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Estimates of catch from the Canadian otter trawl fishery directed for yellowtail flounder based on observer data

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Abstract

Observer data from the Canadian fishery directing for yellowtail flounder from 1998 onward was examined. CPUE for yellowtail flounder, American plaice and cod was estimated using a generalized linear model with gamma error and a log link. Data were combined over the main effects of year, month, division, and tonnage class, all entering the model as factors. The estimated CPUE was then applied to the reported effort to give an estimate of catch in each year. For yellowtail flounder, in most years reported catch was 95% or more of the estimated catch. For the two bycatch species, reported catch was generally a lower proportion of the estimated catch. For American plaice, reported catch in most years was 70-80% of the estimated catch and for cod it was often less than 80% of the estimated catch but the difference in tons was small. Catch estimates using modelled and unmodelled CPUE from the same data were similar. Further exploration of methods of estimating catch is warranted.

Key words: observers, CPUE, catch estimates

Introduction

For some fleets and fisheries, Scientific Council has used estimated catches in its stock assessments, rather than officially reported (STATLANT) data, in many years since the mid 1980's. It has not been possible to document fully the methods or data sources for all of Scientific Council's catch estimates, due mainly to reasons of data confidentiality. The issue of catch estimation has come under increased scrutiny in NAFO in recent years. This paper addresses a standing request from Scientific Council for Contracting Parties to produce documented estimates of catch where possible, to allow comparison with the STATLANT reports.

This paper examines data only from the Canadian fishery for yellowtail flounder from 1998 onward. Canadian vessels are assigned about 98% of the annual NAFO quota for yellowtail in Div. 3LNO, and of this, about 90% has usually been owned by a single Canadian enterprise. This fishery, since it reopened in 1998, has been very different from the fishery prior to 1994. The major difference is that stocks of cod and American plaice, two species which were often part of a mixed otter trawl fishery on the Grand Bank, have not recovered since their collapse, and remain closed to directed fishing. A major factor in the yellowtail flounder fishery since 1998 has been avoidance of by-catch of these species. Thus it is difficult to compare the fishery from the pre and post-moratorium periods, given that the fleet behavior was

influenced by very different rules in these periods. As well, by-catch regulations in the fishery have changed since 1998, most notably allowing an increase in American plaice by-catch from 5% to 15%.

Since the fishery reopened in 1998, reported Canadian catches of yellowtail have fluctuated from less than 200 t (2006) to over 13,000 t (2005) due to a variety of industry-related factors, such as corporate restructuring, labour disputes, price/marketing issues, and on-shore processing requirements. Stock abundance of yellowtail has not been a restricting factor, as stock size increased after 1998, and has remained relatively stable well above Bmsy in recent years. Otter trawl gear takes almost the entire catch, with catches by other gears being less than 10 t annually after 2002. The Canadian catch reported in 2012 was 1795 tons, which is the lowest value since 2006. In 2011 and 2012, most of the catch was taken in April to June, whereas the fishery operated mostly year-round in 2008-2010.

Observers were mandatory on all trips in this fishery up to 2004, and collected tow by tow information such as catch, effort, species composition, and biological samples of the catch. A change in this measure was introduced in 2004, permitting less than 100% observer coverage in both 2004 and 2005, as part of a pilot project. The targeted levels for at-sea observer coverage were 50% from 2004-2008 and then reduced in 2009 to 25%, where they have remained to date. Actual coverage levels - ratio of observed trips to total trips - have not been calculated here.

Methods

The two sources of data were the Canadian catch data base (which provided effort) and the Canadian observer data base from which CPUE was estimated. The number of sets observed in the fishery directed for yellowtail ranged from 0 in 2006 to 6202 in 2003. The number of trips was as high as 71-74 per year in 2001-03, but has been less than 10 per year from 2009-2012 (Table 1). The ratio of observed catch in the directed yellowtail fishery (including sets logged while an observer was on board but not actually observed) to reported catch of yellowtail in all fisheries in Div. 3LNO was between 0.88 and 1.02 from 1998 to 2004 (Table 2). This ratio declined to around 0.75 in 2005 and 2007, then to less than 0.4 since 2009, consistent with the decline in the target coverage levels. Yellowtail accounted for 80 to 92% of the total catch in the fishery each year (Table 3). Discarding has generally been prohibited in the fishery, with exceptions for live release of some species (e.g. wolfish), and for species such as skate to prevent product spoilage. Observed discarding did not exceed 7% by weight in any year, for all species combined (Table 3).

Catch of yellowtail flounder, American plaice and cod in Div. 3LNO (Div. 3NO in the case of cod) was examined for the yellowtail flounder directed fishery conducted by otter trawls starting in 1998. CPUE was calculated as Kg per hour. There were no observed sets during 2006, a fishing year that was cut short by an industrial dispute. Only 1 trip was observed in 2012.

CPUE data were examined as in Smith and Showell (MS 1996). This indicated that a simple multiplicative model would not be appropriate for these analyses (Figure 1). Standard deviation increased with mean CPUE and a log transformation of the CPUE did not result in constant standard deviation. Rather the data suggests a constant coefficient of variation characteristic of a gamma distribution. As a result, a generalized linear model with gamma error and a log link was used (Smith and Showell, MS 1996). Data were combined over the main effects of year, month, division, and tonnage class, all entering the model as factors. The same model structure was used for all three species but in each case the significance of the main effects was tested and any non significant factors removed. Data for yellowtail flounder were also examined on a set by set basis as recommended by Myers et al (MS 1995). Parameter estimates were the same as those produced by combined data, however, sample size was so large that significance tests were not necessarily meaningful. Therefore data were used in a compiled fashion (e.g. see Large, 1992).

Model estimates of catch were compared to the 'raw' estimates derived by taking the annual sum of the observed catch divided by the sum of the observed effort multiplied by the reported effort.

As a further comparison to the method used here, a multiplicative model (Gavaris, 1980) was used to analyze logbook data from the Can (N) fleet identifying yellowtail as the directed species from 1965 to 1993, along with 1998-2005 and 2007-2012 data were also utilized to derive a standardized catch rate series. Catch rate was estimated for yellowtail only. The Can (N) fleet has taken the majority of the catch over the time period from this stock and provided the only source of CPUE data, particularly the late 1970's and also since 1998. The data from 2006 was not included in the standardization because only 177 tons were taken by the Can(N) fleet trawlers due to labour problems within the industry. Ln (CPUE) was the dependent variable in the model. Independent variables (category types) were: (1) a combination country-gear-tonnage-class category type (CGT), (2) NAFO Division, (3) month and (4) Year. Individual observations with catch less than 10 tons or effort less than 10 hours were eliminated prior to analysis. Subsequently, within each independent variable, categories with arbitrarily less than five observations were also eliminated, with the exception of the variable "year", which is the purpose of the standardization. The references chosen for the standardization were tonnage class 5 vessels, Div 3N, October and 1965. Regression and ANOVA results are not presented here but are available in Maddock-Parsons (MS 2013). Only the standardize catch rates series from 1998-2012 are presented here for comparison to the observer series described above.

Results

The number of sets observed in the fishery directed for yellowtail ranged from 0 in 2006 to 6202 in 2003. The number of trips was as high as 71-74 per year in 2001-03, but has been less than 10 per year from 2009-2012 (Table 1). The ratio of observed catch in the directed yellowtail fishery (including sets logged while an observer was on board but not actually observed) to reported catch of yellowtail in all fisheries in Div. 3LNO was between 0.88 and 1.02 from 1998 to 2004 (Table 2). This ratio declined to around 0.75 in 2005 and 2007, then to less than 0.4 since 2009, consistent with the decline in the target coverage levels. Yellowtail accounted for 80 to 92% of the total catch in the fishery each year (Table 3). Discarding has generally been prohibited in the fishery, with exceptions for live release of some species (e.g. wolfish), and for species such as skate to prevent product spoilage. Observed discarding did not exceed 7% by weight in any year, for all species combined (Table 3).

For yellowtail flounder all factors were significant (Table 4). Residuals showed little patterning either against predicted values or against the factors in the model (Figure 2 and 3). Estimated CPUE was lowest in 2002 at about 550 Kg per hour. After that it increased to more than 1000 Kg per hour in 2011 and then declined in 2012, although there was only 1 observed trip in 2012 (Figure 4). There was very good agreement in year to year trends with the standardized series based on Can(N) commercial logbooks (Figure 5). Reported catch was only less than 90% of catch estimated from the observer data in 2 years (1998 and 2011). In most years reported catch was 95% or more of the estimated catch and in 8 of 14 years it was within 2 standard errors of the estimated catch (Table 7, Figure 6).

For American plaice the effect of division was not significant so it was removed from the model leaving year, month and tonnage class as factors (Table 5). Residuals showed little patterning either against predicted values or against the factors in the model (Figure 7 and 8). Estimated CPUE increased from 50 Kg per hour to over 120 Kg per hour in 2007, after which it generally declined (Figure 9). Reported catch was generally 70-80% of the estimated catch although in 2009 it was 145% of the estimated catch (Table 7). In only 5 of the 14 years was the reported catch within 2 standard errors of the estimated catch (Figure 10).

