REVIEW ARTICLES

FISHING GEAR EXPERIMENTS IN FINLAND

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In 1976 and 1980 I went to Finland to do some comparative trials with different fishing gears. This work was done under the auspices of the European Inland Fisheries Advisory Commission (Bagenal 1979), and arose from an EIFAC symposium in Aviemore in 1974 on fish sampling in lakes and other large water bodies. It became clear that different European countries used many different methods in attempting to estimate the numbers of fish in a lake, and EIFAC recommended that an attempt should be made to compare the different methods and then make recommendations. It was hoped that the comparisons might allow the 'efficiency' of one gear to be related to that of the other gears, and even perhaps to use the catches to assess accurately the stock from which they had been obtained.

The work was done in three lakes in central Finland from 23 August to 4 September 1976. The following different gears were used.

1. Surface trawl used by night
2. Bottom trawl used by day
3. Trammel nets, set in the evening and lifted in the morning
4. Surface seine net used by night
5. Bottom seine net used by day
6. Fyke nets, emptied each morning and evening
7. Gill nets, set in the evening and lifted in the morning.

A brief description of these gears is given in the Appendix.

The trawls and fleets of trammel nets were used by a team under Dr E. Dahm from the Institut für Fangtechnik, Hamburg, FRG. The seine nets, gill nets and fyke nets were worked by teams under Dr P. Tuunainen from the Finnish Inland Fisheries and Aquaculture Research Station at Evo, Finland. A total of seven different kinds of gears were used, since the bottom trawl and seine net were differently rigged from those used at the surface.

The experimental design was such that while the gill and fyke nets were being fished in one lake, seines and trammels were used in another and the trawls were being hauled in the third. After every two days the gears were moved around so that each lake was fished by each set of gears, and on the last pair of days the gears were each fished in the lakes where they were first used. This design was chosen in the hope that the catches from the first and last series could be used, together with the knowledge of the catches made in the intervening period, to estimate the population of the different species in each of the lakes. The total number of fish caught in each lake was

expected to be large relative to the resident population, and, since the fish were to be removed and killed, the second fishing should yield smaller catches. The size of this reduction, due to the removal of a known number of fish, can theoretically be used to estimate how many fish were present originally. In the event, as will be discussed later, the catches were very variable and they did not yield figures that could be used in the way theory suggested. The smallest lake of 14·4 ha had been poisoned with rotenone and restocked with known numbers of roach *Rutilus rutilus* (L.), perch *Perca fluviatilis* L., vendace *Coregonus albula* (L.), and bleak *Alburnus alburnus* (L.) before the experiments began but only with roach could corroborative estimates of the number stocked be obtained by an independent method. In this case the number fished out by all the gears, added to the number estimated to be dead when the lake was rotenoned a second time at the end of the experiments, agreed closely with the number stocked.

In each lake, each gear was used several times, so replicate catches taken at the same time of day with the same gear and from virtually the same stock were available to test the within-gear variability, that is, to estimate the precision of each fishing method. Because the means and variances of the catches were correlated a logarithmic transformation was used to dissociate them. The large variability between similar hauls can be illustrated by the catches of roach by bottom seine net, used at the same time on consecutive days, at the same location, in the same lake, which were 25, 8 and 605. Each of these catches is an equally valid estimate of the fish in the area sampled by the net. The arithmetic mean is 212·7 and the geometric mean is 49·5. The arithmetic mean has been heavily influenced by the single large catch, but the geometric mean has not been influenced so greatly.

From an analysis of variance of the catches by each gear separately, confidence limits for the geometric means of different numbers of hauls were calculated. The tables giving these limits are perhaps the most valuable part of the EIFAC report, since they give future workers some idea of the variability they can expect when they attempt quantitative work with conventional fishing gears. The actual values that will be obtained in different localities with different species and different rigs of the gear, probably used in slightly different ways, will not be identical with those found in the Finnish lakes with the conditions and working methods used there. Nevertheless the confidence limits will act as a guide to the variability to be expected. Even experienced commercial freshwater fishermen often find it difficult to believe how variable catches are, and tend to imagine that a poor catch is a reflection on their skill, or to suggest that the gear may not have worked properly. In fact the distribution of fish is so patchy, particularly with a shoaling species, that some small catches are to be expected.

