Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

C S A S / **S C C S**

Canadian Science Advisory Secretariat / **Secrétariat canadien de consultation scientifique**

Research Document 2004/042 / **Document de recherche 2004/042**

Not to be cited without
Permission of the authors *

Ne pas citer sans
autorisation des auteurs *

Mortality of northern Gulf of St. Lawrence cod during the period from 1990 to 2003

La mortalité de la morue du nord du Golfe du St. Laurent lors de la période de 1990 à 2003

Hugues P. Benoît and Ghislain A. Chouinard

Marine Fish Section / Section des poissons marins
Fisheries and Oceans Canada / Pêches et Océans Canada
Gulf Fisheries Centre / Centre des Pêches du Golfe
343 avenue de l'Université
C.P. 5030
Moncton, NB E1C 9B6

* This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at:

Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1499-3848 (Printed / Imprimé)

Canada

ABSTRACT

This document presents the results of analyses aimed at estimating natural mortality (M) of northern Gulf of St. Lawrence cod (NAFO 3Pn4RS) over the period from 1990-2003. In the process, estimates of the total (Z) and fishing (F) mortality during the period are obtained. Two general approaches were used to estimate M. The first involved a direct estimation using general linear models and research vessel survey and commercial fishery catch-at-age data. The second approach involved estimating M via Sequential Population Analysis. Overall, we find that the current value for natural mortality (0.4) used in the assessment of this stock is within the confidence intervals of the various estimates obtained from our analyses. We therefore conclude that a change in the assumption for natural mortality in the assessment of northern Gulf of St. Lawrence cod is not warranted.

RÉSUMÉ

Dans ce rapport nous présentons les résultats d'analyses ayant pour but d'estimer la mortalité naturelle (M) chez la morue du nord du Golfe du Saint-Laurent (OPANO 3Pn4RS) de 1990-2003. Au cours des analyses nous avons aussi obtenu des estimations de la mortalité totale (Z) ainsi que la mortalité par pêche (F). Nous avons adopté deux approches pour estimer M. La première impliquait l'estimation directe de mortalité employant un model linéaire général basé sur les donnés de relevés scientifiques et les prises à l'âge dans la pêche commerciale. La deuxième approche consistait à faire l'estimation via une analyse de population séquentielle. En somme, nous avons déterminé que la valeur de la mortalité naturelle (0.4) présentement utilisée dans l'évaluation de ce stock se trouve dans les intervalles de confiance de nos diverses analyses. Nous concluons donc qu'une modification du postulat de la valeur du taux de mortalité naturelle dans l'évaluation de stock de la morue du nord du Golfe du Saint-Laurent n'est pas justifiée.

INTRODUCTION

This document presents the results of analyses aimed at estimating natural mortality (M) of northern Gulf of St. Lawrence cod (NAFO 3Pn4RS) over the period from 1990-2003. In the process, estimates of the total (Z) and fishing (F) mortality during the period are obtained. Two general approaches were used to estimate M. The first, a purely empirical approach, involved a direct estimation using general linear models and research vessel (RV) survey and commercial fishery catch-at-age data (e.g. Sinclair 2001). The second approach involved estimating M via Sequential Population Analysis (e.g. Chouinard et al. 2003), which involves a statistical fit of the data to a demographic model.

Data inputs for the analyses analysis, namely removals at age and abundance indices for the northern Gulf of St. Lawrence cod stock, were made available by A. Fréchet (DFO, Institut-Maurice-Lamontagne, Mont-Joli, Québec). The removals at age (Appendix 1) included the 2003 estimates. Four abundance indices (catch rate at age) were also updated with 2003 information: the August research vessel survey (1990-2003), the July sentinel trawl survey and the longline and gillnet sentinel indices (1995-2003). One other sentinel index of abundance, an October trawl survey, is also available but the series ends in 2002 (Appendix 2).

RESULTS

i) Direct estimates of mortality from the scientific surveys

Instantaneous rates of Z were estimated for each age and year by taking the difference in the logarithm of RV survey abundance (*N*) of each age-class (*a*) and year (*y*) and the abundance of that same cohort the following year:

$$Z_{a+1,y+1} = \log_e N_{a+1,y+1} - \log_e N_{a,y}$$

This provides unbiased estimates of Z if catchability is constant between age-classes (Ricker 1975). As such, we restricted our estimates to those age-classes that appear to be fully recruited to the survey (see below for details on how those ages were determined). Despite this restriction, the analysis highlights a few clear cases of inter-annual changes in catchability across a range of ages (Fig. 1). In particular, catchability appears to have increased in 1994 relative to 1993, in 1997 vs. 1996 and in 2003 vs. 2002, as evidenced by negative values of Z across almost all ages (i.e. increase in the abundance of cohorts from one year to the next).

