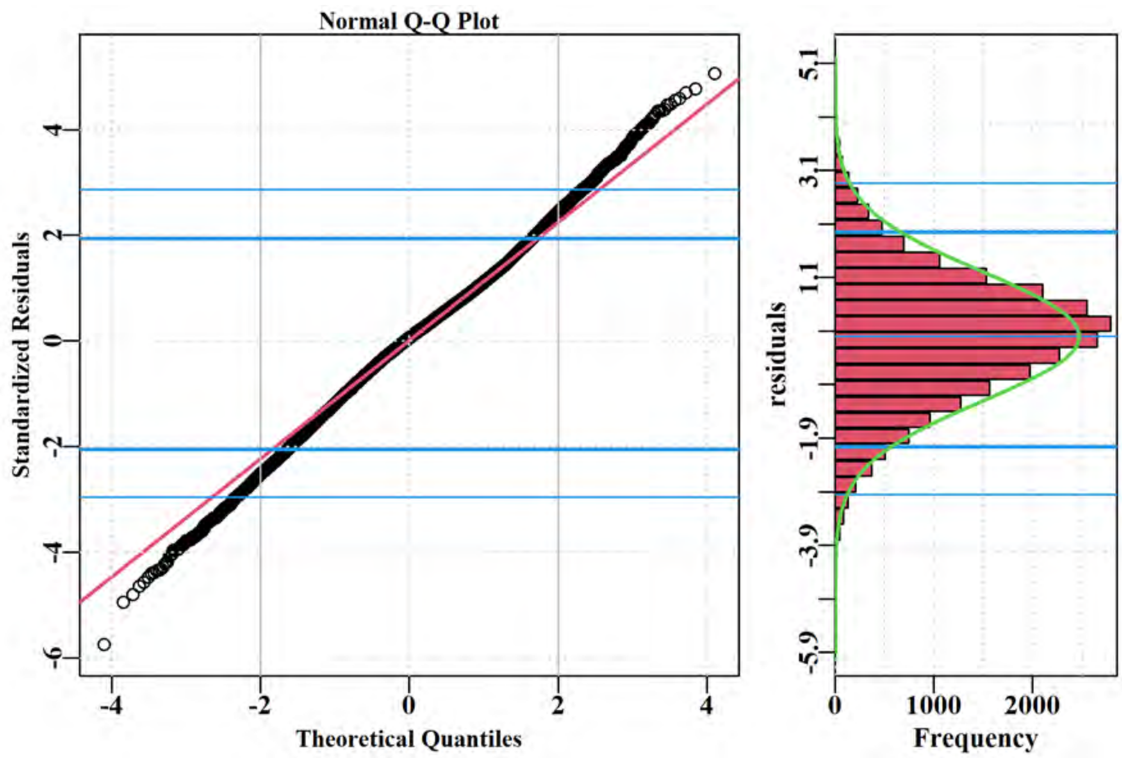

Figure 19: SchoolWhitingTW. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

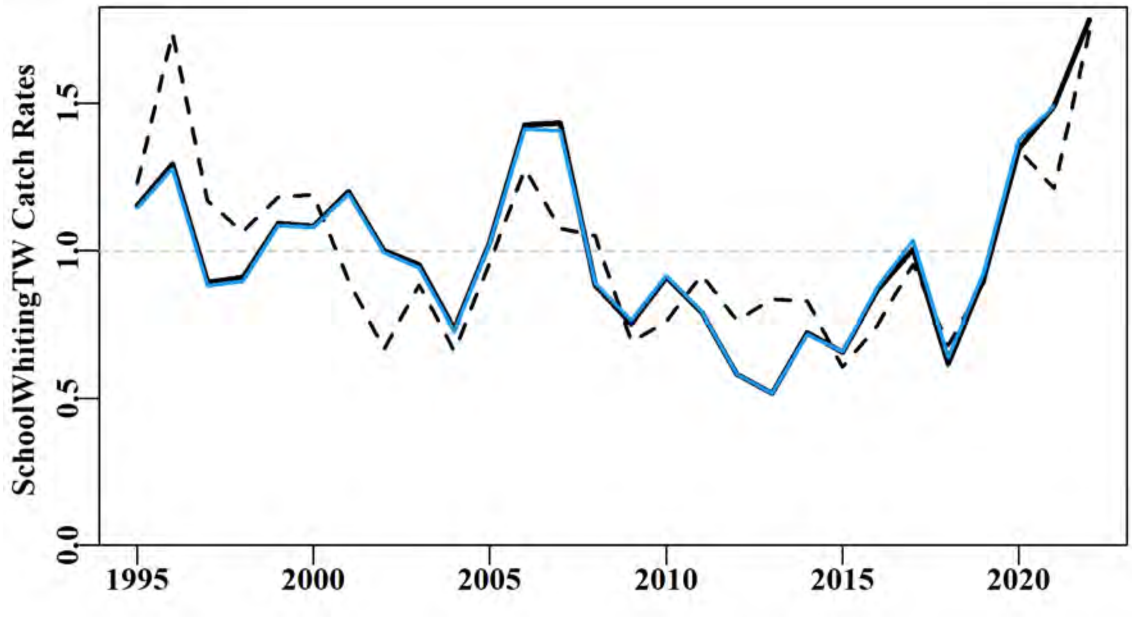

Figure 20: SchoolWhitingTW. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

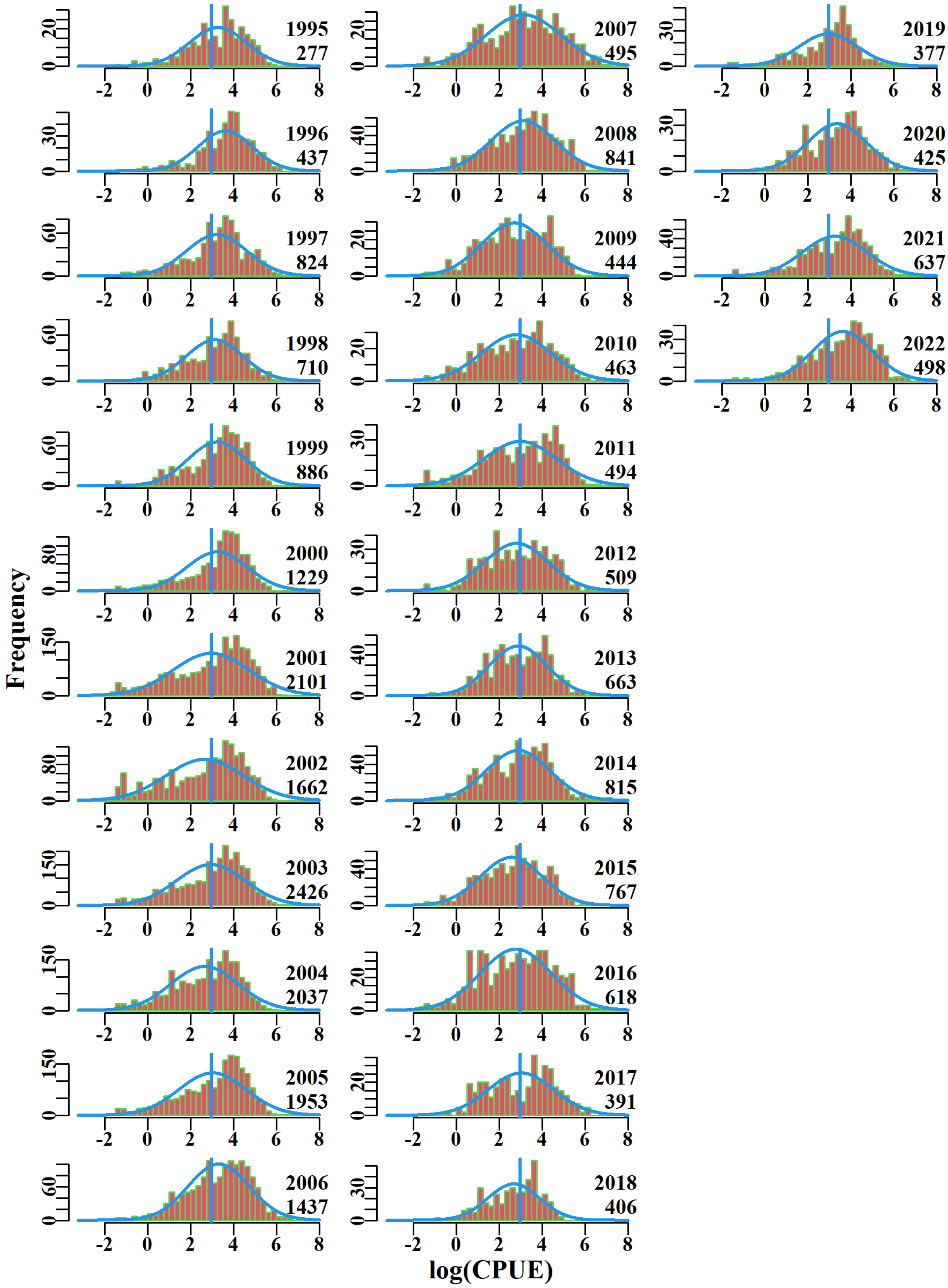

Figure 21: SchoolWhitingTW. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

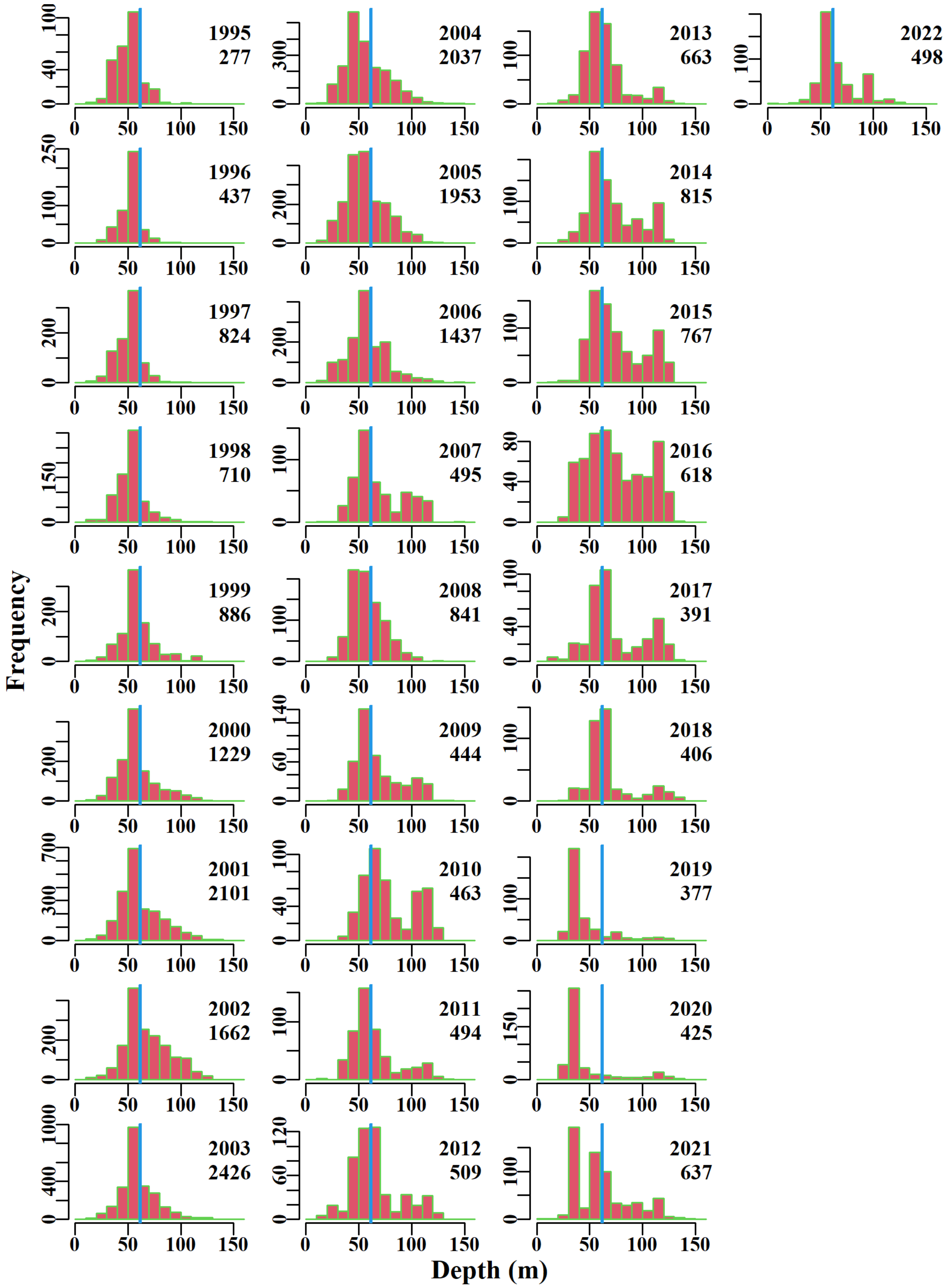

Figure 22: SchoolWhitingTW. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

School Whiting Trawl 10 20

School Whiting (WHS - 37330014 - *Sillago flindersi*) are taken by trawl in zones 10 and 20. All vessels and all records were employed in the analysis for the years 1995 - 2022. CPUE was expressed as the natural log of catch per hour (catch/hr). Initial data selection was based on criteria provided in Table 16 from the Commonwealth logbook database. This analysis omits zone 91, which, even though the fishery is a clear and natural extension of the Commonwealth fishery (as evidenced by plotting the location of each shot) being State waters, and catches are omitted from the standardization for comparison with the complete analysis. A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, Vessel, DayNight, and DepCat and one interaction (DayNight:DepCat) had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics. The qqplot suggests that the assumed Normal distribution is valid.

The 2021 catch of 68.1 t was the highest since 2007. Standardized CPUE is relatively noisy and flat except between 2006 - 2007 (i.e., around the time of the structural adjustment) (Figure 23). More recently, standardized CPUE has exceeded the long-term average in 2016, 2017 and between 2019-2022 based on the 95% confidence intervals. The log-transformed CPUE data is a close fit to a Normal distribution.

Action Items and Issues

The depth distribution of catches has not been stable from year to year, which may reflect the fact that there are only few vessels contributing seriously to this fishery.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 16: SchoolWhitingTW1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SchoolWhitingTW1020
csirocode	37330014
fishery	SET
depthrange	0 - 150
depthclass	10
zones	10, 20
methods	TW, TDO, OTB
years	1995 - 2022

Table 17: SchoolWhitingTW1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DayNight:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1995	1212.6	153	23.3	13	94.1	1.2632	0.000	0.689	0.030
1996	898.2	142	27.7	17	170.8	1.1273	0.154	0.393	0.014
1997	697.4	438	58.2	21	119.6	0.9256	0.124	1.951	0.033
1998	594.2	313	32.7	25	70.8	0.9182	0.130	1.685	0.051
1999	681.3	486	51.5	27	72.0	1.0735	0.123	2.083	0.040
2000	700.9	794	98.9	30	89.8	1.0522	0.117	2.765	0.028
2001	890.9	1453	178.9	34	87.0	1.0870	0.114	6.864	0.038
2002	788.3	1302	128.3	36	78.6	0.9766	0.114	4.992	0.039
2003	866.2	1638	192.6	38	79.1	0.9704	0.113	7.165	0.037
2004	604.9	1281	90.8	38	40.5	0.7610	0.114	7.119	0.078
2005	662.7	1254	132.9	37	65.0	0.9729	0.114	6.453	0.049
2006	667.5	948	140.3	28	79.7	1.5588	0.116	4.665	0.033
2007	535.4	434	80.5	15	122.5	1.5592	0.125	1.835	0.023
2008	502.2	522	68.3	15	81.5	0.8200	0.122	2.344	0.034
2009	462.6	376	30.3	17	46.1	0.7356	0.127	2.204	0.073
2010	408.9	385	37.8	17	55.6	0.8823	0.128	2.137	0.057
2011	373.9	422	50.0	15	84.5	0.7445	0.126	1.941	0.039
2012	435.8	426	40.0	16	57.1	0.6193	0.125	2.445	0.061
2013	510.6	505	45.4	14	50.1	0.4986	0.123	2.810	0.062
2014	698.8	693	63.4	18	58.3	0.7379	0.120	3.551	0.056
2015	741.1	647	47.6	18	39.0	0.6712	0.121	4.158	0.087
2016	698.7	544	58.2	14	66.4	0.8135	0.123	3.137	0.054
2017	743.3	323	37.9	12	67.9	0.9528	0.132	2.077	0.055
2018	589.4	265	16.5	15	27.1	0.6352	0.138	1.691	0.102
2019	479.1	258	23.1	6	51.6	0.9564	0.138	1.103	0.048
2020	511.3	325	47.3	9	82.9	1.2593	0.134	1.610	0.034
2021	703.5	506	68.1	13	83.7	1.4281	0.127	2.605	0.038
2022	437.3	406	67.3	12	115.4	1.9992	0.132	1.549	0.023

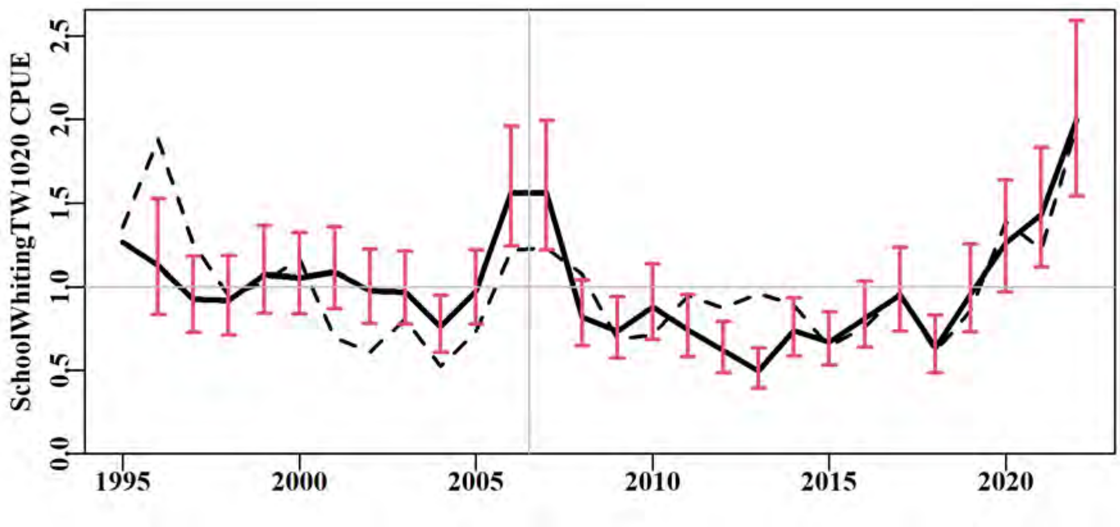

Figure 23: SchoolWhitingTW1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

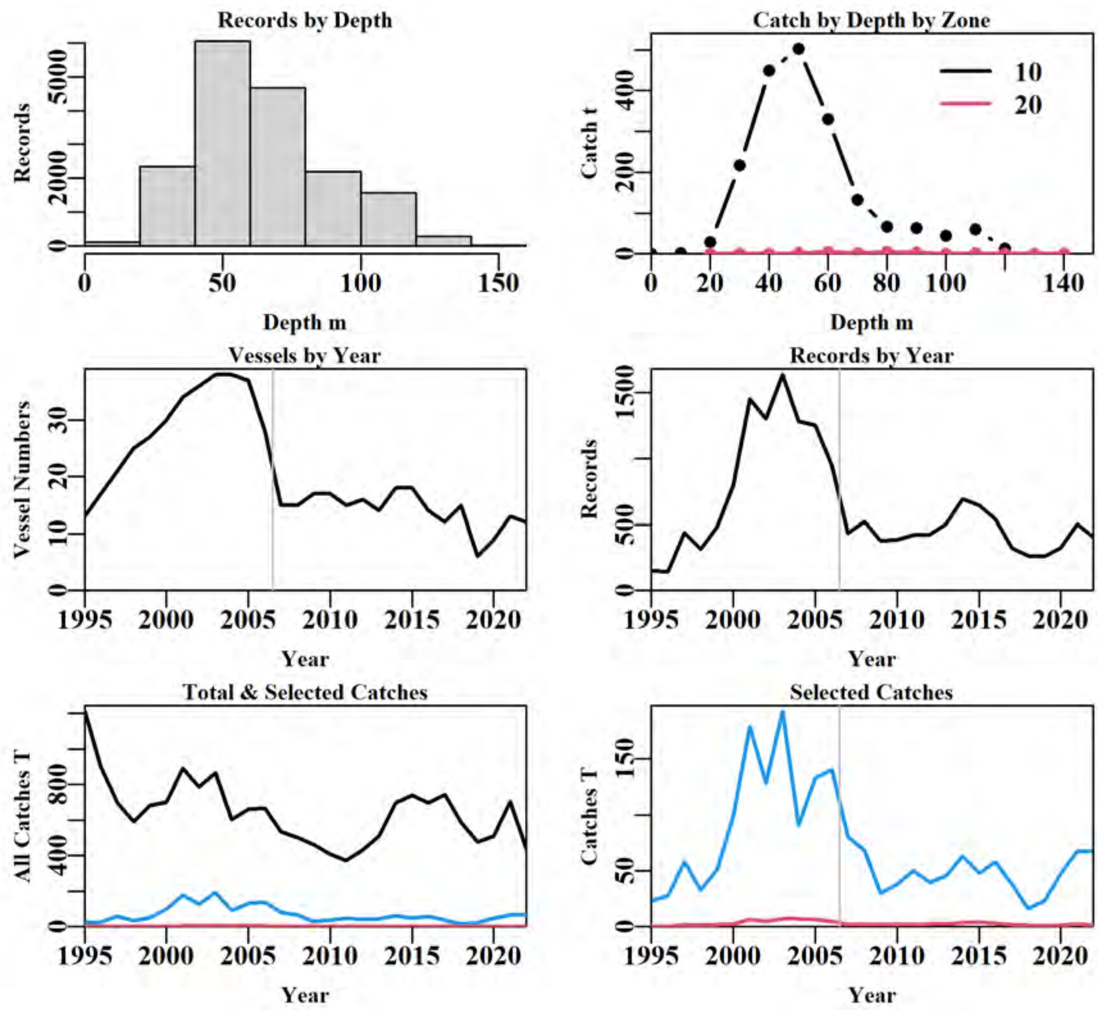

Figure 24: SchoolWhitingTW1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 18: SchoolWhitingTW1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156969	123020	121056	77752	18884	17266	17239
Difference	0	33949	1964	43304	58868	1618	27
Catch	30114	25133	24725	13910	2187	1940	1938
Difference	0	4981	408	10815	11723	247	2

Table 19: The models used to analyse data for SchoolWhitingTW1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DayNight
Model4	Year + Vessel + DayNight + DepCat
Model5	Year + Vessel + DayNight + DepCat + Month
Model6	Year + Vessel + DayNight + DepCat + Month + DayNight:DepCat
Model7	Year + Vessel + DayNight + DepCat + Month + DepCat:Month
Model8	Year + Vessel + DayNight + DepCat + Month + DayNight:Month

Table 20: SchoolWhitingTW1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DayNight:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	18235	49487	1582	17239	28	2.9	0.00
Vessel	11918	34023	17046	17239	99	33.0	30.05
DayNight	10107	30619	20450	17239	102	39.7	6.69
DepCat	9253	29093	21976	17239	116	42.6	2.96
Month	9191	28951	22118	17239	127	42.9	0.24
DayNight:DepCat	8856	28299	22770	17239	156	44.1	1.19
DepCat:Month	9045	28245	22824	17239	267	43.8	0.93
DayNight:Month	9161	28820	22249	17239	151	43.1	0.18

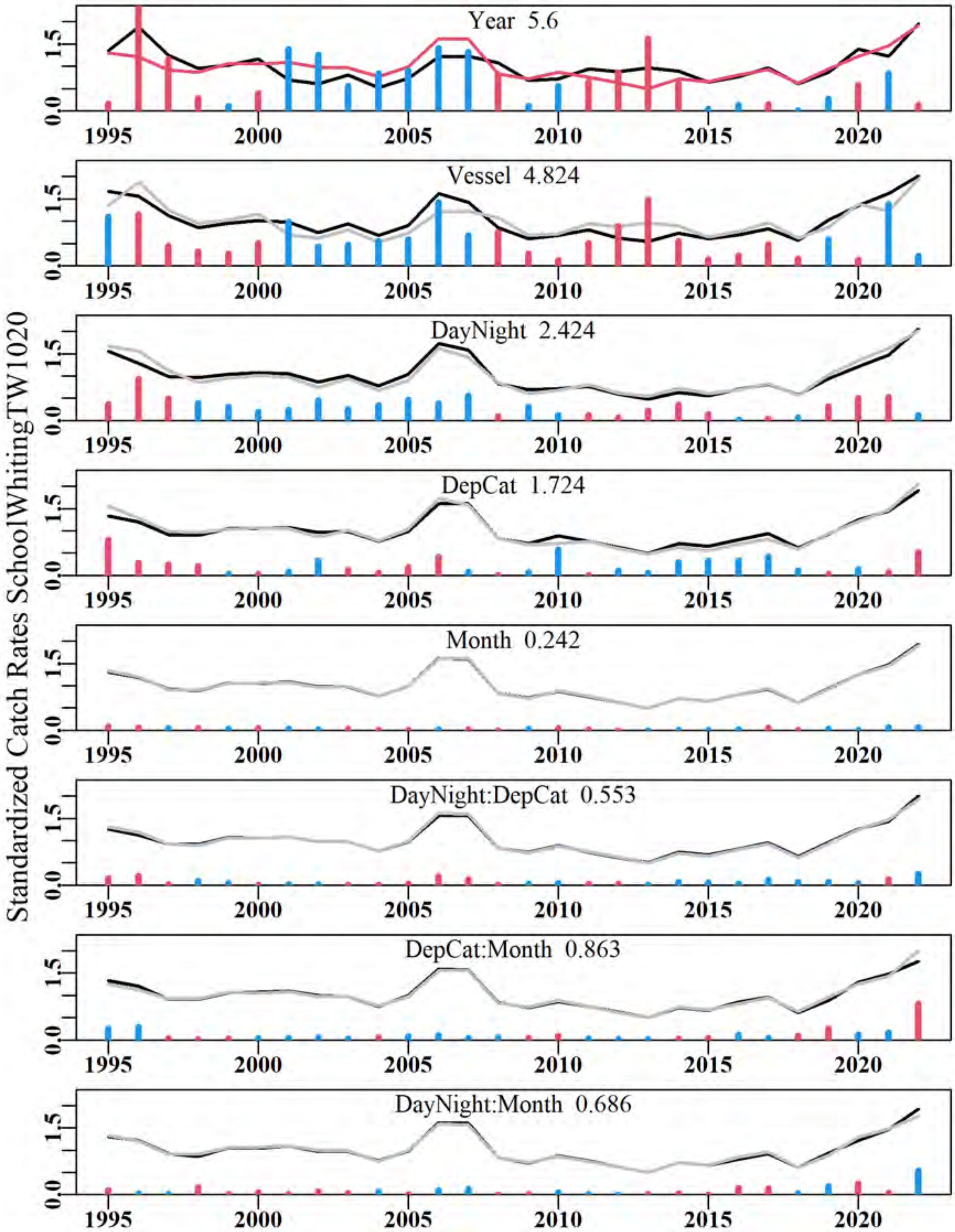

Figure 25: SchoolWhitingTW1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

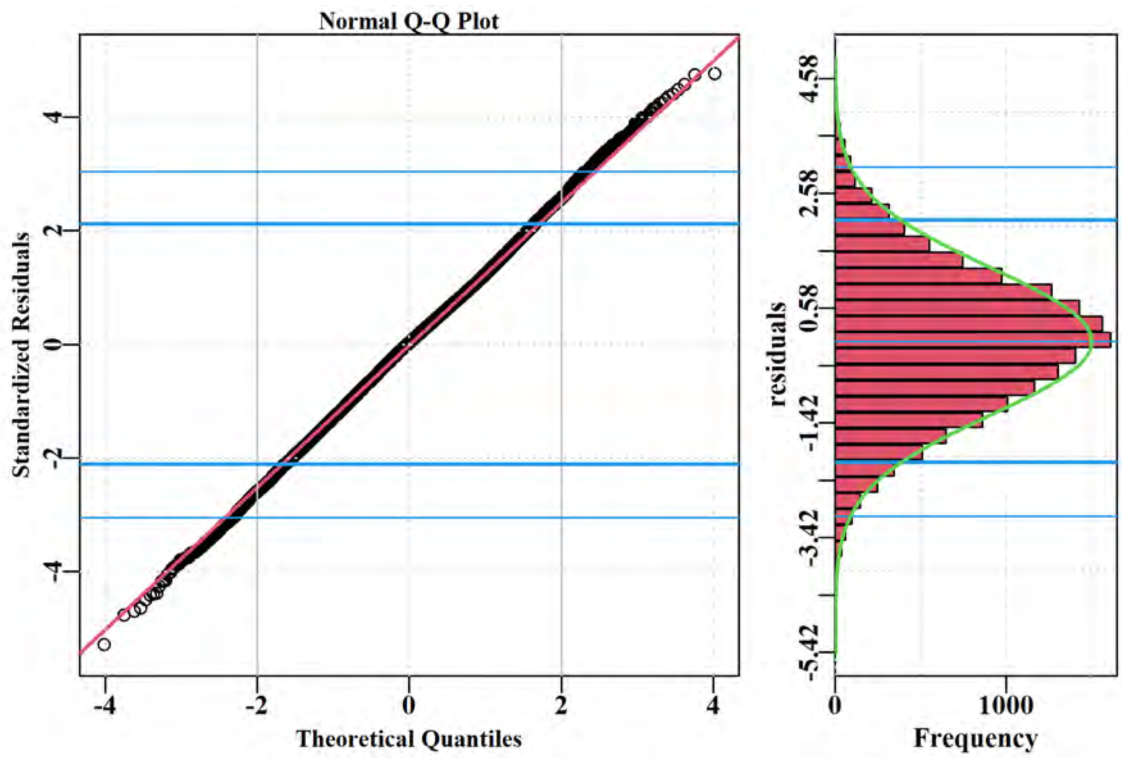

Figure 26: SchoolWhitingTW1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

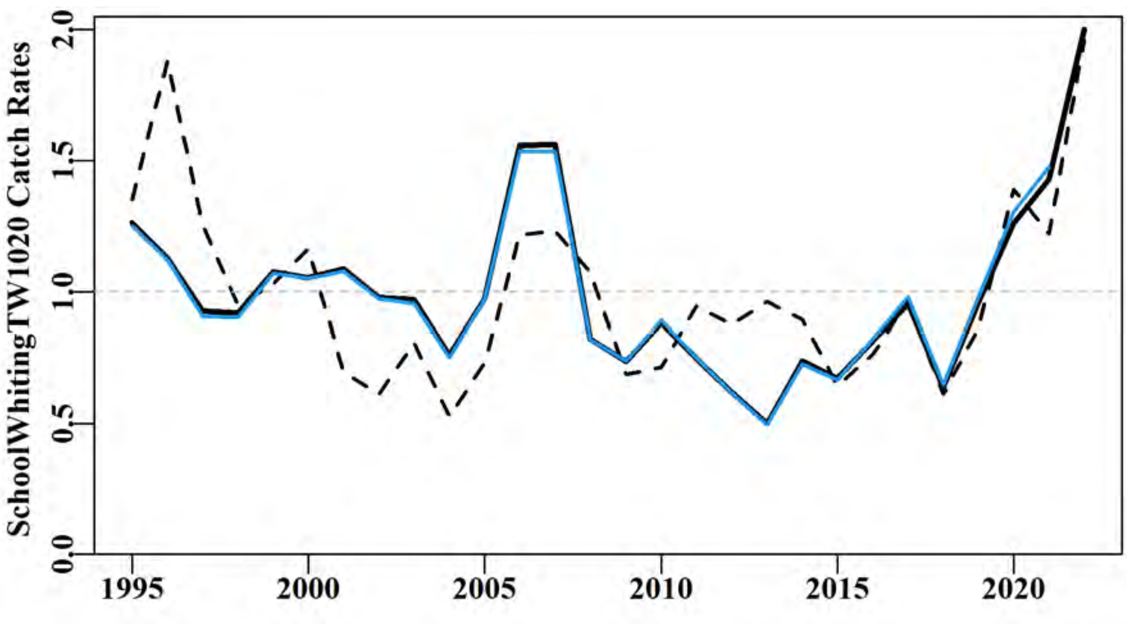

Figure 27: SchoolWhitingTW1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

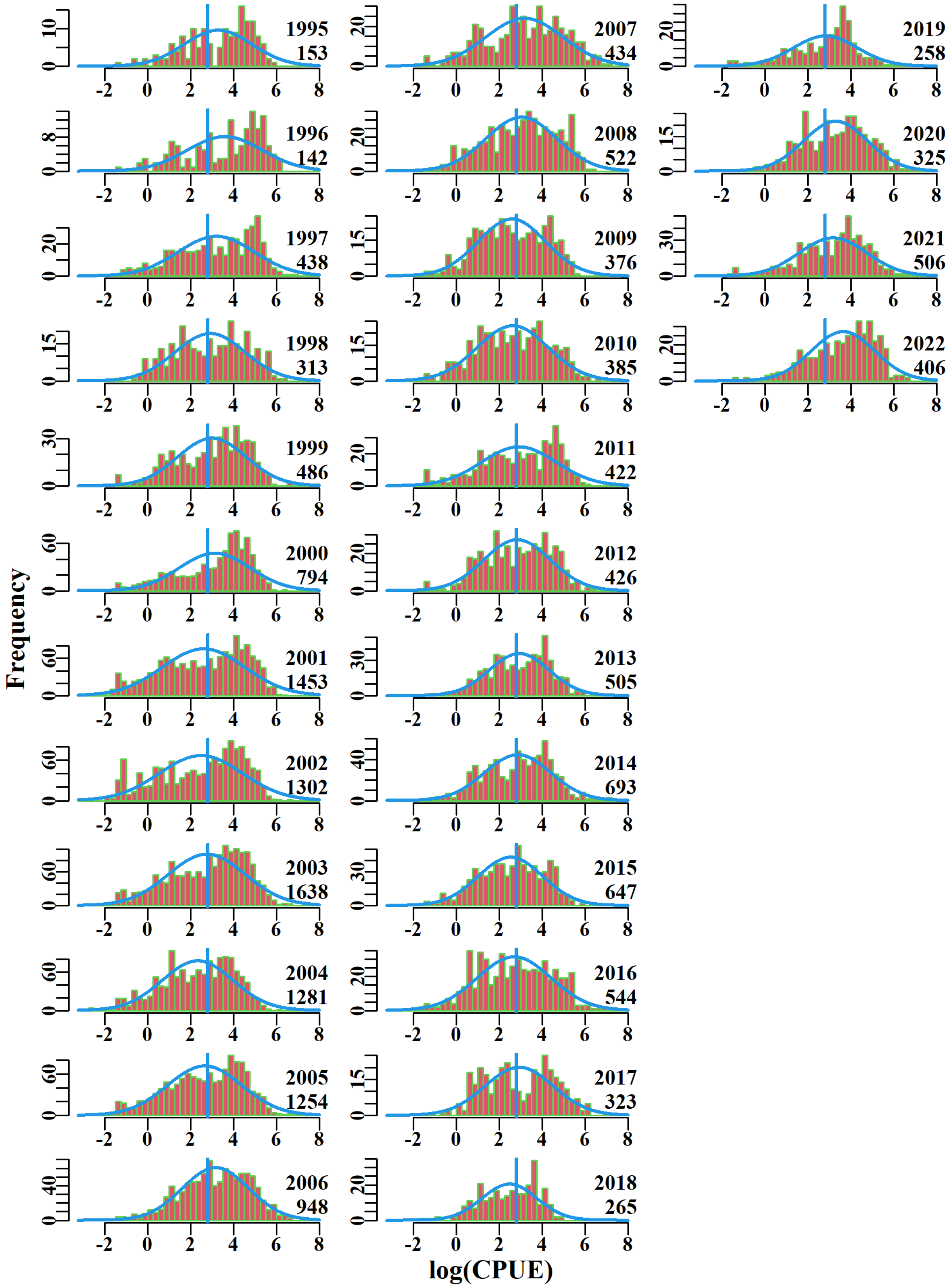

Figure 28: SchoolWhitingTW1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

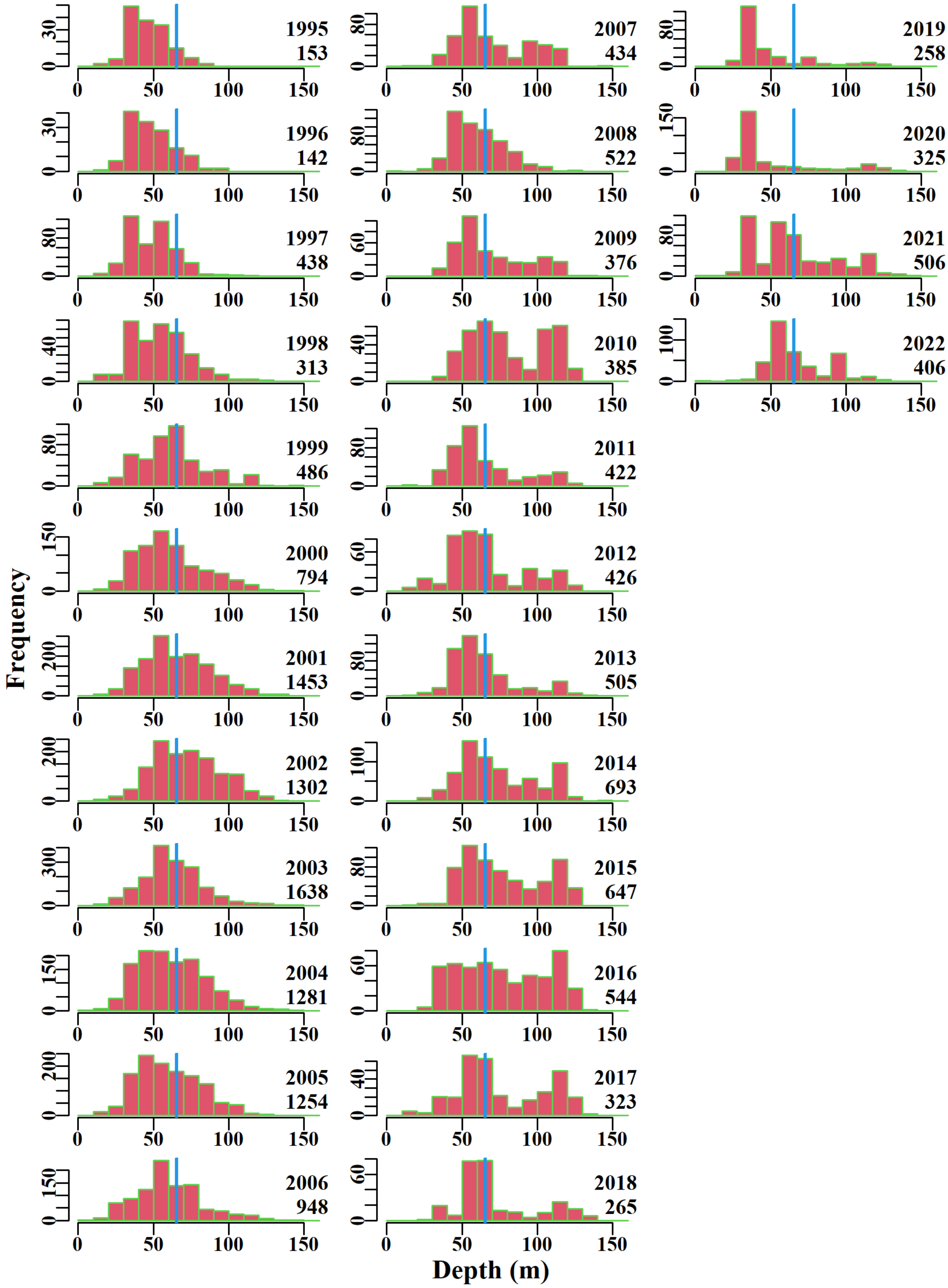

Figure 29: SchoolWhitingTW1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Mirror Dory 10 - 30

Mirror Dory (DOM – 37264003 – *Zenopsis nebulosa*) has a long history within the SESSF with catches being taken widely and by multiple methods. Records corresponding to the trawl fishery based on methods TW, TDO, TMO, OTT, OTB, in zones 10, 20, 30, and depths 0 to 600 m within the SET fishery for the period 1986 - 2022 were used were used in the analysis. Initial data selection was based on criteria provided in Table 21 from the Commonwealth logbook database.

A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, Vessel, DepCat, Month and interaction term Zone:Month had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 25). The qqplot suggests that the assumed Normal distribution is valid (Figure 33).

The Mirror Dory fishery in zones 10 - 30 exhibits large scale, apparently cyclical changes in CPUE. It appears that as catches decline so does CPUE, and as catches increase so does the CPUE. This is unexpected as the intensity of fishing is usually expected to be negatively correlated with CPUE. It may be the case that catches and CPUE change relative to availability of the stock rather than the influence of the fishery on the stock. Better evidence is needed to make such an assertion with confidence. Over the period when CPUE was lower than average (about 1995 - 2004) there was an increase in small shots of < 30 kg (Figure 31), which is suggestive of either low availability or high levels of small fish. Standardized CPUE has declined on average from 2009 to 2016. It differs from unstandardized CPUE early in the fishery (1986 - 1990), in the second half of the fishery (2000 - 2007), over the 2014 - 2017 period and over the last four years. The most recent changes appear strongly correlated with changes in the average depth of fishing with a shift to more relatively shallow water fishing, compared to the second half of the fishery. Standardized CPUE increased in 2022 relative to the previous year and has been below the long-term average and relatively stable for the past five years. The recorded catch of 35.6 t from the east in 2022 was the lowest in the series.

Action Items and Issues

No issues identified.

Table 21: MirrorDory1030. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	MirrorDory1030
csirocode	37264003
fishery	SET
depthrange	0 - 600
depthclass	25
zones	10, 20, 30
methods	TW, TDO, TMO, OTT, OTB
years	1986 - 2022

Table 22: MirrorDory1030. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	402.0	3139	367.9	80	39.2	1.2397	0.000	16.343	0.044
1987	450.8	2953	412.9	70	40.7	1.3530	0.033	15.129	0.037
1988	346.0	3065	313.1	77	33.7	1.2235	0.033	19.277	0.062
1989	591.6	2992	513.4	70	54.5	1.4704	0.034	15.795	0.031
1990	295.8	1801	253.5	61	36.5	1.3968	0.039	10.132	0.040
1991	240.3	2003	168.7	68	27.0	1.2281	0.038	16.089	0.095
1992	167.0	2032	140.4	57	22.3	1.0726	0.038	17.959	0.128
1993	306.2	2997	265.7	62	32.4	1.1663	0.034	21.976	0.083
1994	297.3	3482	260.5	62	25.9	1.0317	0.033	30.013	0.115
1995	244.9	3494	196.0	58	21.7	0.9279	0.033	33.126	0.169
1996	352.7	4377	211.5	68	16.7	0.8120	0.032	43.254	0.205
1997	459.6	4757	287.1	65	19.5	0.8641	0.032	45.256	0.158
1998	355.8	4092	230.1	55	19.4	0.7708	0.033	38.924	0.169
1999	309.5	4211	234.2	59	19.3	0.6815	0.033	39.603	0.169
2000	171.1	4593	142.5	64	11.3	0.5396	0.033	46.471	0.326
2001	243.4	4533	128.7	54	10.0	0.5427	0.033	46.396	0.361
2002	449.6	5032	194.3	53	14.0	0.6786	0.032	44.433	0.229
2003	613.9	5333	403.8	58	29.9	0.9692	0.032	40.852	0.101
2004	507.4	4256	291.0	57	25.8	0.9215	0.033	32.430	0.111
2005	579.9	4356	420.4	55	37.4	1.1846	0.033	30.059	0.071
2006	419.6	3214	296.4	44	35.4	1.1934	0.035	23.588	0.080
2007	289.6	2210	201.1	22	33.6	1.2874	0.038	16.397	0.082
2008	396.2	2476	316.9	26	48.1	1.4327	0.037	17.544	0.055
2009	476.5	2191	333.9	27	55.9	1.5343	0.038	15.733	0.047
2010	580.0	2068	378.3	25	71.5	1.2868	0.039	13.158	0.035
2011	514.5	2208	339.2	26	64.0	1.3141	0.038	14.273	0.042
2012	365.5	1712	281.3	24	66.7	1.0454	0.041	10.981	0.039
2013	279.9	1633	206.6	24	55.6	1.0837	0.041	10.502	0.051
2014	190.0	1731	112.3	25	24.7	0.9028	0.041	15.045	0.134
2015	240.4	2126	163.5	27	31.8	0.8850	0.039	17.175	0.105
2016	249.4	2060	202.2	26	42.4	0.8277	0.039	13.167	0.065
2017	224.3	1410	163.3	22	51.0	0.9464	0.043	11.205	0.069
2018	96.6	1214	58.0	18	18.9	0.5832	0.046	12.155	0.210
2019	104.4	1590	65.9	20	15.2	0.6262	0.043	15.867	0.241
2020	90.6	1409	55.9	18	15.1	0.5725	0.044	12.563	0.225
2021	94.1	1322	65.7	18	20.6	0.6722	0.045	10.596	0.161
2022	75.4	939	35.6	17	15.1	0.7316	0.050	9.751	0.274

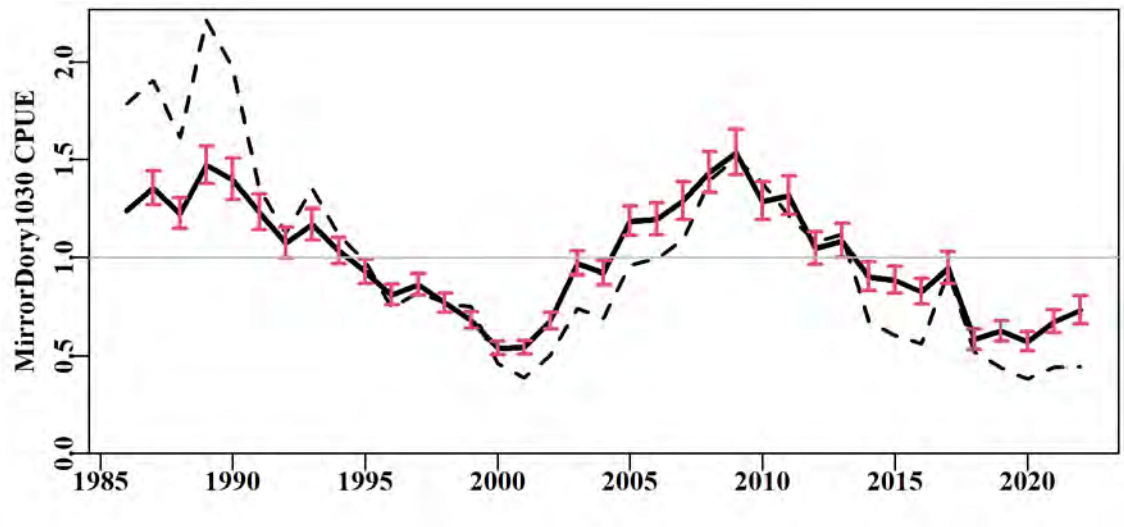

Figure 30: MirrorDory1030 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

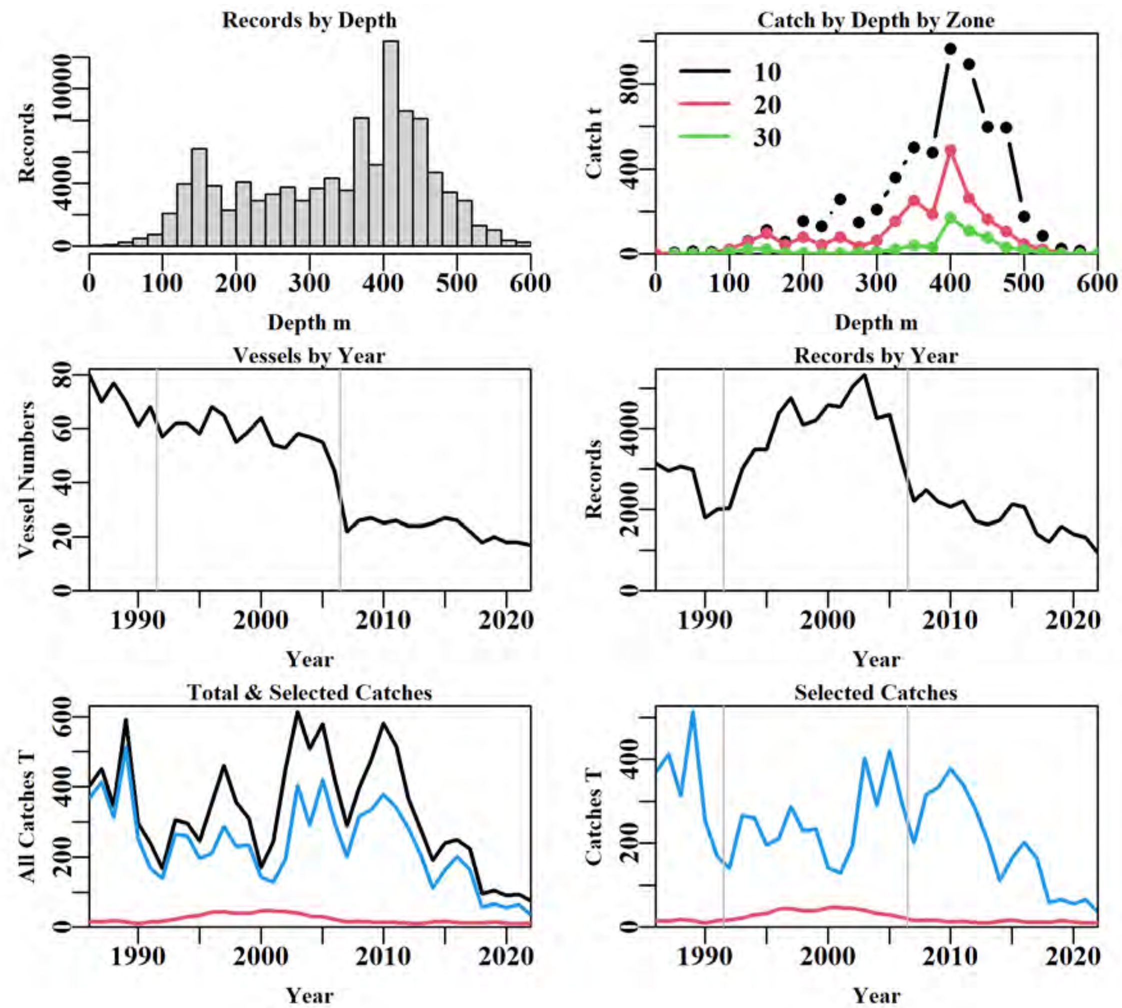

Figure 31: MirrorDory1030 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 23: MirrorDory1030 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156482	151533	149509	148859	108406	105064	105011
Difference	0	4949	2024	650	40453	3342	53
Catch	12115	11987	11813	11773	8789	8715	8712
Difference	0	128	174	41	2983	75	3

Table 24: The models used to analyse data for MirrorDory1030.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + Zone
Model6	Year + Vessel + DepCat + Month + Zone + DayNight
Model7	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:Month
Model8	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:DepCat

Table 25: MirrorDory1030. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	78898	222447	22852	105011	37	9.3	0.00
Vessel	60816	186609	58690	105011	220	23.8	14.48
DepCat	48689	166181	79118	105011	244	32.1	8.33
Month	46592	162861	82437	105011	255	33.4	1.35
Zone	45666	161425	83874	105011	257	34.0	0.59
DayNight	44735	159991	85307	105011	260	34.6	0.58
Zone:Month	42777	156969	88329	105011	282	35.8	1.22
Zone:DepCat	44299	159186	86113	105011	307	34.9	0.30

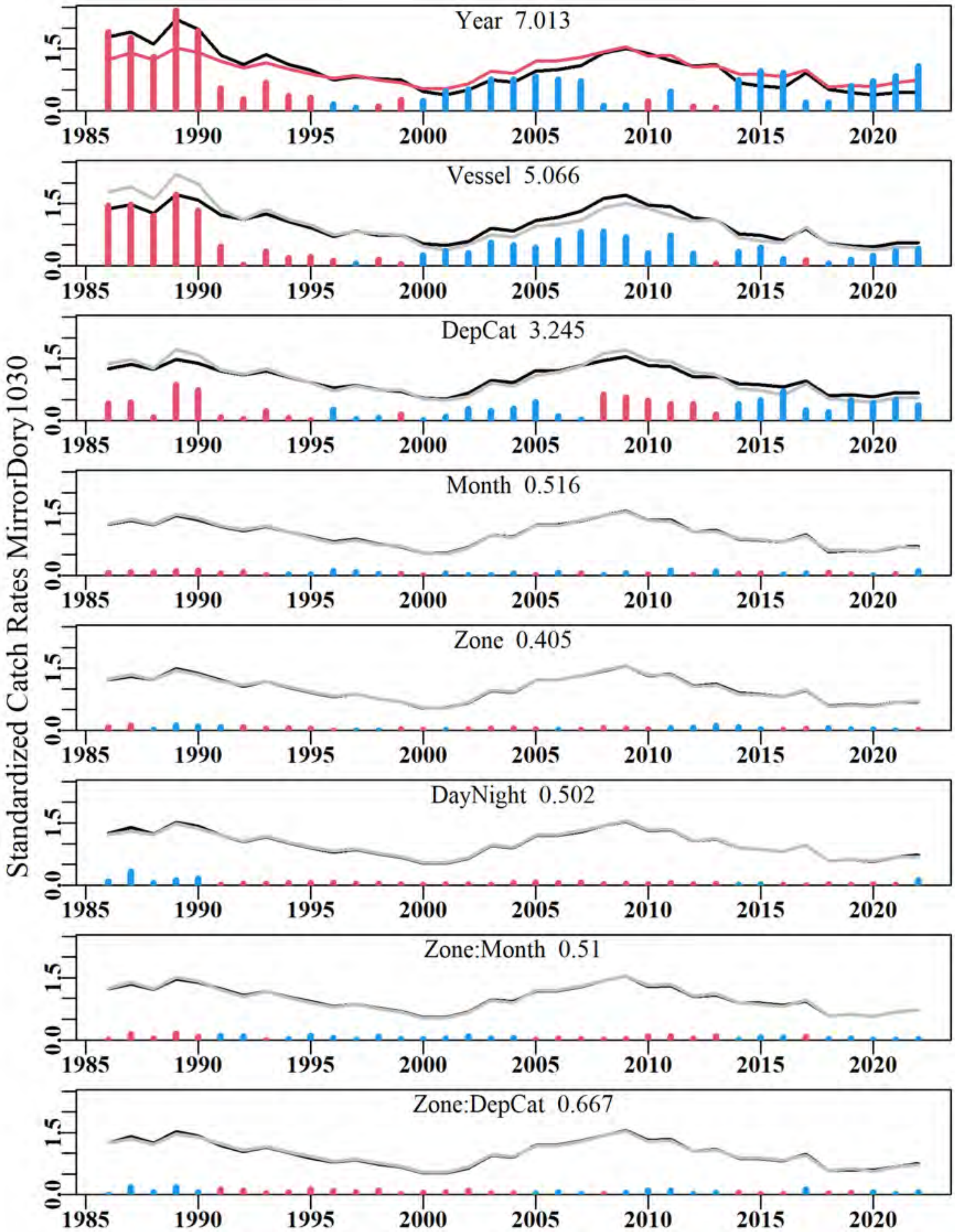

Figure 32: MirrorDory1030. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

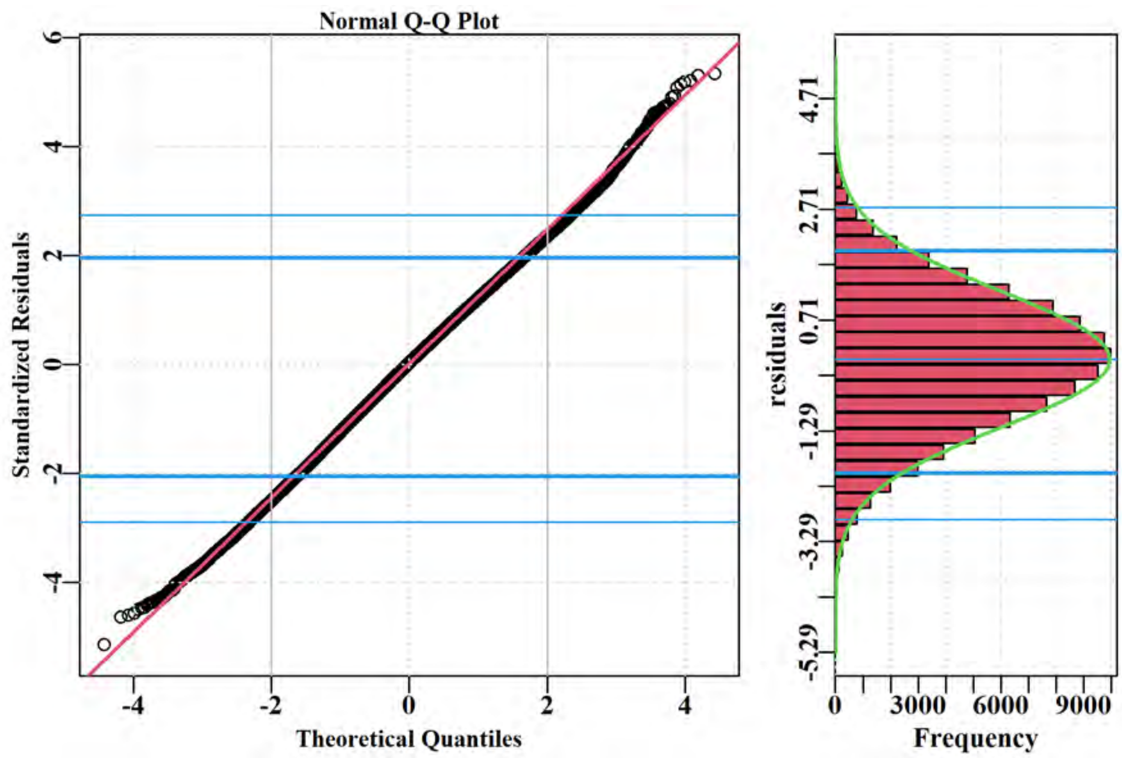

Figure 33: MirrorDory1030. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

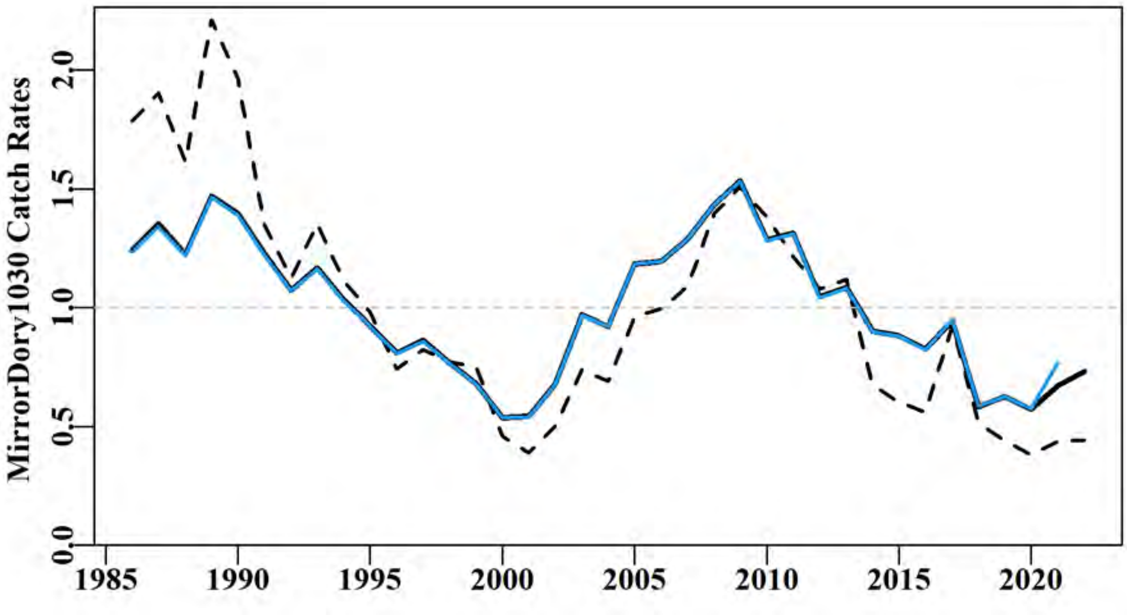

Figure 34: MirrorDory1030. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

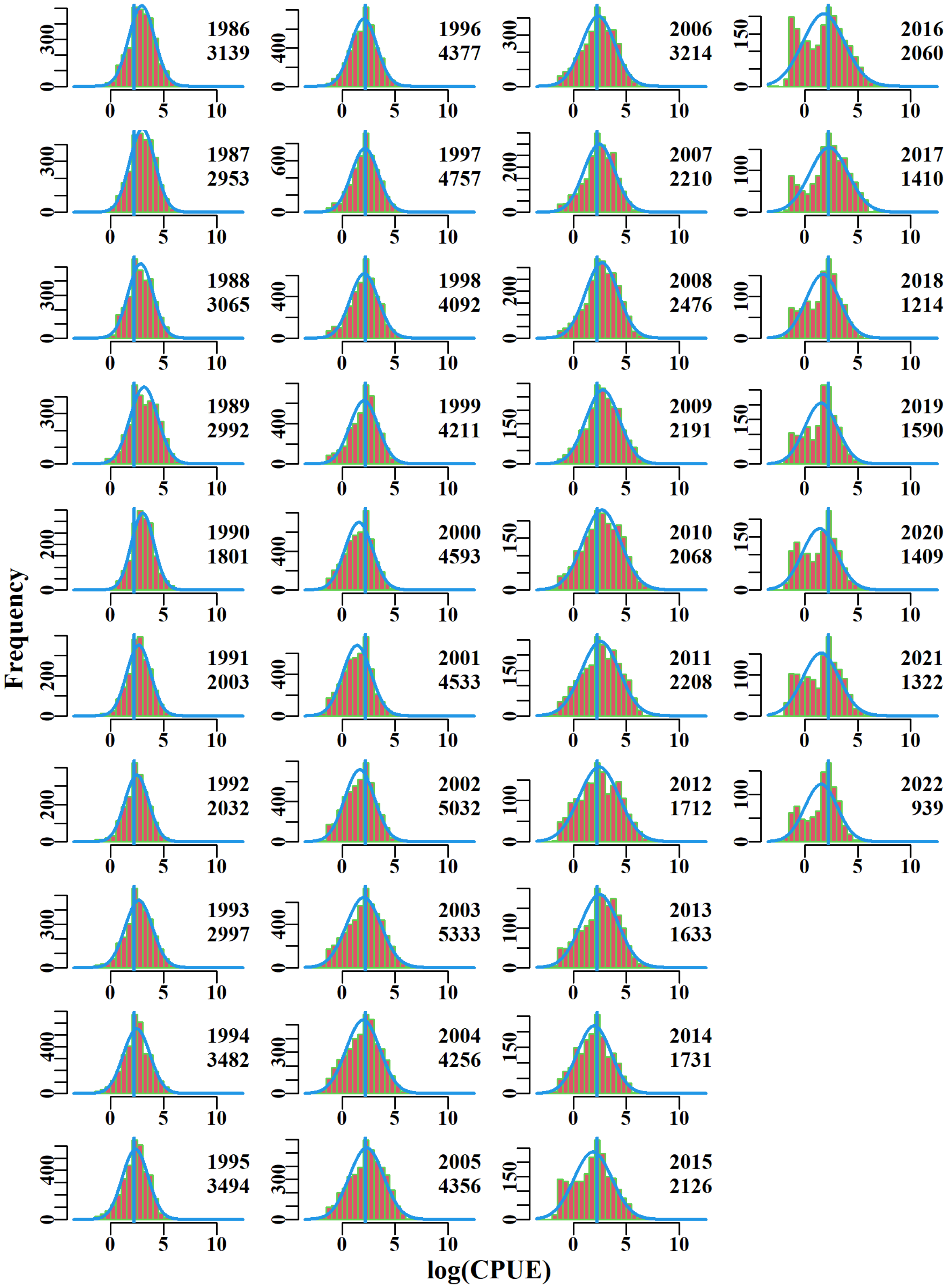

Figure 35: MirrorDory1030. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

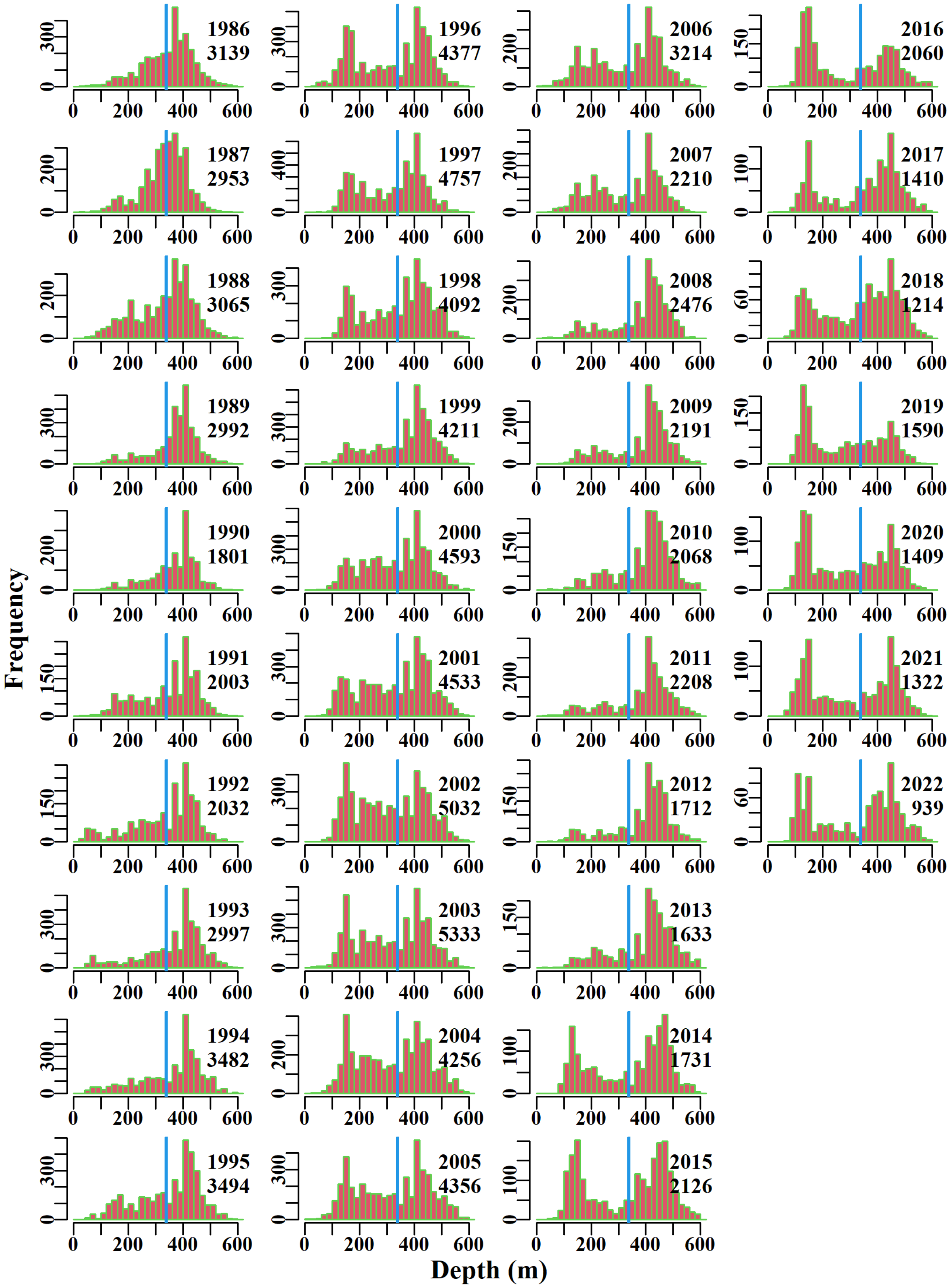

Figure 36: MirrorDory1030. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Mirror Dory 40 - 50

Trawl caught Mirror Dory (DOM – 37264003 – *Zenopsis nebulosa*) using methods TW, TDO, TMO, OTT, OTB, OTM, in zones 40, 50, and depths 0 to 600 m within the SET fishery for the years 1986 - 2022 were analysed. These constitute the criteria used to select data from the Commonwealth logbook database (Table 26).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Mirror Dory catches in the west appear to be episodic with peaks in 1997, 2001 - 2003, and 2010 and 2011, which roughly coincides with minor peaks in CPUE in a manner similar to that observed in the east, although with a more rapid cycle and less extreme variation. There has been an increase of reported catches in waters around 200 m, relative to the start of the series, which is unusual for Mirror Dory in the west. The statistical model fit is very good with the deviations at the extremes in the qqplot being made up of far less than 5% of records at each end.

The amount of catch remains minor until about 1995 (Table 27) after which the amount of catch and the number of records remains at levels that permit usable analyses, with relatively tight precision levels around the mean estimates to be made. From 1990 the CPUE trend for Mirror Dory in the west appears to be relatively periodic and noisy around the long-term average with periods above and below.

Action Items and Issues

It is recommended that the CPUE time-series only be used from 1995 onwards (Figure 37) because catches before then are relatively minor.

Table 26: MirrorDory4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	MirrorDory4050
csirocode	37264003
fishery	SET
depthrange	0 - 600
depthclass	30
zones	40, 50
methods	TW, TDO, TMO, OTT, OTB, OTM
years	1986 - 2022

Table 27: MirrorDory4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	402.0	58	7.4	11	37.2	2.6503	0.000	0.390	0.053
1987	450.8	142	15.5	23	36.1	1.7785	0.185	0.929	0.060
1988	346.0	122	15.0	17	37.2	1.4042	0.194	0.940	0.063
1989	591.6	71	11.1	15	45.3	1.7364	0.206	0.545	0.049
1990	295.8	95	10.0	14	37.9	1.2292	0.210	0.505	0.051
1991	240.3	208	12.8	17	17.8	0.8964	0.183	2.642	0.207
1992	167.0	206	8.3	20	14.6	0.7255	0.185	1.870	0.225
1993	306.2	278	18.1	18	16.7	0.8560	0.180	3.207	0.177
1994	297.3	330	18.2	20	14.8	0.7820	0.178	4.166	0.229
1995	244.9	704	37.9	23	15.4	1.0266	0.175	7.882	0.208
1996	352.7	1433	115.0	26	23.4	1.3706	0.175	12.869	0.112
1997	459.6	1903	148.2	24	24.5	1.3931	0.174	16.696	0.113
1998	355.8	1468	116.2	20	27.5	1.3153	0.175	12.717	0.109
1999	309.5	1316	63.2	23	17.0	0.8548	0.175	13.721	0.217
2000	171.1	975	22.4	30	7.9	0.4698	0.176	11.410	0.510
2001	243.4	2461	105.8	29	14.1	0.8139	0.174	28.871	0.273
2002	449.6	3151	240.2	28	24.8	1.2068	0.174	27.990	0.117
2003	613.9	2420	154.2	28	20.7	1.0038	0.174	20.528	0.133
2004	507.4	2201	159.4	25	20.3	1.0002	0.174	16.778	0.105
2005	579.9	1761	99.7	23	15.2	0.7911	0.175	15.640	0.157
2006	419.6	1053	64.8	19	15.7	0.6581	0.176	8.754	0.135
2007	289.6	1160	63.1	16	14.3	0.5897	0.175	11.733	0.186
2008	396.2	873	57.4	17	16.1	0.6990	0.176	8.632	0.150
2009	476.5	1331	123.0	14	20.0	1.0659	0.175	9.533	0.078
2010	580.0	1582	177.0	14	26.5	1.3010	0.175	9.483	0.054
2011	514.5	1648	157.3	16	21.8	0.9948	0.175	9.446	0.060
2012	365.5	993	69.6	15	16.9	0.5858	0.176	7.420	0.107
2013	279.9	635	54.4	15	20.8	0.7859	0.177	5.055	0.093
2014	190.0	832	67.3	14	19.6	0.9068	0.176	6.618	0.098
2015	240.4	944	70.6	13	17.4	0.9464	0.176	6.918	0.098
2016	249.4	622	41.4	13	16.5	0.6970	0.178	4.790	0.116
2017	224.3	701	57.8	11	16.5	0.9441	0.177	5.681	0.098
2018	96.6	529	31.0	11	10.8	0.5892	0.179	4.534	0.146
2019	104.4	586	34.4	14	11.9	0.6324	0.178	5.025	0.146
2020	90.6	508	28.3	14	9.5	0.6016	0.179	5.009	0.177
2021	94.1	418	24.9	10	10.8	0.7475	0.180	3.756	0.151
2022	75.4	545	34.2	10	10.4	0.9503	0.178	5.027	0.147

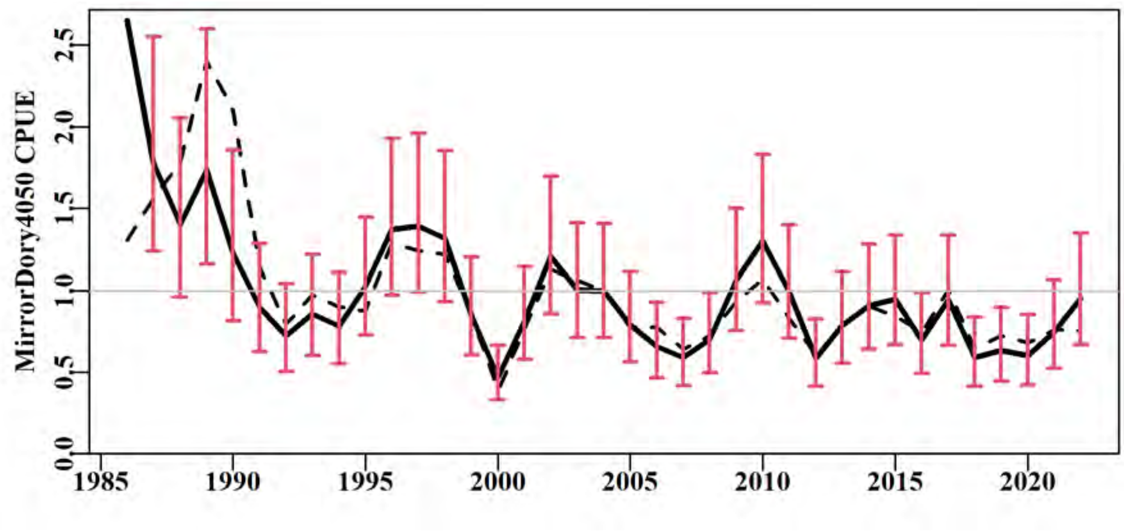

Figure 37: MirrorDory4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

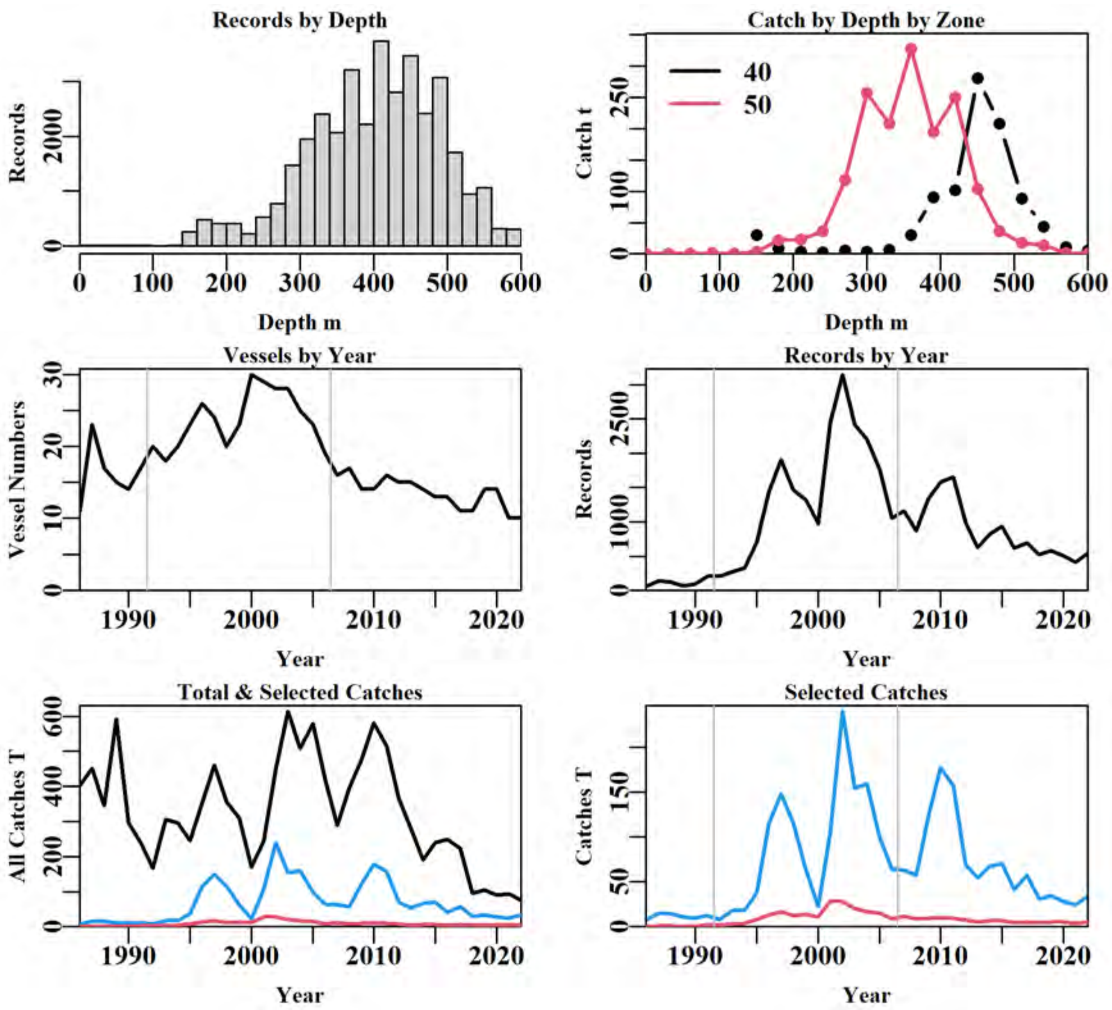

Figure 38: MirrorDory4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 28: MirrorDory4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156482	151533	149509	148859	36507	36319	36263
Difference	0	4949	2024	650	112352	188	56
Catch	12115	11987	11813	11773	2546	2539	2535
Difference	0	128	174	41	9227	7	4

Table 29: The models used to analyse data for MirrorDory4050.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + DepCat
Model5	Year + Vessel + Month + DepCat + DayNight
Model6	Year + Vessel + Month + DepCat + DayNight + Zone
Model7	Year + Vessel + Month + DepCat + DayNight + Zone + Zone:Month
Model8	Year + Vessel + Month + DepCat + DayNight + Zone + Zone:DepCat

Table 30: MirrorDory4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	11044	49073	2430	36263	37	4.62	0.000
Vessel	4468	40718	10785	36263	133	20.65	16.028
Month	2723	38781	12722	36263	144	24.40	3.751
DepCat	674	36610	14893	36263	164	28.60	4.193
DayNight	-592	35349	16154	36263	167	31.05	2.454
Zone	-1012	34940	16563	36263	168	31.85	0.795
Zone:Month	-1410	34538	16966	36263	179	32.61	0.764
Zone:DepCat	-1082	34834	16670	36263	188	32.02	0.170

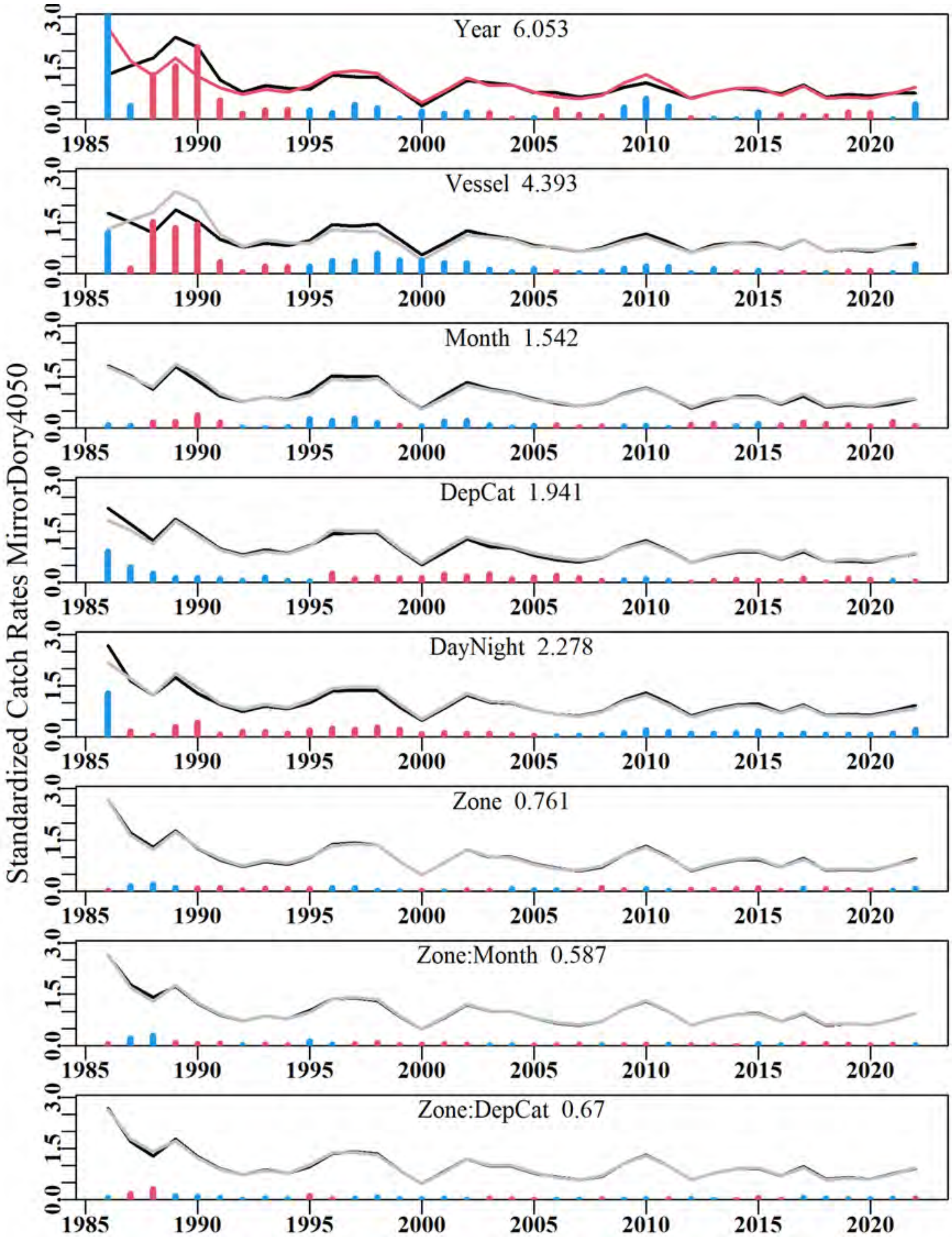

Figure 39: MirrorDory4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

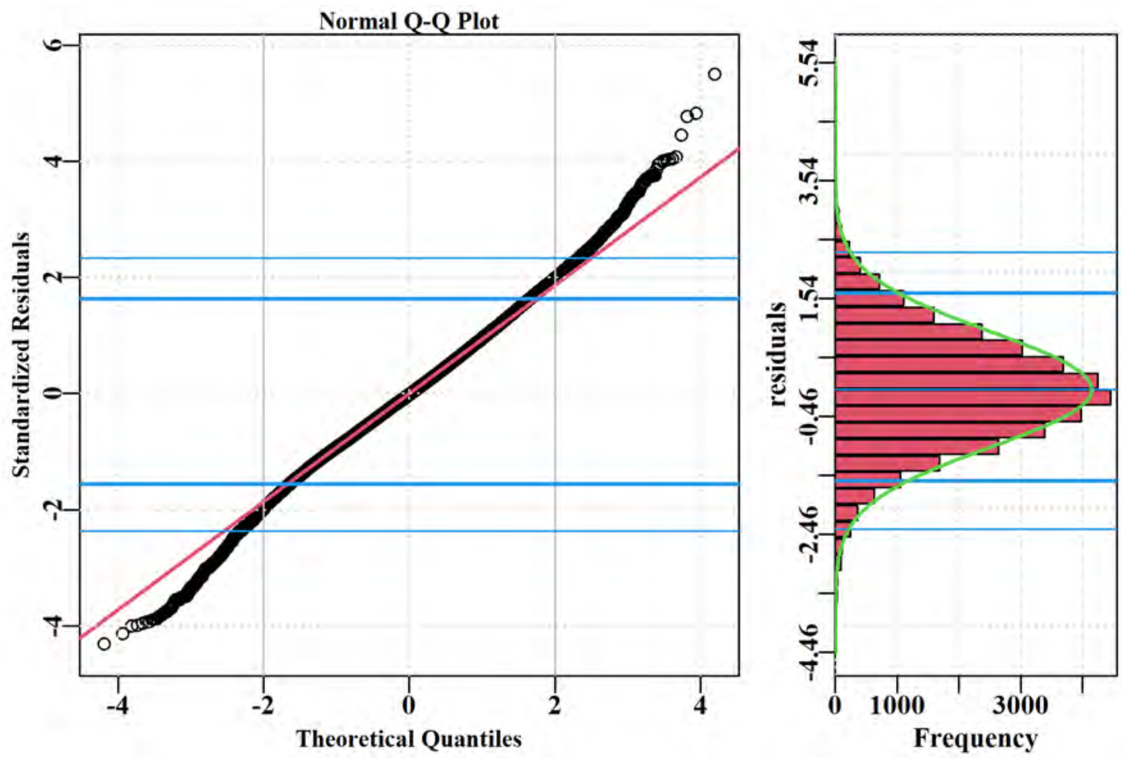

Figure 40: MirrorDory4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

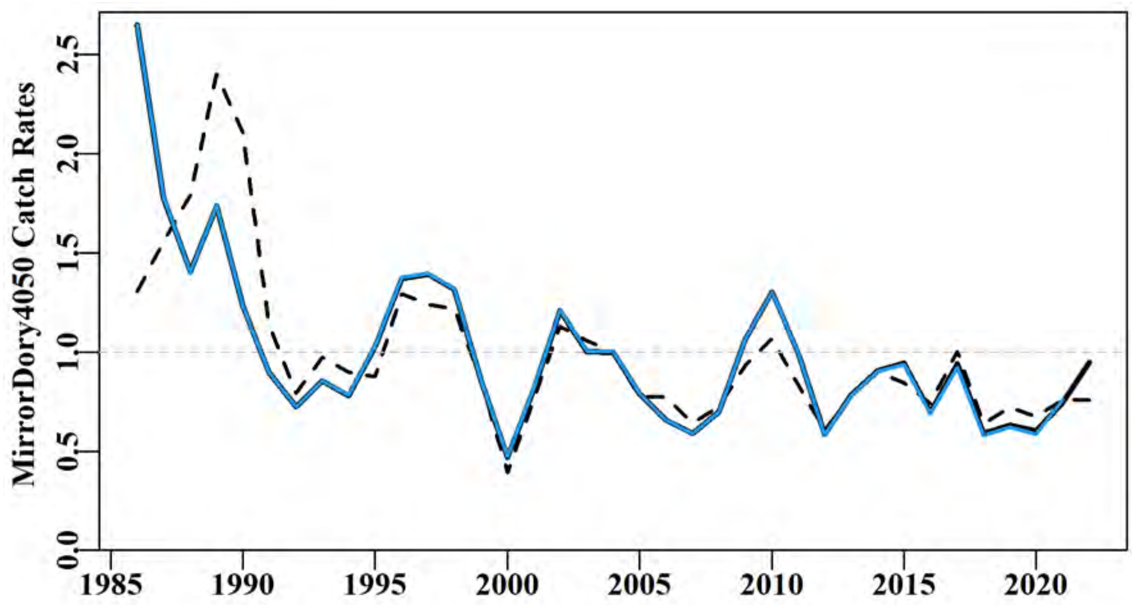

Figure 41: MirrorDory4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

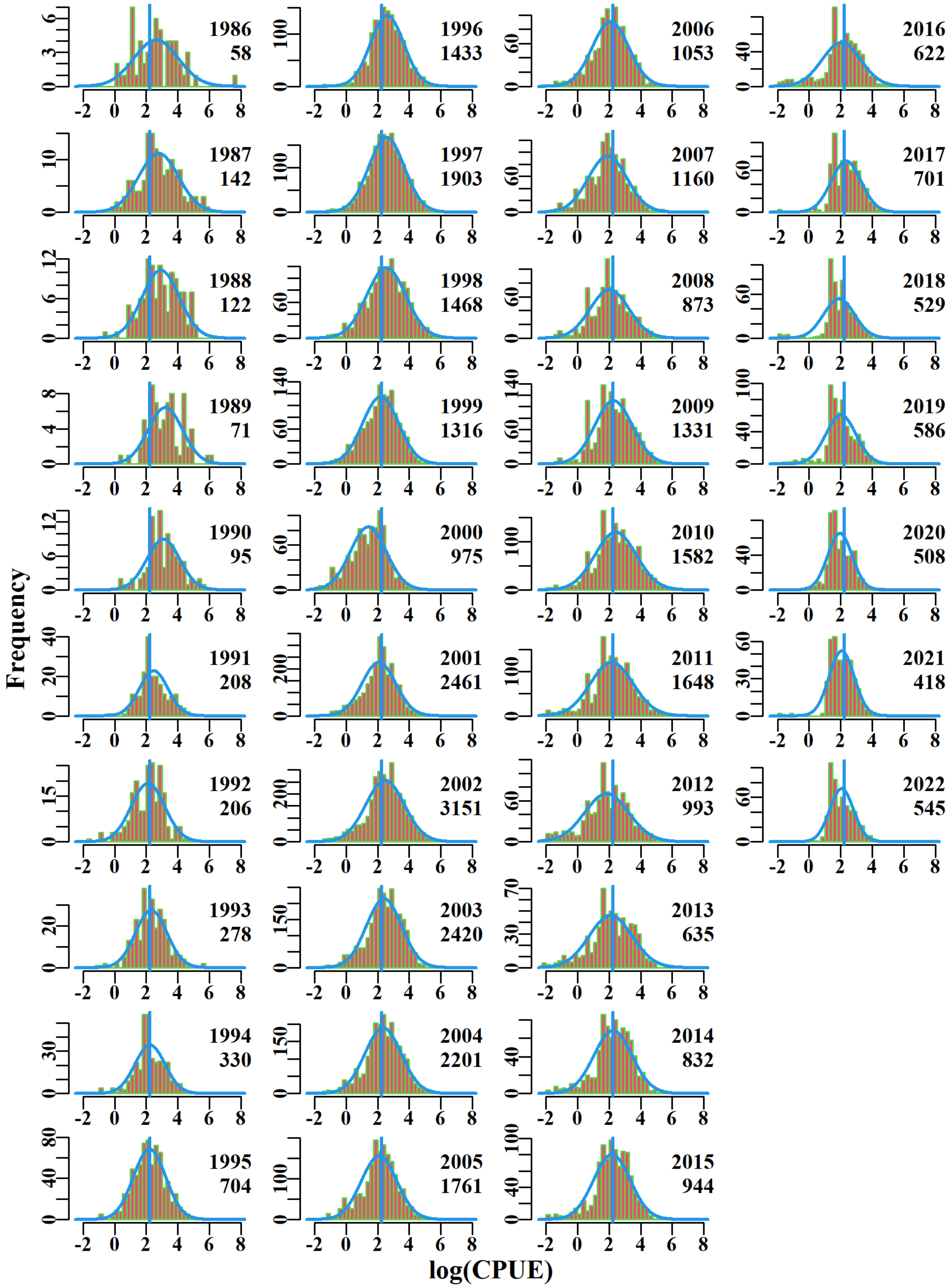

Figure 42: MirrorDory4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

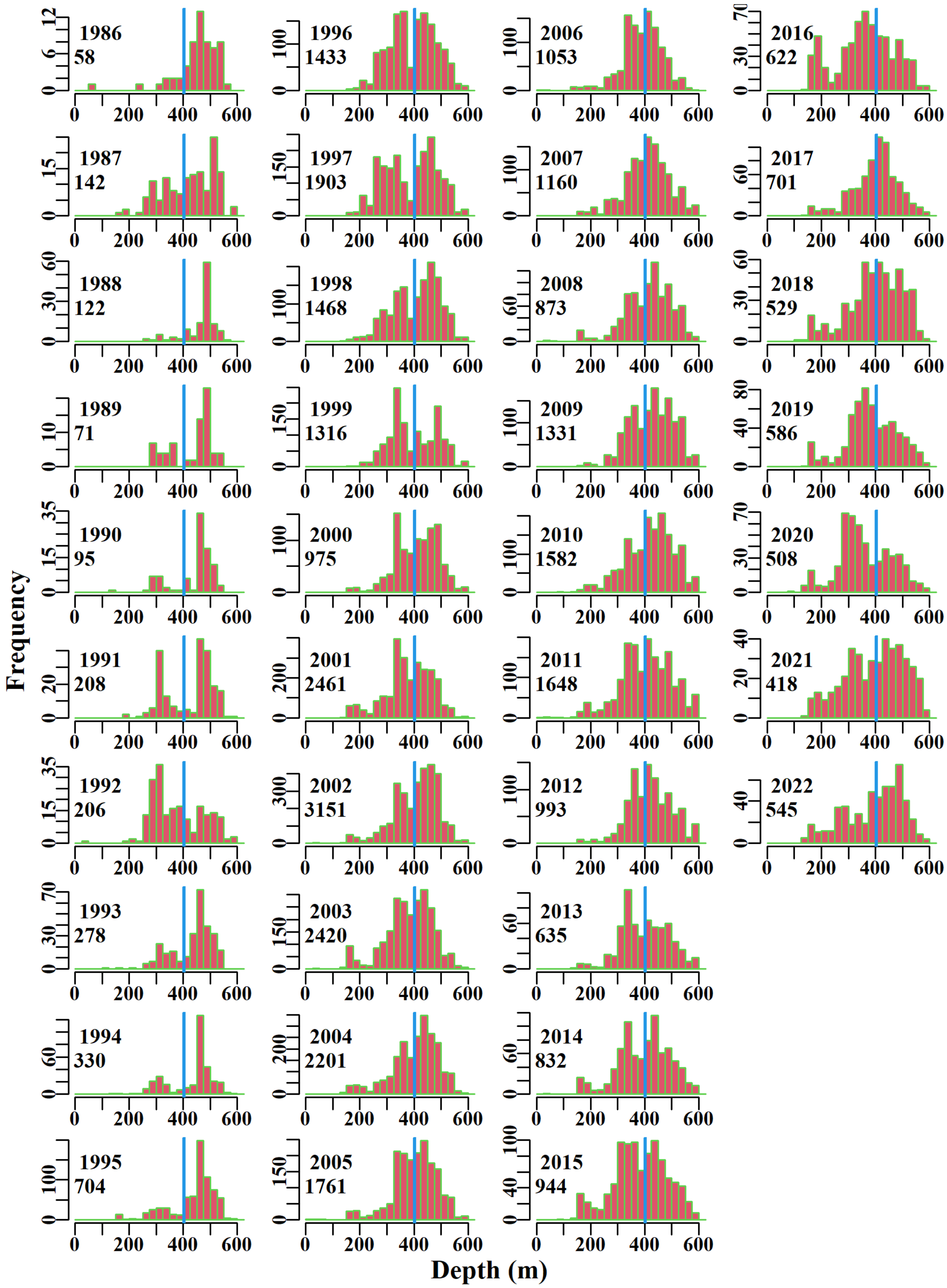

Figure 43: MirrorDory4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Jackass Morwong 30

Jackass Morwong (MOR – 37377003 –*Nemadactylus macropterus*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The criteria used to select data from the Commonwealth logbook database is based on the trawl fishery which uses methods TW, TDO, OTB, in zones 30, and depths 70 to 300 m within the SET fishery for the years 1986 - 2022 (Table 31). A total of 7 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, Month, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 35). The qqplot suggests that the assumed Normal distribution is valid, with small deviations at the tails of the distribution (Figure 47).

Annual standardized CPUE has been below the long-term average since about 2001. More recently, the relative CPUE trend has been flat since at least 2015 (i.e., statistically insignificant from each other over the last nine years) (Figure 44). The recorded catch of 54 t from zone 30 in 2019 was the highest since 2013. By contrast, the recorded catch (14.4 t) from zone 30 in 2021 was the lowest in the series.

Action Items and Issues

With only 68 records and 30 t of reported catch in 1986, it is recommended that the standardization analysis should begin in 1987 or 1988 (Table 32).

The selected depth for Jackass Morwong 30 is from 70 - 300 m, based on the recommendation from the RAG. However, there are records in Zone 30 from 0 - 500 m but only significant catches out to 200 m or 250 m at most. The reasons for the earlier specific depth selection need to be re-iterated and an examination of the effect of making the current depth selection explored.

Catches are low in 1986 and the distribution of log(CPUE) only stabilizes approximately from 1989 onwards (and possibly later), which suggests that including those earlier years in the standardization should be reconsidered.

Table 31: JackassMorwong30. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	JackassMorwong30
csirocode	37377003
fishery	SET
depthrange	70 - 300
depthclass	20
zones	30
methods	TW, TDO, OTB
years	1986 - 2022

Table 32: JackassMorwong30. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DayNight.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	982.8	68	29.8	6	165.9	2.0926	0.000	0.255	0.009
1987	1087.7	205	57.0	13	104.4	2.3475	0.182	0.695	0.012
1988	1483.5	282	207.7	13	272.2	3.2039	0.180	0.684	0.003
1989	1667.4	687	475.0	19	231.9	4.0667	0.173	0.775	0.002
1990	1001.4	379	140.2	26	146.8	2.9191	0.174	0.901	0.006
1991	1138.1	408	184.4	29	154.7	1.9734	0.172	1.060	0.006
1992	758.3	333	106.7	18	109.0	2.2128	0.176	1.050	0.010
1993	1015.0	1031	322.3	27	104.7	1.7685	0.167	2.433	0.008
1994	818.4	759	179.1	22	71.2	1.2212	0.168	2.130	0.012
1995	789.5	821	183.7	19	68.6	1.2163	0.169	4.244	0.023
1996	827.2	888	161.3	19	54.5	1.1575	0.168	5.219	0.032
1997	1063.4	938	202.3	15	71.6	1.2589	0.167	3.422	0.017
1998	876.4	768	190.7	15	74.4	1.2400	0.168	2.123	0.011
1999	961.5	854	246.9	17	91.6	1.4792	0.168	2.310	0.009
2000	945.2	548	123.4	23	66.5	0.9045	0.170	2.126	0.017
2001	790.2	807	110.3	19	43.2	0.5694	0.167	5.349	0.049
2002	811.2	1039	108.3	15	34.7	0.4630	0.166	6.333	0.058
2003	774.6	1121	186.2	19	59.8	0.6190	0.165	5.933	0.032
2004	765.5	1494	200.8	15	41.6	0.4650	0.165	8.776	0.044
2005	784.2	1136	135.6	17	35.0	0.3523	0.166	7.263	0.054
2006	811.3	1112	152.8	14	40.5	0.4329	0.166	5.253	0.034
2007	607.9	705	110.6	8	49.8	0.6142	0.169	2.355	0.021
2008	700.4	752	117.2	9	51.2	0.6257	0.169	2.573	0.022
2009	454.4	456	53.4	10	37.8	0.4339	0.172	1.849	0.035
2010	380.0	340	54.9	9	48.8	0.4807	0.175	1.468	0.027
2011	428.0	444	47.4	8	34.6	0.3287	0.173	2.027	0.043
2012	395.6	518	88.8	8	56.1	0.4342	0.171	1.761	0.020
2013	323.9	595	102.9	10	57.8	0.4788	0.170	2.670	0.026
2014	216.6	358	53.3	9	39.2	0.2546	0.175	2.244	0.042
2015	152.5	455	30.4	11	18.7	0.1541	0.172	3.163	0.104
2016	183.4	768	48.3	10	19.7	0.1688	0.168	5.918	0.123
2017	246.2	611	37.9	9	21.3	0.1877	0.170	4.605	0.121
2018	209.7	468	26.4	9	18.2	0.1467	0.173	3.327	0.126
2019	161.9	623	54.0	12	29.4	0.2580	0.171	4.113	0.076
2020	99.1	388	21.1	8	18.2	0.1479	0.174	3.300	0.156
2021	100.3	322	14.4	9	13.9	0.1532	0.177	2.889	0.201
2022	67.8	251	15.6	7	18.7	0.1691	0.181	1.803	0.116

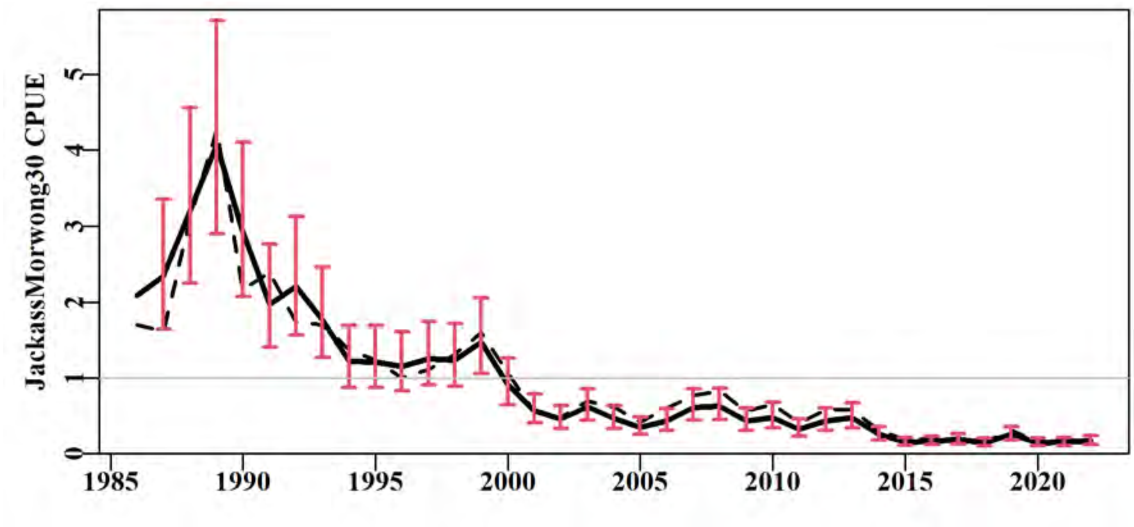

Figure 44: JackassMorwong30 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

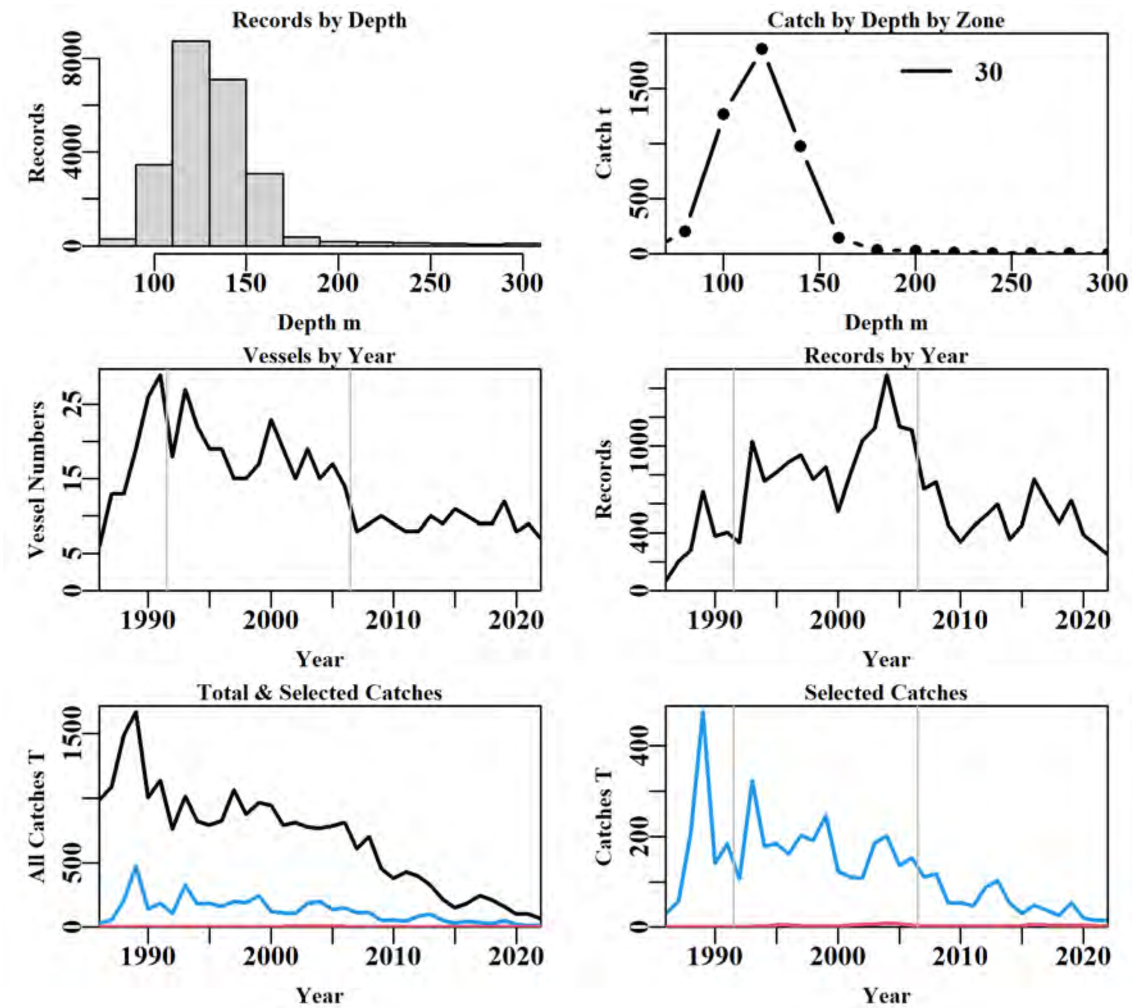

Figure 45: JackassMorwong30 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 33: JackassMorwong30 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	272266	248336	218444	215155	24357	23735	23732
Difference	0	23930	29892	3289	190798	622	3
Catch	25556	24593	23102	22545	4651	4581	4581
Difference	0	963	1490	558	17894	70	0

Table 34: The models used to analyse data for JackassMorwong30.

	Model
Model1	Year
Model2	Year + Month
Model3	Year + Month + Vessel
Model4	Year + Month + Vessel + DepCat
Model5	Year + Month + Vessel + DepCat + DayNight
Model6	Year + Month + Vessel + DepCat + DayNight + Zone:Month
Model7	Year + Month + Vessel + DepCat + DayNight + Zone:DepCat

Table 35: JackassMorwong30. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DayNight.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	14461	43513	14917	23732	37	25.4	0.00
Month	12596	40187	18244	23732	48	31.1	5.67
Vessel	10899	37112	21319	23732	144	36.1	5.01
DepCat	10174	35959	22472	23732	156	38.1	1.95
DayNight	9755	35321	23109	23732	159	39.1	1.09
Zone:Month	9755	35321	23109	23732	159	39.1	0.00
Zone:DepCat	9755	35321	23109	23732	159	39.1	0.00

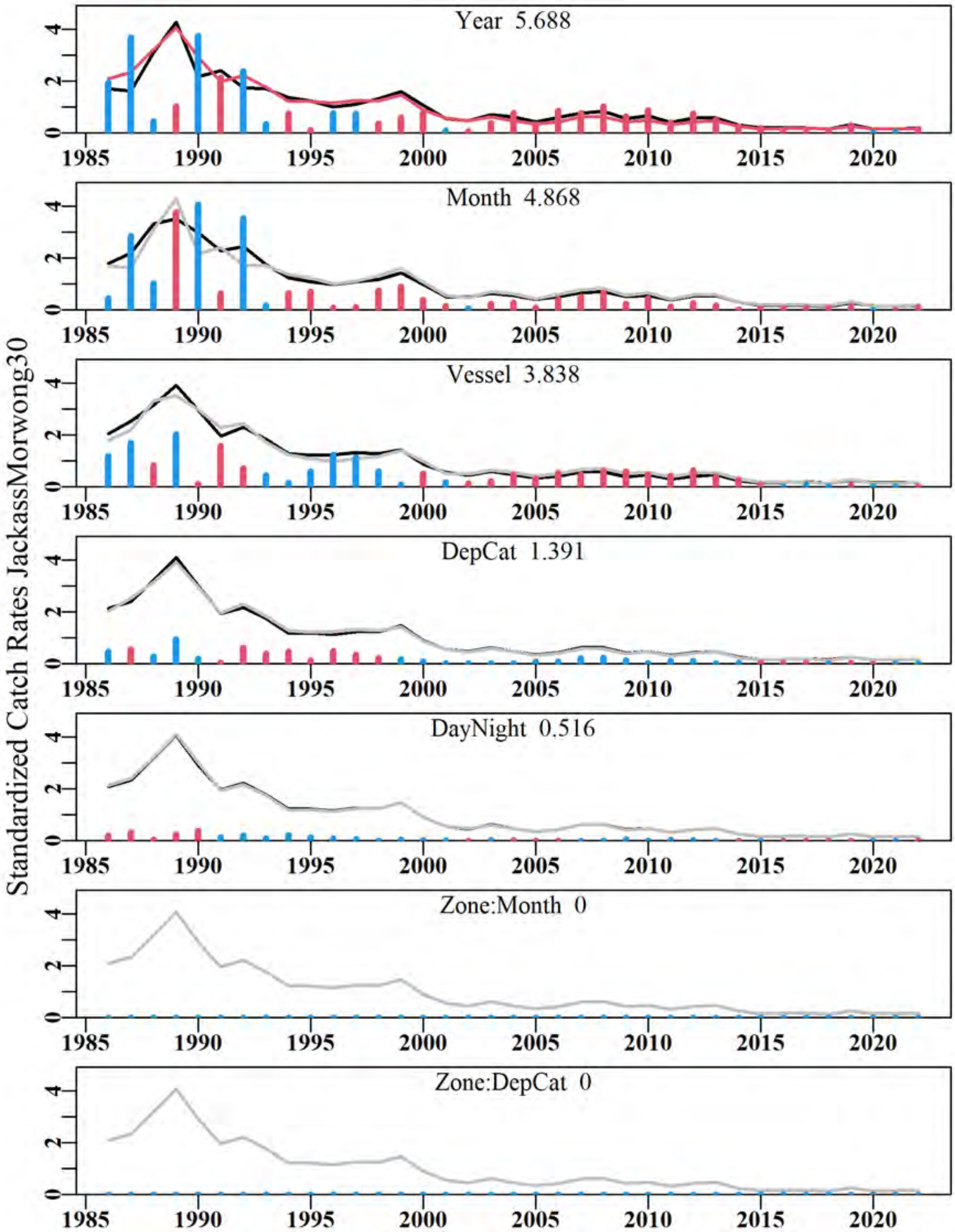

Figure 46: JackassMorwong30. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

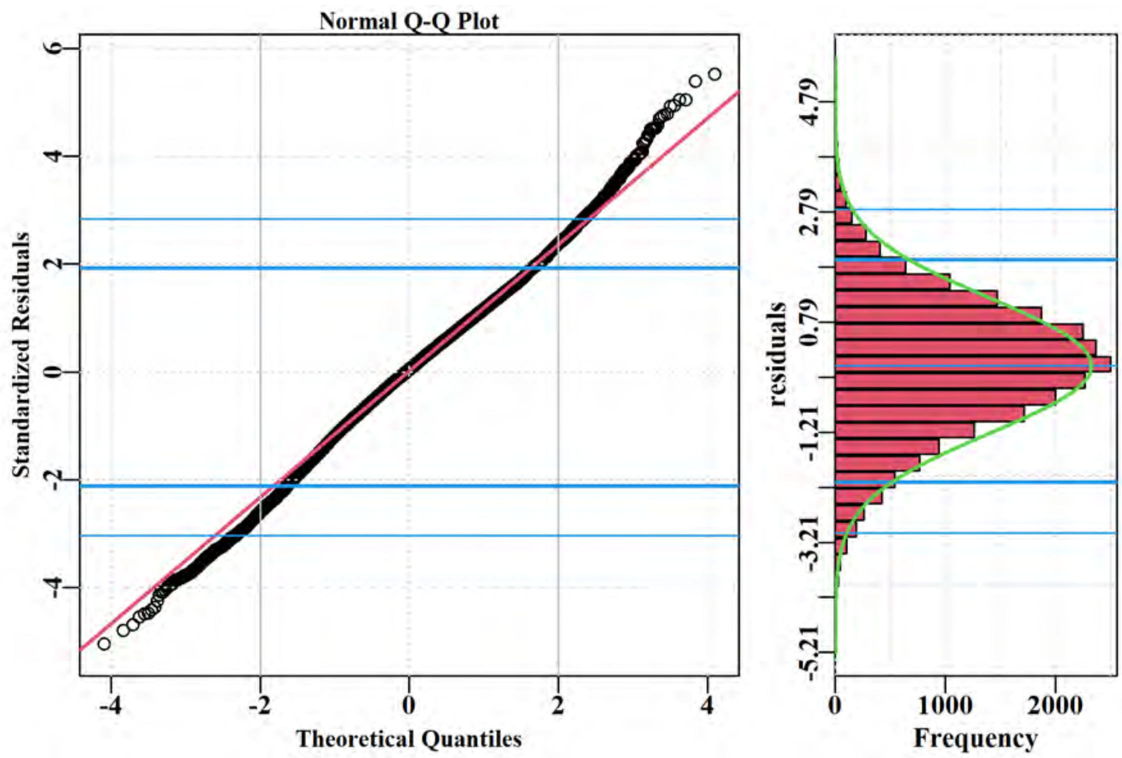

Figure 47: JackassMorwong30. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

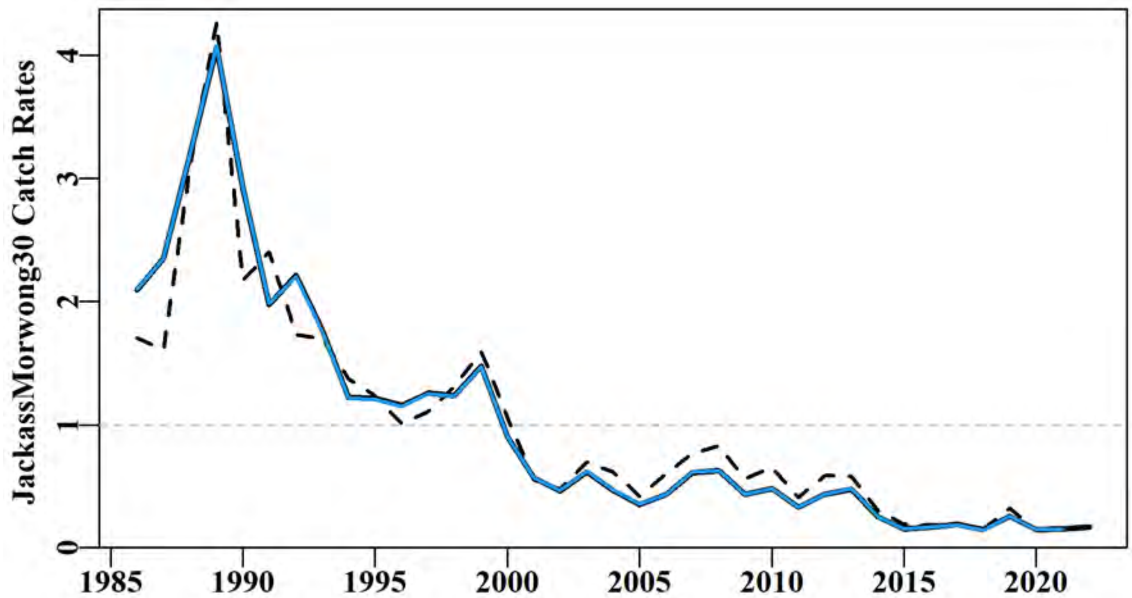

Figure 48: JackassMorwong30. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

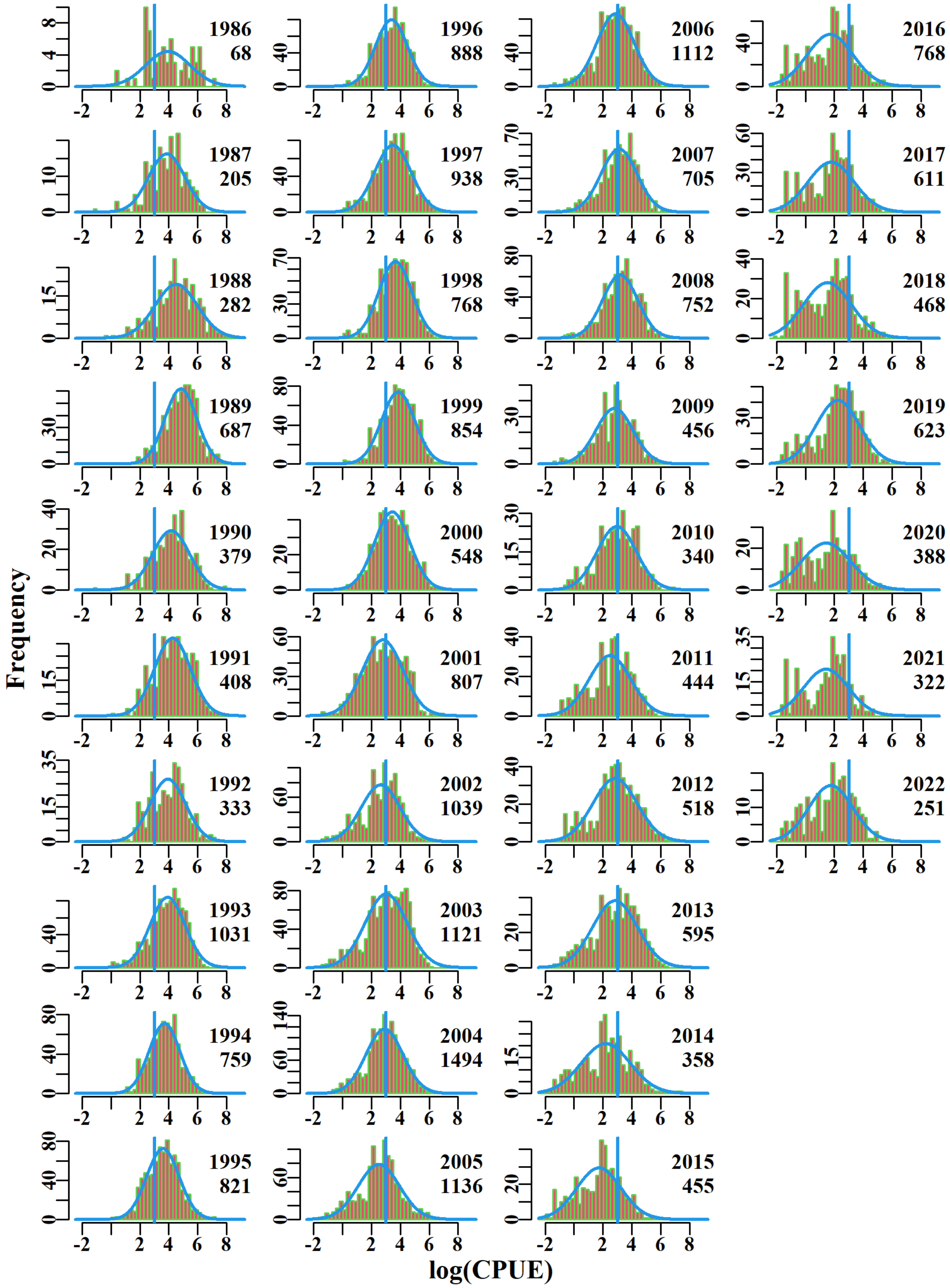

Figure 49: JackassMorwong30. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

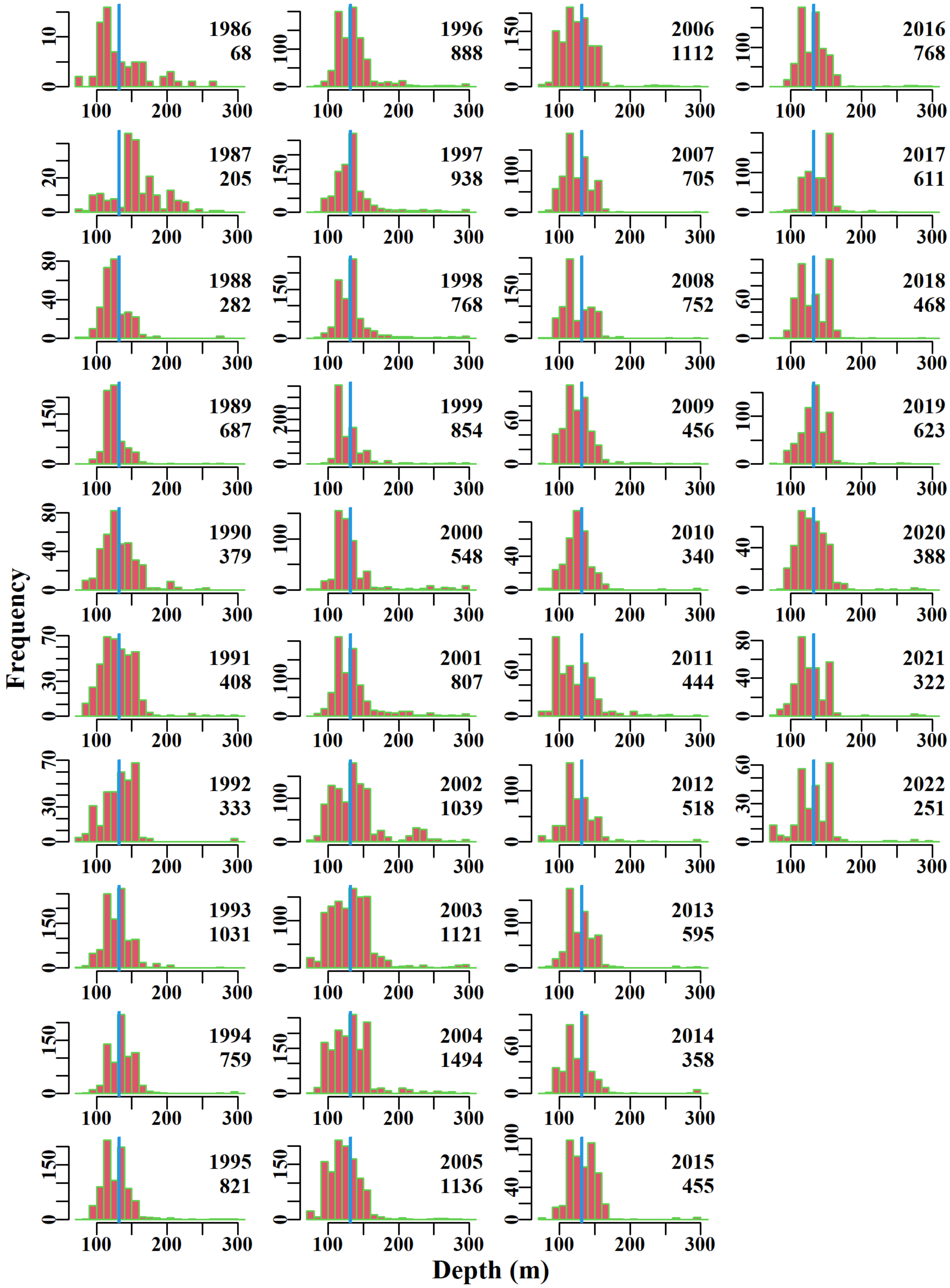

Figure 50: JackassMorwong30. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Jackass Morwong 10 - 20

Jackass Morwong (MOR–37377003 – *Nemadactylus macropterus*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The criteria used to select data from the Commonwealth logbook database was based on the trawl fishery which uses methods TW, TDO, OTB, OTT, in zones 10, 20, and depths 70 to 300 m within the SET fishery for the years 1986 - 2022 (Table 36). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, Vessel, Month and Zone had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 40). The qqplot suggests that the assumed Normal distribution is valid, with small deviations at the upper tail of the distribution (Figure 54).

Most catch was reported in zone 20 in less than 200 m. Annual standardized CPUE has been below the long-term average since about 2000 with apparent periodicity (Figure 51). The recorded catch (14.7 t) from zones 10 and 20 in 2022 was the lowest in the series.

Action Items and Issues

The structural adjustment altered the effect of the vessel factor on the standardized result. However, log(CPUE) has also changed in character from 2014 - 2020, with spikes of low CPUE arising.

Table 36: JackasssMorwong1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	JackasssMorwong1020
csirocode	37377003
fishery	SET
depthrange	70 - 300
depthclass	20
zones	10, 20
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 37: JackasssMorwong1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	982.8	5041	685.5	87	50.9	2.2425	0.000	28.043	0.041
1987	1087.7	4231	851.6	79	69.6	2.7202	0.030	20.466	0.024
1988	1483.5	5127	1020.0	79	65.0	2.5497	0.029	25.887	0.025
1989	1667.4	4305	924.2	65	72.2	2.4271	0.030	19.307	0.021
1990	1001.4	4090	593.5	59	49.2	2.0380	0.031	21.795	0.037
1991	1138.1	4398	651.3	55	54.3	1.8653	0.031	26.145	0.040
1992	758.3	2828	377.4	47	48.6	1.5224	0.035	17.346	0.046
1993	1015.0	3321	462.0	49	45.5	1.6217	0.033	21.593	0.047
1994	818.4	4418	469.0	49	38.6	1.4112	0.031	29.317	0.063
1995	789.5	4575	433.7	47	31.6	1.2948	0.031	33.286	0.077
1996	827.2	6181	541.8	50	29.0	1.1750	0.029	45.827	0.085
1997	1063.4	5994	669.8	52	38.6	1.3045	0.030	38.284	0.057
1998	876.4	4772	435.1	46	32.0	1.0517	0.031	36.545	0.084
1999	961.5	4408	446.6	50	36.3	1.0556	0.032	31.401	0.070
2000	945.2	5615	477.9	55	29.5	0.8991	0.030	40.940	0.086
2001	790.2	4793	251.5	46	18.5	0.6187	0.031	36.983	0.147
2002	811.2	5700	328.2	44	20.4	0.6914	0.031	45.985	0.140
2003	774.6	4555	236.4	47	17.6	0.5491	0.032	35.723	0.151
2004	765.5	4178	219.7	52	17.2	0.5436	0.033	31.301	0.142
2005	784.2	4320	258.8	39	19.4	0.6584	0.032	35.033	0.135
2006	811.3	3388	273.8	36	25.2	0.8051	0.034	27.137	0.099
2007	607.9	2412	211.2	20	31.6	0.7808	0.037	17.177	0.081
2008	700.4	3105	313.1	25	30.5	0.9870	0.035	23.468	0.075
2009	454.4	2400	223.7	19	28.2	0.8945	0.037	18.584	0.083
2010	380.0	2478	184.9	19	24.5	0.6109	0.037	19.898	0.108
2011	428.0	2291	161.6	18	24.2	0.6116	0.038	17.187	0.106
2012	395.6	2111	169.7	19	27.9	0.5988	0.039	14.445	0.085
2013	323.9	1393	96.5	15	25.1	0.4975	0.044	10.082	0.105
2014	216.6	1513	75.9	17	17.0	0.3687	0.043	11.567	0.152
2015	152.5	1094	42.3	20	14.3	0.3111	0.048	8.727	0.206
2016	183.4	1145	70.8	16	24.4	0.3543	0.048	7.792	0.110
2017	246.2	1230	72.6	16	23.2	0.4178	0.046	9.147	0.126
2018	209.7	1396	77.6	16	18.9	0.3334	0.045	10.764	0.139
2019	161.9	1215	52.3	14	14.5	0.2804	0.047	9.759	0.187
2020	99.1	1029	42.3	13	13.4	0.2997	0.050	8.900	0.210
2021	100.3	908	39.3	15	14.8	0.3528	0.051	7.763	0.198
2022	67.8	453	14.7	14	10.1	0.2555	0.068	4.615	0.314

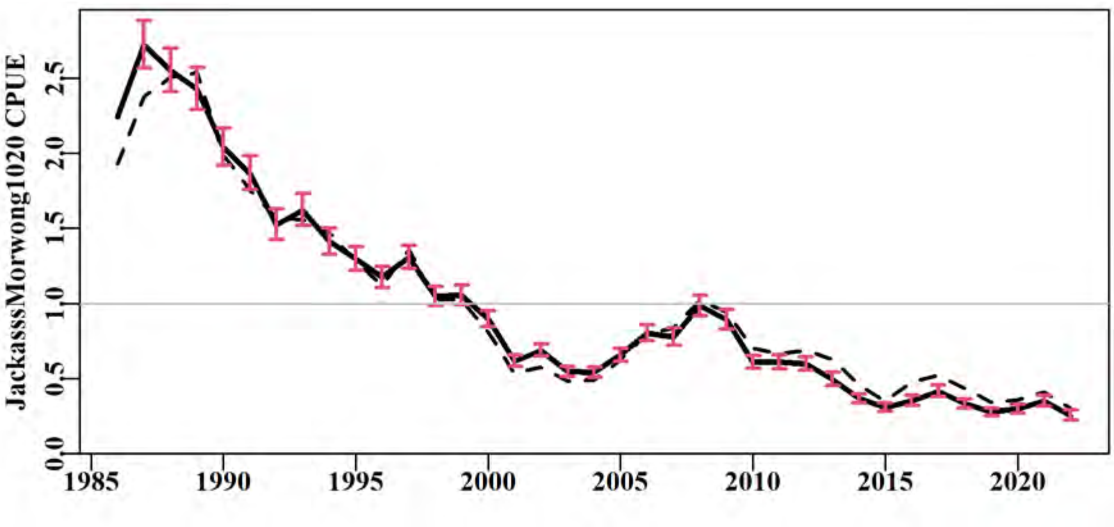

Figure 51: JackasssMorwong1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

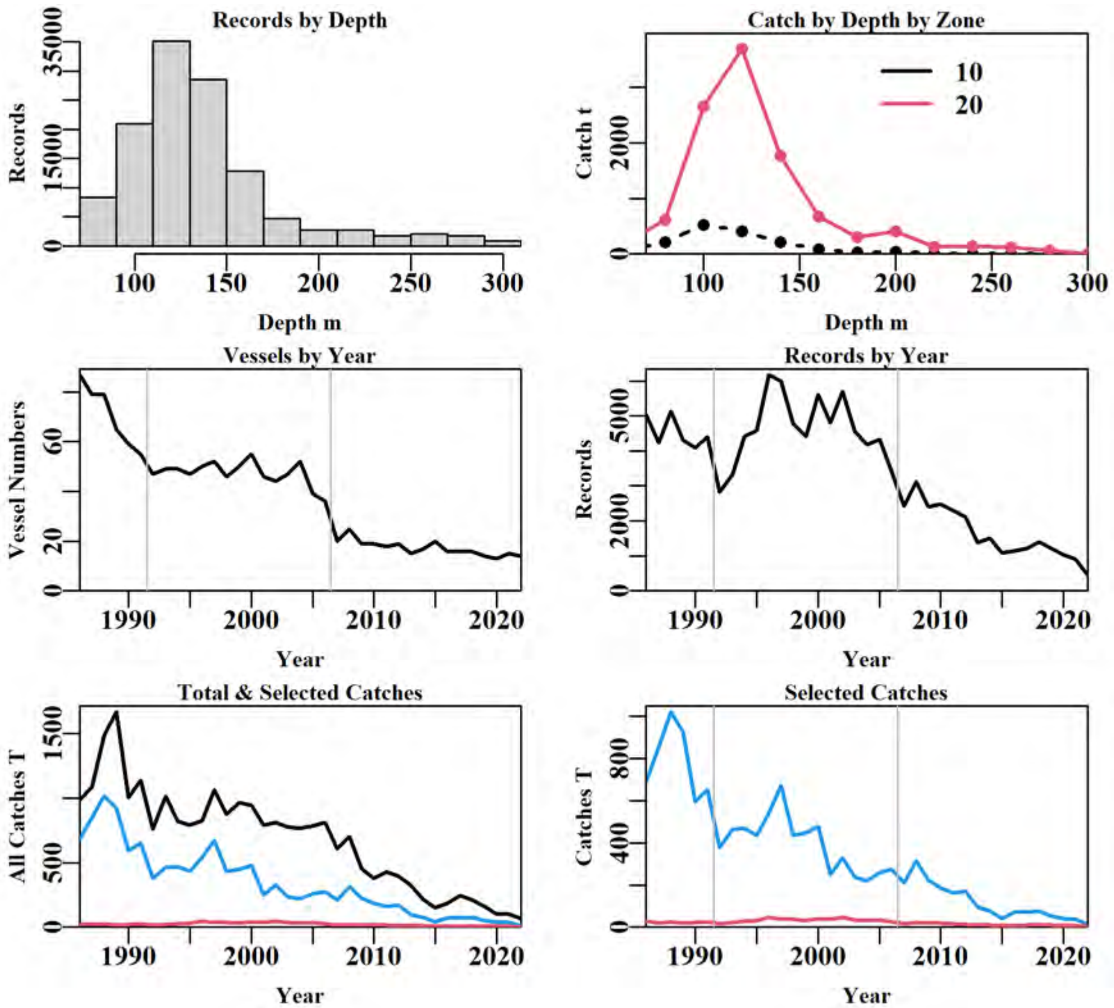

Figure 52: JackasssMorwong1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 38: JackasssMorwong1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	272266	248336	218444	215155	138990	122510	122411
Difference	0	23930	29892	3289	76165	16480	99
Catch	25556	24593	23102	22545	12961	12465	12457
Difference	0	963	1490	558	9583	497	8

Table 39: The models used to analyse data for JackasssMorwong1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + Zone
Model5	Year + Vessel + Month + Zone + DepCat
Model6	Year + Vessel + Month + Zone + DepCat + DayNight
Model7	Year + Vessel + Month + Zone + DepCat + DayNight + Zone:Month
Model8	Year + Vessel + Month + Zone + DepCat + DayNight + Zone:DepCat

Table 40: JackasssMorwong1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	90693	256638	38411	122411	37	13.0	0.00
Vessel	76556	227972	67078	122411	218	22.6	9.60
Month	73343	222026	73023	122411	229	24.6	2.01
Zone	71140	218064	76986	122411	230	26.0	1.34
DepCat	69757	215571	79479	122411	242	26.8	0.84
DayNight	68068	212607	82443	122411	245	27.8	1.00
Zone:Month	67165	211005	84044	122411	256	28.3	0.54
Zone:DepCat	67746	212007	83042	122411	257	28.0	0.20

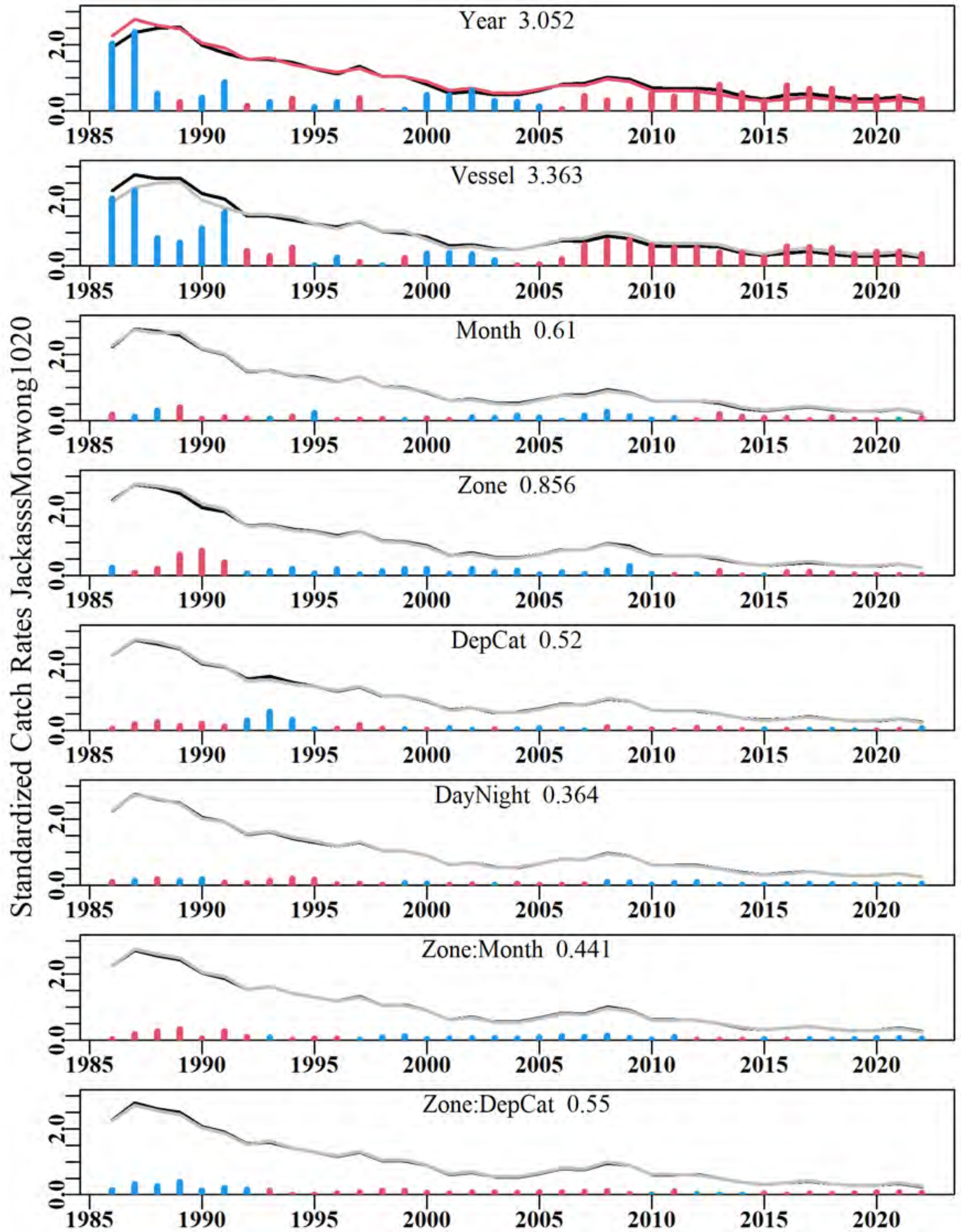

Figure 53: JackasssMorwong1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

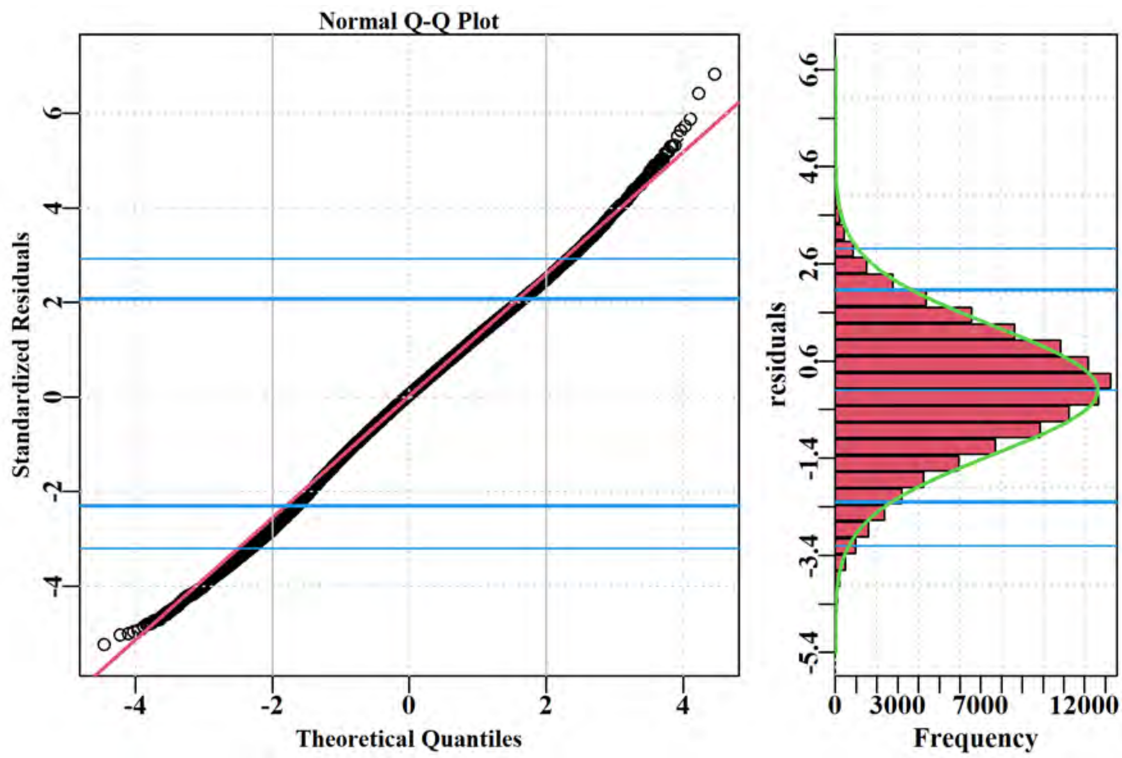

Figure 54: JackasssMorwong1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

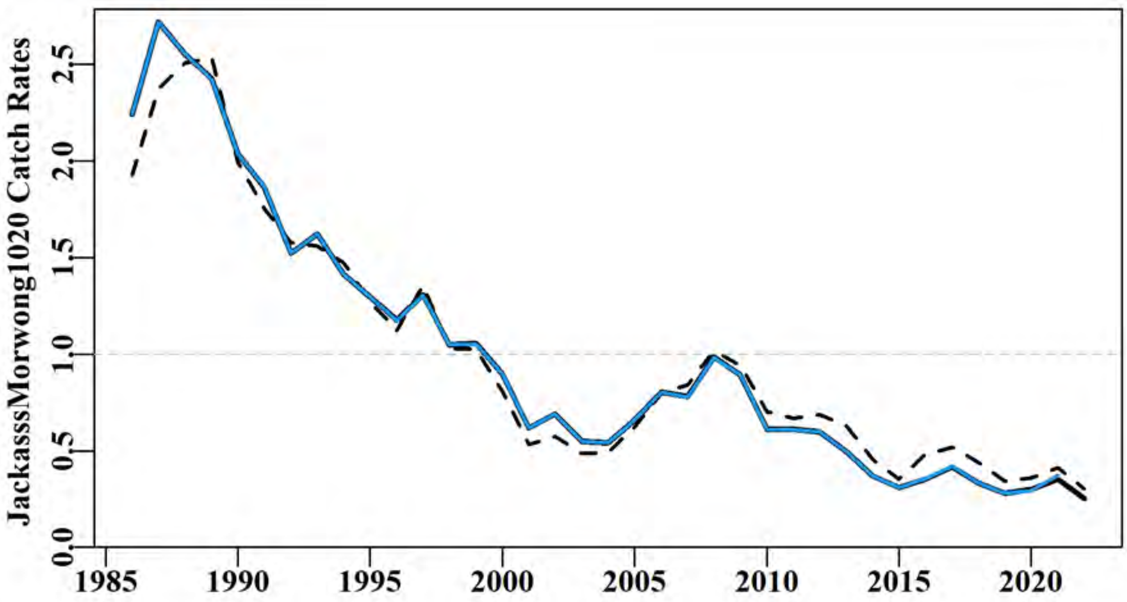

Figure 55: JackasssMorwong1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

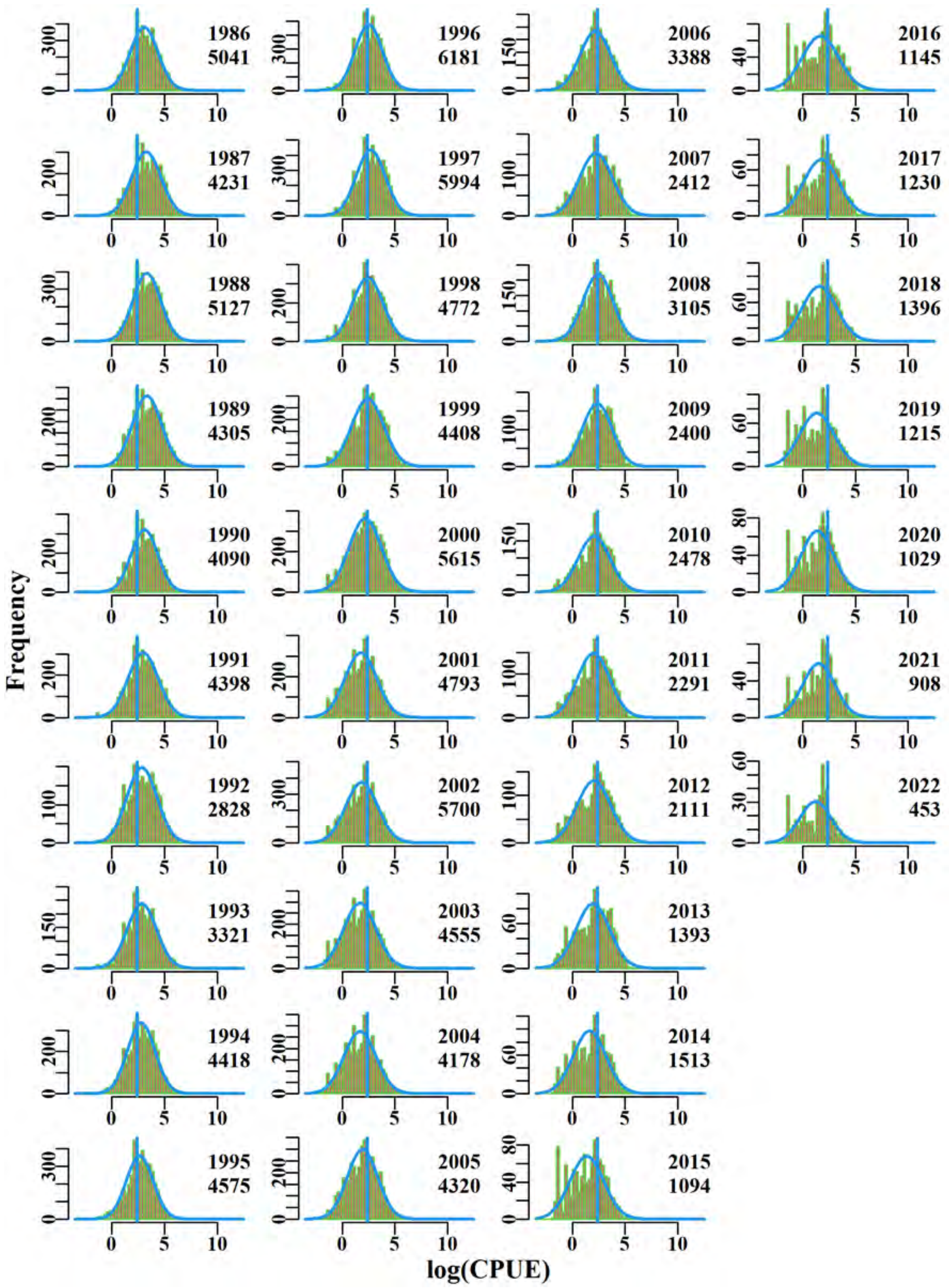

Figure 56: JackasssMorwong1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

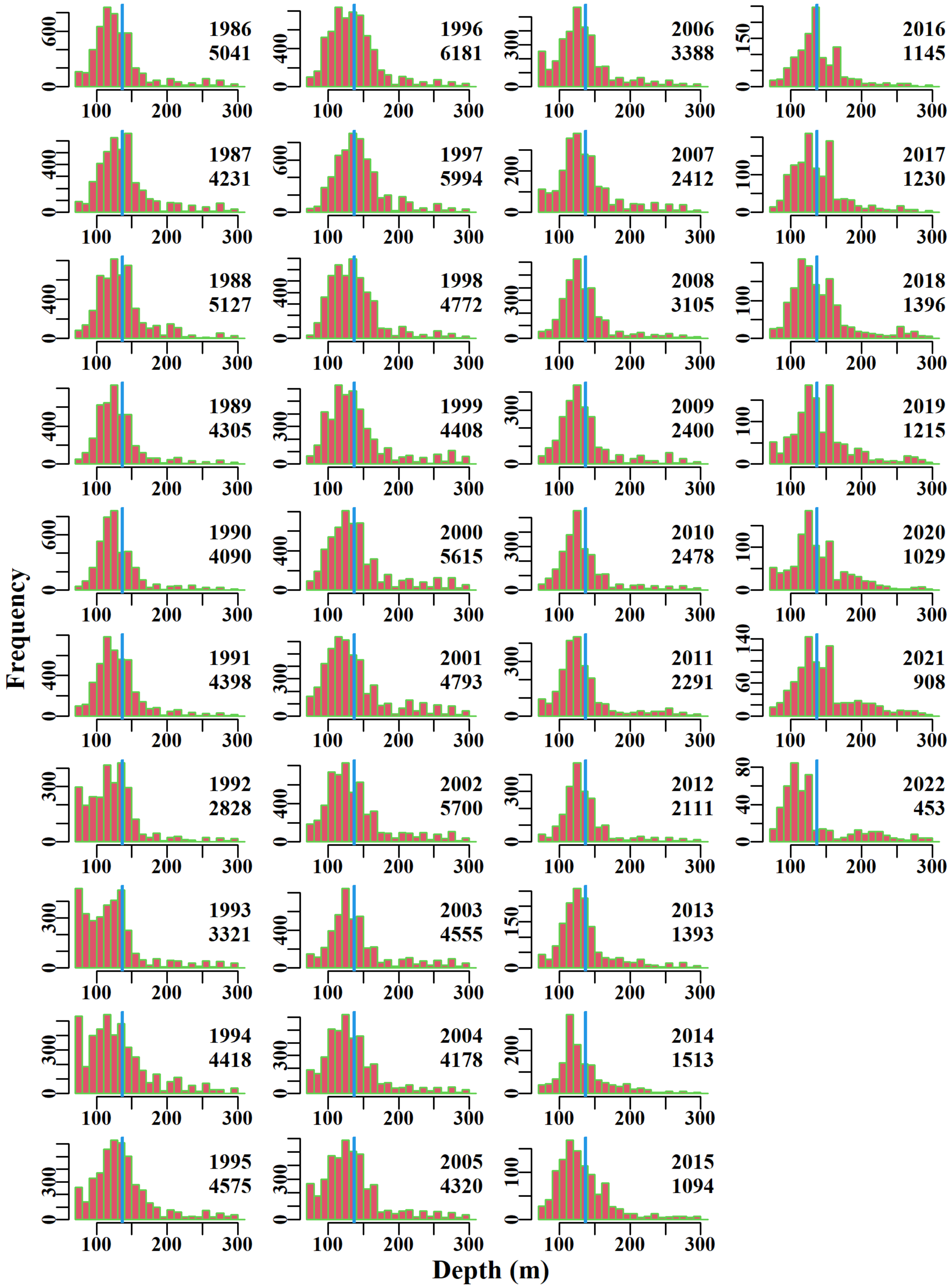

Figure 57: JackasssMorwong1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Jackass Morwong 40 - 50

The fishery for Jackass Morwong (MOR - 37377003 - *Nemadactylus macropterus*) in zones 40 and 50 has been variable with catches peaked over 2001 - 2006 period followed by a rapid decline following the structural adjustment. The criteria used to select data from the Commonwealth logbook database for trawl caught Jackass Morwong was based on methods TW, TDO, OTB, OTT, in zones 40, 50, and depths 70 to 360 m within the SET fishery for years 1986 - 2022 (Table 41). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, DepCat, Month and Vessel had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 45). The qqplot suggests a possible departure from Normality, as depicted by the tails of the distribution (Figure 61).

Most catch from zone 40 occurred at a shallower depth compared to zone 50. Since 2007, standardized CPUE has been below the long-term average, with the most recent estimate decreased relative to the previous year (Figure 58). The recorded catch (7.9 t) from the west in 2020 was the lowest since 2015. The recorded catch of 9.9 t from the west in 2022 corresponds to the lowest number of vessels (7).

Action Items and Issues

The depth factor changed its influence from 2001-2019 reflecting the increase in catches from 2001 and suggesting the fishery changed remarkably at that time. The reasons behind this change should be explored in more detail.

