5.4. Fish monitoring by means of acoustics

by H.Gjøsæter and D. Prozorkevich

The aim of the ecosystem survey is to map the distribution and abundance of several fish species, and this monitoring is partly done by means of acoustics; mainly echo sounders but in recent years sonars are also coming into use.

This chapter is based on "Manual for planning and conducting the yearly joint PINRO-IMR trawl-acoustic survey in the Barents Sea" Version 3.0 – September 1997, by H. Gjøsæter, V. Mamylov, D. Prozorkevitch, E. Shamray, S. Tjelmeland and N. Ushakov.

Acoustic data (echo intensities per nautical mile) are integrated continuously along the course lines about 25-45 nautical miles apart, and mean values per 1 nautical mile are recorded for mapping and further calculations. S_A-values should be collected from the total water column, avoiding the near field of the transducer and the bottom. These values must be carefully scrutinised to exclude noise and ping losses typical for rough weather, and then allocated to the target species and other species or groups (see table below), using the information available from echo sounders with a range of frequencies, echo integrator and trawl hauls. The echograms, with their corresponding s_A-values, are scrutinized every day. Contributions from the seabed, false echoes, and noise are deleted.

The corrected values for integrated echo intensity are allocated to species according to the trace patterns and the frequency responses of the echograms and the composition of the trawl catches. Other tools in the post processing software, like target strength distribution, school boxes, flexible layers and on-screen thresholding are also helpful in this process. For pelagic species, data from pelagic trawl hauls and bottom trawl hauls considered representative for the pelagic component of the stocks, which is measured acoustically, are included in the stock abundance calculations. For demersal species, mostly bottom trawl stations are used.

The echo sounders are watched continuously, and trawl hauls in addition to the predetermined hauls are carried out whenever the recordings change their characteristics and/or the need for biological data makes it necessary. Trawling is thus carried out both for identification purposes and to obtain biological information, i.e., length, weight, maturity stage, stomach data, and age.

The vessels give the s_A-values in absolute terms based on sphere calibrations, that is, as scattering cross section in m^2 per square nautical mile. The acoustic equipment of the vessels is calibrated by standard spheres.

5.4.1. Integration categories

In a multi-vessel survey it is **vital** that acoustic data are interpreted in the same categories and groups on all participating vessel to facilitate easy exchange and joint interpretation of the results. To ensure this the following procedure **must be** followed on all vessels:

Integrator values are put into the following categories and in the following order:

Category	Quality code (LSSS)
Capelin	1 (target)
Herring	1
Polar cod	1
Blue whiting	2 (non target)
Norway pout	2
Cod	1
Haddock	1
Redfish	1
Saithe	2
0-group mixed	3 (others)
Plankton mixed	3
Other scatters	3

5.4.2. Storing of acoustic data

Cod and haddock are scrutinized separately based on the distribution from the neighbouring and most representative trawl catches (both bottom trawl and pelagic trawl).

The same stations used for scrutinizing the different species, are also used in the further analyses of the acoustical data (allocation to length groups etc.). Thus, throughout the survey, lists or maps of which stations that are used in the interpretation of the pelagic channels and the bottom channel on each 5 nm must be produced. To the bottom channel only bottom trawls must be allocated, but for the pelagic channels it's likely that it is necessary to also use bottom hauls in most of the integrated squares in addition to pelagic hauls. The principal rule is that the stations, which at the interpretation time are evaluated to give the most

representative picture of length distributions of the species where integrator values are recorded, should be used.

5.4.3. Pelagic fish trawling in connection with acoustics

Inherent to the acoustic method is the sampling of length, weight and age of the species that are covered by acoustics. This is done by targeted trawling.

Pelagic "Harstad" trawl (specification above) or Åkra trawl (specification below) with a fine mesh size in the cod end and low selectivity is towed, preferably at a single depth during each haul. Trawl hauls are carried out on different echo registrations or in various parts of a continuing registration. The purpose of the hauls are to obtain species- and size distribution of fish in the different depth layers, as well as to get samples for determining age-, sex-, maturity- and weight-composition of the various target species caught. The trawl hauls are not considered to give any information about the density of fish in the sampled layer.

