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The 2nd Take of 2008 Assessment of Redfish in NAFO Divisions 3LN: Going Further on the Exploratory Analysis of ASPIC Formulations

by

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Abstract

Six different arrangements of most of the stratified-random bottom trawl surveys conducted by Canada and Russia in various years and seasons in Div. 3L and Div. 3N from 1978 onwards were used in an exploratory analysis to select a formulation with the best goodness of fit of the ASPIC model to the available survey data.

Introduction

At the end of last STACFIS assessment of redfish in Div. 3LN (2008) a second round of exploratory runs with the revised ASPIC model (Prager, 1994, 2004 and 2007) was performed. The purpose was to avoid the duplication of surveys in the input data sets, as occurred in the original 2008 assessment framework (Canadian autumn survey in Div. 3L both as a single survey biomass series starting in 1985 and in a combined Canadian autumn survey series for Div. 3LN, starting in 1991; Ávila de Melo et al., 2008). The adjustment of the model to alternate arrangements of the available survey data sets was evaluated, namely how the model respond to the inclusion or exclusion of observations considered outliers in their own time series. The work was then presented as a working paper and is know upgraded to a Scientific Council Research Document in order to be cited.

Material and Methods

This exploratory analysis incorporates the 1959-2007 catches conditioned on a 1959-94 CPUE series from Statlant data (Power 1997; Table 1 and Fig.1), and most of the stratified-random bottom trawl surveys conducted by Canada and Russia in various years and seasons in Div. 3L and Div. 3N, from 1978 till 2007 (Table 2 and Fig. 2).

All input series consist of annual observed values and were given equal weight in the analysis. The ASPIC version 5.16 was used with the logistic production model (Schaefer, 1954). Each Canadian survey series is referred by its season and division(s), while the Russian survey series is referred by its country, name of the data reviser (Power, 1992) and divisions.

The 1992 autumn biomass index for Div. 3N and the 1995 autumn index for Div. 3L had anomalously high magnitudes, while staying between relatively low indices from the neighbouring years. The original mean weights per tow have also associated anomalously high errors (highest of each survey series). So survey biomass from these years and divisions were considered outliers of the respective survey series, and the performance of the model was checked with and without these outliers.

Input series ending on the 1st half of the 1990's basically reflect the abundance of the stock till the beginning of the 1990's (3LN Russian survey and 3L summer and winter surveys). While input series extending up today

basically reflect the abundance of the stock over most of the 1990's and 2000's (3L and 3N spring and autumn surveys). Due to the short time overlap, "old" and "new" input time series were not disqualified by negative correlations between them.

The data sets have been re-arranged on six ASPIC formulations as follows:

Run 1	**ASPIC$_{SATCFIS}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3LN autumn survey, 1996-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)+I7(3L autumn survey, 1985-1986, 1990-1994)
Run 2	**ASPIC$_{autumn3L\ with\ 95\ and\ autumn3N\ with\ 92}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 3	**ASPIC$_{autumn3L\ with\ 95\ and\ autumn3N\ without\ 92}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991, 1993-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 4	**ASPIC$_{autumn3L\ without\ 95\ and\ autumn3N\ with\ 92}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)
Run 5	**ASPIC$_{autumn3L\ without\ 95\ and\ autumn3N\ without\ 92}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991,1993-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)
Run 6	**ASPIC$_{autumn3LN\ without\ 92\ and\ 95}$**
	I1 (Statlant CPUE, 1959-1994)+I2 (3LN spring survey, 1991-2005, 2007)+I3 (3LN autumn survey, 1991,1993-1994,1996-2007)+I4Power (3LN Power russian survey, 1984-1991)+
	I5 (3L winter survey,1985-1986, 1990)+I6 (3L summer survey, 1978-1979,1981, 1984-1985, 1990-1991, 1993)

The objective of the present work is not a full review of the ASPIC exploratory/sensitivity protocol already carried out on the assessment paper (Ávila de Melo et al., 2008). Rather is focused on choosing a formulation close to the one of the 2008 ASPIC assessment, but that doesn't duplicate survey data within different time series and at the same time make use of most of the existing survey indices. The selection between several alternate arrangements of CPUE and survey time series was based on two criteria:

- All indices in ASPIC assessment should be in line with the dynamics of the stock given by the model. In other words no negative or "zero" correlations were allowed between the model index and the correspondent observed index (despite the usual low/very low correlations due to the high variability associated with redfish indices), or between series overlapping most of the years.
- Robustness of the model regarding last year of data. In other words, formulations should provide results that stand still regardless the variability of the terminal observations (in this exercise variability was set at -/+ 10% of the 2007 survey biomasses).

In addition to these two requirements the longer and up to date survey series (also the ones with higher numbers of pair wise observations) should have relatively high correlations between them.

Results and Discussion

Correlation among series and main diagnostics for the six new ASPIC formulations are presented on Table 3a and 3b. Correlation between observed and expected time series is generally poor but, as regards the 3L and 3N autumn surveys, the inclusion of the outliers (the $3L_{1995}$ and the $3N_{1992}$ survey biomasses) will lead to an almost null or even negative R^2. Grouping the two series in a single autumn 3LN survey, starting after or excluding the anomalous years (Run 1, as suggested by STACFIS, or Run 6) will be of little help either. The formulation with better diagnostics according to the underlying criteria of this brief exploratory analysis was the one used in Run 5.

