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A Quota Simulation Model for Studying Fleet Restructuring Options

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SUMMARY

This report summarises the results obtained by building and running a quota simulation model using data from one U.K. regional fishery. The outcomes in financial and employment terms of seven possible future fleet structures have been examined.

The analysis has quantified the relationships between number of vessels, average fleet age, profitability, employment opportunities and catching capacity, for different methods of quota allocation.

The results obtained should contribute to discussion of the required objectives of a fleet restructuring policy, and how the SFIA Grant and Loan Scheme should be applied for best effect.

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CONTENTS

1 INTRODUCTION

Within the framework of a Common Fisheries Policy it is necessary to define the national fleet and fisheries management techniques required for the future.

One particular aspect of this general problem is discovering the relationship between fleet size and structure and fish quota allocations.

The computer model, which is presented in this report, has been written as part of the MAFF Commission, Project A.2.1., requiring the IDU to develop techno-economic analysis of fleet restructuring policies and is intended to investigate some aspects of this relationship.

Thus the objective of the model is to simulate the effect of possible quota allocation schemes with a variety of fleet structures, defined by vessel numbers and age distributions, based on a sample of the most recent data available.

As the Authority has a direct influence on the fleet structure through the Grant and Loan scheme for new vessels, the effect of these vessels upon existing fleet operations has been examined.

The data upon which the model is based has been obtained from the 1981 cost and earnings survey conducted by FERU, (Fisheries Economic Research Unit of SFIA) and is described in Apendix I, with the corresponding analysis shown in Appendix II. The data used represent an actual fleet of 65 vessels between 50-55 foot from a particular U.K. region. It should be noted that although these data are believed to be representative, no general quantitative conclusion can be drawn for other sectors of the U.K. fleet from this first analysis.

Eight scenarios, defined in terms of fleet structures and representing the objectives of a variety of restructuring policy options, have been examined. These scenarios are discussed in Section 3 and summarised in Appendix IV. For brevity the complete results are not given in this report, but are published separately in Internal Report No. 1106.

This report has been prepared as a discussion document within the context of the general debate on the structure and management of the U.K. fishing fleet arising from the Government's Consultative Document. (Structure and Management of the U.K. Fishing Fleet, MAFF, March 1983). It therefore does not contain recommendations as such, but is intended to quantify the likely effects of policy options.

2 DESCRIPTION OF THE MODEL

The program simulates the performance of a fleet of vessels in terms of total landings expressed as annual earnings, operating profit(defined as earnings less operating costs), nett profit (defined as operating profit less loan repayments), and employment. It should be noted that all financial results are expressed in thousands of pounds at 1981 values.

The fleet performance data as analysed in Apendix II has been built into the model in the form of average relationships between year built, insured value, earnings and operating profit. The type of simulation performed is designed to incorporate the variation of individual vessels around the average, and can therefore demonstrate the spread of performance under given policies.

It should be noted that a vessels insured value appears to represent the original building cost and is therefore used as the basis for the calculation of loan repayments.

In cases where a chosen scenario results in fleet over capacity the model will apply two quota allocation systems. The first, referred to as individual vessel maximum quota assigns the same annual quota to every vessel in the fleet, irrespective of its ability to land this amount. This type of quota scheme therefore only restricts the most productive vessels. The second quota allocation system, referred to as individual vessel proportional quota, restricts every vessel to the same proportion of its unrestricted landings. This is equivalent to allowing unrestricted fishing until a TAC (Total Allowable Catch - in this case it represents the total fleet quota) is exhausted and then closing the fishery.

These two systems have been chosen as likely extremes with other quota management system such as maximum catch per man per day lying between them.

For a given scenario the program requires the following input data: the fleet structure in terms of number of vessels in each age category, the year being simulated, the total fleet quota (TAC), and grant and loan particulars.

Within the model, fish landings and quotas are measured in terms of £ Sterling, rather than using weight units. This was because of the format of the original data, and, given that annual average fish prices paid will not vary greatly from vessel to vessel within a specific fleet, these two measures may be taken as equivalent.

3 RESULTS

The scenarios detailed below, are summarised in Figures 1 to 3 and Appendix IV.

3.1 Scenario 1

This describes the existing fleet at the end of 1981 and is used as the basis for comparison of the results of the future scenarios (2-8), which represent a variety of possible fleets at the end of 1989.

The total landed value of this scenario (£M 4.479) has been taken to indicate the TAC for the future scenarios.

This fleet, consisting of 65 vessels with an average age of 19 years, employs 254 crew, has a mean nett profit of £2600 per vessel, with 33% of the vessels making a nett loss.

3.2 Scenario 2

This represents the existing fleet after 5 accidental losses during the period 1981 to 1989 (see Appendix I), assuming no other changes to the fleet occur. This rate of accidental loss is based on the average for all Scottish vessels between 1976 and 1981.

This fleet consisting of 60 vessels, has the only outcome with a capacity (£M 4.177) below the TAC.

This fleet has an average age of 27 years, reduces employment to 235 crew, increases its mean nett profit to £6700 and reduces the percentage of vessels making a nett loss from 33% to 23%.

The improvement in nett profit is the result of a lack of new vessels and is at the expense of an ageing and declining fleet, incapable of taking its TAC and reduced employment opportunities.

3.3 Scenario 3

This is the result of allowing automatic replacement of accidentally lost vessels, assuming no other changes to the fleet.

This fleet of 65 vessels has the capacity to earn £M 4.923 which is in excess of the TAC, and therefore must be restricted by a vessel quota system. As an example, the results of the two quota systems, as described in Section 2 above, are shown in Figure 4 for this scenario. It can be seen from the first part of Figure 4, which plots the total fleet landings against the individual vessel maximum quota level, that the required quota per vessel is £116600. This represents a considerable reduction for the top vessels with earnings capacity of £250 - 300000. Such a large reduction is necessary because the restriction is only applied to eleven of the 65 vessels as may be seen from the second part of Figure 4, (curve 2 compared with curve 1) in which the number of vessels is plotted against the individual vessel landings.

Comparison of curve 1 with curve 3 demonstrates the effect of the introduction of a proportional vessel quota system, with all vessels accepting a reduction of 9% in their landings.

The differences in overall fleet performance between the two quota systems are minimal with average nett profits of £4000 and £3900, and 29% of the vessels making a nett loss under both systems. However, as the quota restrictions are more evenly spread over the whole fleet using the proportional system, the average nett losses of new vessels within the fleet is reduced from £27700 to £25300.

Similar results with regard to the small difference between the quota systems are obtained in scenarios 5 and 7.

The fleet in scenario 3 has an average age of 25 years and employs 260 crew.

This scenario demonstrates that automatic replacement of all lost vessels with no other changes to fleet structure results in over capacity, leading to the need for the introduction of a vessel quota system. Although this scenario demonstrates a small improvement in employment it still results in an ageing fleet.

3.4 Scenario 4

In order to avoid the over capacity inherent in scenario 3, replacing all lost vessels, this scenario replaces only two of the vessels lost to match the fleet capacity to the TAC.

The fleet, now consisting of 62 vessels and with an average age of 26 years, employs 245 crew and has an average nett profit of £5800 with 25% of the fleet making a nett loss.

This scenario demonstrates the trade off between improved profitability, compared with scenario 3, and reduced employment, as well as a further ageing of the fleet.

3.5 Scenario 5

This scenario has been prepared to show the effect of a single new vessel over capacity compared with scenario 4.

It demonstrates clearly that only one new vessel in excess of the required capacity either affects 6% of the 63 vessels by reducing their average earnings by 20%, or reduces the earnings of the whole fleet by 3%, depending on the quota scheme.

This implies that if a top skipper wishes to build a new vessel then he may well have to accept lower earnings than with his previous vessel.

3.6 Scenario 6

The policy inherent in this scenario is to scrap a sufficient number of the oldest vessels (13) to allow for the replacement of 5 accidental losses by 5 new buildings yet stay within the TAC.

This fleet of 52 vessels with a mean age of 20 years, employs 218 crew and has average nett profits of £5600 with 25% of the fleet making a nett loss.

Although this fleet structure shows an improved profitability compared with the original fleet, it is at the expense of a large reduction in fleet size and employment opportunities, yet the fleet is still ageing slowly.

