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International Council for the Exploration of the Sea

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REPORT OF THE WORKING GROUP ON HERRING LARVAL SURVEYS SOUTH OF 62°N

Hirtshals 6 - 10 January 1986

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1. INTRODUCTION

1.1 Participants

The meeting was attended by all countries who currently participate in the International Surveys. Further, Norway was represented. The following were present:

K.M. Bhatnagar	Ireland
A.C. Burd	UK (England)
A. Corten	Netherlands
V. Christensen (Chairman)	Denmark
P. Fossum	Norway
H. Halbeisen	Federal Republic of Germany
M.R. Heath	UK (Scotland)
H. Lassen	Denmark
J. Nichols	UK (England)
H. Paulsen	Denmark

1.2 Terms of Reference

The ICES Working Group on Herring Larval Surveys South of 62^{0}N met for 5 days, 6-10 January 1986, in Hirtshals in accordance with C.Res. 1985/2:6 to produce a comprehensive review for full consideration by the North Sea Herring Assessment Working Group at its 1986 meeting, in order that it can evaluate the value of the herring larval surveys for assessment purposes. The terms of reference were:

(i) to review the causes of the continued difficulties in calculating the annual abundance indices using the present method based on abundance of only smaller larvae;

(ii) to evaluate the methods developed for calculating larval production, with confidence limits, from larval size distribution and estimates of larval growth and mortality rates;

(iii) to consider methodologies of calibrating larval production estimates to derive spawning stock biomasses independently of the use of VPA derived values.

1.3 Introduction

Using surveys of the Downs stock, Cushing and Bridger (1966) demon strated the usefulness of herring larval surveys for assessing changes of spawning stock biomass. Following this, the ICES Herring Committee promoted an international effort to conduct herring larval surveys covering all areas of the North Sea. These annual surveys have since been extended to cover ICES Division VIa West of the British Isles.

Initially these surveys were used as confirmation of changes in stock sizes derived from other data sources. In 1974/75, the reduction in larvae production was in itself a major factor in the decision to advise a complete prohibition of herring fishing in the North Sea. Attention was subsequently focussed on the possibility of using larval abundance as an index of spawning stock biomass, particularly in the absence of data derived from other sources. Burd and Wood (1976) showed that in ICES Division IVb there was a highly significant correlation between the abundance of less than 10 mm larvae and spawning stock biomass. This indicated that there was some predictive value in the larval data for estimation of spawning stock biomass.

The Larval Survey Working Group meeting in 1976 (Anon., 1977) produced significant regressions for Divisions IVa and IVb, but it was apparent that the surveys in these and the other areas would have to be improved. Since then many changes have been made in the methodology used to calculate spawning stock biomass. Changes have also been made in the larval survey methods and the method used to calculate an index of larval production. In spite of the numerous modifications, little improvement has occurred in the relationship between the larval index and spawning stock biomass derived from VPA.

2. LARVAL ABUNDANCE INDEX

2.1 Difficulties in Calculating the Larval Index

The difficulty in calculating the larval index cannot be separated from the difficulty of using that index in a predictive regression against the VPA estimate of spawning stock biomass. The poor fit of these regressions in most areas has generated a lack of confidence in the larval estimate. This has caused successive larval working groups to reexamine in detail the problems of calculating larval indices. It has been recognized that in many areas there are problems which can be identified if not satisfactorily resolved (e.g., poor temporal and spatial coverage). The same attention has not been given to the likelihood of the VPA estimates being the major cause of the poor fit of these regressions, although for some areas in some years this is known to be the case.

The major difficulties with the larval index in most cases arises from the decision to use abundance of less than 10 mm larvae. These recently hatched larvae may have a very patchy distribution in space and in time. This has often led to extremely high values in a few rectangles which then drive the index for that sampling period. Such patchiness also leads to some hatching cohorts being completely missed by the present survey methods. The high variability inevitably leads to a high variance on the larval index.

The temporal coverage of the spawning areas in 10 - 15 day periods may also lead to complete hatching cohorts being missed. With larval growth rates of 0.25 mm - 0.35 mm d^{-1}, larvae hatched between surveys may be larger than 9 mm by the time that they are sampled. Poor coverage in time with whole spawning periods missing, serves to exacerbate this problem. No attempt has been made in calculating the larval indices to allow for missing cohorts other than the extrapolations made for sampling periods completely missed.

Attempts have been made in all areas to correct for poor spatial coverage. This has sometimes resulted in a high proportion of an index being generated by interpolated values. Loss of less than 10 mm larvae from an area before they are sampled, and their immigration to another area can also be a source of error in the index. No attempt has been made to allow for such losses or incursions.

Further attempts could be made to improve the less than 10 mm larval indices. However, such adjustments based on past experiences seem unlikely to produce major improvements in the regressions of larval indices against VPA derived spawning stock biomasses.

2.2 Area Specific Problems

2.2.1 Division IVc/VIIb (Southern North Sea and English Channel)

This area is different from all the others in that bigger larvae (less than 17 mm) have already been included in larval abundance indices for many years. Prior to 1984, the index used consisted of the total of all length groups caught. The calculation of an index in this way was necessary in order to get a figure which was comparable to data from the late 1950's, the only period in which the spawning stock was at a reasonably high level. Without using data from the 1950's, no sufficient range in stock sizes was available to calculate a regression of VPA stock sizes on larval abundance indices.

In 1984, the Working Group on Herring Larval Surveys decided that it was no longer necessary to use data from the 1950's since spawning stock had recovered considerably, and data referring to high stock sizes were available from recent years (Anon., 1984b). The sizes of larval indices containing all length categories were discontinued and replaced by sizes based on larvae < 17 mm. This index, consisting of the sum of the small and medium size groups, was considered to provide a more accurate estimate of total larval production than the smallest length group alone.

At present, two problems still exist in using larval abundance indices from this area. The first problem concerns the systematic gap in sampling coverage between 24 December and 2 January, the period in which during some years the peak hatching may occur. The larval index, based on cruises in mid-December and the whole of January, therefore, may contain a relatively high inaccuracy.

The second problem consists of the poor relation between larval abundance indices and VPA stock estimates for this area (see data given by Saville and Rankine, 1985). This discrepancy, however, is considered likely to be due to errors in the VPA rather than to inaccuracies in the larval index.

2.2.2 Division IVb (Central North Sea)

This area has suffered least from the problems of poor spatial and temporal coverage in most years. However, many of the general problems identified above are applicable to some degree in this area.

2.2.3 Division IVa (Orkney/Shetland and Buchan)

In this area there is a problem of occasional early hatching in August before sampling has begun. This has generated cohorts of larger then 9 mm larvae during the September surveys. No attempt has been made to include these missed cohorts in the less than 10 mm index.

The VPA estimate in this area may be an overestimate based on the presence of fish from other areas during the fishing season.

2.2.4 Division VIa(N) (West of Scotland)

The index in this area may not be relative between years due to differences in sampling in time and space relative to spawning. This arises because of changes in both spawning time and sampling times, and from differences in sampling intensity and spatial coverage.

There is a particular problem in this area of the rapid loss of less than 10 mm larvae, hatched in the Cape Wrath area, eastwards into the Orkney - Shetland area.

The VPA estimate of spawning stock biomass in this area is based on poor or non-existent catch data for most of the period when larval data are available. Furthermore, the input F values for the VPA have been selected to give the best fit to the larval data rather than on the basis of some independent criteria.

2.2.5 Division VIa(S)

The existing area used for the calculation of an abundance index based on numbers of larvae less than 10 mm, includes only Division VIa(S). The Herring Assessment Working Group currently performs VPA stock estimates based on catches in areas VIa(S) and VIIb,c combined. Therefore, the larval index does not strictly relate to the VPA stock estimate.

Prior to 1979, the larval survey coverage of VIa(S) has been extremely poor. Despite this, a significant regression was produced between the index for 1973 - 1980 and the VPA estimate of spawning stock size. However, the intercept of this regression is the major component of the estimated biomass and this is a major course for concern with this approach.

3. THE METHOD OF ESTIMATION

The method presented here is a modification of approaches presented by Burd (1985), Christensen (1985), Lassen and Pedersen (1985).

The method is based on the assumption that any length group can be taken as an index of larval abundance, and that these indices can be combined, provided growth and mortality rates are known. The length composition observed on a particular day is folded back into production distributed over time, by raising the number of larvae in each length group for the loss due to mortality and emigration and by finding the corresponding production time by relating length and growth rate. This will provide several production estimates for each production period and it is expected that the average of these estimates would be more accurate than the previous indices where only a few length groups (less than 10 mm) has been used.

3.1 Theory

The assumptions introduced are:

- Growth in length is linear in time
  $l(t) = l_0 + kt$
  where l is the length at time (day) t, l_0 is the hatching length and k is the average growth increment per day.

