SCRS/1982/056 Col.Vol.Sci.Pap. ICCAT, 18 (2): 399-410 (1983)

A CHECK OF TRADITIONAL PARAMETERS BASED ON FISHING EFFORT IN THE SURFACE FISHERY OF JUVENILE ALBACORE IN THE NORTHERN ATLANTIC

A. G. Garcés, J. A. Pereiro
Instituto Español de Oceanografía

SUMMARY

In this paper, the authors try to check if there exists a relationship between catchability and stock size in the juvenile albacore surface fishery in the North Atlantic stock.

The conclusions are that this relationship does not seem to take place; fishing effort reflects very well F, and CPUE changes reflect abundance changes in the stock in the period analyzed.

The authors call readers' attention to the possibility that a "significant" correlation between q and $\bar{N}$ does not mean a cause to effect relationship between these two variables.

RESUME

Les auteurs du présent document ont tenté de vérifier s'il existe une relation entre la capturabilité et la taille du stock dans la pêcherie de surface de germon juvénile du stock de l'Atlantique nord.

Les conclusions sont que cette relation ne semble pas se présenter; l'effort de pêche reflète très bien F et les changements de la CPUE illustrent ceux de l'abondance du stock pour la période analysée.

Les auteurs attirent l'attention du lecteur sur la possibilité de ce qu'une corrélation "significative" entre q et N puisse ne pas signifier qu'il existe une relation de cause à effet entre ces deux variables.

RESUMEN

Este documento intenta comprobar si existe una relación entre la capturabilidad y el tamaño del stock de atún blanco juvenil en la pesquería de superficie del Atlántico Norte.

La conclusión es que no existe tal relación; el esfuerzo pesquero refleja bien la F y los cambios en la CPUE reflejan cambios en la abundancia del stock durante el período analizado.

Los autores señalan que existe una posibilidad de que una correlación "significativa" entre q y $\bar{N}$ no supone una relación causa-efecto entre estas dos variables.

Introduction.-

VPA methodology has allowed to check if parameters whose estimation is derived from the use of fishing effort - and CPUE -, adequately reflect the current dynamics of a stock. Concretely, VPA has allowed to prove or reject the constancy of the catchability coefficient in some stocks, and, - as a consequence -, the proportionality between CPUE and stock abundance, and between fishing effort and the corresponding instantaneous fishing mortality rate.

In this respect, Pupe & Garrod (1975) have claimed that an inverse correlation between catchability and stock biomass seemed to take place in two cod stocks - Northeastern Arctic and Western Greenland -, raised by a reduction in the area of residence, which would corespondingly explicit an increase of fishing power independent of technological modifications of the fishing fleet.

MacCall (1976) confirmed the assertion by Murphy (1966) about a similar relationship between q and $\bar{N}$ in the California sardine stock (Sardinops sagax coerulea), and Ulltang (1976, 1980) claimed that a relation of this kind could have impulsed the collapse of the Arcto-Norwegian herring stock, exploited both in juvenile and in spawner fisheries.

In the case of these pelagic species, the reason of this increase of catchability at low biomass levels should be generated by an "active" contraction of the stock, produced along the reduction of its size; this reduction would generate an increase of fishing efficiency through the reduction of the searching area, and, therefore, the concomitant reduction of searching time. (We must observe that a possible reason of this contraction of the area is the constancy of school size in this kind of species).

The possible presence of this effect on catchability along the reduction in stock abundance, both in demersal - cod - and pelagic species, - sardine, herring -, led the authors to investigate the possibility of the presence of this effect in the north-atlantic juvenile albacore fishery, and to check the consistence between parametric values derived from VPA, and those dependent on fishing effort.

Descriptions of this fishery and the corresponding stock on which is based, can be found in Aloncle & Delaporte (1974), and González-Garcés (1973, 1975, in press).

We will briefly say that the fishery is mainly exploiting 2 to 5 years old juveniles, although 2 and 5 years old are only very partially exploited; the result is that catch in numbers is mostly composed by 3 and 4 years old. The fishery is seasonal, and exploit individuals which are doing a migratory circuit described in papers cited above.

Fishing fleet features are precisely described in González-Garcés et al. (1973); fishing boats are semiartisanal, and use trolling and live-bait gears. During the period under analysis, relevant changes in fishing technology do not seem to have taken place, and, therefore, it can be assumed that there were no changes in fishing power from this source.

Data Base and Methods.-

Period under study includes years from 1967 to 1978.

We disposed of two fishing effort series; one was based on the number of fishing days of the fishing fleet; the second one is a corrected version of the first one, by compairing the fishing power of trolling and live-bait boats on a yearly basis through the daily mean catch in numbers of one sample of each gear, standardizing then the effort of both type of boats; these two series, used by us in a previous work (González-Garcés & Pereiro, 1981), are shown in González-Garcés (1981).

Catch in numbers per age-class have been published by Antoine & González-Garcés (1981).

Parameter values obtained by VPA have been published by Bard & González-Garcés (1980) ; given that abundances in number of 3 and 4 years old at the beginning of the year are not included in that paper, these abundances were computed from the abundance of two years old and fishing mortality rates at ages 2 and 3.

Mean abundances per age class were obtained dividing catch in mumber per age class by the corresponding instantaneous fishing mortality rate.

CPUE's per age class were obtained by dividing catch in number per age class by fishing effort.

Estimates of a global F for age classes 3 and 4 were obtained through two procedures: a) computing the mean fishing mortality rate weighted to the mean stock size (in number), and b) by addition of both fishing mortality rates, obtaining values equivalent to an unweighted mean.

ividing these estimates of a global fishing mortality by non-standardized fishing effort, two different estimates of catchability per year were obtained.

The first step of the study consisted of the plot of the parameter values along the period under study, in order to analyse similiarities and differences in trend of the different parameter time series.

This step was considered of great importance, because it allows to interpret the meaning of correlations among parameters; we tried not to forget that the analysis of one correlation <u>per se</u> does not usually allow to confirm a cause-effect relationship, unlees we dispose of independent information. In deed, it could happen for two parameters to covariate in the same way during a part of the historical period, generating a high correlation, but behaving in a different manner in the rest of the series, making clear the non-existence of a cause-effect relationship between both parameters.

The second step consisted of computing correlations among couples of parameters that showed covariation, to deduce: a) if a high correlation can be raised between two parameters not linked by a cause-effect relationship; b) if traditional parameters based on effort are reliable indexes of stock parameters, - effort to fishing mortality, CPUE to mean abundance -, and checking, therefore, the constancy of the catchability coefficient.

<u>Results and Discussion</u>.-

Fig. nº1 shows the standardised and non-standardised effort series. Both series show an extremely similar decreasing trend till 1974, although steeper for the non-standardized effort series; since that year, standardized effort is maintained practically stable, while non-standardized effort shows a slight increase till 1978; both series are, in fact, very similar.

Fig. Nº2 shows these two same series, but efforts have been standardized, it is to say, substracting mean value from each individual one, and dividing it by its standard deviation; conclusions are the same than from fig. nº1.

Fig. nº3 shows the instantaneous fishing mortality rates for ages 3 and 4; the same decreasing trend in both rates can be observed from 1967 to 1973, but steeper for age 3; since this year, fishing mortality rates remain stable about the same level, but with opposed fluctuations. (The bigger reduction of 3 olders fishing mortality could raise through a bigger reduction of trolling fishing effort, owing to the disertion of this fleet toward the billfish fishery, because of both the smaller cost per unit effort in this fishery, - shorter trips -, and a smaller variability in yield per unit effort; it is known that trolling effort is more directed to 3 olds, and live-bait to four).