3.7 Scenario 7

Scenario 7 is based on a one for one scrap and build policy aimed at maintaining the total fleet size constant and avoiding a continuously ageing fleet. This is implemented by replacement of 5 lost vessels and the scrapping and rebuilding of a further 8. This fleet has dramatic over capacity as it is capable of landing £M 5.853 therefore the introduction of vessel quota limits has to be accepted for this fleet.

The average vessel in this fleet would therefore make a nett loss of £700 or £1000 with 40 or 41% of vessels making a nett loss, depending on the quota system employed, and the fleet employs 275 crew.

Improvements in employment opportunities and the maintenance of the age of the fleet are achieved at large financial cost.

3.8 Scenario 8

To match the fleet capacity to the TAC and avoid an ageing fleet it is necessary to replace the 5 lost vessels, scrap 16 and rebuild 1 vessel.

This results in a fleet of 50 vessels with a mean age of 19 years, an average nett profit of £5200, 26% making a nett loss and employing 213 crew.

Compared with scenario 1, the profitability of the fleet has improved at the expense of dramatic reductions in both the number of vessels and employment, yet it still has not been modernised.

4 DISCUSSION

The model has been used to demonstrate the direct and quantifiable relationship between fleet structure and performance, where the necessary compromise between an ageing fleet, vessel profitability, employment opportunities and matching capacity to TAC, has been highlighted.

This simulation can be used to predict the behaviour of any fleet sector in the U.K. as soon as sufficient data become available.

The scenarios for future fleet structure presented in this report have been chosen to represent possible policy outcomes. However the analysis cannot indicate how each future structure might be achieved, because the effectiveness of new building and decommissioning aid schemes is still unknown. Information must be obtained on the response to financial incentives as methods of structural control, for thesuccessful implementation of any direct restructuring policy.

New vessels have a disproportionate effect on fleet capacity, yet, due to their large capital cost relative to earnings, are, on average, unprofitable. Therefore the SFIA should consider applications for grant and loan in the context of a fleet structure rather than solely on individual merit and past performance of the skipper. It would be advantageous for this to obtain a measure of both existing and future fleet capacity.

Several measures of vessel capacity have been suggested, such as length or historical performance. The data analysed so far suggest that length alone is an insufficient estimator, due to the wide variation of performance between notionally similar vessels, so further parameters such as age or horsepower must be introduced. Similarly historical performance alone is also impractical, as new vessel capacity would be impossible to establish, but would be useful in explaining some of the variation between individual vessel performance.

5 CONCLUSIONS

5.1

Where a fleet is restricted to a total allowable catch the introduction of new vessels into the fleet has a disproportionate effect on the overall fleet capacity affecting not only the profitability of the new vessel but the rest of the fleet as well.

5.2

In the fleet under study in this paper, a scrap one - build one policy woud create dramatic over capacity and most vessels would make a financial loss.

5.3

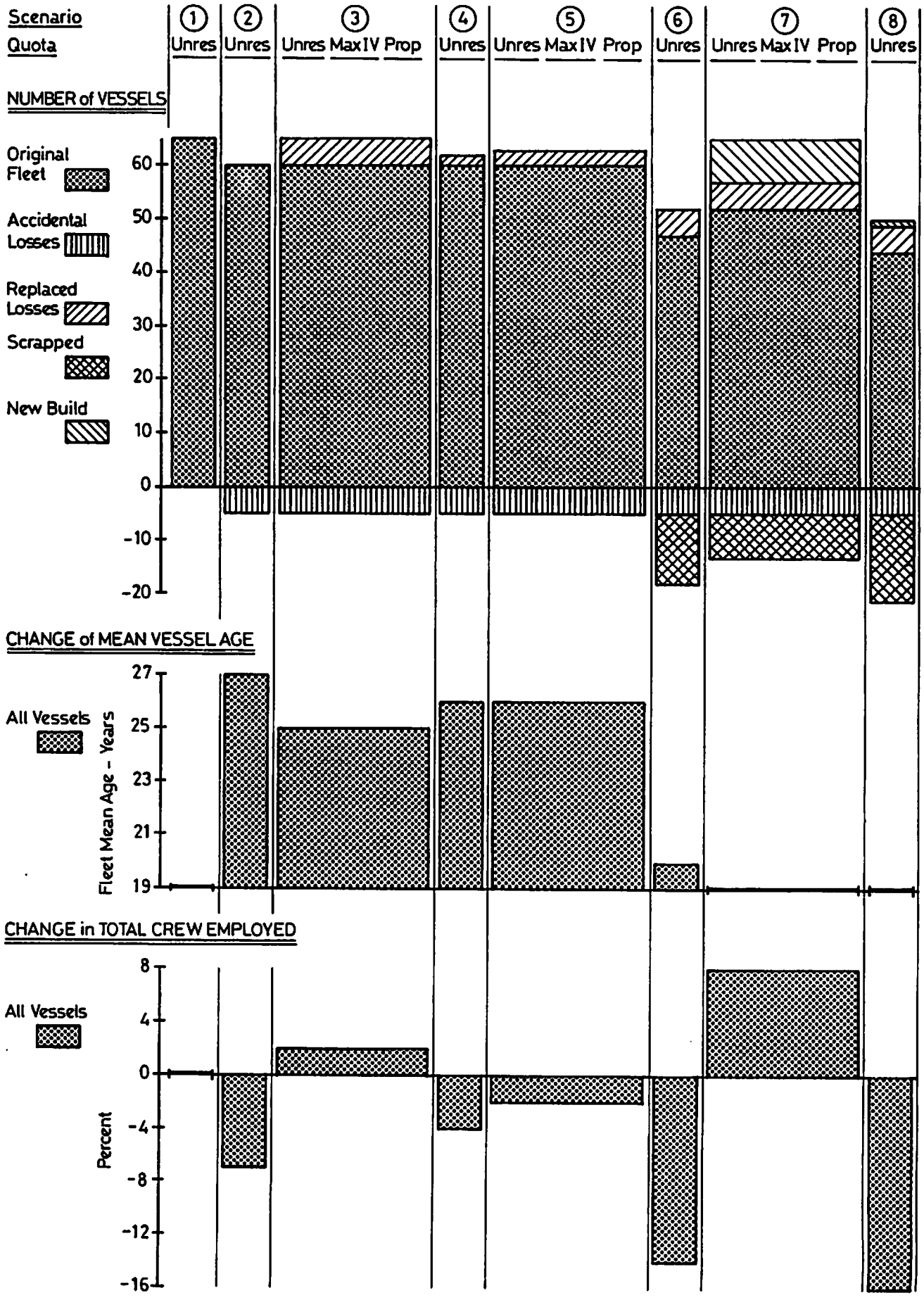
To bring the fleet into general profitability and replace only five accidental losses it would be necessary to scrap 13 vessels from the fleet of 65.

5.4

The simulation model can be used to predict the behaviour of any fleet in the U.K. provided the data are known.

