



Serial No. 2783
(D.c.9)

ICNAF Res.Doc. 72/64

ANNUAL MEETING - JUNE 1972

A groundfish survey of Faroe Bank

by

B.W. Jones and J.G. Pope
Fisheries Laboratory, Lowestoft, Suffolk, England

INTRODUCTION

With increasing interest in the possibility of using groundfish trawl surveys by research ships as a means of monitoring population changes in demersal fish stocks, the present survey was planned as a feasibility study. The objective was to assess the likely accuracy of such surveys, and the appropriate manpower requirements at sea and in the laboratory. The survey was done in June 1971.

GEAR AND METHODS

Ship: RV CIROLANA

Length: 72.5 m O.A., 62.5 m B.P.

Beam: 14.0 m moulded.

Tonnage: 2323 tons displacement, 1593 tons G.R.T.

Shaft horse-power: 2200 ($P_g = 1641$ kW).

Scientific staff: 9 Biologists,

1 Hydrographer.

The hydrographer preferred to be responsible for all the hydrographic observations throughout the cruise. The biologists therefore were divided into five teams, of which three were on duty at any time, giving alternating periods of 9 hours on duty and 6 hours off.

Trawl: Granton

Headline: 23.8 m, with 60 x 0.15 m diameter floats.

Groundrope: 36.6 m.

Bosom 6.1 m, with 7 x 0.53 m steel bobbins.

Bunts each 6.1 m, with 3 x 0.53 m and 4 x 0.46 m steel bobbins.

Legs 13.7 m, with 1 x 0.46 m steel bobbin.

Dan Leno: 0.61 m ball.

Bridles: 27.4 m.

Doors: Fearnought type 3.35 x 1.53 m, 926 kg.

Cod-end: 120 mm nominal mesh size, with blinder of 19 mm nominal mesh size.

Area of survey: Faroe Bank, area approximately 1600 sq. n miles, extending to the 370 m (200 fm) isobath.

Faroe Bank is small in size, making it possible to survey the complete area.

The cod stock on Faroe Bank is known to be a self-contained unit (Jones 1966; Jamieson and Jones 1967), and it seems likely that the same can be said of the haddock. Faroe Bank is fished by English trawlers, and fishery statistics are recorded separately for this area.

Experimental design: Faroe Bank was divided into four quadrants (A-D) of approximately equal area (Figure 1) and four depth strata (1-4) of (1) < 110m, (2) 110-146 m, (3) 146-183 m, and (4) 183-366 m (corresponding depths in fathoms: 60, 80, 100 and 200). The whole bank was covered with a grid of potential stations spaced at 3 mile intervals. Sampling was arranged in the form of two complete replicate surveys, each of 32 stations. For each survey two stations were randomly preselected from each stratum in each quadrant, making eight stations per quadrant. The day was divided into four 6-hour periods, 0000-0600 hours, 0600-1200 hours, 1200-1800 hours and 1800-2400 hours. Each pair of stations was allocated to a specific time period in the form of a latin square, so that each depth and quadrant was sampled at each division of the day. Thus, on analysing the results of each survey, it was possible to consider the significance of the effects of depth, quadrant and time on each species. The latin square used in the first survey was chosen at random from statistical tables; it is set out in Table 1. The latin square used for the second survey was derived from that of the first, by advancing all times by 1200 hours. This allowed the two surveys to be combined to form one in which each depth stratum of each quadrant was sampled twice in the period 0600-1800 hours and twice in the period 1800-0600 hours. This facilitated an investigation of the interactions between the various factors. Making two replicate surveys also enabled considerations of repeatability to be examined and allowed the estimation of crude values of the variance of numbers at age. The relative complexity of this survey design was made practicable by two factors:

- (1) the relative compactness of Faroe Bank, which enabled steams between almost any pair of stations to be made in the average interhaul time;
- (2) the ability of RV GIROLANA and her fishing crew to work round the clock and to average around 8 stations per day, which made sampling one quadrant at a time practicable. This method of working was statistically preferable in case the survey had to be curtailed due to bad weather or other causes.

Tows were of 1 hour duration wherever possible.