Fig. nº4 shows the series of global fishing mortality rates, weighted and unweighted. The similiarity of both series is extremely high, and only appears a slight difference in trend in years 77 and 78; anyway, both series say exactly the same thing, and are fully coherent to previous figures.

Fig. nº5 compares trends of unweighted effort and weighted 3-4 fishing mortality. We think not necessary not to emphatize the extreme similarity between both series.

Figures nº 6, 7 y 8 are very important in our analysis. Fig. nº6 shows the two series of catchabilities derived from the 3-4 fishing mortality rates we are using in this paper. It can be observed that trend is the same till 1974 or 75; since this year, catchability derived from weighted F is stabilized or increases very slightly till 1977, then strongly increasing in 1978, while q derived from unweighted F shows a strong and progressive increase. Non standardised effort has been used to get catchabilities.

The similarity of both series is better shown in fig. nº7, where standardised values of both series of catchabilities are plotted; we can observe then that the biggest difference in trend appears in 1977, while the rest of both series presents a strong similarity.

The coefficients of variation of the catchability coefficients presented here are about 20%.

Fig. nº8 presents the series of mean abundances of 3+4 age classes, together with the catchabilities series presented in fig. nº7. A same trend in all these series can be observed from 1967 to 1969, opposed trends for the period 70–73, the same again from 1973 to 1977, and opposed for 1978 for unweighted F, and for 1977 and 78 for weighted F.

It seems that there is not a clear covariation – neither direct or inverse – of these series of abundance and catchability; this fact is evidently coherent with the data base managed, and we shall go back to it later.

Fig. nº9 shows the series of mean abundance (always in number) of age classes 3 and 4 together, compared to its corresponding 3+4 CPUE series. 1972 points are the only ones that show a net divergence in the series.

Fig. nº 10 and 11 compare trends in mean abundance of age class 3 and the CPUE of this class, and mean abundance of age class 4 and the CPUE of this class, respectively. These two figures show that trends of CPUE and mean abundance are also similar for each age class separately; this similarity is bigger for age class 3 than for age class 4, for which we can see divergences for the short periods 69–70, 72–73 and 77–78. The anomalous 1972 point in fig. nº 10 disappears when age classes 3 an 4 are plotted separately.

Correlations.-

In text-table nº 1 are shown correlations obtained by linear regression of variates relevant for our analysis, and whose time series have been presented above. Correlation values have been derived from predictive regressions. In tis table, regression coefficients, – a as ordinate in the origin, b as the slope – are also shown. As usual, X represents the independent variable, and Y the dependent variable :

T A B L E Nº 1

Results of the regressions between variables indicated below.

X	Y	a	b	r	r^2
Standardised effort	Non standardised effort	11.2	.47	.96	.91
4 years old F	3 years old F	.02	1.14	.63	.39
Unweighted 3–4 F	Weighted 3–4 F	–.06	.57	.99	.98
Non standardised f	Weighted 3–4 F	–.09	.0089	.96	.93
Non standardised f	Unweighted 3–4 F	–.03	.0148	.93	.87
q from unweighted F	q from weighted F	.53	.46	.88	.77
3–4 mean abundance	q from weighted F	9.06	–.0001	–.22	.05
ln(3–4 mean abundance)	ln(q) from weighted F	4.75	–.3	–.3	.09
Id. without 1978 point		5.85	–.42	–.62	.39
3–4 mean abundance	3+4 CPUE	32.11	.0042	.75	.56
3 years mean abundance	3 years old CPUE	19.13	.0047	.76	.58
4 years old mean abundance	4 years old CPUE	5.1	.0052	.75	.56
3–4 mean starting abundance	3+4 CPUE	–1.06	.58	.77	.59
3 years old starting abund.	3 years old CPUE	14.8	4.11	.8	.64
4 years old starting abund.	4 years old CPUE	3.2	4.55	.61	.37
3–4'starting abundance	3–4 mean abundance	2.8	.59	.68	.46

Fig. nº 12 shows the regression between both fishing effort series, and we do not think to be necessary any other comment.

Fig. nº 13 shows the regression between F on 4 years old and on 3 years old; we can point out the relatively big scattering about the regression line.

Fig. nº 14 shows the regression between weighted and unweighted mean F's for age classess 3 and 4 together, that results in a value of the correlation coefficient practically equal to one.

Fig. nº 15 shows the regression between the weighted mean F and non-standardised effort, resulting in a value of r = .9526, highly significant. Fishing effort, therefore, reflects extremely well fishing mortality, as we suspected from the comparison of their time-series. The correlation between mean unweighted F and non standardised effort, shown in fig. nº 16, resulted in a slightly smaller correlation value.

The correlation between both catchability coefficientes series derived from non-standardised effort was .8779, - fig. nº 17 -; this relatively small value is explained by the divergence in 1977; if we do not take into account this year, r increases to .906 (r^2 = .93).

Regression between the catchability derived from weighted F and -always- non-standardised effort, versus mean abundance of 3 and 4 years old resulted in a correlation of .22 only, as it should be expected, (fig. nº 18); however, a fact must be kept in mind: the deletion of only one point, the one corresponding to 1978, would increase r to .63, value that is near the 5% significance level - .69 -. Had we made the regression without this last year between the variables transformed logarthmically, the value of r would be .62, perhaps raising the suspicion of an inverse correlation between catchability and stock size.

Our conclusion is that it is very dangerous to assert the existence of a relationship between catchability and stock size only supported by the existence of a significant inverse correlation between these two variables during a certain time period.

Fig. nº 19 shows the regression between 3+4 CPUE's values and 3+4 mean abundance (both in numbers); this correlation value - r = .75 -, is significant at 5% level, and can be deduced that this CPUE is reflecting the changes occurring in the abundance of the exploited stock.

Fig. nº 20 shows the regression between abundance of 3 years old and its respective CPUE, and fig. nº 21 is the corresponding one for age class 4; results are very similar to those obtained in fig. nº 19.

Fig. nº 22 shows the regression of ln(3+4 CPUE) versus the natural log of the mean abundance of these two age classes in the exploited stock. As we could expect, the regression is significant, but we want to discuss an interesting point about it: if we retransform the variables used in regression to go back to the original ones, we should obtain the best fit corresponding to the following expression :

$$\text{CPUE} = 18.25\ \bar{N}^{(-.55)}$$

that would seem to indicate a curvilinear relationship between CPUE and $\bar{N}$, -"b" very different from 1 ! -, that could support the suspicion of a non-traditional relationship between q and $\bar{N}$. Such a "curve" is, in fact, an artifact generated by forcing the curve to go through the origin, and it has not to do with a non-linearity in this relationship between CPUE and $\bar{N}$.

The regression of 3 years old CPUE vs. the 3 years old abundance at the beginning of the year (fig. nº 23) resulted in a high value of r - .8 -, even higher than the correlation between this CPUE and its corresponding mean stock size. This fact could reflect the importance of the variability of the year class strength as determining the abundance; as a consequence, 3 years old CPUE would indicate so much the variation in recruitment as the variation in stock size through a change in fishing intensity in the period considered.

When we regress 3+4 CPUE vs. 3+4 abundance (fig. nº 24), the correlation between CPUE and abundance at the beginning of the year is slightly smaller than that one between the same CPUE and mean abundance. The same thing happens for parameters corresponding to age claas 4 (fig. nº 25).

