Northwest Atlantic Fisheries Organization

Serial No. N2431 NAFO SCR Doc. 94/60

SCIENTIFIC COUNCIL MEETING - JUNE 1994

An Assessment of the Redfish Stock in NAFO Division 3M

by

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Introduction

There are three species of redfish which are commercially fished on Flemish Cap: beaked redfish (*Sebastes mentella*) golden redfish (*S. marinus*) and American (acadian) redfish (*S. fasciatus*). Because of identification difficulties these species are not identified in commercial catches and considered together as a single management unit. Only in EU-Spanish surveys have the species been identified separately, starting in 1991.

Description of the Fishery

In 1993 a directed redfish fishery was conducted primarily by Latvia, Lithuania, Estonia, Cuba, Portugal and Russia with bottom and midwater trawls as well as with gillnets.

From 1983-1985, catches averaged 20 000 tons (Table 1), increased to the record high of 81 000 tons in 1990 and have subsequently declined to the level of the mid-1980s. The 1993 catch was estimated to be about 29 000 tons. A substantial amount of catch has been estimated since 1989 primarily because of the activity of non-Contracting Parties. The portion of the catch that has been estimated has ranged between 7 600 tons in 1991 to 14 200 tons in 1990. Catch figures for 1990-1992 have been revised based upon updated information related to catches by non-Contracting Parties.

Catches were over double the 20,000 ton TAC in 1987 (at 44,000 tons) and about three times the 20,000 ton TAC in 1989 (at 58,000 tons). Catches have been at the TAC level since 1991.

TACs and catches for last five years were:

	1989	1990	1991	1992	1993
TAC	20	50	50	43	30
Catch	58[1]	81[1,2]	48[1]	43[1,2]	29[1,2]

[1] Includes estimates of non-reported catches.
[2] Provisional.

Commercial Fishery Data

Catch and effort data were obtained from ICNAF/NAFO Statistical Bulletins for 1959 to 1990 and were combined with provisional 1991-1992 NAFO data. These were supplemented by preliminary data available from Canada, Portugal, and Russia. Only those data where redfish comprised more than 50% of the total catch were selected for further analysis with the exception of data from Portugal because they were considered confounded with directed effort for other species. The data for Portugal were obtained from data available in Portuguese research reports in the NAFO SCS Document series for 1989-1994.

The CPUE data were analyzed with a multiplicative model (Gavaris 1980). Effects included in the model were a combination country-gear-tonnage class category type (CGT), NAFO division, month, and

a category type representing the amount of by-catch associated with each observation. Catch or effort data of less than 10 units were eliminated prior to analysis, however, for the analysis utilizing the effort in terms of days fished, any catch less than 10 tons or effort less than an arbitrarily chosen 5 days fished were not included in the analysis. Category types with less than five samples were also eliminated with the exception of the year category type. For all analyses an unweighted regression was run because of unknown percentages of prorating prior to 1984.

The regression utilizing effort in hours fished was significant ($p < .05$), explaining 62% of the variation in catch rates (Table 2). All category types were significant. There is much variability in the series prior to 1972 (Table 4, Fig. 1). Generally, catch rates were stable from 1974 to 1984 and increased thereafter until it peaked in 1987 at the highest rate since 1971. A trend of decline followed to 1993. The estimated catch rate for 1993, based on information from the Portuguese and Russian fleets is the lowest in the time series.

In addition to a standardized CPUE based on hours fished a standardized series based on days fished was also conducted on the premise that such a unit of effort may reflect time searching for concentrations of redfish.

The regression utilizing effort in days fished was significant ($p < .05$), explaining 70% of the variation in catch rates (Table 3). All category types were significant. There is much variability in the series prior to 1974 (Table 5, Fig. 2). Trends were similar to the index based on hours fished. Generally catch rates were stable from 1974 to 1984, increased successively to 1987 at the highest rate since 1972, dropped sharply in 1988 and remained stable to 1992. The preliminary for 1993 suggest a decline to the lowest estimated since 1967.

