

M. Pollock in Subareas 5 and 6

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Additional details and supporting information can be found in the Appendix of the GARM-III Report (NEFSC 2008).

1.0 Background

Pollock, *Pollachius virens* (L.) have traditionally been assessed as a unit stock from the Scotian Shelf (NAFO Divisions 4VWX) to Georges Bank, the Gulf of Maine and portions of the Mid-Atlantic region (Subareas 5 and 6). This stock was last assessed over its range *via* VPA at SAW 16 in 1993 (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). At that time, spawning stock biomass had been declining since the mid-1980s, and was expected to reach its long-term average (144,000 mt). Fishing mortality was estimated to be 0.72 in 1992, above F20% (0.65) and well above F_{med} (0.47). The stock was then considered to be fully exploited and at a medium biomass level.

The state of this stock was first evaluated *via* index assessment in 2000 (Mayo 2001). At that time, it was noted that biomass indices for the Gulf of Maine-Georges Bank portion of the stock, derived from NEFSC autumn bottom trawl surveys, had increased during the mid-1970s, declined sharply during the 1980s, but have been generally increasing since the mid-1990s. Indices derived from Canadian bottom trawl surveys, conducted on the Scotian Shelf, increased during the 1980s, but declined sharply during the early 1990s. The index assessment provided no basis with which to evaluate the state of the stock relative to the control rule as determined by the Overfishing Definition Review Panel (Applegate et al. 1998).

In 2002, index-based biological reference points were developed for a portion of the pollock stock primarily under US management jurisdiction (Subareas 5 and 6), including a portion of eastern Georges Bank (Subdivision 5Zc) that is under Canadian management jurisdiction (NEFSC 2002). The most recent assessment of the resource inhabiting the area comprising this management unit was conducted in August, 2005 at the Second Groundfish Assessment Review Meeting (GARM II) (NEFSC 2005). At that time it was determined that the index of current biomass was greater than ½ of the B_{MSY} proxy reference point and that the index of current F was below the F_{MSY} proxy reference point (Mayo et al. 2005).

2.0 The Fishery

Since 1984, the USA fishery has been restricted to areas of the Gulf of Maine and Georges Bank west of the line delimiting the USA and Canadian fishery zones. The Canadian fishery occurs primarily on the Scotian Shelf and additional landings are obtained from Georges Bank east of the line delimiting the USA and Canadian fishery zones. This fishery on the Scotian Shelf has shifted westward over time and the contribution to the total catch from larger, mobile gear vessels has steadily diminished since 1981.

Commercial landings from the USA portion of the fishery in SA 5&6 were updated through 2007 (Table M1). Revised Canadian landings from Divs. 5Y and 5Z were also included through 2007. There was no need to apply the preferred allocation scheme reviewed at the GARMIII Data Meeting, October, 2007 as pollock are assessed as a unit stock.

The commercial fishery in Subareas 5&6 is dominated by United States vessels; additional catches are taken by Canada and, for a period primarily during the 1970s, by some distant water fleets. The total landings increased steadily from less than 10,000 mt during the 1960s to a maximum of over 26,000 mt in 1986 (Table M1). Landings declined sharply during the late 1980s and have remained below 10,000 mt throughout most of the 1990s. Landings since 1994 have fluctuated between 4,420 and 9,017 mt.

Length and age samples continue to be collected from the USA and Canadian fisheries. For this assessment of the SA5&6 portion of the stock, length and age data have not been utilized since the 1992 assessment of the entire Divs 4VWX and SA 5&6 stock (Mayo and Figuerido 1993, NEFSC 1993a, 1993b). The extent of discarding in the commercial fishery has not been investigated to date.

USA Recreational landings are available in the MRFSS database (Table M2), and have been included in one formulation of this assessment. Annual catches of pollock from the recreational fishery in Subareas 5&6, excluding those caught and released alive, have fluctuated between 52 and 819 mt. In most years the total catch remained below 400 mt.

3.0 Research Survey Indices

Indices of relative biomass (ln re-transformed), derived from NEFSC autumn research vessel bottom trawl surveys covering Georges Bank and the Gulf of Maine have varied considerably since 1963 (Table M3, Figure M2). Indices generally fluctuated between 2 and 5 kg per tow throughout most of the 1960s and 1970s, peaking at over 8 kg per tow during the mid-to-late 1970s, reflecting recruitment of several moderate-to strong year classes from the early 1970s.

Biomass indices declined rapidly during the early 1980s, and continued to decline steadily through the early 1990s, remaining below 1 kg per tow and reaching a minimum during the mid-1990s. Since then, biomass indices from the Gulf of Maine-Georges Bank region have generally increased, and have recently been fluctuating between 2.0 and 2.5 kg/tow (Table M4, Figure M2). The most recent biomass indices once again declined below 1.0 in 2006 and 2007.

4.0 Assessment

Input Data and Model Formulation

An index of relative exploitation (catch/survey biomass index) corresponding to a replacement ratio of 1.0 was developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) for the portion of the unit stock of pollock in NAFO Subareas 5&6 based on the AIM (An Index Method) model. This model was employed again for the present assessment. Autumn NEFSC survey biomass indices (stratified mean catch (kg) per tow) from the Gulf of Maine and Georges Bank region from 1963 through 2007 were used to calculate the replacement ratios, defined as the biomass index in the current year divided by the average biomass indices from the previous 5 years.

Autumn survey biomass indices and total landings were used to compute the relative exploitation rates, defined as the catch in the current year divided by the 3 year average survey biomass index for the current year and the previous and following years. These relative exploitation rates (or relative F) may be considered a proxy for F on that portion of the pollock stock considered in this analysis. The relationship between replacement ratios and relative F was

evaluated by a linear regression of the Log_e replacement ratio on Log_e relative F and the results were used to derive an estimate of relative F corresponding to a replacement ratio of 1.0. This base formulation of the AIM model was accepted by the review panel as the final assessment. A complete description of the AIM model can be found in NEFSC (2002).

Assessment Results

As evident from recent trends in total landings from Subareas 5 and 6 and NEFSC autumn biomass indices calculated for the Gulf of Maine-Georges Bank region, relative Fs (landings/NEFSC autumn biomass index) peaked in the mid-1980s to mid-1990s, after which they began to steadily decline. However, relative Fs have been steadily increasing since 2002 and rose sharply in 2007 (Table M4 Figure M3). Biomass indices from the Gulf of Maine-Georges Bank region had been increasing since the late 1990s, but declined substantially in 2006 and 2007 (Figure M2).

Trends in average replacement ratios are given in Figure M4. Prior to the 1980s, a high proportion of the replacement ratios equaled or exceeded 1.0. During the 1980s and early 1990s, however, most of the replacement ratios were less than 1.0, with ratios greater than 1.0 appearing again by the late 1990s as the biomass indices began to gradually increase from the very low levels of the mid-1990s. However, in 2006 and 2007, the replacement ratios were once again substantially below 1.0.

