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Gulf of St. Lawrence Herring Stock Complex - Spring 1978 Status Report -

by

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Introduction

The herring stock complex occupying the Southern Gulf of St. Lawrence and parts of southwest Newfoundland has represented a major fishery resource since early in this century. Traditionally, catches have been taken by traps, gill-nets and drift-nets set inshore during the spawning season. In 1966, introduction of the mobile fleet, composed primarily of purse-seiners and later mid-water trawls, resulted in a considerable increase in total annual landings (Figure 1) as well as a change in the seasonal deployment of effective effort (Figure 2). The latter occurred because the mobile fleet has been able to concentrate its efforts on both spawning and feeding concentrations, which occur more offshore.

The seasonal distribution of mobile fleet effort has to a large extent followed the migration pattern of the stock. In winter, fishing effort has been concentrated in the southwest Newfoundland area. In early spring, the fleet moves westward to the eastern and western sides of the Laurentian Channel, referred to as the 'edge' area. In summer, the fleet has exploited the feeding concentrations in the Gaspe, American and Orphan Bank areas. Later, in autumn, fishing activity moves to the Chaleus Bay and Gaspe areas where spawning occurs. Finally in late fall, the fleet moves back to the 'edge' area to catch herring on their overwintering migration to S.W. Newfoundland. Although this general pattern has been followed since fleet activity commenced in 1966, there have been major changes in the yearly distribution of effort since 1972. Since that time, fishing effort in the southern Newfoundland area has become almost nil while that on the 'edge' during early spring has dramatically increased. Most of the above events have been summarized in a CAFSAC working paper presented by Messieh (1977).

Annual landings from the Gulf of St. Lawrence herring stock complex for 1958-1976 are presented in Table I. These data were taken from ICNAF statistical bulletins. The catches in 3PN and 4R will include minor exploitation on other herring stock components but until more accurate statistics become readily available these are all we have. The total catch for 1975 and 1976 does not include landings made in St. George's Bay, Newfoundland because more local stocks appear to have been exploited in this area during those years (Winters, et al. 1977).

The extensive exploitation by the mobile fleet in the late sixties resulted in placement of a TAC of 150,000 mt in 1972. This level was based on considerations other than biological. In 1973, the catch has exceeded the TAC of 350,000 mt while in 1974 and 1975 the TAC and catch were fairly close (Table I). In 1976 the TAC of 550,000 mt was not met and although only preliminary catch statistics are available for 1977, it appears that this may again be the case.

Catch Composition

Numbers of fish caught at each age-group are presented in Table 2. Age-length keys and data used to determine age composition of the catches were obtained from Winters (pers. comm.). Age and year-class assignment followed the recommendation adopted by ICNAF Ageing Workshop (Hunt et. al 1973). According to the convention, age-groups have been used instead of ages. Thus a fish is considered age-group 1 on January 1st following its birth, regardless of its spawning origin.

In Table 2 the last number at age for each year really represents the summation of catch from all older age-groups, i.e. in 1967 spring spawners the catch at age 9+ was 263. In 1968, the catch at age 10+ was 230 and so on.

For spring-spawners the dominant year-classes were that of the 1959, 1963 and 1968. Of these the 1959 year-class was the strongest. For autumn 1958, 1962 and 1967. The strong 1958 year-class dominated the autumn fishery until 1972.

Determination of Effective Effort

Messieh (1977) provides monthly estimates of catch per unit effort for various areas of the Gulf from 1967 to 1976. They are based on area total catch and effort figures determined from examination of purse seine log records. The effort, in operating days, includes all time that the ship is at sea but excludes time lost due to bad weather and mechanical failures. The fall fishery in the Chaleur Bay - Gaspe area exploits a mixture spring and fall spawning herring. Consequently, on index of population abundance was calculated using weighted (by area) means of July, August, September and October CUE from the Chaleur Bay, Gaspe, Bradelle and Orphan Bank area (Figure 3). The area used by weighting are not exactly equivalent to those shown in Figure 3 as fishing is generally concentrated in only a portion of the total area (Stobo, pers. comm.).

Catch per unit effort was highest in 1968 at 97.64 mt/op day and gradually decreased to a minimum of 47.43 mt/op day in 1975. The 1977 figure of 121.58 was based on only partial log records and is thus only preliminary. From these statistics it is apparent that the population underwent a dramatic decrease from 1968 to 1972 but has remained at a fairly constant level since that time.

The yearly estimate of CUE was divided into the total catch (Table I) to provide estimates of effective effort. As no statistics are given for 1973, the effort for this year was interpolated from the 1972 and 1974 estimates. Winters (1977) provided effort statistics based on purse seine log records from the Gaspe - Chaleur Bay - Edge area for 1969-76. Except for the 1969 and 1970 estimates, there is fairly good agreement between his estimates and those presented here (Figure 4). Consequently this relationship was used to provide a 1976 estimate of 600 operating days.

From Figure 5 it is evident that both catch and effort reached a peak in 1970 but from 1972 to the present declines have not been as dramatic as in the 1970-72 period.

Calculation of Natural Mortality

Natural mortality for this stock has been assumed to be 0.2 (Winters and Hodder 1975) in past assessments which is consistent with values for other herring stocks (Burd unpub. ; Lea 1930; Runnstrom 1936). However, present management regimes have caused fishing mortality to drop from α0.2 for fully recruited age groups to <0.1 at present. When fishing mortality F, becomes this low, the determination natural mortality becomes critical in the assessment. For this reason we have endeavoured to recalculate natural mortality taking into account the use of the a geometric regression (Ricker 1973) as opposed to the regression of X on Y.

Winters _et al._ (1977) has previously shown a very clear relationship between F from cohort analysis and adjusted fishing effort for 5+ herring. Our premise is that if such a clear relationship is observable in this fashion, calculations of total mortality using catch-per-unit-effort at age data should be possible. Effort values used were those calculated for purse sieners as described in the previous section. In order to use partially recruited age groups in the calculation of average total mortality information is required on the rate of partial recruitment. This was determined from matrix of F values generated by cohort analysis between 1966 and 1974. The reason the latter two years were not used was because of there sensitivity to the intial starting partial recruitments. However, the end partial recruitments were determined by an iterative process whereby the average partial recruitment between 1966 and 1974 was used to determine a sequence of starting fishing mortality values, and when the average partial recruitment and the starting partial recruitment varied only by less than 0.01 were the values accepted.

