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A production model for the FMA 1 scampi fishery, 1989–1992

M. Vignaux and D. Gilbert
MAF Fisheries Greta Point
P.O. Box 297
Wellington

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MAF Fisheries, N.Z. Ministry of Agriculture and Fisheries

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1 Executive summary

In 1992 a standardised Catch Per Unit Effort (CPUE) index was calculated for the scampi fishery in FMA 1 and used in a production model. This report describes an updated version of that analysis, including data from the 1992 calendar year. The index was based on commercial catch and effort data, and was standardised for effects such as seasonality and daily cycles using multiple regression. The index shows a decline of 33% between 1989 and 1991, but no further decline in 1992. This is less of an overall decline than in the index presented in last year's assessment because some data were inadvertently omitted from the analysis last year. Therefore, the production model estimates of virgin biomass (939 t) and maximum sustainable yield (113 $t.y^{-1}$) are higher than in the baseline case presented last year. However, these results are considered to be preliminary because of the shortness of the CPUE time series, the uncertainty in the relationship between CPUE and stock size, and the uncertainty in the parameters of the production model.

2 Introduction

In 1992 a standardised Catch Per Unit Effort (CPUE) index was calculated for the scampi fishery in FMA 1 and used in a production model (Vignaux & Gilbert 1993). The index was based on commercial catch and effort data, and was standardised for effects such as seasonality and daily cycles using multiple regression. This report describes an updated version of that analysis, incorporating data from the 1992 calendar year.

3 CPUE analysis

3.1 Data

The data were extracted from the catch-effort system of the fishery statistics database administered by the Information Technology Directorate. All tows between 1989 and 1992

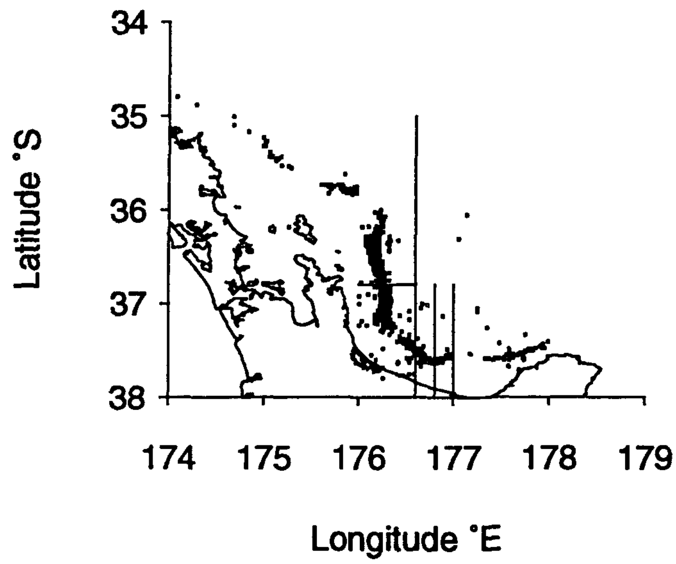

Figure 1: Positions of scampi tows in FMA1 from 1989 to 1992 showing the area divisions used in the regression model

that targeted scampi in the area north of 38° S and west of 178° E were selected from the database. This differs from last year's analysis, in which the data were mainly obtained directly from industry sources.

Errors in the data were detected by careful checking. Where possible, copies of the original forms were obtained and a decision was made whether the error could be corrected or whether the record should be deleted. Where the record also appeared in last year's dataset and the recorded catch differed, the catch from last year's dataset was used.

Unless a tow was confirmed by industry as a valid tow, zero catches were deleted if the tow caught no fish of any species. This was taken as an indication that the tow had failed, and there was no chance of catching scampi. Since comments such as "Gear test" written on the form are not entered into the database, this method seems to be the best indication of incomplete tows.

The remaining zero catches were replaced with an arbitrary catch of 1 kg.

Table 1: Summary of variables in model.