Table 41: JackasssMorwong4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	JackasssMorwong4050
csirocode	37377003
fishery	SET
depthrange	70 - 360
depthclass	20
zones	40, 50
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 42: JackasssMorwong4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	982.8	550	149.1	19	114.8	2.2197	0.000	1.928	0.013
1987	1087.7	349	58.4	21	61.0	1.7399	0.086	2.079	0.036
1988	1483.5	401	65.4	19	66.0	2.5520	0.086	1.803	0.028
1989	1667.4	345	83.2	21	74.7	1.8858	0.091	2.283	0.027
1990	1001.4	410	80.3	22	77.2	1.8970	0.092	2.303	0.029
1991	1138.1	279	40.3	26	39.8	1.2705	0.097	1.790	0.044
1992	758.3	249	28.6	14	33.0	1.0402	0.099	2.122	0.074
1993	1015.0	248	25.0	17	29.6	0.9917	0.101	2.247	0.090
1994	818.4	309	22.5	16	22.9	0.9620	0.094	2.725	0.121
1995	789.5	291	76.9	17	63.5	1.0405	0.095	2.405	0.031
1996	827.2	345	36.1	17	31.3	1.1441	0.092	2.869	0.079
1997	1063.4	489	53.9	20	26.8	0.9123	0.085	4.823	0.090
1998	876.4	266	54.6	19	42.7	0.9570	0.097	2.825	0.052
1999	961.5	382	76.9	17	42.5	0.8613	0.090	3.711	0.048
2000	945.2	429	118.9	28	79.8	1.2734	0.090	3.723	0.031
2001	790.2	920	276.8	25	104.8	1.3703	0.079	5.171	0.019
2002	811.2	850	249.4	21	95.2	1.3766	0.079	4.464	0.018
2003	774.6	649	170.7	24	85.9	1.1741	0.083	3.106	0.018
2004	765.5	674	174.5	25	77.1	1.2355	0.082	2.843	0.016
2005	784.2	717	188.5	21	77.7	1.3333	0.081	3.105	0.016
2006	811.3	799	178.3	19	57.6	1.0596	0.080	3.293	0.018
2007	607.9	585	114.2	15	44.8	0.8759	0.083	2.758	0.024
2008	700.4	466	101.5	16	55.7	0.9042	0.086	1.491	0.015
2009	454.4	409	58.3	13	34.1	0.7285	0.089	2.178	0.037
2010	380.0	408	38.2	13	20.6	0.5341	0.089	2.589	0.068
2011	428.0	621	82.8	14	27.6	0.5704	0.083	2.709	0.033
2012	395.6	341	34.5	14	23.1	0.4230	0.092	2.604	0.076
2013	323.9	463	35.7	13	15.7	0.3915	0.087	3.435	0.096
2014	216.6	252	10.1	13	8.8	0.3054	0.100	2.484	0.245
2015	152.5	154	7.0	9	8.3	0.3891	0.114	1.297	0.185
2016	183.4	255	25.0	11	18.1	0.4669	0.099	1.601	0.064
2017	246.2	495	79.8	12	29.6	0.6969	0.088	2.386	0.030
2018	209.7	224	44.4	10	33.6	0.5471	0.104	1.047	0.024
2019	161.9	218	22.6	10	17.2	0.4099	0.106	1.451	0.064
2020	99.1	129	7.9	10	10.9	0.3773	0.125	0.732	0.093
2021	100.3	130	16.1	8	21.0	0.5964	0.123	0.570	0.035
2022	67.8	97	9.9	7	18.4	0.4864	0.137	0.714	0.072

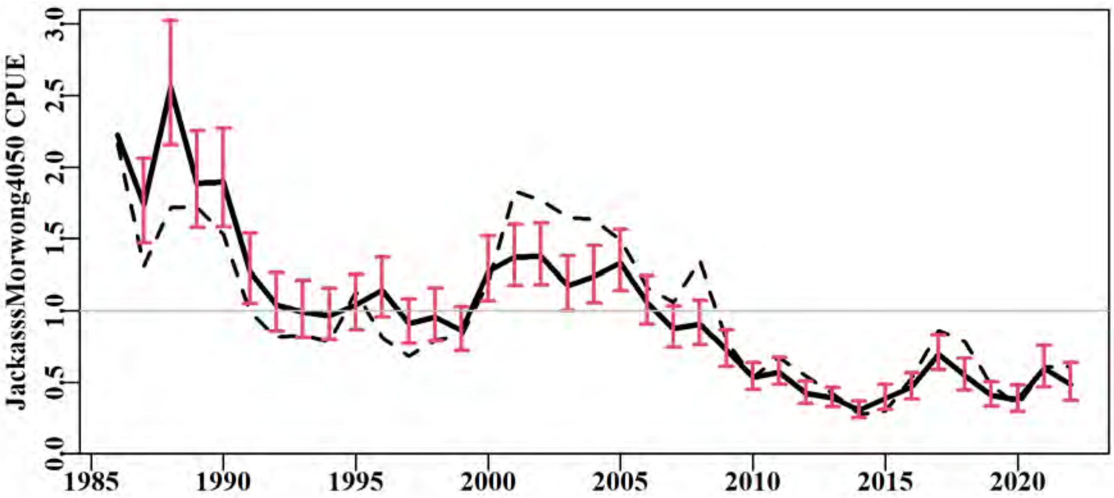

Figure 58: JackasssMorwong4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

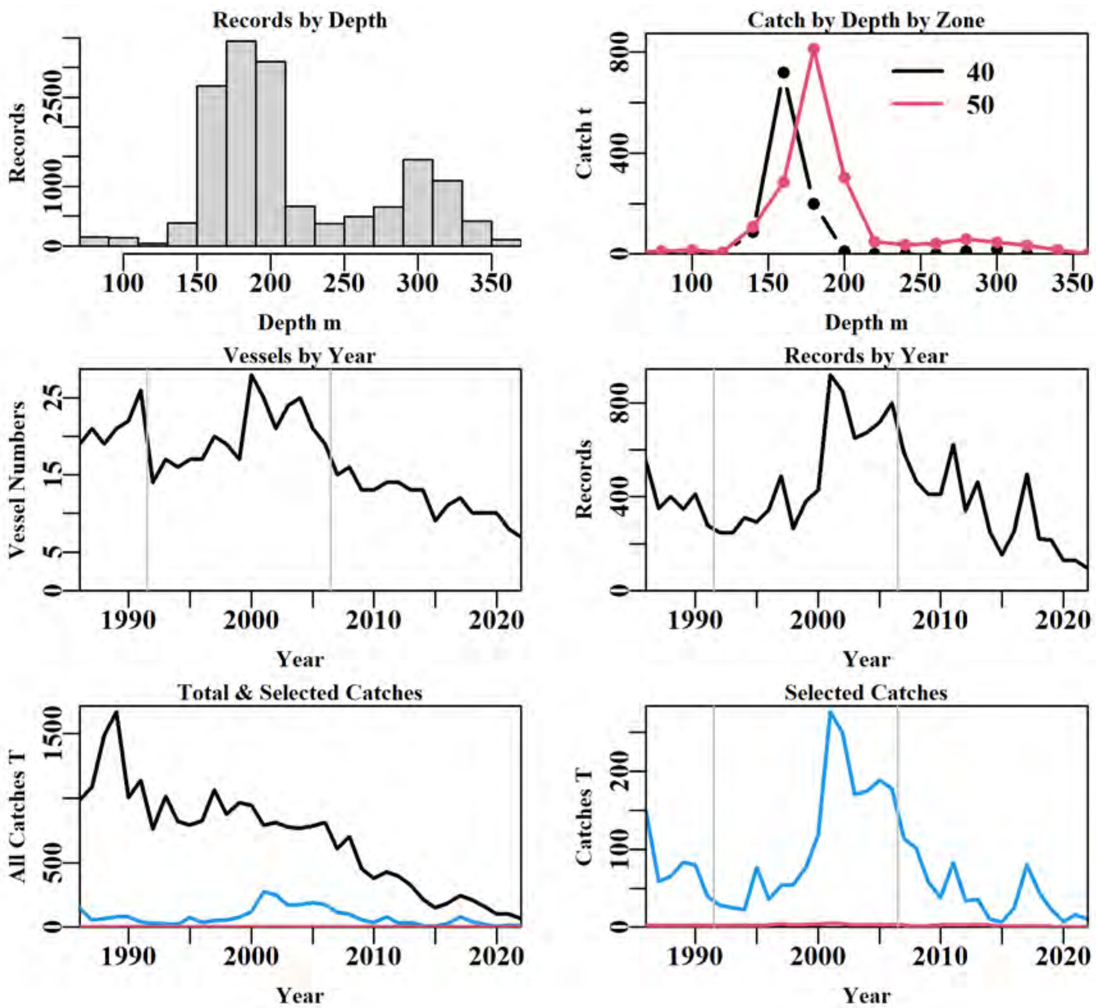

Figure 59: JackasssMorwong4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 43: JackasssMorwong4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	272266	248336	224258	220904	15887	15233	15198
Difference	0	23930	24078	3354	205017	654	35
Catch	25556	24593	23444	22878	2942	2905	2896
Difference	0	963	1149	566	19936	37	9

Table 44: The models used to analyse data for JackasssMorwong4050.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Month
Model4	Year + DepCat + Month + Vessel
Model5	Year + DepCat + Month + Vessel + DayNight
Model6	Year + DepCat + Month + Vessel + DayNight + Zone
Model7	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:Month
Model8	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:DepCat

Table 45: JackasssMorwong4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	8370	26233	3768	15198	37	12.4	0.00
DepCat	6028	22442	7559	15198	52	24.9	12.59
Month	4740	20589	9412	15198	63	31.1	6.15
Vessel	4082	19484	10518	15198	153	34.4	3.31
DayNight	3923	19274	10727	15198	156	35.1	0.69
Zone	3777	19087	10914	15198	157	35.7	0.63
Zone:Month	3620	18863	11138	15198	168	36.4	0.71
Zone:DepCat	3674	18924	11078	15198	171	36.2	0.49

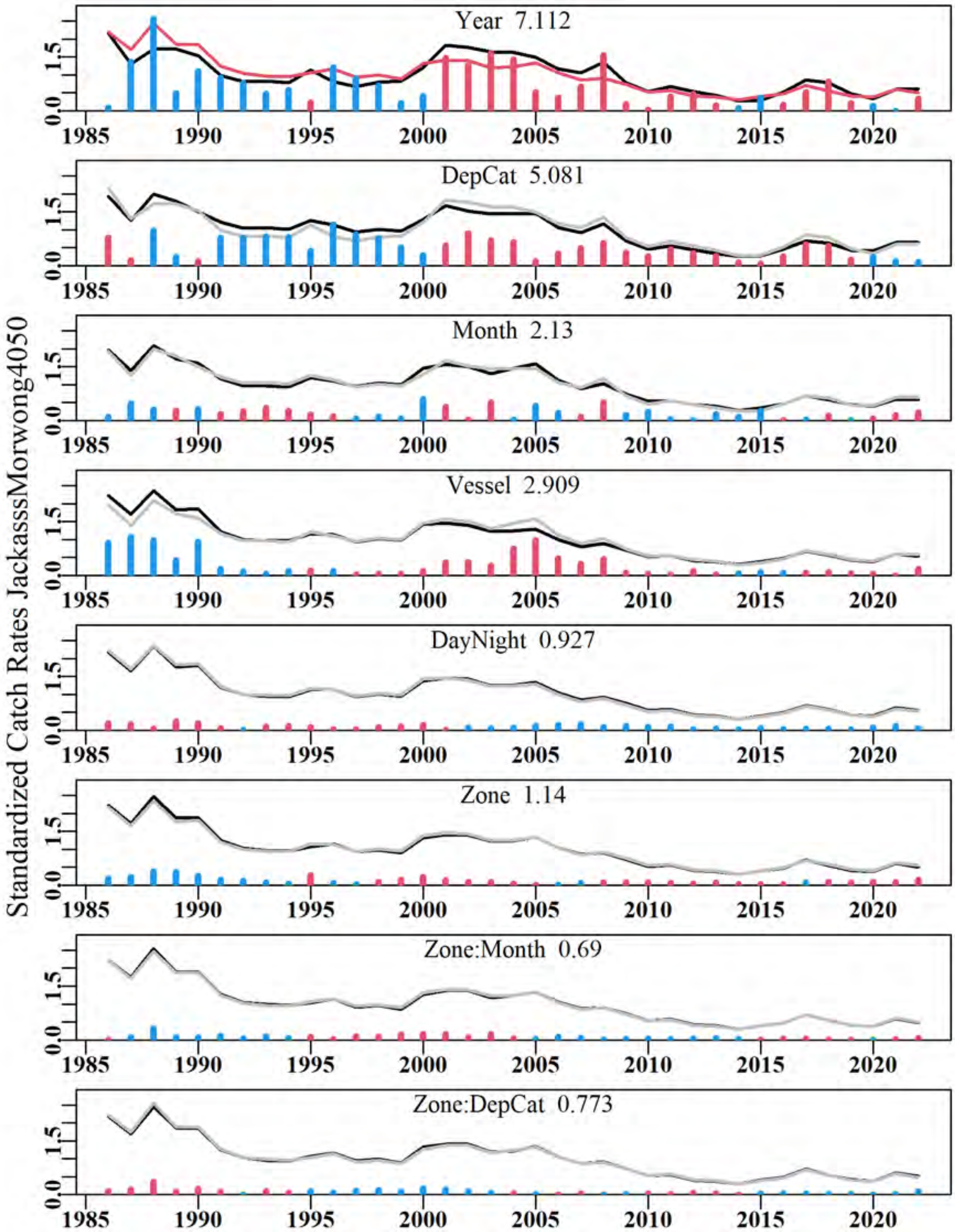

Figure 60: JackasssMorwong4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

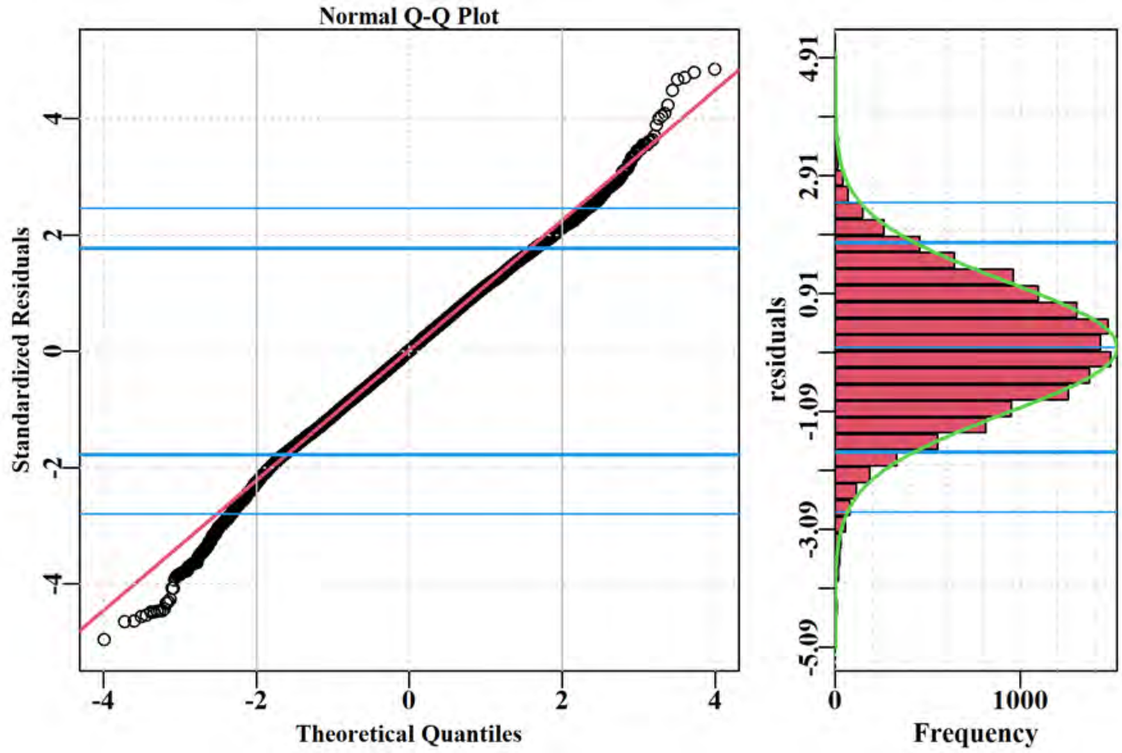

Figure 61: JackasssMorwong4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

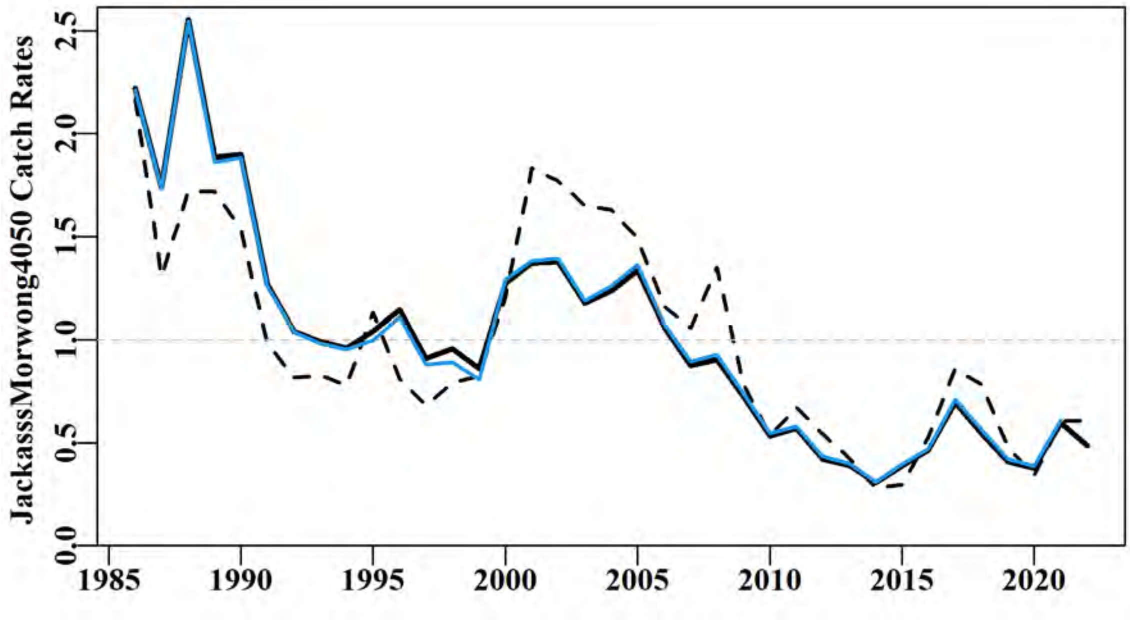

Figure 62: JackasssMorwong4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

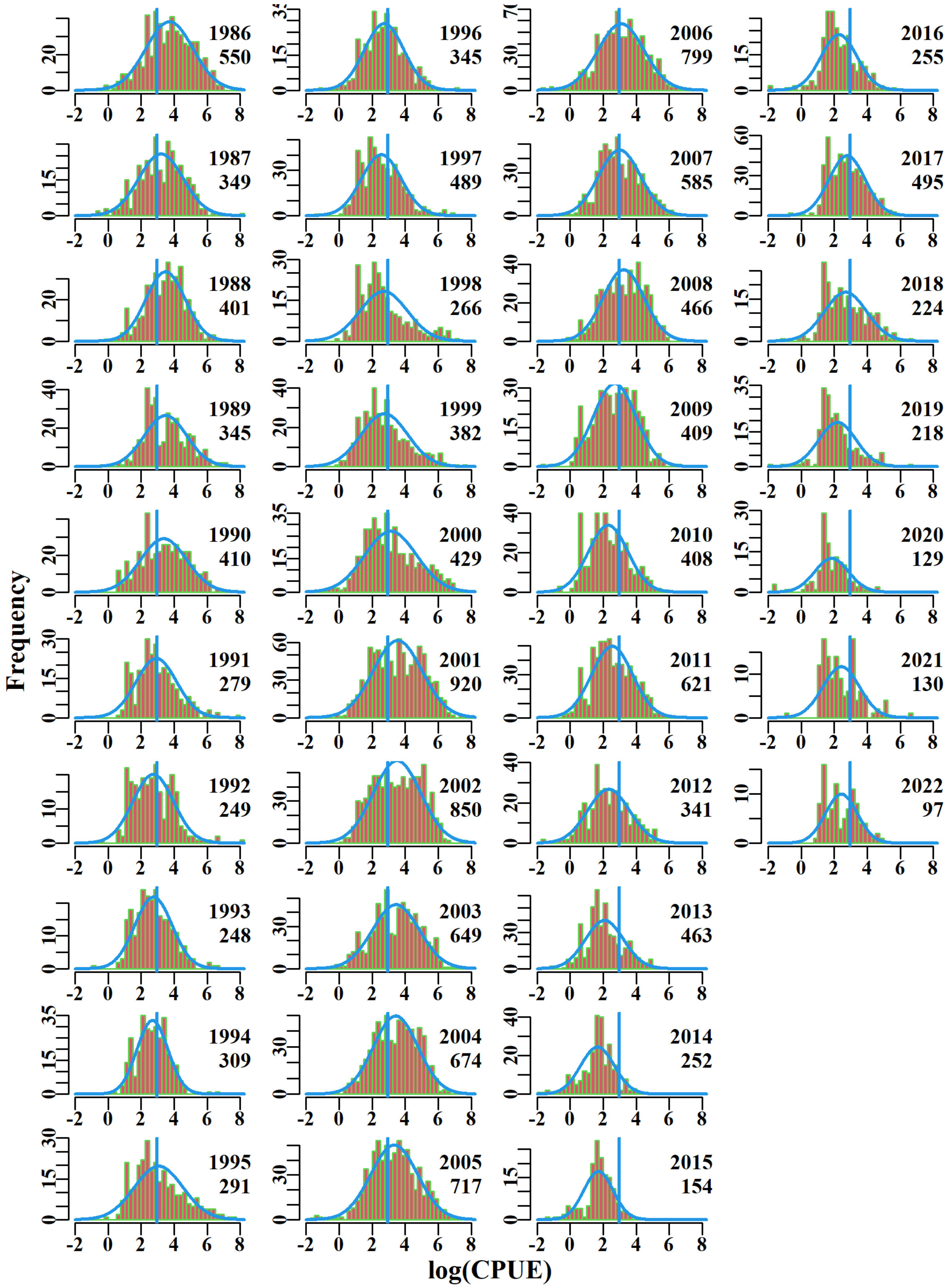

Figure 63: JackasssMorwong4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

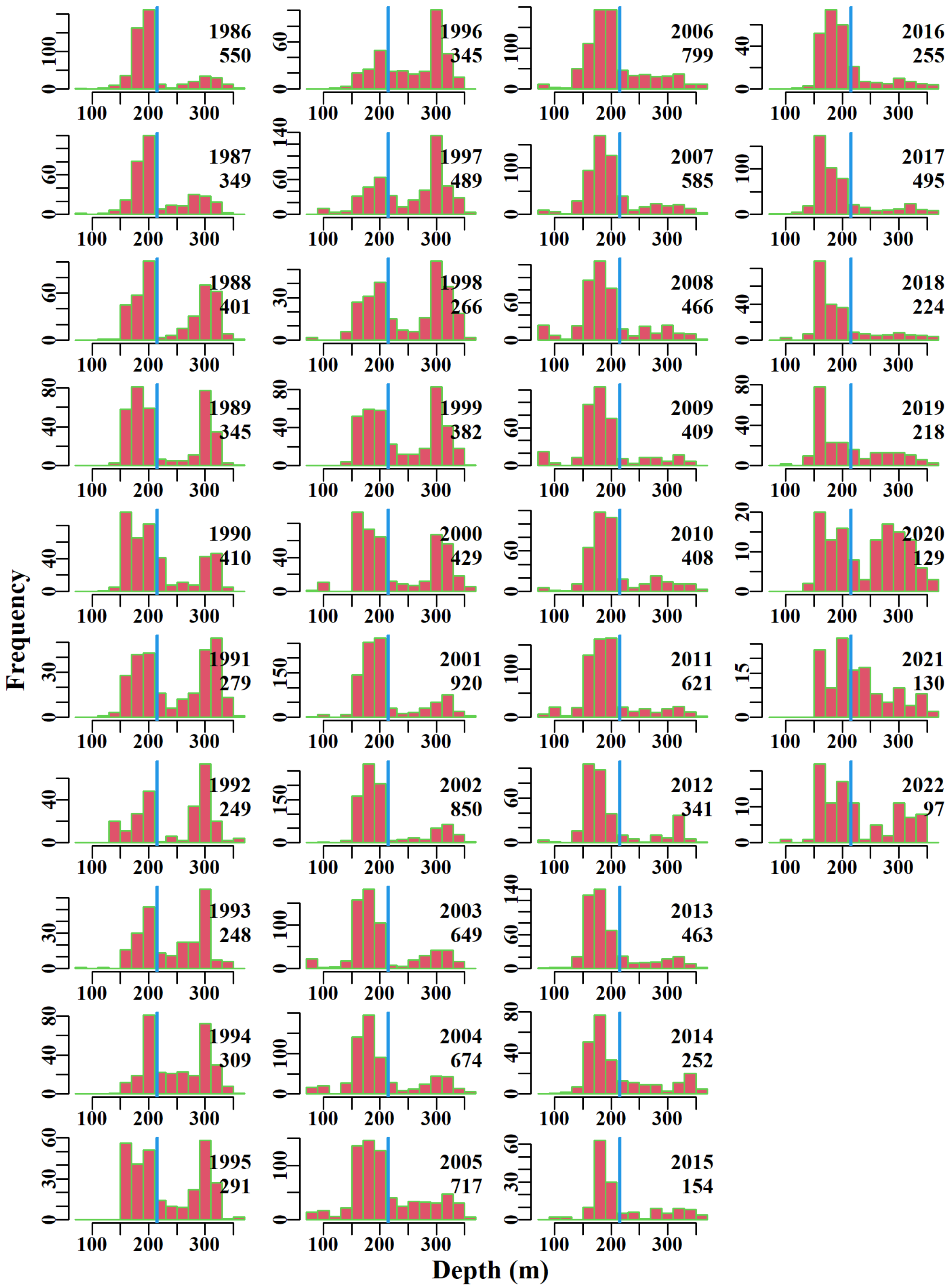

Figure 64: JackasssMorwong4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Silver Warehou 40 - 50

Silver Warehou (TRS–37445006 – *Seriolella punctata*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The criteria used to select data from the Commonwealth logbook database for trawl caught Silver Warehou was based on methods TW, TDO, OTT, OTB, OTM, in zones 40, 50, and depths 0 to 600 m within the SET fishery for years 1986 - 2022 (Table 46). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, Vessel, Month, DepCat and Zone had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 50). The qqplot suggests that the assumed Normal distribution is valid (Figure 68).

Annual standardized CPUE has declined since 2005, and since 2008 has been below the long-term average (Figure 65). The most recent estimate significantly decreased relative to the previous year. The influence of the vessel factor was high from 1999 to about 2006 after which it was less influential. The 2022 catch (85.9 t) of Silver Warehou from the west was the lowest in the series (i.e., since 1986) which also corresponds to the lowest number of vessels (10).

Action Items and Issues

Annual Silver Warehou catches in the west were high (i.e., 1680 t – 2945 t per annum) for the period around 1999 - 2006. Vessels that contributed to these high catches left the fishery after the structural adjustment. This suggests that there have been transitional periods in the time-series of CPUE. This needs more attention because this may imply that CPUE may no longer be acting as a valid index of relative abundance through time.

Table 46: SilverWarehou4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SilverWarehou4050
csirocode	37445006
fishery	SET
depthrange	0 - 600
depthclass	50
zones	40, 50
methods	TW, TDO, OTT, OTB, OTM
years	1986 - 2022

Table 47: SilverWarehou4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1156.5	1118	643.2	23	201.2	1.6418	0.000	4.167	0.006
1987	782.2	723	490.0	26	279.5	1.8378	0.081	2.368	0.005
1988	1646.2	574	684.4	27	553.8	2.1892	0.086	2.295	0.003
1989	926.3	649	569.0	27	287.0	1.8541	0.088	2.663	0.005
1990	1346.6	565	296.6	26	197.1	1.1991	0.088	2.986	0.010
1991	1453.2	691	623.8	29	267.6	1.3041	0.084	3.180	0.005
1992	733.8	582	185.4	21	98.1	0.9789	0.087	3.330	0.018
1993	1815.8	1541	749.3	23	151.1	1.3460	0.072	6.998	0.009
1994	2309.5	1639	753.6	26	155.7	1.2222	0.070	7.735	0.010
1995	2002.9	1672	771.7	24	147.2	1.0050	0.070	8.948	0.012
1996	2188.2	1551	1016.2	26	209.0	1.1237	0.071	8.450	0.008
1997	2562.0	1874	1261.4	24	210.9	1.3609	0.069	9.427	0.007
1998	2166.0	1848	1196.4	22	221.7	1.5587	0.070	7.985	0.007
1999	2834.1	2735	1772.1	24	241.8	1.3149	0.066	11.412	0.006
2000	3401.6	3557	2568.9	30	321.2	1.2824	0.065	15.063	0.006
2001	2970.4	4177	2170.7	29	193.7	0.9521	0.065	20.784	0.010
2002	3841.4	4421	2944.8	27	249.0	1.0217	0.064	20.321	0.007
2003	2910.1	3398	2199.3	28	256.8	1.0557	0.066	14.878	0.007
2004	3202.1	4240	2534.4	25	164.8	1.1523	0.065	14.503	0.006
2005	2648.0	3065	2100.2	24	220.2	1.2616	0.066	11.833	0.006
2006	2191.2	2682	1680.0	21	187.2	1.1192	0.067	10.636	0.006
2007	1816.5	2764	1360.1	16	144.6	1.1060	0.067	10.282	0.008
2008	1381.2	2056	870.0	17	105.7	0.9039	0.069	9.048	0.010
2009	1285.3	2042	719.9	13	73.2	0.7915	0.069	9.352	0.013
2010	1189.4	2319	782.7	14	64.7	0.7170	0.068	11.517	0.015
2011	1108.8	2889	818.3	17	57.4	0.6851	0.067	11.542	0.014
2012	781.2	1846	546.4	15	57.3	0.5139	0.070	10.147	0.019
2013	584.1	1512	342.0	16	48.7	0.4700	0.072	8.189	0.024
2014	356.9	1540	244.0	14	29.2	0.4439	0.072	8.700	0.036
2015	368.4	1380	268.0	13	34.1	0.4828	0.073	6.634	0.025
2016	331.5	1102	172.1	13	25.2	0.3521	0.076	6.353	0.037
2017	325.7	1247	218.7	12	30.0	0.3979	0.075	5.926	0.027
2018	357.6	1236	266.8	12	32.2	0.5266	0.075	3.922	0.015
2019	304.0	1265	227.5	15	30.5	0.4648	0.075	5.438	0.024
2020	261.8	1106	165.2	14	26.3	0.4741	0.077	5.282	0.032
2021	211.4	790	121.2	10	31.3	0.5477	0.082	3.471	0.029
2022	125.6	708	85.9	10	18.4	0.3412	0.084	4.943	0.058

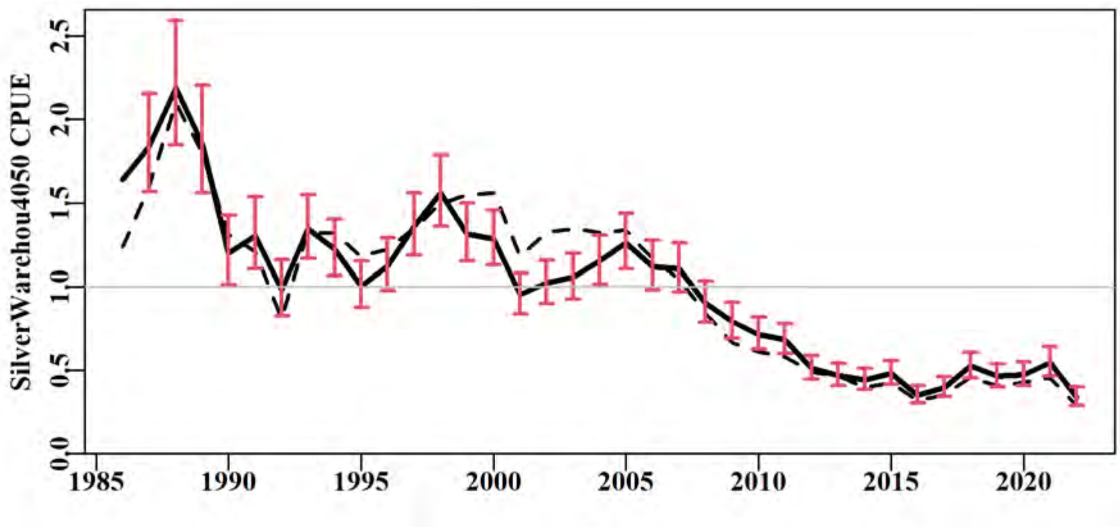

Figure 65: SilverWarehou4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

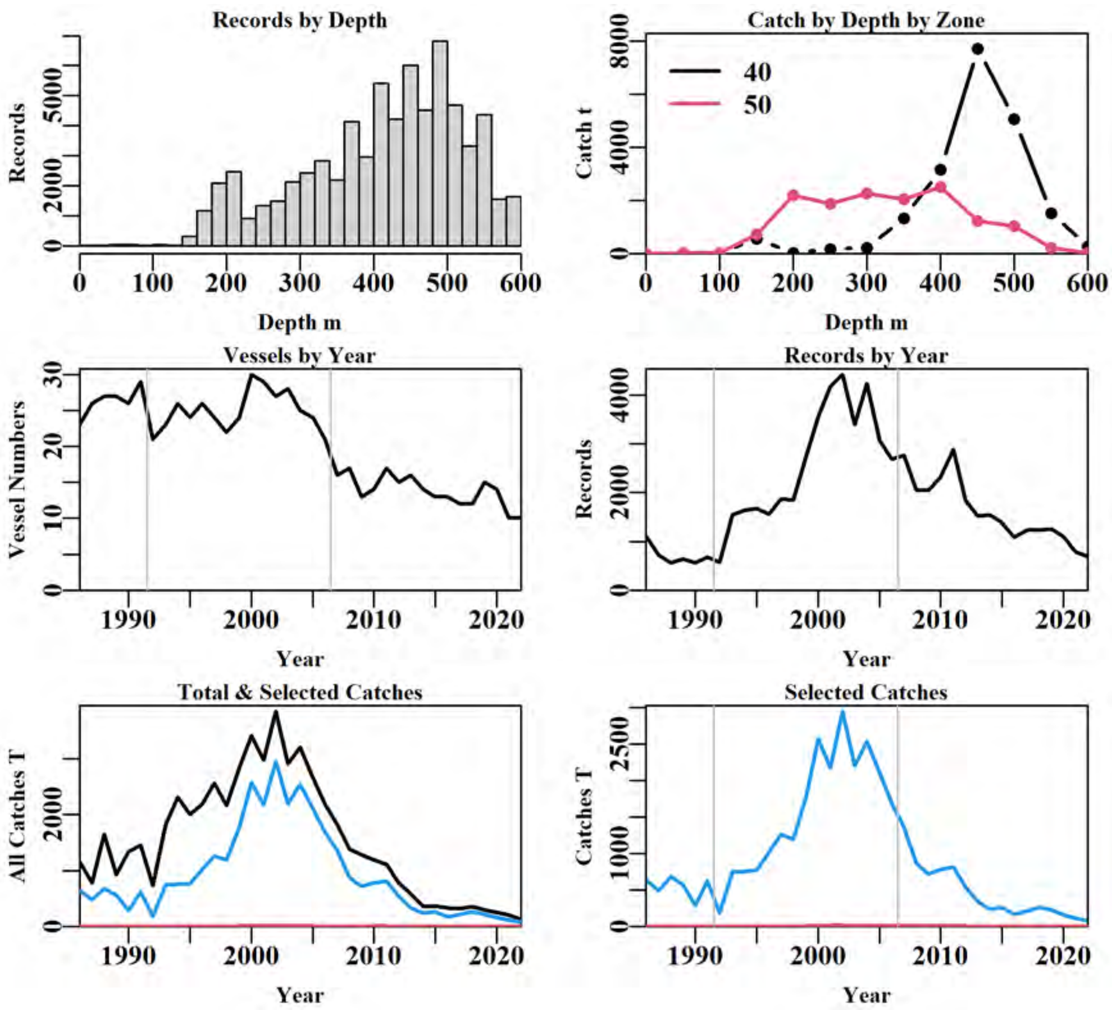

Figure 66: SilverWarehou4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 48: SilverWarehou4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	165682	158790	154310	153288	69468	69228	69104
Difference	0	6892	4480	1022	83820	240	124
Catch	56249	55759	54037	53671	34599	34549	34420
Difference	0	490	1722	366	19073	49	129

Table 49: The models used to analyse data for SilverWarehou4050.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + DepCat
Model5	Year + Vessel + Month + DepCat + Zone
Model6	Year + Vessel + Month + DepCat + Zone + DayNight
Model7	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:Month
Model8	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:DepCat

Table 50: SilverWarehou4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	70464	191372	16954	69104	37	8.09	0.000
Vessel	62523	170089	38238	69104	140	18.19	10.100
Month	59287	162258	46069	69104	151	21.94	3.754
DepCat	58084	159402	48925	69104	163	23.30	1.361
Zone	57154	157266	51061	69104	164	24.33	1.026
DayNight	56826	156509	51818	69104	167	24.69	0.361
Zone:Month	56631	156017	52310	69104	178	24.92	0.225
Zone:DepCat	56589	155917	52410	69104	179	24.96	0.272

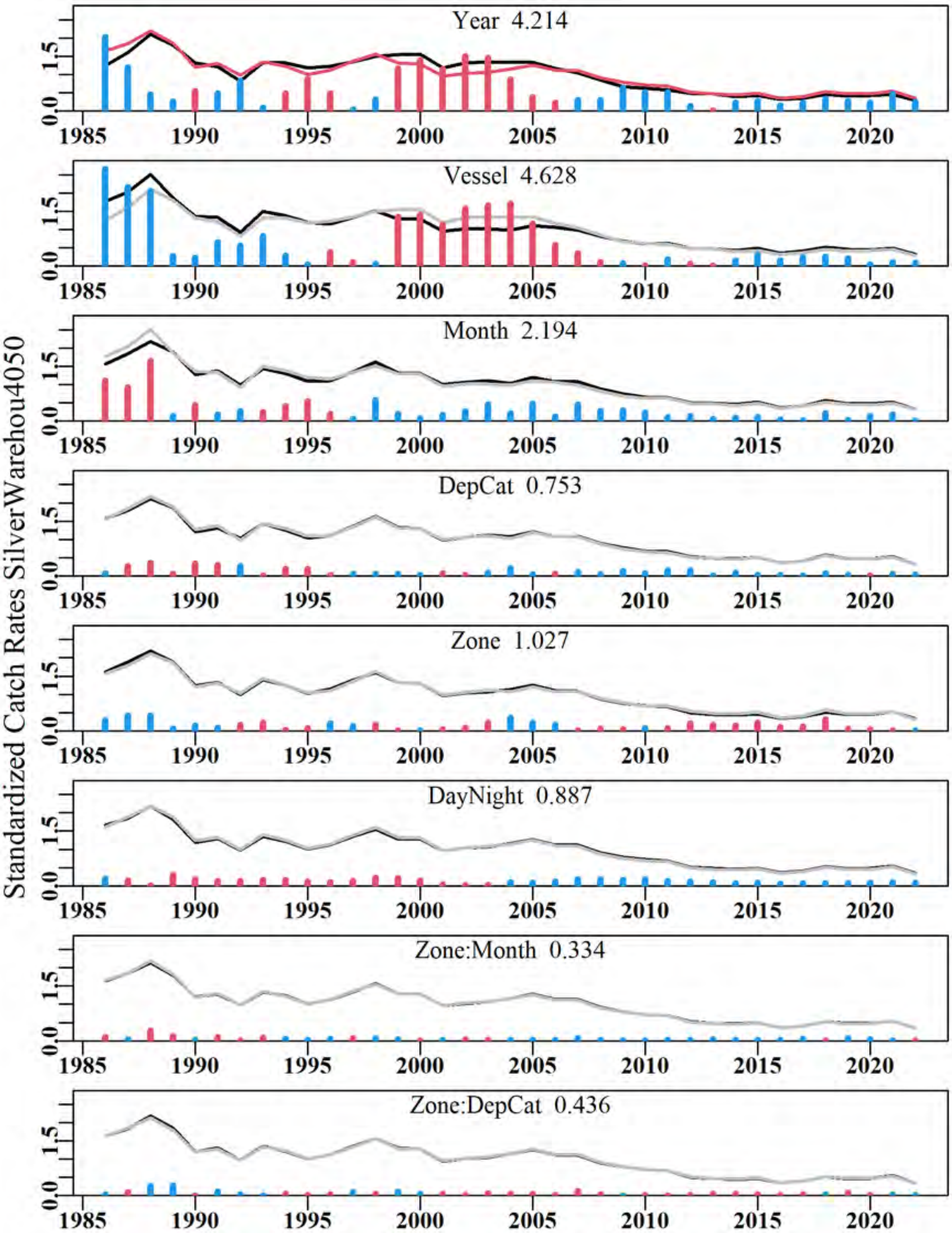

Figure 67: SilverWarehou4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

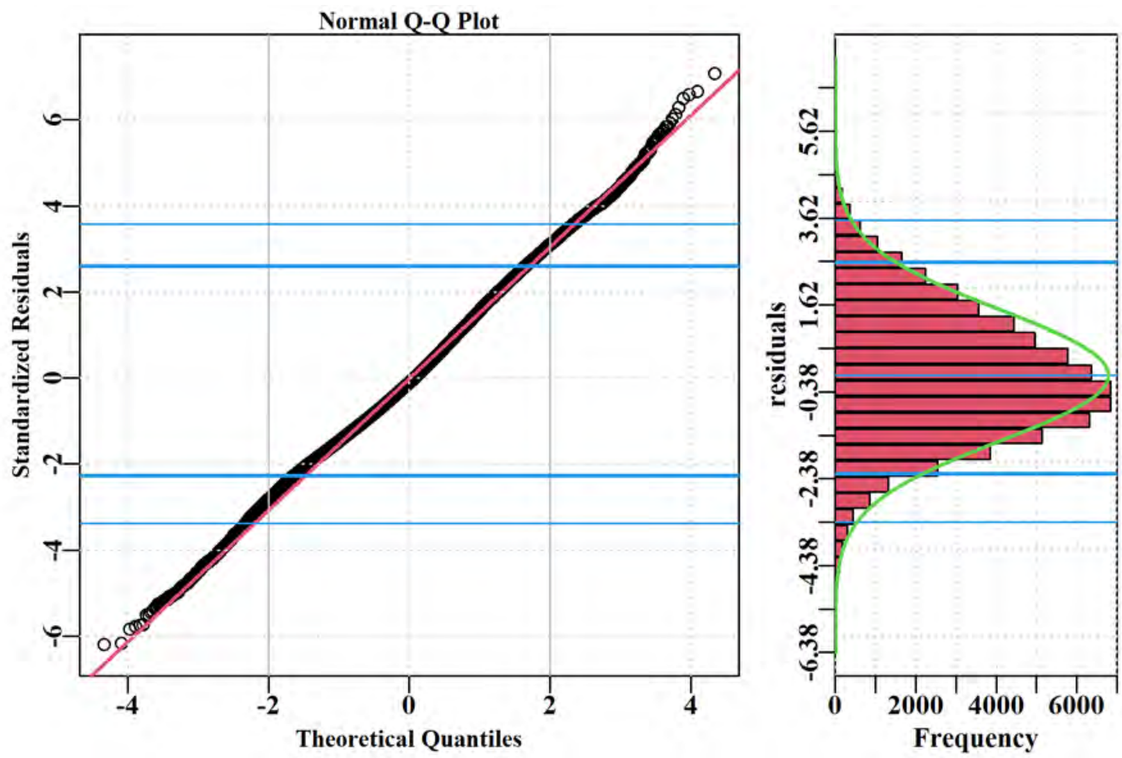

Figure 68: SilverWarehou4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

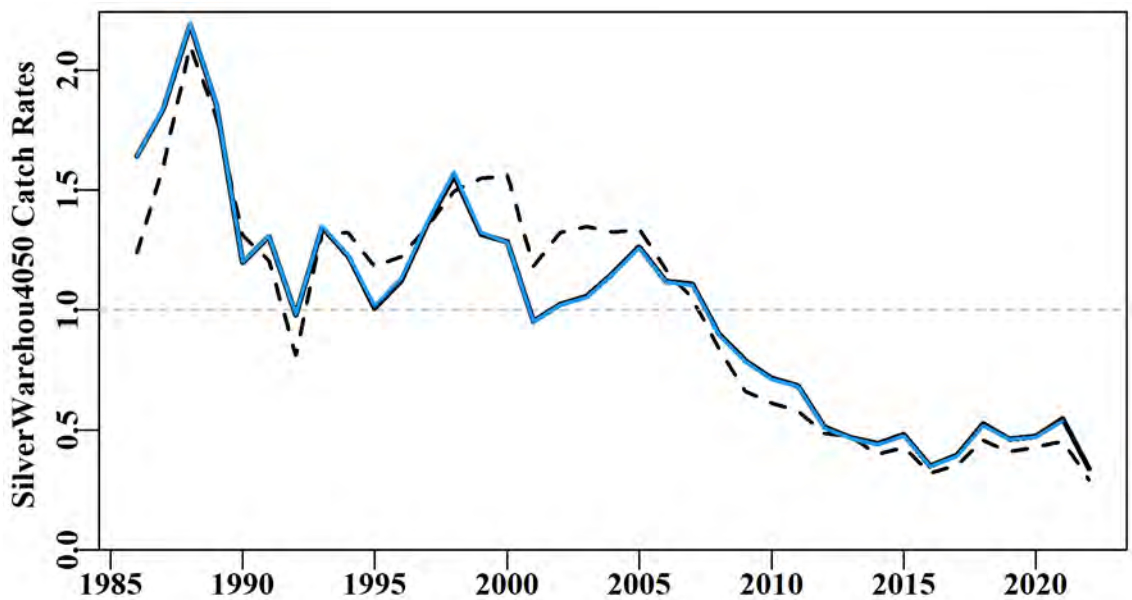

Figure 69: SilverWarehou4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

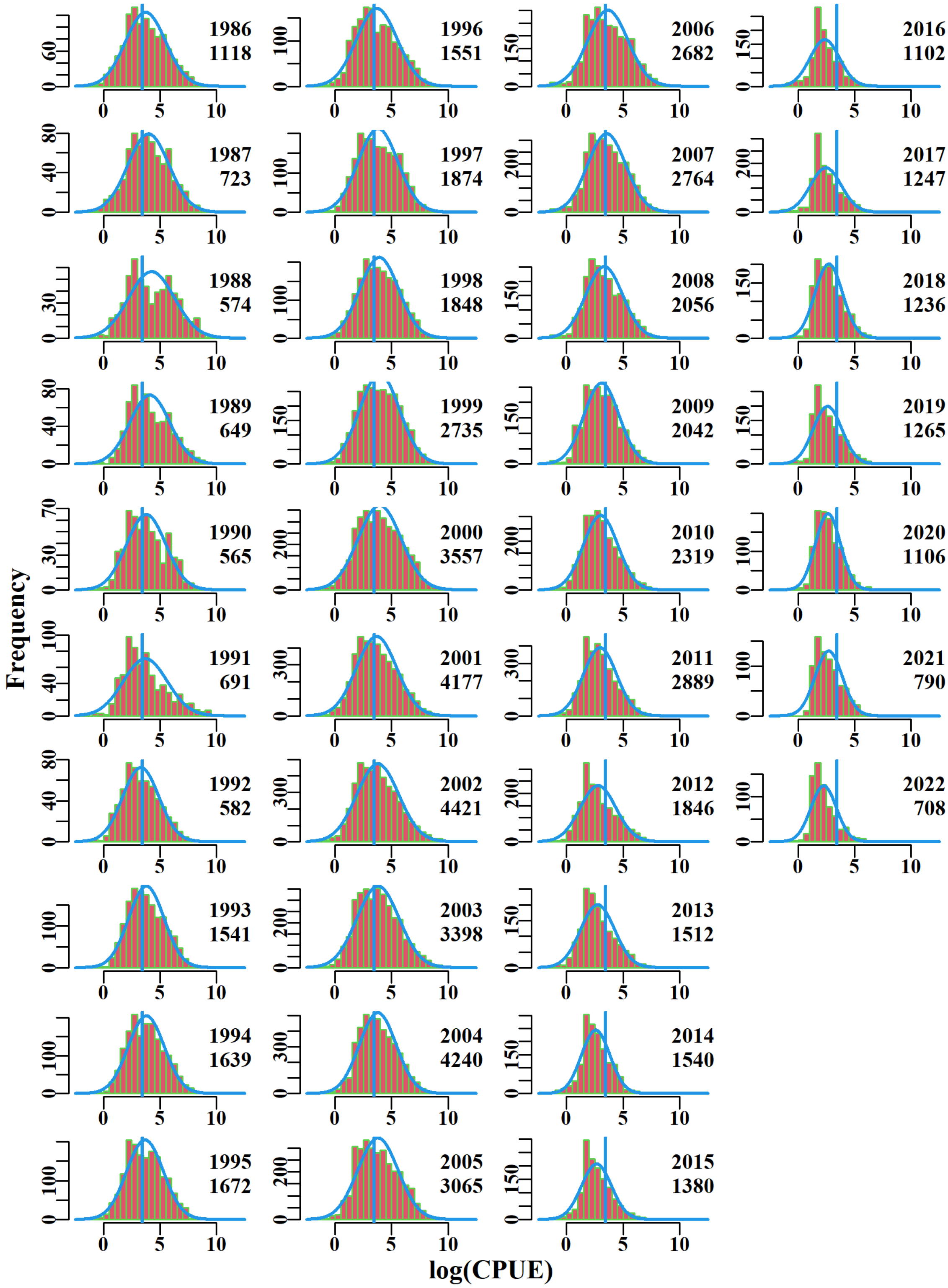

Figure 70: SilverWarehou4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

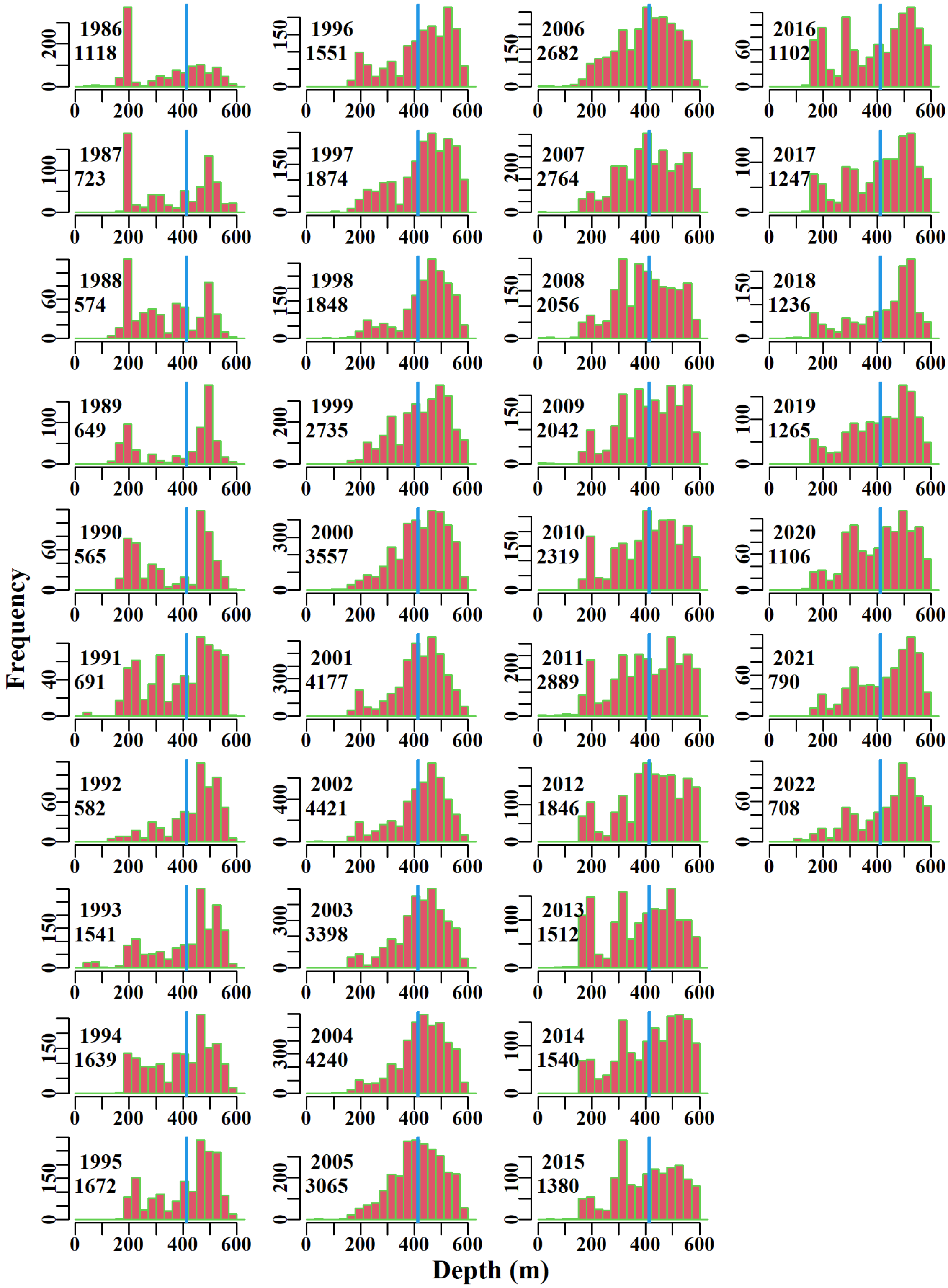

Figure 71: SilverWarehou4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Silver Warehou 10 - 30

Silver Warehou (TRS – 37445006 – *Seriolella punctata*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The criteria used to select data from the Commonwealth logbook database for trawl caught Silver Warehou was based on methods TW, TDO, OTT, OTB, OTM, in zones 10, 20, 30, and depths 0 to 600 m within the SET fishery for years 1986 - 2022 (Table 51).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Most Silver Warehou in the east have been caught in zone 20 across the specified depth range between 1986 - 2022. Both the early catches and the CPUE exhibit high levels of variation and may be suspect before the introduction of quotas, prior to which they were mixed up with catches of Blue Warehou.

The terms Year, Vessel, Month and DepCat had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 55). The qqplot suggests that the assumed Normal distribution is valid (Figure 75).

Annual standardized CPUE has declined since 1994, has been below average since 2000 and flat since about 2013 (Figure 72). The 2022 catch (36.4 t) of Silver Warehou in the east was the lowest in the series (i.e., since 1986).

Action Items and Issues

Annual Silver Warehou catches in the east were relatively high for the period around 1992 – 2006, with specific vessels contributing to these large catches. This suggests that there have been transitional periods in the time-series of CPUE and needs more attention because of the potential implications this has for the index of relative abundance through time.

Table 51: SilverWarehou1030. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SilverWarehou1030
csirocode	37445006
fishery	SET
depthrange	0 - 600
depthclass	50
zones	10, 20, 30
methods	TW, TDO, OTT, OTB, OTM
years	1986 - 2022

Table 52: SilverWarehou1030. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1156.5	1318	491.7	66	113.2	1.9975	0.000	6.906	0.014
1987	782.2	778	264.8	56	112.0	1.9167	0.078	4.472	0.017
1988	1646.2	1668	926.1	69	172.0	2.4525	0.066	8.485	0.009
1989	926.3	1394	336.7	63	62.3	2.0440	0.070	9.172	0.027
1990	1346.6	1398	972.3	59	256.2	2.5941	0.071	5.674	0.006
1991	1453.2	1572	576.6	63	117.7	1.5659	0.070	9.864	0.017
1992	733.8	1256	423.8	41	110.1	1.7957	0.073	7.415	0.017
1993	1815.8	2289	970.5	49	129.5	1.7790	0.066	14.634	0.015
1994	2309.5	2852	1535.2	46	186.7	1.9782	0.065	16.832	0.011
1995	2002.9	3316	1185.2	45	112.4	1.6753	0.064	22.666	0.019
1996	2188.2	4507	1115.2	53	72.4	1.3575	0.062	32.860	0.029
1997	2562.0	3877	1036.3	48	81.8	1.3500	0.064	26.098	0.025
1998	2166.0	2847	777.6	43	72.9	1.1153	0.065	21.294	0.027
1999	2834.1	2398	905.7	43	113.2	0.9723	0.067	17.189	0.019
2000	3401.6	3160	722.0	50	79.2	0.7807	0.065	21.600	0.030
2001	2970.4	3151	637.1	40	72.1	0.7318	0.065	21.675	0.034
2002	3841.4	3981	707.8	42	60.5	0.8473	0.064	27.884	0.039
2003	2910.1	3966	567.6	50	48.1	0.7678	0.064	28.170	0.050
2004	3202.1	3570	487.0	46	43.0	0.8986	0.064	25.638	0.053
2005	2648.0	3791	429.8	42	33.9	0.8390	0.064	30.420	0.071
2006	2191.2	2948	388.7	35	33.2	0.7102	0.066	24.183	0.062
2007	1816.5	1863	274.7	23	44.4	0.5541	0.070	14.426	0.053
2008	1381.2	2301	397.8	24	43.8	0.6522	0.068	19.377	0.049
2009	1285.3	2285	366.4	23	50.0	0.7430	0.068	17.169	0.047
2010	1189.4	2085	282.0	20	40.1	0.5518	0.069	15.392	0.055
2011	1108.8	1983	215.2	22	30.5	0.4791	0.069	15.878	0.074
2012	781.2	1834	188.8	20	33.0	0.4372	0.070	14.161	0.075
2013	584.1	1448	158.9	21	37.9	0.5494	0.073	11.465	0.072
2014	356.9	1342	88.9	22	21.8	0.3737	0.074	11.540	0.130
2015	368.4	1288	64.8	22	16.2	0.2586	0.074	11.574	0.179
2016	331.5	1337	100.1	22	19.6	0.2148	0.074	9.449	0.094
2017	325.7	1069	96.0	18	39.4	0.3039	0.077	7.021	0.073
2018	357.6	1183	84.5	19	24.0	0.3802	0.076	9.122	0.108
2019	304.0	1183	69.9	19	23.6	0.3074	0.076	10.495	0.150
2020	261.8	1109	93.4	16	28.4	0.3652	0.077	10.047	0.108
2021	211.4	765	85.1	14	35.3	0.3601	0.084	6.460	0.076
2022	125.6	534	36.4	16	23.0	0.2999	0.093	5.620	0.154

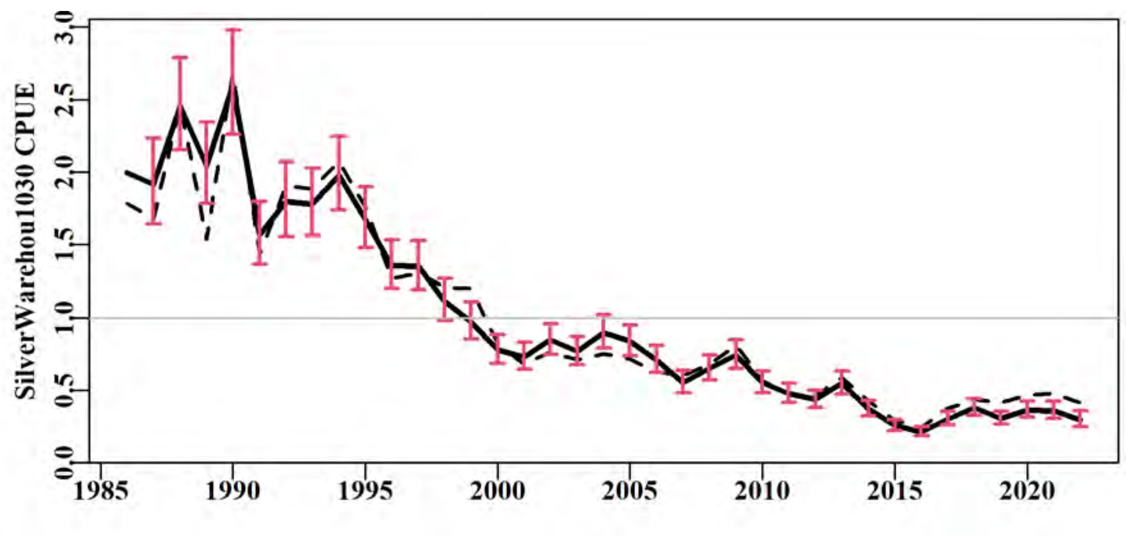

Figure 72: SilverWarehou1030 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

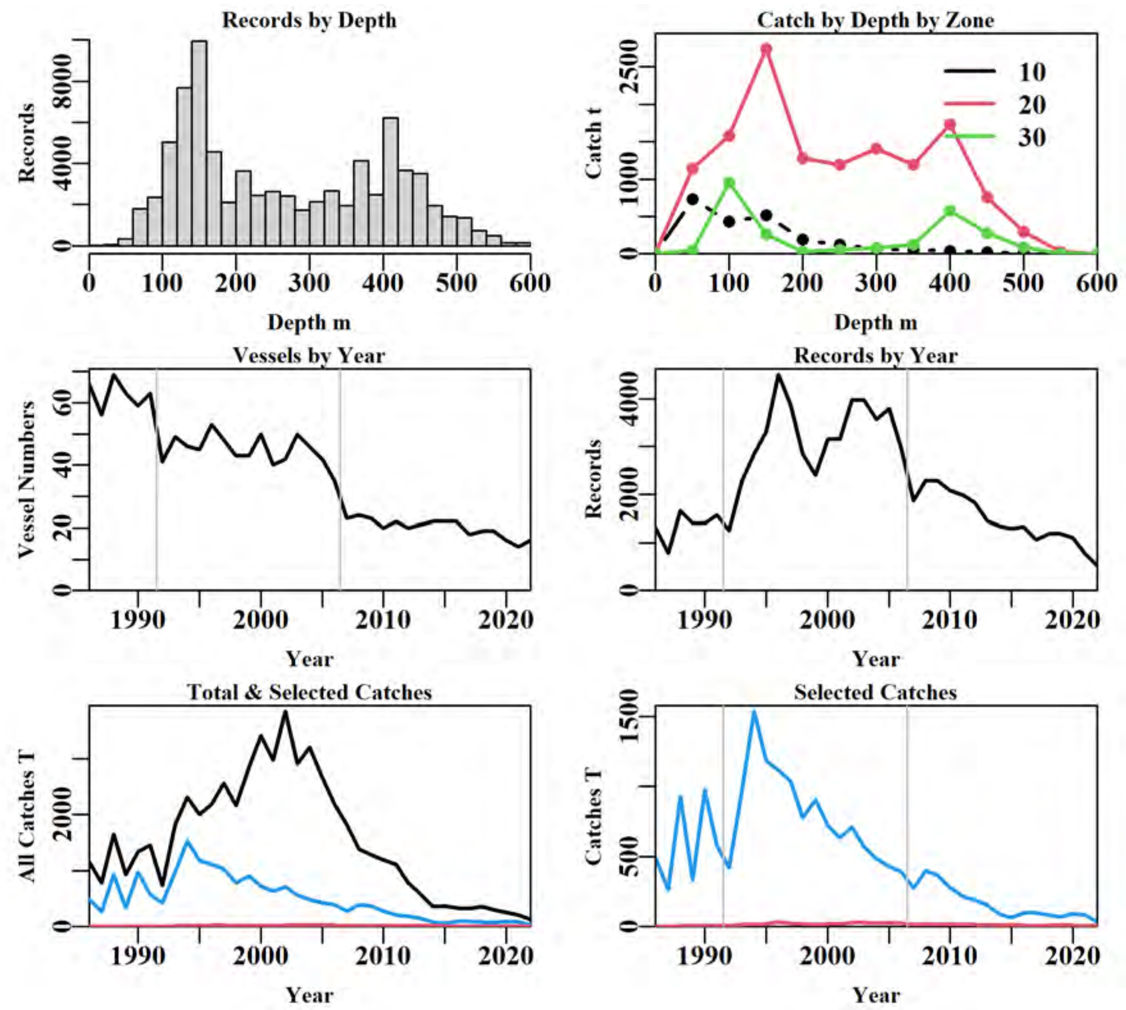

Figure 73: SilverWarehou1030 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 53: SilverWarehou1030 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	165682	158790	154310	153288	81218	79749	79646
Difference	0	6892	4480	1022	72070	1469	103
Catch	56249	55759	54037	53671	18552	18082	18061
Difference	0	490	1722	366	35119	470	21

Table 54: The models used to analyse data for SilverWarehou1030.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + DepCat
Model5	Year + Vessel + Month + DepCat + Zone
Model6	Year + Vessel + Month + DepCat + Zone + DayNight
Model7	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:Month
Model8	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:DepCat

Table 55: SilverWarehou1030. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	88714	242383	23953	79646	37	9.0	0.00
Vessel	82065	221953	44383	79646	219	16.4	7.48
Month	78209	211404	54932	79646	230	20.4	3.96
DepCat	77030	208235	58101	79646	242	21.6	1.18
Zone	76809	207648	58687	79646	244	21.8	0.22
DayNight	76805	207623	58713	79646	247	21.8	0.01
Zone:Month	75803	204914	61422	79646	269	22.8	1.00
Zone:DepCat	75728	204715	61620	79646	270	22.9	1.07

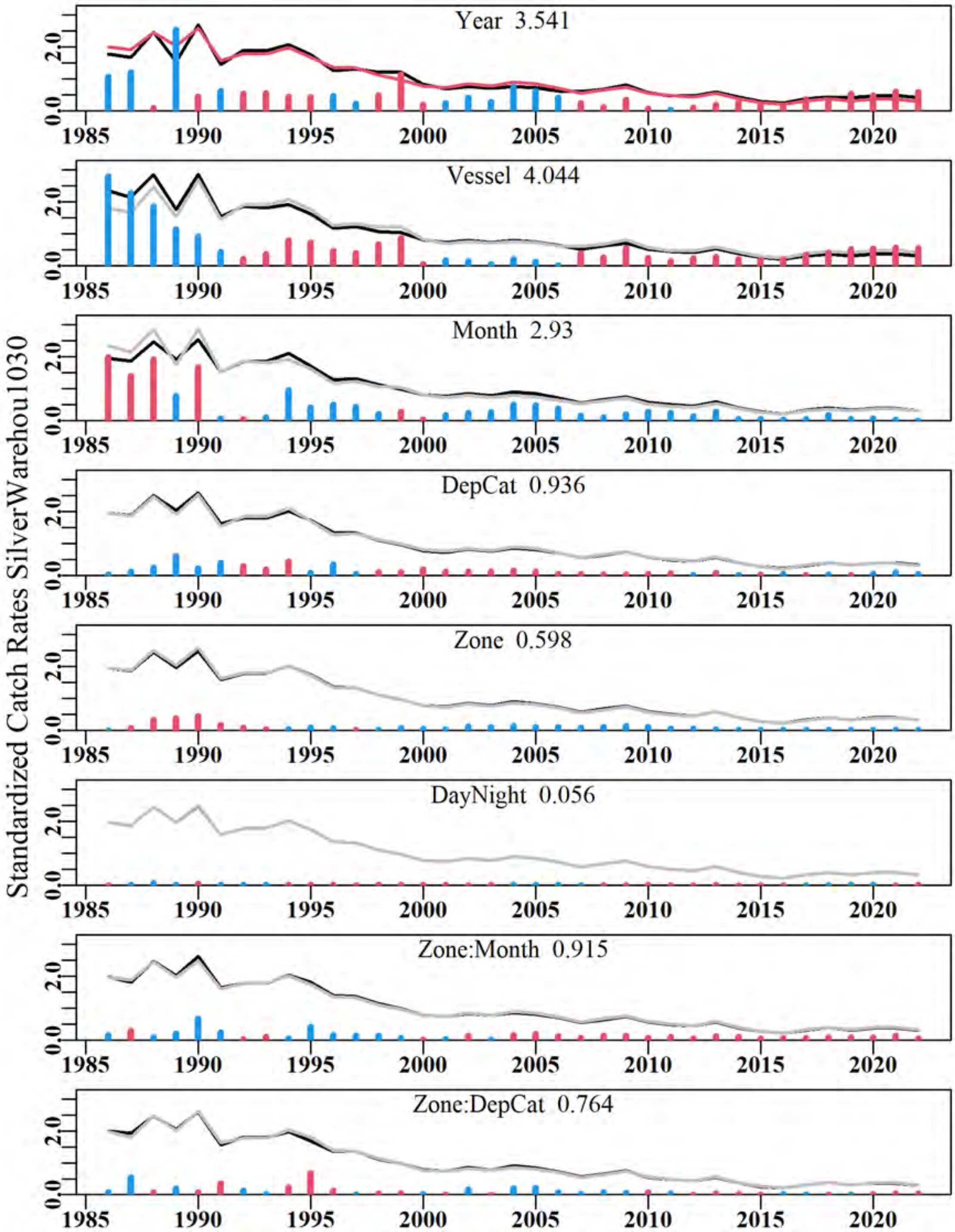

Figure 74: SilverWarehou1030. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

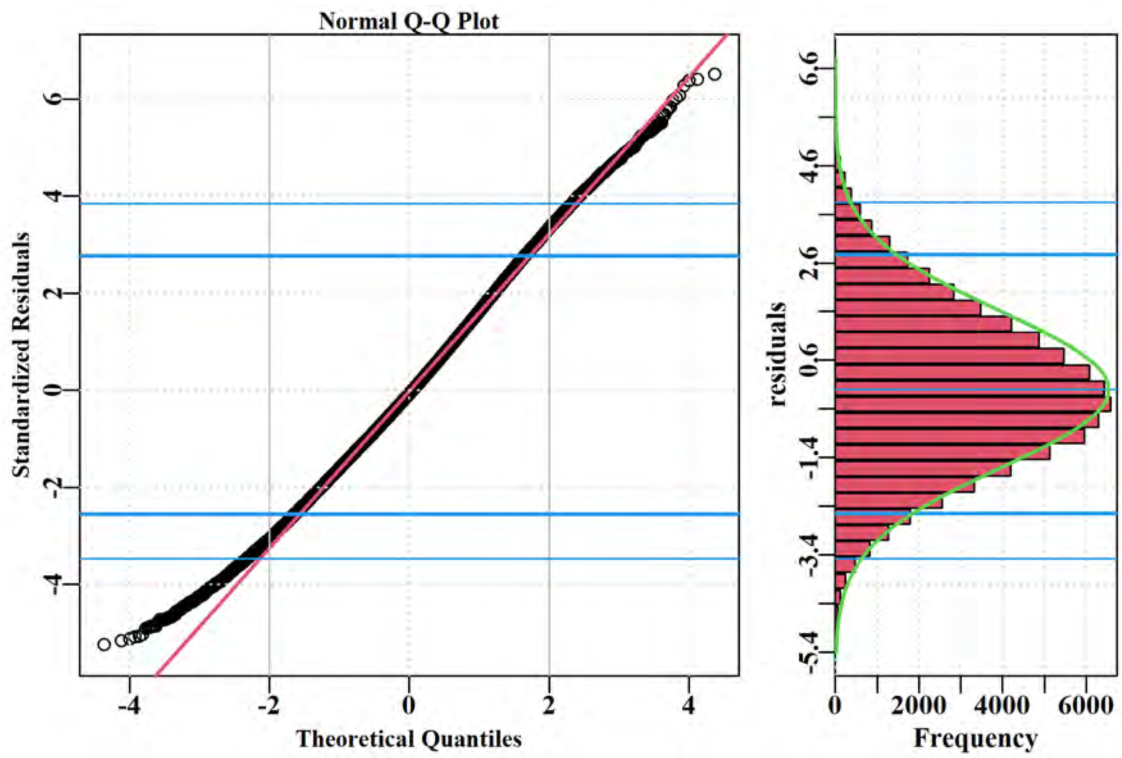

Figure 75: SilverWarehou1030. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

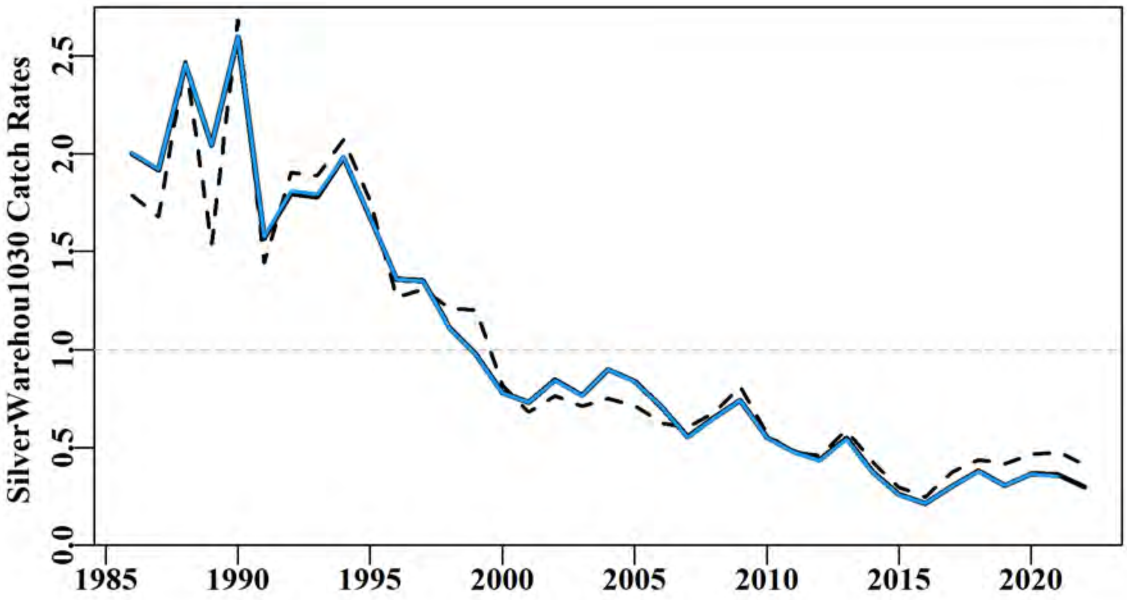

Figure 76: SilverWarehou1030. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

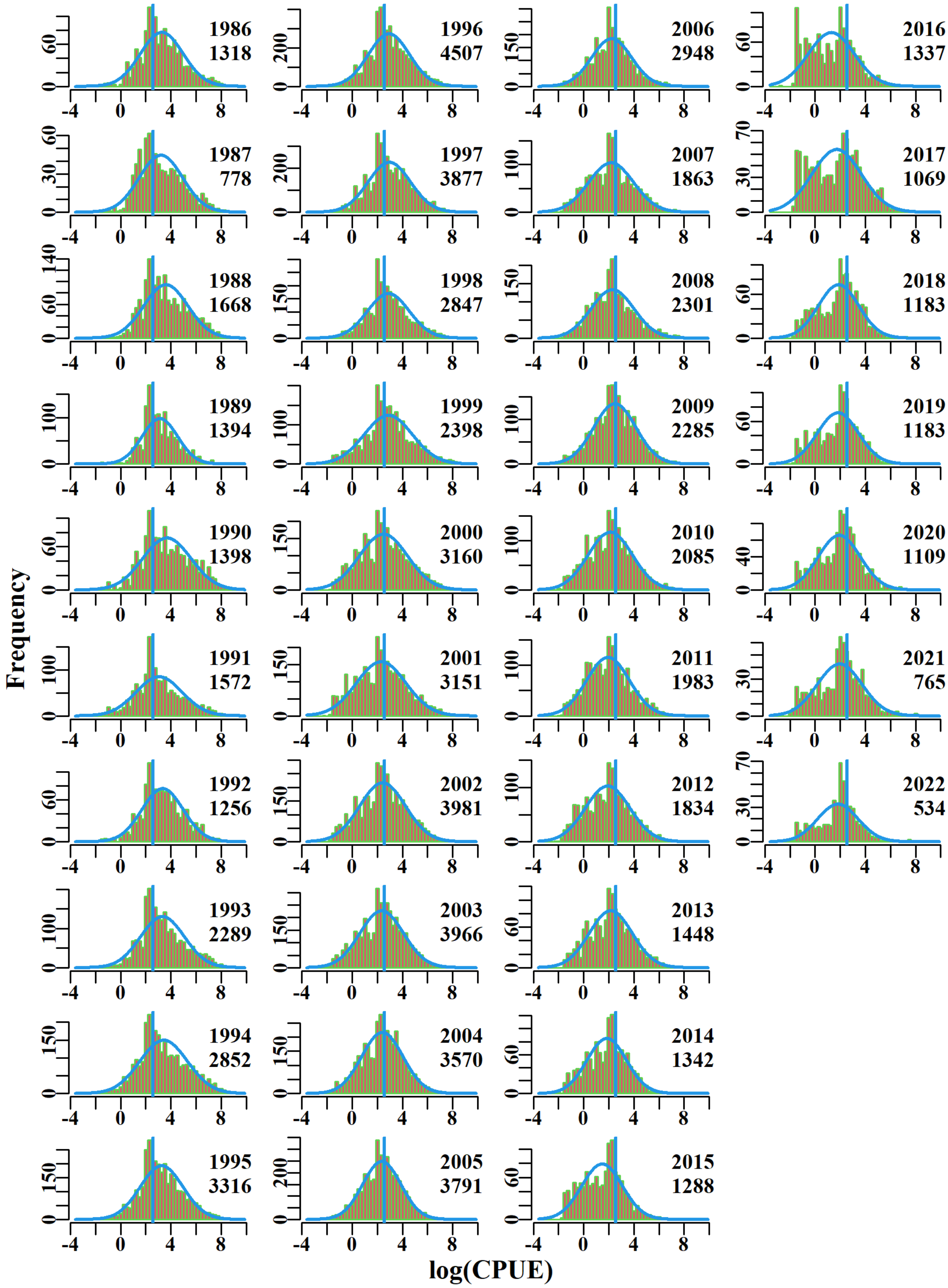

Figure 77: SilverWarehou1030. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

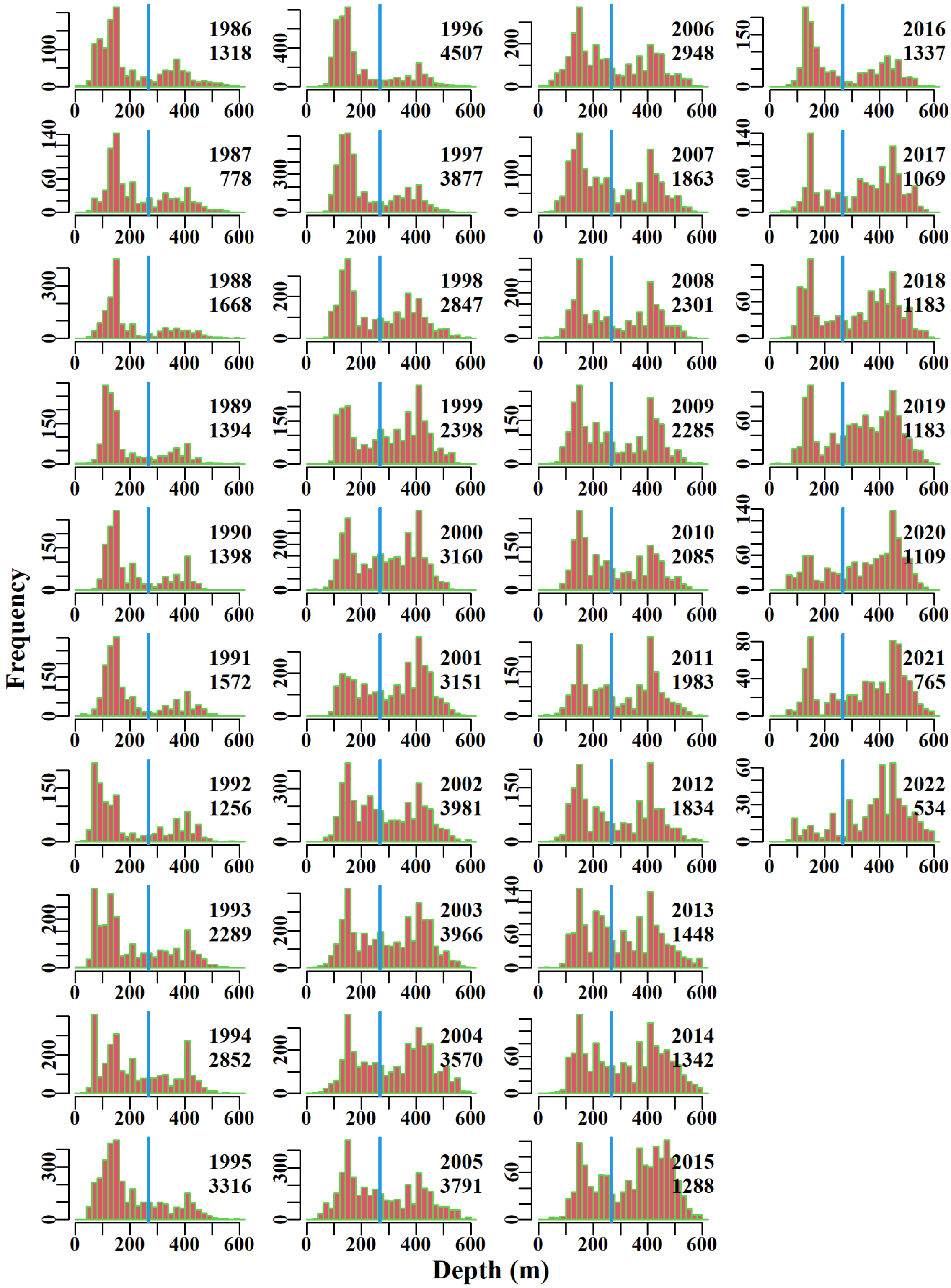

Figure 78: SilverWarehou1030. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Flathead TW 30

Tiger Flathead (FLT – 37296001 – *Neoplatycephalus richardsoni*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The additional generic Flathead group code was added as a result of a change in recording Tiger Flathead as 37296000 (Platycephalidae) in electronic logbooks since 2013. Trawl caught Flathead based on methods TW, TDO, OTB, OTM, OTT, in zones 30, and depths 0 to 300 m within the SET fishery for the years 1986 - 2022 were analysed (Table 56). A total of 7 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The amount of Flathead (*Neoplatycephalus richardsoni* and Platycephalidae) catch in shots <30 kg in zone 30 is small across the analysis period.

The terms Year, Vessel, DepCat, Month and interaction term Month:DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests a small departure of the assumed Normal distribution as depicted by the lower tail of the distribution.

The annual standardized CPUE trend was noisy and flat between 1986 - 2001, and after a transitional period between 2002 - 2006 during which catches surged, was noisy and flat from 2007 to 2022 (Figure 79). The catch in 2022 (154 t) from zone 30 was the lowest since 2012.

Action Items and Issues

The number of records and corresponding catch in 1986 and 1987 are very low. Also, the depth distribution is spread over a large range for these two years compared to all other years in the fishery. It is therefore recommended to remove these two years from the time series for analysis.

Table 56: FlatheadTW30. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	FlatheadTW30
csirocode	37296001, 37296000
fishery	SET
depthrange	0 - 300
depthclass	20
zones	30
methods	TW, TDO, OTB, OTM, OTT
years	1986 - 2022

Table 57: FlatheadTW30. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Month:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1892.2	70	16.7	6	67.0	0.9719	0.000	0.571	0.034
1987	2461.3	87	5.0	9	18.5	0.5640	0.190	0.985	0.196
1988	2469.5	191	39.9	9	53.1	0.9990	0.171	1.272	0.032
1989	2599.1	515	48.4	19	29.4	0.7363	0.164	3.760	0.078
1990	2032.3	248	23.4	27	34.0	0.7371	0.166	1.925	0.082
1991	2230.2	302	32.0	29	28.2	0.7056	0.162	2.614	0.082
1992	2375.4	267	33.5	15	37.6	0.6618	0.166	1.428	0.043
1993	1879.1	891	91.1	24	30.3	0.6176	0.158	6.341	0.070
1994	1710.4	608	64.2	17	31.6	0.6644	0.159	4.671	0.073
1995	1800.6	690	71.0	17	31.4	0.7295	0.159	6.187	0.087
1996	1879.9	713	61.4	17	26.7	0.6611	0.159	6.916	0.113
1997	2356.0	877	104.5	14	42.9	0.8141	0.158	5.243	0.050
1998	2306.4	700	118.2	14	56.0	0.9762	0.158	2.918	0.025
1999	3117.7	769	174.8	17	68.3	1.0881	0.158	3.464	0.020
2000	2945.6	512	83.6	20	50.1	0.8819	0.160	2.501	0.030
2001	2599.5	927	102.3	17	31.6	0.7401	0.157	4.949	0.048
2002	2876.3	1360	211.6	15	46.8	1.3066	0.156	5.332	0.025
2003	3229.9	1443	237.2	21	47.2	1.3368	0.155	3.920	0.017
2004	3222.8	1913	475.7	15	80.2	1.8477	0.155	3.784	0.008
2005	2844.1	1508	383.5	18	77.8	1.6842	0.155	3.731	0.010
2006	2585.8	1299	285.1	13	60.3	1.3673	0.156	2.395	0.008
2007	2648.3	808	170.3	8	64.1	1.1149	0.158	1.834	0.011
2008	2912.3	851	165.9	10	60.3	1.0489	0.157	2.624	0.016
2009	2460.5	590	98.9	10	49.9	1.0148	0.159	1.393	0.014
2010	2502.3	499	101.8	10	58.5	1.0135	0.160	1.737	0.017
2011	2465.9	614	128.8	9	64.5	0.9531	0.159	1.478	0.011
2012	2780.6	702	151.5	9	58.9	1.2209	0.158	1.048	0.007
2013	1941.0	828	190.8	11	65.6	1.1705	0.157	2.406	0.013
2014	2369.9	751	180.0	11	67.5	1.3595	0.158	1.213	0.007
2015	2667.9	1159	290.8	13	69.2	1.2698	0.156	2.088	0.007
2016	2775.6	1555	329.9	12	59.6	1.0389	0.156	6.682	0.020
2017	2311.7	1293	290.2	10	62.3	1.1668	0.156	3.304	0.011
2018	2000.8	1188	212.8	12	46.2	0.8291	0.157	3.601	0.017
2019	1938.1	1617	252.3	13	41.2	0.8450	0.156	5.269	0.021
2020	1990.2	1330	228.4	9	44.5	0.9146	0.156	3.691	0.016
2021	2071.0	1025	204.5	11	51.0	0.9570	0.157	2.427	0.012
2022	1821.9	780	154.0	8	53.6	0.9915	0.158	1.568	0.010

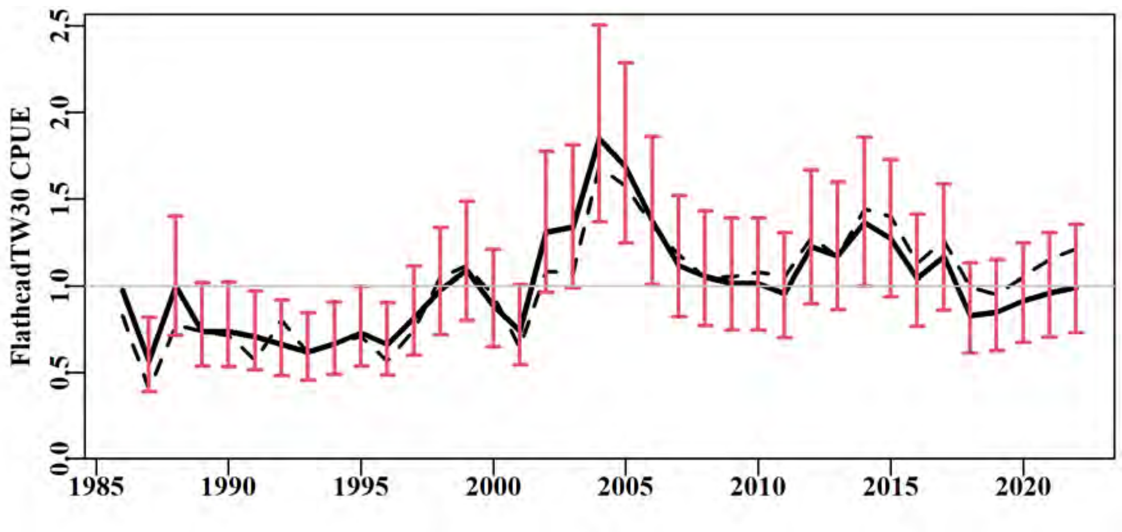

Figure 79: FlatheadTW30 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

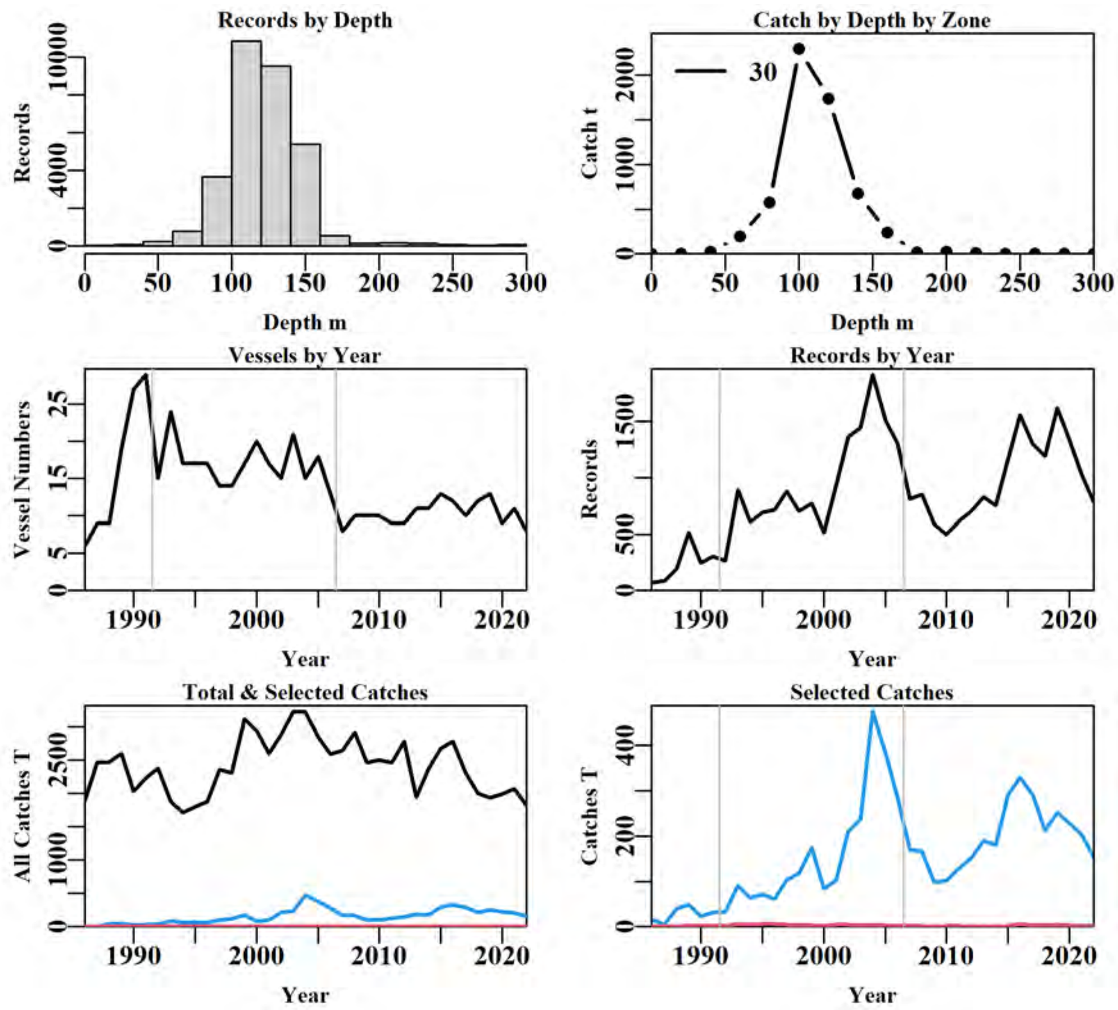

Figure 80: FlatheadTW30 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 58: FlatheadTW30 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	697816	603132	589354	581162	36114	31483	31480
Difference	0	94684	13778	8192	545048	4631	3
Catch	90063	79643	78294	77317	6863	5815	5814
Difference	0	10420	1349	977	70454	1048	0

Table 59: The models used to analyse data for FlatheadTW30.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + DayNight
Model5	Year + Vessel + DepCat + DayNight + Month
Model6	Year + Vessel + DepCat + DayNight + Month + Month:DepCat
Model7	Year + Vessel + DepCat + DayNight + Month + DayNight:Month

Table 60: FlatheadTW30. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Month:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	3309	34887	2500	31480	37	6.6	0.00
Vessel	1224	32451	4937	31480	134	12.8	6.26
DepCat	-3	31180	6207	31480	149	16.2	3.37
DayNight	-165	31015	6373	31480	152	16.6	0.44
Month	-530	30635	6752	31480	163	17.6	0.99
Month:DepCat	-1203	29712	7675	31480	308	19.7	2.11
DayNight:Month	-599	30520	6868	31480	188	17.9	0.25

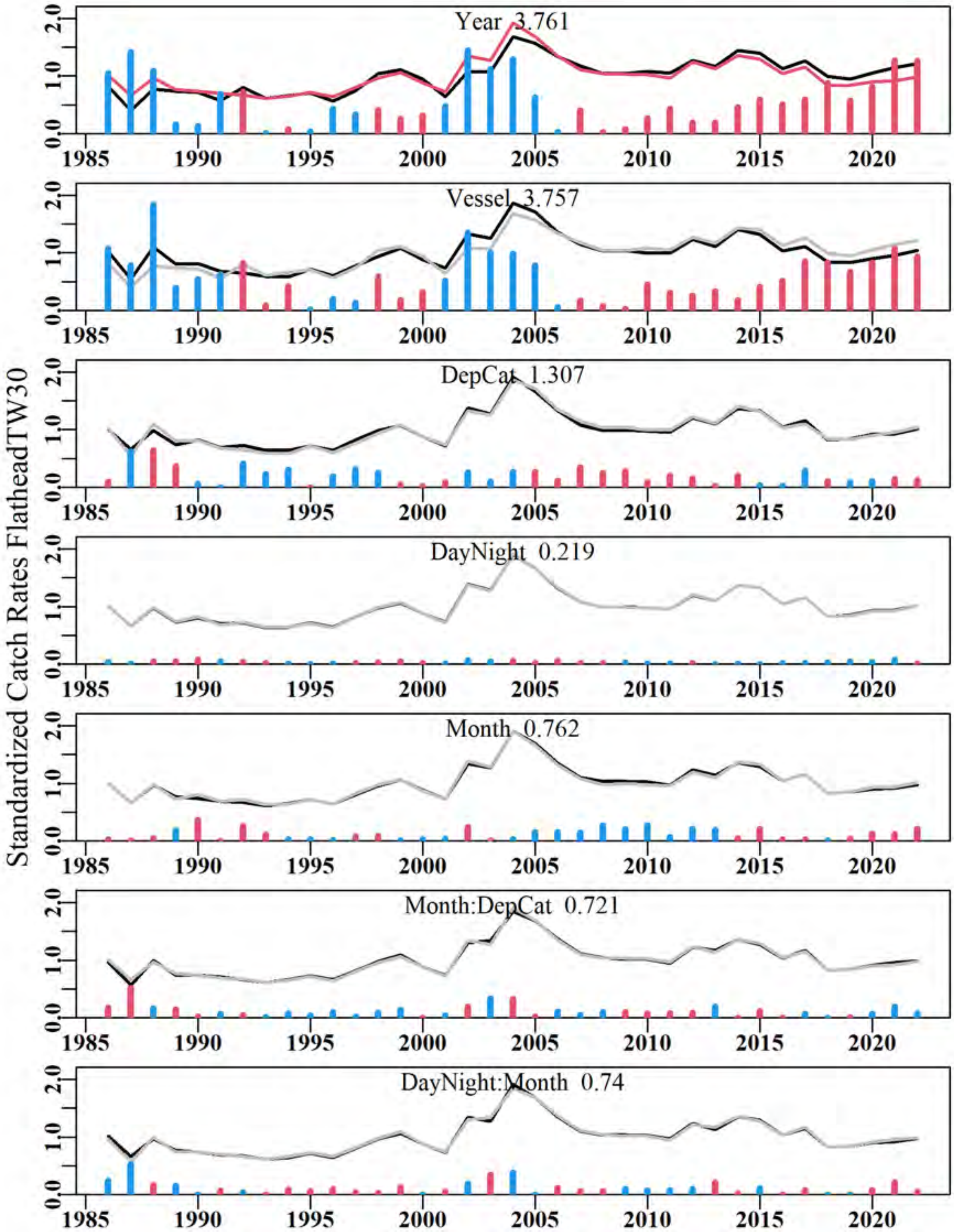

Figure 81: FlatheadTW30. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

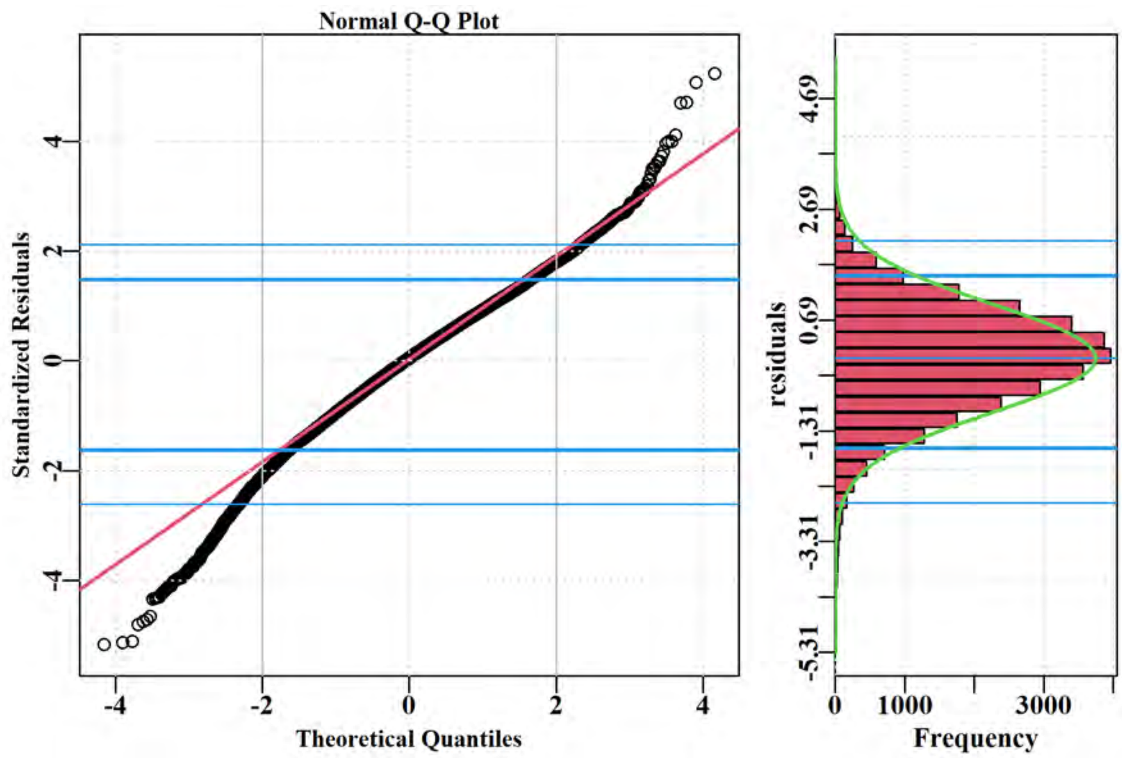

Figure 82: FlatheadTW30. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

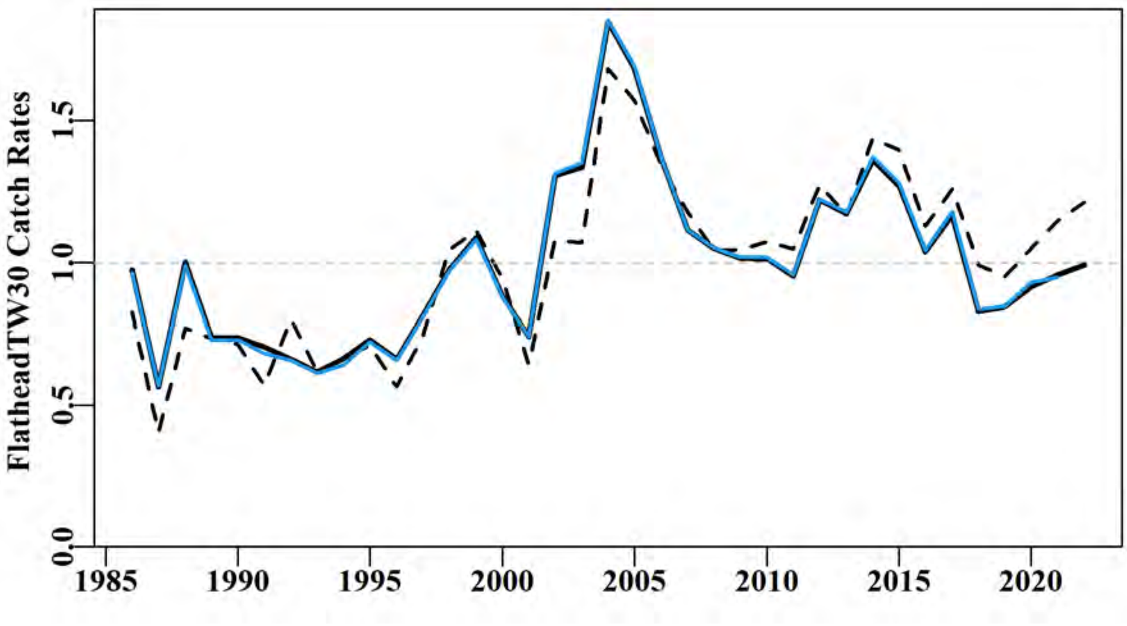

Figure 83: FlatheadTW30. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

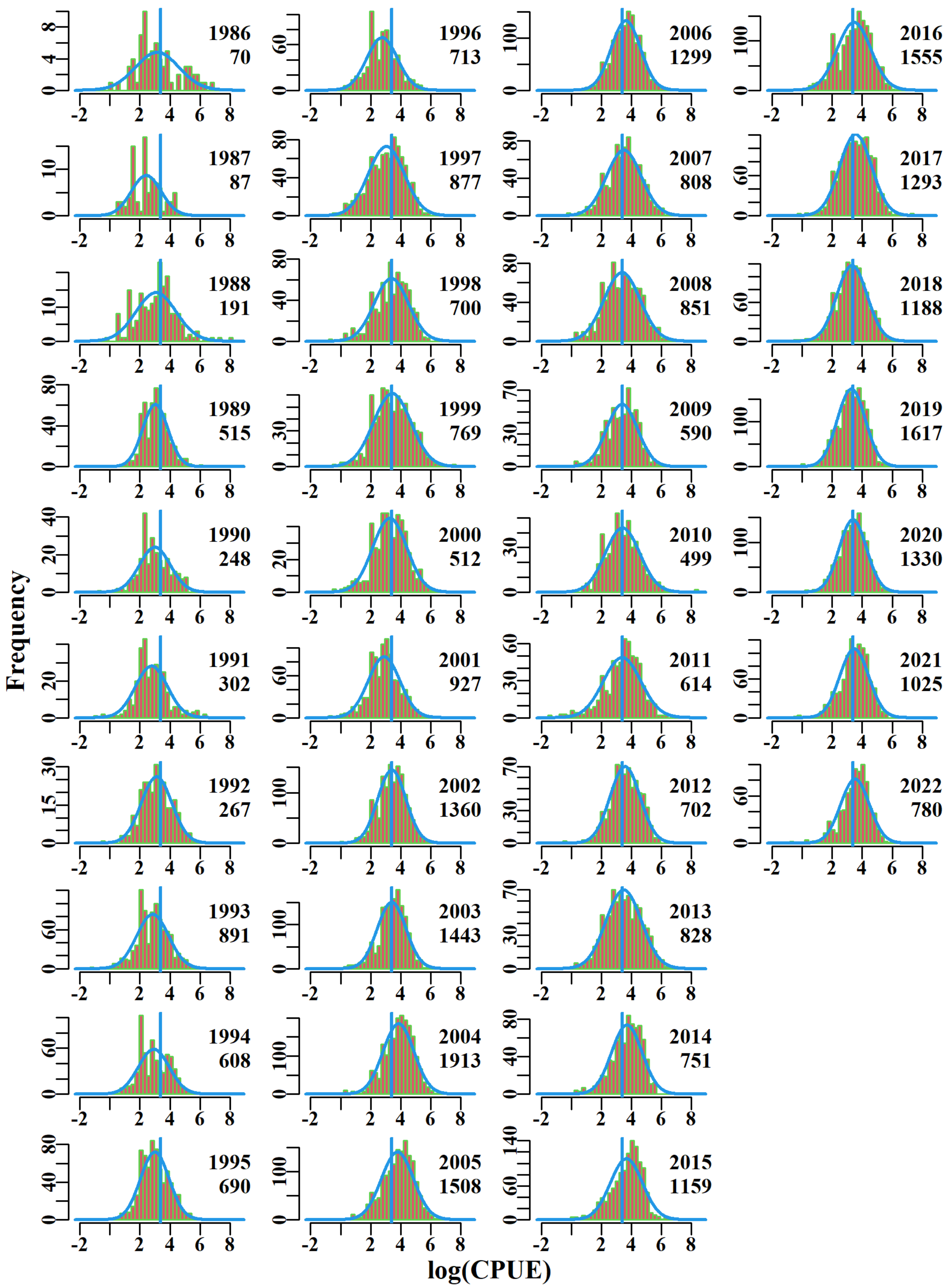

Figure 84: FlatheadTW30. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

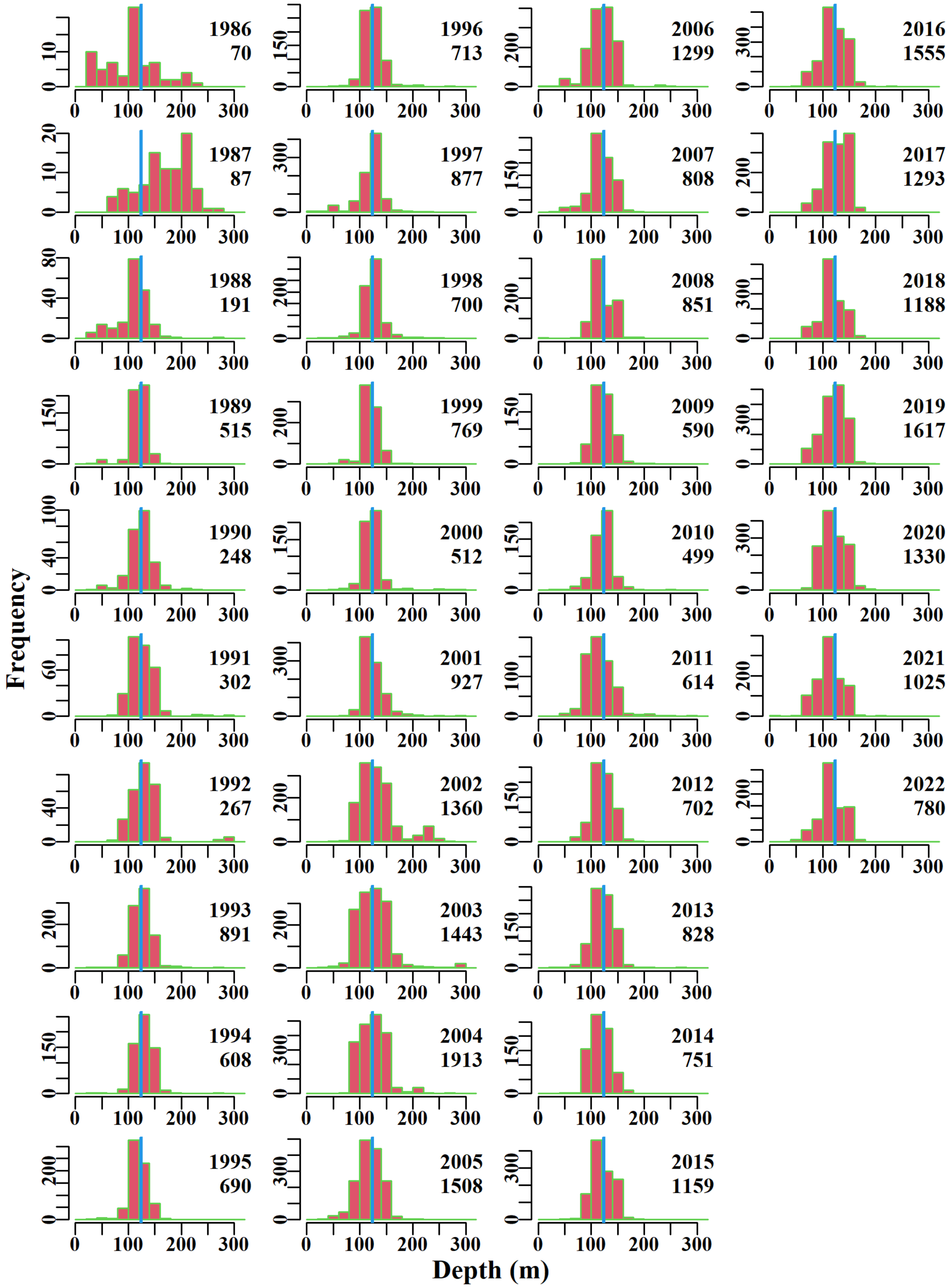

Figure 85: FlatheadTW30. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Flathead TW 10,20

Tiger Flathead (FLT – 37296001 – *Neoplatycephalus richardsoni*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The additional generic flathead group code was added as a result of a change in recording Tiger Flathead as 37296000 (Platycephalidae) in electronic logbooks since 2013. Trawl caught flathead based on methods TW, TDO, OTB, OTM, OTT, in zones 10, 20, and depths 0 to 400 m within the SET fishery for the years 1986 - 2022 were analysed (Table 61).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The amount of Flathead (*Neoplatycephalus richardsoni* and Platycephalidae) catch in shots <30 kg from zone 10 and 20 is small across the analysis period. Most flathead were caught in zone 10 followed by 20. The total Flathead catch (559.3 t) and corresponding number of vessels (18) from zones 10 and 20 in 2022 was the lowest in the series.

The terms Year, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests a small departure of the assumed Normal distribution as depicted by both tails of the distribution (Figure 89).

Annual standardized CPUE appears cyclical above and below average, has remained below average in 2017-2018, increased to the long-term average in 2021, and subsequently decreased to below average based on the 95% confidence intervals (Figure 86). The structural adjustment had a profound effect upon the influence of the vessel factor reducing the standardized trend well below the nominal geometric mean CPUE.

Action Items and Issues

After consideration of Flathead catches in the east by year and vessel for the period around 1992 - 2006 appears to be different from catches by vessel from 2007. This suggests that there have been transitional periods in the time-series of CPUE. This **urgently** needs more attention because of the potential implications this has for the index of relative abundance through time.

Table 61: FlatheadTW1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	FlatheadTW1020
csirocode	37296001, 37296000
fishery	SET
depthrange	0 - 400
depthclass	20
zones	10, 20
methods	TW, TDO, OTB, OTM, OTT
years	1986 - 2022

Table 62: FlatheadTW1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1892.2	10185	962.2	94	31.6	0.8064	0.000	64.431	0.067
1987	2461.3	8056	1004.2	86	41.6	1.0735	0.016	43.737	0.044
1988	2469.5	9149	1169.2	86	42.2	1.1755	0.016	47.288	0.040
1989	2599.1	8802	1206.0	74	44.8	1.1763	0.016	46.430	0.038
1990	2032.3	7701	1212.0	64	52.3	1.3971	0.016	27.684	0.023
1991	2230.2	7750	1136.6	57	52.0	1.3124	0.017	30.402	0.027
1992	2375.4	6864	895.1	54	43.9	1.0400	0.017	29.894	0.033
1993	1879.1	8640	982.2	57	38.8	1.0553	0.016	38.124	0.039
1994	1710.4	10190	894.7	55	29.9	0.7657	0.016	62.692	0.070
1995	1800.6	10232	985.2	54	31.6	0.8079	0.016	65.863	0.067
1996	1879.9	10984	952.3	58	29.3	0.7219	0.016	75.637	0.079
1997	2356.0	10265	988.7	61	31.2	0.7223	0.016	64.965	0.066
1998	2306.4	9953	996.8	52	32.5	0.7634	0.016	63.008	0.063
1999	3117.7	10338	1124.7	57	36.2	0.9237	0.016	56.799	0.051
2000	2945.6	12859	1641.8	59	51.9	1.0151	0.015	62.596	0.038
2001	2599.5	11659	1307.3	52	39.4	0.9727	0.015	52.699	0.040
2002	2876.3	12364	1447.6	49	39.3	1.0552	0.015	55.469	0.038
2003	3229.9	12794	1583.8	52	41.4	1.0418	0.015	58.188	0.037
2004	3222.8	12155	1336.5	52	36.4	0.9065	0.015	62.850	0.047
2005	2844.1	10588	1143.5	49	34.2	0.7817	0.016	62.412	0.055
2006	2585.8	9072	1138.0	45	40.2	0.9462	0.016	43.946	0.039
2007	2648.3	6280	1067.2	25	55.1	1.1547	0.018	21.678	0.020
2008	2912.3	7194	1307.6	27	56.3	1.2164	0.017	26.303	0.020
2009	2460.5	6214	1037.7	26	51.4	1.1293	0.018	22.375	0.022
2010	2502.3	6685	1086.7	25	49.2	1.0879	0.018	25.062	0.023
2011	2465.9	6605	1070.4	24	52.4	1.0720	0.018	23.777	0.022
2012	2780.6	6795	1149.3	25	54.6	1.1747	0.018	25.865	0.023
2013	1941.0	5587	682.8	24	37.4	0.8851	0.018	25.723	0.038
2014	2369.9	6337	943.4	25	46.0	1.0398	0.018	22.647	0.024
2015	2667.9	6358	983.6	30	48.4	1.1749	0.018	15.754	0.016
2016	2775.6	5908	888.9	27	49.3	1.0693	0.018	16.011	0.018
2017	2311.7	5346	714.0	24	43.0	0.8819	0.019	19.043	0.027
2018	2000.8	5557	749.0	25	40.4	0.8779	0.019	18.178	0.024
2019	1938.1	4970	618.6	21	36.0	0.9336	0.019	16.259	0.026
2020	1990.2	5137	680.6	19	37.9	0.9389	0.019	16.392	0.024
2021	2071.0	4935	664.7	21	38.7	0.9821	0.020	18.305	0.028
2022	1821.9	4311	559.3	18	37.2	0.9209	0.021	18.769	0.034

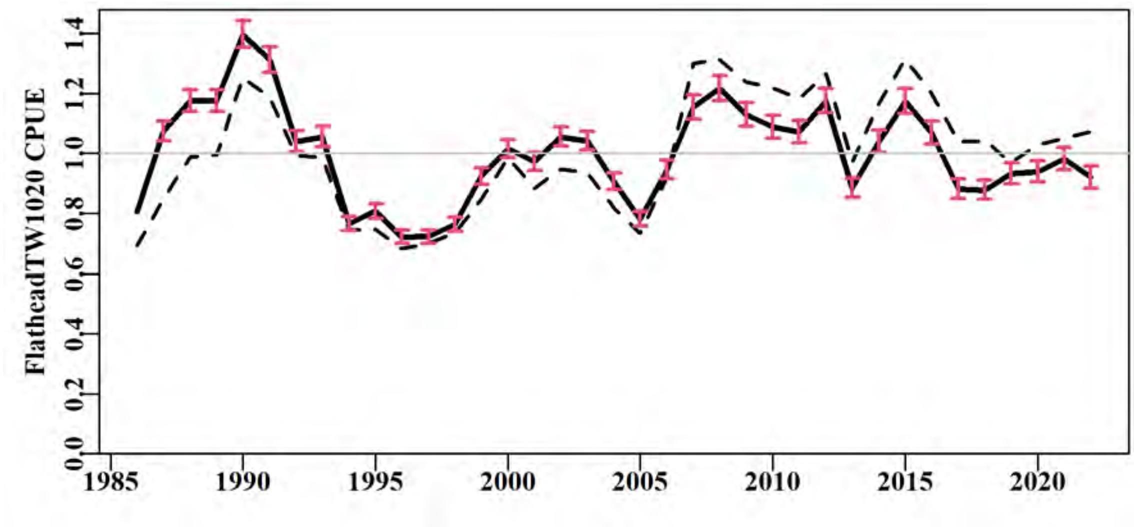

Figure 86: FlatheadTW1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

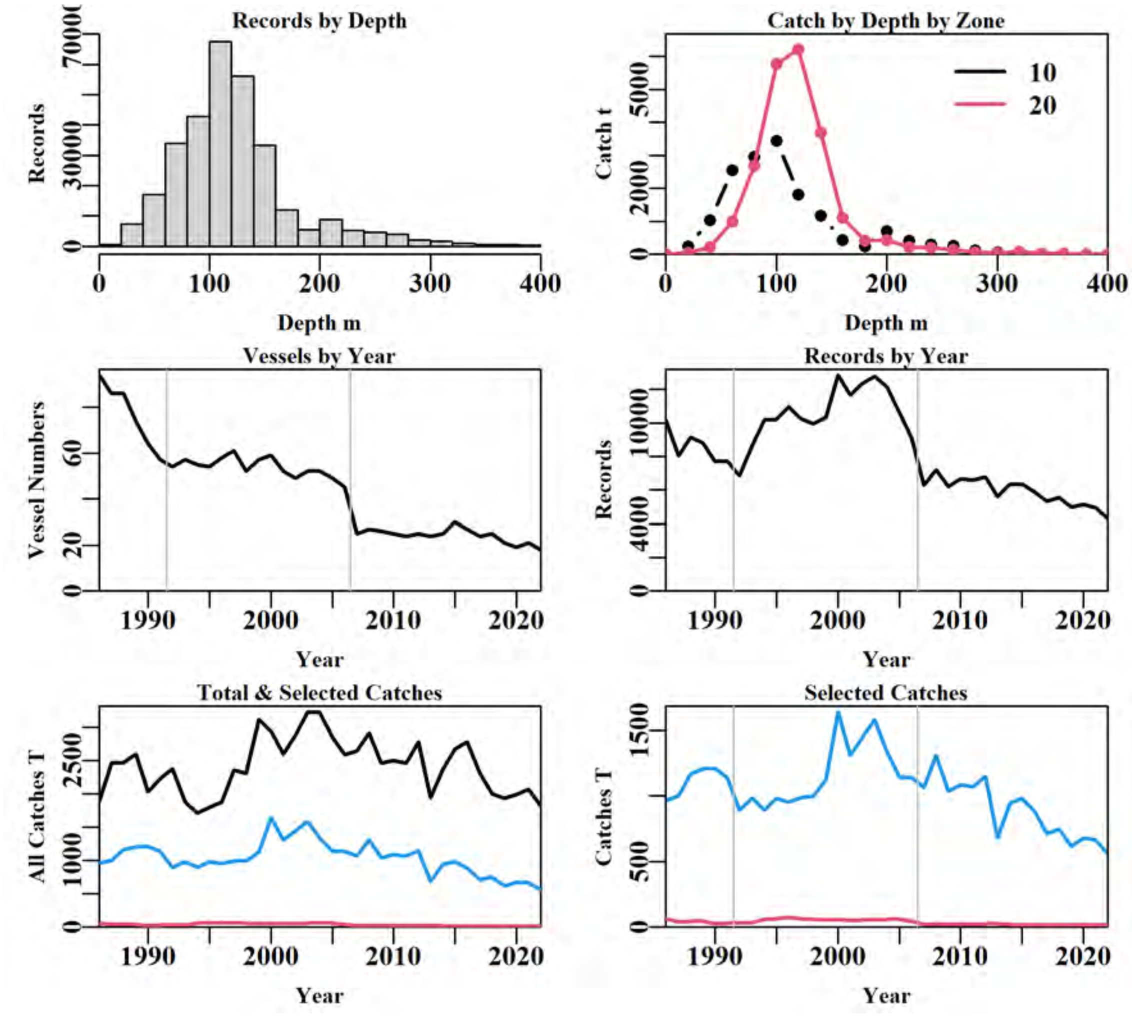

Figure 87: FlatheadTW1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 63: FlatheadTW1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	697816	603132	596201	587919	401321	305130	304819
Difference	0	94684	6931	8282	186598	96191	311
Catch	90063	79643	78777	77794	58095	38349	38312
Difference	0	10420	866	983	19698	19746	37

Table 64: The models used to analyse data for FlatheadTW1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + DayNight
Model6	Year + Vessel + DepCat + Month + DayNight + Zone
Model7	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:Month
Model8	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:DepCat

Table 65: FlatheadTW1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	41630	349341	11937	304819	37	3.3	0.00
Vessel	9921	314438	46840	304819	225	12.9	9.61
DepCat	1115	305445	55834	304819	245	15.4	2.49
Month	138	304446	56833	304819	256	15.7	0.27
DayNight	-402	303900	57378	304819	259	15.8	0.15
Zone	-500	303800	57478	304819	260	15.8	0.03
Zone:Month	-2937	301360	59919	304819	271	16.5	0.67
Zone:DepCat	-3444	300842	60437	304819	280	16.7	0.81

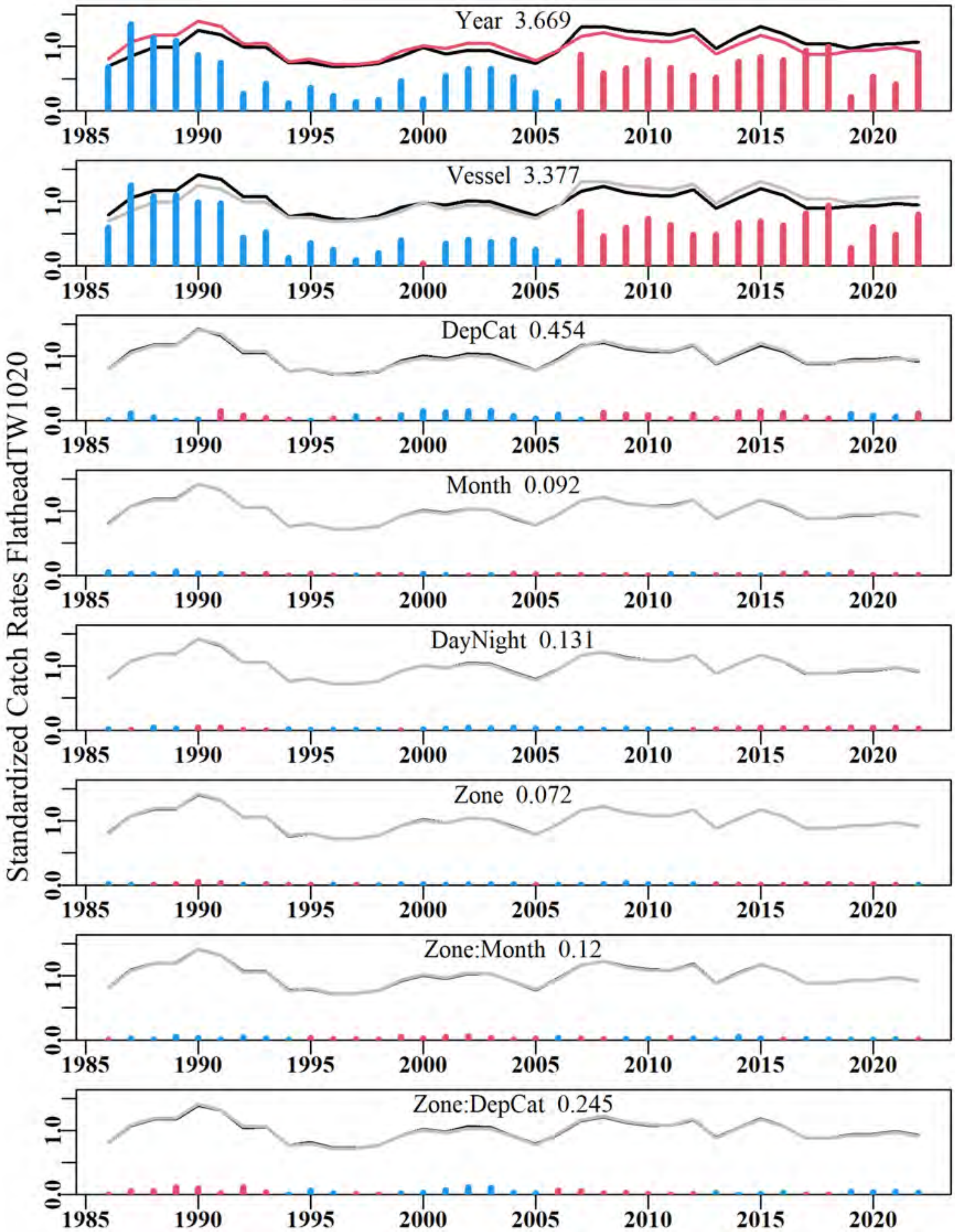

Figure 88: FlatheadTW1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

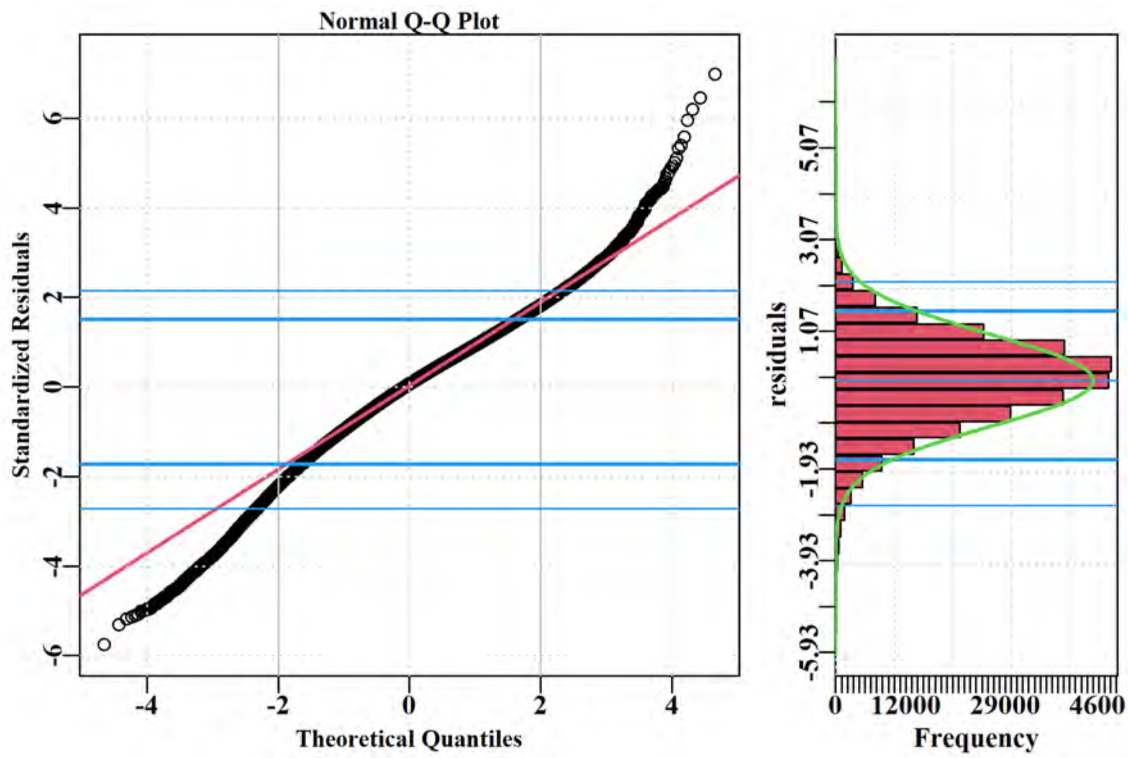

Figure 89: FlatheadTW1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

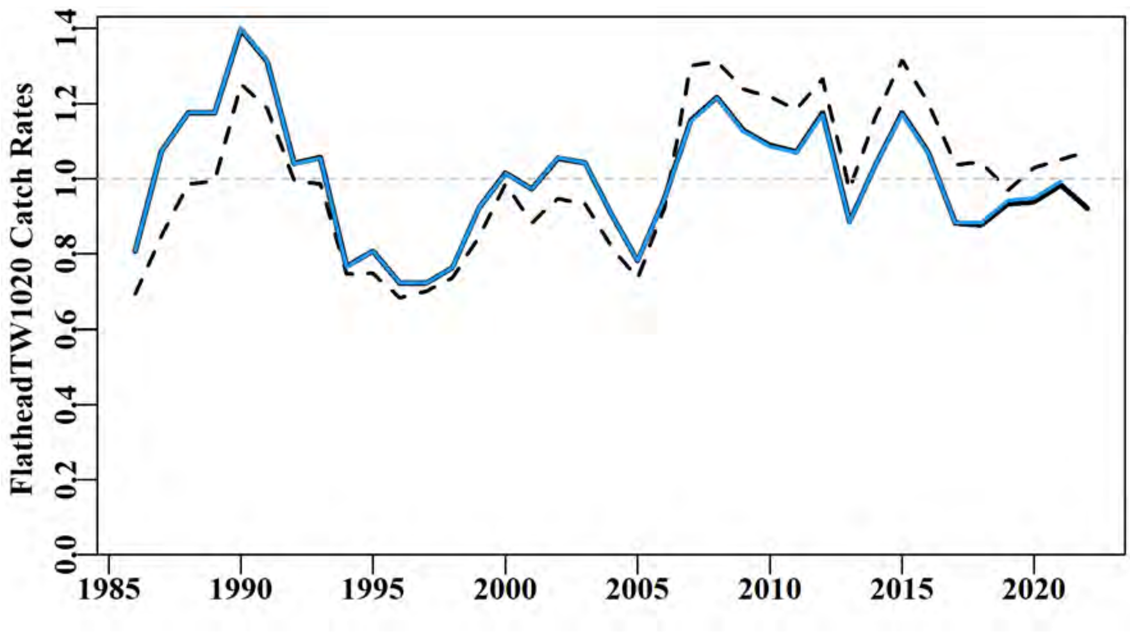

Figure 90: FlatheadTW1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

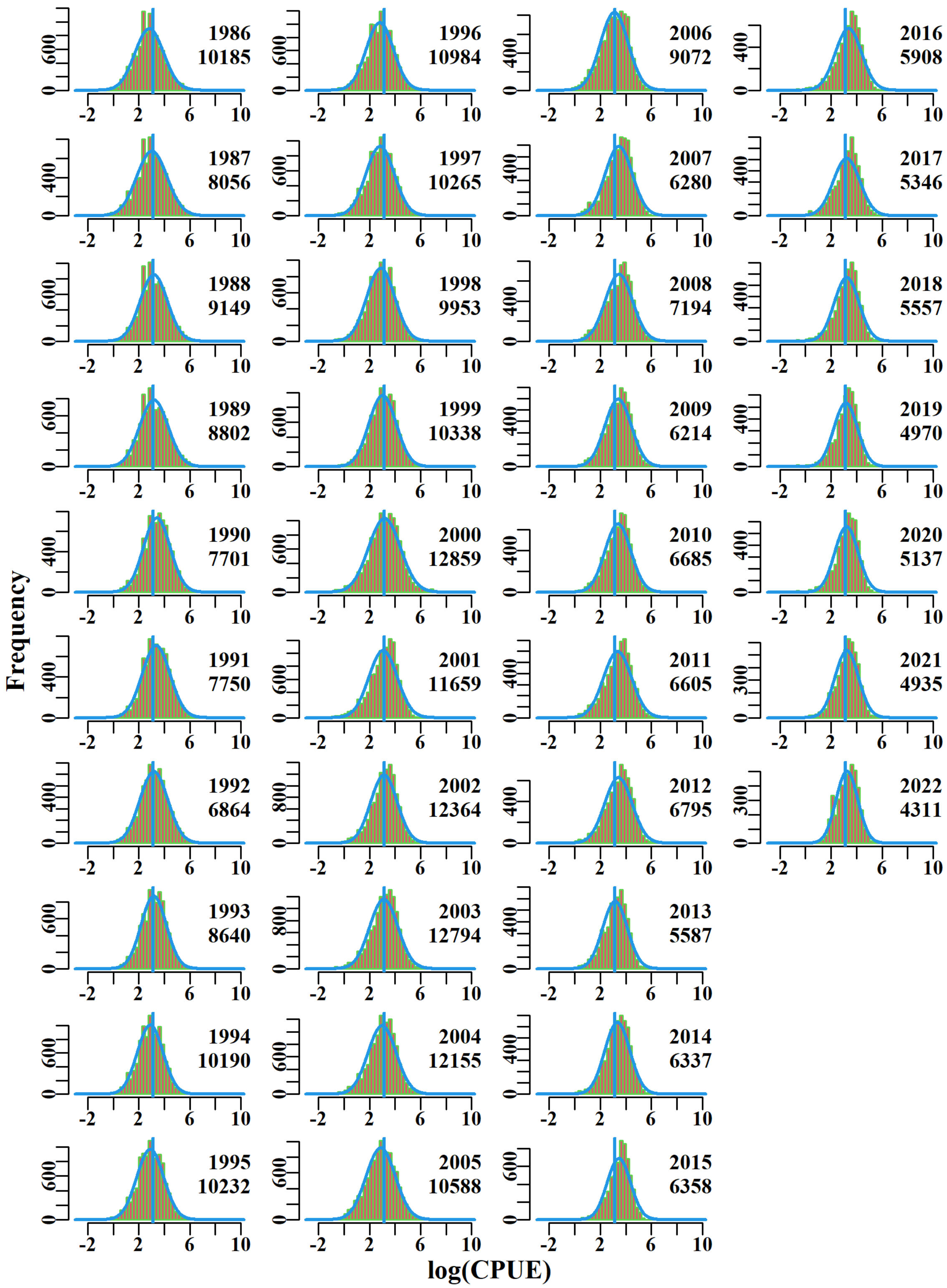

Figure 91: FlatheadTW1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

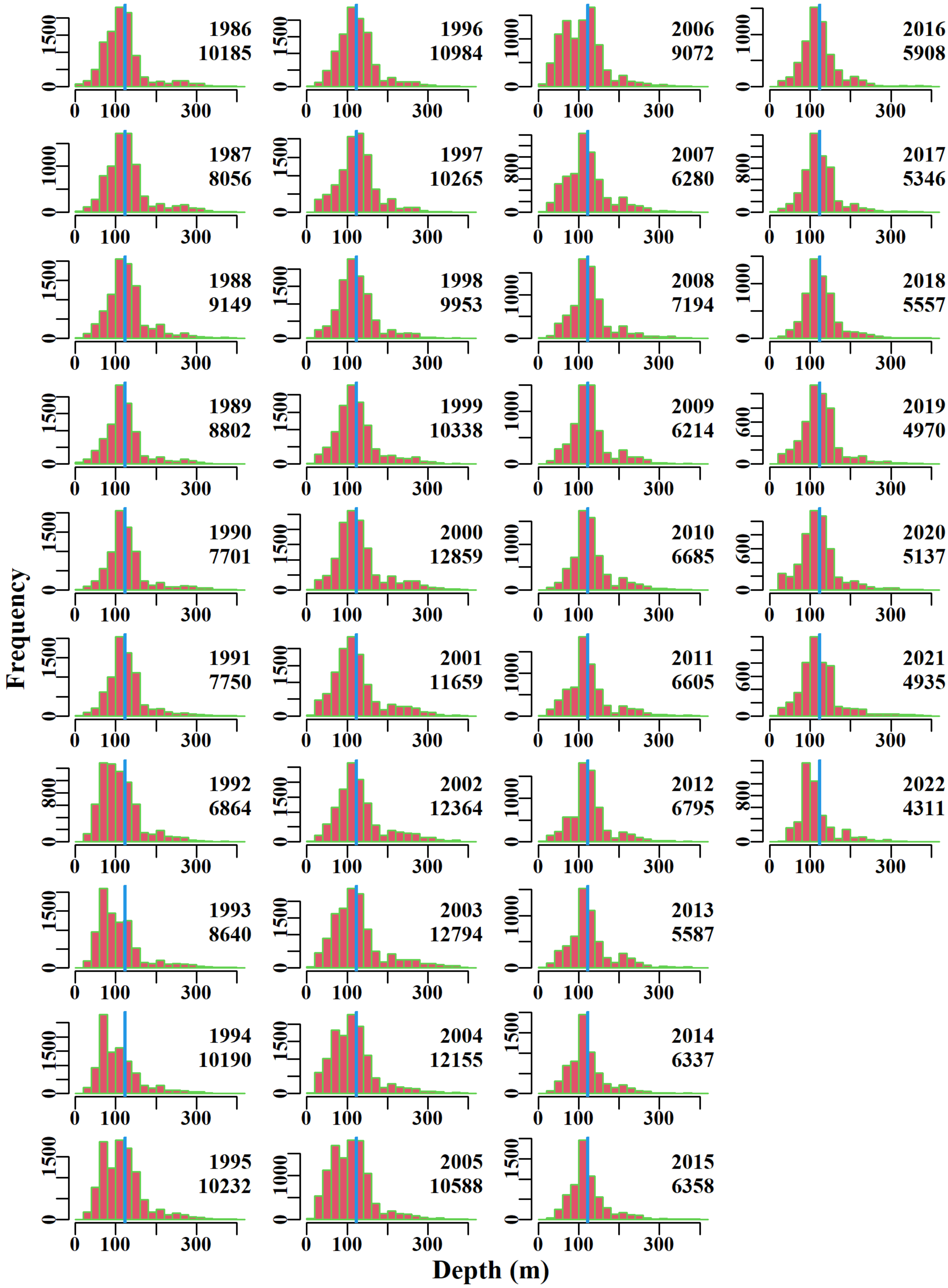

Figure 92: FlatheadTW1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Flathead DS 2060

Tiger Flathead (FLT – 37296001 – *Neoplatycephalus richardsoni*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The additional generic Flathead group code was added as a result of a change in recording Tiger Flathead as 37296000 (Platycephalidae) in electronic logbooks since 2013. Danish seine caught Flathead based on methods DS, SSC, RS, in zones 20, 30, 60, and depths 0 m to 200 m within the SET fishery for the years 1986 - 2022 were analysed (Table 66). The unit of analysis was catch/shot. A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Flathead (*Neoplatycephalus richardsoni* and Platycephalidae) taken by Danish seine are caught in shallower depths in zone 60 compared to zone 20 (Figure 94), with a shift to deeper waters becoming apparent from 1997 onwards which may be related to which vessels were fishing.

The terms Year, DepCat, Month, Vessel, DayNight, Zone and interaction term Zone:Month had the greatest contribution to model fit, based on the AIC and R^2 statistics. The qqplot suggests a departure of the assumed Normal distribution as depicted by the lower tail of the distribution.

Some vessels have remained in this fishery since 1986 with significant catches, while other vessels have left following the structural adjustment in 2007 and not returned. Annual standardized CPUE appears cyclical above and below average and has remained below average over 2012-22, based on 95% confidence intervals (Figure 93). There has also been an overall decrease in standardized CPUE over the 2007-2020 period and significant increases towards the long-term average in the last two years (2021 and 2022) relative to 2020.

Action Items and Issues

It is recommended that an exploration of the fishery dynamics be evaluated to determine whether the CPUE values are being influenced by the species being targeted within individual shots (e.g., is there interference between shots of mostly Flathead compared to shots of mostly School Whiting). This will be important for determining whether estimated annual indices adequately reflect stock abundance.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 66: FlatheadDS2060. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	FlatheadDS2060
csirocode	37296001, 37296000
fishery	SET
depthrange	0 - 200
depthclass	20
zones	20, 30, 60
methods	DS, SSC, RS
years	1986 - 2022

Table 67: FlatheadDS2060. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1892.2	5581	769.2	26	203.5	1.1659	0.000	27.135	0.035
1987	2461.3	5534	1340.9	24	352.5	1.6537	0.024	25.105	0.019
1988	2469.5	5745	1074.7	25	268.3	1.8122	0.024	21.449	0.020
1989	2599.1	5384	1138.0	27	297.1	1.5662	0.024	27.184	0.024
1990	2032.3	4462	568.1	24	157.2	1.0515	0.025	28.665	0.050
1991	2230.2	4463	746.5	28	215.7	1.4294	0.025	24.633	0.033
1992	2375.4	6503	1196.8	23	233.5	1.5273	0.023	27.718	0.023
1993	1879.1	5954	532.9	25	113.2	0.9368	0.024	40.678	0.076
1994	1710.4	7163	633.0	24	124.9	0.8136	0.023	40.569	0.064
1995	1800.6	5420	648.6	21	204.7	0.8337	0.024	24.806	0.038
1996	1879.9	7508	742.7	22	139.0	0.7814	0.023	44.616	0.060
1997	2356.0	8279	1136.0	20	192.2	1.0183	0.023	37.876	0.033
1998	2306.4	9800	1126.5	21	147.9	0.8602	0.022	48.033	0.043
1999	3117.7	8669	1679.4	23	269.0	1.2570	0.022	25.632	0.015
2000	2945.6	7295	1079.7	19	199.3	0.9315	0.023	32.454	0.030
2001	2599.5	7781	1066.4	19	196.4	0.8794	0.023	32.654	0.031
2002	2876.3	8124	1130.0	22	182.0	1.0356	0.023	31.327	0.028
2003	3229.9	8872	1187.0	23	168.5	1.0727	0.023	30.001	0.025
2004	3222.8	7644	1234.5	22	194.6	1.0587	0.023	24.994	0.020
2005	2844.1	7008	1104.9	22	184.3	1.0770	0.024	22.184	0.020
2006	2585.8	5461	950.5	21	233.5	1.0571	0.025	15.784	0.017
2007	2648.3	5493	1165.4	16	293.0	1.2659	0.025	14.912	0.013
2008	2912.3	6161	1268.3	15	279.1	1.1327	0.024	18.287	0.014
2009	2460.5	5434	1153.5	15	318.1	1.1766	0.025	17.949	0.016
2010	2502.3	5997	1159.0	15	274.1	1.0684	0.025	15.542	0.013
2011	2465.9	6798	1113.5	14	209.0	0.9909	0.024	20.671	0.019
2012	2780.6	7158	1372.2	14	299.5	0.9439	0.024	19.403	0.014
2013	1941.0	7307	961.1	14	171.0	0.6710	0.024	31.201	0.032
2014	2369.9	8375	1170.8	14	187.0	0.7309	0.023	32.867	0.028
2015	2667.9	8618	1311.2	15	196.1	0.7224	0.023	39.398	0.030
2016	2775.6	9257	1468.4	16	205.5	0.7533	0.023	40.877	0.028
2017	2311.7	8936	1233.8	18	175.1	0.7264	0.023	43.103	0.035
2018	2000.8	8510	947.2	19	137.2	0.5184	0.023	46.367	0.049
2019	1938.1	8900	950.8	19	133.1	0.4823	0.023	47.063	0.050
2020	1990.2	10333	952.9	19	118.6	0.4527	0.023	55.303	0.058
2021	2071.0	7765	1100.1	19	180.2	0.6457	0.024	35.770	0.033
2022	1821.9	7613	1023.7	18	166.0	0.8991	0.024	37.401	0.037

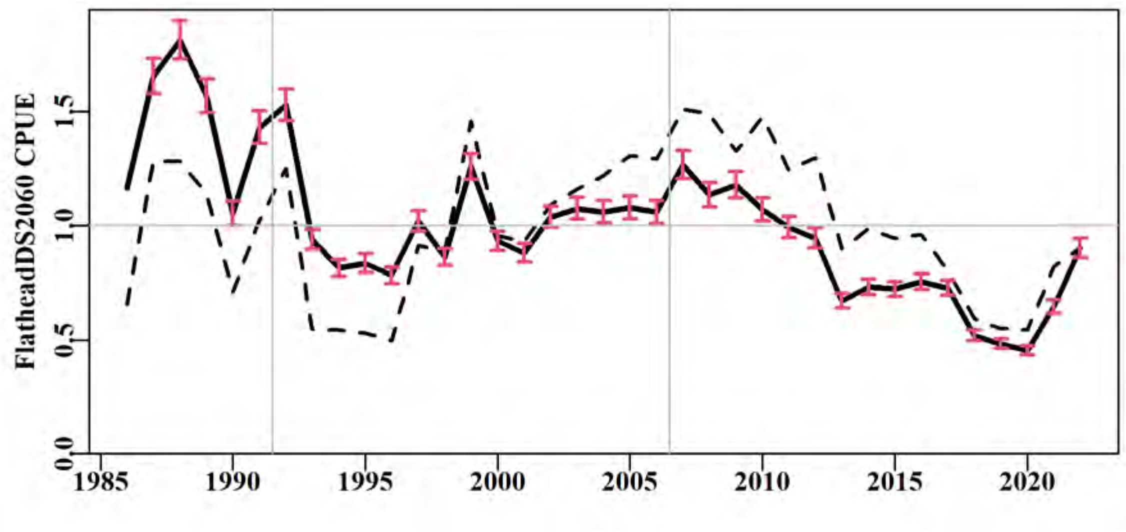

Figure 93: FlatheadDS2060 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

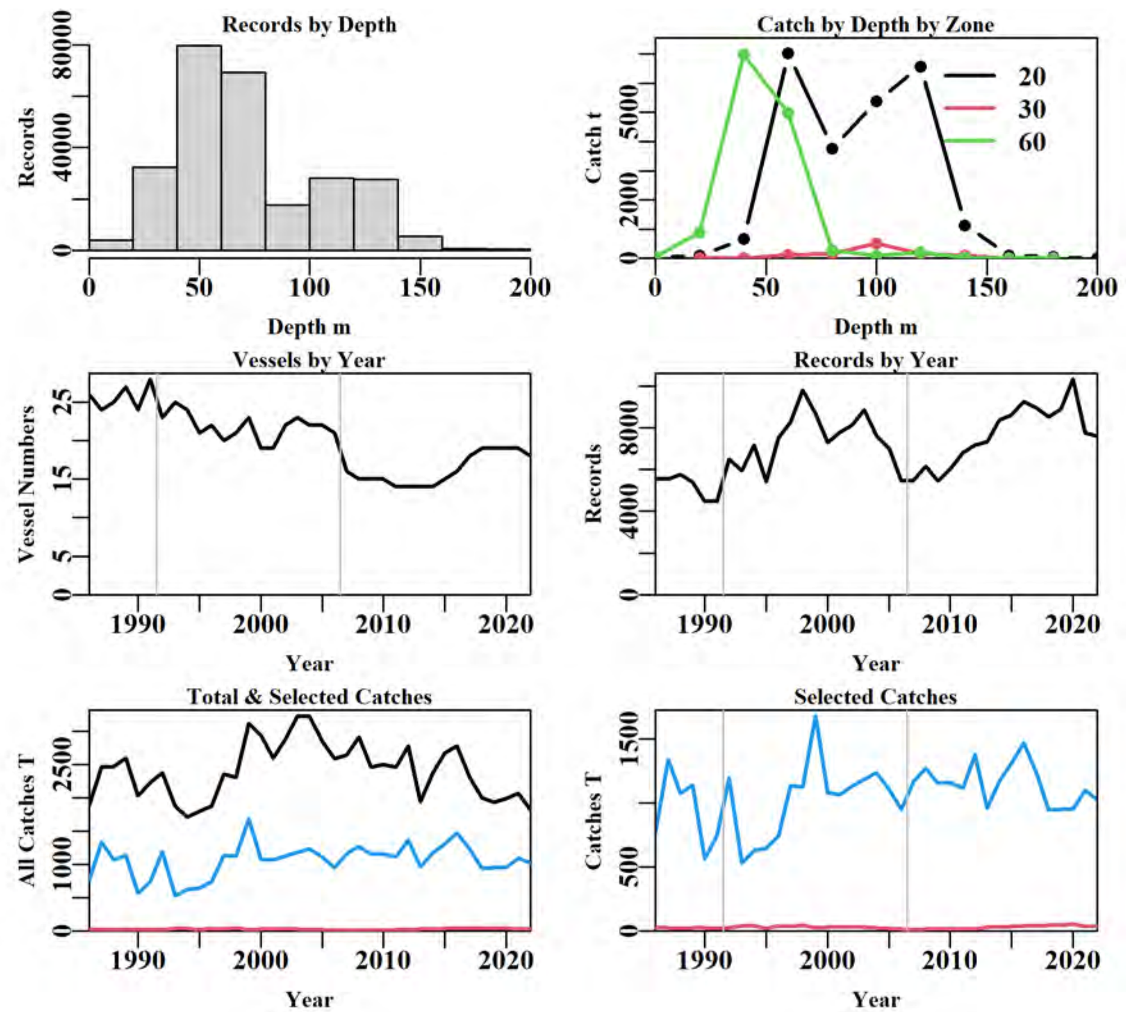

Figure 94: FlatheadDS2060 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 68: FlatheadDS2060 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	697816	679375	633991	625876	440333	267168	265305
Difference	0	18441	45384	8115	185543	173165	1863
Catch	90063	90063	85187	84222	67282	39507	39439
Difference	0	0	4876	966	16940	27775	68

Table 69: The models used to analyse data for FlatheadDS2060.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Month
Model4	Year + DepCat + Month + Vessel
Model5	Year + DepCat + Month + Vessel + DayNight
Model6	Year + DepCat + Month + Vessel + DayNight + Zone
Model7	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:Month
Model8	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:DepCat

Table 70: FlatheadDS2060. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	207960	580827	29309	265305	37	4.8	0.00
DepCat	136826	444191	165944	265305	47	27.2	22.39
Month	124225	423553	186583	265305	58	30.6	3.38
Vessel	109295	400201	209935	265305	116	34.4	3.81
DayNight	104484	392999	217136	265305	119	35.6	1.18
Zone	101365	388401	221735	265305	121	36.3	0.75
Zone:Month	97015	382021	228115	265305	143	37.4	1.04
Zone:DepCat	100701	387384	222752	265305	137	36.5	0.16

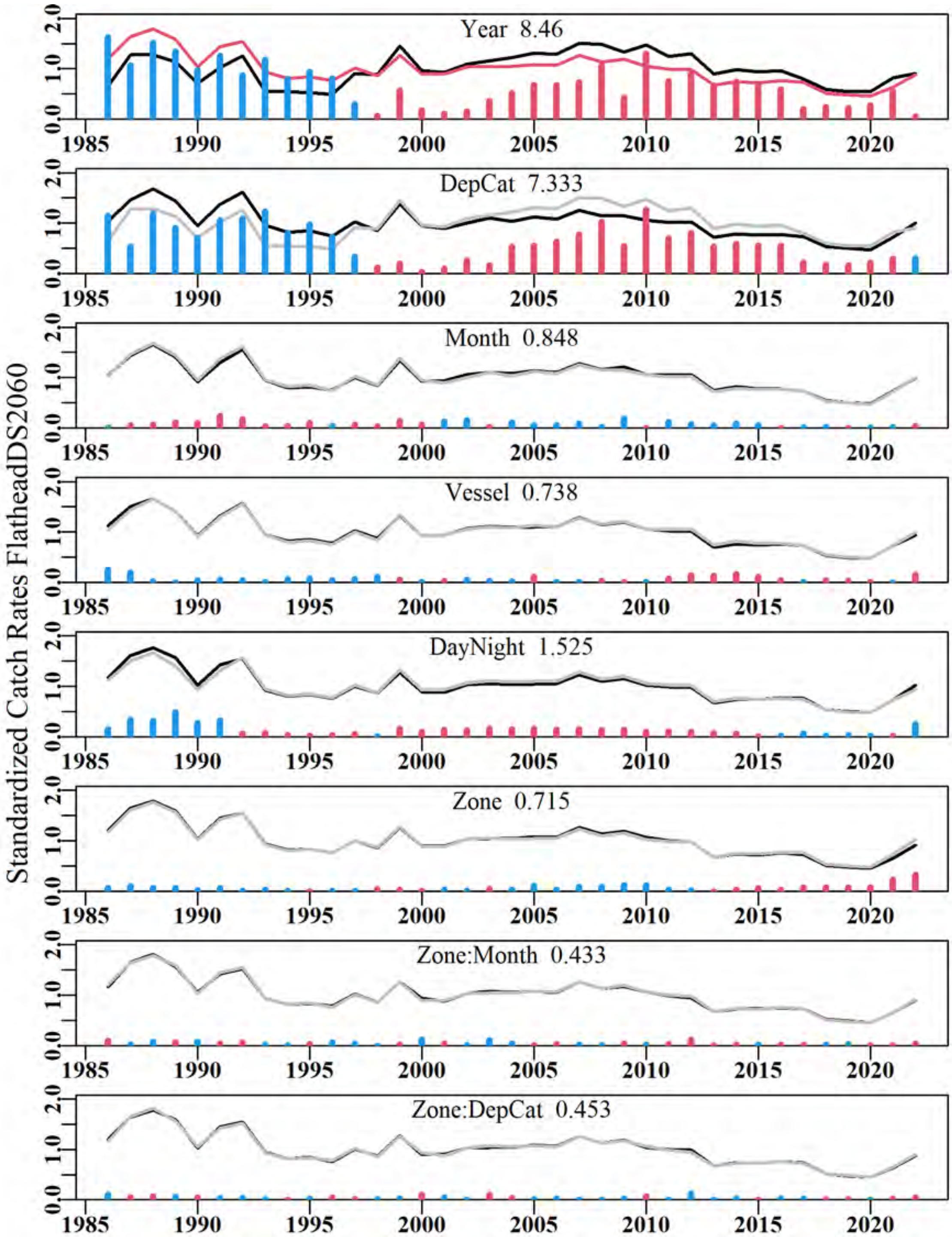

Figure 95: FlatheadDS2060. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

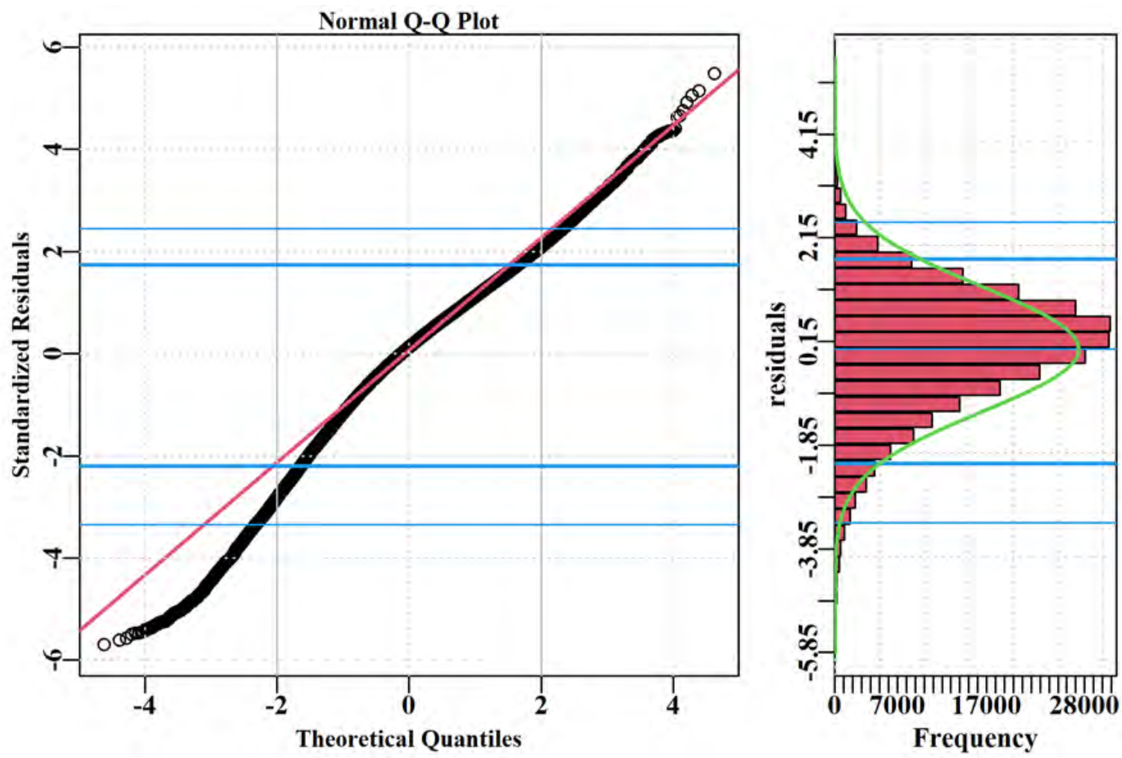

Figure 96: FlatheadDS2060. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

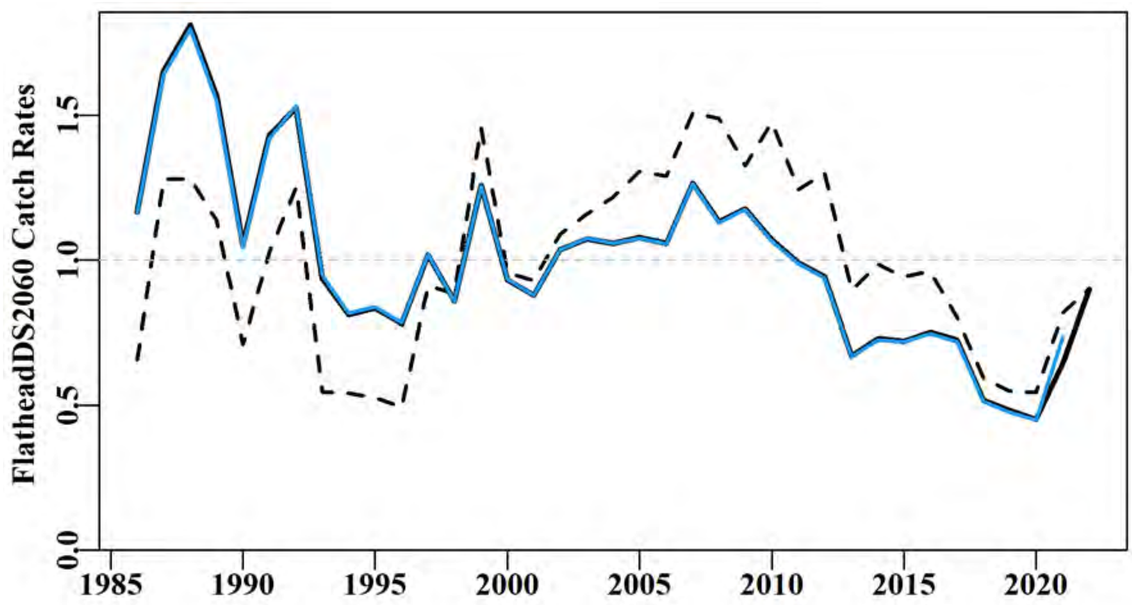

Figure 97: FlatheadDS2060. A comparison of the previous years’ standardization (blue line) with this years’ (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

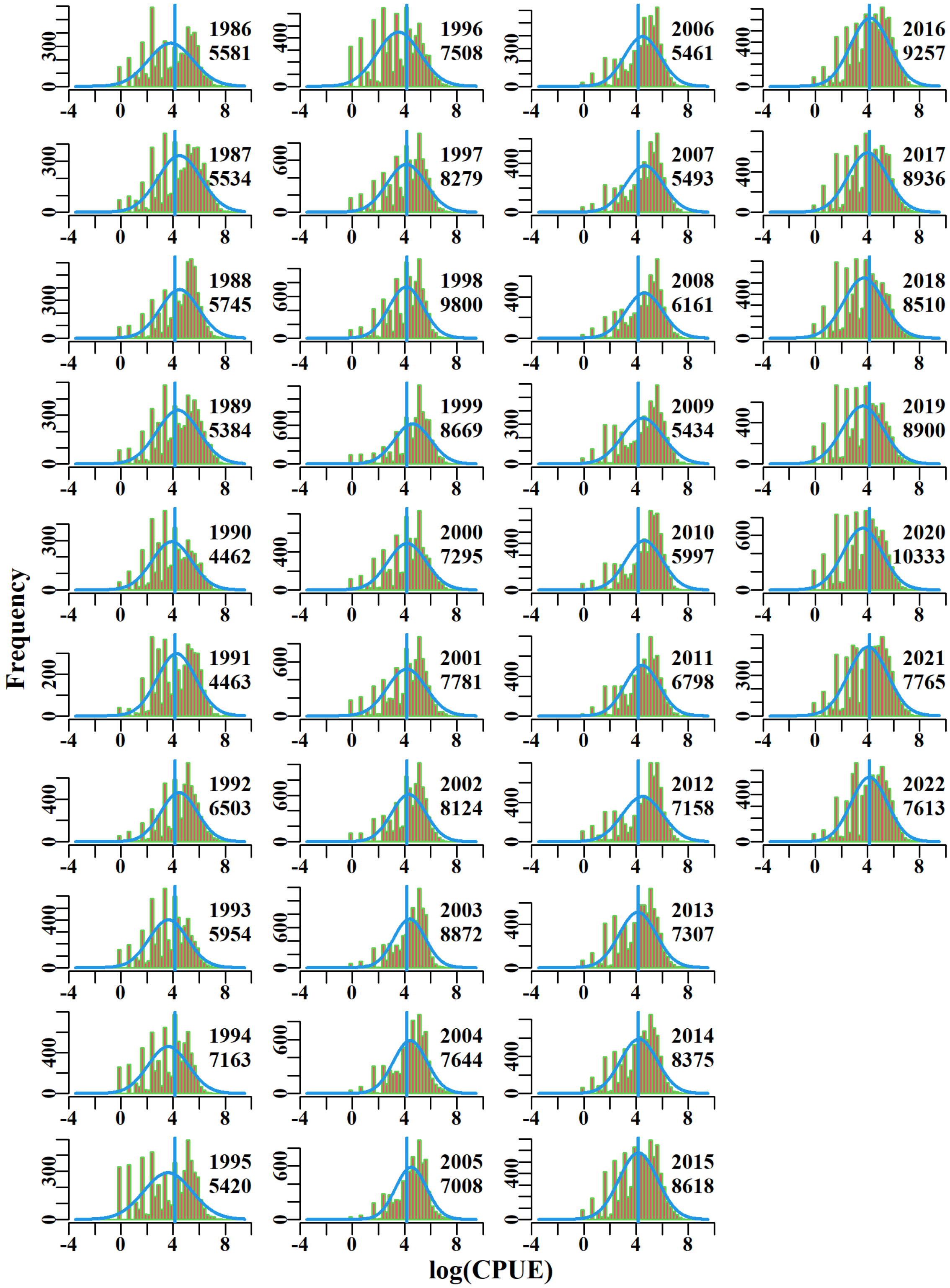

Figure 98: FlatheadDS2060. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

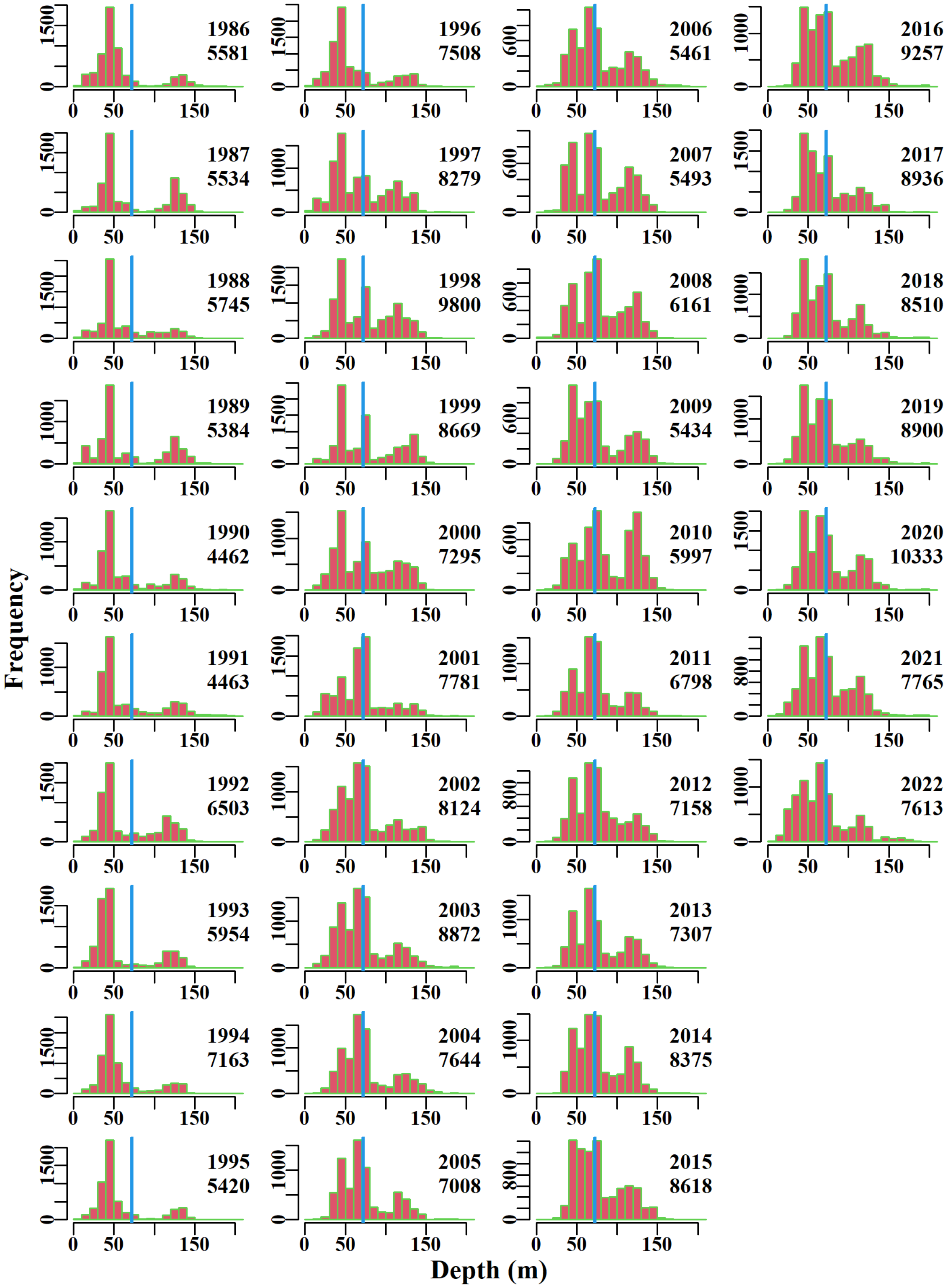

Figure 99: FlatheadDS2060. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Redfish 10 - 20

Redfish (RED – 37258003 – *Centroberyx affinis*) was one of the 16 species first included in the quota system in 1992. Redfish caught by trawl based on methods TW, TDO, OTB, in zones 10, 20, and depths 0 to 400 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 71). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Most trawl caught Redfish has occurred in zone 10 across the analysis period. The total annual Redfish catch from zones 10, 20 in 2022 (9.3 t) employed in the analysis was the lowest recorded in the series (i.e., between 1986 - 2022). Large scale changes in CPUE prior to 1995 have occurred in zones 10 and 20.

