APPLICATION OF ACOUSTIC STOCK ABUNDANCE ESTIMATION ON CAPELIN AND BLUE WHITING

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INTRODUCTION

The use of acoustics for fish abundance estimation is now in a state of progressive improvement. But already at present the method has proved to give valuable informations on stock abundance of both exploited and unexploited fish stocks in the North Atlantic.

In practical application it is of the greatest importance to take into consideration fish behaviour and to carry out the surveys aiming at an abundance estimation when conditions are as fabourable as possible. This may be related to special spawning or feeding seasons.

In the following we shall give two examples of acoustic fish stock abundance estimation. The first one is the estimation of an exploited fish stock, namely the Barents Sea Capelin, which for the time being is the greatest resource for the Norwegian fish meal production. The second example is an acoustic stock size measurement of the

Norwegian Sea Blue Whiting, an unexploited fish stock which by this
investigation can be shown to be one of the greatest known fish stocks in
the North East Atlantic.

SURVEY TACTIQUE

As mentioned above the method for an acoustic abundance estimation
can not be used with the same success under all circumstances.
The best condition for the echo integration technique is given if the
fish stock in question is distributed within a defined area, unmixed
with other species and in continuous scattering layers at moderate
depths in mid water. Conditions are more complicated when the
fish are forming schools or are mixed with other species and
unfavourable situations are found when the fish are distributed close
to the bottom or near the sea surface. Fish behaviour must therefore
be studied and the surveys aiming at an abundance estimation should
be undertaken when conditions are as favourable as possible. This
may be related in some cases to the spawning season or in other cases
to the feeding season. In the two cases delt with in this paper the blue
whiting survey was carried out just before the spawning season when
the ideal conditions were found, whereas the capelin surveys were
undertaken during the summer feeding season again under favourable
conditions.

The density of the grid net should be adjusted to fish density in order
to optimize abundance measurements. The survey grid net must thus
to some extent be flexible and adjusted in accordance with the findings
at all times during the survey. Fish consentrations are often located
in larger units within certain areas and a basic grid net dense enough

to find these areas should be used initially, but as soon as a fish field area is found, the grid net should be changed and a denser coverage adopted. Most often the extension of the area of distribution is unknown before the survey starts. It is then adviceable first to carry out a very rough coverage with the main purpose to locate the actual area to be surveyed in details afterwards. This tactique was followed particularly on the blue whiting survey; but also the capelin surveys were based on initial knowledge of the extention of the actual area in east west direction. By adopting north south courses passing well out of "the echo recordings" on both sides the survey conduction was under full control.

METHOD

The method used is described by Midttun and Nakken(1970) and Blindheim and Nakken(1971) but will be summarized here. When the echo-sounder is set to compensate onc̄way geometric spreading and two ways absorption (20 log R + 2∝R) and the echo voltages are squared before integration, then the output of the echo integrator is proportional to number of fish per unit area, provided that the recorded fish are of equal species and size.

$$\int \rho_A = CM$$

Where ρ_A is the area density in number per unit area, $N/(n.mile)^2$, M integrator deflection in mm and C is a constant depending on fish species and size.

When mixed recordings occur, it is necessary to discriminate between the species, and find the contribution to the integrator recordings from each species. When fish of different length occur it is necessary to know the length composition of the stock and the target strength/length relation for the species in question.

On board the Norwegian research vessels it is therefore routine procedure to identify the echo recordings by trawl catches whenever the recordings apparently changes. It is also routine to scrutinize the acoustic data each day and to decide which species of fish have contributed to the integrated echo intensity. This analysis is done by experienced people on basis of examination of trawl catches and echo recordings.

During the investigations reported in this paper the 6 echo integrators onboard the G.O. Sars were connected to the Simrad scientific sounder EK 38. The 5 upper channels were normally adjusted to integrate in 50 m depth slices down to 250 m, while the 6th channel worked between 250 and 449 m. During the blue whiting survey a slightly different setting was adopted in order to include also the deeper part of the fish layers. All channels have a bottom stop function which stops the integration just above bottom.

The integrated echo intensities were read per nautical mile, averaged for each 25 n. miles (running means) and plotted along the course line.