Variable	Categories	Description
Time of day	12	time at start of tow in 2 hour blocks (eg, midnight to 2 am)
Month	12	month of tow
Area	5	area of tow (as shown on Figure 1)
Vessel	10	the vessel that recorded the tow
Year	4	the calendar year that the tow occurred in
Depth bottom	6	the depth (m) of the bottom under the vessel at the start of the tow
Headline	4	the maximum headline height (m) of the net (new this year)

3.1.1 Method

The variable log(catch per hour) was chosen as the estimate of CPUE. Each of a number of variables (Table 1) was regressed against log(catch per hour) to find the variable which explained most variation in log(catch per hour) (measured by the multiple regression coefficient R^2). This variable was selected into the model, and combined with each of the other variables in turn to find the two variable model which explained most variation. This stepwise procedure continued until the increase in R^2 was only 2%.

Relative year effects can be calculated from the regression coefficients for the year variable, as described by Vignaux (1992).

3.1.2 Results

The same variables were selected into the model as last year, but in a different order (Table 2). This table shows that the monthly and the time of day effects are prominent. Figure 2 is a plot of the monthly and time of day effects measured from the regression coefficients in the model.

The index is shown in Table 3 and Figure 3. The indices for 1989 to 1991 are somewhat more optimistic than those presented in last year's analysis. Not all the data that should have been included in the dataset last year were available (13% were missing). Figure 4 shows that when we use only the tows that are also in last year's dataset, we get nearly the same index as last year (apart from the missing records, there are other minor discrepancies between the two datasets). However, when we add to this dataset the non-zero tows that were omitted from last year's dataset, the index changes. Adding a few apparently genuine zero tows changes the index little more, and nor does adding the 1992 data. It seems that the main change between last year's index and this year's index is

Table 2: Choice of variables in regression of log(catch per hour) for FMA1 1989–92 in order of importance. Numbers in the table are the multiple regression coefficient R^2. In the first step, log(CPUE) was regressed against each of the variables in turn, to find the variable which explained the most variation in log(CPUE) (had the highest multiple regression coefficient R^2). This variable was included in the model. In step 2, log(CPUE) was regressed against this model plus each of the other variables in turn to find the next most significant variable. This process continued in a series of 6 steps.

Step Variable chosen	1	2	3	4	5	6
Time of day	8.64					
Month	7.33	15.42				
Area	8.09	15.18	20.36			
Vessel	7.31	14.46	19.89	23.47		
Year	6.75	13.52	20.08	22.92	25.47	
Depth bottom	2.59	10.76	17.45	21.54	24.18	26.41
Headline	1.44	9.98	16.39	20.94	23.63	25.51
Improvement	8.64	6.78	4.94	3.11	2.00	0.94
Degrees of freedom	3964	3952	3947	3937	3927	3823

Table 3: Relative year effects ($\hat{A}_j$) for regression against log(catch per hour). Reg. coeff. are the regression coefficients of the year variable. Std. err. are the standard errors of these coefficients in the regression and Cov. is the covariance between the coefficients and the coefficient of the base year (1989). $\hat{A}_j$ is the relative year effect and $s_{\hat{A}_j}$ is the standard error of the year effect.

Year	No. tows	Reg. coeff.	Std. err.	Cov	$\hat{A}_j$	$s_{\hat{A}_j}$
1989	616	0.276	0.0277	7.696e-04	1.000	0.000
1990	849	-0.023	0.0238	-2.074e-04	0.741	0.031
1991	1723	-0.126	0.0211	-2.538e-04	0.669	0.028
1992	788	-0.128	0.025	8.383e-05	0.668	0.023

