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New Developments in Computerized Field Data Acquisition Equipment for Groundfish Surveys

by

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Introduction

Groundfish research cruises have been conducted off eastern Canada since the mid-1950's. Standardized, stratified-random surveys for inventories of commercially important fish species were initiated in 1970 on the Scotian Shelf, in the Bay of Fundy, and in the Southern Gulf of St. Lawrence. In 1970, DFO introduced a standardized methodology to be used for conducting these surveys. This methodology resulted from a complete revision of recording formats, the introduction of at-sea protocols and a revision of computerized methods and formats (Halliday and Kohler 1971). A history of groundfish surveys and their applications is given by Halliday and Koeller (1981) and Doubleday (1981).

These procedures included recommendations for minimal sampling requirements from ICNAF. Specific recommendations for subsampling of aging materials, scales and otoliths, as well as total numbers of specimens of commercial species to be measured or weighed, were outlined.

A manual describing the detailed methods of the Marine Fish Division, Maritime Region, to implement the standardized methodology was prepared by Koeller (1981). The methods and procedures adopted by the Gulf Region, Department of Fisheries and Oceans, since 1982 have followed the manual prepared by Koeller. The Gulf Region has attempted to follow the field protocols for data collection to obtain the level of sampling intensity recommended by the standardized methodology adopted in 1970.

Difficulties in obtaining the goals implicit in the recommended intensity of sampling have been experienced due to two major factors. One, manpower and budget constraints limit the number of surveys that can be undertaken as well as the number of personnel participating on each survey. Second, the experience of the personnel on each survey restricts the overall efficiency in acquiring data and therefore the sampling and sub-sampling intensities that can be achieved.

In the northern Gulf of St. Lawrence, intensive groundfish surveys have been conducted in the summer, fall and winter from 1976 to 1981 (Atkinson, 1984). Each of these surveys generally sampled 150 to 250 stations, with 100,000-300,000 fish measured for length frequencies. These surveys were conducted by personnel from St. John's, Newfoundland and have been directed primarily at cod, redfish, and shrimp. The intensity of sub-sampling and detailed data acquisition on other species was restricted (Pitt, Wells and McKone 1981).

Given the cost of these surveys, it was felt that the Gulf Region should follow the full sampling procedure for integrity of historical data bases, to provide comparative time series analysis capabilities.

Additional information on other species in the fish community would be desirable including information on rare species and their distributions and abundance.

Clearly, the recommended procedures and sampling intensities cannot be met with existing budgets and manpower. The potential solutions to this problem are:

a) lower the recommended level of sampling intensity,
b) increase the manpower and budget,
c) increase the level of technician skill, and
d) develop a new method.

Of these potential solutions:

a) Lowering the level of sampling intensity might be possible. However, this would require an in depth evaluation of the statistical power of various levels of sampling. Since statistical theory in this area is complicated, the analysis would be difficult. The sampling intensity applicable to one species may not be appropriate for others, since each species has its own characteristic growth rate, length frequency distributions and age composition.

b) It is not likely that manpower and budgets can be increased.

The present Canadian governmental policy is to reduce spending and manpower. The problem may be how to maintain the current sampling intensities, which are deemed necessary for stock assessments and research, with fewer dollars and person years.

c) Increasing the level of technician skill is very difficult.

Current staff, in the Gulf Region, cannot be expected to quickly develop the level of skill exhibited by longtime employees in other regions. Because of manpower limitations our surveys are staffed by students, vessel technicians, and only a few professional DFO technicians. New people must be trained during each survey. It takes a good portion of the survey for these people to develop the speed and dexterity needed for efficient sampling using the traditional methods.

d) Developing new methods for data acquisition seemed feasible.

We have examined the existing methods and procedures for field data recording on research surveys, laboratory data entry, verification and computerization. We concluded that recent advances in electronic components and computer technology might allow us to develop data acquisition devices, which would facilitate data capture in a computer compatible format.

PROCEDURES FOR GROUNDFISH SURVEYS

Stratified random groundfish surveys (Fig. 1) generally entails towing a bottom trawl for a specified time and speed. The various phases include haulback, sorting, weighing, detailed sampling, paperwork and, after the cruise, data entry, verification and analysis.

Haulback

The process of hauling back involves the deck crew who either dump the catch on deck or into the ship's hold. Several scientific staff may be active during this period taking hydrographic and navigational data.

Groundfish surveys are generally limited to the collection of temperature and less frequently, salinity profiles. Temperature profiles have been recorded on retrievable bathythermographs (BT's). More recently expendable bathythermographs (XBT's), which record data either on strip charts or magnetic tape, have become available. Salinity measurements have been taken using Nansen bottles lowered to retrieve water from various depths. More sophisticated electronic devices, such as rosette samplers, are in use for specialized projects such as plankton sampling or oceanographic research. Electronic devices such as rosette samplers are expensive to purchase and time consuming to deploy and retrieve. Consequently, they have not been adopted for Canadian groundfish surveys.