For cod only data from Div. 3NO were used. All factors were significant and were retained in the model (Table 6). Residuals showed little patterning either against predicted values or against the factors in the

model (Figure 11 and 12). Estimated CPUE had wide confidence intervals (Figure 13). It increased from about 20 Kg per hour in 1998 to just under 55 Kg per hour in 2005. Estimated CPUE declined from 2007 to 2011 and then nearly doubled to 2012. However, the 2012 estimate has very wide confidence intervals. The reported catch was often less than 80% of the estimated catch, however the difference in tons was generally low (Table 7). In all but 4 years, the reported catch was outside of 2 standard errors of the estimated catch (Figure 14).

A comparison of modelled and unmodelled estimates of catch, both based on the observer data is given in Table 8. Although the level of detail of the modelled estimates is much greater, the estimates are reasonably close in most years.

The percentage that reported catch was of the estimated catch was examined over time for Div. 3NO cod and Div. 3LNO American plaice. The percentage was relatively stable with perhaps some increase over time.

Discussion

In two years (2009 for American plaice and 2011 for cod) the reported catch was higher than the estimated catch. Given the restrictions on bycatch it is difficult to imagine that there are incentives for over reporting. This may be indicative of the difficulties in estimating catch of bycatch species, particularly when these catches are low.

There are other methods that can be used to estimate by catch (e.g. Chen 2004). In addition we found that the estimates of catch using the model described here and the unmodelled observer data were reasonably close in most years. Further exploration of methods to estimate catch would be worth while.

On an observed trip not all sets are observed. We have not distinguished between sets where catch has been estimated by the observer and those that are taken from the log book. This distinction should be explored in future.

Since the percentage of observer coverage declined over the period examined it might be expected that the reported catch would be a lower proportion of the estimated catch by the end of the time series. However, there was no indication that this was the case and in fact there was a slight increasing trend over time.

Although there were differences in the estimated and reported catch, especially for American plaice and cod, the level of importance is not clear. For example, in 2012, the reported cod catch was only 67% of the estimated, but this is a difference of only 10 tons. For American plaice, the largest difference was 400 tons in 2001, out of a total STACFIS estimate of 5739 tons in that year.

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Table 1. Number of trips and sets observed, where effort was directed to yellowtail, by Canadian OT vessels in Div. 3LNO, 1998-2012.

		# sets		
Year	# trips	Observed	Logged	Total
1998	40	1357	195	1552
1999	41	2307	358	2665
2000	53	2962	482	3444
2001	71	4396	667	5063
2002	73	5018	917	5935
2003	74	5247	955	6202
2004	44	4808	787	5595
2005	40	3411	730	4141
2006	0	0	0	0
2007	9	932	194	1126
2008	18	1814	334	2148
2009	5	490	105	595
2010	9	593	113	706
2011	4	367	55	422
2012	1	74	14	88

Table 2. Yellowtail catch and effort (observed+logged) from observer data, where effort was directed to yellowtail, by Canadian OT vessels in Div. 3LNO, 1998-2012. Compared to reported data (ZIF or STATLANT) of total Canadian yellowtail catch. All data excludes discards.

Year	Obs catch (t)	Obs Effort (hr)	Rep. Catch	obs/rep
1998	3291	4354	3739	0.88
1999	5407	6941	5746	0.94
2000	8875	9985	9463	0.94
2001	11447	16571	12238	0.94
2002	9379	15761	9959	0.94
2003	12470	15207	12697	0.98
2004	12856	13279	12577	1.02
2005	9892	10017	13140	0.75
2006	0		177	0.00
2007	2824	2728	3674	0.77
2008	5889	5824	10216	0.58
2009	1427	1652	5415	0.26
2010	2067	2037	8056	0.26
2011	1471	1216	3948	0.37
2012	313	328	1795	0.17

Table 3. Yellowtail and total catch (observed+logged) from observer data, where effort was directed to yellowtail by Canadian OT vessels in Div. 3LNO, 1998-2012. Ytail % is the ytail catch divided by total catch

	Ytail			All Species			Ytail %
Year	Kept	Discard	Total	Kept	Discard	Total	
1998	3291	1	3292	3566	69	3635	90.6%
1999	5407	1	5408	5785	107	5892	91.8%
2000	8875	1	8876	9610	244	9854	90.1%
2001	11447	2	11449	13312	504	13816	82.9%
2002	9379	2	9381	11007	659	11666	80.4%
2003	12470	7	12477	14740	885	15625	79.9%
2004	12856	7	12863	14739	742	15481	83.1%
2005	9892	2	9894	11223	571	11794	83.9%
2006	0	0	0	0	0	0	
2007	2824	4	2828	3274	247	3521	80.3%
2008	5889	2	5891	6603	272	6875	85.7%
2009	1427	1	1428	1606	90	1696	84.2%
2010	2067	3	2070	2389	91	2480	83.5%
2011	1471	1	1472	1643	30	1673	88.0%
2012	313	0	313	366	5	371	84.4%

Table 4. Results of generalized linear model fit to catch rate data from observers for Div. 3LNO yellowtail flounder

glm(formula = cpue1 ~ TC + DIV + MONTH + year, family = Gamma(link = log), data = sr1)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.57046	-0.17852	-0.00766	0.14053	0.97366

Coefficients:					
	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	6.67969	0.13511	49.44	<0.00001	***
TC4	-0.6471	0.12937	-5.002	1.19E-06	***
TC6	0.03538	0.06389	0.554	0.580319	
TC7	0.18001	0.07105	2.534	0.012013	*
DIV32	-0.05717	0.08679	-0.659	0.51078	
DIV35	-0.2545	0.04449	-5.721	3.59E-08	***
MONTH1	0.11514	0.10978	1.049	0.295425	
MONTH2	0.20524	0.11097	1.85	0.065773	.
MONTH3	-0.11773	0.10018	-1.175	0.241251	
MONTH4	0.07622	0.08352	0.913	0.3625	
MONTH5	0.25608	0.07477	3.425	0.000738	***
MONTH6	0.31259	0.08292	3.77	0.000212	***
MONTH7	0.26379	0.14443	1.826	0.069197	.
MONTH8	0.39269	0.10012	3.922	0.000118	***
MONTH9	0.12995	0.07708	1.686	0.09328	.
MONTH11	0.08227	0.07829	1.051	0.2945	
MONTH12	0.41815	0.09142	4.574	8.14E-06	***
year1999	0.02306	0.15694	0.147	0.883327	
year2000	0.02462	0.15004	0.164	0.869822	
year2001	-0.20032	0.14978	-1.337	0.182505	
year2002	-0.3544	0.14709	-2.409	0.016833	*
year2003	-0.10368	0.13982	-0.742	0.459163	
year2004	0.03628	0.1424	0.255	0.799137	
year2005	0.04953	0.14203	0.349	0.727627	
year2007	0.088	0.16086	0.547	0.584901	
year2008	0.15132	0.15718	0.963	0.336797	
year2009	0.05954	0.18092	0.329	0.742407	
year2010	0.07585	0.16489	0.46	0.645988	
year2011	0.25228	0.20053	1.258	0.209767	
year2012	-0.10784	0.33673	-0.32	0.749094	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Gamma family taken to be 0.08986932)

Null deviance: 37.851 on 241 degrees of freedom, Residual deviance: 21.947 on 212 degrees of freedom

AIC: 3424.4

Number of Fisher Scoring iterations: 6

Table 5. Results of generalized linear model fit to catch rate data from observers for Div. 3LNO American plaice

glm(formula = cpue1 ~ TC + MONTH + year, family = Gamma(link = log), data = sr1)

Deviance Residuals:

Min 1Q Median 3Q Max

-1.31309 -0.27312 -0.08118 0.21646 1.23278

Coefficients:					
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.76978	0.24842	15.175	<0.000001	***
TC4	-0.89142	0.22421	-3.976	1.17E-04	***
TC6	-0.04822	0.12545	-0.384	0.701351	
TC7	-0.11022	0.13431	-0.821	0.413378	
MONTH1	-0.5996	0.18872	-3.177	0.001867	**
MONTH2	-0.71009	0.18207	-3.9	1.55E-04	***
MONTH3	-0.62506	0.17057	-3.665	0.000363	***
MONTH4	0.17288	0.16062	1.076	0.283829	
MONTH5	0.71981	0.1609	4.474	1.69E-05	***
MONTH6	0.8371	0.16797	4.984	2.00E-06	***
MONTH7	0.27603	0.30161	0.915	0.361826	
MONTH8	0.03234	0.18488	0.175	0.861417	
MONTH9	-0.09094	0.15022	-0.605	0.545992	
MONTH11	0.22634	0.15278	1.482	0.140949	
MONTH12	0.24462	0.17102	1.43	0.155082	
year1999	0.18818	0.28548	0.659	0.510976	
year2000	0.27448	0.28082	0.977	3.30E-01	
year2001	0.62848	0.27904	2.252	0.026019	*
year2002	0.64346	0.27668	2.326	0.021621	*
year2003	0.76327	0.26154	2.918	0.004163	**
year2004	0.61921	0.26538	2.333	0.021202	*
year2005	0.78382	0.26719	2.934	0.003977	**
year2007	1.03043	0.29893	3.447	0.000769	***
year2008	0.69306	0.3021	2.294	0.023425	*
year2009	0.81593	0.33245	2.454	0.015471	*
year2010	0.87931	0.30728	2.862	0.004931	**
year2011	0.60796	0.38667	1.572	0.118374	
year2012	0.61464	0.54612	1.125	0.262511	
year2011	0.25228	0.20053	1.258	0.209767	
year2012	-0.10784	0.33673	-0.32	0.749094	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Gamma family taken to be 0.2107296)

