International Council for the Exploration of the Sea

CM 1980/G:38
Demersal Fish Committee

ESTIMATING HADDOCK POPULATION SIZE BY AGE USING SCOTTISH RESEARCH VESSEL SURVEYS AND VIRTUAL POPULATION ANALYSIS

by

R M Cook

DAFS Marine Laboratory, Aberdeen, Scotland, U.K.

Abstract

Relationships are presented correlating Scottish research vessel survey, population indices for haddock with estimates from virtual population analysis (VPA). The relationships are significant for North Sea and West of Scotland haddock for age groups I-V. Used in conjunction with the International Young Herring Survey (IYHS) results, Scottish survey data can be used to predict an age-structured population for the current year. The implications of the results for existing surveys are discussed.

Résumé

On présente des corrélations qui établissent des rapports entre les indices de population provenant des études des navires de recherche écossais à l'égard de l'églefin et les évaluations provenant d'une analyse virtuelle de la population (A.V.P.). Les corrélations sont significatives pour les églefins de la Mer du Nord et de l'ouest de l'Écosse dans les classes I à V. Employées conjointement avec l'Étude Internationale des Jeunes Harengs, les données nous permettent de pronostiquer une population divisée en classes d'âge pour l'année courante. On discute les implications des résultats à l'égard des études actuelles.

Introduction

When considering the state of the stock of an exploited fish population, an estimate of the stock size in numbers, and its age distribution, is of central importance. One of the techniques presently employed to this end is the use of International Young Herring Survey (IYHS) catch rate data to predict numbers of I and II group fish in the sea. The technique is to derive a relationship between research vessel indices of abundance and Virtual Population Analysis (VPA) estimates of population size. Having established such a relationship from historical data a current research vessel index can be used to predict the present population size. This procedure overcomes to some extent the weakness with VPA that estimates of numbers for the current year and to a diminishing degree the immediately preceding ones, depend heavily on the 'guessed' input values of fishing mortality (F). Data from the IYHS have been successfully applied to I and II group fish of a number of demersal species though only the relationship for I group fish is currently used by the Working Group (Anon, 1980). In this paper the technique is extended up to age V for haddock, using results from Scottish research vessel surveys of the North Sea and West of Scotland. By the extension of the process it is possible to build up an age structured population for the age groups that make the largest contribution to the fishery. Further, with the stock derived in this way and given catch data for the same year an F-at-age array can be calculated.

Source and Treatment of Data

Numbers of haddock caught at each age by Scottish research vessels have been taken from Jones and Hislop (1978) in the case of the North Sea and from 'Annales Biologiques' for the West of Scotland. The North Sea figures are the averages of all cruises in a given year. In some years there have been up to three cruises carried out in spring, summer and autumn but the tendency has been for cruises to occur in the second half of the year. For this reason the research vessel index has been correlated with the same year class given by VPA for the 1st January in the following year. Although averaging cruises throughout the year is not strictly correct, the greater sampling coverage obtained in this way improves the correlations.

In VIa there has generally been only one survey at the end of each year and again indices have been correlated with VPA estimates for the same year class at the beginning of the following year.

All VPA estimates are taken from the values calculated by the 1980 North Sea Roundfish Working Group (Anon, 1980).

Relationships between VPA and Scottish research vessel indices

For the North Sea the VPA and research vessel data overlap for the period 1960-1975. Correlations for this series are given in Table 1, for transformed and untransformed data, and are significant in all cases. Unfortunately the exceptional year classes of 1962 and 1967 distort the correlation because of their distances from the mean. Calculating correlation coefficients omitting those two year classes in general still gives good correlations (Table 1), though these are lower. In particular the correlation between the II group index and III group VPA, ceases to be significant.