- Mortality and emigration are constant over time and independent of length.

  $$N(t) = N(t-1)e^{-z} + P(t) \qquad [1]$$

  where $N(t)$ is the total number of larvae at day t, e^{-z} is the daily survival rate, z is the total mortality coefficient and $P(t)$ is the production at day t. z includes emigration.

- No immigration.

Based on these assumptions, we can formulate:

$$N_l(t) = P\left(t - \frac{l-l_0}{k}\right) \exp\left(-z \times \frac{l-l_0}{k}\right)$$

Where $N_l(t)$ is the total number of larvae of length l at day t. These larvae were hatched at length l_0. The time needed to grow to length l is $\frac{l-l_0}{k}$, where k is the average growth rate (mm/day).

The estimate of the production is then:

$$P\left(t - \frac{l-l_0}{k}\right) = N_l(t) \exp\left[\frac{z}{k}(l-l_0)\right]$$

Consequently, the essential parameters to estimate are z/k measured in per mm and the growth rate k measured in mm per day.

The production estimate from this element of the length composition $N_1(t)$ is then:

$$N_1(t) \times \exp(z/k \times (l-l_0))$$

and the production time (hatching) is:

$$T = t - \frac{l-l_0}{k}$$

Since a larva takes 3-4 days to grow 1 mm, the time unit in the production cannot be finer than about 4 days. For the calculations presented in Section 4.2, the production estimates have been grouped into 10 day periods.

3.2 Estimation of Mortality Rates (z/k)

The ratio z/k is estimated from the length compositions obtained during the survey under the assumption that the average production over some time interval is constant. In order to fulfil this assumption, we have restricted this analysis to only 8 - 16 mm or 10 - 16 mm.

The approach used is to relate the abundance at the survey date t to the corresponding production P.

$$N_l = P \exp(-z \frac{l-l_0}{k})$$

which when taking an average over the survey period and taking logarithms give:

$$\log\bar{N}_l = \log\bar{P} - \frac{z}{k}(l-l_0)$$

Plotting the logarithm of the average abundance by length vs. the length will show a straight line with slope - z/k.

It is important to note over which period the production is averaged. Let the survey take place from day T_1 to day T_2. Then N_l is the average number of larvae of length l observed during the survey. The corresponding production P is during the period day

$$T_1 - \frac{l-l_0}{k} \text{ to day } T_2 - \frac{l-l_0}{k}$$

To illustrate this later assumption, let us take l_0 = 6 mm, z = 0.14 per day and k = 0.35 mm/day or z/k = 0.4^0 per mm as reasonable figures. If we study the length range 10 to 16 mm then and let the survey start at day 40, and last to day 79 (day 1 could be 1 August), then the 10 mm larvae had been hatched between

$$\text{day } 40 - \frac{10 - 6}{0.35} = 29,$$

$$\text{and day } 70 - \frac{10 - 6}{0.35} = 59.$$

Length mm	Hatching period day no.
10	29 - 59
11	26 - 56
12	23 - 53
13	20 - 50
14	17 - 47
15	15 - 45
16	12 - 41

The assumption about constant average production is then that the total number of larvae hatching in these 30-day periods are identical, but not that the detailed production within these time intervals are the same. As an example: if the entire production was between day 29 and 41, this would be fulfilled. The linearity of the plot of log N_1 vs. l (length) is used to judge the applicability of the method.

3.3 Estimation of Growth Rates (k)

The second parameter required is the growth rate k mm/day. This parameter was chosen so that the peak of hatching is found about 10 days after peak spawning. The peak spawning period is observed from the fishery. Lassen and Pedersen (1985) estimated z, total mortality, and derived for the Shetland area a rather low growth rate which led to predicted hatching periods which are well prior to spawning. Therefore, their method was not found applicable.

3.4 Estimation of the Mean Number of Larvae by Length

The estimation of z/k and of production uses the average length composition for each sampling day as the basis. These length compositions were derived as follows:

1. Each standard area was treated separately.

2. The sampling procedure requires that, when a patch is encountered, extra samples to explore this patch are included in the program. This strategy is dealt with by averaging all samples taken within each 10 x 10 n. miles rectangle area on the same day.

3. Each 10 x 10 n. miles rectangle is considered to be representative of the entire standard area. In terms of sampling strategy, this means that the 10 x 10 n. miles rectangles are assumed to be sampled at random. This assumption is critical and is discussed later. Therefore, the length compositions in no/m^2 derived under par. 2 are averaged and weighted by the area of the 10 x 10 n. miles station. The areas are not

identical since the strict definition of the rectangles is 10' x 20' and some of the rectangles are partly land. The resulting average length composition is in no/m^2 and refers to a sampling day.

4. The z/k estimation procedure requires that the length compositions derived under par. 3 should be averaged over some sampling period. Studies of the linearity of the log N_1 vs. l plot suggests that a simple mean over the entire survey period in each year is at least as good as finer time breakdowns studied (coverage, fortnight, or month).

   The simple mean over the survey period for each standard area then gives the length compositions used to estimate the z/k ratio.

3.5 Representativeness of Samples

The length compositions derived above are based on the assumption that each rectangle (10' x 20') is sampled or not sampled at random. This is not so since any cruise program will involve a systematic sampling. However, if this systematic sampling has no bearing on the abundance, i.e., rectangles with high densities are sampled with the same probability as low density rectangles, then the random sample assumption is valid.

The sampling strategy used in the survey, at least in recent years, involves three strata within each standard area: high priority, priority and "do it if you have time". Since these three strata reflect density, the random sample assumption made in these calculations will bias the mean abundance upwards. The extent to which this bias is significant is difficult to judge. In the Central North Sea, inspection of the sampling distributions suggests an overestimation of about 30%. Further analyses will be needed to study this possible bias.

3.6 Estimation of Production

The production is estimated as number of larvae hatched at 6 mm for all standard areas except the Channel and Southern North Sea where 8 mm is used. This is the l_0 parameter.

The production of newly hatched larvae is found from the daily average length composition calculated as described above. The abundance $N_1(t)$ (no/m^2) estimated from survey day t of length group l is raised to production P taking place at day $t-(l-l_0)/k$ with k taken as 0.35 mm/day.

These production estimates are then for each sampling day summed in 10 day production periods. Then these 10 day production estimates originating from different sampling days are averaged over sampling days to give the production estimated by 10 day periods.

It was investigated whether a production estimate based on say 16 mm larvae and on 8 mm larvae sampled 24 days earlier could be assumed to provide comparable estimates. This was done for the Central North Sea and showed a rather wide scatter between the various estimates, but no obvious trends were observed in the data. It can thus be concluded that the back-calculation does not introduce a systematic error in the weighting of small and big larvae in the analysis.

4. RESULTS

4.1 Estimates of Mortality Rates (z/k)

Attempts at calculating values of z/k were made using regressions of abundance indices on length for coverages, fortnightly periods, months and annual estimates. It was decided to rely on the annual estimates based on regressions covering 8-16 mm and 10-16 mm.

The analyses have been attempted for all years in all areas (Table 1, Figure 1). In Division VIaN, linearity was shown for all years for both 8-16 and 10-16 mm groupings, though in 1977 - 1979 and 1983 the slopes were low. A mean z/k ratio of 0.38 was obtained including all values and of 0.42 excluding the more variable values from the period 1972-78 when the survey coverage was about half that in later years.

In the Orkney/Shetland area, 3 out of the series showed no linearity. The mean z/k ratio was 0.31 with only two individual values in excess of 0.40. This low ratio is assumed to reflect immigration of medium-sized larvae from VIaN into the area.

Very few larvae were caught during 1974-79 in Divisions IVc and VIId. Since then the values of the z/k ratio have varied from 0.38 to 0.72 with a mean for the period 1980 to 1984 of 0.53.

Coverage in Division VIa South was inadequate in almost all years surveyed in that the main spawning period was not entirely covered in time.

It was concluded that there was reasonable consistency in the estimates of z/k. However, the determination of linearity did not succeed when the larval abundances were low as in Buchan prior to 1983 and in IVc and VIId prior to 1980.

4.2 Production Estimates

Using the method described in par. 3.6., total production estimates were calculated for each area. The calculations were made using a value for $z/k = 0.40$ and $k = 0.35$ mm/day for all years and all areas. Production was expressed in numbers of larvae at 8 mm for Southern North Sea and Channel, and numbers of larvae at 6 mm for all other areas.

Table 2 presents the newly calculated production estimates, based on all larvae with lengths ≤ 16 mm. For comparison, the presently used indices based on all larvae <10 mm are also given.

The production estimates given in Table 2 should be considered as the first tentative results of a completely new method. The method probably requires a considerable amount of fine-tuning, for which the present Working Group did not have enough time at the present meeting. The following possibilities for refinement of the method should be further investigated:

a. Using a stratification of sampling area in calculating mean number/m^2 for the standard area. The present program assumes that sampling effort is distributed randomly throughout the standard area, which certainly is not the case.

b. There should be some correction for the immigration of older larvae from Division VIa into the Shetland/Orkney area. Presently those older larvae contribute to the estimated production in Shetland/Orkney instead of in Division VIa.

c. If in some (years and areas) we can accurately estimate a z/k value which deviates from 0.40, it seems more reasonable to use the specific z/k value calculated for that area in back-calculating the estimated production at 6 mm.

