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REGIONAL VARIATION IN GLASS EEL CATCHES AN EVALUATION OF MULTIPLE SAMPLE SITES

Willem DEKKER

Netherlands Institute for Fishery Investigation
Haringkade 1 — Ijmuiden, Netherlands

ANGUILLA ANGUILLA
GLASS EELS
NETHERLANDS
SAMPLING

ABSTRACT. — In the Netherlands glass eels are caught for research purposes at various sites. Catches at four sites are compared, using an analysis of variance. It is concluded that three sites basically give the same information, while one, the most southern site, shows independent annual fluctuations. As a side effect of this study, a different indicator for catch sizes is proposed : geometric means reflect more accurately the underlying frequency distribution than common means do.

ANGUILLA ANGUILLA
CIVELLES
ECHANTILLONNAGE
PAYS-BAS

RESUMÉ. — Aux Pays-Bas, des civelles sont échantillonnées dans plusieurs sites. Les captures de 4 points sont comparées par une analyse de variance. Trois sites présentent une même variation tandis qu'une fluctuation annuelle indépendante est remarquée pour le plus méridional. Compte-tenu de ces résultats comparatifs, un nouveau calcul des captures de civelles est proposé : leur distribution statistique est mieux exprimée par les moyens logarithmiques que par les moyennes numériques.

INTRODUCTION

At Den Oever (Fig. 1), the glass eel gathering at the sea side of the sluices is sampled every night in spring at two hourly intervals. In the 1970's additional sampling sites were established at Ijmuiden (1969, 1970 and 1973 onward), Stellendam (1976 onward) and Lauwersoog (1976 onward). Based on the data collected at these four sites, various studies have been published (Deelder, 1960, Heermans, and v. Willigen, 1982) concerning both eel biology and management. Since manpower is limited, the results of the four sampling sites are compared, thereby evaluating the extra research effort of multiple sampling sites within the Nethelands.

METHODS

The sampling method (dipnet, 1 m^2) has been described earlier (Deelder, 1984) and has not been changed among years or between sites. Catches have been made from January through June, at Den

Fig. 1. — Map of the Netherlands, giving the sampling sites.

Table I. — Design used in the analysis of variance

variate	type	remarks
glass eel count	dependent	transformed to Y = log (glass eel count + 1)
year	factor	
month	factor	
hour	factor	two hourly intervals
lunar phase	factor	4 levels
tidal phase	factor	6 levels
cloudiness	factor	5 levels, including fog seperately
wind direction	factor	8 levels
wind strenght	covariate	also squared and cubed, Beaufort
water temperature	covariate	also squared and cubed
sun height	covariate	vertical angle between sun and horizon, also squared.

Oever every night at two hourly intervals; at the other sites at irregular intervals (± twice a month) mostly about two hours after sunset. No effort to concentrate glass eels in the dipnet was made. Glass eels were counted, and a subsample of them measured. Length measurements are recorded elsewhere (Heermans and v. Willigen, 1982).

Analysis of the data was made by a socalled Analysis of Variance (ANOVA).

The design of the ANOVA used is listed in Table I. This design differs from earlier studies based on these data by the transform of the dependent variate : because of the natural count character of this variate, a log-transformation was used : Y = LOG (glass eel count + 1), using Napierian logarithms. A posteriori tests on residuals did not reject this transform.

Site was not included in the ANOVA, since time series differ in length between sites.

RESULTS

In order to select a reasonable model, a full model was tested, using the total Den Oever data set, and the total design listed in table I.

Water temperature cubed, wind strength squared and sun height squared contributed so little to the model, that they were dropped directly. The resulting model is given in table II. All factors turned out to be significant at the 1 % level.

Despite the statistical significance of all factors, it was argued, that the factors moon, tide, clouds, wind direction, wind strength and sun height explained so little of the total variance (their sum explaining only 1.5 %, leaving 43.6 % for temperature, hour, month and year) that their recording cannot be of any practical importance. Therefore, they were dropped from the model. Now it was realized that in the remaining model (water temperature, hour, month and year), water temperature is of a different nature from the other factors : it is the only one not determined by the sampling scheme. Although water temperature may be readily available for the different parts of the Netherlands, it was preferred to drop water temperature from the model, having only the sampling scheme remain. The fact that just the sampling scheme remains, stresses the necessity of careful analysis of glass eel data.

Table II. — Percentages of the total variance explained by the full model for Den Oever.

source	% of total variance
year	13 %
month	8 %
hour	1 %
moon	0 %
tide	0 %
clouds	0 %
sun height	1 %
wind direction	0 %
wind strength	0 %
water temperature	4 %
multicollinearity	14 %
total explained	45%
unexplained	55 %
mean square	2.64

The results of the remaining small model are given in table III to VI, together with the results for the three other sites.

From inspection of table IV, it can be seen that Lauwersoog-Den Oever show a positive correlation : from 1976 to 1981 both time series give high values; since 1982 both show a rapid decline.

Ijmuiden-Den Oever has an even higher correction : not only is the downward trend from 1981 to 1983 adequately represented, but also temporary decreases in 1970, 1973 and 1976 correspond in both time series.

Stellendam-Den Oever, finally, shows no noteworthy correlation at all : despite a marked decrease in catches at Den Oever in 1980, Stellendam reaches its top record in that year.