Besides the better or worst diagnostics, model results are highly sensitive to the internal consistency of the 3N survey series: the two trajectories of relative biomass given by runs including the 1992 3N survey biomass (Run 2

and 4) are similar, but kept well apart of the handful of trajectories from runs that exclude this outlier (Tables 4a and 4b, Fig.3).

As regards the robustness of the model, Run 5, without both autumn 1992 3N and 1995 3L survey biomasses, was tested against Run 2 with these survey points. With the first option relative biomass remained practically unchanged with a 10% upward or downward revision of last year data, whereas Run 2 shifts to the mainstream of biomass trajectories given by the "no 1992 3N" formulations when 2007 survey data are cut by 10% (Table 5a and 5b, Fig. 4a and 4b). So, as regards both diagnostics and robustness, the present analysis shown that ASPIC runs better with no outliers in the unfold 3L and 3N autumn survey series, with the 3L autumn survey going back to its beginning in 1985 (Run 5).

In terms of results, the alternate formulation is very similar to the one used in the original assessment, with the combined 1991-2007 3LN survey series and the single 1985-2007 3L autumn survey used at the same time in the assessment (Ávila de Melo et al., 2008):

- The two ASPIC runs on bootstrap mode with these two formulations gave the same picture of the 3LN redfish history, illustrated by the respective bias corrected trajectories of relative biomass and fishing mortality (Fig. 5a and 5b),
- With close bias corrected estimates of the key parameters(namely MSY, B/B_{msy} and F/F_{msy} despite generally higher biases for the alternate formulation (Tab. 6),
- And similar medium term projections under a constant catch of 5000 tons (roughly the level of the 2008 equilibrium yield for the alternate formulation, Table 6), both with high probability profiles of keeping the stock biomass well above B_{msy} and fishing mortality well bellow F_{msy} in the near future (Fig. 6a and 6b).

In conclusion, the alternate formulation introduced by the present analysis reflects a more rational arrangement of the input survey series available for redfish in Div. 3LN, provides sound diagnostics (*for redfish standards*) and robust results, keeping unchanged the perception of the stock given by the 2008 ASPIC assessment.

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Table 1: Statlant CPUE (1959-1994, Power 1994) and STACFIS catch (1959-2007) used in all ASPIC formulations (2008 assessment, 2nd take)

Year	Statlant CPUE	Catch
1959	1.426	44585
1960	1.602	26562
1961	1.697	23175
1962	1.631	21439
1963	1.632	27362
1964	1.812	10261
1965	2.185	23466
1966	1.781	16974
1967	1.893	27188
1968	0.922	17660
1969	1.338	24750
1970	1.367	14419
1971	1.346	34370
1972	1.387	28933
1973	1.643	33297
1974	1.29	22286
1975	1.669	17871
1976	1.292	20513
1977	1.251	16516
1978	1.106	12043
1979	1.451	14067
1980	1.761	16030
1981	1.594	24280
1982	1.661	21547
1983	1.556	19747
1984	1.049	14761
1985	1.084	20557
1986	1.413	42805
1987	1.523	79031
1988	1.208	53266
1989	1.322	33649
1990	0.825	29105
1991	0.668	25815
1992	0.912	27283
1993	0.801	21308
1994	0.802	5741
1995	-0.001	1989
1996	-0.001	451
1997	-0.001	630
1998	-0.001	899
1999	-0.001	2318
2000	-0.001	3141
2001	-0.001	1442
2002	-0.001	1216
2003	-0.001	1334
2004	-0.001	637
2005	-0.001	659
2006	-0.001	496
2007	-0.001	1728

Table 2: Survey biomass from stratified bottom trawl surveys used in ASPIC formulations
(2008 assessment, 2nd take; shaded area correspond to the selected survey input)

	Canadian						Russian
	I2		I6	I7	I5	I3	I4
	3LNspring	3LNautumn	3Lsummer	3Lautumn	3Lwinter	3Nautumn	3LNPower
1978			311.2				
1979			227.8				
1980							
1981			261.4				
1982							
1983							
1984			277.7				215.9
1985			161.0	98.2	90.2		94.0
1986				17.1	36.6		63.0
1987							70.3
1988							44.9
1989							12.3
1990			92.8	20.7	18.2		8.4
1991	10.6	37.9	37.6	13.7		24.2	18.7
1992	10.1	136.4		13.4		123.0	
1993	22.6	19.2	20.8	6.0		13.2	
1994	4.2	31.8		7.2		24.6	
1995	5.9	90.7		50.1		40.7	
1996	22.8	16.0		4.7		11.3	
1997	14.9	70.7		19.5		51.1	
1998	59.4	112.2		18.5		93.7	
1999	61.5	72.0		38.9		33.1	
2000	87.8	100.5		24.9		75.5	
2001	41.6	132.6		28.6		104.0	
2002	31.0	50.1		11.9		38.2	
2003	27.7	71.9		15.0		56.9	
2004	79.6	49.9		9.3		40.6	
2005	66.5	58.6		16.7		41.9	
2006				27.2		64.7	
2007	218.8	124.8		57.5		67.2	

Table 3a: correlation among input series for ASPIC (2008 assessment, 2nd take).

