INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

C.M. 1986/G : 54
Demersal Fish Committee
Ref. Pelagic Fish Committee
Sess. X

APPLICATION OF THE RESULTS FROM INTERNATIONAL YOUNG FISH SURVEYS IN FISHERIES MANAGEMENT IN RECENT YEARS

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Abstract

Recruitment estimates derived from the International Young Fish Surveys have been used extensively in recent years in setting TAC's for North Sea herring, haddock, and whiting. For other species, IYFS abundance indices have been less useful, either because of a poor correlation between IYFS and VPA (cod), or because the fishery is mainly exploiting 1 year old fish (Norway pout, sprat) and TAC's have to be set before recruitment forecasts are available.
There is still considerable room for increased application of survey results, particularly the abundance indices for 2 year old roundfish and herring. When using IYFS indices for predicting year class strength, working groups should indicate the confidence interval of the predicted value, in order to avoid a false impression of precision.

1. INTRODUCTION

The International Young Fish Survey (IYFS), conducted each February in North Sea, Skagerrak and Kattegat is presently one of the largest international research efforts coordinated by ICES. Seven laboratories in 6 different countries participate in this programme, and the total amount of ship time each year is approximately 200 days. The primary objective of the survey is to provide annual forecasts of recruitment in the various commercial fish species of the North Sea and Skagerrak/Kattegat.

This paper considers the value of the survey indices as estimators of recruitment, and sometimes of total stock size, in the various fish species. As such, it is an extension of a similar review presented in the report of the Working Group on International Young Fish Surveys (Anon., 1985a). Apart from considering the use of survey results in a bit more detail, this paper also presents some personal views on the usefulness and future potential of the survey.

The review presented in this paper is limited mainly to the direct application of survey results for management of commercial species. However, in addition to abundance indices for commercial species, the IYFS also produces a wealth of information on the distribution and abundance of a large number of by-catch species. This information, which is presently also being stored in the IYFS data base in Copenhagen, will be useful for monitoring long term changes in the North Sea ecosystem, and thereby indirectly have a bearing on the management of commercial species.

Another important use of the survey not further discussed here, is the collection of synoptic hydrographical data and of specific biological data such as food consumption in various species. The latter information has been used extensively by the ICES Multispecies Assessment Working Group (Anon., 1986a), and the conclusions of the Working Group concerning predation mortality on younger age groups have been most valuable in roundfish and herring assessment.

Before discussing the present use of survey results, a brief history of the survey is presented. This illustrates how the objectives of a primarily biological survey have been amended over the years to establish a programme which is now an important tool for fisheries management.

Details on the methodology of the survey can be found in the Survey Manual (Anon., 1986b).

2. A BRIEF HISTORY OF THE IYFS

The IYFS has a long history, going back to the years 1960/61, when the first large international surveys were organised under ICES auspices. These first surveys were aimed exclusively at juvenile herring: the distribution of this age group was studied, and it was tried to relate the juvenile herring in the various nurseries to the different adult populations in the North Sea. The purpose of this exercise was to estimate what effect the developing fishery for juvenile herring in the south-eastern North Sea might have on the various adult populations. Although these surveys provided a lot of information on the distribution of juvenile herring, the final objective was not reached because it was not possible to make an accurate split of 1-ringers into racial components (Burd, 1969).

After a short interruption, the surveys were resumed from 1965 onwards, with the more modest objective to obtain annual recruitment forecasts for the combined North Sea herring stocks. In these earlier years, the value of recruitment forecasts for management was limited, mainly because there were no effective international agreements for herring conservation. The main value of recruitment forecasts was to help the industry anticipate next year's catch levels.

Over the years, it was gradually realized that the IYFS (or rather the Young Herring Survey as it was called at that time) could not only provide recruitment forecasts for herring, but also for roundfish species such as cod, haddock, and whiting. A special working group was set up to investigate the usefulness of roundfish data collected during the survey (Anon., 1976). Because the results looked promising, the objectives of the survey were widened to include also the sampling of young gadoid species. This meant that the survey area had to be extended northward, to fully cover the distribution area of juvenile haddock and Norway pout.

During the first years of the survey, it was recommended to use a 78 ft Dutch herring trawl as standard gear. However, this gear could not be operated from slipway trawlers, so most participants used other gears of approximately the same dimensions. This situation was not very satisfactory, and in 1976 a new standard gear was proposed: the French GOV bottom trawl (chalut a Grande Ouverture Verticale). This net was accepted by all participants in the survey, and its introduction has greatly increased the comparability of catch rates, and thereby the reliability of survey indices. A recent analysis of inter-ship variation (Buijse and Daan, 1986) shows that hardly any significant inter-ship differences in catch rate existed in recent years.

The great demand for survey results came with the introduction of the TAC management system in the North Sea around 1975. Suddenly, recruitment forecasts became a vital part of the biological advice for the annual TAC's in various species. ICES assessment working groups, meeting shortly after the IYFS, suddenly became very interested in obtaining recruitment forecasts immediately after the survey. As it was not possible for technical reasons to produce final indices so shortly after the end of the survey (no age-readings were yet available from all participants), it was decided to produce preliminary estimates for the youngest age group in each species on the basis of fixed length criteria (herring < 20cm, cod < 25 cm, etc.). These results were exchanged already while the ships were still at sea, and preliminary indices based on these length categories were available within a few weeks after the end of the survey. Indices for age 2 and older fish were calculated only after all age/length data had been analysed; these results were normally exchanged later in the year, so they were not available to the assessment working groups meetings shortly after the survey.

In the early 1980's the decision was taken to exchange survey results on magnetic tape instead of on the traditional paper record forms. The switch to automatic data processing, however, turned out to be far more complicated than was expected. In the following years, many participants had great problems in providing error-free tapes, and also the development of computer programs for data analysis took much longer than was foreseen. As most participants had stopped the exchange of data in the traditional format in 1983, the result was that no final survey results became available from 1983 onwards. Only in 1986, a first attempt could be made to analyse computerized data from the 1983-85 surveys (Anon., 1986c).

While the original attempts at collecting and analysing computerized data were made at the Dutch laboratory in IJmuiden, it was decided in 1982 to shift this task to ICES headquarters in Copenhagen, and to set up a IYFS data base at this place (Anon., 1982a). Also this attempt at computer processing of survey results was no immediate succes. Even at this stage (summer 1986), the data base is not yet fully operational, and assessment working groups in 1986 still had to work with preliminary indices, calculated directly after the survey by the participants themselves.

One of the main causes for the delay in computer processing was the decision that the new data base should not only contain the usual age/length data for a selected number of commercial species, but also a large amount of additional information on length distributions of all fish species caught. The idea was to increase the use of the survey by having access to much more of the material collected. However, the expansion of the volume of data to be handled greatly slowed down the process of data exchange and analysis, with the result that the primary objective - providing timely recruitment forecasts on the few commercial species - has not yet been achieved. This bottleneck is presently being reviewed, and in future surveys extra provisions must be made to have abundance indices for commercial species quickly available, even if automatic data processing systems might fail again.

A recent development in herring forecasting has been the addition of a plankton sampling programme to the IYFS. This extra programme is aimed at herring larvae of 5 months old, which are sampled by means of an Isaacs-Kidd Midwater Trawl (IKMT).

3. IYFS INDICES AS ESTIMATORS OF DIFFERENT AGE GROUPS IN NORTH SEA SPECIES

The IYFS Working Group in 1985 reviewed the available data on the relationship between IYFS indices and VPA estimates of year class strength for the various species (Anon., 1985a). The resulting plots and regression equations are reproduced here in Figures 1-13. It has not been attempted to update these plots and regressions, as this work will be done during the next meeting of the Working Group. The results of the plots shown in Figures 1 - 15 may be summarized as follows:

Herring (Figure 1,2)

For 1-ringers a good correlation exists between IYFS indices and VPA estimates. Many attempts have been made to split the IYFS index for this age group into racial components, in order to obtain separate recruitment forecasts for the individual North Sea populations (the southern North Sea population has been treated as a separate management unit in recent years). However, although there are small differences in meristic characters between the various populations, these differences are too variable from year to year to use them at the time of the IYFS when the pure stock characteristics of the recruiting year class are still unknown.