The information displayed in Table M4 also provides a means to derive a biomass index which relates to the replacement ratios. In this case, it is evident that most of the replacement ratios below 1.0 occurred during the 1980s and early 1990s when all of the biomass indices were below 2.0 kg/tow (Table M4). During this period the relative Fs were also well above the relative replacement F (Figure M3). This biomass index may be considered as the biomass proxy for B_{MSY} that corresponds to the relative F proxy for F_{MSY} . This represents a change in the present assessment compared to the value (3.0 kg/tow) derived in 2002 (NEFSC 2002) and was accepted by the Biological Reference Point Review Panel. This base model formulation was accepted by the GARM III Panel as the final formulation (see Figure M8).

5.0 Biological Reference Points

A regression of Log_e replacement ratios on Log_e relative F was significant ($p=0.03$, Table M5). The replacement relative F based on this regression equals 5.66 (Table M5, Figure M5). This can be taken as a proxy for F_{MSY} .

The biological reference points first developed by the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) are:

$$\begin{aligned} B_{\text{MSY}} & 3.00 \text{ kg/tow} \\ F_{\text{MSY}} & 5.88 \text{ (Relative F)} \\ \text{MSY} & 17,640 \text{ mt} \end{aligned}$$

Since the relative F relates the catch directly to survey biomass, the catch corresponding to the B_{MSY} proxy can be estimated by multiplying the relative F and the biomass index of B_{MSY} . The following biological reference point proxies were obtained from the index-based AIM model that included commercial and recreational landings.

$$\begin{aligned} B_{MSY} & 2.0 \text{ kg/tow} \\ F_{MSY} & 5.66 \text{ (Relative F)} \\ MSY & 11,320 \text{ mt} \end{aligned}$$

The proxy B_{MSY} and F_{MSY} reference points are given in Table M6 along with corresponding estimates of current (2007) biomass and F proxies.

Diagnostics and Uncertainty

Precision of the estimate of replacement Relative F was derived from the distribution of 1000 bootstrap iterations of the regression of replacement ratio on relative F (Figure M6). The bootstrap analysis provides a 90% CI about the replacement relative F estimate (5.66) of 3.87 – 7.44. The bootstrap mean (5.66) matched the point estimate (Table M5) indicating negligible bias. The range of the 95% confidence limits about the 2007 autumn survey biomass index (0.754 kg/tow) are: 0.552 – 0.982.

Residual patterns from the regression of replacement ratio on relative F appear for the most part random, although there are some instances of 3-4 year blocks of positive and negative residuals (Figure M7). A randomization test indicates that the regression was significant ($p = 0.03$) (Table M5).

6.0 Projections

The AIM software was also used to conduct short-term projections of 2009 catches under 3 scenarios of relative F in 2009 ($F_{STATUS\ QUO}$, F_{MSY} and $F_{REBUILD}$).

$F_{REBUILD}$

Although pollock are not in a rebuilding plan based on the results of the GARMII assessment, the 2007 status shows that biomass is currently below $\frac{1}{2} B_{MSY}$. A 10 year projection was run to obtain an estimate of the relative F required to rebuild biomass to B_{MSY} by 2018. The relative $F_{REBUILD}$ determined from this projection is 5.31, slightly below the estimate of the F_{MSY} proxy relative F (5.66). These projections should be considered as an example for illustration purposes.

2009 Catch Estimates

Annual catches were estimated for 2009 under the 3 scenarios of 2009 relative F as described above. Results are as follows: $F_{STATUS\ QUO}$: 8,133 mt, F_{MSY} : 8,015 mt, $F_{REBUILD}$: 8,003 mt. If relative F is not reduced in 2009, the population biomass index will remain below $\frac{1}{2} B_{MSY}$ in 2009 and will likely decline further in subsequent years. Further details are given in Table M7.

7.0 Summary

Stock Status

The NEFSC autumn survey biomass had been increasing towards the current 2.0 kg/tow B_{MSY} proxy since the mid-1990s. However, the biomass index declined substantially in 2006 and 2007 to 0.959 and 0.754 kg/tow, respectively and is presently below $\frac{1}{2} B_{MSY}$. Between 1999 and 2006, the relative F remained below the relative F_{MSY} proxy, but the 2007 average value (10.975) increased to more than twice the relative F_{MSY} proxy. Replacement ratios remained close to or

above 1.0 between 1996 and 2005, but then declined to less than 0.5 in 2006 and 2007. The biological reference points, based on the AIM model approach, including commercial and recreational landings, are: F_{MSY} proxy (relative F) = 5.66, B_{MSY} proxy = 2.0 kg/tow and $MSY = 11,320$ mt.

Based on these results, the stock is overfished and overfishing is occurring.

Sources of Uncertainty

The AIM model provides an objective means of estimating an F_{MSY} proxy value. Assessment of current stock status is essentially deterministic and relies on a subjective determination of either B_{MSY} or MSY external to the AIM model. This approach does not afford a means of quantifying uncertainty in the estimates of current biomass or exploitation rate within the model framework. Therefore, the status determination plot (Figure M8) is presented without error bars. The Assessment Review Panel recommended that this be explored in the future.

Differences From Previous Assessment

The present assessment includes recreational landings beginning in 1981 in addition to commercial landings. The current basis for the B_{MSY} proxy is the period during the 1980s and 1990s when the biomass indices were below 2.0 kg/tow instead of 3.0 kg/tow in the previous assessment.

8.0 Panel Discussion/Comments

Conclusions

The Panel considered the AIM – based assessment sufficient as a basis for management advice. The relationship between Replacement Ratio and Relative Fishing Mortality is likely informative. Some improvements were suggested including use of a linear rather than a logarithmic relationship in the AIM analysis.

The Panel noted the high uncertainty of the determination of stock status, implying that the estimate of F rebuild is also uncertain. It noted that the transboundary nature of the resource likely confounds interpretation of the survey and catch trends.

As with the other stocks for which stock status is based upon the examination of relative trends in abundance, the Panel recommended that the BRPs and associated indicators of stock status be expressed in their original units (survey kg/tow) as opposed to being converted to swept area biomass. This helps avoid confusion with BRPs and indicators which are expressed in terms of biomass and not proxies.

Research Recommendations

The Panel encouraged the NEFSC to consider the use of state space and other like modeling approaches in this and other relative index based assessed stocks. These models allow comprehensive incorporation of estimates of process and observation uncertainty into the assessment formulations which is lacking from the current approach. This is similar to a recommendation made during the GARM III ‘models’ review. It suggested that the Replacement Ratio – Relative Fishing Mortality relationship be used to provide estimates of uncertainty in stock status.

