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THE INTERNATIONAL NORTH SEA 0-GROUP GADOID SURVEYS: THE METHODOLOGY USED AND EVALUATION OF THE RESULTS

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INTRODUCTION

Part of Council Resolution 1976/2:47 recommended that "papers dealing with the methodology and evaluation of such (0- and I-group) surveys should be encouraged". This paper deals with the North Sea 0-group gadoid surveys. It has been prepared by the co-ordinator on behalf of the group that participated in the surveys.

HISTORY

The surveys started in 1969 with an attempt by the Marine Laboratory, Aberdeen to catch pelagic 0-group gadoids. A Gulf III plankton sampler and a 10 ft (3 m) Isaacs Kidd midwater trawl were used, both unsuccessfully, but a midwater pelagic trawl, especially designed for the work by the Aberdeen laboratory, caught sufficient young gadoids for Hislop (1970) to state that "this net may well be a useful sampling instrument for regular surveys of abundance". The survey was repeated in 1970 (Hislop and Bailey, 1971). Meanwhile, Dutch scientists had been undertaking trials to estimate the abundance of young pelagic gadoids. In 1970 and 1971 they used Isaacs Kidd and 1200 mesh Engels midwater trawls, both unsuccessfully. In 1972 they adopted a commercially made version of the Aberdeen net and undertook their first successful survey (Daan, 1972). In the same year English scientists made their first survey using a 3 x 2 m Boothbay net (Williams and Macdonald, 1972). The three surveys were loosely co-ordinated to cover the whole of the North Sea between 52°N and 60°30'N. At the meeting of the North Sea Roundfish Working Group in 1973 it was agreed that those participating in the survey should use the Aberdeen 0-group gadoid pelagic trawl or its Dutch equivalent (Anon, 1973). This came to be called the international young gadoid pelagic trawl (IYGPT). The areas to be surveyed by each of the three countries that participated (England,

Netherlands, Scotland) were also co-ordinated but the timings of the surveys were not. It was not until 1975, when Denmark also participated in the survey for the first time, that the survey was fully co-ordinated with respect to both area and time. A comparative fishing experiment was also undertaken, in which Norway also participated. In 1976 Norway took part in the survey, which was fully co-ordinated with all vessels using the IYGPT.

METHODOLOGY

Selection of sampling stations

In the original Scottish surveys a different number of hauls was made in each statistical rectangle. By 1973, when the objective of the survey was to cover the whole of the North Sea between 54°N and 61°N, research vessel logistics meant that only one haul could be made in each statistical rectangle. (Certain statistical squares, mainly off the Danish, German and Dutch coasts cannot be fished either because the water is too shallow - less than approximately 30 m - for the IYGPT to be fished, or because navigational hazards exist.) This became the standard pattern with the haul being made approximately in the centre of each rectangle to provide a grid of equally spaced stations.

After the 1974 survey it was obvious that attempting to meet the objective of sampling the whole of the North Sea between 54°N and 61°N on the above basis was over-stretching the research vessels' resources. Furthermore, the surveys that had been done showed that 0-group gadoids were either absent or present only occasionally, and then in small numbers, in certain statistical rectangles. The survey area was modified to exclude these rectangles and this modified scheme has formed the basis of subsequent surveys. The areas are shown in Figure 1. If time permits, statistical rectangles outside the main designated survey areas are fished in order to ascertain that the survey continues to cover the main areas of abundance of pelagic 0-group gadoids.

In so far as possible, the surveys are planned so that the groups of four statistical rectangles by which the data are presented are worked consecutively and so that no ship fishes the same statistical rectangles in the second survey as were fished in the first (see next section).

Timing of surveys

The surveys are designed to assess the relative abundance of three main species; cod, haddock and whiting. The early surveys recorded differences in the timing of maximum abundance both between years for the same species and between species. In 1976, sufficient research vessel time became available to make two surveys possible and these were planned to cover the observed main period of availability to the IYGPT of pelagic 0-group gadoids; this is June.

