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A Review of the Assessments of the American Plaice Stock in Div. 3LNO in Relation to the Recent Decline in Stock Abundance

by

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Introduction

American plaice (Hippoglossoides platessoides) is a flatfish which occurs on both the eastern and western sides of the North Atlantic. The largest commercial fishery for the species occurs on the Grand Bank, NAFO Div. 3LNO (Fig. 1). This fishery developed in the late 1940's, and was essentially Canadian until the mid-1960's (Pitt 1971). Other nations entered the fishery at this time, and catches peaked at 94,000 t in 1967 (Brodie et al., 1990). Catches subsequently stabilized at around 50,000 t, although there was an increase in the mid-1980's as foreign effort increased, mainly in the Tail of the Bank area (Fig. 2), before declining in 1988 and 1989.

This stock has been under TAC regulation since 1973, and up to 1987, the TAC's ranged from 47,000 to 60,000 t. In 1988, the TAC was set at 33,585 t, and was lowered to 30,300 t in 1989 and 24,900 t in 1990 (Fig. 3). Catches have exceeded the TAC a number of times, with the largest overruns occurring in 1985-87 (Fig. 3). This paper will examine the assessment history of the A. plaice stock in Div. 3LNO, focusing on the decline in abundance in the mid to late 1980's. It will examine the indices of abundance derived for the stock and the way in which they were interpreted in the annual assessment of stock status, conducted by ICNAF and then NAFO.

Assessment history

The first published assessment of the A. plaice stock in Div. 3LNO is by Pitt (1971). This and most other assessments in the early 1970's used virtual population analysis (VPA) as the main tool, although Pitt (1973) also used a Schaefer model to assess the stock. VPA was the model used throughout the 1970's, giving way to other sequential population analysis (SPA) models as they evolved, eg. Pope's cohort analysis (Pope 1972) and the adaptive framework (Gavaris 1988).

Pitt (1975) advocated that the assessment of the stock be done separately by division, and in fact separate VPA's were used from 1971 to 1976 on the data for Divs. 3L and 3N. However, ICNAF (1975) noted that this management approach would cause many practical difficulties, and continued to provide advice for Div. 3LNO combined. From 1977 to 1988, data for Divs. 3LN were combined to form the basis of the assessments. Data for Div. 3O were excluded from the VPA models during this period, mainly because of the shortness of the catch at age time series compared to Divs. 3LN (Pitt 1979). However, Brodie and Bowering (1989) recalculated much of the catch at age for Div. 3O back to 1974 allowing data for Divs. 3LNO combined to be used in the stock assessment. Another change in the treatment of the catch at age data for this stock occurred in 1980 when the data for both sexes were combined before being used in SPA (Pitt and Brodie, 1980). Prior to this, the analyses were conducted on each sex separately.

Catch at age data for this stock exist from 1956 onward, but the data for the earlier years are usually based on fewer samples. For Divs. 3LN, the data for 1965 onward have been used in most assessments, while Div. 3O data extends back only to 1974, as noted previously.

Independent indices of abundance

The data used to calibrate the sequential population analyses performed on this stock have come from two sources:

1) The Newfoundland-based offshore trawler fleet

Logbooks maintained by this fleet from the 1950's onward have provided catch per unit of effort (CPUE) information from the commercial fishery (Pitt 1973). Up until the mid-1960's, this fleet consisted of side-trawlers, after which time larger stern-trawlers became prominent. In 1989, the fleet contained only a few remaining side trawlers with the vast majority of vessels being stern trawlers (Brodie et al. 1990). To standardize the CPUE from the two different vessel classes, Pitt (1973) used a conversion factor of 0.8 applied to the less efficient side trawler effort. This approach was continued until Brodie (1987) used a multiplicative model (Gavaris 1980) to standardize the catch rates for vessel class, division, month, and year.

In some early assessments, both the CPUE from the total A. plaice catch and the directed, or main species A. plaice catch were used as indices of abundance, but only the latter series has been used since 1980. Figure 4 shows the CPUE series for A. plaice in Div. 3LNO, as calculated in the most recent assessment (Brodie et al., 1990). An important feature in this series, in relation to the recent stock decline, is the trend in the catch rates from the mid-1980's to the present. With the use of the multiplicative model (1987 onward), the addition of the data for Div. 3Ø (1989 onward) and, mainly, the correction (in 1989) of errors in the effort data from 1984 to 1987, a different perception of the CPUE in the mid-1980's was obtained. Figure 5 shows the CPUE series from 1982 to 1986, as calculated in the 1987 and 1990 assessments, indicating the differences, which are mainly in the values for 1984 and 1985. It should be noted that the 1985 and 1986 assessments also used the same data and calculations that were used in 1987.

In the 1990 assessment of the stock, CPUE at age for the Canadian fishery in Div. 3LNO was derived. These data (Table 1) show that the recent decline in CPUE is more evident at the older ages.

2) Canadian research vessel surveys

Research vessel surveys have been conducted on the Grand Bank on Canadian ships since at least the early 1940's, with regular line transect surveys beginning in the 1950's (Pitt et al. 1981). However, it was not until after stratified random surveys were implemented in 1971 (Grosslein and Pinhorn 1971) that survey data became an important part of the stock assessments for A. plaice in Div. 3LNO. From 1971 to 1982, the surveys were carried out in the spring of each year onboard the research vessel A. T. CAMERON, a side trawler equipped with a Yankee 41.5 otter trawl. There was no comparable survey in 1983 and the surveys from 1984 to 1990 were done with the research vessels W. TEMPLEMAN and A. NEEDLER, sister stern trawlers which used Engels 145 otter trawls. Gavaris and Brodie (1984) calculated conversion factors for American plaice and yellowtail to allow comparison of catch numbers from both vessel-gear combinations. To derive an index of abundance which would be comparable in terms of strata covered, a series of selected strata, fished in most years, was chosen (Brodie 1985). This was later replaced (Brodie 1988a) by a series derived from a multiplicative model, which estimated values for strata not fished in each year. This analysis showed, with the exception of Div. 3L in 1984, that most of the estimated values were for surveys prior to 1982, with few strata being omitted in most surveys after 1982.

Table 2 shows the population numbers of American plaice as derived from the surveys in Div. 3LNO (Brodie et al. 1990). As shown in Fig. 6, there was an increase in abundance up to the early 1980's followed by a sharp decrease. It should be noted that in 1983, which is a key year in evaluating the magnitude of the decline, no spring survey was done in Div. 3LNO. Figure 7 indicates that the decline occurred in all three divisions and that recent values are among the lowest in the time series. These data also show that the largest portion of the Grand Bank A. plaice population occurs in Div. 3L. In addition to the spring survey series in Div. 3LNO, there have been a number of seasonal surveys conducted by Canadian research vessels in Div. 3L since 1981. These data also show a decrease in the abundance of A. plaice from the early 1980's to the present (Fig. 8). USSR stratified random surveys on the Grand Bank show the same pattern as the Canadian surveys, with peak abundance in the late 1970's and early 1980's, followed by a decline to levels similar to those in the early 1970's (Bowering and Chumakov 1990).

It is clear from all available indices that the stock declined in the mid-1980's. The CPUE shows a sudden drop from 1985 to 1986 followed by stability, while the surveys indicate an earlier decline, probably from 1982 to 1984, followed by stability. However, these two indices do not show the same magnitude of decline. Although they both indicate that the stock size in the mid-1970's and late 1980's is about the same, the degree of increase in the late 1970's and subsequent decrease in the mid-1980's is greater in the survey series (Fig. 9). The data also show that there was a succession of strong year-classes in the late 1960's and early 1970's, which supported the high CPUE in the fishery. Following these, however, were a number of weaker year-classes, which led to the drop in the CPUE (Fig. 10).

Calibration of SPA

In all of the early assessments of this stock, the linear relationship between fishing mortality (F) from SPA and fishing effort derived from CPUE data was used to determine the value for F in the most recent year. It was not until 1980 that research vessel survey data came into use as a calibration tool (Table 3), as a sufficient time series was available by that time (Pitt and Brodie 1980). Also at this time, the relationship between aggregate biomass and CPUE was used to tune the SPA. In later years exploitable, or fishable, biomass from SPA replaced aggregate biomass in the CPUE calibration because aggregate biomass included a portion of the population which was not measured by the CPUE index. In the 1985 and 1986 assessments, the relationship between population numbers from SPA and surveys was examined but not used in deciding on terminal F, as there was no 1983 survey and the 1984 survey in Div. 3L was incomplete. The survey data was again used after the 1986 assessment, and in 1989, the Adaptive framework was used in calibrating the SPA, representing the first time that age-disaggregated data had been used in the tuning process for this stock (Brodie and Bowering 1989). ADAPT was again used in 1990, with all data, both CPUE and survey being used age-disaggregated in one formulation of the model (Brodie et al. 1990). One of the features of the ADAPT methodology is that it provides parameter estimates with statistical properties which can be evaluated to determine the best fit of the model (Gavaris 1988). This is a clear advantage over the "ad hoc" tuning methods, in which the best fit for a particular relationship was often determined by evaluating several aspects of a least-squares regression (correlation coefficient, residual pattern, intercept) without well defined and objective criteria as to what actually constituted the best fit. The selection of an appropriate terminal F was often made more difficult by the existence of several such relationships, as indicated for several assessments of this stock (Table 3).