Sorting

The scientific staff sort the catch into baskets by species. Individual fish of varying sizes are randomly distributed in baskets by species. Where large number of individual fish occur, the baskets are subsampled. These procedures generally require four to six scientific staff.

Weighing

The baskets of fish are weighed using spring or platform balances and the data then recorded on a deck sheet. The balances often give erratic readings under rough sea conditions. Two or three staff are required for weighing.

Detailed Sampling

Fish are measured on fish measuring boards generally to the nearest centimeter. Two or three pairs of workers are usually involved. One person measures fish from the board, while the second member of the pair records data on length frequency tally sheets (Fig. 2). Information typically collected includes length measurements, sexes, otoliths taken, individual fish weights. Other subsampling may include maturities, parasites or stomachs. Specimens or materials are set aside for laboratory analysis after the survey.

Each sampling pair attempts to accurately record data on sampling sheets. The sampling is limited by the catch size, the number of measuring boards in use, the time between consecutive sets, weather conditions and the speed and experience of the samplers. Not all species may be adequately measured because of these limitations.

Paperwork

The data at sea is recorded on a variety of forms. These include, station and set sheets, catch cards, deck sheets, fish tally sheets which may differ for various species, detailed fish sheets, hydrographic data sheets, squared subsampling sheets for maturity indices, anal fin ray counts, etc. A number of calculations must be made and recorded between sets. Each set may generate from 5-25 pieces of paper depending on the intensity of sampling.

Data Entry

On returning to the laboratory, the data must be transcribed onto a length-frequency transfer sheet. The deck sheet data for weights and numbers are transcribed onto catch cards as well as calculated numbers of each species taken. Distances towed must be calculated and recorded on the station and set sheet.

The data must be verified by visual inspection then run through a verification system after it is keypunched. Some laboratories have special staff who do data entry and verification. Larger laboratories have electronic data processing personnel who create files and may assist the biologist in running progams to estimate the population biomass from the research vessel survey. These programs are generally run on a mainframe computer. It often takes 3-4 months after the cruise before the data is on a computer in the appropriate format for analysis.

DEVELOPMENT OF DATA ACQUISITION DEVICES

1. ECOBUG

The need to collect chemical/physical hydrographic information in addition to biological data induced us to develop a microprocessor (ECOBUG) placed in a pressure resistant, waterproof housing. This data logger records environmental data by means of external sensors. The device can be programmed to record data at various time intervals using a clock-timer. Alternatively, the pressure sensor can be used to record data at various depth intervals. The ECOBUG has salinity and temperature sensors which can record temperature and salinity profiles in conjunction with the depth sensor. A variety of other sensors could be used with the device such as PH, dissolved oxygen or water velocity sensors. Using multiple channels, various parameters can be measured and recorded simultaneously. The ECOBUG has, at one time, been programmed to control the opening and closing of an experimental closure trawl.

The ECOBUG consists of semiconductors with 16 kilobytes (KB) of solid state memory attached to printed circuit boards operating off batteries. It is relatively inexpensive compared to similar devices developed in the United States and Canada.

2. Electronic Digital Calipers

Several years ago, the second author developed digital calipers (McAllister and Planck, 1981). The calipers can measure objects such as invertebrates to the nearest millimeter. They are waterproof and can transmit data to various computing devices. The calipers have been improved over what was originally described. Presently, they can be used in conjunction with a control box which has a numerical keypad (for entry of other attributes such as weights) and a light emitting diode (LED) display. Data can be recorded on magnetic tape associated with an Epson HX-20 laptop computer or a Hewlett Packard HP-85 computer. The digital calipers are now being used on DFO vessels conducting shrimp surveys as well as in a variety of government, museum, university and private laboratories.

The calipers have potential for measuring small fish, crustaceans and shellfish in the field and in the laboratory. Limnoterra is now developing a caliper which can transfer data to a portable battery operated data logger similar to the ECOBUG. This would make the calipers more portable and stand-alone. These portable calipers would be very useful for research surveys, observers on commercial vessels or for port samplers.

3. Digital Fish Measuring Board

The development of a portable digital fish measuring board was reported last year (Rubec and Planck, 1984). Since then a second prototype incorporating a liquid crystal display (LCD), complete electronics circuity and battery in the headboard has been built and tested. The digital fish measuring board (FMB) is a one meter fiberglass board with "Hall Effect" magnetic sensors. The board is portable, light-weight, rugged and waterproof. The second prototype has an alpha-numeric keypad with 10 numbers and 12 letter keypads on the end of the board for the recording of fish attributes such as sex, maturity stages, otoliths taken, species codes, etc.