GEAR AND METHOD OF FISHING

The choice of gear

As described above, different types of trawl were tried initially but the IYGPT quickly became adopted as the standard gear. In 1975 a comparative fishing experiment was carried out to test whether there were any differences between the Aberdeen and Dutch versions of the IYGPT and between Dutch versions of the IYGPT fished by different vessels. Except for Norway pout, the ranges of the confidence limits for gear-ship combinations overlapped to a considerable extent and the length compositions were identical (Tables 1 and 2). It was concluded that the IYGPT, irrespective of the ship from which it was fished or of slight differences in rigging, gave comparable results for cod, haddock and whiting (Daan *et al*, 1975). A 33 x 33 m capelin trawl fished by the Johan Hjort during this experiment did not give results similar to those obtained with the IYGPT.

One of the major disadvantages of the IYGPT is that on the majority of vessels used in the survey two watches have to be on duty at once to handle it and this limits trawling to 12-14 hours a day. The 2 x 3 m Boothbay net does not suffer this disadvantage and, if it were a suitable gear for 0-group gadoid surveys, would be more cost-effective on certain ships. However, compared with the IYGPT in the comparative fishing experiment, the Boothbay net caught fewer fish, except whiting, even allowing for differences in both the lengths of hauls and the mouth openings of the nets, and failed to catch the upper size range of the length distribution of cod and haddock (Table 2). The results of the comparative fishing experiment confirmed the suitability of the IYGPT as a standard gear for 0-group surveys of cod, haddock and whiting.

Method of fishing

In the initial Scottish surveys the IYGPT was fished in the midwater scattering layer, which is usually associated with the thermocline, if one were present (Hislop, 1973). At the 1973 meeting of the North Sea Roundfish Working Group (Anon, 1973) evidence was presented that Norway pout made diurnal migrations in and out of the scattering layer and that larger 0-group cod were probably not present in it. In the absence of evidence about the distribution of 0-group gadoids it was agreed that hauls should be of one hour's duration, split as follows:-

1 immediately after shooting, the net would be fished as close to the bottom as possible for 20 minutes, starting from the time that the net arrived near the bottom:

2 the net would then be hauled to midwater or to the depth of the thermocline and fished there until 40 minutes had elapsed:

3 it would be hauled as near the surface as possible and fished there until 60 minutes had elapsed when it would be hauled.

The method is illustrated in Figure 2. This technique has been modified slightly in practice; in depths geater than 150 m, 125 m is taken as the "bottom" for sampling purposes, and in shallow water (less than 30 m approximately) only the bottom and surface are sampled, each for 30 minutes. No echo-sounding system is used, except for a headline transducer to locate the depth at which the net is fished, because over most of the survey area either no echo-trace at all, or no echo-trace that can be associated with 0-group gadoids, is recorded.

In 1975 an experiment was undertaken to determine the depth stratification of 0-group gadoids (Daan *et al*, 1975). The experiment was hampered by bad weather but the results indicated that at the time of the experiment (late June), cod, haddock and whiting were largely restricted to the water column above 40 m, which was the depth of the thermocline. Norway pout were more generally distributed.

PRESENTATION OF RESULTS

For each survey a geometric mean with 95% confidence limits is calculated for each species for each of the three areas shown in Figure 1. For groups of four statistical rectangles, and for each species, numbers caught, mean length and its standard deviation and range are also presented together with charts showing numbers of each species caught per haul in each statistical rectangle.

EVALUATION OF THE SURVEYS

Estimation of yearclass size

The objective of the surveys is to assess the relative yearclass abundance of 0-group gadoids. The proposed test as to whether this objective is met is to correlate the results with those obtained from both the International Young Herring Surveys (IYHS) and virtual population analyses. Only three data sets exist for cod and whiting and so to date correlation coefficients have been calculated only for haddock. Neither comparison has resulted in a significant correlation coefficient (Daan *et al*, 1976). This lack of data prevents the surveys being evaluated. However, Daan *et al* (1976) doubt whether surveys made at the appropriate time for cod and haddock will provide an early indication of yearclass size for whiting because this species has a relatively late and prolonged spawning period.