Catch processing: The catch was sorted into species and the total catch of each species was basketed and weighed, using a hanging spring balance of 100 kg capacity or of lesser capacity if the quantity was small. Lengths of all fish of every species were measured unless the catch was sufficiently large for it to be sub-sampled. Otoliths were taken from cod, haddock and lemon sole. Otolith samples were stratified in 5 cm length groups and a maximum of 10 otoliths per length group were taken in each sample. Eight otolith samples - one from each quadrant (first survey) and one from each stratum (second survey) - were taken for each species. One otolith was taken from each fish and the otoliths were stored in tubes, one tube for each 5 cm group of each sample. Fish which were otolithed were individually weighed; the stomach contents were also weighed and the stage of digestion and main food organisms recorded.

Data recording: In the event of groundfish surveys becoming a regular commitment, it would be essential for the data to be computer analysed. It was considered that the development of special computer programs for analysis of this initial survey could not be justified. Nevertheless it was desirable that recording forms should be designed in a format that could be used directly as documents for computer punching and that these recording forms could be given field trials on the present survey. Two such forms were designed, one to record the catch data and the other to record length composition data. An existing form was available as a station log-sheet.

Hydrography: At the hauling position of each trawl station a bathythermograph lowering was made with a Nansen bottle for bottom temperature and salinity.

Surface temperature was recorded continuously on the ship's thermograph.

RESULTS

General: In general there were few problems due to the bottom being unsuitable for trawling. On a few stations it was necessary to move slightly from the

predetermined position to avoid obvious hazards. Very little trawl damage was sustained although the trawl came fast on a few occasions. On some of these hauls the duration of tow was considered adequate to give a reasonable sample, otherwise the tow was repeated.

As far as was possible, the stations of each survey were completed quadrant by quadrant, and within each quadrant the sequence of stations was determined by the time periods in which the stations had to be worked. Because the stations were all relatively close, steaming time between stations was not an important factor and an average of 8 hauls per day was maintained in good weather conditions.

Hydrography: Bottom temperatures were to some degree correlated with depth. Temperatures ranged from 9.18°C on the top of the bank to 7.76°C in the deeper water. There was evidence of a slight overall warming during the cruise. Hydrographic results have been described by Ellett (in press).

Catch composition: Thirty-seven fish species were recorded during the survey and these are listed in Table 2. The weight (kg) of fish caught at each station is tabulated for the main species in Tables 3 and 4. The stations at which the remaining species were caught are listed in Table 5.

For many species, distribution was related to depth. Maximum catch-rates of cod and haddock were taken in the depth range 100-150 m, but saithe had a wider depth distribution. Chimaera, blue whiting, and greater silver smelt, on the other hand, were associated with the deeper water around the edge of the bank.

Statistical analysis: The significance of differences between strata mean weights of catch were investigated for the two surveys, using an analysis of variance. Species investigated by this technique were cod, haddock, saithe, common ling and halibut. Tables 6-10 show the results of the analyses. To obtain approximately homoscedastic variables the transformation $\log_e (W + 1)$ was applied to the weight (kg) of catch from each haul (W). Cod showed significant differences between depths and between quadrants, being seldom caught below 183 m in any quantity and the greatest catches being taken in quadrant D. Haddock showed a similar distribution, with similarly significant results for depth. None of the other species showed any consistently significant results, although ling did show significantly greater weights of catch with increasing depth in the first survey.

The important point about these investigations is that the results found at Faroe Bank will help in the design of future surveys. It is particularly interesting that in no case did the catches vary with the time of the haul. Hence results can be grossed up without any weighting being made for diurnal variations. This result is perhaps not surprising, since at Faroe Bank at the time of the survey the night is extremely short. If this is the reason for the lack of diurnal variation then it suggests that midsummer would be a suitable time for groundfish surveys in high latitude regions.

Accuracy of age data: For cod and haddock the otolith samples were aged and the length compositions converted to age compositions. Age-length keys for different quadrants and strata were compared but no differences were observed. The age-length keys were therefore amalgamated before being applied to each length composition. The resultant age compositions are given in Tables 11 and 12.

