Resource Management Committee **ICES CM 2000/D:01**

REPORT OF THE

STUDY GROUP ON MARKET SAMPLING METHODOLOGY

Marine Laboratory, Aberdeen, Scotland
24–25 January 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1 GENERAL

1.1 Participants

The Study Group met in Aberdeen on 24-25 January 2000 with the following participants:

Henrik Degel	Denmark
Åge Fotland	Norway
David Hirst	Norway
Tore Jakobsen	Norway
Ian Holmes	UK
Steve Flatman	UK
David Maxwell	UK
Carl O'Brien	UK
Martin Pastoors (chair)	The Netherlands
Stuart Reeves	UK
John Simmonds	UK
Iñaki Artetxe	Spain
Els Vanderperren	Belgium

1.2 Terms of reference

The Study Group on Market Sampling Methodology [SGMSM] (Chair: Dr M.A. Pastoors, Netherlands) will meet in Aberdeen, UK from 24–26 January 2000 to:

a) assess the current methods and levels of sampling of commercial catches for a number of demersal and pelagic stocks (cod, plaice and herring) in the North Sea and adjacent waters;

b) evaluate the spatial and temporal variability in the available sampling data;

c) advice on adequate levels of sampling commercial catches for the stocks considered;

d) propose Terms of Reference for the future work of the Study Group to be considered by RMC. They should take into account the priorities outlined in the ICES strategic plan and in particular the priorities adopted by RMC.

1.3 General organization of work

The study group on Market Sampling Methodology was convened in conjunction with a project meeting for the EMAS project (Evaluation of market sampling strategies for a number of commercially exploited stocks in the North Sea and development of procedures for consistent data storage and retrieval, CFP 98/075) in which research institute from Belgium, Denmark, England, Scotland and The Netherlands collaborate. The idea behind the joint meeting was that the topic of market sampling methodology and more specifically the estimation of uncertainty in catch-at-age and weight-at-age data could be of interest to a wider audience than within the project group alone.

The study group is also be linked to the EU FIEFA project which is about to be finished in March 2000 and in which a large number of partners participate. The main objectives of the FIEFA project are to implement well designed and integrated international market sampling programs, data management and data analysis schemes for the most important commercially exploited stocks in ICES sub-areas VI, VII, VIII, IX and X, with a aim to improve the quality of data available for stock assessment and management. Two of the five FIEFA objectives are particularly of relevance to the study group:

- to improve the efficiency and quality of sampling through improved communication between participating laboratories and by reviewing the procedures used in the sampling programs, and
- to assess the quality of the sampling programs through a detailed analysis of selected stocks in order to enable the formulation of general guidelines on the sampling target level.

The focus of the study group, as outlined in the terms of reference, was on a limited number of stocks (plaice, herring and cod) in the North Sea. However, the group occasionally considered other stocks and areas if relevant, notably if areas could not easily be split or if participants had information to contribute that was relevant but did not fit within the area/species limitation.

The study group was limited in duration to two days (24-25 January) and this created some problems in the time-schedule. The meeting of the follow-up workshop (WKIMS) is planned to take the full three days.

The work schedule of the study group consisted of presentation on national sampling schemes and raising procedures, presentation of results of bootstrap and jackknife analysis of catch at age data, discussion on the relationship between landings and sampling intensity (by stratum) and discussion of implications of uncertainty estimates in the assessment models as currently applied.

2 DESCRIPTION OF PROCEDURES

To arrive at national estimates of catch at age and weight at age, the following elements need to be obtained:

- estimation of total catch (by stratum)
- sampling for length and age
- raising samples to total catch level

In the following, details will be presented on how these elements are addressed by the different participants for the different stocks and areas.

2.1 Catch statistics

General: Cod, herring and plaice landings by country are mainly derived from the EC logbook scheme, supplemented by information from sales records. (Tables 2.1, 2.2, 2.3 give the details by country). Some effort information is also available from EC logbooks, but this may not be complete.

Historically, some misreporting by area is known to have occurred, but reliable statistics on the absolute levels are not available. Some countries have instigated schemes to improve the landings estimates where significant misreporting is suspected; for instance the Netherlands has a catch reallocation scheme for herring landings whereby officially-reported catches from EC logbook returns are reallocated on the basis of confidential information from a subset of vessels from the pelagic fleet. The representativeness of the subset of vessels has not been investigated.

2.2 Sampling procedures

Tables 2.1a, b and c include descriptions of sampling procedures for cod, plaice and herring for each country providing such data to the study group. The descriptions contain responses to standard questions so that comparisons of the different approaches may be made. The main differences are summarised below.

Sampling staff: all staff engaged in sampling procedures are trained technicians, but in Denmark and England some of the sampling is carried out by staff also engaged in statutory enforcement duties. This can lead to difficulties in obtaining reliable information or good co-operation from fishermen.

Sampling scheme: generally most countries employ a two-stage scheme based on a large number of length samples and a smaller number of otoliths used to convert length to age. The Netherlands uses a single stage procedure for herring and plaice, where representative samples of fish are aged directly. Denmark uses a similar scheme for cod, herring and plaice.

Data capture: generally on paper before entering to computer systems. The exceptions are for length and weight data from Belgium sampling which use electronic data capture systems, and for sampling at one port in England where a similar system is in use for length data capture.

No information is given for herring sampling in England+Wales. Throughout the period of this study, the majority of England and Wales landings of herring from the North Sea have been made into foreign ports. This has meant that it has proved impossible to sample these landings. With only very small amounts of herring actually being landed into the UK (E&W), usually as by-catch, very little biological data has been collected, and would not relate to the total landings as an indication of length and age structures. The practical solution has been to use biological data from other countries to create the catch numbers at age for the E&W landings.

Figure 2.1-2.3 show sampling system and data-management flowcharts for a number of countries, and Figures 2.4-2.5 the area specification for the sampling (or raising), which together with the information given in the tables, describes the country's scheme in detail. Table 2.4 shows the catch and sampling levels for the three species by each country. There are substantial differences in the number of ages and length-measurements between the different countries.

2.3 Raising procedures

Tables 2.2 and 2.3 describe the data processing and data analysis procedures for cod, plaice and herring for each country providing such data to the study group. The descriptions in the tables contain responses to standard questions so that comparisons of the different approaches may be made. The main differences are summarised below.

<u>Age determination</u>: mostly by sectioning and mounting for cod; embedded in resin for herring; and either whole or broken and burned for plaice. Similar quality control procedures appear to be used by all countries.

<u>Raising</u>: two categories of raising can be distinguished, one based on length samples with separate ALK's and the other with representative samples that can be directly converted into age-length distributions.

<u>Data storage</u>: mostly by individual sample, except Scotland where data is only stored at aggregated ALK level.

All other procedures appear largely similar.

In addition, Figures 2.6-2.11 show the flowcharts of raising procedures as used by each country. Together with the tables, these uniquely describe the methods employed to raise the length and age samples to give total annual estimates of the age composition of the landed catch.

2.4 Discussion

<u>Practical difficulties</u>. Many factors hinder the taking of more samples, and thus impair statistical accuracy or increase costs:

1) Sampling is sometimes undertaken by members of fisheries inspectorates whose principal duty is enforcement of fishery regulations. Their time for sampling is therefore limited and their interaction with the skippers may be influenced by their inspection duties.
2) Fish species may be landed in up to 7 categories (e.g. sole). A length sample cannot be completed if any one category is missing. Certain categories may be selectively removed by merchants, or may simply be impossible to locate in a busy market or when a vessel is rapidly unloaded to a lorry. Incomplete samples must be abandoned.
3) Even when fish are available to measure, the location of capture may be unknown; e.g. when fish from different ICES divisions are mixed in the hold of a vessel, when landings are unlabelled in the market, when landings' declarations are not available quickly enough, or when false declarations are suspected.

<u>Statistical difficulties.</u> Many factors could be biasing estimates of numbers-at-age:

1) Whilst the total quantities landed can occasionally be checked for accuracy by an inspector in the port, the allocation of those quantities to different ICES divisions usually cannot. The problem appears to be worst where long-distance trawlers have ready access to several ICES divisions having separate quota for some species. In some cases, raising factors may be grossly distorted.
2) The preparation of age-length keys from length and age samples is less affected by mis-reporting because sampling staff are often able to correct the reported marine source of a catch by examining the mix of species present, or by informal inquiries. Nevertheless, uncertainties remain. Some length and age samples will be mis-allocated to ICES divisions, and mis-matches will occur when age or length samples are considered to belong to a different division to the declared quantity landed.
3) Landings from different ICES divisions or by different vessels may be mixed or incomplete without the sampler's knowledge.
4) Vessels registered in, for example, UK (England & Wales) but operating mainly from foreign ports with foreign crews may arrive occasionally at a port in England and Wales with little or no notice. Catches can be quickly unloaded so that sampling is often very difficult to arrange. When landed to foreign ports, they are unlikely to be sampled at all. Therefore this sector of the fleet is probably under-sampled. Since the fishing gear and practices of foreign crews may differ from those of nationally based vessels, a bias may result.
5) A sample of a catch taken as a box from a fish market, vessel or lorry is not a random sample from the total population of fish landed by the fleet, but is a cluster sample representing perhaps one haul, by one fishing vessel,

with one gear configuration, in one location, at one time during the quarter, etc. The fact that a hundred or more fish were measured, and numerous otoliths taken from the sample should not disguise the possibility that the sample as a whole poorly represents the total landings for the ICES division for the gear class. Estimated length frequency distributions could therefore be seriously distorted. In addition, variance estimates for numbers-at-age currently do not allow for intra-sample correlation, and therefore give an over-optimistic estimate of sampling uncertainties.

6) Estimated numbers-at-age can be expected not to be independent because of the clustered sampling method. Non-zero covariances between estimated numbers-at-age would mean that errors in one age group would tend to be accompanied by errors in other groups. Similarly, estimated numbers-at-age for different species sampled from the same catch would not be independent. Thus while numbers-at-age may have been estimated for *n* age or species groups, the relationships between them mean that the number of separate decisions worth taking from the data, or models worth fitting to them, is less than *n*, possibly much less.

<u>Options for improvements.</u> Several options for improvements to the sampling of landings can be considered, although some would require radical changes to existing practices:

1) The benefit of sampling effort could possibly be increased by better organisation of international efforts. In addition, countries could seek reciprocal sampling of landings by other countries of vessels in foreign ports.
2) Measurement of a fish is much quicker than removing its otoliths and reading its age. The ALK is an example of a double sampling procedure in which a large sample of an easily measured variable is used to centre a small sample of a hard-to-measure variable, thereby improving estimation of the mean for the second. However, given that numbers-at-length are estimated from a small set of clustered samples and may therefore be biased or unreliable, and measurement of 50 to a 100 fish to prepare a distribution takes appreciable time, questions can be raised about the efficacy of this double sampling procedure. The dropping of length measurements and the sampling of a slightly larger number of otoliths than at present might provide a more accurate and cost-effective sampling scheme. One possibility would be to estimate proportions-at-age for entire landed catches, or by marketed size category. A multi-stage design might be appropriate, e.g. otoliths, within catches, within vessels, within the fleet. Development of a convenient method of picking fish at random from catches without regard to size of the fish, and of randomly sampling the other stages would be needed (ICES 1994)
3) Whatever the method used to estimate proportions-at-age, the problem of inaccurate weight-based raising factors remains due to misreporting. The interception of selected fishing trips, and raising by number of trips per quarter could possibly provide a workable alternative. It would require a random selection procedure for vessels and trips, then careful organisation to ensure that the trip was intercepted before unloading. The skipper would have to be assured that sampling was confidential and independent of enforcement activities.
4) From January 2000 EU vessels will be progressively required, by size category, to carry a satellite position-reporting device for enforcement and management purposes. National governments will run reporting schemes and databases providing data on vessel location, primarily for enforcement of area based license schemes. Currently not all this data can be made available for scientific purposes, but is held confidentially by the enforcement authorities. Data on vessel location and movement could be of considerable help for correct spatial allocation of catch and effort. There is a need to ensure that this data can be made available for scientific purposes to obtain improved spatial data on catch and effort.

Table 2.1.a Market sampling procedures for North Sea COD.

	Belgium	Denmark	England	Scotland	The Netherlands
Status of staff	DVZ sampling team (4 technicians)	Inspectorate, full time staff. DIRES full time staff.	Inspectorate, full time staff. CEFAS full time staff.	Full time FRS technicians	Mostly permanent RIVO staff. and employees of the Dutch producers Organization.
Sample stratification	**period-category-harbour**	**Harbour-period-area-category**	**Harbour-period-gear-area-cat.**	**harbour-period-gear-area**	**harbour-period-category**
Definition of…	*Harbour*: Oostende, Zeebrugge	*Harbour*: W.coast port	*Harbour*: All major points of landing in E&W	*harbour*: all major ports	*period*: quarter
	period: year	*Period*: month	*period*: Month	*period*: month	*category*: market category
	category: market category	*area*: sampling area	*gear*: gear / gear group	*gear*: 7 gears	*harbour*: 2 harbours
		category: market category	*area*: see figure 2.5	*area*: See figure 2.4	
			category: market category		
What is a sample	A unit (box or part) from each size category landed; chosen to yield close to a target number of fish measured.	one or more boxes from each size category landed; chosen to yield close to a target number 100 of fish measured.	A unit (box or part) from each size category landed; chosen to yield close to a target number of fish measured.	Predefined wt for each category of landing	A predefined (minimum) number of fish per market category of a vessel
Frequency of sampling	twice a week	Daily	Daily	Daily (Aberdeen), monthly (elsewhere)	weekly
How to select samples	Random vessels within defined strata	Random boxes within defined strata	Random vessels within defined strata	Random vessels – after permission granted	Random vessels – after permission granted
Data obtained: Length	Measured to cm below.	Measured to cm below.	Measured to cm below.	1 cm below	1 cm below
Sex	Unsexed.	Unsexed.	Unsexed.	unsexed	unsexed
Wt. sampled	Kg	Kg.	Kg, Stones or Pounds.	Each category (in stones)	each category (kg)
Wt. landed	Total weight of each size category landed (Kg)	Kg	Total weight of each size category landed (Kg or stones or pounds)	Each category (in stones)	each category (kg)
Age structure	Otoliths.	Otoliths.	Otoliths.	no age structures	otoliths
Sampling scheme	Length stratified, variable or fixed numbers per class.	The whole sample is measured and age determined.	Length stratified, variable or fixed numbers per class.	only length sampling	length stratified, fixed number (10) per category
Gear validation	ask, logbook		By inspection / ask / logbook.	By inspection of vessel (confirmed by Inspectors)	From skipper / ask
Fishing area validation	ask skipper.	Based on the information given to the auction (sales notes).	Local knowledge / skipper /ask / logbook.	From skipper and/or inspectors	From skipper / ask
How are data recorded	Length samples: ichtyo-meter (electronic data capture). Age samples: SUNBASE software (weight and length of individual fish (electronic data capture). Age readings at the institute (on paper)	Length samples: paper form Age samples: paper form, directly on packets.	Length samples: 1-man board, paper form, electronic data capture. Age samples: 1-man board, paper form, directly on packets.	Lengths on paper	Lengths and weight on paper. Age directly into the computer
Quality control	Check details against EU logbook. Only experienced staff used. Data entry checks. Visual check of landings while sampling.	Only experienced staff used. Data entry checks. Samples collected against target. Visual check of landings whilst sampling. Sampling levels monitored against targets and reviewed adjusted continously.	Check details against EU logbook. Only experienced staff used. Data entry checks. Samples collected against target. Visual check of landings whilst sampling. Sampling levels monitored against targets and reviewed biannually.	Check fishing area against log book. Only experienced staff used	Visual check of landings while sampling to confirm total weight and to ensure that all size categories have been sampled. Sampling levels monitored against targets and reviewed annually.

Table 2.1.b Market sampling procedures for (North Sea) HERRING

	Norway	Belgium	Denmark	England	Scotland	The Netherlands
Status of staff	IMR full time staff	No sampling for herring	Inspectorate, full time staff. DIRES full time staff.	no sampling for herring	Full time FRS technicians	Sampling by crew members of pelagic trawlers. Instruction and processing by RIVO staff.
Sample stratification	**harbour-period**		**Harbour-period-area-category**		**harbour-period-gear-area**	**period - area**
Definition of	harbour: all major ports and from vessels		*Harbour*: W.coast port		*species*: herring	*period*: week
	period: quarter		*Period*: quarter		*harbour*: all major ports	*area*: ICES subdivision
			area: sampling area		*period*: month	
			category: market category		*gear*: 7 gears	
					area: See figure 2.4	
What is a sample	100 specimen from the catch		Sample of 10 – 15 kg from each size category landed.		Predefined wt for each category of landing	A carton (20-23) of the unsorted catch. Presented frozen. Length representative subsample of 25 fish.
Frequency of sampling	not fixed, daily inspection		Daily		Daily (Aberdeen), monthly (elsewhere)	weekly
How to select samples	Randomly chosen vessels		Random boxes within defined strata		Random vessels – after permission granted	1 sample per week, per ICES subdivision and per species.
Data obtained: Length	0,5 cm below		Measured to cm below.		0.5 cm below	0.5 cm below
Sex	male / female		Unsexed.		unsexed	male - female
Wt. sampled	g		Kg.		Each category (in stones)	measured (kg)
Wt. landed	kg		Kg.		Each category (in stones)	logbooks (kg)
Age structure	otoliths		Otoliths.		no age structures	otoliths
Sampling scheme	100 fishes samples as above		In general the whole sample is measured and age determined. A sub-sample is sex-, maturity- and race analysed.		Length stratified. Numbers are species specific by length.	Representative sampling (25 fish).
Gear validation	from skipper				By inspection of vessel (confirmed by Inspectors)	From skipper
Fishing area validation	from skipper		Based on the log-book information only.		From skipper and/or inspectors	From skipper
How are data recorded	length, age, weight, sex, maturity in PC directly		Length samples: paper form. Age samples: paper form, directly on packets.		Lengths on paper	Lengths, Age, weight, maturiy and gonad weight directly into the computer
Quality control	Experienced staff Data checkes Samples collected against targets		Only experienced staff used. Data entry checks. Samples collected against target. Visual check of landings whilst sampling. Sampling levels monitored against targets and reviewed adjusted continously.		Check fishing area against log book. Only experienced staff used	Sampling levels monitored against targets and reviewed annually.

Table 2.1.c Market sampling procedures for North Sea plaice

	Belgium	Denmark	England	Scotland	The Netherlands
Status of staff	DVZ sampling team (4 technicians)	Inspectorate, full time staff. DIRES full time staff.	Inspectorate, full time staff. CEFAS full time staff.	Full time FRS technicians	Mostly permanent RIVO staff. and employees of the Dutch producers Organization.
Sample stratification	**period-category-harbour**	**Harbour-period-area-category**	**Harbour-period-gear-area-cat.**	**harbour-period-gear-area**	**period - category - harbour**
Definition of	*Harbour*: Oostende, Zeebrugge	*Harbour*: W.coast port	*Harbour*: All major points of landing in E&W	*species*: plaice	*period*: quarter
	period: quarter	*Period*: quarter	*period*: Month	*harbour*: all major ports	*category*: market category
	category: market category	*area*: sampling area	*gear*: gear / gear group	*period*: month	*harbour*: 4 harbours
		category: market category	*area*: see figure 2.5	*gear*: 7 gears	
			category: market category	*area*: See figure 2.4	
What is a sample	A unit (box or part) from each size category landed; chosen to yield close to a target number of fish measured.	one or more boxes from each size category landed; chosen to yield close to a target number 100 of fish measured.	A unit (box or part) from each size category landed; chosen to yield close to a target number of fish measured.	Predefined wt for each category of landing	A predefined (minimum) number of fish per market category of a vessel
Frequency of sampling	twice a week	Daily	Daily	Daily (Aberdeen), monthly (elsewhere)	weekly
How to select samples	Random vessels within defined strata	Random boxes within defined strata	Random vessels within defined strata	Random vessels – after permission granted	Random vessels – after permission granted
Data obtained: Length	Measured to cm below.	Measured to cm below.	Measured to cm below.	1 cm below	1 cm below
Sex	male, female	Unsexed.	male-female	unsexed	male - female
Wt. sampled	Kg	Kg.	Kg, Stones or Pounds.	Each category (in stones)	each category (kg)
Wt. landed	Each category (Kg.)	Each category (Kg.) ??	Each category (kg, stones or pounds)	Each category (in stones)	each category (kg)
Age structure	Otoliths.	Otoliths.	Otoliths.	no age structures	otoliths
Sampling scheme	Length stratified, variable or fixed numbers per class.	The whole sample is measured and age determined.	Length stratified, variable or fixed numbers per class.	only length sampling	length stratified, fixed number (15) per category
Gear validation	ask, logbook		By inspection / ask / logbook.	By inspection of vessel (confirmed by Inspectors)	From skipper / ask
Fishing area validation	ask skipper.	Based on the information given to the auction (sales notes).	Local knowledge / skipper /ask / logbook.	From skipper and/or inspectors	From skipper / ask
How are data recorded	Length samples: ichtyo-meter (electronic data capture). Age samples: SUNBASE software (weight and length of individual fish (electronic data capture). Age readings at the institute (on paper)	Length samples: paper form Age samples: paper form, directly on packets.	Length samples: 1-man board, paper form, electronic data capture. Age samples: 1-man board, paper form, directly on packets.	Lengths on paper	Lengths on paper. Age, weight, maturiy and gonad weight directly into the computer
Quality control	Check details against EU logbook. Only experienced staff used. Data entry checks. Visual check of landings whilst sampling.	Only experienced staff used. Data entry checks. Samples collected against target. Visual check of landings whilst sampling. Sampling levels monitored against targets and reviewed adjusted continously.	Check details against EU logbook. Only experienced staff used. Data entry checks. Samples collected against target. Visual check of landings whilst sampling. Sampling levels monitored against targets and reviewed biannually.	Check fishing area against log book. Only experienced staff used	Visual check of landings while sampling to confirm total weight and to ensure that all size categories have been sampled. Sampling levels monitored against targets and reviewed annually.

