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The ICNAF Sampling Program: Need for Standardized Guidelines

by

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1. Introductory Remarks

Section I of ICNAF Sampling Yearbook Vol. 19 (reproduced as Appendix I to this document) represents the first attempt to draw together in a single publication all of the information that is part of the ICNAF sampling program. Previously, the relevant recommendations of STACRES have been scattered throughout many issues of Redbook and instructions for completing sampling forms were included in Circular Letters (e.g. Circular Letter 75/66), but definitions of many of the terms used were often vague. The material in Appendix I is very concise and general. It does not describe in detail the techniques of sampling, nor does it describe the techniques for using these data in preparing stock assessment information. It is designed, however, to draw attention to the requirements of STACRES and to identify the correct procedures to be followed by national statistical offices in reporting sampling data to the Secretariat. The synopsis is based on STACRES recommendations, and includes definitions of the terms used on the prescribed sampling forms, as well as brief notes on the collection and processing of sampling data. This Appendix should serve as a basis of discussion in the Statistics and Sampling Subcommittee so that a revised and more complete version may be generated to describe the desired sampling requirements and form the basis for member countries to design sampling programs that will conform as closely as possible to the STACRES recommendations.

2. Need for Uniformity

The data handling capacity of the Secretariat is becoming dependent upon its ability to use the computer to compile and manipulate the data passed to it by member countries. The development of computer processing of sampling data has progressed to the point where the data are being accepted on magnetic tapes from some member countries; data received on sampling forms from others are key-punched for entry to computer files. In order to use a computer, however, it is necessary that the data be consistent. In an effort to standardize the reporting procedure prescribed forms have been adopted by STACRES, but many problems are created when the correct procedure of reporting is not followed. For example, if sampling data are combined by two or more divisions, besides the coding problems created, the utilization of the data by individual divisions is not possible. Another example relates to some countries reporting fork length measurements and others providing total length measurements for the same species. This creates bias when one country's age-length key is applied to another country's length frequency data to determine age composition of catches. Failure to discriminate sex when required is also another major difficulty. Such inconsistencies create problems in the automatic retrieval and utilization of sampling data.

3. Need for Discussion on Sampling Guidelines

In view of the recent installation of computer facilities in the Secretariat and the development of computerized files of sampling data, the need for uniformity in the reporting of sampling data is of paramount importance. To achieve this objective it is necessary that a detailed set of guidelines be established for the collection and reporting of sampling data by member countries. Although the Secretariat has produced an outline of the ICNAF Sampling Program (Appendix I), this outline is considered to be very inadequate. In order that a more detailed description of the Sampling Program can be prepared for future reference by member countries in collecting and reporting sampling data, STACRES is requested to review the proposed outline and provide guidelines for the preparation of a more detailed plan.

As ICNAF is presently considering greatly expanding the detail in which catch data and sampling data are to be collected, the requirements for automatic data processing are to be emphasized. The torrent of data that is expected can only be handled if it is reduced in variety by adhering to a single consistent sampling program. If the sampling data is processed as efficiently as the catch data, it will further enhance the work of the Assessments Subcommittee.

4. Comments and Suggested Additions to Appendix I

Generally, the faults of the text in Appendix I are those of omission. The need for going beyond the bare framework of minimum requirements and definitions, and expanding this description with comments and discussions of the implications of the recommendations seems obvious, and the following material attempts to correct these faults:

- a) Section 2. Minimum Sampling Requirements. The following two paragraphs should be included after the quoted recommendation of STACRES:

It is emphasized that the requirement is for each division, not stock area. Further, it must be realized that in those cases where the sexes are to be kept separate, twice the number of fish of that species will have to be taken to produce usable age-length keys.

Sampling data must be "in sufficient quantity and detail to enable the calculation of the length and age composition of the commercial catches by stock/area on a monthly basis" (*Redbook 1973*, page 54). The length frequencies that are submitted on a monthly basis for application to a quarterly age-length key must be properly weighted by the catches they represent. Two or more length frequency samples forwarded for the same species, sex and gear in the same division and month, without any weighting factors to describe their relative importance in representing the catch, cannot be pooled to properly represent the monthly catch. Therefore, a single length frequency should be reported for each month, division, gear, species and sex. Anomalous length samples are best recognized by the scientists of the country that collects the data and these should be either pooled with the others after proper weighting or omitted. The onus should be on the reporting scientist to report properly weighted useful data.