We used a modified catch curve analysis (Sinclair 2001) so as to average over these year-effects in catchability and provide more robust estimates of Z. The approach is an extension of a typical catch curve analysis (regression of $\log_e$(abundance) on age) whereby Z is estimated as the common slope from an analysis of covariance that includes several year classes (factor or "class" variable). The analytical model employed was:

$$\log_e A_{ij} = \beta_0 + \beta_{1y} + \beta_2 \text{ age} + \varepsilon$$

where A_{ij} is the stratified mean catch per tow in the RV survey of age *i* cod in year *j*. The vector β_{1y} provides separate estimates of intercepts for each year class (treated as fixed effects). The parameter β_2 was the estimator of Z. Following the approach of Sinclair (2001), this analysis was repeated in successive 4-year blocks to provide approximate estimates of mortality for the middle year of each block.

The age range included in the analysis was restricted to include those ages that are fully recruited to the survey gear. Assuming that mortality is constant over time, departures from linearity in the catch curve analysis suggest changing catchability (Ricker 1975). As such we visually examined the residuals of the analysis with respect to age. The most appropriate age range appeared to be from ages 6-10 years for the RV survey catches (Fig. 2).

Bearing in mind that each Z estimate represents the average over a 4-year block, there is a strong trend over the 1990-2003 period (Fig. 3). Total mortality was relatively large in the early 1990s during years of relatively high fishing intensity, relatively small from 1994-1996 during the first fishery closure, intermediate when a modest fishery was allowed during the late 1990s, and relatively small when the fishery was closed again in 2003 (reflected in the last Z estimate of the series). Those cohorts that were fully recruited to the fishery during the early 1990s (1984-1986 year classes) experienced the highest Z over the ages of 6-10, whereas all subsequent cohorts experienced similar levels of Z over those ages (Fig. 4).

We also used the modified catch curve to estimate Z using the indices of abundance from the Sentinel program (July and October mobile gear surveys, gillnet and long-line catch indices[1]). Although those estimates of Z varied somewhat over time and among indices, they were generally of similar magnitude and trend to the estimates from the RV survey (Fig. 3, inset plot).

It is possible to estimate M using a regression of the annual estimates of Z on an index of fishing mortality (F). In doing so, the intercept and slope provide estimates of M and catchability, respectively (Ricker 1975). Sinclair (1998) proposed using fishery catch-at-age divided by the RV survey numbers at age as an index of F. (Indeed this index and F relate directly, differing only in scale as a result of RV survey catchability). To provide estimates of relative F comparable to

[1] The analysis was conducted using ages 6-10 for the mobile gears and 6-11 for the fixed gears. These age ranges were chosen based on the examination of trends in residuals from the analysis with respect to age (not presented here), as described previously for the research vessel survey.

the estimates of Z from the modified catch curve analysis (i.e. integrating over a 4-year block), we used the slope (β_1) from the following linear model:

$$C_{ij} = \beta_1 A_{ij} + \varepsilon$$

where C is the catch of cod in the commercial fishery and A is the estimated survey numbers for age *i* in year *j*. As with the estimates of Z, this analysis was repeated within successive 4-year blocks. Patterns in the resulting estimates of relative F are generally consistent with the patterns in Z (Fig. 5). In order to estimate M, we used Major Axis (model II) regression since both Z and relative F were estimated with error (Legendre and Legendre 1998). This resulted in an overall estimate of M of 0.35 (±0.11 SE) for the period from 1990-2003 (Fig. 6a). The residuals from that analysis did not show any trend over time (Fig. 6b) suggesting that this estimate of M may be reasonable for the period (i.e. does not suggest a change in intercept or slope over time).

ii) Estimates of natural mortality from SPA

Schnute and Richards (1995) showed, using simulation-estimation techniques, that it is feasible to estimate M in catch-age models. Similarly, Fu and Quinn (2000) found that inter-annual variation in M could be estimated in a stock assessment model of *Pandalus borealis* using the AD model builder methodology. Chouinard et al. (2003) conducted a simulation study to investigate the utility of using the implementation of the ADAPT framework software (Gavaris 1988) used in the calibration of sequential population analysis to estimate M trends for various time periods. The simulations were conducted by first constructing synthetic populations generated with ‘known’ M patterns. Two different catchability profiles (constant for all years) were then used to construct two ‘exact’ survey indices. The indices of abundance were randomly perturbed (30% cv for each index). The perturbed indices and the catch-at-age calculated in generating the population were then used in ADAPT to estimate the population parameters including estimates of M. In the three cases examined, the estimation procedure uncovered the general trends in underlying M. In addition, where abrupt changes in M were used in generating the populations (e.g. a doubling or halving of natural mortality in one year), estimates of M obtained from the 500 replicates were generally close to the underlying values. The approach has been used to estimate natural mortality trends in southern Gulf of St. Lawrence cod (Chouinard et al. 2002), and is used here to estimate patterns in M for the northern Gulf of St. Lawrence cod.