The relationship for 2-ringers has not been investigated in recent years. It was assumed that schooling habits of older herring would lead to an increased inter-haul variance, and thereby to a larger error on the survey mean. Also, the older herring will probably be distributed in deeper water, where they have a more pelagic distribution, and are less vulnerable to a bottom trawl. Still, it would be advisable to review existing data to make sure that the 2-ringers index really cannot be used to update the first estimate based on 1-ringers.

The results of the IKMT programme suggest that the abundance of larvae at an age of 5 months might be used as a first indication of year class strength (Figure 2). It is not to be expected, however, that recruitment forecasts based on larval abundance will ever obtain the same precision as the estimates based on 1-ringers, due to the high and variable natural mortality that the year class will experience after the time of IKMTsampling. Still, the IKMT index might be quite useful for management, as an early warning against weak year classes.

Cod (Figures 3,4,5)

For age 1, the regression between IYFS and VPA is not significant. When a logarithmic transformation is applied to both parameters (ln(x+1)), the regression becomes significant. The value of this regression for recruitment forecasting, however, is questionable (see section 6).

For age 2, a significant regression is obtained between IYFS and VPA.

Haddock (Figures 6,7)

Significant correlations between VPA and IYFS exist for both age 1 and age 2.

Whiting (Figures 8,9)

Significant correlations between IYFS and VPA exist for age 1 and age 2. However, the intercept on the Y-axis is high in both cases (50% of an average year class in age 1). This limits the value of the regressions for prediction purposes.

Sprat (Figure 10)

VPA values of year class strength are of doubtful value because of the uncertain, but presumably very high values of natural mortality. Therefore, no attempts have been made to correlate IYFS indices with VPA estimates, but instead IYFS indices have been correlated with the catches at age 1 and age 2 of the corresponding year class. This gives a significant correlation if year class 1978 is omitted (probably underestimated due to unusual weather conditions during the 1979 survey, see Anon., 1985a).

Norway pout (Figures 11, 12)

A significant correlation between IYFS and VPA exists at age 1. Also there is a good correlation between the IYFS index for age 1+2, and the annual catch in the year of the survey. In the latter case, the IYFS is used not only to estimate recruitment, but also to estimate total stock size.

Mackerel (Figure 13)

There is no significant correlation between IYFS and VPA. However, all recent year classes have been extremely small, and the available set of data is really inadequate to investigate a possible relationship over the range of potential year class sizes.

4. APPLICATION OF SURVEY RESULTS IN FISHERIES MANAGEMENT IN THE NORTH SEA

Table 1 shows the different sources of information that have been used by ICES assessment working groups over the last 5 years for estimating recruitment in the various North Sea stocks. It is seen that IYFS indices have played a major role in most species. The utilisation of IYFS data in assessments of different species is considered in more detail below.

4.1. Herring

It is in this species that the IYFS has really paid off. For more than 10 years now, the ICES Herring assessment Working Group has relied completely on the results from this survey for predicting incoming year classes, and the advice based on the IYFS indices has lead to far-reaching management decisions. For example, the appearance of the weak 1974 year class in the 1976 IYFS greatly strengthened the Working Group's case for a closure of the entire North Sea herring fishery, and this closure was indeed put into effect in 1977. During the period of the closure, the IYFS was the only instrument to monitor the strength of the incoming year classes, and the decision to open the fishery in 1983 was taken following the appearance of the strong 1980 year class in the 1982 IYFS. The expansion of the fishery in subsequent years was controlled (to some extent) by TAC's, set largely on the basis of recruitment estimates from the IYFS.

The most recent TAC advice for northern and central North Sea herring given by ACFM is 600 000 tonnes for 1987. This advice is based on a stock estimate of 2.3 millon tonnes at the beginning of the year, of which 67% (in weight) are 2- and 3-ringers. This component has been estimated entirely on the basis of IYFS indices.

A problem in forecasting herring recruitment is that the IYFS indices for the two most recent year classes (3227 for year class 1983, and 3613 for year class 1984) are far out of the range of values on which the regression in Figure 1 is based. Some caution in extrapolating the relationship between IYFS and VPA is therefore required.

4.2. Cod

The provision of good recruitment forecasts is very important for the cod fishery, as TAC's in recent years were made up for 60-70% of age groups 2+3. This component of the TAC has to be calculated largely on the basis of recruit surveys.

Unfortunately, the IYFS has not been really useful for predicting cod recruitment in recent years. Table 1 shows that the Roundfish Working Group has had great problems in choosing a good method for predicting recruitment; the Working Group tried a different method nearly each year!

There were two reasons why the IYFS information did not satisfy the needs of the North Sea Roundfish Working Group: there was no significant correlation between IYFS and VPA at age 1, and there was no timely provision of survey indices for age 2, for which a correlation does exist.

The Working Group originally accepted an apparent correlation between IYFS and VPA at age 1, but the use of this correlation lead to a serious underestimate of the 1979 year class in 1980 (the year class was underestimated by 50%). In later years, they became much more cautious, and sometimes (in 1982 and 1984) completely ignored the IYFS index, and assumed average recruitment. In 1983, the IYFS index was extremely low, and the Working Group took this as an indication of a weak year class. In 1985 the IYFS Working Group found that a signifant correlation between IYFS and VPA could be obtained if a log transformation was applied to both parameters (Anon., 1985a). Subsequently, the regression based on log-transformed data was used in 1985 for predicting recruitment. How accurate this forecast was, remains to be seen. In 1986, the Working Group discovered a trend over the years in the ratio between VPA and IYFS, which could be considered as a change in the catchability coefficient (Q). They took the value of Q over the most recent years to correct the 1986 IYFS index, before predicting the year class size.

Whereas there are some serious problems in using the IYFS index for age 1, there may be better prospects for using the IYFS index for 2 year old cod. The International Gadoid Survey Working Group in 1981 discovered that IYFS indices of age 2 were strongly correlated with VPA estimates of the same year class, and therefore could be used very well for revising the year class estimate made one year earlier (Anon., 1981). However, in 1983 it was decided to exchange survey results on magnetic tape, with the result that no survey indices became available at all during subsequent years, except for preliminary estimates for the youngest age group (see section 2). Therefore, the Roundfish Working Group had no choice but to use a variety of other sources to estimate the abundance of 2 year old cod. None of these estimates is probably equivalent to the IYFS forecast, since the IYFS covers a wider area, and potentially provides the most up-to-date estimate.

4.3. Haddock

A good correlation exists between IYFS and VPA; yet this correlation has hardly been used for prediction purposes so far. The reason was that the Roundfish Working Group had frequent doubts about the applicability of linear regression techniques because of expected changes in efficiency, catchability, or non-linear relationships in the range of larger year class sizes.

In 1982, the Working Group suspected an increase in efficiency during the survey. Consequently, the IYFS index for age 1 was not used. The next year, worries about increasing efficiency seemed to be forgotten, but now the

Working Group suspected a curvi-linear relationship between IYFS and VPA. Therefore, no regression line was calculated, but the year class size was estimated by inspecting the scatter diagram of VPA on IYFS indices. The Working Group chose this procedure to make it clear that the IYFS/VPA relation could only be used to predict the order of magnitude of the new year class, and not its exact size. The procedure of estimating the year class by eye from a scatter diagram was repeated in 1984.