	series	no pair wise obs.	R^2	
Run 6 ASPIC$_{\text{autumn3LN without 92 and 95}}$	I_2/I_3	14	0.593	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3LN autumn survey, 1991,1993-1994,1996-2007)
Run 1 ASPIC$_{\text{autumn3L till 94 and autmn3LN since 96}}$	I_2/I_3	11	0.495	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1996-2007)
Run 2 ASPIC$_{\text{autumn3L with 95 and autumn3N with 92}}$	I_2/I_3	16	0.196	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991-2007)
Run 4 ASPIC$_{\text{autumn3L without 95 and autumn3N with 92}}$	I_2/I_3	16	0.196	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991-2007)
Run 3 ASPIC$_{\text{autumn3L with 95 and autumn3N without 92}}$	I_2/I_3	15	0.382	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991, 1993-2007)
Run 5 ASPIC$_{\text{autumn3L without 95 and autumn3N without 92}}$	I_2/I_3	15	0.382	I2 (3LN spring survey, 1991-2005, 2007)+I3 (3N autumn survey, 1991,1993-2007)
Run 1 ASPIC$_{\text{autumn3L till 94 and autmn3LN since 96}}$	I_2/I_7	4	-0.337	I2 (3LN spring survey, 1991-2005, 2007)+I7(3L autumn survey, 1985-1986, 1990-1994)
Run 2 ASPIC$_{\text{autumn3L with 95 and autumn3N with 92}}$	I_2/I_7	16	0.579	I2 (3LN spring survey, 1991-2005, 2007)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 3 ASPIC$_{\text{autumn3L with 95 and autumn3N without 92}}$	I_2/I_7	16	0.579	I2 (3LN spring survey, 1991-2005, 2007)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 4 ASPIC$_{\text{autumn3L without 95 and autumn3N with 92}}$	I_2/I_7	15	0.806	I2 (3LN spring survey, 1991-2005, 2007)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)
Run 5 ASPIC$_{\text{autumn3L without 95 and autumn3N without 92}}$	I_2/I_7	15	0.806	I2 (3LN spring survey, 1991-2005, 2007)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)
Run 2 ASPIC$_{\text{autumn3L with 95 and autumn3N with 92}}$	I_3/I_7	17	0.248	I3 (3N autumn survey, 1991-2007)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 3 ASPIC$_{\text{autumn3L with 95 and autumn3N without 92}}$	I_3/I_7	16	0.399	I3 (3N autumn survey, 1991, 1993-2007)+I7(3L autumn survey, 1985-1986, 1990-2007)
Run 4 ASPIC$_{\text{autumn3L without 95 and autumn3N with 92}}$	I_3/I_7	16	0.343	I3 (3N autumn survey, 1991-2007)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)
Run 5 ASPIC$_{\text{autumn3L without 95 and autumn3N without 92}}$	I_3/I_7	15	0.502	I3 (3N autumn survey, 1991, 1993-2007)+I7(3L autumn survey, 1985-1986, 1990-1994, 1996-2007)

Table 3b: Diagnostics for six ASPIC formulations (2008 assessment, 2nd take).

	N restarts	contrast index	nearness index	Total obj. function	R squared in CPUE I1	I2	I3	I4	I5	I6	I7
Run 1 ASPIC$_{\text{autumn3L till 94 and autmn3LN since 96}}$	175	0.850	1.000	19.46	-0.213	0.288	0.029	0.304	0.453	0.701	0.449
Run 2 ASPIC$_{\text{autumn3L with 95 and autumn3N with 92}}$	162	0.616	1.000	33.55	0.260	0.270	-0.346	0.187	0.363	0.551	0.084
Run 3 ASPIC$_{\text{autumn3L with 95 and autumn3N without 92}}$	42	0.774	1.000	29.74	0.110	0.231	0.252	0.245	0.416	0.615	0.007
Run 4 ASPIC$_{\text{autumn3L without 95 and autumn3N with 92}}$	67	0.620	1.000	30.72	0.200	0.299	-0.428	0.2	0.374	0.58	0.194
Run 5 ASPIC$_{\text{autumn3L without 95 and autumn3N without 92}}$	61	0.791	1.000	26.92	0.058	0.263	0.182	0.251	0.418	0.635	0.113
Run 6 ASPIC$_{\text{autumn3LN without 92 and 95}}$	35	0.818	1.000	18.37	-0.061	0.265	0.325	0.279	0.438	0.682	

Table 4a: Deterministic estimates of ASPIC parameters for six $ASPIC_{2008}$ formulations

		K	B1/K	*r*	MSY	Fmsy	$F_{lastyear/}Fmsy$	$B_{lastyear+1/}Bmsy$
Run 1	**$ASPIC_{SATCFIS\ recommendation}$**	213600	0.754	0.531	28340	0.265	0.0298	1.969
Run 2	**$ASPIC_{autumn3L\ with\ 95\ and\ autumn3N\ with\ 92}$**	381100	0.692	0.229	21780	0.114	0.0498	1.569
Run 3	**$ASPIC_{autumn3L\ with\ 95\ and\ autumn3N\ without\ 92}$**	250100	0.783	0.420	26290	0.210	0.0325	1.949
Run 4	**$ASPIC_{autumn3L\ without\ 95\ and\ autumn3N\ with\ 92}$**	374200	0.661	0.234	21930	0.1172	0.0507	1.536
Run 5	**$ASPIC_{autumn3L\ without\ 95\ and\ autumn3N\ without\ 92}$**	256400	0.753	0.401	25700	0.2005	0.03362	1.933
Run 6	**$ASPIC_{autumn3LN\ without\ 92\ and\ 95}$**	229600	0.7605	0.475	27280	0.2376	0.03236	1.96

