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Bottom Trawl Survey Methods of the Northeast Fisheries Center Woods Hole, Mass. USA

by

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INTRODUCTION

Bottom trawl surveys of demersal fishes have been conducted since 1948 by the fisheries laboratory at Woods Hole. The frequency and scope of these surveys increased markedly in 1963 with acquisition of the research vessel, Albatross IV, when the Northeast Fisheries Center began an intensive bottom trawl survey program in SAs 5, 6 and Division 4X.

The major objective of these surveys was to provide an annual quantitative inventory of fish populations; and the critical characteristics of the surveys involved the use of standardized trawl gear and fishing methods on a research vessel, an unbiased method of station selection, and complete records of the weight and length frequency of all fish species in each trawl catch.

A detailed description of the survey methods used by Woods Hole was presented to the ICNAF Working Group on coordinated Groundfish Surveys in January, 1971 (see Res. Doc. 71/32), but until now the methods have not yet been summarized in a readily available form. The purpose of this paper is to document the key elements of the USA survey methods, with emphasis on those aspects where standardization and accuracy of methods are critical for reliable results. Topics are arranged with a view toward a useful format for an ICNAF manual on trawl surveys.

VESSELS AND TRAWL GEAR

Virtually all of the fishery surveys conducted by Woods Hole since 1963 have been carried out with the research stern trawler, Albatross IV, which was designed with this type of work in mind (see Table 1 for general specifications). Features of major importance from the standpoint of survey work are the ability to operate 24 hours a day and adequate space for scientists and scientific work. The Albatross IV can carry up to 15 scientists in addition to a full crew (18), and there are 4 laboratories available for scientific work. At present, Albatross IV is equipped to handle trawls as large as a #41 Yankee and to fish as deep as 200 fathoms.

The Delaware II, another research stern trawler has also been used for trawl surveys. This vessel is somewhat smaller (155 ft as opposed to 187 ft for Albatross IV) and can only carry a scientific party of 6-8 (Table 1). However, Delaware II can handle large trawls more easily by virtue of deck design, has better hydroacoustic equipment, and thus is better suited to midwater work.

The #36 Yankee trawl has been the standard survey trawl used by Woods Hole since the 1950s, and a nylon #36 with specifications as shown in Table 2 and Figures 1a, 1b, has been used for all groundfish surveys since 1963. This trawl is rigged with rollers and fished without ground cables to permit trawling over rough bottom; and a small mesh liner (1/2 inch-stretch upper belly and cod end - see Table 2) has been used routinely for all surveys to retain juvenile fish. Each trawl is carefully checked against the exact specifications of the standard before it is used. On occasion towing performance of standard trawls is checked with trawl mensuration instruments to check on wingspread and headrope height. Ideally this should be done routinely on a haul by haul basis on surveys.

At the beginning of the Albatross IV surveys, fishing power of the #36 trawl was judged adequate for providing useful indices of abundance of most groundfish species. However, in recent years, abundance of fish has declined so much, particularly in Subareas 5 and 6, that the #36 is now considered to be too small for effective survey work, especially during the spring when particular emphasis is directed towards herring and mackerel. Consequently beginning in the spring of 1972, Albatross IV switched to a #41 Yankee trawl, modified to provide a greater vertical opening than the standard commercial version of this trawl. Mensuration tests on this trawl and comparisons with the standard #36 are still in progress, and additional tests are planned in 1974 in cooperation with a USSR vessel. Specifications of the modified version of the #41 for 1974 studies are presented here (Table 3, Figure 2). Note that the fall surveys by Albatross IV are still being conducted with the standard #36, and a changeover for the fall is not planned until a satisfactory conversion factor is obtained from joint US-USSR trawl comparison studies; the earliest changeover date would be fall 1975.

SAMPLING DESIGN

There is now rather wide recognition of the advantages of the stratified random sampling design for demersal fish surveys which are designed to monitor changes in stock abundance, and these advantages have been reviewed by Grosslein (1969), by the reports of the ICNAF Working Group on Coordinated Groundfish Surveys (see Res. Doc. 71/32), and most recently in the FAO manual on demersal fish surveys (Mackett, 1973). For this reason, and the fact that we already have a workable stratification scheme for most of the ICNAF area, the emphasis here will be on specifications of the design used by Woods Hole rather than the general rationale for the stratified random design.

Stratification

The first stratification plan based on depth was used in 1964 when the survey covered the area from Hudson Canyon to western Nova Scotia (strata 1-40, Figure 3). Four depth zones defined by the boundaries--15, 30, 60, 100 and 200 fathoms--were used to subdivide each of the four ecological zones (southern New England, Georges Bank, Gulf of Maine, and western Nova Scotia) which are unique in one or more aspects of the groundfish community and hydrography. The 60-fathom contour represents the approximate depth limit of marked seasonal changes in bottom temperature on Georges Bank and southern New England, and therefore was an obvious choice for the purpose of monitoring the general relation between fish distribution and temperature. The 30-fathom contour represented another useful boundary related to the depth distribution of some of the species sought by U.S. traditional fisheries, including haddock and yellowtail. The other boundaries were chosen largely for practical reasons.

Strata 41 and 42 were added to the survey in 1965, and strata 61-67 were added in the fall of 1967 for the first joint USA-USSR survey (Figure 3). Since the fall of 1970 we have used the Canadian stratification scheme east of Browns Bank, i.e. strata 41-49 as shown in the outset of Figure 3. Note that Canada uses a different numbering system for Div 4X (Halliday and Kohler, 1971).

Also it should be noted that since 1972, the trawl surveys have been extended south to Florida and inshore practically to the beach all along the U.S. east coast from Cape Cod to Florida. These phases of the survey are being carried out by other U.S. laboratories, using Delaware II and other vessels. The same basic stratification scheme has been extended to these waters.

Random Selection of Stations

Random selection of stations within strata is accomplished essentially as follows. Each stratum is subdivided into rectangles of 5 minutes of latitude by 10 minutes of longitude, and each of these rectangles is regarded as a homogeneous sampling unit within which only one trawl haul is necessary to characterize that unit. Each of the 5x10' rectangles are further subdivided into 10 smaller rectangles (each 2-1/2' Lat x 2' Long) and these are numbered throughout the entire stratum, with the 10 numbers within any one 5x10' rectangle being in consecutive order. Numbers are then drawn from a table of random numbers (subject to the restriction that no more than one number is chosen within any given 5x10' rectangle) until the required number of 5x10' rectangles is obtained, corresponding to the number of trawl stations specified for the given stratum. Numbering and random selections are done independently in each stratum. With the above procedure every possible trawling site in each stratum has an equal chance of being selected, and the probability of sampling a particular depth (or ecological niche) within the stratum is proportional to the area represented by that depth (or niche) within the stratum.

Since stratum boundaries are irregular relative to lines of latitude and longitude, it is not possible to subdivide the entire stratum into uniform 5x10' rectangles. This is particularly true around stratum perimeters and in long narrow strata. The problem is largely circumvented by forming irregular-shaped blocks where necessary, with the area of each block equivalent to that of a 5x10' rectangle, and subdividing and numbering as before.

Occasionally random sampling results in a clustering of stations such that there is a rather large area without a single station. In such cases extra stations are deliberately placed along the cruise track to fill such a gap. This is done to insure more uniform coverage for hydrographic observations as well as groundfish and plankton sampling. No more than 3 or 4 such extra stations are normally added to any one cruise for the entire survey region from Hatteras to Nova Scotia. This represents less than 2 percent of the total number of randomly pre-selected stations and therefore the effect on variance estimates and the unbiased character of abundance indices is negligible.

Allocation of Stations to Strata

After fixing the total number of stations for a survey, stations are allocated to individual strata roughly in proportion to stratum areas. Certain areas such as western Nova Scotia, southern New England, and Georges Bank are sampled somewhat more heavily than others because of priorities given to these areas. Also, the deep narrow strata (100-200 fm) are sampled more intensively because of the requirement that there be not less than two stations per stratum to allow variance computation. Assuming that a survey is multispecies oriented, then in general optimum allocation (based on stratum variances and areas) probably will yield little gain in precision over proportional allocation (based on stratum areas alone).

About 300 stations are occupied in a standard survey from Hatteras to Nova Scotia by Albatross IV, representing a density of about 1 station every 250 square miles. Allocation of sampling effort by strata and for various sets of strata on a recent cruise are shown in Table 4.

Occupying Stations at Sea

Trawl stations are occupied on a 24-hour basis following a systematic cruise track which ignores stratum boundaries and tends to minimize steaming time. Most extremely rough bottom areas have been excluded from the survey area (and the station selection process) thus in most cases the trawl is set without searching the area for good bottom. The haul commences when sufficient wire has been payed out to obtain the desired scope and haulback begins 30 minutes later. Scope used for the #36 is 3:1 except in depths greater than 150 fm where a scope of 2½:1 is used. For the #41 a graduated scale is used as follows: 5:1 for < 15 fm, 4:1 between 15-30 fm, 3:1 between 30-150 fm, 2½:1 for > 150 fm. Direction of tow usually is on a heading toward the next station except when towing along a steep edge when the course is determined by the contour of the shelf at the specified depth interval. Sometimes it is

necessary to set into the wind to allow setting the plankton gear which is towed off the side of the ship simultaneously with the trawl tow.