Examination of SPA results

A) Current

The 1990 assessment of this stock showed the population size at ages 5+ to be relatively stable in recent years, at about three quarters of the population size of the mid-1970's (Fig. 11). However, these data also show that the stability has been caused by a slight increase in recruitment, as the population at the older ages (9+) has declined. Figure 12 shows the comparison of the population from the 1990 SPA, the population from the R.V. surveys, and the CPUE index, with each index scaled to its highest point. The SPA shows a more gradual decline in population size, and does not reflect the sudden declines in the survey series (1981-84) or the catch rate (1985-86).

Figure 13 displays the trends in fishing mortality and yield, as taken from the 1990 assessment (NAFO Sci. Coun. Rep., 1990, p. 72). The values of F from 1965 to 1973 are for Divs. 3LN only, and were taken from the 1988 assessment, as the current data set for Div. 3LNO extends back only to 1974. As in previous years, mean fishing mortality at ages 9+, weighted by population numbers from SPA, was the measure of F chosen. This was selected over fully recruited F (ages 11+) to account for some of the large proportion of fishing mortality from the partially recruited age groups (Brodie et a. 1990). These data show an increase in F in the mid-1980's as catches rose, with recent F values being about double those in the late 1970's.

B) Retrospective

As with many other stocks assessed with sequential population models (CAFSAC Ann. Rep. 1986, p. 12), American plaice in Div. 3LNO shows a consistent pattern of underestimated F in the previous assessments compared to the most recent. This can be seen in Fig. 14, which contrasts the estimates of F from the 1989 and 1990 assessments. Although the estimates converge quite rapidly, there is a discrepancy of 20-30% for 1987-89, not all of which can be accounted for by the upward revision of the nominal catches for these years in the 1990 assessment. This level of difference has not been uncommon, as indicated in Fig. 15, which compares the F values for 1979-88 from the 1990 assessment with the values as they were calculated in each year, eg. the 1988 value as calculated in the 1990 and 1989 assessments. The largest discrepancies were in the 1985 and 1986 assessments, when estimated F's were less than 50% of the values indicated in the 1990 assessment (Fig. 16). As noted previously, these 2 years were the only assessments since 1980 which did not use survey data for calibration, because of the gap in the survey series, and the 1984 assessment did not have a point in the survey series for the most recent year. Figure 17 shows that the F's for 1983 were substantially underestimated in

1984-86, before increasing in subsequent assessments. Translated into population sizes, these discrepancies in F meant there was a difference of about double between the 1984-86 assessments and the current value.

Discussion

In the assessments in the 1982-84 period, there was good agreement in the calibrations with the CPUE and survey data (Brodie and Pitt, 1984). Therefore, there was no apparent cause for concern when the 1985 and 1986 assessments did not use the spring survey series in calibrating the SPA, particularly when fall surveys in Div. 3L in 1983-84 showed relative stability in the population size (Fig. 8). Subsequent assessments, however, began to show a discrepancy in the calibrations, with the survey data consistently indicating a higher value for F in the terminal year. For example, the 1988 assessment indicated a fully-recruited F about 25-30% higher in the survey calibrations compared to the CPUE tuning. The problem was further compounded by the trend in the catch rate series, which showed an increase up to a 17-year high in 1985, as well as the previously noted error in the CPUE calculation (Fig. 5). By the time the survey data were again included in the calibration (in 1987), the CPUE had also declined sharply (from 1985 to 1986), which resulted in a totally different perception of stock status. The estimate of F for 1985 in the 1987 assessment was 72% higher than the estimate in the 1986 assessment. However, even when the 1987 assessment indicated these results, there was some doubt as to their validity. It was noted that this stock had a long-term history of stable catches, essentially due to relatively stable recruitment, and that the sudden changes in the indices of abundance may be due in part to changes in availability rather than in population size (NAFO Sci. Coun. Rep. 1987, p. 63). These doubts were caused by some changes noted in the distribution of American plaice on the Grand Bank after the extremely cold bottom temperatures which had been observed in 1984-86 (Wells et al. 1988). However, subsequent assessments showed that the indices of abundance stabilized at the lower levels, and that in fact the stock size was smaller.

There has been much speculation as to the reasons for the severe decline in the stock in the mid-1980's. For a stock not subject to large variations in recruitment, containing fish of about 15 year-classes in the commercial catches, the sudden decreases observed in the indices are difficult to comprehend, as one would expect to see much more gradual changes in such a stock. Although the recruitment was lower, and catches were higher than the $F_{0.1}$ reference level, as indicated by the retrospective analysis, neither of these factors fully explain the decreases. One theory is that the very cold water found on the Grand Bank throughout the mid-1980's produced an increase in natural mortality (m) which was not accounted for in the SPA, where a constant value of m for all years and age-groups has been used in all assessments. Brodie (1987) demonstrated a positive relationship between bottom temperatures and survey catches for A. plaice in Div. 3L, and the effect of low water temperatures in 1962-63 on the mortality of sole in the North Sea has been discussed by many authors (de Veen 1975). In addition, there was a large decline in the biomass of the adjacent A. plaice stock (Subarea 2 + Div. 3K) in the mid-1980's, with the largest decrease occurring in the area where commercial catches were negligible (Brodie 1988b). At present, however, the effects of low temperatures on the A. plaice population on the Grand Bank are not known, and studies are under way to attempt to quantify this.

In interpreting the assessments as they exist, it is clear that the difference in the timing and the severity of the decline between the CPUE and survey indices caused discrepancies in the SPA calibrations. The survey data produced a much more pessimistic view of the resource, a feature common to many stocks where CPUE and survey data are used. In fact, for many stocks, CPUE data have been eliminated from calibration of SPA, as rapidly developing fisheries and technological change have made trends in catch rate data difficult if not impossible to relate to stock abundance. However, it has long been argued that the offshore fishery for the Grand Bank A. plaice stock has not varied greatly over its 40 year existence, with the major change (from side to stern trawlers) being quantifiable. Nonetheless, differences continue to exist in the calibrations with the two indices (Brodie et al. 1990). As further indices of abundance are added (eg. juvenile flatfish surveys) when time series become long enough, and as methods of analyzing the indices and quantifying their variability continue to improve, differences in calibration should be more readily explainable. The use of such techniques as age-disaggregated indices, within the Adaptive framework, are certainly viewed as improvements in terms of SPA calibration. Whether these changes will eliminate the pattern of consistent underestimation of F in the current year remains to be seen.

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TABLE 1. CPUE AT AGE (TENS OF FISH/HR) FROM THE CANADIAN FISHERY.

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
5	0.3	0.9	0.7	0.9	1.4	1.3	0.3	0.2	0.0	0.2	0.1	0.0
6	5.7	3.1	3.1	6.5	4.1	6.7	3.5	0.6	0.4	1.6	0.6	0.3
7	10.1	7.0	7.0	8.5	8.4	13.9	11.3	2.6	2.1	5.0	2.2	2.0
8	9.7	9.2	15.5	11.4	9.5	19.2	14.9	5.5	5.5	9.4	4.7	5.9
9	7.5	9.0	13.3	13.2	11.6	15.4	16.7	9.1	10.3	13.5	8.4	11.9
10	8.6	7.7	9.9	10.8	12.7	12.8	16.8	13.2	14.8	12.5	14.2	17.4
11	6.8	5.6	6.7	6.3	9.1	9.0	13.4	15.7	18.2	13.8	18.4	15.7
12	4.4	4.6	4.1	4.1	6.2	3.9	9.6	13.7	16.7	12.2	12.8	10.0
13	3.7	3.7	2.4	2.3	3.3	1.9	4.4	10.0	9.2	7.4	7.2	4.3
14	2.2	2.6	1.9	1.4	2.0	0.7	1.9	6.5	4.9	4.0	3.6	1.8
15	1.1	1.4	1.1	1.0	1.3	0.4	0.8	3.4	2.3	2.0	1.6	1.1
16	0.6	0.7	0.5	0.3	0.6	0.2	0.3	1.3	0.7	0.6	0.6	0.3
17	0.3	0.5	0.2	0.2	0.2	0.1	0.1	0.5	0.2	0.2	0.1	0.1
18	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.3	0.1	0.1	0.0	0.0
5+	61.0	56.2	66.4	67.1	70.6	85.5	93.9	82.5	85.4	82.5	74.4	70.9
6+	60.7	55.4	65.7	66.2	69.2	84.2	93.6	82.3	85.4	82.3	74.3	70.8
7+	54.9	52.3	62.6	59.6	65.1	77.4	90.1	81.7	85.0	80.7	73.8	70.5
8+	44.9	45.2	55.6	51.1	56.7	63.6	78.8	79.1	83.0	75.7	71.6	68.5
9+	35.2	36.0	40.1	39.8	47.2	44.3	63.9	73.6	77.4	66.3	66.9	62.6

AGE	1986	1987	1988	1989
5	0.1	0.0	0.0	0.0
6	0.7	0.1	0.0	0.2
7	2.4	1.5	1.0	1.8
8	4.7	7.1	4.8	7.7
9	7.6	14.4	11.9	14.5
10	10.4	16.2	14.2	15.2
11	12.6	11.0	13.5	10.9
12	8.7	6.8	8.3	6.5
13	4.5	2.9	3.7	2.8
14	1.9	1.3	1.6	1.3
15	0.9	0.6	0.8	0.7
16	0.3	0.2	0.3	0.2
17	0.1	0.0	0.1	0.0
18	0.0	0.0	0.0	0.0
5+	55.0	62.2	60.2	61.9
6+	54.9	62.2	60.2	61.8
7+	54.2	62.1	60.2	61.6
8+	51.7	60.5	59.2	59.8
9+	47.0	53.5	54.4	52.1

TABLE 2. ABUNDANCE AT AGE (millions) OF A.PLAICE FROM RV SURVEYS IN DIV.3LNO FROM 1973-89.

