

Assessment of the UK bass fishery using a log-book-based catch recording system

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FOREWORD

"In many fisheries, particularly those carried out by small ships from many separate fishing ports, accurate statistics of the whole fishing effort and its distribution cannot readily be obtained."

J. A. Gulland, 1955

It has become necessary to assess more accurately the fisheries for some inshore species including the bass, *Dicentrarchus labrax*, in order to provide sound management advice. As such fisheries are widespread and operated by numerous small fishing units, the usual system for providing catch and fishing effort values, based on a census by the Sea Fisheries Inspectorate (SFI), may be inappropriate. An alternative method using sampling of catch and census of active fleet size (effort census) has been applied to the bass fishery in England and Wales. The technique has involved the use of paid voluntary log-books, returned annually to obtain catch and effort data of individual boats. In order to derive total catches, samples are stratified by regions, fishing method and catching capacity and raised by the appropriate effort in 'boat-months' or 'boat-years'.

Estimated catches in weight are, where appropriate, integrated with SFI-derived values held on the Fishery Statistics data-base. The catch weights produced are applied to age-length keys and length distributions derived from biological sampling to give numbers of bass at each age/length group for five International Council for the Exploration of the Sea (ICES) divisional groups around England and Wales.



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1. INTRODUCTION

Established methods of monitoring catches of the major commercial marine fish species in the UK do not provide adequate coverage of inshore fleets catching 'non-quota' species. For several shellfish species and such roundfish as the bass, *Dicentrarchus labrax*, an improved accuracy in monitoring of catch is required for assessment purposes. These fisheries are seasonal, opportunistic and fragmentary and take mainly small, but high value catches, which are landed to a multitude of small ports and beaches and usually sold outside the larger markets and auctions. The Fisheries Statistics collecting system, operated by staff of the MAFF Sea Fisheries Inspectorate (SFI) was originally set up to monitor, by census, landings from mainly middle and distant-water fleets to the markets at about 12 major ports and a few minor ports. This structure has changed little and, though 60 minor ports are now covered by Fishery Officers, they still find it difficult to obtain comprehensive landing statistics at these places. For the bass fishery at least, a census on landings is impossible to achieve with the current extent and disposition of MAFF resources.

A programme of work on the bass was instigated at the Directorate of Fisheries Research (DFR) at Lowestoft in 1981, in order to advise on the management of a rapidly developing fishery in which there were many conflicts of interest. From the outset, it was apparent that the statistics then available, supplied by the SFI, did not accurately record bass landings either in magnitude, by catching method, or geographically, for the reason given above. Nevertheless, these figures can be used as an index of catches and demonstrate the steady rise in landings of bass recorded in the 1972-83 period (Figure 1).

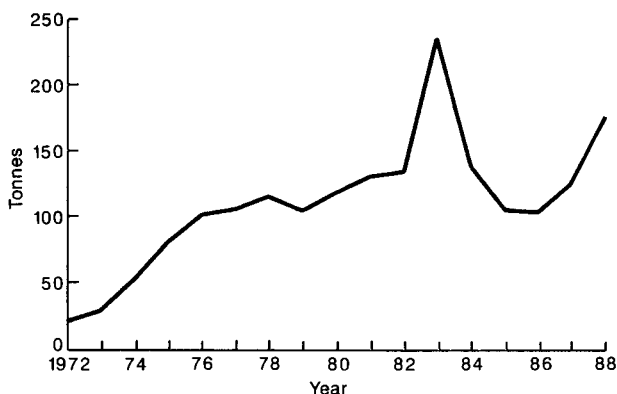


Figure 1. Bass landings in the UK from 1972-88, from SFI returns.

To obtain more comprehensive data on landings from the UK bass fishery, an alternative method of collection of catch statistics was developed. As few bass are landed in Scotland this exercise was carried out by MAFF. It has produced estimates of catches by port and catching method throughout the UK fishery and, coupled with sampling for age distribution (biological sampling), has enabled an annual assessment of the fishery to be made for the years 1984-88.

This report describes the system which has been developed to collect and analyse the data and gives examples of various outputs and assessments.

2. METHODS

2.1 Background

In the UK the bass is caught commercially in predominantly coastal fisheries, which also include shellfish, salmonids, mullet and small boat effort on the periphery of several major international stocks (e.g. sole and cod). Much of the background knowledge of the fishery for bass in 1981-82 was derived from a port-to-port description of the coastal fisheries of England and Wales (Pawson and Benford, 1983). During this survey, contacts were made in the fishing community and, in 1983, 20 individual fishermen were asked to take part in a pilot scheme to report catches of bass and mullet. Half of those approached returned their catch records, which included details of total individual catches, the seasonality of the fishery, and the size range of fish caught. Then, as now, there was no statutory requirement for owners of vessels under 10 m in length to provide catch details, so the scheme was voluntary, although a small incentive payment was made. It was decided to extend and develop this system in 1984 using data on seasonal catch via log-books as the basis of a system for estimating total catch in the fishery (Pickett and Pawson, in press).

2.2 System rationale

In order to estimate total catches from log-book data, it is necessary to treat each boat's catch as a sample of the fleet to which it belongs. Samples should be complete and representative, and cover the whole season and fishery. To produce estimates of total catch from sampled landings, an accurate description and assessment of total annual effort is required. A wide range of fishing gears and vessel types are employed in the bass fishery, and a system of stratified, but otherwise random, sampling of catches by individual boats (daily-monthly-annual) within a framework of strati-

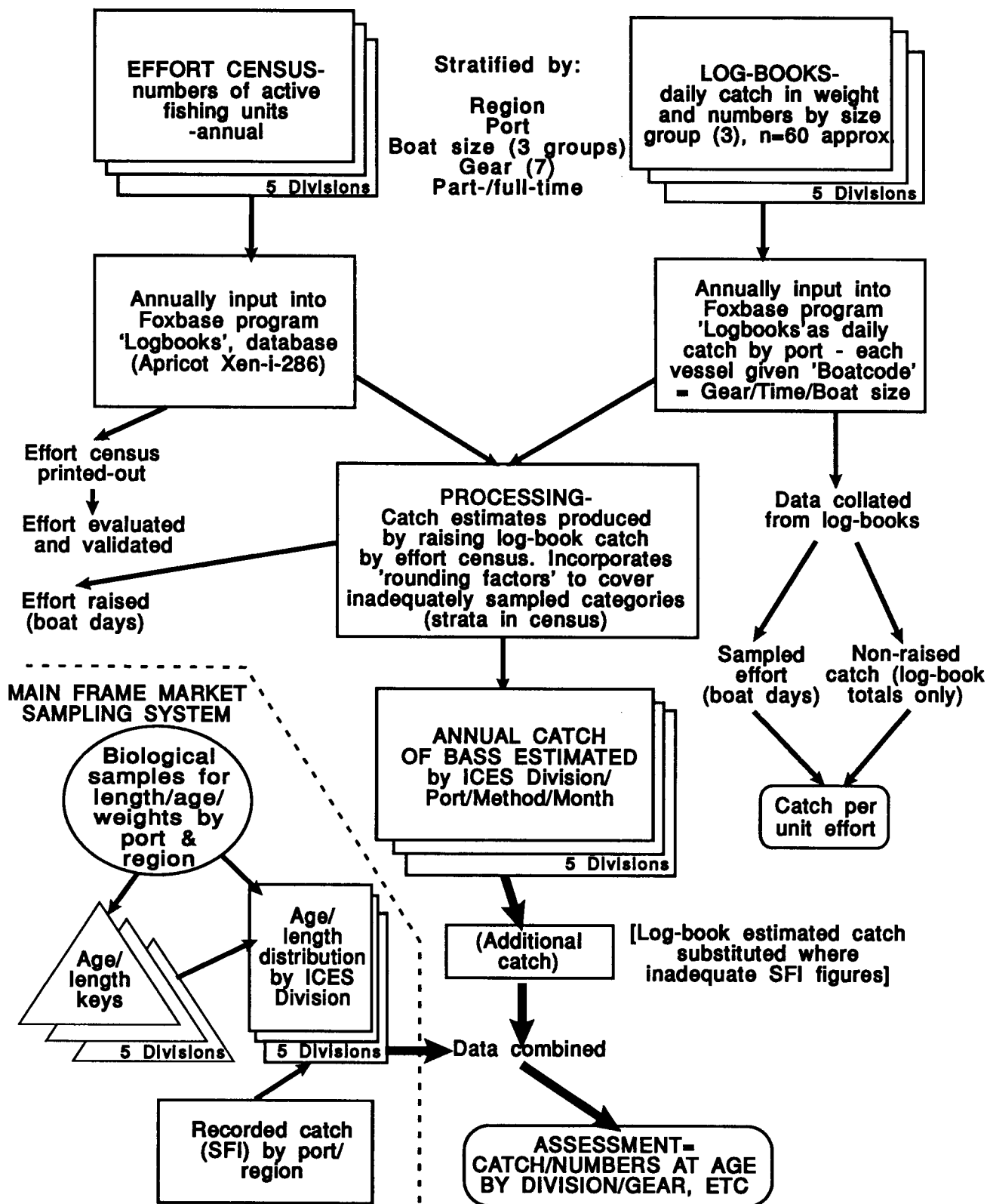


Figure 2. Main processing stages in the bass catch estimates by log-book scheme.

fied effort (in fleets, characterised by port, catching method and vessel size) has been adopted. Total potential effort is obtained by fleet census and is recorded as numbers of active boats (catching bass)

within each stratum at each port. Stratification of effort is by the catching method most commonly used by each boat, cross-stratified with a mesh of six interrelated fishing-powers or catching capacities of

the vessels. Effort frequency/duration is derived from log-book data and is considered to be characteristic for each part of the fishery. Similar methods have been applied to the evaluation of small-boat fisheries in the Mediterranean (Farrugio and Le Corre, 1983) and to the assessment of the bass fishery in Morbras, southern Brittany (Bertignac, 1987).

The system described here is used to produce annual catch estimates for the sampled part of the fishery, which does not include offshore trawling and shore angling. The data are combined with bass landings reported from the major ports by the SFI onto the Fisheries Statistics computer system (Appendix 1) at DFR, Lowestoft which also includes offshore trawling, and from which composite values are produced. Catches in weight and numbers of bass, at each age and length group by gear groups and ICES Divisions, are computed using the biological sampling database. The results are used to evaluate year-class strength, catch and effort trends, exploitation patterns and mortality in the exploited stock, and to model changes in yield to the fishery. The main stages of processing are illustrated in a flow diagram in Figure 2. The system is computerised (using IBM-compatible micro-computers) and full descriptions of the programs and their running are contained in programmers' and users' guides (Ware, 1984; updated version - MAFF, unpublished). A brief description is given in Section 3.

A summary of the sources of data in this study is as follows:

- (a) effort - vessel numbers are derived from effort census, in six main fishing power categories (catching capacity is based on vessel size or number of crew);
 - fishing frequency is derived from log-book data, recorded as 'boat-days';
- (b) catch - seasonality is recorded in log-books (returned annually) giving daily catch rates, aggregate landings and (with (a)) data on catch per effort;
- (c) fish size* and age distributions
 - are obtained from SFI- and DFR-directed biological sampling of landings.

This report is concerned chiefly with points (a) and (b) above, for which the methods involved differ from those used for assessing other UK stocks.

2.3 System design and data types

2.3.1 Effort designations

The first log-book sample-based assessment of the bass fishery, in 1984, relied largely on effort data obtained

from a description of the English and Welsh coastal fisheries as they stood in 1982 (Pawson and Benford, 1983). Subsequent to this, a port-by-port census of bass fishing has been carried out at 2-yearly intervals, with some intermediate annual updating. The census covers most landing places from Wells in the east to Barrow-in-Furness in the north-west (Figure 3) - about 100 ports in total. Major ports where there is adequate SFI coverage of bass landings or markets are excluded. The methods of obtaining the data are by interview - with local fishermen and Fishery Officers (SFI and Sea Fisheries Committee) and by postal questionnaire in a few districts. The census includes all vessels which fish for, or catch, bass whether by commercial or sport fishing, apart from those over 17 m (mainly trawlers) who complete EC log-books. Only boats active during the current season are included. Shore angling is not covered.