In 1985, the Working Group used a predictive linear regression (the one given here in Figure 6). The next year, however, the Working Group suspected an increase in catchability of haddock, and decided to drop again the linear regression mentioned above. Instead they used the mean ratio between IYFS index and VPA value for the 3 most recent years, to convert the IYFS index into a VPA value.

For age 2, the same problem occurred as with cod. A reasonable correlation exists between IYFS and VPA, but IYFS indices for age 2 have not been available in recent years, due to the technical problems mentioned in section 2. Only in 1983, the 2 year-old haddock could be estimated directly from an index for this age group from the IYFS.

4.4. Whiting

The prediction of whiting recruitment by the Roundfish Working Group followed exactly the same pattern as discussed for haddock above. So in 1982 the survey index was not used because of a suspected increase in efficiency; in 1983 and 1984 year class strength of 1 year-olds was estimated from a scatter diagram of IYFS versus VPA; and in 1985 from a predictive linear regression. In 1986 they found no trend in catchability over the years, (in contrast to the situation in cod and haddock). For the sake of uniformity, however, they also corrected the IYFS index with the mean catchability coefficient, which in this case was calculated over the entire historic data series (1971-83).

As in haddock, a good correlation between IYFS and VPA also exists at age 2, but again this relationship has not been used in recent years because no IYFS indices of 2-year olds have become available in time.

4.5. Sprat

In a short-lived species as sprat, the recruiting year class constitutes the bulk of the catch in the year of the survey. In recent years, age 1 sprat have on average made up 50 - 70% of the annual catch in weight.

The Industrial Fisheries Working Group has concentrated its attention on the relationship between age 1 sprat in the IYFS, and the catch of the same year class in the following season (i.e. from 1 July to 30 June the following year). The index for age 1 was normally estimated on the basis of a fixed length criterium (< 10 cm).

The most popular way to use IYFS indices for catch prediction in recent years was the SHOT method, in which the catch in the forthcoming year is estimated partly on the basis of last year's catch, and partly on a recruitment prediction (Anon., 1984a). The general formula for a SHOT prediction is

$$Y(t) = a.Y(t-1) + b.R$$

in which Y(t) = predicted catch in forthcoming year
Y(t-1) = catch last year
R = recruitment index
a = average proportion (weight) of older fish in catch
b = constant

The SHOT method predicts the catch in the forthcoming year if fishing mortality is kept unchanged. In case one would like to reduce F, the TAC should be set below the SHOT prediction.

In practice, no effective conservation measures were taken in the sprat fishery in recent years. TAC's were set at levels which were never attained by the industry. An important practical problem was that TAC's had to be set before the start of the calendar year, whereas the IYFS index became available only in March of the year when the fishery was already taking place. One cannot blame fisheries managers for the fact that TAC's were set above catch levels predicted by the SHOT method; the SHOT estimates were never available at the time when decisions about TAC's had to be taken.

4.6. Norway pout

Most of what was said above about sprat also applies to Norway pout. Again this is a short-lived species, and the fishery is based mainly on 1 year olds, which on average make up 70% of the catch in weight.

The Industrial Fisheries Working Group has made catch predictions for the same year in which the IYFS was conducted. These were based on the IYFS index for age 1, or for age 1+2. In recent years, the SHOT method was used to predict catches; the predictions being based for 25-30% on last year's catch, and for 70-75% on the IYFS index for age 1.

Although the Working Group has been fairly succesful in making catch predictions for the current year, not much use has been made of these predictions for management purposes. As in sprat, the fishing season is already in full progress by the time the catch prediction becomes available, and TAC's have already been decided the year before.

5. APPLICATION OF SURVEY RESULTS IN DIVISIONS IIIa AND VIa

5.1. Div. IIIa (Skagerrak and Kattegat)

This area is covered each year by the survey, and indices are obtained for a number of commercial species.

Herring (Div. IIIa), Figure 14

Juvenile herring in IIIa are a mixture of local recruits and recruits to the North Sea populations. Consequently, it has not been possible to use the

IYFS index as an estimator of local recruitment. The only parameter that the IYFS index can be correlated with, is the commercial catch of 1-ringed herring in the same year. This is not really relevant for management, at least not for advising a TAC for adult herring.

Cod (Div. IIIa)

Assessments for cod in IIIa are now done separately for Skagerrak and Kattegat. However, the Working Group on Div. IIIa Demersal Stocks at its last meeting did not have separate IYFS indices for these two areas. A very rough procedure was used to estimate 1 year old cod in Skagerrak from a limited amount of IYFS data (Anon., 1986). For Kattegat no information was available , and the 1984 and 1985 year classess were assumed to be of average strength. The Working Group concluded that data and methods for predicting recruitment in this area are far from satisfactory, and that utilisation of IYFS data should be improved.

Haddock (Div. IIIa)

No IYFS indices were available at the last working group meeting. The IIIa Working Group expects, however, to have such data available during future assessments.

Whiting (Div. IIIa)

The IYFS index is not considered a reliable predictor for future landings of this species.

Sprat (Div.IIIa), Figure 15

Like in the North Sea, the VPA for sprat in Div.IIIa is of doubtful value, and the IYFS indices have been correlated with catches in the same year of the survey. Also catches in the fjords along the Norwegian west coast have been included, as these sprat are assumed to belong to the IIIa stock. The correlation obtained is significant, but the regression line has a large intercept (more than 50% of an average year class).

No use has been made of IYFS indices in setting TAC's for this area, mainly because IYFS indices can only predict catches in the current year, and TAC's have to be set long before the time of the IYFS.

5.2. Div. VIa (west of Scotland)

The IYFS doesnot extend into the waters west of Scotland. However, the Roundfish Working Group has found that recruitment in haddock and whiting west of Scotland is correlated with recruitment in the corresponding North Sea stocks. They have therefore used plots of VPA estimates at age 1 in the North Sea against the same age group in VIa, to estimate recruitment in the latter area. As the North Sea recruitment estimates are based on IYFS indices, so are the recruitment estimates for haddock and whiting west of Scotland.

6. FUTURE DEVELOPMENTS

Recruitment forecasts are essential under a management regime that is based on TAC's, especially when a large proportion of the catch consists of the recruiting year class. This situation has existed in most commercial North Sea fisheries in the recent years, and is expected to continue in the foreseeable future. Maybe the contribution of the recruiting year class to the total catch will be slightly reduced in some cases (through a reduction of fishing mortality), but estimates of the recruiting year class will stil remain a vital piece of information for setting TAC's.

In future, the IYFS may be used not only to estimate the recruiting year class, but also the abundance of older age groups. Particularly in the demersal species, older age groups may be estimated just as accurately as the youngest age group, and these direct stock estimates for older age groups could also be quite valuable for stock assessment and TAC advice. A clear example are the IYFS indices for age 2 in cod, haddock, and whiting, which are known to be good estimators of stock size, and which have not yet been utilized. It would be worthwhile to analyse the IYFS data also in respect of age 3 fish and older, to see whether any correlations could be obtained with VPA estimates.

Recruitment predictions, based on IYFS indices have proved to be very valuable in managing herring, and to a lesser extent, haddock and whiting. For cod, the timing of the survey is probably not ideal, and better recruitment indices might be obtained from a survey in the 4th quarter of the year (Heessen 1983).

Concerning the attempts to use IYFS indices for cod.at age 1, it is doubtful whether the use of log transformations will do much to improve the situation. In a case such as here, where there is no good correlation between the untransformed parameters, there probably is a good explanation for this, and the higher correlation found for the log transformed data may result from chance. One has to be careful not to introduce too much sophistication, and create the impression that indices can be used for prediction, while in actual fact the predicted values contain such wide confidence limits that they are useless for management.

In general, it would be advisable if working groups indicate in their advice the precision of their recruitment estimates. The confidence intervals of the predicted VPA estimates may be calculated if a normal predictive regression technique is used. These intervals give at least some indication of the possible error in the recruitment forecast. The awareness of the uncertainties in recruitment estimates may lead to less precise, but more realistic TAC recommendations.