Some rough bottom areas, notably inside 60 fathoms in the Gulf of Maine and along western Nova Scotia, have been included in the trawlable category and these do require some searching time for a suitable trawling site. Whenever possible an alternate site is sought within adjacent 5x10' rectangles in the same depth range and preferably in the direction of the next station, and always within the same stratum. Searching time seldom exceeds one hour, after which the station is usually abandoned (and sometimes but not always removed from future consideration as a trawlable location since we often make "successful" hauls over quite rough bottom). An alternate station location may or may not be selected depending upon the number of stations originally assigned to the stratum.

In cases of severe malfunction (e.g. hang-up after 10 minutes of towing, or crossed doors) or severe damage to large sections of a wing or belly, the tow is repeated or made at an alternate site nearby. Tows resulting in only minor damage (e.g. few moderate-size holes in the forward and lower parts of a belly where most tears occur) are counted as standard hauls since trawl efficiency probably has not been significantly reduced. Occasionally the duration of the haul is less than or greater than 30 minutes as a result of a hang-up of some malfunction with a winch. In such cases the haul is considered standard so long as it is at least 20 minutes and no more than 40 minutes, and given that net damage is below acceptable tolerance limits. Depth variation is also allowed as long as the tow remains

Station Procedures

A standard survey station begins with a bathythermograph cast (surface to bottom), meteorological observations, and a surface salinity sample, followed immediately by a 30-minute haul with the survey trawl at 3.5 knots (speed through the water as indicated by ship's magnetic log).

When the brakes on the main winch are set, a pair of Bongo plankton nets are set over the side, and a single 15-minute oblique haul is made in a manner similar to that used on the ICNAF larval herring survey; plankton sampling has been done routinely since 1968. Beginning in 1973 at selected trawl stations (forming approximate transects across the shelf) an STD instrument has been lowered and/or water samples obtained in addition to the BT cast. Station location is recorded as the position where the ship first commenced observations; hydrographic work normally precedes setting the trawl. For each trawl haul a tracing of the bottom profile is saved.

DATA COLLECTION

Environmental and Plankton Data

Observations on weather, sea state, and station data related to bathythermograph and hydrographic casts, are recorded on a standard BT log (Figure 4). In addition, when water samples are collected and/or an STD cast is made, a hydrographic station record is prepared along with necessary detail sheets for identification of salinity samples (Figures 5a, 5b, 5c). A number of other forms are required for submission of hydrographic data to NODC.

A separate log is prepared for each plankton haul, including station data and pertinent data on tow profile, volume filtered, speed of haul, etc. (see Figure 6). A more generalized plankton log is being considered. Plankton samples are preserved for shoreside processing, primarily by the NEFC plankton sorting center at Narragansett, Rhode Island.

Trawl Catch Data Collected

Basic minimum data are the total weight and length frequency of each species. Weights are recorded in pounds and lengths to the nearest centimeter on measuring boards, or on aluminum punch strips attached to the boards. Fork lengths are used except for species without forked tails in which case total length is recorded. Carapace lengths (to eye sockets)

are taken for lobsters, carapace width for crabs, mantle length for squid, wing-width for rays, and shell lengths for scallops; shrimp are weighed only. Length frequency by sex is currently being recorded routinely for lobsters and crabs.

Scale or otolith samples are obtained routinely from 15 priority species; these samples are stratified by length, and except for clupeoids the scales or otoliths are placed dry in small coin envelopes, labeled with cruise and station number, and length, sex, and maturity stage. Scales are collected from haddock and flounders (yellowtail, winter, grey sole, American dab), and otoliths are taken from cod, pollock, hake (red, silver and white), redfish, mackerel, sea herring, blueback and alewife. In the case of the last four species, whole specimens or heads (with individual data on length, etc. attached) are usually frozen and otoliths removed ashore. More detailed biological information is also obtained on priority species including observations and/or samples of gonads, stomach contents, and usually whole frozen or preserved specimens are collected for study in the laboratory.

Sampling Trawl Catches

Except for occasional large hauls, catches are dumped into a checker (box 4x8x1' slotted at one end) from which fish are either picked out by hand or pushed through a slot, sorted into species, and placed in steel baskets of 1 and 2 bushel capacity (about 70 pounds of fish per bushel, net weight). Baskets are weighed to the nearest whole pound from a suspended balance (steelyard). Small catches (< 10 pounds) are weighed in small plastic containers on a suspended spring scale.

It is usually possible to weigh the entire catch of each species, but for large catches it is necessary and desirable in terms of time and required sample size, to measure only a sample of the catch of the more abundant species. Normally catches are sorted by species prior to recording, and care is taken to avoid size-selection by having each person pick all species and sizes of fish from one section of a pile or the checker at a time, tossing them into the appropriate baskets. When baskets of unsorted fish are filled from the slot of the checker, a systematic sampling of the baskets is taken (i.e., 2nd, 5th, 8th baskets, etc.) to avoid bias from possible uneven distribution of fish in the checker. In processing unsorted catches, large fish are removed first and processed separately, so that there is a fairly uniform size distribution of only smaller fish left in the unsorted category. After weighing, the unsorted baskets are sorted and re-weighed by species before length frequencies are taken.

No exact guidelines are followed as to size of sample or subsample to be measured, but suggested minimum sample sizes for each unimodal portion of the length frequency for a given species (or sex if males and females recorded separately) have been as follows:

Range of Length (cm)	Minimum Sample Size (No. Fish)
1-5	25
6-10	50
11-15	75
<15	100

The above sampling rates probably provide estimates of the proportion of fish at each cm interval to within a few percent of the correct value in most cases. However, no comprehensive analysis has been made of the actual sample sizes and levels of precision achieved.

An arbitrary distinction is made between the terms samples and subsamples, to try to reduce errors in documenting the fraction of the catch which was weighed and/or measured. That is, a sample refers to that portion of a catch (e.g. 1 or more baskets) saved for processing when the remainder of the catch is discarded (with amount of discard recorded in terms of numbers, pounds, or number of volumetric units). A subsample refers to a portion of a sample used for a length frequency. Whether a sample or a subsample, the same guidelines are applicable relative to sample size noted above.

Recording Catch Data

All basic catch data and also station data (location, time, etc.) are recorded on a single trawl log (9½"x14" actual size) which has two sides. One side contains station data and length frequency tallies (Figure 7), and the other side contains data on weight, volume and length frequency, as well as sampling of the catch (Figure 8). This log serves the dual purpose of:

1) an original written record of all basic catch data for each trawl haul usually on one sheet, and

2) a coding form from which the coded data are punched onto cards.

Examples of typical entries are shown in Figures 7 and 8, illustrating the major types of sampling used on survey. A number of specific conventions have been defined for indicating various types of a sample but these are not described here; the important point is to devise some clear means of recording the exact nature of the sample or subsample for each species, so that proper expansion factors can be calculated.

Processing of the data are kept to a minimum at sea because errors are easily made due to fatigue and normal loss of personnel efficiency at sea. That is, such things as expansion factors and even net weights are usually not calculated at sea. However, length frequency tallies of priority species are often prepared so that the data are ready for immediate punching and preliminary analysis shortly after a cruise. In all cases, the watch chief or chief scientist examines each log carefully after each haul, and checks for accuracy and completeness.

DATA PROCESSING

Hydrographic Data

After a cruise, XBT temperature traces are checked against reference surface temperatures and for anomalies which might be related to malfunction of the XBT system, and they are read and recorded at 10 m intervals from surface to bottom. Copies (xerox) are then made of the traces and they are sent to the National Oceanographic Data Center (NODC) for digitizing and archiving in NODC format. Surface salinity samples are processed in the laboratory with a salinometer to the nearest .01 o/oo, and the values are transcribed onto the standard BT logs (Figure 4), which are also copied and sent to NODC. Accuracy of BT station data (location, depth, etc.) is checked by comparing BT plots and records with master track chart derived from the original survey charts used at sea. Next contour charts are prepared for bottom and surface temperatures, and surface salinity, and are filed with the NEFC oceanography unit.

Procedures for the processing and recording system including quality control for STD data are still being developed. At the present time, NEFC hydrographic staff analyze the salinity samples from the Nisken bottles checking results against the STD traces, and also record salinity values at every 10 meters. The salinity traces are then sent to other laboratories for further processing, and ultimately to NODC for archiving in digital form with the original traces being returned to NEFC. Reliability of oxygen readings on the STD instruments has yet to be evaluated.

To date, NEFC is not doing any machine processing of hydrographic data, but is exploring feasibility of using NODC services in relation to current needs.

Station Data

The first phase of processing involves checking the accuracy of station data. Station positions and depths recorded on trawl logs, and BT logs are compared with the original survey charts used by ship's officers, and a master cruise track is prepared. In addition, a station index is prepared which summarizes and cross-references basic station data (location, time, depth, temperature, sea state, etc.) for all types of stations including trawl, hydrographic and BT (only) stations. After verification of all entries the station data are coded on the trawl logs and station index forms and then punched onto cards.

Basic Catch Data

The next phase of hand processing involves checking the individual trawl records on total weight and length frequency for each species. Information on sampling and subsampling fractions is carefully reviewed, and the total catch of each species is calculated in terms of net weight and total number of fish; length frequency expansion factors are calculated and recorded, and stroke tallies are converted to numbers. The data are then coded on the original trawl log in preparation for keypunching.