The provision of early estimates of yearclass size arises from the need of the North Sea Roundfish Working Group to have such estimates in setting Total Allowable Catches (TACs). At the time that the surveys were started insufficient data were available from the IYHS to determine whether they would provide reliable indices of gadoid yearclass abundance, and therefore it was a valid decision to start the 0-group surveys as an alternative possibility in case the IYHS failed to do so. The IYHS, which takes place in February each year, eventually did provide useful indices of gadoid yearclass size but this was to some extent fortuitous because, as their name implies, the IYHS were designed not to do this but to provide estimates of herring yearclass size; they have since been modified to provide both.

The North Sea Roundfish Working Group usually meets in March of every year. For any year (n) the data on recruitment of yearclass n, n - 1 etc that are available to the group are as follows:-

Year-class	Source
n	None (average yearclass size used)
n-1	IYHS and 0-group survey
n-2 and earlier	IYHS, 0-group surveys, virtual population analyses

As density-dependent and independent events affecting yearclass size are more likely to have ended by February of year (n) than by June of year (n-1), the IYHS are more likely to provide the better indices of yearclass size. TACs are set by the Working Group for year (n + 1) and the only use to which the data from the 0-group surveys could be put is if the TACs were subject to a revision in the last quarter of year (n), when estimates of yearclass size would be available of gadoids, spawned in year (n) from the 0-group surveys. Whether such a revision is worthwhile depends upon the contribution that one-year-old fish make to the landings. Over the period 1966-75 this has been 7.4% for cod, 11.8% for haddock and 28.4% for whiting. Within this period the largest contribution to the catches made by one-year-old fish was 18.6% for cod in 1966, 62.0% for haddock in 1968 and 54.3% for whiting in 1975 (calculated from Anon, 1976). For haddock, in particular, and to a lesser extent whiting, the use of average yearclass size rather than an actual estimate can lead to serious errors in setting the TACs, especially when large yearclasses enter the fisheries. This, in turn, leads to quota management problems. For cod, the problem is far less acute and the error resulting from using average yearclass size is probably little more than that inherent in the data and methodology used in calculating TACs. Within the present management regime the results from the 0-group surveys cannot be properly utilized; if an up-dating procedure were introduced they could be. Alternatively, if mesh sizes were raised so that these gadoids did not recruit to the fishery until late two-year-olds, estimates of yearclass size as 0-groups would no longer be needed.

General principles

Certain lessons can also be drawn from how the survey has developed. Once two or three surveys had been done the methodology of the survey became fixed because departures from it would have meant that data from different years would not have been comparable. The results from the depth stratification experiment, which was made 6 years after the initial attempt to catch 0-group gadoids, indicate that

trawling for cod, haddock and whiting could be restricted to above the thermocline. Despite this, no alteration has been made to the method of fishing, in order to preserve comparability of results. The comparative fishing experiment showed that there were no marked differences between catches of cod, haddock and whiting made by ships using the IYGPT but an evaluation of the implications of using the IYGPT was not made at an early stage in the development of the survey. It is possible that using a simpler gear which could be fished 24 h a day would be both more cost-effective for some countries and have led to equally valid results. As it takes of the order of a decade to collect sufficient data from this type of survey to determine whether the results are of use, and as the surveys are very costly in ships' time, there is a sound case for evaluating both the methodology that is to be used and whether the results obtained will meet the required objectives before embarking upon series of annual surveys.

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TABLE 1 Comparison of the catch-rates (numbers/hours fishing) by vessels taking part in comparative fishing experiment, modified from Table 2C of Daan *et al*, 1975. IYGPT (A) = Aberdeen version of trawl : IYGPT = commercially made version : CT = capelin trawl : BB = Boothbay net: MEAN is geometric mean : 95% = 95% confidence limits of geometric mean.