The determination of C in the equation 1 was carried out as follows: Fish traces were counted on the recording paper when single fish could be distinguished. The sampling volume (and area) of the echo sounder was found from observed frequency distributions of the detection sector angle (Blindheim and Nakken 1971) or from the directivity diagram of the transducer. Numbers of fish per unit area was calculated by dividing the fish counts with the corresponding sampling areas. Finally C values were obtained from corresponding values for ρ_A and M.

RESULTS

Capelin

The capelin survey in 1971 (Fig 1) were undertaken under favourable conditions. The fish were distributed over wide areas in scattering layers and thin schools well above the bottom, and practically unmixed with other species. The area integration of Fig. 2 gave as result $4.8.10^6$ mm $(nm)^2$.

The conditions for integration in August 1972 (Fig. 3) were more difficult than in September 1971. In the western part of the Barents Sea, the capelin was distributed close to the bottom over wide areas. Further east capelin and polar cod very often were extensively mixed, and at times it was impossible to discriminate between the two species on the echogram. The area integration of Fig. 4 showed $6.5.$ mm $(nm)^2$.

Values of C for capelin were obtained only during the 1971 survey. The numbers varied from $1.8.$ to 2.2 ton/mm/$(nm)^2$, and the mean of 8 values were $2.1.$ ton/mm$(nm)^2$. This is in good accordance with the value obtained by Dragesund and Monstad (1972) in the Newfoundland area.

By multiplying the obtained value of C by the results of the area integration of Fig.s. 2 and 4, the amount of capelin within the investigated areas for the two years 1971 and 1972 were found to be 10.1 and 13.5 million tons respectively.

Blue Whiting

The survey for estimation of the spawning stock size of the blue whiting was carried out under ideal conditions. The fish were mostly consentrated in well defined layers, but also in schools, however, of low density.

The area of distribution was also rather well defined and when compared to the distribution at other times of the year found to be of moderate extention.

The choose of time for the survey was based on previous investigations (Dragesund and Jakupsstovu 1971). During summer time the fish are distributed within wide areas in the Norwegian Sea, while denser consentration of postspawning fish had been located in the Faeroe - Shetland area in April - May (Jakupsstovu and Nakken 1971).

Early Scottish observations reports spawning in the Porcupine Bank - Rockall Bank area (Henderson 1959, Baily and Seaton 1969). It was therefore decided to undertake a survey in March this year, when the fish would be on the spawning grounds and presumably within a welldefined and relatively moderate area of distribution. On the first part of the cruise, during the southward crossing, a very open grid net was adopted and the main purpose was to locate areas with consentrations and then carry out a more detailed survey during the northward crossings (Fig. 5).

The map showing the distribution of blue whiting (Fig. 6) is based on the denser crossings on the way northwards. The fish were located in the warm high saline Atlantic water at depths between 350 and 550 metres, but well above the bottom. The vertical extension of the layers were 30 to 50 metres. The fish were in prespawning state.

The constant C was found to be 570 - 600 fish/mm/miles^2. The calculation gave a stock size of about 5×10^{10} fish or approximately 10 mill. tonns. A more detailed report is given by Jakupsstovu and Midttun (1972).

DISCUSSION

General

The absolute abundance estimate is dependent on a reliable determination of the factor C. This factor is obtained on single fish recordings, but must be assumed to be valied also for denser consentrations.

Capelin

The stock size measured this year is somewhat higher than the corresponding value from 1971. The observations in 1971 did not include any young fish recordings. But this year most of the recordings south of about $76^{\circ}N$ consist of 0- and 1-group fish. Omitting the recorded values from this area, the total stock size amount to **10.5 mill. tonn.** This is insignificantly different from the 1971 estimate.

It should also be noted that the coverage in the eastern part of the area both years did not include the total area of distribution.

The factor C for capelin is probably somewhat high since the counting might have included also traces from other small organisms. Consequently there is a certain degree of overestimation in the total stock size values.

Since the conditions were more favourable for the application of the acoustic method in 1971 compared to this years, the 1971 estimate is the more reliable of the two. It is recommended therefore to carry out future capelin surveys in late September when conditions apparently are better than earlier in the season.

Blue whiting.

Even though the behaviour of the blue whiting by forming well defined scattering layers offered excellent conditions for the use of acoustic technique, the recordings were often disturbed by noise from ship rolling and from ghost bottom echoes. This will cause a minor variance to the estimate.