Keeping in mind the limitations of the production estimates presently available and the possibility of a further refinement, the following comments can be given to the results obtained so far, for the various specific areas.

4.2.1 Division VIa (N)

The back-calculation from the size frequencies of larvae in this area, using a growth rate of 0.35 mm/d generated production curves with peaks generally in the period 3-23 September. The final series of annual production estimates for larvae hatching at 6 mm was highly correlated with the abundance indices based upon numbers smaller than 10 mm (Saville and Rankine, 1985) (Table 2).

Comparison of the larval production estimates and the potential egg production based upon VPA stock size estimates for the area suggested that the two values were of the same order. Larval production was less than the estimated egg potential in all years except four: 1975, 1977, 1978 and 1981.

4.2.2 Division VIa (S)

The production estimates for this area showed very large fluctuations, and the data from 1973 - 80 were not well correlated with the abundance index based on numbers smaller than 10 mm. There are a number of possible reasons for the unlikely nature of these data. First, sampling has been extremely poor in the period 1972 - 78. Secondly, the back-calculation estimated peak production between 24 August and 23 September for 1979 -81, which is clearly too early.

Finally, in the period when sampling has been adequate in October (1982-84), there are large differences in the sampling intensity during September and these have clearly contributed to variations in the production estimates.

4.2.3 Orkney/Shetland

The Shetland/Orkney area has not been sampled very satisfactorily throughout the years. This was especially the case in the years 1972 to 1979 when the sampling during spawning periods were very incomplete.

Despite these incomplete coverages, the calculated z/k ratios gave reasonable values with a mean of z/k = 0.31. This value is lower than in the other areas which may be due to drift of bigger larvae from the VIa North area into the Shetland Orkney area.

For the back-calculation from the actually caught larvae to the estimated larval production, a z/k ratio of 0.40 was used as in the other areas. This gives a peak in hatching in the years 1972 to 1978 in the first half of September. In the following years, the hatching peak occurs earlier (late August to mid-August in 1984).

The estimated larval production declined from 1972 to 1976 continuously from 2.82×10^{13} to 0.36×10^{13}.

The year 1977 is with a production of 4.09×10^{13} very high. There is no satisfactory explanation for these values. It may be mentioned that in this year the estimated larval production in the VIa North area is unusually high, too.

In the following years the larval production recovered very fast and reached a level of 6.74×10^{13} in the year 1980. It keeps on a level near to 5×10^{13} larvae for the following years. A small decline can be observed from 1982-84.

4.2.4 Buchan

This area was recolonized during the early 1980's.

In the years prior to this, only a few larvae were caught in the area. A major proportion of the medium-sized larvae recorded in the area in these years are from the observed larval distribution most likely to have drifted into the area from the Orkney-Shetland area.

It is concluded that the z/k ratios and the production that can be estimated prior to 1983 are too uncertain to be used.

For the years 1983 and 1984, production estimates of 3.26×10^{13} and 5.19×10^{13} larvae are calculated. This may be compared to estimates for Orkney/Shetland for the same years of 5.82×10^{13} and 4.29×10^{13}, respectively.

4.2.5 Central North Sea

The standard area used in the model was reduced by 37 rectangles at the southeastern corner before raising the mean production m^{-2} to total production. The exclusion of these rectangles can be justified on the basis of their failure to contribute to the production in eight survey years and their insignificant contribution for remaining periods.

The larval index in 1984, where there is a seven-fold increase in the production estimate, is considered to be an underestimation of the less than 10 mm group. This was because larvae not hatched during the early September survey had grown through the less than 10 mm group by the time of the next survey at the end of September.

For most years the temporal and spatial coverage in this area was good and gives reason for some confidence in the larval estimate. The production estimate may be influenced by the incursion of larvae from the North (Buchan), but no attempt has been made to quantify this effect.

4.2.6 Southern North Sea/Channel

The low larval abundance and poor spatial and temporal coverage in this area before 1980 are the most notable features of these production estimates. The estimates are based on the z/k ratio of 0.4, whereas the post 1979 plots of production against length suggest a value of ca. 0.5. After 1979 the production estimates show the same overall trends as the larval indices.

5. FECUNDITY

It has been customary to express annual measures of the size of the spawning stock in terms of biomass derived from VPA calculation. Alternatively, the spawning stock may be described in potential egg production (i.e., potential larval production) with the net larval production as estimated from larval surveys. This net production would be the result of mortality on the spawning bed. Comparison of the data could allow inferences to be made on the reliability of the two estimates of spawning stock retrospectively.

The larval production index of less than 10 mm in the latest year of surveying has been used as a predictor of spawning stock biomass from regressions of historic values with VPA stock biomasses. The estimate of total production developed in this report could also be expressed as spawning stock biomass provided some estimates of egg/larval production pr. kg of spawning fish may be available. This could be obtained from historic data series, but more appropriately from current observations.

5.1 Division IVa (Orkney-Shetland)

In this area, it was clear that a change in the length/fecundity relationship had occurred over the period of the larval surveys. It was, therefore, not reasonable to use the same relationship for all years. However, the only data available were collected in 1970, 1973 and 1984. There was no difference between the 1970 and 1973 data, but fecundity at length was approx. 50% higher in 1984.

In addition, length frequency at age data, derived from commercial catches in August and September, were available only for the years 1974-76 and 1983-84. It was, therefore, decided to split the time period into two halves: prior to 1980, and 1980-84. In the first period, 1976 length frequency data were taken as being representative of the years 1977-79, and the 1970 fecundity/length relationship was applied to all years in this period. Length data for 1983 were used in 1980-82, and the 1984 fecundity relationship was applied to all years in the second period.

Pre 1980: fecundity = 1.6×10^{-6} length $^{4.314}$
1980-1984: fecundity = 2.0×10^{-7} length $^{4.712}$

For each age group in each year, the mean fecundity per fish was calculated. The VPA estimate of spawning stock size in numbers at each age was then calculated from the data given in the Herring Assessment Working group report (Anon., 1985), assuming all fish 2 years and older to belong to the spawning stock. This value was used to determine the egg production for each age group for each year. The sum of these productions in each year was then calculated and taken as the total potential egg production of this stock in each year.

5.2 <u>Division VIa(N) West of Scotland</u>

In this area, the procedure from Division IVa was followed. However, in this case the only fecundity data available were collected in the Minch in 1972. These data were very similar to the data for East and West of Scotland in 1970 and 1973. It was, therefore, very difficult to estimate a reasonable length/ fecundity relationship for Division VIa(N), particularly in later years. The procedure adopted was to use the data collected in 1972 for all years up to 1979, and then data collected from fish caught to the West of Shetland for the years 1980-84.

Pre 1980: fecundity = 6.9×10^{-5} length $^{3.662}$
1980-1984: fecundity = 2.0×10^{-7} length $^{4.314}$

Length frequencies at age derived from commercial catches taken in August and September were available for all years except 1973 and 1978-80. In these cases the data from 1974, 1977 and 1981, respectively, were used instead.

Since the majority of larval production in Division VIa(N) occurs in areas outside the Outer Hebrides and off the north coast of Scotland, length composition data from these areas were used in preference to those relating to the Minch. In the absence of data from these areas, data relating to the South Minch were used since older fish are better represented in catches from this area than in catches from the North Minch.

5.3 Bank Herring

Spawning stock age composition at 1 September was calculated according to the methodology of the Assessment Group as reported in (Anon., 1983; Anon., 1984a; and Anon., 1985a). Mean length per age groups have been compiled mainly from English and Dutch sources using data from commercial catches for the years prior to 1977 and mainly from research vessel hauls and by-catch data in the later years.

Fecundity data were collected in 1984 and 1985 at spawning time. The regression of fecundity on length cubed was not significantly different from that given in Burd and Howlett (1974) and this regression has been used for the calculation of mean fecundity. The total egg production at age has been calculated by raising mean values by half the spawning stock size in number. The total annual egg productions are summarized in Table 3, together with the larval production estimates (Figure 2).

5.4 Downs Herring

Estimates of spawning stock size at mid-point of the spawning season (1 Jan) are taken from the ICES Herring Assessment Working Group report (Anon., 1985). It should be recalled that upon 1981 virtually no commercial fishing has taken place in this area since 1971. The basic data used for calculation of VPA have been derived from a miscellaneous collection of research vessel data and by-catch data.

The egg production estimates derived are compared with the larval production estimates on Table 3 and Figure 3. The high VPA stock levels from 1980-85 in part reflect the use of the larval index as a scaling factor in deciding on input data for the latest year used in the VPA calculation.