As fishing for bass is carried out by a large number of boats, using a great diversity of catching methods which may have widely differing efficiencies, a categorisation of vessel types has been used to stratify effort. The first distinction made is whether the boat is fishing *part-time* or *full-time* for bass (though not necessarily whether the boat is used part-time or full-time for fishing *per se*). The bass season may be quite short in some areas, and the designation 'full-time' applies to directed fishing at bass in season, as a main employment. Most full-timers will fish at least 4 days per week, if weather permits. Part-timers are taken to be those who fish for bass on weekends, as an adjunct to other fishing activity, or who take bass as a by-catch in a fishery directed at other species.

Boats are further divided into the three fishing power categories which may also reflect the size of the vessel. In the first 3 years of the system, these divisions were based simply on the number of 'hands' which the vessel employed, viz:

single handed, 2 handed, 3+ handed (or over 10 m).

From 1987 onwards, when analysis demonstrated little difference between the catch of vessels in the 2- and 3-handed strata, this has been amended. Boat angling catches are now treated separately, the new categories being as follows:

charter or casual angling, single handed, 2+ handed.

In addition, boats are identified by the type of gear used - trawls, gill nets, drift nets, trammel nets, long-lines, hand-lines and rod and line, for which the standard MAFF gear codes are used (Appendix 2). Where a vessel uses a variety of gears, the most commonly employed method is normally selected for gear coding. When catches are being analysed (see Section 4) the weight and numbers of fish are aggregated by the actual gear type used each day.

*Lengths and weight

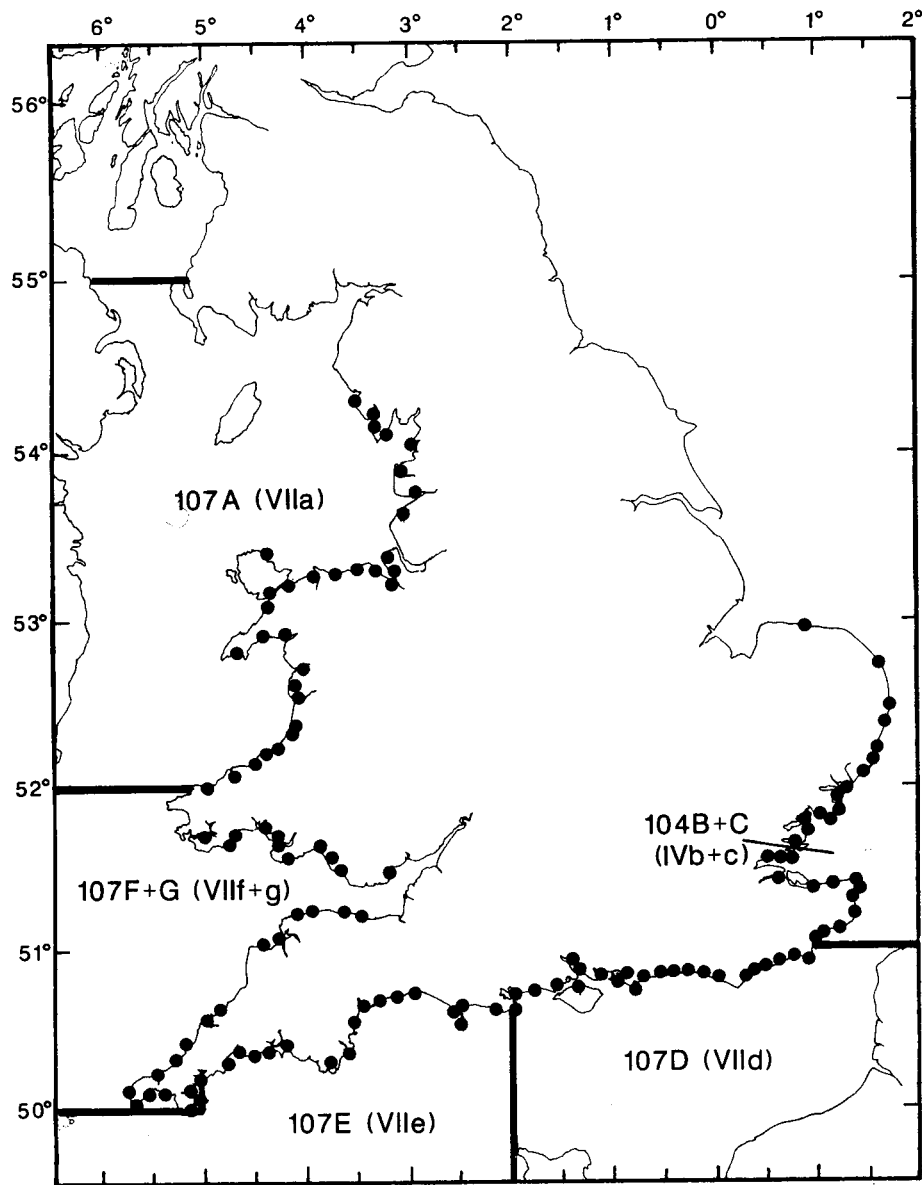


Figure 3. Ports and landing places covered in the bass effort census in 1987.

The effort census is therefore three-dimensional, being based on port of origin, 6 boat-type/fishing power categories (strata) and further sub-divided by 7 main gear types. Each vessel in the effort census is allocated a BOAT-CODE depending on where it is located in the cross-stratification. The code number is based on the 3 components described above, i.e. fishing power category, coded 1, 2 and 3; main fishing method, e.g. gill nets, code 50; and part-time or full-time designation, coded 1 and 2. An example of a valid boat code is 3.41.1. This is a 2+ handed (code 3), drift netting (41) part-time (1) vessel. A charter angling boat, fishing full-time for bass in season, would have a boat code of 1.72.2.

To identify individual boats (as, for example, when two vessels in a port share the same boat-code) a SKIPPER-CODE is used. This consists of the port code as used in the SFI system (Appendices 1 and 2) followed by 1, 2, 3, etc., e.g. 406.2. The number of vessels in each stratum is recorded for each port within each of the 5 main International Council for the Exploration of the Sea (ICES) Divisions around England and Wales (see Figure 3) which are a convenient way of dividing the fishery (see Sub-section 3.2). These are 104C (North Sea), 107D (Eastern English Channel), 107E (Western English Channel), 107F+G (Celtic Sea) and 107A (Irish Sea) (Figure 3). As an example, the total regional effort census for 1987 is shown in Appendix 2. Ninety-eight ports were covered by the census in 1986 and 102 in 1988.

Boat category:	Charter and casual angling		Single-handed commercial vessels								2+ handed commercial vessels							
Gear:	Long-line	Rod and line	Trawl	Drift	Gill	Trammel and tangle	Long-line	Rod and line	Hand-line	Other	Trawl	Drift	Gill	Trammel and tangle	Long-line	Rod and line	Hand-line	Other
Gear code:	71	72	7	41	50	52	71	72	73	64	7	41	50	52	71	72	73	64
Port and code																		
763) P Penberth/ Lamorna)																		
772) P St Ives/ Sennen)																		
778) P Newquay/ St Agnes)																		
781) P Padstow) F																		
784) P Port Isaac) F																		
789) P Clovelly) F																		
791) P Bideford/ Appledore)																		
792) P Ilfracombe) F																		
794) P Combe Martin) F																		
797) P Porlock/ Avonmouth)																		
800) P Newport) F																		
803) P Cardiff/ Pt Talbot)																		
805) P Swansea) F																		
806) P Gower) F (Oxwich/ Penclawdd))																		

F = Full-time (5-6 days/week); P = Part-time (1-2 days/week) or by-catch

Figure 4. Bass effort census (fleet-size) - example of layout of data collection form.

The number of vessels fishing in each region varies from year to year and there are frequent changes in the usage of gears and in the relative proportions of full-

time and part-time effort. An example of the form on which effort census data are collected is shown in Figure 4.

2.3.2 Catch and effort sampling

Whilst the estimation of potential effort in numbers of units in the bass fishery relies on total census, catch and active effort expended is obtained by sampling. The intensity of sampling has been limited by various factors including staff time, financial constraints and response rates of log-book holders. The numbers of log-books distributed and returned are as follows:

	1983	1984	1985	1986	1987	1988
Distributed	20	36	66	120	111	84
Returned	12	30	32	66	60	51
%	60	83	48	55	54	60

The return rate of completed log-books averages around 60% and between 50 and 60 log-books are now used each year as samples of the total catches of some 2000 vessels annually (see Table 1). Ideally, sampling should be stratified randomly, i.e. be proportionally distributed across the various regions and ports according to expected total effort, and selection of sampling vessels should also be a random process. In practice, it is selective, because although books tend to be given to those who agree to complete and return them irrespective of boat type or fishing method used, a special effort has been made to get log-books into areas and for some gear types which seem poorly covered. It is desirable statistically to have at least 10 samples in each of the 6 effort super-strata, but this is not easily achieved at current sampling levels.

There is a higher proportional coverage of full-time fishermen (11%) than part-timers (2%), although more (35:25 in 1987) part-timers actually return log-books (Table 1). This is due to the chance of making contact and identifying bass fishermen in each class. A large proportion of the part-timers fish only on weekends or at night and, having other employment, may wish to remain anonymous. It is a simpler task to identify vessels that are fishing than to contact cooperative individuals. There may therefore be some positive bias in the selection of log-book holders, in that the more regular boats are more likely to be contacted. The system of stratification of vessels used here is an attempt to overcome this problem. Selection of log-book holders and the overall distribution of catch data for the fishery is, therefore, considered to be random for assessment purposes and any bias is probably consistent. Statistically, levels of sampling are satisfactory for full-time effort, but estimation of total catch will consequently be less precise for the part-time component of the fishery.

The national distribution of log-books is shown in Figure 5.

Table 1. Log-book coverage of fleet by 'fishing power' strata : regions and gears combined in 1987 and 1988

	Charter/ casual angling vessel	Single- handed vessel	2+ handed vessel	Total
1987				
Full-time				
Vessels	44	80	103	227
Log-books	2	14	9	25
% coverage	4.5	17.5	8.7	11.0
Part-time				
Vessels	792	546	470	1808
Log-books	11	19	5	35
% coverage	1.4	3.5	1.1	1.9
Totals				
Vessels	836	626	573	2035
Log-books	13	33	14	60
% coverage	1.6	5.3	2.4	2.9
1988				
Full-time				
Vessels	41	67	99	207
Log-books	1	12	9	22
% coverage	2.4	17.9	9.0	10.6
Part-time				
Vessels	754	617	422	1793
Log-books	6	14	9	29
% coverage	0.8	2.3	2.1	1.6
Totals				
Vessels	795	684	521	2000
Log-books	7	26	18	51
% coverage	0.9	3.8	3.4	2.6

2.3.3 Log-book design

The layout of a weekly log-sheet is shown in Figure 6. The main features are as follows:

- (1) number of fishing trips;
- (2) daily catch of bass and mullet by weight and number/size category;
- (3) location and pattern of fishing and the gear used;
- (4) by-catch species and weight.

Days with zero bass catches are valid for this system when fishing is targeted at bass, but not when it is aimed at other species.