Null deviance: 67.752 on 154 degrees of freedom ,Residual deviance: 24.822 on 127 degrees of freedom

AIC: 1566.0

Number of Fisher Scoring iterations: 8

Table 6. Results of generalized linear model fit to catch rate data from observers for Div. 3NO cod

glm(formula = cpue1 ~ TC + DIV + MONTH + year, family = Gamma(link = log), data = sr1)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.8535	-0.4954	-0.1254	0.2486	1.8213

Coefficients:					
	Estimate	Std. err	t value	Pr(>|t|)	
(Intercept)	3.14356	0.28947	10.86	<0.0001	***
TC4	-1.91673	0.30645	-6.255	2.93E-09	***
TC6	0.38217	0.14424	2.65	0.008793	**
TC7	0.43786	0.16264	2.692	0.007782	**
DIV35	0.7393	0.09988	7.402	5.33E-12	***
MONTH1	-2.89215	0.27612	-10.474	<0.0001	***
MONTH2	-3.22709	0.31569	-10.222	<0.0001	***
MONTH3	-3.31324	0.26057	-12.715	<0.0001	***
MONTH4	-1.74444	0.18843	-9.258	<0.0001	***
MONTH5	-1.1781	0.16735	-7.04	<0.0001	***
MONTH6	-0.97983	0.19334	-5.068	1.01E-06	***
MONTH7	0.07744	0.36041	0.215	0.830127	
MONTH8	-0.41327	0.2183	-1.893	0.059983	.
MONTH9	-0.22269	0.16766	-1.328	0.185826	
MONTH11	-0.47026	0.17521	-2.684	0.007971	**
MONTH12	-0.70378	0.19684	-3.575	0.000451	***
year1999	0.43977	0.33542	1.311	0.191532	
year2000	0.45265	0.34496	1.312	0.191165	
year2001	0.74869	0.3267	2.292	0.023107	*
year2002	0.55112	0.32066	1.719	0.087431	.
year2003	0.79582	0.30021	2.651	0.008759	**
year2004	0.8653	0.3073	2.816	0.00542	**
year2005	0.86011	0.31004	2.774	0.006131	**
year2007	0.225	0.34659	0.649	0.517065	
year2008	0.29775	0.34602	0.86	0.390688	
year2009	0.21579	0.42725	0.505	0.614146	
year2010	-0.1216	0.36827	-0.33	0.741653	
year2011	-0.99902	0.43273	-2.309	0.022127	*
year2012	0.07274	0.722	0.101	0.919862	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Gamma family taken to be 0.409408)

Null deviance: 267.46 on 204 degrees of freedom, Residual deviance: 68.03 on 176 degrees of freedom

AIC: 1683.3

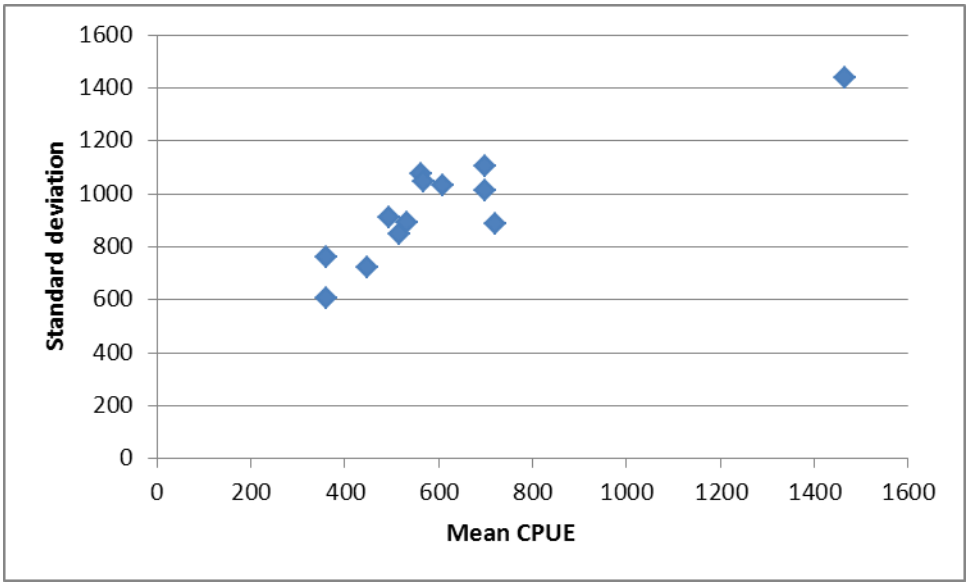
Number of Fisher Scoring iterations: 8

Table 7. Estimated and reported catch in tons for Div. 3LNO yellowtail flounder, American plaice and Div. 3NO cod from 1998 to 2012.

		yellowtail		
Year	estimated	reported	% of estimated	difference in tons
1998	4310	3428	80	883
1999	6610	5443	82	1167
2000	9280	9369	101	-89
2001	12261	12029	98	232
2002	9705	9483	98	222
2003	12431	12636	102	-206
2004	12263	12519	102	-256
2005	13714	13267	97	447
2006				
2007	3636	3672	101	-36
2008	10949	10210	93	740
2009	5921	5411	91	510
2010	8476	8070	95	406
2011	4445	3927	88	518
2012	1638	1768	108	-130
		plaice		
Year	estimated	reported	% of estimated	difference in tons
1998	205	169	83	35
1999	339	279	82	60
2000	719	548	76	171
2001	1741	1309	75	431
2002	1458	1030	71	428
2003	1831	1501	82	330
2004	1466	1248	85	217
2005	1594	1429	90	165
2006				
2007	527	420	80	107
2008	1062	874	82	188
2009	737	1072	145	-335
2010	1180	1123	95	57
2011	456	371	81	85
2012	270	231	85	39
		cod		
Year	estimated	reported	% of estimated	difference in tons
1998	104	85	82	19
1999	192	71	37	122
2000	174	103	59	71
2001	599	392	66	207
2002	479	284	59	195
2003	760	583	77	176
2004	540	386	71	154
2005	506	381	75	125
2006				
2007	161	106	66	55
2008	230	158	69	72
2009	130	130	100	0
2010	129	99	77	30
2011	13	35	268	-22
2012	30	20	67	10

Table 8. A comparison of estimated catch from observer data modelled and 'unmodelled' (raw). The unmodelled is simply the annual sum of observed catch divided by the annual sum of observed effort to produce and unmodelled CPUE. This is then multiplied by the reported effort to get the 'raw' catch estimate. The modelled estimate of catch comes from the method described in this paper.

	year	observed catch	observed effort	raw cpue	reported effort	raw estimate of catch	model estimate of catch
Yellowtail flounder							
	1998	3291865	4354	756	4728	3575	4310
	1999	5407595	6941	779	7172	5588	6610
	2000	8876354	9985	889	9179	8160	9280
	2001	11448725	16571	691	16940	11704	12261
	2002	9381161	15761	595	16090	9577	9705
	2003	12477066	15207	821	16185	13280	12431
	2004	12863290	13279	969	13270	12855	12263
	2005	9893257	10017	988	13572	13405	13714
	2007	2827753	2728	1036	3857	3997	3636
	2008	5890788	5824	1011	9422	9530	10949
	2009	1428420	1652	865	6128	5300	5921
	2010	2070806	2037	1017	8629	8774	8476
	2011	1472451	1216	1211	3718	4502	4445
	2012	313456	328	957	1718	1643	1638
American plaice							
	1998	140524	4344	32	4728	153	205
	1999	254482	6858	37	7172	266	339
	2000	584310	9952	59	9179	539	719
	2001	1369473	16504	83	16940	1406	1741
	2002	1113052	15606	71	16090	1148	1458
	2003	1577563	15056	105	16185	1696	1831
	2004	1419761	13190	108	13270	1428	1466
	2005	1027180	9959	103	13572	1400	1594
	2007	356819	2712	132	3857	508	527
	2008	579212	5815	100	9422	939	1062
	2009	143638	1619	89	6128	544	737
	2010	273937	1960	140	8629	1206	1180
	2011	153586	1216	126	3718	470	456
	2012	51437	328	157	1718	270	270
cod							
	1998	77278	3337	23	4728	110	104
	1999	75354	5328	14	7172	101	192
	2000	117144	5797	20	9179	186	174
	2001	388585	10132	38	16940	650	599
	2002	271529	8901	31	16090	491	479
	2003	579563	9669	60	16185	970	760
	2004	409995	7046	58	13270	772	540
	2005	266304	4545	59	13572	795	506
	2007	74058	1897	39	3857	151	161
	2008	107531	3411	32	9422	297	230
	2009	25308	533	47	6128	291	130
	2010	32101	1022	31	8629	271	129
	2011	4110	591	7	3718	26	13
	2012	1305	116	11	1718	19	30