In fact, the regression between 3-4 abundance at the beginning of the year and mean stock size for both age classess together resulted significant at a 5% level, - r = .68 -, reflecting the importance of the variation in recruitment strength in order to define the abundance of the stock, in spité of the big changes in fishing mortality during the period analysed.

It seems clear, therefore, that it would be difficult to obtain good estimates of mortality rates during the period from CPUE values, in spite of the fact that CPUE was reflecting well enough the stock abundance.

Conclusions.-

The relevant conclusions derived from this paper are, evidently, that fishing effort reflects very adequately fishing mortality, and 3-4 CPUE reflects well enough the exploited stock abundance; 3 years old CPUE seems a good index of the strength of 3 year class. Catchability does not seem to depend on stock abundance.

Other kind of conclusions that may be relevant are related to the fact that a "significant" correlation between two variates can be often submitted to misinterpretation if we cannot dispose of independent information. Concretely, that we suspect that a passive or active contraction of the stock is generating an increase in catchability, it seems it would be convenable to try getting a direct confirmation of such a reduction, if possible, of the zone of residence, - as Csirke (1981) cried for anchoveta -, and avoid to establish indirectly that reduction from a correlation between q and $\bar{N}$ or $\bar{B}$, which could have nothing to do with a relationship cause to effect between both variables.

R E F E R E N C E S

Aloncle, H. & F. Delaporte, 1973 : "donnees nouvelles sur le germon, thunnus alalunga B. 1788 dans le nord-est atlantique". Rev. trav. ISTPM, 37(4), 475-572.

______________, 1974 : "Donnees nouvelles sur le germon, thunnus alalunga B. 1788 dans le nord-est atlantique".Rev.-Trav. ISTPM, 38(1), 5-102.

Antoine, L. & González Garcés, A., 1981 :"Commentaires sur l'etat du stock de germon (Thunnus alalunga) nord atlantique en 1980". ICCAT, SCRS/80/84, col. vol. sci. pap. vol. XV(2), 222-231.

Bard, F.-X. & González Garcés, A., 1980 :"Etat du stock de germon (Thunnus alalunga) nord atlantique en 1979". ICCAT, SCRS/79/68, col. sci. pap. vol. IX, (2), 379-390.

Csirke, J., 1980 :"Recruitment in the Peruvian anchovy and its dependence on the adult population". In "The assessment and management of pelagic fish stocks", ed. by A. Saville.Rapp.-Proc. verb., vol. 177,307-313.ICES.

González-Garcés, A., 1975 :"El bonito del norte o atún blanco". Publ. tec. junta est. pesca, vol. 11, 115-125.

______________, 1981 :"A production model analysis of North Atlantic albacore (Thunnus alalunga), 1957-1978. ICCAT, SCRS/80/62, col.sci.pap. vol. X(2), 211-221.

González-Garcés,A., Quiroga, H., & Cendrero, O., 1973 :"Contribución al estudio de la población de atún blanco (Thunnus alalunga B. 1788) del Atlântico Norte". Bol. IEO nº166.

González-Garcés, A. & Pereiro, J.A., 1981 :"Relationship between effort and fishing mortality in the Atlantic albacore surface fishery". ICCAT, SCRS/80/73, col. sci. pap. vol. XV(2), 202-203.

González-Garcés, A. & Fariña, A.C., (in press) :"Determining age of young albacore, Thunnus alalunga, using spines".

ICES, 1980 :"The assessment and management of Pelagic Fish Stocks", (ed. by A. Saville, ICES Rapp.-Proc. verb. vol. 177.

MacCall, A.D., 1976 :"Density dependence of catchability coefficient in the California

Pacific sardine, Sardinops sagax caerulea, purse seine fishery". Calif. Coop. Ocean. Fish. Invest. Rep., 18: 135–148.

Murphy, G.I., 1966 :"Population biology of the Pacific sardine, (Sardinops caerulea)". Proc. Calif. Acad. Sci., 4th Ser., 34: 1–84.

Paloheimo, J.E., & Dickie, L.M., 1964 :"Abundance and fishing success".Rapp. P.-v. ICES, vol. 155 :152–163.

Pope, J.G. & Garrod, D.J., 1975:"Sources of error in catch and effort quota regulations with particular reference to variations in the catchability coefficient". ICNAF Res. Bull. nº11, 17–28.

Ulltang, Ø., 1976 :"Catch per unit of effort in the Norwegian purse seine fishery for Atlanto-Scandian (Norwegian spring spawning) herring". FAO Fish. Tech. Pap. 155, 91–101.

————, 1980 :"Factors affecting the reaction of pelagic stocks to exploitation and requiring a new approach to assessment and management". In "The assessment and management of Pelagic Fish Stocks", ed. by A. Saville. ICES Rapp. P.-v. des Reunions, vol. 177, 489–504.

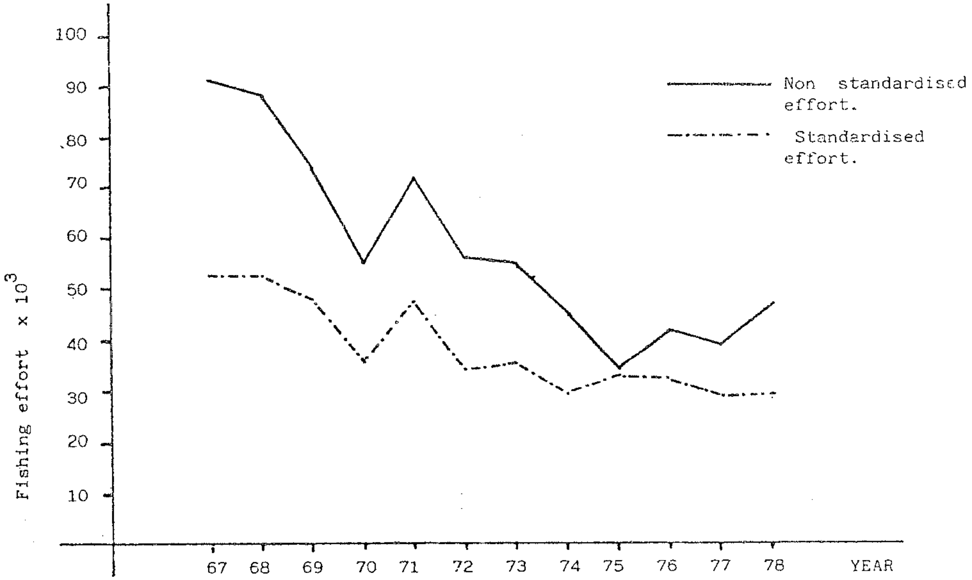

Fig.- 1. Standardised and non standardised effort time series.