The variance of numbers at age has been obtained for cod from considerations of the within strata haul-to-haul variance of the length composition and the variability of the age-length key. The coefficients of variation of the number of cod at each age are given in Table 13(a). For purposes of comparison of the accuracy of research vessel survey data with market samples, the coefficients of variation of North Sea plaice for Lowestoft market samples in January and February 1950 (Gulland 1955) are also given in Table 13(b).

Comparison with Georges Bank survey: Table 14(a) shows results for one of the surveys, set out together with similar data from Georges Bank (Grosslein 1971). The variances from Faroe Bank are broadly similar to those from Georges Bank, bearing in mind that the Faroe units are kg per hour haul, whereas those for Georges Bank are lb per 30 min haul.

The intensity of sampling on Faroe Bank was approximately one station per 50 sq. miles on each survey. This compares with approximately one station per 300 sq. miles on the Georges Bank surveys.

REFERENCES

- Ellett, D. J. (in press). Hydrographic observations on Faroe Bank, 11-21 June 1971. *Annls biol.*, Copenh.
- Grosslein, M. D., 1971. Some observations on the accuracy of abundance indices derived from research vessel surveys. *ICNAF Res. Doc.*, 71/59.
- Gulland, J. A., 1955. Estimation of growth and mortality in commercial fish populations. *Fishery Invest.*, Lond., Ser. 2, 18(9).

Jamieson, A. and Jones, B. W., 1967. Two races of cod at Faroe. *Heredity*, Lond., 22(4).

Jones, B. W., 1966. The cod and the cod fishery at Faroe. *Fishery Invest.*, Lond., Ser. 2, 24(5).

Table 1 Latin squares of quadrants, strata and times used in the two surveys

SURVEY 1

	Quadrant	Stratum (m)			
		< 110	110-146	146-183	183-366
Station no.	A	15 16	11 10	12 13	24 17
Time period		06-12	18-24	00-06	12-18
Station no.	B	5 4	9 3	8 2	7 6
Time period		18-24	12-18	06-12	00-06
Station no.	C	21 14	22 23	33 25	19 18
Time period		00-06	06-12	12-18	18-24
Station no.	D	32 31	27 28	26 34	29 30
Time period		12-18	00-06	18-24	06-12

SURVEY 2

	Quadrant	Stratum (m)			
		< 110	110-146	146-183	183-366
Station no.	A	54 56	60 59	62 53	57 58
Time period		18-24	06-12	12-18	00-06
Station no.	B	68 69	65 66	63 64	71 70
Time period		06-12	00-06	18-24	12-18
Station no.	C	45 52	46 47	48 49	50 51
Time period		12-18	18-24	00-06	06-12
Station no.	D	41 40	44 36	67 43	39 38
Time period		00-06	12-18	06-12	18-24

Table 2 Species list

1	Cod	<i>Gadus morhua</i>
2	Haddock	<i>Melanogrammus aeglefinus</i>
3	Saithe	<i>Pollachius virens</i>
4	Blue Whiting	<i>Micromesistius poutassou</i>
5	Norway Pout	<i>Trisopterus esmarkii</i>
6	Poor Cod	<i>Trisopterus minutus</i>
7	Silvery Pout	<i>Gadiculus argenteus thori</i>
8	Common Ling	<i>Molva molva</i>
9	Blue Ling	<i>Molva dypterygia</i>
10	Tusk	<i>Brosme brosme</i>
11	Greater Fork-beard	<i>Phycis blennoides</i>
12	Catfish	<i>Anarichas lupus</i>
13	Spotted Catfish	<i>Anarichas minor</i>
14	Dab	<i>Limanda limanda</i>
15	Long Rough Dab	<i>Hippoglossoides platessoides</i>
16	Megrin	<i>Lepidorhombus whiffagonis</i>
17	Lemon Sole	<i>Microstomus kitt</i>
18	Plaice	<i>Pleuronectes platessa</i>
19	Halibut	<i>Hippoglossus hippoglossus</i>
20	Angler	<i>Lophius piscatorius</i>
21	Redfish	<i>Sebastes sp.</i>
22	Greater Silver Smelt	<i>Argentina silus</i>
23	Sandeel	<i>Ammodytidae</i>
24	Gurnard	<i>Triglidae</i>
25	Dragonet	<i>Callionymus lyra</i>
26		<i>Triglops sp.</i>
27		<i>Lycenchelys sp.</i>
28	Black-mouthed Dogfish	<i>Galeus melastomus</i>
29	Velvet Belly	<i>Etmopterus spinax</i>
30		<i>Centrophorus squamosus</i>
31	Skate	<i>Raja batis</i>
32	Shagreen Ray	<i>Raja fullonica</i>
33	Cuckoo Ray	<i>Raja naevus</i>
34	Thornback Ray	<i>Raja clavata</i>
35	Sandy Ray	<i>Raja circularis</i>
36	Rabbit-fish	<i>Chimaera monstrosa</i>
37	Lamprey	<i>Petromyzon marinus</i>
38	Squid	<i>Loligo sp.</i>