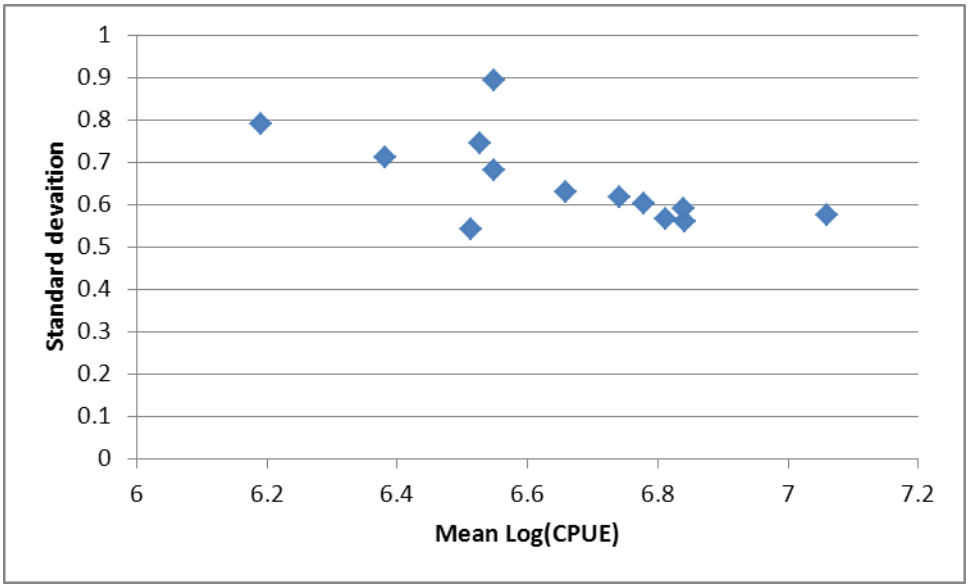


Figure 1. Standard deviation plotted against mean CPUE (top) and mean log (CPUE) bottom for Div. 3LNO yellowtail flounder.

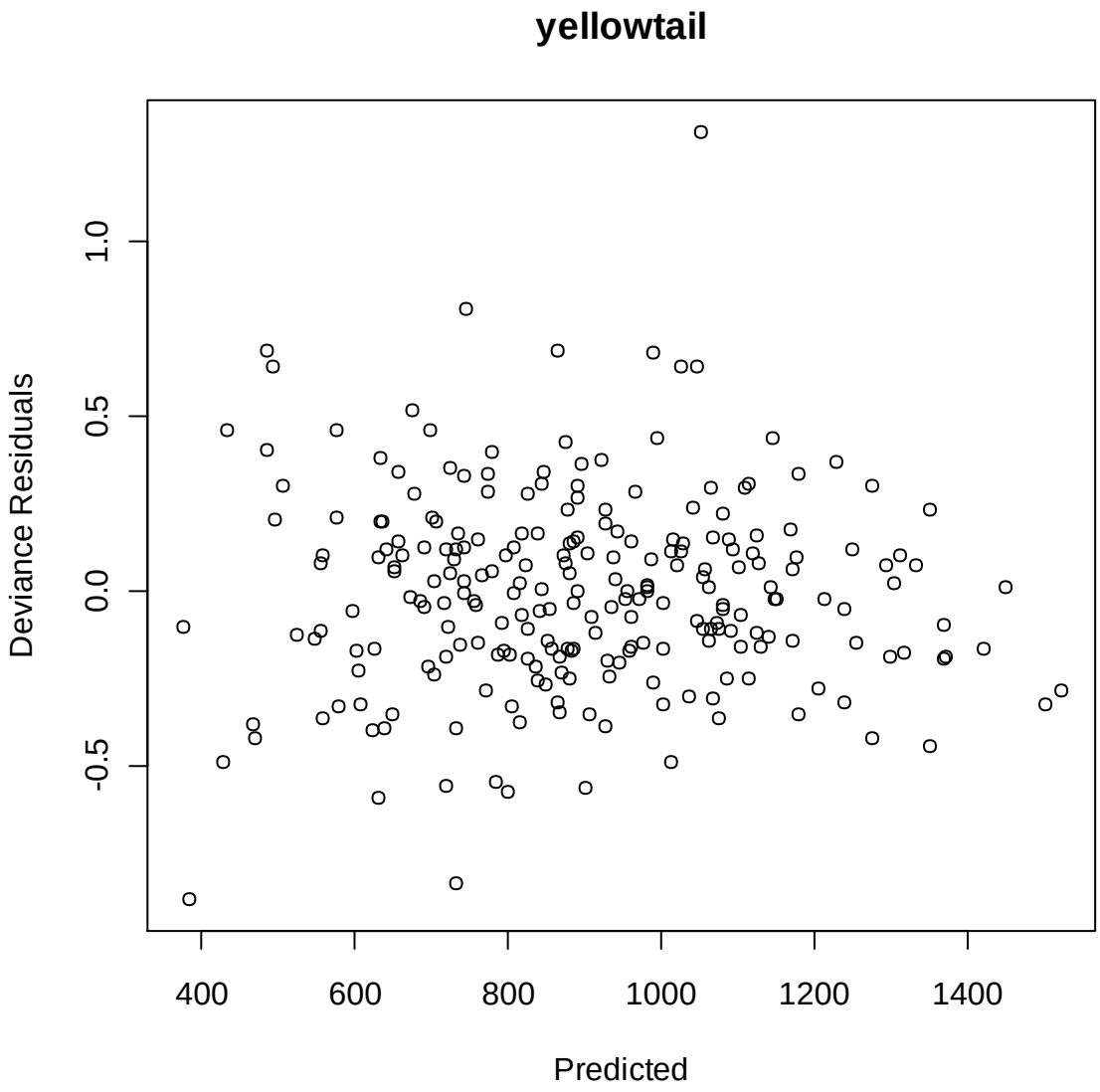


Figure 2. Deviance residuals versus predicted catch rate estimated from observer data for Division 3LNO yellowtail flounder.