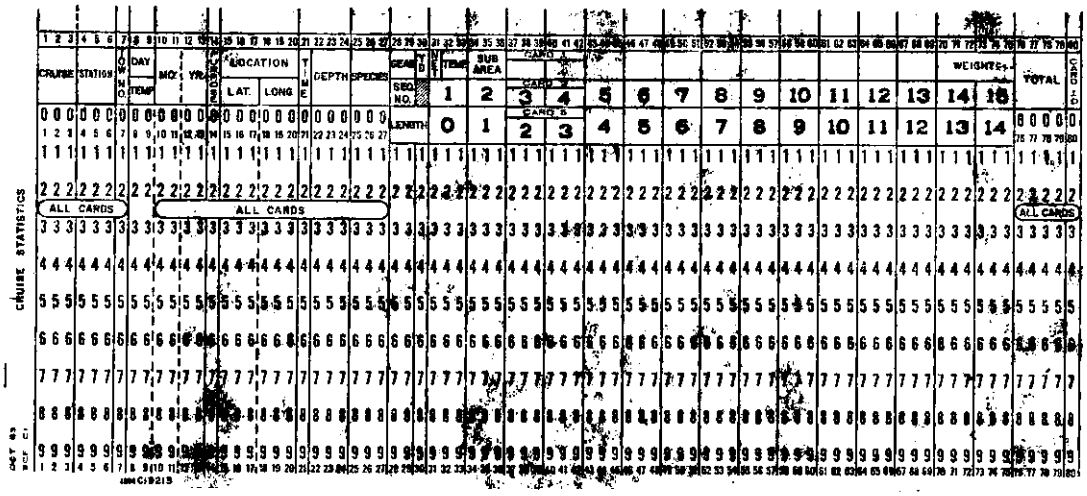
Other Biological Data

An inventory of the scale and otolith samples is prepared shortly after completion of a survey, by comparing records on the envelopes or vials with information on scale-otolith sampling recorded on the trawl logs. Age readings are entered on a special coding form (Figure 9) and then keypunched onto cards. A data listing from the cards is compared with the original scale-otolith envelopes to check for errors in the age-length data, before transfer to tape.

Data processing methods are still being developed for plankton, maturity stage records, and fish food habits data. In all cases, preliminary hand processing is required to check on the accuracy and completeness of the original field record sheets, coding must be done followed by keypunching onto cards and subsequent audits, and finally transfer to magnetic tape files. The station format for these types of data are compatible with the basic format used for the groundfish survey file so that results of the other types of biological data may be compared or integrated with the basic information on abundance and size distribution in an efficient manner.

Card Formats

The basic catch data card format used for groundfish survey data is shown below. Any single card contains catch data for only one species in a single tow; however, usually more than one card is necessary to contain all the available data for a single species in a single tow. Three different card types (using different parts of the basic card shown and denoted in card I.D., column 80) have been designated to hold the following data: total weight and number of a species in a single catch (card type 1), length frequency (card type 2), and age-length frequency (card type 3).



Usually there is only one type 1 card per species per tow (unless catch < 9999 fish), but in most cases there will be more than one type 2 card species per tow. If age-frequency data are collected on a species there will be one type 3 card for each centimeter length interval in the sample. The arrangement of data on each of the three types of card is illustrated in Figure 10.

The data from all type 2 cards combined for a single species in a single tow, represent the length frequency (actual or estimated) of the total catch of that species in the tow. That is, sample length frequencies are expanded either by hand or by computer before transfer to final type 2 cards. In contrast, age-length data on type 3 cards usually represent only a sample of the fish in a catch; these data are pooled into age-length keys and then applied to appropriate length frequencies using a computer program.

Note that except for columns 8-9, columns 1-27 and 76-80 are identical in all three card types. This similarity in format simplifies the problem of simultaneous processing of different card types, particularly in the case of the initial machine audit which, among other things, checks for discrepancies among corresponding columns.

In addition to the three basic catch data cards, there are two other card types (4 and 5) containing principally station data with only one card for each station (Figure 11). Station cards (type 4) contain exactly the same data (and in the same columns) on location and characteristics of each trawl station which appear on the #1 card, but the total otter trawl catch of all species combined is put in the place of catch of individual species. The station cards are useful in a variety of ways including analysis of factors such as scope and weather on the efficiency of trawling. Station index cards (type 5) contain sequential trawl station numbers, and corresponding numbers for other types of data (BT, plankton) taken at the given trawl station. The first seven columns (cruise, stratum-tow) are identical to the other card types. Index cards also contain data on position (nearest minute), depth (meters) and bottom and surface temperature. Thus, the Station Index provides a useful cross-reference listing (particularly by matching corresponding stratum-tow and sequential trawl station numbers), and at the same time it provides all the temperature records (bottom and surface) for a survey including those without corresponding trawl stations.

Computer Audits

The basic catch data on weight and length frequency (#1 and #2 cards) are checked for punching and recording errors by means of two computer audits. The first audit checks for: 1) consistency of station data between #1 and #2 cards which are punched independently; and 2) accuracy of station data relative to a master card which contains acceptable values for the specific cruise, or acceptable limits of values for general items such as depth, position, temperature for each stratum. The first audit also checks for errors in total numbers of fish of each species on each haul, by comparing the #1 card total with the summation of expanded length frequencies on #2 cards. This comparison can detect errors in punching and recording, particularly errors in hand calculations (both totals and expansion factors), and also missing data.

The second computer audit is designed to detect gross mistakes in weight or length frequency which cannot be detected by the initial audit, and at the same time recheck for the same type of errors looked for in the first audit (including missing cards, or cards out of order after corrections due to the initial (audit). The new feature in the final audit is the comparison of "observed" vs "calculated" weight of catch for each species in each haul, where "observed" weight is calculated by hand at the time the original trawl logs are checked and coded, and "calculated" weight is derived from the expanded length frequency and a length-round weight equation. Stations for which deviations between "observed" and "calculated" weights exceed $\pm$ 25% and are automatically flagged by the computer. The final audit also displays on one page of output for each species, the length frequency of each haul within a stratum, thereby making it easy to detect gross anomalies in LF's with a quick eye-scan of these listings. After completion of both audits, we are reasonably sure that all major errors of any consequence have been eliminated, and the basic catch data are then transferred to the magnetic tape file before any further processing is done with the data cards.

LOGISTICS

On the average it requires from 40-45 days at sea (including time lost from bad weather) for Albatross IV to complete a 300-haul survey of the entire area from Cape Hatteras to Halifax, representing nearly 75,000 square miles, which works out to be about 7 stations per day. The survey is normally done in 3 separate legs, and covers an elapsed time of about two months. Recently, however, with changeover to the #41 trawl on spring surveys, and the addition of inshore trawling and special hydrographic and plankton stations, an additional 5 days of sea time or a total of about 50 days are required to complete the survey. Average time spent on each standard trawl station is about 1 hour, and average steaming time between stations is about 1½ hours.

Frequency of severe net damage with the standard #36 has usually been relatively low (< 5 percent of total hauls in a survey). However, it is expected to increase with the #41 trawl partly due to the greater scope used with this trawl, and it may be necessary to exclude more areas from the trawlable category when using the #41 trawl. This has yet to be determined.

Approximately 700 man-days (14 scientists x 50 days) are involved in the collection of data at sea on each standard survey. This includes manpower required to obtain a variety of special non-routine biological samples which are not discussed in this paper. It should be noted that 3 to 4 of these are often trainees or visitors who are not fully efficient or knowledgeable in the standard survey operation. About another 100 man-days are involved in pre-cruise preparations, and data processing up to and including final audits for the basic survey data (weight and length frequency only); this does not include age data or other types of biological data such as maturity stages or stomach contents, or any hydrographic data other than surface and bottom temperatures, and surface salinity. Thus a total of about 800 man-days are required to accomplish the collection and preliminary basic data processing for a single survey. The collection phase uses up an elapsed time of only 2 months (not counting pre-cruise preparation time), but the preliminary processing phase requires from 4 to 6 months elapsed time due to lag time imposed by ADP schedules, and because the groundfish survey staff (4-6 full time people) has many other responsibilities related to assessment work.

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Table 1 . Specifications of the National Marine Fisheries Service's NOAA-operated research vessels Albatross IV and Delaware II.

Specifications	Albatross IV	Delaware II
Year built	1962	1968
Length, overall (LOA)	187' (53 m)	156' (44 m)
Displacement, full load	1088.5 short tons	720 short tons
Draft	13.75' (3.9 m)	11.5' (3.3 m)
Vessel type	Stern trawler, steel	Stern trawler, steel
Cruising speed, Knots	11.5	12.5
Cruising range, Miles	9,000	8,000
Main engine	1000 h.p. diesel	1000 h.p. diesel
Propellar	Controllable	Fixed
Normal days per cruise	10-20	10-20
Maximum days per cruise	30	30
Accommodation:		
Officers and crew	20	14
Scientists	10-13	6-8
Freezer capacity, scientific	Approx. 125 ft.^{3} (9.5 m^3)	4-5 portable chests
Fish hold	None	1800 ft.^{3} (51 m^3)
Navigation and Fish Location Equipment	Radar(2) RDF Magnetic and Gyro Compass with Reporters (12) Echosounder(3), echoranger Loran, Ship's Log, Auto Pilot	About same
Trawl winch		
Type	Electric -2 drum	Hydraulic-2 drum
Power	125 hp	227 hp
Speed	0-400 fpm (122 m)	0-650 fpm (198 m)
Cable	1000 fm (1829 m) 7/8 in. dia.	2000 fm (3658 m) 1/4 in. dia.
Hydrographic winch		
Type	2-electric	Hydraulic
Power	15 hp	---
Speed	2000 fpm (61 m)	0-150 fpm (48 m)
Cable	20,000 ft (6,096 m) 1/4 in. dia.	10,000 ft (3048 m) 1/4 in. dia.
Laboratories	1 each-Rough, Dry, Wet, Hydro, Darkroom, Chemical	Wet-Hydro Lab Dry Lab-Darkroom Radio-Chart room
Oceanographic and Meterological Equipment	Standard equipment plus STD, XBT capabilities	same
Special Features	36" bow thruster driven by reversible 125 hp electric motor.	