ACKNOWLEDGMENT

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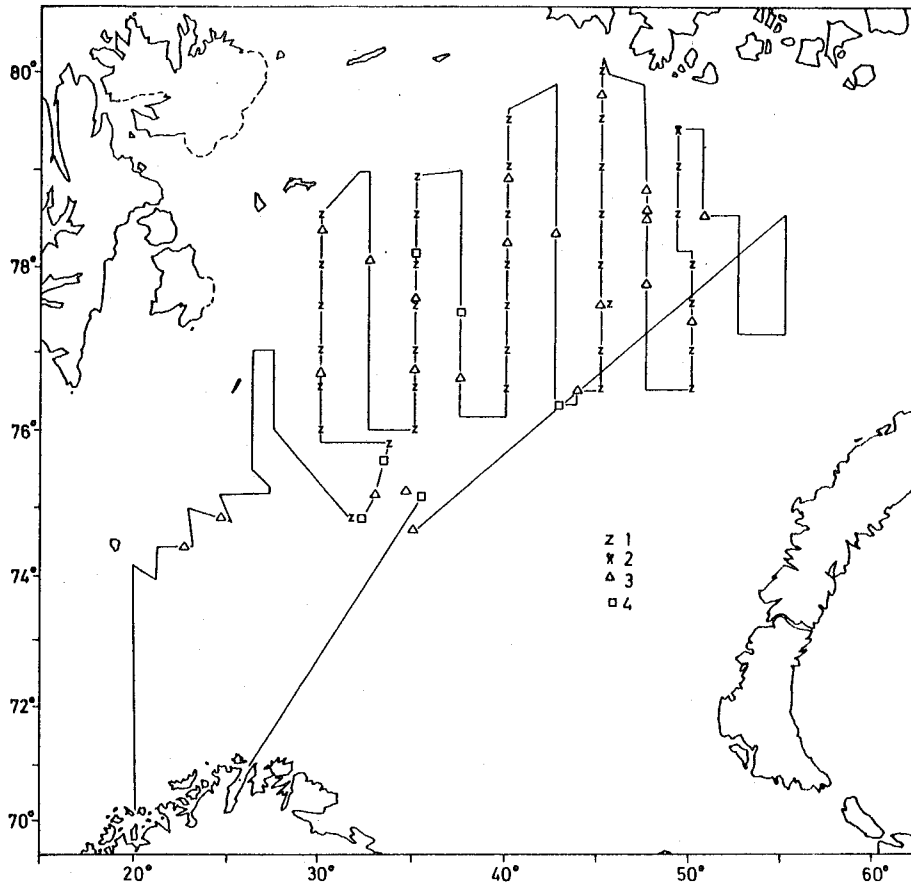Hav Unders., 16: 36 - 48.