The effort values calculated in the previous section were divided into the catch at age for spring and fall spawner combined to give overall catch-per-unit-efforts at age. The CUE's were then divided by the average partial recruitment to give an estimated true representation of the population structure using Palohiemo's linear formula total mortalities at age (7's) where calculated and averaged using the formula,

$$(1)\qquad \bar{Z} = \sum_{a=2}^{a=10} \ln\left(\frac{{}_{a}CUE_{t}}{{}_{a+1}CUE_{t+1}}\right) \Big/ 9$$

to give the following values.

Year	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76
$\bar{Z}$	0.422	(0.029)	0.459	0.296	0.220	0.271	0.243
Avg. Effort (E) Operating Days.	3762	4067	2631	1451	996	866	770

The geometric regression of effort on $\bar{Z}$ (Fig 6.) yielded the relationship.

$$(2)\qquad \bar{Z} = 0.176 + 8.204 \times 10^{-5} E \qquad r^2 = 0.80$$

giving an estimate of natural mortality, M, of 0.176± 0.094 at P <0.30. The 1976 estimate of fishing effort was 600 operating days or a total mortality of 0.225 ± 0.0687 at P<0.30. This leaves an estimate of fishing mortality of 0.049 in 1976. Since this is the average level of F over partially recruited age groups, it was now necessary to pro-rate this value over the entire age structure in 1976 using the formula

$$(3)\qquad F_{start} = \bar{F} \cdot \frac{\sum_{a=2}^{a=10} \partial_a}{9}$$

giving a fully recruit F_{start} value 0.071.

This F value was distributed over the age groups to start the cohort analysis in accord with the partial recruitments (Table III). The results of the cohort analysis are presented in Table IV. After the cohort analysis was ran weighted F values for all age groups were plotted as a fuction of fishing effort within that year. The values were as follows;

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
VPAF	0.050	0.085	0.185	0.237	0.265	0.089	0.055	0.033	0.047	0.02
Effort	1403	1593	2950	4574	3559	1702	1200	792	940	600

The regression of effort on F produced the following relationship

(4) $\hat{F} = 0.012 + 5.792 \times 10^{-5} E$. $r^2 = 0.968$. (Fig. 7)

which was almost a perfect fit. However this by no means suggests the numbers at age generated by the VPA are accurate, because of the trend in effort. Possible error in the cohort estimates are more fully discussed in the next section. A plot of the CUE against the 3+ stock biomass shows a linear relationship between the two (Fig.8) which passes through a point not significantly different from the origin. This relationship is probably the best indicator that we are possibly on the right track since the cumulative F values in 1968 (Table V) would suggest that errors in the initial starting values are nearly damped out. Thus the 1968 point will remain almost fixed as the later values will fluctuate in accord with the starting F value.

When values from Winters VPA (1977) for 5+ stock biomass were plotted against the CUE's this relationship fell apart. In fact the trend in Winter's data is indicative of an underestimate of the starting F values in 1976. It is therefore our conclusion that the present biomass is approximately twice that estimated by Winters et al, (1977) and the TAC should be adjusted accordingly.

Accuracy of Cohort Analysis Results

Pope in his classic 1972 paper undertook as investigation into the errors inherent in population estimates generated by Cohort analysis. He determined that as the technique works backwards up a cohort, the errors in the estimates of fishing mortality, F and population numbers N tend to depreciate so that when the cumulative fishing mortality is greater than 2.0, the errors in the estimates are small (7-14% for a range of Fs + 100 and - 50% of actual). Of course the cumulative F at which errors tend to become small depends on the error in the starting fishing but 2.0 acts as a good indicator. It was also found that it is better to overestimate than underestimate the starting fishing mortality.

The starting Fs in this VPA are low, being 0.071 for fully recruited year-classes. As well, there is a trend of increasing terminal Fs as one goes back in time. Examination of the table of the cumulative Fs (Table V) shows that the value of 2.0 is only first exceeded by 9-11+ individuals in 1968. In fact for most of the table after 1971, the cumulative F's are low and thus the accuracy of F values in this part of the Table are largely a function of what is input as starting F's. From the relationship between $\bar{Z}$ and $\bar{f}$, it was determined that, assuming all the error lies in F, a starting F at 600 operating days of effort could lie between 0.12 and 0.001 70% of the time. In order to see what changes in the population estimates would occur at different starting F's, a number of analyses were carried out using F values ranging from as high as 0.12 to as low as 0.02. For comparison purposes, changes were expressed as a percent of the numbers generated using a terminal F of 0.071. The trends in differences with time are given in Figure 9. In all cases convergence to the estimate is slow, as expected. However, while the numbers generated at a terminal F of 0.12 are never more than 60% lower than the standard, estimates using terminal F's of 0.04 and 0.02 are 150 to 350% higher than the standard. The above discussion, of course, assumes that there is no error in the estimate of M, an unlikely possibility.

In summary, it can be stated that because the F values generated by the VPA are very low, the accuracy in population and fishing mortality estimates depends almost entirely, until 1971 anyway, on the accuracy of the starting F values. These, as said, could vary between 0.001 and 0.12, a variation which would produce dramatically different estimates of abundance and fish mortality. The relationship between F and effort provides little basis for validation of the cohort analysis since, as stated, the F is largely a function of what is input. Some independent source of data, such as that from research survey cruises, is needed to provide a population structure against which the results of the cohort analysis can be compared and verified. Unfortunately no such data exists at this time and we must therefore be content with the best estimates of terminal fishing mortalities, the means.

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Table I. Herring catches (metric tons) in the Gulf of St. Lawrence, 1958-77.

Year	ICNAF Subdivision			Total Catch	TAC
	4T	4R	3PN		
1958	24705	-	-	24705	
1959	22350	-	-	22350	
1960	21711	-	-	21711	
1961	18823	1574	19	20416	
1962	34442	1983	38	36463	
1963	39900	2274	27	42201	
1964	39333	5148	47	44528	
1965	44254	4868	58	49180	
1966	36905	6490	127	43522	
1967	62636	6019	259	68914	
1968	112130	7379	35996	155505	
1969	154406	3287	95459	253152	
1970	175497	5014	94224	274735	
1971	134846	10596	69912	215354	
1972	53590	12183	18993	84766	150000
1973	40357	26995	395	67747	35000
1974	35153	6642	74	41869	45000
1975	44565	4796	24	44589*	45000
1976	39453	11234	15	39468*	55000
1977					60000

* excluding St. Georges Bay

Table II. Catch composition (numbers x 10^{-5}) of Gulf of St. Lawrence. Herring Stock Complex for 1967-1976.