Tables 2.2 Data management Cod, Herring and Plaice

	Belgium	Denmark	England	Scotland	The Netherlands
Status of staff data input	DvZ staff.	All full time employees of DIFRES for data management.	Inspectorate full time staff for data entry. All full time employees of CEFAS for data management.	All FRS employees	Mostly permanent RIVO staff.
Data Manager	Co-ordinator(s) for market sampling, data management and stock files	Two skilled tecnicians full time assigned to data management. Manager for databases and stock files.	Manager for databases and stock files. Separate co-ordinators responsible for specific functional areas.	Fleet landings database managed by experienced individual Market sampling database by different manager. Each species has 'expert' to review data	Each species group has coordinator responsible for data-processing, monitoring of sampling level and quality control. Recently: one database manager
How does the data reach the main Lab?	Information collected at the port immediately to the institute Age readings are performed at the institute	Sample data entered from paper forms, otoliths sent to Laboratory in packets and boxed, with printed copy of data sheet (cod, plaice). Whole sample transferred to DIFRES where the sample is analysed (herring)	Sample data entered into database at ports mostly from paper forms, but also electronic data capture. Otoliths sent to Laboratory in packets and boxed, with printed copy of data sheet.	Measurements recorded on sheets, otoliths in packets or trays	Paper forms. Otoliths sent to Lab. in packets with written data on. printed copy of data sheet. Flatfish and pelagic samples consist of whole fish that are processed at the lab.
How is data input to database ?	Information collected at the port: directly into the institutes database (electronic and manual data input). Data input age readings: separate files	All length and biological data entered at labs.	All length and biological data entered at port of collection.	Passed to data input unit who use two processors	Length directly from paper (Cod). Biological data entered directly in database. Age added later from paper forms.
Frequency of data input	Landings and biological data: continuously Age data added to the overall database after reading and checking.	Daily input of landings and biological data. Age data added after reading and checking.	Daily input of landings and biological data. Age data added after reading and checking.	Batch job for all species once a month	Ad hoc
Age determination	Sectioned and mounted otoliths.	Sectioned and mounted otoliths.	Whole, sectioned or broken/burned otoliths.	Whole, sectioned or broken Otolith	otoliths mounted on slides (cod) embedded in resin (herring) or left whole (plaice).
How is historical data available	Landings data: Data from 1945 on, earlier years available on paper, Biological data: 1969-1979:data on paper. 1979-1995: no data available since 1995: data computerised	Conversion of old data into new format under proces. Data after 1997 are in new format. Old data are (not easily) accessible. All data back to app. 1981 are expected to be available in the new format before 2001.	Landings data: 1982 – present on database. Data from 1941 – 1981 held on database in different format. Biological data: 1983 – present on line. Earlier data on paper.	1960 – present on line for immediate access. Only available at stratum level. Original ASCII files held in separate building on optical disc	Landings and effort data: from 1990 on line. Earlier data (1967-1983) also available in database. Biological data available in computerized format since 1957. Pelagic logbook data available since 1984
Quality control	Database access restricted. Sampled weight < recorded landed weight by strata. Wt/Length calculation within preset tolerance. Landings and vessel data validated daily. Length and age sample data validated weekly. Only use experienced personnel for data management/validation. Regular verification of age determination through strict training procedure and quality control scheme. Participation in otolith exchanges and workshops.	Only use very experienced personnel for data management/validation. Regular verification of age determination through strict training procedure followed by quality control scheme for experienced otolith readers. Participation in otolith exchanges and workshops.	Database access restricted. Sampled weight < recorded landed weight by strata. Wt/Length calculation within preset tolerance. Landings and vessel data validated daily. Length and age sample data validated weekly. Only use experienced personnel for data management/validation. Regular verification of age determination through strict training procedure and quality control scheme. Participation in otolith exchanges and workshops.	Sum checks on length frequencies Codes checked. Upper and lower parameters on data. Wt/Length calculation within 10% of wt sampled. Double checking of input Visual screening of fleet data Only use very experienced personnel for data management Regular verification of age determination. Participation in otolith exchanges	Each species read by trained staff. Staff under training receive checking until fully-trained. Database access restricted. Full backup and recovery procedures in place. Checks on: Conditionfactor, Gonadweight / freshweight, Length per market category, Length at age, Position, Age, Otolith size, Gonad weight. Visual check of ALK's.

Table 2.3 Data analysis

	Belgium	Denmark	England	Scotland	The Netherlands
Type of information on database(s):	Landings, length, biological, fleet and effort data	Landings, length, biological, fleet and effort data	Landings, length, biological, fleet and effort data	Landings, length, biological. Fleet/ Effort/Economy	Landings, length, biological, fleet and effort data
Aggregation: landings	trip/gear/area/day,/rectangle/species (kg)	Trip / area / day / gear / fishing ground.	Trip / area / day / gear / ground.	gear/month/rectangle/nation by Kg	vessel/trip/gear/day,/rectangle/species (kg)
Effort	Days absent. Gear specific measures. trip	Days absent. Gear specific measures.	Days absent. Gear specific measures	As for landings – recorded as Hours Fishing, Days Absent, Hours on Ground	As for landings – recorded as Time absent (days at sea) and Horsepower days at sea.
Length	At initial level & aggreg.	At initial level & aggregated.	At initial level & aggregated.	At aggregated level only.	At initial level
Age	As collected & ALKs.	As collected.	As collected & ALKs.	ALK by 'cell'	As collected & ALKs.
Type of analyses	Standard retrievals provide monthly, quarterly and annual data for stock assessment and statistical purposes. Raising procedures - See flowchart. Len/Wt Relationships . SOP checks used during processing.	Standard retrievals provide monthly, quarterly and annual data for stock assessment and statistical purposes. Raising procedures - See flowchart. Len/Wt Relationships . SOP checks used during processing.	Standard retrievals provide monthly, quarterly and annual data for stock assessment and statistical purposes. Raising procedures -See flowchart. Len/Wt Relationships . Quarterly condition factor used for data screening (external CF). SOP checks used during processing. Variance estimations available.	Raising procedures: see flowchart. Len/Wt Relations monthly for major species, updated 5/10 years. Filling missing data from nearest appropriate cell. SoP factors available	Raising procedures: see flowchart. Len/Wt Relations calculated automatically. Filling missing data from nearest stratum (herring). SoP factors available
Generation of landings data	Estimated landings from logbooks & salenotes.	Estimated landings from logbooks & salenotes.	Estimated landings from logbooks & salenotes.	Estimating landings provided by Fishery Office from logbooks & salenotes	Off. landings from Ministry (logbooks). Category composition from auctions. Confidential logbooks for pelagic fleet (see text)
Destination of results	Internal. External contracts. ICES Working Groups	Internal. External contracts. ICES Working Groups	MAFF HQ., Internal & External contracts. ICES Working Groups Industry	National government, ICES WG, Data used for ad hoc enquiries	National government, ICES WG, Data used for ad hoc enquiries
Confidentiality	Disaggregated data, or information relating to individuals, never released outside CLO/DZ.	Disaggregated data, or information relating to individuals, never released outside DIFRES (at least 3 samples must be included in each cell).	Disaggregated data, or information relating to individuals, never released outside CEFAS/MAFF.	Vessel names erased Disaggregated data never released. Exemption from Data Protection Act	Disaggregated data never released. Aggregated data may be used for analysis and publications.

Quality Control	Experienced full-time staff used. Visual inspection of data during processing, including checking for outliers in ALK etc. SOP checks built into spreadsheets/programs. Formal and on-job training given	Experienced full-time staff used. Visual inspection of data during processing, including checking for outliers in ALK etc. SOP checks built into spreadsheets/programs. Peer checking of Annual Data Files and International data.	Experienced full-time staff used. Visual inspection of data during processing, including checking for outliers in ALK etc. SOP checks built into spreadsheets/programs. Standard written instructions for checks and processing protocols. Formal and on-job training given; Peer checking of Annual Data Files and International data.	Experienced fulltime staff used. Separate data managers for demersal, pelagic and landings. Visual inspection of data. Checks built into programmes	Experienced staff used. Data entry checks. Visual inspection of data during processing, including checking for outliers in ALK etc. SOP checks built into programs. Peer checking of Annual Data Files. Peer checking of International data aggregation.

Table 2.4 Overview of landings, number of age samples, number of ages, number of length samples and number of length measurements.

Species: COD, year: 1998

country	landing tonnes	N age samples	N aged	N length samples	N measured
belgium	4907	10	723	22	4093
denmark	22994	29	2394	29	2395
england	17657	NA	8645	716	103096
norway	7032	-	-	-	-
netherlands	14669	40	2097	111	4147
scotland	33979	356	11690	356	66160
Total	**101238**	**435**	**25549**	**1234**	**179891**

Species: HER, year: 1998

country	landing tonnes	N age samples	N aged	N length samples	N measured
belgium	-	-	-	-	-
denmark(Con.)	29781	17	2811	-	-
denmark(Ind.)	14284	65	370	-	-
england	6073	-	-	-	-
norway	76533	37	3395	41	3887
netherlands	77090	82	2050	-	-
scotland	45331	48	2219	48	9415
Total	**249092**	**249**	**10845**	**89**	**13302**

Species: PLE year: 1998

country	landing tonnes	N age samples	N aged	N length samples	N measured
belgium	5321	13	738	17	3751
denmark	10089	16	3486	-	-
england	10267	NA	2936	219	32324
norway	1063	-	-	-	-
netherlands	30441	83	4967	-	-
scotland	8644	-	-	-	-
Total	**65825**	**112**	**12127**	**236**	**36075**

Figure 2.1 AZTI protocol for taking market samples (left) and data management (right).

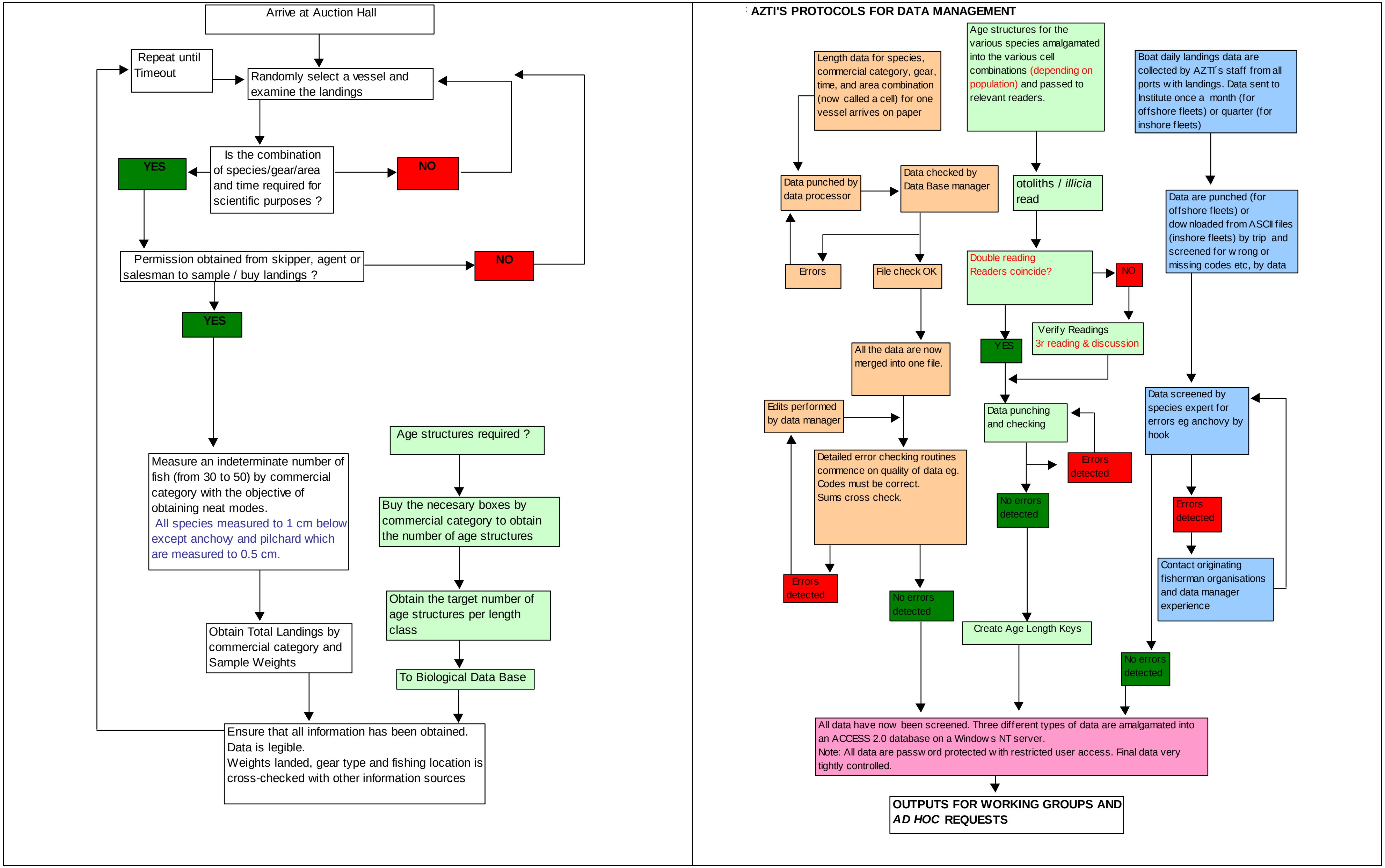


Figure 2.2 Protocol for taking market samples (left) and data management (right) in Scotland (MLA).

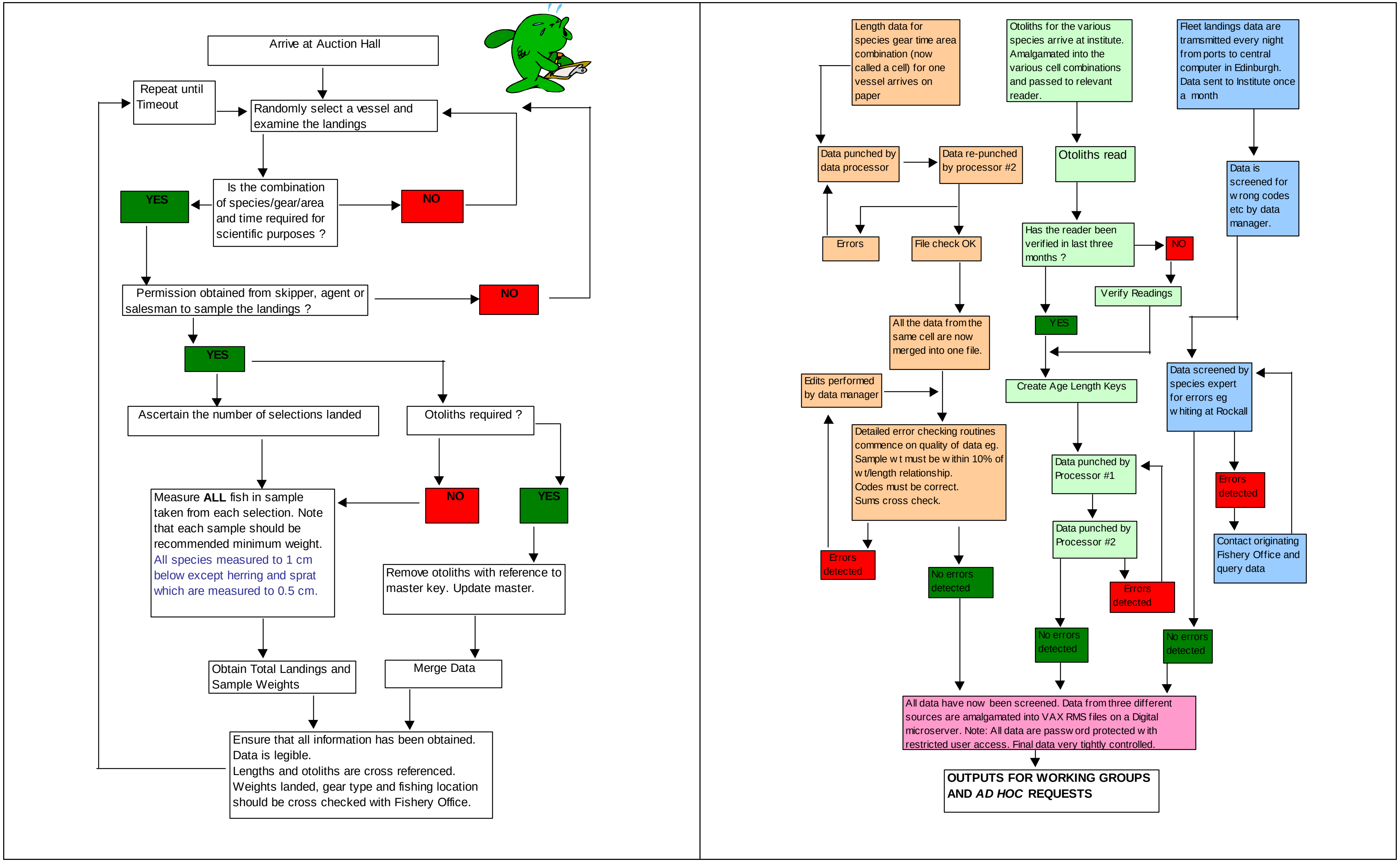


Figure 2.3 Protocol for taking market samples in England and Wales (CEFAS).

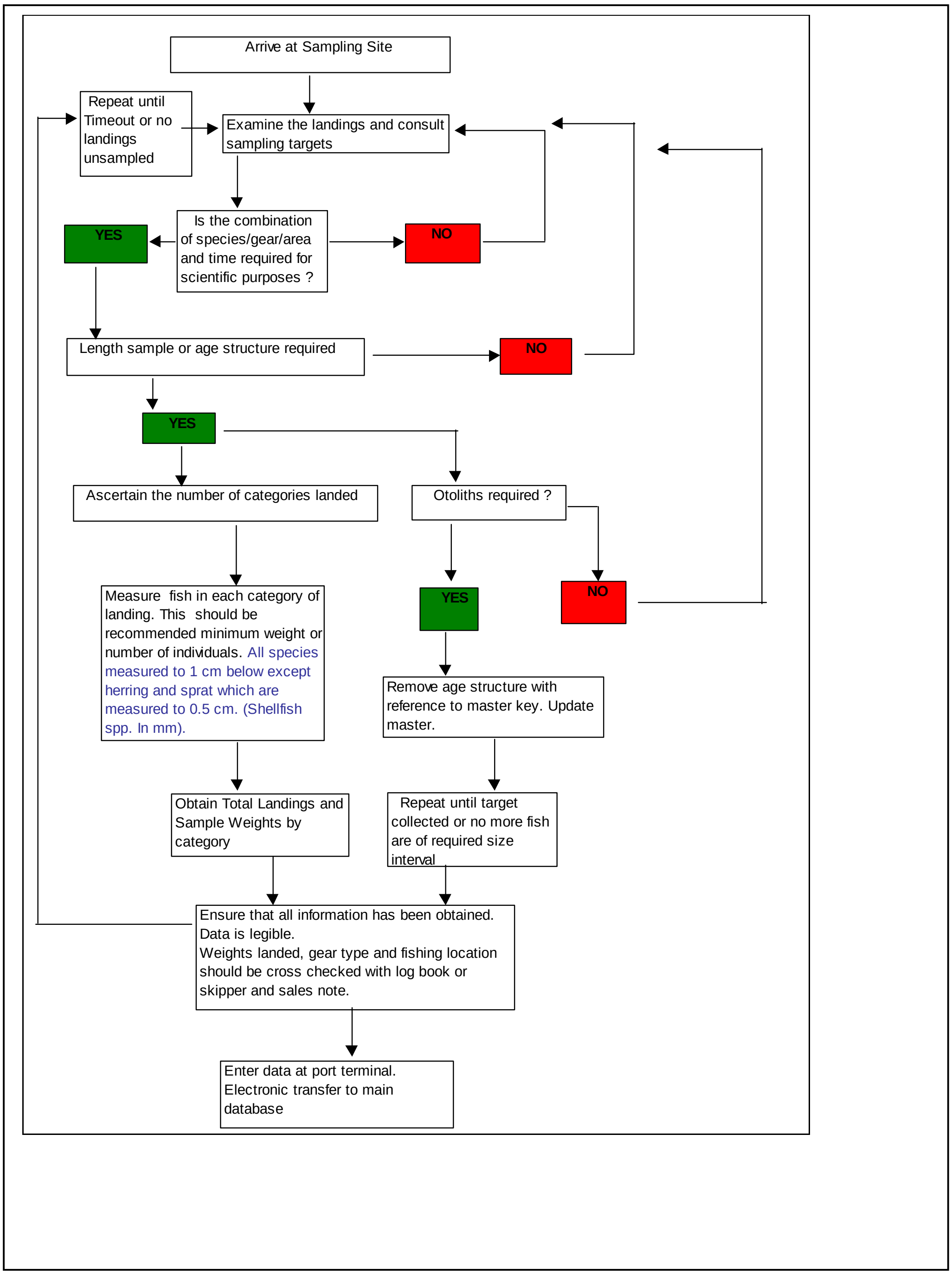


Figure 2.4 Maps of sampling areas for demersal (left) and herring (right) sampling in Scotland (MLA).