AGE	1973	1975	1976	1977	1978	1979	1980	1981	1982	1984	1985	1986	1987	1988	1989
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2	1	2	1	1	1	2	2	4	1	0	0	0	1	0	0
3	10	10	13	6	17	7	7	21	6	1	3	2	5	4	5
4	15	20	24	30	34	25	15	20	20	3	11	7	13	12	26
5	58	27	40	77	112	71	50	39	22	10	22	18	29	27	26
6	73	47	51	137	144	111	99	83	44	36	46	56	74	69	69
7	96	88	94	196	198	172	173	157	81	96	104	120	147	122	99
8	60	115	175	249	224	240	270	311	163	138	126	113	152	122	106
9	48	120	173	189	163	186	218	235	228	144	94	93	92	106	85
10	60	105	172	179	130	157	141	173	184	95	72	53	55	46	38
11	52	61	108	86	47	76	64	84	106	43	45	25	23	27	20
12	44	43	68	58	33	36	41	38	50	27	24	13	18	18	14
13	25	24	36	25	16	13	21	17	25	13	12	12	11	10	8
14	16	13	13	11	9	8	8	7	13	8	8	5	6	6	5
15	8	8	12	7	5	5	6	6	5	5	5	4	4	4	5
16	5	4	6	4	2	3	5	4	4	4	3	2	2	3	2
17	3	1	4	2	1	1	2	2	2	2	1	1	1	1	1
18	2	0	1	1	0	0	1	1	1	1	0	0	1	0	1
19	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1+	576	688	991	1257	1138	1114	1122	1263	957	625	575	529	636	578	510
2+	576	688	991	1257	1138	1114	1122	1262	956	625	575	529	636	578	510
3+	575	687	990	1256	1137	1112	1120	1259	955	625	575	529	634	578	509
4+	564	677	977	1250	1120	1105	1113	1238	949	624	572	527	629	574	504
5+	549	657	954	1221	1086	1080	1098	1218	929	621	561	520	616	562	478
6+	491	631	914	1143	974	1009	1048	1178	906	611	539	503	587	535	452
7+	419	583	863	1007	829	897	949	1096	862	575	493	447	513	465	383
8+	323	495	769	810	631	726	777	938	781	479	389	327	366	344	284
9+	263	380	594	561	407	486	506	627	619	341	264	214	214	222	179
10+	215	260	421	373	244	299	289	332	391	197	170	121	122	116	94
11+	155	154	249	193	113	143	148	158	206	103	98	68	67	69	56
12+	103	93	141	108	66	67	93	74	100	59	53	45	44	43	36

Table 3. Chronology of SPA calibration methods used in the assessments of American plaice in Divisions 3LNO.

Period	Calibration techniques
1971-79	Fishing mortality from SPA vs. fishing effort.
1980-83	F vs. effort, biomass from SPA vs. CPUE, population numbers from SPA vs. population numbers from r.v. surveys.
1984	Fishable biomass from SPA vs. CPUE, SPA numbers vs. RV numbers.
1985-86	Fishable biomass from SPA vs. CPUE.
1987-88	Fishable biomass from SPA vs. CPUE, SPA numbers vs. RV numbers.
1989	ADAPT-2 separate formulations: fully recruited biomass vs. CPUE, and SPA numbers vs. RV numbers (age-disaggregated).
1990	ADAPT-1 formulation: SPA numbers vs. CPUE at age, SPA numbers vs. RV numbers, all age-disaggregated.

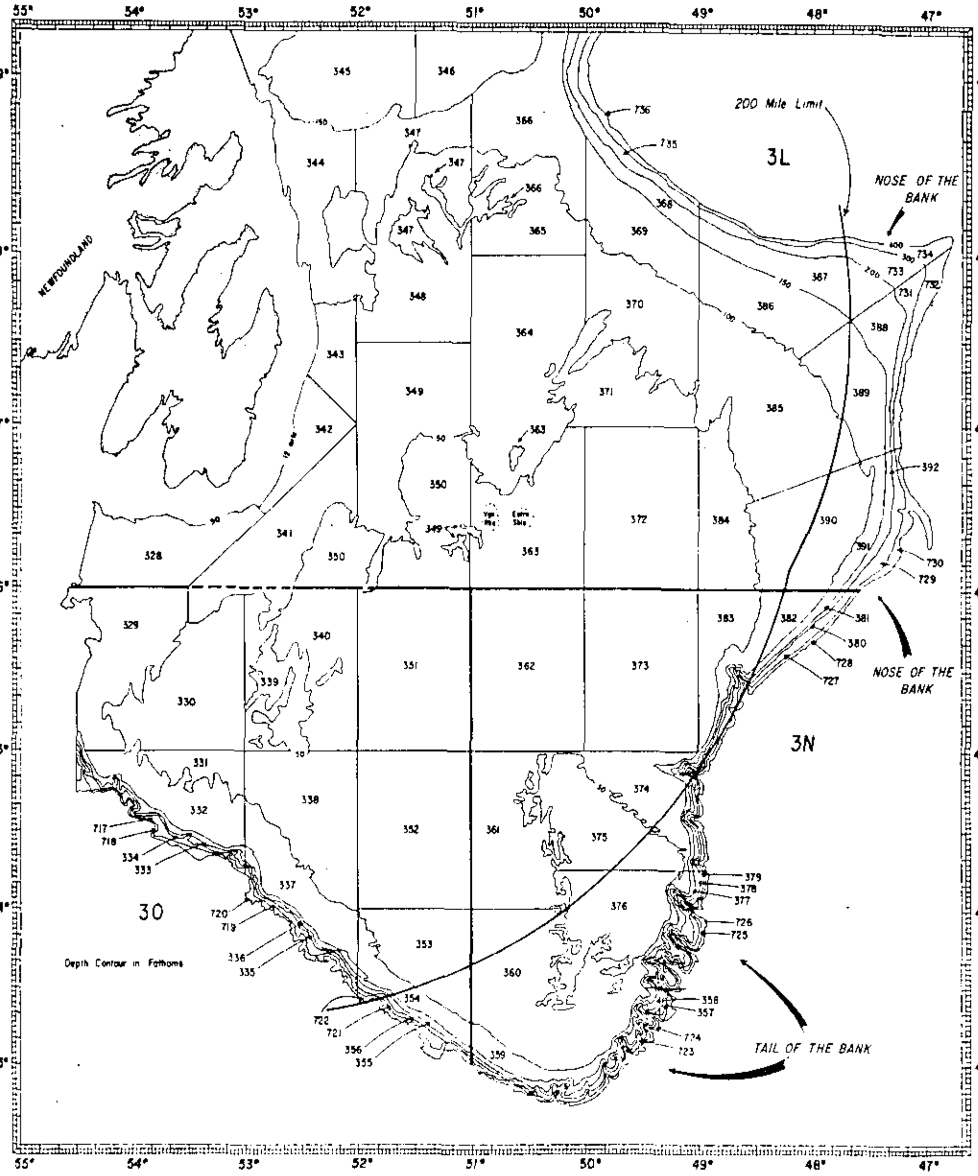

FIG.1. MAP OF THE GRAND BANK, NAFO DIV.3LNO, WITH THE CANADIAN 200-MILE LIMIT AND THE STRATIFICATION SCHEME USED IN CANADIAN RESEARCH VESSEL SURVEYS.

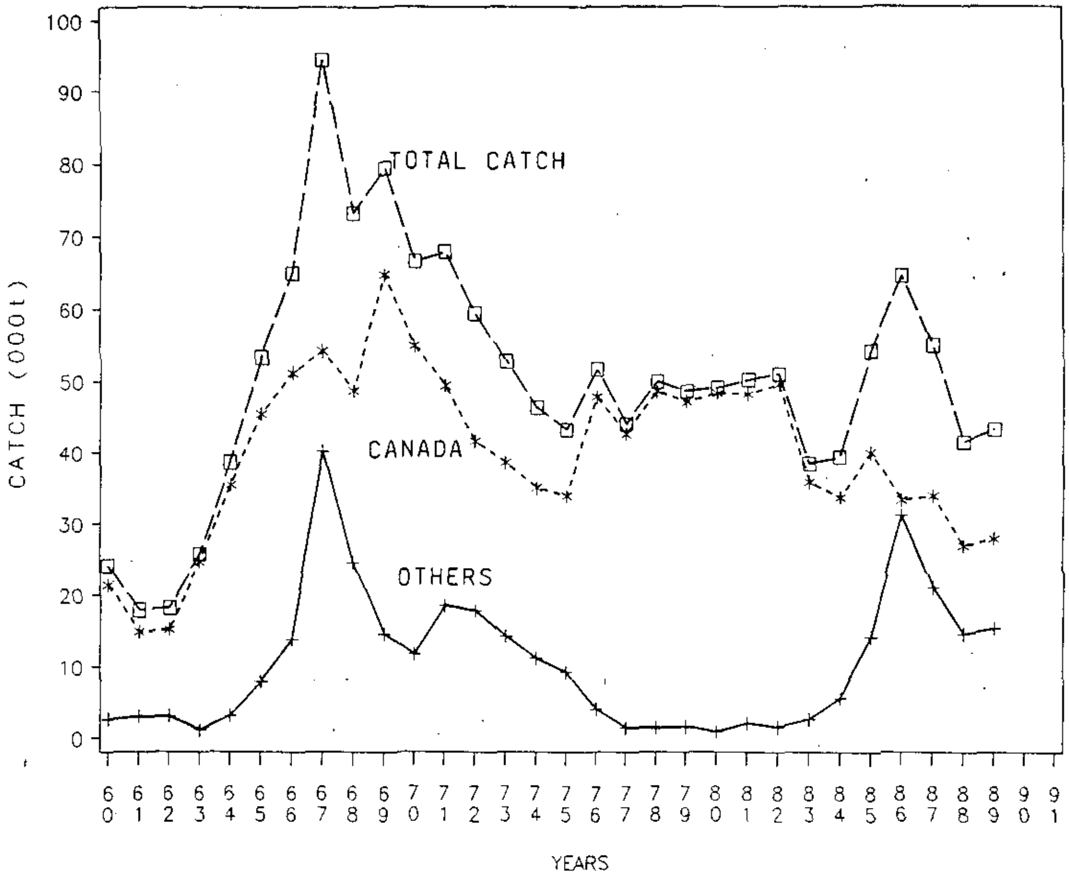

FIG.2. A.PLAICE CATCHES IN DIV.3LNO.