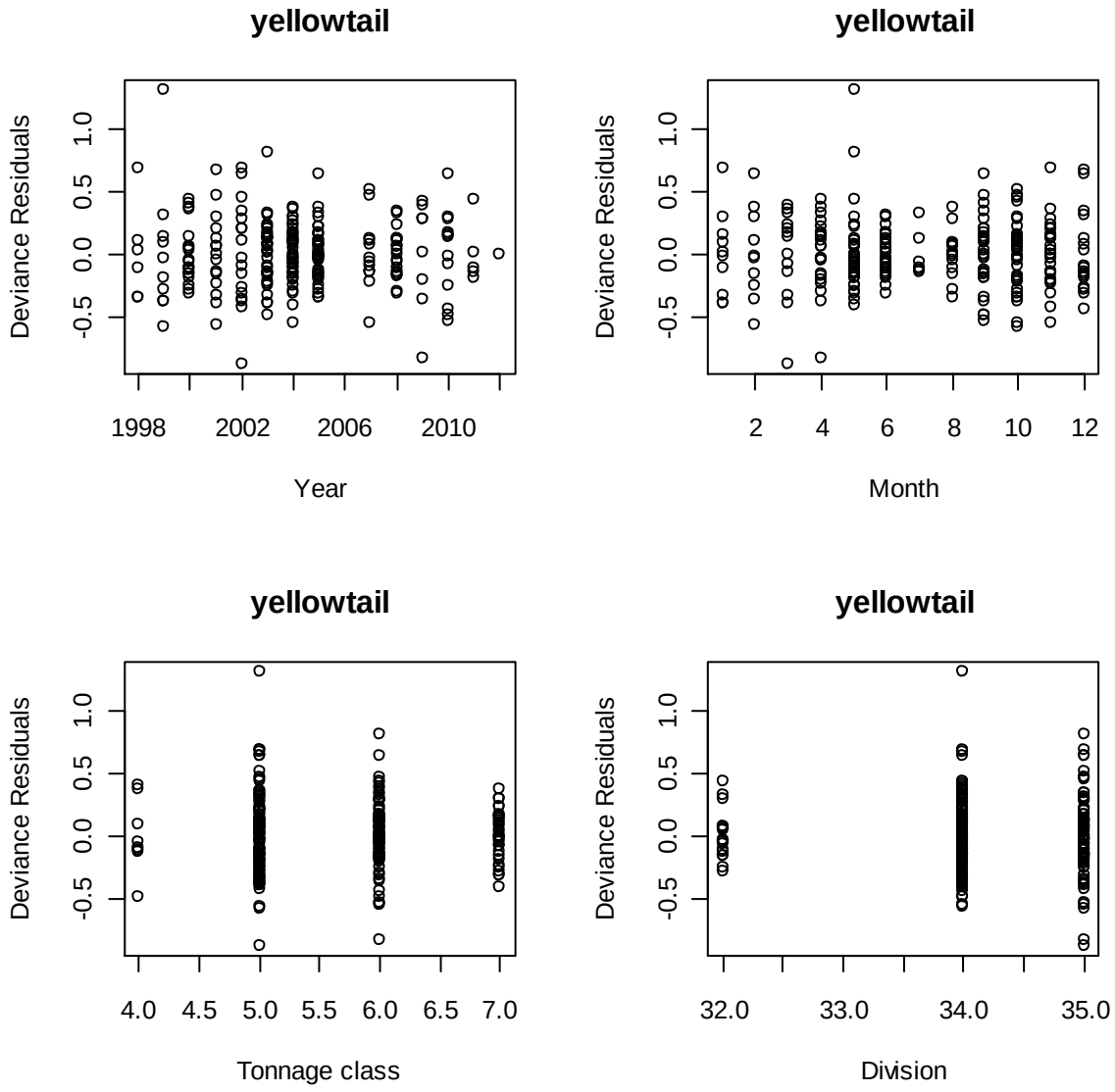


Figure 3. Deviance residuals versus year, month, tonnage class and division for Div. 3LNO yellowtail flounder catch rate estimated from observer data.

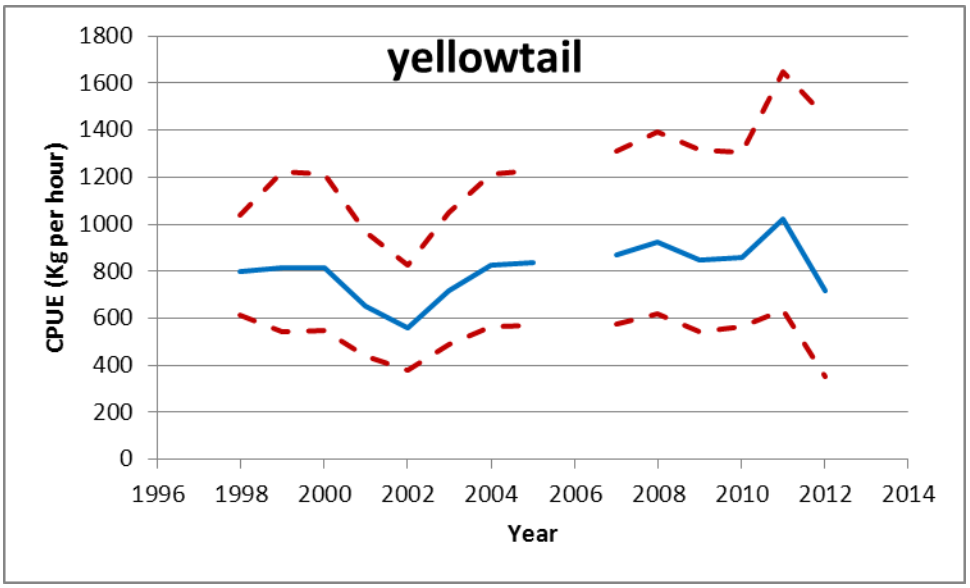


Figure 4. Estimated annual CPUE (Kg per hour) for Div. 3LNO yellowtail flounder with 95% confidence intervals. Estimate is referenced to month 10, tonnage class 5 and Div. 3N.

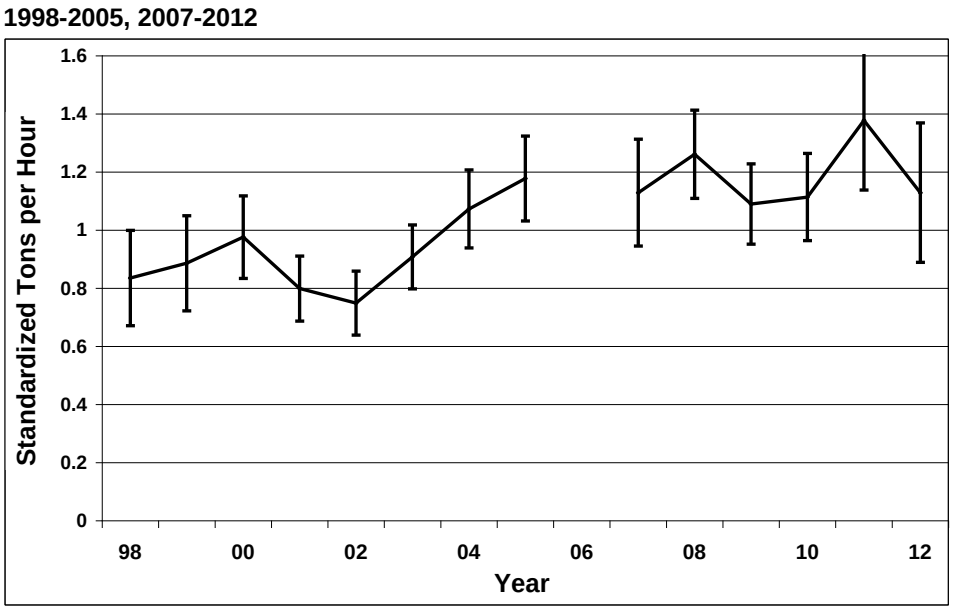


Figure 5. Standardized CPUE ± 2 s.e. for Yellowtail in Div. 3LNO from 1998-2012 (preliminary) based on a standardization of Can(N) logbook data from 1965-2012.

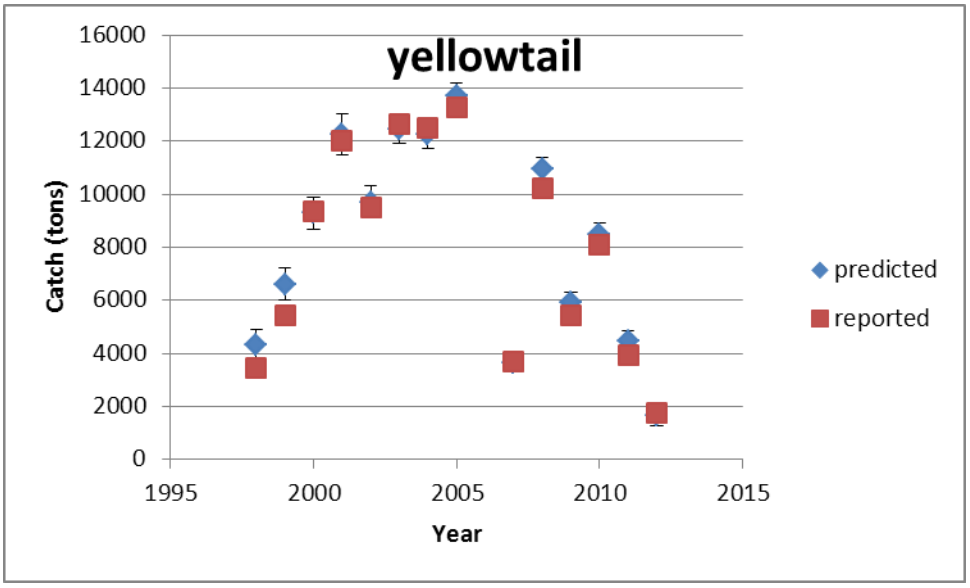


Figure 6. Estimated annual catch (± 2 Std. err.) for 3LNO yellowtail flounder, along with reported catch.