Table 3 Weight of catch (kg) of the main species at each station. Survey 1

Species	Station																																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	24	25	26	27	28	29	30	31	32	33	34		
Cod	6	58	42	65	5		11	106		96	19	69	22	101	116				370	71	43	5		26	177	195		5	96	251		14		
Haddock	6	31	13	41	5		7	97	35	30	22	32	17	239	46	+			104	24	25		10	67	186	286	10	7	17	24	10	14		
Saithe	7	612	62	79	148	84	19	11	396	385	103	203	13	226	60	67	170	35	15	757	121	66	118	155	299	190	172	392	124	261	176	50		
Blue Whiting			2	1	2	78	5		1	1	5				35	65	44				25							+	1		6			
Norway Pout	13	5						1	10	5	+	12	+	2	1				1	17	2		1	+	2		11	+	+	+	8	1		
Silvery Pout					2		+		9		6					5	2	+			41					4			5					
Common Ling	16	+	+	12	45	84	64			17	53	7		8	18	4	7			14		13					4	12		48				
Tusk	2			7	19	28		+			5		2	11	15	9	1	7								1		14		14				
Merlin									+	2		2				+				+	1					+	6	+	+		1			
Lemon Sole	1	1	+	1	+		+	3	2	1	1	4	4	+	2	+	+		5	+	1				1	1	1	+	+	2	3	+		
Halibut			7	1	15		5		2	3	5	1		14	22	7			2	3	3	4	6			7	8	13	2	1	2	18		
Angler																					16	30				3								
Redfish	11		14	3	7	2	14	4	+	10	26	9	2	4	46	8	2	8	8	12	1	4			+					1	13			
Greater Silver Smelt					18	412	75		1	1	157	8	+	1	109	46	13	+			+	4			+		244	34		116	3			
Rabbit-fish					65	246	15				2				2	113	124				20													
Squid					4	4	3	1	66	4	4	5	6	74		12	11	3	15		8	7		2	5	8			12	10	1	2		
Depth (m)	163	111	107	96	298	321	170	102	163	135	164	120	108	104	118	287	279	339	104	138	134	279	174	160	121	127	211	228	106	106	172	171		

Table 5 Stations where catches of the less important species were recorded

Species	Stations recorded
Poor Cod	21, 31, 40, 44, 46, 54, 65, 68
Blue Ling	19, 38, 39, 50, 51, 58, 70
Greater Fork-beard	7, 18, 19, 24, 39, 51, 57, 58
Catfish	10, 32, 40, 49, 50
Spotted Catfish	4, 21
Dab	4, 13, 16, 26, 27, 28, 36, 41, 43, 44, 47, 48, 49, 56, 60, 64, 66, 68, 70
Long Rough Dab	10, 11, 12, 16, 18, 24, 26, 29, 34, 48, 50, 53, 57, 60, 62, 64, 67, 69, 70, 71
Plaice	32
Sandeel	5, 60
Gurnard	10, 13, 22, 23, 25, 26, 27, 28, 32, 34, 36, 41, 43, 46, 48, 52, 59, 63, 66, 67, 69
Dragonet	26, 48, 62, 69
<u>Triglops</u> sp.	27, 56, 65
<u>Lycenchelys</u>	19, 39, 57
Black-mouthed Dogfish	7, 13, 17, 18, 19, 24, 39, 51, 57, 58
Velvet Belly	18, 19, 39, 51, 57, 58
<u>Centrophorus squamosus</u>	19, 57
Skate	27, 45, 59, 62
Shagreen Ray	60, 62
Cuckoo Ray	13
Thornback Ray	9, 45, 54
Sandy Ray	34, 50, 54
Lamprey	57

