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Results of comparative fishing between the A. T. Cameron and the Wilfred Templeman during July-August 1983

by

S. Gavaris and W. B. Brodie
Fisheries Research Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland A1C 5X1

ABSTRACT

Results of a comparative fishing experiment between the research vessels A. T. Cameron and W. Templeman in 1983 are presented. The numbers of cod, American plaice, and yellowtail in the paired catches were analyzed by species, with a multiplicative model to determine if conversion factors were required to account for possible differences in the fishing power of the two vessels. The results showed no difference for cod but significant differences for yellowtail and American plaice, with conversion factors for the latter species required for two size categories of fish (<28 cm, ≥28 cm). Analysis of the catches by fishing depth was inconclusive. Estimates of the conversion factors for the three species are given along with discussion on their limitations.

RESUME

Le présent document contient les résultats d'une expérience de pêche comparative entre l'A.T. Cameron et le W. Templeman menée en 1983. Les nombres de morues, de plies canadiennes et de limandes à queue jaune dans les prises des deux navires ont été analysés dans un modèle multiplicatif, en vue de déterminer s'il était nécessaire d'utiliser un facteur de conversion pour expliquer les différences de capacité de pêche des deux. Nous n'avons pas trouvé de différence dans le cas de la morue, mais il y eut des différences significatives avec la plie canadienne et la limande à queue jaune, cette dernière nécessitant des facteurs de conversion différents pour deux catégories de taille (< 28 cm, ≥ 28 cm). Une analyse des prises par profondeur de pêche n'a pas donné de résultats concluants. Nous donnons des estimations de facteurs de conversion pour les trois espèces et discutons de leurs limitations.

INTRODUCTION

The research vessel A. T. Cameron conducted random stratified surveys in the Newfoundland and Labrador region during the period 1971-1982 and these surveys are an important part of annual groundfish stock assessments. When the research vessel Wilfred Templeman was scheduled to replace the A. T. Cameron in 1982, it was decided to conduct a comparative fishing experiment between the two vessels to determine if any differences existed in their fishing capacities.

The ultimate aim of this experiment was to produce conversion factors for major groundfish species, if necessary, so that future random stratified surveys by the Wilfred Templeman would be comparable with the earlier series done by the A. T. Cameron. This report presents the results of the experiment carried out between the side trawler A. T. Cameron using a Yankee 41.5 otter trawl and the stern trawler Wilfred Templeman using an Engels 145 otter trawl.

METHODS AND MATERIALS

The comparative fishing experiment was conducted with the aim of obtaining a significant number of comparable tows over a wide range of numbers of fish per set for the target species (cod, American plaice, yellowtail, and redfish). To achieve this, the vessels were to locate concentrations of the target species and fish in that area until several catches of various sizes were taken. NAFO Division 3L was chosen as the site for the experiment because good concentrations of the target species were known to exist there. Where possible, the vessels towed side by side, as close as was safely permissable, so that the depths fished could be maintained within ± 10% of the intended depth. Where this method was not possible due to sloping grounds, the vessels towed in the same direction, following the depth contour, separated by a distance of approximately two miles. In all cases, the fishing gear of both vessels was to start and end fishing as close to the same times as possible, and all tows were scheduled to be thirty minutes in duration at a speed of 3.5 knots.

For each comparative fishing set the following information was collected:

1. temperature trace at the end of the set by XBT (W. Templeman only)
2. weight of the catch by species
3. length frequency of the catch by species

In cases where only a portion of the catch of a particular species was measured, the length frequency was adjusted to the total catch for that set.

Specifications for the A. T. Cameron and its Yankee 41.5 otter trawl and the Wilfred Templeman and its Engels 145 otter trawl are given in Table 1.

The data were analyzed separately for each of three species of fish: cod, American plaice and yellowtail. Based on previous experience, it was suspected

that length of fish might have an influence on the conversion factor. Before attempting to estimate any conversion factor this aspect was explored. Let

C_{1jk} = catch by the W. Templeman at length group k from set j

C_{2jk} = catch by the A. T. Cameron at length group k from set j

The difference between $\ln\sum_j C_{1jk}$ and $\ln\sum_j C_{2jk}$ was plotted versus length and examined. The difference between ln catches was used in order to be consistent with the model used, which will be described subsequently. Based on this examination, length groups which appeared to have similar conversion factors were pooled. In subsequent notation then, the subscript k for length group will be dropped and C_{ij} will refer to the catch from vessel i and set j for a particular collection of length groups which have been pooled.