During 1985, further improvements to the digital FMB design were made (Fig. 3). A final design was adopted which has a complete alpha-numeric keypad of magnetically induced sensors along the side of the FMB. The present FMB has 26 upper case letter keypads, 11 numeric keypads, 15 lower case letter keypads, 7 function keypads and 5 query keypads arranged in two rows along the side with 2.5 cm spacing. The digital FMB can be used stand-alone by a single sampler or it can be linked to a computer and used as part of a distributed processing system. The board records data concerning length measurements (0.25 cm resolution), sex, maturity stages,ageing samples, locality, species codes, etc. by means of 95 cm of magnetically induced sensors and the other magnetic keypads mentioned. The data appears on the LCD as it is collected and the board emits an audible beep for each entry.

The FMB can reduce the time required to collect, transcribe and computerize fisheries data. It has two internal microprocessors, battery, up to 6 memory chips, each of which currently has 2 KB of battery protected memory, and is programmed with 3700 lines of machine code. The system if flexible, cost-effective and reduces errors by eliminating the need to manually transcribe data (Rivard 1981).

4. Shipboard Balances

A fourth device being developed as part of a ship-board data acquisition system are electronic digital balances that compensate for ship motion. During 1983, a 5 kg balance was built and tested on the research vessel the Wilfred Templeman. This balance has two microprocessors and a known weight built into it. The balance corrects for the acceleration due to the motion of the ship. The readings of the weight by the first microprocessor are corrected by the readings by a second microprocessor of a known weight built into the balance. A 50 kg balance working on the same principle had been built for weighing baskets of fish at sea on groundfish surveys.

SHIPBOARD DATA ACQUISITION SYSTEM

The devices mentioned were developed because of our need to come up to the required levels of sampling on stratified-random groundfish surveys. They are intended to be part of an integrated system for the computerization of all data collected during the survey. The system would eliminate the need for transcribing, keypunching and verification of data following the cruise. The

devices allow the data to be recorded and verified in a computer compatible format, as it is collected on board ship. This allows error detection while the material is still available i.e. wrong entries for species. It also allows length-frequency sampling totals to be examined on board and therefore decisions on sampling and sub-sampling to be made.

During August 1985, a stratified random groundfish survey on the Lady Hammond allowed the ship-board data acquisition system to be implemented and tested. The following description mimics the order and procedures of traditional groundfish surveys, while eliminating all the paperwork.

1. Haulback

The station and set sheet used by the ship's navigator was replaced by a query program running on an Epson HX-20 laptop computer. The computer prompted the user to record such information as the set number, date, latitude and longitude, ship speed, depth at the beginning of the tow, cloud cover, wind direction, etc. The clock/calendar in the HX-20 recorded the date and the time the tow started and ended when beginning and end latitude and longitute values were entered. The navigator found that the HX-20 was very convenient because it was lightweight (1.7 kg) and battery operated. It could be moved about the bridge near various instruments while data was being entered on the computer. This tended to reduce coding errors.

At the end of each tow, the data was printed out by the 42 line per minute printer in the HX-20 and recorded by the computer's tape drive. The paper hard copy (Fig. 4) was taken below decks after each set for reference by the scientific staff. At the end of each day data on the magnetic tape was transferred to an IBM compatible host computer, a Corona PC-2.

Hydrographic data was experimentally collected with the ECOBUG. It was placed in a 20 X 6½" underwater housing mounted on a wooden sled. The housing and the sled were attached to the headline of a Western IIA trawl on board the Lady Hammond. The device recorded water temperature with depth as the trawl was deployed for a standard groundfish haul of 0.5 hours at 3.5 knots. Once the trawl was back on deck, the data collected by the ECOBUG was transferred by RS-232C cable to an Epson HX-20. The ECOBUG remained attached to the trawl to collect more data on subsequent sets.

The ECOBUG was deployed to 180 fathoms during the first half of the survey. During the latter half of the survey, the device was destroyed when the housing imploded at a depth of 270 fathoms. Fortunately, DFO has another ECOBUG to replace the one lost on survey.

Data collected by the ECOBUG is being compared to data collected by the Sippican XBT system. Another comparison has been done by deploying an ECOBUG at a shore locality in conjunction with a Ryan thermograph near the Bedford Institute of Oceanography. The ECOBUG still needs further testing to evaluate the salinity sensor. In the near future, the ECOBUG may replace the XBT system as a means of collecting hydrographic data on groundfish surveys. The ECOBUG has the advantage that it can collect both vertical profiles and can also collect data during bottom tows. The collection of hydrographic data associated with trawling may help explain the distribution and abundance of commercial fish species. The cost of XBT's for one survey covers the cost of an ECOBUG which may be used on many surveys.