- b) Section 7. Length Conversions. The following paragraph should be added:

The calculation of mean lengths from samples in which the measurements are truncated to the lower length interval boundary are not directly comparable to mean lengths in which the measurements are rounded to the nearest length interval boundary. The appropriate conversion is to add 1/2 of the interval used to the truncated mean length.

- c) After Section 7, a new section should be added, to be numbered Section 8:

Weight Conversions (new Section 8). As in catch statistics, the weights reported in sampling data are required to be round fresh weights. Any correction factors that may be required to convert gutted or otherwise dressed fish (including freezing) may be found in "Conversion Factors: North Atlantic Species, 1970. *FAO Bull. Fish. Stat.* No. 25".

Calculating mean weight from length-weight regressions must be done with consideration of the biases possible in incorrect application. It is incorrect to apply a simple mean length to a length-weight regression intended for individual fish. The result will be an underestimate of the mean weight and a consequent overestimate of the number of fish in the catch. A second potential error is using a length frequency that does not correspond in measuring technique to the technique used to generate the length-weight regression (fork *versus* total as well as round *versus* truncated measurements). Correct application requires that the non-linearity of the length-weight regression be accounted for. This is done by generating an intermediate vector of weights at length which is applied to the length frequency for each length interval. Then the weights and numbers are summed to give the correct mean weight. Obviously, care must be taken to select the correct length-weight regression. Every effort should be made to estimate mean weights at age following these comments as well. (An example of the difficulties that have arisen in dealing with these estimates may be found in Section 4 of the Report of the *Ad Hoc Mackerel Working Group, Redbook 1974*, pages 31 to 36.)

- d) Section 8. Sampling by Sex. This section is inadequate as it stands and should be replaced with the following revised version as Section 9:

Differences in growth rate and maximum length between the male and female of many species (most flatfish, hakes, deepwater fish and capelin) require that the sex of the sampled fish be determined. Failure to discriminate sex in these species results in meaningless age distributions. There are two ways to proceed, of which the first is recommended when feasible:

- 1) To treat each sex as an independent sampling unit, and to gather length frequency data and ageing data for each sex as if it were a separate species, except that the sex ratio must be reflected in the length frequency totals for each sex. In other words, for each sex the frequency will total to the per mille sex ratio, not to 1,000. Mean lengths and mean weights should always be given for each sex and not just for the sexes combined.

- ii) In cases where sex is difficult to recognize while collecting length frequency data, the alternative is to discriminate sex only in the preparation of age-length keys. Then it is important that the selection of fish in each length interval be random with respect to sex; that is, to ensure that the sex ratio of fish sampled at a given length interval will be the true sex ratio for that length. From a sexed age-length key of an adequate number of fish, a satisfactory age distribution for each sex can be derived. In this case, only a single mean weight will be collected as a field measurement.
- e) Sections 9 and 10 to be renumbered Sections 10 and 11 respectively.
- f) Sampling Notes (new Section 12). A mention of the role of the sampling notes should be made. Moreover the contents of these notes should be defined and the following is suggested:

Information in detail is required to establish that sampling procedures are comparable from one country to another, and to establish that practices with the potential for biases are not being used. It must be remembered that the sampling data will be referred to for a very long time into the future, and, unless suitably detailed descriptions of techniques accompany the data, the correct interpretation of the data will not be assured.

Descriptions of how the lengths, mean weights and ages were collected is essential to recognize any limitations on the use of these data by other scientists. If any correction factors are used (such as to convert from fork length to total length) to standardize the collected data, these should be reported. If mean weight is calculated from applying length data to a length-weight regression, the constants of that regression should be reported. If any error-correcting techniques have been applied to ageing data (such as in Res.Doc. 75/99) these should also be reported.

APPENDIX I

ICNAF Sampling Program

1. Introduction

In "A Fishery Research Program for the Northwest Atlantic", adopted by the Commission at its 1953 Annual Meeting (ICNAF *Annu. Proc.*, Vol. 3, page 23), the need for catch sampling is emphasized as follows: "In order to recognize the effect of fishing, it is necessary to record the lengths of the fish in adequate samples of catches, showing fish discarded and fish retained. This is considered essential for all the fisheries for the important species by all the participating countries throughout the Convention Area. The total range of fish caught can be sampled only at sea by specially trained observers. The sea sampling of the sizes retained should be supplemented by sampling of landings ashore."

At its 1956 Annual Meeting, the Commission approved the following recommendation of the Standing Committee on Research and Statistics (STACRES): "For each species sampled, each country should report to the Secretariat the sizes, ages, weights and sexes of the fish sampled by place and time of capture. The Commission should publish these statistics (ICNAF *Annu. Proc.*, Vol. 6, page 11). The first issue of Sampling Yearbook was published in 1958, containing sampling data for the years 1955 and 1956. This was the beginning of the ICNAF Sampling program.