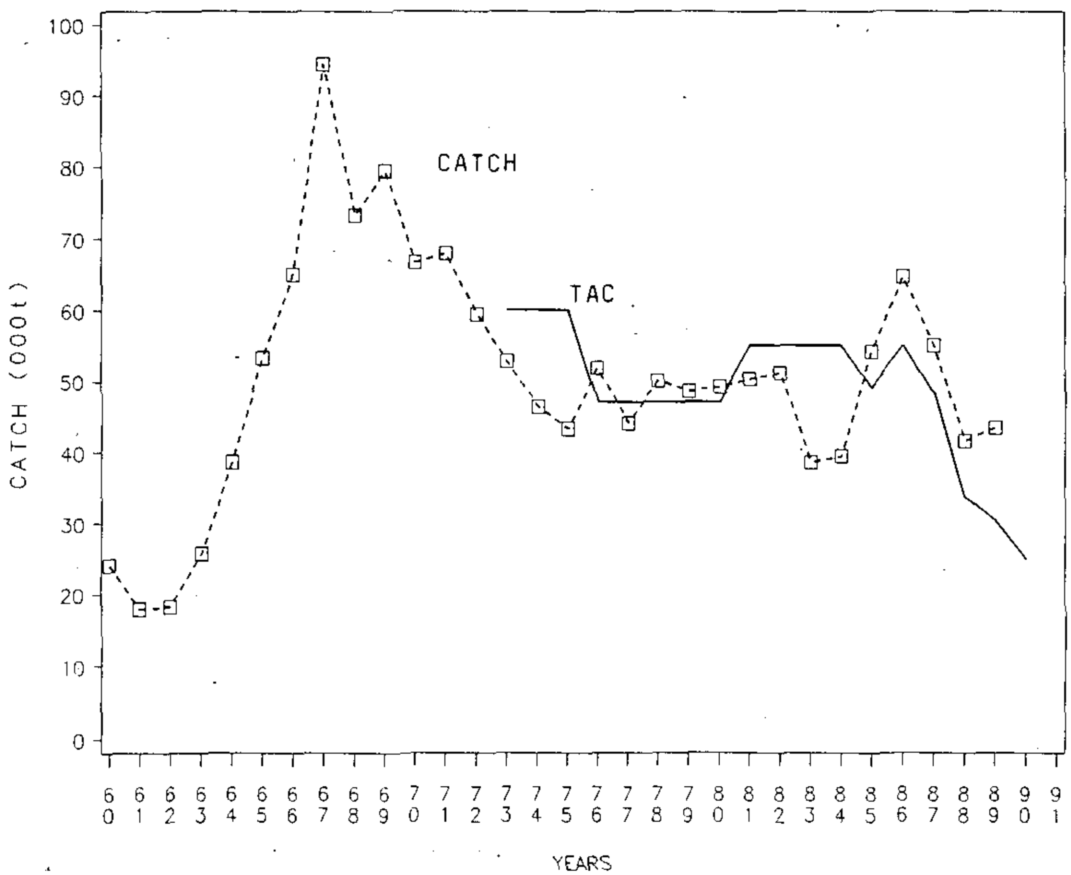

FIG.3. A.PLAICE TOTAL CATCHES AND TACs IN DIV.3LNO.

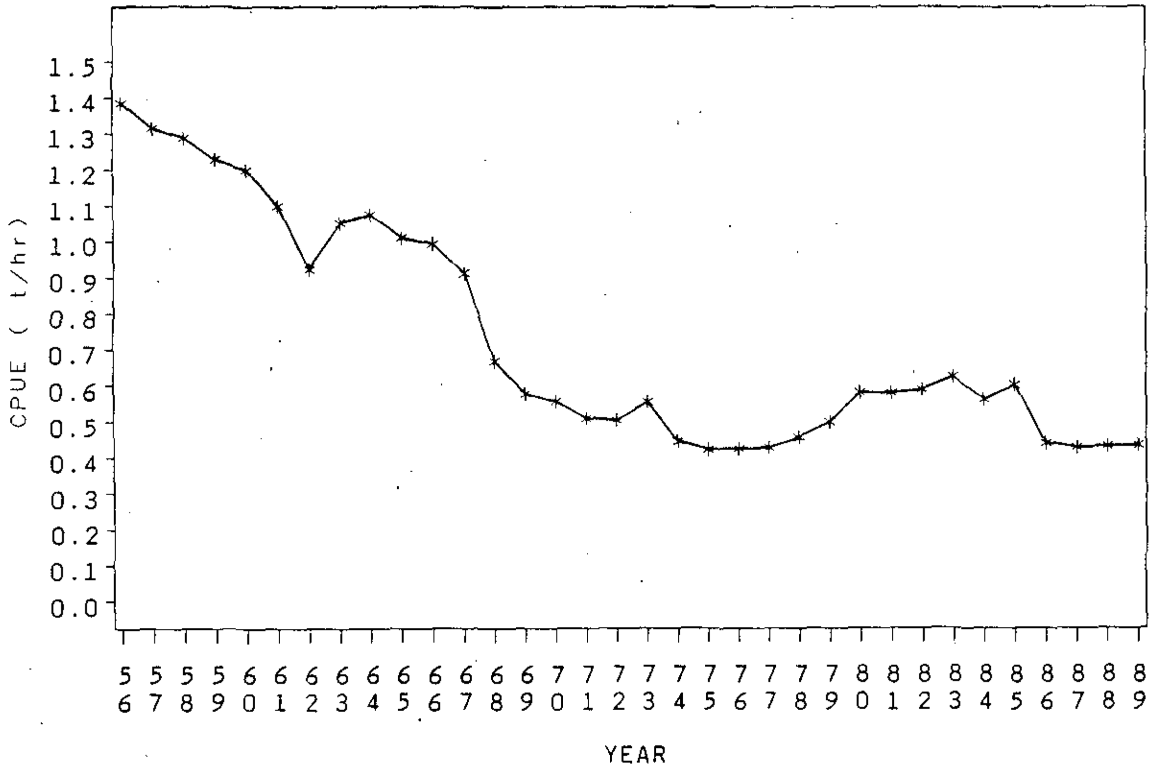

FIG.4. CPUE INDEX FOR A.PLAICE IN DIV.3LNO FROM 1956-89.

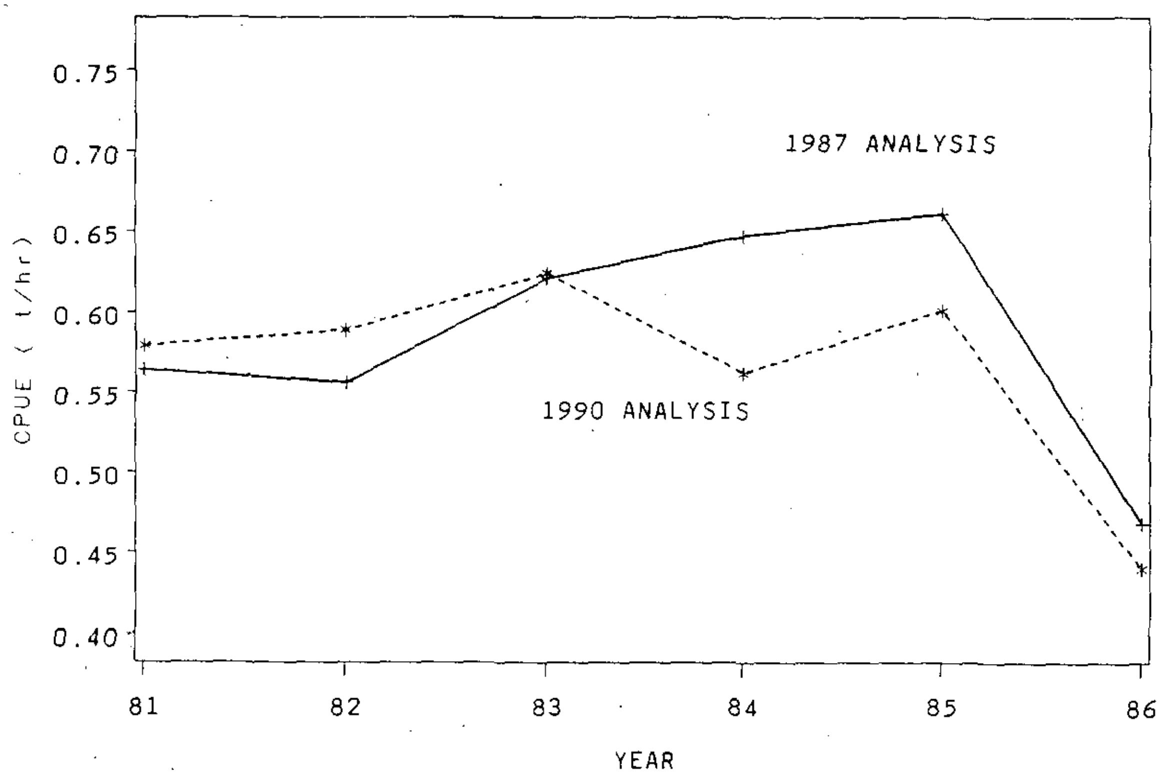

FIG.5. COMPARISON OF CPUE FOR 1982-86 FROM 1987 AND 1990 ANALYSES.