The terms Year, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 75). The qqplot suggests that the assumed Normal distribution is valid (Figure 103).

Annual standardized CPUE has declined since 1994 (relative to the previous year) and has been below average since 2000 (Figure 100). There have been minimal increases in three of the last four years.

Action Items and Issues

After consideration of Redfish catches in zones 10 and 20 by year and vessel, the period around 1993 - 2006 appears to be different from the catches by vessel from 2007. This suggests that there have been transitional periods in the time-series of CPUE. This needs more attention because of the potential implications this has for the index of relative abundance through time.

Table 71: Redfish1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	Redfish1020
csirocode	37258003
fishery	SET
depthrange	0 - 400
depthclass	25
zones	10, 20
methods	TW, TDO, OTB
years	1986 - 2022

Table 72: Redfish1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1687.5	5336	1598.0	87	119.3	2.0525	0.000	23.159	0.014
1987	1252.7	3903	1181.8	79	121.1	1.7670	0.034	17.828	0.015
1988	1125.5	3966	1078.0	75	95.2	1.9862	0.034	17.697	0.016
1989	714.3	2710	641.2	72	80.1	1.4643	0.038	15.566	0.024
1990	931.4	2573	785.7	58	104.9	1.8505	0.039	11.772	0.015
1991	1570.6	3330	1231.1	52	140.8	2.0454	0.037	14.904	0.012
1992	1636.7	3174	1514.1	48	198.7	2.5818	0.038	14.286	0.009
1993	1921.3	3755	1754.8	53	205.4	3.0933	0.036	16.091	0.009
1994	1487.7	5439	1329.1	53	111.4	2.2770	0.033	28.214	0.021
1995	1240.6	5675	1188.8	52	82.3	1.4766	0.033	34.359	0.029
1996	1344.0	5775	1297.5	55	90.4	1.3393	0.033	33.779	0.026
1997	1397.3	4363	1340.7	58	138.4	1.4057	0.035	25.498	0.019
1998	1553.7	4296	1526.0	49	187.0	1.6524	0.035	23.599	0.015
1999	1116.5	3934	1089.3	53	145.2	1.3798	0.036	21.181	0.019
2000	758.5	4661	734.3	53	80.4	0.9273	0.035	28.968	0.039
2001	742.3	4559	718.3	47	75.8	0.8841	0.035	29.022	0.040
2002	807.1	5188	770.8	49	69.5	0.8265	0.034	32.706	0.042
2003	615.6	4096	553.9	51	62.6	0.7082	0.036	27.500	0.050
2004	475.2	3951	447.7	50	52.0	0.6284	0.036	27.007	0.060
2005	483.5	3768	451.1	46	47.4	0.6959	0.037	26.639	0.059
2006	325.5	2573	302.3	42	46.5	0.6480	0.040	19.702	0.065
2007	216.3	1870	208.1	23	46.8	0.6439	0.045	13.417	0.064
2008	183.8	1921	179.3	25	35.3	0.5649	0.045	15.431	0.086
2009	160.5	1602	153.6	23	33.5	0.4808	0.047	12.758	0.083
2010	152.8	1838	146.2	24	28.9	0.4710	0.045	15.962	0.109
2011	87.3	1397	82.8	22	21.8	0.3453	0.049	10.828	0.131
2012	66.4	1345	61.9	21	18.2	0.2423	0.050	11.194	0.181
2013	62.7	1129	60.3	20	20.1	0.3037	0.053	9.787	0.162
2014	86.9	1411	82.6	22	25.9	0.4009	0.049	11.904	0.144
2015	52.2	1192	50.0	22	17.5	0.2477	0.052	10.106	0.202
2016	38.4	959	35.8	21	15.3	0.2047	0.057	7.646	0.214
2017	25.4	606	22.0	18	16.6	0.2015	0.068	5.182	0.235
2018	29.9	740	27.4	17	13.8	0.1833	0.064	5.389	0.197
2019	26.7	576	20.2	16	14.0	0.2213	0.070	5.038	0.250
2020	47.1	560	21.1	15	14.9	0.2524	0.072	5.096	0.242
2021	48.8	572	23.4	15	17.0	0.2866	0.072	5.812	0.248
2022	15.3	339	9.3	13	11.4	0.2595	0.090	5.042	0.540

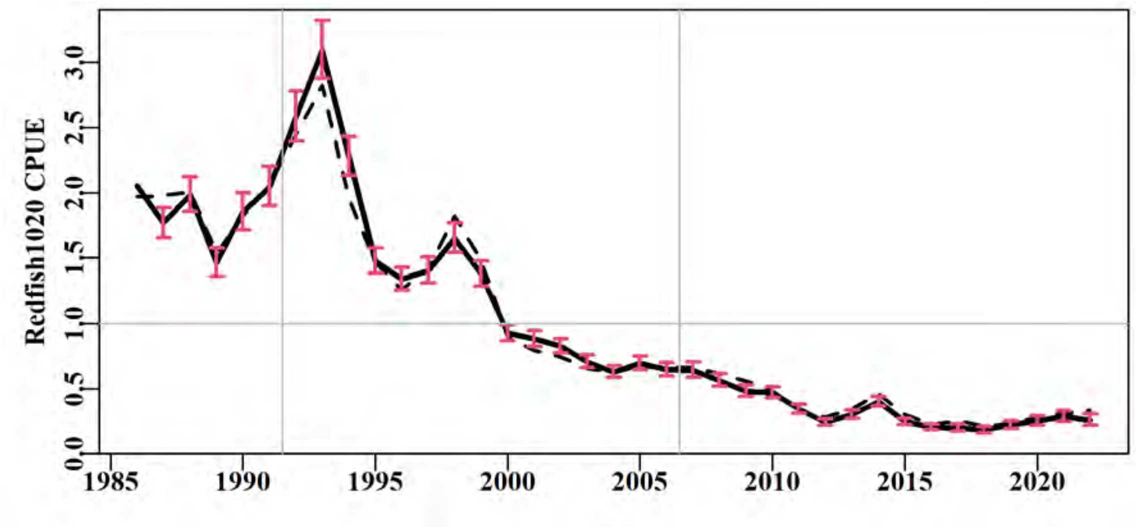

Figure 100: Redfish1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

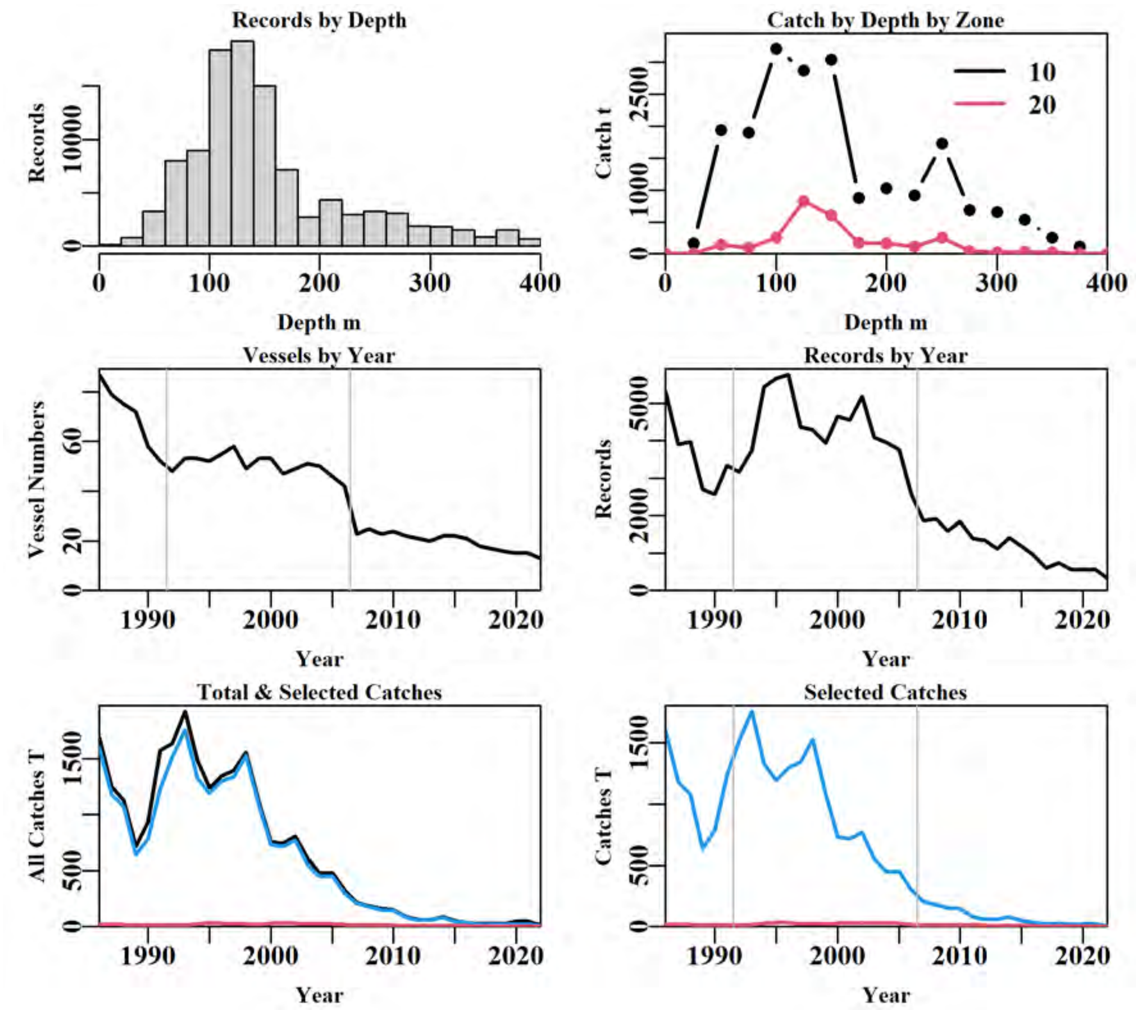

Figure 101: Redfish1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 73: Redfish1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	123812	117773	114428	113471	106234	105145	105082
Difference	0	6039	3345	957	7237	1089	63
Catch	24638	24140	23738	23597	22877	22721	22718
Difference	0	498	402	141	720	156	2

Table 74: The models used to analyse data for Redfish1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Zone
Model5	Year + Vessel + DepCat + Zone + DayNight
Model6	Year + Vessel + DepCat + Zone + DayNight + Month
Model7	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:Month
Model8	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:DepCat

Table 75: Redfish1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	113617	309594	43430	105082	37	12.3	0.00
Vessel	95251	259158	93866	105082	197	26.5	14.18
DepCat	89987	246420	106604	105082	213	30.1	3.60
Zone	88629	243252	109773	105082	214	31.0	0.90
DayNight	87976	241730	111294	105082	217	31.4	0.43
Month	87608	240836	112188	105082	228	31.6	0.25
Zone:Month	87478	240486	112538	105082	239	31.7	0.09
Zone:DepCat	87203	239835	113190	105082	244	31.9	0.27

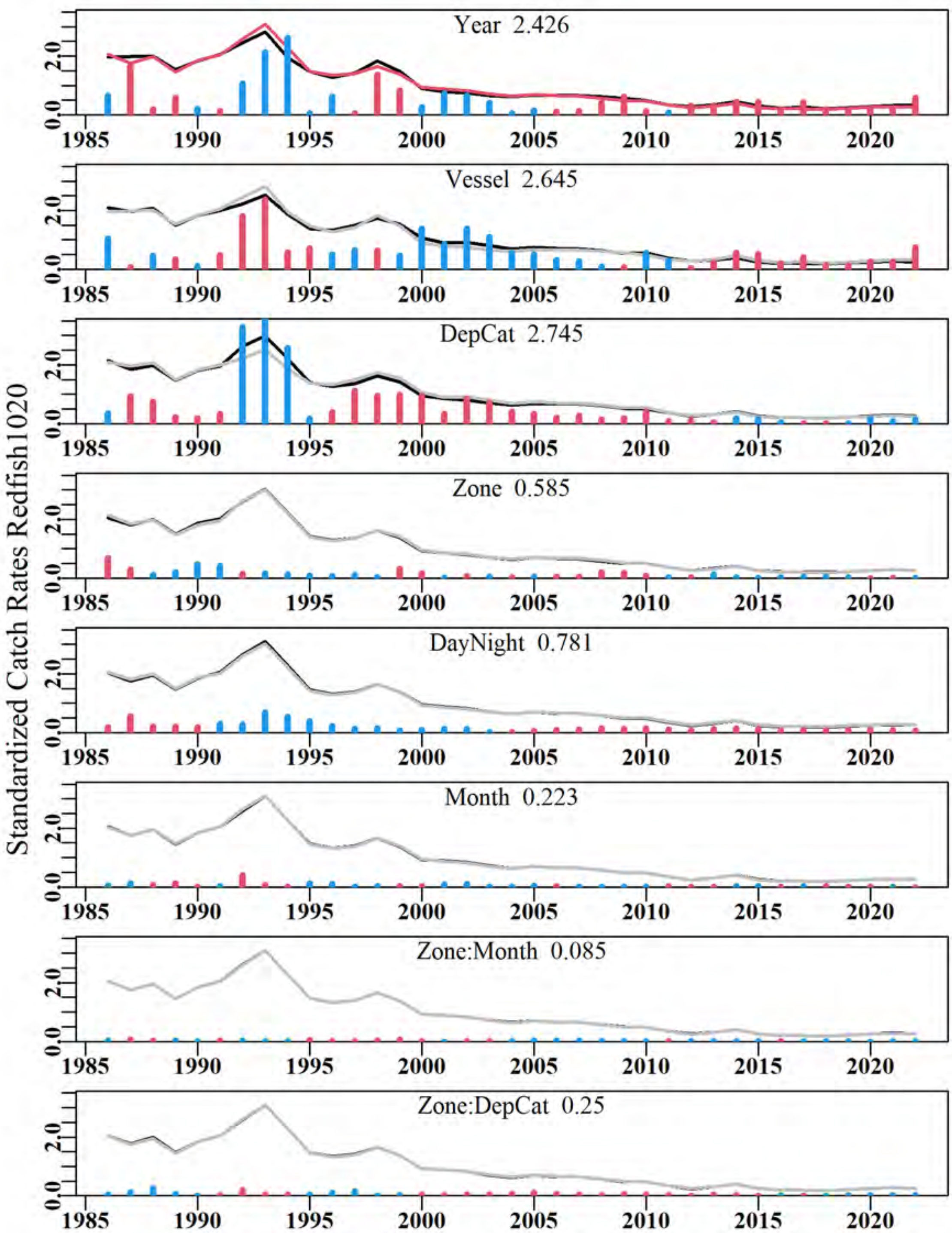

Figure 102: Redfish1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

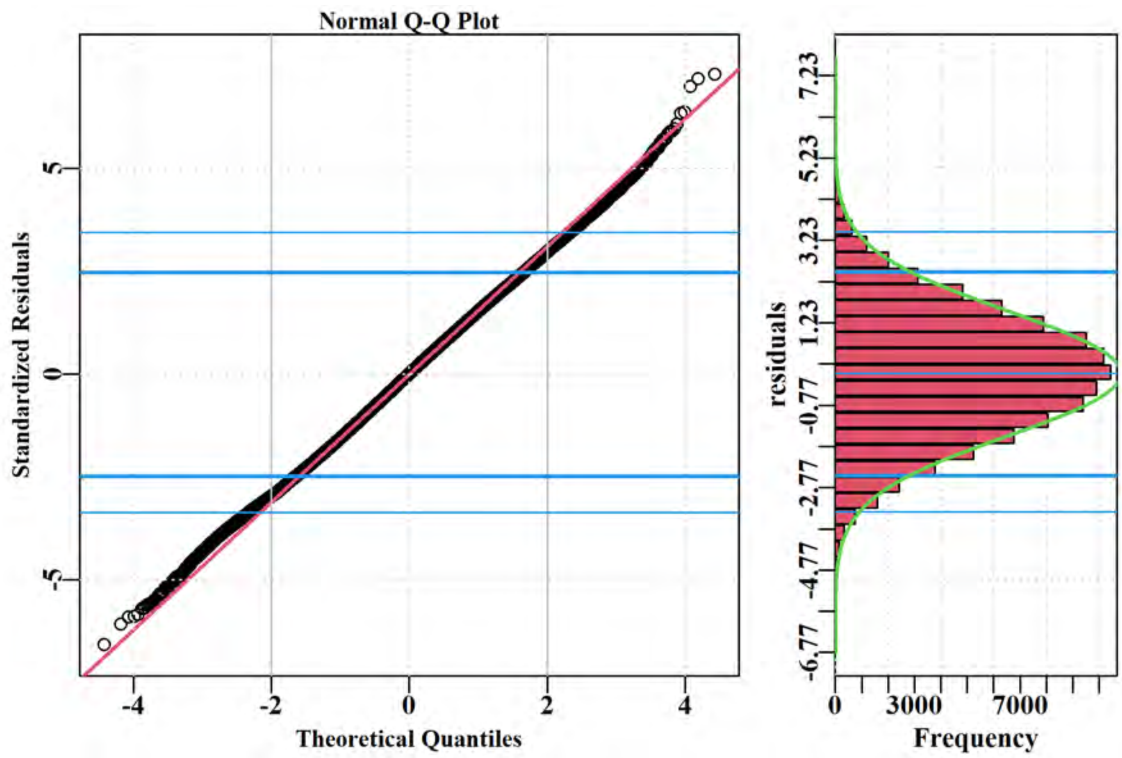

Figure 103: Redfish1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

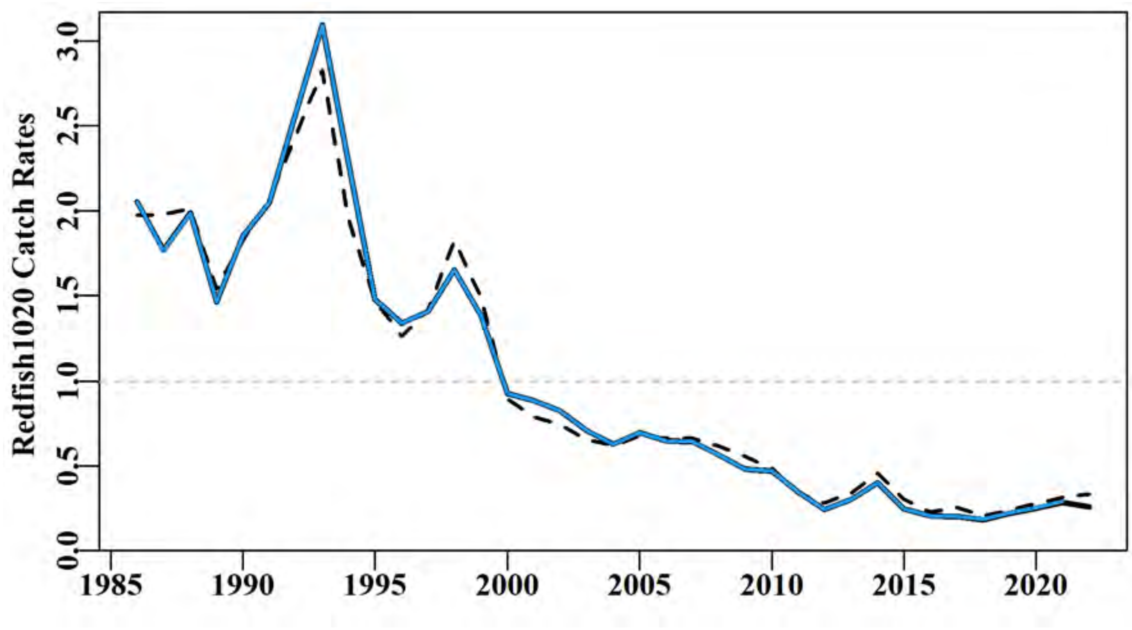

Figure 104: Redfish1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

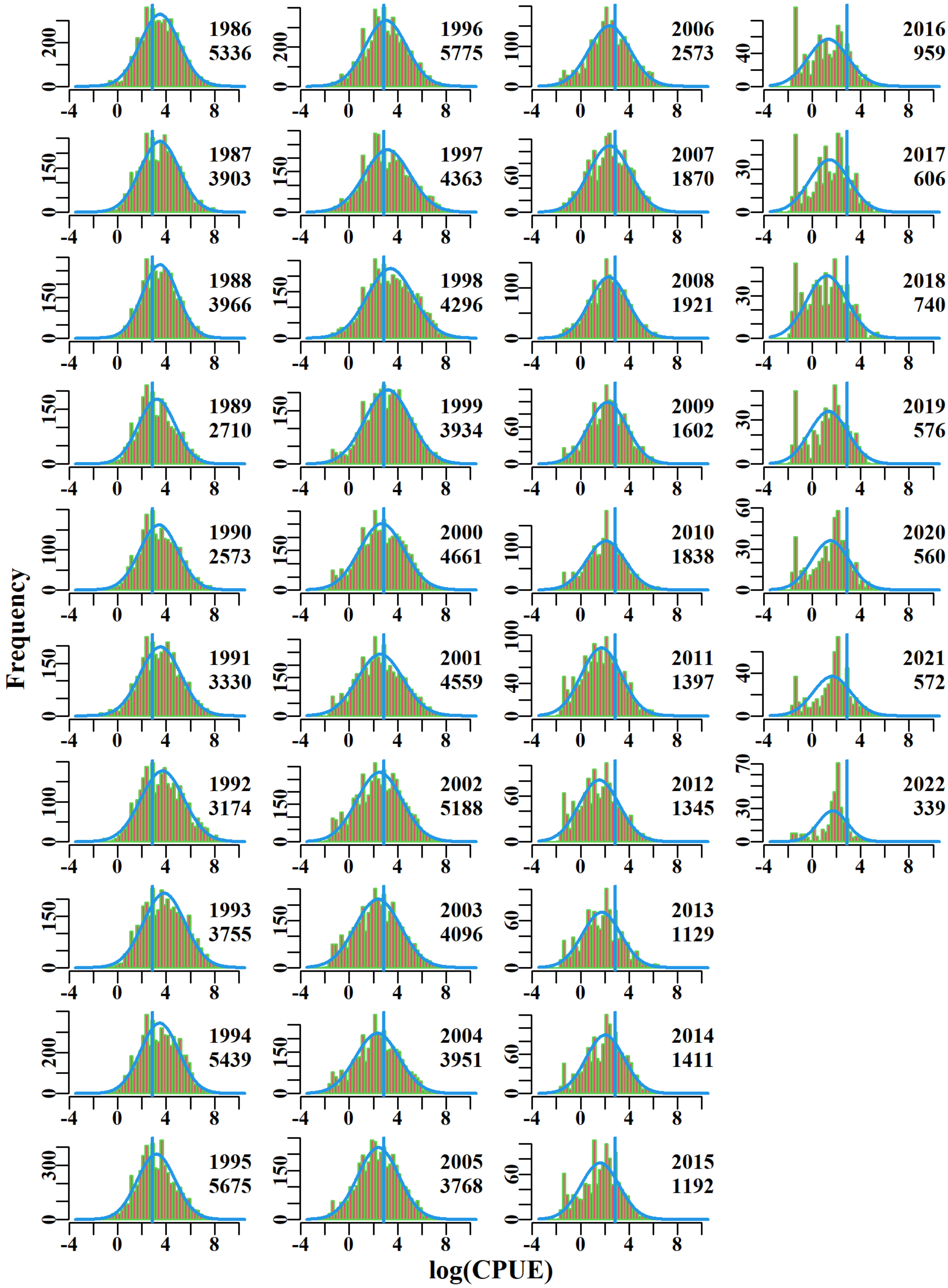

Figure 105: Redfish1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

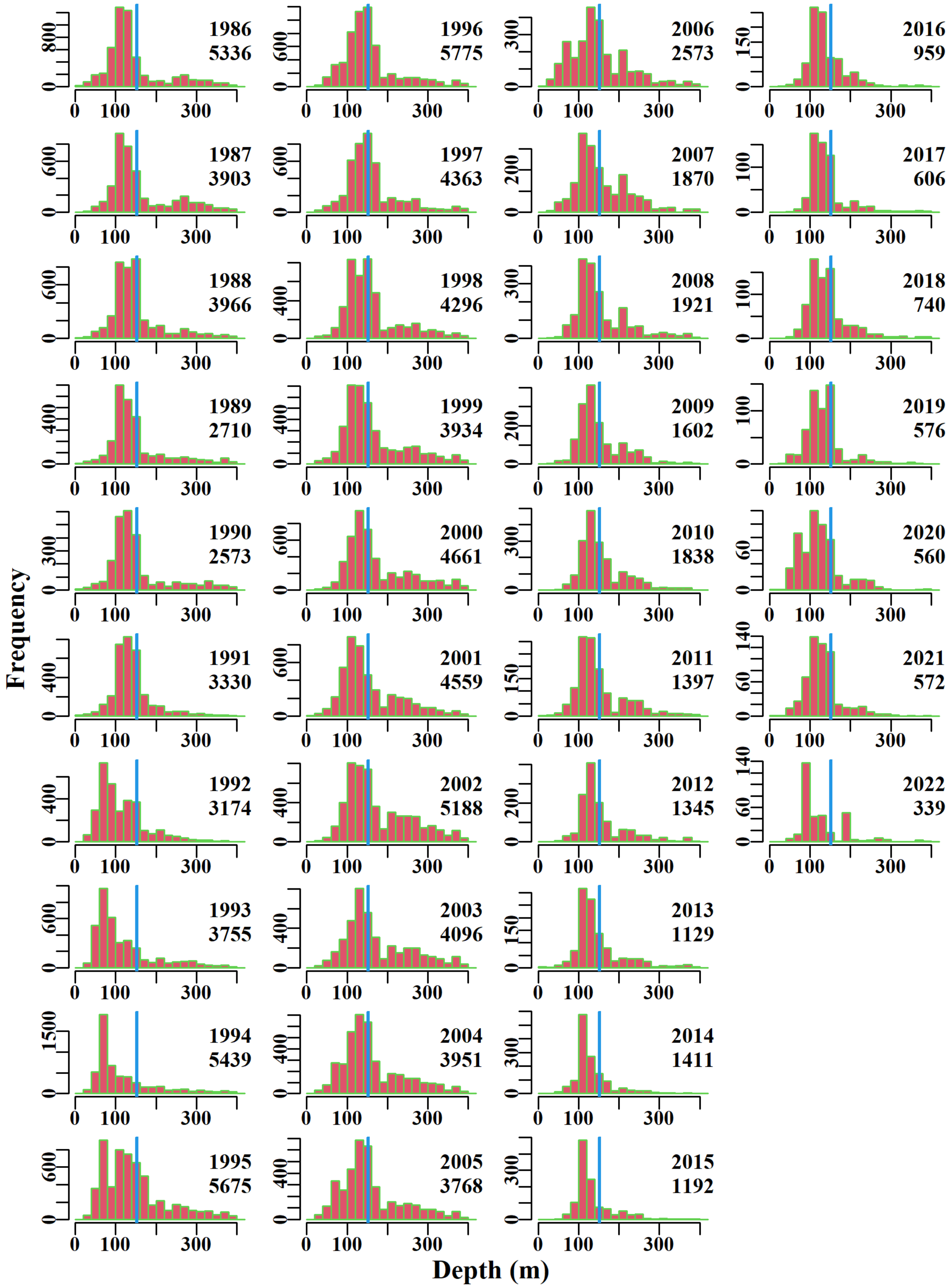

Figure 106: Redfish1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Blue-Eye Trevalla TW 2030

Blue-Eye Trevalla (TBE – 37445001 – *Hyperoglyphe antarctica*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. Trawl caught Blue-Eye Trevalla based on methods TW, TDO, OTB, OTT, in zones 20, 30, and depths 0 to 1000 m within the SET fishery for the years 1986 - 2022 were used in the analysis. Recently, Ocean Blue-Eye Trevalla (37445014 - *Schedophilus labyrinthicus*) was also included in this analysis. These constitute the criteria used to select data from the Commonwealth logbook database (Table 76). Standardized CPUE based on line caught Blue-Eye Trevalla can be found in Sporcic (2023a, b).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Catches appear to change relative to availability rather than the influence of the fishery on the stock. Over the period when CPUE was lower than average (about 1996 - 2006) there was an increase in small shots of < 30 kg (Figure 108), which is suggestive of either low availability or high levels of small fish.

The terms Year, Vessel and Zone had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 80). The qqplot suggests a departure from the assumed Normal distribution as depicted by the tails of the distribution (Figure 110).

Annual standardized CPUE has been below average since about 1996 and shows a relatively flat trend (Figure 107).

Action Items and Issues

Given the ongoing low catches (with the lowest in the series in 2012 and 2020), the major changes in the fleet contributing to the fishery, the dramatically changing character of the CPUE data itself, and the recent disjunction between nominal CPUE and the standardized CPUE it is questionable whether this time-series of standardized CPUE is indicative in any useful way of the relative abundance of Blue-Eye Trevalla. Whether this analysis should be continued should be considered.

Table 76: BlueEyeTW2030. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	BlueEyeTW2030
csirocode	37445001, 37445014
fishery	SET
depthrange	0 - 1000
depthclass	50
zones	20, 30
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 77: BlueEyeTW2030. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	38.0	166	9.1	17	21.9	2.5808	0.000	1.453	0.159
1987	15.5	189	10.0	14	17.6	2.4280	0.137	1.769	0.177
1988	105.2	305	19.3	21	22.7	3.0128	0.130	3.404	0.176
1989	88.1	313	33.3	32	38.2	3.3496	0.133	2.849	0.086
1990	79.3	263	39.8	36	89.5	4.4272	0.135	1.574	0.040
1991	76.0	473	29.2	37	20.9	2.2979	0.127	5.507	0.189
1992	49.3	310	13.8	23	16.5	1.7195	0.134	3.321	0.241
1993	59.7	725	37.4	31	19.7	1.4120	0.124	7.126	0.190
1994	110.0	853	89.0	33	41.6	1.5973	0.124	7.877	0.089
1995	58.6	485	28.2	29	17.4	1.0728	0.128	6.015	0.213
1996	71.7	643	35.3	29	16.4	0.8733	0.126	6.625	0.188
1997	471.5	602	19.9	31	10.7	0.8018	0.128	6.481	0.326
1998	476.0	471	18.7	24	11.3	0.9342	0.130	5.166	0.277
1999	575.0	631	41.7	27	9.2	0.9550	0.127	6.515	0.156
2000	671.4	656	35.7	35	7.6	0.5941	0.125	5.636	0.158
2001	648.3	699	25.2	24	4.6	0.5174	0.125	6.042	0.240
2002	843.9	701	33.7	28	12.0	0.5096	0.127	5.847	0.173
2003	605.3	720	13.6	25	6.1	0.5076	0.127	5.452	0.401
2004	612.3	622	15.2	28	11.6	0.4996	0.128	4.486	0.296
2005	755.2	486	17.4	26	16.5	0.5075	0.131	3.086	0.178
2006	573.7	326	36.8	17	67.9	0.6234	0.136	2.087	0.057
2007	937.1	246	10.6	11	9.7	0.5173	0.141	1.652	0.156
2008	398.9	429	13.4	15	26.3	0.4807	0.135	2.720	0.203
2009	521.0	240	22.8	14	90.1	0.4547	0.142	1.294	0.057
2010	437.4	190	10.7	13	32.3	0.3152	0.148	0.979	0.091
2011	554.2	214	7.2	12	12.7	0.3248	0.145	1.192	0.166
2012	463.8	149	1.3	11	2.7	0.3005	0.154	0.924	0.694
2013	398.4	146	4.1	11	25.9	0.2609	0.156	0.921	0.224
2014	460.5	120	20.6	11	337.4	0.3490	0.162	0.554	0.027
2015	305.4	185	22.1	14	368.3	0.3421	0.151	0.833	0.038
2016	332.7	140	9.5	12	83.4	0.2864	0.157	0.775	0.082
2017	385.3	187	34.4	11	592.4	0.3928	0.150	0.840	0.024
2018	345.9	189	33.8	10	573.3	0.4065	0.150	0.703	0.021
2019	303.7	111	9.6	13	74.1	0.3181	0.168	0.567	0.059
2020	236.1	96	2.1	12	9.0	0.3346	0.172	0.647	0.304
2021	218.7	109	5.0	10	48.3	0.3167	0.167	0.758	0.153
2022	269.0	46	8.5	6	52.0	0.3782	0.212	0.295	0.035

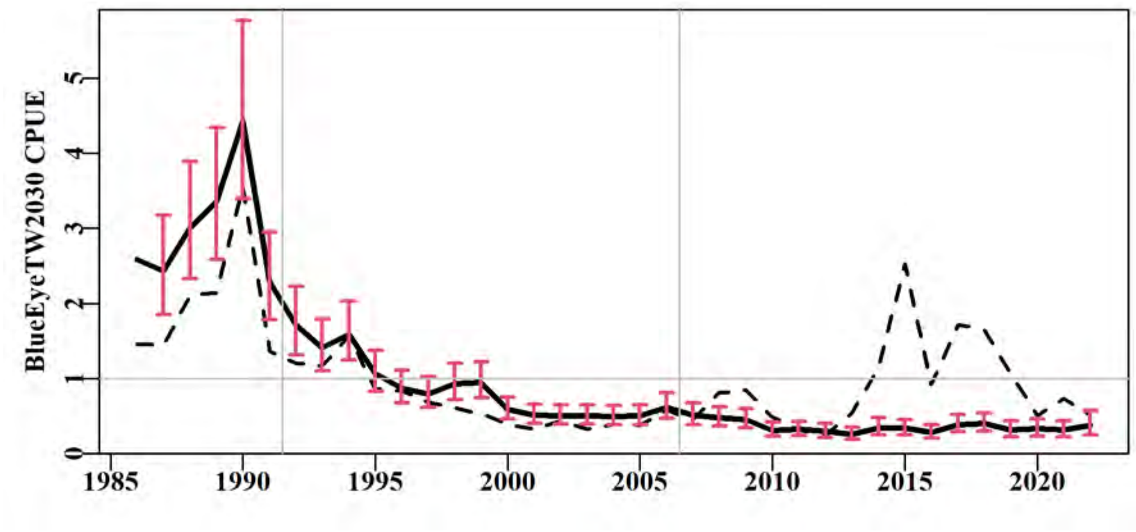

Figure 107: BlueEyeTW2030 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

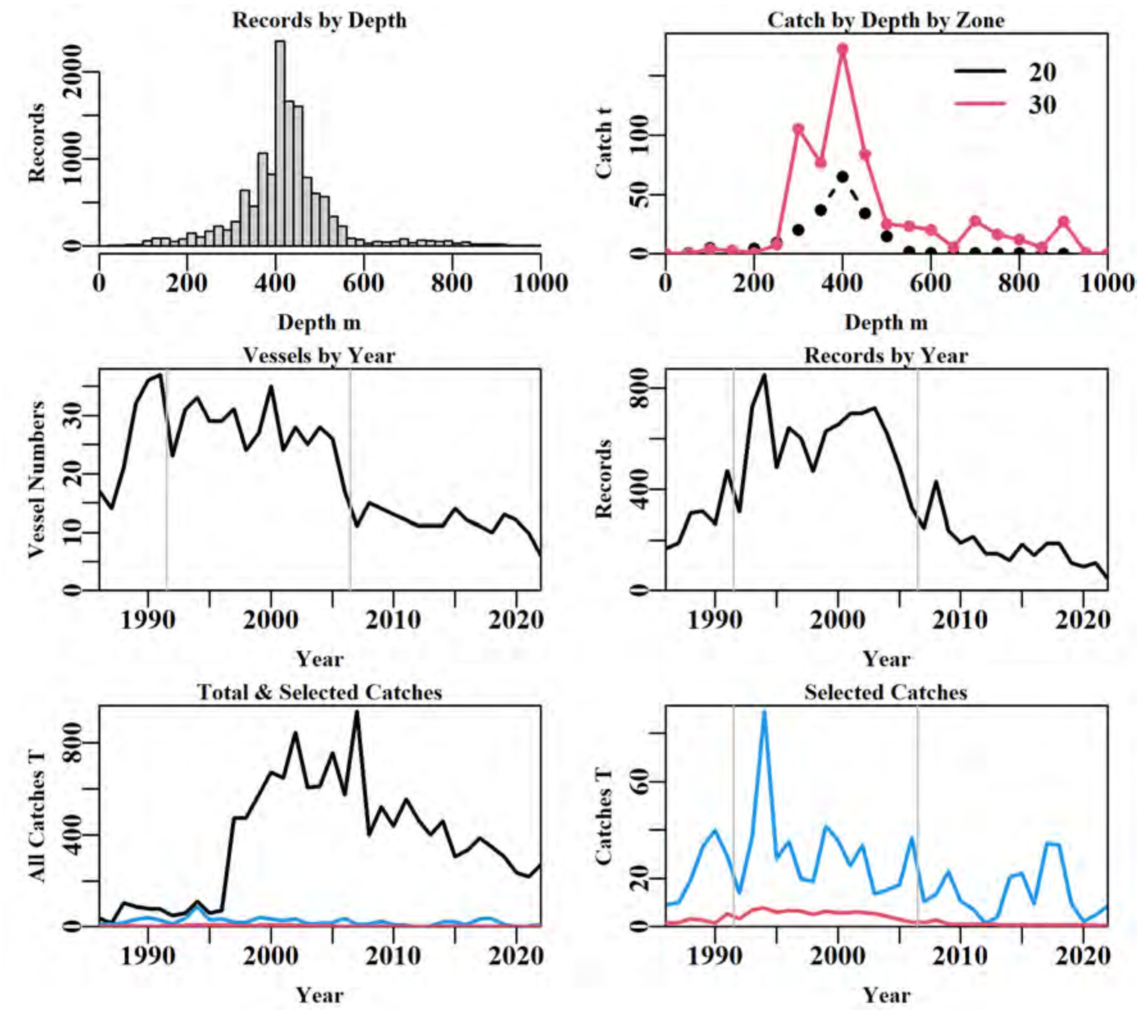

Figure 108: BlueEyeTW2030 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 78: BlueEyeTW2030 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	59143	37589	37354	37135	15851	13446	13436
Difference	0	21554	235	219	21284	2405	10
Catch	13635	5699	5674	5598	1741	822	818
Difference	0	7935	25	76	3856	919	4

Table 79: The models used to analyse data for BlueEyeTW2030.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Zone
Model4	Year + Vessel + Zone + DepCat
Model5	Year + Vessel + Zone + DepCat + Month
Model6	Year + Vessel + Zone + DepCat + Month + DayNight
Model7	Year + Vessel + Zone + DepCat + Month + DayNight + Zone:DepCat
Model8	Year + Vessel + Zone + DepCat + Month + DayNight + Zone:Month

Table 80: BlueEyeTW2030. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	13396	36215	5401	13436	37	12.7	0.00
Vessel	5074	19139	22477	13436	160	53.5	40.71
Zone	4650	18542	23075	13436	161	54.9	1.45
DepCat	4596	18413	23204	13436	181	55.2	0.25
Month	4568	18345	23272	13436	192	55.3	0.13
DayNight	4536	18293	23324	13436	195	55.4	0.12
Zone:DepCat	4367	18013	23604	13436	214	56.0	0.62
Zone:Month	4496	18209	23408	13436	206	55.6	0.17

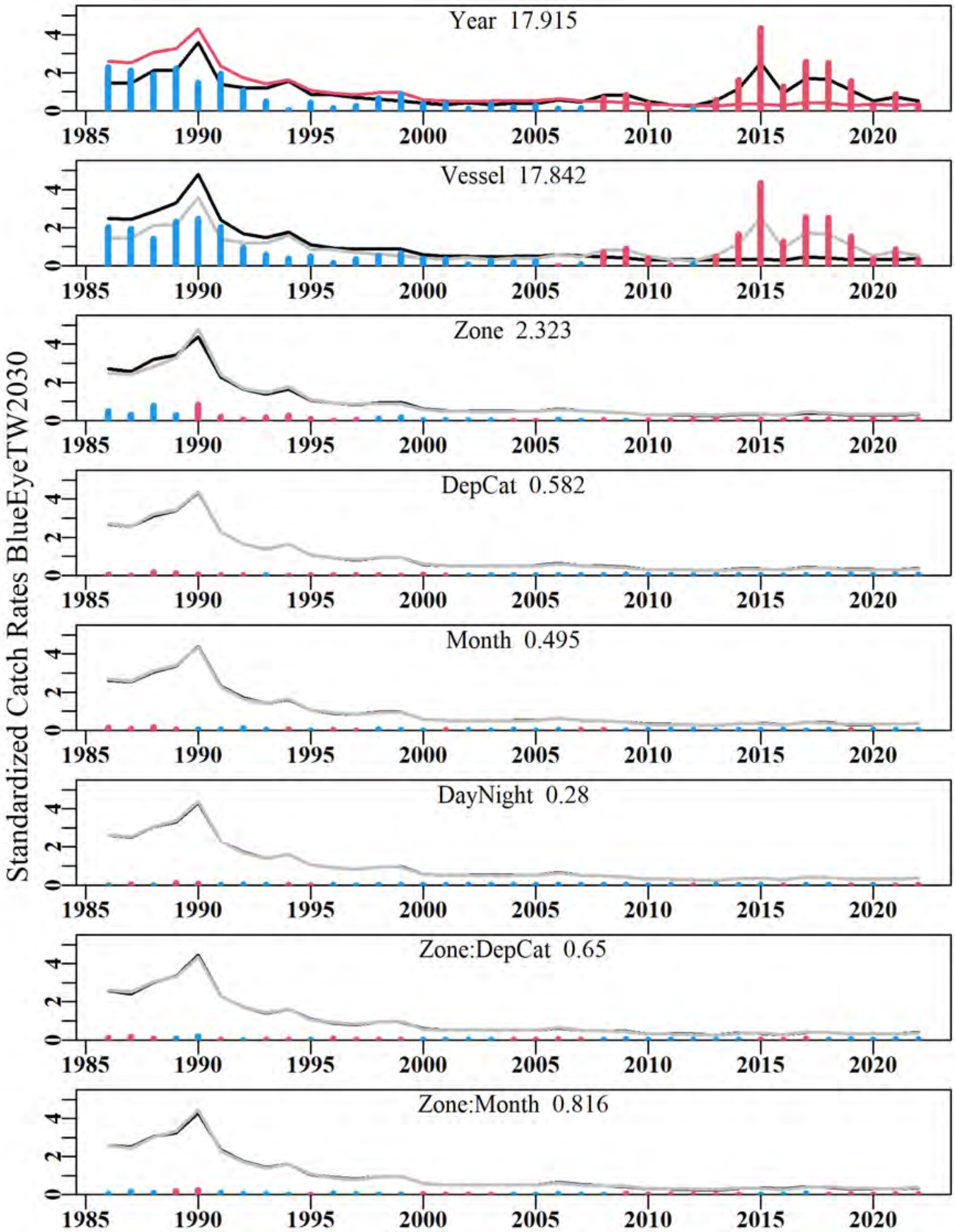

Figure 109: BlueEyeTW2030. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

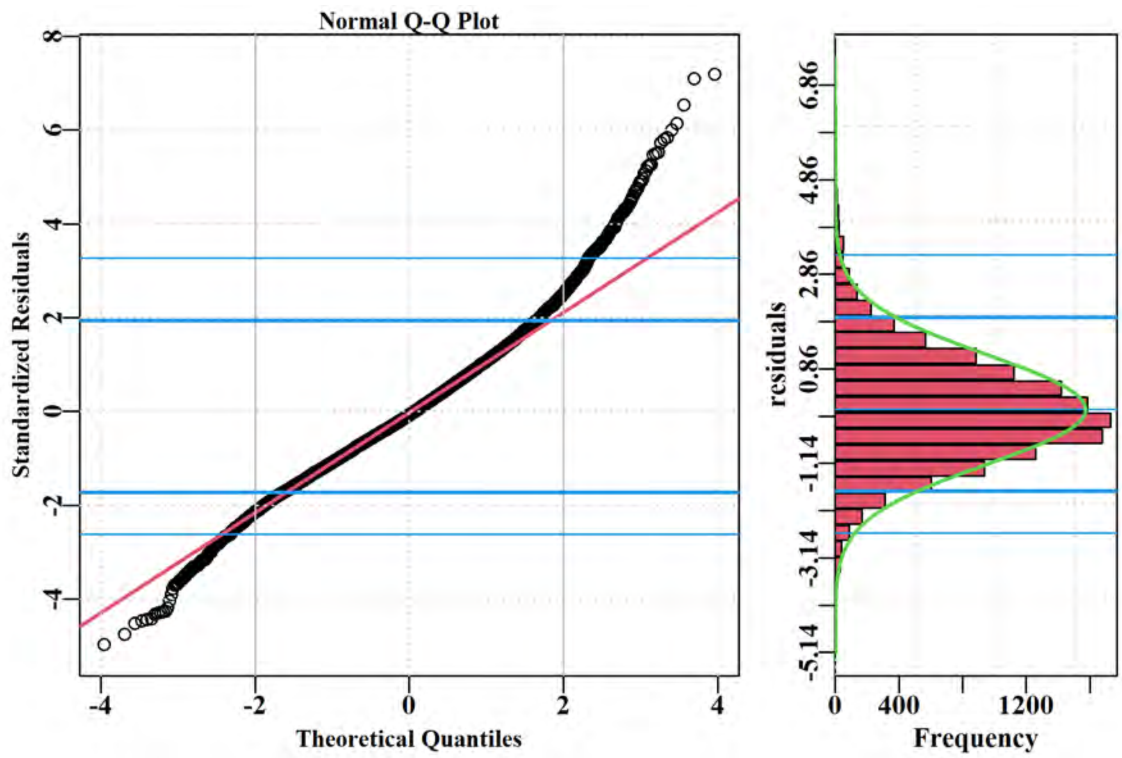

Figure 110: BlueEyeTW2030. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

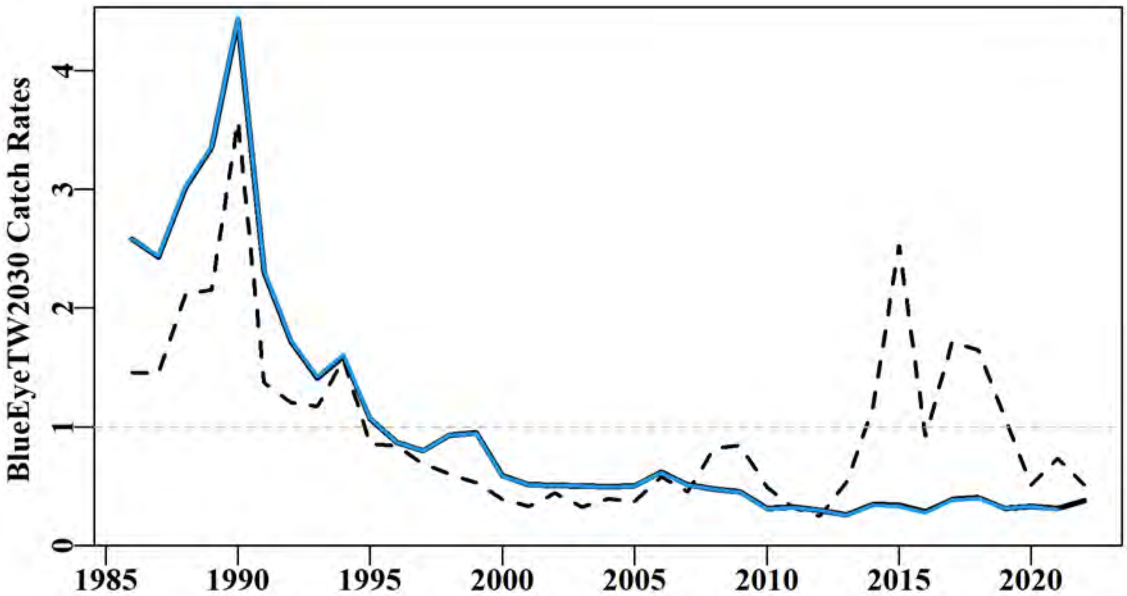

Figure 111: BlueEyeTW2030. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

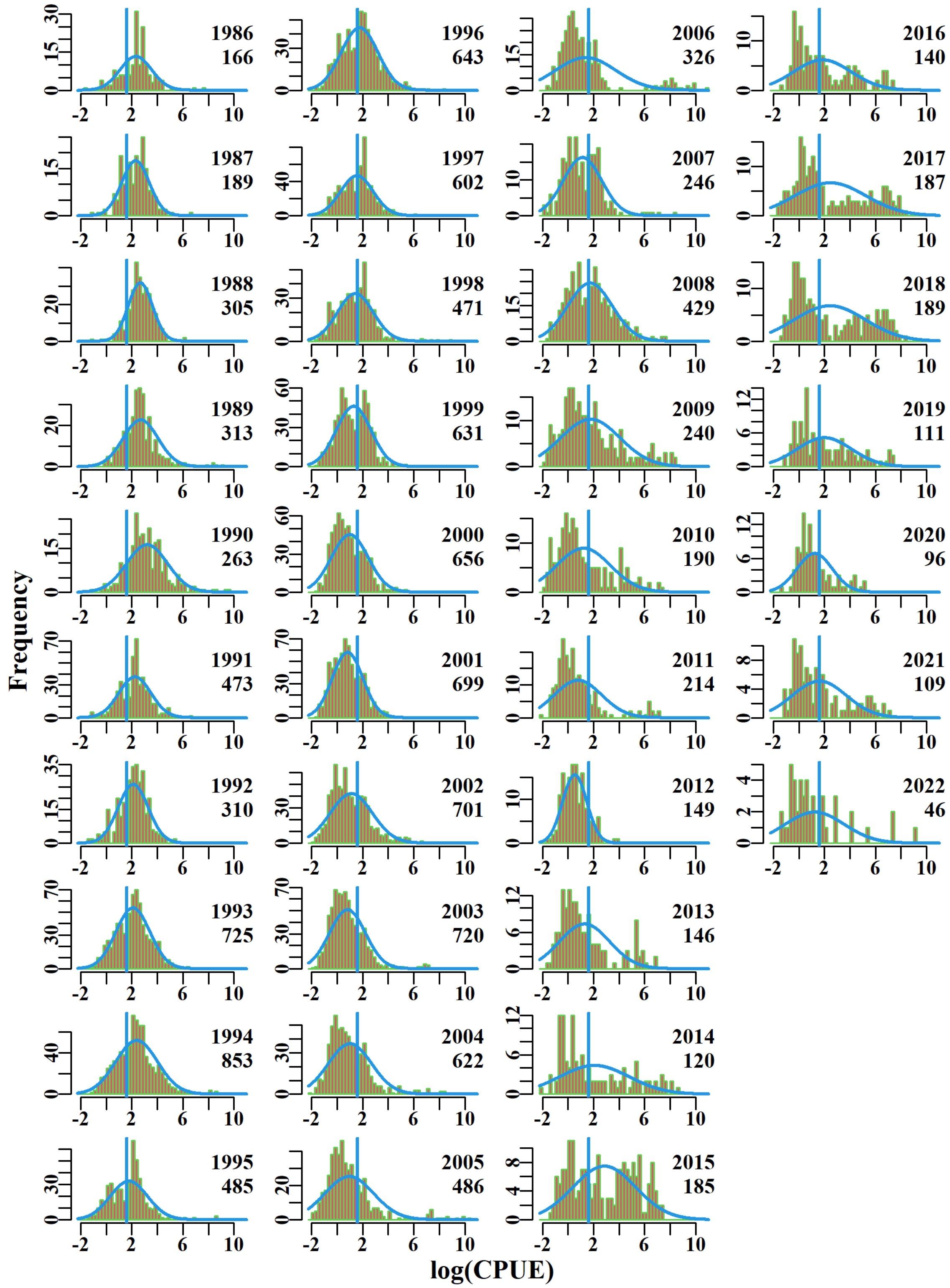

Figure 112: BlueEyeTW2030. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

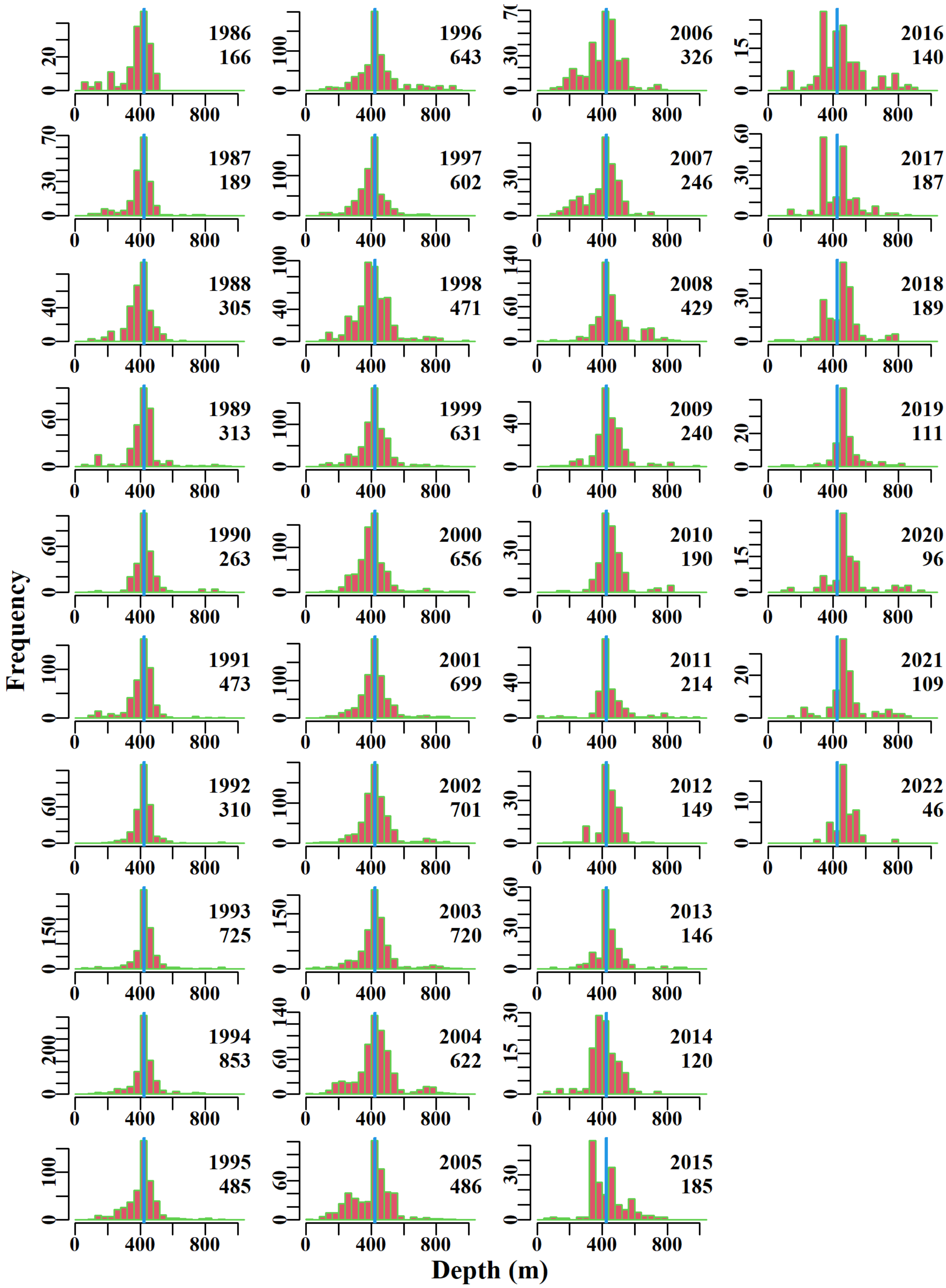

Figure 113: BlueEyeTW2030. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Blue-Eye Trevalla TW 4050

Blue-Eye Trevalla (TBE – 37445001 – *Hyperoglyphe antarctica*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. Trawl caught Blue-Eye Trevalla based on methods TW, TDO, OTB, OTM, in zones 40, 50, and depths 0 to 1000 m within the SET fishery for the years 1986 - 2022 were used in the analysis. Recently, Ocean Blue-Eye Trevalla (37445014 - *Schedophilus labyrinthicus*) was also included in this analysis. These constitute the criteria used to select data from the Commonwealth logbook database (Table 81). Standardized CPUE based on line caught Blue-Eye Trevalla can be found in Sporcic (2023).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Catches appear to change relative to availability rather than the influence of the fishery on the stock. Over the period when CPUE was lower than average (about 1992 - 2006) there was an increase in small shots of < 30 kg, which suggests that these are merely bycatch to the usual fishing practices (Figure 115).

The terms Year, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 85). The qqplot suggests a departure from the assumed Normal distribution as depicted by the tails of the distribution (Figure 117).

Annual standardized CPUE has been mostly below average since about 1996 while the trend has been mostly flat (Figure 114). CPUE are consistent from 1988 - 1991 (i.e., before the introduction of quotas in 1992) but are double that following the introduction of quota. Relatively very few vessels now contribute to significant catches.

Action Items and Issues

If this analysis is to continue, then the early CPUE data from 1988 to 1991 should be explored in more detail to ensure it is representative of the fishery and does not contain systematic errors. After introducing quota, CPUE distributions became more consistent through time, although relatively low numbers of observations are now contributing to a change in their character in the latest years.

Table 81: BlueEyeTW4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	BlueEyeTW4050
csirocode	37445001, 37445014
fishery	SET
depthrange	0 - 1000
depthclass	50
zones	40, 50
methods	TW, TDO, OTB, OTM
years	1986 - 2022

Table 82: BlueEyeTW4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	38.0	194	16.0	18	26.9	1.0973	0.000	1.602	0.100
1987	15.5	56	3.1	14	19.8	0.8345	0.177	0.356	0.113
1988	105.2	142	76.4	15	474.9	2.5989	0.157	0.716	0.009
1989	88.1	238	44.0	24	93.5	2.2504	0.138	2.149	0.049
1990	79.3	156	30.9	15	65.7	2.2529	0.159	1.840	0.060
1991	76.0	125	18.6	18	35.4	1.8102	0.159	1.149	0.062
1992	49.3	129	28.6	15	596.3	2.2395	0.157	0.908	0.032
1993	59.7	289	18.1	19	16.3	1.0064	0.140	3.992	0.220
1994	110.0	348	16.3	19	14.1	1.0192	0.136	5.148	0.316
1995	58.6	497	26.2	21	12.3	0.9187	0.133	6.638	0.253
1996	71.7	521	30.0	24	17.8	0.9662	0.133	6.277	0.209
1997	471.5	788	82.4	18	22.3	0.9786	0.130	7.718	0.094
1998	476.0	778	58.9	19	14.6	1.1605	0.131	8.746	0.148
1999	575.0	875	46.2	19	15.5	1.1720	0.130	9.412	0.204
2000	671.4	1104	44.6	24	13.1	1.0129	0.129	11.127	0.249
2001	648.3	966	43.4	26	15.0	0.9751	0.131	10.771	0.248
2002	843.9	803	32.3	26	13.6	0.8115	0.131	8.786	0.272
2003	605.3	389	11.0	25	8.5	0.7134	0.137	3.775	0.344
2004	612.3	848	31.2	24	10.0	0.6283	0.131	7.179	0.230
2005	755.2	507	12.7	22	7.5	0.6016	0.134	4.366	0.343
2006	573.7	527	16.2	17	7.3	0.5958	0.134	3.967	0.245
2007	937.1	530	26.1	16	12.9	0.6368	0.134	3.655	0.140
2008	398.9	321	16.4	14	14.9	0.8522	0.139	2.685	0.164
2009	521.0	342	15.8	13	10.6	0.8035	0.139	2.540	0.161
2010	437.4	423	30.9	14	15.6	0.8215	0.136	2.775	0.090
2011	554.2	379	14.7	14	6.5	0.6322	0.137	3.017	0.205
2012	463.8	251	9.0	11	4.7	0.4680	0.145	1.736	0.194
2013	398.4	201	18.7	15	10.9	0.6126	0.148	1.565	0.084
2014	460.5	216	8.7	13	6.6	0.5743	0.147	2.118	0.243
2015	305.4	106	2.7	9	5.3	0.3693	0.167	0.745	0.281
2016	332.7	92	3.3	13	7.1	0.6100	0.170	0.842	0.255
2017	385.3	228	17.3	10	18.1	1.0197	0.151	2.029	0.117
2018	345.9	193	8.4	10	6.9	0.6396	0.152	2.098	0.248
2019	303.7	188	9.2	9	12.3	0.7260	0.150	1.697	0.184
2020	236.1	71	3.9	10	11.6	0.6022	0.185	0.676	0.173
2021	218.7	29	1.8	7	11.5	1.0368	0.251	0.272	0.151
2022	269.0	55	5.2	7	8.7	0.9513	0.195	0.609	0.117

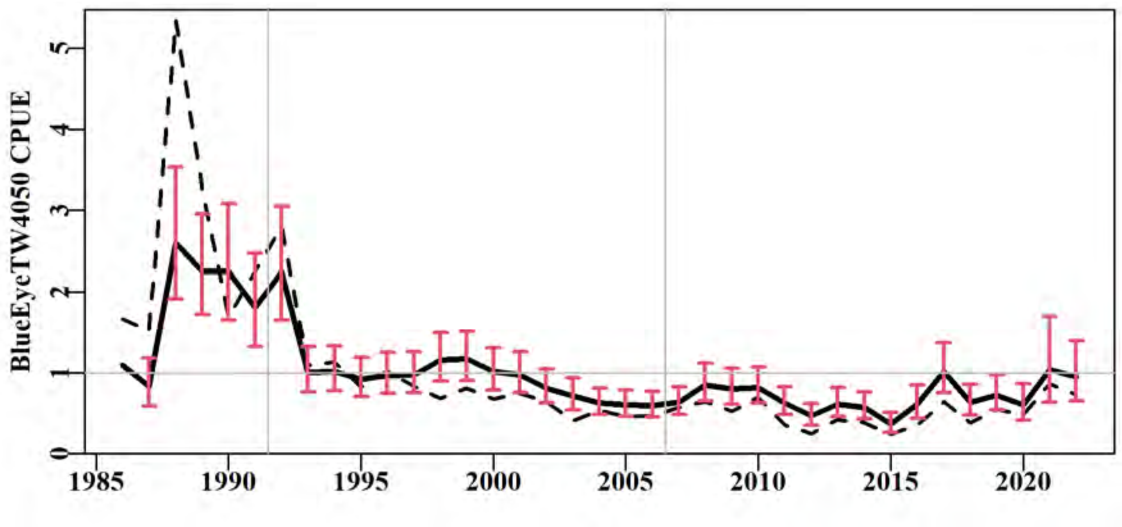

Figure 114: BlueEyeTW4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

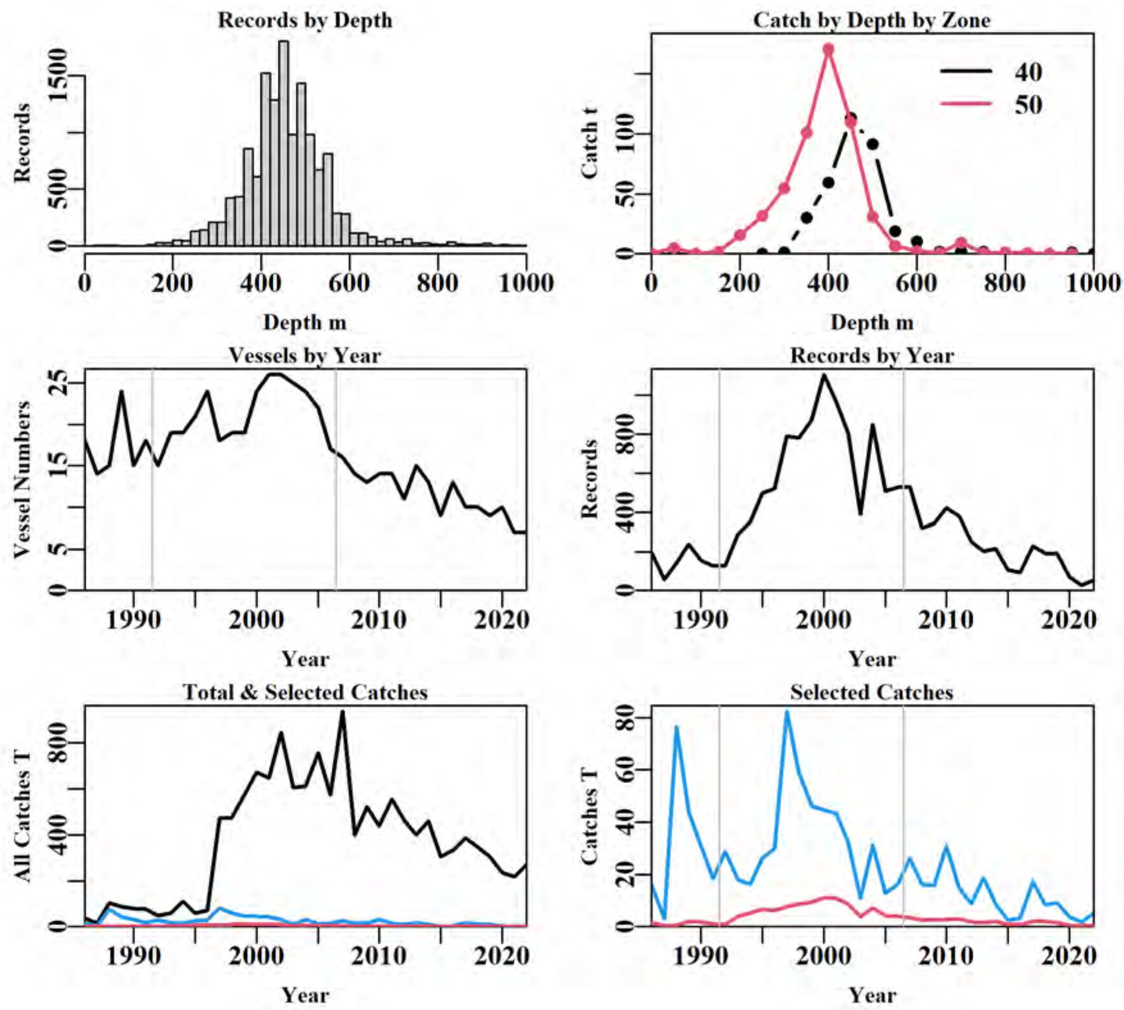

Figure 115: BlueEyeTW4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 83: BlueEyeTW4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	59143	37589	37354	37135	15576	13929	13905
Difference	0	21554	235	219	21559	1647	24
Catch	13635	5699	5674	5598	1521	880	879
Difference	0	7935	25	76	4076	641	1

Table 84: The models used to analyse data for BlueEyeTW4050.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Zone
Model5	Year + Vessel + DepCat + Zone + DayNight
Model6	Year + Vessel + DepCat + Zone + DayNight + Month
Model7	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:DepCat
Model8	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:Month

Table 85: BlueEyeTW4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	9112	26636	3372	13905	37	11.0	0.00
Vessel	3459	17515	12492	13905	125	41.1	30.10
DepCat	3062	16973	13035	13905	145	42.8	1.74
Zone	2986	16878	13129	13905	146	43.2	0.31
DayNight	2853	16710	13297	13905	149	43.7	0.55
Month	2748	16558	13449	13905	160	44.2	0.47
Zone:DepCat	2733	16500	13508	13905	177	44.3	0.13
Zone:Month	2748	16532	13476	13905	171	44.2	0.05

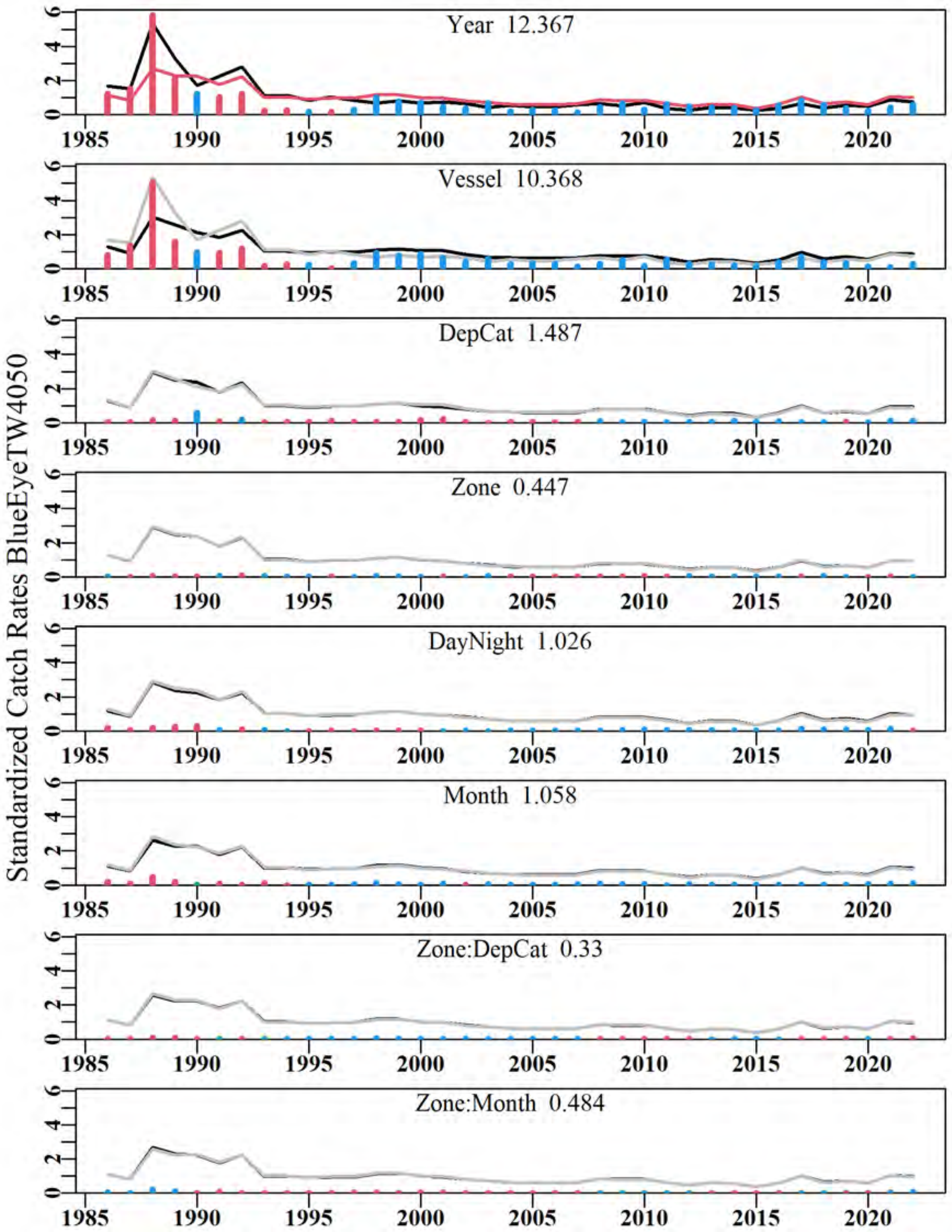

Figure 116: BlueEyeTW4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

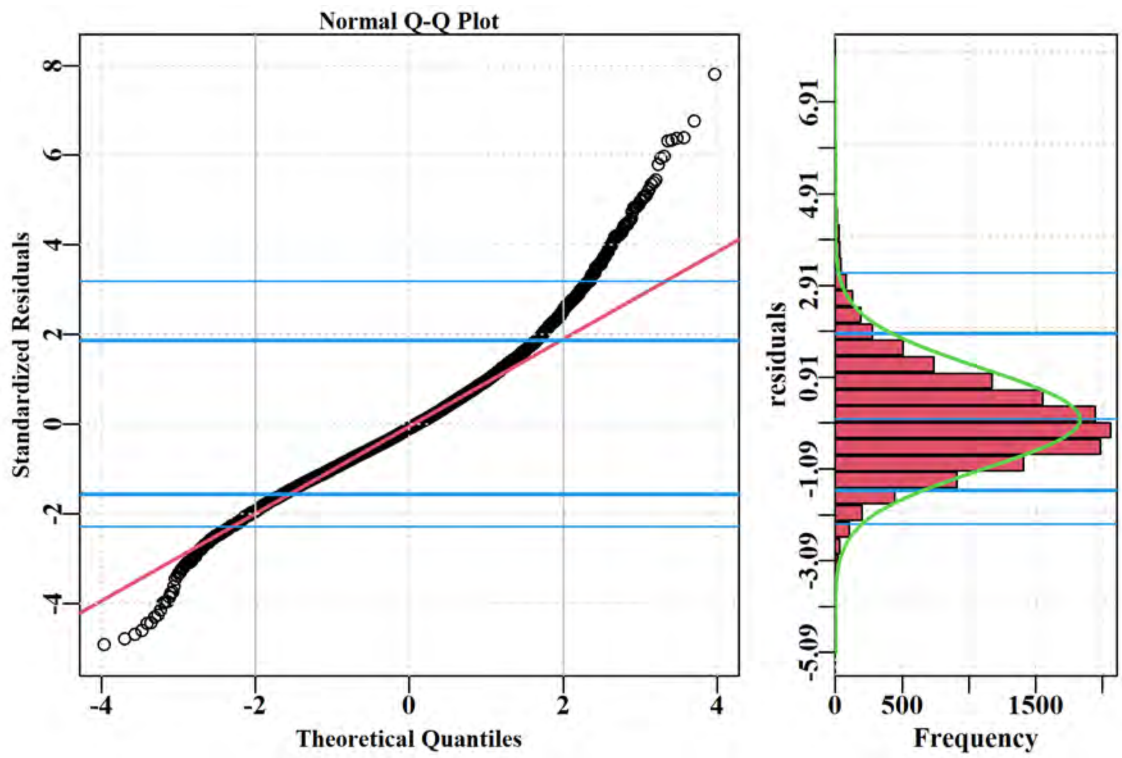

Figure 117: BlueEyeTW4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

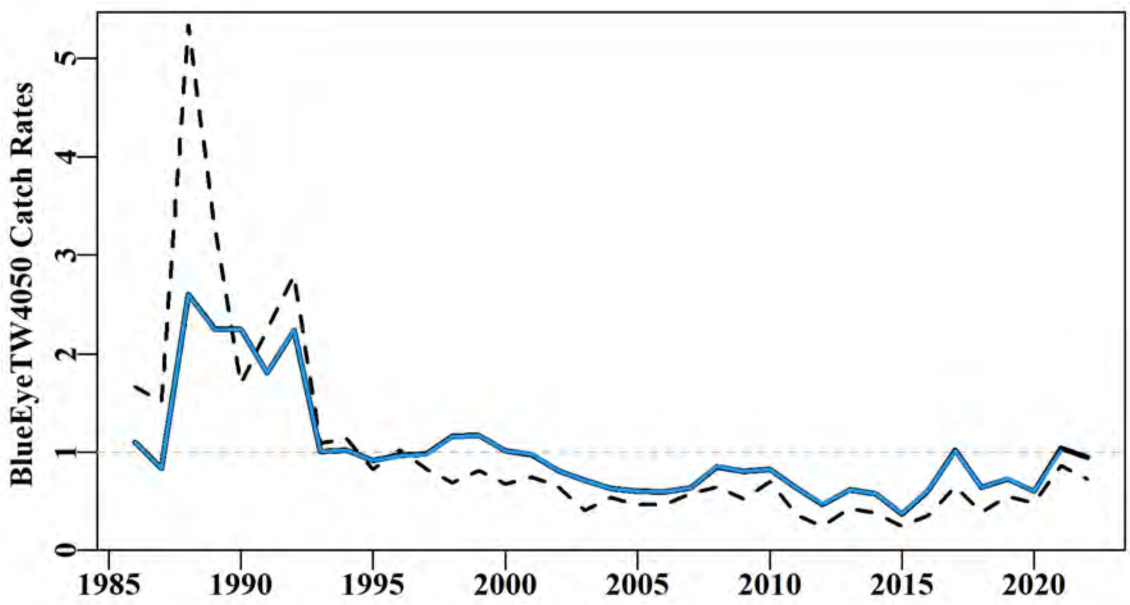

Figure 118: BlueEyeTW4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

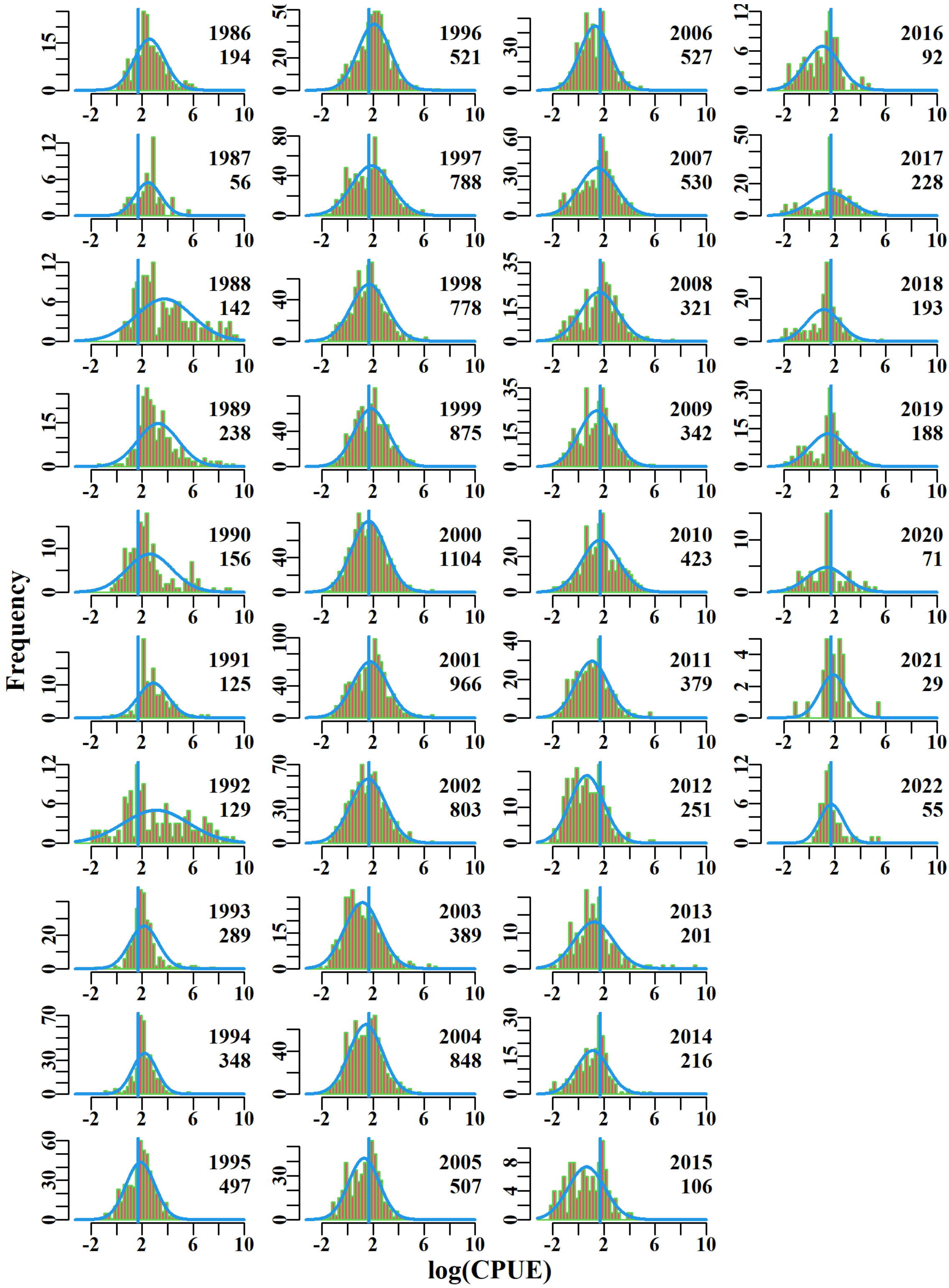

Figure 119: BlueEyeTW4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

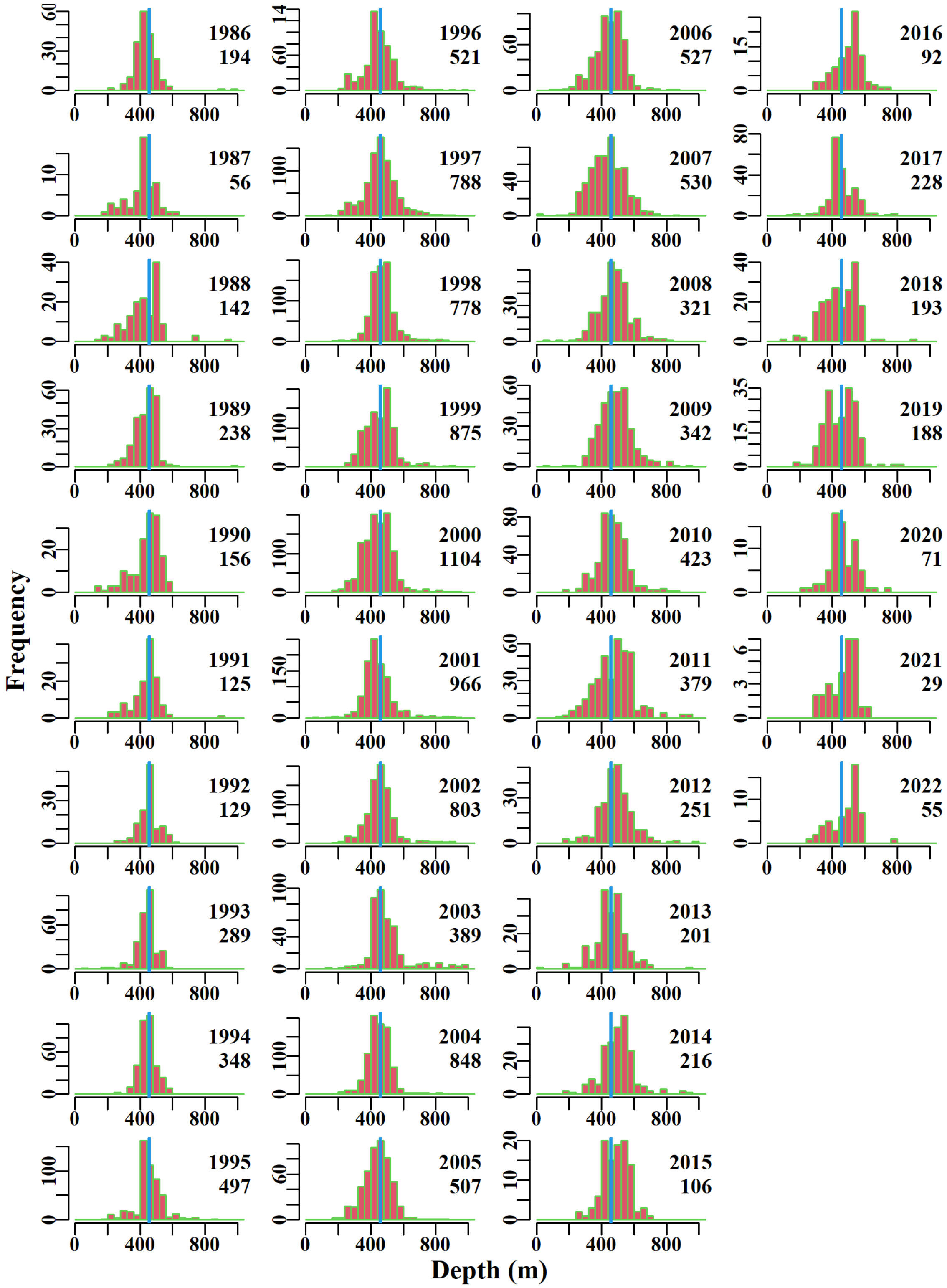

Figure 120: BlueEyeTW4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Blue-Grenadier Non-Spawning

Blue Grenadier (GRE – 37227001 – *Macroronus novaezelandiae*) was one of the 16 species first included in the quota system in 1992. Trawl caught Blue Grenadier based on methods TW, TDO, OTB, OTT, OTM, in zones 10, 20, 30, 40, 50, 60 and depths 100 to 1000 m within the SET fishery for the years 1986 - 2022 were used in the analysis, apart from winter spawning records (Table 86).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Blue grenadier (non-spawning) was mostly caught in zone 50 and 40, followed by zone 20 and 30 across the analysis period. The 2022 catch (889.9 t) was the lowest since 2013.

The terms Year, Vessel, DayNight, DepCat, Zone and Month and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 90). The qqplot suggests a slight departure from the assumed Normal distribution as depicted by the upper tail of the distribution (Figure 124).

Annual standardized CPUE have been below average between 1993 - 2013, with two apparent cycles, each peaking in 1999 and 2008 respectively. Between 2014 to 2015, these indices were above average. Also, there has been a consistent and above average increase between 2018-20, despite the decrease in 2021 and 2022 (Figure 121).

Action Items and Issues

It is recommended that alternate statistical distributions be considered.

Table 86: BlueGrenadierNS. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	BlueGrenadierNS
csirocode	37227001
fishery	SET
depthrange	100 - 1000
depthclass	50
zones	10, 20, 30, 40, 50, 60
methods	TW, TDO, OTB, OTT, OTM
years	1986 - 2022

Table 87: BlueGrenadierNS. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1205.5	3188	1183.2	92	141.8	1.5065	0.000	12.975	0.011
1987	1462.5	3561	1434.5	91	135.0	1.9235	0.034	14.597	0.010
1988	1530.1	3952	1469.1	102	129.2	2.1043	0.034	17.925	0.012
1989	1854.7	4302	1811.6	99	151.3	2.1070	0.034	18.000	0.010
1990	1710.8	3520	1468.5	92	149.1	2.0851	0.036	12.473	0.008
1991	2780.7	4244	2334.0	86	206.1	1.4894	0.034	15.704	0.007
1992	1760.8	3232	1505.6	62	178.1	1.2065	0.037	12.483	0.008
1993	1670.0	4190	1615.4	63	125.4	0.9182	0.035	19.071	0.012
1994	1341.2	4469	1306.7	66	94.2	0.8301	0.035	22.544	0.017
1995	1020.1	5059	1012.7	61	58.6	0.5707	0.034	32.505	0.032
1996	1092.7	5352	1054.4	72	56.4	0.5192	0.034	38.052	0.036
1997	1032.0	6175	993.4	73	43.8	0.5385	0.033	45.709	0.046
1998	1488.0	6584	1450.2	65	74.8	0.8696	0.033	41.062	0.028
1999	2113.3	8032	2043.8	65	89.6	0.9143	0.032	47.051	0.023
2000	1768.0	7667	1747.4	73	73.4	0.6578	0.033	49.517	0.028
2001	1062.1	7325	1020.8	60	40.3	0.3801	0.033	56.149	0.055
2002	1151.4	6331	1124.3	57	54.9	0.3762	0.034	40.900	0.036
2003	707.7	5650	667.3	56	33.8	0.3153	0.034	36.186	0.054
2004	1444.4	6362	1198.8	56	56.1	0.5291	0.034	23.385	0.020
2005	1626.5	5282	1164.6	54	66.0	0.6385	0.034	18.083	0.016
2006	1486.5	4317	1292.9	42	84.6	0.8520	0.036	11.037	0.009
2007	1312.0	3619	1193.3	27	86.6	0.7570	0.037	10.146	0.009
2008	1312.5	3365	1254.7	26	110.9	0.8371	0.037	8.968	0.007
2009	1150.9	3388	1112.5	23	89.2	0.7761	0.037	9.648	0.009
2010	1167.6	3266	1130.8	25	81.9	0.7780	0.037	8.044	0.007
2011	923.1	3907	882.3	26	49.4	0.6401	0.036	9.375	0.011
2012	645.7	3116	602.4	29	41.6	0.5088	0.038	9.802	0.016
2013	774.5	3024	732.1	26	58.1	0.9078	0.038	7.204	0.010
2014	994.1	3036	919.3	28	77.9	1.0914	0.038	6.127	0.007
2015	1069.9	2963	1046.8	29	105.5	1.1882	0.038	8.165	0.008
2016	981.4	2527	964.8	24	111.0	0.9933	0.040	5.583	0.006
2017	1279.9	2953	1240.6	24	116.8	1.1137	0.038	4.753	0.004
2018	1087.2	2837	1050.2	23	97.6	0.8949	0.039	5.080	0.005
2019	1437.4	3038	1414.8	22	136.5	1.1890	0.038	4.263	0.003
2020	1514.6	2754	1453.2	22	140.4	1.7055	0.039	2.265	0.002
2021	1139.6	2579	1093.6	20	116.1	1.1885	0.040	3.938	0.004
2022	934.6	2222	889.9	19	94.0	1.0986	0.041	2.365	0.003

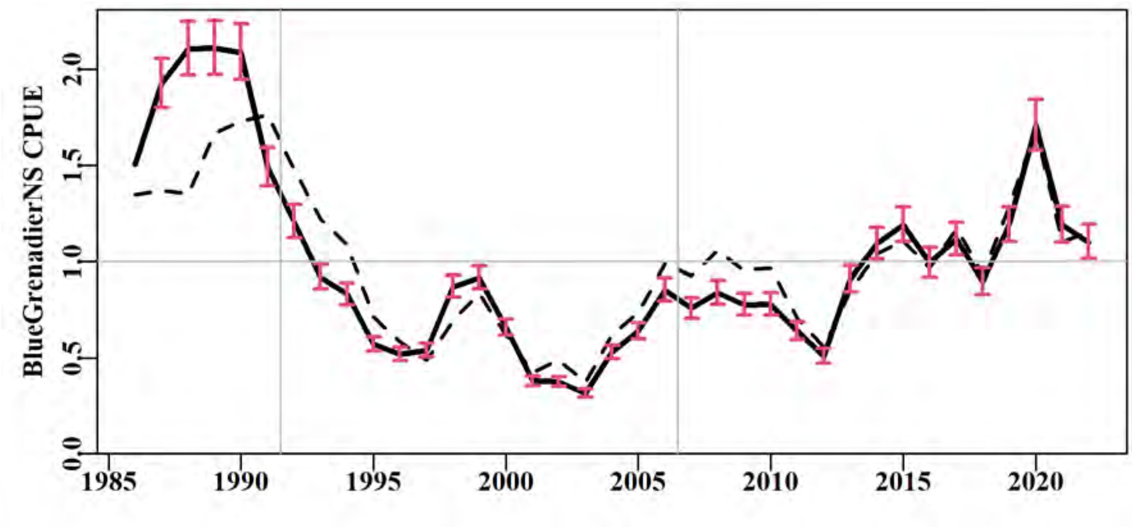

Figure 121: BlueGrenadierNS standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

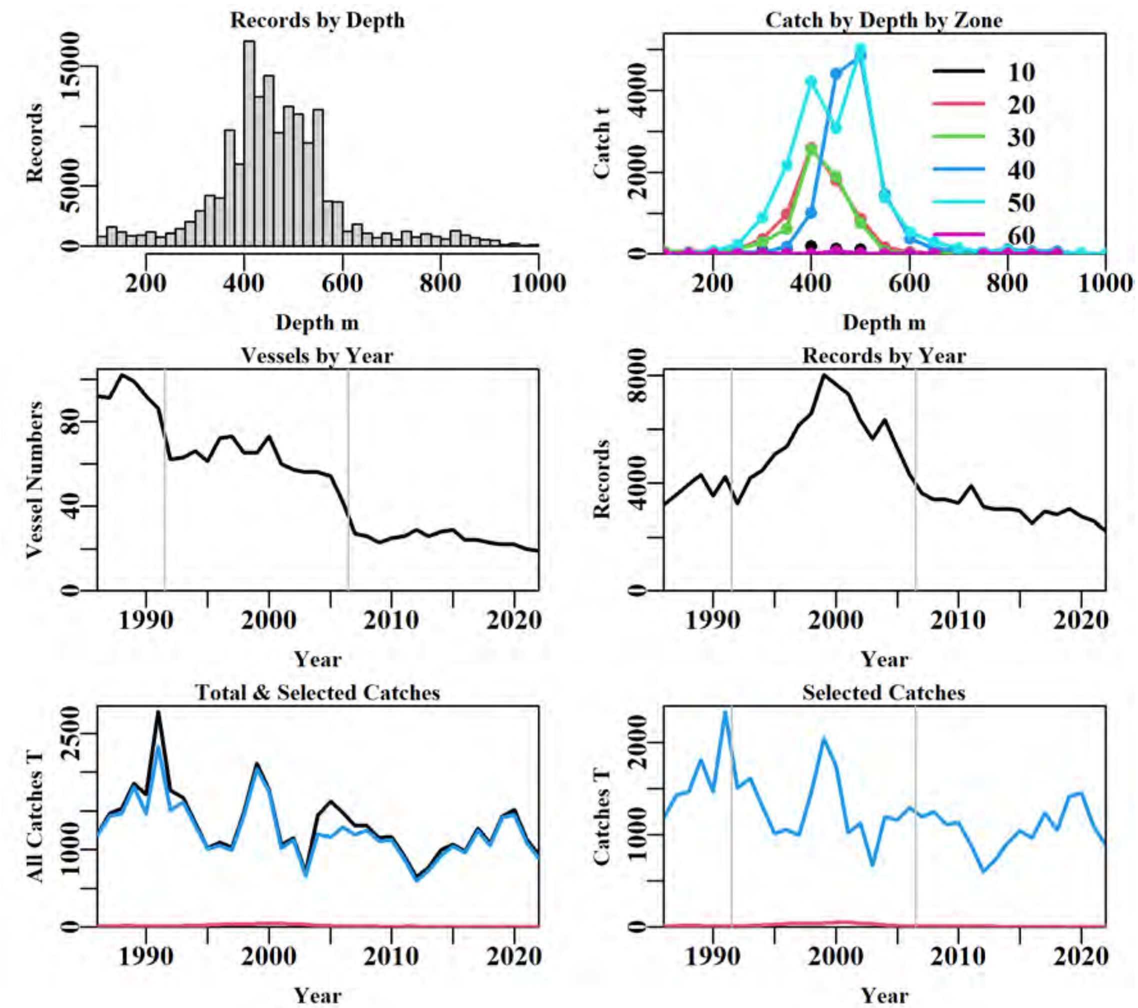

Figure 122: BlueGrenadierNS fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 88: BlueGrenadierNS data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	186437	167734	166047	164267	159997	157507	157388
Difference	0	18703	1687	1780	4270	2490	119
Catch	49648	49014	48487	47873	46414	45900	45881
Difference	0	634	527	614	1459	514	19

Table 89: The models used to analyse data for BlueGrenadierNS.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DayNight
Model4	Year + Vessel + DayNight + DepCat
Model5	Year + Vessel + DayNight + DepCat + Zone
Model6	Year + Vessel + DayNight + DepCat + Zone + Month
Model7	Year + Vessel + DayNight + DepCat + Zone + Month + Zone:DepCat
Model8	Year + Vessel + DayNight + DepCat + Zone + Month + Zone:Month

Table 90: BlueGrenadierNS. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	144831	394832	28033	157388	37	6.6	0.00
Vessel	119627	335552	87312	157388	237	20.5	13.92
DayNight	109343	314317	108547	157388	240	25.6	5.03
DepCat	99285	294791	128073	157388	258	30.2	4.62
Zone	94041	285111	137753	157388	263	32.5	2.29
Month	89212	276459	146405	157388	274	34.5	2.04
Zone:DepCat	87514	273200	149664	157388	358	35.2	0.74
Zone:Month	85668	270124	152741	157388	326	36.0	1.48

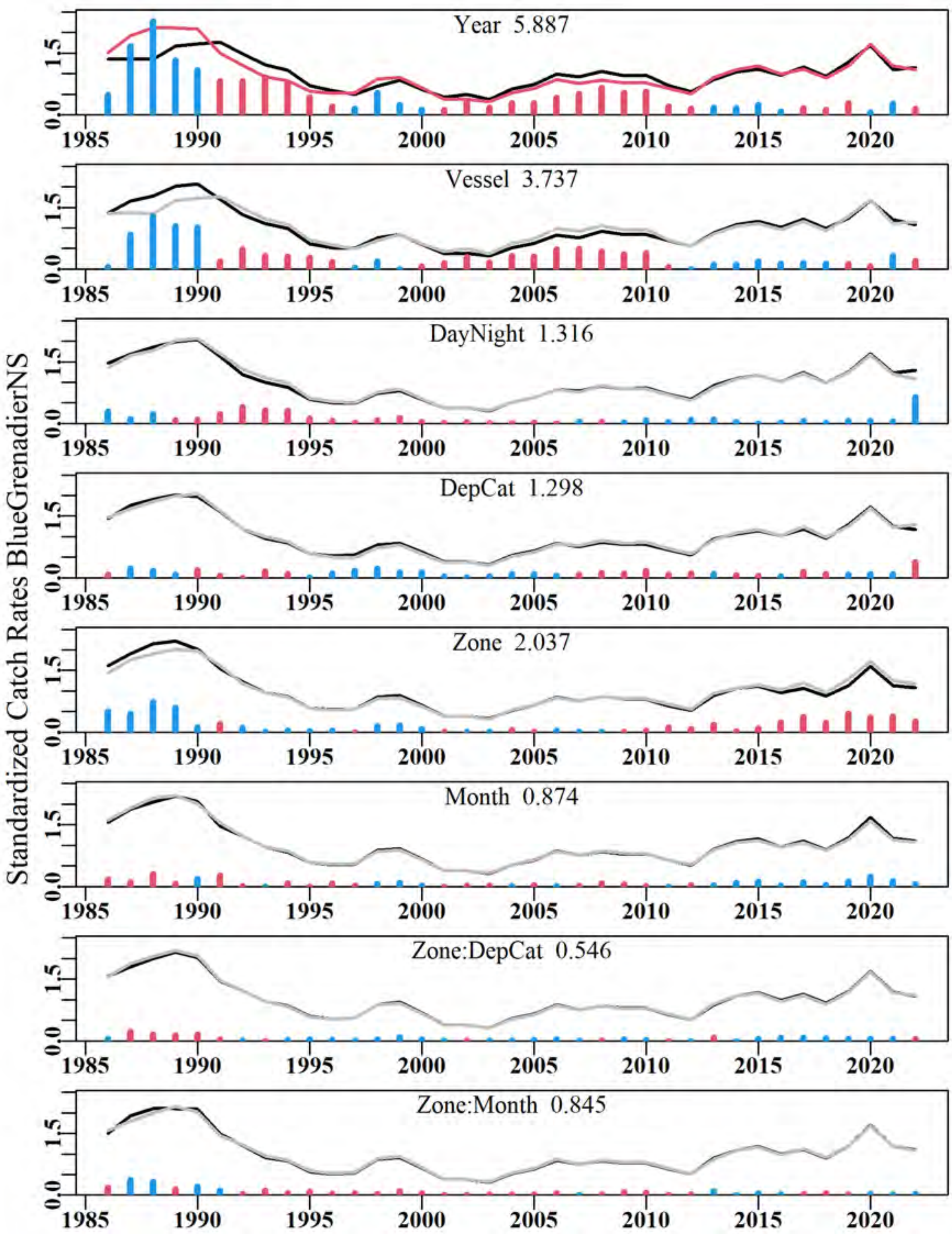

Figure 123: BlueGrenadierNS. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

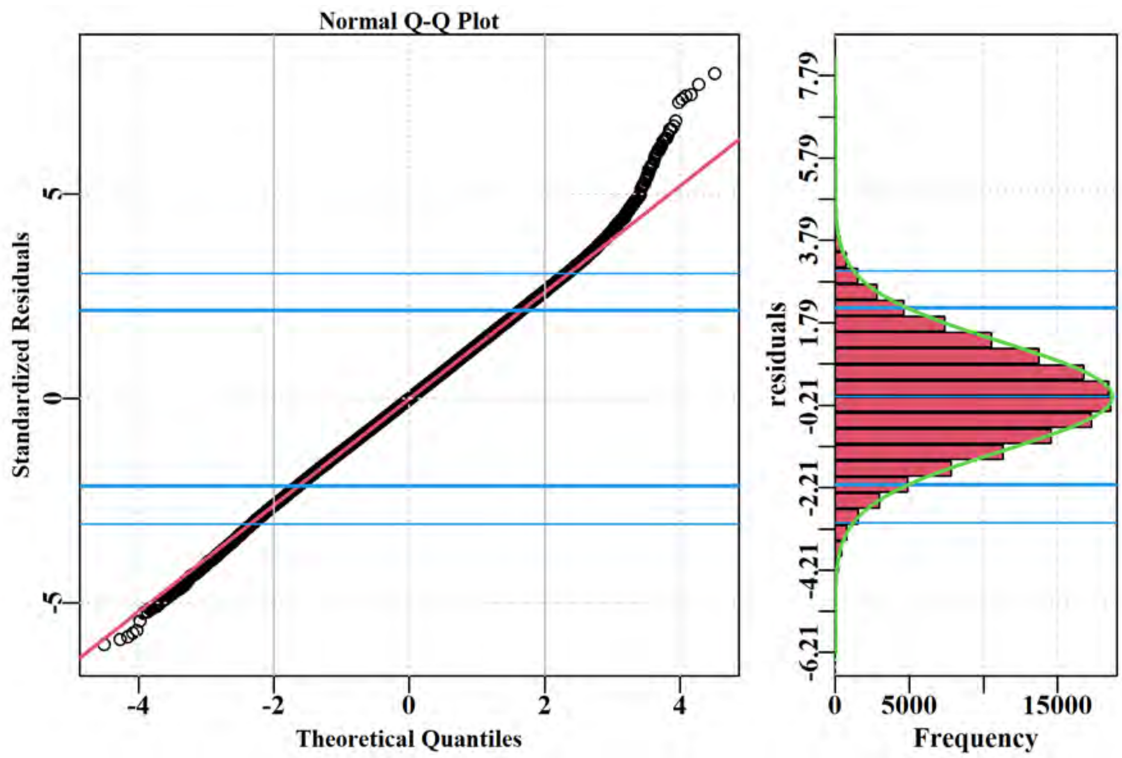

Figure 124: BlueGrenadierNS. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

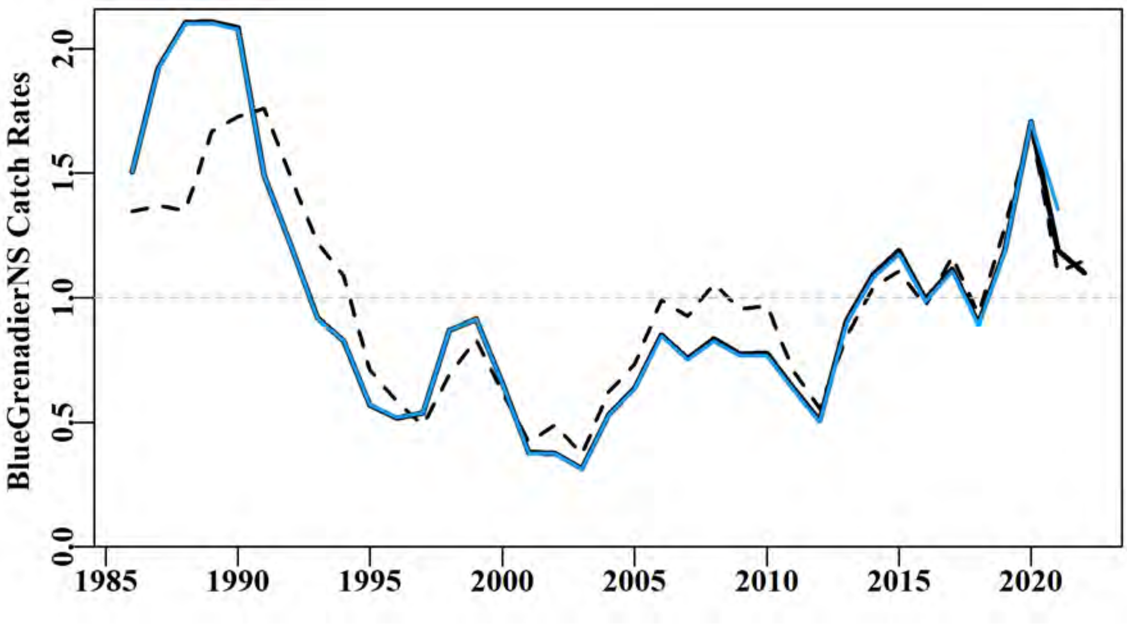

Figure 125: BlueGrenadierNS. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

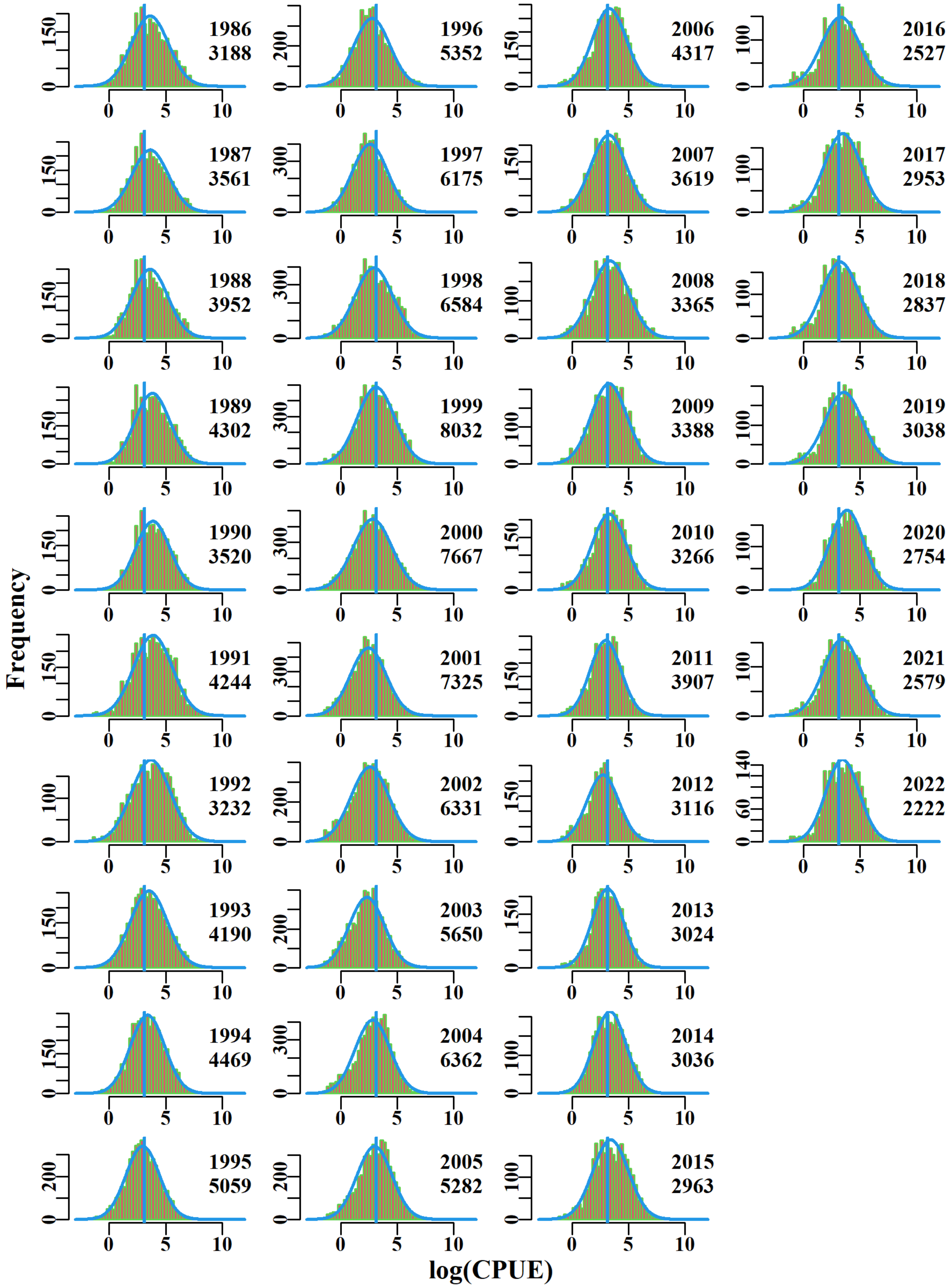

Figure 126: BlueGrenadierNS. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

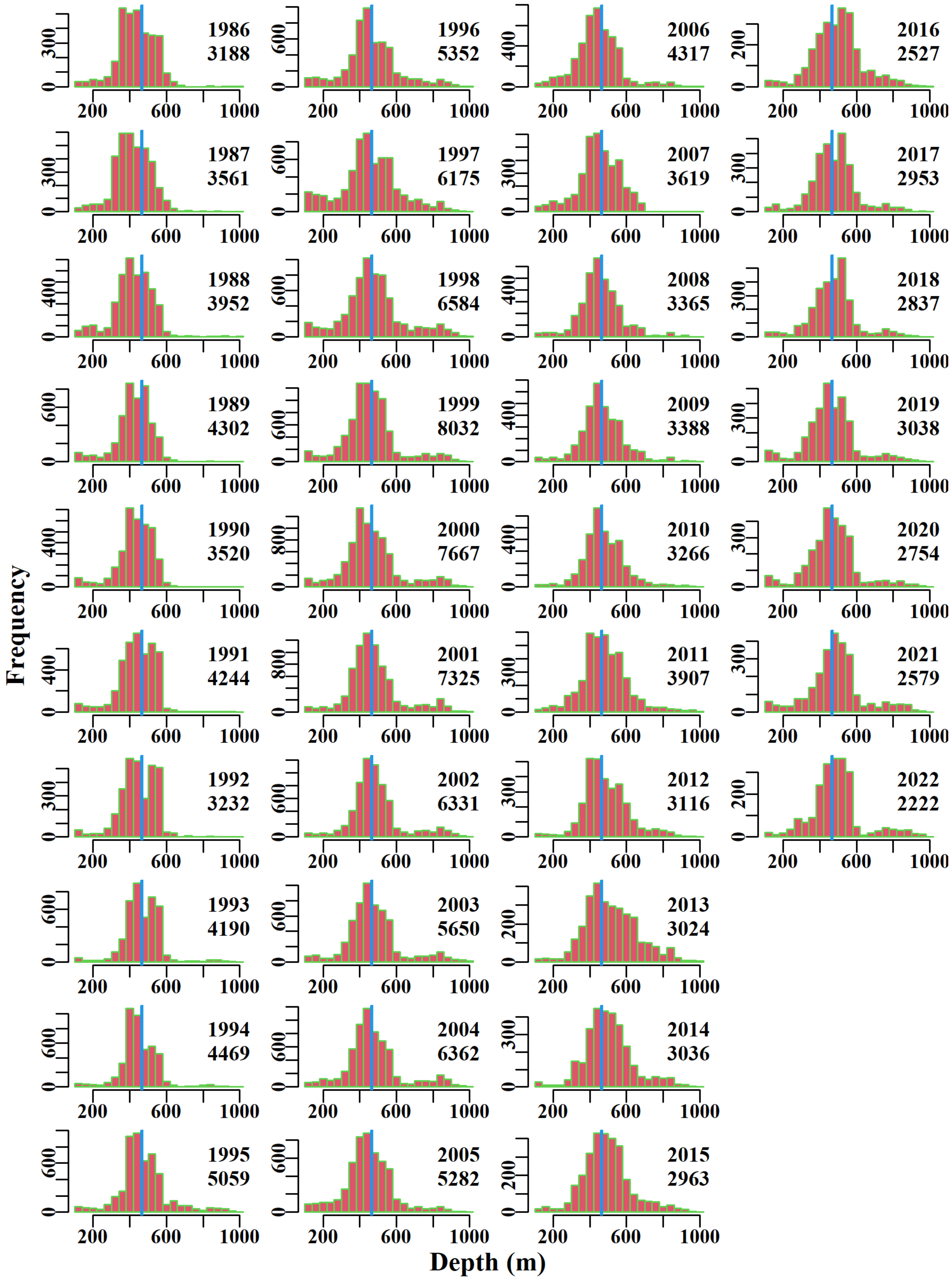

Figure 127: BlueGrenadierNS. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Pink Ling TW 10 - 30

Pink Ling (LIG – 37228002 –*Genypterus blacodes*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. Pink Ling caught by trawl based on methods TW, TDO, OTM, OTB, OTT, in zones 10, 20, 30, and depths 250 to 600 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 91). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Pink Ling were mostly caught in zone 20, followed by zone 10 and 30 across the analysis period.

The terms Year, Vessel, DepCat and Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 95). The qqplot suggests a departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 131).

Annual standardized CPUE has been below average corresponding to a relatively flat trend over the 2001-19 period, with the most recent estimate just below the long-term average, based on 95% confidence intervals (Figure 128). More recently, CPUE has increased since 2015, despite the decrease in 2021 relative to the previous year. The structural adjustment had a major effect upon the influence of the vessel factor from 2006 or 2007 onwards.

Action Items and Issues

A detailed consideration be given to the change in vessel effects following the structural adjustment to ensure that the time-series of Pink Ling CPUE was not broken by this management intervention.

Table 91: PinkLing1030. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	PinkLing1030
csirocode	37228002
fishery	SET
depthrange	250 - 600
depthclass	25
zones	10, 20, 30
methods	TW, TDO, OTM, OTB, OTT
years	1986 - 2022

Table 92: PinkLing1030. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	679.0	4510	498.2	80	44.9	1.1539	0.000	24.955	0.050
1987	765.1	4251	491.4	77	46.0	1.2166	0.022	22.694	0.046
1988	583.1	3603	398.3	77	40.5	1.1697	0.024	17.925	0.045
1989	678.9	3869	421.2	76	39.9	1.0127	0.023	20.150	0.048
1990	674.5	2768	411.6	67	52.7	1.4570	0.026	11.056	0.027
1991	736.8	2903	366.0	71	46.2	1.4281	0.026	13.338	0.036
1992	568.3	2417	329.4	58	45.9	1.1241	0.027	11.224	0.034
1993	892.8	3471	500.7	58	50.3	1.0783	0.025	16.847	0.034
1994	895.4	4036	468.4	62	42.7	1.1010	0.024	21.041	0.045
1995	1208.9	4346	585.6	57	49.3	1.3726	0.023	21.920	0.037
1996	1233.3	4254	666.7	63	56.2	1.3691	0.023	17.576	0.026
1997	1696.8	4772	730.9	61	52.0	1.3928	0.023	19.670	0.027
1998	1592.4	4883	728.3	56	53.1	1.3809	0.023	22.477	0.031
1999	1651.6	5934	831.1	59	48.8	1.2576	0.022	27.979	0.034
2000	1507.5	5100	658.8	62	46.3	1.1054	0.023	24.500	0.037
2001	1393.0	4555	484.9	52	38.0	0.8661	0.024	24.294	0.050
2002	1330.3	3882	360.3	52	35.2	0.7578	0.025	22.555	0.063
2003	1353.1	4277	444.3	57	38.6	0.7936	0.024	19.522	0.044
2004	1522.9	3328	345.6	54	37.1	0.7107	0.026	14.208	0.041
2005	1203.3	3370	324.5	51	32.6	0.6623	0.026	13.679	0.042
2006	1069.2	2566	321.1	38	42.1	0.7965	0.027	6.841	0.021
2007	875.9	1627	202.8	23	42.0	0.7595	0.032	4.487	0.022
2008	980.3	2342	325.4	24	46.7	0.9021	0.029	5.268	0.016
2009	775.0	1886	208.3	27	34.7	0.6493	0.030	5.024	0.024
2010	906.2	1923	265.5	23	47.0	0.8025	0.030	4.976	0.019
2011	1081.9	2122	287.3	22	46.7	0.8453	0.029	4.720	0.016
2012	1030.9	1919	268.1	24	49.5	0.9027	0.030	4.917	0.018
2013	752.9	1560	184.3	22	40.9	0.7529	0.032	4.498	0.024
2014	861.2	1639	234.4	24	48.5	0.8348	0.031	5.039	0.022
2015	721.9	1650	188.9	24	41.1	0.7255	0.031	5.273	0.028
2016	736.0	1515	192.7	25	42.0	0.7391	0.033	4.896	0.025
2017	896.7	1862	276.1	22	53.4	0.8714	0.031	5.064	0.018
2018	874.0	1603	226.6	20	48.3	0.8961	0.032	3.764	0.017
2019	799.2	1721	229.0	19	49.2	0.9620	0.032	4.393	0.019
2020	801.4	1426	226.5	17	56.9	1.0651	0.034	2.310	0.010
2021	766.4	1600	212.6	17	44.9	0.9288	0.033	4.167	0.020
2022	884.0	1331	247.6	17	56.9	1.1562	0.035	2.947	0.012

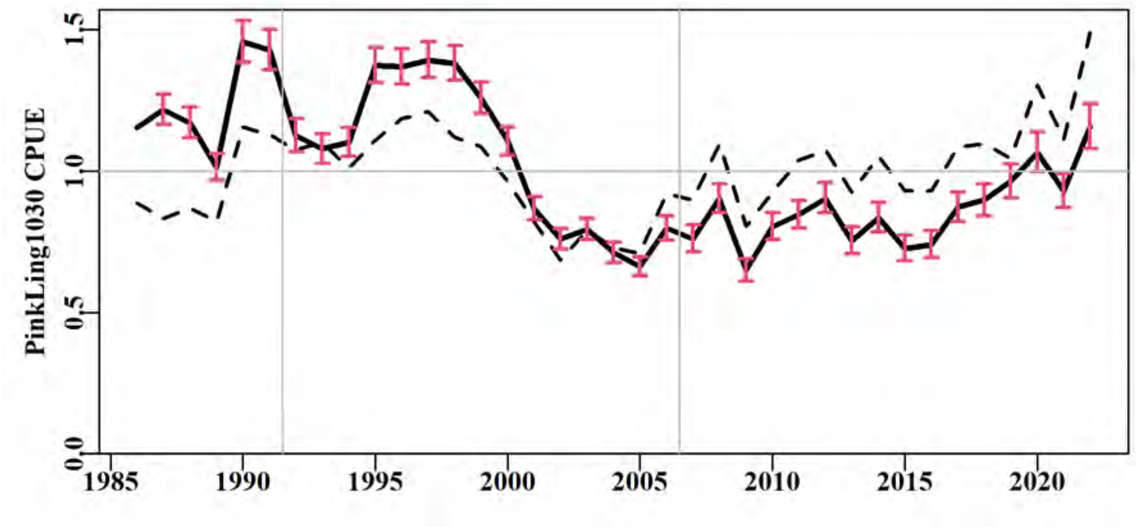

Figure 128: PinkLing1030 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

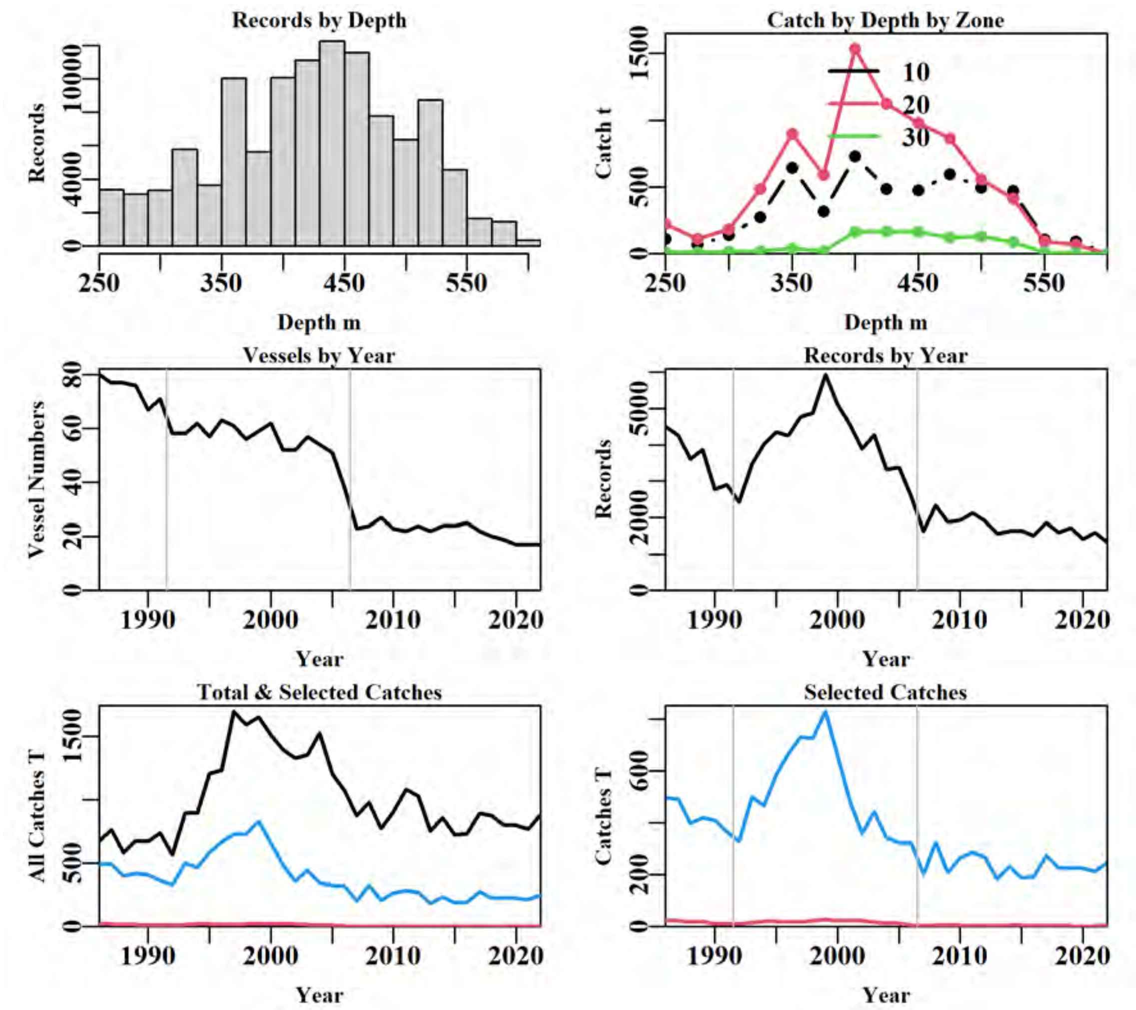

Figure 129: PinkLing1030 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 93: PinkLing1030 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	335421	304906	204388	202084	113526	110866	110821
Difference	0	30515	100518	2304	88558	2660	45
Catch	37398	30220	26667	26282	14841	14153	14143
Difference	0	7179	3553	385	11441	689	9

Table 94: The models used to analyse data for PinkLing1030.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + Zone
Model6	Year + Vessel + DepCat + Month + Zone + DayNight
Model7	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:DepCat
Model8	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:Month

Table 95: PinkLing1030. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	35020	151905	3201	110821	37	2.0	0.00
Vessel	16763	128400	26707	110821	223	17.1	15.02
DepCat	5819	116297	38809	110821	237	24.9	7.81
Month	1853	112186	42921	110821	248	27.5	2.65
Zone	1255	111579	43528	110821	250	27.9	0.39
DayNight	1045	111361	43745	110821	253	28.0	0.14
Zone:DepCat	-256	110006	45100	110821	281	28.9	0.86
Zone:Month	-16	110256	44850	110821	275	28.7	0.70

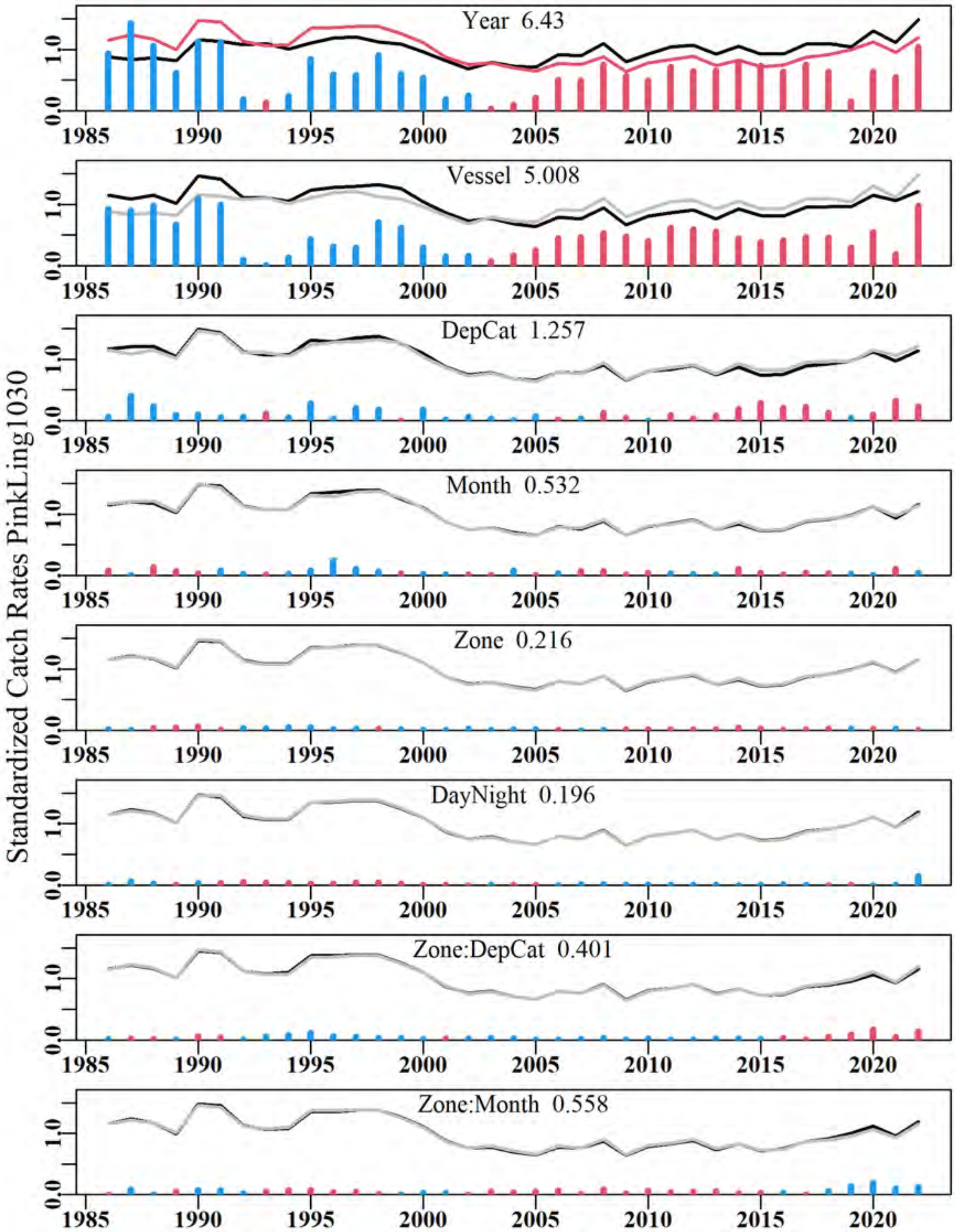

Figure 130: PinkLing1030. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

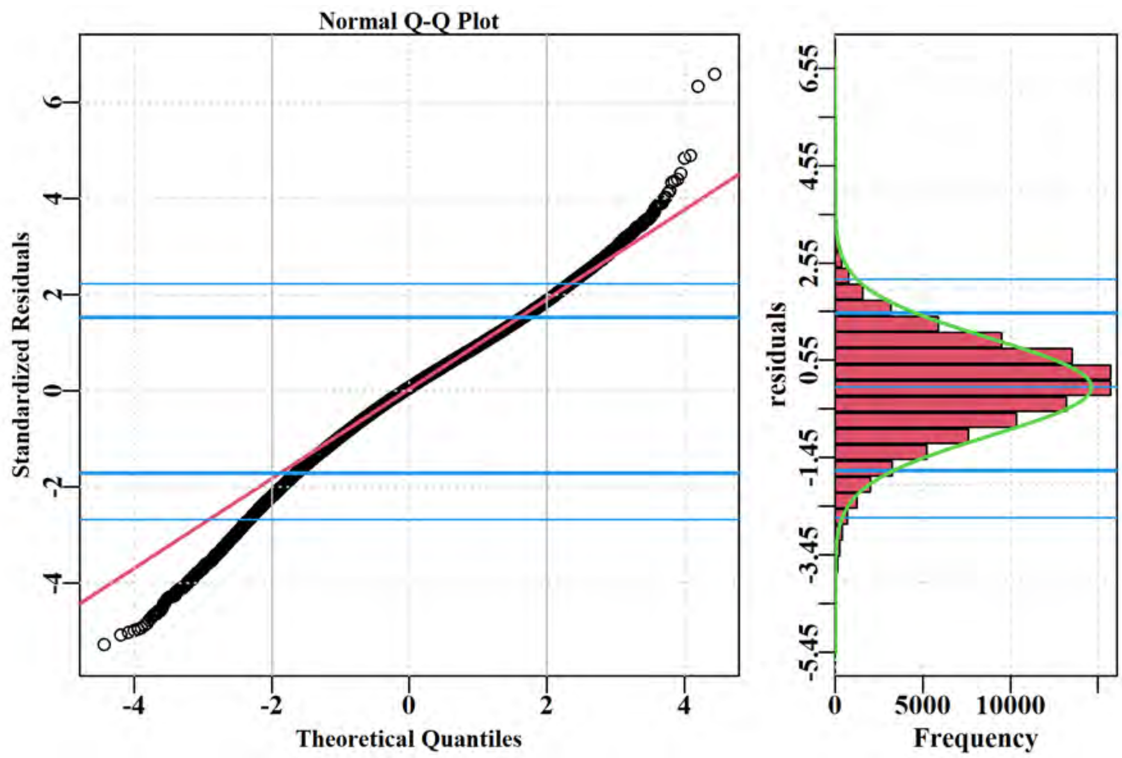

Figure 131: PinkLing1030. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

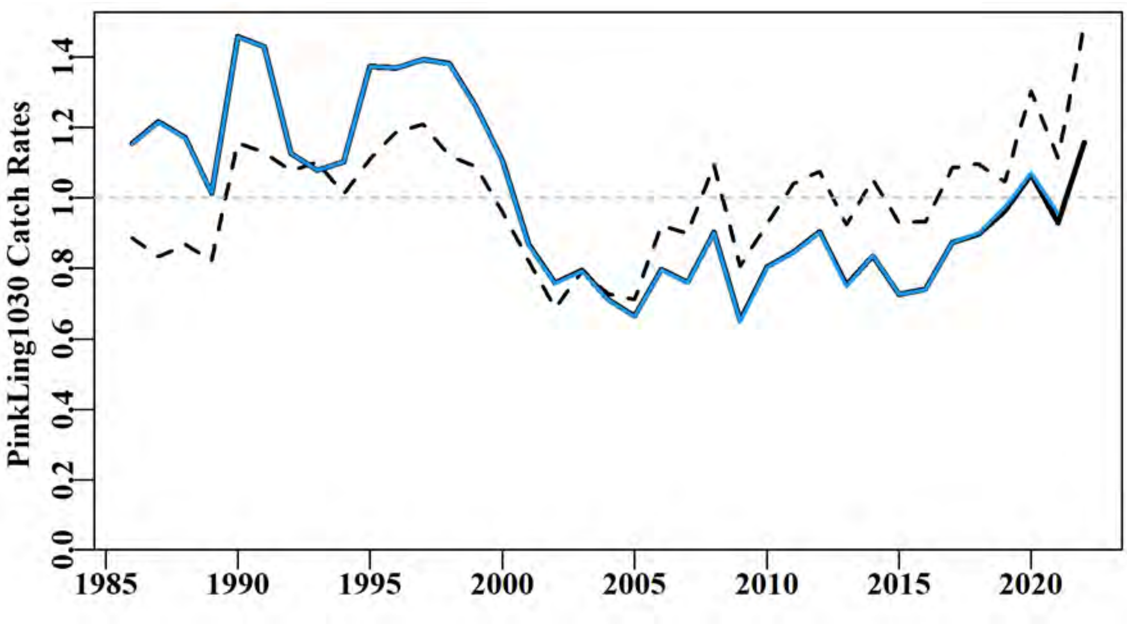

Figure 132: PinkLing1030. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

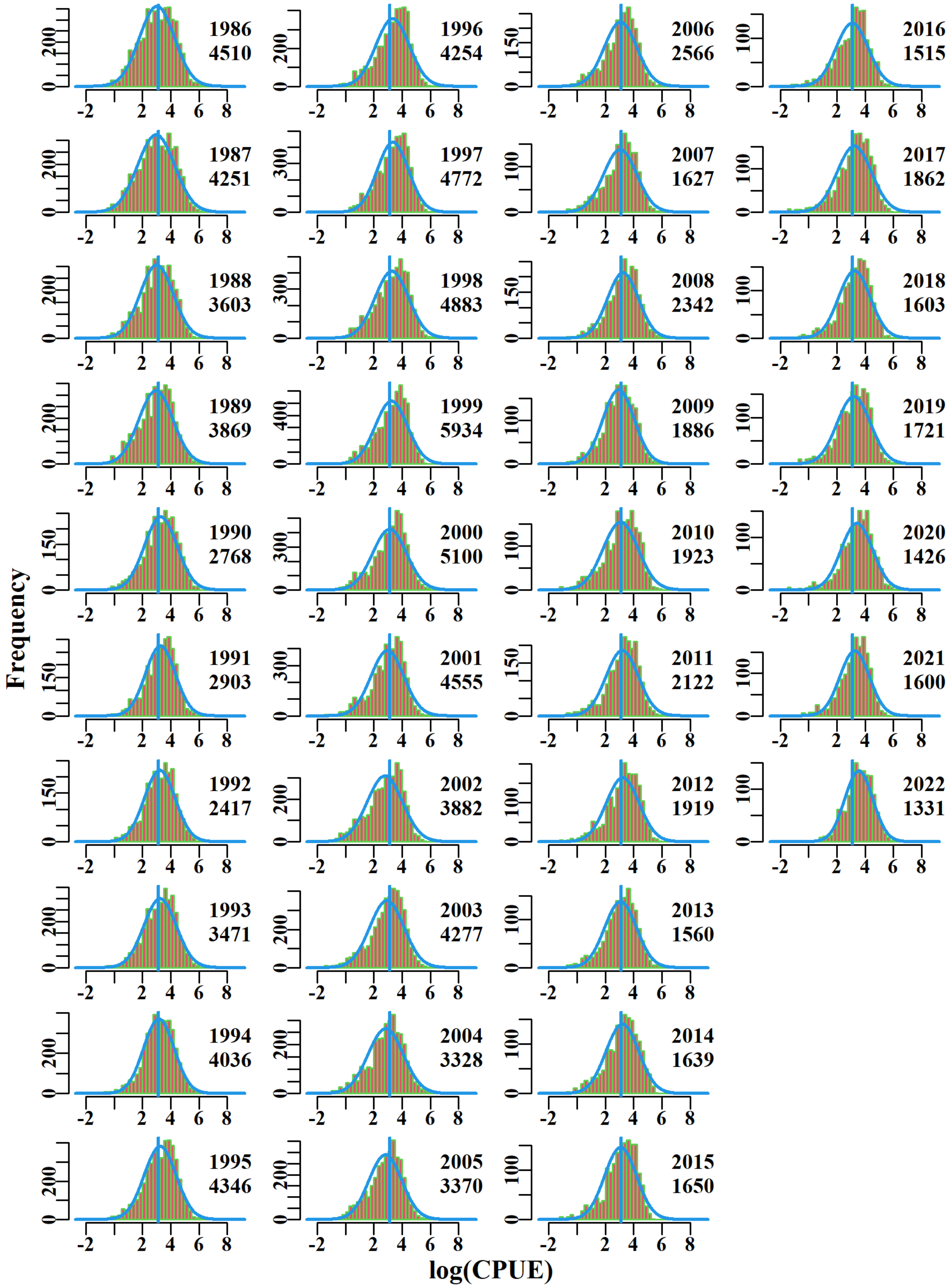

Figure 133: PinkLing1030. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

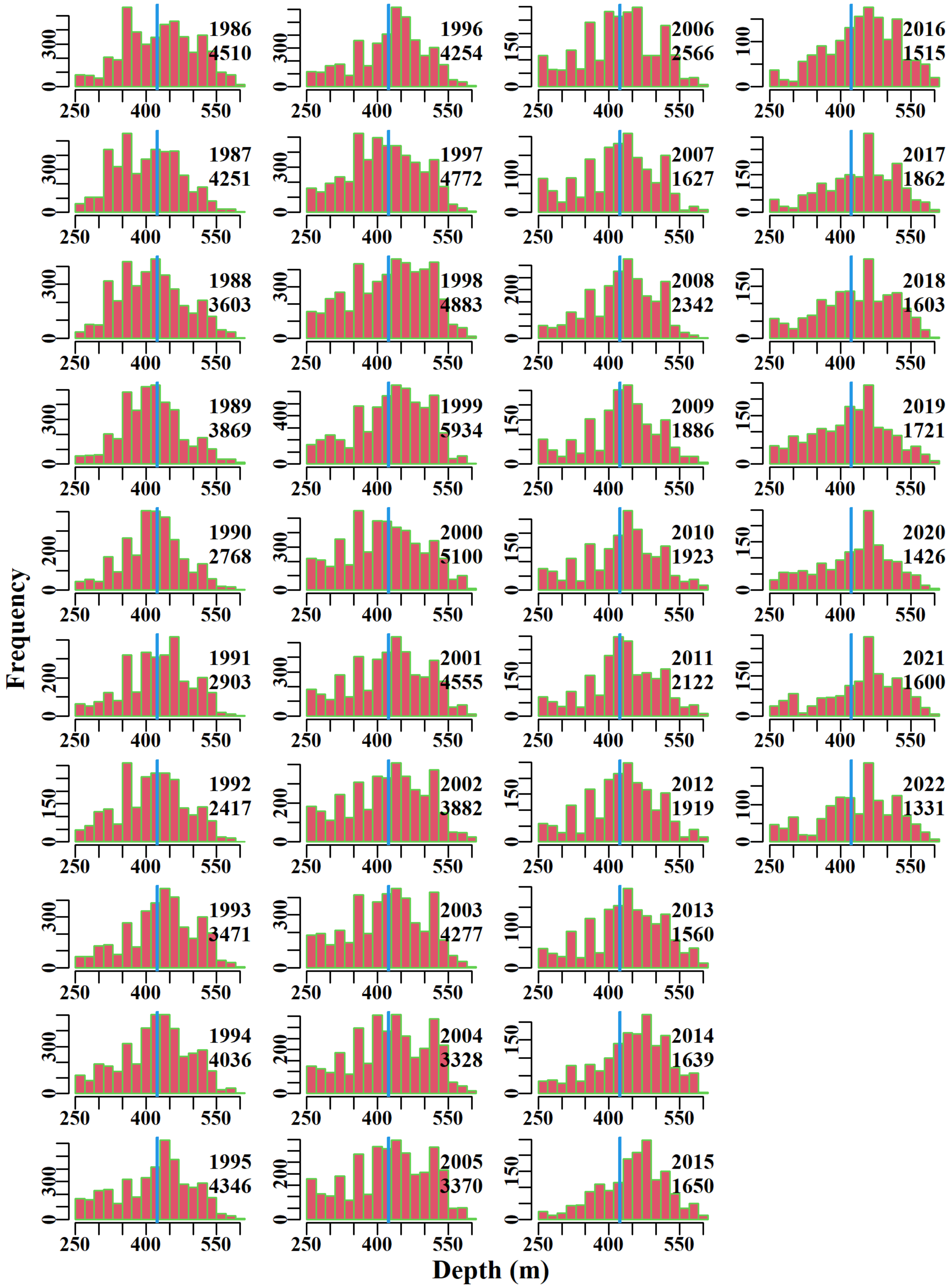

Figure 134: PinkLing1030. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Pink Ling TW 40 - 50

Pink Ling (LIG – 37228002 – *Genypterus blacodes*) was one of the 16 species first included in the quota system in 1992. Pink Ling based on methods TW, TDO, OTM, OTB, in zones 40, 50, and depths 200 to 800 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 96).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this slope species occurred in zone 40 followed by zone 50.

The terms Year, DepCat, Vessel, Month, Zone and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 100). The qqplot suggests a departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 138).

Annual standardized CPUE reached to a minimum in 2005 and increased since then to the long-term average from 2013 to 2016, increased to above average in 2017 to 2018, decreased to the long-term average in 2019 and has been above the long-term average since 2020, based on the 95% confidence intervals (Figure 135). Also, there has been an overall increase in CPUE since 2005 (i.e., the lowest CPUE index). The differences between this years' and last years' standardized series can be mostly attributed to a change in the number of vessels analysed. A vessels' distinguishing symbol which was originally categorized as two different vessels, has been re-categorized as the same vessel in this years' analysis.

Action Items and Issues

Further work on the effect of the structural adjustment is required for Pink Ling in zones 40 and 50.