TABLE 2 . Specifications - Yankee #36 Survey Trawl

Part	Material	Mesh Size (stretched mesh) inches	Length (meshes)	Width (meshes) Fore	Aft.
Upper wings	No. 54 Tan braided nylon	5"	64 (flymeshes)	10	60
Lower wings	"	5"	108 (flymeshes)	30	45
Square	"	5"	35	180	140
Bellies	"	5" & 4½"	85	140	42
Codend	"	4½"	50	80(around)	80

Chafer mat. of polyethelene strands covering aft half (underside only) of cod end.

Groundwarps (none)

Bridles Top 60'x5/8" wire
Bottom 60'x3/4" wire

Headrope total length 60'x7/8" wire rope in three 20' sections.

Floats 8" diameter, spherical (no collar) aluminum deep sea type. 8 floats evenly spaced on each wing, and 20 floats evenly spaced on bosom section.

Footrope Total length 80'x3/4" wire in five sections 22½'--10'--15'--10'--22½'

Roller Gear Hard rubber 16" diameter x 5" wide separated by rubber spacers 5½" diameter x 7" long. Center section of 15' with 9 rollers separated by 2 spacers -- two 10' sections each with 5 rollers separated by 3 spacers -- two 22½" sections with 4" rubber discs.

Doors Steel, 1200 pounds BNV oval.

Liners 1/2" stretched mesh white knotless nylon in aft half (35 meshes) of top belly only.

1/2" stretched mesh white knotless nylon throughout cod end.

TABLE 3 . Specifications of Modified #41 Trawl

Part	Material	Mesh size inches (stretched mesh)	Length (meshes)	Width Meshes Fore	Aft
Upper wings	No. 54 braided nylon	5"	80 (fly-meshes)	60 (V-cut wing tips)	75
Lower wings	No. 84 braided nylon	5"	125 (fly-meshes)	60 (V-cut wing tips)	60
Lengthening piece--(none)					
Square	No. 54 braided nylon	5"	45	220	170
Top belly	No. 54 " "	5"	100	170	50
Lower belly	No. 84 " "	5"	100	170	50
Codend	No. 102 " "	4½"	50	80(around)	80

Chafer Mat of polyethylene strands covering aft half (underside only) of cod end.

Groundwarps (none)

Bridles Top 65'x5/8" wire
Bottom 60'x3/4" wire

Headrope Total length 80'x7/8" combination wire rope in three sections (33'x14'x33')

Floats --- 8" diameter, spherical (no collar) aluminum deep sea type. 20 floats evenly spaced on each wing and 13 evenly spaced on bosom section.*

Hanging Line Total length 125'x3/4" polydacron rope.

Footrope Total length 100'x7/8" wire in 8 pieces 8" each and 2 end pieces 18'each. All pieces connected with 7/8" chackles

Roller Gear First sections (end)- 18' each with 4" diameter discs.

Second sections - 8' each with rubber spacers 5½" diameter x 7" long.

Third sections - 8' each with three hard rubber rollers 14" diameter x 5" wide and spacers.

Fourth Section - 8' each with hard rubber rollers, three 14" and two 16" diameter x 5" wide separated by rubber spacers.

Fifth Section (Center) - 8' each with hard rubber rollers, one 16" and three 18" diameter x 5" wide separated by rubber spacers.

Doors Steel, 1500 lb BMV oval.

Liner 1/2" stretched mesh/knotless nylon in aft half (50 meshes) of top belly only.

1/2" stretched mesh white knotless nylon throughout cod end.

Chain 60 pounds of heavy chain attached to the bottom of each wingend.

* There are also four standard 8-inch floats on each gore, one at the junction of the square and the belly with the remaining three floats equally spaced between there and the forward end of the wing.

Table 4. Stratum areas, and allocation of sampling effort by stratum, fall 1972 groundfish survey by Albatross IV.

Subregion	Stratum No.	Area (Sq. Naut. Mi.)	No. of Hauls	Subregion	Stratum No.	Area (Sq. Naut. Mi.)	No. of Hauls
Cape	61	1318	3	Georges	13	2374	9
	62	243	2		14	656	4
Hatteras	63	86	2	Bank	15	230	3
	64	60	2		16	2980	12
to	65	2832	7	and	17	360	4
	66	555	3		18	172	3
Hudson	67	86	2	Great	19	2454	9
	68	52	2		20	1221	6
Canyon	69	2433	6	South	21	424	4
	70	1024	4		22	454	4
	71	281	2	Channel	23	1016	5
	72	105	2		24	2569	6
	73	2145	5		25	390	4
	74	1273	4				
	75	139	2				
	76	60	2				
Totals	16	12692 (Ave. 1 sta/254 mi.^{2})	50		13	15300 (Ave. 1 sta/210 mi.^{2})	73
Hudson	1	2516	7	Gulf	26	1014	5
	2	2078	7		27	720	4
Canyon	3	566	3	of	28	2249	7
	4	188	3		29	3245	9
to	5	1475	7	Maine	30	619	3
	6	2554	11		36	4069	9
Nantucket	7	514	3		37	2108	5
	8	230	3		38	2560	5
Shoals	9	1522	5		39	730	5
	10	2722	9		40	578	3
	11	622	3				
	12	176	3				
Totals	12	15163 (Ave. 1 sta/237 mi.^{2})	64		10	17892 (Ave. 1 sta/325 mi.^{2})	55
Western	31	2185	7				
	32	712	5				
Nova	33	861	4				
	34	1766	6				
Scotia	35	1097	4				
	41	1570	6				
	42	156	2				
	43	860	4				
	44	934	6				
	45	150	2				
	46	247	2				
	47	1159	4				
	48	1184	5				
	49	198	3				
Totals	14	13079 (Ave. 1 sta/218 mi.^{2})	60				