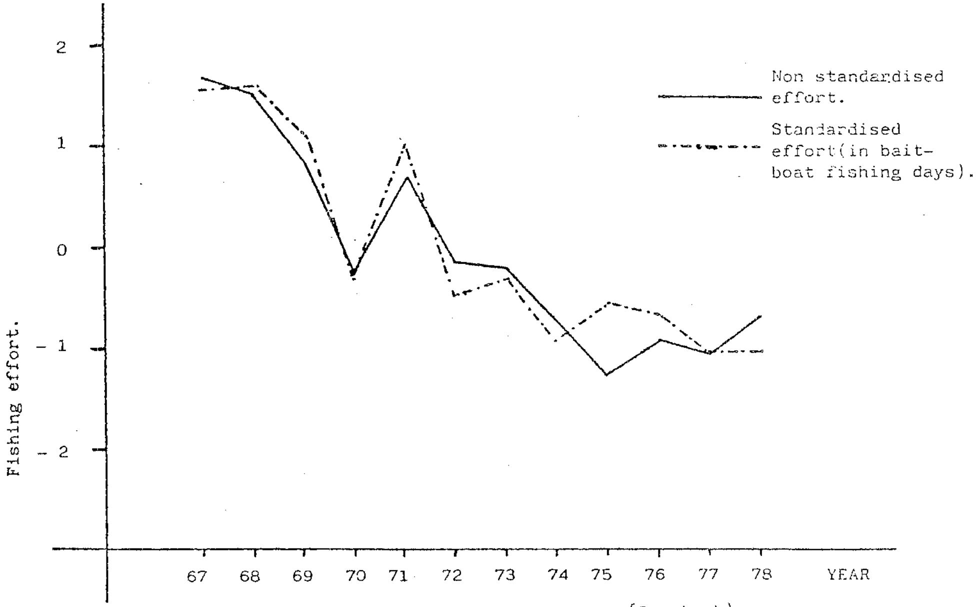

Fig.- 2. Standard values of effort time series.(See text)

Fig.- 3. 3 and 4 years old fishing mortality time series.

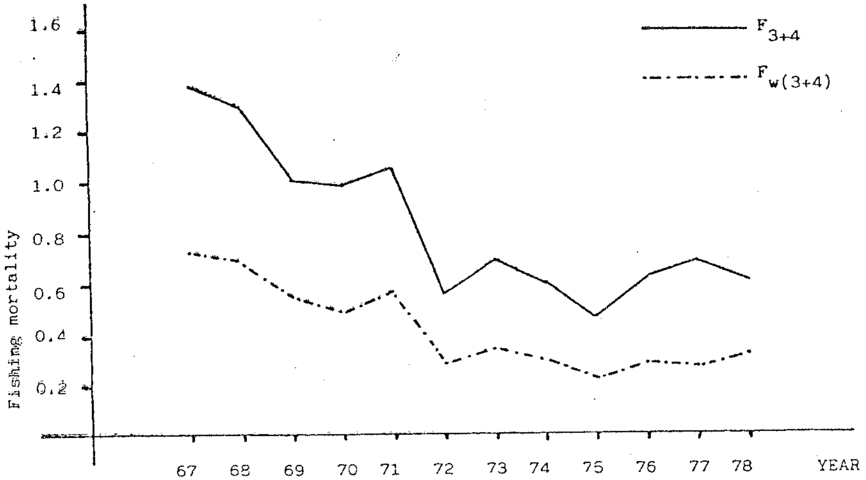

Fig.- 4. Weighted and unweighted 3-4 fishing mortality time series.

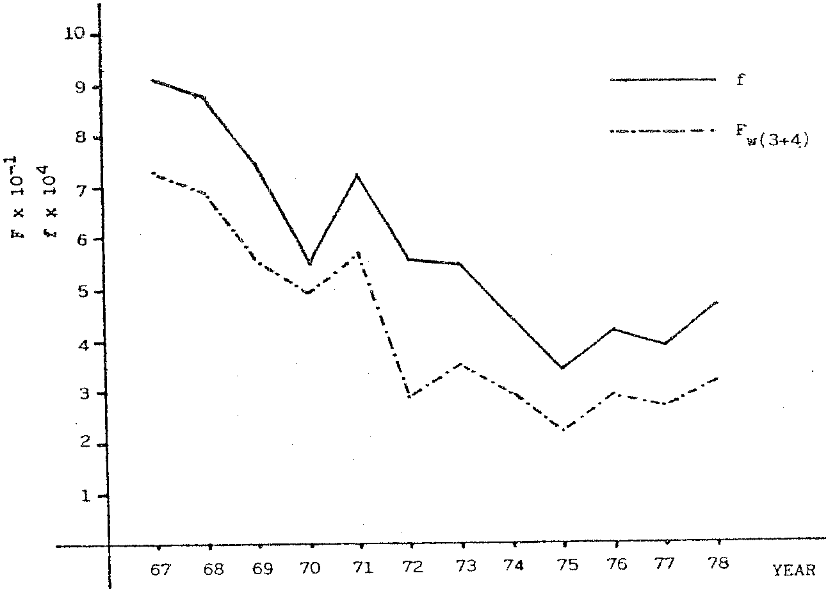

Fig.- 5. Time series of non-standardised effort and 3-4 weighted fishing mortality.

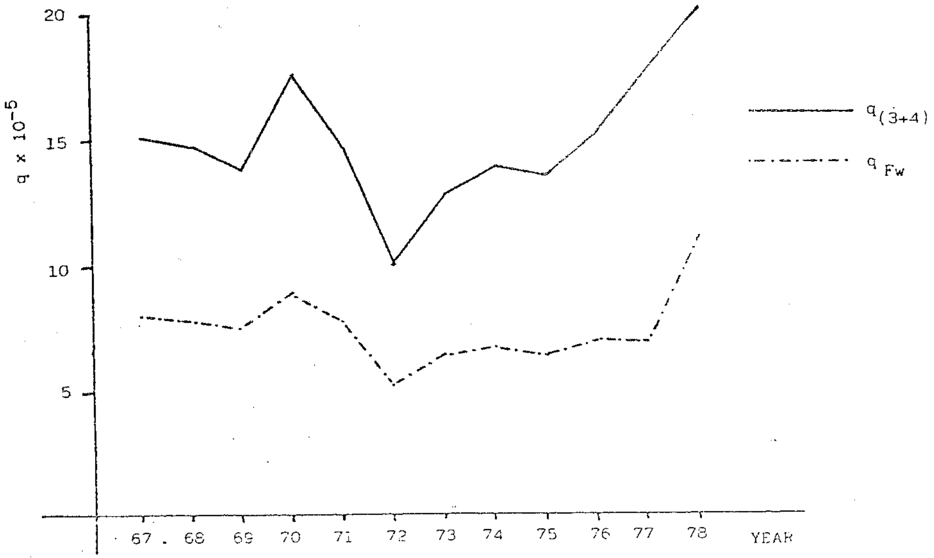

Fig.- 6. Catchabilities from weighted and unweighted 3-4 fishing mortality time series.