6. SHIP ALLOCATION DURING FUTURE SURVEYS

The allocation of survey areas and periods, agreed during the 1984 Working Group meeting, has so far been adhered to with some minor amendments.

The following coverage is envisaged for 1986/87:

Area	September		October		November		December		January	
	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31
Shetland/ Orkney	NET FRG	NET SCO	-	-	-	-	-	-	-	-
Buchan	SCO	SCO DEN	-	-	-	-	-	-	-	-
Central NS	NET	ENG	ENG	ENG	-	-	-	-	-	-
South NS/ Channel	-	-	-	-	-	-	NET	NET	ENG	ENG
VIa North	SCO	FRG	SCO	SCO	-	-	-	-	-	-
VIa South	-	-	IRE	IRE	IRE	-	-	-	-	-

Now that larvae larger than 9 mm are also used for production estimates, there seems to be a need for coverage of the Shetland/ Orkney and Buchan areas during October. This could possibly be achieved by shifting some of the sampling efforts in these areas from September to October.

7. CONSIDERATION OF STANDARD AREAS

7.1 Boundary Between Divisions IVa and VIa (N)

The index of larvae smaller than 10 mm includes only larvae which have drifted for a period of up to approximately 10 days from hatching. Potential error in the index through allocation of larvae hatched in VIa(N) to the index for IVa is, therefore, limited to some extent.

The new method, based upon back- calculation to the numbers produced at hatching from the numbers of medium-sized and large larvae, contains no such safeguard. Consideration should therefore be given to redefining the 4^0W boundary between VIa(N) and IVa for the purpose of the larval surveys.

This concerns two statistical rectangles bounded to the east by the Pentland Firth and Orkneys ($58^0$30 - $59^0$00 N and $59^0$00 - $59^0$30 N). It was clear that the more northerly of these rectangles contributed a significant production of larvae (based on the distribution of small individuals) and that this rectangle should continue to contribute to the calculations for IVa. However, it was not possible to make such a judgement for the southerly rectangle ($58^0$30 - $59^0$00 N) without an examination of the relative catches of small and large larvae, and of independent physical and biological data on the advection rates in the vicinity of the North coast of Scotland and the Pentland Firth.

This problem should be reconsidered at a future meeting.

7.2 Standard Area for West of Ireland

Larval survey data for the standard area in Division VIa(S) is very poor up to 1978. From 1979 onwards, sampling has been adequate. In addition from 1981 onwards, data have been collected on a routine basis during October and November from Divisions VIIb,c. From the problems with the existing larval index for this region which relates only to VIa(S), it seems reasonable to start new calculations for 1981 onwards on the basis of sampling from both VIa(S) and VIIb,c combined. Figure 4 shows a new standard area to be used for this purpose which is based on the distribution of herring larvae presented by Grainger and McArdle (1985).

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YEAR	VIa(N) z/k	VIa(N) std. error	VIa(S) z/k	VIa(S) std. error	Ork/Shet z/k	Ork/Shet std. error	Buchan z/k	Buchan std. error	Centr N.S. z/k	Centr N.S. std. error	IVc+VIId z/k	IVc+VIId std. error
1972	0.49	0.02	-	-	0.57	0.11	-	-	0.42*	0.09*	-	-
1973	0.62	0.05	0.76	0.07	0.38	0.02	-	-	0.34	0.02	-	-
1974	0.36	0.02	-	-	-	-	0.27	0.02	0.49	0.04	-	-
1975	0.46	0.02	0.39*	0.09*	-	-	-	-	0.39*	0.06*	-	-
1976	0.32	0.02	-	-	0.42	0.06	-	-	0.45*	0.03*	-	-
1977	-	-	0.41	0.04	0.11	0.01	-	-	-	-	-	-
1978	-	-	0.59	0.08	-	-	0.70*	0.04*	-	-	-	-
1979	-	-	0.62	0.03	0.29*	0.03*	-	-	0.40	0.03	-	-
1980	0.38	0.01	0.74	0.03	0.32*	0.03*	-	-	-	-	0.38*	0.04*
1981	0.33	0.02	0.45	0.04	0.29	0.01	-	-	-	-	0.48*	0.05*
1982	0.34	0.03	0.72	0.06	0.25*	0.01*	0.12	0.02	0.40	0.02	0.67*	0.06*
1983	-	-	0.58	0.03	0.23	0.01	0.41	0.04	0.33	0.02	0.72*	0.10*
1984	0.52	0.02	0.56	0.03	0.20	0.02	0.42	0.01	-	-	0.42*	0.07*
Mean	0.42		0.58		0.31		0.42		0.41		0.53	
Std. Dev.	0.10		0.13		0.13		0.01		0.05		0.15	

Table 1. Estimated mortality (z/k) rates for the six standard areas over the years 1972-1984. Estimates marked with an asterix (*) are based on regression over the larval length range 10-16 mm. Other estimates are based on the length range 8-16 mm. The two bottom lines gives mean and standard deviation of the estimates by area. In Buchan and IVC+VIId the calculations of the means are based on only the more recent years, where substantial spawning have taken place in the areas, i.e. from 1983 and 1980, respectively.

YEAR	VIa(N) PROD EST.	VIa(N) LARV. INDEX	VIa(N) RATIO	VIa(S) PROD EST.	VIa(S) LARV. INDEX	VIa(S) RATIO	Ork/Shet PROD EST.	Ork/Shet LARV. INDEX	Ork/Shet RATIO
1972	3.00	2.39	1.26	0.08	-	-	2.82	5.78	0.49
1973	3.67	2.44	1.50	1.28	3.91	0.33	1.73	2.39	0.72
1974	2.85	1.19	2.39	1.25	3.55	0.35	1.69	1.28	1.32
1975	1.84	0.88	2.09	0.23	1.75	0.13	1.10	0.44	2.50
1976	0.71	0.19	3.74	0.27	0.32	0.84	0.36	0.66	0.55
1977	2.73	0.79	3.46	0.31	0.69	0.45	4.09	1.32	3.10
1978	1.60	0.33	4.85	0.16	1.38	0.12	1.67	3.71	0.45
1979	1.40	1.07	1.31	1.15	4.48	0.26	5.93	5.65	1.05
1980	3.42	1.44	2.38	0.45	1.51	0.30	6.74	3.98	1.69
1981	5.37	2.15	2.50	0.54	1.00	0.54	4.52	3.94	1.15
1982	3.15	1.89	1.67	0.64	0.86	0.74	6.66	3.80	1.75
1983	1.33	0.67	1.99	0.50	1.12	0.45	5.82	3.35	1.74
1984	2.92	2.13	1.37	0.23	0.72	0.32	4.29	3.54	1.21

YEAR	BUCHAN PROD EST.	BUCHAN LARV. INDEX	BUCHAN RATIO	CENTRAL N.S. PROD EST.	CENTRAL N.S. LARV. INDEX	CENTRAL N.S. RATIO	IVc + VIId PROD EST.	IVc + VIId LARV. INDEX	IVc + VIId RATIO
1972	0.03	0.01	3.00	0.20	0.11	1.82	0.02	0.17	0.12
1973	0.05	0.01	5.00	0.90	0.73	1.23	0.01	0.13	0.08
1974	0.23	0.38	0.61	0.53	0.63	0.84	-	0.03	-
1975	0.08	0.44	0.18	0.39	0.06	6.50	-	0.03	-
1976	0.03	0.00	-	0.12	0.08	1.50	-	0.02	-
1977	0.24	0.23	1.04	0.70	0.17	4.11	0.00	0.02	-
1978	0.18	0.36	0.50	0.86	0.46	1.87	0.02	0.11	0.18
1979	4.77	0.20	23.9	0.59	0.19	3.11	0.01	0.40	0.03
1980	1.06	0.02	53.0	1.21	0.21	5.76	0.20	1.19	0.17
1981	1.25	0.02	62.5	2.33	0.36	6.47	0.71	4.86	0.15
1982	1.13	1.00	1.13	0.78	0.34	2.29	0.60	3.71	0.16
1983	3.26	4.48	0.73	0.87	0.66	1.32	0.38	2.35	0.16
1984	5.20	4.30	1.21	6.53	1.05	6.22	0.49	2.27	0.22

Table 2. Larvae production estimates (* 10^13 larvae) for the standard areas over the years 1972-1984. The production estimates are compared to the larvae index (Saville and Rankine, 1985). The column 'ratio' gives the ratio between the production estimates and the larval index.

