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Analysis of CPUE from the Norwegian bottom trawl fleet

by

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ABSTRACT

Commercial logbooks with catch and effort data have been collected and recorded by the Norwegian Directorate of Fisheries since 1971. Annual age segregated CPUE indices are calculated with different methods for North-east Arctic cod, North-east Arctic haddock and North-east Arctic saithe. The correlation between biomass estimates from VPA/survey and commercial CPUE are explored, using different qualification levels. For most of the analyzed species and age groups the trend in CPUE time series is quite similar with that of VPA and survey.

INTRODUCTION

Until the 1960s commercial catch per unit effort (CPUE) was the most important measure of stock abundance (Gunderson 1993). Today most stocks are assessed using catch-at-age models (VPA). Scientific survey data has become more important over time, due to a number of problems with commercial CPUE data (Godø 1994). Though still used, CPUE therefore plays a minor role in assessments of most economic important stocks. When catch data are reliable, VPA is adequate for estimating historical stock levels but abundance indices from surveys or fishery data must be used to calibrate the most recent VPA results (Pope and Shepherd 1984).

An advantage of commercial CPUE compared with survey data is the continuous supply of large data quantities. Scientific surveys are often conducted annually over a short period of time. The approach thus assumes that the stock behaves similarly between years, i.e. the catchability is constant. This assumption is probably often

violated (Godø 1994, Pennington and Godø 1995). Survey abundance estimates of older fish are often imprecise or even lacking since old individuals are rare and are often behaving and distributed differently compared to the younger part of the stock. Further, surveys are often focused on producing indices for the age groups that is recruiting to the commercial fisheries. Commercial CPUE therefore has a potential of providing better information about abundance of old fish. Increasing the use of commercial catch data may also improve mutual understanding between fishermen and scientists.

When CPUE is used as an index of abundance proportionality to stock abundance is normally assumed. This implies that CPUE is proportional to fish density in the fished areas, and that mean fish density in the fished areas is proportional to stock size. Fishermen are often able to locate concentrations and obtain high catch rates even at low stock levels, which may undermine this assumption. Another problem is to find an adequate measure of effort. Different vessels in a fleet have different catching efficiencies on a given fish density (different fishing power). In addition, the vessels are expected to increase their efficiency with time due to learning and technological improvements, causing the chosen effort unit to gradually remove a greater proportion of the stock. Availability of fish often varies seasonally in temperated areas due fish migrations. Interannual variation in the fleet's temporal and spatial distribution of effort during the season may therefore violate the assumption about proportionality between CPUE and stock size. In todays multi-species fisheries such variation in the distribution of effort is likely to occur because of the continuously changing strategy in relation to quotas, market prizes and interaction between vessels. All these sources of error have to be taken into account when using commercial CPUE as an index of abundance, and different methods for adjustment of CPUE time series are described in the literature (see. e.g. Gulland 1983).

In this work we apply existing methods for calculation of abundance indices based on commercial CPUE to catch and effort data from the Norwegian bottom trawl fleet. Age segregated CPUE indices are calculated for North-east Arctic cod (*Gadus morhua*), North-east Arctic haddock (*Melanogrammus aeglefinus*) and North-east Arctic saithe (*Pollachius virens*). These indices are compared with abundance estimates from surveys and VPA.

MATERIAL AND METHODS

Datasets

The catch and effort data from the Norwegian bottom trawl fleet are taken from a logbook database. The logbooks have been collected and recorded by the Norwegian Directorate of Fisheries since 1971. Each individual record includes vessel, date, species, position according to the area-location scheme used by the Directorate of Fisheries, summarised catch (in kilograms) and summarised duration (in hours) of all the trawl hauls the recorded date. If a vessel operates in different locations on the same day, the location with the largest trawl catch is recorded. An individual CPUE observation from a given vessel is thus catch per trawling hour, per day. Effort is then measured as hours of trawling.

Information about the age composition in the trawl catches is taken from the research database owned by the Institute of Marine Research in Bergen. Representative samples of individual age and size from commercial bottom trawl catches are used. The times and positions of the sampled catches are recorded in the database.

Abundance estimates from VPA and surveys are taken from ICES (*in press*). Survey indices for cod and haddock are from the Norwegian bottom trawl survey conducted in January-March each year. The survey indices for saithe are from the Norwegian acoustic survey in October-November. Information about individual weights are also taken from the survey results.

Selection of observations

Due to limitations in the availability of age samples, the selected time period for the analysis is 1986-1999 for haddock and 1985-1999 for cod and saithe. The areas from where CPUE observations and research samples are selected are north of 62° northern latitude for saithe and north of 67° northern latitude for haddock and cod. These are the assumed distributional limits used in the assessments. A simple catch composition criteria for selection of observations is the minimum weight proportion of a species in the catch, and this is defined as the qualification level (Ketchen 1964). CPUE observations are selected using different qualification levels. With a certain qualification level it is likely that the selected observations are from trawl hauls where the species of interest was targeted by the skipper.