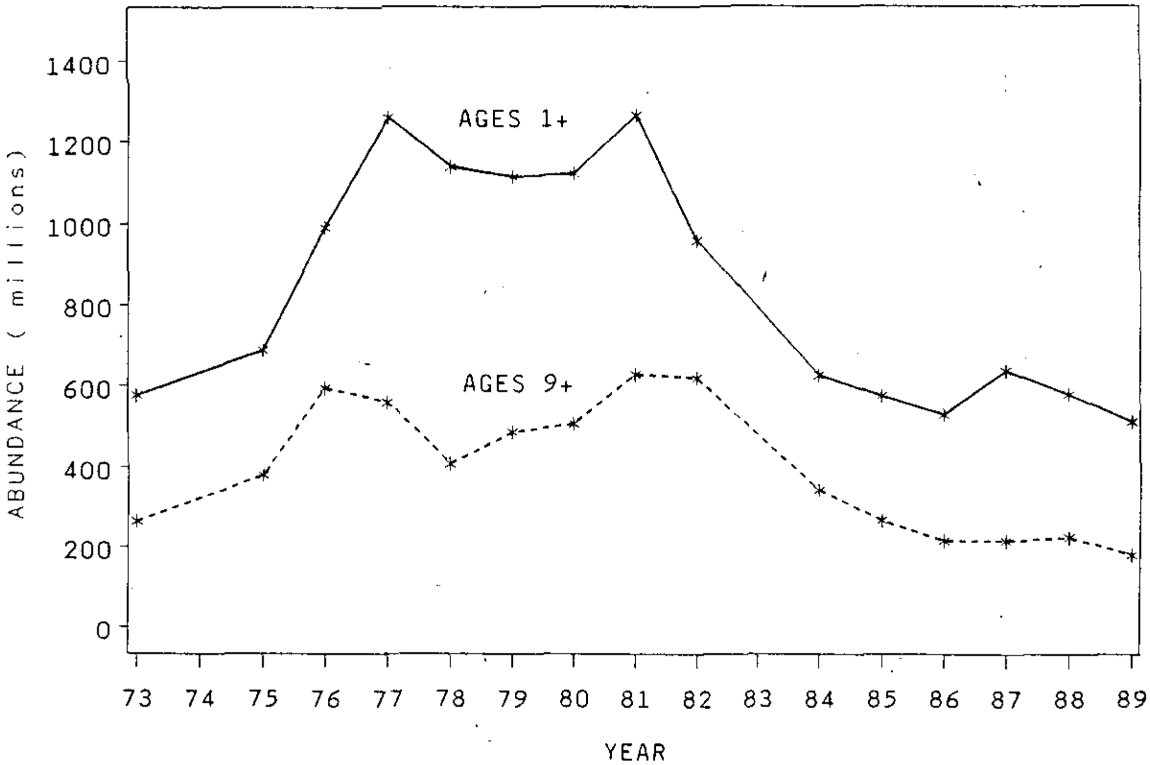

FIG.6. RV SURVEY INDICES (1+ & 9+) FOR A.PLAICE, DIV.3LNO, 1973-89.

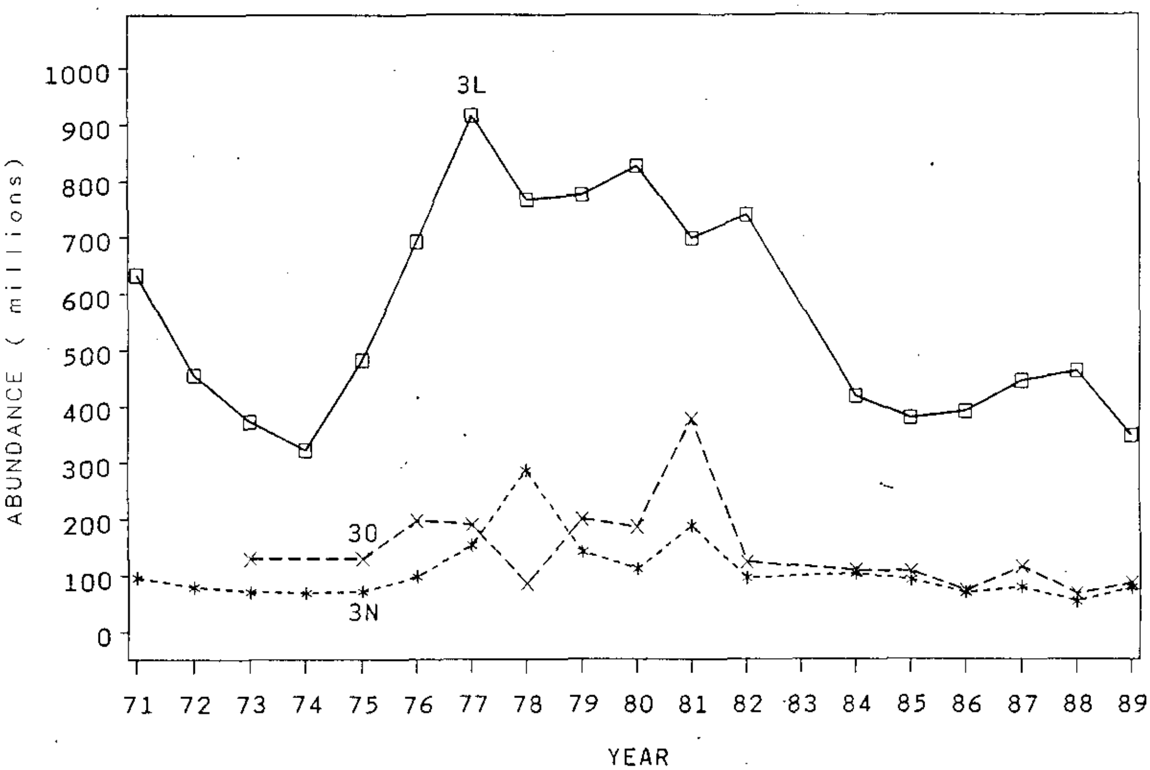

FIG.7. RV SURVEY INDICES (AGES 1+), A.PLAICE, DIV.3L,3N,3O, 1971-89.

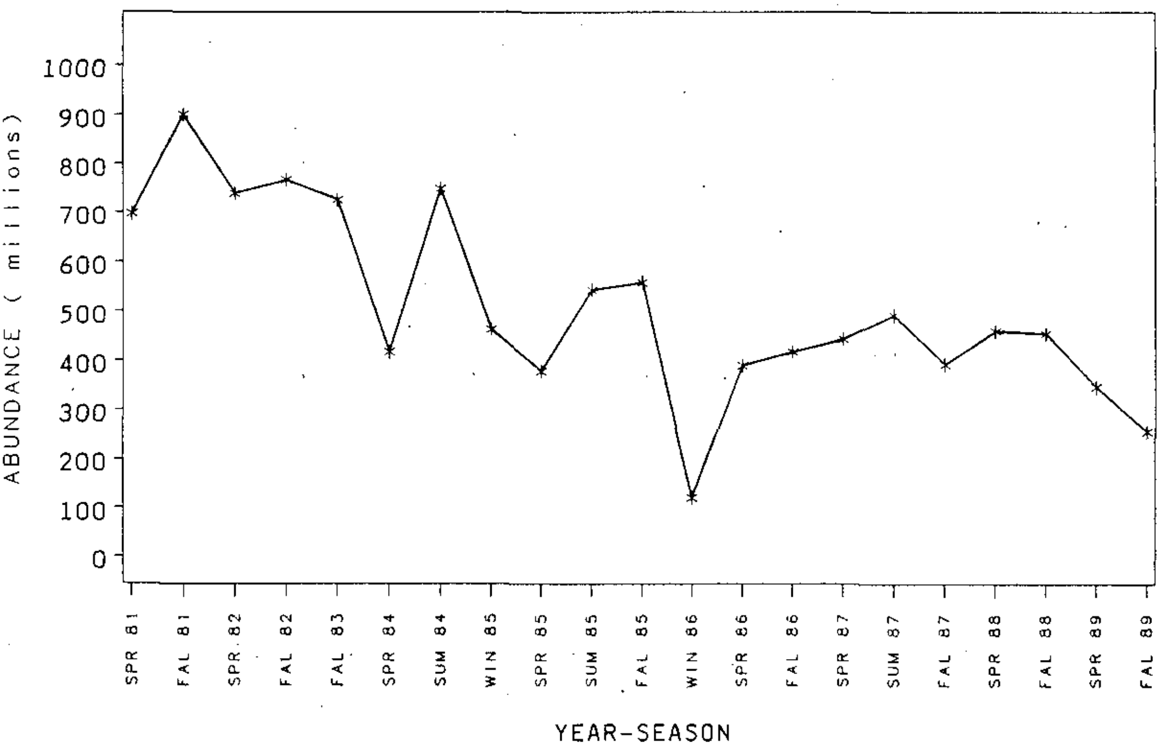

FIG.8. ABUNDANCE OF A.PLAICE IN DIV.3L FROM SURVEYS CONDUCTED IN DIV.3L AT VARIOUS TIMES FROM 1981-1989.