AREA: VIaN

YEAR	SSB (10^7 kg)	SSN (10^7)	EGG PROD (10^12)	EGGS/FISH (10^3)	EGGS/KG (10^5)
1975	12.502	58.798	18.28	31.12	1.462
1976	10.143	52.894	12.46	23.58	1.228
1977	7.280	36.312	10.87	29.94	1.493
1978	7.393	36.504	10.16	27.83	1.374
1979	10.855	55.953	16.17	28.90	1.490
1980	17.396	87.279	35.44	40.61	2.037
1981	18.710	88.656	39.58	44.64	2.115
1982	19.027	92.736	37.01	39.91	1.945
1983	18.021	86.872	33.78	38.89	1.875
1984	26.563	139.298	46.37	33.29	1.746

AREA: IVa

YEAR	SSB (10^7 kg)	SSN (10^7)	EGG PROD (10^12)	EGGS/FISH (10^3)	EGGS/KG (10^5)
1975	7.08	34.8	11.26	32.36	1.590
1976	12.05	63.9	18.27	28.59	1.520
1977	9.28	44.6	14.53	32.58	1.566
1978	11.13	49.1	17.44	35.52	1.567
1979	11.76	53.2	19.23	36.15	1.635
1980	13.42	56.8	22.70	39.97	1.692
1981	14.39	61.5	21.70	35.29	1.508
1982	21.07	98.4	33.62	34.17	1.596
1983	31.90	156.0	48.75	31.25	1.528
1984	57.93	305.6	96.48	31.57	1.666

Table 3a. Egg production estimates (according to VPA). Eggs/fish and eggs/kg are inclusive males.

AREA: IVb

YEAR	SSB (10^7 kg)	SSN (10^7)	EGG PROD (10^12)	EGGS/FISH (10^3)	EGGS/KG (10^5)
1972	4.226	23.5	6.3	27.0	1.50
1973	7.944	46.0	12.0	26.0	1.51
1974	7.765	43.0	11.9	28.0	1.54
1975	2.703	13.6	4.7	33.0	1.63
1976	0.860	4.4	1.3	29.5	1.53
1977	0.438	2.1	0.6	29.0	1.40
1978	0.664	3.4	1.1	31.0	1.60
1979	1.040	5.5	2.0	36.0	1.88
1980	1.628	8.6	3.4	39.0	2.23
1981	2.984	15.8	6.1	38.0	2.04
1982	6.321	34.2	10.9	32.0	1.73
1983	11.345	61.1	19.2	31.5	1.70
1984	35.369	201.5	53.9	26.5	1.52

AREA: IVc+VIId

YEAR	SSB (10^7 kg)	SSN (10^7)	EGG PROD (10^7)	EGGS/FISH (10^3)	EGGS/KG (10^5)
1972	3.8	26.9	7.1	26.5	0.936
1973	2.0	14.8	3.7	25.0	0.930
1974	1.4	10.0	2.4	24.5	0.868
1975	0.9	6.8	1.8	27.0	1.011
1976	0.3	1.7	0.4	26.0	0.735
1977	0.7	5.6	1.4	25.5	1.016
1978	1.4	10.6	3.3	31.0	1.180
1979	3.0	18.9	6.4	34.0	1.070
1980	1.9	13.2	4.3	33.0	1.144
1981	6.0	45.3	12.7	28.0	1.059
1982	6.9	48.6	15.3	31.5	1.108
1983	12.0	84.6	26.4	31.0	1.100
1984	19.9	135.8	41.5	30.5	1.043

Table 3b. Egg production estimates (according to VPA). Eggs/fish and eggs/kg are inclusive males.

YEAR	VIa(N) EGG PROD.	VIa(N) LARV. PROD.	IVa EGG PROD.	IVa LARV. PROD.	IVb EGG PROD.	IVb LARV. PROD.	IVc+VIId EGG PROD.	IVc+VIId LARV. PROD.
1972	-	30.0	-	28.5	8.0	2.0	7.1	0.2
1973	-	36.7	-	17.8	14.2	9.0	3.7	0.1
1974	-	28.5	-	45.4	13.7	12.5	2.4	17.0
1975	18.3	18.4	11.3	11.8	6.6	3.9	1.8	-
1976	12.5	7.1	18.3	3.9	3.6	1.2	0.4	-
1977	10.9	27.3	14.5	43.3	3.3	7.0	1.4	0.0
1978	10.2	16.0	17.4	18.5	3.0	8.6	3.3	0.2
1979	16.2	14.0	19.2	107.0	2.1	5.3	6.4	0.1
1980	35.4	34.2	22.7	77.7	3.4	12.1	4.3	2.0
1981	39.6	53.7	21.7	57.7	6.1	23.3	12.7	7.1
1982	37.0	31.5	33.6	77.9	10.9	7.8	15.3	6.0
1983	33.8	13.3	48.8	90.8	19.2	8.7	26.4	3.8
1984	46.4	29.2	96.5	94.9	53.9	65.3	41.5	4.9

Table 4. Comparison of estimated egg production (* 10^12 eggs) from V.P.A. and fecundity data, and estimated larvae production (* 10^12 larvae). Area IVa includes the Orkney/Shetland and Buchan areas.

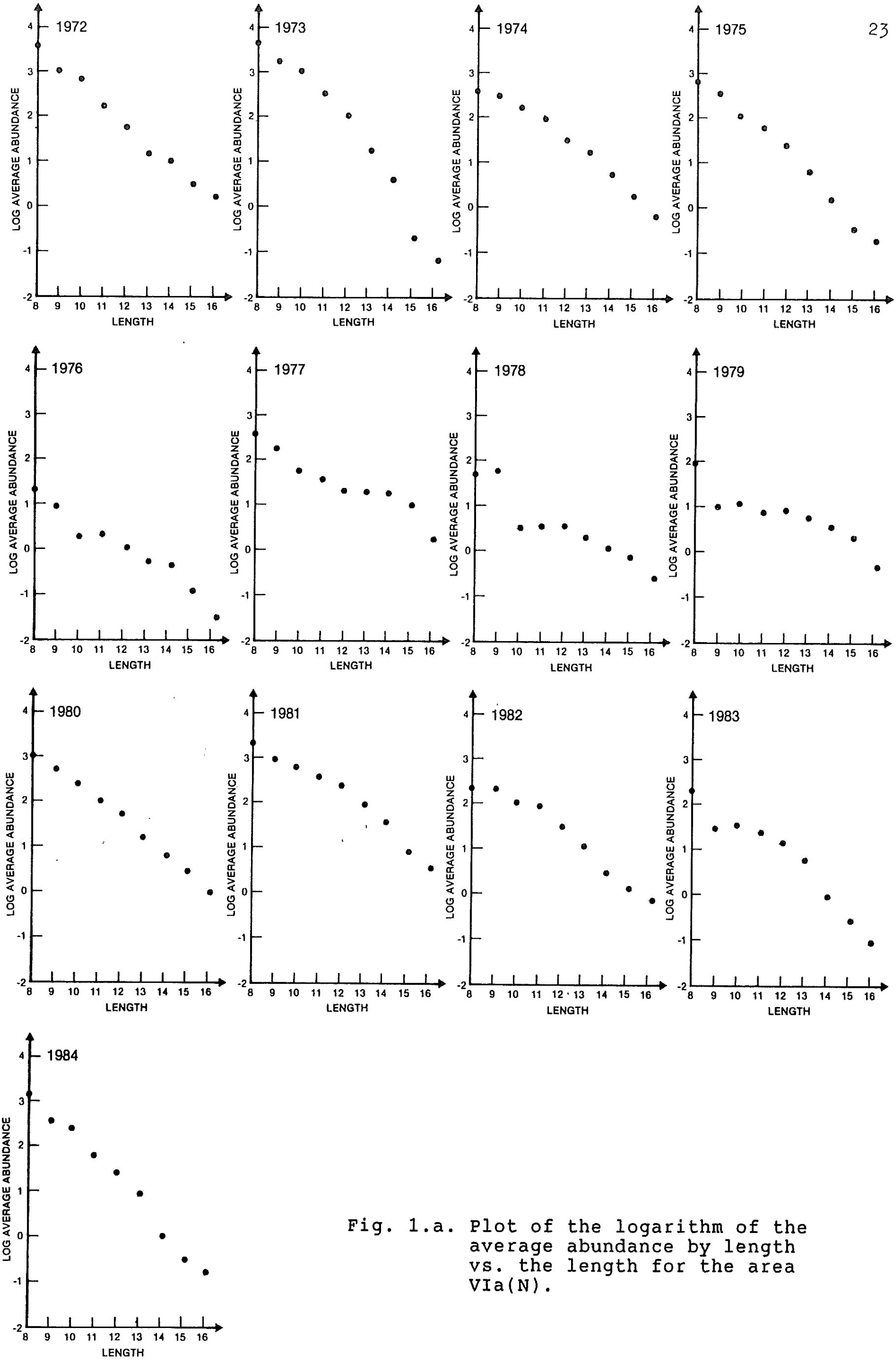


Fig. 1.a. Plot of the logarithm of the average abundance by length vs. the length for the area VIa(N).