Fig. 1.   Survey route and grid of stations
          12-29 September 1971.
          1)   Hydrographic stations with TSD sonde,
          2)   hydrographic stations with water bottles,
          3)   pelagic trawl stations,
          4)   bottom trawl stations.
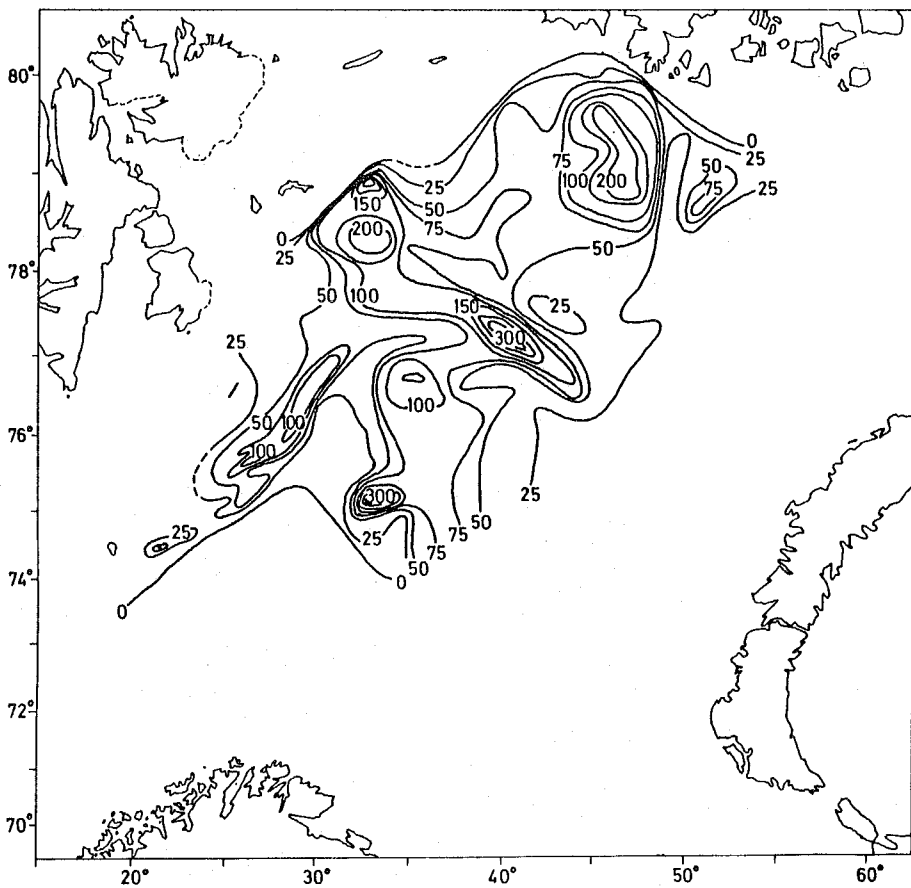
Fig. 2.   Integrated echo intensity (mm deflection)
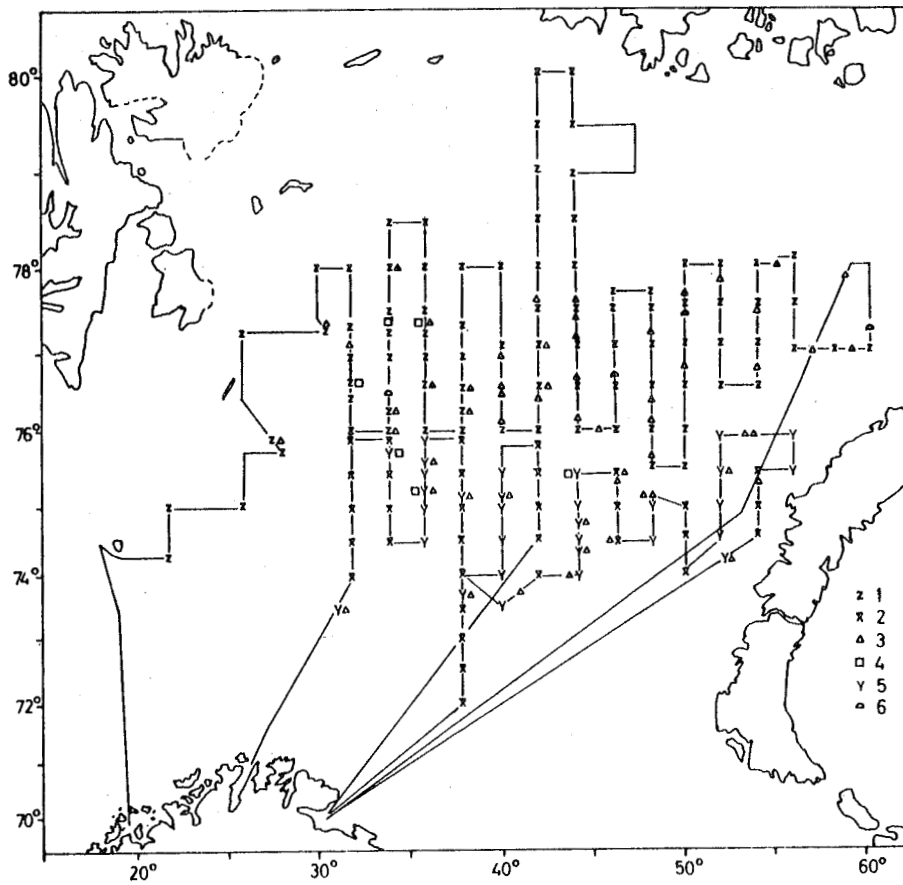   of capelin 12-29 September 1971.

Fig. 3.   Survey route and grid of stations
          5-20 August 1972.