The effects of different fish behaviour by day and by night on their patchiness, and so on the variability of the catches, is seen in the coefficients of variation of the different gears. While this coefficient may not be the most accurate measure for comparing gears, it will suffice here since I am interested only in the ranked order of increasing variability. The least variable were the gill nets and the most variable were the bottom trawls, with the other gears ranked as in the following list:

Gill net
Surface seine
Mid-water trawl
Fyke net
Trammel net
Bottom seine
Bottom trawl

The most variable catches were from those gears used by day on the bottom, and the least variable were those used by night at the surface. Many species of fish form discrete and compact shoals lying close to the bottom during the day. At dusk these shoals break up and the fish become more uniformly distributed in the upper layers throughout the night.

The amount of variability in the catches of all the gears resulted in an inability to find consistent and statistically significant differences between mean catches when different gears fished the same population. The result is that the findings of the experiments were rather negative, since it was not possible to say that one gear was more 'efficient' than any other when used to estimate the abundance of the same population, and it is inappropriate to try to find calibration coefficients so that the catch of one gear could be stated in terms of one of the others.

After the report of the 1976 experiments had been submitted and accepted by EIFAC at its 10th Session in Hamburg, it was resolved that the work should continue by examining the use of acoustic systems for pelagic fish stock assessment. These experiments were planned for 1980 in Konnevesi, a lake of 188 km^2 in central Finland. The original plan was that the acoustic survey would be made of a known population whose size had been determined by a capture – mark – recapture experiment. The fish, which in this experiment would be vendace, were to be marked by the removal of the adipose fin, and the recaptures were to be made by trawling, which would be done by the same German team as in 1976. Although the Finns marked about 10 000 vendace in North Konnevesi during the autumn of 1979, this part of the experiment did not yield useful results. The reasons were partly because the marked and unmarked fish did not mix until about ten months after marking, secondly because the mortality rate could not be estimated accurately enough and thirdly because the topography of the lake resulted in a very heterogeneous distribution of the vendace.

However an attempt was made to relate the density of fish as determined from the echo sounder with the number of fish per 1000 m^3 filtered by the