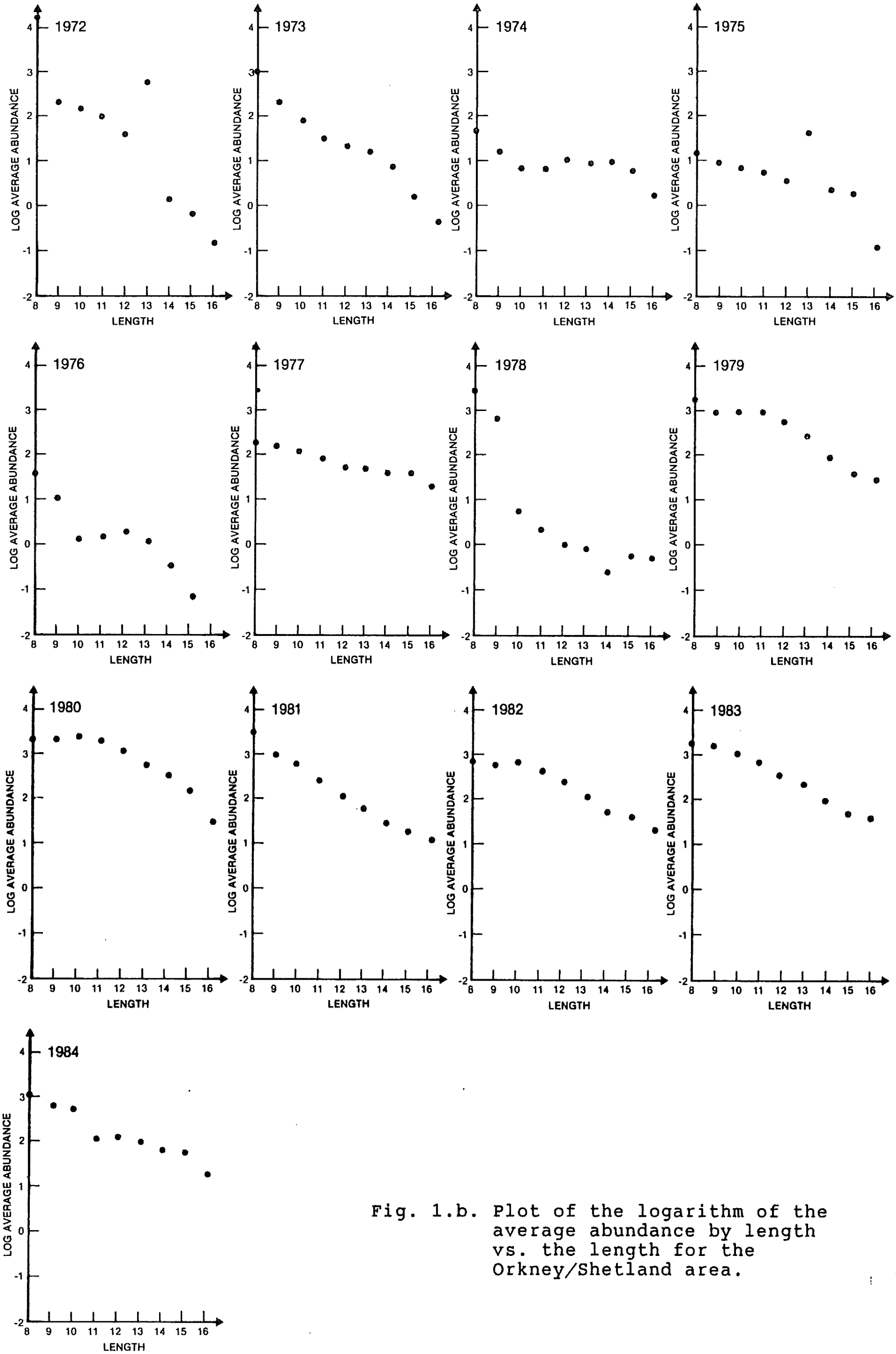


Fig. 1.b. Plot of the logarithm of the average abundance by length vs. the length for the Orkney/Shetland area.

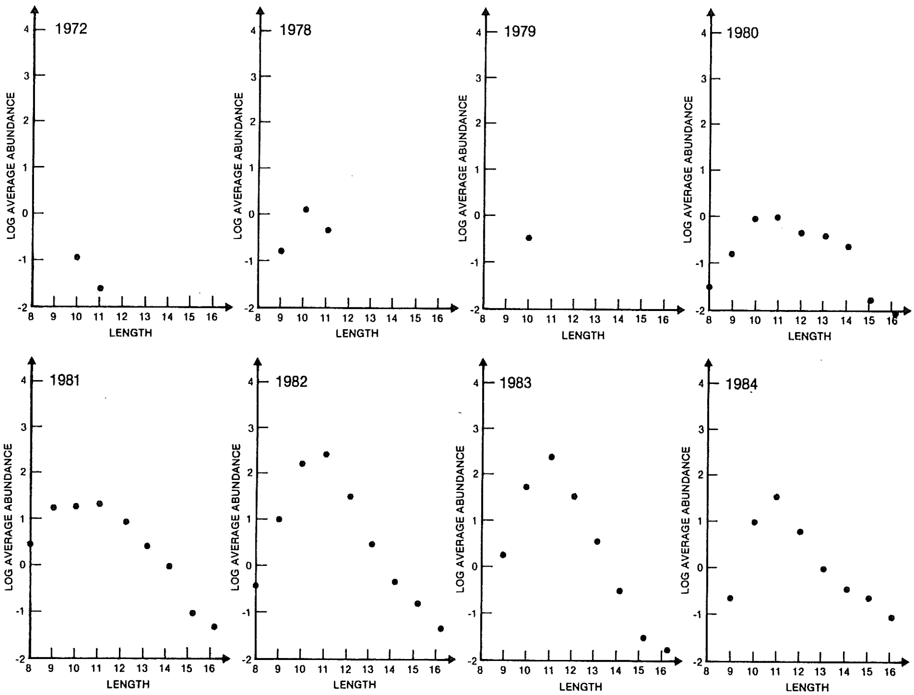
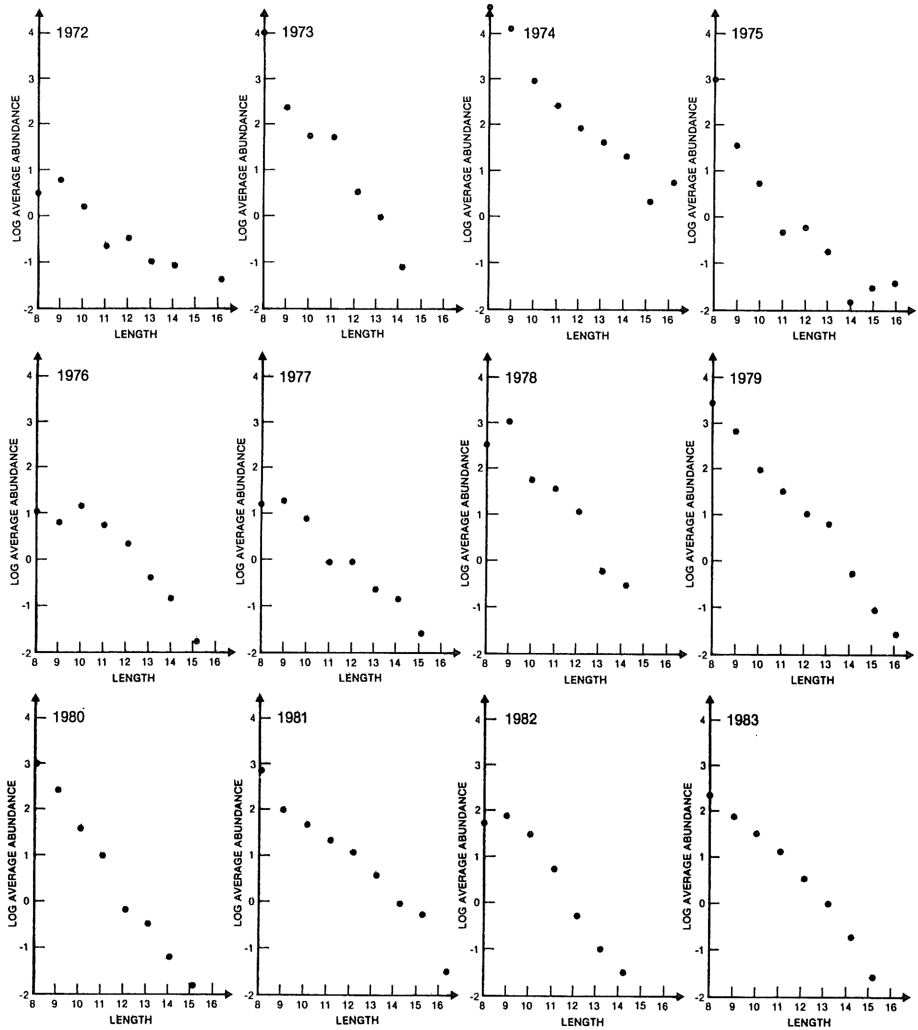


Fig. 1.e. Plot of the logarithm of the average abundance by length vs. the length for the area IVc+VIId.