Sampling data were limited and consisted of *S. mentella* and *S. marinus* length and age composition for Portuguese gillnetters (Alpoim et al., 1994) and length composition from bycatches in the Spanish pair-trawl fishery (Vazquez, 1994).

Fish in the range of 17-53 cm occurred in the Spanish pair-trawl catches. Males 30-33 cm and 39-43 cm and females 29-34 cm and 38-43 cm dominated the catches. Among catches obtained during April-July redfish specimens appeared to be larger in June (0.9 kg mean weight).

Portuguese directed effort for redfish stayed relatively constant between 1992 and 1993 but catch rates dropped from 0.891 t/h in 1992 to 0.471 t/h in 1993 and was the lowest one observed since 1989.

Portuguese gillnet catches consisted of *S. mentella* in the range of 18-65 cm and *S. marinus* 16-69 cm long. For both species lengths 35-40 cm dominated the catches. Smaller fish at modal 30 were also well represented in catches. Mean length in the *S. mentella* catches increased by 5 cm for males and 2 cm for females in 1993 compared to 1992.

Research Survey Data

Two surveys were conducted in June-July 1993: EU bottom trawl survey on board R/V *Saavedra* (Vazquez, 1994) and a Russian trawl-acoustic survey on board of R/V *Vilnius* (Vascov, 1994). Trawlable biomass (Table for EU survey was divided into three redfish species and an aggregate juvenile group (<15 cm). Redfish species identification during Russian survey was not conducted. Each survey was based on a stratified random design and utilized the same stratification scheme down to 732 m (400 fathoms).

The EU trawl survey and the Russian trawl acoustic survey have both shown a gradual decrease of stock since 1988 to 1991 (Table 6). In 1992 biomass index of EU-survey indicated higher stock while the bottom component on the Russian data decreased significantly while the total biomass remained at about the same level as 1991. From 1992 to 1993, trawlable biomass estimates decreased for the EU survey but increased for the Russian survey. Total biomass from the Russian survey in 1993 increased 1.5 times (147.1 thous. tons) compared with the 1991-1992 level.

As in previous years *S. mentella* produced the biggest portion of total biomass estimated from the EU survey. Compared with 1992 its biomass declined almost 3 times and made up 25.1 thous. tons in 1993. Individuals in the range of 15-48 cm occurred in catches.

Length frequencies from the Russian bottom trawl survey indicate a mode at about 15-16 cm that corresponds to the 1990-1991 years classes. These size groups represented about 20% of the research catch in the 1993 survey. Those size groups were also dominant in the EU survey results.

Prognosis

The biomass of this stock has declined at least from 1988 to 1991-1992. Large catches over the past eight years that have likely been well above the stock sustainable production and have resulted in high fishing mortalities. This stock will continue to decline into the future if the present level of catches is maintained. Both Russian and EU surveys indicated a relatively good pulse of recruitment that will start recruiting to the commercial fishery in the late 1990s, however, the abundance of these cannot be precisely determined.

There is no information to evaluate where the current TAC (26,000 tons) stands in relation to an appropriate reference catch. Therefore, a cautious approach is warranted in establishing an appropriate catch level. In consideration of this there continues to be non-reported catch from the Regulatory area that is primarily due to activity by non-Contracting Parties.

References

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TABLE 1. Nominal catches of Redfish in Div. 3M for 1983-1993 (1991-93 are provisional).

Country	1983	1984	1985	1986	1987	1988	1989[a]	1990	1991	1992	1993
CAN	0	0	0	0	0	0	0	0	2	0	10
CUB	2324	1562	1831	1764	1757	1759	1765	4195	1772	2303	945
DDR	40	98	0	88	0	0	0	4025	0	0	0
GRL	0	0	0	0	0	0	0	0	0	1	0
JPN	390	389	313	400	131	393	885	2082	1432	1424	967
SUN/RUS	14517	15005	15703	15045	19875	13747	13937	34581	24661	2937	2035
LVA	0	0	0	0	0	0	0	0	0	7441	5099
LTU	0	0	0	0	0	0	0	0	0	0	2128
EST	-	-	-	-	-	-	-	-	-	-	2188
E GER	0	769	848	145	0	0	2	91	5847	3443	0
E ESP	589	282	281	643	825	146	211	1916	472	204	100
E GBR	0	0	0	0	0	0	0	0	5	0	0
E PRT	1667	2123	1306	10783	21823	7101	13012	11665	3787	3198	4781
KOR-S	0	0	0	5	0	43	17885	8332	2936	8350	2962
FAROE IS.	0	0	0	0	0	0	0	0	0	16	0
OTHER[a]	-	-	-	-	-	-	10405	14159	7575	14000	7778
TOTAL	19527	20228	20282	28873	44411	23189	58102	81048	48489	43317	28993