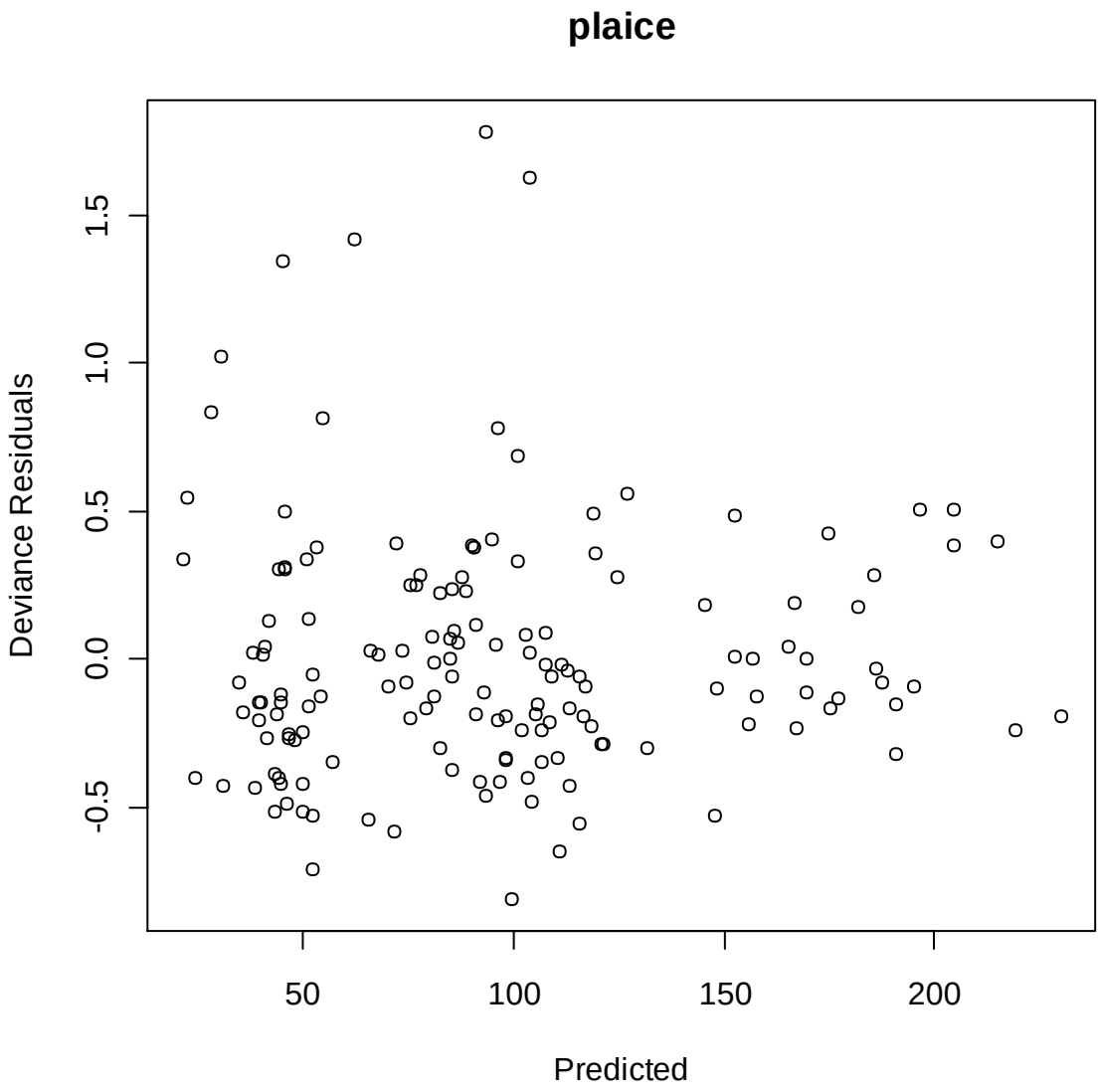


Figure 7. Deviance residuals versus predicted catch rate estimated from observer data for Division 3LNO American plaice.

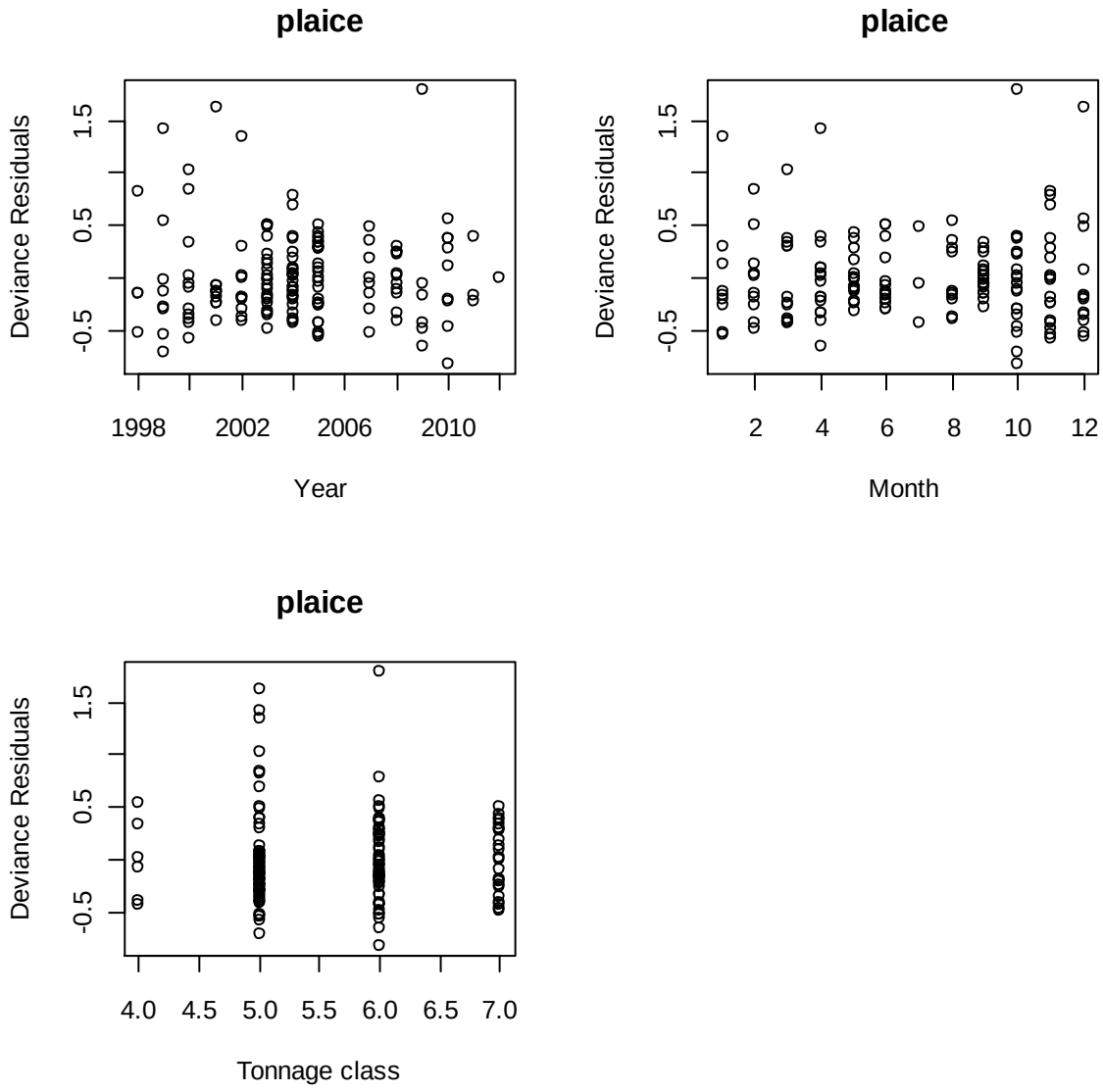


Figure 8. Deviance residuals versus year, month, and tonnage class for Div. 3LNO American plaice catch rate estimated from observer data.

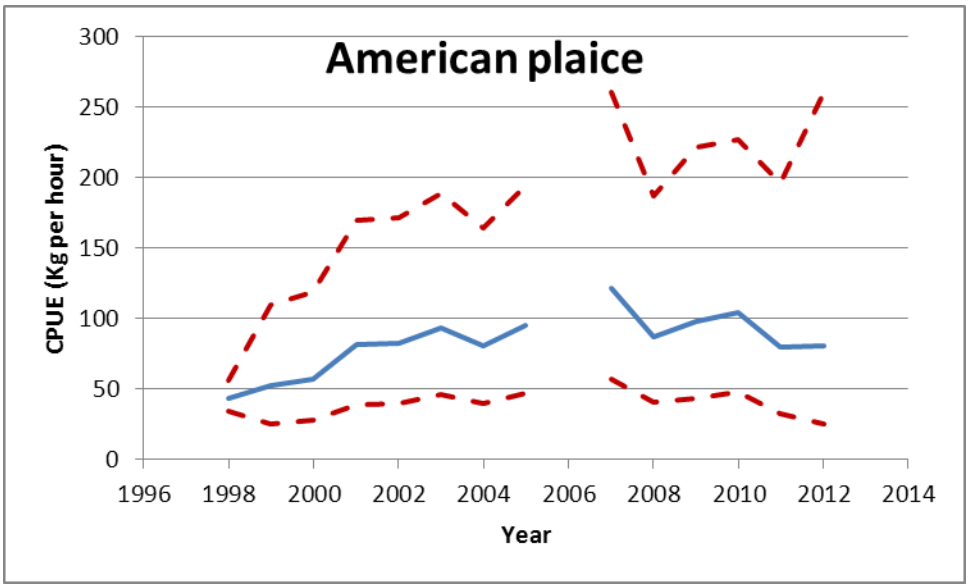


Figure 9. Estimated annual CPUE (Kg per hour) for Div. 3LNO American plaice with 95% confidence intervals. Estimate is referenced to month 10 and tonnage class 5.