The purpose of obtaining a correlation is ultimately to use the relationship predictively. This creates certain difficulties because the research vessel index is determined by the numbers in the sea (and therefore by implication VPA estimates) whereas in practice the relationship is to be used in reverse with survey data predicting numbers in the sea. For this reason a geometric mean regression is fitted to the data. Regression coefficients are presented in Table 1 for untransformed and log transformed data, as well as for untransformed data with the 1962 and 1967 year classes omitted. The goodness of fit of these regressions can be compared by examining the sum of squares of the residuals (Table 2). In the case of the log transformed data the fitted curve has been transformed back to a power curve for the calculation. Residuals have been calculated for all points and also with the omission of the 1962 and 1967 year classes. This has been done because, for predictive purposes, it is typical populations that must be predicted most accurately. On this basis the straight line calculated, excluding exceptional years, is best though the power curve gives a better all round performance (see Figure 1).

Data for the West of Scotland can be treated in a similar way. The series is shorter and the coverage lower and more erratic but for the most part correlations are satisfactory (Tables 3 and 4). Because the data are fewer it is not possible to omit the very large year classes. Generally a power curve gives a slightly better fit to the data (see Figure 2).

The value of survey data

It is evident that just as the IYHS can be used to predict the population size of I and II group fish, so survey data from Scottish research vessels show that the method could be used for older fish, at least up to age V. Appendix I shows how these relationships can be applied to the 1979 haddock population.

Although for the North Sea, Scottish data can be used in this way, in the longer term it would be preferable to carry out the same process using more detailed data on age from the IYHS because the area covered by this survey is much greater. At present data from IYHS are available for an undifferentiated group of fish of 3 years and older. The IYHS index for these fish correlates fairly well with VPA (Table 5) suggesting it would be worthwhile extracting figures for each age group in the future.

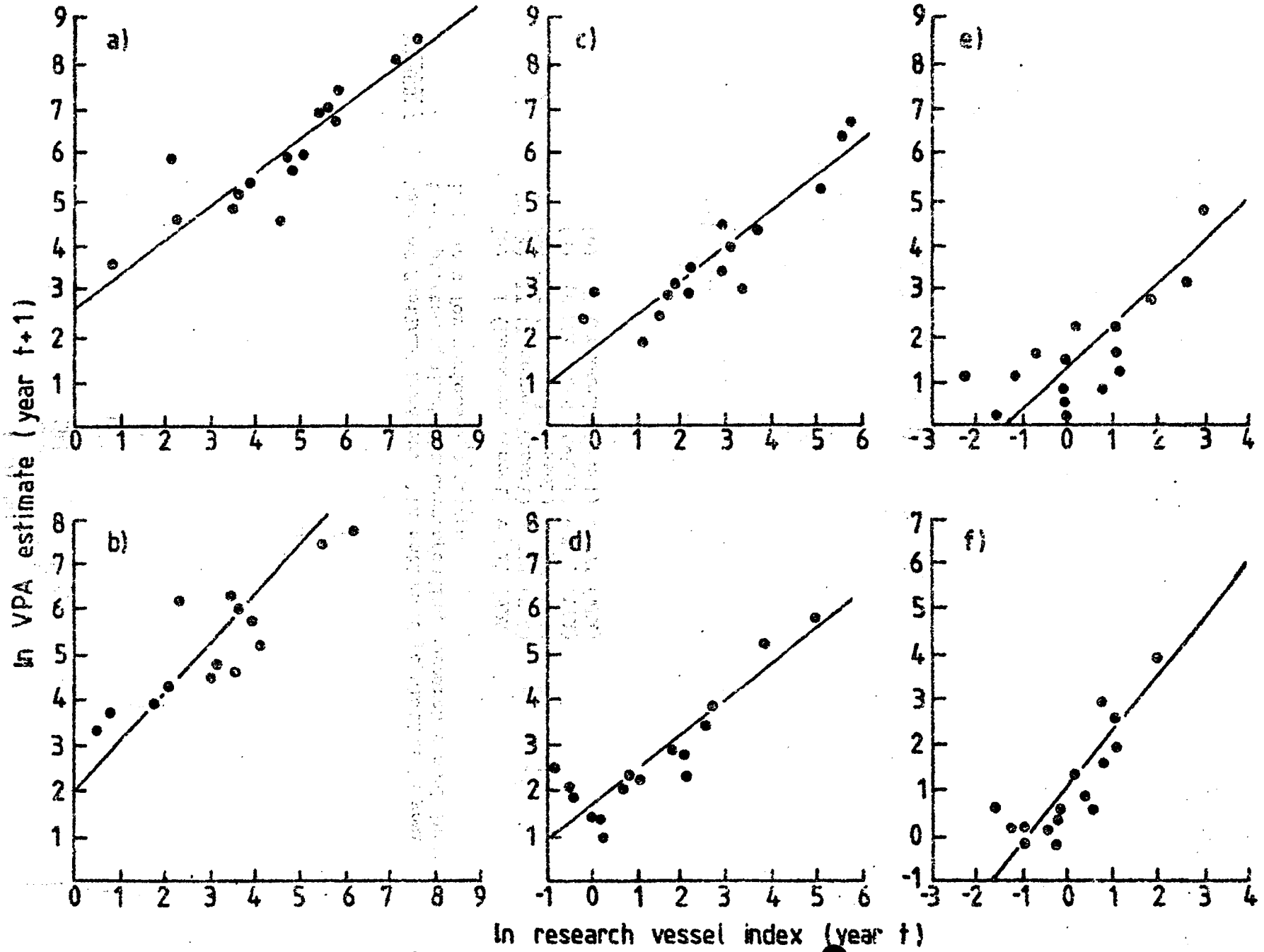
The results for the West of Scotland are not as good as those for the North Sea. At present however these surveys, now augmented by the French, are the only source of data comparable to the IYHS and should be maintained, if not developed further.