It is mandatory to have trawl samples in all registrations that give an appreciable contribution to the mean s_A in each square. It is important not only for certain species identification, but also to obtain biological samples that are representative of the main part of the fish in each square. One should not rely on trawl samples obtained for other purposes (bottom trawl, 0-group trawl), although such pre-determined hauls may in some cases give valuable information.

The Harstad trawl is suitable for fishing capelin as well as polar cod, but for faster-swimming fish like herring and blue whiting a larger trawl, like e.g. the Åkra trawl, is preferable.

Bottom trawls (e.g. the Campelen trawl) may be used to take samples of species residing close to the bottom. It must be born in mind, though, that such samples are not generally representative for the fish recorded by echo sounders, and samples from bottom trawls should be used with caution as a source of length-, weight-, or age-information for stock size estimation.

When trawling on registration in connection with the acoustic stock size estimation method, the trawl hauls give no quantitative information on fish density and do not need to be standardized regarding length of haul, speed of trawling etc.

5.4.4. Acoustic stock size estimation

The stock size estimates are based on a mean s_A value (calculated based on all the s_A values obtained in the square) and a corresponding length distribution of fish (compiled from the length distributions from all the samples allocated to the square) in each of the basic WMO squares. The number of fish in each of the length groups in the length distribution is calculated using equation 2 (where l is the mean length of the fish within each length group). The estimated number of fish is then distributed to age groups applying age-length keys compiled for sub-areas containing several basic squares. How to combine basic squares into sub-areas is decided from inspection of the biological data from all samples. The sub-areas are made to minimise the variation in length-at-age and weight-at-length, to assure that the age-length and length-weight keys constructed for each sub-area is representative for the squares contained in each sub-area. The biomass of fish in each length group in each square is calculated from the length-weight keys constructed for the sub-area where the square belongs, using equation 3. The number and biomass in the basic squares are combined to give the total stock size estimate in subareas and total area.

The computations of number of individuals and biomass per length- and age group of the pelagic fish stocks are made using the stock size estimation program "BEAM" built on SAS GIS and developed at IMR. A strata system, dividing the Barents Sea in squares of 1º (latitude) x 2º (longitude), is used as basis for the calculation.

The mean s_A-value in each basic square is converted to fish area density p_A using the relation

$$\rho_A = \frac{s_A}{\bar{\sigma}}$$

where the proportionality factor σ is called the mean acoustic cross section. The number of fish is found by multiplying with the area of the square. Numbers are converted to biomass by multiplying with observed mean fish weight in each length group.

The species specific target strength relation (the relation between TS and σ) is given by:

$$TS = 10 \cdot \log\left(\frac{\sigma}{4\pi}\right) = a \cdot \log L - b$$

The coefficients a and b in this relationship, and thus the σ and TS for each of the target species to be used during the joint acoustic surveys, are the ones currently accepted by the two institutes and the ICES Working Groups doing the assessment of the species.

For *capelin*, a = 19.1 and b = 74, corresponding to a σ-value of $5.00 \cdot 10^{-7} \cdot L^{1.91}$

For *polar cod* and *blue whiting*, a = 21.8 and b = 72.7, corresponding to a σ-value of $6.7 \cdot 10^{-7} \cdot L^{2.18}$

For *herring*, a = 20.0 and b = 71.9, corresponding to a σ -value of $8.1 \cdot 10^{-7} \cdot L^{2.00}$

Acoustic registrations of demersal fish were carried out along all cruise tracks, with division of s_A-values by species based on trawl catches data. Acoustic stock size estimates have, however, not been calculated for these species.

Stock abundance indices based on acoustic methods are calculated for the pelagic species capelin, polar cod, herring and blue whiting. The capelin index (which is actually treated as an absolute stock size estimate in the further stock assessment) is reported to The Arctic Fisheries Working Group (ICES AFWG) while the herring and blue whiting indices are reported to the ICES Working Group on Widely Distributed Stocks(WGWIDE). The polar cod abundance index is reported by PINRO to Russian fisheries authorities and is used for setting national quotas for the polar cod fishery in Russia.