On several occasions one or both vessels had catches which did not contain fish of a given species for the pooled length groups being considered. An important question is whether one vessel consistently caught some fish while the other caught none. Inspection of the data led us to reject this notion. Generally, the number of sets with zero catch were about the same for both vessels. Furthermore, the catch by a vessel was usually low when the other vessel caught none, mostly one or two and often zero. Given these observations it was determined that a model without an intercept would be adequate when considering the functional relationship:

$$C_{1j} = f(C_{2j})$$

The pattern of points from scatterplots did not provide any support for a model more complicated than a simple linear relationship:

$$C_{1j} = b_1 C_{2j}$$

It is important to note that both C_{1j} and C_{2j} have random error components associated with them, therefore simple least squares does not apply here. Further inspection of the scatterplots revealed that the dispersion tended to be greater for larger catches. It has been commonly observed that catches by research survey vessels are not normally distributed, generally showing some positive skewness. Log transformations have frequently been used to stabilize variance and will reduce the skewness inherent in the raw data. For the ensuing analysis it was assumed that catches were lognormally distributed. Based on these considerations the following model was used for estimating b_1, the conversion factor:

$$C_{ij} = C_0 \, b_1^{x_1} \prod_j b_j^{x_j} \exp(\varepsilon_{ij}) \quad j = 2, 3, 4...$$

where C_0 = predicted catch by the A. T. Cameron in the first set

b_1 = power of the W. Templeman relative to the A. T. Cameron

b_j = density of set j relative to the first set

$\varepsilon_{ij} \sim N(0,\sigma)$

X_1 = 1 for W. Templeman
0 for A. T. Cameron

X_j = 1 if catch is for set j
0 otherwise

Taking natural logarithms we have

$$\ln C_{ij} = \ln C_0 + (\ln b_1)X_1 + \sum_j (\ln b_j) X_j + \varepsilon_{ij}$$

A conversion factor is defined here as a constant applied to a catch by the A. T. Cameron, for which there is no corresponding catch by the W. Templeman. An estimate of $\ln b_1$, from ordinary least squares, would be such a factor to be added to natural logarithms of catches by the A. T. Cameron. It is generally more convenient, however, to work in the original scale. To obtain a factor which could be used to multiply catches by the A. T. Cameron in order to make them comparable to catches by the W. Templeman, the results from Bradu and Mundlak (1970) can be applied giving

$$\hat{b}_1 = \exp(\widehat{\ln b}_1)\, g_m\left[\frac{-m+1}{2m}\ \hat{\sigma}^2_{\widehat{\ln b}_1}\right]$$

and as an estimate of its variance

$$\hat{\sigma}^2_{b_1} = \exp(2\,\widehat{\ln b}_1)\left\{g_m^2\left[\frac{-m+1}{2m}\ \hat{\sigma}^2_{\widehat{\ln b}_1}\right] - g_m\left[\frac{-m+1}{m}\ 2\hat{\sigma}^2_{\widehat{\ln b}_1}\right]\right\}$$

where m = degrees of freedom for the residuals

$\hat{\sigma}^2_{\ln b_1}$ = is the estimate of variance for $\widehat{\ln b}_1$

Ebbeler (1973) has shown that for computation the following result may be used:

$$\lim_{m\to\infty} g_m(t) = \exp(t) \text{ for all } t$$

This model is related to the one proposed by Gavaris (1980) for analyzing catch rates from commercial data.

Only sets where both vessels had non-zero catches for the species and length groups considered were subjected to this analysis, zero sets having been examined as discussed previously. The analysis was carried out separately for depths <100m and depths ≥100m. If no differences by depth were evident the data were combined and a single conversion factor estimated.

RESULTS

A total of 72 successful comparative sets were made between July 21 and August 8, 1983, and from these, data for three of the four target species were analyzed separately. No analysis was attempted for redfish because this species occurred in only a few sets and then only in very small quantities.

COD

The plot of difference between ln catches versus length (Fig. 1) did not reveal any definite patterns. This is in contrast to previous experience with comparisions between the Gadus Atlantica and the A. T. Cameron where the Gadus appeared to catch larger fish better while for small fish the two vessels caught fish almost equally well. Given these results all length groups were pooled together for cod.

The analysis by depth zone showed that the relative power of the W. Templeman with respect to the A. T. Cameron was higher for depths ≥100 m. Although this result appears reasonable the two values were less than one standard deviation apart. Given the variability of the data it was decided that separate conversion factors for each depth zone could not be estimated, for practical purposes, with these data.

The estimate of the conversion factor for cod between the W. Templeman and the A. T. Cameron, pooling all length groups and combining depth zones, was 0.9 with a standard error of 0.09. Examination of the residuals from the regression did not reveal any unusual cases or extreme deviation from normality. The scatterplot of the catches with the estimated line drawn in is shown in Fig. 2. It is evident from this figure that the distribution of catch sizes was inadequate for estimating a conversion factor for large catches. Furthermore, near the origin it appears that the variation is very high. Based on these observations and the fact that the conversion factor is not significantly different from 1.0 a conversion factor different from 1.0 cannot be recommended.