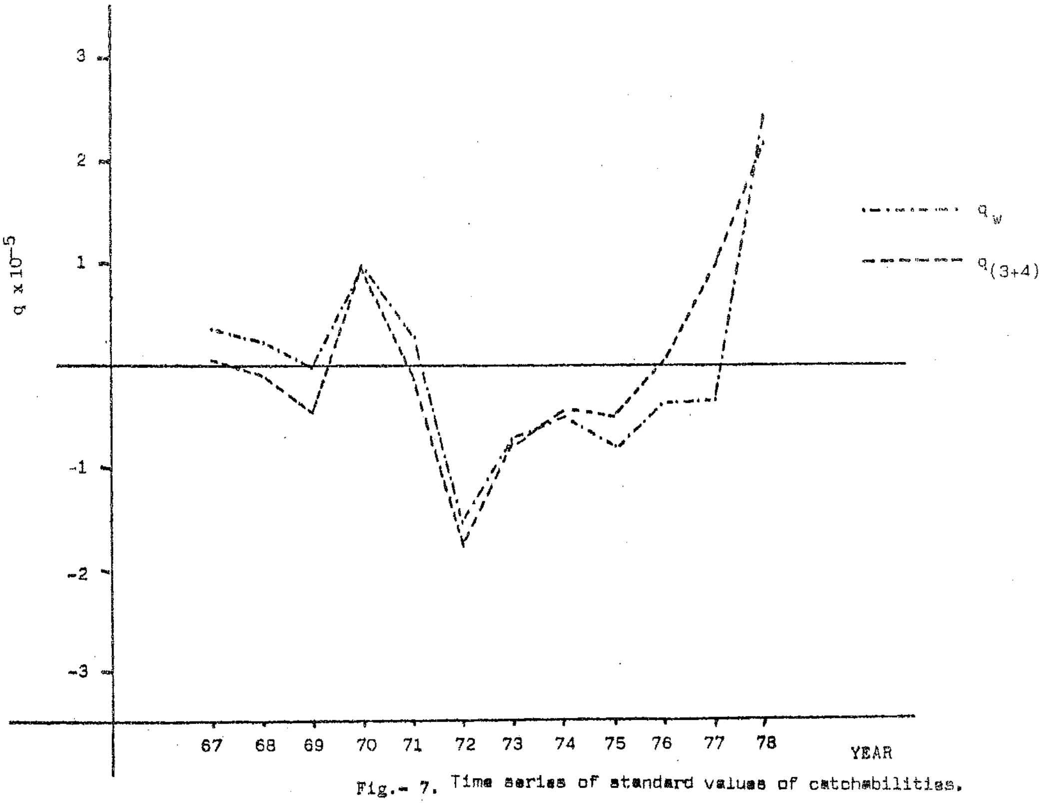

Fig.- 7. Time series of standard values of catchabilities.

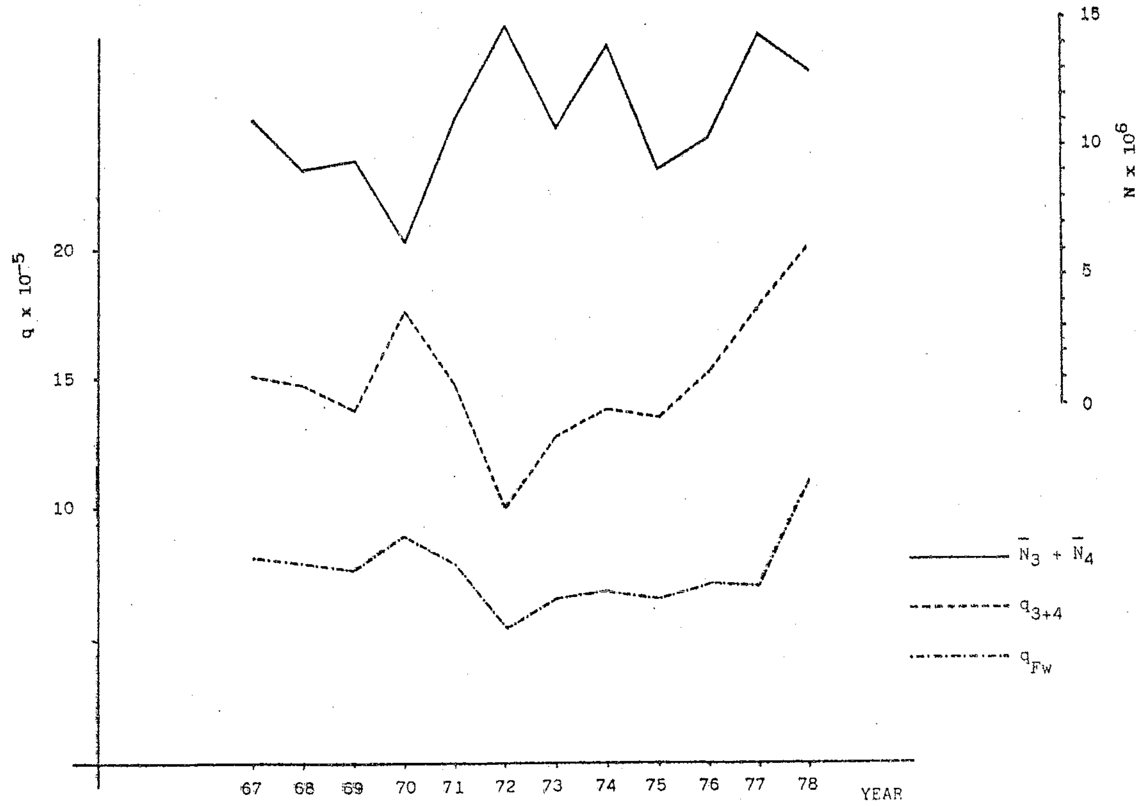

Fig.- 8. Catchabilities from weighted and unweighted F and 3-4 mean abundance time series.

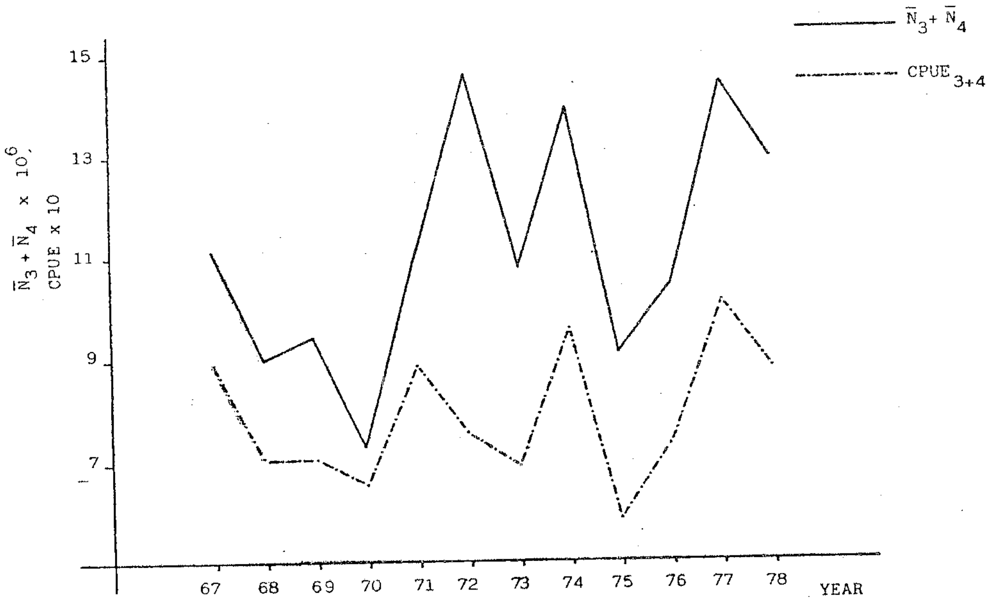

Fig.- 9. 3-4 mean abundance and 3-4 CPUE time series.