9.0 References

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Table M1. Commercial landings (mt) of pollock from SA5&6 by USA, Canadian and DWF fleets and NEFSC autumn bottom trawl survey biomass indices (kg/tow).

Year	Autumn	Total 5&6		USA 5&6	Other 5&6	USA 5&6
	Biom Index	Landings(mt)	000s mt	Landings	Landings	Percent
1960		10397	10.397	8186	2211	78.7
1961		8219	8.219	7861	358	95.6
1962		6151	6.151	5550	601	90.2
1963	4.939	6241	6.241	4673	1568	74.9
1964	2.716	9008	9.008	4768	4240	52.9
1965	2.362	9000	9.000	4916	4084	54.6
1966	1.795	9847	9.847	3171	6676	32.2
1967	1.310	8534	8.534	2784	5750	32.6
1968	2.654	5222	5.222	2981	2241	57.1
1969	3.424	9822	9.822	3507	6315	35.7
1970	1.699	11976	11.976	3592	8384	30.0
1971	2.189	15203	15.203	4732	10471	31.1
1972	3.279	13013	13.013	5243	7770	40.3
1973	4.037	13076	13.076	5731	7345	43.8
1974	1.542	12393	12.393	8050	4343	65.0
1975	1.494	13871	13.871	8577	5294	61.8
1976	8.567	13382	13.382	10244	3138	76.6
1977	5.628	16273	16.273	12729	3544	78.2
1978	3.862	22305	22.305	17545	4760	78.7
1979	4.074	18452	18.452	15420	3032	83.6
1980	2.647	23539	23.539	17905	5634	76.1
1981	1.083	22068	22.068	18018	4050	81.6
1982	1.364	19466	19.466	14092	5374	72.4
1983	1.274	17816	17.816	13433	4383	75.4
1984	0.564	20633	20.633	17343	3290	84.1
1985	1.742	21069	21.069	19305	1764	91.6
1986	1.089	26507	26.507	24316	2191	91.7
1987	1.223	23467	23.467	20251	3216	86.3
1988	1.787	17648	17.648	14900	2748	84.4
1989	0.619	12434	12.434	10518	1916	84.6
1990	0.994	11518	11.518	9432	2086	81.9
1991	0.649	10053	10.053	7882	2171	78.4
1992	0.910	10671	10.671	7192	3479	67.4
1993	0.505	10238	10.238	5676	4562	55.4
1994	0.328	7332	7.332	3769	3563	51.4
1995	0.504	4611	4.611	3358	1253	72.8
1996	0.654	4420	4.420	2963	1457	67.0
1997	1.003	5794	5.794	4252	1542	73.4
1998	0.772	7865	7.865	5583	2282	71.0
1999	1.532	5726	5.726	4595	1131	80.2
2000	0.844	5376	5.376	4043	1333	75.2
2001	2.448	5784	5.784	4111	1673	71.1
2002	1.855	5354	5.354	3580	1774	66.9
2003	2.197	6735	6.735	4794	1941	71.2
2004	1.925	7254	7.254	5070	2184	69.9
2005	2.533	8358	8.358	6510	1848	77.9
2006	0.959	7043	7.043	6067	976	86.1
2007	0.754	9017	9.017	8370	647	92.8

Table M2. Recreational catch of pollock from SA5&6.

Year	Total Catch of Pollock (Including Released Alive)			Retained Catch of Pollock (Excluding Released Alive)				AB1 Avg Wgt (kg)
	Numbers (000s)	SE	Weight (mt)	Numbers (000s)	SE	Weight (mt)	SE	
1981	2226.624	12.2	1158.963	1444.987	13.3	752.119	13.5	0.520502
1982	1539.039	16.9	1573.219	800.907	15	818.694	15.5	1.022209
1983	971.096	18.4	1313.407	429.476	20	580.866	20	1.352499
1984	508.016	22.2	179.5818	324.49	32.1	114.706	32.1	0.353496
1985	1491.151	35.2	317.1506	1217.767	42.5	259.005	42.8	0.212688
1986	522.937	20.2	177.1421	421.769	24	142.872	24.6	0.338745
1987	670.942	22.5	302.8073	255.847	19.8	115.468	20.3	0.451317
1988	1266.767	47.5	572.7964	369.793	19.2	167.21	19.9	0.452172
1989	602.586	18.1	495.5234	315.064	17.1	259.086	16.1	0.822328
1990	352.358	19	270.9374	201.94	30.9	155.277	31.6	0.768926
1991	440.764	35.9	389.2567	113.179	17.6	99.953	18.8	0.883141
1992	167.569	15.3	96.78733	85.738	21.2	49.522	22.7	0.577597
1993	396.704	15.3	109.7715	187.381	19.1	51.85	20.2	0.276709
1994	861.982	20.2	455.0012	479.202	29.2	252.949	29.5	0.527855
1995	806.888	28.4	760.9678	261.394	31.8	246.518	32	0.94309
1996	464.625	18.2	562.4352	280.171	25.3	339.151	25.6	1.210514
1997	284.892	17	368.364	151.825	28.9	196.309	29	1.292995
1998	452.361	10.3	314.1495	184.906	17.7	128.411	17.8	0.694466
1999	562.123	13.5	230.3734	217.516	26.4	89.144	26.4	0.409827
2000	1075.624	9.7	976.4788	436.617	15.9	396.372	15.9	0.907825
2001	1058.024	7.6	1920.753	355.713	11.6	645.767	11.6	1.815416
2002	496.294	14.4	791.9331	239.175	15.8	381.65	15.8	1.595694
2003	356.07	15.2	210.058	158.465	17.2	93.484	17.2	0.589935
2004	307.629	13.7	354.2347	223.697	16.8	257.587	16.8	1.1515
2005	254.132	12.5	533.5437	156.804	13.8	329.206	13.8	2.099475
2006	278.236	15	551.5738	175.068	20.8	347.054	20.9	1.982395
2007	239.035	15.3	568.3184	161.172	20.8	383.195	18	2.377553

Table M3. Stratified mean catch per tow in weight (kg) and numbers for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFSC offshore spring and autumn bottom trawl surveys¹, 1963-2007³. Indices for the total stock and the mature component are listed.