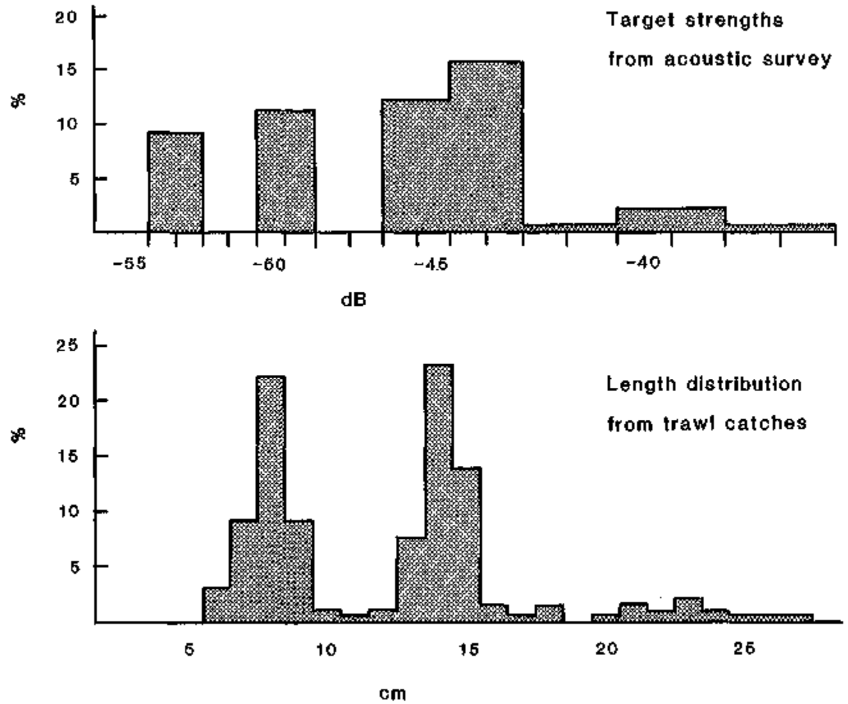

FIG. 1. Percentage length-frequency of all fish from trawl hauls in Konnevesi on 8/9 September 1980, and target strength histogram from an acoustic survey made on the same night and at the same depth.

trawl. The German team used two trawls; a commercial vendace trawl with a mouth opening which varied from 98 to 102 m^2 depending on the depth fished, and a Young Fish Trawl with a mouth opening varying from 60 to 77 m^2.

The echo sounder system was designed and operated by Dr T. Lindem of the Institute of Physics, Oslo University. It consisted of a Simrad E Y – M, which is a machine specially designed for use in freshwater fish stock assessment. The signal was recorded on tape and the data were later processed by an analogue-to-digital converter and a computer program written by Dr Lindem. The program gives a print-out of the fish per 1000 m^3 and also a frequency distribution of the target strengths.

The precision of the echo sounder was extremely good, particularly in deeper water, where two replicate estimates differed by only 0·4% from their mean. Even near the surface between 4 and 8 m, the estimates differed only by 8·5% from their mean. However, the echo sounder recorded considerably fewer fish near the surface than the trawl catches indicated were there, and it appears that the boat towing the transducer disturbed a large number of fish from its path. In deeper water however the acoustic survey gave considerably higher population estimates than the trawl. It seems likely that there was net-avoidance leading to an underestimate from the trawl catches, because the alternative hypothesis, that the acoustic survey over-estimated the fish density, is difficult to explain.

The length frequencies of the mixed species in the trawl catch can be linked satisfactorily with the frequency distributions of the target strengths. On one date there were three modes in the fish lengths; at 6 cm, 14 cm and at about 22 cm, produced by smelt *Osmerus eperlanus* L., vendace, and whitefish *Coregonus* spp. respectively. There were four modes in the target-strength frequencies. The target-strength of a fish depends primarily on the size and shape of the swim bladder, and so an exact relationship of target-strength to fish length that would apply to all species cannot be expected. The data are shown in Fig. 1. The mode at −53 and −54 dB was probably produced by 0-group smelt of 3 to 4 cm which were too small to be retained quantitatively in the trawl, though some were caught inadvertently.

In conclusion, it seems that the acoustic survey gave reasonable population estimates for pelagic fish 10 m and more below the surface, and the target-strength distributions were shown to mirror the length distributions from the trawl catches; a close correlation, however, is not possible, particularly in a population containing more than one species. The advantage of the acoustic method is that it is quick and requires little labour. Its disadvantage is that it is not possible to identify the species and so it must be supplemented by another, conventional, method.

Reference

Bagenal, T. B. (1979). EIFAC fishing gear experiments. *EIFAC tech. Pap.* No. 34, 87 pp.

Appendix

Glossary of Gears

The following are descriptions of the gears as used at Evo, Finland.

Fyke net: a wall of netting with a trap at one end. A fish meeting the netting swims along it, through a non-return valve and into the trap.

Gill net: a wall of netting made of fine twine, set vertically in the water, into which fish swim and get stuck.

Seine net: a netting bag, with wings on each side, which is hauled by ropes to the shore. It can be arranged to be dragged either over the bottom or through the surface water.

Trammel net: a wall of fine netting with walls of coarser mesh on each side. A fish swimming into a trammel net passes through the coarse net and then carries the fine mesh with it through the second coarse mesh, and so forms a pocket in which it is caught.

Trawl: a netting bag, with wings on each side, which is towed by boats across the lake. It can be arranged to be dragged either over the bottom or through the surface layers.