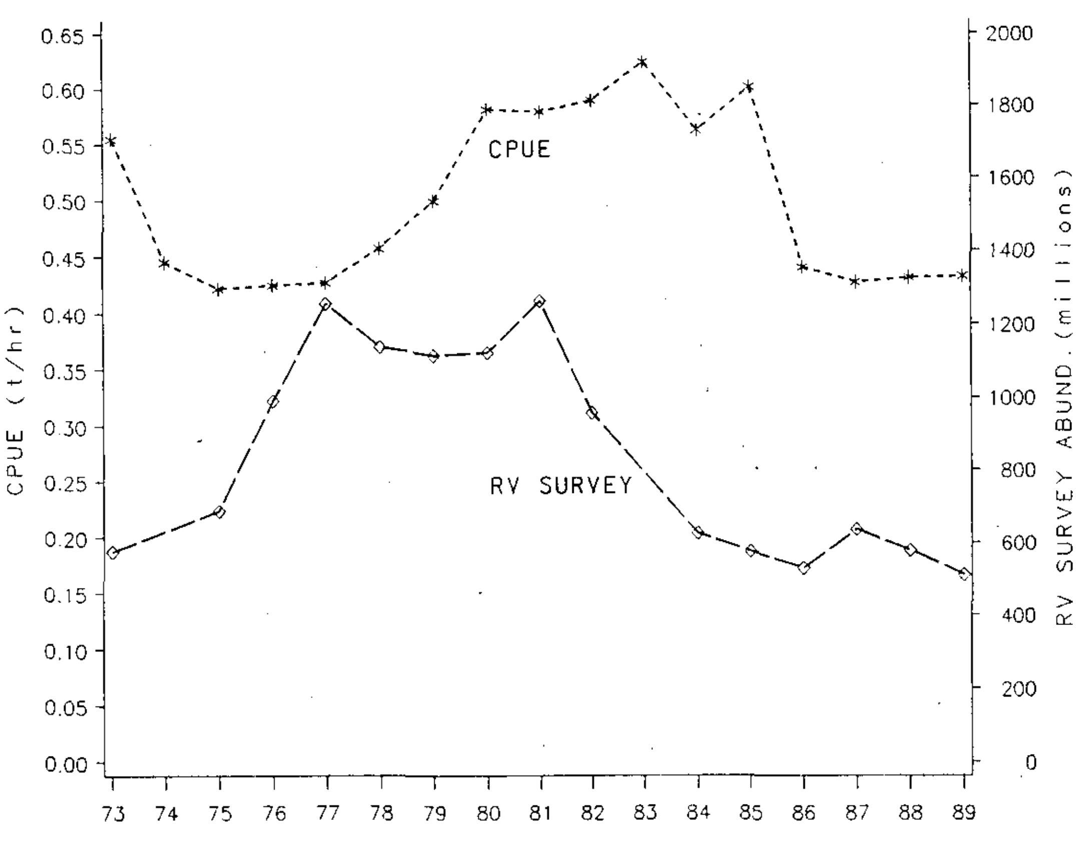

FIG.9. RV SURVEY AND CPUE INDICES FOR A.PLAICE IN DIV 3LNO.

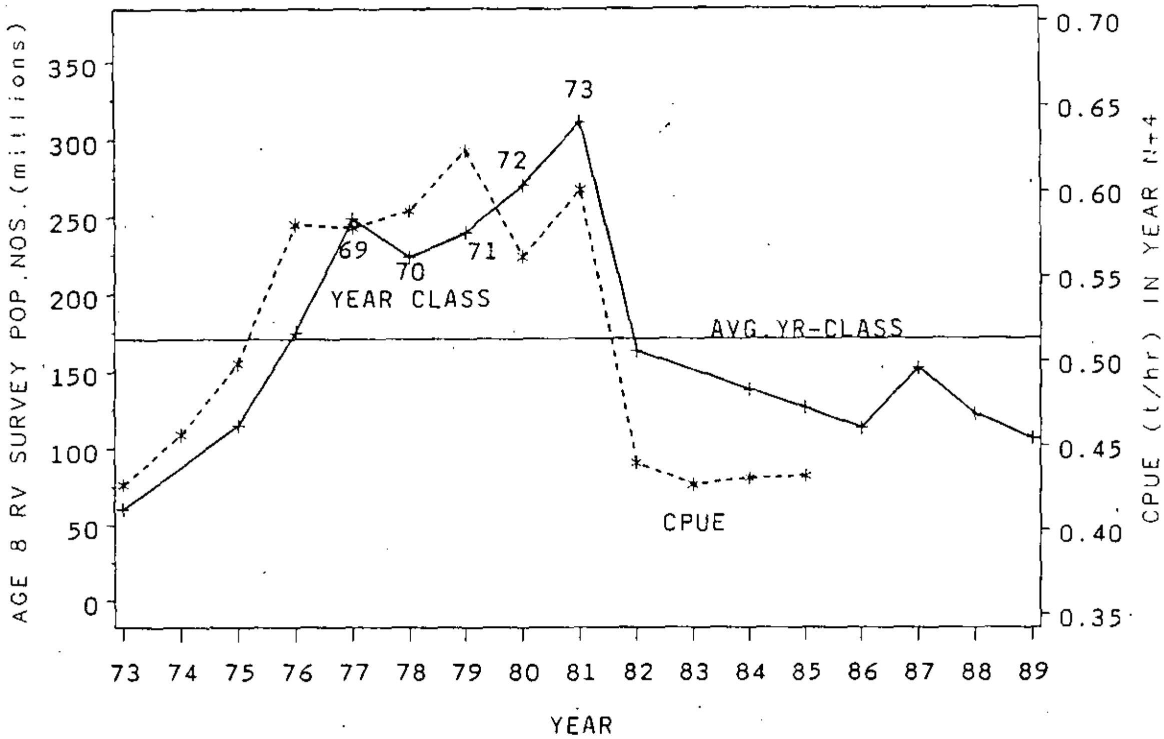

FIG.10. POPULATION AT AGE 8 FROM RV SURVEYS IN YEAR n AND CPUE FROM THE CANADIAN FLEET IN YEAR n+4 FOR A.PLAICE IN DIV.3LNO.

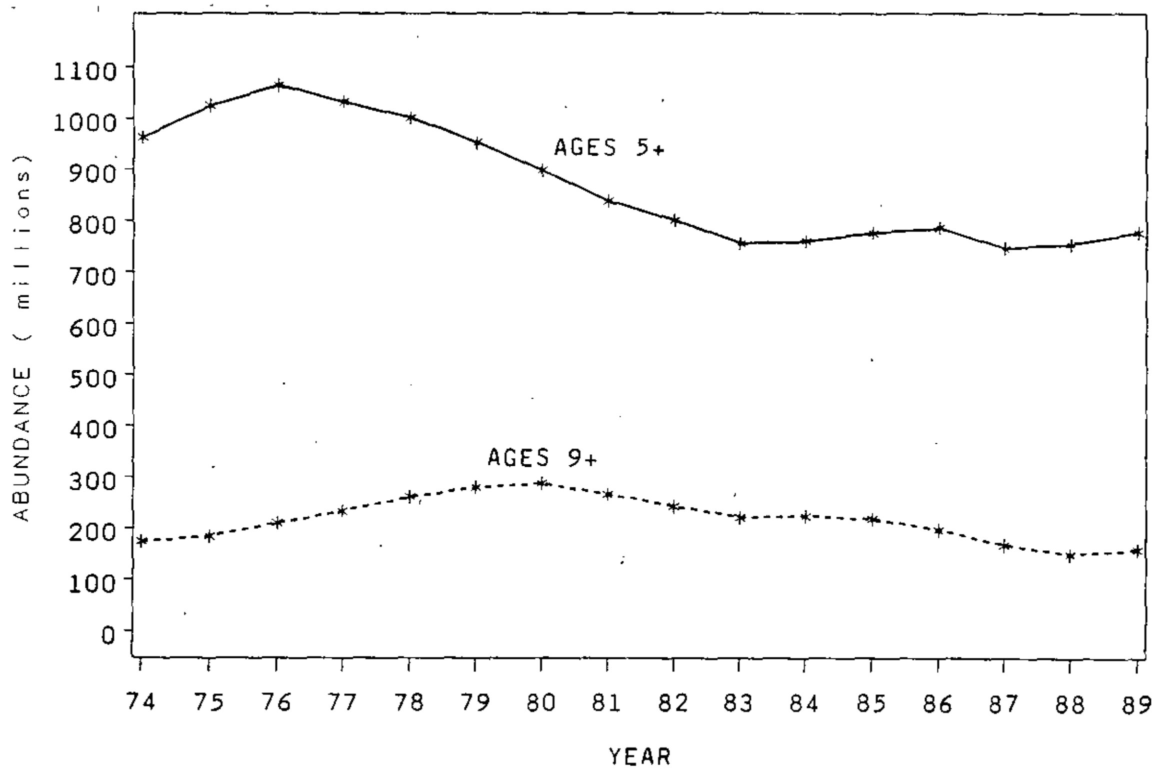

FIG.11. POPULATION NOS.(5+ & 9+) FROM SPA FOR A.PLAICE, DIV.3LNO,1974-89.