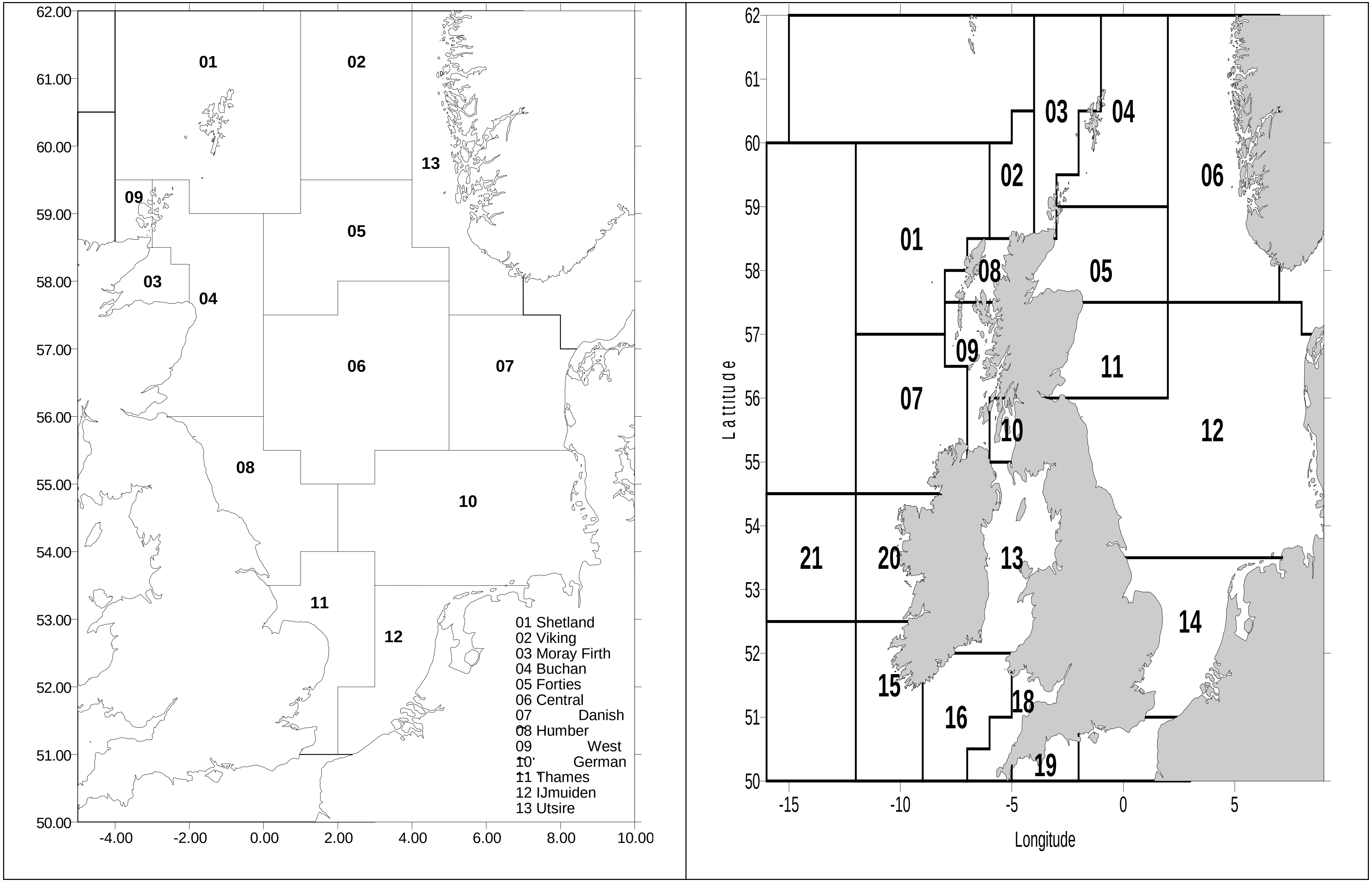
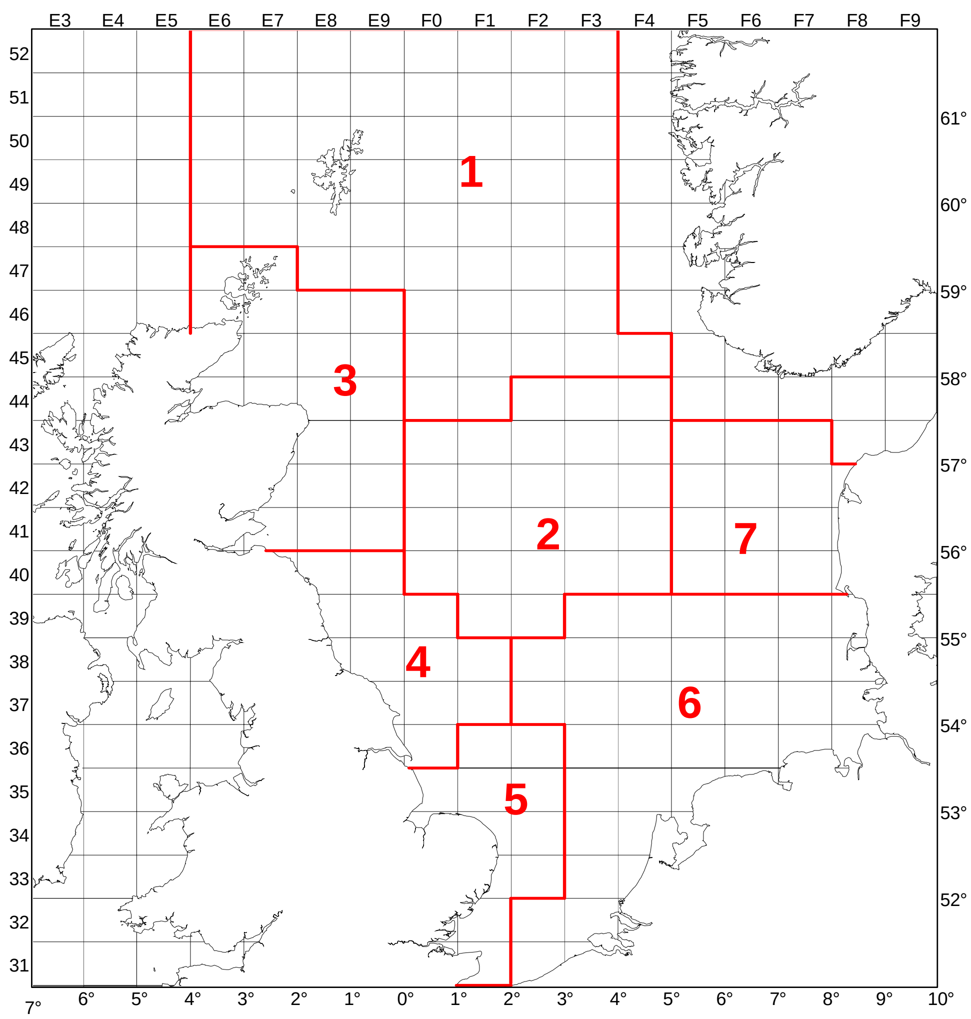


Figure 2.5 Maps of sampling areas for North Sea cod (left, England and Wales) and raising areas for herring (right, the Netherlands).



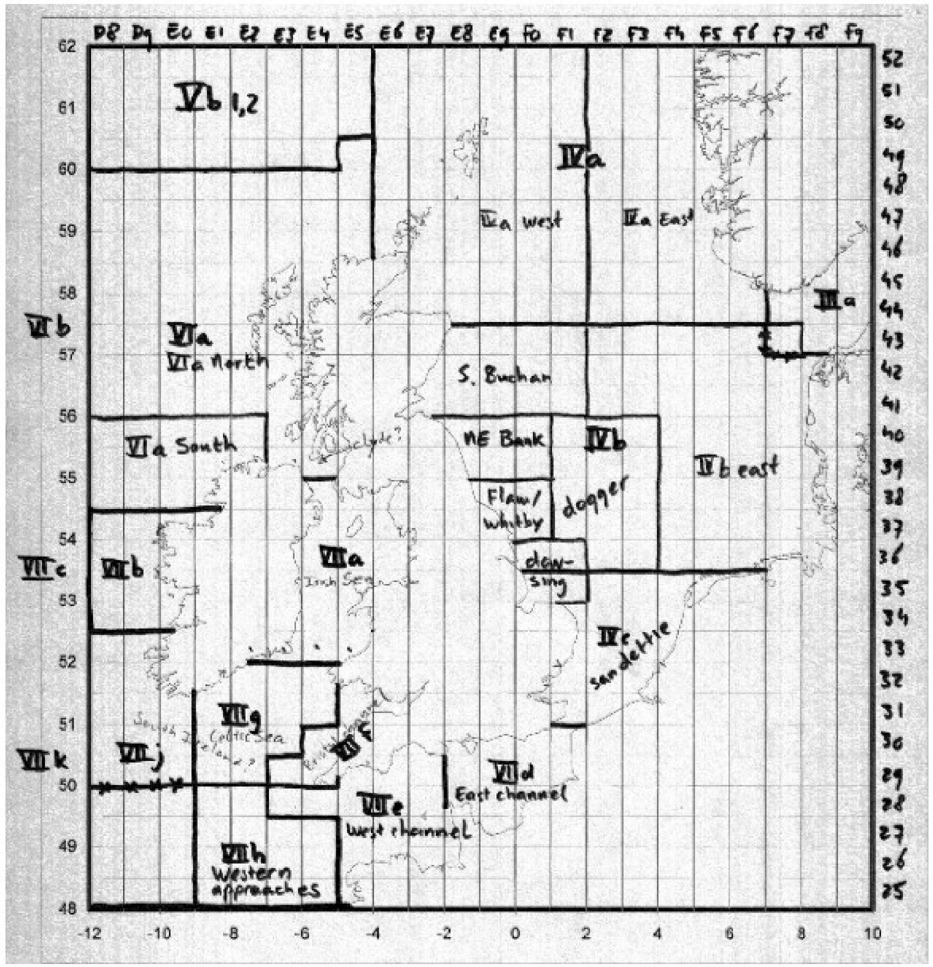


Figure 2.6 Flowchart of AZTI protocol for raising market samples to age compositions.

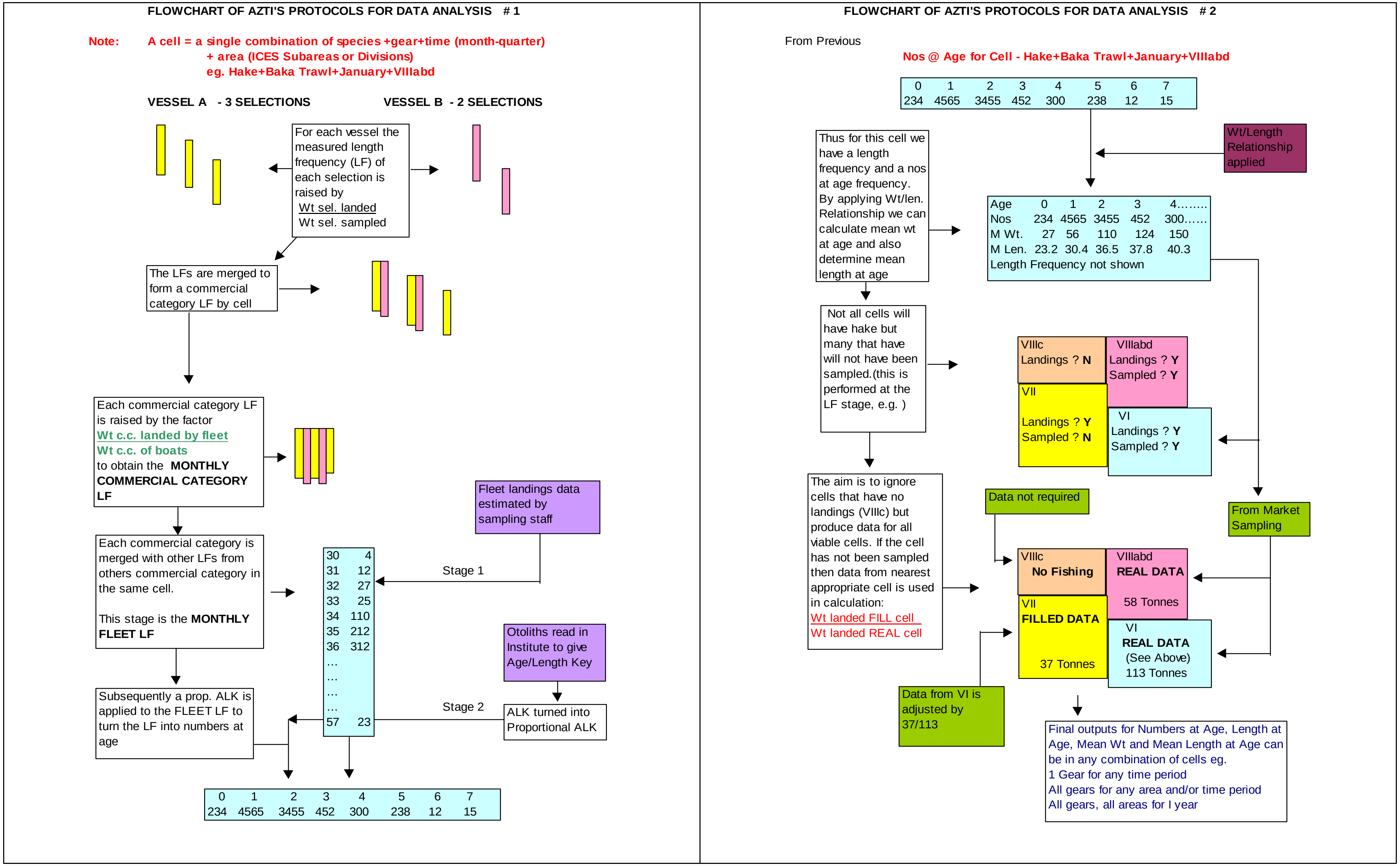
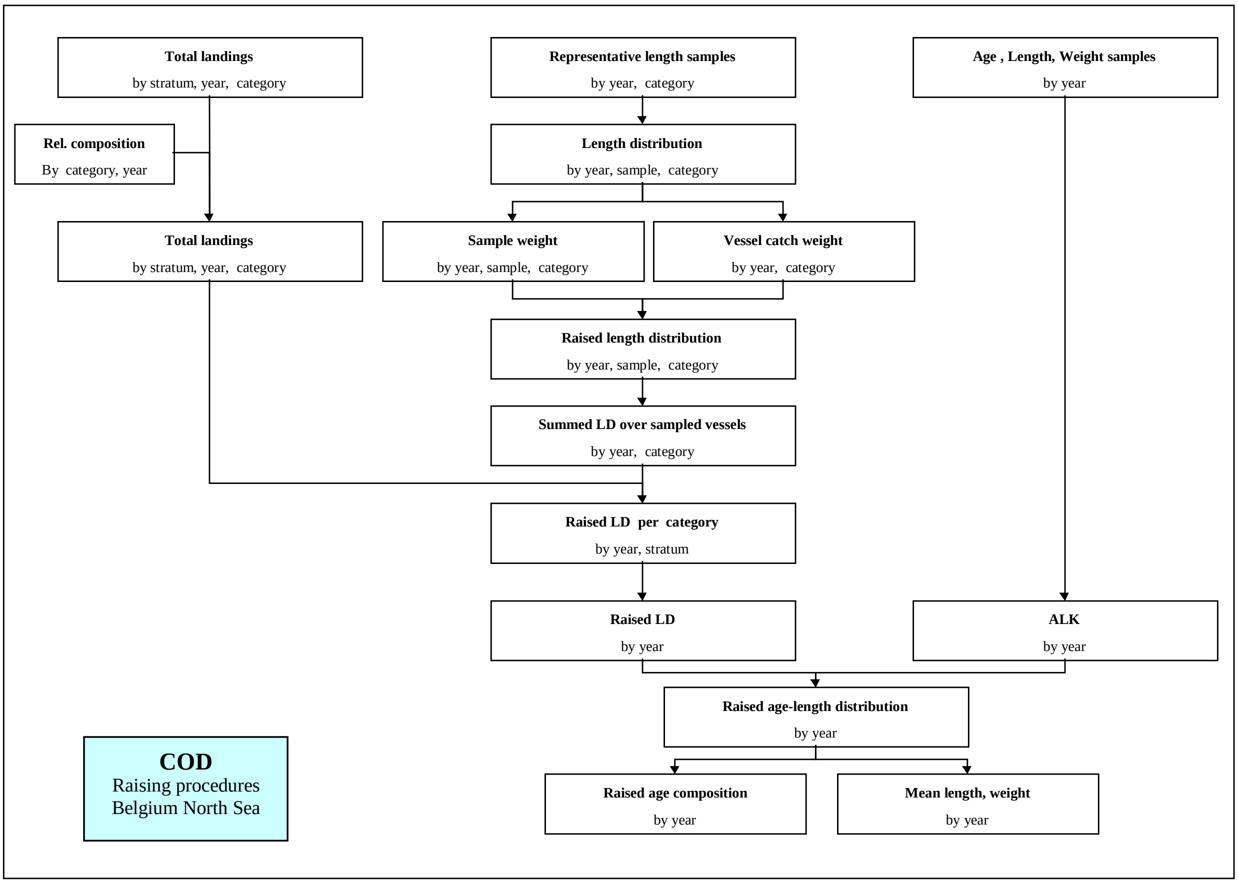


Figure 2.7. Belgium raising procedures for cod (top) and plaice (bottom)



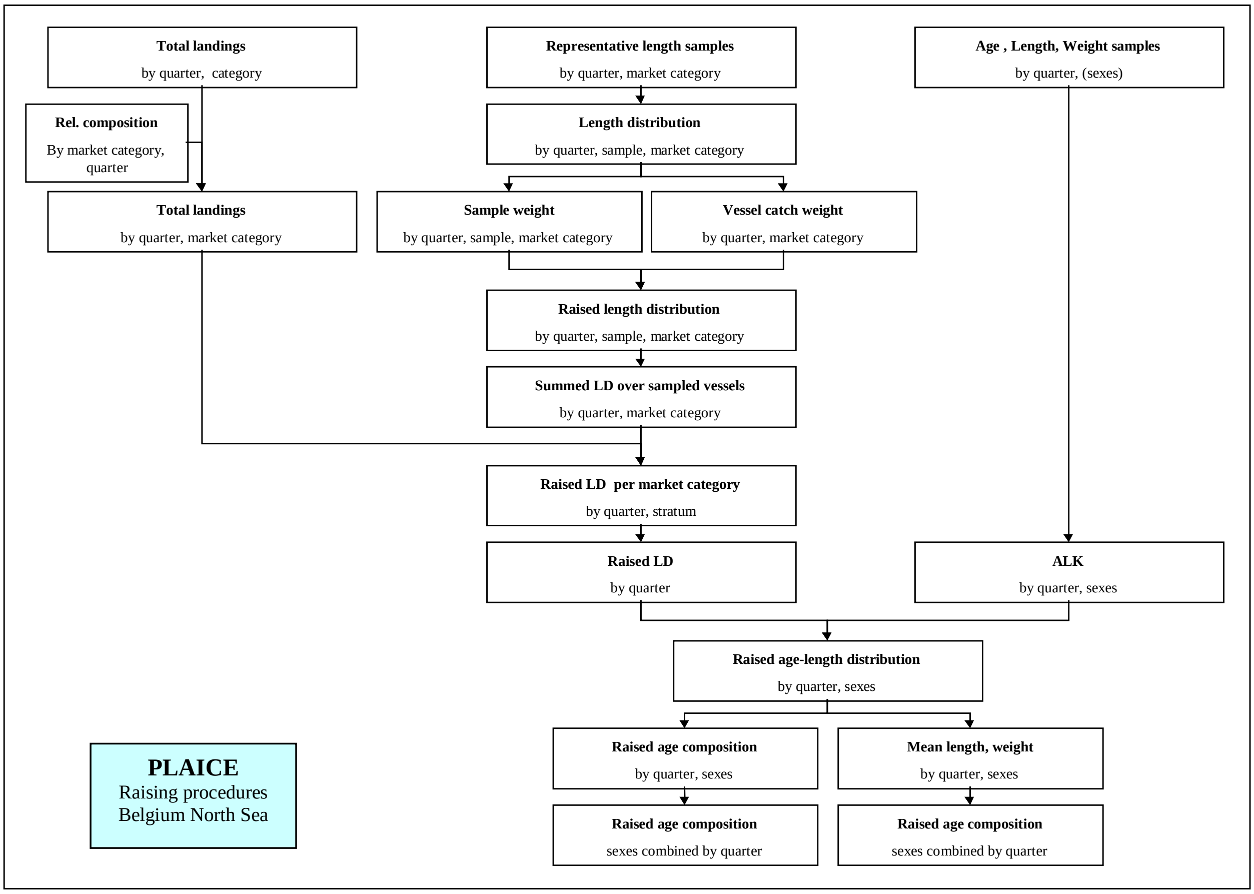


Figure 2.8 Danish raising procedures for plaice and cod (left) and herring (right)

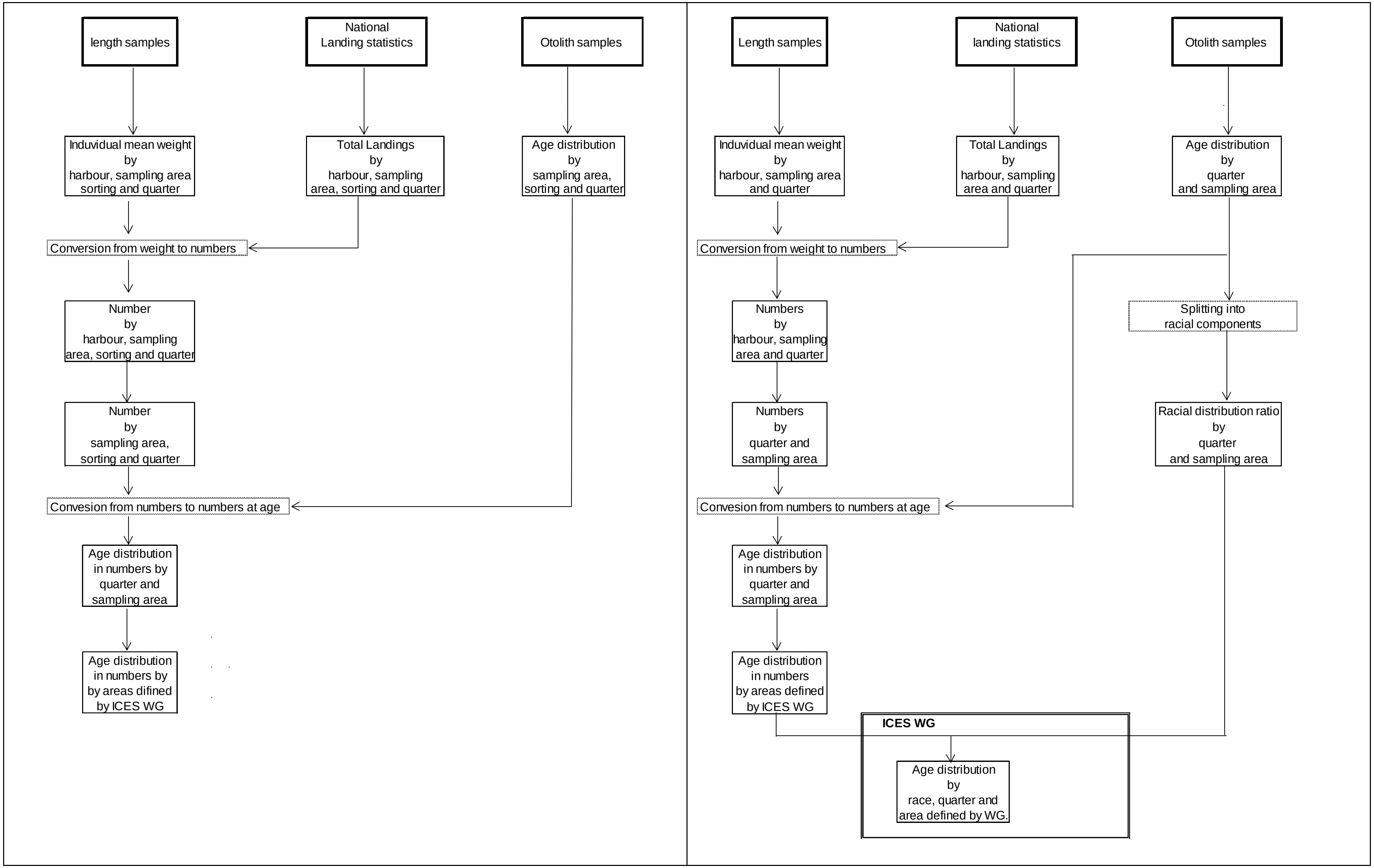


Figure 2.9 England raising procedures for North Sea plaice (left) and North Sea cod (right)