Standardisation of effort

To compensate for the vessels' individual differences in fishing power the effort units from each vessel is calibrated, relative to the effort units of one particular standard vessel. The applied methodology for this standardisation is described by Salthaug and Godø (*in press*). The principle in this method is to calculate power factors between pairs of vessels by comparing their catch rates when they are fishing at the same time and place (defined as a meeting), and thereafter calculate conversion factors relative to a standard vessel for each vessel in the fleet. This process is conducted in 5 separate time periods à 3 years (during 1985-1999) for each species. For each species a qualification level of 10 % is used during the standardisation, and the standard vessel is the trawler with the highest number of observations containing the analysed species. The minimum number of meetings between two vessels required for estimation of a relative power factor is 10.

Calculation of indices

Various methods exist for calculation of abundance indices based on catch and effort data. In this work we compare four different methods:

- A. Summarised catch divided by summarised (unstandardised) effort each year.
- B. Averaging of individual CPUE observations (unstandardised effort) each year. In this way each observation is treated as a density observation, like CPUE from scientific surveys.
- C. Averaging of individual CPUE observations (unstandardised effort) over each month and then averaging of these monthly indices over the year. Gulland (1983) suggested this method to compensate for interannual variation in the fleet's distribution of effort during the season.
- D. Same as in C but with standardised effort using the described standardisation method.

Age segregation

The average weight fraction of each age group in the trawl catches a given year is calculated by averaging the age composition of the individual catches which were sampled. These are first averaged over each quarter to compensate for uneven temporal distribution of sampling effort. Missing age groups in the individual catches are included as zero-values in the averaging process. Age segregated yearly indices (I_a) are then calculated as follows:

$$I_a = I f_a$$

where I is the CPUE index of trawlable biomass for the species and f_a is the average weight fraction of age group a in the trawl catches the given year.

Comparison with estimates from VPA and surveys

Since the CPUE indices are of biomass and the survey indices are of numbers, the indices are multiplied by estimated weights at age taken from the respective surveys. Except for the saithe survey, all VPA and survey results are from the start of each year. To make these estimates comparable with the yearly CPUE indices, estimates from year t and year $t+1$ are averaged (following the same age group). In this way the estimates are from the middle of each year. The correlations between some time series of CPUE and VPA/survey are explored for different qualification levels, and the trends are compared in plots.

RESULTS

The trends in indices from method D seem to differ somewhat from the other three methods for all the species, but especially for saithe (Figure 1). Methods A-C give quite similar results. The correlation between CPUE indices and VPA/survey estimates vary for different age groups (Figure 2 and Figure 3), with the lowest values for saithe. For qualification levels higher than about 20 % the trends seem to stabilize slightly for most age groups and species (Figure 2). Qualification levels of more than 70 % affect the trends; for haddock the correlations increase and for cod they decrease. The average age distributions in sampled trawl catches are almost similar for the three species (Figure 4). The frequency distribution of proportion in catch for haddock differ substantially from that of cod and saithe (Figure 5). Most trawl catches of haddock has a very low proportion of the species (by-catch species).

DISCUSSION

The small differences in trend between the methods A-C may indicate that the spatial and temporal distribution of effort during the season were fairly constant between years during the analysed time period. In theory, the use of qualification levels should increase the probability that the selected observations are from trawl hauls where the skippers target the analysed species, and thus uses the effort in the core of the distributional area. This may explain the sudden increase in correlation for haddock at very high qualification levels. However, by-catch regulations (e.g. a maximum allowable proportion of a species in the catch) may also lead skippers to aim at low proportions of the target species, and this type of strategy is likely to change when regulations change. Even though a low proportion of a species in the catch may indicate that the trawl haul was taken in the limit of the species' distributional area, the observation still gives information about density. A high qualification level may also lead CPUE to only measure density in the concentrations of fish and thereby failure to detect declines in number of concentrations causing underestimation of decreases in abundance (Kimura 1981). Too high qualification levels may also result in a considerable loss of observations.

Generally, the distributional characteristics of the individuals in a fish stock are determinant for whether CPUE is proportional to stock abundance. For schooling stocks, like e.g. herring, CPUE can be misleading to use as an index of abundance (Ulltang *et al.* 1980). Saithe are often distributed in dense concentrations making it easy to locate (with echosounder) and catch for trawlers. The CPUE indices for the youngest age groups of saithe are not correlated with VPA and survey estimates. This may indicate that catch per hour of trawling is a bad measure of stock abundance for saithe. Another problem with saithe is that a substantial proportion of the youngest age groups in the analysed area may join the North Sea stock as adults, causing stock identity problems. Haddock and cod individuals are more dispersely distributed than saithe. However, density-dependent and stock size dependent catchability has been indicated for other haddock and cod stocks (Crecco and Overholtz 1999, Rose and Kulka 1999).