References

Anon.	1980	Report of the North Sea Roundfish Working Group. ICES Doc. CM 1980/G:8.
Jones, R and Hislop, J R G	1978	Changes in North Sea haddock and whiting. Rapp. P.-v. Reun. Cons. int. Explor. Mer., 172: 58-71.

FIGURE 1 North Sea haddock. VPA estimated population in year t + 1 plotted against the corresponding research vessel index in year t for various age groups

(a) I (Research Vessel) v II (VPA)
(b) II (Research Vessel) v III (VPA)
(c) III (Research Vessel) v IV (VPA)
(d) IV (Research Vessel) v V (VPA)
(e) V (Research Vessel) v VI (VPA)
(f) VI+ (Research Vessel) v VII+ (VPA)


a)
b)
c)
d)
e)
f)
ln VPA estimate (year t+1)
ln research vessel index (year t)

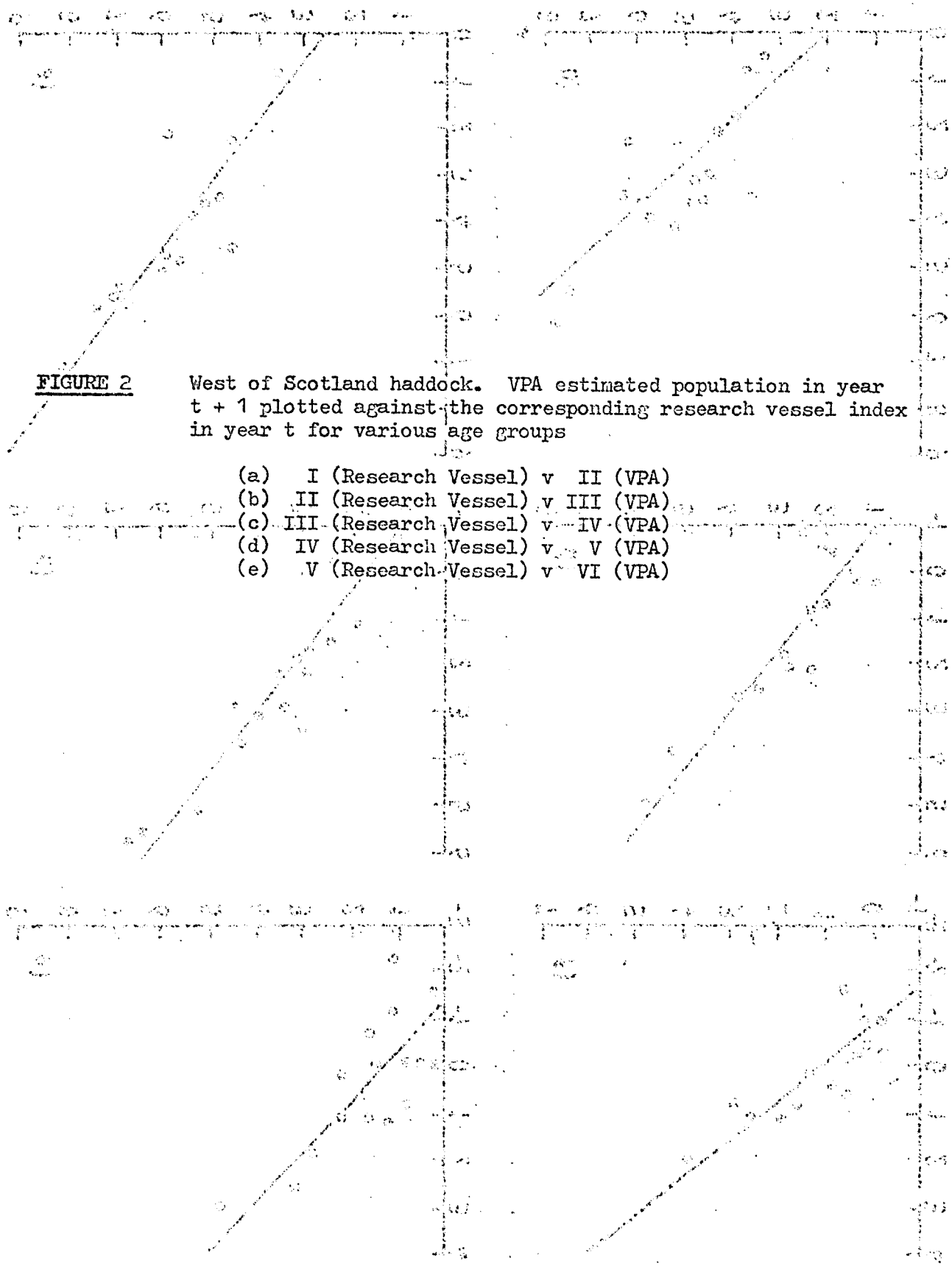


FIGURE 2 West of Scotland haddock. VPA estimated population in year t + 1 plotted against the corresponding research vessel index in year t for various age groups

(a) I (Research Vessel) v II (VPA)
(b) II (Research Vessel) v III (VPA)
(c) III (Research Vessel) v IV (VPA)
(d) IV (Research Vessel) v V (VPA)
(e) V (Research Vessel) v VI (VPA)