[a] Estimates of non-reported catch from various sources.

TABLE 2. ANOVA RESULTS AND REGRESSION COEFFICIENTS FROM A MULTIPLICATIVE MODEL UTILIZED TO DERIVE A STANDARDIZED CATCH RATE SERIES FOR REDFISH IN DIV. 3M. EFFORT IS MEASURED IN HOURS FISHED (1991-1993 BASED ON PRELIMINARY DATA).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.790
MULTIPLE R SQUARED..... 0.624

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	2.382E1	2.382E1	
REGRESSION	77	2.658E2	3.452E0	12.461
Country¦Gear¦TC (1)	28	1.764E2	6.300E0	22.745
Month (2)	11	8.732E0	7.938E-1	2.866
Bycatch PCT (3)	4	1.098E1	2.746E0	9.913
Year (4)	34	2.913E1	8.568E-1	3.093
RESIDUALS	577	1.598E2	2.770E-1	
TOTAL	655	4.494E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
Country¦Gear¦TC	20127	INTERCEPT	0.868	0.166	655
Month	4				
Bycatch PCT	95				
Year	59				
(1)	2125	1	-0.105	0.197	10
	2155	2	0.110	0.266	5
	3125	3	-0.878	0.174	12
	3154	4	-0.082	0.210	8
	3155	5	0.248	0.148	21
	4127	6	-0.231	0.164	14
	4157	7	0.204	0.125	34
	10127	8	-0.066	0.207	8
	11155	9	0.004	0.223	7
	11157	10	0.070	0.236	6
	14124	11	-0.989	0.205	9
	14125	12	-1.363	0.172	12
	14126	13	-1.165	0.134	24
	14127	14	-0.826	0.108	46
	14156	15	-1.181	0.235	6
	16127	16	-0.867	0.189	13
	17116	17	-0.607	0.199	11
	17126	18	-0.666	0.152	25
	17127	19	-0.807	0.215	8
	20114	20	-1.928	0.160	35
	20116	21	-0.627	0.216	12
	20126	22	-0.428	0.254	5
	20156	23	-0.048	0.152	21
	20157	24	0.370	0.082	135
	25126	25	0.202	0.166	18
	25127	26	0.543	0.146	33
(1)	27125	27	0.170	0.233	6
	31157	28	-0.208	0.245	9
(2)	1	29	-0.291	0.111	36
	2	30	-0.325	0.105	42
	3	31	-0.320	0.090	68
	5	32	-0.145	0.092	60
	6	33	-0.338	0.093	61
	7	34	-0.265	0.092	70
	8	35	-0.302	0.093	66
	9	36	-0.383	0.095	57
	10	37	-0.441	0.106	42
	11	38	-0.261	0.108	40
	12	39	-0.168	0.117	31
(3)	55	40	-0.488	0.119	33
	65	41	-0.455	0.086	52
	75	42	-0.246	0.090	50
	85	43	-0.136	0.066	102
(4)	60	44	0.637	0.425	2
	61	45	0.760	0.326	4
	62	46	0.426	0.326	4
	63	47	0.447	0.302	5
	64	48	0.157	0.577	1
	65	49	0.283	0.296	5
	66	50	-0.191	0.584	1
	67	51	-0.127	0.583	1
	68	52	0.369	0.296	5
	69	53	0.152	0.346	3
	70	54	1.074	0.260	7
	71	55	0.684	0.210	14
	72	56	0.093	0.198	17
	73	57	-0.067	0.242	8
	74	58	0.223	0.197	21
	75	59	0.018	0.196	21
	76	60	-0.069	0.208	22
	77	61	-0.145	0.196	27
	78	62	0.019	0.192	32
	79	63	-0.289	0.184	43
	80	64	-0.154	0.186	33
	81	65	-0.052	0.189	29
	82	66	-0.067	0.188	29
	83	67	-0.184	0.190	31
	84	68	-0.173	0.196	24
	85	69	-0.128	0.206	20
	86	70	0.276	0.217	15
	87	71	0.342	0.209	19
	88	72	-0.135	0.209	18
	89	73	-0.257	0.198	38
	90	74	-0.389	0.181	70
	91	75	-0.359	0.226	21
	92	76	-0.440	0.225	27
	93	77	-0.540	0.229	13