AMERICAN PLAICE

A previous experiment with the Gadus Atlantica and the A. T. Cameron suggested that the length of American plaice may have an influence on the conversion factor between vessels. The plot of the difference between ln catches of the W. Templeman and the A. T. Cameron versus length (Fig. 3) strongly supports this theory. From this figure it can be seen that the W. Templeman caught larger plaice better than the A. T. Cameron while the A. T. Cameron caught smaller plaice better. As a result of this, it was decided to split the data into two groups: <28cm and ≥28cm, as this is the point in the curve where ln difference changes from negative to positive. It is also interesting to note the apparent linear trend over the range of length groups from 10-34cm.

The results by depth zone (<100m, ≥100m) were somewhat contradictory when examined for each of the length groupings. For plaice <28cm, the relative power of the W. Templeman with respect to the A. T. Cameron was greater for

depths ≥100m while for plaice ≥28cm, the relative power was less for depths ≥100m. Due to the considerable variability of the data in some of the size-depths categories, it was felt that separate conversion factors by depth for the two size categories could not be considered reliable so the analysis was done with depth zones combined.

For plaice <28cm, all depths combined, the estimate of the conversion factor was 0.5 (relative power of the W. Templeman versus the A. T. Cameron) with a standard error of 0.05. The residual plots from the regression did not show non-normality or any extreme outliers. The plot of the paired catches showing the regression line is given in Figure 4. Analysis of the data with the largest outlier removed (largest catch by the A. T. Cameron) resulted in an increase of only 1.6% in the conversion factor. As was the case for cod, there is a large cluster of points near the origin and only a few points representing large catches.

For American plaice ≥28cm, all depths combined, the estimate of the relative power of the W. Templeman with respect to the A. T. Cameron was 1.3 with standard error of 0.09. Again, residual plots did not reveal anything unusual. The scatterplot, including the fitted line, is shown in Fig. 5. Analysis of the data with the largest outlier removed (largest catch by the W. Templeman) resulted in a decrease of only 2.7% in the conversion factor. Again, there is a sizable cluster of points near the origin, although in this case there is a wider distribution of catch sizes.

YELLOWTAIL

Unlike those for American plaice, the results for yellowtail from the Gadus Atlantica - A. T. Cameron comparative fishing experiment suggested that length may not be a factor in determining a conversion factor. The plot of the difference between ln catches of the W. Templeman and the A. T. Cameron (Fig. 6) shows the relative power of the W. Templeman to be greater than the A. T Cameron over the range of length groups. Although there appears to be an increasing trend in the relative power of the W. Templeman to the A. T. Cameron as length increases, the portion of the curve representing the majority of the catch (34-40 cm length groups) is relatively flat. Subsequently, it was decided to pool all lengths together for yellowtail. Also, since all usable sets in which yellowtail occurred in this experiment were in depths between 65 and 88m, depth was not considered in determining a conversion factor.

The resulting conversion factor for yellowtail, with lengths pooled and depth zones combined was 1.5 (power of W. Templeman relative to the A. T. Cameron) and the standard error was 0.26. Examination of the residual plots did not reveal anything unusual. Analysis of the data with the largest outlier removed (largest catch by the W. Templeman) resulted in a decrease of the conversion factor to 1.4 with a standard error of 0.22. The scatterplot of the catches, showing both conversion factor lines (with and without outlier), is given in Fig. 7. The distribution of catch sizes is fairly even over the observed range and, although the catches were much smaller on average than catches of American plaice, the range of values observed for both species was typical of past surveys done by the A. T. Cameron in this area.

REFERENCES

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Ebbeler, D. H. 1973. A note on estimation in log-normal linear models. J. Statist. Comput. Simul. 2: 225-231.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37: 2272-2275.

Table 1. Vessel and trawl characteristics for the boats and gears used in the comparative fishing experiment.

	A. T. Cameron			W. Templeman
Vessel type	Side trawler			Stern trawler
B.H.P.	1000			2000
Tonnage	753			925
Length	53m			50m
Trawl	Yankee 41.5			Engels 145
Footrope (ft)	100			145
Headrope (ft)	79			96
Net Panel lengths (ft)		[Mesh sizes (in.)]		
Top wings	35	5	7	38
Square	13	5	7	29
Bellies	32	4.25avg.	5.125-6	48
Lengthening Piece	24	3.25	-	-
Codend	24	3.25	5.125	60
Total	128			175
Doors				
Type	Brompton(rectangular)			Polyvalent (oval)
Weight (lbs)	1300			3307
Net opening (ft)				
Wing spread	45			45
Headline height	8-11			16-22