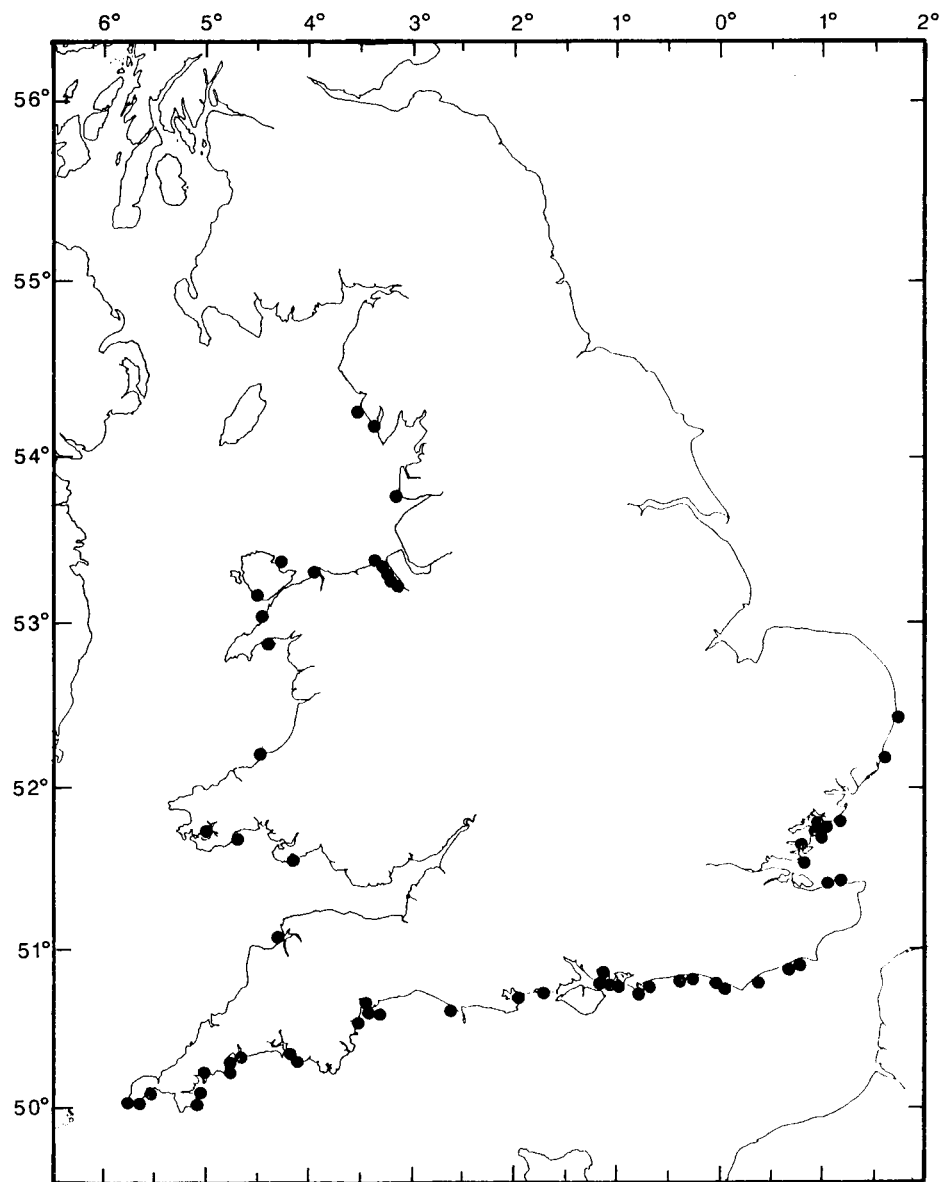


Figure 5. Ports where bass log-books were distributed in 1987.

The bass fishery in some areas is closely linked with that for the grey mullets (*Liza ramada*, *Liza aurata* and *Chelon labrosus*), and they are often caught together in gill nets. The mullet fishery is the subject of a separate investigation and, as useful data can be obtained from the same source, catch details of these species are requested together with those for bass. By-catch information for other species is requested, as it is useful for assessing the relative importance of bass in the fishery.

Standard port-codes (see Appendix 2) are used at each landing location, and for listing purposes the boat is identified by a code (skipper code) comprising the port code and log-book number within each port (1, 2, etc.). To protect confidentiality, names and addresses of fishermen are stored apart from the catch data (on a separate computer database).

The current rate of payment for each weekly sheet with at least one bass fishing entry is £5.

3. DATA INPUT AND PROCESSING

3.1 Programs

A suite of programs (called 'LOGBOOKS') has been written in 'FOXBASE' ('FOXBASE'+ 1.19b(c), 1986, Fox Software) to collate and analyse the data and maximise output flexibility. Multiple spreadsheet systems which are now available, e.g. Supercalc 5 (Computer Associates International Ltd), could probably handle the data in a similar fashion, but would require more user training. 'LOGBOOKS' is menu-

Skipper code:			Week:				Port code:			
Date	Grounds fished	Gear used	Species	Enter numbers of fish in size range			Total weight (lb)	Other species (numbers and weight of each type)	For Fish. Lab. use	
				Under 1.5 (lb)	1.5 - 6 (lb)	Over 6 (lb)			Rect-angle	Gear
Sun			Bass							
			Mullet							
Mon			Bass							
			Mullet							
Tue			Bass							
			Mullet							
Wed			Bass							
			Mullet							
Thurs			Bass							
			Mullet							
Fri			Bass							
			Mullet							
Sat			Bass							
			Mullet							

Figure 6. Layout of weekly sheet from bass and mullet log-book.

driven to match effort census layout to log-sheet format, and data can be output unraised (i.e. single boat) or raised (fleet) in various region/month/gear formats (Appendix 3). No knowledge of how the database operates is required by the user.

3.2 Statistical analysis and logic

Although various raising factors are employed in calculating total catch from the input log-book data, there is no statistical evaluation incorporated into the system. Direct estimates are produced from averaged or aggregated values scaled-up by effort within the various strata. Any statistical analysis, for example, analysis of variance or calculation of confidence limits, on the products which might be used to validate the distribution of catches by boat code within the various

strata, must be undertaken outside the system. There are two statistical assumptions about the pattern of the fishery which need to be tested annually. These are:

- (1) that there are measurable differences in annual mean total catch between vessels in each *fishing power* stratum (otherwise there is no point in stratifying catch records in this way);
- (2) that these arithmetic relationships, which can take the form of simple ratios, are consistent for each season.

In the case of the minor strata, e.g. *gear*, it is assumed that there are likely to be differences in catching efficiency between gears, but at the inception of the

scheme these were not quantifiable (but see Sub-section 3.4.3). In the case of *ports*, of which around 100 feature in the bass effort census, it has not been possible to sample catch (using only 60 returned log-books) at all locations. The assumption is made that catches within each fishing-power/gear-type stratum will be similar at sampled and non-sampled ports within groups having characteristic fishing patterns. For this reason, the fishery has been divided into the five ICES Divisions listed at Sub-section 2.3(a) which, although they are only broadly different in terms of fishery and exploitation patterns, must be treated separately for assessment and possibly management purposes (Pawson and Pickett, 1987). Due to the level of sampling achieved in the system (an average of 12 samples in each region), it is assumed that the *catch rate* (kg per boat-day) relationships between fishing-power strata are constant in all regions, although total catch across these strata may vary between regional divisions due to factors such as the number of effort units in operation and the length of season.

To obtain realistic catch estimates, non-sampled ports must be included in the assessment. Estimates for these ports can be obtained by extrapolation from strata sampled at other ports within the region. At current sampling levels, not all of the strata covered by each region's effort census will be sampled. Following the assumption that the fishing-power strata are arithmetically related, catches from sampled strata are used to substitute for missing samples and raised or lowered accordingly. The ratios by which substituted samples are multiplied or divided are called ROUNDING FACTORS. These are now calculated and adjusted prior to each year's data processing using observed mean catch rates per nationally grouped fishing-power stratum. The various combinations of mathematical variables necessary for processing are calculated within the computer program following input of the simple rounding factors. These can be changed annually (see Sub-section 3.4.3).

Note: Readers who do not wish to dwell overlong on the details of the input and processing of data associated with the 'LOGBOOKS' program given in Sub-sections 3.3 and 3.4 may go straight to the Results (Section 4).

3.3 Data input

3.3.1 Effort census

The 'LOGBOOKS' program is composed of two separate sections - effort (number of vessels in fleets) census and log-book catch and effort records - which are amalgamated during processing. Normally, the annual effort census must be compiled, establishing

numbers of boats by category around the coast, and input before any log-book data are entered. Effort details are keyed-in by port-code and skipper code, and the number of boats fishing per boat-code category (Appendix 2) can be adjusted seasonally and within one year by an 'add data' or 'edit data' option in the menu. The completed effort census is stored in a file on hard disk and must be checked and validated before processing can take place. It is possible to reprocess data for one year using different effort census values (levels and pattern of effort).

3.3.2 Catch data

Each log-book is assigned codes for ICES Division, port and boat-type. These are keyed-in prior to data entry and data will not be accepted unless there is a match by boat-code in the effort census. Daily data are keyed in the following sequence: day, month, gear, numbers of bass (in 3 size categories) and total weight of bass in pounds (the program converts to kg). Checks can be made using hard copy output of entered data and input mistakes are correctable by edit. The data are stored in a file on hard disk together with a detail file which contains one record (skipper code) for each boat's data input for the specified year. The detail file is used simply to list individual boat's catches as input, and acts as a check for any mistakes in data entries.

3.4 Data processing

3.4.1 Non-raised data

The non-raised catch (by sampled boats only) can be retrieved as it was input, i.e. daily by vessels, or formatted and aggregated by ICES Divisions, ports, months, years or gears. The latter option involves some processing of individual boat's data sets (each of which can involve several catching methods), and grouping on a port/boat-code/month/gear basis. These combined, but non-raised, data are copied to a processed data file on hard disk. Catch enquiries can then be made. The various output tabulations are identical to those used for raised data and enable direct comparisons to be made between the levels of sampled and estimated total catches. Data in non-raised form are used for producing CPUE estimates (see Section 4), through collation of effort in units of *boat days*. An example of an output format is given in Table 2.

3.4.2 Raised catch

On data entry, port codes, gear codes, boat size (fishing power - 3 codes) and part-time/full-time designation are input, and the program sorts and analyses the data based on these stratifications. After all the log-book data for one year have been entered, and with an

Table 2. Fish landed in ICES Divisions by log-book holders, separated by gear, all regions combined - retyped example of catch output from 'LOGBOOKS' program

Gear used	Boat days	Bass numbers			Bass (kg)	Mullet numbers			Mullet (kg)
		<1.5 (lb)	1.5-6 (lb)	>6 (lb)		<1.5 (lb)	1.5-6 (lb)	>6 (lb)	
Otter trawl	121	231	471	12	1879	11	0	0	6
Drift net	346	1309	4615	81	6215	1787	1921	24	3509
Gill nets	915	3015	6533	124	8739	2303	9377	8	11843
Trammel nets	305	84	445	70	916	6	416	5	590
Long-lines	164	235	904	93	1549	35	113	14	236
Angling	930	2583	4727	519	9102	4	23	0	32
Hand-lines	367	30	1894	162	2847	0	0	0	0
Grand total	3148				31247				16216

appropriate effort census entered and validated, the program will, on request, execute the total catch estimation procedure. The data file containing the sampled catches and effort by port is used as the basis for raising catches to the total estimated effort, by combining the effort census and processed data files, and producing a 'rounded-up' data file. In order to produce a final catch estimate, it is necessary to incorporate the rounding factors which are used to extrapolate across the boat-code stratification, weighting the catch 'sample' according to the fishing power and full-time/part-time designations described in Sub-section 3.2.

The raising (of sampled catch) process is as follows:

- (1) if only one boat lies within a particular stratum in the relevant ICES Division, the catches of the boat are multiplied by the total number of boats in that stratum as recorded in the effort census;
- (2) if 2 or more boats have the same boat-code, an arithmetical mean of the catches is calculated and this is raised appropriately;
- (3) if a stratum is not covered by a log-book, a program called 'BOAT SEARCH' comes into play. This scans through a specified number of ports for a log-book entry with a matching boat-code and may enter the adjacent region according to the fishing characteristics of the area;

- (4) if a match is not found, another boat is sought within the home region using the *same method* of fishing but in a different fishing-power stratum. In this event, rounding factors are used and the appropriate ratio is applied to the catch of the boat to substitute for catch data from the non-sampled stratum. The re-calculated or 'adjusted' catch is then raised by the number of fishing units in the non-represented stratum within the ICES Division. In this way, almost all boats recorded in the effort census are allotted a real or substitute catch for each month that fishing is taking place for the port/boat combination used as the sample. The sum of real and extrapolated catches will give the total estimated catch.