Table 96: PinkLing4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	PinkLing4050
csirocode	37228002
fishery	SET
depthrange	200 - 800
depthclass	20
zones	40, 50
methods	TW, TDO, OTM, OTB
years	1986 - 2022

Table 97: PinkLing4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	679.0	1265	112.9	23	27.8	1.1361	0.000	6.366	0.056
1987	765.1	1306	205.7	28	52.0	1.2823	0.037	5.740	0.028
1988	583.1	1025	95.5	32	28.0	0.9968	0.040	6.722	0.070
1989	678.9	1466	182.8	34	36.2	1.0269	0.038	8.690	0.048
1990	674.5	1483	135.2	32	26.7	0.9226	0.038	11.943	0.088
1991	736.8	1874	194.8	37	25.6	0.9860	0.037	11.915	0.061
1992	568.3	1629	101.9	24	17.0	0.7365	0.038	12.661	0.124
1993	892.8	2249	235.2	24	26.6	0.9962	0.036	15.744	0.067
1994	895.4	2096	246.1	24	30.8	1.2028	0.036	12.093	0.049
1995	1208.9	3503	425.5	25	31.9	1.2303	0.034	21.945	0.052
1996	1233.3	3385	446.1	26	33.1	1.2975	0.034	22.301	0.050
1997	1696.8	3716	572.2	24	37.2	1.3627	0.034	21.065	0.037
1998	1592.4	3704	555.3	21	38.2	1.3458	0.034	19.110	0.034
1999	1651.6	3784	426.2	24	30.4	1.0677	0.034	23.836	0.056
2000	1507.5	4642	508.4	30	28.6	0.9483	0.034	31.181	0.061
2001	1393.0	5084	500.3	28	24.5	0.8468	0.034	36.867	0.074
2002	1330.3	4619	428.9	27	21.5	0.7336	0.034	36.499	0.085
2003	1353.1	3806	358.4	27	20.5	0.7397	0.034	26.224	0.073
2004	1522.9	3880	302.7	25	17.7	0.6939	0.034	17.723	0.059
2005	1203.3	2650	194.9	23	15.6	0.5801	0.036	11.283	0.058
2006	1069.2	2298	207.9	21	17.9	0.6146	0.036	6.710	0.032
2007	875.9	2505	284.5	16	21.7	0.6765	0.036	7.621	0.027
2008	980.3	1777	211.8	17	24.5	0.8795	0.037	4.357	0.021
2009	775.0	1956	258.3	13	24.6	0.8552	0.037	4.144	0.016
2010	906.2	2316	268.9	14	20.9	0.8323	0.036	4.801	0.018
2011	1081.9	2772	355.3	16	21.6	0.8278	0.035	5.216	0.015
2012	1030.9	2264	333.0	14	25.8	0.8883	0.036	4.383	0.013
2013	752.9	1756	277.7	17	27.9	0.9921	0.038	3.547	0.013
2014	861.2	1944	284.6	15	24.8	0.9759	0.037	3.547	0.012
2015	721.9	1638	238.4	13	25.1	0.9560	0.038	2.734	0.011
2016	736.0	1582	232.0	13	27.5	1.0369	0.038	3.653	0.016
2017	896.7	1768	294.1	12	28.7	1.1871	0.038	1.999	0.007
2018	874.0	1688	318.2	12	30.8	1.1516	0.038	1.716	0.005
2019	799.2	1586	242.0	13	24.5	1.0742	0.038	2.869	0.012
2020	801.4	1477	258.7	12	29.3	1.2324	0.039	3.104	0.012
2021	766.4	1415	256.9	10	32.8	1.2812	0.039	2.713	0.011
2022	884.0	1463	306.8	9	31.5	1.4058	0.039	2.204	0.007

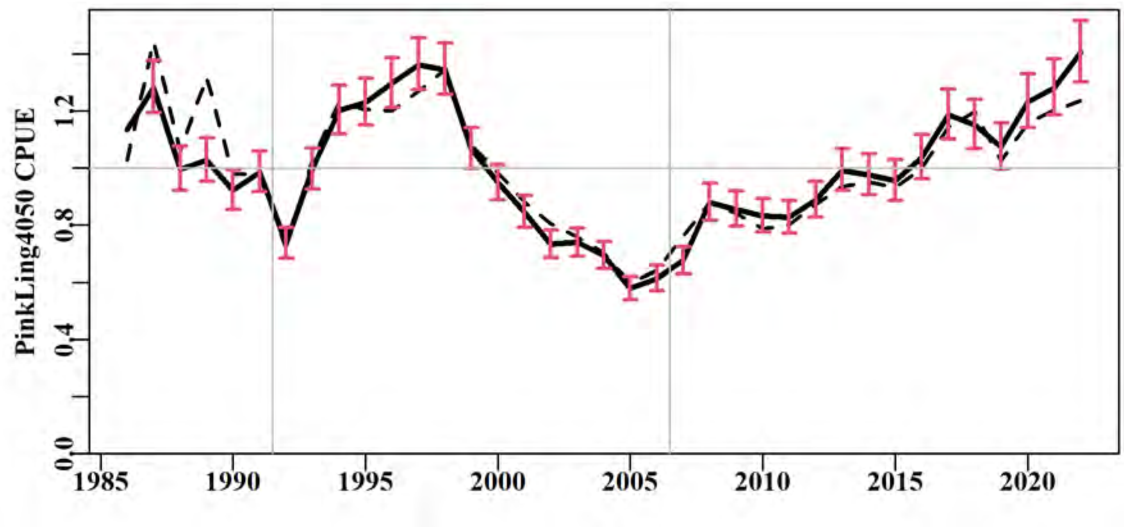

Figure 135: PinkLing4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

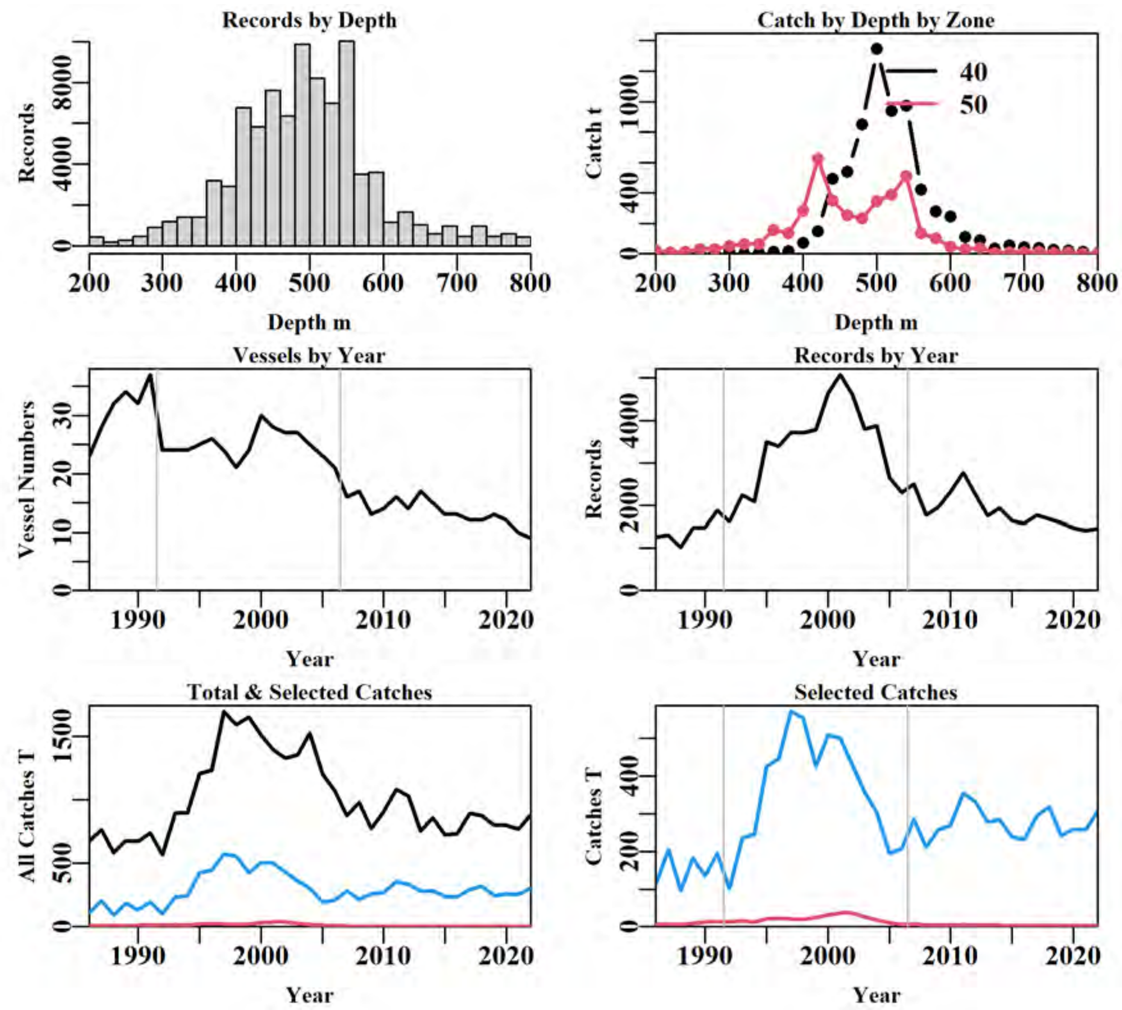

Figure 136: PinkLing4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 98: PinkLing4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	335421	304906	226603	224124	91021	89455	89371
Difference	0	30515	78303	2479	133103	1566	84
Catch	37398	30220	28294	27891	11700	10862	10858
Difference	0	7179	1926	403	16191	837	5

Table 99: The models used to analyse data for PinkLing4050.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + Month
Model5	Year + DepCat + Vessel + Month + Zone
Model6	Year + DepCat + Vessel + Month + Zone + DayNight
Model7	Year + DepCat + Vessel + Month + Zone + DayNight + Zone:DepCat
Model8	Year + DepCat + Vessel + Month + Zone + DayNight + Zone:Month

Table 100: PinkLing4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	-1445	87865	4270	89371	37	4.6	0.00
DepCat	-14470	75898	16238	89371	67	17.6	12.97
Vessel	-21551	69958	22178	89371	168	23.9	6.37
Month	-24591	67602	24534	89371	179	26.5	2.55
Zone	-25637	66814	25322	89371	180	27.3	0.86
DayNight	-25674	66782	25354	89371	183	27.4	0.03
Zone:DepCat	-26622	66033	26103	89371	213	28.2	0.79
Zone:Month	-27382	65501	26634	89371	194	28.8	1.38

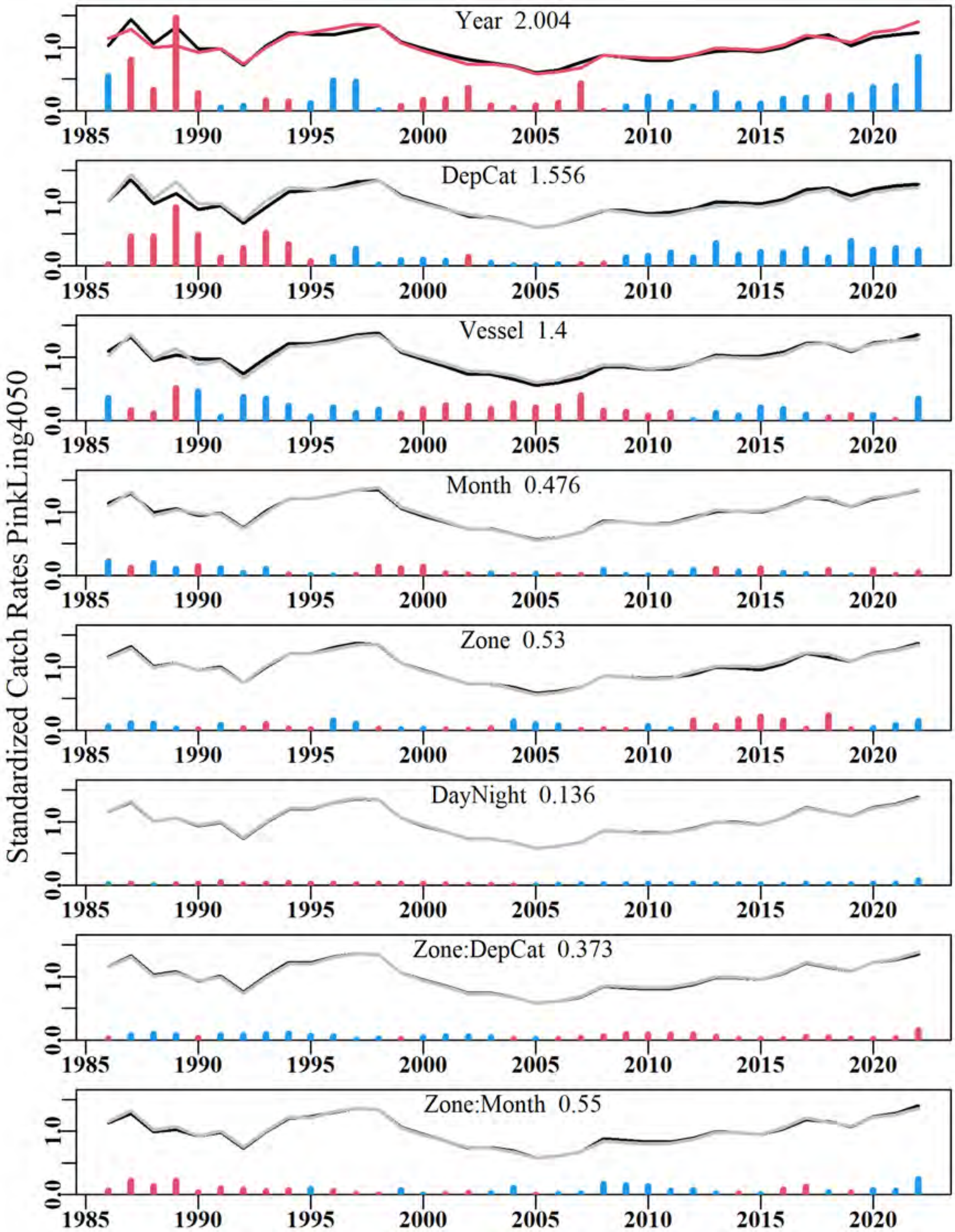

Figure 137: PinkLing4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

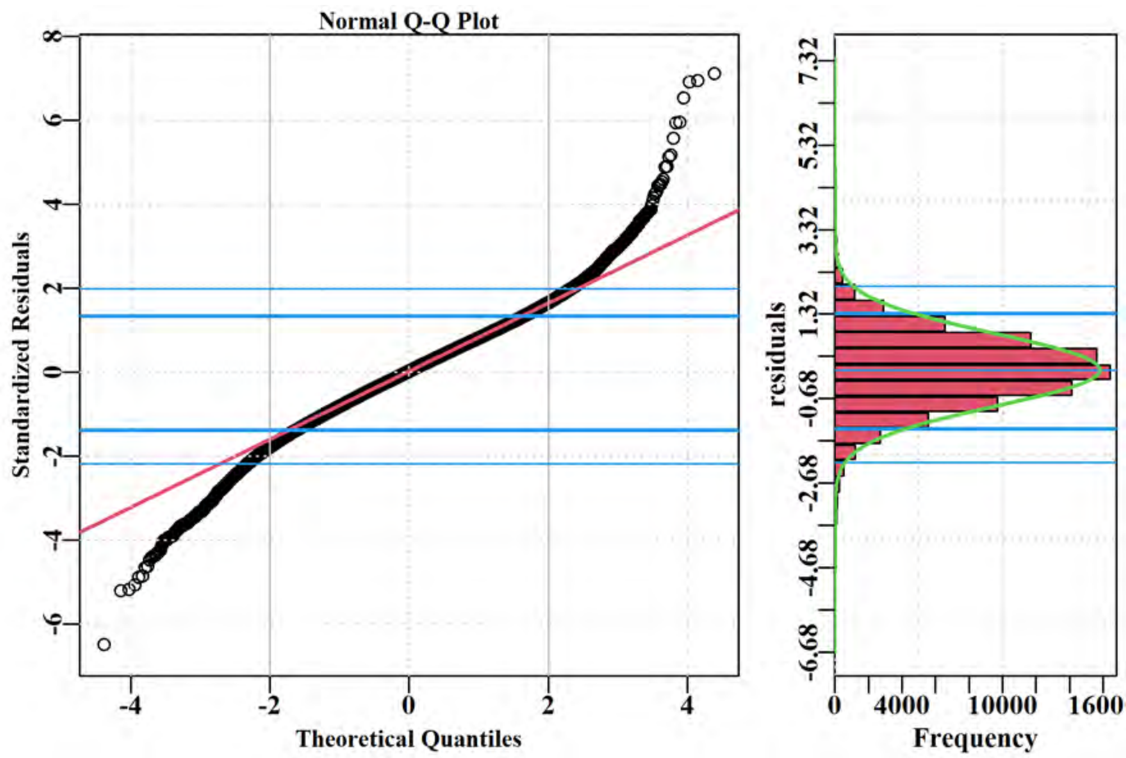

Figure 138: PinkLing4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

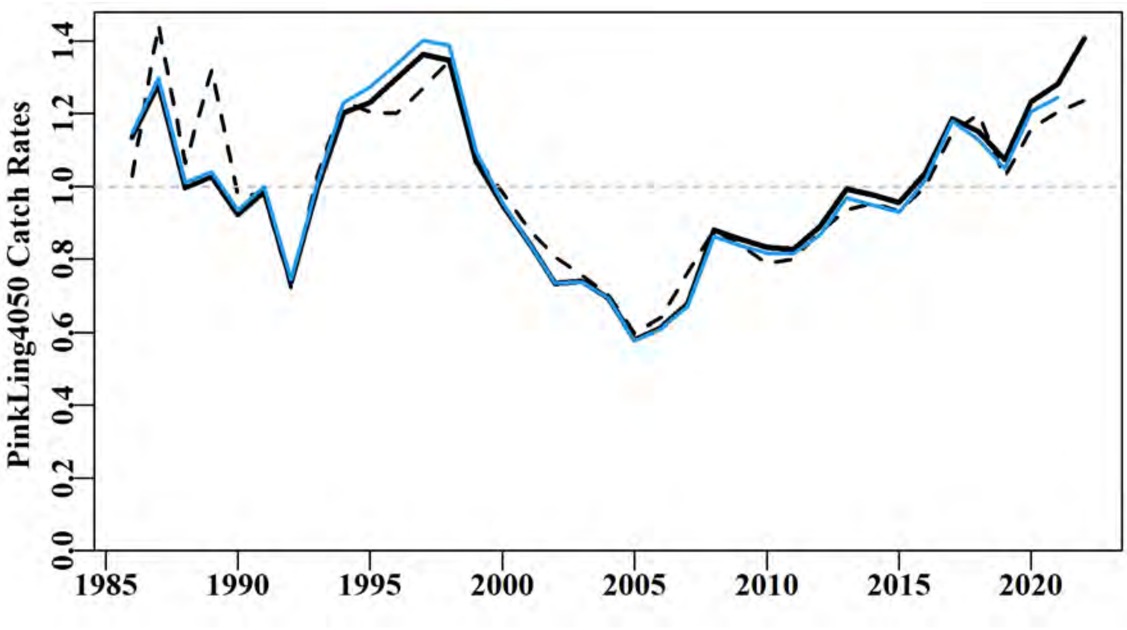

Figure 139: PinkLing4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

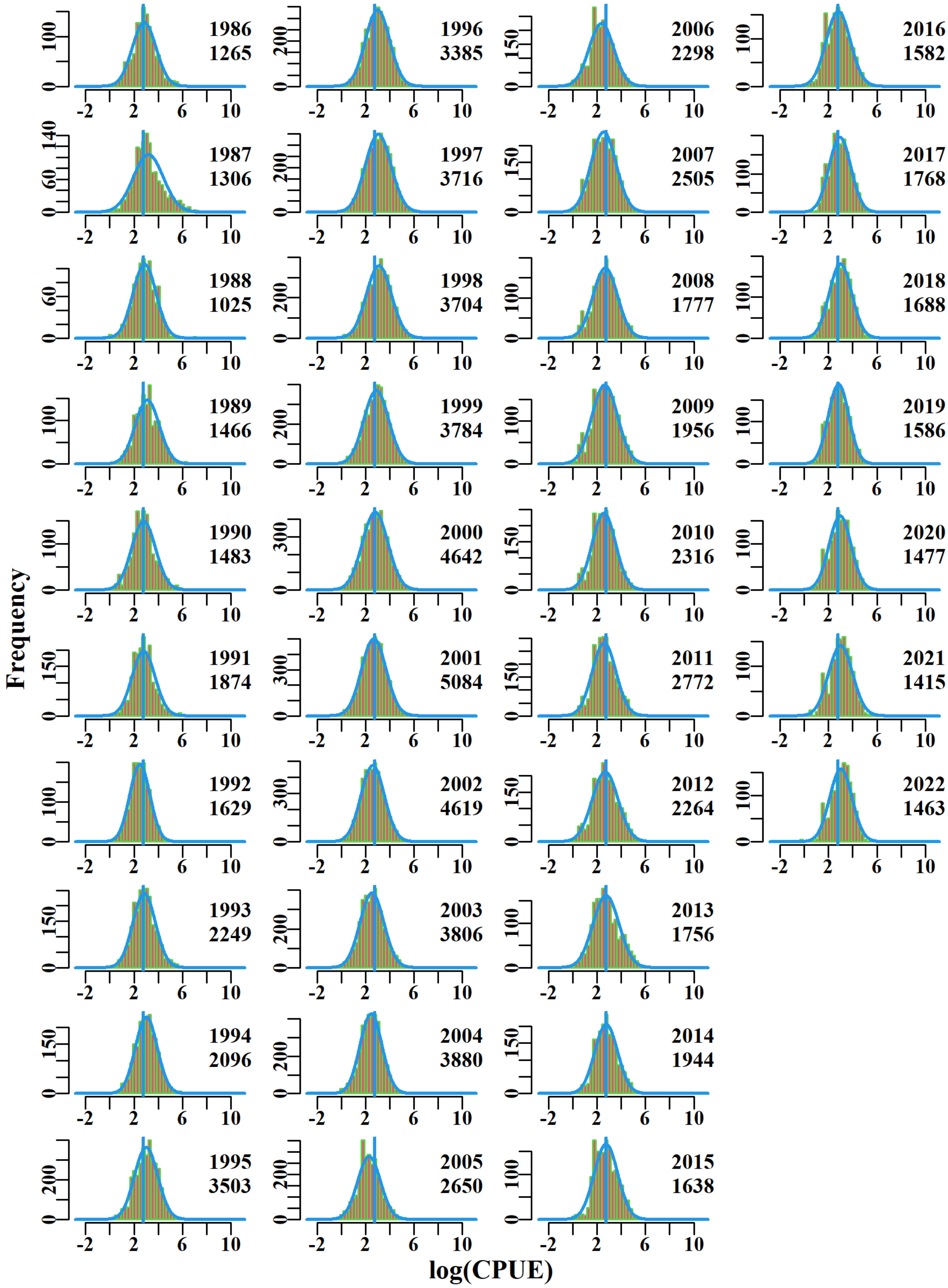

Figure 140: PinkLing4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

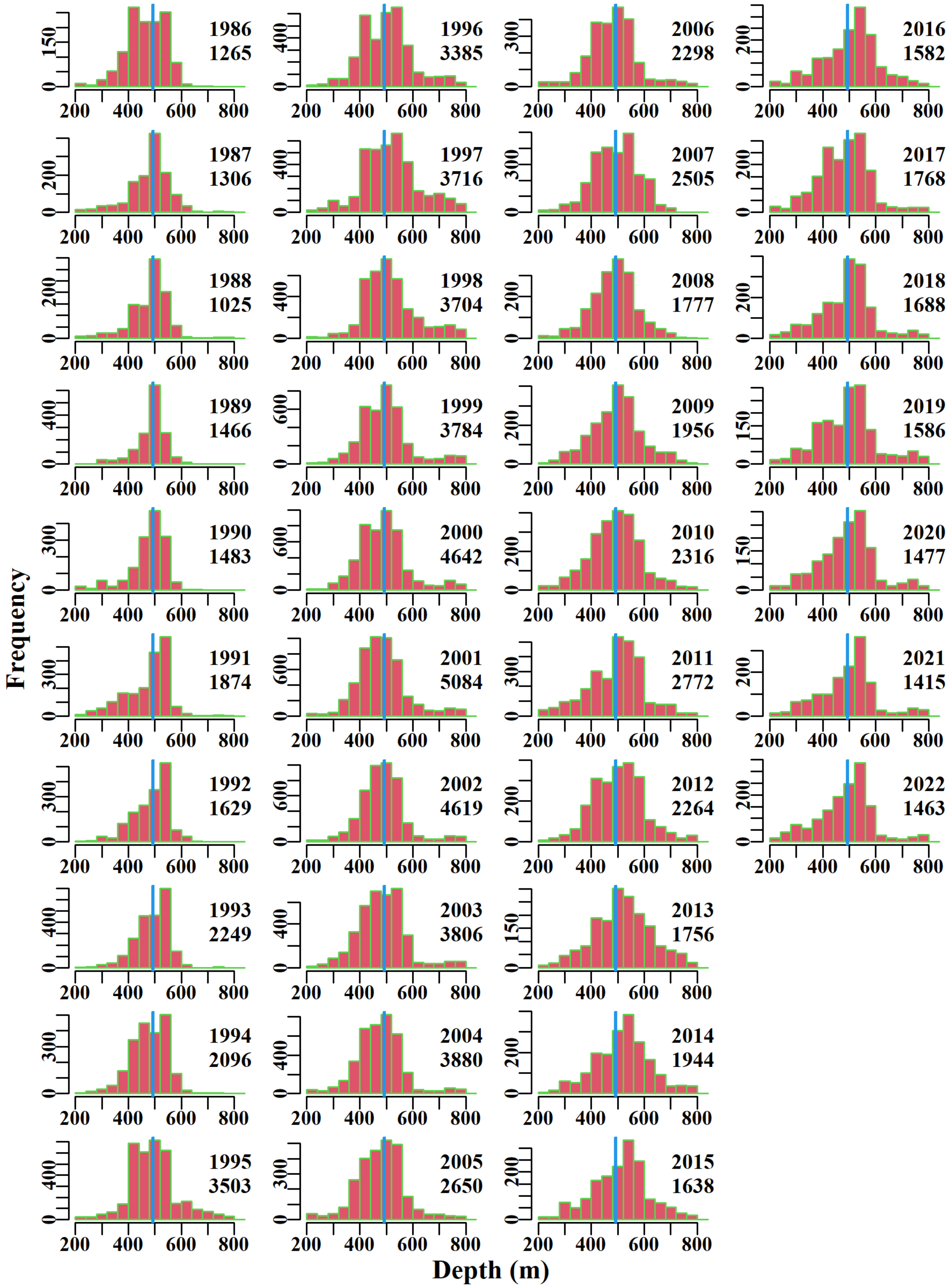

Figure 141: PinkLing4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Ocean Perch Offshore 1020

Offshore Ocean Perch (REG–37287001 – *Helicolenus percoides*) was one of the 16 species first included in the quota system in 1992. Trawl caught offshore Ocean Perch based on methods TW, TDO, OTB, OTT, in zones 10, 20, and depths 200 to 700 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 101).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 10 followed by zone 20. Over the period when CPUE was lower than average (about 1996 - 2006) there was an increase in shots of < 30 kg (Figure 143), which is suggestive of either low availability or high levels of small fish. The total Offshore Ocean Perch catch (87.1 t) and corresponding number of vessels (14) from zones 10 and 20 in 2022 was the lowest in the series.

The terms Year, Month, Vessel, DepCat and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining up to 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 105). The qqplot suggests a slight departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 145).

Annual standardized CPUE has been below average and relatively flat between 1995 and 2006. The trend from 2007 to 2010 has also been relatively flat and on average, below average and flat between 2011 to 2016 and increasing to either on or above average since 2017, based on 95% confidence intervals (Figure 142). Also, standardized CPUE has increased since 2015 and the 2022 estimate was the highest in the series.

Action Items and Issues

No issues identified.

Table 101: OceanPerchOffshore1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	OceanPerchOffshore1020
csirocode	37287901, 37287093, 37287001, 91287001, 92287001
fishery	SET
depthrange	200 - 700
depthclass	25
zones	10, 20
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 102: OceanPerchOffshore1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	262.4	3478	207.4	77	21.5	0.9526	0.000	27.364	0.132
1987	198.4	3137	132.8	70	15.8	0.8772	0.026	27.705	0.209
1988	188.4	2806	150.7	73	18.6	0.9796	0.027	23.405	0.155
1989	209.2	3029	159.6	67	19.6	0.9417	0.027	24.547	0.154
1990	181.7	1958	115.3	57	20.6	1.2499	0.030	15.715	0.136
1991	223.6	2073	138.0	53	24.5	1.3180	0.030	16.912	0.123
1992	169.7	1850	114.2	48	20.4	1.1221	0.031	16.166	0.142
1993	259.6	2905	197.4	52	21.7	1.1267	0.027	25.126	0.127
1994	257.3	3000	179.9	49	22.0	1.0489	0.027	26.269	0.146
1995	240.0	3138	150.0	50	18.1	0.9269	0.027	31.852	0.212
1996	263.9	3401	176.1	53	17.8	0.8301	0.026	31.446	0.179
1997	298.8	3707	192.6	53	17.2	0.8737	0.026	35.444	0.184
1998	295.0	3837	194.0	49	17.3	0.7783	0.026	36.497	0.188
1999	295.8	4398	218.4	52	16.8	0.8668	0.025	42.854	0.196
2000	270.2	4168	180.7	53	14.9	0.7322	0.026	40.560	0.224
2001	281.6	4050	184.5	43	16.7	0.8462	0.026	38.378	0.208
2002	255.3	3631	150.2	45	15.9	0.7877	0.027	32.844	0.219
2003	322.7	3944	184.5	53	17.3	0.8374	0.026	35.032	0.190
2004	316.3	3111	149.7	46	17.9	0.8471	0.028	25.834	0.173
2005	316.8	3041	167.5	46	19.9	0.9585	0.028	26.055	0.156
2006	237.6	2309	112.7	38	15.6	0.8314	0.030	22.962	0.204
2007	180.6	1519	94.7	22	20.2	1.0678	0.033	14.042	0.148
2008	184.3	1830	101.4	23	17.5	0.9681	0.032	16.250	0.160
2009	173.9	1662	98.9	23	20.0	0.9716	0.033	15.540	0.157
2010	195.6	1726	117.2	21	22.7	0.9467	0.032	14.324	0.122
2011	186.9	1843	115.5	22	23.4	0.8750	0.032	15.249	0.132
2012	183.9	1673	113.4	22	26.2	0.9222	0.033	13.219	0.117
2013	171.2	1275	102.3	20	30.1	0.9880	0.035	9.158	0.090
2014	174.4	1521	115.8	21	29.6	0.9681	0.033	10.391	0.090
2015	150.8	1404	104.9	22	31.5	0.8388	0.034	9.146	0.087
2016	132.1	1144	93.4	23	31.1	0.9013	0.037	6.982	0.075
2017	155.7	1390	107.6	19	29.7	0.9597	0.035	8.647	0.080
2018	151.8	1290	102.3	17	28.3	1.0617	0.036	8.103	0.079
2019	165.5	1296	105.3	18	28.2	1.2793	0.036	8.596	0.082
2020	141.8	1295	96.0	16	25.2	1.4289	0.036	9.341	0.097
2021	170.8	1360	123.6	14	31.8	1.5315	0.036	7.184	0.058
2022	150.2	1022	87.1	14	26.1	1.5581	0.039	6.423	0.074

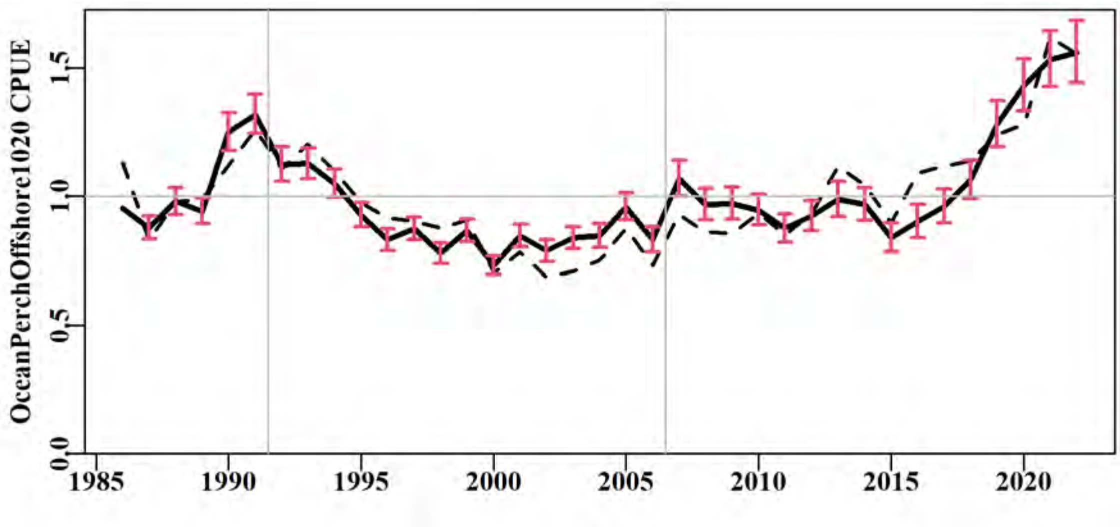

Figure 142: OceanPerchOffshore1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

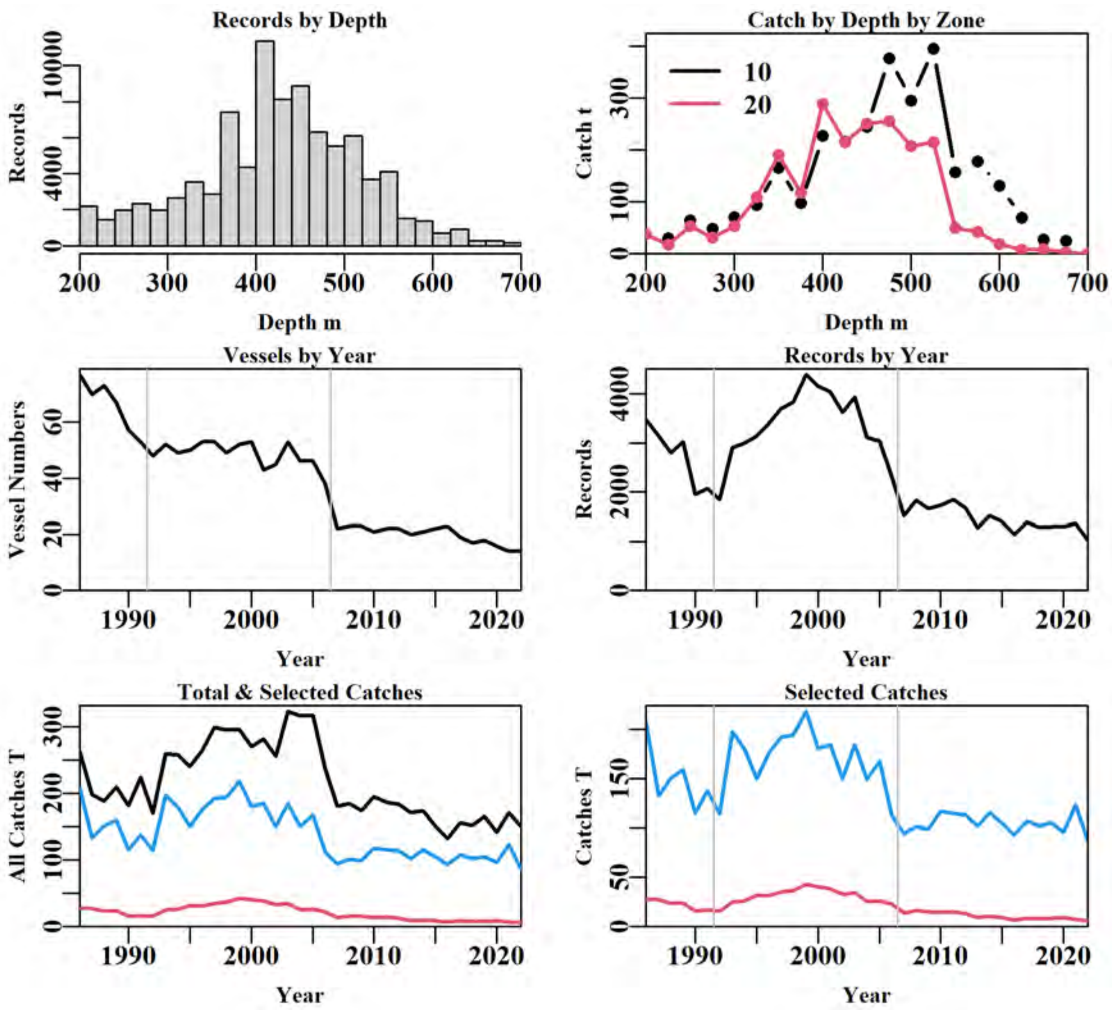

Figure 143: OceanPerchOffshore1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 103: OceanPerchOffshore1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	186507	166098	135397	133631	91162	90268	90221
Difference	0	20409	30701	1766	42469	894	47
Catch	8157	7523	6625	6490	5212	5139	5135
Difference	0	634	897	135	1278	73	4

Table 104: The models used to analyse data for OceanPerchOffshore1020.

	Model
Model1	Year
Model2	Year + Month
Model3	Year + Month + Vessel
Model4	Year + Month + Vessel + DepCat
Model5	Year + Month + Vessel + DepCat + DayNight
Model6	Year + Month + Vessel + DepCat + DayNight + Zone
Model7	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:Month
Model8	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:DepCat

Table 105: OceanPerchOffshore1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	28102	123091	3323	90221	37	2.6	0.00
Month	26641	121084	5330	90221	48	4.2	1.58
Vessel	12019	102597	23817	90221	211	18.7	14.49
DepCat	1290	91053	35361	90221	231	27.8	9.14
DayNight	671	90424	35990	90221	234	28.3	0.50
Zone	647	90398	36016	90221	235	28.3	0.02
Zone:Month	-1376	88373	38041	90221	246	29.9	1.60
Zone:DepCat	96	89808	36606	90221	255	28.8	0.45

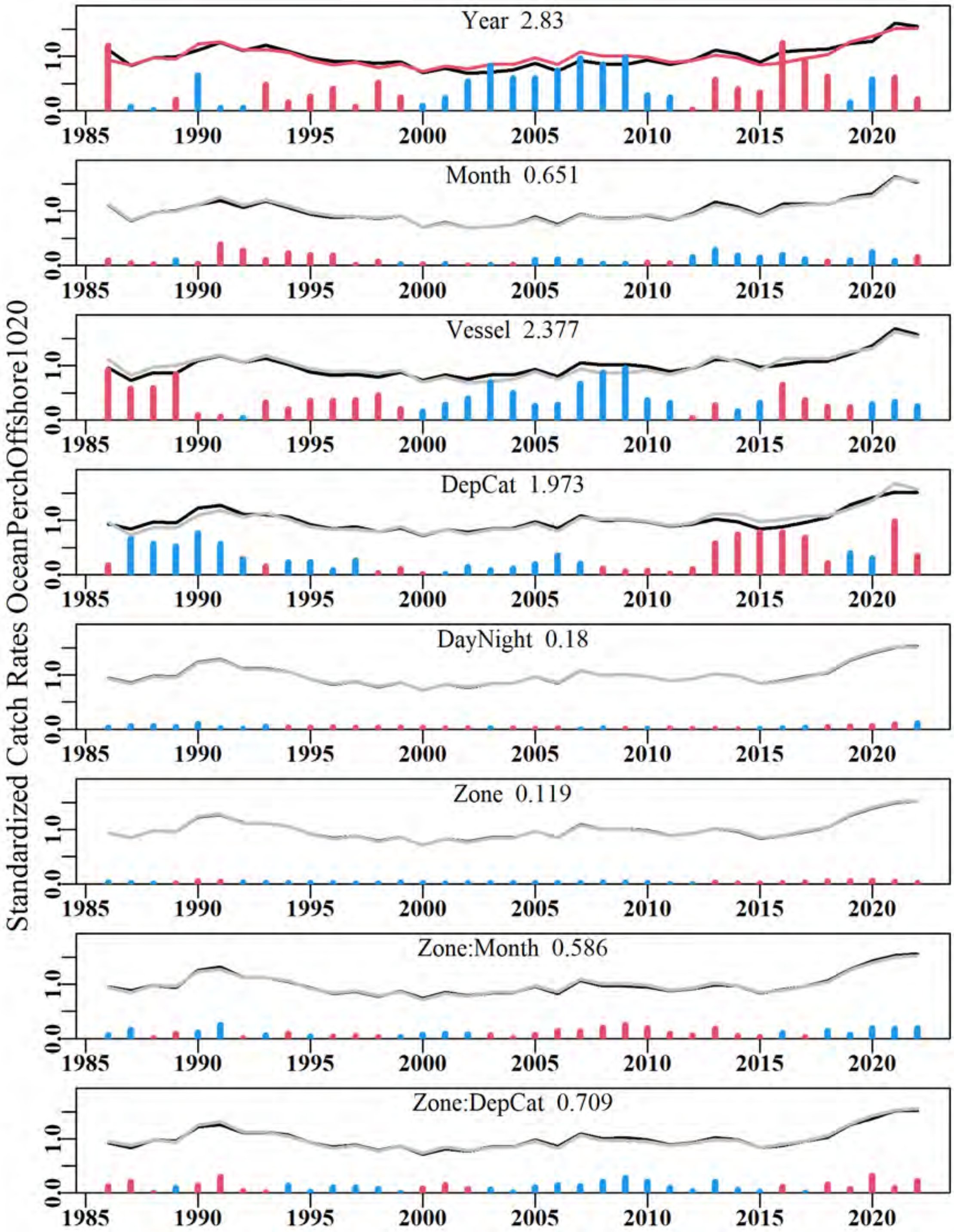

Figure 144: OceanPerchOffshore1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

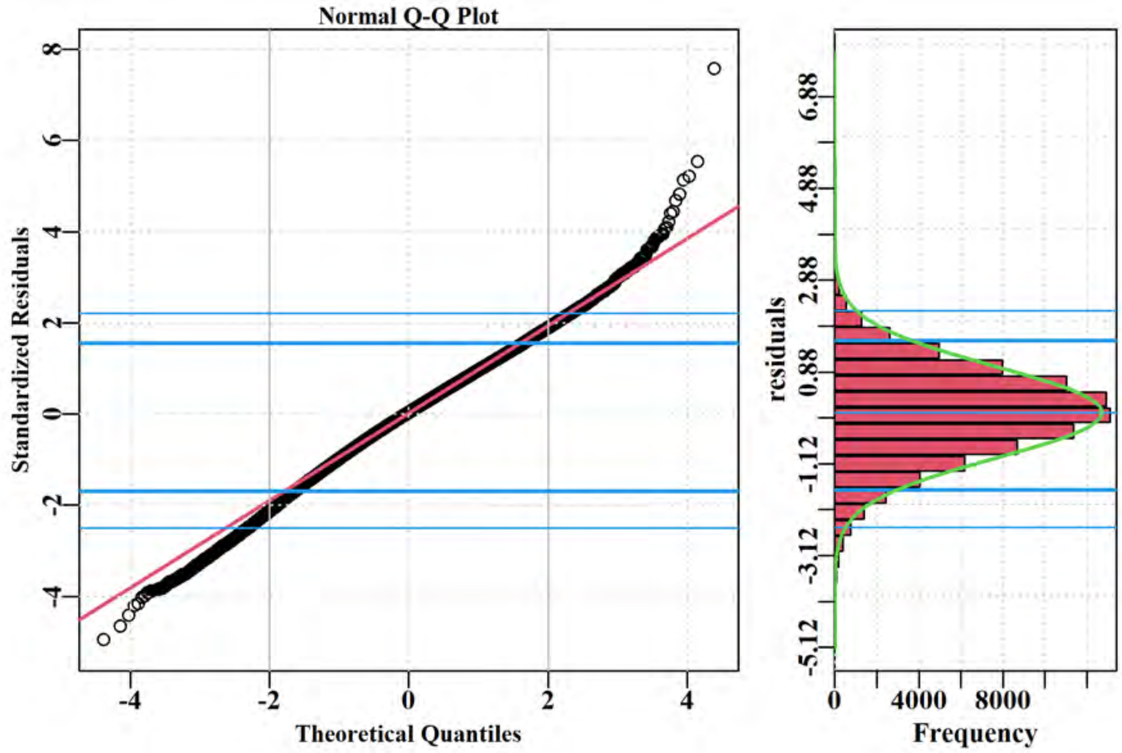

Figure 145: OceanPerchOffshore1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

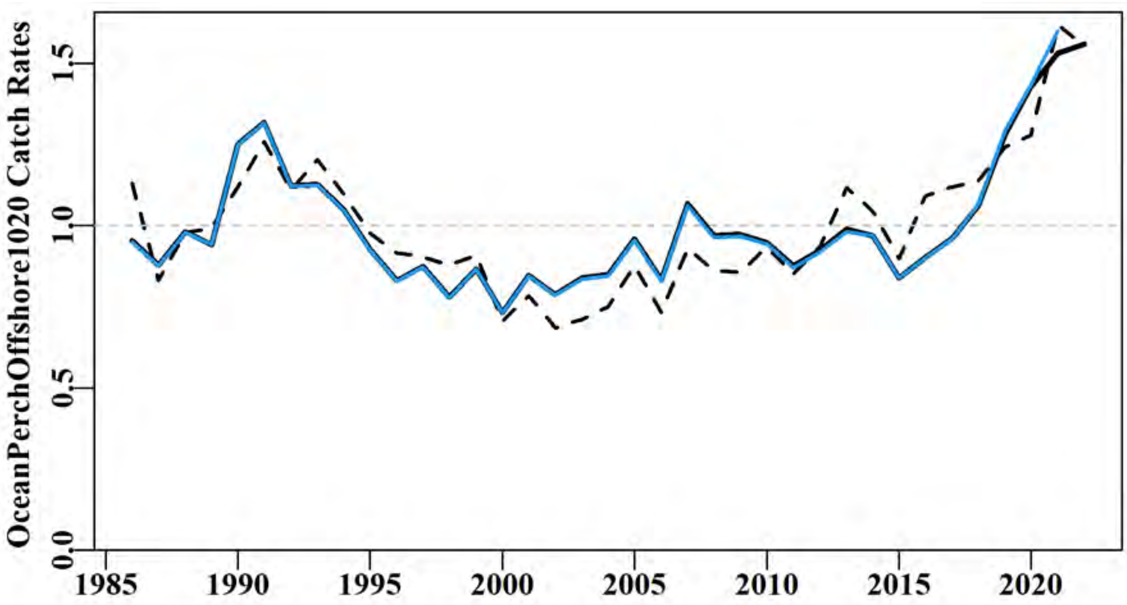

Figure 146: OceanPerchOffshore1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

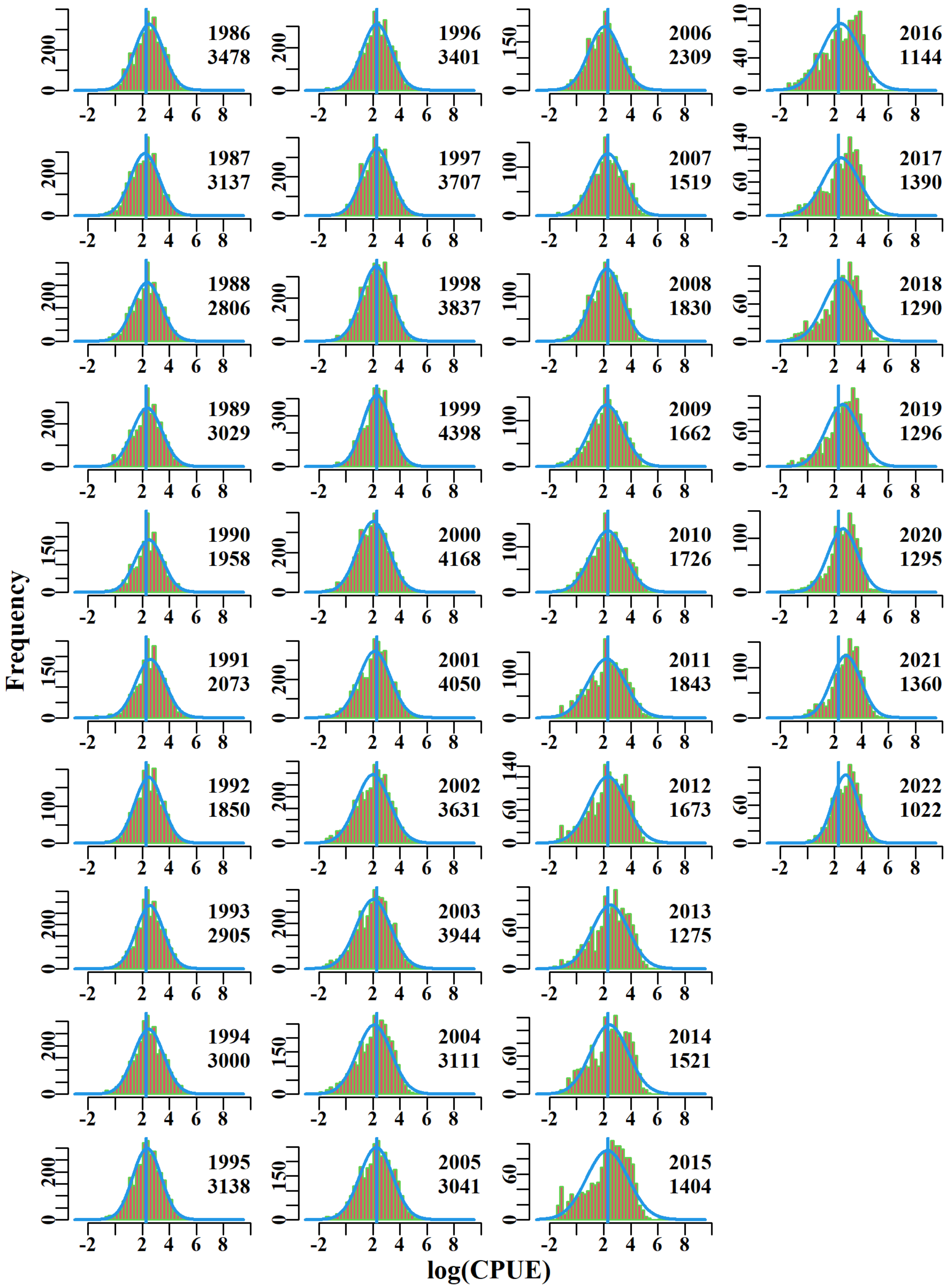

Figure 147: OceanPerchOffshore1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

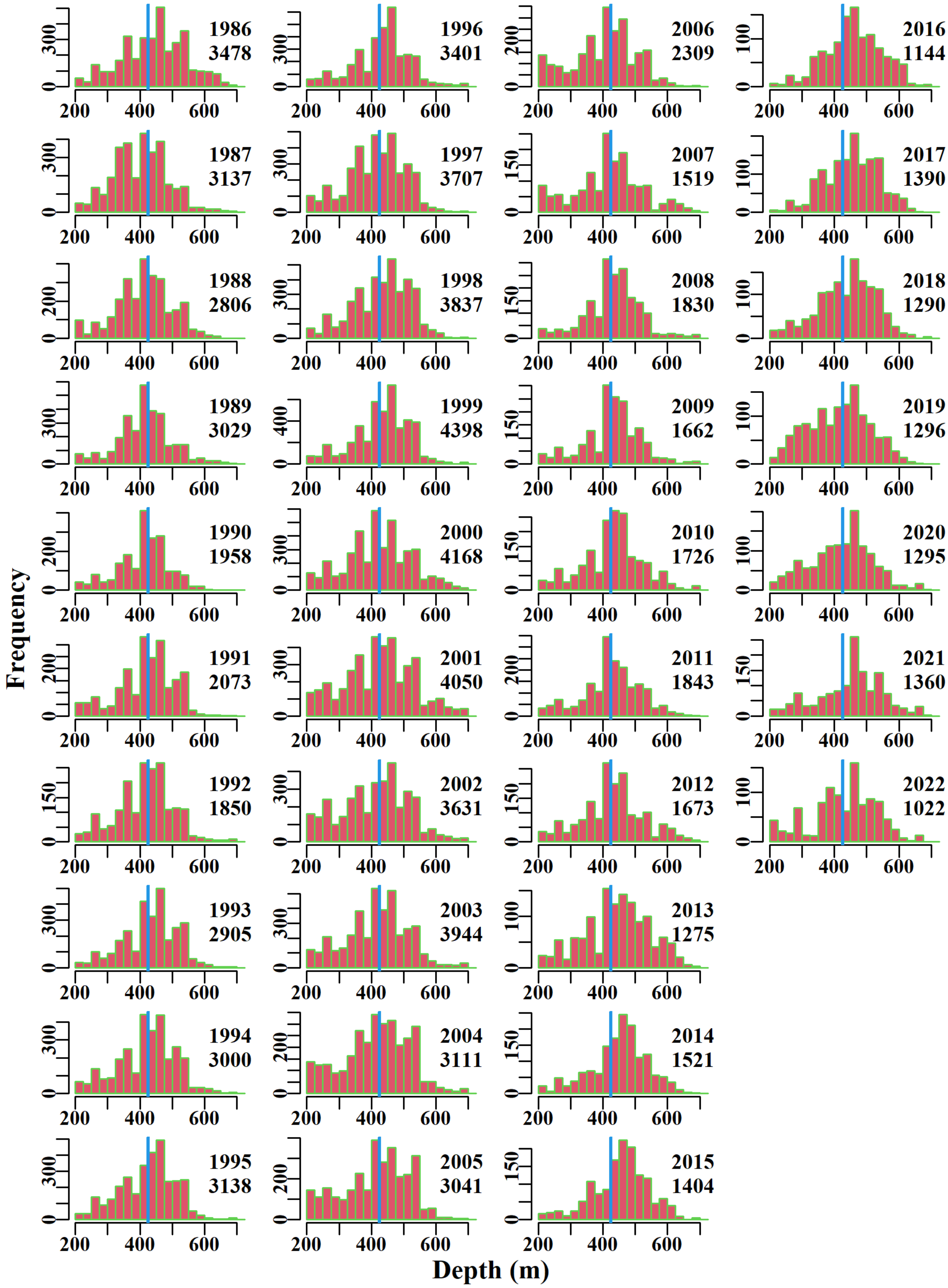

Figure 148: OceanPerchOffshore1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Ocean Perch Offshore 10-50

Offshore Ocean Perch (REG - 37287001 - *Helicolenus percoides*) caught by trawl based on methods TW, TDO, OTB, OTT, in zones 10, 20, 30, 40, 50, and depths 200 to 700 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 106).

A total of 8 statistical models were fitted sequentially to the available data.

Inferences

The majority of catch of this species occurred in zone 10 followed by zone 20 while catches in zones 30, 40, and 50 remain relatively minor. Over the period when CPUE was lower than average (about 1996 - 2006) there was an increase in shots of < 30kg (Figure 150), which is suggestive of either low availability or high levels of small fish.

The terms Year, Month, Vessel, DepCat, Zone and interaction Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining up to 1% of the overall variation in CPUE, based on the AIC and R^2 statistics.

Annual standardized CPUE has been below average and relatively flat between 1995 and 2006. The trend from 2007 to 2010 has also been relatively flat and on average, below average and flat between 2011 to 2016 and consistently increasing to either on average or above average since 2017, based on 95% confidence intervals (Figure 149). Also, CPUE has increased since 2015 and the 2022 estimate was the highest in the series.

Action Items and Issues

The generally lower CPUE for Offshore Ocean Perch in zones 30, 40, and 50 suggest it is not a major target species in those zones. It is recommended that the Tier 4 for Offshore Ocean Perch continue using the analysis presented in Offshore Ocean Perch for zones 10 and 20 as CPUE in those zones would seem to be more indicative of the main location for the stock.

Table 106: OceanPerchOffshore1050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	OceanPerchOffshore1050
csirocode	37287901, 37287093, 37287001, 91287001, 92287001
fishery	SET
depthrange	200 - 700
depthclass	25
zones	10, 20, 30, 40, 50
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 107: OceanPerchOffshore1050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	262.4	3727	220.7	92	20.9	1.0394	0.000	29.820	0.135
1987	198.4	3409	144.5	93	15.7	0.9476	0.024	30.071	0.208
1988	188.4	3097	161.3	93	18.4	1.0687	0.025	26.371	0.163
1989	209.2	3412	173.2	86	18.8	1.0399	0.025	29.526	0.170
1990	181.7	2423	131.5	80	18.6	1.3154	0.027	22.128	0.168
1991	223.6	2853	169.5	87	21.3	1.3690	0.026	26.864	0.159
1992	169.7	2375	130.3	70	17.7	1.1260	0.027	22.496	0.173
1993	259.6	3644	221.9	68	19.2	1.1664	0.024	35.361	0.159
1994	257.3	3782	208.3	66	19.1	1.1184	0.024	38.140	0.183
1995	240.0	4437	191.0	69	15.2	1.0360	0.023	50.683	0.265
1996	263.9	4848	213.8	76	14.5	0.9210	0.023	53.199	0.249
1997	298.8	5594	246.5	71	13.8	0.9591	0.023	59.734	0.242
1998	295.0	5325	240.4	67	14.6	0.8859	0.023	55.634	0.231
1999	295.8	5776	255.7	72	14.8	0.9196	0.023	61.811	0.242
2000	270.2	5686	217.7	79	12.9	0.7919	0.023	59.058	0.271
2001	281.6	5960	228.9	68	13.4	0.8548	0.023	63.067	0.276
2002	255.3	5596	195.1	69	12.4	0.8123	0.023	57.058	0.292
2003	322.7	5775	231.1	66	13.4	0.8786	0.023	57.348	0.248
2004	316.3	5099	202.2	68	12.9	0.8968	0.024	50.046	0.248
2005	316.8	4505	201.2	64	14.9	0.9202	0.024	42.533	0.211
2006	237.6	3337	137.9	52	12.4	0.8218	0.026	34.920	0.253
2007	180.6	2609	121.6	33	13.6	0.9474	0.027	26.037	0.214
2008	184.3	2665	124.5	32	13.8	0.9428	0.027	25.722	0.207
2009	173.9	2705	128.7	32	13.9	0.9278	0.027	27.628	0.215
2010	195.6	2892	150.7	32	14.4	0.9442	0.026	29.748	0.197
2011	186.9	3107	146.6	30	14.6	0.8069	0.026	29.911	0.204
2012	183.9	2755	135.9	30	16.9	0.7802	0.027	23.894	0.176
2013	171.2	2302	126.1	29	17.5	0.8364	0.028	19.464	0.154
2014	174.4	2401	136.8	30	18.6	0.8793	0.028	20.507	0.150
2015	150.8	2171	124.2	31	19.8	0.7834	0.029	17.105	0.138
2016	132.1	1714	109.0	30	21.3	0.8683	0.031	12.294	0.113
2017	155.7	1943	121.8	26	22.9	0.9308	0.030	14.726	0.121
2018	151.8	1629	112.3	25	23.3	1.0529	0.031	11.054	0.098
2019	165.5	1778	121.0	24	21.7	1.2443	0.031	13.334	0.110
2020	141.8	1682	108.4	22	20.5	1.3097	0.031	13.494	0.125
2021	170.8	1762	137.5	21	25.9	1.3835	0.031	10.782	0.078
2022	150.2	1581	111.1	21	18.9	1.4732	0.032	12.301	0.111

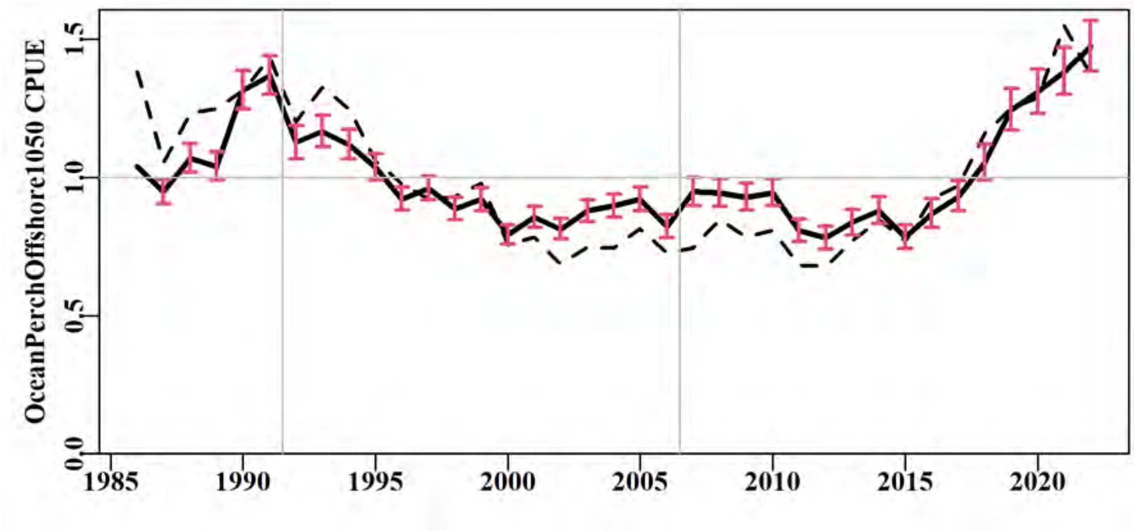

Figure 149: OceanPerchOffshore1050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

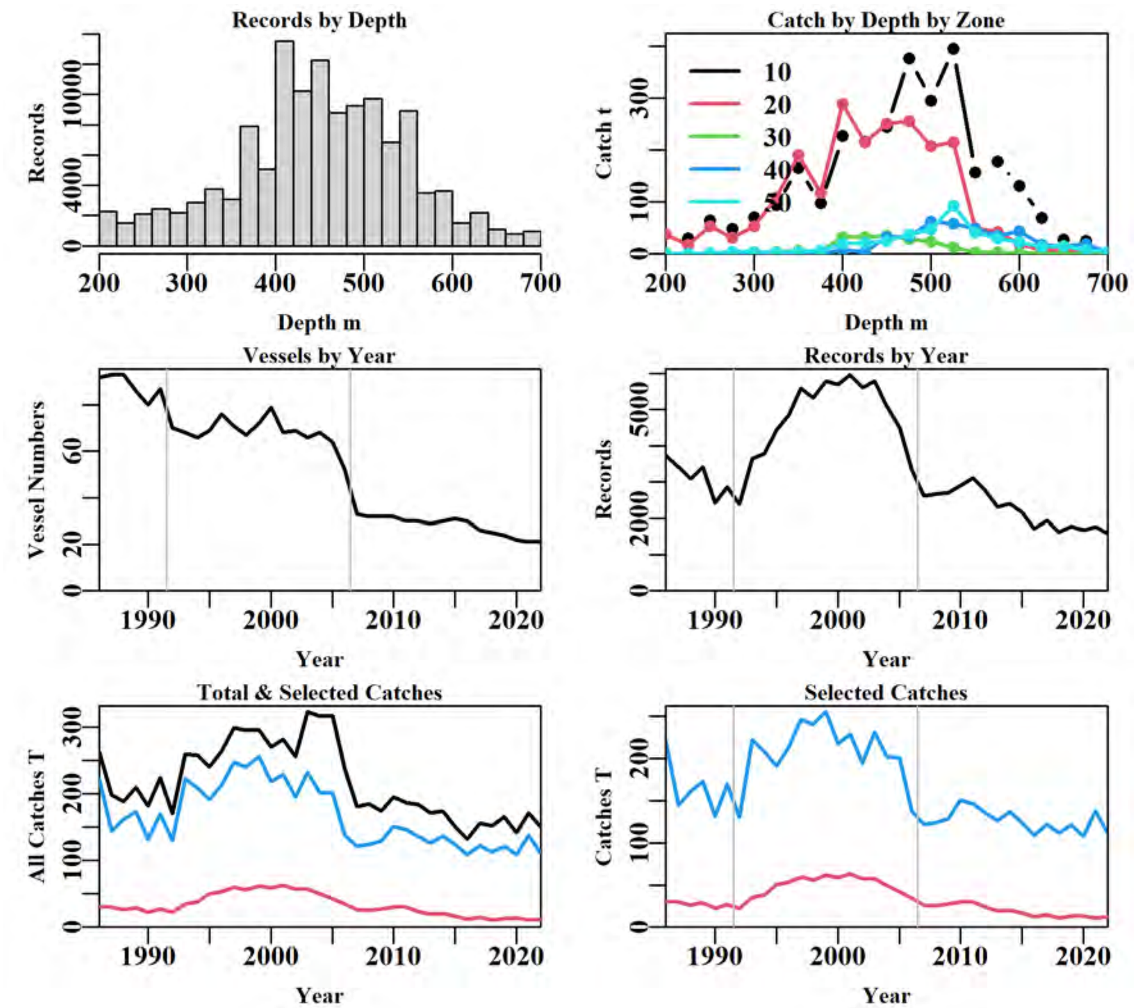

Figure 150: OceanPerchOffshore1050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 109: The models used to analyse data for OceanPerchOffshore1050.

	Model
Model1	Year
Model2	Year + Month
Model3	Year + Month + Vessel
Model4	Year + Month + Vessel + DepCat
Model5	Year + Month + Vessel + DepCat + DayNight
Model6	Year + Month + Vessel + DepCat + DayNight + Zone
Model7	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:Month
Model8	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:DepCat

Table 110: OceanPerchOffshore1050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	40989	174671	6984	126356	37	3.8	0.00
Month	40477	173935	7721	126356	48	4.2	0.40
Vessel	10942	137233	44423	126356	254	24.3	20.09
DepCat	2515	128338	53318	126356	274	29.2	4.90
DayNight	1091	126894	54762	126356	277	30.0	0.80
Zone	-7097	118925	62731	126356	281	34.4	4.39
Zone:Month	-9755	116368	65288	126356	325	35.8	1.39
Zone:DepCat	-9051	116952	64704	126356	361	35.4	1.05

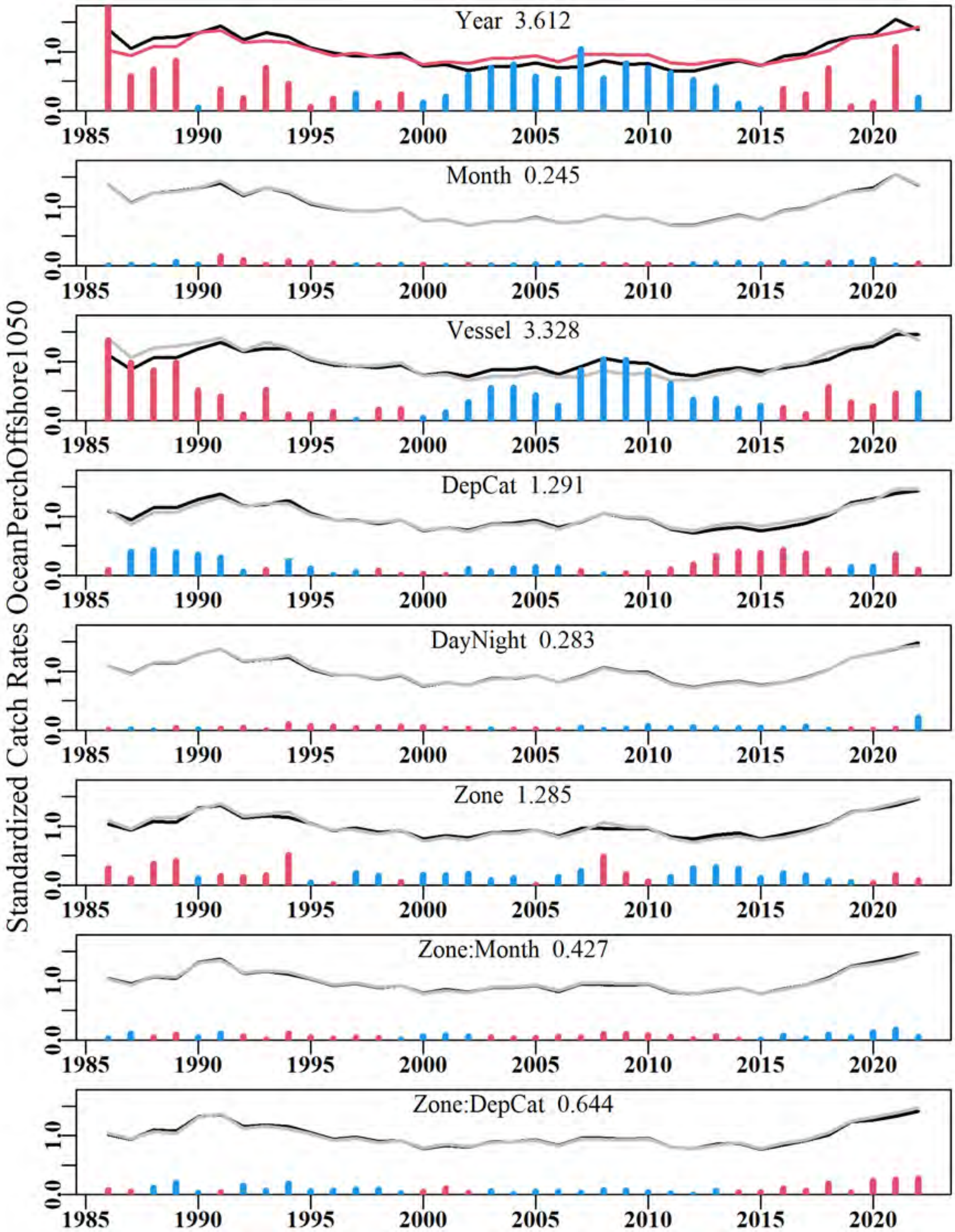

Figure 151: OceanPerchOffshore1050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

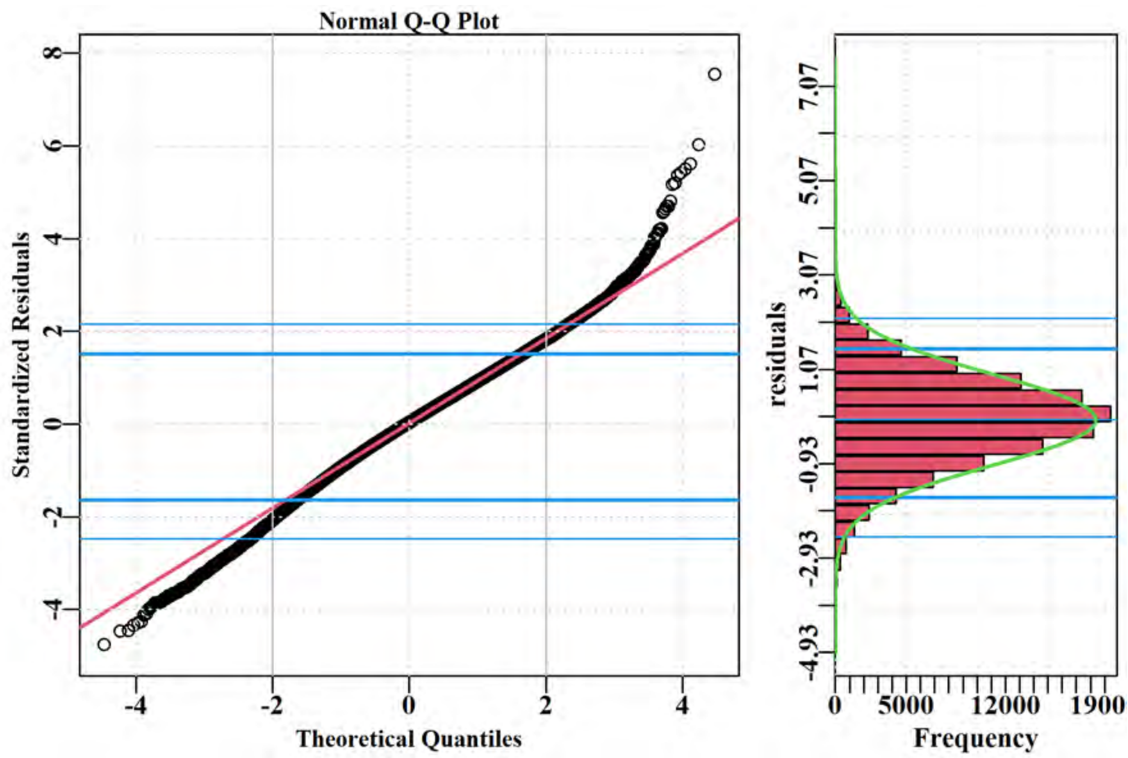

Figure 152: OceanPerchOffshore1050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

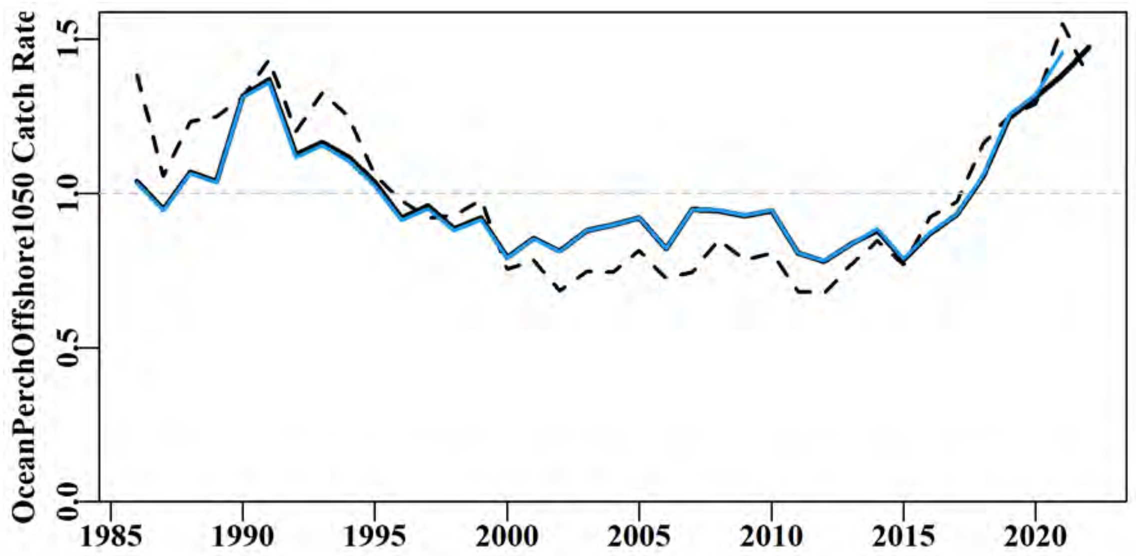

Figure 153: OceanPerchOffshore1050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

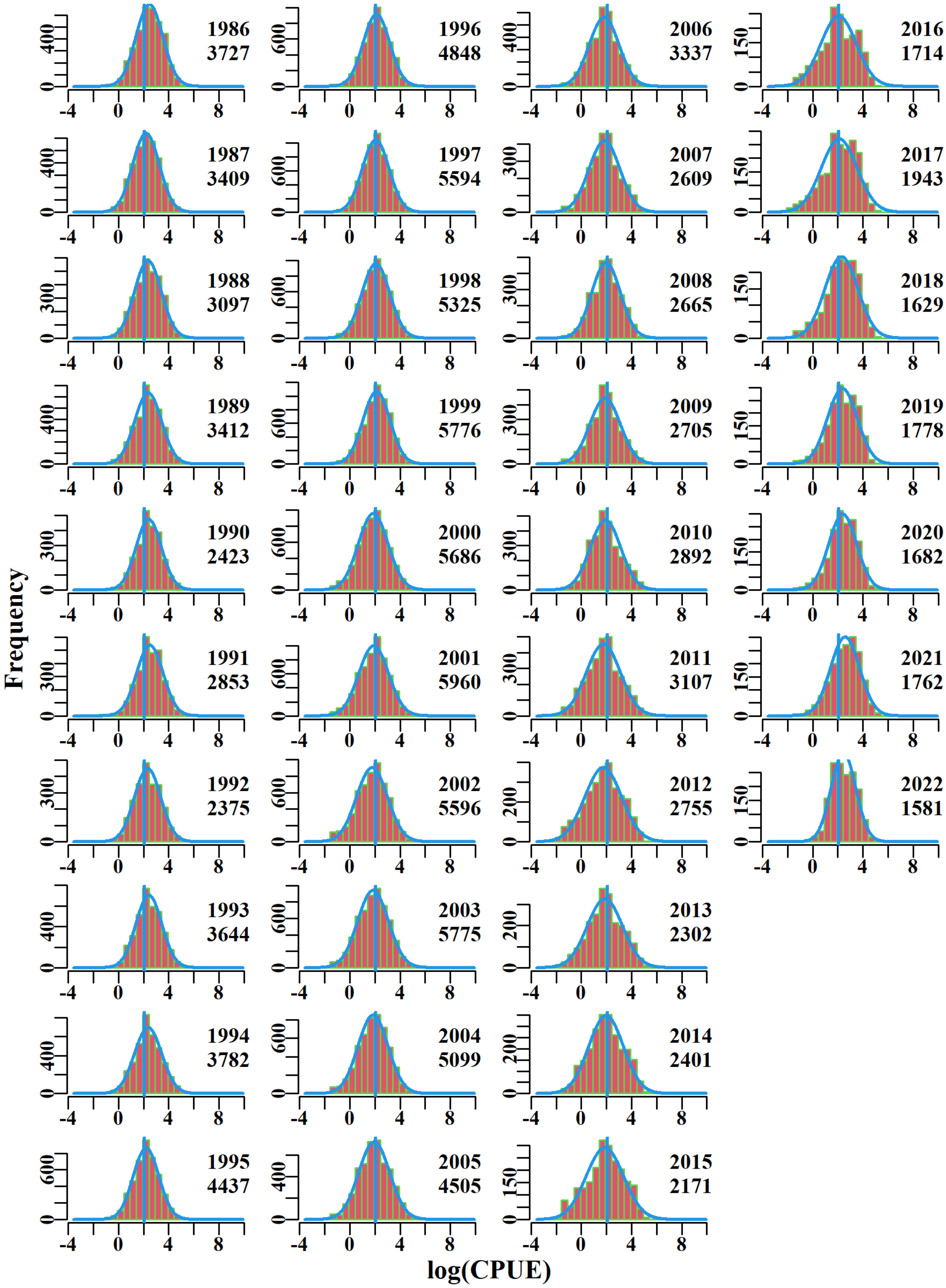

Figure 154: OceanPerchOffshore1050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

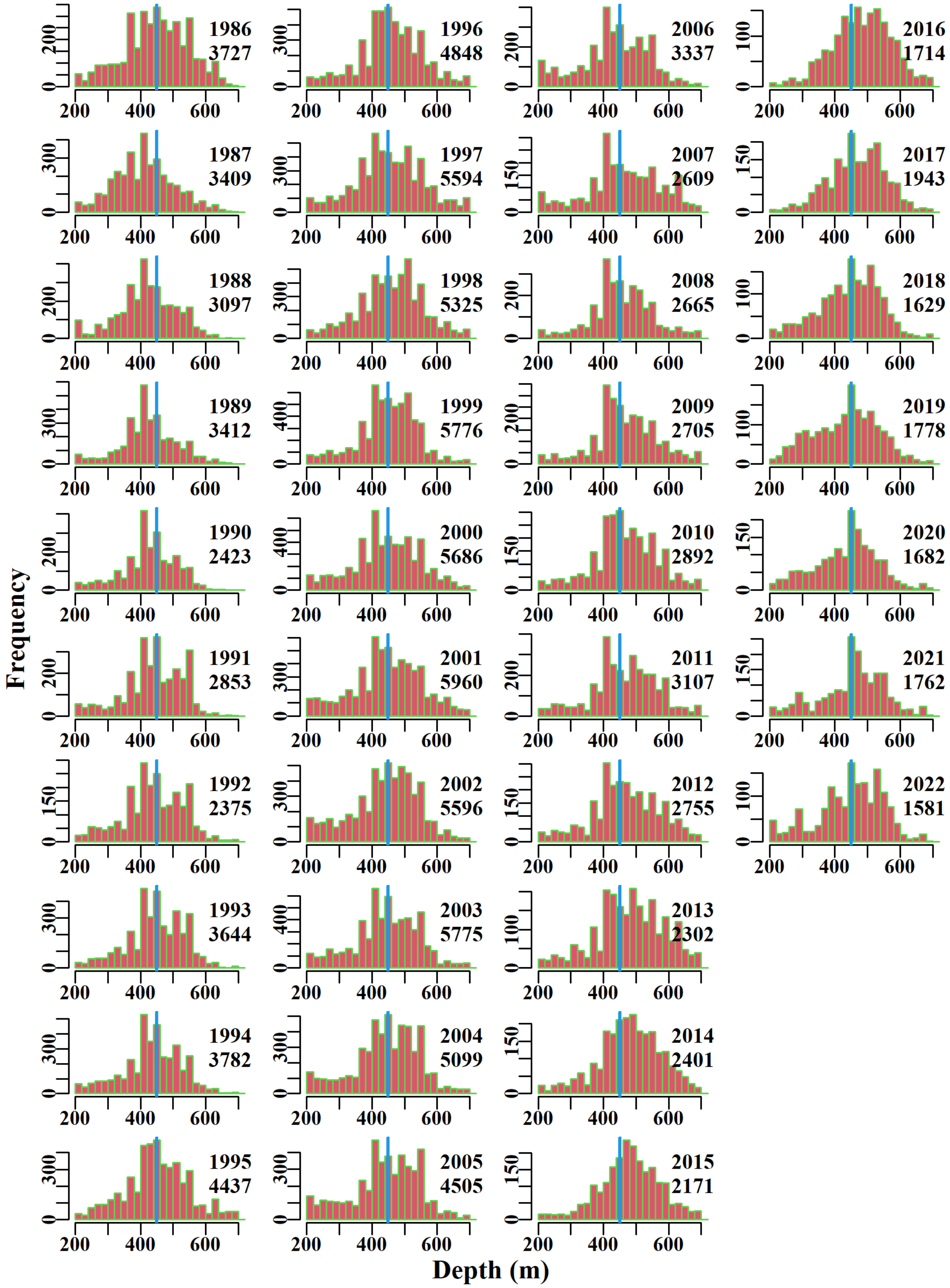

Figure 155: OceanPerchOffshore1050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Comparison of Offshore Ocean Perch: Zones 10-20 and 10-50

Table 111: The reported log-book catches (t) and records by zone, with catches first and then records for each zone in sequence. The difference between the analyses is only due to the inclusion of the catches reported in zones 30, 40, and 50.

Year	10	10	20	20	30	30	40	40	50	50
1986	156.950	2760	50.410	718	0.147	4	8.165	77	4.985	168
1987	94.015	2375	38.735	762	0.436	13	4.723	65	6.599	194
1988	94.771	1825	55.902	981	2.848	51	3.513	63	4.300	177
1989	100.196	1993	59.388	1036	2.157	48	5.915	115	5.531	220
1990	54.821	1055	60.477	903	1.943	57	6.390	91	7.881	317
1991	78.857	1077	59.136	996	7.086	188	8.492	150	15.909	442
1992	75.724	1043	38.504	807	1.167	47	7.235	144	7.696	334
1993	126.157	1524	71.269	1381	3.788	109	11.762	255	8.902	375
1994	113.584	1587	66.297	1413	6.452	227	14.490	262	7.501	293
1995	97.423	1935	52.557	1203	6.091	225	24.716	661	10.237	413
1996	110.279	2073	65.845	1328	7.249	229	15.802	539	14.620	679
1997	120.977	2217	71.629	1490	8.876	317	23.834	760	21.230	810
1998	130.625	2398	63.419	1439	4.364	134	19.413	664	22.618	690
1999	124.493	2460	93.942	1938	12.433	314	11.595	539	13.222	525
2000	108.089	2172	72.597	1996	8.670	241	15.340	715	13.020	562
2001	97.880	1885	86.571	2165	17.421	598	15.190	745	11.806	567
2002	81.965	1789	68.227	1842	13.187	396	16.692	878	15.037	691
2003	91.907	1693	92.553	2251	12.500	336	19.819	824	14.363	671
2004	69.578	1281	80.126	1830	13.094	366	13.241	600	26.113	1022
2005	92.629	1415	74.858	1626	8.974	300	10.216	541	14.559	623
2006	60.097	980	52.584	1329	5.702	157	8.332	392	11.233	479
2007	59.453	644	35.265	875	3.142	124	15.007	599	8.750	367
2008	48.393	704	53.036	1126	5.207	211	9.962	370	7.913	254
2009	51.817	634	47.050	1028	6.500	186	14.135	535	9.238	322
2010	69.609	770	47.630	956	5.069	146	14.458	494	13.930	526
2011	63.509	712	51.962	1131	4.392	180	11.866	594	14.840	490
2012	72.051	722	41.315	951	3.957	183	10.137	594	8.406	305
2013	58.325	517	43.976	758	4.180	181	7.537	391	12.128	455
2014	68.110	586	47.720	935	1.389	60	9.121	415	10.476	405
2015	61.210	531	43.673	873	4.408	139	6.550	348	8.310	280
2016	61.392	508	32.052	636	1.870	83	6.810	290	6.868	197
2017	51.956	531	55.607	859	3.137	141	4.555	238	6.551	174
2018	40.587	418	61.761	872	2.691	101	2.611	108	4.686	130
2019	46.891	439	58.399	857	4.922	198	3.420	102	7.364	182
2020	33.681	330	62.314	965	3.430	149	3.152	80	5.807	158
2021	57.984	504	65.626	856	2.712	151	1.283	41	9.931	210
2022	30.066	293	57.020	729	2.619	118	5.465	144	15.891	297

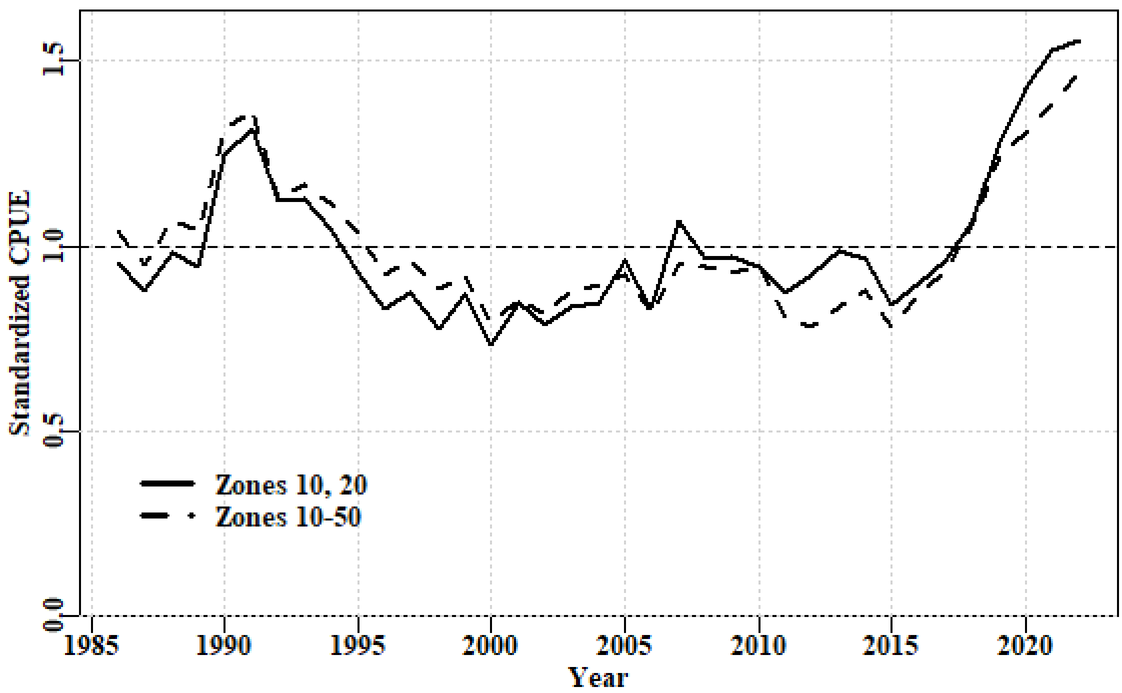

Figure 156: A comparison of the optimum standardization for Offshore Ocean Perch when using just Zones 10 and 20 and when including records from zones 30, 40 and 50.

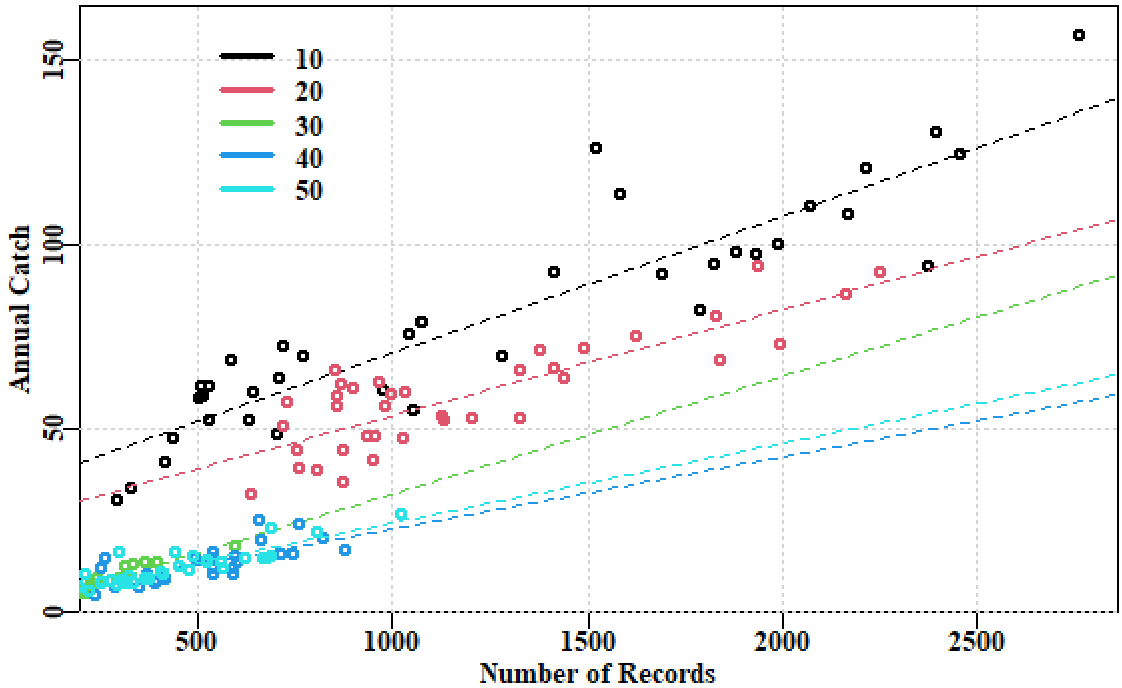

Figure 157: A plot of the different reported Catch vs reported number of records for each zone from 10 to 50 for Offshore Ocean Perch. The dotted lines are the linear regressions in each case illustrating the different average ratio CPUE for each zone and that fact that CPUE in zones 30 - 50 is generally lower for the same effort than in zones 10 and 20.

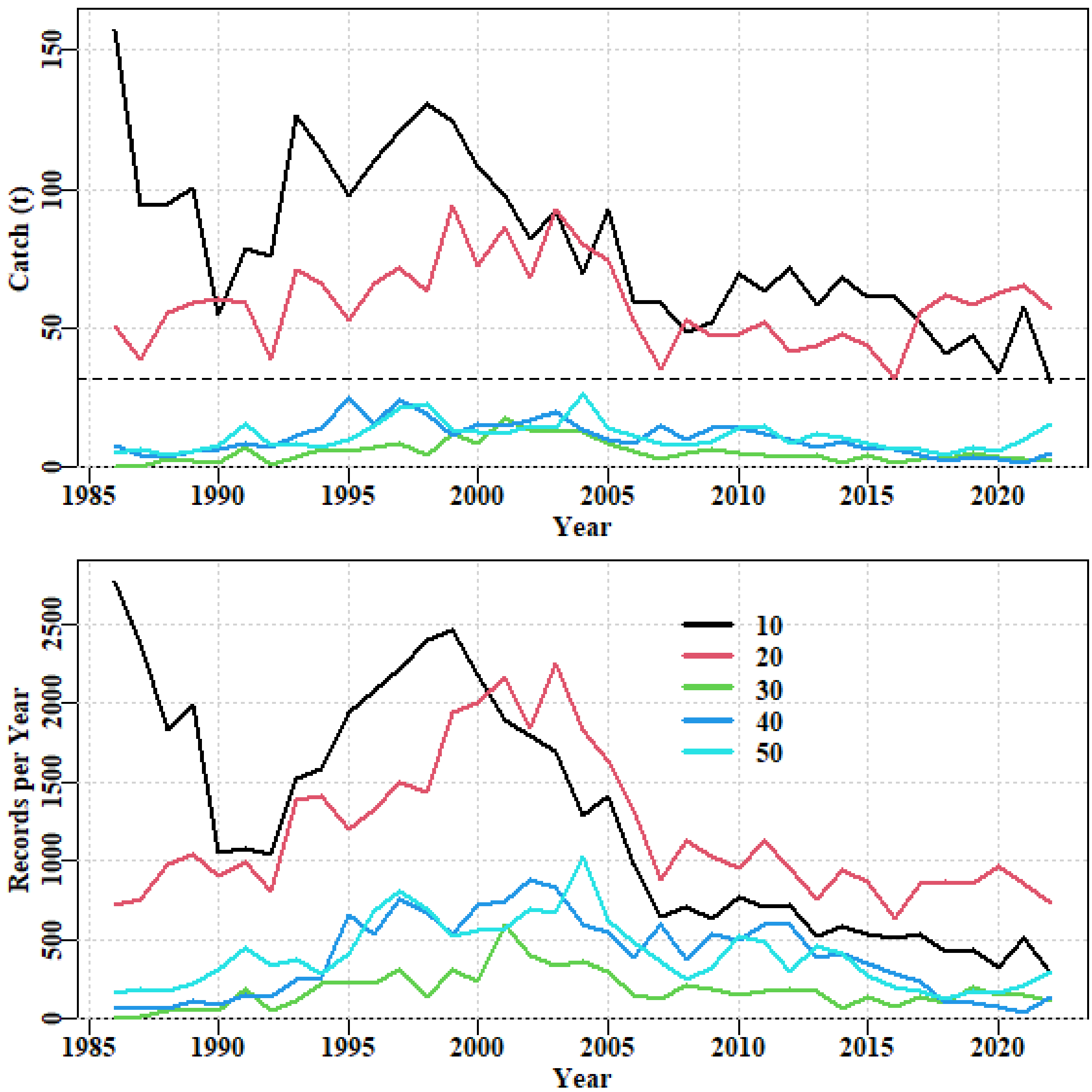

Figure 158: Catch and Records by Zone through time illustrating that catches in 30 to 50 have never been as great as those in zones 10 and 20 although th enumber of records can be relatively high.

Ocean Perch Inshore 1020

Inshore Ocean Perch (REG – 37287001 – *Helicolenus percoides*) was one of the 16 species first included in the quota system in 1992. Trawl caught inshore Ocean Perch based on methods TW, TDO, OTB, OTT, in zones 10, 20, and depths 0 to 200 m within the SET fishery for the years 1986 - 2022 were analysed (Table 112). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 10 followed by zone 20. Small shots < 30 kg appear throughout the analysis period. Also, there was an increase in small shots of < 30 kg over the 1992 - 2006 period, which is suggestive of either low availability or high levels of small fish (Figure 160).

The terms Year, Month, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 116). The qqplot suggests a small departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 162).

Annual standardized CPUE has been relatively flat in six of the last seven years with the 2022 estimate above average, based on the 95% confidence intervals (Figure 159).

Action Items and Issues

As the discarding rate continues to be very high (up to ~90% of all catches) it is recommended that this analysis not be conducted as it may mistakenly be assumed to be informative of the stock’s relative biomass through time.

Table 112: OceanPerchInshore1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	OceanPerchInshore1020
csirocode	37287901, 37287093, 37287001, 91287001, 92287001
fishery	SET
depthrange	0 - 200
depthclass	10
zones	10, 20
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 113: OceanPerchInshore1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	262.4	338	15.2	50	11.9	0.8707	0.000	3.786	0.248
1987	198.4	403	11.9	58	10.7	1.0165	0.092	4.053	0.340
1988	188.4	517	16.5	58	11.6	1.1686	0.089	5.689	0.345
1989	209.2	436	15.0	52	12.4	1.1244	0.093	4.817	0.322
1990	181.7	438	15.0	43	11.9	1.2147	0.094	4.444	0.297
1991	223.6	480	19.4	42	16.9	1.2996	0.093	4.962	0.255
1992	169.7	261	14.0	26	19.7	1.7270	0.105	2.624	0.187
1993	259.6	446	23.3	33	20.5	1.9386	0.096	3.858	0.166
1994	257.3	544	22.3	32	15.6	1.7828	0.093	6.112	0.274
1995	240.0	592	20.8	32	13.4	1.3408	0.091	7.659	0.368
1996	263.9	679	20.6	39	11.0	1.2030	0.090	8.841	0.429
1997	298.8	554	15.2	39	10.3	1.1305	0.093	6.486	0.427
1998	295.0	633	15.0	38	9.3	0.9981	0.092	8.329	0.554
1999	295.8	666	15.3	38	8.8	0.8924	0.091	8.525	0.558
2000	270.2	1316	30.4	37	8.8	1.0549	0.086	15.227	0.501
2001	281.6	1034	23.1	34	8.7	1.0210	0.088	10.701	0.462
2002	255.3	1405	24.7	34	6.5	0.7320	0.087	12.224	0.495
2003	322.7	1069	17.0	37	5.9	0.5683	0.088	9.449	0.555
2004	316.3	944	14.7	38	6.1	0.5741	0.089	7.482	0.509
2005	316.8	850	17.3	39	7.0	0.6468	0.090	7.912	0.459
2006	237.6	585	8.9	34	4.7	0.5427	0.093	4.704	0.531
2007	180.6	386	8.6	20	9.5	0.7864	0.100	4.281	0.500
2008	184.3	317	7.6	20	8.9	0.9639	0.103	3.388	0.448
2009	173.9	259	6.0	21	8.2	0.8285	0.107	2.847	0.471
2010	195.6	275	6.3	21	8.3	0.8769	0.105	3.098	0.494
2011	186.9	244	5.2	19	7.8	1.0073	0.108	2.414	0.464
2012	183.9	372	7.3	20	7.4	0.8409	0.100	3.514	0.481
2013	171.2	218	4.9	14	7.7	1.0057	0.110	2.815	0.575
2014	174.4	152	3.0	15	6.4	0.7415	0.121	1.724	0.572
2015	150.8	119	2.5	14	6.6	0.4518	0.128	1.049	0.416
2016	132.1	96	2.5	13	8.7	0.8108	0.139	1.014	0.405
2017	155.7	80	2.1	12	7.7	0.9065	0.145	1.035	0.504
2018	151.8	95	4.8	10	16.8	0.8529	0.140	1.103	0.229
2019	165.5	172	5.5	14	11.3	0.8541	0.119	2.003	0.365
2020	141.8	153	5.2	14	12.7	0.8802	0.122	1.571	0.300
2021	170.8	131	5.9	10	17.8	0.9494	0.131	1.271	0.217
2022	150.2	115	7.4	11	22.1	1.3958	0.138	1.178	0.160

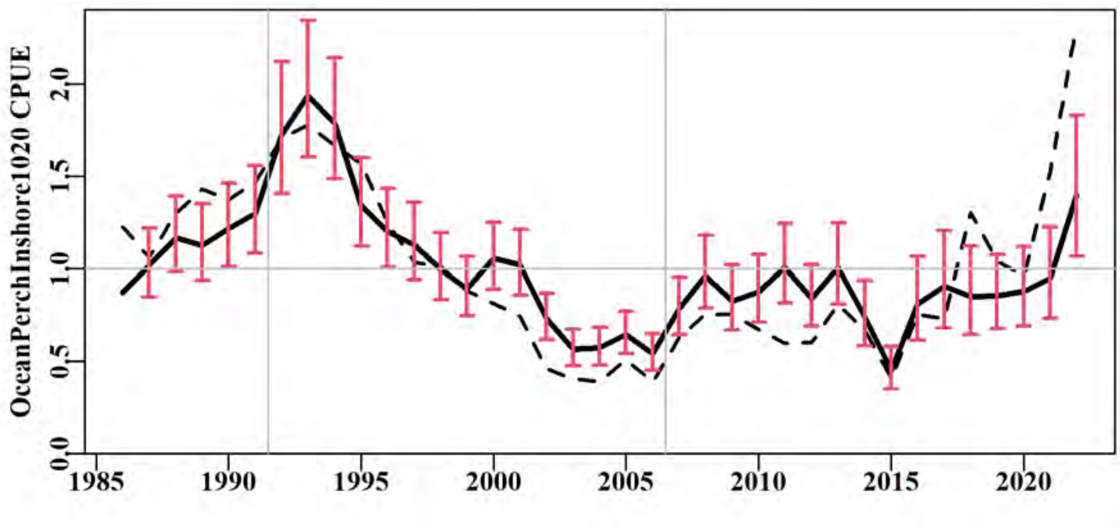

Figure 159: OceanPerchInshore1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

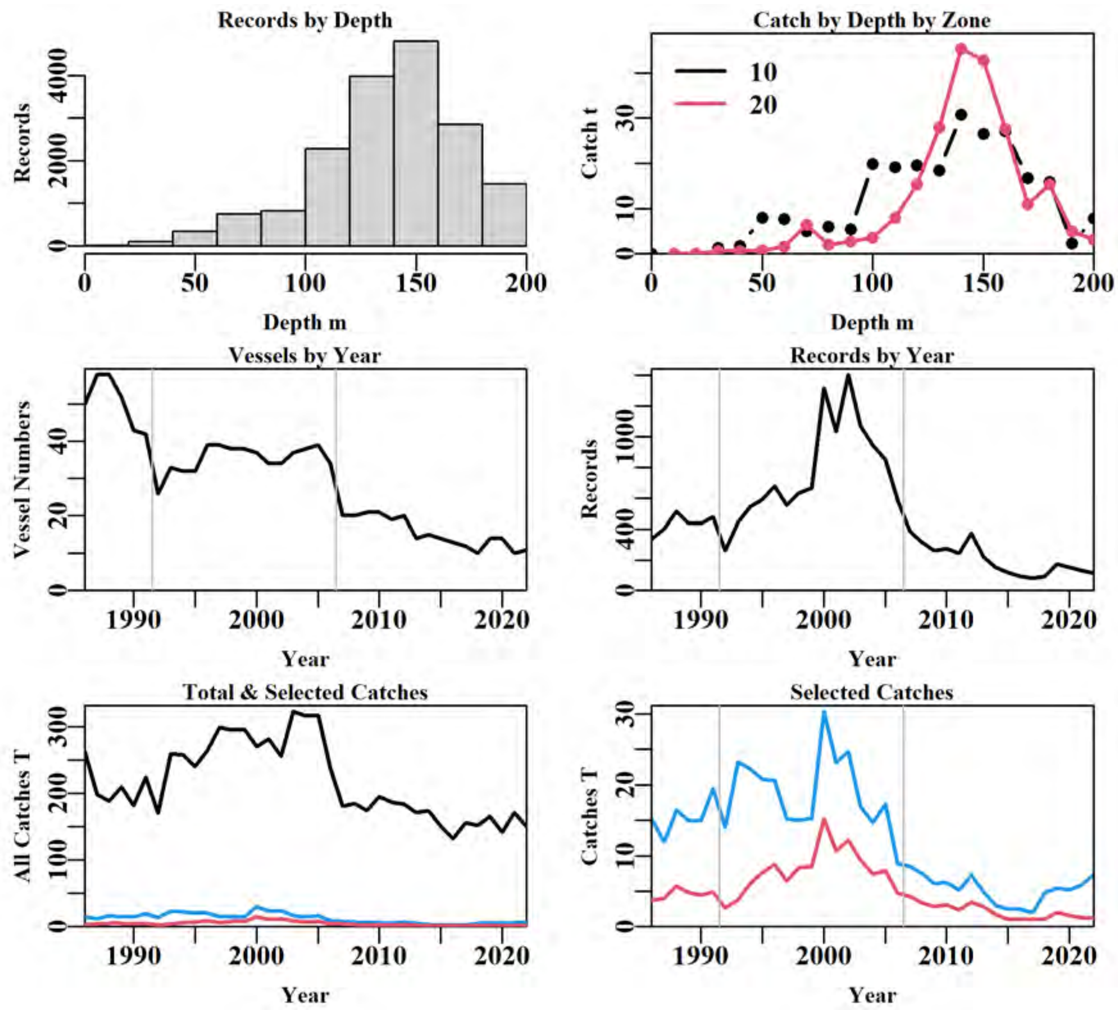

Figure 160: OceanPerchInshore1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 114: OceanPerchInshore1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	186507	166098	25700	25494	17741	17397	17374
Difference	0	20409	140398	206	7753	344	23
Catch	8157	7523	691	683	466	461	460
Difference	0	634	6832	7	217	4	1

Table 115: The models used to analyse data for OceanPerchInshore1020.

	Model
Model1	Year
Model2	Year + Month
Model3	Year + Month + Vessel
Model4	Year + Month + Vessel + DepCat
Model5	Year + Month + Vessel + DepCat + DayNight
Model6	Year + Month + Vessel + DepCat + DayNight + Zone
Model7	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:Month
Model8	Year + Month + Vessel + DepCat + DayNight + Zone + Zone:DepCat

Table 116: OceanPerchInshore1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	6072	24537	4111	17374	37	14.2	0.00
Month	5767	24081	4567	17374	48	15.7	1.54
Vessel	2323	19409	9238	17374	199	31.5	15.75
DepCat	1671	18652	9995	17374	219	34.1	2.60
DayNight	1591	18560	10088	17374	222	34.4	0.31
Zone	1537	18500	10147	17374	223	34.6	0.21
Zone:Month	1534	18474	10174	17374	234	34.6	0.05
Zone:DepCat	1432	18349	10299	17374	242	35.0	0.46

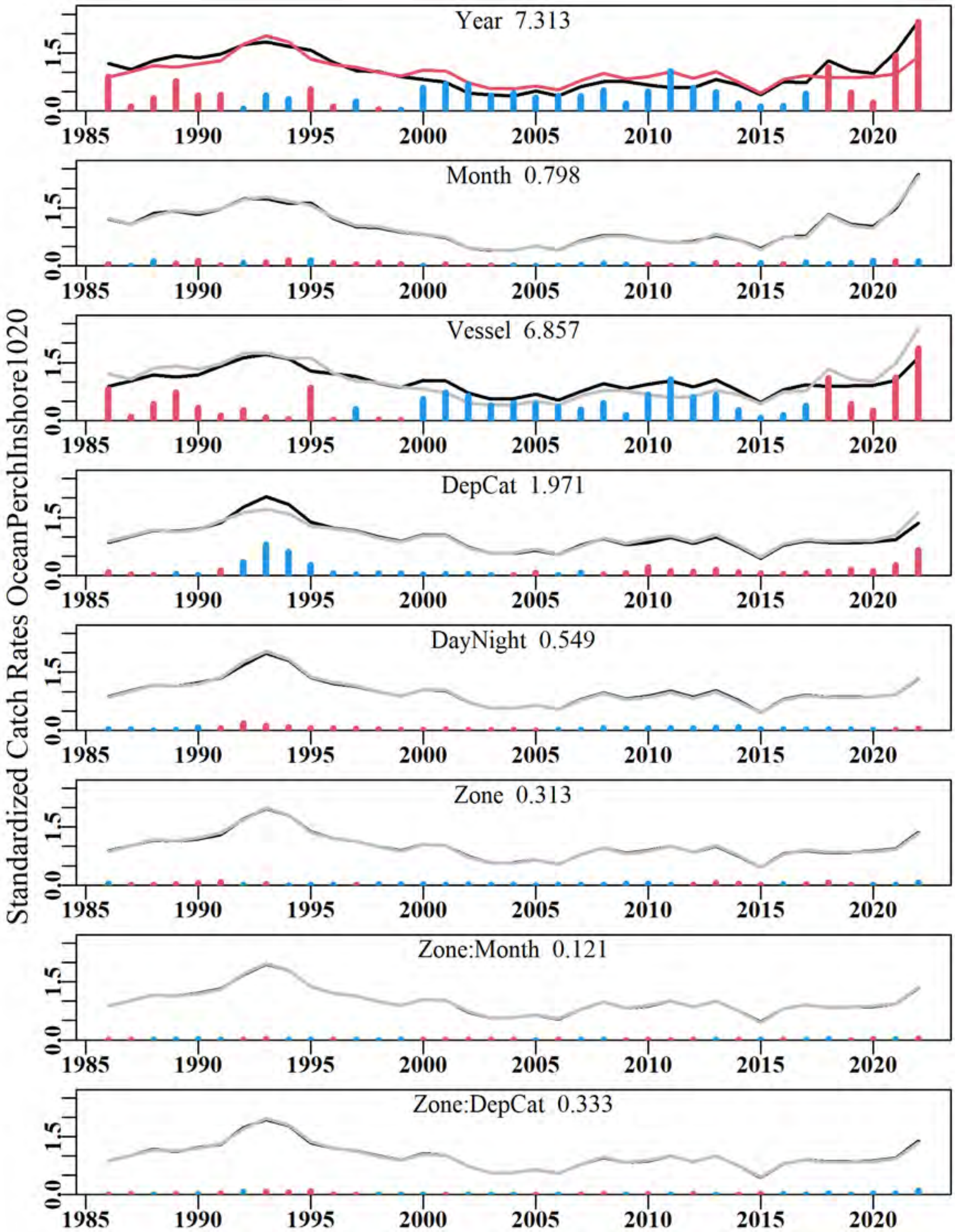

Figure 161: OceanPerchInshore1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

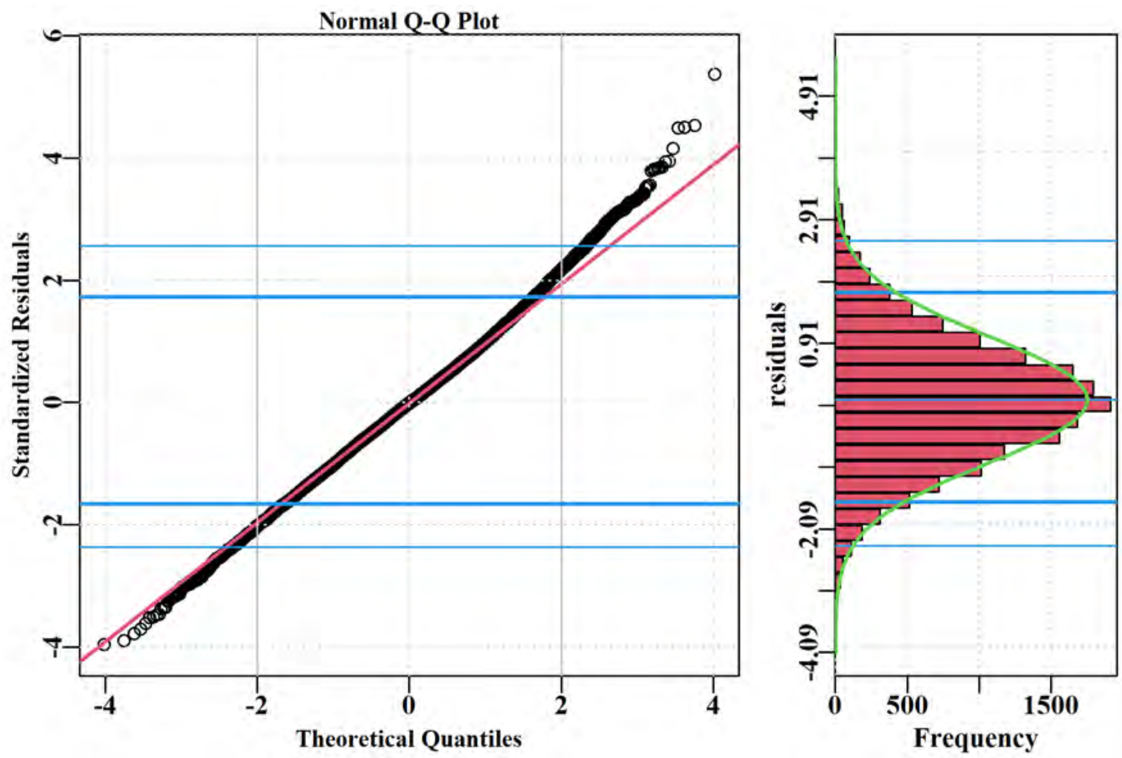

Figure 162: OceanPerchInshore1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

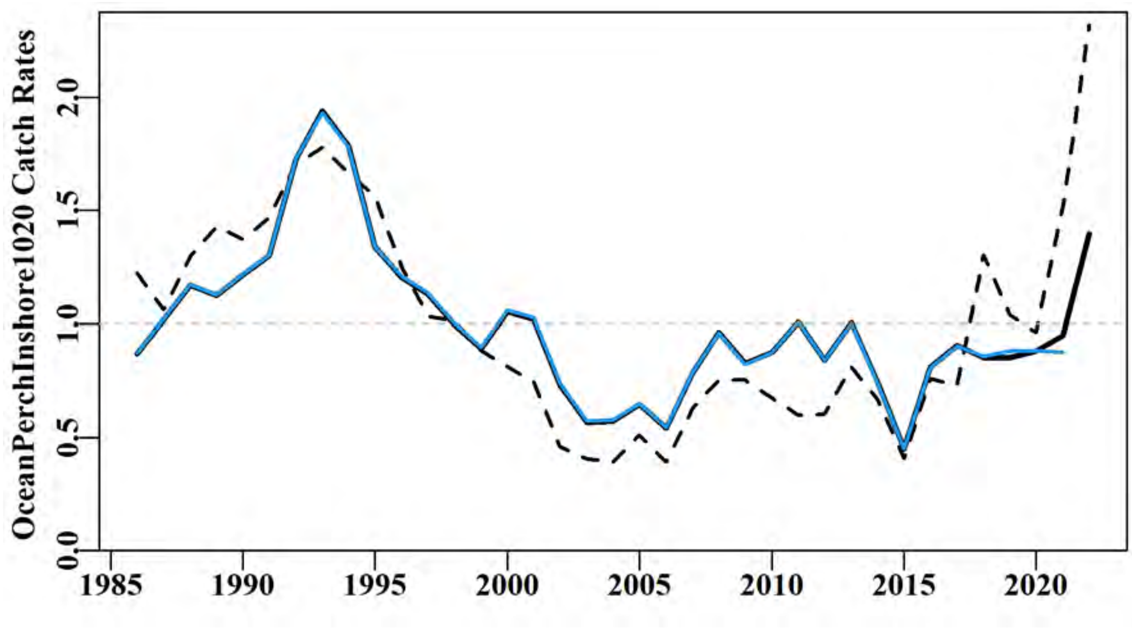

Figure 163: OceanPerchInshore1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

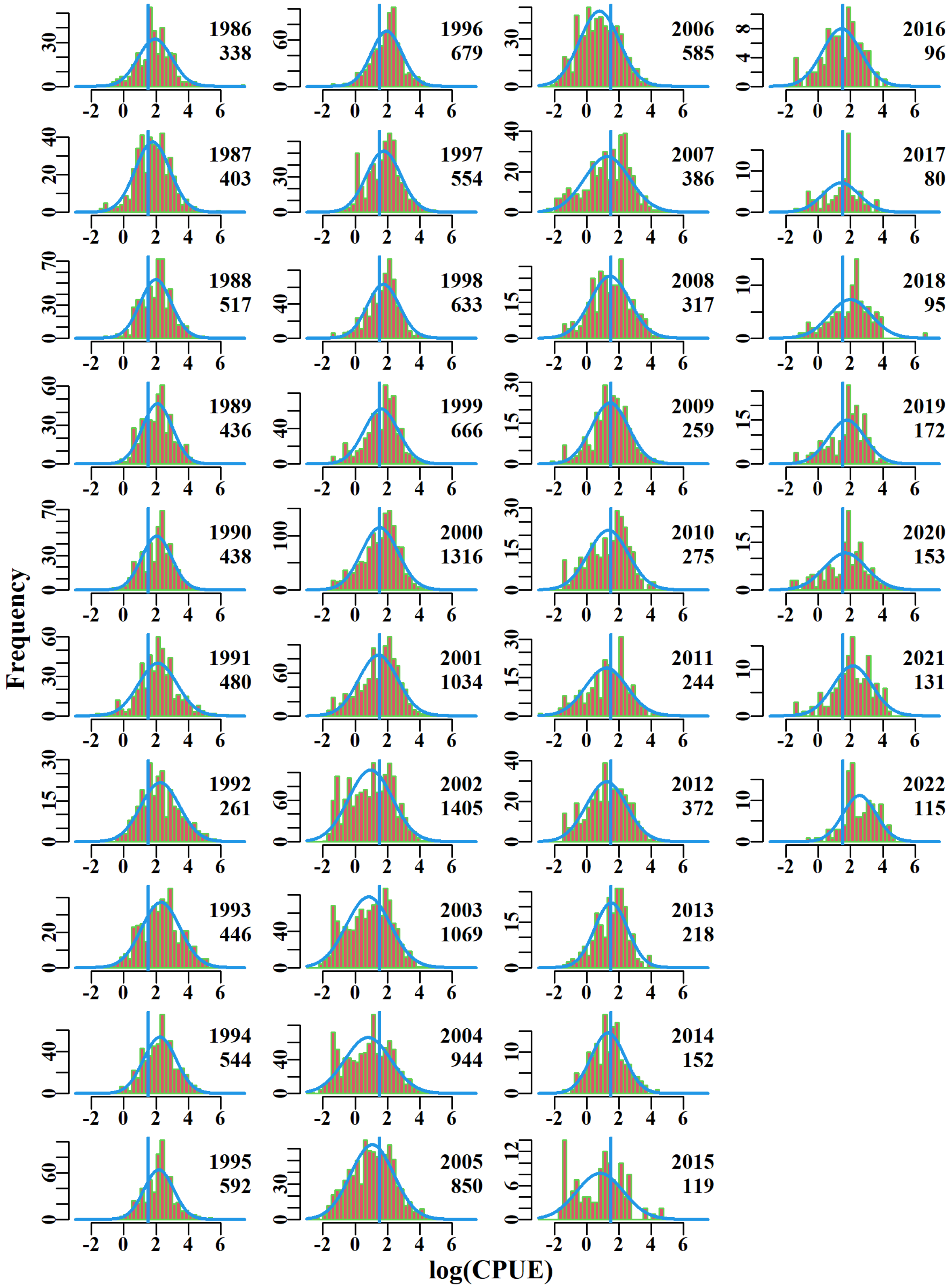

Figure 164: OceanPerchInshore1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

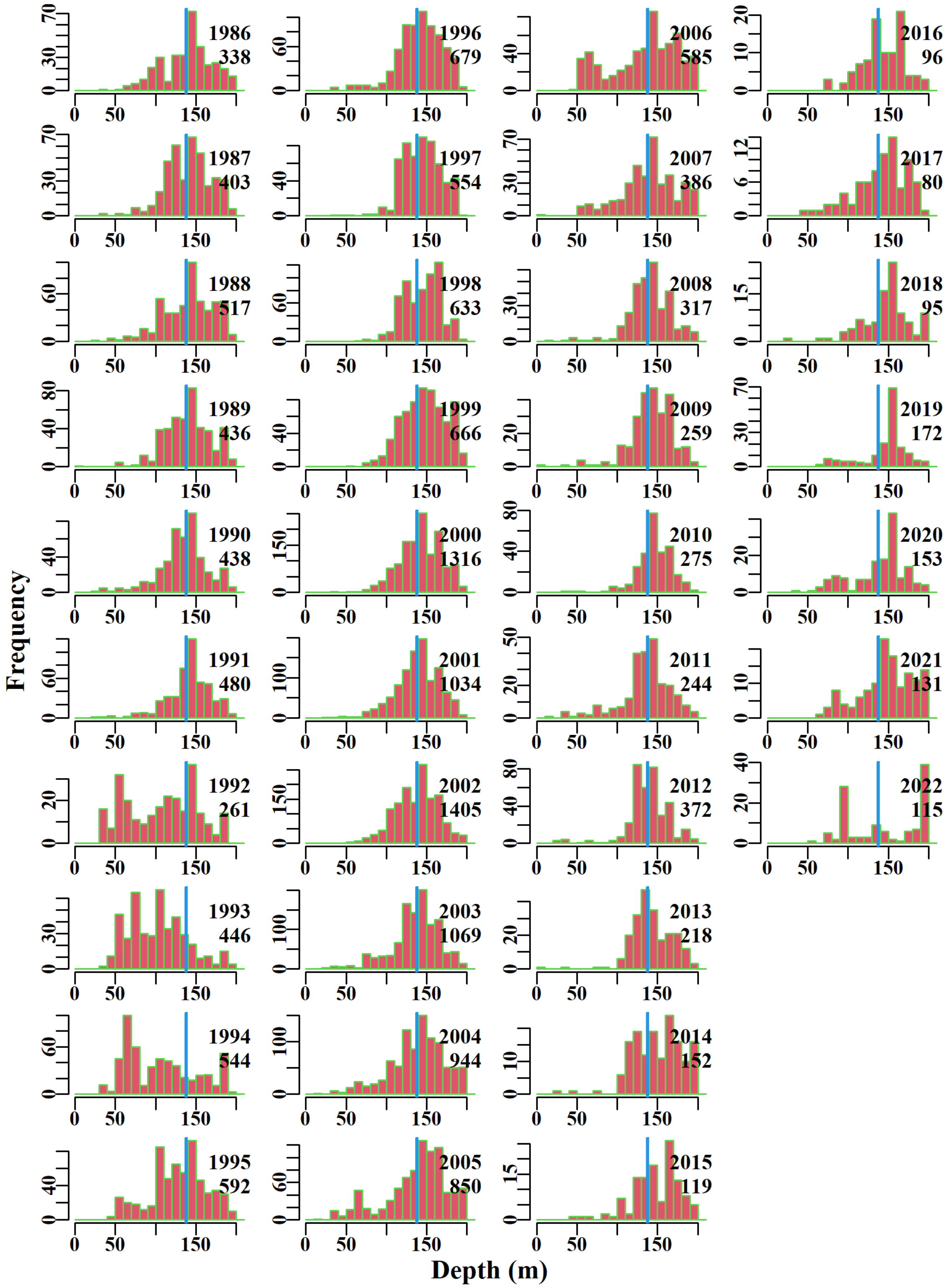

Figure 165: OceanPerchInshore1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Ocean Jackets 1050

Ocean Jackets (LTC – 37465006 – *Nelusetta ayraudi* and Leather Jackets LTH – 37465000). Trawl caught Ocean Jackets based on methods TW, TDO, OTB, OTT, in zones 10, 20, 30, 40, 50, and depths 0 to 300 m within the SET fishery for the years 1986 - 2022 were analysed (Table 117). A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 10 followed by zone 20, with minimal catches in the remaining zones. Small shots < 30 kg appear throughout the analysis period. There was an increase in small shots of < 30 kg over the 1992 - 2006 period, which is suggestive of either low availability or high levels of small fish (Figure 167).

The terms Year and Vessel had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 121). The qqplot suggests a small departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 169).

Annual standardized CPUE are relatively flat and below average between 1986-2003 reflecting the relatively low catches at the time. It increased rapidly along with catches from 2004 - 2007 after which it has continued to be relatively high (declining slightly from 2007 - 2016), decreased from 2017 to just above average in 2018, further decreased to the long-term average in 2019 and has been above average since 2020 based on the 95% confidence intervals (Figure 166). The 2022 catch of 85.5 t corresponding to 18 vessels was the lowest since 2001.

Action Items and Issues

No issues identified.

Table 117: OceanJackets1050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	OceanJackets1050
csirocode	37465006, 37465000
fishery	SET
depthrange	0 - 300
depthclass	20
zones	10, 20, 30, 40, 50
methods	TW, TDO, OTB, OTT
years	1986 - 2022

Table 118: OceanJackets1050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	56.4	2471	44.7	75	7.3	0.6049	0.000	26.955	0.603
1987	53.4	1432	28.0	61	7.6	0.6438	0.038	16.203	0.579
1988	66.3	1905	45.6	66	8.8	0.7749	0.035	22.651	0.497
1989	71.7	1800	32.6	65	6.9	0.6653	0.036	20.112	0.617
1990	91.0	1542	33.0	46	7.6	0.6581	0.038	16.489	0.499
1991	170.5	1325	24.7	46	6.7	0.5737	0.040	15.249	0.618
1992	88.9	1190	24.5	41	6.7	0.5854	0.041	14.472	0.591
1993	71.9	1325	28.9	42	6.9	0.6356	0.040	16.806	0.581
1994	74.4	1436	34.4	45	8.3	0.7183	0.039	19.246	0.559
1995	140.2	2216	58.9	41	9.0	0.7043	0.035	27.382	0.465
1996	199.6	2553	71.5	53	9.9	0.7283	0.034	30.221	0.423
1997	177.4	1993	52.1	51	9.5	0.6651	0.036	21.864	0.420
1998	189.9	2479	67.7	44	9.4	0.6602	0.035	27.232	0.402
1999	202.8	2682	88.0	52	10.6	0.7744	0.034	31.123	0.354
2000	198.8	2982	73.2	53	7.7	0.6258	0.034	37.466	0.512
2001	222.6	3194	64.4	55	6.5	0.5572	0.034	37.862	0.588
2002	378.5	4865	199.1	61	10.8	0.6661	0.032	52.170	0.262
2003	482.3	5464	185.8	58	9.8	0.6327	0.031	54.008	0.291
2004	692.6	6200	311.4	60	16.0	1.0335	0.031	56.415	0.181
2005	890.6	5131	341.2	54	21.1	1.1654	0.031	39.369	0.115
2006	741.5	4599	300.1	50	21.2	1.2919	0.032	34.980	0.117
2007	564.8	3073	284.1	27	31.3	1.5413	0.034	19.766	0.070
2008	490.4	3519	316.3	29	28.9	1.4626	0.034	23.006	0.073
2009	610.0	3229	374.2	28	36.6	1.6364	0.034	19.665	0.053
2010	483.9	3201	294.0	29	30.5	1.3395	0.034	20.507	0.070
2011	487.4	3192	274.6	29	30.0	1.2746	0.034	21.184	0.077
2012	519.7	3405	340.4	30	33.6	1.4533	0.034	21.441	0.063
2013	488.5	2811	262.2	27	28.7	1.4556	0.035	16.442	0.063
2014	512.0	3362	273.0	28	24.5	1.3025	0.034	21.360	0.078
2015	414.9	3066	248.0	31	25.7	1.2540	0.034	19.929	0.080
2016	467.1	2599	238.5	28	29.9	1.2932	0.036	16.962	0.071
2017	424.9	1854	219.6	25	44.2	1.5791	0.038	7.889	0.036
2018	306.5	1643	146.9	24	30.7	1.0472	0.039	9.211	0.063
2019	258.6	1788	126.1	19	23.6	0.9675	0.039	11.886	0.094
2020	288.4	1523	157.8	22	30.3	1.1139	0.040	9.232	0.059
2021	299.2	1193	163.3	22	39.7	1.5357	0.043	4.577	0.028
2022	294.6	790	85.5	18	31.6	1.3789	0.048	3.102	0.036

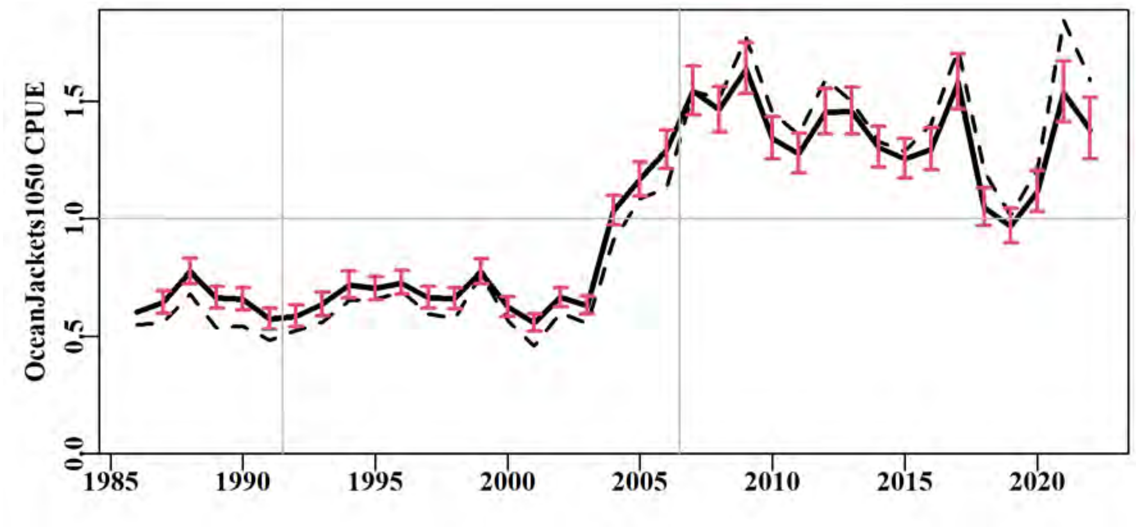

Figure 166: OceanJackets1050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

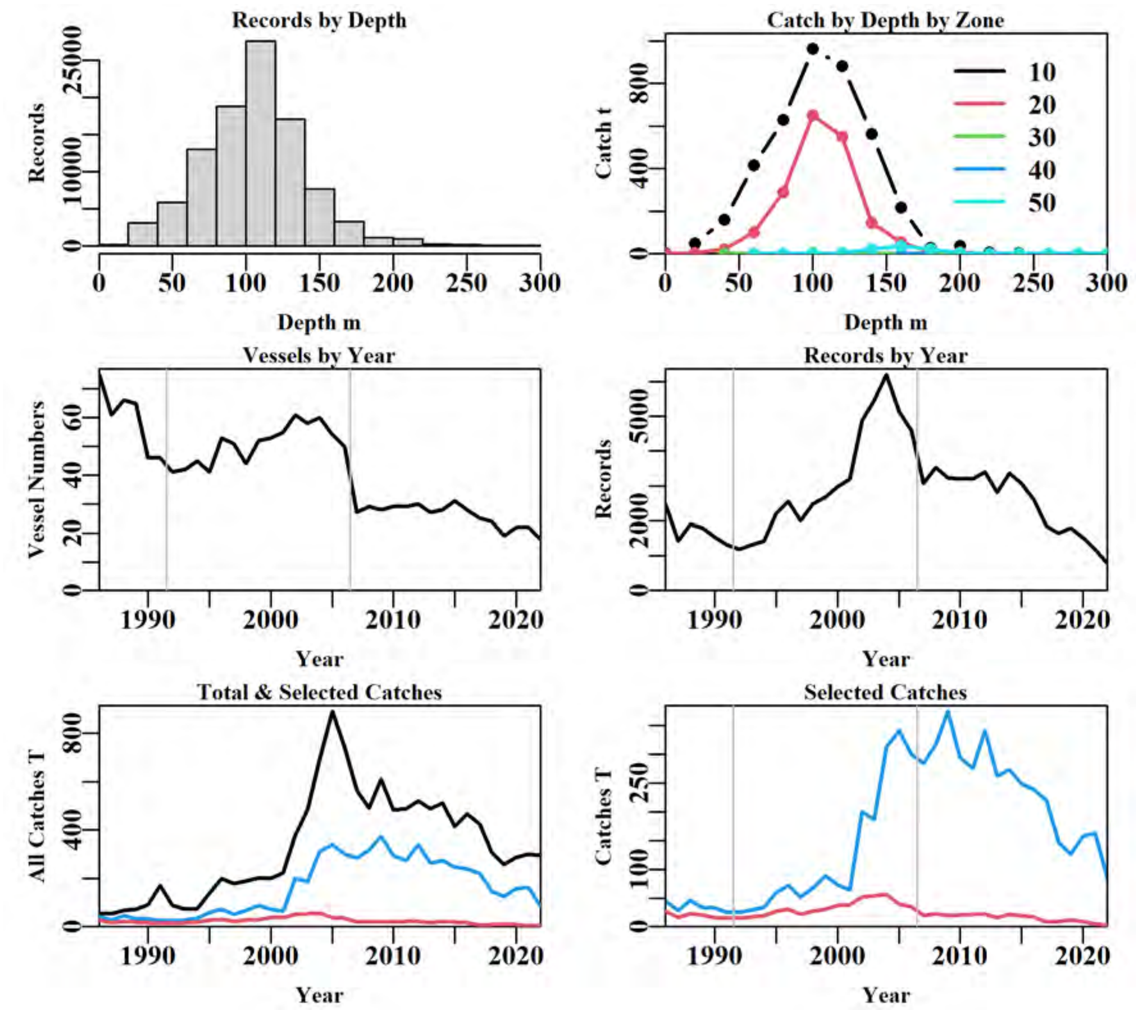

Figure 167: OceanJackets1050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 119: OceanJackets1050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	200768	182228	180399	176532	105028	99210	99032
Difference	0	18540	1829	3867	71504	5818	178
Catch	12747	12606	12469	11923	6007	5929	5914
Difference	0	141	136	547	5915	78	14

Table 120: The models used to analyse data for OceanJackets1050.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + Zone
Model6	Year + Vessel + DepCat + Month + Zone + DayNight
Model7	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:Month
Model8	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:DepCat

Table 121: OceanJackets1050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	27549	130697	18782	99032	37	12.5	0.00
Vessel	13503	113017	36463	99032	211	24.2	11.70
DepCat	12858	112249	37230	99032	226	24.7	0.50
Month	11761	110988	38492	99032	237	25.6	0.84
Zone	10713	109811	39669	99032	241	26.4	0.79
DayNight	10592	109669	39810	99032	244	26.5	0.09
Zone:Month	10355	109318	40161	99032	284	26.7	0.21
Zone:DepCat	9539	108429	41051	99032	281	27.3	0.80

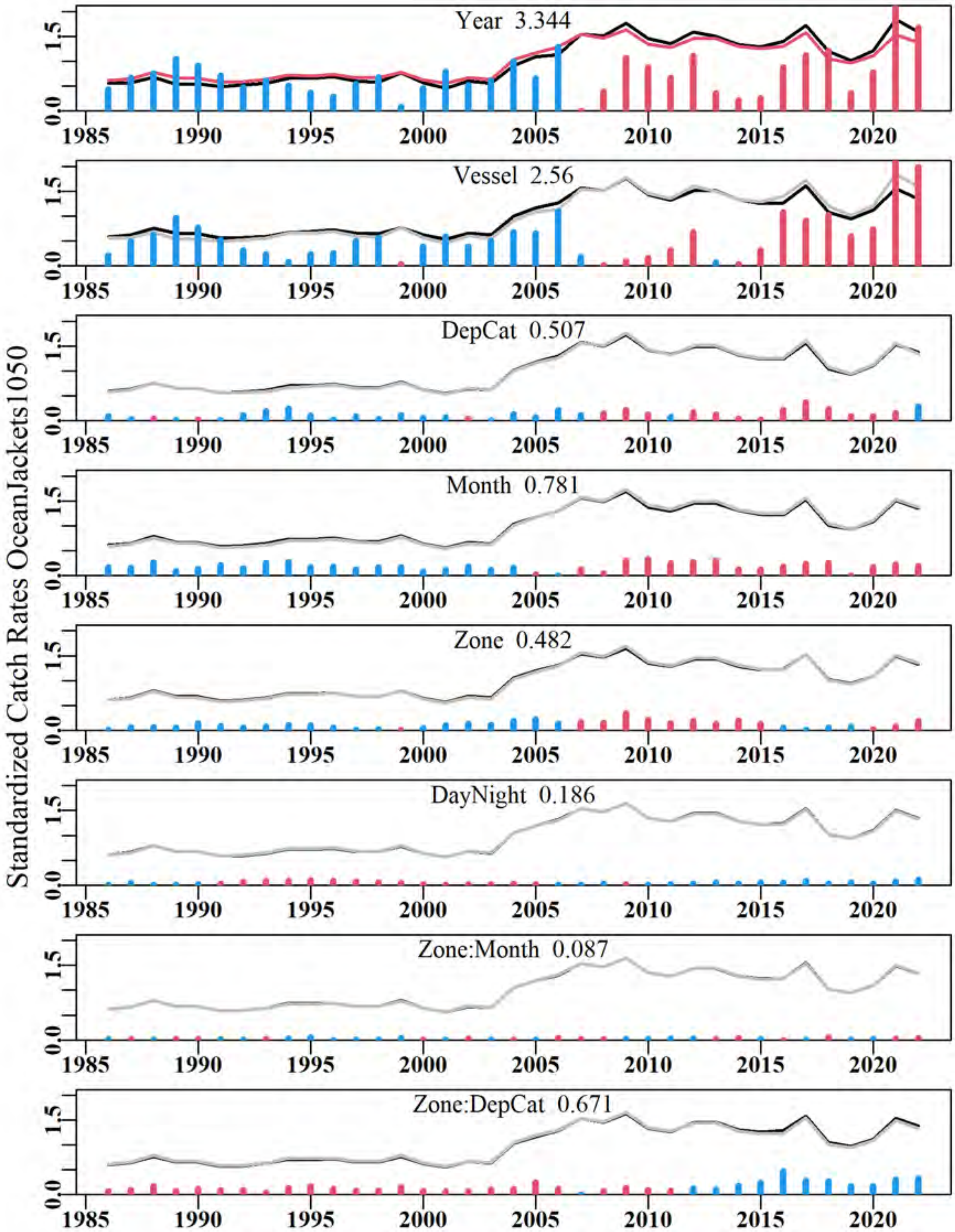

Figure 168: OceanJackets1050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

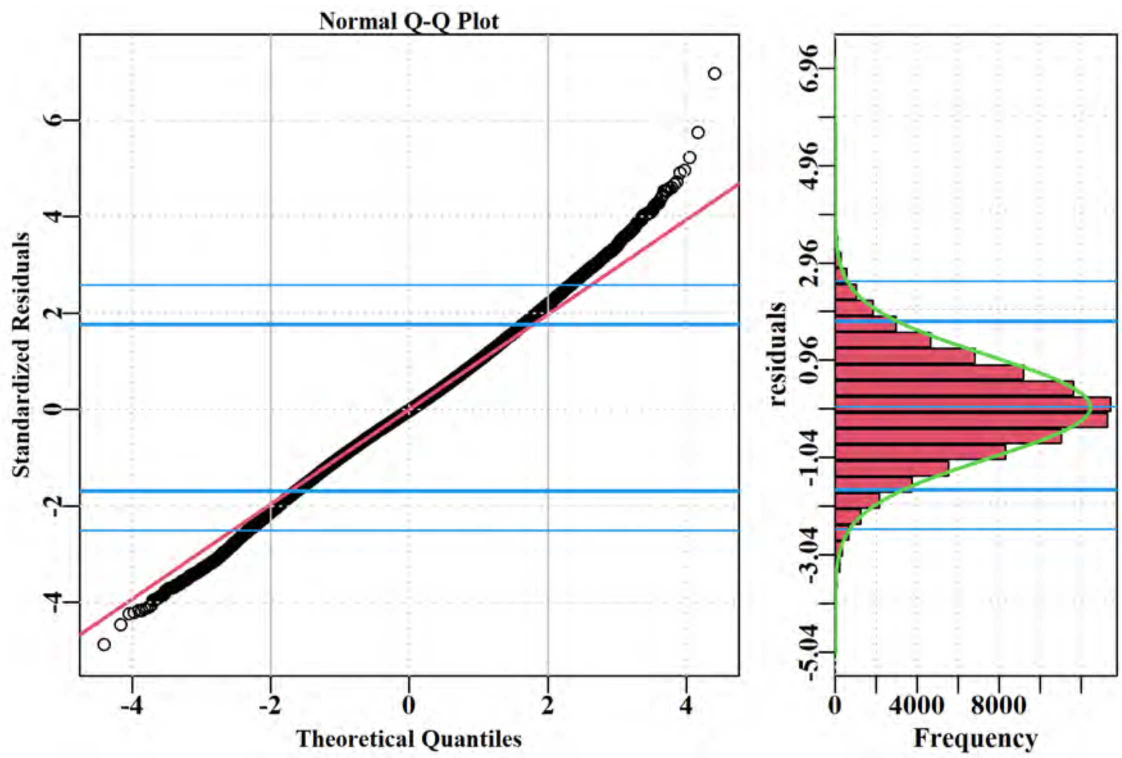

Figure 169: OceanJackets1050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

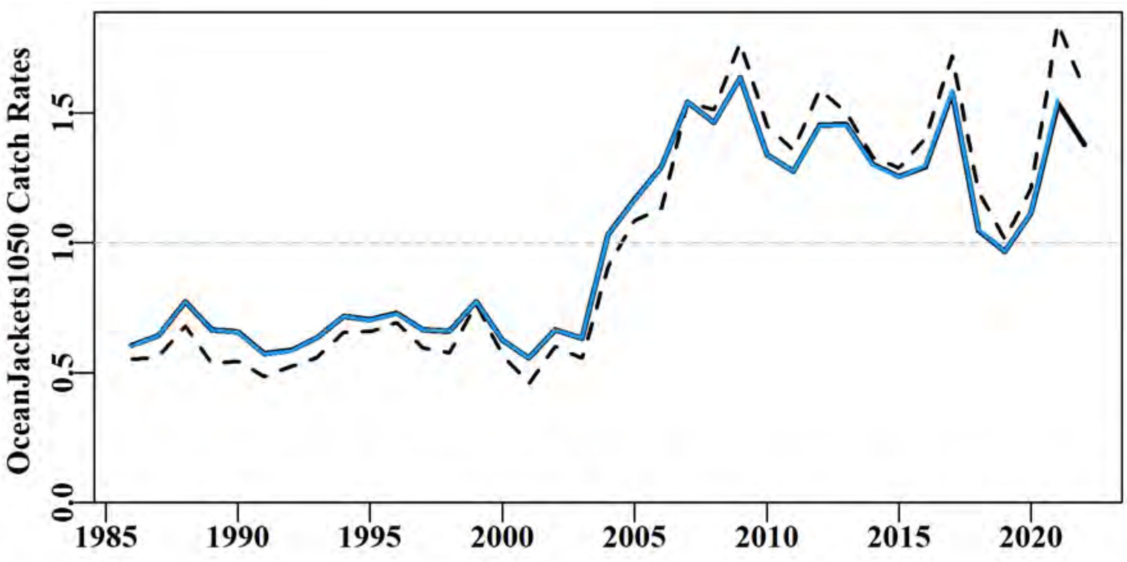

Figure 170: OceanJackets1050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

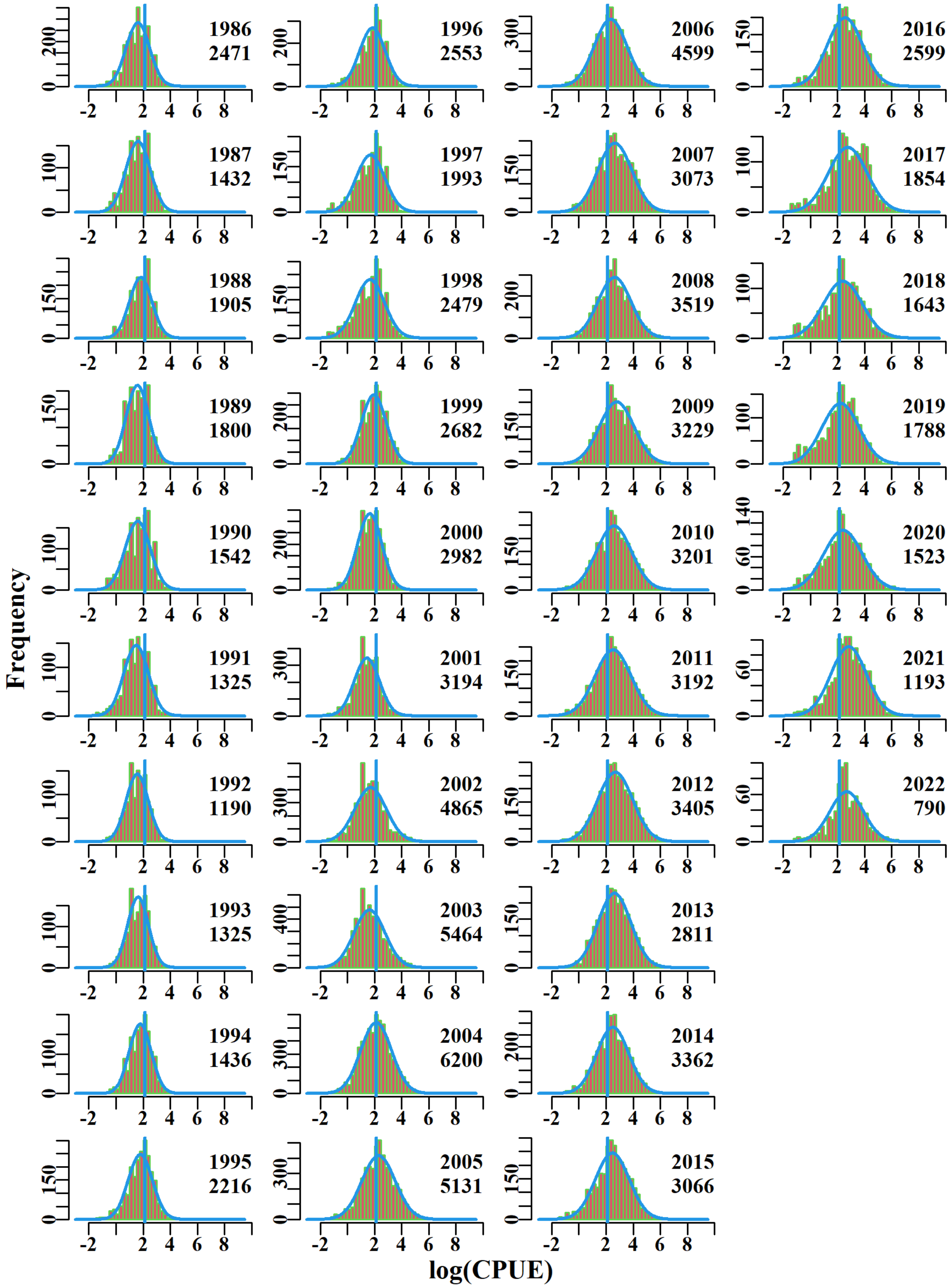

Figure 171: OceanJackets1050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

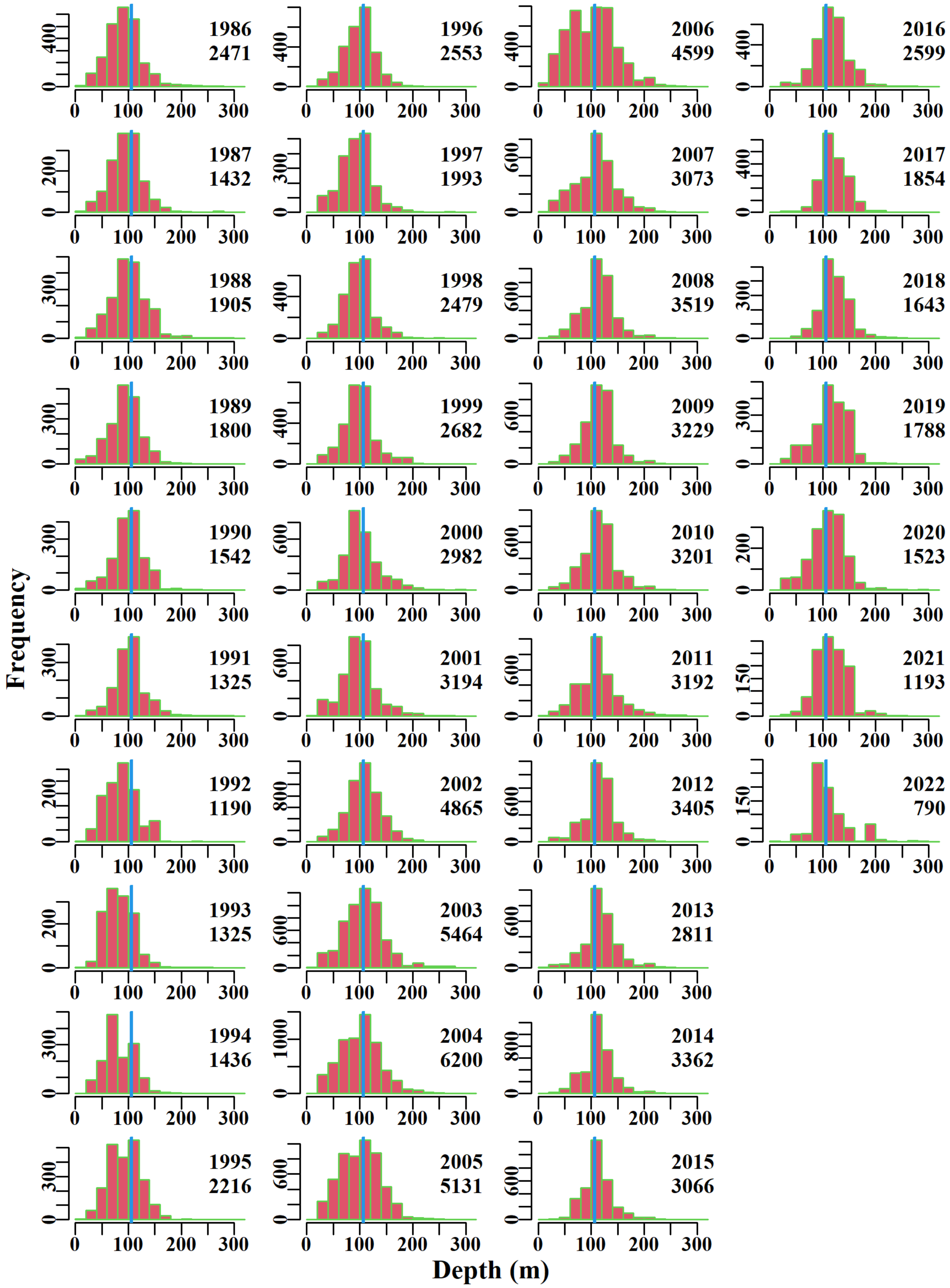

Figure 172: OceanJackets1050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Ocean Jackets GAB

Ocean Jackets (LTC – 37465006 – *Nelusetta ayraudi* and Leather Jackets LTH – 37465000). Trawl caught Ocean Jackets based on methods TW, TDO, OTT, OTB, PTB, in zones 82, 83, and depths 0 to 300 m within the GAB, GBQ fishery for the years 1986 - 2022 were analysed. These constitute the criteria used to select data from the Commonwealth logbook database (Table 122).

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 83 followed by zone 82 in the GAB. A large spike of catches occurred from 2002 - 2006, which declined rapidly following the structural adjustment, although this may not have caused the decline in the GAB. The total catch of 120.6 t in 2021 was the lowest since 1999. By contrast, the total catch of 196.4 t in 2022 of Ocean Jackets in the GAB was the highest since 2016.

The terms Year, DayNight, Vessel, DepCat and Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 126). The qqplot suggests a small departure from the assumed Normal distribution as depicted by both tails of the distribution (Figure 176).

Annual standardized CPUE are noisy and flat across the 1986 - 2022 period (Figure 173) but catches and numbers were low from 1986 - 1989.

Action Items and Issues

No issues identified.

Table 122: OceanJacketsGAB. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	OceanJacketsGAB
csirocode	37465006, 37465000
fishery	GAB_GBQ
depthrange	0 - 300
depthclass	20
zones	82, 83
methods	TW, TDO, OTT, OTB, PTB
years	1986 - 2022

Table 123: OceanJacketsGAB. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	56.4	137	8.0	1	15.1	1.1952	0.000	2.520	0.317
1987	53.4	206	21.7	3	22.9	0.9912	0.105	2.270	0.105
1988	66.3	244	15.6	7	20.8	1.1299	0.183	1.603	0.103
1989	71.7	570	34.5	7	18.0	1.1689	0.182	4.168	0.121
1990	91.0	916	51.2	11	15.7	0.7803	0.179	8.675	0.169
1991	170.5	1248	139.2	8	26.8	0.9953	0.179	6.470	0.046
1992	88.9	923	57.5	7	14.1	0.8528	0.179	9.354	0.163
1993	71.9	813	38.4	4	9.9	0.5804	0.179	9.442	0.246
1994	74.4	736	36.1	5	10.6	0.5159	0.179	7.495	0.208
1995	140.2	1311	78.0	5	12.9	0.6769	0.178	12.907	0.165
1996	199.6	1712	122.3	6	14.9	0.7941	0.178	15.049	0.123
1997	177.4	2123	119.5	9	11.8	0.6532	0.178	21.575	0.180
1998	189.9	1787	115.6	9	13.8	0.7043	0.178	16.270	0.141
1999	202.8	1573	108.4	7	13.6	0.8017	0.178	12.140	0.112
2000	198.8	1567	123.4	5	17.3	0.8236	0.178	11.452	0.093
2001	222.6	1992	146.1	6	15.5	0.8562	0.178	12.521	0.086
2002	378.5	1793	148.1	6	16.3	0.9129	0.178	11.991	0.081
2003	482.3	2791	275.1	9	19.3	1.0407	0.178	11.385	0.041
2004	692.6	3399	360.3	9	20.9	1.1447	0.178	13.172	0.037
2005	890.6	4287	519.8	10	23.8	1.2141	0.177	14.604	0.028
2006	741.5	3573	405.1	11	21.4	0.9432	0.178	11.905	0.029
2007	564.8	2591	248.8	8	19.8	0.8473	0.178	10.479	0.042
2008	490.4	2314	144.0	6	12.9	0.7355	0.178	14.610	0.101
2009	610.0	2139	218.4	4	20.9	1.0298	0.178	11.145	0.051
2010	483.9	1777	167.1	4	19.0	1.1847	0.178	5.245	0.031
2011	487.4	1880	192.4	4	21.0	1.1772	0.178	5.741	0.030
2012	519.7	1722	155.8	5	17.3	1.1523	0.178	3.205	0.021
2013	488.5	2218	204.7	6	17.4	1.2587	0.178	1.018	0.005
2014	512.0	2043	209.2	6	18.3	1.2947	0.178	0.332	0.002
2015	414.9	1569	148.5	3	18.4	1.2398	0.178	0.893	0.006
2016	467.1	1656	203.3	4	23.8	1.3011	0.178	4.774	0.023
2017	424.9	1623	183.7	4	21.8	1.1956	0.179	10.354	0.056
2018	306.5	1515	149.7	4	19.9	1.1428	0.179	10.383	0.069
2019	258.6	1401	121.5	3	17.8	1.0673	0.179	7.618	0.063
2020	288.4	1414	122.9	3	17.0	1.0115	0.179	9.504	0.077
2021	299.2	1231	120.6	3	18.8	1.2399	0.179	3.347	0.028
2022	294.6	1684	196.4	3	22.5	1.3463	0.178	2.671	0.014

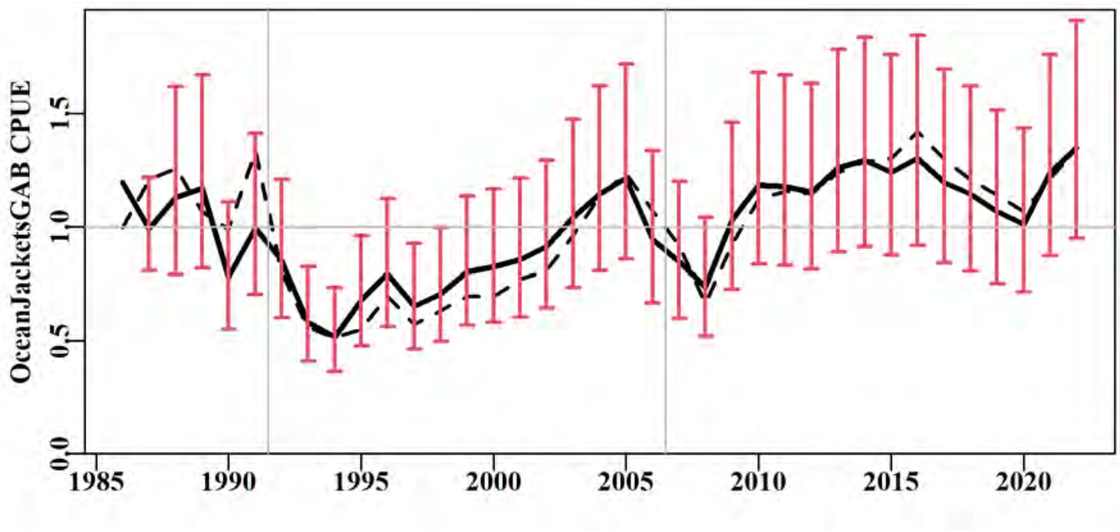

Figure 173: OceanJacketsGAB standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

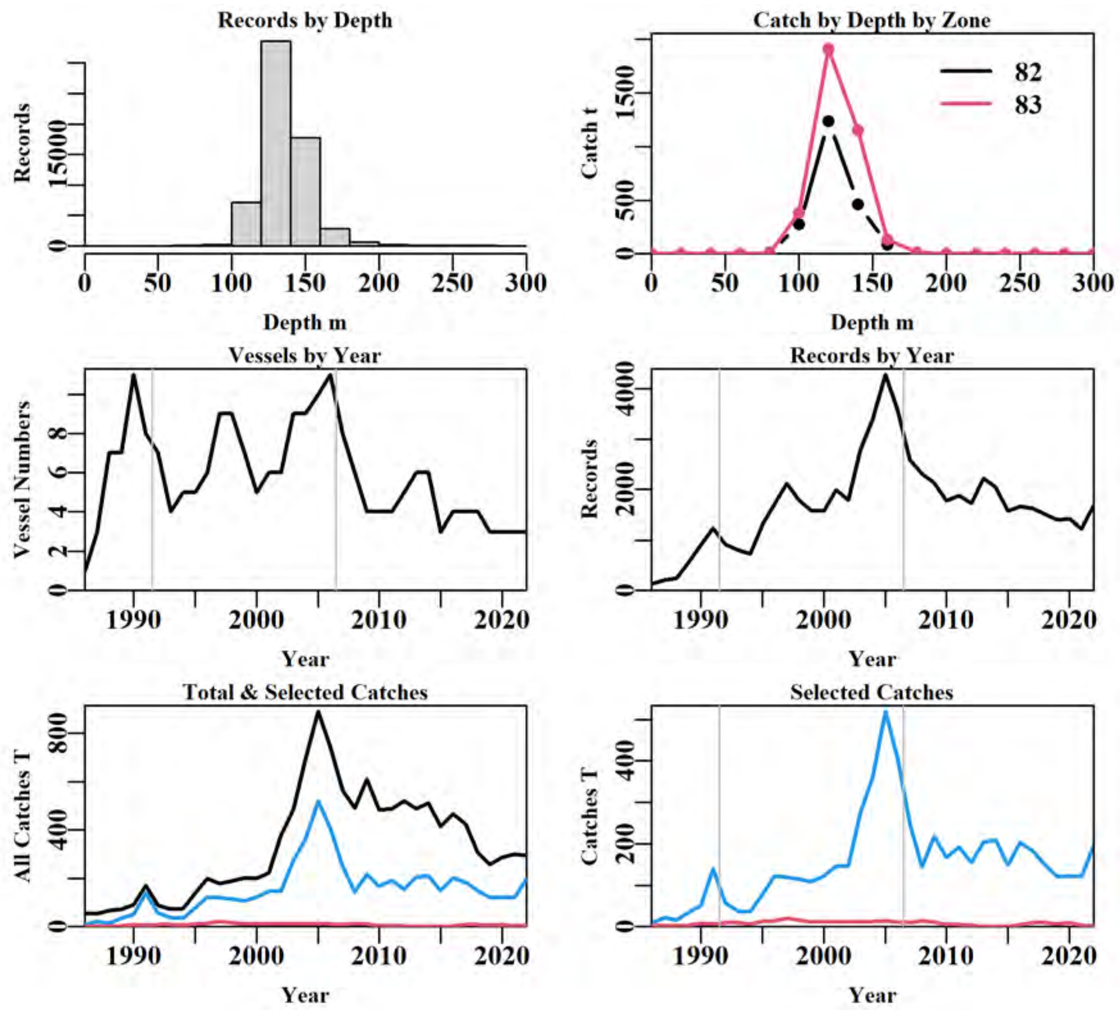

Figure 174: OceanJacketsGAB fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 124: OceanJacketsGAB data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	200768	182455	180612	176745	65431	62493	62478
Difference	0	18313	1843	3867	111314	2938	15
Catch	12747	12606	12470	11923	5746	5711	5711
Difference	0	141	136	547	6177	35	1

Table 125: The models used to analyse data for OceanJacketsGAB.