Table 4b: B/Bmsy trajectories for six $ASPIC_{2008}$ formulations (2008 assessment, 2nd take)

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
1959	1.507	1.384	1.565	1.321	1.506	1.521
1960	1.312	1.253	1.373	1.193	1.325	1.328
1961	1.303	1.221	1.344	1.164	1.299	1.310
1962	1.325	1.209	1.344	1.154	1.301	1.322
1963	1.359	1.206	1.357	1.154	1.315	1.346
1964	1.336	1.172	1.324	1.123	1.284	1.319
1965	1.462	1.228	1.423	1.182	1.382	1.433
1966	1.452	1.214	1.409	1.171	1.371	1.423
1967	1.498	1.233	1.445	1.193	1.408	1.466
1968	1.450	1.199	1.400	1.161	1.367	1.420
1969	1.491	1.216	1.433	1.181	1.400	1.458
1970	1.464	1.196	1.408	1.162	1.377	1.433
1971	1.529	1.229	1.463	1.199	1.432	1.493
1972	1.414	1.159	1.363	1.129	1.335	1.386
1973	1.368	1.119	1.317	1.090	1.291	1.341
1974	1.293	1.058	1.245	1.029	1.219	1.266
1975	1.324	1.055	1.263	1.027	1.235	1.291
1976	1.388	1.075	1.313	1.048	1.282	1.349
1977	1.418	1.081	1.337	1.056	1.306	1.376
1978	1.475	1.107	1.387	1.084	1.355	1.431
1979	1.557	1.156	1.463	1.135	1.430	1.510
1980	1.601	1.193	1.511	1.174	1.480	1.557
1981	1.617	1.219	1.535	1.202	1.506	1.579
1982	1.564	1.201	1.496	1.185	1.470	1.532
1983	1.546	1.197	1.483	1.183	1.459	1.516
1984	1.547	1.203	1.486	1.191	1.463	1.518
1985	1.588	1.235	1.524	1.224	1.501	1.558
1986	1.572	1.235	1.514	1.225	1.492	1.545
1987	1.378	1.121	1.344	1.110	1.326	1.361
1988	0.895	0.819	0.916	0.804	0.905	0.904
1989	0.645	0.645	0.691	0.626	0.680	0.664
1990	0.552	0.565	0.606	0.543	0.591	0.573
1991	0.482	0.502	0.545	0.476	0.525	0.507
1992	0.427	0.449	0.501	0.420	0.473	0.455
1993	0.333	0.381	0.433	0.346	0.396	0.373
1994	0.269	0.336	0.401	0.295	0.352	0.324
1995	0.354	0.372	0.501	0.326	0.433	0.417
1996	0.515	0.436	0.658	0.384	0.567	0.575
1997	0.737	0.516	0.851	0.459	0.739	0.783
1998	0.990	0.605	1.055	0.544	0.929	1.012
1999	1.241	0.700	1.252	0.636	1.121	1.237
2000	1.452	0.795	1.419	0.729	1.294	1.427
2001	1.611	0.890	1.554	0.824	1.443	1.576
2002	1.740	0.996	1.673	0.931	1.579	1.703
2003	1.829	1.104	1.764	1.042	1.689	1.795
2004	1.886	1.208	1.829	1.151	1.771	1.858
2005	1.926	1.311	1.880	1.259	1.836	1.905
2006	1.951	1.407	1.915	1.361	1.883	1.935
2007	1.967	1.496	1.940	1.456	1.917	1.956
2008	1.969	1.569	1.949	1.536	1.933	1.960

Table 5a: B/Bmsy Run 5 trajectories for +/- 10% on 2007 surveys (2008 assessment 2nd take)

	-10% Run 5	+10% Run 5	Run 5
1959	1.520	1.490	1.506
1960	1.335	1.312	1.325
1961	1.309	1.287	1.299
1962	1.311	1.288	1.301
1963	1.326	1.302	1.315
1964	1.295	1.271	1.284
1965	1.394	1.368	1.382
1966	1.383	1.358	1.371
1967	1.420	1.395	1.408
1968	1.378	1.355	1.367
1969	1.411	1.388	1.400
1970	1.388	1.365	1.377
1971	1.444	1.420	1.432
1972	1.345	1.325	1.335
1973	1.300	1.280	1.291
1974	1.228	1.209	1.219
1975	1.245	1.224	1.235
1976	1.294	1.270	1.282
1977	1.318	1.293	1.306
1978	1.368	1.342	1.355
1979	1.444	1.417	1.430
1980	1.492	1.466	1.480
1981	1.518	1.493	1.506
1982	1.480	1.458	1.470
1983	1.469	1.448	1.459
1984	1.473	1.453	1.463
1985	1.511	1.491	1.501
1986	1.501	1.483	1.492
1987	1.333	1.318	1.326
1988	0.907	0.902	0.905
1989	0.681	0.679	0.680
1990	0.592	0.589	0.591
1991	0.527	0.522	0.525
1992	0.477	0.469	0.473
1993	0.401	0.392	0.396
1994	0.358	0.345	0.352
1995	0.444	0.422	0.433
1996	0.584	0.550	0.567
1997	0.763	0.716	0.739
1998	0.959	0.899	0.929
1999	1.156	1.087	1.121
2000	1.330	1.259	1.294
2001	1.476	1.408	1.443
2002	1.609	1.547	1.579
2003	1.714	1.661	1.689
2004	1.792	1.749	1.771
2005	1.853	1.819	1.836
2006	1.895	1.870	1.883
2007	1.926	1.907	1.917
2008	1.939	1.925	1.933