2. Sorting

The manual process of sorting fish by species has not been changed with the new system. Research vessels with conveyor belt systems can ease the process of separating species.

3. Weighing

Because of problems with the waterproof housing for the 50 kg digital balance, a Chatillon dial balance (50 kg) was used on board the Lady Hammond, to weigh baskets of fish in the traditional manner. However, rather than recording data on deck sheets, fish weights, subsample weights and counts were entered onto an Epson HX-20. A query program was developed for recording species codes, weights and counts as the data is obtained. Subsequently, the electronic data were

transferred to the Corona host computer by means of RS-232C. This procedure eliminated the need for deck sheets on the cruise.

4. Detailed Sampling

Three digital FMB's were installed in the wet laboratory on the Lady Hammond. The operators commenced sampling by entering a lower case letter for signifying locality, followed by the set number. Each operator than zeroed the counter on the liquid crystal display, entered a lower case character code signifying a species and an upper case three letter species code ie. sCOD. By placing a fish on the board and touching its tail with the handle of a filleting knife containing magnets, the fish's length was entered. By touching other magnetically induced keypads other information such as sex, otoliths taken, redfish anal fin ray count, basket numbers etc., were added to the fish's data record. All information concerning commercial fish species measured were entered through the digital FMB's for 174 sets on the August 1985 redfish survey in NAFO divisions 4RST.

Rather than having six samplers measuring and recording, three operators measured fish with the digital FMB's without the assistance of recorders (Fig. 5). No length frequency tally sheets, catch cards, squared sheets, individual fish sheets or stratification sheets were used. Otolith coin envelopes were replaced with Falcon 24-Well Tissue Culture plates with plastic lids. The fish sampled for otoliths were recorded by activating keypads on the FMB's. At each set, 24 otoliths were taken and placed in the wells in the sequence that the fish were sampled. Otoliths recorded can than be sequentially numbered by the computer.

The data from the FMB's were transmitted by cables to an RS-232C splitter box. A single cable from the box was strung from the wet laboratory to the Corona-PC in the dry laboratory. Data from the boards were transferred to the RAM memory of the host computer. A program polled each FMB in sequence by sending a device code A, B or C. The boards responded by transmitting data records, queries or only their device code. The computer copied the data automatically onto floppy disks. The program continuously updated, on a monitor in the dry lab, the total number of males, females, juveniles and otoliths taken from each length of each species for each station by the FMB's. It also presented totals of fish measured and sampled for each species for all sets to date on the cruise.

Five query keypads on the FMB's were programmed to elicit information from the host computer such as the cumulative totals for the set or for all sets in the cruise up to the point the query was made. The computer replied by sending information which was displayed on the liquid crystal display of the FMB or on the monitor display in the wet laboratory. Such information was used to facilitate subsampling of the fish.

On the Lady Hammond survey, we wished to sample about equal numbers of male and female fish. A sampler could put a fish on the FMB and enter its length and sex. Then by touching a query keypad the person could ask the computer how many fish of that species, length and sex had been previously measured at that station (set). Another query keypad was touched when the sampler wanted to know what the cumulative number of fish of a particular species, length and sex had been measured for all stations up to the time the query was made.

Since the survey was primarily devoted to estimating the abundance of redfish in the Gulf of St. Lawrence, we wished to stratify the collection of otoliths between two species, Sebastes mentella and S. fasciatus. An indication of which redfish species is present can be obtained by means of anal fin ray counts. Consequently a third query keypad was used to ask how many otoliths for a particular species, length, sex and anal fin ray count (<=7 or >7) were previously sampled on the set. Similarly a fourth query keypad gave cumulative totals for all sets for otoliths taken from redfish of a particular length, sex and anal fin ray count (<=7 or > 7).

Some vessel technicians have expressed the desire to have real time updates of all subsampling for all species appear on a video monitor in the wet laboratory. This is impractical since there would not be room for all the totals on the monitor. Generally, all the sampler wishes to know is what length intervals of a species need to be sampled for otoliths, stomach, maturities, etc. The computer was progammed to display on the wet laboratory monitor, by species, only those length intervals in need of further subsampling. When a query is made from the FMB, the program displays, on the wet laboratory monitor, length intervals on the basis of which species is being measured at that time. As the quota of samples per length interval are fulfilled the completed lengths disappear from the monitor display, leaving only those lengths for which samples are still required.