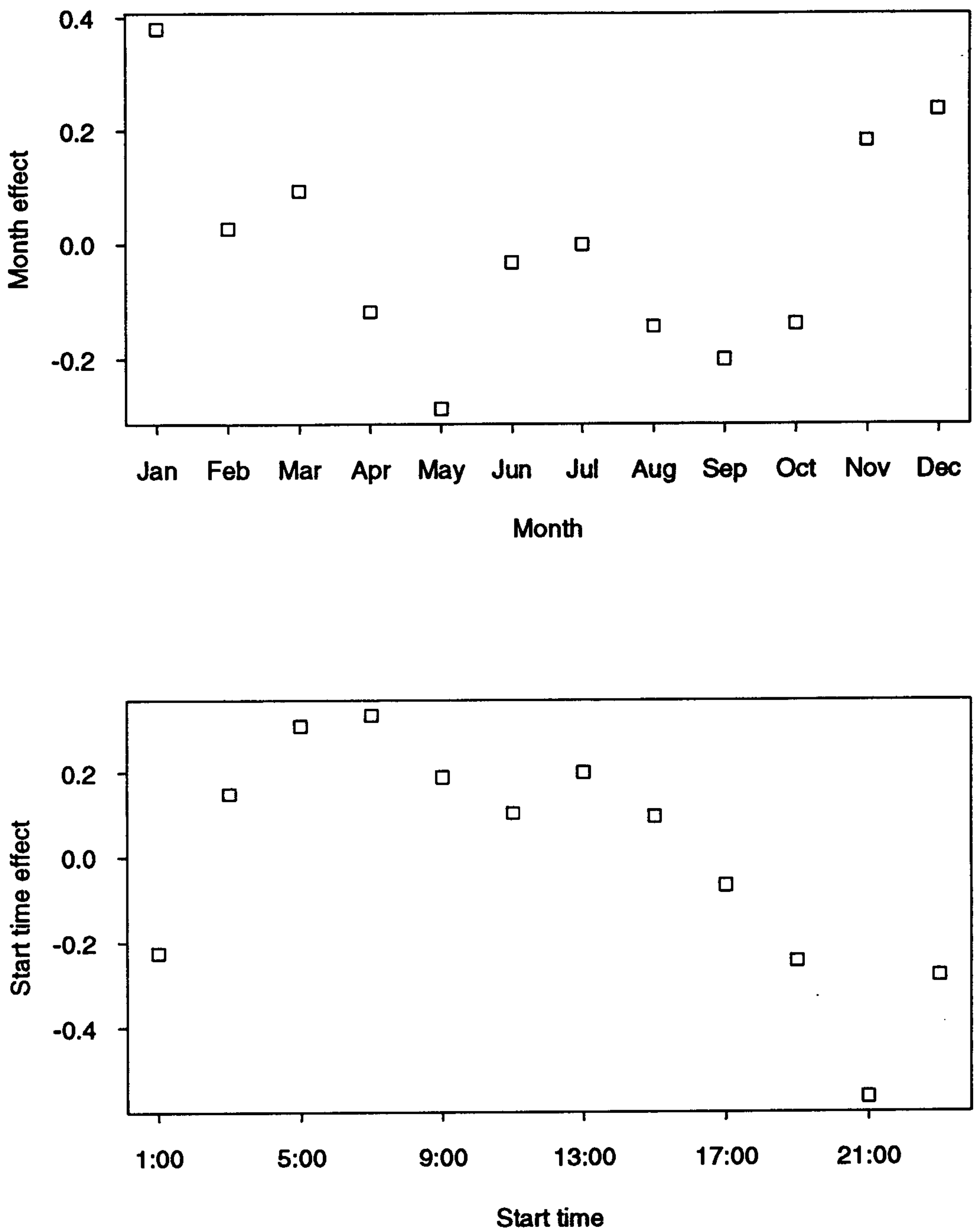

Figure 2: Regression coefficients of month and of time of day in the model of scampi CPUE

Table 4: Estimated total catch of scampi from FMA 1 obtained from reported catches, with corrections for errors and omissions. The column "Catch in CPUE dataset" is the total estimated catch of scampi in all tows used in the CPUE analysis.

Fishing year	Total catch (t)	Catch in CPUE dataset	Proportion
1986-87	5	-	-
1987-88	15	-	-
1988-89	60	39	0.65
1989-90	103	102	0.99
1990-91	179	160	0.89
1991-92	129	128	0.99
1992-93	120†	-	-

†for the 1992-93 year a projected catch equal to the quota was assumed

due to the non-zero tows that were omitted from last year's analysis.

The total estimated catch of scampi in the present dataset is very similar to the total catches used in the production model except in 1988–89 when some vessels were not filling in Trawl Catch Effort and Processing Returns (Table 4). It is unlikely that there are still significant numbers of missing records.

The index is not sensitive to the choice of the arbitrary zero replacement catch of 1 kg. Changing this replacement value to 10 kg changes the index only slightly.