The size of the confidence interval is determined by errors both in the IYFS index and in the VPA estimates. Only the error in the IYFS index can be quite large already. This author (Corten, 1977, 1978, 1979) calculated confidence limits on the survey mean for herring in a number of years. He found that the 90% confidence interval of the survey mean could vary from +/- 35% to +/- 50%. So the real abundance of the year class may differ by more than 50% from the survey mean in one out of every 10 cases.

For the "industrial species" sprat and Norway pout, the survey may give an estimate of total stock size. However, these survey indices have not yet been used for management purposes because of the need to decide TAC's before the results from the IYFS become available. It is not certain whether this situation can be improved in future. Postponing the decision on the ultimate size of the TAC to somewhere halfway through the fishing season would not be an attractive idea for the industry. In fact, the whole idea of managing the industrial species by TAC's may be open for debate. Normal management objectives such as stabilising catches, building up a stock of older age groups, and maximising yield by reducing fishing mortality, are hardly applicable in this case. Because of the high natural mortality, a reduction in F will not automatically result in a large increase in stock size. Fluctuations in stock size are mainly caused by large fluctuations in recruitment, which in turn seem to be determined largely by environmental conditions.

The main value of the IYFS in sprat and Norway pout may be in monitoring changes in stock size. The IYFS provides accurate data on changes in abundance and distribution, which in combination with commercial catch statistics give a nice picture of the long term changes in these stocks. Such changes may be indicative of long term changes in the North Sea ecosystem, which in turn may be relevant to the management of other commercial species.

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Table 1. Sources of information used by ICES assessment working groups to estimate youngest age groups of various commercial fish species in the North Sea.

COD

year	age 1	age 2	reference
1982	average recent years	VPA(1)	Anon., 1982c
1983	IYFS	IYFS	Anon., 1983b
1984	average recent years	VPA(2)	Anon., 1984c
1985	IYFS	EGFS + DGFS	Anon., 1985c
1986	IYFS	IYFS(1) + EGFS	Anon., 1986d

VPA(1) = using catch in last year and assuming average fishing mortality
VPA(2) = using catch in last year and estimating F by means of Rho method
EGFS = English Groundfish Survey
DGFS = Dutch Groundfish Survey
IYFS(1)= previous year's estimate at age 1, reduced by mortality in year 2

HADDOCK

year	age 1	age 2	reference
1982	VPA(1)	VPA(1)	Anon., 1982c
1983	IYFS	IYFS(1)	Anon., 1983b
1984	IYFS	IYFS(1)	Anon., 1984c
1985	IYFS	IYFS(1)	Anon., 1985c
1986	IYFS	IYFS(1) + EGFS	Anon., 1986d

Table 1. Continued

WHITING

year	age 1	age 2	reference
1982	VPA(1)	VPA(1)	Anon., 1982c
1983	IYFS	IYFS(1)	Anon., 1983b
1984	IYFS	IYFS(1)	Anon., 1984c
1985	IYFS	IYFS(1)	Anon., 1985c
1986	IYFS	IYFS(1)	Anon., 1986d

HERRING

year	ring 1	ring 2	reference
1982	IYFS	IYFS(1)	Anon., 1982b
1983	IYFS	IYFS(1)	Anon., 1983a
1984	IYFS	IYFS(1)	Anon., 1984b
1985	IYFS	IYFS(1)	Anon., 1985b
1986	IYFS	IYFS(1)	Anon., 1986c

SPRAT

year	age 1	age 2	reference
1982	IYFS	-	Anon., 1982d
1983	IYFS	-	Anon., 1983c
1984	IYFS	-	Anon., 1984a
1985	IYFS	-	Anon., 1985d
1986	?	-	

Table 1. Continued

NORWAY POUT

year	age 1	age 2	reference
1982	IYFS	-	Anon., 1982d
1983	IYFS	-	Anon., 1983c
1984	IYFS	-	Anon., 1984a
1985	IYFS	-	Anon., 1985d
1986	?	-	

Figure 1. Herring, North Sea.
Relation between IYFS index for 1-ringers and VPA estimate for the same age group.

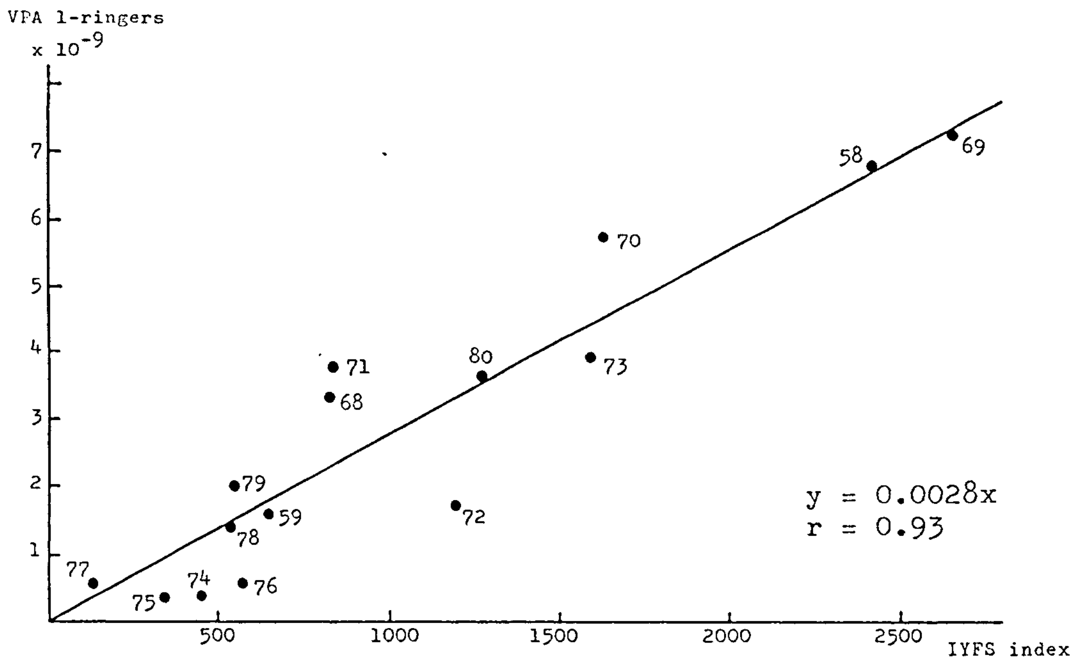


Figure 2. Herring, North Sea.
Relation between IKMT index for 0-ringers and VPA estimate for the same age group.

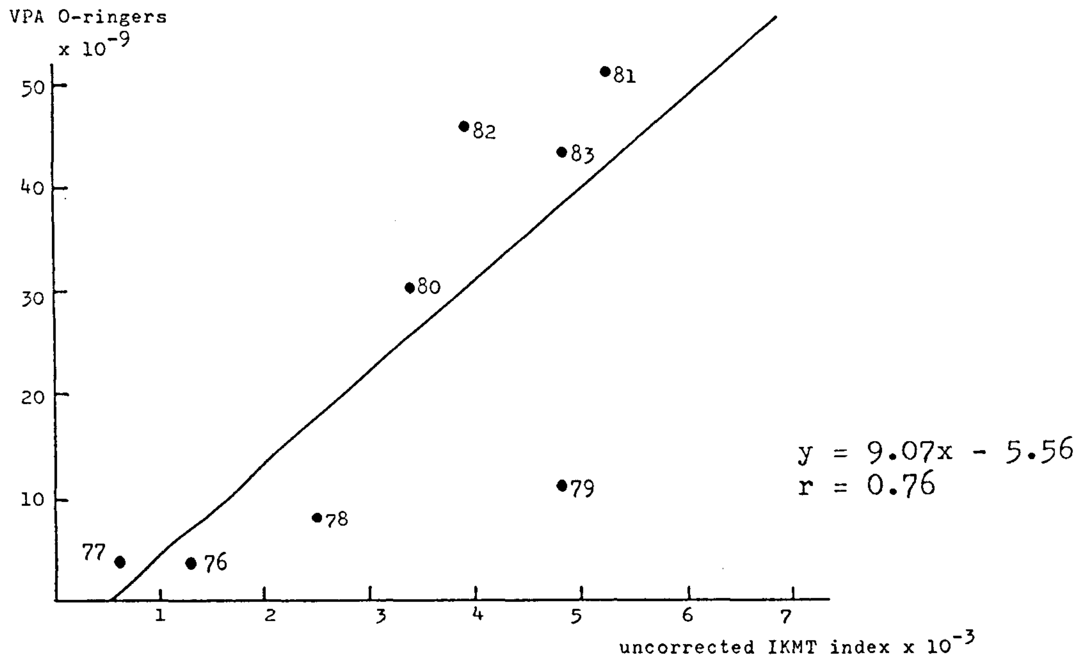


Figure 3. Cod, North Sea.
Relation between IYFS index for 1 year olds and VPA estimate for the same age group.