TABLE 3. ANOVA RESULTS AND REGRESSION COEFFICIENTS FROM A MULTIPLICATIVE MODEL UTILIZED TO DERIVE A STANDARDIZED CATCH RATE SERIES FOR REDFISH IN DIV. 3M. EFFORT IS MEASURED IN DAYS FISHED (1991-1993 BASED ON PRELIMINARY DATA).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.834
MULTIPLE R SQUARED..... 0.696

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	3.597E3	3.597E3	
REGRESSION	74	2.547E2	3.442E0	14.726
Country¦Gear¦TC (1)	25	1.704E2	6.816E0	29.164
Month (2)	11	3.580E0	3.255E-1	1.393
Bycatch PCT (3)	4	8.454E0	2.114E0	9.043
Year (4)	34	1.387E1	4.080E-1	1.746
RESIDUALS	476	1.113E2	2.337E-1	
TOTAL	551	3.963E3		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
Country¦Gear¦TC	20127	INTERCEPT	3.302	0.164	551
Month	4				
Bycatch PCT	95				
Year	59				
(1)	2125	1	0.172	0.194	9
	3125	2	-0.796	0.185	9
	3154	3	0.005	0.201	8
	3155	4	0.334	0.157	17
	4127	5	-0.362	0.162	13
	4157	6	-0.062	0.129	34
	10126	7	-0.313	0.217	8
	10127	8	-0.127	0.198	8
	10157	9	-0.076	0.228	9
	11155	10	-0.138	0.213	7
	14124	11	-1.027	0.207	8
	14125	12	-1.343	0.175	11
	14126	13	-1.393	0.149	18
	14127	14	-1.189	0.124	31
	14156	15	-1.358	0.239	5
	16127	16	-0.766	0.244	8
	17116	17	-0.453	0.203	9
	17126	18	-0.529	0.154	21
	20114	19	-1.586	0.181	31
	20116	20	-0.887	0.208	11
	20156	21	-0.337	0.168	16
	20157	22	0.465	0.089	128
	25126	23	-0.030	0.167	16
	25127	24	0.565	0.149	28
	31157	25	-0.295	0.239	8
(2)	1	26	-0.277	0.115	27
	2	27	-0.239	0.106	35
	3	28	-0.159	0.091	54
	5	29	-0.052	0.089	57
	6	30	-0.103	0.092	55
	7	31	-0.085	0.095	54
	8	32	-0.054	0.093	57
	9	33	-0.200	0.097	46
	10	34	-0.196	0.104	38
	11	35	-0.053	0.106	34
	12	36	0.047	0.122	24
(3)	55	37	-0.455	0.126	28
	65	38	-0.447	0.090	42
	75	39	-0.307	0.090	45
	85	40	-0.098	0.068	87
(4)	60	41	-0.024	0.401	2
	61	42	-0.269	0.311	4
	62	43	0.680	0.566	1
	63	44	0.216	0.310	4
	64	45	-0.497	0.541	1
	65	46	-0.322	0.280	5
	66	47	-0.273	0.569	1
	67	48	-1.112	0.560	1
	68	49	-0.156	0.333	3
	69	50	-0.411	0.399	2
	70	51	-0.222	0.309	4
	71	52	-0.302	0.230	8
	72	53	-0.085	0.193	14
	73	54	-0.174	0.222	9
	74	55	-0.083	0.190	20
	75	56	-0.205	0.192	18
	76	57	-0.256	0.208	17
	77	58	-0.367	0.195	23
	78	59	-0.383	0.193	27
	79	60	-0.435	0.186	29
	80	61	-0.402	0.193	23
	81	62	-0.299	0.195	20
	82	63	-0.457	0.195	23
	83	64	-0.449	0.189	27
	84	65	-0.396	0.205	17
	85	66	-0.250	0.208	17
	86	67	0.086	0.223	12
	87	68	0.087	0.213	16
	88	69	-0.438	0.214	14
	89	70	-0.383	0.198	37
	90	71	-0.484	0.187	59
	91	72	-0.538	0.214	31
	92	73	-0.385	0.222	27
	93	74	-0.766	0.229	12