Despite the rounding and boat searching processes, in most years a few boats recorded in the effort census will remain outside the coverage of sampling and are not used in estimating total catch. The boat-codes and port-codes that relate to these vessels are identified to the user as a menu option, which also produces a list of port/boat codes, for which substitute data have been extrapolated using catches from ports other than 'home' ports.

3.4.3 Adjustment of rounding factors and searching routines

In the logbook system, the variables (rounding factors) used in the 'prototype' (1984-85) were based on observed ratios between mean annual catches in the various strata extracted from the 1983-84 log-book

returns. These were roughly in the order of 1:2:3 for the boat categories, single handed, 2 handed and 3+ handed, respectively and 1:3 for part-time to full-time effort, reflecting, perhaps, the daily economic requirement of boats in these respective categories.

The rounding factors used in 1984-85 were subsequently revised following analysis of the increasingly large sample of catch records. The ratios of mean catch per effort in each stratum in 1986-87 for categories 1, 2 and 3 were 1.0:1.3:4.0 respectively (replacing 1:2:3) and the part-time/full-time ratio was 1:6. Changing the rounding factors initially required the assistance of a computer programmer who simply changed all of the specified values within the named program. Rounding variables can now be altered as a menu option, being calculated and incorporated by part of the program. When rounding down, as when substituting a full-time log-book for a part-time vessel in the effort census, the variables are divided into the catch weights rather than multiplied.

Rounding factors can now be altered annually, according to the actual relationship between boat codes derived from the processed but non-raised data in the current year. In the past, the values obtained for one year have been used for years 2 and 3, i.e. retrospectively. In future, each year will become 'self-validating' by incorporating the statistical analysis of actual/observed catch distribution. Rounding variables and searching routines will then be adjusted before full processing commences.

At the outset, mathematical stratification between gear-types was excluded from the raising process as there were no calculated differences in catch rates (kg per day) between gears. Analysis of catch data over 4 years has, however, shown consistently different national catch rates by gear type (see Section 4). The raising process, where it involves catch substitution via rounding factors, is two-dimensional (boat type x part-time/ full-time mesh) and generates 22 search actions/variable calculations. Although inclusion of arithmetic relationships between gear strata would improve the method of substitution, by selecting catches closer to the home port, three-dimensional adjustment of searching routines involving up to 154 calculations of variables would be necessary. As it is not possible at this stage to calculate the improvement which this would give in accuracy in estimating non-sampled catch, no major alterations to the present system are envisaged in the short term.

Inevitably, however, more accurate assessments which involve sampling of catch will only be achieved by more widespread and representative log-book coverage, which would reduce the need for catch substitution using the rounding factors.

4. RESULTS

4.1 Annual estimates of effort

In the present study, two parameters of effort have been measured:

- (a) numbers of vessels fishing (fleet size); and
- (b) number of actual boat days fished.

Each of these has been stratified by port, region, gear and fishing power category. A more detailed method of estimating effort, e.g. length of gill net, trawling power of vessel, numbers of rod-hours per boat, has not been used as the present objective is to estimate total catch and not some function of catch per unit effort.

4.1.1 Fleet size

The total number of vessels catching bass in the UK, derived from effort census in the years 1985-88 was 1875, 2106, 2035 and 2000, respectively (Table 3). The apparent increase in overall fleet size between 1985 and 1986 was not seen in ICES Division 107E, where there had been a steady decline over this period. In Division 107F+G, effort peaked in 1987, following a rapid expansion in the fishery in south Wales at that time, and has subsequently dropped slightly. Effort in Division 107D has declined since 1986 but it still remained higher in 1988 than it was in 1985, and a similar situation obtained in Division 104B+C. The number of vessels fishing in Division 107A changed little over the period. The decline in Division 107E is due to a combination of factors; lower catch rates in the hand-line fishery have caused some fishermen to forsake it temporarily, and in some gill-net fisheries the fixed net prohibitions consequent on the Salmon Act 1986 (Great Britain - Parliament, 1986) have restricted opportunities for gill netting.

The proportion of full-time seasonal bass fishermen in the fishery was similar in 1988 and 1985 (\cong 10%).

A fuller description of the characteristics and spatio-temporal variation between the different fisheries in each region is given in Pawson and Pickett (1987).

4.1.2 Boat days - distribution of effort

The number of boat days collectively fished by the sampled vessels is available as part of a 'catch enquiry' on a port or regional format (see example in Table 2). Recorded total effort is as follows:

Year	Boat days		
	Sampled	Estimated total	% sampled
1985	1 603	98 188	1.6
1986	3 559	106 257	3.3
1987	3 359	106 994	3.1
1988	3 148	117 026	2.7

The number of boat days estimated nationally rose slightly over the 4 years, but underlying these figures are regional and seasonal variations in trends in fishing effort. The seasonality of effort varies (Figure 7), but a mainly summer fishery is indicated in all regions. Particularly noticeable are the declines in effort in peak season in Divisions 107D and 107A between 1986 and 1987, with a corresponding increase in 107F+G. A common feature in all divisions is a decline in effort in August due, perhaps, to socio-economic factors such as the fishermen's summer holidays and the tourist (boat trip) trade, with either an increase or a lesser decline in September.

Similar data can be derived for the distribution of effort by various gears, but this is not an important part of the present assessment of the UK bass fishery.

4.2 Catch rates

The annual mean catch per boat day for the years 1985-88 given in Table 4 suggest that catch rates differ consistently between the major gear groups. The daily catches by drift net were significantly higher in each year than by any other gear though, importantly, gill-net (mainly fixed) catches were not significantly different from hand-line/angling catches. This interpretation assumes that the same part of the fleet is sampled across the years. This criterion was not met with long-lines in 1985, because then they were less extensively used to catch bass, and with trawls in 1988, when they were used more in directed fishing for bass. The values given in Table 4 provide a useful comparison of catch rates by gear for the sampled part of the fleet. However, they are not necessarily representative of the total fleet covered by the effort census. The gross mean catch from vessels sampled in 1988 was

Table 3. Summary of the distribution of the bass fishing fleet by numbers of active vessels, 1985-88, from English and Welsh ports

	ICES Divisions					Totals
	104C	107D	108E	107F+G	107A	
1985 P	166	533	514	119	364	1696
F	18	102	44	7	8	179
Total	184	635	558	126	372	1875
1986 P	228	607	403	217	380	1835
F	26	132	40	22	51	271
Total	254	739	443	239	431	2106
1987 P	225	601	339	267	376	1808
F	26	81	60	27	33	227
Total	251	682	399	294	409	2035
1988 P	264	570	319	265	375	1793
F	21	85	39	25	37	207
Total	285	655	358	290	412	2000

P = Part-time

F = Full-time

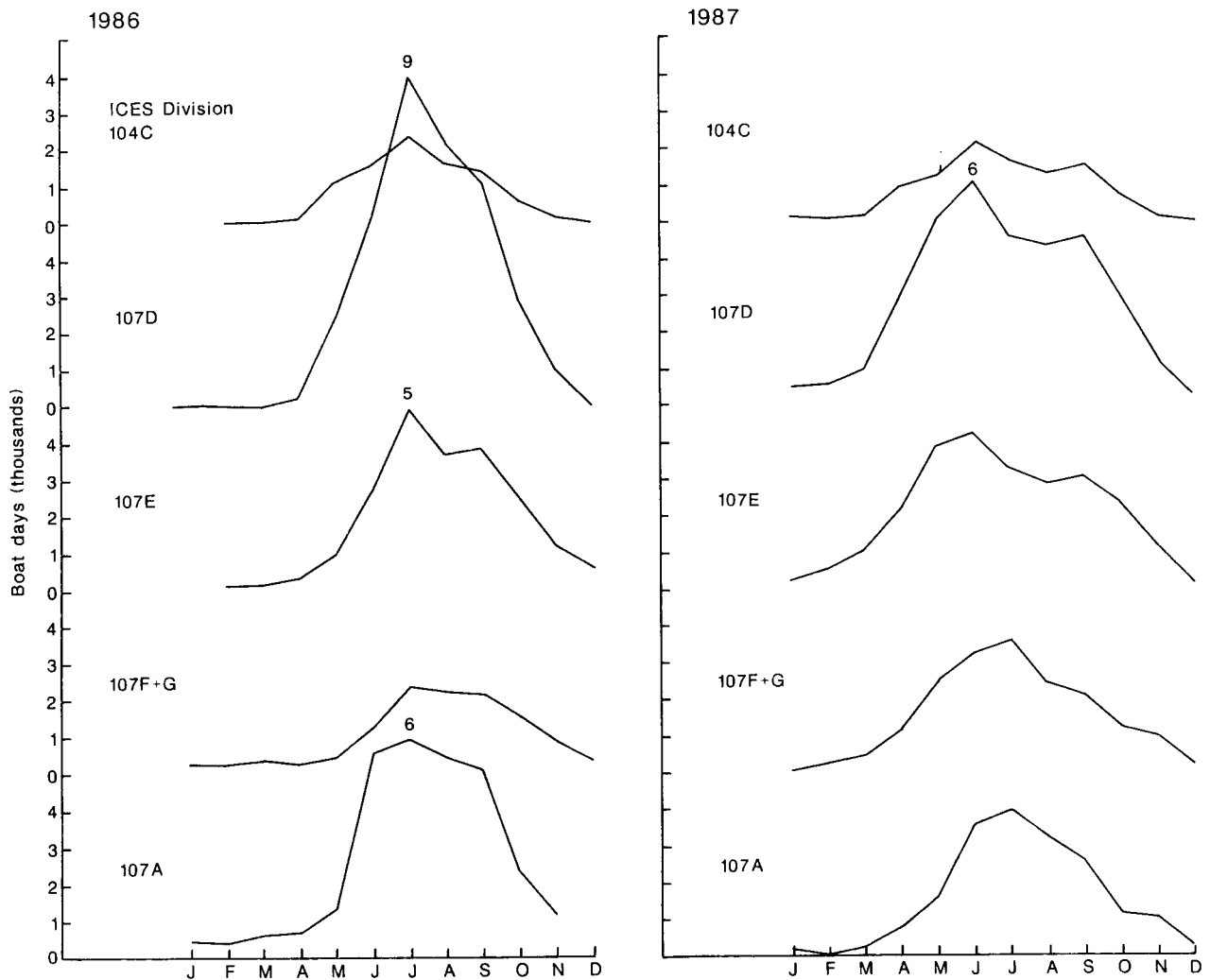


Figure 7. Estimated monthly effort in boat days, by ICES Division, in the UK bass fishery, in 1986 and 1987.

Table 4. Mean bass catch (kg) per boat day for sampled boats (Sampled effort in boat days is in parenthesis)

	1985	1986	1987	1988
Trawls	5.1 (93)	3.0 (256)	3.0 (149)	15.5 (121)
Drift nets	34.1 (57)	26.1 (180)	20.4 (310)	18.0 (346)
Gill nets	4.0 (653)	8.4 (1093)	8.8 (904)	8.8 (846)
Trammel nets	2.4 (106)	2.2 (569)	3.3 (453)	3.0 (305)
Long-lines	5.3 (4)	12.1 (222)	9.1 (271)	9.4 (164)
Angling)			8.4 (968)	9.8 (930)
)	11.1 (690)	11.7 (1239)		
Hand-lines)			8.9 (304)	7.8 (367)

Table 5. Distribution of average catches (kg per year) per sampled boat in the 'fishing power' strata - 1987 and 1988 data combined

	Category 1	Category 2	Category 3	All
Full-time boats	3	28	18	49
Total catch	1950	19047	26099	47096
Catch/boat	650	680	1450	961
s.d.	786.0	480.5	1578.9	
Part-time boats	16	33	13	62
Total catch	2134	5890	6037	14061
Catch/boat	147	179	464	227
s.d.	128.5	208.9	448.3	
All boats	19	61	31	
Total catch	4084	24937	32136	
Catch/boat	215	409	1037	

9.7 kg per boat day, whereas the weighted mean (derived from fully processed data) was 4.4 kg per boat day. It should be noted that the units used in calculating total catch were recorded as total catches per boat year for sampled vessels. Individual total catches depended on a number of variables including frequency of fishing - hence, the full-time/part-time designation. Catch rates in terms of catch per boat day, for example, would probably be independent of this. Total landings of bass by individual vessels range from a few kilograms each season for some small, part-time boats, especially those targeting other species, to about 6000 kg per year for some larger, full-time specialist bass boats.