Vessel	Gear	Hauls	COD		HADDOCK		WHITING		NORWAY POUT	
			Mean	95%	Mean	95%	Mean	95%	Mean	95%
Explorer	IYGPT (A)	4	27.3	9-82	447	65-3044	203.6	33-1242	472	35-6146
Corella	IYGPT	9	27.3	20-38	675	408-1117	90.2	53-154	7982	1873-34010
Tridens	IYGPT	14	20.5	14-30	305	210-441	57.7	32-104	243	111-530
Dana	IYGPT	7	40.5	20-83	980	512-1876	0**	-	1095	521-2303
Johan Hjort	CT	14	16.8	6-42	1025*	262-1788*	0	-	12254*	-3477-27985*
Clione	BB	12	3.4	2-5	53	33-84	81.5	57-117	2.7	1-7

*Arithmetic mean and confidence limits based on assumed normal distribution

**Whiting probably misidentified

TABLE 2 Number of each species caught per hour's fishing by vessels taking part in comparative fishing experiment, modified from Table 3 of Daan *et al.*, 1975. E = EXPLORER, CA = CORELLA, T = TRIDENS, D = DANA, JH = JOHAN HJORT and CE = CLIONE: other abbreviations as in Table 1

Ship	E	CA	T	D	JH	CE
Gear	IYGPT (A)	IYGPT	IYGPT	IYGPT	CT	BB
cm						
COD						
1	-	-	0.2	-	-	0.3
2	2.0	2.5	3.9	3.2	-	1.9
3	16.0	13.7	8.6	23.8	1.5	0.7
4	7.7	8.0	5.6	11.3	5.5	0.1
5	1.2	1.9	1.5	1.4	6.0	0.1
6	0.2	0.2	0.2	0.1	0.9	-
7	-	0.1	-	-	-	-
Total	27	26	20	40	14	3
$\bar{l}$	3.83	3.87	3.71	3.79	4.85	2.76
sd	0.74	0.76	1.06	0.43	0.72	0.98
WHITING						
1	1.8	0.4	2.1	-	-	21.3
2	98.4	52.5	27.5	-	-	49.8
3	92.2	33.3	23.0	-	-	9.0
4	1.7	0.9	1.0	-	-	0.6
5	0.2	0.3	0.1	-	-	-
6	-	-	0.1	-	-	-
7	-	-	-	-	-	-
Total	194	88	54	0	0	81
$\bar{l}$	2.98	2.94	2.95	-	-	2.39
sd	0.46	0.70	0.56	-	-	0.56

/Continued

TABLE 2 (Continued)

Ship	E	CA	T	D	JH	CE
Gear	IYGPT (A)	IYGPT	IYGPT	IYGPT	CT	BB
cm						
HADDOCK						
1	1.5	3.1	2.3	2.1	-	4.0
2	80.2	162.7	58.1	189.0	18.7	26.7
3	218.4	313.0	138.6	440.7	231.4	17.5
4	86.0	137.2	64.5	187.4	318.9	3.1
5	16.2	32.4	28.6	73.6	195.3	0.6
6	3.4	8.2	9.1	39.8	131.4	0.2
7	0.2	1.4	3.7	12.7	61.3	-
8	0.2	-	1.0	3.3	40.4	-
9	0.7	-	0.4	1.0	27.4	-
Total	407	658	306	950	1025	52
$\bar{l}$	3.64	3.60	3.87	3.86	5.15	2.90
sd	0.82	0.80	1.08	1.10	1.54	0.74
NORWAY POUT						
1	1.3	-	9.9	5.0	-	1.1
2	32.3	59.1	117.5	571.4	141.5	3.4
3	198.7	1639.1	49.0	245.9	3869.7	0.6
4	123.7	1895.7	68.5	178.3	5116.0	-
5	31.7	501.9	14.8	40.5	2146.9	0.4
6	2.2	105.9	17.7	17.0	973.8	0.1
7	-	-	-	-	3.0	-
Total	390	4202	27.7	1058	12251	6
$\bar{l}$	3.89	4.26	3.54	3.25	4.48	2.51
sd	1.53	0.73	1.20	0.96	0.90	1.36