It is important to be aware that the VPA estimates are not independent of CPUE in this work. CPUE from the Norwegian bottom trawl fleet is involved in the tuning process of the most recent VPA estimates. The same data are also used (together with other catch data) in the estimation of catch at age, which is the input data in VPA. Both the abundance estimates from VPA (Ulltang 1977) and survey (Godø 1994) are characterized by a number of methodological sources of errors. It is therefore difficult to evaluate different methods for abundance estimation since there are no "correct" measures of abundance. However, estimates with a high correlation with estimates from other methods is considered to be positive in this work. The estimate of age composition in trawl catches probably also suffer from uncertainty due to limited sampling effort.

Information about the fleets spatial distribution is not utilized in this work. Various statistical techniques exist for incorporating spatial information when calculating abundance indices based on density measurements (Foote and Stefansson 1993). Most

of these, however, require that the measurements are taken from the entire distributional area of the stock. Since fishermen normally operate in areas with high fish densities there are often important areas without any fishing and thereby without information (Hilborn and Walters 1992). Techniques like spatial stratification will then often produce estimates quite similar to the simple average. Another error source which is not compensated for in this work is the gradual increase in catching efficiency due to learning and technological improvements. This probably causes a gradual change in catchability with time. It is reasonable to assume that learning and technological improvements took place in the analyzed time period of 15 years, but it is difficult to adjust the effort units for this effect.

Quantitative information about misreporting and discards are lacking in our data, but this certainly occurred during the analysed time period. The size selection in trawls and illegal discards of small fish (age 3 and age 4) are likely to vary within and between years due to differences in individual growth and fishermen's changing strategy. This may violate the assumption about proportionality between CPUE and stock size for these age groups. Substantial biomass fluctuations for an age group within the season is also likely to occur due to temporal variation in mortality and individual growth, and this may cause additional uncertainty in the estimates of average biomass from VPA and survey. Stefánsson (1987) avoided this problem by using CPUE from a limited part of the season.

The method applied for standardisation of effort in this work requires a high number of between-vessel comparisons within a time period (Salthaug and Godø *in press*). Time periods with a low number of possible comparisons may therefore result in poorer estimates of relative fishing power making the chosen method inappropriate. The CPUE indices in this work will probably become a better measure of stock abundance if the quality of the catch data is improved. A haul by haul resolution of the data together with more and better samples from trawl catches throughout the year would be major improvements.

Conclusions

Standardised CPUE indices from the Norwegian bottom trawl fleet seems to track trends in abundance for trawlable age groups of North-east Arctic cod, North-east Arctic haddock and possibly for older age groups of North-east Arctic saithe. Qualification levels are not critical to use when selecting observations, but some kind of effort standardisation should be carried out.