During the years since the inception of the program, there have been many recommendations for improvements in relation to both the quantity and quality of the required data and the need for full participation by member countries. In the following sections an attempt has been made to outline the present sampling requirements.

2. Minimum Sampling Requirements

At its 1974 Annual Meeting STACRES reviewed several aspects of the sampling program. In reiterating the necessity for all member countries to adequately sample their commercial fisheries for length and age composition of catches, the minimum sampling requirement was revised to read as follows:

"That the ICNAF sampling requirement should be specified at one sample per 1,000 tons of fish caught for each division, quarter of year, and gear. As an approximate guideline, such samples should consist of 200 fish from the entire length range for length composition and one fish per centimeter length group for age composition."

3. Source of Sampling Data

In the past, sampling data have usually been classified as research, exploratory or commercial, depending on the type of fishing operations being undertaken at the time when the samples were collected. There has often been some confusion over the use of the terms, particularly in regard to the applicability of the various types of sampling data for assessment work, and some clarification is necessary.

- a) Research. These samples are taken on true research vessels, operating independently of the commercial fishing fleet and using true research vessel fishing gear (e.g. otter trawl, with codend meshes considerably different from those in commercial trawls, or with codends lined or covered with small-meshed material irrespective of the mesh size of the codend). Because these samples are not representative of commercial operations, they cannot be applied to the nominal catches, but are often of value for predicting future recruitment. Research samples are usually the outcome of survey programs to generate abundance and recruitment indices.
- b) Commercial. Samples taken from the catches of exploratory and/or commercial fishing vessels using gear normally used for commercial fishing (in accordance with ICNAF trawl regulations, where applicable) should be classified as commercial samples. Such sampling implies that the escapement from the codend is not restricted by codend liners or topside covers or chafers and that the samples are representative of the commercial catches.

Sampling data derived from exploratory or research fishing operations should be designated as research or commercial, depending on the gear used as mentioned above.

4. Sampling of Catches versus Landings

Commercial samples may be taken at sea from catches before any discarding has occurred (the term "discarding", as used here, implies fish thrown overboard and not included in the nominal catches, as opposed to fish used for fishmeal and included in the nominal catch), from catches after discarding, from landed catches at the dock or processing plant prior to discarding, or from landed catches after discarding. Thus commercial samples should be designated by type as follows:

- a) The samples should be designated as catch samples, if it is fairly certain or definitely known that no discarding has occurred prior to sampling, whether the samples are taken from the catches at sea or taken from the landed catch at the dock or in the processing plant.
- b) The samples should be designated as landing samples, whether they are taken at sea or in port, if it is known that discarding of small fish has occurred prior to sampling. Every effort should be made to obtain samples of discarded fish.

In some countries the only opportunity for sampling is of landings of fish that have been sorted into market categories (i.e. large, medium and small). Samples taken in this way must be properly weighted (by the catch or landing for each category) and combined into a representative sample of the catch (or landings) prior to submission to ICNAF.

5. Length Sampling Data

Length measurements should always be taken of fish which are randomly sampled from the actual catches (or landings) and which are in the natural condition (round fresh fish). If the fish are measured in any other condition (e.g. gutted or dressed), necessitating the use of conversion factors, the appropriate conversion of the length measurements to those representative of "whole fresh" fish should be made before the length frequencies are reported to ICNAF.

At the 1975 Annual Meeting, there was some discussion on the proper length to be measured for the various species, i.e. fork length and total length (ICNAF Redbook 1975, page 79). In the light of evidence brought forward that the method of measuring differs among countries for the different species, it was strongly emphasized that information on measuring methods be reported by countries in their annual sampling notes. In order to ensure that the measuring method is recorded for all samples, it was recommended that provision be made on the standard sampling forms for countries to report the type of length measurement appropriate to the sampling data reported on the form. The revised forms (for soliciting 1975 sampling data) provide for the recording of the various types of length measurements as follows:

- a) Fork length - from the tip of the snout to the apex of the V forming the fork of the tail, for species with forked tails.
- b) Total length - from the tip of the snout to the tip of the longest lobe of the tail when the lobe is extended posteriorly in line with the body. This is sometimes referred to as greatest total length. For fishes with non-forked tails, only total length is appropriate.
- c) Other (to be specified) - for example, mantle length for squids, upper valve greatest diameter for scallops.