	NEFSC Spring Survey ²								NEFSC Autumn Survey							
	Total Biomass		Mature Biomass		Total Numbers		Mature Numbers		Total Biomass		Mature Biomass		Total Numbers		Mature Numbers	
	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans	Linear	Re-trans
1963	-	-	-	-	-	-	-	-	5.502	4.939	5.164	4.636	1.401	1.289	1.113	1.024
1964	-	-	-	-	-	-	-	-	4.755	2.716	4.092	2.337	1.770	1.136	0.975	0.626
1965	-	-	-	-	-	-	-	-	2.977	2.362	2.657	2.108	0.903	0.847	0.555	0.521
1966	-	-	-	-	-	-	-	-	2.567	1.795	2.003	1.401	1.060	0.637	0.488	0.293
1967	-	-	-	-	-	-	-	-	1.973	1.310	1.809	1.201	0.560	0.478	0.391	0.334
1968	4.537	2.876	4.292	2.721	1.121	0.932	0.677	0.563	3.494	2.654	3.343	2.539	0.758	0.696	0.569	0.522
1969	2.723	2.584	2.404	2.281	1.157	1.014	0.519	0.455	7.208	3.424	6.994	3.322	1.395	0.884	1.248	0.791
1970	5.295	3.920	4.928	3.648	1.659	1.449	0.994	0.868	2.251	1.699	2.082	1.571	0.609	0.588	0.377	0.364
1971	3.474	2.831	3.266	2.661	0.973	0.897	0.593	0.547	4.365	2.189	3.833	1.922	1.201	0.778	0.612	0.396
1972	5.003	3.618	4.051	2.930	3.871	2.140	0.867	0.479	4.589	3.279	4.079	2.915	1.448	1.174	0.733	0.594
1973	4.927	3.835	3.508	2.731	4.329	1.710	1.018	0.402	4.683	4.037	4.382	3.778	1.267	1.106	0.865	0.755
1974	3.951	4.157	3.553	3.738	1.344	1.176	0.755	0.661	3.332	1.542	2.912	1.348	0.953	0.576	0.654	0.395
1975	5.919	5.580	5.409	5.099	1.621	1.298	1.014	0.812	2.087	1.494	1.905	1.364	0.718	0.493	0.381	0.262
1976	7.204	7.490	6.798	7.068	1.612	1.483	1.227	1.129	18.261	8.567	17.406	8.166	4.038	1.895	3.674	1.724
1977	3.591	3.295	3.205	2.941	1.717	1.318	0.882	0.677	9.376	5.628	8.789	5.276	2.272	1.303	1.739	0.997
1978	5.130	3.107	4.272	2.587	1.898	0.835	1.091	0.480	6.275	3.862	6.033	3.713	1.064	0.723	0.790	0.537
1979	4.585	3.750	4.348	3.556	1.036	0.939	0.785	0.712	4.770	4.074	4.504	3.847	0.865	0.719	0.718	0.597
1980	4.191	3.531	3.711	3.127	1.451	1.069	0.987	0.727	3.298	2.647	3.202	2.570	0.580	0.544	0.470	0.441
1981	5.749	5.391	5.415	5.078	1.395	1.221	0.989	0.866	2.683	1.083	2.178	0.879	1.033	0.341	0.672	0.222
1982	6.372	3.349	5.839	3.069	3.755	1.767	2.076	0.977	2.118	1.364	1.966	1.266	0.759	0.574	0.493	0.373
1983	1.592	1.018	1.533	0.980	0.897	0.662	0.251	0.185	2.989	1.274	2.834	1.208	0.976	0.579	0.479	0.284
1984	3.119	2.298	3.002	2.212	1.084	0.914	0.688	0.580	0.909	0.564	0.778	0.483	0.421	0.367	0.188	0.164
1985	29.132	8.446	26.404	7.655	14.587	2.725	12.014	2.244	2.114	1.742	1.875	1.545	1.080	0.708	0.454	0.298
1986	8.256	4.283	8.123	4.214	1.973	1.333	1.686	1.139	1.707	1.089	1.466	0.935	0.898	0.571	0.528	0.336
1987	2.778	1.870	2.510	1.690	1.616	0.738	0.599	0.274	2.035	1.223	1.924	1.156	0.597	0.506	0.383	0.325
1988	2.015	1.384	1.950	1.339	0.907	0.758	0.339	0.283	13.021	1.787	12.088	1.659	3.754	0.869	3.131	0.725
1989	5.216	2.156	5.041	2.084	1.998	1.024	1.577	0.808	1.223	0.619	0.723	0.366	1.883	0.771	0.461	0.189
1990	1.821	1.165	1.675	1.072	0.760	0.560	0.442	0.326	2.079	0.994	1.888	0.903	0.823	0.586	0.502	0.357
1991	5.051	2.797	4.738	2.624	2.303	1.399	1.762	1.070	1.055	0.649	0.851	0.524	0.728	0.535	0.409	0.301
1992	3.349	2.166	3.139	2.030	1.787	1.242	0.755	0.525	1.697	0.910	1.507	0.808	1.051	0.643	0.520	0.318
1993	1.602	1.248	1.358	1.058	1.648	1.163	0.534	0.377	0.769	0.505	0.570	0.374	1.043	0.567	0.195	0.106
1994	1.065	0.840	0.972	0.767	0.562	0.504	0.380	0.341	0.603	0.328	0.500	0.272	0.422	0.311	0.270	0.199
1995	3.716	1.307	2.659	0.935	3.432	0.820	1.984	0.474	1.017	0.504	0.787	0.390	0.840	0.465	0.516	0.286
1996	1.080	0.758	1.023	0.718	0.650	0.510	0.342	0.268	1.060	0.654	0.862	0.532	1.009	0.666	0.435	0.287
1997	4.573	2.060	3.866	1.742	3.369	1.802	1.693	0.906	1.512	1.003	1.095	0.726	1.766	0.921	0.611	0.319
1998	2.643	1.564	2.139	1.266	2.609	1.506	0.900	0.520	1.308	0.772	0.860	0.508	2.104	0.748	0.539	0.192
1999	1.069	0.862	0.745	0.601	2.165	1.022	0.419	0.198	3.099	1.532	2.595	1.283	2.414	1.394	1.161	0.670
2000	1.369	0.997	1.222	0.890	1.502	0.973	0.434	0.281	1.441	0.844	0.522	0.306	2.770	1.333	0.583	0.278
2001	2.029	1.275	1.854	1.165	1.693	1.272	0.728	0.547	3.567	2.448	3.067	2.105	2.385	1.811	1.361	1.033
2002	1.578	1.247	1.475	1.166	0.760	0.630	0.482	0.400	5.920	1.855	5.420	1.698	3.135	1.460	2.305	1.073
2003	0.890	0.667	0.731	0.548	1.439	0.734	0.242	0.123	7.951	2.197	6.348	1.754	7.363	2.043	4.790	1.329
2004	0.744	0.585	0.703	0.553	0.487	0.380	0.180	0.140	4.206	1.925	3.440	1.574	3.221	1.395	2.122	0.919
2005	5.620	2.377	5.459	2.305	2.016	1.235	1.588	0.973	7.415	2.533	6.507	2.223	4.769	1.636	2.700	0.926
2006	2.589	1.493	2.534	1.467	0.972	0.758	0.766	0.597	1.856	0.959	1.578	0.815	1.591	0.568	0.574	0.205
2007	4.671	2.655	4.466	2.538	1.988	1.423	1.425	0.805	1.394	0.754	1.314	0.711	0.607	0.438	0.404	0.292

¹ NEFSC Strata 01130-01300, 01330-01340, 01360-01400.