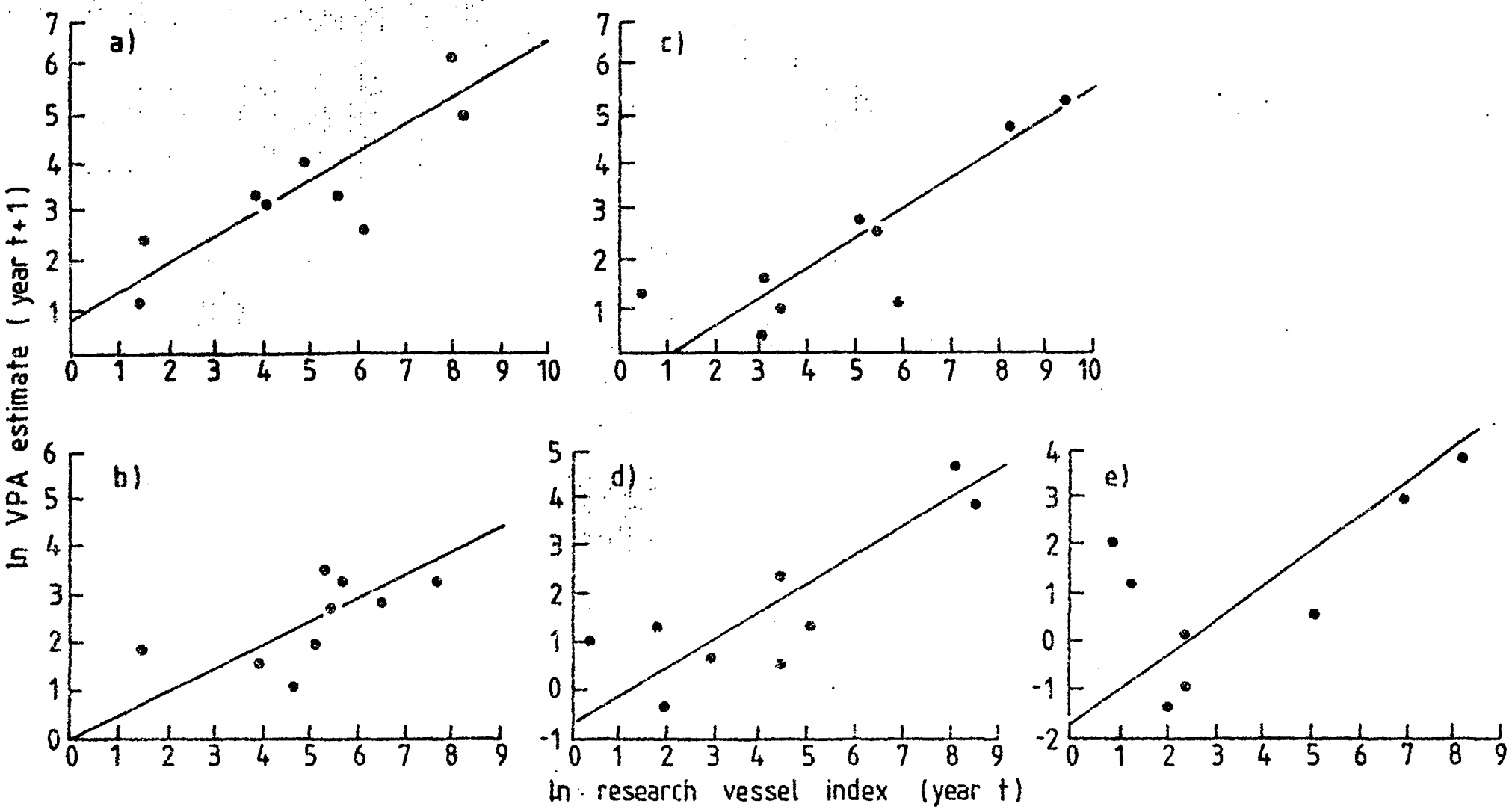

a)
b)
c)
d)
e)
ln VPA estimate (year t+1)
ln research vessel index (year t)

TABLE 1 NORTH SEA HADDOCK

	RV index/VPA						Geometric mean regression
	I/II	II/III	III/IV	IV/V	V/VI	VI+/VII+	
r	.98	.96	.98	.97	.91	.92	
U_0	165.96	91.00	- 2.67	5.98	- 5.46	- 4.89	linear; all points
U_1	2.65	1.53	2.43	2.45	5.23	7.13	
n	17	16	16	16	16	16	
r	.90	.50	.92	.90	.78		
U_0	- 19.80	- 16.56	16.14	1.93	.49	N/A	linear; 1962, 1967 year classes omitted
U_1	4.13	3.26	1.40	2.72	2.53		
n	15	14	14	14	14		
r	.88	.91	.90	.88	.75	.80	
U_0	2.68	1.92	1.76	1.67	1.30	.98	log transformed; all points
U_1	.75	.80	.78	.80	.85	1.25	
n	17	16	16	16	16	16	

Correlation and regression coefficients for research vessel index vs VPA for North Sea Haddock

r = correlation coefficient

U_0 = intercept

U_1 = slope

n = number of observations

TABLE 2. NORTH SEA HADDOCK

SUM OF SQUARES OF RESIDUALS

Age Group	1962/1967 yrs omitted	All points	Fitted curve
I/II	852,299	925,440	(1)
	675,219	11,855,044	(2)
	779,051	1,828,631	(3)
II/III	320,877	497,667	(1)
	427,749	9,676,866	(2)
	332,801	433,502	(3)
III/IV	30,368	33,225	(1)
	5,595	189,518	(2)
	12,749	129,315	(3)
IV/V	501	6,152	(1)
	405	8,294	(2)
	650	7,815	(3)
V/VI	514	2,302	(1)
	102	4,585	(2)
	130	5,246	(3)
VI+/VII+	-	378	(1)
	-	-	(-)
	-	560	(3)