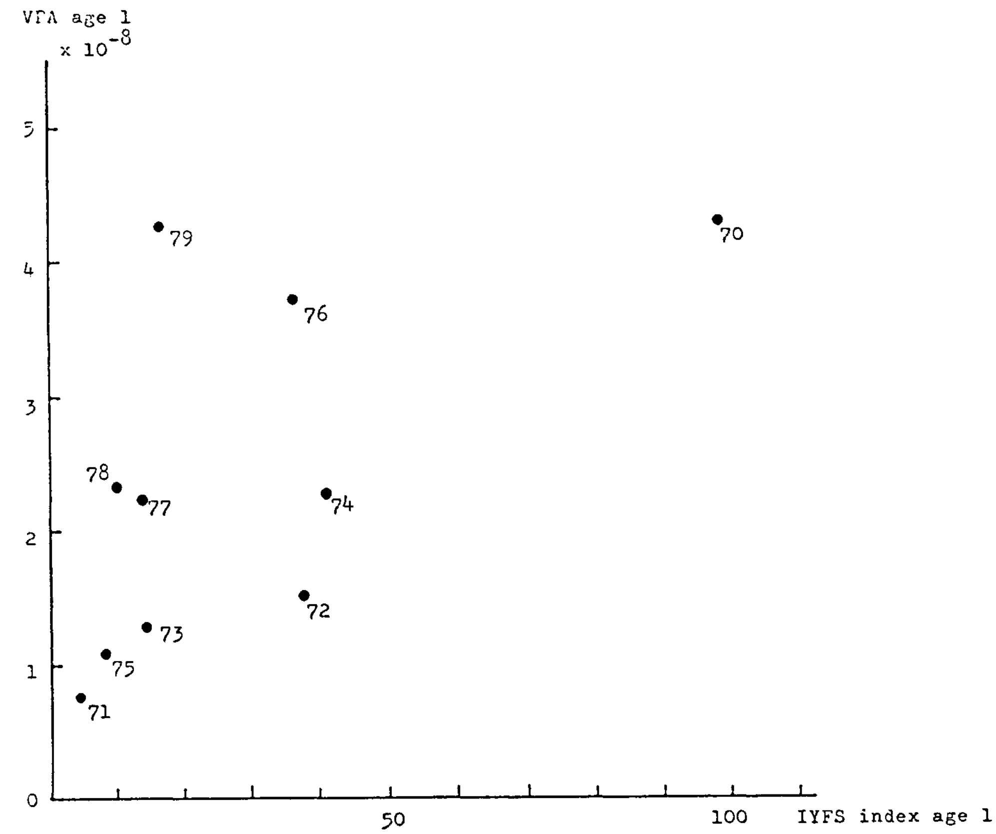


Figure 4. Cod, North Sea.
Relation between log-transformed values of IYFS index for 1 year olds, and VPA estimate for the same age group.

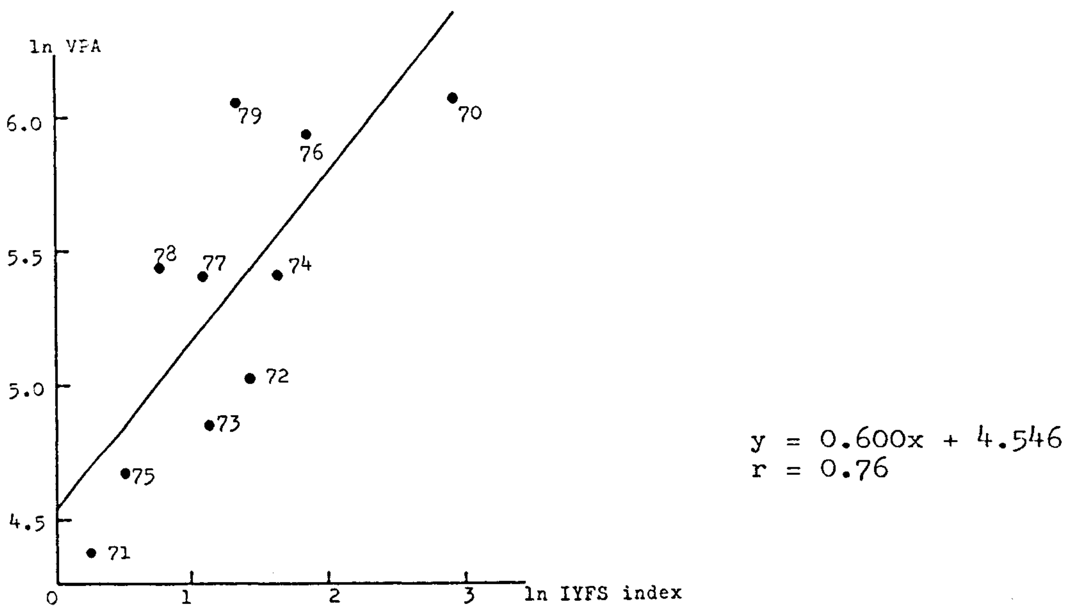


Figure 5. Cod, North Sea.
Relation between IYFS index for 2 year olds and VPA estimate for the same age group.