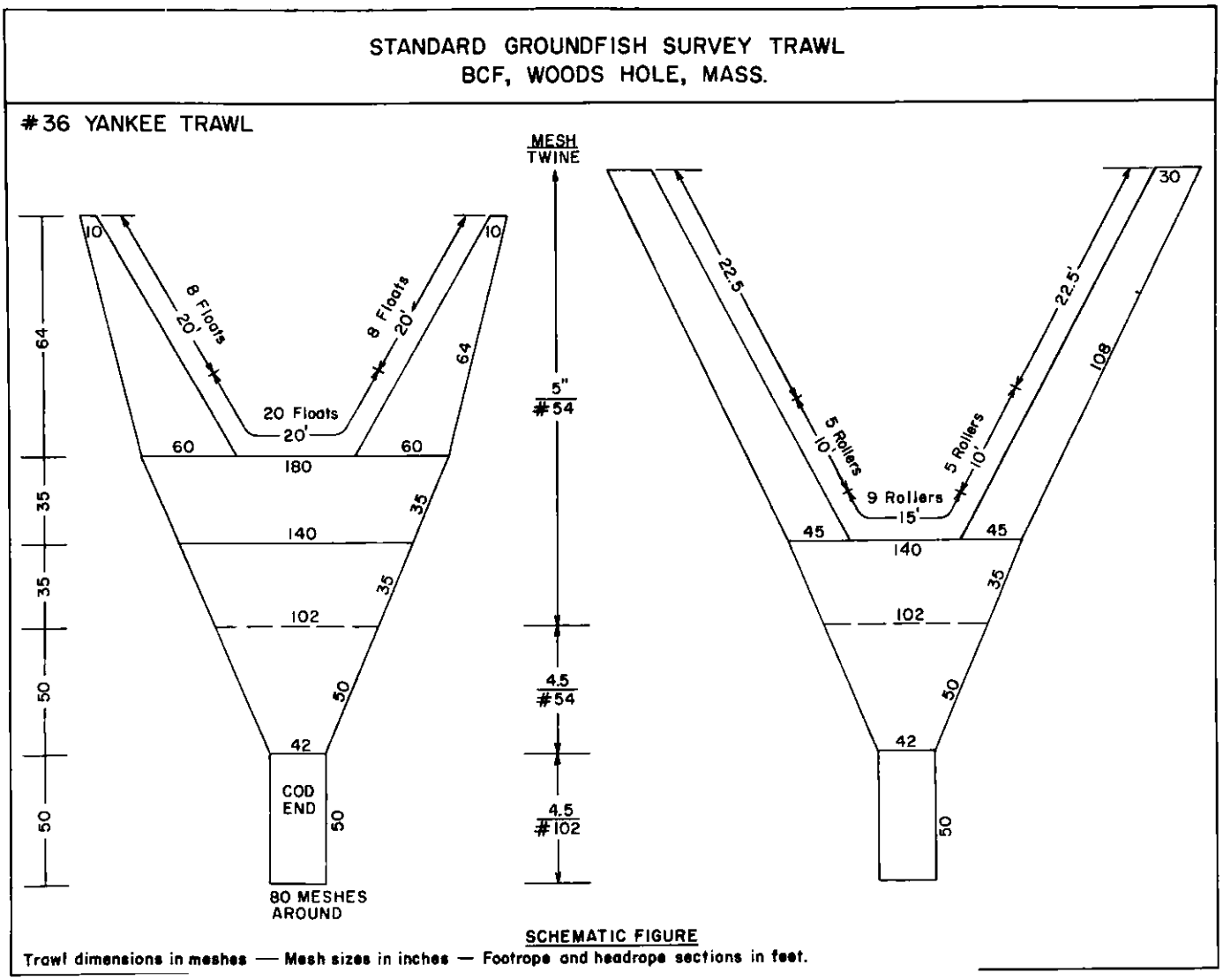
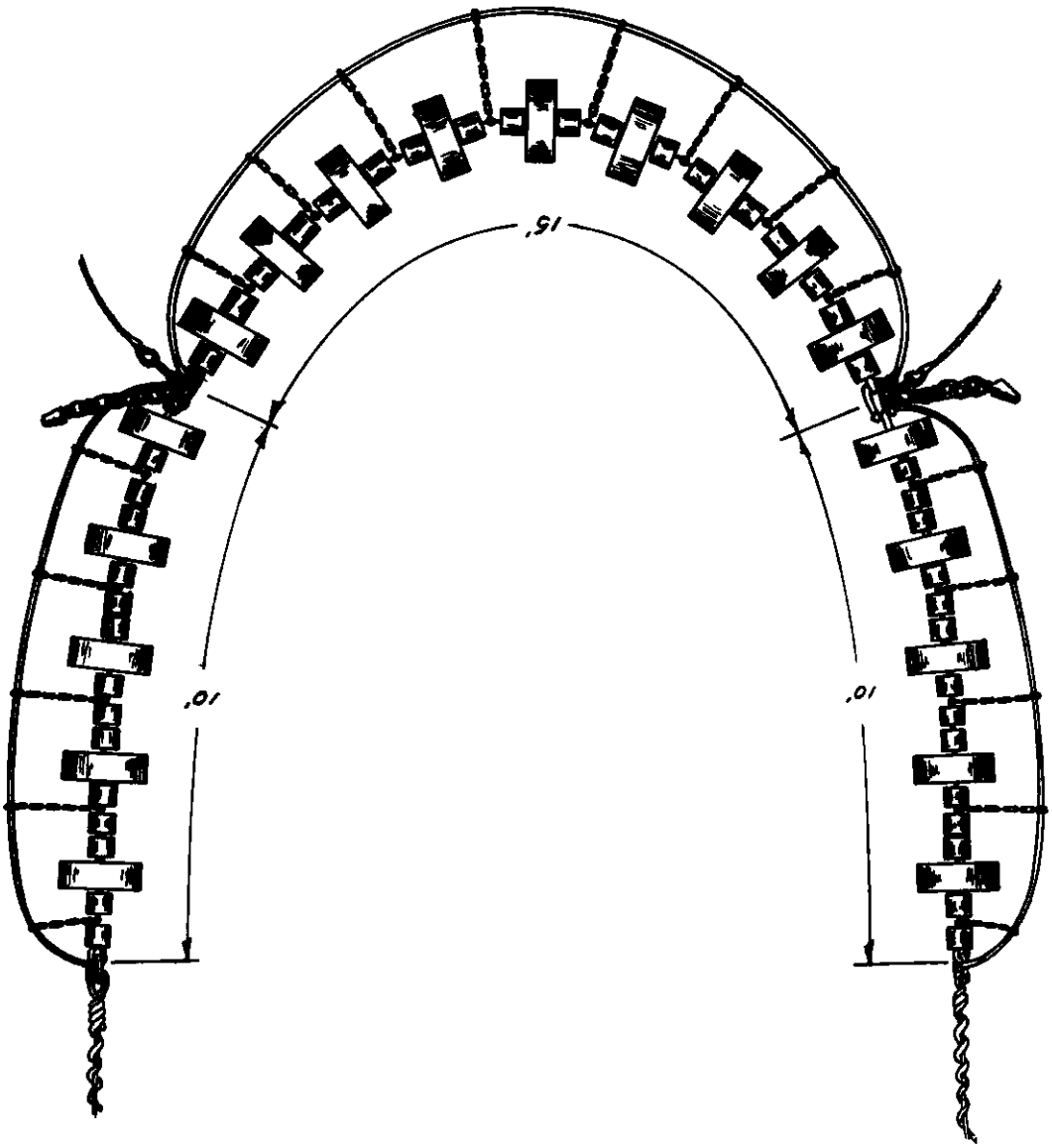


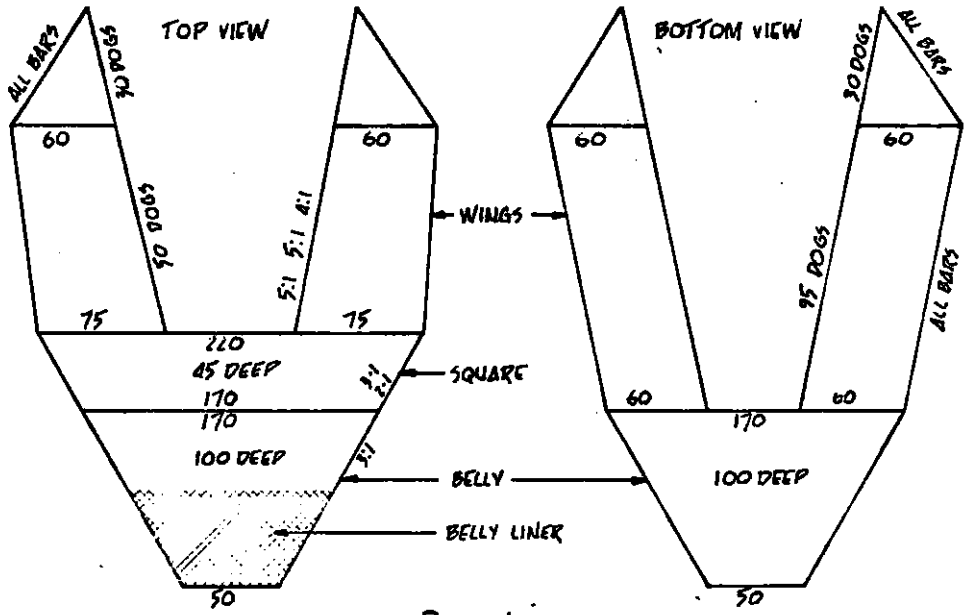
FIGURE 1a . Specifications of standard #36 Yankee trawl used for groundfish surveys.



ROLLER RIGGING
for
YANKEE 36 TRAWL

FIGURE 1b . Roller rigging on standard #36 survey trawl.

ALTERED VERSION MODIFIED #41 2-SEAM HIGH OPENING BOTTOM TRAWL



DESIGN

MATERIAL: BOTTOM #200 VIRGIN BRAID NYLON, 5" MESH
TOP #54 VIRGIN BRAID NYLON, 5" MESH
HEAD ROPE LENGTH: 80 FT. (⅜" COMBINATION WIRE)
FOOT ROPE LENGTH: 100 FT. (⅞" STEEL WIRE)
GORE: 3 MESHES ON EACH SIDE REINFORCED ⅜" POLYPLUS
NUMBER & SIZE OF FLOATS: 20, 8" STANDARD FLOATS ON EACH WING (EVENLY SPACED)
13, 8" STANDARD FLOATS IN BOSOM (EVENLY SPACED)
HANGING RATIO: 25% MORE ROPE THAN SWEEP
COD END: 80 MESH ON ROUND X 50 MESH DEEP WITH ½" LINER (STRETCHED MEASURE)
BELLY LINER: ½" (STRETCHED MEASURE) FROM COD END 50 MESH DEEP INTO TOP BELLY SECTION EXTENDING FROM GORE TO GORE
END OF SWEEP: 63 POUND WEIGHTS ATTACHED EACH END