In addition to indicating the type of length measurement (as noted above), it is very important that countries provide the method of recording the measurements as follows:

- d) Nearest cm (rounded) - measurements are recorded to the nearest centimeter (i.e. fish in the length range 29.5-30.4 cm are actually recorded as 30 cm).
- e) Cm below (truncated) - measurements are recorded to the centimeter below (i.e. fish in the length range 30.0-30.9 cm are recorded as 30 cm).

6. Age Sampling data

In order to assess the status of fish stocks by means of analytical models such as "Virtual Population" or "Cohort" analysis, realistic estimates of the age compositions of the catches are essential. The usual procedure is to collect substantial length composition data as being representative of the commercial catches of a species in a particular area over a given period of time. These data are supplemented by additional material for ageing, from which age-length keys are constructed. The representative length compositions are converted to age compositions by the application of the age-length keys to the length frequencies. These age composition estimates are then weighted by the catches to estimate the removals at age from the stock.

While the samples for length composition represent the basic sampling units, and these must be composed of fish randomly selected from the catches (or landings), samples taken to provide material for ageing may consist of fish which are randomly selected from the catches or which are selected by a stratified procedure:

- a) Random sampling for age means that the sample is a random subsample of the length composition or it may be a separate small random sample of the catch taken specifically for ageing purpose, with no attempt to select fish by length groups.
- b) Supplemented random sampling for age implies that the basic age sample was taken as in (a), but some effort is made to supplement the basic sample with fish in the upper and lower parts of the length frequency distribution in order to broaden the length spectrum of the age-length key.

- c) Stratified sampling for age implies that a certain number of fish are selected from each length group represented in the catch length composition, and that the fish are selected at random within each length group.

Random age samples are the least effective of the three types, in that the number of specimens in each sample is usually only a fraction of the number of fish in the length sample, and consequently the entire range of the length groups represented by the catch length composition will rarely be covered. Thus ages cannot be properly assigned to those length groups in the length frequency where there are no ages in the corresponding length groups of the age-length key.

In contrast, stratified age samples are the most effective in that the length groups in the length frequency sample are usually also represented in the age-length key. This type of sample is also the most efficient in that the least number of fish are required to be taken for age determination.

7. Length Conversions

If the length measurements of fish taken for ageing are collected from specimens in the "round fresh" condition, the length groups in the length composition sample and those in the age-length key are directly comparable. If, on the other hand, the length composition sample consists of fish measured in the "round fresh" condition and the length measurements of the fish in the age sample are taken after the fish have been in frozen storage for a period of time, and, assuming that some shrinkage has occurred prior to measuring the frozen specimen, then the length intervals of the actual length composition data and of the age-length key are not directly comparable. The application of such an age-length key to the length composition data results in age compositions that are biased toward the higher age groups. A very small shrinkage factor (say 3%) can result in serious bias in the calculated age compositions. It is therefore extremely important that the length measurements of fish from frozen age samples be adjusted by appropriate conversion factors to make them representative of "round fresh" fish, if the actual length samples are measured when the fish are "round fresh".

8. Sampling by Sex

When it is required that sex be discriminated in the sampling, there are two ways to proceed to ensure that the different growth characteristics of each sex (i.e. initial growth rate and size at full growth) do not affect the age distribution.

- a) One way is to treat each sex as an independent sampling unit, and to gather length frequency samples and age-length keys for each sex as if they were separate species.
- b) In those cases where sex is difficult to recognize while collecting length frequency data, the alternative treatment is to discriminate sex only in the age-length keys. If some number of fish are taken as an age sample at a certain length, then as long as the sampling was random with respect to sex, the data can be used to generate independent age distributions for each sex even though the length frequencies are not sexed. The ratio of males to females in a certain length of the age-length key should also be the sex ratio of the fish at that length in the length frequency sample.

9. Length Intervals and Sexing Criteria

At the 1974 Annual Meeting, the Statistics and Sampling Subcommittee reviewed the length groups to be used for the reporting of length frequencies and age-length keys, for most of the species sampled in the ICNAF Area, and specified the particular species for which it is essential that the data be provided by sex (males and females separately). The following list also includes changes agreed to at the 1975 Annual Meeting:

Species	Length Group
Atlantic cod (<i>Gadus morhua</i>)	3 cm
Pollock (=Saithe) (<i>Pollachius virens</i>)	3 cm
Cusk (<i>Brosme brosme</i>)	3 cm
White hake (<i>Urophycis tenuis</i>)	3 cm
Wolffishes (<i>Anarhichas</i> sp.)	3 cm
Roundnose grenadier (<i>Macrourus rupestris</i>)	3 cm (by sex)
Haddock (<i>Melanogrammus aeglefinus</i>)	2 cm
Greenland cod (<i>Gadus ogac</i>)	2 cm
Red hake (<i>Urophycis chuss</i>)	2 cm