Table 6 Analysis of variance: Cod

Cause	Degrees of freedom	Sum of squares	Mean squares	F ratios	Significance
1st Survey					
Quadrants	3	8.4	2.8	3.6	*
Depths	3	95.8	31.9	40.9	***
Times	3	2.6	0.9	1.1	
Errors	22	17.2	0.8		
2nd Survey					
Quadrants	3	16.3	5.4	4.3	*
Depths	3	81.6	27.2	21.6	***
Times	3	7.7	2.6	2.0	
Errors	22	27.7	1.3		

Levels of significance: * 5%
 ** 1%
 *** 0.1%

Table 7 Analysis of variance: Haddock

Cause	Degrees of freedom	Sum of squares	Mean squares	F ratios	Significance
1st Survey					
Quadrants	3	6.8	2.3	3.5	*
Depths	3	48.4	16.1	25.0	***
Times	3	5.0	1.7	2.6	
Errors	22	14.2	0.6		
2nd Survey					
Quadrants	3	6.2	2.1	2.0	
Depths	3	25.7	8.6	8.5	***
Times	3	1.9	0.6	0.6	
Errors	22	22.2	1.0		

Table 8 Analysis of variance: Saithe

Cause	Degrees of freedom	Sum of squares	Mean squares	F ratios	Significance
1st Survey					
Quadrants	3	7.8	2.6	2.1	
Depths	3	5.9	2.0	1.6	
Times	3	0.2	0.1	0.1	
Errors	22	27.7	1.3		
2nd Survey					
Quadrants	3	2.8	1.0	1.5	
Depths	3	1.7	0.6	0.9	
Times	3	1.1	0.4	0.6	
Errors	22	14.0	0.6		

Table 9 Analysis of variance: Common Ling

Cause	Degrees of freedom	Sum of squares	Mean squares	F ratios	Significance
1st Survey					
Quadrants	3	12.3	4.1	2.7	
Depths	3	20.5	6.8	4.4	*
Times	3	6.1	2.7	1.7	
Errors	22	34.1	1.6		
2nd Survey					
Quadrants	3	8.0	2.7	1.7	
Depths	3	14.1	4.7	3.0	
Times	3	4.9	1.4	0.9	
Errors	22	34.3	1.6		

Table 10 Analysis of variance: Halibut

Cause	Degrees of Freedom	Sum of squares	Mean squares	F ratios	Significance
1st Survey					
Quadrants	3	3.3	1.1	1.1	
Depths	3	0.3	0.1	0.1	
Fishes	3	6.8	2.3	2.2	
Errors	22	22.6	1.0		
2nd Survey					
Quadrants	3	0.2	0.1	0.0	
Depths	3	5.6	1.9	1.3	
Fishes	3	1.1	0.4	0.3	
Errors	22	32.7	1.5		

Table 11 Age compositions of cod. Numbers per 100 hours fishing

Age-group	Mean length (cm)	Numbers per 100 hours fishing										
		Quadrant				Stratum				Survey		Total
		A	B	C	D	1	2	3	4	1	2	
1	20.3	13	63	31	288	106	288			134	63	98
2	51.6	250	319	150	288	494	413	100		222	281	252
3	75.0	64	124	270	273	464	180	75	13	165	200	182
4	86.8	202	435	234	416	632	357	290	6	331	312	322
5	93.8	21	68	36	53	78	64	35		45	45	45
6	102.1	8	33	19	36	49	32	15		22	26	24
7	103.0	19	68	36	63	90	60	33		41	51	46
8	107.6	13	38	20	25	44	35	16		19	29	24
9	108.9	29	40	33	29	78	34	20		30	36	33
10	107.1	7	22	14	15	26	23	9	6	12	18	15
11	111.3	10	13	12	8	29	10	7		10	12	11
12	112.5	1	2	3	1	2	4	0		1	2	2
13	117.5	5	2	5		8	2	1		3	3	3