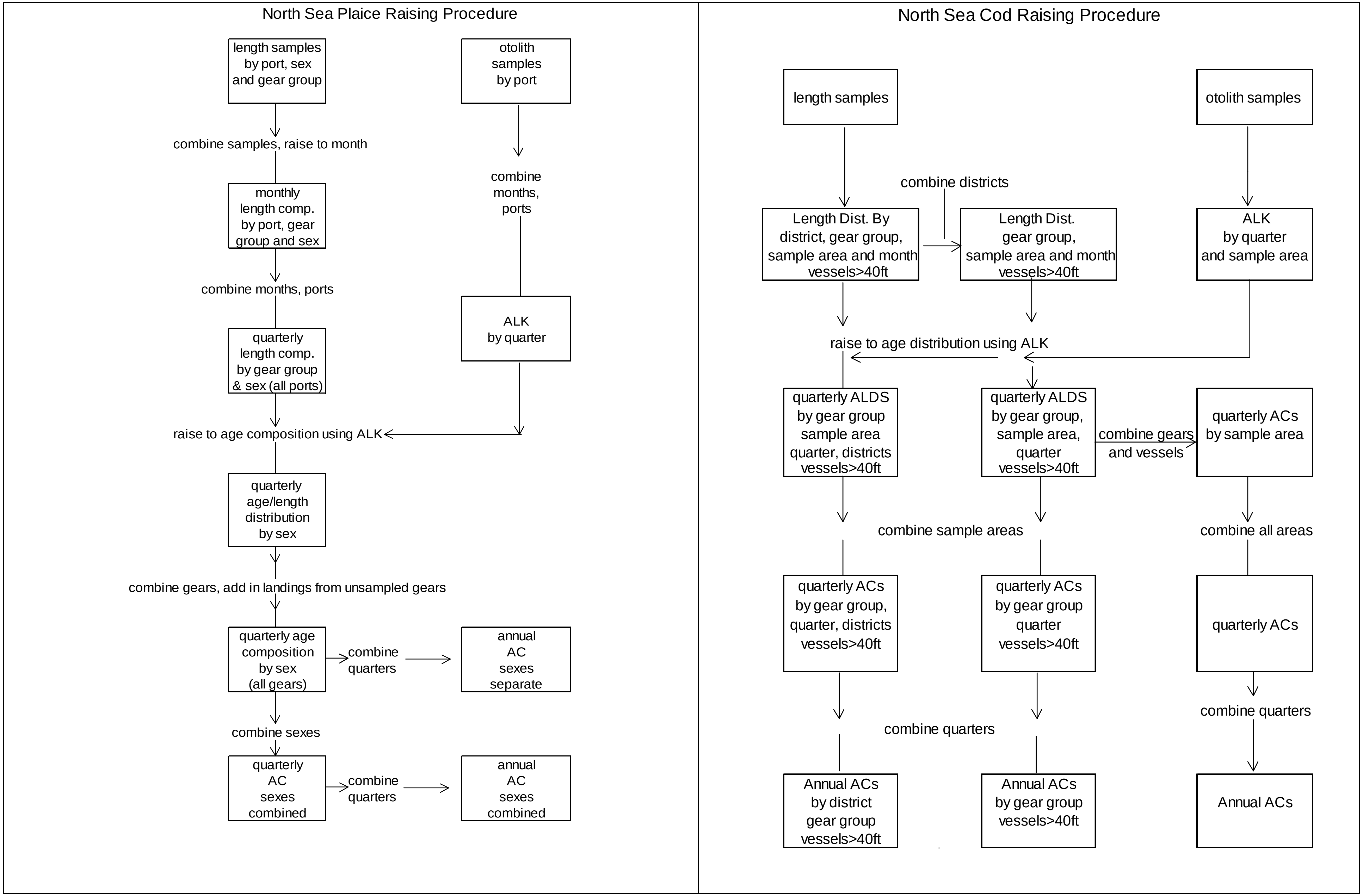


Figure 2.10 Scotland raising procedure for herring (left) and cod (right)

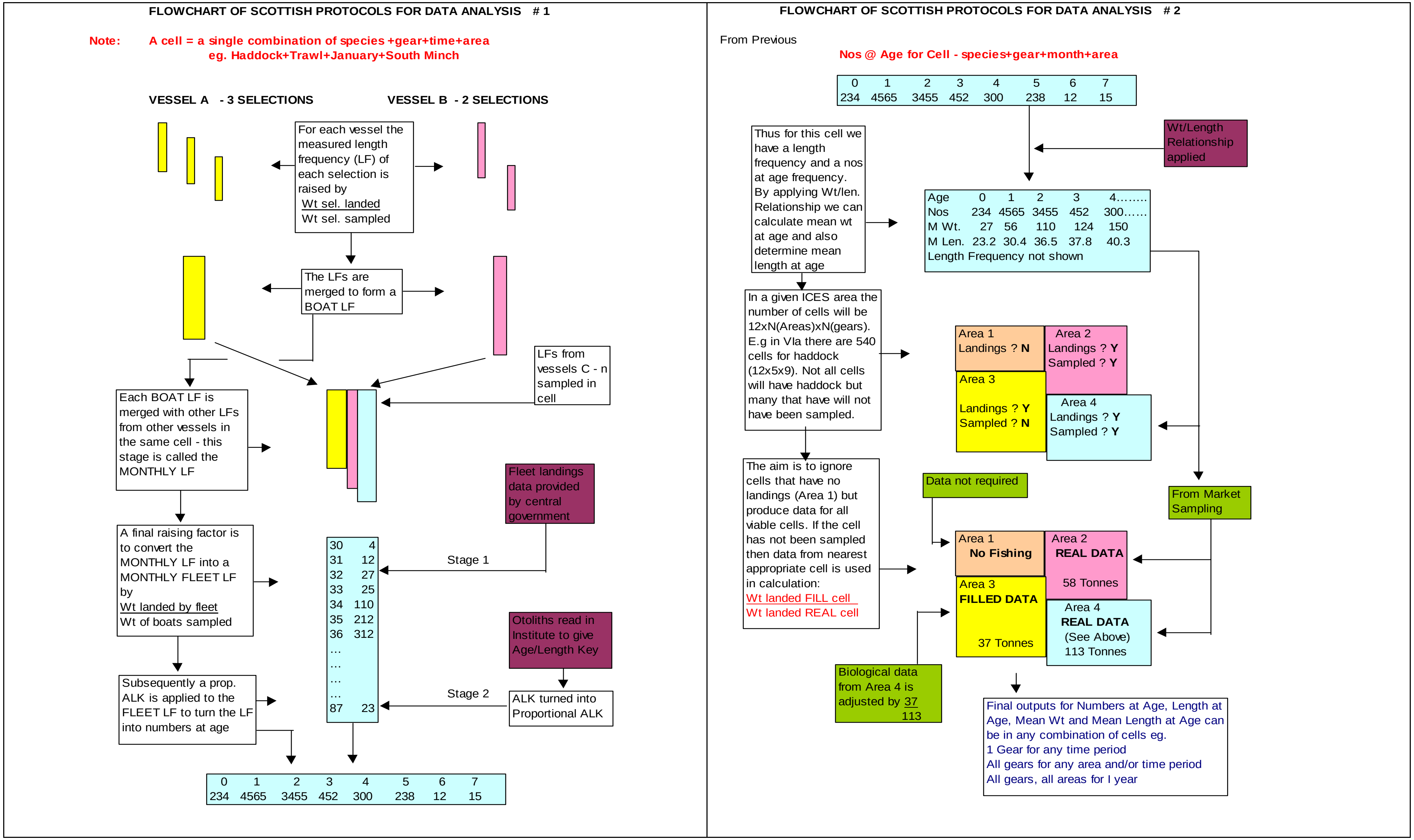
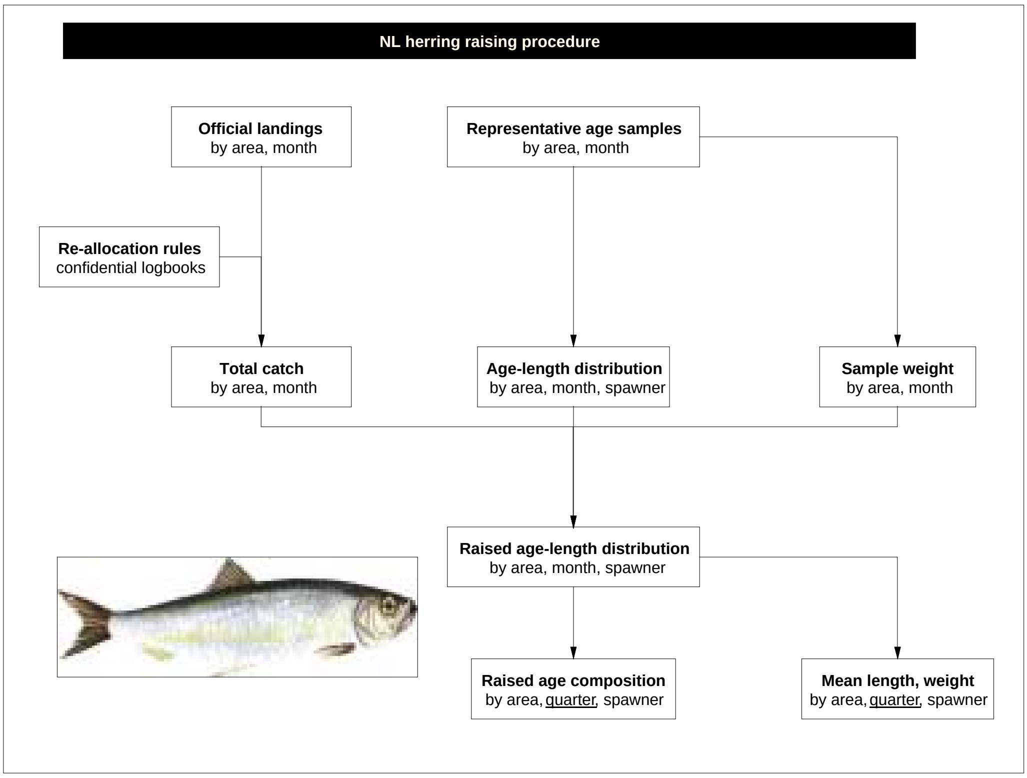


Figure 2.11a The Netherlands raising procedure for herring (top) and plaice (bottom)



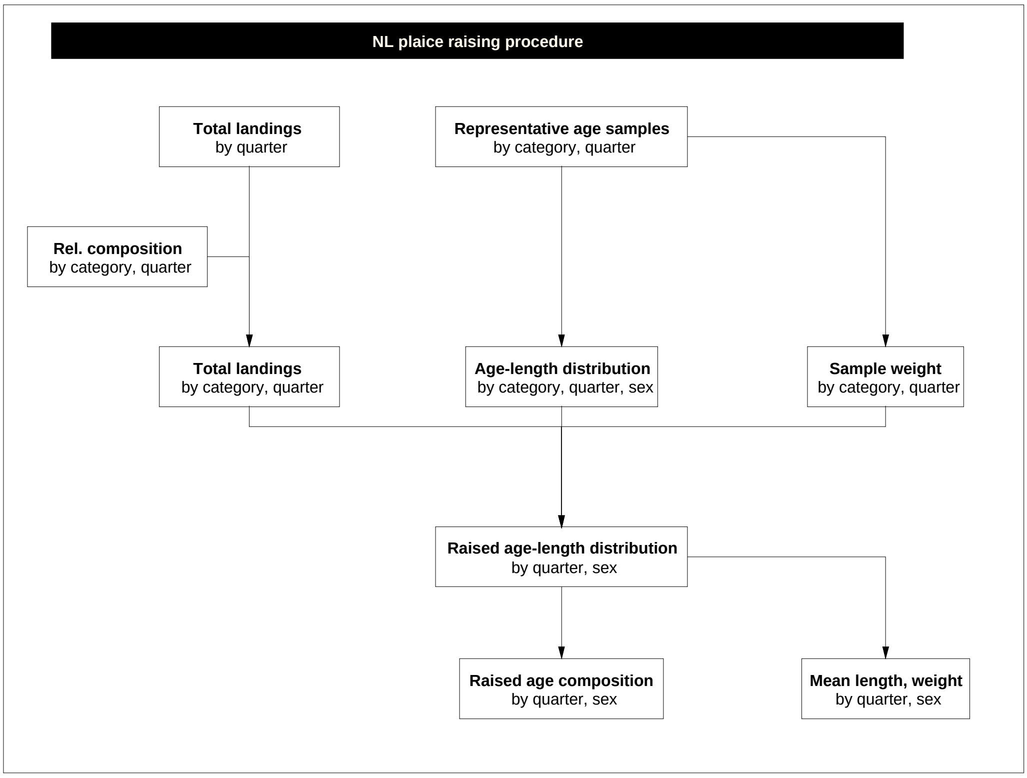
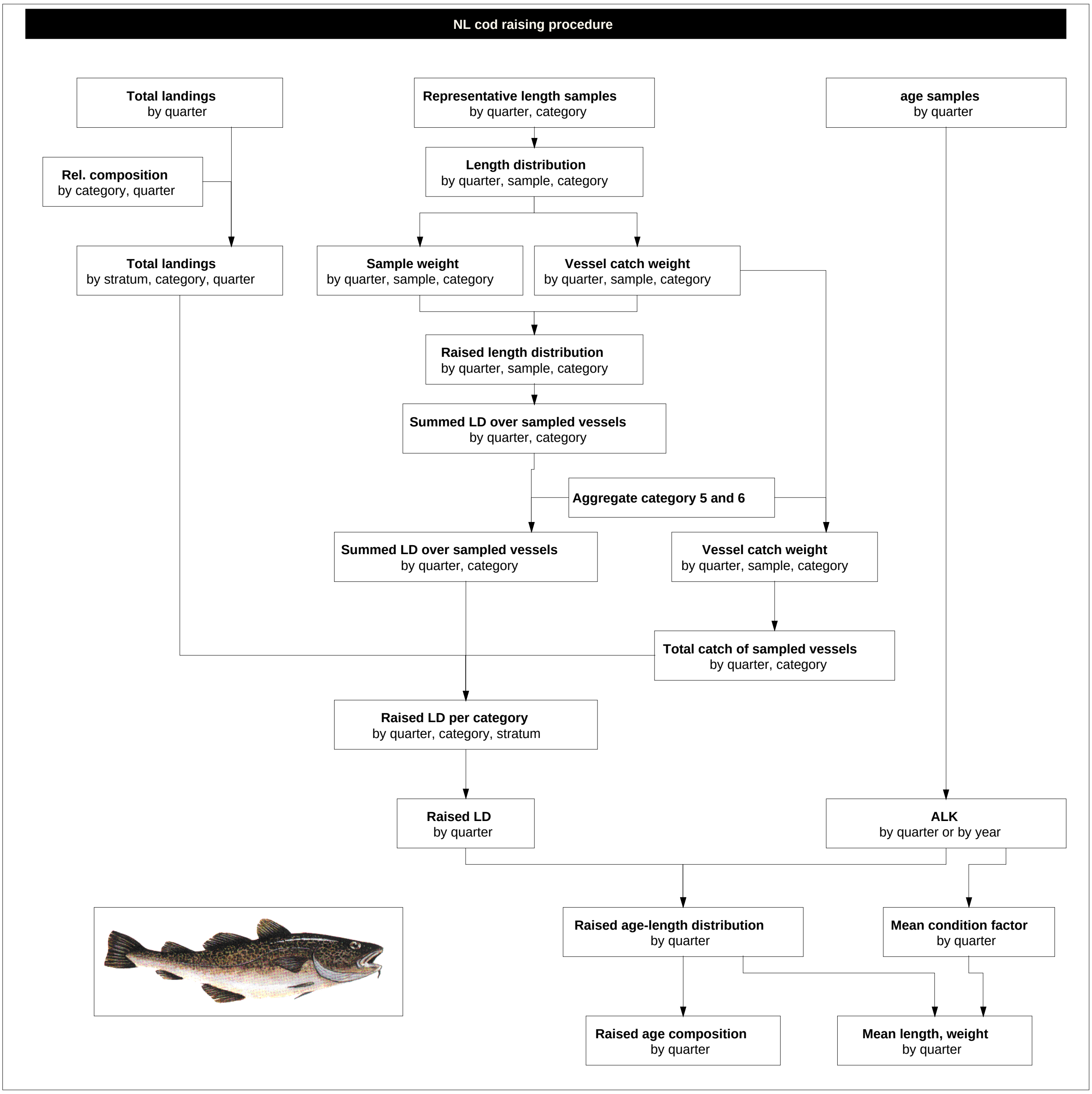


Figure 2.11b The Netherlands raising procedure for cod



3 ANALYSIS OF MARKET SAMPLING

3.1 Spatio-temporal variability

In order to assess the spatio-temporal variability in the market sampling data, several aspects should be considered:

- spatial and temporal mapping of market samples on the landings statistics
- proportion of landings into a country covered by sampling (e.g. two way table)
- analysis of spatial-temporal differences in ALK, age composition and weights at age

Spatio-temporal mapping

In order to assess the spatio-temporal coverage of market sampling in relation to landings, an example was worked out for the Dutch landings and sampling of plaice, herring and cod. An overview was made of the age samples and landings by ICES sub-division and by quarter (cod, plaice) or month (herring).

Landings of cod of the Dutch fleet were predominantly taken in ICES sub-divisions IVc and to a slightly lesser extend in IVb (Table 3.1.1). The number of samples per sub-division was on average equally distributed between the two areas, which indicates that the stratification by harbour may not give an appropriate reflection of the distribution of the fleet. It should be noted that in the raising procedure for cod additional samples are used from the IBTS survey, in order to make up for missing ages at smaller lengths. These samples were not considered in Table 3.1.1.

Landings of herring of the Dutch fleet (based on the official logbooks, not on the re-allocated landings) were predominantly reported in areas IVa and IVb, but also in VIa and VIId (Table 3.1.2). Sampling followed in general the same pattern. The sampling in area IVc and VIId was apparently more intense, but this will be influenced by the misreporting behaviour of the fleet.

Landings of plaice of the Dutch fleet were predominantly taken in area IVb but also in IVc (Table 3.1.3). Sampling followed in general the same pattern. In this case the stratification by harbour does reflect the spatial distribution of the fleet.

Landings inside/outside flag-country

In most market sampling schemes only landings are sampled by vessels that land in the country of their flag, i.e. English vessels will only be sampled if they land in England and not if they land in a third country. Table 3.1.4 gives an overview per species and per country of the landings inside and outside the country in 1998. The conclusion from this table is that substantial proportions of the plaice and herring landings in 1998(≈22%) were un-sampled because they are landed in third countries.

Spatio-temporal variability

Unfortunately, no data was presented at the study group that would enable the analysis of spatial and temporal variability in ALK's, age compositions and weights at age. The group considered that this work be taken up in a sequence to this study group (Workshop on the International Analysis of Market Sampling and the Evaluation of Raising Procedures and Data-Storage (WKIMS), Lowestoft 28-30 November 2000).

3.2 Uncertainty of age compositions and weights at age

3.2.1 England

Aspects of the collection of biological and landings data within the UK (England & Wales) for the purposes of stock assessments are presented elsewhere in this report (see Section 2). In this Section, the word *fish* is used to mean fish of one species only, and the words *catch* and *caught* refer to the landed catch. The landed catch does not include an adjustment for discarded fish and landings may not be known with the accuracy that one would ideally like; i.e. landings may be misreported. Fish caught by foreign registered vessels that land in England and Wales are not sampled.

Method

Market sampling data are used to produce estimates of catch-at-age and weight-at-age. The distributional properties and correlation structure of these variables are necessary if the statistical modelling of catch-at-age data is to be based upon appropriate assumptions. It is not possible to repeat the market sampling within a year, but bootstrapping (Efron & Tibshirani, 1993); namely, resampling from the complete collection of market samples taken within a year, can be used in lieu of the required information. The basic sampling unit proposed is a vessel. The method, algorithm and computer coding are discussed in the context of catch-at-age and weight-at-age data routinely collected under a market sampling program (SGMSM 2000/2).

Bootstrapping the catch at age data was carried out at the vessel level. The original data were extracted from the Biological Sampling System (BSS) which holds length and biological sample data, along with combined and raised processed data.

Firstly, using the sample number and vessel codes in BSS, two lists were formed: the boat-trips from which age samples and length samples had been taken. Each list was sampled with replacement to form a new list – the *bootstrap*. The *bootstrap* length and age samples were then comprised of the data from the boat-trips included in the new lists. Catch-at-age estimates were then calculated from the bootstrap length and age samples. This bootstrap procedure was repeated 100 times for each stock and period of interest in order to test and validate the SAS code developed. Subsequently, bootstrapped samples of size 1000 were implemented for catch-at-age analysis and bootstrapped samples of size 500 were implemented for weight-at-age analysis.

For the stocks and period of interest the following steps are carried out.

Initial set-up

1. Calculate total commercial catch weight, TOTWT.

2. Count number of age samples that were taken, ASAMPLES.

3. Count number of length samples that were taken, LSAMPLES.

Bootstrap steps

4. Create list of the identifying codes of the boat-trips that were sampled.

   (The number of entries in this list is ASAMPLES.)

5. Sample with replacement ASAMPLES entries from the list of identifying codes. This gives a list of boat-trips that make up the bootstrap age sample.

6. Extract the data for the list of identifying codes formed in step 5. This dataset is the bootstrap age sample.

7. Define a plus group for the age data.

8. – 10. Repeat steps 4 – 6, this time for length samples, to produce a bootstrap length sample.

Calculation steps

11. Form length distribution. No. by length group in length sample = LENSUM

    1cm length groups are used.

12. Form ALK.

    No. by length group in age sample = TOTAL

    No. by age and length group in age sample = AGE_TOT

Proportion at each age by length group, PROP = AGE_TOT / TOTAL.

13. Form ALD.

    Estimates of catch numbers-at-age in length sample,

    N_AT_AGE = LENSUM * PROP

14. Calculate total sample weight in length sample, SAMPWT.

15. Raise ALD to fleet level,

    N_AT_AGE = N_AT_AGE * TOTWT / SAMPWT

16. Sum ALD across length groups to give catch numbers-at-age.

This gives a set of catch-at-age estimates for one bootstrap sample. The bootstrap steps and calculation steps outlined above are then repeated for the required number of bootstrap iterations and the results from all the iterations stored in an output file for subsequent processing. Summary statistics such as mean, variance and coefficient of variation at age (CV_a) are calculated from the bootstrap catch-at-age values. Analytic CVs are routinely calculated (see, for example, Flatman, 1990) for numbers-at-age through the relationship

CV n-at-age = CV due to ageing + CV due to length sampling

based upon separating the variance of the numbers-at-age into its two components. The analytic and bootstrap coefficient of variation at age were compared.