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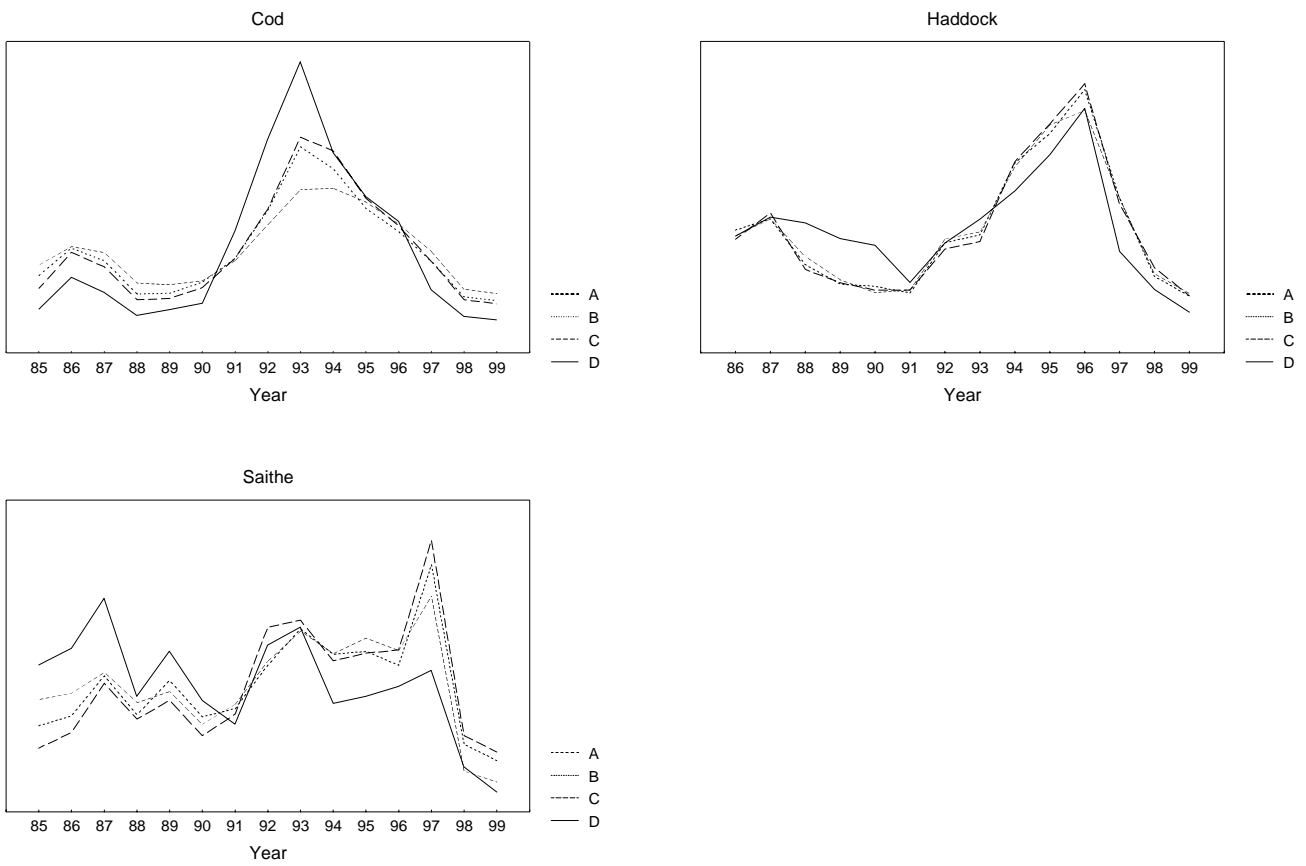


Figure 1. Trend in annual CPUE indices of trawlable biomass for the three analysed species when applying the four described calculation methods. The qualification level is 20 % and the same observations are used in the different methods.