	Model
Model1	Year
Model2	Year + DayNight
Model3	Year + DayNight + Vessel
Model4	Year + DayNight + Vessel + DepCat
Model5	Year + DayNight + Vessel + DepCat + Month
Model6	Year + DayNight + Vessel + DepCat + Month + Zone
Model7	Year + DayNight + Vessel + DepCat + Month + Zone + Zone:Month
Model8	Year + DayNight + Vessel + DepCat + Month + Zone + Zone:DepCat

Table 126: OceanJacketsGAB. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	-278	62127	4813	62478	37	7.1	0.00
DayNight	-6749	56009	10931	62478	40	16.3	9.14
Vessel	-9509	53525	13415	62478	77	19.9	3.67
DepCat	-12799	50755	16185	62478	92	24.1	4.13
Month	-14059	49724	17216	62478	103	25.6	1.53
Zone	-14057	49724	17216	62478	104	25.6	0.00
Zone:Month	-14247	49556	17385	62478	115	25.8	0.24
Zone:DepCat	-14080	49682	17258	62478	119	25.6	0.05

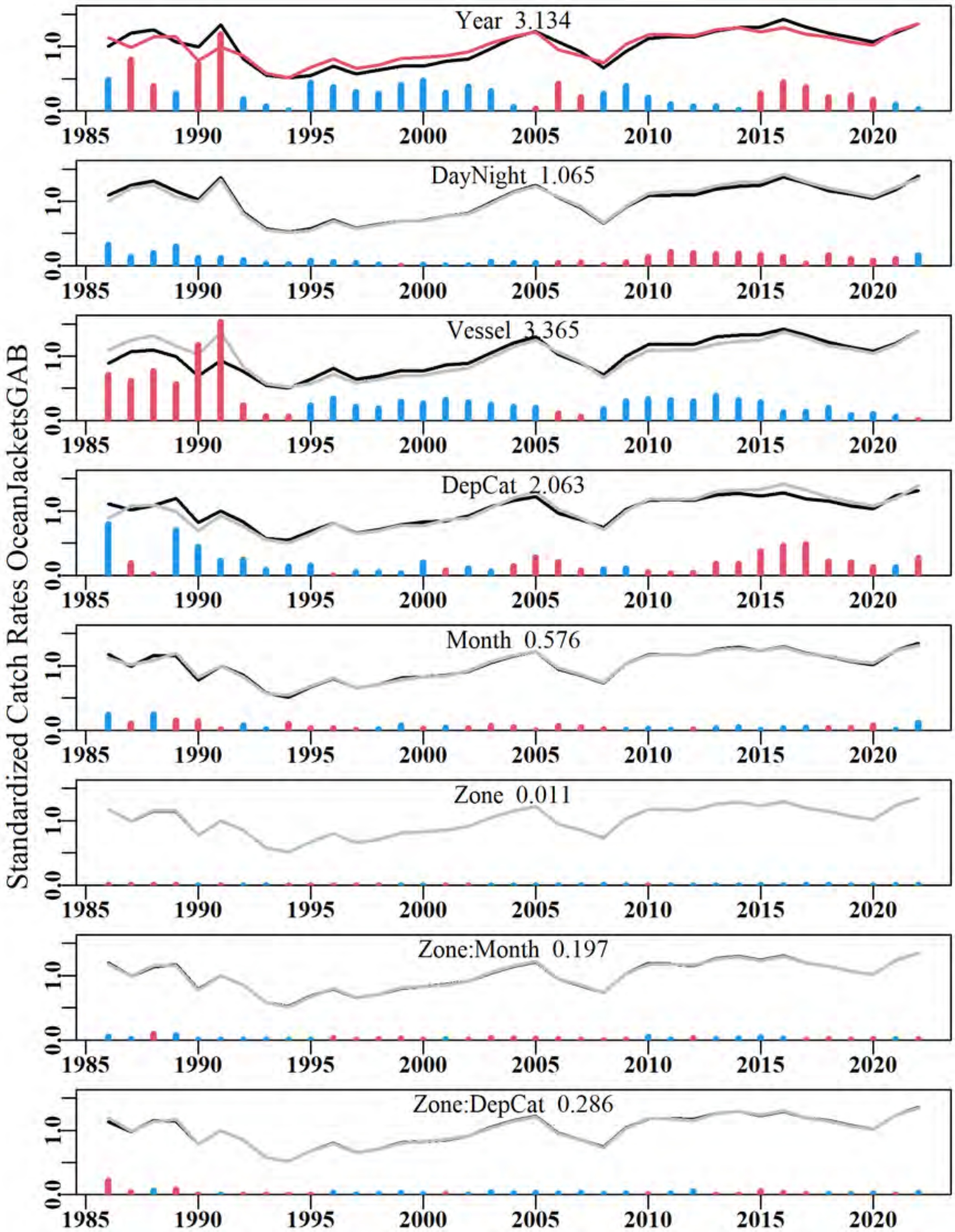

Figure 175: OceanJacketsGAB. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

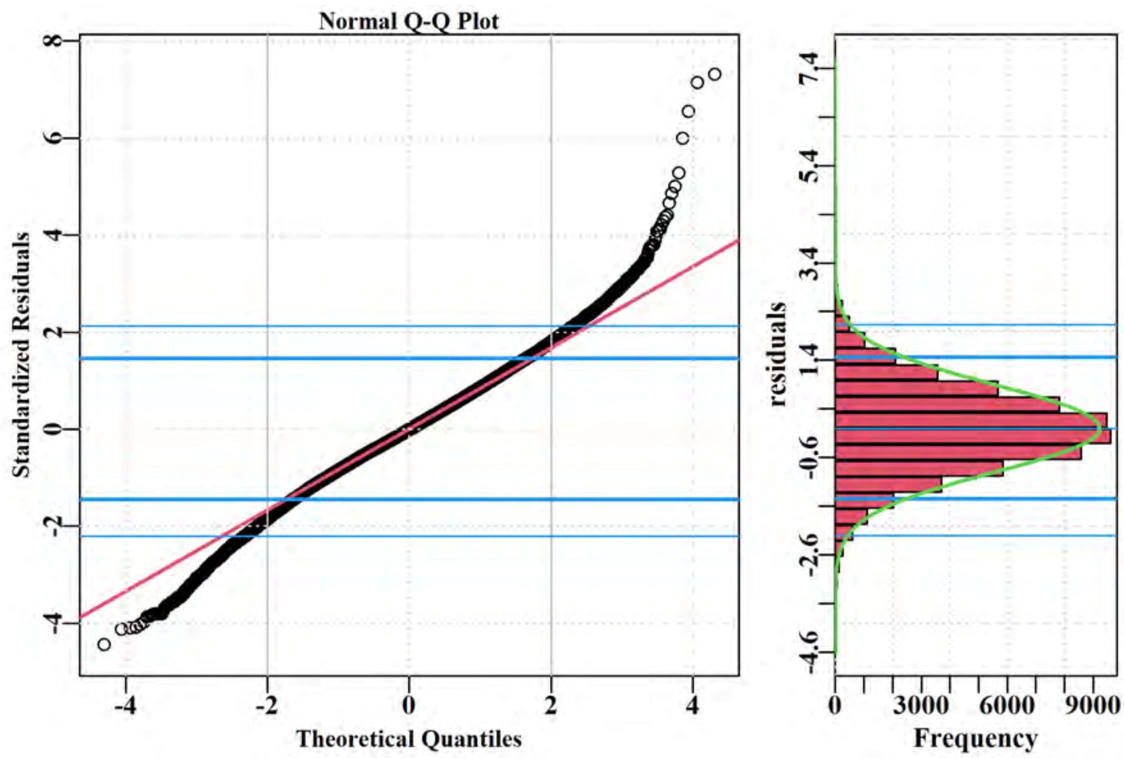

Figure 176: OceanJacketsGAB. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

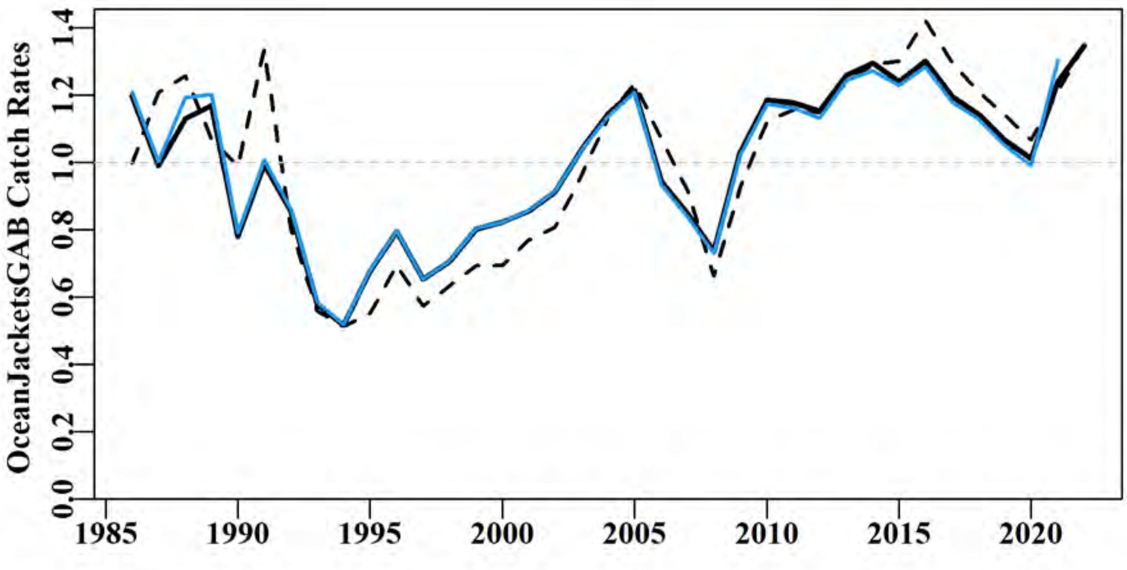

Figure 177: OceanJacketsGAB. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

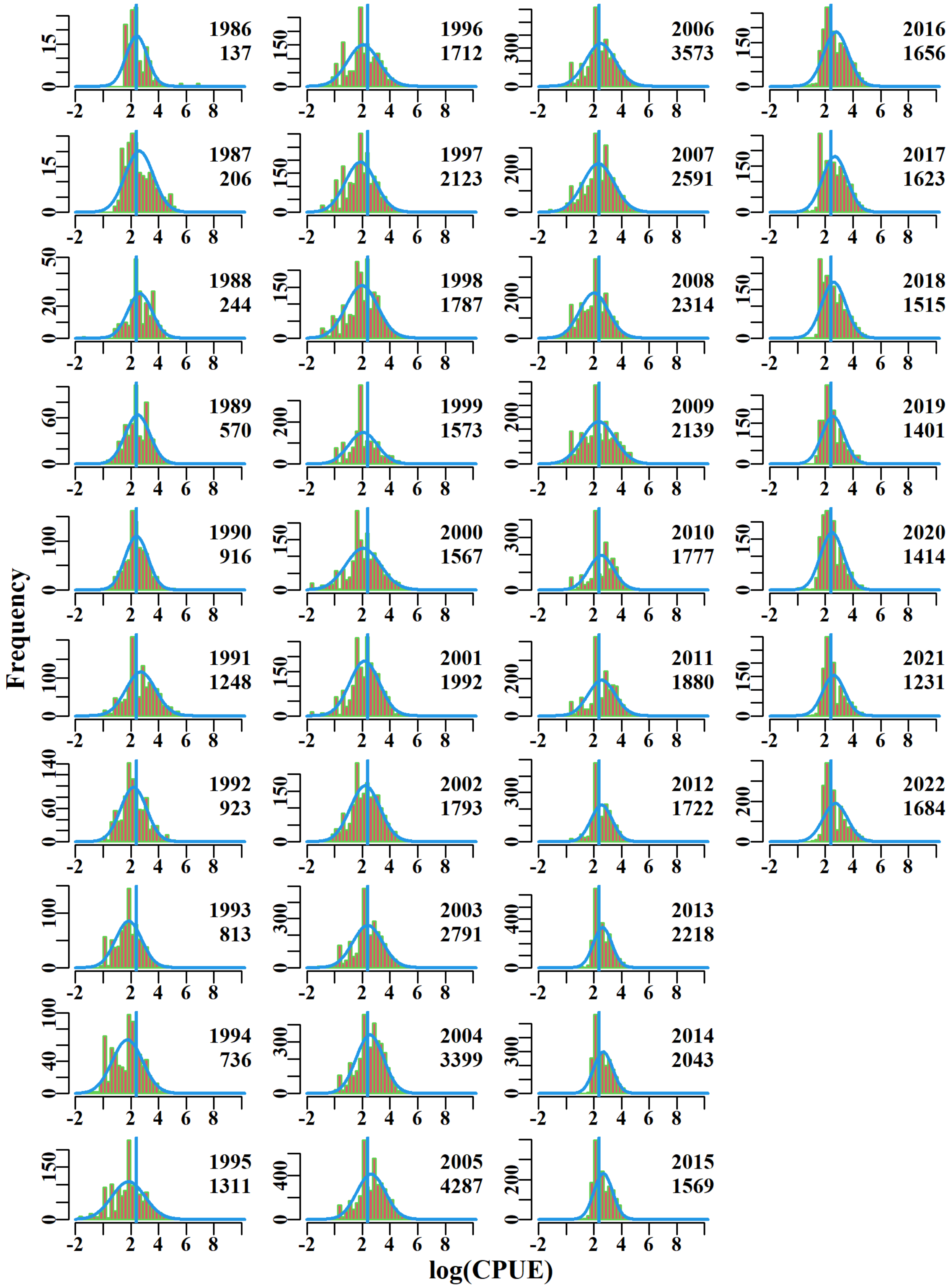

Figure 178: OceanJacketsGAB. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

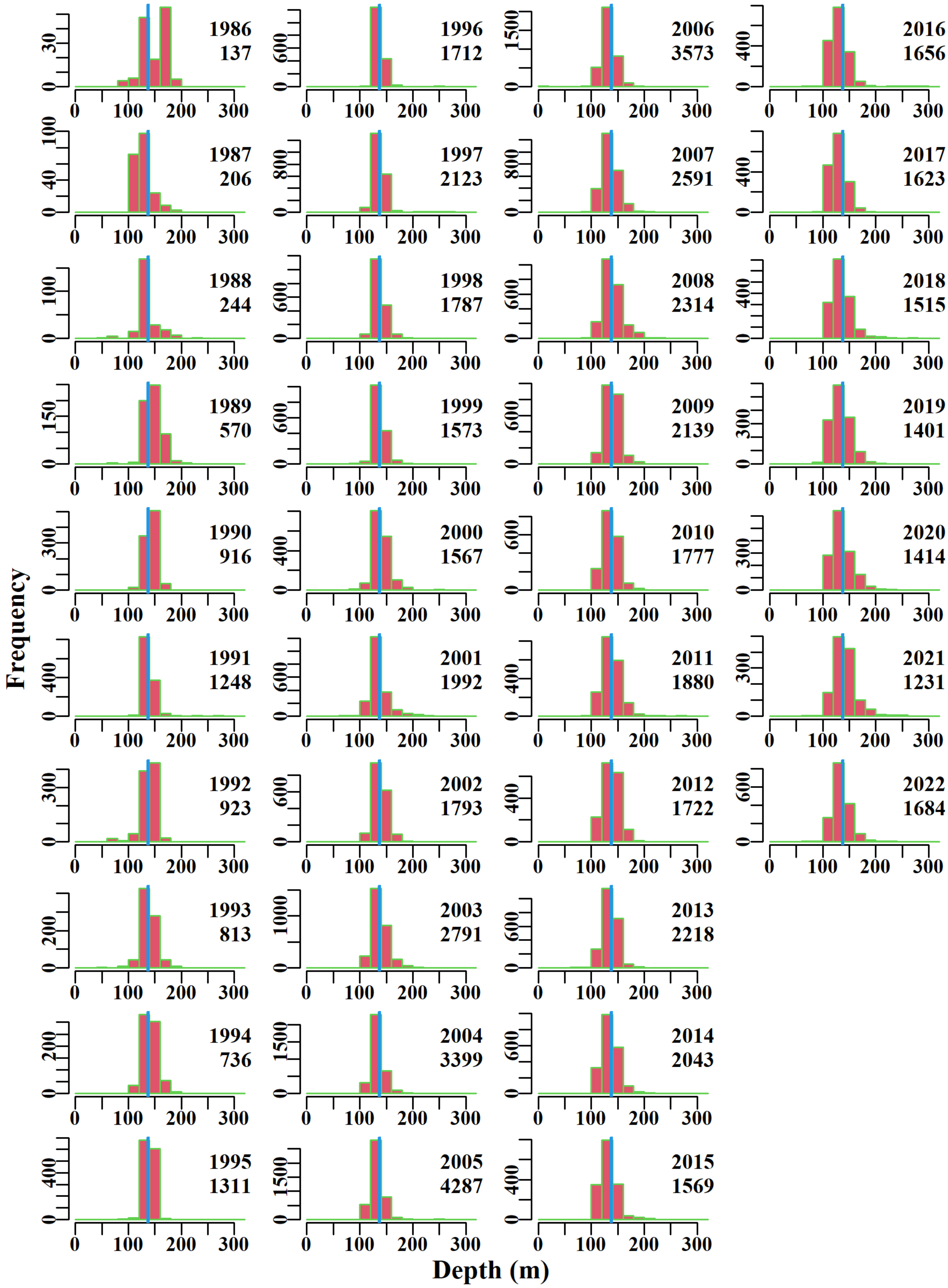

Figure 179: OceanJacketsGAB. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Western Gemfish 4050

Initial data selection for western Gemfish (GEM– 37439002 – *Rexea solandri*) in zones 40 and 50 was conducted according to the details given in Table 127.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 50 with minimal catches in zone 40.

The terms Year, DepCat, Vessel and DayNight had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 131). The qqplot suggests a small departure from the assumed Normal distribution as depicted by the upper tail of the distribution (Figure 183).

Annual standardized CPUE are noisy and flat since 1992 and consistently mostly below average since 2001 (Figure 180). However, there has been an overall increase in CPUE (to the long-term average) since 2007, with estimates in the last three years above the long-term average.

Action Items and Issues

No issues identified.

Table 127: gemfish4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	gemfish4050
csirocode	37439002, 91439002, 92439002
fishery	SET
depthrange	100 - 700
depthclass	50
zones	40, 50
methods	TW, TDO, OTM, OTB
years	1986 - 2022

Table 128: gemfish4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	307.7	1681	306.8	24	63.4	2.3595	0.000	5.837	0.019
1987	250.2	1210	248.2	26	68.3	2.2379	0.045	4.464	0.018
1988	223.4	1204	220.5	27	63.1	2.2200	0.047	6.723	0.030
1989	156.7	1076	156.6	28	50.0	1.8758	0.049	6.139	0.039
1990	135.2	1023	134.4	24	44.1	1.4287	0.053	8.274	0.062
1991	268.5	1353	247.4	25	57.4	1.4196	0.049	7.115	0.029
1992	89.7	661	80.7	15	43.1	0.9657	0.057	4.224	0.052
1993	101.8	711	101.4	16	40.0	0.9400	0.057	5.646	0.056
1994	96.0	825	95.0	18	33.4	1.0044	0.054	5.739	0.060
1995	84.0	961	83.9	21	29.1	0.8737	0.052	8.373	0.100
1996	142.9	1130	142.5	26	44.2	0.9420	0.050	9.811	0.069
1997	152.9	1373	152.3	21	42.6	0.8427	0.048	11.465	0.075
1998	122.4	1255	121.9	20	40.2	0.8931	0.049	10.284	0.084
1999	176.9	1685	175.5	18	37.2	0.8456	0.047	14.406	0.082
2000	231.9	1904	229.0	28	57.3	0.9256	0.047	14.844	0.065
2001	168.5	1668	168.2	26	45.0	0.7397	0.048	13.752	0.082
2002	85.9	1395	85.1	23	19.9	0.5549	0.049	13.044	0.153
2003	122.7	1045	121.5	23	41.0	0.6480	0.052	7.667	0.063
2004	107.1	1212	105.2	22	25.4	0.6056	0.052	8.132	0.077
2005	116.1	1053	114.1	18	32.9	0.6375	0.053	5.770	0.051
2006	104.7	882	101.6	17	25.5	0.5220	0.056	4.491	0.044
2007	60.0	688	57.2	14	20.1	0.4903	0.058	3.687	0.064
2008	55.4	747	52.8	13	14.9	0.5765	0.057	4.709	0.089
2009	60.0	926	56.2	12	12.9	0.6290	0.054	6.100	0.108
2010	90.1	1364	86.1	14	12.9	0.6834	0.050	8.024	0.093
2011	55.2	1063	53.5	12	10.1	0.6994	0.052	6.881	0.129
2012	49.6	710	46.4	13	13.6	0.6703	0.058	4.037	0.087
2013	42.2	570	37.8	14	13.2	0.5964	0.062	3.080	0.082
2014	70.5	669	68.9	14	25.2	0.8448	0.059	2.098	0.030
2015	48.7	653	46.3	12	17.2	0.7042	0.060	2.041	0.044
2016	53.3	658	50.6	13	17.8	0.7963	0.060	2.161	0.043
2017	82.9	853	81.5	10	20.3	1.0957	0.057	1.039	0.013
2018	44.3	623	43.9	10	12.7	0.8804	0.062	1.084	0.025
2019	96.3	893	95.7	12	20.4	1.0099	0.056	1.373	0.014
2020	62.3	695	61.2	12	18.6	1.0637	0.060	1.426	0.023
2021	61.0	647	60.5	9	18.2	1.3206	0.061	0.326	0.005
2022	72.6	650	70.2	8	17.8	1.4573	0.060	0.047	0.001

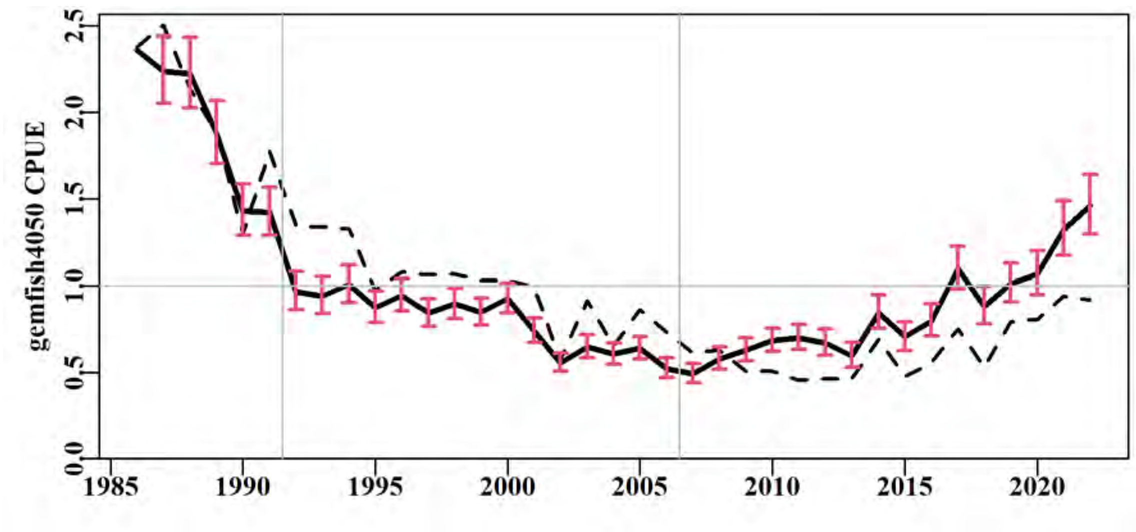

Figure 180: gemfish4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

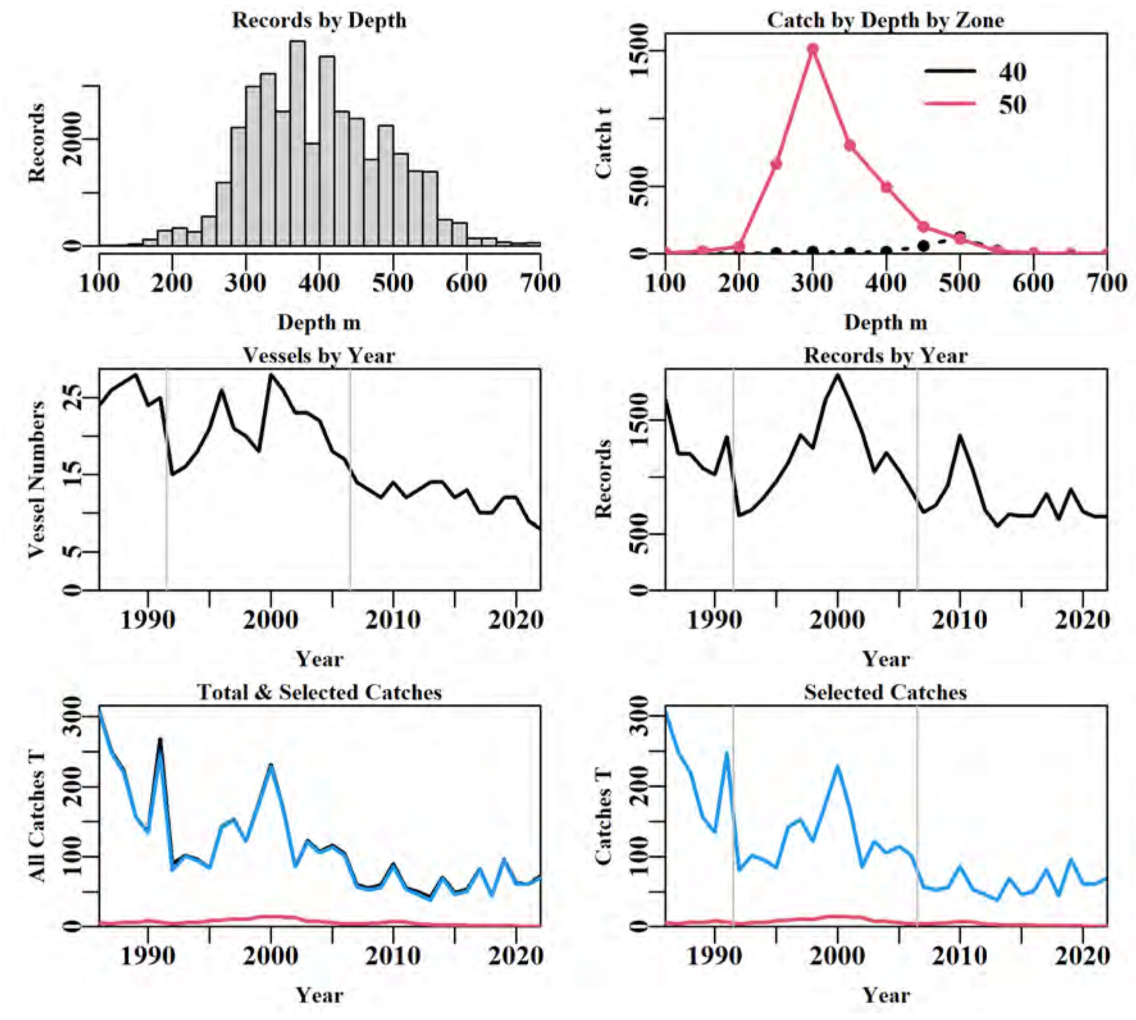

Figure 181: gemfish4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 129: gemfish4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	41777	39307	38955	38169	38169	37759	37716
Difference	0	2470	352	786	0	410	43
Catch	4398	4359	4338	4189	4189	4162	4161
Difference	0	39	21	148	0	27	2

Table 130: The models used to analyse data for gemfish4050.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + Zone
Model5	Year + DepCat + Vessel + Zone + DayNight
Model6	Year + DepCat + Vessel + Zone + DayNight + Month
Model7	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:Month
Model8	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:DepCat

Table 131: gemfish4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	24059	71237	8705	37716	37	10.8	0.00
DepCat	14784	55671	24271	37716	49	30.3	19.47
Vessel	9127	47681	32261	37716	142	40.1	9.86
Zone	8998	47516	32427	37716	143	40.3	0.21
DayNight	8273	46604	33339	37716	146	41.5	1.14
Month	7903	46122	33820	37716	157	42.1	0.59
Zone:Month	7557	45674	34268	37716	168	42.6	0.55
Zone:DepCat	7815	45988	33955	37716	168	42.2	0.15

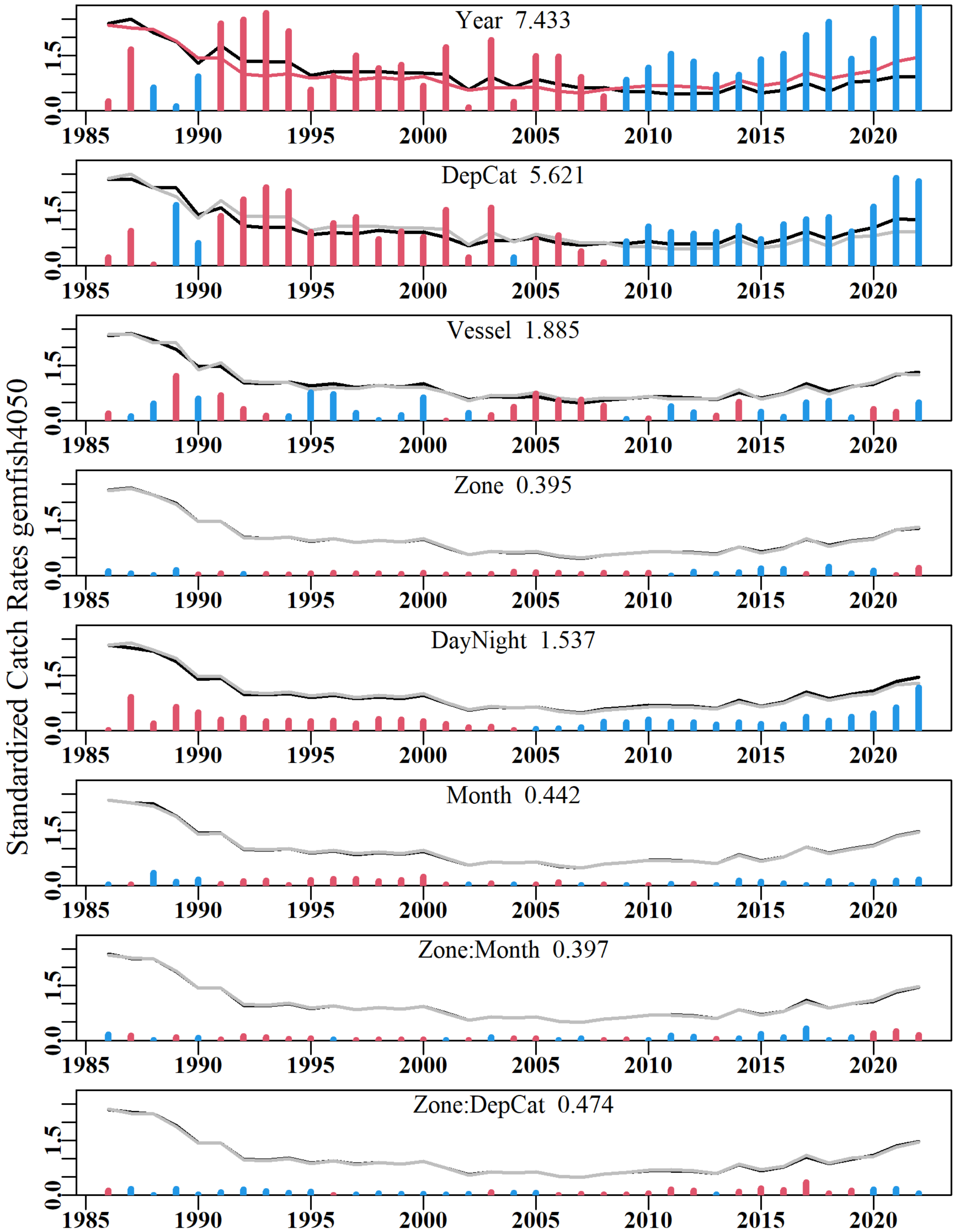

Figure 182: gemfish4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

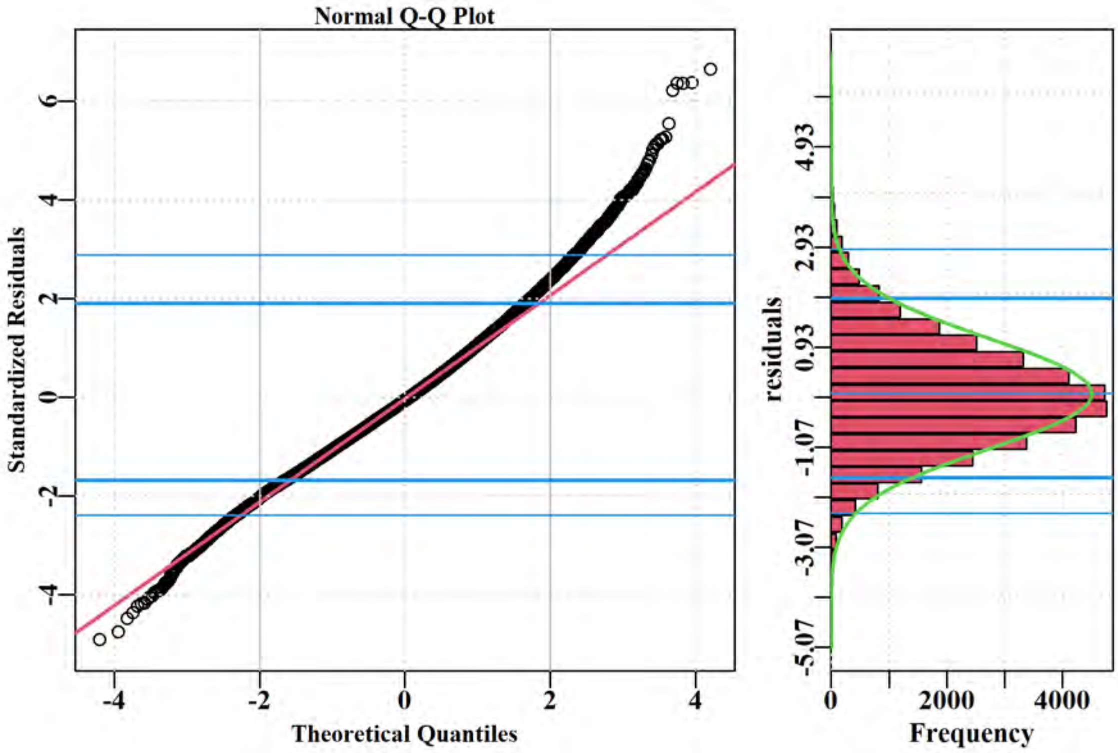

Figure 183: gemfish4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

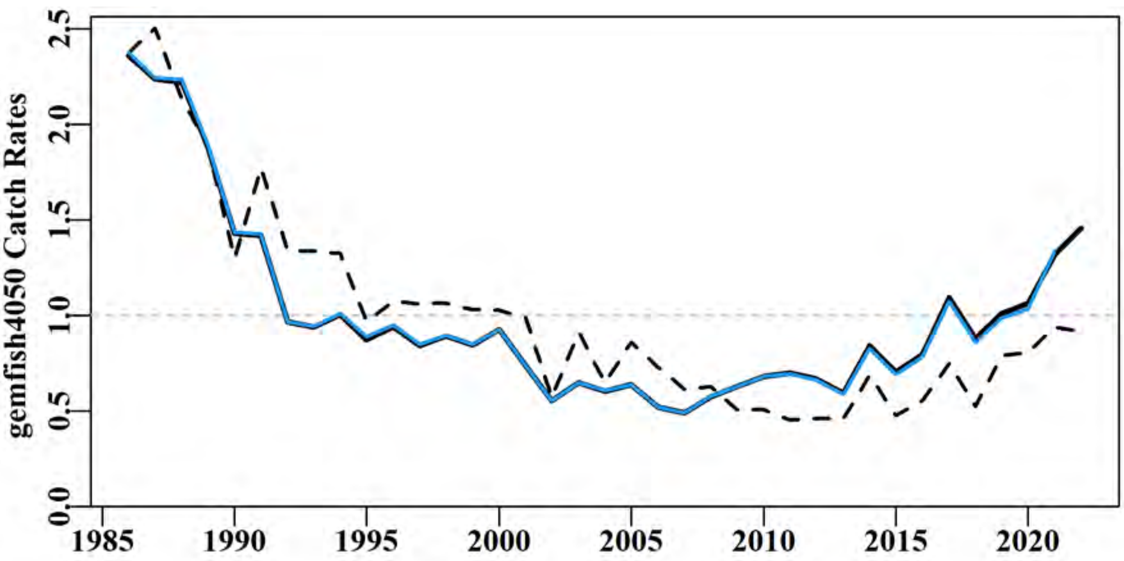

Figure 184: gemfish4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

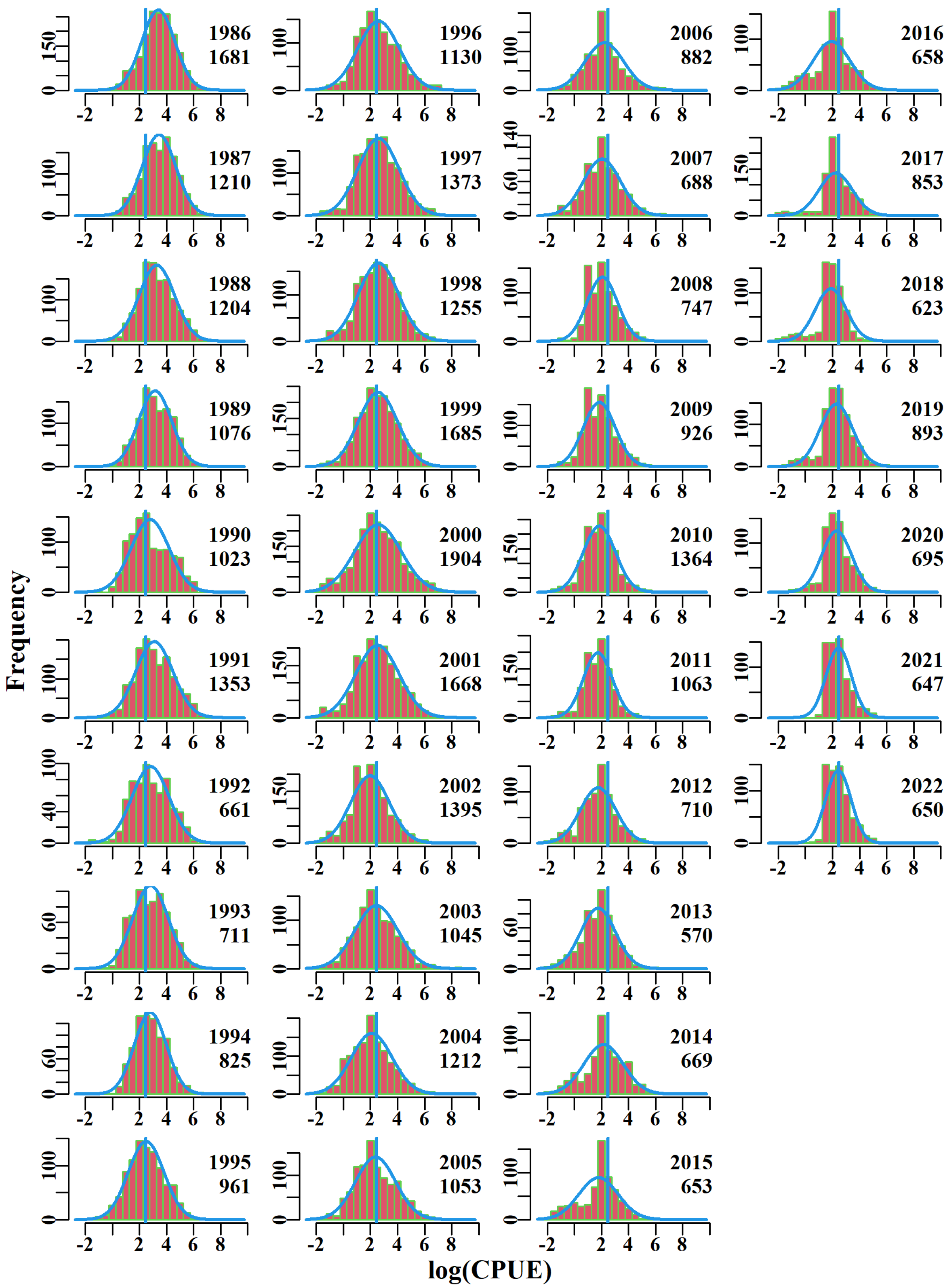

Figure 185: gemfish4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

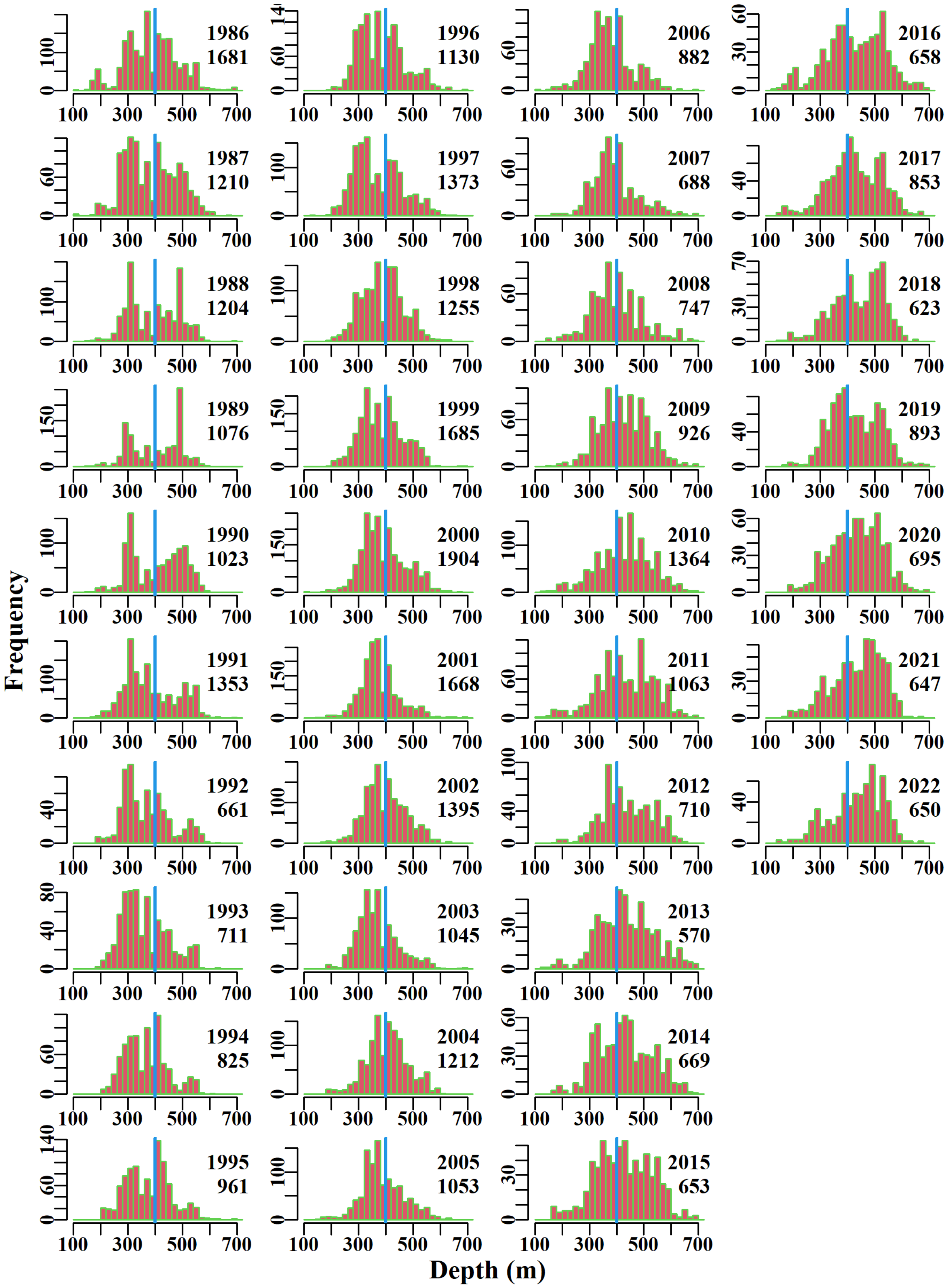

Figure 186: gemfish4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Western Gemfish 4050GAB

Initial data selection for western Gemfish (GEM– 37439002 – *Rexea solandri*) in zones 40, 50 and the GAB was conducted according to the details given in Table 132.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 50 followed by zone 82 and minimal catches in the remaining zones.

The terms Year, DepCat, Vessel, Zone and DayNight and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 136). The qqplot suggests the assumed Normal distribution is valid with a slight departure as depicted by the tails of the distribution (Figure 190).

Annual standardized CPUE has been consistently below average and flat since 1999, with small overall increases in annual estimated CPUE (to the long-term average) in 2020 and to above the long-term average since 2021 (Figure 187). However, the CPUE from 1986 - 1994 is more representative of zone 50 than of the GAB. Given recent evidence that the stocks of western Gemfish in the GAB and most of zone 50 are different biological stocks it is doubtful that these data should be combined.

Action Items and Issues

This analysis is recommended to be abandoned as it combines data from two biological stocks.

Table 132: gemfish4050GAB. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	gemfish4050GAB
csirocode	37439002, 91439002, 92439002
fishery	SET_GAB_GBQ
depthrange	100 - 650
depthclass	50
zones	40, 50, 82, 83, 84, 85
methods	TW, TDO, OTT, OTM, OTB
years	1986 - 2022

Table 133: gemfish4050GAB. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	308.9	1700	306.5	25	62.3	2.2770	0.000	6.369	0.021
1987	263.8	1283	261.5	29	67.9	2.1120	0.045	5.264	0.020
1988	260.2	1399	254.9	36	63.3	1.9935	0.048	8.098	0.032
1989	185.3	1397	184.8	37	45.6	1.5619	0.048	8.774	0.047
1990	146.2	1231	145.2	35	38.5	1.3489	0.052	10.504	0.072
1991	300.0	1560	278.4	32	56.2	1.3376	0.049	8.992	0.032
1992	105.7	797	96.7	21	41.4	0.9875	0.056	5.404	0.056
1993	108.7	892	108.2	20	35.4	0.8292	0.055	7.358	0.068
1994	110.8	1037	109.8	24	33.3	0.8480	0.053	7.391	0.067
1995	106.9	1284	106.7	26	27.1	0.8190	0.050	11.458	0.107
1996	162.9	1576	161.7	32	30.7	0.9325	0.049	15.841	0.098
1997	214.8	2090	214.1	28	32.8	0.8341	0.047	19.333	0.090
1998	208.1	1964	207.2	26	35.9	0.9637	0.047	16.454	0.079
1999	323.9	2324	320.4	24	42.6	0.9711	0.046	17.891	0.056
2000	264.1	2331	261.2	32	52.9	0.8294	0.047	17.644	0.068
2001	259.9	2333	258.6	30	47.1	0.7760	0.047	17.391	0.067
2002	129.7	1748	128.5	28	20.4	0.5926	0.048	15.336	0.119
2003	207.5	1605	200.9	33	34.3	0.6515	0.049	11.011	0.055
2004	488.2	1942	480.3	30	48.1	0.6926	0.049	11.003	0.023
2005	389.6	1871	378.4	27	50.5	0.7021	0.050	8.591	0.023
2006	463.3	1614	437.1	26	56.6	0.6561	0.051	6.624	0.015
2007	426.7	1398	416.6	20	63.7	0.5943	0.052	5.950	0.014
2008	169.0	1237	155.7	18	19.5	0.6378	0.052	7.665	0.049
2009	113.5	1266	104.9	16	13.7	0.6599	0.052	8.242	0.079
2010	139.6	1700	128.4	18	12.7	0.7183	0.049	10.095	0.079
2011	87.3	1284	74.8	16	10.4	0.7438	0.052	8.259	0.110
2012	108.2	1043	100.3	18	16.3	0.7997	0.055	5.473	0.055
2013	55.9	706	47.2	20	13.1	0.6854	0.060	3.150	0.067
2014	97.7	838	89.1	17	24.5	0.9077	0.057	2.300	0.026
2015	57.0	716	50.2	14	16.5	0.7553	0.060	2.238	0.045
2016	55.8	678	51.2	15	17.2	0.8479	0.061	2.312	0.045
2017	86.0	933	83.7	13	18.8	1.0745	0.057	1.277	0.015
2018	46.9	699	46.2	13	11.9	0.9285	0.061	1.507	0.033
2019	97.4	925	96.3	14	20.0	1.0258	0.057	1.586	0.016
2020	63.5	731	62.0	15	17.9	1.0702	0.061	1.679	0.027
2021	61.9	659	60.9	12	17.9	1.3486	0.062	0.393	0.006
2022	73.1	665	70.5	10	17.4	1.4862	0.062	0.202	0.003

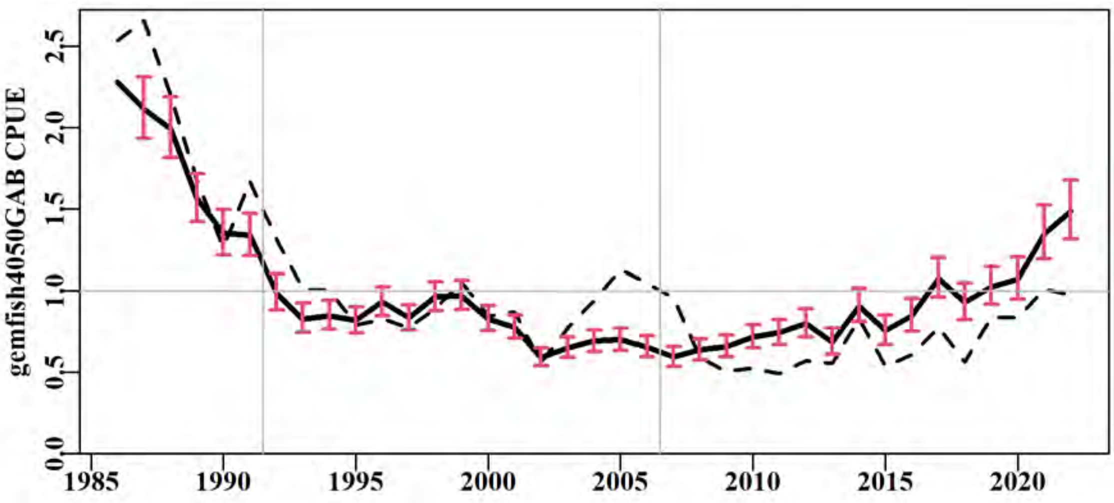

Figure 187: gemfish4050GAB standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

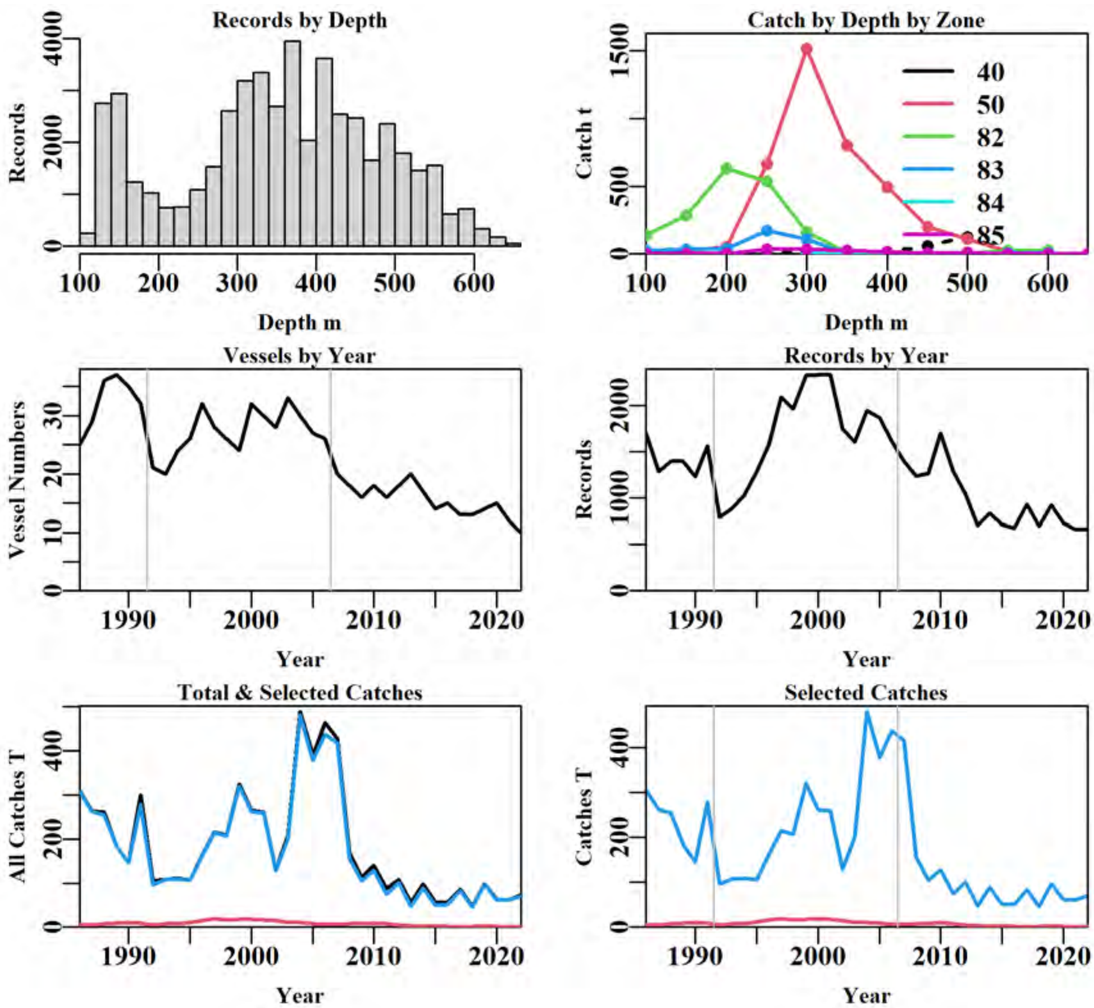

Figure 188: gemfish4050GAB fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 134: gemfish4050GAB data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	56835	54639	53649	52654	52654	49501	49456
Difference	0	2196	990	995	0	3153	45
Catch	6938	6907	6843	6678	6678	6541	6539
Difference	0	31	64	165	0	138	2

Table 135: The models used to analyse data for gemfish4050GAB.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + Zone
Model5	Year + DepCat + Vessel + Zone + DayNight
Model6	Year + DepCat + Vessel + Zone + DayNight + Month
Model7	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:Month
Model8	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:DepCat

Table 136: gemfish4050GAB. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	39563	109897	8995	49456	37	7.5	0.00
DepCat	25741	83065	35826	49456	48	30.1	22.57
Vessel	17345	69773	49119	49456	162	41.1	11.06
Zone	16490	68564	50328	49456	167	42.1	1.01
DayNight	15342	66982	51910	49456	170	43.5	1.33
Month	15125	66659	52232	49456	181	43.7	0.26
Zone:Month	14006	65026	53865	49456	235	45.0	1.32
Zone:DepCat	14640	65869	53022	49456	233	44.3	0.61

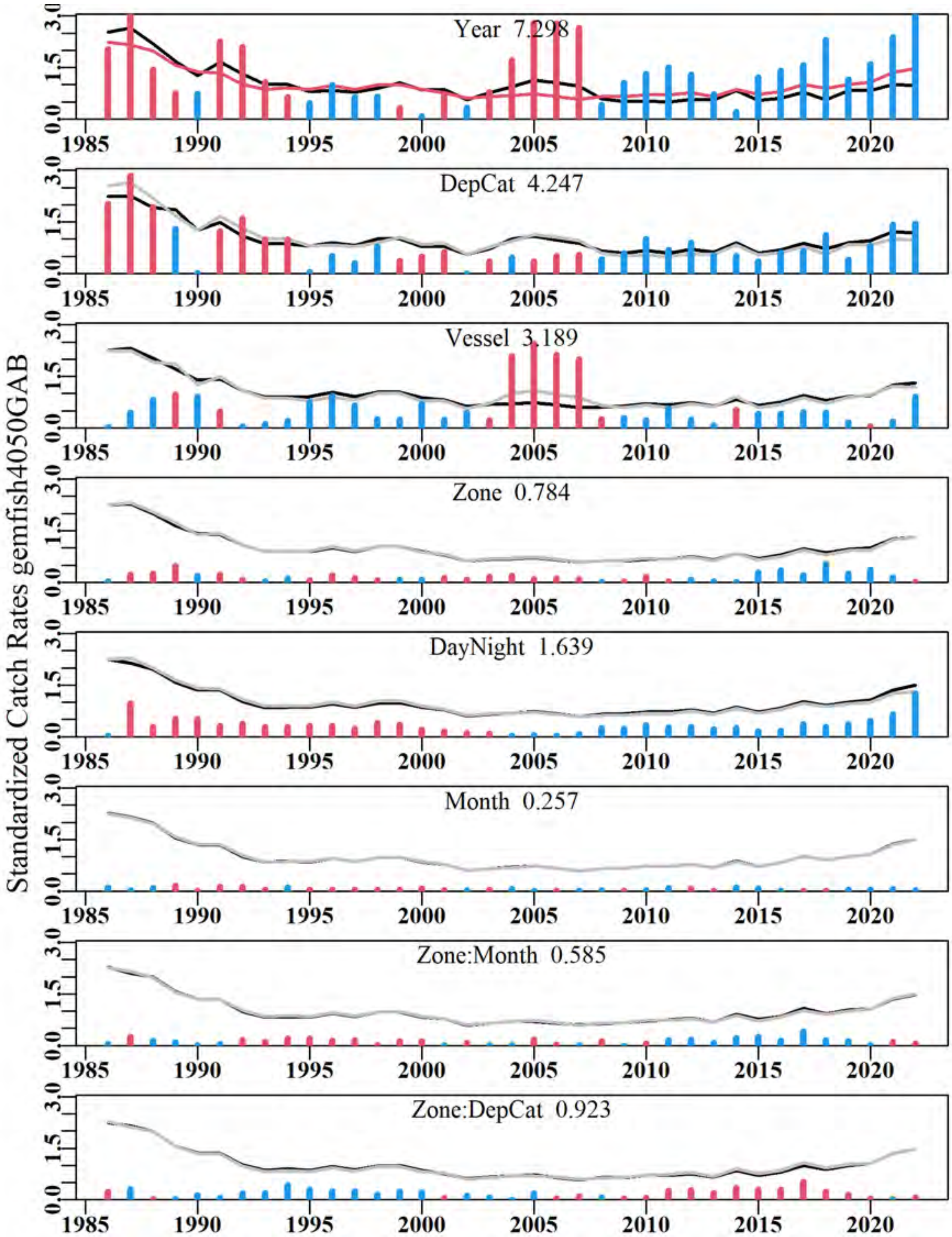

Figure 189: gemfish4050GAB. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

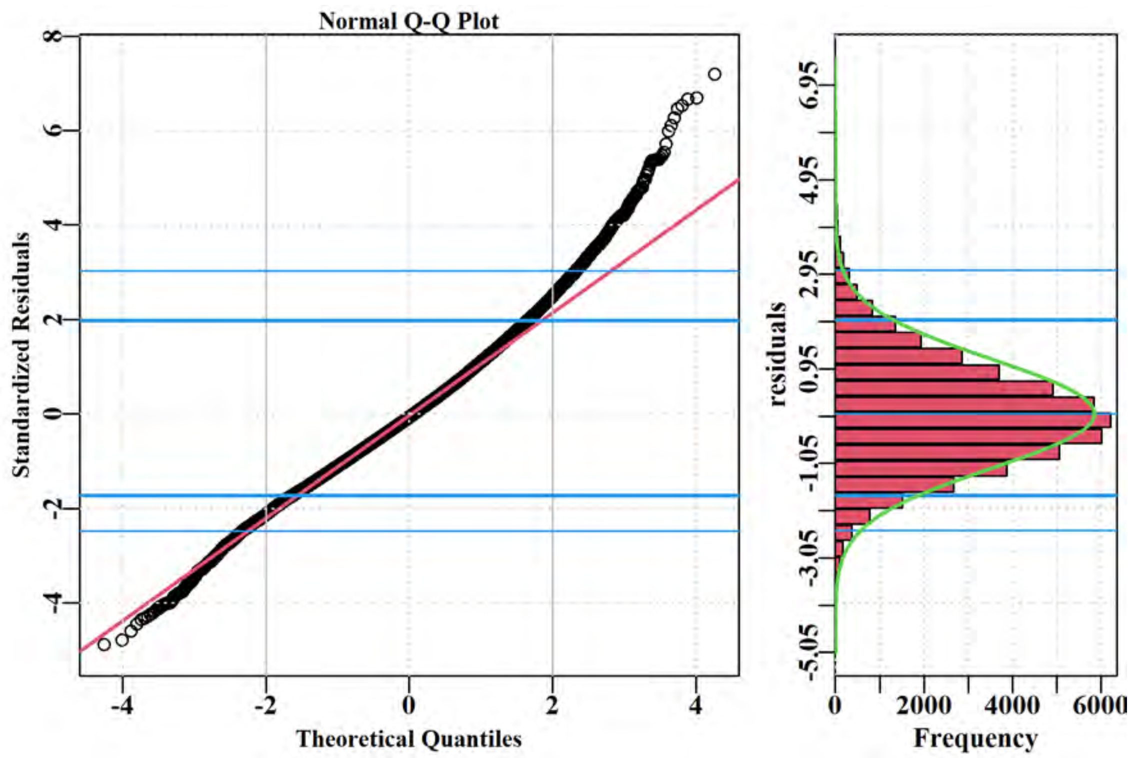

Figure 190: gemfish4050GAB. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

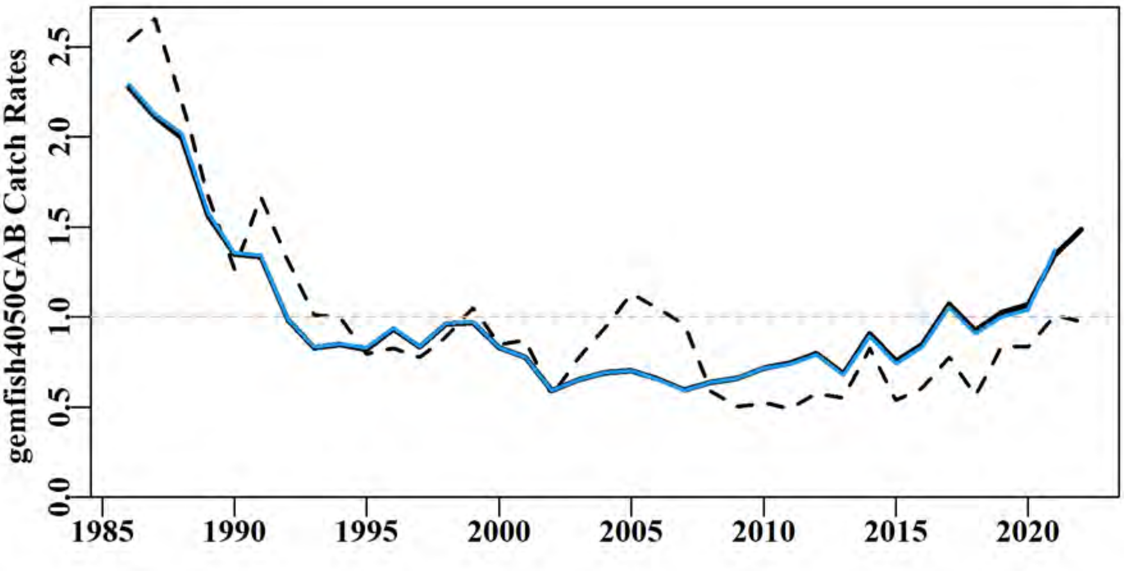

Figure 191: gemfish4050GAB. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

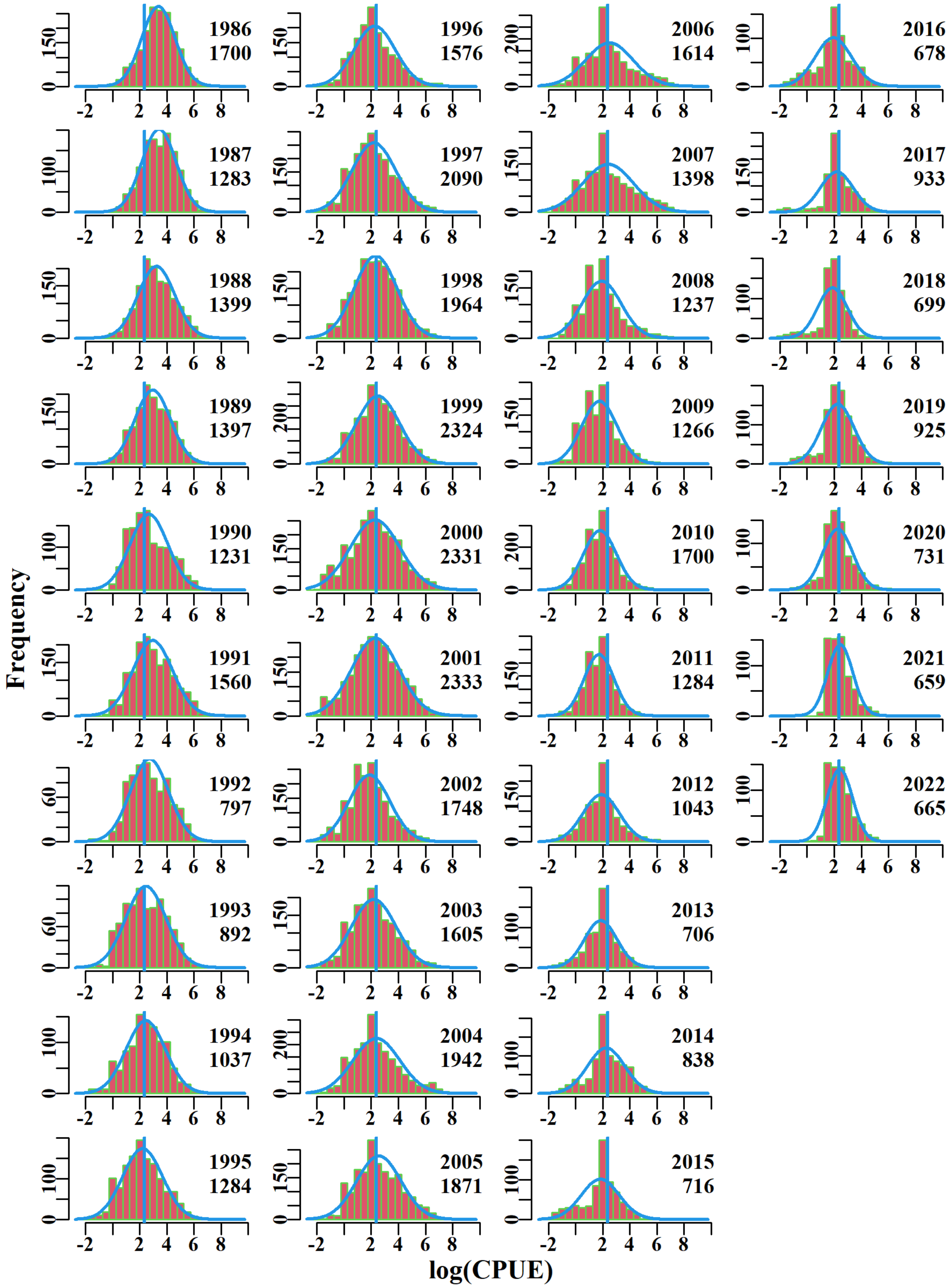

Figure 192: gemfish4050GAB. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

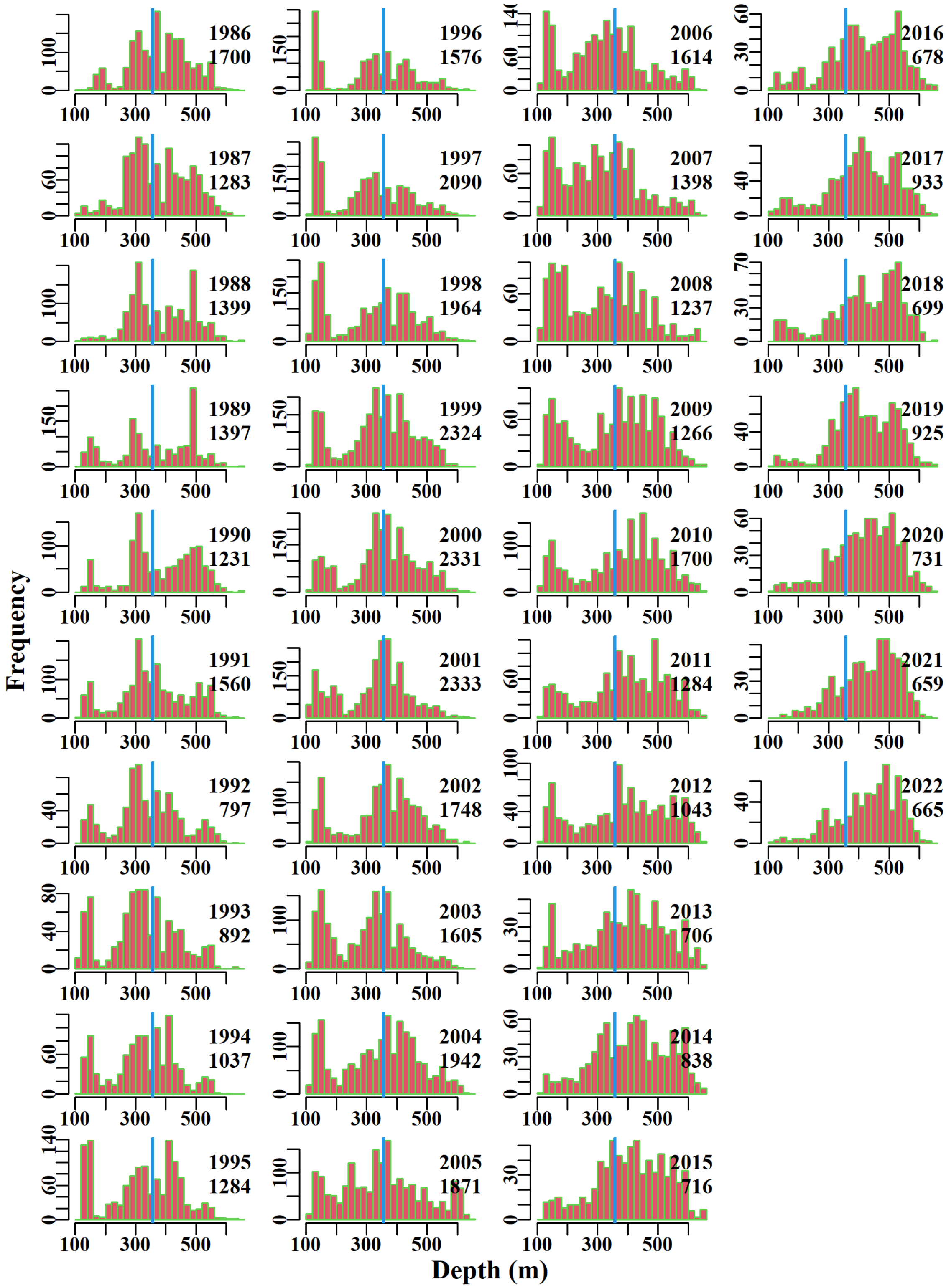

Figure 193: gemfish4050GAB. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Western Gemfish GAB

Initial data selection for western Gemfish (GEM – 37439002 – *Rexea solandri*) in GAB zones was conducted according to the details given in Table 137.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 82 followed by zone 83 with minimal catches in the remaining GAB zones. There were a small number of records (30) and corresponding catch (0.7 t) in 2016 across these zones. Similarly, there were only 39 records accounting for 0.9 t in 2019 and only 40 records accounting for 0.9 t in 2020 across these two zones. Only 13 records corresponding to 0.5 t were analysed in 2021, followed by 17 records corresponding to 0.4 t in 2022, the latter the lowest in the series. There were very high catches between 2004-2007.

The terms Year, DepCat, Vessel, Zone, DayNight, Month and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 141). The qqplot suggests a small departure from the assumed Normal distribution as depicted by the upper tail (Figure 197).

Annual standardized CPUE are noisy and flat across the years analysed (Figure 194), with the effect of the exceptional vessel being accounted for in the standardization.

Action Items and Issues

The number of records corresponding to 0.4 t in 2022 are the lowest in the series. Also, annual catches of western Gemfish in the GAB less than 1 t since 2019 and the increase of the proportion of catch <30 kg questions whether this species was actively targeted during this period.

Table 137: gemfishGAB. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	gemfishGAB
csirocode	37439002, 91439002, 92439002
fishery	GAB_GBQ
depthrange	100 - 650
depthclass	50
zones	82, 83, 84, 85
methods	TW, TDO, OTT, OTB
years	1995 - 2022

Table 138: gemfishGAB. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1995	181.7	324	22.5	5	13.2	0.7267	0.000	3.093	0.138
1996	382.2	448	19.2	7	7.1	0.9288	0.093	6.034	0.314
1997	572.0	718	61.7	9	12.9	0.9212	0.089	7.883	0.128
1998	404.8	708	85.3	8	24.8	1.3918	0.090	6.170	0.072
1999	448.7	643	144.9	7	59.0	1.6899	0.093	3.520	0.024
2000	336.5	428	32.2	6	14.6	0.5903	0.098	2.805	0.087
2001	331.5	670	90.3	7	42.9	0.9926	0.092	3.634	0.040
2002	195.9	351	43.2	6	20.7	0.8793	0.102	2.283	0.053
2003	268.0	559	79.2	10	20.7	0.8376	0.097	3.308	0.042
2004	569.0	732	375.2	10	116.2	1.1078	0.097	2.901	0.008
2005	511.8	818	264.3	10	83.4	0.9871	0.097	2.821	0.011
2006	544.9	732	335.7	11	133.6	0.9491	0.097	2.133	0.006
2007	599.1	713	359.6	9	174.3	0.8306	0.095	2.271	0.006
2008	294.9	494	103.2	7	28.0	0.8612	0.097	2.975	0.029
2009	194.9	347	48.9	4	15.2	0.7989	0.104	2.161	0.044
2010	220.7	345	42.7	4	11.7	0.8376	0.104	2.100	0.049
2011	147.7	228	21.5	4	12.4	0.8969	0.115	1.415	0.066
2012	168.6	333	53.9	5	22.7	1.2775	0.107	1.437	0.027
2013	103.8	148	9.7	6	11.5	1.1790	0.132	0.154	0.016
2014	130.3	176	20.2	5	20.7	1.2108	0.133	0.246	0.012
2015	86.6	68	4.1	2	10.5	1.1296	0.173	0.209	0.051
2016	74.6	30	0.7	3	7.4	0.7854	0.245	0.196	0.273
2017	119.2	85	2.6	4	7.8	0.8142	0.160	0.312	0.120
2018	74.3	77	2.3	4	6.9	1.5186	0.167	0.423	0.184
2019	158.1	39	0.9	2	8.1	1.0067	0.217	0.237	0.257
2020	121.4	40	0.9	3	5.2	0.7158	0.215	0.333	0.372
2021	118.5	13	0.5	3	7.4	1.0516	0.357	0.068	0.134
2022	112.0	17	0.4	2	5.3	1.0834	0.314	0.155	0.355

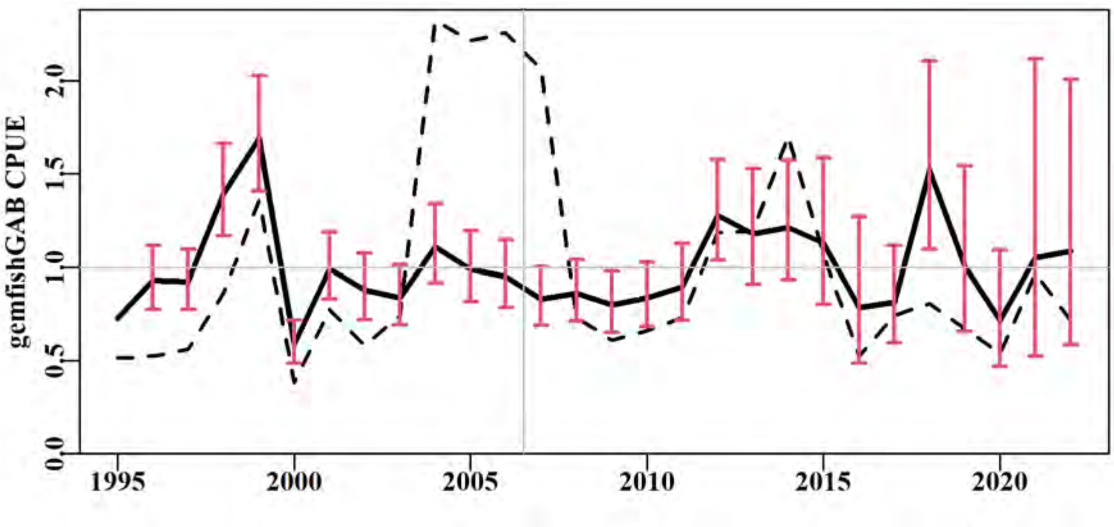

Figure 194: gemfishGAB standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

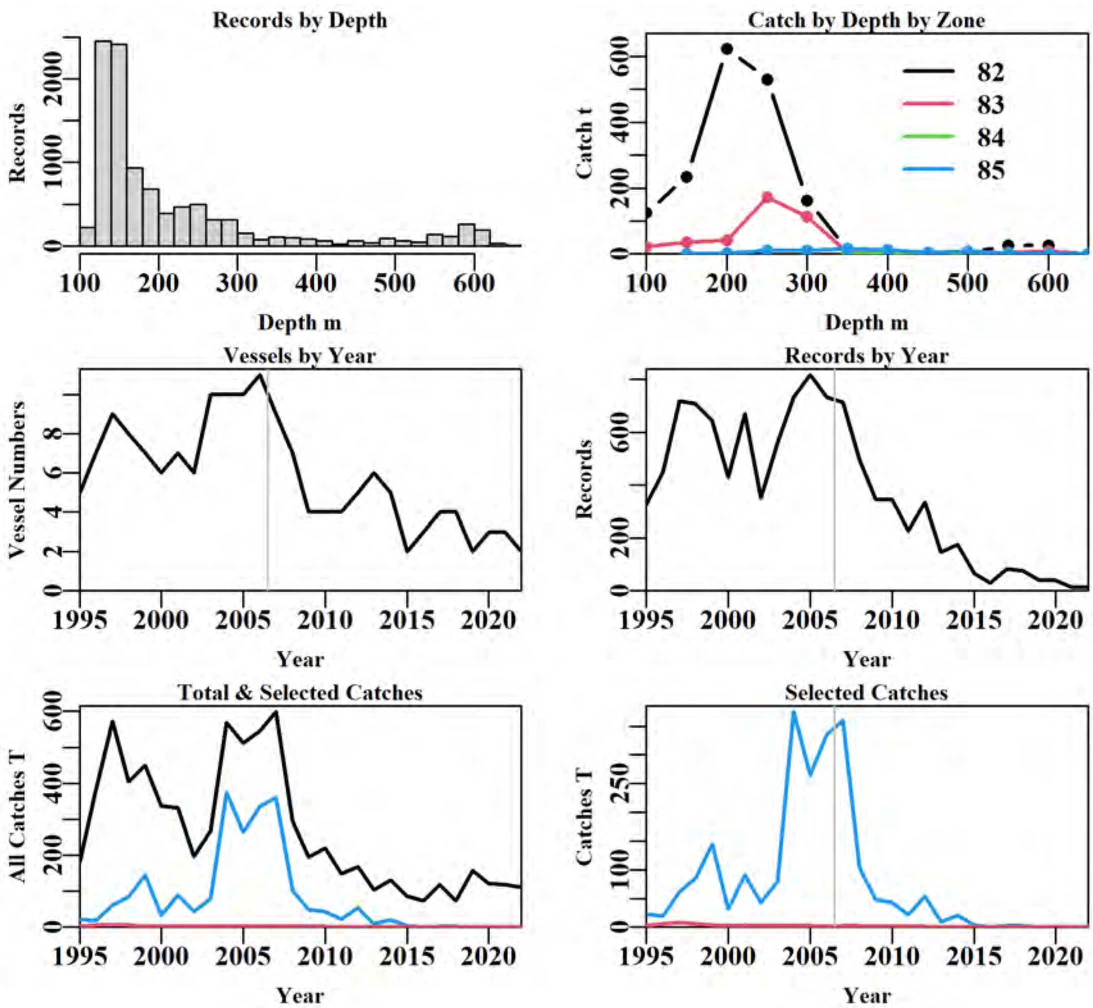

Figure 195: gemfishGAB fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 139: gemfishGAB data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	141675	132824	130362	92124	12251	10298	10284
Difference	0	8851	2462	38238	79873	1953	14
Catch	24235	23995	23762	7367	2317	2227	2226
Difference	0	240	234	16394	5051	89	1

Table 140: The models used to analyse data for gemfishGAB.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + Zone
Model5	Year + DepCat + Vessel + Zone + DayNight
Model6	Year + DepCat + Vessel + Zone + DayNight + Month
Model7	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:Month
Model8	Year + DepCat + Vessel + Zone + DayNight + Month + Zone:DepCat

Table 141: gemfishGAB. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	11153	30253	3467	10284	28	10.0	0.00
DepCat	7481	21125	12596	10284	39	37.1	27.07
Vessel	5931	18088	15633	10284	62	46.0	8.92
Zone	5549	17418	16303	10284	65	48.0	1.98
DayNight	5182	16799	16922	10284	68	49.9	1.83
Month	4886	16287	17434	10284	79	51.3	1.48
Zone:Month	4599	15740	17980	10284	111	52.8	1.48
Zone:DepCat	4810	16082	17638	10284	106	51.8	0.48

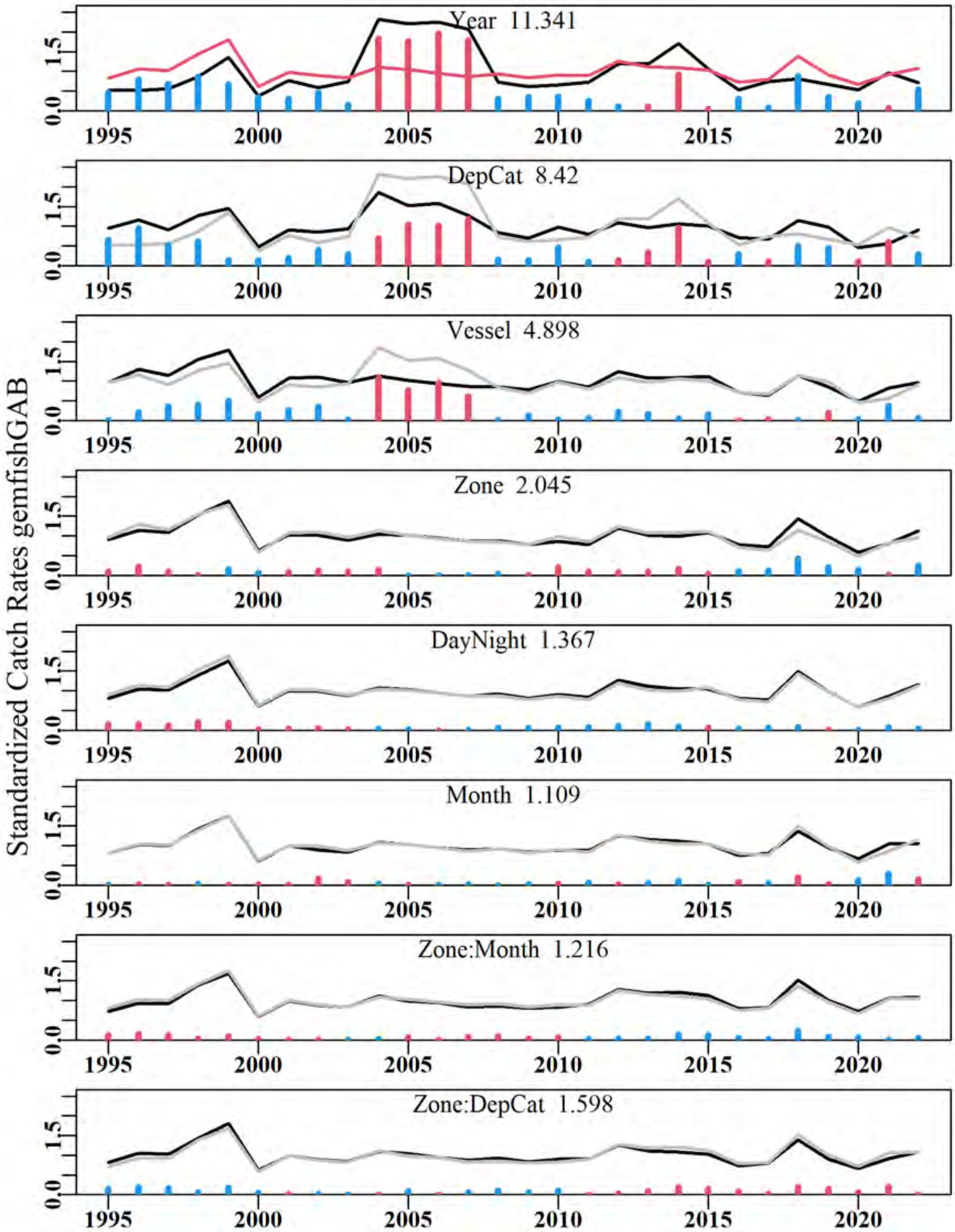

Figure 196: gemfishGAB. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

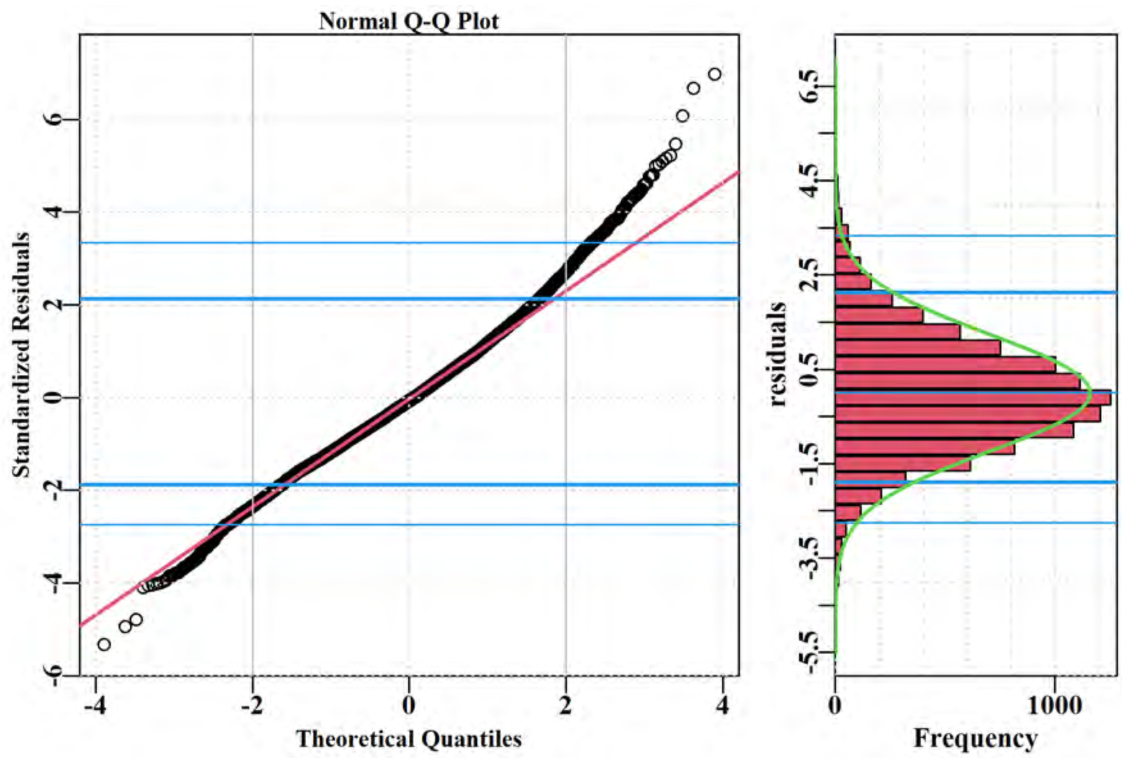

Figure 197: gemfishGAB. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

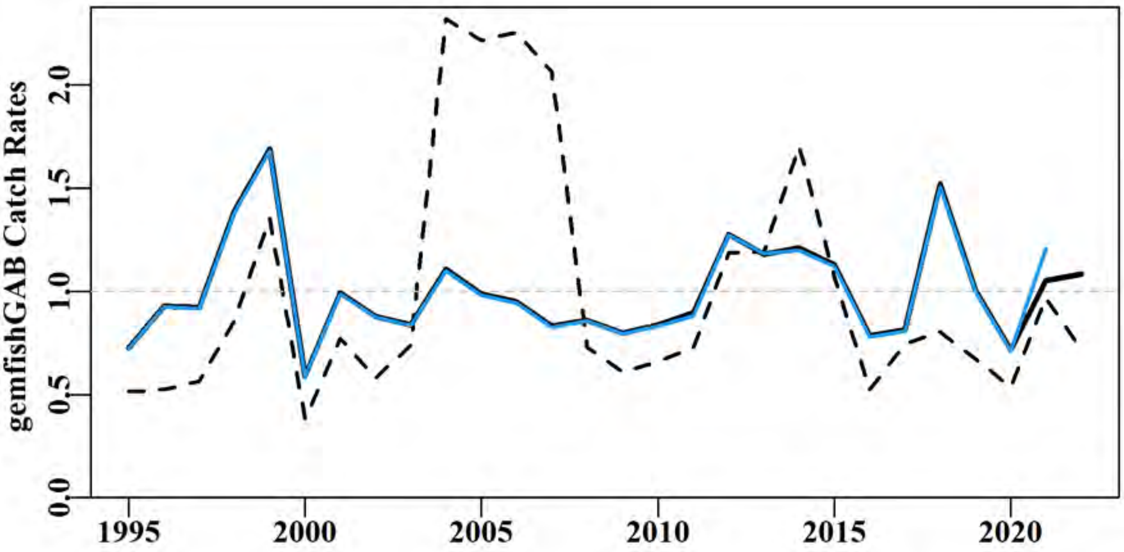

Figure 198: gemfishGAB. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

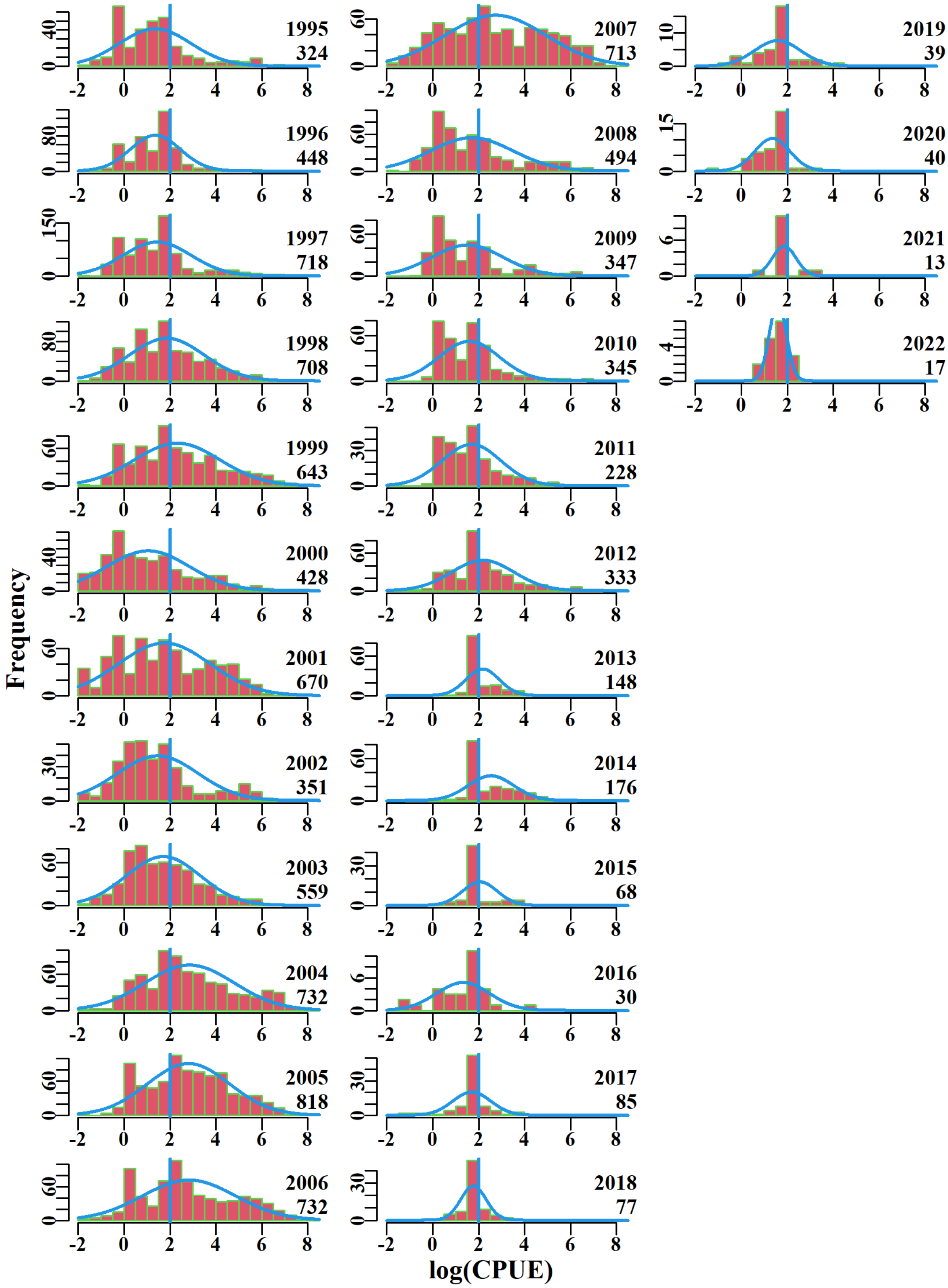

Figure 199: gemfishGAB. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

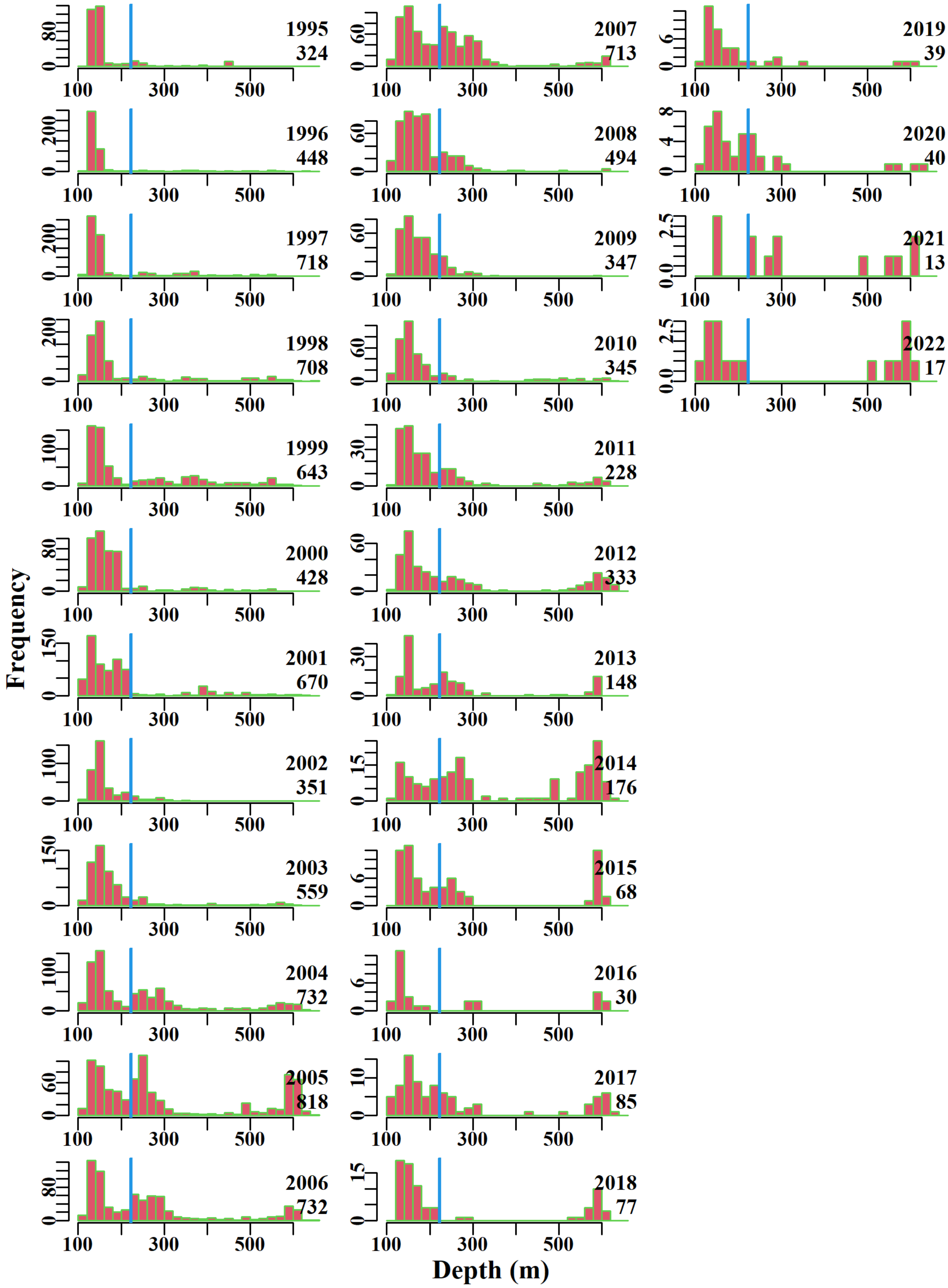

Figure 200: gemfishGAB. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Blue Warehou 10 - 30

For Blue Warehou (TRT – 37445005 – *Seriolella brama*) in zones 10 to 30, initial data selection was conducted according to the details given in Table 142.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 20 followed by zones 30 and 10. Large catches continued from about 1988 - 1998 and have since dropped to trivial levels and have been below 10 t since 2019.

The terms Year and Vessel had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 146). The qqplot suggests that the assumed Normal distribution is valid as depicted with slight departures from the tails of the distribution (Figure 204).

Annual standardized CPUE trend is flat since 1992 and consistently below average since 1999 (Figure 201).

Action Items and Issues

No issues identified.

Table 142: bluewarehou1030. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	bluewarehou1030
csirocode	37445005, 91445005, 92445005
fishery	SET
depthrange	0 - 400
depthclass	25
zones	10, 20, 30
methods	TW, TDO, OTB
years	1986 - 2022

Table 143: bluewarehou1030. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	211.9	700	138.7	40	69.8	2.4744	0.000	3.563	0.026
1987	405.9	457	168.2	40	84.9	2.9376	0.105	2.506	0.015
1988	544.0	772	333.6	33	122.0	3.6463	0.095	3.566	0.011
1989	776.0	1172	654.9	41	180.8	4.8142	0.093	4.010	0.006
1990	881.4	816	504.6	41	182.2	4.3780	0.098	3.118	0.006
1991	1284.2	1557	462.9	54	99.8	2.4594	0.092	8.997	0.019
1992	934.4	1331	401.4	40	96.0	2.0606	0.093	8.172	0.020
1993	829.6	2174	428.5	45	61.2	1.6148	0.090	14.159	0.033
1994	944.8	2428	469.7	43	63.7	1.5342	0.089	16.815	0.036
1995	815.4	2631	467.1	44	59.6	1.3808	0.089	19.900	0.043
1996	724.4	3543	530.7	48	53.9	1.5164	0.088	26.062	0.049
1997	935.2	2467	403.0	42	57.3	1.4685	0.090	16.367	0.041
1998	903.2	2552	457.2	39	65.4	1.3403	0.089	17.177	0.038
1999	591.1	1640	131.6	39	27.2	0.7226	0.092	12.412	0.094
2000	470.5	2221	185.7	41	25.1	0.6112	0.090	15.442	0.083
2001	285.5	1469	57.3	33	11.1	0.3581	0.094	10.220	0.178
2002	290.5	1854	62.9	36	8.1	0.2710	0.093	12.452	0.198
2003	234.0	1311	40.8	38	6.1	0.2012	0.095	8.270	0.203
2004	232.9	1243	51.8	38	11.5	0.2710	0.097	8.430	0.163
2005	289.1	820	21.2	33	5.6	0.1901	0.101	4.649	0.219
2006	379.5	772	25.6	28	8.3	0.2146	0.103	4.635	0.181
2007	177.8	577	16.5	14	5.8	0.2172	0.107	3.838	0.233
2008	164.4	730	26.5	18	8.7	0.3038	0.103	5.475	0.207
2009	135.8	443	35.7	15	21.6	0.3914	0.112	2.854	0.080
2010	129.3	361	11.7	15	7.6	0.2388	0.118	2.212	0.189
2011	103.3	427	9.6	13	5.0	0.2019	0.114	2.601	0.270
2012	52.3	346	9.8	14	5.8	0.1642	0.119	1.872	0.192
2013	68.0	163	3.7	17	5.8	0.1576	0.147	0.934	0.255
2014	15.3	88	1.8	12	3.7	0.1062	0.184	0.376	0.211
2015	5.4	55	1.6	9	8.1	0.1279	0.223	0.302	0.190
2016	19.3	209	7.2	14	8.4	0.1326	0.138	1.366	0.190
2017	26.6	339	6.0	13	4.3	0.0821	0.121	1.938	0.324
2018	44.6	282	6.2	10	6.7	0.1254	0.126	2.241	0.363
2019	21.2	206	11.1	13	16.2	0.1497	0.144	1.614	0.145
2020	2.7	59	0.4	8	1.9	0.0499	0.217	0.333	0.787
2021	2.4	64	0.4	6	1.2	0.0387	0.211	0.183	0.427
2022	4.7	82	1.2	9	3.4	0.0475	0.194	0.444	0.379

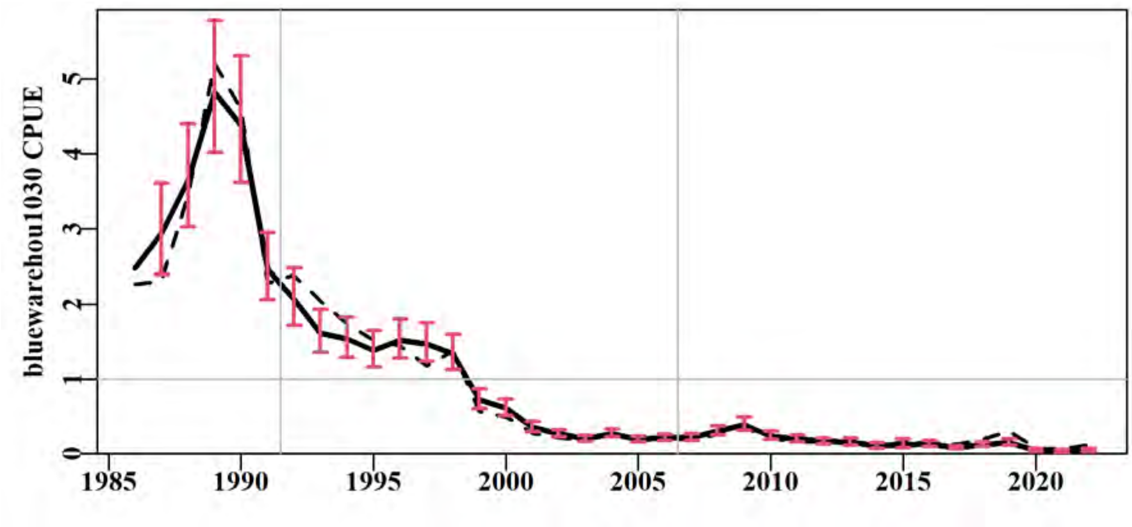

Figure 201: bluewarehou1030 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

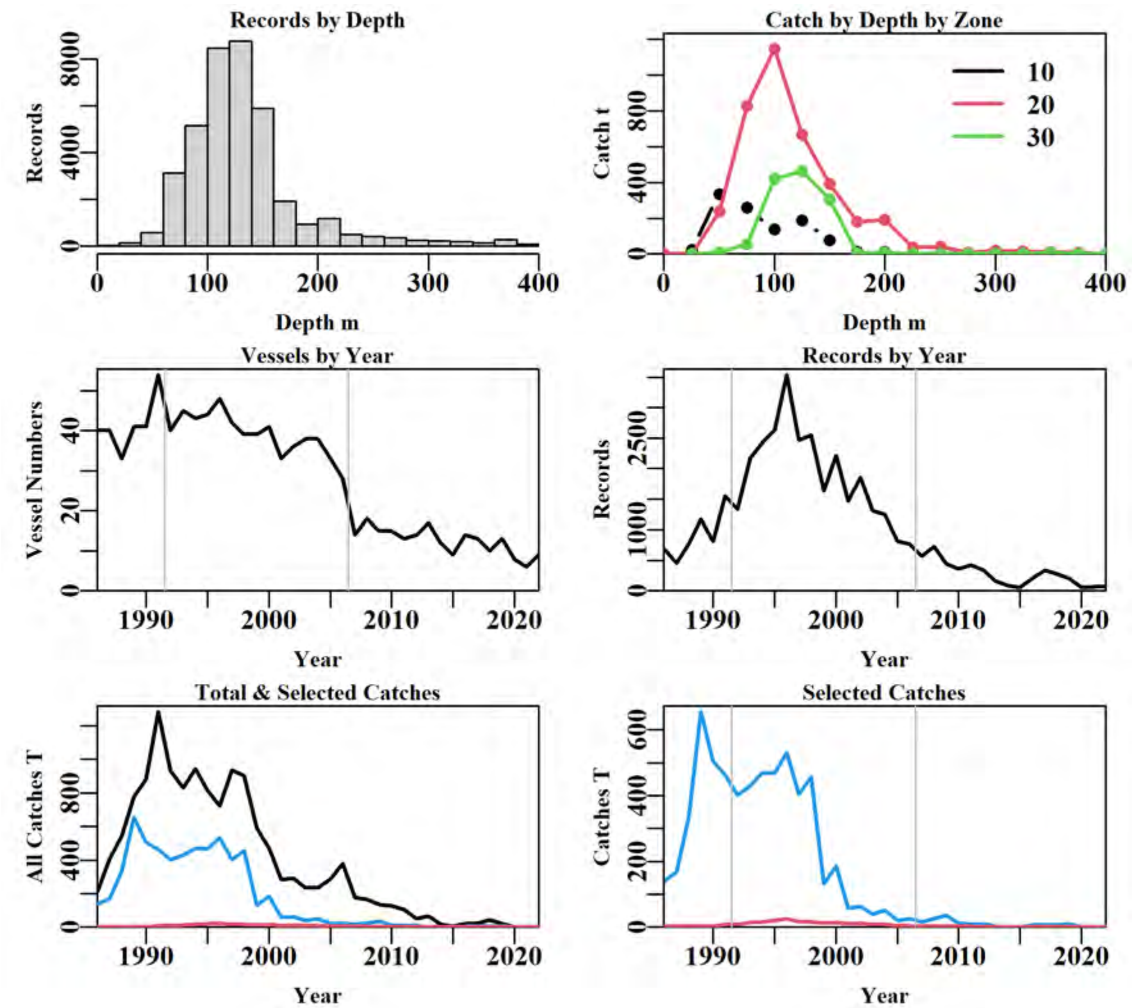

Figure 202: bluewarehou1030 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 144: bluewarehou1030 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	69520	62768	59873	59671	41498	38418	38361
Difference	0	6752	2895	202	18173	3080	57
Catch	14004	13618	12880	12836	6737	6149	6147
Difference	0	387	737	44	6100	588	2

Table 145: The models used to analyse data for bluewarehou1030.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + Zone
Model6	Year + Vessel + DepCat + Month + Zone + DayNight
Model7	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:Month
Model8	Year + Vessel + DepCat + Month + Zone + DayNight + Zone:DepCat

Table 146: bluewarehou1030. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	38384	104138	42063	38361	37	28.7	0.00
Vessel	33697	91362	54838	38361	204	37.2	8.47
DepCat	33230	90180	56021	38361	220	38.0	0.79
Month	33045	89696	56504	38361	231	38.3	0.31
Zone	32672	88819	57382	38361	233	38.9	0.60
DayNight	32586	88606	57594	38361	236	39.0	0.14
Zone:Month	32270	87779	58422	38361	258	39.6	0.53
Zone:DepCat	32319	87854	58347	38361	266	39.5	0.47

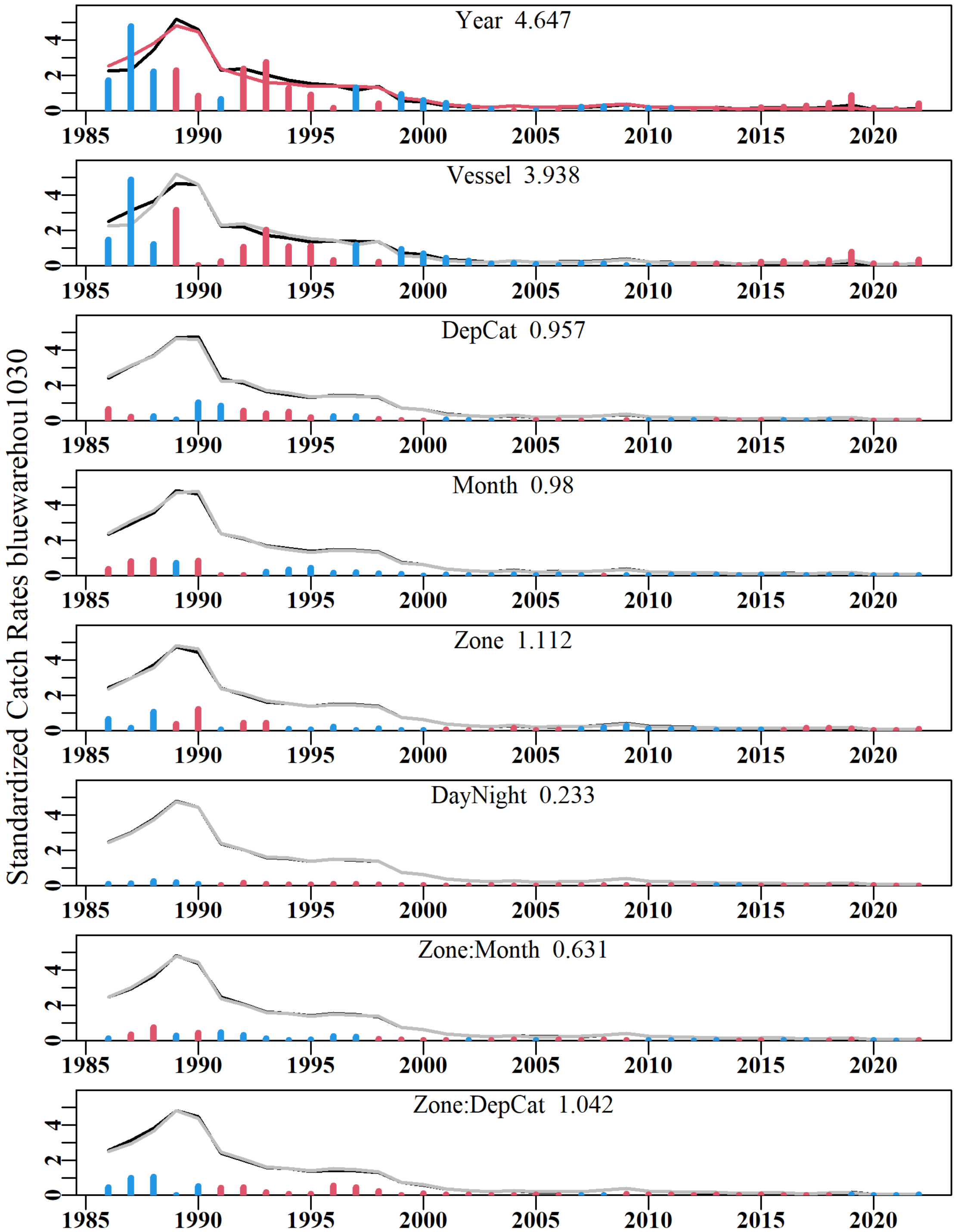

Figure 203: bluewarehou1030. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

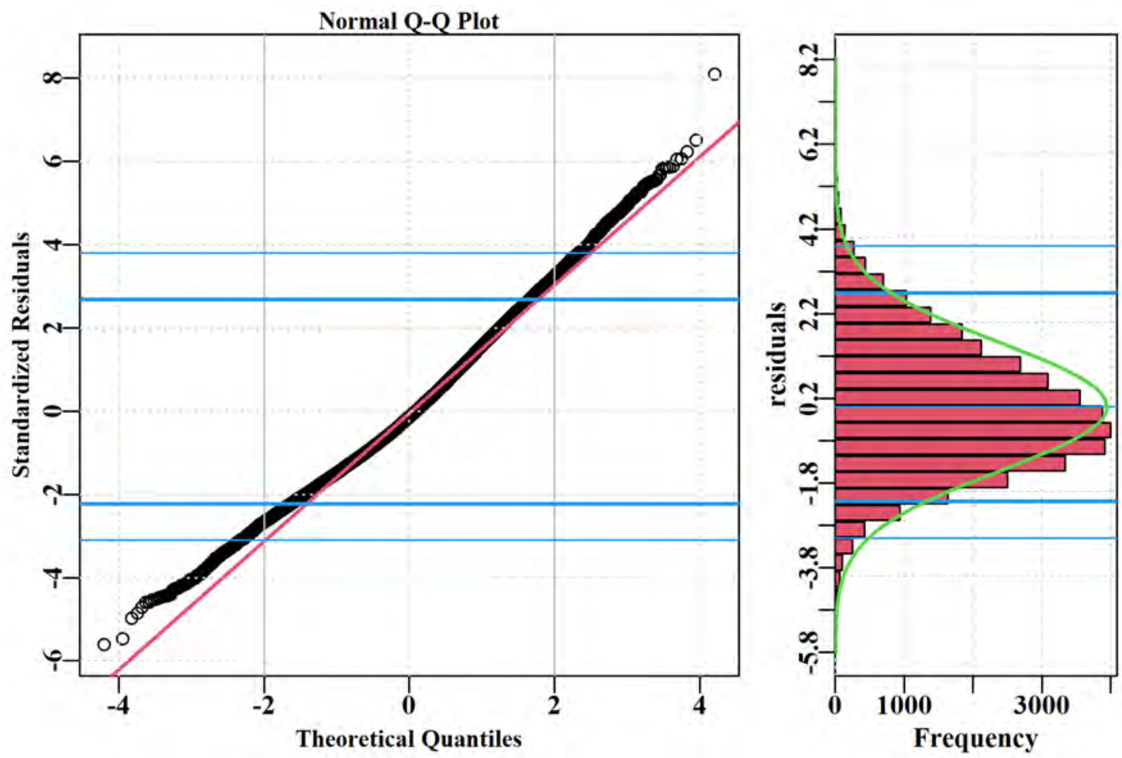

Figure 204: bluewarehou1030. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

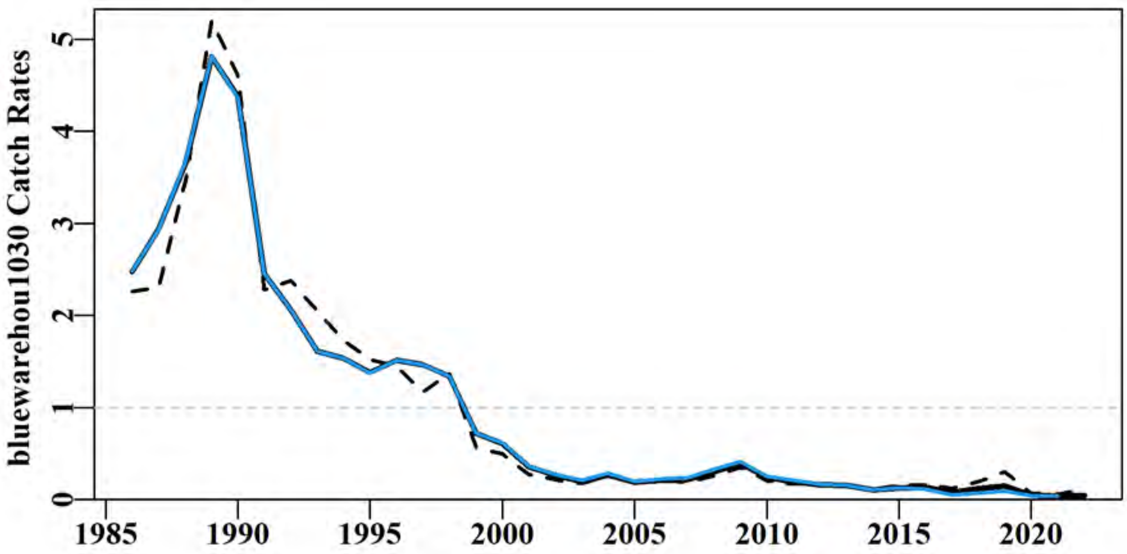

Figure 205: bluewarehou1030. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

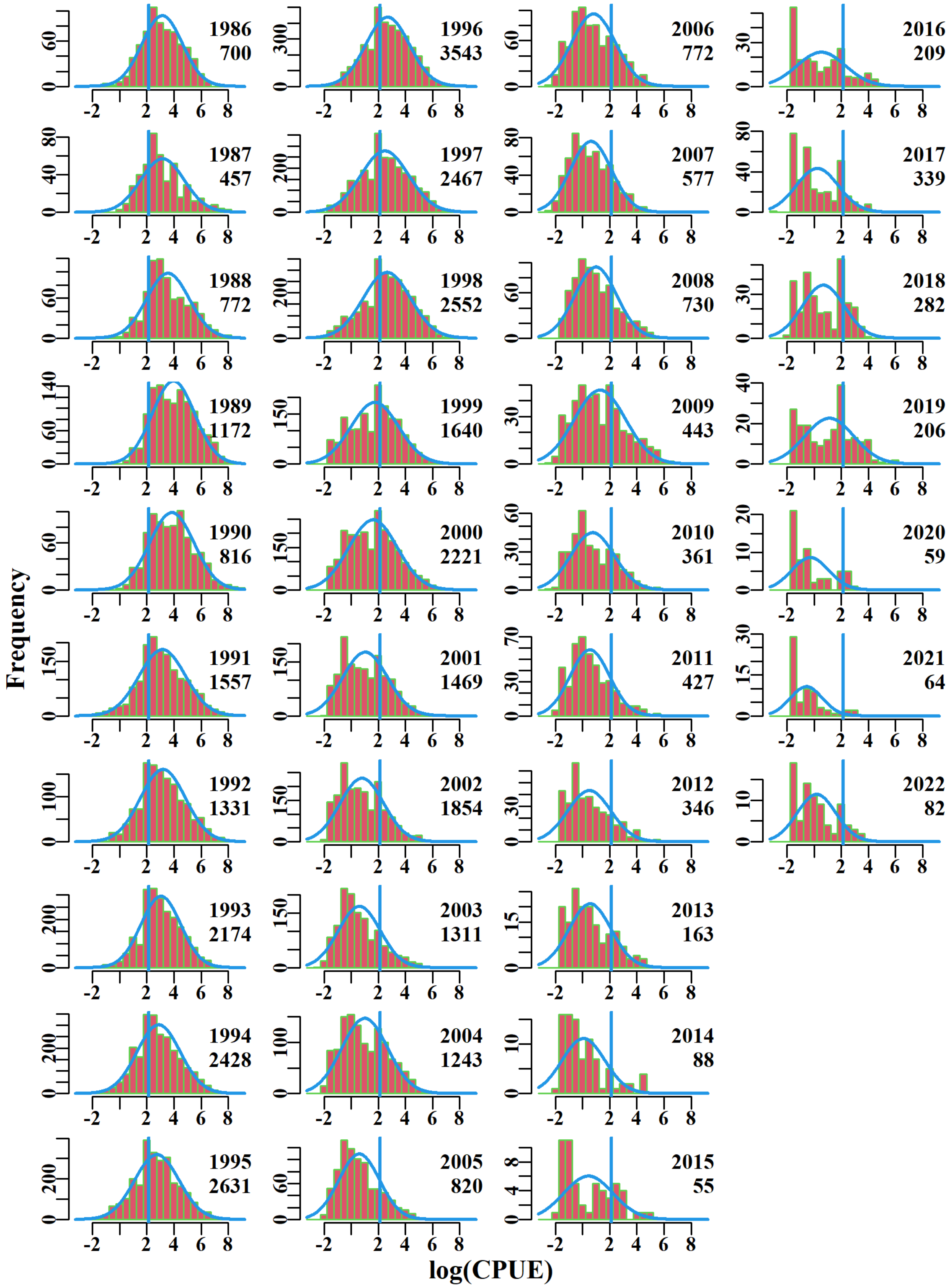

Figure 206: bluewarehou1030. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

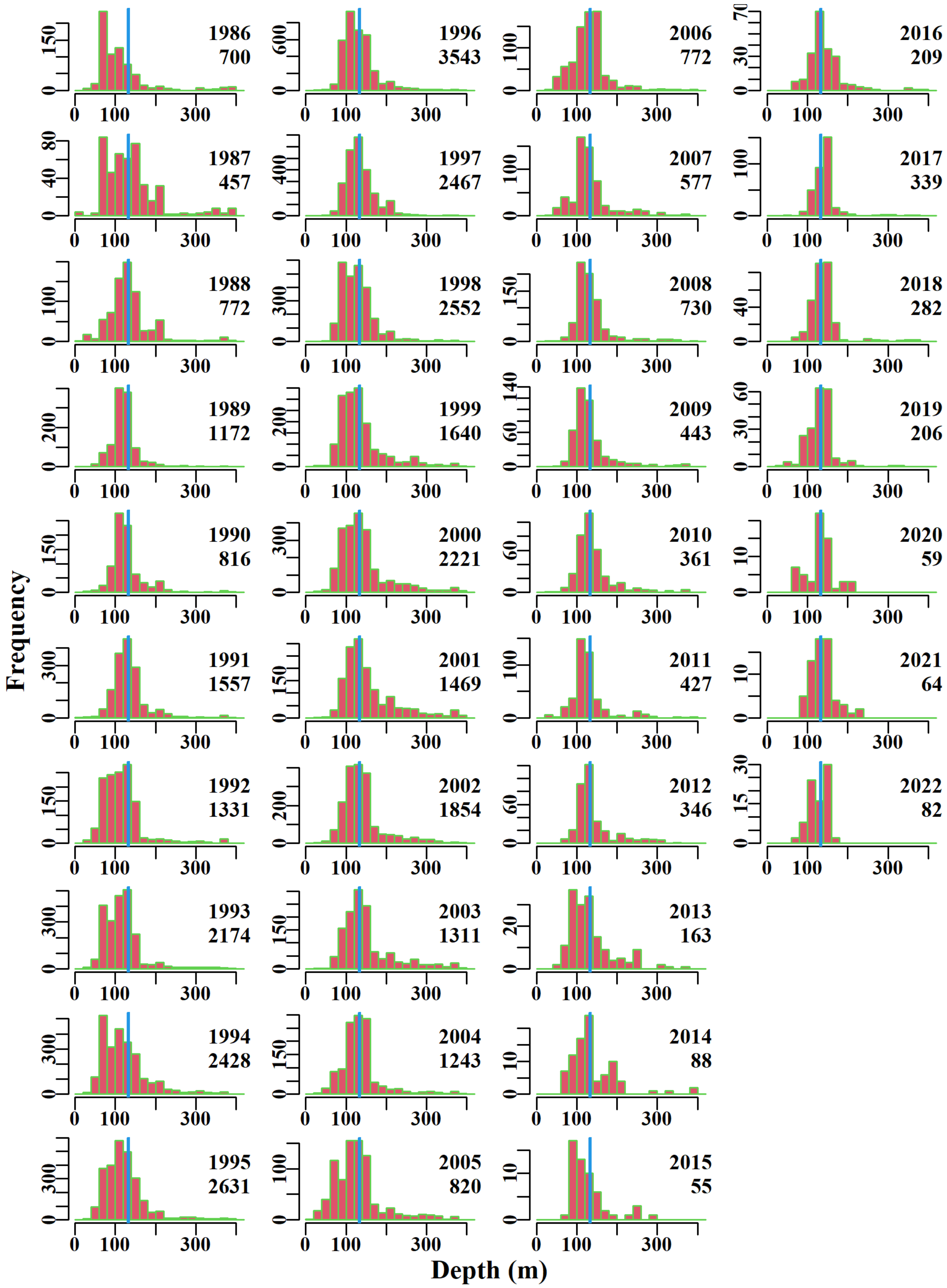

Figure 207: bluewarehou1030. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Blue Warehou 40 - 50

For Blue Warehou (TRT – 37445005 – *Seriolella brama*) in zones 40 and 50, initial data selection was conducted according to the details given in Table 147.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms determined by which accounted for the most variation as they were added. The sequential development of the standardization models simplifies the search for the optimum model requires consideration of the different performance statistics such as the AIC (Akaike's Information Criterion, the smaller the better; Burnham and Anderson, 2002) or the adjusted R^2 (the larger the better; Neter et al., 1996).

Inferences

The majority of catch of this species occurred in zone 50 and minimal catches occurred in the remaining zone (40). There were small record numbers (17 and 43) and corresponding catch (0.6 t and 2.6 t) in 2015 and 2016 respectively. The recorded catch in 2021 (0.3 t) was the lowest in the series analysed.

The terms Year, Vessel, Month and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 151). The qqplot suggests that the assumed Normal distribution is valid with a slight departure in the lower tail of the distribution (Figure 211).

Annual standardized CPUE trend is flat since 1992 and mostly below average (Figure 208). Catch rates prior to the introduction of quotas are highly variable both within years and between years. At that time Blue Warehou data was mixed with Silver Warehou data so this early data is less trustworthy. Data are now so sparse that the analysis results can no longer be trusted to represent the stock.

Action Items and Issues

Exploration of the early CPUE data could be made to examine whether there are obvious or consistent errors leading to mean CPUE values four times greater than the long-term average.

Table 147: bluewarehou4050. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	bluewarehou4050
csirocode	37445005, 91445005, 92445005
fishery	SET
depthrange	0 - 600
depthclass	25
zones	40, 50
methods	TW, TDO, OTB
years	1986 - 2022

Table 148: bluewarehou4050. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	211.9	159	71.4	14	162.6	3.8716	0.000	0.759	0.011
1987	405.9	183	215.6	10	635.9	4.2138	0.241	0.334	0.002
1988	544.0	179	198.0	12	566.9	1.8052	0.249	0.700	0.004
1989	776.0	56	81.3	13	562.1	4.6515	0.309	0.235	0.003
1990	881.4	439	298.1	13	341.8	1.8296	0.234	2.210	0.007
1991	1284.2	595	647.1	18	850.5	3.1176	0.232	1.060	0.002
1992	934.4	536	429.7	17	472.9	1.6723	0.234	1.733	0.004
1993	829.6	494	362.7	21	412.9	1.2888	0.235	1.700	0.005
1994	944.8	820	444.1	21	245.7	1.4128	0.230	2.525	0.006
1995	815.4	820	323.6	22	155.8	0.9605	0.228	4.180	0.013
1996	724.4	696	180.9	24	87.2	0.6388	0.230	4.248	0.023
1997	935.2	430	243.5	23	353.9	0.6793	0.235	3.038	0.012
1998	903.2	582	354.5	19	459.6	1.0471	0.234	2.728	0.008
1999	591.1	687	169.4	19	122.6	0.5781	0.232	4.505	0.027
2000	470.5	651	203.6	24	157.7	0.4604	0.233	3.736	0.018
2001	285.5	685	194.0	23	98.5	0.4727	0.232	4.249	0.022
2002	290.5	528	217.9	23	184.0	0.5996	0.235	2.977	0.014
2003	234.0	361	172.4	19	185.9	0.5516	0.240	2.421	0.014
2004	232.9	432	159.0	21	135.6	0.6016	0.237	2.276	0.014
2005	289.1	457	257.4	18	333.5	0.9625	0.237	1.735	0.007
2006	379.5	693	337.5	16	212.7	0.6508	0.234	3.736	0.011
2007	177.8	462	147.7	16	116.3	0.5450	0.237	2.541	0.017
2008	164.4	349	117.0	12	88.9	0.4470	0.240	2.016	0.017
2009	135.8	308	89.0	11	70.1	0.3285	0.242	1.337	0.015
2010	129.3	407	105.3	12	52.7	0.3880	0.238	1.833	0.017
2011	103.3	517	77.8	14	31.2	0.3623	0.236	2.225	0.029
2012	52.3	254	30.7	14	22.3	0.2052	0.246	1.654	0.054
2013	68.0	304	57.9	13	37.3	0.2846	0.243	1.522	0.026
2014	15.3	60	11.6	9	48.9	0.1984	0.303	0.457	0.039
2015	5.4	17	0.6	5	5.9	0.0847	0.437	0.049	0.085
2016	19.3	43	2.6	9	11.6	0.2974	0.330	0.270	0.103
2017	26.6	98	15.4	9	24.0	0.5633	0.279	0.657	0.043
2018	44.6	180	28.5	9	27.6	0.3040	0.254	0.626	0.022
2019	21.2	87	7.4	8	16.2	0.2530	0.282	0.283	0.038
2020	2.7	22	1.1	5	8.7	0.1695	0.413	0.163	0.146
2021	2.4	10	0.3	4	5.0	0.1329	0.541	0.089	0.269
2022	4.7	12	2.0	3	20.5	0.3701	0.505	0.055	0.027

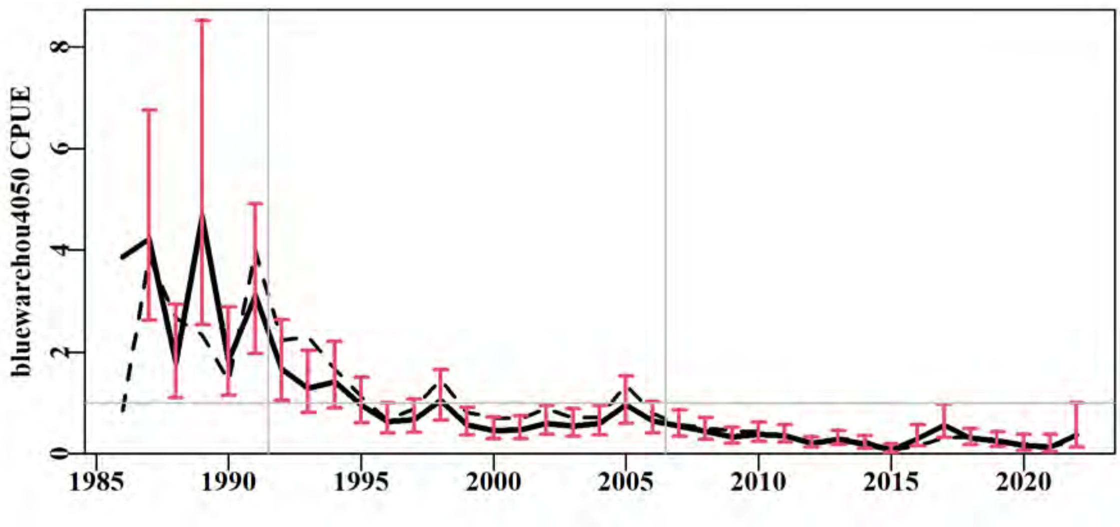

Figure 208: bluewarehou4050 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

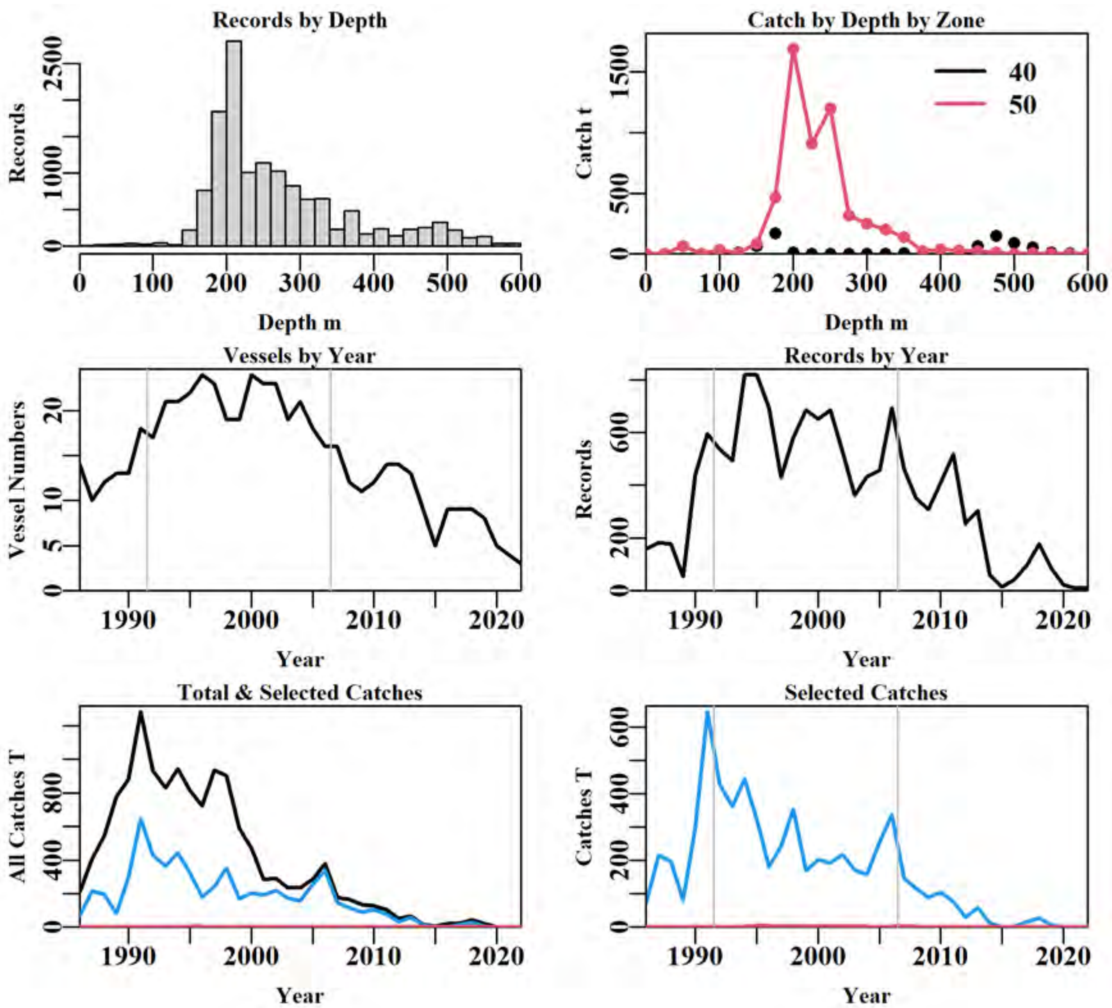

Figure 209: bluewarehou4050 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 149: bluewarehou4050 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	69520	62768	62257	62025	14412	13634	13613
Difference	0	6752	511	232	47613	778	21
Catch	14004	13618	13519	13452	6399	6260	6257
Difference	0	387	99	68	7052	139	3

Table 150: The models used to analyse data for bluewarehou4050.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + DepCat
Model5	Year + Vessel + Month + DepCat + Zone
Model6	Year + Vessel + Month + DepCat + Zone + DayNight
Model7	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:Month
Model8	Year + Vessel + Month + DepCat + Zone + DayNight + Zone:DepCat

Table 151: bluewarehou4050. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	14852	40312	6563	13613	37	13.8	0.00
Vessel	13661	36485	10389	13613	120	21.5	7.70
Month	12648	33815	13059	13613	131	27.2	5.69
DepCat	11975	32069	14805	13613	155	30.8	3.64
Zone	11973	32061	14813	13613	156	30.8	0.01
DayNight	11919	31919	14955	13613	159	31.1	0.29
Zone:Month	11887	31793	15081	13613	170	31.3	0.22
Zone:DepCat	11917	31816	15058	13613	180	31.2	0.12

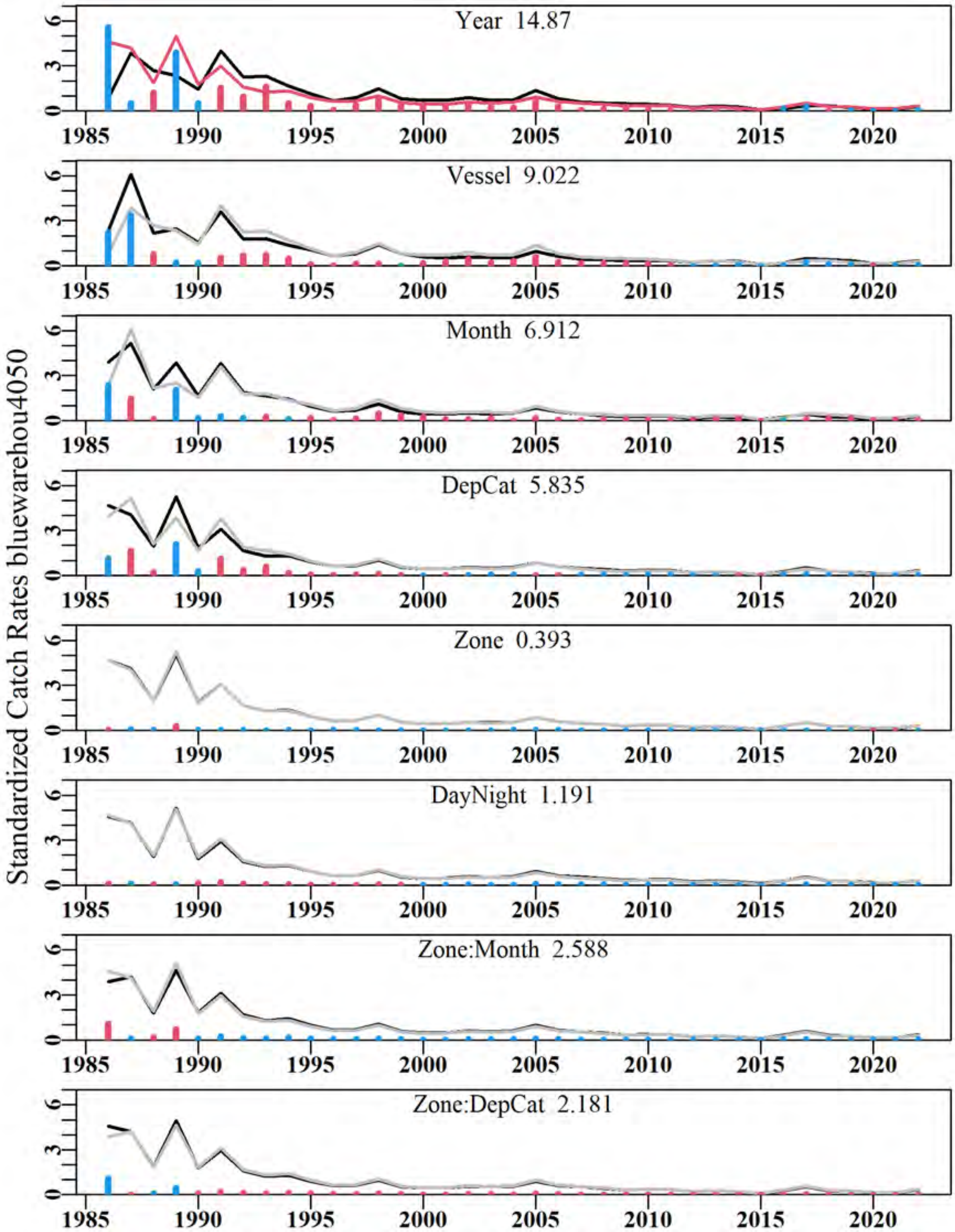

Figure 210: bluewarehou4050. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

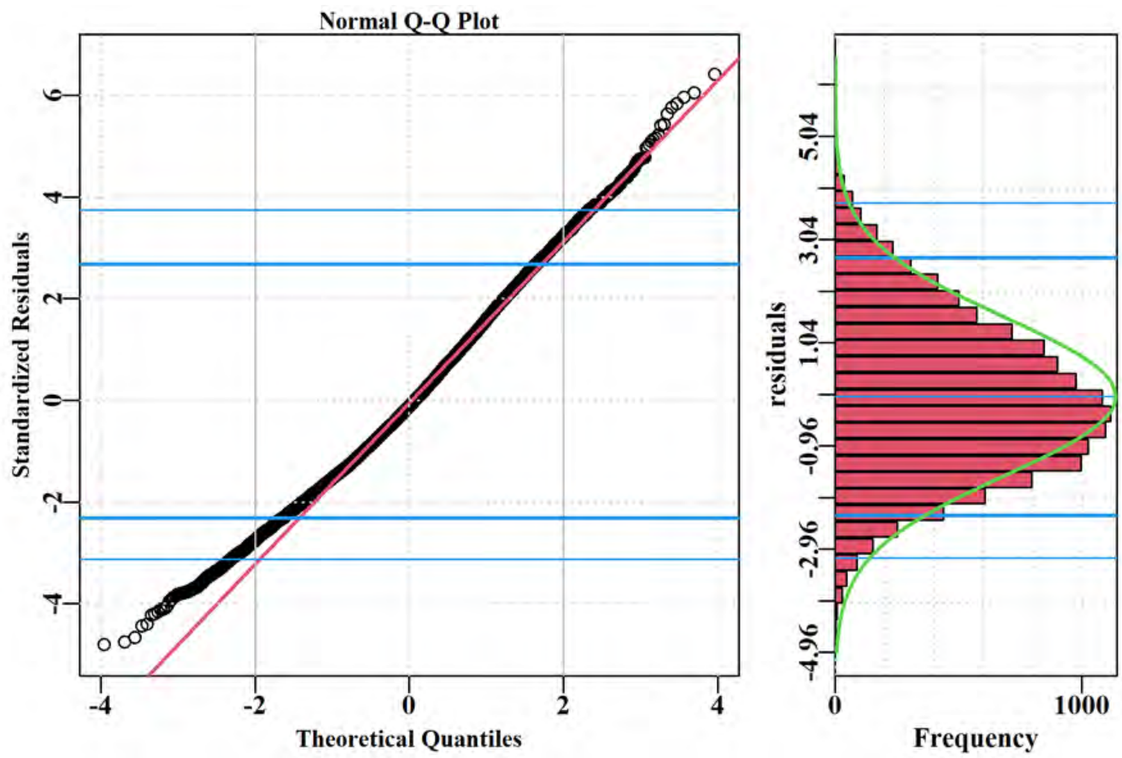

Figure 211: bluewarehou4050. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

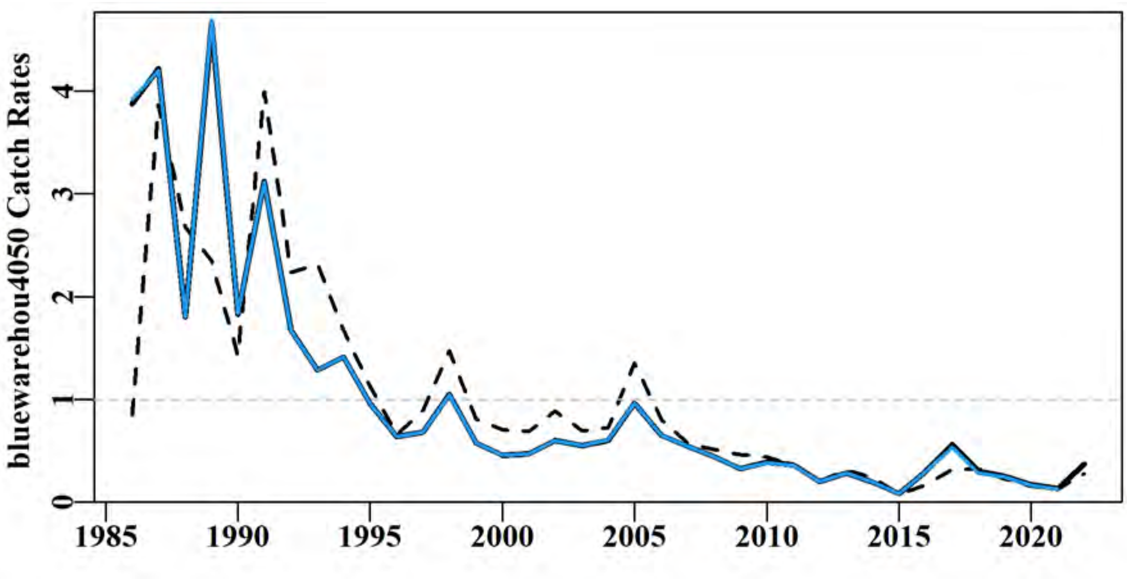

Figure 212: bluewarehou4050. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

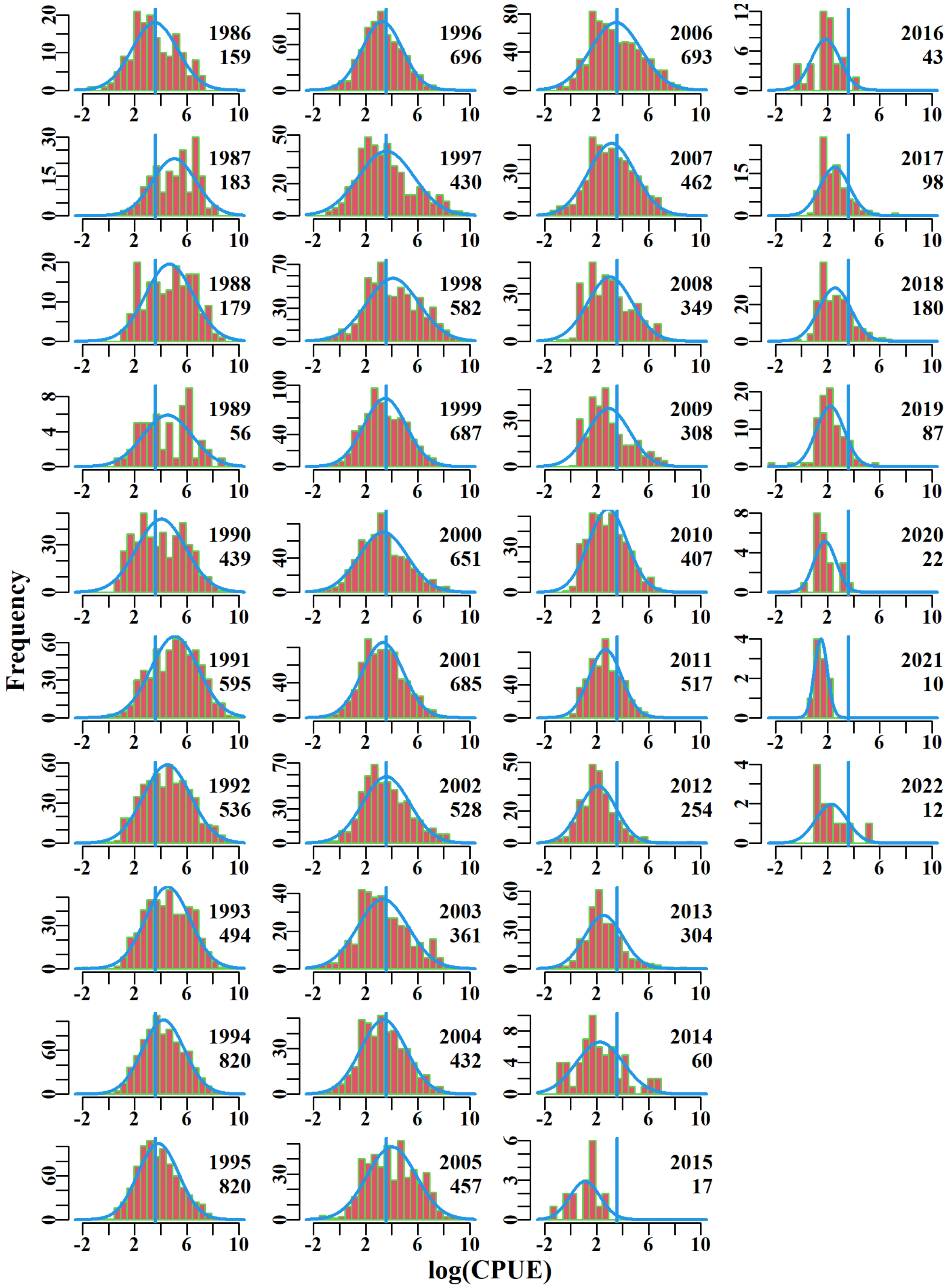

Figure 213: bluewarehou4050. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

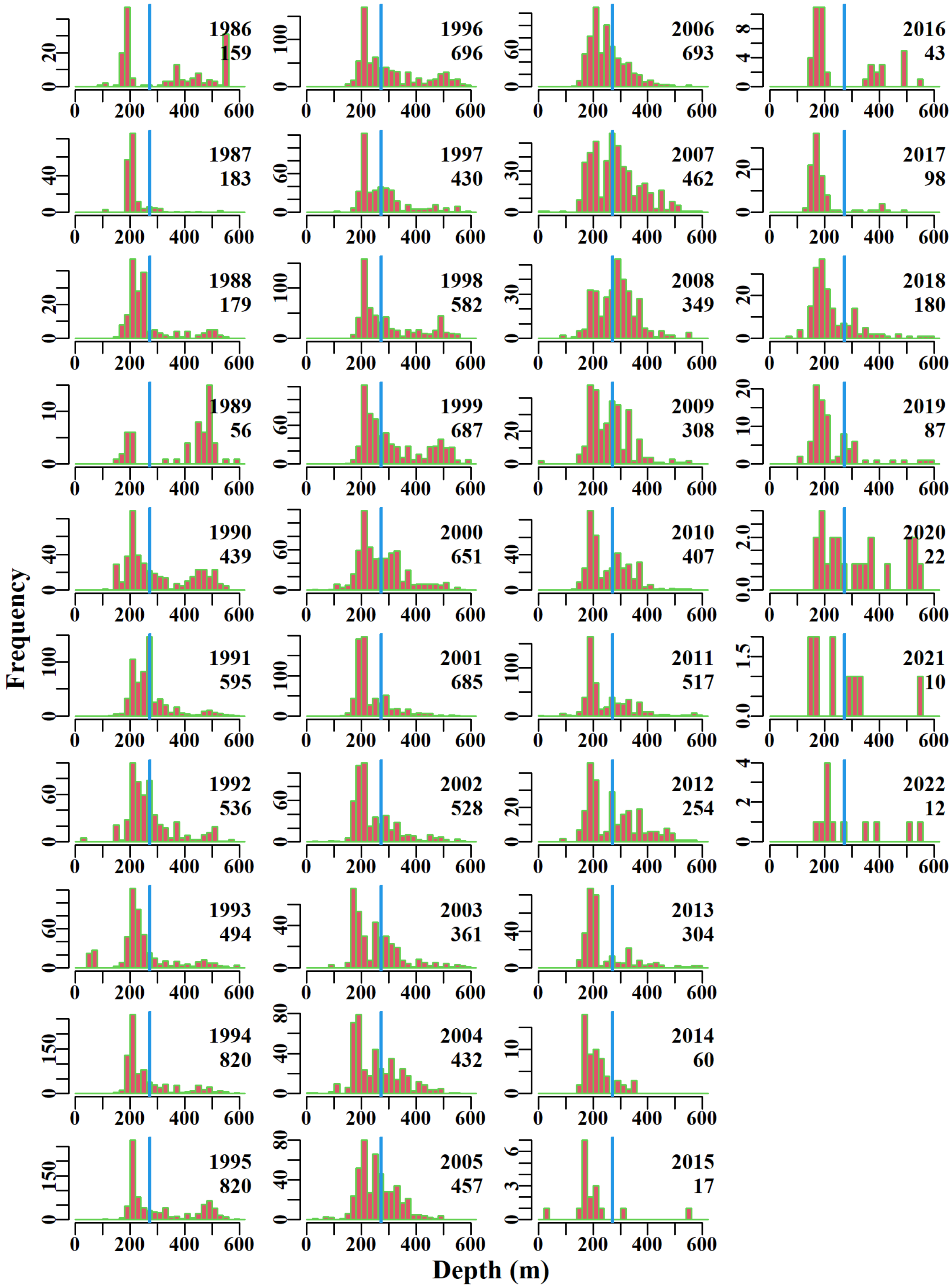

Figure 214: bluewarehou4050. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Deepwater Flathead

The initial data selection for Deepwater Flathead (FLD – 37296002 – *Platycephalus conatus*) in the GAB was conducted according to the details given in Table 152.

A total of 9 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in longitude 129-130 (degrees longitude - takes the place of zones to provide more detail).

The terms Year, Vessel, Zone, Month, DepCat, DayNight and two interaction terms (Zone:Vessel and Zone:DepCat) had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 156). The qqplot suggests a departure from the assumed Normal distribution as depicted by the tails of the distribution (Figure 218).

Annual standardized CPUE has been cyclical in the early years following the increases and decreases in catches (prior to 2007) and relatively flat and mostly below average since 2005, despite the small increases since after 2017 (Figure 215). The GAB-catch of 340.3 t in 2022 was the lowest since 1988.

Action Items and Issues

It is recommended that alternate statistical distributions be considered.