Table 5b: B/Bmsy Run 2 trajectories for +/- 10% on 2007 surveys (2008 assessment 2nd take)

	-10% Run 2	+10% Run 2	Run 2
1959	1.538	1.353	1.384
1960	1.369	1.221	1.253
1961	1.333	1.191	1.221
1962	1.321	1.179	1.209
1963	1.321	1.177	1.206
1964	1.284	1.145	1.172
1965	1.358	1.201	1.228
1966	1.342	1.187	1.214
1967	1.368	1.207	1.233
1968	1.328	1.175	1.199
1969	1.351	1.192	1.216
1970	1.327	1.172	1.196
1971	1.371	1.206	1.229
1972	1.285	1.137	1.159
1973	1.242	1.098	1.119
1974	1.173	1.038	1.058
1975	1.179	1.034	1.055
1976	1.213	1.054	1.075
1977	1.228	1.060	1.081
1978	1.267	1.086	1.107
1979	1.332	1.134	1.156
1980	1.377	1.171	1.193
1981	1.405	1.196	1.219
1982	1.378	1.179	1.201
1983	1.372	1.176	1.197
1984	1.378	1.182	1.203
1985	1.413	1.214	1.235
1986	1.409	1.214	1.235
1987	1.267	1.103	1.121
1988	0.901	0.806	0.819
1989	0.701	0.634	0.645
1990	0.618	0.553	0.565
1991	0.557	0.489	0.502
1992	0.510	0.435	0.449
1993	0.445	0.366	0.381
1994	0.411	0.320	0.336
1995	0.482	0.353	0.372
1996	0.593	0.411	0.436
1997	0.729	0.487	0.516
1998	0.877	0.570	0.605
1999	1.028	0.661	0.700
2000	1.169	0.751	0.795
2001	1.297	0.842	0.890
2002	1.425	0.945	0.996
2003	1.537	1.050	1.104
2004	1.632	1.154	1.208
2005	1.714	1.258	1.311
2006	1.779	1.356	1.407
2007	1.831	1.447	1.496
2008	1.864	1.524	1.569

Tab 6: Summary of the bootstrap results of the two 2008 ASPIC alternate assessments with two different arrangements of the available survey series.

Parameter name	Point estimate	Bias corrected	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits				Inter-quartile range	Relative IQ range
					80% lower	80% upper	50% lower	50% upper		
$B1/K_{1st\ take}$	0.7033	0.770	0.067	9.5%	0.502	1.216	0.585	0.906	0.322	0.458
$B1/K_{2nd\ take}$	0.7532	0.841	0.088	11.65%	0.5188	1.178	0.609	0.957	0.349	0.463
$K_{1st\ take}$	283800	289451	5651	2.0%	236600	383900	259300	329500	70220	0.247
$K_{2nd\ take}$	256400	267990	11590	4.52%	211200	302600	228000	274500	46510	0.181
$MSY_{1st\ take}$	24440	**25051**	611	2.5%	21780	26600	22850	25330	2484	0.102
$MSY_{2nd\ take}$	25700	**25678**	-22	-0.08%	23590	28620	24630	27110	2478	0.096
$Ye(2008)_{1st\ take}$	5519	6606	1087	19.7%	2178	15670	3295	9964	6669	1.208
$Ye(2008)_{2nd\ take}$	3339	4840	1501	44.96%	1463	7720	1967	4933	2967	0.888
$Y.@Fmsy_{1st\ take}$	45950	46200	250	0.5%	33400	52700	40480	49300	8821	0.192
$Y.@Fmsy_{2nd\ take}$	49680	**48659**	-1021	-2.06%	42920	56630	46630	53340	6710	0.135
$Bmsy_{1st\ take}$	141900	144725	2825	2.0%	118300	192000	129600	164800	35110	0.247
$Bmsy_{2nd\ take}$	128200	133993	5793	4.52%	105600	151300	114000	137200	23260	0.181
$Fmsy_{1st\ take}$	0.172	0.181	0.009	5.0%	0.117	0.225	0.139	0.196	0.058	0.334
$Fmsy_{2nd\ take}$	0.201	0.198	-0.002	-1.18%	0.157	0.273	0.180	0.238	0.058	0.289
$B/Bmsy_{1st\ take}$	1.880	**1.836**	-0.044	-2.36%	1.552	1.959	1.756	1.933	0.177	0.094
$B/Bmsy_{2nd\ take}$	1.933	**1.889**	-0.044	-2.28%	1.821	1.974	1.894	1.963	0.06893	0.036
$F/Fmsy_{1st\ take}$	0.038	**0.039**	0.001	2.38%	0.033	0.053	0.035	0.043	0.008	0.215
$F/Fmsy_{2nd\ take}$	0.034	**0.035**	0.001	4.26%	0.029	0.039	0.031	0.036	0.005	0.140
$Y/MSY_{1st\ take}$	0.226	0.276	0.051	22.4%	0.080	0.694	0.129	0.428	0.299	1.322
$Y/MSY_{2nd\ take}$	0.130	0.198	0.068	52.40%	0.051	0.326	0.072	0.200	0.128	0.986