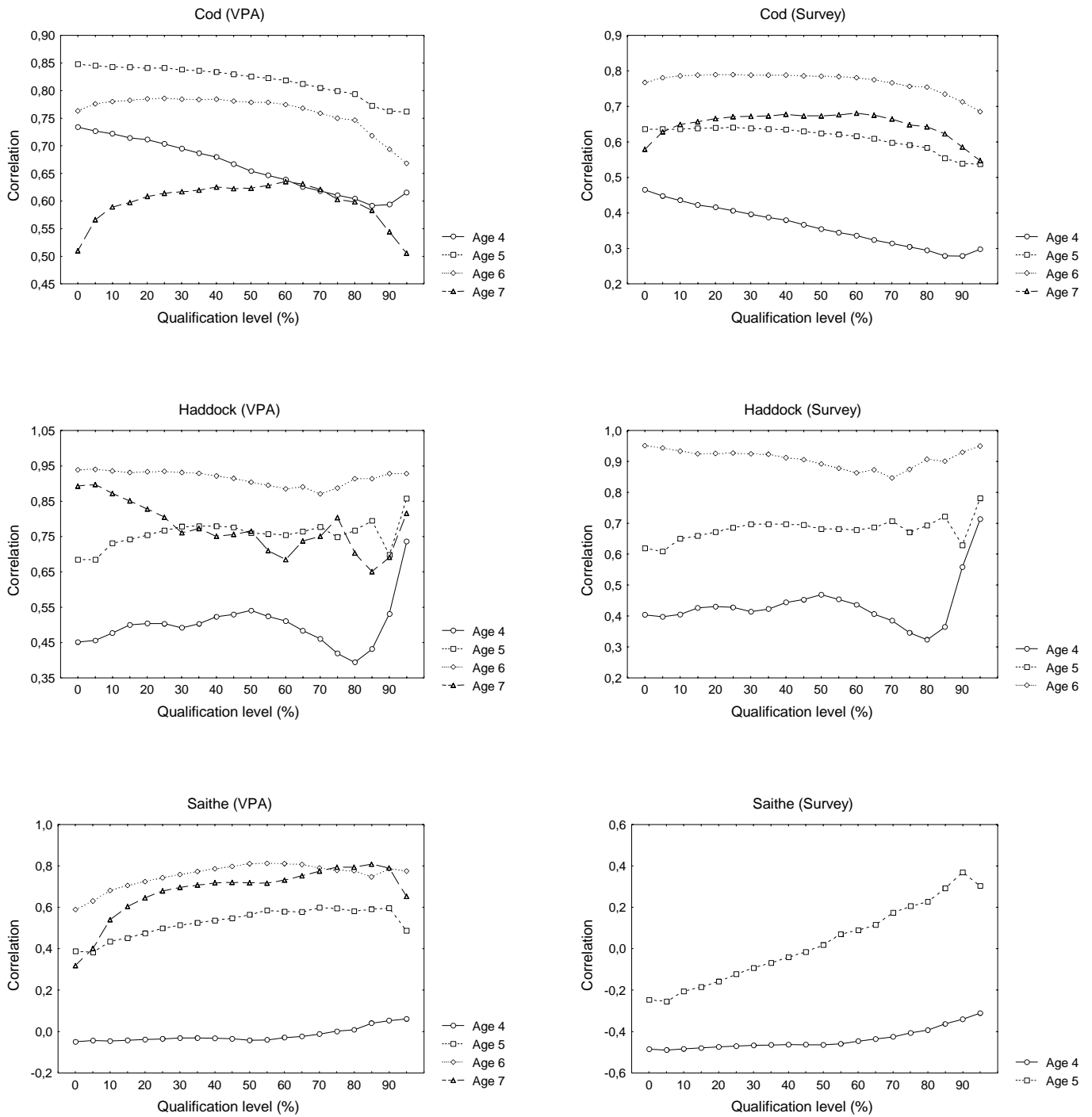


Figure 2. Correlation between some age segregated CPUE indices and VPA and survey (indicated in brackets) when varying the qualification levels. Method D is used for calculation of indices and the qualification level is 20 %.