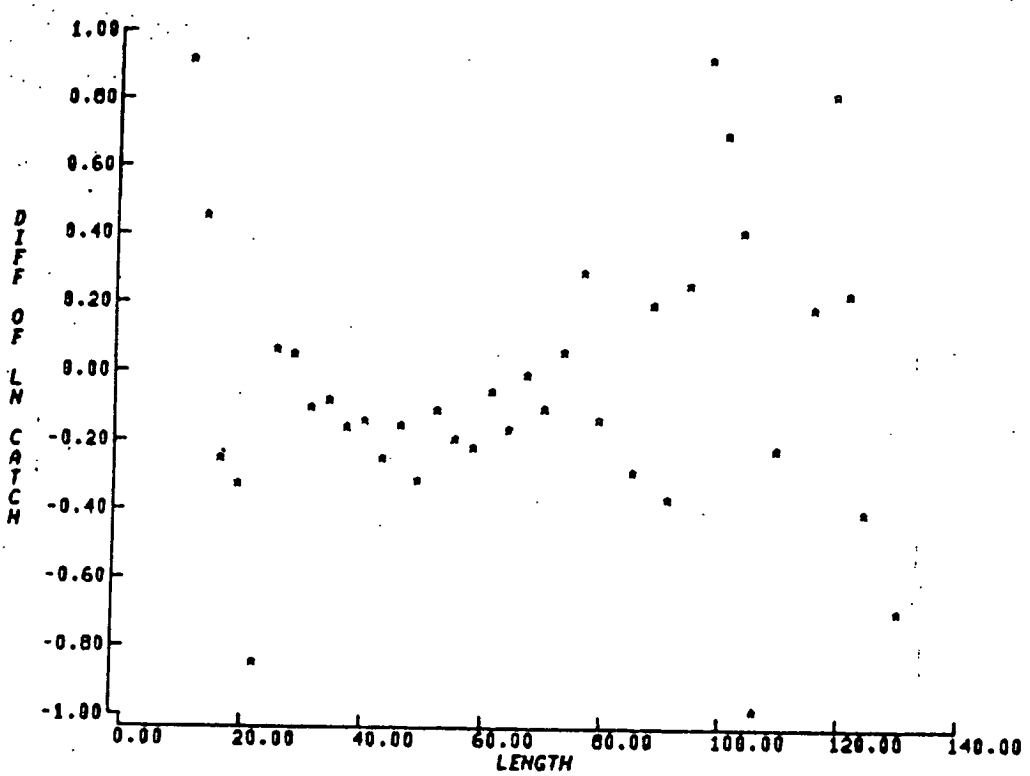

Fig. 1. Difference of ln catches (W. Templeman minus A. T. Cameron) versus length for cod.