Table 7: Bias corrected trajectories from the 2008 ASPIC bot assessment (1st and 2nd take)

	B/B_{msy} bias corrected		F/F_{msy} bias corrected	
	1st take	2nd take	1st take	2nd take
1959	1.541	1.681	1.412	1.280
1960	1.312	1.402	0.913	0.832
1961	1.257	1.335	0.808	0.738
1962	1.237	1.312	0.745	0.681
1963	1.237	1.308	0.961	0.879
1964	1.198	1.266	0.351	0.321
1965	1.281	1.353	0.775	0.711
1966	1.268	1.336	0.553	0.508
1967	1.301	1.369	0.885	0.814
1968	1.263	1.327	0.574	0.529
1969	1.294	1.358	0.799	0.737
1970	1.275	1.335	0.458	0.423
1971	1.327	1.390	1.106	1.024
1972	1.241	1.295	0.979	0.906
1973	1.200	1.253	1.180	1.092
1974	1.132	1.183	0.808	0.747
1975	1.145	1.199	0.633	0.584
1976	1.187	1.245	0.708	0.652
1977	1.208	1.268	0.555	0.510
1978	1.254	1.316	0.386	0.355
1979	1.325	1.389	0.430	0.396
1980	1.373	1.439	0.475	0.439
1981	1.402	1.465	0.718	0.666
1982	1.374	1.432	0.644	0.598
1983	1.368	1.423	0.588	0.548
1984	1.376	1.429	0.432	0.403
1985	1.415	1.468	0.593	0.555
1986	1.411	1.461	1.308	1.229
1987	1.262	1.301	3.052	2.894
1988	0.874	0.890	2.824	2.708
1989	0.664	0.670	2.194	2.114
1990	0.578	0.583	2.161	2.082
1991	0.514	0.519	2.151	2.066
1992	0.463	0.469	2.632	2.523
1993	0.389	0.394	2.423	2.316
1994	0.345	0.351	0.644	0.606
1995	0.416	0.431	0.182	0.167
1996	0.532	0.563	0.033	0.029
1997	0.679	0.730	0.037	0.032
1998	0.840	0.910	0.043	0.038
1999	1.003	1.089	0.094	0.083
2000	1.151	1.248	0.112	0.099
2001	1.281	1.384	0.046	0.041
2002	1.409	1.511	0.035	0.032
2003	1.518	1.617	0.036	0.032
2004	1.610	1.700	0.016	0.015
2005	1.688	1.769	0.016	0.015
2006	1.751	1.823	0.011	0.011
2007	1.803	1.865	0.039	0.035
2008	1.836	1.889		