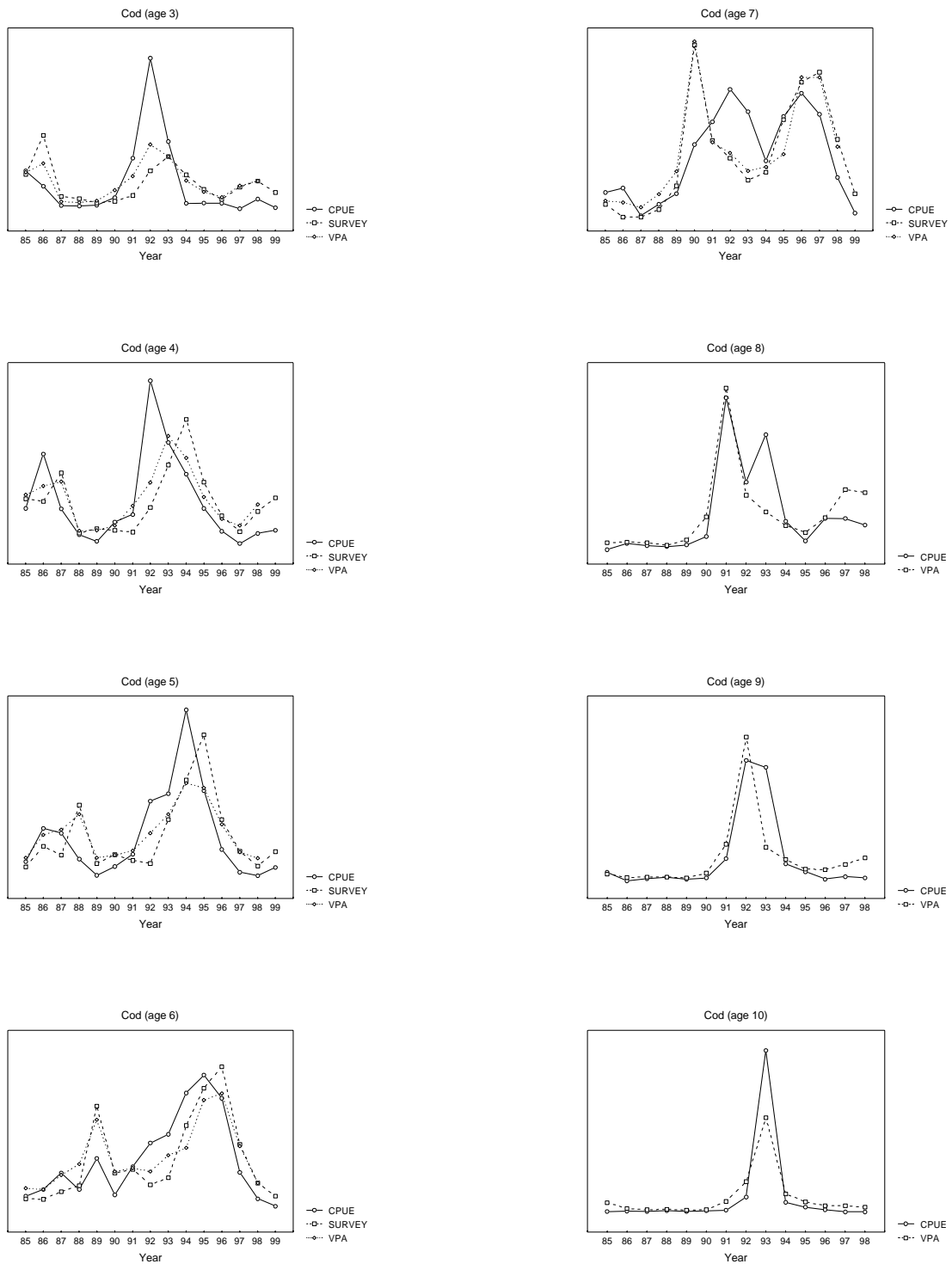


Figure 3. Comparison of the trend in annual estimates of average biomass from CPUE, survey and VPA. Method D is used for calculation of CPUE indices and the qualification level is 20 %.

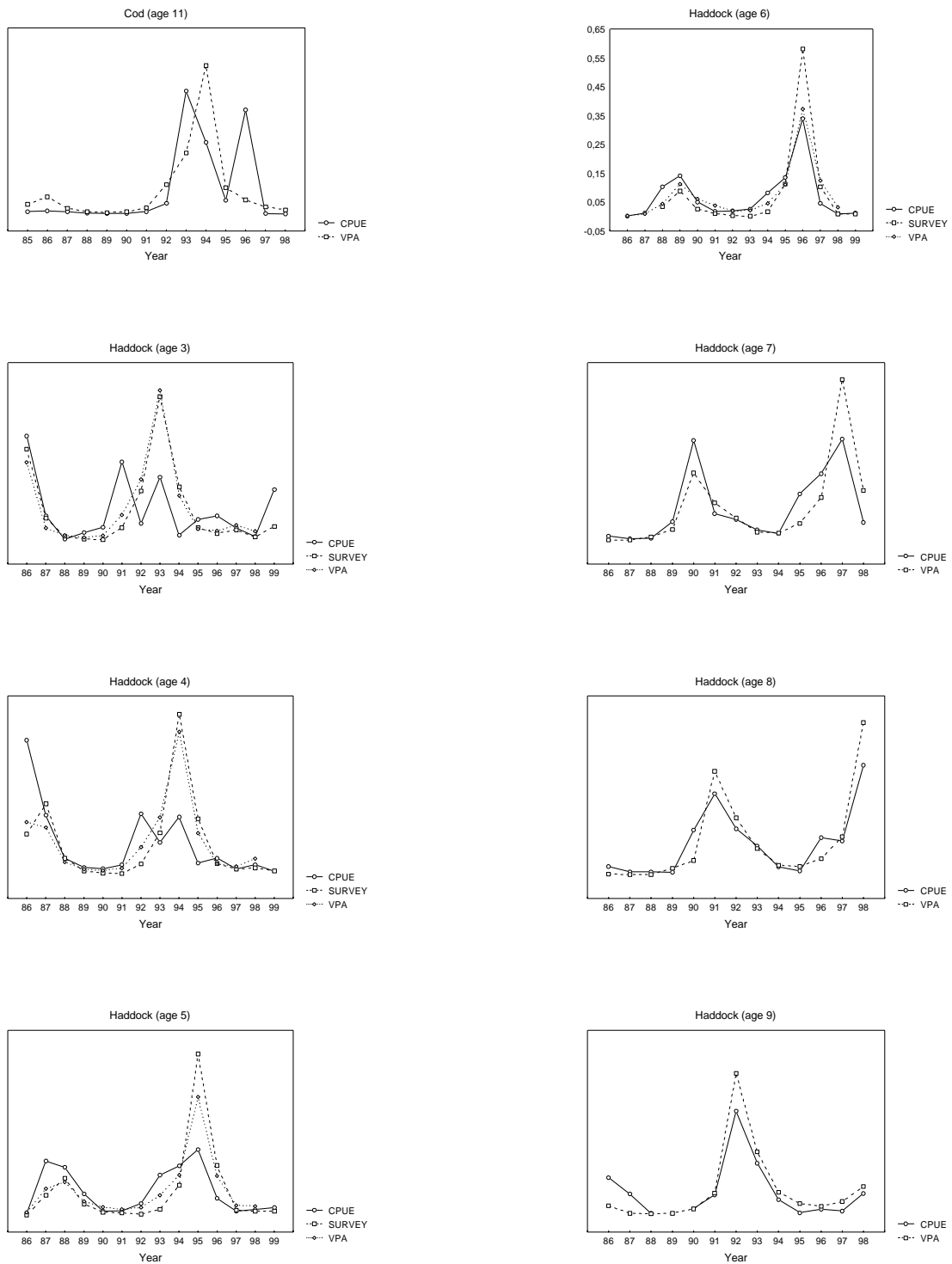


Figure 3 (continuing). Comparison of the trend in annual estimates of average biomass from CPUE, survey and VPA. Method D is used for calculation of CPUE indices and the qualification level is 20 %.