A) Spring Spawning Component

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	1	54	1	1	32	1	58	47	16	80
3	35	99	172	84	660	21	25	88	268	55
4	132	28	184	407	68	291	30	34	192	237
5	190	224	129	127	136	64	469	18	32	81
6	58	174	293	166	96	58	77	268	168	27
7	224	56	251	326	91	43	45	39	201	3
8	890	273	85	356	153	48	79	42	25	102
9	263	1098	486	102	150	51	29	62	33	15
10		230	1554	393	56	53	31	11	53	14
11			178	1127	170	14	12	3	18	66
12				87	478	30	9	3	5	21
13					30	29	26	2	3	16
14						1	25	9	2	16
15							1	9	15	2
16								1	15	6
17									4	15
18										2

B) Fall Spawning Componet

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	1	6	24	22	49	57	1	47	1	1
3	21	50	219	422	331	52	38	50	22	3
4	36	17	200	590	929	156	48	163	41	19
5	212	343	195	302	356	514	83	60	255	47
6	76	467	911	254	600	213	218	40	70	273
7	105	220	1197	1604	888	294	100	99	33	43
8	175	217	384	1032	1158	270	132	27	50	20
9	1446	532	505	429	586	245	102	53	22	42
10	629	1501	940	618	315	125	153	40	37	9
11		745	2915	842	358	81	68	60	36	33
12			459	2222	594	142	29	25	54	32
13				201	1200	169	28	20	23	62
14					126	338	33	19	18	14
15						34	67	22	17	10
16							8	46	20	11
17								5	42	13
18									4	32
19										16

Table III. Estimates of Partial Recruitment at age or used in present study's cohort analysis.

AGE	PARTIAL RECRUITMENT (2)
2	0.042
3	0.225
4	0.437
5	0.493
6	0.693
7	0.803
8	0.817
9	0.859
10	0.930
11+	1.000

Table IV. Results of cohort analysis on combined (spring and fall)
at age for Gulf herring complex

A) Population Numbers x 10^{-5}

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	13176	6049	8141	11133	3171	14848	7470	13587	4884	29666
3	9357	11048	5018	6804	9316	2585	12399	6210	11308	4080
4	17159	7795	9128	3850	5243	6905	2101	10340	5082	9218
5	10982	14236	6496	7304	2316	3484	5381	1691	8491	4048
6	4507	8841	11419	5151	5732	1492	2392	4007	1346	6858
7	7761	3657	6828	8474	3935	4170	1003	1736	3078	911
8	16315	6207	2814	4400	5339	2404	3188	708	1329	2367
9	20035	12707	4757	1930	2419	3277	1724	2480	531	1046
10	3464	15237	9164	3081	1133	1354	2477	1326	1975	395
11		2328	11193	5401	1658	610	973	1909	1065	1574
12			1270	6554	2726	907	425	742	1543	844
13				643	3382	1305	603	321	597	1240
14					355	1710	913	456	249	477
15						181	1123	712	357	191
16							120	880	569	270
17								92	695	445
18									72	540
19										56

B) Fishing Mortalities

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	.000	.011	.003	.002	.028	.004	.009	.008	.004	.003
3	.007	.015	.089	.085	.123	.031	.006	.025	.028	.016
4	.011	.006	.047	.332	.233	.073	.041	.021	.051	.031
5	.041	.044	.056	.066	.264	.200	.119	.052	.038	.035
6	.033	.082	.122	.093	.142	.221	.145	.088	.214	.049
7	.047	.086	.263	.286	.317	.092	.172	.091	.087	.057
8	.074	.090	.201	.422	.312	.156	.075	.113	.064	.058
9	.098	.151	.258	.357	.404	.104	.087	.052	.120	.061
10	.221	.132	.353	.444	.443	.155	.085	.043	.051	.066
11		.431	.359	.508	.427	.186	.094	.037	.057	.071
12			.504	.486	.561	.232	.103	.042	.043	.071
13				.420	.506	.181	.103	.078	.049	.071
14					.496	.244	.072	.069	.092	.071
15						.237	.068	.049	.103	.071
16							.086	.060	.070	.071
17								.074	.075	.071
18									.079	.071
19										.071

Table V. Cumulative fishing mortalities generated by cohort analysis performed on total catch at age matrix.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	.612	1.387	.881	.550	.424	.117	.120	.067	.019	.003
3	.892	.612	1.376	.878	.548	.395	.113	.111	.059	.016
4	1.115	.886	.597	1.288	.793	.424	.364	.107	.086	.031
5	1.624	1.104	.880	.550	.955	.560	.351	.323	.086	.035
6	1.649	1.583	1.059	.824	.484	.691	.360	.232	.271	.049
7	1.845	1.616	1.500	.937	.730	.341	.470	.216	.144	.057
8	2.089	1.797	1.530	1.237	.651	.413	.249	.298	.125	.058
9	2.100	2.015	1.707	1.330	.815	.339	.257	.174	.186	.061
10	2.618	2.002	1.864	1.449	.972	.411	.235	.171	.122	.066
11		2.397	1.870	1.511	1.005	.530	.256	.150	.128	.071
12			1.966	1.510	1.003	.578	.343	.162	.114	.071
13				1.462	1.025	.442	.346	.240	.120	.071
14					1.043	.519	.261	.243	.163	.071
15						.546	.275	.189	.174	.071
16							.309	.206	.141	.071
17								.224	.146	.071
18									.150	.071
19										.071

Table VI. Results of Cohort Analysis on spring catch at age data from the Gulf herring complex.