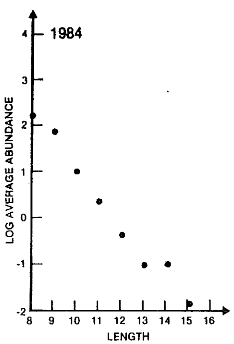


Fig. 1.f. Plot of the logarithm of the average abundance by length vs. the length for the area VIa(S).

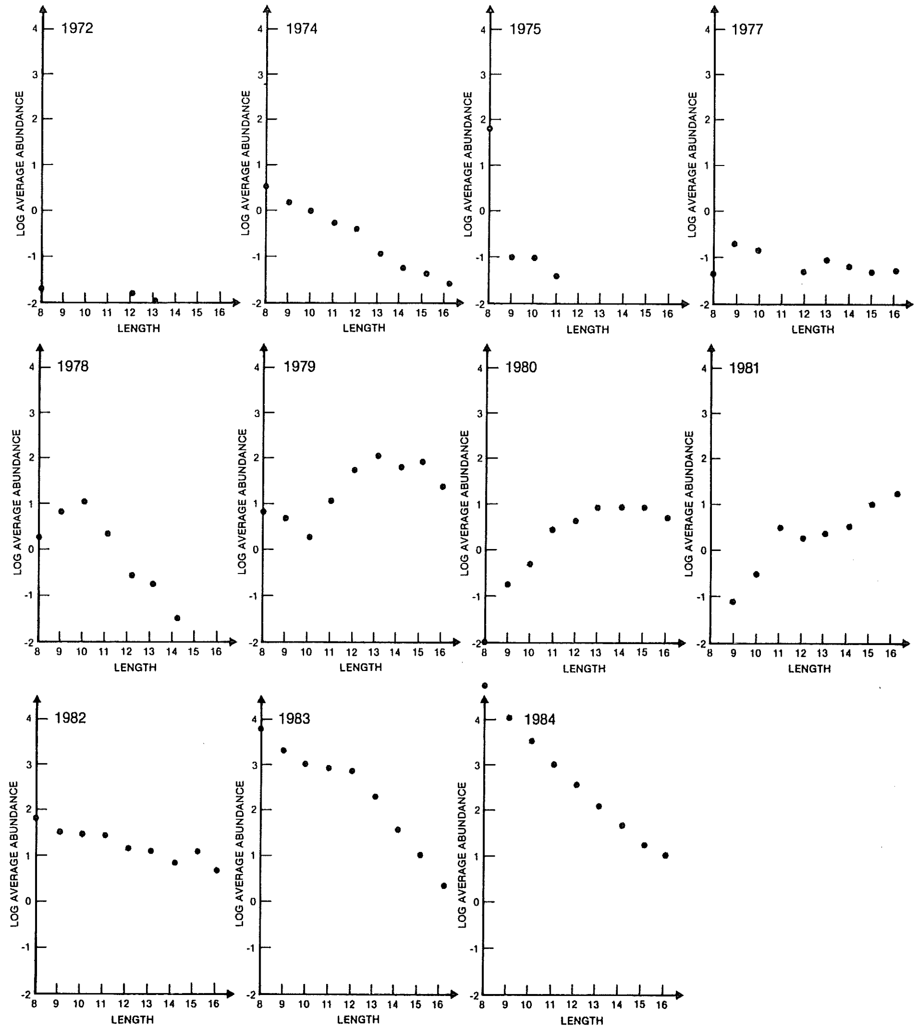


Fig. 1.c. Plot of the logarithm of the average abundance by length vs. the length for the Buchan area.

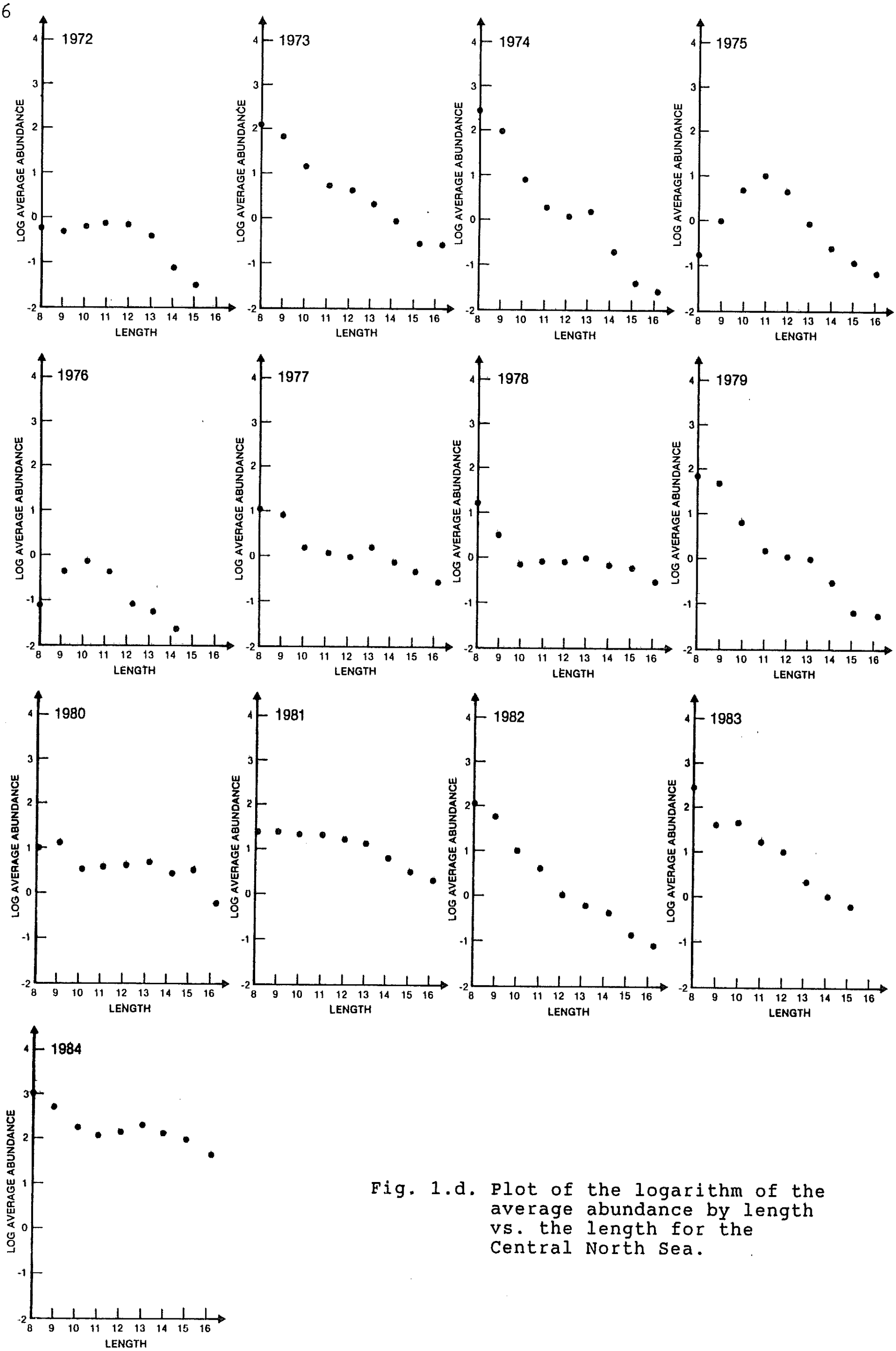


Fig. 1.d. Plot of the logarithm of the average abundance by length vs. the length for the Central North Sea.