	Index			
Replacement value	1989	1990	1991	1992
1 kg	1	0.741	0.669	0.668
10 kg	1	0.740	0.660	0.661

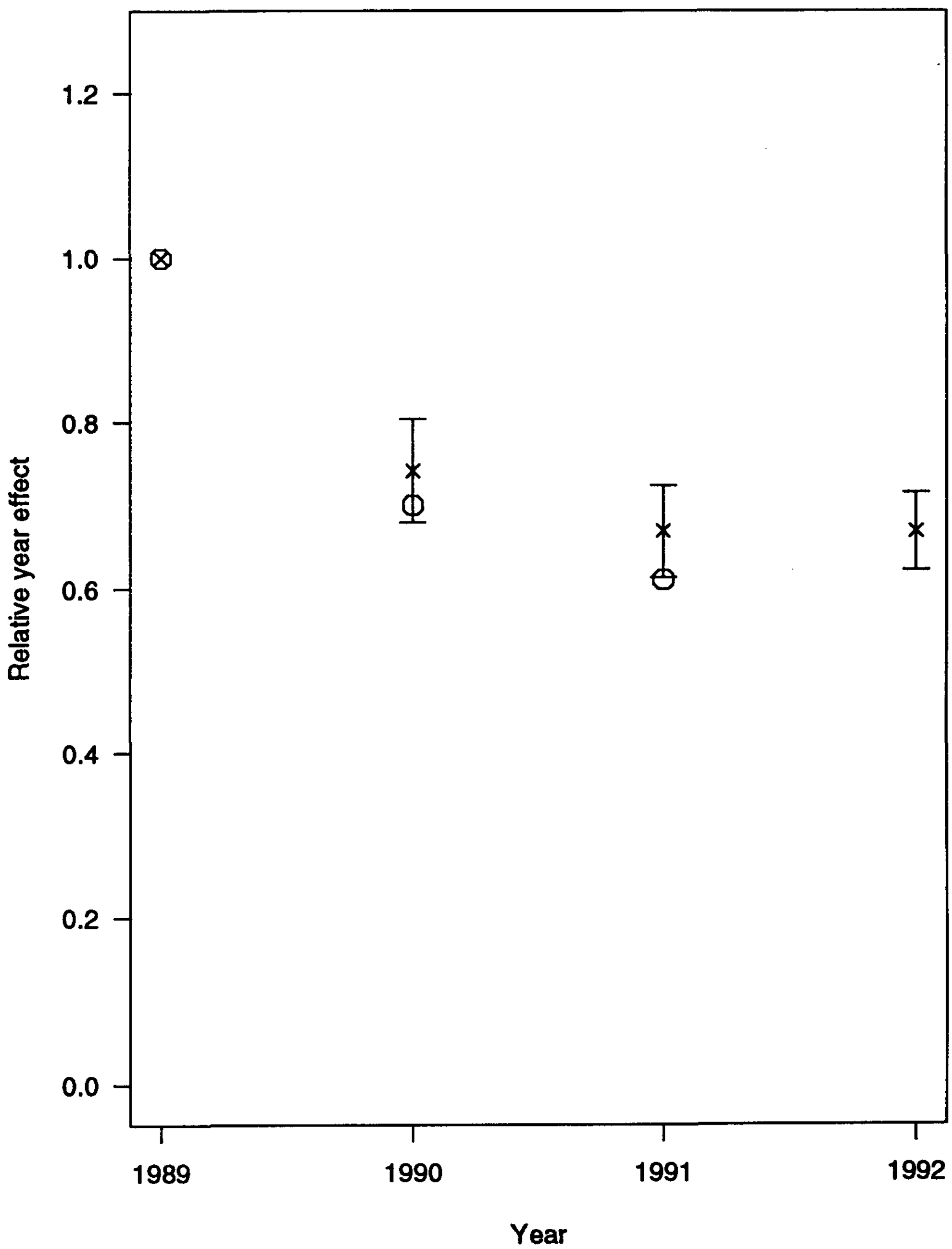

Figure 3: Relative year effects (×) estimated from log(catch per hour) compared with index from last year's assessment (∘). Lines are $\pm 2 s_{\hat{A}_j}$.

