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Report of the Seventh NEFC Stock Assessment Workshop (Seventh SAW)

National Marine Fisheries Service
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EXECUTIVE SUMMARY

The 1988 Autumn Stock Assessment Workshop (SAW 7) was held during the last week of November in Woods Hole, MA. The workshop involved participants from state fisheries agencies, fishery management council scientific staffs, National Marine Fisheries Service personnel from the Northeast Fisheries Center (NEFC), Northeast Regional Office (NERO), and the Southeast Fisheries Center (SEFC), representatives from academia, and invited international researchers. Objectives of the workshop were to (1) review current assessments of various fish stocks, (2) consider recent developments and methodologies for analyzing assessment data, (3) review reports prepared by other organizations related to resource status and (4) consider future needs for assessment information.

Revised or updated assessment information was examined for Georges Bank and Gulf of Maine cod stocks, Southern New England and Georges Bank yellowtail flounder stocks, and scup in Southern New England. In all cases, abundance of these stocks has undergone a serious decline in recent years and current fishing mortality exceeds the target levels. In the case of Southern New England yellowtail, the decreased stock biomass has resulted in a substantial reduction in directed yellowtail effort for that area.

Several methodologies to estimate long-term potential catch and evaluate multispecies and technical interactions were reviewed. It was determined that the development of accurate long-term potential catch models for many species is data limited. A simulation model was presented for surf clams to determine the possible long-term maximum catch given stochastic recruitment. The model provided an estimate of MSY for offshore surf clam populations comparable to the one currently used in management. Other models examined predator/prey interactions within fish populations and technological interactions between competing fishing fleets. The concept of a directed fishery is not necessarily applicable given the mixed-species nature of many fisheries (e.g. New England otter trawl); economics and spatial distribution patterns of fishing effort exerted by the fleets should be considered in addition to the distribution of the resource.

The workshop reviewed a report, presented by the Technical Monitoring Group of the New England Fisheries Management Council , which evaluated the effectiveness of current management measures contained within the Northeast Multispecies FMP. Discussion of the report centered on issues of reducing fishing mortality and technical aspects of SSB/R's as management targets. Management and assessment approaches in New Zealand were compared with those in the Northeastern U.S. Stocks are heavily exploited in both countries. The New Zealand individual transferrable quota management system requires more detailed biological data than the SSB/R approach used for the Northeast Multispecies plan. However, detailed data are not available for many New Zealand stocks.

Proposed NOAA Fisheries Stock Assessment and Fishery Evaluation (SAFE) requirements and their potential effects on future assessments were reviewed. Current information on the SAFE proposal is not adequate to determine specific requirements, although it was apparent that more effort will be required to produce an acceptable stock assessment than is currently required under many of the FMP's in force.

An overview of the Chesapeake Bay Stock Assessment Committee (CBSAC) draft research plan was presented. The participants felt that the SAW would be a suitable forum to review the CBSAC assessment research plans and results. Review of the program and completed assessment documents were considered as terms of reference for the next workshop (SAW 8).

Working groups formed at previous SAW's reported on: (1) methods for developing catch/effort indices for summer flounder and (2) regional growth patterns for winter flounder. The Summer Flounder Working Group will continue its work until terms of reference developed for the group had been completed. The SAW also requested development of a new working group to examine the utility and extent of scup and black sea bass catch data for a stock assessment.

The next workshop will be held the last week of April 1989. Among the proposed topics were (1) updates of squid and butterfish stocks, (2) the relationship between fish growth, maturity and SSB/R, (3) stock rebuilding strategies and (4) age sampling requirements for assessments.

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1. INTRODUCTION

1.1. OVERVIEW

The Seventh Stock Assessment Workshop was held at the Northeast Fisheries Center, Woods Hole, MA from November 28 to December 1, 1988. The reports of these workshops serve as the best available information on the status of the stocks and are reviewed for use by groups with fishery management responsibilities. The special topics and working groups provide specific information to interested user groups (the annual document "Status of the Fishery Resources off the Northeastern United States" [NEFC 1987a] provides a more general description of the status of each of the stocks in this region). In the present report, a source document, where available, is identified for each assessment for further information.

1.2. TERMS OF REFERENCE

The participants in the previous SAW recommended several terms of reference for the Seventh SAW (NEFC 1988). These recommendations formed the basis for the adopted terms of reference and include:

1.2.1. Assessment Terms of Reference

1. Revised assessments of the southern New England and Georges Bank yellowtail flounder stocks.
2. Assessments of Gulf of Maine and Georges Bank cod stocks
3. Assessment update for scup

1.2.2. Special Scientific terms of reference

1. Review of regional growth patterns in winter flounder
2. Review of long-term potential yield for surf clams
3. Discussion of the Technical Monitoring Group report to the New England Fishery Management Council
4. Report on activities by the Chesapeake Bay Stock Assessment Committee
5. Review and discussion of the E.E.C. workshop on technological interactions held in Nantes, France during spring of 1987 (part of a special session to be held on technical interactions).
6. Report of Trawl Survey Workshop held in Woods Hole, MA in November 1988 and an update on the door and vessel standardization experiments.
7. Report from the working group reviewing methods for calculation of CPUE for summer flounder.

1.2.3. Generation of Stock Assessment Information

1. Review of SAFE requirements relative to the Stock Assessment Workshops

2. Development of terms of reference for SAW VIII

1.3. IDENTIFICATION OF WORKING PAPERS

Several working papers were distributed to participants, as listed in Appendix 1. These are cited as "7th SAW Working Paper #". Some papers were distributed that had been prepared for other purposes but were relevant to workshop discussions. Working papers should not be cited without permission of the author.

1.4. REVISION AND ADOPTION OF AGENDA

A revised version of the draft agenda available in October was adopted (Appendix 2 of this report). Some talks were rescheduled during the meeting to accommodate participant schedules.

2. NEW ENGLAND FISHERY RESOURCES

2.1. UPDATED GEORGES BANK COD ASSESSMENT

Source Document: Serchuk, F. M., and S. E. Wigley. 1986. Assessment and status of the Georges Bank and Gulf of Maine Atlantic cod stocks - 1986. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 86-12, 84 p.

2.1.1. Status of the Resource

Recreational Fishery

Landings - USA recreational catch estimates of cod in 1986 and 1987 [from both the Georges Bank and Gulf of Maine stocks combined] were 3,500 t and 3,800 t, respectively, and were the lowest values in the 1979-1987 NMFS Marine Recreational Fishery Statistics Surveys time series. During 1981-1985, annual recreational cod catches varied between 5,400-9,000 t and averaged 7,900 t. Since detailed data on the distribution and size composition of recreational cod landings by stock area are not available, the catches could not be apportioned between the Georges Bank and Gulf of Maine stocks. The recreational catches were thus not included in either the Georges Bank or Gulf of Maine stock assessments.

Commercial Fishery

Landings - Total commercial landings in 1987 were 30,900 t, 19% higher than in 1986, but still the second lowest annual catch since 1977 (Table 2.1.1). The USA and Canada accounted for 62% and 38%, respectively, of the 1987 total. The 1987 USA catch (19,000 t) was 9% greater than in 1986 but far below the

1980-1985 USA annual average of 35,000 t. Apart from 1986 and 1987, USA catches exceeded 20,000 t in every year from 1977 onward. Canadian 1987 landings totaled 11,900 t, a 39% increase from 1986, and the highest Canadian catch since 1983.

Otter trawl landings accounted for most (73%) of the total 1987 catch. Otter trawlers accounted for 80% of the 1987 USA catch and 63% of the Canadian catch.

Catch Composition - Estimates of catch-at-age for combined USA and Canadian landings are available from 1978 through 1987 (Table 2.1.2). In 1987, landings were dominated by the 1985 year class which accounted for 63% of the total catch by number and 37% by weight. The next most important year class was the 1983 cohort which comprised 17% of the numbers landed and 28% of the catch weight. Overall, age groups 2-4 constituted 92% by number and 77% by weight of the 1987 Georges Bank cod catch.

Effort - USA catch rate indices (CPUE) in 1987 declined to record-low levels for all vessel classes in the fishery. Canadian CPUE in 1987 was the lowest since 1984 and the second lowest since 1976. In terms of relative fishing effort, the combined USA and Canadian data indicate that fishing effort in 1987 increased to record-high levels (Figure 2.1.1).

Research Vessel Survey Abundance Indices - NMFS spring and autumn 1987 catch-per-tow indices (#'s and wt) declined from 1986 and were among the lowest in the survey time series (Figure 2.1.2). The autumn 1987 number-per-tow index was the lowest since 1983; the autumn 1987 indices of spawning stock biomass (age 3+, number and weight) were each the second lowest ever (Figure 2.1.3). Age composition data from the 1987 surveys indicated that the 1985 year comprised more than 50% of the total stock, by both number and weight.

Spring and autumn 1988 survey indices were slightly higher than in 1987 and near the 1986 levels. These increases reflected full recruitment of the strong 1985 year class to the survey gear and an apparently strong 1987 cohort.

Mortality estimates derived from survey data indicate that total mortality (Z) has increased two-fold since 1982 and is presently at a record-high level (Table 2.1.3).

Assessment Results - Estimates of fishing mortality (F), stock size, and stock biomass were obtained from virtual population analysis (VPA). The VPA was calibrated (tuned) by comparing fishing mortality with commercial effort and stock biomass with commercial CPUE. A separable VPA (SVPA) was also performed to derive the partial recruitment vector selection pattern in 1987. The SVPA results indicated full recruitment at age 3 and older. Estimates of the strength of the 1986 and 1987 cohorts at age 1 (in 1987 and 1988) and the 1985 year class at age 2 (in 1987) were obtained using the RCRTINX2 method.

The VPA results indicate that F in 1987 was a record-high [F=0.95] and about 2.5X greater than in 1978 [F=0.39] (Table 2.1.4; Figure 2.1.1). Total and spawning stock biomasses in 1987 and 1988 were at record-low levels; SSB at the beginning of 1988 (30,900 t) was only 1/3 of the SSB in 1980. Despite strong recruitment from the 1977, 1978, 1980, and 1983 year classes, SSB has sequentially declined since 1982. VPA trends in F, stock biomass, and recruitment agree closely with those derived from survey analyses and commercial CPUE data.

An additional VPA was also run using the Laurec-Shepherd method. These results gave same F on age 3 in 1987 as the conventional VPA (0.96 vs 0.95) but produced slightly lower F values for older age groups in 1987. In general, however, the Laurec-Shepherd results supported the findings from the conventional VPA.

Yield per recruit analyses (Figure 2.1.1) indicate that $F_{0.1}$ = 0.15 and F_{max} = 0.27. Relative to F_{max}, the 1987 F generates about 20% less yield per recruit and 80% less spawning stock biomass per recruit under equilibrium conditions.

Catch and Stock Size Projections - Catches and stock biomasses were projected through 1989 (ie., the beginning of 1990) based on the estimated 1988 stock size (64,950 t total biomass; 30,850 t SSB), a predicted recruitment of the 1987 year class at age 1 of 22.8 million fish, and assuming average recruitment (17.6 million fish) at age 1 in 1989 and 1990 (Table 2.1.5). Two options for F in 1989 were considered: (1) F89 = F87 = 0.95 and (2) F89 = 0.66(F87)= 0.63. Catch in 1988 was assumed to be 35,800 t based on projecting Jan - Sep 1988 USA and Canadian landings for the entire year. The assumed 1988 catch corresponds to F88 = 1.14.

At F89 = 0.95, SSB at the beginning of 1990 would be 24,700 t (Table 2.1.6), the lowest in the VPA time series. At F89 = 0.63, SSB in 1990 would equal that at the beginning of 1988 (30,500 t) but the 1989 catch would be about half of that assumed for 1988 (19,400 t vs 35,800 t).

The estimated size of the 1985 year class in 1987 (25.0 million fish) and 1988 (13.6 million fish) plays a critical role in the short-term projections. In 1988, the 1985 cohort is projected to account for 59% of the catch weight and comprise 53% of the total spawning stock biomass. Under both fishing mortality projection options for 1989, the 1985 year class accounts for 30% of the catch weight and 40% of the total SSB. Although the strength of the 1985 cohort in 1987 has been estimated using VPA-research vessel survey relationships [which have previously been quite accurate], there is still some doubt as to the exact size of the year class. If the year class has been underestimated, F in 1988 will be lower than assumed (ie., < 1.14) and SSB in 1989 higher than projected. However, the strength of the 1985 cohort would have to have been grossly underestimated for the decline in SSB to be halted by 1990, without any significant reduction in F in 1989. Since annual changes in F have seldom exceeded 20-25%, any marked recovery in Georges Bank cod SSB should not be expected even if the 1985 cohort is larger than estimated. The historical pattern in the fishery (Table 2.1.4; Figure 2.1.1) is to exert high F's on good year classes thereby dissipating potential gains in SSB from good recruitment.

2.1.2. Discussion

Evaluation of Stock Conditions - The status of the Georges Bank cod stock was last reviewed at the 3rd SAW in September 1986. At that time, the SAW noted that VPA results presented for the 1978-1985 period indicated that fishing mortality was at a record-high in 1985 (F=0.82) and that F had doubled between 1978 and 1985. Spawning stock biomass in 1985 was the lowest in the VPA time series and was only half of the 1978 SSB. Survey indices, commercial CPUE, changes in age composition and other indicators all pointed to significant declines in stock abundance. The 3rd SAW concluded that the stock appeared to have been growth overfished and was perhaps in danger of recruitment overfishing.

The updated assessment described herein indicates that stock conditions have deteriorated further. Fishing mortality in 1987 (F=0.95) is the highest ever recorded for Georges Bank stock and well above the biological reference points of $F_{0.1}$(0.15) and F_{max} (0.27). At the current F, only 30% of the stock survives from one year to the next. Because the fishery continues to be highly dependent on young fish (ages 2 and 3), rebuilding of the spawning stock has been precluded despite good recruitment. Spawning stock biomass has continued to decline since 1982; SSB at the beginning of 1988 was a record low (30,500 t). At the present F level, target % MSP goals established for this stock will not be attained. Short-term catch and stock projections for 1988 and 1989 suggest that SSB will decline even further unless fishing mortality is reduced by at least 30%. The SAW expressed concern that the SSB may be approaching a level where the probability of future strong recruitment to the stock is low.

Technical Comments - A question was raised regarding the contribution of age 2 fish in the 1987 landings in light of minimum size restrictions in place for that year. When it was suggested that these data are obtained from interviews of fishermen, it was pointed out that age composition estimates are derived from commercial length and age samples stratified by market category collected by the NEFC port sampling program. In response to a question concerning Canadian age composition estimates, it was pointed out that, due to probable differences in USA and Canadian ageing of cod from 1978 through 1985, USA age/length samples were used to prorate Canadian landings by age. The discrepancy between USA and Canadian ageing was resolved in 1986 and age composition estimates derived by USA and Canadian scientists for their respective fleet components were combined for 1986 and 1987.

It was noted that the catch-at-age matrix does not include discards or catch from the recreational fishery. If significant trends in these missing elements have occurred over time, the VPA results may be biased. Although it is not possible to evaluate with available data either the magnitude or direction of any such bias, it is unlikely that the bias would be large enough to change the general conclusions on the status of the stock.

In response to a question concerning the strength of the 1985 year class, it was noted that the estimate from the Canadian assessment was higher than that obtained from the USA assessment. However, the Canadian assessment also indicated a substantial decline in SSB in 1987. SSB is not significantly affected by age 2 stock size estimates since, on average, only about 25% of age 2 cod are mature.

Questions were also raised about the stock recruitment relationship for Georges Bank cod. Although no stock-recruit plot was presented, some individuals suggested [based on examination of trends in VPA stock size and recruitment, and survey indices] that the size of strong year classes had been declining over time, while the frequency of occurrence of strong year classes had remained unchanged.

An observation was made that recent declines in SSB had been accompanied by relatively high levels of F at age 2, but that the increase observed in F on age 2 fish between 1984 and 1985 (when the strong 1983 year class recruited at age 2) was not evident between 1986 and 1987 (when the strong 1985 year class recruited at age 2). As a result, it was suggested that perhaps F on age 2 fish in 1987 was under-estimated. It was also suggested that management measures may have shifted F from age 2 to age 3 in 1987.

Estimates of Z derived from bottom trawl survey data appear generally consistent with F's derived from the VPA. Given this, it was suggested that perhaps survey data alone could be used to indicate stock status in future assessments. However, it was noted that when annual survey indices [for age groups 3+] were used to calibrate the VPA, the results were more variable and produced much lower terminal F values for 1987 than those obtained when commercial effort and CPUE were used in the tuning. A change in otter trawl doors may have introduced an increase in catchability for cod on trawl surveys conducted since 1985 [analyses are currently underway by the NEFC to examine possible differences in catchability associated with the new survey doors]. However, it was reported that the 1988 Canadian assessment of the Georges Bank cod stock tuned on age groups 1-4 using NEFC survey data with the ADAPT tuning model produced generally similar results to those presented in the SAW assessment.

Methods for calibrating the VPA's were discussed. It was suggested that the Laurec-Shepherd [L-S] disaggregated fleet approach could have been carried further to include various fleet sectors within the USA fishery, and that incorporation of survey data in the L-S analysis might also provide some insight into possible changes in catchability associated with the change in survey trawl doors in 1985. It was agreed that survey catch rates could be used in conjunction with commercial CPUE data in the calibration process. In addition, it was suggested that use of the ADAPT tuning procedure be explored, particularly with reference to tuning the VPA to survey data.

Table 2.1.1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), and the Gulf of Maine (NAFO Division 5Y), 1960 - 1987.

	Georges Bank and South					Gulf of Maine					Totals				
Year	USA	Canada	USSR	Other	Total	USA	Canada	USSR	Other	Total	USA	Canada	USSR	Other	Total
1960	10834	19	-	-	10853	3448	129	-	-	3577	14282	148	-	-	14430
1961	14453	223	55	-	14731	3216	18	-	-	3234	17669	241	55	0	17965
1962	15637	2404	5302	143	23486	2989	83	-	-	3072	18626	2487	5302	143	26558
1963	14139	7832	5217	1	27189	2595	3	133	-	2731	16734	7835	5350	1	29920
1964	12325	7108	5428	304	25165	3226	25	-	-	3251	15551	7133	5428	304	28416
1965	11410	10598	14415	1910	38333	3780	148	-	-	3928	15190	10746	14415	1910	42261
1966	11990	15601	16830	8713	53134	4008	384	-	-	4392	15998	15985	16830	8713	57526
1967	13157	8232	511	14852	36752	5676	297	-	-	5973	18833	8529	511	14852	42725
1968	15279	9127	1459	17271	43136	6360	61	-	-	6421	21639	9188	1459	17271	49557
1969	16782	5997	646	14514	37939	8157	59	-	268	8484	24939	6056	646	14782	46423
1970	14899	2583	364	7806	25652	7812	26	-	423	8261	22711	2609	364	8229	33913
1971	16178	2979	1270	7752	28179	7380	119	-	163	7662	23558	3098	1270	7915	35841
1972	13406	2545	1878	7230	25059	6776	53	11	77	6917	20182	2598	1889	7307	31976
1973	16202	3220	2977	6524	28923	6069	68	-	9	6146	22271	3288	2977	6533	35069
1974	18377	1374	476	7104	27331	7639	120	-	5	7764	26016	1494	476	7109	35095
1975	16017	1847	2403	4741	25008	8903	86	-	26	9015	24920	1933	2403	4767	34023
1976	14906	2328	933	1759	19926	10172	16	-	-	10188	25078	2344	933	1759	30114
1977	21138	6173	54	2	27367	12426	106	-	-	12532	33564	6279	54	2	39899
1978	26579	8904	-	-	35483	12426	384	-	-	12810	39005	9288	-	-	48293
1979	32645	6011	-	-	38656	11680	379	-	-	12059	44325	6390	-	-	50715
1980	40053	8094	-	-	48147	13528	161	-	-	13689	53581	8255	-	-	61836
1981	33849	8508	-	-	42357	12534	599	-	-	13133	46383	9107	-	-	55490
1982	39333	17862	-	-	57195	13582	1369	-	-	14951	52915	19231	-	-	72146
1983	36756	12132	-	-	48888	13981	2752	-	-	16733	50737	14884	-	-	65621
1984	32915	5761	-	-	38676	10806	1404	-	-	12210	43721	7165	-	-	50886
1985	26828	10441	-	-	37269	10693	1445	-	-	12138	37521	11886	-	-	49407
1986	17490	8508	-	-	25998	9664	800	-	-	10464	27154	9308	-	-	36462
1987 *	19035	11843	-	-	30878	7527	487	-	-	8014	26562	12330	-	-	38892

*

1987 landings values are provisional; USA landings from NMFS, NEFC, Detailed Weighout Files & Canvass data; Canadian landings from tabular data provided by Joe Hunt, DFO Canada, on 15 July 1988.

Table 2.1.2. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978 - 1987.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11+	Total
					Total Commercial Catch in Numbers (000's) at Age							
1978	-	442	7651	2185	834	71	385	46	37	10	-	11661
1979	41	1916	678	4863	1077	477	70	289	-	37	16	9464
1980	106	3609	5658	344	2270	1143	496	91	183	-	-	13900
1981	31	3829	4522	2453	126	1284	413	90	137	57	-	12942
1982	473	11422	3586	2445	1830	170	657	169	73	33	49	20907
1983	108	4711	7391	1654	1135	961	114	290	117	34	38	16553
1984	81	1328	3604	3356	593	487	496	32	200	51	56	10284
1985	160	6879	2328	1364	1771	338	213	201	15	84	22	13375
1986	156	1323	4560	804	485	634	88	73	47	4	26	8200
1987	29	7662	1471	2077	272	249	262	61	36	17	6	12142
					Total Commercial Catch in Weight (Tons) at Age							
1978	-	570	18904	8066	3730	369	2895	365	475	109	-	35483
1979	36	2916	1670	20914	5359	3485	640	2969	-	493	174	38656
1980	89	5379	14020	1372	13146	7664	4212	790	1475	-	-	48147
1981	27	5746	10671	8314	656	9426	3470	896	2037	1114	-	42357
1982	363	15937	10226	9401	9969	1098	6225	1744	908	528	796	57195
1983	107	7053	18152	5681	5339	6156	904	2984	1296	441	775	48888
1984	85	2203	8961	12220	3209	3324	4468	315	2276	668	947	38676
1985	147	9528	4995	5519	9349	2234	1745	2121	194	1069	368	37269
1986	145	1951	11152	2944	2723	4562	790	729	598	56	348	25998
1987	21	11342	3624	8681	1579	1918	2346	607	405	229	126	30878
					Total Commercial Catch Mean Weight (kg) at Age							
1978	-	1.290	2.471	3.692	4.472	5.197	7.519	7.935	12.838	10.900	-	3.043
1979	0.878	1.522	2.463	4.301	4.976	7.306	9.143	10.273	-	13.324	10.875	4.085
1980	0.840	1.490	2.478	3.988	5.791	6.705	8.492	8.681	8.060	-	-	3.464
1981	0.871	1.501	2.360	3.389	5.206	7.341	8.402	9.956	14.869	19.544	-	3.273
1982	0.767	1.395	2.852	3.845	5.448	6.459	9.475	10.320	12.438	16.000	16.245	2.736
1983	0.991	1.497	2.456	3.435	4.704	6.406	7.930	10.290	11.077	12.971	20.395	2.953
1984	1.049	1.659	2.486	3.641	5.411	6.825	9.008	9.844	11.380	13.098	16.911	3.761
1985	0.919	1.385	2.146	4.046	5.279	6.609	8.192	10.552	12.933	12.726	16.727	2.786
1986	0.929	1.475	2.446	3.662	5.614	7.196	8.977	9.986	12.723	14.000	13.385	3.170
1987	0.724	1.480	2.464	4.180	5.805	7.703	8.954	9.951	11.250	13.471	21.000	2.543
					Total Commercial Catch Mean Length (cm) at Age							
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	-	64.9
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	108.4	101.0	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	-	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.8	115.0	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	107.4	114.8	63.3
1984	47.2	52.3	61.8	70.1	79.8	86.8	95.0	97.6	102.6	107.6	116.2	68.9
1985	45.3	51.4	58.4	72.7	79.3	85.4	91.9	100.1	105.6	106.1	117.6	61.2
1986	45.0	51.9	61.0	69.2	80.7	87.7	94.4	98.0	105.6	111.3	109.5	64.4
1987	40.5	51.8	60.8	73.0	81.9	90.1	94.4	97.8	102.2	108.1	122.1	59.4

[a] Mean weight.
[b] Mean length.

Table 2.1.3. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Georges Bank and Gulf of Maine Atlantic cod stocks for eight time periods, 1964 - 1987, derived from NEFC offshore spring and autumn bottom trawl survey data.[2]

Time Period	Georges Bank						Gulf of Maine					
	Spring		Autumn		Geometric Mean		Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F	Z	F	Z	F	Z	F
1964-1967	-	-	0.73	0.53	0.73	0.53	-	-	0.39	0.19	0.39	0.19
1968-1972	0.34	0.14	0.49[3]	0.29	0.41	0.21	0.37[4]	0.17	0.43	0.23	0.40	0.20
1973-1976	0.70	0.50	0.56	0.36	0.63	0.43	0.35[5]	0.15	0.45	0.25	0.40	0.20
1977-1981	0.44	0.24	0.63	0.43	0.53	0.33	0.47	0.27	0.57	0.37	0.52	0.32
1982-1984	0.74	0.54	1.29	1.09	0.98	0.78	0.61	0.41	0.78	0.58	0.69	0.59
1985-1987	1.00	0.80	1.17	0.97	1.08	0.88	0.88[6]	0.68	0.91	0.71	0.89	0.69
1986-1987	1.29	1.09	0.90	0.70	1.08	0.88	0.88	0.68	1.29	1.09	1.07	0.87
1987	1.16	0.96			1.16	0.96	0.78	0.58			0.78	0.58

[1]Instantaneous natural mortality (M) assumed to be 0.20.

[2]Estimates derived from:

Georges Bank spring: ln (Σ age 4+ for year i to j/Σ age 5+ for years i+1 to j+1).
Georges Bank autumn: ln (Σ age 3+ for years i-1 to j-1/Σ age 4+ for years i to j).

Gulf of Maine spring: ln (Σ age 4+ for year i to j/Σ age 5+ for years i+1 to j+1).
Gulf of Maine autumn: ln (Σ age 3+ for years i-1 to j-1/Σ age 4+ for years i to j).

[3]Excludes autumn 1971-1972 data (3+/4+) since these gave negative Z value.

[4]Excludes spring 1972-1973 data (4+/5+) since these gave large negative Z value.

[5]Excludes spring 1973-1974 data (4+/5+) since these gave unreasonably high Z value.

[6]Excludes spring 1985-1986 data (4+/5+) since these gave unreasonably high Z value.

Table 2.1.4. Estimates of fishing mortality [F and F(c)], stock size (thousands of fish) and stock biomass (metric tons) derived from Virtual Population Analysis [VPA] for Georges Bank cod (NAFO Division 5Z and Statistical Area 6), 1978 - 1987.

AGE	YEAR 1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
					FISHING MORTALITY					
1	–	0.002	0.007	0.001	0.030	0.014	0.004	0.031	0.006	[0.003]
2	0.166	0.100	0.240	0.348	0.456	0.455	0.244	0.501	0.376	[0.408]
3	0.409	0.411	0.472	0.533	0.642	0.608	0.766	0.883	0.745	0.950
4	0.376	0.497	0.378	0.386	0.625	0.707	0.624	0.761	0.910	0.950
5	0.374	0.321	0.457	0.231	0.558	0.676	0.599	0.813	0.684	0.950
6	0.107	0.381	0.670	0.511	0.554	0.651	0.705	0.841	0.797	0.950
7	0.357	0.146	0.877	0.548	0.538	0.922	0.858	0.791	0.548	0.950
8	0 391	0.499	0.287	0.376	0.455	0.486	0.735	1.108	0.704	0.950
9	0.256	–	0.690	0.930	0.600	0.664	0.744	0.966	0.871	0.950
10	0.393	0.439	–	0.478	0.604	0.630	0.696	0.835	0.760	0.950
11+	–	0.439	–	–	0.604	0.630	0.696	0.835	0.760	0.950
MEAN F_{3+}	0.391	0.439	0.496	0.478	0.604	0.630	0.696	0.835	0.760	0.950
F(c)	0.327	0.370	0.409	0.428	0.522	0.549	0.582	0.657	0.619	0.722

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
					STOCK SIZE						
1	27132	22754	17565	41728	17760	8339	23377	5834	30760	[10400]	[22800]
2	3182	22214	18581	14292	34146	14118	6733	19086	4633	[25045]	8489
3	24992	2207	16459	11966	8263	17717	7335	4318	9464	2606	13632
4	7650	13597	1198	8404	5748	3560	7896	2791	1463	3679	825
5	2931	4302	6776	672	4679	2520	1438	3464	1068	482	1165
6	770	1651	2555	3512	437	2193	1049	647	1257	441	153
7	1406	566	924	1070	1726	206	937	424	228	464	140
8	155	805	400	315	507	825	67	325	158	108	147
9	180	–	400	246	177	263	415	26	88	64	34
10	34	114	–	164	80	79	111	162	8	30	20
11+	–	49	–	–	118	89	122	42	53	11	13
TOT NUMBER	68434	68259	64858	82370	73640	49908	49480	37119	49180	43330	47418
SPWN NUMBER	28598	26125	27099	24319	26408	23927	17233	14982	11238	12666	13091

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
					STOCK BIOMASS AT AGE						
1	17989	15336	11031	28709	9750	6387	21344	4236	22639	[7592]	[16644]
2	2972	25701	21257	16050	37629	15134	8632	22999	5393	[29378]	9958
3	46810	3932	31964	22437	17095	32794	14149	8148	17413	4967	21648
4	24328	44327	3756	24356	17313	11141	23608	8849	4096	11766	2639
5	11291	18439	33817	3063	20107	10718	6197	15185	5088	2222	5372
6	3445	9438	14755	22900	2535	12957	5946	3866	7750	2901	1003
7	9043	3902	7276	8034	14391	1472	7116	3173	1760	3725	1121
8	1181	7077	3619	2893	4717	8141	592	3170	1428	1021	1389
9	1829	–	4313	2794	1967	2815	4493	297	1021	676	363
10	433	1492	–	2442	1226	1009	1337	1943	110	394	264
11+	–	814	–	–	1947	1465	2011	698	879	175	213
TOT BIO	119321	130457	131788	133677	128679	104034	95423	72563	67578	64817	64949
SPWN BIO	79143	88185	92462	81220	81957	72603	59066	46825	33877	32977	30852

Table 2.1.5. Data used in yield per recruit analysis and in catch and spawning stock projections for Georges Bank cod.

Age	1988 Stock Size (000's)	Exploitation Pattern	Mean Weight[1] of Catch (kg)	Mean Weight[1] of Stock (kg)	Maturity[2] Ogive
1	22800[3]	0.0171[4]	0.827	0.733	-
2	8489	0.5448[4]	1.478	1.169	0.25
3	13632	1.0000	2.455	1.873	0.63
4	825	1.0000	3.921	3.000	0.86
5	1165	1.0000	5.710	4.688	1.00
6	153	1.0000	7.450	6.370	1.00
7	140	1.0000	8.966	7.870	1.00
8	147	1.0000	9.969	9.257	1.00
9	34	1.0000	11.987	11.108	1.00
10	20	1.0000	13.736	13.274	1.00
11+	13	1.0000	16.500	16.500	1.00

For projected age 1 stock size in 1989, the VPA geometric mean age 1 stock size for 1978 - 1985 was used: 17.6 million fish.

[1]Average of 1986-1987 values.

[2]Values from Gabriel (1985).

[3]Predicted value from RCRTINX2 analysis.

[4]Geometric mean of 1985-1986 partial recruitment values.

Table 2.1.6. Short-term catch and stock size projections for Georges Bank cod, 1988 - 1990. Biomass and catch values are expressed in thousands (000's) of metric tons. Spawning stock biomass refers to the beginning of the year.

The reference F is the mean F (weighted by stock size) for ages 3 - 9.

$F_{0.1} = 0.15$

$F_{max} = 0.27$

The number of recruits (000's of fish at age 1) per year is as follows:

Year	Recruitment	Source of Recruitment Estimate
1988	22800	RCRTINX2 estimate of 1987 year class at age 1
1989	17600	Geometric mean recruitment at age 1 during 1978-1985.
1990	17600	Geometric mean recruitment at age 1 during 1978-1985.

Assuming Catch (88) = 35,800 mt [USA: 23,800 mt; CAN: 12,000 mt], F(88) = 1.14, SSB(88) = 30,450 mt.

Option	Basis	F(89)	Predicted Catch (89) (000's t)	Predicted SSB (90) (000's t)	Consequences/Implications
A	F(87)	0.95	26.1	24.7	SSB declines further to new record low level.
B	0.66 F(87)	0.63	19.4	30.5	SSB maintained at the 1988 level.

Continued fishing at current levels of fishing mortality (F87 or F88) will lead to continued declines in spawning stock biomass.