Bootstrapping the weight at age data was carried out at the vessel level, as in the case of the catch-at-age. Once again, using the sample number and vessel codes in BSS, a list was formed of the boat-trips from which age samples had been taken. This list was sampled with replacement to form a new list – the *bootstrap*. The *bootstrap* age samples were then comprised of the data from the boat-trips included in the new lists. Weight-at-age estimates were then calculated from the bootstrap age samples. However, the bootstraps of the catch-at-age data and the weight-at-age data were performed independently but in future the two data sources should be resampled jointly to reduce the effects of bias in weight data; with a consequent change in the algorithm of the weight-at-age bootstrap.

This bootstrap procedure was repeated 100 times for each stock and period of interest in order to test and validate the SAS code developed (SGMSM 2000/2). Subsequently, bootstrapped samples of size 500 were implemented for weight-at-age analysis.

The relationship between the mean and variance of the numbers-at-age is fundamental to any future statistical modelling of catch numbers-at-age. The underlying relationship was investigated by considering the mean and variance of the numbers-at-age obtained from the resampling of the market sampling data and compared to the power relationship:

$$\text{variance}\{\text{bootstrapped numbers-at-age}\} = e^{a} \,.\, \text{mean}\{\text{bootstrapped numbers-at-age}\}^{b}$$

Estimated values and asymptotic standard errors of the regression parameters a and b are calculated.

Results
Using the algorithm described above, bootstrap samples were taken for annual and quarterly data (1991-1998) for North Sea cod and North Sea plaice (combined sexes, females only, males only). Detailed results are presented in working documents 2-4 and summarized below.

Cod - numbers at age

For cod, the annual percentage coefficients of variation (CVs) show a consistent pattern across years (Table 3.2.1.1). The estimated CVs are around 15% for age 1, decrease to 5-10% for 2 to 4 year-olds, increase to around 25% for 8 year-olds and are mostly 30% or 40% for 9 year-olds and above. The quarterly data show a similar pattern across age as in the annual data. The only exception to this is that there are few 1 year-olds in the first two quarters; resulting in much higher CVs (Table 3.2.1.1). The CVs for quarterly catch-at-age are higher than for the annual data. However, they broadly appear to follow the anticipated pattern that the quarterly CVs are twice those of the annual CVs.

A comparison was made between the bootstrapped CVs and those derived analytically for the last two years – 1997 and 1998. The bootstrapped CV values are all greater than those calculated analytically but exhibit a similar pattern through the ages within each year. The reason for the difference requires further investigation.

Estimated values and asymptotic standard errors of the regression parameters a and b of the relationship between mean and variance of number at age (see above), are given in Table 3.2.1.2 and shown in Figure 3.2.1.1. The intercept and slope coefficients are consistent across years and for the annual and quarterly data. The underlying correlation of catch numbers-at-age was estimated using the numbers-at-age obtained from the resampling of the market sampling data. Image plots of the correlation matrix for annual and quarterly data, respectively, are given in SGMSM 2000/3. Generally, the correlation on the off-diagonals is less pronounced for the quarterly based correlation matrices of catch numbers-at-age than for the annual correlation matrices. The most acceptable patterns (in terms of diagonal matrices) being produced for the quarterly based correlation matrices of catch numbers-at-age.

Cod: weight-at-age

Gutted weights need to be transformed to un-gutted weights and conversion factors will be applied as described by Bedford *et al*. (1986). No results are available for the bootstrapping of the UK (England & Wales) market sampling data but it is planned to produce these shortly.

Plaice: numbers-at-age

The CVs for plaice are given in Table 3.2.1.3 for combined sexes and for females and males separately in 3.2.1.4 and 3.2.1.5 (see also: SGMSM 2000/4)

The combined sex, annual data CVs decrease from 23% for 2 year-olds to 7% for 4 year-olds, are comparable for ages 4 to 7 and then gradually increase with age. This general pattern is consistent across years and is present for both the annual and quarterly data for both combined and single sex data.

As with North Sea cod, the CVs for quarterly data are generally twice those for the annual data, with the CVs for ages 4-7 for combined sexes are 10-15%. The CVs for females are slightly higher than for those for the combined data and the CVs for males are higher than those for the females. The annual and quarterly CVs for females aged 4-7 years are between 7-10% and 15-20%, respectively. The annual and quarterly CVs for males aged 4-7 years are between 8-15% and 15-30%, respectively.

A comparison was made between the bootstrapped CVs and those derived analytically for the last two years – 1997 and 1998. The bootstrapped CV values for males and females are generally greater than those calculated analytically. Like the cod, the reason for the difference requires further investigation.

Estimated values and asymptotic standard errors of the regression parameters a and b of the relationship between mean and variance of number at age (see above), are given in Table 3.2.1.6 and shown in Figures 3.2.1.2-3.2.1.4. The intercept and slope coefficients are consistent across years and for the annual and quarterly data. The slope coefficients appear similar for the males and females and are, in general, slightly higher than for the combined sex data. The underlying correlation of catch numbers-at-age was estimated using the numbers-at-age obtained from the resampling of the market sampling data. Image plots of the correlation matrix for annual and quarterly data, respectively, are given in SGMSM 2000/4. Generally, the correlation on the off-diagonals is negligible except for the annual combined sex bootstraps; with the most acceptable patterns (in terms of diagonal matrices) being produced for the single sex correlation matrices of catch numbers-at-age.

Plaice: weight-at-age

The percentage coefficient of variation of weights-at-age for single sex (female) and single sex (male) are tabulated separately in Appendix A of SGMSM 2000/4. Box-and-whisker plots of the percentage coefficient of variation for the two situations - females only and males only – are shown in Appendix B of WD4. The differences between the weights-at-age of males and females were such that a combined sex analysis was not undertaken. For each sex separately, the coefficient of variation is essentially constant over the age range recorded in the market sampling data and the inter-quartile range of the coefficient of variation appears not to be dependent upon age.

3.2.2 Scotland

Data

The data collected is aggregated to monthly based region and gear length distributions with age length keys. These data are collected from multiple samples, however as the data is combined before entry into the database, it is no longer possible to separate the individual samples at age and the data is treated as a series of length samples with associated age sampling. The total landings for the fleet are collected as a census by region, gear and month. The data can be thought of as estimates of 'data cells' where each cell is has a landing, and a length distribution and may have an age length key. The catch-numbers (N_{armg}) and catch-biomass (W_{armg}) at age are calculated as:

$$N_{armg} = \sum_{l} n_{lrmg} p_{larmg} * L_{rmg} / \sum_{l} n_{lrmg} w_{lrm}$$

$$W_{armg} = \sum_{l} n_{lrmg} p_{larmg} w_{lrm} * L_{rmg} / \sum_{l} n_{lrmg} w_{lrm}$$

where n_{lrmg} is the number sampled at length by region, month and gear, p_{larmg} is the proportion at age for each length by region, month and gear. (for herring this is independent of gear), L_{rmg} is the landings by weight by region, month and gear, w_{lrmg} is the weight of an individual fish at length by region, month, derived from long weight length relationships (region and month dependant for herring, monthly for cod)

The p_{larmg} are calculated from the number of fish aged at each length.

Both *p* and on occasion *n* may be missing for a particular month, region and gear. In this case the *p* are 'filled in' from another region, gear or adjacent month. These fill-in sequences are provided as a standard from the sampling program.

Methods

Three main methods were applied to try to estimate the precision of the Scottish market sampling scheme;

- a simple jackknife (Efron and Tibshirani, 1993) procedure with the use of fill-in rules for missing data,
- a grouped bootstrap (Efron and Tibshirani, 1993) where monthly and gear categories were combined to give a number of samples by region and quarter, these were then bootstrapped by group,
- a weighted jackknife similar to the simple jackknife but weighing the probability of a data-cell being removed according to estimates of the probability of sampling the cell based on 8 years data.

For all procedures the following initial set up was carried out

1) Obtain total catch for commercial catch per data cell L
2) Obtain a length frequency distribution per data cell LF
3) Obtain an age length key for those cells for which it was available ALK
4) Obtain a list of links between length keys to age length keys, for all data cells, using fill-in rules as required
5) For Group Bootstrap group these data by quarter for all gears
6) Find the number of length and age/length keys per group

Repeat 1000 times for Jackknife and bootstrap replicates

For Jackknife the following procedure was used:

- Select d data cells for removal randomly without replacement; for simple jackknife select with equal probability; for weighted Jackknife select with observed probability of being missed over 8 years
- Create new data set with selected samples removed
- Find new fill-ins for data cells without length or age length keys

For Bootstrap the procedure was:

1) Select randomly with replacement the a number of length and age/length keys per group equal to the original number per group
2) Create new data set with randomly selected samples assigned to data cells (LF & ALK)
3) Create quarterly and annual age length keys
4) Find new fill-ins for data cells without age/length keys
5) In all cases check that the linked age length key contains proportions at age for each length in the length frequency. As required insert probabilities of age at length from quarterly aggregated keys or as a second step yearly aggregated keys,

Following the creation of a data set the total catch at age is calculated:

1) Calculate the mean weight W of fish for each data cell using standard monthly, region dependent length weight relationship and length frequency LF.
2) Calculate the total number of fish N for each data cell from the total catch L and the mean weight W
3) Calculate the number at age N_a for each data cell using the total N, the length frequency LF and the age length key ALK
4) Calculate the mean weight at age for each data cell using the length frequency LF, weight at length W_l and the age length key ALK
5) Calculate the total numbers at age by summing the numbers at age per data cell
6) Calculate the total biomass at age by summing the numbers * mean weight at age per data cell

Following 1000 replications

1) Check that 1000 values have similar mean to original data
2) Calculate CV from mean and variance of 1000 replicates.
3) Correct the Jackknife estimates of CV for number of data cells and removed samples (Efron and Tibshirani, 1993)

For each series of 1000 replicates:

1) For the bootstrap take 1000 replicates directly
2) For Jackknife inflate catch number at age of each replicate by scaling the replicates about the mean and setting the small number of negative observations (<1%) to zero.

Fill-in Rules
For both Cod and Herring sampling, the procedure attempts to estimate data cells organised by month, area and gear. As the sampling is only partial, inevitably it is not possible to fill all of the cells where landings are reported in the year. In some cases no data is available at all, in others length keys only are available and age length key data must be supplied. The current method used is to assign length or more usually age/length key data from another cell. This process is in effect a step-wise spatial temporal gear based model, estimated by nearest neighbour method. The nearest neighbour is dealt with by sequence of assignment from previous or following month based on first the most similar areas and failing that the gears. The presence of data in the same area gear cell is checked in previous and subsequent months, then in sequence (1st, 2nd, 3rd etc.) an alternative area gear cell is checked in the same, previous and subsequent months, until an alternative is found (Table 3.2.2.1a). In the case of herring the age length key is assumed to be the independent of gear, the fill in rules are thus only by area (Table 3.2.2.1b).

Results
Coefficient of Variation at age

The jackknife procedures give estimates of precision for the national market sampling scheme, year by year. The results of the different analyses expressed as CV at age and correlation coefficients at age are tabulated in Tables 3.2.2.2-3.2.2.6 for North Sea cod and Tables 3.2.2.7-3.2.2.8 for North Sea herring. The relative change in CV at age is similar for all methods. The CV starts high at age 1 and reduces to a minimum for the year usually at ages 3 or 4 and then rises at older ages. However, the absolute level is different for the different analyses. This is primarily due to the underlying assumptions behind each method. The simple jackknife assumes all the data cells have an equal probability of being sampled, which is not strictly correct, some cells are sampled every year, and some in only 1 of eight years. The group bootstrap, has a similar problem but additionally assumes that the between cell variance within a group is part of the measurement error. In fact using this method also introduces some bias between the observed results and the bootstrap analysis, because there are systematic difference between catch proportions at age and total biomass by gear. The weighted jackknife technique attempts to compensate for the different probabilities of missing data cells but the method has not been fully validated. In particular the use of the same correction factor that is applied for the simple jackknife (see above) needs to be checked. Until this method is validated the simple jackknife method should be used to provide the estimates of precision.

Correlation coefficients between estimates at age

The mean correlation coefficient between estimates of catch at age are given in the Tables 3.2.2.6 and 3.2.2.8 for the different methods. The correlation between estimates at age is positive and significant for ages 3 to 8 for Cod and ages 4-9 for herring. The use of length stratified sampling for age, with pure random sampling would give rise to small negative correlation between ages. However, it appears from this analysis, that the process is dominated by groups of fish at older ages being landed together in groups, so the presence of a group of ages increases or decreases together. It is important that this type of correlation within the estimates of catch are dealt with correctly within the assessment. Both the Jackknife and Bootstrap methods of analyses of Scottish data show this behaviour supporting the view that it is a property of the sampling program.

Conclusions

Currently until a method for dealing with the different probabilities of sampling different data cells is validated, the simple jackknife method should be used to describe the Scottish market sampling scheme.

3.2.3 The Netherlands

Methods

The bootstrap analysis of the Dutch catch at age data for cod and plaice, followed the same approaches as in Section 3.2.1, whereby only the raising procedure was specific for the Dutch case (SGMSM 2000/1). However, the resampling was only performed at the year level and not at the quarterly level.

Results

The bootstrap analysis for <u>cod</u> consisted of 1000 iterations using the same number of age and length samples as used for the contribution to the WGNSSK. Each iteration consisted of a random selection from both the list of age samples and from the list of length samples in a given year. Raising was stratified by quarter, gear (1991-1993 only) and market category. Results of the analysis are summarized in Table 3.2.3.1. Coefficients of variation (CV) for ages 2 and sometimes 3 and 4 are around 10-20%, but CV goes up rapidly for older ages.

The bootstrap analysis for <u>plaice</u> likewise consisted of 1000 iterations using the same number of age samples as used for the contribution to the WGNSSK. Each iteration consisted of a random selection from the list of available age samples in a given year. Raising was stratified by quarter, sex and market category. Results of the analysis are summarized in Table 3.2.3.2a-b. Coefficients of variation (CV) of females tend to be rather flat at 10-20% but the CV for males increases with age.

Table 3.1.1 NL landings (top) and number of age-samples (bottom) of North Sea COD.

Landings (tonnes)

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
3A	0	1	1	2	13	4	1	7	29
4A	16	21	12	5	19	5	13	8	98
4B	2277	4034	3990	2629	4228	4065	4661	4749	30633
4C	3842	5399	4896	3261	6554	4858	6665	9605	45081
6A							1	1	3
7A						22	27	20	69
7D	0	1	0		0	0		19	21
7H						11		6	17
OTHER	383	1135	935	392	372	244	332	254	4048
ALL	6518	10592	9834	6289	11186	9209	11701	14669	79999

Age samples

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
4A				1					1
4B	8	22	23	21	18	17	21	18	148
4C	21	15	15	18	22	21	16	22	150
ALL	29	37	38	40	40	38	37	40	299

Table 3.1.2 NL landings (top) and number of age-samples (bottom) of HERRING.

Landings (tonnes)*

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
2A						8815	12299	14196	35309
3A	63		38		385			548	1034
4A	26814	28015	26474	18796	24554	3223	5834	11218	144928
4B	23939	25974	30376	32624	31024	18473	14976	27468	204853
4C	9058	7884	7150	6460	11208	6082	5925	2348	56115
5B						3		11	15
6A	8278	6114	9655	5956	7839	9400	10075	10153	67470
7B	593	1719	745	1932	1184	1818	1245	724	9959
7C		220							220
7D	9100	10083	11609	10009	12655	7942	8215	8900	78513
7F	154								154
7G	1019	811	610	791	555	353		221	4360
7H	360	92	121	0		502	598	1023	2696
7J	293	349	589	377	407	134	306	188	2641
7K		51		95					145
OTHER	1134	398	629	2162	9636	20861	5976	93	40889
ALL	80806	81710	87996	79201	99447	77605	65448	77090	649303

* Note: landings based on official logbook data (not corrected for misreporting)

Age samples

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
2A					10	12	16		38
4A	30	14	17	10	18	6	13	34	142
4B	36	20	20	12	18	3	11	18	138
4C	9	17	17	26	19	10	14	6	118
6A	9	9	13	20	8	1	1	11	72
7B	1		1	3	1		2		8
7D	10	9	16	25	12	11	16	13	112
7E				1					1
7G	1		1	1					3
7J			1	1		1			3
OTHER			1		2	1	1		5
ALL	96	69	87	99	88	45	74	82	640

Table 3.1.3 NL landings (top) and number of age-samples (bottom) of PLAICE.

Landings (tonnes)

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
2A		2	0					3	5
3A	8	19	9	19	36	12	2	43	148
4A	354	469	380	196	413	15	25	63	1917
4B	44239	31201	30648	33987	27098	20044	20653	17482	225352
4C	17320	16497	14971	14213	16159	14950	13102	12634	119847
6A							20	11	31
7A						58	100	27	184
7B							4		4
7D					2	0			2
7H						49		13	62
NVT	3846	2205	2209	1575	523	319	178	165	11020
ALL	65767	50394	48218	49991	44231	35448	34084	30441	358573

Age samples

	1991	1992	1993	1994	1995	1996	1997	1998	ALL
4A		1		1					2
4B	51	55	45	50	45	49	38	54	387
4C	28	23	29	28	42	26	36	27	239
6A			1				1		2
7A				1		3	7		11
7F						1			1
7H								2	2
NVT							3		3
ALL	79	79	75	80	87	79	85	83	647

Table 3.1.4 Landings inside and outside sampling nations (tonnes - 1998).

	Cod			Plaice			Herring		
Country	**Inside**	**Outside**	**Total**	**Inside**	**Outside**	**Total**	**Inside**	**Outside**	**Total**
Belgium	2689	2152	4841	2746	2560	5306	0	0	0
Denmark	20918	2083	23001	9465	633	10098	28831	955	29786
Netherlands	14626	51	14677	30249	294	30543	41795	0	41795
Norway	6167	865	7032	90	973	1063	51787	24746	76533
UK*	49308	2328	51636	8543	10367	18910	32344	19214	51558
Total	93708	7479	101187	51093	14827	65920	154757	44915	199672
Proportion	93%	7%		78%	22%		78%	22%	

* UK split up by region

UK(E+W)	16342	1315	17657	4811	5456	10267	154	6073	6227
UK(Scot)	32966	1013	33979	3732	4911	8644	32190	13141	45331

Table 3.2.1.1. E&W COD. Tabulated percentage coefficient of variation of numbers-at-age by age and year obtained from resampling of the market sampling data.

All year	91	92	93	94	95	96	97	98
1	11	18	21	13	12	13	11	22
2	7	8	8	7	6	6	7	5
3	6	8	13	4	6	5	4	5
4	6	7	11	10	8	7	5	6
5	7	13	16	10	13	10	8	9
6	9	16	23	13	16	16	9	14
7	16	16	26	18	19	21	15	16
8	15	24	29	26	25	25	23	23
9	28	25	49	30	39	34	38	33
10	35	46	39	82	36	48	34	39
11+	42	46	61	37	42	55	18	22

Q1	91	92	93	94	95	96	97	98
1				69	59			
2	18	14	13	18	16	18	15	15
3	17	13	10	8	11	12	9	10
4	16	10	14	16	13	12	8	9
5	13	17	16	14	19	14	10	13
6	12	22	29	19	24	24	15	20
7	26	23	45	26	34	36	25	23
8	21	45	43	41	49	44	36	33
9	51	43	71	64	85	50	56	51
10	57	75	67	70	49	72	66	75
11+	53	88	95	58	80	71	38	39

Q3	91	92	93	94	95	96	97	98
1	21	23	23	26	19	20	16	55
2	9	19	7	9	11	10	12	9
3	7	11	13	8	13	10	5	9
4	12	18	11	19	17	13	10	13
5	11	30	14	23	35	22	17	18
6	12	32	25	31	40	35	17	24
7	32	36	37	52	49	42	32	28
8	32	60	37	68	76	69	51	60
9	71	49	67	63	75		61	81
10	59	83	72	74	84	73	59	74
11+	75	76	82	70	82	109	30	37

Q2	91	92	93	94	95	96	97	98
1	42	52	73	75	41	NA	58	57
2	14	11	18	17	9	13	14	11
3	10	9	22	7	13	9	8	9
4	12	8	17	14	14	14	8	12
5	12	15	27	18	23	23	13	16
6	15	20	50	21	35	35	19	29
7	30	21	52	33	43	59	39	30
8	26	37	59	44	50	66	60	65
9	56	43	82	45	60	141	80	86
10	81	65	108	103	87	87	75	95
11+	106	71	81	82	94	86	48	35

Q4	91	92	93	94	95	96	97	98
1	12	27	25	12	15	17	16	23
2	7	18	8	9	8	9	10	5
3	8	19	12	11	12	7	8	12
4	16	21	16	35	17	17	13	19
5	20	34	22	41	28	21	20	32
6	21	37	42	51	34	43	25	47
7	63	42	40	79	35	58	40	53
8	47	52	68	121	60	48	46	62
9	63	60	76	79	108		66	53
10	64	NA	85				88	92
11+	66	63	55		52	69	37	55

Table 3.2.1.2: Intercept (a) and slope (b) estimates from the fit of a linear regression of log(variance) on log(mean) for the annual (top) and quarterly (middle and bottom) E&W bootstrap analysis of North Sea cod.

	Annual			
Year	**a**	**st.err.a**	**b**	**st.err. b**
91	1.995	1.071	1.477	0.0904
92	0.770	0.837	1.614	0.0726
93	1.764	0.707	1.575	0.0616
94	1.589	0.752	1.520	0.0664
95	1.373	0.508	1.548	0.0443
96	2.191	0.523	1.482	0.0453
97	2.312	1.042	1.431	0.0886
98	1.835	0.862	1.493	0.0737

	1st Quarter				**2nd Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	2.309	1.365	1.510	0.1274	2.646	0.942	1.462	0.0928
92	3.455	0.787	1.397	0.0758	2.455	0.784	1.449	0.0789
93	1.761	0.684	1.567	0.0681	2.579	0.504	1.555	0.0516
94	1.771	0.729	1.547	0.0745	1.260	1.173	1.614	0.1197
95	2.282	0.618	1.518	0.0626	2.154	0.626	1.542	0.0630
96	2.521	0.632	1.498	0.0609	2.550	0.533	1.500	0.0551
97	3.574	0.989	1.353	0.0941	3.312	0.795	1.398	0.0790
98	2.209	0.921	1.510	0.0853	3.519	0.745	1.408	0.0720

	3rd Quarter				**4th Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err. a**	**b**	**st.err. b**
91	1.943	0.677	1.484	0.0674	1.724	0.472	1.508	0.0495
92	1.252	0.497	1.632	0.0502	-0.140	0.401	1.773	0.0419
93	1.722	0.512	1.527	0.0523	1.033	0.694	1.621	0.0735
94	1.007	0.520	1.624	0.0542	3.938	0.640	1.394	0.0614
95	1.948	0.488	1.575	0.0490	0.999	0.570	1.605	0.0585
96	1.683	0.551	1.559	0.0549	2.495	0.648	1.476	0.0616
97	2.001	0.781	1.482	0.0776	2.705	0.700	1.448	0.0690
98	1.985	0.516	1.503	0.0540	2.629	0.711	1.474	0.0725

Table 3.2.1.3. E&W PLAICE. Tabulated percentage coefficient of variation of numbers-at-age by age and year obtained from resampling of the market sampling data (resampling by year, sexes combined).