    1)   Hydrographic station with TSD sonde,

    2)   hydrographic station with water bottles,

    3)   pelagic trawl station,

    4)   bottom trawl station,

    5)   bathy station,
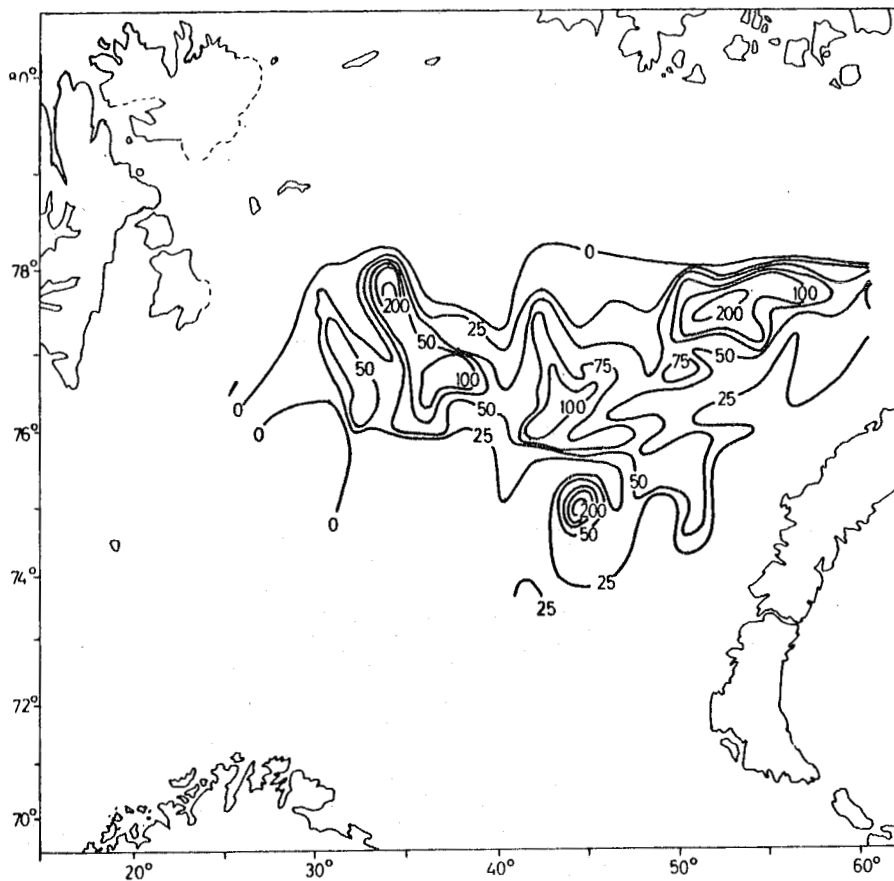
    6)   purse net station.

Fig. 4.   Integrated echo intensity (mm deflection)
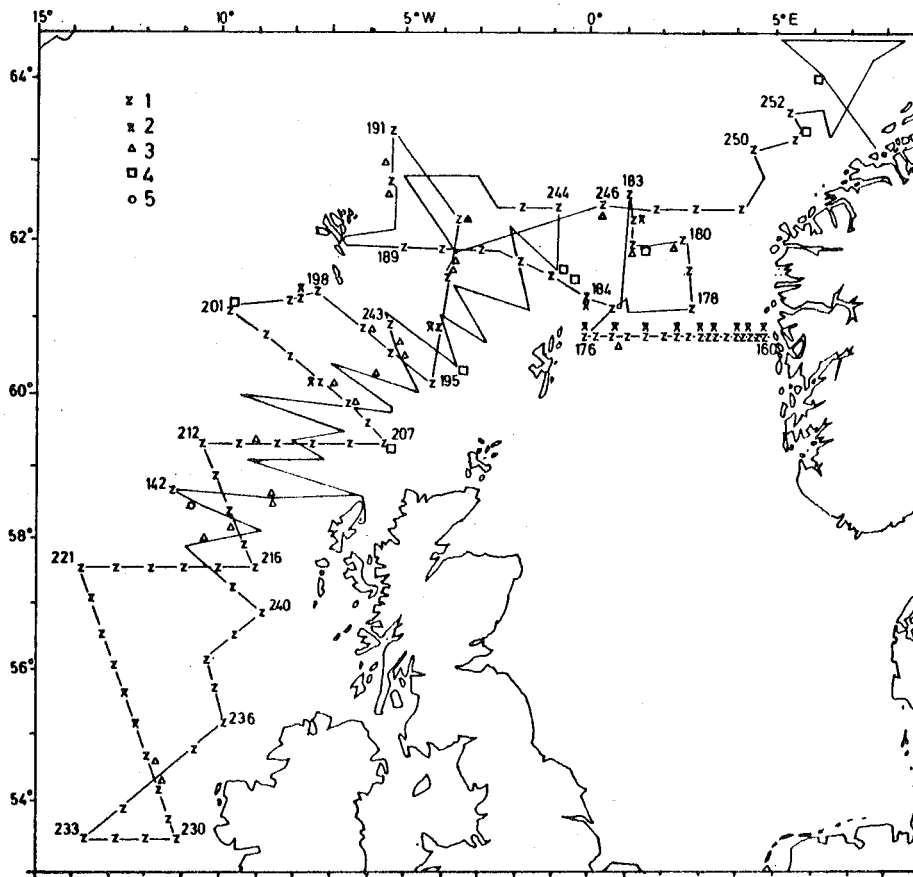   of capelin 5-20 August 1972.