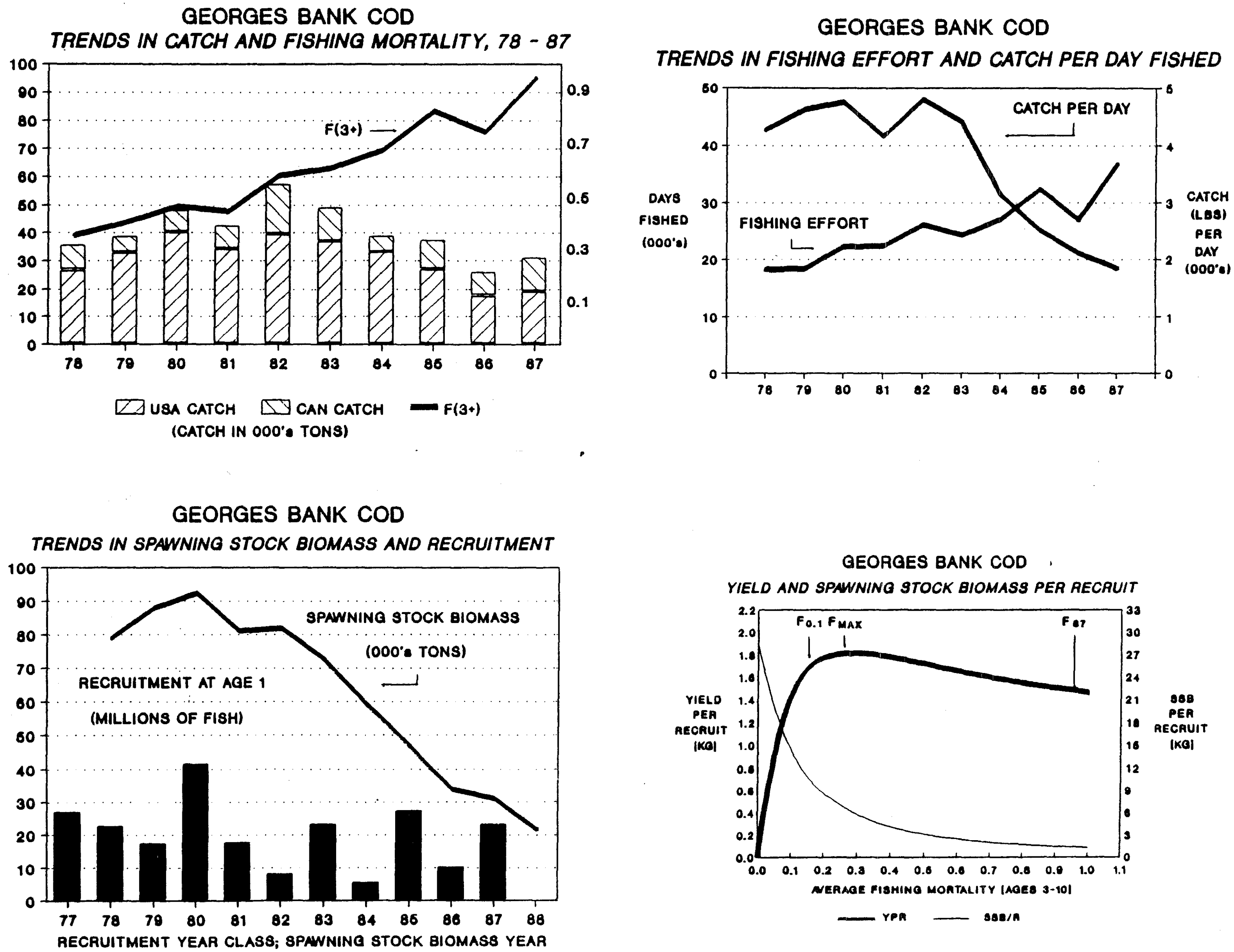


Figure 2.1.1. Stock assessment diagram for Georges Bank cod.

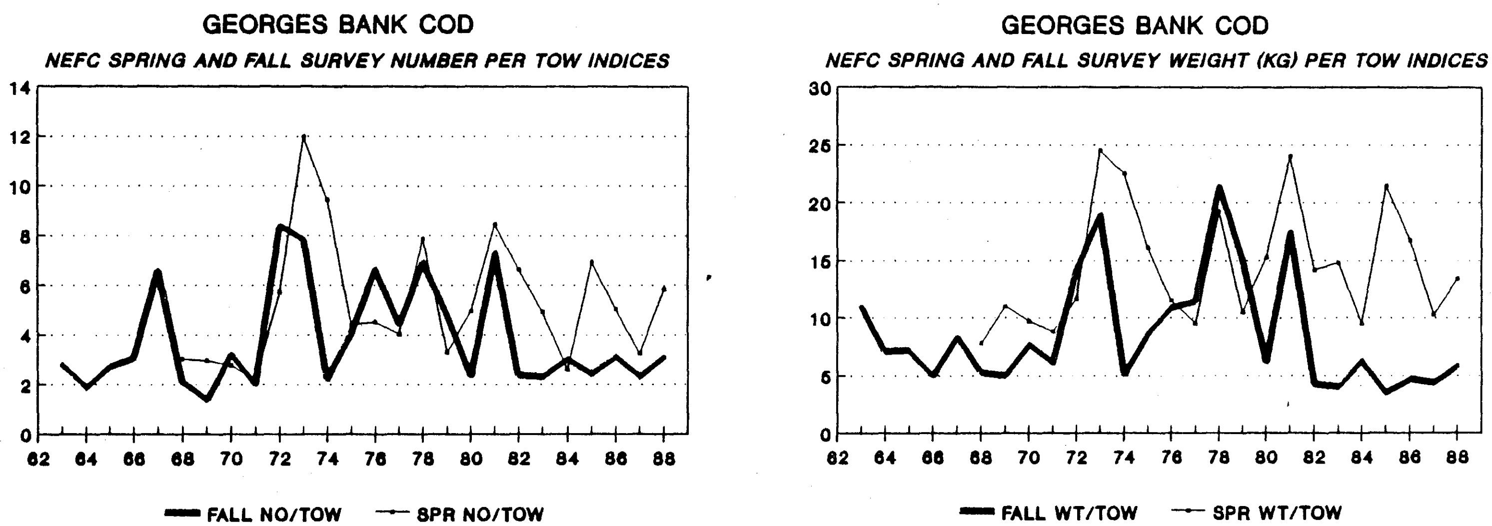


Figure 2.1.2. Stratified mean number per tow and stratified mean weight (kg) per tow in NEFC spring and autumn offshore bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1988.

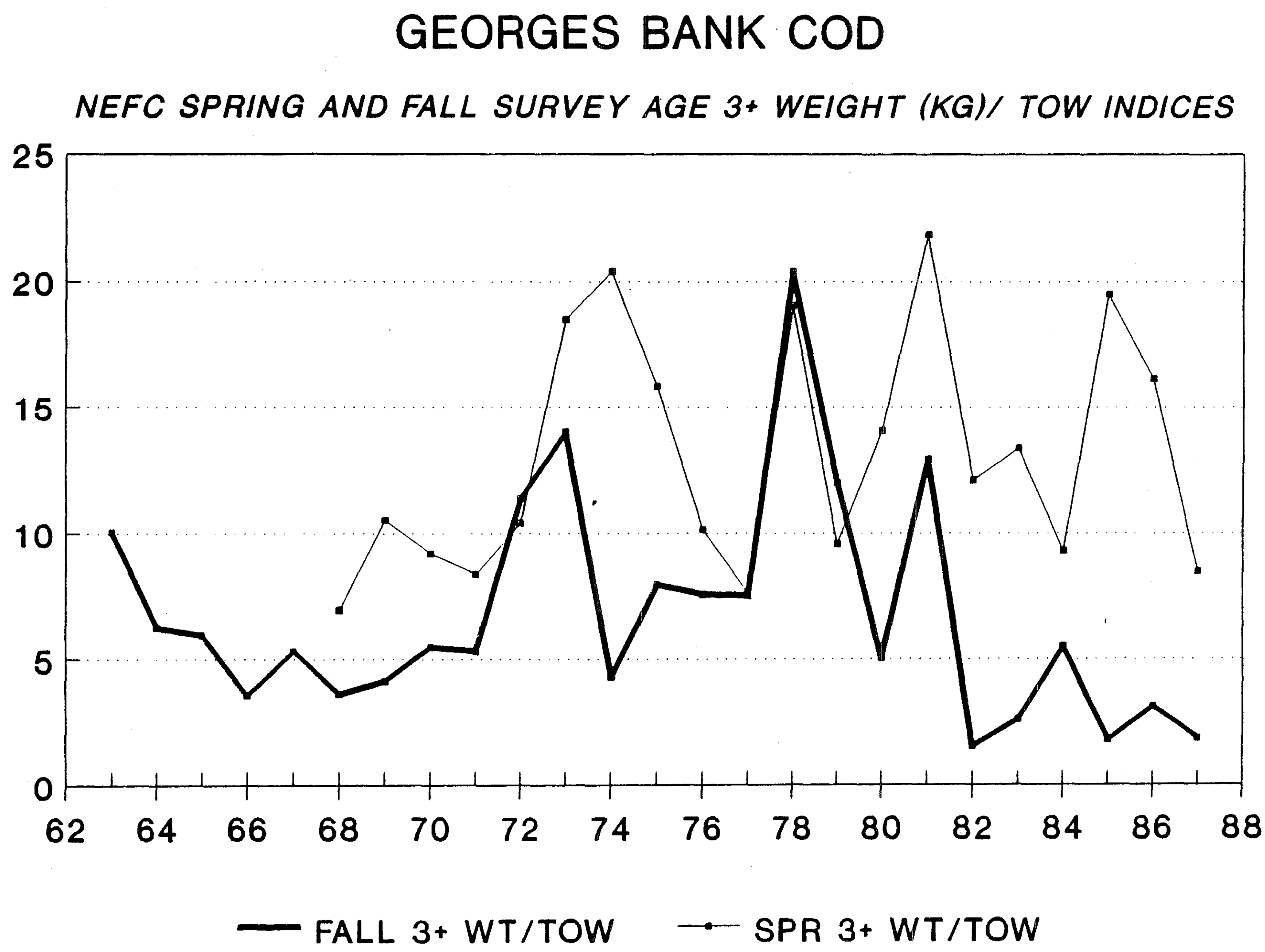


Figure 2.1.3. Stratified mean weight per tow indices of spawning stock biomass (age 3+) for Georges Bank cod from NEFC spring and autumn offshore bottom trawl surveys, 1963-1987.

2.2. REVISED GULF OF MAINE COD ASSESSMENT

Source Document: Serchuk, F. M., and S. E. Wigley. 1986. Assessment and status of the Georges Bank and Gulf of Maine Atlantic cod stocks - 1986. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 86-12, 84 p.

2.2.1. Status of the Resource

Recreational Fishery

Landings - USA recreational catch estimates of cod in 1986 and 1987 [from both the Georges Bank and Gulf of Maine stocks combined] were 3,500 t and 3,800 t, respectively, and were the lowest values in the 1979-1987 NMFS Marine Recreational Fishery Statistics Surveys time series. During 1981-1985, annual recreational cod catches varied between 5,400-9,000 t and averaged 7,900 t. Since detailed data on the distribution and size composition of recreational cod landings by stock area are not available, the catches could not be apportioned between the Georges Bank and Gulf of Maine stocks. The recreational catches were thus not included in either the Georges Bank or Gulf of Maine stock assessments.

Commercial Fishery

Landings - Total commercial landings in 1987 were 8,000 t, 23% less than in 1986, and the lowest annual catch since 1974 (Table 2.1.1). The 1987 USA catch (7,500 t) was the lowest since 1973 and nearly 2,200 t less than in 1986. During 1976-1985, USA landings varied between 10,000 - 14,000 t and averaged 12,200 t per year. Reported 1987 Canadian landings were 490 t, 39% lower than in 1986. However, Canadian scientists consider that, due to misreporting from 1982 onward, all Canadian cod landings reported as Gulf of Maine catch during 1982-1987 were actually caught from the Scotian Shelf cod stock (NAFO 4X cod stock). Accordingly, only USA catch data were used in the Gulf of Maine assessment analyses.

Otter trawl landings accounted for 58% [by weight] of the USA 1987 catch. Although otter trawl landings have traditionally accounted for the majority of the Gulf of Maine catch, the 1987 percentage is the lowest in the 1965-1987 time series.

Catch Composition - Estimates of catch-at-age for USA landings are available from 1982 through 1987 (Table 2.2.1). In 1987, landings were dominated by the 1983 year class which accounted for 47% of the total catch by number and 48% by weight. The next most important year classes were the 1982 and 1984 cohorts which contributed 18% and 13%, respectively, to the 1987 catch weight. Overall, age groups 3-5 constituted 85% by number and 79% by weight of the 1987 Gulf of Maine cod catch.

Effort - USA catch rate indices (CPUE) in 1987 declined to record-low levels for all vessel classes in the fishery (Table 2.2.2). USA otter trawl fishing effort [for any trips in which cod were caught] attained a record high level in 1987 (Figure 2.2.1).

Research Vessel Survey Abundance Indices - NMFS spring and autumn 1987 catch-per-tow indices (#'s and wt) declined from 1986 and were among the lowest in the survey time series (Figure 2.2.2). Both spring and autumn 1987 survey weight-per-tow indices were the lowest ever, as were the 1987 survey indices of spawning stock biomass [age 3+, weight] (Figure 2.2.3). Age composition data from the 1987 surveys indicated that the 1985 year comprised about 40% of the total stock size in numbers, while the 1983 cohort dominated the biomass accounting for 30% of the stock weight.

Spring and autumn 1988 survey indices were much higher than in 1987. These increases reflected full recruitment of a strong 1985 year class to the survey gear and an apparently very strong 1987 cohort.

Mortality estimates derived from survey data indicate that total mortality (Z) has increased two-three fold since the late 1970's and is presently at a record-high level (Table 2.1.3).

Assessment Results - Estimates of fishing mortality (F), stock size, and stock biomass were obtained from virtual population analysis (VPA). The VPA was calibrated (tuned) by comparing fishing mortality and exploitable biomass with commercial CPUE, survey CPUE, and relative fishing effort indices derived from survey data (Table 2.2.3; Figure 2.2.4). A separable VPA (SVPA) was also performed to derive the partial recruitment vector [selection pattern] in 1987. The SVPA results indicated full recruitment at age 4 and older. Based on comparing survey indices with VPA stock size estimates for the 1980 -1984 cohorts, year class strengths were derived for the 1986 and 1987 year classes at age 1 [in 1987 and 1988], and the 1985 year class at age 2 (in 1987). The 1986 year class at age 1 [4.8 million fish] was set equal to the geometric mean age 1 stock size during 1982-1985. The 1985 year class in 1987 was set equal to the average of the age 2 stock sizes of the 1981 and 1982 year classes (which had similar age 2 survey abundance indices as the 1985 cohort). The 1987 cohort, which had the highest age 1 index ever observed in both spring and autumn 1988 surveys, was set equal to the back-calculated age 1 stock size of the best year class in the VPA time series (ie., the 1980 cohort at age 1 = 11.0 million fish).

The VPA results indicate that F in 1987 was at the same record-high levels as in 1985 and 1986 [F=1.00] and about 60% higher than in 1982 [F=0.63] (Table 2.2.4; Figure 2.2.1). Total stock biomass in 1987 was a record-low (19,500 t) and 47% less than in 1982. Total stock biomass increased in 1988 to the 1985 level. Spawning stock biomass has consistently declined since 1982. SSB in 1988 [9,400 t] was 60% lower than in 1982.

An additional VPA was also run using the Laurec-Shepherd method. These results gave virtually identical trends in F and stock size as the conventional VPA but slightly higher F's in 1985-1987 (about F= 1.1).

Yield per recruit analyses (Figure 2.2.1) indicate that $F_{0.1}$ = 0.15 and F_{max} = 0.27. Relative to F_{max}, the 1987 F generates about 22% less yield per recruit and 77% less spawning stock biomass per recruit under equilibrium conditions.

Due to the short time period covered in the VPA [ie., only six years], the VPA results must be considered as provisional. Nonetheless, the VPA findings are generally in good agreement with other indicators of abundance such as survey indices and CPUE values.

2.2.2. Discussion

Evaluation of Stock Conditions - The status of the Gulf of Maine stock was last reviewed at the 3rd SAW in September 1986. At that time, the SAW noted that commercial CPUE, survey indices, and other measures of abundance were at historic low levels, and that fishing mortality was far above the biological reference points of $F_{0.1}$ and F_{max}. The SAW concluded that the stock was in poor condition and in a state of overall decline. The SAW felt that growth overfishing was occurring and that recruitment overfishing was a possibility, although less certain.

The revised assessment (now based on VPA) described here indicates that the stock is still in poor condition. Fishing mortality in 1987 (F=1.00) is at the same record-high level as in 1985 and 1986. The VPA results indicate that SSB at the beginning of 1988 was a record-low and 60% lower than in 1982. Although there are indications of strong 1985 and 1987 year classes in the stock, the SAW expressed concern that the risk of recruitment overfishing may be higher now than in 1986 when the stock was last evaluated. Continuation of the present F level (F=1.0) in the future will preclude attainment of the target %MSP goals established for this stock.

Technical Comments - Discussion focused primarily on differences in growth between Georges Bank and Gulf of Maine cod. It was noted that growth is slower in the Gulf of Maine, thereby allowing for an additional year before full exploitation. It was suggested that, given these differences in growth, the Georges Bank maturity at age schedule may not be appropriate for SSB calculations in the Gulf of Maine. It was also suggested, however, that the potential for high discard rates in the Gulf of Maine in the small mesh fishery may offset the benefits afforded by slower growth.

Table 2.2.1. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 1987.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+	Total
Total Commercial Catch in Numbers (000's) at Age											
1982	30	1380	1633	1143	633	69	91	61	41	37	5118
1983	-	866	2357	1058	638	422	47	61	23	24	5496
1984	4	446	1240	1500	437	194	74	19	15	28	3957
1985	-	407	1445	991	630	128	78	32	4	22	3737
1986	-	84	2164	813	250	177	39	24	20	12	3583
1987	2	216	595	1109	277	66	51	9	8	11	2344
Total Commercial Catch in Weight (Tons) at Age											
1982	24	1595	2717	3160	3019	461	813	608	531	654	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	371	13981
1984	3	516	2071	4080	1607	1145	603	186	193	402	10806
1985	-	513	2523	2816	2814	705	615	363	51	293	10693
1986	-	110	3976	2375	1153	1072	296	243	253	186	9664
1987	2	283	1001	3641	1340	451	455	88	116	150	7527
Total Commercial Mean Weight (kg) at Age											[a]
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	17.636	2.654
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	15.161	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	14.602	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.955	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	15.296	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.697	3.212
Total Commercial Mean Length (cm) at Age											[b]
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	118.6	59.9
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	111.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	111.1	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	109.0	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	98.7	105.8	113.3	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	98.7	109.5	111.6	65.4

[a] Mean weight.
[b] Mean length.

Table 2.2.2. USA commercial landings (L)[1], days fished (DF)[2], and landings per day fished (L/DF), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from Gulf of Maine (NAFO Division 5Y), 1965 - 1987. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight ['directed trips'].

	Class 2			Class 3			Class 4			Totals	
Year	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
ALL TRIPS											
1965	1412	2691	0.52	935	965	0.97	46	92	0.50	2393	0.70
1966	1265	2379	0.53	1093	938	1.17	113	83	1.36	2471	0.85
1967	1790	2175	0.82	2341	1232	1.90	108	196	0.55	4239	1.41
1968	1839	2696	0.68	1955	1266	1.54	219	182	1.20	4013	1.13
1969	2992	3301	0.91	2874	1497	1.92	549	337	1.63	6415	1.42
1970	3359	4834	0.69	2010	1666	1.21	389	425	0.92	5758	0.89
1971	2917	4000	0.73	1727	1475	1.17	293	422	0.69	4937	0.88
1972	2190	4104	0.53	1463	1637	0.89	192	244	0.79	3845	0.68
1973	2018	3915	0.52	1172	1430	0.82	194	252	0.77	3384	0.64
1974	2292	3954	0.58	2108	1455	1.45	458	367	1.25	4858	1.02
1975	3108	4423	0.70	2599	1818	1.43	311	373	0.83	6018	1.02
1976	3168	4404	0.72	3143	2096	1.50	262	527	0.50	6573	1.08
1977	3816	4354	0.88	3903	2448	1.59	341	631	0.54	8060	1.21
1978	3859	5063	0.76	3334	2618	1.27	489	809	0.60	7682	0.97
1979	3731	5623	0.66	3169	2425	1.31	475	779	0.61	7375	0.94
1980	3967	6252	0.63	3497	3181	1.10	571	908	0.63	8035	0.83
1981	3722	4912	0.76	3253	3277	0.99	737	986	0.75	7712	0.86
1982	3619	6086	0.59	4466	4343	1.03	1281	1448	0.88	9366	0.84
1983	3473	5512	0.63	4874	4731	1.03	1326	1782	0.74	9673	0.85
1984	2188	5444	0.40	3217	5042	0.64	883	1668	0.53	6288	0.54
1985	1801	4890	0.37	3457	5921	0.58	1515	2675	0.57	6773	0.52
1986	1638	4721	0.35	3088	6149	0.50	1513	2990	0.51	6239	0.46
1987	1131	4782	0.24	2005	6417	0.31	1012	2724	0.37	4148	0.31
50% TRIPS											
1965	394	183	2.15	310	74	4.19	1	1	1.00	705	3.05
1966	253	92	2.75	329	85	3.87	12	4	3.00	594	3.38
1967	656	179	3.66	1202	270	4.45	1	1	1.00	1859	4.17
1968	656	155	4.23	995	224	4.44	50	16	3.13	1701	4.32
1969	1399	324	4.32	1384	292	4.74	104	38	2.74	2887	4.46
1970	1369	395	3.47	719	152	4.73	46	15	3.07	2134	3.89
1971	1033	370	2.79	540	124	4.35	74	24	3.08	1647	3.31
1972	621	283	2.19	322	88	3.66	46	11	4.18	989	2.76
1973	380	179	2.12	96	33	2.91	1	1	1.00	477	2.28
1974	467	186	2.51	529	92	5.75	181	31	5.84	1177	4.48
1975	1047	331	3.16	1039	232	4.48	66	14	4.71	2152	3.84
1976	1197	384	3.12	1277	308	4.15	22	6	3.67	2496	3.65
1977	1390	386	3.60	1825	334	5.46	44	6	7.33	3259	4.69
1978	1314	421	3.12	1373	297	4.62	48	7	6.86	2735	3.94
1979	1114	382	2.92	1233	287	4.30	46	7	6.57	2393	3.70
1980	1198	360	3.33	1205	283	4.26	99	22	4.50	2502	3.82
1981	1587	317	5.01	1218	273	4.46	98	15	6.53	2903	4.83
1982	1354	381	3.55	2296	499	4.60	334	54	6.19	3984	4.38
1983	1399	397	3.52	2609	603	4.33	224	29	7.72	4232	4.24
1984	478	215	2.22	941	313	3.01	21	5	4.20	1440	2.77
1985	438	269	1.63	1024	319	3.21	205	67	3.06	1667	2.78
1986	398	249	1.60	602	295	2.04	143	49	2.92	1143	2.00
1987	253	180	1.41	273	206	1.33	79	41	1.93	605	1.44

1Metric tons, live weight.
2Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.
3Total L/DF was derived by weighting individual tonnage class L/DF values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.

Table 2.2.3. Summary of Gulf of Maine cod VPA tuning results. Values presented are from regression equations [linear Y = a+ bX] where a = Y intercept and b = slope. Tuning measures include the coefficient of determination (Rsq), the mean average absolute residual for 1982-1987 (MAR), the sum of residuals for 1986-1987 (SR), the sum of the squared residuals for 1986-1987 (SSR), and the absolute value of the residual for 1987 (87 R). An asterisk (*) denotes best fit (either maximization of the coefficient of determination or minimization of residuals. Non-significant (P>0.05) intercept values and slope values are denoted by "N".

Tuning Procedure	Terminal (1987) F value					
	0.60	0.70	0.80	0.90	1.00	1.10
[a] Exploitable VPA Stock Biomass Regressed on USA CPUE Derived From All Otter Trawl Trips Landing Cod (Y = a + bX)						
Rsq	0.7857	0.8537	0.8883	0.9078	0.9200	0.9271 *
a	5920 N	3687 N	2029 N	713 N	-307 N	-1148 N
b	2.29E+04	2.58E+04	2.78E+04	2.95E+04	3.08E+04	3.18E+04
SR (86-87)	4245	3631	3177	2823	2550	2327 *
SSR (86-87)	1.09E+07	7.46E+06	5.41E+06	4.12E+06	3.28E+06	2.71E+06 *
MAR (82-87)	2081	1826	1777	1738	1702	1678 *
87 R	3084	2476	2016	1667	1383	1156 *
[b] Exploitable VPA Stock Biomass Regressed on Survey 3+ kg/tow Index (Avg Spring & Fall) (Y = a + bX); 85 data excluded.						
Rsq	0.8489	0.8861	0.9009	0.9075	0.9091	0.9102 *
a	6263 N	3831 N	2025 N	586 N	-516 N	-1447 N
b	3023	3408	3691	3923	4094	4243
SR (86-87)	5307	4844	4503	4242	4035	3873 *
SSR (86-87)	1.46E+07	1.30E+07	1.22E+07	1.18E+07	1.17E+07	1.16E+07 *
MAR (82-87)	1725	1507	1455 *	1559	1651	1717
87 R	2148	1628	1233	938	692	505 *
[c] Mean F (4+) Regressed on Total Relative Effort Derived from Survey 3+ kg/tow Index (Y = a + b ln X); 85 data excluded.						
Rsq	0.0535	0.2298	0.5003	0.7026	0.7717 *	0.7688
a	-0.6559 N	-1.7879 N	-2.9292 N	-4.0943 N	-5.2629 N	-6.4418 N
b	0.1792 N	0.3287 N	0.4791 N	0.6323 N	0.7858	0.9403
SR (86-87)	0.2137	0.2061	0.1898	0.1670	0.1393 *	0.1623
SSR (86-87)	0.0324	0.0238	0.0180	0.0152 *	0.0156	0.0188
MAR (82-87)	0.1006	0.0832	0.0639	0.0529	0.0495 *	0.0649
87 R	-0.1759	-0.1387	-0.0992	-0.0580	-0.0155 *	0.0283

Table 2.2.4. Estimates of fishing mortality [F and F(c)], stock size (thousands of fish) and stock biomass (metric tons) derived from Virtual Population Analysis [VPA] for Gulf of Maine cod (NAFO Division 5Y), 1982 - 1987.

AGE	1982	1983	1984	1985	1986	1987
			FISHING MORTALITY			
1	0.005	0.000	0.001	0.001	0.000	[<0.001]
2	0.184	0.213	0.113	0.075	0.056	[0.051]
3	0.539	0.545	0.534	0.632	0.700	0.683
4	0.633	0.826	0.822	1.146	0.925	1.000
5	0.611	0.916	1.036	1.055	1.084	1.000
6	0.542	1.141	0.816	1.051	1.028	1.000
7	0.592	0.903	0.617	0.963	1.175	1.000
8	0.833	1.066	1.272	0.599	0.938	1.000
9	0.626	0.911	0.853	1.086	0.974	1.000
10+	0.626	0.911	0.853	1.086	0.974	1.000
MEAN F_{4+}	0.626	0.911	0.853	1.086	0.974	1.000
F(c)	0.482	0.585	0.621	0.780	0.759	0.704

AGE	1982	1983	1984	1985	1986	1987	1988
			STOCK SIZE				
1	6078	5808	7482	2044	5863	[4800]	[11000]
2	9012	4955	4603	6172	1695	[4800]	3930
3	4289	6136	3278	3367	4686	1312	3735
4	2660	2049	2914	1573	1465	1904	542
5	1512	1156	735	1049	409	476	574
6	180	672	379	214	299	113	143
7	223	86	176	137	61	88	34
8	118	101	29	78	43	16	26
9	96	42	28	7	35	14	5
10+	87	44	53	36	21	19	10
TOT NUMBER	24255	21049	19677	14677	14577	13542	19999
SPWN NUMBER	9457	8966	7120	6536	5504	4329	4593

AGE	1982	1983	1984	1985	1986	1987	1988
			STOCK BIOMASS AT AGE				
1	4036	3560	3015	1253	3594	[3701]	[8481]
2	8696	4787	4345	6789	1944	[5520]	4520
3	5850	8498	4569	4791	7128	1944	5535
4	6288	4158	6191	3427	3308	4677	1332
5	5669	3735	2217	3655	1483	1788	2156
6	1010	3581	1787	962	1556	636	804
7	1648	538	1222	936	398	643	251
8	1157	979	274	740	382	136	231
9	1121	419	331	69	413	161	55
10+	1323	664	808	548	319	288	150
TOT BIOMASS	36798	30919	24759	23170	20525	19494	23515
SPWN BIOMASS	23194	20041	15928	14572	12372	10277	9408

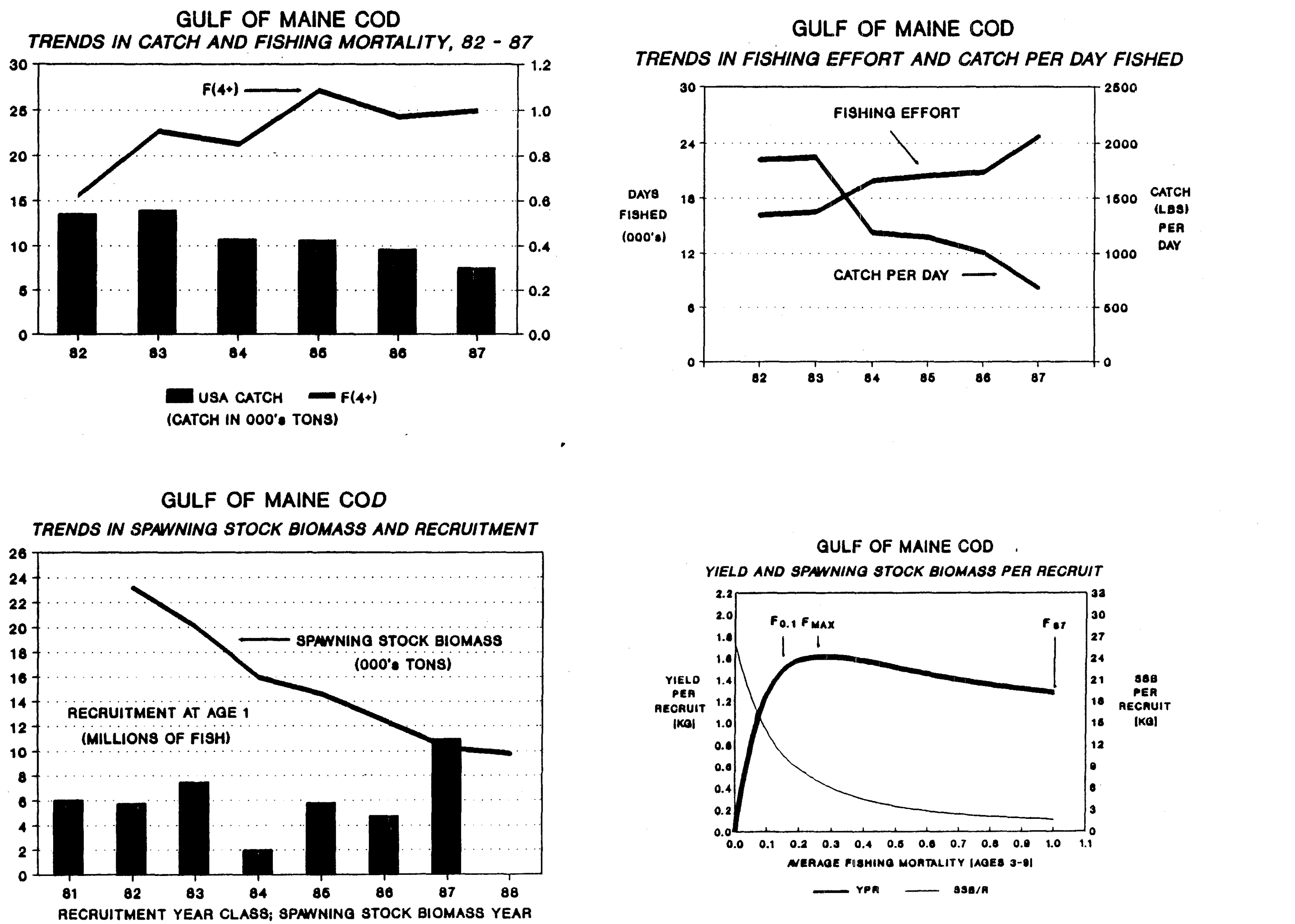


Figure 2.2.1. Stock assessment summary diagram for Gulf of Maine cod.

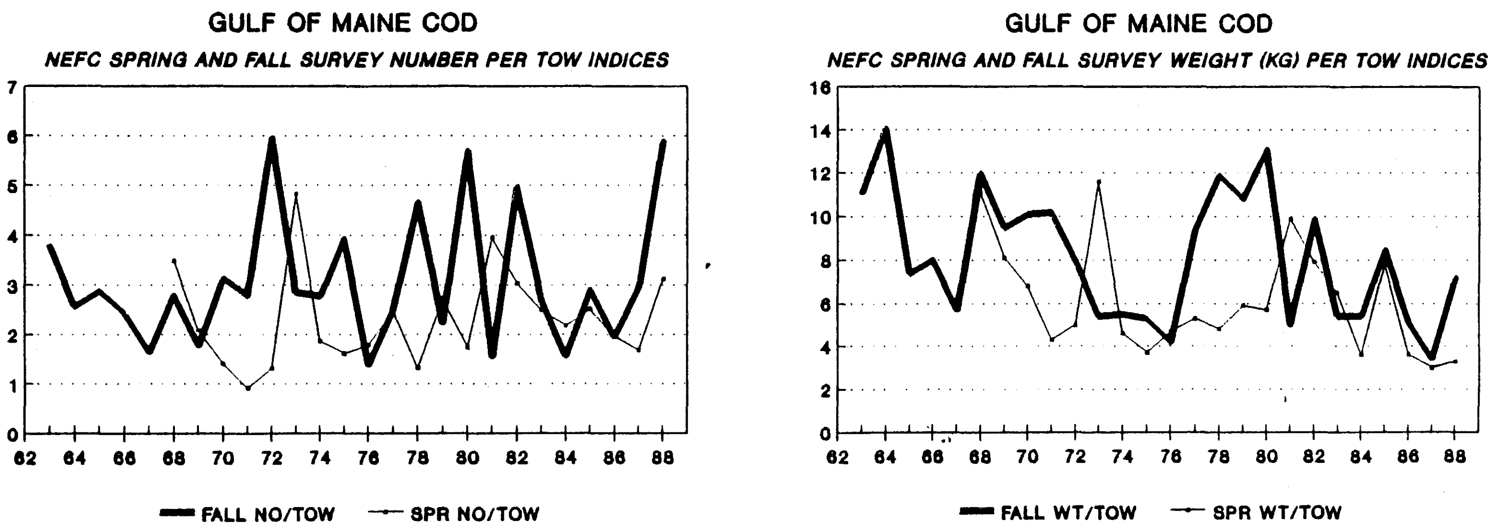


Figure 2.2.2. Stratified mean number per tow and stratified mean weight (kg) per tow in NEFC spring and autumn bottom trawl surveys in the Gulf of Maine (Strata 26-30; 36-40), 1963-1988.