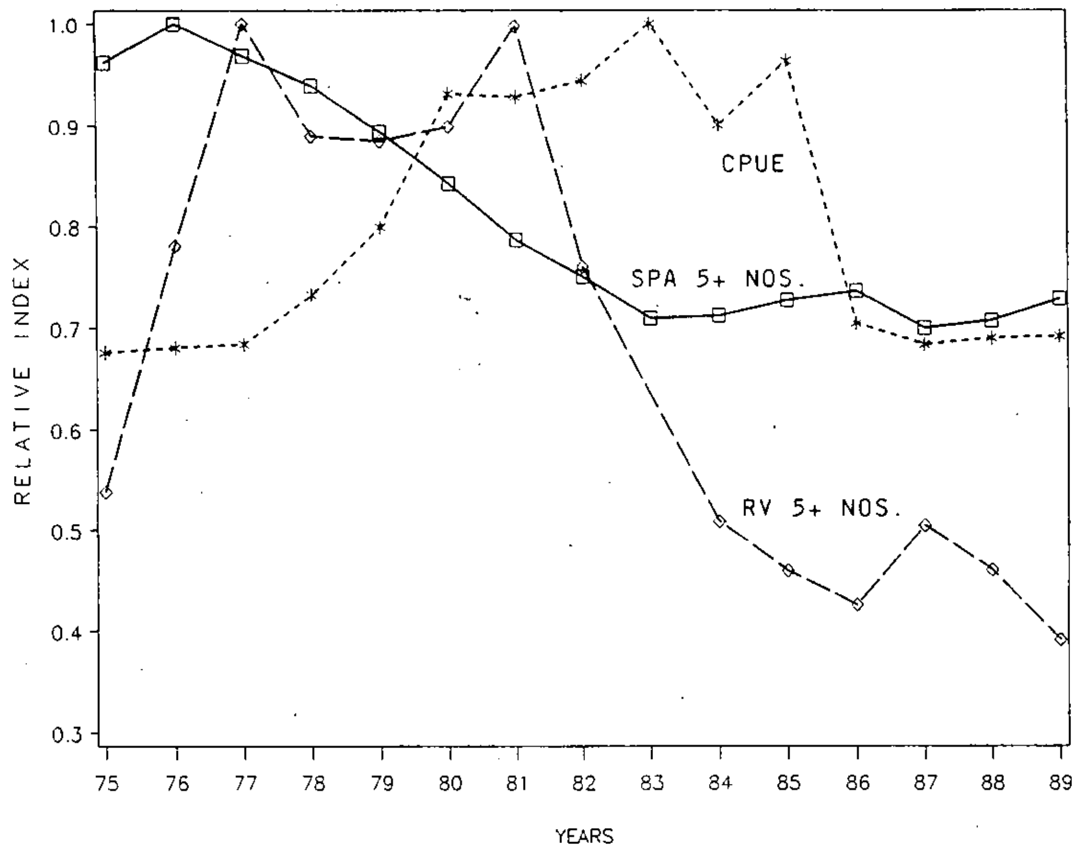

FIG.12. RV SURVEY, CPUE, AND SPA INDICES (SCALED TO HIGH POINT) FOR A.PLAICE IN DIV 3LNO, 1975-1989.

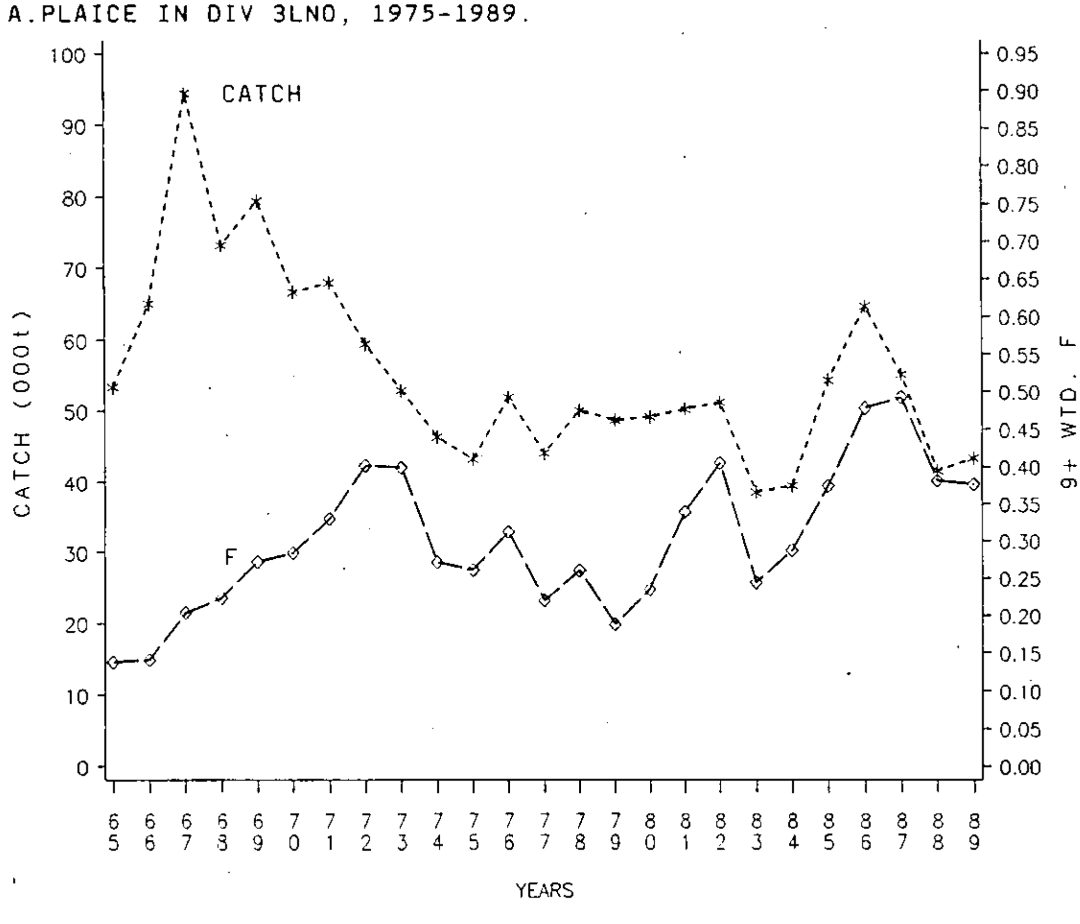

FIG.13. CATCHES AND FISHING MORTALITY OF A.PLAICE IN DIV 3LNO.

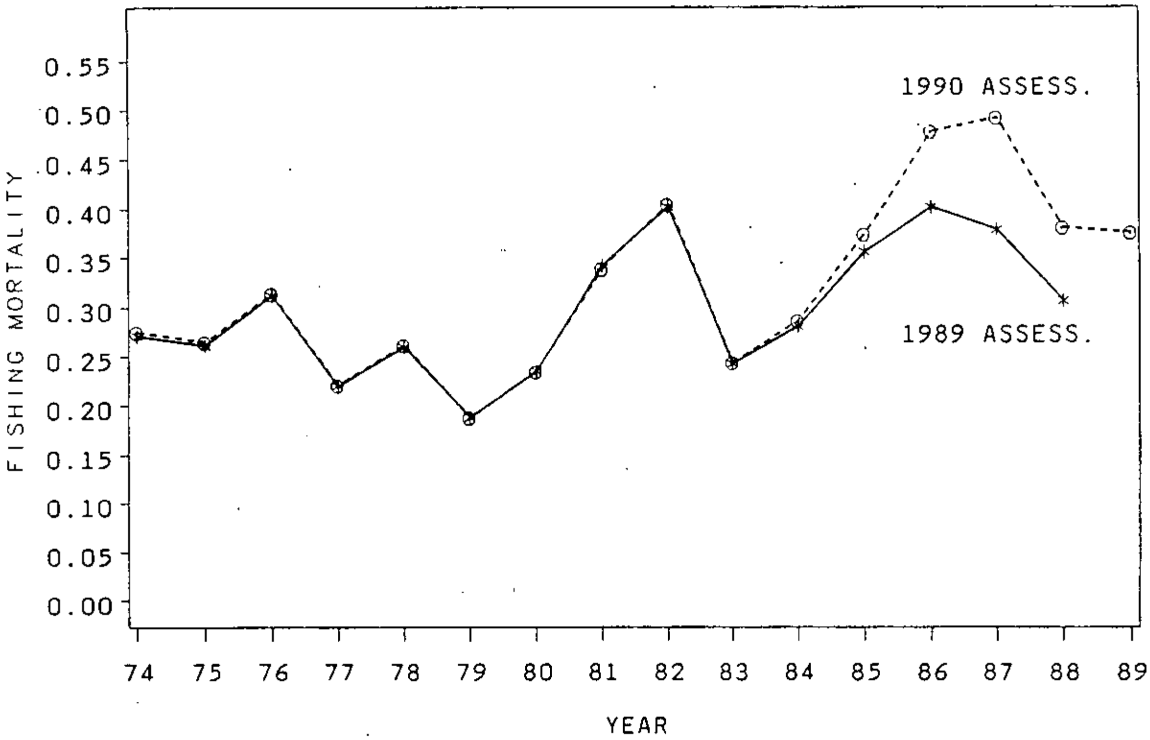

FIG.14. MEAN FISHING MORTALITY (WTD. BY 9+ SPA NOS.) FROM THE 1989 AND 1990 ASSESSMENTS. OF DIV. 3LNO A.PLAICE.