² The "36 Yankee" trawl was used from 1970-1972, and 1982-2002; the "41 Yankee" trawl was used from 1973-1981.

No gear conversion factors are available to adjust for differences in fishing power.

³ BMV oval doors were used from 1970-1984; since 1985 Portuguese polyvalent doors have been used. No door conversion factors were applied. Surveys performed using *R/V Albatross IV* and *R/V Delaware II*; No vessel conversion factors were applied.

Table M4. Assessment measures used to evaluate the SA 5&6 component of the pollock stock
Landings include recreational harvest.

Year Factor	Autumn Kg/tow	Landings (mt)	Relative F	Replacement Ratio
1963	4.939	6241	1.631	
1964	2.716	9008	2.698	
1965	2.362	9000	3.928	
1966	1.795	9847	5.404	
1967	1.31	8534	4.446	
1968	2.654	5222	2.120	1.011
1969	3.424	9822	3.789	1.580
1970	1.699	11976	4.914	0.736
1971	2.189	15203	6.364	1.006
1972	3.279	13013	4.107	1.454
1973	4.037	13076	4.429	1.524
1974	1.542	12393	5.256	0.527
1975	1.494	13871	3.586	0.586
1976	8.567	13382	2.559	3.416
1977	5.628	16273	2.704	1.487
1978	3.862	22305	4.933	0.908
1979	4.074	18452	5.231	0.966
1980	2.647	23539	9.049	0.560
1981	1.083	22820	13.439	0.219
1982	1.364	20285	16.354	0.394
1983	1.274	18397	17.236	0.489
1984	0.564	20748	17.387	0.270
1985	1.742	21328	18.847	1.256
1986	1.089	26650	19.721	0.903
1987	1.223	23583	17.260	1.014
1988	1.787	17815	14.727	1.516
1989	0.619	12693	11.200	0.483
1990	0.994	11674	15.483	0.769
1991	0.649	10153	11.931	0.568
1992	0.91	10721	15.583	0.863
1993	0.505	10290	17.711	0.509
1994	0.328	7585	17.019	0.446
1995	0.504	4858	9.808	0.744
1996	0.654	4759	6.607	1.129
1997	1.003	5991	7.399	1.729
1998	0.772	7994	7.252	1.289
1999	1.532	5815	5.542	2.349
2000	0.844	5772	3.590	0.945
2001	2.448	6430	3.748	2.547
2002	1.855	5735	2.647	1.406
2003	2.197	6829	3.427	1.474
2004	1.925	7512	3.386	1.084
2005	2.533	8687	4.811	1.366
2006	0.959	7390	5.221	0.438
2007	0.754	9400	10.975	0.398

Table M5. AIM model estimates of the F_{MSY} proxy and the probability value for the randomization test for Pollock in Subareas 5 and 6.

	Point Estimate (90 % CI)	Bootstrap Mean
F_{MSY} proxy	5.66 (3.87 – 7.44)	5.66
Randomization test p value	0.03	

Table M6. Biological reference point estimates and 2007 stock status for Pollock in Subareas 5 and 6.

2007 Relative F	F_{MSY} proxy
10.97	5.66
2007 Biomass Index	B_{MSY} Proxy
0.754 kg/tow	2.0 kg/tow

Table M7. Projections of catch and minimum population biomass in 2009 under 3 relative F scenarios in 2009.

2008		Relative F (2009)	2009	
Catch (mt)	Population Biomass Index (kg/tow)		Catch (mt)	Population Biomass Index (kg/tow)
11,240	1.02	F _{sq} (10.975)	8,133	0.74
8,013	1.42	F _{MSY} (5.66)	8,015	1.42
7,756	1.46	F _{REBUILD} (5.31)	8,003	1.51

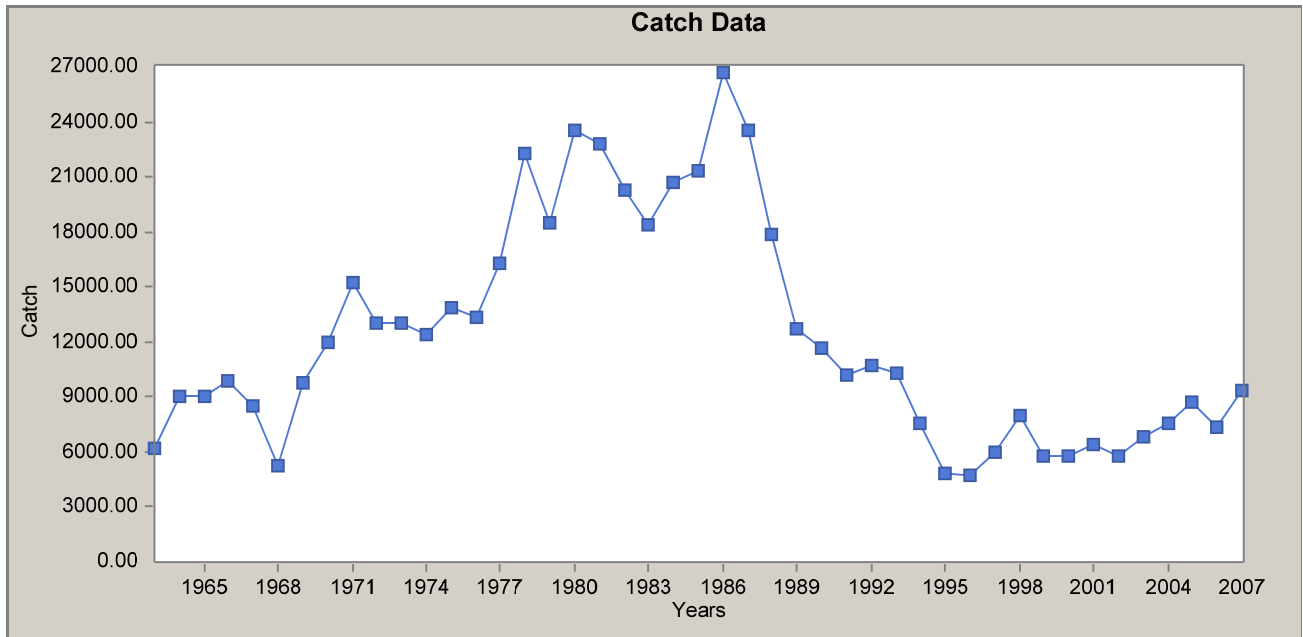


Figure M1. Total commercial and recreational landings (mt) of pollock from SA 5&6.