A) Population Numbers x 10^{-5}

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	6944	2705	1998	12404	800	2785	7116	13086	5313	22145
3	2665	5822	2219	1675	10401	642	2335	5915	10931	4441
4	3273	2203	4792	1703	1328	8118	519	1935	4880	8922
5	3192	2624	1822	3850	1056	1051	6542	408	1592	3916
6	809	2503	1995	1410	3113	761	823	5057	325	1305
7	3160	626	1939	1405	1030	2522	585	620	3995	119
8	9314	2445	473	1397	880	781	2076	449	484	3166
9	1150	6996	1800	319	845	598	611	1669	338	383
10		724	4862	1065	174	571	455	486	1342	253
11			396	2654	533	95	431	353	397	1077
12				169	1194	291	67	350	293	317
13					62	563	217	48	291	241
14						25	446	158	38	241
15							20	351	124	30
16								16	286	90
17									12	226
18										7

B) Fishing Mortalities

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	.000	.022	.001	.000	.045	.000	.009	.004	.003	.004
3	.014	.019	.088	.056	.072	.036	.012	.016	.027	.014
4	.045	.014	.043	.302	.058	.040	.065	.019	.044	.029
5	.067	.098	.080	.037	.152	.069	.082	.049	.022	.023
6	.081	.079	.175	.138	.034	.087	.108	.060	.829	.023
7	.081	.103	.152	.292	.101	.019	.088	.071	.057	.028
8	.110	.130	.218	.326	.211	.069	.042	.108	.058	.036
9	.287	.188	.349	.429	.215	.098	.053	.041	.113	.044
10		.426	.429	.516	.432	.107	.077	.025	.044	.062
11			.674	.623	.428	.176	.031	.009	.051	.069
12				.822	.575	.119	.159	.009	.019	.075
13					.744	.058	.140	.047	.011	.075
14						.045	.063	.064	.059	.075
15							.056	.028	.141	.075
16								.072	.059	.075
17									.436	.075
18										.075

Table VII. Results of Cohort Analysis on fall catch at age data from the Gulf herring complex.

A) Population Numbers x 10^{-5}

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	7058	3541	7029	2227	2560	16105	2489	872	246	634
3	6743	5918	2964	5873	1847	2102	13454	2086	688	205
4	14099	5635	4917	2285	4539	1246	1715	11248	1704	557
5	7789	11791	4710	3941	1376	2955	902	1395	9283	1391
6	3734	6338	9574	3771	3028	828	2008	680	1115	7552
7	4626	3062	4887	7194	2930	1990	499	1484	534	871
8	6999	3783	2367	3002	4564	1644	1400	327	1154	418
9	18905	5709	2974	1633	1573	2767	1132	1053	250	922
10	3454	14530	4301	2032	977	782	2096	856	834	189
11		2321	10811	2746	1138	531	542	1618	681	666
12			1264	6397	1532	626	371	392	1302	538
13				640	3329	741	395	284	306	1042
14					352	1693	466	306	220	235
15						180	1110	361	239	168
16							120	870	282	185
17								93	687	219
18									74	538
19										58

B) Fishing Mortalities

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	.000	.002	.004	.011	.021	.004	.000	.061	.004	.002
3	.003	.009	.084	.082	.218	.027	.003	.027	.036	.016
4	.003	.003	.045	.331	.253	.147	.031	.016	.027	.038
5	.030	.032	.046	.087	.332	.211	.106	.048	.030	.038
6	.022	.084	.110	.076	.244	.330	.126	.066	.071	.040
7	.025	.082	.311	.279	.402	.176	.247	.076	.070	.055
8	.028	.065	.195	.471	.324	.198	.109	.094	.048	.054
9	.087	.107	.205	.338	.522	.102	.104	.057	.101	.051
10	.222	.120	.273	.404	.434	.192	.083	.052	.050	.053
11		.432	.349	.408	.421	.182	.147	.041	.059	.056
12			.505	.477	.551	.284	.089	.072	.046	.067
13				.420	.500	.287	.081	.080	.086	.067
14					.495	.246	.080	.070	.094	.067
15						.231	.068	.069	.081	.067
16							.076	.059	.080	.067
17								.060	.069	.067
18									.061	.067
19										.067

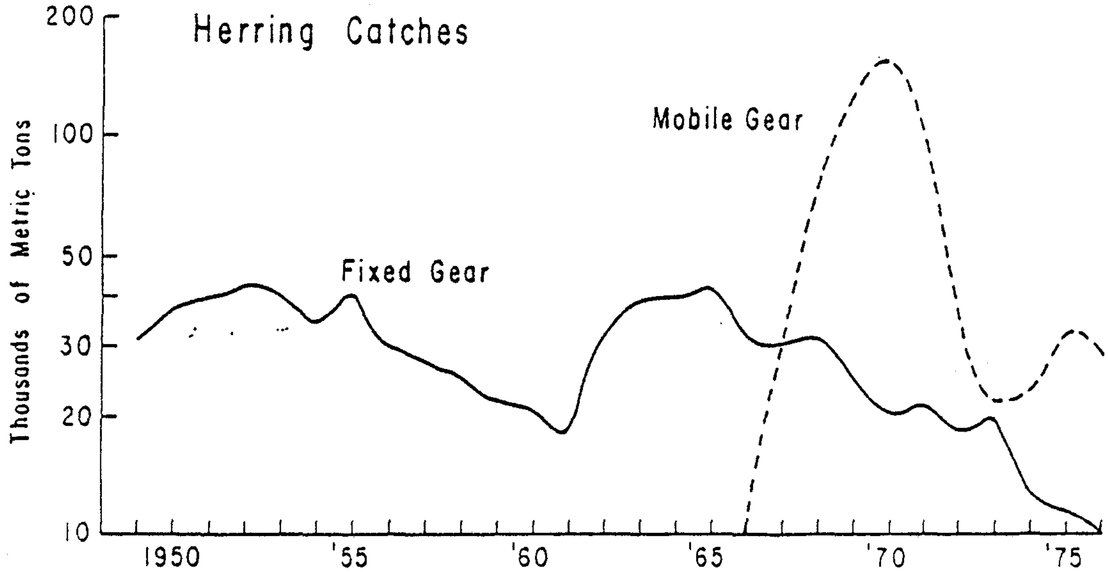


Figure 1. Herring catches ('000 MT) in the southern Gulf of St. Lawrence (Div. 4T) by fishing gear, 1949-76. (From Messieh, 1978)