The query keypads and monitors can allow the operators of the FMB's to be fully updated on the level of sampling accomplished and help direct their choice of subsamples. The Lady Hammond survey succeeded in subsampling redfish to the intensity levels required.

INTENSITY OF SAMPLING BY SPECIES

Using the three digital FMB's linked to the Corona-PC allowed the technicians to measure appreciably more fish (1.5X) than pairs of samplers recording data on paper. The operators found themselves finishing measuring sooner, despite the fact that more redfish and other species were measured per set. A high level of satisfaction was expressed by the vessel technicians, DFO scientific staff and students with the ease of use and speed of the new shipboard data acquisition system. Using this system and relatively inexperienced personnel, the level of sampling and the quality of the data were markedly improved.

This year we collected length frequencies by sex from 3 fish species, otoliths from 2 redfish species and length frequencies which were unsexed from 30 other fish species. Next year, the addition of another FMB and the integration of the 50 kg digital balance into the system will further enhance data acquisition capabilities. It would then be possible to increase the intensity of detailed fish sampling. This could either be by increasing the types of samples taken from the main species of interest, redfish and cod, or by increasing the sampling intensity for a wider variety of species. Koeller (1981) recommended length frequencies by sex for 20 species, unsexed length frequencies for an additional 12 species, maturities from 19 species and otoliths subsampled from 17 species on groundfish surveys.

PAPERWORK AND DATA ENTRY

All the data collected on the Lady Hammond survey was stored electronically during the cruise. Of more significance is that there is no need for transcription of data onto catch cards and onto length frequency transfer sheets after the survey. Similarly there is no need for data entry after the survey (Table 1). This constitutes significant savings in both time and cost for data entry and verification. Data file editing can be done on board.

Software Development

Programs need to be developed to process the raw data captured during the survey. We are developing programs which will compute length frequencies from data records, summarize cruise data in a report format, plot distributions and abundance of each species, plot the cruise track and create files compatible with existing historical data bases.We are using readily available commercial software packages such as GWBASIC, Wordstar, Sidekick and DBASE III. Each of these packages, and software developed using them, can be easily moved to different brands of computers.

The digital FMB's have demonstrated their ability to speed the accurate collection of fish measurement data while eliminating the need for field sheets. Some computations can be done on board ship such as keeping count of otoliths, tabulation of the total numbers of fish taken at each station in addition to totaling length frequencies to determine their distributions.

By taking the information on the area swept by the trawl, it is possible to calculate the population numbers in different depth zones for various fish species. A program has been developed which can run on an IBM compatible microcomputer. By completing the development of software, it may be possible to estimate population numbers at length for various commercial species as the ship returns from a random-stratified groundfish survey. Such information would benefit the management of commercial fish species, through the provision of more timely biological advice.

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Table 1. Comparison of manpower deployment for traditional groundfish surverys versus new electronic data acquisition system.

	Traditional System				Electronic System			
Technicians	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Haulback	XBT	Checks trawl	Wet laboratory	Obtains bridge data	Ecobuq transfer to HX-20	Checks trawl	Wet laboratory	Obtains HX-20 data
Sorting	all personnel				all personnel			
Weighing	2 weighing spring balance		1 records	Special samples	1 weighing digital balance	1 records on Epson HX-20	Measures fish on FMB	Measures fish on FMB
Detailed Sampling	Measures fish	Records data	Measures fish	Records data	Measures fish on FMB	Measures fish on FMB	Measures fish on FMB	Checks host computer or measures on 4th FMB
Paper Work	Data tallied verified	Calculates numbers	Data tallied verified	Calculates numbers	Edits data on host	Merges data files	Processing of data	
Post Survey								
Transcription of Data, Verification	T_1	T_2						
Coding Cruise Card	T_1	T_2						
Edit Program Corrections			T_3	T_4				
Data entry and analysis	T_1	T_2						