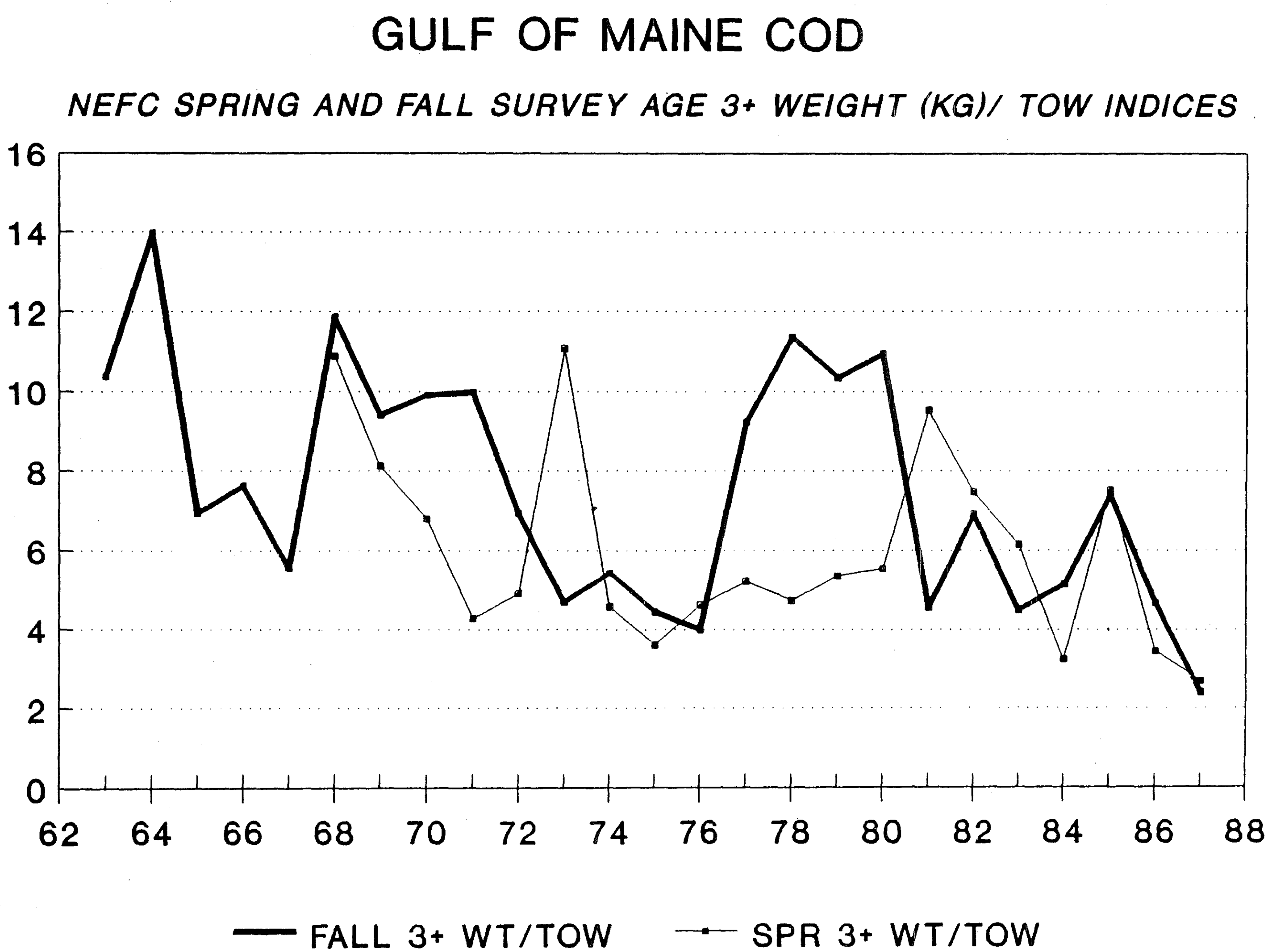


Figure 2.2.3. Stratified mean weight per tow indices of spawning stock biomass (age 3+) for Gulf of Maine cod from NEFC spring and autumn offshore bottom trawl surveys, 1963-1987.

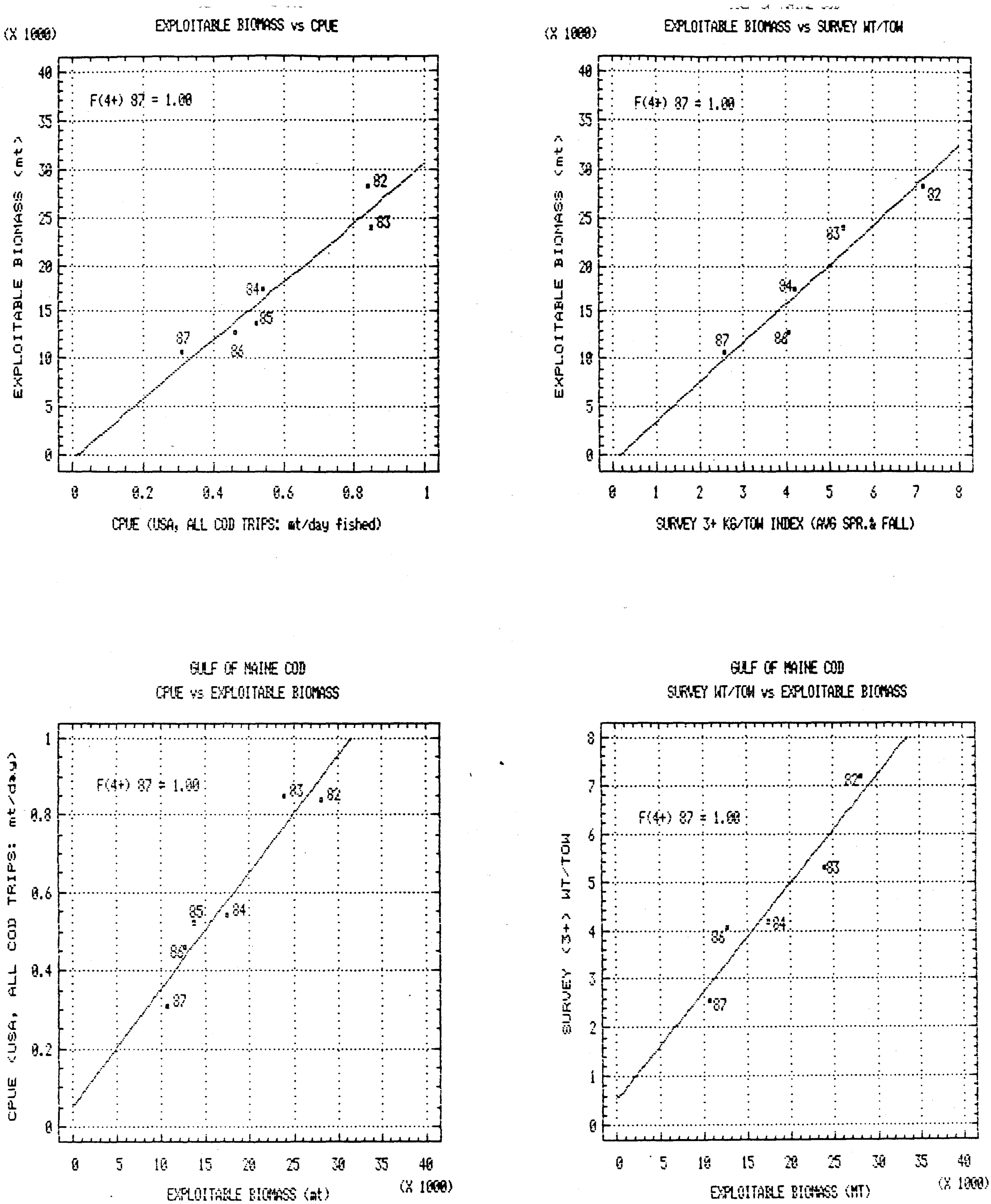


Figure 2.2.4. Regression of VPA exploitable biomass vs commercial catch-per-unit effort (CPUE) and NEFC survey weight (kg, age 3+) per tow for Gulf of Maine cod. All data shown for F (4+) 87 = 1.00.

2.3. TECHNICAL MONITORING GROUP'S REPORT TO THE NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Source Document: Anon. 1988. An assessment of the effectiveness of the Northeast Multispecies FMP with recommendations for plan and management system improvements. Report to the New England Fishery Management Council's Demersal Finfish Committee. 40 pp.

2.3.1. Report

The Chairman of the TMG described the TMG's report, "An Assessment of the Effectiveness of the Northeast Multispecies FMP with Recommendations for Plan and Management System Improvements," completed in 1988. This report addresses the New England FMC's Multispecies FMP, as well as the overall fishery management system, including enforcement and economics, because this perspective is important to understand the general functioning of the FMP. The TMG's terms of reference were reviewed and its third objective was emphasized: "complete ... a review...to reaffirm, revise or improve on plan judgments and assumptions." Three activities were identified:

1) reviewing details of FMP implementation
2) participating in a special session with a NEFC SAW
3) conducting a series of interviews with fishermen, processors, port agents, and fishery enforcement officers.

The TMG classified FMP provisions into three categories according to how well they appear to be functioning:

<u>Working Well</u>
minimum fish size

<u>Working Marginally - Difficult to Improve But Possible</u>
minimum mesh size
spawning closure for haddock
large mesh area

<u>Not Working - Difficult to Improve But Possible</u>
exempted fisheries program
southern New England/Mid/Atlantic area closure for yellowtail flounder

The TMG report emphasized that the %MSP targets are not being met, and the status of many of the stocks is extremely poor. Figures from the report were shown which summarized the observed SSB/R levels for Georges Bank haddock, cod, and yellowtail flounder compared to the FMP target levels. Large discrepancies between current SSB/R and target levels were noted. Additionally, some of the SSB/R targets were recommended by the TMG to be increased over the levels set in the FMP, based on more recent analyses.

Portions of the Executive Summary were referred to as follows:

> There are several reasons for the inadequacy of the management system. First, there is the FMP itself. Regulations that are difficult to enforce, unlikely to be enforced, or easy to subvert,

combine to undermine the FMP's effectiveness. Second, some of the premises stated in the FMP do not appear to be realistic. For example, the FMP did not take realistic account of "the willingness of fishermen to comply with changes in fishing regulations and the ability of NMFS, the states, and the Coast Guard to enforce them." It is apparent that this willingness and ability are, in reality, quite limited. Regarding enforcement, the Council's urging for more enforcement resources and a different approach to monitoring compliance with regulations have been to no avail. Specifically, no near-shore, at-sea enforcement capability, exclusive of the Coast Guard, has been considered; enforcement contracts with states have not been sustained; existing shoreside and offshore enforcement capabilities have, in some cases, been reduced (e.g., Coast Guard budget cutbacks); and, there have been no new enforcement appropriations.

Third, most of the incentives for compliance do not exist. The risks and costs of receiving citations are comparatively low, and perhaps most importantly, the economic cost of compliance is significant for individual fishermen. A key problem for the present management system is compliance. Finally, the difference in management approach between the U.S. and Canada, particularly as it is manifest in the two countries management regulations for transboundary groundfish stocks on Georges Bank and in the Gulf of Maine, has been incompatible with the achievement of the Council's management objectives for several key stocks.

The response to the TMG report has been positive, with much discussion within the Council. Adoption of some of the specific recommendations is pending in Amendment 2. Other recommendations have been noted, and additional information has been requested on what changes to existing FMP measures might be required. The TMG itself will also be addressing the possible use of other management strategies to directly control fishing mortality.

An addendum to the TMG report to describe data needs is in preparation. An important part of this addendum will focus on what is needed to establish a framework for allowing evaluation of other management approaches, especially bioeconomic modeling research that was discussed during the Spring 1988 (6TH) SAW. The center was thanked for its assistance with analysis and data used in the report. The data/research needs section should allow all providers of technical advice to know all future data/analyses requests well in advance.

2.3.2. Discussion

Several points about the TMG's report were raised in discussion. The workshop noted that the current fishing mortality levels appear to be far too high to meet the FMP target SSB/R levels given current mesh regulations, even if compliance were perfect. Preliminary studies have suggested that there may be as much as three times too much fishing effort in the fishery to meet target levels. Participants felt it was important to evaluate the amount of F reduction resulting from a tightening up of management measures envisioned within the scope of the FMP before other approaches are extensively evaluated.

The terms of reference for the TMG were discussed (they are listed in the TMG report), and it was asked how these terms relate to the scope of advice that the TMG is able to give. Specifically, it was questioned if the TMG stated clearly that the SSB/R goals are not being met. TMG members responded that they felt the report was quite clear on this point and that, indeed, the Council had asked the Council Staff to evaluate what would be required within the FMP framework to achieve the goals.

Two points were raised about the SSB/R approach. One was whether or not possible limitations of the theory, when stocks are at very low levels, were being communicated to the Council. It was noted in response that this had not been focused on because of the great difference between current and target levels. A second point was whether or not the appropriateness of the FMP approach of defining "rebuilding targets" for SSB/R had been considered for additional stocks. TMG members indicated that it had not been addressed in the report, and that there were difficulties because no technical basis for objectively defining such rebuilding targets exists. There is a need to further evaluate the behavior of the SSB/R approach to define what would be required to ensure rebuilding of stocks from extremely low levels observed recently for haddock, redfish, and yellowtail flounder. Additionally, it was noted that there was interest in the Council to evaluate additional measures, such as area closures to protect strong incoming year classes, as a method to promote rebuilding of stocks.

The changes of minimum landing sizes that are anticipated by the Council under Amendment 2 were designed to decrease the number of legal fish that are allowed to escape the current minimum mesh size; this approach was noted to have arisen from discussions with fishermen who suggested that this would tend to promote fishermen's compliance with the mesh size. It was noted that this approach had the effect of increasing discards. Similar discussions in the European Economic Community were described, however, where the opposite conclusion was reached. That is, changing minimum fish size and mesh size to minimize the amount of discarding would better promote compliance by fishermen. It was not clear why these two discussions had come to opposite conclusions.

Finally, it was emphasized by the TMG chairman that changes to the plan to reduce F on the groundfish stocks would have to be accompanied by changes in the management system itself. Without system changes (e.g. increased law enforcement as well as more communication and cooperation with Canada) the benefit of any plan changes would be jeopardized.

2.4. REVISED GEORGES BANK YELLOWTAIL FLOUNDER ASSESSMENT

Source Documents: Clark,S.H., M.M.McBride and B. Wells. 1984. Yellowtail flounder assessment update - 1984. Woods Hole, MA, NMFS,NEFC. Woods Hole Lab. Ref. Doc. 84-39. 30 pp.

NEFC. 1986. Report of the Second Stock Assessment Workshop. Woods Hole, MA, NMFS,NEFC. Woods Hole Lab. Ref. Doc. 86-09. 114 pp.

2.4.1 Report

Total catch (landings and estimated discards) from the Georges Bank stock (statistical areas 522-525) fluctuated about an average of 17,000 mt from the mid-1960's through the early 1970's, and then declined to 4,700 mt in 1978 (Table 2.4.1). Subsequent catches increased to above 11,000 mt during 1982-1983, but have since declined, reaching historic lows (2,600 - 3,000 mt) during 1985-1987.

Effort (days fished) increased slightly between 1986 and 1987, rising from 3,500 days to 3,800 days fished.

CPUE in 1987 declined to a record low of 0.7 tons per day fished (Figure 2.4.1).

Survey indices of abundance and biomass from the 1987 NEFC autumn bottom trawl survey (Table 2.4.2) were the lowest on record and indices from the 1988 NEFC spring survey were also among the lowest in the time series (Figure 2.4.2).

Virtual Population Analysis for the 1969-1986 catch-at-age data for the Georges Bank stock indicated F's (age 3+) ranged from a low of 0.54 in 1971 to a high of 1.98 in 1984 (Table 2.4.3). Estimates of F have since decreased to 0.83 in 1986. Spawning stock biomass (SSB) increased during the early 1980's, primarily due to a strong 1980 year class, and reached a peak of 16,500 mt in 1983. Increased fishing mortality during the early 80's decreased the SSB to 2,500 by 1985, which was an all time low level. Total stock size has also decreased to record lows during recent years.

Recruitment of yellowtail flounder since 1983 has generally been poor. Apart from the 1984 year class, all year classes since the 1982 cohort have been the lowest in the time series.

Yield per recruit analysis (Figure 2.4.3) indicate that $F_{0.1}$ = 0.21 and F_{max} = 0.58. F in 1986 (0.83) was nearly 4 times greater than $F_{0.1}$, and over 42% higher than F_{max}. Relative to F_{max}, the 1986 F generates approximately 14% less stock biomass per recruit and 25% less spawning stock biomass per recruit under equilibrium conditions.

Catch and stock size projections were made using three different estimation methods for predicting 1988-1990 annual recruitment. Each projection estimated continued reductions in stock biomass (SB) and spawning stock biomass (SSB) at current high F levels. Reduction of F to F_{max} could result in increased stock biomass, but the resultant stock size would still be well below the long-term average through 1990.

Conclusions: Results indicate that the Georges Bank yellowtail flounder stock has been severely reduced during the 1980's. Spawning stock biomass has continued a decline begun in the early 1970's. Commercial landings and CPUE have followed the same long-term decline, interrupted only by the influences of an infrequent strong year class. Recruitment estimates provided by the VPA results and NEFC bottom trawl surveys do not provide an optimistic picture for future recruitment. Given current resource conditions, no recovery of the Georges Bank yellowtail stock should be expected unless fishing mortality is significantly reduced.

2.4.2. Discussion

Discussion of the assessment work on the Southern New England (SNE) and the Georges Bank (GB) stocks are reported together in section 2.5.2.

Table 2.4.1. Commercial catch of yellowtail flounder (000's of metric tons) from Georges Bank, 1960-1987.

Year	USA	USA Discard	Foreign	Total Catch
1960	4.4	1.5	-	5.9
1961	4.2	1.5	-	5.7
1962	7.7	2.7	-	10.4
1963	11.0	5.6	0.1	16.7
1964	14.9	4.9	-	19.8
1965	14.2	4.4	0.8	19.4
1966	11.3	2.1	0.3	13.7
1967	8.4	5.5	1.4	15.3
1968	12.8	3.6	1.8	18.2
1969	15.9	3.9	2.4	22.2
1970	15.5	2.9	0.3	18.7
1971	11.9	0.7	0.5	13.1
1972	14.2	1.7	2.2	18.1
1973	15.9	1.6	0.3	17.8
1974	14.6	0.1	1.0	15.7
1975	13.8	0.5	0.1	14.4
1976	11.4	0.1	<0.1	11.5
1977	9.5	0.2	-	9.7
1978	4.5	0.2	<0.1	4.7
1979	5.5	0.1	<0.1	5.6
1980	6.4	0.1	<0.1	6.5
1981	6.4	0.1	<0.1	6.5
1982	10.7	0.4	<0.1	11.1
1983	11.4	0.2	<0.1	11.6
1984	5.8	0.2	<0.1	6.0
1985	2.5	0.1	<0.1	2.6
1986	3.0	<0.1	<0.1	3.0
1987	2.7			

Table 2.4.2. Stratified mean catch per tow in numbers by age and total weight per tow (kg) for Georges Bank yellowtail flounder in NEFC offshore spring and autumn bottom trawl surveys 1963-1988.

	Age									Total	Total
Year	0	1	2	3	4	5	6	7	8+	No.	wt. (kg)
	Spring										
1968	0.00	0.26	4.79	5.16	0.44	0.11	0.26	0.18	0.00	11.20	3.77
1969	0.00	1.55	13.46	16.05	4.47	2.06	0.65	0.12	0.25	38.61	15.10
1970	0.00	0.12	6.46	8.55	3.66	0.83	0.18	0.09	20.07	7.16	
1971	0.00	1.23	5.09	6.73	4.97	1.08	0.33	0.14	-	19.57	6.23
1972	0.00	0.19	10.31	10.40	5.09	1.43	0.05	0.16	0.14	27.77	8.72
1973	0.00	2.80	4.73	3.43	1.54	0.59	0.25	0.03	0.03	13.40	3.97
1974	0.00	0.46	3.22	2.67	1.80	0.52	0.27	0.10	0.03	9.07	3.67
1975	0.00	0.61	4.61	1.01	0.41	0.25	0.07	0.00	0.02	6.98	2.25
1976	0.00	1.58	6.26	1.81	0.45	0.28	0.04	0.07	0.06	10.55	3.07
1977	0.00	0.00	0.98	1.62	0.57	0.09	0.02	0.00	0.00	3.28	1.35
1978	0.00	1.36	1.16	0.73	0.30	0.06	0.00	0.01	0.00	3.62	1.00
1979	0.00	0.40	2.81	0.54	0.47	0.08	0.07	0.05	0.01	4.43	1.66
1980	0.00	0.08	6.69	8.39	0.68	0.08	0.05	0.00	0.00	15.99	6.02
1981	0.00	1.71	3.07	1.09	0.36	0.13	0.03	0.00	0.01	6.40	3.12
1982	0.00	0.09	7.59	2.50	0.70	0.16	0.00	0.00	0.05	11.09	3.98
1983	0.00	0.00	2.68	4.00	0.86	0.26	0.09	0.00	0.05	7.94	3.57
1984	0.00	0.00	0.95	1.25	1.23	0.65	0.05	0.00	0.00	4.13	2.21
1985	0.00	0.00	2.13	0.21	0.28	0.15	0.00	0.00	0.00	3.00	0.99
1986	0.00	0.05	3.18	0.51	0.10	0.24	0.10	0.00	0.00	4.18	1.47
1987	0.00	0.05	0.13	0.27	0.21	0.09	0.10	-	-	0.85	0.57
1988										2.09	0.98
	Autumn										
1963	0.00	12.39	6.28	9.53	1.21	0.41	0.08	0.14	0.09	30.13	9.99
1964	0.00	1.42	7.97	6.04	4.92	2.21	0.31	0.08	0.02	22.97	10.64
1965	0.02	0.96	4.79	4.82	2.89	1.29	0.09	0.17	0.02	15.05	7.10
1966	1.17	9.93	1.46	1.40	0.67	0.10	0.04	0.00	0.00	14.77	3.12
1967	0.05	7.49	7.63	2.21	0.83	0.25	0.06	0.05	0.00	18.57	5.92
1968	0.00	9.67	9.72	4.76	0.64	0.78	0.03	0.00	0.00	25.60	8.22
1969	1.05	6.67	8.52	4.97	1.36	0.36	0.22	0.15	0.00	23.12	7.25
1970	0.78	3.77	4.21	2.58	1.60	0.37	0.05	0.01	0.00	13.37	3.88
1971	0.03	2.97	5.64	4.08	1.84	0.45	0.19	0.02	0.02	15.24	4.97
1972	0.73	2.04	5.34	3.96	1.72	0.52	0.26	-	-	14.56	4.93
1973	0.10	2.04	4.51	4.18	2.41	1.00	0.34	0.14	0.02	14.74	5.07
1974	1.01	3.79	2.35	1.24	0.87	0.38	0.20	0.11	0.00	9.95	2.86
1975	0.36	3.79	2.06	0.72	0.47	0.27	0.03	0.00	0.03	7.73	1.81
1976	0.00	0.27	1.58	0.39	0.10	0.10	0.03	0.00	0.06	2.53	1.18
1977	0.00	0.91	2.13	1.56	0.01	0/10	0.06	0.04	0.02	4.83	2.56
1978	0.04	4.59	1.24	0.75	0.39	0.13	0.01	0.00	0.02	7.17	2.15
1979	0.02	1.27	2.00	0.25	0.13	0.13	0.03	0.06	0.02	3.91	1.37
1980	0.08	0.66	5.27	5.57	0.67	0.27	0.16	0.03	0.03	12.74	6.07
1981	0.00	1.67	2.26	1.28	0.61	0.07	0.05	0.00	0.08	6.02	2.37
1982	0.00	1.99	1.62	1.27	0.35	0.07	0.00	0.00	0.00	5.50	1.77
1983	0.00	0.07	1.83	1.45	0.37	0.02	0.01	0.00	0.03	3.78	1.56
1984	0.00	0.48	0.34	0.25	0.20	0.06	0.01	0.00	0.01	1.46	4.63
1985	0.00	1.40	0.57	0.18	0.05	0.08	0.00	0.00	0.00	2.29	0.73
1986	0.00	0.29	1.15	0.36	0.08	0.00	0.00	0.00	0.00	1.88	0.85
1987	0.00	0.12	0.39	0.40	0.05	0.08	0.00	0.00	0.00	1.03	0.51

Table 2.4.3. Estimates of fishing mortality (F), stock size (000's of fish) and stock biomass (metric tons) from Virtual Population Analysis of Georges Bank (1969-1986).

YEAR

FISHING MORTALITY

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.057	0.041	0.011	0.046	0.073	0.012	0.050	0.013	0.039	0.027	0.030	0.014
2	0.445	0.241	0.130	0.300	0.393	0.497	1.010	0.814	0.639	0.265	0.321	0.214
3	0.607	0.579	0.427	0.561	0.749	0.918	1.282	0.772	1.432	1.015	0.764	0.816
4	0.877	0.930	0.641	0.927	0.963	1.120	1.375	0.967	1.139	1.095	1.097	0.892
5	0.801	1.010	0.789	0.997	1.093	1.200	1.259	0.847	0.881	1.236	1.584	1.026
6	0.743	0.931	0.905	0.905	0.757	0.829	0.832	1.023	1.117	0.683	2.056	1.423
7	0.731	0.840	0.573	0.496	0.614	0.805	0.979	1.133	1.066	0.899	1.702	0.276
8+	0.708	0.727	0.539	0.720	0.847	1.023	1.264	0.970	1.354	1.042	0.925	0.835
MEAN F	0.708	0.727	0.539	0.720	0.847	1.023	1.264	0.970	1.354	1.042	0.925	0.835
REC AGE	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+

AGE	1981	1982	1983	1984	1985	1986
1	0.008	0.087	0.063	0.100	0.031	0.038
2	0.109	0.403	0.827	0.791	0.827	0.543
3	0.714	0.846	1.251	1.541	0.847	0.631
4	1.329	1.337	0.760	2.155	1.230	1.339
5	1.963	1.767	1.090	2.608	1.679	1.352
6	1.353	1.408	0.984	3.279	0.766	1.456
7	0.169	1.086	0.821	2.032	0.917	0.830
8+	0.976	1.030	1.167	1.977	1.101	0.831
MEAN F	0.976	1.030	1.167	1.977	1.101	0.831
REC AGE	3+	3+	3+	3+	3+	3+

STOCK SIZE

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	64565.6	63474.4	61975.9	34710.4	26084.7	36805.9	49477.0	19563.2	14036.1	36278.3	22627.5	22873.0
2	68475.9	49944.2	49906.2	50214.7	27132.8	20869.0	29781.9	38517.8	15809.3	11053.5	28897.2	17977.4
3	34975.8	35919.9	32134.7	35888.1	30465.8	15001.8	10399.0	8885.3	13969.3	6832.2	6945.8	17161.4
4	17296.7	15602.3	16489.7	17173.0	16770.0	11795.1	4905.6	2362.1	2752.3	2732.4	2027.3	2649.2
5	5617.3	5893.2	5042.0	7112.9	5564.6	5241.0	3131.6	1015.9	735.6	721.2	748.2	554.1
6	1714.5	2064.5	1757.4	1876.2	2148.1	1526.7	1292.5	732.7	356.7	249.7	171.6	125.7
7	802.9	668.0	666.1	582.3	621.7	824.7	545.5	460.4	215.7	95.6	103.3	18.0
8+	380.4	542.3	458.2	185.5	265.7	372.8	248.7	257.9	186.7	99.4	77.5	20.7
TOT NOS	193829.2	174110.8	168430.3	147743.0	109053.4	92437.1	99801.8	71795.4	48061.8	58062.2	61598.3	61379.5
WGHTUNAD	52841.4	43192.5	42788.3	45580.0	35771.8	26284.7	19890.8	18282.1	13202.3	8958.3	11841.6	15270.1
SPWN NOS	96911.6	87657.1	83439.7	88830.7	70168.5	46418.9	37062.9	33400.7	26523.5	17539.0	25143.5	30236.8
WGHTUNAD	41886.8	36664.3	35491.5	37438.7	31224.5	22806.3	14952.9	13177.8	11118.2	7177.0	8164.9	12708.3
3+ NOS	60787.7	60690.2	56548.1	62818.0	55835.9	34762.2	20542.9	13714.3	18216.4	10730.4	10073.6	20529.1
WGHTUNAD	31858.4	30798.0	28704.3	29867.2	27101.9	19636.2	10570.5	8323.7	9200.9	5776.8	4706.5	10350.8

AGE	1981	1982	1983	1984	1985	1986
1	34862.9	21645.2	5621.6	8754.5	19580.0	4549.5
2	18482.9	44600.6	16252.2	4320.3	6488.7	15539.6
3	11878.1	13569.9	24403.5	5819.4	1603.0	2322.5
4	6211.0	4760.6	4768.7	5719.8	1020.8	562.8
5	889.2	1346.8	1023.8	1825.4	543.0	244.3
6	162.7	102.3	188.3	281.8	110.2	82.9
7	24.8	34.4	20.5	57.6	8.7	41.9
8+	0.2	5.2	12.2	20.8	0.0	21.0
TOT NOS	92511.8	86065.0	52290.7	26799.5	29354.3	23364.6
WGHTUNAD	15332.6	21416.0	18749.0	7535.1	3489.2	5789.0
SPWN NOS	30331.5	42576.4	38623.9	16180.8	7217.5	11091.4
WGHTUNAD	11853.8	15535.0	16446.9	6982.6	2467.2	3759.9
3+ NOS	19165.9	19819.2	30416.9	13724.7	3285.6	3275.5
WGHTUNAD	9466.7	9957.6	14308.5	6510.3	1600.2	1932.1

STOCK BIOMASS AT AGE

AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	645.7	507.8	309.9	347.1	313.0	220.8	445.3	97.8	112.3	362.8	113.1	137.2
2	20337.3	11886.7	13774.1	15365.7	8356.9	6427.6	8875.0	9860.6	3889.1	2818.6	7022.0	4782.0
3	15039.6	15050.4	13689.4	14821.8	13130.8	6990.9	4804.3	4691.5	6272.2	3060.8	2715.8	8014.4
4	10326.1	8595.9	8986.9	8723.9	8351.5	6853.0	2487.1	1561.3	1700.9	1718.7	1165.7	1692.9
5	4033.2	4237.2	3473.9	4260.6	3221.9	3522.0	1887.8	779.2	575.3	566.8	505.8	470.5
6	1393.9	1655.7	1465.7	1420.3	1486.5	1181.7	827.2	632.3	268.6	227.5	153.8	124.7
7	704.1	675.4	634.8	412.9	583.2	728.2	379.7	375.7	208.4	86.2	86.7	23.2
8+	361.4	582.4	453.6	227.8	328.2	360.5	184.3	283.7	175.5	116.8	78.8	25.2

AGE	1981	1982	1983	1984	1985	1986
1	1097.3	129.9	101.2	70.0	137.1	40.9
2	4768.6	11328.6	4339.3	954.8	1751.9	3916.0
3	5107.6	5807.9	10835.1	2071.7	639.6	1175.2
4	3621.0	3084.9	2594.2	2957.2	529.8	358.5
5	370.9	905.0	703.4	1151.8	338.8	165.7
6	146.4	115.0	139.9	247.4	84.6	68.3
7	20.6	18.7	22.0	38.9	7.4	34.8
8+	0.2	6.1	14.0	23.3	0.0	29.5

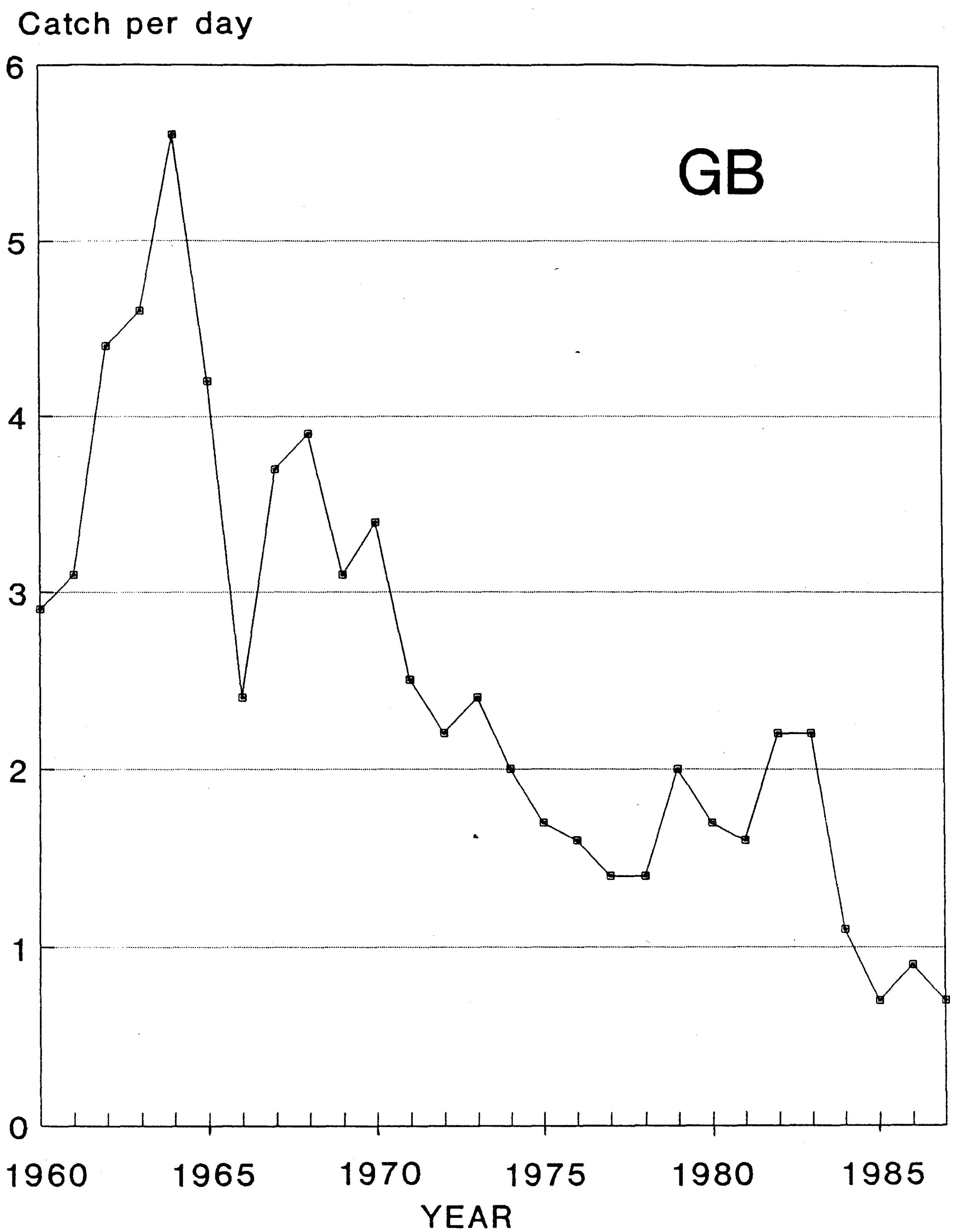


Figure 2.4.1. Commercial abundance indices (metric tons per standard day fished) for Georges Bank yellowtail flounder (1960-1987).