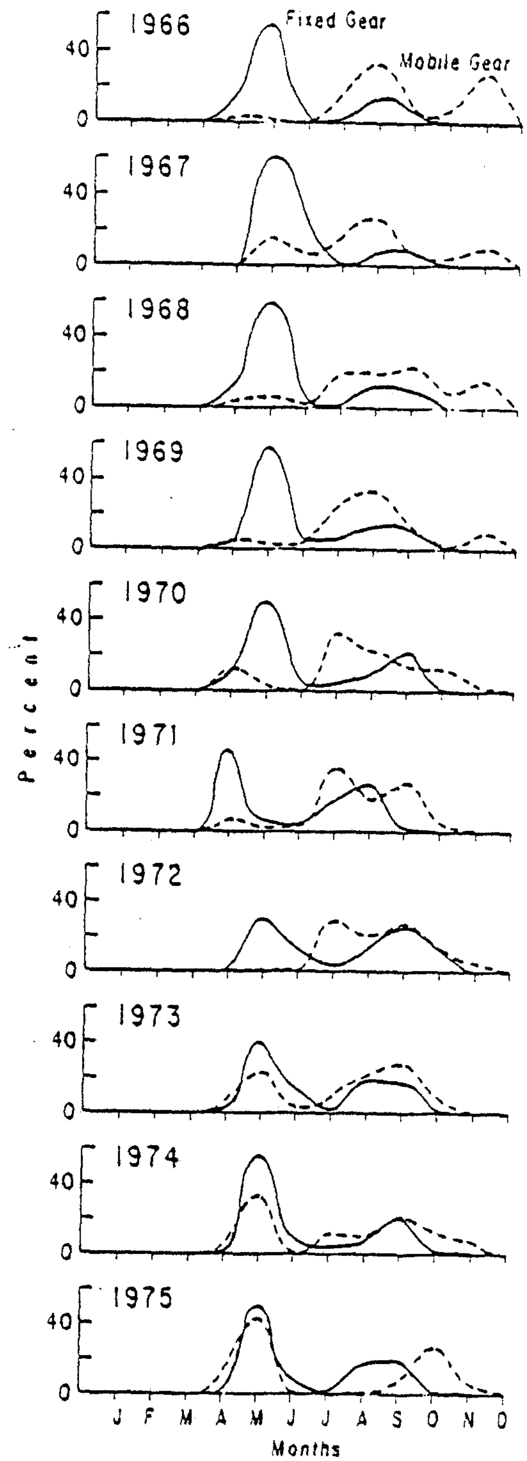
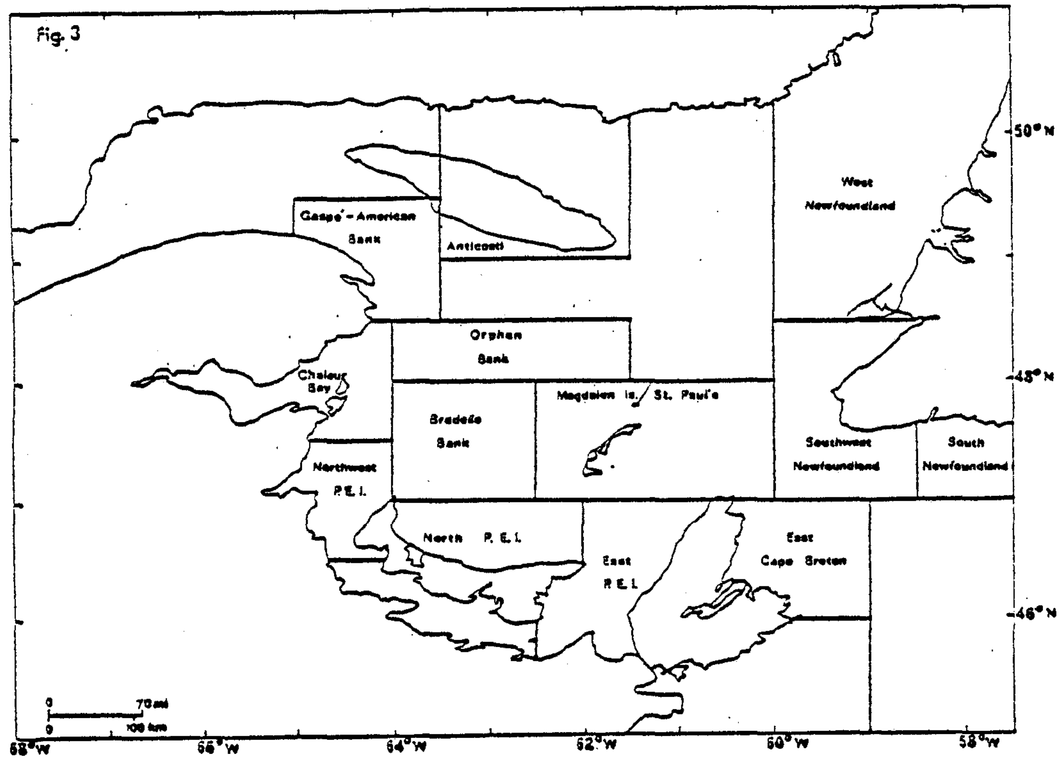


Figure 2 Seasonal pattern of herring catches by fishing gear in the southern Gulf of St. Lawrence, 1966-75. (From Messieh, 1978)

Fig. 3. Areas need to calculate CUE.