Mean annual catches for 1987 and 1988 combined for full-timers were 959 kg and 225 kg for part-timers, for the sampled part of the fleet. There was inevitably a wide variability of catches within each fishing power stratum, producing the large standard deviation of values given in Table 5. It will be noticed that mean catches in categories 1 and 2 (charter/casual angling and single-handed vessels) are similar for both full-time and part-time vessels although sampling levels of full-timers are generally low in category 1.

4.3 Estimated total catch

Since 1985, the log-book system has been the main tool used to estimate total catch in the bass fishery in the UK. For assessment purposes, it is necessary to adjust the final figures by adding catch from non-sampled sources, e.g. offshore trawlers and some major

ports, derived from SFI statistics. Grossed UK bass catch estimates (t) are as follows:

	1	2	3	4	
Year	Sampled catch	Estimated total catch	Adjusted total catch	SFI total catch	Ratio (3:4)
1985	12.9	565.8	579.2	105.8	5.5/1
1986	33.1	597.9	616.6	103.0	6.0/1
1987	29.6	759.9	784.7	125.1	6.3/1
1988	31.2	512.6	570.3	176.9	3.2/1

These figures suggest that, whilst the landings recorded by SFI have been consistently under-reported, there was a higher proportional catch census by SFI in 1988, probably due to the much higher trawl catch recorded then (Table 4).

It is clear that we still underestimate the total catches of bass in the UK as no account is taken of catches by shore anglers, which are impossible to assess using the methods reported here. An independent study of the economics of the bass fishery (Dunn *et al.*, 1989) includes an estimate of 666 t for the retained part of the shore-angling catch in 1987. If this figure is added to our estimate of 785 t for the commercial and boat-angling catches, a total UK value of 1451 t is obtained, with shore angling making up 46%.

Table 6. Estimated bass landings (t) in the UK fisheries from 1985-88

ICES Divisions	1985	1986	1987	1988
104B+C	65.633	59.368	91.435	94.485
107D	180.310	181.574	188.708	219.004
107E	231.619	120.536	224.991	133.326
107F+G	44.368	107.565	165.782	68.042
107A	57.220	147.557	113.782	55.429

Total	579.150	616.600	784.698	570.286

4.3.1 Regional annual catch estimates

Regional catches for the years 1985-88 are given in Table 6. These figures, when split by gear groups, are the basis for an annual assessment of the bass fishery. Regional differences and seasonal fluctuations are apparent and these agree well with trends in fishing activity in each area as recorded, for example, in quarterly reports by Fishery Officers of various Sea Fisheries Committees.

4.3.2 Regional catch by gear-type

The log-book system has produced annual catch estimates by 7 main gear types. The separation of these fishing methods has been incorporated into the system:

- (a) to show trends in their usage and relative catching effectiveness; and
- (b) to examine the effect of possible differences in selectivity and size composition of the catch.

These aspects will be discussed more fully in a later paper, but for information, details of estimated catches by each gear by ICES Divisions are given for one year (1987) in Appendix 4. A fundamental part of the annual assessment of the UK bass fishery, however, is the production of regional age and length compositions of catch, stratified by gear groups. These are used:

- (a) to attempt to avoid bias in estimating size and numbers of fish caught due to year-to-year variation in gear use; and
- (b) to determine the effect of possible management measures which may be gear-related.

Due to inadequate levels of biological sampling for single gear types, assessment has only been possible on a fairly coarse grid of 4 gear-groupings, i.e. all trawls, gill nets and similar nets, long-lines and hand-lines (including angling). There are consistent regional variations in gear usage (and resultant catches) even at this level of grouping; gill nets are used universally, but trawls catch relatively few bass in the southern North Sea and the Irish Sea. Long-lines, traditionally only used for bass in the eastern Channel, are now being employed in other areas.

4.3.3 Age- and length-based assessment of the fishery

The estimated catch weights in the form of log-book-derived/SFI-recorded totals for each of the four main gear groups in each region are used in processing biological sampling data on the DFR market sampling system. This follows the basic production of length distributions, age-length keys (ALKs) and age compositions in a manner developed for other fish stocks (e.g. by Gulland, 1955). Sampling for length and age by the various strata is not comprehensive for bass and, out of 20 ALKs produced each year, only 12-14 are usable without some combination of gears or regions. ALKs are applied to sampled length distributions which have been raised by sampled weight to total catch weight for each stratum. The processing is carried out on the HP1000 (Hewlett Packard) computer and follows similar procedures to those used for other roundfish stocks. For bass, this is shown in diagrammatic form in Appendix 5. The main difference with the bass assessment is the use of integrated catch estimates. With the exception of trawls in most regions, log-book-derived catch estimates exceed SFI catch figures on the statistical database. These are incorporated by subtracting the smaller values (SFI figures by region/gear group) and inputting the difference as 'additional catch'. The data can be input at

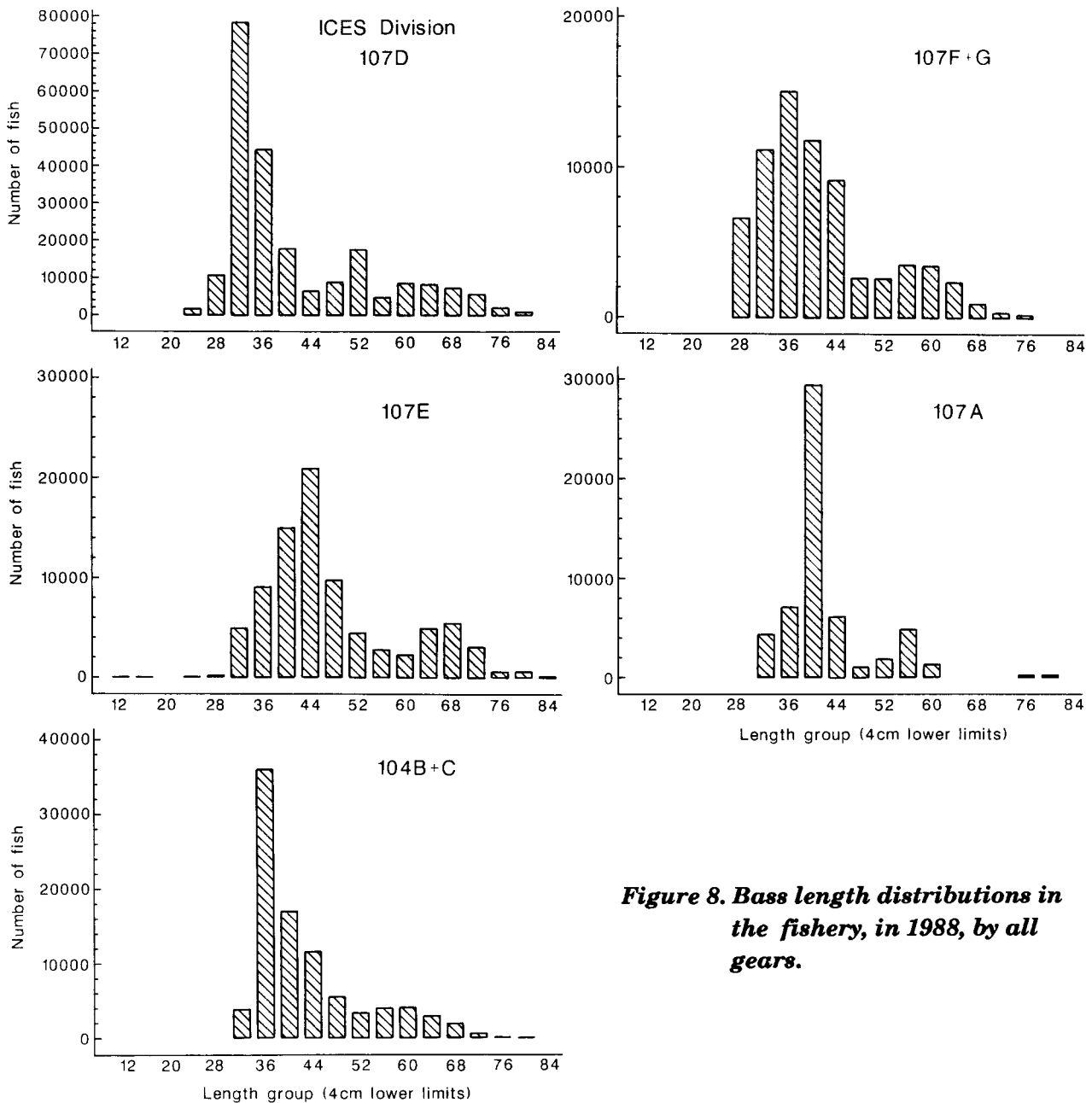


Figure 8. Bass length distributions in the fishery, in 1988, by all gears.

either of two stages, after the production of age/length distributions, thereby raising the age composition of the catch, or earlier, to produce fully raised length distributions as shown in Appendix 6. The products of this system are regional, gear-grouped and 'all gears combined' age and length compositions from which exploitation patterns, year-class abundance, and yields can be determined.

The histograms in Figure 8 show how the exploitation patterns differ regionally within one season (1988).

The minimum legal landing size for bass at this time was 32 cm total length and an increase to 36 cm came into force on 1 January 1990. The data show clearly where the most significant impact of this will be experienced in the fishery from 1990 onwards. Figure 9 shows the changes in age distribution within the catch between 1985 and 1988. A feature to note is the persistence of the exceptionally good 1976 year class throughout the fishery, shown at ages 9, 10, 11 and 12 years respectively.

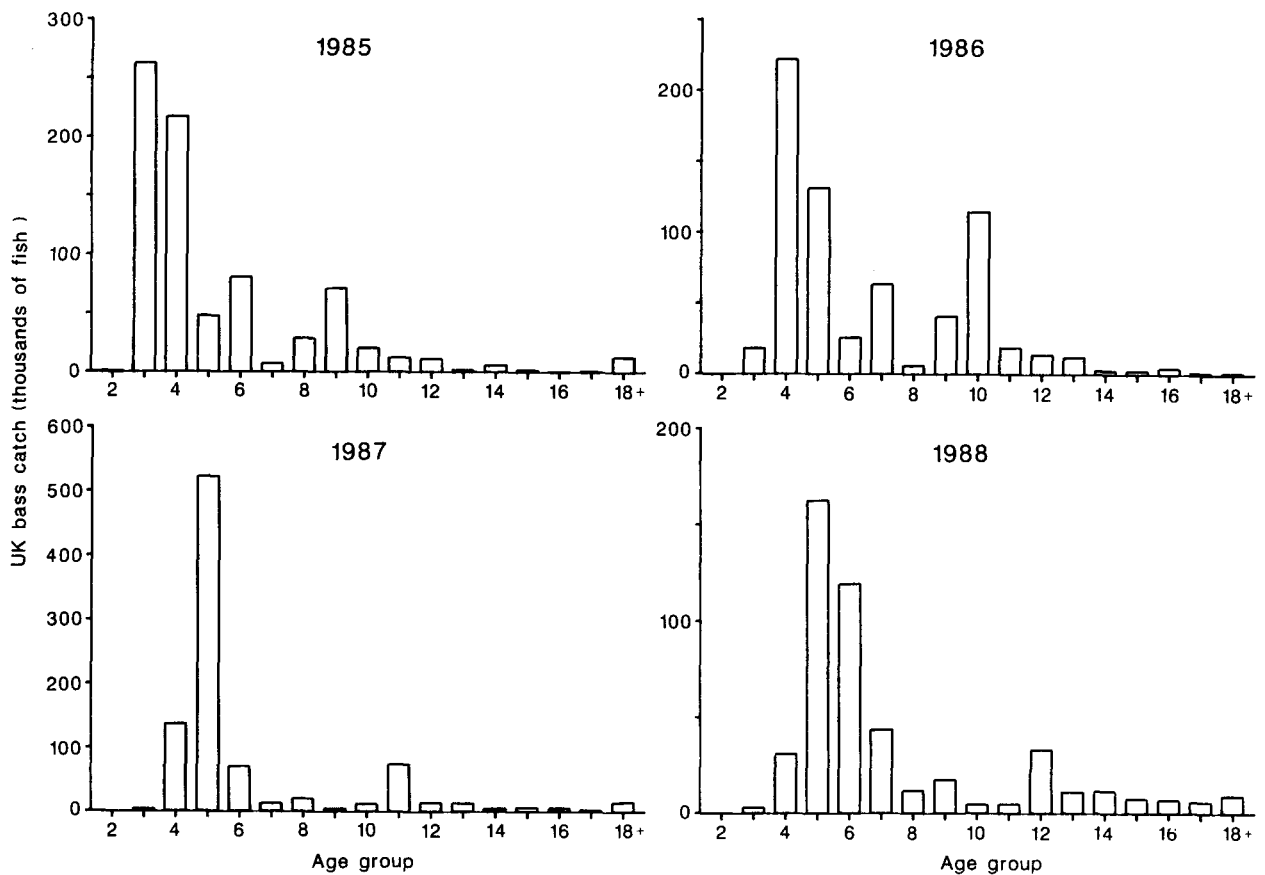


Figure 9. Bass age distributions in the fishery, in 1985-88.