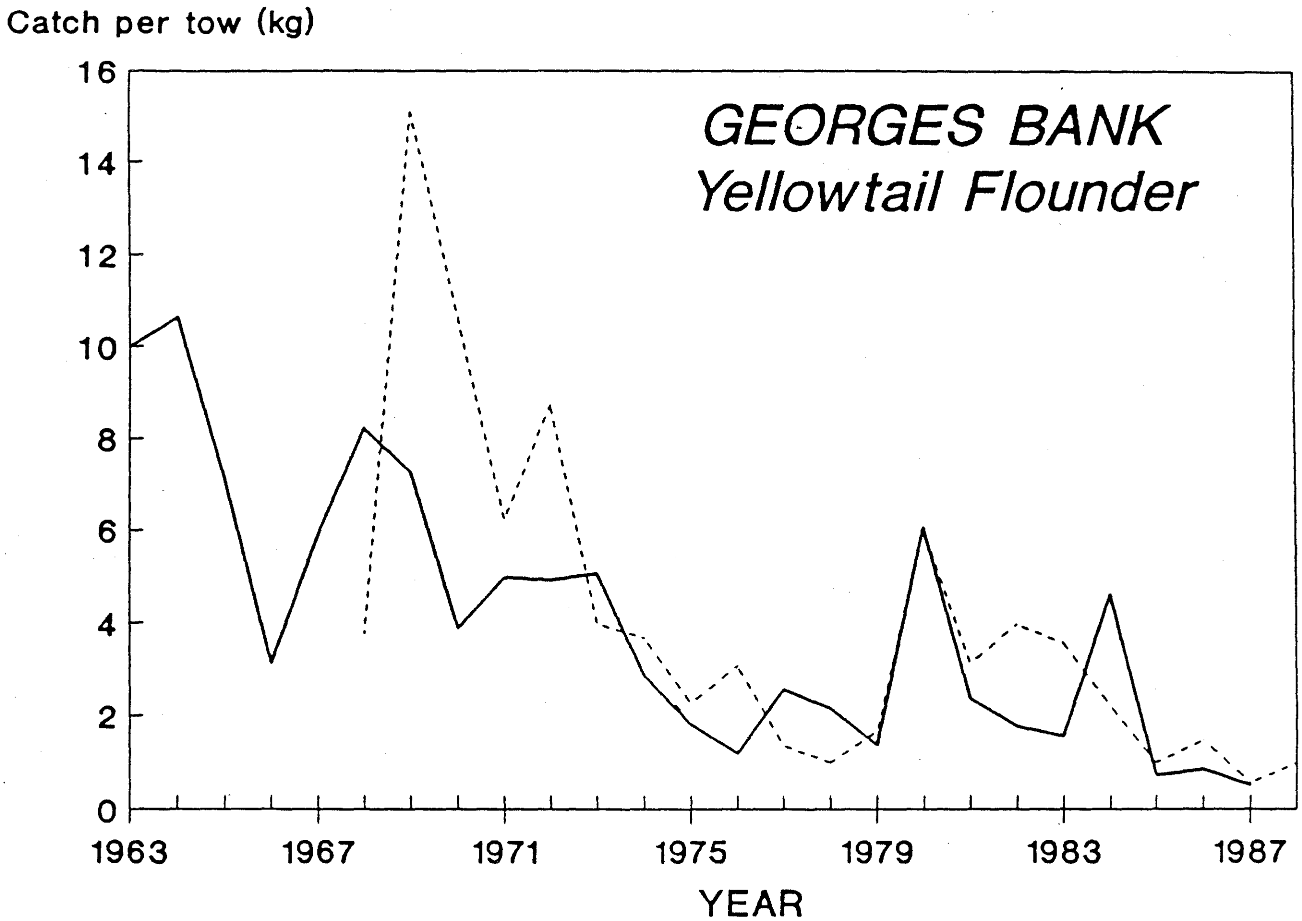


Figure 2.4.2. Stratified mean catch per tow (kg) of Georges Bank yellowtail flounder from NEFC offshore spring (---) and autumn (——) surveys 1963-1987.

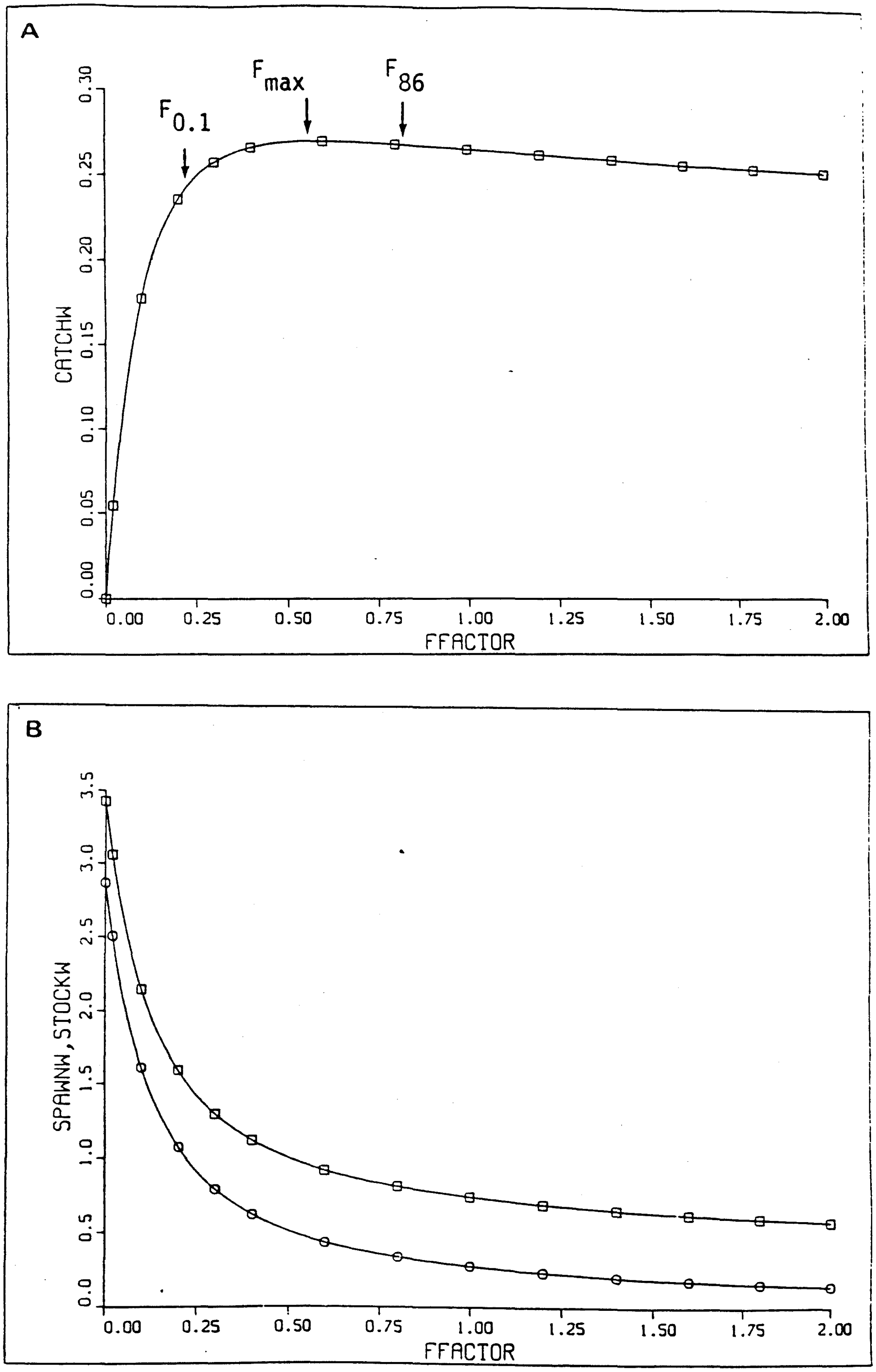


Figure 2.4.3. (A) Long-term yield per recruit; and (B) Long-term total stock and spawning biomass per recruit relationships for Georges Bank yellowtail flounder.

2.5. REVISED SOUTHERN NEW ENGLAND YELLOWTAIL FLOUNDER ASSESSMENT

Source Documents: Clark,S.H., M.M.McBride and B. Wells. 1984. Yellowtail flounder assessment update - 1984. Woods Hole, MA, NMFS,NEFC. Woods Hole Lab. Ref. Doc. 84-39. 30 pp.

NEFC. 1986. Report of the Second Stock Assessment Workshop. Woods Hole, MA, NMFS,NEFC. Woods Hole Lab. Ref. Doc. 86-09. 114 pp.

2.5.1. Report

Total catch (landings and estimated discards) of yellowtail flounder in the Southern New England stock (statistical areas 526,537-539) rose from 1,700 MT in 1976 to 18,500 MT in 1983, following a period of good recruitment in the early 1980's (Table 2.5.1). Landings have since decreased to a low of 1,600 MT in 1987.

Effort (days fished) decreased between 1986 and 1987 from 3,800 to 2,200 days fished.

CPUE in 1987 declined to a record low of 0.7 tons per days fished (Figure 2.5.1).

Survey indices of abundance and biomass have steadily declined since 1982 (Figure 2.5.2). The 1988 spring and 1987 autumn NEFC survey indices were among the lowest in the time series (Table 2.5.2).

Virtual Population Analysis for the Southern New England stock covering the period 1970-1986 indicated that F's (age 3+) ranged from 0.60 in 1971 to 1.92 in 1984 (Table 2.5.3) and was 1.48 in 1986. Spawning stock biomass (SSB) reached 22,000 mt in 1983 due to good recruitment of the 1980 year class. Record high fishing mortality rates since 1983 have resulted in a marked decline in SSB; SSB in 1985 and 1986 were the lowest since 1976.

Recruitment from the 1979-1981 year classes was above average. Subsequent year classes have been either average or poor.

Yield per recruit analysis indicated that F in 1986 far exceeded both $F_{0.1}$ (0.21) and F_{max} (0.54) (Figure 2.5.3). F in 1986 (1.48) was approximately 7 times larger than $F_{0.1}$ and nearly 3 times larger than F_{max}. Relative to F_{max}, the 1986 F would generate approximately 35% less stock biomass per recruit and 60% less spawning stock biomass per recruit under equilibrium conditions.

Catch and stock size projections were made using two different estimation methods for predicting 1988-1990 annual recruitment. Each projection indicated little improvement in SB and SSB at current F levels. Reduction of F to F_{max} could result in increased stock biomass, but SSB would still be well below the long-term average.

Conclusion: The Southern New England yellowtail stock is currently in a depressed state. CPUE and survey indices in 1987 were the lowest in the time series; spawning stock biomass in 1986 was the lowest on record. Prospects for stock recovery will depend on improvement in recruitment and a sharp reduction in fishing mortality.

2.5.2. Discussion

Although a number of technical points regarding the assessments were raised and there is uncertainty associated with some of the estimated parameters, it is clear that fishing mortality levels for both stocks are very high and that spawning stock biomasses are very low. Significant reductions from the fishing mortality levels seen over the past few years would be needed to rebuild the stocks.

The estimation of discards for the SNE stock assumed that a regulated cod end mesh size was in effect since 1969 (4.5 inches during 1969-70 and 5.125 inches during 1971-86). This was only the case in part of the SNE stock area as the remaining area was unregulated. Although this made it difficult to evaluate the impact of this problem on the assessment results, it was clear that discards were underestimated for the SNE stock, especially in the early part of the time series (1969-73). It was recommended that future research examine the implication of mesh size changes on discard estimates to determine the impact on the SNE assessment results.

Length frequency distributions from the commercial landings were used to estimate cull points in both the SNE and GB assessments. Length frequency distributions for the research surveys were then used in conjunction with the estimated cull points to estimate discards. It was pointed out that the use of roller gear in the research surveys (but not with the commercial gear) may make small yellowtail less vulnerable to the research gear. Examination of other available survey data may be warranted to examine the potential problem. If the survey data underestimates small yellowtail availability, then discards would be underestimated using these data and estimation methods. It was suggested that for both the SNE and the GB stocks, much of the problem could be avoided by truncating the early years of the time series (perhaps 1969-73) where most of the discarding occurred.

Noting the large increase in landings of age 1 fish in 1986 (for both stocks), some members of the SAW questioned whether the minimum size landing regulations implemented in 1986 are working well for yellowtail.

Yellowtail stock structure was discussed. In particular, the need to consider six separate areas was questioned. The original separation, based on the work of Lux (1963) (determined from growth, tagging, and other data), seemed to make biological sense. The assessments focus on the SNE and GB stocks because they constitute the bulk of the landings. Research survey indices for the southern New England, Georges Bank, Mid-Atlantic and Cape Cod stocks are provided in the annual NEFC Status of the Fishery Resources report (NEFC 1988).

For both the SNE and GB stocks, the question was raised about differences between the VPA recruitment estimates and corresponding indices from the research survey. However, it was difficult for the SAW to carry out a careful examination of the overall stock size trends from the two sources. It was suggested that such a comparison be made and included when the assessments are finalized. Recruitment estimates (for both stocks) may be subjected to larger variability due to the low level of catch, the difficulties with the discard estimates (discussed above) and large variances in trawl survey indices in recent years. Since these estimates tend to have the greatest influence on the forward projections, there may be a good deal of uncertainty associated with the projections as well.

For the SNE stock, it was noted that mean weight estimates for age 1 fish increased dramatically in 1982 and remained at the higher level through 1986. It was not clear whether this difference is real or could be attributed to smaller sample sizes in recent years. It was suggested that some of the mean weight estimates were unrealistic (e.g. 4 grams for age 1 fish in 1978). If the mean weights are biased, then estimates of age 1 catch (in numbers) will be directly affected.

Table 2.5.1. Commercial catch of yellowtail flounder (000's of metric tons) from Southern New England, 1960-1987.

Year	USA	USA Discard	Indust.	Foreign	Total Catch
1960	8.3	3.2	0.5	-	12.0
1961	12.3	4.7	0.7	-	17.7
1962	13.3	5.3	0.2	-	18.8
1963	22.3	5.4	0.3	0.2	28.0
1964	19.5	9.5	0.5	-	29.5
1965	19.4	7.0	1.0	1.4	28.8
1966	17.6	5.3	2.7	0.7	26.3
1967	15.3	7.7	4.5	2.8	30.3
1968	18.2	6.3	3.9	3.5	31.9
1969	15.6	2.4	4.2	17.6	39.8
1970	15.2	4.5	2.1	2.5	24.3
1971	8.6	2.2	0.4	0.3	11.5
1972	8.5	1.8	0.3	3.0	13.6
1973	7.5	0.8	0.3	0.2	8.8
1974	6.4	0.4	<0.1	0.1	6.9
1975	3.2	0.1	<0.1	-	3.3
1976	1.6	0.1	<0.1	<0.1	1.7
1977	2.8	0.1	<0.1	<0.1	2.9
1978	2.3	0.1	<0.1	-	2.4
1979	5.4	0.3	<0.1	-	5.7
1980	6.0	0.3	<0.1	-	5.2
1981	4.9	0.3	<0.1	-	6.2
1982	11.5	0.6	-	-	12.1
1983	17.9	0.6	-	-	18.5
1984	8.5	0.2	-	-	8.7
1985	3.2	0.1	-	-	3.3
1986	3.3	0.1	-	-	3.4
1987	1.6		-	-	

Table 2.5.2. Stratified mean catch per tow in numbers by age and total weight (kg) per tow for Southern New England yellowtail flounder in NEFC spring and autumn bottom trawl surveys 1963-1988.

Year	Age 0	1	2	3	4	5	6	7	8+	Total No.	Total wt. (kg)
	Spring										
1968	0.00	2.80	45.36	46.22	27.17	1.44	0.16	0.09	0.00	1123.24	32.21
1969	0.00	7.44	28.12	39.55	21.42	3.84	0.25	0.00	0.00	100.62	23.10
1970	0.00	2.15	15.24	28.93	20.38	5.98	1.55	0.33	0.14	74.70	20.28
1971	0.15	1.79	23.09	28.43	9.46	1.49	0.04	-	0.03	74.48	18.49
1972	0.00	0.84	31.38	21.26	6.64	12.69	1.92	0.44	0.00	75.17	18.55
1973	0.00	1.90	10.47	18.34	9.06	6.15	9.53	1.18	0.66	57.29	14.69
1974	0.00	1.07	4.28	3.36	3.60	2.35	0.85	1.44	0.32	17.27	5.04
1975	0.00	0.82	2.25	0.72	1.00	1.28	0.68	0.05	0.21	7.01	1.98
1976	0.00	0.04	4.70	0.75	0.38	0.43	0.38	0.19	0.09	6.96	2.45
1977	0.00	0.35	1.76	2.24	0.22	0.26	0.12	0.04	0.16	5.15	1.99
1978	0.00	4.43	14.04	2.85	1.03	0.27	0.05	0.07	0.20	22.94	5.15
1979	0.00	2.22	4.84	2.57	0.45	0.16	0.00	0.00	0.01	10.25	2.15
1980	0.00	0.54	6.21	4.73	3.90	0.42	0.15	0.02	0.04	16.01	5.95
1981	0.00	0.35	14.55	5.24	2.16	0.78	0.11	0.00	0.07	23.26	6.85
1982	0.00	1.09	22.58	13.53	3.12	0.99	0.28	0.04	0.00	41.63	10.38
1983	0.00	0.12	6.05	18.59	1.28	0.32	0.00	0.00	0.00	26.36	8.03
1984	0.00	0.00	1.36	3.73	2.20	0.51	0.23	0.00	0.00	8.03	2.85
1985	0.00	0.07	0.70	0.37	0.27	0.43	0.29	0.00	0.00	2.47	0.67
1986	0.00	0.00	6.98	2.87	0.50	0.13	0.06	0.00	0.00	10.67	2.78
1987	-	0.00	0.34	1.61	0.27	-	-	-	-	2.22	0.70
1988	-									2.76	0.69
	Autumn										
1963	0.05	16.46	15.23	13.98	4.26	0.55	0.00	0.08	0.00	50.61	16.83
1964	0.00	18.47	26.19	4.80	7.13	3.27	0.80	0.11	0.00	60.77	19.03
1965	0.26	11.63	16.90	6.20	1.77	1.73	0.21	0.04	0.00	38.74	12.68
1966	0.88	35.92	10.44	1.78	1.02	0.19	0.00	0.00	0.00	50.23	9.43
1967	0.27	18.44	25.65	11.14	1.57	0.40	0.06	0.13	0.00	57.66	14.05
1968	0.00	10.72	9.47	18.08	1.12	0.00	0.61	0.19	0.04	40.23	10.06
1969	0.00	11.88	9.74	27.48	5.47	0.12	0.04	0.04	0.00	54.77	14.39
1970	0.04	4.23	5.52	16.34	10.62	2.51	0.43	0.07	0.00	39.76	10.96
1971	0.00	6.34	10.84	6.25	15.20	2.69	0.22	0.16	0.00	41.70	9.18
1972	-	4.25	15.98	19.35	19.13	12.75	1.76	0.07	0.00	73.28	20.11
1973	0.00	1.56	1.19	1.80	1.34	1.00	0.83	0.23	0.00	7.95	2.25
1974	0.21	1.02	1.64	0.59	2.25	0.96	0.40	0.19	0.07	7.33	2.13
1975	0.00	1.67	0.50	0.19	0.23	0.22	0.00	0.09	0.00	2.90	0.71
1976	0.00	2.99	6.18	0.54	0.07	0.11	0.30	0.35	0.15	10.69	2.96
1977	0.04	1.70	2.19	0.80	0.12	0.04	0.04	0.08	0.00	5.01	1.50
1978	0.00	3.26	7.20	0.43	0.38	0.04	0.01	0.08	0.03	11.43	3.06
1979	0.00	1.73	4.42	2.40	0.37	0.04	0.04	0.00	0.00	9.00	2.57
1980	0.00	1.49	4.33	1.18	0.34	0.00	0.00	0.00	0.00	7.33	1.96
1981	0.00	3.24	9.25	1.06	1.21	0.02	0.04	0.00	0.00	14.82	3.79
1982	0.00	2.14	24.17	7.02	0.84	0.33	0.00	0.00	0.00	34.50	8.13
1983	0.00	2.61	15.93	8.17	0.70	0.08	0.00	0.04	0.00	27.53	6.51
1984	0.00	0.54	1.82	1.97	0.54	0.00	0.00	0.00	0.00	4.91	1.37
1985	-	1.20	0.53	0.17	0.16	0.00	0.00	0.00	0.00	2.06	0.44
1986	-	0.37	1.97	0.42	0.09	0.00	0.00	0.00	0.00	3.48	0.88
1987	-	1.53	0.66	0.56	0.05	0.04	-	0.04	-	2.98	0.61

Table 2.5.3. Estimates of fishing mortality (F), stock size (000's of fish) and stock biomass (metric tons) from Virtual Population Analysis for Southern New England (1970-1986).

FISHING MORTALITY

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.046	0.010	0.041	0.029	0.051	0.042	0.015	0.011	0.006	0.011	0.009	0.006
2	0.390	0.189	0.302	0.341	0.723	0.774	0.227	0.484	0.176	0.401	0.405	0.154
3	0.580	0.326	0.506	0.645	1.067	1.064	0.642	1.026	0.594	0.871	0.973	1.101
4	1.129	0.591	0.542	0.768	0.973	0.686	0.492	0.654	0.847	0.608	1.334	1.478
5	1.227	0.874	0.941	0.713	1.091	1.078	0.351	1.025	0.647	1.123	1.243	1.771
6	1.061	0.658	1.078	0.713	0.931	1.051	0.931	1.092	0.489	1.025	1.181	1.708
7	1.010	0.675	0.844	0.560	1.399	1.705	0.930	0.845	0.578	0.703	0.761	0.540
8+	1.010	0.675	0.844	0.560	1.399	1.705	0.930	0.845	0.578	0.703	0.761	0.540
MEAN F	0.810	0.604	0.662	0.689	1.047	1.014	0.667	0.985	0.676	0.858	1.096	1.241
REC AGE	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+	3+

AGE	1982	1983	1984	1985	1986
1	0.003	0.101	0.018	0.034	0.030
2	0.327	0.590	0.861	0.644	0.515
3	1.196	1.512	1.980	0.697	1.461
4	1.091	1.332	1.870	1.295	1.463
5	1.226	0.743	1.389	1.614	1.659
6	0.830	2.250	1.958	1.169	1.549
7	0.416	1.122	0.818	1.757	1.480
8+	0.416	1.122	0.818	1.757	1.480
MEAN F	1.181	1.485	1.922	1.135	1.480
REC AGE	3+	3+	3+	3+	3+

STOCK SIZE

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	39029.3	40630.7	16445.9	7762.3	7041.4	12977.3	8728.3	27808.8	24760.9	23587.3	34816.9	95730.7
2	31880.6	30525.7	32979.0	12925.9	6176.1	5478.2	10188.0	7045.3	22543.1	20146.7	19102.6	28249.0
3	52938.9	17678.4	20684.1	19969.0	7524.1	2454.3	2068.6	6649.5	3556.4	15483.6	11051.0	10433.7
4	26637.5	24276.9	8552.6	10208.6	8580.8	2119.9	693.2	891.5	1952.2	1608.4	5304.8	3420.5
5	7719.5	7053.0	11005.2	4074.1	3877.1	2654.6	874.5	347.1	379.5	685.4	716.7	1144.2
6	1785.2	1852.3	2533.7	3516.6	1634.3	1065.7	739.3	412.5	101.9	162.6	182.6	169.2
7	189.1	505.7	785.1	705.8	1411.9	327.6	305.0	238.6	113.3	51.2	47.9	45.9
8+	55.5	66.5	330.8	141.3	254.3	264.4	189.5	462.2	69.0	0.2	36.2	5.2
TOT NOS	160235.6	122589.2	93316.4	59303.6	36500.1	27541.9	23784.3	43855.7	53476.2	61725.4	71258.6	139198.5
WGHTUNAD	43078.3	30923.2	26801.2	18857.5	11297.6	5283.6	5231.1	5651.2	7230.2	10857.2	11896.2	14032.6
SPWN NOS	104104.1	65652.2	58671.7	44436.4	26134.5	11758.8	9513.3	12674.1	16562.1	27307.6	26436.5	29610.0
WGHTUNAD	38198.3	25958.0	21954.1	17263.2	10433.1	4486.4	3579.9	4635.5	4686.4	8419.0	9376.4	9533.6
3+ NOS	89325.7	51432.8	43891.4	38615.4	23282.5	9086.4	4870.0	9001.5	6172.3	17991.4	17339.1	15218.7
WGHTUNAD	34661.3	22305.3	18243.4	16042.8	9791.6	3923.8	2534.3	3948.1	2780.4	6609.2	7647.7	6600.0

AGE	1982	1983	1984	1985	1986
1	46677.2	7527.6	11636.8	20780.1	13696.6
2	77953.8	38163.1	5573.2	9358.2	16441.3
3	19833.7	46022.3	17320.1	1929.3	4024.2
4	2841.9	4910.7	8304.9	1957.2	786.9
5	639.0	781.3	1060.9	1048.1	439.0
6	159.4	153.5	304.3	216.6	170.9
7	25.1	56.9	13.3	35.2	55.1
8+	7.7	12.5	25.5	21.3	69.2
TOT NOS	148137.8	97627.9	44238.9	35345.9	35683.1
WGHTUNAB	24965.0	27186.8	10677.1	4793.3	5825.0
SPWN NOS	58608.9	68796.9	29714.4	9743.3	13030.3
WGHTUNAB	15050.9	21958.8	9779.7	3200.2	3620.7
3+ NOS	23506.7	51937.1	27028.9	5207.6	5545.2
WGHTUNAB	8269.9	18030.3	9262.3	2222.1	2027.1

STOCK BIOMASS AT AGE

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	351.3	284.4	82.2	54.3	42.2	77.9	322.9	139.0	99.0	117.9	313.4	765.8
2	8065.8	8333.5	8475.6	2740.3	1463.7	1281.9	2373.8	1564.1	4350.8	4130.1	3935.1	6666.8
3	18899.2	7071.4	7653.1	7488.4	2588.3	871.3	870.9	2460.3	1330.1	5264.4	4177.3	3808.3
4	10788.2	10220.3	3677.6	4287.6	3724.1	951.8	388.9	~~468.0~~	~~1005.4~~	762.4	2705.4	1768.4
5	3751.7	3505.3	4765.2	1845.6	1837.8	1205.2	513.3	240.6	258.1	413.3	529.9	806.7
6	1053.3	1070.6	1345.4	1891.9	807.3	498.7	434.7	277.6	70.1	123.3	148.6	154.8
7	125.9	359.1	560.5	456.7	686.2	250.6	191.8	177.1	77.9	45.7	52.4	55.3
8+	43.0	78.3	241.5	92.7	148.0	146.2	134.7	324.5	38.8	0.2	35.1	6.6

AGE	1982	1983	1984	1985	1986
1	1260.3	188.2	244.4	353.3	164.4
2	15434.9	8968.3	1170.4	2217.9	3633.5
3	6384.4	15003.3	5161.4	673.3	1235.4
4	1321.5	2342.4	3330.2	810.3	351.7
5	408.3	489.8	517.7	561.8	239.2
6	121.9	137.1	212.7	129.1	98.6
7	24.0	48.1	17.1	25.4	44.0
8+	7.7	9.6	23.2	22.2	58.1

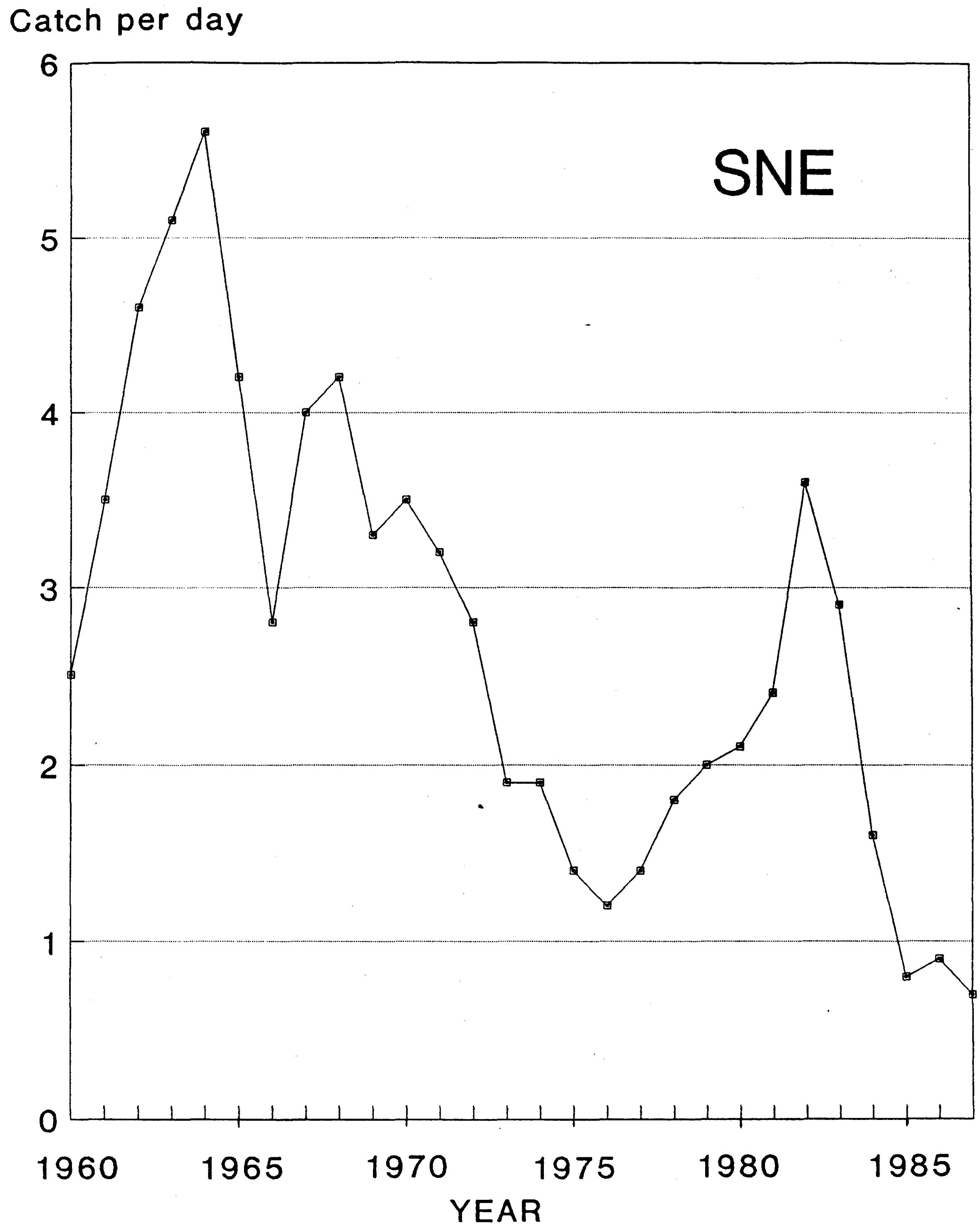


Figure 2.5.1. Commercial abundance indices (metric tons per standard day fished) for Southern New England flounder (1960-1987).

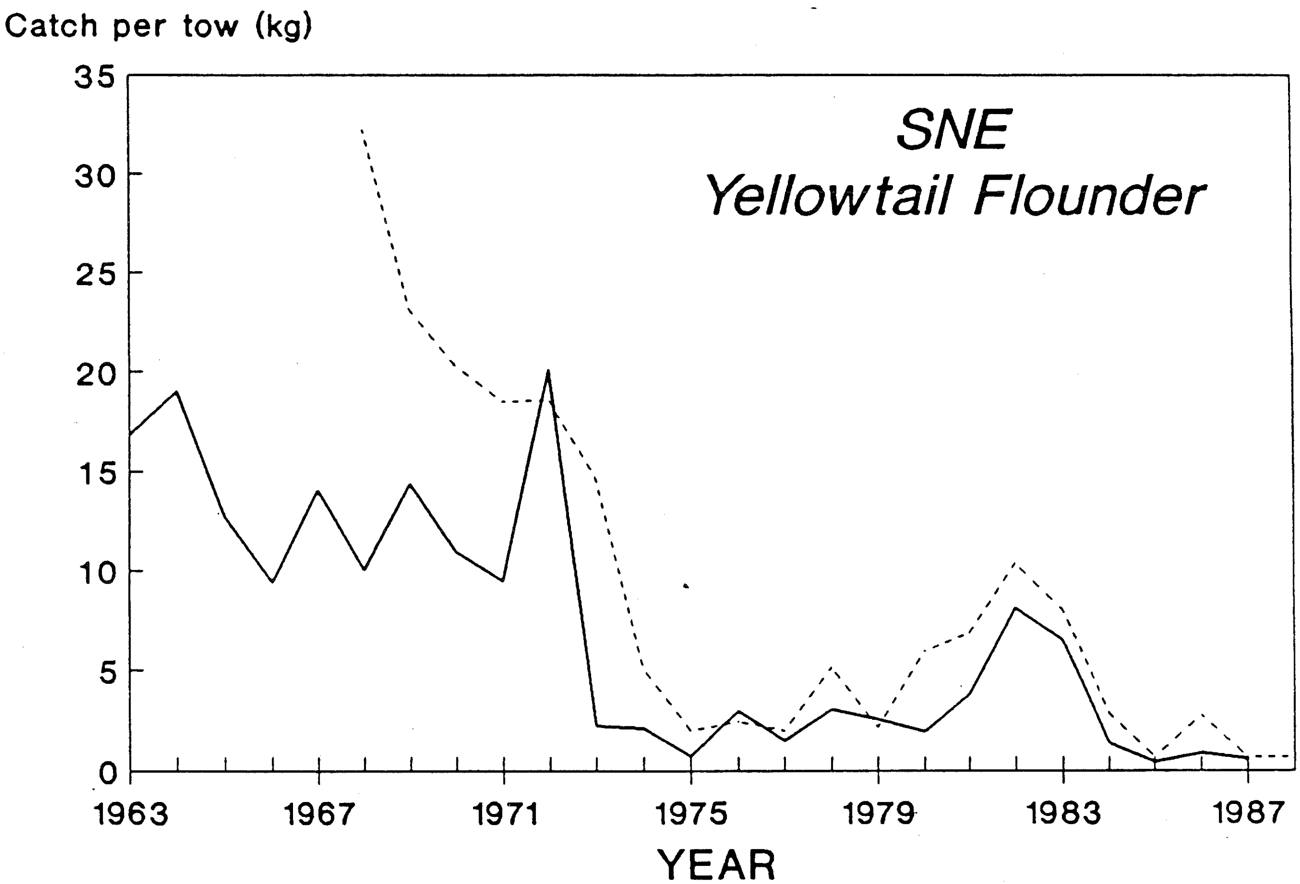


Figure 2.5.2. Stratified mean catch per tow (kg) of Southern New England yellowtail flounder from NEFC offshore spring (---) and autumn (——) surveys 1963-1987.