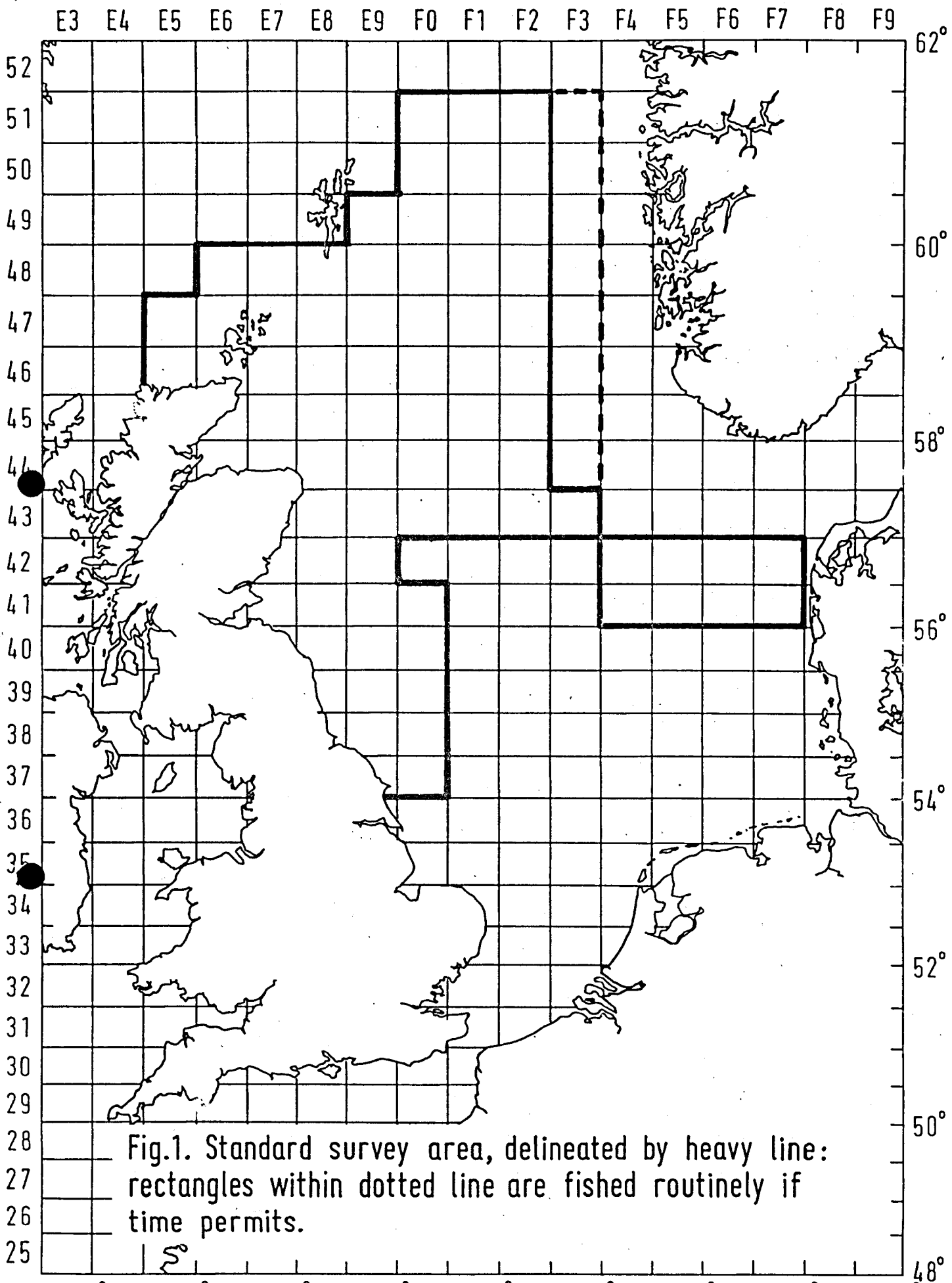

Fig.1. Standard survey area, delineated by heavy line: rectangles within dotted line are fished routinely if time permits.