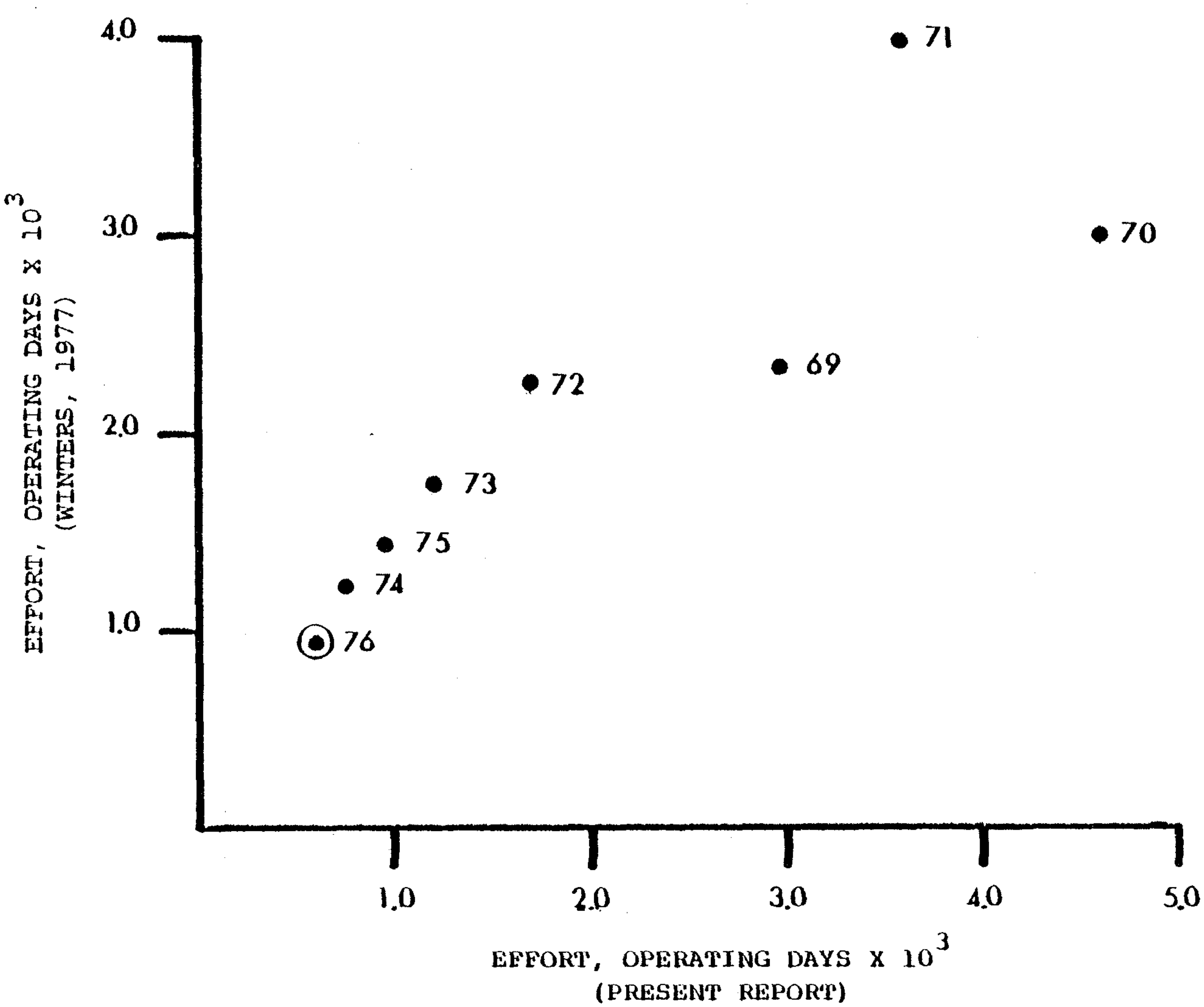


Year	CUE BY AREA*				Weighted
	Gaspe (4.25)	Chaleur (3)	Orphan B. (3)	Bradelle (1)	CUE (MT/on/ Day)
1967	49.9	54.77	42.4	-	49.13
1968	92.4	76.5	126.2	-	97.64
1969	72.5	90.1	100.3	-	85.79
1970	65.3	75.8	36.9	-	60.06
1971	69.2	61.7	-	20.0	60.51
1972	59.23	53.0	20.4	88.5	49.82
1973	-	-	-	-	-
1974	39.4	38.2	-	154.2	52.88
1975	42.45	39.7	62.2	-	47.43
1976	-	-	-	-	-

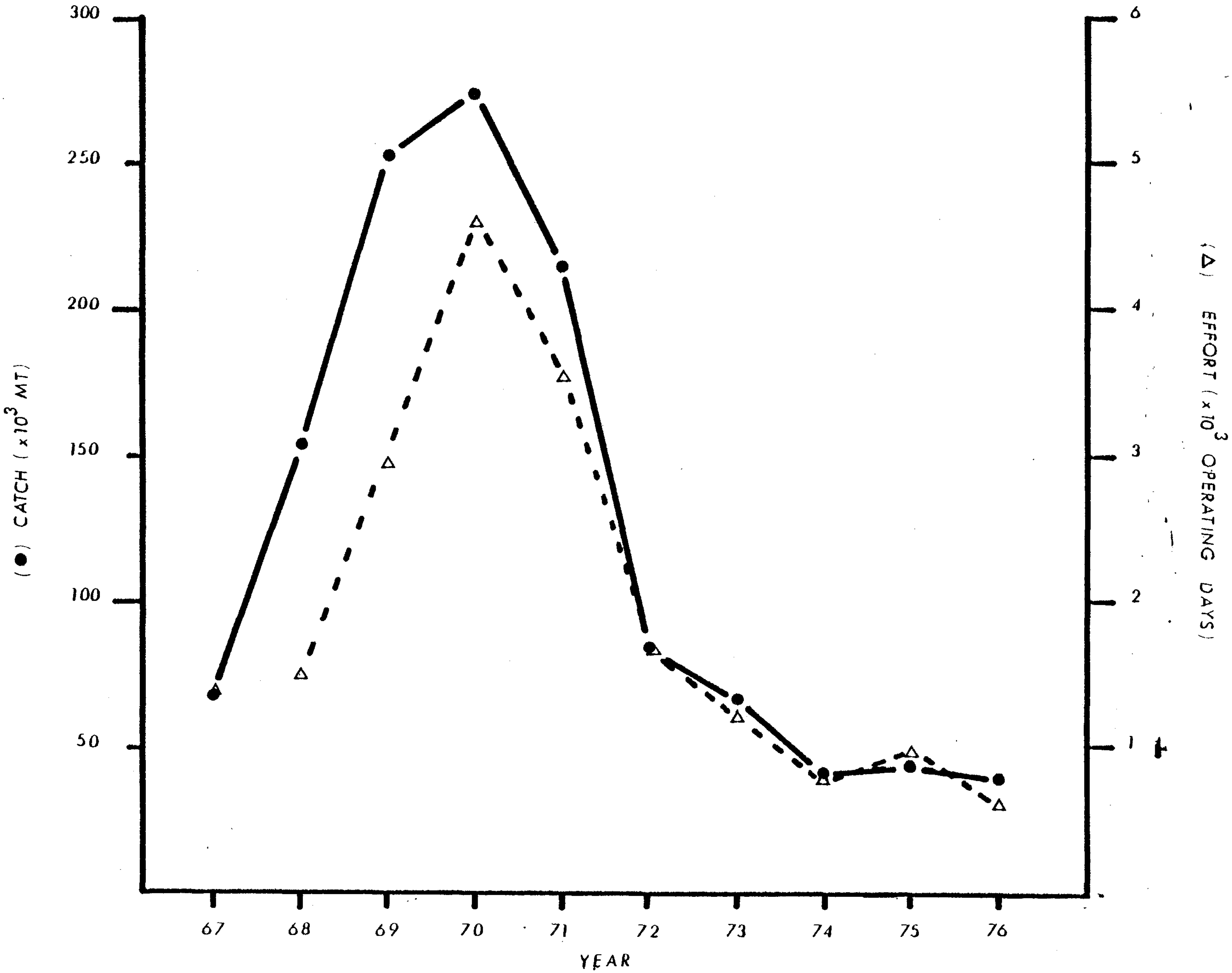
* weightings used in parenthesis.