The coherence of the abundance indices (correlation between the abundance index in year *i* and age *a* with that in year *i+1* and age *a+1*) was examined. Coherence was generally found to be low for most indices except for the longline index. The lack of coherence can be caused by several things: lack of contrast in the data, large inter-annual variation in Z or large changes in the catchability for the index. Given the generally short time-series, the cause(s) for the lack of coherence is (are) not clear. However, it is likely that some indices currently used in the assessment calibration such as the index for gillnets for younger ages may have low and potentially highly variable catchability.

Except for the estimates of M, the formulation of the ADAPT model (including the abundance indices) was the same as the one used in the previous assessment of the stock (Fréchet et al. 2003). To reduce the possibility of the results being affected by transient trends in catchability, estimates of natural mortality were examined for periods of 4 to 9 years. The periods were defined starting with the terminal year (e.g. for 4-year periods: years 2003-2000, 1999-1996, 1995-1992, 1991-1988; 9-year periods: years 2003-1995, 1995-1987). Because the indices of abundance used for the assessment of this stock begin in 1990, it is not possible to estimate M for complete periods prior to 1990. Assumptions of M for years prior to 1990 have no impact on the results because of the order in which the SPA calculations are done and because the calibration depends only on data for 1990-2003. For periods spanning 1990 (i.e. starting before and ending after 1990), the estimates of M only depend on data starting in 1990 to the end of the period. In addition, an analysis estimating one value of M for the entire period 1990-2003 was also conducted. This was repeated using abundance indices excluding age-groups where coherence was particularly low.

All of the calibrations of ADAPT where M was estimated converged. The mean square error (MSE) from the analyses suggested little difference in the fit (Table 1). The estimates of M from the ADAPT calibrations suggested that M may have been slightly higher in the early 1990s than in recent years (Figure 7). However, none of the estimates were significantly different. The value of M recently being used in stock assessment (0.4) was within the confidence intervals of all estimates. For periods spanning 1990, the confidence intervals were considerably wider because of the small number of years (2 or 3; see 4 to 6-year estimates) of data available in the estimation.

The estimate of M for the period 1990-2003 was 0.42 (95% confidence interval 0.34 to 0.52). An analysis excluding the abundance indices for which coherence was particularly poor (i.e. August research survey age 13, July sentinel survey age 2, August sentinel survey age 13 and sentinel gillnet ages 3 to 7) resulted in a similar estimate but with improved mean square error (0.29).

CONCLUSIONS

In summary, the current value for M (0.4) used in the assessment of this stock is within the confidence intervals of the various estimates obtained in the modified catch curve and ADAPT analyses. Although the results from the latter analyses suggest that M may have been slightly higher than 0.4 (though non-significantly), particularly in the early 1990s, the estimates do not suggest that M has declined appreciably since then. These analyses do not suggest that a change in the assumption of M is warranted.

ACKNOWLEDGEMENTS

We wish to thank Linda Currie, Manon Mallet, Rod Morin and Doug Swain for their constructive review of a previous draft of this document.

References

Chouinard, G.A., M.O. Hammill and D.P. Swain 2002. Unaccounted mortality in fisheries: correspondence between changes in grey seal population abundance and variation in natural mortality of southern Gulf of St. Lawrence cod. ICES C.M. 2002/V:11

Chouinard, G.A., Swain, D.P., Currie, L., Poirier, G.A., Rondeau, A., Benoît, H., Hurlbut, T. and Daigle, D. 2003. Assessment of the southern Gulf of St. Lawrence cod stock, February 2003/ Évaluation du stock de morue du sud du Golfe du St-Laurent, février 2003. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/015:116 p.

Fréchet, A., Gauthier, J., Schwab, P., H. Bourdages, D. Chabot, F. Collier, F. Grégoire, Y. Lambert, G. Moreault, L. Pageau and J. Spingle. 2003. L'état du stock de morue du nord du golfe du Saint-Laurent (3Pn,4RS) en 2002 / The status of cod in the Northern Gulf of St. Lawrence in 2002. Can. Sci. Adv. Sec. Res. Doc. 2003/065:90 p.