TABLE 4. STANDARDIZED CATCH RATE SERIES FOR DIV. 3M REDFISH FROM A MULTIPLICATIVE MODEL UTILIZING HOURS FISHED AS A MEASURE OF EFFORT.

	PREDICTED CATCH RATE					
	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1959	0.8682	0.0276	2.699	0.446	59	22
1960	1.5050	0.1740	4.742	1.897	60	13
1961	1.6280	0.0991	5.569	1.712	61	11
1962	1.2944	0.0973	3.992	1.217	62	16
1963	1.3153	0.0843	4.104	1.168	63	15
1964	1.0250	0.3220	2.725	1.431	64	23
1965	1.1516	0.0793	3.493	0.965	65	19
1966	0.6769	0.3296	1.917	1.016	66	34
1967	0.7407	0.3288	2.044	1.083	67	33
1968	1.2367	0.0800	3.802	1.055	68	18
1969	1.0201	0.1107	3.014	0.976	69	23
1970	1.9422	0.0575	7.785	1.842	70	9
1971	1.5520	0.0300	5.342	0.920	71	13
1972	0.9612	0.0217	2.972	0.436	72	24
1973	0.8016	0.0394	2.511	0.494	73	29
1974	1.0907	0.0217	3.383	0.496	74	22
1975	0.8865	0.0209	2.759	0.397	75	27
1976	0.7996	0.0249	2.524	0.396	76	30
1977	0.7232	0.0200	2.344	0.330	77	33
1978	0.8869	0.0193	2.762	0.382	78	28
1979	0.5788	0.0153	2.034	0.251	79	39
1980	0.7139	0.0162	2.327	0.296	80	34
1981	0.8164	0.0172	2.577	0.337	81	31
1982	0.8010	0.0170	2.538	0.330	82	32
1983	0.6842	0.0178	2.257	0.300	83	37
1984	0.6955	0.0213	2.279	0.331	84	37
1985	0.7397	0.0253	2.377	0.376	85	36
1986	1.1439	0.0318	3.549	0.629	86	24
1987	1.2104	0.0270	3.802	0.621	87	23
1988	0.7336	0.0260	2.361	0.378	88	37
1989	0.6113	0.0220	2.094	0.309	89	43
1990	0.4791	0.0156	1.840	0.230	90	49
1991	0.5087	0.0330	1.879	0.339	91	48
1992	0.4284	0.0320	1.735	0.308	92	53
1993	0.3281	0.0329	1.569	0.283	93	59

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.219

TABLE 5. STANDARDIZED CATCH RATE SERIES FOR DIV. 3M REDFISH FROM A MULTIPLICATIVE MODEL UTILIZING DAYS FISHED AS A MEASURE OF EFFORT.