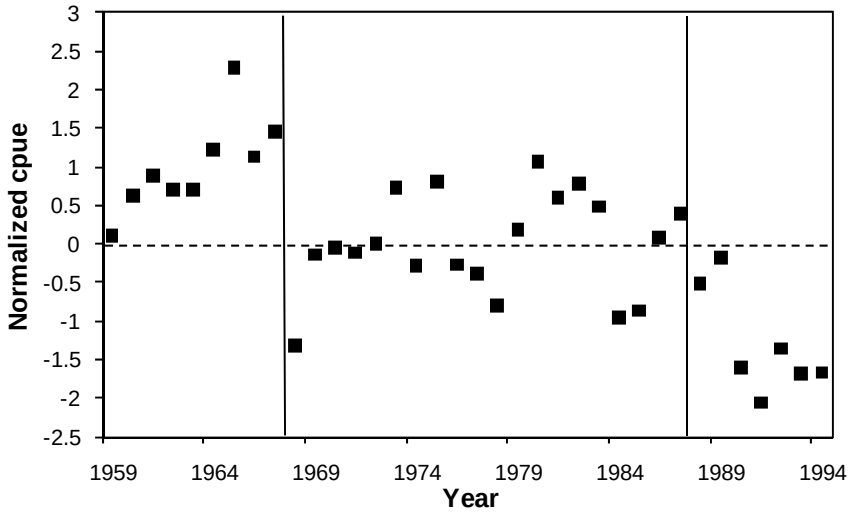

Fig. 1: Redfish Div. 3LN cpue 1959-1994

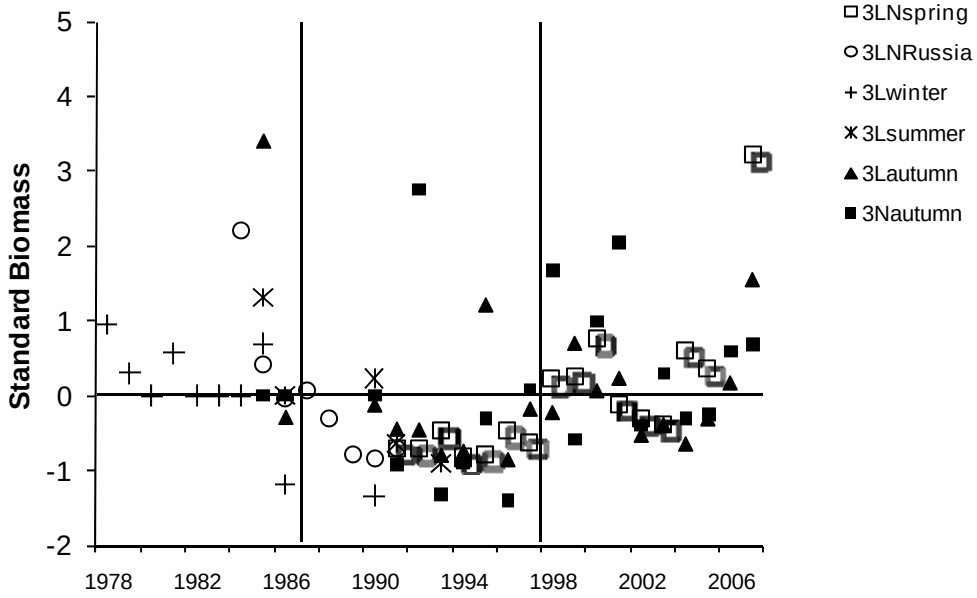

Fig. 2: Standardized Survey Biomass

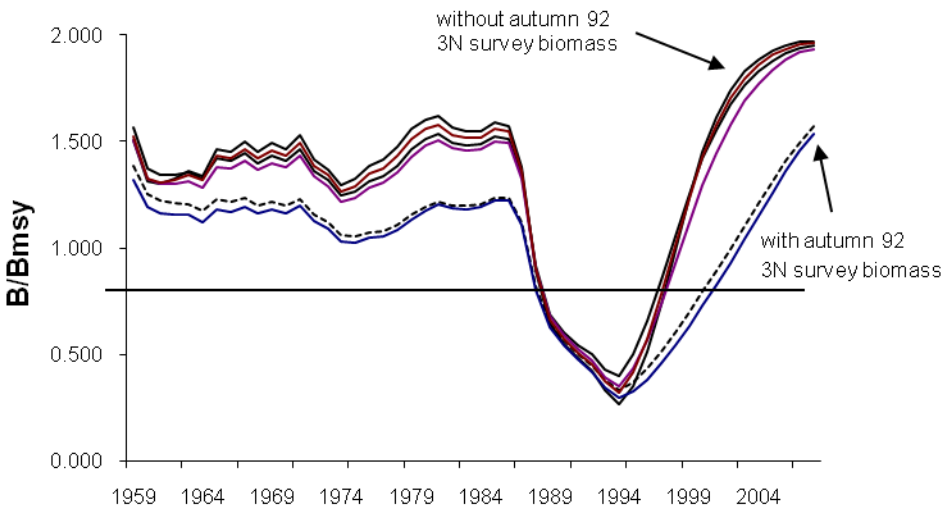

Fig. 3: B/Bmsy trends for 6 ASPIC formulations
(2008 assessment, 2nd take)

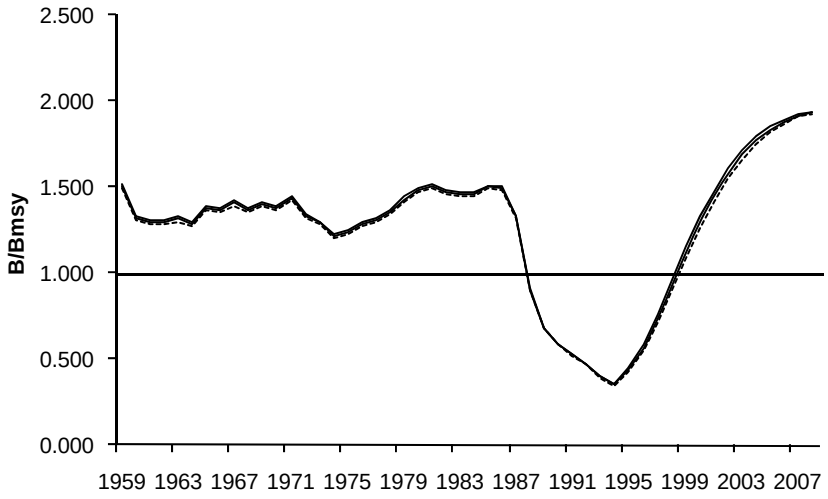

Fig. 4a: B/Bmsy Run 5 trajectories (original and for +-10% on 2007 surveys (2008 assessment, 2nd take)