Fu, C. and Quinn, T.J., II. 2000. Estimability of natural mortality and other population parameters in a length-based model: Pandalus borealis in Kachemak Bay, Alaska. Can. J. Fish. Aquat. Sci. 57:2430-2432.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 88/29: 12 p.

Legendre, P. and L. Legendre. 1998. Numerical Ecology, 2nd English edition. Elsevier, Amsterdam.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Bd. Can. 191.

Schnute, J.T. and Richards, L.J. 1995. The influence of error on population estimates from catch-age models. Can. J. Fish. Aquat. Sci. 52:2063-2077.

Sinclair, A.F. 2001. Natural mortality of cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. ICES J. Mar. Sci. 58:1-10.

Sinclair, A.F. 1998. Estimating trends in fishing mortality at age and length directly from research survey and commercial catch data. Can. J. Fish. Aquat. Sci. 55:1248-1263.

Table 1: Mean square error from the fits to the sequential population analyses used to estimate *M* for northern Gulf of St. Lawrence cod.

Analysis	Number of parameters estimated	*M* estimates	Mean square error
Estimates of *M* in 4-year periods	77	4	0.311
Estimates of *M* in 5-year periods	76	3	0.311
Estimates of *M* in 6-year periods	76	3	0.310
Estimates of *M* in 7-year periods	75	2	0.310
Estimates of *M* in 8-year periods	75	2	0.311
Estimates of *M* in 9-year periods	75	2	0.312
Estimate of *M* for 1990-2003	74	1	0.313
Estimate of M for 1990-2003 (reduced number of indices)	74	1	0.292
Assessment framework	73	0	0.313

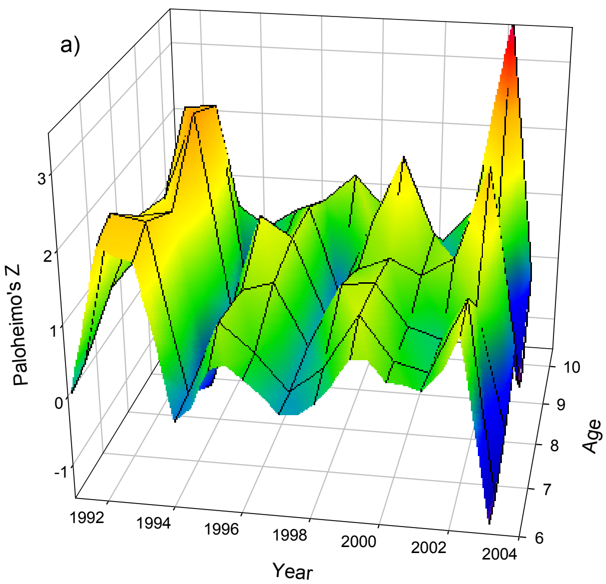

Figure 1: Estimates of total mortality of northern Gulf cod by age and year, for the ages that are fully recruited to the RV survey. Estimates in blue/teal are negative values (i.e., increasing abundance of the cohort from one year to the next).

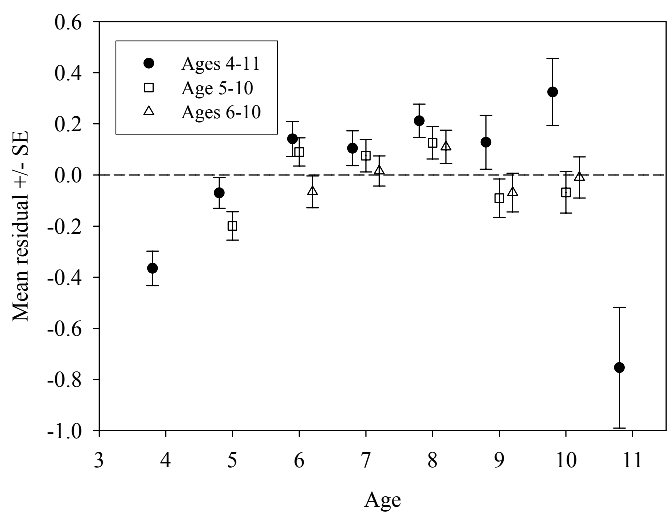

Figure 2: Mean residuals (±SE) at age from the modified catch curve analyses including different age ranges (4-11 years, 5-10 years and 6-10 years). The residual pattern was convex (departure from linearity) for analyses including years 4-11 or 5-10, but showed no pattern for analyses including ages 6-10.