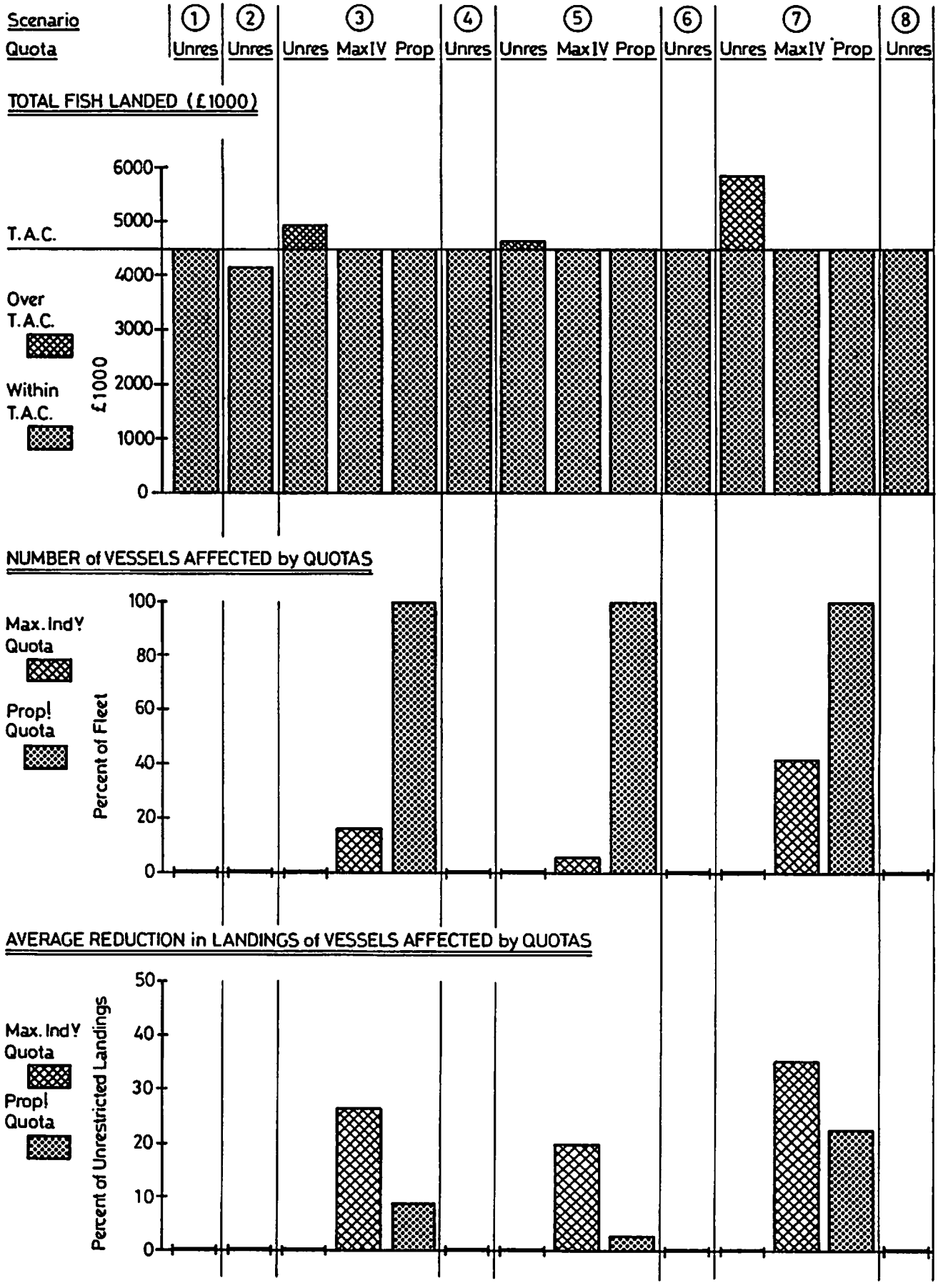
5.5

The SFIA should consider using the model to evaluate grant applications for new vessels with fleet performance as a criteria rather than individual vessel performance.