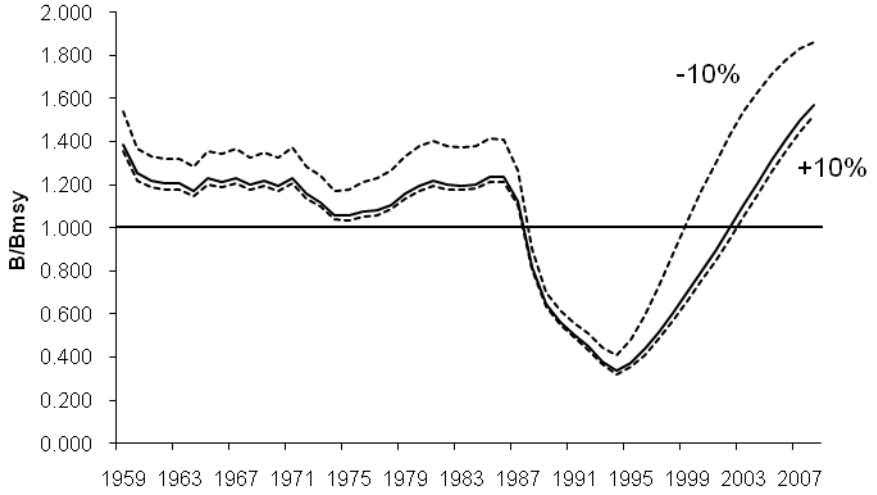

Fig. 4b: B/Bmsy Run 2 trajectories (original and +-10% on 2007 surveys (2008 asessment, 2nd take)

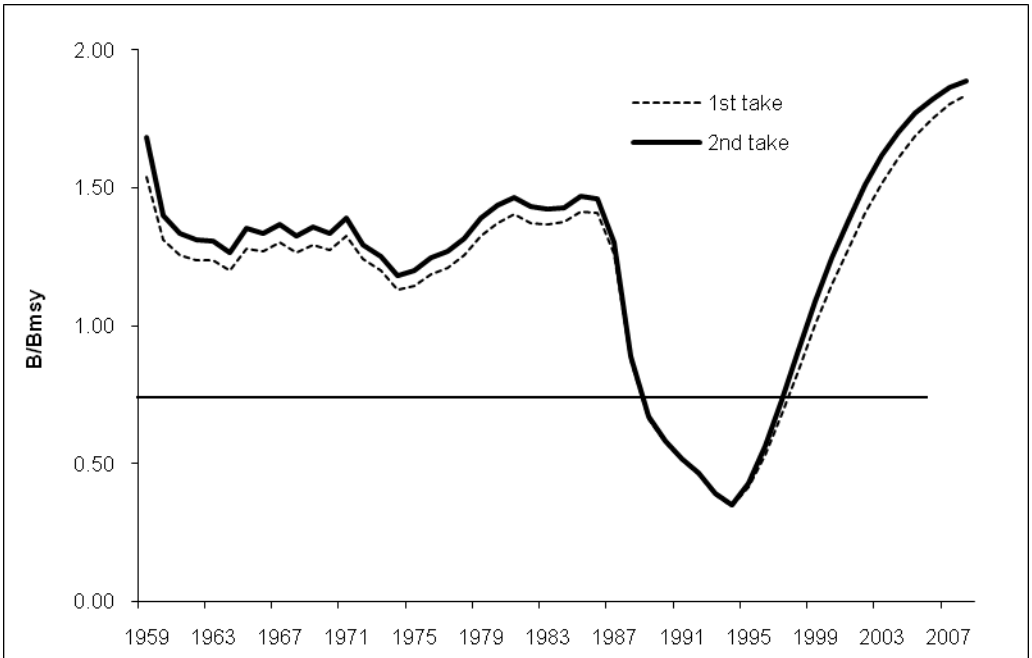

Fig. 5a: B/Bmsy bias corrected trajectories (2008 ASPIC bot assessments 1st and 2nd take)

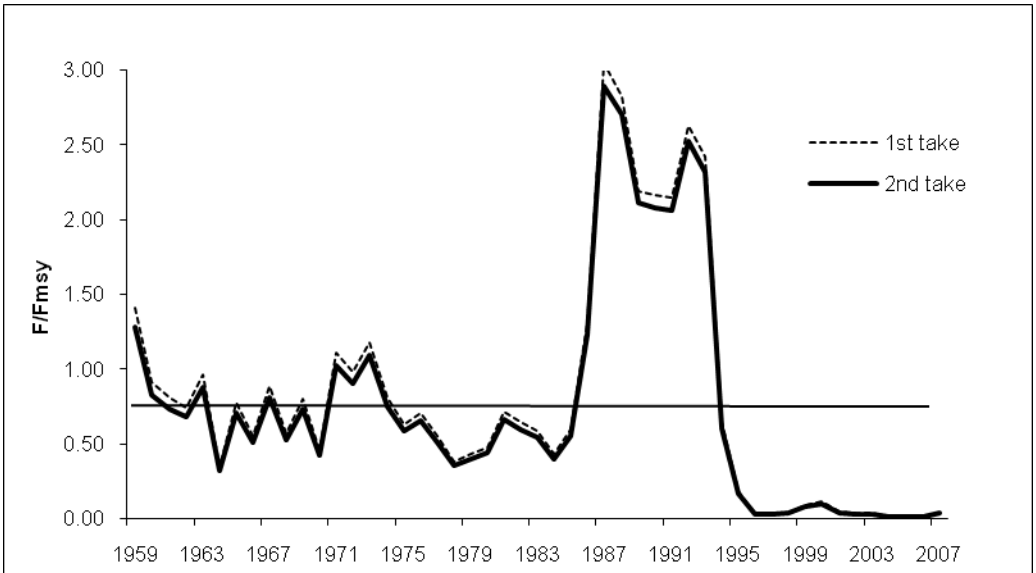

Fig. 5b: F/Fmsy bias corrected trajectories (2008 ASPIC bot assessments 1st and 2nd take)