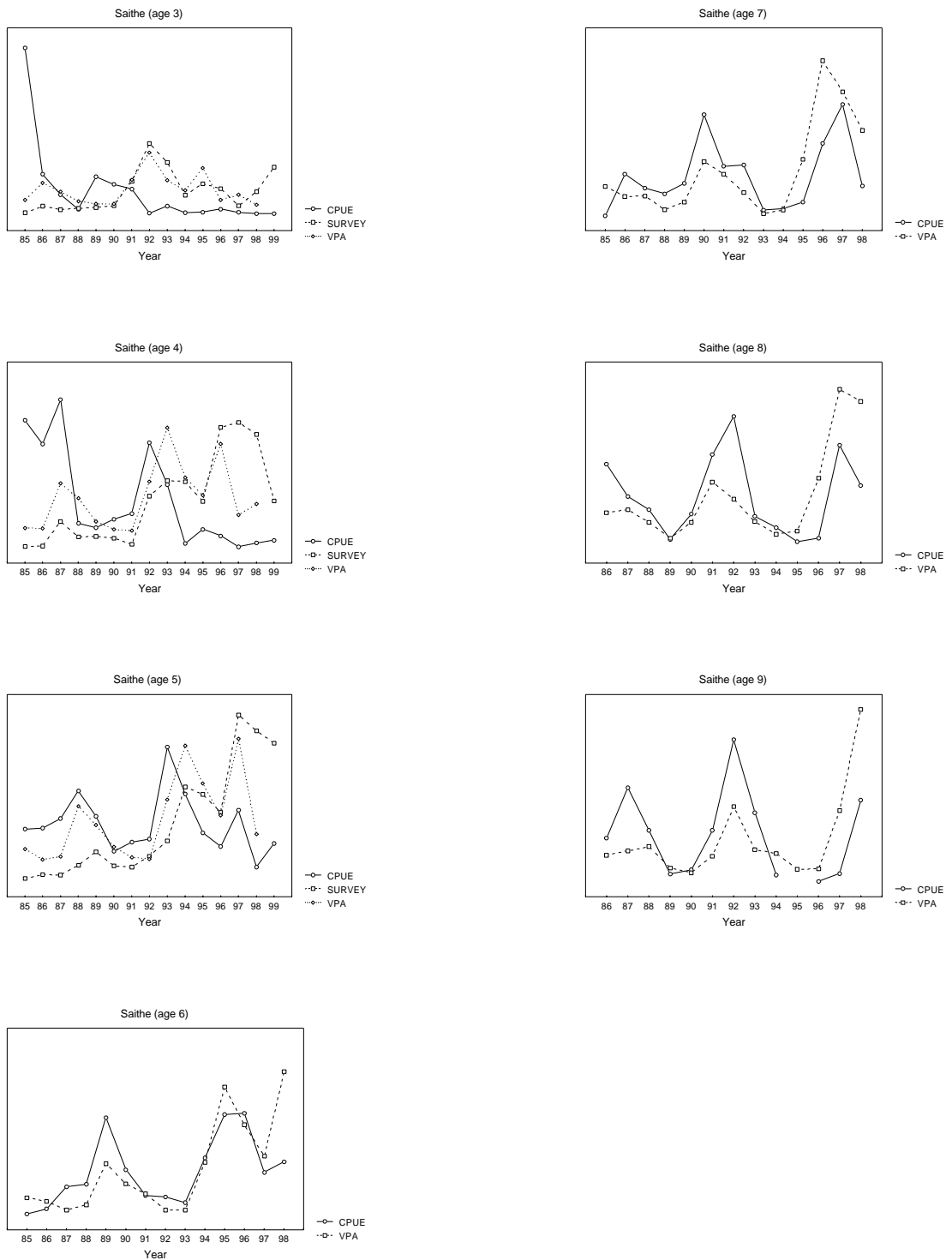


Figure 3 (continuing). Comparison of the trend in annual estimates of average biomass from CPUE, survey and VPA. Method D is used for calculation of CPUE indices and the qualification level is 20 %.