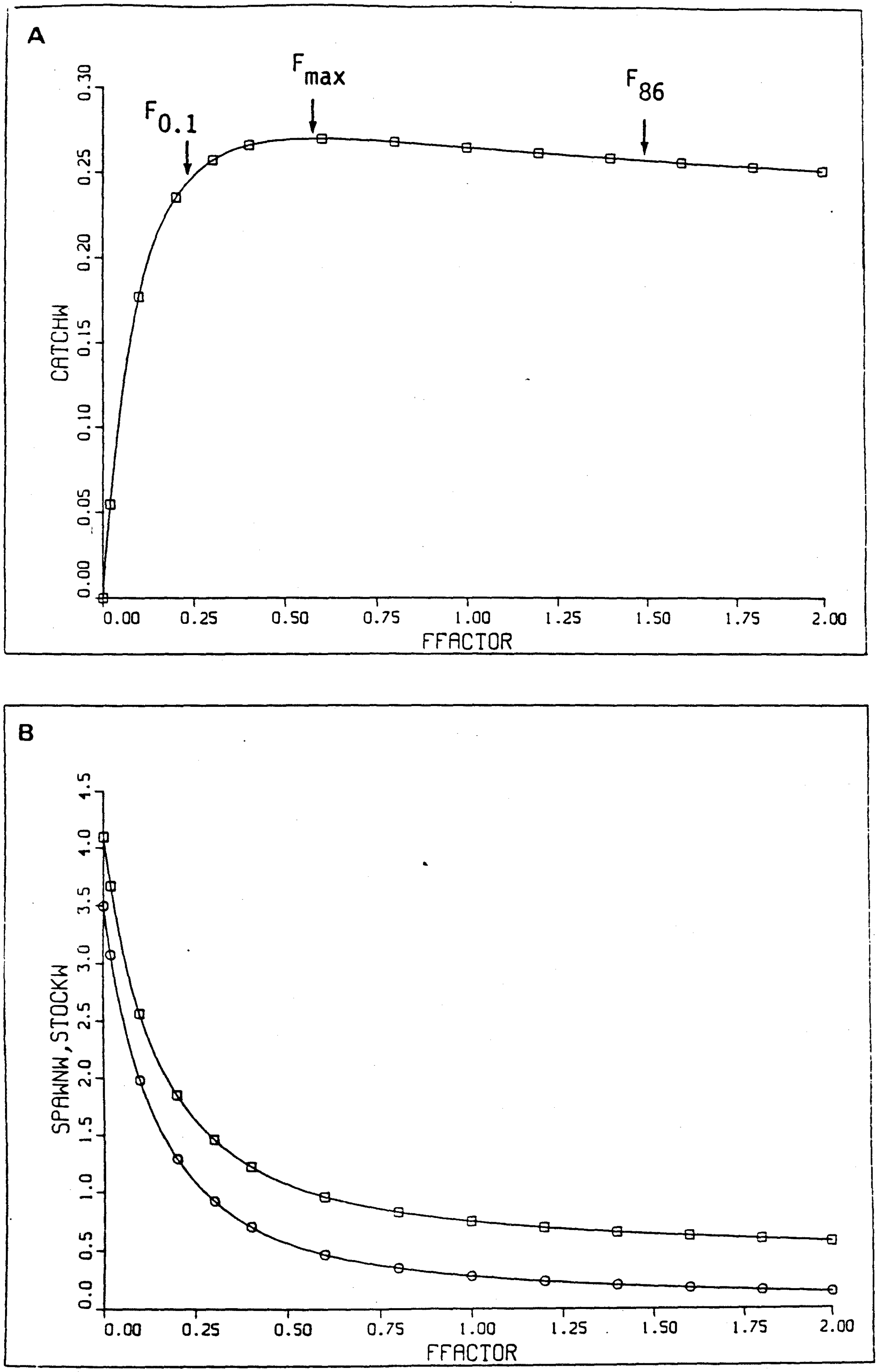


Figure 2.5.3. (A) Long-term yield per recruit; and (B) long-term total stock and spawning stock biomass per recruit relationships for Southern New England yellowtail flounder.

3. MID-ATLANTIC FISHERY RESOURCES

3.1. MAXIMUM SUSTAINABLE YIELD COMPUTATIONS FOR SURF CLAM

Source Documents: Murawski, S.A. 1986. Assessment updates for Middle Atlantic, New England, and Georges Bank offshore surf clam, **Spisula solidissima**, populations - Summer 1986. Woods Hole Lab. Ref. Doc. 86-11.

3.1.1. Report

The surf clam-ocean quahog FMP currently specifies an MSY value of 50 million pounds (20,430 mt) of meats per year for the Mid-Atlantic fishery. This value is problematic for several reasons: (1) it is based on an historic average catch for a period of years when the surf clam populations were in substantial flux, (2) it includes landings from the inshore areas not regulated under the plan, and (3) it does not include provisions for resources in areas such as Southern New England and Georges Bank, that began contributing to the landings **after** the period considered for the long-term average catch, and (4) it is not clear that the average catch values, taken for any period, represent the 'long-term potential catch' from a stock.

Although the concept of MSY certainly does not apply in the true equilibrium sense to stocks such as surf clam that exhibit substantial inter-annual variability in recruitment, there is nevertheless the ability in stocks with low natural mortality rates to 'stockpile' fishable biomass, and thereby buffer the effects of highly stochastic recruitment. The purpose of this study was to determine by Monte Carlo simulation the maximum constant catch that could be taken from the stock, subject to risks of unacceptable stock, catch, and/or fishing effort fluctuations.

A population simulation model for surf clams (Figures 3.1.1 and 3.1.2; Table 3.1.1) was constructed incorporating a 'bimodal' recruitment frequency distribution, which may be a realistic depiction of the stock/recruitment dynamics for this population. Good recruitment in the stock is very infrequent and so a log-normal probability density function may overestimate the probability of such year classes. The simulator (Figure 3.1.2) is driven by a double Monte Carlo scheme in which it is first determined if recruitment for a given year will be 'good' or 'bad', and then once determined, the actual recruitment value is selected from an appropriate gaussian with given mean and SD. Input parameters for the model are given in Table 3.1.1. An important aspect of the simulation was the mechanism to constrain catch below the available stock for years when the constant catch goal could not be taken. For the purposes of this simulation the catch in such years was set to 95% of the catch that would be taken at F=3.0 (an arbitrary but very substantial proportion of the total harvestable population).

A series of simulation experiments was conducted varying both the target constant catches (=MSY by this definition), and some of the important population parameters (primarily PGOOD, the probability of 'good' recruitment). Results of these simulations are summarized in Table 3.1.2 and Figures 3.1.3-3.1.5 for a number of key stock and fishery attributes including the mean and CV of fishing mortality, stock size, catch, delta catch (the average difference in catches in successive years), length of run (the average period of consecutive years in which the constant catch goal is achieved), and the proportion of years simulated in which the constant catch goal was met.

Simulation results can be used to evaluate the effects of the choice of MSY target with respect to potential consequences for stock and fishery expectation (mean levels) and variability. In this respect the fishery manager can select an MSY goal that may reduce risks of unacceptable levels or fluctuations in particularly important attributes. The choice of which stock or fishery variables are important is subjective, but where stability in catches is desirable (such as in the surf clam fishery), one would want to reduce substantial variation in catch and to a certain extent fishing effort (proportional to fishing mortality).

For Mid-Atlantic Bight surf clam populations, the 'best' constant catch policy (our working definition of MSY) is probably in the 20-25 thousand metric ton per year range. Although average yield is maximized at an MSY of 45 thousand tons, marginal increases in yield beyond 20 thousand tons are modest (Table 3.1.2). The difference in average yield between MSYs of 25 and 45 thousand tons is 14%. A target MSY of 25 thousand tons results in a CV of catch and a proportion of years with insufficient stock to give the constant catch of 28%. Delta catch is 3% of the mean. At 30 thousand tons the proportion of years with insufficient stock increases to nearly half (47%). Although mean catch increases only 1% between 25 and 30 thousand ton MSY targets, the CV of catch increases 14% (to 42%), and the average stock size declines by nearly a third. A 15 thousand ton or lower MSY is probably overly restrictive as the average length of run is 375 years, with the proportion of years with insufficient stock of 3%. Perhaps more significant is the high CV of fishing mortality rate (2.58) at a 15 thousand ton MSY, which would imply a very large slack capacity in fishing effort must be maintained in order to meet the infrequent and variable demand for high fishing mortality called for in the constant catch strategy. An MSY of 25 thousand tons reduces the CV in F by over half. This variability in fishing mortality rate could be controlled by applying a lower maximum fishing mortality rate to the simulation (than setting MSY to 95% of the catch at F=3.0), when the stock is insufficient for the target MSY.

If a provisional MSY for the stock of 20-25 thousand tons is accepted, based on the above criteria, the MSY for all offshore surf clam populations can be extrapolated based on the relative clam biomass in the various areas as determined from NEFC surveys. If the same population dynamics parameters (primarily PGOOD) are assumed for all stocks, the overall MSY for offshore surf clam populations is 25-31 thousand metric tons. There is some indication that the frequency of 'good' year classes may be different in the New England areas. Assuming a higher probability of good recruitment (e.g. on Georges Bank), the overall MSY increases to 26-33 thousand metric tons.

3.1.2. Discussion

The discussion on maximum sustainable yield for surf clam focused on several areas related to the concepts of MSY and the techniques for estimation in the specific case examined. The use of maximum constant catch as a working definition was debated since this is a restrictive and literal interpretation of the MSY concept. It was noted that other MSY definitions, such as maximum average yield (MAY), and approaches based on the application of constant fishing mortality rates would obviously result in different levels computed for the stock. It was noted that given the apparent desirability on the part of managers to maintain the stocks at levels such that interannual catch fluctuations are low, that the maximum constant catch approach may be the most applicable. One reason that the constant catch strategy does so well is the lack of relationship between recruitment and stock size assumed in the model (i.e. the lack of penalty for reducing the stock to low levels). Comparisons of yields under a constant catch scenario with those from constant fishing mortality strategies ($F_{0.1}$, F_{max}) indicate marginal increases in average yields under constant F values, but at the expense of higher variability in catch, particularly in the average difference in yields between successive years (DELTA CATCH).

It was noted that managers could be presented with MSY options in tabular form, and thus can evaluate 'optimal' MSY values in relation to risks of various stock/fishery conditions to which they may want to be averse (e.g. there may be more of a premium on reducing stock variability, catch variability, effort variability or a combination of attributes).

Technical comments on the simulation approach focused on the applicability of the bimodal probability density function for surf clam, the arbitrary catch set to 0.95*catch at F=3.0 when stock size cannot support the constant catch goal, and the implications for short-medium term advice of the choice of simulation time-interval. Sensitivity analyses indicate the importance of the choice of 'PGOOD', a parameter that is not well estimated. The choice of a 10,000 year time interval for the simulations was predicated on the desirability of negating the influence of starting conditions (numbers at age), and to better estimate values such as the CV's of DELTA CATCH and Length of Run, which are poorly estimated when the simulation intervals are $\leq$ several hundred years. The 10,000 year simulation interval gives robust results in the equilibrium context, but is not as useful for a shorter term prognosis (e.g. for tactical fishery management advice). Other simulation strategies (e.g. multiple short-term model runs) would be appropriate in the latter context.

Table 3.1.1. Input data and parameters for stochastic yield simulations of Atlantic surf clam populations. Simulations are based on a bimodal frequency distributions of recruitment (Figures 3.1.1 and 3.1.2)

Parameter Values	Description of Variable
30 1	Number of Ages, First Age in Analysis
.004 .017 .037 .061 .083 .088 .092 .096 .1 .103 .105 .109 .111 .114 .116 .118 .121 .123 .126 .128 .131 .133 .136 .138 .141 .144 .146 .149 .152 .155	Mean Weight At Age for Catch and Stock
.05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05	Natural Mortality Rate at Age
0 0 0 .3 .6 .8 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Partial Recruitment at Age
.5 .9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Partial Maturity at Age
200e6 185e6 175e6 165e6 155e6 135e6 115e6 100e6 95e6 75e6 4290e6 1072e6 46e6 34e6 30e6 25e6 22e6 19e6 16e6 14e6 12e6 10e6 9e6 8e6 7e6 5e6 4e6 4e6	Starting Numbers at Age
.05	Annual Probability of 'Good' Recruitment
4000e6 800e6	Mean and Standard Deviation of 'Good' Recruitment
200e6 50e6	Mean and Standard Deviation of 'Bad' Recruitment
10000 1	Number of Iterations Per Simulation Experiment, Number of Experiments
25000	MSY Target Level for Simulation of Constant Catch Strategy

Table 3.1.2. Results of stochastic MSY yield simulations for Mid-Atlantic surf clam populations, using the bimodal recruitment distribution simulator (Figures 3.1.1 and 3.1.2). Simulations are based on varying MSY target values: other input data are as given in Table 3.1.1. Catch, stock size and delta catch are given in thousands of metric tons.

Response Variable	Target MSY Level (Thousand Metric Tons) 10	15	20	25	30	35	40	45	50	55
Fishing Mortality										
Mean	0.03	0.18	0.63	0.91	1.42	1.62	1.74	1.92	2.06	2.20
SD	0.02	0.46	1.01	1.14	1.23	1.19	1.15	1.07	1.00	0.89
CV	0.59	2.58	1.60	1.26	0.86	0.74	0.66	0.56	0.49	0.41
Catch										
Mean	10.0	14.9	18.5	21.4	21.6	22.8	24.2	24.3	24.0	23.3
SD	0.0	0.6	3.3	5.9	9.1	11.6	13.9	15.9	17.6	18.9
CV	0.00	0.04	0.18	0.28	0.42	0.51	0.58	0.66	0.73	0.81
$\log_e$ Catch										
Mean	9.21	9.61	9.80	9.92	9.87	9.89	9.91	9.88	9.83	9.78
SD	0.00	0.05	0.22	0.35	0.49	0.56	0.62	0.66	0.69	0.70
CV	0.00	0.01	0.02	0.04	0.05	0.06	0.06	0.07	0.07	0.07
Stock Size										
Mean	460.8	365.1	295.5	245.6	165.8	145.0	131.4	113.9	103.2	87.7
SD	229.9	216.8	227.8	215.1	171.2	160.5	143.0	129.6	124.7	105.1
CV	0.50	0.59	0.77	0.88	1.03	1.11	1.09	1.14	1.21	1.20
Delta Catch										
Mean	0.00	0.04	0.37	0.73	1.28	1.82	2.44	3.05	3.38	4.05
SD	0.00	0.32	1.13	2.09	3.13	4.43	5.89	7.20	8.16	9.61
CV	0.00	7.42	3.10	2.85	2.43	2.44	2.41	2.36	2.41	2.37
Length of Run										
Mean	10000	374.5	91.7	48.6	27.1	17.7	13.3	10.2	8.8	6.6
SD	0.00	384.0	77.3	36.5	19.2	16.7	9.8	7.9	6.3	4.3
CV	0.00	1.03	0.84	0.75	0.71	0.94	0.73	0.78	0.72	0.66
Proportion Years < MSY	0.00	0.03	0.18	0.28	0.47	0.54	0.58	0.64	0.70	0.75

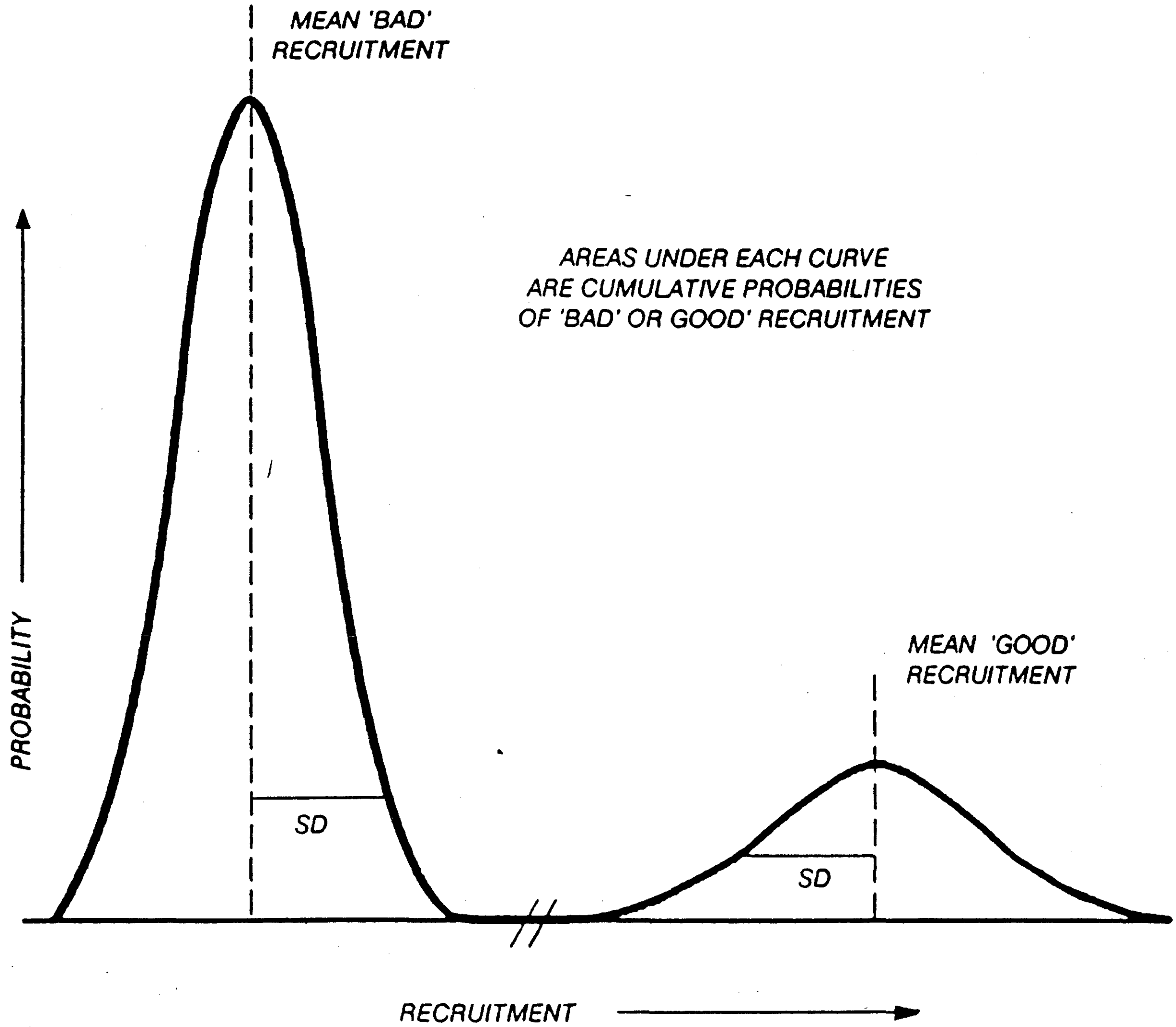


Figure 3.1.1. Probability density function (PDF) for the bimodal frequency distribution of recruitment values. Dashed lines indicate the means of separate gaussians for 'good' vs. 'bad' recruitment. SD is the standard deviation of each gaussian.

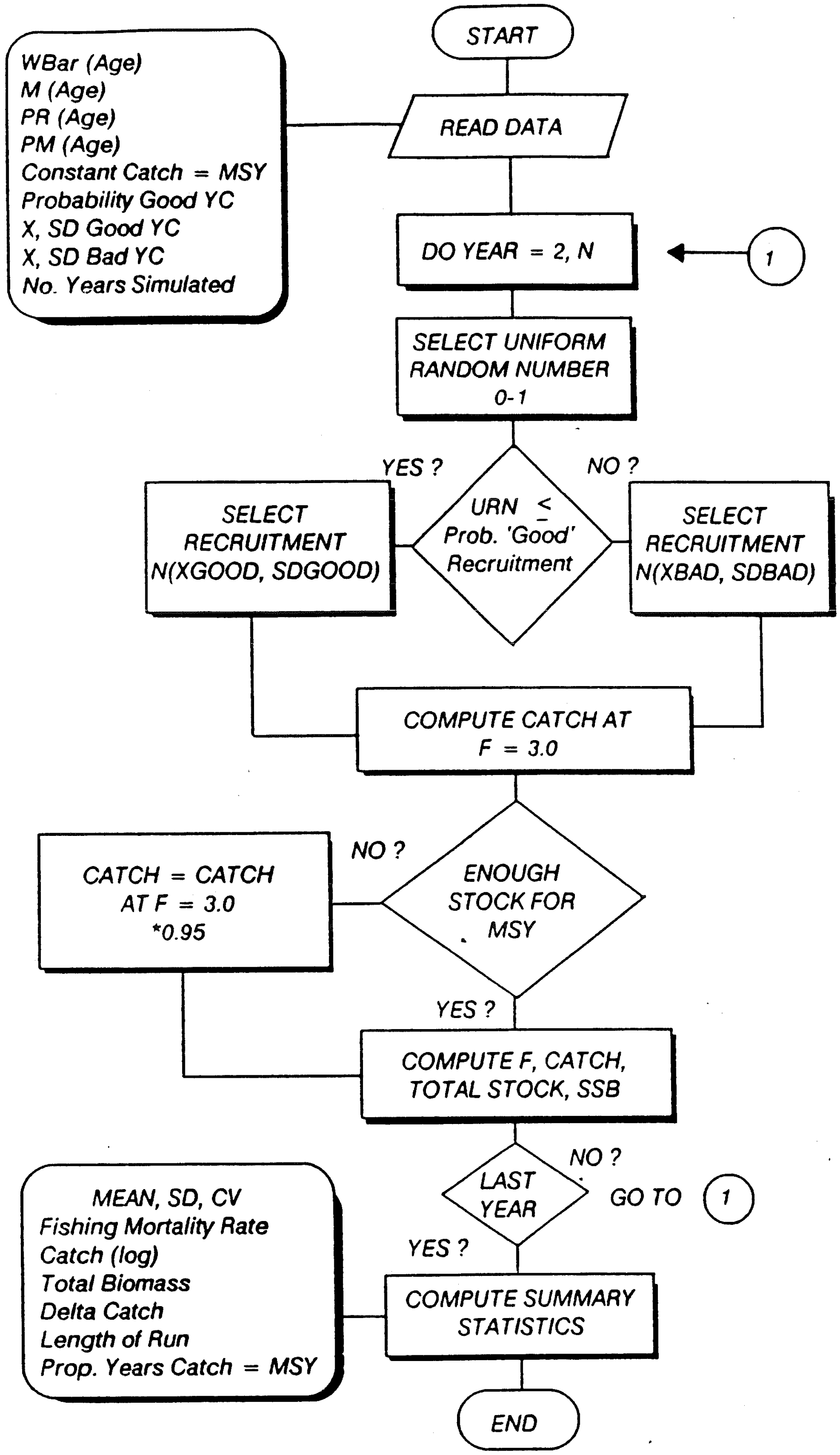


Figure 3.1.2. Logic flow diagram for stochastic yield simulations assuming bimodal recruitment frequency distribution.

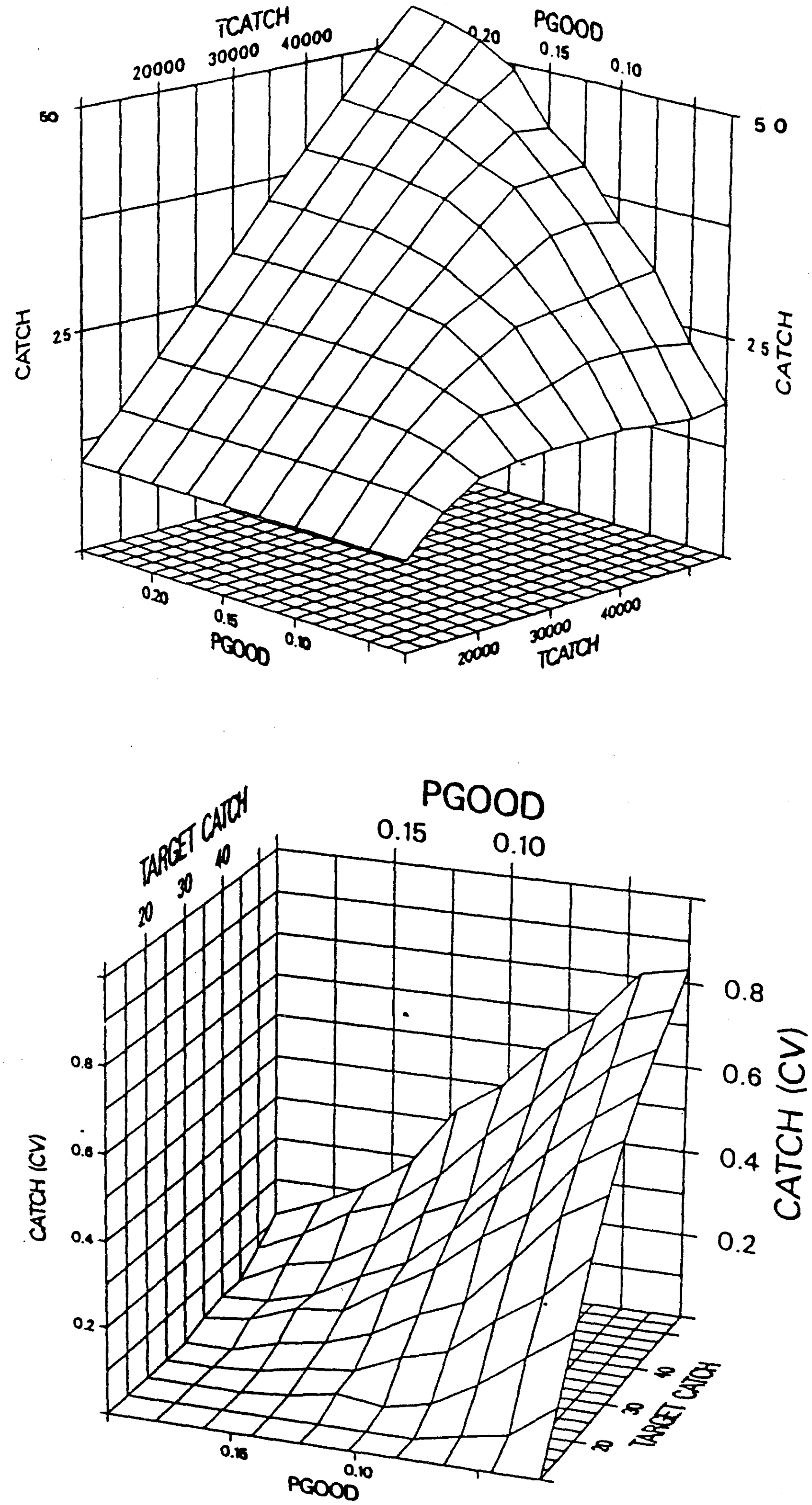
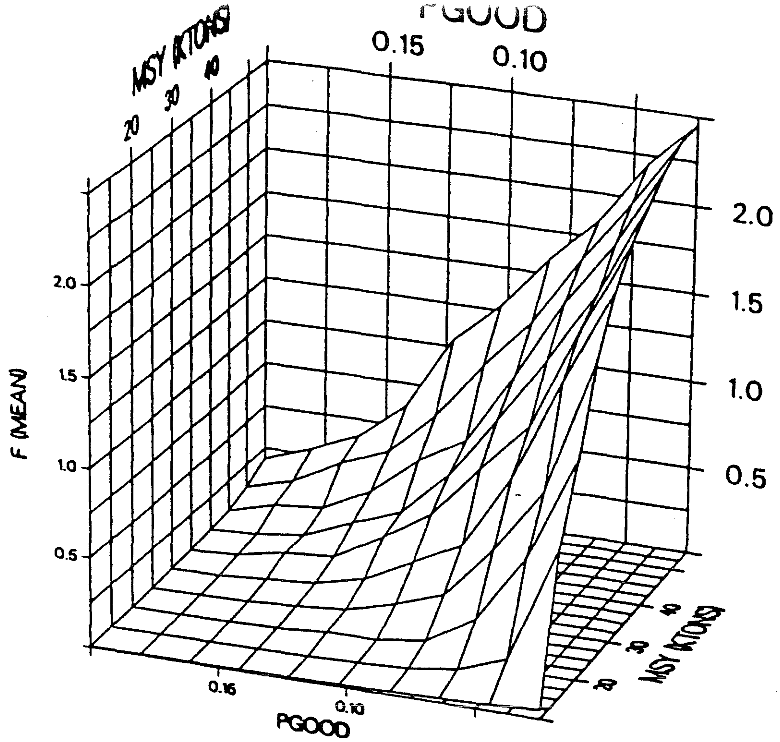


Figure 3.1.3. Simulated mean (above) and CV (below) of surf clam catch (thousands of tons) as a function of the probability of good recruitment (PGOOD), and constant catch (=MSY) target (TCATCH). Simulation results are for the model outlined in Figure 3.2.2.



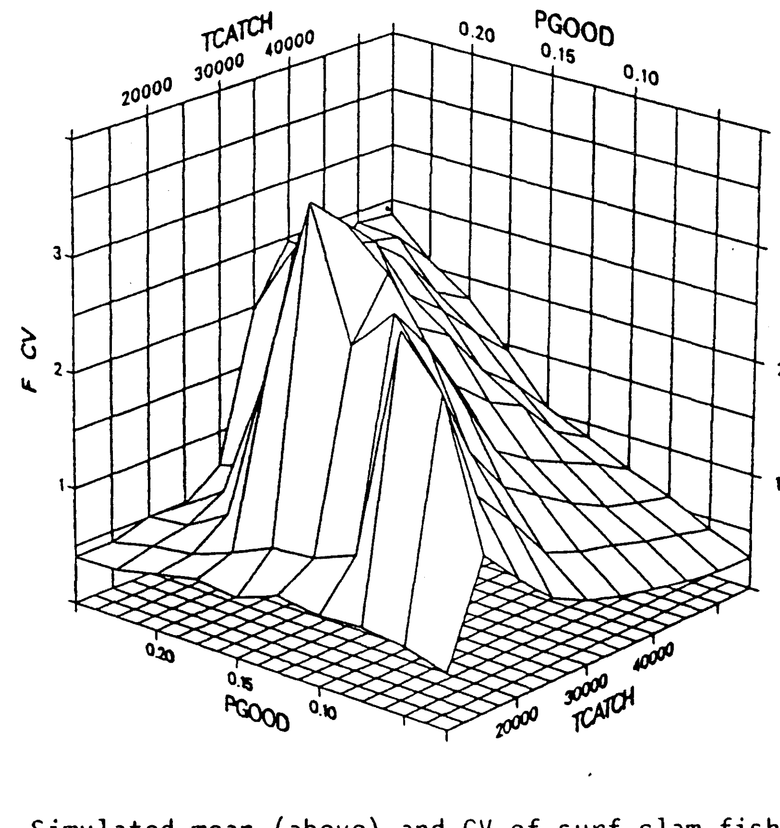


Figure 3.1.4. Simulated mean (above) and CV of surf clam fishing mortality rate as a function of the probability of good recruitment (PGOOD) and constant catch (=MSY) target (TCATCH).

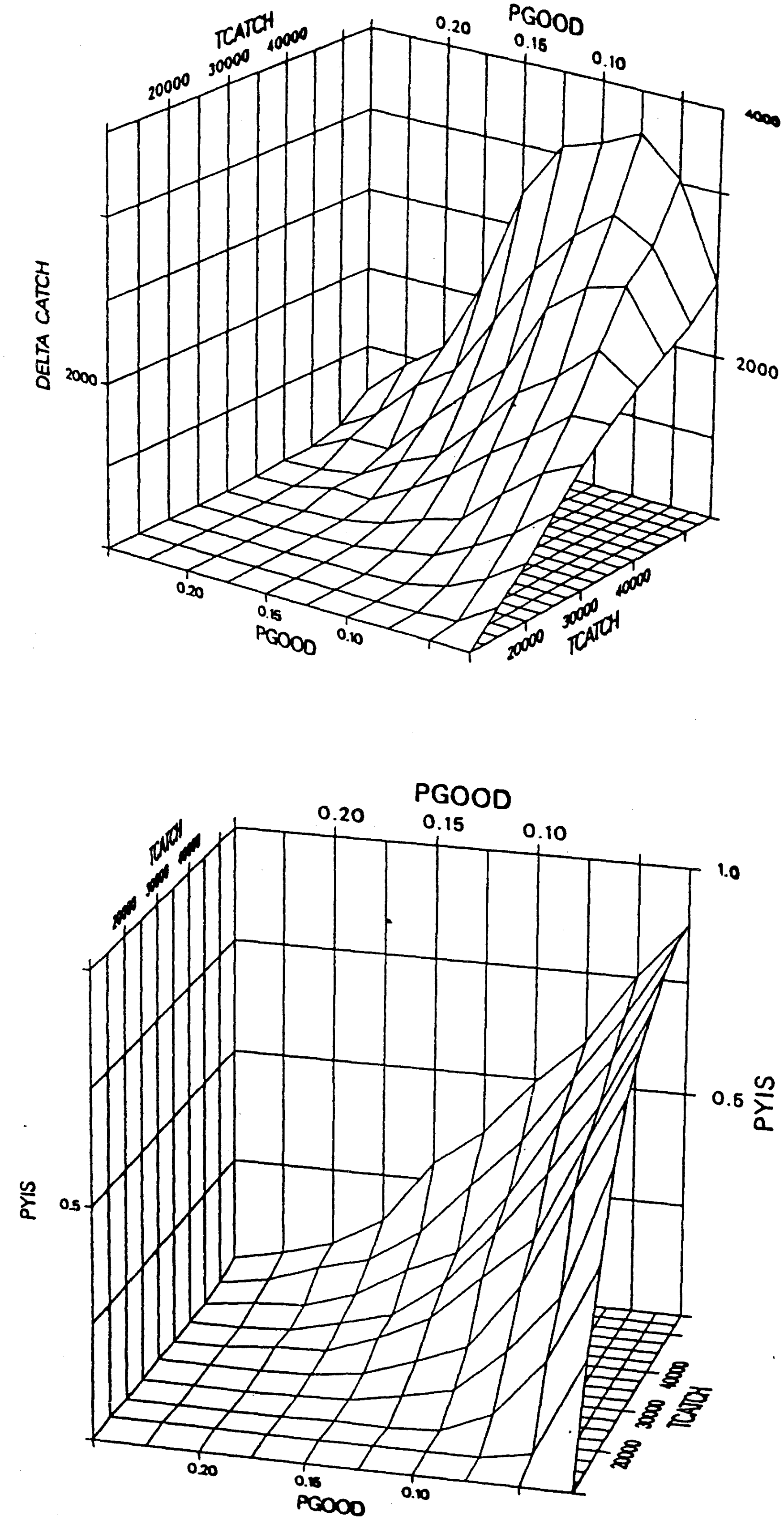


Figure 3.1.5. Simulated mean Delta catch (above) and proportion of years with insufficient harvestable surf clam stock to yield constant catch goal, as a function of the probability of good recruitment (PGOOD), and constant catch (=MSY) target (TCATCH).