FIGURE 2

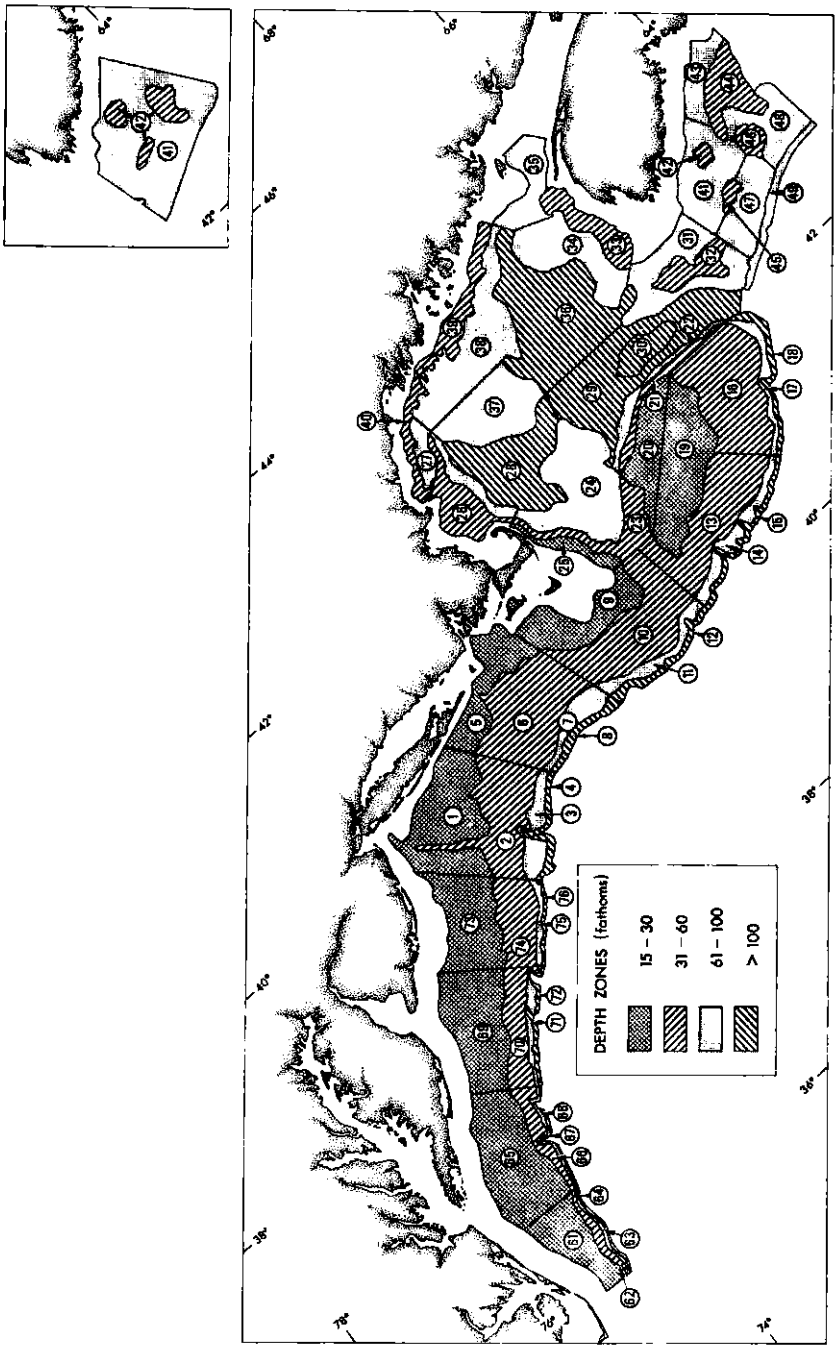


FIGURE 3 . Sampling strata used in spring and fall USA groundfish surveys. Strata 41, 42 (outset) used until 1970 when switched to strata 41-49 , corresponding to Canadian strata.

FIGURE 4

Bathythermograph Data Form

Vessel: | Cruise: | Institute (Activity): | Country: | Sheet Number:

Station	XBT		Date			Time (GMT)		Latitude			Longitude			Sounding at time of drop		Wind		Air Temp.		Barometer (Mbs.)	Weather	Cloud		Wave	Ref. Temp.		Recorder's	Relative
	Probe Type	Trace Number	Day	Month	Year	Hour	Min.	°	′	N S	°	′	E W	Fms.	M.	Dir.	Speed	°F.	°C.			Type	Amt.	Height ft m	Injection °F °C	Bucket °F °C	Initials	Information

Remarks:

FIGURE 5a

HYDROGRAPHIC STATION RECORD
(HSR)

U.S. Dept. of Commerce - NOAA
National Marine Fisheries Service

OPERATIONAL UNIT _____

THERMOMETER PERFORMANCE Codes: Malfunctions: 99.99 Off Scale: 88.88

STD Used	Date (GMT) Month	Day	Time (GMT) Hour	Minute	Station No.	BT Numbers	Hydro. Station Number
						-	

CRUISE

VESSEL

SAMPLE BOTTLE NO.			CAST (S)	Desired Depth	Wire L L (6-9)	Meter Wheel Reading Down	Instrument or Sample Bottle Number	Left Thermometer (P)			Middle Thermometer (P)			Right Thermometer (U)			Casts		Time GMT		
Salinity	Nutrients	O_2						Therm. Number (10-15)	Main (T') (16-19)	Aux. (1) (20-22)	Therm. Number (23-28)	Main (T') (29-32)	Aux. (1) (33-35)	Therm. Number (36-41)	Main (T') (42-45)	Aux. (1) (46-49)	Cast No.	Surface Wire Angle	Down Time	Messenger Time	Start Up Time
								1			1			1			1.				
								2			2			2			2.				
								3			3			3			3.				
								4			4			4			First Observers				
								5			5			5			Asst. Observers				
								6			6			6			1st Therm. Reader				
								7			7			7			2nd Therm. Reader				
								8			8			8			Remarks:				
								9			9			9							
								10			10			10							
								11			11			11							
								12			12			12							
								13			13			13							
								14			14			14							
								15			15			15							
								16			16			16							
								17			17			17							
								18			18			18							
								19			19			19							
								20			20			20							
								21			21			21							

Recorded By | Date | Reviewed by Field Party Chief | Page of

NAVMAP Form 73-2 (1/73)

FIGURE 5b

STD LOG PAGE____OF____

CRUISE:_____ STATION:_____

DATE: _____ TIME:_____LOCAL

BUCKET TEMP:_____ °C BOTTOM DEPTH:_____FMS._____M.

SURFACE SALINITY BOTTLE #_____

FREQUENCIES AS READ FROM COUNTER

SURFACE

SALINITY:_____ TEMP:_____

DEPTH: _____ D.O. _____

BOTTOM OF SCALE 1 OR BOTTOM OF CAST

SALINITY: _____ TEMP:_____

DEPTH: _____ D.O._____

TOTAL WIRE OUT_____M.

BOTTOM OF CAST (SCALE)

FIRST NISKEN SAMPLE

SALINITY: _____ TEMP:_____

DEPTH: _____ D.O._____

SECOND NISKEN SAMPLE

SALINITY:_____ TEMP:_____

DEPTH: _____ D.O._____

THIRD NISKEN SAMPLE

SALINITY: _____ TEMP:_____

DEPTH: _____ D.O._____

FOURTH NISKEN SAMPLE

SALINITY: _____ TEMP:_____

DEPTH: _____ D.O._____

FIGURE 5c

SALINITY COLLECTION DATA

SHEET ____ OF ____

CRUISE _____

STATION NO.	B.T. SLIDE NO.	SAL. BOX NO.(HYDR)	NO. OF BOTT./STA.	NANSEN BOTT. NO.	COLLECTION (DATE)	TITRATION (DATE)	TIME DIFF. (DAYS)	OBSERV. INITIALS	TITRATOR INITIALS	REMARKS

ALBATROSS IV 73-8 — 1973 - Fall Groundfish Survey

CRUISE	VS.	MO.	DAY	HR.	STA.	LAT.	LONG.	GR	M	SP.	DIST. ← in meters
7308	02	10	17	20	021	4021	6800			35	

↑ vessel code; ↑ nearest hour; ↑ gear code; ↑ mesh; ↑ ship speed

TIME OUT	WIRE OUT	TIME IN
00.00	00	
	10	
	20	
	30	
	40	
	50	
	60	
	70	
1:45	(80)	8:00
	90	
	100	
	110	
	120	
	130	
	140	
	150	
	160	
	170	
	180	
	190	
	200	

flowmeter #

	TIME	LORAN	LORAN	LOG	③ 61cm Port FmTr (in)	FmTr (out)	④ 61cm Stbd FmTr (in)	FATHOM DEPTH	METER DEPTH
START	1943			3287.11	327189		206409	27 F	49 M
END	1953			3288.13	331284		212311		

GEAR: 61 cm Bongo Sampler; 122 cm V-fin Depressor; 6mm dia. towing wire

MESH: .505 mm. Port + .333 mm. Stbd

TOW TYPE: Direct oblique

REMARKS: eg. Herring larvae seen
Nets clogged (½ way)
Rough seas
Meters windmilling

TDR = 17 lines = 45 meters maximum gear depth

ON WATCH: JOHN DOE

FIGURE 6 . Field log in current use for plankton samples taken on groundfish surveys.