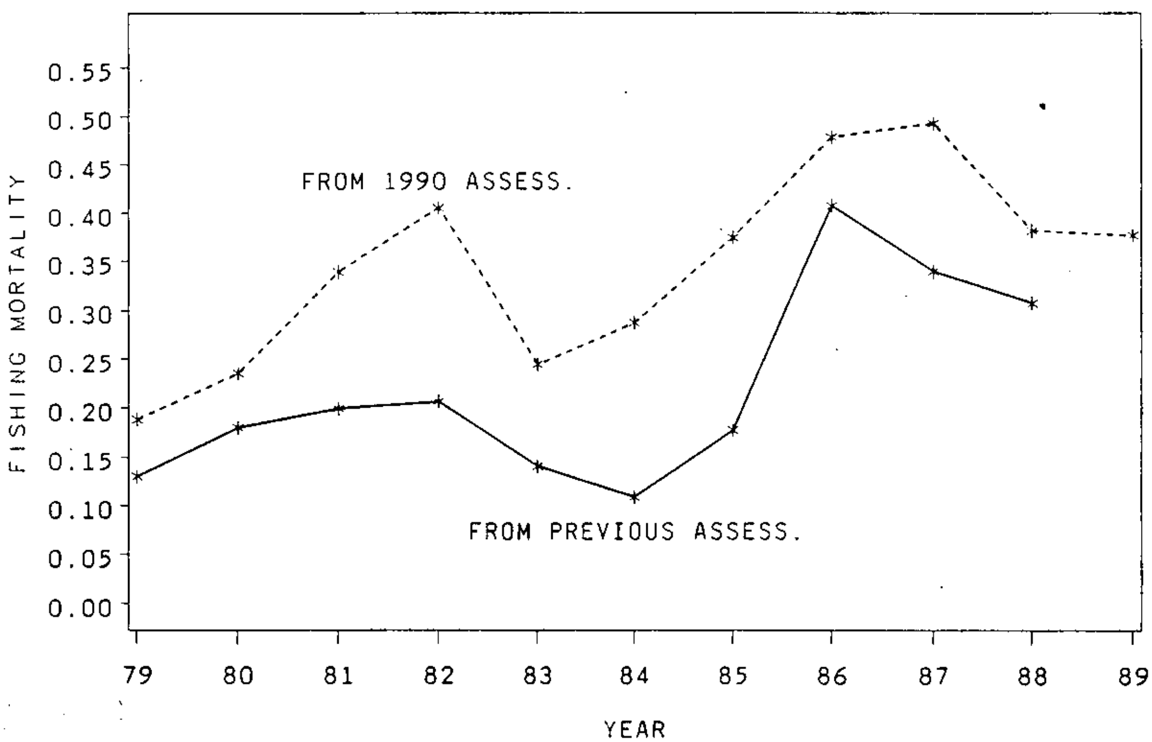

FIG.15. MEAN FISHING MORTALITY (WTD. BY 9+ SPA NOS.) FROM THE 1990 ASSESSMENT AND THE TERMINAL YEAR OF PREVIOUS ASSESSMENTS.

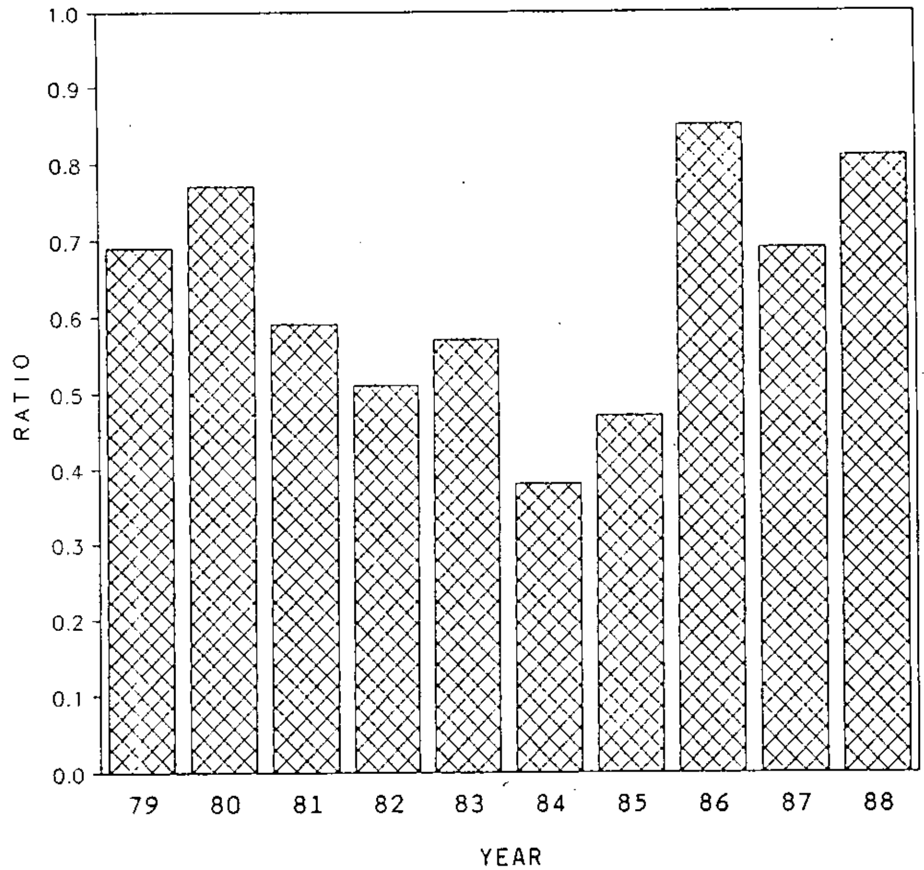

FIG. 16. RATIO OF FISHING MORTALITY IN THE CURRENT (1990) ASSESSMENT TO F IN THE TERMINAL YEAR OF PREVIOUS ASSESSMENTS

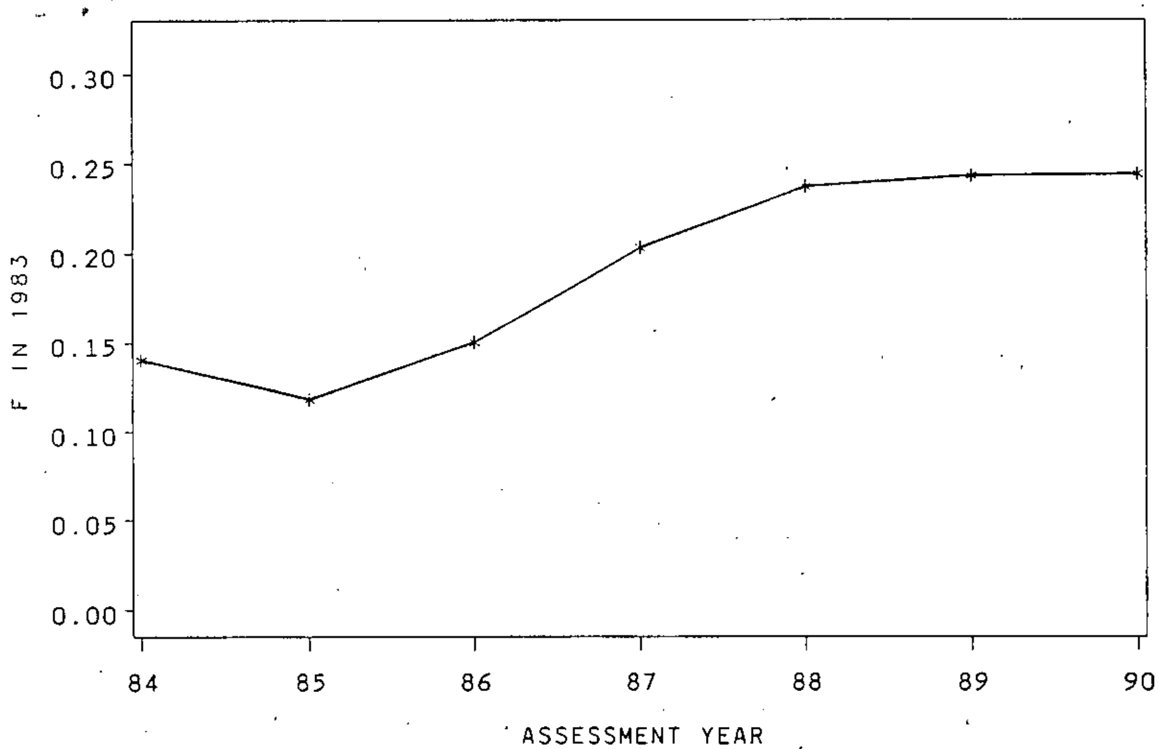

FIG.17. MEAN FISHING MORTALITY (WTD. BY 9+ SPA NOS.) FOR 1983 FROM THE 1984-1990 ASSESSMENTS OF DIV. 3LNO A.PLAICE.