3.2. SCUP ASSESSMENT UPDATE

Source Documents: R.K. Mayo, 1982. An Assessment of the Scup, Stenotomus chrysops (L.), population in the Southern New England and Mid-Atlantic regions. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 82-46, 59pp.

NEFC. 1986. Report of the Fourth Stock Assessment Workshop. Woods Hole, MA. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 87-07. 101pp.

3.2.1. Report

Fishery landings and stock abundance from the NMFS Inshore Autumn Survey and surveys conducted by the states of Massachusetts, Rhode Island, and Connecticut were reviewed in the 1987 update of scup. Inconsistencies among survey trends made interpretation difficult, but all of the data sets showed recent adult biomass at low levels. Estimates of total mortality (Z) from catch curve analyses of age frequencies from the Massachusetts and Connecticut survey catches had originally been reported as 0.59-0.64 for the early 1980s. Revised estimates, eliminating the few older age fish (Age 11+) taken each year, ranged from 0.6-0.8 for these years. Catches from both surveys in 1986-87 were comprised of fish less than age 8, resulting in total mortality estimates exceeding 1.0. Length-based analysis (Parrish and MacCall 1978) resulted in estimates from 0.8-1.1 since 1984. These estimates greatly exceed the 1980 estimate of 0.5 (Mayo 1982) and an historical level of 0.56 derived from the length-based method applied to 1929-32 New Jersey trawl survey length frequencies (Neville and Talbot 1964). Subtracting a natural mortality rate (M) of 0.2, present estimates of fishing mortality (F) range from 0.5-0.8. This fishing rate results in a stock biomass less than 10% that of the virgin stock, and age frequencies younger than age 10.

A Thompson and Bell yield per recruit model, discussed in the 1987 update, resulted in an estimate of $F_{max} = 0.38$. A Ricker stock-recruitment function fitted to the Massachusetts Survey data from 1978-86, with equilibrium lines for F=0.3-0.5 (Gulland 1983), showed that fishing rates exceeding 0.3 would result in decreased recruitment, and fishing rates exceeding 0.5 would ultimately lead to recruitment failure. However, since the data set was small and did not include parent stock levels near the origin needed to fit the inflection point, the alternative method of determining a replacement fishing rate (Sissenwine and Shepherd 1987) from the plot of parent biomass versus numbers of age 2 recruits two years later was used. This method was applied to three data sets: the NMFS Inshore Autumn Survey 1974-86, the Massachusetts Autumn Survey 1978-87, and the Niantic Bay (CT) Trawl Monitoring Program carried out by Northeast Utilities from 1977-87. Replacement fishing rates were estimated by comparing parent biomass per recruit ratios (slope of the line bisecting the plot) to biomass per recruit estimates from the Thompson and Bell model at various levels of fishing mortality. The three data sets resulted in estimates of replacement F levels of 0.35, 0.30, and 0.33, respectively. All methods therefore gave similar results, indicating that present mortality rates (F>0.5) are too high to be sustained. The truncated age frequencies seen in the Massachusetts and Connecticut surveys since 1985 may be the first evidence of an escalating mortality rate.

Possible management strategies which could be explored include implementation of a universal minimum length limit on the recreational catch throughout the range of the stock (presently only Massachusetts and Connecticut have 7 and 8 inch limits, respectively), and an assessment of discard mortality in the commercial fishery with recommendations for minimum codend mesh regulations to compliment a universal minimum length limit (presently only Massachusetts, Connecticut, New York and New Jersey have 7-8 inch limits).

3.2.2. Discussion

The Rhode Island trap fishery was discussed relative to discard mortality. It is a large fishery which takes fish before they spawn, possibly resulting in a substantial discard mortality. Experience with the Massachusetts trap fishery has shown little discard mortality when the fish are dip netted out of the trap.

The last two years of good recruitment were in 1978 and 1984. It was not certain if any good recruitment had occurred between these years. However, in 1987 the 1984 year class (3 years old) were no longer a significant part of the fishery. Even with high F's, recruitment is still occurring but few fish survive past age 4. The stock-recruitment plots utilized survey data; for example, the Sissenwine - Shepherd plots used biomass of age 2 and older scup in the survey versus age 2 scup lagged by 2 years.

It was suggested that Perry Jeffries' (URI) 30 yr. time series of trawl survey indices for scup be analyzed and possibly used to develop a stock-recruitment model. Another useful time series of data may be the Rhode Island survey of Mt. Hope Bay.

It was asked if the rise in F was attributable to any one of the fisheries. In the analysis three fisheries were used; 2 commercial (75%) and 1 recreational (25%). The commercial fisheries are comprised of the summer inshore (45%) and the offshore (30%). These percentages are based on landing in the late 1970's and early 1980's but it is possible that the recreational catch is increasing to the level of the commercial catch. Presently the recruitment pattern for the recreational fishery is 10% of age 1 and 100% of age 2. A change in this pattern will not affect F.

It was recommended that a minimum size of 7 - 8 inches be implemented if the plan wishes to protect 2 year olds. The hooking mortality is low for this size range and is not a problem if fish are well handled. One problem mentioned was that fisherman off Long Island have reported tremendous amounts of discarded small scup by vessels involved in joint ventures.

Table 3.2.1 Age Frequency of Scup taken in Massachusetts 1982-1987.

Frequency (percent)

Age: Year	2	3	4	5	6	7	8 & Up	Sample Size (per tow)
1978	29	43	15	10	2	0.4	0.9	19.5
1979	42	20	13	17	5	2	1.2	32.9
1980	48	15	11	14	3	5	7.1	16.6
1981	52	17	9	11	4	3	4.8	50.2
1982	50	26	9	12	0.7	0.3	1.9	9.5
1983	57	24	10	7	0.1	*	*	31.1
1984	36	16	13	16	5	2	3.6	8.3
1985	65	20	8	7	1	0	*	96.1
1986	70	22	9	2	0.2	0	0	34.5
1987	69	27	3	0.5	0.5	0.2	0	2.4

* = 0 < frequency < 0. 1

Table 3.2.2. Age Frequency of Scup taken in Long Island Sound 1982-1987.

Frequency (percent)

Age: Sample Year	1	2	3	4	5	6	7	8 & Up	Size (total)
1982	56	27	11	5.5	0.8	0.3	0.2	*	5,810
1983	70	12	8	6.2	1.9	0.8	0.4	0.3	4,080
1984	90	5	3	1.4	0.6	0.1	*	*	8,748
1985	82	13	4	0.8	0.4	0.3	0.2	0.1	9,235
1986	77	18	4	0.7	0.1	*	*	*	12,903
1987	63	33	4	0.8	*	*	*	0	5,571

* = 0 < frequency < 0.1

Table 3.2.3. Three-point moving average of annual estimates of total mortality for Massachusetts and Connecticut Survey scup catches by year.

	CATCH CURVE		LENGTH BASED	
YEARS	MASS	CONN	MASS	CONN
1978-80	0.65		0.57	
1979-81	0.57		0.93	
1980-82	0.54		1.13	
1981-83	0.61		1.33	
1982-84	0.60		1.00	0.83
1983-85	0.71	0.79	1.04	0.81
1984-86	0.93	0.83	0.86	0.86
1985-87	1.19	1.06	1.10	0.98

(Annual SE ~ 0.1-0.2) (L_r =15cm L_{max} =39cm)

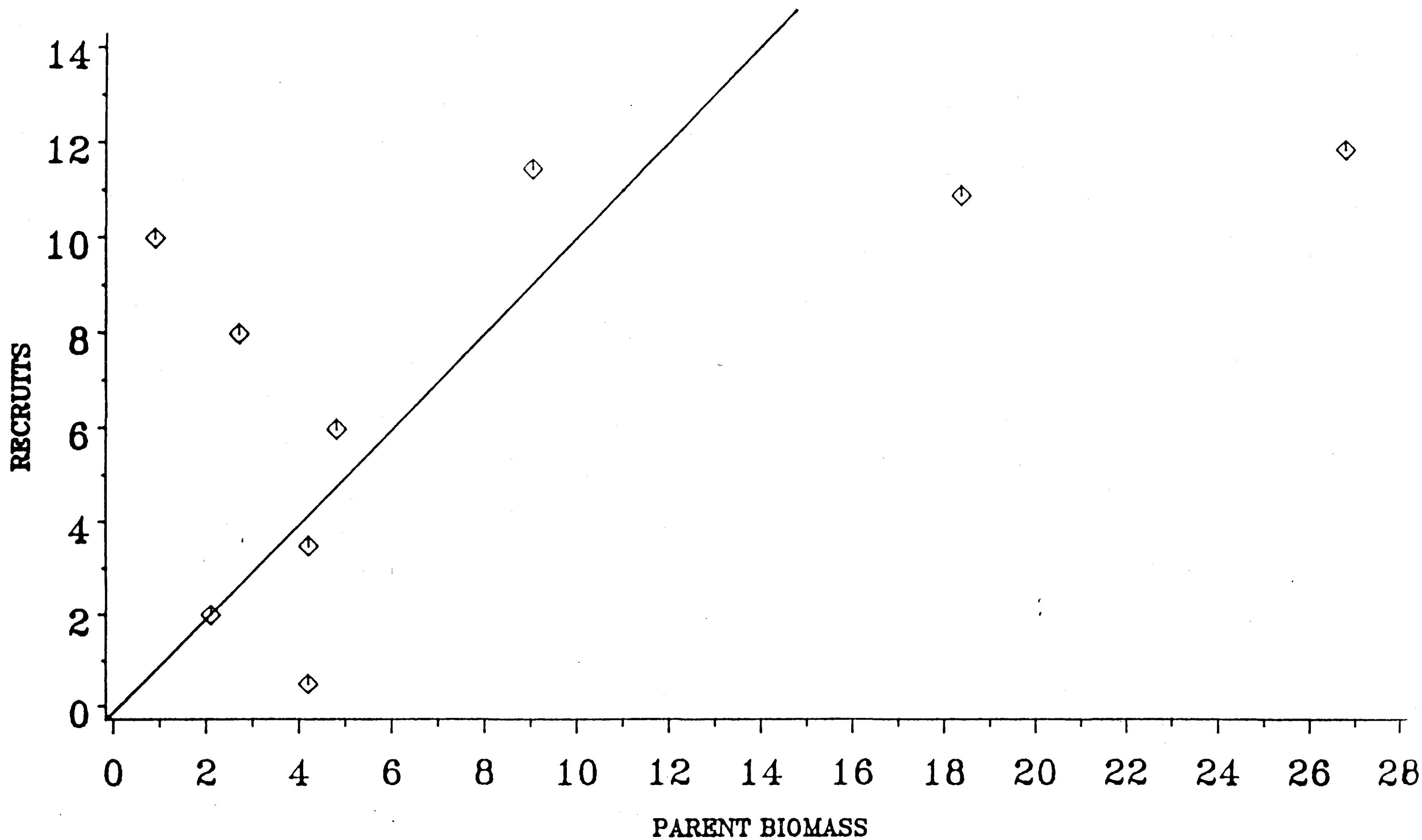


Figure 3.2.1. Scup stock-recruitment relationship showing 50th percentile replacement line. Data from Niantic Bay (CT) survey 1977-1987.

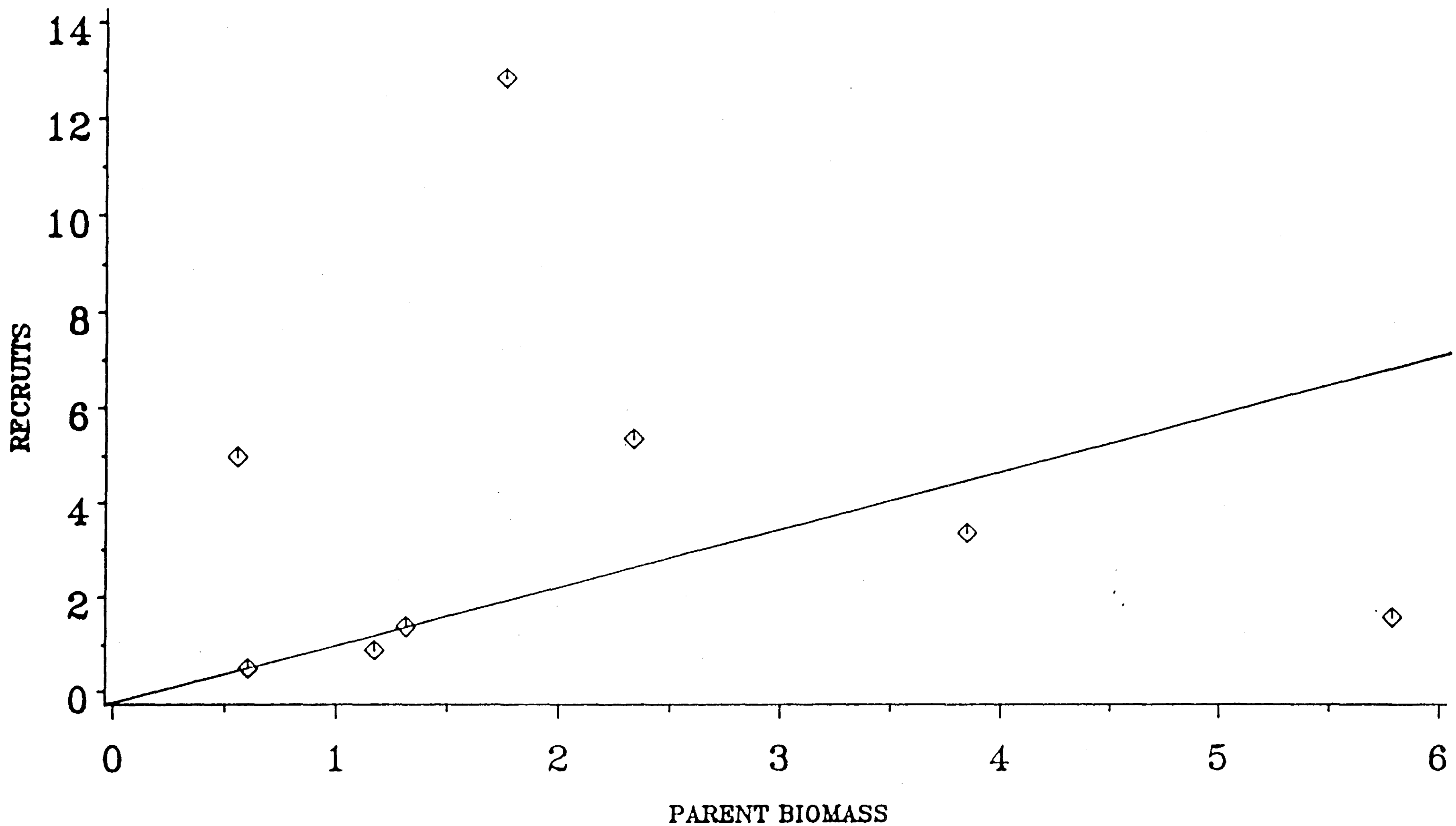


Figure 3.2.2. Scup stock recruitment relationship showing 50th percentile replacement line. Data from Massachusetts survey 1978-1987.

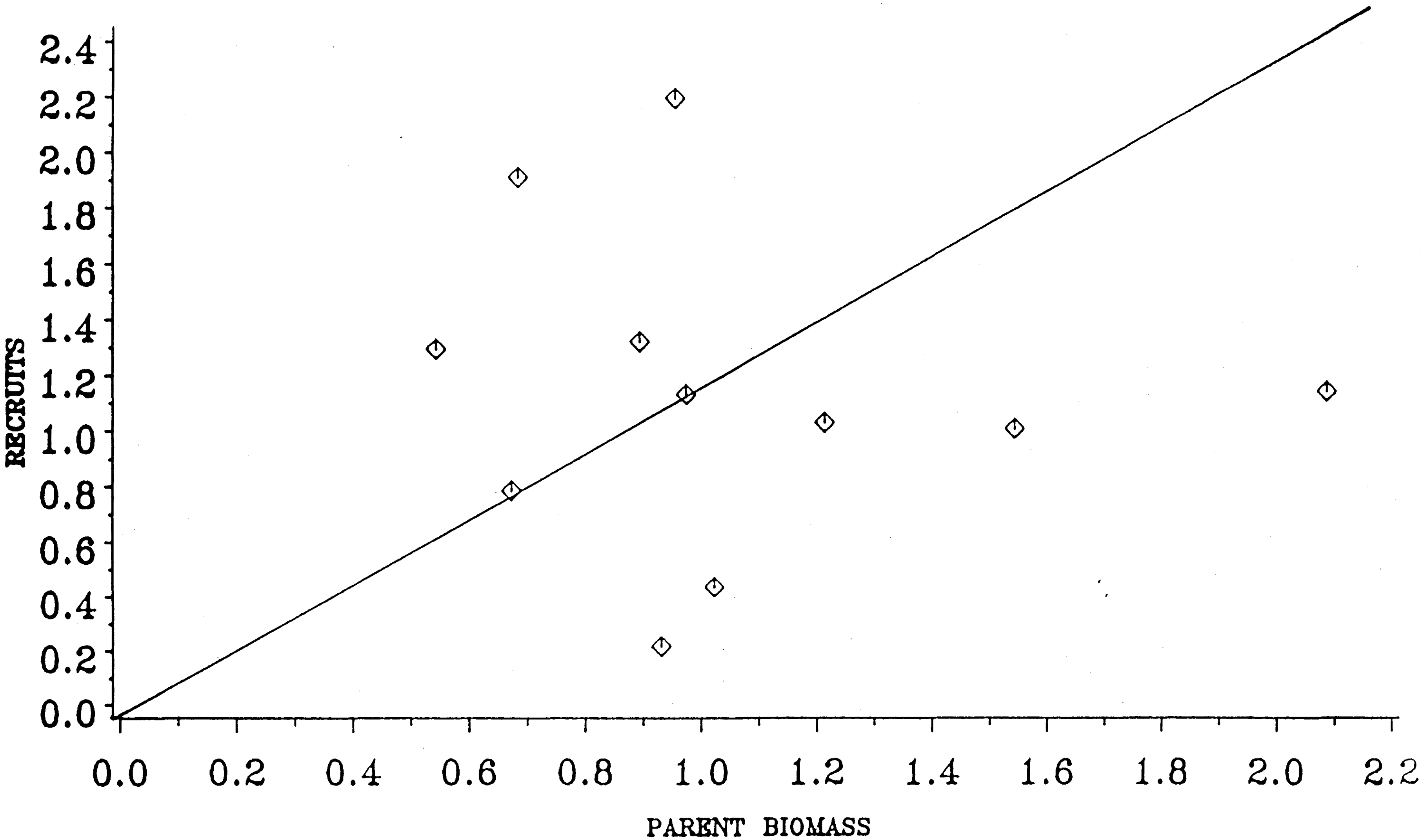


Figure 3.2.3. Scup stock recruitment relationship showing 50th percentile replacement line. Data from NMFS Inshore Autumn Bottom Trawl Survey 1974-1986.

4. COASTAL AND ESTUARINE FISHERY RESOURCES

4.1. REPORT OF CHESAPEAKE BAY STOCK ASSESSMENT COMMITTEE

Source Document: CBSAC 1988. Chesapeake Bay: Stock Assessment Plan. Available from Chesapeake Bay Liason Office, 410 Severn Ave. Annapolis, MD 21403.

4.1.1. Report

In recognition of the important values - economic, recreational, ecological, aesthetic, and symbolic - that are attributed to Chesapeake Bay living resources, the 1987 Chesapeake Bay Agreement contains an extensive list of commitments related to restoring and protecting the Bay's living resources. The Chesapeake Bay Stock Assessment Plan responds to one of these commitments:

> "by July 1988, to develop, adopt, and begin to implement a baywide plan for the assessment of commercially, recreationally, and selected important species."

The Plan was developed by the Chesapeake Bay Stock Assessment Committee, a federal/state committee sponsored by the National Oceanic and Atmospheric Administration (NOAA). Membership includes scientists and resource managers from Maryland, Virginia, Pennsylvania, the District of Columbia, NOAA's Fisheries, and the Estuarine Programs Office, as well as the US Fish and Wildlife Service.

This summary [from the Chesapeake Bay Stock Assessment Plan] highlights the conclusions and recommendations of the Stock Assessment Plan.

BACKGROUND

Stock assessment is the interpretation of fish population data for describing the status of fish stocks and for predicting the results of fishery management options. Stock assessment analyses take population characteristics such as growth, mortality, and reproduction and relate them to controlling factors which include fishing pressure and environmental stress such as climatic fluctuations, pollution, and habitat degradation.

Maryland, Virginia, and the District of Columbia have all been conducting stock assessments on selected species, but many of the ongoing programs are limited in terms of geographic coverage and range of species. The Plan concludes that existing programs do not constitute a comprehensive stock assessment program for the Bay and its tributaries, and it recommends routine, systematic assessments that provide long-term data for the critical life stages of finfish and shellfish species in the Bay.

WHAT DO WE KNOW ?

Chapter 2 of the Plan describes present knowledge of several representative Chesapeake Bay finfish and shellfish species. For some species, i.e. menhaden, there is adequate information upon which to make informed management decisions. Other species, such as the oyster, have not received the level of attention their importance would seem to warrant.

In general, there is sufficient basic biological information, but little reliable catch, effort, and recruitment data are available. This deficiency is significant because these data are the major types of information required for stock assessment analyses.

Stock assessment data needs include improved catch data, fishing effort data, and biological data (length, age, weight, sex) from commercial and recreational fisheries. These three categories are called "fishery dependent" data.

"Fishery independent" data are also necessary so that unbiased information essential for stock assessments is collected on juveniles and adults. Fishery independent sampling does not rely on commercial or recreational fishermen for collecting fish and is conducted through standardized surveys, such as the Maryland beach seine survey which is used to estimate a juvenile index for striped bass.

Short-term intensive research is also needed to understand the environmental and biological processes that affect growth, mortality, and reproduction within fishery stocks.

The Plan calls for baseline fisheries data that are 1) collected with standard methods Baywide, 2) precise and accurate, 3) representative of the distribution and abundance of Bay species, 4) inclusive of all major species and their critical life stages, and 5) long-term in scope.

PROPOSED PROCESS FOR IMPLEMENTATION

Approximately 100 people in over twenty organizations are currently working on some aspect of stock assessment in the Bay region . Research, monitoring, and management programs that contribute to stock assessments spend about three million dollars per year; most of these funds ($2.5 million) are administered by federal agencies, in particular NOAA and the Fish and Wildlife Service. Coordination of personnel and financial resources will be a key goal for implementing the proposed baywide data collection program and for conducting stock assessment analyses.

The Chesapeake Bay Stock Assessment Committee (CBSAC) was formed in 1985 to improve the coordination of technical stock assessment problems. The plan recommends that the Committee continue its coordination role and begin to oversee the active development of baywide stock assessments.

The major features of a baywide stock assessment program and recommended dates of implementation are summarized below.

Fishery Dependent Programs: July 1989

Initiate a baywide fishery statistics program to provide improved estimates of catch and fishing effort for each type of fishing gear and area of the Bay.

Outline procedures for collecting such data, to include the implementation of a trip-ticket system for commercial fishermen and more extensive recreational fisheries surveys.

Institute a program for obtaining species and age composition, as well as other biological characteristics of commercial and recreational catch.

Fishery Independent Programs: Spring 1989

Complete final design for a Baywide trawl survey to obtain fishery independent estimates of abundance and distribution.

Augment trawl survey with other sampling methodologies to obtain abundance indices for species and life stages not captured by the trawl survey, such as the ongoing beach seine surveys in Maryland and Virginia.

Develop research programs to investigate the effects of the environment on juvenile fish and shellfish populations.

Coordinate these surveys and studies with the Chesapeake Bay Program Baywide Monitoring Program.

Stock Assessment Implementation: July 1988

Chesapeake Bay Stock Assessment Committee (CBSAC) will have oversight responsibilities for Baywide Stock Assessment.

Maintain CBSAC working group roles for reporting on status of Bay stocks, investigating analytical techniques, and data management.

Establish new stock assessment working groups on finfish, oysters, and blue crab to begin immediately with the evaluation of available data and proposed sampling programs.

Produce annual reports on the status of stocks, fishery statistics, and periodic Baywide stock assessment reports.

4.1.1. Discussion

CBSAC is funded under a line item appropriation from Congress and relies on participating states to designate people with appropriate knowledge and expertise (state government, academia, and federal government) to serve on the committee and working groups. People serving on working groups are responsible for implementing the terms of reference for the group and producing some written reports (e.g., Fisheries Statistics Reports). At this time, an estimated 30 additional people are needed to implement the entire Chesapeake Stock Assessment Program. Some members of CBSAC serve on other committees within the complex of committees comprising the Chesapeake Bay Program. A first step will be to develop and maintain a unified bay-wide data base.

CBSAC research is funded under cooperative agreements. States are sensitive about funds going to NOAA. NOAA divides the available funds among four co-operative agreements, which forces competition between states with co-op agreements. A major problem is that not all institutions in every state are aware of the chance to participate in the co-op agreements and, as a result, there is a perception that the RFP (Request for Proposal) and funding is a closed process. This has been addressed by development of a list at the Washington level of all institutions to be mailed RFP's, in order to dispel the concern that some institutions are excluded.

States submit proposals for research under the Co-op agreements. If proposals do not address the RFP's, they are not considered initially. However, if money remains after relevant proposals are funded and the proposal receives favorable reviews, it may be funded. The Co-op agreements (900K) are monitored by Dr. Gabriel. There is concern regarding the confidentiality and format of the review process. The committee intends to revise the review process to include a format that will be more confidential and standardized than it has in the past.

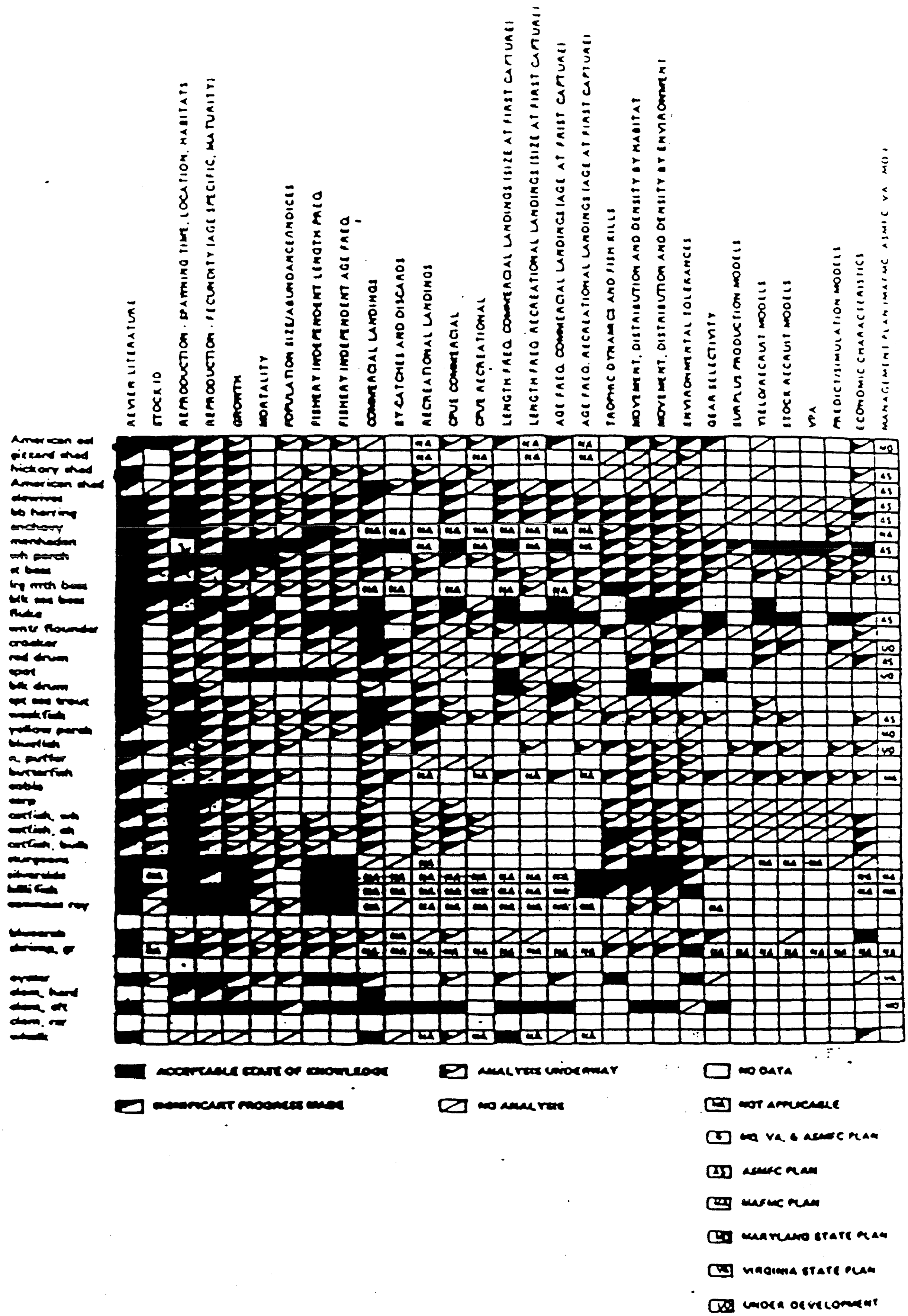


Figure 4.1.1. Status of knowledge (CBSAC SOSK Working Group, Jan. 1988)

The CBSAC Terms of Reference state that it will undertake a program for the baywide assessment of fishery resources that will partition the effects of fishing mortality, natural mortality, and contaminants on variation and trends in abundance. Specifically, the committee will:

- ✔ Identify and describe state and federal stock assessment programs
- ✔ Identify and describe additional data collection systems needed to characterize the future status of the stocks and explain their fluctuations
- ✔ Review fishery statistics needs and recommend programs to improve the current fishery statistics collection program
- ✔ Plan and integrate biological effects studies with stock assessments
- ✔ Recommend research projects
- ✔ Provide guidance to Sea Grant to insure that low D.O. and other biological effects studies on fish and shellfish are supportive of stock assessment studies

Figure 4.1.2. Terms of reference for Chesapeake Bay Stock Assessment Committee.

Chesapeake Bay Stock Assessment Committee

Fishery Dependent Statistics Working Group

Fishery Independent Statistics Working Group

Stock Assessment Working Groups

- **Mollusks**
- **Blue Crab**
- **Anadromous Fish**
- **Marine Fish**

Figure 4.1.3. Organization of Chesapeake Bay Stock Assessment Committee.

Program Responsibilities

Fisheries Management
VMRC
MD-DNR
PRFC
DC
PA Fish and Game

Applied Research
Academia
Sea Grant
State Marine Fisheries Agencies
Federal Agencies

Basic Research
Academia
Sea Grant

Data Collection Activities

Fishery-Dependent Data
Catch Statistics
Report Statistics
Biological Characteristics

Fishery-Independent Data
Abundance and Distribution
Disease/Pathogens
Stock ID
Age, Sex, Maturity, Growth, Fecundity
Mortality
Biological Effects

Analytical Activities

Data Compilation and Interpretation
Statistical Summaries
Time Series Analysis
Modeling
Impacts of Biological Effects
Status Reports

Chesapeake Bay Fishery Stock Assessments

Figure 4.1.4. Activities and responsibilities for the Chesapeake Bay Stock Assessment Committee.

5. SPECIAL TOPICS

5.1. STOCK ASSESSMENT IN NEW ZEALAND

5.1.1. Report

In October 1986, New Zealand implemented a comprehensive property rights system for fisheries management. Most of the country's fisheries were subject to individual transferable quotas (ITQ). Once established, each ITQ was to be valid in perpetuity as a fixed amount rather than as a percentage of an annually adjusted total allowable catch. The primary mechanism for varying quotas was for the government to enter the quota trading market. This could be an expensive process if quota-in-perpetuity was overestimated initially.

Prior to the advent of the ITQ system it had not been necessary to provide regular stock assessment advice in a formal, structured manner. There were few time series of fishery-independent data, basic demographic parameters had not been estimated for many species, the commercial statistics system was in its infancy, and research and computer facilities were limited. The stock assessment process has been in a continual state of evolution since 1985 when preliminary estimates of quotas were first calculated.

The research branch of New Zealand Fisheries now provides annual advice on the management of 31 species, comprising 167 "stocks" or management units. A structured framework has been developed for the provision of management advice. This has involved the formulation of biological reference points that take account of the fisheries legislation, the dynamic nature of fish stocks, the different amounts and qualities of data available for each stock and the practical difficulties of varying quotas from year to year. A two-tier approach has been used. The first tier specifies the maximum constant yield (MCY) that is estimated to be sustainable in the short to medium term. The second tier specifies a current annual yield (CAY) that could be achieved under a management strategy that tracks fluctuations in stock size.

It is intended that the first tier be used either when the stock biomass is unknown from year to year or when it is not feasible to vary quotas up and down from year to year. The second tier would be used whenever there is sufficient research to produce annual estimates of biomass. In general, but not always, CAY will be greater than MCY and the maximum average yield from a CAY strategy will almost certainly be greater than the maximum constant yield that can be extracted from a variable stock. Both tiers are related to the concept of maximum sustainable yield, as required by the New Zealand fisheries legislation. The first tier stresses the sustainable aspect of maximum sustainable yield; the second tier stresses the maximum aspect. The difference between the two is one way of assessing the value of research designed to estimate biomass.

Techniques for estimating MCY and CAY have been developed with the aid of standard stock assessment models, stochastic computer simulation models and surveys of results produced by other stock assessment agencies. In some cases it has been necessary to infer demographic parameters by analogy. MCY has now been estimated for all ITQ stocks and estimates of CAY are available for most of the major fisheries.

Since economic efficiency is part of the underlying rationale for property rights systems, there has also been an attempt to include bio-economic analyses in the stock assessment process. A number of generalized bio-economic simulation models have been developed for the purpose of investigating the effects of alternative management actions on net present value. To date, these models have only been used to evaluate decisions already made on some other basis. Formulation of an economic database and specification of an appropriate objective function and discount rate are necessary prerequisites to the proper integration of economic analyses in the stock assessment process.

3.1.2. Discussion

In the discussion following the presentation, a description of both commercial and recreational fisheries was given. The commercial fishery is composed of a traditional inshore component made up primarily of small vessels, while the offshore component, developed only 5-8 yrs ago, is prosecuted by large vessels in waters down to 1250 meters. During the first years of the offshore fishery, it was predominantly a joint venture fishery with vessels from Japan and Korea; however, there have been more New Zealand vessels in recent years. Traditional and recreational fisheries have generally been given precedence over commercial fisheries by managers.