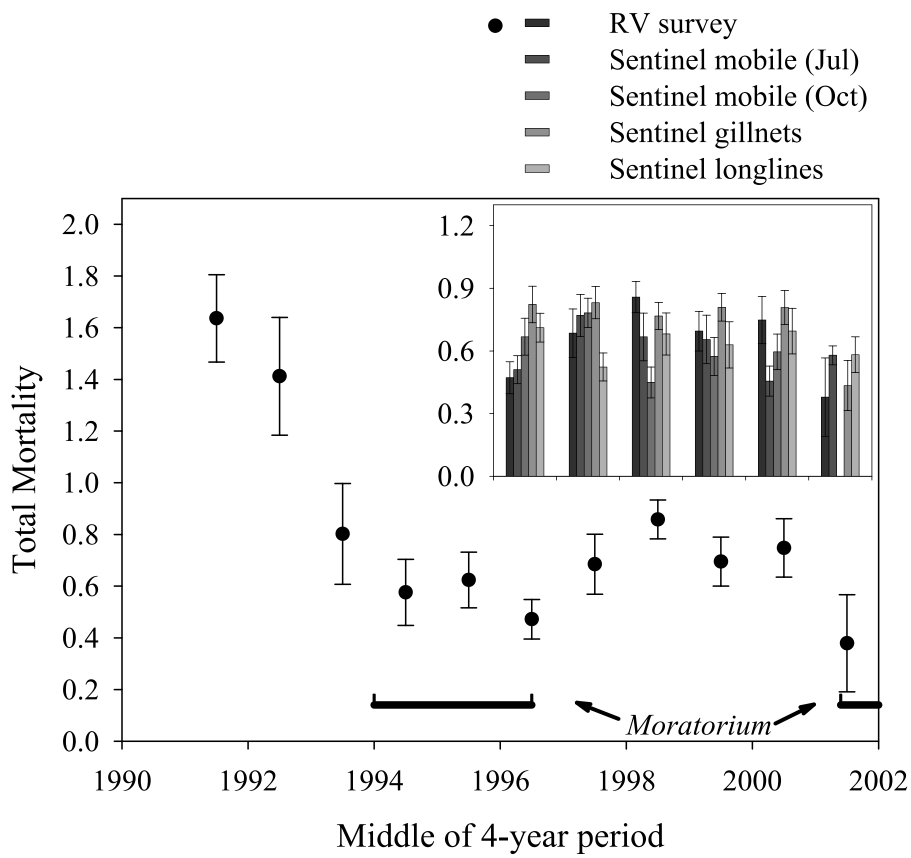

Figure 3: *Main plot*: Total cod mortality (±SE) estimated from the modified catch curve analysis in successive four-year blocks for ages 6-10 in the RV survey. The middle year of each four-year block is indicated on the x-axis.
Inset plot: Total mortality estimates (±SE) based on various indices of abundance for ages 6-10 (RV and Sentinel trawl surveys) or ages 6-11 (Sentinel gillnet and long-line indices).
Note: there was no Sentinel mobile gear survey in October 2003.

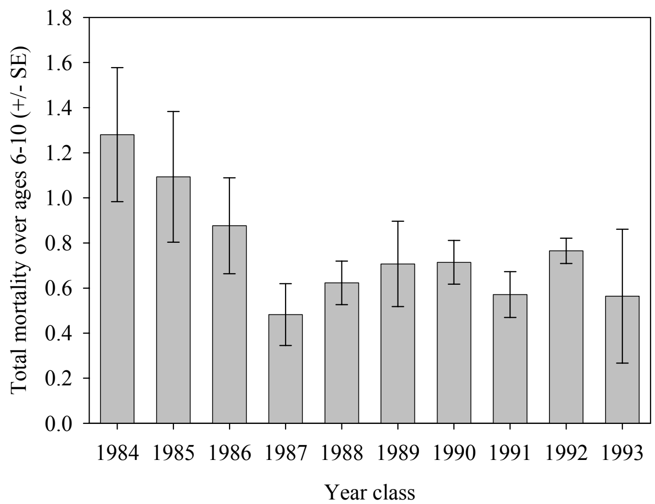

Figure 4: Estimates of total mortality (±SE) estimated via catch curve analysis for ages 6-10 for each cod cohort (year class) from the RV survey. Estimates were only made for cohorts with observed numbers at ages 6 through 10.