Figure 4

COMPARISON OF EFFORT STATISTICS USED BY WINTERS (1977) TO THOSE USED IN PRESENT REPORT



TREND IN TOTAL CATCH AND EFFECTIVE EFFORT OF SOUTHERN GULF HERRING STOCK COMPLEX DURING 1967 - 1976.



MEAN TOTAL MORTALITY, $\overline{z}$, AS A FUNCTION OF MEAN EFFECTIVE FISHING EFFORT, $\overline{f}$, (OPERATING DAYS)

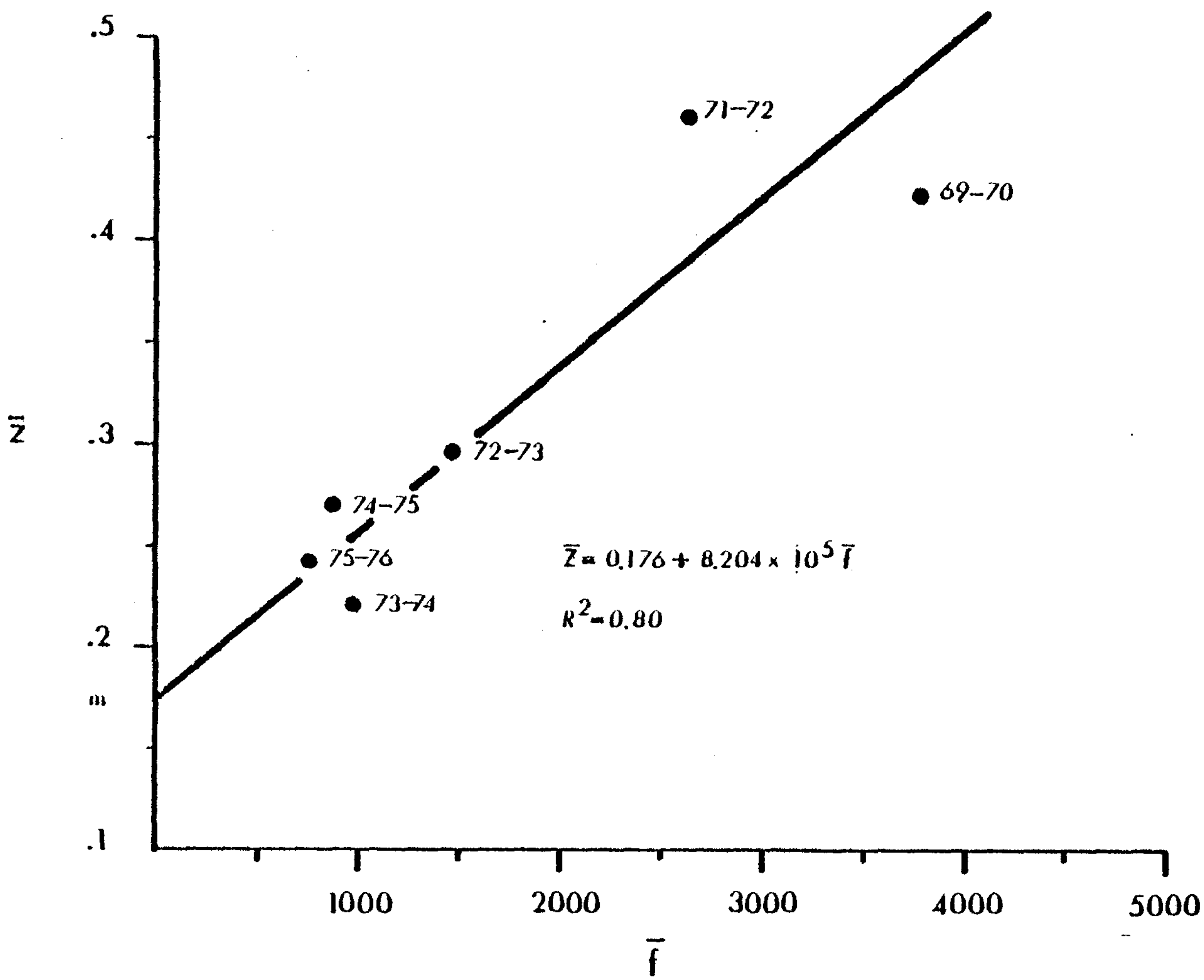


Figure 7

THE RELATIONSHIP BETWEEN THE POPULATION NUMBERS WEIGHTED FISHING MORTALITY OF THE COHORT ANALYSIS AND EFFECTIVE EFFORT IN OPERATING DAYS.