The question of how major changes or improvements in the understanding of the biology or population dynamics of a species could be incorporated into the ITQ system was also discussed. It has recently been acknowledged that growth in orange roughy, a species supporting one of the most important and highest valued fisheries, is far slower than previously assumed. In this case, the effect should be a reduction in the value of quotas (without the government buying back portions of the quotas to keep the value up). However, it was stated that the government has not yet bought back any quota and it is too soon to determine the actual effect of this new knowledge.

It was also stated that a problem with the system was the speed with which it was introduced on the fishery. The time from which the ITQ system was proposed until its implementation was only 2-3 years, the result being that research and assessment information lagged behind and there is currently little data upon which to base many of the quotas. Quotas were awarded in most cases based on historical catches or individuals' investment into the fishery with little scientific information about long term potential yield.

5.2. STOCK ASSESSMENT AND FISHERY EVALUATION REPORTS:RELATIONSHIP TO THE STOCK ASSESSMENT WORKSHOPS

5.2.1. Report

The regulations and guidelines for implementation of the Magnuson Act are currently being revised by NOAA. The second national standard under Section

602 of the guidelines requires that the best scientific information be used in the fishery management process. A proposed amendment to this standard requires the preparation of a Stock Assessment and Fishery Evaluation (SAFE) Report for each stock or stocks managed as part of a fishery management unit. Proposed specific guidelines for SAFEs will be published in the Federal Register in the near future for public comment.

CONTENTS OF SAFEs

The latest information on what the proposed guidelines for SAFEs will contain is summarized here.

1. The SAFE report is a document or set of documents that provides Councils with a summary of the most recent biological, social, and economic conditions (past, present, and future) of the fisheries being managed under Federal regulation.

2. The SAFE report has to be prepared, and reviewed annually and changed as necessary for each FMP. The exact group responsible for preparation and overseeing review of the report is unclear (Councils? NMFS?). The Councils and NMFS have to participate in the preparation and review process.

3. SAFE reports should contain information that can be used for:

   - determining annual harvest levels for each stock,

   - documenting significant trends or changes in the resource and fishery over time, and

   - assessing the relative success of existing State and Federal fishery management programs.

   The SAFE report may also be used to update or expand previously prepared environmental and regulatory impact documents, and ecosystem and habitat descriptions.

4. Each SAFE report should contain information upon which to base harvest specifications, such as:

   - estimates of total biomass or spawning biomass,

   - annual surplus production, and

   - MSY,

   and should also contain information on how long it would take stocks to recover under various harvest levels and prevailing environmental conditions.

5. Each SAFE report should contain information on which to assess the

condition of the recreational and commercial fishing industries and fish processing industries, such as:

- estimates of the annual harvest, by category (commercial, recreational, joint venture, foreign, etc.),

- ex-vessel value of harvest,

- amounts and values of processed products,

- numbers of commercial vessels, by gear, type, and in terms of individual vessels,

- numbers of commercial fishermen employed,

- numbers of processing plants, individual and by product type,

- numbers of recreational fishermen, number of chartered vessels and party boats involved, and

- estimated value of the recreational fishery.

6. SAFE reports <u>may</u> also contain other social and economic information, such as:

   - history of enforcement actions,

   - significant changes in State regulations and their anticipated effects,

   - significant changes in the character of the fisheries,

   - potential conservation and management problems, their possible causes, and solutions.

IMPLICATIONS FOR SAWs

The requirement to produce SAFEs could have several implications in terms of conduct of the semi-annual stock assessment workshops.
<u>How much change will be needed in the SAW format?</u> Initially, SAFEs will have to be prepared for all stocks, which may cause a modification to the SAW format. After the initial shock, however, the SAW should be able to revert to its current format, perhaps in an expanded mode to handle more of the fishery evaluation aspects. The Northeast is probably much further along than other regions in this regard.

<u>Who will be responsible for preparation of each SAFE?</u> The wording in the guidelines has probably been left unclear on purpose. A protocol should be developed, probably on a stock-by-stock or FMP-by-FMP basis.

<u>Is the SAW process adequate for getting the SAFE information to the fishery management councils in a useful format?</u> Council staff attend SAWs, but does a

more structured process need to be established? What information transfer mechanisms should be developed, changed, or maintained?

5.2.2. Discussion

Discussion on the development of SAFEs revealed that the intent was to provide an historical perspective and accountability for the FMP decision makers. The frequency in which the SAFEs need to be developed may vary. It may be possible to develop an initial document and then provide an annual update. A first step necessary in developing and implementing SAFES is to define overfishing or required threshold levels. One problem is that SAFEs may require an updated assessment for all species even if such a detailed assessment is not currently available. Such requirements would be difficult given data limitations. It was agreed that, if SAFEs were developed in the SAW process, two or three times the present effort would probably be required to initially develop SAFEs, but the same groups (state, council staffs, academia, NMFS) would be involved. Also other groups would need to be involved (habitat, economics etc.) to meet the legal requirements of the SAFEs.

5.3. TRAWL SURVEY WORKSHOP RESULTS

5.3.1. Report

A trawl survey workshop for state and federal researchers was held in Woods Hole, MA on November 1-3, 1988. The workshop was sponsored by the Atlantic States Marine Fisheries Commission (ASMFC) and supported by the ASMFC and the Northeast Fisheries Center (NEFC). The purpose of the workshop was to provide a forum for information exchange and develop areas of cooperation among researchers. The agenda was designed to assist those who are planning to institute, as well as those who are presently conducting, fisheries assessment trawl surveys.

Individual reports describing present surveys and plans for new surveys were given for the states of ME, MA, RI, CT, NY, NJ, DE, MD, VA, NC, SC, GA, FL and the District of Columbia. NMFS personnel also gave overviews on the cooperative state-federal northern shrimp survey in the Gulf of Maine, the NMFS spring and fall surveys in the northeast and the south Atlantic cooperative state-federal SEAMAP trawl survey.

A series of speakers gave brief presentations then led discussion sessions on the following topics:

1. Trawl survey design.
2. Selection and standardization of sampling gears.
3. Data collection and processing.
4. Alternate and/or complimentary sampling techniques.
5. New applications for trawl survey data.

A summary discussion was held before adjournment and the following recommendations resulted:

1. New programs should be conducted in a coordinated manner.

2. Data should be integrated into regional data base systems; this was determined to be especially important for coastal migratory species.

3. Further workshops should be conducted by ASMFC in order to compare and calibrate the different gears used in different areas, and

4. ASMFC and NMFS should conduct periodic workshops and seminars geared toward upgrading fisheries personnel capabilities in data handling, management and analysis.

A comprehensive report of the workshop will be distributed by the ASMFC early next year.

5.3.2. Discussion

How abstracts of the workshop would be published was discussed. The ASMFC will publish a report of workshop proceedings but the possibility of a NEFC technical report was suggested. A greater commitment to editing by NEFC would be required for this to happen.

It was asked how many state surveys are ongoing and how many are planned. A push in the middle Atlantic states for trawl survey initiation was one of the motivations for the workshop and most of the planned surveys are from this region.

A need to explore means of cooperation, establish common data bases, and to standardize gear and procedures was expressed. Differences in vessel availability, bottom types, data needs, and a host of other factors will make complete standardization very difficult. There is however, more hope in standardizing data handling procedures.

As a related topic, the proliferation of assessment related committees within the northeast region was characterized as becoming extreme. Perhaps better coordination could lead to less time required by staffs of various organizations in meeting commitments.

It was stated that the workshop objectives were met in the sense that additional expertise was made available to various states.

5.4. NEFC TRAWL SURVEY STANDARDIZATION

Source Documents: Byrne, C.J. and Fogarty, M.J. 1985. Comparison of the fishing power of two fisheries research vessels. NAFO SCR Doc 85/90, 20 pp.

Byrne, C.J. and J.R.S. Forrester, 1987. Effect of a gear change on a standardized bottom trawl survey time series. Proceeding of Oceans '87 Conf. p.614-621.

5.4.1. Report

In 1980 a series of experiments was initiated to examine the relative fishing power of NEFC's two research vessels, the ALBATROSS IV and DELAWARE II. A completely randomized experimental design was conducted within 100 square nautical mile areas. Starting times for the tows were fixed, but tow directions and starting positions were randomized. Although study areas were carefully selected, these areas proved to be too large to assure species homogeneity. Given the limited number of tows that could be accomplished with the vessel time available, a paired experimental design to reduce variability was chosen for subsequent work. These experiments occurred during the Autumn Bottom Trawl Surveys of 1982, 1987 and 1988. Both ships employed standard NEFC survey protocol in making simultaneous paired tows. Results of the 1982 paired study indicate significant differences ($P<0.05$) in overall number caught of 32 species of fish and invertebrates. No significant differences in species composition or size composition of the catches were noted. Significant species specific differences in terms of weight and/or number were found for 8 of the 32 species examined. The R/V DELAWARE II appears to have a greater fishing power for more demersal species.

In 1983, it became apparent that the design of the standard NEFC trawl doors, obtained from a Norwegian company, was undergoing a slow but constant design evolution and that it would soon be impossible to secure "standard" trawl doors from that source. In response to this, the polyvalent trawl door that is in current use was selected as the new standard trawl door. An experiment was begun in 1983 to investigate the relative fishing power of the two trawl door types in anticipation of changing the standard doors. The experiment was set up as a paired tow design, but there was evidence of differences between the two ships. Therefore, a randomized complete block experimental design was employed in 1984. This experimental design accommodated combinations of door type and time of day and eliminated other confounding factors. This work was conducted in 25 square nautical mile areas (blocks). Due to a number of factors (primarily vessel and weather related), the work was unable to be completed before the polyvalent door were put into routine use during the spring of 1985. Analysis of the 1984 data shows highly significant differences ($P<0.05$) for a few species in both weight and numbers. In addition, differences appear to exist in catch rates for all species combined.

5.4.2. Discussion

The problem of using tows with zero catch was discussed. If both vessels did not capture a species it was a zero tow and was not used. If however, one vessel captured a species while the other did not, a value of 0.05 kg and 0.1 in number was assigned to the vessel with zero catch in order to meet requirements of the statistical analysis.

In answer to the significance of 1982 findings it was stated that catch conversion coefficients for 22 species were not significantly different from zero at the 95% level. There was a difference for ten species. It was also noted that during these paired trials ratios among species varied widely. This may be a function of variability in species behavior. Generally, the Delaware II caught more fish in weight and number than did the Albatross IV. The apparent differences in catch may be attributed to doors and warp. The polyvalent doors appear to spread and hold bottom better than the BMV doors in use on the Albatross IV and may catch a greater number of demersal fish. The towing warp on the Delaware II is larger in diameter and, given scope length, may add significant weight.

A question of sample size for those species with no significant differences during the 1984 trials was discussed. It was stated that in many of those species, sample size was large and that results did not seem to be related to sample size.

It was pointed out that negative confidence intervals which occurred for several species may be due to changes to zero values. Also, a log normal distribution was assumed but the possibility of other distributions will be explored.

When asked if it was possible to assess age group or size group differences it was noted that this had been done superficially for vessels - no differences found - but that it had not been done for doors. Size composition differences are important and the use of this data is critical because some management is driven by survey indices.

Although the work is preliminary, real differences may not actually exist or may be lost in the high variability of the survey data. There was concern about extrapolating results from a high intensity/low variability study (vessel comparisons) to a low intensity/ high variability study (survey).

It was stated that the door comparison trials may be extremely important in light of the imminent retirement of the Albatross IV. The question was raised if enough comparison data exists to be able to convert catch rates from the Albatross IV to the Delaware II then to future research vessels. The question was deferred until after the discussion of vessel comparison trials. However, there may be a need for more trials in the middle Atlantic and Gulf of Maine and more field work needs to be done with door comparisons.

6. BIOLOGICAL and TECHNICAL INTERACTIONS

6.1. REVIEW OF EEC MEETING ON METHODS FOR ASSESSMENT OF TECHNICAL INTERACTIONS

6.1.1. Report

An overview was presented by B. Mesnil (IFREMER, France) to introduce the main concepts and research perspectives. As an initial definition, it can be stated that technical (or harvesting) interactions arise whenever changing patterns of fishing a species component in a resource mix has effects on other components in that mix. Such interactions are recognized to be an ubiquitous problem, but are seldom addressed explicitly in the assessment and management process. This eventually causes frustration and non-compliance by the industry or even failure to achieve the management objectives. They involve various considerations, some of which are:

- The fleets are heterogeneous, with a variety of practices (gears, spatial or seasonal distribution of activities), preferences and constraints, and objectives.

- The distribution areas of the stocks overlap, widely at times, and every unit of fishing effort deployed onto the fishing grounds is bound to impact several stocks and different components (age groups, year classes, mature/immature) of a given stock.

- The stocks in a given area have different dynamics (patterns of recruitment, fluctuations of biomasses, sensitivity to environmental factors, etc.), and therefore different, if not conflicting, requirements in terms of conservation. They respond differently depending on which component is impacted or controlled.

- Whenever a gear is set in waters where several resource components are available, it creates a determined functional linkage between their individual dynamics. Different fishing strategies by different fleets generate a variety of interactions which can be decided upon to some degree by changing the structure and pattern of activities of the fleets.

- Technical interactions are also relevant in the single-species context and may occur, although the fisheries are segregated in space and/or time (e.g.; fisheries on nursery grounds vs. fisheries on spawning concentrations).

- None of the single technical measures are sufficient to fulfill either conservation or optimization objectives. TACs (potentially) and licenses control overall effort, not the distribution of mortalities at age; gear selectivity is not simply a matter of mesh or hook size, discards are legal under most regulations. As this is true in the single-species context, it is no wonder that they are less effective in multiple-stock fisheries, as exemplified in the TAC compatibility issue.

- Preserving the balance of equity among fleet components entails an account of all the resources on which they depend for their revenue and consideration of the costs and opportunities of alternative targets.

In many respects, there are conceptual similarities in the treatment of the fleets and some species of predators. Both may refer to the concepts of catchability, effort (predator stock size), targeting, preference and flexibility, and may imply the collection of analogous data. The existence of biological interactions is as unquestionable as that of technical interactions, but it seems that there are few instances in which management advice would be seriously distorted if they were simply added to the residual noise. The interactions also raise problems of cost and precision of the data, especially due to the large variability among years, seasons and areas, and of robustness of the models due to the unavoidably large set of parameters. However, incorporation of predator-prey interactions is desirable in the long run, especially if the data and models can be made available and used routinely at a reasonable cost.

The idea behind the technical interaction approach is to evolve from stock assessment towards fishery assessment. The principle entity is taken to be the fisherman, or more generally the vessel or fleet, both as the actor and as the beneficiary of the fishing activity. Moreover, the system is regulated by means of quantitative and qualitative control of fishing mortality, and this control variable is best materialized by the fleet components. This is why we may prefer to structure the problem from the viewpoint of the fleets, instead of from that of the stocks which are controlled indirectly.

To date, biologists have had a major input into the advice provided to fisheries management agencies. As long as this prevails, pros and cons of taking a species-oriented or fleet-oriented approach are quite balanced. Now if we think that it is time to incorporate social and economic considerations into the advice, the latter provide the best interface between biological and economic models, and are most suitable to take account of the stratification of costs, revenues and manpower which is essentially fleet dependent.

APPROACHES

The considerations listed above indicate that the assessment of fisheries is very much a problem of analyzing a system with two sources of heterogeneity, one due to the fleets and one to the stocks, resulting in intricate interactions. The challenge is to arrive at a sort of classification (or stratification) into subsets which are sufficiently consistent internally with respect to the terms of reference of the analysis, and in limited number to preserve tractability.

Still, we have two points of views : one which favors the fish and consists of defining time/space strata with consistent species assemblages, while the other puts more emphasis on the vessels and allocates them to groups depending the similarity of their fishing characteristics and strategies. Arguments can be found to support both. We may prefer the latter on the grounds that entities defined relative to vessels have more persistence and stability, and can be practically perceived and controlled. An important point is that the classification should result in a clear delineation of the groups used in the assessment, and enable managers to assign to these groups the objects which they have to manipulate or decide upon in a straightforward and unambiguous manner.

The concept (if this is a correct term for an instrument which has more practical than theoretical basis) of "mètier" emphasized by the EEC Workshop is one attempt at defining such operational groups for the needs of the analyses. It embraces consideration of the gear and vessel characteristics, of a typical distribution of fishing in space and time, of a target (group of) species; it is both more precise and more flexible than the notion of fleet.

The prime concern in establishing the groups is to arrive at within- and among-species catchability matrices for each mètier which encapsulate the essential properties of the mètiers for modelling and assessment purposes, especially for predictions. Pending an account of individual fishing power of vessels, variations of effort deployed in each mètier are easily translated into variations of the fishing mortalities onto the species of interest and, to some extent, changes in the directivity of fishing can be quantified by transfers of effort from one mètier to another one.

Flexibility is an important feature in the classification. The groups which are eventually considered in the assessments are bound to vary in nature and composition depending on what question is asked to the analyst. If it is to evaluate the implications of a technical measure (i.e. mesh size of trawls), then the vessels which are unaffected may be pooled into a "non-trawl" group. If it is to find a regional management plan, vessels impacting the stocks' components laying outside the region or having alternative fishing opportunities there, might better be aggregated in an "outsiders" mètier. Bio-economic analyses may imply that the groups be broken down further to take account of the structure of price and costs. These requirements may imply that very disaggregated data be stored in databases, and efficient methods be designed to consolidate these into whichever grouping is deemed relevant for a given analysis.

THE TOOLS

The toolbox used to manipulate the entities defined in the classification contains a number of simulation models for either analysis/evaluation or predictions. The report of the EEC workshop lists typical implementations of multiple-species, multiple-fleet simulators, and the essential points of their construction and recent developments.

As previously mentioned, mixed-fisheries models must by necessity be disaggregated to rather fine levels with respect to stock and fleet components, and this implies a multiplication of the number of parameters. A compromise must be found, but it is essential that the share of and implications for each fleet subset be clearly spelled out. This is the key to eliminate those management regulations which are so drastic for some operators that they are socially or politically unacceptable and therefore unlikely to be implemented. The biologist is also interested in checking that management schemes which are economically advisable do not endanger any of the resource components. The typical output of the models is a double-entry table, one for the resource components, one for the fleet components.

Evaluations of the interactions between mètiers and the appropriateness or desirability of technical measures are best carried out using long term equilibrium models. By analogy with sensitivity analyses, some consider the effects on each mètier of small (1-10 %) changes of the effort multiplier in the others. Interaction plots of individual or overall yields obtained under large ranges of effort multipliers also add to the understanding of the fishery and of the essence of the interactions (sequential, competitive, ...).

Short- and medium-term simulations are best suited to spell out the practical implications of enforcing measures which were deemed advisable in principle in the equilibrium analysis. They compliment the assistance to decision-making with the evaluation of timeliness, severity (social or economic impact), constraints, and planning of stepwise implementation. Stochastic simulations are a useful approach to make explicit the inherent dimension of risk involved in management decisions. This is a case where good biological studies are needed to evaluate the form and amplitude of variability in growth and recruitment of the various species. There may be a great deal of unpredictability in the decisions by fishermen regarding the choice of a given mètier or in their response to the implementation of regulations.

In recent years, length-based models have been used to evaluate the impact and implications of changing legal mesh sizes and minimum landing sizes, and also to incorporate a large range of species in the assessment by use of comparatively cheap catch-at-length data. They were multiple-fleet to allow for variable current sizes (or non relevance of such measures) and multiple-species to consolidate the gains and losses over all components of the resources fished by each mètier, but were inherently of the equilibrium type, with results given as immediate effects and long term expectations. It was thought that this was insufficient to evaluate the implications of changes of mesh sizes since such simulations gave no clue to the time required to compensate the immediate losses or the accumulated losses over the interim period, although these might be critical for some fleets. The idea of building a length-based short/medium term simulation tool was proposed during the EEC workshop. Eventually, the option of using transition matrices was abandoned as being too complicated, and the prototype of an hybrid age-length model using current length at age distributions in the catches for each mètier to distribute the simulated F's at age over lengths is under development.

Most existing prediction models compute the effects of user-specified scenarios regarding the amount of effort and its distribution by mètier. In a simpler form, the basic element of the model is the 3 dimensional (species, mètiers, ages or lengths) matrix of catchabilities, and effort is allocated to or swapped among mètiers. A refinement is necessary when the study is focussed on fleets that can practice several mètiers ; an effort allocation matrix must be set up on top of the Q matrices to distribute the simulated effort by each fleet among the possible mètiers. The ultimate fisheries model is one in which, instead of being preset, the effort allocation matrix is calculated at each time step with reference to some decision rules and depending on current results (catch rates, profits, etc.). This is the option implemented in the model SIMUCEL, also suggested by Hilborn and Walters (1987), which might be incorporated in the forthcoming model for Gulf of Maine fisheries. One may think of another step forward that would allow for variable sizes of fleets (investment/decommissioning), while the existing attempts deal with a fixed number of vessels.

A major problem remains with the inability of basic population dynamics models to deal with spatial heterogeneity in the distribution and composition of the stocks, although the situation is common in the field, and therefore allow evaluations of such favored measures as box closures. Also, spatial distribution of effort is a strong component of the fleets' tactics, depending on costs involved, fishing time vs. sea time ratios, frequency of landings, etc. The problem is being addressed by the EEC Working Group on improvement of the exploitation patterns in the North Sea, and some elements are mentioned by Hilborn and Walters (1987). Basically, one would need matrices of dispersion coefficients enabling redistribution, at given time intervals, the survivors of each species at each age among the different areas. Such matrices could be set up by processing tagging data in a suitable way. Unfortunately, tagging experiments were seldom carried out with this objective, so the results would be of little use, since the size of the matrices may be untractable if there are too many compartments and species-ages. A possibility is to use data from adequate surveys to set up a seasonal (quarterly would generally be sufficient) mapping of the age groups and species. In default, we might have to continue with the current substitute, which is to try and incorporate the spatial component into the definition of the métiers (especially if the essential aspect is differential distribution of young and adult fish) and possibly refine this by using a seasonal disaggregation of the data and models with a quarterly time scale.

Lastly, the essential requirement is that of appropriate data. It has been recognized that the availability of discard data is critical in the evaluation of technical interactions, as fish which are currently discarded constitute the main reservoir for potential gains in the fishery system and the node of linkage between the competing metiers.

6.1.2. Discussion

It was noted in response to a question on incorporating spatial patterns that the importance of spatial considerations in modeling of technical interactions should be considered early on in the exercise.

Sample sizes needed to conduct species mapping studies were discussed, with particular reference to NEFC survey data collected using a random sampling design. It was stated that an adequate survey pattern should provide a good data set for mapping. It was noted that previous mapping of NEFC data has shown some biological interaction patterns, but the analysis have not been followed up. For example, the distribution of year-classes may be different depending on their relative sizes.

The poor seasonal resolution in the NEFC data was mentioned (i.e. few winter and summer surveys). The survey was originally designed to track relative abundance. Also, the spatial resolution needed for modeling (gross level) is different than that needed for management (fine level). The seasonal/spatial distribution of Atlantic herring was incorporated in the New England Fishery Management Council's late 1970's Atlantic Herring Fishery Management Plan.

5.2. TRENDS IN DIRECTED AND MIXED CATCH AND EFFORT IN THE NEW ENGLAND OTTER TRAWL FISHERY 1982-87

5.2.1. Report

An understanding of the extent to which vessels are capable of directing their effort towards specific species or stocks is fundamental to developing abundance indices from commercial catch data in mixed species fisheries and for evaluating the possible effects of various management options. Analyses of the landing composition on a trip basis for the New England otter trawl fishery were presented to provide insights into the directedness of this fishery and possible temporal trends in directed effort.

Landings for the 10 principal groundfish species (i.e. American plaice, cod, haddock, pollock, redfish, silver hake, winter flounder, white hake, witch flounder and yellowtail flounder) caught in the otter trawl fishery were examined. In 1982, these species accounted for 85 to 95% (depending on vessel size) of all otter trawl landings. These percentages have declined in recent years, especially for vessel class 2 which had only 60% of the total landings accounted for by these species in 1987.

The percentage of trips with no principal species dominant ranged from 35 to 60%, indicating that a large fraction of the trips had a mixed species composition. These percentages tended to be higher for the Gulf of Maine than for Georges Bank and have been increasing in recent years. The fraction of the total catch for a species represented by these mixed trips varies greatly among species and less between areas and vessel classes. However, for all species except silver hake, the fraction of the total landings in mixed trips usually exceeds 30% and for many species exceeds 50%. The trips with no dominant catch would not be considered directed trips as traditionally defined in many assessments, yet they represent a significant fraction of all effort being expended in the otter trawl fishery.

In most trips dominated by one of the principal groundfish species, the fraction of the total catch of a species caught as by-catch in trips dominated by another species was small. In other words, most of the by-catch for a species is accounted for by mixed trips or trips in which that species is dominant. The one exception was winter flounder, which had a large fraction of total landings from cod dominated trips.

Vessel performance, defined as total catch per day fished, revenue per day absent and average trip length, were always somewhat lower in mixed trips among vessel class 4. The greatest relative difference was in revenue per day absent between mixed and dominant trips and has increased in recent years. In 1987 the difference was about 20%. For vessel classes 2 and 3, there were no consistent differences in catch per day or average trip length between mixed and dominant trips, while dollars per day absent in mixed trips for vessel class 3 (but not vessel class 2) was consistently less than in dominant trips.

5.2.2. Discussion

Discussion focused on the specific applicability of results given the aggregation of semi-discrete fleet components that may operate in small areas during specific seasons. Re-analysis of trends in directability, in light of the definition of fleet components ('metiers'), would be important in resolving the sensitivity of the overall conclusions to the level of spatial and temporal aggregation of mixed-species catch and effort data.

The assumption of directability based on a single species was also discussed. It is possible that the fleets may target two co-occurring species (e.g. cod/winter flounder, etc.), three species, etc. Re-analysis based on these assumptions of multispecies targeting may result in different conclusions. Such analyses were the basis for mixed-species fishery definition studies conducted several years ago, utilizing numerical classification techniques applied to mixed-species catch and effort disaggregated in time and space.

The question of fishermen's behavior was discussed as it influences the degree of 'directedness' of fishing, as opposed to the 'dominance' of individual species in mixed catches. The catch of a particular dominant species may be somewhat probabilistic, particularly when fishing a highly mixed resource. The interpretation of such trips as 'directed' may lead to incorrect conclusions, particularly with respect to time-series CPUE analyses.

It was further noted that the general increase in the mixed nature of catches as opposed to directed species fishing may reflect changing patterns of species discarding, with a wider variety of species/sizes being returned in more recent years.

6.3. AN ANALYSIS OF TECHNOLOGICAL INTERACTIONS AMONG GULF OF MAINE FISHERIES - OUTLINE AND FRAMEWORK

Source Documents: Anonymous. 1987. Assessment of technical interactions in mixed fisheries: Report of a workshop held at IFREMER in Nantes (France) under the auspices of EEC (DGXIV) European Economic Commission Published Report 15.

Murawski, S.A. 1984. Mixed-species yield per recruitment accounting for technological interactions. Can. J. Fish. Aquat. Sci. 41:897-916.

Shepherd, J.G. 1988. An exploratory method for the assessment of multispecies fisheries. J. Cons. int. Explor. Mer 44:189-199.

6.3.1. Report

Gulf of Maine (Figure 6.3.1) demersal fisheries utilize about 20 species of finfish and invertebrates, of which the top six accounted for about 60% of the landings in 1987. In recent years pollock was the predominant demersal fish, with silver hake, cod, and American plaice the most important species in particular years since 1976. Total landings from the Gulf of Maine demersal fisheries (Figure 6.3.2) have trended downward in recent years, with an overall doubling of trawl fishing effort since 1976, and a recent significant increase in gill net fishing. Multispecies CPUE has been reduced dramatically since the late 1970s. Although trawling is the most important gear used in the Gulf of Maine demersal fisheries, other gear types, including gill nets, set lines, and recreational fishing, account for a portion of the overall landings. Within the trawl fisheries there are two major categories: small mesh (<140 mm) and large mesh. By regulation, small mesh fisheries are limited to nearshore Gulf of Maine waters (Figure 6.3.1), which are generally important juvenile nursery areas for demersal fishes such as flounders, redfish, haddock, and cod.

NEFC researchers are currently developing an analytical modeling approach for assessing mixed-stock resources exploited by multiple fleets. The objectives of this effort are several-fold. Because of the recent declines in demersal resources supporting large-mesh fisheries (e.g. haddock, flounders, cod), there is increasing speculation as to the impacts of discards from small mesh trawling (for northern shrimp and hakes) with respect to mortality rates on sub-marketable sized groundfish. NEFC will initiate an intensive at-sea sampling program aboard commercial fishing vessels in early 1989. This program will provide estimates of the species composition, weight, and size distribution of discards from both small and large mesh fisheries, as well as other data previously unobtainable by sampling fishery landings. The modeling studies underway will provide a framework for the collection and analysis of such data, to ensure that the at-sea data collection activities provide the necessary data to evaluate the significance of discarding with respect to fishing mortality rates at age. Once age-specific rates of fishing and discard mortality have been estimated for each major fleet component, the model under development will allow managers to assess the impact of changes in mesh size, minimum landed length, fishing effort allocation among component fleets, and catch quota controls on yields of the individual species and the mixed-species resources as a whole. Simple price/abundance relationships for the species will allow for evaluation of the impact of various combinations of the above management measures on total revenues from the fishery. Ex-vessel values for resources such as witch flounder, winter flounder and haddock are several times those of the hakes, pollock and redfish (Figure 6.3.3). Thus, management schemes resulting in maximum revenue from the system may not necessarily be similar to regulatory scenarios generating maximum catches.

The model currently under development combines elements of mixed-species yield per recruitment analyses developed for fishery systems on Georges Bank, in the North Sea, and the Celtic Sea (see Sources above). Specifically, the analysis incorporates: (1) appropriate seasonality of fisheries, (2) catchability coefficient matrices for fisheries/species, (3) explicit stock/recruitment relationships, (4) surplus production relationships for species with inadequate age/size structured population dynamics data, (5) estimates of fishing mortality for stocks that are fished outside of the Gulf of Maine during some portion of the year, (6) variable spawning times for the species in order to compute realistic spawning stock biomass estimates, (7) variable ex-vessel prices as a function of landings, and (8) explicit estimates of discards as fishery yields accruing no revenue.

6.3.2. Discussion

Discussion centered around the importance of including economic information in the model and the difficulties in accounting for stocks with little age-based assessment data. It was considered very appropriate and timely to include economic aspects in the model but caution was needed in using the data. Price data alone would not answer the needs of a truly 'bio-economic' model. The objective function in the model should address the optimization of both biological and economic aspects of the fishery. The lack of adequate biological data needed for assessments of many of the stocks to be included in the model was recognized but the problem could be addressed in the construction and implementation of the model. By developing a framework model, information can be added in increments as it becomes available. Also, in constructing the model, areas of needed data and/or research may be more readily identified. Already this framework will be useful as a guide in defining data needs from the new sea sampling initiative scheduled to begin in January 1989. Questions were also raised about the impact on model results from changes in accuracy of the reported data due to recent management measures. It was felt that sea sampling may help address these problems.

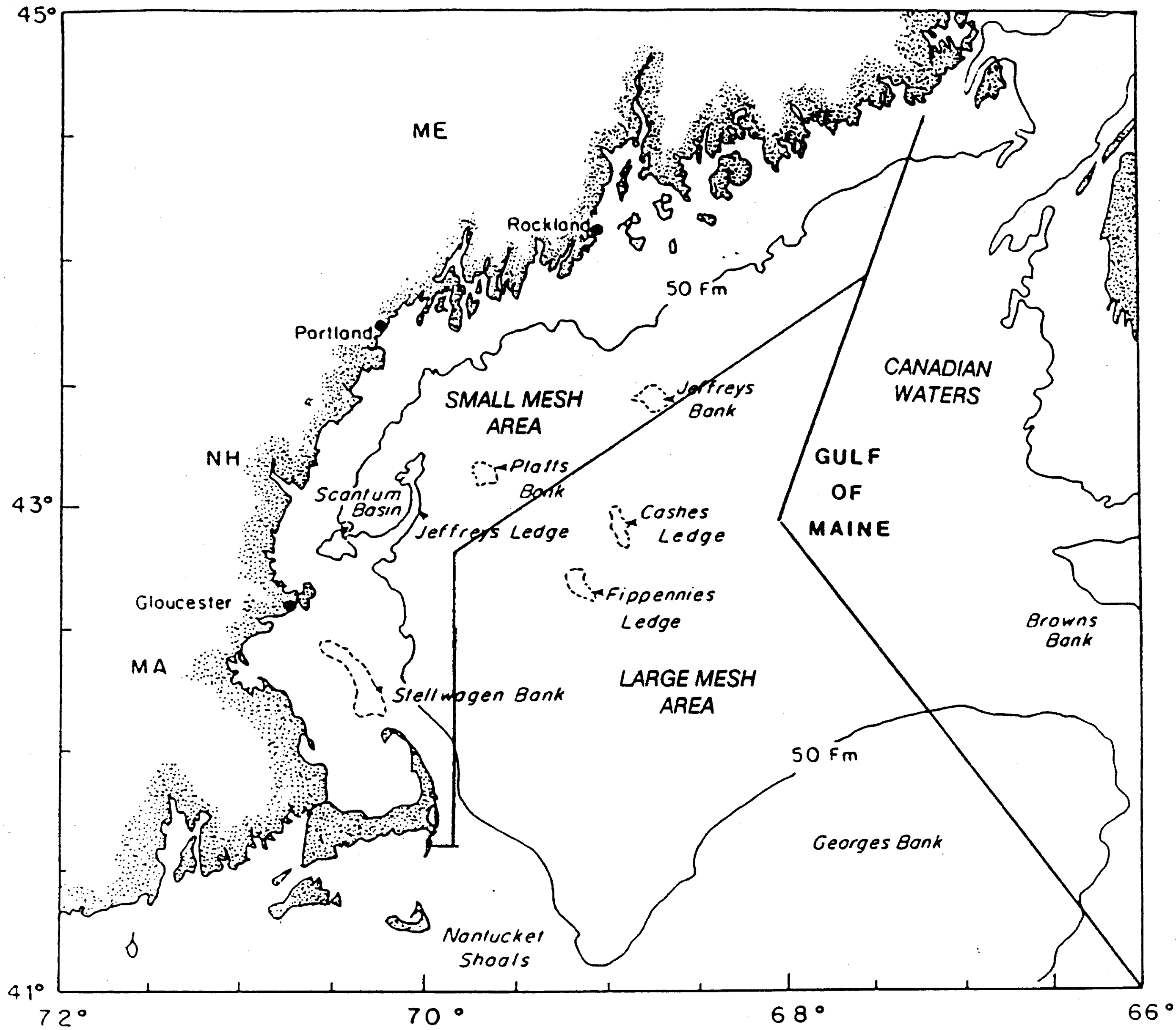


Figure 6.3.1. Chart of the Gulf of Maine region showing geographical boundaries of regulated large mesh area (>140 mm), and exempted small mesh fishing area in nearshore waters. The US/Canada maritime boundary is also shown.