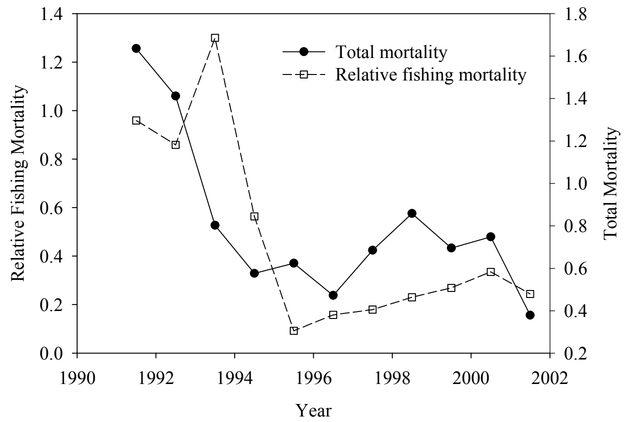

Figure 5: Relative fishing mortality over the period of 1990-2003, as estimated using linear regressions of commercial catch-at-age on survey numbers-at-age in successive four-year blocks for ages 6-10. Trends in total mortality (Figure 3) are presented for comparison. The middle year of each four-year block is indicated on the x-axis.

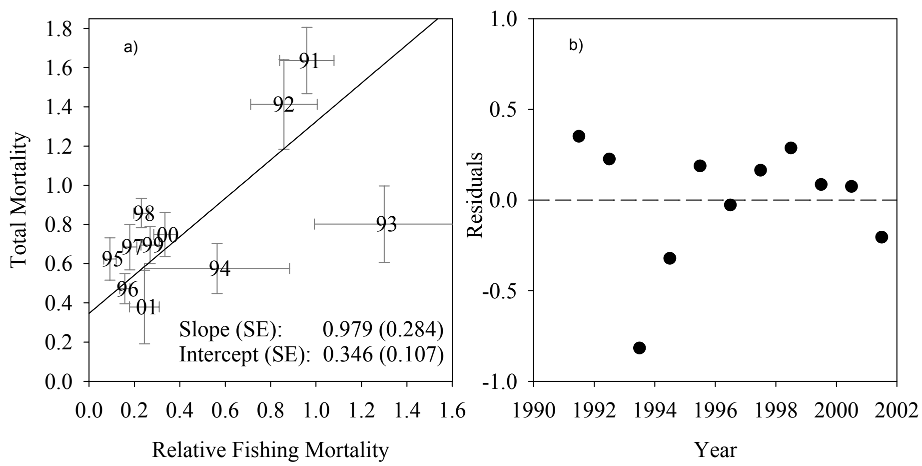

Figure 6: Major axis regression of total mortality on relative fishing mortality.
a) Scatter plot and fitted line of annual values (indicated by the symbols) with ±1 SE bars. The intercept of the fitted line is the estimated natural mortality (M=0.346).
b) Residuals from the analysis as a function of year.