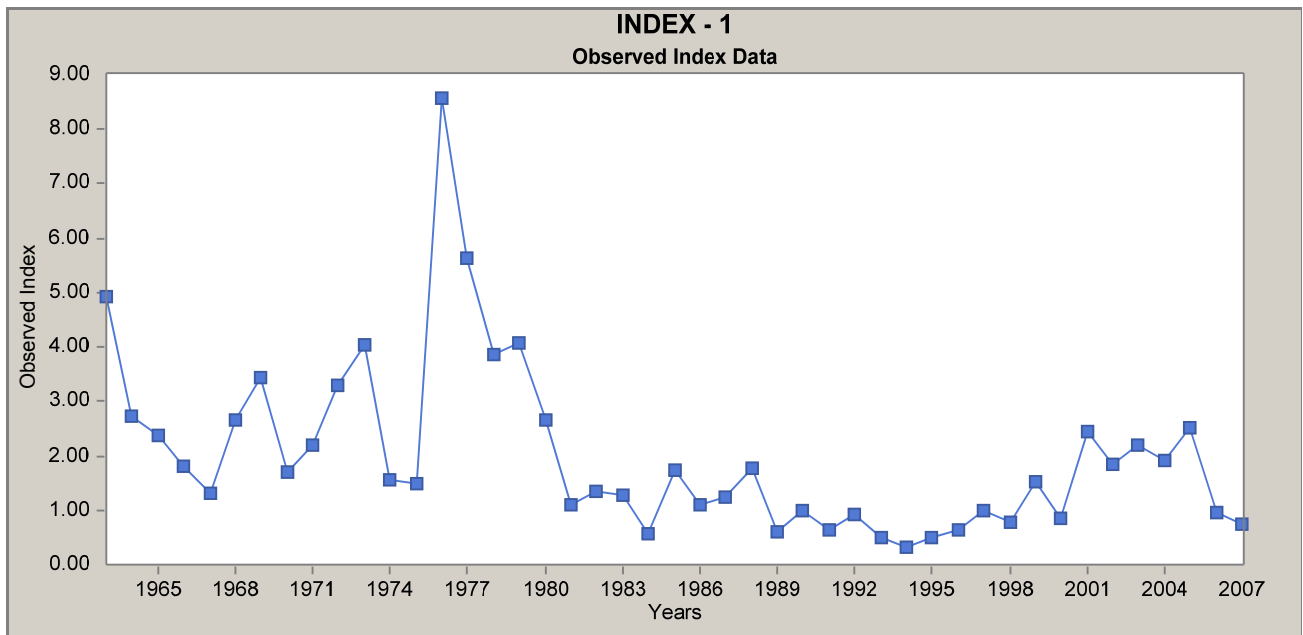


Figure M2. Population biomass index (kg/tow) for pollock in SA 5&6 from the NEFSC autumn bottom trawl surveys.

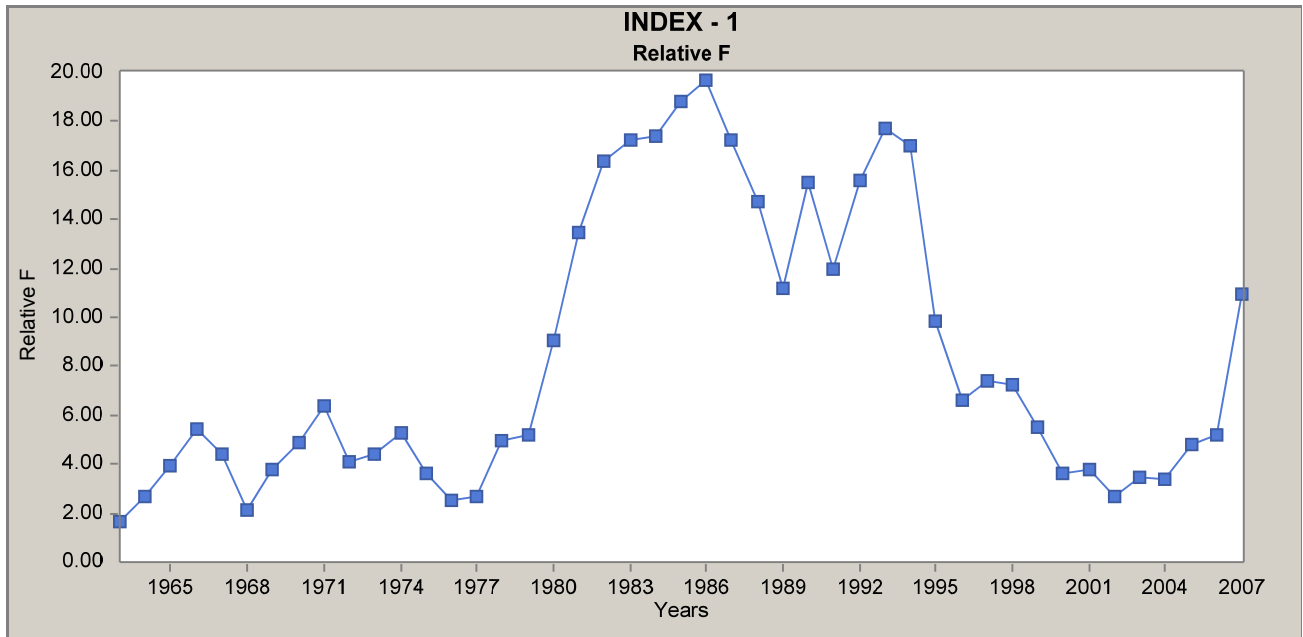


Figure M3. Average relative F (commercial and recreational landings/biomass index) for pollock in SA 5&6.