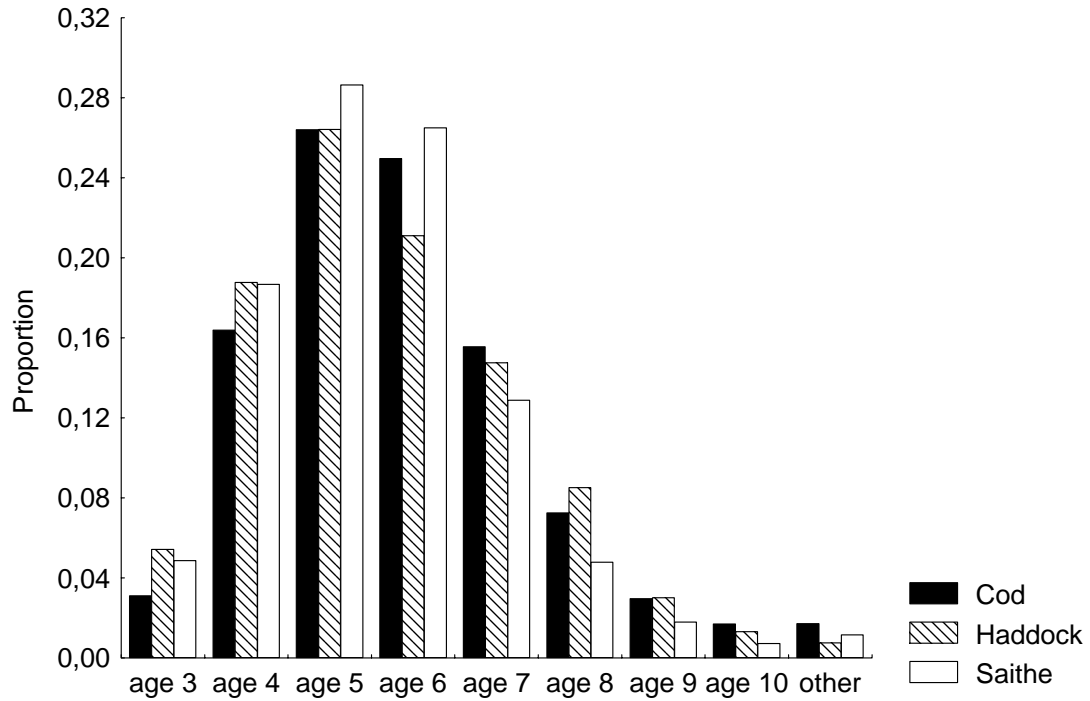


Figure 4. Average proportion (in numbers) of each age group in sampled trawl catches in the period 1985-1999.

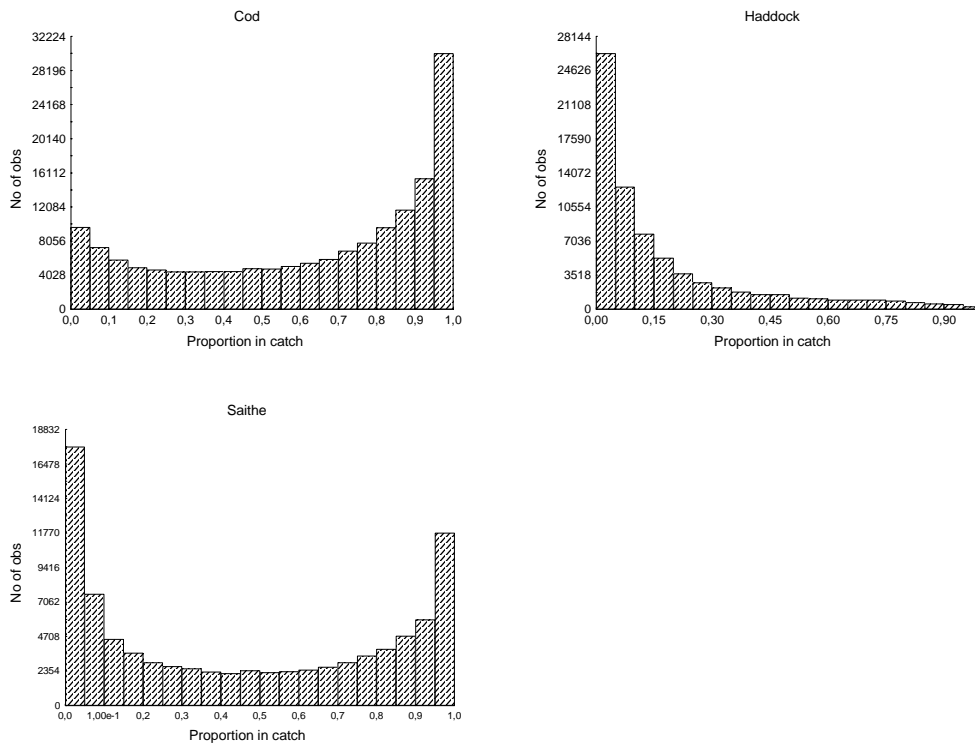


Figure 5. Frequency of proportion (in weight) of the species in individual CPUE observations. The approximate number of observations which is lost when using different qualification levels can be read from the figure.