Table 152: deepwaterflathead. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	deepwaterflathead
csirocode	37296002
fishery	GAB_GBQ
depthrange	50 - 350
depthclass	25
zones	82, 83, 84, 85
methods	TW, TDO, OTB, OTT, PTB
years	1987 - 2022

Table 153: deepwaterflathead. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1987	80.3	291	50.8	4	54.5	0.4669	0.000	0.525	0.010
1988	317.2	580	273.9	5	186.6	1.0354	0.051	0.884	0.003
1989	402.6	944	345.6	6	100.3	1.0428	0.049	0.803	0.002
1990	430.2	1297	393.9	6	90.8	1.0228	0.048	0.900	0.002
1991	621.0	1468	514.4	8	85.4	0.9856	0.046	0.819	0.002
1992	524.1	958	499.5	3	117.9	1.2600	0.048	0.345	0.001
1993	593.1	881	580.7	5	149.5	1.7066	0.048	0.570	0.001
1994	1285.9	1684	1233.8	6	173.3	2.0984	0.045	0.327	0.000
1995	1585.1	1849	1552.3	5	176.6	2.0130	0.045	0.030	0.000
1996	1499.2	2726	1450.5	6	110.2	1.3392	0.044	0.405	0.000
1997	1030.0	2684	944.5	7	72.0	0.9295	0.045	1.340	0.001
1998	690.4	2401	669.2	7	57.0	0.7141	0.045	3.280	0.005
1999	571.0	2064	549.4	7	53.7	0.8490	0.046	1.530	0.003
2000	845.6	2378	773.9	5	67.5	0.9252	0.045	1.857	0.002
2001	973.1	2411	910.5	5	75.6	1.1124	0.045	1.207	0.001
2002	1708.9	3113	1613.1	8	103.5	1.5347	0.045	0.900	0.001
2003	2260.6	4468	2156.6	10	93.8	1.5293	0.045	0.387	0.000
2004	2155.2	5349	2054.2	9	74.5	1.2076	0.044	0.923	0.000
2005	1426.0	5014	1238.5	10	49.5	0.7694	0.044	1.642	0.001
2006	1014.2	4151	947.2	10	45.9	0.7114	0.044	1.667	0.002
2007	1039.9	3659	908.2	6	50.8	0.7819	0.045	2.978	0.003
2008	813.2	3086	766.5	4	50.6	0.9312	0.045	2.089	0.003
2009	849.4	3193	824.6	4	52.3	0.8238	0.045	2.793	0.003
2010	966.8	2803	927.0	4	67.8	1.0445	0.045	1.300	0.001
2011	963.2	3269	789.3	4	47.1	0.8324	0.045	1.490	0.002
2012	1018.6	3449	841.7	4	48.2	0.8306	0.045	1.724	0.002
2013	874.7	3233	649.5	4	39.1	0.7264	0.045	2.080	0.003
2014	588.6	2572	485.3	4	37.5	0.6729	0.046	2.314	0.005
2015	593.8	2247	471.8	3	42.2	0.7501	0.046	1.574	0.003
2016	737.3	2531	591.4	4	48.6	0.7942	0.046	2.013	0.003
2017	547.4	2486	435.5	3	36.5	0.5974	0.046	3.474	0.008
2018	522.5	2244	391.2	4	37.0	0.6124	0.046	2.925	0.007
2019	620.1	2162	486.0	3	45.7	0.7452	0.046	2.041	0.004
2020	522.9	1876	423.6	3	47.6	0.8289	0.046	1.465	0.003
2021	716.5	2137	501.6	3	48.8	0.8501	0.046	1.570	0.003
2022	467.2	1270	340.3	3	57.0	0.9248	0.048	0.715	0.002

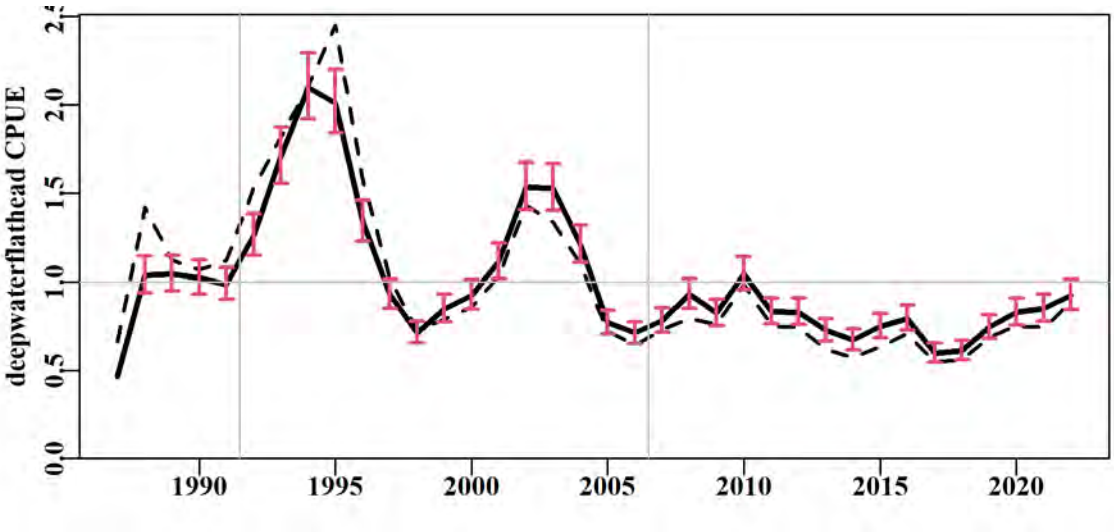

Figure 215: deepwaterflathead standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

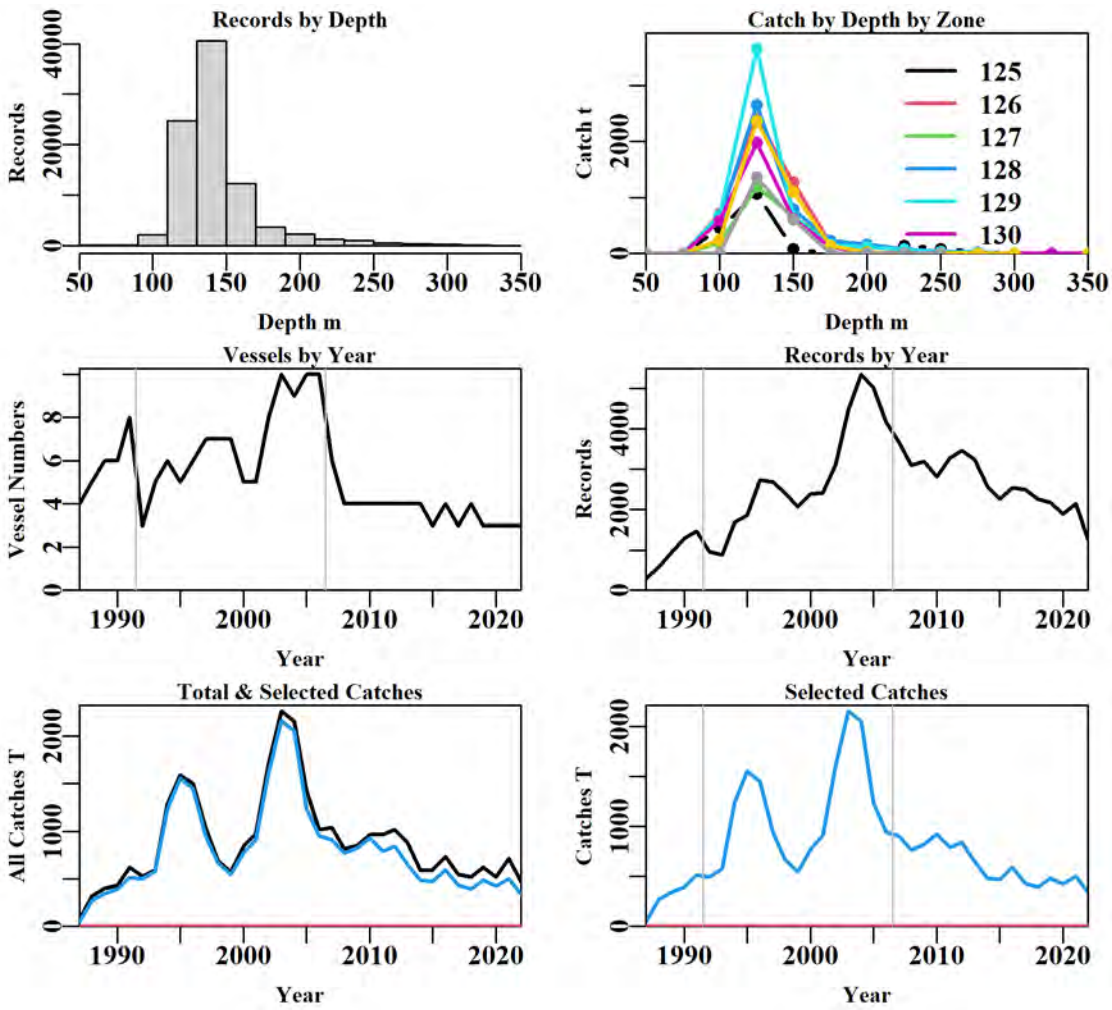

Figure 216: deepwaterflathead fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 154: deepwaterflathead data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	69520	62768	62257	62025	14412	13634	13613
Difference	0	6752	511	232	47613	778	21
Catch	14004	13618	13519	13452	6399	6260	6257
Difference	0	387	99	68	7052	139	3

Table 155: The models used to analyse data for deepwaterflathead.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Zone
Model4	Year + Vessel + Zone + Month
Model5	Year + Vessel + Zone + Month + DepCat
Model6	Year + Vessel + Zone + Month + DepCat + DayNight
Model7	Year + Vessel + Zone + Month + DepCat + DayNight + Zone:Month
Model8	Year + Vessel + Zone + Month + DepCat + DayNight + Zone:Vessel
Model9	Year + Vessel + Zone + Month + DepCat + DayNight + Zone:DepCat

Table 156: deepwaterflathead. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	-44034	54155	10829	88928	36	16.6	0.00
Vessel	-49891	50682	14302	88928	55	22.0	5.33
Zone	-56639	46970	18014	88928	62	27.7	5.71
Month	-60457	44985	19999	88928	73	30.7	3.05
DepCat	-61684	44357	20627	88928	85	31.7	0.96
DayNight	-63478	43469	21516	88928	88	33.0	1.37
Zone:Month	-64682	42810	22175	88928	165	34.0	0.96
Zone:Vessel	-65644	42302	22682	88928	215	34.7	1.70
Zone:DepCat	-65971	42196	22789	88928	163	34.9	1.91

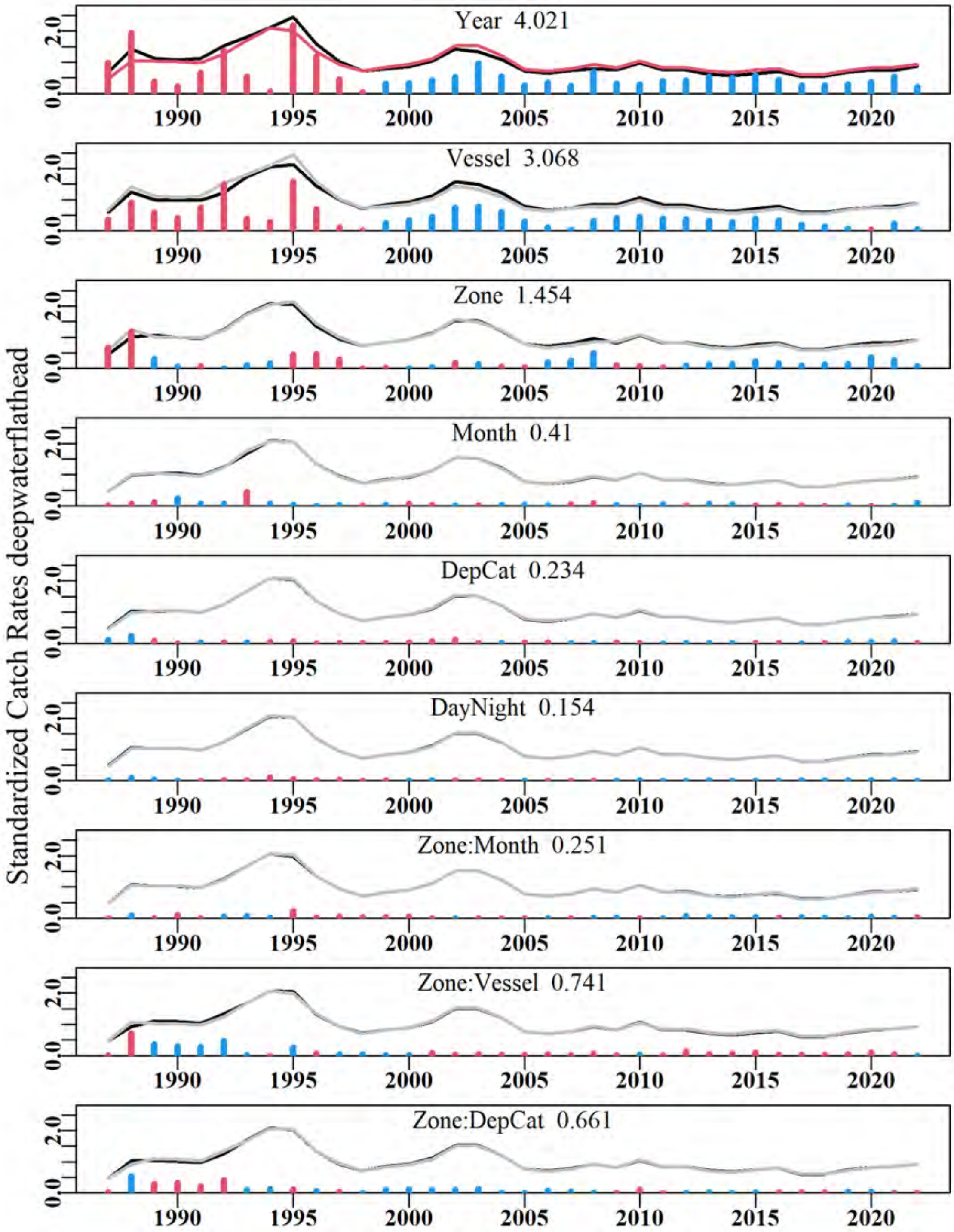

Figure 217: deepwaterflathead. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

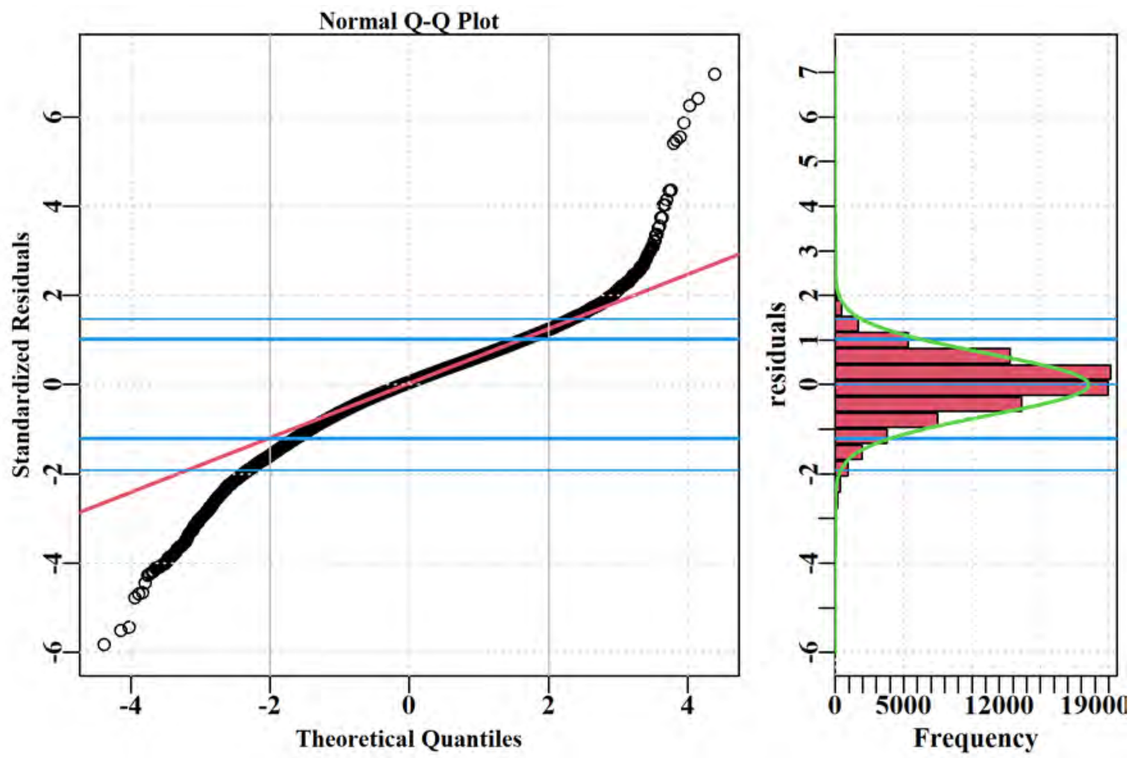

Figure 218: deepwaterflathead. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

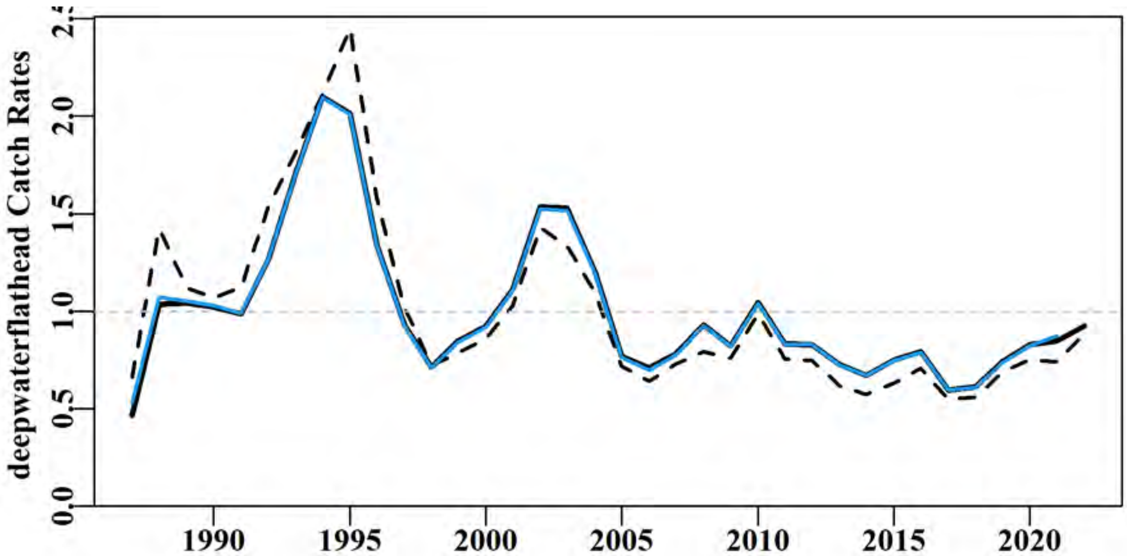

Figure 219: deepwaterflathead. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

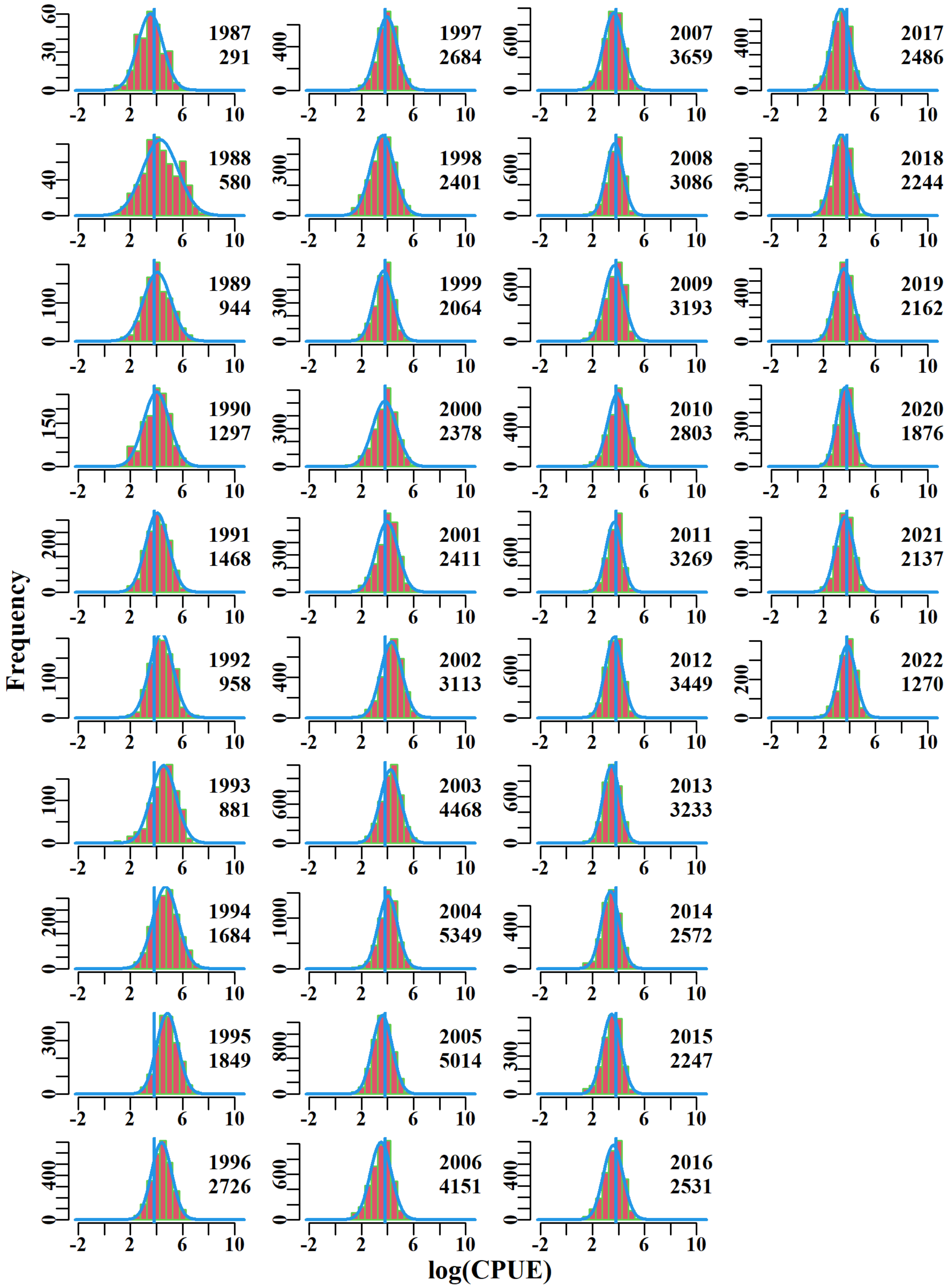

Figure 220: deepwaterflathead. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

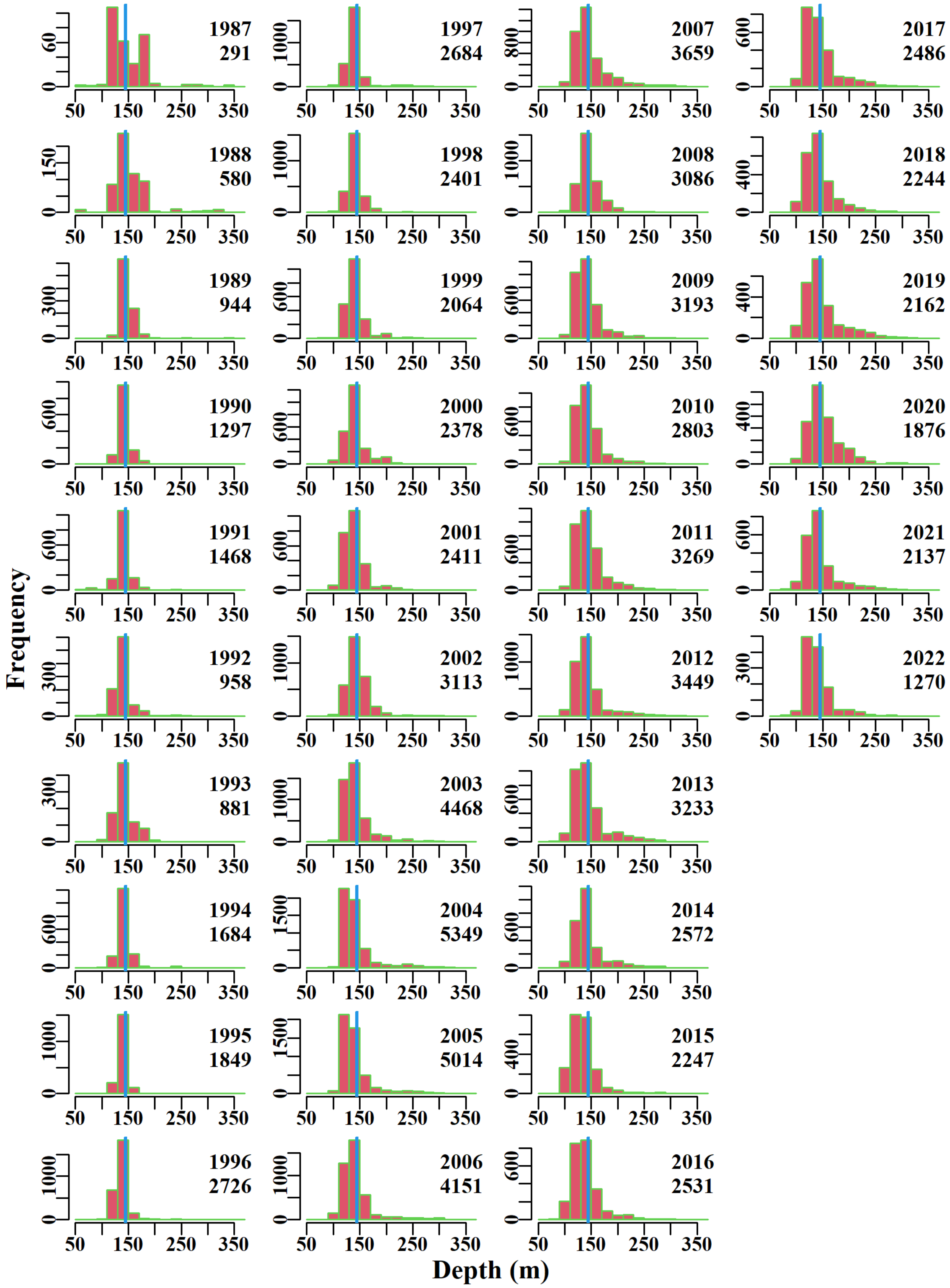

Figure 221: deepwaterflathead. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Bight Redfish

Initial data selection for Bight Redfish (FLD – 37258004 – *Centroberyx gerrardi*) in the GAB was conducted according to the details given in Table 157.

A total of 9 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 131, again with degree longitude taking the place of zones to provide more detail. The total GAB-catch of 105.3 t in 2022 was the lowest since 1988 and 46% less than the total GAB-catch in the 2021.

The terms Year, DayNight, Zone, Month, Vessel and interaction term Zone:DepCat had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 161). The qqplot suggests a departure from the assumed Normal distribution as depicted by the tails of the distribution (Figure 225).

Annual standardized CPUE trend is flat since 1992 and oscillating above and below average (Figure 222), and this is despite major changes in the distribution of the log(CPUE) from 2012 - 2022. The number of vessels involved in the fishery are now low (< 10 since 2006), so the interpretation of CPUE should also consider which vessels are fishing and where.

Action Items and Issues

It is recommended that alternate statistical distributions be considered.

Table 157: bightredfish. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	bightredfish
csirocode	37258004
fishery	GAB_GBQ
depthrange	50 - 300
depthclass	25
zones	82, 83
methods	TW, TDO, OTT, PTB, OTB
years	1986 - 2022

Table 158: bightredfish. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1987	47.4	190	34.5	4	54.6	2.4820	0.000	0.295	0.009
1988	88.0	449	74.4	5	61.2	2.4647	0.102	1.120	0.015
1989	173.6	737	148.2	6	62.1	1.5720	0.100	2.017	0.014
1990	290.1	1045	252.8	8	75.1	1.4417	0.098	2.220	0.009
1991	274.0	1018	221.8	7	58.8	1.3247	0.096	3.790	0.017
1992	132.1	719	117.0	3	39.7	0.9777	0.098	3.816	0.033
1993	108.7	688	105.9	5	37.2	0.9242	0.099	4.561	0.043
1994	163.6	1275	159.3	6	35.9	0.6346	0.094	7.128	0.045
1995	176.9	1396	175.4	5	30.2	0.7560	0.094	7.773	0.044
1996	334.1	2029	328.7	6	37.8	0.9258	0.093	10.358	0.032
1997	375.9	1922	366.0	7	46.2	0.9719	0.093	9.838	0.027
1998	442.2	1794	434.0	7	57.1	1.1352	0.093	8.723	0.020
1999	328.3	1495	327.2	7	51.8	1.0063	0.095	5.404	0.017
2000	397.5	1715	390.3	5	64.5	0.8928	0.094	6.689	0.017
2001	228.9	1641	227.7	5	34.9	0.6982	0.095	7.421	0.033
2002	374.5	2123	369.8	8	37.2	0.7474	0.094	9.152	0.025
2003	853.2	3144	845.0	10	57.8	1.0396	0.093	8.796	0.010
2004	882.2	3782	754.4	9	42.7	1.0132	0.093	15.491	0.021
2005	759.5	3532	718.2	10	43.0	0.9657	0.093	13.678	0.019
2006	958.4	3294	930.1	9	72.1	1.0577	0.092	10.318	0.011
2007	756.0	2744	683.8	6	67.8	0.9787	0.093	11.605	0.017
2008	661.5	2427	643.1	4	68.0	1.0473	0.094	9.294	0.014
2009	462.6	2307	453.4	4	48.4	0.9774	0.094	11.703	0.026
2010	285.3	1858	280.8	4	34.8	0.7868	0.094	10.622	0.038
2011	329.1	2184	321.2	4	30.7	0.7894	0.094	10.872	0.034
2012	266.4	1881	259.6	4	26.7	0.7151	0.095	14.511	0.056
2013	198.2	1519	191.4	4	22.9	0.6444	0.096	12.283	0.064
2014	238.1	1428	235.6	4	32.1	0.7031	0.096	8.433	0.036
2015	173.4	1192	170.3	3	29.8	0.6935	0.097	5.431	0.032
2016	437.9	1800	434.4	4	39.6	0.9617	0.095	8.295	0.019
2017	281.2	1443	279.5	3	45.6	0.9913	0.096	5.984	0.021
2018	214.5	1228	211.9	4	40.1	0.8842	0.097	6.867	0.032
2019	153.3	1052	149.7	3	32.3	0.7142	0.098	5.863	0.039
2020	164.6	1039	161.8	3	32.7	0.7702	0.098	6.210	0.038
2021	230.3	1526	228.2	3	30.4	0.6834	0.096	8.685	0.038
2022	107.0	875	105.3	3	24.3	0.6277	0.099	6.587	0.063

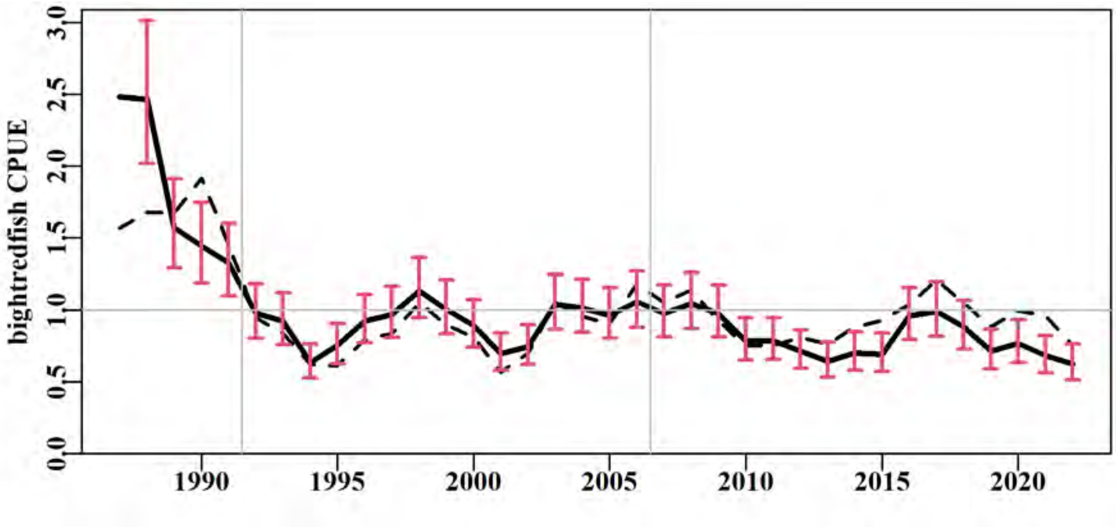

Figure 222: bightredfish standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

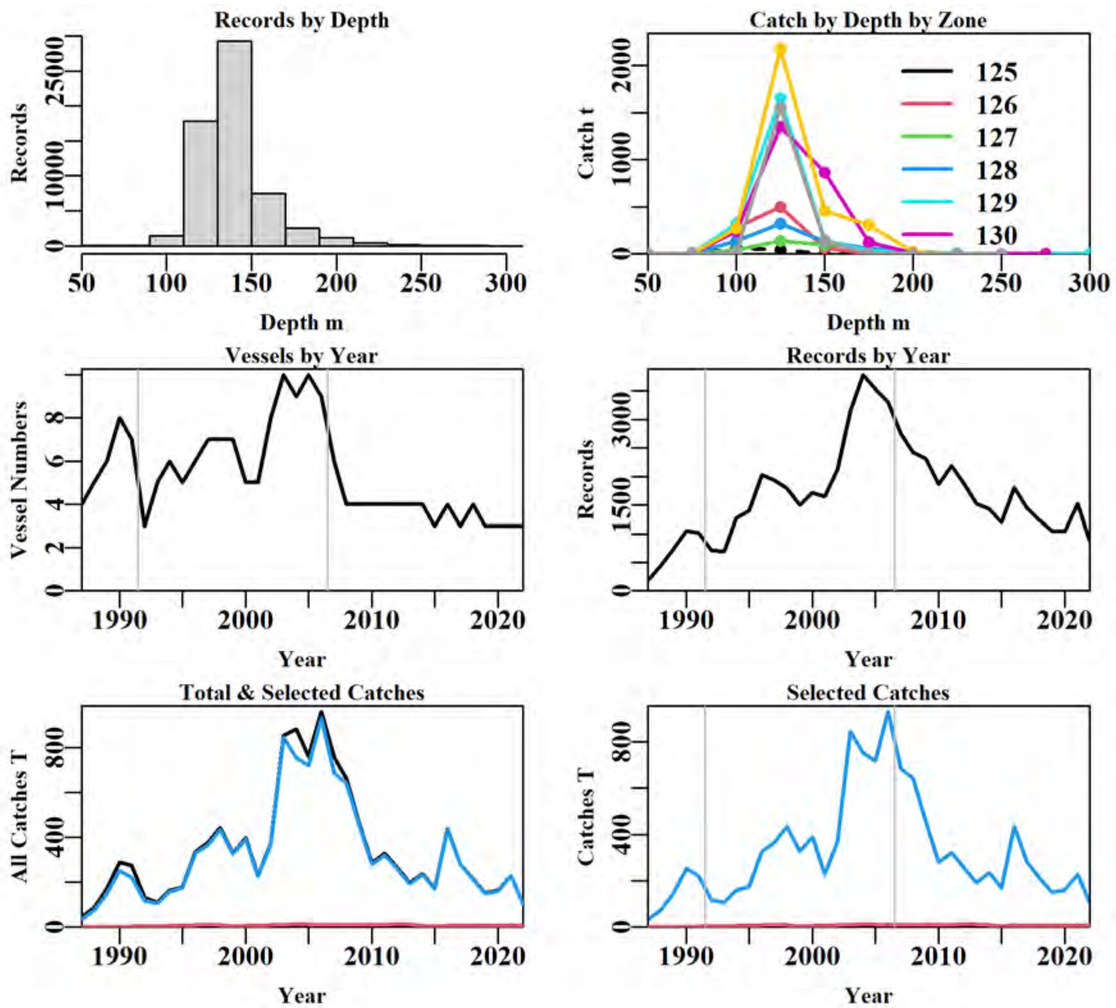

Figure 223: bightredfish fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 160: The models used to analyse data for bightredfish.

	Model
Model1	Year
Model2	Year + DayNight
Model3	Year + DayNight + Zone
Model4	Year + DayNight + Zone + Month
Model5	Year + DayNight + Zone + Month + Vessel
Model6	Year + DayNight + Zone + Month + Vessel + DepCat
Model7	Year + DayNight + Zone + Month + Vessel + DepCat + Zone:Month
Model8	Year + DayNight + Zone + Month + Vessel + DepCat + Zone:Vessel
Model9	Year + DayNight + Zone + Month + Vessel + DepCat + Zone:DepCat

Table 161: bightredfish. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	34742	106928	3192	59997	36	2.8	0.00
DayNight	29486	97950	12171	59997	39	11.0	8.15
Zone	23471	88585	21536	59997	46	19.5	8.50
Month	19420	82771	27350	59997	57	24.8	5.27
Vessel	18283	81166	28955	59997	76	26.2	1.44
DepCat	18063	80841	29280	59997	86	26.5	0.28
Zone:Month	17060	79298	30823	59997	163	27.8	1.31
Zone:Vessel	17333	79526	30594	59997	213	27.5	1.04
Zone:DepCat	16395	78463	31658	59997	148	28.6	2.09

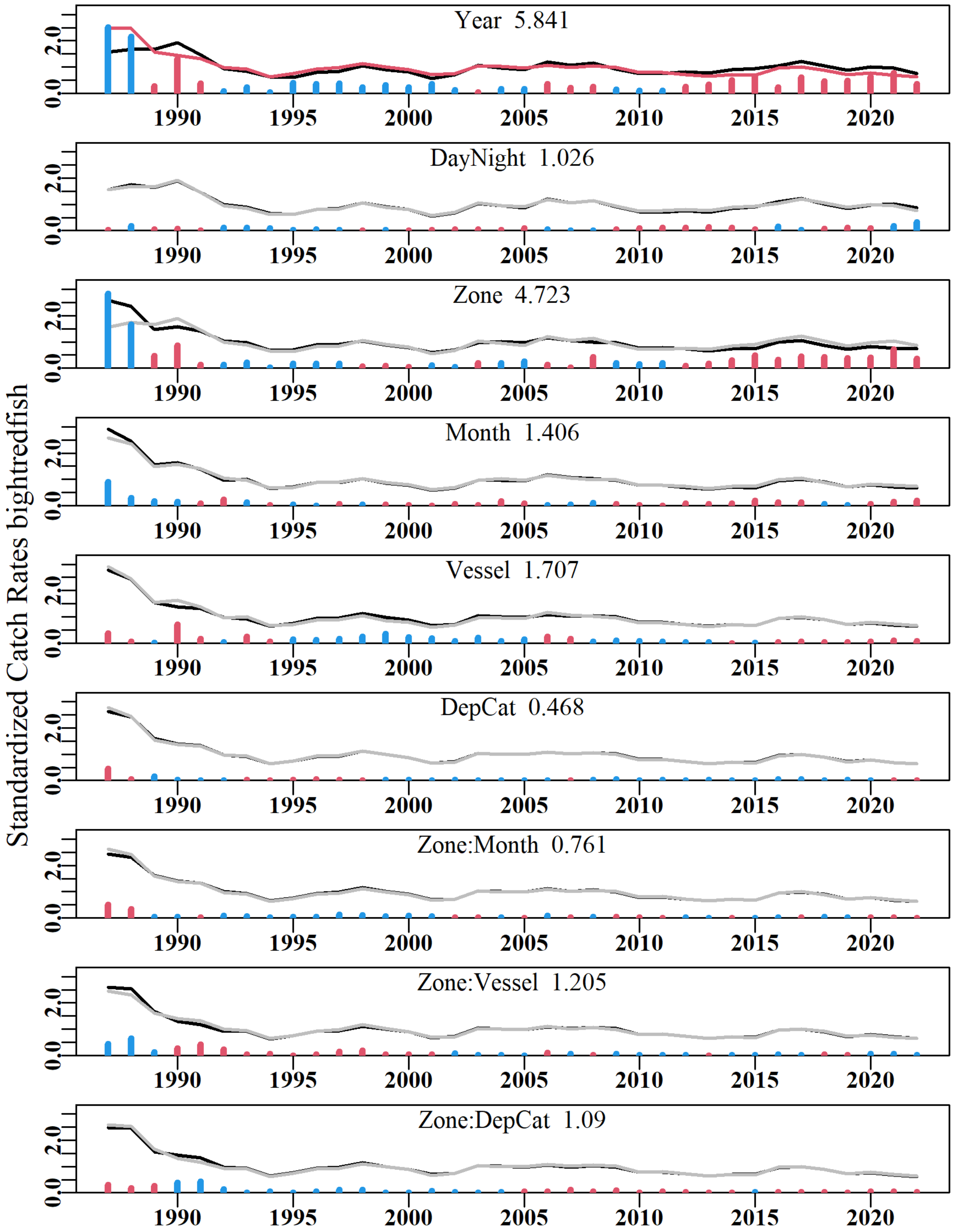

Figure 224: bightredfish. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

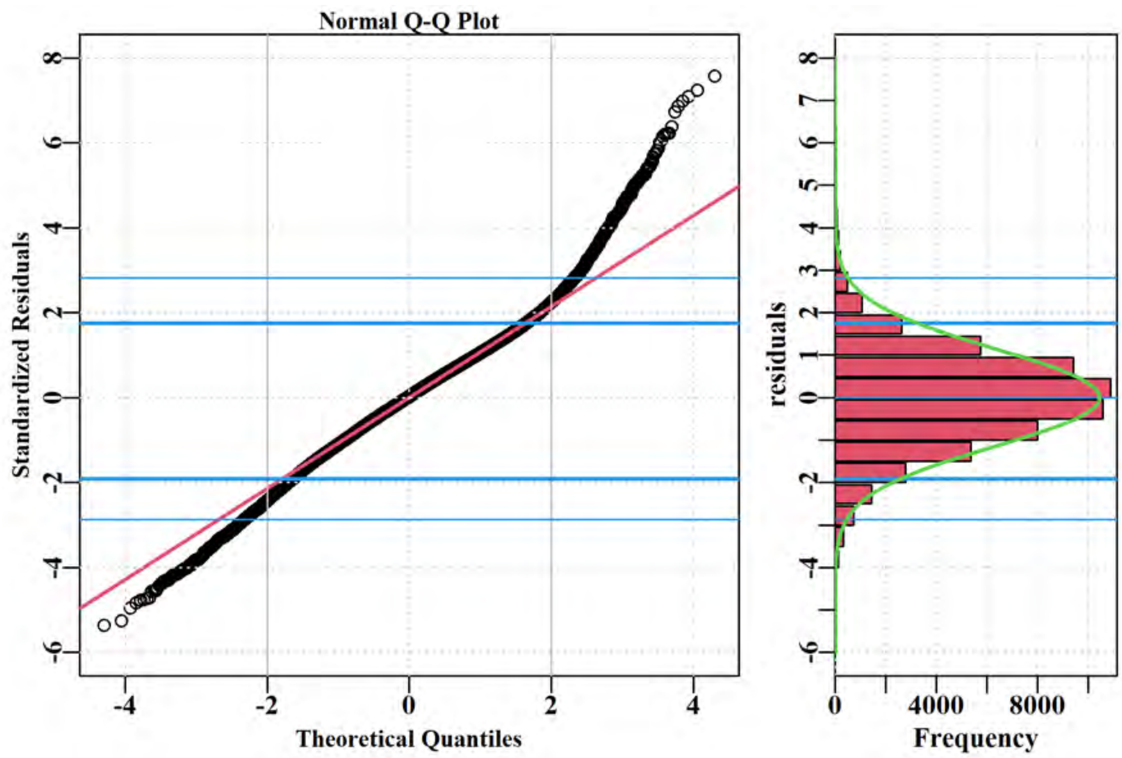

Figure 225: bightredfish. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

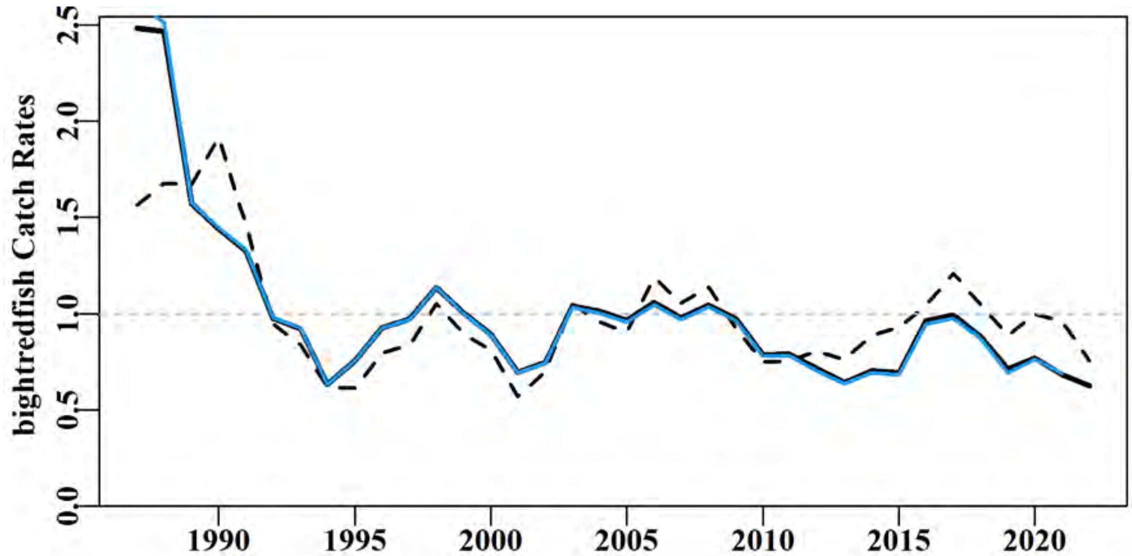

Figure 226: bightredfish. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

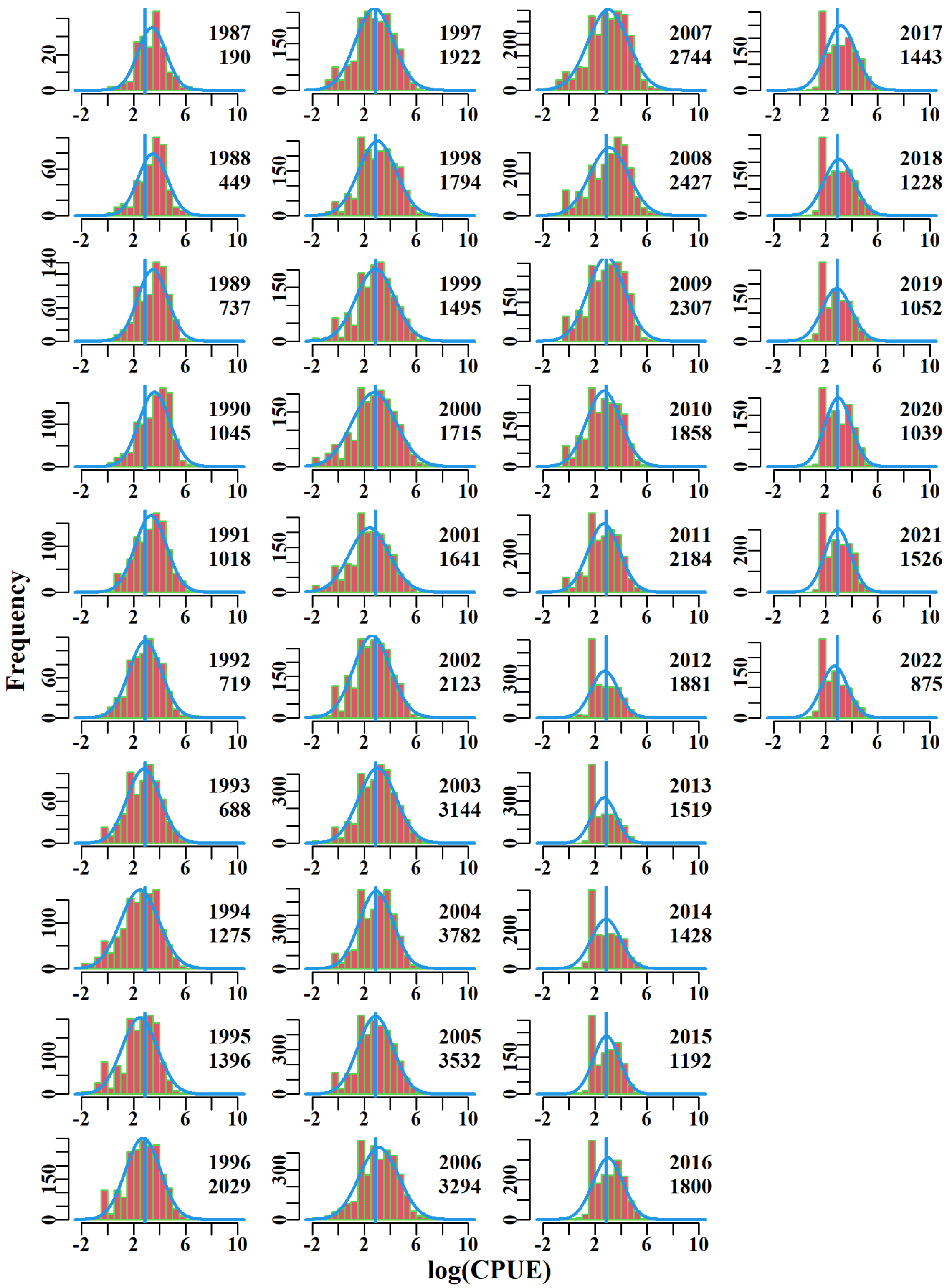

Figure 227: bightredfish. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

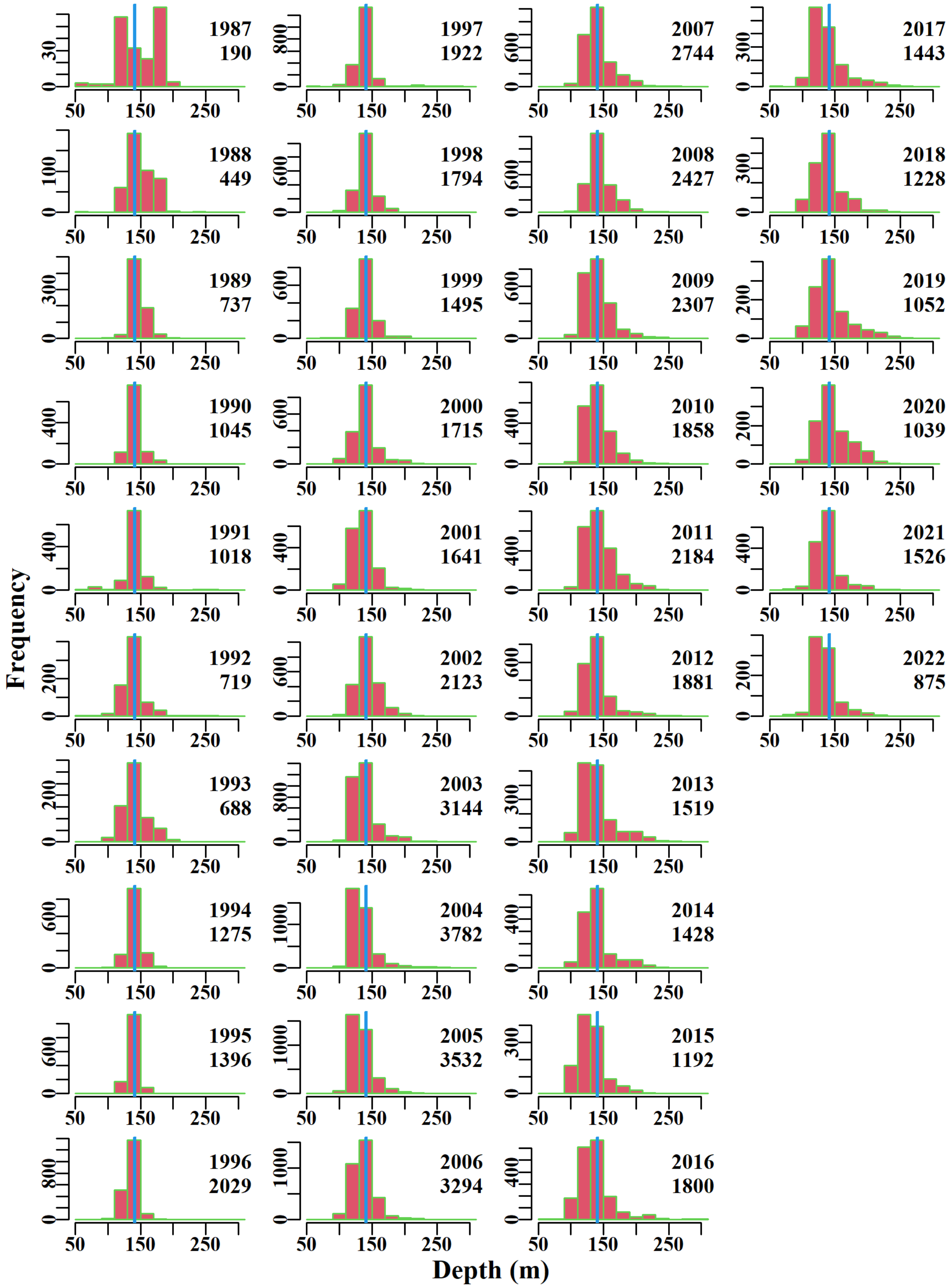

Figure 228: bightredfish. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Ribaldo 10-50

Initial data selection for Ribaldo (RBD – 37224002 – *Mora moro*) in the SET was conducted according to the details given in Table 162.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch occurred in zone 40, 50, 20 and 30 and minimal catches in zone 10. There were increases in catches < 30 kg during the 1995-2005 period.

The terms Year, Vessel, DepCat, Zone, Month and interaction term Zone:Month had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 166). The qqplot suggests a departure from the assumed Normal distribution as depicted by the tails of the distribution (Figure 232).

The number of records by depth was highly variable and sometimes bimodal from 1986 - 1994, after which the number of records increased, and the distributions became more consistent through time. The number of vessels contributing to the fishery also increased markedly after 2003. It is questionable whether the earlier years of CPUE are representative of the whole stock.

Annual standardized CPUE trend is noisy and relatively flat since 1996 and mostly below average (Figure 229). The differences between this years' and last years' standardized series can be mostly attributed to a change in the number of vessels analysed. A vessels' distinguishing symbol which was originally categorized as two different vessels, has been re-categorized as the same vessel in this years' analysis.

Action Items and Issues

It is recommended that the geographical distribution of catches be explored to determine the representativeness of the entire stock's distribution during the early years. It is also recommended that alternate statistical distributions be considered.

Table 162: RibaldoTW. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	RibaldoTW
csirocode	37224002
fishery	SET
depthrange	0 - 1000
depthclass	50
zones	10, 20, 30, 40, 50
methods	TW, TDO, OTT, OTB, OTM
years	1986 - 2022

Table 163: RibaldoTW. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	4.1	72	3.5	11	24.3	2.0459	0.000	0.655	0.186
1987	7.9	158	7.3	14	16.5	1.3751	0.142	1.509	0.207
1988	10.9	122	7.9	22	25.7	1.9618	0.157	0.855	0.108
1989	11.3	136	7.7	14	30.2	2.0294	0.155	1.114	0.144
1990	3.7	58	2.3	11	14.0	1.4928	0.176	0.648	0.287
1991	7.8	145	5.2	22	11.9	1.4194	0.155	1.697	0.329
1992	13.3	226	11.7	26	16.1	1.3889	0.145	1.982	0.170
1993	22.8	330	19.8	37	18.8	1.2169	0.146	3.424	0.173
1994	41.9	423	23.6	30	18.5	1.3302	0.143	4.945	0.209
1995	90.3	1139	85.9	26	18.9	1.4136	0.139	10.299	0.120
1996	82.3	1483	76.6	32	15.0	1.0245	0.139	14.889	0.194
1997	103.1	1708	96.2	30	14.0	0.9239	0.138	16.008	0.166
1998	99.9	1665	91.9	33	13.6	0.9087	0.139	16.781	0.183
1999	72.1	1132	59.7	32	12.6	0.8163	0.139	13.618	0.228
2000	66.8	1173	53.8	41	10.5	0.7627	0.139	12.935	0.240
2001	82.5	1129	52.6	37	9.9	0.7120	0.139	12.191	0.232
2002	157.8	1139	57.0	30	10.0	0.6642	0.139	11.246	0.197
2003	180.8	1302	65.6	35	10.0	0.6453	0.139	12.107	0.184
2004	181.1	1253	66.1	33	11.1	0.7035	0.139	7.617	0.115
2005	90.4	649	28.4	32	9.5	0.6201	0.141	3.891	0.137
2006	122.6	619	31.2	34	11.5	0.6544	0.141	3.234	0.104
2007	78.3	398	15.3	24	8.6	0.4950	0.144	2.556	0.167
2008	78.5	356	16.9	24	9.9	0.6777	0.145	2.272	0.134
2009	105.0	554	31.9	20	11.9	0.7180	0.142	3.169	0.099
2010	91.9	672	36.6	22	11.6	0.7355	0.141	5.060	0.138
2011	93.9	849	44.1	20	9.9	0.7493	0.140	4.554	0.103
2012	107.2	707	39.8	19	11.7	0.7437	0.141	3.542	0.089
2013	122.7	916	68.4	23	14.5	0.8939	0.140	3.885	0.057
2014	138.2	855	59.9	22	12.5	0.8843	0.140	4.387	0.073
2015	99.8	743	50.8	25	13.4	0.8579	0.141	3.530	0.070
2016	66.6	599	40.2	20	12.6	0.7935	0.142	3.272	0.081
2017	80.9	596	42.1	18	15.0	0.8525	0.142	2.719	0.065
2018	94.0	627	43.7	17	14.1	0.8393	0.142	3.181	0.073
2019	122.3	742	66.8	21	16.6	0.9526	0.141	3.471	0.052
2020	135.9	686	53.8	20	15.2	0.9410	0.141	3.118	0.058
2021	101.1	543	39.8	16	14.0	0.8449	0.142	2.830	0.071
2022	97.0	604	41.1	15	12.9	0.9114	0.142	2.287	0.056

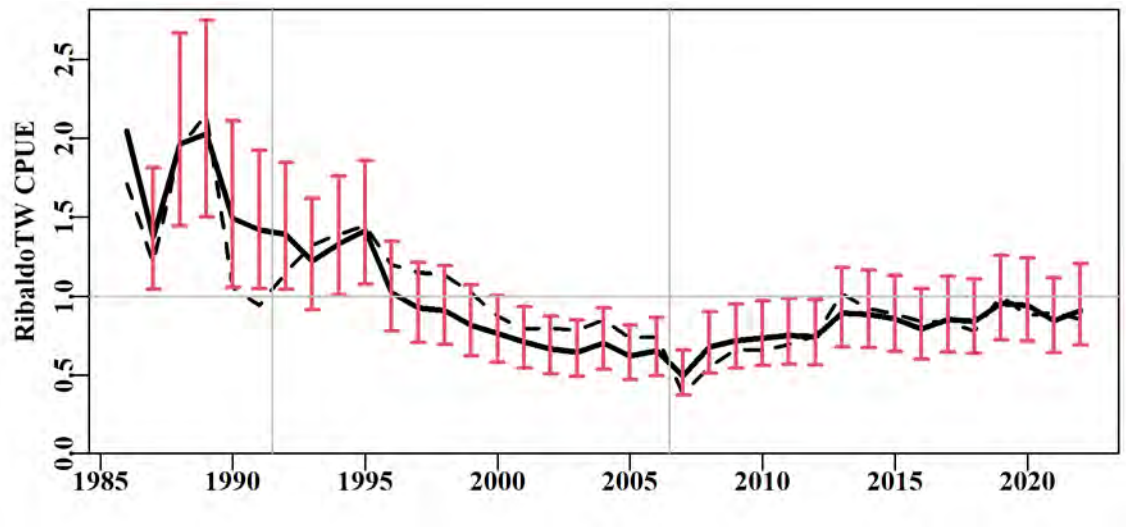

Figure 229: RibaldoTW standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

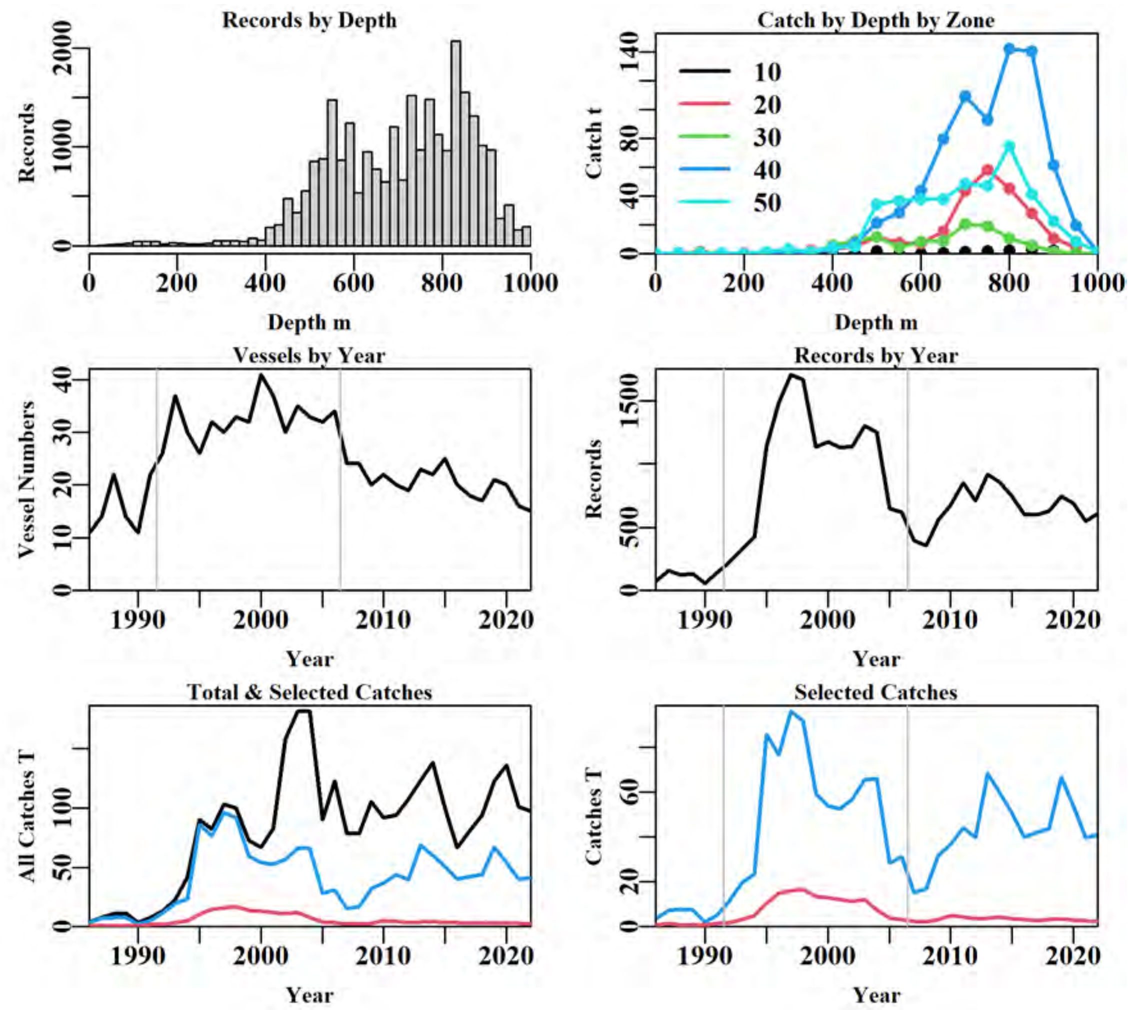

Figure 230: RibaldoTW fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 164: RibaldoTW data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	40614	31844	30822	30483	28020	26518	26508
Difference	0	8770	1022	339	2463	1502	10
Catch	3100	2070	2019	1986	1778	1546	1545
Difference	0	1031	51	33	208	232	1

Table 165: The models used to analyse data for RibaldoTW.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Zone
Model5	Year + Vessel + DepCat + Zone + DayNight
Model6	Year + Vessel + DepCat + Zone + DayNight + Month
Model7	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:Month
Model8	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:DepCat

Table 166: RibaldoTW. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	-337	26100	1681	26508	37	5.9	0.00
Vessel	-3071	23308	4474	26508	170	15.6	9.64
DepCat	-6917	20129	7652	26508	190	27.0	11.46
Zone	-7567	19636	8145	26508	194	28.8	1.78
DayNight	-7690	19540	8241	26508	197	29.1	0.34
Month	-7763	19471	8311	26508	208	29.4	0.22
Zone:Month	-8374	18964	8818	26508	252	31.1	1.72
Zone:DepCat	-8378	18916	8865	26508	283	31.2	1.81

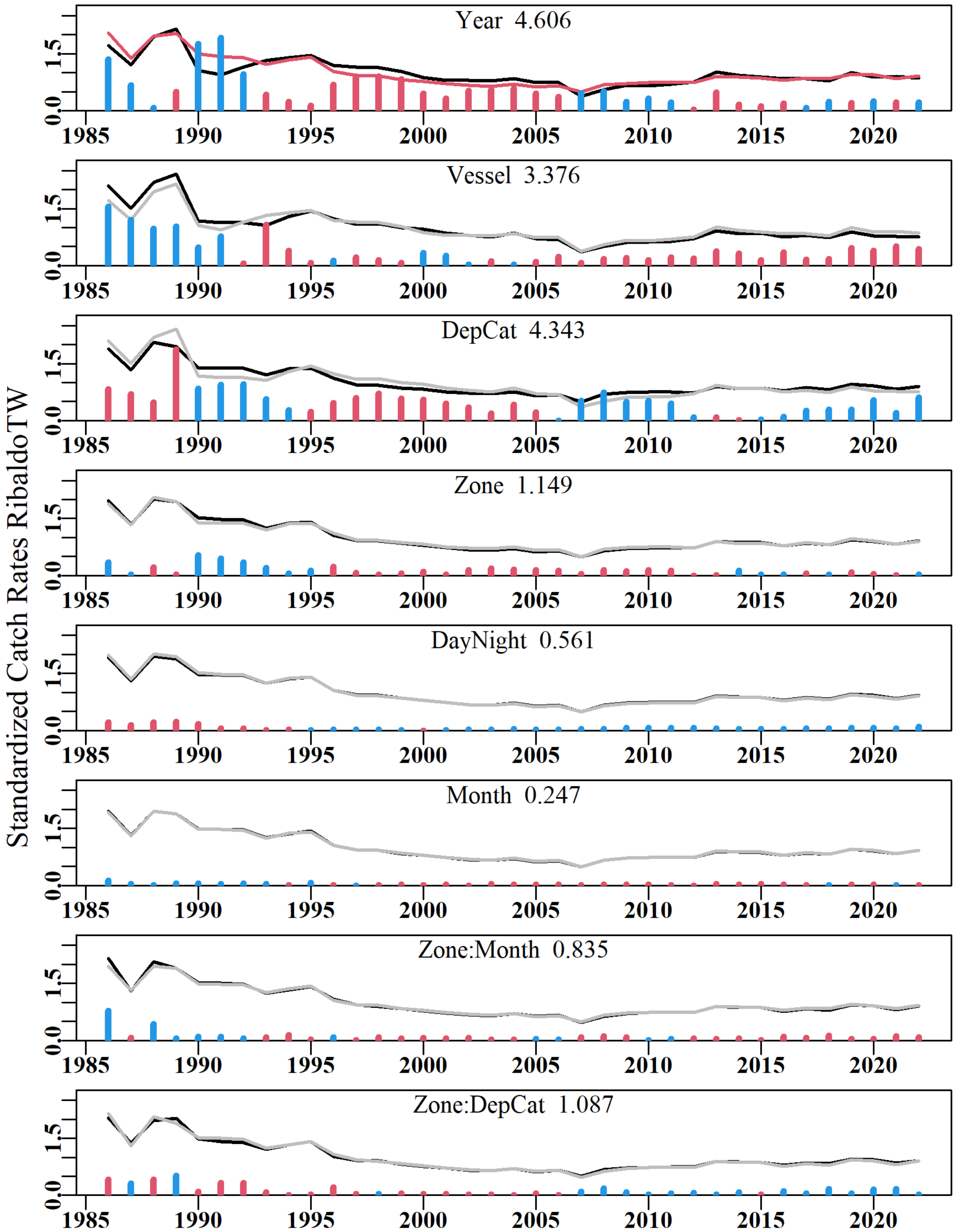

Figure 231: RibaldoTW. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

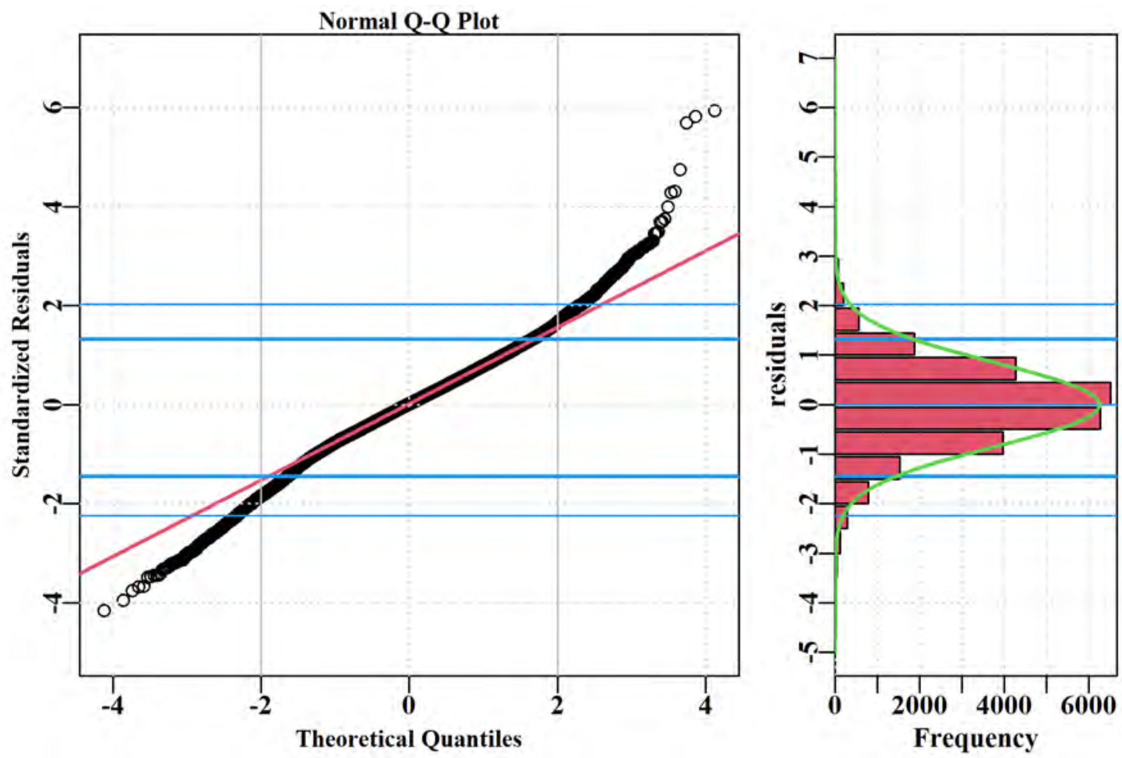

Figure 232: RibaldoTW. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

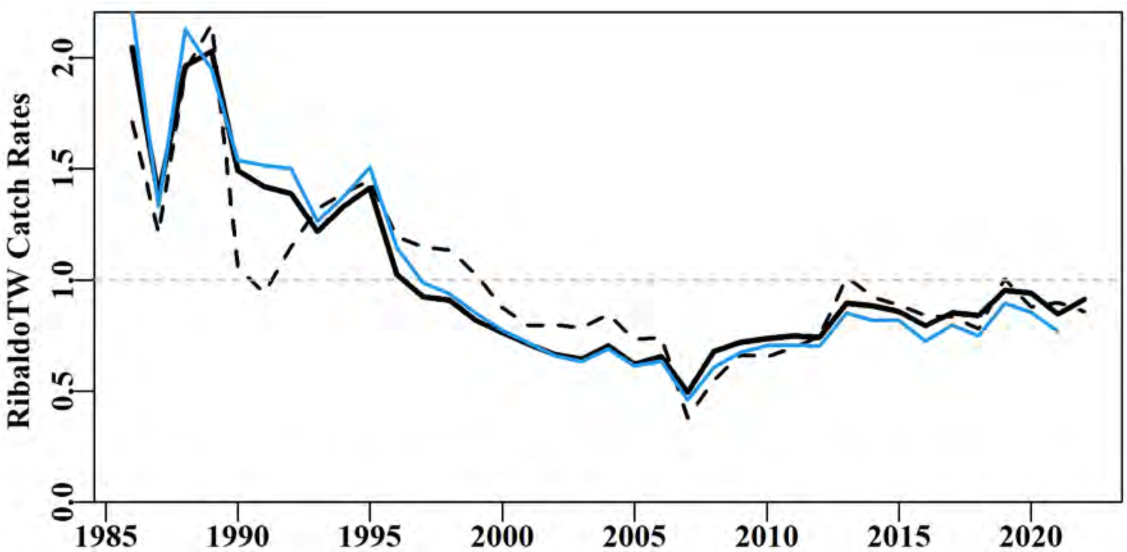

Figure 233: RibaldoTW. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

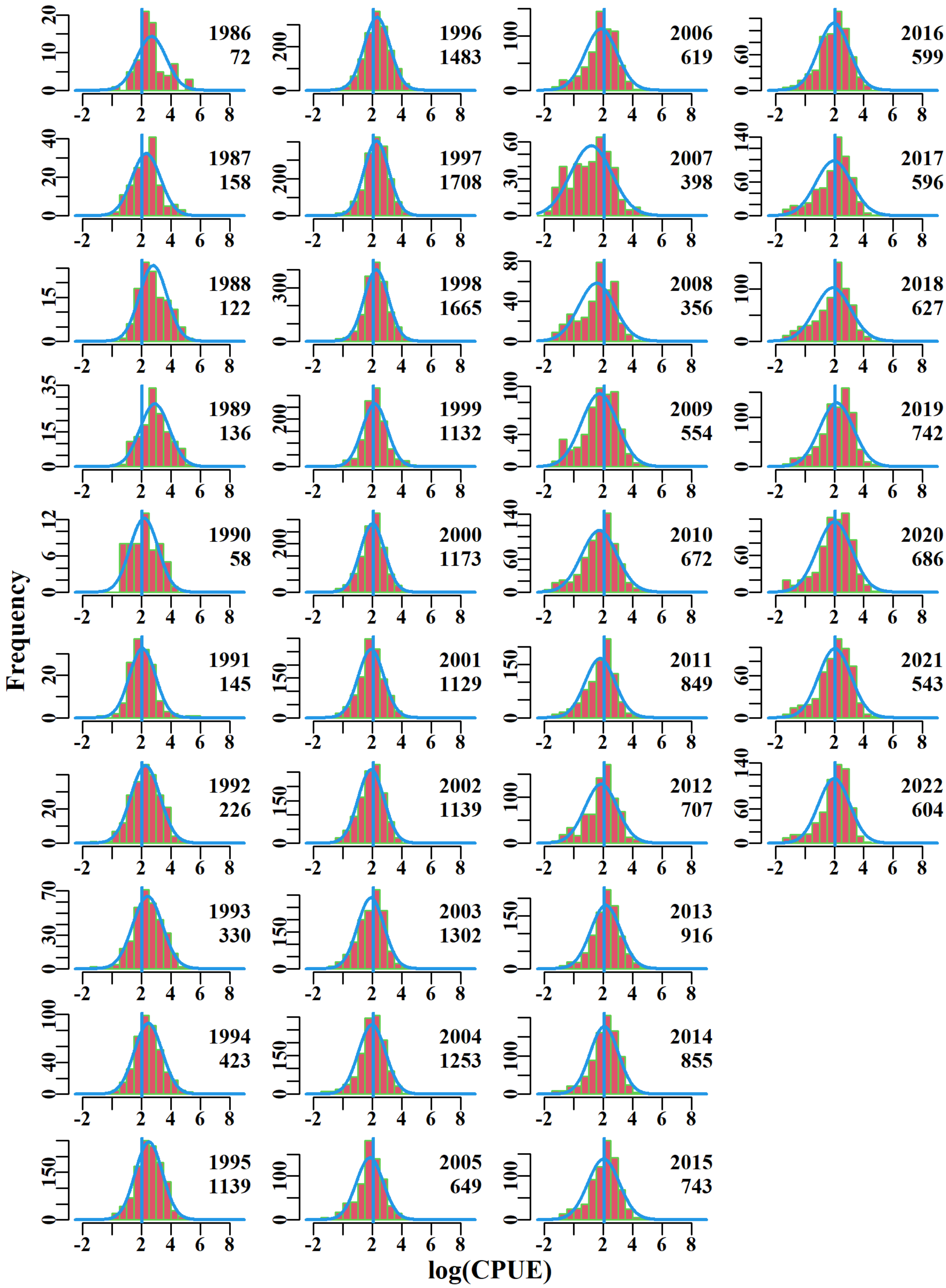

Figure 234: RibaldoTW. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

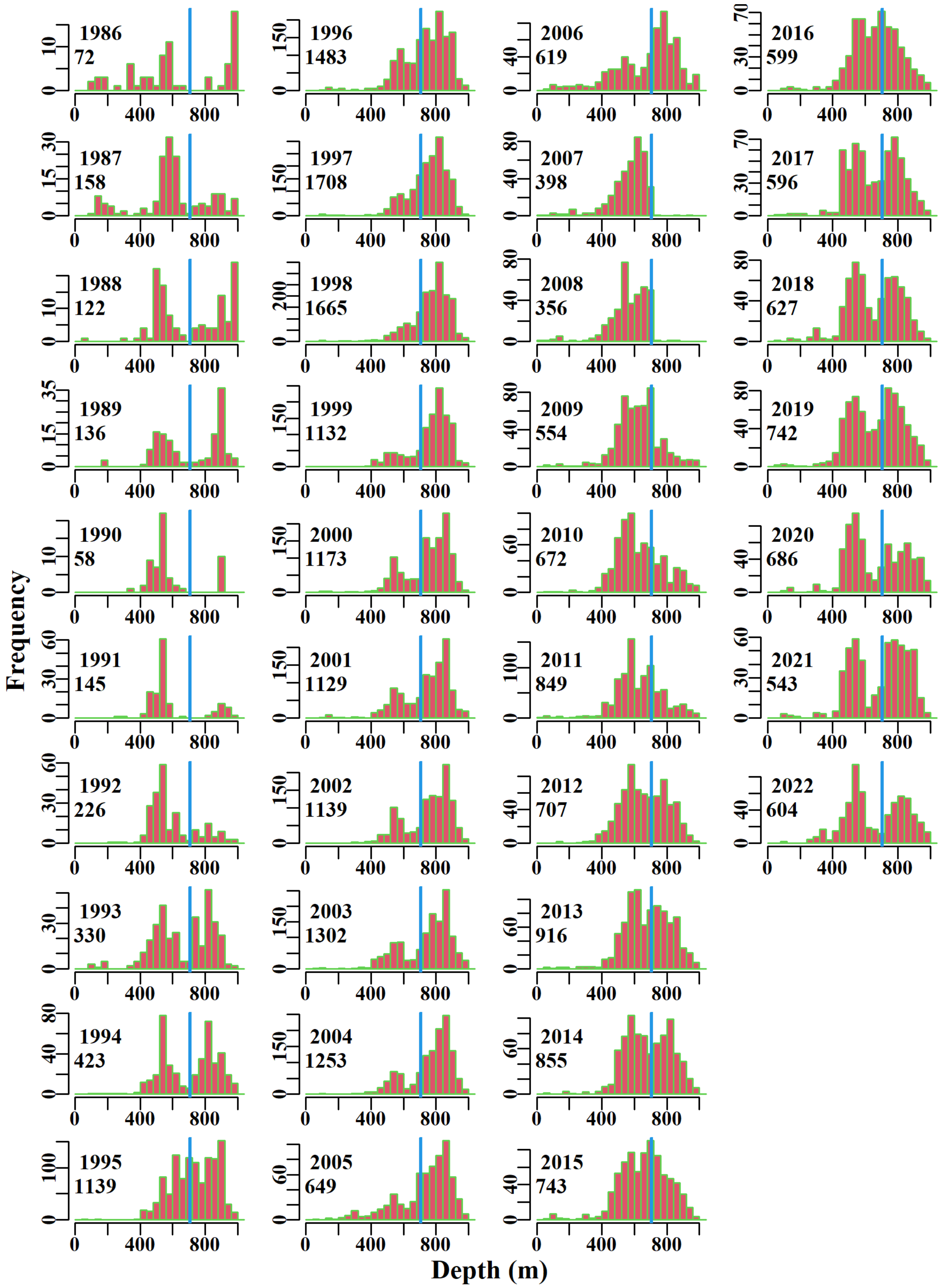

Figure 235: RibaldoTW. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

RibaldoAL

Initial data selection for Ribaldo (RBD – 37224002 – *Mora moro*) in the SEN and GHT was conducted according to the details given in Table 167.

A total of 7 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Most of the catch occurred in zone 30, followed by zone 40, 20 and 50.

The terms Year, Vessel, DepCat, Zone and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 171). Few vessels have ever contributed to this fishery and the early years are only made up from the catches of low vessel numbers. Two vessels have contributed to the Ribaldo auto-line catch since 2019. The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted by the upper tail of the distribution (Figure 239).

Annual standardized CPUE trend is noisy and relatively flat since about 2005 and mostly below average (Figure 236).

Action Items and Issues

The first two or three years of data need to be examined to determine how representative these data are of the whole stock. It may also benefit from being converted to catch-per-hook rather than catch-per-shot analysis.

Table 167: RibaldoAL. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	RibaldoAL
csirocode	37224002
fishery	SEN_GHT
depthrange	0 - 1000
depthclass	50
zones	20, 30, 40, 50, 83, 84, 85
methods	AL, ALL, LLA
years	2001 - 2022

Table 168: RibaldoAL. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
2001	82.5	63	15.7	2	268.8	1.1028	0.000	0.205	0.013
2002	157.8	257	94.7	4	455.0	2.7692	0.192	0.878	0.009
2003	180.8	336	102.7	7	359.3	2.0471	0.188	1.553	0.015
2004	181.1	713	96.6	11	131.9	1.8699	0.183	5.324	0.055
2005	90.4	308	37.1	7	127.7	1.1689	0.188	2.417	0.065
2006	122.6	605	65.4	8	123.5	1.1535	0.183	3.488	0.053
2007	78.3	386	27.8	6	73.2	0.6849	0.186	2.580	0.093
2008	78.5	401	56.8	6	168.8	0.8142	0.184	2.130	0.038
2009	105.0	432	68.3	6	218.5	0.7954	0.182	2.266	0.033
2010	91.9	381	51.7	5	175.7	0.7714	0.184	1.811	0.035
2011	93.9	354	46.3	5	163.8	0.8984	0.185	1.871	0.040
2012	107.2	293	58.4	6	282.2	0.8481	0.187	1.228	0.021
2013	122.7	275	49.8	5	241.2	0.7032	0.188	1.143	0.023
2014	138.2	265	66.0	4	506.8	0.7282	0.189	0.853	0.013
2015	99.8	196	35.0	3	270.3	0.6505	0.193	0.865	0.025
2016	66.6	238	23.2	3	129.5	0.4371	0.191	1.365	0.059
2017	80.9	295	36.8	3	150.3	0.5880	0.187	1.459	0.040
2018	94.0	291	47.6	3	220.2	0.7509	0.188	1.309	0.028
2019	122.3	295	45.9	2	218.1	0.7188	0.188	1.266	0.028
2020	135.9	363	77.5	2	337.6	1.0530	0.184	1.324	0.017
2021	101.1	298	51.2	2	233.2	0.7048	0.187	1.336	0.026
2022	97.0	326	53.9	2	204.9	0.7417	0.185	1.147	0.021

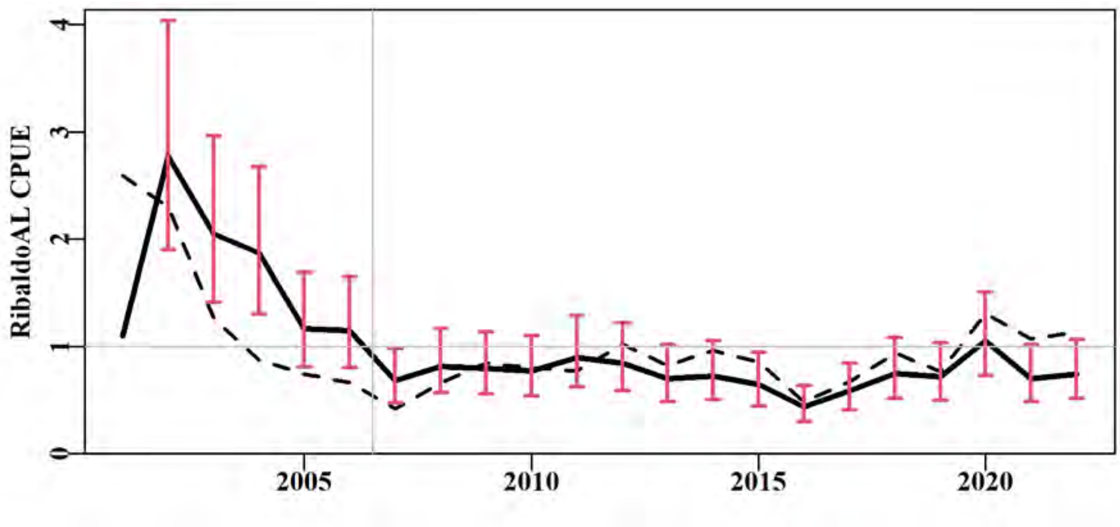

Figure 236: RibaldoAL standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

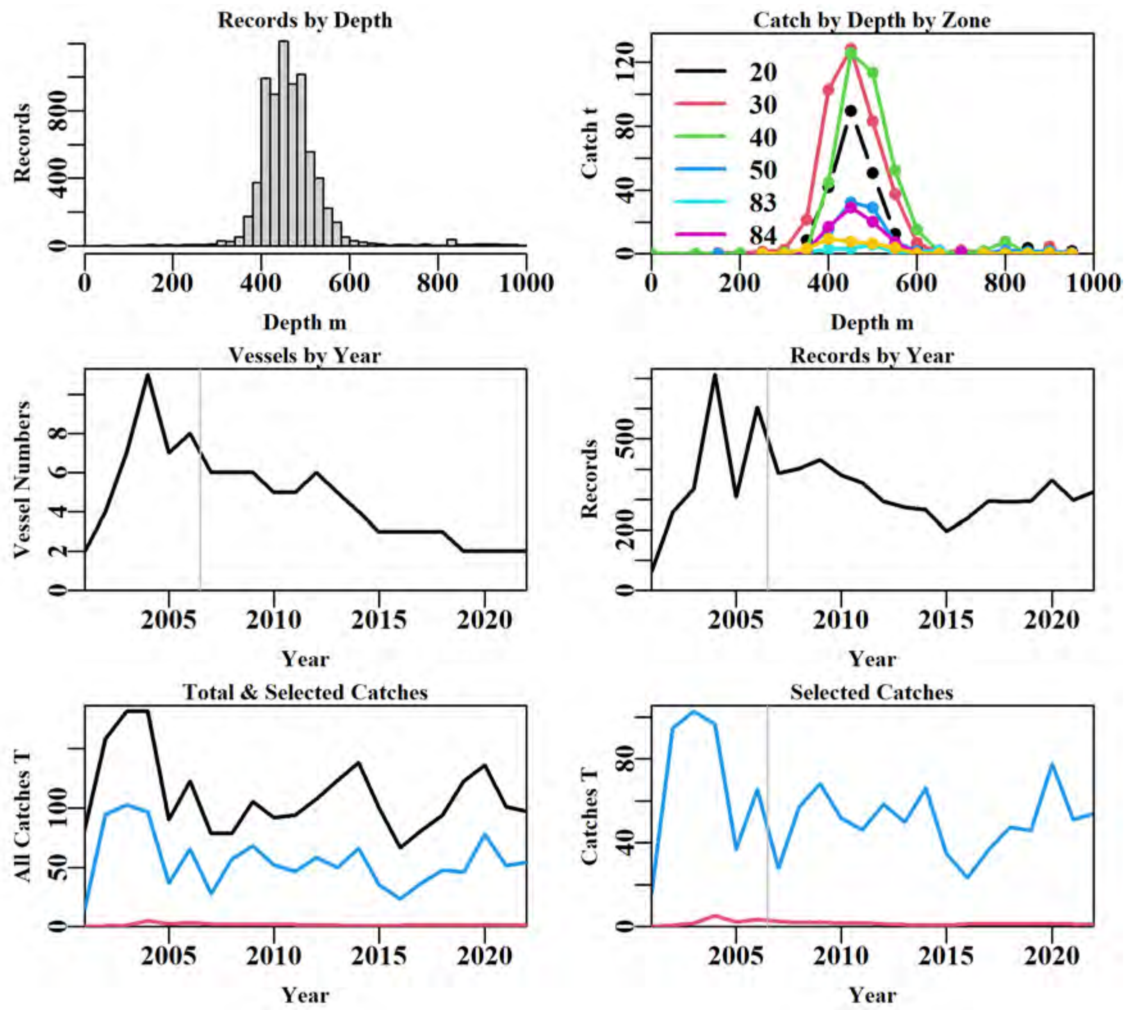

Figure 237: RibaldoAL fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 169: RibaldoAL data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	40614	39160	38071	26439	25325	7396	7371
Difference	0	1454	1089	11632	1114	17929	25
Catch	3100	3100	3036	2384	2265	1211	1208
Difference	0	0	65	651	119	1054	3

Table 170: The models used to analyse data for RibaldoAL.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Zone
Model5	Year + Vessel + DepCat + Zone + Month
Model6	Year + Vessel + DepCat + Zone + Month + Zone:Month
Model7	Year + Vessel + DepCat + Zone + Month + Zone:DepCat

Table 171: RibaldoAL. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	7257	19611	870	7371	22	4.0	0.00
Vessel	5060	14506	5976	7371	35	28.8	24.87
DepCat	4489	13359	7122	7371	53	34.3	5.46
Zone	4222	12863	7619	7371	59	36.7	2.39
Month	4179	12750	7732	7371	70	37.2	0.46
Zone:Month	4010	12239	8243	7371	136	39.1	1.97
Zone:DepCat	4132	12428	8054	7371	141	38.1	0.99

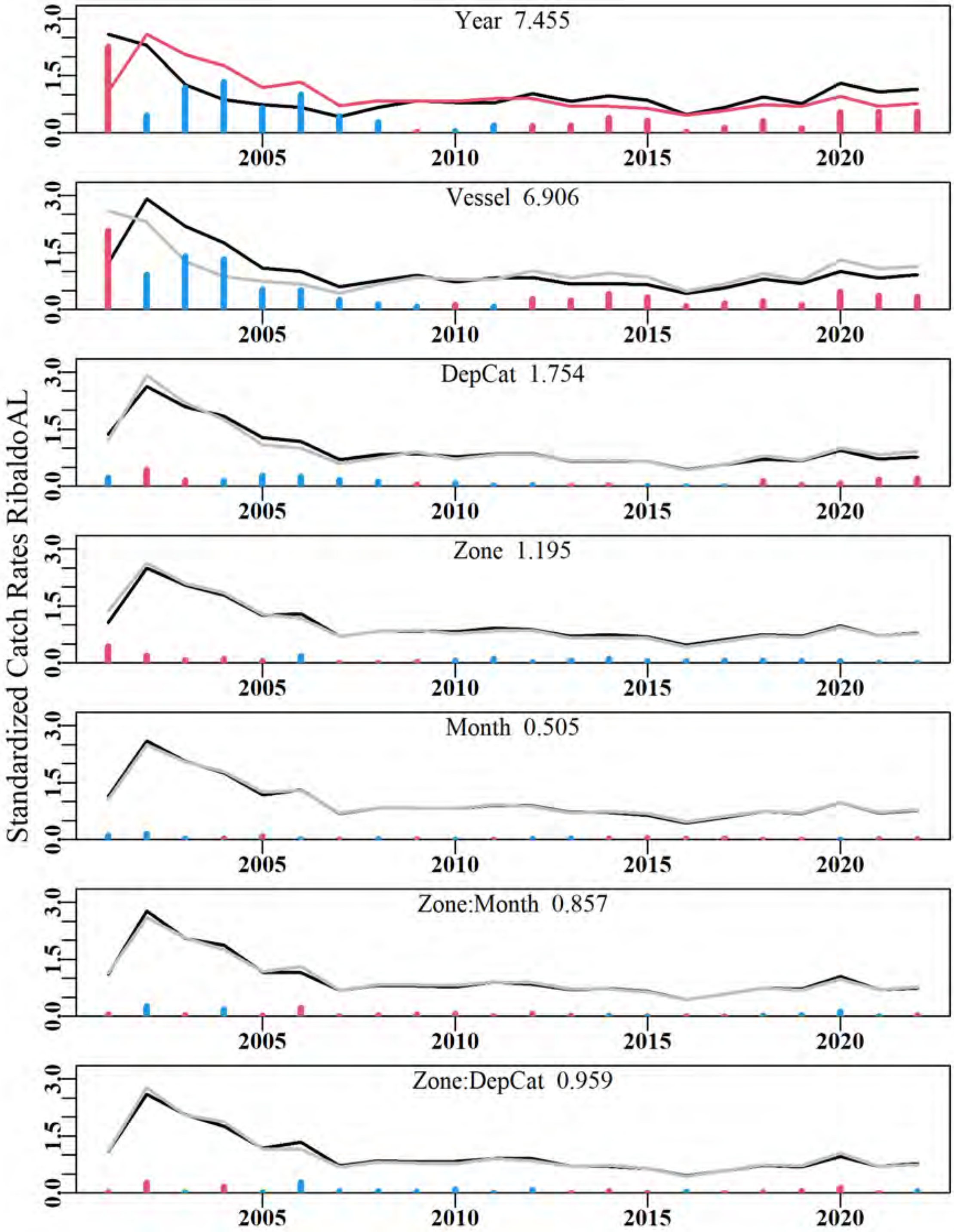

Figure 238: RibaldoAL. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

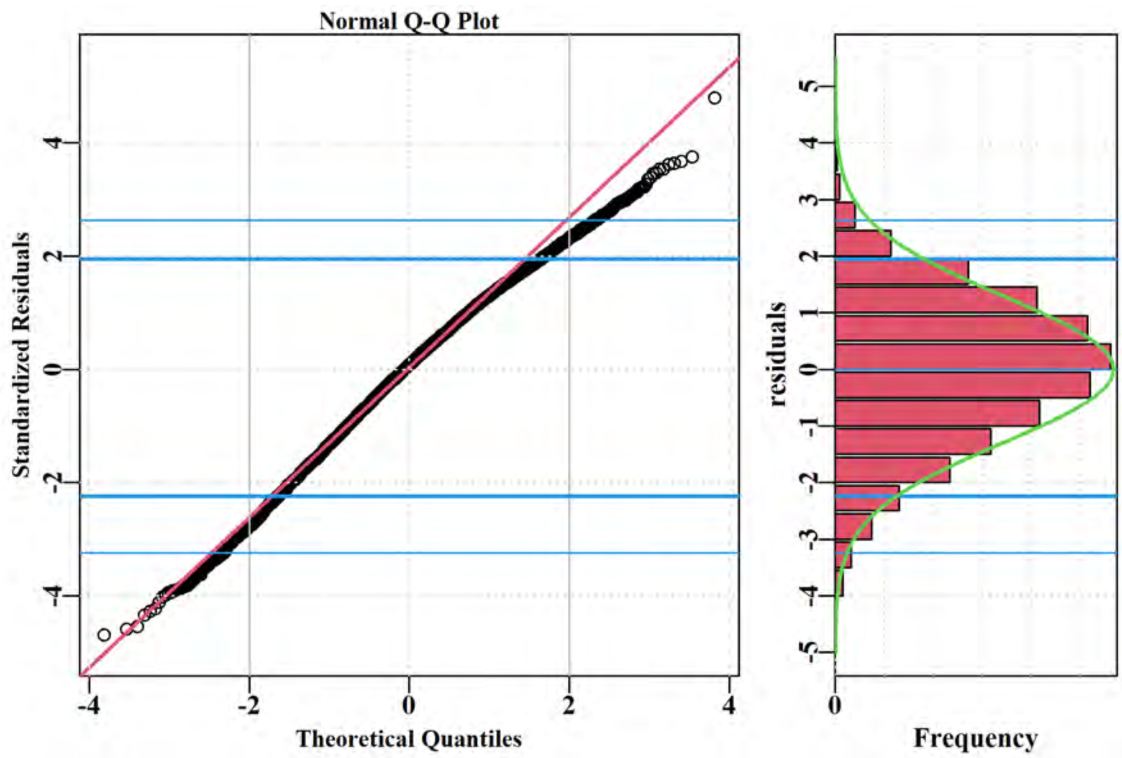

Figure 239: RibaldoAL. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

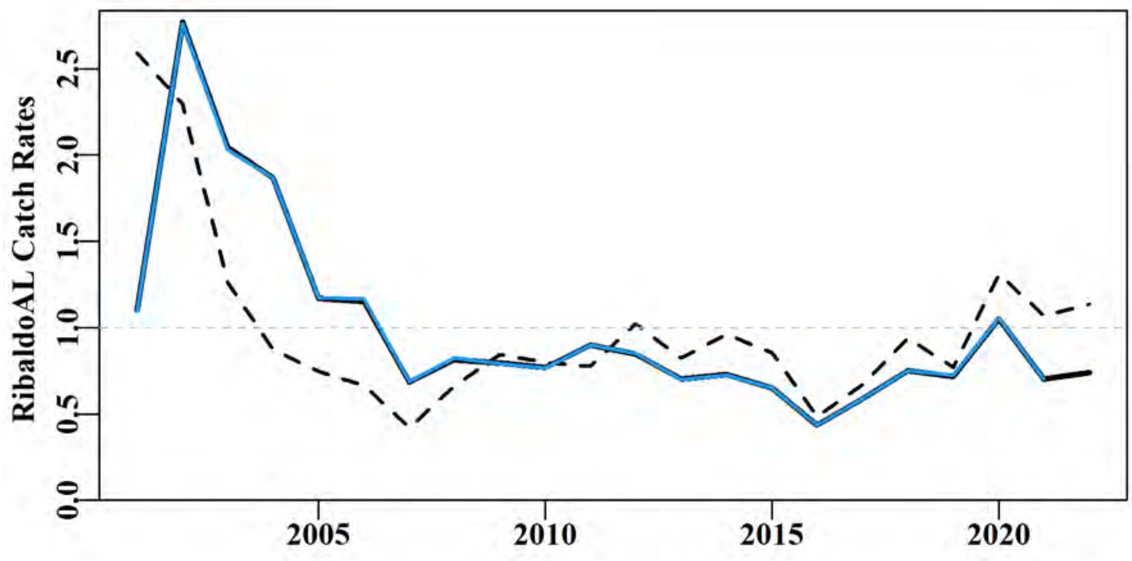

Figure 240: RibaldoAL. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

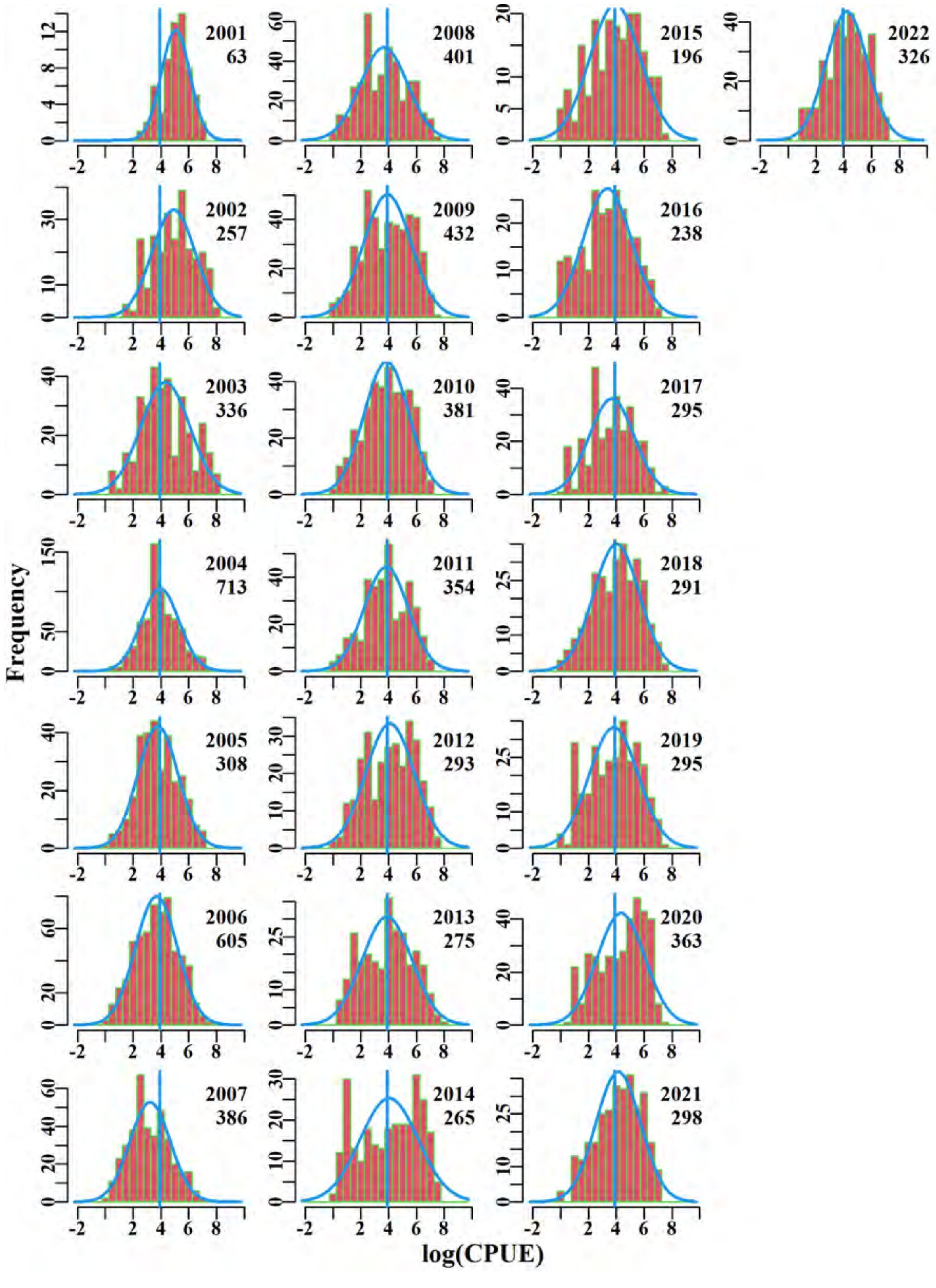

Figure 241: RibaldoAL. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

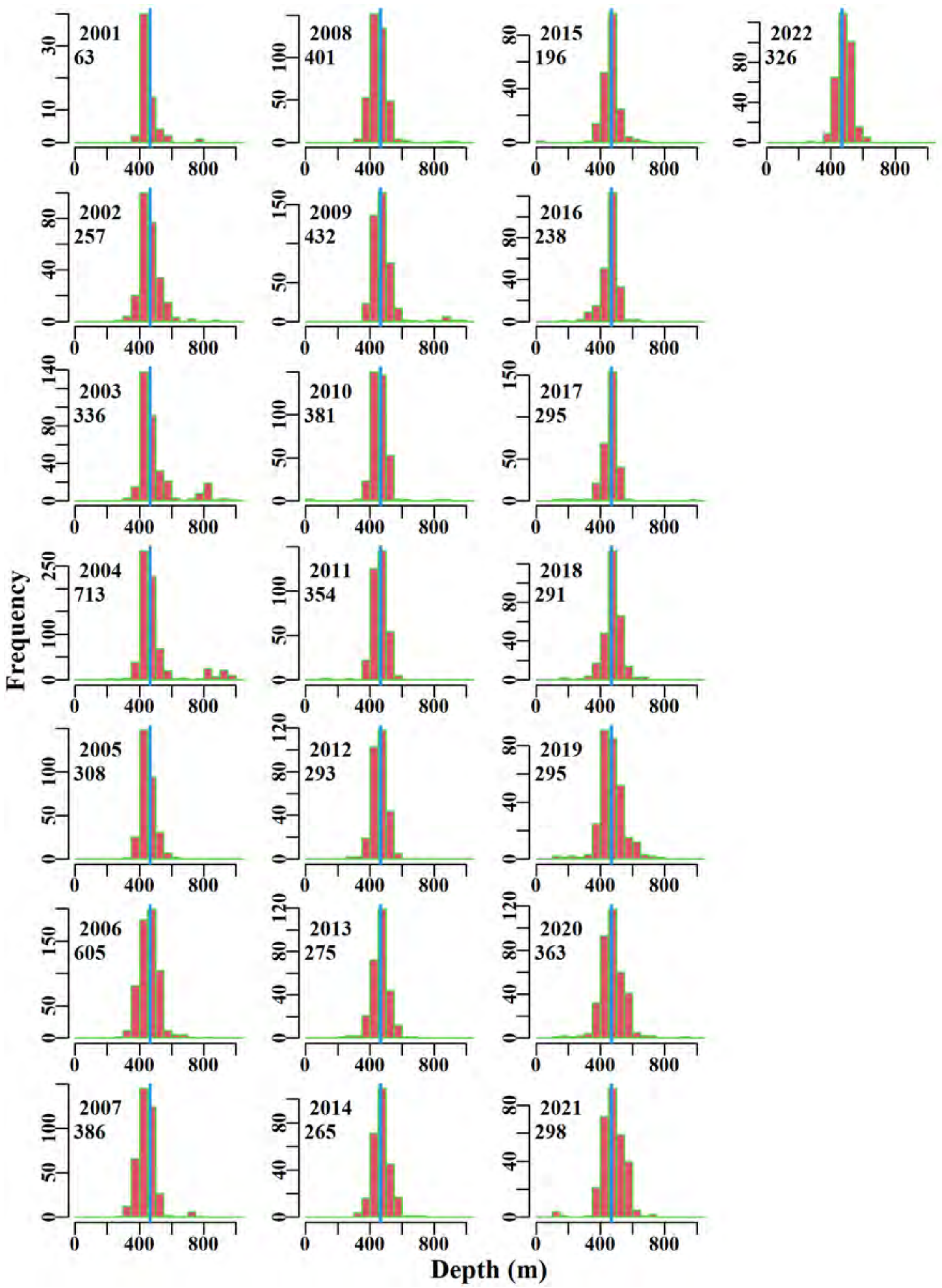

Figure 242: RibaldoAL. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Silver Trevally 1020

Initial data selection for Silver Trevally (TRE – 37337062 – *Pseudocaranx georgianus*) in the SET was conducted according to the details given in Table 172.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

Most of the catch occurred in zone 10, followed by 20.

The terms Year, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 176). The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted at the lower tail of the distribution (Figure 246).

Annual standardized CPUE trend is noisy and relatively flat since about 1992 and has remained mostly below average since 2012, despite recent increases towards average between 2020 and 2022 relative to 2019, based on 95% confidence intervals (Figure 243). A major change from the nominal geometric mean occurs from 2013 onwards and this is mainly due to changes in the vessels operating, the depths in which they fish, and the reduced amount of fish caught. The number of vessels actively contributing to this fishery has reduced to low numbers and this may also be related to the recent major deviation from the nominal CPUE. Seven vessels operated in 2019 contributing to a total of only 1.9 t, the lowest in the series. By contrast, annual catches have increased between 2020-2022 which corresponds to more vessels operating across these years. The 2020 catch (32.7 t) is comparable with the 2018 catch (30 t).

Action Items and Issues

Further exploration of the reasons behind the recent deviation of the standardized time-series from the nominal geometric mean are required to provide a more detailed explanation for these changed dynamics.

Table 172: SilverTrevally1020. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SilverTrevally1020
csirocode	37337062
fishery	SET
depthrange	0 - 200
depthclass	20
zones	10, 20
methods	TW, TDO, OTB
years	1986 - 2022

Table 173: SilverTrevally1020. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	469.5	1976	306.3	74	49.4	1.1595	0.000	14.045	0.046
1987	198.5	1253	133.7	64	43.6	1.3496	0.057	9.101	0.068
1988	278.5	1581	244.0	56	51.4	1.5638	0.052	12.112	0.050
1989	376.2	2193	332.7	62	60.6	1.9987	0.048	13.682	0.041
1990	450.4	2081	344.2	53	59.7	2.3282	0.050	11.655	0.034
1991	340.7	2216	251.4	50	43.8	2.0240	0.050	14.239	0.057
1992	296.5	1691	249.2	45	40.8	1.2569	0.053	11.775	0.047
1993	377.7	2264	281.1	49	42.7	1.2621	0.050	16.074	0.057
1994	392.8	3282	360.0	48	38.8	1.0714	0.047	24.712	0.069
1995	413.4	3347	383.2	48	44.6	1.2063	0.046	25.171	0.066
1996	340.6	3208	315.3	53	39.8	1.0938	0.047	24.514	0.078
1997	328.8	2815	292.9	56	53.7	1.0657	0.048	19.728	0.067
1998	210.1	2287	177.6	46	39.0	0.8154	0.049	17.833	0.100
1999	166.1	1857	114.4	45	31.9	0.7990	0.052	13.539	0.118
2000	154.8	2010	122.9	49	26.3	0.6186	0.051	14.713	0.120
2001	270.2	3255	229.0	45	36.3	0.7498	0.046	21.930	0.096
2002	232.8	2776	209.6	44	38.3	0.7046	0.048	17.710	0.085
2003	337.9	2732	277.9	49	59.7	0.7522	0.048	16.611	0.060
2004	458.2	3316	365.1	45	64.3	0.9204	0.047	19.378	0.053
2005	291.1	2301	240.1	43	59.0	0.7980	0.050	13.644	0.057
2006	247.3	1684	209.0	39	82.8	0.8658	0.053	9.278	0.044
2007	172.7	832	115.4	22	89.2	0.8432	0.064	4.408	0.038
2008	128.4	1054	95.8	23	49.0	0.9778	0.060	6.864	0.072
2009	164.1	1142	135.3	23	57.8	0.9813	0.059	6.689	0.049
2010	240.2	1231	191.3	24	99.9	1.2469	0.058	6.212	0.032
2011	193.5	1103	175.3	20	112.9	1.0658	0.059	5.548	0.032
2012	139.7	954	129.0	21	99.1	0.8332	0.062	5.062	0.039
2013	122.8	720	112.9	19	97.4	0.8839	0.067	3.918	0.035
2014	107.0	887	97.8	20	62.4	0.6762	0.063	5.216	0.053
2015	79.5	570	73.1	22	69.7	0.6976	0.073	2.914	0.040
2016	52.4	388	49.5	18	109.4	0.8797	0.084	1.858	0.038
2017	52.9	399	45.0	15	77.7	0.8097	0.083	2.192	0.049
2018	37.7	207	30.0	14	119.9	0.5931	0.109	1.269	0.042
2019	3.8	43	1.9	7	22.8	0.1979	0.225	0.234	0.121
2020	39.4	144	32.7	12	305.9	0.5796	0.136	0.674	0.021
2021	20.8	127	17.4	13	108.4	0.5211	0.139	0.964	0.055
2022	35.7	172	23.7	11	87.7	0.8091	0.131	1.163	0.049

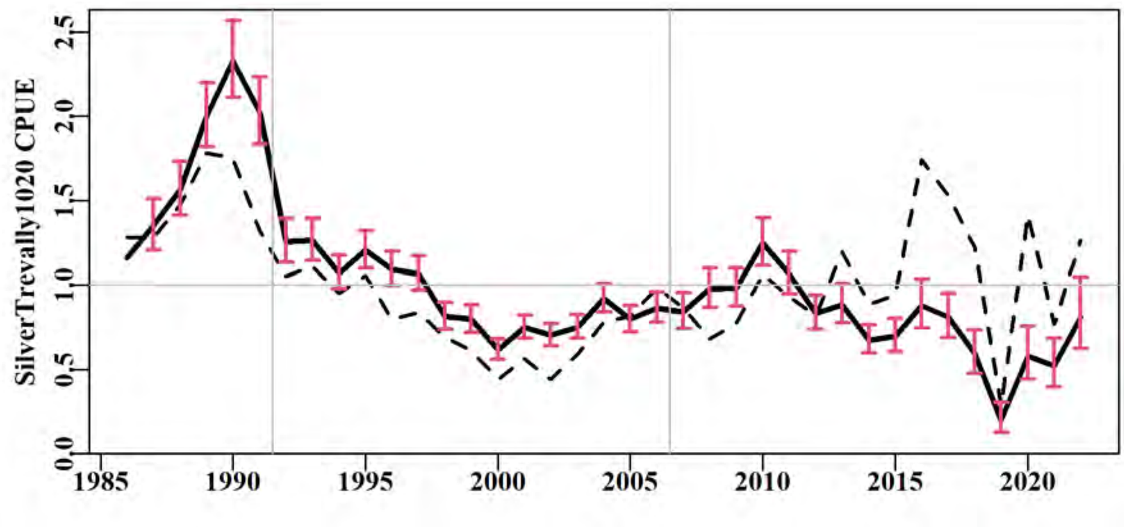

Figure 243: SilverTrevally1020 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

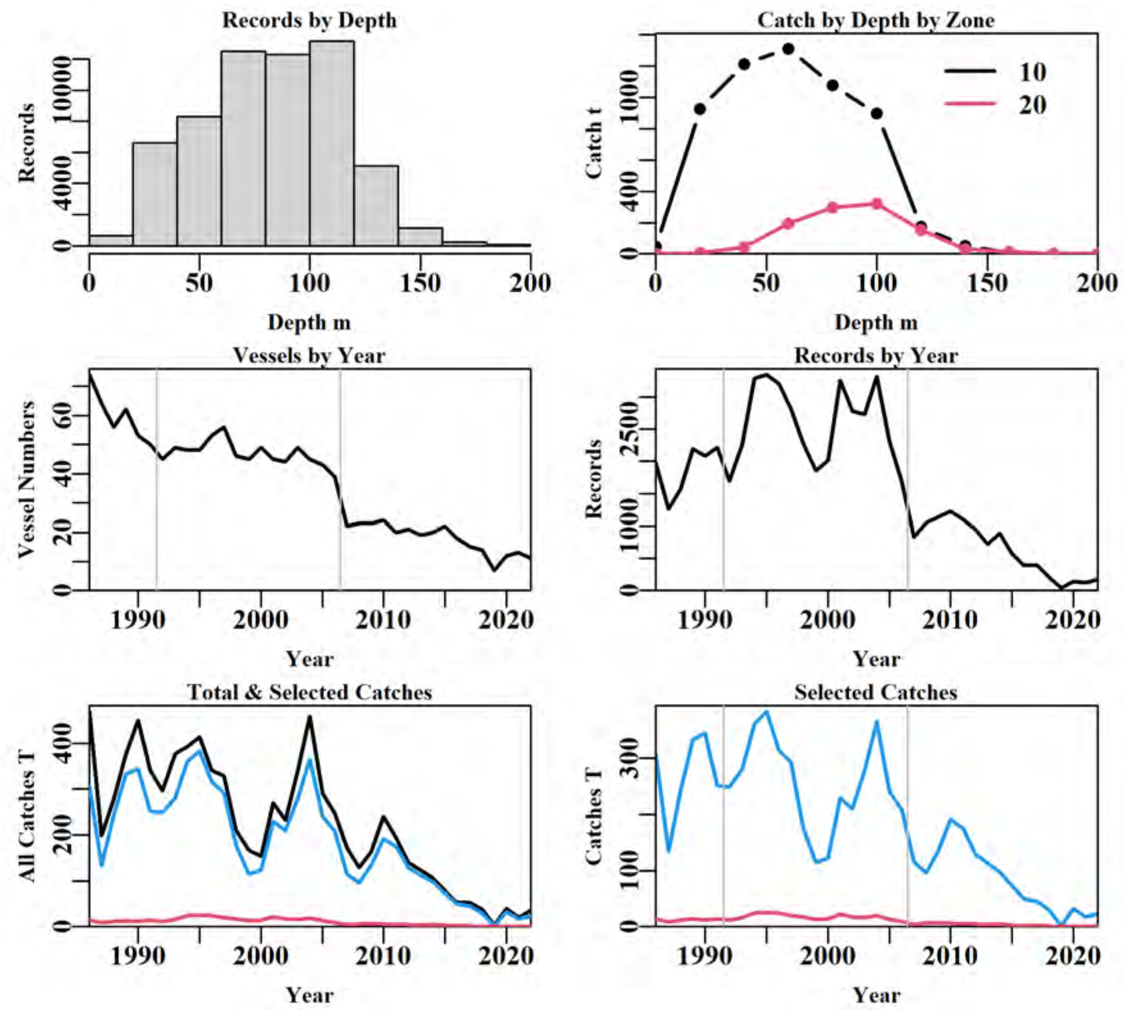

Figure 244: SilverTrevally1020 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 174: SilverTrevally1020 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	77239	74015	72386	71507	61559	60154	60098
Difference	0	3224	1629	879	9948	1405	56
Catch	8388	8212	7924	7758	6812	6772	6765
Difference	0	176	288	165	946	39	7

Table 175: The models used to analyse data for SilverTrevally1020.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + DayNight
Model6	Year + Vessel + DepCat + Month + DayNight + Zone
Model7	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:Month
Model8	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:DepCat

Table 176: SilverTrevally1020. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	63359	172259	8115	60098	37	4.4	0.00
Vessel	49237	135471	44903	60098	195	24.7	20.21
DepCat	45874	128056	52319	60098	205	28.8	4.11
Month	45155	126488	53887	60098	216	29.6	0.86
DayNight	44313	124715	55660	60098	219	30.6	0.98
Zone	44281	124644	55731	60098	220	30.6	0.04
Zone:Month	44140	124307	56068	60098	231	30.8	0.18
Zone:DepCat	44254	124552	55823	60098	229	30.7	0.04

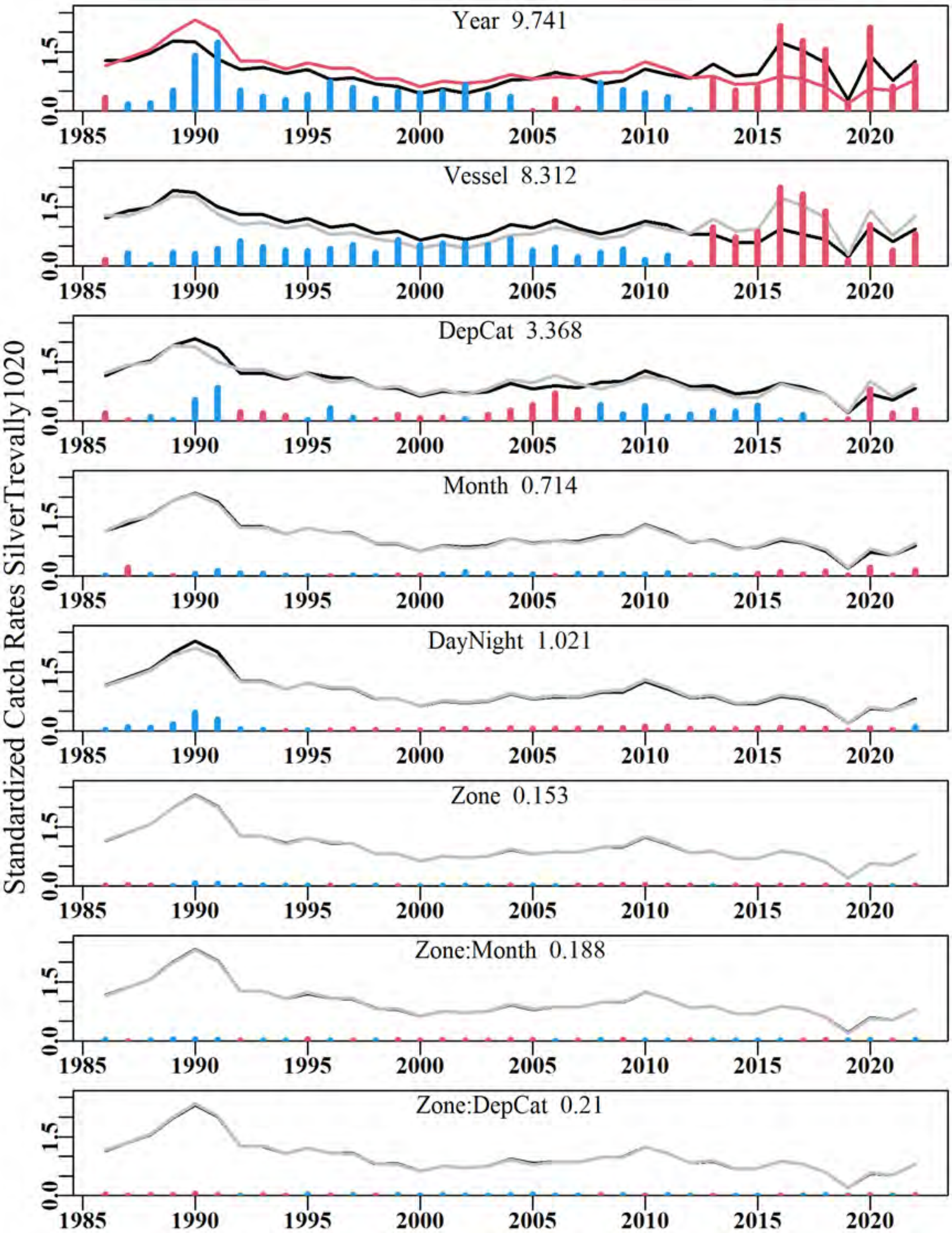

Figure 245: SilverTrevally1020. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

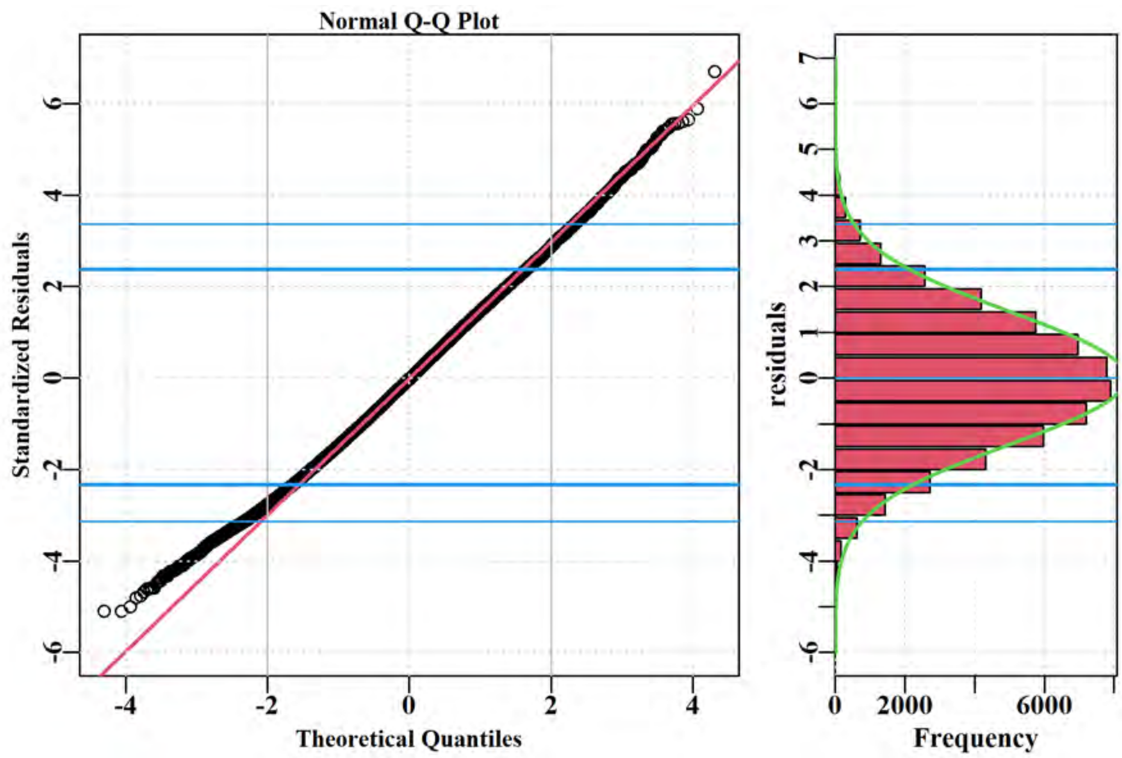

Figure 246: SilverTrevally1020. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

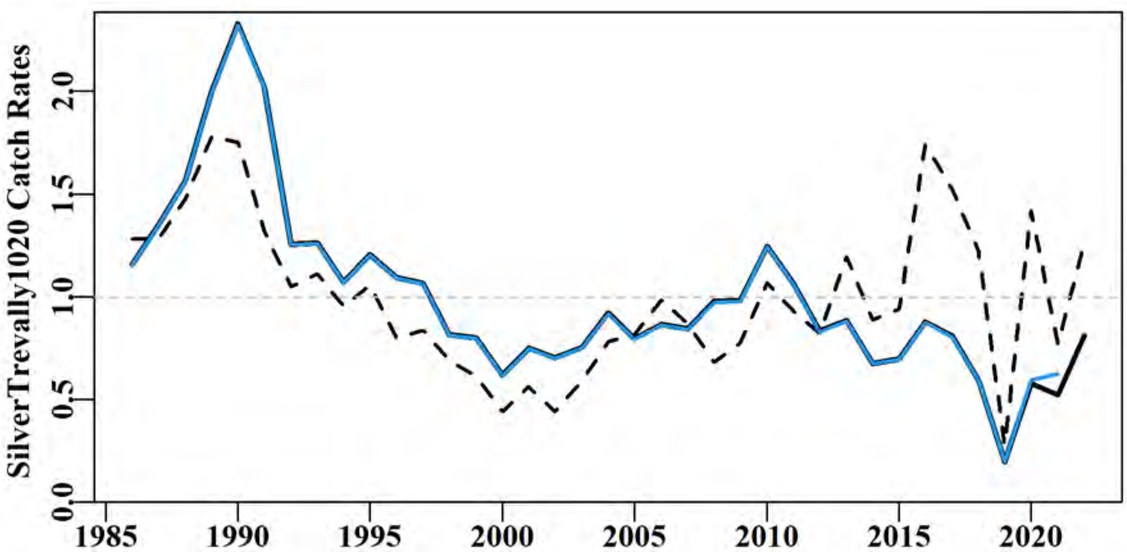

Figure 247: SilverTrevally1020. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

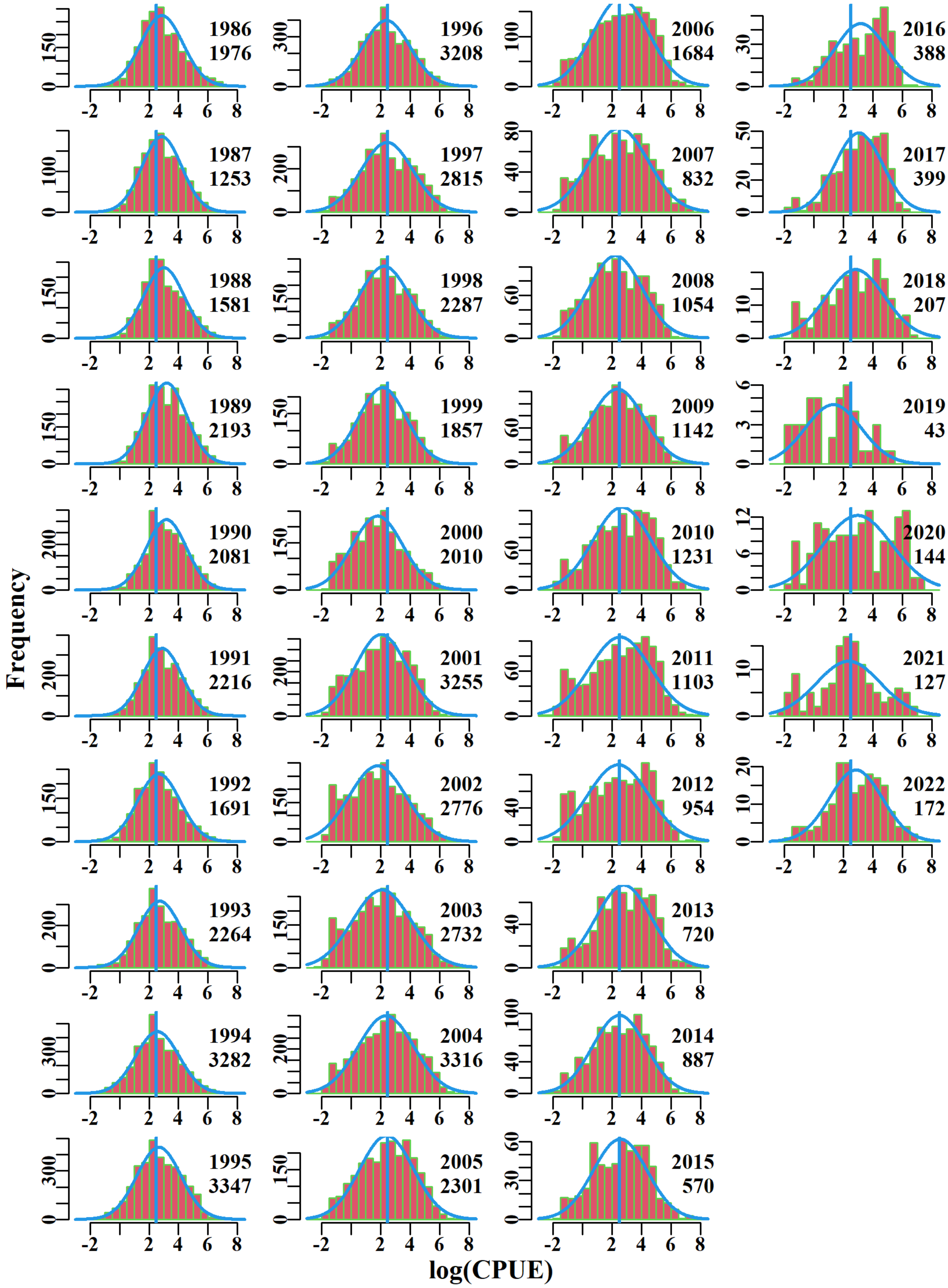

Figure 248: SilverTrevally1020. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

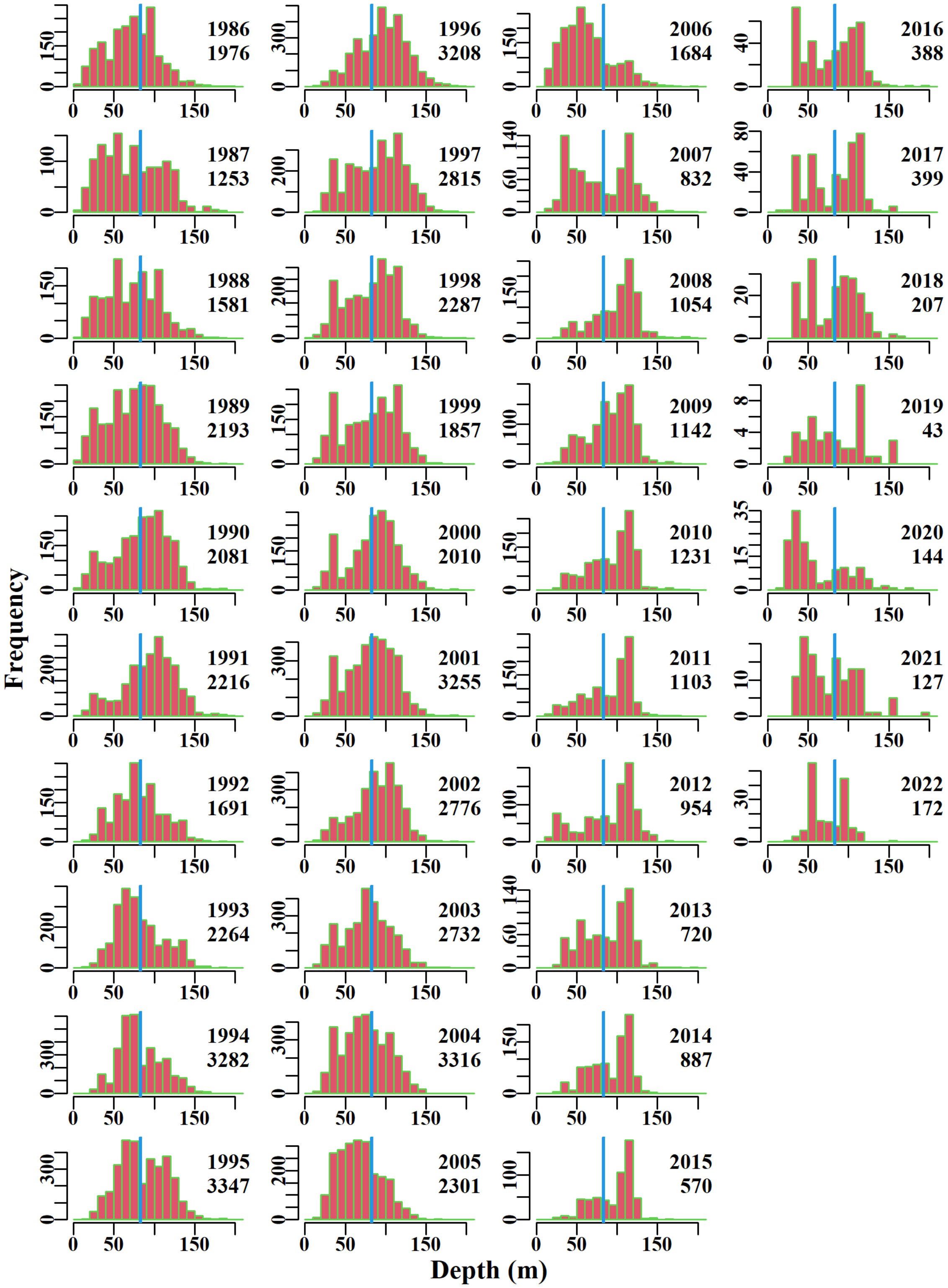

Figure 249: SilverTrevally1020. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Silver Trevally 1020 - No MPA

Initial data selection for Silver Trevally (TRE - 37337062 - *Pseudocaranx georgianus*) in the SET was conducted according to the details given in Table 177 and then records reported as State waters, which includes the Bateman's Bay marine protected area (MPA) were excluded.

A total of 8 statistical models were fitted sequentially to the available data.

Inferences

Most of the catch of this species occurred in zone 10.

The terms Year, Vessel, DepCat, Month and DayNight had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted at the lower tail of the distribution (Figure 253).

Annual standardized CPUE trend is noisy and relatively flat since about 2012 and mostly below average, despite recent increases towards average between 2020 and 2022 relative to 2019, based on 95% confidence intervals (Figure 250).

A deviation similar to that in the 'include MPA' scenario is apparent where the standardized trend deviates markedly from the nominal geometric mean trend from 2013 - 2017 and for the same reasons of changes in vessels fishing, low numbers of significantly contributing vessels, changes in the depth distribution of fishing and lower catches and numbers of records.

Action Items and Issues

Further exploration of the reasons behind the recent deviation of the standardized time-series from the nominal geometric mean are required to provide a more detailed explanation for these changed dynamics.

Table 177: SilverTrevally1020nompa. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SilverTrevally1020nompa
csirocode	37337062
fishery	SET
depthrange	0 - 200
depthclass	20
zones	10, 20
methods	TW, TDO, OTB
years	1986 - 2022

Table 178: SilverTrevally1020nompa. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	469.5	1765	285.3	74	49.0	1.2789	0.000	12.762	0.045
1987	198.5	1077	120.9	62	45.8	1.5236	0.061	7.630	0.063
1988	278.5	1258	226.7	53	59.1	1.9589	0.056	9.599	0.042
1989	376.2	1846	282.5	62	56.2	2.1056	0.051	12.318	0.044
1990	450.4	1834	292.0	52	55.1	2.4646	0.052	10.697	0.037
1991	340.7	1957	218.8	49	42.5	2.1745	0.053	12.580	0.057
1992	296.5	1358	170.8	45	34.6	1.3423	0.057	9.772	0.057
1993	377.7	1407	152.3	48	35.2	1.3748	0.057	10.899	0.072
1994	392.8	2073	176.8	47	28.2	1.0946	0.053	16.809	0.095
1995	413.4	1942	179.2	44	31.5	1.2294	0.053	16.202	0.090
1996	340.6	2179	177.6	49	27.6	1.0663	0.053	18.281	0.103
1997	328.8	1647	115.7	49	24.9	0.9980	0.056	13.637	0.118
1998	210.1	1226	64.0	42	19.4	0.7091	0.059	10.434	0.163
1999	166.1	1022	49.0	40	17.3	0.7183	0.062	8.024	0.164
2000	154.8	1244	54.5	46	13.9	0.5537	0.059	9.600	0.176
2001	270.2	2024	121.5	43	23.7	0.6795	0.053	13.786	0.113
2002	232.8	1812	97.7	39	19.0	0.5480	0.055	11.638	0.119
2003	337.9	1526	89.8	49	21.9	0.5595	0.056	9.592	0.107
2004	458.2	1868	151.7	43	36.8	0.8032	0.054	11.342	0.075
2005	291.1	1013	98.7	41	41.5	0.6928	0.062	6.210	0.063
2006	247.3	695	79.3	37	59.7	0.8795	0.069	4.529	0.057
2007	172.7	557	79.2	21	92.1	1.0150	0.075	2.895	0.037
2008	128.4	887	80.6	22	46.9	0.9844	0.065	5.931	0.074
2009	164.1	933	107.0	23	55.7	0.9769	0.064	5.623	0.053
2010	240.2	1011	152.6	24	89.7	1.2425	0.063	5.213	0.034
2011	193.5	910	149.6	20	113.8	1.0702	0.065	4.590	0.031
2012	139.7	733	97.6	21	72.6	0.7695	0.069	4.241	0.043
2013	122.8	520	72.4	19	70.9	0.8446	0.076	2.924	0.040
2014	107.0	673	66.7	20	51.2	0.6370	0.070	4.127	0.062
2015	79.5	473	61.2	21	67.6	0.7029	0.079	2.422	0.040
2016	52.4	288	33.6	18	89.7	0.8105	0.095	1.528	0.045
2017	52.9	291	33.4	15	69.8	0.8174	0.095	1.634	0.049
2018	37.7	132	14.7	14	58.5	0.4078	0.132	0.926	0.063
2019	3.8	39	1.8	7	21.1	0.2104	0.233	0.196	0.111
2020	39.4	108	16.7	12	124.5	0.4427	0.153	0.546	0.033
2021	20.8	110	12.5	13	88.9	0.5146	0.147	0.902	0.072
2022	35.7	132	17.0	11	88.7	0.7985	0.145	0.843	0.049

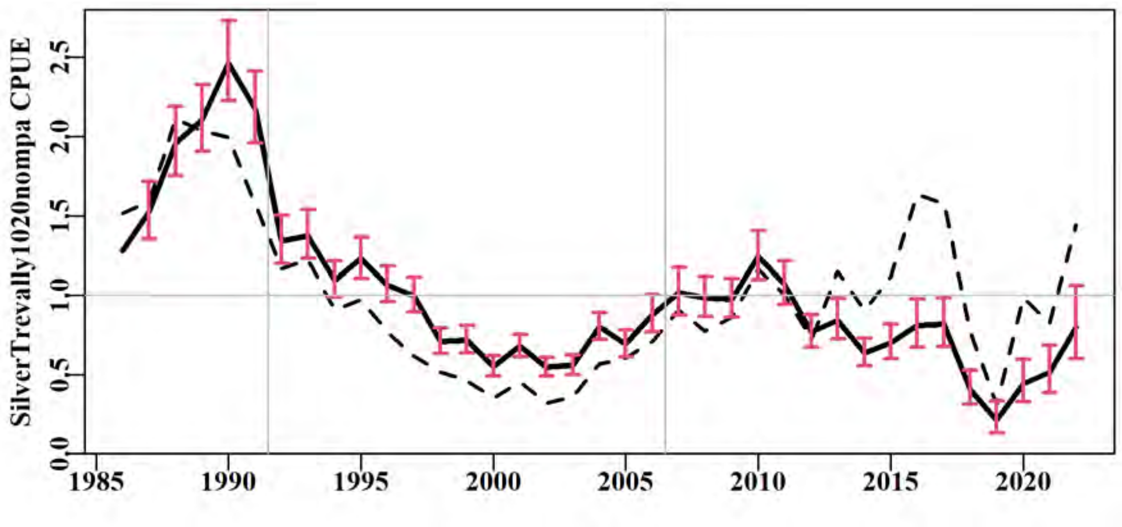

Figure 250: SilverTrevally1020nompa standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

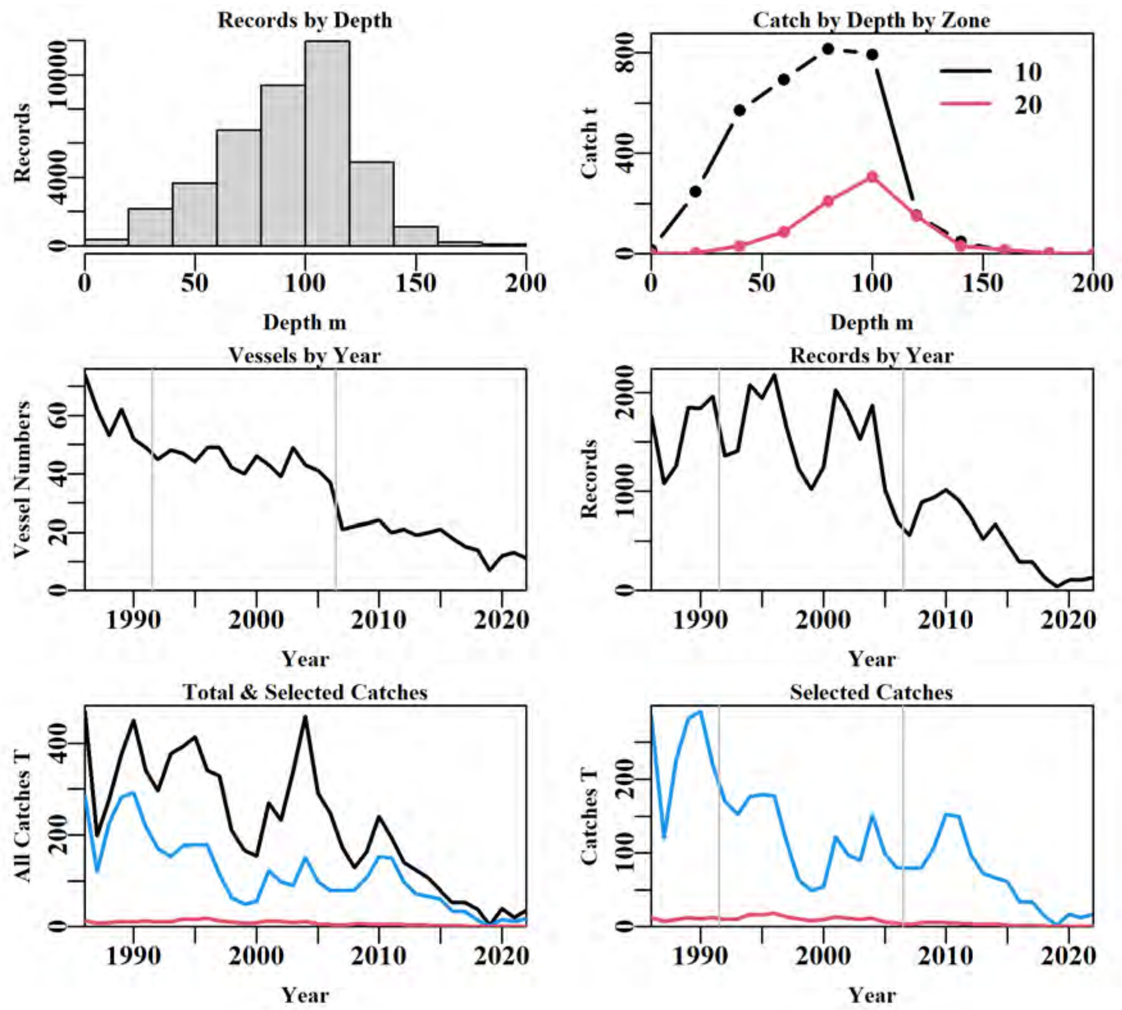

Figure 251: SilverTrevally1020nompa fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 179: SilverTrevally1020nompa data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery	NoMPA
Records	77239	74015	72386	71507	61559	60154	60098	40570
Difference	0	3224	1629	879	9948	1405	56	19528
Catch	8388	8212	7924	7758	6812	6772	6765	0
Difference	0	176	288	165	946	39	7	0

Table 180: The models used to analyse data for SilverTrevally1020nompa.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + DayNight
Model6	Year + Vessel + DepCat + Month + DayNight + Zone
Model7	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:Month
Model8	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:DepCat

Table 181: SilverTrevally1020nompa. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	40064	108715	12300	40570	37	10.1	0.00
Vessel	31228	86768	34248	40570	193	28.0	17.87
DepCat	30017	84176	36840	40570	203	30.1	2.13
Month	29282	82619	38397	40570	214	31.4	1.27
DayNight	28653	81336	39680	40570	217	32.4	1.06
Zone	28594	81214	39802	40570	218	32.5	0.10
Zone:Month	28501	80984	40031	40570	229	32.7	0.17
Zone:DepCat	28571	81132	39883	40570	227	32.6	0.05

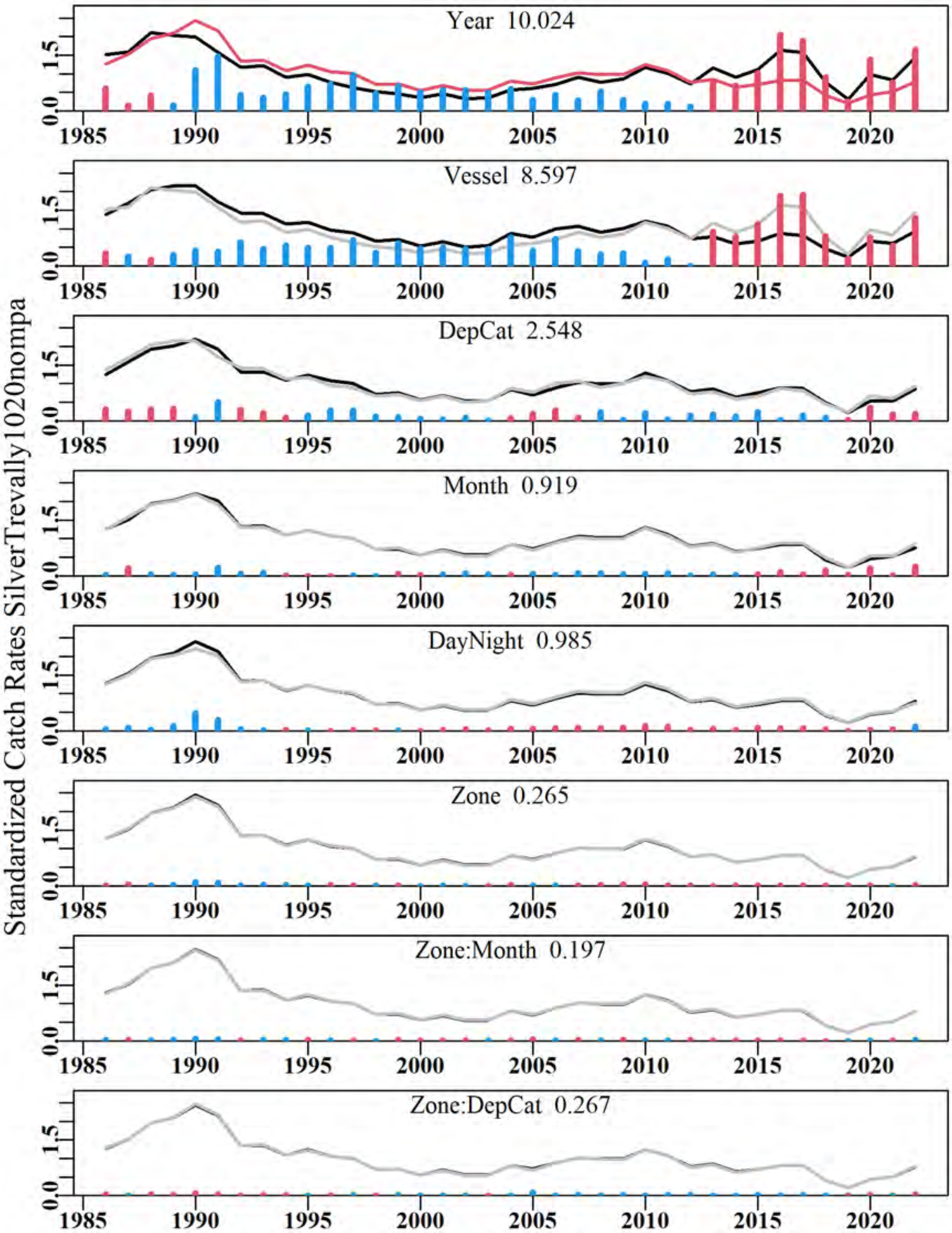

Figure 252: SilverTrevally1020nompa. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

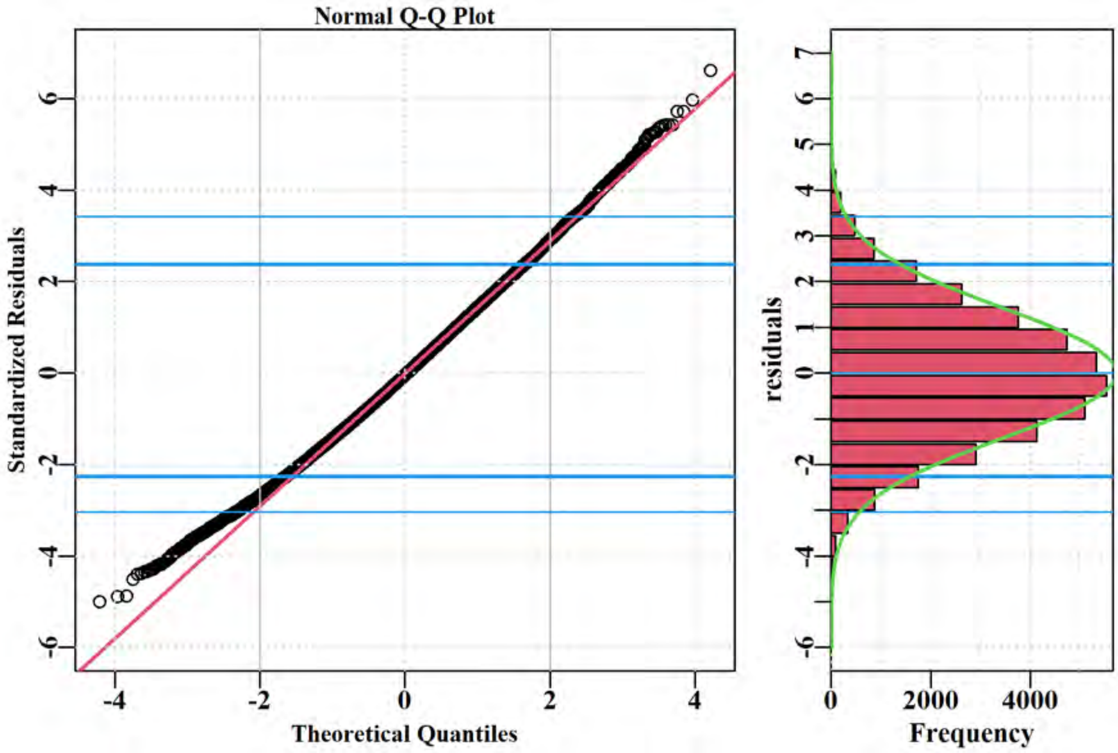

Figure 253: SilverTrevally1020nompa. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

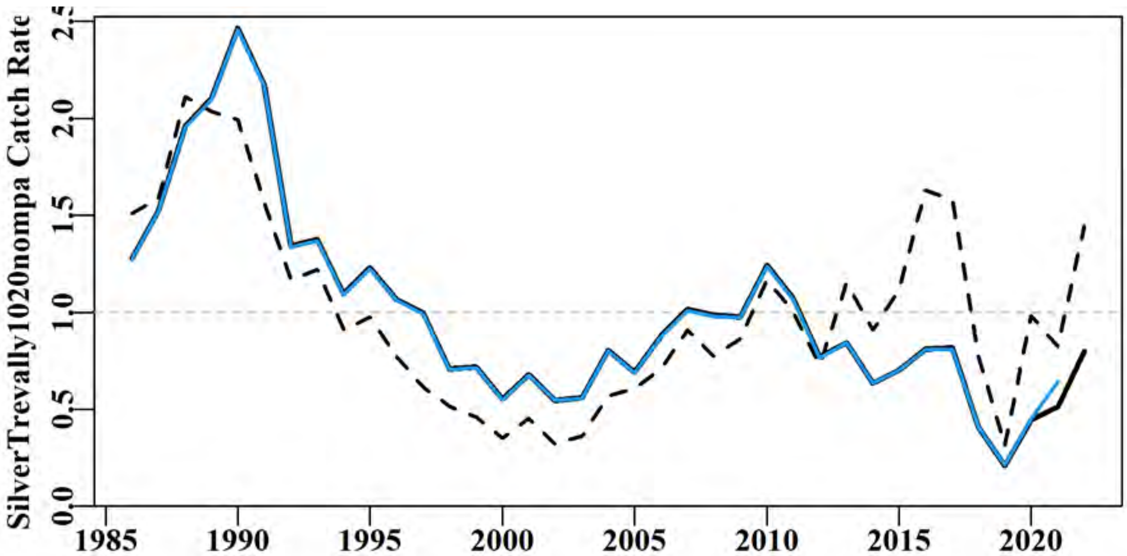

Figure 254: SilverTrevally1020nompa. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

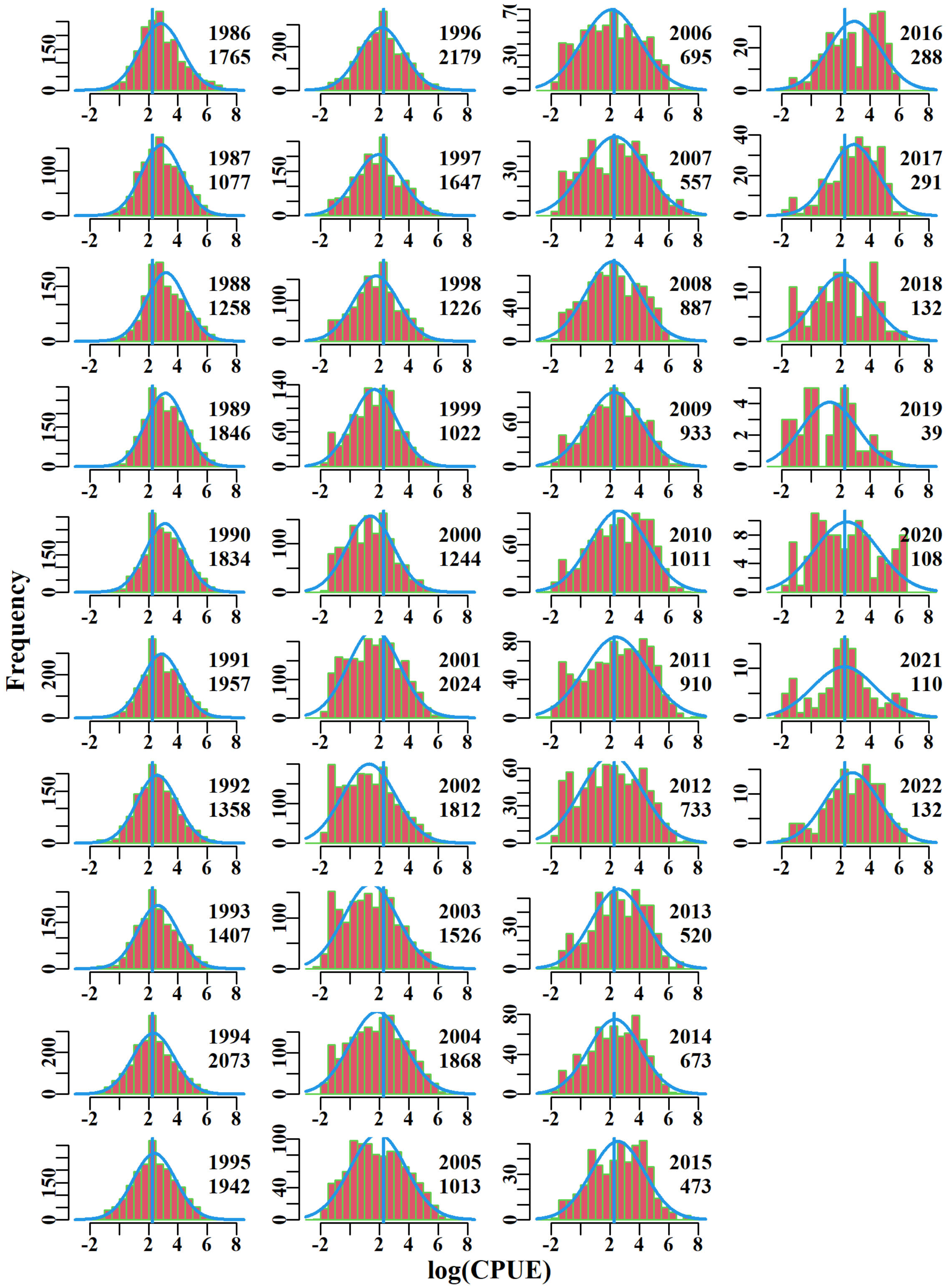

Figure 255: SilverTrevally1020nompa. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

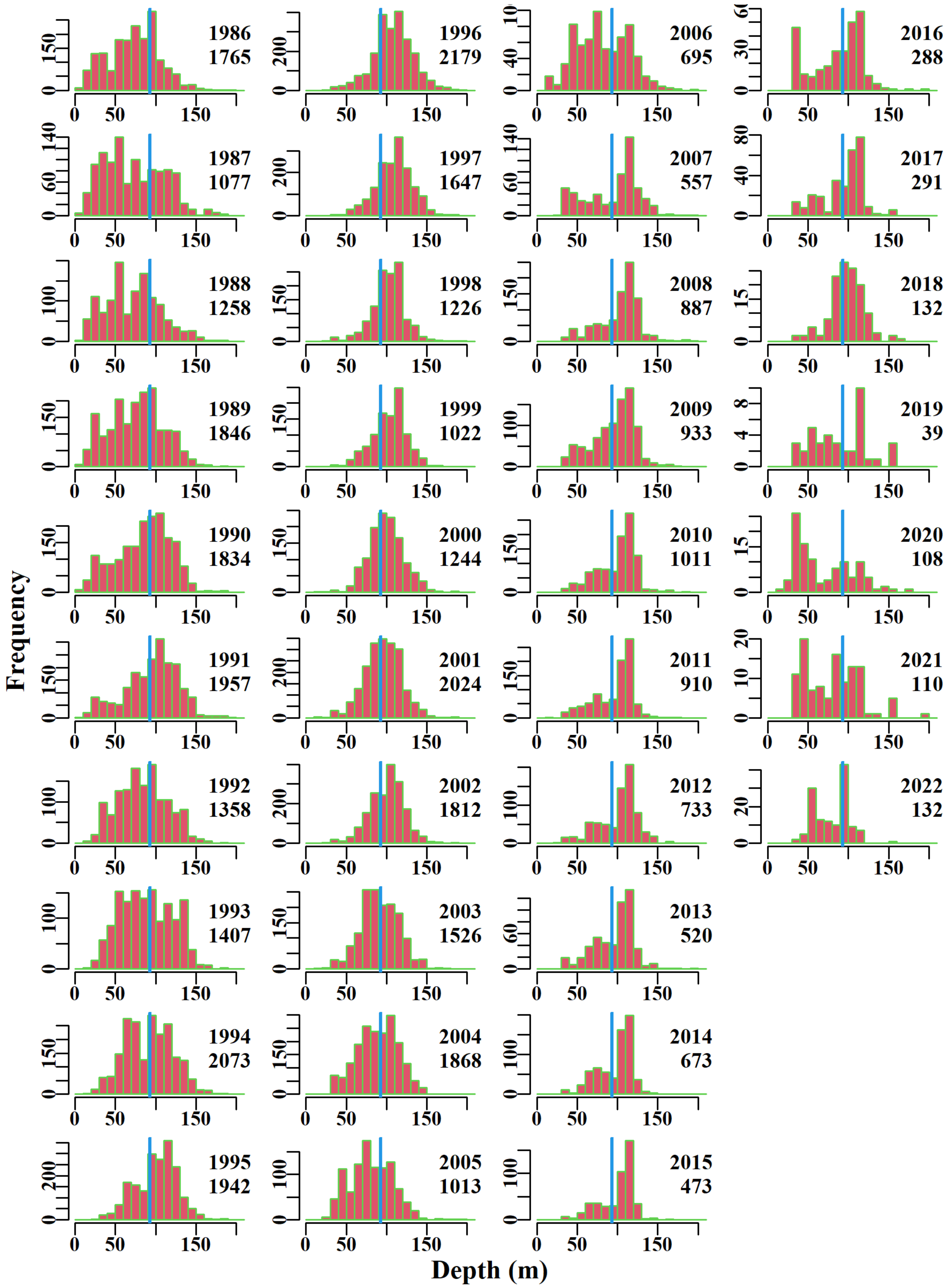

Figure 256: SilverTrevally1020nompa. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Royal Red Prawn 10

Initial data selection for Royal Red Prawn (PRR – 28714005 – *Haliporoides sibogae*) in the SET was conducted according to the details given in Table 182.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, DepCat, Vessel, Month and interaction term Month:DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 186). The qqplot suggests a departure from the assumed Normal distribution as depicted at the lower tail (<5% of records) of the distribution (Figure 260).

Annual standardized CPUE trend is noisy and relatively flat across the years analysed, except between 2017 and 2020, where the trend is increasing and above the long-term average (Figure 257). From 2013 - 2016 the standardized trend deviates from the nominal geometric mean trend such that the trend stays on the long-term average CPUE while the geometric mean appears to rise well above it. The significant drop in the 2021 standardized CPUE relative to 2020 is attributed to the relatively low and sparse catches in 2021 (3.4 t) from only two vessels. This species was not actively fished in 2021, based on the high proportion (0.44) of small catches less than 30 kg. So, the standardization has become more uncertain and dependent on fishers specific fishing activities.

There are now very few vessels contributing to this fishery and it appears that fishing is more focused at different depths in 2019 and 2020 compared with previous years. Also, fishing in 2021 and 2022 was focused on deeper waters relative to the previous two years.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020. This analysis used these modified fishing depths.

Action Items and Issues

It is recommended that alternate statistical distributions be considered. This species was not actively fished in 2021, based on the high proportion of small catches less than 30 kg. Also, the recorded catch of 3.4 t (zone 10) in 2021 was the lowest in the series. So, the standardization has become more uncertain and dependent on fishers specific fishing activities.