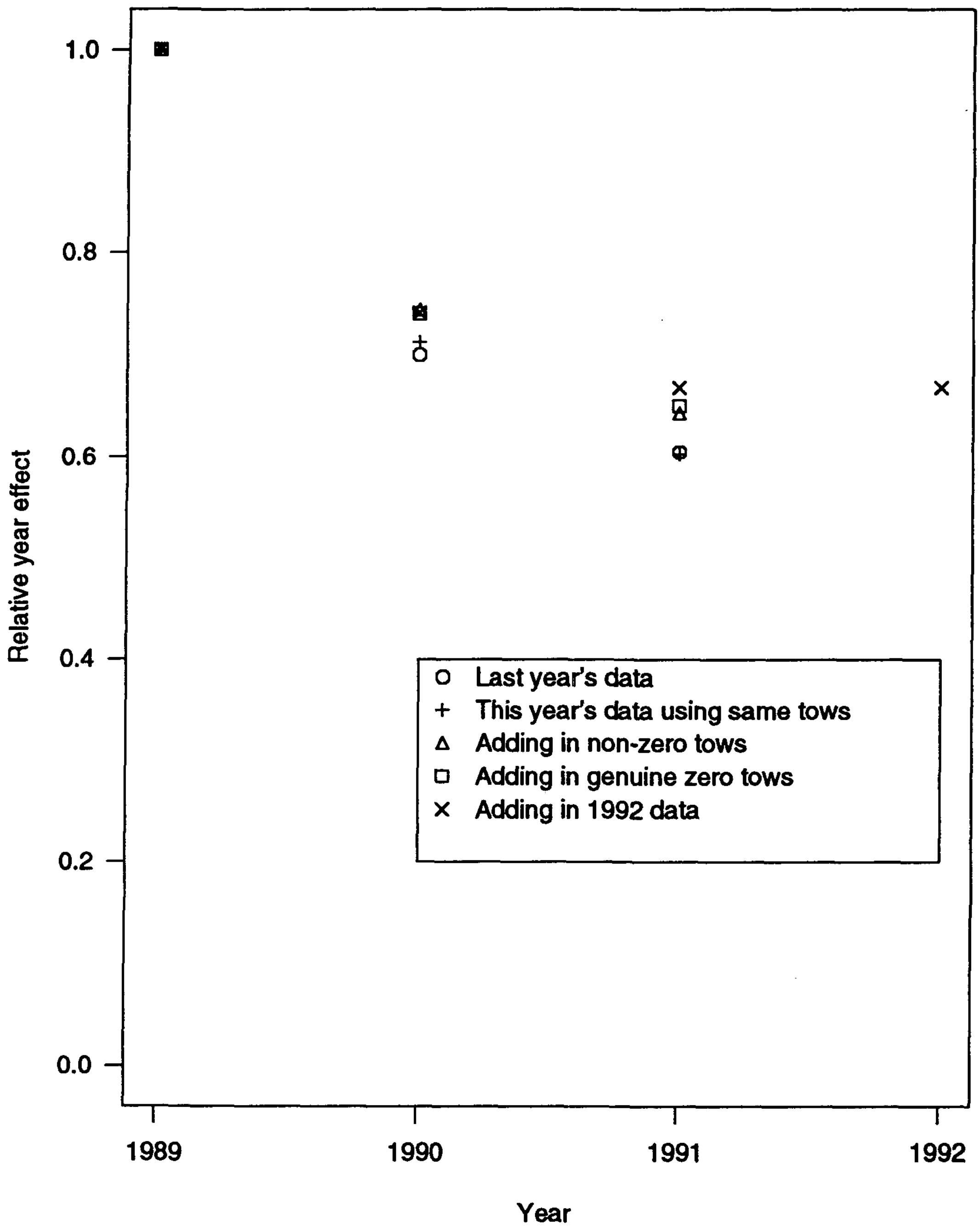

Figure 4: Relative year effects (o) estimated from log(catch per hour) in last year's assessment compared with an index calculated this year using tows that could be identified in last year's dataset(+) (apart from the missing tows, there are other minor discrepancies between the two datasets), index calculated after adding non-zero tows that were not in last year's dataset ($\triangle$), index calculated after adding all genuine zero tows ($\square$), and index calculated after adding 1992 data ($\times$).

4 Production model

A model similar to the production model used last year (Vignaux & Gilbert 1993) was fitted to the stock index. As in last year's analysis, the baseline productivity model was a parabola with maximum at $0.4B_0$ and a productivity at that point of 0.3. This was shown as Parabola A in Vignaux & Gilbert 1993. The sensitivity of the estimates to the value of the maximum productivity was examined using extreme values of 0.1 and 0.8 (Parabolas B and C in Vignaux & Gilbert 1993).