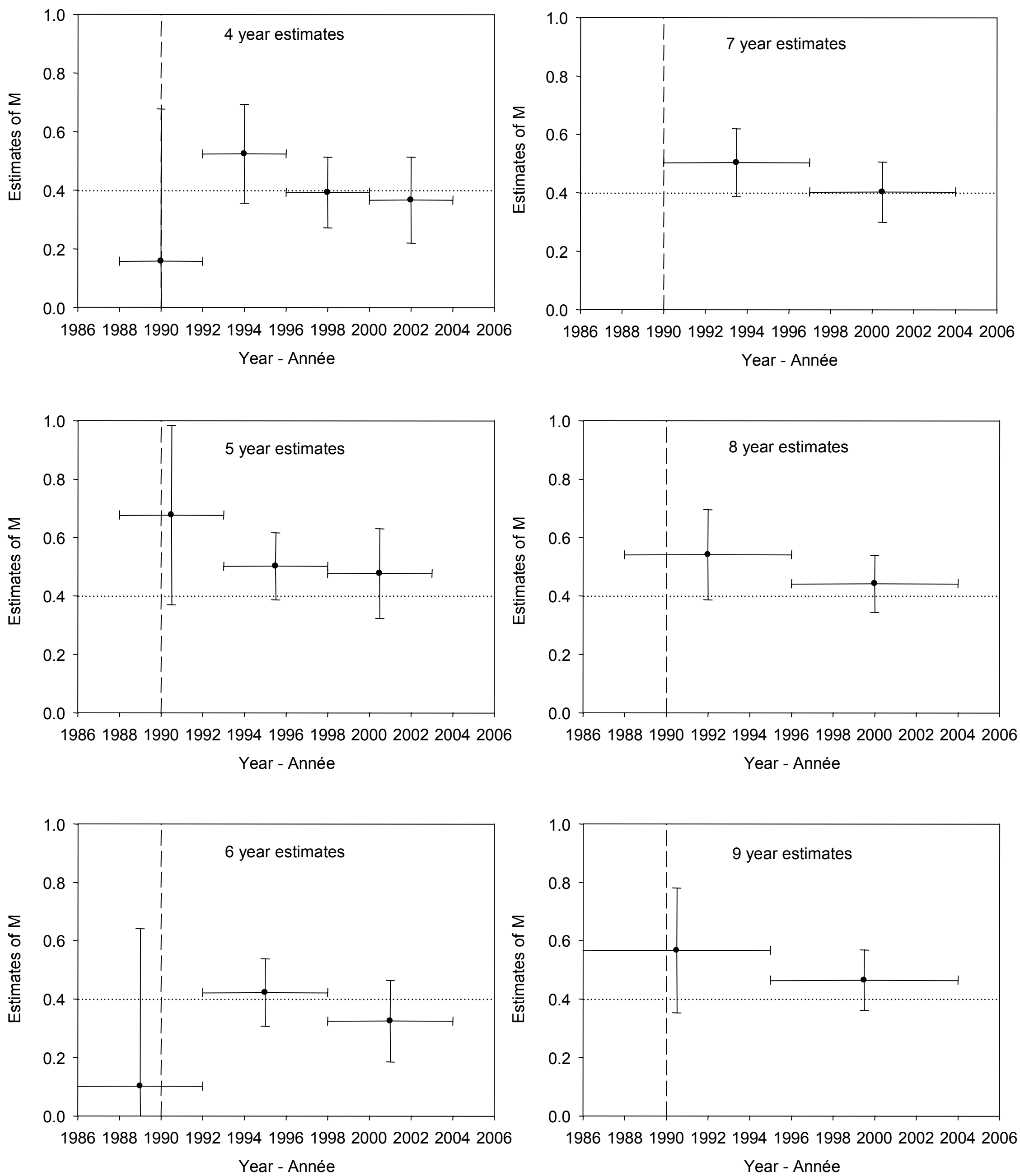

Figure 7: Estimated natural mortality for periods of 4 to 9 years (circles, with lateral lines spanning the period covered) with approximate 95% confidence intervals (+/- 2 SE). The vertical line in 1990 indicates the starting year of abundance indices available for calibration of SPA. The horizontal line at 0.4 indicates the value recently used for M in the time period starting in 1986.

Appendix 1 : Catch-at-age ('000) for northern Gulf of St. Lawrence cod, 1974-2003. Note that small catches of cod were made during the moratorium in fisheries directed at other species.

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1974	0	741	4069	9607	13498	5303	6658	2794	1509	413	173	82
1975	0	35	4313	7707	5091	7185	2930	2757	1719	740	316	135
1976	0	217	5210	12535	6323	4244	5750	1991	2561	993	395	147
1977	0	14	2672	10124	12756	7943	2628	3274	1098	894	394	291
1978	0	61	2678	10794	17616	9292	2163	1064	1261	538	441	235
1979	0	70	3404	13995	12871	12592	4822	1429	721	543	300	141
1980	0	605	3390	17515	20196	11624	7064	1531	483	289	324	77
1981	0	316	6689	8999	20054	13971	4730	2154	939	294	172	163
1982	0	229	3231	18782	12747	13768	8673	3372	2109	618	145	74
1983	0	840	4901	15255	18451	10206	6002	3061	1161	817	211	214
1984	0	47	2947	7733	13493	20246	7394	5688	2095	821	406	145
1985	0	175	2518	15909	13820	10688	9818	3179	2317	828	200	81
1986	0	215	2415	8534	15635	11847	6024	6189	2284	1748	461	185
1987	0	15	1194	8426	12310	11864	7210	3650	1843	1470	575	261
1988	0	117	1274	6037	11452	6078	5145	1515	656	826	277	142
1989	0	370	1882	5059	8190	8576	4101	2703	1085	480	380	145
1990	0	362	3083	7677	5916	5435	3984	1665	913	273	112	61
1991	0	109	3004	6928	6896	3344	2587	1996	487	433	115	57
1992	0	309	4276	9148	6080	3414	1661	1132	679	210	104	51
1993	0	169	1949	3807	5985	2863	888	343	215	130	22	20
1994	0	1	2	41	65	89	47	7	7	2	2	1
1995	0	2	10	23	52	40	33	17	5	2	1	1
1996	0	2	22	60	107	90	57	41	13	2	1	1
1997	0	18	296	386	764	475	517	220	248	31	10	3
1998	0	1	30	350	349	460	222	136	123	40	17	4
1999	0	1	45	200	953	454	776	375	178	136	54	7
2000	0	1	48	400	675	1269	375	429	159	50	14	11
2001	0	1	161	298	638	642	1016	333	188	50	30	24
2002	0	1	63	283	874	748	823	658	168	46	7	26
2003	0	0	5	19	30	33	19	12	13	2	1	0