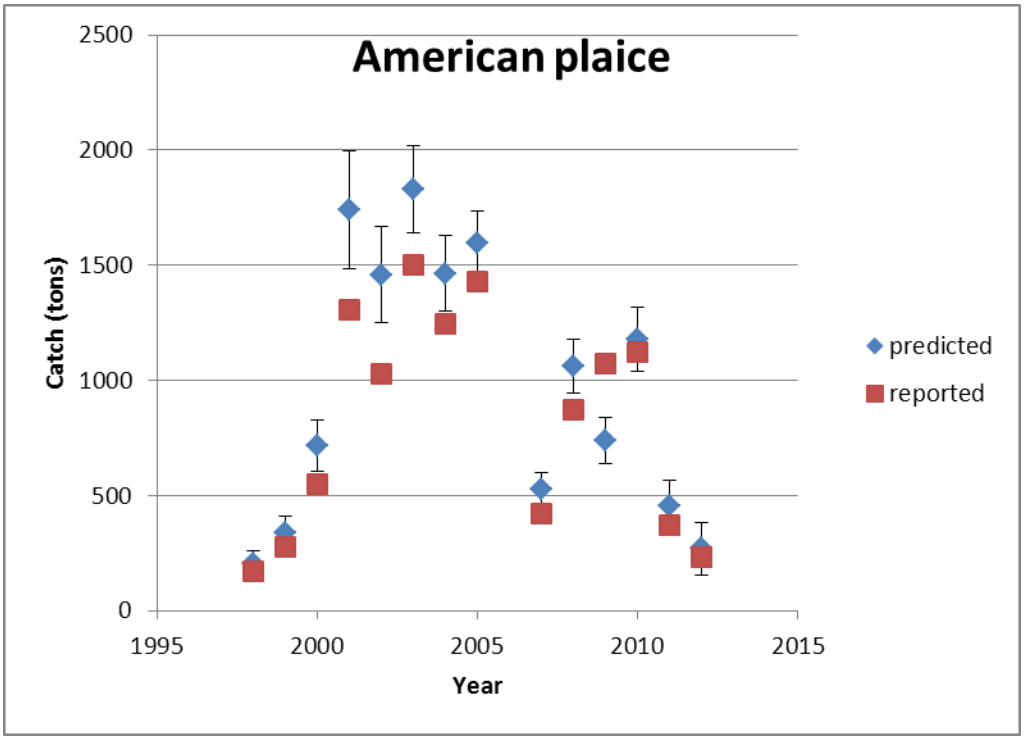


Figure 10. Estimated annual catch (± 2 Std. err.) for 3LNO American plaice, along with reported catch.

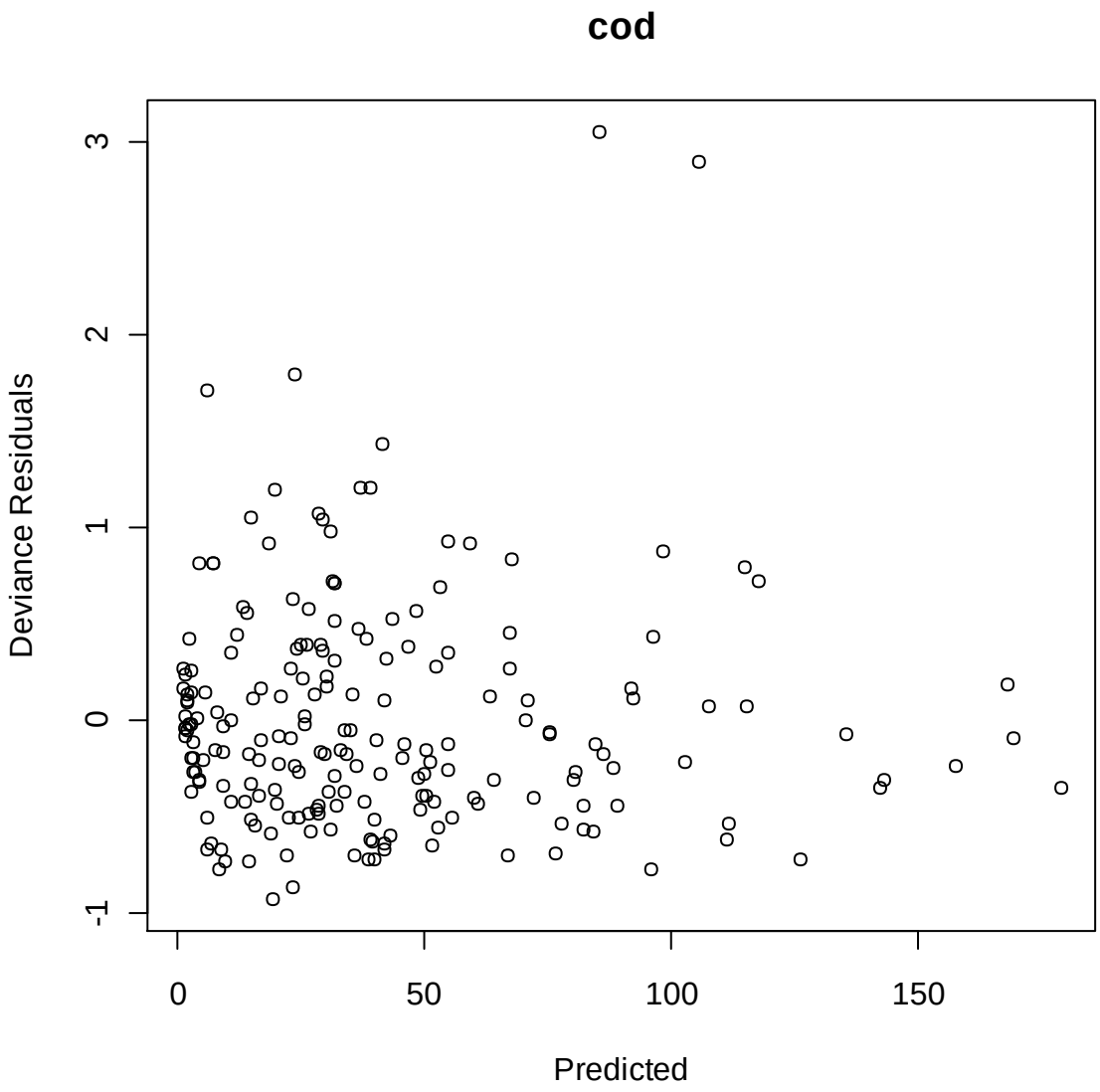


Figure 11. Deviance residuals versus predicted catch rate estimated from observer data for Division 3NO cod.