Table 182: RoyalRedPrawn. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	RoyalRedPrawn
csirocode	28714005
fishery	SET
depthrange	200 - 700
depthclass	40
zones	10
methods	TW, TDO, OTB
years	1986 - 2022

Table 183: RoyalRedPrawn. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Month:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	277.7	1591	231.7	47	71.7	0.6169	0.000	6.689	0.029
1987	351.3	1763	324.7	47	93.0	0.7736	0.038	4.739	0.015
1988	362.5	1392	343.3	41	124.5	0.8433	0.041	3.627	0.011
1989	329.3	1143	310.8	39	139.3	0.7198	0.043	3.462	0.011
1990	337.1	719	308.6	25	175.4	1.3622	0.050	0.615	0.002
1991	334.1	728	296.3	29	183.2	1.1995	0.051	1.447	0.005
1992	166.9	426	142.3	19	164.7	0.8991	0.059	0.728	0.005
1993	298.8	671	232.1	21	172.6	1.0697	0.050	1.377	0.006
1994	359.8	650	234.3	26	169.5	1.0081	0.050	1.308	0.006
1995	335.6	1066	252.3	25	105.3	0.8131	0.044	1.862	0.007
1996	360.8	1212	272.1	24	95.5	0.7222	0.043	1.653	0.006
1997	252.7	850	165.2	21	86.8	0.6711	0.047	1.309	0.008
1998	233.3	1228	190.0	23	67.8	0.7075	0.043	2.549	0.013
1999	367.0	1579	342.8	25	84.5	0.7308	0.041	2.569	0.007
2000	434.9	1537	398.2	26	127.1	0.9248	0.041	3.619	0.009
2001	276.8	1313	228.9	22	75.7	0.7899	0.043	3.874	0.017
2002	484.2	1735	415.8	23	131.5	0.9435	0.040	4.529	0.011
2003	230.8	796	161.8	26	114.9	0.9573	0.050	3.164	0.020
2004	193.9	569	167.4	22	206.8	0.9943	0.054	2.108	0.013
2005	173.9	587	152.8	21	149.1	0.9090	0.054	2.192	0.014
2006	192.3	453	177.3	17	295.8	1.0935	0.059	1.714	0.010
2007	121.5	323	115.7	9	249.3	0.7687	0.066	1.480	0.013
2008	75.8	252	70.6	8	220.9	0.6772	0.074	1.340	0.019
2009	68.8	248	67.3	9	159.3	0.8476	0.078	0.647	0.010
2010	96.8	343	82.8	9	138.1	0.8198	0.066	1.561	0.019
2011	110.9	288	107.9	8	207.2	1.1814	0.070	0.510	0.005
2012	126.5	359	120.5	9	167.3	0.9428	0.064	1.002	0.008
2013	212.2	416	198.1	9	280.6	1.2434	0.067	0.643	0.003
2014	121.7	348	118.3	11	178.1	0.9774	0.065	0.535	0.005
2015	126.5	345	119.8	8	219.9	1.0133	0.066	0.723	0.006
2016	145.3	323	136.9	9	273.9	1.1330	0.067	0.733	0.005
2017	137.1	308	133.2	8	270.3	1.3521	0.069	0.490	0.004
2018	164.5	304	159.4	4	356.4	1.8331	0.072	0.708	0.004
2019	146.6	244	142.2	5	374.3	2.0009	0.078	0.615	0.004
2020	98.8	136	92.7	3	433.2	2.3639	0.104	0.238	0.003
2021	8.4	156	3.4	2	10.8	0.5922	0.121	1.517	0.451
2022	10.7	53	6.3	4	100.3	0.5042	0.214	0.291	0.046

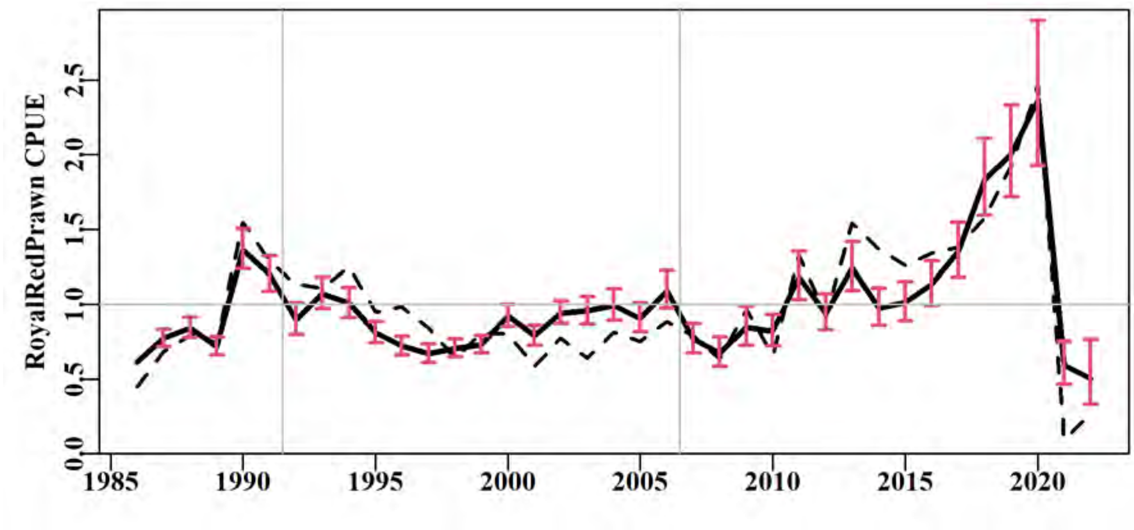

Figure 257: RoyalRedPrawn standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

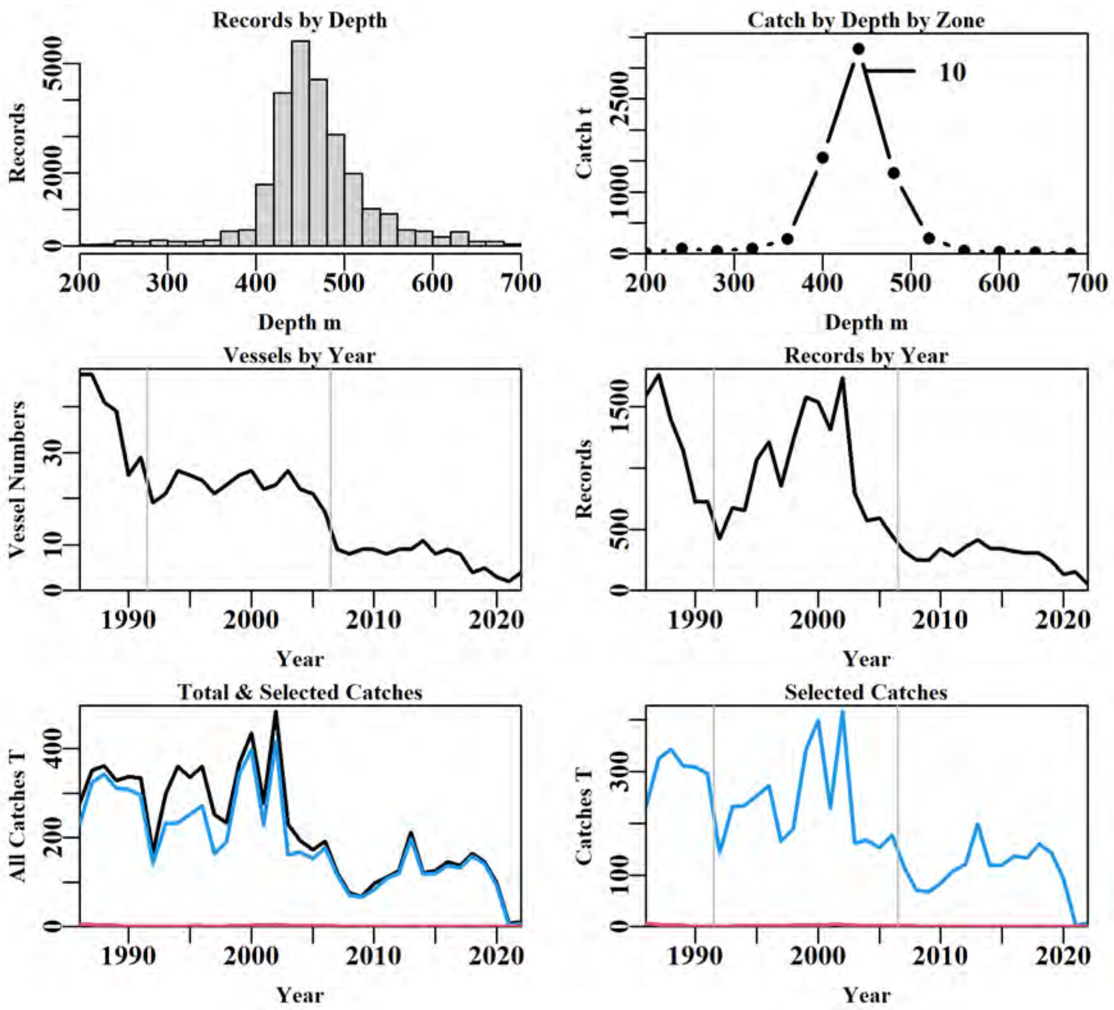

Figure 258: RoyalRedPrawn fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 184: RoyalRedPrawn data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	42889	35344	34822	34355	26579	26454	26454
Difference	0	7545	522	467	7776	125	0
Catch	8183	8090	7985	7928	7062	7024	7024
Difference	0	93	105	57	866	38	0

Table 185: The models used to analyse data for RoyalRedPrawn.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + Month
Model5	Year + DepCat + Vessel + Month + DayNight
Model6	Year + DepCat + Vessel + Month + DayNight + DayNight:DepCat
Model7	Year + DepCat + Vessel + Month + DayNight + Month:DepCat
Model8	Year + DepCat + Vessel + Month + DayNight + DayNight:Month

Table 186: RoyalRedPrawn. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Month:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	15296	47031	3505	26454	37	6.8	0.00
DepCat	10756	39578	10958	26454	49	21.5	14.73
Vessel	4313	30817	19719	26454	137	38.7	17.16
Month	2526	28780	21756	26454	148	42.7	4.03
DayNight	2318	28549	21987	26454	151	43.2	0.45
DayNight:DepCat	2197	28348	22188	26454	184	43.5	0.33
Month:DepCat	1862	27786	22750	26454	281	44.4	1.24
DayNight:Month	2317	28478	22058	26454	183	43.3	0.07

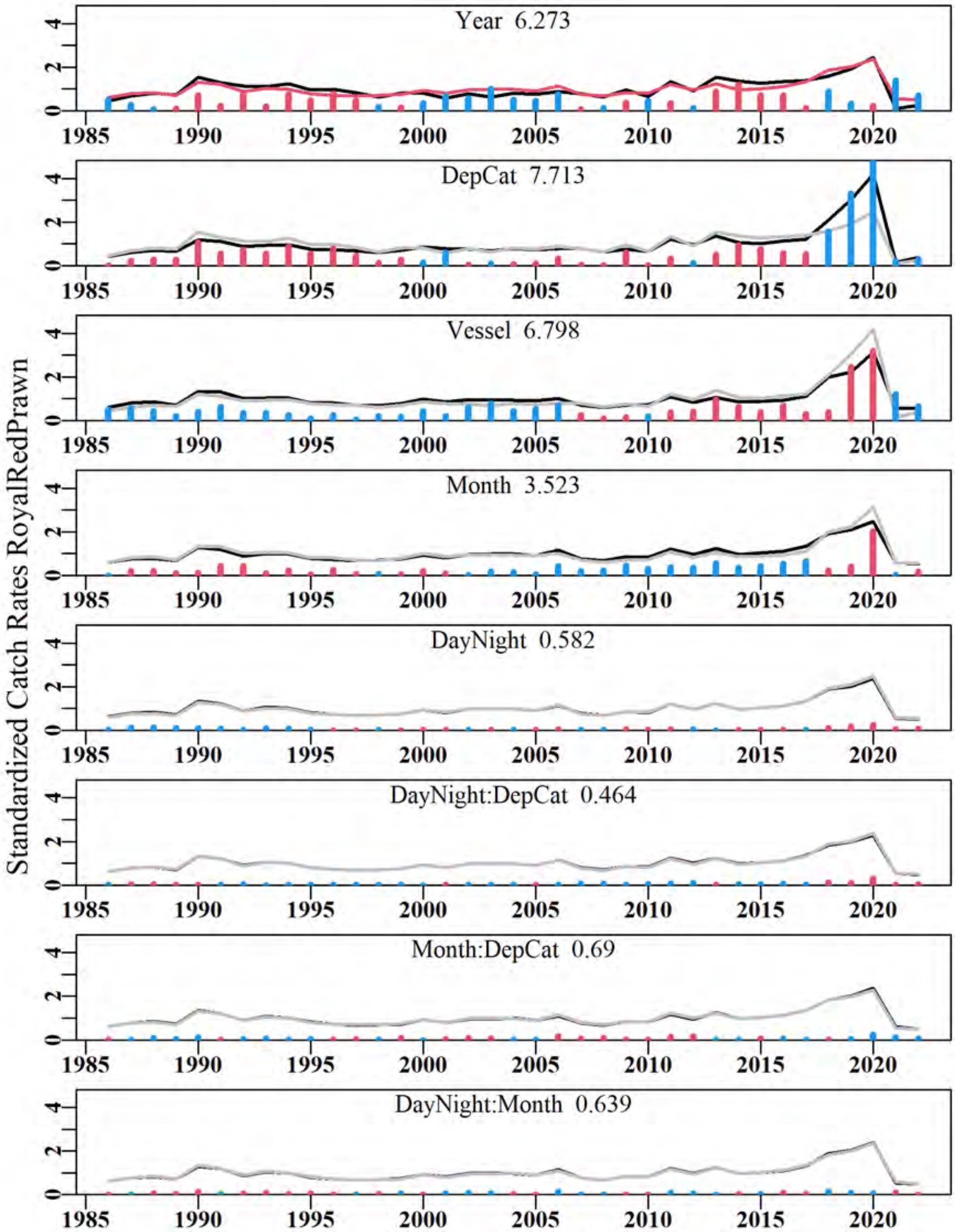

Figure 259: RoyalRedPrawn. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

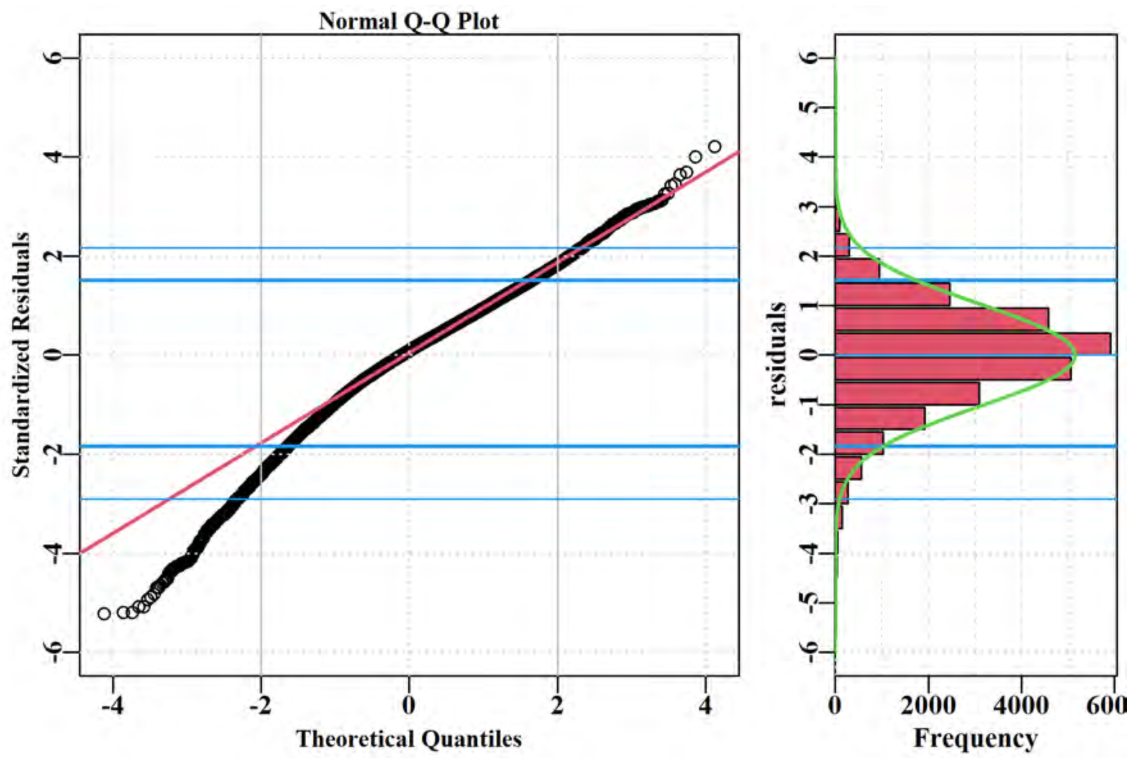

Figure 260: RoyalRedPrawn. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

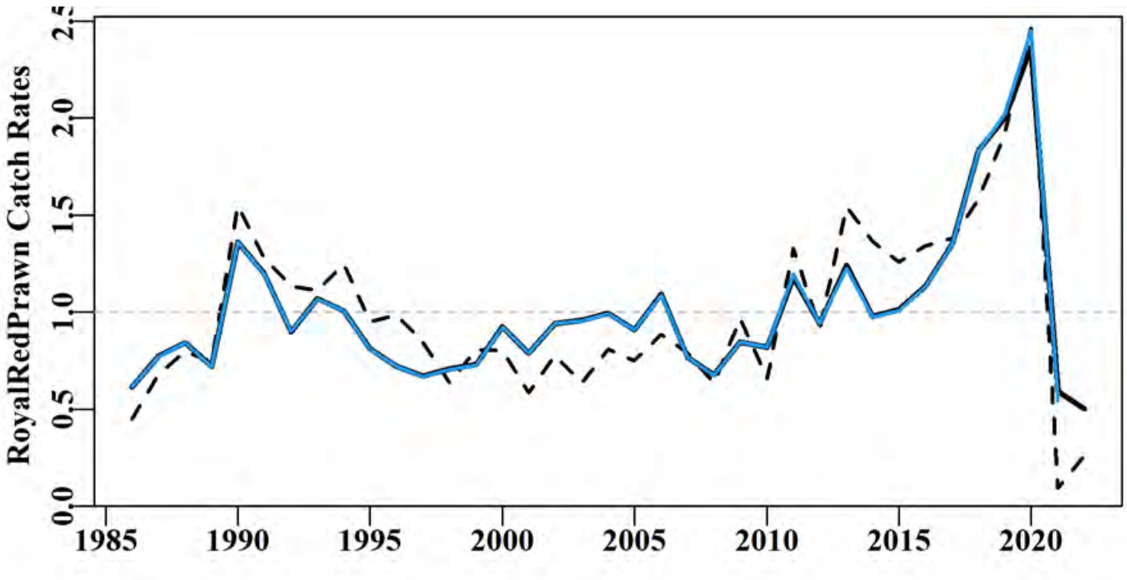

Figure 261: RoyalRedPrawn. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

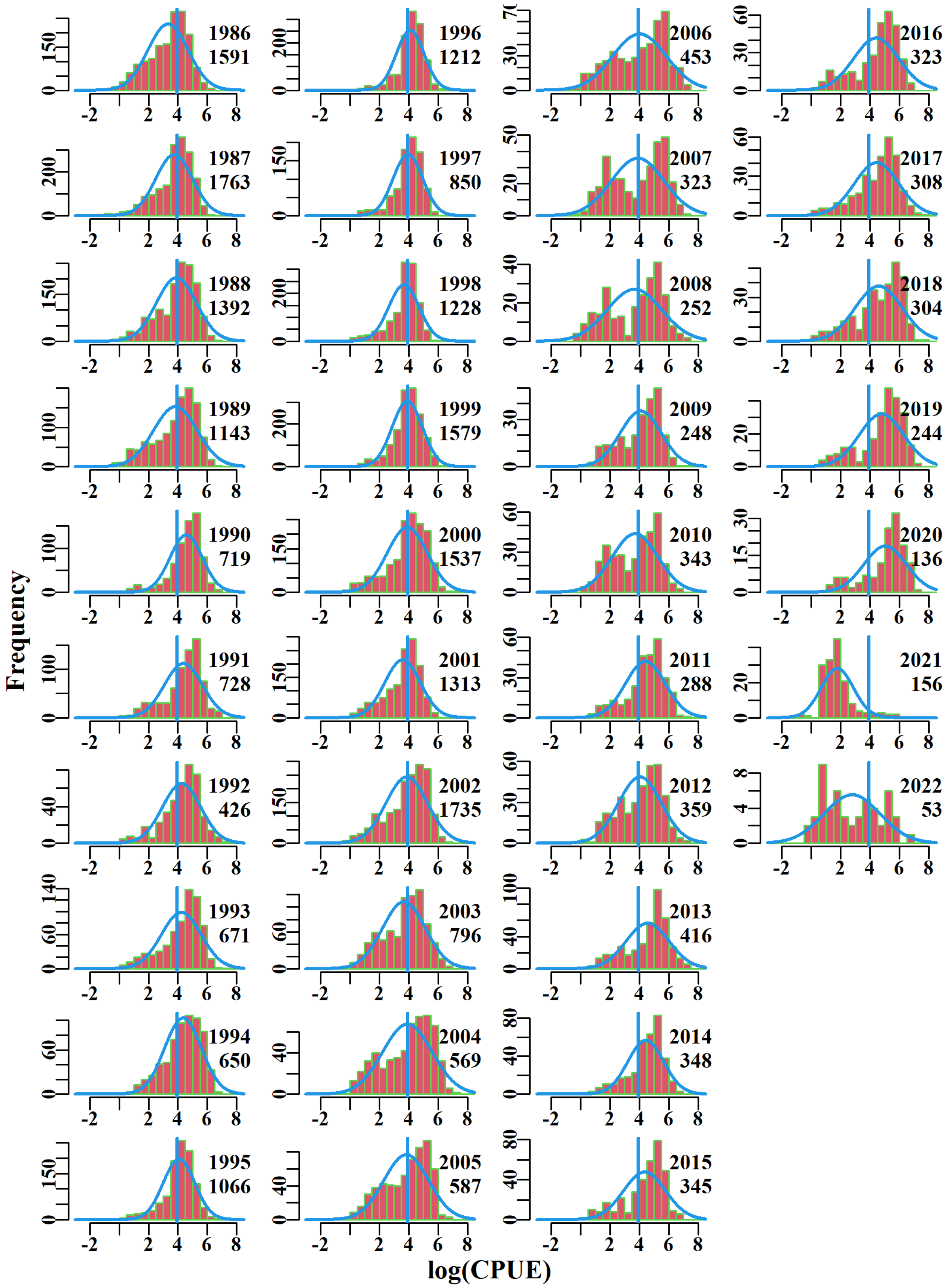

Figure 262: RoyalRedPrawn. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

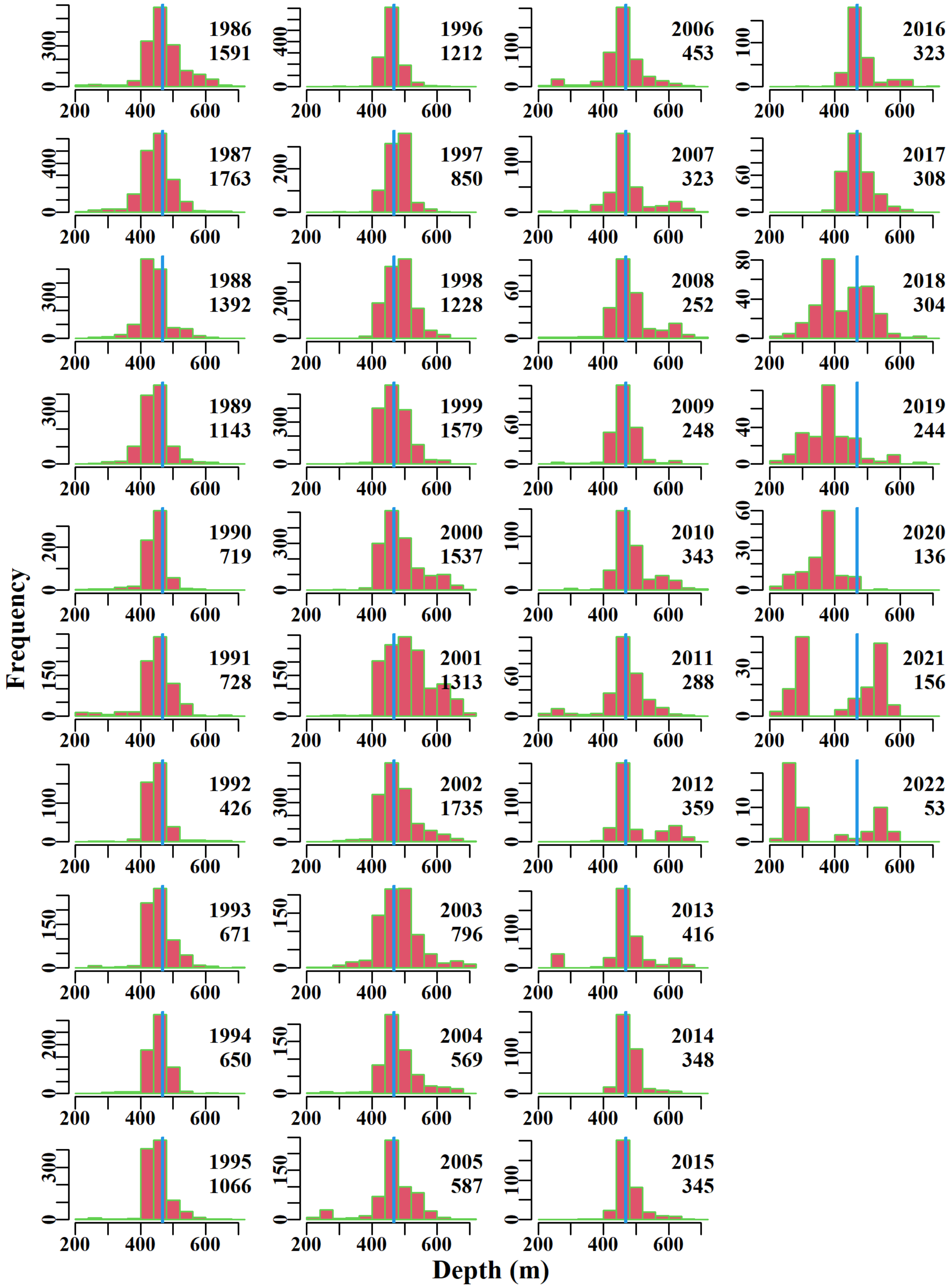

Figure 263: RoyalRedPrawn. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Eastern Gemfish NonSpawning

For non-spawning eastern Gemfish (GEM – 37439002 – *Rexea solandri*) in the SET, initial data selection was conducted according to the details given in Table 187.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 10, followed by 20 and 30.

The terms Year, Vessel and DepCat had the greatest contribution to model fit, with the remaining terms each explaining up to 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 191). The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted at the lower tail of the distribution (Figure 267).

Following a large spike in standardized CPUE in the late 1980s, which coincided with a large spike in catches, the annual standardized CPUE trend dropped rapidly despite large reductions in catches and, since 1995 has been relatively flat and below average although with what appears to be a 14 - 15 year cycle of rise and fall (Figure 264). The 2021 estimate significantly increased relative to the previous year and there was no discernible difference between the last two years. It has been reported that there have been efforts to actively avoid eastern Gemfish for the last few years and this may have been reflected in the change apparent in the depth of fishing. If these reports are correct, this means that the most recent CPUE, from about 2013, will not be representative of the state of the stock.

Action Items and Issues

No issues identified.

Table 187: EasternGemfishNonSp. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	EasternGemfishNonSp
csirocode	37439002
fishery	SET
depthrange	0 - 600
depthclass	40
zones	10, 20, 30, 40
methods	TW, TDO, OTB, OTM, OTT
years	1986 - 2022

Table 188: EasternGemfishNonSp. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	647.9	2028	389.4	85	50.9	2.8752	0.000	13.705	0.035
1987	1027.6	1882	761.6	74	121.6	3.9926	0.043	9.656	0.013
1988	744.5	2187	497.2	77	64.7	3.2950	0.043	13.954	0.028
1989	306.7	1427	143.5	69	29.5	2.1505	0.048	13.936	0.097
1990	251.0	745	87.3	68	35.6	2.1347	0.058	5.730	0.066
1991	367.6	719	63.3	71	23.6	1.4100	0.059	7.059	0.111
1992	243.5	682	134.6	50	41.0	1.9962	0.060	4.859	0.036
1993	183.3	1521	93.7	58	20.2	1.5801	0.048	14.627	0.156
1994	148.2	1820	63.1	55	12.9	1.0971	0.046	18.222	0.289
1995	137.7	1683	49.9	54	11.5	0.9838	0.047	18.718	0.375
1996	223.7	1938	55.5	61	9.8	0.7679	0.046	18.655	0.336
1997	265.6	1775	65.3	58	9.5	0.7990	0.049	18.355	0.281
1998	238.8	1241	45.5	49	9.9	0.7550	0.051	12.901	0.283
1999	318.2	1342	30.3	53	7.2	0.5537	0.051	12.684	0.419
2000	248.6	1713	32.2	58	6.2	0.4909	0.048	15.019	0.466
2001	239.3	1636	32.1	50	4.7	0.3925	0.049	12.320	0.384
2002	146.9	1612	19.0	50	3.0	0.3048	0.049	10.864	0.571
2003	205.5	1574	20.0	48	3.7	0.3290	0.050	10.222	0.512
2004	454.9	1759	38.4	54	6.9	0.4637	0.049	12.383	0.322
2005	436.3	1711	40.4	48	7.3	0.5011	0.049	12.613	0.312
2006	425.6	1316	32.0	43	7.1	0.5325	0.052	10.140	0.317
2007	495.6	779	28.0	22	10.2	0.7011	0.059	5.844	0.209
2008	203.9	828	34.7	26	14.6	0.9384	0.058	6.769	0.195
2009	146.9	501	25.3	27	24.6	0.9732	0.069	3.767	0.149
2010	150.5	680	21.9	23	10.0	0.6994	0.062	5.334	0.244
2011	101.2	776	21.8	22	8.4	0.6245	0.060	5.621	0.258
2012	130.2	697	21.7	23	9.4	0.6157	0.062	4.916	0.227
2013	80.4	585	23.2	23	14.8	0.7046	0.066	4.098	0.177
2014	104.5	516	9.6	23	6.0	0.4303	0.068	3.437	0.356
2015	68.7	619	16.1	24	10.4	0.4617	0.064	3.447	0.214
2016	52.8	412	7.4	23	6.4	0.2994	0.073	2.664	0.358
2017	102.5	557	19.1	21	15.9	0.3348	0.067	3.287	0.173
2018	56.8	516	15.7	20	14.3	0.4375	0.069	3.059	0.195
2019	121.0	745	26.7	20	14.6	0.4494	0.063	4.685	0.175
2020	87.1	510	24.0	17	13.5	0.4934	0.070	2.967	0.124
2021	89.3	469	26.1	18	19.9	0.7067	0.072	2.662	0.102
2022	97.3	295	17.9	15	24.7	0.7248	0.086	1.442	0.080

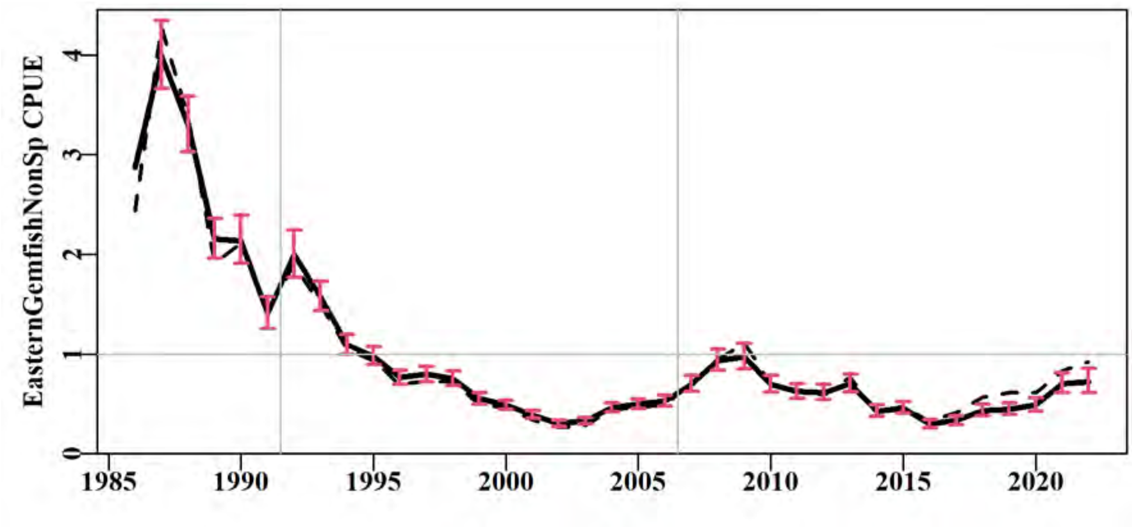

Figure 264: EasternGemfishNonSp standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

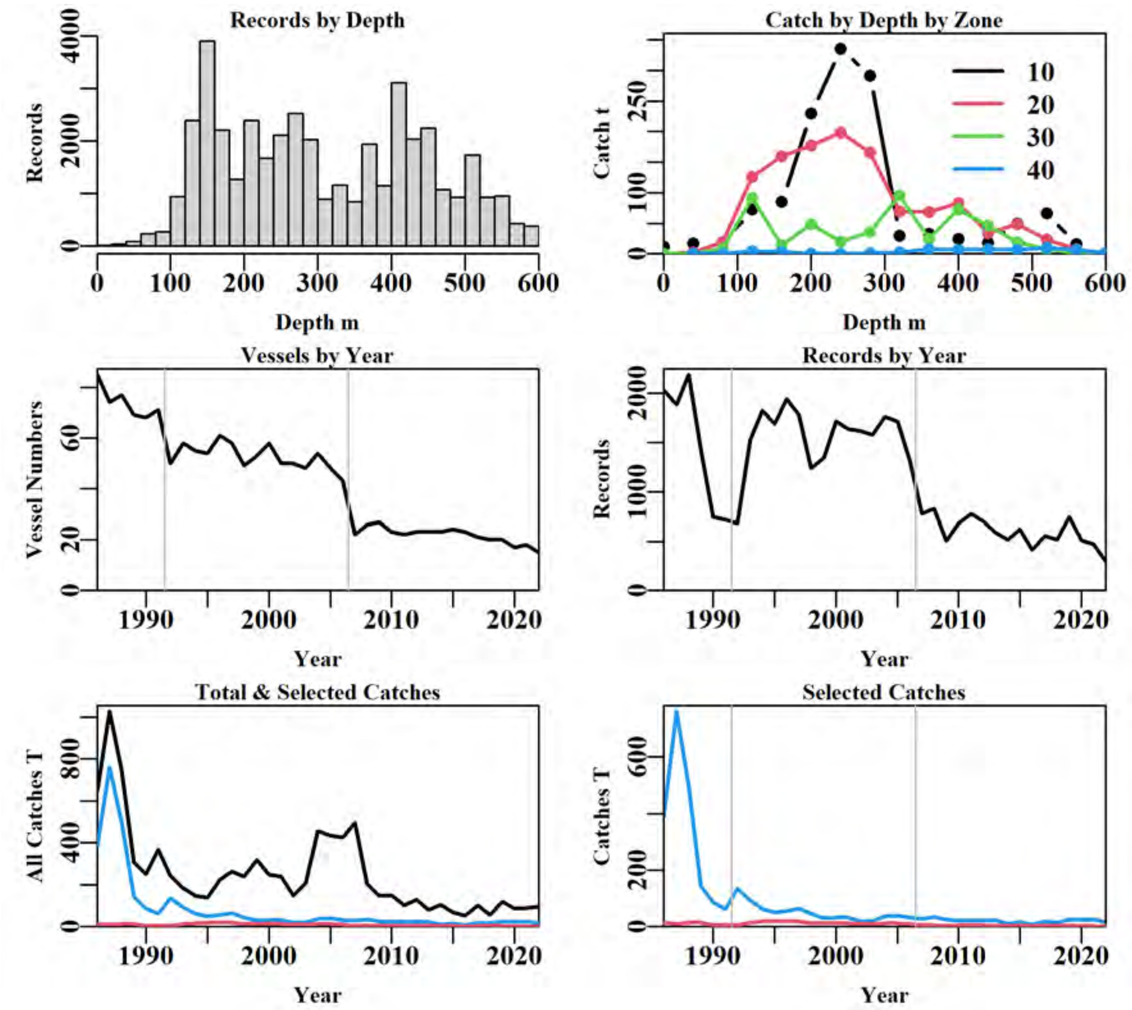

Figure 265: EasternGemfishNonSp fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 189: EasternGemfishNonSp data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	100030	87646	85556	83643	43254	41856	41796
Difference	0	12384	2090	1913	40389	1398	60
Catch	9634	9368	9159	8888	3129	3045	3034
Difference	0	266	209	271	5758	84	12

Table 190: The models used to analyse data for EasternGemfishNonSp.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + DayNight
Model6	Year + Vessel + DepCat + Month + DayNight + Zone
Model7	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:DepCat
Model8	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:Month

Table 191: EasternGemfishNonSp. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	28450	82411	23929	41796	37	22.4	0.00
Vessel	21603	69322	37018	41796	228	34.5	12.02
DepCat	19865	66451	39889	41796	243	37.1	2.69
Month	19334	65578	40762	41796	254	38.0	0.81
DayNight	18965	64991	41349	41796	257	38.5	0.55
Zone	18512	64282	42058	41796	260	39.2	0.67
Zone:DepCat	17811	63080	43260	41796	304	40.2	1.07
Zone:Month	18173	63661	42679	41796	293	39.7	0.54

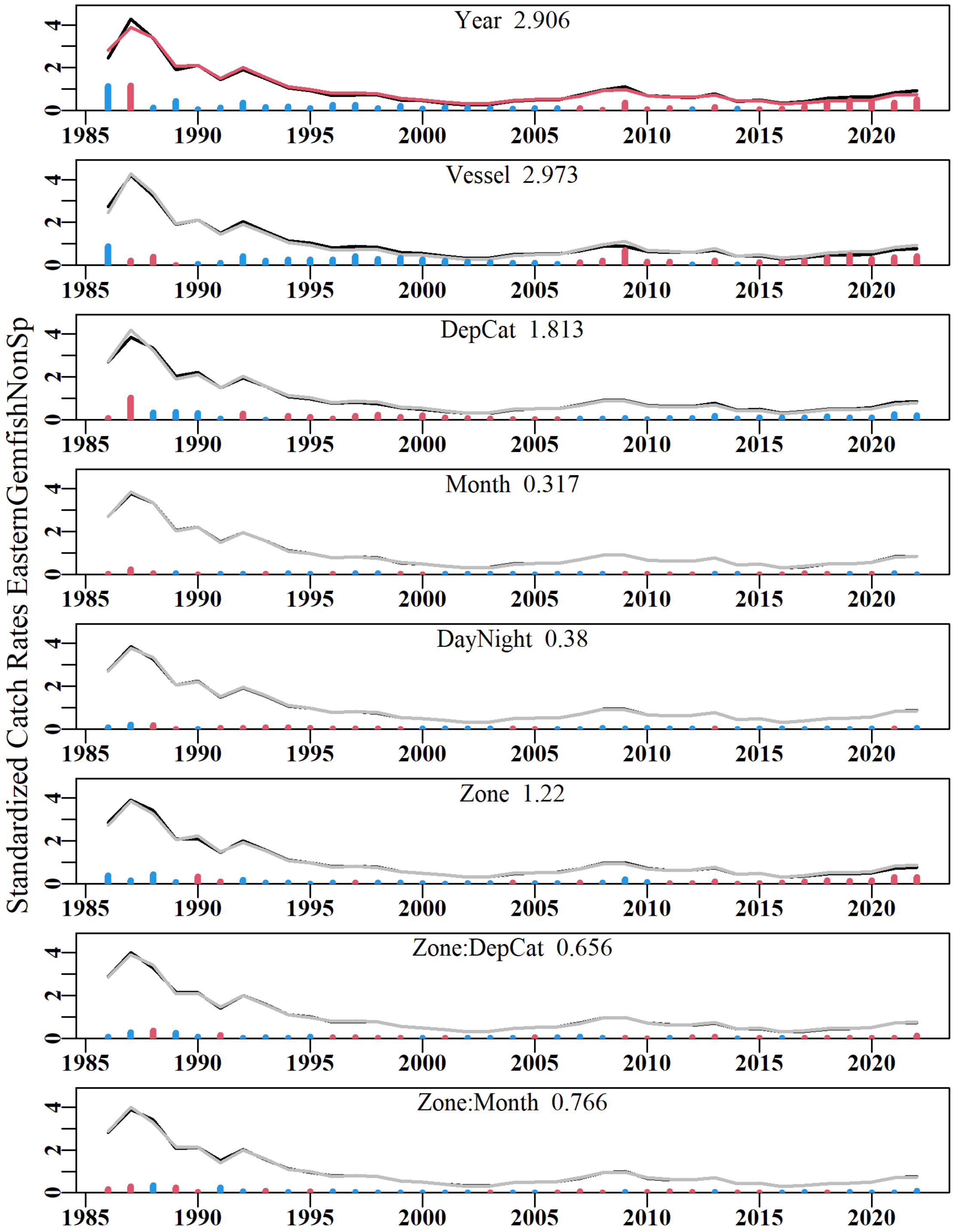

Figure 266: EasternGemfishNonSp. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

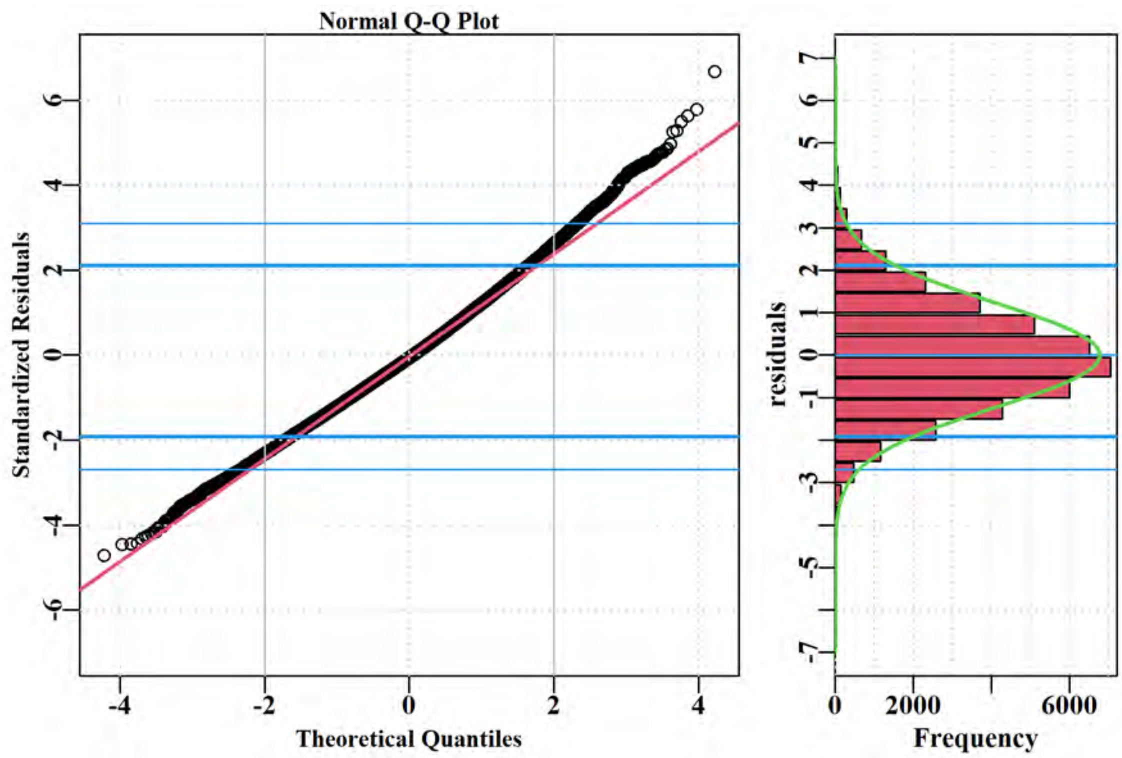

Figure 267: EasternGemfishNonSp. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

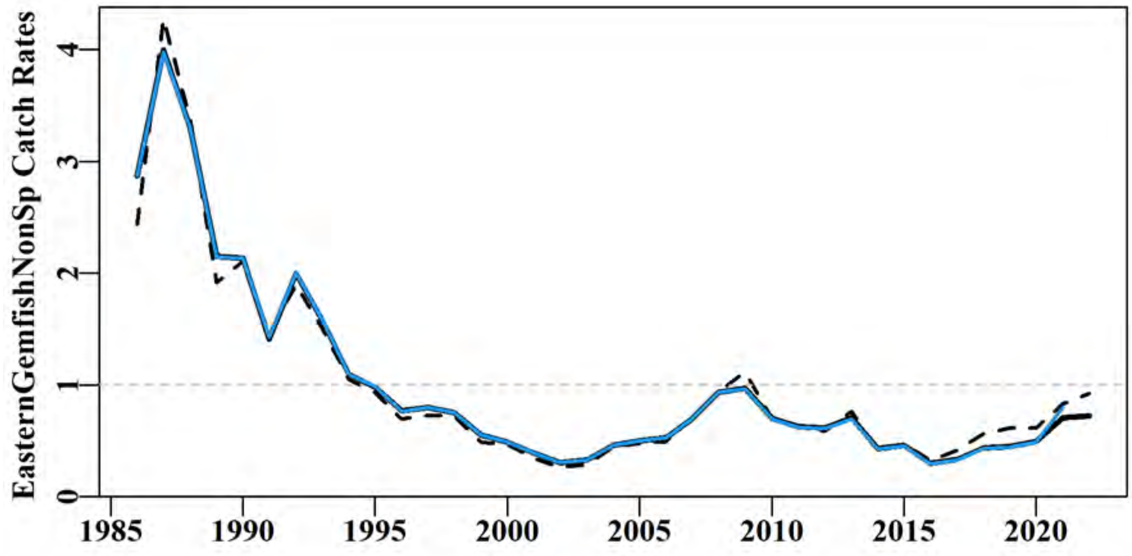

Figure 268: EasternGemfishNonSp. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

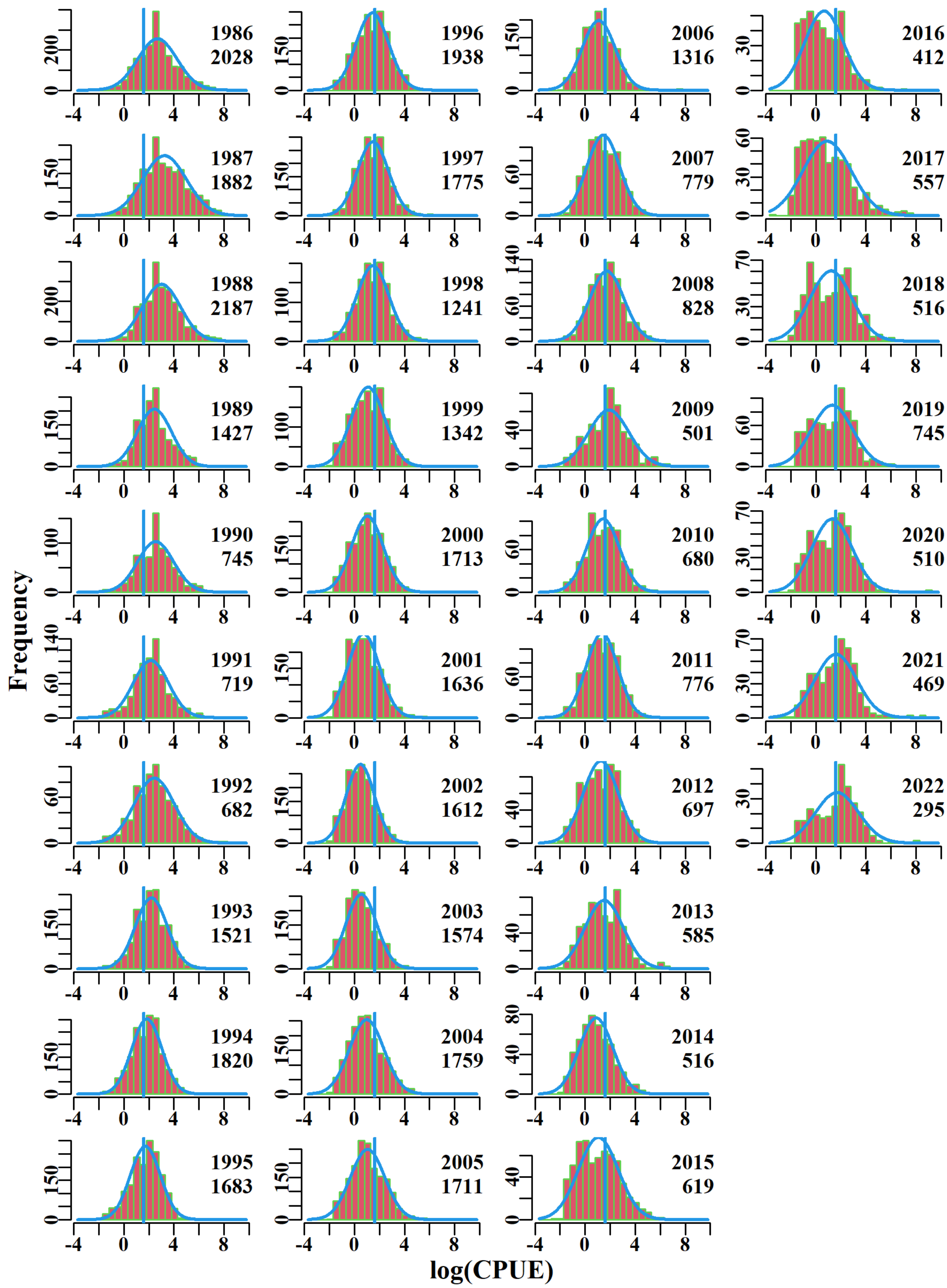

Figure 269: EasternGemfishNonSp. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

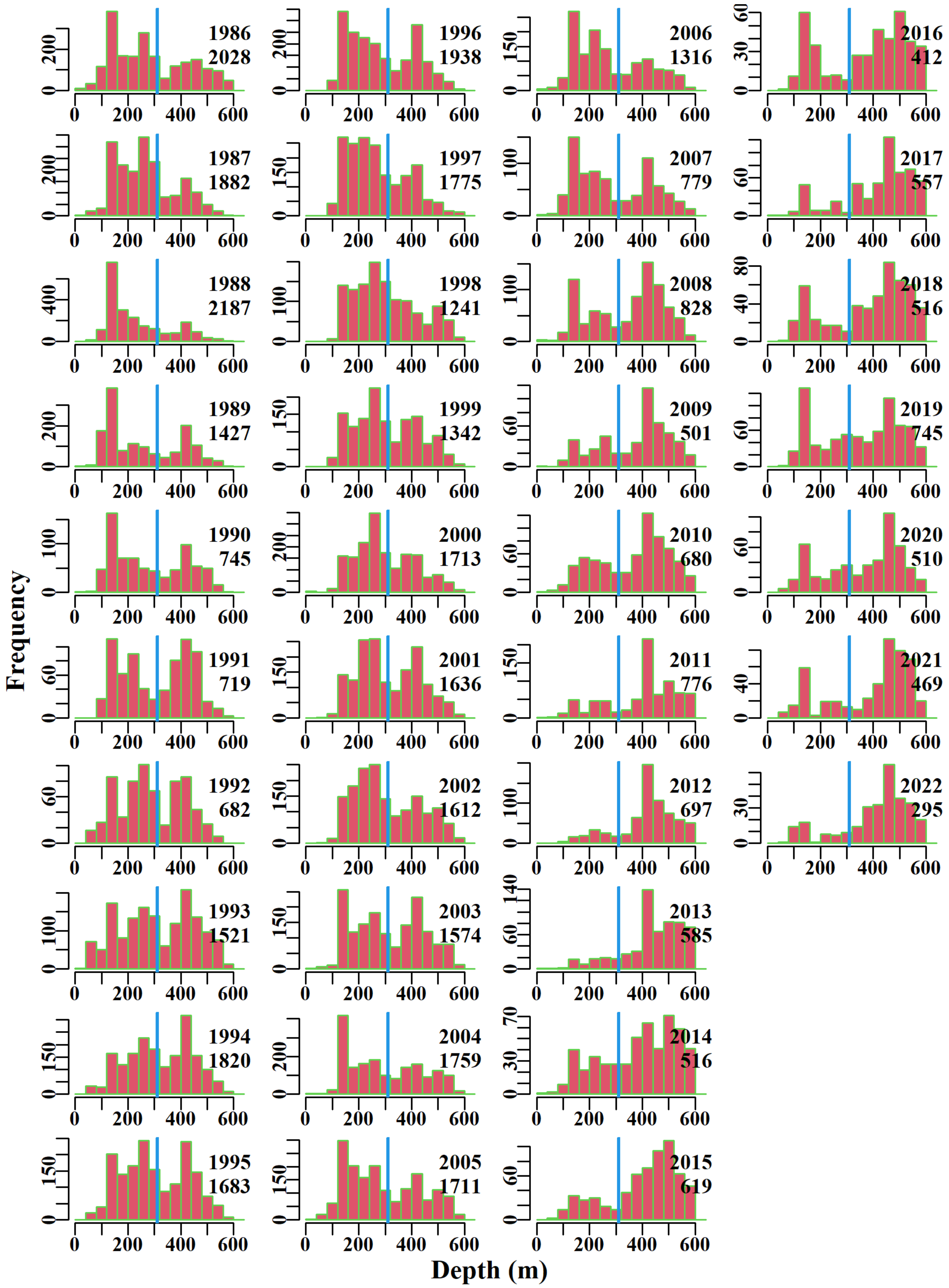

Figure 270: EasternGemfishNonSp. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Eastern Gemfish Spawning

Initial data selection for the eastern Gemfish spawning run fishery (GEM – 37439002 - *Rexea solandri*) in the SET was conducted according to the details given in Table 192. In addition, specific Eastern Gemfish survey vessels and trips are removed from the data to be analysed as not being typical of standard fishing in recent years.

A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The majority of catch of this species occurred in zone 10, followed by 20 and minimal catches in the remaining zones. Even though survey vessel data were removed there were still increased catches in 1996, 1997 and 1998, but catches have been less than 42 t since 2000. The catch of 4.2 t in 2022 was the lowest in the series.

The terms Year, Vessel, Month, DepCat, Month and interaction term Zone:Month had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 196). The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted at the upper tail of the distribution (Figure 274).

Annual standardized CPUE trend has declined since 2010 and remained below average since 2011, with the last two years either below or above average, based on 95% confidence intervals (Figure 271). This reflects what appears to be a longer term cycle of CPUE values, which suggests that CPUE values would soon be expected to rise, which occurred in 2019, 2020 and 2021. However, the relatively low catches since the past eight years indicate that industry avoidance strategies are effective, and this means the recent CPUE may not provide an unbiased representation of relative stock status.

Action Items and Issues

No issues identified.

Table 192: EasternGemfishSp. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	EasternGemfishSp
csirocode	37439002
fishery	SET
depthrange	300 - 500
depthclass	20
zones	10, 20, 30, 40
methods	TW, TDO, OTB, OTM, OTT
years	1993 - 2022

Table 193: EasternGemfishSp. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1993	205.9	819	132.9	50	40.2	2.4310	0.000	5.357	0.040
1994	97.2	814	48.6	47	22.1	1.5963	0.063	7.120	0.146
1995	57.2	657	21.9	48	12.1	1.0659	0.066	7.390	0.338
1996	197.6	768	135.1	49	35.3	1.3389	0.064	6.914	0.051
1997	342.5	1225	268.0	47	62.6	2.0122	0.059	7.393	0.028
1998	188.9	879	144.6	46	40.5	1.3397	0.063	7.610	0.053
1999	168.5	1064	87.9	45	21.7	1.0935	0.062	10.350	0.118
2000	103.4	1176	37.0	44	9.9	0.7263	0.062	11.959	0.323
2001	102.6	853	32.7	47	11.7	0.7296	0.066	8.229	0.252
2002	54.1	922	22.4	42	7.3	0.5301	0.065	8.882	0.396
2003	75.0	959	31.5	48	10.7	0.7415	0.064	8.516	0.270
2004	220.2	625	19.7	44	9.8	0.7100	0.071	5.296	0.269
2005	143.2	635	21.4	40	10.2	0.6407	0.070	5.958	0.278
2006	228.1	567	34.6	35	18.3	1.0009	0.072	4.245	0.123
2007	132.8	305	25.3	19	25.0	1.2212	0.087	1.730	0.068
2008	65.1	441	34.9	23	23.1	1.4900	0.080	3.376	0.097
2009	63.1	404	35.2	22	26.5	1.3984	0.081	3.176	0.090
2010	77.8	378	41.0	24	31.1	1.4575	0.082	2.484	0.061
2011	47.1	408	26.7	21	17.2	1.0597	0.080	3.392	0.127
2012	41.8	379	28.0	21	18.3	0.6855	0.083	3.279	0.117
2013	33.9	290	16.0	20	18.2	0.8662	0.089	2.873	0.179
2014	30.8	368	11.2	19	8.7	0.6172	0.083	3.000	0.267
2015	18.8	320	7.8	20	8.0	0.4779	0.087	2.591	0.333
2016	18.8	304	5.4	21	5.2	0.3500	0.088	2.395	0.440
2017	16.0	212	5.2	18	7.9	0.4301	0.100	1.551	0.298
2018	14.0	208	6.9	17	9.9	0.4064	0.101	1.695	0.246
2019	31.9	303	14.5	18	15.6	0.7321	0.091	2.386	0.165
2020	35.9	288	12.5	15	14.2	0.7052	0.093	2.118	0.170
2021	25.9	281	14.7	16	18.0	1.0303	0.093	1.905	0.130
2022	15.7	124	4.2	10	13.3	1.1158	0.129	0.803	0.191

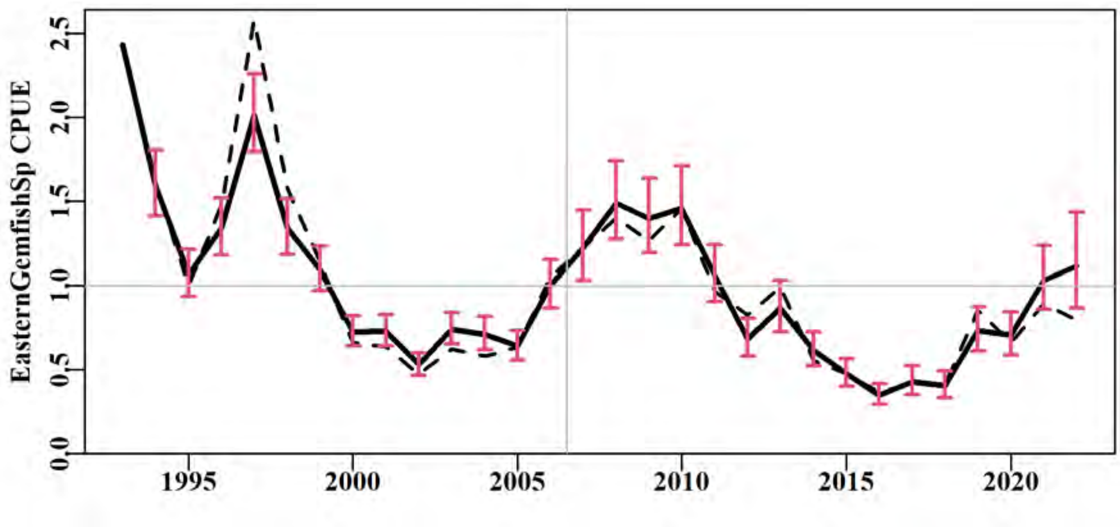

Figure 271: EasternGemfishSp standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

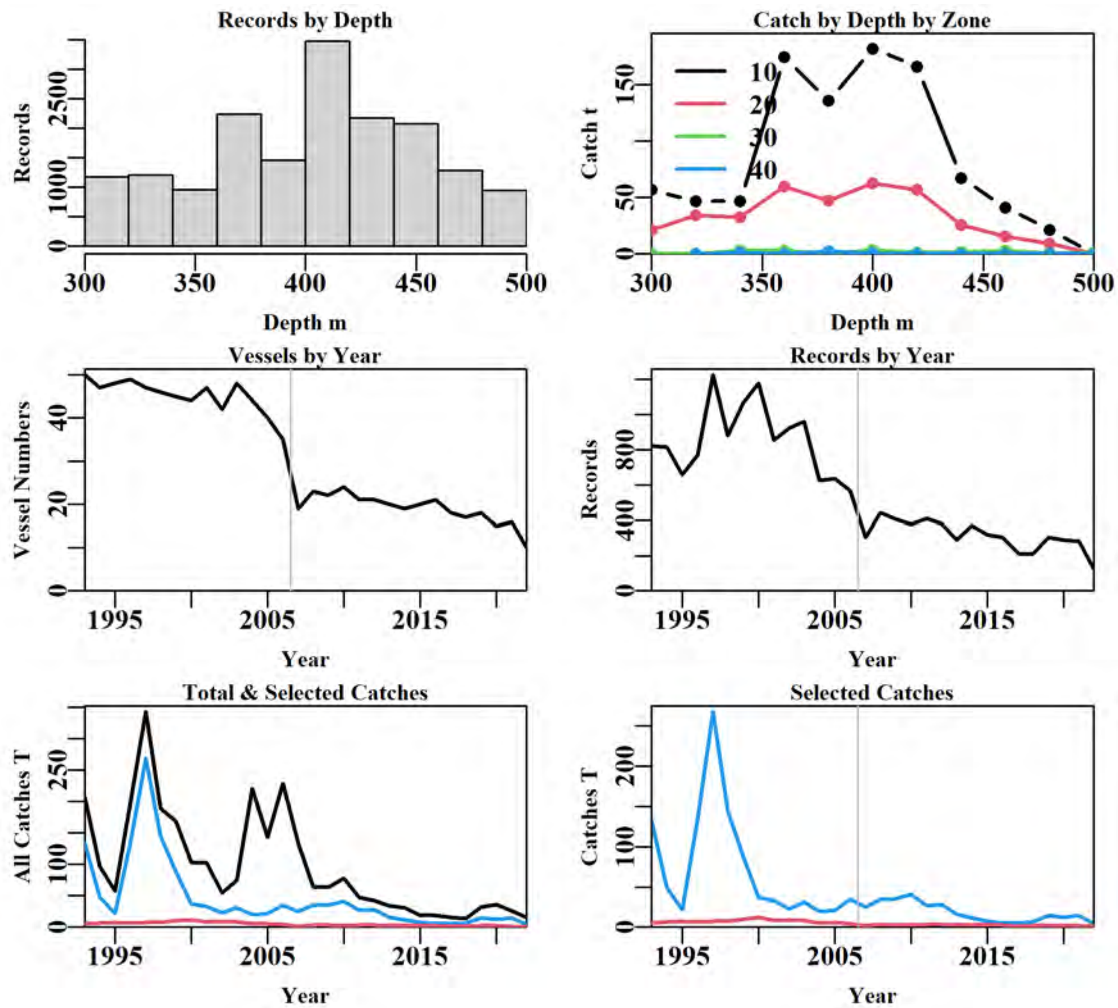

Figure 272: EasternGemfishSp fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 194: EasternGemfishSp data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	53509	47432	33113	22311	17158	16976	16976
Difference	0	6077	14319	10802	5153	182	0
Catch	16434	16180	14164	2112	1353	1328	1328
Difference	0	255	2016	12052	760	25	0

Table 195: The models used to analyse data for EasternGemfishSp.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + Month
Model4	Year + Vessel + Month + DepCat
Model5	Year + Vessel + Month + DepCat + DayNight
Model6	Year + Vessel + Month + DepCat + DayNight + Zone
Model7	Year + Vessel + Month + DepCat + DayNight + Zone + Zone:Month
Model8	Year + Vessel + Month + DepCat + DayNight + Zone + Zone:DepCat

Table 196: EasternGemfishSp. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	9946	30391	4782	16976	30	13.4	0.00
Vessel	8149	26993	8180	16976	138	22.6	9.18
Month	7287	25648	9525	16976	141	26.5	3.84
DepCat	6924	25076	10097	16976	151	28.1	1.60
DayNight	6814	24904	10269	16976	154	28.6	0.48
Zone	6793	24865	10308	16976	157	28.7	0.10
Zone:Month	6565	24507	10666	16976	166	29.6	0.99
Zone:DepCat	6769	24745	10427	16976	186	28.9	0.22

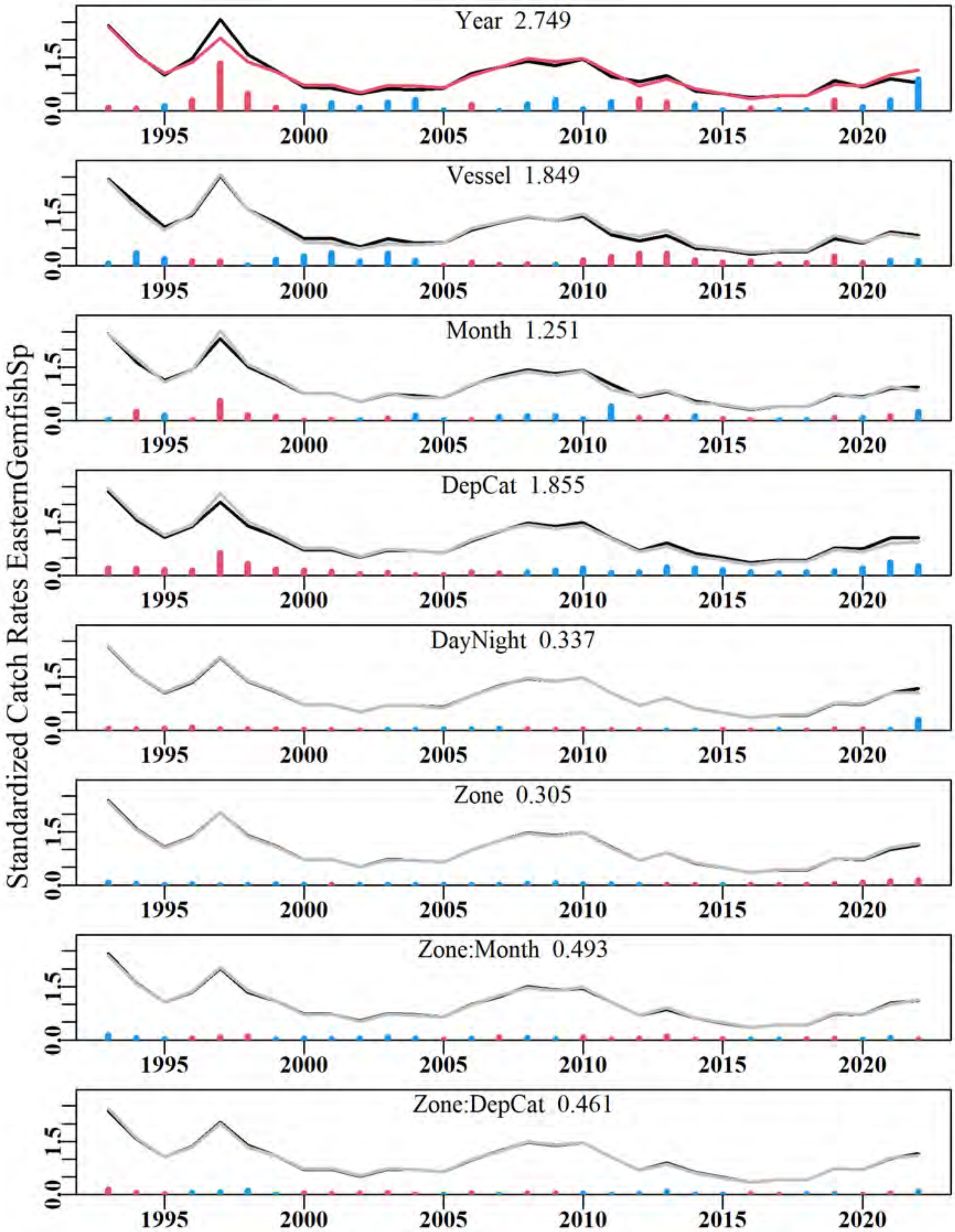

Figure 273: EasternGemfishSp. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

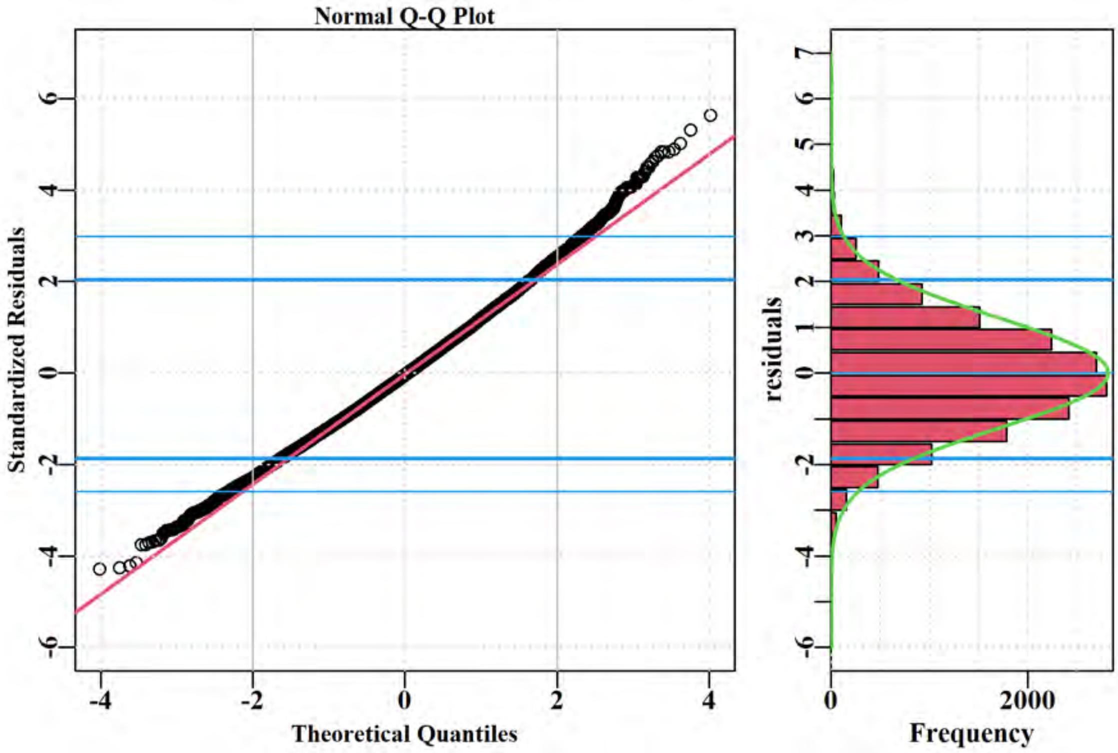

Figure 274: EasternGemfishSp. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

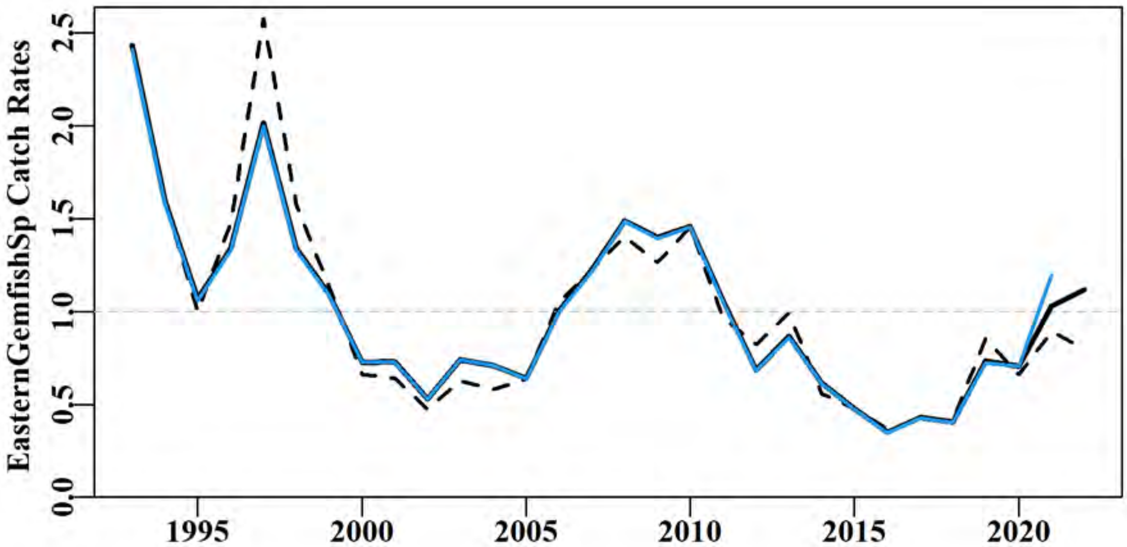

Figure 275: EasternGemfishSp. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

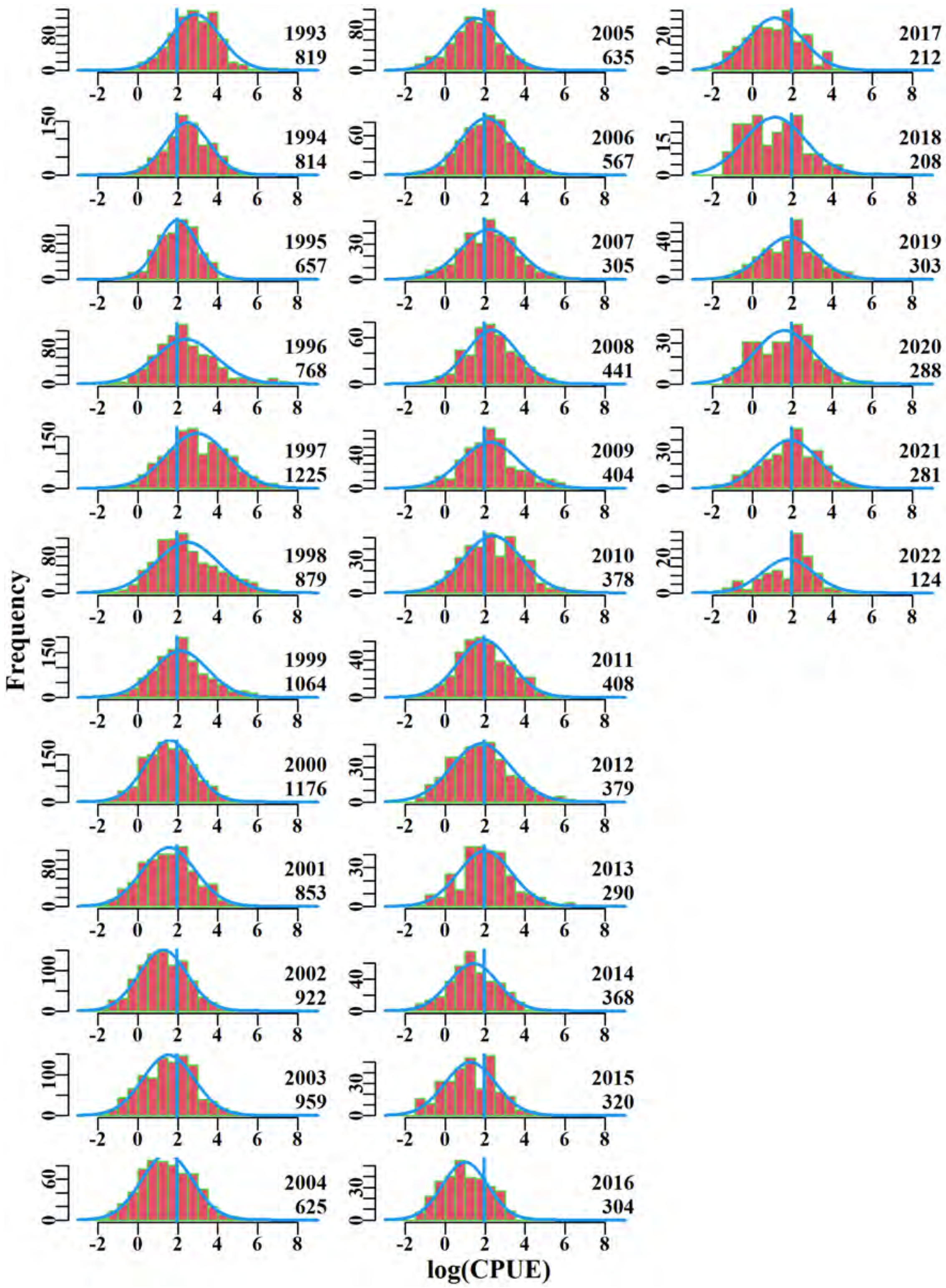

Figure 276: EasternGemfishSp. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

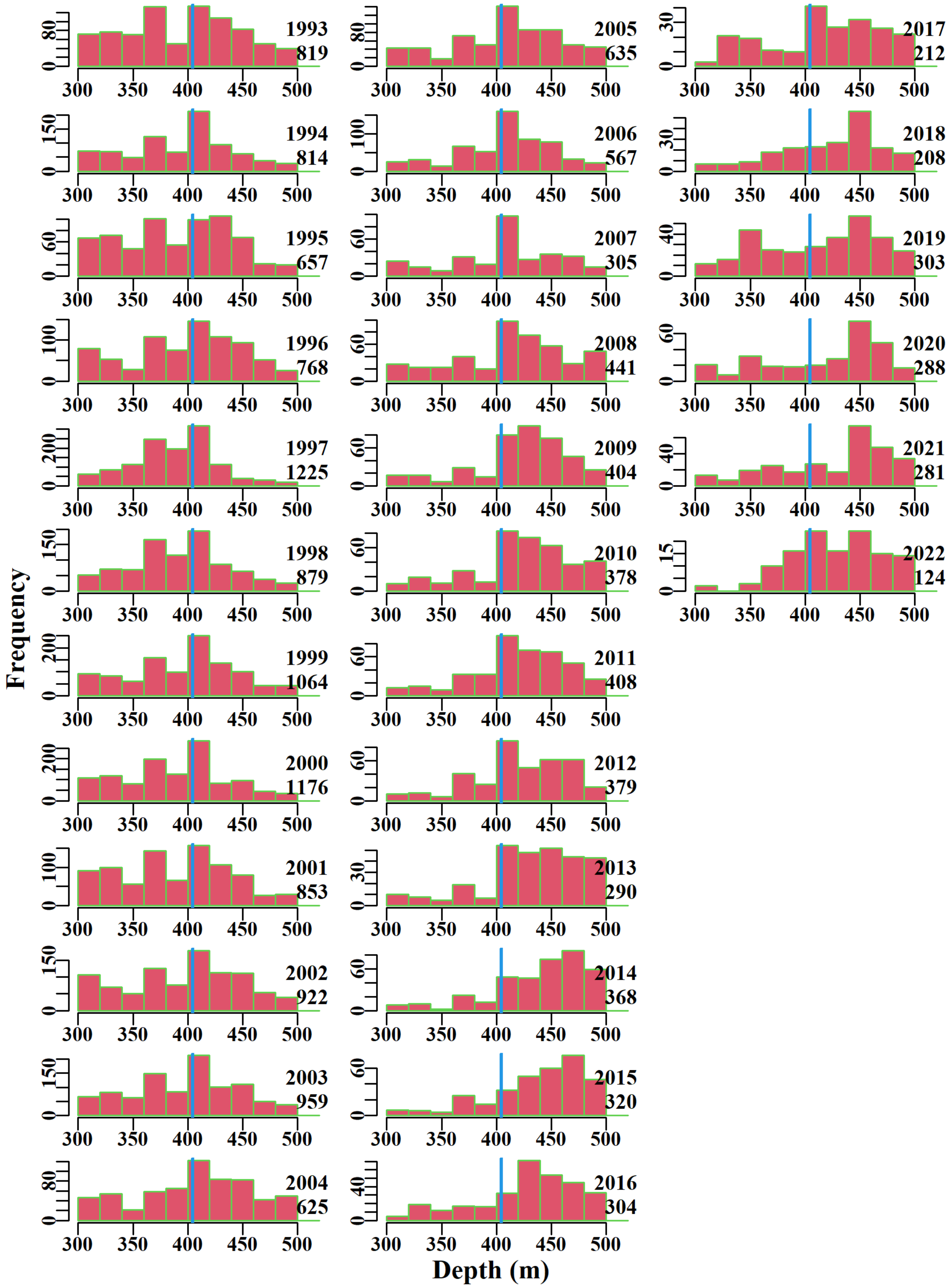

Figure 277: EasternGemfishSp. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Alfonsino

Initial data selection for Alfonsino (ALF - 37258002 - *Beryx splendens*) in the SET was conducted according to the details given in Table 197.

A total of 7 statistical models were fitted sequentially to the available data.

Inferences

The terms Year, Vessel, Zone, DepCat and interaction term Zone:DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot indicates that less than 5% of records, those in the lower tail of the distribution, deviate from the Normality assumption.

Annual standardized CPUE trend is noisy and relatively flat across the years analysed (Figure 278).

Action Items and Issues

There have been up to 4 t of Alfonsino caught annually in the last three years and it appears that fishing is in more focused depths. With small annual catches, the standardization can be expected to become more uncertain and dependent on their specific fishing activities.

Table 197: Alfonsino. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	Alfonsino
csirocode	37258002
fishery	SET
depthrange	0 - 1000
depthclass	50
zones	10, 20, 30, 40, 50, 60, 70, 80, 81, 82, 83, 84, 85, 91, 92
methods	TW, TDO, OTB, OTM
years	1986 - 2022

Table 198: Alfonsino. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:DepCat.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1988	0.5	8	0.5	2	52.7	1.6406	0.000	0.138	0.257
1989	2.6	11	2.3	5	62.0	2.0804	0.656	0.120	0.052
1990	3.6	31	3.6	12	33.7	1.9939	0.596	0.352	0.097
1991	5.7	68	5.3	22	30.6	0.7508	0.568	0.962	0.182
1992	18.7	72	17.8	18	95.4	1.5599	0.532	0.565	0.032
1993	5.2	68	5.0	15	25.3	1.4673	0.551	0.826	0.164
1994	15.6	100	7.8	22	40.3	2.0609	0.550	1.137	0.146
1995	8.6	72	7.4	16	36.4	1.1159	0.561	0.834	0.113
1996	12.4	63	12.0	14	51.5	1.6123	0.565	0.727	0.061
1997	11.8	65	7.5	16	24.6	1.0965	0.568	0.805	0.107
1998	6.8	62	3.4	11	22.9	2.1227	0.574	0.501	0.146
1999	55.0	163	8.3	20	22.1	1.6376	0.552	1.971	0.238
2000	504.6	177	35.3	21	88.3	1.4715	0.555	2.463	0.070
2001	337.9	144	5.6	24	17.3	0.8368	0.556	1.948	0.350
2002	2643.0	222	24.9	31	153.3	1.0988	0.552	1.786	0.072
2003	1819.6	126	6.0	24	18.0	0.8646	0.556	1.589	0.264
2004	1411.3	172	16.1	27	19.7	1.0256	0.554	1.448	0.090
2005	445.2	161	7.9	24	23.6	0.9487	0.552	1.366	0.174
2006	458.4	223	11.0	22	29.8	1.1619	0.549	1.893	0.172
2007	530.2	205	8.5	13	15.4	1.2513	0.551	1.774	0.209
2008	260.2	359	48.2	13	37.6	1.2616	0.545	3.158	0.065
2009	98.8	336	15.3	14	24.2	0.9087	0.546	3.030	0.197
2010	57.9	261	8.8	16	10.1	0.5432	0.549	1.798	0.204
2011	807.2	229	4.3	15	4.6	0.4597	0.549	1.712	0.401
2012	616.1	131	1.9	14	4.3	0.3566	0.555	0.826	0.436
2013	225.6	95	3.7	14	8.5	0.3214	0.560	0.793	0.214
2014	85.0	100	5.9	12	85.4	0.4645	0.558	0.703	0.120
2015	76.2	178	13.5	13	120.1	0.4130	0.551	0.731	0.054
2016	23.3	96	3.2	10	18.9	0.2228	0.560	0.321	0.100
2017	8.2	136	6.1	12	27.8	0.3004	0.555	0.740	0.122
2018	8.4	151	5.3	12	21.2	0.3738	0.554	0.843	0.160
2019	34.5	160	7.7	15	10.7	0.3632	0.552	0.853	0.110
2020	5.3	113	3.2	14	6.5	0.3672	0.558	0.812	0.253
2021	5.9	114	3.2	13	16.4	0.4592	0.557	0.886	0.273
2022	5.9	65	4.0	12	11.1	0.3866	0.569	0.519	0.130

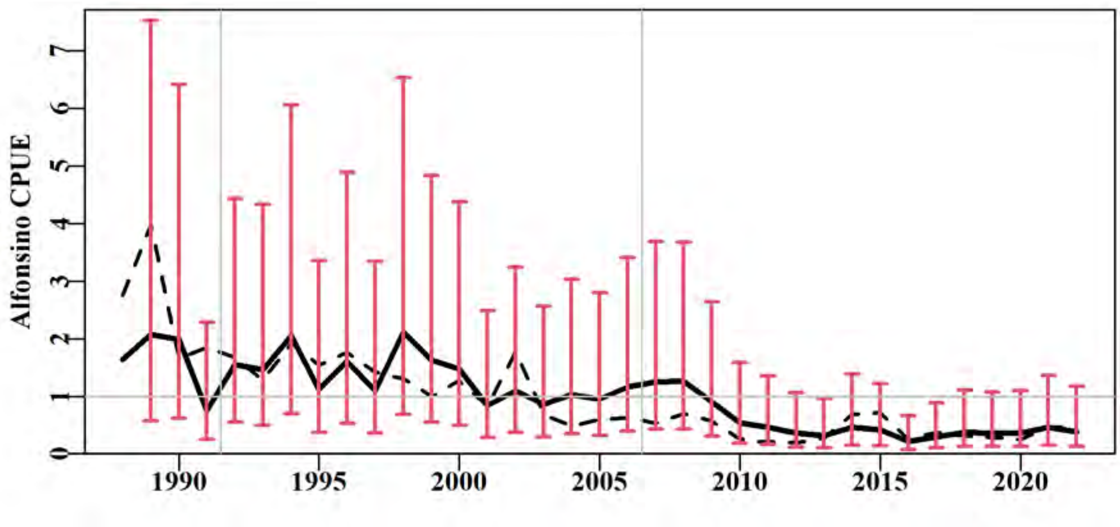

Figure 278: Alfonsino standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

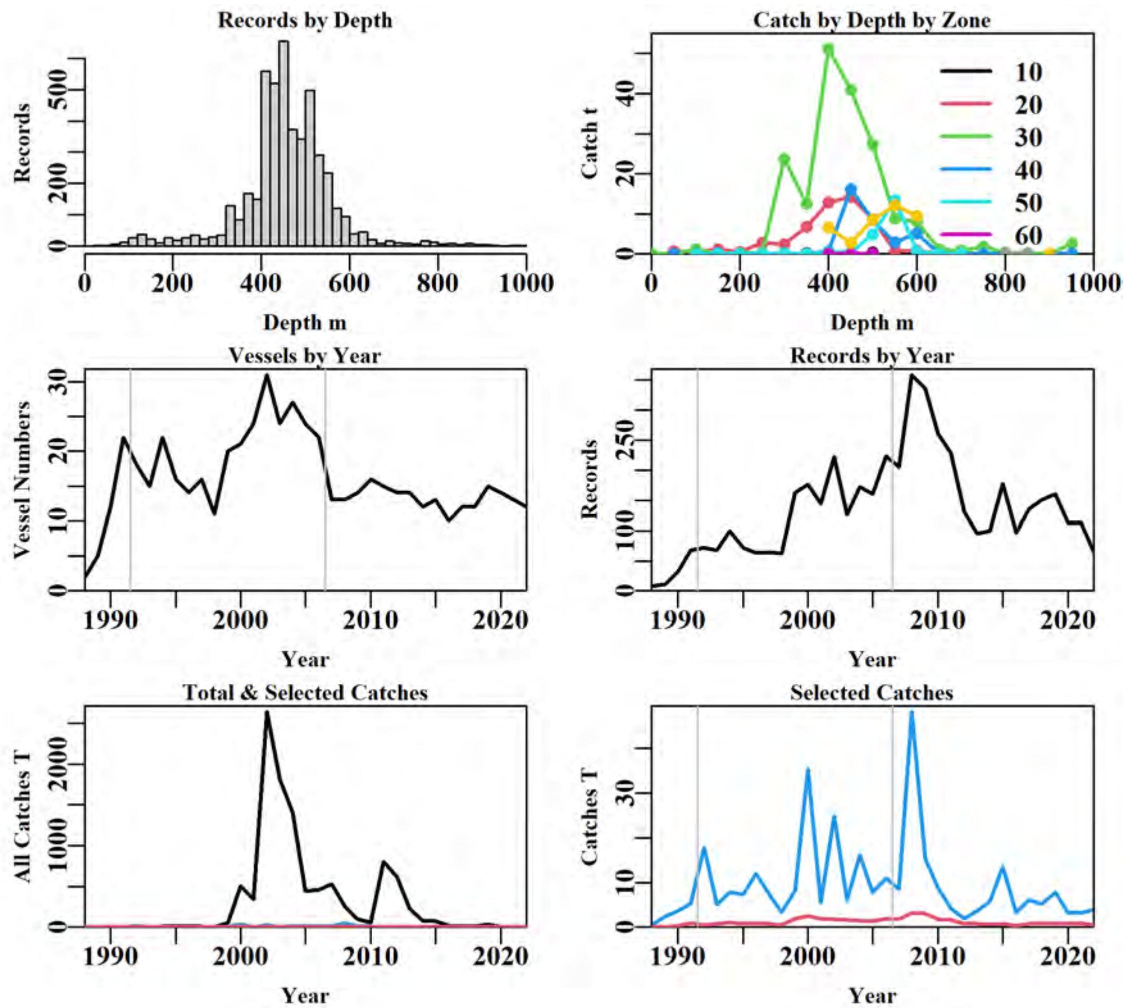

Figure 279: Alfonsino fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 199: Alfonsino data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	14841	10963	10853	10772	7437	6396	4737
Difference	0	3878	110	81	3335	1041	1659
Catch	10617	10531	10421	10420	1952	1935	331
Difference	0	85	111	1	8467	17	1604

Table 200: The models used to analyse data for Alfonsino.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Zone
Model5	Year + Vessel + DepCat + Zone + DayNight
Model6	Year + Vessel + DepCat + Zone + DayNight + Month
Model7	Year + Vessel + DepCat + Zone + DayNight + Month + Zone:DepCat

Table 201: Alfonsino. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:DepCat.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	5618	15282	2106	4737	35	11.5	0.00
Vessel	3183	8732	8656	4737	143	48.2	36.75
DepCat	3140	8585	8803	4737	162	48.9	0.66
Zone	2927	8182	9206	4737	169	51.2	2.32
DayNight	2886	8105	9283	4737	171	51.7	0.44
Month	2823	7961	9427	4737	182	52.4	0.74
Zone:DepCat	2765	7666	9722	4737	242	53.5	1.15

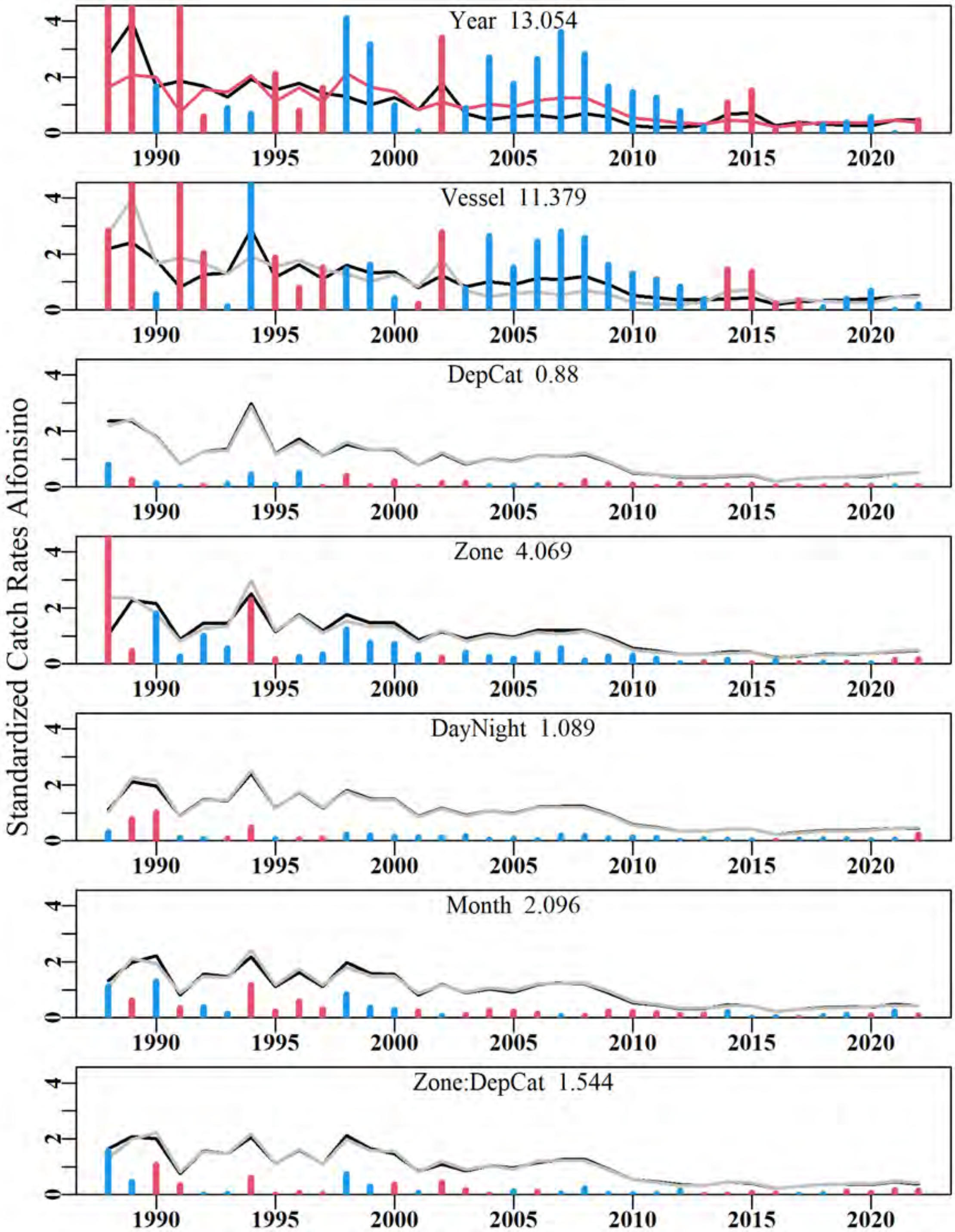

Figure 280: Alfonsino. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

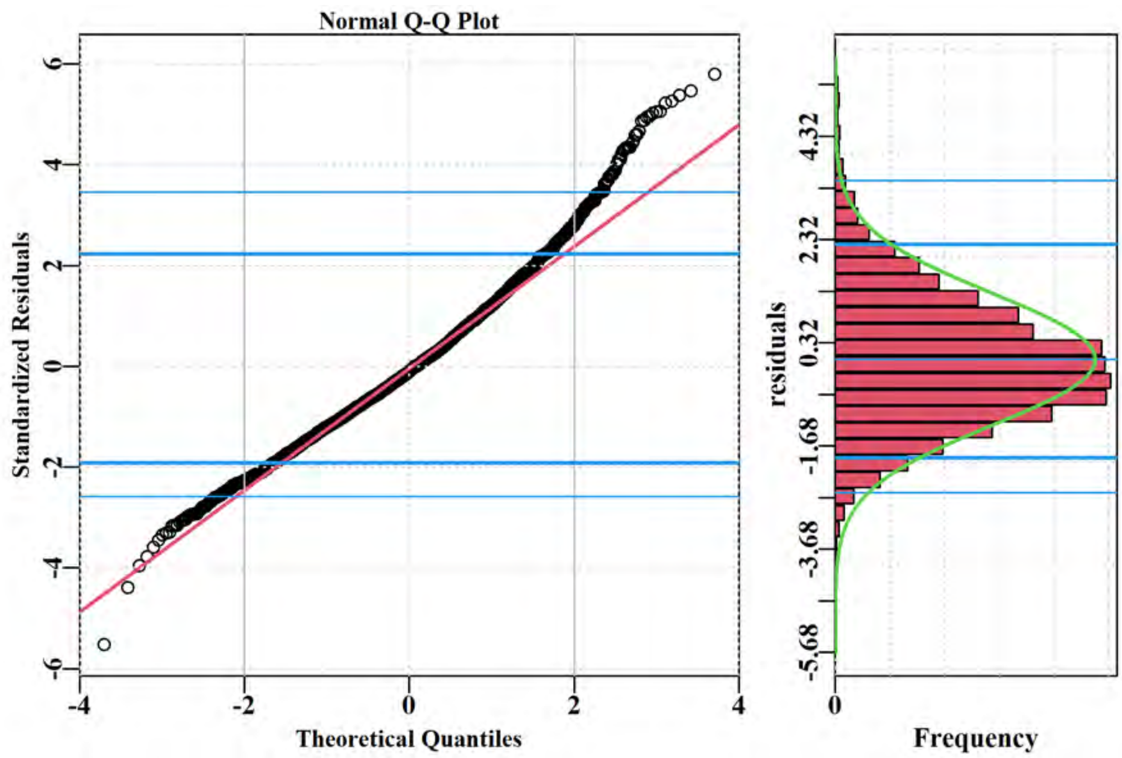

Figure 281: Alfonsino. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

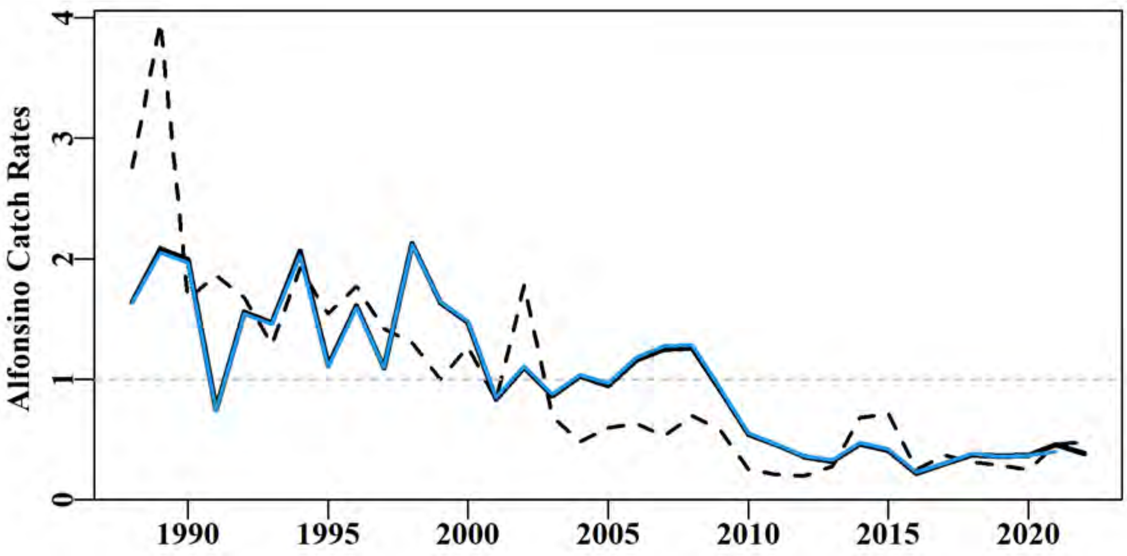

Figure 282: Alfonsino. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

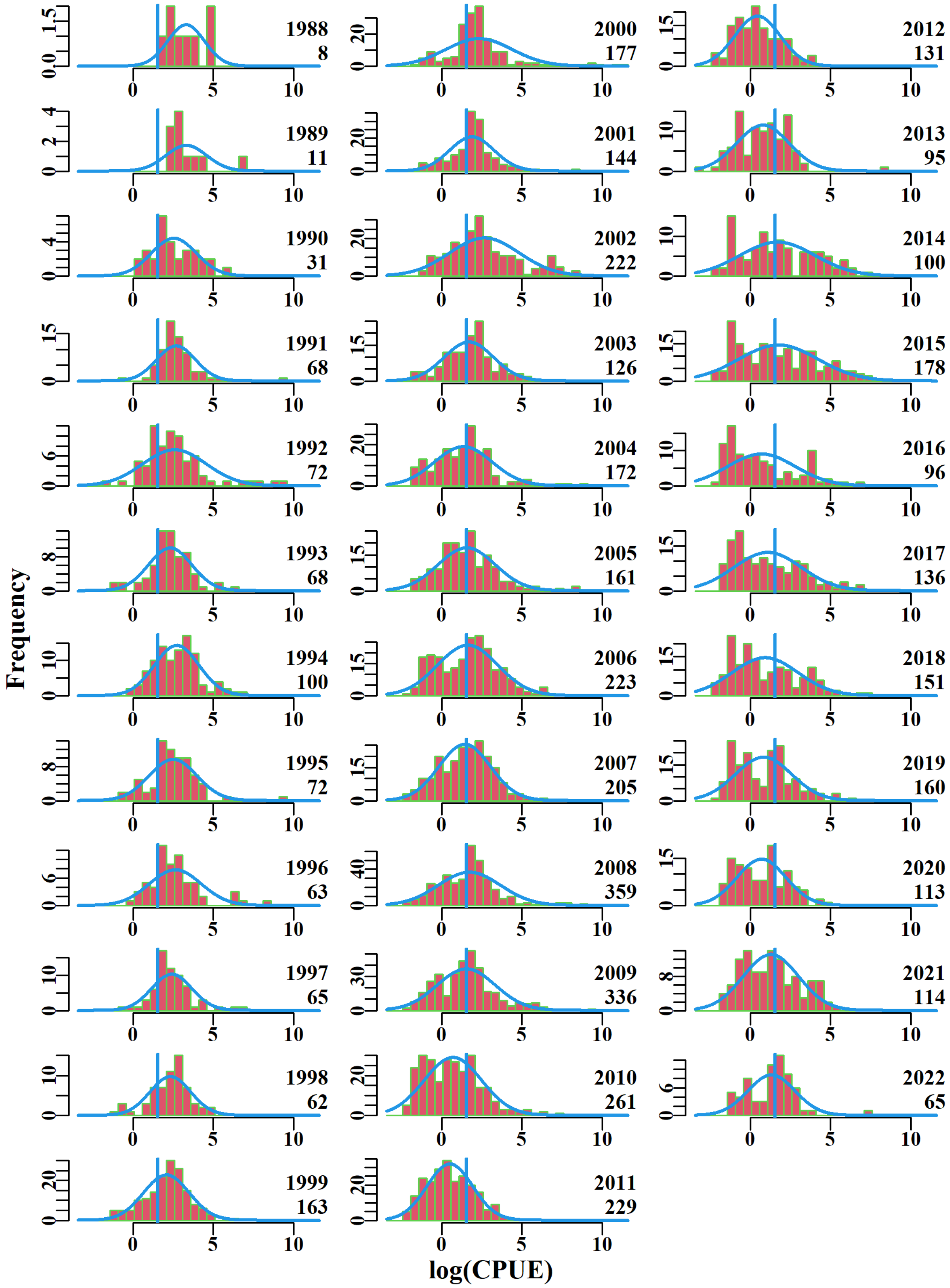

Figure 283: Alfonsino. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

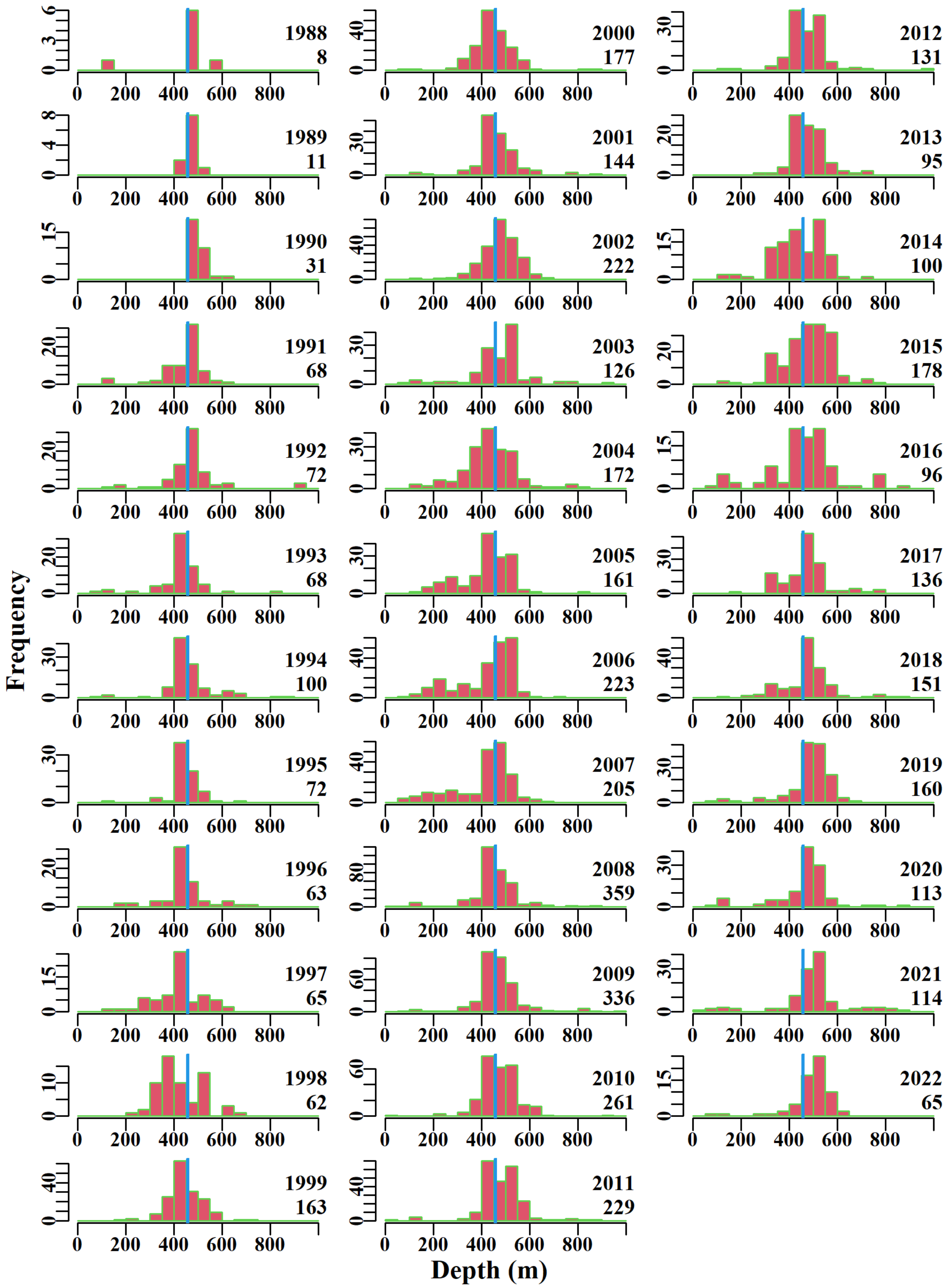

Figure 284: Alfonsino. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Redfish 10

Redfish (RED – 37258003 – *Centroberyx affinis*) was one of the 16 species first included in the quota system in 1992. Redfish caught by trawl based on methods TW, TDO, OTB, OTM, OTT, in zones 10, and depths 0 to 400 m within the SET fishery for the years 1986 - 2022 were used in the analysis (Table 202). A total of 7 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The total annual Redfish catch in 2022 (8.8 t) employed in the analysis was the lowest recorded in the series (i.e., between 1986 - 2022). Large scale changes in CPUE have occurred in zone 10.

The terms Year, Vessel, and DepCat had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics (Table 206). The qqplot suggests that the assumed Normal distribution is valid (Figure 288).

Annual standardized CPUE has declined between 1994-96 (relative to 1993) and has been below average since after 2000, based on 95% confidence intervals (Figure 285).

Action Items and Issues

After consideration of Redfish catches in zones 10 by year and vessel, the period around 1993 - 2006 appears to be different from the catches by vessel from 2007. This suggests that there have been transitional periods in the time-series of CPUE. This needs more attention because of the potential implications this has for the index of relative abundance through time.

Table 202: Redfish10. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	Redfish10
csirocode	37258003
fishery	SET
depthrange	0 - 400
depthclass	25
zones	10
methods	TW, TDO, OTB, OTM, OTT
years	1986 - 2022

Table 203: Redfish10. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1687.5	4504	1528.6	81	143.1	2.0505	0.000	18.299	0.012
1987	1252.7	3366	1111.6	73	141.0	1.6191	0.037	14.700	0.013
1988	1125.5	2964	903.8	70	116.2	1.7245	0.039	12.169	0.013
1989	714.3	2148	586.3	64	100.0	1.4062	0.043	11.362	0.019
1990	931.4	1883	691.5	49	137.1	1.8675	0.045	8.111	0.012
1991	1570.6	2453	1051.4	44	165.0	1.9780	0.042	10.458	0.010
1992	1636.7	2492	1414.9	42	265.8	2.7087	0.042	9.890	0.007
1993	1921.3	2983	1598.1	47	253.0	3.2394	0.040	11.246	0.007
1994	1487.7	4216	1130.2	49	130.1	2.2462	0.037	20.580	0.018
1995	1240.6	4397	1023.3	46	92.7	1.4645	0.036	23.928	0.023
1996	1344.0	4057	1097.0	49	116.5	1.2538	0.037	22.841	0.021
1997	1397.3	2937	1154.4	50	202.3	1.4562	0.040	14.685	0.013
1998	1553.7	3105	1369.6	43	259.0	1.7893	0.040	13.289	0.010
1999	1116.5	3005	969.2	44	166.1	1.4418	0.040	14.534	0.015
2000	758.5	3290	639.9	49	99.8	0.9806	0.039	18.241	0.029
2001	742.3	3211	603.8	41	96.4	0.9319	0.039	19.138	0.032
2002	807.1	3453	598.4	44	86.1	0.7630	0.039	19.599	0.033
2003	615.6	2665	477.2	43	90.9	0.7569	0.041	15.409	0.032
2004	475.2	2696	388.5	44	69.7	0.6362	0.041	17.164	0.044
2005	483.5	2419	359.6	41	61.8	0.6483	0.042	14.484	0.040
2006	325.5	1753	255.5	34	58.9	0.6175	0.047	11.515	0.045
2007	216.3	1200	148.4	18	50.3	0.5512	0.054	7.909	0.053
2008	183.8	1387	154.8	22	42.0	0.5185	0.052	10.073	0.065
2009	160.5	1161	123.1	20	35.7	0.4059	0.055	8.969	0.073
2010	152.8	1210	112.0	19	32.3	0.3914	0.054	10.241	0.091
2011	87.3	861	57.0	17	27.9	0.3120	0.061	6.378	0.112
2012	66.4	968	54.5	17	22.5	0.2589	0.058	8.376	0.154
2013	62.7	761	51.5	18	25.1	0.3098	0.063	6.980	0.136
2014	86.9	1093	75.7	19	29.0	0.4383	0.056	9.408	0.124
2015	52.2	936	47.2	19	18.9	0.2871	0.059	8.546	0.181
2016	38.4	659	31.1	19	18.3	0.2370	0.068	6.080	0.195
2017	25.4	438	20.5	15	18.5	0.2473	0.079	4.334	0.211
2018	29.9	495	23.0	16	17.8	0.2080	0.077	3.970	0.173
2019	26.7	388	17.3	13	16.9	0.2456	0.086	3.657	0.211
2020	47.1	425	19.8	14	16.0	0.3264	0.083	4.338	0.219
2021	48.8	432	21.9	14	17.4	0.3743	0.084	5.094	0.233
2022	15.3	284	8.8	11	11.2	0.3082	0.100	4.573	0.521

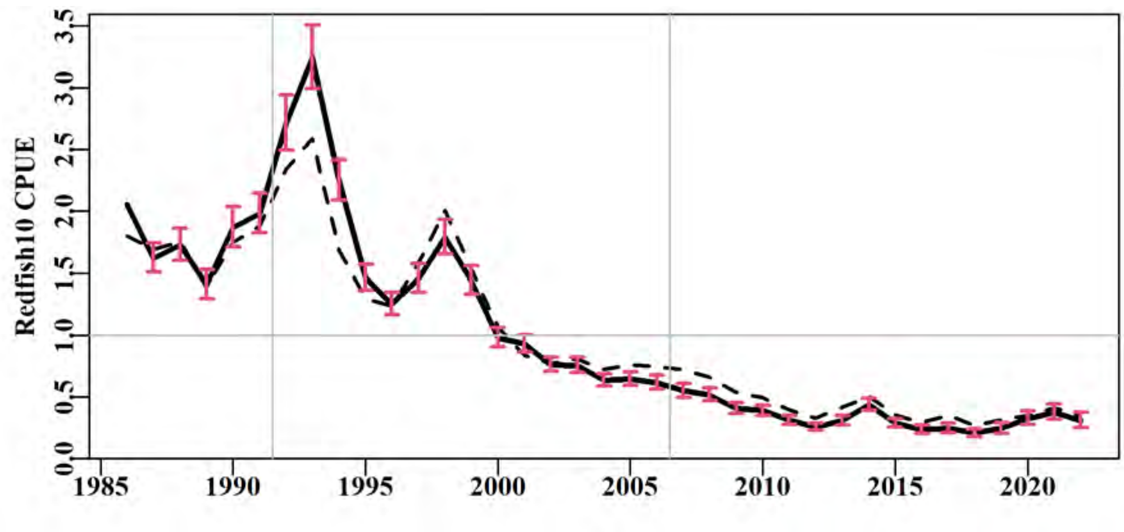

Figure 285: Redfish10 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

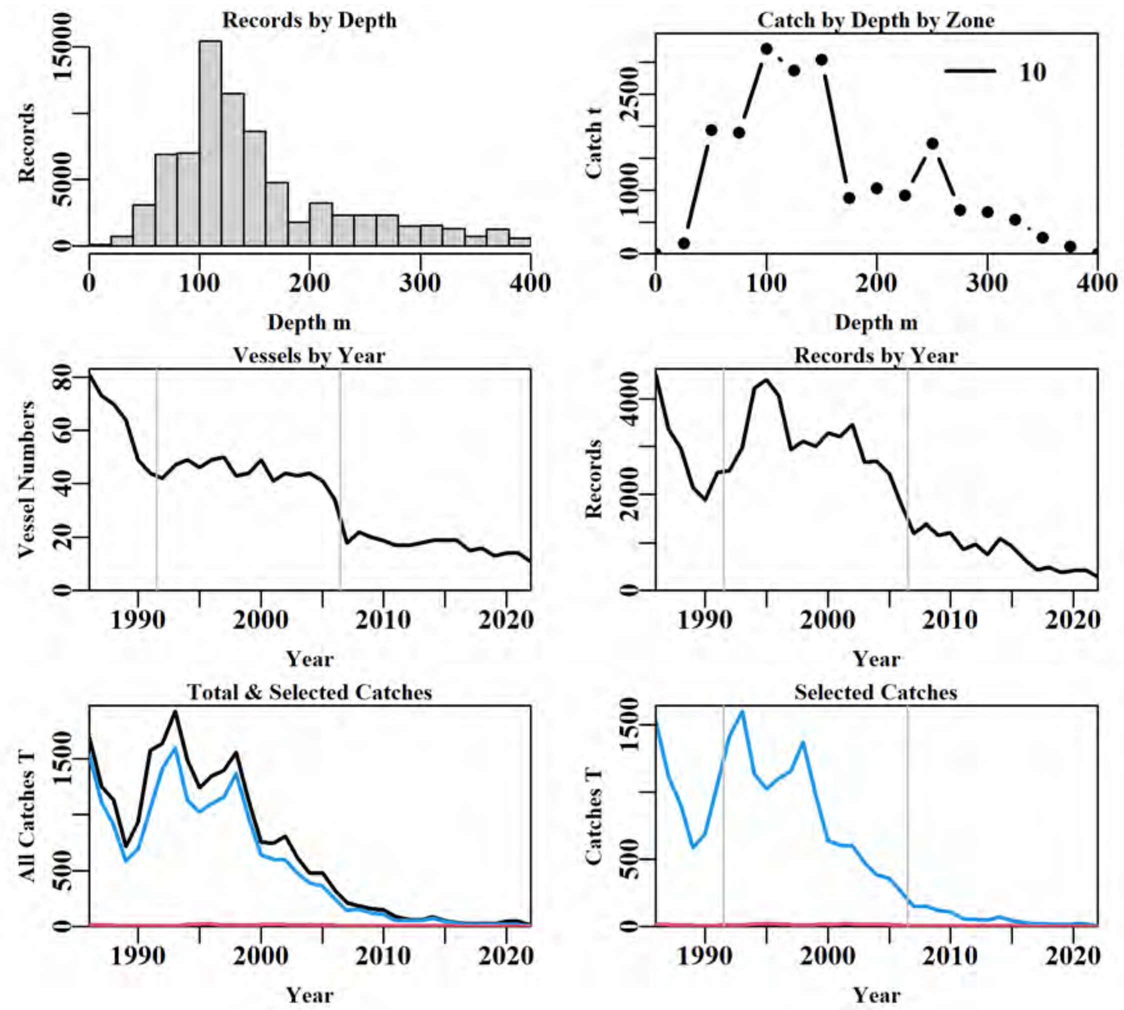

Figure 286: Redfish10 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 204: Redfish10 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	123812	117773	114428	113471	77192	76722	76695
Difference	0	6039	3345	957	36279	470	27
Catch	24638	24140	23738	23597	20049	19921	19919
Difference	0	498	402	141	3548	127	2

Table 205: The models used to analyse data for Redfish10.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + DayNight
Model5	Year + Vessel + DepCat + DayNight + Month
Model6	Year + Vessel + DepCat + DayNight + Month + Zone:Month
Model7	Year + Vessel + DepCat + DayNight + Month + Zone:DepCat

Table 206: Redfish10. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	78862	214248	23420	76695	37	9.8	0.00
Vessel	70207	190630	47037	76695	188	19.6	9.78
DepCat	65658	179577	58091	76695	204	24.2	4.65
DayNight	64689	177309	60359	76695	207	25.2	0.95
Month	64559	176958	60710	76695	218	25.3	0.14
Zone:Month	64559	176958	60710	76695	218	25.3	0.00
Zone:DepCat	64559	176958	60710	76695	218	25.3	0.00

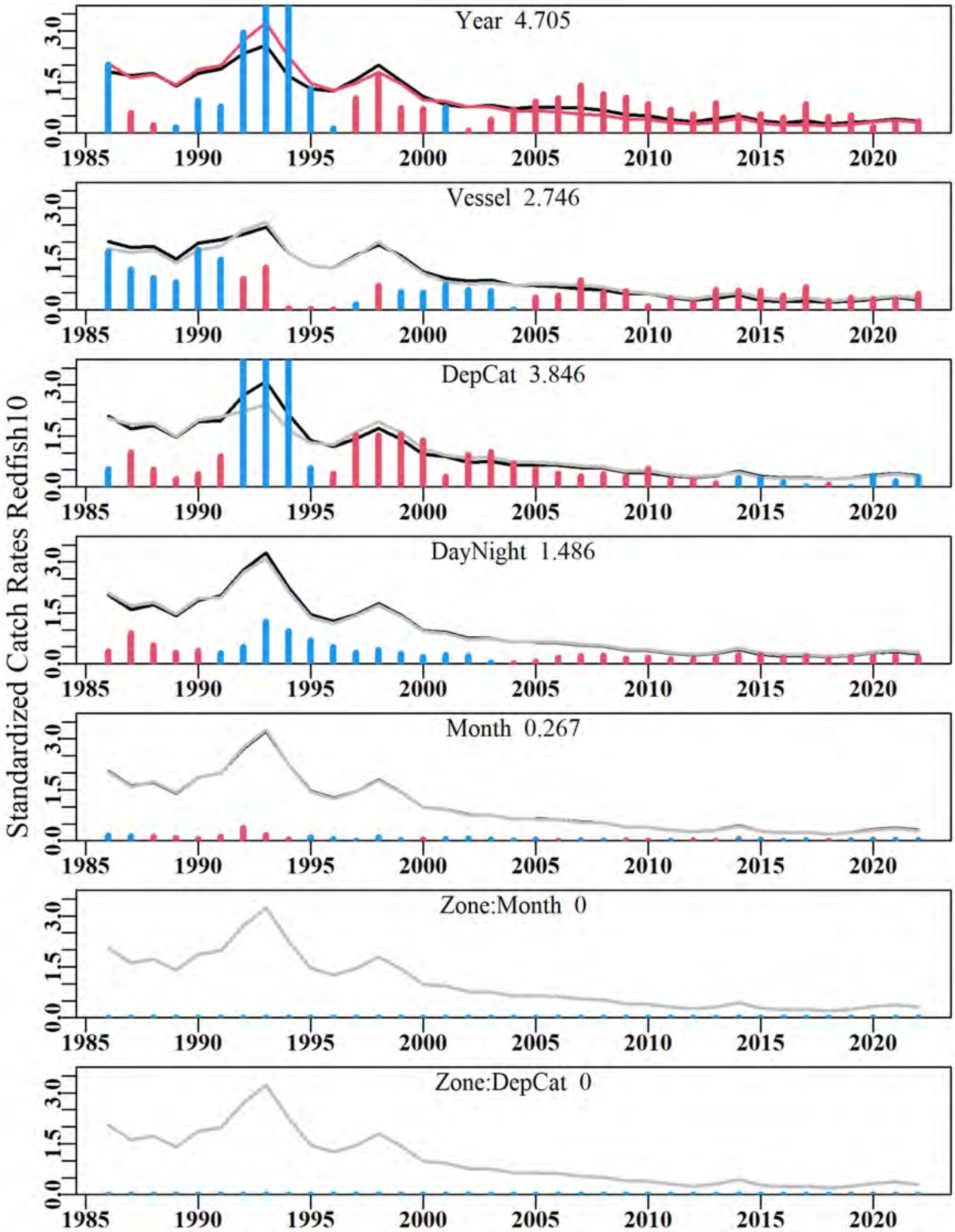

Figure 287: Redfish10. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

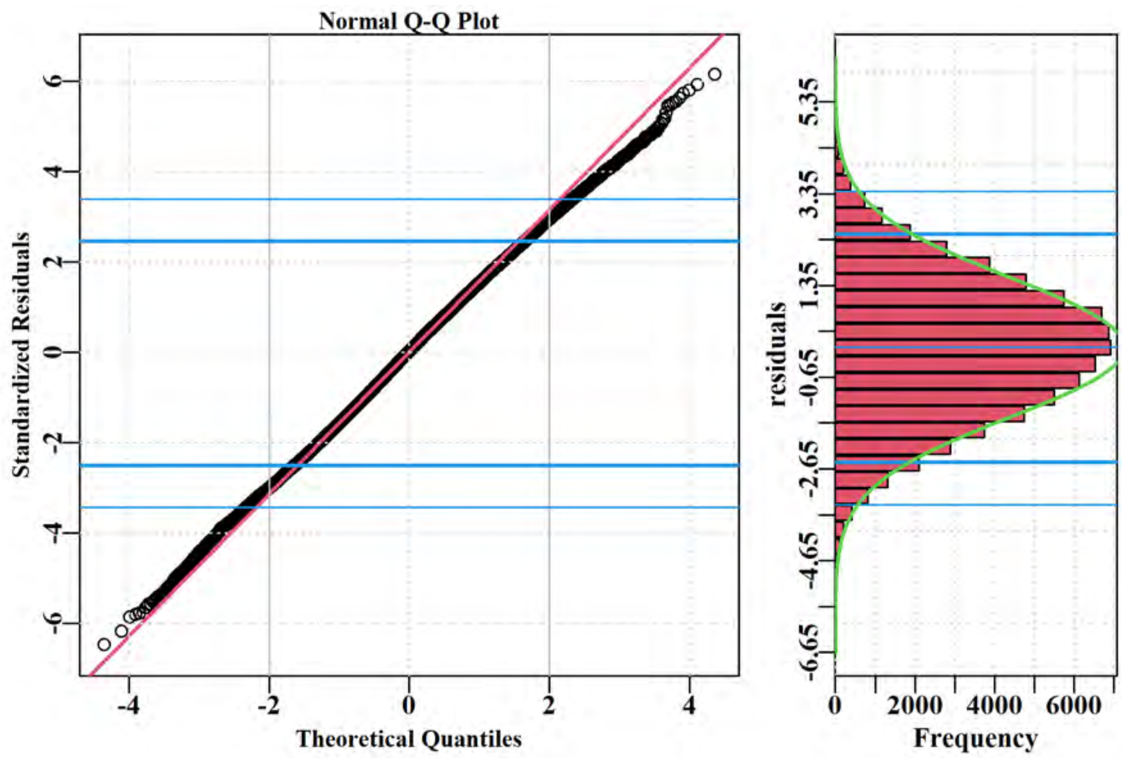

Figure 288: Redfish10. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

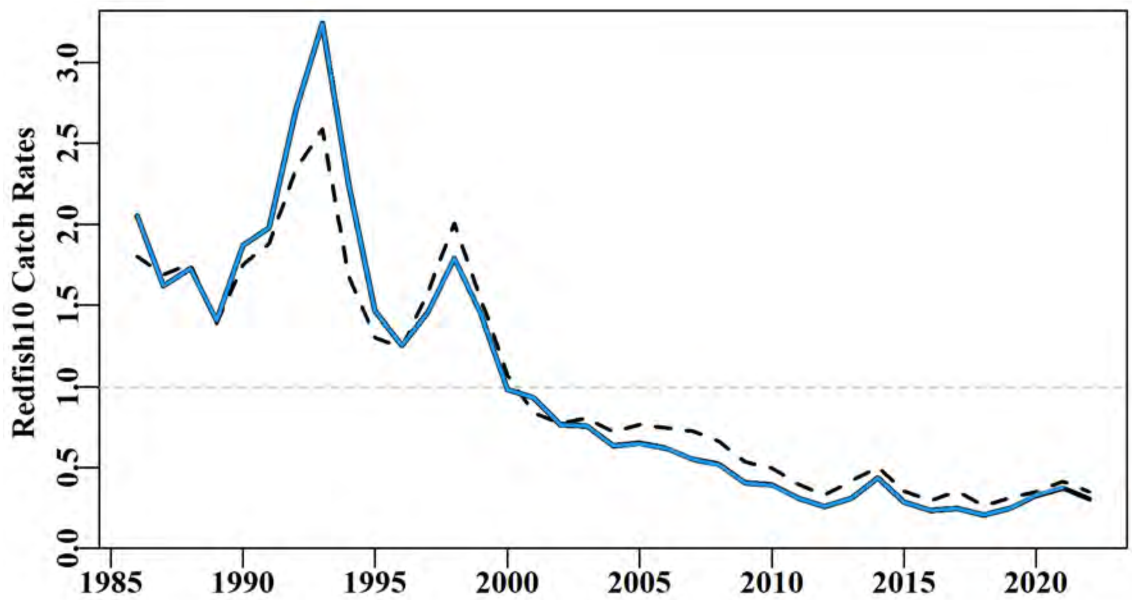

Figure 289: Redfish10. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

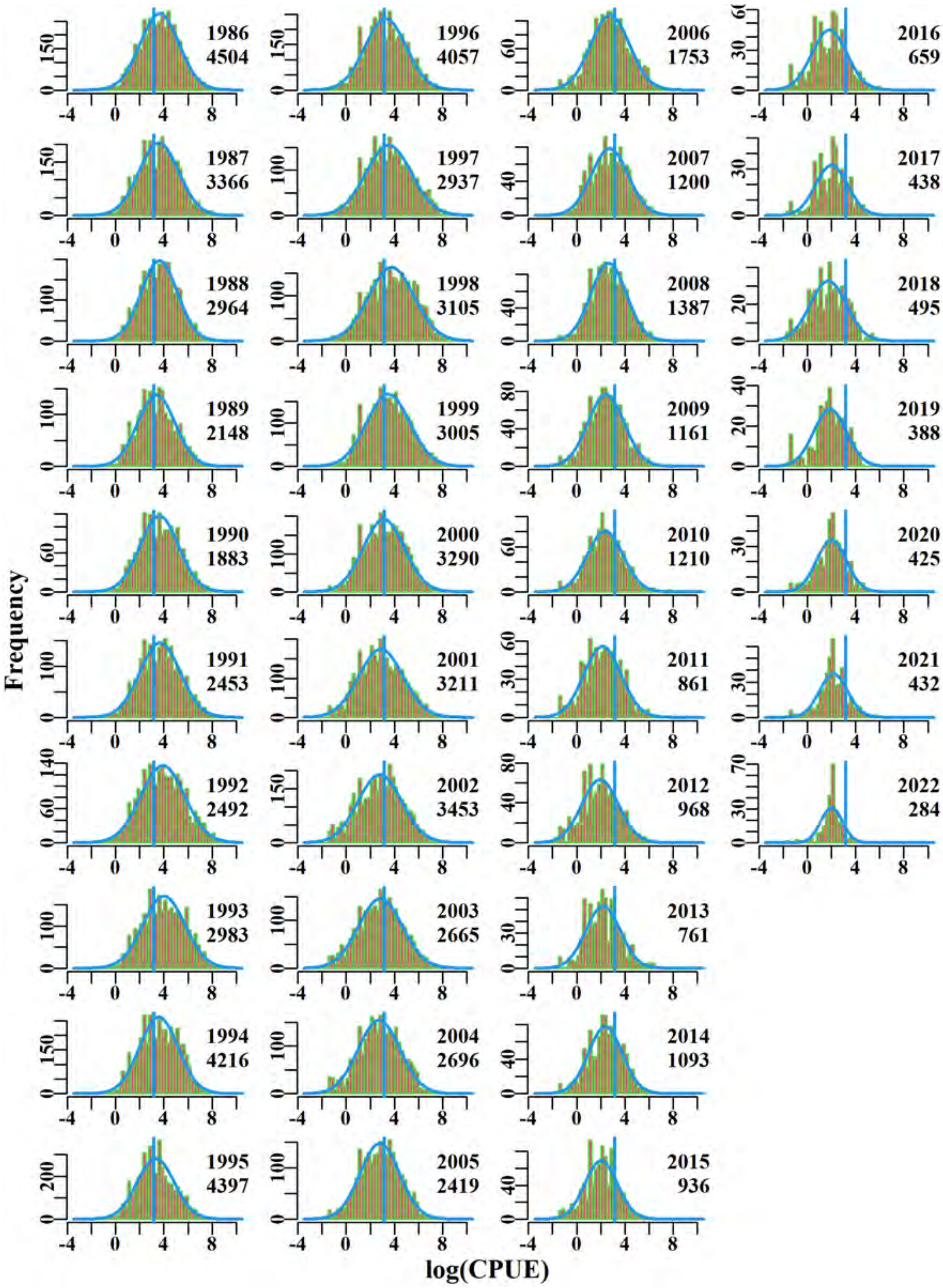

Figure 290: Redfish10. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

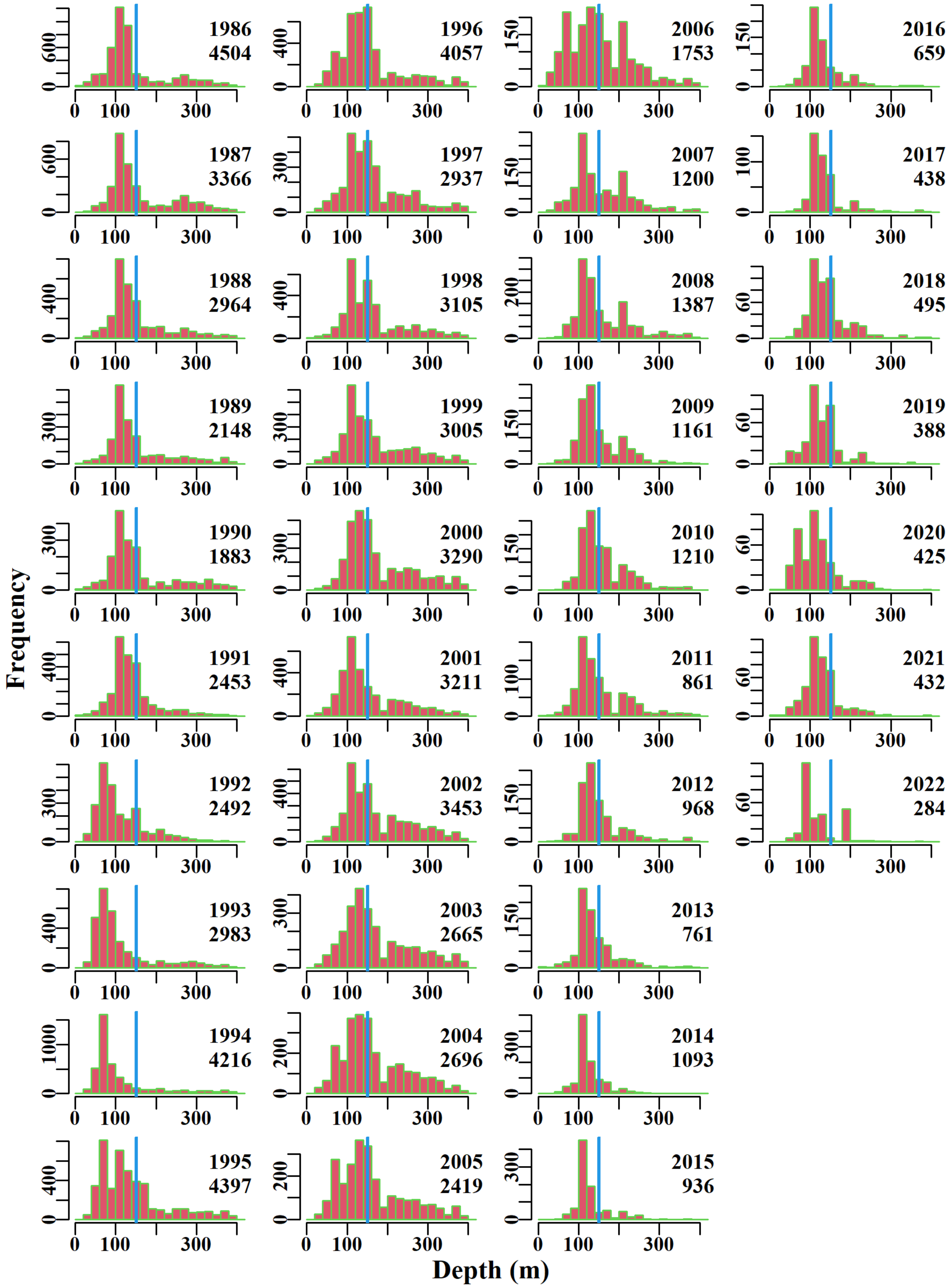

Figure 291: Redfish10. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Flathead DS 2060 - Excluding seismic survey records

Tiger Flathead (FLT – 37296001 – *Neoplatycephalus richardsoni*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The additional generic flathead group code was added as a result of a change in recording Tiger Flathead as 37296000 (Platycephalidae) in electronic logbooks since 2013. Danish seine caught Flathead based on methods DS, SSC, RS, in zones 20, 30, 60, and depths 0 m to 200 m within the SET fishery for the years 1986 - 2022 were analysed (Table 207). The unit of analysis was catch/shot. A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit. This analysis excluded records from a seismic survey conducted from 1 January to 7 July 2020 (Knuckey et. al., 2022), as recommended by SESSFRAG (Meeting 27-29 April 2022).

Inferences

Flathead (*Neoplatycephalus richardsoni* and Platycephalidae) taken by Danish seine are caught in shallower depths in zone 60 compared to zone 20 (Figure 293), with a shift to deeper waters becoming apparent from 1997 onwards which may be related to which vessels were fishing.

The terms Year, DepCat, Month, Vessel, DayNight and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests a departure of the assumed Normal distribution as depicted by the lower tail of the distribution.

Some vessels have remained in this fishery since 1986 with significant catches, while other vessels have left following the structural adjustment in 2007 and not returned. Annual standardized CPUE appears cyclical above and below average and has remained below average since 2012 (Figure 292). There has also been an overall decrease in standardized CPUE over the 2007-2020 period despite the significant increases in CPUE since 2020 (i.e., in 2021 and 2022).

Action Items and Issues

It is recommended that an exploration of the fishery dynamics be evaluated to determine whether the CPUE values are being influenced by the species being targeted within individual shots (e.g., is there interference between shots of mostly Flathead compared to shots of mostly School Whiting). This will be important for determining whether estimated annual indices adequately reflect stock abundance.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 207: FlatheadDS2060S1. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	FlatheadDS2060S1
csirocode	37296001, 37296000
fishery	SET
depthrange	0 - 200
depthclass	20
zones	20, 30, 60
methods	DS, SSC, RS
years	1986 - 2022

Table 208: FlatheadDS2060S1. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1892.2	5581	769.2	26	203.5	1.1648	0.000	27.135	0.035
1987	2461.3	5534	1340.9	24	352.5	1.6522	0.024	25.105	0.019
1988	2469.5	5745	1074.7	25	268.3	1.8086	0.024	21.449	0.020
1989	2599.1	5384	1138.0	27	297.1	1.5643	0.024	27.184	0.024
1990	2032.3	4462	568.1	24	157.2	1.0502	0.025	28.665	0.050
1991	2230.2	4463	746.5	28	215.7	1.4273	0.025	24.633	0.033
1992	2375.4	6503	1196.8	23	233.5	1.5250	0.023	27.718	0.023
1993	1879.1	5954	532.9	25	113.2	0.9358	0.024	40.678	0.076
1994	1710.4	7163	633.0	24	124.9	0.8125	0.023	40.569	0.064
1995	1800.6	5420	648.6	21	204.7	0.8322	0.024	24.806	0.038
1996	1879.9	7508	742.7	22	139.0	0.7804	0.023	44.616	0.060
1997	2356.0	8279	1136.0	20	192.2	1.0176	0.022	37.876	0.033
1998	2306.4	9800	1126.5	21	147.9	0.8597	0.022	48.033	0.043
1999	3117.7	8669	1679.4	23	269.0	1.2553	0.022	25.632	0.015
2000	2945.6	7295	1079.7	19	199.3	0.9306	0.023	32.454	0.030
2001	2599.5	7781	1066.4	19	196.4	0.8782	0.023	32.654	0.031
2002	2876.3	8124	1130.0	22	182.0	1.0335	0.023	31.327	0.028
2003	3229.9	8872	1187.0	23	168.5	1.0712	0.023	30.001	0.025
2004	3222.8	7644	1234.5	22	194.6	1.0572	0.023	24.994	0.020
2005	2844.1	7008	1104.9	22	184.3	1.0754	0.024	22.184	0.020
2006	2585.8	5461	950.5	21	233.5	1.0554	0.025	15.784	0.017
2007	2648.3	5493	1165.4	16	293.0	1.2638	0.025	14.912	0.013
2008	2912.3	6161	1268.3	15	279.1	1.1319	0.024	18.287	0.014
2009	2460.5	5434	1153.5	15	318.1	1.1749	0.025	17.949	0.016
2010	2502.3	5997	1159.0	15	274.1	1.0674	0.024	15.542	0.013
2011	2465.9	6798	1113.5	14	209.0	0.9895	0.024	20.671	0.019
2012	2780.6	7158	1372.2	14	299.5	0.9420	0.024	19.403	0.014
2013	1941.0	7307	961.1	14	171.0	0.6702	0.024	31.201	0.032
2014	2369.9	8375	1170.8	14	187.0	0.7299	0.023	32.867	0.028
2015	2667.9	8618	1311.2	15	196.1	0.7217	0.023	39.398	0.030
2016	2775.6	9257	1468.4	16	205.5	0.7530	0.023	40.877	0.028
2017	2311.7	8936	1233.8	18	175.1	0.7262	0.023	43.103	0.035
2018	2000.8	8510	947.2	19	137.2	0.5188	0.023	46.367	0.049
2019	1938.1	8900	950.8	19	133.1	0.4830	0.023	47.063	0.050
2020	1990.2	9607	933.2	19	122.8	0.4880	0.023	50.350	0.054
2021	2071.0	7765	1100.1	19	180.2	0.6483	0.024	35.770	0.033
2022	1821.9	7613	1023.7	18	166.0	0.9039	0.024	37.401	0.037

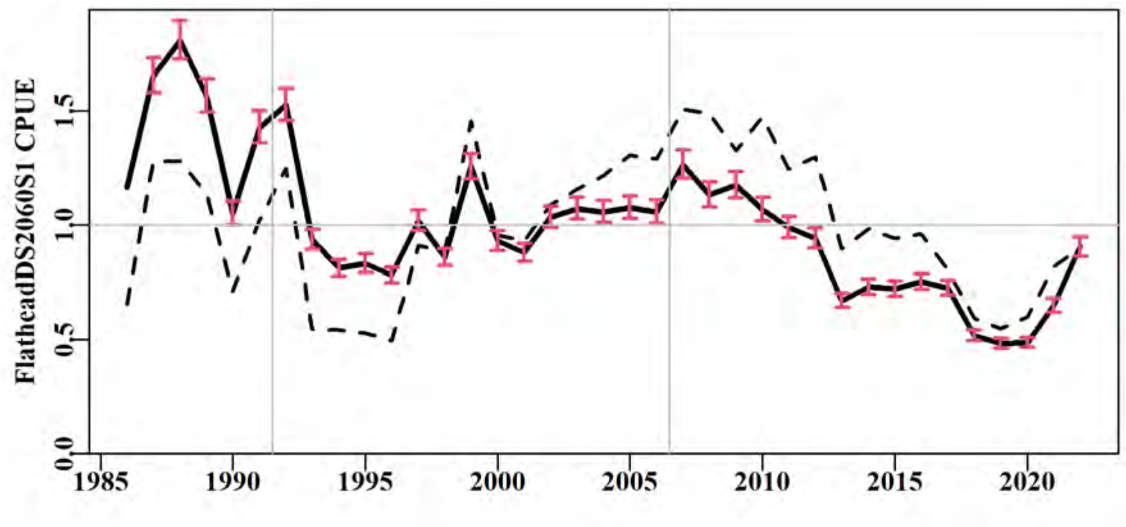

Figure 292: FlatheadDS2060S1 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

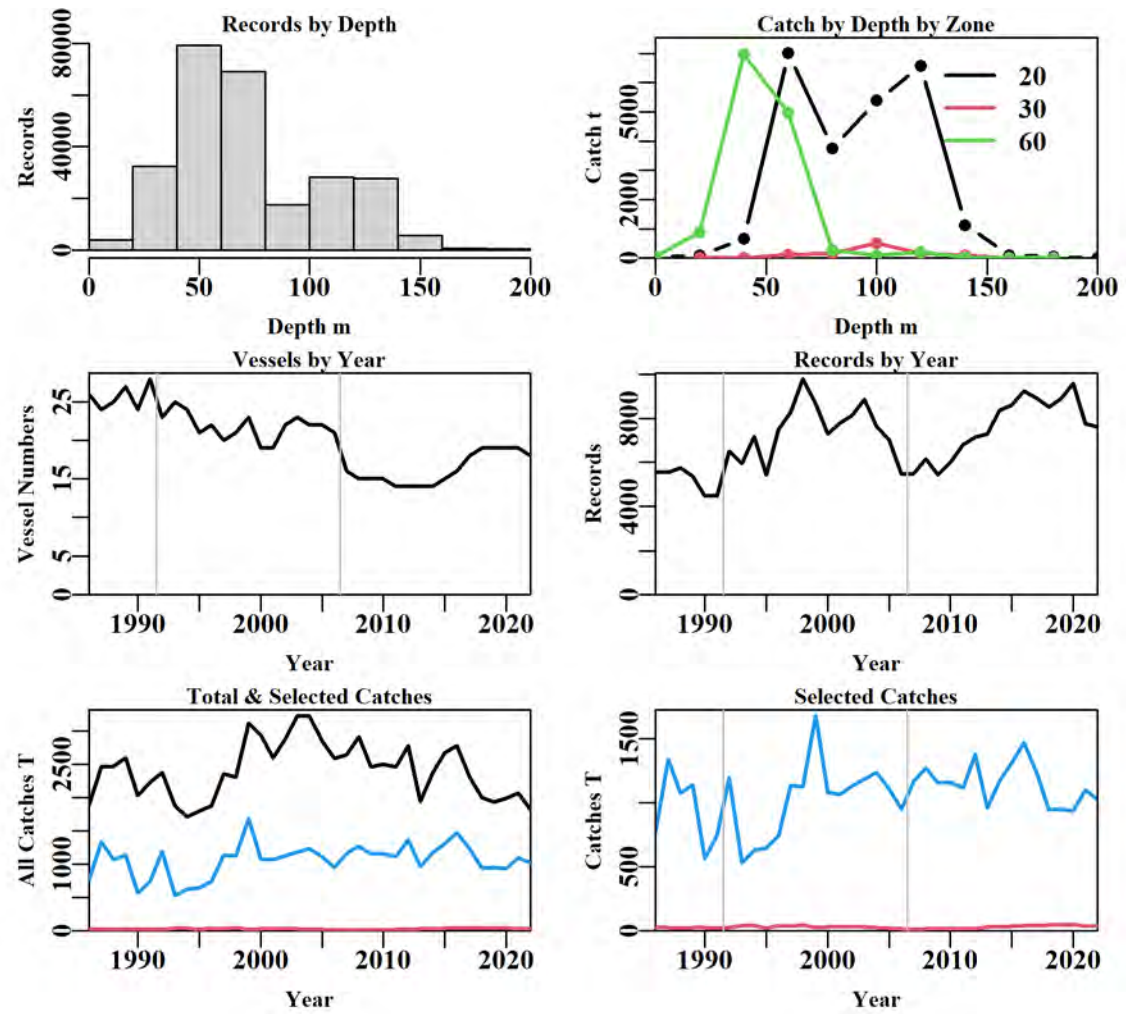

Figure 293: FlatheadDS2060S1 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 209: FlatheadDS2060S1 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	697816	679375	633991	625876	440333	267168	265305
Difference	0	18441	45384	8115	185543	173165	1863
Catch	90063	90063	85187	84222	67282	39507	39439
Difference	0	0	4876	966	16940	27775	68

Table 210: The models used to analyse data for FlatheadDS2060S1.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Month
Model4	Year + DepCat + Month + Vessel
Model5	Year + DepCat + Month + Vessel + DayNight
Model6	Year + DepCat + Month + Vessel + DayNight + Zone
Model7	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:Month
Model8	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:DepCat

Table 211: FlatheadDS2060S1. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	206793	577930	28166	264579	37	4.6	0.00
DepCat	135833	441942	164154	264579	47	27.1	22.44
Month	123261	421397	184699	264579	58	30.5	3.39
Vessel	108211	397922	208174	264579	116	34.3	3.86
DayNight	103363	390689	215407	264579	119	35.5	1.19
Zone	100267	386137	219959	264579	121	36.3	0.75
Zone:Month	95915	379775	226321	264579	143	37.3	1.04
Zone:DepCat	99595	385111	220985	264579	137	36.4	0.17

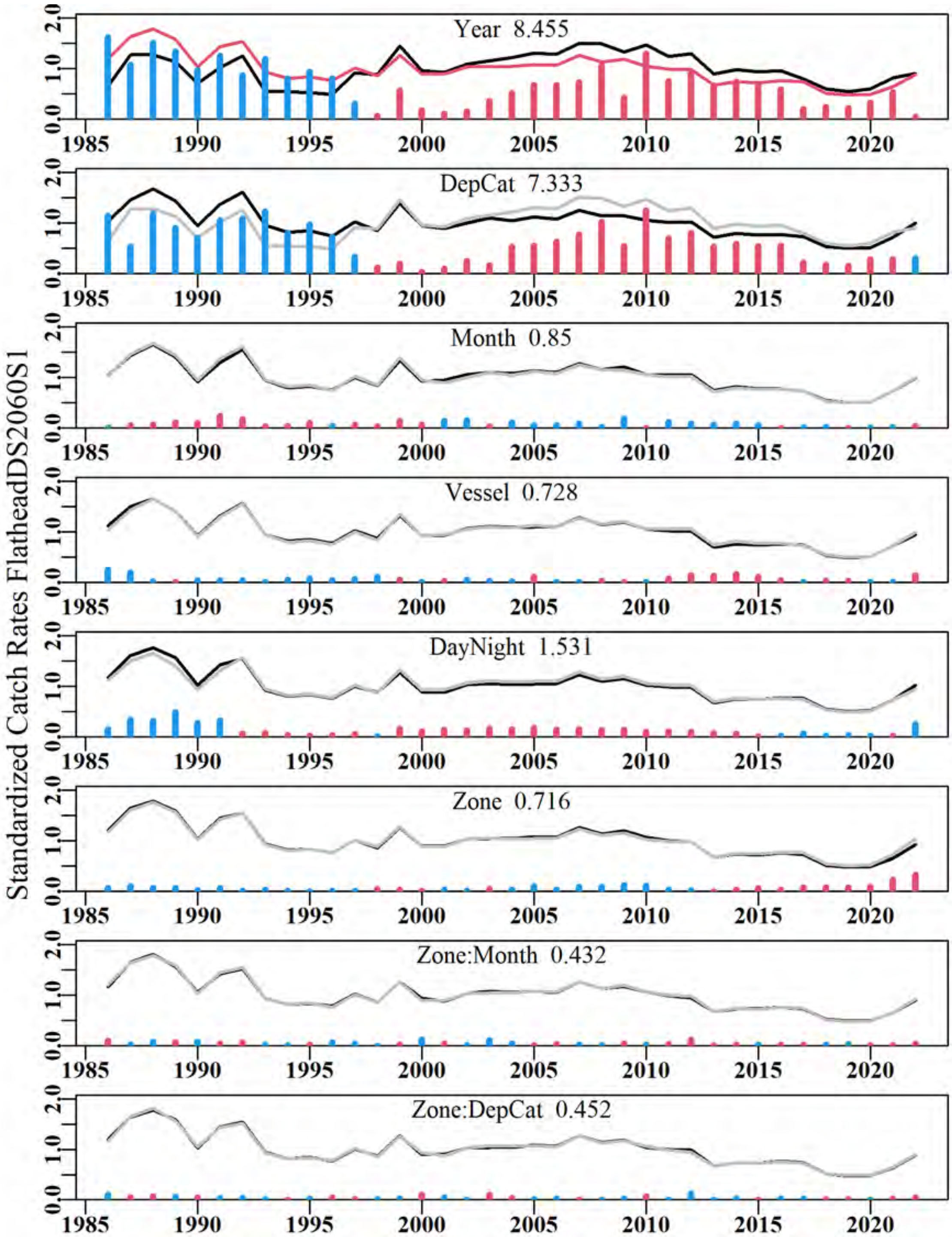

Figure 294: FlatheadDS2060S1. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

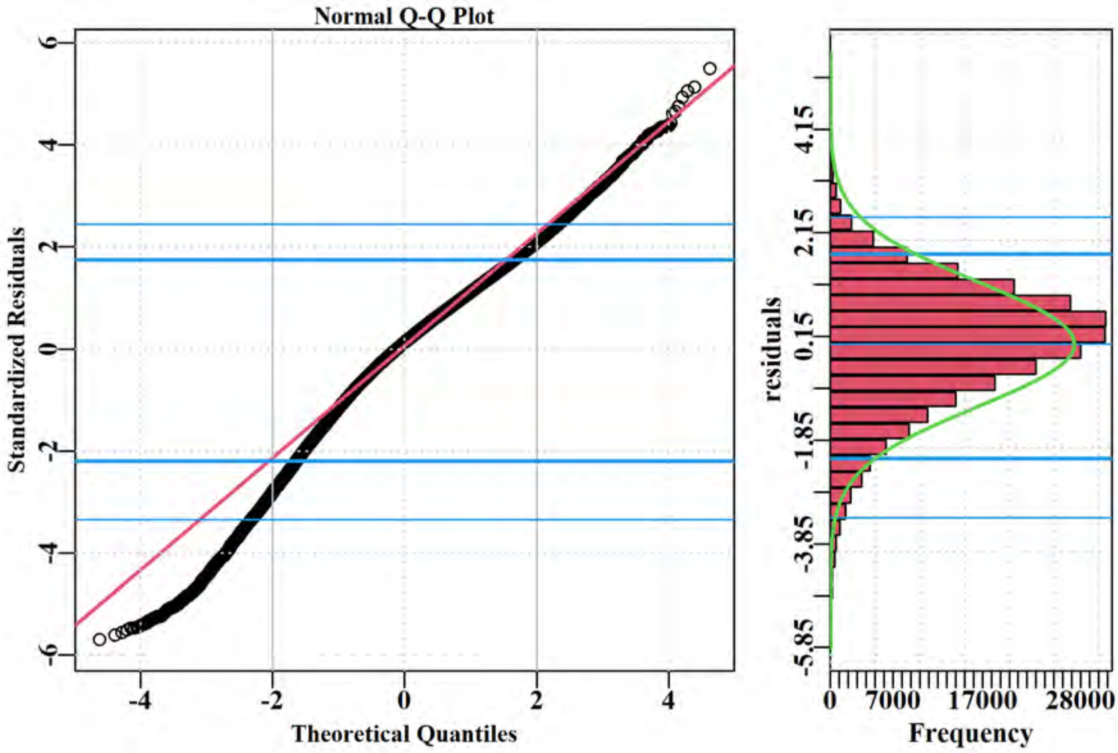

Figure 295: FlatheadDS2060S1. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

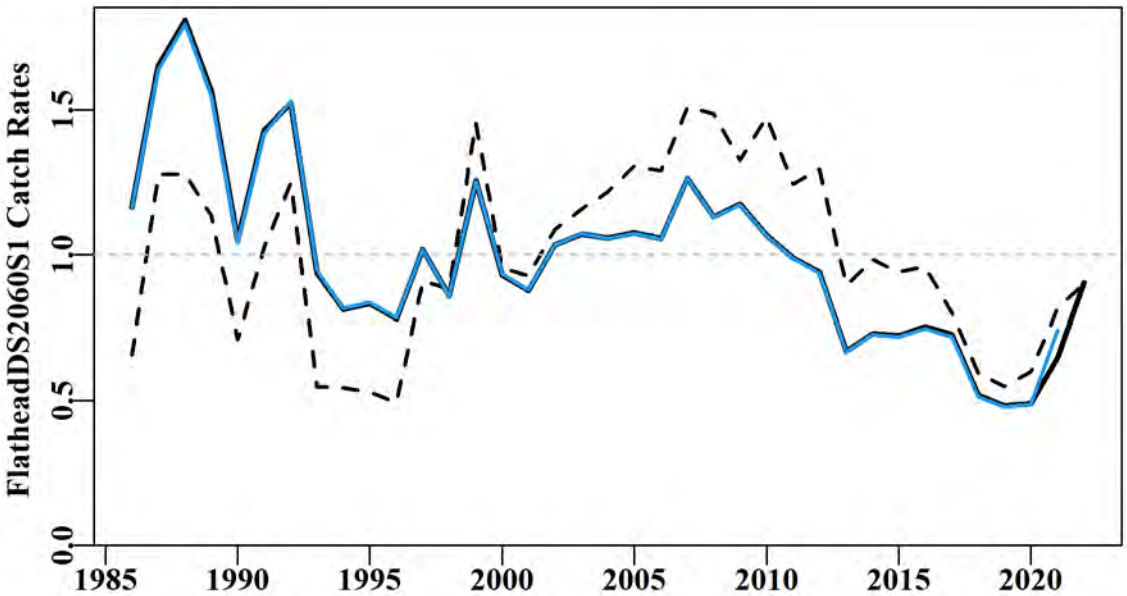

Figure 296: FlatheadDS2060S1. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

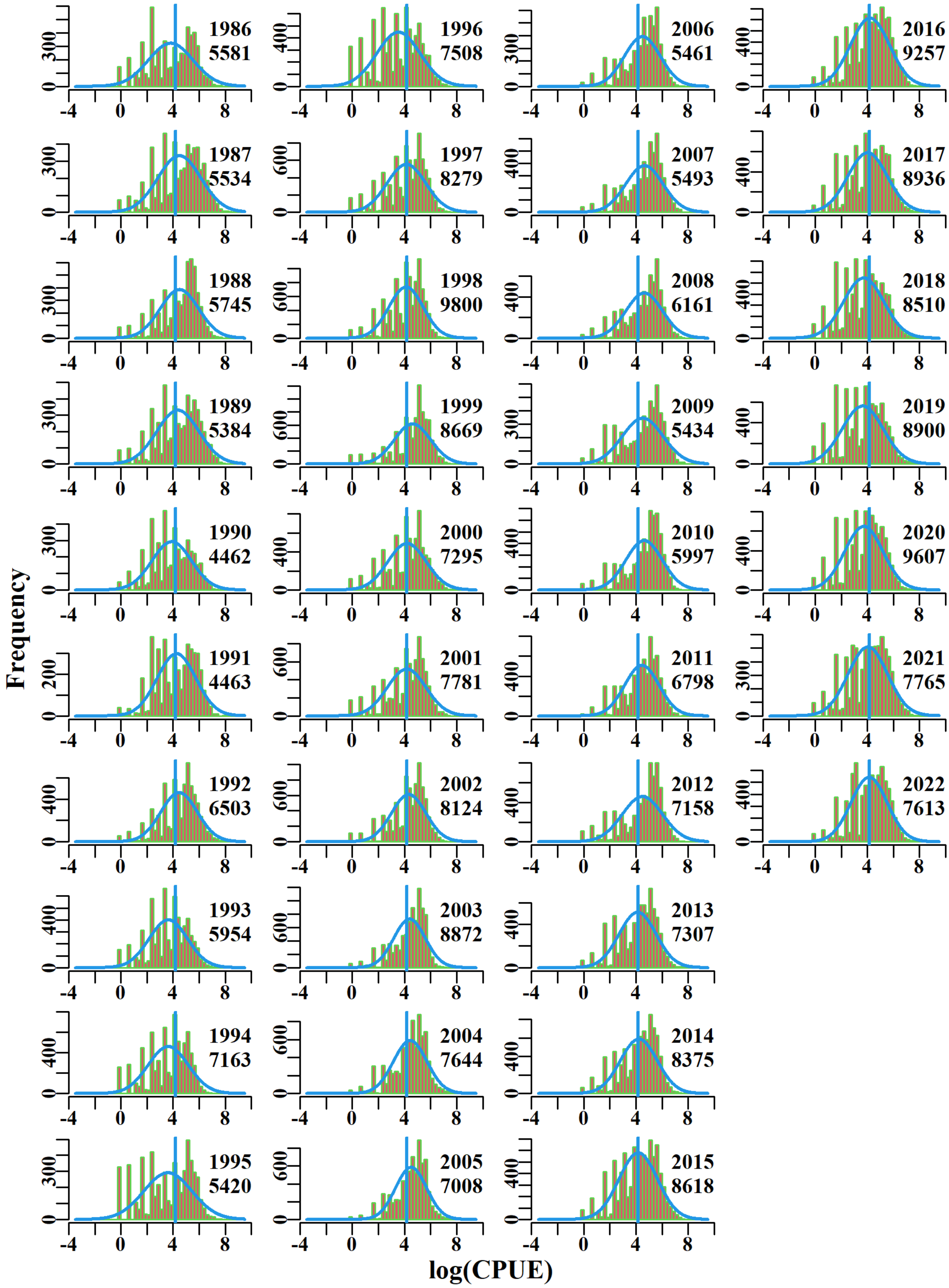

Figure 297: FlatheadDS2060S1. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

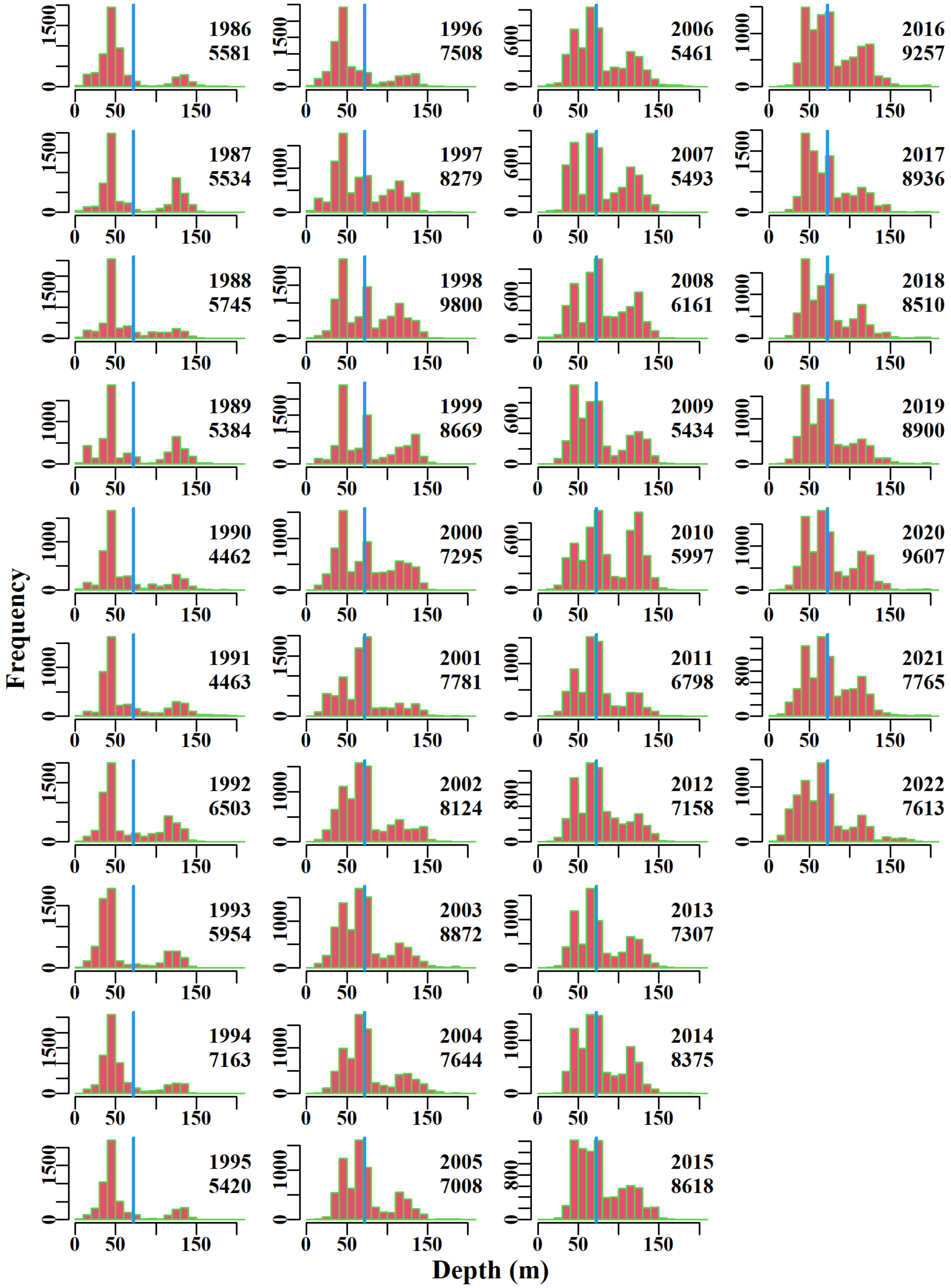

Figure 298: FlatheadDS2060S1. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Flathead DS 2060 - Excluding seismic survey records and non-survey records from same space-time period

Tiger Flathead (FLT – 37296001 – *Neoplatycephalus richardsoni*) was one of the 16 species first included in the quota system in 1992, which reflects its long history within the SESSF. The additional generic flathead group code was added as a result of a change in recording Tiger Flathead as 37296000 (Platycephalidae) in electronic logbooks since 2013. Danish seine caught Flathead based on methods DS, SSC, RS, in zones 20, 30, 60, and depths 0 m to 200 m within the SET fishery for the years 1986 - 2022 were analysed (Table 212). The unit of analysis was catch/shot. A total of 8 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit. This analysis excluded records from a seismic survey conducted from 1 January to 7 July 2020 (Knuckey et. al., 2022), as recommended by SESSFRAG (Meeting 27-29 April 2022). In addition, it also excluded records by vessels that fished in the area and time period of the survey, but were not part of the survey.