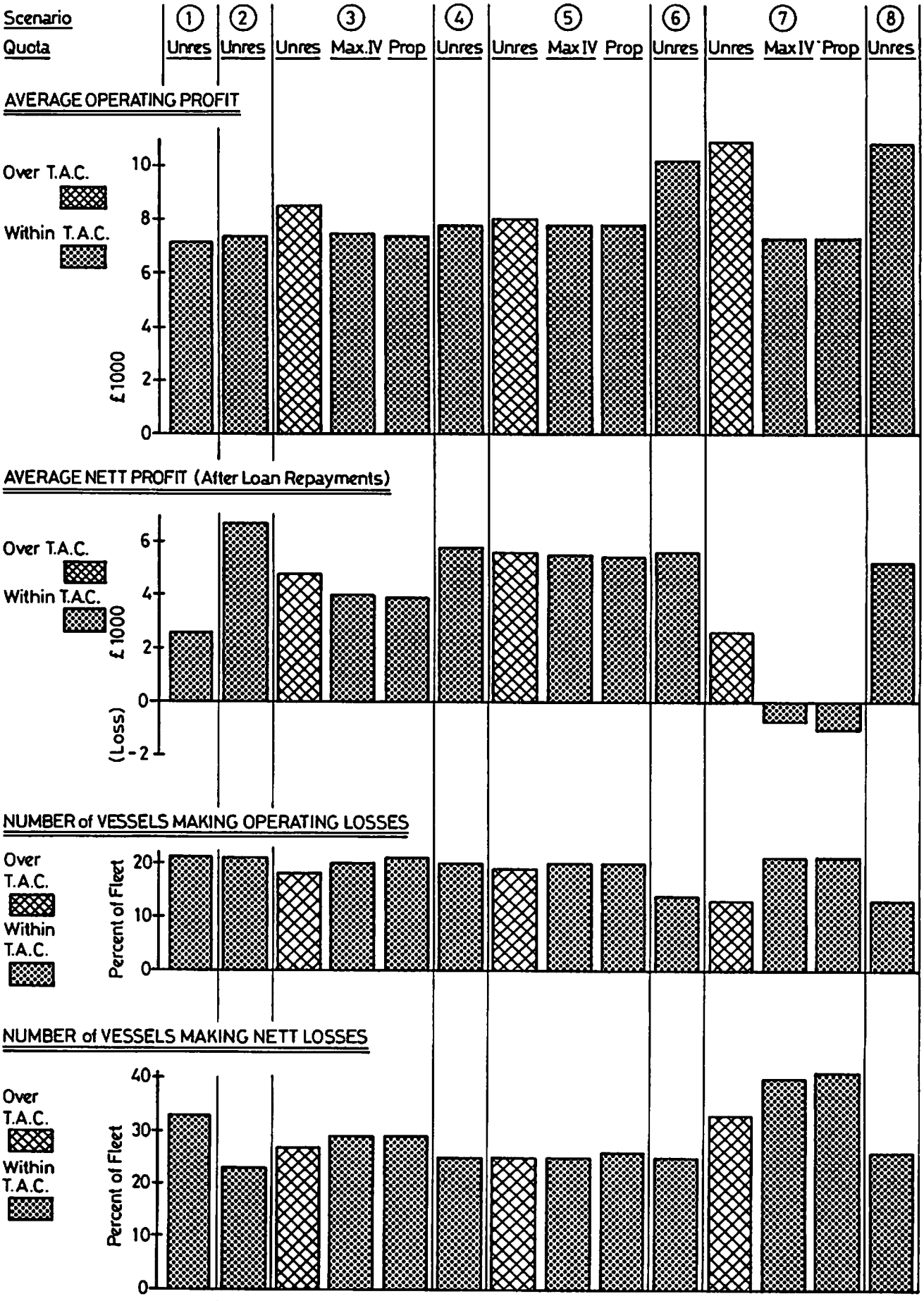
Fleet Structure and Employment

Figure 1



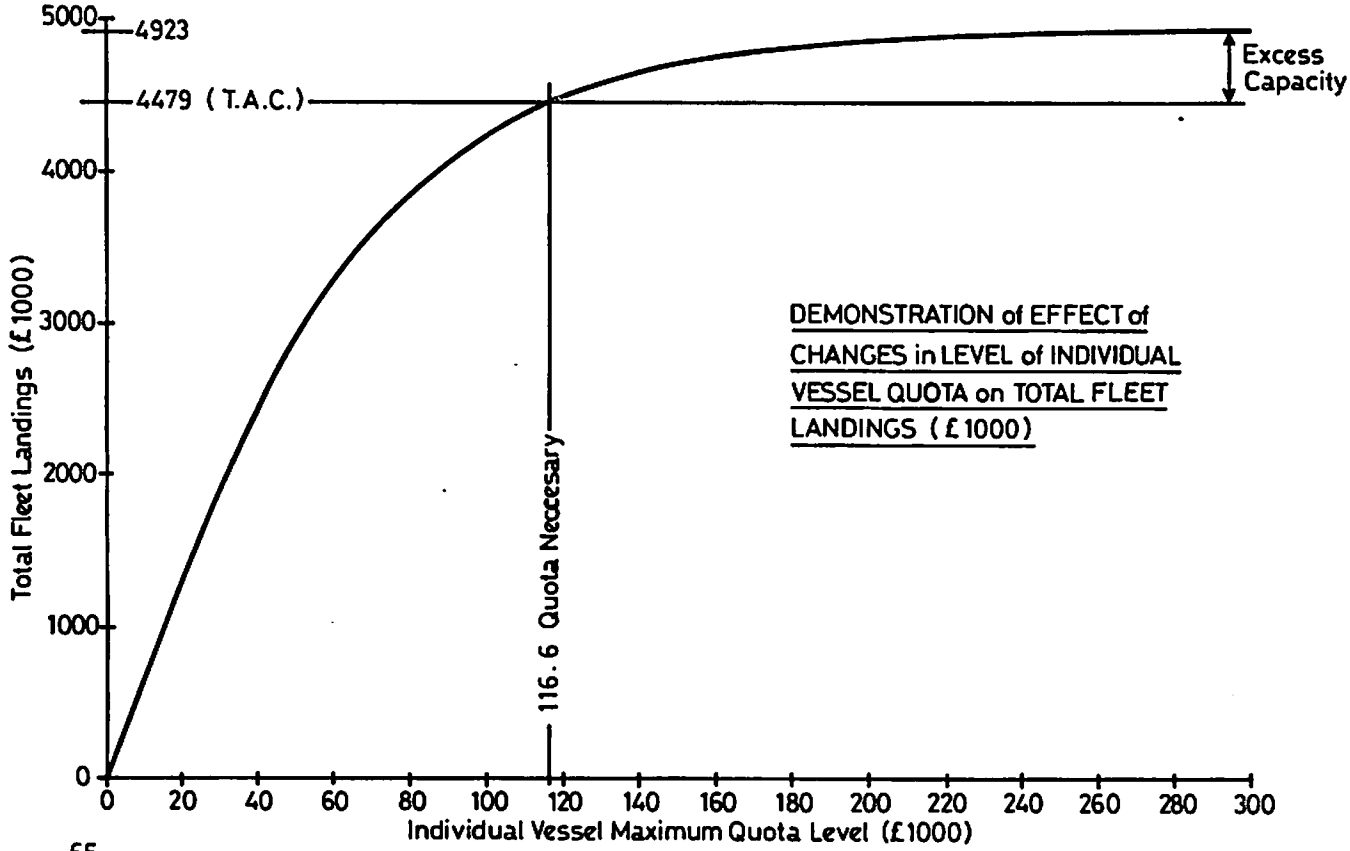
Fish Landings and Quota Effects

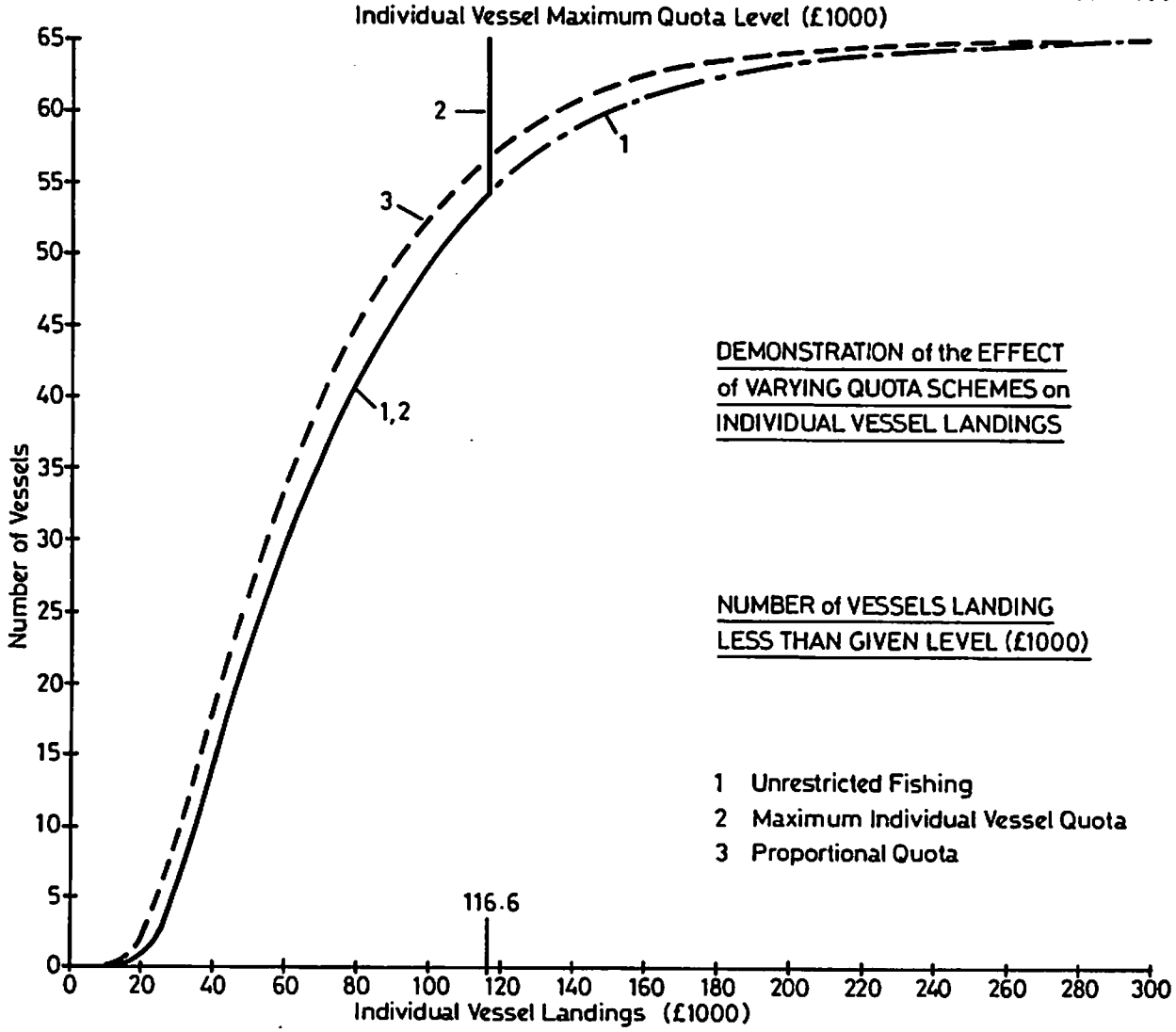
Figure 2



Financial Outcomes

Figure 3





Scenario 3 - 5 Lost Vessels Replaced

Figure 4

APPENDIX I

Description of Data

The model is based on 1981 Cost and Earnings Survey returns provided by FERU (Fisheries Economics Research Unit). Thirty of these returns have been selected as representative of an actual fleet of 65 vessels between 50 and 55 feet registered length, based in a particular UK region. This fleet was selected as the corresponding returns provided the largest available homogeneous sample. Further details of the fleet cannot be given in order to maintain the confidentiality of the survey, and for this reason the region is not defined. The data is summarised in Table 1 overleaf.

In order to obtain the fleet structure in 1989 the number of accidental losses suffered by the fleet in each age category must be estimated.

This estimate has been based on a preliminary investigation of accidental losses suffered by the Scotish fleet between 1976 and 1981 and is shown below.

Year Built	Number in 1981	Assumed Loss Rate	Expected No. in 1989	Existing Fleet Structure by 1989
78-81	3	1.00% pa	2.76	3
74-77	7	0.86% pa	6.52	7
70-73	10	0.91% pa	9.27	9
65-69	15	0.97% pa	13.84	14
60-64	7	1.03% pa	6.42	6
50-59	12	1.13% pa	10.91	11
40-49	8	1.26% pa	7.19	7
14-39	3	1.40% pa	2.66	3
Total	65			60

All the scenarios have been prepared with the assumptions of a 25% grant for new building, with balance being borrowed over a period of 10 years with an interest rate of 12% pa.

It should be noted that the regional boundaries and age categories used are those defined in TR 197.