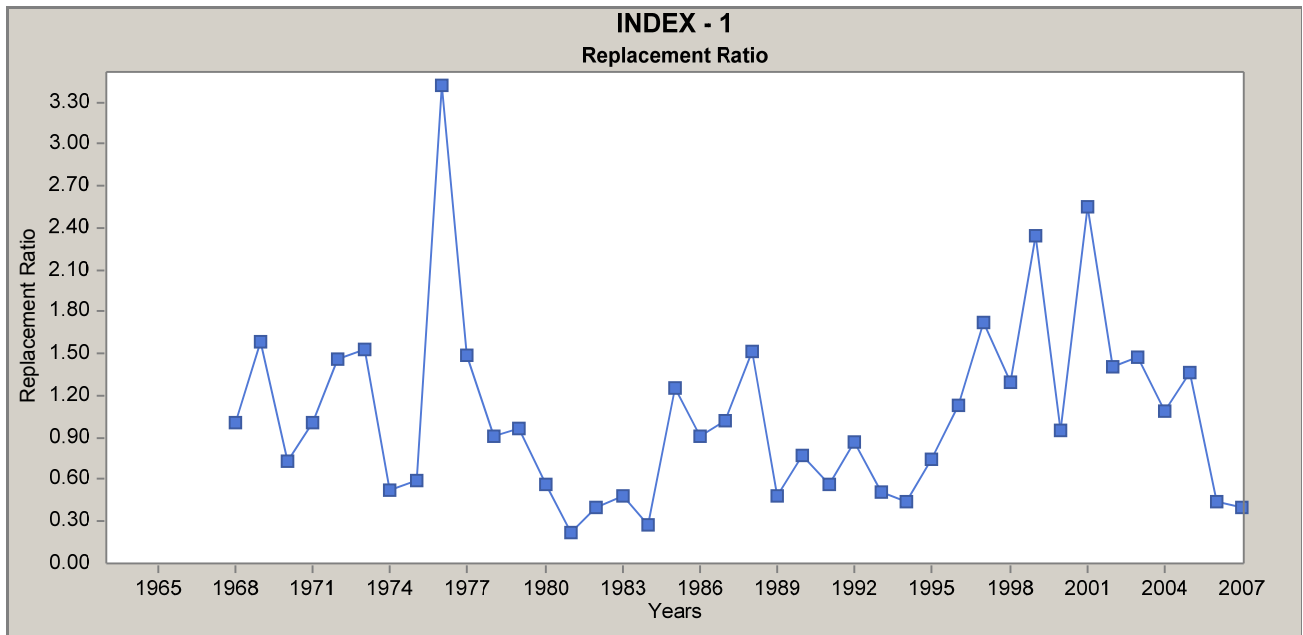


Figure M4. Replacement Ratios for pollock in SA 5&6.

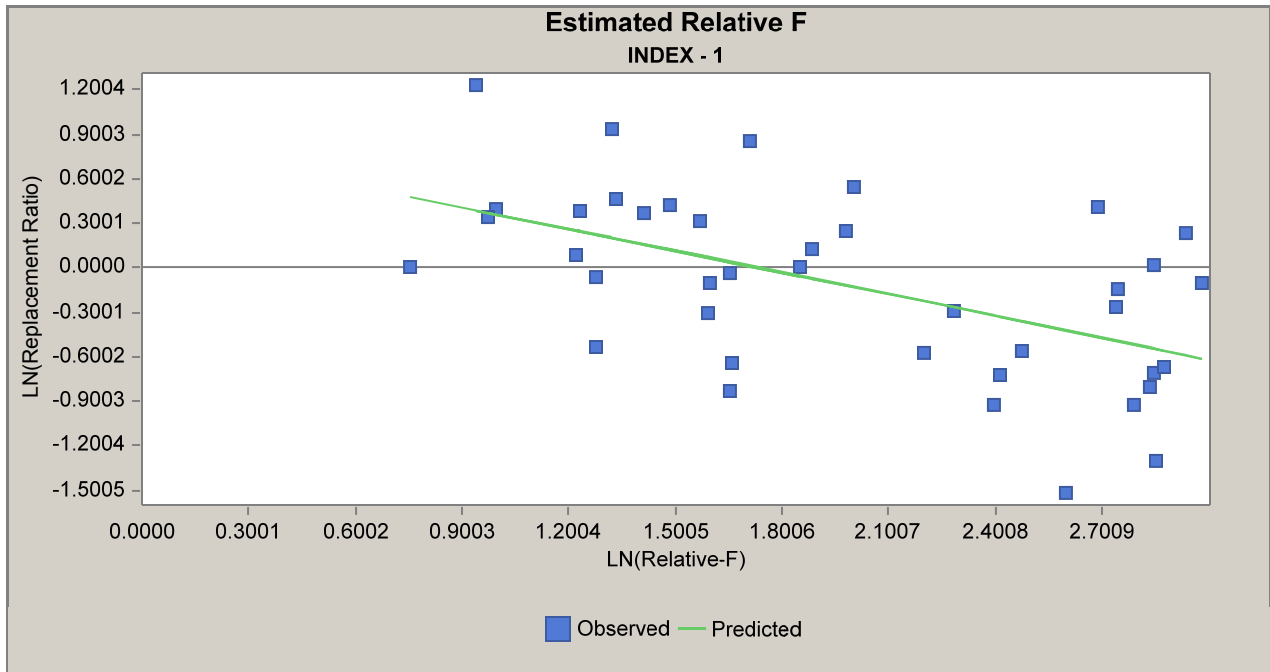


Figure M5. Regression of replacement ratio on relative F used to estimate F_{MSY} proxy ($5.66 = \exp 1.733$) derived from the AIM model for pollock in SA 5&6.

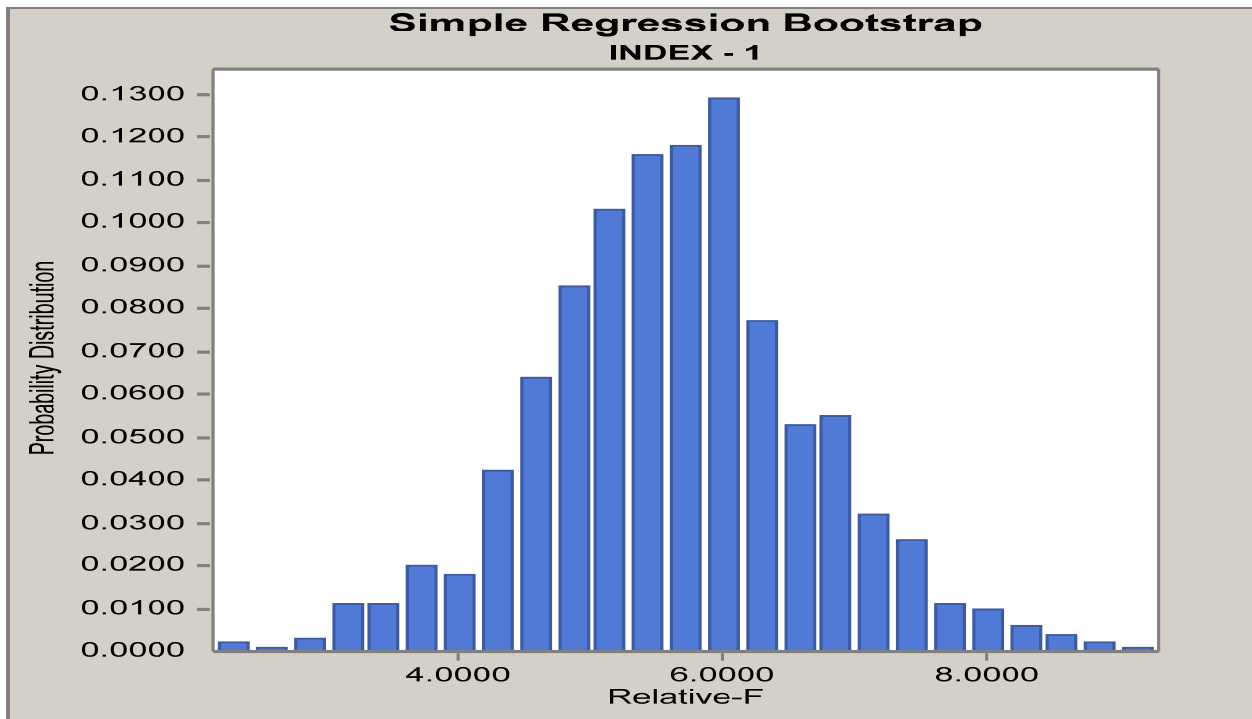


Figure M6. Distribution of 1000 bootstrap iterations of the regression of replacement ratio on relative F for pollock in SA 5&6. The 90% confidence interval about the replacement relative F estimate (5.66) ranges from 3.87 to 7.44.