All year	91	92	93	94	95	96	97	98
1		53		53				
2	23	22	23	23	23	23	24	21
3	13	11	11	9	12	13	9	8
4	7	8	6	5	6	8	6	5
5	6	6	7	7	9	5	7	6
6	4	7	6	8	7	7	6	8
7	8	6	8	8	9	8	8	8
8	12	12	6	11	10	9	8	9
9	13	12	10	9	11	9	9	9
10	11	13	12	12	11	11	12	10
11	17	14	12	15	13	10	15	13
12	18	19	13	14	18	13	13	14
13	23	18	19	14	15	16	15	11
14	25	18	19	16	16	16	17	17
15+	10	11	9	12	10	10	10	9

Q1	91	92	93	94	95	96	97	98
1				50				
2	59	70	66	54				53
3	42	26	24	28	30	33	23	15
4	14	21	11	12	12	19	16	11
5	11	13	11	10	18	10	13	12
6	7	12	12	13	14	13	9	11
7	15	10	12	14	17	13	18	14
8	18	24	11	17	14	15	12	17
9	26	25	21	18	16	14	14	17
10	16	25	23	18	17	20	18	13
11	33	20	20	27	31	16	23	26
12	31	40	22	21	29	25	24	29
13	40	47	33	26	26	28	25	19
14	56	32	35	32	31	26	35	32
15+	20	20	16	22	22	14	15	12

Q3	91	92	93	94	95	96	97	98
1								
2	44	30	53	43	64	51	35	33
3	22	19	19	15	27	22	16	16
4	11	11	11	13	11	18	11	9
5	11	11	12	21	14	12	13	13
6	8	15	14	20	10	12	11	17
7	18	11	17	16	15	16	13	16
8	26	21	13	33	21	20	18	21
9	29	21	25	15	26	19	15	17
10	23	26	25	22	22	18	30	26
11	30	33	22	36	23	22	35	28
12	45	28	27	23	35	27	26	29
13	48	25	58	32	33	28	35	22
14	47	38	26	36	32	34	38	33
15+	16	22	16	19	22	24	22	19

Q2	91	92	93	94	95	96	97	98
1								
2		57			61	59	67	60
3	28	17	22	23	29	18	16	18
4	13	18	14	10	11	12	9	11
5	9	13	13	13	12	9	12	10
6	6	11	10	15	16	15	12	14
7	15	13	15	17	15	13	13	14
8	21	24	9	21	21	15	18	15
9	23	28	13	16	22	16	17	19
10	28	24	21	26	22	23	28	21
11	35	27	27	26	17	20	34	27
12	29	34	24	37	31	19	25	26
13	42	37	31	31	31	32	22	27
14	42	45	40	25	20	29	33	29
15+	19	29	18	17	17	21	17	20

Q4	91	92	93	94	95	96	97	98
1		53						
2	36	30	27	23	19	45	32	32
3	23	15	14	12	11	24	13	13
4	14	11	12	11	13	13	12	9
5	14	9	19	15	16	10	12	14
6	9	14	19	17	17	17	11	18
7	20	12	20	20	26	15	17	17
8	28	25	17	22	25	23	18	20
9	31	25	29	22	22	19	21	20
10	21	25	34	19	17	24	21	19
11	39	40	27	33	25	20	44	25
12	41	60	26	38	56	39	23	30
13	57	48	49	31	47	49	35	20
14	62	37	53	43	52	55	34	37
15+	21	16	24	38	19	20	22	21

Table 3.2.1.4 E&W PLAICE. Tabulated percentage coefficient of variation of numbers-at-age by age, quarter and year obtained from resampling of the market sampling data (FEMALES ONLY).

All year	91	92	93	94	95	96	97	98
2	29	25	28	25	24	25	25	25
3	16	13	13	11	13	14	11	9
4	8	9	8	8	7	9	8	6
5	7	7	9	9	10	7	9	8
6	5	9	9	10	10	9	8	10
7	11	8	11	10	13	10	10	10
8	14	12	7	17	13	13	11	12
9	18	15	14	10	13	11	13	12
10	16	20	14	15	12	14	16	14
11	28	16	15	16	16	12	19	16
12	16	20	17	17	21	15	16	16
13	22	18	24	20	20	21	16	14
14	36	26	25	26	24	22	24	21
15+	10	13	10	15	14	12	11	10

Q1	91	92	93	94	95	96	97	98
2			62	60				
3	47	40	30	33	52	37	22	23
4	21	21	16	16	22	22	23	12
5	15	14	17	17	25	15	16	14
6	11	13	18	15	17	17	13	16
7	21	14	21	14	22	14	22	18
8	24	27	12	26	18	20	15	29
9	42	38	25	15	23	20	18	21
10	27	40	32	25	20	28	23	19
11	47	26	27	32	33	20	32	29
12	28	52	23	24	33	33	27	31
13	36	35	51	33	35	34	26	24
14	50	79	39	62	48	34	36	31
15+	18	20	19	28	29	17	17	17

Q3	91	92	93	94	95	96	97	98
2	47	34	73	46	68	53	36	34
3	26	20	19	18	23	26	18	15
4	13	13	11	14	10	20	13	9
5	14	13	19	23	17	16	19	15
6	10	20	17	20	20	17	15	20
7	23	13	22	20	23	22	16	16
8	33	20	16	37	24	28	30	25
9	28	25	31	18	34	22	29	26
10	22	39	30	34	27	26	30	40
11	44	35	29	39	36	25	48	29
12	46	29	45	35	45	34	30	35
13	40	33	76	40	40	45	35	26
14	61	35	34	42	59	52	51	55
15+	23	25	20	36	25	36	24	23

Q2	91	92	93	94	95	96	97	98
2	NA	70	NA	NA	64	74	72	72
3	41	20	25	29	24	21	18	20
4	16	22	17	15	11	15	13	9
5	11	15	17	18	18	12	15	14
6	8	15	15	21	22	16	17	21
7	22	14	23	20	18	19	16	22
8	26	27	13	39	25	22	21	22
9	46	31	19	24	26	22	26	29
10	33	37	23	44	29	24	37	28
11	44	35	32	36	18	22	30	40
12	28	40	25	42	40	22	31	37
13	40	49	36	50	45	41	35	36
14	65	43	47	50	26	55	42	35
15+	19	28	18	26	27	23	27	19

Q4	91	92	93	94	95	96	97	98
2	38	30	35	26	22	48	32	39
3	25	18	16	14	10	24	13	16
4	13	13	14	14	13	16	14	11
5	16	12	18	14	16	11	17	21
6	12	16	19	19	17	22	14	26
7	27	16	26	23	26	22	28	19
8	27	31	20	27	36	25	25	27
9	29	26	31	23	33	24	32	26
10	29	49	35	25	23	26	35	26
11	35	50	32	34	27	31	48	28
12	49	58	40	45	61	36	23	33
13	65	36	53	39	46	52	41	28
14	53	52	55	61	40	60	51	56
15+	21	23	21	37	33	22	25	19

Table 3.2.1.5 E&W PLAICE. Tabulated percentage coefficient of variation of numbers-at-age by age, quarter and year obtained from resampling of the market sampling data (MALES ONLY).

All year	91	92	93	94	95	96	97	98
1	NA	52	NA	54	NA	NA	NA	NA
2	40	30	42	36	35	31	33	26
3	19	14	14	15	14	19	14	12
4	12	11	9	11	10	12	11	10
5	10	9	10	11	13	9	12	11
6	8	11	11	15	11	11	10	13
7	15	10	15	17	14	11	13	14
8	22	22	14	20	19	15	14	16
9	22	20	20	21	21	17	14	15
10	19	21	24	23	26	22	25	17
11	26	25	20	36	24	17	24	25
12	35	33	25	33	35	24	21	25
13	45	36	30	31	30	23	27	21
14	43	30	33	31	26	24	29	30
15+	18	20	19	27	18	15	21	15

Q1	91	92	93	94	95	96	97	98
1	NA	NA	NA	55	NA	NA	NA	NA
2	62	73	NA	51	NA	NA	NA	58
3	60	36	39	45	36	49	41	21
4	22	41	15	23	15	30	21	25
5	21	20	13	14	21	17	26	23
6	13	20	19	25	26	24	18	23
7	31	20	22	28	27	18	26	20
8	33	41	22	23	33	21	22	27
9	38	44	35	38	32	30	22	31
10	29	42	34	29	37	42	40	25
11	45	35	31	57	45	24	30	49
12	59	52	67	44	47	42	37	55
13	57	64	47	47	67	37	38	34
14	54	43	59	44	62	39	59	NA
15+	29	35	38	33	38	30	25	20

Q3	91	92	93	94	95	96	97	98
1								
2	53	50	57	65	NA	63	47	44
3	28	23	27	25	35	38	22	24
4	25	16	16	20	19	25	19	15
5	21	15	17	23	25	17	21	19
6	15	22	21	29	18	22	19	28
7	34	20	34	40	23	20	22	34
8	35	37	37	48	39	31	30	31
9	39	30	42	28	61	37	23	27
10	37	45	62	46	50	35	80	36
11	44	55	58	53	35	45	62	43
12	83	66	47	38	51	50	54	42
13	60	56	65	79	64	39	57	48
14	76	69	56	66	51	49	64	50
15+	37	36	42	35	40	27	44	30

Q2	91	92	93	94	95	96	97	98
1								
2	NA	77	NA	NA	60	59	76	64
3	41	26	30	44	45	27	24	26
4	23	22	23	30	26	16	20	21
5	16	19	16	31	23	19	27	21
6	15	19	19	28	19	25	19	22
7	26	24	29	34	25	28	25	28
8	48	50	26	36	45	29	28	29
9	41	57	29	39	39	38	29	27
10	48	51	48	50	52	54	62	36
11	60	50	47	59	33	46	55	51
12	66	98	53	68	54	54	39	44
13	62	104	59	54	57	61	41	48
14	80	92	59	52	36	49	48	57
15+	38	67	29	44	34	34	28	28

Q4	91	92	93	94	95	96	97	98
1	NA	51	NA	NA	NA	NA	NA	NA
2	54	47	47	41	27	64	40	34
3	33	19	21	21	17	30	23	17
4	24	18	16	20	18	21	24	18
5	21	17	26	22	33	18	21	23
6	15	26	33	37	33	22	28	27
7	41	18	37	34	58	19	27	31
8	65	47	36	37	58	37	31	39
9	61	41	55	47	43	33	32	32
10	41	40	70	33	84	67	36	39
11	71	53	45	76	43	39	55	51
12	53	78	45	95	81	64	47	57
13	79	54	59	56	55	66	61	39
14	61	53	65	67	61	54	62	44
15+	43	37	41	80	48	45	41	49

Table 3.2.1.6a: Intercept (a) and slope (b) estimates from the fit of a linear regression of log(variance) on log(mean) for the annual (top) and quarterly (middle and bottom) E&W bootstrap analysis of North Sea PLAICE - Sexes combined

	Annual			
Year	**a**	**st.err.a**	**b**	**st.err. b**
91	8.322	0.827	1.107	0.0584
92	5.230	0.850	1.340	0.0598
93	5.496	1.366	1.309	0.0941
94	5.610	1.044	1.305	0.0736
95	3.352	1.961	1.460	0.1370
96	7.026	2.024	1.181	0.1432
97	6.272	1.681	1.230	0.1197
98	6.540	1.426	1.190	0.1029

	1st Quarter				**2nd Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	6.132	1.005	1.273	0.0802	8.064	0.916	1.126	0.0712
92	8.205	0.806	1.154	0.0614	5.276	0.940	1.372	0.0724
93	7.369	1.162	1.183	0.0890	5.117	1.353	1.354	0.1020
94	5.024	0.791	1.367	0.0615	6.401	1.134	1.265	0.0864
95	2.897	1.689	1.531	0.1293	4.664	1.434	1.388	0.1121
96	6.427	2.040	1.235	0.1578	9.003	1.638	1.031	0.1287
97	5.476	1.212	1.300	0.0946	6.576	0.985	1.214	0.0786
98	4.537	0.583	1.357	0.0466	6.096	0.718	1.242	0.0581

	3rd Quarter				**4th Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	8.888	0.953	1.086	0.0735	7.445	0.907	1.186	0.0724
92	5.844	1.204	1.316	0.0912	6.309	1.037	1.269	0.0821
93	6.613	1.531	1.255	0.1169	5.865	0.842	1.329	0.0646
94	3.371	1.674	1.513	0.1286	5.042	0.866	1.364	0.0683
95	5.989	1.694	1.304	0.1310	6.090	1.136	1.271	0.0912
96	6.635	2.004	1.243	0.1559	7.350	1.739	1.169	0.1403
97	5.840	1.229	1.279	0.0980	5.145	1.788	1.334	0.1427
98	5.758	1.408	1.280	0.1126	4.845	1.432	1.334	0.1176

Table 3.2.1.6b: Intercept (a) and slope (b) estimates from the fit of a linear regression of log(variance) on log(mean) for the annual (top) and quarterly (middle and bottom) E&W bootstrap analysis of North Sea PLAICE - **FEMALE**

	Annual			
Year	**a**	**st.err.a**	**b**	**st.err. b**
91	6.042	1.267	1.265	0.0937
92	4.019	1.246	1.422	0.0899
93	4.460	1.343	1.390	0.0960
94	4.150	1.178	1.408	0.0857
95	3.526	1.400	1.457	0.1019
96	4.610	1.473	1.358	0.1085
97	5.108	1.323	1.314	0.0985
98	6.318	1.098	1.207	0.0825

	1st Quarter				**2nd Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	4.156	1.261	1.428	0.1058	5.223	1.162	1.347	0.0953
92	6.262	1.792	1.291	0.1437	3.451	0.959	1.512	0.0778
93	5.664	1.074	1.317	0.0866	3.261	1.035	1.511	0.0804
94	5.205	0.891	1.347	0.0728	5.180	0.762	1.384	0.0614
95	3.374	1.632	1.511	0.1334	5.123	1.062	1.359	0.0861
96	4.684	1.496	1.364	0.1239	7.236	1.733	1.181	0.1404
97	3.728	1.033	1.425	0.0871	5.470	0.913	1.317	0.0756
98	6.087	0.997	1.240	0.0820	7.169	0.774	1.171	0.0646

	3rd Quarter				**4th Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	5.901	1.218	1.311	0.0980	4.913	0.899	1.370	0.0754
92	4.689	1.112	1.402	0.0874	4.554	1.126	1.407	0.0923
93	6.406	1.493	1.279	0.1187	3.020	0.712	1.538	0.0580
94	3.871	0.980	1.481	0.0790	4.759	0.707	1.378	0.0587
95	6.960	1.412	1.240	0.1130	4.335	0.934	1.397	0.0792
96	4.515	1.290	1.423	0.1048	5.127	1.215	1.344	0.1027
97	4.250	0.970	1.420	0.0806	5.317	1.133	1.325	0.0949
98	6.246	0.897	1.225	0.0759	5.096	1.410	1.316	0.1217

Table 3.2.1.6c: Intercept (a) and slope (b) estimates from the fit of a linear regression of log(variance) on log(mean) for the annual (top) and quarterly (middle and bottom) E&W bootstrap analysis of North Sea PLAICE - **MALE**

	Annual			
Year	**a**	**st.err.a**	**b**	**st.err. b**
91	6.941	0.664	1.221	0.0510
92	5.474	0.505	1.341	0.0381
93	5.382	0.585	1.336	0.0440
94	5.625	0.648	1.353	0.0486
95	4.056	1.072	1.441	0.0814
96	6.573	1.136	1.227	0.0865
97	6.651	0.806	1.235	0.0609
98	6.651	0.550	1.210	0.0424

	1st Quarter				**2nd Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	5.355	0.672	1.373	0.0566	6.478	0.630	1.262	0.0550
92	5.594	0.841	1.383	0.0684	6.320	0.669	1.317	0.0573
93	7.332	0.848	1.210	0.0686	4.315	0.435	1.438	0.0371
94	4.335	0.800	1.471	0.0651	5.140	1.100	1.434	0.0905
95	4.636	0.930	1.451	0.0752	2.706	1.128	1.587	0.0985
96	7.099	1.566	1.222	0.1271	7.094	0.533	1.176	0.0478
97	6.025	1.288	1.315	0.1040	4.859	0.856	1.384	0.0747
98	3.733	0.748	1.478	0.0628	4.385	0.738	1.399	0.0669

	3rd Quarter				**4th Quarter**			
Year	**a**	**st.err.a**	**b**	**st.err. b**	**a**	**st.err.a**	**b**	**st.err. b**
91	4.545	0.711	1.430	0.0618	4.200	0.883	1.470	0.0786
92	6.372	0.683	1.280	0.0574	5.221	0.608	1.370	0.0523
93	4.627	0.763	1.430	0.0656	4.572	0.918	1.457	0.0770
94	3.790	1.313	1.519	0.1108	4.426	0.608	1.454	0.0533
95	2.644	0.885	1.590	0.0768	4.014	1.062	1.486	0.0944
96	7.202	1.474	1.192	0.1264	6.829	1.191	1.223	0.1047
97	6.587	0.637	1.233	0.0560	4.668	0.881	1.416	0.0760
98	5.798	1.286	1.303	0.1107	6.306	0.461	1.245	0.0408

Table 3.2.2.1a Alternative areas and gears for cod, Search is by month, same, previous, subsequent, then by area (1-4, zero not used) and finally by gear (1-3, zero not used). Area numbers in **Figure 2.4**.

Area	Gear	Area replace priority				Gear replace priority		
		1	2	3	4	1	2	3
1	1	1	4	2	0	1	0	0
2	1	2	5	6	0	1	0	0
3	1	3	4	8	0	1	0	0
4	1	4	3	8	0	1	0	0
5	1	5	6	2	0	1	0	0
6	1	6	5	7	0	1	0	0
7	1	7	6	5	0	1	0	0
8	1	8	4	3	0	1	0	0
9	1	9	1	3	0	1	0	0
10	1	10	6	0	0	1	0	0
11	1	11	6	0	0	1	0	0
12	1	12	10	0	0	1	0	0
13	1	13	2	0	0	1	0	0
1	2	1	4	2	0	2	3	4
2	2	2	5	6	0	2	3	4
3	2	3	4	8	0	2	3	4
4	2	4	3	8	0	2	3	4
5	2	5	6	2	0	2	3	4
6	2	6	5	7	0	2	3	4
7	2	7	6	5	0	2	3	4
8	2	8	4	3	0	2	3	4
9	2	9	1	3	0	2	3	4
10	2	10	6	0	0	2	3	4
11	2	11	6	0	0	2	3	4
12	2	12	10	0	0	2	3	4
13	2	13	2	0	0	2	3	4
1	3	1	4	2	0	3	2	4
2	3	2	5	6	0	3	2	4
3	3	3	4	8	0	3	2	4
4	3	4	3	8	0	3	2	4
5	3	5	6	2	0	3	2	4
6	3	6	5	7	0	3	2	4
7	3	7	6	5	0	3	2	4
8	3	8	4	3	0	3	2	4
9	3	9	1	3	0	3	2	4
10	3	10	6	0	0	3	2	4
11	3	11	6	0	0	3	2	4
12	3	12	10	0	0	3	2	4
13	3	13	2	0	0	3	2	4

Area	Gear	Area replace priority				Gear replace priority		
		1	2	3	4	1	2	3
1	4	1	4	2	0	4	3	2
2	4	2	5	6	0	4	3	2
3	4	3	4	8	0	4	3	2
4	4	4	3	8	0	4	3	2
5	4	5	6	2	0	4	3	2
6	4	6	5	7	0	4	3	2
7	4	7	6	5	0	4	3	2
8	4	8	4	3	0	4	3	2
9	4	9	1	3	0	4	3	2
10	4	10	6	0	0	4	3	2
11	4	11	6	0	0	4	3	2
12	4	12	10	0	0	4	3	2
13	4	13	2	0	0	4	3	2
1	5	1	4	2	0	5	3	0
2	5	2	5	6	0	5	3	0
3	5	3	4	8	0	5	3	0
4	5	4	3	8	0	5	3	0
5	5	5	6	2	0	5	3	0
6	5	6	5	7	0	5	3	0
7	5	7	6	5	0	5	3	0
8	5	8	4	3	0	5	3	0
9	5	9	1	3	0	5	3	0
10	5	10	6	0	0	5	3	0
11	5	11	6	0	0	5	3	0
12	5	12	10	0	0	5	3	0
13	5	13	2	0	0	5	3	0
1	6	1	4	0	0	6	3	0
2	6	2	0	0	0	6	3	0
3	6	3	4	0	0	6	3	0
4	6	4	0	0	0	6	3	0
5	6	5	0	0	0	6	3	0
6	6	6	2	5	0	6	3	0
7	6	7	2	5	6	6	3	0
8	6	8	4	0	0	6	3	0
9	6	9	3	0	0	6	3	0
10	6	10	2	5	6	6	3	0
11	6	11	0	0	0	6	3	0
12	6	12	2	5	6	6	3	0
13	6	13	0	0	0	6	3	0

Table 3.2.2.1b Alternate areas for herring by priority (area numbers in **Figure 2.4**)

Replace priority	Area													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2	1	4	3	4	5	1	9	8	9	5	11	10	12
2	8	3	2	5	11	4	9	2	7	13	12	6	9	6
3	3	8	1	6	6	11	8	1	1	7	6	14	7	11

Table 3.2.2.2 CV at age for Scottish sampling for COD in ICES area IV using simple Jackknife.

year	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
1	14	16	17	15	17	25
2	6	5	4	7	4	7
3	5	6	7	4	6	5
4	12	8	8	6	7	7
5	10	13	10	8	9	10
6	9	12	14	10	13	15
7	14	15	22	16	20	28
8	14	23	17	23	27	33
9	26	21	26	33	32	20
10	34	27	30	30	27	48
11	29	39	34	31	33	36
12	32	43	33	39	33	35

Table 3.2.2.3 Scotland. Comparison of selected years for Cod simple jackknife (SJ) and group bootstrap (GB)

	Grouped bootstrap		*Simple Jackknife*	
	1991	1994	1991	1994
1	9	13	14	15
2	5	164	6	7
3	5	74	5	4
4	13	27	12	6
5	15	13	10	8
6	18	13	9	10
7	17	16	14	16
8	14	24	14	23
9	32	45	26	33
10	73	60	34	30
11	99	68	29	31
12	57	64	32	39

Table 3.2.2.4 Scotland. Comparison of selected years for Cod simple jackknife and weighted jackknife

	Simple jackknife		*Weighted jackknife*	
	1991	1994	1991	1994
1	14	15	9	10
2	6	7	4	4
3	5	4	3	3
4	12	6	7	4
5	10	8	7	5
6	9	10	6	6
7	14	16	9	10
8	14	23	12	16
9	26	33	16	13
10	34	30	12	20
11	29	31	9	10
12	32	39	8	17

Table 3.2.2.5 Scotland. CV at age for Scottish sampling for COD in ICES area IV using weighted Jackknife

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
1	9	9	12	10	11	11	8	12
2	4	3	2	4	3	3	3	2
3	3	3	5	3	4	2	2	3
4	7	5	5	4	5	3	3	4
5	7	7	6	5	6	5	5	5
6	6	7	9	6	8	9	5	6
7	9	8	14	10	14	14	8	8
8	12	11	11	16	15	20	13	12
9	16	11	17	13	17	18	14	11
10	12	12	14	20	16	21	19	12
11	9	16	9	10	18	17	14	23
12	8	13	14	17	21	17		

Table 3.2.2.6 Scotland. Correlation coefficients for age for Scottish sampling for cod in ICES area IV using simple Jackknife (top) and weighted jackknife (bottom)

Age	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1	1											
2	0.3	1										
3	0	0	1									
4	0	0	0.3	1								
5	0	0	0.1	0.4	1							
6	0	0	0.1	0.3	0.5	1						
7	0	0	0	0.2	0.3	0.4	1					
8	0	0	0	0.1	0.3	0.3	0.4	1				
9	0	0	0	0	0.1	0.1	0.2	0.4	1			
10	0	0	0	0	0.1	0.1	0.1	0.2	0.1	1		
11	0	0	0	0	0.1	0.1	0.1	0.2	0.3	0.1	1	
12	0	0	0	0	0	0	0	0	0.1	0	0.1	1

age	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1	1											
2	0.1	1										
3	-0.3	-0.2	1									
4	-0.3	-0.5	0.2	1								
5	-0.3	-0.3	0	0.3	1							
6	-0.2	-0.2	-0.1	0.1	0.4	1						
7	-0.1	-0.2	0	0.1	0.3	0.3	1					
8	-0.1	0	0	0.1	0.2	0.2	0.3	1				
9	-0.1	0.1	0	0	0.1	0.1	0.2	0.3	1			
10	0	0	0	0	0.1	0.1	0.1	0.2	0.1	1		
11	0	0.1	0.1	0	0.1	0.1	0.1	0.1	0.3	0.1	1	
12	0	0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	1

Table 3.2.2.7 CV at age for Scottish sampling for HERRING in ICES area IV using the weighted jackknife.