(1) linear; all points

(2) linear; 62, 67 yrs omitted

(3) power curve; all points

TABLE 3 WEST OF SCOTLAND HADDOCK

	I/II	II/III	III/IV	IV/V	V/VI	Geometric mean regression
r	.74	.47	.98	.78	.97	
U_0	- 4.89	8.66	7.83	1.82	2.52	linear
U_1	.11	.02	.02	.02	.01	
n	9	9	9	8	8	
r	.83	.62	.84	.82	.70	
U_0	.63	- .04	- .76	- .63	- 1.68	log transformed
U_1	.58	.50	.63	.58	.72	
r	9	9	9	8	8	

Correlation and regression coefficients for West of Scotland haddock. See Table 1 for definition of symbols.

TABLE 4 WEST OF SCOTLAND HADDOCK

Sum of squares at Residuals		
I/II	98,754 93,031	(1) (2)
II/III	1,189 966	(1) (2)
III/IV	2,042 2,561	(1) (2)
IV/V	4,851 3,526	(1) (2)
V/VI	84 374	(1)

(1) linear
(2) power curve

TABLE 5 NORTH SEA HADDOCK : IYBS

Geometric reg.	r	U_0	U_1	Sums of Squares of Residuals	IYHS index
linear	.81	102.95	2.22	95,979	unadjusted
power curve	.79	2.52	.72	94,821	
linear	.74	109.37	2.16	132,965	adjusted
power curve	.79	2.49	.72	128,226	

Regression coefficients for VPA vs IYBS abundance indices for 3++ haddock. Data are taken from Anon (1979). The adjusted index is an abundance index corrected for incomplete coverage by the survey.

Appendix I

One way of evaluating the predictive worth of the regression method would be to compare past Working Group predictions of haddock populations for a given year with the equivalent prediction had the information presented here been available. Unfortunately the input data and consequent VPA were substantially revised at the 1980 North Sea Roundfish Working Group which makes such a comparison of little value. However recent Research Vessel cruise indices can be used to predict the 1979 population which can be compared with the Working Group's population estimate for the same year. In Table IA the 1979 'regression' population and 1979 VPA population are shown and compare favourably over the age range II-IV. A further comparison may be made by calculating the 1980 'regression' population (Table IA) and using 1979 catch data, to compute the 1979 population. This estimate in Table IA can be compared with the previous two estimates; it agrees with them fairly well. It should be noted also that the numbers of I group fish calculated in this way is within 30% of the IYHS estimate given in the 1979 VPA population. Due to its greater coverage the IYHS figure is always to be preferred though the level of agreement in encouraging for the validity of the regressions presented here, particularly since the 1979 catch statistics are only provisional.

TABLE 1A

NORTH SEA HADDOCK

Age	(1) 1979 (RV_{79})	(2) 1979 (VPA)	(3) 1979 (RV_{80})	(4) 1980 (RV_{80})
I	-	1,599,770*	1,219,660	
II	461,072	406,891	432,962	750,789
III	79,287	75,010	83,641	142,830
IV	18,944	15,666	17,229	29,557
V	23,668	45,590	36,107	6,480
VI	3,198	9,727	8,042	7,570
VII+	301	1,957		1,408

Population estimates of haddock based on VPA and regression methods

(1) Regression estimated population using 1978 cruise data and curve 2 of Table 2.

(2) VPA estimated population from 1980 Roundfish Working Group (Anon 1980).

(3) Population calculated from (4) using 1979 catch data and natural mortality m = 0.2.

(4) Regression estimated population using 1979 cruise data and curve 2 of Table 2.

* IYHS figure