In last year's analysis, the stock indices, which were calculated by calendar year, were taken to apply to the size of the stock at the start of October, which is the start of the next fishing year. This year, the indices were taken to apply at the start of July, which is half way through the calendar year, but three-quarters of the way through the fishing year. This involves only a minor change to the model, but means that the stock indices were used to index the stock in the middle of the period over which they were calculated. The catch history is given in Table 4.

The fit of the model to the index is shown in Figure 5 and the results are given in Table 5. The estimated virgin biomass for the baseline case is 939 t and the estimated Maximum Sustainable Yield is 113 t.y^{-1}. When the maximum productivity is reduced to one-third of the baseline value, the estimated virgin biomass increases by a factor of 1.3 to 1198 t, and the estimated MSY reduces by a factor of 2.4 to 48 t. When the maximum productivity is increased to 2.7 times its baseline value, the estimated virgin biomass reduces by a factor of 0.5 to 493 t and the estimated MSY increases by a factor of 1.4 to 158 t. The 1992 biomass is estimated to be about 65% of virgin biomass in all three cases.

The results are more reliable than last year's, as they are based on a more complete CPUE dataset for 1989–91 and on a time series of 4 years instead of 3. However, they remain preliminary.

5 Discussion

This analysis updates the analysis presented last year. The CPUE index is somewhat more optimistic than the index presented last year, due to the inclusion of some additional data from 1989–91, and the maintenance of 1991 catch rates in 1992. Therefore the estimates of virgin biomass and MSY from the production model are higher than in the baseline case presented last year. However, these results are still considered to be preliminary because of a number of uncertainties and assumptions in the analysis.

First, the analysis depends on the assumption that the CPUE index is proportional to stock size. Any factors not included in the model which change systematically over the years could affect the index, for example, changes in gear or in fisher skill.