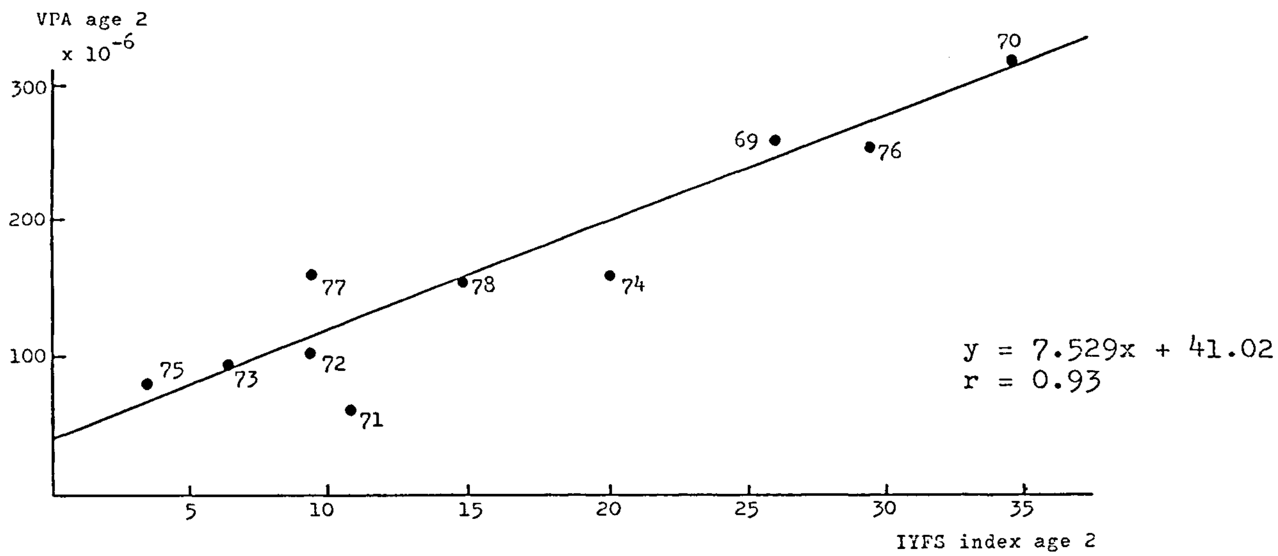
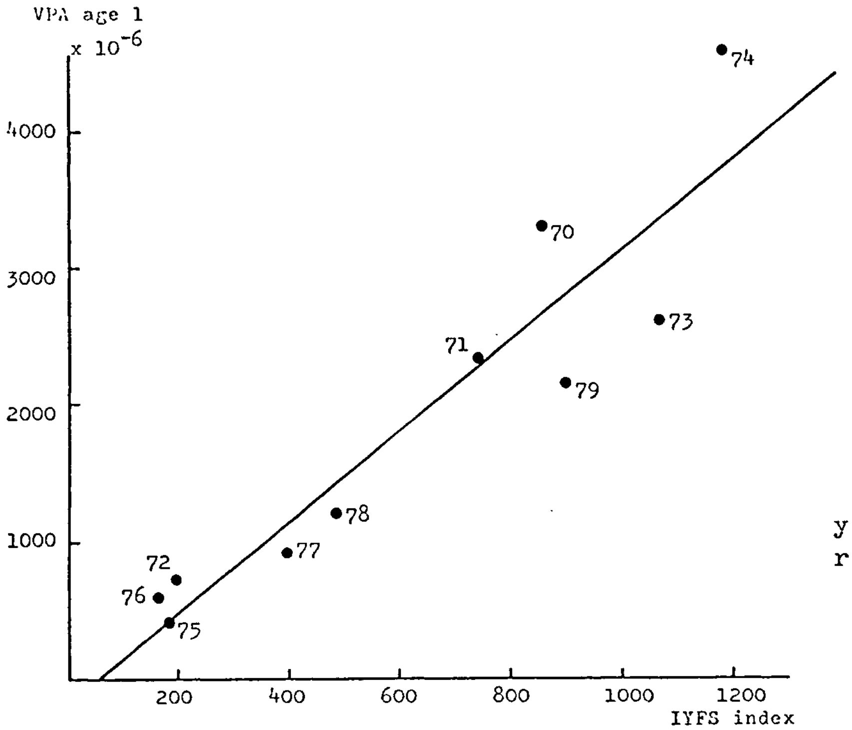
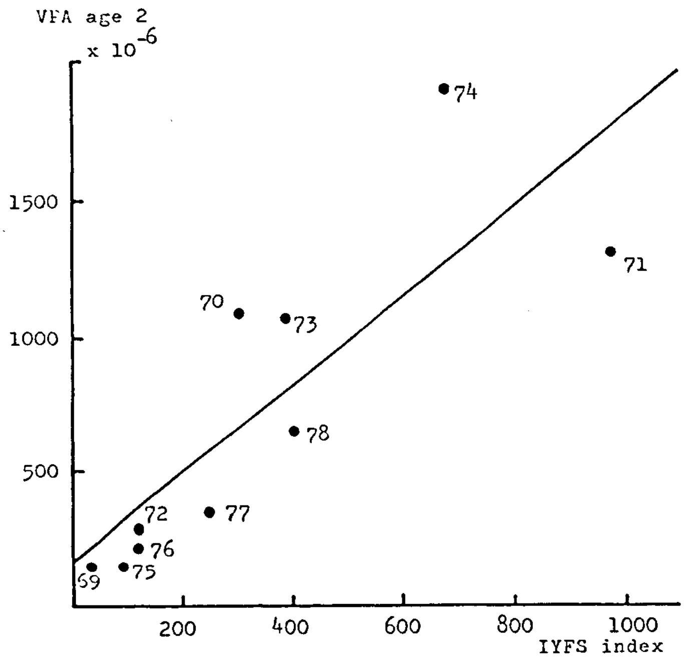


Figure 6. Haddock, North Sea.
Relation between IYFS index for 1 year olds and VPA estimate for the same age group.



$y = 3.311x - 145.15$
$r = 0.93$

Figure 7. Haddock, North Sea.
Relation between IYFS index for 2 year olds and VPA estimate for the same age group.



$y = 1.671x + 166.71$
$r = 0.84$

Figure 8. Whiting, North Sea.
Relation between IYFS index for 1 year olds and VPA estimate for the same age group.

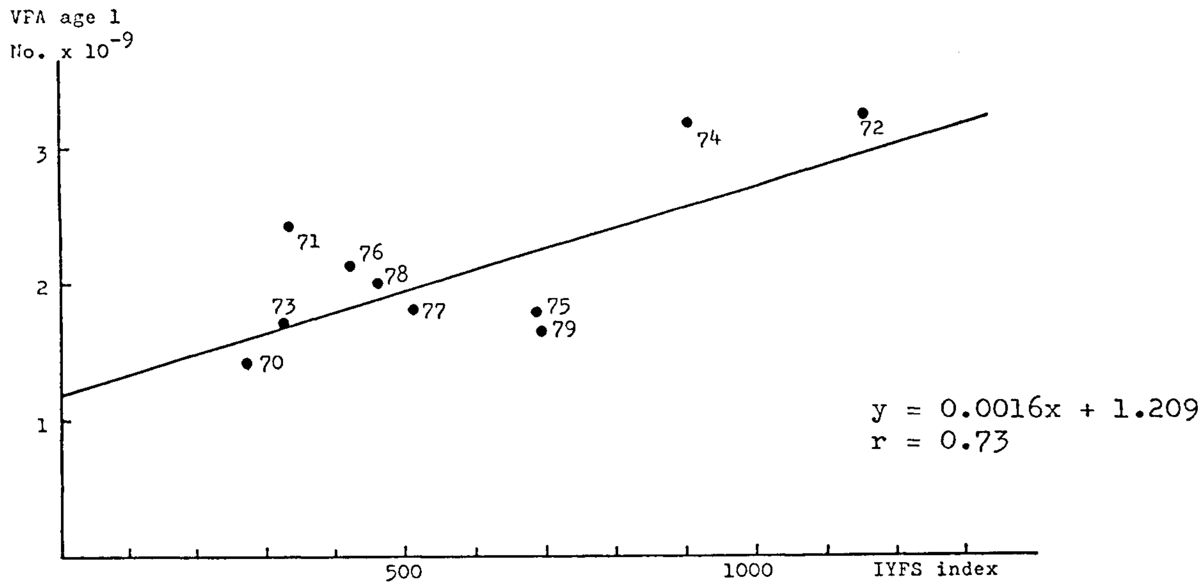


Figure 9. Whiting, North Sea.
Relation between IYFS index for 2 year olds and VPA estimate for the same age group.