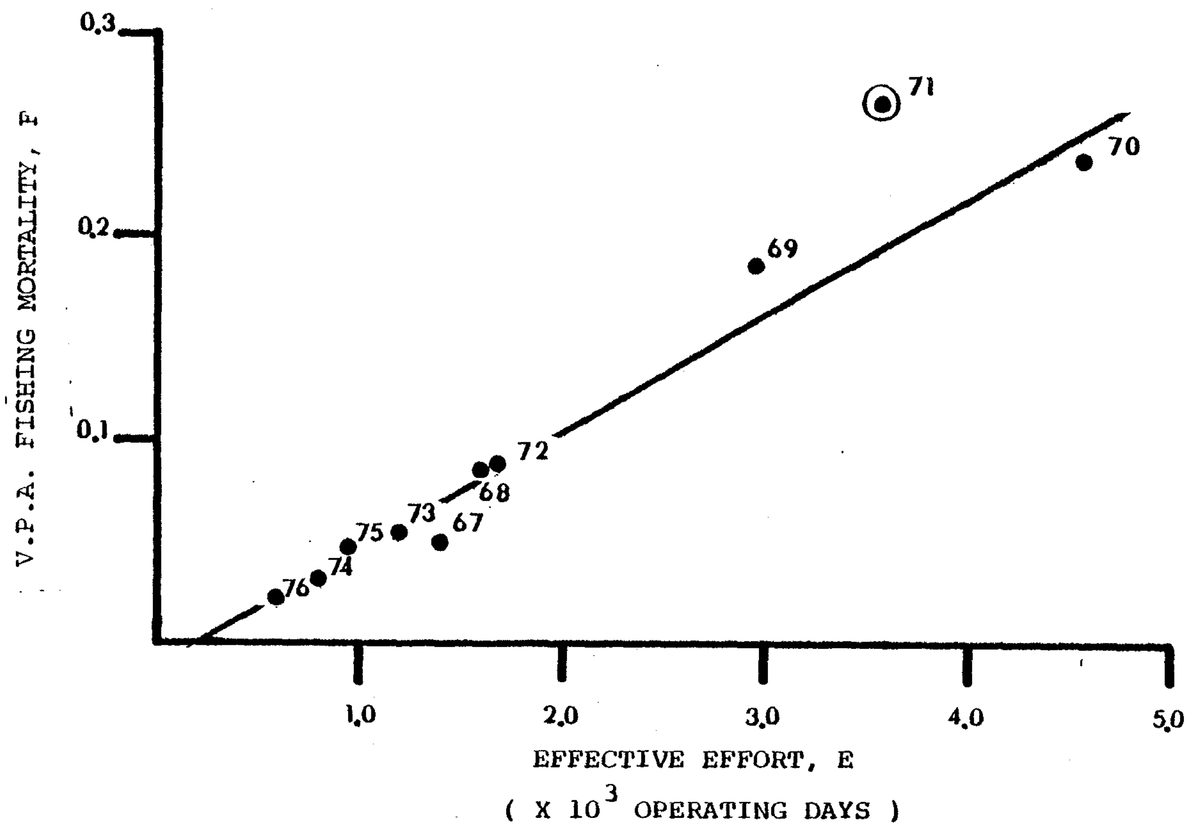
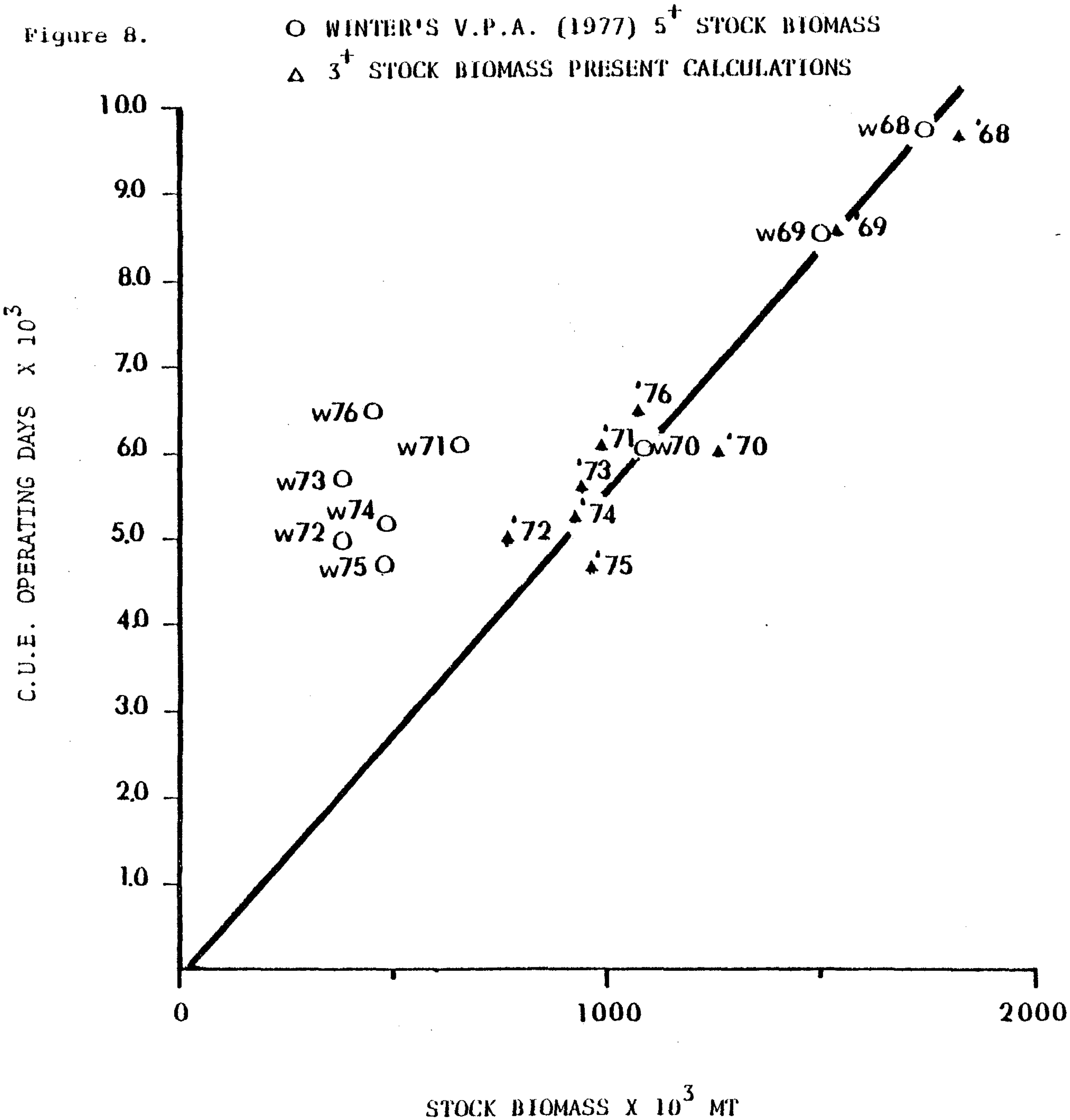


Figure 8.



O WINTER'S V.P.A. (1977) 5+ STOCK BIOMASS
Δ 3+ STOCK BIOMASS PRESENT CALCULATIONS
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
C.U.E. OPERATING DAYS X 10^3
w68
'68
w69
'69
'76
w76
w71
'71
w70
'70
'73
w73
w74
'74
w72
'72
w75
'75
0
1000
2000
STOCK BIOMASS X 10^3 MT

Figure 9

TRENDS IN CONVERGERCE OF POPULATION NUMBERS ON ESTIMATED NUMBERS USING VARYING STARTING FISHING MORTALITIES, F.