5. DISCUSSION

The system described in this report has produced sets of catch and effort values relating to the bass fishery which may be used in various ways. The simple net weight of the national total catch is of little use in itself, other than to give an estimate of the value of the fishery, perhaps in relation to other fisheries or, if a time series is established, to follow trends in landings. The average annual bass catch of the commercial fishery over the period 1985-88 is estimated to be around 637 t. In terms of gross tonnage this appears small alongside other main commercial species, e.g. cod 36 414 t and plaice 21 611 t in 1988. The high unit value of bass would, however, place it in the top ten of annual first-sale values in the English and Welsh fisheries at about £4.8 million (average 1985-88 total value), when using the catch estimates given above. The SFI-derived, but unpublished, 'official statistics' give an average annual catch for 1985-88 of 128 t, worth approximately £0.8 million. There is clearly a large discrepancy between these statistics which is due to the reliance of one (SFI) on catch *census* in the larger ports, and the other on catch *sampling* throughout the fishery. It is recognised that with the level of sampling reported here, estimates will tend to be less precise for some *gears* in the *ports* where the SFI

carries out its census. For this reason, the data are combined to get the best out of each method. For example, trawls are known to be under-sampled by the log-book system as catch estimates tend to be lower for this method than the SFI figures in all regions. Because the SFI census also probably underestimates trawl landings, the log-book figures are obviously grossly underestimating real catch levels. So far, however, it has not been possible to evaluate any *overestimating*. The latter is thought mainly to occur when raised catches are assigned to individual ports, since only about 40% of the ports covered by the fleet (*effort*) census are represented by log-books and catches are extrapolated for the rest. We have, however, relied on the principle of levelling-out ('some up - some down') knowing that both over- and under-estimating will occur. A method of calculating this variance has not yet been devised for this system.

Widely inaccurate estimates can be ascribed to two causes:

- (a) poor fleet census data/stratification; and
- (b) unrepresentative or biased sampling by returned log-books.

In the case of (a), the effect of varying effort census values will be seen mainly in the catches estimated by port. Tests with various combinations of census applied to the same catch data in 'dummy runs' using the 'LOGBOOKS' program, showed less than 0.5% total catch variation when the total from the census for the regional fleet was raised or lowered by around 10% in one fishing power stratum. Consequently, a port with a zero fleet census will always be allocated zero catch.

The system's method of producing raised catch figures may seem to be too complicated and simpler methods could possibly be employed. An example is the use of CPUE (effort = annual) to derive catch. In its simplest form this would be an unstratified, annual estimate of total catch, i.e.

$$\text{mean catch per boat} \times \text{total effort} = \text{total catch.}$$

This would entail using the mean catch of all gears or annual total catch per sampled boat raised by the total number of boats. For 1988 the result would be as follows:

$$\begin{aligned} & *549.0 \text{ kg} \times 2000 \text{ (fleet census total)} \\ & = 1\,098\,000 \text{ kg} = 1\,098 \text{ t.} \end{aligned}$$

Alternatively, we could use CPUE (units of effort = boat days) raised by total estimated boat days. For 1988 this equation would be:

$$\begin{aligned} & \#9.9 \text{ kg} \times 117\,026 \text{ (Appendix 3)} \\ & = 1\,158\,557 \text{ kg} = 1\,159 \text{ t.} \end{aligned}$$

Whilst these values are similar they are, however, both significant overestimates, because the mean catches used are unweighted, being derived from samples of catch (log-books) unevenly distributed between full-time and part-time boats of the fleet (compare with calculated total of 570.3 t, Table 6). The benefit of the 'rounding' device is to weight the mean catch values to represent proportionally the numbers of full-time and part-time vessels. The calculated (gross weighted) values for mean annual and mean daily catches are 284.9 kg and 4.9 kg respectively, compared to 549.0 kg and 9.9 kg as given above. These values are illustrative only, and are not being used in the processing of data due to the complexity of region and gear stratifications. Whereas a similar effect may possibly be achieved with simpler stratification of catch and effort data, this would result in the loss of some of the finer detail needed at present to accurately describe the bass

* derived from Table 5.

derived from Table 4.

fishery. The most likely course would be to combine some regions used in the assessment, but this would chiefly be done to overcome the inadequacy of biological (length and age) data.

Since the inception of the system in 1984, large improvements have been made in our methods of handling the data produced by log-book returns. With the inclusion of more statistical rigour into both sampling strategy and treatment of results, it will be possible to maintain a system of estimating catch with full evaluation of the standards of accuracy.

6. SUMMARY AND CONCLUSIONS

The system described here has produced estimated national and regional catches of bass in weight and numbers. These estimates have become more robust due to refinements to the system and account taken of an increasingly robust time-series of individual boat's catch records. The figures produced demonstrate that the bass fishery in England and Wales is larger and more valuable than the SFI-derived landings figures indicate.

At present, the figures produced by both systems are integrated to give best estimates. For example, the log-book estimates of trawl catches of bass often fall short of the SFI-reported values and so the latter figures are used. The end-product of the system is numbers of bass caught at age/length and a time-series of at least 4 usable years' data has been established. These data should be sufficiently reliable to eventually include in short-term forecasts of catch and biomass and VPA-type analyses. This could be particularly important if the bass fishery (or part of it) required regulation under international arrangements, e.g. catch controls.

With slight modification to the log-book format, effort census scope or to the programs themselves, the techniques described here could be used to evaluate other locally-directed or multi-species fisheries. By-catch data (in the bass fishery) are collected as part of the log-book system. The figures for the grey mullets are already compiled and processed alongside the bass catch estimates. A full evaluation of by-catch weights and values will enable the relative importance of bass and other species in a multi-species fishery to be assessed.

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APPENDIX 1. Background information on DFR's computerised systems.

Fisheries statistics landings: current system overview

Introduction

The Fisheries Department of MAFF is charged, amongst other things, with the management of fishing quotas; with the provision of information to, and negotiation with, the European Community; and with the complex scientific task of fisheries monitoring and assessment. To help satisfy these requirements, information on fish landings in England and Wales is gathered by the Sea Fisheries Inspectorate and passed on to the Fisheries Statistics Computer System.

The system consists of three linked divisions:

- (1) data entry at the ports by SFI;
- (2) data validation at DFR, Lowestoft; and
- (3) retrieval of data from the fisheries statistics database on the IBM computer at Guildford.

Data entry

Data collected by the port staff consist of:

- (1) the quantity of each species of fish landed by vessel by area of capture;
- (2) the amount for which each quantity was sold;
- (3) the estimated amount of fish rejected at sea; and
- (4) various measures of the effort expended in catching the fish, e.g. number of hours fishing; number of days absent.

The data are keyed into TORCH micro-computers at the port office. Basic data validation is carried out at this point and corrections are made by the Fishery Officers. The data are then added to a file pending transmission to the central computer facilities. Sub-sets of the data are used by separate programs on the micro to meet the port needs for local records and quota management (although most local needs for information

are met through the central retrieval system via the Fisheries Statistics Unit (FSU). Each night a similar micro-computer in the Lowestoft laboratory dials, automatically, each port in turn and collects the information entered by the port staff during the previous working day.

Twenty-five micro-computers were introduced during the period May 1985-October 1988 and replaced an existing paper-based system. Support for the micros is provided by DFR whilst local quota management programs are maintained by FSU.

Retrieval system

Each morning, DFR updates the main database on the Guildford computer via a direct line. The updating process includes the addition of new data, plus the correction of existing records which have been found to be incomplete or in error. Access to the data is provided by terminals and printers in both DFR and FSU, and can be carried out independently, with the proviso that the combined usage of the two sites does not exceed the budget agreed as part of the Service Level Agreement between the Fisheries Department and Information Technology Directorate (ITD). Retrievals are submitted during the day for off-peak running overnight, although a small number of priority jobs are allowed.

DFR retrieves information for users within DFR for scientific purposes and produces machine-readable data for outside bodies such as ICES* and SFIA†, whilst FSU retrieves information for various policy, administrative and enforcement purposes including data for transmission to the EC (as part of the Common Fisheries Policy). Both DFR and FSU retrieve information to meet *ad hoc* requests from outside bodies for which charges are made.

DFR passes data files produced by the retrieval system back to the HP1000 computer, to serve other systems, the main recipient being the biological sampling system which requires statistics on landings for stock assessment.

The retrieval system was developed in Scientific Information Retrieval (SIR) and run by Service in

* *The International Council for the Exploration of the Sea.*

† *The Sea Fish Industry Authority.*

Informatics and Analysis (SIA) Ltd, on its bureau machine from June 1983 to August 1986. At the end of the contract period, it was transferred to the IBM computer at Guildford, conversion being carried out by DFR with assistance from ITD. System maintenance and development is now the responsibility of DFR. Data from 1949 onwards are available, with the total size of the databases being in the region of 1800 megabytes.

Biological sampling: current system overview

Introduction

A major part of the work of DFR, Lowestoft is involved with fish stock assessment and the most important input to that work is estimates of age compositions of stocks provided from the biological sampling system.

The age compositions are derived from samples of numbers at length (length distribution) and otoliths (age data) taken from fish landings at ports in England and Wales, together with catch statistics for those landings.

Sound scientific estimates of stock levels rely on both adequate sampling of fish stocks and accurate estimates of landings of these fish stocks and the biological sampling system should be seen as an integral part of fisheries statistics rather than existing on the periphery of it.

In a similar way to the fisheries statistics system, the biological sampling system consists of three parts:

- (1) data entry at the ports by SFI;
- (2) data validation on the HP1000; and
- (3) processing on the HP1000 at DFR.

Data entry

Data collected by port staff consist of measurements of numbers of fish at length of samples of fish landed at the markets (length distribution), together with the details of otoliths removed from certain of these fish (age data). The targets of what species of fish to sample, how many to measure and how many otoliths

to take are set by DFR in agreement with SFI at the beginning of each year.

Data are entered on paper forms and posted to DFR on a monthly basis together with the otoliths that have been taken.

Data validation

Paper forms of length data received at DFR are keyed to disk and undergo comprehensive validation before being stored in an IMAGE database on the HP1000

Paper forms of otolith* data received lack age information for each fish. This is supplied by DFR staff who examine the otoliths and are skilled in determining, from the structure of the otoliths, the age of each fish. These data when complete are also keyed to disk and undergo validation before storage on the database.