TABLE 1

COST AND EARNINGS SURVEY SAMPLE DATA

Vessel Number	Year Built	Insured Value £000	Earnings £000	Operating Profit £000	Number of Crew
1	62	45	72.6	7.85	4
2	65	52.35	50.5	2.33	3-4
3	67	94	99	21.40	3-4
4	74	96.9	66.9	12.12	3-4
5	65	60.55	65.8	5.80	3-4
6	47	69	48.8	-3.48	4
7	70	80	105.6	19.38	4
8	69	85	67.9	6.27	5
9	55	35	36.8	9.98	3
10	75	180	151.6	20.06	5
11	69	50	72	10.70	3
12	67	100	56.2	17.43	4
13	80	250	98.3	16.09	4
14	77	250	156.5	25.00	5
15	49	31	26.8	2.39	3
16	78	260	127.3	10.18	5
17	72	100	63.4	-1.07	5
18	59	36	41.2	0.60	4
19	73	90	83.5	-2.89	5
20	74	100	105.9	5.81	5
21	72	70	137.8	23.68	5
22	52	38	34.5	-4.33	3
23	56	46	30	-5.31	4
24	65	50	58.2	14.49	4
25	26	28	29.8	6.79	3
26	59	129.72	57.6	5.75	3
27	61	105.44	71	6.23	4
28	39	97.1	65.1	2.09	3
29	57	46.87	19.5	0	3
30	61	25	36.7	-2.95	4

APPENDIX II

Data Analysis

II-i Insured Value

The only measure of capital investment of the fleet available is the insured value as reported to FERU. Examination of this data, which is plotted against year of building in Figure 2.1 below, shows that vessels generally appear to be insured for their actual original building costs, rather than replacement or written down value.

A least squares regression analysis gave the following relationship which explained 62% of the variance between individuals:

$$\text{Log}_e\ (\text{INSVAL}) = 3.7039 + 9.0186 \times 10^{-14} \times (\text{YEAR})^7 + \varepsilon_1$$

where ε_1 has been taken as normally distributed with mean of zero and standard deviation 0.39386.

II-ii Earnings

The earnings of each vessel, which is the annual total gross earnings reported to FERU for 1981, has been found to be primarily a function of age as shown in Figure 2.2. below.

However, it was observed that vessels with higher than average investment, e.g. the vessel at point A in Figure 2.1, tend to have higher than average earnings, point A in Figure 2.2.

A least squares regression analysis gave the following relationship which explained 71% of the variance between individuals:

$$\text{Loge (EARNINGS)} = 2.7883+3.4935\text{x}10\text{-}6\text{x(YEAR)}3+0.3486\text{x}\frac{\text{Actual Ins Val}}{\text{Average Ins Val}}+\varepsilon_2$$

where ε_2 has been taken as normally distributed with mean of zero and standard deviation 0.28894.

II-iii Operating Profit

The operating profit of each vessel, as reported to FERU for 1981, is the annual gross earnings less running costs, labour share and boats expenses. It has been found to be primarily a linear function of earnings, which thus represents fixed and variable costs, but these costs vary slightly with the age of the vessel, as can be seen in Figure 2.3.

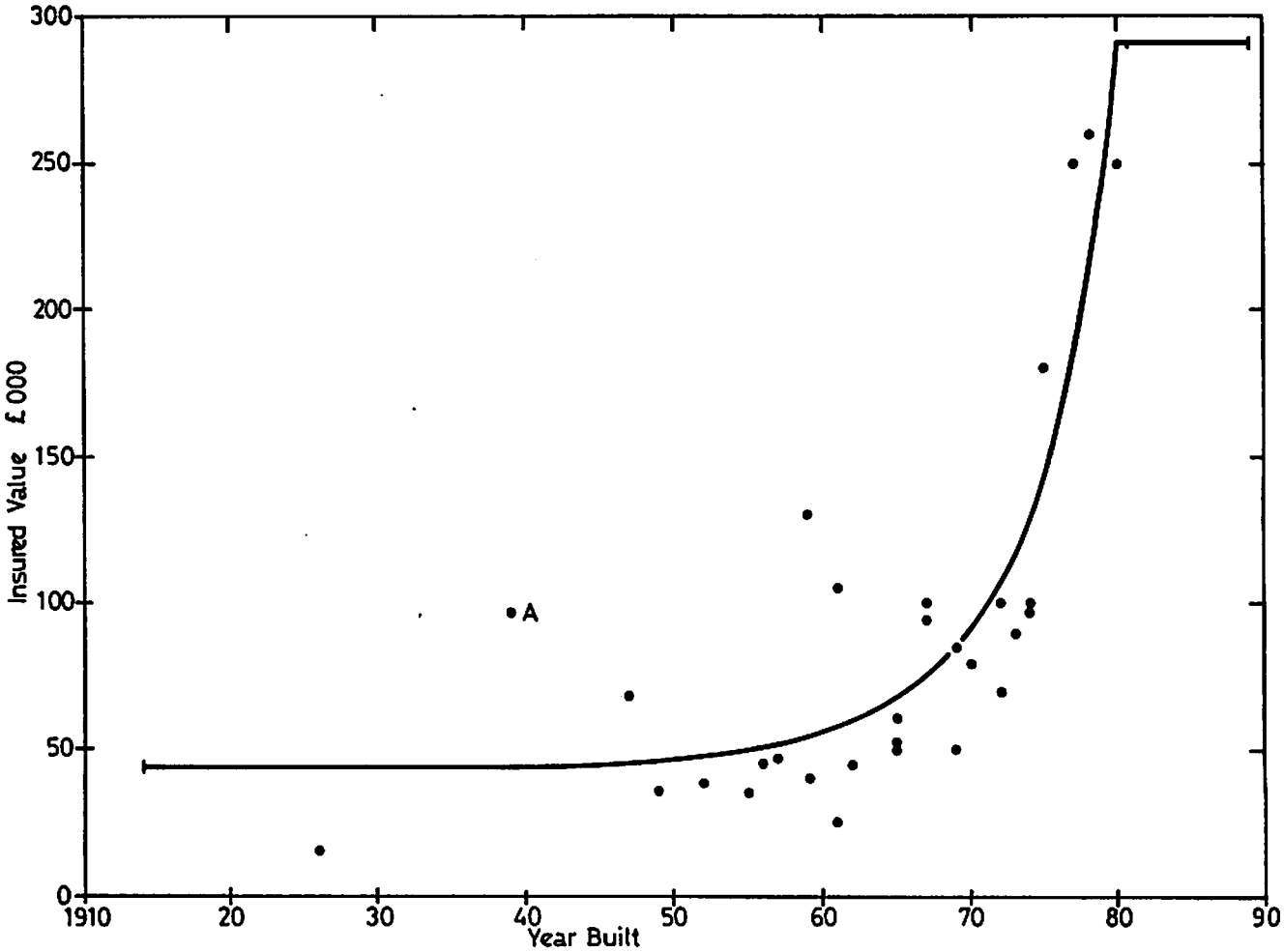
A least squares regression analysis gave the following relationship which explained 54% of the variance between individuals:

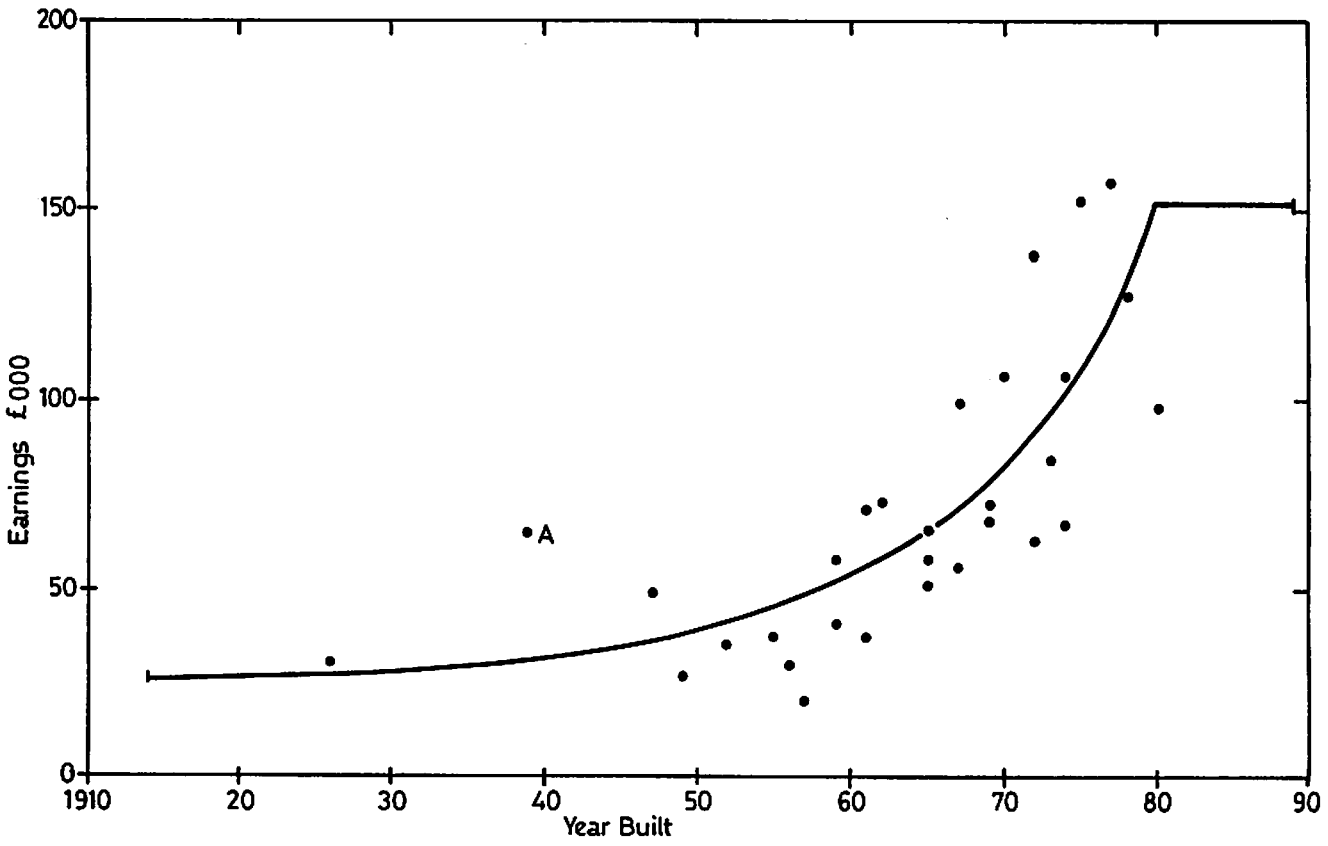
$$\text{PROFIT} = (0.1508+0.000391*\text{YEAR})*\text{EARNINGS}-(0.0428*\text{YEAR}+2.16+\varepsilon_3)$$

where ε_3 has been taken as normally distributed with mean of zero and standard deviation 5.988.

Insured Value - Year Built

Figure 2·1





Earnings - Year Built

Figure 2·2

II-iv Number of Crew

The average number of crew, which includes skippers, as reported to FERU for 1981, is required for each vessel to estimate total fleet employment. The data is shown in Figure 2.4, and an average number of crew per vessel estimated for each year built category as below:

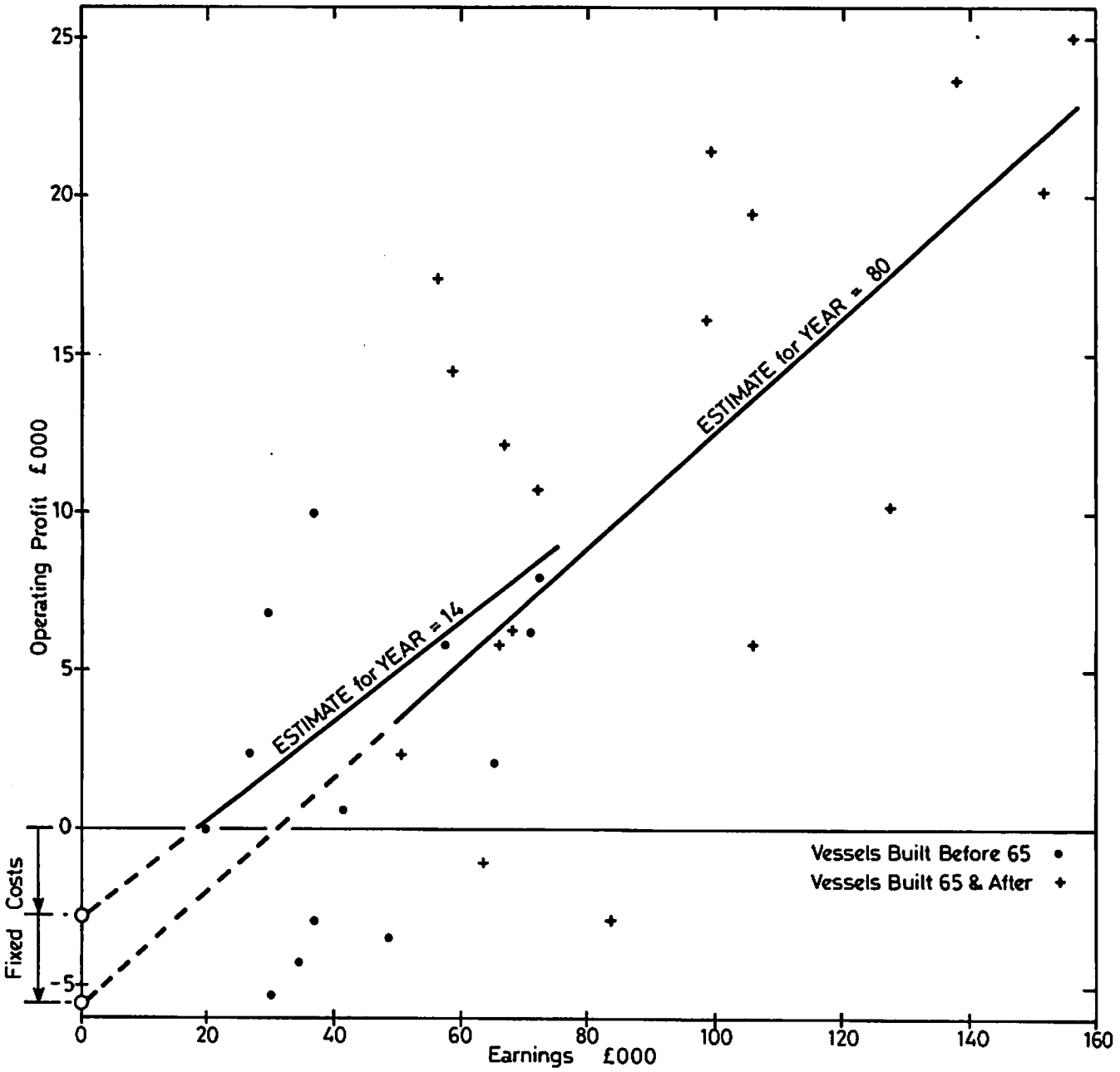
Year Built Category	Average Crew per Vessel
78-81	5.00
74-77	4.67
70-73	4.33
65-69	4.00
60-64	3.75
50-59	3.50
40-49	3.25
14-39	3.00