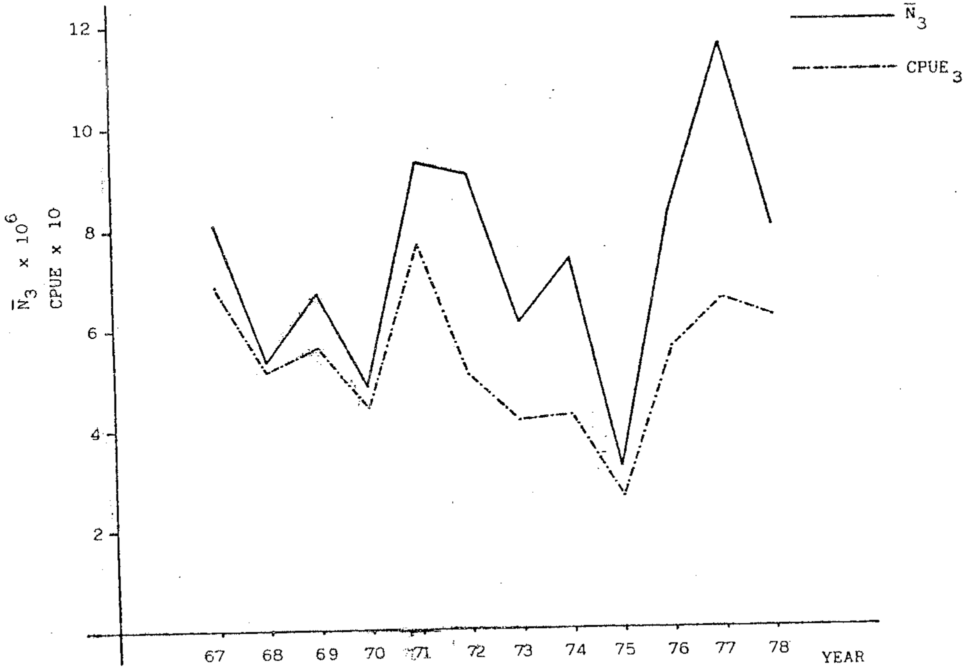

Fig.- 10. 3 years old mean abundance and corresponding

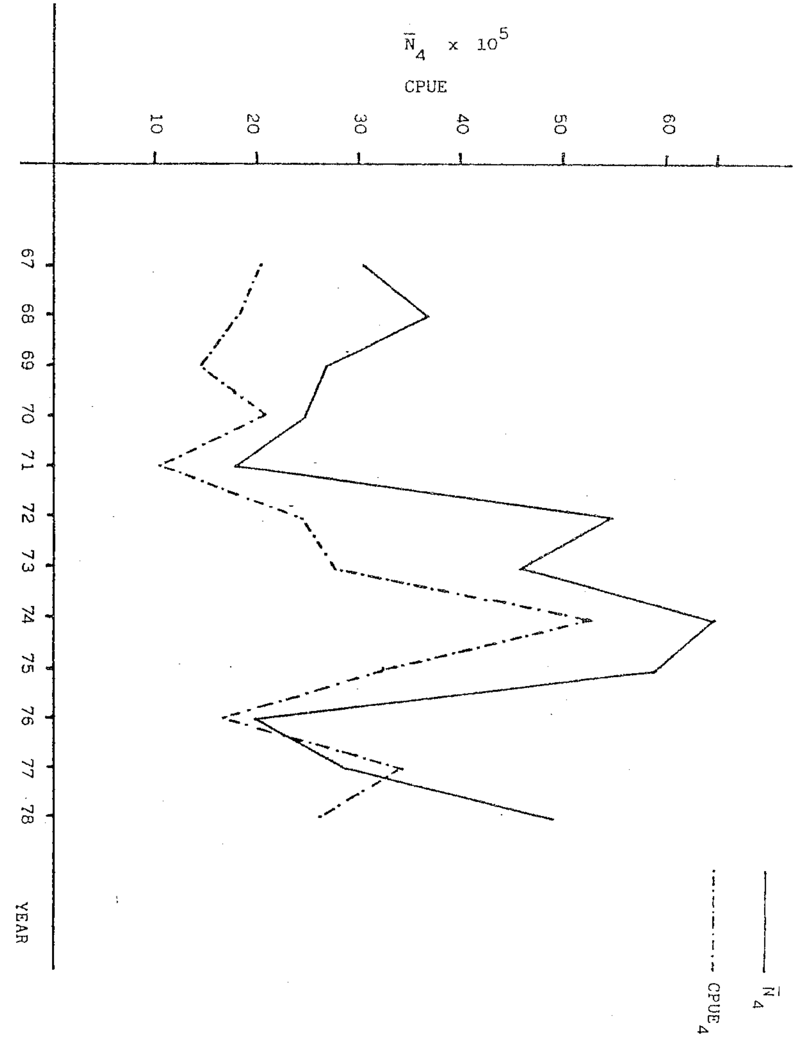

Fig.- 11. 4 years old mean abundance and corresponding CPUE time series.

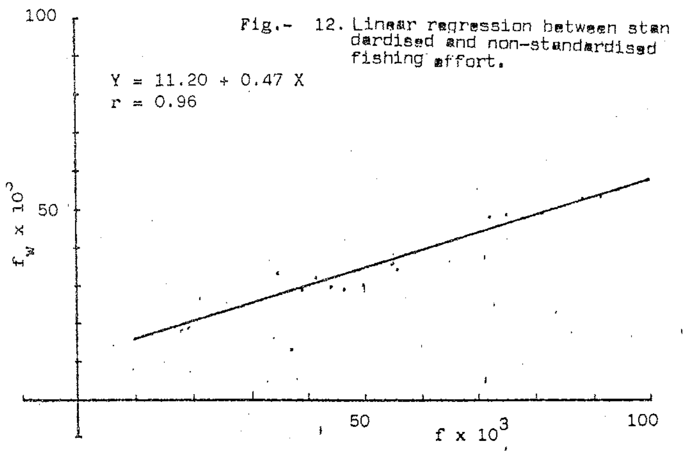
Fig.- 12. Linear regression between standardised and non-standardised fishing effort.

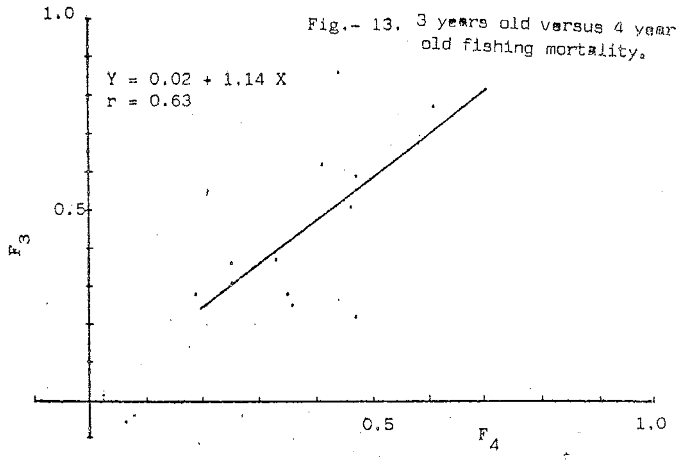
Fig.- 13. 3 years old versus 4 year old fishing mortality.

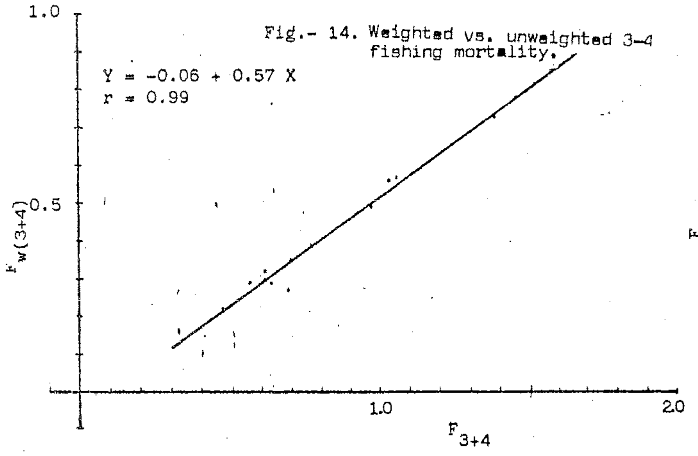
Fig.- 14. Weighted vs. unweighted 3-4 fishing mortality.