	PREDICTED CATCH RATE					
	LN TRANSFORM		RETRANSFORMED			
YEAR	MEAN	S.E.	MEAN	S.E.	CATCH	EFFORT
1959	3.3021	0.0268	30.138	4.910	59	2
1960	3.2781	0.1616	27.502	10.635	60	2
1961	3.0332	0.0960	22.247	6.736	61	3
1962	3.9818	0.3104	51.592	26.673	62	1
1963	3.5177	0.0951	36.131	10.892	63	2
1964	2.8051	0.2900	16.070	8.070	64	4
1965	2.9799	0.0762	21.303	5.775	65	3
1966	3.0291	0.3117	19.886	10.300	66	3
1967	2.1902	0.3034	8.630	4.419	67	8
1968	3.1458	0.1100	24.725	7.987	68	3
1969	2.8910	0.1612	18.677	7.213	69	4
1970	3.0797	0.0951	23.316	7.029	70	3
1971	3.0005	0.0453	22.086	4.653	71	3
1972	3.2169	0.0219	27.743	4.089	72	3
1973	3.1286	0.0316	25.276	4.462	73	3
1974	3.2191	0.0210	27.818	4.017	74	3
1975	3.0976	0.0211	24.634	3.559	75	3
1976	3.0459	0.0264	23.331	3.771	76	3
1977	2.9353	0.0208	20.947	3.012	77	4
1978	2.9195	0.0210	20.618	2.974	78	4
1979	2.8670	0.0175	19.597	2.580	79	4
1980	2.9005	0.0193	20.245	2.801	80	4
1981	3.0031	0.0209	22.415	3.230	81	4
1982	2.8452	0.0212	19.137	2.778	82	4
1983	2.8530	0.0190	19.309	2.655	83	4
1984	2.9060	0.0260	20.289	3.255	84	4
1985	3.0519	0.0279	23.454	3.897	85	4
1986	3.3879	0.0357	32.694	6.126	86	3
1987	3.3887	0.0297	32.817	5.620	87	3
1988	2.8644	0.0299	19.423	3.339	88	5
1989	2.9190	0.0232	20.583	3.119	89	4
1990	2.8180	0.0182	18.653	2.511	90	5
1991	2.7638	0.0296	17.568	3.002	91	5
1992	2.9173	0.0308	20.471	3.570	92	4
1993	2.5359	0.0334	13.961	2.533	93	7