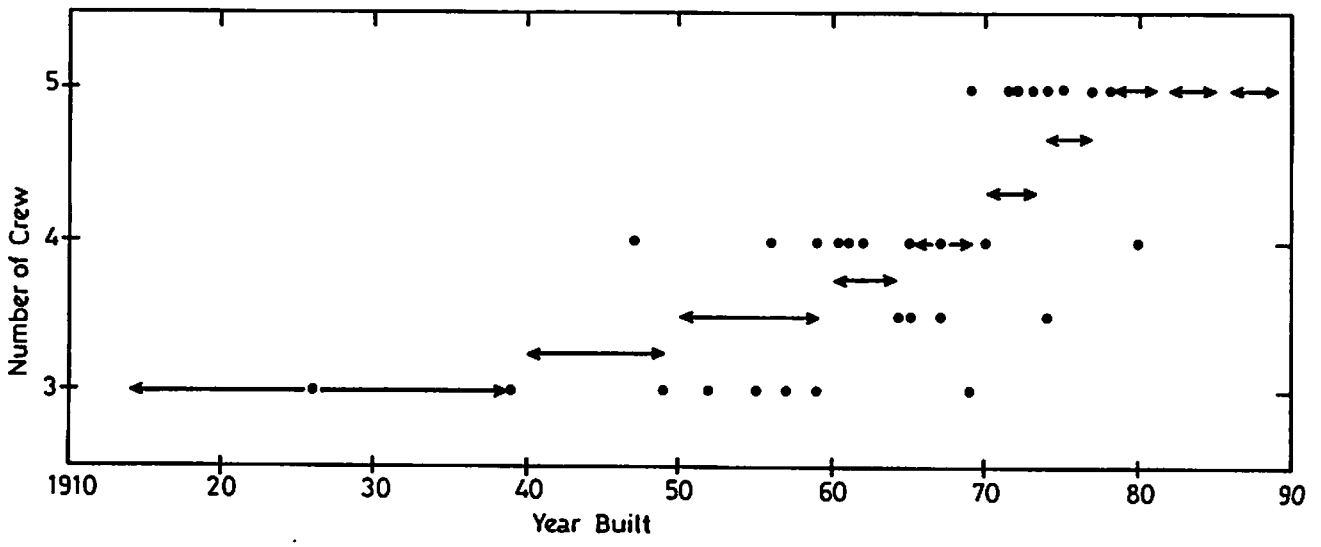
II-v Assumed Future Projections

For each of the four variables above, viz Insured Value, Earnings, Operating Profit and Number of Crew, it has been assumed that new vessels built into the fleet will have characteristics identical to the most recent constructions. This implies that all money values in the model are expressed in 1981 prices, and no major technological improvements are foreseen.

Operating Profit - Earnings

Figure 2.3





Number of Crew - Year Built

Figure 2.4

APPENDIX III

Description of Program

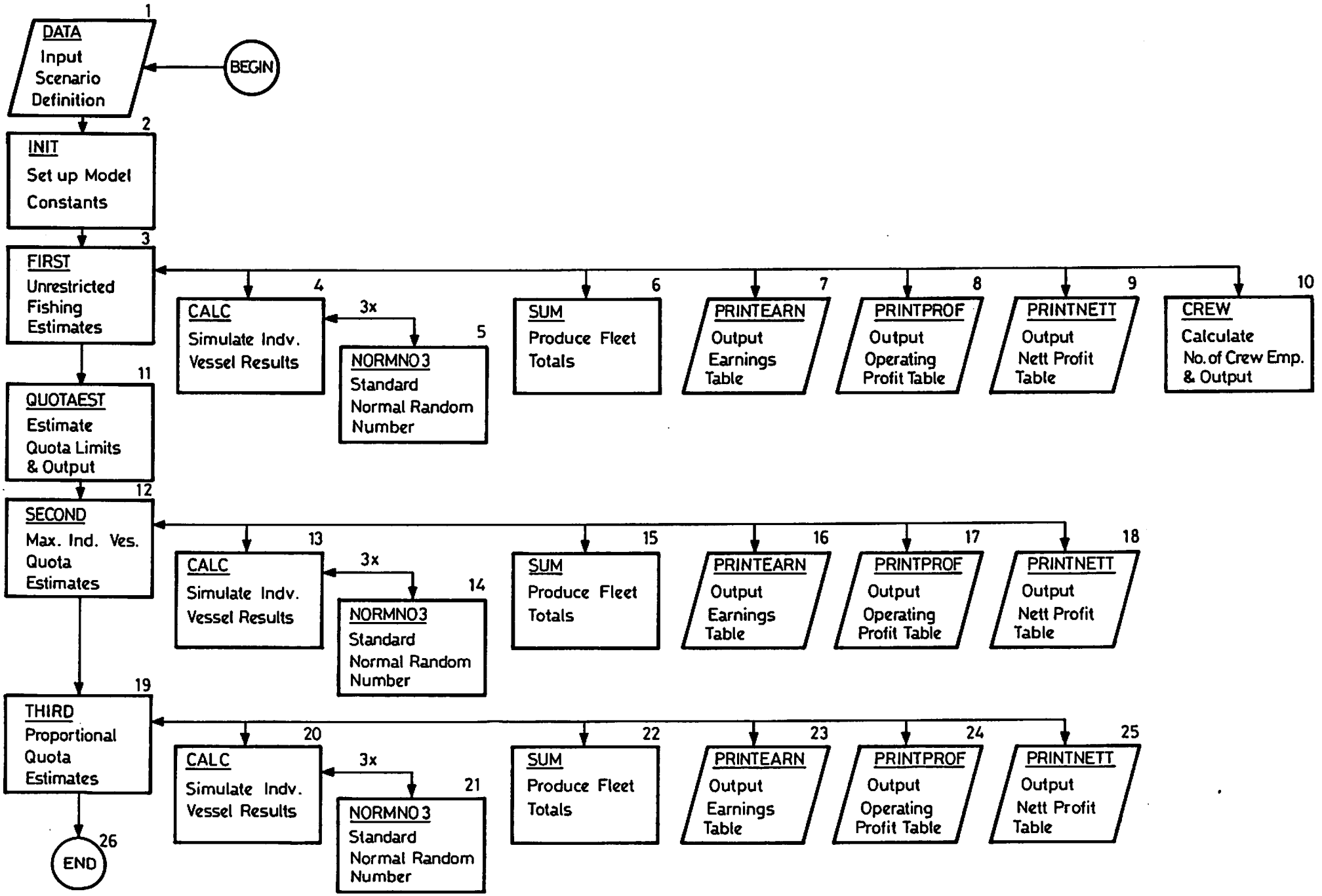
The model used the Monte Carlo simulation technique as discussed in TR 192, and is written in Apple II Pascal. The model structure is shown in Figure 3.1 and a complete program listing is given in Internal Report No. 1106. In Figure 3.1 the relationship between the procedures are shown together with each procedure's main function. The central procedure, named CALC, is described in detail by its flow chart as given in Figure 3.2

Referring to the procedures as numbered in Figure 3.1: after obtaining the definition of the required scenario (1) and initialising the model constants (2), the program performs a complete calculation (4-10) for an unrestricted fishing case (3). This calculation has QL, the individual vessel maximum quota, set equal to 999.9 and QR, the proportional quota, set equal to 1.

From the results of this calculation it is possible to estimate (11) both types of individual vessel quota (QL and QR), required to fish at the fleet total quota level.