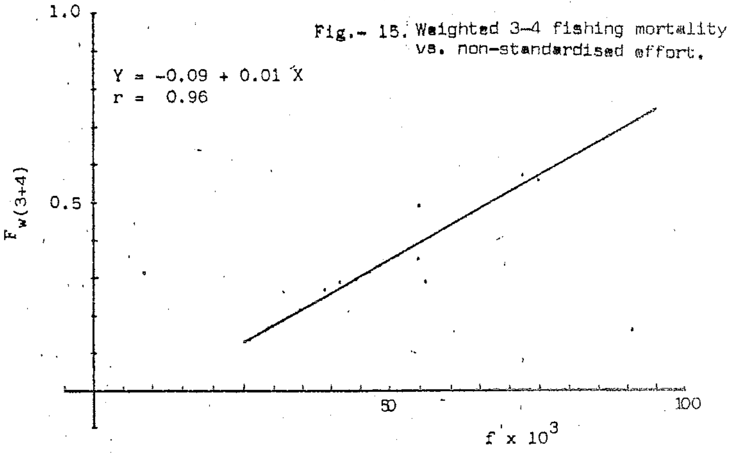
Fig.- 15. Weighted 3-4 fishing mortality vs. non-standardised effort.

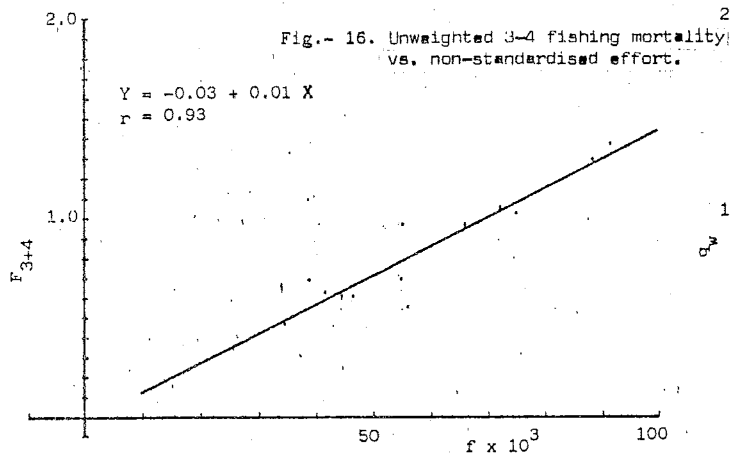
Fig.- 16. Unweighted 3-4 fishing mortality vs. non-standardised effort.

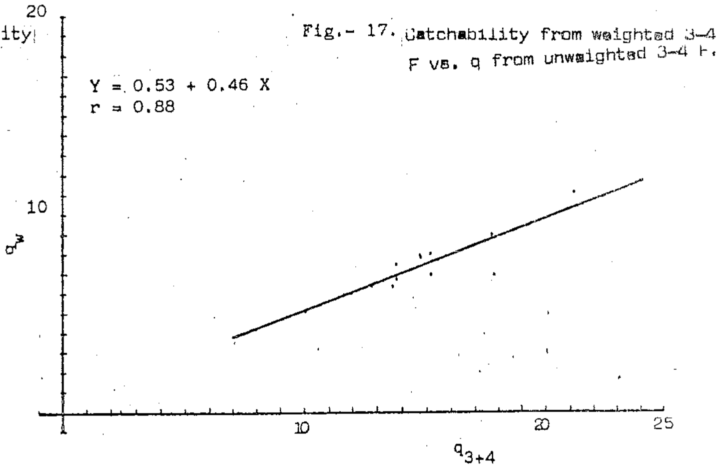
Fig.- 17. Catchability from weighted 3-4 F vs. q from unweighted 3-4 F.

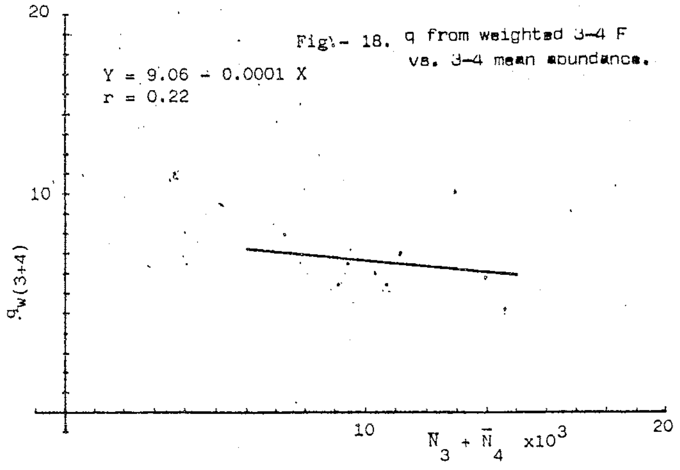
Fig.- 18. q from weighted 3-4 F vs. 3-4 mean abundance.

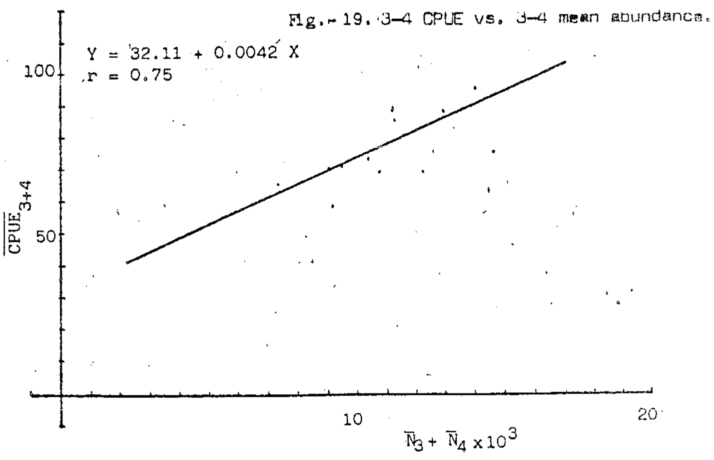
Fig.- 19. 3-4 CPUE vs. 3-4 mean abundance.

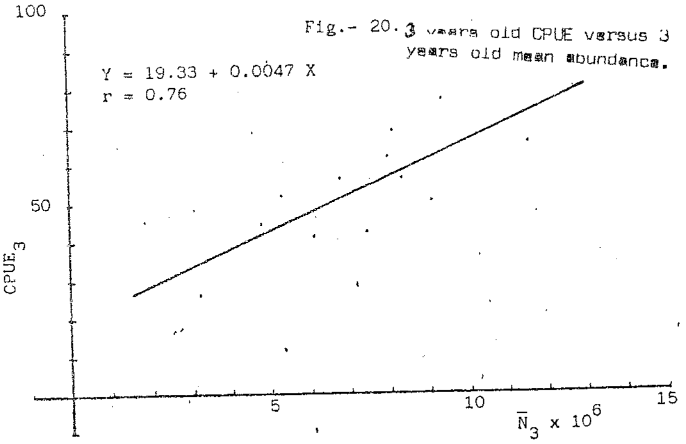

Fig.- 20. 3 years old CPUE versus 3 years old mean abundance.