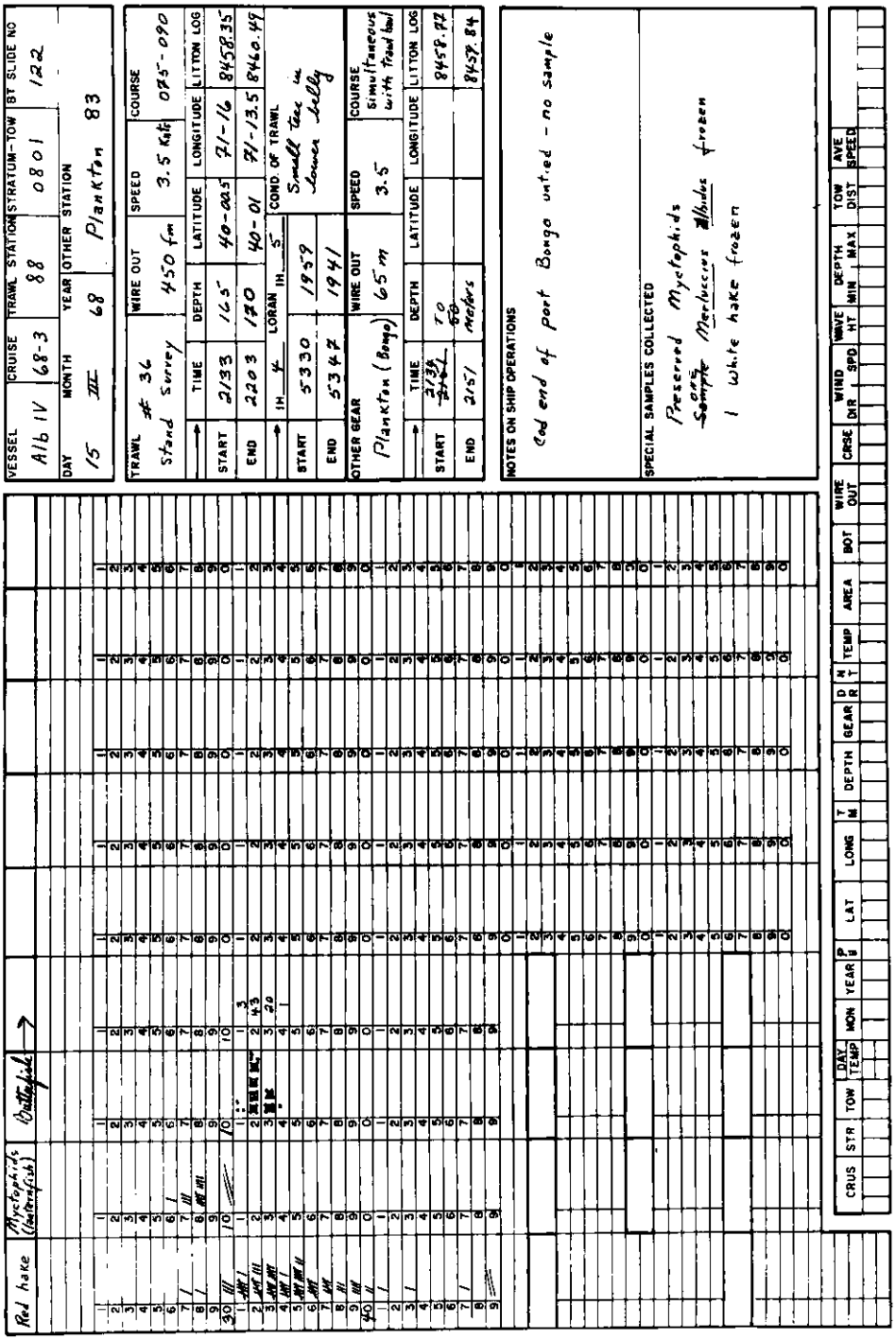
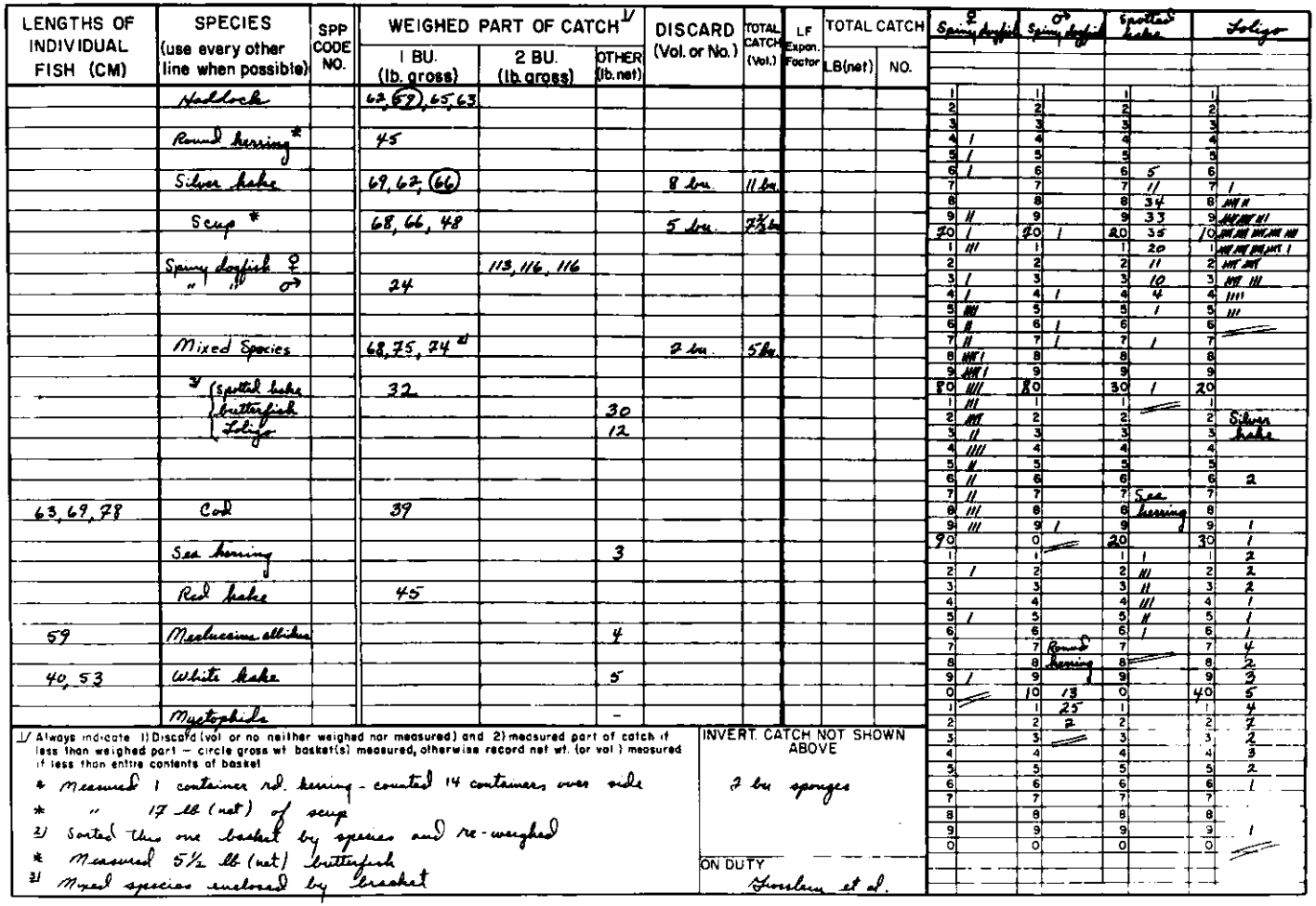


FIGURE 7 . Side 1 of the groundfish survey trawl log.



LENGTHS OF INDIVIDUAL FISH (CM)	SPECIES (use every other line when possible)	SPP CODE NO.	WEIGHED PART OF CATCH 1/ 1 BU. (lb. gross)	2 BU. (lb. gross)	OTHER (lb. net)	DISCARD (Vol. or No.)	TOTAL CATCH (Vol.)	LF Expan. Factor	TOTAL CATCH LB(net)	NO.
	Haddock		62, 59, 65, 63							
	Round herring *		45							
	Silver hake		69, 67, 66			8 bu.	11 bu.			
	Scup *		68, 66, 48			5 bu.	7½ bu.			
	Spiny dogfish ♀			113, 116, 116						
	" " ♂		24							
	Mixed Species		68, 75, 74 2/			2 bu.	5 bu.			
	3/ (spotted hake		32							
	butterfish				30					
	Loligo				12					
63, 69, 78	Cod		39							
	Sea herring				3					
	Red hake		45							
59	Merluccius albidus				4					
40, 53	White hake				5					
	Myctophids				-					

1/ Always indicate 1) Discard (vol or no neither weighed nor measured) and 2) measured part of catch if less than weighed part — circle gross wt basket(s) measured, otherwise record net wt. (or vol.) measured if less than entire contents of basket

* Measured 1 container rd. herring - counted 14 containers over side

* " 17 lb (net) of scup

2/ Sorted thru one basket by species and re-weighed

* Measured 5½ lb (net) butterfish

3/ Mixed species enclosed by bracket

INVERT. CATCH NOT SHOWN ABOVE

2 bu sponges

ON DUTY

Gunderson et al.

	♀ Spiny dogfish	♂ Spiny dogfish	Spotted hake	Loligo
1		1	1	1
2		2	2	2
3		3	3	3
4	1	4	4	4
5	1	5	5	5
6	1	6	6 5	6
7		7	7 11	7 1
8		8	8 34	8 IIII
9	II	9	9 33	9 IIII III
20	1	20 1	20 35	10 IIII IIII IIII IIII
1	III	1	1 20	1 IIII IIII IIII 1
2		2	2 11	2 IIII IIII
3	1	3	3 10	3 IIII III
4	1	4 1	4 4	4 IIII
5	III	5	5 1	5 III
6	II	6 1	6	6
7	II	7 1	7 1	7
8	IIII 1	8	8	8
9	IIII 1	9	9	9
30	III	30	30 1	20
1	III	1	1	1
2	IIII	2	2	2 Silver hake
3	II	3	3	3
4	IIII	4	4	4
5	II	5	5	5
6	II	6	6	6 2
7	II	7	7 Sea	7
8	III	8	8 herring	8
9	III	9 1	9	9 1
40		0	20	30 1
1		1	1 1	1 2
2	1	2	2 III	2 2
3		3	3 II	3 2
4		4	4 III	4 1
5	1	5	5 II	5 1
6		6	6 1	6 1
7		7 Round	7	7 4
8		8 herring	8	8 2
9	1	9	9	9 3
0		10 13	0	40 5
1		1 25	1	1 4
2		2 2	2	2 7
3		3	3	3 2
4		4	4	4 3
5		5	5	5 2
6		6	6	6 1
7		7	7	7
8		8	8	8
9		9	9	9 1
0		0	0	0

FIGURE 8 . Side 2, groundfish survey trawl log.