Table 12 Age compositions of haddock. Numbers per 100 hours fishing

Age-group	Mean length (cm)	Numbers per 100 hours fishing												Total
		Quadrant				Stratum				Survey				
		A	B	C	D	1	2	3	4	1	2	3	4	
1	19.2	10 069	5 712	7 981	8 246	3 398	18 839	8 388	1 384	7 825	8 179			8 002
2	29.6	882	689	637	1 075	1 437	1 351	416	79	940	701			821
3	43.2	1 764	1 640	1 314	2 747	3 759	2 782	869	57	2 305	1 428			1 867
4	53.1	382	329	623	774	579	840	518	171	588	466			527
5	57.7	126	88	182	160	187	185	139	43	149	129			139
6	68.6	28	26	28	52	38	74	17	4	43	23			33
7	66.5	18	13	20	27	22	37	16	5	23	16			20
8	71.1	26	17	15	41	32	56	10	1	34	15			25
9	72.9	23	16	10	39	26	54	8	1	32	13			22
10	71.9	6	1	2	6	7	6	1		5	2			4
11										0	0			0
12	82.5	2			2	2	2			2	0			1

Table 13 Accuracy of age-length data

(a) Faroe Bank Cod

	Age (years)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Number from survey	63	161	118	205	28	17	30	15	21	9	8	1	1
Coefficient of variation (%)	22	11	18	11	33	44	29	42	35	56	62	150	103

(b) North Sea Plaice (Lowestoft market samples in January and February 1950)

	Age (years)												
	1	2	3	4	5	6	7	8	9	10	11	12+	13
Number x 10 ⁻³	215	1114	1870	689	321	153	172	127	70	52	88		
Coefficient of variation (%)	18.3	8.2	6.1	9.6	14.2	19.3	17.7	20.0	27.7	33.3	19.3		

Table 14

(a) Mean transformed catch per haul [$\log_e (kg + 1)$] and variance estimates from second survey at Faroe Bank

	Mean	Variance	Standard deviation	Coefficient of variation (%)	95% confidence limits
Cod	2.77	0.0393	0.1982	7	2.37-3.17
Haddock	2.91	0.0315	0.1775	6	2.55-3.27
Saithe	4.63	0.0394	0.1985	4	4.23-5.03
Ling	1.46	0.0487	0.2207	15	1.02-1.90
Halibut	1.11	0.0465	0.2156	19	0.68-1.54

(b) Stratified mean catch per haul (lb \log_e scale) for haddock and cod on Georges Bank (ALBATROSS IV fall surveys, strata 13-25). From Grosslein (1971)

Cruise	Mean	Variance	Standard deviation	Coefficient of variation (%)	95% confidence limits
HADDOCK					
63- 7	3.34	0.052176	0.2284	7	2.88-3.80
64-13	3.86	0.080315	0.2834	7	3.29-4.43
65-14	4.02	0.042355	0.2058	5	3.61-4.43
66-14	2.43	0.044512	0.2110	9	2.01-2.85
67-21	2.45	0.052075	0.2282	9	1.99-2.91
68-17	1.15	0.029587	0.1720	15	0.81-1.49
69-11	1.10	0.021536	0.1467	13	0.81-1.39
70- 6	1.35	0.0345	0.1857	14	0.98-1.72
COD					
63- 7	1.75	0.084829	0.2912	17	1.17-2.33
64-13	1.29	0.056270	0.2372	18	0.82-1.76
65-14	1.32	0.041737	0.2043	15	0.91-1.73
66-14	1.20	0.040673	0.2017	17	0.80-1.60
67-21	1.74	0.047301	0.2175	12	1.30-2.18
68-17	1.04	0.031888	0.1786	17	0.68-1.40
69-11	1.32	0.025381	0.1593	12	1.00-1.64
70- 6	1.35	0.0332	0.1822	13	0.99-1.71