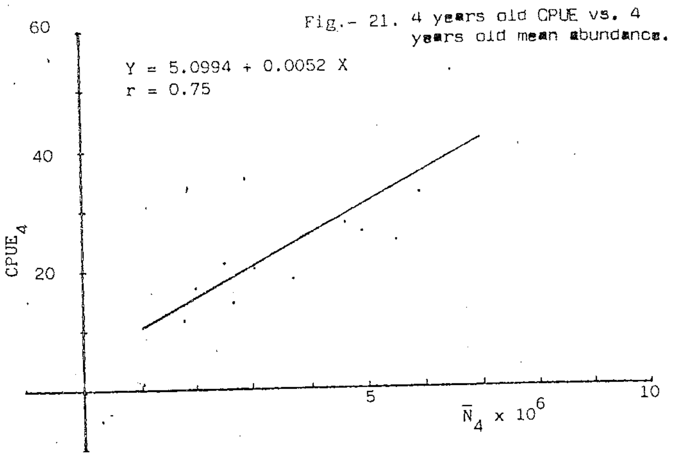

Fig.- 21. 4 years old CPUE vs. 4 years old mean abundance.

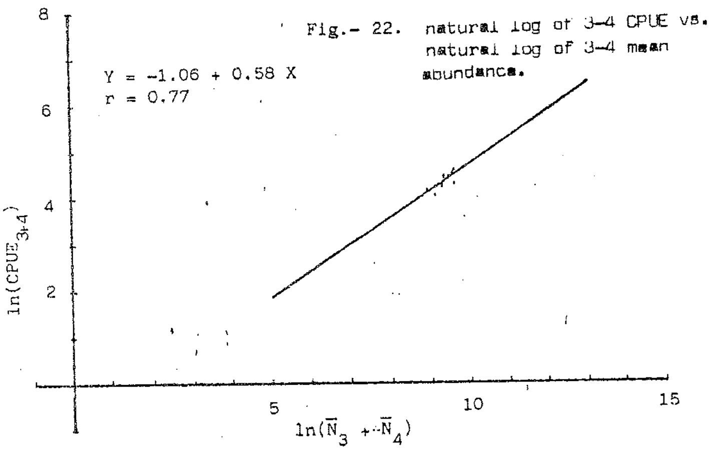

Fig.- 22. natural log of 3-4 CPUE vs. natural log of 3-4 mean abundance.

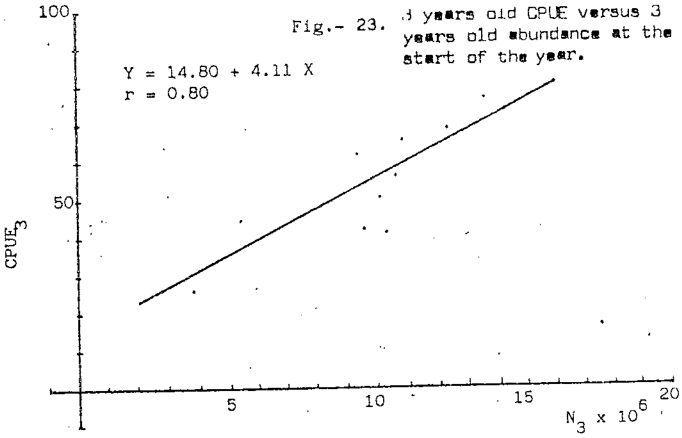

Fig.- 23. 3 years old CPUE versus 3 years old abundance at the start of the year.

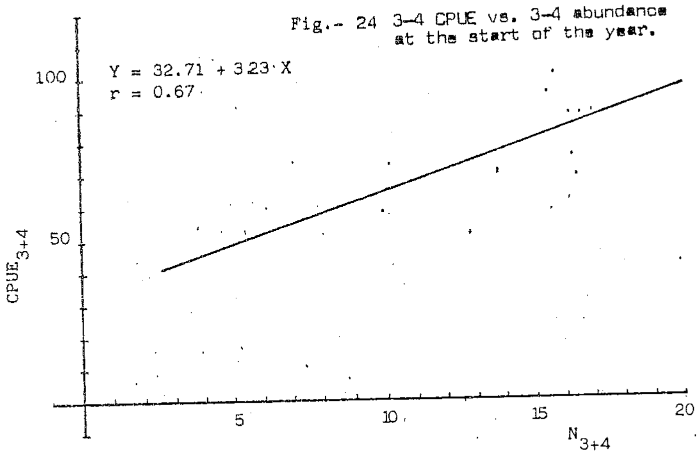

Fig.- 24 3-4 CPUE vs. 3-4 abundance at the start of the year.

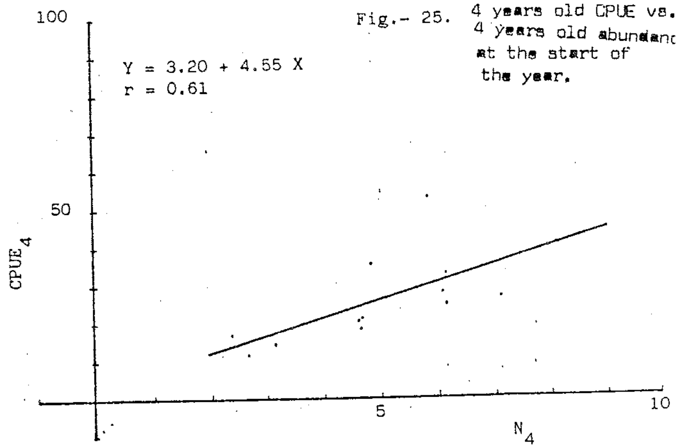

Fig.- 25. 4 years old CPUE vs. 4 years old abundanc at the start of the year.

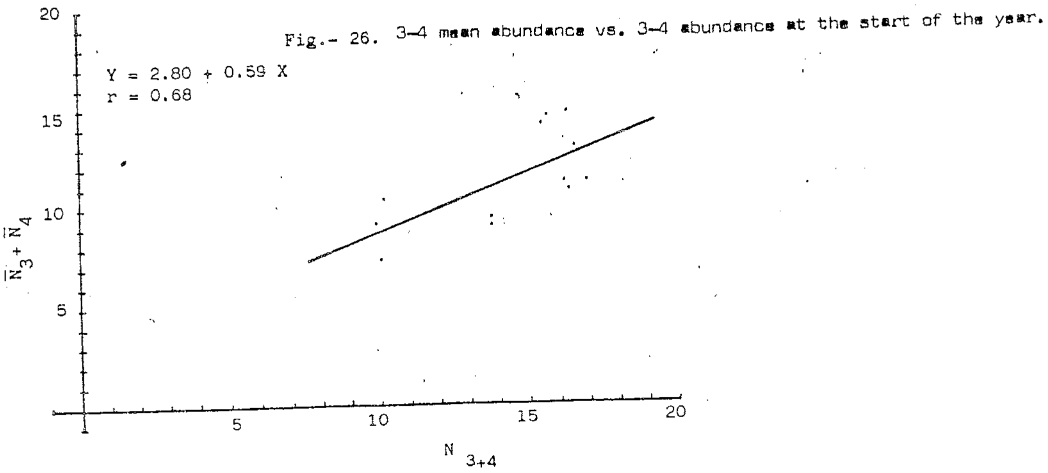

Fig.- 26. 3-4 mean abundance vs. 3-4 abundance at the start of the year.