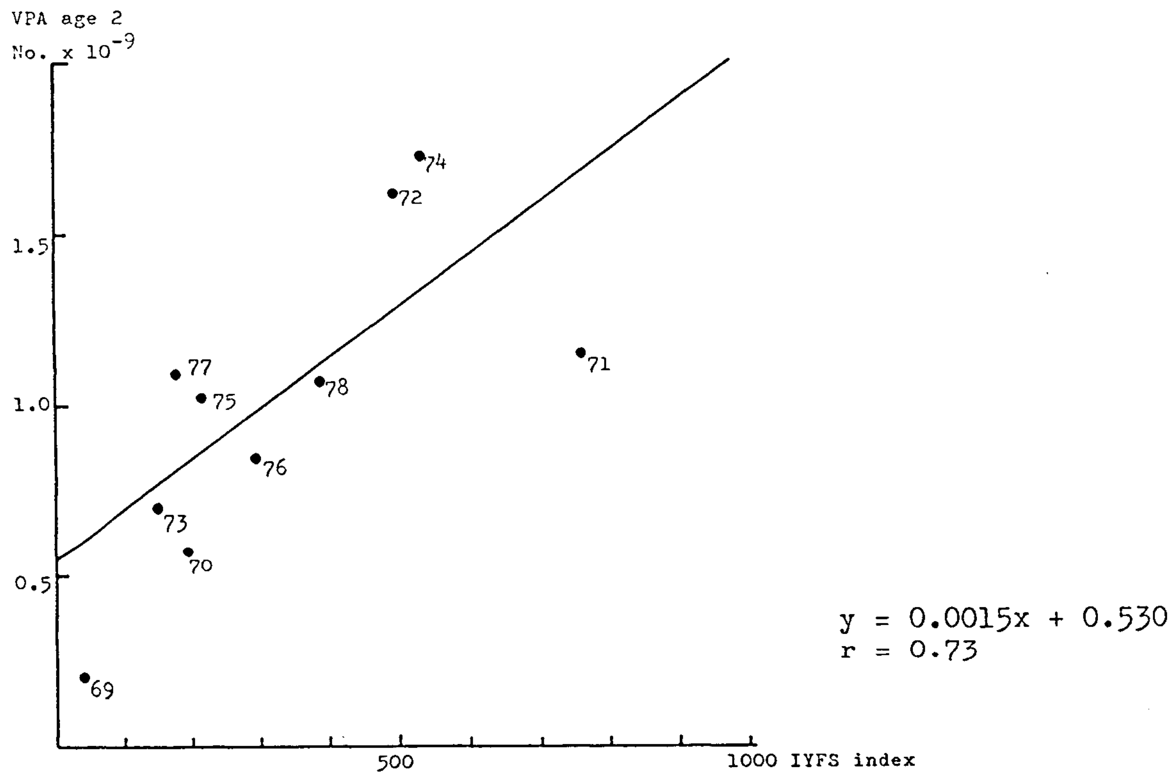


Figure 10. Sprat, North Sea.
Relation between IYFS index for 1-ringers in Division IVb and the catch of 1+2 ringers in the total North Sea.

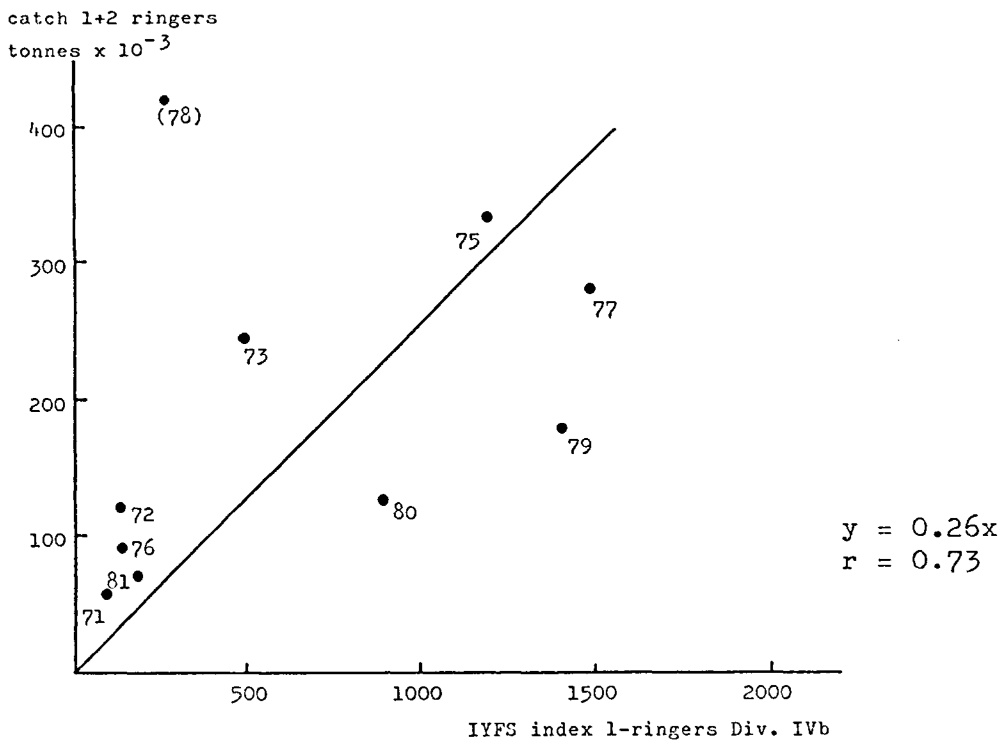


Figure 11. Norway Pout, North Sea.
Relation between IYFS index for 1 year olds and VPA estimate for the same age group.

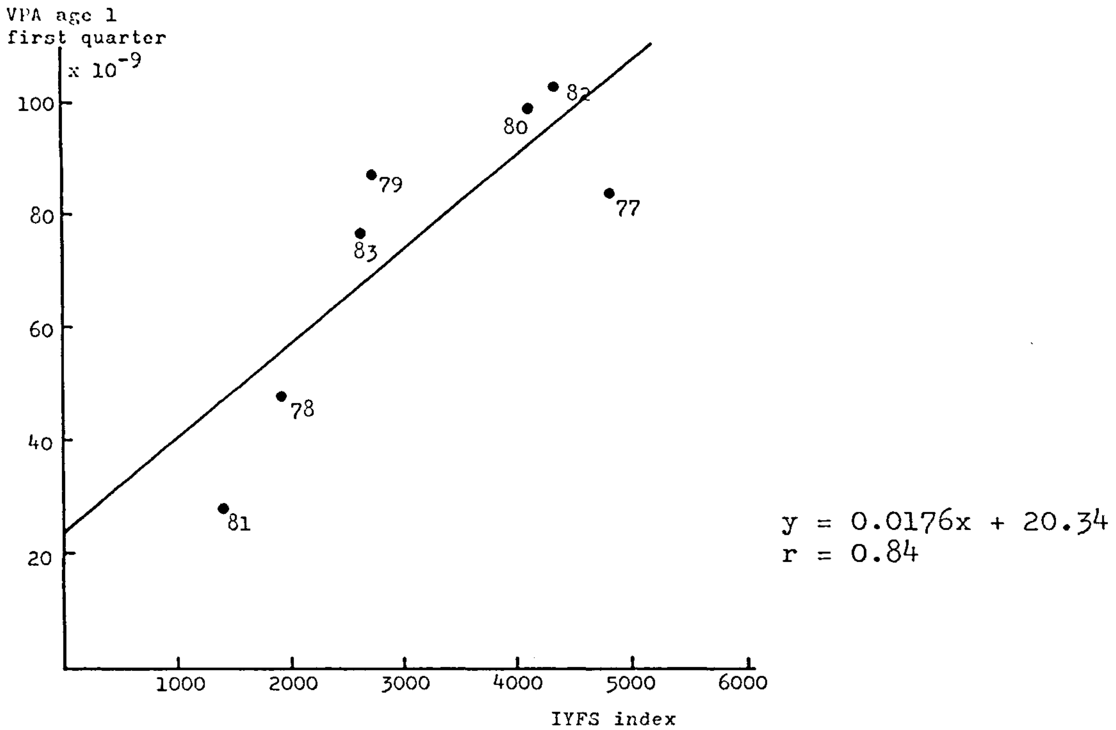


Figure 12. Norway Pout, North Sea.
Relation between IYFS index for 1+2 year olds and annual catch of all age groups.