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*avg*
0		188					74		131
1	22	73	36	35	45	28	132	42	52
2	15	19	19	8	8	14	14	9	13
3	12	12	9	13	8	5	5	11	9
4	4	7	10	12	26	10	5	15	11
5	4	5	13	15	20	11	15	22	13
6	7	4	12	12	32	23	22	26	17
7	13	10	14	15	34	14	23	29	19
8	42	14	16	16	20	16	28	39	24
9	24	33	28	30	26	19	18	38	27
10	33	24	21	70	31	20	21	37	32
11	119	34	37	31	37	44	43	32	47
12		38	111	74	32	20	46	39	51

Table 3.2.2.8 Scotland. Correlation coefficients for age for Scottish sampling for herring in ICES area IV using weighted jackknife.

age	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1	1											
2	0.1	1										
3	0	0	1									
4	-0.2	-0.5	0.1	1								
5	-0.1	-0.3	-0.1	0.3	1							
6	-0.1	-0.5	-0.2	0.2	0.3	1						
7	-0.1	-0.5	-0.2	0.2	0.3	0.4	1					
8	-0.1	-0.4	-0.1	0.1	0.1	0.1	0.3	1				
9	-0.1	-0.3	-0.2	0	0	0.2	0.5	0.4	1			
10	-0.1	-0.3	-0.1	0.1	0	0.2	0.4	0.4	0.6	1		
11	-0.1	-0.2	-0.2	0	0.1	0.3	0.3	0.2	0.4	0.3	1	
12	-0.1	-0.2	-0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.2	1

Table 3.2.3.1 The Netherlands. CV at age for COD, SEXES COMBINED in ICES area IV using bootstrap method.

quarter 1

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
0			101						101
1	56	130	197	127	100	116	122	409	157
2	7	6	3	18	7	5	10	4	7
3	4	13	9	10	15	9	7	21	11
4	8	10	10	21	10	23	18	11	14
5	10	14	10	13	27	13	32	13	17
6	12	13	21	21	31	33	16	39	23
7	38	17	33	35	28	36	38	26	31
8	70		27	46	48	46	54	43	48
9		46	54	71	50	72	63	42	57
10		57	59	124	65	59	64	24	65

quarter 2

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
0						78			78
1	41	41	90	57	39	58	62	97	60
2	10	5	4	12	5	7	8	6	7
3	26	15	18	11	43	18	15	32	22
4	21	17	31	44	15	36	19	43	28
5	17	22	28	48	63	14	34	32	32
6	21	44	46	48	40	63	31	63	45
7	47	38	49	45	53	43	63	33	46
8	99		44	48	57	63	48	71	61
9		53		53			68	53	57
10		54	64	94	86		61	60	70

quarter 3

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
0	105		63						84
1	18	4	28	10	16	55	19	74	28
2	10	16	5	19	11	12	12	7	12
3	14	23	15	14	42	33	16	24	22
4	25	24	19	31	23	37	43	13	27
5	46	48	26	36	52	18	61	34	40
6	15	47	31	56	77	52	44	113	55
7	38	62	57	105	47	89	53	61	64
8			55	101	61	55	93	101	78
9		64		67			62	88	70
10		54	103		75		113	64	82

quarter 4

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
0			65			103		67	78
1	4	2	13	11	5	12	9	105	20
2	19	15	11	49	12	11	28	4	19
3	19	31	31	48	39	28	18	20	29
4	13	16	46	32	16	40	36	36	30
5	41	52	27	33	62	26	40	76	45
6	23	41	50	59	80	62	35	87	55
7	53	44	53	91	71	65	86	76	67
8	58		63	63	88	84	61	101	74
9		73		70	119	80	79	91	85
10		80	69		76	86	73	87	79

Table 3.2.3.2a The Netherlands. CV at age for PLAICE, FEMALES in ICES area IV using bootstrap method.

quarter 1

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1									
2		44	47	43	42	39	42	35	42
3	27	17	15	19	13	12	11	14	16
4	16	13	13	9	11	10	11	5	11
5	12	15	13	11	10	10	8	6	11
6	8	11	11	12	11	12	11	11	11
7	14	9	10	10	10	11	12	22	12
8	21	17	11	13	12	14	20	16	15
9	16	13	13	12	15	14	16	18	15
10	18	23	20	18	13	19	16	27	19
11	23	22	18	25	29	16	20	21	22
12	33	30	37	25	34	27	28	24	30
13	43	36	44	33	53	28	33	52	40
14	38	36	34	44	53	48	39	49	43
15	29	28	37	41	53	48	44	57	42

quarter 2

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1									
2	49	30	48	25	22	23	37	27	33
3	17	12	23	14	11	10	11	7	13
4	14	13	13	14	13	13	11	9	13
5	13	22	14	14	9	12	27	19	16
6	15	19	14	13	12	12	18	31	17
7	19	16	12	19	18	15	18	21	17
8	26	31	19	20	25	20	32	34	26
9	24	57	23	20	20	21	26	28	27
10	19	44	22	37	16	17	32	38	28
11	33	41	28	36	29	17	30	30	30
12	41	43	35	51	36	41	56	28	42
13	43	53	34	51	54		50	37	46
14		45	58	53	57	50	51	39	50
15	32	39	57	45	51	49	50	46	46

quarter 3

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1		53	58		57	85			63
2	22	26	33	18	26	16	12	18	21
3	14	11	12	13	14	15	9	9	12
4	22	17	16	13	17	17	18	7	16
5	14	23	19	11	20	24	13	25	19
6	14	22	16	15	27	24	30	17	21
7	33	18	18	18	28	34	31	29	26
8	25	17	17	17	21	21	42	34	24
9	38	45	28	19	26	25	30	33	31
10	32	38	23	26	17	26	23	49	29
11	48	28	34	24	33	23	32	39	33
12	48	64	39	51	40	28	25	47	43
13	47	53		48	42	46	46	48	47
14	51	50	52	51	40	50			49
15	46	51		52	53	51	32		48

quarter 4

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1	44	52	47	56	51	48	51		50
2	20	21	16	13	17	8	12	12	15
3	13	14	13	16	13	11	10	13	13
4	18	15	18	11	17	11	15	10	14
5	19	22	16	18	17	16	19	20	18
6	18	12	26	19	18	12	21	13	17
7	23	20	21	22	23	21	17	28	22
8	29	21	23	17	22	28	25	20	23
9	23	31	29	12	20	29	36	35	27
10	31	19	32	20	19	27	30	25	25
11	32	29	47	22	31	46	57	28	36
12	57	25	56	38	36	46	24	43	41
13	50	52		31	53	48		42	46
14	40	52		52	52	55	47	53	50
15	50	40		51	45	52	48	48	48

Table 3.2.3.2b The Netherlands. CV at age for PLAICE, MALES in ICES area IV using bootstrap method.

quarter 1

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1									
2		39	52	44	25	66	60	50	48
3	27	20	21	16	11	12	10	14	16
4	14	11	11	8	11	10	11	11	11
5	11	11	13	11	15	13	13	18	13
6	10	16	15	16	24	18	18	24	18
7	24	21	18	22	25	20	22	39	24
8	30	33	24	27	37	33	25	60	34
9	34	42	45	53	56	46	47	54	47
10	53	54	61	50	50	59	57	50	54
11	46			50			53	51	50
12		52	49				51		51
13									
14				49		52			50
15									

quarter 2

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1									
2	49	35	43	27	27	41	41	29	37
3	21	16	19	16	15	14	14	13	16
4	16	24	14	27	15	13	19	15	18
5	24	26	19	30	31	19	26	41	27
6	28	32	23	27	35	34	24	35	30
7	45	35	49	44	55	39	43	53	45
8	58	53	34	53	34	44	66	65	51
9	51	56	52	59			48		53
10						50	51	54	52
11							52		52
12								54	54
13									
14									
15									

quarter 3

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1		53	56		42	52			51
2	27	30	34	23	23	21	13	33	26
3	14	15	13	13	13	12	15	14	14
4	21	20	21	22	19	30	31	16	23
5	22	25	27	40	25	35	53	31	32
6	36	32	35	59	32	47	53	60	44
7	37	46	41	58	62	72	52	49	52
8		56	50	46	60	52	47	53	52
9				52	74		68	52	62
10		51				52	50		51
11							51		51
12									
13									
14									
15									

quarter 4

AGE	1991	1992	1993	1994	1995	1996	1997	1998	AVG
1		67	42	51	37	54	51		50
2	23	21	15	14	21	14	19	17	18
3	12	17	16	9	16	14	10	14	13
4	18	17	19	17	20	22	20	17	19
5	24	21	33	28	35	29	40	35	31
6	24	17	38	40	33	29	28	51	33
7	43	49	42	52	73	49	52	51	51
8	62	53	55	44	63		53		55
9							53		53
10		48		50	54		62		54
11		48							48
12									
13									
14									
15								53	53

Figure 3.2.1.1 Mean-variance plots of England & Wales bootstrapped catch at age data. COD. Sexes combined. Top: yearly data. Bottom four panels: quarterly data.

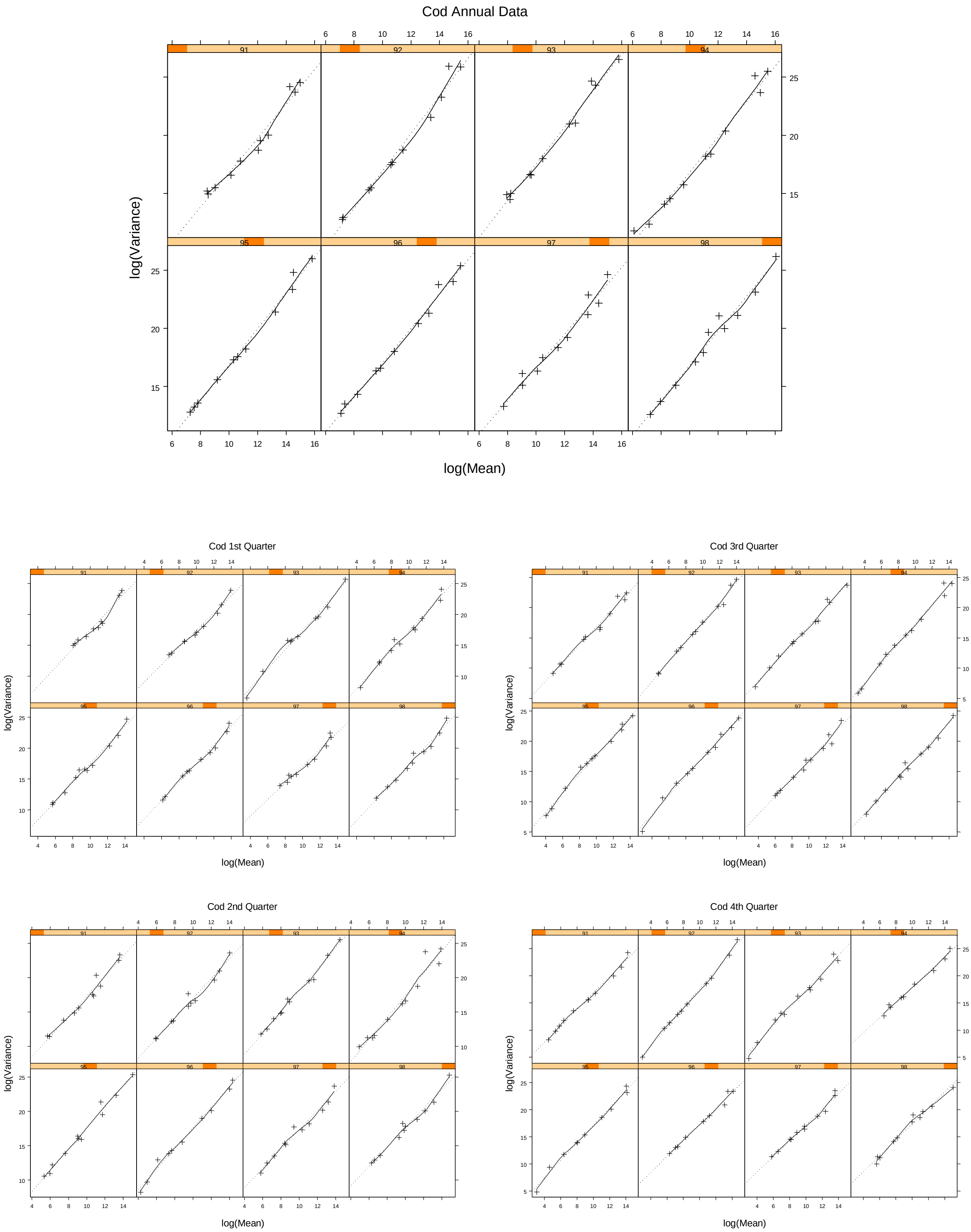
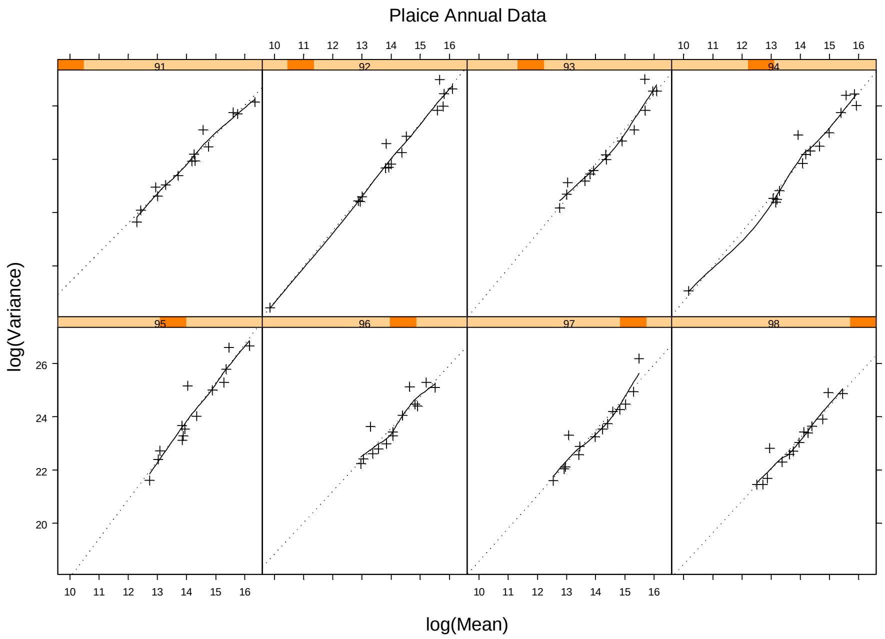
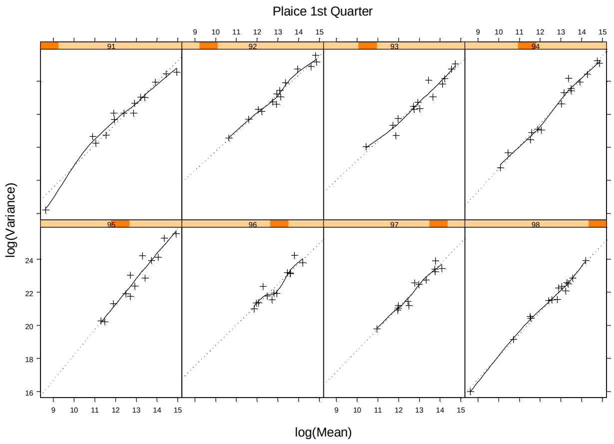
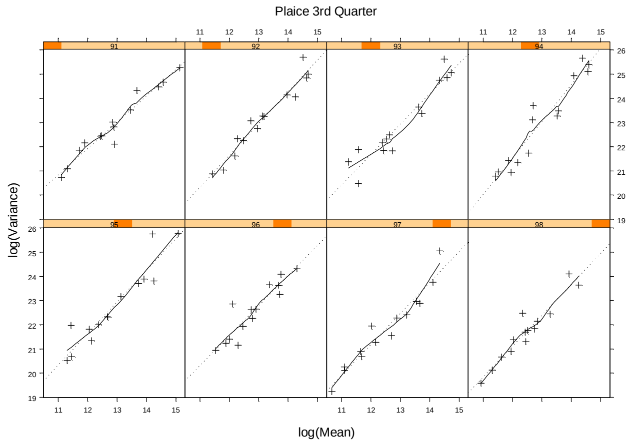
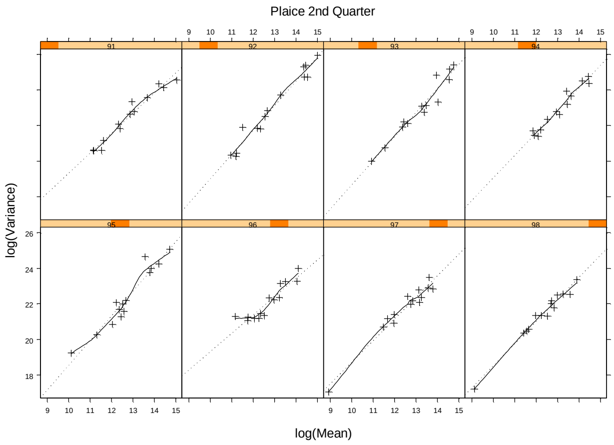


Figure 3.2.1.2 Mean-variance plots of England & Wales bootstrapped catch at age data. PLAICE. Sexes combined. Top: yearly data. Bottom four panels: quarterly data.









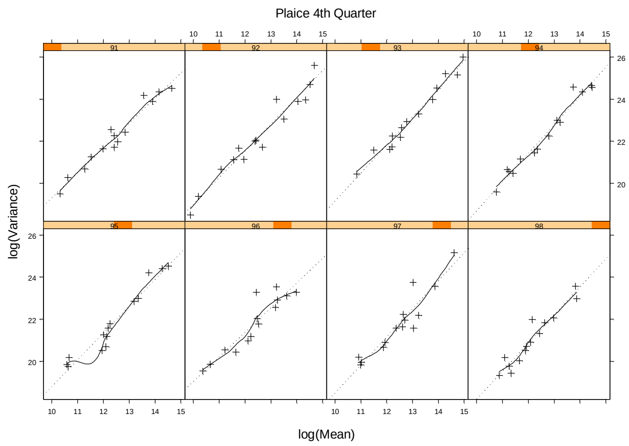


Figure 3.2.1.3 Mean-variance plots of England & Wales bootstrapped catch at age data. PLAICE, FEMALES ONLY. Top: yearly data. Bottom four panels: quarterly data.