FIGURE 9

SURVEY CRUISE - AGE SAMPLE

Cruise	Consec. Tow No.	
		Card Colm'n
Cruise		1-3
Stratum		4-5
Tow		6-7
Day		8-9
Month		10-11
Year		12-13
Purpose		14
Latitude *		15-17
Longitude *		18-20
Time		21
Depth		22-24
Species		25-27
Sex		(14)

*Degrees and 10' intervals

Length Code (28-30)	AGE 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total (76-79)
5																
6																
7																
8																
9																
0																
1																
2																
3																
4																
5																
6																
7																
8																
9																
0																
1																
2																
3																
4																
5																
6																
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9																
0																
1																
2																
3																
4																
5																
6																
7																
8																
9																
0																

FIGURE 9 . Age tally and coding form for groundfish survey.

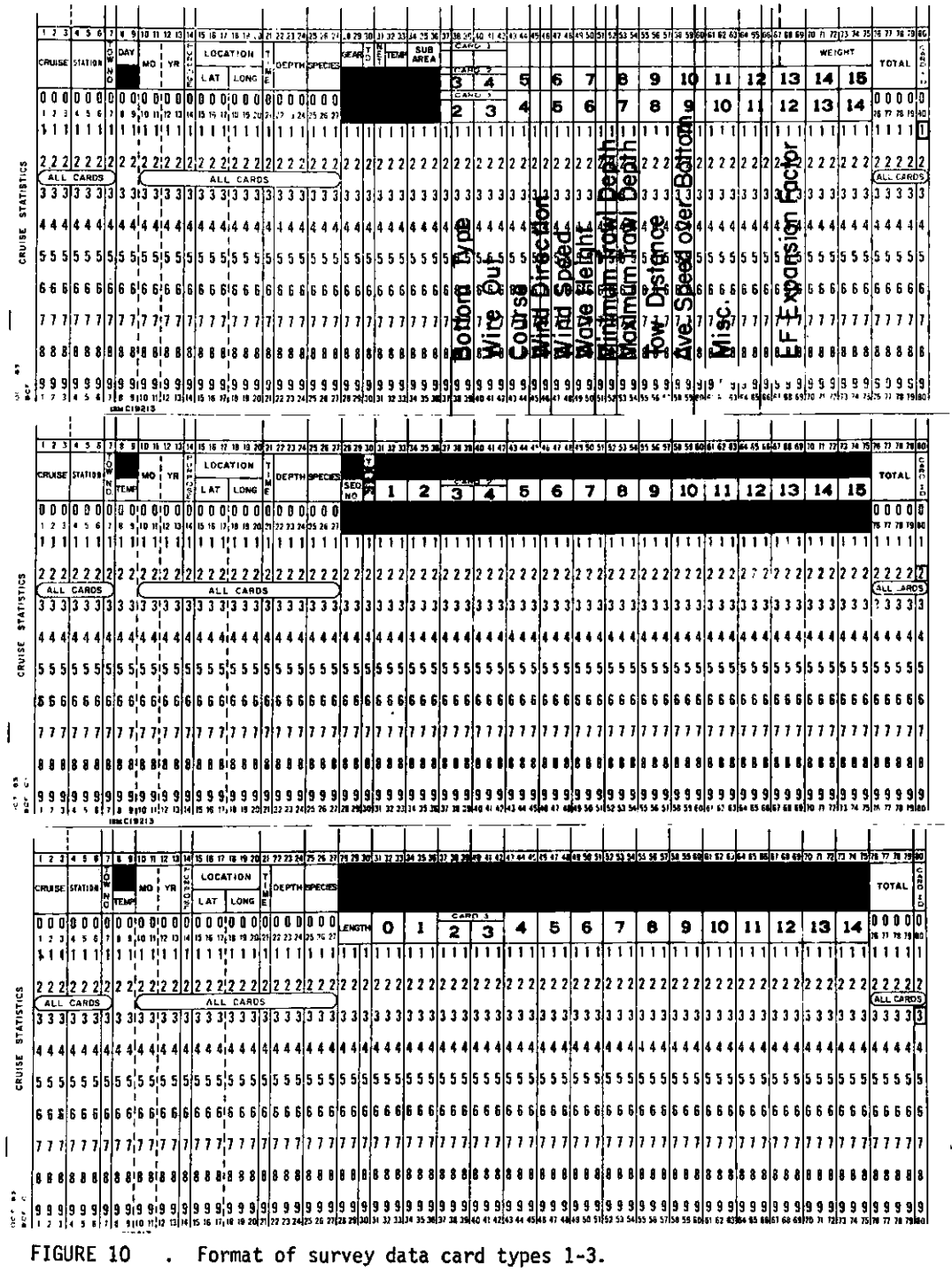

FIGURE 10 . Format of survey data card types 1-3.

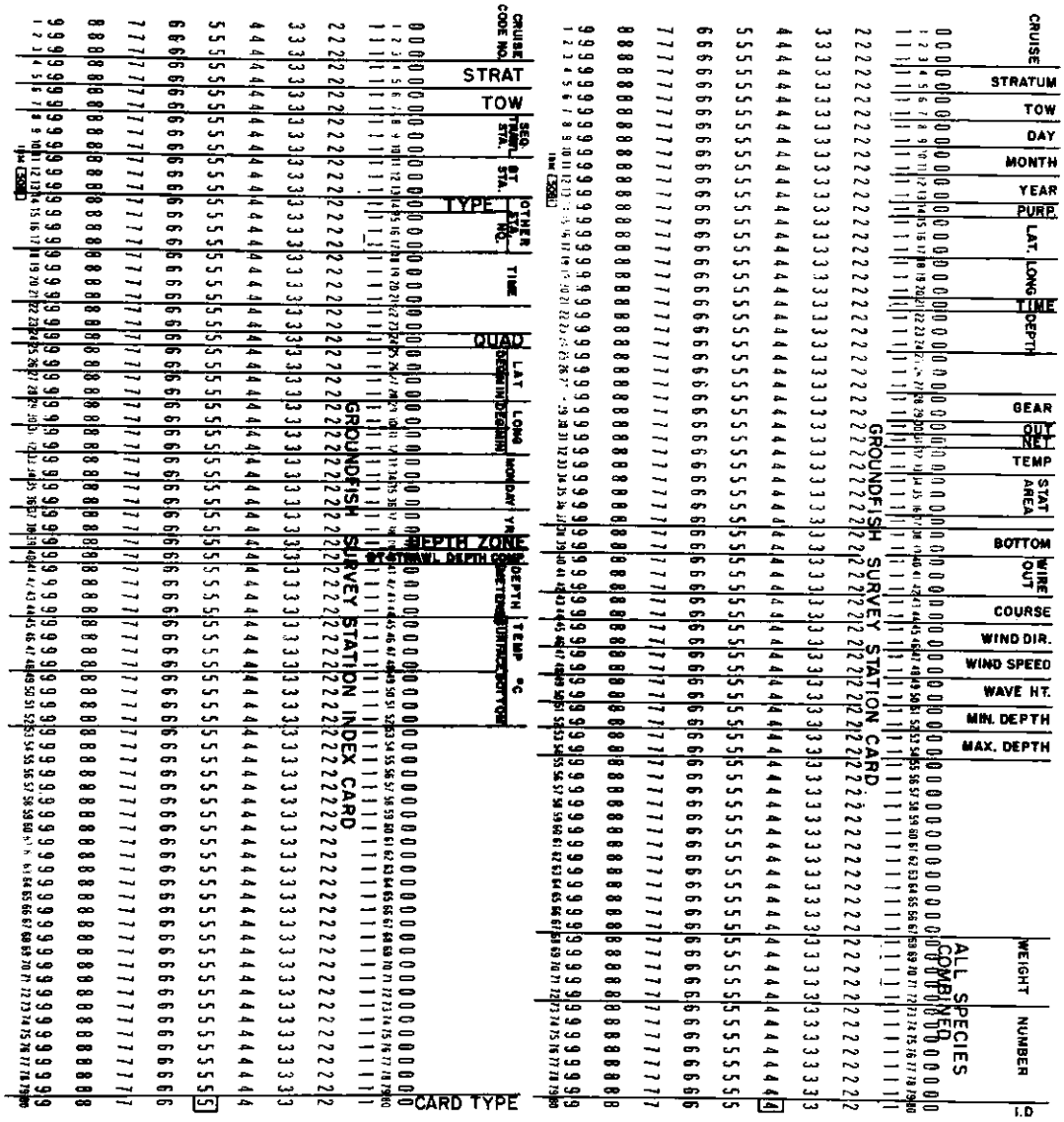

FIGURE 11 . Format of survey data card types 4-5.