Appendix 2: Indices of abundance for the calibration of population models for the northern Gulf of St. Lawrence cod stock.

a) August research vessel survey (population estimates)

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1990.7	3682	23621	18926	9820	3730	3666	3533	736	239	76	30	53
1991.7	4037	21310	45809	24156	10702	3004	1772	1874	435	252	47	74
1992.7	1633	4116	9031	9149	3509	1092	515	370	162	85	45	22
1993.7	1054	1497	1535	1810	1734	388	168	31	30	0	16	0
1994.7	2187	7817	4156	2481	2456	2010	729	173	57	25	29	0
1995.7	869	1047	4416	3170	2105	989	899	182	113	34	0	0
1996.7	1505	6248	3392	3986	2195	1256	387	300	63	0	10	0
1997.7	2153	3242	8979	3395	4046	2203	1166	405	402	20	0	0
1998.7	1165	5972	7040	7779	3485	2811	811	591	167	0	0	0
1999.7	4160	8134	8502	3868	4569	1109	990	336	89	172	32	20
2000.7	2440	9912	8112	4933	2177	2662	709	513	157	75	83	18
2001.7	2480	5563	4647	3202	2910	1449	1966	277	545	79	85	29
2002.7	911	1938	4240	1657	1141	675	638	200	151	14	0	0
2003.7	8373	13942	15170	11636	6477	4177	1766	909	1003	193	91	0

b) July sentinel survey (population estimates)

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1995.6	4926	5676	11705	7782	4683	3279	2884	579	138	60	20	0
1996.6	3999	17617	15048	12058	5821	2961	1999	1571	357	62	26	0
1997.6	7328	15377	34713	12408	11075	4294	1722	1283	412	109	7	0
1998.6	5398	22015	17317	18555	7836	7618	2492	1700	652	403	99	0
1999.6	5477	13649	15636	9157	7889	2919	2506	509	227	126	34	0
2000.6	3272	19929	27396	15399	10436	9343	2144	2124	753	125	32	19
2001.6	14245	28461	24997	12700	7868	4574	3473	1213	809	250	112	26
2002.6	1558	7879	21184	12107	9823	5336	4298	2286	686	191	13	19
2003.6	2808	11094	18293	14941	7136	5107	2370	1910	1497	535	113	51

Appendix 2 (continued)

c) October sentinel survey (population estimates)

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1995.8	12745	10331	7435	4142	3723	1688	1559	399	122	24	0	15
1996.8	2275	11489	8390	6376	4836	2985	1523	1230	511	70	8	25
1997.8	3587	7146	13479	4522	4262	1880	924	432	256	95	0	0
1998.8	5749	11348	9720	9378	3864	3134	1060	565	291	137	56	0
1999.8	7741	9793	10850	5514	4808	1624	1221	654	196	162	79	9
2000.8	2685	12072	14428	10377	5806	5613	1816	1045	692	23	164	6
2001.8	4237	9915	10205	6606	3802	2263	2497	503	317	113	6	7
2002.8	2220	4175	8020	4147	3577	1861	1609	1216	241	124	7	5

d) Longline sentinel index (numbers per 1000 hooks X 100)

	Age										
Year	3	4	5	6	7	8	9	10	11	12	13
1995.6	24	162	186	273	360	348	104	24	7	5	4
1996.6	44	154	258	299	357	213	185	45	6	2	1
1997.6	31	137	160	302	200	142	104	70	11	4	1
1998.6	115	320	589	560	425	206	152	70	30	9	3
1999.6	109	605	465	839	377	456	125	82	46	21	4
2000.6	92	566	835	808	855	269	150	27	9	10	3
2001.6	55	609	972	954	824	845	269	109	40	15	5
2002.6	44	335	545	713	569	366	362	75	40	6	4
2003.6	14	197	585	717	668	349	231	244	47	19	5

e) Gillnet abundance index (numbers per net X 100)

	Age										
Year	3	4	5	6	7	8	9	10	11	12	13
1995.6	3	21	64	196	316	384	96	26	4	4	4
1996.6	2	17	257	512	464	297	213	64	3	1	1
1997.6	2	28	92	335	250	181	129	75	11	3	0
1998.6	16	69	351	230	277	136	83	74	20	8	1
1999.6	2	14	87	298	197	253	77	40	22	9	1
2000.6	1	14	139	323	455	169	119	34	12	7	7
2001.6	0	8	48	113	146	220	81	33	7	6	1
2002.6	0	5	56	219	202	179	164	33	19	2	3
2003.6	1	12	163	459	619	347	217	258	38	19	1