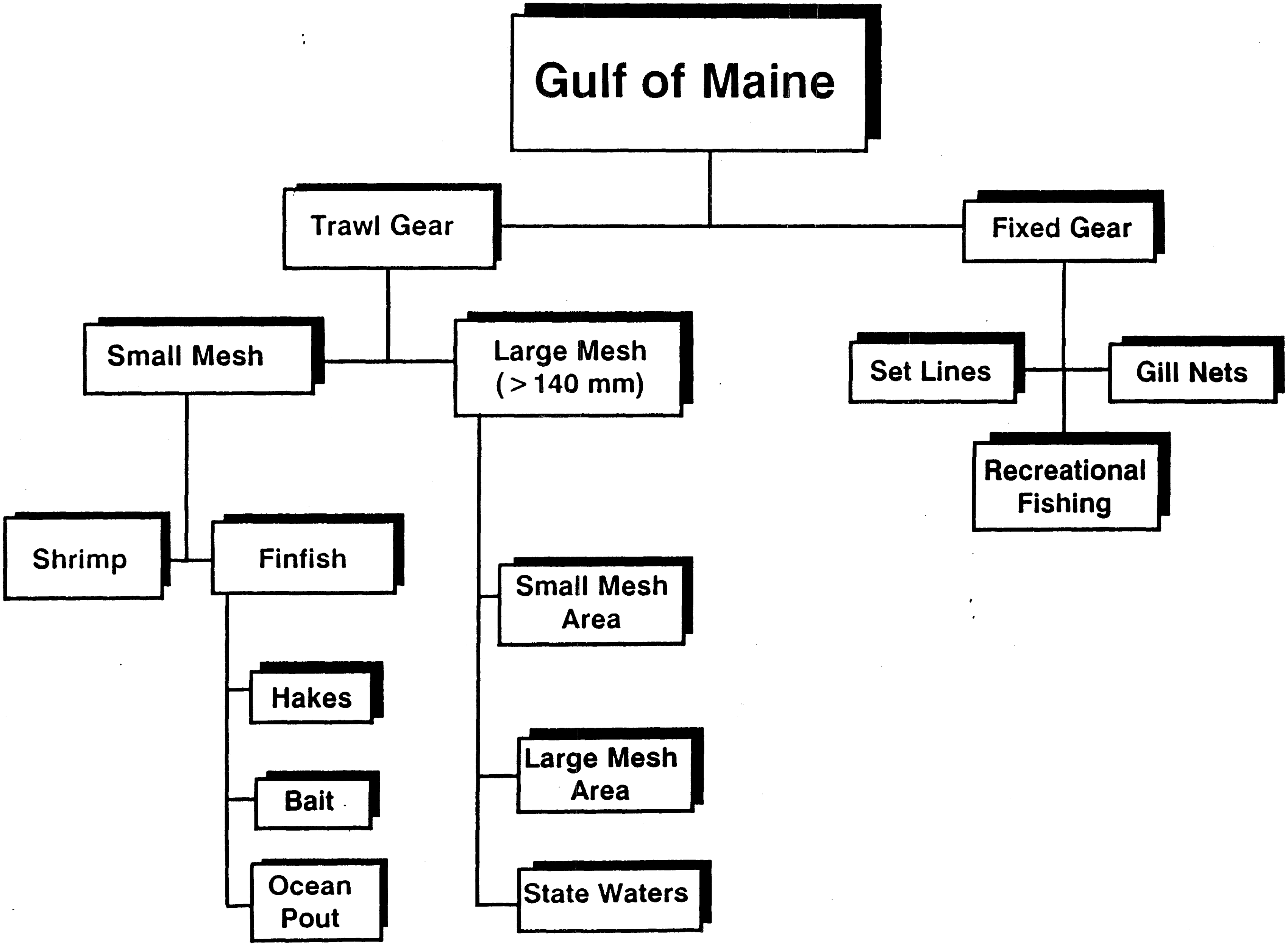


Figure 6.3.2. Structure of fisheries in the Gulf of Maine Region harvesting demersal and benthic fishery resources.

Figure 6.3.3. Ex-vessel value per ton ($) of selected demersal fishery resources from the Gulf of Maine region, 1987.

6.4. IMPACT OF PREDATION ON THE PELAGIC FISH ECOSYSTEM OFF THE NORTHEASTERN USA: PRELIMINARY RESULTS

6.4.1. Report

An age structured simulation model, incorporating stochastic recruitment, was constructed to investigate the impacts of major predators on the pelagic fish community on the continental shelf off the eastern USA. Ten species of marine mammals, composed of humpback, fin, and minke whales, six species of smaller odontocetes and harbor seals, three species of seabirds and four piscivores were included in the analysis. The objectives of the model were to better understand the magnitude and composition of natural mortality attributable to various predators on the pelagic fish community. Further goals included exercising the model to evaluate management objectives on a regional basis in the context of a dynamic ecosystem, and assessing the impact of a potentially large biomass of marine mammals and seabirds. The model includes seasonal and age specific predation and is constructed so that different functional feeding relationships can be incorporated into the model structure.

Preliminary results suggest that natural mortality rates on the youngest age groups of fish in the pelagic fish community are much higher than previously thought. Consumption accounts for far more biomass on an annual basis than present harvests; consumption of mackerel for instance is about 2 times the present harvest. Piscivorous fish probably account for most of the mortality in this system followed by marine mammals and seabirds. Although individual species of marine mammals by themselves do not consume a very large quantity of fish from this ecosystem, total consumption by all marine mammals is significant. Simple management decisions, such as an increased fishery on a prey species, predator reductions, or protection of marine mammal populations, will be investigated. General theories of predation by mammals and fish will also be evaluated.

6.4.2. Discussion

Discussion focused on the potential inclusion of large pelagic fishes such as tunas and billfish in the model. It was noted that large pelagics are primarily resident on the northeast continental shelf in summer and early autumn, whereas the primary prey resources (mackerel and herring) move northward and are concentrated in the Gulf of Maine and the Canadian Maritimes during warmer months. Thus, there may be little spatial overlap among these resources. Literature review of feeding data for tunas and large sharks indicate relatively little consumption of mackerel, herring and sand lance, although it was noted that these prey items have occurred in some studies. Personnel from the Massachusetts Division of Marine Fisheries conducted stomach contents studies during the summer of 1988, and analyses of these data may be helpful in indicating the necessity of including large pelagics in the overall model.

Workshop participants also discussed the potential utility of these studies to resolving basic questions on the nature of functional feeding relationships among resources of predators and prey varying in abundance over time. The 25 year time series of feeding data taken from surveys conducted over conditions of widely changing resource abundance is unequalled for marine ecosystem studies, and should allow for interpretation of diet shifts in relation to the availability and vulnerability of potential prey items. It was also emphasized that, because of the potential impact of marine mammal species on predation mortality rates of pelagic species, examination of diet contents of marine mammals killed in fishing operations is an important priority since there are few feeding data for these species off the northeast USA.

6.5. REVIEW OF FISHERIES AND BIOLOGICAL INTERACTIONS RESEARCH AT NEFC

6.5.1. Report

The four previous presentations of research approaches and results were reviewed and the integration of these types of interactions research into the work of the Northeast Fisheries Center in the Population Dynamics Branch was discussed. This type of research was contrasted with the more traditional single species stock assessment work, noting that the latter is organized according to geography. There are three groups (Investigations) conducting specific assessments, with the coastal and estuarine species handled by one group, and the further offshore New England and Mid-Atlantic species handled by two other groups. The interactions research, in contrast, is handled by various staff from the three Investigations, depending on specific expertise and interests. For example, the technical interactions modeling work in the Gulf of Maine is being lead from the Mid-Atlantic Investigation, but with involvement from staff from both of the other investigations. Similarly, the work on individual vessel activity patterns is being lead from the New England Investigation, but with involvement from both the Mid-Atlantic and the Coastal and Estuarine Investigation.

The four previous presentations described research that are of increasing interest to management groups. For example, the New England FMC's Multispecies FMP is designed to address the mixed species nature of the fishery, and an improved understanding of the many interactions in the overall fishing system has been identified as a high priority by the NEFMC's Technical Monitoring Group. Similarly, the Mid-Atlantic FMC has recently begun accommodating reduced mackerel growth rates in managing the mackerel stock; intraspecifc and interspecific biological interactions may soon become important in managing that fishery as well. The Mid-Atlantic FMC is also working toward amendment of its Summer Flounder FMP to add black sea bass and scup, in recognition of the mixed nature of that fishery.

This approach to organizing such research projects leads to considerable flexibility and makes the best use of existing expertise, especially in balancing the needs for both research information as described here and the more traditional single species stock assessments. However, even with this flexibility it is not possible with reducing budgets and staff to meet all of the needs for both of these types of research. The need for increasing the amount of research as presented here, has forced tradeoffs to be made resulting in downgrading the sophistication of some of our assessments. Discussions within the SAW can provide a useful basis for adjusting the many tradeoffs among these two types of research, and indeed, for different types of interactions research.

7. WORKING GROUP REPORTS

7.1. METHODS FOR MEASURING LONG TERM POTENTIAL CATCH (WG 9 report)

Members: Brian Rothschild (Chair), Ray Conser (NEFC), Tom Hoff (MAFMC), Vaughn Anthony (NEFC), Howard Russell (NEFMC), Mike Fogarty (NEFC)

7.1.1. Report

The terms of reference for the working group were set during the 3rd SAW (spring 1986):

1. Review the classic definition of maximum sustainable yield (MSY) as well as the qualifications associated with the definitions.

2. Consider alternatives to that definition and specify how these alternatives provide advice on either maximum yield, sustainable yield, or the desired combination of the two.

3. Review existing FMP's to determine how this problem has been handled under the FCMA.

4. Make recommendations on the future research, noting any constraints in implementation.

Work presented during the 4th SAW addressed the first point of the terms of reference. WG 9 met again during this SAW and addressed the second point. Work on the third point has also been ongoing. The WG concluded that in the New England and Mid-Atlantic regions, two types of fisheries were evident; (1) those with lots of data (e.g. cod, haddock, and yellowtail) and (2) those with little data (e.g. scup, bluefish, and sharks). The great differences in quantity (and quality) of data necessitate two different approaches for estimating MSY. A schematic describing the approaches is shown in Figure 7.1.1.

The WG concluded that while general guidelines for estimating MSY's for both types of fisheries could be provided at this time, there was a need to go through the steps of estimating MSY for several species in each category before concrete, practical advice could be presented. The WG proposed to examine cod, haddock, and yellowtail as examples of the first category ("lots of data") and to examine summer flounder, scup, and sharks as examples of the second category ("little data"). The WG recognized that it had not completed its terms of reference and plans to meet again prior to the next SAW to continue its work.

7.1.2. Discussion

The discussion following the report noted that the WG was initially formed to look at MSY for summer flounder, but it became apparent that the problem was more generic, thus the current terms of reference were established. However, case by case studies are still necessary because there is no one best method for all species.

It was noted that the WG should be able to develop some general rules regardless of the level of data. There should be some standard methods which are common to all cases. MSY was said to be a relatively easy concept in the deterministic equilibrium situation, but not in practice. In reality one cannot get maximum yield and sustainable yield simultaneously. Therefore management guidelines are needed before developing the model. The most significant problem of having little data is in not being able to estimate the total biomass. While natural mortality is also difficult to estimate directly, this problem is common in the "lots of data" situation, as well.

With the future implementation of SAFE's, it was decided that proper guidelines for determining MSY using various levels of data was more important now than ever. The SAW agreed that additional work was needed and requested a report for the Spring 1989 meeting.

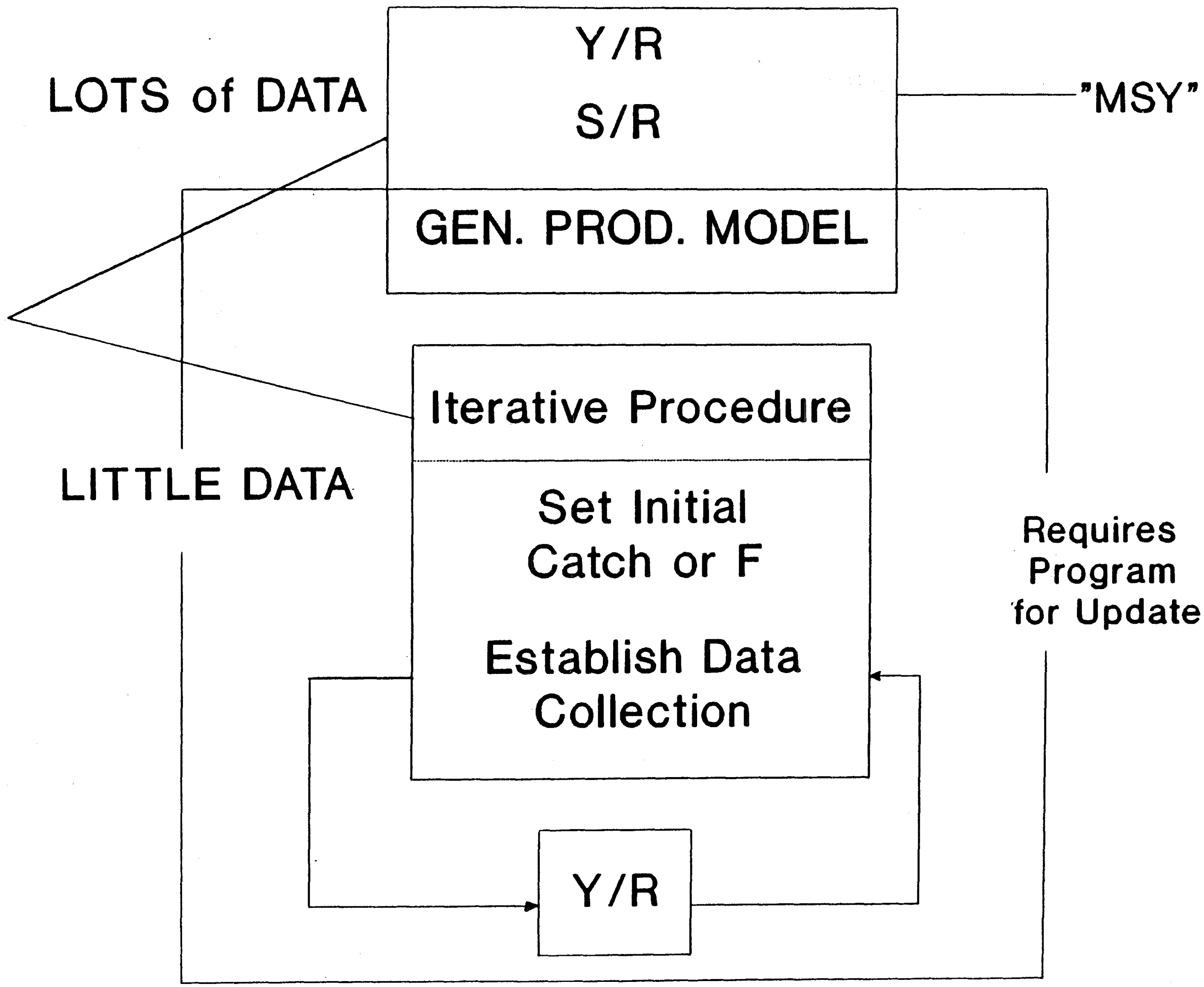


Figure 7.1.1. Conceptual model describing development of an MSY under two data scenarios.

7.2. SUMMER FLOUNDER CPUE METHODOLOGY - WG 21

7.2.1. Report

The Working Group discussed the most appropriate way to evaluate how closely landing patterns in the weigh-out data base reflect landing patterns as reported the Fisheries of the U.S. (which include canvas data). A summary of the weigh-out data base by year, state, quarter and distance from shore (EEZ vs. territorial sea) is being prepared for the summer flounder otter trawl landings and will be compared to the general canvas data.

The group discussed the relationship between different areal components of the fishery and the potential for differences in age structure of those components. The No. Carolina/Virginia winter trawl fishery may catch younger fish as they recruit to the fishery. Northern fisheries may have operated on a higher proportion of older fish in earlier years, although that pattern may be changing. The group would be interested in investigating the feasibility of developing CPUE at age indices, as aggregate CPUE indices may be influenced by the varying relative contribution of each component fishery over time. Otherwise, qualitative evaluation of age structure of component fisheries would be helpful.

A bibliography of statistical and fisheries-based discussions of general linear models (GLM) and underlying assumptions is available. Synopses will be included as final analyses are produced.

Preliminary research on recreational CPUE was reviewed. The data base was inspected and an apparently erroneous intercept sample, which had undue influence on catch estimates, was adjusted to provide a more reasonable estimate of total catch for 1980. The Mid-Atlantic private rental boat component of the fishery contributed most of the catch for both coastwide and Mid-Atlantic private rental series. Indices based on expanded estimates of catch and effort were quite variable. This may be due to problems of defining and estimating directed effort in the expanded data base or unreliable expanded catch estimates, although the former problem appeared more likely. This problem is reduced for indices based on intercept data alone. Intercept indices based on unadjusted Mid-Atlantic private boat rental CPUE and GLM-adjusted coastwide private boat rental CPUE showed no major differences: any trend in those indices appeared slightly downward.

Preliminary analyses of commercial CPUE were modified or amplified based on comments obtained at the previous SAW. A computational error in calculation of adjusted CPUE was corrected. The index peaks in 1981 and declines to 1987. Patterns in raw CPUE are similar to those in adjusted CPUE, although adjusted patterns show stronger peaks. Evaluation of effects at the 5% significance level led to the addition of depth to the model (year/tonnage class/ quarter /depth). Evaluation of residuals revealed normality in 71% of the cells; most non-normality was observed in cells with fewer than 5 observations. Not surprisingly, more significant area effects were observed after 1977, when the weigh-out data base expanded through time to include landings from states other than Massachusetts and Rhode Island (MA/RI).

Although the MA/RI landings are a very low percentage of total landings, an index based on MA/RI landings alone showed trends similar to those based on the total weigh-out landings data base. Likewise, shifts towards increasing tonnage classes and a winter fishery were observed in the MA/RI data. Thus, these trends are not artifacts of adding southern states to the weigh-out system. Comparison of year coefficients (from GLM) with adjusted CPUE showed occasional small discrepancies. Although all indices (CPUE and Survey) show similar downward trends since 1981, the divergence between survey and CPUE has not been completely explained, and the group has left this question unresolved. The group felt it may be appropriate to truncate the time series to correspond with the data available for the VPA (beginning in 1976) or to correspond with a CPUE data base expanded beyond MA/RI (beginning in 1978). It may also be of interest to examine CPUE based on all trips landing summer flounder rather than the 10% criteria used here.

No progress has been made in obtaining North Carolina data for calculating CPUE.

7.2.2. Discussion

During a brief discussion, the working group was asked if they could now slow the rate of work on summer flounder CPUE research. It was noted that the next step needed in the development of the summer flounder assessment was construction of the catch-at-age matrix for VPA, with CPUE indices reconsidered as the VPA is developed. The SAW recognized the need for a continuation of the work of this group and requested a report during the spring 1989 workshop.

7.3. **ESTUARINE WINTER FLOUNDER - WG 16**

7.3.1. Report ON REVIEW OF WINTER FLOUNDER REGIONAL GROWTH PATTERNS

Length-at-age data for inshore populations of winter flounder from Connecticut, Rhode Island, Massachusetts, and Georges Bank were summarized with respect to differences in growth between the various regions. The analyses were conducted to provide information concerning the effect and possible consequences of increasing winter flounder minimum sizes from 11" to 12" in the Northeast Multispecies FMP. No attempt was made to correlate the results of the age data summarization with trends in fishing mortality or other stock dynamics for any of the stocks.

Length-at-age data for approximately 7,000 individuals collected from the late 1960's to the present were summarized. The von Bertalanffy growth equation was found to be an inappropriate model for winter flounder growth due to; 1) the inadequate representation of both younger (age 0 and 1) and older fish associated with most sampling, 2) the model's tendency to overestimate growth at intermediate ages and underestimate asymptotic length, and 3) the difficulty in conducting statistical comparisons with the three-parameter model. A semi-logarithmic model was utilized which provided better fits of the data and allowed statistical comparisons of the resulting linear expressions of growth using analysis of covariance. Due to regional variability in age at maturity of male winter flounder, analyses were performed only for females, which first spawn at age 3.

Results indicated that age interpretations obtained from scales, whole otoliths, and sectioned otoliths were comparable, although greater variability in the timing of annulus formation was observed in otoliths, necessitating caution in assigning proper ages.

Based on differences in growth, 10 significantly different inshore groups of winter flounder were identified. These included three groups in Long Island Sound, one in Rhode Island Sound, two in Narragansett Bay, two south of Cape Cod, and two north of Cape Cod. Information for Georges Bank winter flounder was included as a comparison of an offshore stock with the inshore groups. Calculated ages of female flounder from the ten groups (plus Georges Bank) at the current minimum size (11 in., 27.9 cm) and the proposed minimum (12 in., 30.5 cm) are presented in Table 7.3.1. The data indicate that growth rates generally decrease from south to north, with Long Island Sound winter flounder growing much slower than those north of Cape Cod.

7.3.2. Discussion

It was noted that some of the differences in 'system specific' growth may be functions of temperature. For example, growth would be impeded in shallow waters such as salt ponds where high summer temperatures would cause flounder to slow their metabolism until cooler temperatures prevailed. As a result of this, growth studies done using fish from shallow areas may be biased since the faster growing individuals from each age group would recruit from the nursery areas to deeper waters leaving behind their smaller cohorts.

It was also suggested that differences in Long Island Sound may be due to the migration of fish from west to east and not due to actual differences in growth. Differences in growth due in part to a west-east pollution gradient were discounted.

It was noted that the ASMFC planned on developing a management plan, and that work would likely involve the members of the Estuarine Winter Flounder working group. No specific terms of reference were identified for the spring 1989 SAW, and the working group was thanked for its efforts.

Table 7.3.1. Calculated ages of female winter flounder from 10 groups from Long Island Sound to Boston Harbor (and Georges Bank) at the current minimum size of 11" and a proposed minimum size of 12".

Stock	Age at Size 11"	Age at Size 12"
Western Long Island Sound	5.1	6.4
Central Long Island Sound	3.6	4.3
Eastern Long Island Sound	3.1	3.7
Rhode Island Sound	2.2	2.7
Lower Narragansett Bay	3.0	3.8
Upper Narragansett Bay	3.0	3.9
South of Cape Cod	2.5	3.0
Nantucket Sound	2.2	2.7
North of Cape Cod	2.5	3.1
Boston Harbor	2.4	3.0
Georges Bank	1.4	1.6

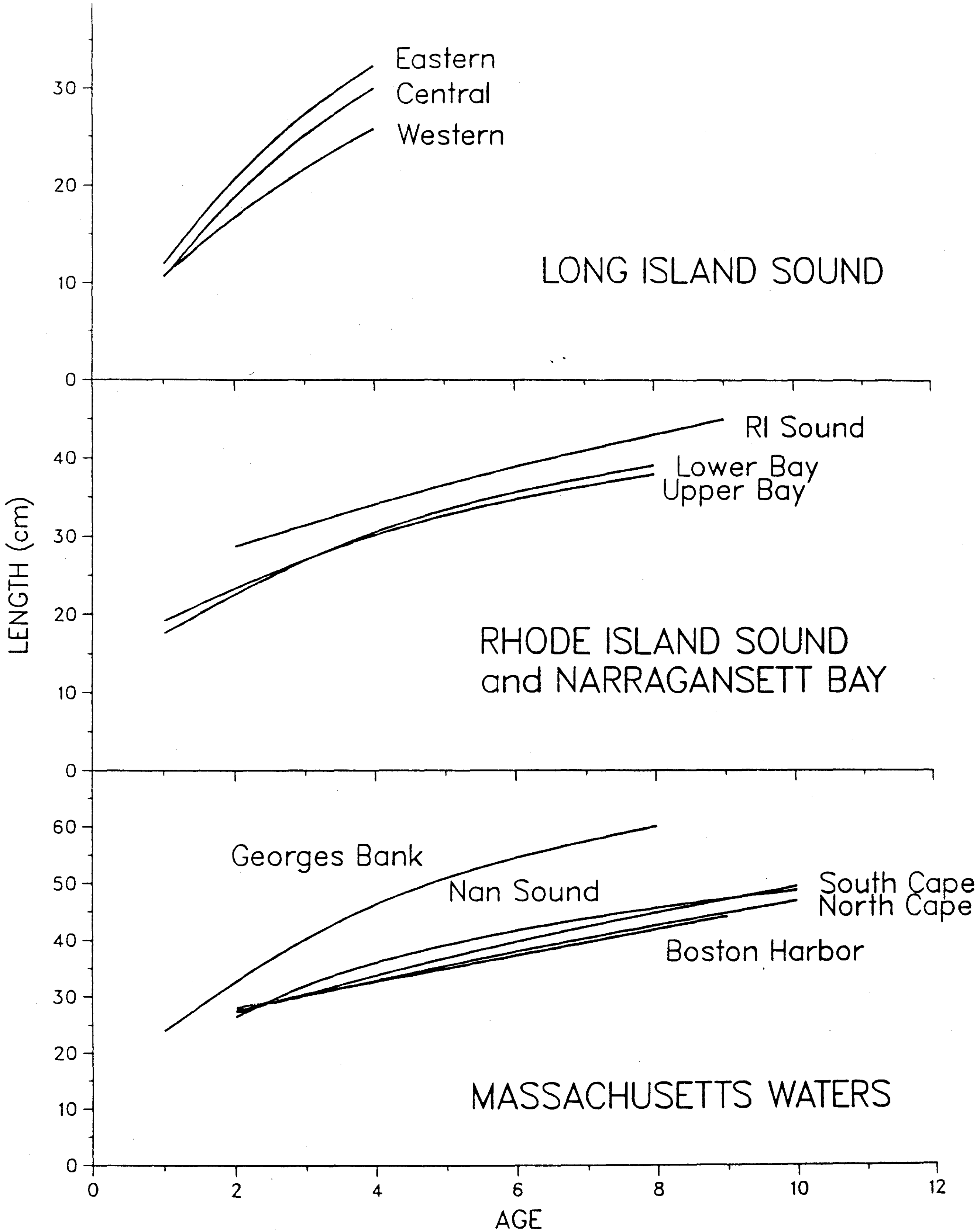


Figure 7.3.1. Regional growth curves of winter flounder using semi-logarithmic growth model.

8. TERMS OF REFERENCE FOR NEXT SAW

Several assessment and special topics were identified for possible inclusion in the spring 1989 SAW:

8.1. ASSESSMENT REVISIONS OR UPDATES

1. Update status of stocks for Illex, Loligo and butterfish

8.2. SPECIAL TOPICS

1. Report of NEFC Maturity Working group on growth and maturity interactions and the effect of SSB/R
2. Status report on available temperature data and long term temperature changes
3. Review and discussion of stock rebuilding strategies
4. Report by ASMFC Recreational sub-committee on recreational surveys
5. Examine the extent of the bottom-tending gillnet fishery in the Northwest Atlantic
6. Report on the adequacy of age sampling and data: How much is enough? and the role of states in meeting sample needs.
7. Update of SAFE requirements
8. Review CBSAC assessment research program and results to date
9. Review of methods for inclusion of discards and recreational catch data in the development of catch at age matrices.
10. Individual vessel effort statistics.

8.3. WORKING GROUPS

1. Black sea bass and scup working group (WG 22).
   Members: Dave Keifer (MAFMC - chair), Gary Shepherd (NEFC), others to be named.

   Terms of reference: In support of MAFMC plans to expand the summer flounder FMP, this WG was asked to consider:

   - develop biological reference points over the geographic range
   - examine available fisheries statistics

2. Summer flounder working group (WG 21)
3. Long term potential yield working group (WG 9)

8.4 TIMING OF SPRING 1989 SAW

The next Stock Assessment Workshop was scheduled for the week of April 24 - 28, 1989.

8.5 INTERNATIONAL COOPERATION

Workshop participants expressed their thanks to collegues from France (IFREMER) and New Zealand (New Zealand Ministry of Fisheries) for participating in the Seventh NEFC Stock Assessment Workshop.

9. REFERENCES

Gulland, J.A. 1983. Density-dependent recruitment and total yield. In: Fish Stock Assessment, FAO/Wiley Series on Food and Agriculture, 223pp. New York: John Wiley and Sons Ltd.

Hilborn, R. and C.J. Walters. 1987. A general model for simulation of stock and fleet dynamics in spatially heterogenous fisheries. Can. J. Fish. Aquat. Sci. 44(7):1366-1369.

Lux, F.E. 1963. Identification of New England yellowtail flounder groups. U.S. Fish Bull. 63(1):1-10.

NEFC. 1987a. Status of the Fishery Resources Off the Northeastern United States for 1987. NOAA Tech. Mem. NMFS-F/NEC-50. 132 pp.

NEFC. 1987b. Report of the Fourth NEFC Stock Assessment Workshop. Woods Hole, MA:NMFS,NEFC. Woods Hole Laboratory Reference Document 87-07.102 pp. Available from: Northeast Fisheries Center, Woods Hole, MA.

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Neville, W.C and G.B. Talbot. 1964. The fishery for scup with special reference to fluctuations in yield and their causes. USFWS Special Scientific Report - Fisheries No.459. 61pp.

Parrish, R.H and A.D. MacCall. 1978. Climatic variation and exploitation in the Pacific mackerel fishery. CA Dept. Fish and Game, Fish Bulletin 167.

Sissenwine, M.P. and J.G. Shepherd. 1987. An alternative perspective on recruitment overfishing and biological reference points. Can. J. Fish. Aquat. Sci. 44:913-918.

10. APPENDICES

10.1. APPENDIX 1: WORKING PAPERS

Working papers used during the 7th SAW should not be cited without permission of the author.

#1. Status and Assessment of Georges Bank and Gulf of Maine Cod Stocks 1988 - Fredric M. Serchuk

#2. Georges Bank Cod Stock Assessment Highlights - 1988 Selected Data Tables and Figures - Fredric M. Serchuk

#3. Gulf of Maine Cod Stock Assessment Highlights - 1988 Selected Data Tables and Figures - Fredric M. Serchuk

#4. Impact of Predation on the Pelagic Fish Ecosystem off the Northeastern USA: Preliminary Results - William Overholtz

#5. Chesapeake Bay Stock Assessment Plan Executive Summary - Chesapeake Bay Stock Assessment Committee, Wendy Gabriel

#6. Technical Interactions in Assessment, Why? Background to Discussion - Benoit Mesnil

#7. A Probablistic Approach to Maximum Sustainable Yield: Risk Aversion Given Stochastic Recruitment - S.A. Murawski and J.S. Idoine

#8. Yellowtail Flounder, _Limanda_ _ferruginea_, Status of the Stocks 1988 - Margaret Mary McBride

#9. Figures Illustrating Trends in Directed and Mixed Catch and Effort in the New England Otter Trawl Fishery 1982-87 - Tom Polacheck

#10. NEFC Technical Interactions Research Plans - Tim Smith

10.2. AGENDA

Fall 1988 Stock Assessment Workshop (SAW VII)

Revised AGENDA

Monday, November 28, 1988

Chairperson: Gary Shepherd
Preliminaries

1:45 - 1:50	Introduction and Welcome
1:50 - 2:00	Revision and Adoption of Agenda

Chairperson: Dr. Fred Serchuk
New England Fisheries Investigation

2:00 - 2:45	Gulf of Maine cod assessment revision - Fred Serchuk
2:45 - 3:15	Georges Bank cod update - Fred Serchuk
3:30 - 4:00	Report of Chesapeake Bay Stock Assessment Committee - Wendy Gabriel
4:00 - 4:30	Discussion of Technical Monitoring Group report to NE Fishery Management Council - David Pierce

Tuesday, November 29, 1988

Chairperson: Dr. Wendy Gabriel
Coastal and Estuarine Fisheries Investigation

9:00 - 9:45	Southern New England yellowtail flounder revision - Margaret McBride
9:45 - 10:30	Georges Bank yellowtail flounder revision - Margaret McBride
10:45 - 11:30	Report of Summer Flounder CPUE working group (WG 21) - Wendy Gabriel
11:30 - 1:00	Lunch

Chairperson: Dr. Steven Murawski
Mid-Atlantic Fisheries Investigation

1:00 - 1:45	Stock Assessment in New Zealand - Pamela Mace
1:45 - 2:30	Review of long-term potential yield for surf clams - Steve Murawski
2:30 - 3:00	Review of regional winter flounder growth patterns (WG 16) - Jay Burnett

3:15 - 3:45	Review of SAFE requirements and relation to SAW - John Boreman
3:45 - 4:30	Scup assessment update - Penny Howell
6:00 - 8:00	Reception

Wednesday, November 30, 1988

Chairperson: Dr. Benoit Mesnil
IFREMER, France

9:00 - 9:45	Review of EEC meeting on Methods for Assessment of Technical Interactions - Benoit Mesnil
9:45 - 10:15	Analyses of multispecies trends in directed effort - Tom Polacheck
10:30 - 11:00	Review of ICES Multispecies trends in directed effort - Steve Murawski
11:00 - 11:30	Review of proposed NEFC research program on technical interactions - Tim Smith
11:30 - 12:15	Impact of predation on the pelagic fish ecosystem off the Northeastern USA: preliminary results - William Overholtz
12:15 - 1:30	Lunch

Chairperson: Gary Shepherd
Coastal and Estuarine Fisheries Investigation

1:30 - 2:30	Working Group Reports WG 9 (Methods for measuring long term potential catch) - Brian Rothschild
2:30 - 3:00	Discussion of trawl survey workshop - Tom Azarovitz
3:15 - 4:00	Discussion of terms of reference for next SAW
4:00 - 5:00	Review of draft session reports

Thursday, December 1, 1988

9:00 - 12:00	Finalize workshop report

10.3. **PARTICIPANTS**

NMFS/NEFC - Woods Hole, MA
Gary Shepherd
Ambrose Jearld
Margaret McBride
Scott Moseley
Jeff Darde
Tom Morrissey
John Boreman
Vaughn Anthony
Kevin Friedland
Ray Conser
Tim Smith
Karen Foster
Mark Terceiro
Anne Lange
Jay Burnett
Ralph Mayo
Anne Richards
Gordon Waring
Frank Almeida
Fred Serchuk
Steve Clark
Josef Idoine
Wendy Gabriel
Steven Murawski
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