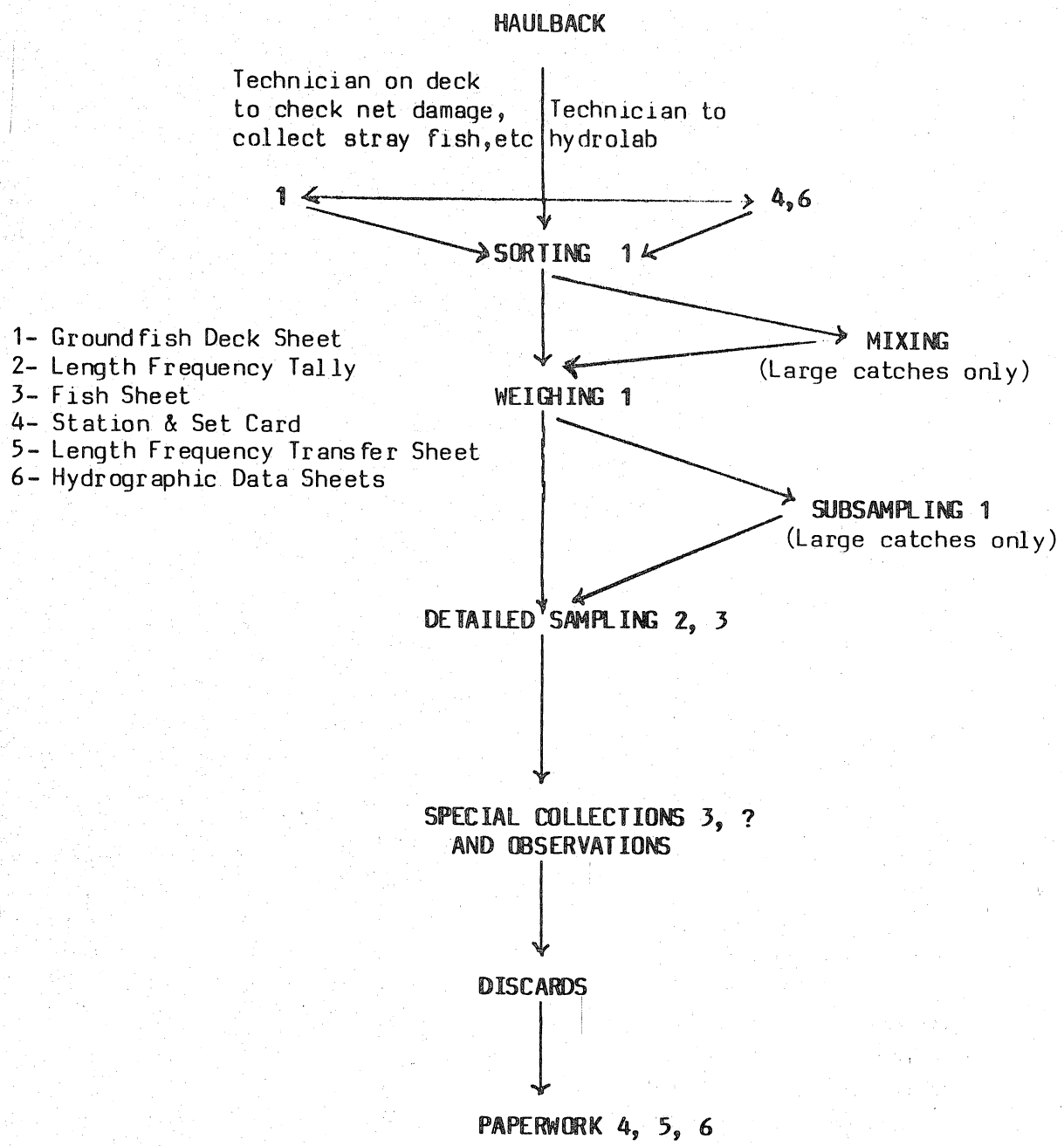

Figure 1. Sequence of events and data sheets used during groundfish survey operations.