Species	Length Group
American plaice (<i>Hippoglossoides platessoides</i>)	2 cm (by sex)
Witch (<i>Glyptocephalus cynoglossus</i>)	2 cm (by sex)
Yellowtail (SA 3-4) (<i>Limanda ferruginea</i>)	2 cm (by sex)
Greenland halibut (<i>Reinhardtius hippoglossoides</i>)	2 cm (by sex)
Atlantic herring (<i>Clupea harengus</i>)	1 cm
Atlantic mackerel (<i>Scomber scombrus</i>) ¹	1 cm
Butterfish (<i>Peprilus triacanthus</i>)	1 cm
Squids (<i>Loligo</i> and <i>Illex</i>)	1 cm
Argentine (<i>Argentina silus</i>)	1 cm
Redfish (<i>Sebastes</i> sp.)	1 cm (by sex)
Silver hake (<i>Merluccius bilinearis</i>) ²	1 cm (by sex)
Yellowtail (SA 5-6) (<i>Limanda ferruginea</i>)	1 cm (by sex)
Capelin (<i>Mallotus villosus</i>)	1/2 cm (by sex)
Other species not listed above should initially be reported by 1-cm length groups.	

¹ At the 1975 Annual Meeting, it was recommended that length frequencies and age-length keys reported for mackerel be based on measuring the fork length to the centimeter below.

² At the 1975 Annual Meeting, it was recommended that silver hake be reported by 1-cm length groups and also by sex, instead of by 2-cm length groups as in the past. Length frequencies not reported by sex must be supported by age-length keys for males and females separately.

10. ICNAF Sampling Forms

The completeness of the ICNAF data base, with regard to sampling data for the major commercial fisheries in the Northwest Atlantic, depends entirely on the extent to which member countries of ICNAF sample the catches of their fishing fleets and report these statistics to the Secretariat. As the ICNAF Sampling Program has gradually evolved over the years since its introduction in the early 1950's, various types of forms have been adopted for use by member countries in reporting their sampling data to the Secretariat. More recently, with the need for standardization to facilitate computer-processing of the data, the basic information required has been consolidated into two forms, referred to as ICNAF Sampling Form 1 and Sampling Form 2.

- a) Sampling Form 1 is designed for use in reporting sampling data for species for which both length and age data are available. For each quarter of the year, and for each gear, division (or smaller management unit as required), and species, a separate sheet must be used. There is provision for a per mille length frequency for each month of the quarter on the right hand side, with details on the samples below each frequency. The length groups of the length frequency data correspond to the length groups of the age-length key. It is important that the length group be marked in the top left hand part of the form. The main body of the sheet is for the age-length key for the quarter, expressed as the actual numbers of fish sampled for age (not on a per mille basis, and not subject to any smoothing or error removing routines). The bottom section of the form is provided for listing the per mille age composition in each of the three months, found by applying the quarterly age-length key to each of the monthly length frequencies. The box in the lower left hand part of the form (number of age samples making up the age-length key) must be completed.
- b) Sampling Form 2 is designed for use in reporting length compositions when no age data are available. The layout is similar to Sampling Form 1 except that more columns are provided for recording length frequencies.

For species which are required to be reported by sex, if both length and age data are available for males and females separately, use a copy of Sampling Form 1 for reporting each sex. If length composition data are not available by sex but age-length keys for each sex are available, then Sampling Form 2 should be used for the length frequencies and Sampling Form 1 for the age-length keys (males and females on separate sheets). While every effort should be made to distinguish the sexes, there may be situations in which the sex cannot be distinguished in a part of the samples (e.g. juveniles). In such cases a separate age-length key is required to provide an age breakdown of the juvenile portion of the catch length composition.

The details of each sample requested at the bottom of each length frequency must be as complete as possible. The "number of samples" (both length and age) and the "number of fish measured" must always be given, as these are used to assess the adequacy of sampling in relation to the minimum sampling requirements.

While the mean length of fish in each length frequency can readily be calculated, the mean weight of fish in the length frequency is particularly important, as this is used to weight the length frequency (and age frequency) up to the catch weight to estimate the composition of the catch. This weight is, of course, expressed as "round fresh" weight, as opposed to gutted or otherwise dressed weights. Information on gear size and deep range is often very useful in evaluating how applicable the sampling data reported are to commercial fishing operations.