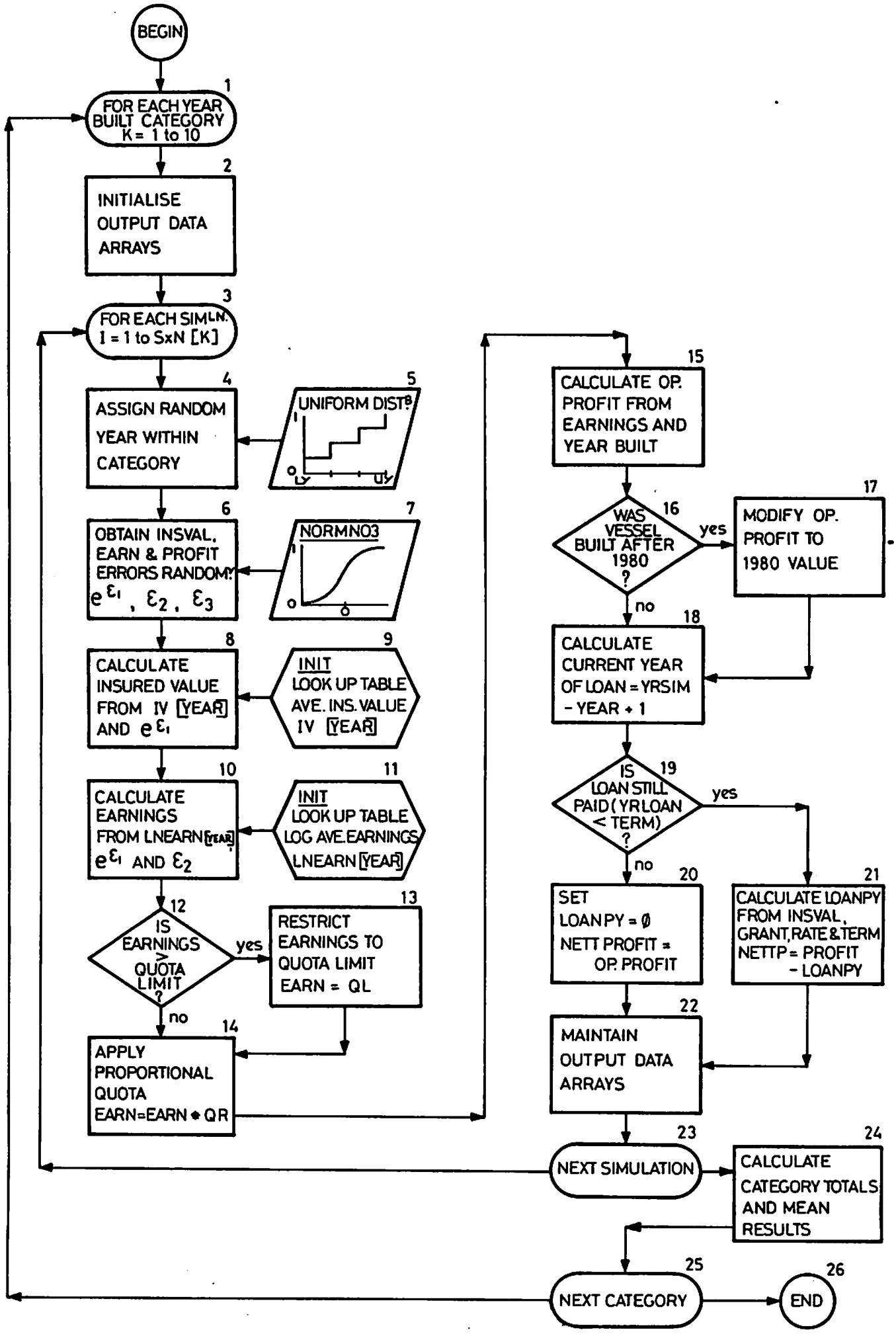
The complete calculations (13-18) are then repeated for the individual vessel maximum quota case (12) with QL as estimated previously (11) and QR = 1. A third complete calculation (20-25) is then performed for the proportional quota case (19) with QR as calculated previously (11) and QL = 999.9.

The central procedure CALC, Figure 3.2, is based on Monte Carlo simulation of the errors of estimates about the regression lines described in Appendix I. The sample size for each year built category is a constant (S) times the number of vessels within the category ($N[K]$).



Program Quotasimf Model Structure

Figure 3.1



Procedure CALC Flow Chart

Figure 3·2

APPENDIX IV

Scenarios

The scenarios for which the program has been run, the results of which are given in Table 2 overleaf, have been chosen to represent the outcomes of a range of possible policies.

Scenario 1 describes the existing fleet at the end of 1981 and the total landings obtained have been used as the fleet TAC for the future scenarios 2 to 8, which represent various fleets at the end of 1989.

Scenario 2 is the existing fleet after 5 accidental losses have occurred during the period 1981 to 1989 (see Appendix I), but which are not replaced.

Scenario 3 is the same as scenario 2 with the 5 lost vessels replaced by new vessels.

Scenario 4 is the same as scenario 2 but with only 2 lost vessels replaced, to match the fleet capacity to the available landings.

Scenario 5 is the same as scenario 4, but with 3 lost vessels replaced to show the effect of one new vessel over capacity.

Scenario 6 represents a policy whereby sufficient old vessels (13) are scrapped to allow all 5 lost vessels to be replaced without creating over capacity.

Scenario 7 is based on a one for one scrap and build policy aimed at maintaining the total fleet size constant and avoiding the continuously ageing fleet which results from scenarios 2 to 6. This implies total replacement of the 5 lost vessels and scrapping and rebuilding a further 8 vessels.

Scenario 8 is the result of matching fleet capacity to available landings in combination with avoiding an ageing fleet. This implies total replacement of the 5 lost vessels, scrapping 16 and rebuilding 1 vessel.

SCENARIO	1	2	3		
DESCRIPTION	EXISTING FLEET	EXISTING FLEET WITH 5 LOST VESSELS	FLEET WITH 5 LOST VESSELS REPLACED		
QUOTA	UNRESTRICTED	UNRESTRICTED	UNRESTRICTED	MAX. IND. VSL.	PROPORTIONAL
No. of VESSELS	65	60	65	65	65
Lost	-	5	5	5	5
Replaced	-	-	5	5	5
Scrapped	-	-	-	-	-
New Built	-	-	-	-	-
MEAN AGE	19	27	25	25	25
Quota (Level or %)	-	-	-	116.6	91%
% Vsl. Affected	-	-	-	16	100
Total Earnings	4479	4177	4923	4481	4487
Mean Earnings	68.9	69.6	75.7	68.9	69
Tot. Oper. Profit	471	442	550	486	481
Mean Oper. Profit	7.2	7.4	8.5	7.5	7.4
% Vsl. Oper. Loss	21	21	18	20	21
Tot. Nett Profit	166	400	314	262	251
Mean Nett Profit	2.6	6.7	4.8	4.0	3.9
% Vsl. Nett Loss	33	23	27	29	29
Nett Prof. Youngest Vsl.	- 20.6	6.4	- 24.0	- 27.7	- 25.3
TOTAL EMPLOYMENT	254	235	260	260	260

SCENARIO	4	5		6
DESCRIPTION	FLEET WITH 2 VSL. REPLACED TO CATCH SAME AS SCENARIO 1	FLEET WITH 3 LOST VESSELS REPLACED TO SHOW EFFECT OF 1 VESSEL OVER CAPACITY		FLEET WITH 5 REPLACED AND 13 SCRAPPED TO CATCH SAME AS SENARIO 1
QUOTA	UNRESTRICTED	UNRESTRICTED	MAX. IND. VSL.	PROPORTIONAL	UNRESTRICTED
No. of VESSELS	62	63	63	63	52
Lost	5	5	5	5	5
Replaced	2	3	3	3	5
Scrapped	-	-	-	-	13
New Built	-	-	-	-	-
MEAN AGE	26	26	26	26	20
Quota (Level or %)	-	-	151.7	97%	-
% Vsl. Affected	-	-	6	100	-
Total Earnings	4479	4627	4466	4483	4470
Mean Earnings	72.2	73.4	70.9	71.2	86.0
Tot. Oper. Profit	486	507	493	490	529
Mean Oper. Profit	7.8	8.0	7.8	7.8	10.2
% Vsl. Oper. Loss	20	19	20	20	14
Tot. Nett Profit	362	351	344	340	293
Mean Nett Profit	5.8	5.6	5.5	5.4	5.6
% Vsl. Nett Loss	25	25	25	26	25
Nett Prof. Youngest Vsl.	- 27.1	- 27.1	- 26.6	- 24.8	- 24.0
TOTAL EMPLOYMENT	245	250	250	250	218

SCENARIO	7			8
DESCRIPTION	FLEET MAINTAINED WITH SAME NUMBER AND SAME MEAN AGE AS IN SCENARIO 1			FLEET MAINT'D WITH SAME CATCH AND MEAN AGE AS IN 1
QUOTA	UNRESTRICTED	MAX. IND. VSL	PROPORTIONAL	UNRESTRICTED
No. of VESSELS	65	65	65	50
Lost	5	5	5	5
Replaced	5	5	5	5
Scrapped	8	8	8	16
New Built	8	8	8	1
MEAN AGE	19	19	19	19
Quota (Level or %)	-	87.3	77%	-
% Vsl. Affected	-	42	100	-
Total Earnings	5853	4481	4496	4482
Mean Earnings	90.0	68.9	69.2	89.6
Tot. Oper. Profit	709	476	475	539
Mean Oper. Profit	10.9	7.3	7.3	10.8
% Vsl. Oper. Loss	13	21	21	13
Tot. Nett Profit	171	- 47	- 68	260
Mean Nett Profit	2.6	- 0.7	- 1.0	5.2
% Vsl. Nett Loss	33	40	41	26
Nett Prof. Youngest Vsl	- 23.0	- 32.7	- 28.9	- 23.5
TOTAL EMPLOYMENT	275	275	275	213

NOTE: The Scenario 1 is 1981. All Others are 1989.