Processing

Processing is divided into a number of sub-systems for the production of:

- (1) length compositions;
- (2) age length keys (ALKs);
- (3) age length distributions; and
- (4) age compositions.

At each stage, other than in the production of ALKs, raising processes require catch and effort data from the fish landings system. These data have to be retrieved from the fisheries statistics database on the IBM computer and stored in the system.

(a) Length compositions

Selection: Validated length samples are selected by some combination of Species/Sex/Year/Period/Area of Capture/Gear/Port/Vessel Length Group where any selection parameter can be a combination of values stored in the system for that data item(s).

Raising process: For each length sample selected, for each category measured, the numbers at length are raised in the ratio of weight landed for the category to the weight measured taking the discard rate into

account, and combined with other categories from the same sample to give a length distribution for the boat. Length distributions for each boat sampled are then combined and raised further in the ratio of landings by all vessels for the particular selection stratum to the landings by the sampled vessels.

(b) Age length keys (ALKs)

Selection: Validated biological samples are selected by some combination of Species/Sex/Year/Period/Area of Capture/Gear/Port/Maturity/Stock/Data Source where any selection parameter can be a combination of values stored in the system for that data item(s).

Processing: From the biological samples selected, a matrix of age against length (group) is constructed.

(c) Age length distributions

Selection: Length distributions stored in the system are selected by some combination of Species/Sex/Year/Period/Area of Capture/Gear/Port/Vessel Length Group where any selection parameter in the stratum can be a combination of one or more of those values stored with the length distribution for that parameter. Using a similar string of values, catch and effort data are selected from the system. The required ALK is selected by reference number.

Processing: For all length distributions selected, the numbers at length are combined and raised in the ratio of catch selected to the catch stored with the length distributions.

The resulting length distribution is then matched with the selected ALK whereby adjustments are made to the bottom and/or top of the sets of data, and the ALK is then raised by the numbers at length to produce an age length distribution.

(d) Age compositions

Age compositions (numbers of fish at age), obtained from the age length distribution, are the end-product of the processing and are made available to scientists in their stock assessment work.

* In the case of bass, scale samples.

APPENDIX 2. Bass effort census, including gear and port codes, for 1987.

Port	Code	Charter/casual angling vessel						Single-handed vessel						2+ handed vessel							
		7	41	50	52	71	72	73	7	41	50	52	71	72	73	7	41	50	52	71	72
ICES Division 104C																					
Wells	406 P	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Winterton	436 P	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pakefield- Kessingland	443 P	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Southwold	451 P	-	-	-	-	-	5	-	1	-	2	-	1	-	-	-	-	-	-	-	-
Sizewell	454 P	-	-	-	-	-	-	-	-	2(1)	2	-	-	-	-	2	-	-	-	1	-
Aldeburgh	456 P	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	2	5(1)	-	-
Orford	457 P	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Felixstowe	461 P	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-
Harwich	466 P	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	1	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-
Walton	467 P	-	-	-	-	-	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Clacton	469 P	-	-	-	-	-	4	-	-	4	1	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Brightlingsea	476 P	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mersea	478 P	-	-	-	-	-	5	-	-	-	-	-	-	-	1	-	2(1)	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(1)	-	-	-	-
Bradwell	484 P	-	-	-	-	-	8(2)	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Burnham	490 P	-	-	-	-	-	9(1)	-	-	-	-	-	-	-	1	-	1	-	-	-	-
Southend	506 P	-	-	-	-	-	13	-	-	3	2(1)	-	-	-	-	-	3	-	-	-	-
Leigh	511 P	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canvey	513 P	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3	-	-	-	-	-
	F	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Medway Ports	535 P	-	-	-	-	-	10	-	-	1	-	-	-	-	1	-	2	-	-	-	-
Whitstable	550 P	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
Herne Bay	603 P	-	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	4	-
	F	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	4(1)	-
Margate	604 P	-	-	-	-	-	2	-	-	1	6	-	-	-	-	-	-	-	-	-	-
Broadstairs	607 P	-	-	-	-	-	3	-	-	-	-	-	-	-	-	4	-	-	-	-	-
Ramsgate	610 P	-	-	-	-	-	10	-	-	3	3	-	-	-	2	-	2	2	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5	2	-	-	-	-
Deal/Walmer	612 P	-	-	-	-	-	10	-	-	-	3	-	-	-	-	1	-	-	-	-	-
Folkestone	617 P	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	5	-	-	-	-
Hythe	620 P	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
ICES Division 107D																					
Dungeness	623 P	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Rye	626 P	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Hastings	628 P	-	-	-	-	-	-	-	-	2	2	-	-	-	-	2	10	-	-	-	-
Bexhill	630 P	-	-	-	-	-	5	-	-	3	-	-	5	-	-	-	-	-	-	-	-
Eastbourne/ Langney	632 P	-	-	-	-	-	10	-	-	5	5(1)	-	2	-	-	2	-	1	20	-	-
Newhaven	636 P	-	-	-	-	-	10	-	-	4	2	-	-	-	10(1)	-	2	1	1	2	-
	F	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	2(1)	-	-	-	-
Brighton	638 P	-	-	-	-	-	5	-	-	-	10	-	-	-	-	-	-	-	-	-	-
Shoreham	639 P	-	-	-	-	-	20	-	-	-	2	-	-	-	4	-	5	5	3	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Worthing	640 P	-	-	-	-	-	-	-	1	-	2	1	-	-	-	-	20	2	-	-	-
	F	-	-	-	-	-	-	-	1	-	2(1)	-	-	-	-	2	4	-	-	-	-
Littlehampton	645 P	-	-	-	-	-	15	-	-	-	3	-	5	-	-	7	6	2	5	-	-
	F	-	-	-	-	-	-	-	-	3	-	-	-	-	-	2	-	2	-	-	-
Bognor	646 P	-	-	-	-	-	5	-	-	-	2	2	-	-	-	-	-	-	-	-	-
Selsey	647 P	-	-	-	-	-	-	-	-	5	5	0	-	-	-	2	2	2	4	-	-
	F	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2	2	-	-
Emsworth	651 P	-	-	-	-	-	10	-	-	6	-	-	-	-	-	6	-	-	6	-	-
	F	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Hayling Island	653 P	-	-	-	-	-	10	-	1	-	-	-	-	-	8	-	-	-	10	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	6	-	-
Portsmouth	654 P	-	-	-	-	-	40	-	6	-	2	2	10	-	6	2	4	4	6	4	-
	F	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	3(1)	-	1	-	-
Southampton	655 P	-	-	-	-	-	16	-	-	2	-	-	-	-	2	-	1	-	-	2	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	-
Lymington	661 P	-	-	-	-	-	25	-	-	-	-	-	-	-	-	8	8	-	-	-	-
Poole	662 P	-	-	-	-	-	40	-	4	20	5	1	5	-	10	-	-	-	2	5	-
	F	-	-	-	-	-	12(1)	-	-	6	-	-	-	-	-	3	-	-	-	5	-
Swanage	663 P	-	-	-	-	-	3	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Christchurch	664 P	-	-	-	-	-	10	-	8	-	-	-	6	-	-	-	-	-	-	2	-
	F	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-

APPENDIX 2. Continued.

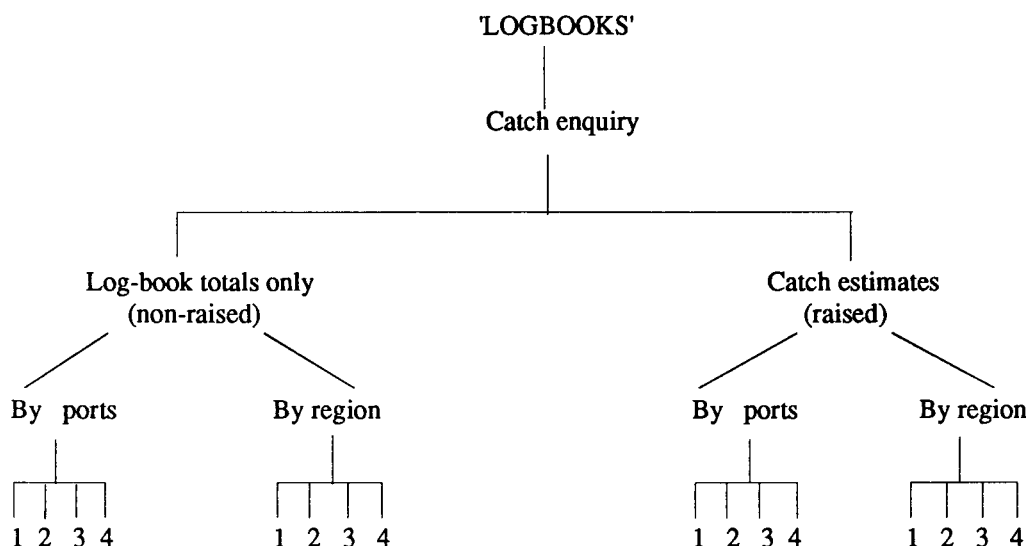
Port	Code	Charter/casual angling vessel						Single-handed vessel						2+ handed vessel								
		7	41	50	52	71	72	73	7	41	50	52	71	72	73	7	41	50	52	71	72	73
ICES Division 107E																						
Weymouth area	669 P	-	-	-	-	-	50	-	-	-	10	10	-	-	-	5	-	35	35	-	5	5
	F	-	-	-	-	-	-	-	-	-	8	8	-	-	-	-	-	-	-	-	4	4
Lyme/West Bay	690 P	-	-	-	-	-	3	-	-	-	1	-	-	-	-	3(1)	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Sidmouth	705 P	-	-	-	-	-	10	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Exmouth	706 P	-	-	-	-	-	9	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	2(1)	-	-	-	-	-	-	2	-	-	-	4	-	-	-	-
Teignmouth	713 P	-	-	-	-	-	2	-	-	-	3	-	-	2	-	2	-	-	-	-	4	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(1)	-	-	-	-	2	-
Torquay/Paignton	716 P	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dartmouth	721 P	-	-	-	-	-	2	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
Salcombe	725 P	-	-	-	-	-	2	-	-	-	-	-	2	-	1	-	2	-	-	-	2	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Plymouth	730 P	-	-	-	-	-	20(1)	-	-	2	5(1)	2	1	-	-	-	5	-	-	-	4	-
	F	-	-	-	-	-	-	-	2	3	-	-	-	-	-	3	-	-	-	-	-	-
Polperro	738 P	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-
Fowey	740 P	-	-	-	-	-	5(1)	-	-	-	-	-	-	5	-	-	-	-	-	-	2	-
	F	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Mevagissey/Par	742 P	-	-	-	-	-	5(2)	-	-	-	2	-	-	5	-	-	2	-	-	-	-	-
Falmouth	746 P	-	-	-	-	-	10(1)	-	-	-	2	-	-	-	-	-	5	-	-	-	-	-
Helford River	748 P	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Porthoustock	751 P	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	1	-
	F	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-
Coverack	755 P	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-
	F	-	-	-	-	-	5	-	-	-	-	-	1	1	-	-	-	-	-	-	2	-
Newlyn	761 P	-	-	-	-	-	6(1)	-	-	-	6	-	-	-	-	-	2	-	-	-	-	-
ICES Division 107F + G																						
Penberth	763 P	-	-	-	-	-	-	-	-	-	-	-	-	2(1)	-	-	-	-	-	-	-	4
	F	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2
St Ives	772 P	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	5	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Newquay	778 P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
Padstow	781 P	-	-	-	-	-	5	-	-	-	12	-	-	-	1	-	2	-	-	-	-	-
Clovelly	789 P	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Bideford/	791 P	-	-	-	-	-	10	-	-	-	-	-	2	-	-	-	-	-	-	-	6	-
Appledore	F	-	-	-	-	-	4	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-
Ilfracombe	792 P	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Combe Martin	794 P	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Porlock-	797 P	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avonmouth																						
Cardiff-	803 P	-	-	-	-	-	21	-	10	-	4	-	-	-	-	-	-	-	-	-	-	-
Port Talbot																						
Swansea	805 P	-	-	-	-	-	20	-	1	-	1	-	1	-	2	2	2	-	-	-	-	-
	F	-	-	-	-	-	6	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Gower	806 P	-	-	-	-	-	10	-	-	-	-	-	-	12	-	1	2	-	-	-	6	-
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(1)	-
Llanelli	820 P	-	-	-	-	-	40	-	-	-	3	-	-	-	-	6	-	-	1	-	2	-
	F	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
Pendine	824 P	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Saundersfoot/	825 P	-	-	-	-	-	5(1)	-	-	-	5	-	-	1	-	2	-	-	-	-	-	-
Tenby																						
Milford Haven	833 P	-	-	-	-	-	5	-	-	-	4	-	-	1	-	2	-	1	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	4	-
ICES Division 107A																						
Cardigan-Llangranog	842 P	-	-	-	-	-	4	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Newquay	843 P	-	-	-	-	-	2	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Aberaeron	844 P	-	-	-	-	-	4	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-
Aberystwyth-Borth	849 P	-	-	-	-	-	15	-	-	-	9(1)	-	-	-	-	-	-	-	-	-	-	-
Aberdovey-Tygwyn	854 P	-	-	-	-	-	15	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-
Barmouth	856 P	-	-	-	-	-	10	-	-	-	6	-	-	10	-	-	-	-	-	-	-	-
Traeth Bach area	860 P	-	-	-	-	-	4	-	-	-	3	-	1	-	-	-	-	-	-	-	-	-
Poromadog-Pwllheli	868 P	-	-	-	-	-	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 2. Continued.