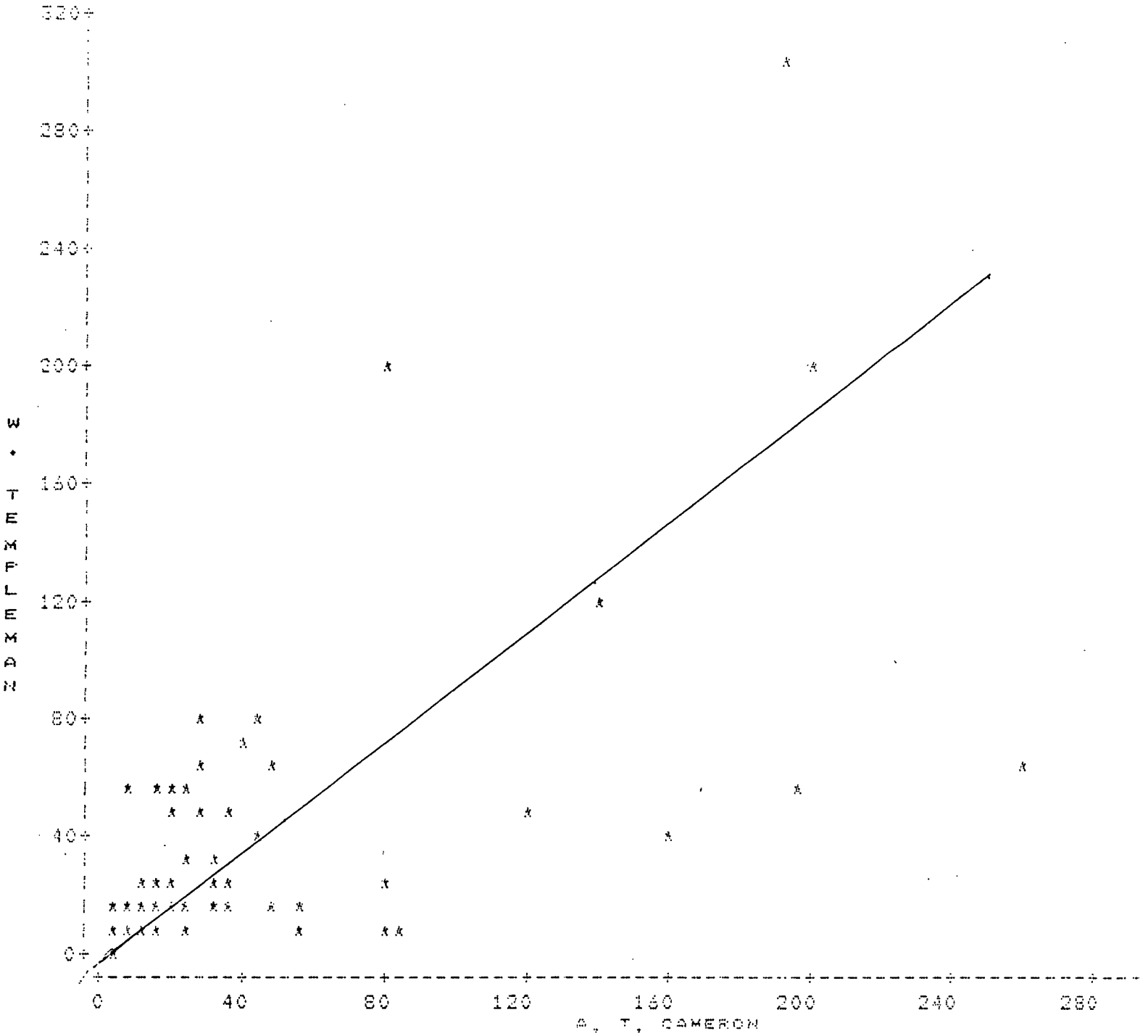

Fig. 2. Scatterplot of cod catches with the conversion factor line drawn in. All lengths were pooled and the depth zones were combined.

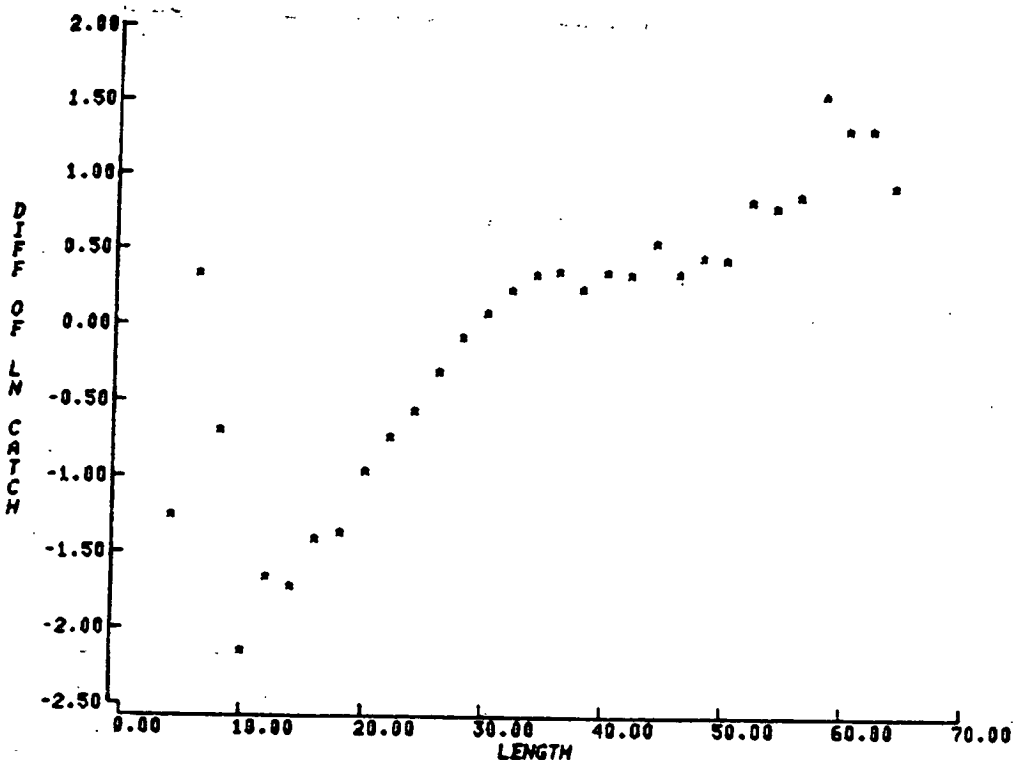

Fig. 3. Difference of ln catches for American plaice.