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.232

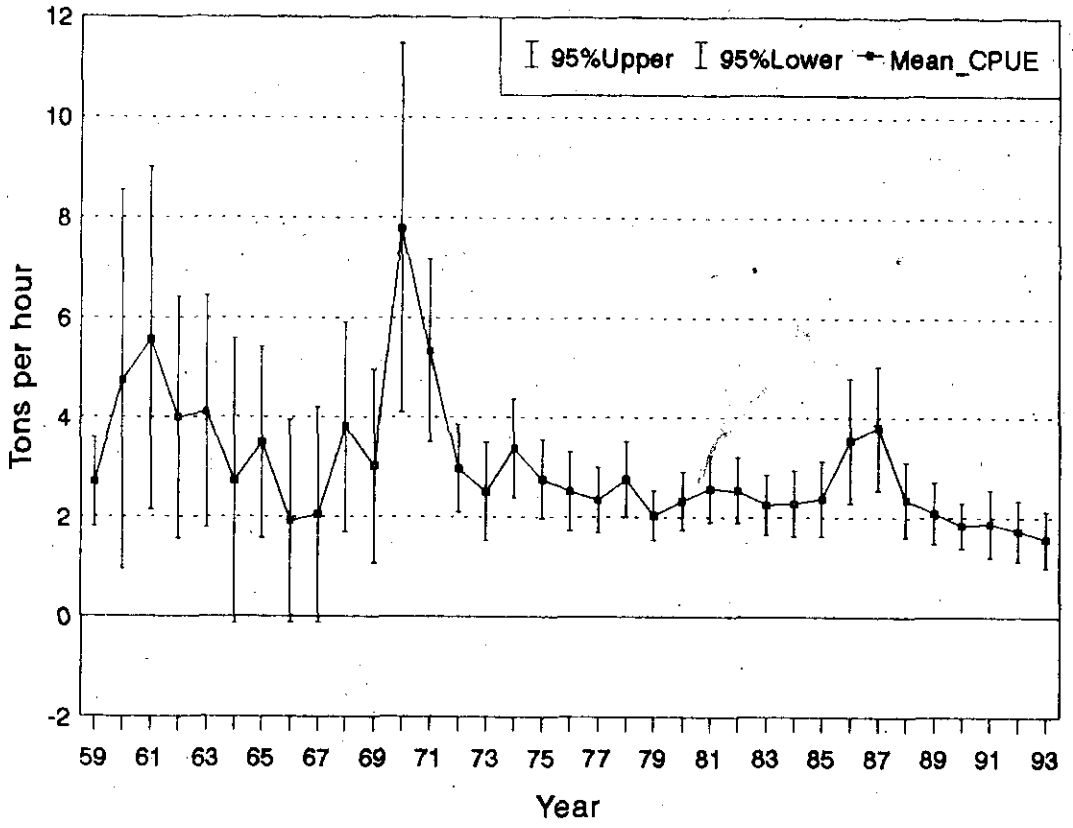

Fig. 1. Standardized CPUE and approximate 95% confidence interval for Div. 3M redfish based on effort in hours fished.

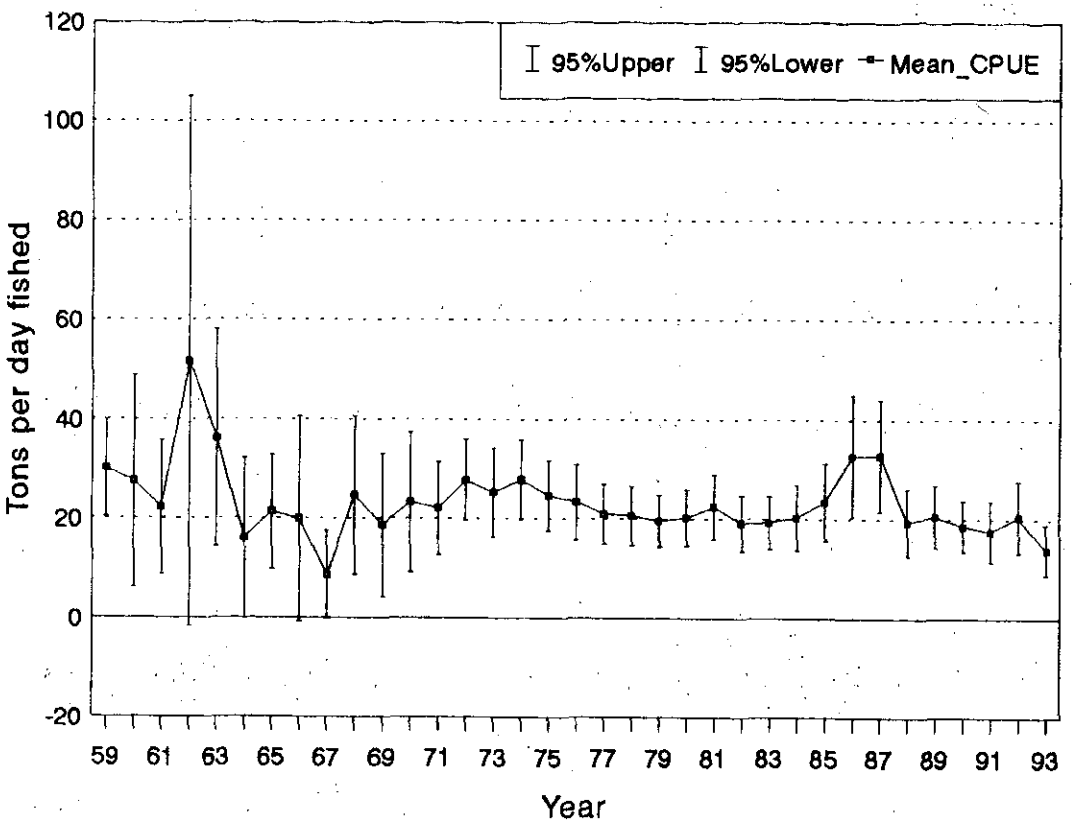

Fig. 2. Standardized CPUE and approximate 95% confidence interval for Div. 3M redfish based on effort in days fished.