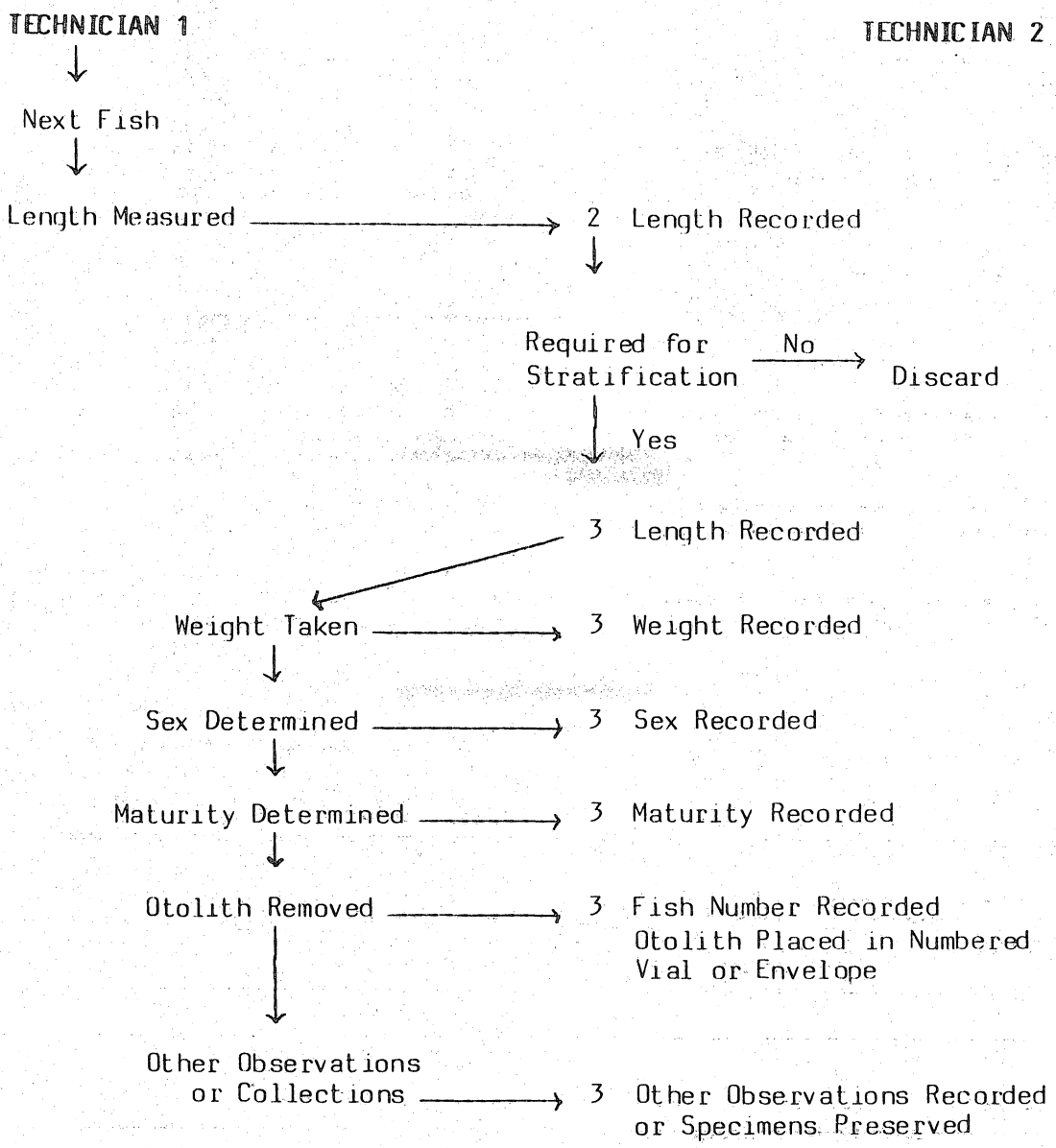

Figure 2. Sequence of events and data sheets used during detailed fish sampling.

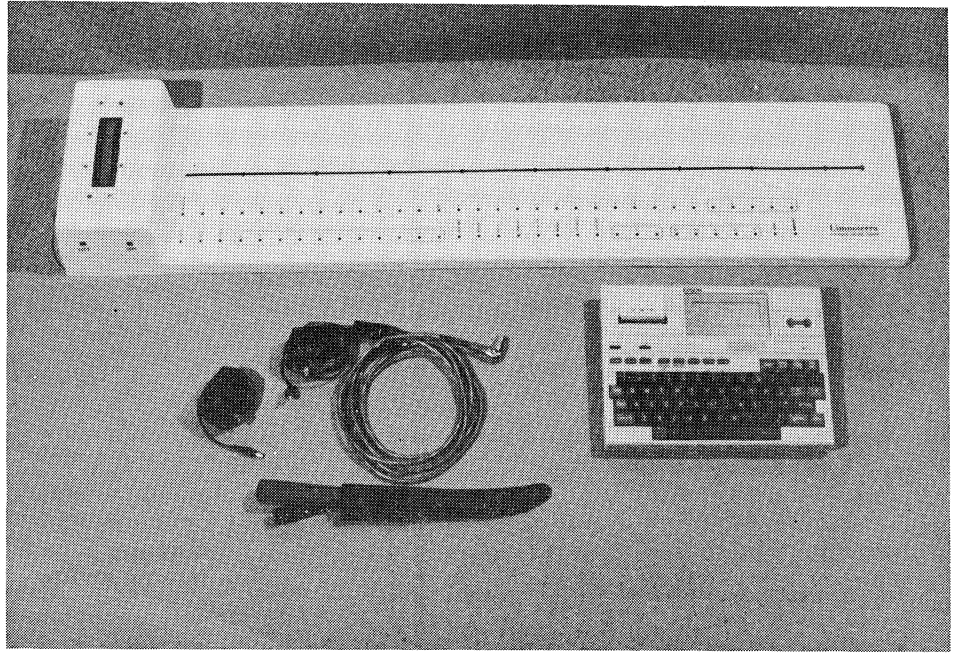

Figure 3. Photograph of digital fish measuring board developed du

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Cruise H140
Stratum 811
Set  116
Date 08/17/85
Ship speed 3.5
Latitude 48 13 44
Longitude 59 41 69
How obtained 4
Bottom depth 107
Log reading 2191.7
Ship direction 350
Wind direction 7
Force 2
Barometer 1012
Air temperature 16C
Weather 02
Clouds 6
Sea 1
Swell 1
Start time 23:31:28
Stop time 00:01:45
Latitude 48 15 26
Longitude 59 42 07
Bottom depth 105
Bottom max 111
bottom min 98
Log reading 2193.6