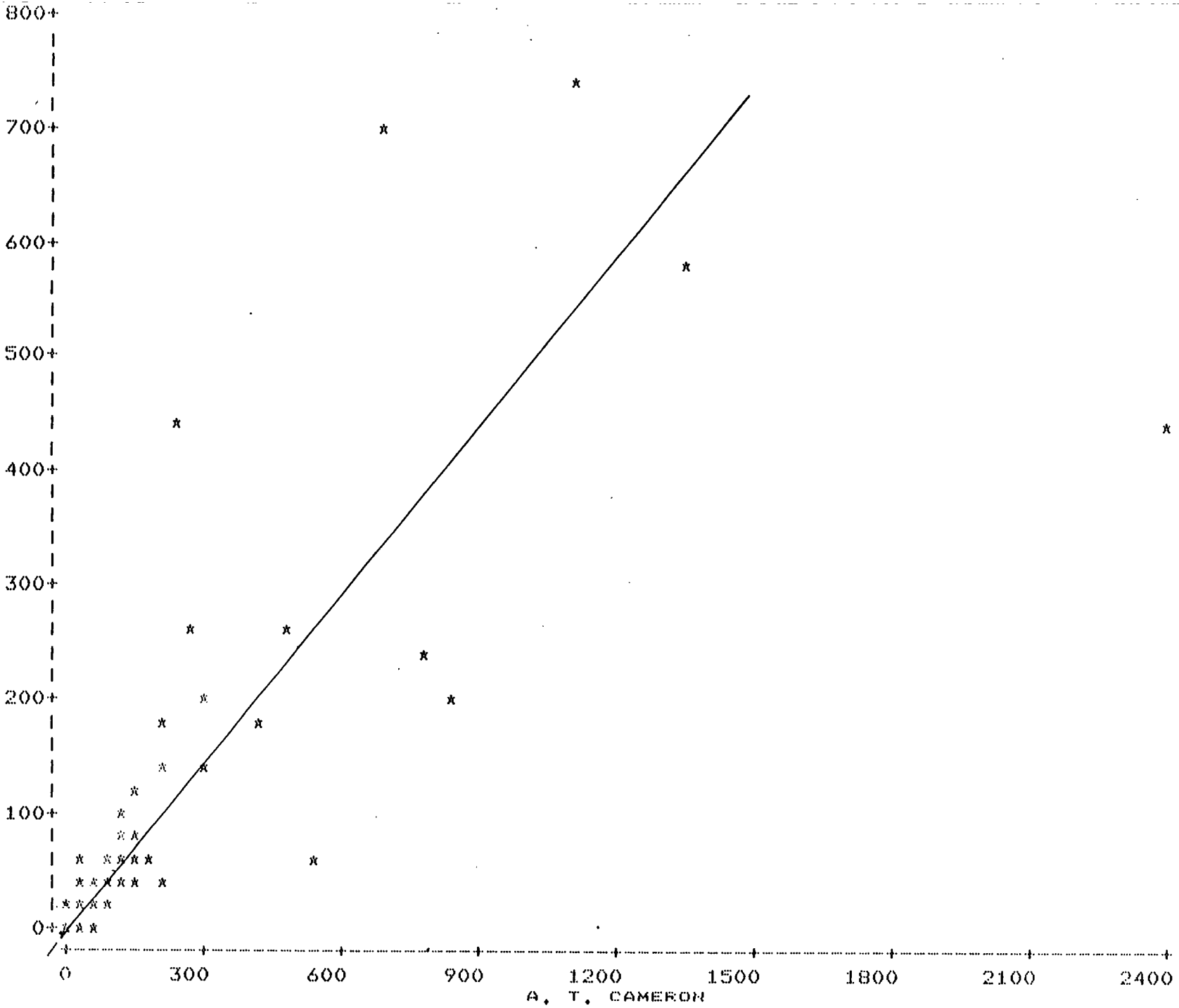

Fig. 4. Plot of plaice (<28 cm) catches showing calculated line. All depth zones were combined.