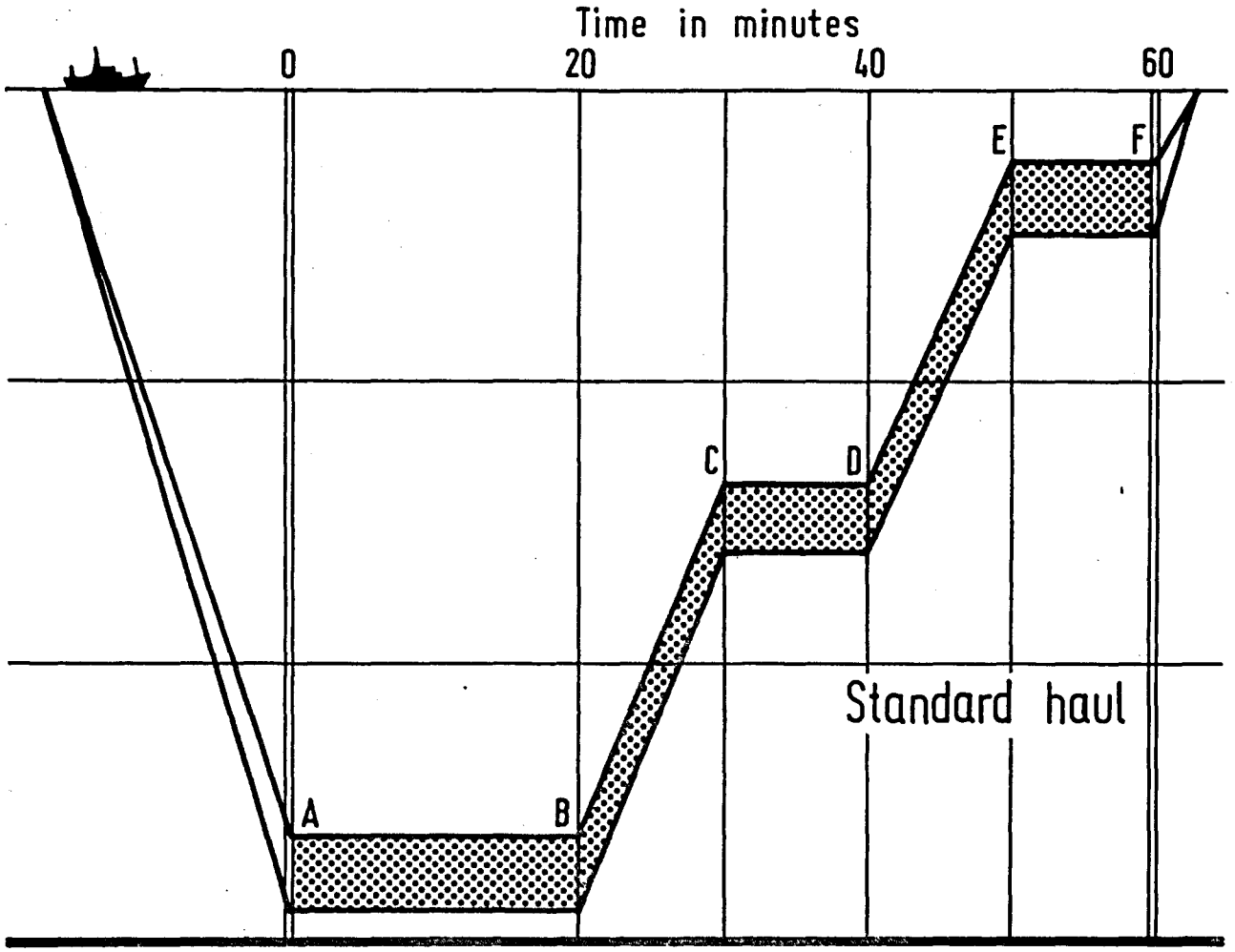

Fig. 2. Method of making a standard 1 hour haul: C-D is at thermocline if one present.