START SET  116   5135
END =>  5221
```

Figure 4. Paper printout off Epson HX-20 showing bridge data which replaces station and set sheet.

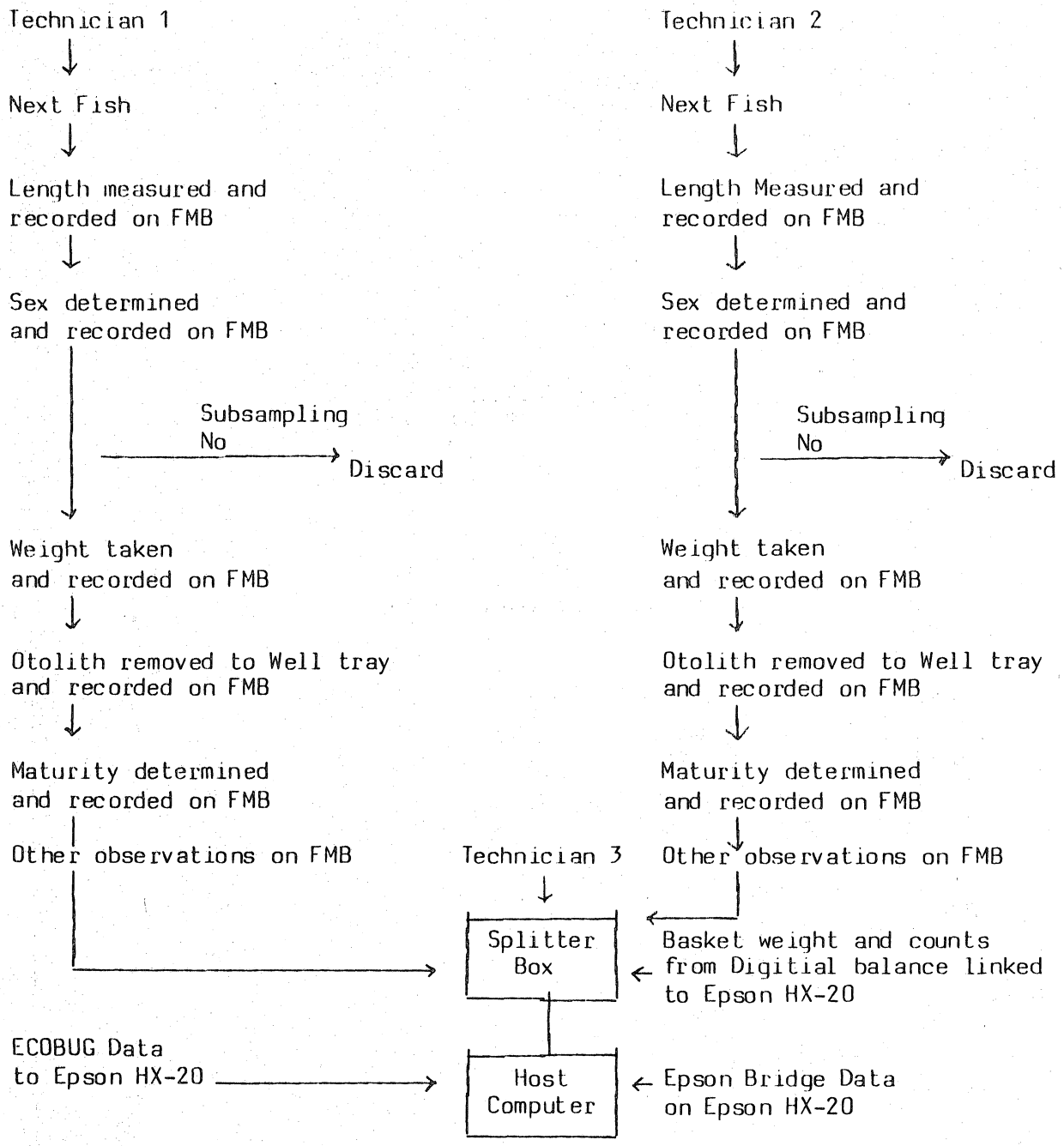

Figure 5. Sequence of events used during detailed fish sampling with electronic data acquisition system.