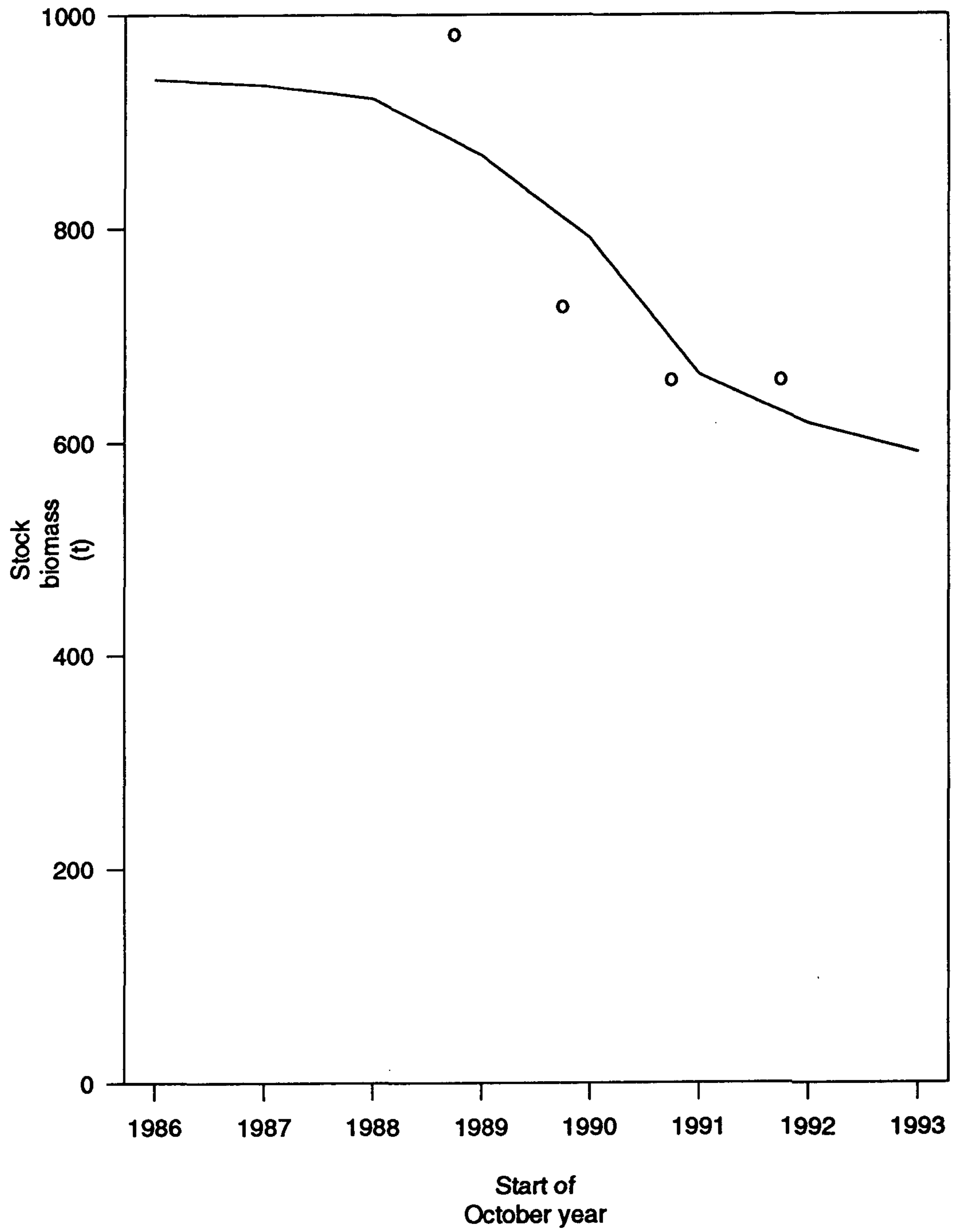

Figure 5: Fit of the production model to the CPUE index.

Table 5: Estimates of biomass (t) and yield (t.y^{-1}) for scampi from FMA 1 fitted to CPUE stock index. (B_0 = virgin biomass, B_{92} = stock biomass at start of 1992–93 season, CSP_{92} = production corresponding to B_{92}, MSY = Maximum Sustainable Yield).

	Assumptions			Estimates			
Model	Location of maximum	Productivity at MSY	MSY	B_0	B_{92}	CSP_{92}	MSY
Parabola A 1992 baseline	$0.4B_0$	0.3	$0.12B_0$	647	$0.49B_0$	76	78
Parabola A 1993 baseline	$\mathbf{0.4B_0}$	**0.3**	$\mathbf{0.12B_0}$	**939**	$\mathbf{0.66B_0}$	**92**	**113**
Parabola B	$0.4B_0$	0.1	$0.04B_0$	1198	$0.65B_0$	40	48
Parabola C	$0.4B_0$	0.8	$0.32B_0$	493	$0.64B_0$	135	158

It is also likely that scampi are not uniformly distributed in space, but are found in patches of differing density. If fishers are able to target these patches, and reaggregation is too slow to maintain the density distribution, it may be that the CPUE index will reflect changes in the size or frequency of these patches, as well as any changes in the total stock size.

Also, on a larger scale, there may be areas of the stock as yet unexploited by the fishery. Clearly catch rates can index only the portion of the stock fished, and therefore the production model will not include potential production in unexploited areas.

If there are areas where the fish are on average larger (for example in deeper water), then it might be worth targeting these areas even if this reduced the gross catch rate, as the price of large fish is higher. If this targeting behaviour changed from year to year, then CPUE would reflect these changes, as well as changes in stock size.

Second, the CPUE index is too short to be sure that changes in the index are not due to fluctuations in catchability. If we had a long time series, random fluctuations in catchability would not affect the trend, but a time series of only 4 years may show a trend that is simply a result of random fluctuations.

Third, the shape, particularly the height, of the production curve for scampi used in the production model is not well known.

Preliminary results of a random trawl survey (voyage KAH9301, MAF Fisheries unpublished data) which surveyed similar regions to those fished by the commercial fishery gave an absolute biomass estimate of 242 t, assuming 100% catchability. This result would be consistent with the estimates from the production model if catchability were in fact 40%.

It also estimated that 95% of the biomass in FMA 1 is in depths that are commercially fished, so it is unlikely that there is a great deal of biomass in unexploited depths within the area of the trawl survey.

6 Acknowledgments

We thank members of the Shellfish Working Group for discussions and suggestions.

7 References

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