Fig. 5. Survey route and grid of stations
         28 February - 26 March 1972.
         1) Hydrographic station with TSD sonde,
         2) hydrographic station with water bottles,
         3) pelagic trawl station,
         4) bottom trawl station,
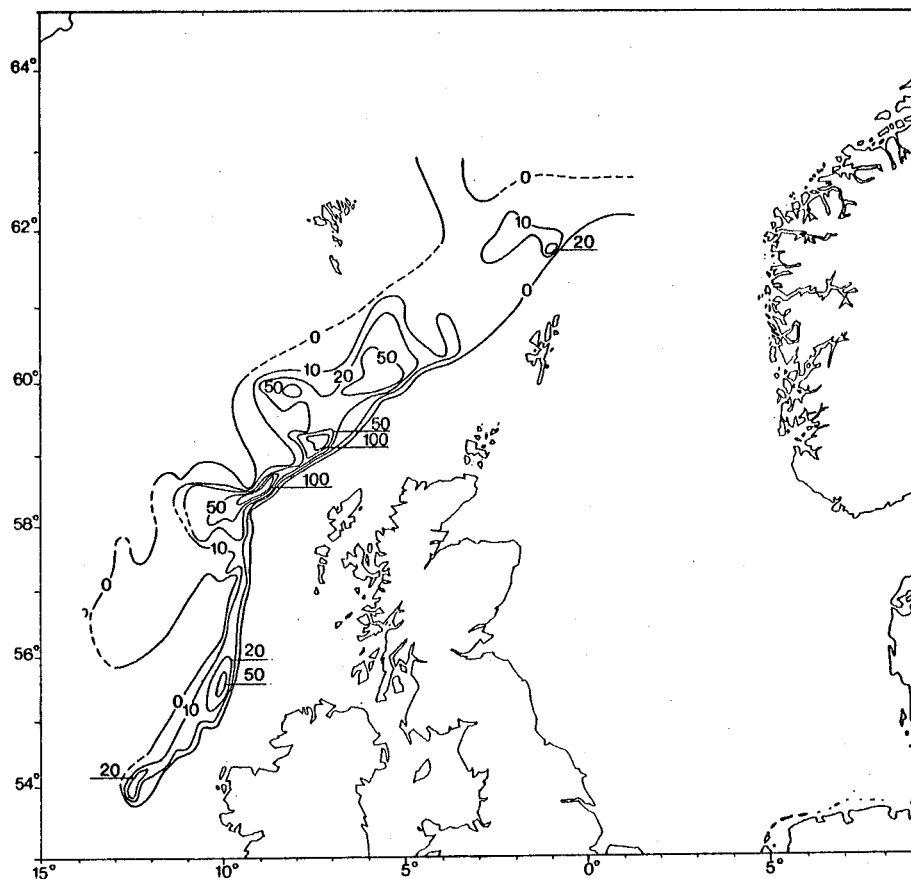   5) plankton station,

Fig. 6. Integrated echo intensity (cm deflection)
         of blue whiting 12 - 26 March 1972