Table III. — Percentages of the total variance explained by the reduced model for all sites.

source/site	Lauwersoog	Den Oever	Ijmuiden	Stellendam
year	14 %	19 %	25 %	36 %
month	27 %	13 %	14 %	13 %
hour	4 %	5 %	0 %	3 %
multicollinearity	1 %	2 %	13 %	4 %
total explained	47 %	39 %	53 %	56 %
unexplained	53 %	61 %	47 %	44 %
mean square	3.35	2.46	3.45	2.04

Table IV. — Estimated year effects at all sites.

Year/site	Lauwersoog	Den Oever	Ijmuiden	Stellendam
1969		0.01	−2.05	
1970		0.23	−0.02	
1971		0.05		
1972		0.59		
1973		0.07	−0.50	
1974		0.43	1.16	
1975		0.78	1.24	
1976	0.22	0.36	0.20	−0.70
1977	0.46	0.93	0.49	−0.06
1978	0.35	0.68	0.69	0.41
1979	0.03	1.06	0.67	0.17
1980	0.47	0.43	0.87	1.03
1981	0.55	0.37	−0.18	0.29
1982	−0.06	−0.19	−1.10	−0.56
1983	−1.16	−0.54	−1.25	−0.55
1984	−0.75	−0.42		
1985		−0.60		

Table V. — Estimated month effects at all sites.

month/site	Lauwersoog	Den Oever	Ijmuiden	Stellendam
February	−1.68	−0.98	−1.87	0.07
March	−0.87	0.21	−0.22	−0.29
April	1.57	1.24	0.48	0.93
May	1.36	0.42	0.47	−0.11
June	−0.38	−0.88	1.14	−0.60

Table VI. — Estimated hour effects at all sites.

hour/site	Lauwersoog	Den Oever	Ijmuiden	Stellendam
17-19		−0.97		−0.82
19-21	0.09	−0.36		−0.37
21-23	0.22	0.38		−0.26
23-01	0.33	0.52	no data	0.32
01-03	0.15	0.52		0.15
03-05	−0.79	0.10		0.52
05-07		−0.19		0.47

DISCUSSION

This study concerns an evaluation of research work. The first point to consider is the appropriateness of the evaluation procedure. Although many aspects of the analysis may be questioned, the discussion will be restricted to the choice of the Y-variate. Basically, an a priori choice was made for the most frequently used transform in case of natural counts : a log transform. Furthermore, a posteriori tests on the distribution of the error terms did not show any significant deviation from the theoretical expectation. However, the choice of a log transform

Table VII. — Results from a bootstrap simulation using the 1952 Den Oever data, to compare year totals and mean log transforms as indicator variables of year class strength. N = number of 'samples', C.V. = coefficient of variation.

'sample' number	year totals		mean log transforms	
N	C.V.	C.V. * sqrt (N)	C.V.	C.V. * sqrt (N)
1	0.54	0.54	0.21	0.21
10	0.31	0.96	0.06	0.18
100	0.08	0.80	0.02	0.19
1 000	0.03	1.05	0.01	0.19
10 000	0.01	0.62	0.00	0.19

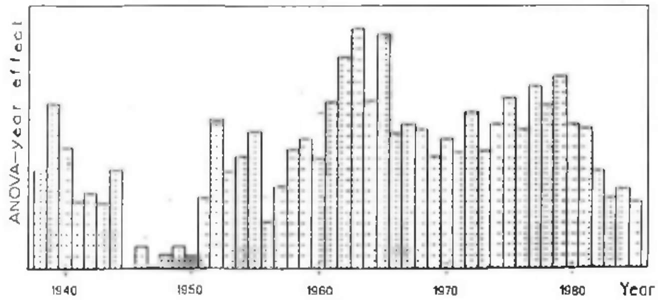

Fig. 2. — ANOVA-estimated year effects at Den Oever.

necessitates a drastic change in accepted views on year class strengths in the Ijsselmeer : figure 2 is definitely different from total year catch figures, as for instance given in Deelder, 1984 : year class 1952 is not a very exceptionally strong year class, and 1958 is average sized instead of top record, while 1963 turns from a moderate year class into the top record. However, long term variations are quite comparable. In order to select a judgement criterion between year totals and mean log transforms, a small bootstrap simulation was set up : table VII lists coefficients of variation (taking 10 runs) of both indices of various numbers of artificial 'samples' taken at random from the 1952 raw sampling data at Den Oever. Furthermore, these coefficients of variation are multiplied by the square root of the number of 'samples', to correct for differences in accuracy induced by the number of 'samples'. From table VII, it can be concluded that year totals heavily depend on the number of samples, and that sample numbers up to 1000 and 10000 are still not enough, while means of log transforms stabilize at sample numbers of 10 to 100. Therefore, means of log transforms are to be preferred.

Secondly, the rationale of this study should be discussed. The primary aim is to stop all work on superfluous sampling sites. It should be stressed that Den Oever is not evaluated, since this sampling site will be continued because of practical considerations. From table IV, it can be concluded that both Lauwersoog and Ijmuiden are superfluous. Sampling is not intense enough to monitor very short term changes, and long term changes do not contradict the Den Oever series. However, Stellendam gives independent information.

Finally, one should have some doubts on the usefullness of these time series to monitor year class strength. Since all four sites discussed concern steep transitions from one water body into another, one can not accept at forehand that instantaneous densities are reliable estimators of the flow of glass eels through some borderline. May be catching devices can fill in this gap at Den Oever.

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