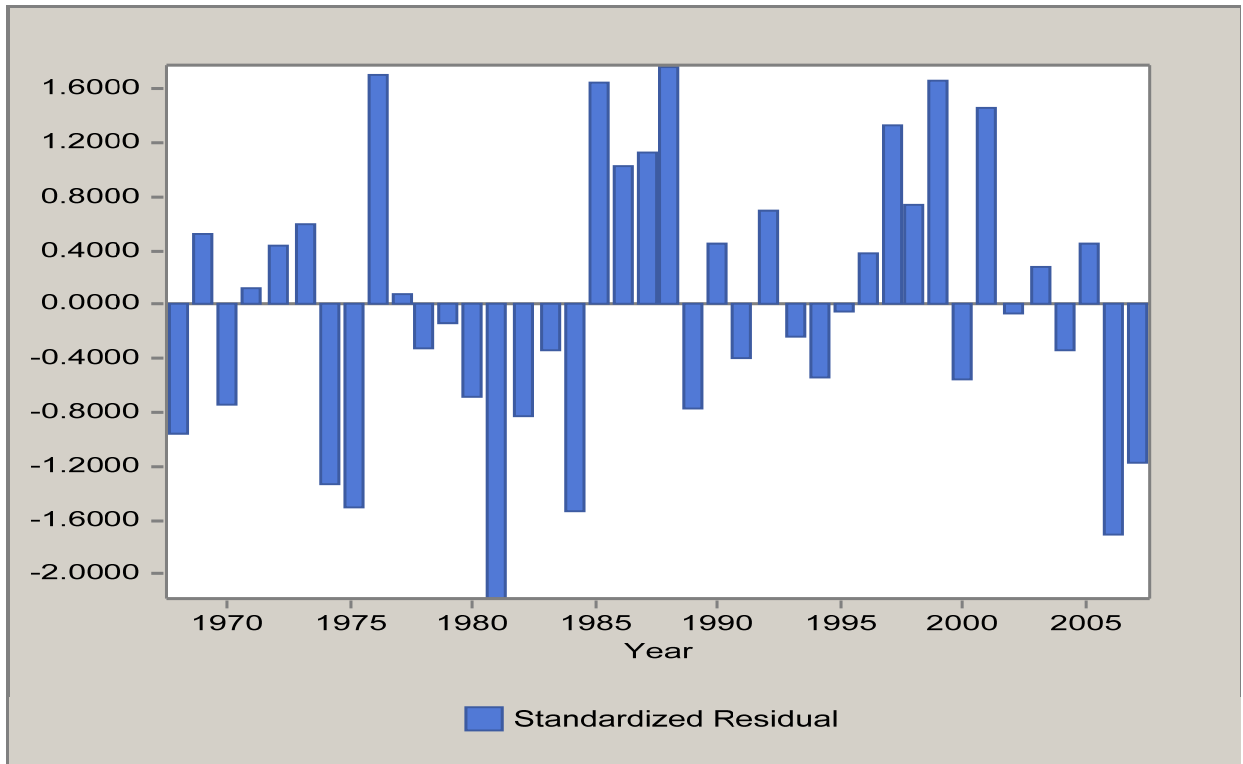


Figure M7. Residual patterns from the regression of replacement ratio on relative F for pollock in SA 5&6.

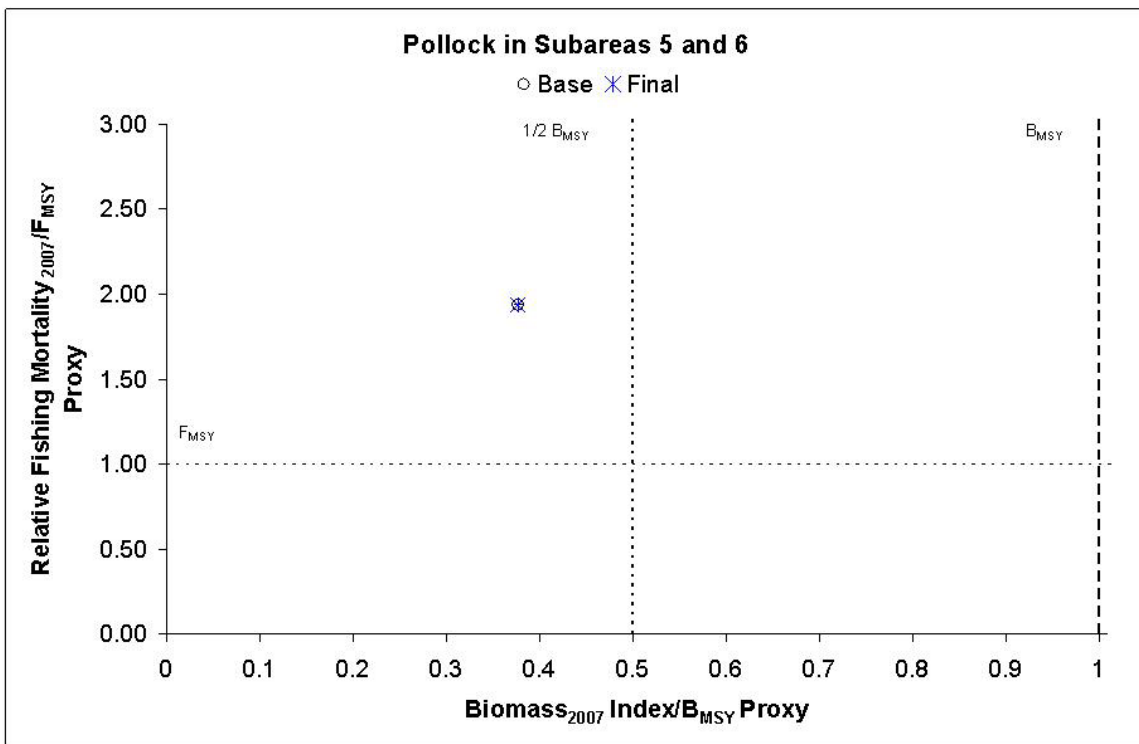


Figure M8. Status determination of pollock in Subareas 5 and 6 in 2007.