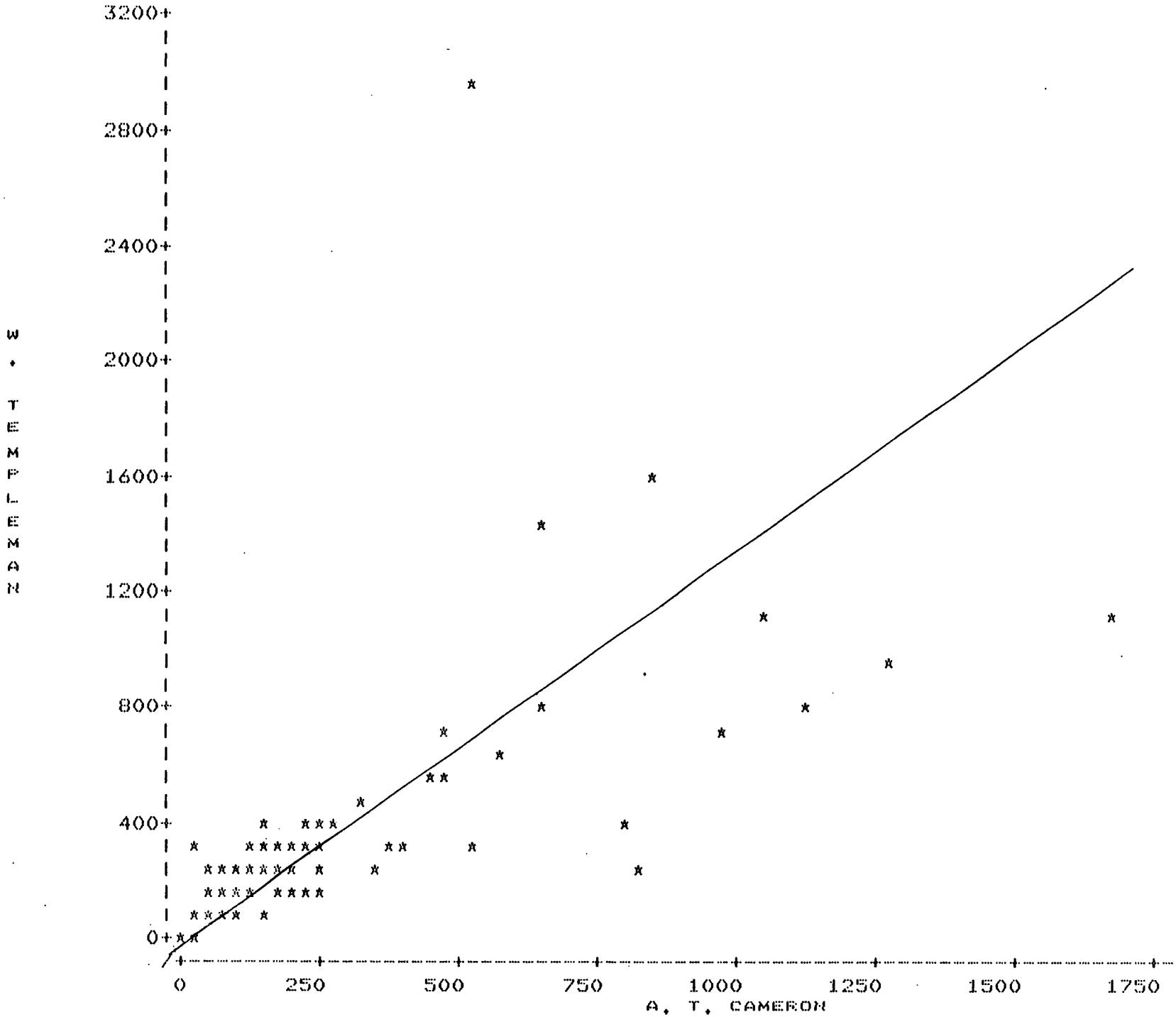

Fig. 5. Plot of plaice (≥28 cm) catches showing calculated line. All depth zones were combined.