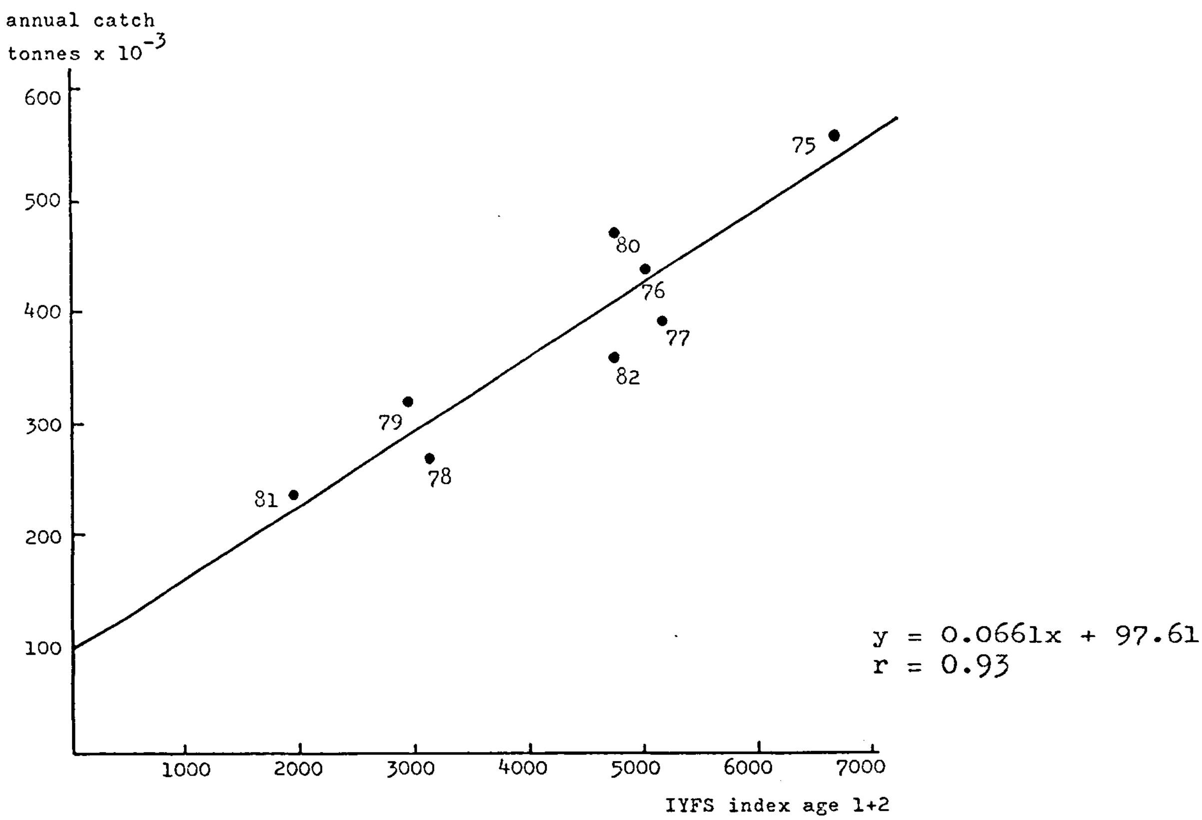


Figure 13. Mackerel, North Sea.
Relation between IYFS index for 1 year olds and VPA estimate for the same age group.

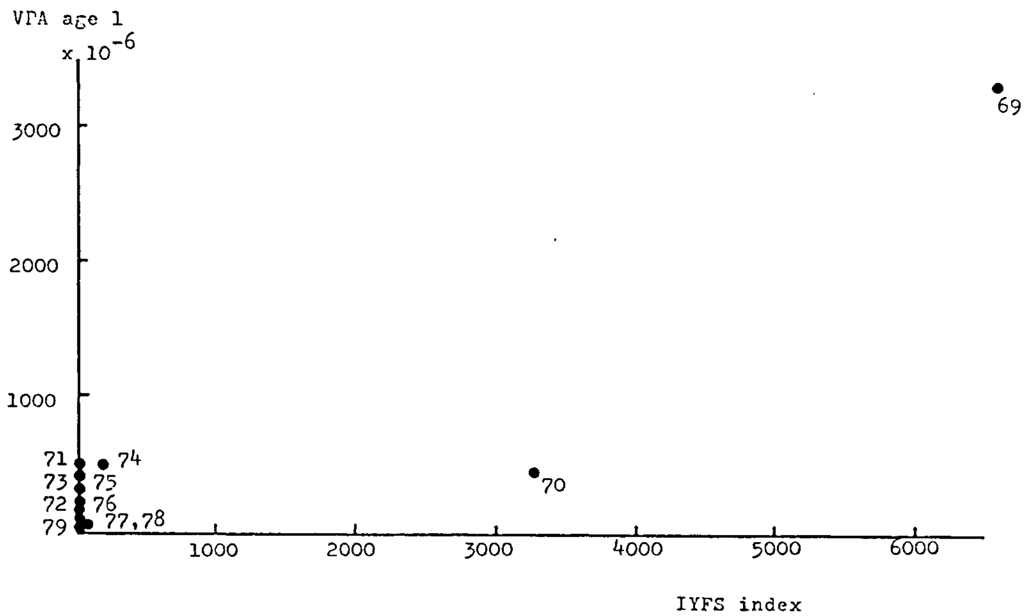


Figure 14. Herring, Division IIIa.
Relation between IYFS index for 1-ringers and catch of the same age group.

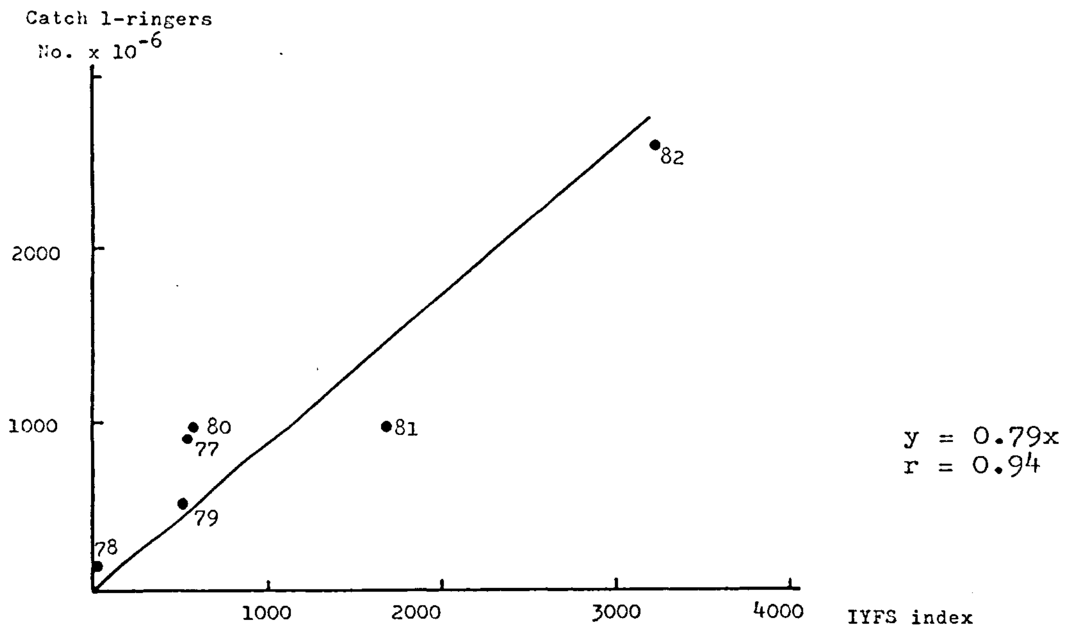


Figure 15. Sprat, Division IIIa.
Relation between IYFS index for 1 year old sprat in Div.IIIa and total annual catch of all age groups in Div.IIIa plus fjords of western Norway.