Inferences

Flathead (*Neoplatycephalus richardsoni* and Platycephalidae) taken by Danish seine are caught in shallower depths in zone 60 compared to zone 20 (Figure 300), with a shift to deeper waters becoming apparent from 1997 onwards which may be related to which vessels were fishing.

The terms Year, DepCat, Month, Vessel and interaction term Zone:Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests a departure of the assumed Normal distribution as depicted by the lower tail of the distribution.

Some vessels have remained in this fishery since 1986 with significant catches, while other vessels have left following the structural adjustment in 2007 and not returned. Annual standardized CPUE appears cyclical above and below average and has remained below average since 2012 (Figure 299). There has also been an overall decrease in standardized CPUE over the 2007-2020 period despite the significant increases in CPUE towards the long-term average since 2020 (i.e., in 2021 and 2022).

Action Items and Issues

It is recommended that an exploration of the fishery dynamics be evaluated to determine whether the CPUE values are being influenced by the species being targeted within individual shots (e.g., is there interference between shots of mostly Flathead compared to shots of mostly School Whiting). This will be important for determining whether estimated annual indices adequately reflect stock abundance.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 212: FlatheadDS2060S2. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	FlatheadDS2060S2
csirocode	37296001, 37296000
fishery	SET
depthrange	0 - 200
depthclass	20
zones	20, 30, 60
methods	DS, SSC, RS
years	1986 - 2022

Table 213: FlatheadDS2060S2. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1892.2	5581	769.2	26	203.5	1.1654	0.000	27.135	0.035
1987	2461.3	5534	1340.9	24	352.5	1.6530	0.024	25.105	0.019
1988	2469.5	5745	1074.7	25	268.3	1.8092	0.024	21.449	0.020
1989	2599.1	5384	1138.0	27	297.1	1.5651	0.024	27.184	0.024
1990	2032.3	4462	568.1	24	157.2	1.0507	0.025	28.665	0.050
1991	2230.2	4463	746.5	28	215.7	1.4280	0.025	24.633	0.033
1992	2375.4	6503	1196.8	23	233.5	1.5251	0.023	27.718	0.023
1993	1879.1	5954	532.9	25	113.2	0.9359	0.024	40.678	0.076
1994	1710.4	7163	633.0	24	124.9	0.8128	0.023	40.569	0.064
1995	1800.6	5420	648.6	21	204.7	0.8324	0.024	24.806	0.038
1996	1879.9	7508	742.7	22	139.0	0.7806	0.023	44.616	0.060
1997	2356.0	8279	1136.0	20	192.2	1.0177	0.022	37.876	0.033
1998	2306.4	9800	1126.5	21	147.9	0.8598	0.022	48.033	0.043
1999	3117.7	8669	1679.4	23	269.0	1.2554	0.022	25.632	0.015
2000	2945.6	7295	1079.7	19	199.3	0.9305	0.023	32.454	0.030
2001	2599.5	7781	1066.4	19	196.4	0.8782	0.023	32.654	0.031
2002	2876.3	8124	1130.0	22	182.0	1.0334	0.023	31.327	0.028
2003	3229.9	8872	1187.0	23	168.5	1.0712	0.023	30.001	0.025
2004	3222.8	7644	1234.5	22	194.6	1.0572	0.023	24.994	0.020
2005	2844.1	7008	1104.9	22	184.3	1.0754	0.024	22.184	0.020
2006	2585.8	5461	950.5	21	233.5	1.0553	0.025	15.784	0.017
2007	2648.3	5493	1165.4	16	293.0	1.2636	0.025	14.912	0.013
2008	2912.3	6161	1268.3	15	279.1	1.1314	0.024	18.287	0.014
2009	2460.5	5434	1153.5	15	318.1	1.1746	0.025	17.949	0.016
2010	2502.3	5997	1159.0	15	274.1	1.0669	0.024	15.542	0.013
2011	2465.9	6798	1113.5	14	209.0	0.9891	0.024	20.671	0.019
2012	2780.6	7158	1372.2	14	299.5	0.9416	0.024	19.403	0.014
2013	1941.0	7307	961.1	14	171.0	0.6700	0.024	31.201	0.032
2014	2369.9	8375	1170.8	14	187.0	0.7297	0.023	32.867	0.028
2015	2667.9	8618	1311.2	15	196.1	0.7216	0.023	39.398	0.030
2016	2775.6	9257	1468.4	16	205.5	0.7528	0.023	40.877	0.028
2017	2311.7	8936	1233.8	18	175.1	0.7262	0.023	43.103	0.035
2018	2000.8	8510	947.2	19	137.2	0.5187	0.023	46.367	0.049
2019	1938.1	8900	950.8	19	133.1	0.4829	0.023	47.063	0.050
2020	1990.2	9185	905.1	19	125.5	0.4866	0.023	47.313	0.052
2021	2071.0	7765	1100.1	19	180.2	0.6481	0.024	35.770	0.033
2022	1821.9	7613	1023.7	18	166.0	0.9038	0.024	37.401	0.037

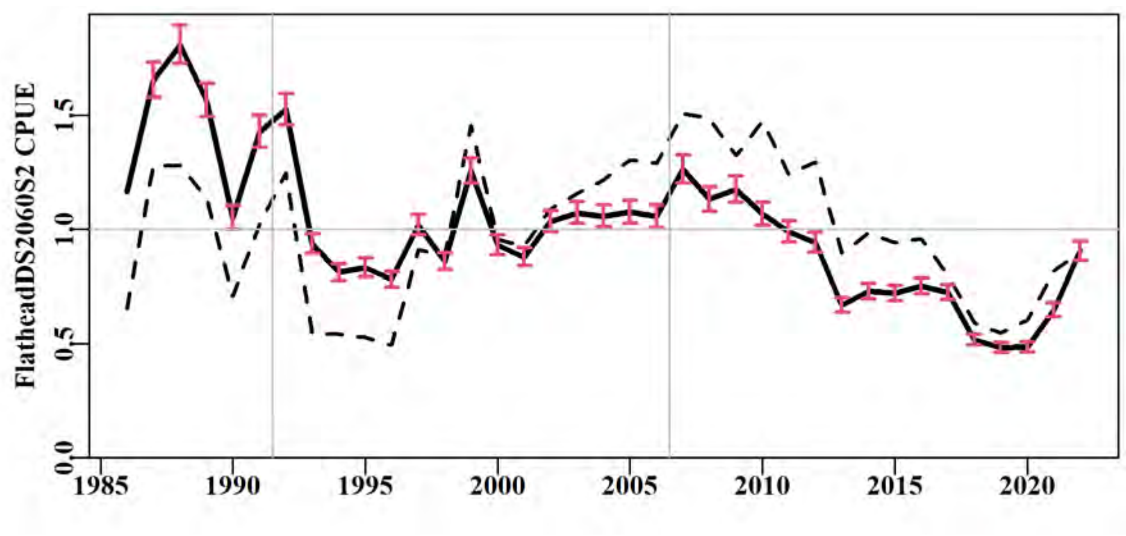

Figure 299: FlatheadDS2060S2 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

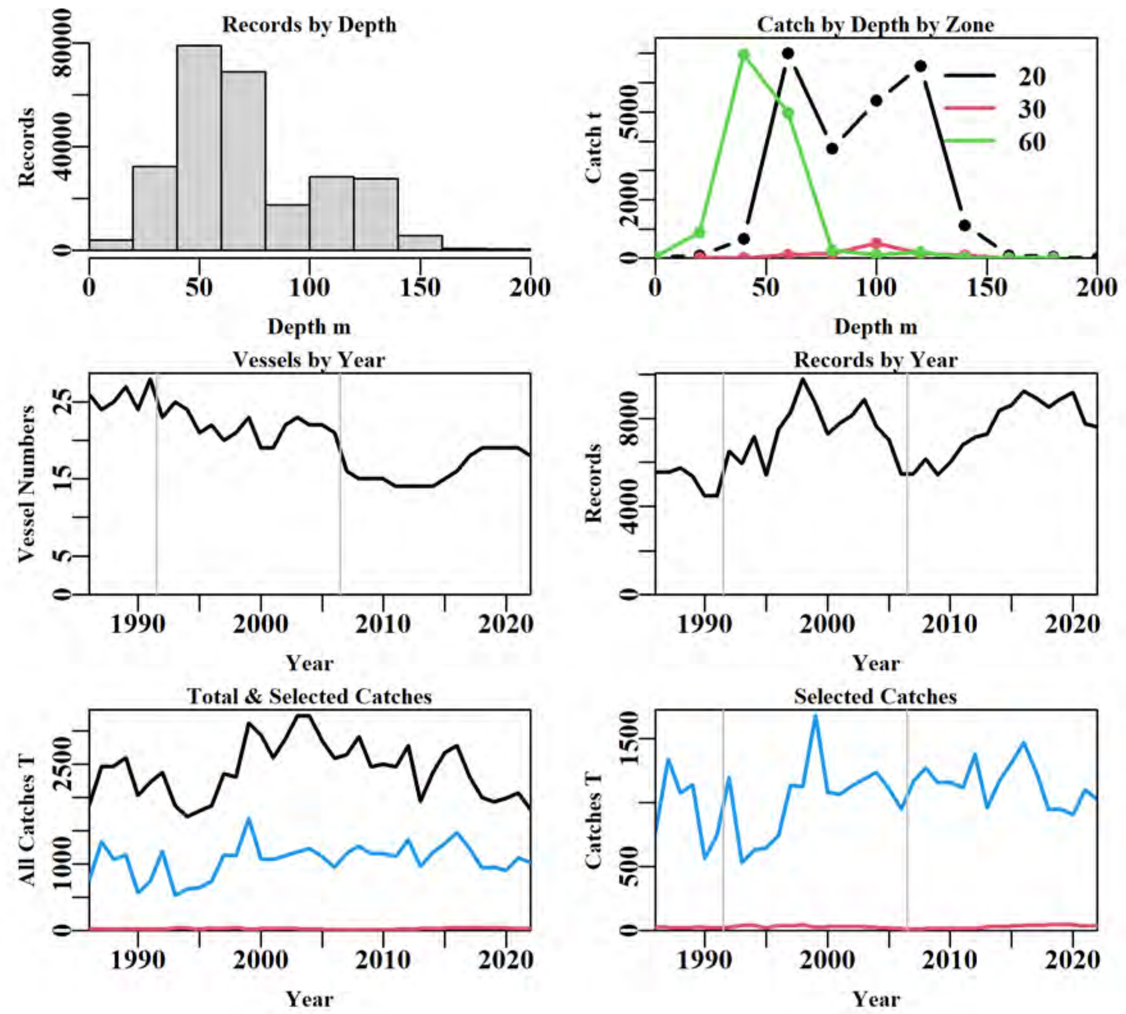

Figure 300: FlatheadDS2060S2 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 214: FlatheadDS2060S2 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	697816	679375	633991	625876	440333	267168	265305
Difference	0	18441	45384	8115	185543	173165	1863
Catch	90063	90063	85187	84222	67282	39507	39439
Difference	0	0	4876	966	16940	27775	68

Table 215: The models used to analyse data for FlatheadDS2060S2.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Month
Model4	Year + DepCat + Month + Vessel
Model5	Year + DepCat + Month + Vessel + DayNight
Model6	Year + DepCat + Month + Vessel + DayNight + Zone
Model7	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:Month
Model8	Year + DepCat + Month + Vessel + DayNight + Zone + Zone:DepCat

Table 216: FlatheadDS2060S2. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	206578	577259	28017	264157	37	4.6	0.00
DepCat	135669	441325	163951	264157	47	27.1	22.46
Month	123115	420805	184470	264157	58	30.5	3.39
Vessel	108085	397356	207919	264157	116	34.3	3.86
DayNight	103223	390102	215173	264157	119	35.5	1.20
Zone	100129	385554	219722	264157	121	36.3	0.75
Zone:Month	95775	379186	226089	264157	143	37.3	1.05
Zone:DepCat	99459	384529	220746	264157	137	36.4	0.17

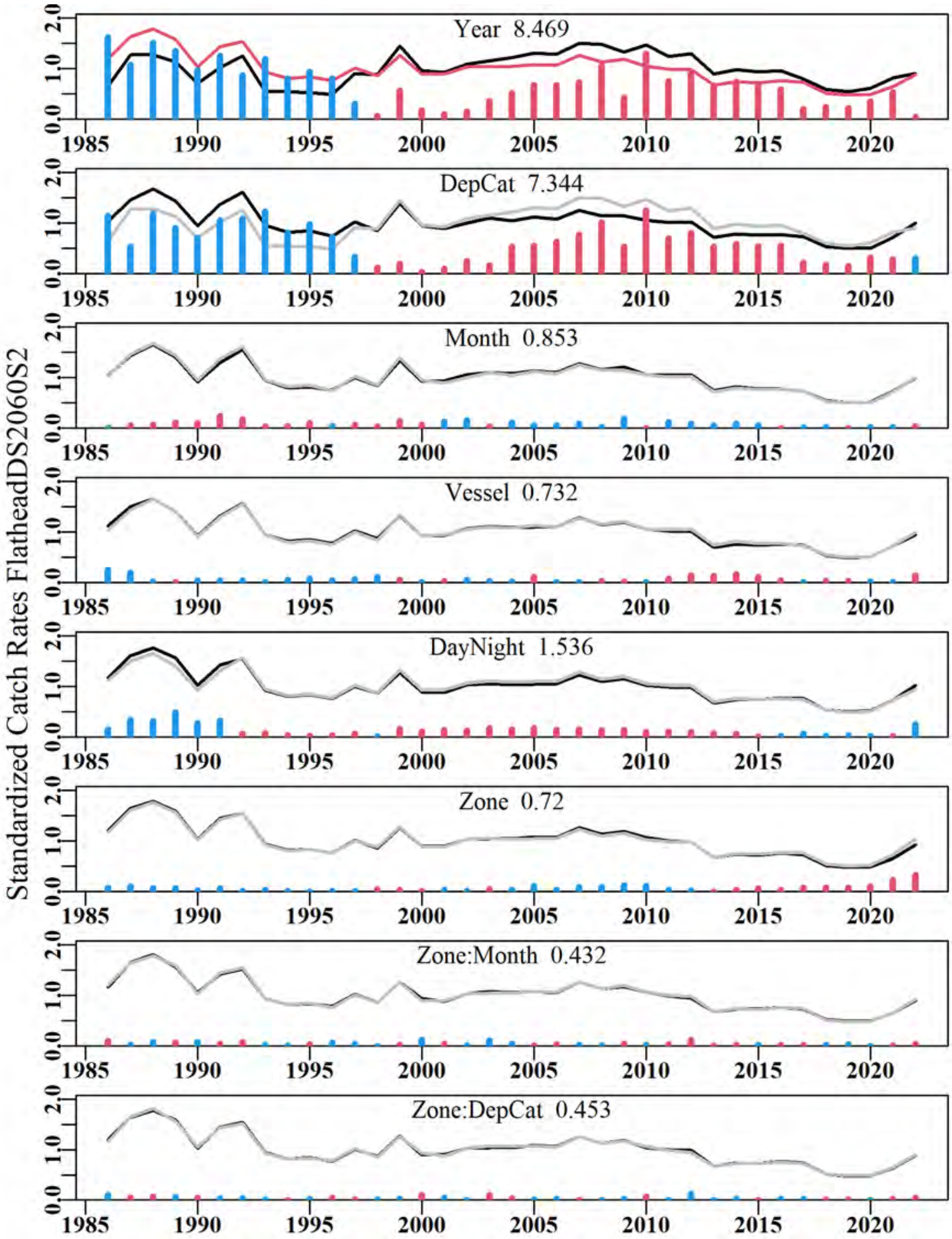

Figure 301: FlatheadDS2060S2. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

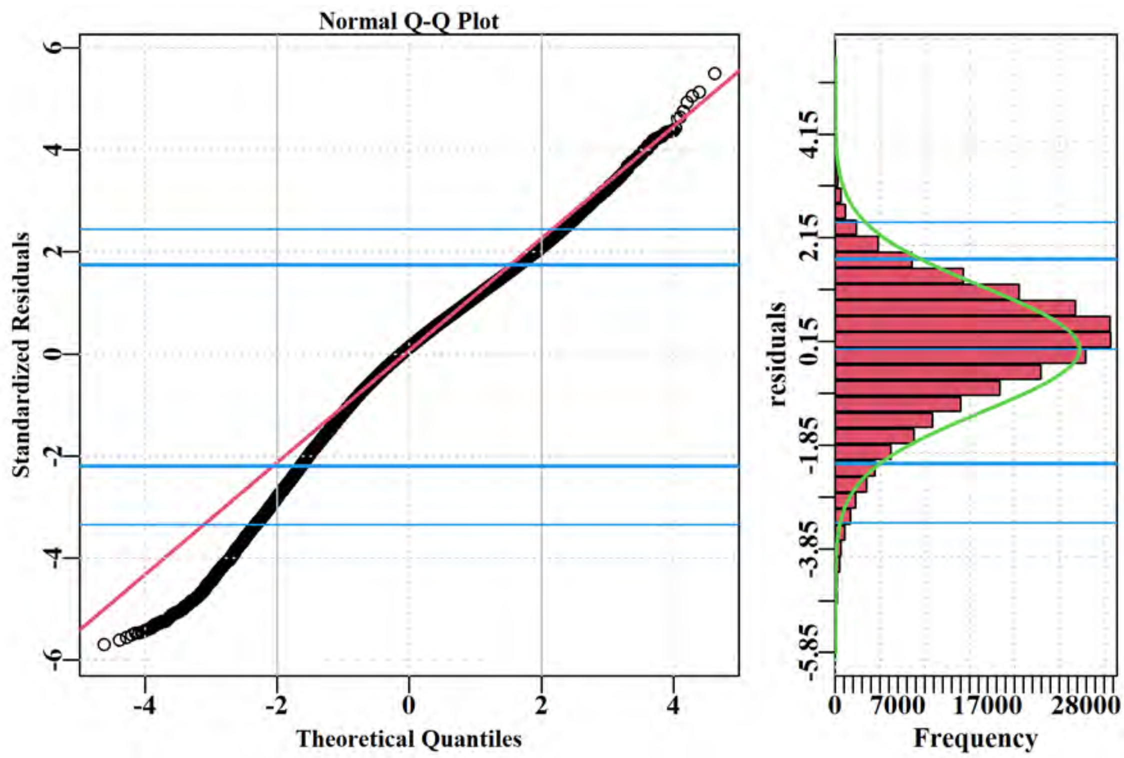

Figure 302: FlatheadDS2060S2. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

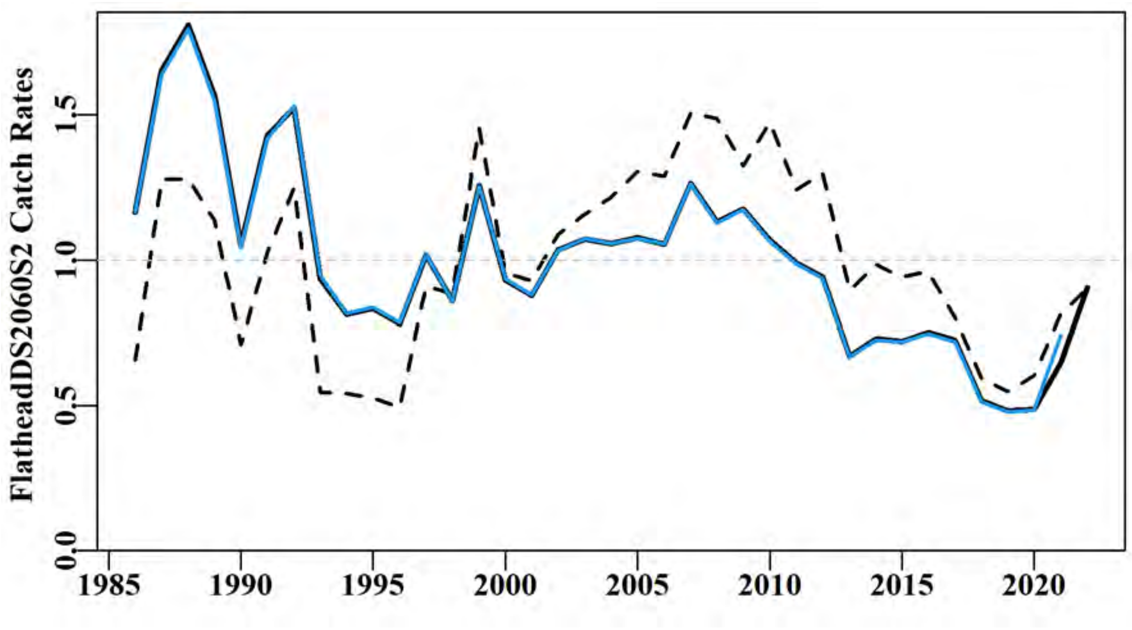

Figure 303: FlatheadDS2060S2. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

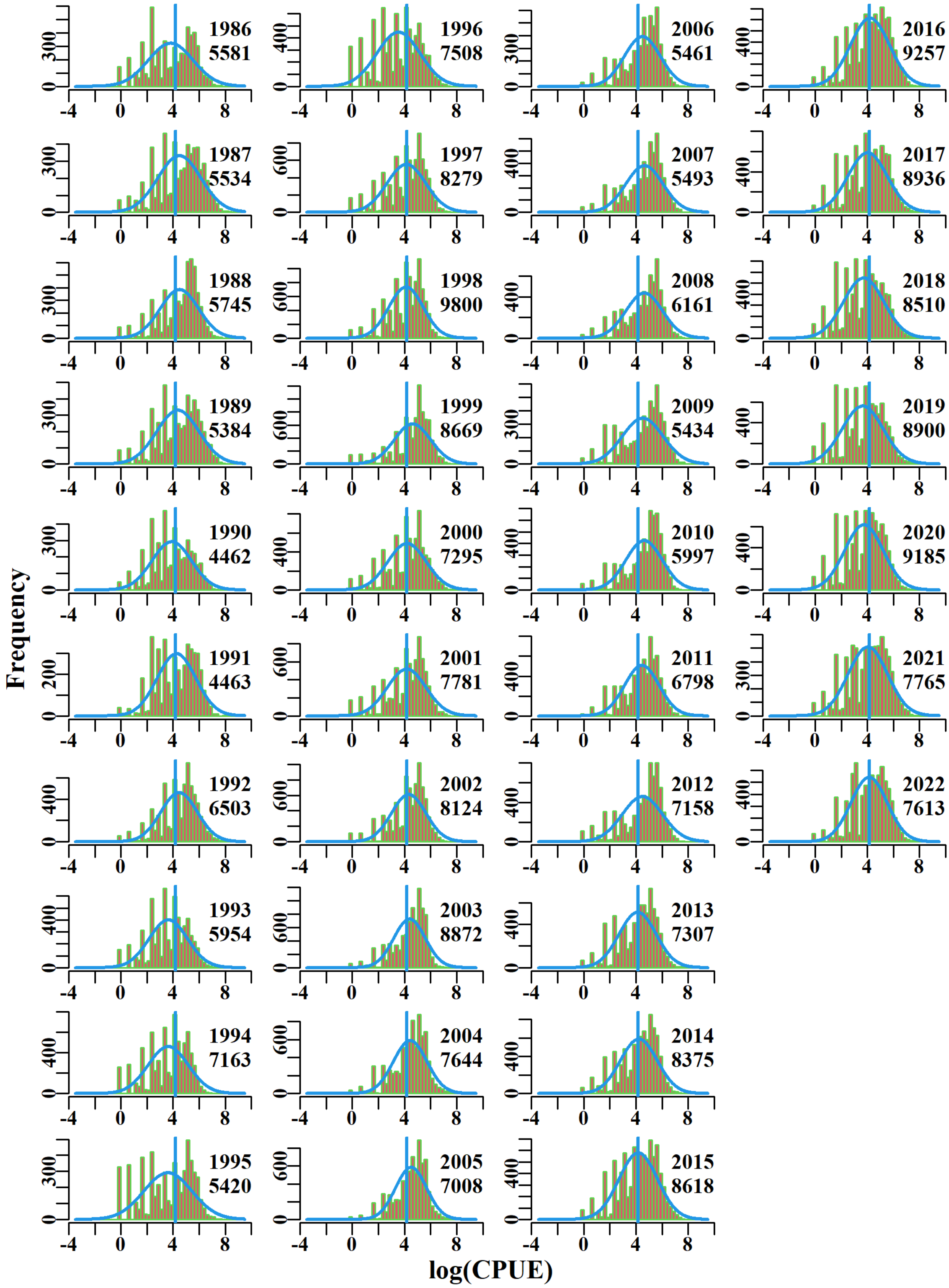

Figure 304: FlatheadDS2060S2. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

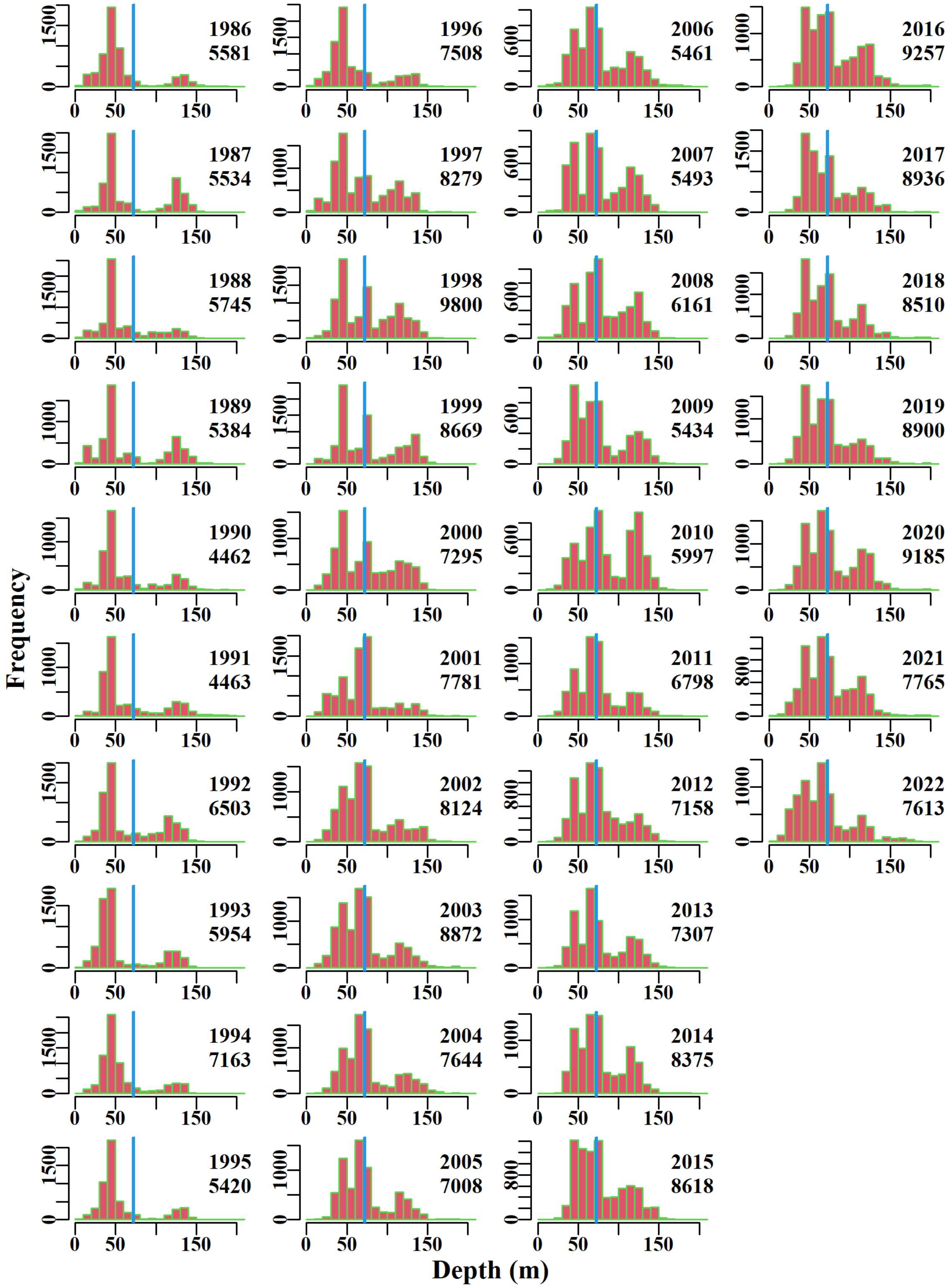

Figure 305: FlatheadDS2060S2. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

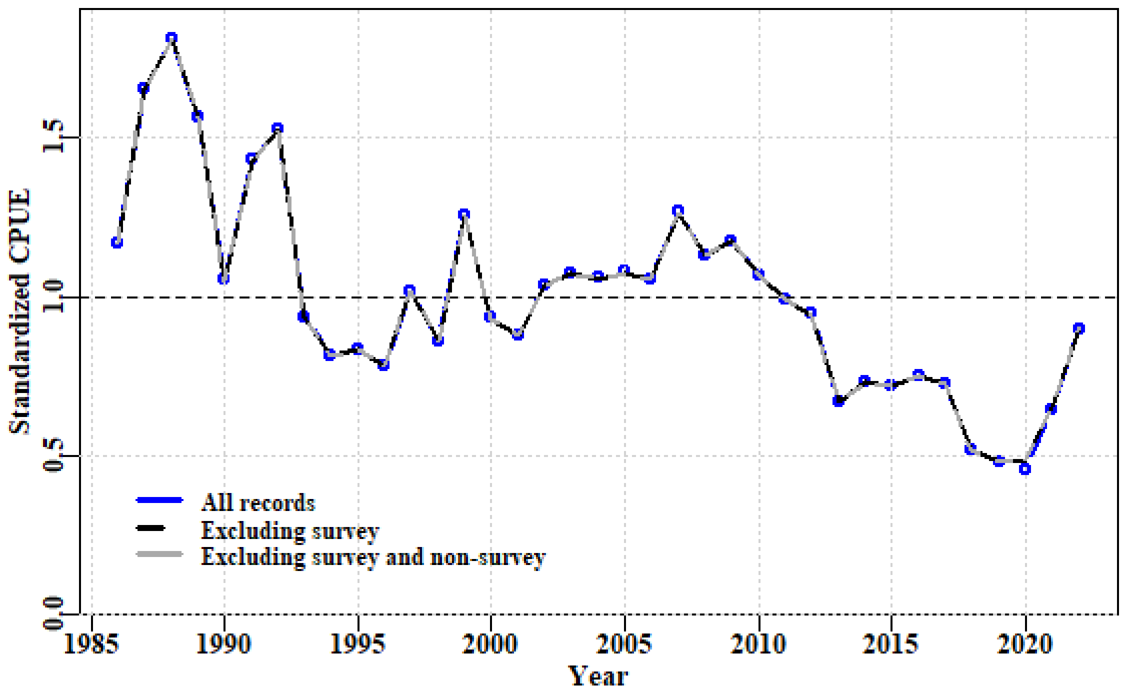

Figure 306: Comparison of the optimum standardization for Flathead with all data (All records), removal of seismic records (Excluding survey) and removal of seismic records and also non-survey records from the same survey area and temporal period that were not part of the survey (Excluding survey and non-survey).

School Whiting DS 60 - Excluding seismic survey records

School Whiting (WHS – 37330014 – *Sillago flindersi*) are taken primarily by Danish seine (and within State waters). In Commonwealth waters, catches are primarily in zone 60, and in depths up to 100 m. All vessels and all records were included in the analysis. CPUE was expressed as the natural log of catch per shot (catch/shot). The years used in the analysis were 1986 - 2022. Initial data selection was based on criteria provided in Table 217 from the Commonwealth logbook database. This analysis excluded records from a seismic survey conducted from 1 January to 7 July 2020 (Knuckey et. al. 2022), as recommended by SESSFRAG (Meeting 27-29 April 2022). A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The early years of this data exhibit relatively large inter-annual variation, far greater than the stock itself could be under-going. This suggests either flaws in the data or some unknown factor having a sporadic effect upon the fishery. Since a low point in 1997, CPUE have been slowly rising and at approximately the long-term average over the 2013-2016 period. The terms Year, DayNight, Vessel and Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 221). Since 2013, there has been fewer catches in deeper waters (i.e., greater than 50 m). Standardized CPUE exhibits a flat trend over 2012-17 and has declined and dropped below the long-term average over the 2017-20 period, based on 95% confidence intervals (Figure 307). Also, there has been an increase in standardized CPUE in 2021 relative to the previous year, followed by a decrease in 2022 relative to 2021.

Action Items and Issues

The qqplot suggests that the assumed Normal distribution of the log-transformed CPUE, in fact log(catch per shot) may be invalid, as relatively high proportions of the tails of the distribution deviate from the expected straight line (Figure 310). Further work is required to determine the reason behind the frequent occurrence of spikes of low values of catch-per-shot and how they may best be described or explained.

The influence of vessels fishing changed in about 2003 onwards and this was reinforced by the DayNight term. The vessel effect also changed dramatically since 2014, at which time the distribution of catches among the vessels participating became more even than previously.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 217: SchoolWhiting60S1. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SchoolWhiting60S1
csirocode	37330014
fishery	SET_GHT
depthrange	0 - 100
depthclass	20
zones	60
methods	DS, SSC, RS
years	1986 - 2022

Table 218: SchoolWhiting60S1. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DepCat:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1302.4	5616	1167.1	26	262.4	1.2055	0.000	18.476	0.016
1987	996.0	4058	909.2	23	271.6	1.3402	0.029	12.131	0.013
1988	1255.7	3767	1157.7	25	375.6	1.7098	0.030	10.303	0.009
1989	1061.5	4421	989.1	26	260.6	1.1355	0.029	14.045	0.014
1990	1930.4	6082	1803.1	24	351.5	1.7512	0.027	15.136	0.008
1991	1630.3	4645	1456.3	26	407.7	1.5416	0.029	10.954	0.008
1992	854.1	2906	751.3	23	362.0	1.1306	0.033	8.103	0.011
1993	1694.9	4809	1511.1	24	444.4	1.6105	0.029	9.958	0.007
1994	946.2	4407	864.8	23	273.8	0.9387	0.029	12.619	0.015
1995	1212.6	4198	1050.0	21	337.1	1.1989	0.030	9.197	0.009
1996	898.2	4126	692.3	22	223.6	0.7902	0.030	13.981	0.020
1997	697.4	3066	442.1	20	202.5	0.5971	0.032	11.232	0.025
1998	594.2	2913	447.6	20	211.5	0.5730	0.033	10.661	0.024
1999	681.3	1870	411.5	21	345.1	0.6554	0.039	6.013	0.015
2000	700.9	1916	343.9	18	266.9	0.6820	0.038	7.058	0.021
2001	890.9	1990	424.6	19	296.0	0.9355	0.039	6.779	0.016
2002	788.3	2186	428.2	20	258.4	0.9026	0.037	7.753	0.018
2003	866.2	2338	460.0	20	275.4	0.9451	0.037	7.942	0.017
2004	604.9	1751	332.0	20	264.4	0.8553	0.040	6.951	0.021
2005	662.7	1562	296.4	20	255.6	0.9520	0.041	4.883	0.016
2006	667.5	1404	263.4	18	258.3	0.8622	0.043	5.336	0.020
2007	535.4	1469	343.1	14	330.0	1.1498	0.042	4.479	0.013
2008	502.2	1248	313.7	15	370.2	1.1335	0.045	4.280	0.014
2009	462.6	1548	347.6	15	309.7	1.2303	0.042	5.171	0.015
2010	408.9	1167	270.8	15	339.6	1.0673	0.046	4.199	0.016
2011	373.9	1564	257.2	14	198.8	0.8534	0.041	6.430	0.025
2012	435.8	1562	302.3	14	262.7	0.9209	0.042	5.604	0.019
2013	510.6	1765	336.1	14	249.9	0.9623	0.040	6.569	0.020
2014	698.8	2047	480.8	14	336.2	1.0745	0.038	6.106	0.013
2015	741.1	2449	563.7	14	327.5	1.0438	0.036	7.530	0.013
2016	698.7	2334	557.6	15	303.8	1.0167	0.037	7.843	0.014
2017	743.3	2381	631.9	16	378.2	0.9462	0.037	6.235	0.010
2018	589.4	2646	510.0	17	242.0	0.7223	0.035	9.530	0.019
2019	479.1	2792	402.1	17	175.1	0.6195	0.035	10.879	0.027
2020	511.3	2230	392.8	18	230.2	0.5812	0.038	9.856	0.025
2021	703.5	1866	587.5	17	236.0	0.7332	0.040	7.065	0.012
2022	437.3	1795	296.9	17	207.7	0.6322	0.040	7.123	0.024

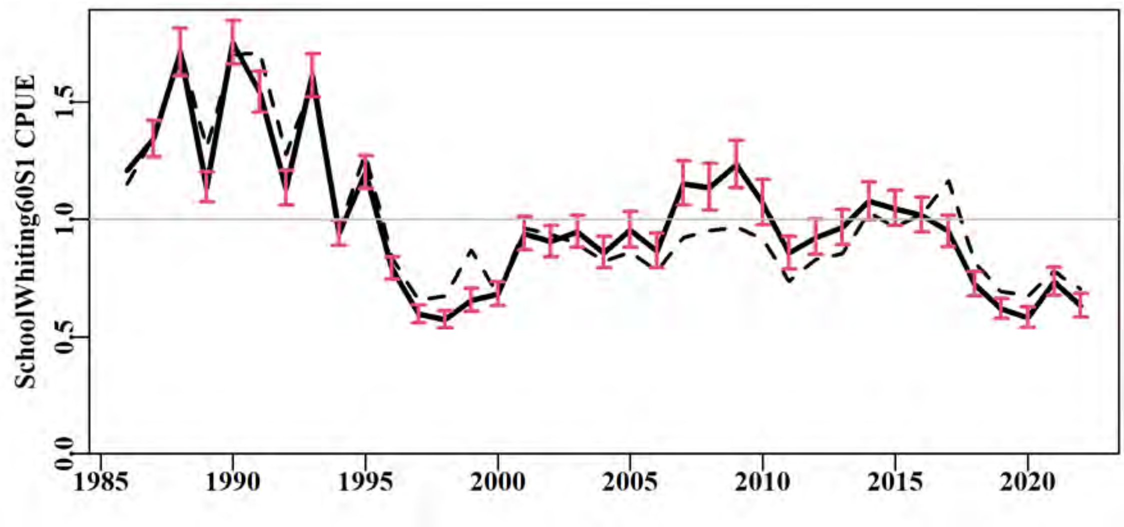

Figure 307: SchoolWhiting60S1 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

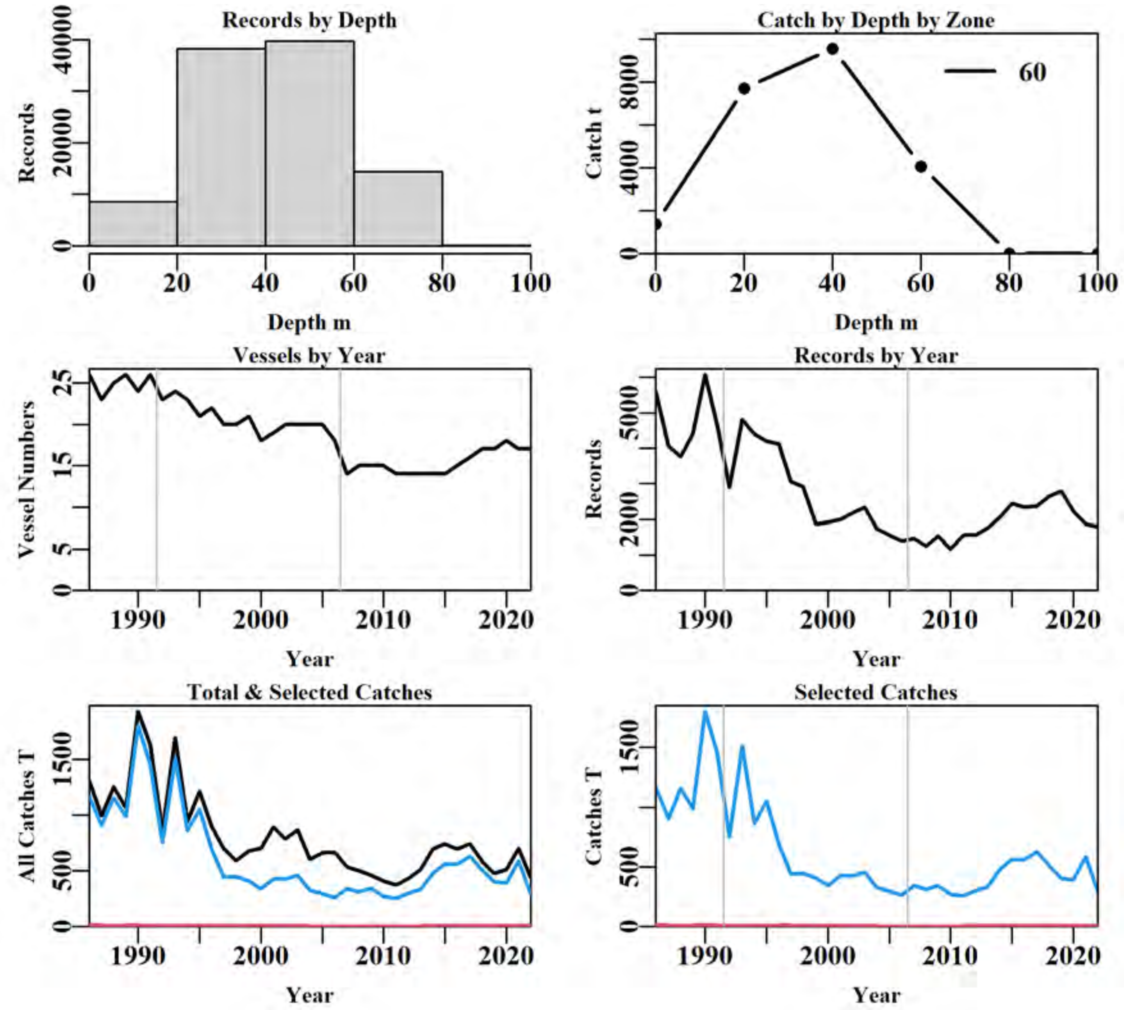

Figure 308: SchoolWhiting60S1 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 219: SchoolWhiting60S1 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156969	148163	143086	141114	106889	104111	101182
Difference	0	8806	5077	1972	34225	2778	2929
Catch	30114	30114	29373	29031	23923	23503	22813
Difference	0	0	741	342	5108	420	690

Table 220: The models used to analyse data for SchoolWhiting60S1.

	Model
Model1	Year
Model2	Year + DayNight
Model3	Year + DayNight + Vessel
Model4	Year + DayNight + Vessel + Month
Model5	Year + DayNight + Vessel + Month + DepCat
Model6	Year + DayNight + Vessel + Month + DepCat + DayNight:DepCat
Model7	Year + DayNight + Vessel + Month + DepCat + DepCat:Month
Model8	Year + DayNight + Vessel + Month + DepCat + DayNight:Month

Table 221: SchoolWhiting60S1. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DepCat:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	74149	210242	9406	100894	37	4.2	0.00
DayNight	70111	201982	17666	100894	40	8.0	3.76
Vessel	65905	193539	26109	100894	91	11.8	3.80
Month	64728	191253	28395	100894	102	12.8	1.03
DepCat	64213	190260	29388	100894	107	13.3	0.45
DayNight:DepCat	64030	189873	29775	100894	118	13.5	0.17
DepCat:Month	63509	188780	30867	100894	149	13.9	0.64
DayNight:Month	63953	189645	30003	100894	140	13.5	0.25

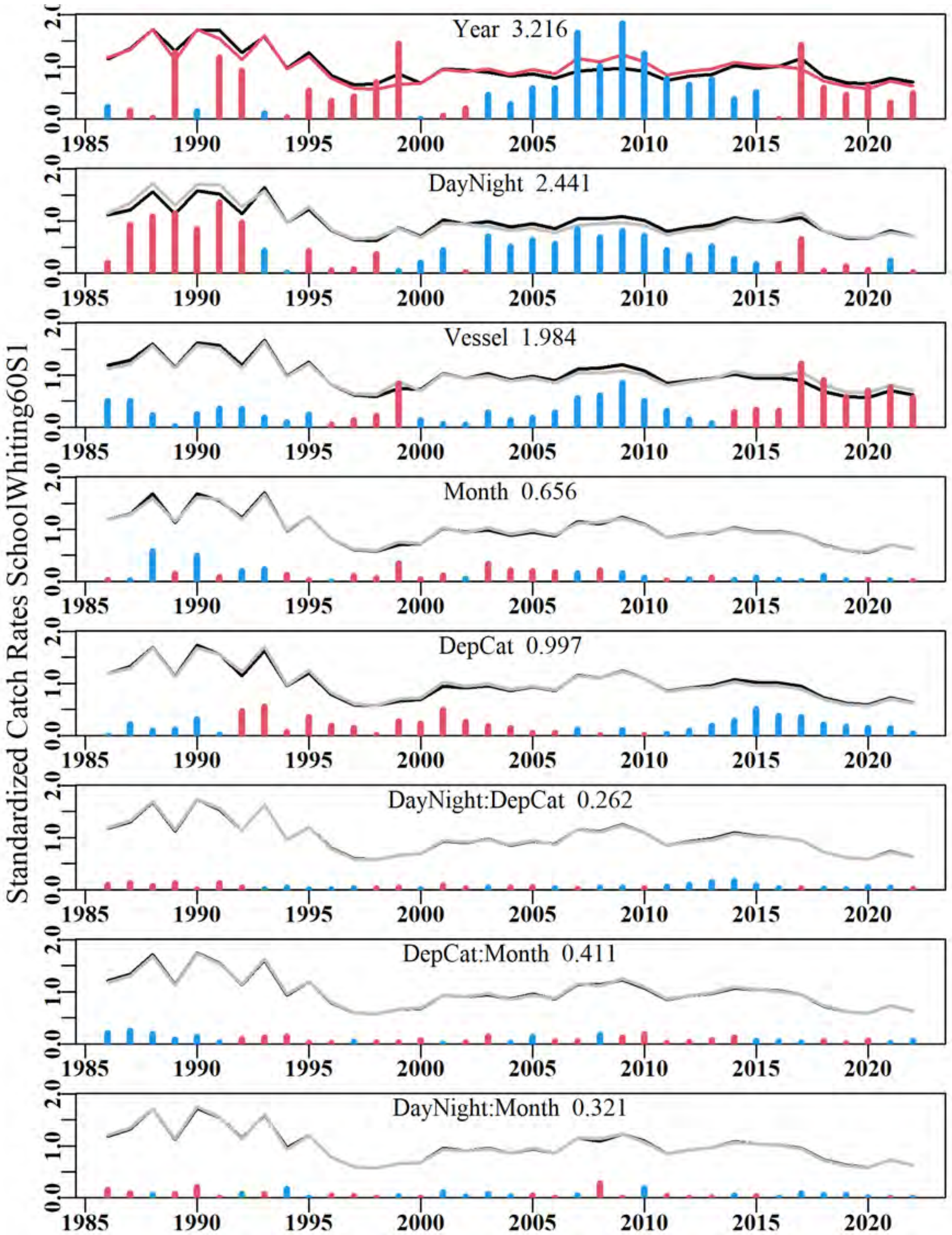

Figure 309: SchoolWhiting60S1. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

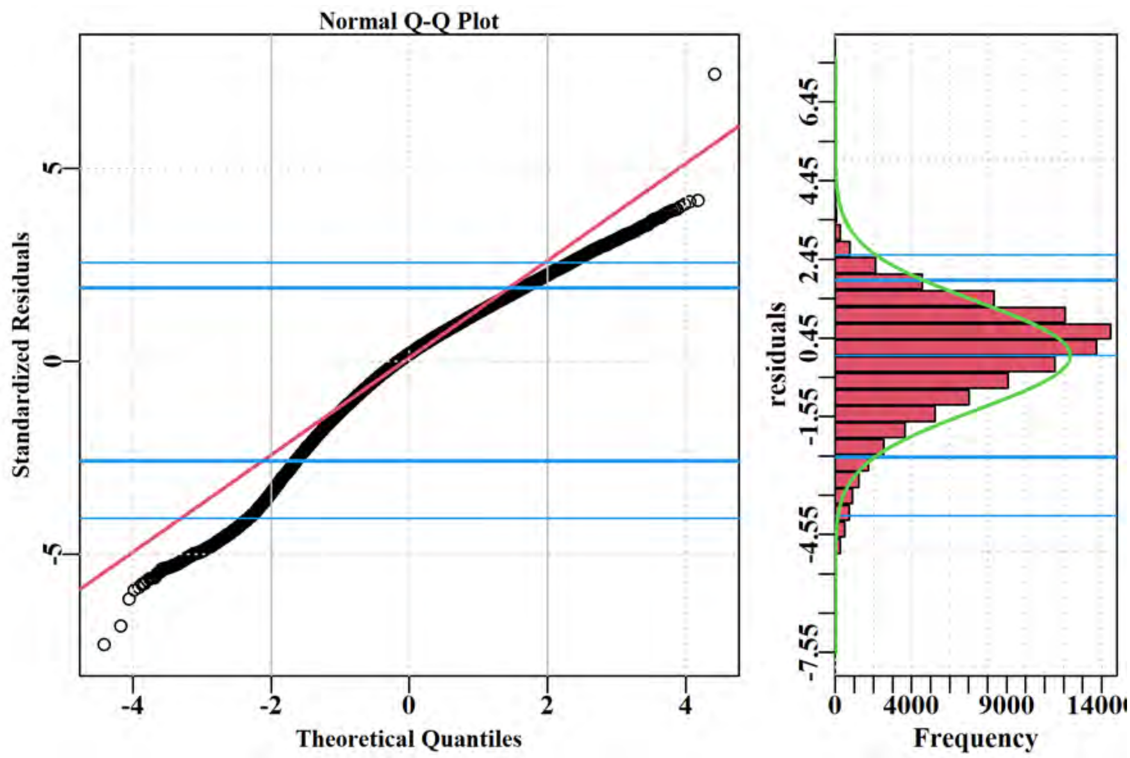

Figure 310: SchoolWhiting60S1. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

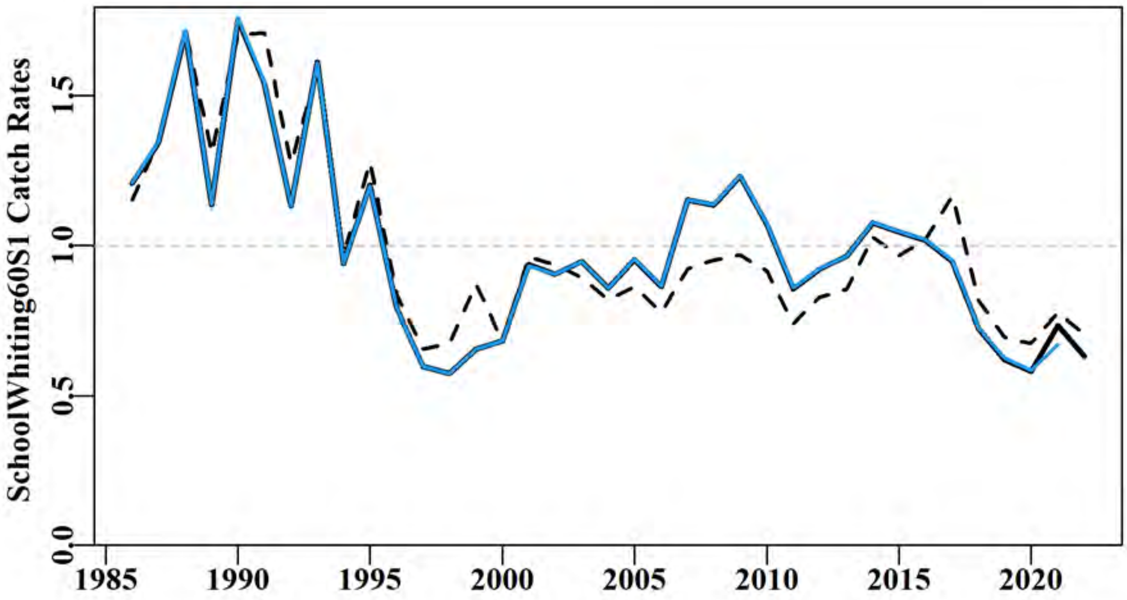

Figure 311: SchoolWhiting60S1. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

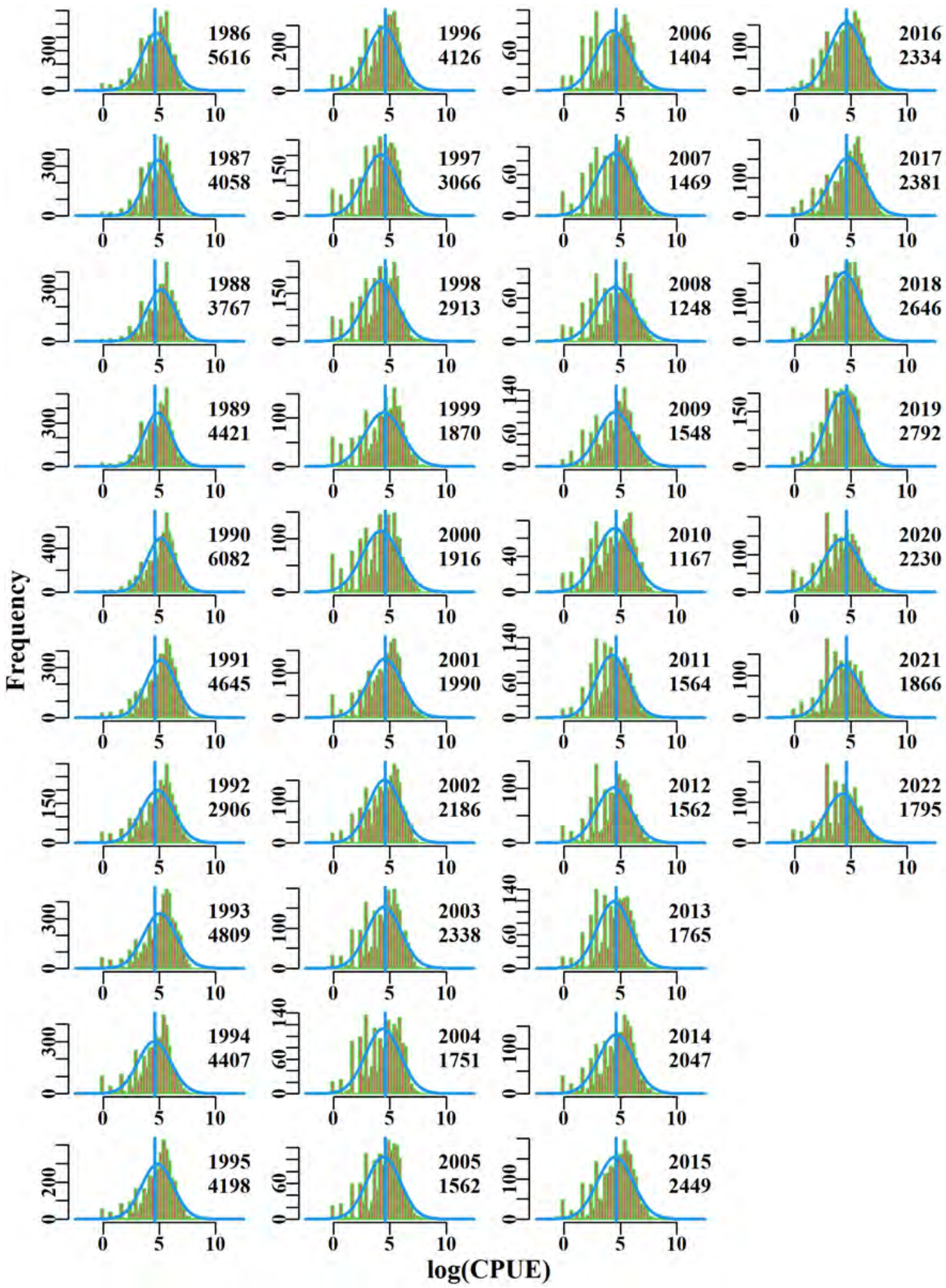

Figure 312: SchoolWhiting60S1. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

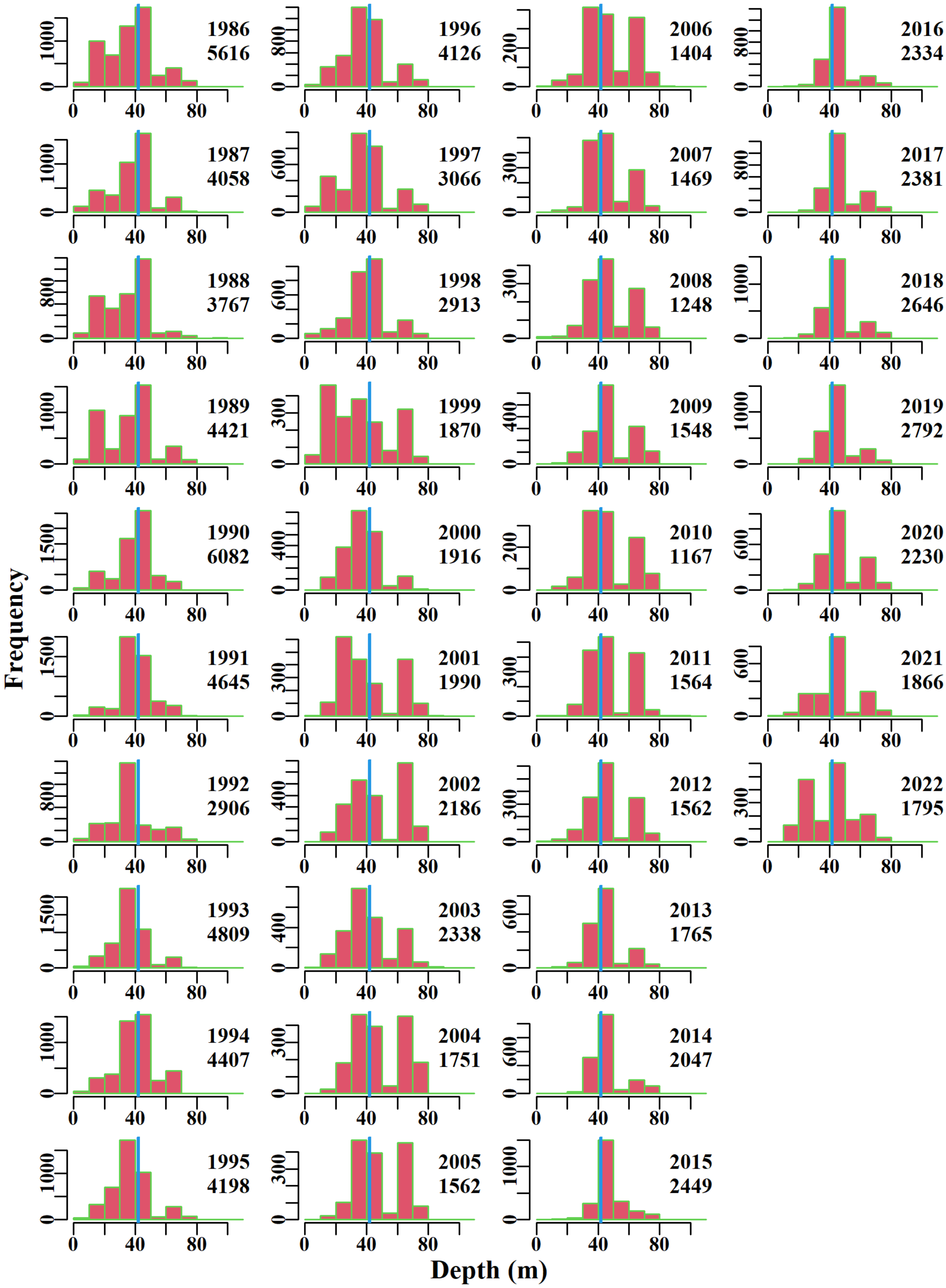

Figure 313: SchoolWhiting60S1. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

School Whiting DS 60 - Excluding seismic survey records and non-survey records from same space-time period

School Whiting (WHS – 37330014 – *Sillago flindersi*) are taken primarily by Danish seine (and within State waters). In Commonwealth waters, catches are primarily in zone 60, and in depths up to 100 m. All vessels and all records were included in the analysis. CPUE was expressed as the natural log of catch per shot (catch/shot). The years used in the analysis were 1986 - 2022. Initial data selection was based on criteria provided in Table 222 from the Commonwealth logbook database. This analysis excluded records from the seismic survey conducted from 1 January to 7 July 2020 (Knuckey et. al., 2022), as recommended by SESSFRAG (Meeting 27-29 April 2022). In addition, it also excluded records from vessels that fished in the survey area and over the same temporal period but were not involved in the survey. A total of 8 statistical models were fitted sequentially to the available data, and the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The early years of this data exhibit relatively large inter-annual variation, far greater than the stock itself could be under-going. This suggests either flaws in the data or some unknown factor having a sporadic effect upon the fishery. Since a low point in 1997, CPUE have been slowly rising and at approximately the long-term average over the 2013-2016 period. The terms Year, DayNight, Vessel and Month had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE based on the AIC and R^2 statistics (Table 226). Since 2013, there has been fewer catches in deeper waters (i.e., greater than 50 m). Standardized CPUE exhibits a flat trend over 2012-17 and has declined and dropped below the long-term average over the 2017-20 period, based on 95% confidence intervals (Figure 314). Also, there has been an increase in standardized CPUE in 2021 relative to the previous year, followed by a decrease in 2022 relative to 2021.

Action Items and Issues

The qqplot suggests that the assumed Normal distribution of the log-transformed CPUE, in fact log(catch per shot) may be invalid, as relatively high proportions of the tails of the distribution deviate from the expected straight line (Figure 317). Further work is required to determine the reason behind the frequent occurrence of spikes of low values of catch-per-shot and how they may best be described or explained.

The influence of vessels fishing changed in about 2003 onwards and this was reinforced by the DayNight term. The vessel effect also changed dramatically since 2014, at which time the distribution of catches among the vessels participating became more even than previously.

Fishing depths have been (i) recorded as single values or (ii) recorded at more than one constant value across different operations in the Commonwealth logbook database for certain vessels since about 2016. These fishing depths have been modified based on positional bathymetry and have been used in the standardization analysis presented here, as agreed by SESSFRAG since 2020.

Table 222: SchoolWhiting60S2. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SchoolWhiting60S2
csirocode	37330014
fishery	SET_GHT
depthrange	0 - 100
depthclass	20
zones	60
methods	DS, SSC, RS
years	1986 - 2022

Table 223: SchoolWhiting60S2. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/shot), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was DepCat:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1986	1302.4	5616	1167.1	26	262.4	1.2048	0.000	18.476	0.016
1987	996.0	4058	909.2	23	271.6	1.3396	0.029	12.131	0.013
1988	1255.7	3767	1157.7	25	375.6	1.7091	0.030	10.303	0.009
1989	1061.5	4421	989.1	26	260.6	1.1344	0.029	14.045	0.014
1990	1930.4	6082	1803.1	24	351.5	1.7501	0.027	15.136	0.008
1991	1630.3	4645	1456.3	26	407.7	1.5408	0.029	10.954	0.008
1992	854.1	2906	751.3	23	362.0	1.1302	0.033	8.103	0.011
1993	1694.9	4809	1511.1	24	444.4	1.6095	0.029	9.958	0.007
1994	946.2	4407	864.8	23	273.8	0.9380	0.029	12.619	0.015
1995	1212.6	4198	1050.0	21	337.1	1.1981	0.030	9.197	0.009
1996	898.2	4126	692.3	22	223.6	0.7897	0.030	13.981	0.020
1997	697.4	3066	442.1	20	202.5	0.5967	0.032	11.232	0.025
1998	594.2	2913	447.6	20	211.5	0.5726	0.033	10.661	0.024
1999	681.3	1870	411.5	21	345.1	0.6551	0.039	6.013	0.015
2000	700.9	1916	343.9	18	266.9	0.6817	0.038	7.058	0.021
2001	890.9	1990	424.6	19	296.0	0.9349	0.039	6.779	0.016
2002	788.3	2186	428.2	20	258.4	0.9023	0.037	7.753	0.018
2003	866.2	2338	460.0	20	275.4	0.9447	0.037	7.942	0.017
2004	604.9	1751	332.0	20	264.4	0.8549	0.040	6.951	0.021
2005	662.7	1562	296.4	20	255.6	0.9516	0.041	4.883	0.016
2006	667.5	1404	263.4	18	258.3	0.8617	0.043	5.336	0.020
2007	535.4	1469	343.1	14	330.0	1.1496	0.042	4.479	0.013
2008	502.2	1248	313.7	15	370.2	1.1332	0.045	4.280	0.014
2009	462.6	1548	347.6	15	309.7	1.2297	0.042	5.171	0.015
2010	408.9	1167	270.8	15	339.6	1.0670	0.046	4.199	0.016
2011	373.9	1564	257.2	14	198.8	0.8530	0.041	6.430	0.025
2012	435.8	1562	302.3	14	262.7	0.9207	0.042	5.604	0.019
2013	510.6	1765	336.1	14	249.9	0.9616	0.040	6.569	0.020
2014	698.8	2047	480.8	14	336.2	1.0747	0.038	6.106	0.013
2015	741.1	2449	563.7	14	327.5	1.0439	0.036	7.530	0.013
2016	698.7	2334	557.6	15	303.8	1.0169	0.037	7.843	0.014
2017	743.3	2381	631.9	16	378.2	0.9468	0.037	6.235	0.010
2018	589.4	2646	510.0	17	242.0	0.7224	0.035	9.530	0.019
2019	479.1	2792	402.1	17	175.1	0.6194	0.035	10.879	0.027
2020	511.3	2147	387.3	18	236.5	0.5933	0.038	9.350	0.024
2021	703.5	1866	587.5	17	236.0	0.7341	0.040	7.065	0.012
2022	437.3	1795	296.9	17	207.7	0.6328	0.040	7.123	0.024

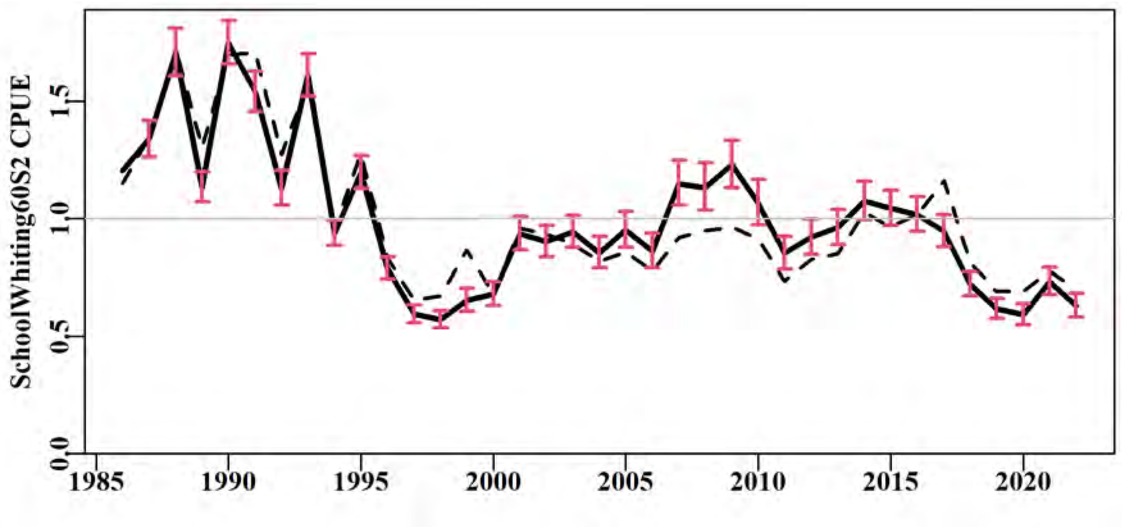

Figure 314: SchoolWhiting60S2 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

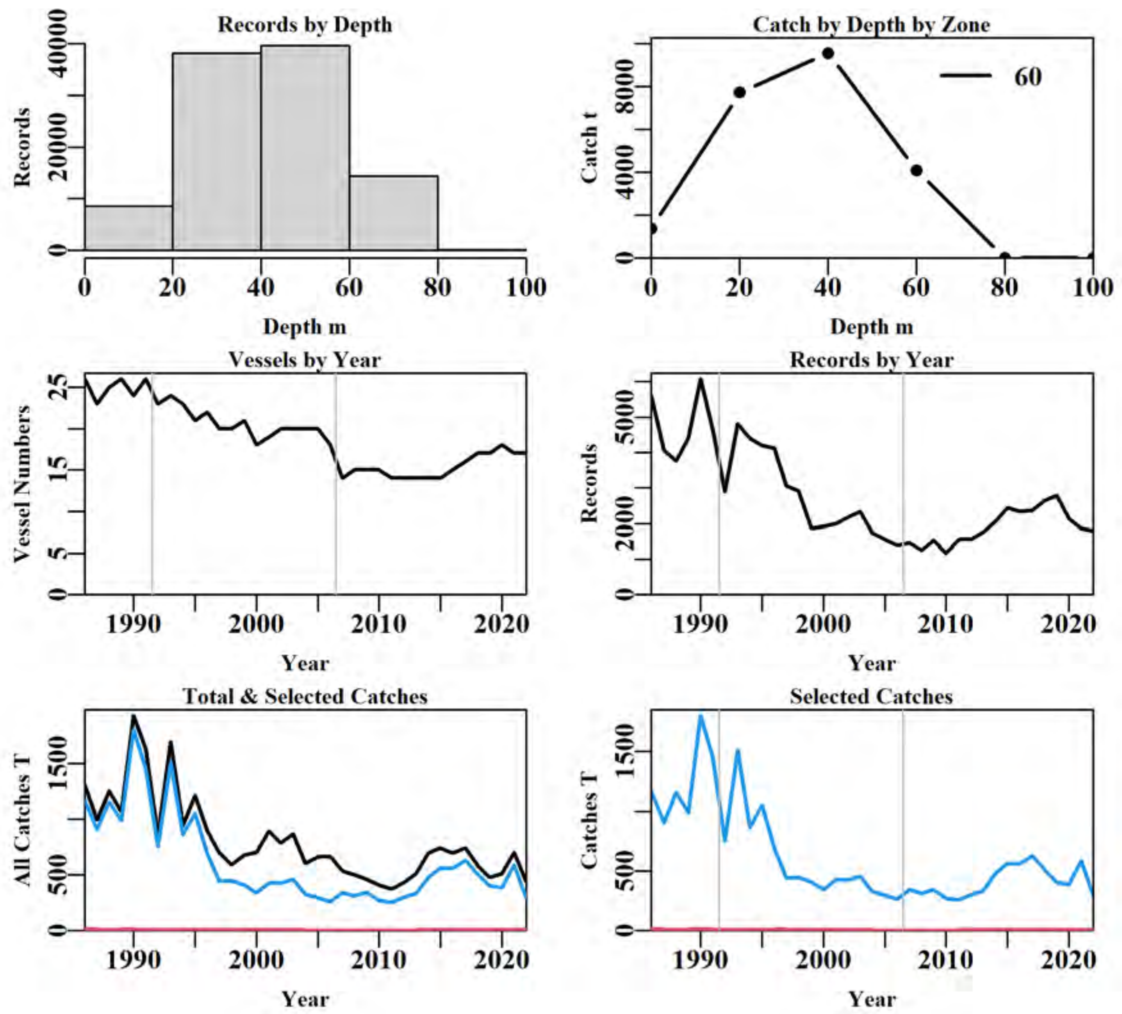

Figure 315: SchoolWhiting60S2 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 224: SchoolWhiting60S2 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	156969	148163	143086	141114	106889	104111	101182
Difference	0	8806	5077	1972	34225	2778	2929
Catch	30114	30114	29373	29031	23923	23503	22813
Difference	0	0	741	342	5108	420	690

Table 225: The models used to analyse data for SchoolWhiting60S2.

	Model
Model1	Year
Model2	Year + DayNight
Model3	Year + DayNight + Vessel
Model4	Year + DayNight + Vessel + Month
Model5	Year + DayNight + Vessel + Month + DepCat
Model6	Year + DayNight + Vessel + Month + DepCat + DayNight:DepCat
Model7	Year + DayNight + Vessel + Month + DepCat + DepCat:Month
Model8	Year + DayNight + Vessel + Month + DepCat + DayNight:Month

Table 226: SchoolWhiting60S2. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was DepCat:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	74074	210039	9343	100811	37	4.2	0.00
DayNight	70041	201791	17591	100811	40	8.0	3.76
Vessel	65858	193393	25989	100811	91	11.8	3.78
Month	64675	191095	28287	100811	102	12.8	1.04
DepCat	64163	190108	29275	100811	107	13.3	0.45
DayNight:DepCat	63980	189721	29661	100811	118	13.4	0.17
DepCat:Month	63460	188630	30752	100811	149	13.9	0.64
DayNight:Month	63902	189493	29889	100811	140	13.5	0.25

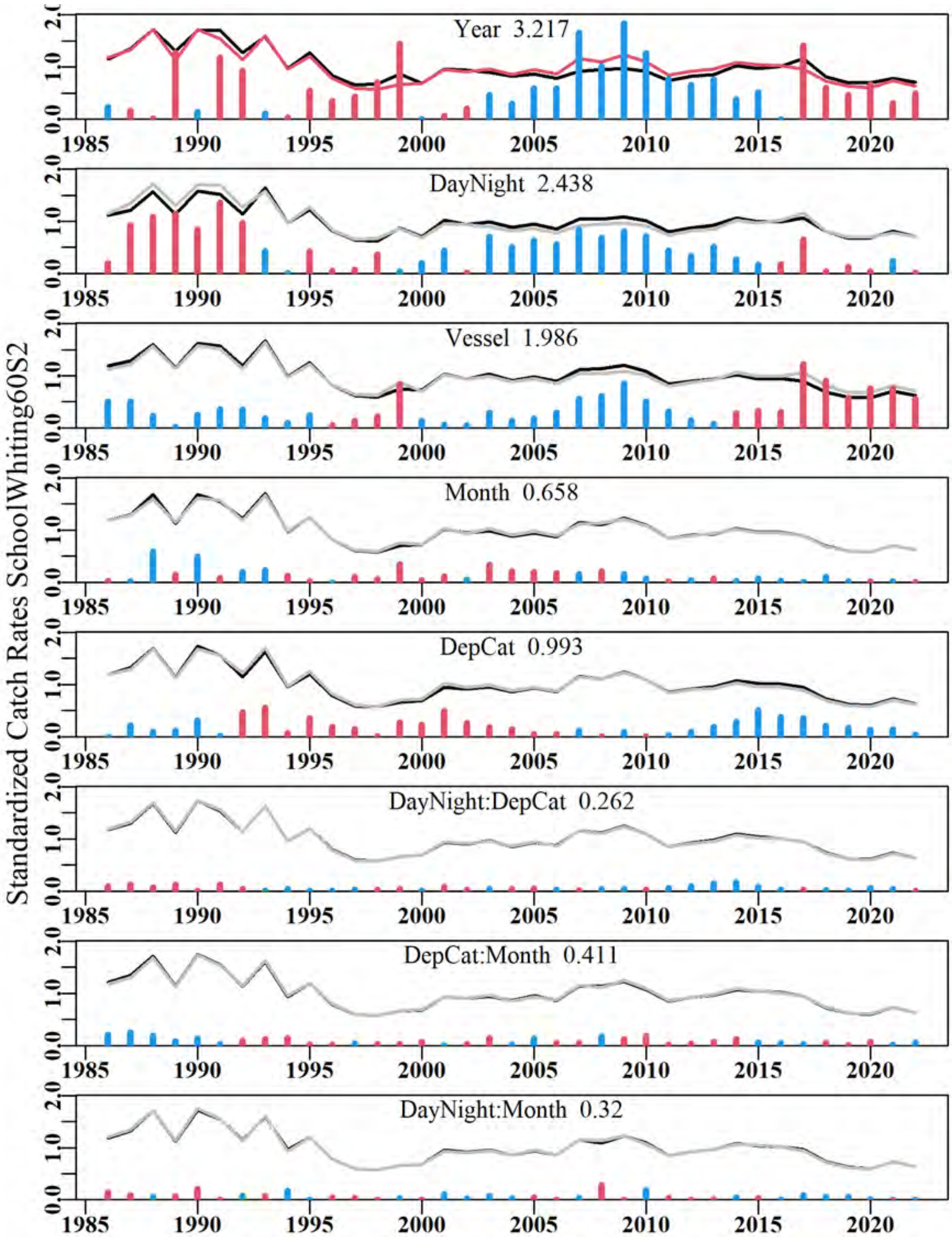

Figure 316: SchoolWhiting60S2. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

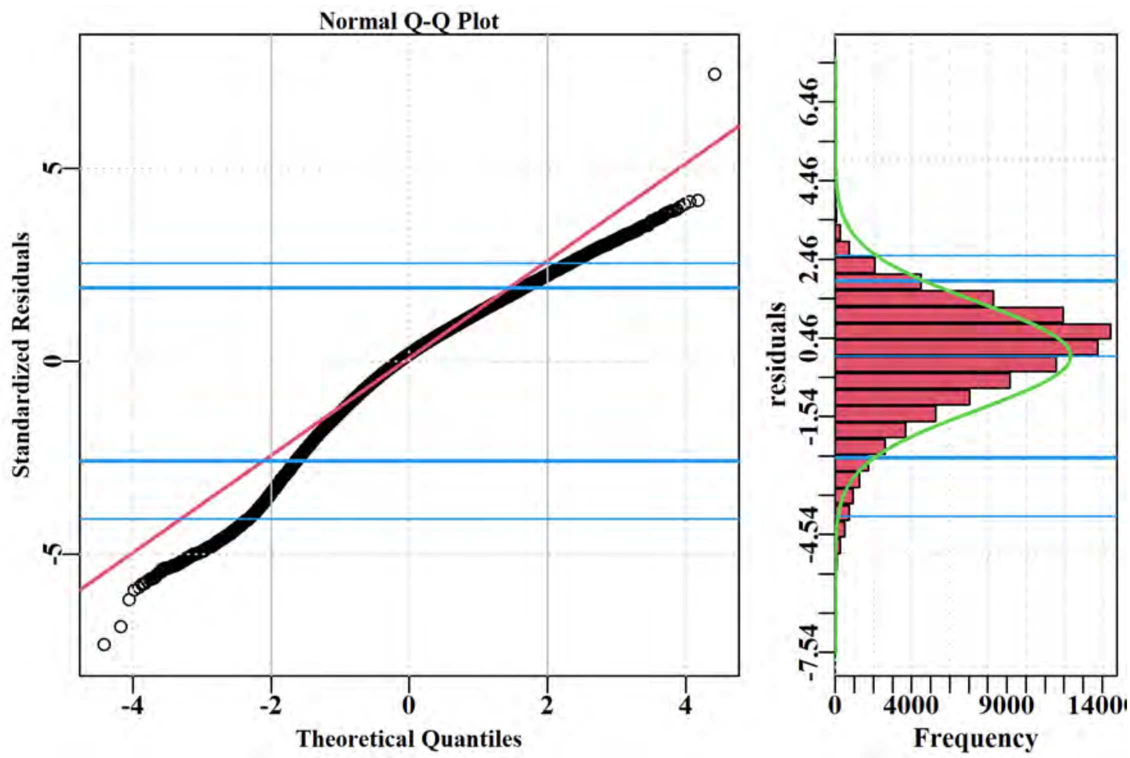

Figure 317: SchoolWhiting60S2. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

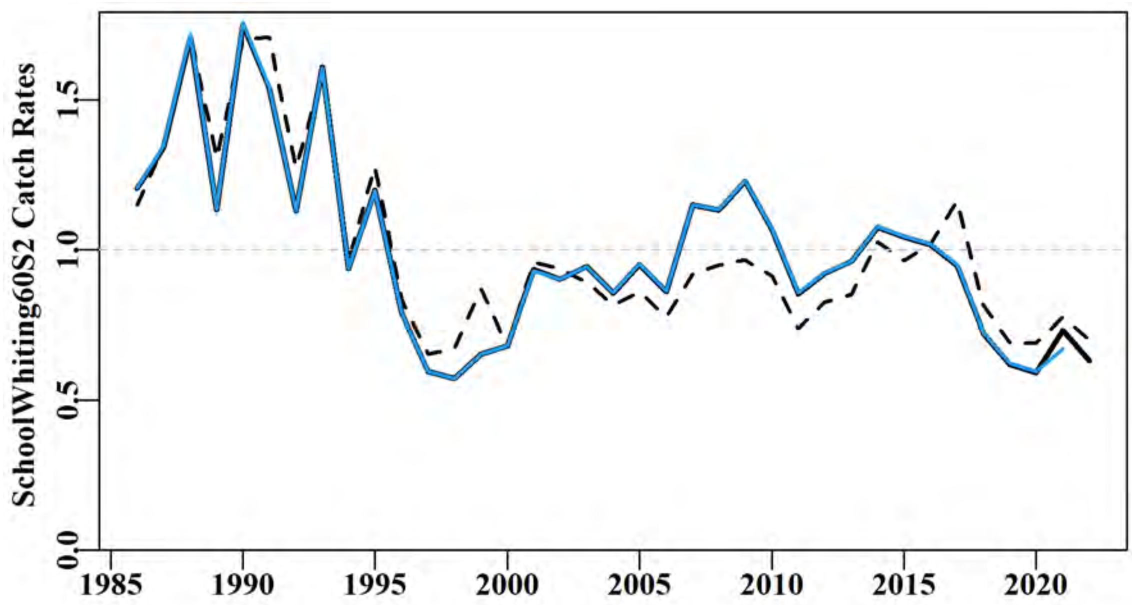

Figure 318: SchoolWhiting60S2. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

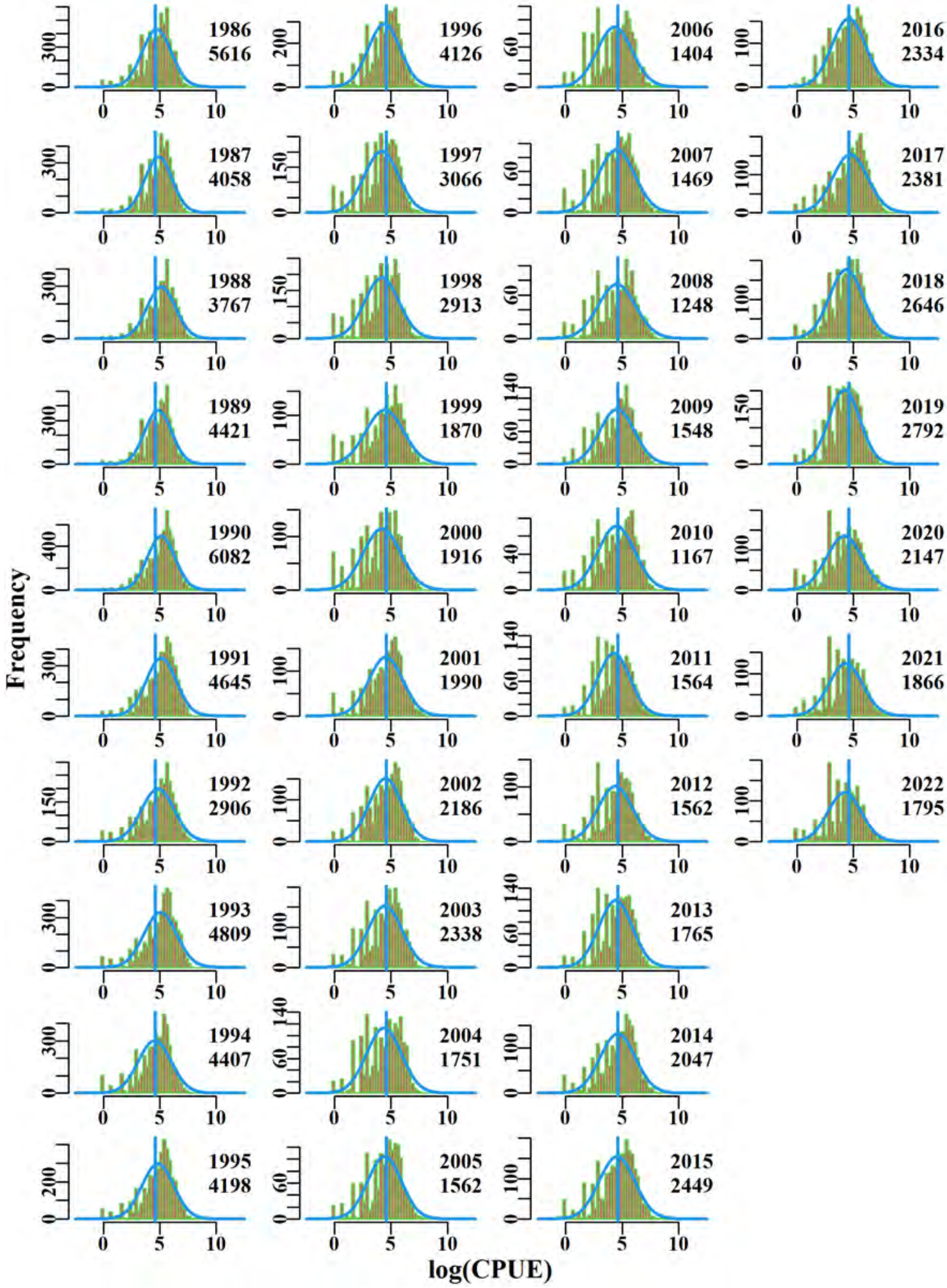

Figure 319: SchoolWhiting60S2. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

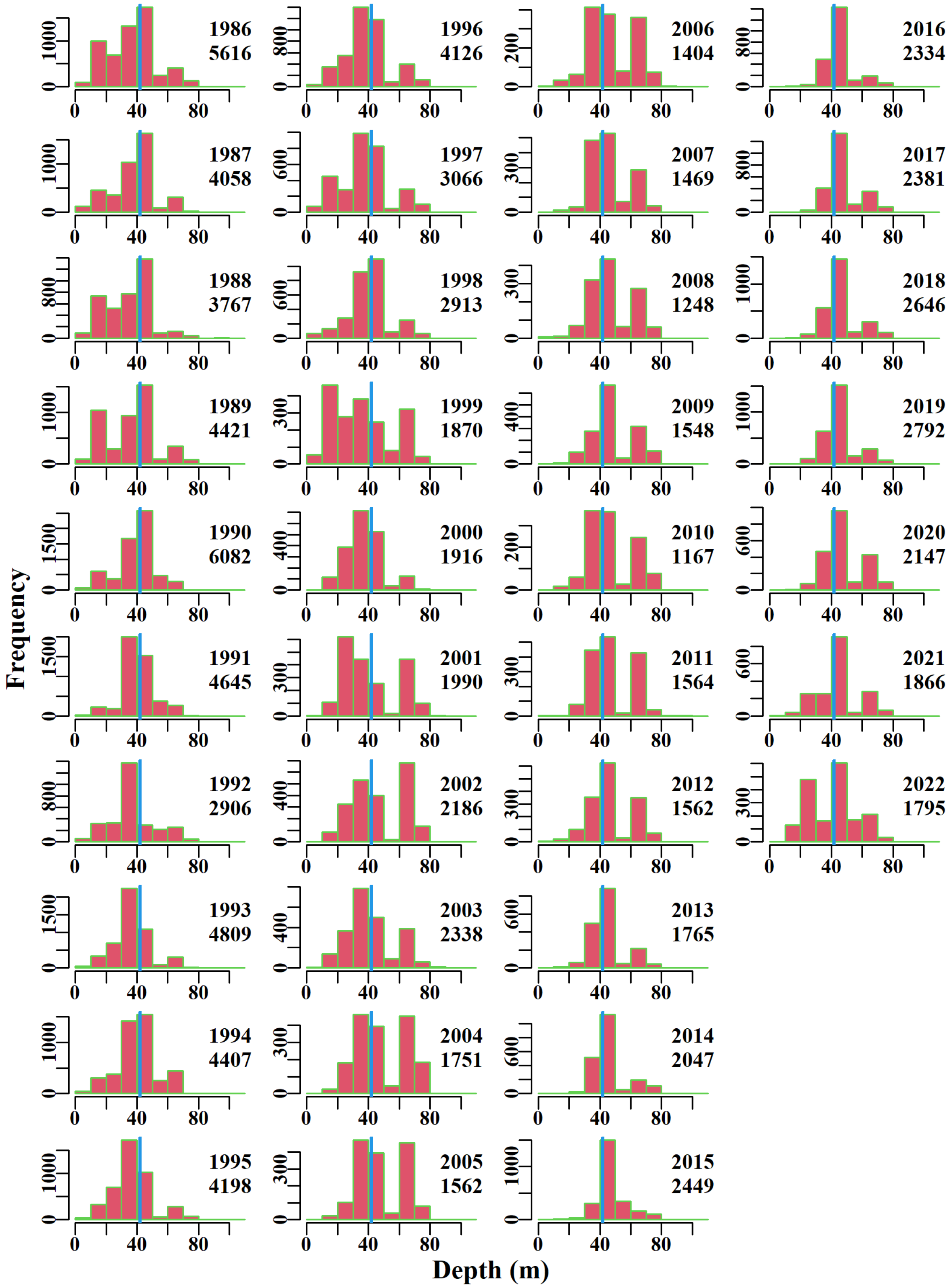

Figure 320: SchoolWhiting60S2. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

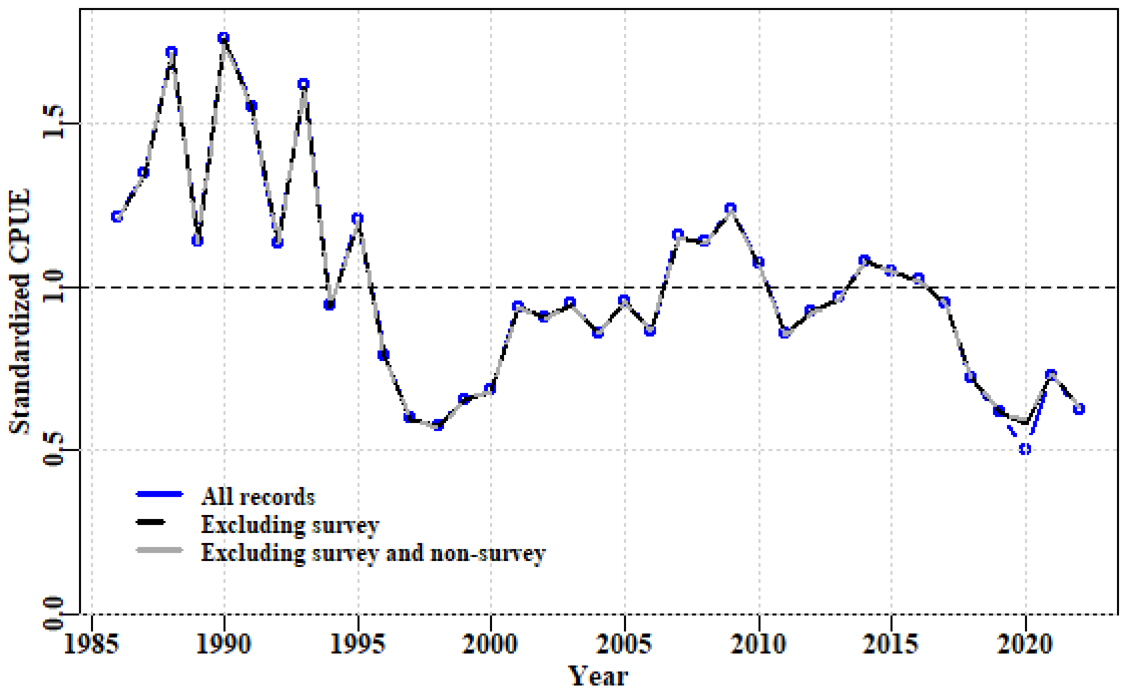

Figure 321: Comparison of the optimum standardization for School Whiting with all data (All records), removal of seismic records (Excluding survey) and removal of seismic records and also non-survey records from the same survey area and temporal period that were not part of the survey (Excluding survey and non-survey).

Western Gemfish 50

Initial data selection for western Gemfish (GEM– 37439002 – *Rexea solandri*) in zone 50 was conducted according to the details given in Table 227.

A total of 5 statistical models were fitted sequentially to the available data, with the order of the non-interaction terms added based on the relative contribution of each term to model fit.

Inferences

The terms Year, DepCat, Vessel, DayNight and Month had the greatest contribution to model fit, based on the AIC and R^2 statistics (Table 231). The qqplot suggests a small departure from the assumed Normal distribution as depicted by the upper tail of the distribution (Figure 325).

Annual standardized CPUE are noisy and flat since 1992 and consistently below average between 2001 and 2013 (Figure 322). However, there has been an overall increase in CPUE (to the long-term average) since 2007, with estimates in the last two years above the long-term average.

Action Items and Issues

No issues identified.

Table 227: gemfish50. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	gemfish50
csirocode	37439002, 91439002, 92439002
fishery	SET
depthrange	100 - 700
depthclass	50
zones	50
methods	TW, TDO, OTM, OTB
years	1992 - 2022

Table 228: gemfish50. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1992	89.3	634	80.4	14	42.5	1.3541	0.000	3.992	0.050
1993	90.1	697	89.8	12	38.9	1.2041	0.061	5.526	0.062
1994	90.3	793	89.3	14	32.6	1.3185	0.059	5.385	0.060
1995	82.3	892	82.1	17	30.0	1.1420	0.058	7.696	0.094
1996	139.6	1081	139.2	21	43.3	1.2276	0.056	9.366	0.067
1997	150.0	1301	149.4	19	40.0	1.0996	0.054	11.095	0.074
1998	121.9	1181	121.4	17	38.6	1.1901	0.055	9.972	0.082
1999	175.6	1561	174.3	14	36.8	1.1321	0.053	13.646	0.078
2000	229.4	1669	226.6	20	55.1	1.2944	0.053	13.501	0.060
2001	164.9	1503	164.6	18	42.0	0.9995	0.054	12.567	0.076
2002	83.6	1206	82.9	18	20.5	0.7137	0.056	12.103	0.146
2003	121.5	964	120.3	17	41.6	0.8144	0.058	7.078	0.059
2004	105.4	1077	103.5	18	27.7	0.7154	0.058	6.980	0.067
2005	111.1	993	109.1	16	32.2	0.7724	0.059	5.491	0.050
2006	102.4	825	99.3	14	25.9	0.6243	0.062	4.221	0.043
2007	59.1	616	56.3	11	21.0	0.5977	0.065	3.270	0.058
2008	53.5	699	51.2	12	15.4	0.6583	0.064	4.429	0.086
2009	56.1	748	52.5	9	14.6	0.6779	0.062	4.707	0.090
2010	80.6	1071	76.8	12	13.9	0.6955	0.059	6.377	0.083
2011	45.4	784	43.9	10	10.9	0.6352	0.062	4.821	0.110
2012	45.1	512	42.0	10	15.6	0.8006	0.069	2.736	0.065
2013	39.1	443	34.7	11	14.2	0.7240	0.071	2.419	0.070
2014	66.6	510	65.3	11	28.8	1.1198	0.069	1.286	0.020
2015	44.3	459	42.2	9	18.9	0.9597	0.071	0.983	0.023
2016	46.8	446	45.0	10	22.5	0.8933	0.071	1.208	0.027
2017	77.7	683	76.5	8	19.8	1.2846	0.066	0.226	0.003
2018	36.6	392	36.3	8	14.4	0.9550	0.075	0.250	0.007
2019	83.7	662	83.4	8	21.0	1.1418	0.066	0.498	0.006
2020	51.2	480	50.3	8	19.3	1.1590	0.072	0.322	0.006
2021	50.7	471	50.3	6	16.1	1.3148	0.071		
2022	66.2	535	63.9	6	19.1	1.7805	0.070		

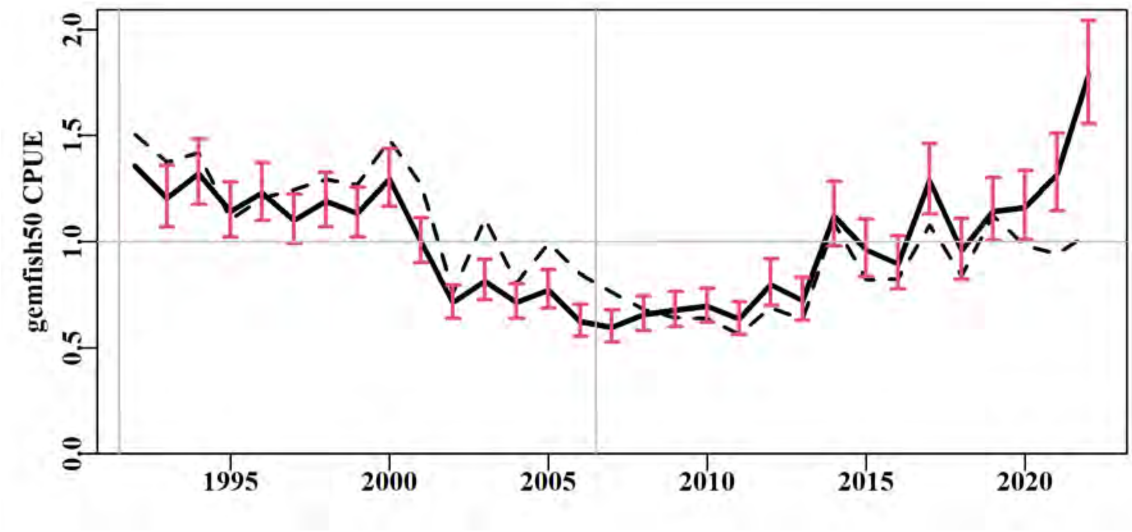

Figure 322: gemfish50 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

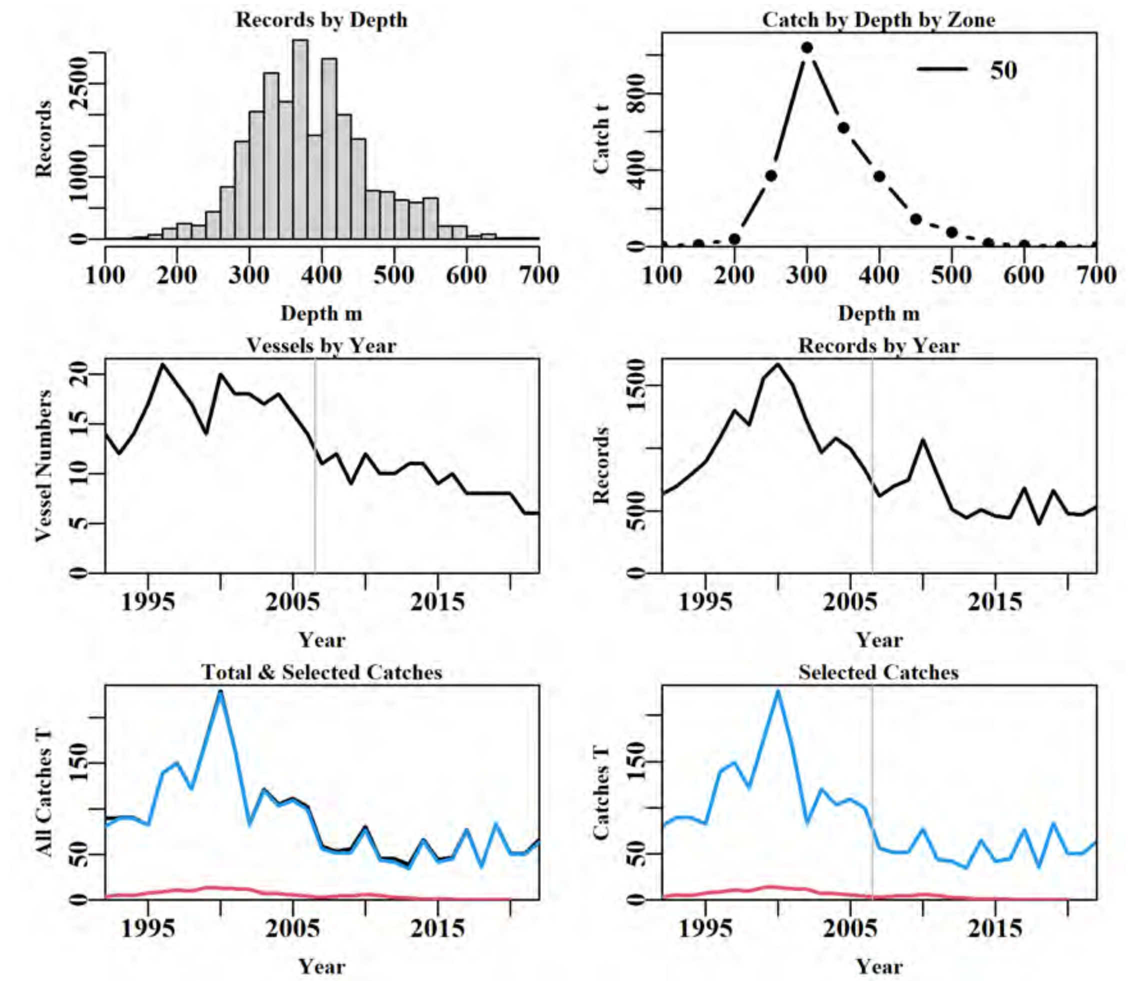

Figure 323: gemfish50 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 229: gemfish50 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery
Records	35713	33548	33316	26169	26169	25931	25888
Difference	0	2165	232	7147	0	238	43
Catch	4119	4083	4066	2715	2715	2705	2703
Difference	0	36	16	1351	0	10	2

Table 230: The models used to analyse data for gemfish50.

	Model
Model1	Year
Model2	Year + DepCat
Model3	Year + DepCat + Vessel
Model4	Year + DepCat + Vessel + DayNight
Model5	Year + DepCat + Vessel + DayNight + Month

Table 231: gemfish50. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	12074	41172	2053	25888	31	4.6	0.00
DepCat	8016	35166	8059	25888	43	18.5	13.87
Vessel	5822	32182	11043	25888	94	25.3	6.77
DayNight	4962	31123	12102	25888	97	27.7	2.45
Month	4472	30514	12710	25888	108	29.1	1.38

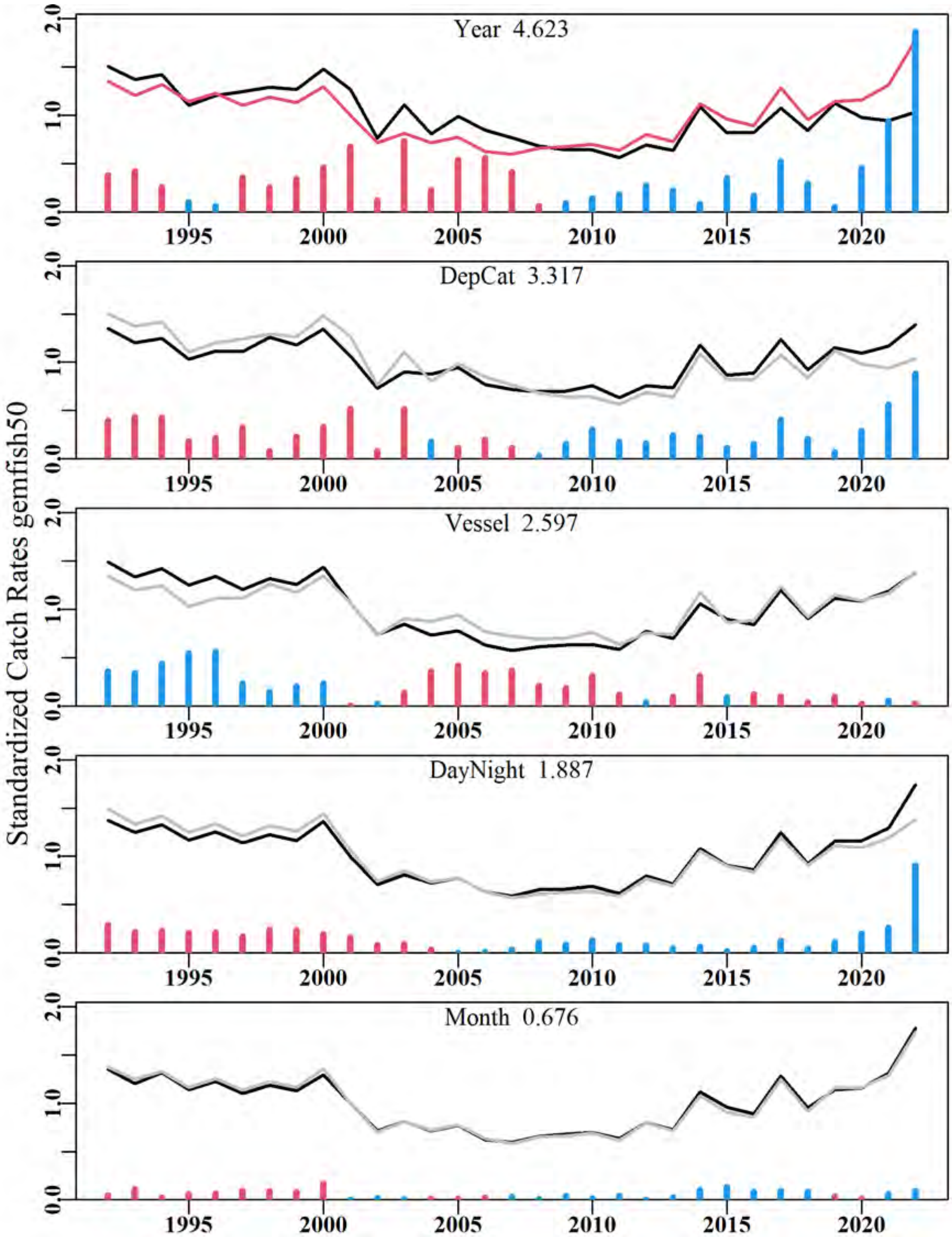

Figure 324: gemfish50. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

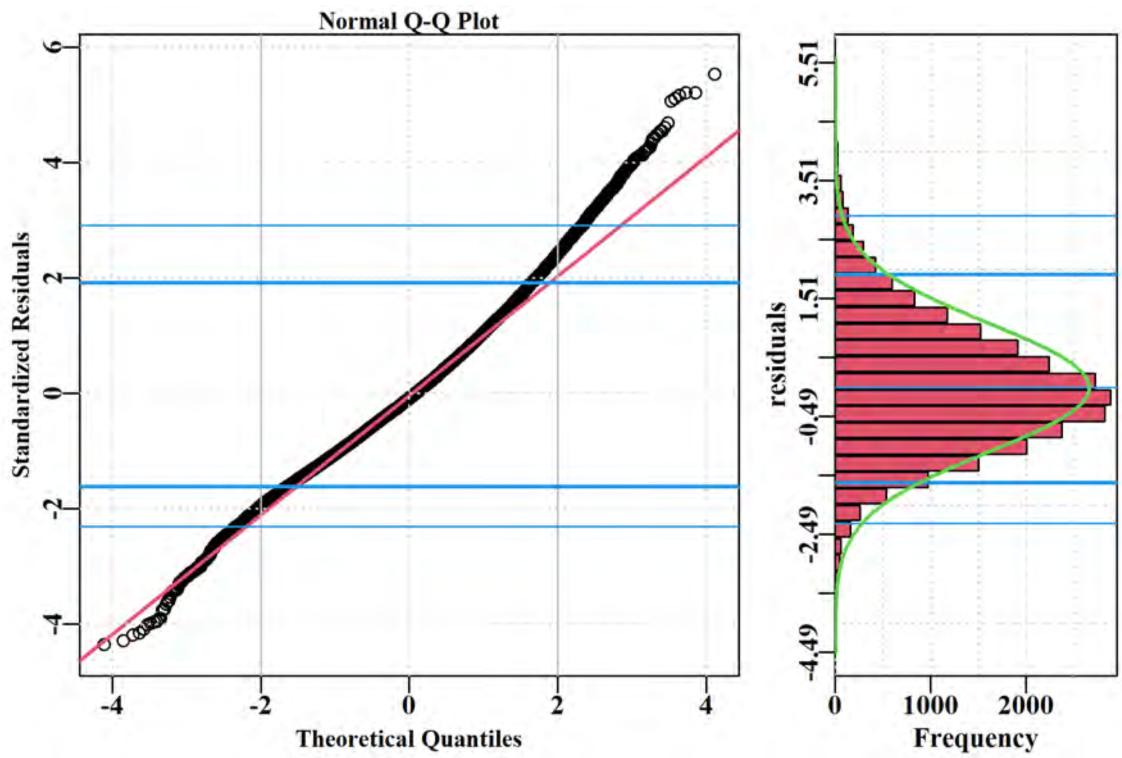

Figure 325: gemfish50. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

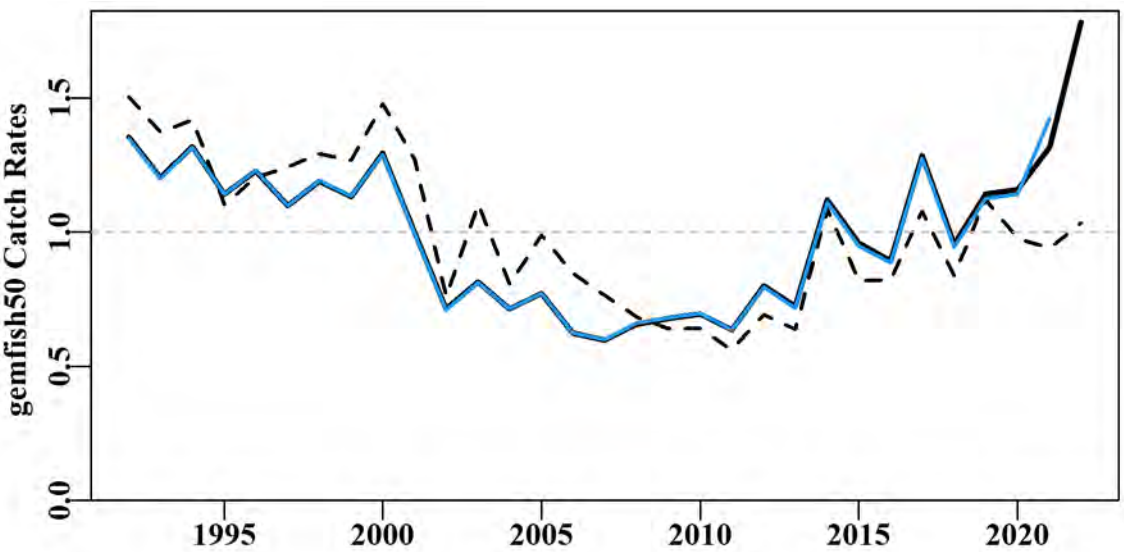

Figure 326: gemfish50. A comparison of the previous years' standardization (blue line) with this years' (solid black line). They should lie on top of each other, although small deviations may relate to data adjustments, particularly in very recent years. The dashed black line represents the geometric mean CPUE.

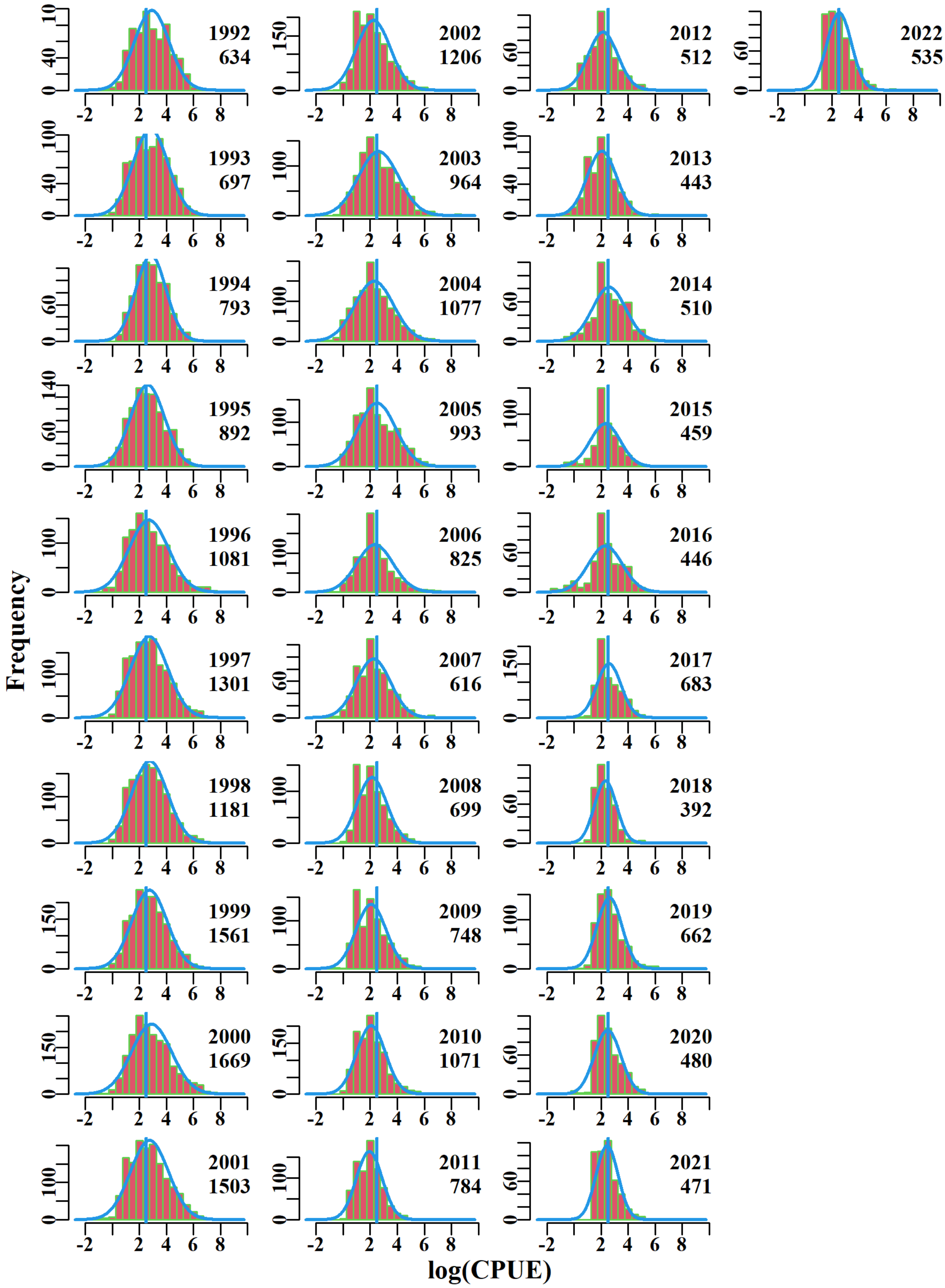

Figure 327: gemfish50. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

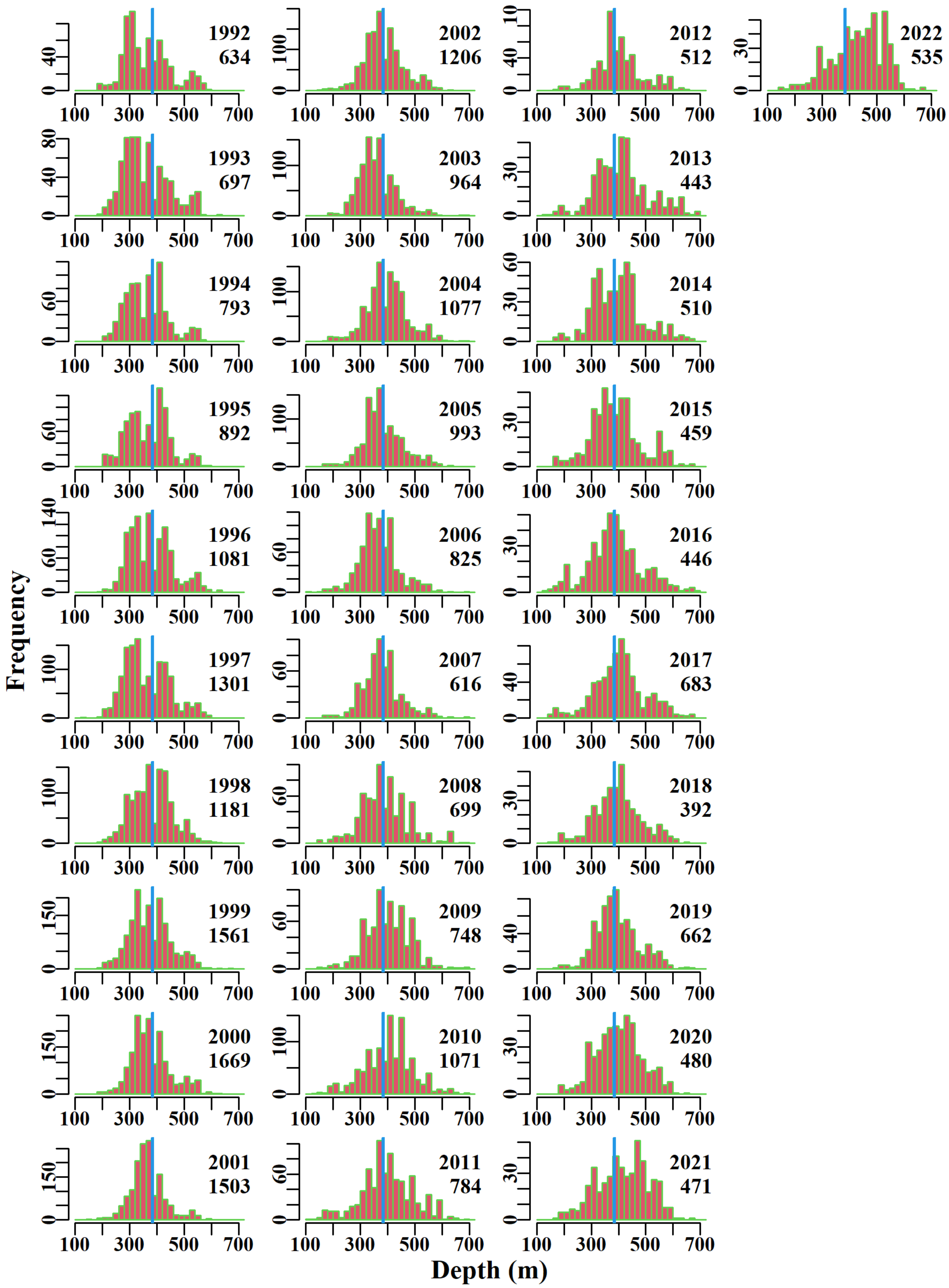

Figure 328: gemfish50. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

Silver Trevally 1020 - No MPA. 1992 - 2022

Initial data selection for Silver Trevally (TRE - 37337062 - *Pseudocaranx georgianus*) in the SET was conducted according to the details given in Table 232 and then records reported as State waters, which includes the Bateman's Bay marine protected area (MPA) were excluded.

A total of 8 statistical models were fitted sequentially to the available data.

Inferences

Most of the catch of this species occurred in zone 10.

The terms Year, Vessel, DepCat, Month and DayNight had the greatest contribution to model fit, with the remaining terms each explaining < 1% of the overall variation in CPUE, based on the AIC and R^2 statistics. The qqplot suggests that the assumed Normal distribution is valid with a slight departure as depicted at the lower tail of the distribution (Figure 332).

Annual standardized CPUE trend is noisy and relatively flat since about 2012 and mostly below average despite recent increases towards average in the last three years (Figure 329). A deviation similar to that in the 'include MPA' scenario is apparent where the standardized trend deviates markedly from the nominal geometric mean trend from 2013 - 2017 and for the same reasons of changes in vessels fishing, low numbers of significantly contributing vessels, changes in the depth distribution of fishing and lower catches and numbers of records.

Action Items and Issues

Further exploration of the reasons behind the recent deviation of the standardized time-series from the nominal geometric mean are required to provide a more detailed explanation for these changed dynamics.

Table 232: SilverTrevally1020nompa1992. The data selection criteria used to specify and identify the fishery data to be included in the analysis.

Property	Value
label	SilverTrevally1020nompa1992
csirocode	37337062
fishery	SET
depthrange	0 - 200
depthclass	20
zones	10, 20
methods	TW, TDO, OTB
years	1992 - 2022

Table 233: SilverTrevally1020nompa1992. Total catch (Total; t) is the total reported in the database, number of records used in the analysis (N), reported catch (Catch; t) in the area and depth used in the analysis and number of vessels used in the analysis (Vess). GeoM is the geometric mean of catch rates (kg/hr), standard deviation (StDev) relates to the optimum model. C<30kg denotes the amount of catch in shots of <30kg, and P<30kg is the proportion of total. The optimum model was Zone:Month.

Year	Total	N	Catch	Vess	GeoM	Opt	StDev	C<30kg	P<30kg
1992	296.5	1358	170.8	45	34.6	1.7590	0.000	9.772	0.057
1993	377.7	1407	152.3	48	35.2	1.7589	0.058	10.899	0.072
1994	392.8	2073	176.8	47	28.2	1.4371	0.053	16.809	0.095
1995	413.4	1942	179.2	44	31.5	1.5848	0.054	16.202	0.090
1996	340.6	2179	177.6	49	27.6	1.3734	0.054	18.281	0.103
1997	328.8	1647	115.7	49	24.9	1.2763	0.058	13.637	0.118
1998	210.1	1226	64.0	42	19.4	0.9189	0.061	10.434	0.163
1999	166.1	1022	49.0	40	17.3	0.9119	0.064	8.024	0.164
2000	154.8	1244	54.5	46	13.9	0.7175	0.061	9.600	0.176
2001	270.2	2024	121.5	43	23.7	0.8893	0.055	13.786	0.113
2002	232.8	1812	97.7	39	19.0	0.7046	0.057	11.638	0.119
2003	337.9	1526	89.8	49	21.9	0.7208	0.059	9.592	0.107
2004	458.2	1868	151.7	43	36.8	1.0221	0.057	11.342	0.075
2005	291.1	1013	98.7	41	41.5	0.8674	0.065	6.210	0.063
2006	247.3	695	79.3	37	59.7	1.0779	0.072	4.529	0.057
2007	172.7	557	79.2	21	92.1	1.1685	0.078	2.895	0.037
2008	128.4	887	80.6	22	46.9	1.1603	0.069	5.931	0.074
2009	164.1	933	107.0	23	55.7	1.1653	0.067	5.623	0.053
2010	240.2	1011	152.6	24	89.7	1.4666	0.066	5.213	0.034
2011	193.5	910	149.6	20	113.8	1.2706	0.068	4.590	0.031
2012	139.7	733	97.6	21	72.6	0.9078	0.072	4.241	0.043
2013	122.8	520	72.4	19	70.9	0.9707	0.080	2.924	0.040
2014	107.0	673	66.7	20	51.2	0.7616	0.074	4.127	0.062
2015	79.5	473	61.2	21	67.6	0.8082	0.084	2.422	0.040
2016	52.4	288	33.6	18	89.7	0.8466	0.099	1.528	0.045
2017	52.9	291	33.4	15	69.8	0.8975	0.099	1.634	0.049
2018	37.7	132	14.7	14	58.5	0.4649	0.137	0.926	0.063
2019	3.8	39	1.8	7	21.1	0.2376	0.240	0.196	0.111
2020	39.4	108	16.7	12	124.5	0.4366	0.162	0.546	0.033
2021	20.8	110	12.5	13	88.9	0.5753	0.154	0.902	0.072
2022	35.7	132	17.0	11	88.7	0.8418	0.153	0.843	0.049

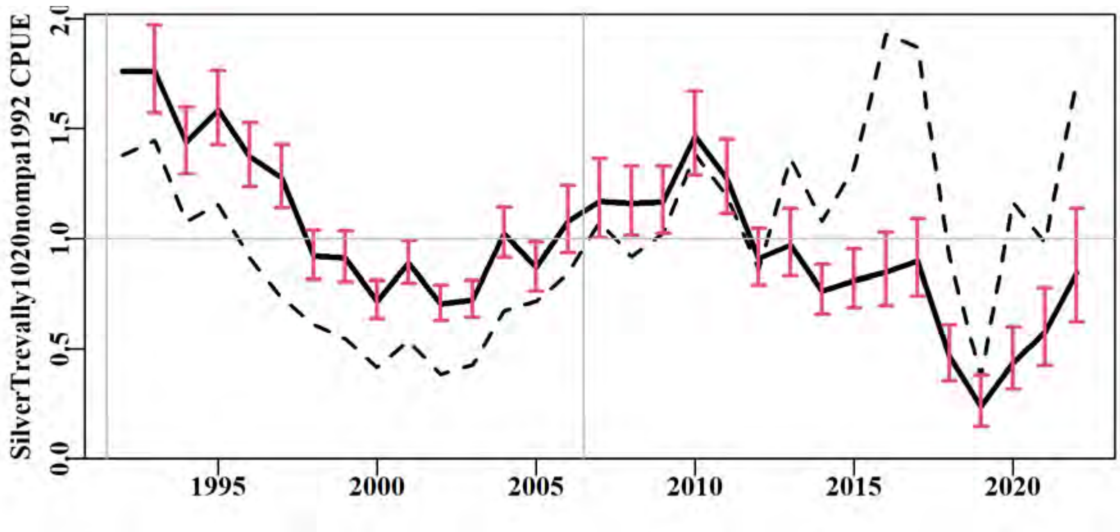

Figure 329: SilverTrevally1020nompa1992 standardization. The dashed black line represents the geometric mean CPUE, solid black line the standardized CPUE. The red bars are the 95% confidence intervals about the mean estimates. The graph scales both time-series of standardized CPUE relative to the mean of each time-series.

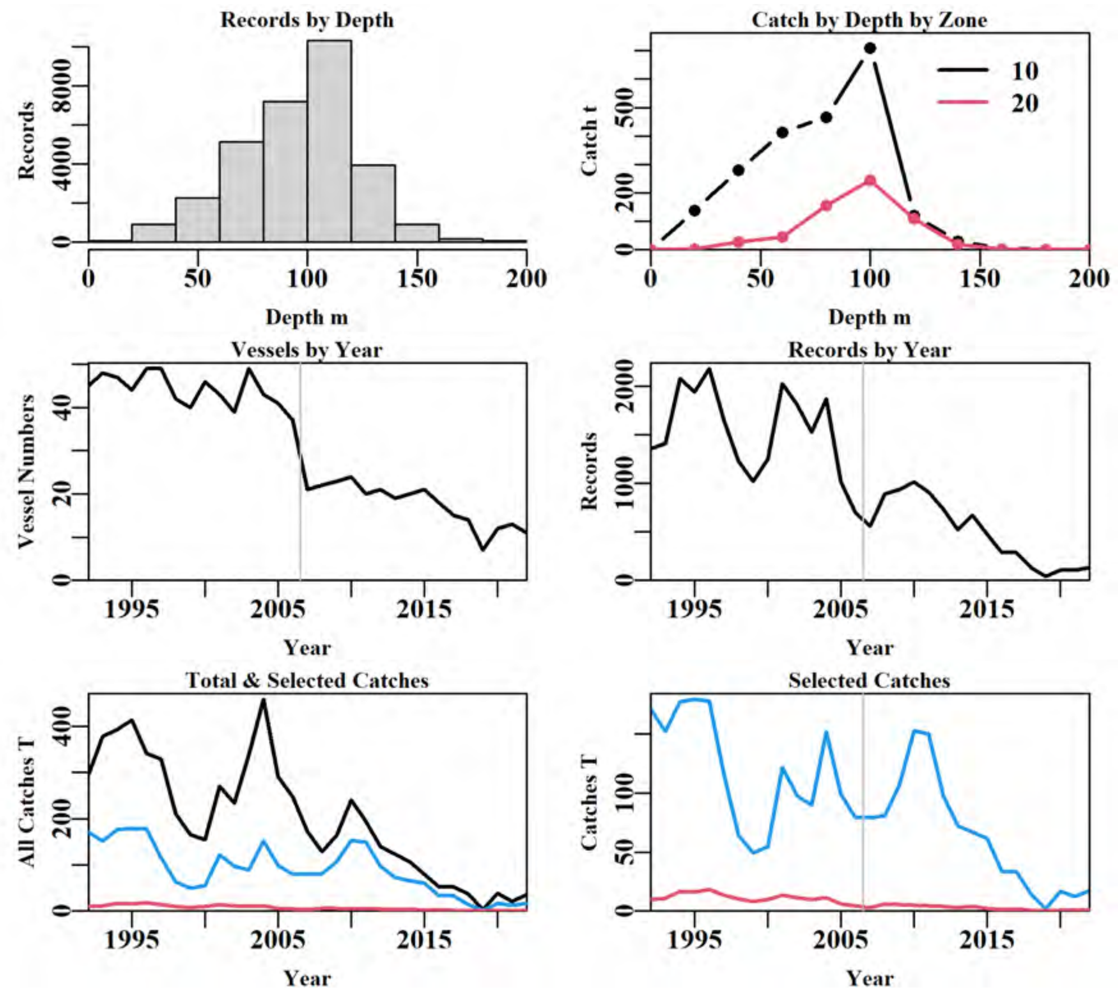

Figure 330: SilverTrevally1020nompa1992 fishery details. The bottom left plot depicts all known catches (top black line), and all selected catches used in the analysis (middle blue line); the lower red line: selected catches < 30 kg).

Table 234: SilverTrevally1020nompa1992 data selection effects. Total is the total number of records in the database, NoCE removes those records with either missing catch or effort, and then only those records are kept that meet the criteria for depth, years, zone, method and fishery.

	Total	NoCE	Depth	Years	Zones	Method	Fishery	NoMPA
Records	77239	74015	72386	58651	50087	48854	48798	30833
Difference	0	3224	1629	13735	8564	1233	56	17965
Catch	8388	8212	7924	5804	5187	5160	5153	0
Difference	0	176	288	2120	617	27	7	0

Table 235: The models used to analyse data for SilverTrevally1020nompa1992.

	Model
Model1	Year
Model2	Year + Vessel
Model3	Year + Vessel + DepCat
Model4	Year + Vessel + DepCat + Month
Model5	Year + Vessel + DepCat + Month + DayNight
Model6	Year + Vessel + DepCat + Month + DayNight + Zone
Model7	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:Month
Model8	Year + Vessel + DepCat + Month + DayNight + Zone + Zone:DepCat

Table 236: SilverTrevally1020nompa1992. The row names are the Akaike Information Criterion (AIC), residual sum of squares (RSS), model sum of squares (MSS), number of usable observations (Nobs), number of parameters (Npars), adjusted R^2 (adj_r2) and the change in adjusted R^2 (%Change). The optimum model was Zone:Month.

	AIC	RSS	MSS	Nobs	Npars	adj_r2	%Change
Year	33333	90708	5541	30833	31	5.7	0.00
Vessel	25389	69648	26601	30833	132	27.3	21.66
DepCat	24525	67680	28569	30833	142	29.4	2.03
Month	23825	66114	30134	30833	153	31.0	1.61
DayNight	23258	64895	31354	30833	156	32.2	1.27
Zone	23224	64820	31429	30833	157	32.3	0.08
Zone:Month	23165	64650	31599	30833	168	32.5	0.15
Zone:DepCat	23208	64749	31500	30833	166	32.4	0.05

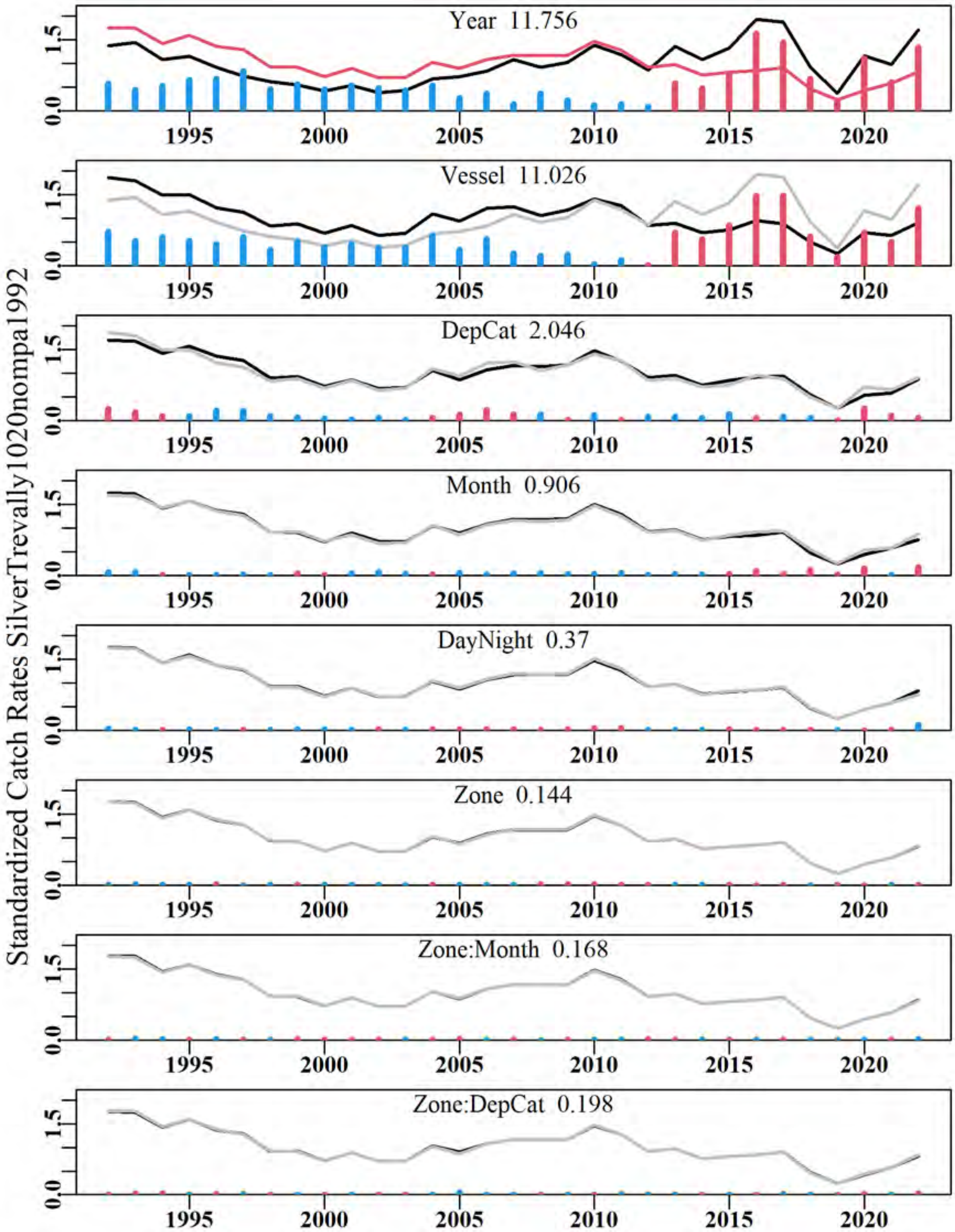

Figure 331: SilverTrevally1020nompa1992. The influence of each factor on the optimal standardization. The top graph depicts the geometric mean (black line) and the optimum model (red line). The difference between them is illustrated by vertical bars with blue bars indicating the optimum model is higher than the geometric mean and red bars indicating it is lower. The top graph bars are the sum of all the bars in the graphs below. The graphs for individual factors are cumulative. Thus the second graph has the geometric mean (grey line) and the effect of adding Year + factor2 (Model 2). In the third graph, the grey line represents Model 2 and the black line the effect of adding factor3 to the model. The remaining graphs continue in the same cumulative manner except for the interaction terms which are added singularly to the final single factor model.

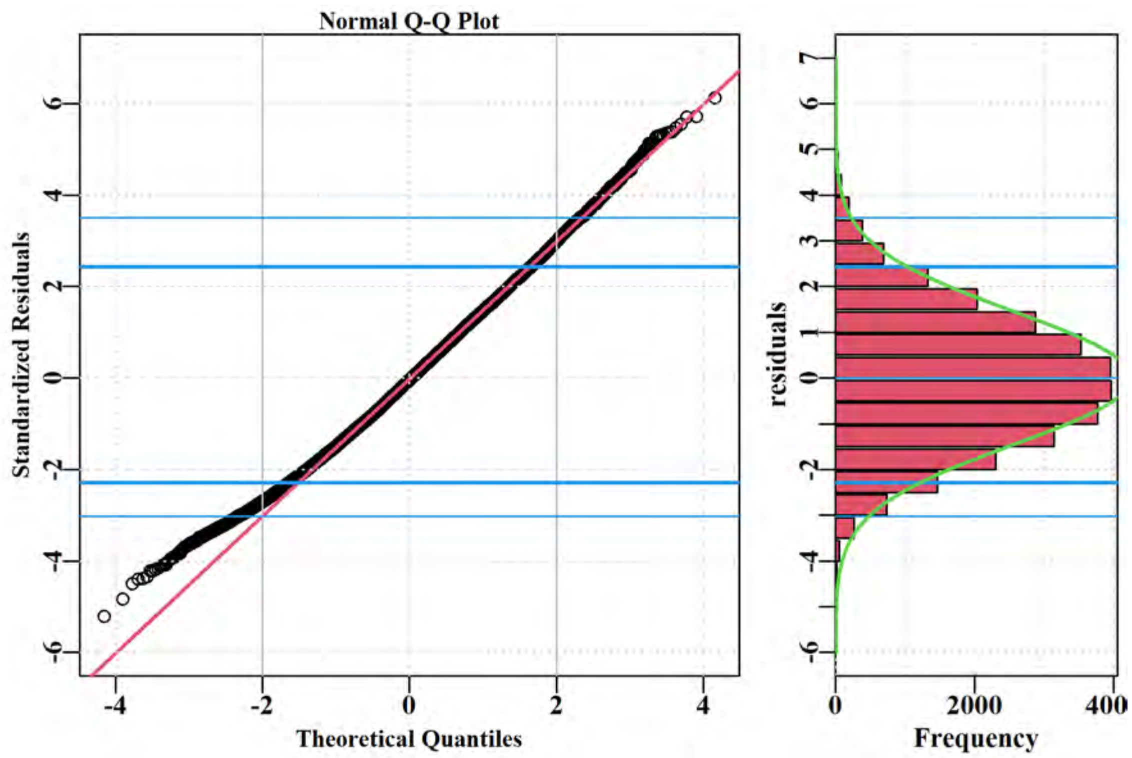

Figure 332: SilverTrevally1020nompa1992. diagnostic plots. The distribution of residuals from the optimum fit. The qqplot indicates the fit to the expected normality, while the histogram of residuals illustrates the 90% quantiles to indicate the intensity of any lack of fit at the margins of the distribution.

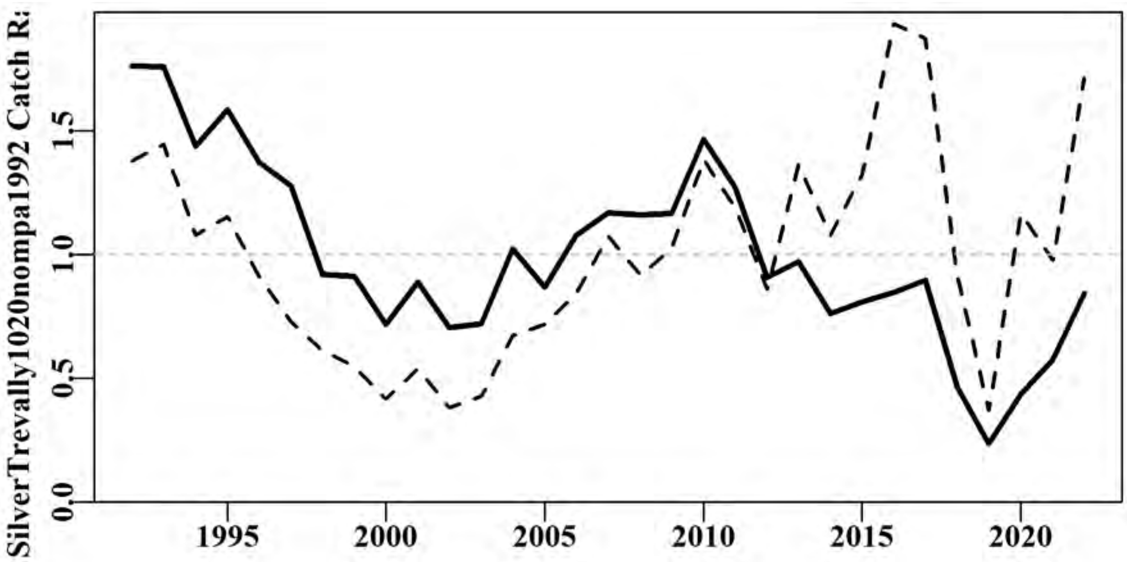

Figure 333: SilverTrevally1020nompa1992. Standardized CPUE for Silver Trevally from zone 10, 20 (no MPA) between 1992 to 2022 (solid black line). The dashed black line represents the geometric mean CPUE.

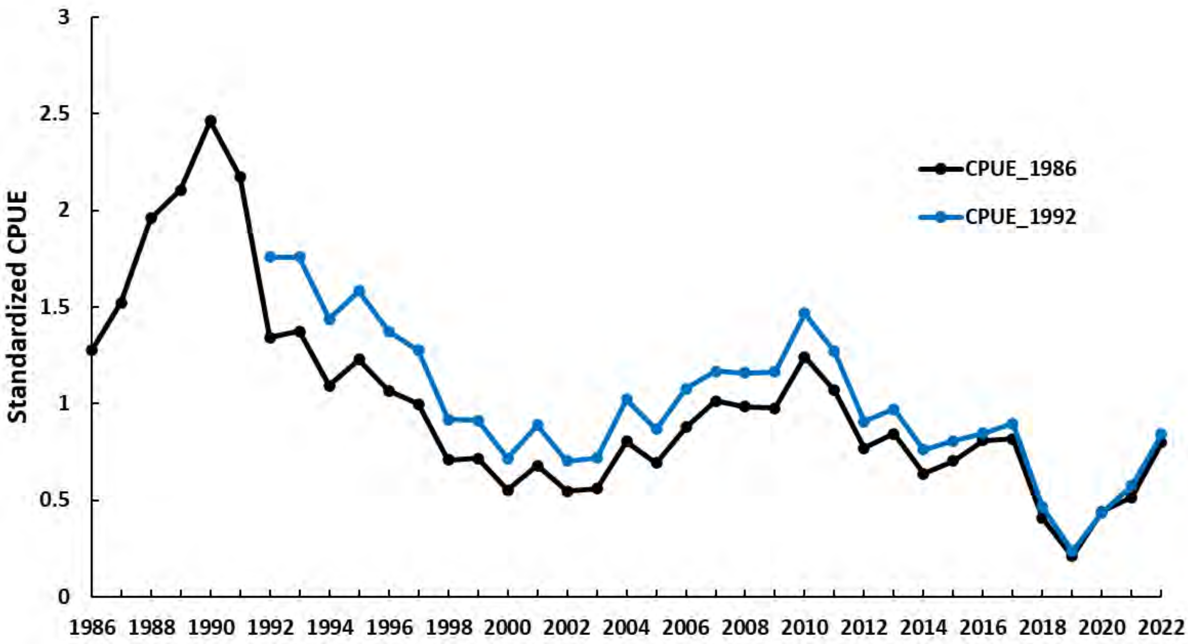

Figure 334: SilverTrevally1020nompa1992. Comparison of standardized CPUE for Silver Trevally from zone 10, 20 (no MPA) between 1992 - 2022 (blue line) and between 1986 – 2022 (black line; see also page 292).

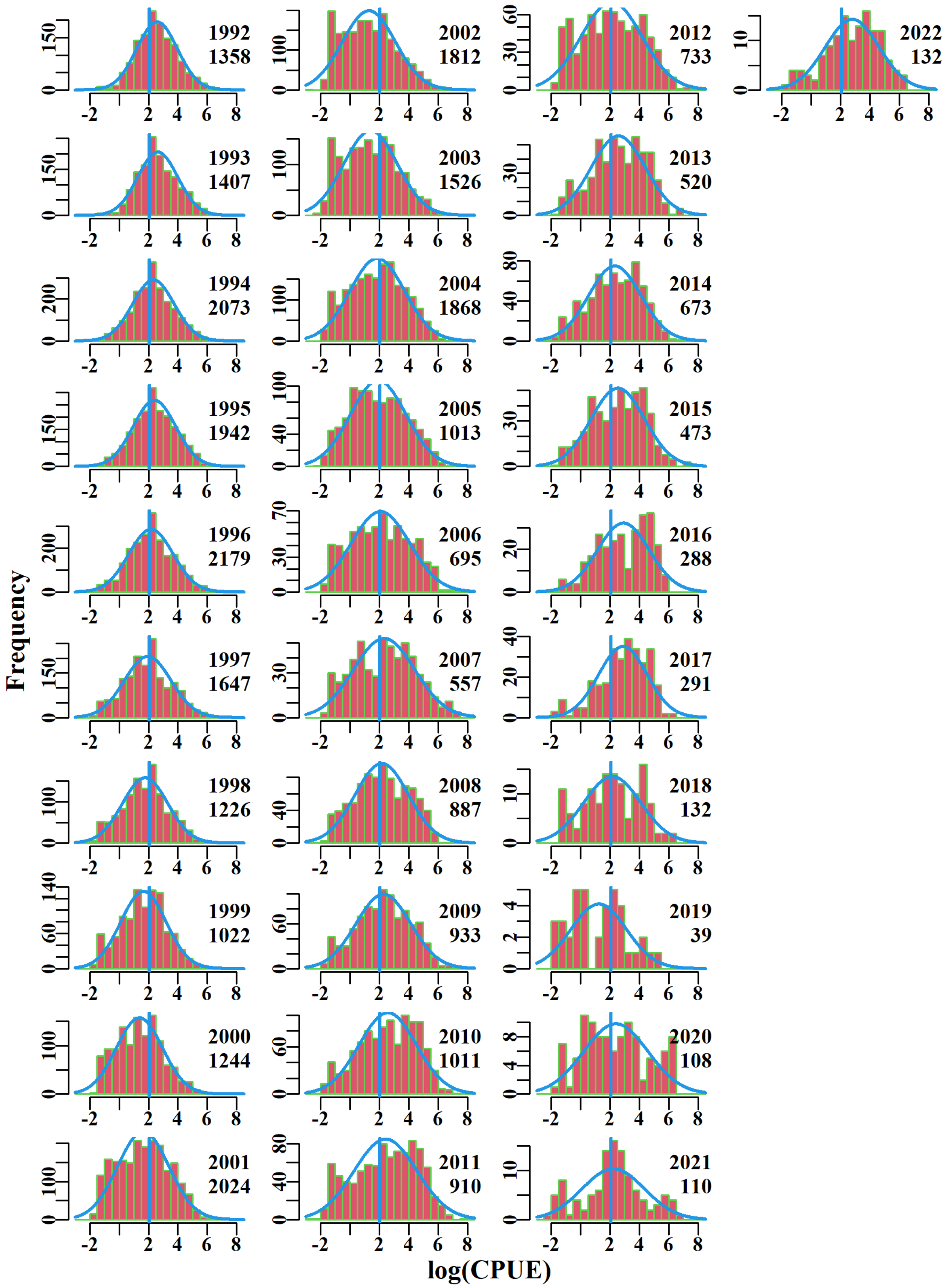

Figure 335: SilverTrevally1020nompa1992. The natural log(CPUE) for each year of data available the blue lines are normal distributions fitted to the histogram frequencies. The numbers in each plot are the year and number of records.

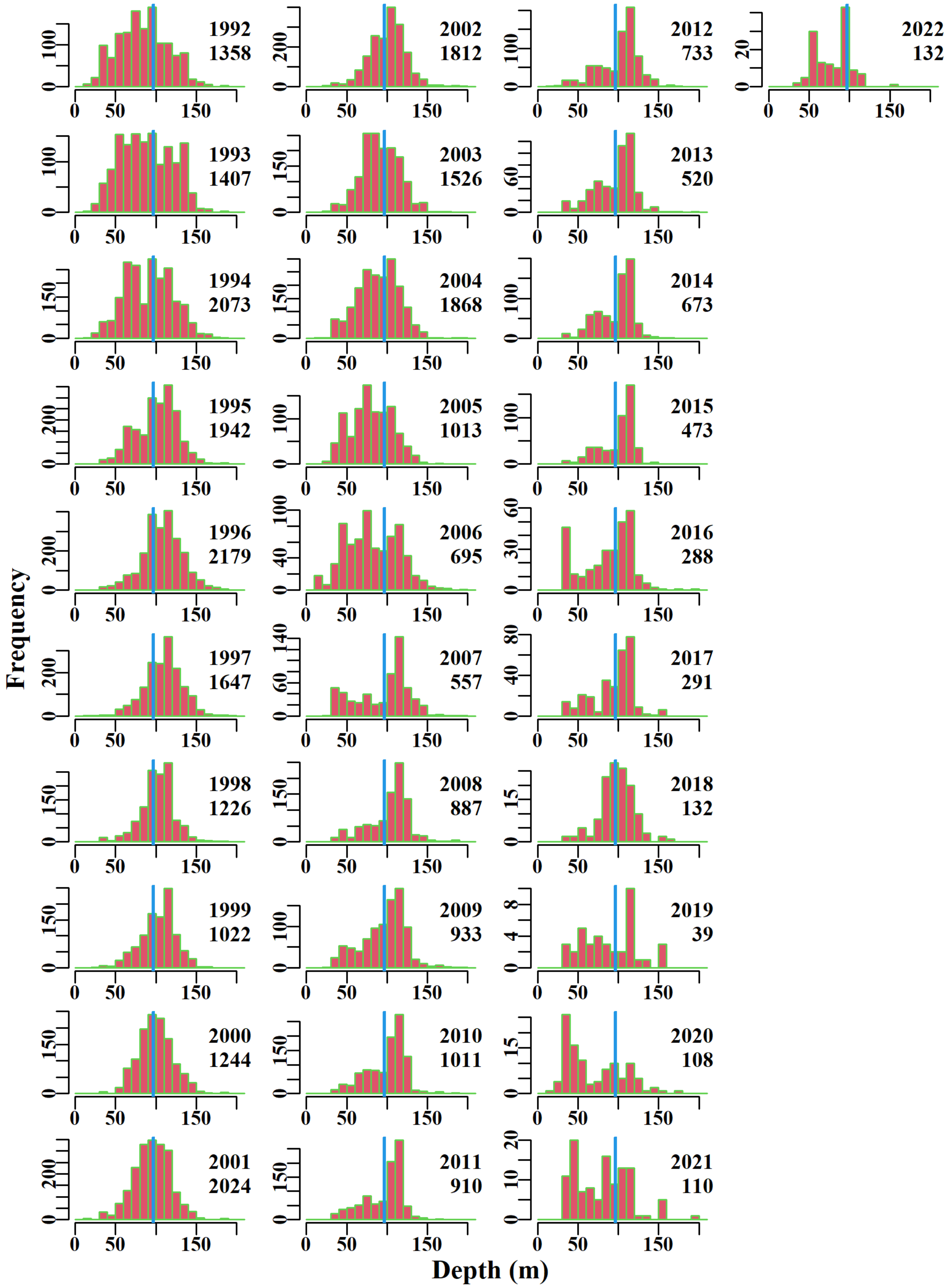

Figure 336: SilverTrevally1020nompa1992. The average Depth of fishing for each year of data available to illustrate the development of the fishery through time. The numbers in each plot are the year and number of records.

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