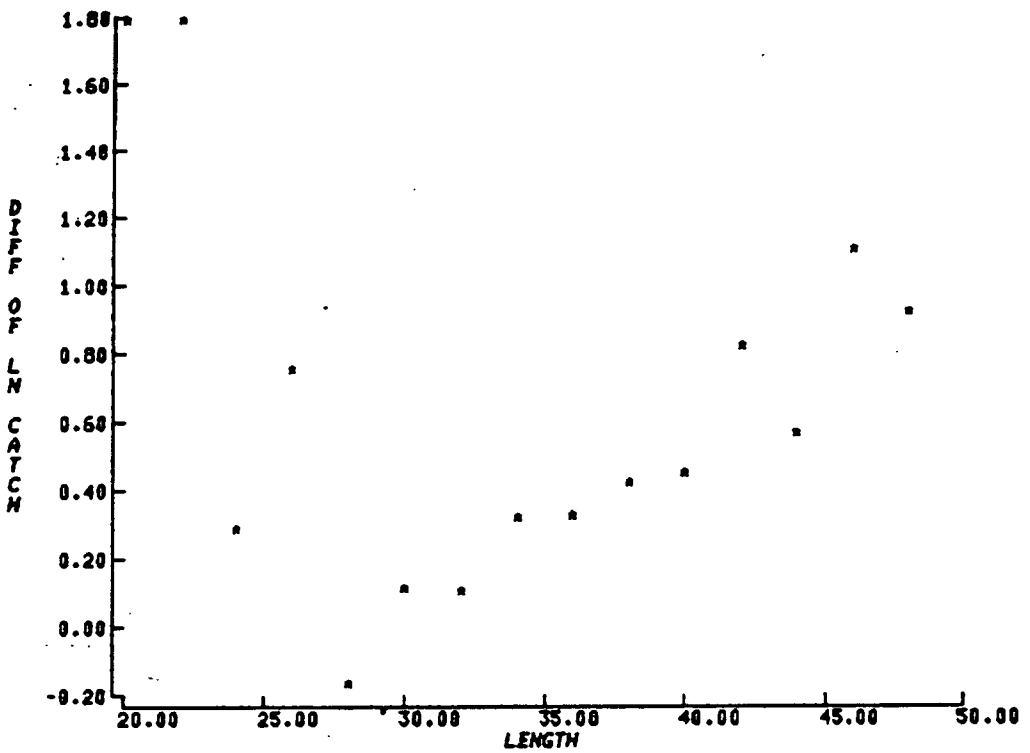

Fig. 6. Difference in ln catches versus length for yellowtail.

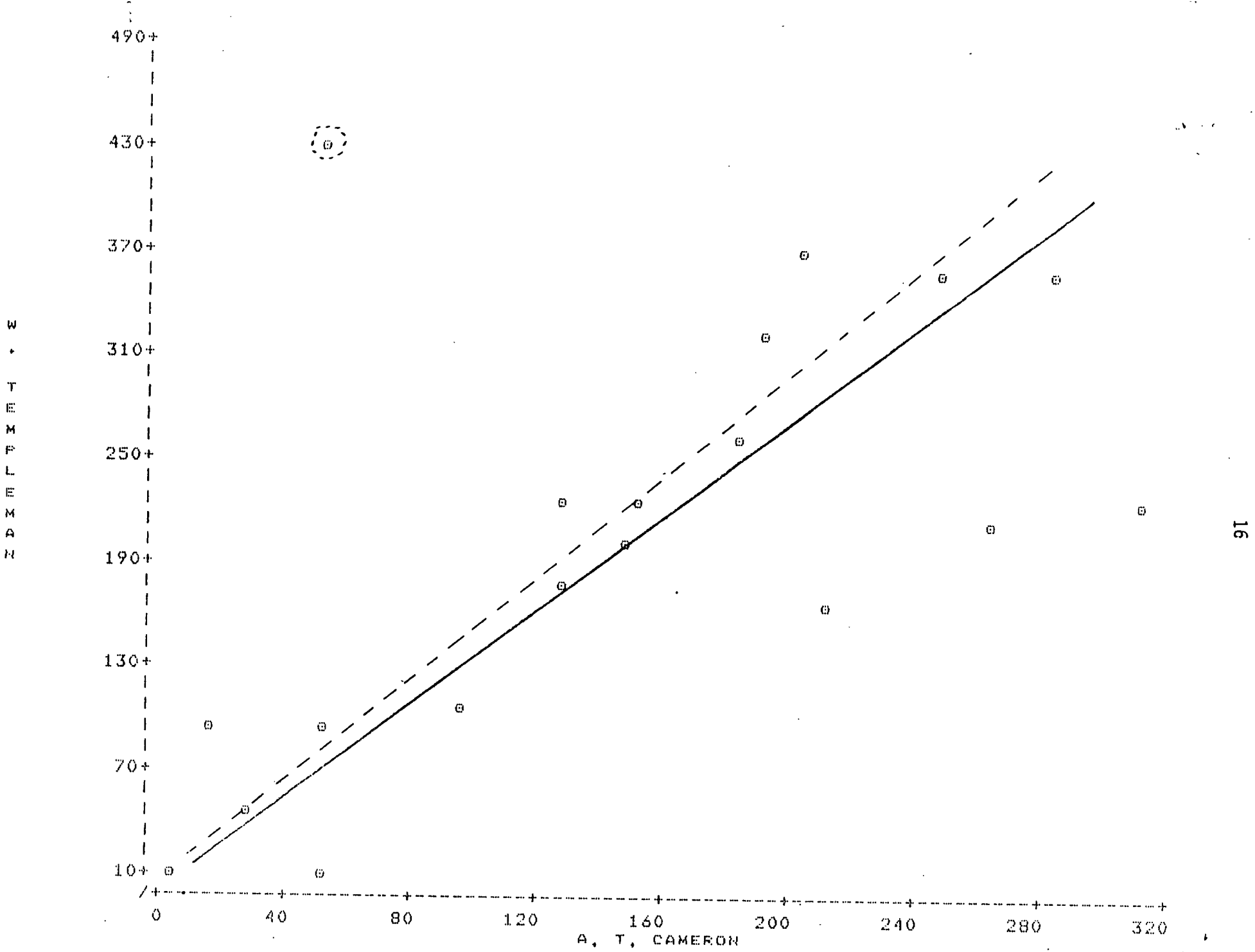

Fig. 7. Plot of yellowtail catches showing calculated lines - broken line includes all points and unbroken line was calculated with circled point omitted. All lengths were pooled and all depth zones combined.