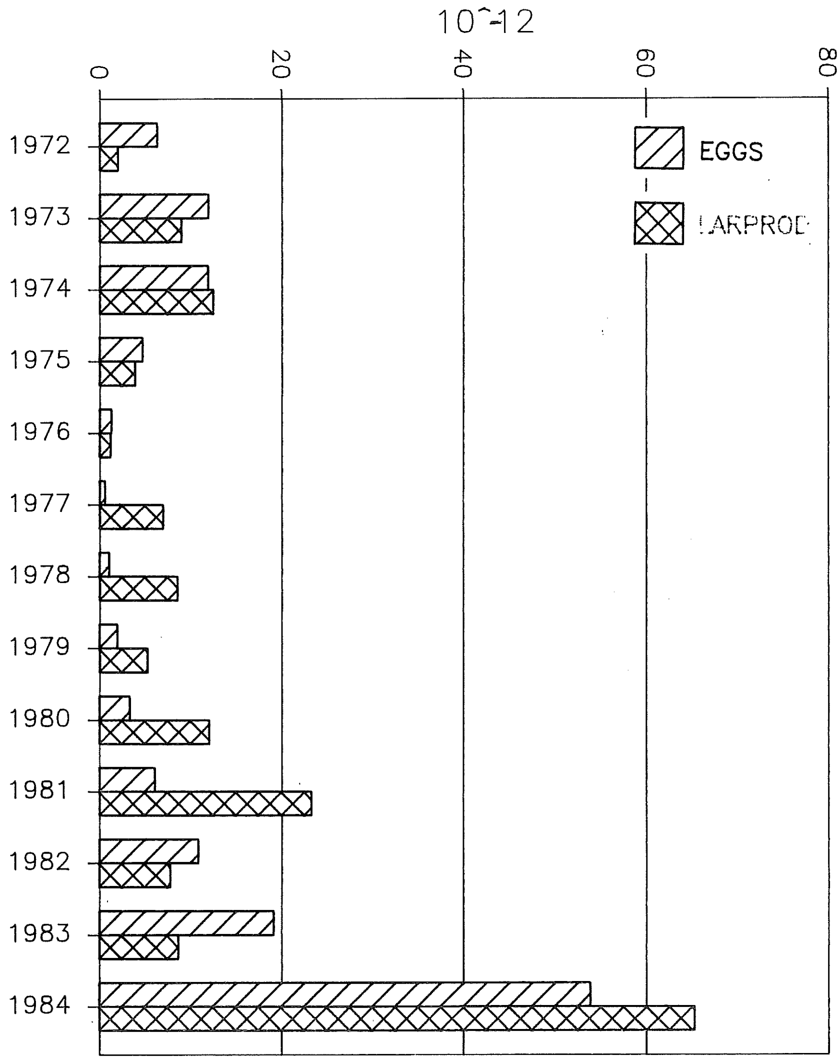


Fig. 2. Potential Egg production ("EGGS" * 10^12) from VPA spawning stock biomass compared with estimates of production of larvae compared to estimated larvae production ("LARPROD" * 10^12) for the Central North Sea, 1972 - 1984.

IVC

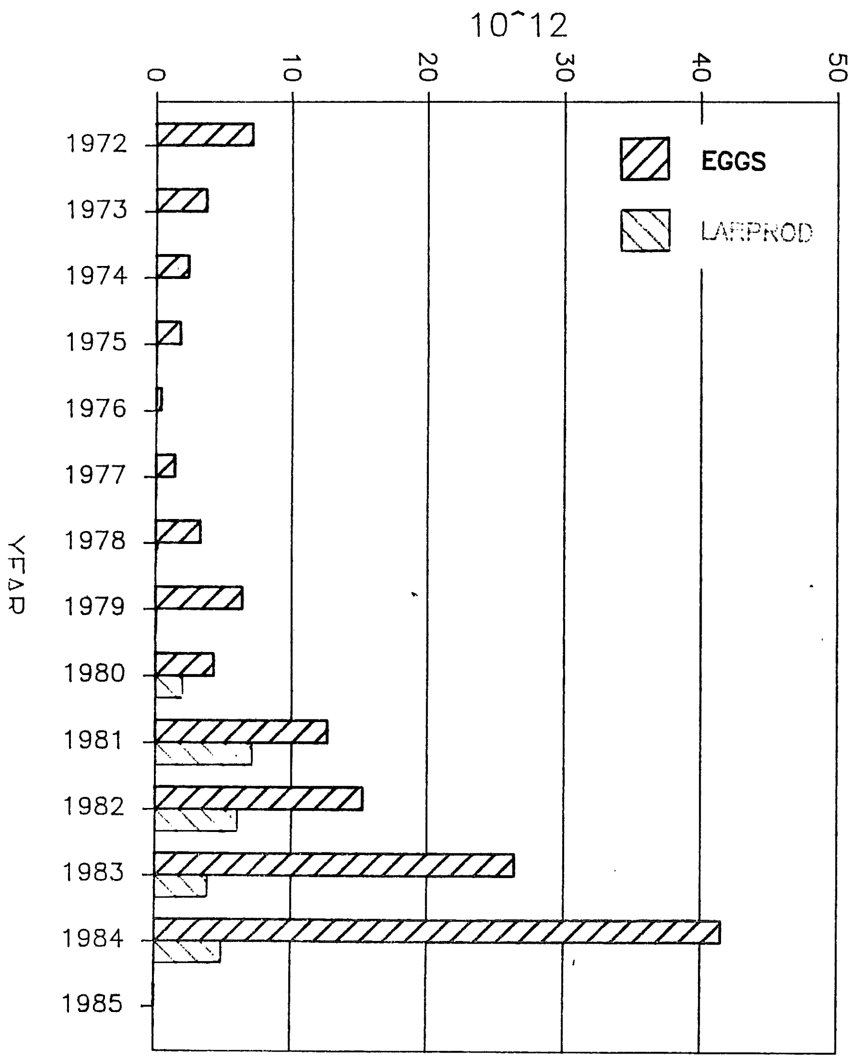


Fig. 3. Potential Egg production ("EGGS" * 10^12) from VPA spawning stock biomass compared with estimates of production of larvae compared to estimated larvae production ("LARPROD" * 10^12) for area IVc + VIId, 1972 - 1984.

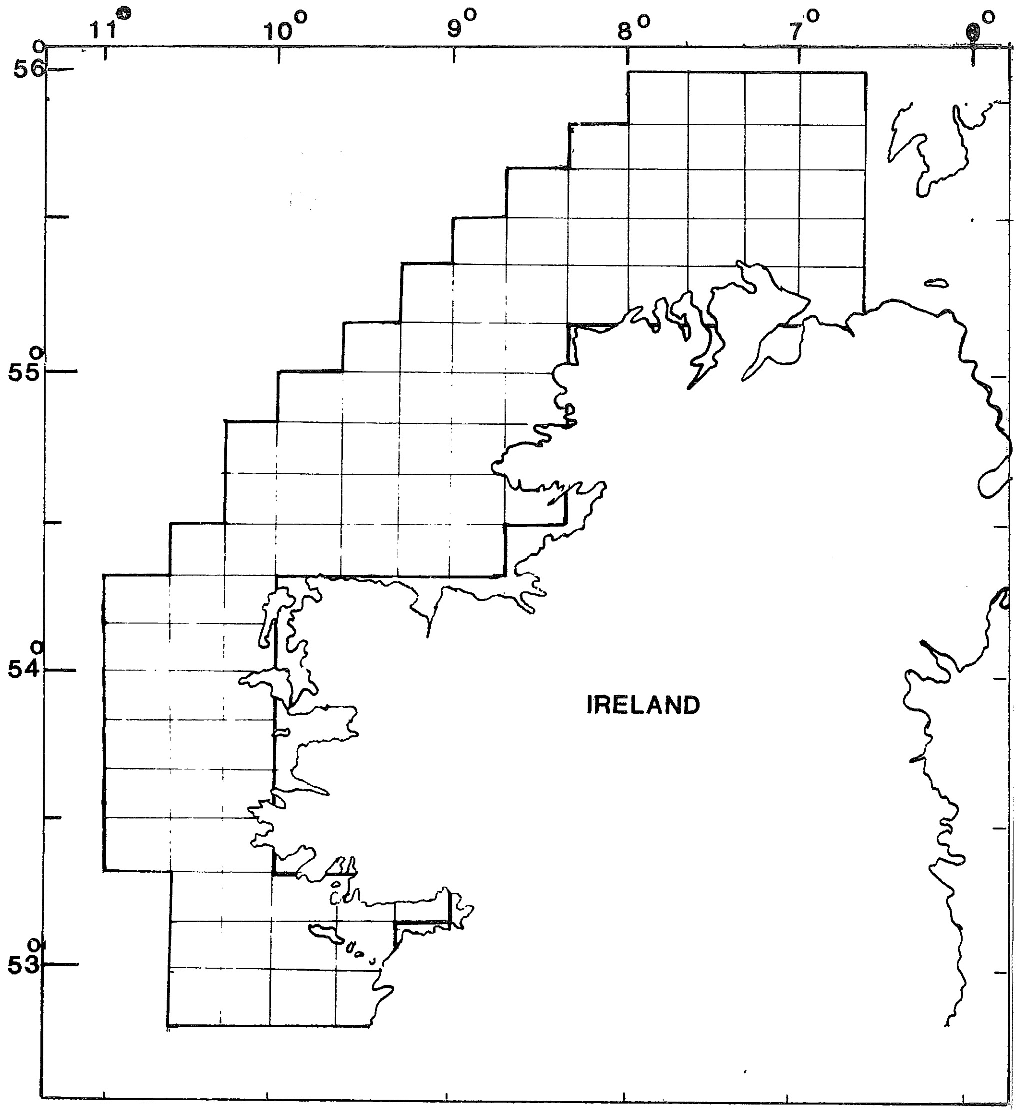


Fig. 4 Herring Larvae Survey standard area for north and west of Ireland. Divisions VIa (South) plus VII b,c. October and November