Port	Code	Charter/casual angling vessel						Single-handed vessel						2+ handed vessel								
		7	41	50	52	71	72	73	7	41	50	52	71	72	73	7	41	50	52	71	72	73
ICES Division 107A																						
Pwllheli-	872 P	-	-	-	-	-	3	-	-	-	-	-	10(1)	-	-	-	-	-	-	-	-	-
Aberdaron	876 P	-	-	-	-	-	6	-	-	-	-	-	25(1)	-	-	-	-	-	-	-	-	-
Caernarfon	F	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Caernarfon-	877 P	-	-	-	-	-	15	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Bangor	F	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anglesey	880 P	-	-	-	-	-	10(1)	-	-	-	-	-	2(1)	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	7	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-
Bangor	888 P	-	-	-	-	-	3	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Conwy	892 P	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-
	F	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-
Rhyl-Connah's	898 P	-	-	-	-	-	2	-	-	-	-	-	56(2)	2	-	-	-	-	-	-	-	-
Quay	F	-	-	-	-	-	-	-	-	-	-	-	4(1)	-	-	-	-	-	-	-	-	-
Parkgate-	903 P	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Hoylake																						
Lytham St Annes	934 P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Morecambe	949 P	-	-	-	-	-	20	-	-	3	-	-	3	-	-	6	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Coast Road	963 P	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Barrow	968 P	-	-	-	-	-	40	-	-	-	-	-	3(1)	-	-	10	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-

F = full-time; P = part-time; 7 = trawl; 41 = drift-net; 50 = gill-net; 52 = trammel -net; 71 = long-lines; 72 = angling; 73 = hand-lines

APPENDIX 3. Catch and output menu options obtainable from 'LOGBOOKS' system.

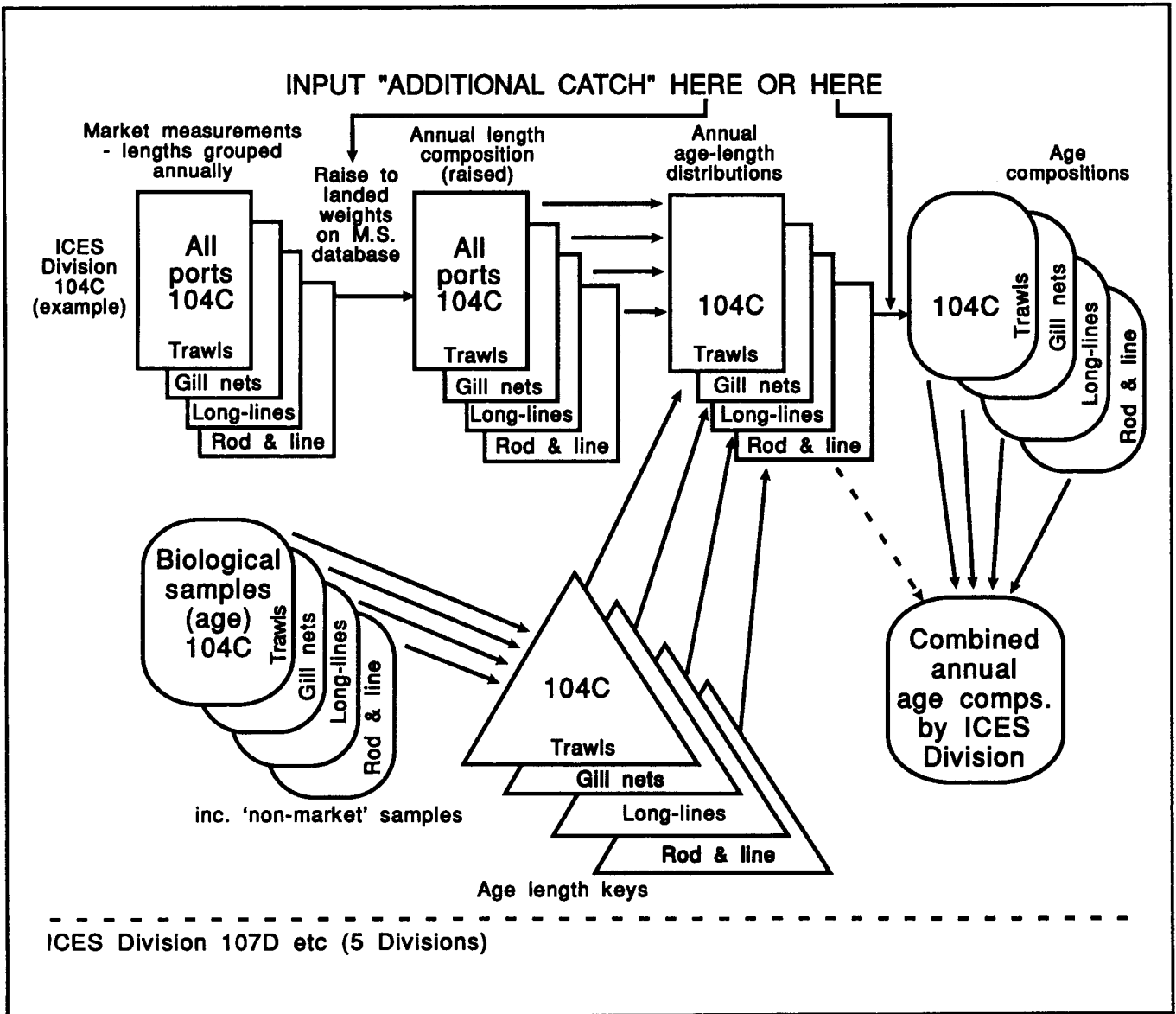


1 = Month/gear/boat size format; 2 = Month/gear format; 3 = Gear format; 4 = Month format

APPENDIX 4. Layout of the data for the 1987 annual bass and mullet catch by region and gear, as output from 'LOGBOOKS' system.

Gear used	Boat days	Bass (lb)			Bass (kg)	Mullet (lb)			Mullet (kg)
		< 1.5	1.5- 6	> 6		< 1.5	1.5-6	> 6	
Fish landed in ICES Division 104B+C									
Otter trawl	1389	4364	1928	76	4386	74	72	0	128
Drift net	276	277	1393	47	1577	3713	6673	7	9547
Gill net	2428	16279	47139	241	52207	12199	12662	7	53387
Trammel net	827	279	1437	364	3674	3	688	40	1037
Long-lines	313	7	287	201	1180	0	0	0	0
Angling	5240	8745	12268	708	21971	469	1000	0	1630
Sub-totals	10473				84995				65729
Fish landed in ICES Division 107D									
Otter trawl	2951	9949	4080	112	9452	201	201	0	371
Drift net	2161	8739	9703	484	15201	19763	54890	197	64402
Gill net	6405	55182	67165	777	93141	109287	21413	25	69963
Trammel net	4302	1143	5234	1389	14302	426	1046	149	2113
Long-lines	1408	2763	4936	952	10801	0	1	0	2
Angling	17134	44693	16594	1366	40201	1762	927	0	2010
Hand-lines	16	15	19	2	44	0	0	0	0
Sub-totals	34377				183142				138861
Fish landed in ICES Division 107E									
Otter trawl	886	2218	873	10	2075	165	9	0	84
Drift net	2178	4239	46050	497	54297	15325	58517	251	67423
Gill net	8041	73877	66894	659	102155	178591	25182	0	105325
Trammel net	2734	469	3279	711	8125	360	581	1	919
Long-lines	16	61	108	37	294	0	0	0	1
Angling	10074	27740	17771	1279	35223	1564	73	0	1609
Hand-lines	1441	28	5387	2146	15740	0	4	0	0
Sub-totals	25370				217909				175361
Fish landed in ICES Division 107F+G									
Otter trawl	506	2134	704	0	1694	0	11	0	11
Drift net	1712	4376	39175	58	45843	9905	63841	100	69181
Gill net	5070	36690	9781	76	28716	97240	13838	18	57496
Long-lines	56	99	175	49	445	7	23	3	47
Angling	9654	17200	50075	2136	72134	1489	50	0	759
Hand-lines	1335	385	9367	339	13416	0	157	0	329
Sub-totals	18333				162248				127823
Fish landed in ICES Division 107A									
Drift net	845	357	1244	66	2117	1678	8674	71	10804
Gill net	6599	7450	11010	374	17544	3794	18470	302	23875
Trammel net	1132	116	993	423	2705	224	3192	1	3973
Long-lines	80	128	403	77	860	24	85	13	174
Angling	9780	5071	64168	3157	88407	1070	0	0	550
Hand-lines	5	2	6	0	10	0	0	0	0
Sub-totals	18441				111643				39376
Grand totals	106994				759937				547150

APPENDIX 5. Processing stages in the production of an age-based assessment of bass.



APPENDIX 6. Example of fully raised age/length distribution - SFI and DFR data combined.

Length group (cm)	Total fish landed	Total otoliths read	Numbers at age													
			5	6	7	8	9	10	11	12	13	14	15	16	17	
35.0	89	1	89													
36.0	148	3	99	49												
37.0	415	6	208	208												
38.0	590	3		590												
39.0	845	9	94	751												
40.0	682	4		682												
41.0	993	11		813	181											
42.0	1967	11		1610	358											
43.0	2424	14		1212	866	173	173									
44.0	2776	12		1157	1388	0	231									
45.0	1183	9	131	657	394											
46.0	2165	13		999	999	0	167									
47.0	1472	13		453	566	0	340	113								
48.0	1047	8			655	262	0	0	131							
49.0	325	3			108	108	0	0	108							
50.0	281	4			141	0	70	0	0	70						
51.0	119	3			40	0	79									
52.0	30	1							30							
53.0	59	1			59											
59.0	59	1									59					
60.0	89	2								44	0	0	0	44		
64.0	59	1											59			
66.0	59	1														59
Totals	17879	134	621	9181	5754	543	1060	113	269	115	59	0	59	44	59	
Total otoliths read			8	64	39	4	9	1	3	2	1	0	1	1	1	
Mean length (cm)			39.1	42.9	45.7	47.1	46.5	47.5	49.3	54.4	59.5	0.0	64.5	60.5	66.5	
Mean weight (isometric) (kg)			0.641	0.839	1.009	1.107	1.067	1.126	1.264	1.730	2.213	0.000	2.819	2.326	3.089	
Mean weight (external) (kg)			0.635	0.830	0.999	1.096	1.056	1.115	1.251	1.713	2.191	0.000	2.791	2.303	3.058	