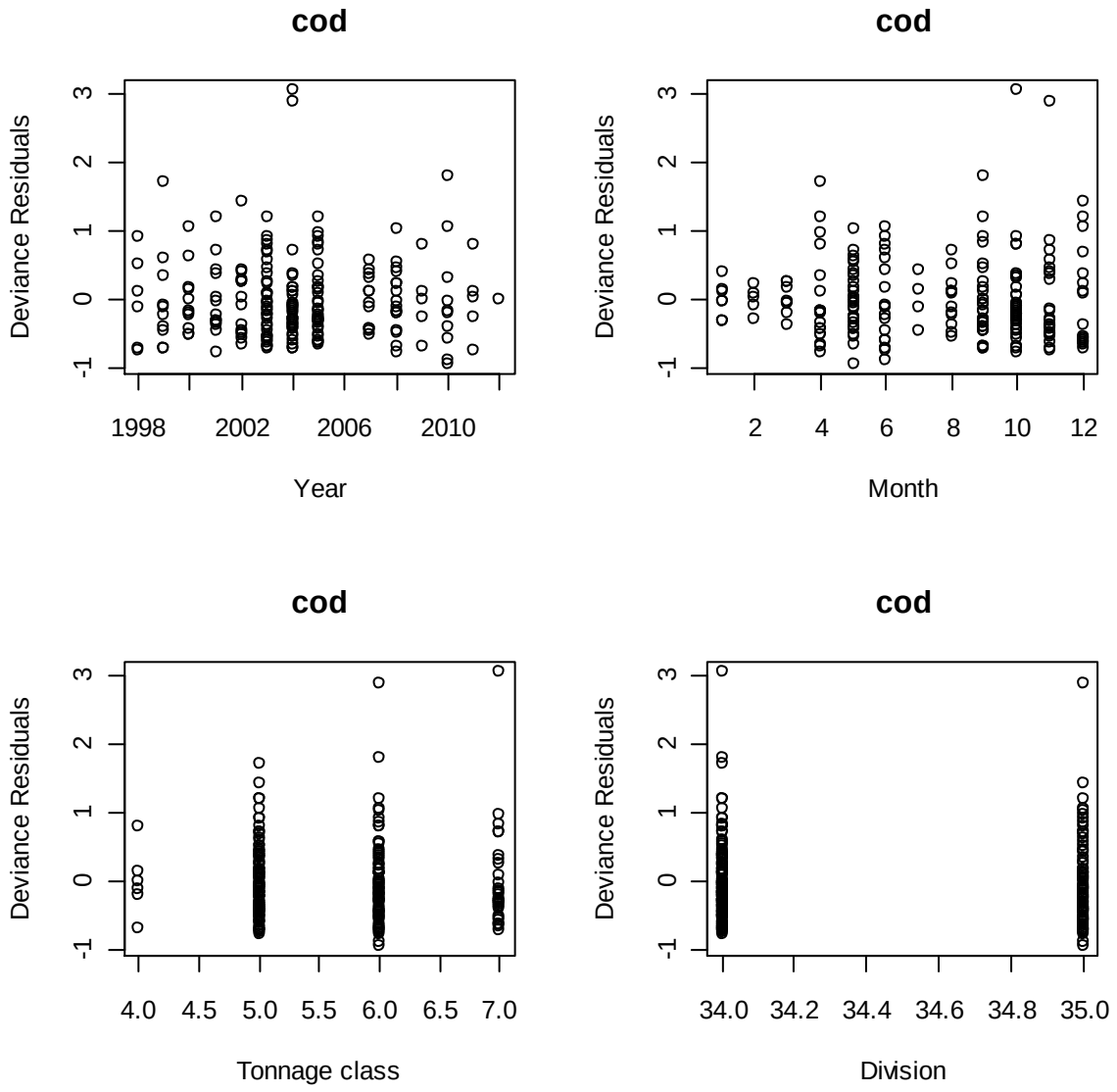


Figure 12. Deviance residuals versus year, month, tonnage class and division for Div. 3NO cod catch rate estimated from observer data.

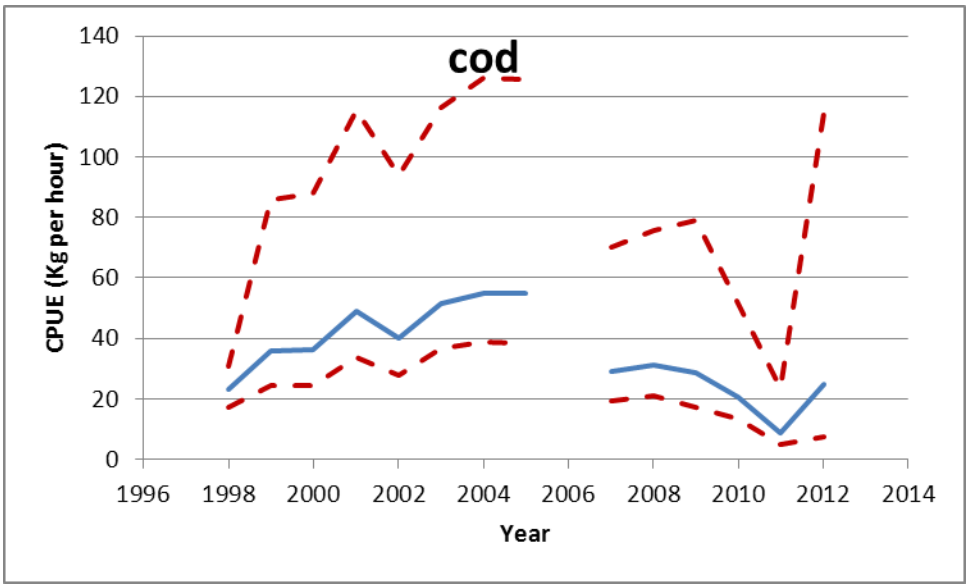


Figure 13. Estimated annual CPUE (Kg per hour) for Div. 3NO cod with 95% confidence intervals. Estimate is referenced to month 10, tonnage class 5 and Div. 3N.

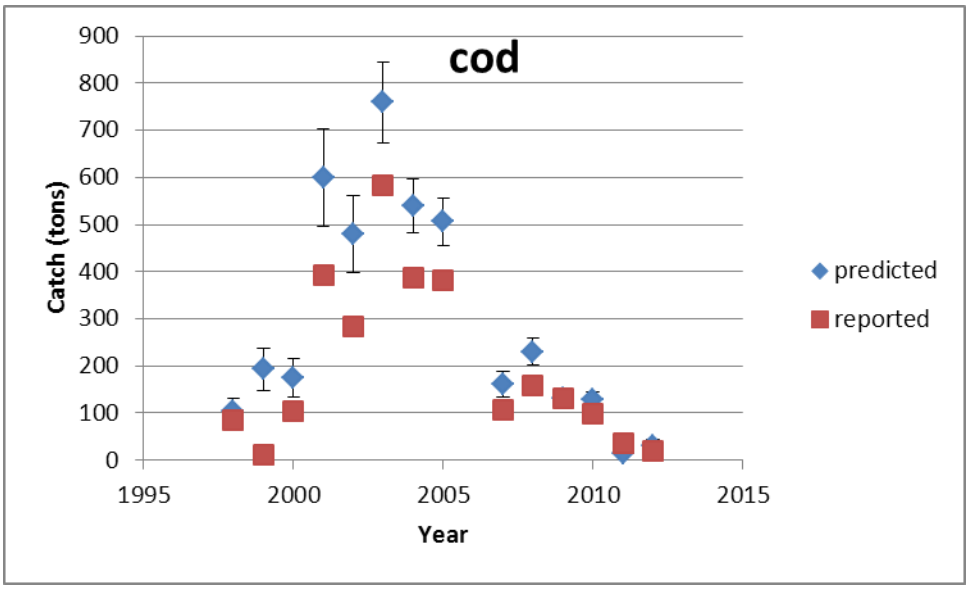


Figure 14. Estimated annual catch (± 2 Std. err.) for 3NO cod, along with reported catch.

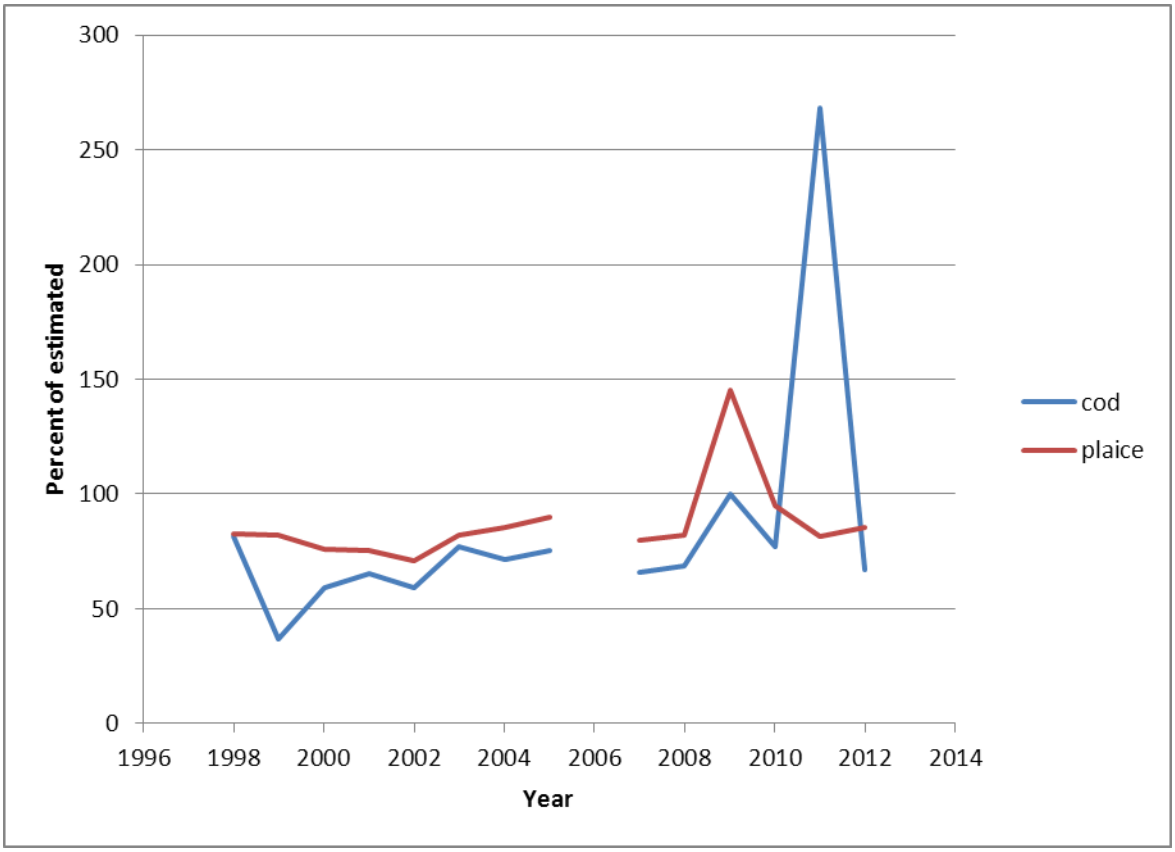


Figure r1. Percentage reported catch of estimated catch for Div. 3NO cod and Div. 3LNO American plaice.