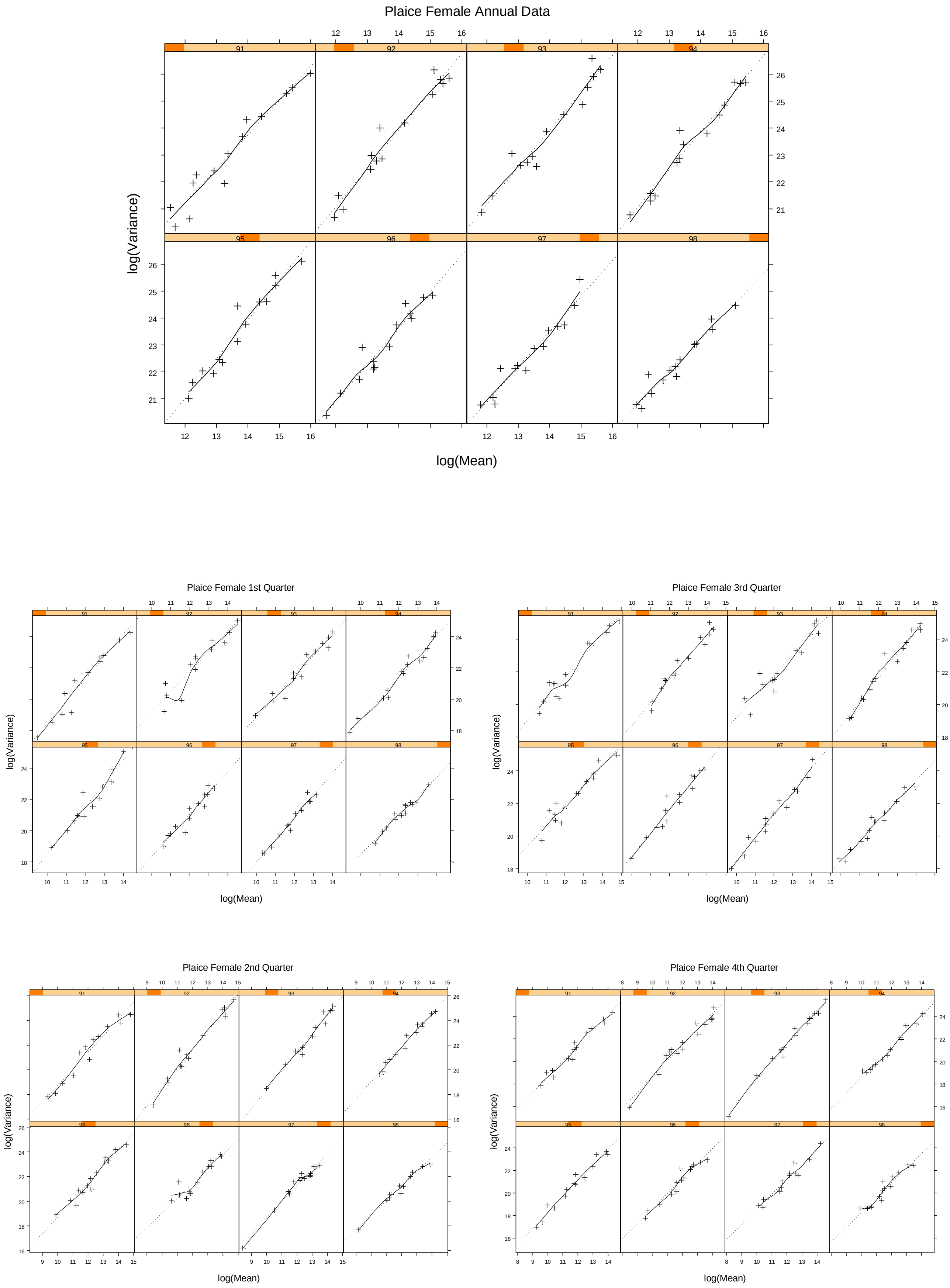
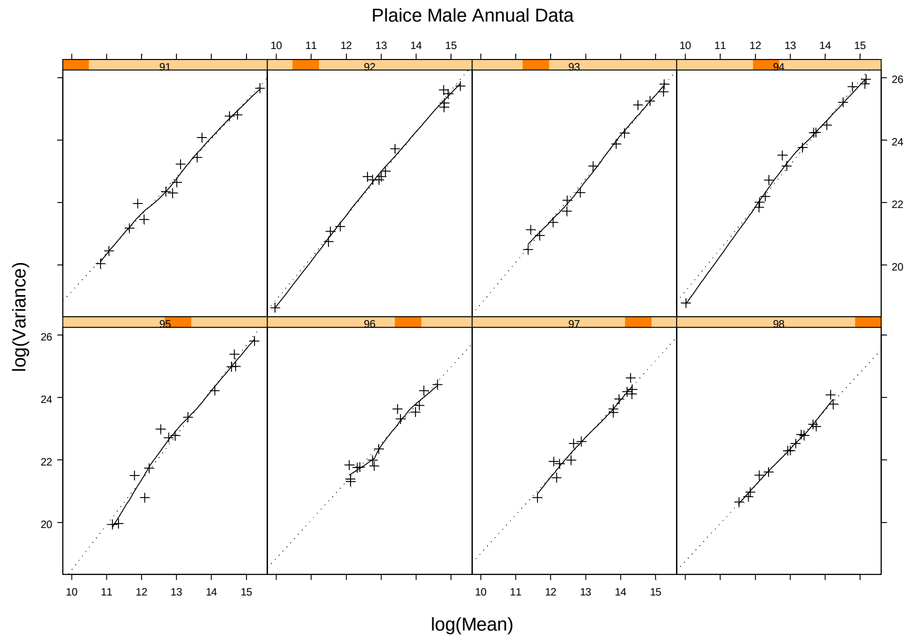
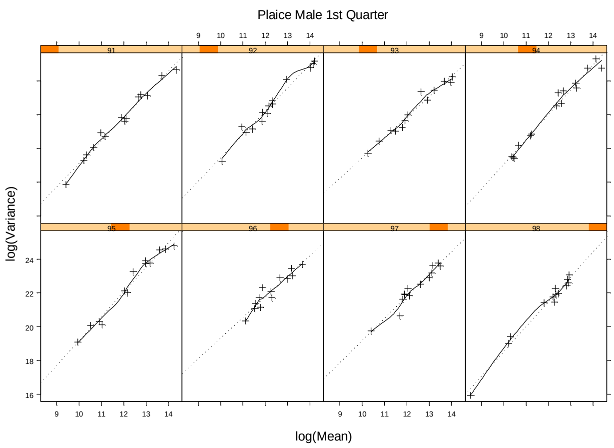
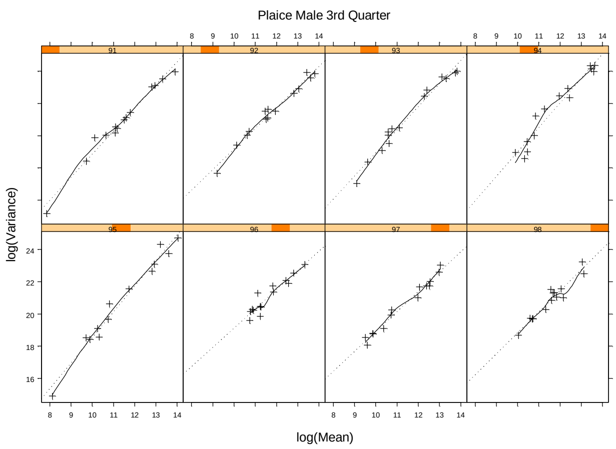
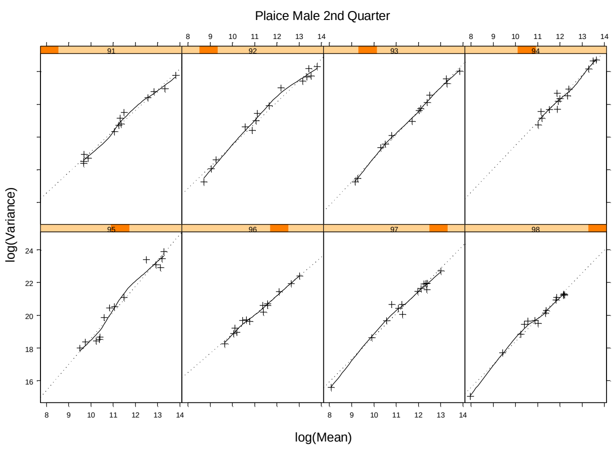


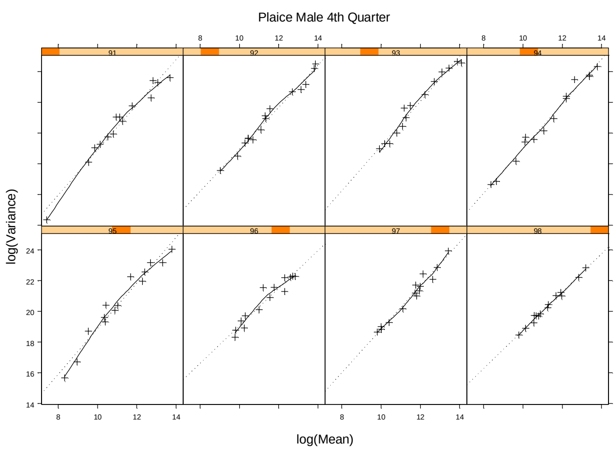
Figure 3.2.1.4 Mean-variance plots of England & Wales bootstrapped catch at age data. PLAICE, MALES ONLY. Top: yearly data. Bottom four panels: quarterly data.











4 FURTHER WORK

4.1 WKIMS

The Study Group found itself unable to finish all terms of reference during the two day meeting. Several aspects could not be properly addressed. However, at the ASC 1999 is was decided that a Workshop be held on the International Analysis of Market Sampling and the Evaluation of Raising Procedures and Data-Storage [WKIMS]. This workshop is scheduled to be held in Lowestoft from 28-30 November 2000 and can be interpreted as a follow-up from the current study group. The terms of reference for the Workshop are:

a) how well the total international sampling effort covers the total fishing activity;

b) how different methods of combining national age compositions and weights at age affects the estimation of the international age compositions and weights at age;

c) estimation of uncertainty of age compositions and weights at age and the precision of estimated CV's and variances;

d) how raising procedures can be formalised;

e) how data-storage of these market sampling data should be organised.

The study group expressed the wish to make the scope of the future workshop wider than the current meeting, both in terms of the stocks and the areas covered during the meeting. Especially, links could be established with integrated market sampling programs in the Baltic Sea (*anon.*, 1998) and for the south-western areas (FIEFA, e.g. *anon.*, 1999). The workshop is also closely linked to the progress in the EMAS project on evaluation of market sampling which is due to be finished by April 2001.

4.2 A Model Based Approach to estimating Catch-at-age

There are two separate issues in the estimation of catch-at-age: Estimating catch-at-length, and estimating the distribution of age given length. Analysis elsewhere in this report shows that the variability in age-length keys is the major source of the overall variability in catch at age, which implies that there is a lot to be gained by improving its estimation. This could be done by taking more age samples, or by a modelling approach. At present each element in the key (i.e. each length by age cell in the matrix) is estimated independently, from a very small sample size. Adjacent cells in the matrix are highly correlated (e.g. the probability that a fish of length 30cm is age 4 is very similar to the probability that a fish of length 28cm is age 4). Taking advantage of this information alone would greatly reduce the variability. This problem will not be discussed further here, rather we will consider the problem of estimating catch-at-length. In addition we will simplify the problem by only considering the binomial problem of estimating the number of 'small' and 'large' fish caught (where small and large can be defined in whatever way seems sensible). The principles are the same when the full multinomial problem of estimating a length (or age) distribution is considered.

There are three main problems: (1) Raising sample values to totals for region, season or whatever stratum is required (2) 'Filling in' missing strata, and (3) estimating the variance of the resulting combined estimate. A fourth problem, designing a sampling scheme, should be relatively straight-forward to solve if a model for the estimation procedure can be established.

One approach to all three problems is to construct a multi-level model for the number of small fish caught. We have the total weight or number of fish caught in a stratum (gear by season by region for example). The aim is now to estimate the proportion of small fish in this total. Sampling is from a limited number of fish within a haul. There is a hierarchical structure to the data, with hauls within trips within vessels being a possible structure. One approach is the following:

Assume the sampling unit is the haul, and that hauls can be randomly sampled within trips. Let the proportion of small fish in a haul be p_{ijk}, where i references vessels, j trips by that vessel and k hauls within that trip. Suppose N fish are sampled from each haul (N may in fact vary between hauls, but this is unimportant at the moment), and n_{ijk} small fish are found. n_{ijk} is binomial (N,p_{ijk}) and p_{ijk} can be estimated as n_{ijk}/N. The variance of this estimate depends on N, and this variance will be carried through into the variance of the final estimate.

Now assume that the proportion of small fish varies from haul to haul, say

$$\mathrm{logit}(p_{ijk})=\log(p_{ijk}/(1-p_{ijk}))\sim N(\mu_{ij},\sigma^2_{ij})$$

i.e. the distribution of p_{ijk} varies from trip to trip, but within a trip the hauls are independent samples from the above distribution. We can make assumptions about the distributions of μ_{ij} and σ_{ij}, for example μ_{ij}~$N(\theta_i, \Sigma^2_i)$, $\log(\sigma^2_{ij})$~$N(a_i,b_i)$ with similar assumptions about θ_i , Σ_i, a_i and b_i. e.g. θ_i~$N(M,S^2)$. In other words we assume that there is a haul effect (proportion of small fish is different from haul to haul), a trip effect (hauls within a trip are more similar than hauls from different trips) and a vessel effect (some vessels will tend to catch more small fish). It is possible (and to be hoped) that some of these effects are negligible, i.e. that some of the variances are very small. In fact the data may not allow estimation of all the different strata, since there are few (if any) replicate hauls within trips, or even trips within vessels. In principle however data could be collected to estimate the various parameters. It is simple (in theory at least) to extend this model to include spatial effects, and this will give advantages beyond simply filling in missing strata. The proportions of small fish will be correlated between various cells, and it makes no sense to estimate them all independently. An extra level can be added to the hierarchy, so that M is a realisation from a random field, which has a spatial correlation (so that it takes similar values in adjacent regions). (Note here that 'Spatial' correlation could and should include temporal and gear effects.)

This structure enables (a) an optimal sampling strategy to be established, and (b) the best estimator to be constructed from the samples obtained. For (a), it is necessary to cost various sampling possibilities, for example it will always be better statistically to take 1 fish from 100 hauls than to take 100 fish from 1 haul, but this will almost certainly be more expensive. The optimum will depend on the relative sizes of the between haul variance and the binomial variance due to taking only N samples from a haul, and the extra cost of taking samples from different hauls. Similarly, if the between trip variance is large compared to the between haul variance, it will be much more beneficial to sample extra trips, rather than multiple hauls in the same trip. If the model is kept simple, the optimum strategy can be found analytically, in any case it should be possible to simulate from various options.

For (b), it is necessary to make various assumptions. The model as described assumes that all effects (haul, vessel and trip) are *random* rather than *fixed*. This implies that each unit (haul, trip or vessel) is just one from an infinite number of possibilities. The alternative is to regard each vessel (for example) as a level of a fixed effect, and to estimate the proportion of small fish caught by that vessel individually. The distinction is very important, and it is not obvious which is the best strategy. The decision depends on the relative variances of the various strata, and the proportion of the total number of levels sampled.

In the random effects models we want to estimate M, which is essentially the logit of the proportion of small fish *in the catchable population*. Since we assume there are an infinite number of vessels, this will in fact be the expected value of the proportion in the total catch. The estimate of M will depend on the number of samples in each strata, and their relative variances. For example, if two hauls are sampled within a trip, they will be down-weighted compared to two samples from different trips. The estimate of M however does NOT depend on the actual number of fish caught in each haul, trip or vessel. In other words the raising procedure would depend on the sampling design (how many samples were taken and where) but not on the totals caught.

The alternative is to regard the vessels as *fixed* effects, i.e. to estimate each individual vessel effect. This is the true situation, in that there are only a fixed number of vessels. In this case the estimation of proportions would be done at the vessel level, and the raising would take into account the numbers of fish caught by each vessel. This approach could also be taken at the trip or haul level. Whether or not this is a sensible approach depends on the proportion of vessels sampled, and the relative variances at each level in the hierarchy. Taking the random effects approach will always give a lower variance estimate, since it means estimating only one mean and one variance, rather than a parameter for each vessel. It may however be biased. Consider the following examples:

1. One haul is sampled from each of 10 vessels (the entire fleet). Each vessel has made a large number of hauls. There is a large haul effect, but (almost) no vessel or trip effect. Now the proportion of small fish caught by an individual vessel is not well estimated by the proportion in the haul sampled from that vessel; if a different haul had been sampled, the result would have been very different. It is better estimated by the average proportion over all the vessels (since all the hauls can be regarded as independent samples from the same population). Therefore the total should not be raised by individual vessel catches, rather the mean proportion calculated and applied to the total catch.

2. Same situation but there are no haul or trip effects, and a large vessel effect. The catches from each vessel are different. Now the sample from each haul gives a good estimate of the proportion of small fish caught by that vessel. The totals for each vessel can therefore be well estimated, and the total should be raised by individual catch.

3. Same as (2), but there are 100 vessels in the fleet. Now it makes sense to use the actual catches from each sampled vessel, but the only sensible estimate for the un-sampled vessels is the mean *proportion* from those sampled. Since 90% of vessels are un-sampled, it makes very little difference whether or not the total is adjusted to take account of

the 10 known catches. It is certainly wrong to take the raised estimate for the 10 sampled vessels (as in (2) above) and assume this is representative for the fleet. This is equivalent to assuming the proportion of small fish on the un-sampled vessels is well estimated by a weighted average of the sampled vessels, where the weights are proportional to the individual catches of those vessels. There is no justification for this, and it simply gives the estimate of the true proportion a higher variance.

4. Same as (2) but the 'raising factors' are badly estimated. In this situation it may be best to take the random effects approach regardless, since the increase in variance involved in using bad estimates may be unacceptably large. If the variance of the estimates of the raising factors is known, an estimator could be constructed which 'shrank' them towards a common value. i.e. a vessel with a particularly high estimated catch would get a higher weight in the total, but not as high as the given catch would suggest.

These examples are just intended to illustrate the difficulties, and the necessity of estimating the variances at each level. Note that it is impossible to distinguish between situations (1) and (2) if only one sample is taken from each vessel, and yet the answers could be very different.

The vessels may be regarded as fixed or random effects for the purpose of estimating those areas which have been sampled. For the un-sampled areas however they must be regarded as random effects. This is because there is no data with which to estimate fixed effects, and also because the only parameter which could be regarded as spatially correlated is the proportion of small fish in the catchable population, i.e. the parameter at the highest level in the random effects model. Therefore it will be necessary to estimate the random effects model in any case, though it is not so clear how the final estimate will be constructed.

It is therefore possible to construct a model which will enable much better estimation of the catch-at-age. There are considerable difficulties involved in estimating the variances of the various strata, but it should be noted that a model of this kind is implicit in the estimation techniques being used at the moment. In particular, (i) the raising procedures imply a very strict variance structure. For example if the catches are raised by total vessel catch, from samples taken from an individual haul, this implies a model in which there is no between haul variance, and where all vessels are sampled. Also (ii) the filling-in procedure implies a correlation of 0 between strata where samples exist (regardless of how few samples there are or how similar the strata are known to be), and 1 between a missing stratum and exactly one other stratum.

5 CONCLUSIONS

The Study Group on Market Sampling Methodology (SGMSM) was intended to address the following issues:

1) assess the current methods and levels of sampling of commercial catches for a number of demersal and pelagic stocks (cod, plaice and herring) in the North Sea and adjacent waters;
2) evaluate the spatial and temporal variability in the available sampling data;
3) advice on adequate levels of sampling commercial catches for the stocks considered;

Below, conclusions will be drawn which are relevant to these terms of reference.

5.1 Assessment of current methods and levels of sampling

The overview of sampling and raising methods for North Sea cod, herring and plaice has shown that for the countries considered, there can be substantial differences in the methods for collecting data and for raising sample data to a fleet level. Merging basic data at the international level appears to be hindered by the differences in sampling strategy, area definitions and the use of different market categories. In order to be able to assess the uncertainty of international age-compositions, the best way forward is to generate bootstrapped or jack knifed replicates of national age-compositions and to merge these replicates to arrive at international replicates.

The overview also showed that for herring and plaice a substantial part of the international landings (around 22%) is un-sampled because these landings are made in foreign ports.

Results for the bootstrap and jackknife analyses have shown that in general CV tends to increase with age. Also, higher aggregations tend to lower the CV; the CV by quarter and sex is in general higher than the CV by year. The overall level of CV at the most exploited ages tends to be rather different between different sampling schemes. It is not yet clear whether these differences can be ascribed to different resampling methods (e.g. bootstrap vs. jackknife) or to real differences in data. The patterns of variability appear to be similar over years.

A comparison between the direct CV calculated during the raising procedure and the CV of the bootstrap estimates for the English sampling schemes for cod and herring indicates that the two show broadly the same tendencies and also the same level.

The variance-mean relationship appears to be proportional and the parameters are consistent over years within a species. This property will facilitate the development of appropriate statistical models of catch-at-age that do not assume a log-normal distribution for catch-at-age. In general, a particular choice of error distribution will necessitate careful and detailed analysis. Mis-specification could have severe implications for any modelling and estimation. A potentially less restrictive approach could be to base the modelling process of fisheries data on a broad class of mean-variance relationships, without direct specification of an underlying error distribution.

Define $\{Y_{yqfa}$; y = 1991, 1992, ..., 1998; q = 1, 2, 3, 4; f = cod, plaice, herring; a = 0, 1, 2, 3, …, $a_f+\}$ to be the set of independent random variables Y_{yqfa} which represent the catch of fish in the North Sea for an age-class a of a species f in a quarter q during a year y. The plus-group is denoted by a_f+ for a species f. From the analyses reported at this study group, the Y_{yqfa} may justifiably be assumed to have the general expectation

$$E(Y_{yqfa}) = \mu_{yqfa}(\boldsymbol{\beta})$$

and variance

$$\mathrm{var}(Y_{yqfa}) = \phi_{yqfa} V_{yqfa}(\mu_{yqfa})$$

for the species considered. Noting that knowledge of the variance function determines, for example, which member of the exponential family is being implicitly assumed, one is led to the idea of assuming only the form of this variance function, rather than the full distributional form. This technique is known as quasi-likelihood [Wedderburn(1974)]. To define the quasi-likelihood (QL) model one need only specify a relation between the mean and variance of the observations and the QL can then be used for estimation. For a one-parameter exponential family the quasi-likelihood is the same as the log-likelihood. Commonly encountered mean-variance relations are:

Mean-variance	**Distribution**
$\mathrm{var}(Y_i) = \phi$	Normal (Gaussian)
$\mathrm{var}(Y_i) = \phi\ \{\mu_i(\boldsymbol{\beta})\}$	Poisson
$\mathrm{var}(Y_i) = \phi\ \{\mu_i(\boldsymbol{\beta})\}^2$	Gamma
$\mathrm{var}(Y_i) = \phi\ \{\mu_i(\boldsymbol{\beta})\}^3$	Inverse Gaussian

Note that for a constant CV the QL is the same as the likelihood obtained by treating the observations as if they had a gamma distribution. The use of such modelling assumptions for catch-at-age needs further investigation and is currently under review.

5.2 Evaluation of spatial and temporal variability

Evaluation of spatial and temporal variability in the available sampling data was not carried out by the study group due to time restrictions. A first attempt to spatially evaluate sampling and catch data was presented for the Dutch fisheries. More work is needed on the spatio-temporal analysis of ALK's.

5.3 Advice on adequate levels of sampling

In order to assess the adequacy of sampling, the effects of sampling should be taken forward into the assessment models and perhaps even into the projection models. At present this has not yet been attempted. It is envisioned that the follow-up workshop (WKIMS) could address this issue. WKIMS should also address the balance between length samples and age samples.

6 RECOMMENDATIONS

Further work on the analysis of market sampling data is necessary. The Workshop on the International Analysis of Market Sampling and the Evaluation of Raising Procedures and Data-Storage [WKIMS] will provide a suitable forum for this continuation. The study group recommends that the Workshop should have a broad coverage and should not be limited to North Sea stocks. The Study Group notes that linkages should be sought to other relevant EU projects, e.g. EMAS and SAMFISH (follow-up from FIEFA).

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