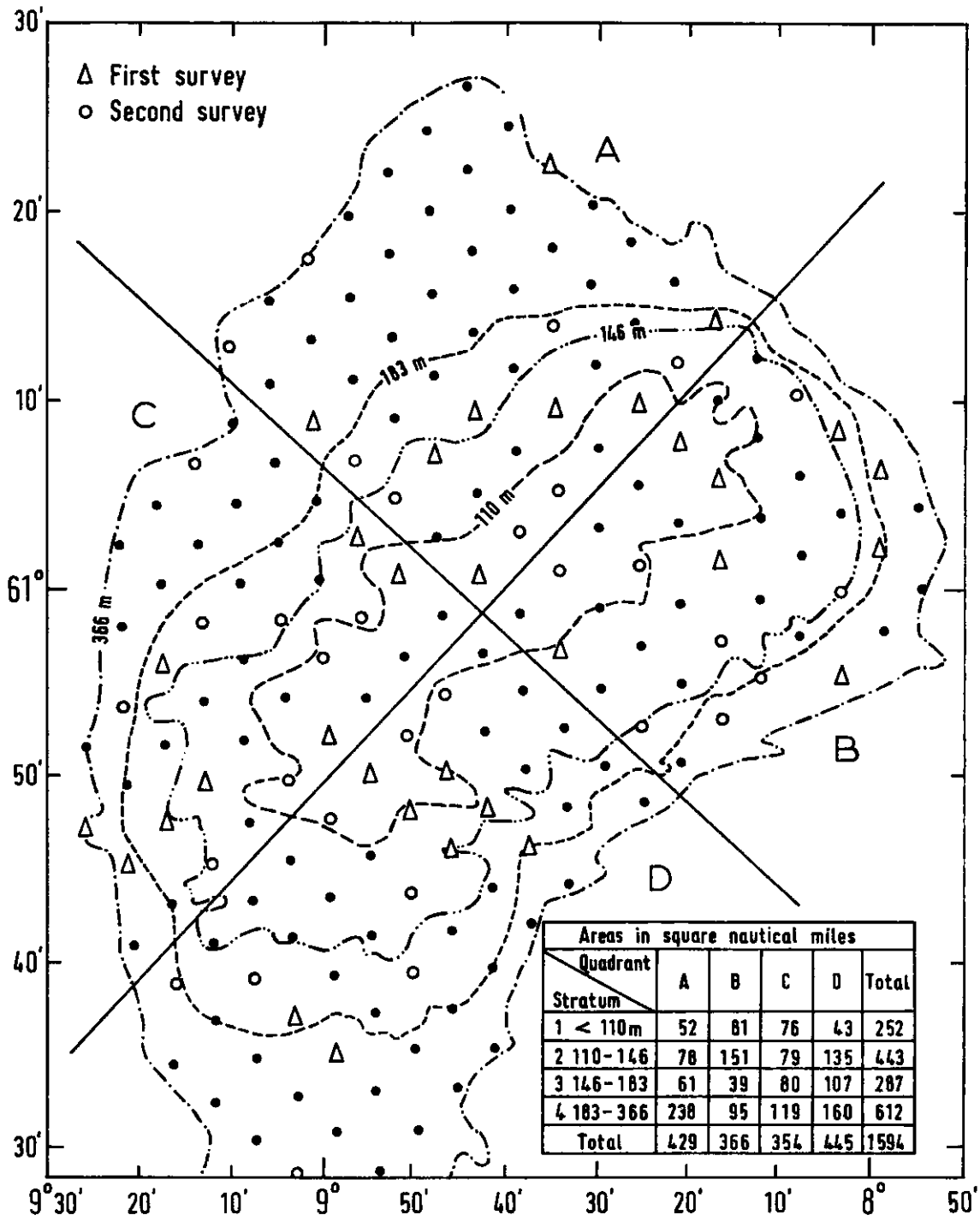


Figure 1 Chart of Faroe Bank showing quadrants, depth strata, the grid of potential stations, and stations worked on the first and second surveys.